SECTION 3

AIR INTAKE SYSTEM

CONTENTS

AIR INTAKE SYSTEM

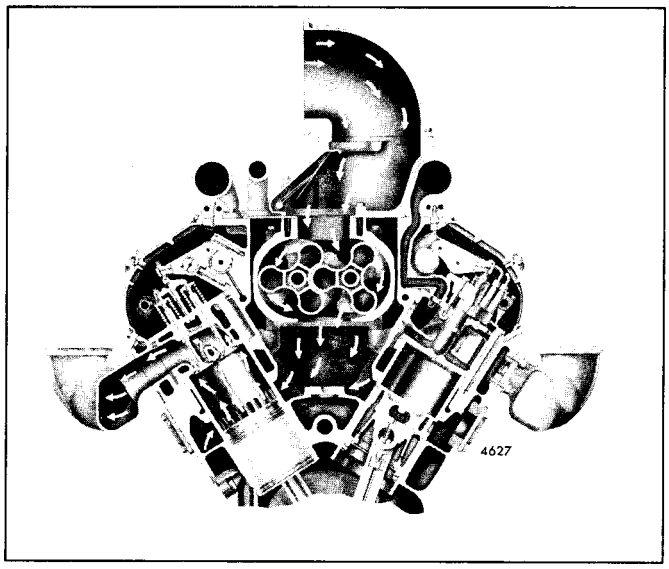


Fig. 1 - Air Flow Through Blower and Engine

In the scavenging process employed in the Series 149 engines, a charge of air is forced into the cylinders by the blower and thoroughly sweeps out all of the burned gases through the exhaust valve ports. This air also helps to cool the internal engine parts, particularly the exhaust valves. At the beginning of the compression stroke, therefore, each cylinder is filled with fresh, clean air which provides for efficient combustion.

The air, entering the blower from the air cleaner or air silencer, is picked up by the blower rotor lobes and carried to the discharge side of the blower as indicated by the arrows in Fig. 1. The continuous discharge of fresh air from the blower enters the air chamber of the cylinder block and sweeps through the intake ports of the cylinder liners.

The angle of the ports in the cylinder liners creates a uniform swirling motion to the intake air as it enters the cylinders. This motion persists throughout the compression stroke and facilitates scavenging and combustion.

Effective with engine serial numbers 12E-8157 and 16E-7668, turbocharged-intercooled engines were equipped with a blower bypass valve. This valve was located in a chamber between the intercooler and the blower (Fig. 2).

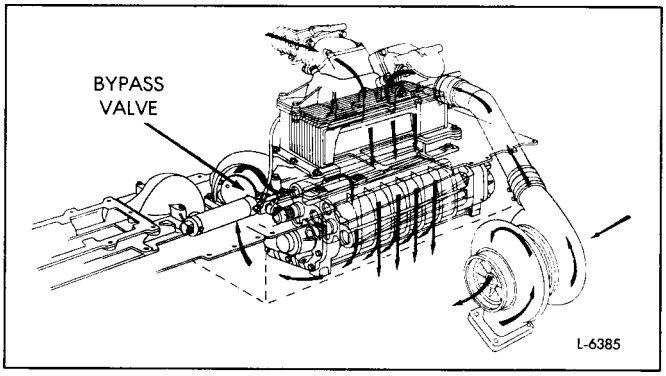


Fig. 2 - Air Flow Schematic - Former Flapper Style Blower Bypass Valve-Equipped Engine

• Effective with unit serial numbers 8E02594, 12E08925, and 16E08960, this “flapper” style blower bypass valve system was replaced by the piston style blower bypass valve system (Fig. 3).

During high rpm or high load engine operation the blower bypass valve opens, equalizing air pressure on the inlet and outlet sides of the blower and virtually eliminating its pumping horsepower requirement. Driven by the engine gear train, the blower continues to turn, but it does not compress the incoming air. Instead, the exhaust gas-driven turbocharger does the compressing. The blower requires little horsepower to operate in this manner, and it is this reduced horsepower need that helps improve fuel economy.

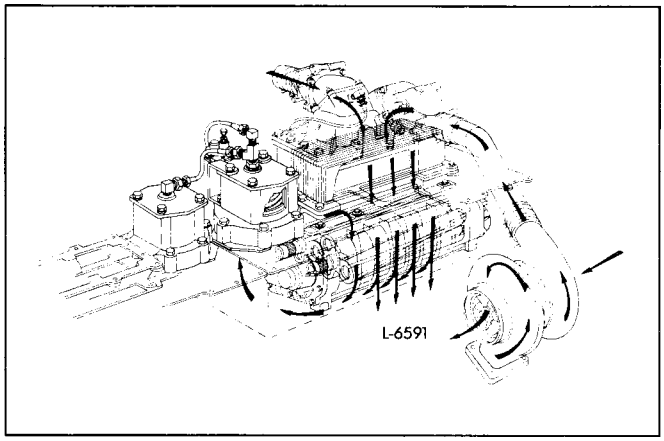


Fig. 3 - Air Flow Schematic — Current Piston Style Blower Bypass Valve-Equipped Engine

AIR CLEANER

Both heavy duty and light duty oil bath type air cleaners and a multistage dry type air cleaner are used on the Series 149 engines, depending on the application and/or operating conditions.

The air cleaners are designed to remove dust and foreign material from the air, pass the required volume of air for efficient combustion and scavenging, and maintain their efficiency for a reasonable period of time before requiring service.

The importance of keeping dust and grit-laden air out of an engine cannot be overemphasized, since clean air is so essential to satisfactory engine operation and long engine life. The air cleaner must be able to remove fine materials such as dust and blown sand as well as coarse material like chaff, sawdust or lint from the air. It must also have a capacity large enough to retain the material separated from the air to permit operation for a reasonable period before cleaning is required.

Dust and dirt entering an engine will cause rapid wear of piston rings, cylinder liners, pistons and the exhaust valve mechanism with a resultant loss of power and high lubricating oil consumption. Also dust and dirt which is allowed to buildup in the air cleaner passages will eventually restrict the air supply to the engine and result in heavy carbon deposits on the pistons and valves due to incomplete combustion.

No hard fast rule for servicing an air cleaner can be given since it depends upon the type of air cleaner, air conditions and the type of application. A cleaner operating in severe dust conditions will require more frequent service than one operating in relatively clean air. The most satisfactory service period should be determined by inspecting the cleaners frequently, under normal operation, then setting the service period to best suit the requirements of the application.

A service indicator may be attached near the outlet side of some air cleaners to provide a visual means of determining when the cleaner requires service.

Air Cleaner Maintenance

Although air cleaners are highly efficient, the efficiency may be offset by leaks in the duct work, loose hose connections or damaged gaskets which permit dustladen air to completely bypass the cleaner and enter the engine directly.

The following maintenance procedure will assure efficient air cleaner operation:

1. Keep the air cleaner tight on the air intake to the engine.
2. Keep the air cleaner properly assembled so that the joints are strictly oil and air tight.
3. If the air cleaner, intake or connections are damaged, repair them at once.
4. In dusty areas, inspect the air cleaner frequently. Clean the oil cup often enough to prevent the oil from becoming excessively thick with sludge.
5. After servicing the air cleaner, remove the air inlet housing and clean accumulated dirt deposits from the blower screen and the air inlet housing. Make sure all air intake passages and the air box are kept clean.

DRY TYPE AIR CLEANER

The heavy duty dry type air cleaner is designed to provide highly efficient air filtration under all operating conditions and is not affected by engine speed (Fig. 1). The cleaner assembly consists of a centrifugal air cleaner in series with a replaceable impregnated paper filter element. Dust and dirt removed by the first stage centrifugal cleaner can be collected in a dust chamber or automatically removed by the use of vacuator valves. The centrifugal cleaner and replaceable filter element are held together in a steel housing. Positive sealing between the two elements and the housing is provided by rubber gaskets. The steel housing incorporates filter fasteners, mounting flanges and an outlet for the filtered air.

Operation

As air is drawn through the perforated sections of the steel housing, vanes in the tubes of the centrifugal stage of the cleaner impart a swirling motion to the air entering the cleaner and centrifuge the dust particles against the walls of the tubes. The dust particles are then carried to the dust chambers by a small portion of the air and either automatically removed by vacuator valves or stored for later removal. The remainder of the air then reverses direction in the tubes and spirals back along the tubes again centrifuging the air. The filtered air flow direction is again reversed and the air enters the replaceable filter element through the center of the tubes. The air is filtered once more as it passes through the paper element before entering the engine.

Service

Service and replace the air cleaner elements according to the manufacturer's recommendations. See Section 15.1 for element change intervals.

Under no engine operating conditions should the maximum allowable air intake restriction shown in Section 13.2 of the service manual be exceeded. Check restriction with a water manometer using the procedure outlined under "final RUN-IN" in Section 13.2.1. In addition, inlet restriction should be adjusted for high altitude conditions (see TABLE 1). A clogged air cleaner element will cause excessive intake restriction, reduce air supply to the engine, poor performance and higher valve and cylinder temperatures.

The filter manufacturer has no control over the field cleaning method or procedure. Therefore, it is the responsibility of the person or shop cleaning the element to assure the reliability of the filter after cleaning. It is also the responsibility of the installer to assure proper sealing of the gaskets.

Clean the air cleaner elements as follows:

1. Clean the tubes, dust bin and paper element with compressed air.

INTAKE DEPRESSION DERATING FOR ALTITUDE ALL ENGINES FOR ALL SPEEDS

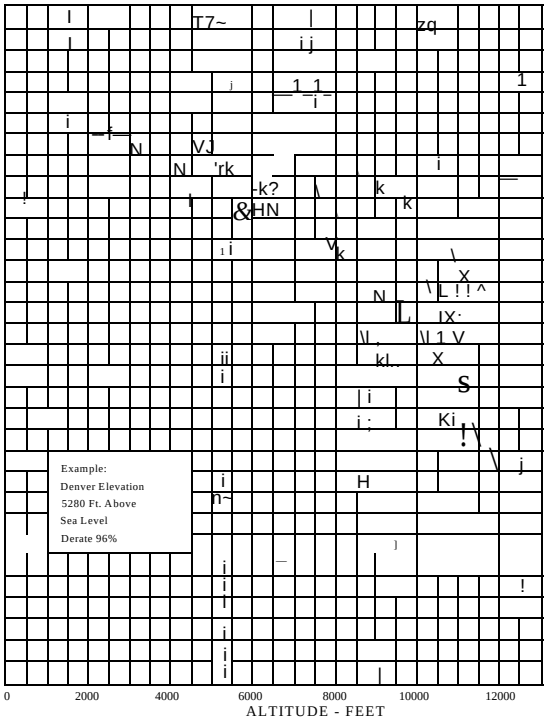


TABLE 1

NOTICE: When cleaning the paper element, direct the air jet against the inside of the element. Do not attempt to clean the element by beating or rapping it.

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

2. If compressed air is not available, run water through the element. Use a gentle stream of water (less than 40 psi or 276 kPa).

   a. Clean the elements from the inside only.

   b. If mechanical dryers are used, the air must be circulated and must not exceed 180°F (82°C).

3. If the element is clogged with soot, carbon, lint and oil, use water and Donaldson filter cleaner compound or a non-sudsing equivalent.

   a. If compressed air is available, remove the loose dust by blowing from the inside of the element out. *Use less than 100 psi (689 kPa).* If compressed air is not available, use a stream of water (less than 40 psi or 276 kPa) to wash from the inside out.

   b. Soak the element in a solution of water and Donaldson filter cleaning compound or a non-sudsing equivalent.

NOTICE: Do not use fuel oil, gasoline or other volatile solvents.

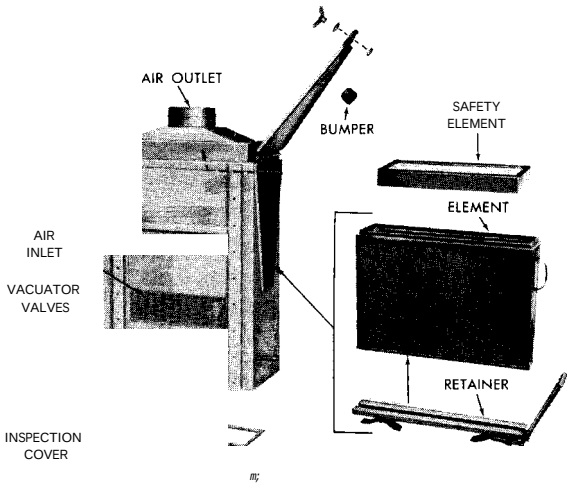


Fig. 1 - Heavy Duty Dry Type Air Cleaner

c. Gently swirl the element in the solution to loosen the dirt.

4. If plugged, clean the tubes with a stiff fiber brush or compressed air. Do not exceed 40 psi (276 kPa) air pressure.

5. Replace the safety element when the restriction (measured with a new or cleaned element) is one-third of the way from initial to maximum allowable restriction.

If a specific air cleaner has an initial restriction of 12 inches (2.99 kPa) of water (with a new vee pac and safety elements) and a maximum allowable restriction of 30 inches (7.47 kPa) of water, the safety element should be replaced when the restriction reaches 18 inches (4.48 kPa) or more (with a new or cleaned element).

Do not attempt to clean or reuse the safety element. Replace with a new element.

NOTICE: The safety element in early Donaldson SEG type air cleaners did not provide sufficient air flow when used on turbocharged engines and it was recommended that the element be removed and discarded. However, a new safety element, with increased filtering area and filter paper treated to resist the effects of exhaust soot, has replaced the former element for service. The new safety element can be used in SEG air cleaners on both turbocharged and non-turbocharged engines.
The SRG and STG type air cleaners, different in size and shape from the SEG type, have a safety element which flows sufficient air for all engine applications.

Inspection

After cleaning the air cleaner elements and before installation, inspect them.

Check the paper element with a bright light by holding the light on one side and checking for bright spots on the other side, which would indicate a rupture.

Inspect the gasket inside of the housing.

Check with a light to make sure that the tubes are clean and not plugged.

Install the elements.

Element Life

The recommended product life (shelf life plus service life) of Donaldson dry type air cleaner elements is three years. Consequently, Donaldson elements should be put into service no later than two years from the date of manufacture. Farr air cleaner elements should be put into service within one year from the date of manufacture.

OIL BATH TYPE AIR CLEANER

Heavy-Duty (Fig. 2): In this type of air cleaner, the air is drawn into the cleaner through the inlet opening at the top. The air passes over the oil and is then directed upwards by baffles and then passes through a removable screen assembly. During this change in direction of flow, the larger particles of foreign matter are removed from the air by the oil and the screen assembly and settle in the oil cup sump. The air continues upward through a metal-wool element where the finer particles and the entrained oil are removed. The clean air is then discharged through a side outlet near the top of the cleaner body and flows through the air inlet housing to the intake side of the blower assembly.

Light-Duty (Fig. 3): In this type of air cleaner, the air is drawn into the cleaner through a series of slots around the perimeter of the cleaner body just above the oil cup assembly. The air passes over the oil and is then directed upwards by baffles and then passes through a removable screen assembly (Fig. 4). During this change in the direction of flow, the larger particles of foreign matter such as lint, chaff, leaves, etc., are removed from the air by the oil and the screen assembly and settles in the oil cup sump. The air continues upward through a metal-wool element where finer particles such as dust and the entrained oil are removed. The clean air is then discharged through a side outlet near the top of the cleaner body and flows through the air inlet housing to the intake side of the blower assembly.

Air Cleaner Service

Loosen the clamp and remove the oil cup from the air cleaner. Then take the removable element or screen from the cup. Empty the oil from the cups. Remove the inner cup and clean the sludge from both cups with fuel oil.

Clean the separator screen or removable element by washing in a solvent and drying it with compressed air. An even pattern of light should be visible through the screen when held up to a light. If the screen or element cannot be cleaned, replace it.

Clean the air cleaner inlet center tube by running a solvent soaked swab completely through it.

Reassemble the oil cups and fill them to the indicated oil level with clean engine oil of the same viscosity and grade as used in the engine. Install the removable element or screen and install the cup assembly on the air cleaner. Make sure the oil cup is securely fastened to the air cleaner body.

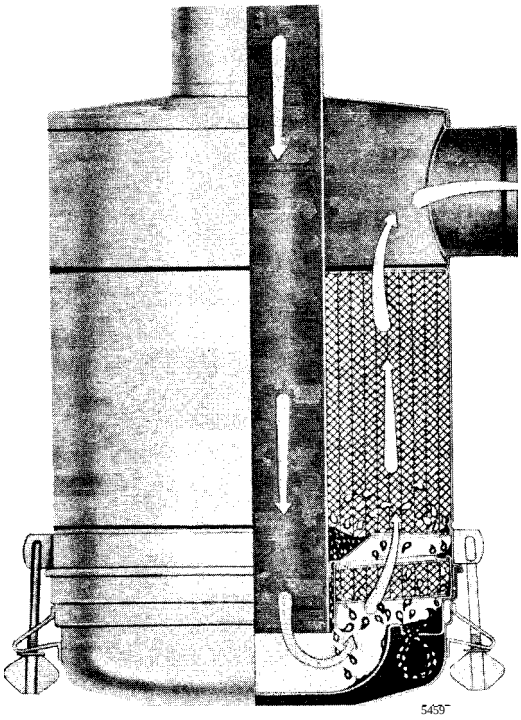


Fig. 2 - Air Flow Through Heavy Duty Oil Bath Type Air Cleaner

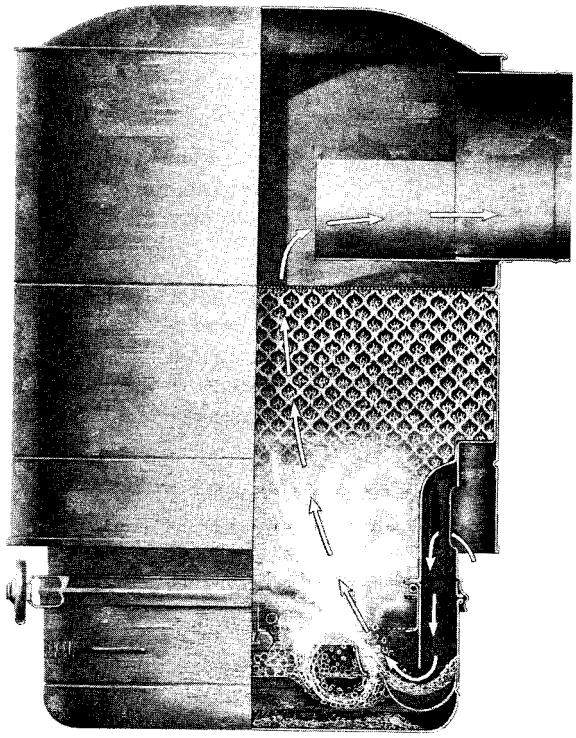


Fig. 3 - Air Flow Through Light Duty Oil Bath Type Air Cleaner

NOTICE: Do not overfill the oil cup. If too much oil is used, it may be pulled through the air cleaner and into the engine, carrying dirt into the cylinders and also result in excessive engine speed. Insufficient oil will decrease efficiency of the air cleaner.

Make sure all gaskets and joints are tight. Check all connections from the air cleaner to the engine for air leaks to prevent any air bypassing the air cleaner.

At some regular period of engine service, or when there is an indication of contaminant buildup or plugging, remove the entire air cleaner from the engine and clean the fixed element.

NOTICE: Do not remove the fixed element from the air cleaner body. If the element cannot be cleaned, the air cleaner should be replaced.

With the oil cup removed, pump solvent through the air outlet with sufficient force and volume to produce a hard even stream out the bottom of the air cleaner body. Continue reverse flushing until all foreign material is removed. If a recirculating system is used, it should be large enough to allow contaminants to settle out before the solvent is recirculated.

NOTICE: Do not use gasoline and never try to burn off lint or chaff. This heat will make the element brittle and will melt soldered joints.

When clean, allow the fixed element to dry thoroughly before installing the air cleaner on the engine. Clean out the center tube.

Reinstall the air cleaner body. Install new rubber seal rings, if used. Tighten the retaining device evenly and securely. Use a new gasket if the air cleaner is flange mounted. Service the oil cup and removable element and assemble it to the air cleaner.

If the fixed element requires too frequent cleaning, it is advisable to relocate the air intake to provide a cleaner air supply.

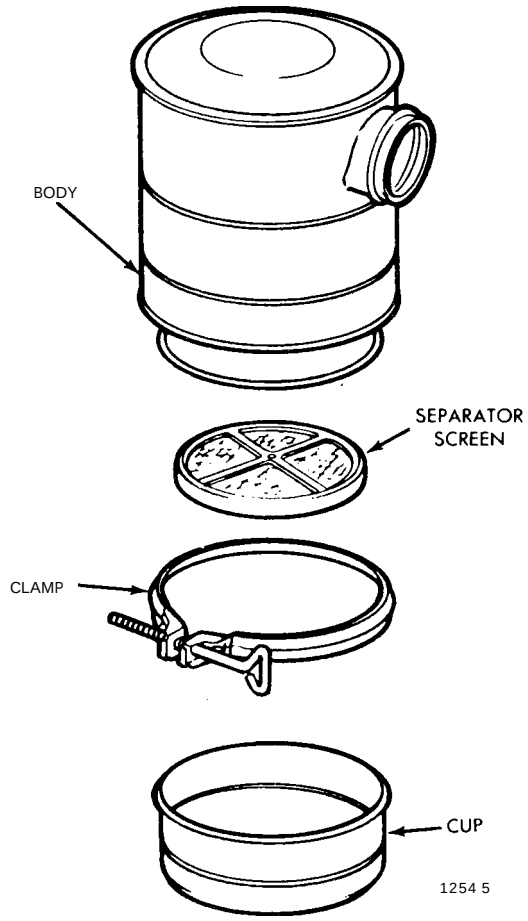


Fig. 4 - Light-Duty Air Cleaner Details and Relative Location of Parts

AIR SHUTDOWN HOUSING

TURBOCHARGED ENGINES

After passing through the air cleaners, and turbochargers, if used, the engine scavenging and combustion air supply flows through the air inlet housing, air shutdown housing, the blower and then into the engine air box and cylinders (Fig. 1).

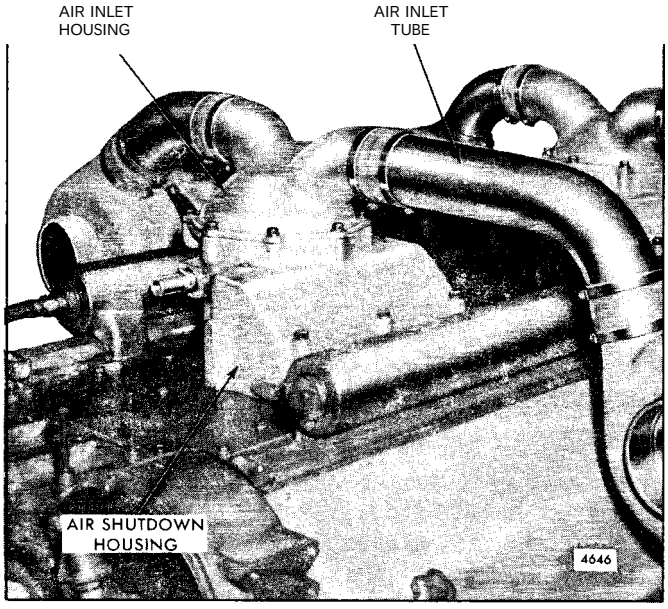


Fig. 1 - Typical Air Shutdown Housing Mounting

The air shutdown housing contains two air shutoff valves that shut off the air supply and reduce the speed of the engine whenever abnormal engine operating conditions require an emergency shut down.

The 12V and 16V naturally aspirated and turbocharged engines are equipped with two air shutdown housings connected together by a shaft and coupling arrangement (Fig. 2).

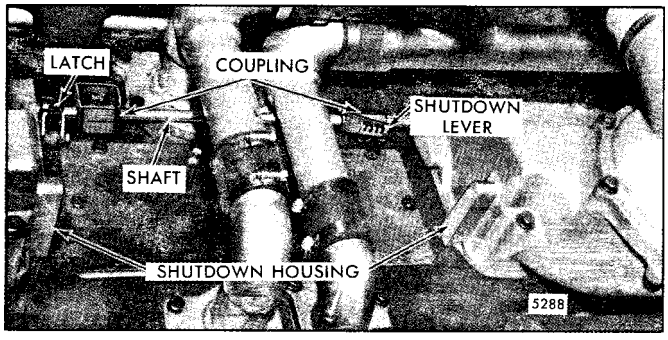


Fig. 2 - Air Shutdown Shaft and Coupling Arrangement

Remove Air Shutdown Housing

1. Disconnect and remove the air ducts between the air cleaner and the air shutdown housing. On turbocharged engines, loosen the hose clamps and slide the hose back over the air inlet tubes.
2. Disconnect the shutdown mechanism from the air shutdown latch. Then, remove the crossover shaft between the two air shutdown housings (12V and 16V) by removing the cotter pins in the couplings, loosening the bolts and sliding the couplings toward the shutdown housings.
3. Remove the eight bolts and washers which attach the air inlet housing to the air shutdown housing. Remove the air inlet housing and gasket.
4. Remove the bolts, lock washers and washers which attach the air shutdown housing to the blower. Then, remove the housing, blower screen, striker plate and gasket (current engines). Cover the blower opening to prevent dirt or foreign material from entering the blower.

Disassemble Air Shutdown Housing

1. Refer to Fig. 3 and remove the pin from the end of the shutdown shaft. Then, remove the spacer (current engines) or washer from the shaft and the seal rings from the housing.
2. Remove the pins which secure the air shutoff valves to the shaft.
3. Remove the bolt, lock washer and plain washer which attach the latch to the housing. Then, remove the latch, latch spring and bushing.
4. Note the position of the air shutoff valve; spring and valves. Then, withdraw the shaft from the housing to release the valves and spring.
5. If the shaft is to be replaced, remove the cam pin and the cam from the shaft.

Inspection

Clean all of the parts thoroughly, including the blower screen, with fuel oil and dry them with compressed air.

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

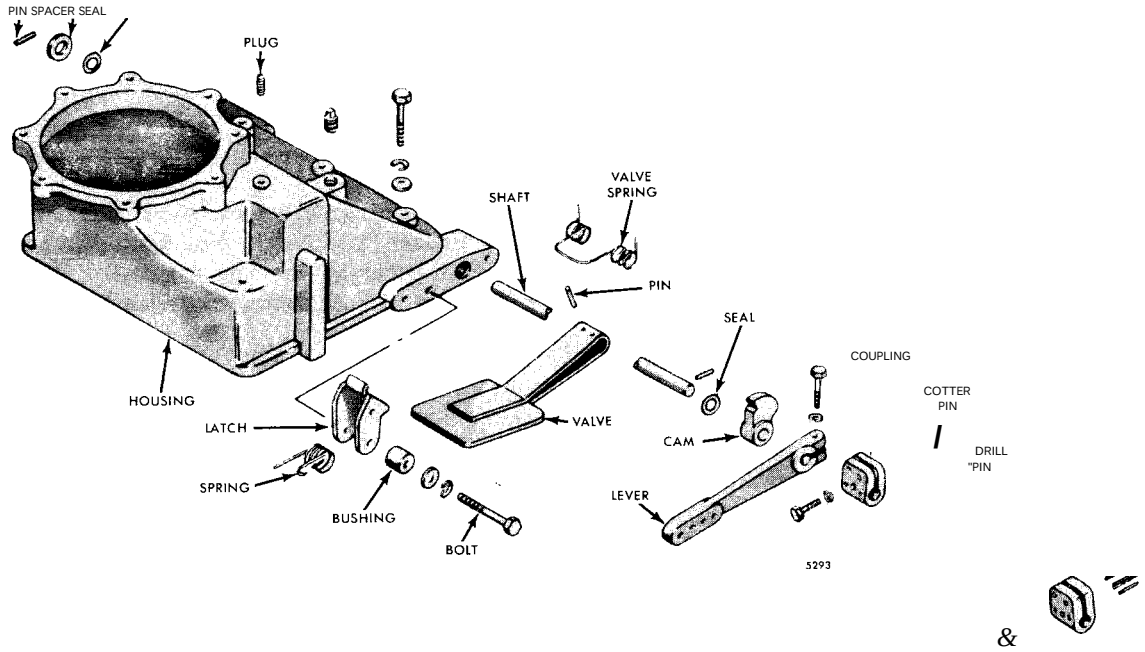


Fig. 3 - Air Shutdown Housing Details and Relative Location of Parts

Inspect the parts for wear or damage. The faces of the air shutoff valves must be perfectly flat to ensure a tight seal when they are in the *closed* position. Bend the valves *slightly*, if necessary.

Before replacing a turbocharger that has experienced compressor or turbine wheel damage, always inspect the air induction systems for damage and debris. Check air inlet ducting from the turbocharger compressor inlet pipe to the air cleaner assembly. Look for cracks or signs of air leakage and remove any dirt or debris. Check turbocharger discharge-to-blower piping for leaks or debris.

• A 3.75" long X 3.25" diameter hose and thick (.035") band stainless steel T-bolt clamp are currently used between the turbochargers, air outlet tubes, and air inlet housings of Series 149 engines. The former 3.25" long X 3.50" diameter hose and T-bolt clamp (.025" thick band) should be replaced with the new at time of normal engine overhaul, or earlier if sealing or clamping concerns are experienced.

Check the exhaust system from the cylinder head exhaust ports to the exhaust outlet piping on the turbine side of the turbocharger and the inside of the exhaust manifold(s). Remove any debris left over from the damaged turbocharger. Repair or replace any other damaged or defective components in the air induction systems.

Failure to remove contaminants or debris from these systems can result in damage to the replacement turbocharger. On engines equipped with mechanical emergency shutdown, check for proper operation of *each* flapper valve.

Assemble Air Shutdown Housing

The holes for the cam and retaining pins must be drilled, using a 1/8" diameter drill, at the time a new service shaft or air shutoff valve is assembled (see Shop Notes in Section 3.0 for the procedure). The valves must be in the same plane within .030" when in the *stop* position (flush with the housing face).

1. Place the valves and spring in position in the housing and slip the shaft in place. The shaft must extend 1.80" from the side of the housing where the shutdown latch is assembled.

2. Install a new seal ring at each end of the shaft. Be sure the seal rings are seated in the counterbores of the housing.

3. Install the cam on the shaft. Then install the pin which retains the cam to the shaft.

4. Install a spacer (formerly a washer) and retaining pin at the other end of the shaft.

5. Assemble the eccentric (bushing), spring and latch to the shutdown housing with the l/4"-20 bolt, lock washer and plain washer.

   a. Align the notch on the bushing with the notch on the latch and lock the bushing in this position.

   b. Install the pins in the valves to retain them on the shaft, with the cam release latch set and the valves in the *run* position.

c. Level the valves in the *shutoff* position.

d. Adjust the bushing so that the valves contact the housing when the cam release latch is set.

Install Air Shutdown Housing

1. Place the striker plate and gasket, if used, on the blower cover plate.
2. Place a new gasket and screen assembly on the striker plate or the blower cover plate. Position the gasket and screen assembly on the blower cover plate or the striker plate with the screen side of the gasket against the cover plate or striker plate. Otherwise, a positive seal may not be obtained and the engine may continue to run after attempting a shut down.
3. Position the air shutdown housing on the gasket and screen assembly and secure it in place with 7/16"—14 bolts, lock washers and washers. Tighten the bolts to 46-50 lb-ft (62-68 N*m) torque.
4. Install the air inlet housing, using a new gasket on the air shutdown housing, with eight (8) 3/8"-16 bolts, washers and lock washers. Tighten the bolts to 30-35 lb-ft (41—47 N*m) torque.
5. Connect the air inlet tubes. Be sure all connections are air-tight.
6. When both air shutdown housings have been installed (12V or 16V engine), position the crossover shaft and manual shutdown lever between the housings. Before securing the couplings, close the valves in both of the shutdowns and center the couplings on both housing shafts with the aid of new cotter pins. Tighten the bolts in the coupling to 21-26 lb-ft (28-35 N*m) torque.
7. Reset the air shutdown to the *run* position.
8. Before starting the engine, check the mechanical operation of the air shutdown assembly. Then, test the shutdown assembly as follows:
   a. Start and run the engine at slow idle and no load.
   b. Increase the speed to 600 rpm no load.
   c. After the engine has stabilized at the specified speed in Step “b”, trip the air shutdown. The engine speed must be reduced to at least 300 rpm.
   d. If a reduction in speed to 300 rpm or less cannot be obtained, the air shutdown assembly must be removed and checked.
9. After this test has been satisfactorily performed, drill and pin the couplings and linkage to the shafts with two (2) roll pins for each coupling and link (ball coupling), using a 1/8" diameter drill.

TURBOCHARGED INTERCOOLED ENGINES

The engine scavenging and combustion air supply flows through the air shutdown housings and air shutdown housing adaptors after having passed through the air cleaners and the turbochargers. The air then passes through the intercoolers where the temperature of the air is reduced before entering the blowers and then into the engine air box and cylinders.

On 12V and 16V engines, four air shutdown housings, an end and intermediate housing are mounted on each air inlet housing adaptor which is mounted on each intercooler. These housings contain an air shutoff valve that shuts off the air supply and reduces the speed of the engine whenever abnormal engine operating conditions require an emergency shut down.

Each pair of air shutdown housings (end housings and intermediate housings) are connected together by a cross-shaft and coupling arrangement, which in turn are linked together and controlled by a solenoid mechanism (Fig. 4). An air shutdown reset lever is attached to the end air shutdown housing shaft.

Remove Air Shutdown Housing (End Or Intermediate Housing)

1. Loosen the hose clamps at the shutdown housing and slide the hose back on the air inlet tube. The steel straps used with the hose clamps at both ends of the air inlet tube have been eliminated. Remove and discard the straps from all 12V and 16V turbocharged-intercooled high efficiency engines.
2. Disconnect the solenoid from the air shutdown latch (end housing). Disconnect the linkage at the crossover shafts. Remove the cotter pins and loosen the bolts in the coupling. Slide the coupling toward the shutdown housing and disconnect the crossover shaft. Disconnect the crossover shaft at the other housings in the same manner, if necessary.
3. Remove the four (4) bolts, washers, lock washers and one (1) stud nut, lock washer and washer which attach an air shutdown housing to an air inlet housing adaptor.
4. Remove the air inlet housing gasket. Discard the gasket.

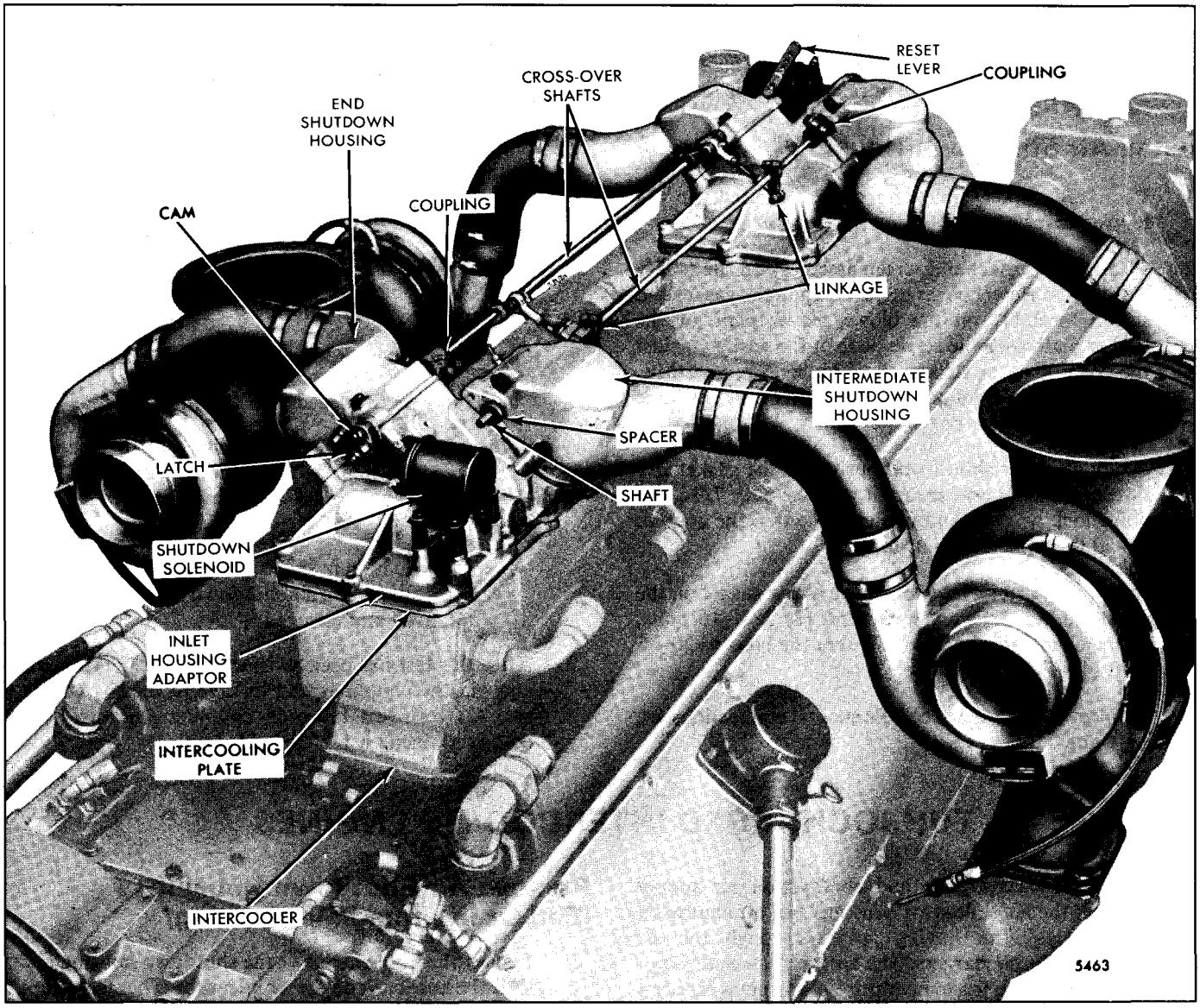


Fig. 4 - Intercooled Engine Air Shutdown Housing Mounting

NOTICE: Cover the air inlet housing adaptor opening to prevent dirt or foreign material from entering the intercooler.

Disassemble End Air Shutdown Housing

1. Refer to Fig. 5 and remove the retaining pin from the spacer and the shutdown shaft. Remove the spacer from the shaft and the seal ring from the housing. Discard the seal ring.

2. Remove the bolt and lock washer which attach the latch to the housing. Remove the latch, latch spring and bushing.

3. Remove the nut, washer and bolt that secures the valve to the valve lever.

4. Loosen the bolt that secures the valve lever to the shaft. Observe the position of the air shutoff valve spring and valve lever on the shaft.

5. Partially withdraw the shaft from the valve lever and remove the key. Withdraw the shaft from the housing to release the valve lever and spring. Remove the seal ring from the housing. Discard the seal ring.

6. Remove the cam pin and the cam from the shaft. Note the flat on the cam and its relationship to the key way of the shaft for reassembling.

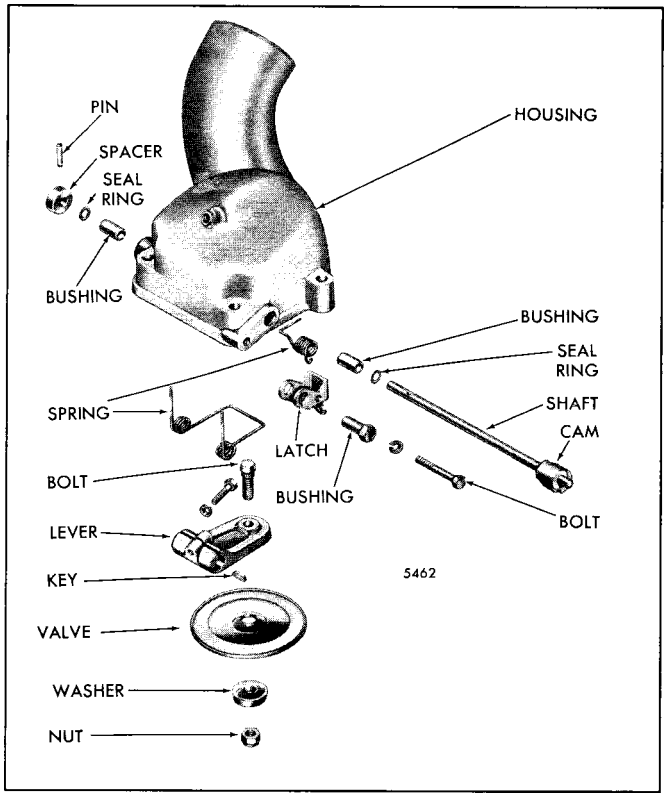


Fig. 5 - Intercooled Engine Air Shutdown Housing Assembly

Disassemble Intermediate Air Shutdown Housing

1. Refer to Fig. 5 and remove the retaining pin from the spacer at one end of the shutdown shaft. Remove the spacer from the shaft and the seal ring from the end of the housing. Discard the seal ring.
2. Remove the nut, washer and bolt that secures the valve to the valve lever.
3. Loosen the bolt that secures the valve lever to the shaft. Observe the position of the air shutoff valve spring and valve lever on the shaft.
4. Partially withdraw the shaft from the valve lever and remove the key. Withdraw the shaft from the housing to release the valve lever and spring. Remove the seal ring from the housing. Discard the seal ring.
5. If the shaft is to be replaced, remove the retaining pin and spacer.

Inspection

Clean all of the parts thoroughly with fuel oil and dry them with compressed air.

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

Inspect the parts for wear or damage. The face of the air shutoff valve must be perfectly flat to ensure a tight seal when it is in the *closed* position.

Before replacing a turbocharger that has experienced compressor or turbine wheel damage, always inspect the air induction and exhaust systems for damage and debris. Check air inlet ducting from the turbocharger compressor inlet pipe to the air cleaner assembly. Look for cracks or signs of air leakage and remove any dirt or debris. Check turbo discharge-to-blower piping for leaks or debris.

• A 3.75" long X 3.25" diameter hose and thick (.035") band stainless steel T-bolt clamp are currently used between the turbochargers, air outlet tubes, and air inlet housings of Series 149 engines. The former 3.25" long X 3.50" diameter hose and T-bolt clamp (.025" thick band) should be replaced with the new at time of normal engine overhaul, or earlier if sealing or clamping concerns are experienced.

Check the exhaust system from the cylinder head exhaust ports to the exhaust outlet piping on the turbine side of the turbocharger and the inside of the exhaust manifold(s). Remove any debris left over from the damaged turbocharger. Repair or replace any other damaged or defective components in the air induction or exhaust systems.

Failure to remove contaminants or debris from these systems can result in damage to the replacement turbocharger. On engines equipped with mechanical emergency shutdowns, check for proper operation of *each* flapper valve.

The bypass blower valve lever on certain early 8V engines may be capable of “going over center” (moving beyond its *center limit* position). If this occurs, the bypass blower valve may stick in the *open* position, causing inefficient engine operation and intermittent smoking, especially at low rpm. To eliminate the possibility of inefficent engine operation and smoking caused by a stuck-open bypass valve, Detroit Diesel recommends installing the bypass blower valve lever stop plate on early 8 V engines (see Shop Notes - Section 3.0).

Assemble End Air Shutdown Housing

The hole for the cam and spacer retaining pins must be drilled, using a 1/8" diameter drill, at the time the cam and spacer are assembled to a new service shaft (see Shop Notes in Section 3.0 for procedure).

1. Place the valve spring-and valve lever in position in the housing. Partially slide the shaft through the housing, valve spring and lever. Install the key in the shaft. Then, continue to slide and position the shaft through the valve lever, spring and shutdown housing.

2. Install a new seal ring at each end of the shaft. Be sure the seal rings are seated in the counterbores of the housing.

3. Install a spacer and retaining pin at the end of the shaft. Drill and pin the spacer to the shaft. To eliminate possible bind due to metal expansion, be sure to leave .020"-.025" end play between the spacer and the housing. Also apply a dry type anti-seize thread compound, such as Molykote "Z" or equivalent, to both ends of the shaft assembly.

4. Assemble the bushing (eccentric), spring and latch to the housing with the l/4"-20 bolt and lock washer. Align the notch on the bushing with the notch on the latch and lock the bushing in this position.

5. Install the cam on the shaft. Align the flat of the cam with the notch on the latch and hold the cam in this position. Drill the retaining pin hole through the cam and the shaft and install the retaining pin.

6. Install the valve to the valve lever with the 5/16"-18 bolt, washer and nut. Tighten the nut.

   a. With the cam release latch set, the valve spring in place and the valve in the *run* position, tighten the valve lever to shaft bolt.

   b. Level the valve in the *shutoff* position.

   c. Adjust the bushing (eccentric) so that the valve contacts the housing when the cam release latch is set.

7. Be sure the bolt hole in the center of the housing is sealed with the bolt and copper washer.

Assemble Intermediate Air Shutdown Housing

The hole for the spacer retaining pins must be drilled, using a 1/8" diameter drill, at the time the spacers are assemblied to a new service shaft (see Shop Notes in Section 3.0 for procedure).

1. Place the valve spring and valve lever in position in the housing. Partially slide the shaft through the housing, valve spring and valve lever. Install the key in the shaft. Then, continue to slide and position the shaft through the valve lever, spring and housing.

2. Install a new seal ring at each end of the shaft. Be sure the seal rings are seated in the counterbores of the housing.

3. Install a spacer and retaining pin at each end of the shaft. Drill the retaining pin hole through the spacers and shaft and install the retaining pins.

4. Install the valve to the valve lever with the 5/16"—18 bolt, washer and nut. Tighten the nut.

5. With the valve spring in place and the valve in the *run* position, tighten the valve lever to shaft bolt.

6. Level the valve in the *shutoff* position.

7. Be sure the bolt hole in the center of the housing is sealed with the bolt and copper washer.

Install Air Shutdown Housing (End Or Intermediate Housing)

1. Place a new gasket on the air inlet housing adaptor.

2. Place the air shutdown housing and stud assembly on the housing adaptor and secure it with the four (4) 3/8"—16 bolts, washers and lock washers and stud nut, lock washer and washer. Tighten the bolts and nut to 30-35 lb-ft (41-47 N«m) torque.

3. Slide the hose back over the air inlet tube, position and tighten the hose clamps. Be sure all connections are air tight.

4. Connect the end shutdown housing solenoid to the air shutdown latch.

5. On 12V and 16V engines, couple the crossover shaft to each air inlet housing shaft. Tighten the bolts to 21-26 lb-ft (28-35 N*m) torque. Install a new cotter pin in each coupling.

6. If removed, couple the other cross-over shaft to the air inlet housing shafts in the same manner and connect the linkage between the crossover shafts. Before securing the couplings, close the valves in all of the shutdown housings and center the couplings on all of the housing shafts with the aid of new cotter pins. Tighten the bolts in the coupling to 21-26 lb-ft (28—35 N*m) torque. Be sure the linkage operates freely.

7. Install the reset lever and tighten the attaching bolt.

8. Reset the air shutdowns to the *run* position.

9. Before starting the engine, check the mechanical operation of the air shutdown assembly. Then, test the shutdown assembly as follows:

   a. Start and run the engine at slow idle and no load.

   b. Increase the speed to 600 rpm no load.

   c. After the engine has stabilized at the specified speed in Step "b", trip the air shutdown. The engine speed must be reduced to at least 300 rpm.

   d. If a reduction in speed to 300 rpm or less cannot be obtained, the air shutdown assembly must be removed and checked.

10. After this test has been satisfactorily performed, drill and pin the couplings and linkage to the shafts with two (2)roll pins for each coupling and link (ball coupling), using a 1/8" diameter drill.

BLOWER

The Series 149 engine blower, designed especially for efficient diesel operation, supplies the fresh air needed for combustion and scavenging. Its operation is similar to that of a gear-type oil pump. Two hollow three-lobe rotors revolve with very close clearances in a housing located within the cylinder block, between the two banks of cylinders. To provide continuous and uniform displacement of air, the rotor lobes are made with a helical (spiral) form.

• A single blower is used on 8V engines. Two blowers, coupled together (12V and 16V engines), are mounted in tandem in the air box (Fig. 1) of 12V and 16V engines. The basic parts for the 8V, 12V and 16V blowers are identical and interchangeable with the exception of the housing and rotors which differ in length.

Normal gear wear causes a decrease of rotor-to-rotor clearance between the leading edge of the right-hand helix (drive) rotor and the trailing edge of the left-hand helix (driven) rotor. Clearance between the opposite sides of the rotor lobes is increased correspondingly.

The blower rotors are timed by the two rotor gears at the rear end of the rotor shafts. This timing must be correct, otherwise the required clearance, obtained by the use of shims behind the gears, between the rotor lobes will not be maintained.

While the rotor-to-rotor lobe clearance may be corrected by adjustment, gear backlash cannot be corrected. When gears have worn to the point where the backlash exceeds .004", the gears should be replaced.

The right-hand helix rotor of the blower is driven at approximately twice engine speed by the blower drive shaft (refer to Section 1.7.6). The blower drive shaft is splined at one end to a flexible drive hub attached to the blower drive gear and at the other end to a flexible coupling attached to the right-hand helix blower timing gear. The mating left-hand helix timing gear drives the left-hand helix rotor.

A flexplate coupling, consisting of three spring plates, is used to take up misalignment between the blower and blower drive gear.

Metal ring-type oil seals are incorporated in the blower. Each oil seal consists of a carrier pressed on the rotor shaft, a collar pressed into the end plate and a seal ring contained in a groove in the carrier. The outside diameter of the seal ring seats against the collar and the sides of the seal ring seat against the groove in the carrier to prevent leakage of air or oil.

Each rotor is supported in the doweled end plates of the blower housing by a roller bearing at the front end and a two row pre-loaded radial and thrust ball bearing at the gear end.

Lubrication

The blower bearings, timing gears and governor drive assembly are pressure lubricated by means of oil passages which lead from the main oil galleries to an oil passage in each blower end plate.

A cup-shaped oil strainer has been incorporated in the vertical oil passage at the bottom of each blower end plate to remove any foreign material in the lubricating oil.

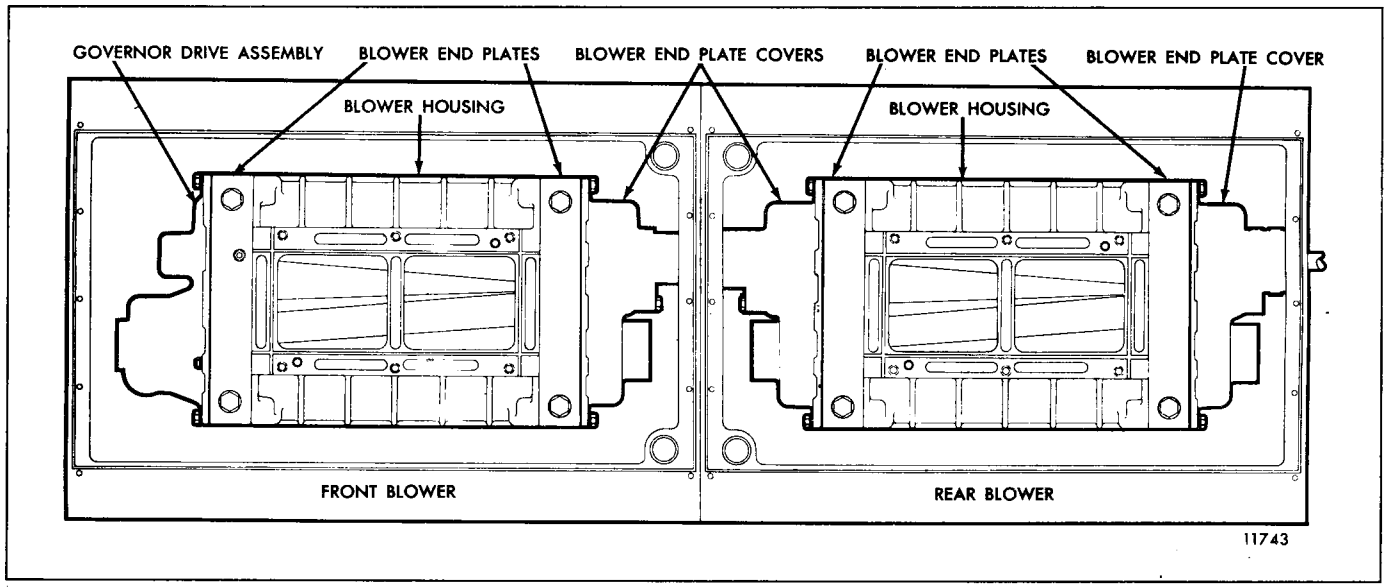


Fig. 1 – Tandem Blower Installation (12V–149)

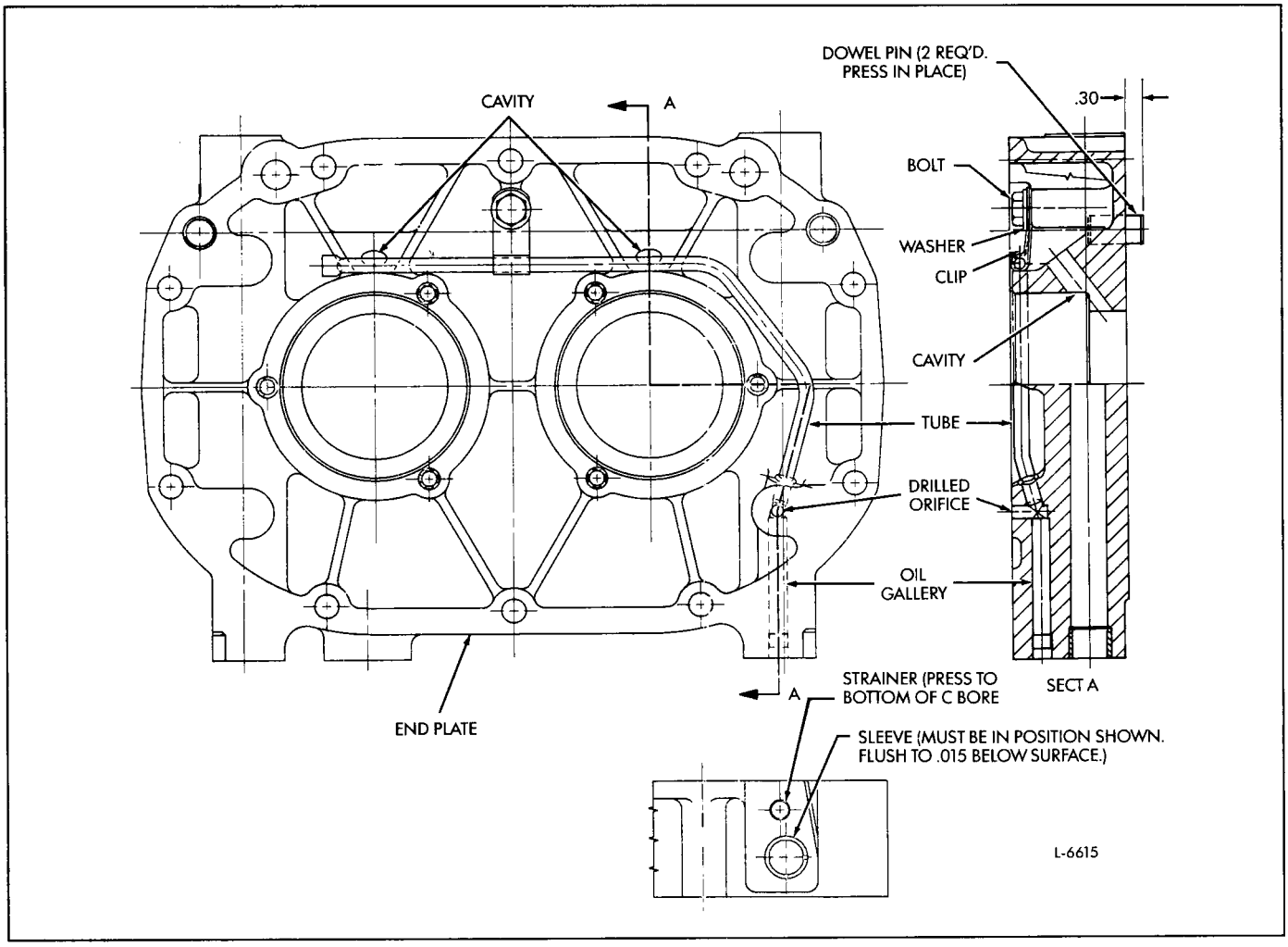


Fig. 2 – Blower Housing Rear End Plate

The oil flows upward through the end plate into the end plate cover and leaves through a small orifice spraying the splines on the drive couplings and drive shafts. It is then carried by splash to the bearings and timing gears. Oil which collects at the bottom of each end plate flows into a drain passage which leads back to the crankcase via oil passages in the cylinder block.

• Blowers on current Series 149 engines incorporate a rear end plate with a steel lubrication tube securred by a bolt, washer, and clip (Fig. 2). Oil diverted to the tube squirts out two discharge holes, filling the cavities above the bearing bores in the end plate. As oil drains from the cavities, it flows over the bearings, providing positive lubrication and cooling.

Two timing gears, located on the drive end of the rotor shafts, space the rotor lobes with a close tolerance. Therefore, as the lobes of the two rotors do not touch at any time, no lubrication is required.

The blower drive support bushings receive oil under pressure from an oil passage in the cylinder block to passages in the blower drive support. Excess oil drains back to the crankcase by way of the gear train.

Preliminary Inspection

The blower may be inspected without being removed from the engine. However, the air inlet housing and the air shutdown housing must be removed first.

Dirt or chips drawn through the blower will make deep scratches in the rotors and housing and throw up burrs around such abrasions. If burrs cause interference between the rotors or between the rotors and the housing, the blower should be removed from the engine and the parts dressed down to eliminate interference. The rotors should be replaced if they are too badly scored.

Oil radiating away from the oil seals in the blower end plates usually indicates worn oil seals. However, on turbocharged engines, once the turbocharger has cut in, worn oil seals will be detected by high crankcase pressure due to air leaking past the seals.

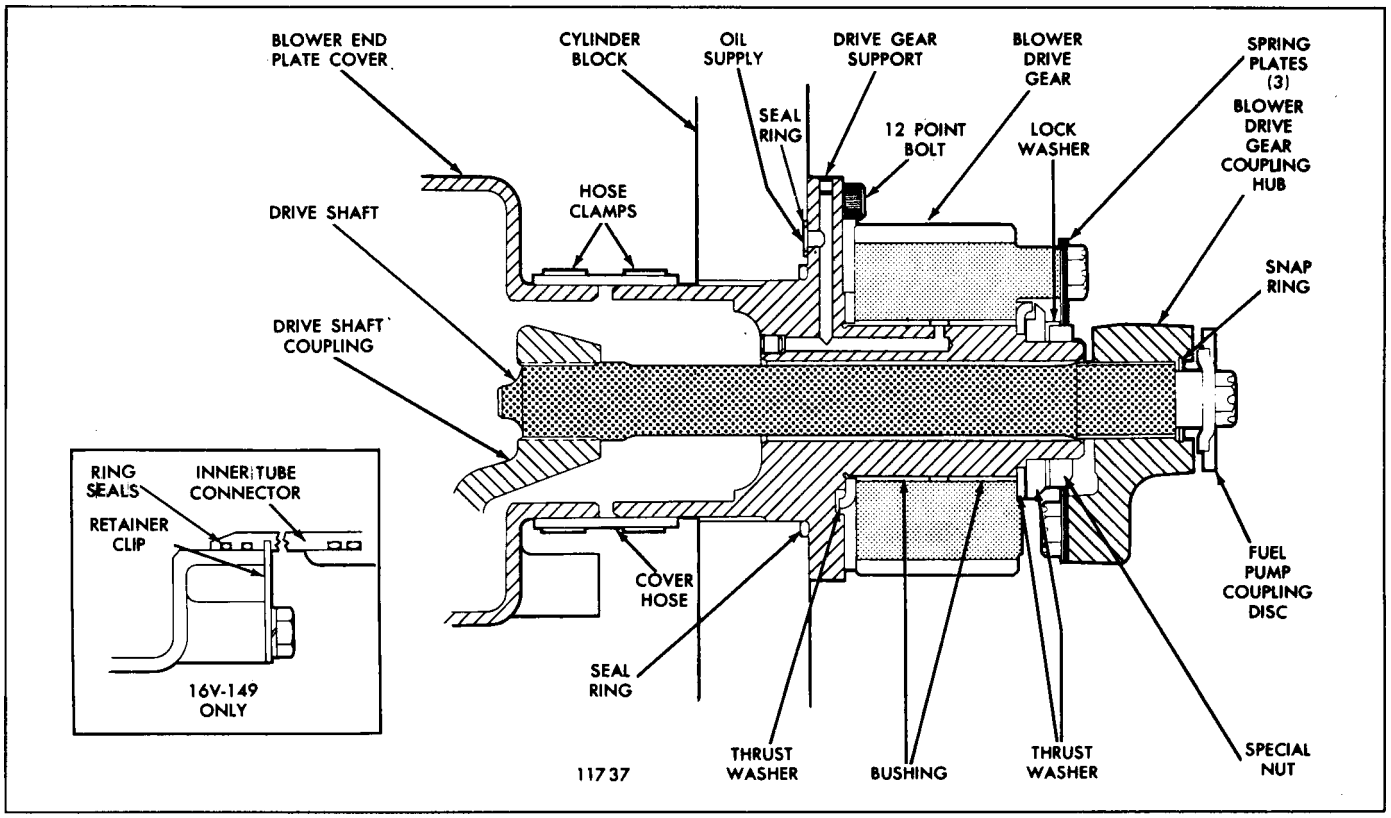


Fig. 3 – Blower Drive Hub and Gear Assembly (12V–149)

Loose rotor shafts or damaged bearings will cause rubbing and scoring between the crowns of the rotor lobes and the mating rotor roots, between the rotors and the end plates, or between the rotors and the housing. Generally a combination of these conditions exists. A loose shaft usually causes rubbing between the rotors and the end plates. Worn or damaged bearings will cause rubbing between mating rotor lobes at some point or perhaps allow the rotor assemblies to rub the blower housing. This condition will usually show up at the end where the bearings have failed.

Excessive backlash between the blower timing gears usually results in the rotor lobes rubbing throughout their entire length.

The blower inlet screen should be inspected periodically for an accumulation of dirt which, after prolonged operation, may affect the air flow. Servicing of the screen consists of throughly washing in fuel oil and cleaning with a stiff brush until the screen is free of all dirt deposits.

Remove Blower(s) From Engine

1. On non-turbocharged engines, loosen the hose clamps and slide the air inlet housing hoses back to disconnect the housing from the air cleaners. On engines equipped with turbochargers, disconnect and remove the air inlet and outlet tubes from the turbochargers.

2. Remove the eight (8) bolts, lock washers and plain washers securing the air inlet housing to the air shutdown housing. Remove the air inlet housing and gasket.

3. Disconnect the wire cable from the air shutoff cam pin handle.

4. On tandem blower installations, remove the shutdown linkage between the two air shutdown housings (Section 3.3).

5. Remove the engine ventilating system (Section 4.8).

• 6. Remove the 7/16" bolts, lock washers and plain washers securing air shutdown housings to the lower cover plate, then remove the air shutdown housings and gaskets.

7. Remove the governor control housing, blower cover plate and gaskets as outlined in the governor section of this manual.

8. Remove the fuel pump from the flywheel housing (Section 2.2).

9. Remove the blower drive shaft (Fig. 3) from the blower drive gear hub assembly (Section 1.7.6).

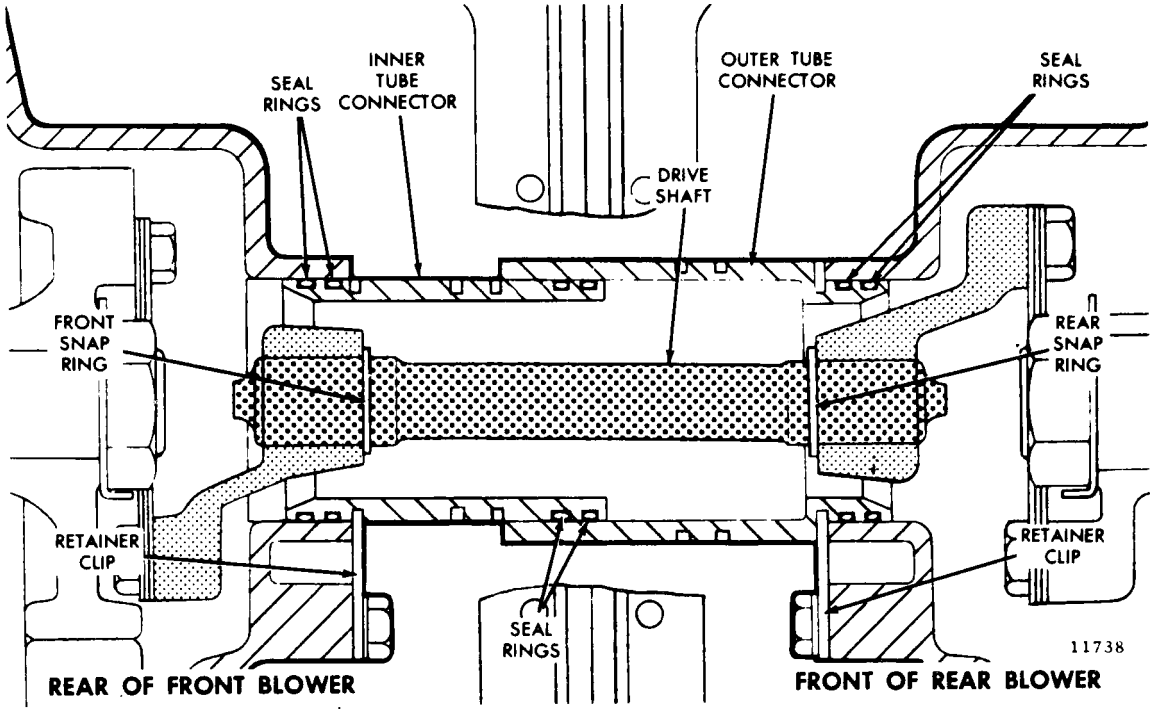


Fig. 4 - Tandem Blower Drive Shaft and CouplingInstallation

10. On 12V engines, loosen the two (2) hose clamps securing the cover hose to the blower end plate cover and the blower drive gear support (Fig. 3) and slide the hose back over the drive support. The 16V-149 engine uses a blower inner tube connector (inset, Fig. 3) in place of the hose and hose clamps. Remove the retainer clip and slide the inner tube connection back into the blower drive gear support.

11. Disconnect the center drive shaft and tube connections on 12V and 16V engine tandem blower applications as follows (Fig. 4):

    a. Remove the retainer bolts and clips securing the inner and outer tube connections in position.

    b. Slide the inner tube connector inside of the outer tube connector to expose the blower drive shaft front snap ring.

    c. Remove the front snap ring from its slot in the drive shaft and slide it toward the center of the shaft.

    d. Slide the drive shaft into the front blower coupling (toward the direction of the loosened snap ring) to disengage the drive shaft from the rear blower.

    e. Slide the outer tube connector out from the rear blower.

12. Remove the four (4) bolts and washers securing each blower to the block.

13. Attach a suitable rope to the webbing of the blower housing and, using a hoist, remove the blower or blowers from the cylinder block.

    NOTICE: On the 12V and 16V engines, remove the rear blower first, slide the center drive shaft and tube connector from the front blower and then remove the front blower.

14. Remove the oil seal rings in the cylinder block counterbores.

Remove Governor Drive Assembly, Blower End Plate Covers And Drive Components

After removing the blower(s) from the engine, remove the governor drive assembly, blower end plate covers and the drive components from the blowers as follows:

1. On 12V engines, remove the nine (9) 3/8”—16 x 3-1/4" bolts, one (1) nut, lock washers and plain washers securing the governor drive assembly to the front blower and remove the governor drive assembly and gasket. Place a clean cloth between the rotors and remove the 1 5/16"-18 retainer nut and spacer from the R.H. helix rotor.

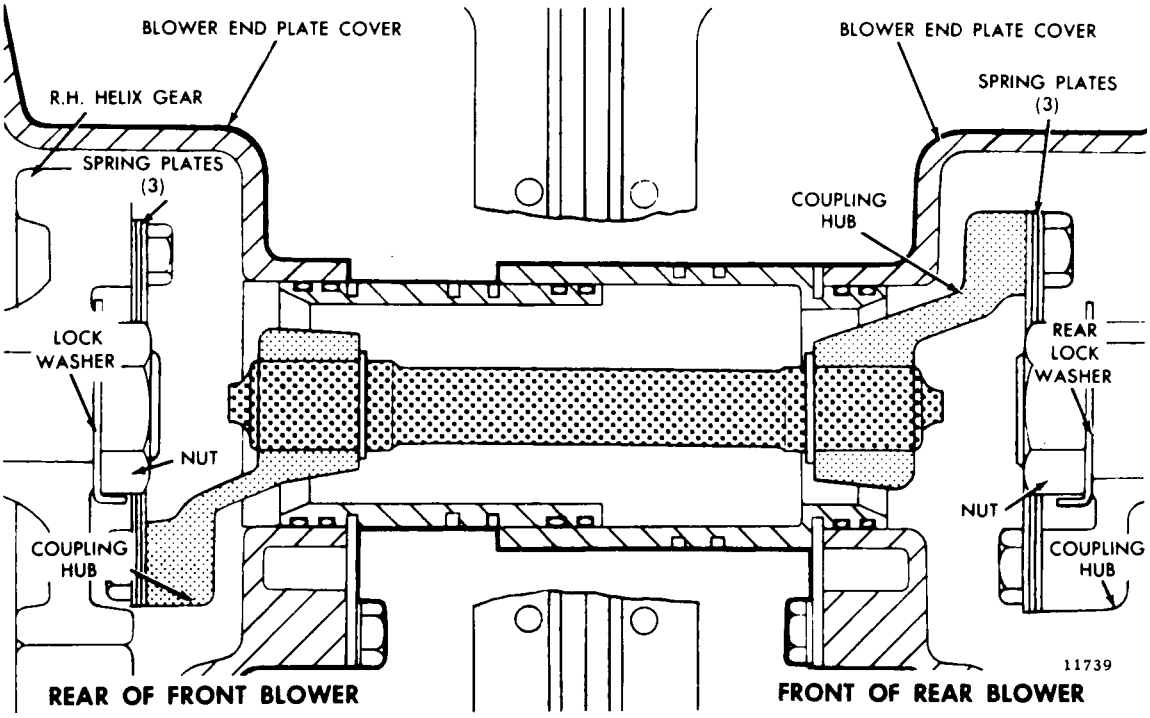


Fig. 5 - Tandem Blower Coupling Hubs

2. On 16V engines, remove the governor drive assembly and spacer, retaining nut and spacer as follows:

   a. Remove the nine (9) 3/8"-16 x 5" bolts, one (1) nut, lock washers and plain washers securing the governor drive assembly to the blower and remove the governor drive assembly and gasket.

   b. Remove the governor drive assembly spacer and gasket.

   NOTICE: Do not pry the housing or spacer from the dowels. If necessary, tap lightly with a plastic hammer.

   c. Place a clean cloth between the rotors and remove the 1-5/16" retaining nut and spacer on the front R.H. helix rotor (Fig. 13).

3. Remove the ten (10) 3/8"-16 x 3-1/4" bolts, lock washers and plain washers securing each of the blower end plate covers to the rear of the front blower and the front and rear of the rear blower. Remove the blower end plate covers and gaskets.

4. Remove the three (3) 7/16"-20 x 7/8" self-locking bolts securing each blower drive coupling hub to the R.H. helix timing gear of each blower (Figs. 4 and 5). Remove the hub and spring plate assemblies.

5. Remove the three (3) 7/16"-20 x 7/8" self-locking bolts securing the blower drive coupling hub to the front of the rear blower (Fig. 5). Remove the hub and spring plate assembly.

6. Place a clean cloth between the rotors and bend the tang of the lock washer back. Remove the 1—5/16”—18 retaining nut and lock washer securing the blower drive coupling hub to the front of the R.H. helix rotor on the rear blower.

7. Remove the blower drive coupling hub from the front R.H. helix rotor shaft of the rear blower with puller J 22706-16 (inset, Fig. 13).

   NOTICE: Place a clean cloth between the rotors when removing the hub.

Disassemble Blower

This disassembly procedure will apply to all blowers although disassembly of only one blower will be covered in the text.The difference, if any, will be noted in the text. Disassemble the blower as follows:

NOTICE: On tandem blowers, matchmark the blower components when disassembling the blowers.

1. Place a clean cloth between the rotors. Then, bend the tang of each of the lock washers open and remove the l-5/16"-18 retaining nuts securing the timing gears to the rotor shafts.

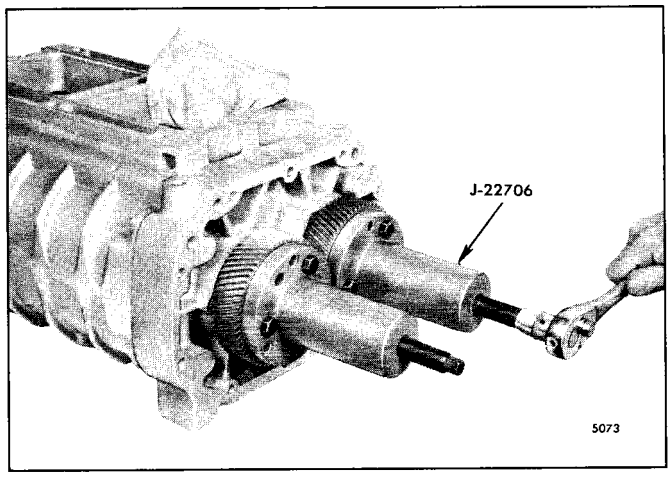


Fig. 6 – Removing Blower Gears using Tool J 22706–16

2. Remove the 1—5/16"—18 retainer nut from the front end of the L.H. rotor assembly.

3. Remove the self-locking bolts securing the rotor shaft bearing retainers to the front blower end plate. Remove the retainers and outer bearing spacers.

4. Remove the blower front end plate. Tap the end plate with a plastic hammer to loosen it from the housing.

NOTICE: The roller bearing inner races will remain on the shafts of the rotors.

5. Remove the timing gears with pullers J 22706-16 (Fig. 6). Both gears must be pulled at the same time as follows:

   a. Back out the center screws of both pullers and place the flanges against the gear faces, aligning the flange holes with the tapped holes in the gears. Secure the pullers to the gears with six (6) 7/16"-20 x 1—1/2" bolts (three on each gear).

   b. With a clean cloth placed between the rotors to prevent rotation, turn the two puller screws uniformly clockwise and withdraw the gears from the rotor shafts (Fig. 6).

v 6. Remove the shims from the rotor shafts and note the number and thickness of shims on each rotor shaft to ensure identical replacement when assembling the blower.

7. Remove the three (3) self-locking bolts securing each rotor shaft bearing retainer to the rear blower end plate. Remove the retainers.

8. Remove the rotors from the rear end plate and blower housing as follows:

   a. Install two (2) temporary hold down bolts through the rear blower end plate (Fig. 7).

   b. Back out the center screws of the pullers (J 22706-16) far enough to allow the flanges of the pullers to lay flat on the face of the rear end plate.

   c. Align the holes of the puller flanges with the tapped holes in the end plate. Secure the pullers to the end plate with six (6) 5/16"—18 x 1-1/4" bolts.

NOTICE: Be sure that the 5/16”—18 bolts are threaded all the way into the tapped holes in the end plate to provide maximum anchorage for the pullers and to eliminate possible damage to the end plate.

   d. Turn the puller screws in a clockwise direction to push the blower rotors out of the rear end plate (Fig. 7). Push the rotors out together.

   e. Remove the bolts securing the rear end plate to the housing and remove the rear end plate.

NOTICE: It may be necessary to tap the rear end plate lightly with a plastic hammer.

9. Remove the bearings and ring-type oil seals, carriers, roller bearing inner races and collars from the blower rotor shafts and end plates as follows:

   a. Clamp one lobe of the rotor in a bench vise equipped with soft jaws (Fig. 8). Tighten the vise just enough to hold the rotor stationary.

   b. Remove the oil seal ring from the seal ring carrier on each blower rotor shaft with a pair of snap ring pliers (Fig. 8).

   c. Refer to Fig. 9 and place the seal ring carrier remover adaptor J 22706-7 over the carrier. Make sure the adaptor is seated in the groove of the carrier.

   d. Back out the center screw of puller J 22706-16 far enough to permit the puller flange to lay flat against the adaptor J 22706-7.

   e. Place the puller over the end of the rotor shaft and against the adaptor on the oil seal ring carrier. Align the holes in the puller flange with the tapped holes in the adaptor, then secure the puller to the adaptor with two (2) bolts.

   f. Turn the puller screw clockwise and pull the oil seal ring carrier and roller bearing inner race (front end of blower rotors only) from the rotor shaft (Fig. 9).

   g. Remove the remaining oil seal ring carriers from the rotor shafts in the same manner.

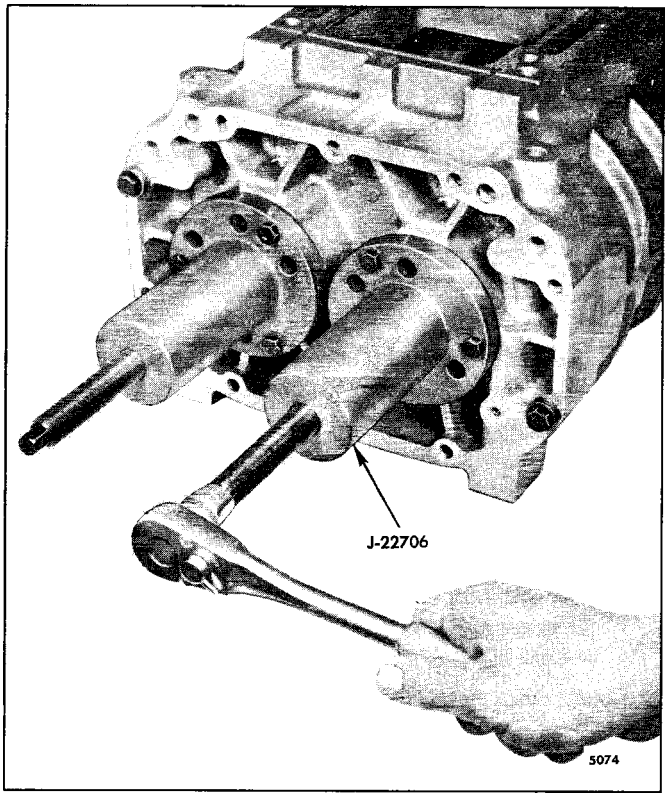


Fig. 7 - Removing Blower Rotors from Housing and Rear End Plate using Tool J 22706-16

• h. Remove the bolt, washer, and clip securing the oil supply tube to the rear end plate. Pull the tube out of the end plate.

i. Refer to Fig. 10 and support the outer face of the blower end plate on wood blocks on the bed of an arbor press.

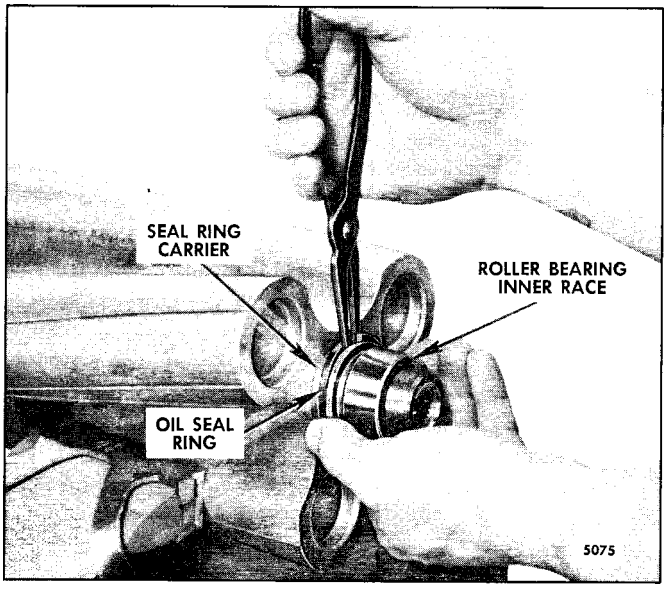


Fig. 8 - Removing or installing Oil Seal Ring

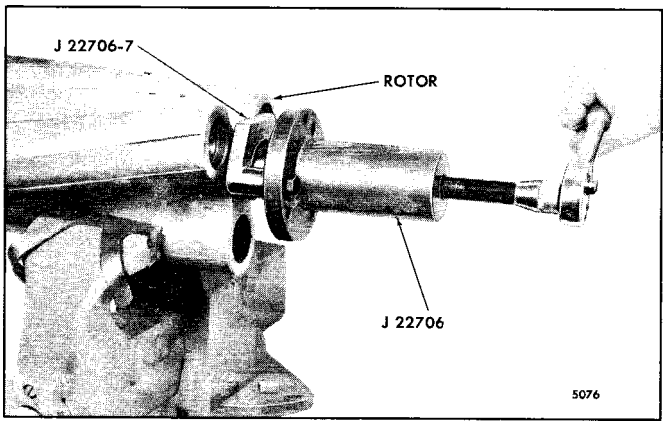


Fig. 9 - Removing Oil Seal Ring Carrier from Blower Rotor Shaft

j. Place the long end of the oil seal remover and installer J 22706-3 down through the oil seal ring collar and into the bearing, with the opposite end of the remover under the ram of the press (Fig. 10). Then, press the bearing and oil seal ring collar out of the end plate.

k. Remove the remaining bearings and oil seal ring collars from the end plates in the same manner. Keep each roller bearing inner race with its mating outer race.

Inspection

Wash all of the blower parts in clean fuel oil and dry them with compressed air.

CAUTIONiTo prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Examine the ball bearings for any indications of corrosion or pitting. Lubricate each bearing with light engine oil. Then, while holding the bearing inner race from turning, revolve the outer race slowly by hand and check for rough spots. The double-row ball bearings are pre-loaded and have no end play. A new double-row bearing will seem to have considerable resistance to motion when revolved by hand.

Check the oil seal rings, carriers and collars for wear and scoring. If worn excessively, replace them.

Inspect the blower rotor lobes, especially the sealing ribs, for burrs and scoring. Rotors must be smooth for efficient operation of the blower. If the rotors are slighly scored or burred, they may be cleaned up with emery cloth.

Examine the rotor shaft serrations for wear, burrs or peening.

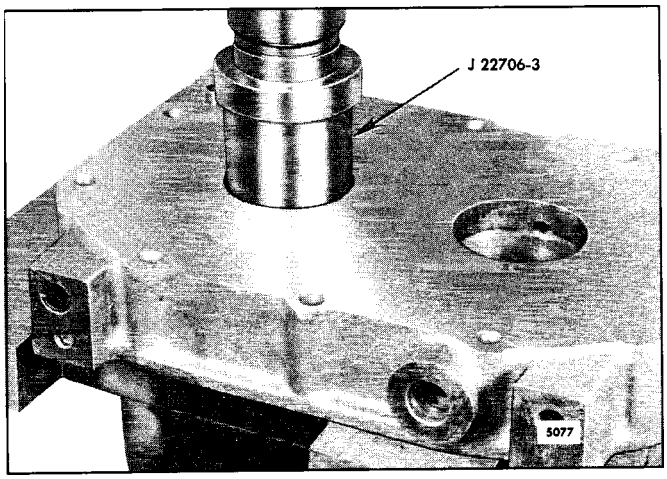


Fig. 10 - Removing Oil Seal Ring Collar and Bearing from End Plate using Tool J 22706-3

Inspect the inside surface of the blower housing for burrs and scoring. The inside surface must be smooth for efficient operation of the blower. If the inside surface of the housing is slightly scored or burred, it may be cleaned up with emery cloth.

Check the finished ends of the blower housing for flatness and burrs. The end plates must set flat against the blower housing.

The finished inside face of each end plate must be smooth and flat. If the finished face is slightly scored or burred, it may be cleaned up with emery cloth.

The bottom surface of each blower end plate must be smooth and flat. A service blower shim is available for use when the blower end plates show signs of fretting corrosion and can not be cleaned up with emery cloth (see Shop Notes in Section 3.0).

• Blowers on current Series 149 engines incorporate a rear end plate with a steel lubrication tube securred by a bolt, washer, and clip (Fig. 2). Make sure oil discharge holes and drain cavities are open.

> **NOTICE:** Do not mix a salvaged end plate and a new end plate on the same blower. The service shim must be used in pairs (one under each end plate.)

Examine the serrations in the blower timing gears for wear and peening; also check the teeth for wear, chipping or damage. If the gears are worn to the point where the backlash between the gear teeth exceeds .004", or are damaged sufficiently to require replacement, both gears must be replaced as a set.

Check the blower drive shaft serrations for wear or peening. Replace the shaft if it is bent.

Inspect the blower drive couplings, hub and spring plates for wear.

> **NOTICE:** Effective with engine serial numbers 12E-5700 and 16E-5276 new ductile iron hubs (drive gear, drive coupling and rotor coupling) identified by the part number on the casting are being used. Former and new hubs are interchangable. When one or more hubs require replacement all of the hubs should be replaced.

Replace all worn or excessively damaged blower parts.

• Check the rear end plate oil supply tube for damage or plugging. Clean or replace as required.

Clean the oil strainer in the vertical oil passage at the bottom of each blower end plate and blow out all oil passages with compressed air.

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

Clean the orifice plug in the oil passages of the blower end plate cover with compressed air (Fig. 12).

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

Replace the plugs, if necessary. Press the orifice plugs flush to .020" below the surface of the cover and stake them securely.

> **NOTICE:** Current engines use a four hole orifice plug to lubricate the blower drive coupling. Prior to engines 12E-2100 and 16E-2072, a two hole orifice was used. However, only the four hole plug is serviced.

On the former 12V-149 front blower (prior to engine 12E-387), install the spray nozzle in the front end plate of the front blower as follows:

1. Position the spray nozzle so that when the shank end of a No. 60 drill is inserted in the hole in the side of the nozzle a sighted line along the drill will pass within 1/8" of the center of the rotor stub shaft (Fig. 11).
2. When the nozzle is properly positioned, press it into the blower front end plate.

• On certain early 8V-149 engines equipped with a flapper style blower bypass valve, the bypass valve lever may be capable of “going over center” (moving beyond its center limit position). If this occurs, the bypass valve may stick in the *open* position, causing inefficient engine operation and intermittent smoking, especially at low rpm. To eliminate the possibility of inefficient engine operation caused by a stuck-open bypass valve, DDC recommends installing the blower bypass valve lever stop plate on early 8 V-149 engines. Refer to Shop Notes, section 3.0.

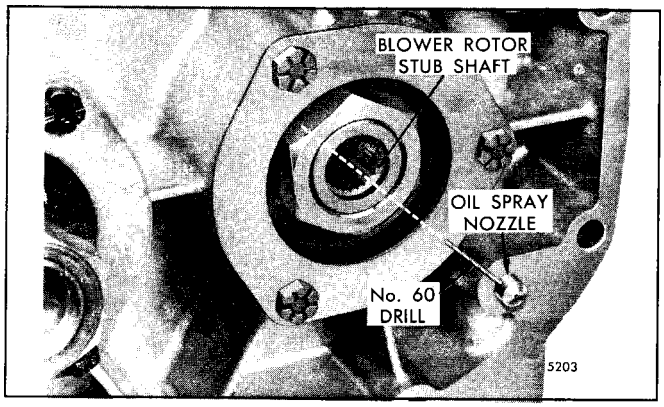


Fig. 11 - Positioning Blower Spray Nozzle (Former)

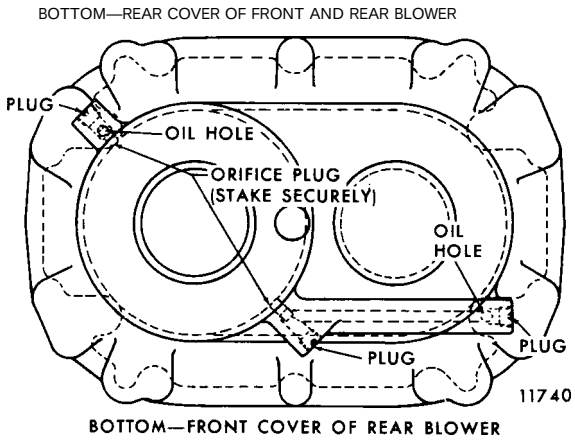


Fig. 1 2 - Location of Orifice Plugs in Blower End Plate Cover

• See section 3.4.2 for blower bypass valve description, disassembly, and assembly procedures. See section 3.0 for troubleshooting blower bypass valve performance. See section 15.1 for preventive maintenance.

Assemble Blower

Several precautions are given below to assure the proper assembly of the rotors and gears for correct blower timing.

1. The lobes on the *driving* blower rotor and the teeth on its gear form a right-hand helix while the lobes and teeth of the *driven* rotor and gear form a left-hand helix. A rotor with right-hand helix lobes must be used with a gear having right-hand helix teeth.

2. One serration is omitted on the drive end of each blower rotor shaft and a corresponding serration is omitted in each gear. Assemble the gears on the rotor shafts with the serrations in alignment (Fig. 22).

NOTICE: The blower rotor timing gears are a press fit on the rotor shafts. With the splines of the *rear* rotor shafts coated with light engine oil, the torque required to move the gears down the shaft should fall within a range of 30-130 lb—ft (41-177 N*m) torque (corresponds to .0015"-.0045" press fit).

If the installation torque does not fall within the 30-130 lb—ft (41-177 N*m) range, the timing gears or rotor assemblies must be replaced. A minimum and maximum torque is not required on the *front* rotor shaft splines. A loose spline fit can result in a major blower failure.

3. The rotors must be assembled in the blower housing with the omitted serrations in the rotor shafts aligned (Fig. 22).

4. The rotors are stamped GEAR END on one of the rotor lobes of each rotor.

With these precautions in mind, proceed with assembly of the blower.

1. Install the ring type oil seals, carriers, collars and roller bearing inner races on the rotor shafts and in the end plates as follows:

   a. Support one of the rotor assemblies on wood blocks on the bed of an arbor press (Fig. 14).

   b. Lubricate the inside diameter of the oil seal ring carrier with engine oil, then start the carrier straight over the end of the rotor shaft with the chamfered inside diameter end facing the rotor.

   c. Place the oil seal ring carrier installer J 22706-4 and adaptor J 22706-9 over the end of the rotor shaft and against the carrier with the end of the installer under the ram of the press. Then, press the carrier down tight against the rotor.

   d. Install the remaining oil seal ring carriers on the rotor shafts in the same manner.

   e. Position the roller bearing inner race, numbered side up, over the front end of the rotor shaft and press the race on the shaft with tool J 22706-4 until the bearing race contacts the shoulder on the shaft.

   f. Install the bearing inner race on the front end of the other rotor in the same manner.

   g. Install an oil seal ring in the ring groove of each carrier with a pair of snap ring pliers in the same manner as shown in Fig. 8.

NOTICE: To avoid breaking the oil seal rings, do not spread them any more than necessary to place them over the end of the carrier. Do not twist the rings or possible distortion may result in loss of side contact area.

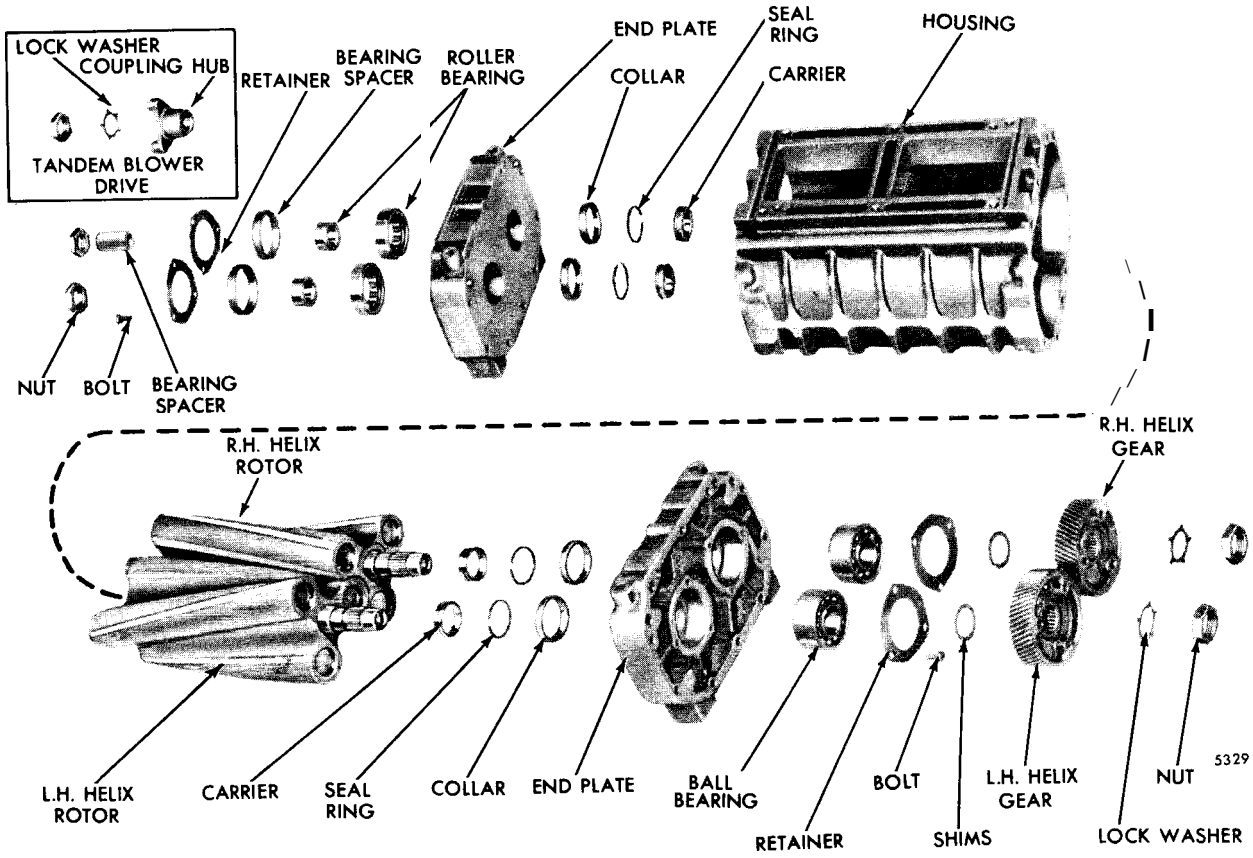


Fig. 13 - Blower Components

h. Support one of the blower end plates, inner face up, on wood blocks on the bed of an arbor press (Fig. 15).

i. Lubricate the outside diameter of a seal ring collar with engine oil, then start the chamfered outside diameter end of the collar straight into the bore in the end plate.

j. Place the oil seal ring collar installer J 22706-3 on top of the seal ring collar and under the ram of the press (Fig. 15). Then, press the collar into the end plate until the shoulder on the installer contacts the end plate. The collar must be flush to .010" below the surface of the end plate.

k. Install the remaining oil seal ring collars in the end plates in the same manner.

Assemble Rotors And End Plates

1. Install the blower front end plate on the blower rotors as follows:

r

a. Check the dowel pins. The dowel pins must project .300" from the flat inner face of the front end plate to assure proper alignment of the end plate with the housing.

b. Support the front end plate on two wood blocks approximately 4" high, with the inner face of the end plate facing up and the TOP side of the plate away from the technician and the bottom toward the technician (Fig. 16).

c. Lubricate the oil seal ring in the carrier on the front end of the right-hand helix rotor shaft with engine oil.

d. Hold the right-hand helix rotor in a *vertical* position (with end stamped GEAR END up). Position the seal ring in the carrier so the ring protrudes from its groove the same amount on each side.

e. Start the end of the rotor shaft straight into the right-hand shaft opening in the end plate (Fig. 16). Continue to lower the rotor until the oil seal ring contacts the seal ring collar in the end plate. Then, carefully work the oil seal ring into the collar until the rotor contacts the end plate.

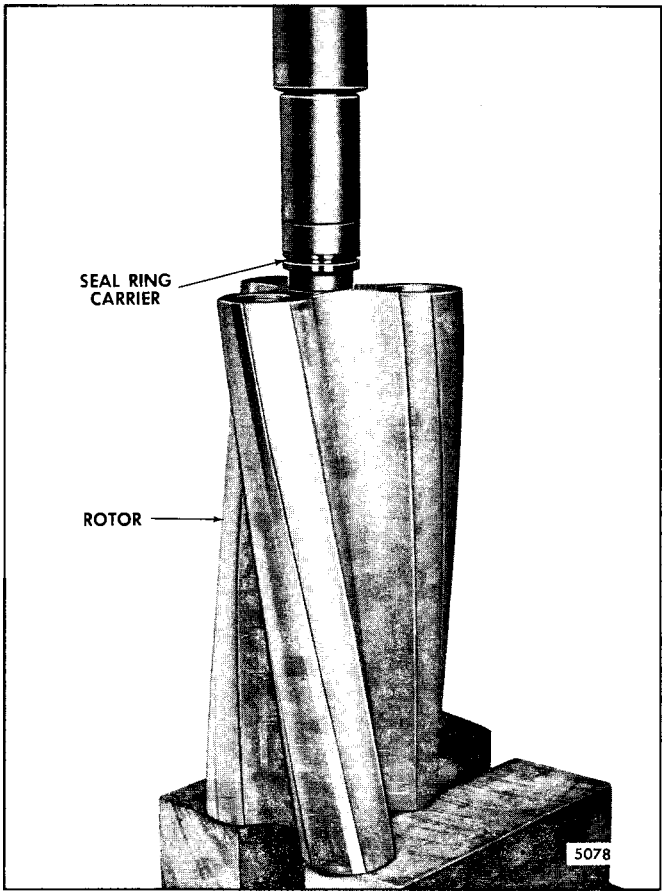


Fig. 1 4 - Installing Oil Seal Ring Carrier on Blower Rotor Shaft

NOTICE: Position the rotor so that the missing serration is facing toward the left (Fig. 22).

f. Perform Steps “c” and “d” on the left-hand helix rotor.

g. Position the rotors so the lobes are in mesh and the omitted serrations in the splines of both rotor shafts are facing toward the left side of the end plate (Fig. 22). Then, start the end of the rotor shaft straight into the left-hand opening in the end plate. Continue to lower the rotor until the oil seal ring contacts the seal ring collar in the end plate. Then, carefully work the oil seal ring into the collar until the rotor contacts the end plate.

2. Install the blower housing over the rotors and attach it to the front end plate as follows:

   a. Position the blower housing over the top of the rotors. Then lower the housing over the rotors until it contacts the dowel pins in the end plate.

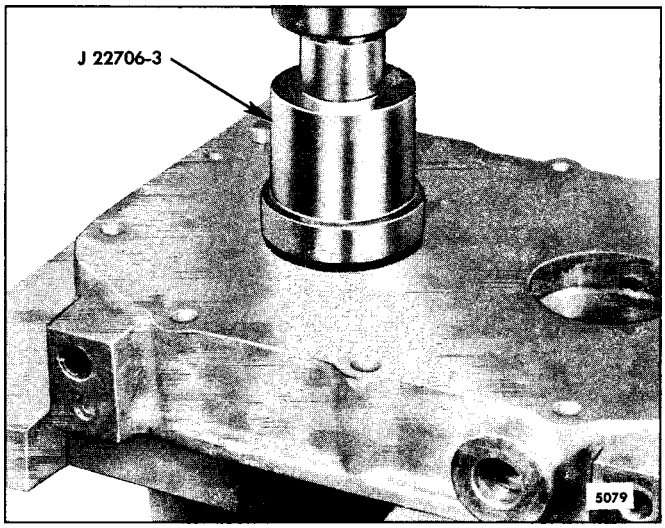


Fig. 1 5 - Installing Oil Seal Ring Collar in End Plate using Tool J 22706-3

   b. Align the dowel pin holes in the housing with the dowel pins in the end plate and push the housing tight against the end plate. If necessary, tap the housing lightly with a plastic hammer.

   c. Temporarily insert four (4) 3/8"-16 x 2-1/2" bolts with washers through the front end plate and thread them into the housing. Tighten the bolts securely.

3. Install the blower rear end plate on the rotor shafts and housing as follows:

   a. Check the dowel pins. The dowel pins must project .300" from the flat inner face of the rear end plate to assure proper alignment of the end plate with the housing.

   b. Lubricate the oil seal rings in the carriers on the rotor shaft with engine oil. Position the seal ring on each carrier so the ring protrudes from its groove the same amount on each side.

   c. Position the rear end plate over the top of the rotor shafts with the inner face of the end plate facing the rotors.

   d. Lower the end plate straight over the rotor shafts until the dowel pins in the end plate contact the blower housing (Fig. 17). Then, carefully work the dowel pins into the dowel pin holes in the housing and the oil seal rings into the collars. Push the end plate tight against the housing. If necessary, tap the end plate lightly with a plastic hammer.

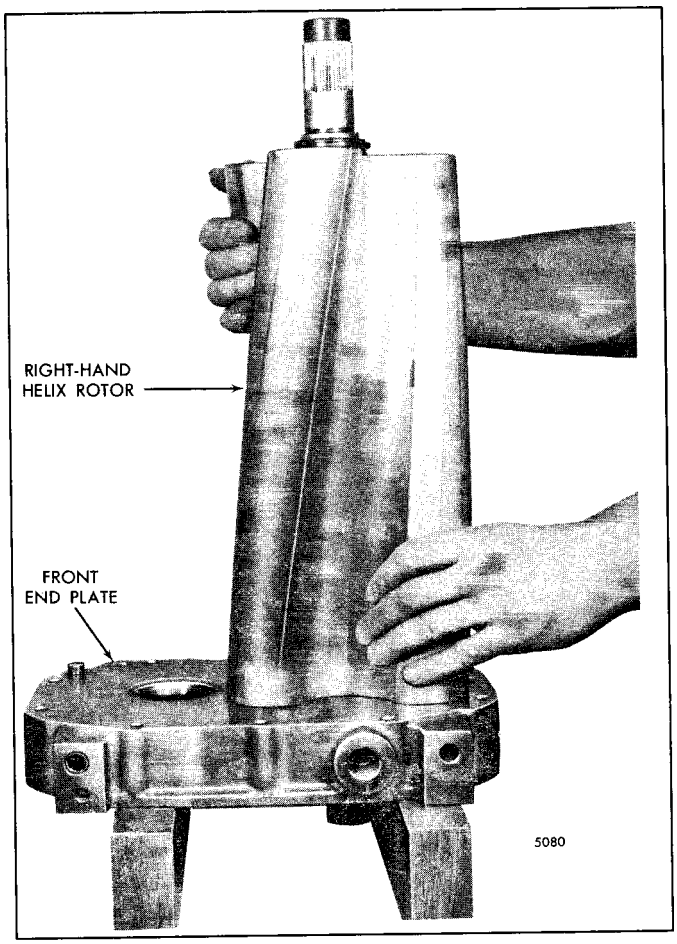


Fig. 16 – Installing Blower Rotor in Front End Plate

e. Temporarily insert four (4) 3/8"—16 x 2-1/2" bolts with washers through the rear end plate and thread them into the housing. On former 12V blowers, the front end plate of the front blower must have the oil nozzle positioned so the oil flow is directed toward the governor drive (Fig. 11). Tighten the bolts securely.

If the governor weight housing or the complete governor assembly is replaced on an early engine (prior to engine 12E-387), it will be necessary to remove the spray nozzle from the blower end plate and include a new governor-to-blower gasket. The tab on the gasket is to assure the gasket is in place.

Install Blower Rotor Shaft Bearings And Gears

1. With the blower housing, rotors and end plates still supported in a vertical position on the two wood blocks, install the ball bearings on the rotor shafts and in the rear end plate as follows:

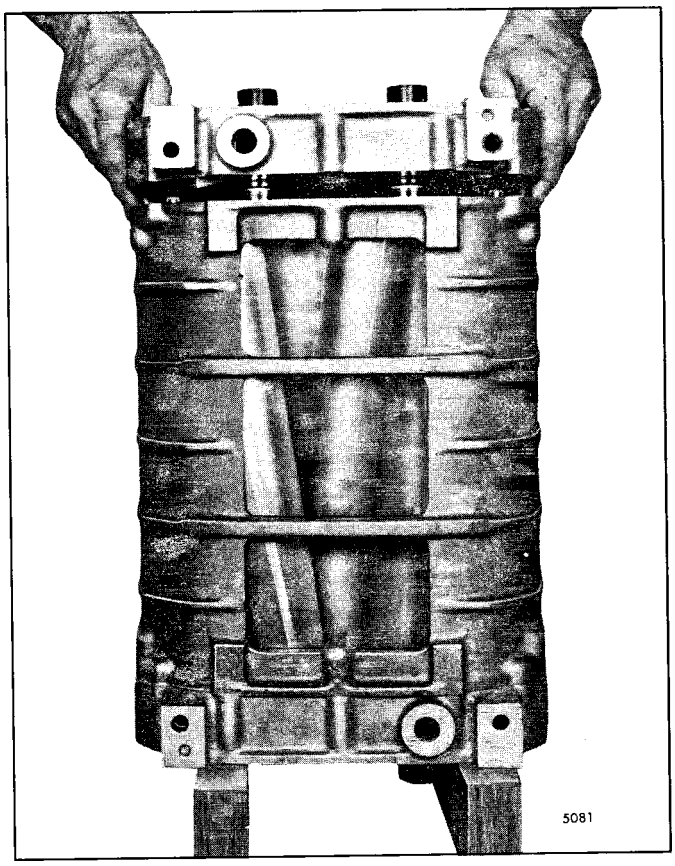


Fig. 17 - Installing Rear End Plate on Blower Rotors and Housing

a. Lubricate one of the ball bearings with light engine oil. Start the bearing, numbered end up, straight on one of the rotor shafts.

b. Place installer J 22706-5 on top of the bearing and tap the bearing straight on the shaft and into the rear end plate (Fig. 18).

c. Install the second ball bearing on the remaining rotor shaft in the same manner.

d. Place the bearing retainers on top of the bearings and the end plate. Then, install three self-locking retainer bolts in each retainer. Tighten the bolts to 13-17 lb-ft (18-23 N*m) torque.

2. Install the roller bearing outer race assemblies in the front end plate as follows:

a. Reverse the position of the blower housing on the two wood blocks (Fig. 19).

b. Lubricate one of the roller bearings with light engine oil. Start the bearing over the rotor shaft and bearing inner race and into the end plate.

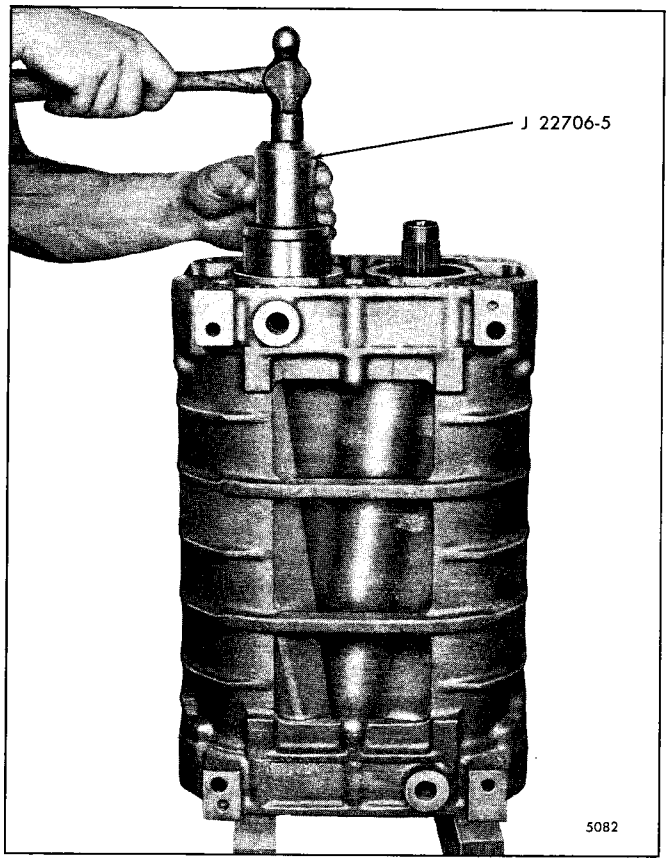


Fig. 18 - Installing Ball Bearings on Rotor Shafts and in Rear End Plate using Tool J 22706-5

c. Place installer J 22706-5 on top of the bearing and tap the bearing straight on the inner race and into the front end plate (Fig. 19).

d. Install the second roller bearing on the remaining rotor shaft in the same manner.

e. Install bearing spacers over the outer races of the roller bearings (Fig. 13).

f. Place the bearing retainers on top of the bearings and the end plate. Then, install three self-locking retainer bolts in each retainer. Tighten the bolts to 13-17 lb-ft (18-23 N*m) torque.

• g. Insert the steel lube oil supply tube into the drilled oil passage of the rear end plate. Secure in place with bolt, washer, and clip.

3. Before installing the blower rotor timing gears on the rotor shafts, observe precautions “2” and “3” relative to the rotor shaft and timing gear alignment under *Assemble Blower.*

The stamped “O” mark in the end of each gear at the omitted serration will assist in aligning the gears on the shafts.

If shims were removed from the back side of the gears (between the inner race of the bearing and the gear), replace them in their *original* positions before installing the gears.

4. Install the blower timing gears as follows:

a. Place the blower assembly on the bench, with the top of the housing up and the rear end (ball bearing end) of the blower facing the outside of the bench.

b. Rotate the rotors to bring the omitted serrations on the shafts in alignment and facing to the left.

c. Install the same number and thickness of shims on the rotor shafts that were removed at the time of disassembly.

d. Lubricate the serrations of the rotor shafts with light engine oil.

e. Place the teeth of the rotor gears in mesh so that the omitted serrations inside the gears are in alignment and facing the same direction as the omitted serrations on the shafts.

f. Start both rotor gears straight on the rotor shafts with the right-hand helix gear on the right-hand helix rotor and the left-hand helix gear on the left-hand helix rotor, with the omitted serrations in the gears in line with the omitted serrations on the rotor shafts (Fig. 22).

g. Place a clean folded cloth between the lobes of the rotors to prevent the gears from turning.

h. Press the gears on the rotor shafts with gear installers J 22706^1 and J 22706-10. The torque required to move the gears down the shafts should fall within a range of 30-130 lb-ft (41-177 N*m) torque. The gears must be pressed on simultaneously. One gear will move freely for only a short distance down the shaft before it binds with the mating gear.

NOTICE: The 30-130 lb-ft (41-177 N«n) torque corresponds to .0015"-.0045" press fit. The 30 lb-ft (41 N*m) minimum torque ensures a interference fit between each timing gear and rotor shaft. This is required to prevent working between the gear and the shaft at the spline. The 130 lb-ft (177 N«m) maximum torque prevents excessive interference fit between each timing gear and rotor shaft. Higher interference may prevent the gear from sliding back on the shaft to secure the inner bearing race.

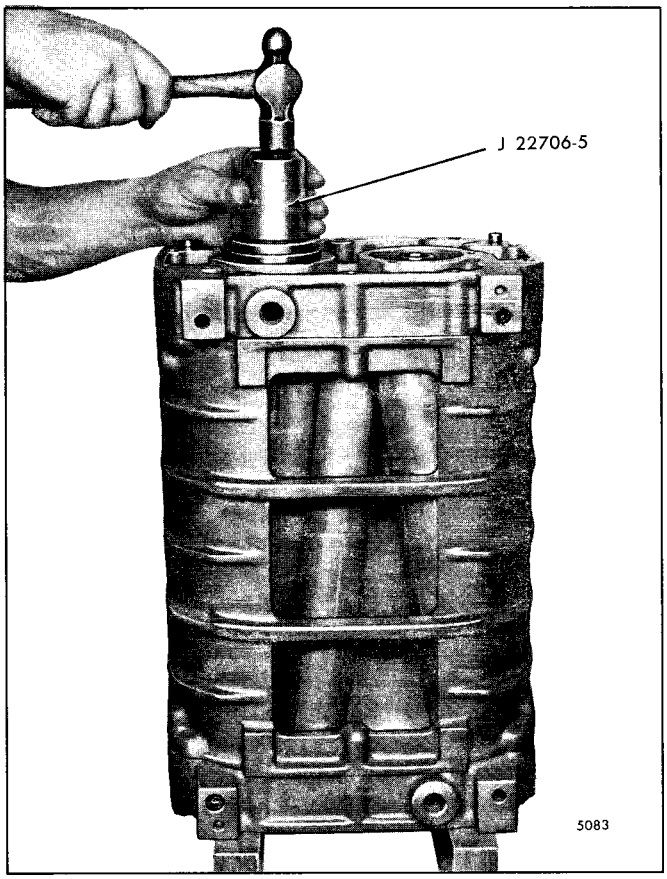


Fig. 19 - Installing Roller Bearings on Rotor Shafts and in Front End Plates using Tool J 22706-5

If the installation torque does not fall within the 30-130 lb-ft (41-177 N»m) torque, the timing gear or rotor assembly must be replaced.

i. Place a lock washer over each end of the rotor shaft, with the tang of the lock washer positioned in the hole in the gear.

NOTICE: The inner face of the locking washer (tang type) must be clean and dry to prevent it from turning.

j. Apply a small quantity of International Compound No. 2, or equivalent, on the threads of the rear rotor shafts and the contact face of the gear retaining nuts and start the nuts on the shafts. *Do not* use International Compound on the shaft splines. After the timing gears have been worked down the shafts and begin to bottom, continue to tighten the 1—5/16"—18 retaining nuts alternately to 200-250 lb-ft (271-339 N«m) torque (Fig. 13). Bend one or more of the tangs on each lock washer against the side of its retaining nut.

k. Apply a small quantity of International Compound No. 2, or equivalent, on the threads of the front L.H. helix rotor shaft and the contact face of the retaining nut and start the nut on the shaft. Tighten the 1-5/16" retaining nuts to 200-250 lb-ft (271-339 N«m) torque.

• 1. Apply a small quantity of International Compound No. 2, or equivalent, to the threads on the front of the front blower right-hand rotor stub shaft and the contact face of the 1-5/16 retaining nut. Install the 1.70" tube spacer and start the nut on the shaft. Tighten the retaining nut to 200 - 250 lb-ft (271 - 399 N»m) torque.

NOTICE: A minimum and maximum torque is not required on the front rotor shaft spline.

Hold the blower firmly on the work bench and keep the rotors from turning so that the correct torque can be obtained when tightening the retaining nuts. A suggested fixture to hold the blower firmly on the work bench would be a “C” clamp with the ball swivel pad removed. The ball portion of the “C” clamp should be inserted into the blower end plate mounting hole and clamped finger tight to the work bench. Torque can then be applied to the rotor nuts without the blower moving on the work bench.

Timing Blower Rotors

After the blower rotors and timing gears are installed, make a preliminary check of the rotor-to-end plate and rotor-to-rotor clearances with a feeler gage (Figs. 20 and 23). Refer to Fig. 21 for minimum blower clearances. The blower rotors, when properly positioned in the housing, run with a slight clearance between the lobes. This clearance may be varied by moving one of the helical gears in or out on the shaft relative to the other gear.

If the right-hand helix gear is moved out, the right-hand helix rotor will turn counterclockwise when viewed from the gear end. If the left-hand helix gear is moved out, the left-hand helix rotor will turn clockwise when viewed from the gear end. This positioning of the gear, to obtain the proper clearance between the rotor lobes, is known as blower timing.

Moving the gears OUT or IN on the rotor shafts is accomplished by adding or removing shims between the gears and the bearings.

The clearance between the rotor lobes may be checked with 1/2" wide feeler gages in the manner shown in Fig. 20. A specially designed feeler gage set, J 1698-02, for the blower clearance operation is available.

It is preferable to measure the clearance with a feeler gage comprised of two or more feelers since a combination is more flexible than one single feeler gage. When measuring clearances of more than .005", use gages made up of .002", .003" or .005" feeler stock to obtain accurate readings.

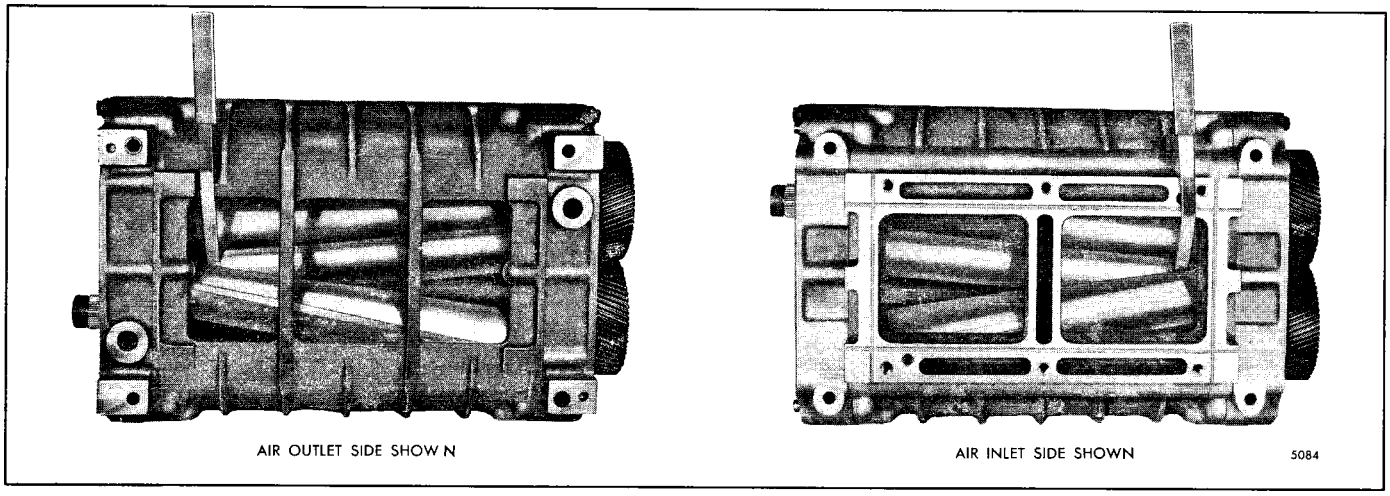


Fig. 20 - Measuring "CC" and "C" Clearance BetweenBlower Rotor Lobes

Time the rotors as follows:

1. Time the rotors to have a minimum clearance of .014" between the *trailing* edge of the right-hand helix rotor and the *leading* edge of the left-hand helix rotor ("CC" clearance) measured from both the inlet and outlet sides (Figs. 20 and 21). Check the clearance between the *leading* edge of the right-hand helix rotor and the *trailing* edge of the left-hand helix rotor ("C" clearance) for the minimum clearance of .024". Rotor-to-rotor measurements should be taken 1" from each end, and at the center of the blower.

2. After determining the amount one rotor must be revolved to obtain the proper clearance, add shims back of the proper gear to produce the desired result (Fig. 22). When more or less shims are required, both gears must be removed from the rotors. Placing a .003" shim in back of a rotor gear will revolve the rotor .001",

3. Install the required thickness of shims back of the proper gear and next to the bearing inner race and reinstall both gears. Recheck the clearances between the rotor lobes.

4. Determine the minimum clearances at points "A" and "B" (Fig. 21). Insert the feeler gages, (Fig. 23), between the end plates and the ends of the rotors. This operation must be performed at the ends of each lobe, making 12 measurements in all. Refer to Fig. 21 for the minimum clearances.

5. Check the clearance between each rotor lobe and the blower housing at both the inlet and outlet side — 12 measurements in all. Refer to Fig. 21 for the minimum clearances.

After the blower rotors are timed, complete the assembly of the blower as outlined below:

1. Remove the temporary hold down bolts from the blower end plates (front and rear of both blowers).

2. If removed, attach three (3) spring plates to the blower drive coupling hub with three (3) 7/16"-30 x 7/8" self-locking bolts. Tighten the bolts to 57-61 lb-ft (77-83 N*m) torque.

3. Attach the hub and spring plate assembly to the R.H. helix timing gear of the rear blower with three (3) 7/16"-20 x 7/8" self-locking bolts. Tighten the bolts to 57-61 lb-ft (77-83 N«m) torque.

4. Install the blower end plate cover gasket and blower end plate cover over the gear end of the rear blower (Fig. 13). Install ten (10) 3/8"-16 x 3-1/4" bolts, lock washers and plain washers.

   NOTICE: Be sure the lubrication hole in the gasket is aligned with the oil supply hole in the blower end plate. Tighten the bolts to 30-35 lb-ft (41-47 N#m) torque.

5. Place a cloth between the rotors when installing the coupling hub. Install the blower rotor coupling hub on the front of the R.H. helix rotor of the rear blower with gear installer J 22706^1 and installer set J 22706-10 (inset, Fig. 13).

Place a cloth between the rotors when installing the coupling hub.

NOTICE: Be sure the coupling hub is seated against the inner race of the front roller bearing.

6. Apply a small quantity of International Compound No. 2, or equivalent, on the threads of the front R.H. helix rotor shaft and the contact face of the retaining nut. Install the lock washer with the tang positioned in the slot provided in the coupling hub and start the nut on the shaft. Tighten the 1—5/16"—18 retaining nut to 200-250 lb—ft (271-339 Nem) torque.

7. Bend one or more of the tangs on the lock washers against the side of the nut to lock the nut in position.

8. If removed, install three spring plates to each of the inner blower rotor coupling hubs with three (3) 7/16"—20 x 7/8" self-locking bolts (Fig. 5). Tighten the bolts to 57-61 lb—ft (77-83 Nem) torque.

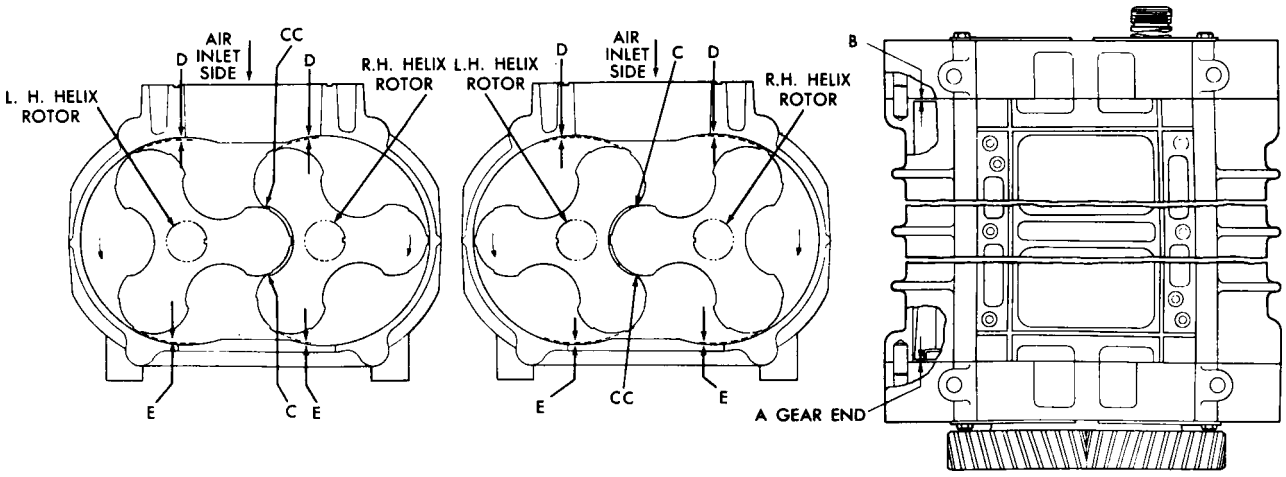
9. Attach one hub and spring plate assembly to the front blower rotor coupling hub on the front of the rear blower with three (3) 7/16"-20 x 7/8" self-locking bolts. Tighten the bolts to 57-61 lb-ft (77-83 Nem) torque.

10. Use a new gasket and install the blower end plate cover on the front of the rear blower (Fig. 13). Install ten (10) 3/8"-16 x 3-1/4" bolts, lock washers and plain washers. Tighten the bolts to 30-35 lb-ft (41-47 Nem) torque.

NOTICE: Be sure the lubrication hole in the gasket is aligned with the oil supply hole in the blower end plate. The tab on the gasket is to assure the gasket is in place.

11. Attach the other hub and spring plate assembly to the rear of the front blower R.H. helix timing gear with three (3) 7/16"-20 x 7/8" self-locking bolts. Tighten the bolts to 57-61 lb-ft (77-83 Nem) torque.

12. Use a new gasket and install the blower end plate cover on the gear end of the front blower (Fig. 13). Install ten (10) 3/8"-16 x 3-1/4" bolts, lock washers and plain washers. Tighten the bolts to 30-35 lb-ft (41-47 Nem torque.



VIEWS FROM GEAR END OF BLOWER NEW PARTS

VIEW	A	B	C	CC	D	E
MIN. 12 V-149 MAX.	.007" TO .013"	.013" TO .030"	.024" MIN.	.014" MIN.	.021" MIN.	.007" MIN.
MIN. 8V, 16 V-149 MAX.	.007" TO .013"	.021" TO .038"	.024" MIN.	.014" MIN.	.021" MIN.	.007" MIN.

VIEWS FROM GEAR END OF BLOWER USED PARTS

VIEW	A	B	C	CC	D	E
MIN. 12V-149 MAX.	.007" TO .013"	.013" TO .050"	.024" MIN.	.014" MIN.	.021" MIN.	.007" MIN.
MIN. 8V, 16 V-149 MAX.	.007" TO .013"	.021" TO .058"	.024" MIN.	.014" MIN.	.021" MIN.	.007" MIN.

NOTE: Time rotors to dimensions on chart for clearance between trailing side of R.H. Helix Rotor and leading side of L.H. Helix Rotor (cc) from both inlet and outlet side of blower.

Fig. 21 - Chart of Minimum Blower Clearances

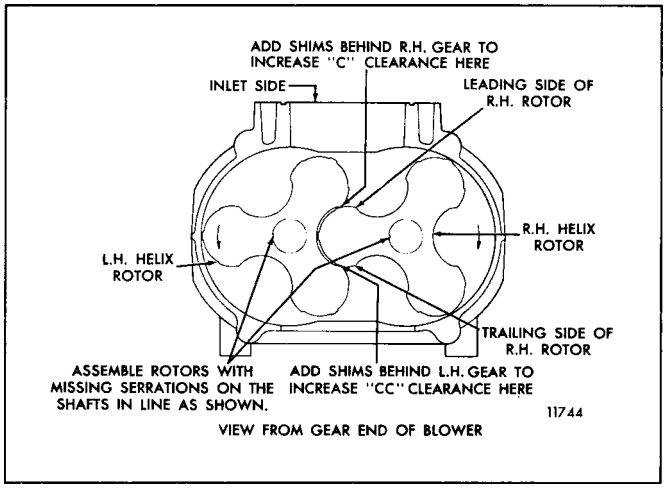


Fig. 22 - Diagram Showing Proper Location of Shims for Correct Rotor Lobe Clearances

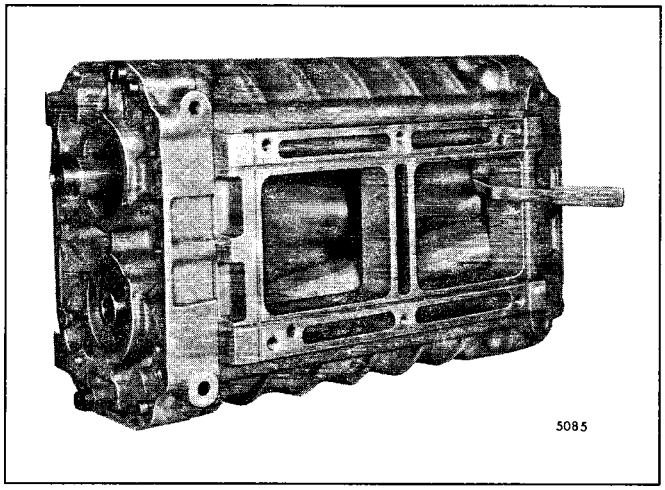


Fig. 23 - Measuring End Clearance Between Blower Rotors and End Plate

13. If removed, press two (2) 1/2" x 15/16" dowel pins .300" above the end surface of the front blower end plate on a 12V front blower (Fig. 24).

NOTICE: Be sure the lubrication hole in the gasket is aligned with the oil supply hole in the blower end plate. The tab on the gasket is to assure the gasket is in place.

14. On a 16V front blower, tap the 1/2" x 2-3/4" dowel pins in the blower end plate. They must extend 2.100" from the end surface of the end plate.

15. Use a new gasket and install the governor drive assembly over the dowel pins and against the front end plate on a 12V front blower.

NOTICE: Be sure the lubrication hole in the gasket is aligned with the oil supply hole in the blower end plate. The tab on the gasket is to assure the gasket is in place.

It may be necessary to rotate the drive shaft slightly to align the splines of the drive shaft and the blower rotor shaft.

16. Install nine (9) 3/8"-16 x 3-1/4" bolts, one nut, washers and plain washers. Tighten the bolts and nut to 30-35 lb-ft (41-47 N*m) torque.

17. Install the governor drive assembly on a 16V front blower as follows:

a. Use a new gasket and install the governor drive housing spacer over the two (2) dowel pins and up against the blower end plate. If necessary, tap the spacer lightly with a plastic hammer.

NOTICE: Be sure the lubrication hole in the spacer and gasket is aligned with the oil supply hole in the blower end plate.

b. Use a new gasket (refer to note above)and install the governor drive assembly over the dowel pins and up against the spacer.

It may be necessary to rotate the drive shaft slightly to align thesplines of the drive shaft and the blower rotor shaft.

c. Install nine (9) 3/8"-16 x 5" bolts, one nut, lock washers and plain washers. Tighten the bolts and nut to 3CU35 lb-ft (41-47 N»m) torque.

Install Blower(s) In Engine

The current engines use 9/16"-12 x 10" blower hold-down bolts in place of the 7/16"—14 x 10" bolts formerly used. The blower end plates and cylinder blocks were revised to accommodate the larger bolts. J 23459 fixture should be used when reworking former cylinder blocks to accept the larger blower hold down bolts. Install the blower(s) as follows:

1. Install new oil seal rings in the cylinder block.

2. Before positioning the blower in the block, install the blower drive cover hose on the blower drive gear hub (12V engine only — Fig. 3) or install four new seals on the inner tube connector and slide the tube connector into the blower drive gear hub on 16V applications (inset, Fig. 3).

NOTICE: The inner tube connector used on the 16V engines has a bevel at the inner diameter at one end only. Install the beveled end towards the blower end plate cover (inset, Fig. 3).

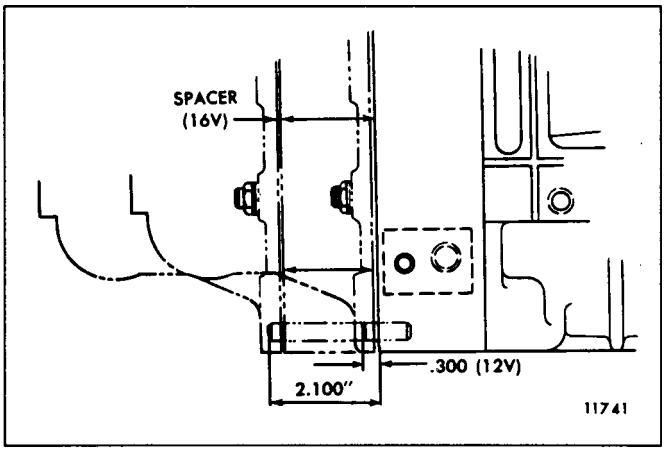


Fig. 24 – Governor Drive Assembly

3. Carefully lower the blower into the cylinder block, using a hoist, so as not to dislodge the oil seals in the cylinder block.

NOTICE: Alignment studs should be used when lowering the blower into the block to facilitate proper installation. Alignment studs can be fabricated by cutting the heads off of two (2) 9/16"-12 x 10" or two (2) 7/16"-14 x 10" bolts.

When installing the rear blower on a 12V engine, it will be necessary to jockey the blower into position to clear the block center joint bolt and also to install the blower drive cover hose (Fig. 3).

4. On 12V and 16V engines, install the front blower first and then proceed as follows:

   a. Position both snap rings over the blower center drive shaft with the front snap ring loose on the shaft (Fig. 4).

   b. Insert the drive shaft in the drive shaft coupling hub on the front blower.

   c. Place four new seal rings in position on the inner tube connector and slide the inner tube connector into the outer tube connector (Fig. 4).

NOTICE: The inner and outer tube connectors each have a bevel on the inner diameter at one end only (Fig. 4). The beveled end must be installed towards the blower end plate covers.

   d. Place two (2) new seal rings in position on the outer tube connector and slide the tube connector assembly into the rear of the front blower (Fig. 4).

   e. Place the rear blower on a hoist and lower it into position in the air box.

NOTICE: Use extreme care when seating the blower over the spring pins in the block. The pins could gouge the aluminum blower end plates, allowing oil to be forced into the air box.

5. Apply engine oil only to the threads and the underside of the bolt heads. Then, install four (4) blower hold-down bolt and *special washers* in each blower. Tighten the 9/16"—12 bolts to 75-85 lb—ft (102-115 N*m) torque or the 7/16"-14 bolts to 50-55 lb—ft (68-75 N*m) torque.

NOTICE: Do not over-torque the blower hold-down bolts. International Compound No. 2 should *NOT* be used.

6. Connect the center blower drive shaft on the tandem blowers and the blower drive shaft as follows:

   a. With the rear snap ring in position on the blower drive shaft, slide the shaft into position against the rear blower drive coupling hub (Fig. 4).

   b. Slide the inner and outer connector tube assembly toward the rear blower to expose the front end of the drive shaft. Install the front snap ring in the groove on the shaft.

   c. Position the inner and outer tube connectors in the blower end plate covers and secure them in place with retainer clips.

   d. On 12V engines, slide the cover hose, located on the blower drive gear support, over the blower end plate cover with two (2) hose clamps.

   e. On the 16V engine, slide the inner tube connector into the blower end plate cover and secure it in place with a retainer clip (inset, Fig. 3).

   f. Install the blower drive shaft as outlined in Section 1.7.6.

• A new double-shaft drive system has been released to provide direct (shaft) drives to the rotor of both blowers used in Series 149 hydrofracturing units (see Section 1.7.6).

7. Install the fuel pump (Section 2.2).

8. Install the blower cover plates and access covers on the 12V and 16V engines as follows:

   a. Install a new blower to cover plate seal ring in the groove of the blower housing on each blower.

   b. Install a new cylinder block to cover plate seal ring in the groove of each cylinder block.

NOTICE: The seal rings must lay flat in the grooves and must not be twisted.

c. Install four (4) new "0"-rings (two per block) in the counterbores at the breather passages near the center of the blocks.

d. Install the cover plates and tighten the bolts.

9. Install the governor and control linkage as outlined in the governor section of this manual.

10. Install the air shutdown housing (or housings) and linkage (Section 3.3).

11. Install the air inlet housing or housings (Section 3.3).

Install the turbochargers, if removed (Section 3.5).

Install the engine breather (Section 4.8).

Install any other accessories on the engine that were removed.

Check the cooling system (Section 5).

Check the lubrication system (Section 4).

Perform the governor and injector rack control adjustment as outlined in Section 14.

Check for and correct any water or oil leaks after the engine has been run.

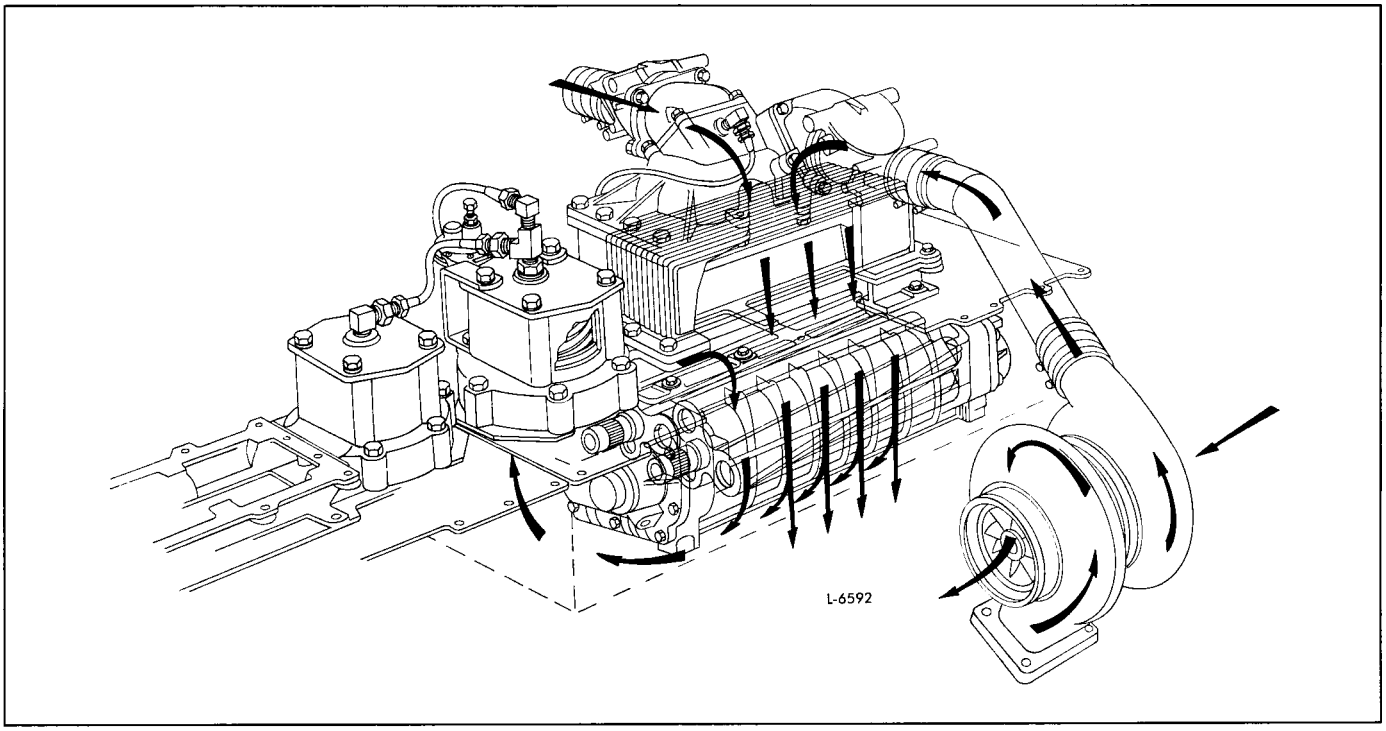


Fig. 2 – Air Flow Schematic – Series 149 Blower Bypass Valve Equipped Engine (Current Piston Style Valve System)

As engine rpm increases, airbox pressure rises until it reaches a point at which it can overcome valve spring tension and effect a bypass. The valve then is moved off its seat, allowing air from the turbocharger to bypass the blower and flow directly into the airbox.

Former and new bypass valves are interchangeable on a system-for-system basis, but not part for part. Components of the former flapper valve style system will be serviced, except for the valve housing. When this requires replacement, the former system must be removed and replaced with the new system.

RECOMMENDATION: Because of the improved combustion efficiency that results, DDC recommends replacing the former system with the new system when the former system requires repair or at time of engine overhaul.

The following disassembly, assembly, and adjusting procedures apply to the current piston style blower bypass valve system.

Disassemble Current Blower Bypass Valve

This procedure can be performed on the engine or on the bench.

CAUTION: The bypass valve cover is under spring tension. To prevent the possibility of personal injury, Kent-Moore tool J 37466 and the following procedure must be used to remove it for service and/or cleaning of the piston valve.

ToolJ 37466 (Fig. 4) consists of a threaded rod with a handle on the end and a special retaining collar attached to a hex nut which moves up and down the threaded rod. This tool is inserted through the air supply lines hole in the cover to aid in the disassembly and assembly of the bypass valve.

1. Remove the air line and associated fittings to expose the hole in the cover of the piston valve housing (Fig. 5).
2. Insert the threaded end of tool J 37466 through the hole and screw it into the tapped hole in the piston.
3. Tighten the nut until the retaining collar is seated firmly against the top of the cover.
4. Remove the four (4) cap screws that secure the cover to the housing. Tool J 37466 will hold the cover and spring in place.
5. Move the retaining collar by slowly turning the nut up the threaded shaft. This will release spring tension.
6. When the spring is relaxed, pull the piston, spring, and cover from the valve housing and complete the disassembly of the piston.

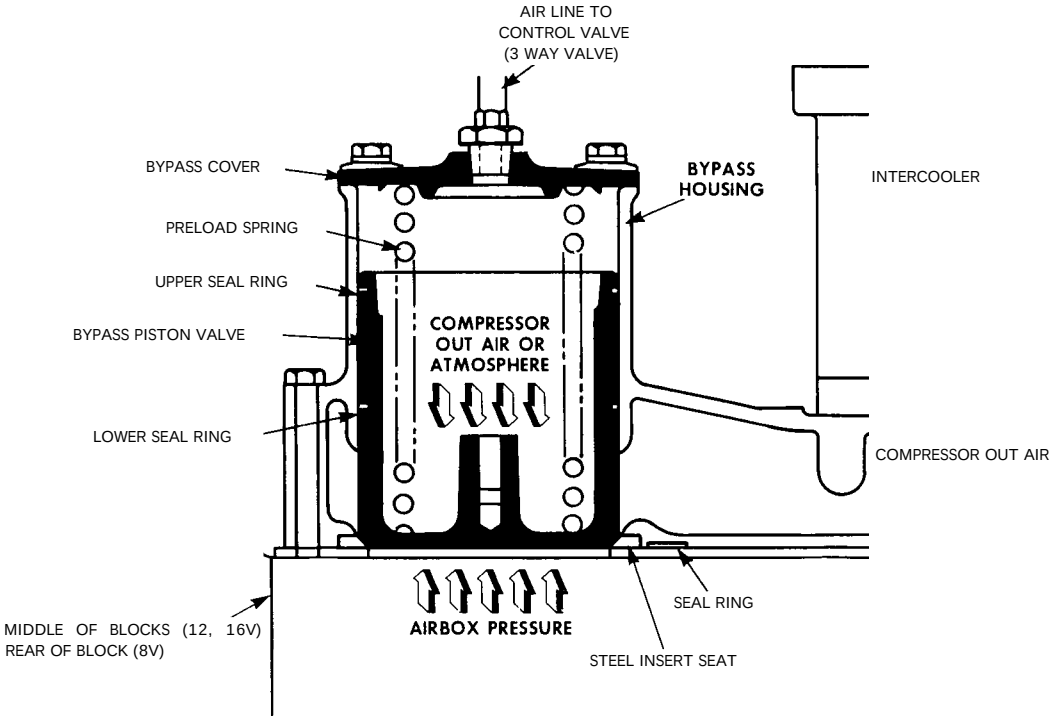


Fig. 3 - Piston Style Blower Bypass Valve Assembly

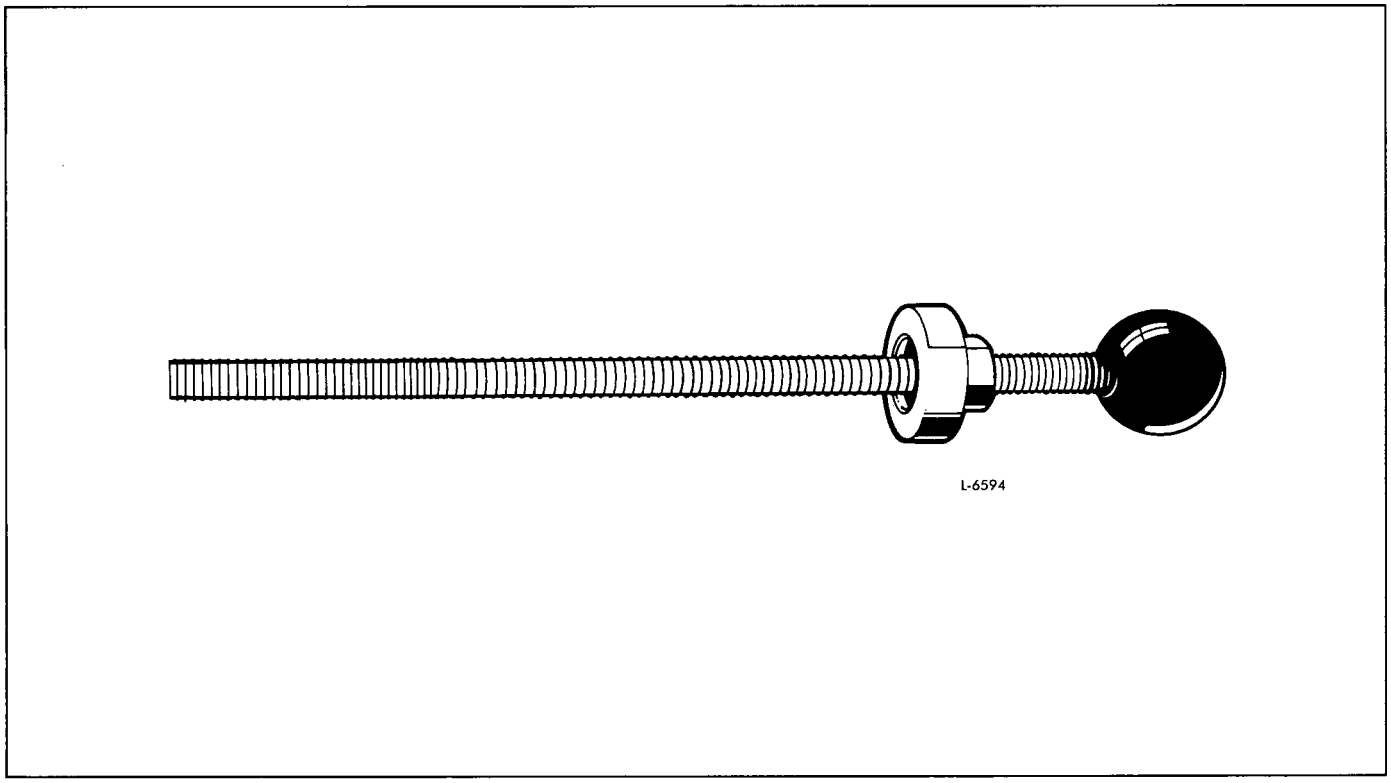


Fig. 4 – Bypass Valve Assembly/Disassembly Tool J–37466

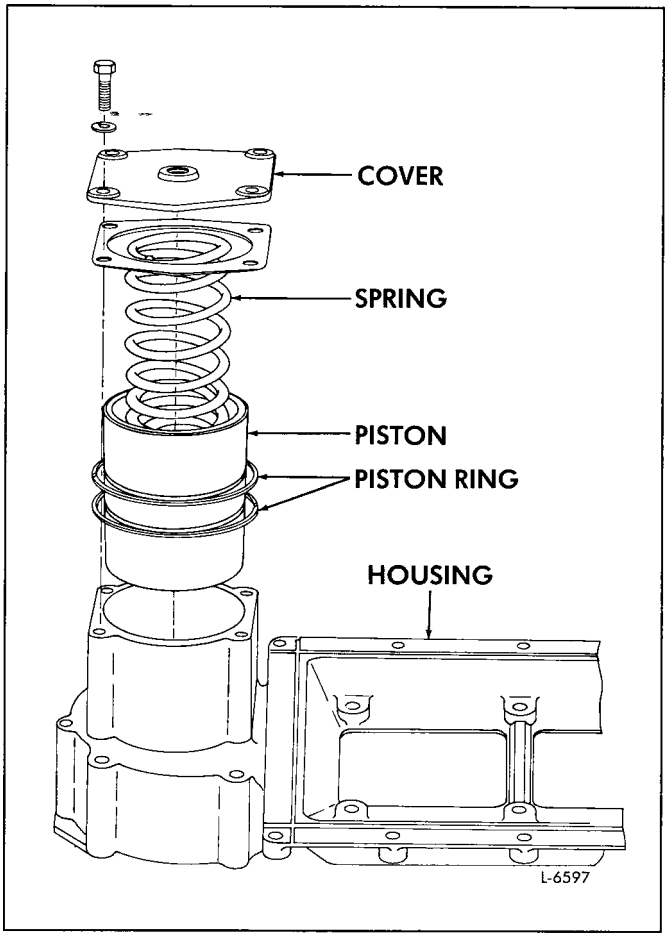


Fig. 5 – Blower Bypass Valve Assembly

Assemble Blower Bypass Valve

This procedure can be completed on the engine or on the bench. To assemble the blower bypass valve, refer to Fig. 5 and proceed as follows:

1. Load the piston assembly using Kent-Moore tool J 8037 or an equivalent piston ring compressor.
2. Place the spring in the housing, locating it correctly on the spring seat in the piston.
3. With the retaining collar and nut at the top of tool J 37466, insert the threaded end through the center hole in the cover and position the cover with the tool in place over the bypass housing. The piston should be in the bottom of the bore and the spring in place.
4. Screw the threaded end securely into the piston.
5. Turn the retaining collar nut until the cover is in place.
6. Install the four cap screws into the cover and tighten to 30 lb-ft (41 N*m) torque.
7. Unscrew the threaded rod from the piston and remove the tool.

CAUTION: To alert serving personnel to a potential hazard and avoid possible personal injury from improper disassembly /assembly, always replace the *CAUTION* label (Fig. 6) on the cover after servicing the bypass valve.

****CAUTION****
COVER UNDER LOAD
TO AVOID PERSONAL INJURY
DO NOT REMOVE CAP SCREWS
BEFORE CONSULTING ^
SERVICE MANUAL ^

L-6596

Fig. 6 - Caution Label

Remove Bypass Valve Housing From Engine

Instructions in steps 1, 2, 3 and 4 apply to all bypass housings. Step 3 applies to 12V-149 engines with small intercooler systems only.

1. Remove the intercooler per instructions in section 3.5.2 of the service manual (or the air inlet housing for non-turbocharged engines) to expose the bypass valve housing.
2. Remove the following bolts, lockwashers, and plain washers that attach the housing to the engine:

BOLTS PER HOUSING	SIZE	HOUSING STYLE	ENGINE
8	7/16"— 14 x 2-1/4"	Lg. Intrclr	8V, 16V
6	7/16"— 14 x 2-1/4"	Lg. Intrclr	12V
8	7/16" — 14 x 1-5/8"	Sml. Intrclr	8V, 16V
2	7/16"— 14 x 1-1/4"	Sml. Intrclr	12V

In addition, five (5) 3/8" -16x3 3/4" bolts per housing must be removed from the piston valve end of all bypass housing systems.

3. On 12V-149 engines with small intercoolers *only*, four (4) 7/16" - 14 x 4 1/4" bolts are also used to interconnect the intercooler and the bypass housing through the top airbox plate into the blower. These may have been removed per instructions in step one. If not, they must be removed now.
4. Lift the bypass valve housing from the engine and discard the two (2) seal rings.

Install Bypass Valve Housing On Engine

1. Clean the seal ring grooves in the bottom of the valve housing.

2. Lubricate two (2) new seal rings and the grooves in the bottom of the housing with Lubricone, or equivalent, and install the seal rings.

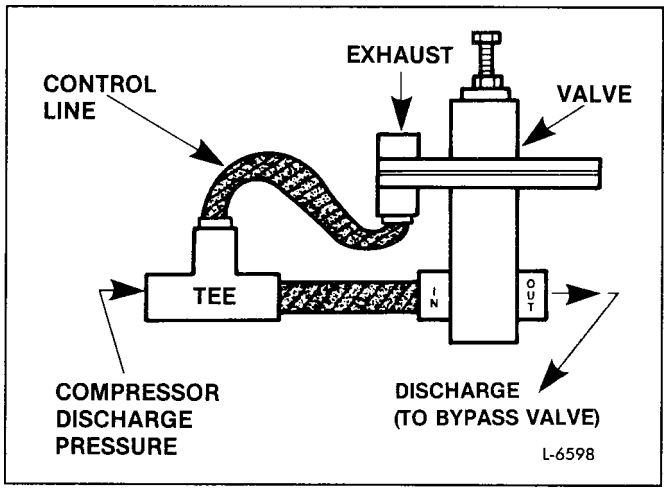
3. Position the housing on the cover plate and install the correct number of properly sized bolts as outlined in the previous section. Install lockwashers and flatwashers under each bolt. To prevent air box leakage, use Loctite 271 sealant, or equivalent, or the five (5) 3/8" - 16 x 3 3/4" bolts on the piston end of all bypass valve housings). Tighten 7/16" bolts to 46 - 50 lb—ft (62 - 68 N«m) torque. Tighten 3/8" bolts to 30-50 lb—ft (41-47 N*m) torque.

Bypass Valve Adjustment

A special three-way valve controls air pressure to the bypass assembly. An adjusting screw on the control valve is used to regulate air pressure. Maximum air delivery should be set to occur between 6 and 9 psi (41.4 and 62.1 kPa). This will automatically set the valve to cut off air between 9 and 14 psi (62.1 and 97 kPa).

Proper adjustment of the control valve is critical to engine operation. Adjustment is *best* completed with the valve disconnected from the engine. If this is impractical, an on-the-engine adjustment may be made until an appropriate bench adjustment can be performed. Control valve settings should be checked every 5000 hours and reset, if necessary.

The control valve is connected according to the following schematic:



Compressor discharge pressure is “teed” to the *inlet* and *control* ports of the valve. The *discharge* (out) port of the valve is plumbed to the bypass valve housings. This insures seating of the piston valve during light load operation.

Control Valve Adjustment (on Bench)

This procedure requires the use of two 0-40 psi (0 - 276 kPa) gages, a 0 - 100 psi (0 - 689 kPa) air pressure regulator, and shop air of approximately 100 psi (689 kPa) pressure. Refer to Fig. 7.

1. Attach one pressure gage to the *discharge* port of the control valve with a “tee.” The open end of the “tee” should be plugged so that there is no airflow beyond the gage.

2. Connect the second pressure gage between the regulator and a “tee” fitting. Connect a hose from the tee to the *control* port of the valve. Connect another hose from the tee to the *inlet* port.

3. Connect shop air pressure to the regulator valve. **Important:** The control hose should be in place when the valve is adjusted.

4. Loosen and back out the adjusting screw on the three-way valve.

5. Adjust the air pressure regulator valve to obtain a supply side pressure of 10 psi (69 kPa).

6. Adjust the three-way valve screw until the gage on the discharge side just reaches the maximum value and stops moving. Back off the adjusting screw until the discharge pressure just starts to drop. Then *slowly* readjust back to the maximum value and stop adjustment immediately when this point is reached.

7. Tighten the adjusting screw locknut.

8. *Slowly* increase supply air pressure with the air pressure regulator until 14 - 18 psi (97 - 124 kPa) is reached. *Discharge* pressure should read zero.

9. Readjust as needed to obtain the required calibration.

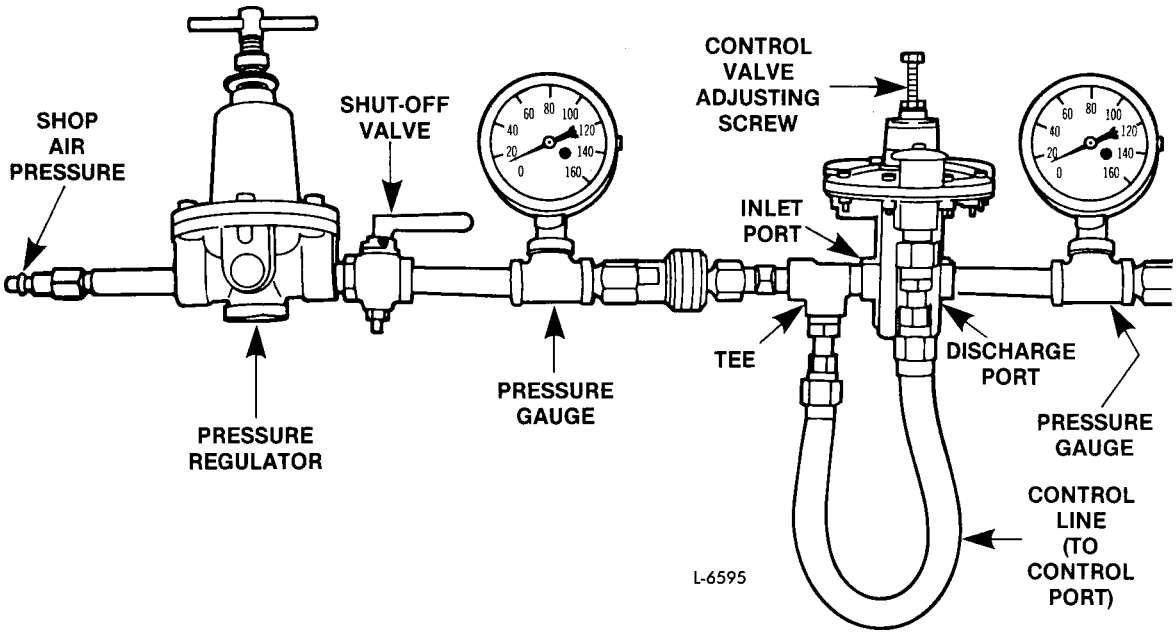


Fig. 7 - Control Valve Adjustment Set-up (Bench)

Control Valve Adjustment (on Engine)

The control valve can be calibrated on the engine, although not as accurately as on the bench. After the piston style blower bypass valve system has been installed, adjust the control valve as follows:

1. Install pressure gages to read airbox pressure and turbocharger compressor discharge pressure in inches of mercury (0 - 100 Hg gages).
2. Back out the adjusting screw on the control valve.
3. Start the engine and run it at a speed and load that will provide approximately 30 in. Hg airbox pressure.
4. *Slowly* adjust the screw on the 3-way valve until the smallest differential between airbox pressure and turbocharger compressor discharge pressure is obtained.
5. Tighten the adjusting screw locknut.

This procedure will adjust the valve close enough until an appropriate bench calibration can be performed.

TURBOCHARGER (AIRESEARCH)

T18 A40, TV7101 AND TV8115 TURBOCHARGERS

The turbocharger (Fig. 1) is designed to increase the overall efficiency of the engine. Power to drive the turbocharger is extracted from the waste energy in the engine exhaust gas.

The turbocharger consists of a radial inward flow turbine wheel and shaft, a centrifugal compressor wheel and a center housing which serves to support the rotating assembly, bearings, seals, turbine housing and compressor housing. The center housing has connections for oil inlet and oil outlet fittings.

The turbine wheel is located in the turbine housing and is mounted on one end of the turbine shaft. The compressor wheel is located in the compressor housing and is mounted on the opposite end of the turbine wheel shaft to form an integral rotating assembly.

The rotating assembly consists of a turbine wheel and shaft assembly, piston ring(s), thrust spacer, compressor wheel and wheel retaining nut. The rotating assembly is supported on two pressure lubricated bearings which are retained in the center housing by snap rings. Internal oil passages are drilled in the center housing to provide lubrication to the turbine wheel shaft bearings, thrust washer, thrust collar and thrust spacer.

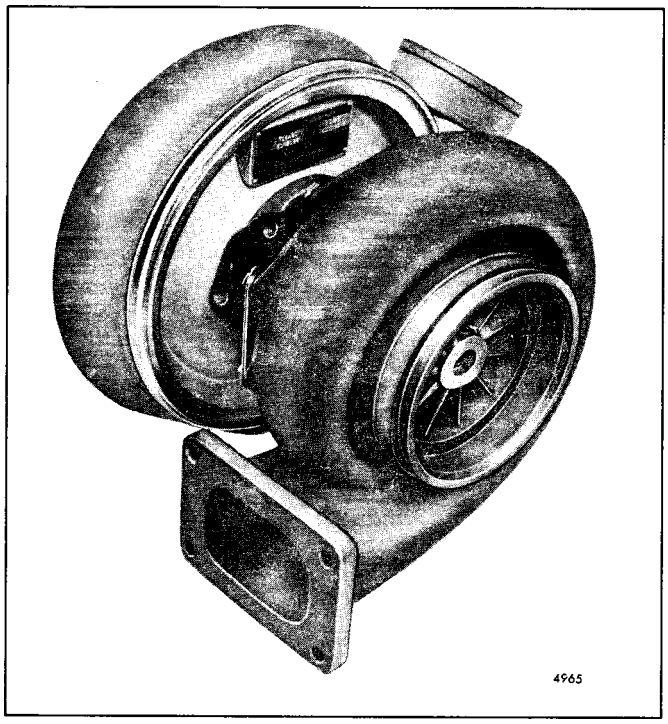


Fig. 1 - Turbocharger Assembly

The turbine housing is a heat resistant alloy casting which encloses the turbine wheel and provides a flanged engine exhaust gas inlet and an axially-located turbocharger exhaust gas outlet. The T18A40 turbine housing is bolted to the turbine end of the center housing and the TV7101 and TV8115 turbine housings are secured with a “V” band coupling, thus providing a compact and vibration free assembly.

The compressor housing which encloses the compressor wheel provides an ambient air inlet and a compressed air discharge outlet. The compressor housing is secured to the compressor end of the center housing backplate assembly with a “V” band coupling.

Operation

The turbocharger is mounted on the exhaust outlet flange of the engine exhaust manifold. After the engine is started, the exhaust gases flowing from the engine and through the turbine housing cause the turbine wheel and shaft to rotate (Fig. 2). The gases are discharged into the atmosphere after passing through the turbine housing.

The compressor wheel, which is mounted on the opposite end of the turbine wheel shaft, rotates with the turbine wheel. The compressor wheel draws in fresh air, compresses it and delivers high pressure air through the engine blower to the engine cylinders.

During operation, the turbocharger responds to the engine load demands by reacting to the flow of the engine exhaust gases. As the engine power output increases or decreases, the turbocharger responds to the engine’s demand to deliver the required amount of air under all conditions.

Certain engines are equipped with intercoolers to reduce the temperature of the discharge air from the turbocharger before it enters the engine blower (refer to Section 3.5.2).

Lubrication

Lubricating oil for the turbocharger is supplied under pressure through an external oil line extending from the engine cylinder block to the top of the center housing. From the oil inlet in the center housing, the oil flows through the drilled oil passages in the housing to the shaft bearings, thrust ring, thrust bearing and backplate or thrust plate (Fig. 3). The oil returns by gravity to the engine oil pan through an external oil line extending from the bottom of the turbocharger center housing to the oil pan (current engines) or the side of the cylinder block (former engines).

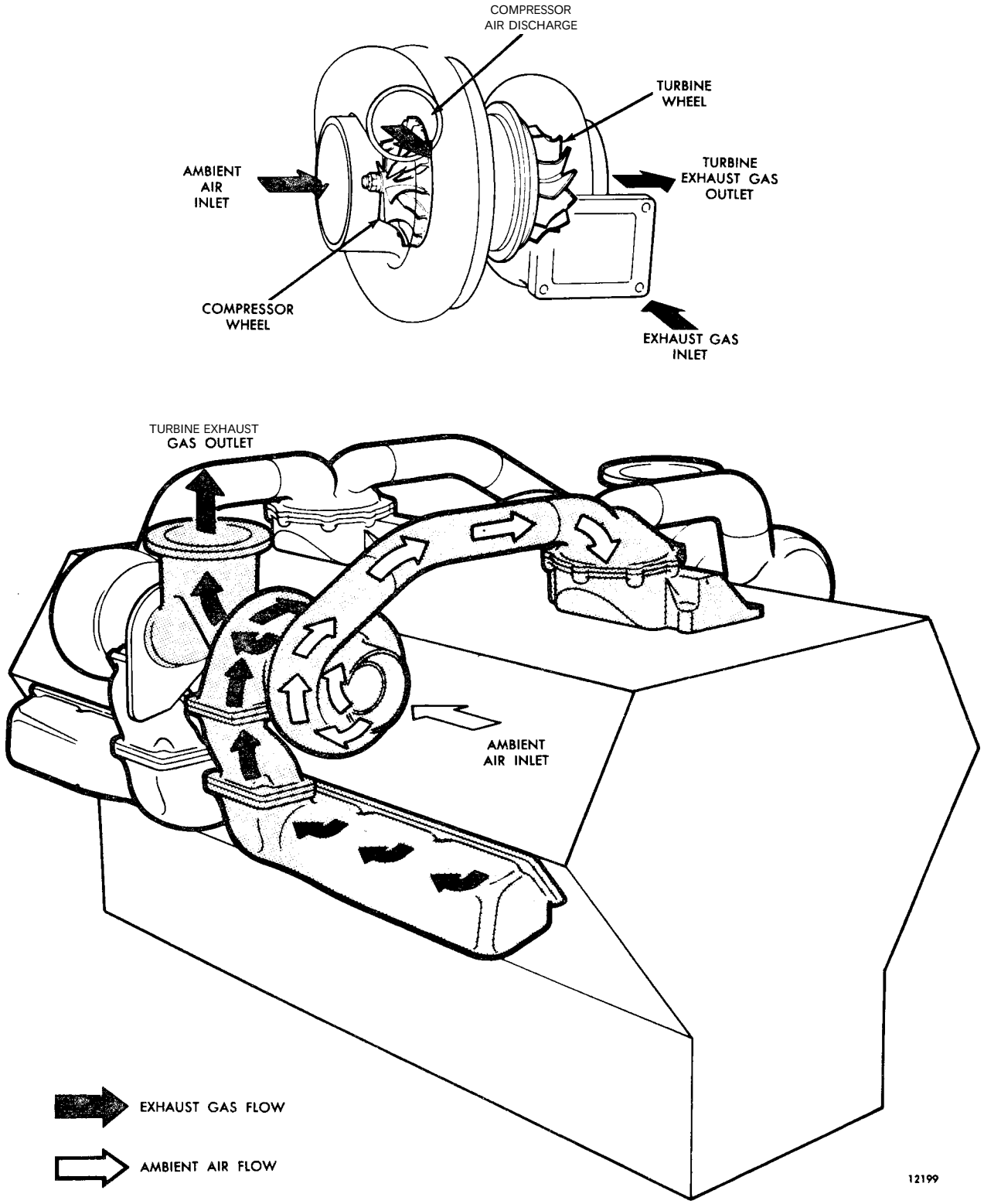


Fig. 2 - Schematic Air Flow Diagram

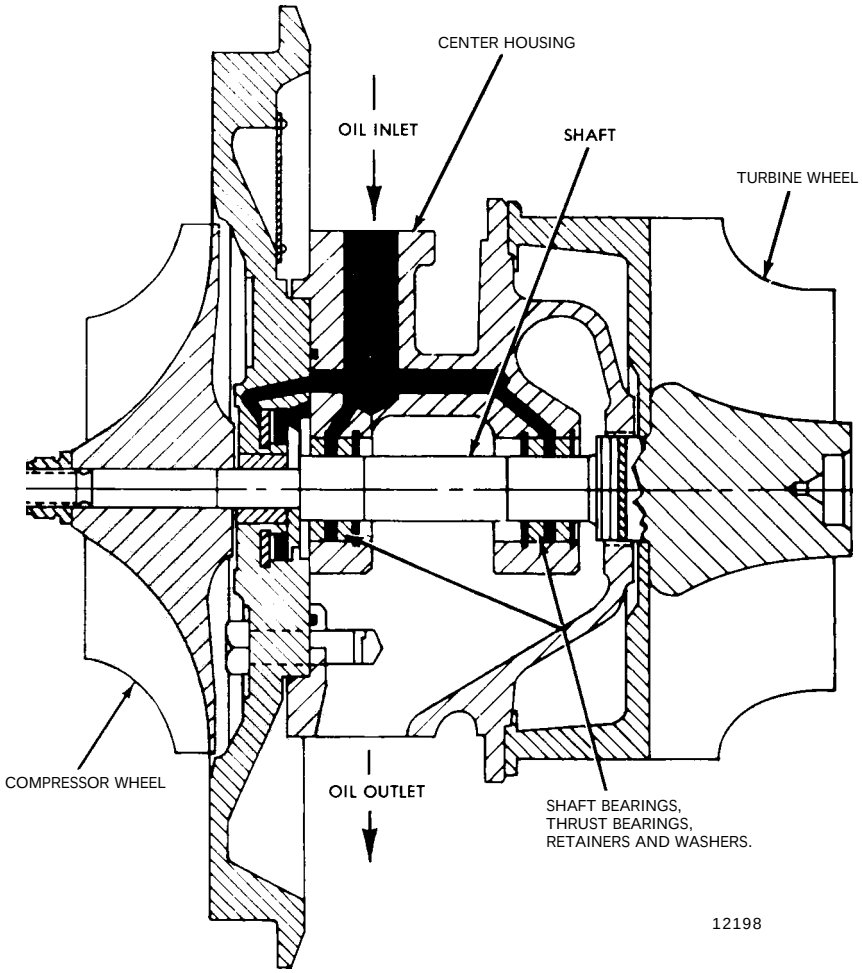


Fig. 3 -Turbocharger Oil Flow Diagram

Before the initial engine start, when a new or overhauled turbocharger is installed, the turbocharger must be pre-lubricated as outlined under *Install Turbocharger.*

NOTICE: Failure to perform the prelubrication procedure may result in premature bearing failure due to *oil lag* or lack of lubrication.

■ **NOTICE:** DO NOT permit "drafting" of the turbocharger without an adequate flow of oil to the bearings. "Drafting" refers to wheel shaft rotation caused by strong outside air currents passing over the compressor or turbine wheels while the engine is stopped. Wheel shaft rotation without adequate lubrication can lead to serious turbocharger bearing damage. Drafting can occur if strong air currents enter the turbo while the engine is in transit (on the bed of a moving truck, for example). It can also result from air currents entering an open exhaust manifold while the engine is stationary (during set-up on a dynamometer, for example). A cover on the turbocharger inlet can protect against drafting.

Periodic Inspection

NOTICE: A turbocharger compressor inlet shield, (Fig. 4) J 26554—A, is available for use anytime the engine is operated with the air inlet piping removed. The shield helps to prevent foreign objects entering the turbocharger and prevents a service technician from touching the moving impeller. The use of this shield *does not* preclude any other safety practices contained in this manual.

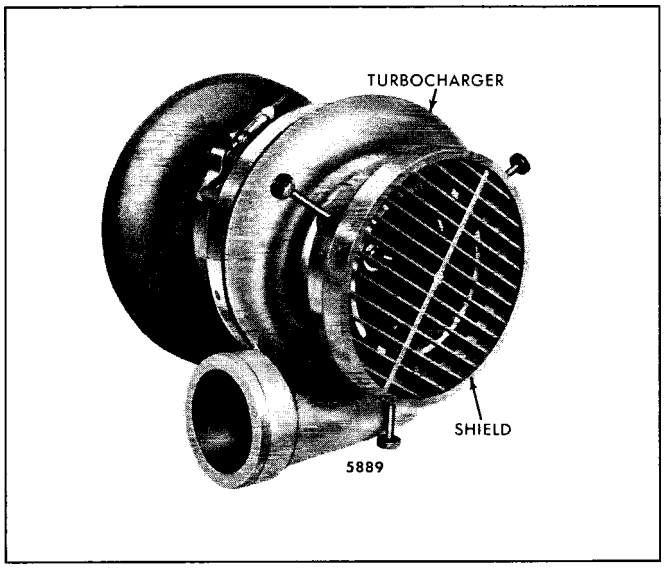


Fig. 4 - Inlet Shield (J 26554-A)

Inadequate air filtering and excessive restrictions to air and exhaust flows will adversely affect turbocharger life and performance. Do not permit restriction levels to exceed the specified limits (refer to Section 13.2).

A periodic inspection of the turbocharger should be made along with an engine inspection.

Inspect the turbocharger mountings and check all of the air ducting and connections for leaks. Make the inspection with the engine running and with it shutdown. Check for leaks at the manifold connection, the turbine inlet and exhaust manifold gasket.

NOTICE: Do not operate the engine if leaks are found in the turbocharger ducting or if the air cleaner is not filtering efficiently. Dust leaking into the air ducting can damage the turbocharger and the engine.

Remove the inlet duct to the turbocharger compressor housing and check for carbon or dirt build up on the impeller or in the housing. Excessive accumulations indicate either a leak in the ducting or a faulty air filtering system. Remove all such accumulations and determine and correct the cause. Refer to *Trouble Shooting Charts* (Fig. 5). Uneven deposits left on the compressor wheel can affect the balance and cause premature bearing failure.

NOTICE: Do not attempt to remove carbon or dirt build up on the compressor or turbine wheels without removing the turbocharger from the engine. The blades on the wheels must be thoroughly cleaned. If chunks of carbon are left on the blades, an unbalanced condition would exist and subsequent failure of the bearings would result if the turbocharger is operated. However, it is not necessary to disassemble the turbocharger to remove dirt and dust buildup.

For proper operation, the turbocharger rotating assembly must turn free. Whenever the exhaust ducting is removed, spin the turbine wheel by hand. If it does not spin freely, refer to Chart 1 of Fig. 5. Inspect the compressor and turbine wheels for nicks or loss of material. Both wheels are precision balanced. A broken or bent blade can throw the rotating assembly out of balance and shorten the life of the turbocharger.

Inspect the oil inlet and oil return lines to make certain all of the connections are tight and that the lines are not dented or looped so that oil flow to and from the center housing is restricted. Looping the oil return lines disrupts gravity flow of the oil back to the engine.

NOTICE: Be sure the oil inlet lines are filled with oil and that they are clear of the turbine housings.

Check for signs of oil leaking from the turbocharger housings.

Lubricant applied under pressure to the center housing while the shaft is not turning may allow oil to enter the turbine and compressor housings. However, after the turbocharger has been operated for a time under load conditions and with the inlet restriction at normal, oil in these sections should disappear. If the oil does not disappear, refer to Chart 2 of Fig. 5.

Oil pull-over from an oil bath type air cleaner can also cause oil to enter the compressor housing. Check for a dirty air cleaner element or for too low viscosity oil in the air cleaner. Also, too small an air cleaner could create excessive air flow velocity and result in oil pull-over.

Evidence of oil in the inlet or outlet ducts or dripping from either housing indicates a seal problem that will require overhaul of the turbocharger. Refer to Chart 3 of Fig. 5.

Tests show there are three conditions that contribute to oil seal leakage at the internal turbocharger oil seal.

1. A worn or defective oil seal, which must be replaced.

2. High air inlet restriction (above specified limits). This will cause oil to be pulled past the oil seal.

3. Long periods of operation where the engine is being motored (using the engine as a braking device when going down a long hill). This can also cause oil to pass by the oil seal.

TROUBLE SHOOTING CHARTS

CHART1

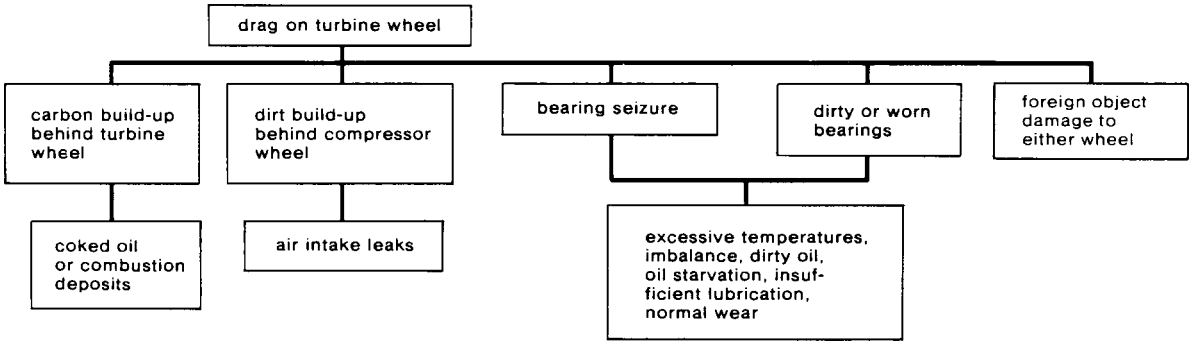


CHART 2

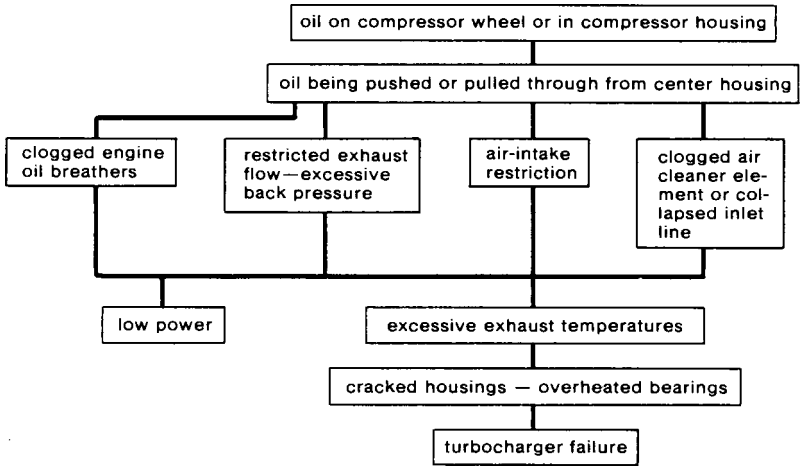


CHART 3

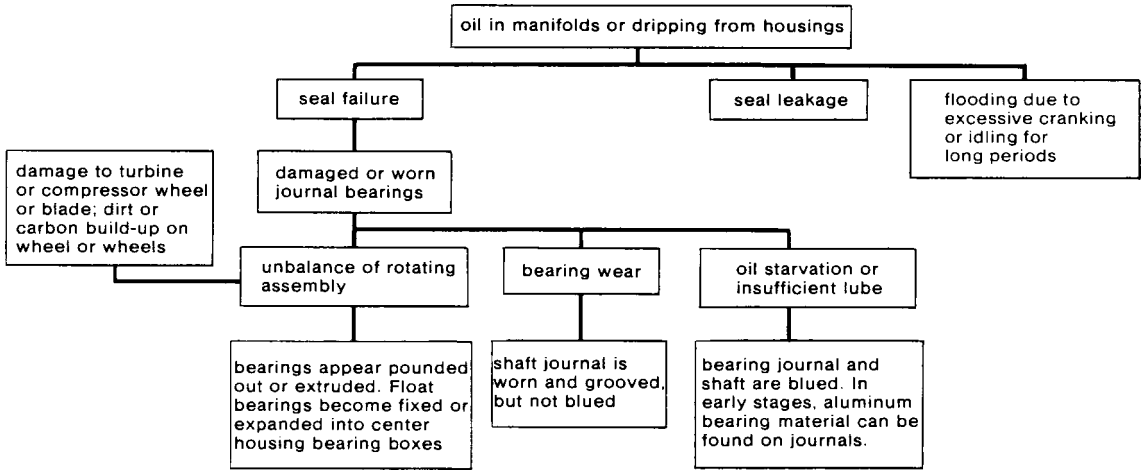


Fig. 5 - Inspection Checks for Turbocharger

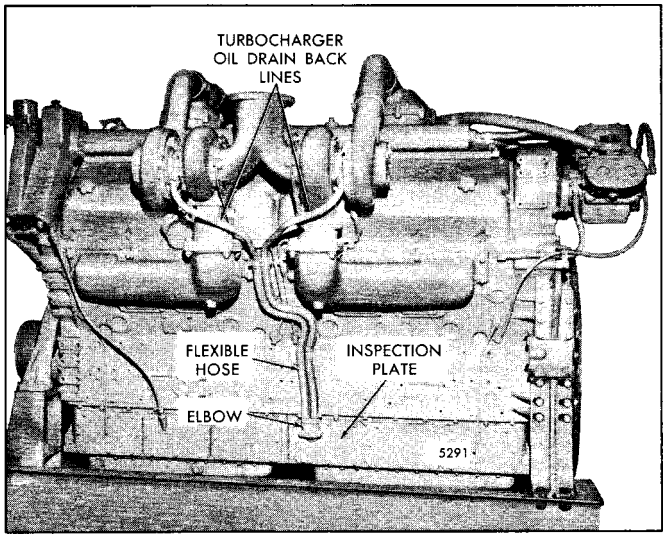


Fig. 6 - Turbocharger Oil Drain and Oil Supply Line Connections (Former Engines)

To confirm oil leakage from one or more of these conditions, remove the compressor housing and inspect the backplate. If the surface is wet with oil, it indicates leakage.

If this test does not show leakage patterns, the oil seal assembly is good for normal operation. This simple test will allow some positive testing on each engine in all cases.

Turbocharger compressor end shaft oil seal effectiveness can be determined by the following procedure:

1. Determine that air inlet restriction is within the Detroit Diesel maximum limit. Refer to Section 13.2.

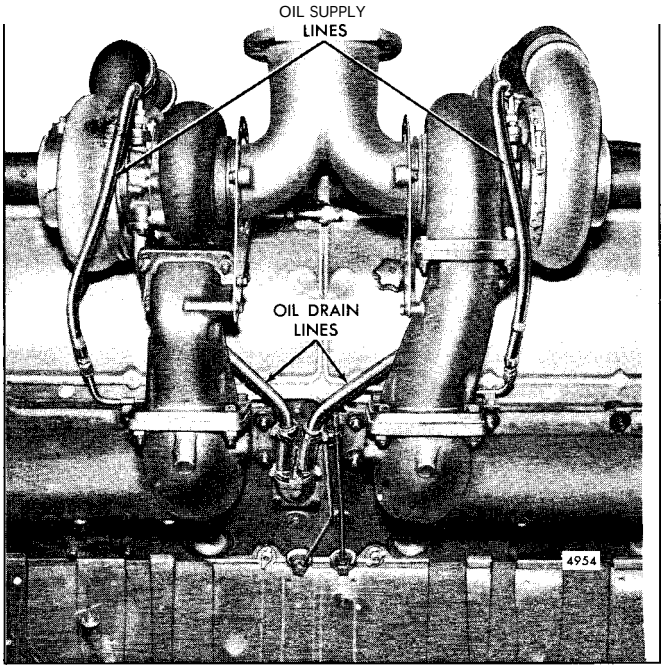


Fig. 7 -Turbocharger Oil Drain and Oil Supply Line Connections (Former Engines)

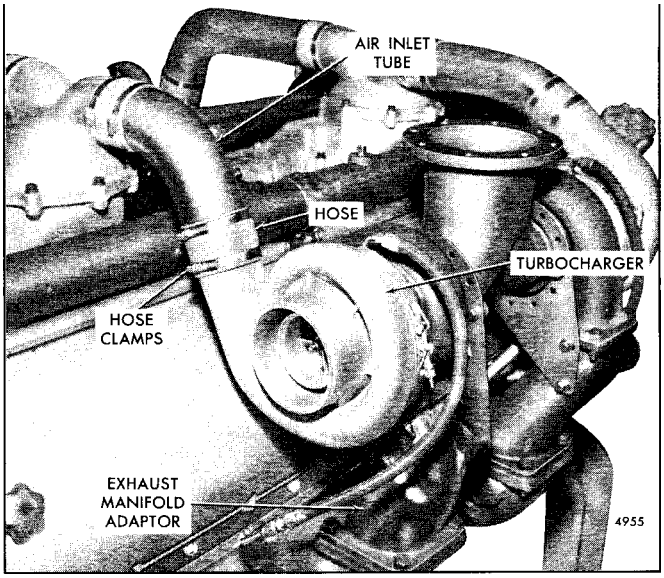


Fig. 8 - Turbocharger-to-Air Inlet Tube Connection

2. Be certain that the turbocharger oil drain line is unrestricted.

3. Be certain that the turbocharger has not obviously been damaged and in need of major repair.

4. Remove air intake ducting. Inspect inside of ducting for evidence of oil. If oil is found in the intake system, determine the source before proceeding with the compressor seal test and also thoroughly remove oil from the intake. Some external sources of oil are oil bath air cleaners, air compressor line, or a leak near an oil source such as an engine breather, etc.

5. Remove the compressor housing from the turbocharger.

6. Thoroughly clean the internal surfaces of the compressor housing, impeller cavity behind the impeller, and the backplate annulus with suitable solvent spray and then dry completely with shop air.

7. Spray the backplate annulus with a light coating of “Spot-Check” developer type SKD-MF, or equivalent.

8. Install the compressor housing on the turbocharger and reconnect the inlet and outlet connections.

9. Warm up the engine to normal operating temperature.

10. Operate the engine at no load at the governor limited high speed for approximately five minutes.

11. Return the engine to low idle and then stop it.

12. Remove the intake duct and outlet hose and then remove the compressor housing. Evidence of compressor end shaft seal oil leakage will be observed as oil streaks in the "Spot-Check" developer on the backplate annulus. This surface should be completely free of oil streaks after the test.

13. If leakage is detected, and oil is positively not entering through the intake duct, then the turbocharger may be removed from the engine and inspected for damaged components.

Remove Turbocharger

1. Disconnect the oil supply line and the oil drain line from the turbocharger (Figs. 6 and 7).

2. Cover the end of each oil inlet and outlet line and the air inlet and exhaust outlet openings on the engine to prevent the entrance of foreign material.

3. Loosen the two hose clamps securing the hose to the turbocharger and the air inlet tube and slide the hose up over the inlet tube (Fig. 8).

   NOTICE: The steel straps used with the hose clamps at both ends of the air inlet tube have been eliminated. Remove and discard the straps from all 12 V-149 and 16 V-149 turbocharged-intercooled high efficiency engines.

4. Remove the four bolts, nuts and washers securing the turbocharger to the exhaust manifold adaptor and remove the turbocharger and gasket.

Disassemble Turbocharger

Clean the exterior of the turbocharger with a non-caustic cleaning solvent before disassembly and proceed as follows:

NOTICE: Mark related positions of the compressor housing, center housing and turbine housing with a punch or scribe prior to disassembly to assure reassembly in the same relative position.

1. Refer to Figs. 9 and 10 and loosen the "V" band coupling (1) securing the compressor housing (2) to the backplate assembly (14) and remove the compressor housing and "V" band.

   NOTICE: Exercise care when removing the compressor housing and turbine housing to prevent damage to the compressor and turbine wheels.

2. With the T18A40 turbocharger bend down the ends of the lockplates (4) and remove the eight bolts (3) securing the four lockplates and turbine housing clamps (5) to the center housing (27) and turbine housing (6). With the TV7101 and TV8115 turbochargers loosen the "V" band coupling (28) securing the turbine housing (6) to the center housing (27). Remove the turbine housing from the center housing.

   NOTICE: Tap the housing with a soft hammer if force is needed for removal.

3. Position the turbine wheel (9) of the center housing assembly in a suitable holding fixture (Fig. 11). Remove the wheel nut (7) from the shaft. To prevent the possibility of bending the turbine wheel shaft, remove the compressor wheel nut from the shaft with a double universal socket and tee handle.

   NOTICE: If a holding fixture is not available, clamp a suitable socket or box end wrench in a vise and place the extended hub on the shaft in the socket or wrench. Hold the center housing upright and remove the wheel nut from the shaft.

4. Press the compressor wheel (8) from the wheel shaft assembly (9).

5. Withdraw the wheel shaft assembly (9) from the center housing. The wheel shroud (10), which is not retained, will fall free when the wheel shaft is removed.

6. With the TV7101 and TV8115 turbochargers remove and discard the turbine piston ring (11) from the wheel shaft.

7. Bend down the lock tabs and remove the four bolts (12) and lockplates (13) securing the backplate assembly (14) to the center housing (27) and remove the backplate assembly.

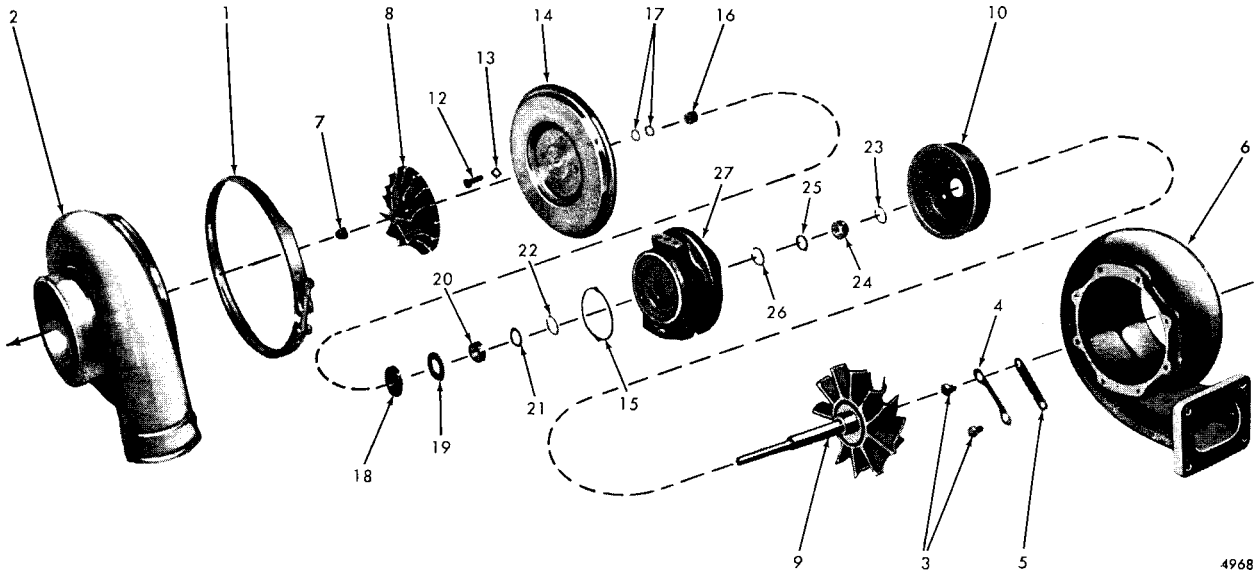
   NOTICE: Tap the backplate lightly to remove it from the center housing recess.

8. Remove and discard the seal ring (15) from the groove in the center housing.

9. Remove the thrust spacer (16) and piston ring(s) (17) from the backplate assembly. Discard the piston ring(s).

10. Remove the thrust collar (18), inboard thrust washer (19), bearing (20), bearing washer (21) and snap ring (22) from the center housing. Discard the thrust washer, bearing, washer and snap ring.

11. Remove the snap ring (23), bearing (24), bearing washers (25) and snap ring (26) from the opposite end of the center housing. Discard the snap rings, bearing and washers.



1.	Coupling—"V" Band	8.	Wheel—Compressor	15.	Ring—Seal	21.	Washer—Bearing
2.	Housing—Compressor	9.	Shaft—Turbine Wheel Assembly	16.	Spacer—Thrust	22.	Ring—Snap
3.	Bolt	10.	Shroud—Turbine Wheel	17.	Ring—Piston	23.	Ring—Snap
4.	Lockplate	12.	Bolt	18.	Collar—Thrust	24.	Bearing
5.	Clamp—T urbine Housing	13.	Lockplate	19.	Washer—Inboard Thrust	25.	Washer—Bearing
6.	Housing—T urbine	14.	Backplate Assembly	20.	Bearing	26.	Ring—Snap
7.	Nut—Self-Locking					27.	Housing—Center

Fig. 9 - T18A40 Turbocharger Details and Relative Location of Parts

Cleaning

Before cleaning, inspect the parts for signs of burning, rubbing or other damage which might not be evident after cleaning.

Soak all parts in a non-caustic cleaning solvent for about 25 minutes. After soaking, use a stiff bristle brush and remove all dirt particles. Dry all of the parts thoroughly.

CAUTION: Never use a caustic cleaning solution for cleaning as this will damage certain parts. Use the cleaning solution in an open or well ventilated area. Avoid breathing the fumes. Keep away from open flames. Do not use a wire brush or a steel blade scraper to clean the parts.

Make sure that both wheel blades are thoroughly clean. Deposits left on the blades will affect the balance of the rotating assembly.

Clean all of the internal cavities and oil passages in the center housing thoroughly with dry compressed air.

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

Clean the oil passage in the center housing thrust plate with dry compressed air.

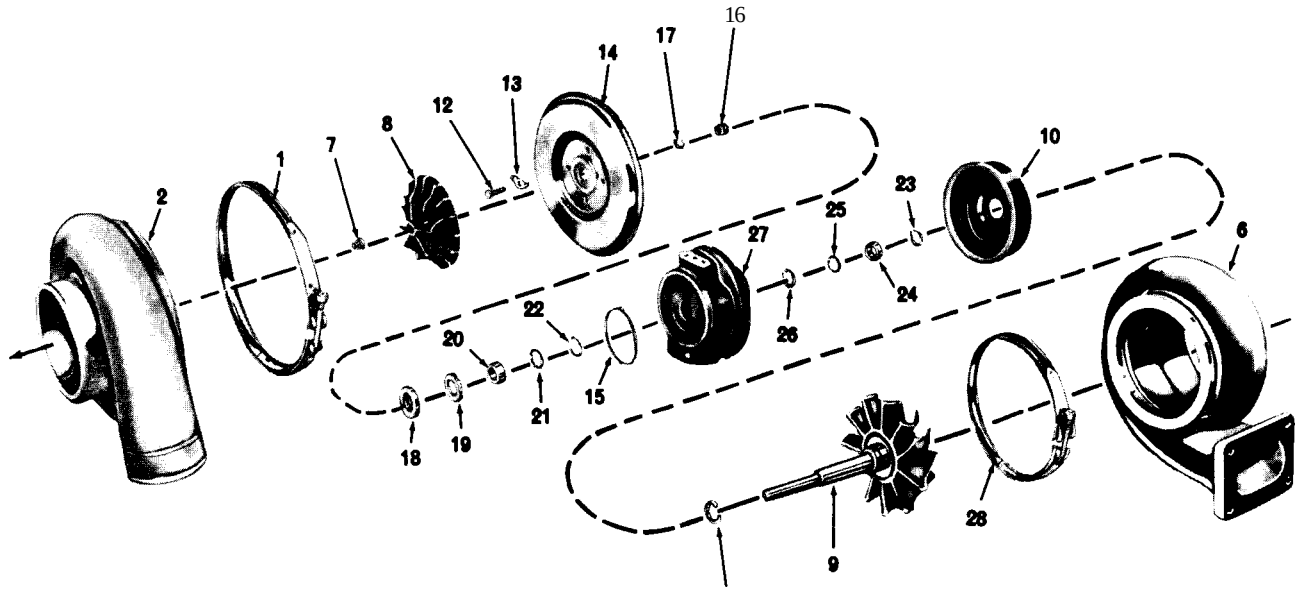
Remove the oil inlet and outlet lines from the engine and thoroughly clean the oil lines inside and out. An oil line that is dented or crimped enough to restrict the flow of oil must be replaced.

Inspection

Inspect all of the parts for signs of damage, corrosion or deterioration. Check for nicked, crossed or stripped threads.

Visually check the turbine wheel for signs of rubbing or wear. For shaft bearing journal dimensions and wear limits, refer to Section 3.0.

Inspect the shaft for signs of scoring, scratches or bearing seizure.



1.	Coupling—"V" Band	10.	Shroud—T urbine Wheel	16.	Spacer—Thrust	22.	Ring—Snap
2	Housing—Compressor	11.	Ring—Turbine Piston	17.	Ring—Piston	23.	Ring—Snap
6	Housing—T urbine	12.	Bolt	18.	Collar—Thrust	24.	Bearing
7	Nut—Self-Locking	13.	Lockplate	19.	W asher—Inboard Thrust	25.	W asher—Bearing
8	Wheel—Compressor	14.	Backplate Assembly	20.	Bearing	26.	Ring—Snap
9.	Shaft—Turbine Wheel Assembly	15.	Ring—Seal	21.	Washer—Bearing	27.	Housing—Center
						28.	Coupling—"V" Band

Fig. 10 - TV7101 and TV8115 Turbocharger Details and Relative Location of Parts

Check the compressor wheel for signs of rubbing or damage from foreign material. Check to see that the wheel bore is not galled. The wheel must be free of dirt and other foreign material.

Inspect the seal parts for signs of rubbing or scoring of the running faces.

Approximately November, 1976, the turbine wheel shaft assembly in the T18A40 turbocharger was revised in that the new turbine wheel has fillets between the blade roots to strengthen the blades (Fig. 12).

Inspect the backplate for wear or damaged bore (piston ring groove).

Inspect the housing for contact with the rotating parts. The oil and air passages must be clean and free of obstructions.

Minor surface damage may be burnished or polished. Use a Silicone Carbide abrasive cloth for aluminum parts or a crocus abrasive cloth for steel parts.

It is recommended that the piston ring(s), thrust washers, bearings, bearing washers and snap rings be replaced at time of disassembly.

Inspect the exhaust outlet elbow seal ring for signs of wear or breakage.

Assemble Turbocharger

Check each part prior to installation to ensure cleanliness. As the parts are assembled, cover the openings to prevent entry of dirt or other foreign material.

Refer to Figs. 9 and 10 for parts orientation and proceed as follows:

1. Lubricate the new bearings (20 and 24) with clean engine oil.

2. Install a new snap ring (26), bearing washer (25), bearing (24) and snap ring (23) in the turbine end of the center housing (27).

3. Install a new snap ring (22), bearing washer (21) and bearing (20) in the compressor end of the center housing.

NOTICE: Install the current inboard thrust bearing (three oil grooves) with the smooth side against the center housing.

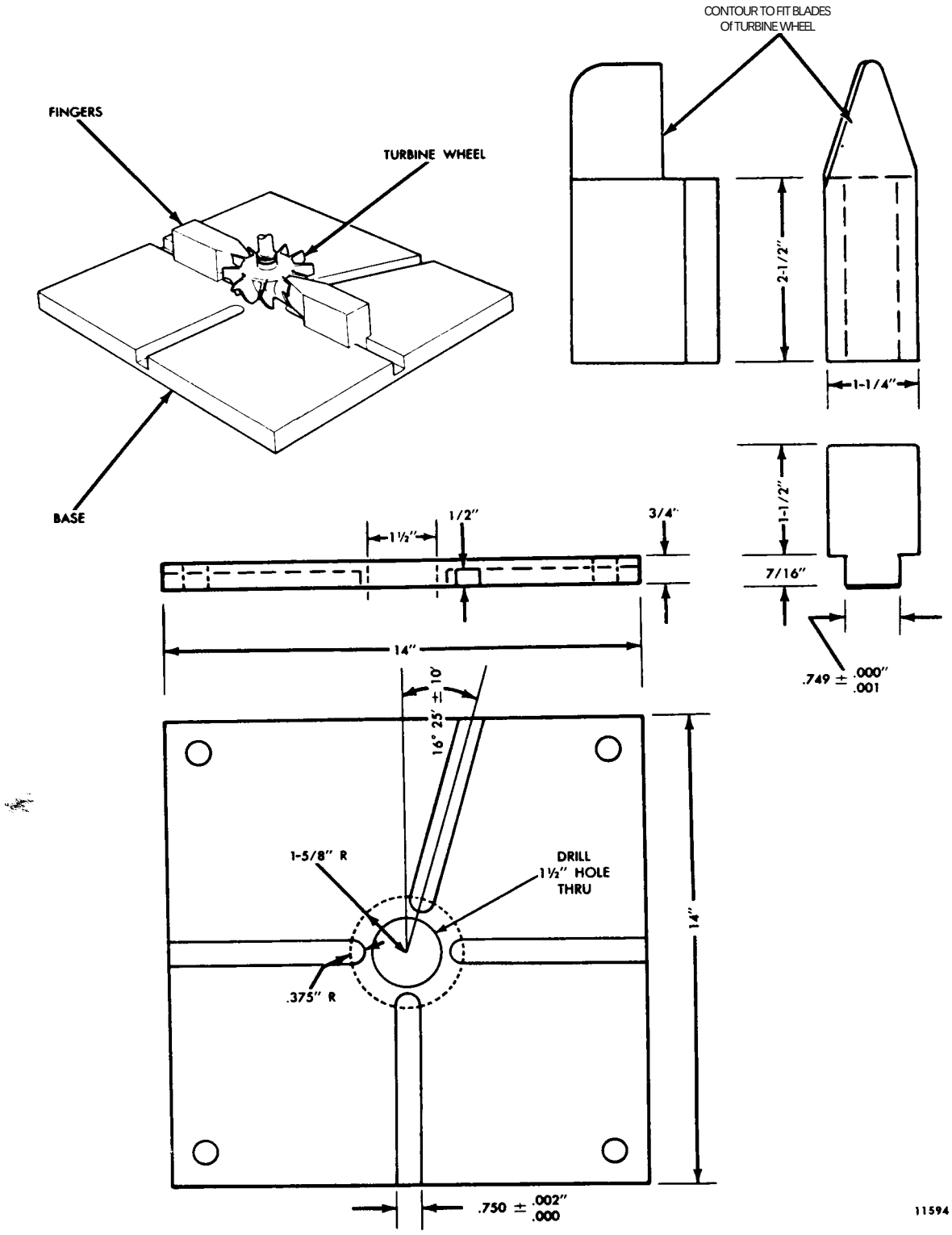


Fig. 1 1 - Turbocharger Holding Fixture

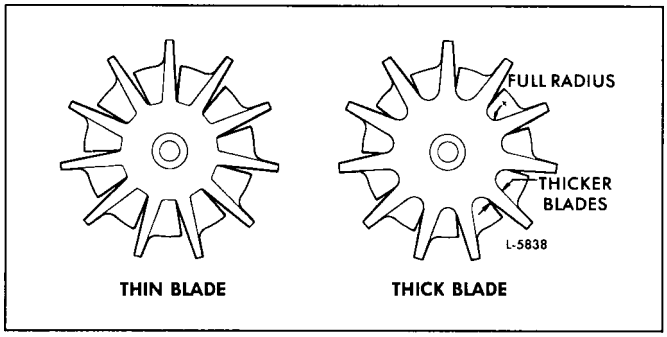


Fig. 12 - Comparison of Former and Current Turbine Wheels

4. Install a new piston ring(s) (17) on the thrust spacer (16) and gently insert the spacer into the backplate assembly (14). The current thrust spacer has two grooves. When replacing the former one groove spacer with the two groove spacer, be sure and include two piston rings. Do not force the piston rings into place.

   NOTICE: Make sure the *current* small diameter thrust spacer (.672"-.673") is used with the current thrust collar (Fig. 13). The former spacer was .677"-.678" in diameter.

5. Make sure the compressor bearing is in place, then position the new inboard thrust washer (19) flat against the center housing with the hole and cutout in the thrust washer in alignment with the pins in the center housing.

6. Install the thrust collar (18) snugly against the thrust washer. Lubricate the thrust collar and thrust washer with clean engine oil.

7. Install a new seal ring (15) in the groove at the compressor end of the center housing.

8. Align the oil feed holes in the center housing (27) and the backplate assembly (14) and attach the backplate to the center housing with four bolts (12) and new lockplates (13). Tighten the T18A40 bolts to 90-110 lb-in (10-12 N*m) torque or the TV7101 and TV8115 bolts to 80-100 lb-in (9-11 N*m) torque and bend the lockplate tangs up against the side of the bolt heads.

   NOTICE: If a new backplate with a warning plate is inadvertently installed, *the warning plate must be removed and the three drive screw holes plugged to prevent air leakage.*

9. On TV7101 and TV8115 turbochargers, install a new turbine piston ring (11) on the wheel shaft assembly.

   NOTICE: Before installing the piston ring, fill the piston ring groove with Dow Corning High Vacuum Silicone grease, or equivalent.

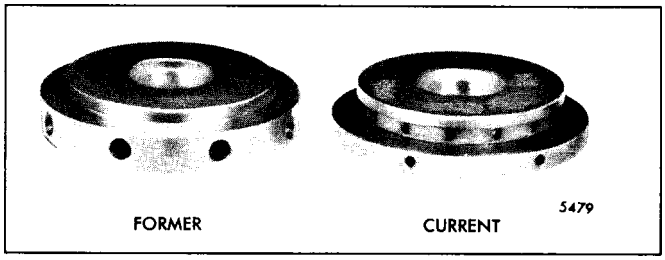


Fig. 1 3 - Former and Current Thrust Collar

10. Position the wheel shroud (10) against the center housing (27) and insert the wheel shaft assembly (9) through the wheel shroud and into the center housing.

    NOTICE: Be careful not to scuff or scratch the bearings when installing the shaft.

11. Place the turbine wheel shaft assembly, shroud, center housing and backplate upright in a suitable holding fixture (Fig. 11).

    NOTICE: If a holding fixture is not available, clamp a suitable socket or box wrench in a vise and place the extended hub on the shaft in the socket or wrench.

12. With the compressor wheel at room temperature, position it over the shaft.

13. Lightly lubricate the shaft threads and wheel face that will be under the nut with engine oil and install the retaining nut. Tighten the nut to 125-150 lb-in (14—17 N«m) torque to seat the compressor wheel against the thrust spacer.

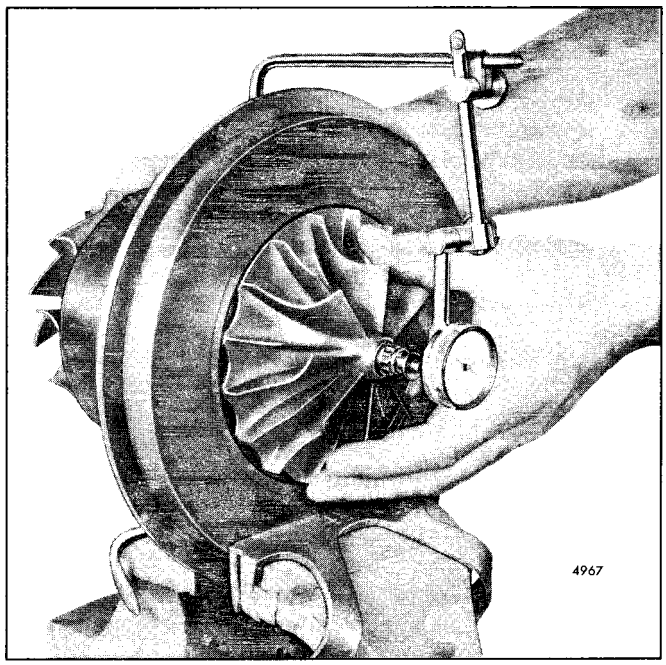


Fig. 14 – Checking Bearing Axial End Play

14. Loosen the nut and inspect the nut face and front face of the compressor wheel to be sure they are smooth and clean.

15. Retighten the nut to 35-55 lb-in (4-6 N*m) torque.

16. Continue to tighten the retaining nut until the shaft increases in length ,007"-.008" (T18A40) or ,009"-.010" (TV7101 and TV8115). Tighten the nut in such a manner as not to impose bending loads on the shaft.

NOTICE: If equipment is not available to measure the shaft stretch, tighten the wheel retaining nut to 35-55 lb-in (4-6 N«m) torque. Then, continue to tighten the nut through an angle of 100-110° turn for the T18A40 turbocharger or 120-130° turn for the TV7101 and TV8115 turbochargers (90° = 1/4 turn).

17. Check the bearing axial end play:

a. Clamp the center housing assembly in a bench vise equipped with soft jaws (Fig. 14).

b. Fasten the dial indicator and magnetic base (J 7872-2) to the center housing so that the indicator tip rests on the end of the rotating shaft on the compressor side (Fig. 14).

c. Move the shaft axially back and forth by hand. The total indicator reading (thrust float) should be between .004" and .009" (TT18A40) or .003" and .010" (TV7101 andTV8115). If the total dial indicator readings do not fall within the specified limits, repair or replace the rotating assembly.

18. Position the turbine housing (6), as marked at disassembly, against the center housing (27) and secure it in place.

a. Secure the T18A40 turbine with four clamps (5), four new lockplates (4) and eight bolts(3). Tighten the bolts to 100-130 lb-in (11-15 N*m) torque.

b. Secure the TV7101 and TV8115 turbine housing with the “V” band coupling (28). Position the V-band so the “T” bolt end does not interfere with the turbine housing (Fig. 10). Failure to properly orient the “T” bolt end of the clamp can result in an exhaust leak and/or turbine wheel damage. Tighten the toggle nut as follows:

1. Lubricate the toggle bolt threads with a high temperature anti-seize compound, such as Jet Lube (Mil Spec A-907D), or equivalent.

2. Tighten the nut on the “V” band toggle bolt to approximately 160 lb-in (18 N*m) torque.

NOTICE: Do not pull a misaligned turbine housing into alignment with the “V” band coupling. The parts must be aligned and seated first.

3. Loosen the “V” band coupling nut to approximately 50 lb-in (6 N*m) torque, then retorque the nut to 152-168 lb-in (17-19 N*m) torque.

19. Position the compressor housing (2), as marked at disassembly, against the backplate (14) and secure it in place with the “V” band coupling (1). Lightly lubricate the threads of the toggle bolt with engine oil and tighten the nut to 110-130 lb-in (12-15 N*m) torque.

20. Check the shaft radial movement:

a. Position the magnetic base J 7872-2 with the swivel adaptor J 7872-3 on the flat surface of the turbine housing inlet flange (Fig. 15).

b. Fasten the dial indicator extension rod J 7872-1 to the dial indicator J 8001-3 and attach the dial indicator to the swivel adaptor.

c. Insert the extension rod J 7872-1 into the oil drain tube mounting pad opening so that the rod is against the wheel shaft and is perpendicular to the shaft.

NOTICE: Make sure the extension rod does not make contact with the sides of the center housing, otherwise it will be impossible to obtain an accurate reading.

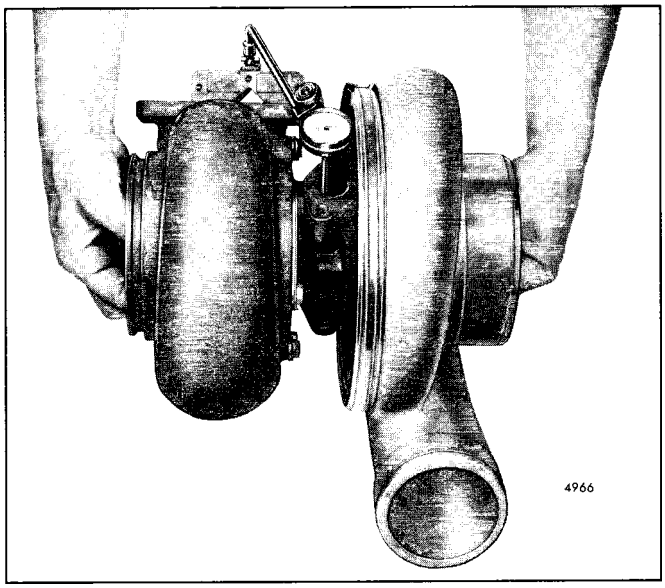


Fig. 1 5 - Checking Shaft Radial Movement

d. Grasp each end of the rotating assembly and, applying equal pressure at each end, move the rotating shaft first toward and then away from the dial indicator, creating a transverse movement in the shaft (Fig. 15). The dial indicator displacement should be between .003" and .007". If the displacement does not fall within these limits, disassemble and repair or replace the rotating assembly.

21. If it is to be stored, lubricate the unit internally and install protective covers on all openings.

22. Stamp the letter "R" in the lower left-hand corner of the name plate to identify that the turbocharger has been reworked.

Install Turbocharger

• To improve engine breathing and to keep oil from blowing out the breather tube, the turbocharger oil drain back flexible hoses have been relocated from the center inspection plate on the upper oil pan to the center of the block (Fig. 7).

• When replacing the former front or rear cylinder block with the current front or rear blocks, it is recommended that the turbocharger oil drain back flexible hoses be relocated using the current parts. Also, the oil drain back hole in the upper oil pan center inspection plate must be plugged.

• A 3.75” L x 3.25" diameter hose and thick band (.035") stainless steel T-bolt clamp are currently used between the trubochargers, air outlet tubes, and air inlet housings of Series 149 engines. The former 3.25" L x 3.50" diameter hose and T-bolt clamp (.025" thick band) should be replaced with the new at time of normal engine overhaul, or earlier if sealing or clamping concerns are experienced.

Before replacing a turbocharger that has experienced compressor or turbine wheel damage, always inspect the air induction and exhaust systems for damage and debris. Check air inlet ducting from the turbocharger compressor inlet pipe to the air cleaner assembly. Look for cracks or signs of air leakage and remove any dirt or debris. Check turbo discharge-to-blower piping for leaks of debris.

Check the exhaust system from the cylinder head exhaust ports to the exhaust outlet piping on the turbine side of the turbocharger and the inside of the exhaust manifold(s). Remove any debris left over from the damaged turbocharger. Repair or replace any other damage or defective components in the air induction or exhaust systems.

NOTICE: Failure to remove contaminants or debris from these systems can result in damage to the replacement turbocharger. On engines equipped with mechanical emergency shutdowns, check for proper operation of *each* flapper valve.

1. Install the seal ring on the exhaust outlet elbow.

2. Position the turbocharger on the exhaust manifold adaptor and into the exhaust outlet elbow. Use a new mounting gasket and secure the turbocharger in place with four bolts, washers and nuts (Figs. 6 and 7).

NOTICE: When attaching the exhaust manifold adaptor to the turbine housing, be sure the inner diameter of the adaptor is the same as the turbine housing inner diameter. The turbine opening in the T18A40 turbocharger is 3.850", the TV7101 turbocharger is 3.480" and the TV8115 turbocharger is 3.892".

3. Slide the hose over the end of the turbocharger air outlet opening with the “T” bolt positioned away from the parting line of the tube (Fig. 8).

Tighten the two hose clamps so a .017" feeler gage will pass freely between the coils. Do not collapse the clamp spring completely. A collapsed spring may cause clamp breakage.

4. Install the oil drain line between the opening in the bottom side of the center housing and the cylinder block (Figs. 6 and 7).

5. Attach the oil inlet line at the cylinder block.

6. After installing a rebuilt or new turbocharger, it is very important that all moving parts of the turbocharger center housing be lubricated as follows:

a. Clean the area and disconnect the oil inlet (supply) line at the bearing (center) housing (Fig. 3).

b. Fill the bearing housing cavity with clean engine oil. Turn the rotating assembly by hand to coat all of the internal surfaces with oil.

c. Add additional clean engine oil to completely fill the bearing housing cavity and reinstall the oil line. Clean off any spilled oil.

d. Start and run the engine at idle until oil pressure and supply has reached all of the turbocharger moving parts. A good indicator that all of the moving parts are getting lubrication is when the oil pressure gage registers pressure (10 psig or 69 kPa at idle speed).

CAUTION: Do not hold the compressor wheel, for any reason, while the engine is running. This could result in personal injury.

The free floating bearings in the turbocharger center housing require positive lubrication. This is provided by the above procedure *before the turbocharger reaches its maximum operating speed* which is produced by high engine speed. Starting any turbocharged engine and accelerating to any speed above idle before engine oil supply and pressure has reached the free floating bearings can cause severe damage to the shaft and bearings of the turbocharger.

7. Check all connections, ducts and gaskets for leaks.
8. Operate the engine at rated output and listen for sounds of metallic contact from the turbocharger. If any such noise is apparent, stop the engine immediately and correct the cause.

NOTICE: After the turbocharger has been operating long enough to permit the unit and the oil to warm up, the rotating assembly should coast freely to a stop after the engine is stopped. If the rotating assembly jerks to a sudden stop, the cause should be immediately determined and eliminated.

TURBOCHARGER INTERCOOLER

On 12V-149 and 16V-149 engines, two intercoolers (Fig. 1) are mounted on the top of the engine between the air discharge end of the turbochargers and the air inlet side of the blowers. One intercooler is used on 8V engines.

Cooling of the air is accomplished by circulating engine coolant from the engine water inlet tube through the cells of each intercooler core and out to the water manifolds. The compressed air enters the intercooler via individual air inlet housings mounted on the top of each intercooler and circulates past the cooler cores.

• The coolant circulated through the intercoolers on a turbocharged-intercooler engine is protected by a water strainer. Current engines use a bracket-mounted basket-type strainer assembly (Fig. 3) located on top of the engine. One strainer is used on 8V engines, while two are used on 12V and 16V engines. This basket-type strainer filters the coolant going into the intercooler(s). It is in the system to prevent plugging of the water side of the intercooler core, which would result in excessive cylinder temperatures. Former engines used a 20 mesh cone-shaped screen located at the water connection in the water pump-to-engine oil cooler tube (“S tube”).

Remove Intercooler(s)

1. Drain the engine cooling system (Section 5) and each intercooler at the draincock provided at the outlet connector.

2. Disconnect each turbocharger air inlet tube at the air shutdown housing.

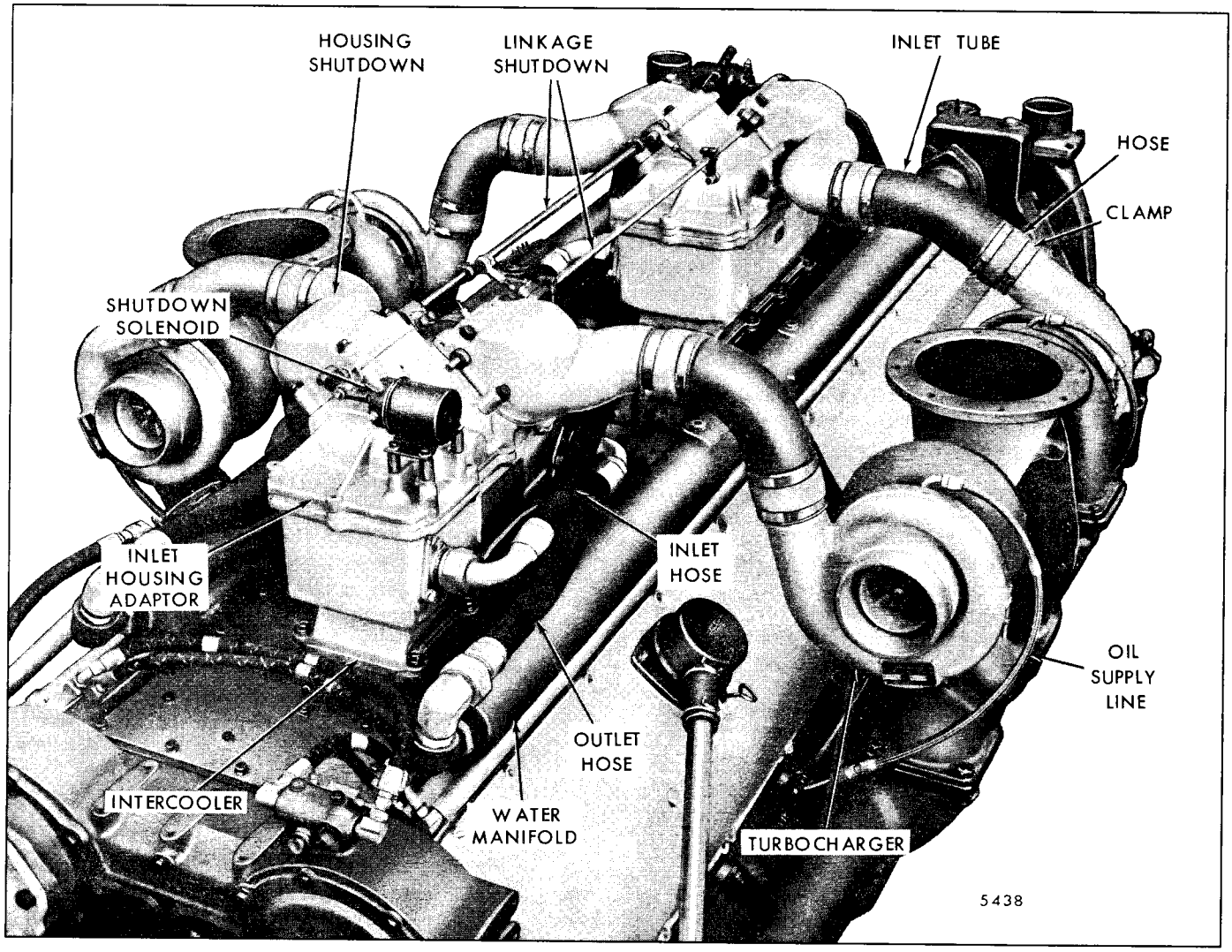


Fig. 1 - Typical Intercooler Mounting

NOTICE: The steel straps used with the hose clamps at both ends of the air inlet tube have been eliminated. Remove and discard the straps from all 12V-149 and 16V-149 turbocharged-intercooled high efficiency engines.

3. Disconnect the water hoses at the inlet and outlet connectors from each intercooler.

4. Disconnect each shutdown solenoid from the shutdown linkage.

5. Disconnect and remove the shutdown linkage from the shutdown housing (Section 3.3).

6. Remove the air shutdown housing and the air inlet housing adaptor (Section 3.3).

7. Remove six 7/16"—14 x 1 3/4" bolts, lock washers and washers from each intercooler on 12V-149 engines or eight bolts, lock washers and washers on 8V-149 and 16V-149 engines. Then, remove the intercoolers and seal rings. Discard the seal rings.

Disassemble Intercooler

1. Remove the two bolts and lock washers and withdraw the drain adaptor with the draincock from the drain hole below the intercooler outlet connector (Fig. 2).

2. Remove three bolts and lock washers from each connector and withdraw the inlet and outlet connectors straight out from the intercooler. Remove and discard the gaskets.

3. Remove the drain, inlet and outlet tubes and seal rings from the water openings in the intercooler. Remove and discard the two seal rings on each tube.

4. Remove the four cross head screws from the intercooler adaptor plate, then remove the plate and discard the seal ring.

5. Remove the top one-piece aramid fiber pad and two smaller pads.

6. Lift the intercooler core straight up and out of the housing. Do not use sharp or prying tools.

7. Remove the four upright aramid fiber pads.

Inspection

Clean all of the parts thoroughly and dry them with compressed air.

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

Clean the intercooler core by immersing it in a scale solvent consisting of 1/2 pound of oxalic acid to each 2-1/2 gallons of a solution composed of 1/3 muriatic acid and 2/3 water. The cleaning action is evident by the bubbling and foaming. Carefully observe the process and remove the intercooler core from the solution when the bubbling stops (this generally takes from 30 to 60 seconds). Then thoroughly flush the intercooler core with clean hot water under pressure.

CAUTION: To avoid possible personal injury, wear adequate eye protection and avoid breathing the fumes or direct contact of the acid with your skin.

• The strainer should be removed and inspected for damage or clogging when the cooling system is cleaned. If badly clogged or damaged, replace the strainer. *Do not operate an intercooled engine without the strainer in place.*

Solid contaminants in the engine coolant which is allowed to bypass a missing or damaged water filter screen, can not be effectively removed from the core. Contaminated cores must be replaced.

Pressure Check Intercooler Core

1. Make a suitable adaptor to which an air hose can be attached and fasten it to the inlet pipe of the cooler core. Use a suitable piece of hose, a plug and clamp to seal the outlet pipe.

2. Attach an air hose and supply approximately 30 psi (207 kPa) air pressure. Then, submerge the cooler core in a tank of water. Any leaks will be indicated by air bubbles in the water.

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

3. After the pressure test is completed, remove the air hose, clamp, plug, hose and adaptor and dry the cooler core with compressed air. Replace the cooler core if leaks were indicated.

Assemble Intercooler

1. Fix the four upright and two horizontal (bottom) aramid fiber pads in place in the intercooler housing using Silastic 732 RTV, or equivalent. Air dry for twenty-four (24) hours to cure the Silastic or heat in an oven at 250-300°F (121-149°C) for four hours.

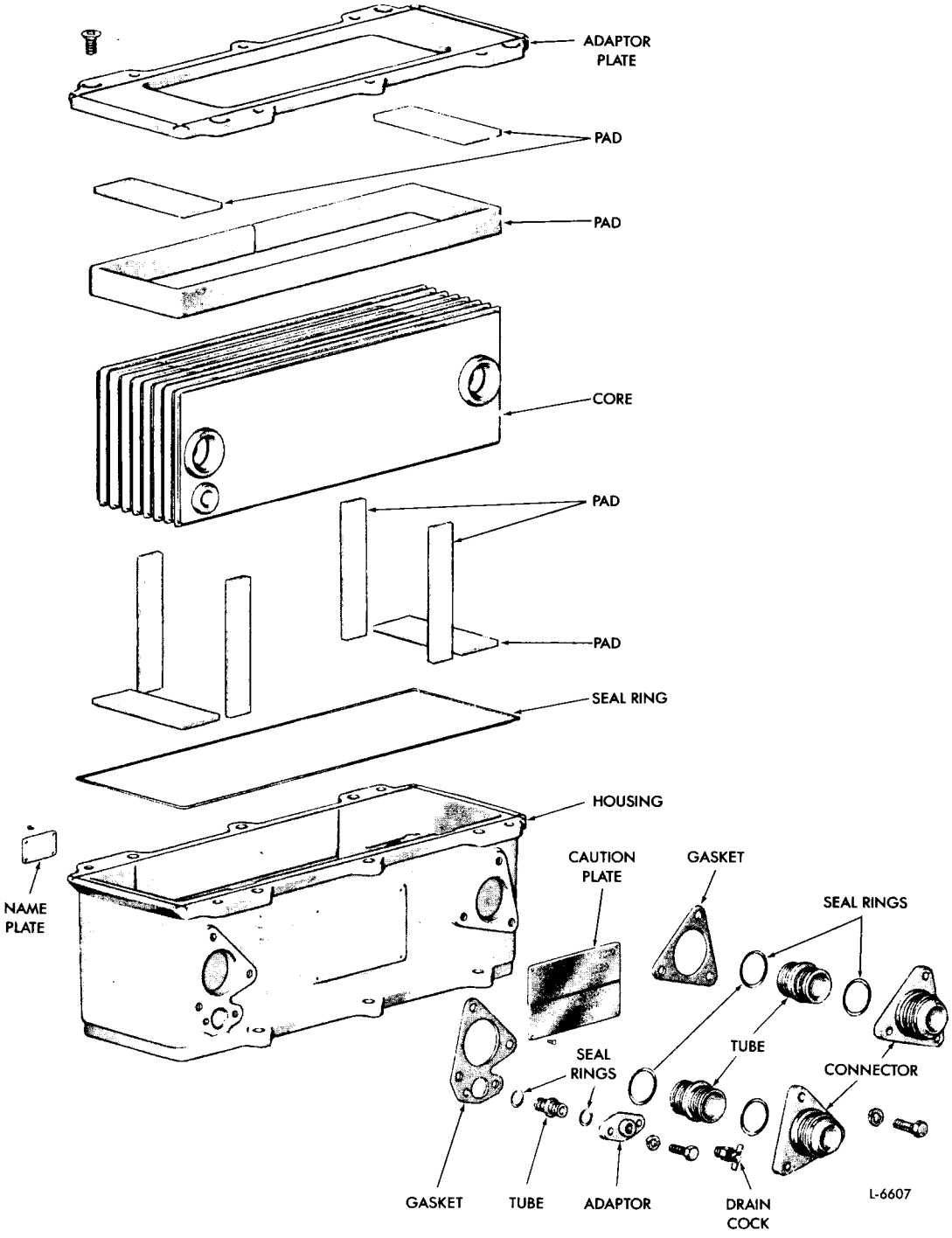
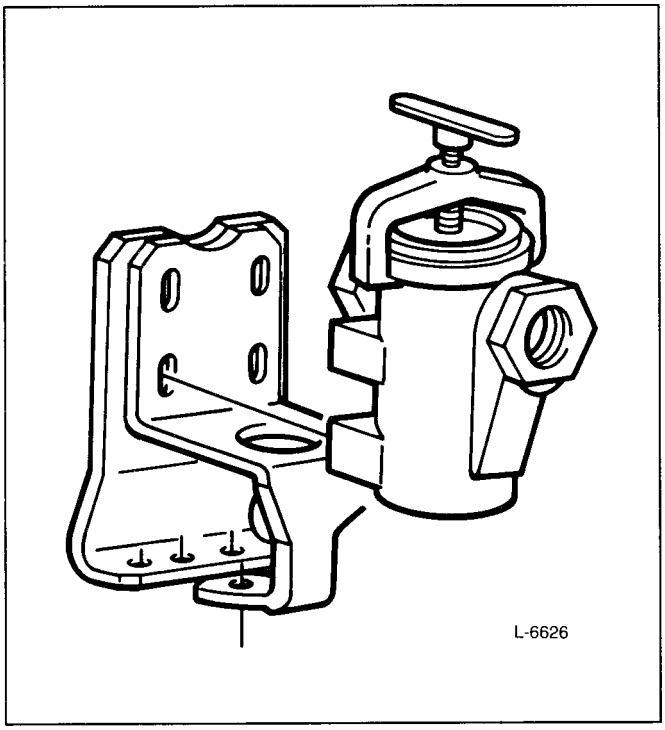


Fig. 2 - Intercooler Details and Relative Location of Parts



• Fig. 3 Water Strainer Assembly

2. Place the intercooler core straight down into the housing. Some spray lubricant may be required on the vertical side pads to allow the core to slide into place. Check the clearance of the core to the case wall. End clearance and side clearance (nipple side) is minimum .150 to maximum .230".

3. Fix the one-piece aramid fiber pad around the top side of the housing. It should butt together at the center of the housing and must not overlap. Bond the pads on the top of the core.

4. Lubricate a *new* seal ring and the groove in the adaptor plate with lubricone and install the seal ring in the plate. Place the adaptor plate on the intercooler housing and thread the four 3/8”—16 x .75" screws into the housing. Tighten the screws to 250-300 **lb-in** (28-34 N*m) torque.

5. Spray the core collars with GM silicone spray or equivalent.

6. Lubricate new seal rings and the two grooves on each water tube with GM silicone spray or an equivalent spray. Then, place the seal rings on the tubes.

7. Position the tubes in the water openings in the side of the housing, and insert the tubes with a *downward twisting motion.* This helps prevent seal distortion and rollout.

8. Use new gaskets and install the water inlet and outlet connectors on the housing with three each 3/8"-16 x 1" bolts and lock washers. Tighten the bolts to 240 **lb-in** (27 N*m) torque.

   NOTICE: The gasket with the drain hole is used at the outlet opening.

9. Install the drain adaptor and drain cock with two 5/16"—18 x .88" bolts and lock washers. Tighten the bolts to 120 **lb-in** (14 N*m) torque.

Test For Leaks

1. With the drain cock closed, install a cap on one nipple and connect a regulated air cource with a shutoff valve to the other nipple. Install a 50 psi (345 kPa) gage between the shutoff valve and the nipple.

2. Pressurize the assembled core to 30 psi (207 kPa) and close the shutoff valve.

3. Observe the pressure after five minutes. A pressure loss of more than 0.5 psi (3.5 kPa) indicates leaking “O” ring seals. Replace leaking “O” ring seals.

Install The Intercooler

1. Lubricate *new* seal rings and the groove in the bottom of the intercooler housings with lubricone and install a seal ring in each housing.

2. Install the intercooler on the blower cover plate with six 7/16"—14 x 1 3/4" bolts (12V-149 engines) or eight 7/16"-14 x 1 3/4" bolts (8V-149 and 16V-149 engines), lock washers and washers. Tighten the bolts to 46-50 lb—ft (62-68 N*m) torque.

3. Install the air inlet adaptors and air shutdown housing assemblies (Section 3.3).

4. Install the shutdown solenoids and shutdown linkage (Section 3.3).

5. Connect the water hoses at the inlet and outlet connectors for each intercooler.

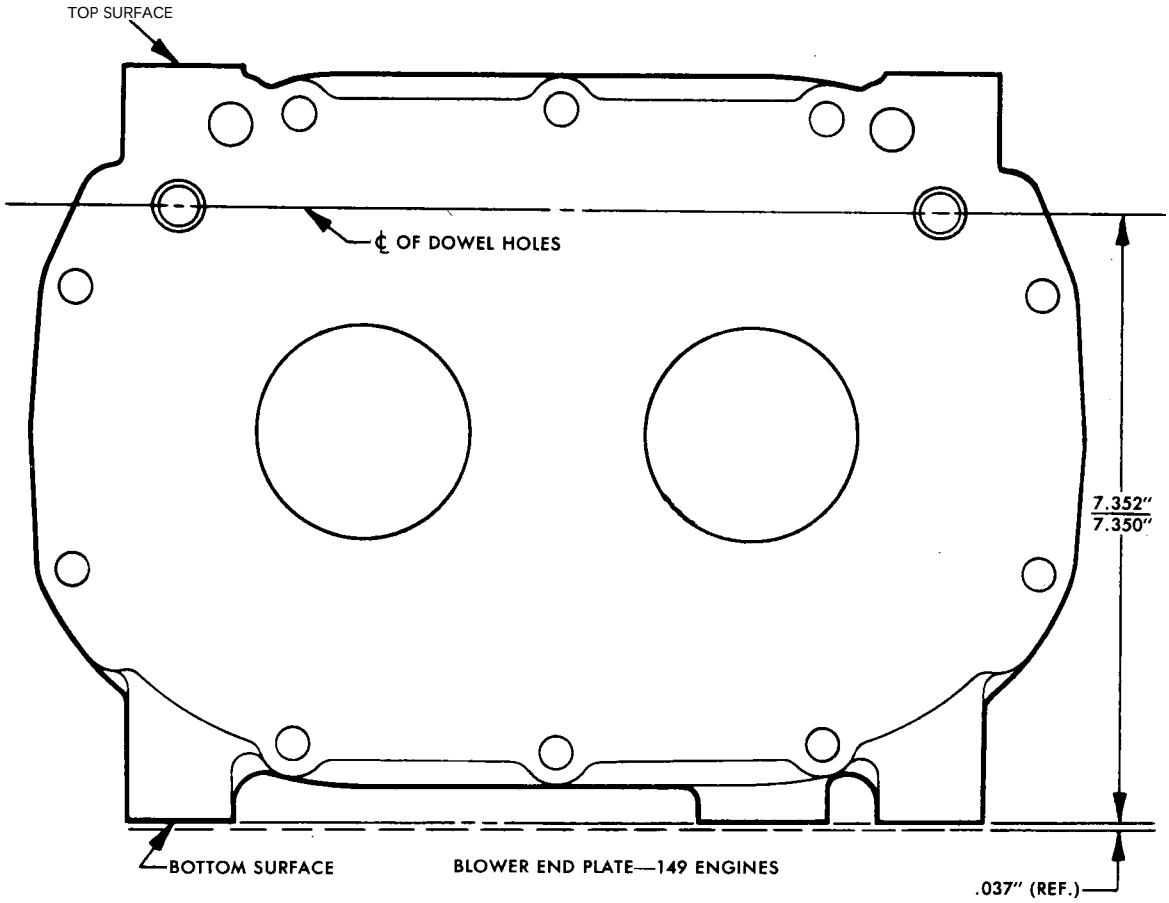
6. Connect each turbocharger air inlet tube at the air shutdown housing.

7. Fill the intercooler and engine cooling system with coolant (Section 5).

SHOP NOTES - TROUBLESHOOTING SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

REWORKING BLOWER END PLATE



o Oo

SHIM

Fig. 1 - Blower End Plate

The bottom surface of each blower end plate must be smooth and flat. To reuse a blower that has end plates that show signs of fretting corrosion and cannot be cleaned up with emery cloth, a service blowor shim is provided. The shim is .048"-.042" thick with a controlled thickness of .037" after the blower (end plate) has been installed in the cylinder block.

When it becomes necessary to rework a blower end plate, mill off material from the bottom of the end plate to achieve the 7.352"-7.350" height (Fig. 1). Then, for future identification stamp “RW” on the top left side of the case portion of the reworked blower end plate. Do not remove more or less material than the referenced .037".

The new shim will position the reworked blower to the required height necessary to achieve alignment of both blowers in the cylinder block. Position the shim such that all holes are open to allow oil flow to the blower and oil drainage is not affected. Do not mix a salvaged end plate and a new end plate on the same blower. The service shim must be used in pairs (one under each end plate).

DRILLING PROCEDURE FOR AIR SHUTDOWN REPLACEMENT SHAFT

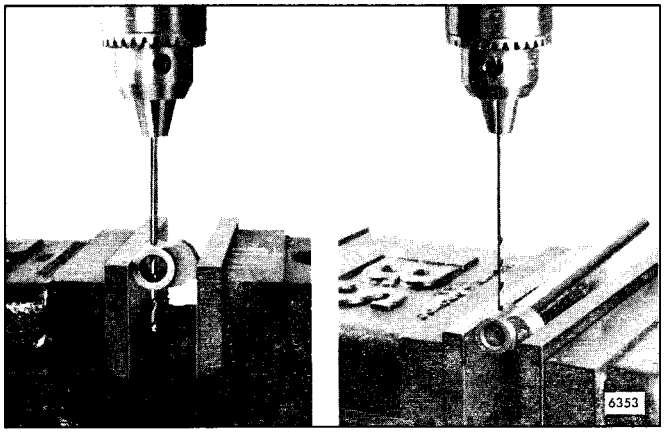


Fig. 2 - Aligning Drill Bit and Drilling Shaft

Whenever a replacement air shutdown valve shaft is installed on a Series 149 engine, the shaft must be match-drilled to the cam and the flapper valve in order to ensure positive air shutdown operation. Failure to properly index the shaft can result in improper flapper valve operation and engine run-on at shutdown. Use the following procedure to drill the air shutdown valve shaft:

1. Install a 1/8" drill bit in the chuck of a drill press, then locate and align the bit through the existing hole in the shutdown cam (Fig. 2). Lock the cam in the holding fixture on the drill press, and withdraw the bit.
2. Insert the replacement shaft into the cam until the end of the shaft is recessed 1/8" from the end of the cam. Start the drill and bore a hole through the shaft (Fig. 2). Withdraw the drill bit, install the pin handle through the hole and remove the shaft from the drill press.
3. Insert the shaft into the shutdown housing bore and install the spacer on the end of the shaft. Place a .015" feeler gage between the housing and spacer and mark the shaft with a center punch inserted into the existing hole in the spacer (Fig. 3).
4. Remove the shaft from the housing. Locate and align the 1/8" drill bit through the hole in the spacer and lock the spacer in the holding fixture on the drill press. Withdraw the drill bit.

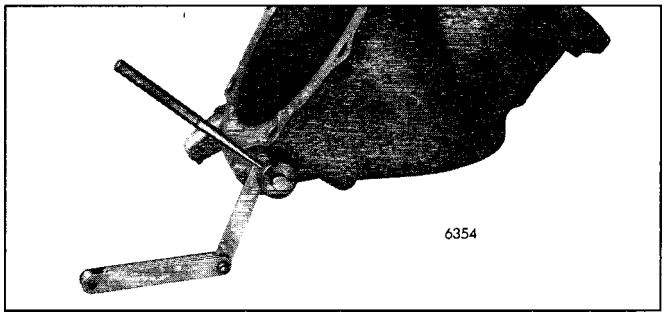


Fig. 3 - Center Punch Shaft thru Spacer Hole

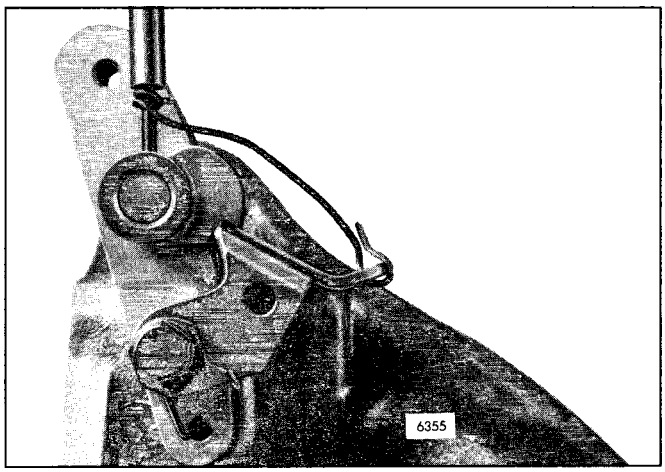


Fig. 4 - Cam and Latch Wired to Prevent Movement

5. Insert the shaft through the spacer, locate the center punched mark and drill a hole through the shaft. Remove the shaft and spacer from the drill press.
6. Assemble the shaft, seal rings spring, flapper valve and spacer in the housing (see Section 3.3). If using a new valve, center punch for holes in approximately the same position as on the old valve. If reusing the old valve, center punch for holes just inside the existing holes.
7. Align the notch on the cam with the latch and hold in this position with a piece of stiff wire (Fig. 4).
8. Place the housing on the drill press. With the valve held in the wide open *run* position, align the 1/8" drill bit with the marks center punched on the valve in Step 6. Then, drill through the valve and shaft (Fig. 5). Install the retaining pins to hold the valve to the shaft.
9. Clean the air shutdown assembly thoroughly and check for proper operation before installing it on the engine.

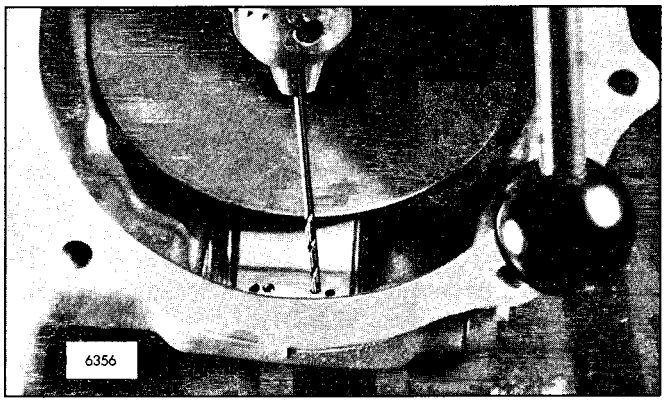


Fig. 5 - Drilling Valve-to-Shaft Holes

INSTALL BYPASS BLOWER VALVE LEVER STOP PLATE

• Effective with unit serial number 8E2524, a lever stop plate (Fig. 6) was installed on the blower cover plate below the bypass valve lever of all 8V-149 engines. Use of this plate was discontinued when the flapper style bypass valve was replaced by the piston style valve (unit serial number 8E2594).

To accommodate the additional stop plate thickness, two (2) 7/8" bolts formerly used to hold the cover plate to the block were replaced by two (2) 1-1/4" bolts with anaerobic (RTV) sealant applied to the threads.

To eliminate the possibility of inefficient engine operation and smoking caused by a stuck-open bypass valve, Detroit Diesel recommends installing the bypass blower valve lever stop plate on 8V engines built prior to serial number 8E-2524 (Fig. 7). This is a very simple operation and can be done whenever practical. If the bypass blower valve lever stop plate is not readily available, an acceptable substitute can be manufactured from any 3/8" thick low carbon steel (Fig. 8).

NOTICE: When installing the blower cover plate and lever stop plate, RTV sealant must be used on the bolt threads to ensure the proper air seal between the blower cover plate and engine air box. Failure to coat the bolt threads before installation can result in air leakage around the bolts, lowered airbox pressure and inefficient engine operation.

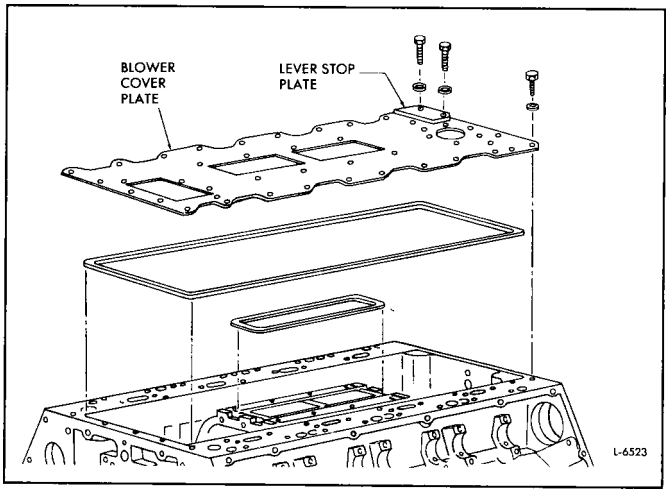


Fig. 6 - Bypass Blower Valve Lever Stop Plate Location

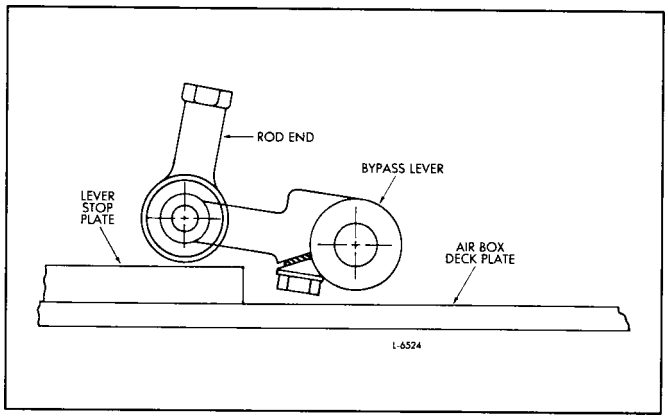


Fig. 7 - Bypass Blower Valve Lever/Lever Stop Plate Schematic

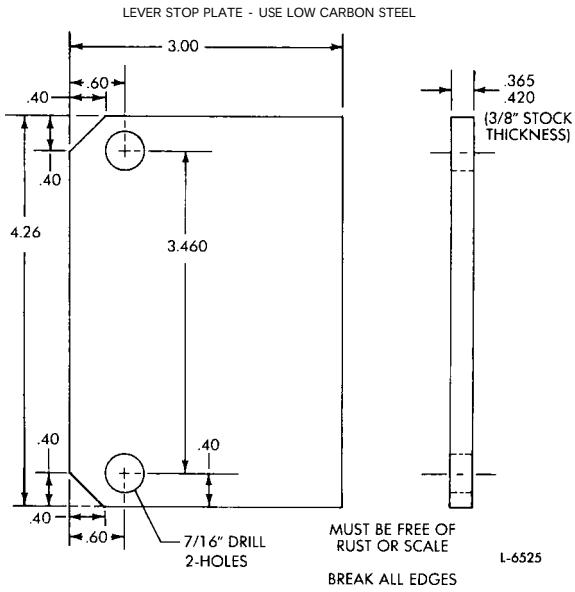


Fig. 8 - Lever Stop Plate Dimensions

TROUBLESHOOTING
BLOWER BYPASS VALVE

Beginning early in 1984, a bypass valve-equipped air induction system has been used on all turbocharged and turbocharged-intercooled engines. Ths system increases fuel efficiency by reducing the amount of engine power required to operate the blowers.

The bypass valve is located in an adaptor on the top deck of the engine. Each air inlet housing has its own individual bypass valve and mechanism. At engine start-up and during light-load operation the valve is closed. As load and engine speed increase, turbocharger boost pressure also increases, raising the pressure in the line from the air inlet housing to the air cylinder which activates the bypass valve mechanism. At 7 psi (48 kPa) the charge of air overcomes the force of the spring within the cylinder, causing the valve to open. The valve is fully open at 10 psi (69 kPa). Opening the valve allows air pressure on the inlet and outlet sides of the blower to equalize, eliminating most of the pumping load of the blower.

A bypass valve stuck in the *open* position will cause the engine to black smoke heavily during acceleration. If stuck in the *closed* position, the benefits of improved fuel ecomony may not be fully realized.

Refer to Section 15.1, Item 49, for the bypass valve preventive maintenance procedure.

TURBOCHARGER

CONDITION	PROBABLE CAUSE	SUGGESTED REMEDY
NOISY OPERATION OR VIBRATION	**WHEEL SHAFT BEARINGS ARE NOT BEING LUBRICATED**	Locate cause of loss of oil pressure and repair. Remove, dis-assemble and inspect turbocharger for bearing damage.
	IMPROPER CLEARANCE BETWEEN TURBINE WHEEL AND HOUSING	Remove, disassemble, and inspect turbocharger.
	LEAK IN ENGINE AIR INTAKE OR EXHAUST MANIFOLD	Tighten all loose connections or replace exhaust manifo'd gaskets as necessary.
ENGINE WILL NOT DELIVER RATED POWER	**CLOGGED AIR INTAKE SYSTEM**	Check air cleaner and clean air intake ducts.
	FOREIGN MATERIAL LODGED IN COMPRESSOR OR TURBINE WHEELS	Remove, disassemble and clean turbocharger.
	EXCESSIVE DIRT BUILD-UP IN COMPRESSOR	Thoroughly clean compressor assembly. Clean air cleaner arid check for leaks.
	LEAK IN ENGINE AIR INTAKE OR EXHAUST MANIFOLD	Tighten all loose connections or replace exhaust manifold gaskets as necessary.
	ROTATING ASSEMBLY BEARING SEIZURE	Remove and overhaul turbocharger.

SPECIFICATIONS

Specifications, clearances and wear limits are listed satisfactory performance. It should be emphasized that the below. It should be specifically noted that the clearances figures given as “Limits” must be qualified by the judgement apply only when all new parts are used at the point where the of personnel responsible for installing new parts. These wear various specifications apply. This also applies to references limits are, in general, listed only for the parts more frequently within the text of the manual. The column entitled “Limits” replaced in engine overhaul work. For additional in this chart lists the amount of wear or increase in clearance information, refer to the text,
which can be tolerated in used engine parts and still ensure

TABLE OF SPECIFICATIONS, NEW CLEARANCES AND WEAR LIMITS

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
BLOWER			
Backlash—timing gears	.0005”	.0025"	.0040"
Clearances:			
Rotor to end plate (gear end)	.0070"	.0130"	
Rotor to end plate (front end - 12V)	.0130"	.0230"	
Rotor to end plate (front end - 16V2)	.0210"	.0310"	
Rotor to housing (inlet side)	.0210"		
Rotor to housing (outlet side)	.0070"		
Trailing edge of right-hand helix rotor to leading edge of left-hand helix rotor	.0140"		
Leading edge of right-hand helix rotor to leading edge of left-hand helix rotor	.0240"		
TURBOCHARGER			
End play — rotating shaft (T18A40 and TV8115)	.0040"	.0090"	
End play — rotating shaft (TV71 and TV81)	.0030"	.0100"	
Radial movement — rotating shaft	.0030"	.0070"	
Turbine wheel shaft journal bearing:			
Inside diameter	.6268"	.6272"	
Outside diameter	.9780"	.9785"	
Journal diameter — turbine wheel shaft	.6247”	.6250”	
Bearing bore — center housing (inside diameter)	.9830"	.9835"	
Backplate Seal Bore:			
Inside diameter	.6875"	.6885"	.6895"
Thrust Collar:			
Thickness	.2990"	.3000"	.2970"
Bore - Inside Diameter	.3754"	.3758"	.3778"
Thrust Spacer:			
Outside diameter	.6715"	.6725"	.6705"
Ring groove width	.0685”	.0695"	.0715"
Thrust Washer, Inboard:			
Thickness	.0900"	.0920"	
Compressor Wheel Bore:			
Inside diameter	.3736"	.3739"	.3749"

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb—ft)	Nam	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	Nam
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

BOLT IDENTIFICATION CHART

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD	(lb-ft)	(N*m)
Fuel pump coupling disc bolt	3/8-24	50-55	68-75
* Blower hold-down bolt	7/16-14	50-55	68-75
* Blower hold-down bolt	9/16-12	78-85	102-115
# Blower timing gear and bearing retaining nuts	1 5/16-18	200-250	271-339

* Threads and under head of bolt to be lubricated with engine oil.
#Threads lubricated with International Compound No. 2, or equivalent (refer to Parts Catalog or Microfiche, Section 12.8000A).

SERVICE TOOLS

TOOL NAME	TOOL NO.
BLOWER	
Blower-to-block drilling and tapping fixture	J 23459
Blower service tool set	J 22706-02
Feeler gage (blower timing)	J 1698-02
. BLOWER BYPASS VALVE	
Blower bypass valve assembly/disassembly tool	J 37466
TURBOCHARGER	
Dial indicator set (magnetic base)	J 7872
Turbocharger inlet shield	J 26554-A

SECTION 4

LUBRICATION SYSTEM

CONTENTS

LUBRICATION SYSTEM

Fig. 1 schematically illustrates the flow of oil through a typical Series 149 engine lubrication system including the various components such as the oil pump, oil filter, oil cooler, pressure regulator and bypass valve.

The gear type oil pump is mounted on the main bearing caps and is gear driven from the rear end of the crankshaft. The oil pump accommodates a tandem installation of a scavenging pump section whereas oil is picked up from the front of the engine and dumped in the rear near the oil pump intake.

Oil is drawn by suction from the oil pan through the intake screen and pipes to the oil pump where it is pressurized. The oil then passes from the pump into a short gallery in the cylinder block to the oil filter adaptor and into the oil filter. At the same time, oil from the pump is directed to a spring-loaded pressure relief valve mounted on the oil pump. This valve discharges excess oil when the pump pressure exceeds 100 psi (689 kPa) with the former valve, 130 psi +10 psi (896 + 69 kPa) with the current valve. The former valve should be replaced with the current valve at time of engine overhaul.

From the oil filter, the oil passes back to the cylinder block where a short longitudinally drilled passage carries the oil to the oil cooler. The oil is then directed from the oil cooler to a vertically-drilled passage in the cylinder block to the main oil gallery.

Stabilized lubricating oil pressure is maintained within the engine at all speeds, regardless of the oil temperature, by two pressure regulator valves located at the ends of the vertical oil galleries connected to the main oil gallery. When the oil pressure at the valve exceeds 70 psi (483 kPa) (current and high output engines) or 50 psi (345 kPa) (former engines), the regulator valve opens, discharging the excess oil back into the sump.

From the main oil gallery, the pressurized oil flows through a drilled passage to each main bearing and through a drilled passage in the crankshaft to adjacent connecting rod bearings. By use of grooves in the unloaded halves of the rod bearings, the oil is directed to the rifle drilled passages in the rod to the piston pin and through the piston pin and carrier, spraying the underside of the piston dome. The drain oil from the piston dome is “sloshed” back and forth between the piston skirt and the carrier wall, with a portion of the oil draining through two holes drilled near the bottom of the carrier back to the crankcase.

Lubrication is supplied under pressure from the main oil gallery through drilled passages in the cylinder block to each camshaft bearing. Oil is then picked up by diagonal holes in the camshaft and directed through the rifle drilled longitudinal passage of the camshaft to lubricate the couplings and drive shafts at the rear ends of each camshaft.

The valve and injector operating mechanism is lubricated from the camshaft bearing caps where the lubricating oil is picked up from the grooves in the camshaft bearings. The lubricating oil enters the rocker arm shaft through drilled passages in the bearing caps. From there the oil follows the drilled shaft to each rocker arm where it enters a drilled passage leading to the valve adjusting screw. Lubricating oil is then directed through another drilled passage in the valve adjusting screw, where it lubricates the frictional surfaces between the base of the adjusting screw and the valve button.

The contact surface between the camshaft lobes and the rocker arm rollers is lubricated by jets machined in the bearing caps which spray oil on the rollers.

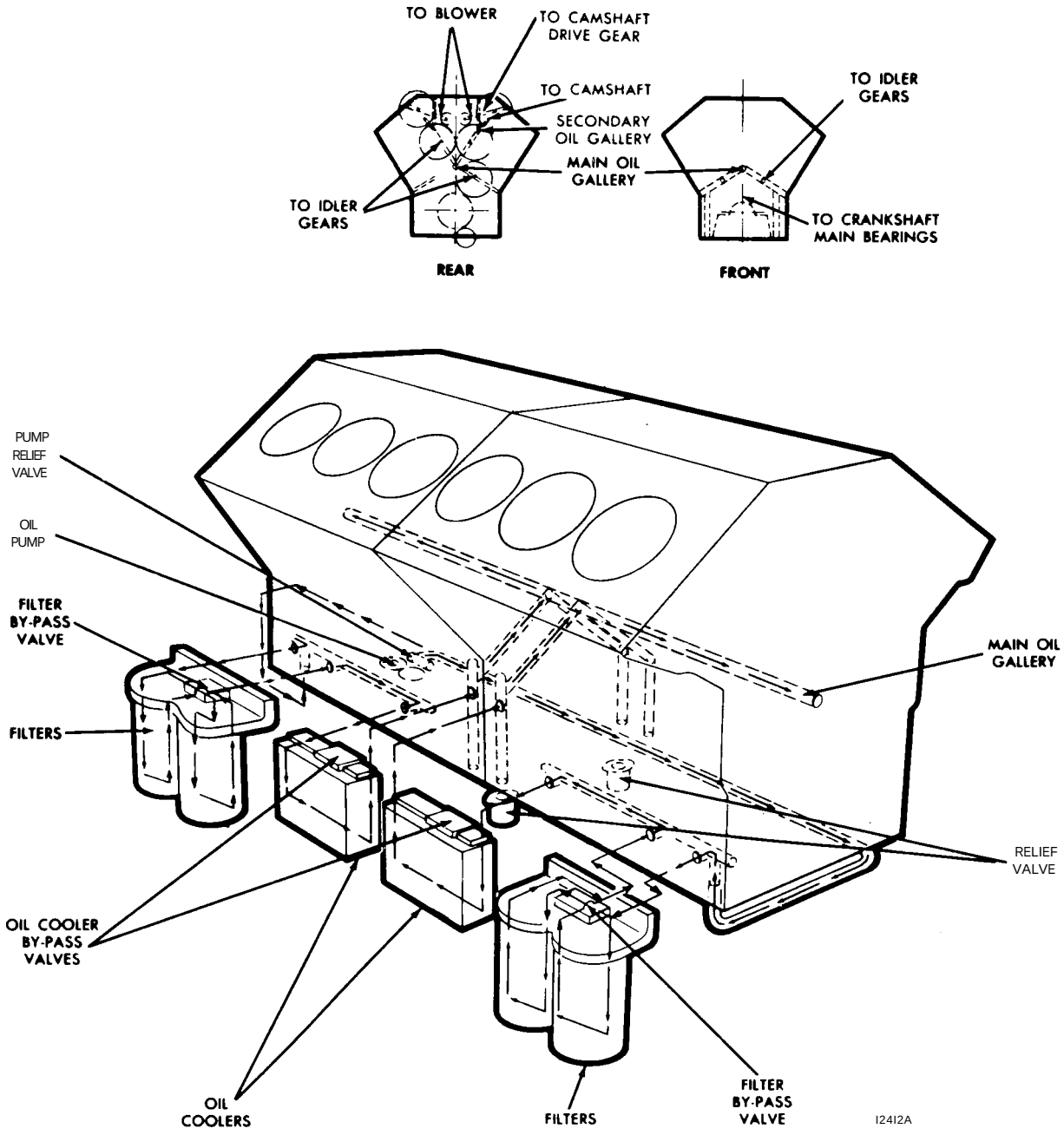


Fig. 1 - Typical 149 Lubrication System

Excess oil from the rocker arms lubricates the exhaust valve stems.

The gear train is lubricated by oil from the longitudinally drilled passages in the camshaft hubs, idler gear center retaining bolts and by oil splash from the oil pan. A certain amount of oil also spills into the gear train compartment from the blower drive bearing and the idler gear bearings. The idler gear bearings are lubricated by oil directly from the cylinder block oil gallery.

The camshaft gears and the idler gears (front and rear gear train) are pressure lubricated by oil from the cylinder block oil gallery. Oil enters a longitudinal drilled passage in the hub center retaining bolt on both the front and rear gear train idler gears. A hole is drilled in the side of the center bolt allowing oil to flow through a transverse drilled passage in the idler hubs where it is circulated around the roller bearings in the rear gear train and the bushings in the front gear train.

Lubrication System Maintenance

Use the proper viscosity grade and type of *heavy duty* oil as outlined in the *Lubrication Specifications* in Section 13.3. Change the oil and replace the oil filter elements at the periods recommended to ensure trouble-free lubrication and longer engine life (refer to *Pressurize Fuel System - Check for Leaks* in Section 2.0).

The oil level should never be allowed to drop below the *low* mark on the dipstick. Overfilling the crankcase may contribute to abnormal oil consumption, high oil temperatures, and also result in oil leaking past the crankshaft rear oil seal.

To obtain the true oil level, the engine should be stopped and sufficient time (approximately twenty minutes) allowed for the oil to drain back from the various parts of the engine. If more oil is required, add only enough to bring it to the proper level on the dipstick.

Cleaning Lubrication System

Thorough flushing of the lubrication system is required at times. Should the engine lubrication system become contaminated by ethylene glycol antifreeze solution or other soluble material, refer to Section 5 for the recommended cleaning procedures.

Detection Of Lube Oil Leaks

Detroit Diesel Corporation uses red dye to detect lube oil system leaks during engine test. Customers receiving new engines may notice some residual dye remaining in their lube oil systems. This dye should be quickly dispersed after the first few hours of engine operation.

LUBRICATING OIL PUMP

The gear-type lubricating oil pump is mounted on the rear two main bearing caps and is driven by the crankshaft gear (Fig. 1).

Oil is drawn by suction from the oil pan through the oil pump inlet screen and elbow into the oil pump where it is pressurized and directed to the oil filters, oil coolers and the main oil gallery in the cylinder block.

The scavenging pump, mounted in tandem with the pressure pump, is used in conjunction with a deep oil pan which has a shallow reservoir at one end. Oil which flows to the shallow end of the oil pan, during inclined operation of the engine, is transferred to the deep end, or sump, by the scavenging pump and is then picked up by the pressure pump for distribution throughout the engine.

Remove Oil Pump

Refer to Figs. 1 and 2.

1. Remove the oil drain plug from the lower oil pan and drain the oil from the engine.
2. Remove the lower oil pan, gasket and as many upper oil pan inspection hole covers, as necessary, to allow removal of the oil pump and piping (refer to Section 4.7).

8V-149 Engines

Follow steps 3 thru 5 when removing oil pump from 8 V engine.

3. Remove the six bolts and lock washers which secure the oil pump outlet adaptor (Fig. 2) to the oil pump and the cylinder block. Remove the adaptor and pressure relief valve as an assembly. Discard the gasket and seal ring.
4. Remove the four bolts and lock washers which attach the oil pump inlet elbow to the pump. Remove the elbow and screen assembly and discard the gasket.
5. Remove the two bolts and two stud nuts which secure the oil pump to the main bearing caps. Remove the oil pump. Shims are used between the oil pump mounting flange and the rear main bearing cap. Save the shims for reinstallation of the oil pump.

12V and 16V Engines

Follow steps 3 thru 10 when removing oil pump from 12V or 16V engine.

3. Remove the scavenging pump inlet pipe supports.
4. Remove the four bolts and lock washers which secure the scavenging pump inlet pipe to the oil pump. Then, remove the pipe and screen assembly. Discard the seal ring and gasket.
5. Remove the support brackets and clips which secure the oil pump outlet pipe to the main bearing caps.
6. Remove the four bolts and lock washers which secure the oil pump outlet pipe to the cylinder block and the oil pump outlet adaptor. Remove the pipe and discard the gasket and seal ring.
7. Remove the six bolts and lock washers which secure the oil pump outlet adaptor (Fig. 4) to the oil pump and the cylinder block. Remove the adaptor and pressure relief valve as an assembly. Discard the gasket and seal ring.

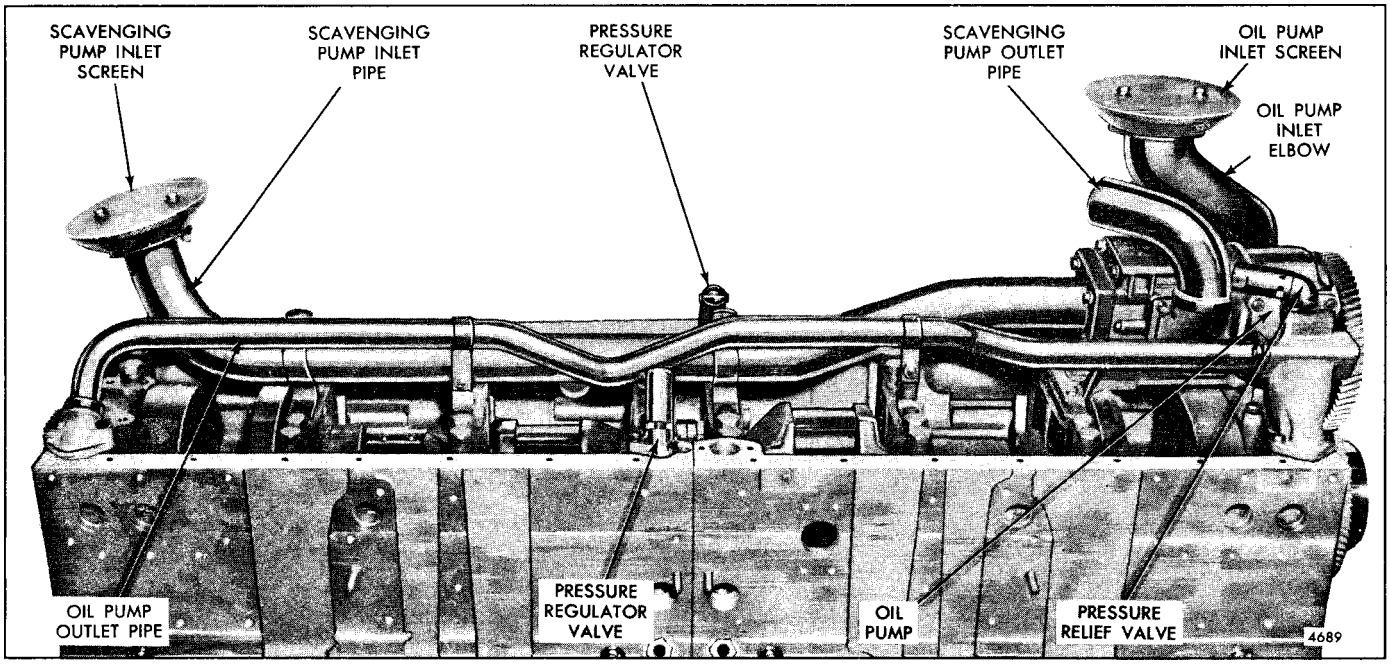


Fig. 1 - Typical Oil Pump Mounting (Rear Sump)

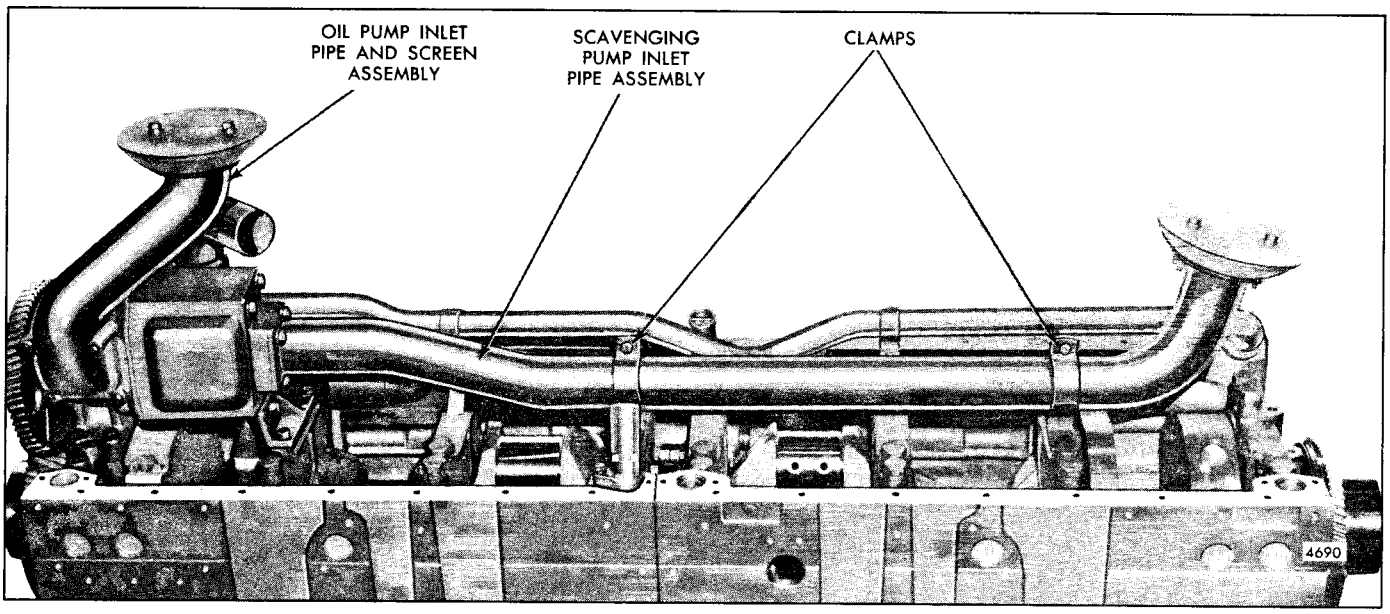


Fig. 2 - Typical Oil Pump Inlet Piping (Rear Sump)

8. Remove the four bolts and lock washers which secure the scavenging pump outlet pipe to the pump. Remove the pipe and discard the gasket.

9. Remove the four bolts and lock washers which attach the oil pump inlet elbow to the pump. Remove the elbow and screen assembly and discard the gasket.

10. Remove the four bolts and two stud nuts (six bolts on former engines) which secure the oil pump to the main bearing caps. Remove the oil pump. Shims are used between the oil pump mounting flange and the rear main bearing cap. Save the shims for reinstallation of the oil pump.

Disassemble Oil Pump (8V Engines)

Refer to Fig. 3.

1. Remove the bolts which secure the cover to the oil pump body.
2. Withdraw the oil pump drive and driven gears and remove the key from the drive shaft.
3. Remove the oil pump drive gear with a gear puller. Then, remove the key from the drive shaft.

   NOTICE: Place a washer between the end of the drive shaft and the puller screw to prevent damage to the drive shaft.
4. Remove the pin from the pump body and driven shaft and withdraw the shaft.

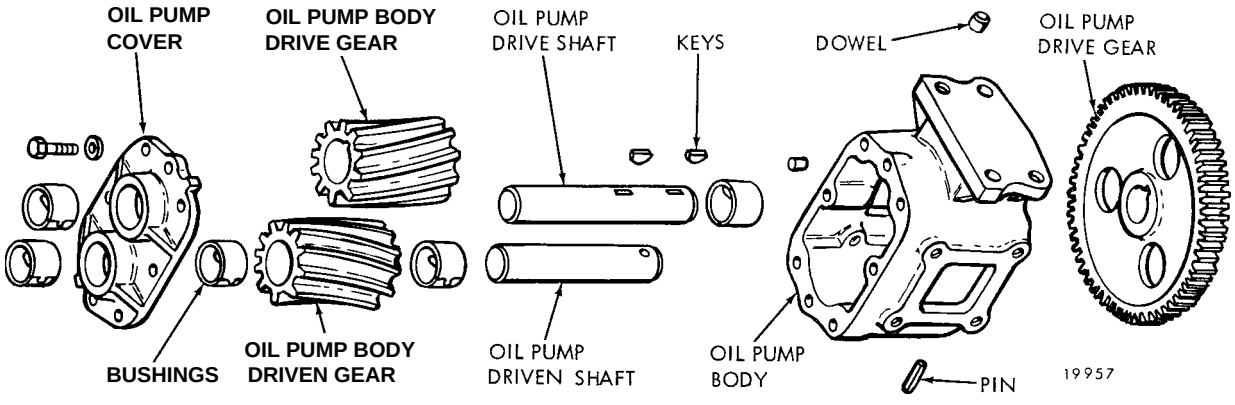


Fig. 3 - Oil Pump Details and Relative Location of Parts (8V Engines)

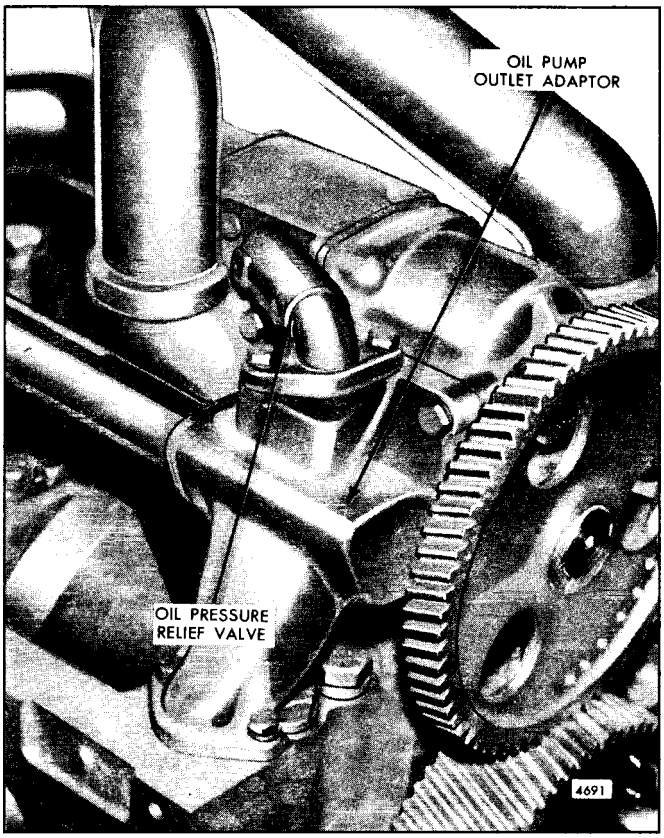


Fig. 4 - Oil Pump Outlet Adaptor (12V and 16V Engines)

Disassemble Oil Pump (12V and 16V Engines)

Refer to Fig. 5.

1. Remove the four bolts, washers and lock washers which secure the front pump support to the scavenging pump body, then remove the support.
2. Loosen and remove the four bolts which secure the scavenging pump section to the oil pump and withdraw the scavenging pump body.
3. Withdraw the scavenging pump drive and driven gears and remove the keys from the drive shaft.
4. Remove the spacer.
5. Remove the external pump drive gear with a gear puller. Then, remove the key from the drive shaft.

   NOTICE: Place a washer or nut between the end of the drive shaft and the puller screw to prevent damage to the drive shaft.

6. Withdraw the drive shaft and drive gear.
7. On current oil pumps, withdraw the driven gear. Then, remove the pin from the pump body and driven shaft and withdraw the shaft.

   On former pumps, the driven gear is keyed to the shaft and the shaft is not pinned to the pump body.

8. If necessary, press the drive gear from the shaft, then remove the key from the shaft. On former pumps, press the gear from the driven shaft and remove the key.

Inspection

Wash all of the parts with clean fuel oil and dry them with compressed air.

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

Inspect the pump and related parts (8V engines). Inspect the pump inlet and outlet pipes and related parts (12V and 16V engines). Replace any damaged parts.

Examine the oil pump body for indications of excessive wear or scoring in the gear cavities (8V engines). Examine the oil pump and scavenging pump bodies for indications of excessive wear or scoring in the gear cavities (12V and 16V engines). Check the bushings for excessive wear. The shaft-to-bushing clearance with new parts is .0015" to .0032". The inside diameter of a new bushing is 1.5015" to 1.5027" and the diameter of a new drive or driven (former 12V and 16V engines) shaft is 1.4995" to 1.5000".

Check the pump spacer and the pump shafts for excessive wear or scoring. Also, check the keyways in the shafts for damage.

Inspect the pump gears for scoring or excessive wear. The helix gears should have a free-running fit, without looseness, within the pump body. Excessively worn helix gears can result in low oil pressure which could cause serious damage to the engine.

Inspect the bushings in the driven gears, used in current pump assemblies, for excessive wear or scoring. The shaft-to-gear bushing clearance with new parts is .0015" to .0032". The inside diameter of a new bushing is 1.5025" to 1.5037" and the diameter of a new (pinned), driven shaft is 1.5005" to 1.5010".

Replace excessively worn or damaged parts.

Service (8V Engines)

Refer to Fig. 7.

1. Clean the pump components with fuel oil and dry them with compressed air.

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

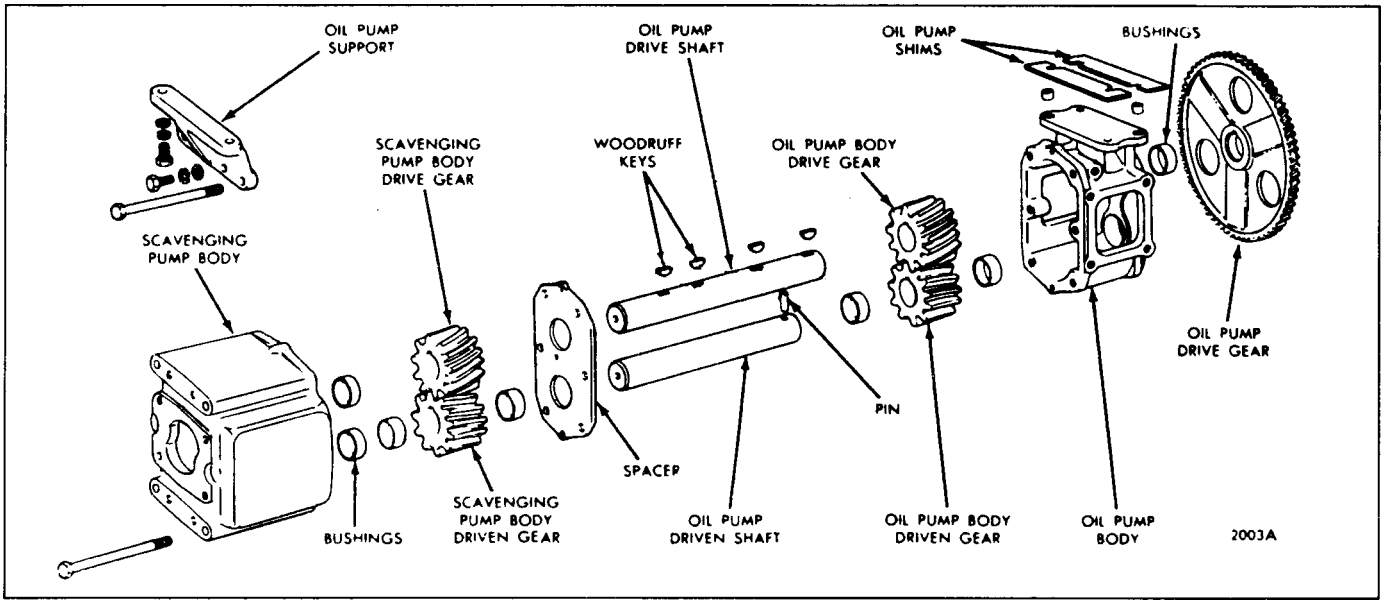


Fig. 5 - Oil Pump Details and Relative Location of Parts (12V and 16V Engines)

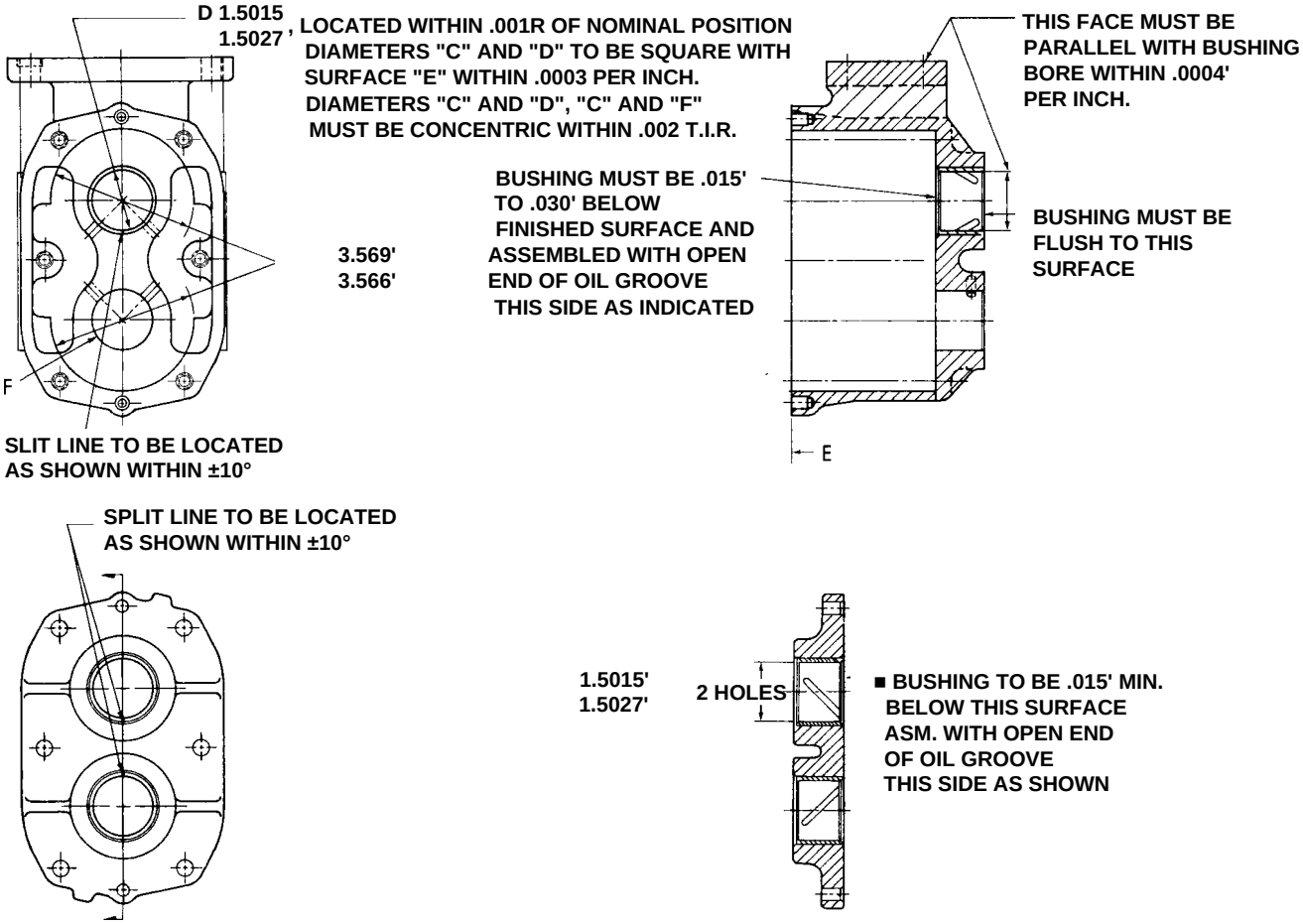


Fig. 6 - Location and Position of Oil Pump Bushing (8V Engines)

Clean the new bushings and mating parts with a suitable degreaser or chlorinated solvent.

CAUTION: The chlorinated solvent must be used in a properly ventilated area with all safety precautions.

2. After the parts are completely dry, apply a continuous fdm of Loctite 75 retaining compound completely around the bushing bore (just inside the entry lip of the bore) in the pump body. It is not desirable to coat the entire width of the bore.
3. Press the bushing in place and remove the excess compound with a clean, dry cloth. *Do not use solvent.*

Loctite 75 develops fixturing strength in approximately fifteen minutes; full cure takes approximately four hours.

After installing, each bushing must withstand a load of 4,000 pounds without moving.

When installing new bushings in the driven helix gear, press each bushing in .030" below the face of the gear and with the open end of the oil groove facing toward the center of the gear.

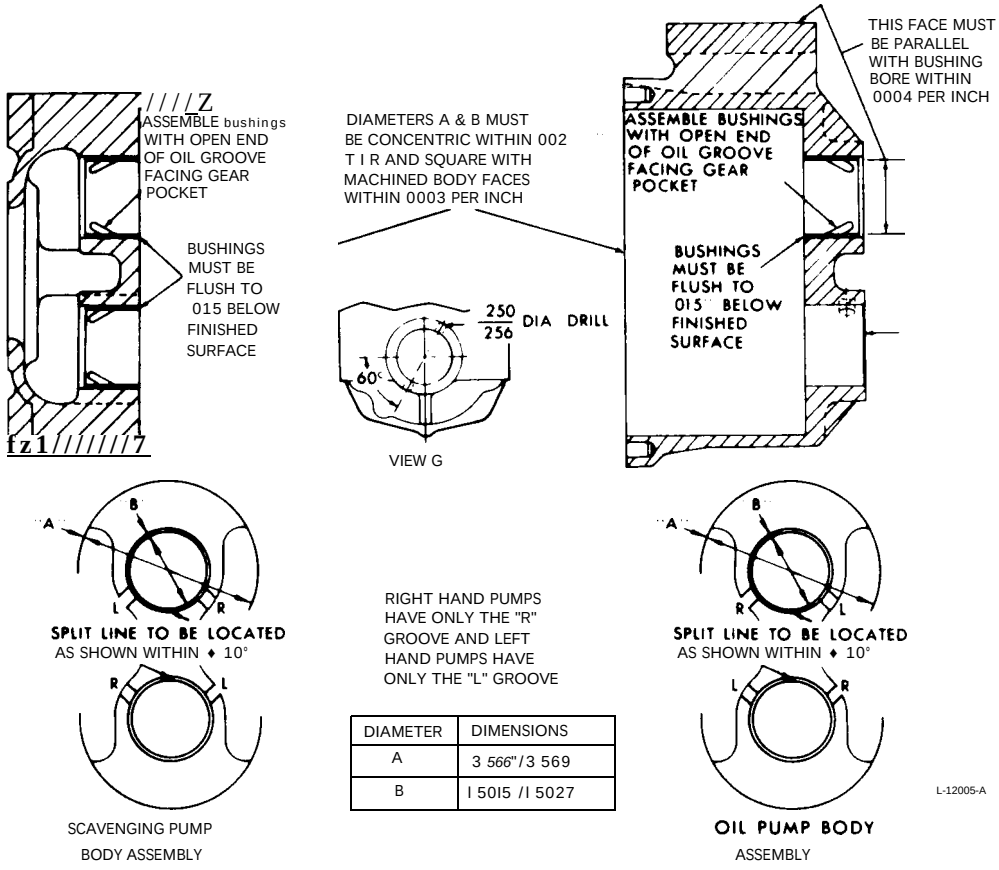
If the bushing in the oil pump body is worn excessively, replace the pump body unless suitable boring equipment is available for finishing the new bushing.

When installing new bushings, replace all of the bushings in both the pump body and the pump cover. The bushings must be located and positioned as shown in Fig. 6. Ream the bushings to 1.5015" to 1.5027.

Service (12V and 16V Engines)

Effective with engines 12E-762 and 16E-037 (approximate serial numbers), new oil pump assemblies replaced the old. The pump bodies in the new pumps have thicker walls and increased bearing bores (1.6865" to 1.6880") to accomodate bushings with a larger outside diameter (.100/. 104" thick wall) to give greater holding capability. The bearing bores in the former pump bodies were 1.6245" to 1.6260". The old pump assemblies and their components are not serviced. Worn components must be replaced by a current pump assembly.

The oil pump assemblies were further revised by adding bushings to both of the *driven* helix gears and pinning the drive gear end of the driven shaft so that the gears rotate



DIAMETER	DIMENSIONS
A	3 566"/3 569
B	I 5015 /I 5027

Fig. 7 - Location and Position of Oil Pump Bushings (1 2V and 1 6V Engines)

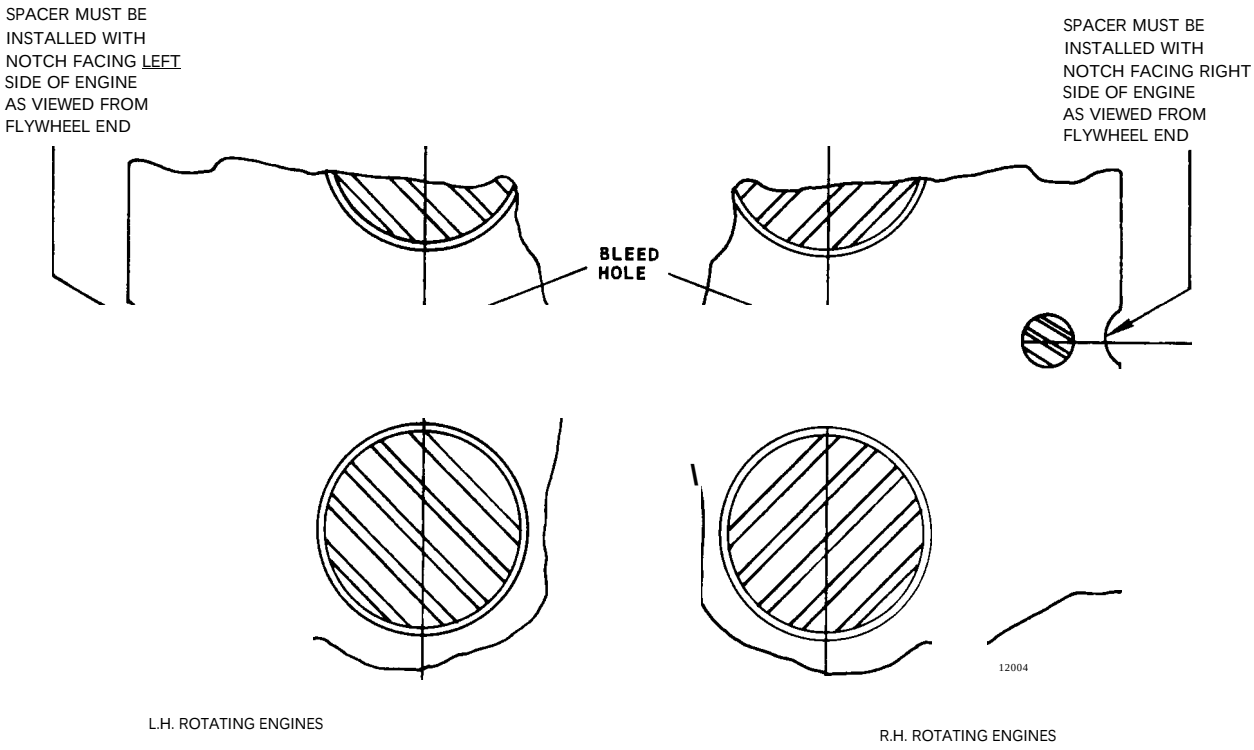


Fig. 8 - Orientation of Oil Pump Spacer Bleed Hole

on the shaft. The former pump assemblies (incorporating the larger bushings) can be reworked by drilling a hole in the pressure pump body (Fig. 7) to receive a 1/4" x 2 1/2" long slotted spring pin and replacing the driven shaft and driven gears with the current parts. Only the drilled shaft and the current gear and bushing assemblies are available for service.

The outside diameter of the current drive and driven gears is approximately .005” smaller.

Effective with engines 12E-5002 and 16E-4207 (approximate serial numbers), new oil pump assemblies featuring a new body, body spacer, drive shaft and a driven gear bushing replace the former pumps.

The new pump body differs from the former in that it provides oil grooves to improve bushing lubrication. These grooves are positioned to agree with pump rotation and the body is stamped “LH” or “RH” for identification.

Oil grooves have also been provided in a new body spacer (center plate) for improved lubrication to a new inner driven gear bushing. The new bushing has an oil groove across the entire width. In addition, the new spacer has a pump assembly rotation identification notch in the upper left-hand corner for a right-hand rotation pump as viewed from the scavenging end. The opposite notch location applies for a left-hand rotation pump assembly.

The new pump drive shaft is hardened at the center portion and at both ends to provide increased strength. Only the ends of the former shaft were hardened.

Only the new pump assemblies will be available for service.

Current oil pump assemblies have Loctite 75 retaining compound applied to the bushings in the driven helix gears and the pump pressure and scavenging bodies. When new bushings are installed, apply Loctite 75, or equivalent, as follows:

1. Clean the pump components with fuel oil and dry them with compressed air.

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

   Clean the new bushings and mating parts with a suitable de-greaser or chlorinated solvent.

   CAUTION: The chlorinated solvent must be used in a properly ventilated area with all safety precautions.

2. After the parts are completely dry, apply a continuous film of Loctite 75 retaining compound completely around the bushing bore (just inside the entry lip of the bore) in the pump body. It is not desirable to coat the entire width of the bore.

3. Press the bushing in place and remove the excess compound with a clean dry cloth. *Do not use solvent.*

Loctite 75 develops fixturing strength in approximately fifteen minutes; full cure takes approximately four hours.

To replace the bushings in the driven helix gears, press each new bushing in .030" below the face of the gear and with the open end of the oil groove facing toward the center of the gear. After installation, each bushing must withstand a load of 2,500 pounds without moving. Ream the bushings to 1.5025" to 1.5037" diameter.

If the bushings in the pump bodies are worn excessively, replace the pump bodies unless suitable boring equipment is available for finishing the new bushings.

When installing new bushings, replace all of the bushings in both the pressure pump body and the scavenging pump body. The bushings must be located and positioned as shown in Fig. 7. The gear bore and bushing bore in both pump bodies must be concentric within .002" total indicator reading. The bushing bores must be square with the machined faces of the pump bodies within .0003" per inch and parallel with the pump body mounting flange within .0004" per inch. The bushings must withstand a load of 2,500 pounds without moving. Ream the bushings to 1.5015" to 1.5027" diameter.

Assemble Oil Pump (8V Engines)

Refer to Fig. 3.

1. Lubricate the driven shaft with engine oil and insert the drilled end in the pump body. Align the drilled holes in the shaft and body and install a new pin to secure the shaft.
2. Install a key in the second keyway from the drive gear end of the drive shaft. Lubricate the shaft with engine oil. Then, align the slot in the drive gear with the key and press the gear on the shaft. Position the gear 2.22" from the drive gear end of the shaft.
3. Lubricate the end of the drive shaft with engine oil and slip the gear and shaft assembly through the bushing in the pump body. Install a key in the shaft.
4. Start the oil pump drive gear on the drive shaft with the ribbed side facing away from the pump and the slot in the gear aligned with the key. Then, press the gear on the shaft to give .020" maximum clearance when the internal gear is against the pump body and .006" minimum when the internal gear is against the pump cover.
5. Lubricate the driven shaft with engine oil and slide the driven gear on the driven shaft.
6. Attach the cover to the body with six 3/8"—16 x 1 1/2" bolts and lock washers. Tighten the bolts to 30-35 lb—ft (41—47 N*m) torque.

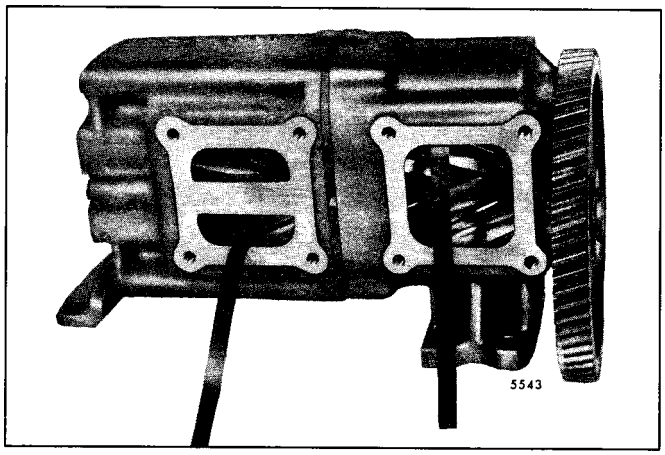


Fig. 9 - Checking Minimum Clearance Between Oil Pump Gear and Body

Assemble Oil Pump (12V and 16V Engines)

Refer to Fig. 5.

1. Lubricate the driven shaft with engine oil and insert the drilled end in the lower bushing in the pump body. The shaft should be a slip fit in the pump body. Align the drilled holes in the shaft and body and install a new pin to secure the shaft.
2. Install a key in the second keyway from the drive gear end of the drive shaft. Lubricate the shaft with engine oil. Then, align the slot in the pump body drive gear with the key and press the gear on the shaft. Position the gear 2.22" from the drive gear end of the shaft.
3. Lubricate the end of the shaft with engine oil and slip the gear and shaft assembly through the upper bushing in the pump body. Install a key in the shaft.
4. Start the external pump drive gear on the shaft with the ribbed side facing away from the pump and the slot in the gear aligned with the key. Then press the gear on the shaft to give .020" maximum clearance when the internal gear is against the pump body and .006" minimum when the internal gear is against the pump spacer. A left-hand helix external drive gear is used for a right-hand rotation engine and a right-hand helix external gear is used for a left-hand rotation engine.

   The clearance between the drive gear and the pump body on early pumps (with the small diameter bushings) was .006"-.012".
5. Slide the driven gear on the driven shaft. On former pumps, the driven gear was keyed to the shaft and positioned 1.28" from the drive gear end of the driven shaft.
6. Install the spacer. When installing the spacer between the pump bodies, be sure the bleed hole is located on the discharge side of the oil pump assembly (refer to Fig. 8).

7. Lubricate the drive shaft with engine oil and install two keys in the remaining keyways. Then, align the slot in the scavenging pump drive gear with the keys and press the gear on the shaft.

8. Lubricate the driven shaft with engine oil and slide the scavenging pump driven gear on the shaft.

9. Install the scavenging pump body over the gears and shafts. Then, install four 3/8"—16 x 7 1/2" bolts in the lower four bolt holes to secure the scavenging pump body to the oil pump body. Before final tightening of the bolts, center the two pump bodies to provide equal clearance at all places between each gear and its pump body. The minimum clearance at any point between a gear and its pump body should be .003" (Fig. 9). Then, tighten the bolts to 30-35 lb—ft (41-47 N*m) torque.

10. Attach the oil pump support to the scavenging pump body with two 3/8"-16 x 1 1/8" bolts and lock washers and two 3/8"—16 x 7 1/2" bolts. *Do not tighten the bolts at this time.* Turn the oil pump drive gear by hand to ensure that the shafts turn freely.

Install Oil Pump

Refer to Figs. 1 and 2

1. If removed, install the two hollow dowel pins in the oil pump mounting flange.

2. Position the pump over the mounting studs on the rear main bearing cap so that the oil pump drive gear meshes with the crankshaft gear. Install the same number and thickness of shims that were removed at time of disassembly. Then, install two 1/2"—13 x 1 1/2" bolts with lock washers and two stud nuts and lock washers to secure the pump in place. Tighten the bolts and nuts to 71-75 lb-ft (96-102 N«m) torque.

   On earlier 12V and 16V engines, four bolts were used to attach the pump to the rear main bearing cap. To facilitate installation when replacing an oil pump, install two l/2"-13 x 2.24" studs, in the positions opposite the pump locating dowel counterbores, in the bearing cap to replace two of the pump attaching bolts.

3. With the engine in the normal running position, check the clearance (backlash) between the oil pump drive gear and the crankshaft gear with a feeler gage or dial indicator. The clearance should be .006" to .012". Shims of .003" and .005" thickness are available for adjusting this clearance. Each .005" shim will change the clearance .0035".

8V Engines

Follow steps 4 thru 10 below when installing oil pump on 8V Engine.

4. Use a new gasket and attach the oil pump inlet elbow and screen assembly to the oil pump with two 3/8"—16 x 3 1/2" bolts and lock washers and two 3/8"—16 x 1 3/8" bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 N*m) torque.

5. Install the oil pump outlet adaptor (Fig. 3) to the oil pump and the cylinder block as follows:

   a. Use a new gasket and a new seal ring and position the adaptor against the oil pump and cylinder block.

   b. Attach the adaptor to the pump with four 3/8"-16 x 1 1/8" bolts and lock washers. *Do not tighten the bolts.*

   c. Attach the adaptor to the cylinder block pan rail with two 3/8"-16 x 1 1/8" bolts and lock washers. *Do not tighten the bolts.*

   d. To avoid breakage of the adaptor, tighten the attaching bolts in the following sequence.

      1) First snug down the two flange bolts at the block pan rail so that there is a slight metal-to-metal contact. This will keep the adaptor positioned against the block and also enable it to slide when attaching the other end to the oil pump.

      2) Snug down the four adaptor-to-pump bolts.

      3) Tighten the four adaptor-to-pump bolts to 30-35 lb-ft (41—47 N*m) torque, thus compressing the gasket the full amount.

      4) Tighten the two adaptor-to-block bolts to 30-35 lb-ft (41—47 N.m) torque.

6. If removed, install the pressure relief valve on the oil pump outlet adaptor (Section 4.1.1).

7. Use a new gasket and attach the cover to the oil pump adaptor with two 3/8"—16 x 1 1/8" bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 N«m) torque.

8. Use new gaskets and install the upper oil pan inspection hole covers.

9. Use a new gasket and attach the lower oil pan to the upper oil pan.

10. Fill the oil pan to the proper level with the oil recommended in the “Lubrication Specifications” in Section 13.3.

12V and 16V Engines

Follow steps 4 thru 15 below when installing oil pump on 12V and 16V engines.

4. After the gear clearance has been adjusted, install the two l/2"-13 x 1 1/2" bolts, lock washers and flat washers which attach the front oil pump support to the main bearing cap. Tighten these bolts to 71-75 lb-ft (96-102 N*m) torque *first* to prevent binding of the

pump shafts. This will allow the support to shift and align itself within the support-to-pump bolt holes clearance limits. Then, tighten the four 3/8"—16 support-to-pump bolts (previously installed but not tightened) to 30-35 lb—ft (41-47 N«m) torque.

5. Use a new gasket and attach the scavenging pump outlet pipe to the scavenging pump body with four 3/8"—16 x 1" bolts and lock washers. Tighten the bolts to 30-35 lb—ft (41-47 N*m) torque.
6. Install the oil pump outlet adaptor (Fig. 4) to the oil pump and the cylinder block, as follows:
   a. Use a new gasket and a new seal ring and position the adaptor against the oil pump and cylinder block.
   b. Attach the adaptor to the pump with four 3/8"-16 x 1 1/8" bolts and lock washers. *Do not tighten the bolts.*
   c. Attach the adaptor to the cylinder block pan rail with two 3/8"—16 x 1 1/8" bolts and lock washers. *Do not tighten the bolts.*
   d. To avoid breakage of the adaptor, tighten the attaching bolts in the following sequence:
      1) First snug down the two flange bolts at the block pan rail so that there is a slight metal-to-metal contact. This will keep the adaptor positioned against the block and also enable it to slide when attaching the other end to the oil pump.
      2) Snug down the four adaptor-to-pump bolts.
      3) Tighten the four adaptor-to-pump bolts to 30-35 lb—ft (41-47 N*m) torque, thus compressing the gasket the full amount.
      4) Tighten the two adaptor-to-block bolts to 30-35 lb-ft (41-47 N*m) torque.
7. Use a new seal ring and a new gasket and install the oil pump outlet pipe. Attach the front end of the pipe to the cylinder block with two 3/8"-16 x 1 3/4" bolts and lock washers. Attach the other end to the oil pump adaptor with two 3/8”—16 x 1 1/8" bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 N*m) torque.
8. Secure the oil pump outlet pipe to the main bearing caps with two support brackets and two clips. Fasten the clips to the brackets with two 3/8"-24 x 1" bolts, four washers and two nuts. Attach the brackets to the main bearing caps with two l/2"-13 x 1" bolts and lock washers.
9. If removed, install the pressure relief valve on the oil pump outlet adaptor (Section 4.1.1).
10. Use a new gasket and attach the oil pump inlet elbow and screen assembly to the oil pump with two 3/8"-16 x 3 1/2" bolts and lock washers and two 3/8"-16 x 1 1/8" bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 N*m) torque.
11. Slide the flange and a new seal ring over the scavenging pump inlet pipe and screen assembly. Then, place the pump inlet adaptor on the end of the pipe and, using a new adaptor-to-pump gasket, attach the inlet pipe assembly to the scavenging pump body with four 3/8"—16 x 1 5/8" bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 N*m) torque.
12. Position the four supports (in pairs) on the scavenging pump inlet pipe. Fasten each pair together with a 3/8"-24 x 1 1/8" bolt, lock washer and nut. Fasten the supports to the main bearing caps with four l/2"-13 x 1" bolts and lock washers.
13. Use new gaskets and install the upper oil pan inspection hole covers.
14. Use a new gasket and attach the lower oil pan to the upper oil pan.
15. Fill the oil pan to the proper level with the oil recommended in Section 13.3.

LUBRICATING OIL PRESSURE REGULATOR AND RELIEF VALVES

REGULATOR VALVE

Stabilized lubricating oil pressure is maintained within the engine at all speeds, regardless of oil temperature, by means of pressure regulator valve(s) (Fig. 1). The 8V engines are equipped with one valve. On the 12V and 16V engines, two valves are located at the end of vertical oil galleries near the center of the cylinder block.

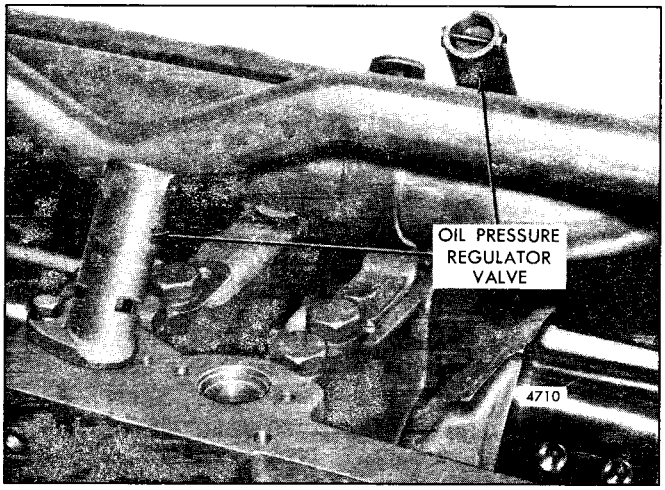


Fig. 1 - Oil Pressure Regulator Valve Mounting

The oil pressure regulator consists of a valve body, a hollow piston-type valve, a spring, a spring seat and a pin to retain the valve assembly within the valve body (Fig. 2).

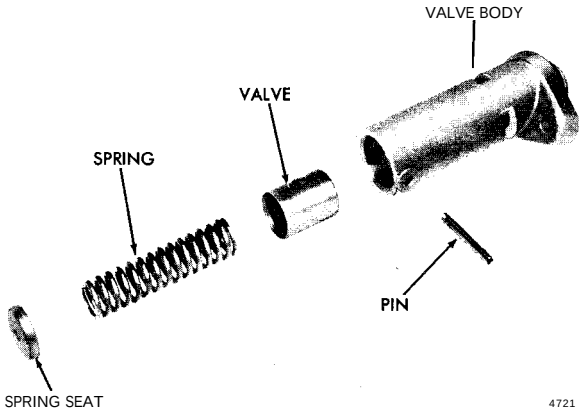


Fig. 2 - Oil Pressure Regulator Valve Details and Relative Location of Parts

The valve is held on its seat by the spring, which is compressed by the pin in back of the spring seat. The entire assembly is bolted to the lower flange of the cylinder block and sealed against leaks by a seal ring between the block and the valve housing. When conditions are such that the oil pressure at the valve exceeds the valve setting, the valve is forced from its seat and oil from the engine gallery is bypassed to the engine oil pan. Thus, stabilized lubricating oil pressure is maintained at all times.

Under normal conditions, the oil pressure regulator should require very little attention. If sludge has been allowed to accumulate in the lubricating system, the valve may not work freely, thereby remaining open or failing to open at the normal operating pressure.

Whenever the lubricating oil pump is removed for inspection, remove the regulator valve and spring and thoroughly clean and inspect them.

Remove Regulator Valves

Remove each pressure regulator assembly from the cylinder block, as follows:

1. Remove the regulator-to-cyUnder block attaching bolt and lock washer.
2. Tap the regulator body lightly to loosen it from the cylinder block. Remove the regulator and discard the seal ring.

The former regulator valve should be replaced with the current regulator valve at time of engine overhaul.

Disassemble Regulator Valve

Disassemble the regulator valve, as follows:

1. Clamp the regulator assembly in a bench vise equipped with soft jaws and remove the spring seat retaining pin from the regulator body.

   • CAUTION: Always depress spring seat and hold securely while removing pin. Release spring tension slowly when pin is removed. Failure to observe this precaution could allow the spring seat and spring to leave the valve body with force during pin removal, possibly causing personal injury.

2. Remove the spring seat, spring and valve from the regulator body.

Inspection

Clean all of the regulator components in fuel oil and dry them with compressed air.

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

The regulator valve must move freely in the valve body. If the valve or the valve body is scored and cannot be cleaned up with crocus cloth, replace them. Replace a pitted or fractured spring.

Effective with engine 12E-784, the relief slots have been relocated, 90° from their *original* position, to direct the oil away from the ventilation passages at the joint surface of the cylinder block.

• Effective with unit serial numbers 8E02537, 12E08778, and 16E08567, a new 70 psi (483 kPa) lube oil pressure regulator valve replaced the former 50 psi (345 kPa) valve in the following engines:

— All 8V, 16V tube and shell-equipped engines

— Model 9123-7301 when used in hydrofrac applications

— Models 9123-7311, 9163-7311, 9163-7316

Concurrent with this change, the former 50 psi (345 kPa) valve was also replaced by a new 50 psi valve on all other Series 149 engines.

Both new valve assemblies consist of identical components, including a valve body with two sets of valve spring seat retaining pin holes (Fig. 3). The 70 psi (483 kPa) valve has the pin installed in the holes identified by a cast, raised number “70.” On the 50 psi (345 kPa) valve, the pin is installed in the holes identified by a cast, raised number “50.” The former 50 psi valve assembly (Fig. 2) had one set of valve spring seat retaining pin holes.

Because of the improved lubrication provided to tube and shell oil cooler-equipped engines by the higher pressure valve, DDC recommends replacing the former 50 psi (345 kPa) valve with the 70 psi (483 kPa) valve at time of major engine repair or normal engine overhaul.

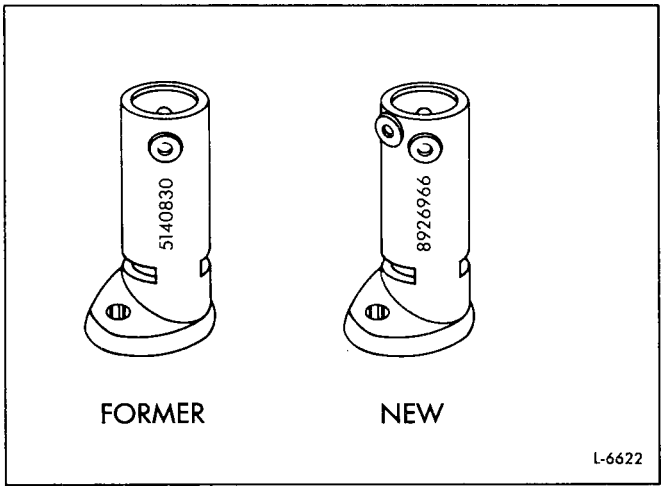


Fig. 3 - Former and New Lube Oil Pressure Regulator Valve Bodies

Assemble Regulator Valve

After the parts have been cleaned and inspected, refer to Figs. 1 and 2 and assemble the regulator, as follows:

1. Apply clean engine oil to the outer face of the valve and slide it into the regulator body, closed end first.
2. Insert the spring in the valve and install the spring seat. While compressing the spring, install the retaining pin behind the spring seat. Press the pin flush to .010" below the surface of the valve body.

Install Regulator Valves

Install each regulator assembly to the cylinder block, as follows:

1. Clean the regulator counterbores in the cylinder block.
2. Install a new seal ring and secure the regulator assembly to the cylinder block with one bolt and lock washer. Tighten the bolt.

RELIEF VALVE

Oil leaving the pump under pressure passes by a pressure relief valve (Fig. 4). The former spring-loaded valve opens when the pressure exceeds approximately 100 psi (689 kPa) or 130+10 psi (896+69 kPa) for current engines and directs the excess oil to the oil pan. The pressure relief valve is located on the oil pump outlet adaptor attached to the oil pump body.

The pressure relief valve consists of a valve body, a hollow piston-type valve, a spring, spring seat and a pin to retain the valve assembly within the valve body (Fig. 5).

The current high output pressure relief valve consists of a valve body, hollow piston-type valve, innerspring, two innerspring seats, outer spring, spring seat and a pin to retain the valve assembly within the valve body (Fig. 6).

Remove Relief Valve

1. Remove the two relief valve-to-adaptor attaching bolts and lock washers.
2. Tap the relief valve body lightly to loosen it from the gasket and the oil pump outlet adaptor. Remove the relief valve and gasket.

The former valve should be replaced with the current valve at time of engine overhaul.

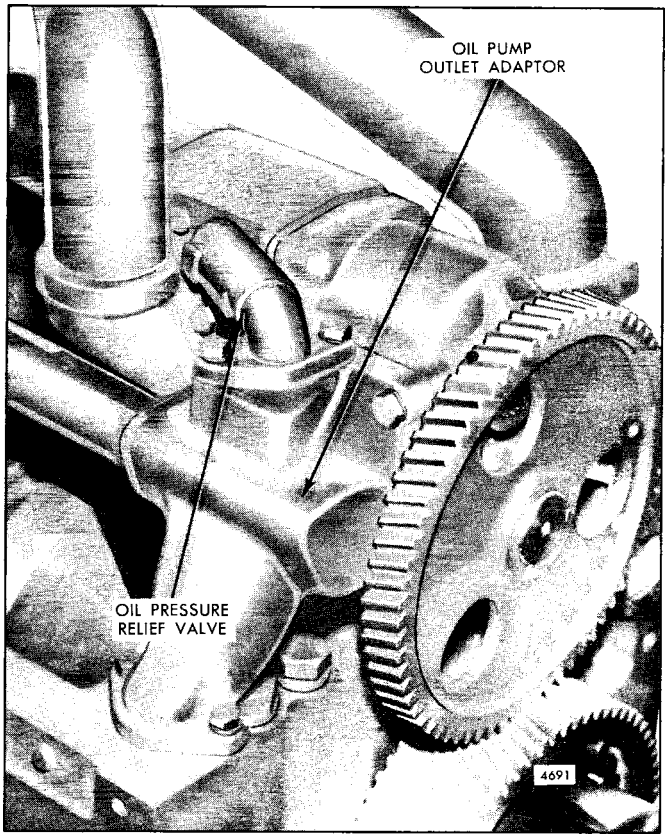


Fig. 4 - Oil Pressure Relief Valve Mounting

Disassemble Relief Valve

1. Clamp the oil pressure relief valve in a bench vise equipped with soft jaws and remove the spring seat retaining pin from the valve body.

   • CAUTIOI\I:Always depress spring seat and hold securely while removing pin. Release spring tension slowly when pin is removed. Failure to observe this precaution could allow the spring seat and spring to leave the valve body with force during pin removal, possibly causing personal injury.

2. Remove the spring seats, springs and valve from the valve body.

Inspection

1. Remove all traces of old gasket material from the oil pressure relief valve and oil pump outlet adaptor.

Clean all of the pressure relief valve components in fuel oil and dry them with compressed air.

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

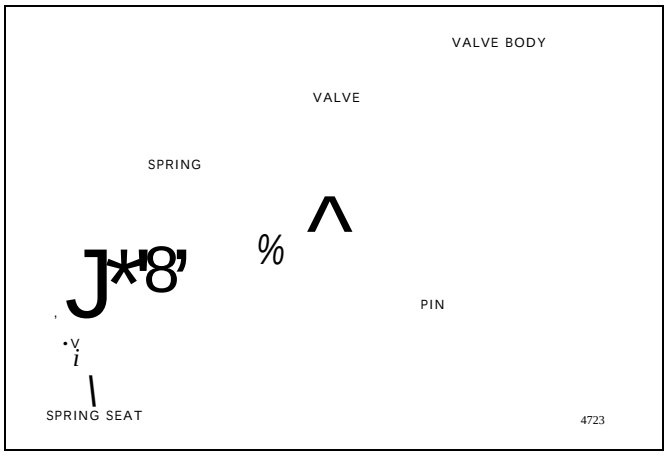


Fig. 5 - Former Oil Pressure Relief Valve Details and Relative Location of Parts

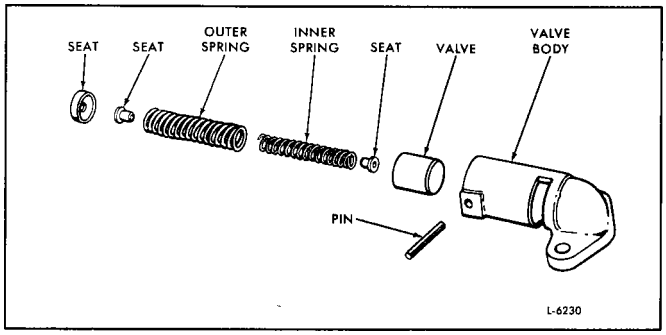


Fig. 6 - Current Oil Pressure Relief Valve Details and Relative Location of Parts

Check the relief valve to see that it moves freely in the valve body. If the valve is scored and cannot be cleaned up with crocus cloth, replace the valve. Replace a pitted or fractured spring.

Assemble Relief Valve

• 8V Engines

Refer to Fig. 5 or 6 and assemble the oil pressure relief valve as follows:

1. Apply clean engine oil to the outer face of the valve and slide it into the relief valve body (closed end first).
2. Insert the spring in the valve and install the spring seat. If the current high output valve assembly is used, insert the inner spring inside the outer spring with an inner spring seat on each end of the inner spring. Insert one end of this assembly into the valve and install the spring seat (Fig. 6).
3. While compressing the spring, install the retaining pin behind the spring seat. Press the pin flush to .010" below the surface of the valve body.

• 12V and 16V Engines

Refer to Figs. 5 or 6 and assemble the oil pressure relief valve as follows:

1. Apply clean engine oil to the outer face of the valve and slide it into the relief valve body (closed end first).
2. Insert the spring in the valve and install the spring seat. If the current high output valve assembly is used, insert the innerspring inside the outer spring with an innerspring seat on each end of the innerspring. Insert one end of this assembly into the valve and install the spring seat (Fig. 6).
3. While compressing the spring, install the retaining pin behind the spring seat. Press the pin flush to .010" below the surface of the valve body.

Install Relief Valve >

1. Place a new gasket on the oil pressure relief valve body.
2. Secure a relief valve assembly with a cast iron body to the oil pump outlet adaptor with two bolts and lockwashers. When installing a relief valve assembly with an aluminum body, use two 3/8" plain washers and two 3/8"-16 x 7/8" bolts.

LUBRICATING OIL FILTERS

Each engine is equipped with full flow type lubricating oil filters which are attached to the base of the cylinder block or are remotely mounted (Fig. 1). The 12V and 16V engines use four filters (two at the front and two at the rear of the cylinder block). An oil filter adaptor provides a support and a cover for each pair of oil filters.

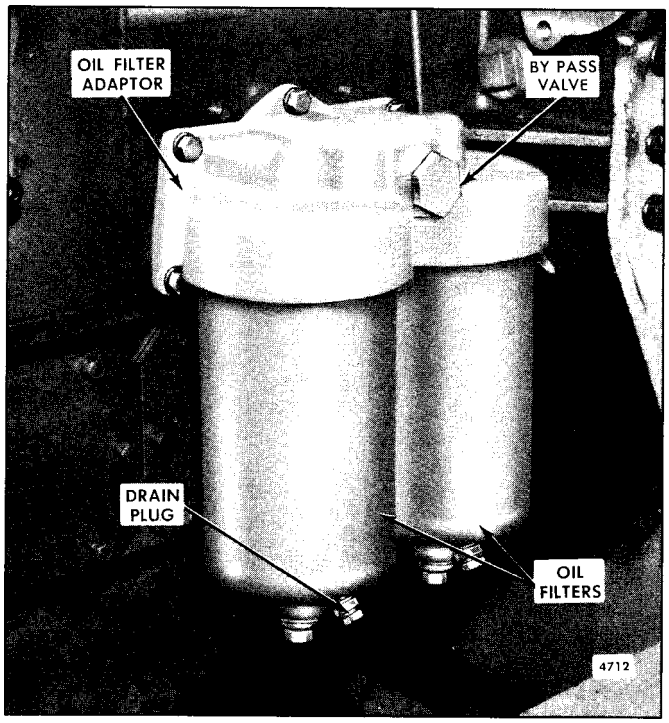


Fig. 1 - Oil Filter Mounting (Canister)

• Multi-pack oil filter adaptors with spin-on filters are used on engines with tube and shell oil coolers. The adaptor on 8V engines requires three (3) filters, the adaptor on 12V engines requires four (4) filters, and the adaptor on 16V engines (Fig. 2) requires six (6) filters.

All of the oil supplied to the engine by the oil pump passes through the filter before reaching the various moving parts of the engine. The oil is forced by pump pressure through a passage in the filter adaptor to the space surrounding the filter element. Impurities are filtered out as the oil is forced through the element to a central passage surrounding the center stud and out through another passage in the filter adaptor to the oil cooler.

A valve, which opens at approximately 23-28 psi (159-193 kPa), is located in each oil filter adaptor and will bypass the oil directly to the oil cooler should the filter become clogged.

• Depending on the engine, multi-pack oil filter adaptors used with tube and shell oil coolers have two (8V), three (12V), or four (16V) filter bypass valves.

If the engine is equipped with a remote mounted bypass type oil filter, a *.156" diameter orifice must be installed on the discharge side of the filter.* This will regulate the oil flow through the filter and aid in maintaining the proper oil pressure. If a multiple bypass oil filter arrangement is used, *all of the oil discharging from the filters must pass through a single .156' orifice.*

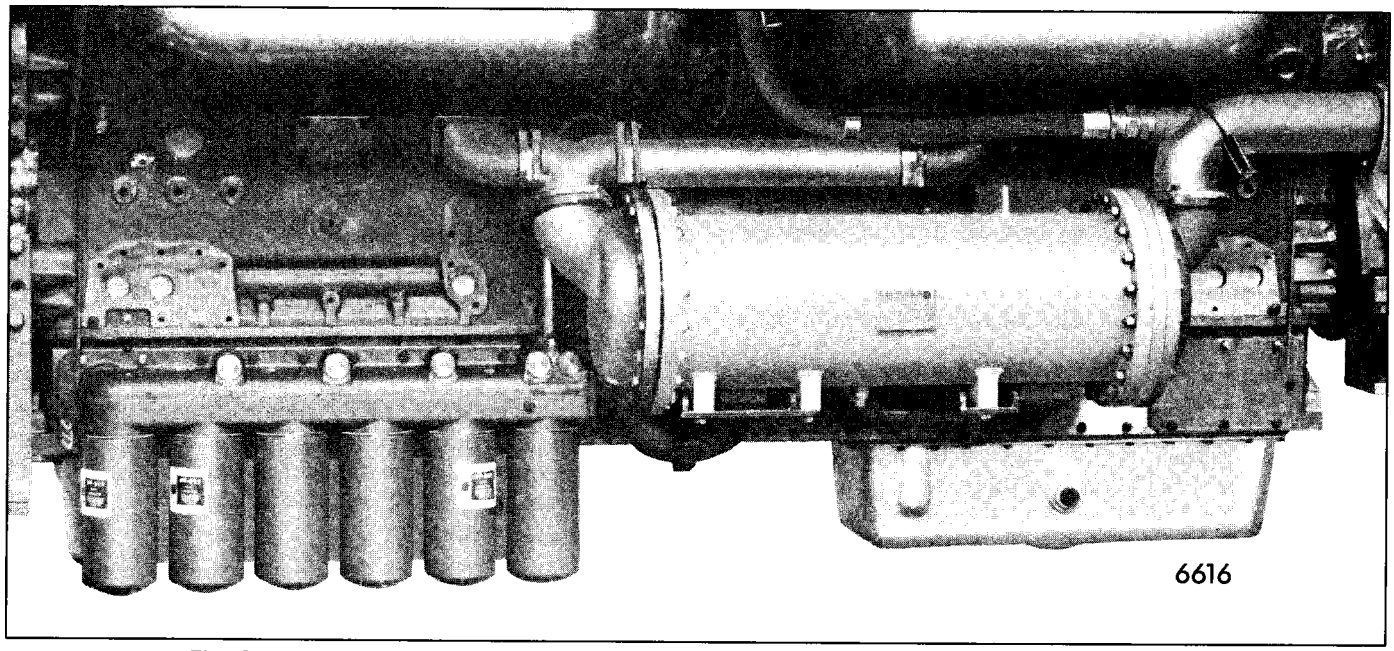


Fig. 2 – Typical Spin–On Oil Filter Mounting–16V Engine with Tube and Shell Oil Cooler

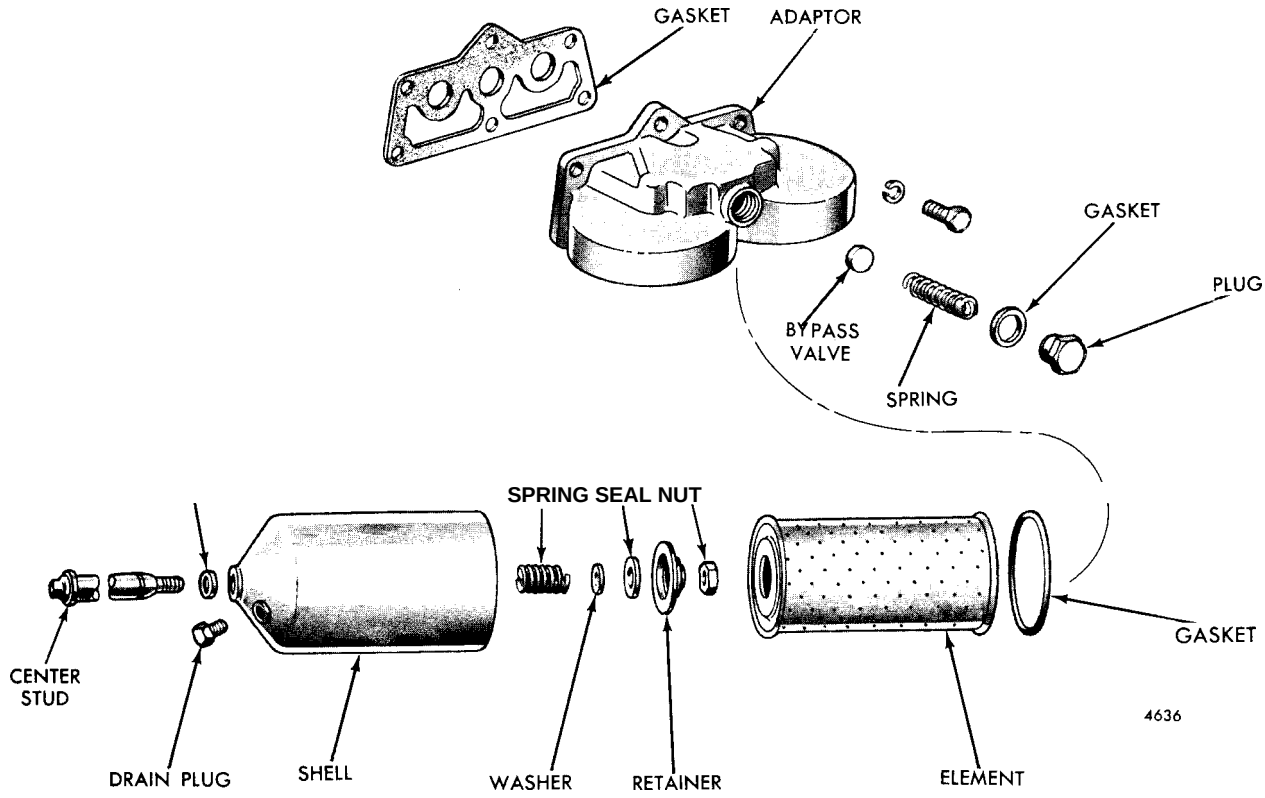


Fig. 3 - Oil Filter Details and Relative Location of Parts (Canister)

The former canister-type filter assembly consists of a replaceable element enclosed within a shell which is mounted in an adaptor or base (Fig. 3). When the filter shell is in place, the element is restrained from movement by a coil spring. The current spin-on filter consists of a shell, element and gasket combined into a unitized assembly (Fig. 4).

A new spin-on oil filter adaptor assembly now used on 12V and 16V-149 engines replaces the canister-type adaptor assembly formerly used on 16V engines. This new adaptor assembly also replaces the spin-on adaptor assembly formerly used on 12V engines. The new spin-on filter adaptor assembly can be distinguished from the former by the different contours on the top of the adaptor body (Fig. 5). •

• An optional AC service filter is available which has a synthetic (fiberglass), rather than an organic (cellulose) filtering medium. The filter is available in spin-on or canister style and is otherwise identical to the current production filter. The new filter traps particles as small as 12 microns (at 98% efficiency per AC test procedures), compared to 45 microns for the production filter. Because of its increased filtering capability, DDC recommends using it on new, rebuilt, or newly overhauled engines being placed in service.

NOTICE: The new service filter will improve oil filtration on a properly maintained and operated engine. It will not prevent wear or malfunctions caused by poor maintenance or improper engine operation.

Oil Filter Maintenance

With the use of detergent lubricating oils, the color of the lubricant has lost value as an indicator of oil cleanliness or proper filter action. Due to the ability of the detergent compounds to hold minute carbon particles in suspension, heavy duty oils will always appear dark-colored on the oil level dipstick.

Heavy sludge deposits found on the oil filter elements at the time of an oil change must be taken as an indication that the detergency of the oil has been exhausted. When this occurs, the oil drain interval should be shortened. The removal of abrasive dust, metal particles and carbon must be ensured by replacement of the oil filter elements at the time the engine oil is changed.

Selection of a reliable oil supplier, strict observation of his oil change period recommendations and proper filter maintenance will ensure trouble-free lubrication and longer engine life.

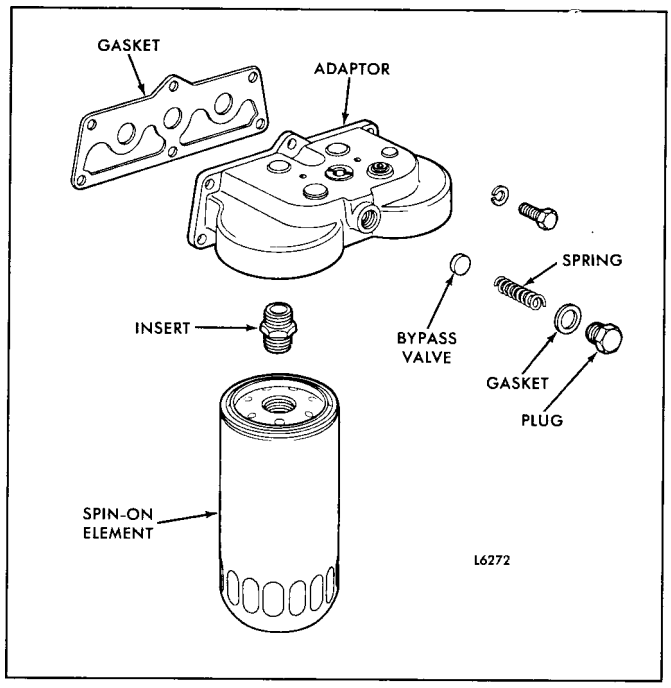


Fig. 4 – Spin–On Oil Filter Details and Relative Location of Parts

Replace Oil Filter Element (Canister Type)

Replace the oil filter element (Fig. 3) as follows:

1. Remove the drain plug from the filter shell and drain the oil.
2. Back out the center stud and withdraw the shell, element and stud as an assembly. Discard the element and the shell gasket.
3. Remove the center stud and gasket. Retain the gasket unless it is damaged and oil leaks occurred.
4. Remove the nut on the center stud.
5. Remove and discard the element retainer seal (Fig. 3). Install a new seal.
6. Clean the filter shell and the adaptor.
7. Assemble the spring, washer, seal and retainer on the stud. Use a new gasket and slide the stud through the filter shell.
8. Install a new shell gasket in the filter adaptor.

   NOTICE: Before installing the filter shell gasket, be sure all of the old gasket material is removed from the filter shell and the adaptor. Also make sure the gasket surfaces of the shell and the adaptor have no nicks, burrs or other damage.

9. Position the new filter element carefully over the center stud and within the shell. Then place the shell, element and stud assembly in position on the filter adaptor and tighten the stud to 50-60 lb—ft (68-81 N-m) torque.
10. Install the drain plug.
11. Start and run the engine for a short period and check for oil leaks. After any oil leaks have been corrected, and the engine has been stopped long enough (approximately twenty minutes) for the oil from various parts of the engine to drain back to the crankcase, add sufficient oil to bring it to the proper level on the dipstick.

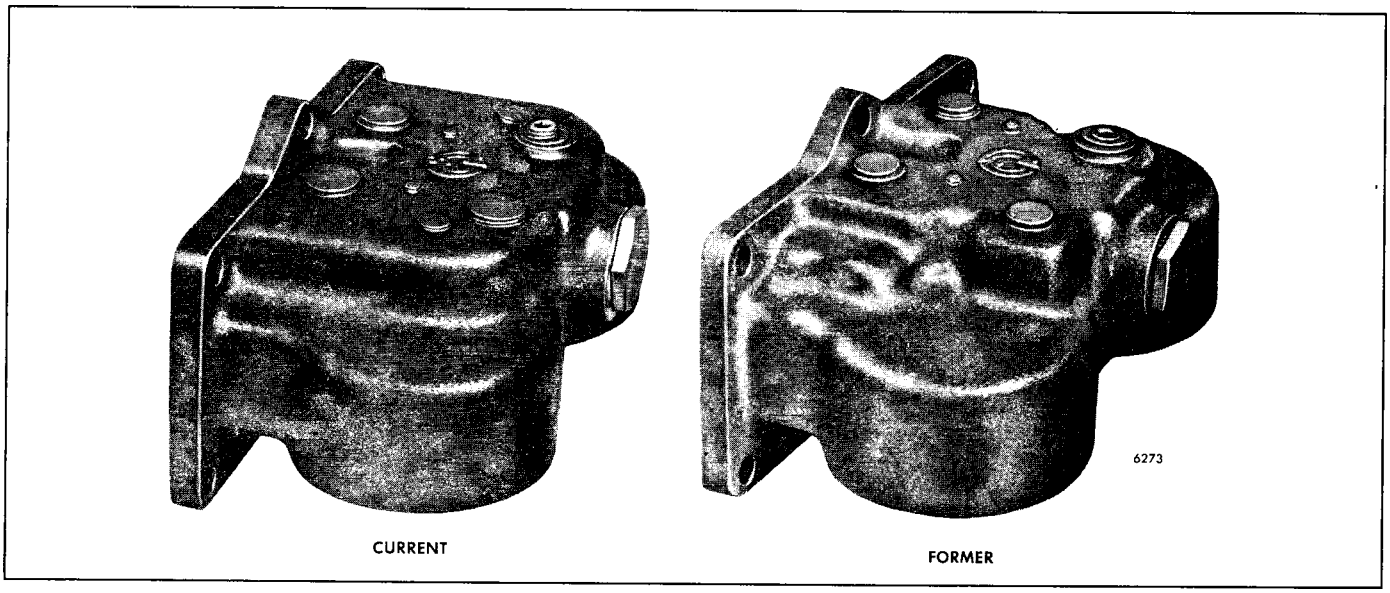


Fig. 5 - Spin-On Lube Oil Filter Adaptor Assembly

Replace Spin-On Filter

1. Remove the spin-on oil filter (Fig. 4) using strap wrench tool J 29917 which must be used with a 1/2" drive socket wrench and extension.
2. Discard the used oil filter.
3. Clean the filter adaptor with a clean, lint-free cloth.

   •**NOTICE:** Do not clean multi-pack lube oil filter adaptors by "hot tanking." Multi-pack oil filter adaptors used with tube and shell oil coolers are impregnated with a special compound to seal any porosity in the cast iron. *This compound can be removed by hot tanking.* Clean adaptors by immersing in pure mineral spirits or clean fuel oil.
4. Lightly coat the oil filter gasket (seal) with clean engine oil.
5. Start the new filter on the adaptor and *tighten by hand* until the gasket touches the mounting adaptor head. Tighten an additional two-thirds turn.

   NOTICE: Mechanical tightening will distort or crack the filter adaptor.
6. Start and run the engine for a short period and check for oil leaks. After any oil leaks have been corrected and the engine has been stopped long enough for oil from the various parts of the engine to drain back to the crankcase (approximately 20 minutes), add sufficient oil to raise the oil level to the proper mark on the dipstick.

Remove And Install Bypass Valve

1. Remove the plug and gasket and withdraw the spring and bypass valve (Figs. 3 and 4).
2. Wash all of the parts in clean fuel oil and dry them with compressed air.

   CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.
3. Inspect the parts for wear. If necessary, install new parts.
4. Reassemble and install the bypass valve. Tighten the l-l/4"-16 bypass valve plug to 95-105 lb—ft (129-143 N‘m) or the 1—1/2"—6 plug to 110-130 lb—ft (150-177 N • m) torque.

LUBRICATING OIL COOLER

To perform its functions satisfactorily, the lubricating oil must be kept within the proper temperature limits. If the oil is too cold, it will not flow freely. If the oil is too hot, it cannot support the bearing loads, it cannot carry away enough heat and it may result in too great an oil flow. As a consequence oil pressure may drop below acceptable limits and oil consumption may become excessive.

In performing its lubricating and cooling functions, the oil absorbs a considerable amount of heat and this heat must be dissipated by an oil cooler(s).

PLATE TYPE OIL COOLER

• Two oil coolers are used on the 12V and 16V engines and are centrally located on the right side of the cylinder block (Fig. 1). A new, increased-capacity, 30 plate lube oil cooler core has been released for 12V and 16V engines. The new oil cooler core is completely interchangeable with the 26-plate oil cooler core formerly used, and only the new 30-plate core should be installed on 12V and 16V engines. Current high strength, 30-plate cores are made of stainless steel and have regularly spaced, rounded rises (bumps) on their plate surfaces.

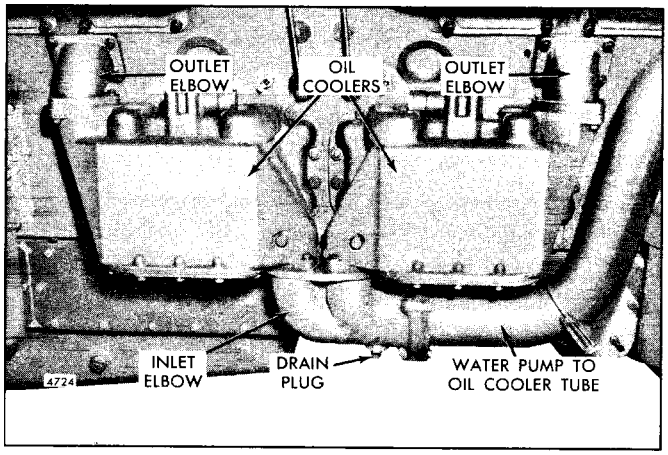


Fig. 1 - Oil Cooler Mounting

To cool the lubricating oil used in a Torqmatic converter or a marine gear, a separate oil cooler core is mounted on the opposite side of the engine (Fig. 2).

Oil from the lubricating oil pump flows through a passage in the oil filter adaptor to the oil filter, then through the oil cooler and finally through the outlet passage in the cooler adaptor which leads to the cylinder block oil galleries. The engine coolant is pumped through the oil cooler and completely surrounds the oil cooler core.

To ensure continuing engine lubrication should the oil cooler become plugged, a bypass valve is installed in the oil cooler adaptor (Fig. 3).

Remove Oil Cooler Assembly

1. Remove the oil drain plug from the oil pan and drain the lubricating oil system.

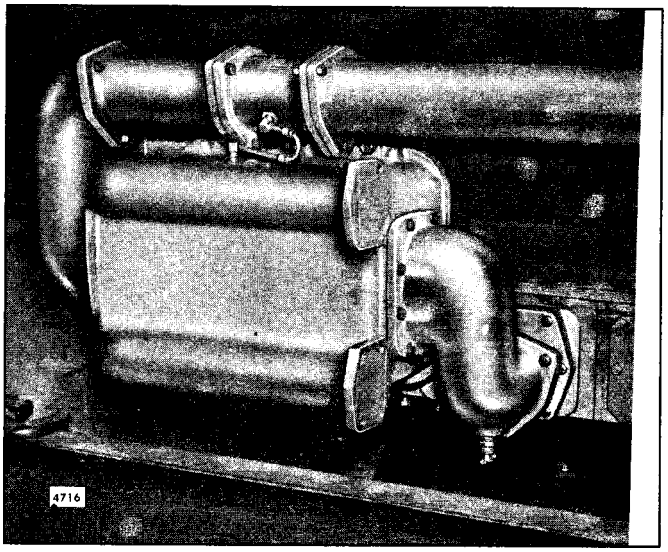


Fig. 2 - Torqmatic Converter Oil Cooler

2. Drain the cooling system by removing the drain plug located at the bottom of the oil cooler. On units where the oil cooler water inlet elbow is located at the bottom of the oil coolers, remove the drain plug from the elbow (Fig. 3).
3. Remove the three bolts and lock washers securing the oil cooler inlet elbow to the water pump-to-oil cooler tube.
4. Remove the six bolts and lock washers securing the oil cooler inlet elbow to the oil coolers and remove the inlet elbow, seal ring and gaskets.
5. Remove the three bolts and lock washers securing the oil cooler outlet elbow to the cylinder block and remove the outlet elbow and gaskets. On units equipped with a Torqmatic converter, remove the outlet elbow located at the bottom of the oil coolers (Fig. 2).
6. Remove the six bolts and lock washers securing the oil cooler to the cylinder block. Then, suitably support the oil cooler and remove the two remaining nuts and lock washers securing the oil cooler and remove the oil cooler and gasket from the cylinder block.
7. Clean all traces of gasket material from the cylinder block and the oil cooler components.

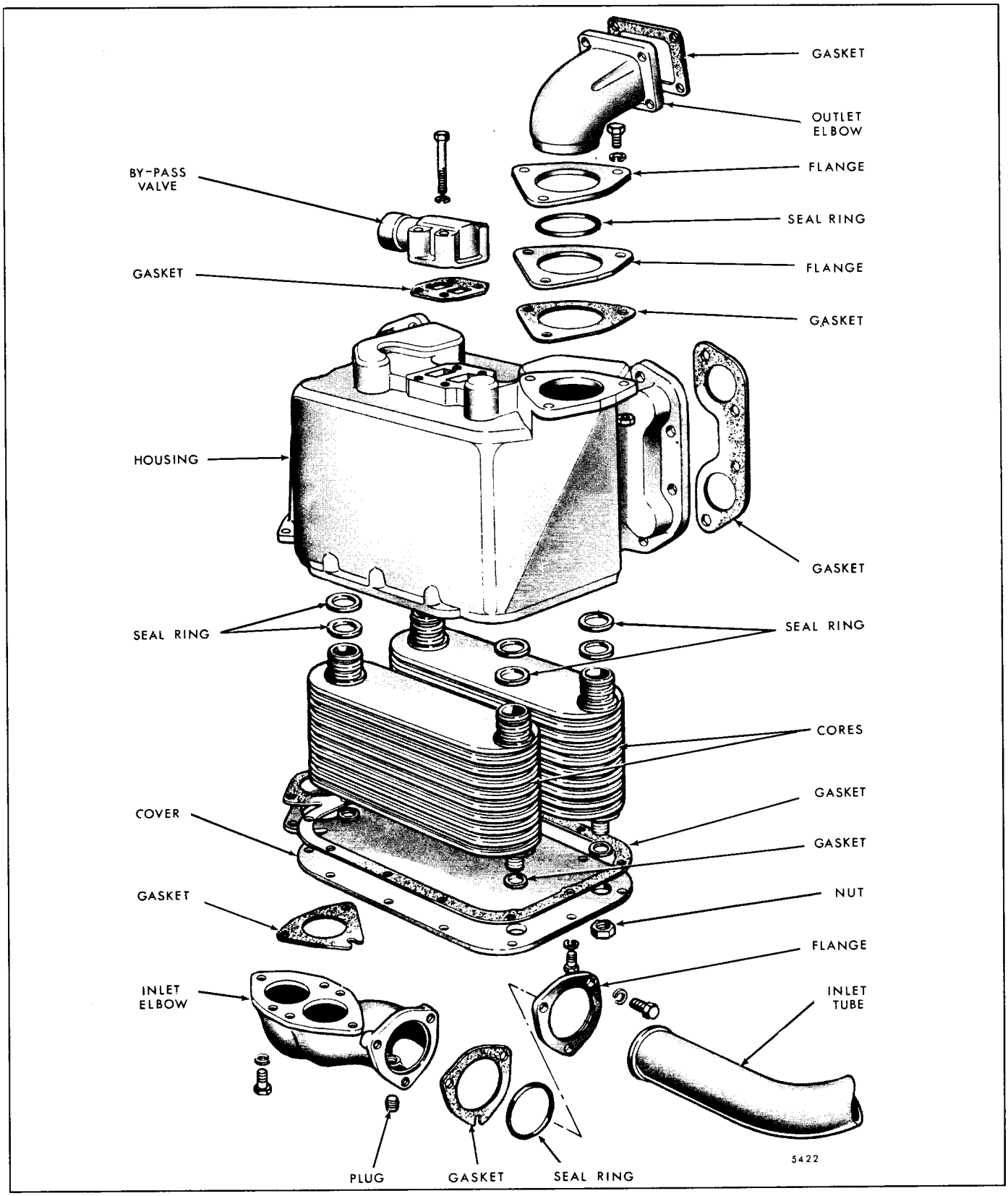


Fig. 3 - Lubricating Oil Cooler and Relative Location of Parts

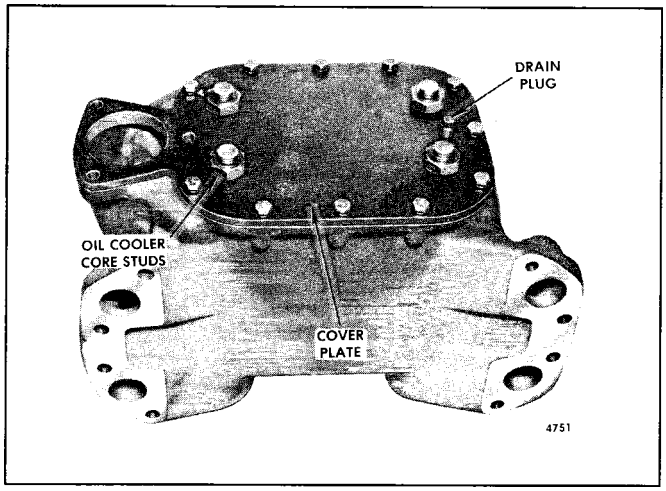


Fig. 4 - Oil Cooler Cover Plate Mounting

Disassemble Oil Cooler

1. Refer to Fig. 4 and remove the four nuts securing the oil cooler cores to the oil cooler base plate.
2. Refer to Fig. 3 and remove the eleven bolts and lock washers securing the cover plate to the oil cooler housing and remove the cover plate and gasket.
3. Slide the two oil cooler cores out from the oil cooler housing and remove the oil seal rings from the cores.
4. Remove the four bolts and lock washers securing the oil cooler bypass valve to the top of the oil cooler and remove the bypass valve and gasket. Refer to *Lubricating Oil Cooler Bypass Valve* in this section for maintenance on the bypass valve.

Clean Oil Cooler Core

1. Clean the oil passages in the oil cooler core by circulating a solution of 1,1,1 -tricholorethane through the passages with a force pump.

CAUTION: To avoid personal injury, perform this operation in the open or in a well ventilated area. Avoid breathing the fumes or direct contact of the chemicals with your skin. Use recommended safety equipment, as required.

Clean the oil cooler core before the sludge hardens. If the oil passages are badly clogged, circulate a cleaning solution through the oil cooler core and flush it thoroughly with clean, hot water.

NOTICE: Do not attempt to clean an oil cooler core when an engine failure occurs in which metal particles from worn or broken parts are released into the lubricating oil. In this instance, replace the oil cooler core.

2. After cleaning the oil passages, clean the water side of the oil cooler core by immersing it in a solution made as follows: add 1/2 pound of oxalic acid to each 2-1/2 gallons of a solution composed of 1/3 muriatic acid and 2/3 water. The cleaning action is evident by the bubbling and foaming. Carefully observe the process and remove the oil cooler cover from the solution when the bubbling stops (this usually takes from 30 to 60 seconds). Then, thoroughly flush the oil cooler core with clean, hot water. After cleaning, dip the oil cooler core in light oil.

CAUTION: Protect your eyes and avoid breathing the fumes or direct contact of the acid with your skin.

Pressure Check Oil Cooler Core

1. Make a suitable adaptor to which an air hose can be attached and fasten it to the inlet pipe of the cooler core. Use a suitable piece of hose, a plug and clamp to seal the outlet pipe.
2. Attach an air hose and apply approximately 75-150 psi (517-1034 kPa) air pressure. Then, submerge the cooler core in a tank of water. Any leaks will be indicated by air bubbles in the water.

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

3. After the pressure test is completed, remove the air hose, clamp, plug, hose and adaptor and dry the cooler core with compressed air. Replace the cooler core if leaks were indicated.

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

Inspection

Check the bores in the oil cooler housing for corrosion, pitting and wear. The bores must be clean and smooth to prevent leaks and damage to the oil seals. Repair worn seal bores as outlined in Section 4.0.

Assemble Oil Cooler

1. Refer to Fig. 3 and install the oil cooler bypass valve and a new gasket on the oil cooler using four 5/16"-l 8 bolts and lock washers. Tighten the bolts to 13-17 lb—ft (18-23 N*m) torque.
2. Place new oil seal rings on the oil cooler core inlet and outlet tubes.
3. Insert the oil cooler cores into the oil cooler housing, making sure not to dislodge the oil seal rings on the inlet and outlet tubes. The inlet and outlet openings in

the oil cooler core are marked IN and OUT. Make sure the oil cooler core is reinstalled in its *original* position, otherwise the oil flow will be reversed and could result in foreign particles that may not have been removed to be loosened and circulated through the engine. If the openings are unidentified, it is suggested that they be marked before installing the oil cooler core.

4. Position the oil cooler cover plate, with a new gasket, against the bottom of the oil cooler housing with the oil cooler core studs aligned through the four holes in the cover plate. Insert one 3/8"-16 alignment bolt through the inner hole of the oil cooler water inlet to maintain the gasket in position. To insure proper installation of the cover plate, one side is stamped “inside”.
5. Secure the cover plate to the housing with eleven 5/16"—18 bolts and lock washers. Tighten the bolts to 13-17 lb-ft (18-23 N«m) torque. Remove the aligning bolt.
6. Thread the four nuts over the core studs and tighten them to 70-80 lb-ft (95-108 N*m) torque.

Install Oil Cooler

Refer to Fig. 1 and install the engine oil coolers, as follows:

1. Use a new gasket and position the oil cooler over the two studs and up against the cylinder block. Thread the two stud nuts and lock washers over the studs and draw the nuts up finger tight only. On the 12V and 16V engines, position both oil coolers before proceeding with the installation of the remaining bolts.
2. Install the water inlet elbow and gasket and tighten the bolts finger tight only.
3. Install the water outlet elbows, spacers and gaskets. Center the elbow flanges on the cooler flanges, then install and tighten all of the bolts finger tight only.
4. Install the inlet tube between the water pump and the oil cooler inlet elbow, leaving the bolts loose. Position the tube brackets.
5. With coolers, elbows and tube in position (Fig. 1), proceed to tighten the bolts, as follows:
   a. Tighten the bolts on the water inlet elbow. Start with one of the four top bolts and alternately tighten the bolts to 30-35 lb-ft (41-47 N»m) torque.
   b. Tighten the cooler to block bolts and nuts. Start at the center and work toward the outside. Tighten the stud nuts to 83-93 lb-ft (113-126 N*m) torque and the bolts to 71-75 lb-ft (96-102 N«m) torque.
   c. With the flanges centered, tighten the water outlet elbow bolts (elbow to block bolts first). Then, gradually and alternately tighten the elbow to cooler bolts to avoid cracking the flange.
   d. Alternately tighten the water inlet tube to water inlet elbow bolts. Then alternately tighten the water inlet tube to water pump flange bolts. Tighten the bolts to 30-35 lb-ft (41-47 N«m) torque.
   e. Tighten the water inlet tube bracket bolts.
   f. If removed, install the drain plug in the water inlet elbow or the bottom of the oil cooler. On engines equipped with a Torqmatic converter, install the outlet elbow at the bottom of the oil cooler, between the oil cooler and the water crossover tube.
6. Install the oil pan drain plug and fill the oil pan to the proper level on the dipstick with the lubricating oil recommended in *Lubrication Specification* (Section 13.3).
7. Start and run the engine for a short period and check for oil and water leaks. Stop the engine and, after approximately twenty (20) minutes, recheck the oil level on the dipstick.

LUBRICATING OIL C< ILER BYPASS VALVE

To ensure engine lubrication should the oil cooler become plugged, a bypass valve (Fig. 5) is installed in the oil inlet passage of the oil cooler housing. The valve opens and allows oil to bypass the oil cooler when the pressure at the inlet side exceeds the pressure at the outlet side by 26.5 psi (179 kPa).

The bypass valve assembly consists of a housing, valve, spring, retaining plug and gasket. The bypass valve should be removed, cleaned, inspected and reassembled whenever the oil cooler core is cleaned or replaced. However, the bypass valve can be disassembled without removing the oil cooler.

Remove Oil Cooler Bypass Valve

1. Remove the four bolts and lock washers securing the bypass valve housing to the oil cooler and remove the housing and gasket.
2. Remove the retaining plug and gasket from the housing and withdraw the spring and valve.

Inspection

Clean the housing and bypass valve components with fuel oil and dry them with compressed air.

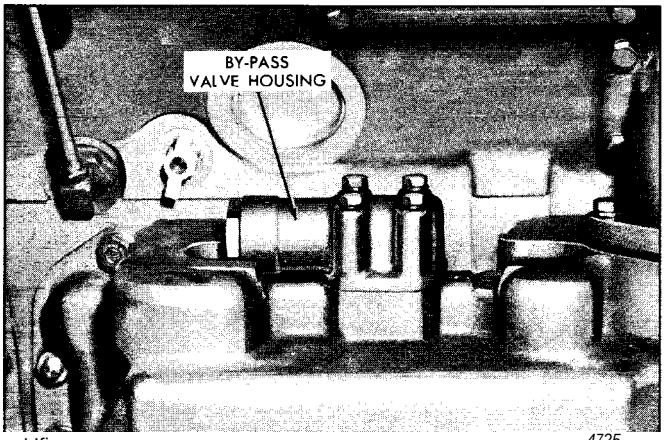


Fig. 5 - Oil Cooler Bypass Valve Mounting

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

Inspect the valve and spring for wear or damage and replace them, if necessary. The bypass valve spring has an approximate free length of 2.73". Use spring tester J 22738-02 to check the spring load. When a force of 39.25 pounds or less will compress the spring to a length of 2.201", replace the spring.

Install Oil Cooler Bypass Valve

1. Apply clean engine oil to the outside surface of the bypass valve and place it in the bypass valve housing. Be sure to place the closed end of the valve toward the back of the housing cavity.
2. Insert the spring inside the bypass housing and into the valve cup.
3. Place a new gasket on the retaining plug and install the retaining plug. Tighten the 1—1/16"—16 plug to 80-90 lb—ft (108-122 N«m) torque.
4. Place a new gasket on the oil cooler bypass valve housing mounting surface and install the housing on the oil cooler using four 5/16"-18 bolts and lock washers. Tighten the bolts to 13-17 lb-ft (18-23 N#m) torque.

TUBE TYPE OIL COOLER

TURBOCHARGED INTERCOOLED ENGINES

• Tube type oil cooler assemblies (Fig. 6) are installed on certain 8 V, 12V, and 16V-149 turbocharged-intercooled engines.

The original water inlet housing and seal (Fig. 7) used on tube type oil coolers were replaced approximately April, 1985. The new water inlet housing is similar to the former, except that the seal gland lead-in chamfer is wider. The new seal is slightly thinner than the former seal and has a different profile (Fig. 7), which allows it to be compressed more easily. This design insures direct metal-to-metal contact between the water inlet housing, the weep ring, and the tube bundle shell. Without metal-to-metal contact, the fasteners holding these parts together can lose torque and loosen, resulting in a coolant leak.

The former seal and housing are not longer available. When seal replacement is required on assemblies with the former housing, the former housing *must* be reworked to permit installation of the new seal. See rework instructions (section 4.0).

NOTICE: Before disassembling a tube and shell oil cooler assembly, match marks should be scribed on oil cooler end covers and housing and the locations of nuts and bolts should be noted.

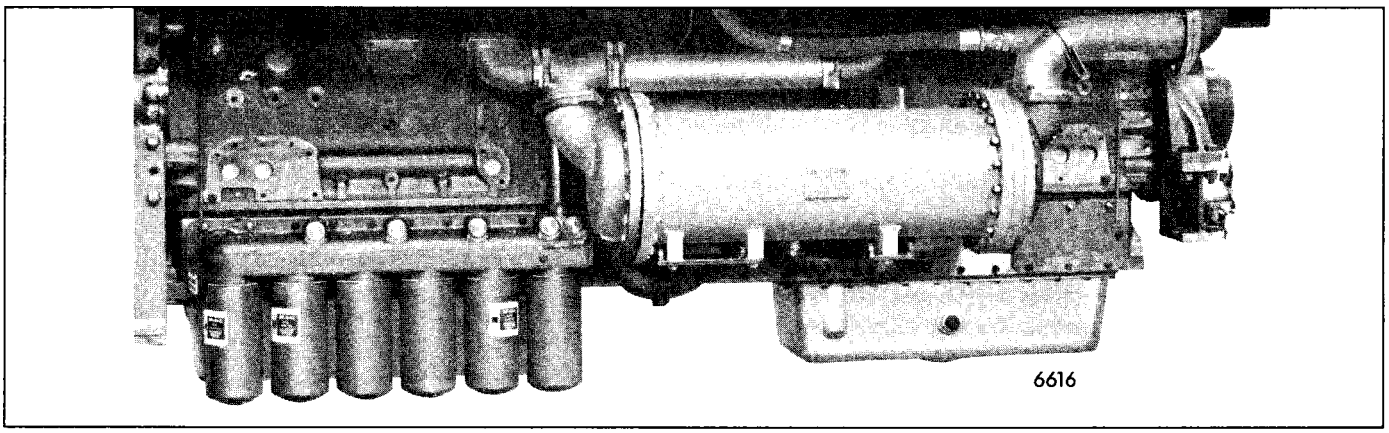


Fig. 6 – Tube and Shell Oil Cooler Mounting (16V–149 Engine Shown)

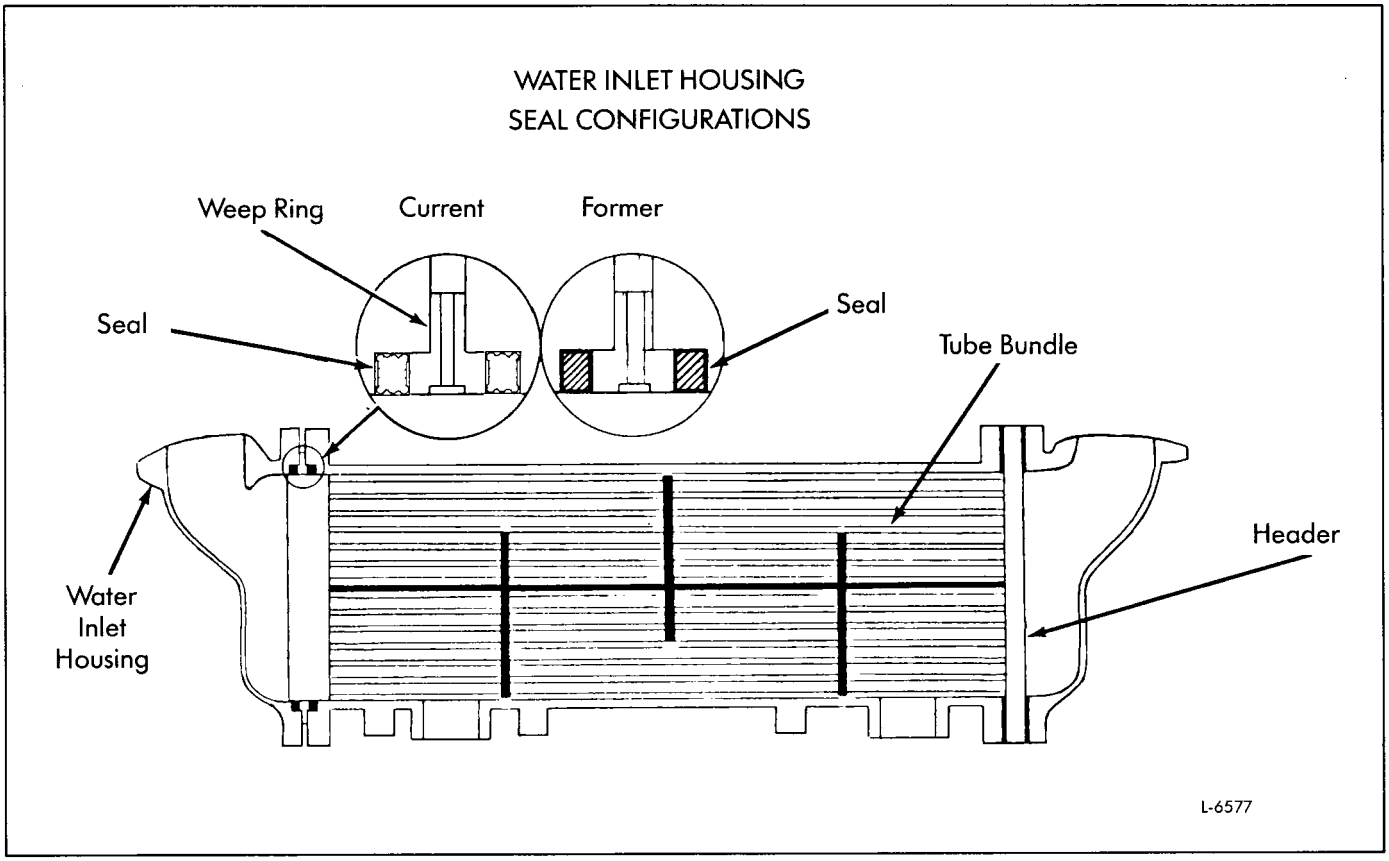


Fig. 7 – Tube and Shell Oil Cooler

Remove Oil Cooler

1. Drain the cooling system.
2. Remove the water pump to oil cooler tube.
3. Remove the oil cooler to cylinder block tube.
4. Remove the two elbows attached to the bottom of the oil cooler.
5. Remove the bolts and lockwashers which secure the oil cooler assembly to the support brackets. Remove the oil cooler.
6. Drain the oil from the oil cooler.
7. Clean the exterior surface of the oil cooler with fuel oil.
8. Remove the tube bundle from the shell.

Clean Oil Cooler

CAUTION: To avoid personal injury, perform this operation in the open or in a well ventilated area. Avoid breathing the fumes or direct contact of the chemicals with your skin. Use recommended safety equipment, as required.

NOTICE: Do not attempt to clean an oil cooler core when an engine failure occurs in which metal particles from worn or broken parts are released into the lubricating oil. In this instance, replace the oil cooler core.

Clean the tubes by circulating a cleaning solvent (Stoddard Solvent or equivalent) through the tubes. Then, run a brush through the tubes. After the brushing is completed, rinse the tubes with clean hot water.

NOTICE: Precautions must be taken so the cleaning agents do not corrode the tubes. If an acid solution is used, the residue must be neutralized.

Assemble Oil Cooler

1. Place the shell in a *vertical* position on the floor and place a gasket on the end of the shell.
2. Insert the tube bundle into the shell. Align match marks.
3. Place the oil cooler water inlet cover gasket on the end of the shell.
4. Align and bolt the water inlet housing (cover) on the fixed end of the oil cooler assembly with seventeen (17) bolts, lockwashers and nuts, and three bolts with

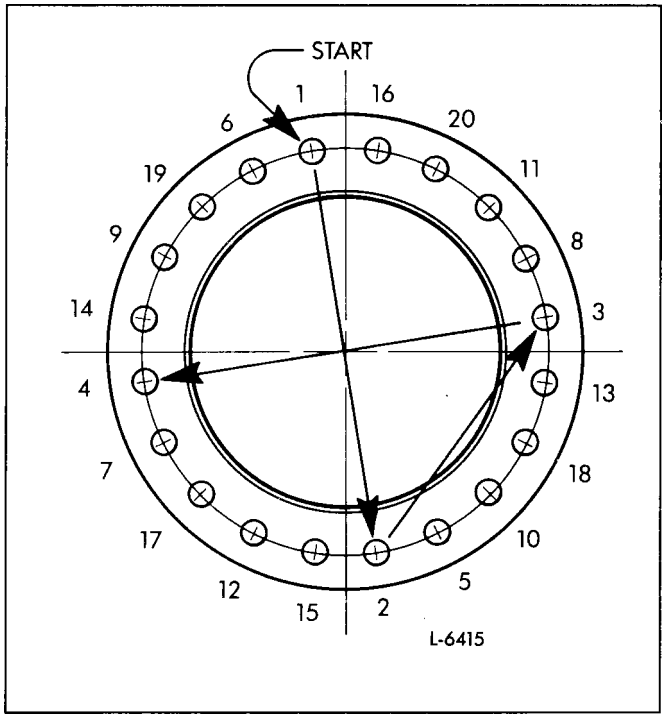


Fig. 8 - Bolt Tightening Sequence

lockwashers in the threaded holes at the top of the flange. Tighten the bolts to 30 lb—ft (41 N*m) torque using the sequence outlined in Fig. 8.

5. Place the metal weep ring on the end of the shell.
6. Place a seal (packing ring) in the water outlet housing (cover).
7. Align and bolt the water outlet housing (cover) to the floating end of the oil cooler assembly with seventeen (17) bolts, lockwashers and nuts, and three (3) bolts with lockwashers in the threaded holes at the top of the flange. This cover is not to be mounted flush to the shell flange. A gap must be maintained for the weep ring. Tighten the bolts to 35 lb—ft (47 N*m) torque using the sequence outlined in Fig. 8.
8. Apply sealant to the oil drain plug and install the plug in the bottom of the oil cooler.
9. Apply sealant to the drain plug and install the plug in the water inlet housing (cover) on the front end of the oil cooler.
10. Apply sealant to the drain plug and install the plug in the water outlet housing (cover) on the opposite end of the oil cooler.

.Install Tube And Shell Oil Cooler — 8V-149 Engine

Refer To Fig. 9

1. Using a new gasket, attach oil filter outlet elbow (A) to oil filter adaptor (B) with three (3) l/2"-13 x 1 3/8" bolts, one (1) l/2"-13 x 1.25" bolt, one (1) l/2"-20 nut, and four (4) 1/2" lockwashers. Tighten to 71-75 lb—ft (96-102 N*m) torque.
2. Using a new gasket, attach oil inlet elbow (C) to block with two (2) 1/2"—13 x 1 1/2" bolts and lockwashers. Tighten to 71-75 lb-ft (96-102 N«m) torque.
3. Attach front and rear oil cooler mounting brackets to block with six (6) 1/2"—13 x 1 3/8" bolts and lockwashers (front and rear brackets) and two (2) 7/16”—14 x 1 1/4" bolts and lockwashers (rear bracket). Using fabricated mounting bracket alignment tool (refer to Shop Notes, Section 4.0), align mounting brackets and tighten bolts. Tighten l/2"-13 bolts to 71-75 lb-ft (96-102 N*m) torque. Tighten 7/16"-14 bolts to 46-50 lb-ft (62-68 N#m) torque.
4. Install 90° hydraulic fluid elbow (D) into oil cooler oil outlet elbow (E). Elbow must face inboard. Install 1" connector into elbow (D). Install oil bypass hose assembly to connector.
5. Using a new gasket, install oil cooler oil outlet elbow (E)-with bypass hose attached onto front of oil cooler with four (4) 1/2"—13 x 1.50"L bolts and lockwashers. Tighten to 71-75 lb-ft (96-102 N*m) torque.
6. Using a new gasket and seal, attach flange, plate, and oil cooler water inlet elbow (F) to rear of oil cooler housing with three (3) 3/8"—16 x 1.75"L bolts and lockwashers. Install loose. Do not tighten at this time.
7. Using a suitable support, move the oil cooler to the engine. The bypass hose must be positioned between the oil cooler and block. Attach oil cooler to mounting brackets with four (4) 1/2"—13 x 1 3/8" bolts and lockwashers (front and rear brackets). Tighten bolts to 71-75 lb-ft (96-102 N»m) torque.
8. Using a new gasket, attach rear water inlet elbow (F) to block with four (4) 3/8"-16 x 1.135" flange hex head bolts. Tighten to 30-35 lb-ft (41-47 N«m) torque.
9. Using a new seal and gasket, attach oil cooler oil outlet elbow (E) to oil inlet-to-block elbow (C) with flange, plate, and three (3) 3/8" - 16 x 1.75"L bolts and lockwashers. Tighten to 30-35 lb-ft (41-47 N«m) torque.
10. Using new seals, attach water pump outlet tube (G) to front of oil cooler housing with flange and three (3) 3/8" - 16 x 1 3/8"L bolts and lockwashers. Slip flange and new seal onto opposite end of water pump outlet tube and install to water pump with three (3) 3/8"-16 x 1 3/8"L bolts and lockwashers. Install breather pipe clip under top, left flange bolt. Tighten all bolts to 30-35 lb-ft (41-47 N*m) torque.
11. Install 1 5/16"-12 flared tube connector into oil cooler oil inlet/bypass elbow assembly (H). Then secure a new oil cooler housing gasket to the top of the oil inlet/bypass elbow assembly.

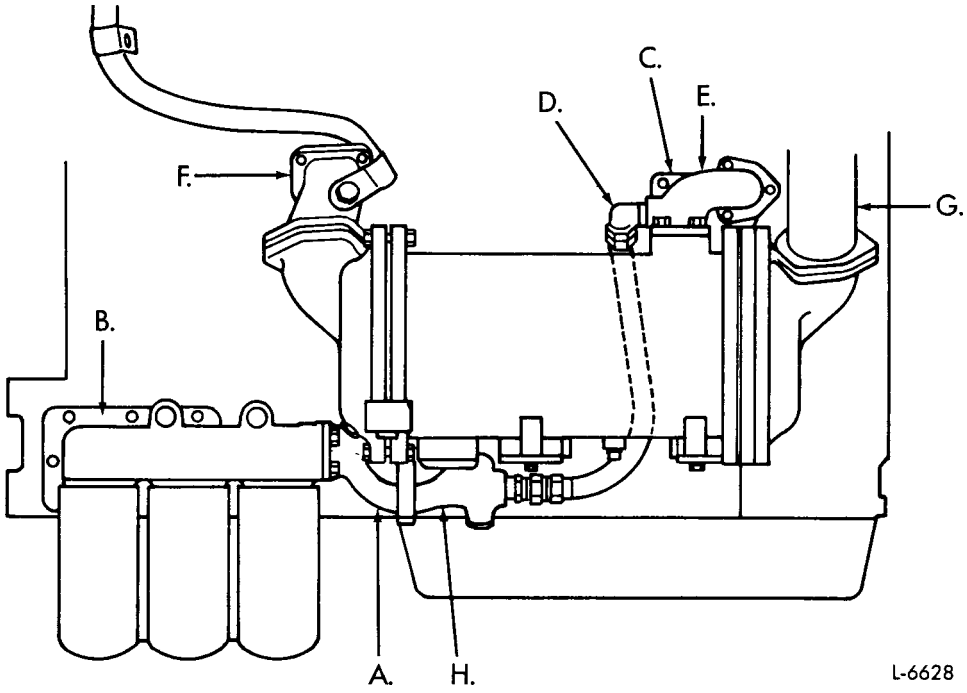


Fig. 9 - 8V-149 Oil Cooler Installation

12. Using a new seal, attach oil inlet/bypass elbow assembly (H) to oil filter outlet elbow (A) with flange, two (2) 3/8"—16 x 1 3/8"L bolts, one (1) 3/8"—16 x 1 5/8" L bolt and one 3/8 1 6 nut (bottom, outboard), and lockwashers. Install loose. Do not tighten at this time.
13. Attach oil inlet/bypass elbow assembly (H) to bottom rear of oil cooler housing with four (4) 1/2"—13 x 1 1/2"L bolts and lockwashers. Tighten to 71-75 lb—ft (96-102 N*m) torque.
14. Tighten the 3/8"—16 bolts holding oil inlet/bypass elbow assembly (H) to oil filter outlet elbow (A) to 30-35 lb—ft (41-47 N»m) torque.
15. Install end of oil bypass hose assembly into connector in oil inlet/bypass elbow assembly (H).

•Install Tube And Shell Oil Cooler — 12V, 16V-149 Engines

Refer To Fig. 10

1. Using a new gasket, attach oil cooler outlet (A) to oil filter adaptor (B) with three (3) l/2"-13 x 1.50" bolts, one (1) 1/2"—13 x 1 1/4" bolt (left, upper outer hole), and lockwashers. Tighten bolts to 71-75 lb—ft (96-102 N«m) torque.
2. Attach front and rear oil cooler mounting brackets loosely to side of block with eight (8) l/2"-13 x 1 3/8" bolts and lockwashers, and two (2) 7/16"-14 x 1 1/4" bolts and lockwashers (front bracket only). Do not tighten at this time.
3. Using a new gasket, attach oil cooler outlet tube assembly (C) to block with four (4) 1/2"—13 x 3.00" bolts and lockwashers. Mount loosely. Do not tighten at this time.
4. Slip two (2) flanges and new seals onto oil filter bypass tube (D). Slip open end of bypass tube into oil cooler outlet tube assembly (C). Using a new gasket and two (2) 3/8"—16 x 1.135" bolts and lockwashers, install bypass tube onto oil filter adaptor (B). Tighten bolts to 3CU35 lb-ft (41—47 N*m) torque.
5. Secure bypass tube bracket to block with one (1) 7/16"-14 x 3/8" bolt and lockwasher. Tighten to 46-50 lb-ft (62-68 N*m) torque.
6. Using fabricated oil cooler mounting bracket alignment tool (refer to Shop Notes, Section 4.0), align oil cooler mounting brackets and tighten attaching bolts. Tighten 1/2"—13 bolts to 71-75 lb-ft (96-102 N*m) torque. Tighten 7/16"—14 bolts to 46-50 lb-ft (62-68 N»m) torque.

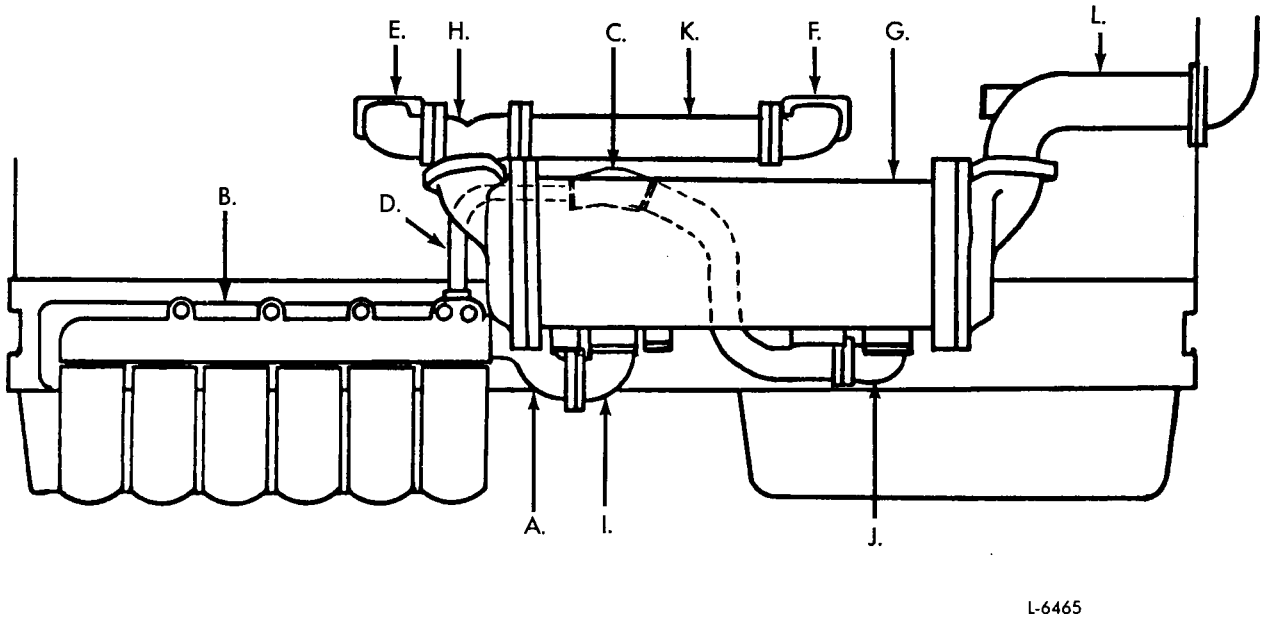


Fig. 10 - Tube and Shell Oil Cooler Mounting 16V-149 Engine Mounting Shown

7. Attach rear water elbow (E) and front water elbow (F) to block using new gaskets and eight (8) 3/8"-16 x 1.25" bolts and lockwashers. Tighten front elbow mounting bolts to 30-35 lb—ft (41^-7 N*m) torque. Do not tighten rear elbow at this time.

8. Apply Formagasket to left outlet flange of oil cooler (G), place new gasket on flange, and install water outlet tee (H) using three (3) 3/8"—16 x 1.38 bolts. Tighten to 30-35 lb—ft (41—47 N»m) torque.

9. Using a hoist or other suitable means, properly support the oil cooler assembly and move to the engine. Two 1/2" dowels may be installed in the right and center cooler bases to aid in aligning cooler base bolt holes with brackets. When the oil cooler is in position, remove the two dowels and install six (6) 1/2-13 x 1 1/4" mounting bolts. Tighten to 71-75 lb—ft (96-102 N*m) torque.

10. Slip flange and seal ring onto open end of oil filter outlet elbow (A). Insert open end into oil cooler inlet elbow (I). Then, using a new gasket and four (4) l/2"-13 x 1 1/2" bolts and lockwashers, install oil cooler inlet elbow to bottom left of oil cooler. Using two (2) 3/8"-16 x 1 3/8" bolts, one 3/8"-16 x 1.62" bolt, one 3/8" nut, and lockwashers, attach oil cooler inlet elbow (I) to oil filter outlet elbow (A). Install the 1.62" long bolt, the nut, and a lockwasher in the bottom bolt hole. Tighten the four 1/2" mounting bolts to 71-75 lb—ft (96-102 N«m) torque. Then tighten the 3/8" bolts to 30-35 lb—ft (4-1—47 N*m) torque.

11. Tighten the four l/2"-13 bolts holding the tube assembly (C) to the block to 71-75 lb—ft (96-102 N.*m) torque.

12. Slip flange and seal ring onto open end of tube assembly (C). Slip end of tube assembly into oil cooler outlet elbow (J). Using a new gasket, four (4) l/2"-13 x 1 1/2" bolts and lockwashers, attach outlet elbow to bottom right of oil cooler. Do not tighten at this time.

13. Using three (3) 3/8"-16 x 1" bolts and lockwashers, attach oil cooler outlet elbow (J) to flange on end of tube assembly. Install loose. After lining up elbow and tube assembly, tighten the four 1/2" elbow-to-cooler bolts to 71-75 lb—ft (96-102 N*m) torque. Then tighten the three 3/8" elbow-to-tube assembly flange bolts to 30-35 lb—ft (41-47 N*m) torque.

14. Tighten the two 3/8"—16 flange bolts holding the end of the bypass tube (D) to the oil cooler outlet tube assembly (C) to 30-35 lb—ft (41-47 N«m) torque.

15. Using flange, plate, a new gasket and seal ring, and three (3) 3/8"—16 x 1.62" bolts and lockwashers, attach oil cooler water outlet tee (H) to the rear water elbow (E). Snug all bolts. Then tighten the four rear elbow mounting bolts to 30-35 lb—ft (41—47 N*m) torque.

Tighten the three tee-to-elbow bolts to 30-35 lb—ft (41-47 N*m) torque.

16. Install tube assembly (K) between the tee and front water elbow. On left side install with flange, seal, plate, new gasket, and three (3) 3/8"—16 xl.62 bolts and lockwashers. On right side install with flange (w/tapped holes), gasket, plate, seal, flange (no tapped holes), three 3/8"—16 x 1.62" bolts and lockwashers. Tighten all bolts to 30-35 lb—ft (41-47 N*m) torque.

17. After installing water pump, install water pump outlet tube (L) to oil cooler using new gasket and three (3) 3/8"-16 x 1.38 bolts and lockwashers. Tighten to 30-35 lb—ft (41-47 N*m) torque.

.TUBE AND SHELL OIL)OLER BYPASS VALVE

To ensure lubrication if the tube and shell oil cooler should become plugged, a bypass valve is installed in the oil inlet/bypass elbow assembly on 8V engines and in the oil filter adaptor on 12V and 16V engines. The valve opens and allows the oil to bypass the oil cooler when the pressure at the inlet side exceeds the pressure at the outlet side by 26.5 psi (179 kPa).

Besides the valve housings which are machined into the elbow or adaptor, bypass valve components consist of a valve, spring, retaining plug, and gasket. Bypass valves should be disassembled, cleaned, inspected, and reassembled whenever the tube and shell oil cooler is removed from the engine.

Disassemble Oil Cooler Bypass Valve

1. Loosen and *slowly* remove the bypass valve retaining plug.

CAUTION: The valve plug is under spring pressure. To avoid possible personal injury, hold the plug securely while removing.

2. Remove the plug gasket and withdraw the spring and valve.

After Installing Oil Cooler

After installing the oil cooler on an 8V, 12V, or 16V-149 engine, proceed as follows:

1. Fill the cooling system to the proper level.
2. Add sufficient oil to bring the oil level to the proper mark on the dipstick.
3. Start and run the engine for a short period and check for oil or coolant leaks. After leaks have been corrected and the engine has been stopped long enough for the oil from various parts of the engine to drain back to the crankcase (approximately 20 minutes), bring the oil level up to the proper mark in the dipstick. Allow the engine to cool and add coolant as required to bring coolant to the proper level.

Inspection

Clean bypass valve components with fuel oil and dry with compressed air.

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

Inspect the valve and spring for wear or damage and replace them, if necessary. The bypass valve spring has an approximate free length of 2.73". Use spring tester J 22738-02 to check the spring load. When a force of 39.25 pounds or less will compress the spring to a length of 2.201", replace the spring.

Install Oil Cooler Bypass Valve

1. Apply clean engine oil to the outside surface of the bypass valve and place it in the bypass valve housing. Place the closed end of the valve toward the back of the housing cavity.
2. Insert the spring inside the housing and into the valve cup.
3. Place a new gasket on the retaining plug and install the retaining plug. Tighten the 1 1/16”—16 plug to 80-90 lb-ft (108-122 N*m) torque.

OIL LEVEL DIPSTICK

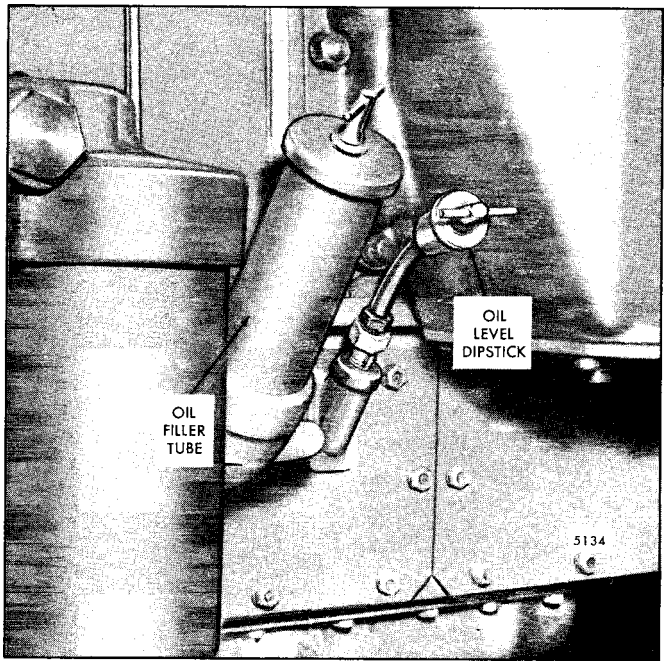


Fig. 1 - Typical Dipstick Mounting

A steel ribbon type oil level dipstick is used to check the quantity of oil in the engine oil pan. The dipstick is located in the side of the cylinder block or the oil pan (Fig. 1). The current engines include a 3/4" long rubber oil seal which prevents the escape of vapors carrying oil from the dipstick tube.

Maintain the oil level between the full and low marks on the dipstick and never allow it to drop below the *low* mark. No advantage is gained by having the oil level above the *full* mark. Overfilling will cause the oil to be churned by the crankshaft throws causing foaming or aeration of the oil. Operation below the low mark will expose the pump pick-up causing aereation and/or loss of pressure.

Check the oil level after the engine has been stopped for a minimum of twenty minutes to permit oil in the various parts of the engine to drain back into the oil pan.

NOTICE: Check the oil level at the start of each (8 hour) shift or before starting the engine.

Dipsticks are normally marked for use only when the equipment the engine powers is on a level surface. Improper oil levels can result if the oil level is checked with the equipment on a grade.

Fill the crankcase with oil as follows:

1. Fill the oil pan to the full mark on the dipstick.
2. Start and run the engine for approximately ten minutes.
3. Stop the engine and wait a minimum of twenty minutes. Then add the required amount of oil to reach the *full* mark on the dipstick. Each engine oil filter will require approximately two additional quarts (1.9 liters) of oil.

Marine Engines

Dipsticks in marine engines are located and marked to provide the proper oil level at any angle within the recommended maximum installation angle applicable to the specific boat.

In a properly filled crankcase, the oil level must be *below* the crankshaft rear oil seal when the boat is at rest.

OIL PAN

The engine incorporates two oil pans: an upper oil pan and a lower oil pan (Fig. 1).

The upper oil pan is a one-piece iron casting on the 8V-149 engine and a two-piece iron casting on the 12 and 16V-149 engines, with a series of hand hole plates located along each side. These plates provide access to the connecting rod bearing caps, oil pressure regulator and relief valves, and oil pump.

The lower oil pan is a one-piece stamping which bolts to the upper oil pan and houses the main body of lubricating oil.

A baffle between the lower and upper oil pans ensures sufficient oil in the lower pan at all times (Fig. 2). Positive seal between the upper oil pan and the cylinder block is accomplished by a seal ring located in a machined groove around the top of the oil pan frame. Preformed gaskets provide a seal for the upper oil pan hand hole plates and between the upper and lower oil pan.

Remove Oil Pan

1. Remove the drain plug located in the bottom of the oil pan and drain the lubricating oil.
2. Remove the bolts and lock washers securing the lower oil pan to the upper oil pan and remove the lower oil pan, baffle and gaskets.
3. Remove the oil level dipstick and shroud assembly from the upper oil pan frame.
4. When the engine is equipped with the current turbocharger drain back hoses, loosen the bolts and remove the drain back elbow from the oil pan hand hole plate on each side of the upper oil pan.
5. On units equipped with a Torqmatic converter oil cooler, disconnect and remove the water outlet elbows located on each side of the engine at the upper oil pan hand hole plates (Section 4.4).
6. Remove the four 5/8"-11 bolts and shims securing the upper oil pan to the flywheel housing.
7. Remove the remaining bolts, nuts and lock washers holding the upper oil pan to the cylinder block and remove the oil pan and seal ring.

Inspection

Clean all of the parts with fuel oil and dry them with compressed air.

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

Inspect the lower oil pan for cracks or other damage.

Remove the hand hole plates from the upper oil pan and check the frame for cracks. Check the seal ring groove in the top of the upper oil pan for burrs or foreign material. Scrape all of the old gasket material from the oil pan and hand hole plates.

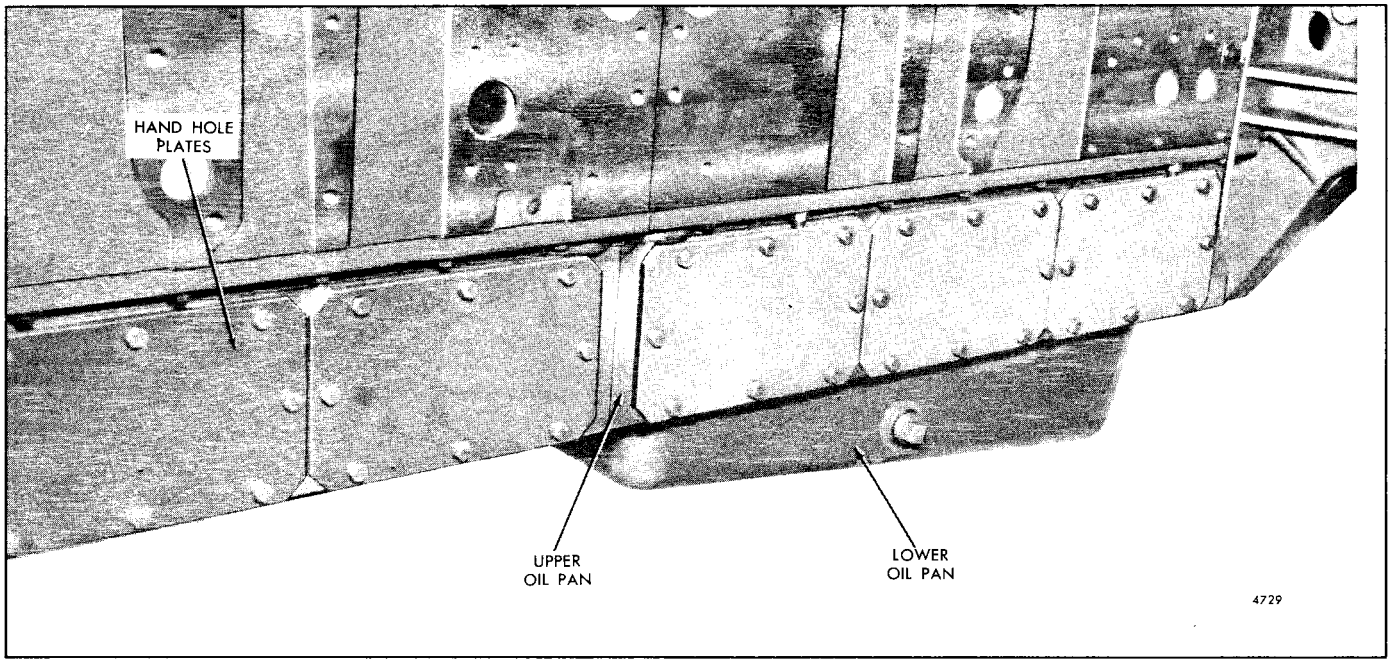


Fig. 1 – Oil Pan Installed on 12V–149 Engine

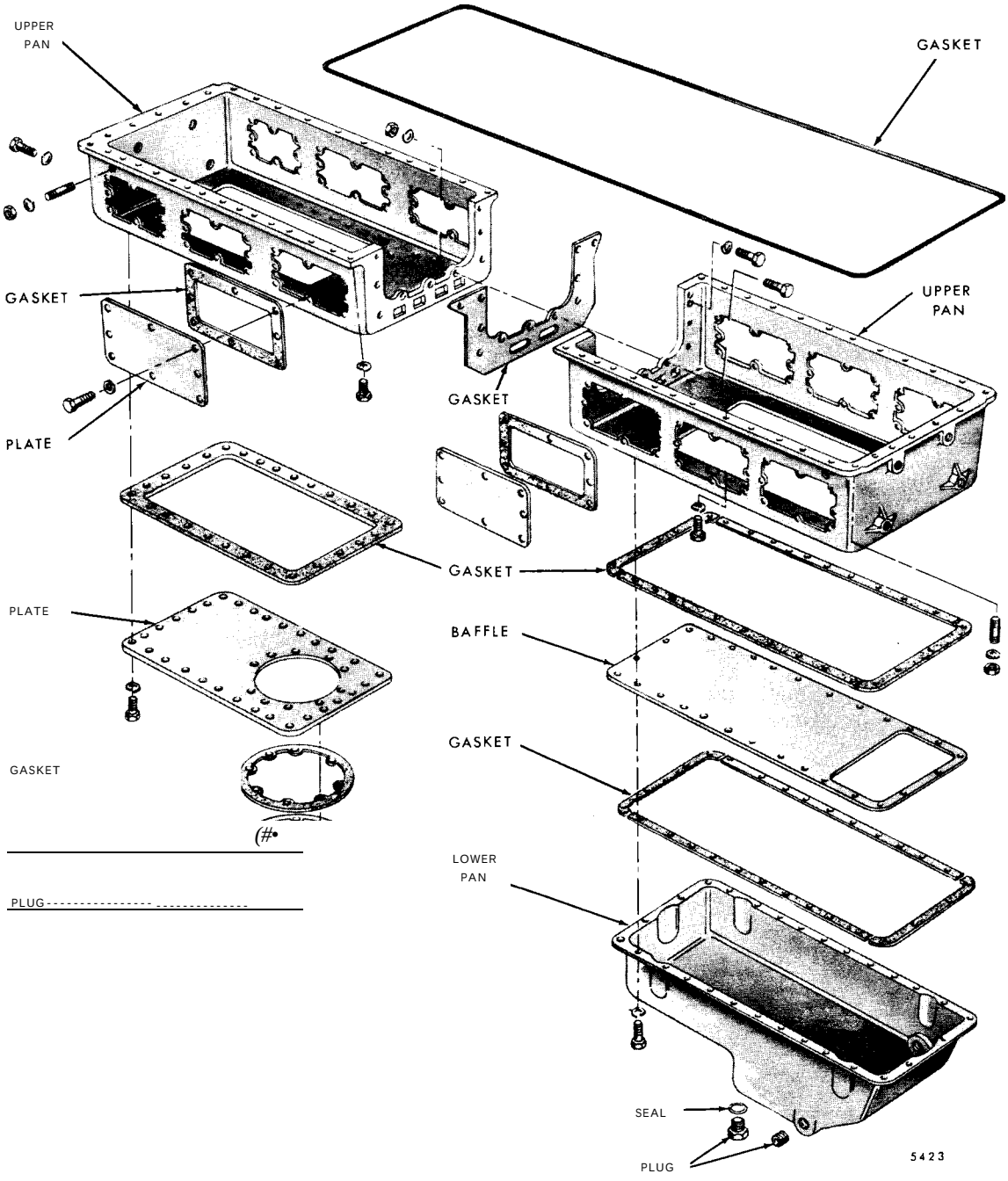


Fig. 2 - Typical Oil Pan and Relative Location of Parts

Assemble Oil Pan (Upper)

1. Refer to Fig. 2 and place a new gasket between the two oil pan halves. Install the seven l/2"-20 bolts, nuts and lock washers and the two 1/2"—13 bolts and lock washers. Tighten the l/2"-20 bolts to 83-93 lb—ft (113-126 N • m) torque and the 1 /2" -13 bolts to 71-75 lb-ft (96-102 N-m) torque. *Trim the excess gasket material flush on the sides and bottom of the seal ring groove to allow installation of the seal ring.*
2. Move a dial indicator across the top surfaces of the upper oil pans at the joint between the two pan halves. The mismatch, if any, between the top surfaces of the pans must not exceed .005" on either side.

Install Oil Pan

- 1. Apply a thin coat of 3M EC-1300 Rubber Adhesive, or equivalent, in the seal ring groove at the top of the upper oil pan and install a new seal ring. *The seal ring must lay flat in the groove and must not be twisted.*
- 2. Check to make sure mating surfaces of the block and upper oil pan are clean and free of nicks and burrs.
- 3. Position the upper oil pan against the cylinder block and secure it in place with bolts, nuts and lock washers. Tighten the bolts and nuts to 45-50 lb-ft (61-68 N • m) torque, except the 4 bolts on the bottom of the flywheel housing. Seclect shims to fill in the space between the flywheel housing and upper pan. Shims available are .010", .003" and .005" in thickness. Install the shims and tighten the bolts to 137-147 lb-ft (186-200 N*m) torque.

  NOTICE: Install the new scavenging oil pump inlet tube, if used, before installing the upper oil pan.

- 4. Install the upper oil pan hand hole plates, using new gaskets. Coat each side of gaskets with Permatex 3D Sealer, or equivalent, before installing. Secure each plate with bolts, nuts and lock washers as required. Tighten the bolts and nuts to 30-35 lb-ft (41-47 N • m) torque.
- 5. Apply Permatex Spray Adhesive to contact surfaces and place a new gasket around both the top of the lower oil pan and the baffle. Install the lower oil pan and baffle against the upper oil pan with twenty-eight 3/8"-16 bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 N-m) torque. Current oil pan attaching bolts are coated with a locking material. To reactivate the locking ability of the used bolts, apply a drop or two of Loctite J 26558-242, or equivalent, at reassembly.

6. On units equipped with a Torqmatic converter oil cooler, install the water outlet elbows (Section 4.4).
7. When the engine is equipped with the current turbocharger drain back hoses, install the drain back elbow, using a new gasket on the oil pan hand hole plate on each side of the upper oil pan. Tighten the bolts.
8. Install the oil level dipstick and shroud assembly on the upper oil pan.
9. Install the drain plug in the lower oil pan and tighten it to 25-35 lb-ft (34—47 N*m) torque. Fill the lubricating oil system to its proper level. Refer to Section 13.3 for the recommended grade of oil.
10. Run the engine for a short period and check for oil leaks. Then stop the engine and, after a minimum of twenty minutes, check the oil level. Add oil if necessary.

VENTILATING SYSTEM

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

Effective with engine serial numbers 12E-5672 and 16E-5308 breathing is through a cast breather body, element, screens and retainers mounted on the valve rocker cover (Fig. 1), as well as through passages in the joint face of the cylinder blocks. The cast body is mounted on the left bank front and right bank rear rocker covers for naturally aspirated engines and is mounted on all the rocker covers except the right bank front cover for turbocharged engines.

Certain engines have an additional steel breather assembly mounted on the flywheel housing.

On former turbocharged engines a steel breather and oil separator assembly are mounted on two of the four valve rocker covers (Fig. 2).

On early naturally aspirated and turbocharged engines breathing is through the passages in the joint face of the blocks and through elbows and piping mounted on the air box cover plate of the rear cylinder block (Figs. 3 and 4).

The breather pipes and elbows should be kept clean for efficient breathing and inspected periodically for damage that would restrict breathing.

Both the early, former and new breather systems will be serviced. When installing the new cast breather assembly on former or early engines, new rocker covers are required because of breather and turbocharged interferences. The new rocker covers are the same as the former covers, except that the 19.36" dimension locating the breather mounting pad is now 10.08". Both the former and new rocker covers are serviced. Also new cylinder block air box cover plates are required. This is due to the elimination of the two 1.56" diameter breather system holes. Both the former and new cover plates are serviced.

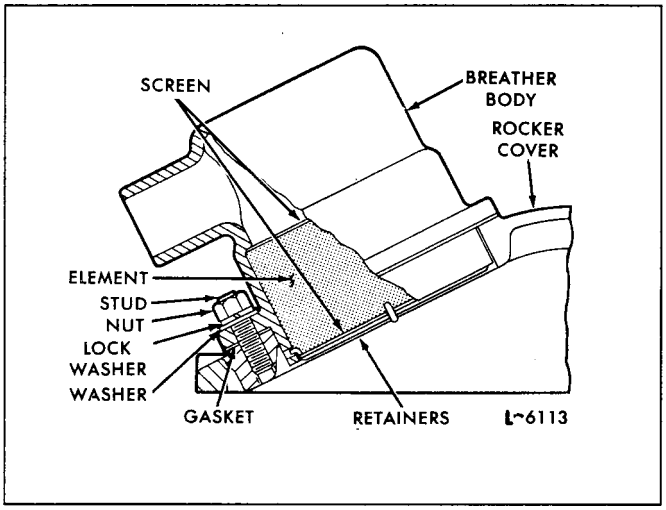


Fig. 1 - Engine Breather Mounting (Current Engines)

SERVICE

If for any reason a new cast breather housing and rocker cover are installed on a former naturally aspirated engine, it will be necessary to replace the air box cover plate or seal off the vent holes in the former plate and cylinder block. Refer to Shop Note “Breather Hole Plugs in Cylinder Block” in Section 1.0. The new breather housing cannot be mounted on the former rocker covers of turbocharged engines due to turbocharger interference.

Remove Early Breather Tubing

1. Remove the bolts, flat washers and lock washers securing the breather pipe assembly to the air box cover plate.

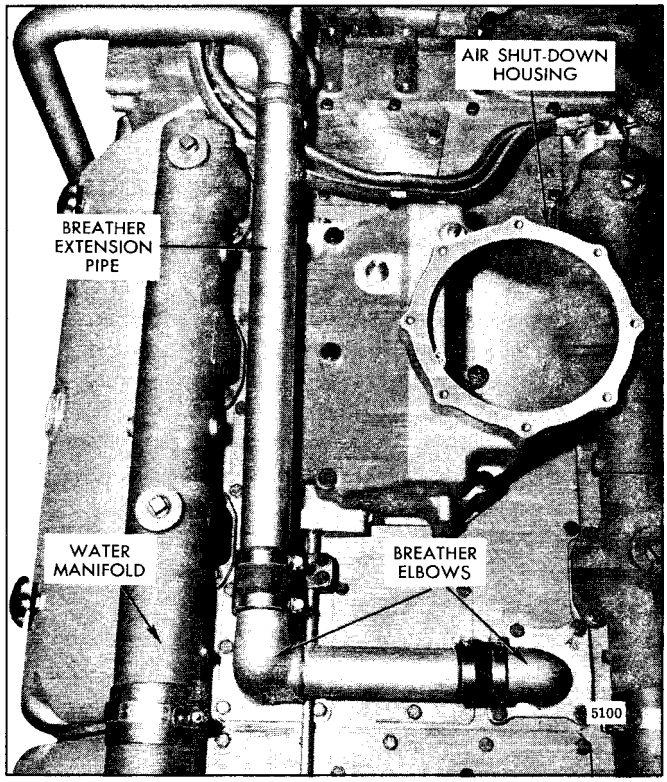


Fig. 2 - Engine Breather Mounting (Former Naturally Aspirated Engines)

2. Remove the bracket holding the breather pipe extension to the cylinder block.
3. Loosen the hose clamps and separate the breather pipes.
4. Remove the breather elbows and gaskets from the engine.

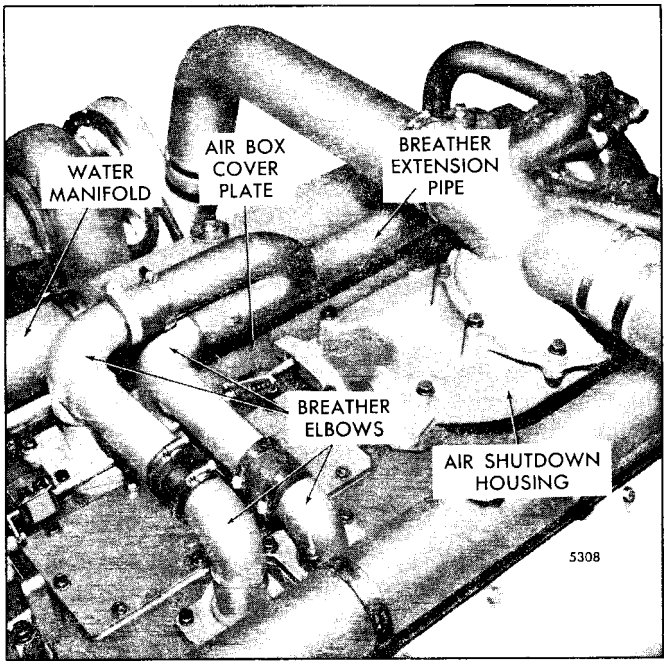


Fig. 3 - Engine Breather Mounting (Early Turbocharged Engines)

Inspection

Clean the breather assembly and inspect the former and early breather pipes and elbows for any damage that would restrict engine breathing.

The current cast breather housing assembly can be removed for cleaning without removing the rocker cover. This is not the case with the steel breather assembly.

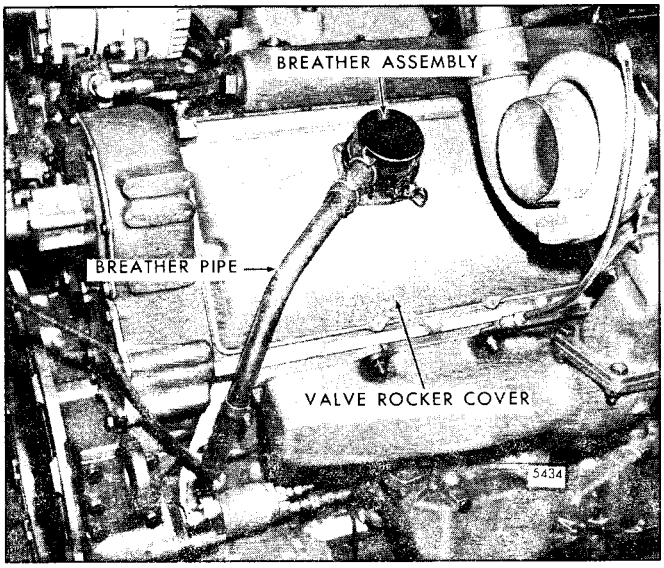


Fig. 4 - Engine Breather Mounted on Valve Rocker Cover (Former Turbocharged Engines)

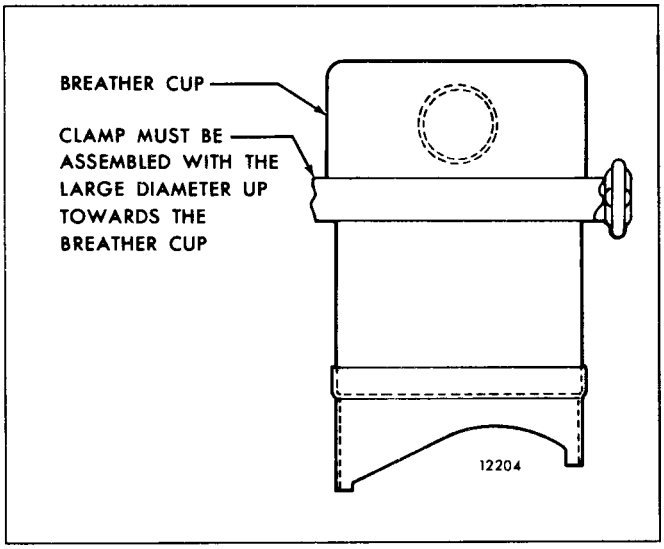


Fig. 5 - Correct Installation of Breather Clamp

The cylinder block breather system formerly used on naturally aspirated engines has been eliminated, however, the various tubes will continue to be serviced. When adding the valve rocker cover breather system (Fig. 1) to a naturally aspirated or a turbocharged engine it is necessary to remove the former breather tubing and seal the air box openings on the top of the cylinder block with covers and gaskets.

Install Early Breather Tubing

1. Use new gaskets and install the breather elbows. Tighten the 3/8"-16 bolts to 30-35 lb-ft (41-47 N.m) torque. There are different gaskets for the right and left bank breather elbows.
2. Install the breather pipe extension and tighten the hose clamps.
3. Connect the breather pipe extension to the bracket with a 3/8" bolt, nut and lock washer.

Service

The breather assembly mounted on the flywheel housing, or the valve rocker cover on former turbocharger engines (Fig. 4), consists of a wire mesh pad, a steel shell and a breather body. The pad filters out any oil which may be present in the crankcase vapors. A slot in the shell permits the oil to drain back to the crankcase. Clean the breather pad with fuel oil and dry it with compressed air.

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

NOTICE: Be sure the pad covers the slot in the shell.

The element in the breather assembly mounted on the valve rocker cover should be cleaned if excessive crankcase pressure occurs. Also clean the breather pipe.

NOTICE: Dirt can collect around the breather clamp. Clean out the dirt thoroughly before disassembling the breather.

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

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

When reassembling the breather, *be sure the clamp is installed with the large (open) diameter facing up* as illustrated in Fig. 5. If the clamp is improperly installed, it could eventually loosen.

SHOP NOTES - SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

REPAIRING OIL COOLER HOUSINGS WITH WORN SEAL BORES

Engine oil cooler housings with worn oil cooler core inlet and outlet O-ring seal bores (Fig. 1) can be restored to serviceable condition if the bores are machined oversize and sleeved. Use the following procedure.

1. Rework the housing by reaming all four seal bore holes to 1.618" + .002" diameter. Break top of hole edges .010" maximum (Fig. 2).
2. Cut four .88" long sleeves from SAE 1010-1020 mild steel tube stock having a finished outside diameter that will provide a sleeve-to-bore press fit of .0005" to .0015" (Fig. 3). Outside surfaces of the sleeves must be smooth and free from burrs. Chamfer (break) the outside edge on one end of each sleeve 15° - 20° for lead into housing.
3. Wash all cuttings from the housing and sleeves with clean mineral spirits and dry with compressed air.

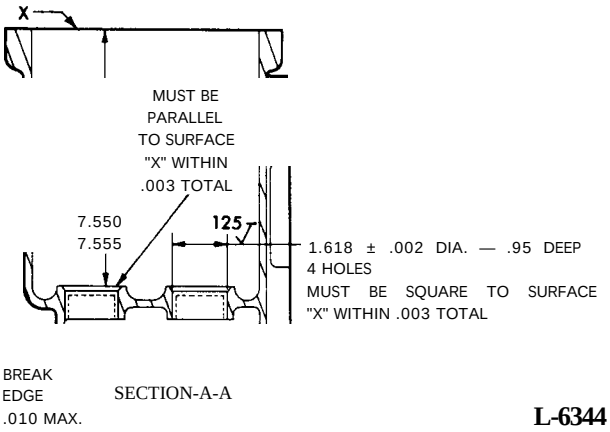


Fig. 2 - Initial Machining of Used Housing

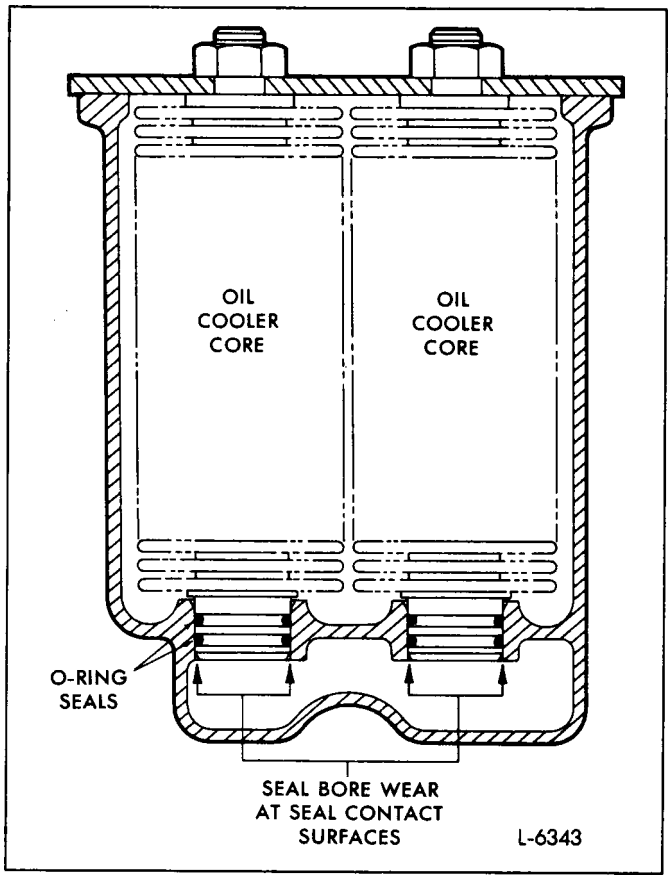


Fig. 1 - Oil Cooler Housing with Seal Bore Wear Area

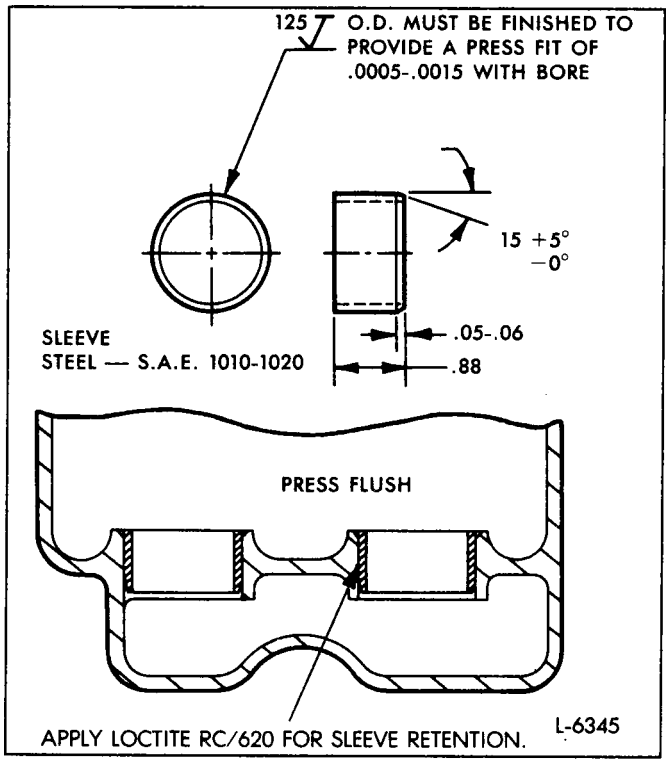


Fig. 3 – Machined Sleeve Pressed into Housing

CAUTION: Do not exceed 20 psi (138 kPa) air pressure. Wear adequate eye protection and provide proper ventilation to avoid personal injury.

4. The sleeve and all mating part surfaces must be free of oil, grease or other contaminants. Use a chlorinated solvent or suitable degreaser on a clean, dry rag to wipe parts clean. Allow to dry completely after cleaning.

CAUTION: To avoid personal injury, clean parts in a properly ventilated area, wear adequate safety equipment (face guard, gloves, etc.), and observe safety precautions recommended by the cleaning product manufacturer.

5. Coat the inside of the housing bores and the outside of the sleeves with a continuous film of Loctite RC/620 retaining compound, or equivalent (Fig. 3).

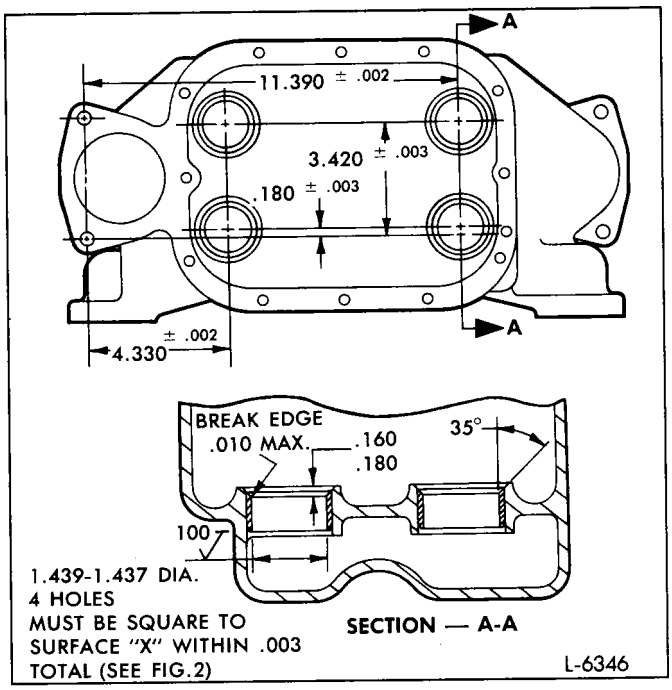


Fig. 4 – Final Machining of Housing

6. Start the sleeves into the housing bores chamfered ends first and press the sleeves in until flush with the top of the casting (Fig. 3).

7. Remove excess compound with a clean dry cloth. *Do not use solvent.* Loctite RC/620 develops fixturing strength in approximately 15 minutes. Full cure takes approximately 4 hours.

8. Ream the sleeves to provide an inside diameter of 1.437" to 1.439". After reaming, machine a 35° chamfer into the top end of the sleeves and housing to a depth of .160" to 180" (Fig. 4).

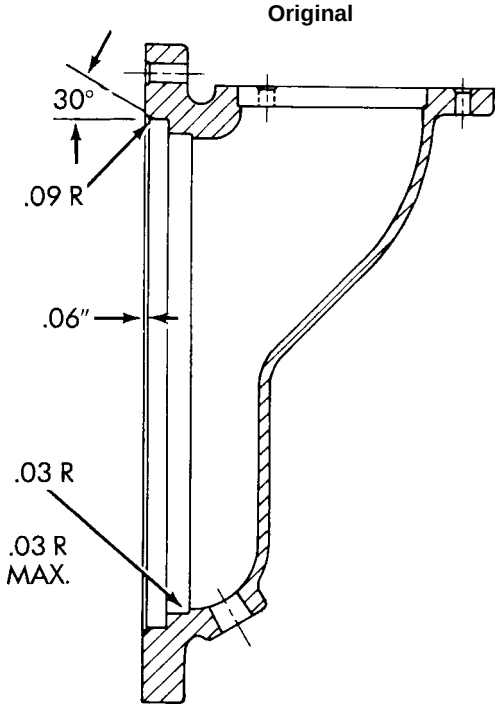
9. Wash all cuttings from the housing. After cleaning, inspect the housing carefully. The beveled openings and inside of the sleeves must be free from burrs and sharp edges to avoid damaging the oil cooler core seal rings at assembly.

.REWORK INSTRUCTIONS

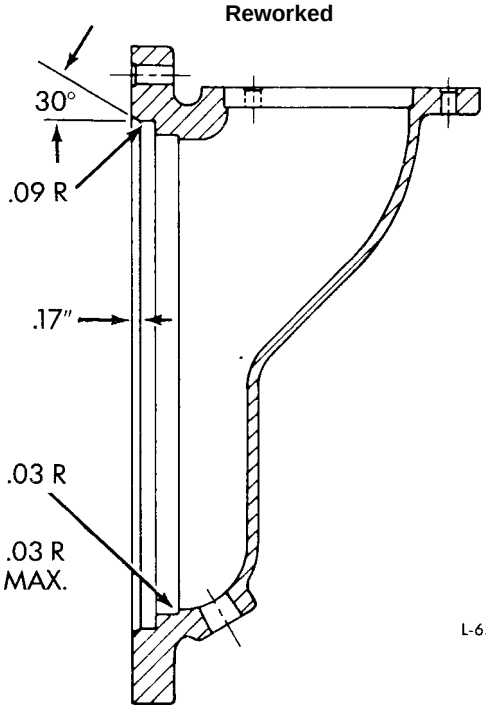
TUBE AND SHELL OIL COOLER WATER INLET HOUSING

Before installing new seals in a cooler assembly having the former water inlet housing, the lead-in chamfer must be machined to a depth of .17" by a reliable machine shop. The original and reworked housings are shown below.

Original



Reworked



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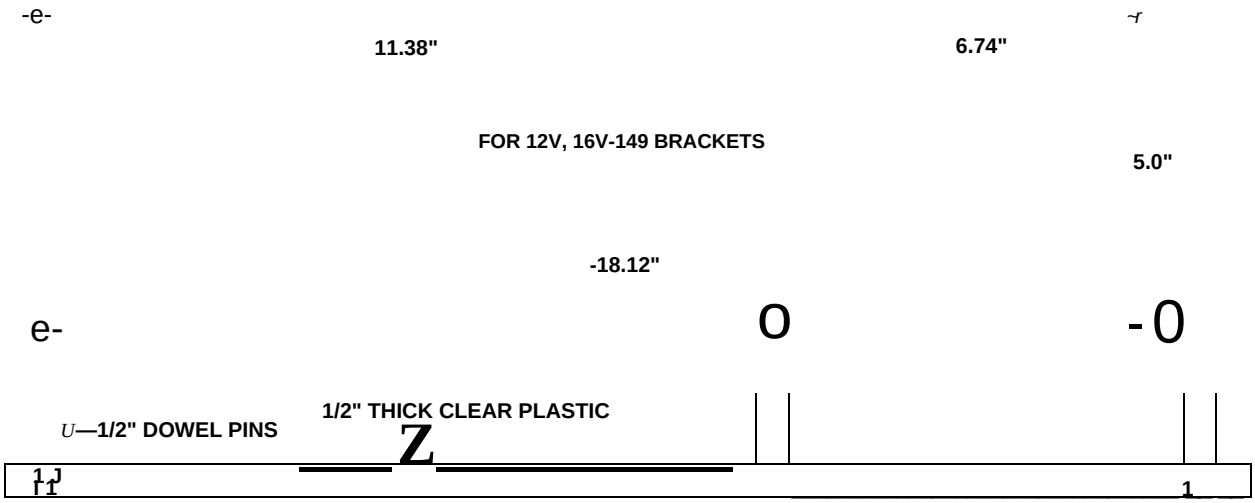
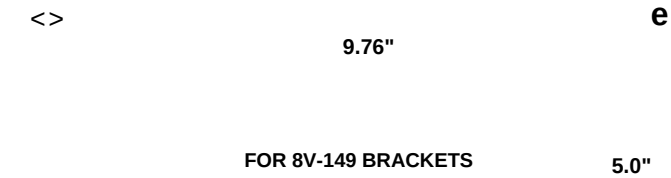
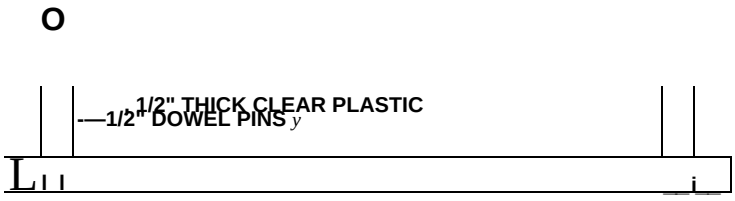
NOTE: The angle and radius of the counterbone remain the same.

TUBE AND SHELL OIL COOLER MOUNTING BRACKET ALIGNMENT TOOL







NOTE: DIMENSIONS SHOWN ARE HOLE CENTER TO HOLE CENTER

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb—ft)	N»m	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	l\Um
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 Idenlification Marking on Boll 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
— H e x 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

BOLT IDENTIFICATION CHART

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD	TORQUE (lb—ft)	TORQUE (N*m)
Lubricating oil filter center stud	5/8-18	50-60	68-81
Oil cooler bypass retaining plug	1 1/16-16	80-90	108-122
Oil cooler core stud nuts	3/4-10	70-80	95-108
Oil filter bypass valve plug	1 1/4-16	95-105	129-143
Oil filter bypass valve plug	1 1/2-6	110-130	150-177
Oil pan drain plug (nylon washer)	18MM	25-35	34—47

SERVICE TOOLS

TOOL NAME	TOOL NO.
Spring checking gage	J 22738-02
Strap wrench (spin-on filter)	J 24783

SECTION 5

COOLING SYSTEM

CONTENTS

COOLING SYSTEM

To effectively dissipate the heat generated by the engine, one of three different types of cooling systems is used on the Series 149 engines; radiator and fan, heat exchanger and raw water pump, or keel cooling. Each system is provided with a centrifugal type water pump that circulates the engine coolant. Each system incorporates thermostats to maintain a normal engine operating temperature (refer to Section 13.2).

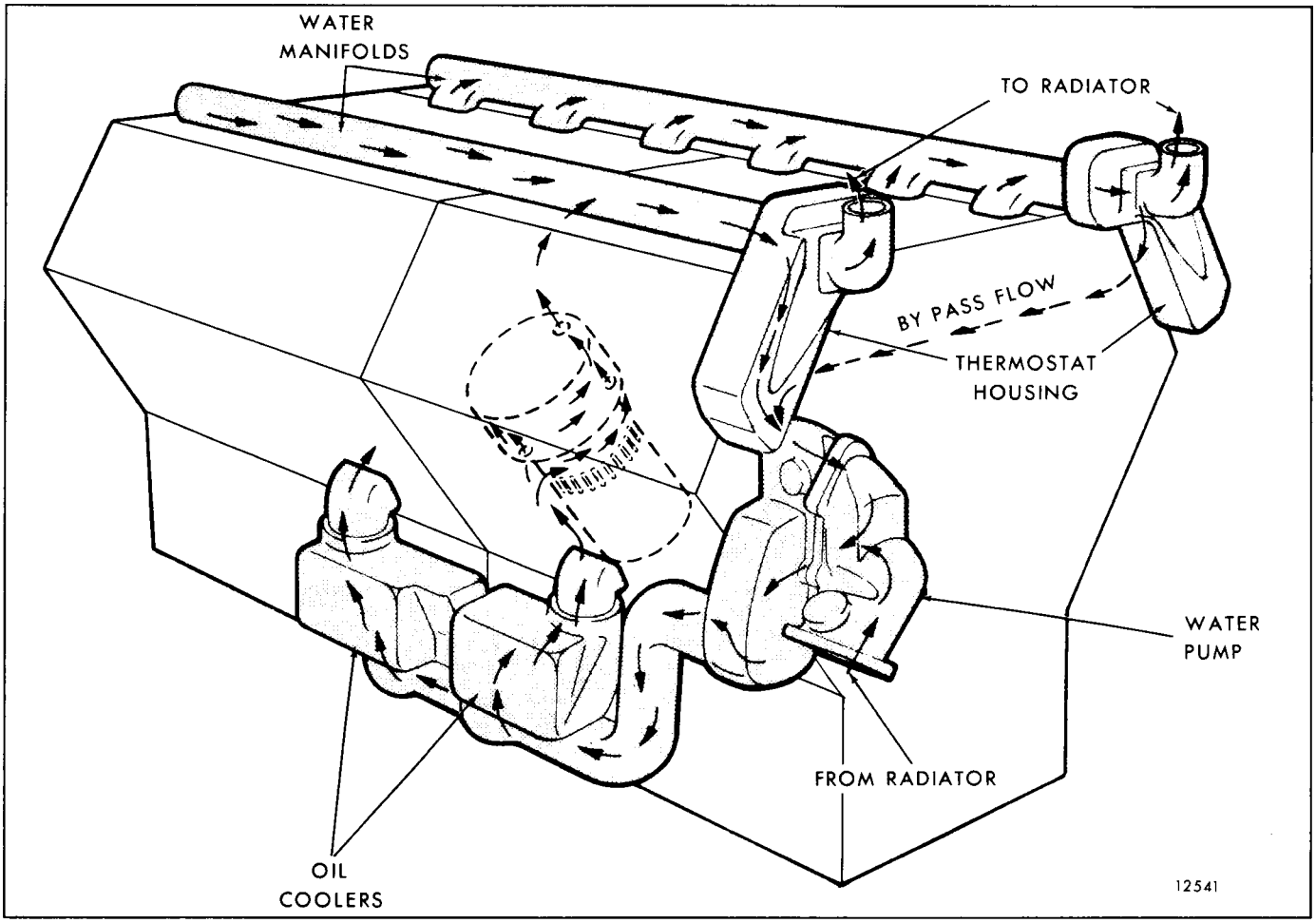


Fig. 1 – Schematic Diagram of Typical Engine Cooling System

RADIATOR COOLING SYSTEM

Coolant is drawn from the lower portion of the radiator by the water pump and is forced through the oil cooler housing and into the cylinder block (Fig. 1).

From the cylinder block, the coolant passes up through the cylinder heads into the water manifold and, when the engine is at normal operating temperature, through the thermostats into the upper portion of the radiator. The coolant passes down a series of tubes where its temperature is lowered by the air stream created by the revolving fan.

Upon starting a cold engine or when the coolant is below operating temperature, the coolant is restricted at the thermostats and a bypass provides water circulation within the engine during the warm-up period.

HEAT EXCHANGER COOLING SYSTEM

In the heat exchanger cooling system, the coolant is drawn by the engine water pump from the heat exchanger and is forced through the engine oil cooler, cylinder block, cylinder heads, exhaust manifolds and water manifolds to the thermostat housings. A bypass from the thermostat housings to the inlet side of the water pump permits circulation of coolant through the engine when the thermostats are closed. When the thermostats are open, the coolant flows through the heat exchanger where it is cooled.

Engine driven raw water pumps circulate raw water (sea water) through the heat exchanger to lower the temperature of the engine coolant.

KEEL COOLING SYSTEM

In the keel cooling system, the coolant is drawn by the engine water pump from the keel cooler and is forced through the engine oil cooler, cylinder block, cylinder heads and exhaust manifolds and to the thermostat housings. A bypass from the thermostat housings to the inlet side of the water pump permits circulation of coolant through the engine when the thermostats are closed. When the thermostats are open, the coolant flows through the keel cooling coils to be cooled.

The heat of the engine coolant is transferred through the coils of the keel cooler to the surrounding sea water.

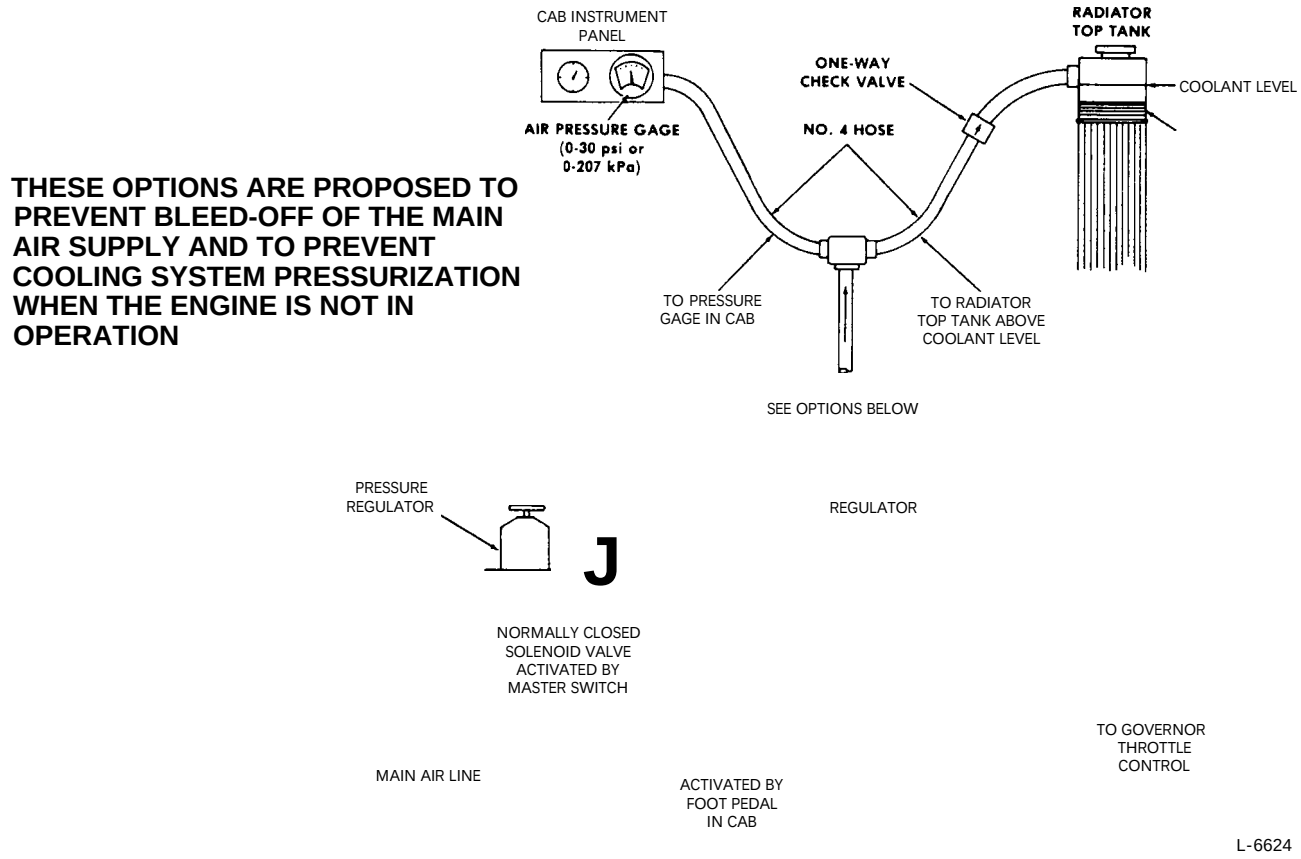


Fig. 2 - Pressurized Top Tank Installation

COOLING SYSTEM REQUIREMENTS FOR DIRECT RADIATOR-COOLED ENGINES

Pressurized Cooling System

The cooling system must be pressurized to operate properly. Pressure in the cooling system prevents cavitation, suction leaks and localized boiling.

System pressure is produced by the expansion of the coolant as it is heated. Checking the coolant level while coolant temperature is hot will result in a loss of this pressure. This pressure may not be completely restored until the system is allowed to cool and then heated again. To avoid this situation an auxiliary air supply is required to maintain system pressure (see Fig. 2). The pressure from this air supply should be regulated to 7-10 psi (48.3-68.9 kPa).

MAXIMUM ENGINE COOLANT TEMPERATURE

The heat dissipating capacity of the Series 149 engine cooling system and related components must be sufficient to prevent the engine coolant-out temperature from rising above 200°F (93.3°C). This temperature must not be exceeded under any engine operating condition, regardless of altitude, type of coolant used, or cooling system condition.

When the cooling system is sized properly, the engine will operate under thermostat control so that the coolant-out temperature is between 170°F and 187°F (76.7°C-86°C) the majority of the time. Maximum engine life will be obtained when the engine is operating under thermostat control. Coolant temperatures above 187°F (86°C) are out of thermostatic control and will rise on a 1 to 1 basis with an increase in the ambient air temperature.

Site Conditions:	
Operating site altitude	**8000 Feet**
Maximum recorded temperature at nearest official temperature recording station	**IOf F (38.36°C)**
Site temperature difference compared to nearest temperature recording station	**+ 4° F (2.22°C)**
Special site conditions	**2° F (1.11° C)**
Type of coolant (Ethylene Glycol/Water)	**50/50 Mix**
Calculations:	
Maximum allowed coolant-out temperature	**200° F (93°C)**
Altitude compensation (2° F/1000 Ft) 8000 Ft/1000 +2° F	**-16° F (-8.89° C)**
Maximum recorded temperature	**-101° F (-56.16° C)**
Temperature difference, operating site to official weather station	**—4° F (-2.22° C)**
Recirculation effects	**—2° F (-1.11° C)**
Coolant compensation	**—6° F** *(-3.33C)*
Cooling index requirement (ATW) Corrected to sea level	**71° F (21.7° C)**
Conclusions:	
The measured cooling index (ATW) for this application must be 71° F (21.7° C) or less to qualify at this operating site.	

Fig. 3 - Sample Calculation for Determining Required Cooling Index

COOLING INDEX

The cooling index is a measurement that represents differences between the stabilized coolant-out temperature and the true ambient air temperature while the engine is operating under full load conditions at rated speed with the thermostats fully open. This temperature difference is referred to as "ATW" (air-to-water) and indicates the performance of the cooling system. The cooling index is corrected to sea level so that it can be compared to cooling index requirements for specific operating sites. Smaller ATW values have greater cooling capability than larger ATW values.

A *new measured cooling index must be determined if changes are made to the application that influence engine cooling. These changes include increasing the horsepower, altering fan pitch, fan size, shrouding or baffles around the radiator, any site condition or operating location changes.*

COOLING INDEX REQUIREMENT

The *cooling index requirement* is a calculated number representing the maximum allowable cooling index (ATW) that will provide adequate engine cooling. This number is based on the requirement that the engine coolant-out temperature must not exceed 200°F (93.3°C) during the most severe ambient conditions for a specific operating site. The number is calculated by applying correction factors for altitude, maximum operating temperature, and type of coolant from the maximum engine coolant-out temperature. A brief description of these parameters follows (see Fig. 3 for sample calculation):

ALTITUDE

Increasing altitude reduces air density and the ability of the cooling system to dissipate engine heat to the air. Higher altitudes will increase the cooling index by 2°F (1.1°C) per 1000 feet (305m). Altitude corrections to sea level are applied to the cooling index and the

cooling index requirement for comparative purposes. Minimum cap pressure at all altitudes is 14 psi (96.6 kPa).

MAXIMUM OPERATING SITE TEMPERATURE

When calculating the cooling index requirements, the maximum ambient temperature for the operating location must be determined. To establish this temperature, the nearest official weather recording station must be consulted to determine the highest ambient temperature ever recorded at that station. Once this is established, the difference between that station and the operating site must be determined. For example, a characteristic of deep pit mines is that the pit tempertaure can be as much as 30°F (16.7°C) higher than the ambient temperature recorded in the nearest official temperature recording station. Combining the maximum weather station recorded temperature with the difference of the operating site and weather station temperatures, will extablish the maximum ambient temperature design criteria for the cooling system. Furthermore, additional variations in ambient temperature can occur on the same haul road due to tail winds causing recirculation of air around the radiator, pit wall radiated heat, etc. *Actual tests should be conducted to establish the highest ambient temperature encountered during a haul cycle, including the effect of winds and radiated heat.*

ENGINE COOLANT

The use of ethylene glycol antifreeze reduces the ability of the cooling system to dissipate heat. For example, a 50/50 mixture of water and ethylene glycol (the maximum concentration of antifreeze recommended by DDC) will increase the measured cooling index by 6°F (3.3°C). Water is generally used for the coolant when the cooling test is performed. Therefore, *the cooling index requirement must be reduced by* 6°F *(3.3°C) if antifreeze is to be used in the application.*

SHORT DURATION FULL LOAD OPERATION

In cases where *full-fuel* operation is less than 8 minutes and the duty cycle *will not* increase, test data has shown that the cooling index requirement can be increased. *Written concurrence by DDC's Engineering Department is necessary to exceed the cooling index requirement.*

ENGINE COOLING SYSTEM MAINTENANCE

The function of the engine coolant is to absorb the heat, developed as a result of the combustion process in the cylinders, from components such as exhaust valves, pistons and cylinder liners which are surrounded by water jackets. In addition, heat absorbed by the oil is also removed by the engine coolant in the oil-to-water oil cooler. When operating within the proper temperature range and not exceeding the recommended horsepower output of the unit, all engine parts will be within their design operating temperature range and at their proper operating clearances. Coolant must be properly selected and maintained (refer to Section 13.3 for *Coolant Specifications).*

A pressurized cooling system, which normally operates at temperatures higher than a non-pressurized system, is used. It is essential that the cooling system is kept clean and leakproof, that the filler cap and pressure relief mechanism be correctly installed and that the coolant level be properly maintained.

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.

Cooling System Capacity

The capacity of the basic engine cooling system (cylinder block, cylinder heads, water manifolds, thermostat housings and oil cooler housing) is shown in Table 1. These quantities do not include the capacity of the radiator, hoses or related parts.

BASIC ENGINE COOLANT CAPACITY

BASIC ENGINE	QUARTS	LITERS
8V-149TI (Standard)	91	86.1
8V-149TI (Large)	95	89.9
12V-149	142	134.4
12V-149T	142	134.4
12V-149TI (Standard)	148	140.1
12V-149TI (Standard, T&S)	147	139.1
12V-149TI (Large, T&S)	151	142.9
16V-149	175	165.6
16V-149T	175	165.6
16V-149TI (Standard)	182	172.2
16V-149TI (Standard, T&S)	181	171.3
16V-149TI (Large, T&S)	187	177.0

"Standard" and "Large" Indicate Size of Intercoolers.
"T&S" Means Tube and Shell Oil Cooler.

TABLE 1

Fill Cooling System

To permit proper filling of the cooling system, it is necessary that an air bleed hose be installed between the top

of each thermostat housing and the radiator top tank (Section 5.3), or the top of the expansion tank (Section 5.5).

Before starting the engine, close all of the drain cocks and fill the cooling system with coolant (refer to Section 13.3). If the unit has a raw water pump, it should be primed, since operation without water may cause impeller failure. Start the engine and, after the normal operating temperature has been reached, check the coolant level. The coolant level should be within two inches of the top of the filler neck.

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.

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

Drain Cooling System

To ensure that all of the coolant is drained completely from a unit, all cooling system drains should be opened. Should any entrapped water in the cylinder block or radiator freeze, it will expand and may cause damage. When freezing weather is expected, drain all units not adequately protected by antifreeze. Leave all drain cocks open until refilling the cooling system.

The engine coolant is drained by opening the drain cocks and removing the cooling system filler cap. Removal of the filler cap permits air to enter the cooling passages and the coolant to drain completely from the system.

Drain cocks are located on each side of the cylinder block at both the front and rear of the engine. The drain cocks are below the exhaust manifold.

In addition to the cylinder block drains, the oil cooler housing has a drain cock at the extreme bottom. Radiators are drained by opening a drain cock in the bottom of the tank.

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

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

An engine equipped with intercoolers has a cone shaped water filter (screen) at the water connection in the water pump to the engine oil cooler tube. Refer to Section 15.1 for service and preventive maintenance.

Flushing

If a coolant filter or corrosion inhibitor supplement is used and properly maintained, the cooling system need not be flushed. However, if the cooling system was not properly protected, drain and flush the cooling system each fall. Examine the cooling system for contamination and, if necessary, chemically clean it. Perform the flushing operation as follows:

1. Drain the coolant from the engine.
2. Refill with soft clean water.

   NOTICE: If the engine is hot, fill *slowly* to prevent rapid cooling and distortion of the engine castings.
3. Start the engine and operate it for fifteen minutes to thoroughly circulate the water.
4. Drain the engine completely.
5. Refill with the solution required (refer to Section 13.3).

Cooling System Cleaners

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

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

Reverse Flushing

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

The radiator is reverse flushed as follows:

1. Remove the radiator inlet and outlet hoses and replace the radiator cap.
2. Attach a hose at the top of the radiator to lead water away from the unit.

3. Attach a hose to the bottom of the radiator and insert a flushing gun in the hose.
4. Connect the water hose of the gun to the water outlet and the air hose to the compressed air outlet.
5. Turn on the water and, when the radiator is full, turn on the air in short blasts, allowing the radiator to fill between air blasts.

   NOTICE: Apply air gradually. Do not exert more than 30 psi (207 kPa) air pressure. Too great a pressure may rupture a radiator tube.
6. Continue flushing until only clean water is expelled from the radiator.

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

1. Remove the thermostats and the water pump.
2. Attach a hose to the water inlet of the cylinder block or cylinder head to drain the water away from the engine.
3. Attach a hose to the water outlet at the top of the cylinder block or cylinder head and insert the flushing gun in the hose.
4. Turn on the water and, when the water jackets are filled, turn on the air in short blasts, allowing the block or head to fill with water between air blasts.
5. Continue flushing until the water from the engine runs clean.

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

Miscellaneous Cooling System Checks

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

When water connection seals and hoses are installed, be sure the connecting parts are properly aligned and the seal or hose is in its proper position before tightening the clamps.

All external leaks should be corrected as soon as detected.

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

Contaminated Engines

When the engine cooling or lubricating system becomes contaminated, it should be flushed thoroughly to remove the contaminants before the engine is seriously damaged. One possible cause of such contamination is a cracked oil cooler core. With a cracked oil cooler core, oil will be forced into the cooling system while the engine is operating, and when it is stopped, coolant will leak into the lubricating system.

Coolant contamination of the lubricating system is especially harmful to engines when the cooling system is filled with an ethylene glycol antifreeze solution. If mixed with the oil in the crankcase, this antifreeze forms a varnish which can cause the engine to seize or result in severe bearing wear.

Make certain that the cause of the internal coolant leak has been corrected before flushing the contaminated systems.

Contaminants may be flushed from the engine systems as follows:

COOLING SYSTEM

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

1. Prepare a mixture of Calgon, or equivalent, and water at the rate of two ounces (dry measure) to one gallon of water.
2. Remove the engine thermostats to permit the Calgon and water mixture to circulate through the engine and the radiator or heat exchanger.
3. Fill the cooling system with the Calgon solution.
4. Run the engine for five minutes.
5. Drain the cooling system.
6. Repeat Steps 1 through 5.
7. Fill the cooling system with clean water.
8. Let the engine run five minutes.
9. Drain the cooling system completely.
10. Install the engine thermostats.
11. Close all of the drains and refill the cooling system with fresh coolant (refer to Section 13.3).

LUBRICATION SYSTEM

• When the engine lubricating system has been contaminated by an ethylene glycol antifreeze solution or other water soluble material, the following cleaning procedure, using DPM (Dipropylene Glycol Methyl Ether), or equivalent, is recommended.

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

1. Drain all of the lubricating oil.
2. Remove and discard the oil filter elements. Clean and dry the filter shells and replace the elements.
3. Mix two parts of DPM, or equivalent, with one part SAE 10 engine oil. Fill the engine crankcase to the proper operating level with the mixture.
4. Start and run the engine at a fast idle (1,000 to 1,200 rpm) for thirty minutes to one hour. Check the oil pressure frequently.
5. After the specified time, stop the engine and immediately drain the crankcase and the filters. *Sufficient time (approximately twenty minutes) must be allowed to drain all of the fluid.*
6. Replace the drain plugs and refill the crankcase with SAE 10 oil and run the engine at the same fast idle for ten or fifteen minutes and again drain the oil thoroughly.
7. Remove and discard the oil filter elements, clean the filter shells and install new elements.
8. Replace the drains and fill the crankcase to the proper level with the oil recommended for normal engine operation.
9. To test the effectiveness of the cleaning procedure, it is recommended that the engine be started and run at a fast idle (1,000 to 1,200 rpm) for approximately thirty minutes. Then, stop and immediately restart the engine. There is a possibility that the engine is not entirely free of contaminant deposits if the starting speed is slow.
10. If the procedure for cleaning the lubricating oil system was not successful, it will be necessary to disassemble the engine and to clean the affected parts thoroughly.

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

MAXIMUM ENGINE COOLANT TEMPERATURE

The heat-dissipating capacity of Series 149 engine cooling systems and related components must be sufficient to prevent the coolant temperature from rising above 200°F (93°C). This temperature must not be exceeded under any engine operating condition, regardless of altitude, type of coolant used, or cooling system condition. Exceeding this limit can result in malfunction or serious engine damage.

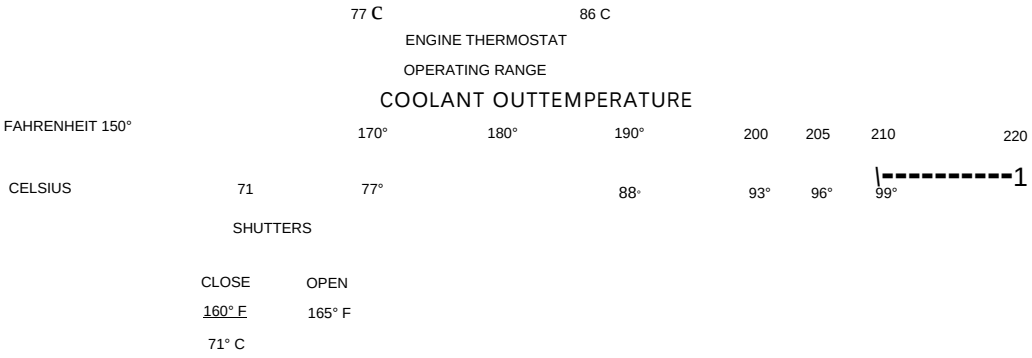
TEMPERATURE CONTROL COMPONENTS

These engines are designed to operate with 160°F (71°C) or 170°F (77°C) thermostats which, combined with a radiator or heat exchanger, regulate coolant temperature within a range of 160°F - 177°F (71°C - 81°C) or 170°F - 187°F (77°C - 86°C). Many engines also use radiator shutters, clutch fans or combinations of both to help control coolant temperature. These “add on” cooling system components must operate in proper sequence to prevent coolant temperature instability and/or engine overheating.

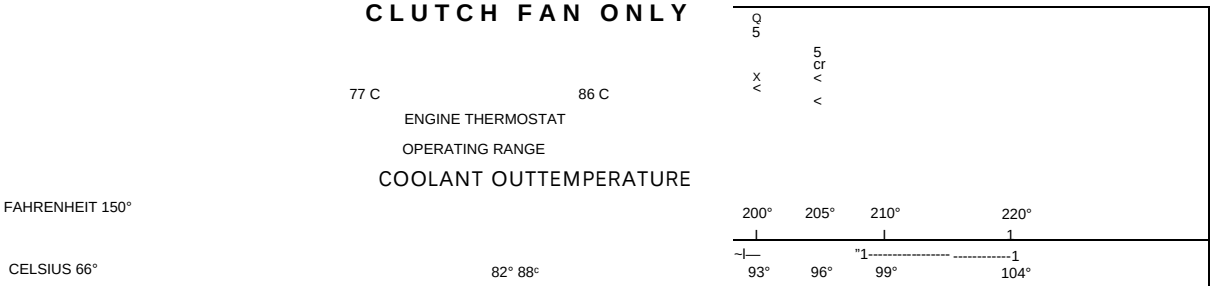
A badly adjusted operating sequence can also have a detrimental effect on the life of the “add on” components as well.

The following chart gives the recommended temperature settings for various coolant temperature control devices. These settings should not be exceeded, since this will unnecessarily increase the engine coolant and lubricating oil temperature, possibly resulting in serious engine damage.

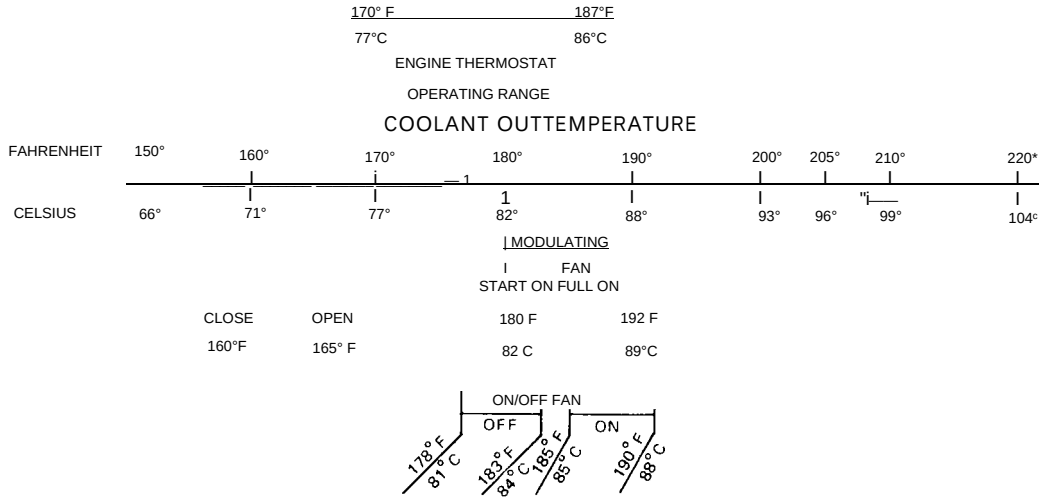
SHUTTERS ONLY



CLUTCH FAN ONLY



CLUTCH FAN AND SHUTTER COMBINATION



NOTE: For engines with 160 F thermostats, reduce shutter and clutch fan operating temperatures by 10°F; reduce Celsius temperatures by 6°C. Maximum and alarm temperatures remain at 200°F (93°C) and 205°F (96°C), respectively.

CHART - 170°F Thermostat

WATER PUMP

The centrifugal-type water pump (Fig. 1) circulates engine coolant through the oil coolers, cylinder block, cylinder heads and radiator.

The pump is mounted on the engine front cover and is driven by the front crankshaft gear through two idler gears.

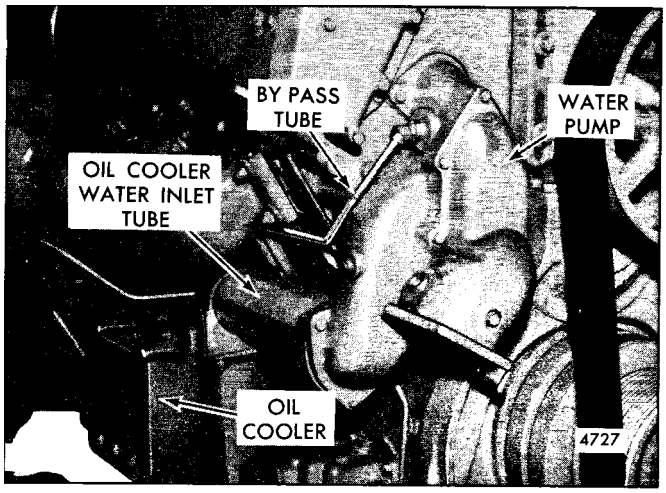


Fig. 1 - Water Pump Mounting

A bronze impeller is secured to one end of a stainless steel shaft by a locknut. A drive gear is pressed on the opposite end of the shaft. Two ball bearings are used to carry the shaft. The larger bearing is used at the drive gear end of the shaft to accommodate the thrust load.

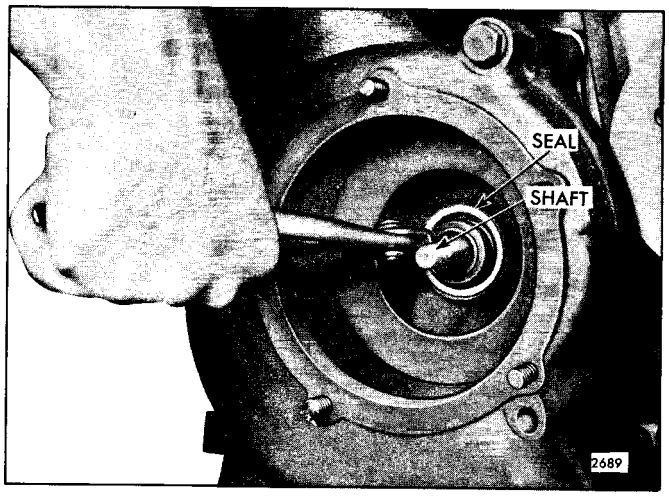


Fig. 2 - Removing Water Seal from Pump

An oil seal is located in front of the smaller bearing and a spring-loaded face-type water seal is used behind the impeller.

Refer to *Troubleshooting* in Section 5.0 for combustion gas leakage into the cooling system.

To prevent water pump weep hole plugging on engines working in a dirty environment, periodically push a piece of wire into the weep hole and pull out any dirt that may be in there. The hole must remain open, draining any coolant that may leak past the water seal and preventing it from accumulating and possibly contaminating the bearings or engine oil with coolant.

Lubrication

The pump bearings are lubricated with oil splashed by the water pump gear.

Replace Water Seal

The water seal can be replaced without removing the pump if the radiator, fan and fan shroud have been removed.

1. Remove the pump cover and gasket (Fig. 3).
2. Remove the locknut and washer and withdraw the impeller with puller J 24420-A.
3. Grasp the water seal assembly with suitable pliers and pull the seal out of the retainer (Fig. 2).
4. To prevent possible coolant leakage, apply a light coat of non-hardening sealant to the outside diameter of a new water seal. Then, tap the seal into the seal cavity with a suitable sleeve which has an inside diameter large enough to fit around the seal and rest on the brass cartridge lip.

•5. Inspect the water pump impeller for wear (erosion) and reuse or replace, as required. If the impeller is reused, the ceramic impeller insert *must* be replaced. Use a new ceramic insert on the impeller and bond it to the impeller, as follows:

   a. Bake the insert and impeller assembly at 500°F (260°C) for 90 minutes. The insert can be removed easily while the adhesive is hot. After removing the insert, clean the insert area on the impeller with sandpaper, wire brush or a buffing wheel to remove the old adhesive, oxide, scale, etc.

   b. Wet a clean cloth with suitable solvent such as alcohol and thoroughly clean the impeller insert area and the grooved side of a new ceramic insert. Then, wipe the parts with a clean, dry cloth.

   c. Place the adhesive washers (2) in the impeller bond area with the ceramic insert on top. The polished face of the ceramic insert should be visible to the assembler.

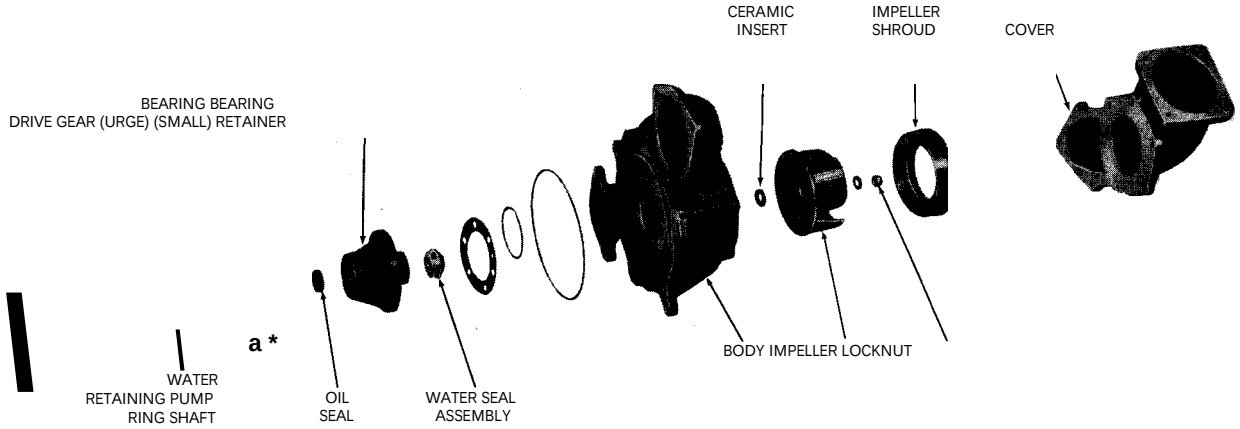


Fig. 3 - Water Pump Details and Relative Location of Parts (8V, 12V-149 Pump Shown)

Clamp the ceramic insert and impeller together with a 3/8" bolt and nut and two *smooth* .125" thick washers. Tighten the bolt to 10 lb—ft (14 Nam) torque.

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

d. Place the impeller assembly in a level position, with the ceramic insert up, in an oven preheated to 350°F (17TC) for one hour. The face of the ceramic insert must be square with the axis of the tapered bore within .004". The pump shaft may be used as a mandrel for this inspection.

e. Remove the impeller from the oven and, after it has cooled to room temperature, install it in the pump. Do not loosen and remove the clamping bolt and washers until the assembly cools.

6. Make sure the mating surfaces of the water seal and the ceramic insert are free of dirt, metal particles and oil film.

7. Apply a small quantity of International Compound No. 2, or equivalent, to the threads of the pump shaft.

8. Place the impeller and washer on the shaft and start a new lock washer on the shaft. Hold the pump gear securely while drawing the impeller down on the shaft with the locknut. Tighten the nut to 35-40 lb—ft (47-54 N«n) torque.

9. Use a new gasket and install the water pump cover. Tighten the nuts securely.

Remove Pump

1. Drain the engine cooling system. Refer to Section 5.

2. If necessary, remove the radiator, fan shroud and fan.

3. Remove the three bolts, two nuts and lock washers securing the water pump to the oil cooler inlet tube.

4. Remove the four bolts, nuts and lock washers securing the water pump to the radiator or heat exchanger outlet tube.

5. Remove the nut and lock washer at the back side of the water pump.

6. Remove the seven bolts and lock washers securing the water pump to the front cover and remove the water pump. Be careful not to damage the gear teeth while removing the water pump.

   When removing the water pump on engines built prior to engine 12E-215, be sure to remove the bolt located inside the water pump cover. The bolt may be reached by using a socket and rachet and working through the inlet opening.

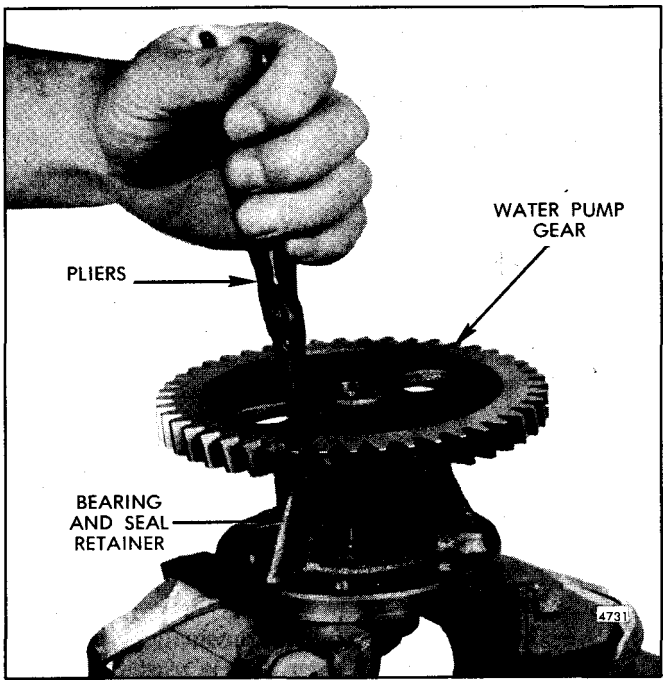


Fig. 4 - **Removing Retaining Ring with Pliers** J 4646

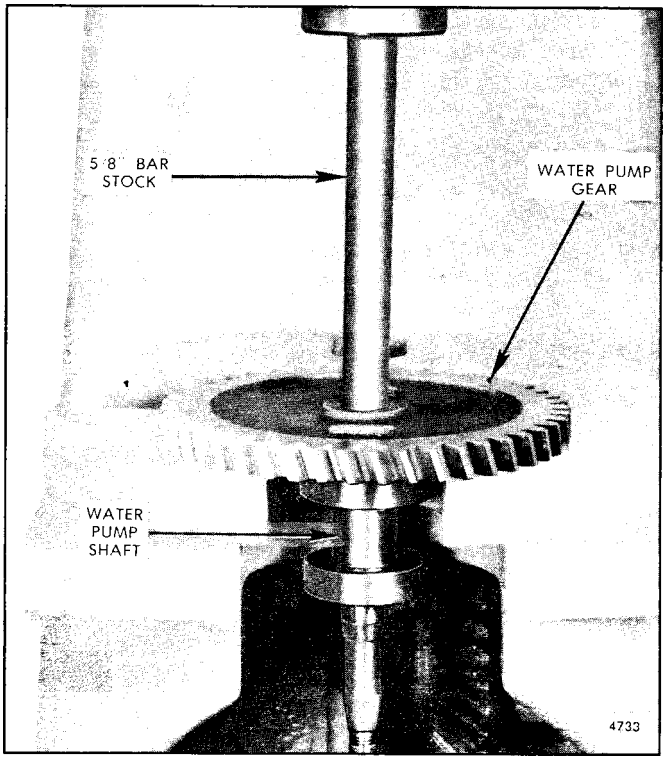


Fig. 5 - Pressing Shaft Out of Gear

7. Remove the two water seal rings from the back side of the water pump.

Disassemble Pump

NOTICE: Refer to Fig. 3 unless otherwise indicated.

1. Remove the pump cover and gasket.
2. With a suitable puller, remove the impeller shroud from the pump body (12V-149 engines only).
3. Remove the locknut and washer and withdraw the impeller with puller J 24420-A.
4. Remove the six nuts and lock washers securing the bearing retainer to the water pump and remove the bearing retainer from the pump body.
5. Turn the pump gear so the slot is over the ends of the bearing retaining ring, insert pliers J 4646 into the slot and, with the aid of a small screw driver, remove the ring from the groove (Fig. 4).
6. While supporting the bearing and seal retainer, tap the threaded end of the shaft lightly with a soft hammer to separate the shaft and bearing assembly from the retainer.
7. Place the gear on the bed of an arbor press with the shaft extending downward. Then, place a short piece of .6250" diameter bar stock between the shaft and the ram of the press and press the shaft out of the gear as shown in Fig. 5.
8. Support the shaft assembly on the inner race of the large bearing with the threaded end down. Place a flat plate between the ram of the press and the shaft and press the pump shaft out of the large bearing.
9. Invert the shaft, support it on the inner race of the small bearing and repeat the process described in Step 8.
10. Pry the water seal out of the bearing retainer with a screw driver, if necessary.
11. Push the oil seal out of the retainer.

NOTICE: The water and oil seals must not be reused if they are removed. A new ceramic impeller insert must be used if the seals were removed.

Inspection

Wash all of the pump parts in clean fuel oil, dry them with compressed air.

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

Inspect parts for cracks, wear or other damage. Replace damaged or worn parts. A new ceramic insert must be used. Refer to *Replace Water Seal.*

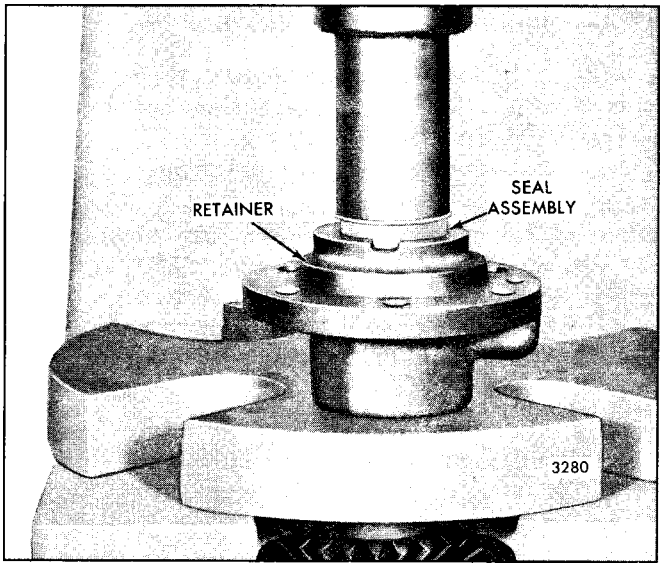


Fig. 6 - Installing Water Seal Assembly

• Inspect impeller and shaft taper area. If either the shaft taper or the impeller taper shows evidence of wear, circular score lines, scratches or abrasion, the worn part must be replaced. If a new shaft is used, make sure it has an “H” marked on the gear end.

Examine the bearings for corrosion, pitting, wear and freedom of movement. Apply engine oil to the bearings; hold the inner race and slowly revolve the outer race to check for roughness. Replace the bearings, if necessary.

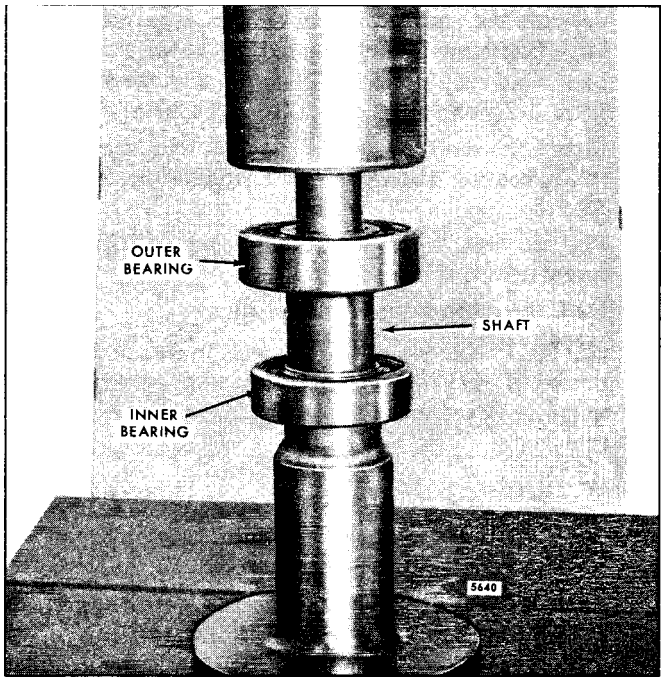


Fig. 7 - Pressing Bearing on Pump Shaft using Tool J 25257

NOTICE: When replacing an inner or outer bearing, always replace the other bearing.

Check the studs in the water pump body for damage. Apply a sealant to the threads of new studs and drive them in to 20-30 lb—ft (27-41 N«m) torque.

The current water pump used on 16V engines (except marine) has a strengthened pump body. All other pump components remain the same. However, the water inlet bolt circle diameter has been increased from 6.250" to 6.390" requiring a new water inlet elbow and gasket. When a new service pump or body assembly is used, the new elbow and gasket must be included to ensure interchangability.

Assemble Pump

Assemble the water pump, as follows:

1. Lubricate the bearing bores and shaft bearing surfaces. Use bearing and gear installer J 25257 and press the ball bearings against the shoulders on the shaft (Fig. 7).
2. Support the bearing retainer on the bed of an arbor press, water seal end down, and press the shaft and bearing assembly into the retainer. Make sure shaft is marked with “H” on gear end.

   NOTICE: Apply pressure to the outer race of the large bearing only when installing the shaft and bearing assembly in the retainer.

3. Install the bearing retainer ring.
4. With gear installer J 25257 positioned on the impeller end of the shaft, place the water pump on the bed of an arbor press. Press the gear on the shaft so it is flush with the end of the shaft.
5. Affix a new gasket and install the bearing retainer on the pump body with six lock washers and nuts. Tighten the nuts.
6. Apply a film of engine oil to the circumference of the oil seal and place it on installer J 8501 with the lip of the seal away from the tool.
7. Use a suitable sleeve and tap the seal into place until the edge of the seal is flush with the edge of the seal cavity on the bearing side.
8. To reduce possible coolant leakage, apply a light coat of suitable non-hardening sealant on the outside diameter of a new water seal. Then, press the seal assembly in place with a suitable sleeve, with an inside diameter large enough to fit around the seal and resting on the brass cartridge lip.
9. Make sure the mating surfaces of the water seal and the ceramic insert are clean and free of dirt, metal particles, grease or oil film.

   NOTICE: The gear and impeller on the shaft must withstand a torque of 80 lb—ft (108 N*m) without slipping.

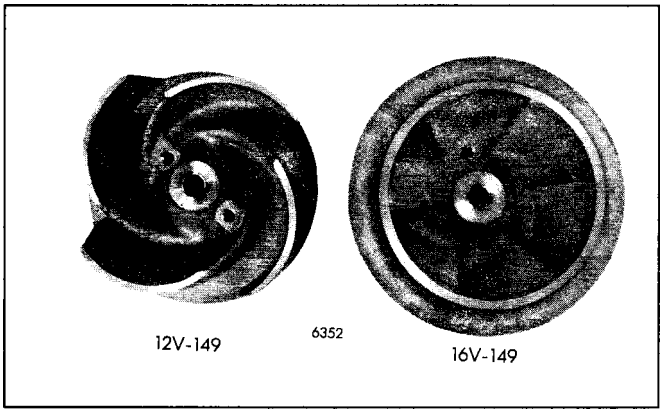


Fig. 8 - Water Pump Impeller Identification

Always install the proper impeller when overhauling a Series 149 engine fresh water pump. The 12V-149 engine fresh water pump is smaller than the 16V-149 engine pump and uses an impeller with a separate impeller shroud. The 16V-149 pump uses an impeller with a cast-in shroud (Fig. 8).

Though a 12V-149 pump impeller will fit into the larger 16V-149 pump housing, it is not functionally interchangeable and should not be installed in the 16V-149 pump. Failure to install the correct impeller can result in pump cavitation, insufficient coolant flow and serious engine damage.

NOTICE: Never attempt to reuse the impeller ceramic insert, regardless of its apparent condition. During water pump operation, the seal contacts the surface of the ceramic insert and takes on a wear pattern that may not be easily detected. If a new seal with a new surface is installed against the old insert, the wear pattern on the ceramic may not provide proper contact with the seal face, causing a leak between the two surfaces. To avoid this possibility, always replace the ceramic insert or the impeller assembly with insert at the time of overhaul.

*10. With the water pump assembly sitting squarely on the table of an arbor press, place a 1" x 5/8" piece of bar stock under the pump shaft at the drive gear end. *This is necessary to prevent damaging the shaft bearings, breaking the retaining ring, or moving the large water pump shaft bearing off its seat during impeller installation.*

11. Place a 4" x 5/8" brass sleeve over the threaded end of the shaft. This will protect the threads during impeller installation.

12. Position the water pump impeller over the end of the shaft so the ceramic insert faces the gear end of the pump and mates with the water seal surface. With a force of 400 lbs. (1779 Newtons) min. to 600 lbs. (2669 Newtons) max., press the impeller onto the shaft until firmly seated.

13. Lubricate the threads of the shaft with a small quantity of International Compound No. 2. Install a new flat washer and lock nut.

14. Hold the pump body and gear securely in fixture J-34034 and tighten the impeller-to-shaft lock nut to 40—45 lb/ft. (54—61 N«m) torque.

15. Check the water pump impeller and gear slip torque as follows:

    a. Attach Kent-Moore tool J-34034-2 to the end of a torque wrench and place it over the impeller. Hold pump and gear in fixture J-34034.

    b. Apply 80 lb/ft. (108 N*m) of torque to the impeller in the direction opposite to the arrow on the impeller. *The impeller and gear must withstand this torque without slipping.*

    c. If the impeller slips, remove impeller, clean shaft and impeller tapers with solvent and assemble again. Recheck slip torque. If the impeller rubs on the body of the pump, check for pump or impeller irregularities, such as casting flash. Repair as required. Install a new impeller, if necessary, using the torquing method stated above.

Install Pump

1. Lubricate the new large and small water seal rings with grease and position them in the pump body.
2. Position the pump against the front cover, making sure the pump gear teeth are engaged correctly with the idler gear teeth.
3. Install the six pump body-to-front cover bolts and lock washers.
4. Install the nut and lock washer at the back side of the water pump.
5. Tighten the bolts to 30-35 lb—ft (41-47 N*m) torque and the nut to 25-30 lb—ft (34—41 N«m) torque.
6. To check the gear backlash (clearance) between the water pump gear and the idler gear, set the dial indicator pointer against one of the impeller vanes, and while keeping the idler gear stationary, rock the impeller. The gear backlash setting should be .004" to .008".

The current engine front cover has a 1/4" access hole located in line with the right front idler gear to permit holding the idler gear in a loaded position while checking the gear backlash. The idler gear must be held stationary in the loaded position to eliminate the possibility of including the idler gear to idler gear backlash in the idler gear to water pump gear backlash readings. For engines without the access hole, see Section 5.0. A 1/4” pipe plug is used to seal the opening after the gear lash check is completed.

When the specified gear backlash cannot be obtained, loosen the pump attaching bolts and nut and move the pump up as required to obtain the correct gear backlash. Retighten the bolts and nut, as noted in Step 5.

7. Position the impeller shroud in the pump body (8V and 12V-149 engines only).
8. Install the pump cover and a new gasket.
9. Connect the outlet tube from the radiator or heat exchanger.
10. Connect the oil cooler inlet tube to the pump.
11. Install the fan, radiator and fan shroud, if removed.
12. Refill the cooling system as required for warm or cold weather operation. Refer to Section 5.

WATER MANIFOLD

The water manifolds (Fig. 1) are attached to the cylinder block at each water opening with two bolts and lock washers. A separate gasket is used at each attaching flange. The front right and left bank manifolds are also attached to their respective thermostat housings with a flange, seal, plate, gasket and three bolts and lock washers. The front and rear manifolds on each cylinder bank are joined and sealed together with seals and clamps.

Coolant passes through the water jacket in the cylinder head and enters each water opening in the manifold, then flows into the thermostat housing.

Refer to *Troubleshooting* in Section 5.0 for combustion gas leakage into the cooling system.

Remove Water Manifolds

1. Open the drain cock or remove the plug at the bottom of each thermostat housing and drain the cooling system to the proper level.
2. Disconnect any water lines attached to the water manifolds.

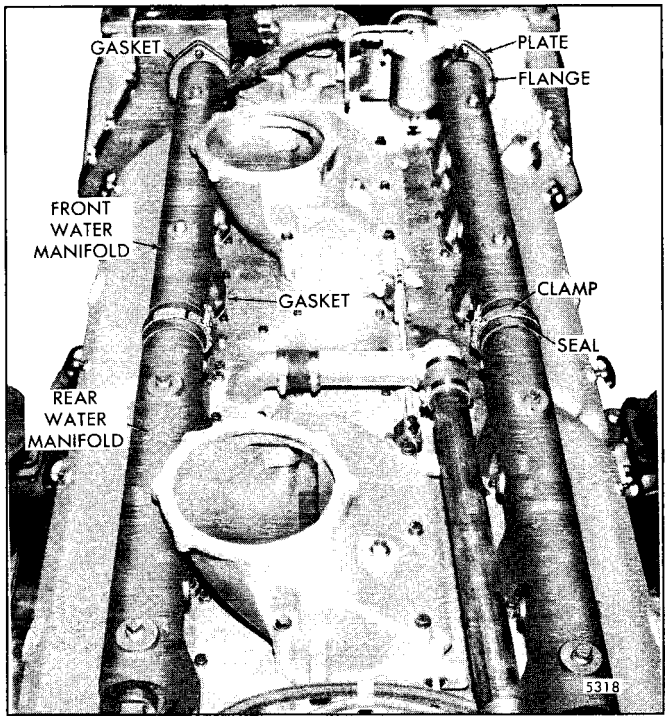


Fig. 1 - Typical Water Manifold Mounting

3. On 12V and 16V engines, loosen the seal and clamp between each front and rear manifold. Discard the seals.
4. Remove the three manifold flange attaching bolts and lock washers from each thermostat housing. Then, slide each flange, seal and plate back on the manifolds. Discard the seals and gaskets.
5. Remove the bolts and lock washers which attach the manifolds to the cylinder block. Then, remove the manifolds from the cylinder block.
6. Remove and discard the gaskets.

Install Water Manifolds

1. Attach a new gasket at each water opening in the cylinder block.
2. Install a new seal in the flange of each front manifold.
3. Place one of the front manifolds in position on the cylinder block and, using a new gasket, install the plate and three flange-to-thermostat housing bolts and lock washers. Do not tighten the bolts at this time.
4. Install the manifold-to-block bolts and lock washers. Do not tighten the bolts at this time.
5. 12V and 16V engines only:
   a. Place a new seal and a clamp on the rear manifold.
   b. Place the rear manifold on the cylinder block and install the manifold-to-block bolts and lock washers. Do not tighten the bolts at this time.
   c. Align the front and rear manifolds, position the seal and tighten the clamp.
6. Tighten the 3/8"—16 manifold-to-block and manifold-to-thermostat housing bolts to 30-35 lb—ft (47—47 N*m) torque.
7. Install the manifolds on the opposite cylinder bank in the same manner.
8. Install and connect any water lines previously removed.
9. Close the drain cock or install the drain plug in each thermostat housing.
10. Fill the cooling system to the proper level.

THERMOSTAT

The temperature of the coolant is automatically controlled by six blocking type thermostats (Figs. 1 and 2) which are located in the two thermostat housing covers (three in each cover) at the front of the engine.

•Construction

Thermostats used in Detroit Diesel engines consist of a brass cup filled with a heat-expansive wax-like material. The wax compound is retained within the cup by an elastomeric seal. The valve of the thermostat is attached to a piston which is held on the elastomer by a spring.

•Thermostat Operation

Two thermostat heat motor (power element) designs are shown (Fig. 3). The basic principle (expansive wax) remains the same for all thermostats. The valve is in the closed position when the thermostat is cold (wax solid). When the wax-filled brass cup is heated by engine coolant, the wax-like material expands. As the coolant temperature in the engine reaches the calibrated "start-to-open" thermostat setting, the force of the expanding wax on the piston exceeds the closing force of the spring and the valve begins to open. As the coolant temperature continues to increase, the wax-like material continues to expand and the valve opens further until it reaches its maximum design travel.

When the temperature of the engine coolant drops, the wax cools and contracts. This reduces the pressure on the piston and allows the spring to draw the valve back toward its seat (closed thermostat).

Operation In The Engine

At water temperatures below the start-to-open setting, the thermostat valves remain closed, blocking the flow of coolant through the radiator or heat exchanger core. The coolant then bypasses the radiator or heat exchanger and flows back through the water pump to the oil cooler, cylinder block, cylinder heads and back up through the thermostat housings. As the coolant temperature continues to rise, the thermostat valves start to open, allowing some of the coolant to pass down through the radiator or heat exchanger where the coolant is cooled and then circulated through the water pump to the engine. As the temperature rises, more coolant is allowed to pass through the thermostat. When the thermostat valves are fully open, most of the coolant is circulated through the radiator or heat exchanger, thereby regulating the coolant temperature.

•Type

Full blocking type thermostats (Fig. 4) are used in Series 149 engines. The full blocking type thermostat simultaneously controls the flow of coolant to the radiator and bypass circuit. During the engine warm-up, all engine coolant flows through the bypass circuit. As the thermostat opens, increasing amounts of coolant flow to the radiator and the bypass flow is correspondingly reduced. At approximately 17° - 20°F above the opening temperature of the thermostat, the bypass opening is fully blocked and the total flow of coolant is directed into the radiator. Series 149 thermostats are non-vented due to the rapid warm-up cooling system.

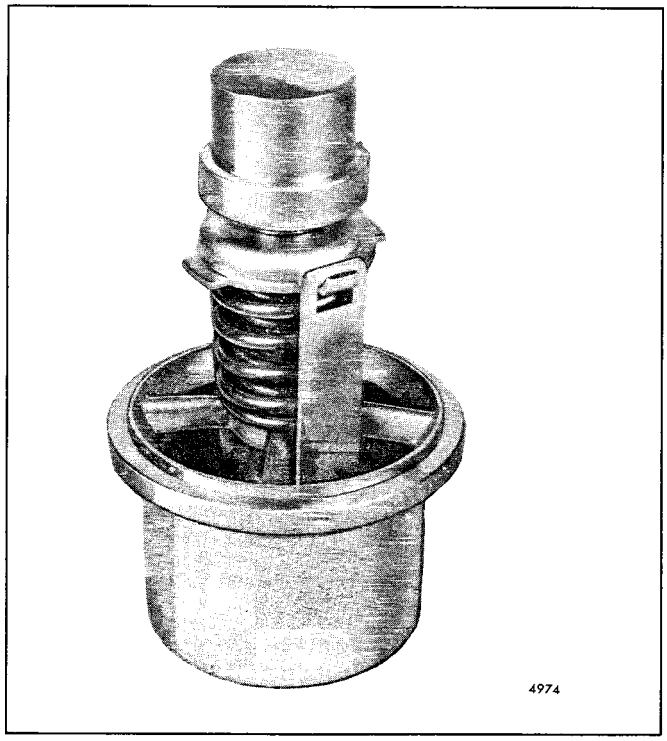


Fig. 1 – Blocking Type Thermostat (Former)

•The Bypass Circuit

The bypass circuit (Fig. 4) provides a route for coolant circulation before the thermostat opens. Coolant from the top of the engine flows back to the water pump without passing through the radiator or other heat exchanger. This flow of bypass coolant permits the engine to warm up to operating temperature while preventing "hot spots" which might damage the engine during this period of operation.

•Running Without A Thermostat

Operating an engine without a thermostat is not recommended. Removing the thermostat can permit the engine to run too cool or too hot. If engines run too cool, condensation of water from the combustion process can mix with lubricating oil and other products of combustion to form corrosive acids and sludge. These, in turn, can restrict the flow of oil and accelerate engine wear. Low combustion

chamber temperatures can also lead to rough idling and increased amounts of pollutants and white smoke.

Running without a thermostat can cause overheating, since the bypass systems using full blocking thermostats will remain open. This may prevent an adequate flow of coolant to the radiator core.

Preventive Maintenance

Check thermostat calibration and the condition of thermostat seals after 5,000 hours of operation or once per year, whichever comes first. Replace as required. Always replace thermostats and seals at time of engine overhaul, regardless of condition.

NOTICE: Attempting to reuse defective thermostats and/or seals can result in inefficient engine operation and/or damage.

Properly operating thermostats are essential for efficient operation of the engine. If the engine operating temperature deviates from the normal range (refer to Section 13.2) the thermostats must be removed and checked.

When comments of low operating temperatures are reported, check for the following *before* considering thermostat replacement.

1. Inaccurate temperature gauge.
2. Casting interference restricting thermostat valve movement.
3. Thermostat cocking or misalignment.
4. System contamination-sand or debris holding the thermostat open.
5. Malfunctioning rapid warm-up system.

Many cold complaints actually relate to lack of cab heat rather than engine temperature. When this is the case, look for such causes as a plugged heater core or restricted heater core hoses, improperly routed heater hoses, blocked heater ducts, inadequate heater coolant flow, etc.

Remove Thermostats

1. Open the drain cock located at the bottom of each thermostat housing and drain the cooling system to that level (Fig. 5).
2. Loosen the hose clamps securing the radiator or heat exchanger hoses to the thermostat housing covers and remove the hoses from the thermostat housing covers.

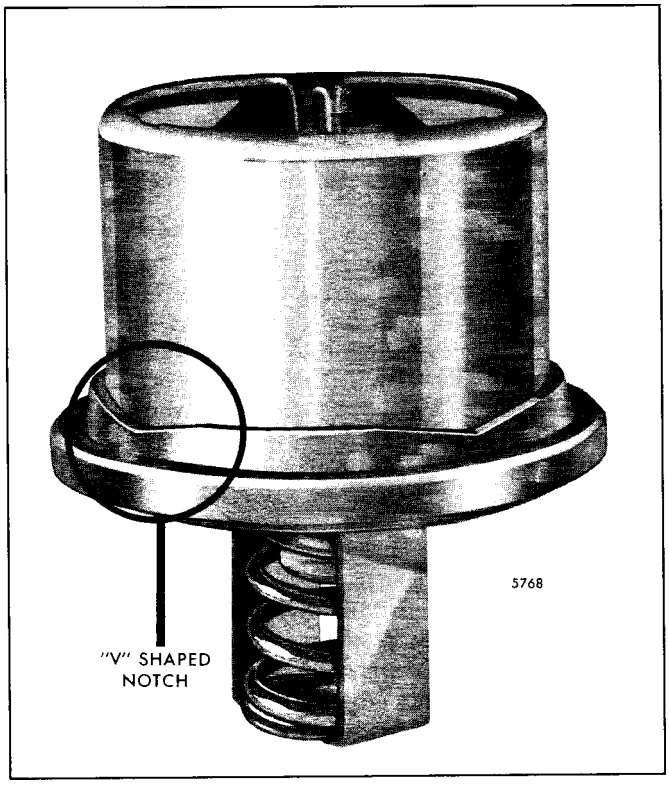
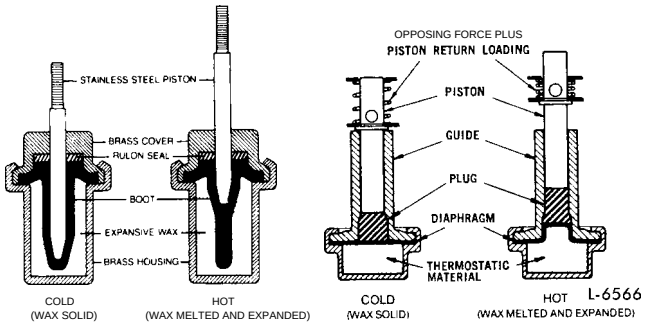


Fig. 2 - Weir Type Thermostat (Current)

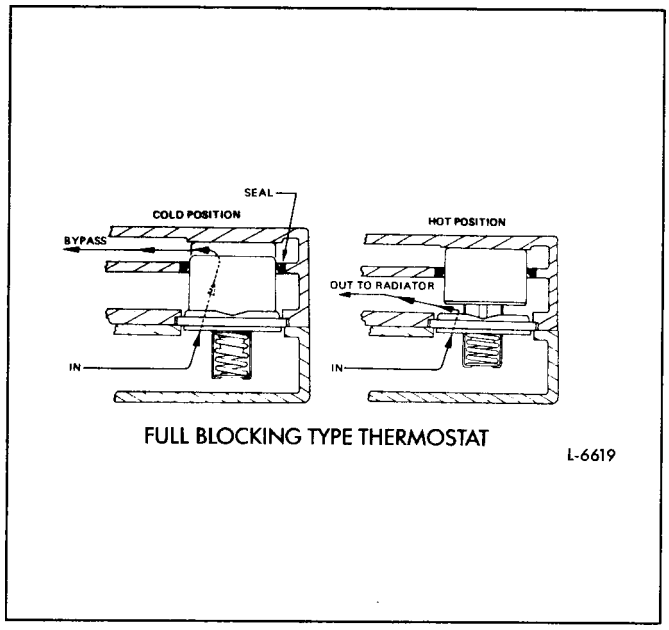
3. Remove the bolts and lock washers securing the covers to the thermostat housings. Then remove the thermostat housing covers and gaskets.
4. Remove the thermostats from the covers.
5. Clean the thermostat seating surfaces in the thermostat housing covers.
6. Remove the seals from the thermostat housing covers and discard the seals.

Inspection

1. Check the thermostats.



.Fig. 3 - Thermostat Heat Motors



•Fig. 4 - Full Blocking Type Thermostat

A defective thermostat which remains closed, or only partially open, will restrict the flow of coolant and cause the engine to overheat. A thermostat which is stuck in a full open position may not permit the engine to reach its normal operating temperature. The incomplete combustion of fuel due to cold engine operation will result in excessive carbon deposits on the pistons, rings and valves. To check the operation of thermostats, refer to Section 5.0.

• 2. Check the thermostat flange counterbore in the housing. Make sure it is clean and free from any obstructions that could prevent full seating of the flange.

• 3. Check the thermostat housing cover bypass cast seal ring. Check for wear and proper alignment of thermostat. Replace the cover if the thermostat will not properly block off the bypass cavity during full-open thermostat operation.

Install Thermostats

1. Always install a new seal when replacing a thermostat. Install new seals in the thermostat housing covers with installer J 8550 and driver handle J 7079-2. Position the seals so that the lips of the seals face up (away from the thermostats) when the cover is installed on the thermostat housing. The seal installing tool assures that the seal is positioned the correct distance from the bottom face of the cover and parallel with the cover face.

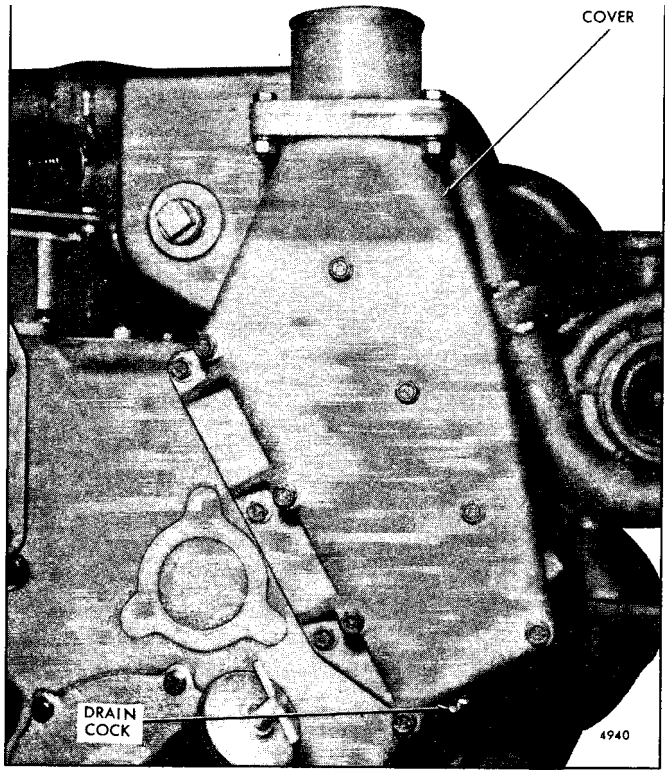


Fig. 5 - Thermostat Housing Mounting

2. Install the thermostats in the thermostat housing covers.
3. Place new gaskets on the thermostat housings.
4. Attach the covers to the thermostat housings. Tighten the bolts to 30-35 lb—ft (41—47 N«m) torque.
5. Slide the radiator or heat exchanger-to-thermostat housing hoses over the thermostat housing covers and secure them in place with hose clamps.
6. Close the thermostat housing drain cocks and fill the cooling system to the proper level. Refer to Section 5.
7. Start the engine and check for leaks.

RADIATOR

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

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

To increase the cooling efficiency of the radiator, a metal shroud is placed around the fan (Fig. 1). The fan shroud must be fitted airtight against the radiator to prevent recirculation of the hot air drawn through the radiator. Hot

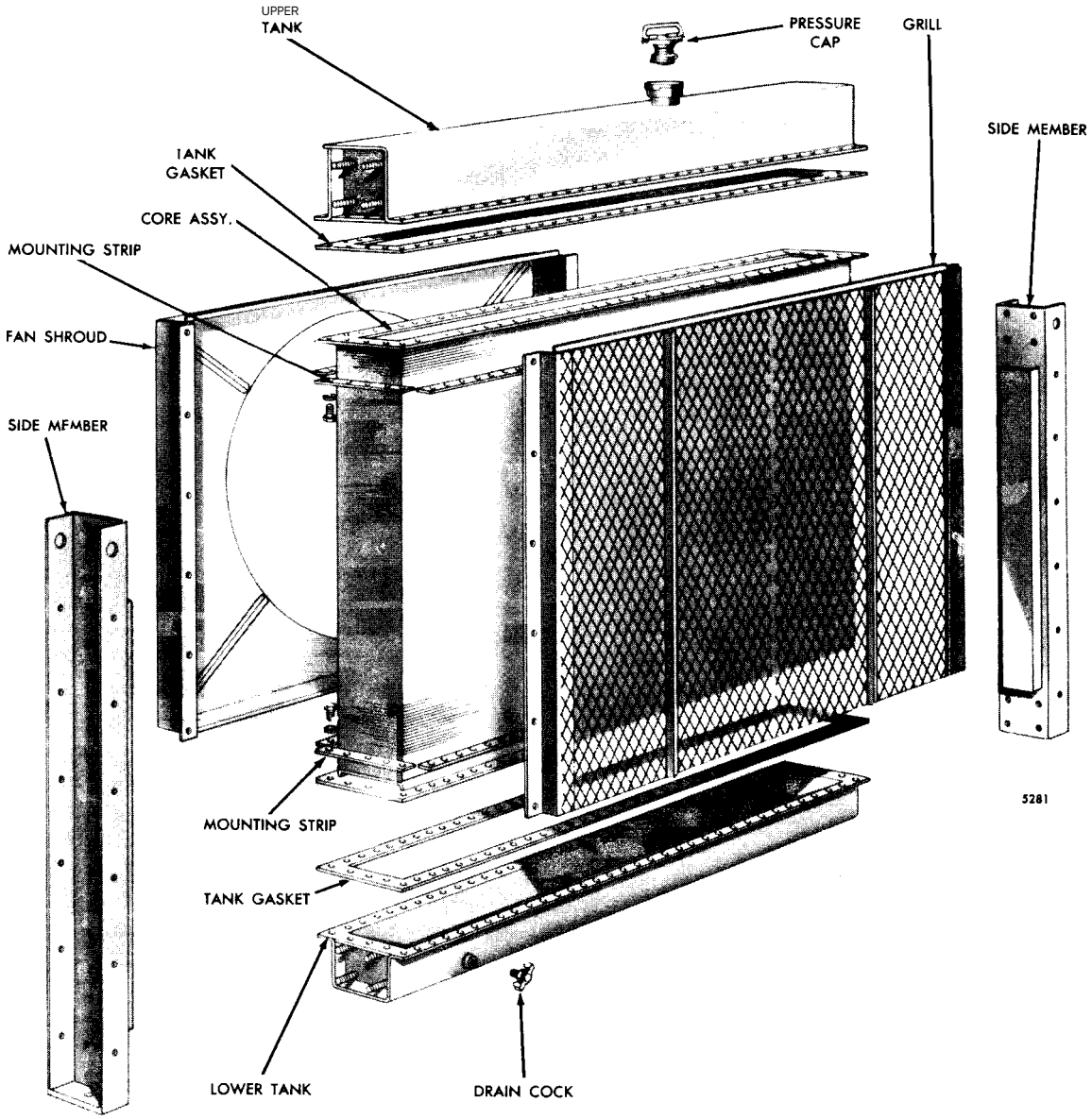


Fig. 1 - Radiator Details and Relative Location of Parts

air which is permitted to pass around the sides or bottom of the radiator and is again drawn through the radiator will cause overheating of the engine.

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

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

The external cleanliness of the radiator should be checked if the engine overheats and no other causes are apparent. To permit proper filling of the radiator, it is necessary that an air bleed hose be installed between the top of each thermostat housing and the radiator top tank. When a unit is not equipped with air bleed hoses, they can be installed as follows:

NOTICE: The thermostat housings do not have internal air bleed holes.

Remove the 3/8" pipe plug in the top of each thermostat housing. Install a 3/8" I.D. constant rise air bleed hose (with no bends) to each top side of the radiator.

NOTICE: Tapped holes are provided in the top of the radiator supplied by Detroit Diesel.

Cleaning Radiator

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

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

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

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

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

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

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

CAUTION: To avoid possible personal injury when working with steam or chemical solvents, wear adequate protective clothing (face shield, rubber apron, gloves, boots, etc.) and work in a well ventilated area.

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

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

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

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

After the solvent and neutralizer have been used and the cooling system is flushed, completely drain the entire system again and fill it with coolant (refer to *Engine Coolant* in Section 13.3). After filling the cooling system, inspect the radiator and engine for water leaks. »

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

After the radiator core has been thoroughly cleaned and dried, reinstall the fan shroud and grille, if removed.

Remove Radiator

1. Remove the radiator filler cap and open the drain cock to drain the cooling system. Also open the drain cock on the oil cooler and the engine block.
2. Remove the bolts, lock washers and nuts which attach the fan guards to the fan shroud.
3. Loosen the hose clamps at the radiator inlet hose and remove the hose.
4. Loosen the hose clamps at the radiator outlet hose and remove the hose.
5. Use a chain hoist and a suitable lifting device (through the filler neck or otherwise) and draw the hoisting chain taut to steady the radiator.
6. Remove the bolts, lock washers, plain washers, nuts and bevel washers (if used) which attach the radiator shell to the engine base.

   NOTICE: Since the shroud is very close to the tips of the fan blades, to prevent damage to these parts great care must be exercised whenever the radiator is removed.
7. Lift the radiator enough to clear the engine base and move it directly away from the engine.
8. Remove the fan shroud and the radiator core by removing the bolts securing them in place.

Inspection

Clean all radiator parts thoroughly, removing dirt, scale and other deposits. Examine the radiator for cracks or other damage. The core fins should be straight and evenly spaced to permit a full flow of cooling air. The core tubes should be clean inside and outside and have no leaks.

If repainting the raidator core becomes necessary, it is recommended that a thin coat of dull black radiator paint or another high quality flat black paint can be used. Ordinary oil paints have an undesirable glossy finish and do not transmit heat as well.

Check all radiator hoses and clamps. Replace cracked and deteriorated hoses and damaged clamps.

Install Radiator

Assemble the radiator, grill and shroud. Then mount the assembly on the engine base by reversing the procedure given for removal.

Check for clearance between the tips of the fan blades and radiator shroud after the radiator is in place. There must be sufficient clearance or damage to the fan and shroud will result when the engine is started. Use shims between the radiator and base, if necessary, to obtain the proper clearance.

COOLANT PRESSURE CONTROL CAP

• The radiator (or expansion tank) has a pressure control cap with a normally closed valve. The cap, with a number 7 or 14 stamped on its top, is designed to permit a pressure of approximately 7 psi (48.3 kPa) or 14 psi (96.6 kPa) in the system before the valve opens. A 7psi (48.3 kPa) pressure cap is used at altitudes below 5000 ft (1525 m). At altitudes above 5000 ft (1525 m), a 14 psi (96.6 kPa) cap is required. This pressure raises the boiling point of the cooling liquid and permits somewhat higher engine operating temperatures without loss of any coolant from boiling. To prevent the collapse of hoses and other parts which are not internally supported, a second valve in the cap opens under vacuum when the system cools. *Refer to "Pressurized Cooling System " (Section 5) for Information on Pressurized Top Tank Installation.*

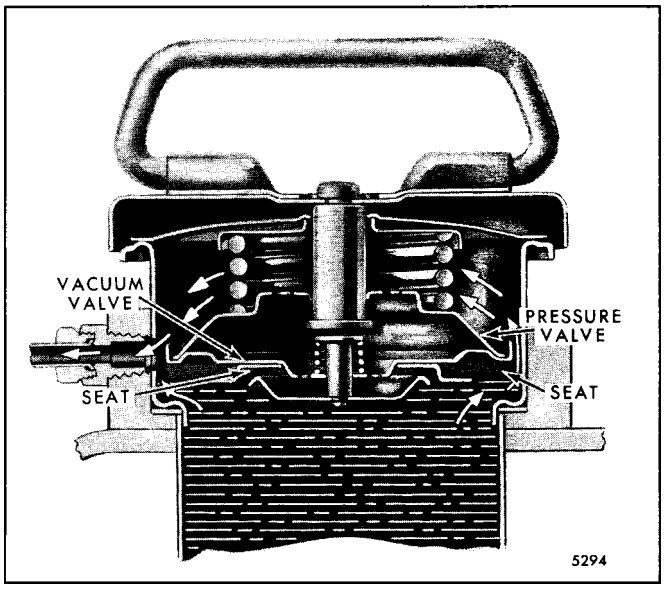


Fig. 1 - Pressure Control Cap (Pressure Valve Open)

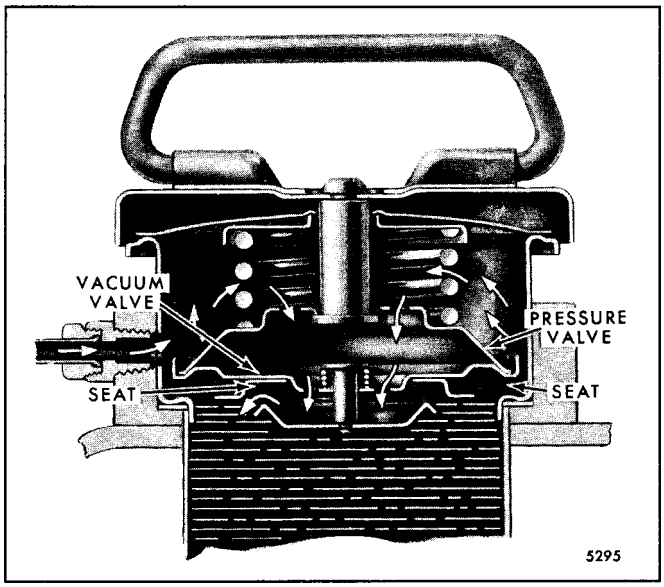


Fig. 2 - Pressure Control Cap (Vacuum Valve Open)

CAUTION: Use extreme care when removing the coolant pressure control cap. Remove the cap *slowly* after the engine has cooled. 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.

To ensure against possible damage to the cooling system from either excessive pressure or vacuum, check both valves periodically for proper opening and closing pressures. If the pressure valve does not open between 6.25 psi (43.1 kPa) and 7.5 psi (51.7 kPa) or the vacuum valve does not open at .625 psi (4.3 kPa) (maximum), replace the pressure control cap.

ENGINE COOLING FAN

The fan used for cooling radiator equipped engines is belt driven from the crankshaft pulley.

The fan is bolted to a hub and pulley which are carried on two tapered roller bearings. The fan bracket and shaft are an integral unit which is mounted to the engine front cover by four bolts, lock washers and special flat washers (Fig. 1). Fan height is adjusted by means of an adjusting screw and adjusting bracket.

Poly-V belts are used on all Series 149 engines. Poly-V is the name given to a type of drive belt which has a drive surface of longitudinal V-shaped ribs formed on a common base.

Lubrication

The tapered roller bearings are pressure lubricated before being installed in the hub. A cap and seal retain a supply of grease in the cavity between the bearings. Refer to Section 15.1 for the maintenance schedule.

Fan Belt Adjustment

Adjust the fan belt periodically as outlined in Section 15.1.

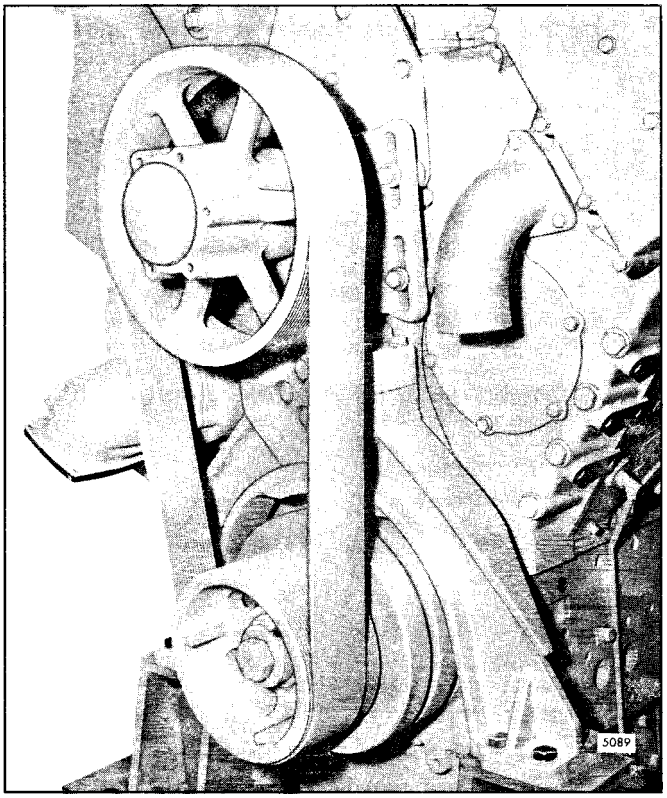


Fig. 1 - Typical Fan Drive Mounting

Remove And Install Fan Blade Assembly

Remove the fan blades from the hub by removing the six bolts and lock washers, providing enough clearance exists between the fan blades and the inner face of the radiator core with the belt guard and fan guard removed. If the fan blades cannot be removed in this manner, the fan, hub and bracket may be removed as an assembly from the support on the engine front cover, and then the fan blades removed from the hub. See *Remove Fan, Hub and Bracket* below.

The fan blades may be installed by reversing the procedure used for removal.

Remove Fan, Hub And Adjusting Bracket

The fan blades must rotate in a vertical plane parallel with and a sufficient distance from the radiator core. Bent fan blades reduce the efficiency of the cooling system, may throw the fan out of balance, and are apt to damage the radiator core. Before removing the fan, check the blades for alignment. Do not rotate the fan by pulling on the fan blades.

1. Remove the belt and fan guards.
2. Remove the six attaching bolts and lock washers, then remove the fan and spacer (if used).

NOTICE: If insufficient clearance exists between the fan and radiator, remove the fan, hub and adjusting bracket as an assembly.

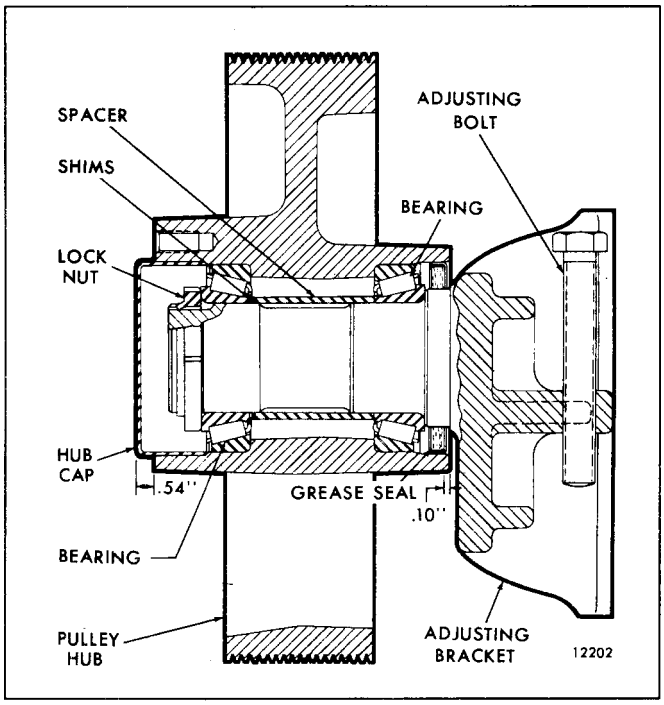


Fig. 2 – Fan Drive and Support Assembly

3. Loosen the four adjusting bolts and lower the fan shaft bracket by turning the adjusting screw on the adjusting bracket. Then remove the fan drive belt.
4. Remove the four adjusting bolts, lock washers and special flat washers. Remove the fan, hub and bracket as an assembly from the engine.

NOTICE: Early engines required two spacers between the fan hub bracket and the front engine lifter bracket.

Disassemble Fan, Hub And Bracket

Disassemble the fan, hub and bracket as follows:

NOTICE: Whenever tapered roller bearings are removed, all parts must be matchmarked and kept as a set to be reassembled in their original position.

1. Remove the six bolts and lock washers securing the fan and spacer to the pulley. Remove the fan blades and spacer.
2. Remove and discard the hub cap. Then pry out that part of the lock nut staked into the shaft and remove the nut.
3. Support the pulley hub, front face up, on wood blocks high enough to allow the adjusting bracket to be removed. Tap the shaft with a plastic hammer to free the bracket assembly from the bearings in the pulley hub.
4. Support the pulley hub, front face up, on wood blocks spaced far enough apart to permit removal of the felt grease seal and bearing from the hub.
5. Remove and discard the felt grease seal in the rear of the hub. Then remove the rear roller bearing cone, spacer and shims.

NOTICE: Record the number of shims removed to insure identical replacement when assembling the fan hub.

6. Remove the rear roller bearing cup from the hub by tapping alternately around the rear face of the cup with a small brass rod and hammer.
7. Reverse the pulley hub on the wood blocks and remove the front roller bearing from the hub in the same manner as described in Steps 5 and 6.

Inspection

Wash the fan and fan drive components with fuel oil and dry them with compressed air.

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

Inspect the bearing rollers and cups for wear or damage.

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

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

Assemble Fan, Hub And Bracket

1. Before assembling the tapered roller bearings into the pulley hub, pressure lubricate the bearings. Use Texaco Premium RB or an equivalent Lithium base multi-purpose grease.
2. Install the rear roller bearing in the pulley hub, numbered side out, as follows:
   a. Press the cup into the pulley hub.
   b. Place the cone in the bearing cup.
3. Press a new felt grease seal, numbered side out, in 3/32" (.100") from the end of the pulley hub (Fig. 2).
4. Place the adjusting bracket on wood blocks on the bed of an arbor press. Then press the pulley hub on the fan shaft.
5. Fill the pulley hub cavity 20-30% full of grease.
6. Install the spacer and necessary shims on the fan shaft.
7. Install the front roller bearing, numbered side out, in the pulley hub and on the fan shaft as follows:
   a. Press the cup into the pulley hub.
   b. Press the cone on the fan shaft and against the shims.
8. Install the lock nut and tighten it to 195-205 lb-ft (265-278 N*m) torque while rotating the pulley hub.
9. Check the end play. It must be .001" to .006". If necessary, remove the lock nut and front bearing and add or remove shims as required.

NOTICE: The pulley must rotate freely after assembly.

10. After the specified end pla; obtained, stake the lock nut to the fan shaft.
11. Fill the cap 70-80% full of grease and install it in the pulley hub.

Install Fan, Hub And Bracket

1. Secure the fan and spacer to the pulley hub with six bolts. Tighten the bolts to 71-75 lb-ft (92-102 N*m) torque.

2. Attach the fan, hub and bracket assembly to the engine front cover with four 1/2"—13 bolts, lock washers and special flat washers. Leave the bolts loose.

NOTICE: Early engines required two spacers between the fan hub bracket and the engine front lifter bracket.

3. Install the drive belt.

NOTICE: Before a Poly-V belt is installed, it is very important that the crankshaft pulley and the fan drive pulley are in alignment.

Misalignment between the pulleys cannot be more than .009" per inch of center line distance. A straight line can be determined by placing a straight edge on the rims of the pulleys.

4. Adjust the bracket to provide the proper belt tension (Section 15.1). Tighten the bolts to 71-75 lb—ft (96-102 N*m) torque.

HEAT EXCHANGER

The heat exchanger system incorporates two cooler cores located in separate heat exchanger tanks which are mounted on each side of a large expansion tank (Fig. 1).

The heat exchanger core consists of a series of cells with a header at one end and a water inlet at the opposite end. The core is mounted inside of the heat exchanger tank with the header or outlet end bolted to the tank at the top and the inlet end sealed inside a retainer. A gasket between the tank and the flange of the core, another gasket between the flange of the core and the outlet cover, and seals surrounding the circular inlet end prevent the coolant from mixing with the raw cooling water on its course between the cells of the cooling core.

In this sytem of engine cooling, the hot coolant leaving the thermostat housing passes into the heat exchanger tank, then through the cells of the cooling core. After leaving the heat exchanger, the engine coolant is picked up by the fresh water pump and circulated through the engine. The raw water is forced between the cells of the core and serves to lower the temperature of the coolant as it passes through the cells.

To protect the heat exchanger core from the electrolytic action of the raw water, zinc electrodes are located in the heat exchanger inlet and outlet connections and in the raw water pump inlet elbow.

The expansion tank provides a means of filling the engine cooling system, as well as space for expansion of the coolant as its temperature rises. An overflow pipe, near the top of the tank, provides a vent to the atmosphere. To permit proper filling of the heat exchanger cooling system, it is necessary that an air bleed hose be installed between the top of each thermostat housing and the top of the expansion tank. When a unit is not equipped with air bleed hoses, they can be installed as follows:

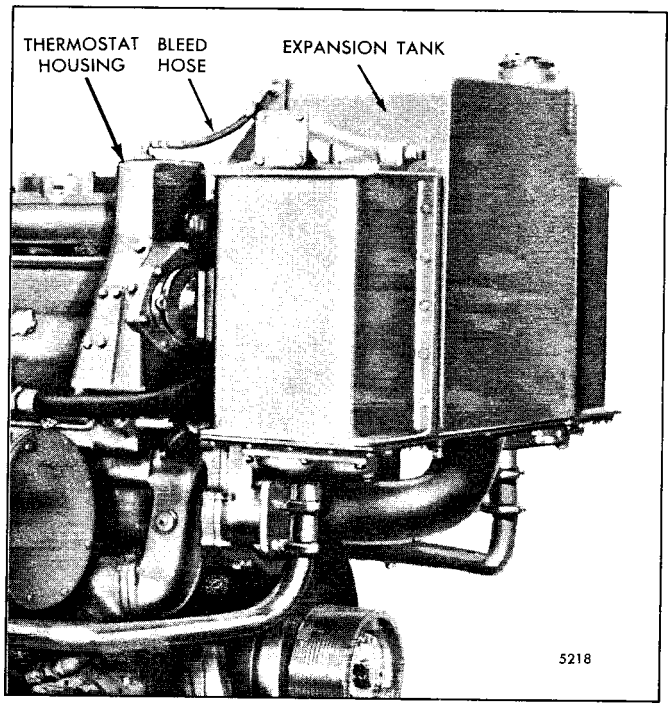


Fig. 1 – Heat Exchanger Mounting

NOTICE: The thermostat housings do not have internal air bleed holes.

Remove the 3/8" pipe plug in the top of each thermostat housing. Install a 3/8" I.D. constant rise air bleed hose (with no bends) to each top side of the expansion tank (Fig. 1).

NOTICE: Tapped holes are provided in the top of the expansion tank supplied by Detroit Diesel.

The length of time a heat exchanger will function satisfactorily before cleaning will be governed largely by the kind of coolant used in the engine and the kind of raw water used. Soft water, plus a good grade of rust inhibitor or antifreeze, should be used as the engine coolant. The coolant level should be maintained near the top of the expansion tank.

If the heat exchanger fails to cool the engine properly, the core assembly should be examined for foreign deposits.

Remove Heat Exchanger Core

1. Drain the fresh and raw water systems by opening the drain cocks.

2. Remove the bolts that hold the outlet cover and the heat exchanger core to the tank. Remove the cover and the gasket.

3. Remove the bolts that hold the seal retainer to the inlet cover. Remove the retainer and gasket.

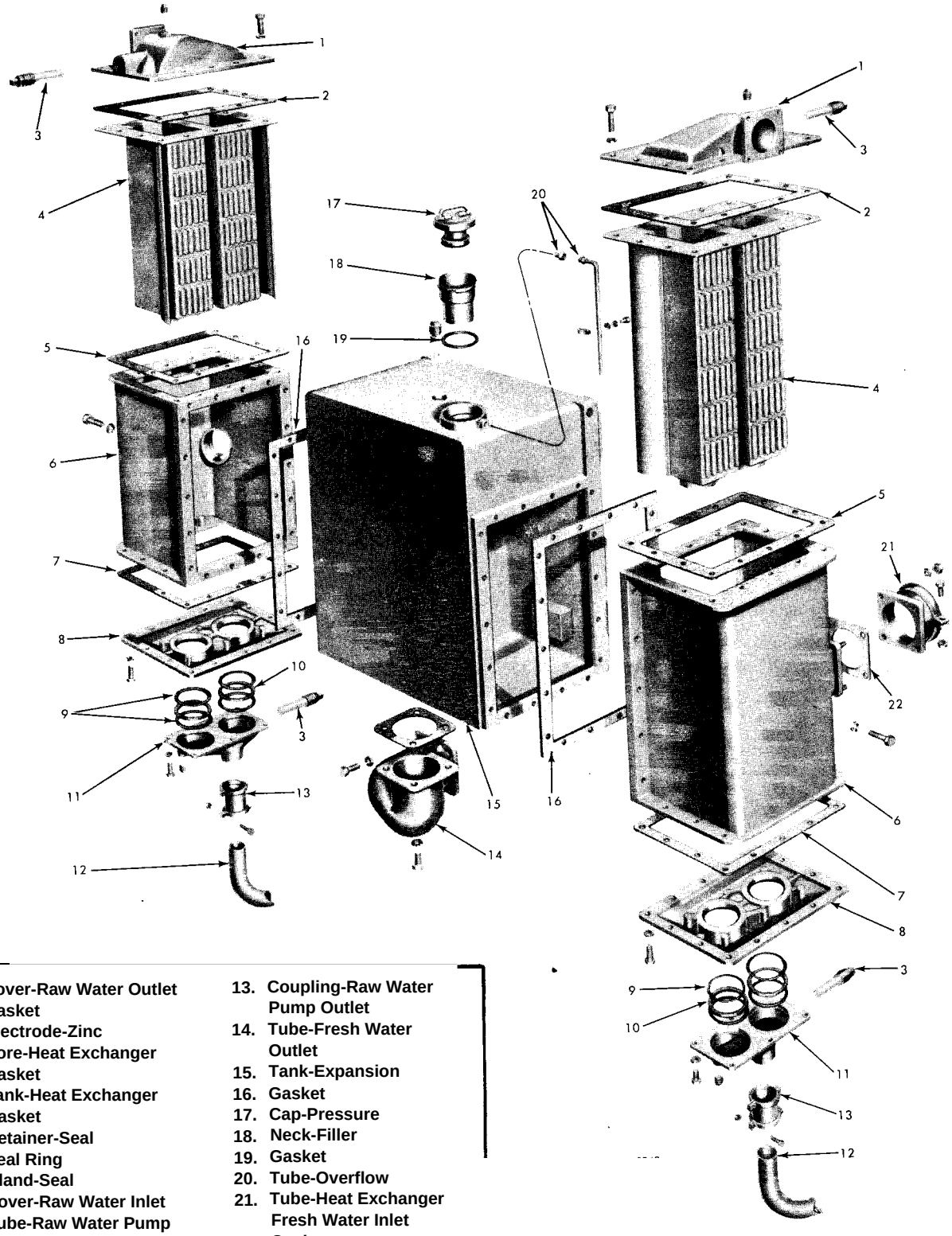
4. Remove the seals and the seal gland from the tank.

5. Withdraw the heat exchanger core and gasket from the top of the heat exchanger tank.

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 (1/3) muriatic acid and two-thirds (2/3) water to which one-half (1/2) pound of oxalic acid has been added to each two and one-half (2-1/2) 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.



1. Cover-Raw Water Outlet
2. Gasket
3. Electrode-Zinc
4. Core-Heat Exchanger
5. Gasket
6. Tank-Heat Exchanger
7. Gasket
8. Retainer-Seal
9. Seal Ring
10. Gland-Seal
11. Cover-Raw Water Inlet
12. Tube-Raw Water Pump Outlet
13. Coupling-Raw Water Pump Outlet
14. Tube-Fresh Water Outlet
15. Tank-Expansion
16. Gasket
17. Cap-Pressure
18. Neck-Filler
19. Gasket
20. Tube-Overflow
21. Tube-Heat Exchanger Fresh Water Inlet
22. Gasket

Fig. 2 - Heat Exchanger Details and Relative Location of Parts

CAUTION: To avoid possible personal injury when working with chemicals, steam and/or hot water, wear adequate protective clothing (face shield, rubber apron, gloves, boots, etc.), work in a well ventilated area, and exercise caution.

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

Inspect Zinc 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.

Install Heat Exchanger Core

After the heat exchanger core has been cleaned and inspected, refer to Fig. 2 and 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.

Refill the fresh and raw water systems and check for leaks.

ENGINE COOLING RAW WATER PUMP (JABSCO)

Raw water for lowering the temperature of the engine coolant is circulated through the heat exchangers by two positive displacement pumps (Fig. 1). The pumps are attached to adaptors which are bolted to the flywheel housing and are driven through couplings attached to the rear idler gears (Fig. 2).

The drive from the idler gear is to the pump drive shaft which is carried on a double-row ball bearing located in the flange end of the pump housing.

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

• Two types of raw water pump are used on Series 149 engines. In the first type, the impeller rotates against a bronze cam in the impeller housing. A single wear plate is installed between the impeller and the housing end to prevent wear of the pump housing. A slot machined in the outer periphery of the plate registers with a dowel pin in the pump housing, thus preventing it from rotating with the impeller.

In the second type of raw water pump, the impeller rotates against a polyurethane cam/liner inside the pump body (housing). Two wear plates — one at each end of the impeller — are used to prevent wear of the pump housing and the cover gasket. Slots in these plates register with dowel pins in the pump housing, cam/liner, and cover, thus preventing the plates from rotating with the impeller.

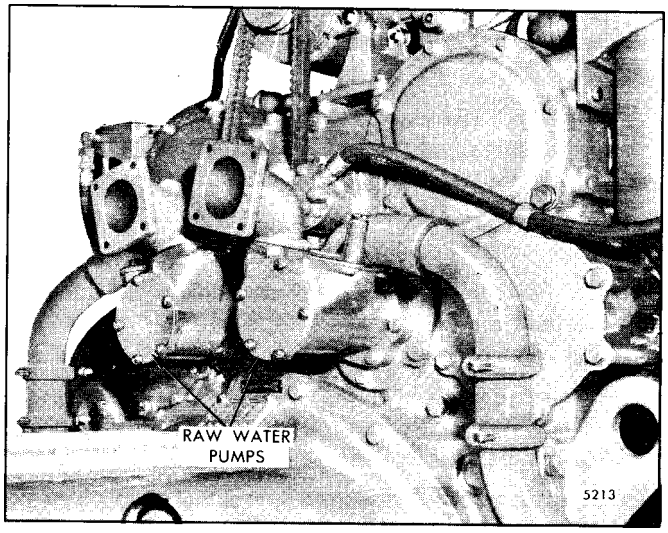
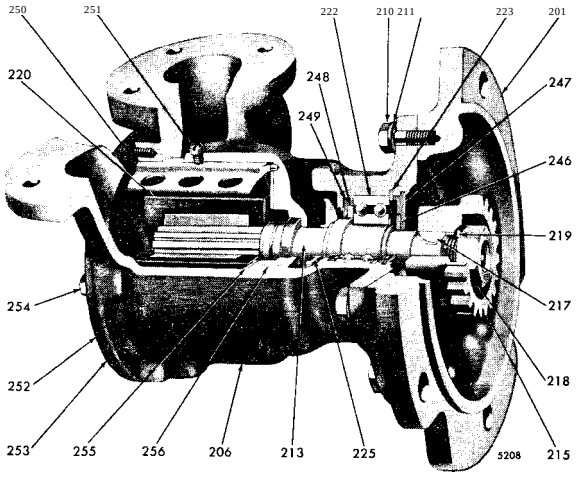


Fig. 2 - Raw Water Pump Mounting

Wear plates on both types of pumps can be reversed if wear on the plates becomes excessive. A rotary type seal assembly seals against leakage along the shaft.



201. Adaptor—Pump
206. Housing—Pump
210. Bolt—Housing to Adaptor
211. Lock Washer
213. Shaft—Drive
215. Gear—Drive
217. Key—Woodruff
218. Nut—Gear Retaining
219. Lock Washer
220. Impeller
222. Ball Bearing
223. Retainer—Bearing
225. Oil Slinger—Shaft
246. Washer—Felt
247. Seal—Bearing
248. Washer—Felt
249. Seal—Bearing
250. Cam—Offset
251. Bolt—Cam
252. Cover
253. Gasket—Cover
254. Bolt—Cover
255. Wear Plate
256. Seal Assy.

Fig. 1 - Raw Water Pump Assembly

Operation

The pump can be operated in a clockwise or counterclockwise direction. Raw water is drawn into the pump through the outlet opening, both openings being located at 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.

Raw Water Pump (With Bronze Cam)

The following service procedures apply to raw water pumps with bronze cams (Fig. 1, 3).

Replace Pump Seal

Seal parts may be removed and replaced with new parts by removing the impeller, but without removing the pump from the engine.

NOTICE: Use care not to scratch or burr the lapped surface of the seal seat or that portion of the shaft which the seal contacts.

1. Remove the cover screws and lift the cover and gasket from the housing (Fig. 3).
2. Use pliers to grasp a blade at each side of the impeller and pull the impeller from the shaft. The spline plug will come out with the impeller.
3. Insert two wires, each with a hook at one end, between the housing and the seal, with the hook over the edge of the carbon seal. Pull the seal assembly from the shaft.
4. The seal seat and gasket may be removed in the same manner.
5. If removed, place the gasket and the seal seat over the shaft and press them into position in the seal cavity.
6. Assemble the carbon seal, seal ring and washer in their correct relative positions and slide them over the shaft and against the seal seat. Care must be used to assure that the seal ring is contained snugly within the ferrule, thereby gripping the shaft.
7. Install the Marcel washer next to the flat washer.
8. Compress the impeller blades to clear the off-set cam and press the impeller onto the splined shaft. Install the spline plug.
9. Turn the impeller several turns, in that direction in which it will normally operate, to position the blade properly.
10. Install the cover on the housing, using a new gasket.

Remove Pump From Engine

If complete disassembly or replacement of the pump becomes necessary, refer to Fig. 2 and proceed as follows:

1. Drain the raw water system.
2. Loosen the hose clamps at the outlet elbow and intermediate tube and slide the hose along the tube.
3. Loosen the hose clamps at the inlet elbow and the inlet tube and slide the hose along the tube.
4. Remove the bolts and lock washers holding the inlet and outlet elbows to the pump and lift the elbows from the pump. Remove the gaskets.
5. Remove the adaptor to flywheel housing bolts and lock washers.
6. Loosen the pump from the flywheel housing by tapping on the edge of the adaptor with a soft hammer.
7. Withdraw the pump straight out from the flywheel housing, disengaging the drive gear from the coupling. Cover the pump opening in the flywheel housing with a clean cloth to prevent the entrance of foreign matter.

Disassemble Pump

Refer to Fig. 3 and disassemble the pump as follows:

1. Remove the seal assembly as previously outlined.
2. Mark the housing and the adaptor for reference when reassembling, then remove the bolts and lock washers and separate the adaptor from the housing.
3. Clamp the drive gear in a vise equipped with soft jaws and remove the retaining nut and lock washer from the shaft.
4. Take the gear from the vise and, using a suitable puller, pull the gear from the shaft. Remove the Woodruff key from the shaft.
5. Remove the bearing retainer from the groove in the housing.
6. Support the pump housing in an arbor press, with the mounting flange resting on the bed of the press and the splined end of the shaft under the ram of the press. Use a brass rod between the shaft and the ram and press the shaft and ball bearing from the housing.
7. Remove the slinger from the housing.
8. Pull the bearing seal from the pump housing.
9. Use an arbor press and a suitable sleeve to press the shaft from the bearing.
10. Remove the bolt and lift the cam from the housing.
11. Lift the wear plate off of the dowel.

Inspect Pump Parts

After disassembly, clean all of the parts thoroughly, except the bearing. *The shielded bearing must not be washed; dirt may be washed in and the cleaning fluid could 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.

Inspect the oil seal contact surfaces of the shaft for scratches or grooves. If scratched, smooth the surface with crocus cloth wet with fuel oil.

Inspect the impeller to make sure the bond between the neoprene and the metal is good. If the impeller blades have a permanent set, use a new impeller.

Remove burrs from the wear plate. If wear on the plate is excessive, it may be reversed when the pump is assembled.

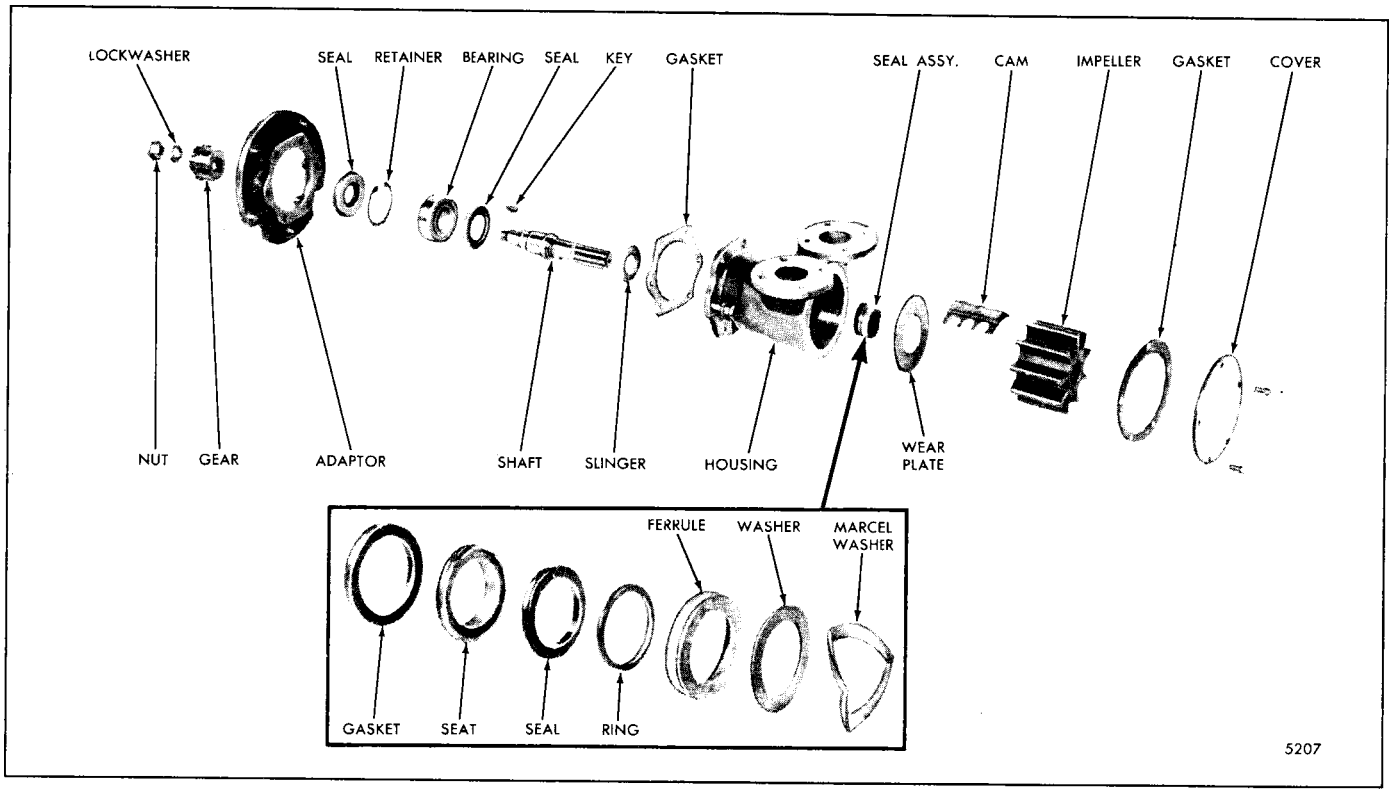


Fig. 3 – Raw Water Pump Details and Relative Location of Parts (Bronze Cam Design)

Assemble Pump

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

1. Install the wear plate in the pump housing, with the locating hole in the plate over the dowel in the housing.
2. Place the cam in the housing so the end of the cam is flush with the end of the housing and install the bolt.
3. Support the splined end of the shaft on a wood block on the bed of the arbor press. Start the bearing straight on the shaft and, using a sleeve between the ram of the press and the inner race of the bearing, press the bearing tight against the shoulder on the shaft.
4. Install the bearing seal in the housing with the lip facing toward the bearing.
5. Place the slinger in position and then press the shaft and bearing into the counterbore in the housing.
6. Install the bearing retainer in the groove in the housing.
7. Install a Woodruff key in the shaft and start the gear straight on the shaft over the key.
8. Place the housing in an arbor press, with the splined end of the shaft supported on a wood block, and press the gear tight against the shoulder on the shaft.
9. Clamp the gear in a vise equipped with soft jaws. Install the lock washer and retaining nut. Tighten the nut to 25-30 lb—ft (34—41 N*m) torque. Do not exceed the specified torque, otherwise shaft fracture and consequent early pump failure may result.
10. Position the adaptor on the housing by aligning the marks made when disassembling and install the six lock washers and bolts.

Raw Water Pump (With Polyurethane Cam/Liner)

The following service procedures apply to raw water pumps with polyurethane cam/liners (Fig. 4).

Remove Pump From Engine

If complete disassembly on replacement of the pump becomes necessary, refer to Fig. 2 and proceed as follows:

1. Drain the raw water system.
2. Loosen the hose clamps at the outlet elbow and intermediate tube and slide the hose along the tube.
3. Loosen the hose clamps at the inlet elbow and the inlet tube and slide the hose along the tube.
4. Remove the bolts and lock washers holding the inlet and outlet elbows to the pump and lift the elbows from the pump. Remove the gaskets.

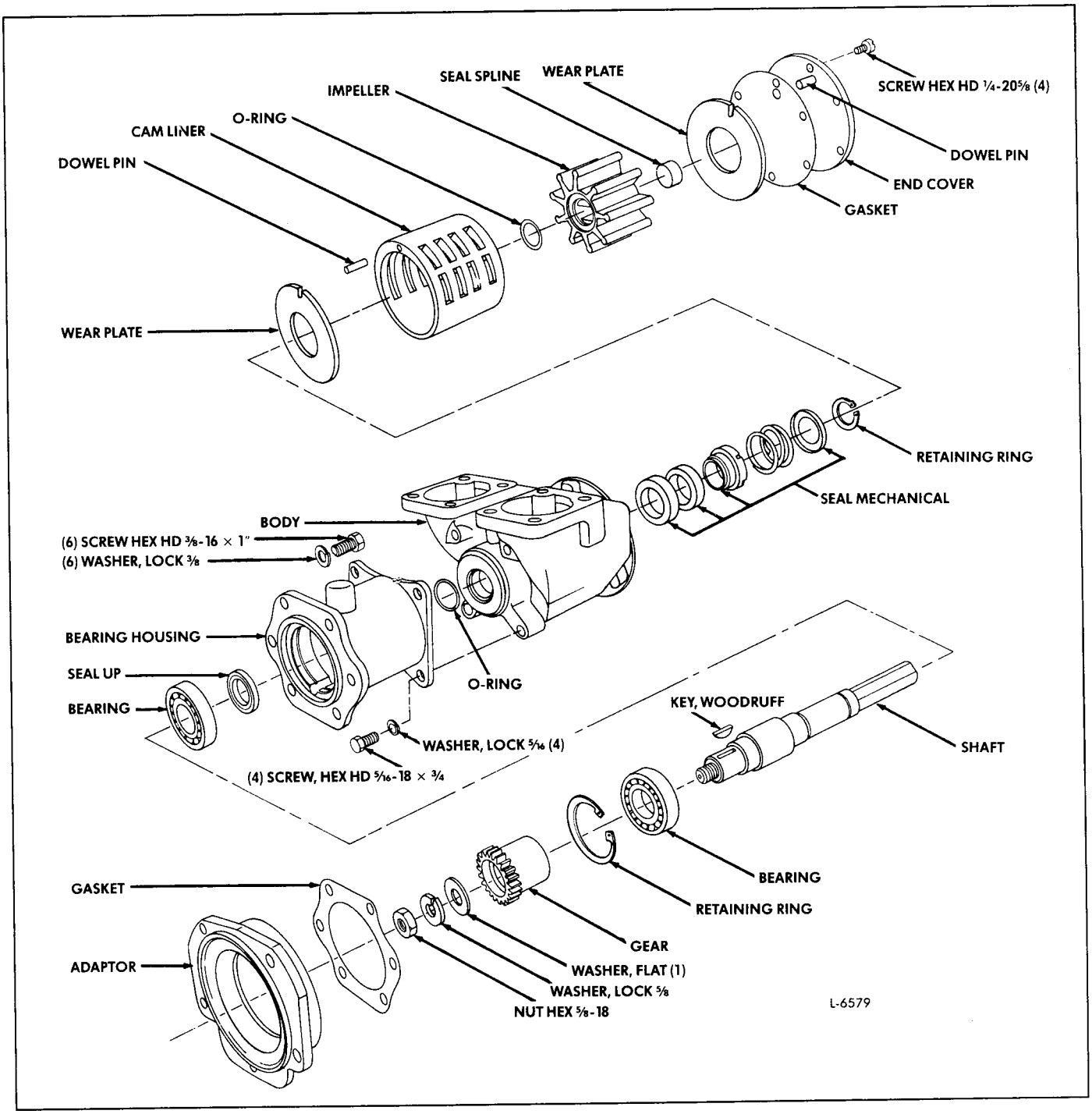


Fig. 4 Raw Water Pump Details and Relative Location of Parts (Polyurethane Cam/Liner Design)

5. Remove the adaptor to flywheel housing bolts and lock washers.
6. Loosen the pump from the flywheel housing by tapping on the edge of the adaptor with a soft hammer.
7. Withdraw the pump straight out from the flywheel housing, disengaging the drive gear from the coupling.

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

Disassemble Pump Body

1. Remove end cover screws and end cover. Remove gasket and outer wear plate.

2. Grasp hub of impeller with pliers and remove from impeller bore. If impeller O-ring remains on shaft, remove it.
3. Remove cam/liner from pump body.
4. Remove inner wear plate.
5. Remove seal retaining ring, taking care not to scratch shaft. Remove carbon portion of mechanical seal with tensioning spring attached.
6. Remove bolts securing adaptors to pump inlet and outlet ports. With pump body held securely to keep it from falling, remove four (4) 5/16" screws and lockwashers holding pump body to bearing housing.
7. Remove pump body from bearing housing and shaft sub-assembly. Remove anty remaining gasket material from port adaptors.
8. Remove slinger O-ring from shaft.
9. From drive end of pump body, press out remaining portions of mechanical seal (boot and ceramic seat).
10. Clean and inspect all parts for wear. Worn wear plate(s) should be reversed, if reusable, or replaced. If cam/liner thickness is 3/8" or less at its thickest section, it should be replaced.

Assemble Pump Body

1. Install new slinger O-ring on shaft near bearing housing.
2. Install mechanical seal components. *Do not allow seal components to become soiled during assembly.* Lubricate ceramic seal seat boot with *water* only and press into seal bore of pump body. Install ceramic seal seat. Exposed ceramic surface should face toward impeller bore.
3. Slide pump body over shaft, taking care not to dislodge seal seat as body is moved toward (and aligned with) bearing housing. Attach pump body to bearing housing with four (4) 5/16" screws and lockwashers. Tighten to 14 - 15 lb-ft (19-22 N*m) torque.
4. Install carbon portion of mechanical seal with tensioning spring and spring washer over shaft, and locate in seal bore with carbon face against ceramic seal seat. Slide seal retaining ring over shaft against seal thrust ring and locate in retaining ring groove.
5. Install inner wear plate in pump body, aligning notch in wear plate with pin in body.
6. Lubricate bore of body with film of water pump grease. Align hole in top of cam/liner with pin in pump body and push cam/liner into body. Cam liner should be recessed about 1/8" from end cover surface to permit installation of wear plate.
7. Liberally coat inside of cam/liner with water pump grease.
8. Insert impeller O-ring in groove in impeller recess. With O-ring end of impeller facing pump housing, rotate impeller in direction of pump rotation to bend vanes under cam and push into bore until impeller insert flats align with shaft flats. Then push impeller all the way into impeller bore. End of impeller should be approximately even with cam/liner. Install rubber spline plug into end of impeller.
9. Install outer wear plate (align notch in wear plate with hole in top of cam/liner) and place end cover gasket over pin in end cover.
10. Install end cover, aligning pin with hole in cam/liner. Install six (6) 1/4" fillister head screws in end plate cover. Tighten to 72 - 78 lb-in (8.13 - 8.81 N«m) torque. *Do not overtorque.*

Disassemble Pump Bearing Housing

1. Follow disassembly steps 1 through 10 of minor service instructions.
2. With housing held securely to keep it from falling, remove the six (6) 3/8" screws and lockwashers in housing flange and remove bearing housing and shaft sub-assembly from adaptor.
3. Prevent shaft from rotating by holding it with a wrench on shaft flats on impeller end. Then remove drive gear retaining nut, lock washer, and retaining flat washer.
4. Remove drive gear from shaft. A punch and small mallet may be used to gently tap the underside of the drive gear teeth to loosen gear from shaft. Remove woodruff key.
5. Remove retaining ring securing bearing in bearing housing.
6. Press against impeller end of shaft to remove shaft and bearing sub-assembly from bearing housing.
7. Support inner race of bearing and press shaft out of bearing. Repeat procedure on second bearing.
8. From pump end of bearing housing, push oil seal out of bearing housing. Discard seal.

Inspect Pump Parts

After disassembly, clean all parts thoroughly, except the bearing, and replace as required. The shielded bearing must not be cleaned. 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. Clean any remaining gasket material from face of adaptor flange on engine.

Assemble Pump Bearing Housing

1. Lightly coat the outside diameter of a new oil seal with clean engine oil. From drive end of bearing housing, press new oil seal into seal bore. Seal lip must point to drive end of housing.

2. With pressure applied to *inner* race of bearings, press bearings onto shaft.
3. With pressure applied to *outer* race of outer bearing, install bearing and shaft sub-assembly into bearing housing.
4. Install bearing retaining ring in bearing housing, insuring it is securely seated in ring groove.
5. Insert woodruff key into groove on end of shaft. Install drive gear onto shaft by gently tapping it with a small plastic-face mallet.
6. Install flat washer, lock washer, and retaining nut onto shaft. Prevent shaft from rotating by holding it with a wrench on shaft flats at impeller end, and tighten retaining nut to 24 - 30 lb—ft (33 - 41 N*m) torque.
7. Follow steps 1 through 10 of minor assembly instructions to install pump body and components.
8. Install new adaptor flange gasket, and secure pump assembly to adaptor with six (6) 3/8" screws, flat washers, and lock washers. Tighten to 13 - 15 lb—ft (18 - 20 N*m) torque.
9. Using new gaskets, attach raw water pump inlet and outlet adaptors.

Install Pump On Engine

The pump may be installed by reversing the procedure used for removal.

Note that the end cover is marked to show the outlet port for RH rotation and the outlet port for LH rotation.

Follow these markings when installing the raw water pump to avoid any difficulty regarding direction of flow. Also, when installing the inlet elbow or the outlet elbow, be sure to use two flat washers on the bolt being installed in the blind hole in the pump housing.

COOLANT FILTER AND CONDITIONER

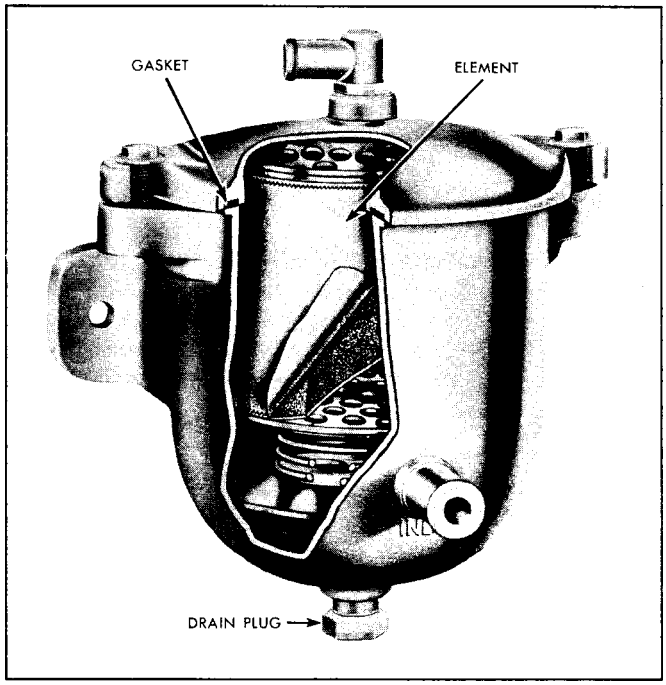


Fig. 1 - Coolant Filter and Conditioner (Canister Type)

The engine cooling system filter and conditioner is a compact by-pass 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).

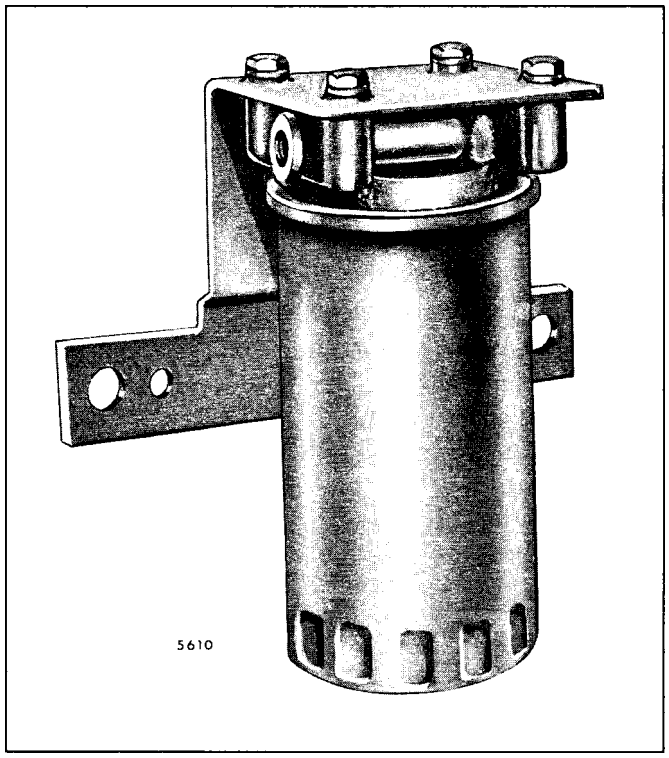


Fig. 2 - Coolant Filter and Conditioner (Spin-On Type)

The current type filter assembly includes one filter element while the former filter assembly included two filter elements. Two coolant filters connected in parallel are used on the Series 149 engine (Fig. 4).

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 filter 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 acts 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).

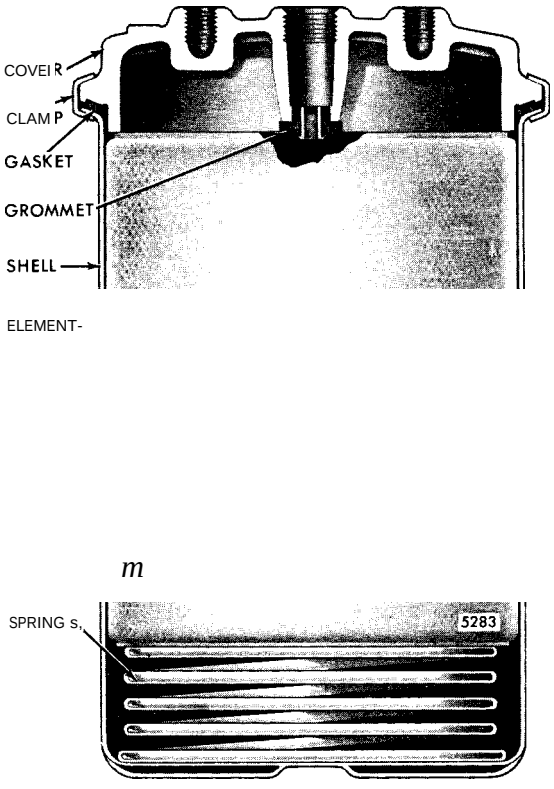


Fig. 3 - Coolant Filter and Conditioner (Clamp-On Type)

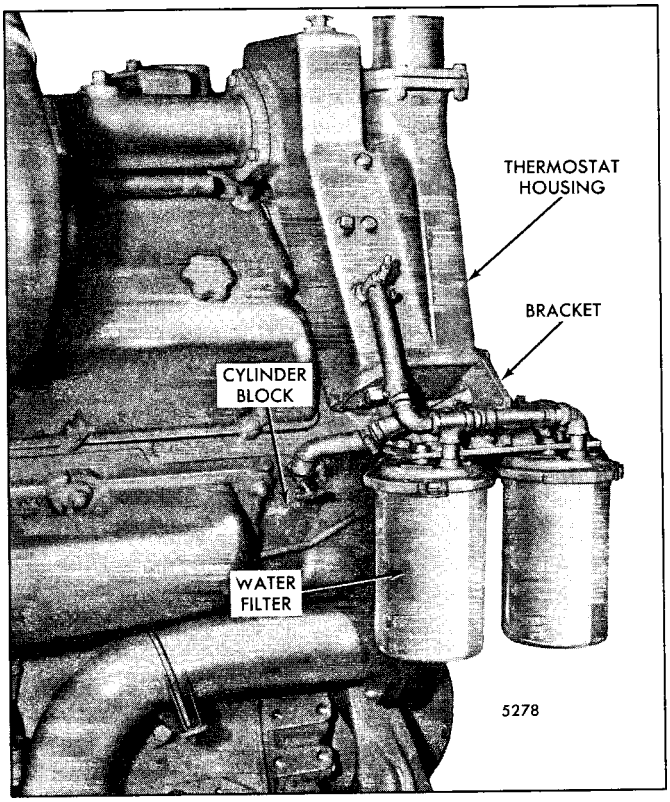


Fig. 4 - Typical Coolant Filter Mounting

The other components of the element perform the function of cleaning and preparing the cooling passages while the corrosion inhibitors protect them.

Filter Installation

If a 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 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).

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

1. Close the filter inlet and outlet shut-off valves. If shut-off valves are not provided, vise grip pliers can be used to clamp each hose closed during the filter change. Use caution to avoid damaging the hoses with the vise grip pliers.
2. Canister Type Element:
   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, if used.
   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.

3. Spin-On Type Element:
   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 1/2 to 3/4 turn after gasket contact assures a positive leakproof seal.
4. Clamp-On Type Element:
   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.
5. Open the inlet and outlet lines byopening the shut-off valves or removing the vise grip plier clamps.
6. 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 - TROUBLESHOOTING SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

DRAINING JABSCO RAW WATER PUMP

Although the engine is provided with draincocks for the purpose of draining the cooling system, a small amount of coolant may remain in the impeller housing of the raw water 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, the impeller housing of the raw water pump be completely drained. This may easily be accomplished by loosening the five (5) 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.

BACKLASH BETWEEN WATER PUMP GEAR AND IDLER GEAR (ACCESS HOLE)

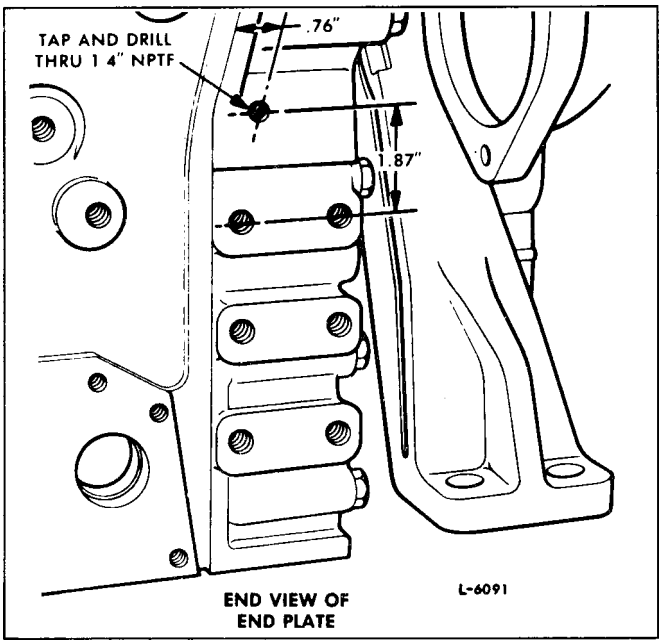


Fig. 1 - Location of Access Hole

If the engine front cover is the former style and does not contain an access hole, it is advisable that one be machined at the time of overhaul (Fig. 1).

Use 1/4 inch pipe plug to seal the opening after the hole is machined and the gear lash check is complete.

TROUBLESHOOTING

COMBUSTION GAS LEAKAGE INTO THE COOLING SYSTEM

Determining the area from which combustion gas is leaking into the cooling system can be both troublesome and time consuming. If a visual inspection of the cylinder kits through the air box (see Section 1.6) or a pressure check of the cooling system does not reveal the source of the leakage, the following procedure may be used:

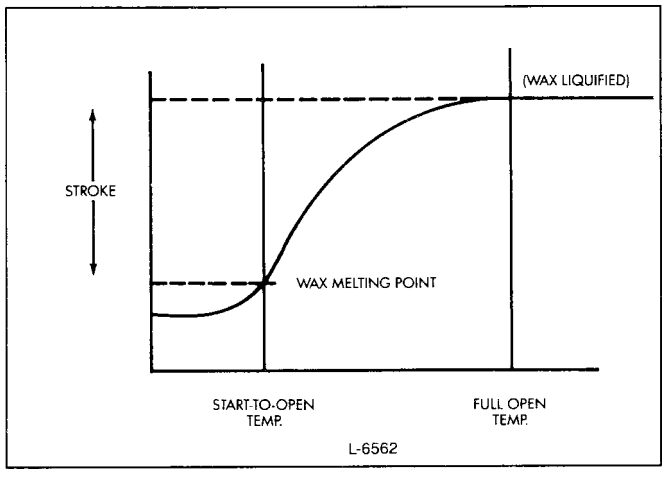
1. Drain the coolant from the engine.
2. Refer to Section 5.1:
   a. Remove the water pump cover and gasket.
   b. Remove the locknut and washer and withdraw the impeller using puller J 24420-A.
   c. Remove the vanes from an impeller. A vaneless impeller is required to render the pump inoperative while maintaining an effective pump seal. Make sure the ceramic insert remains in the impeller counterbore. Place this impeller and a washer on the shaft and start the locknut on the shaft. Hold the pump gear securely while drawing the impeller down with the locknut. Tighten the nut to 35-40 lb—ft (47-54 N*m) torque.
   d. Install the water pump cover and gasket. Tighten the nuts securely.
3. Refer to Section 5.2:
   a. Disconnect any water lines attached to the water manifolds.
   b. Loosen the seal and clamp between each front and rear manifold. Discard the seals.
   c. Remove the three manifold flange attaching bolts and lock washers from each thermostat housing. Slide each flange, seal and plate back on the manifolds. Discard the seals and gaskets.
   d. Remove the bolts and lock washers which attach the manifolds to the cylinder block, then remove the manifolds from the cylinder block. Remove and discard the gaskets.
4. Refill the cooling system so that the coolant level rises to the open water manifold outlet holes in the block. Do not overfill the cooling system.
5. To locate the faulty cylinder, start the engine and visually check for combustion gas bubbles forming at the water manifold outlet holes. Because coolant will not circulate through the engine with the impeller vanes removed, care must be taken not to allow the engine to exceed normal operating temperatures.
6. Replace the vaneless water pump impeller with a serviceable one (refer to Section 5.1).
7. Install the water manifolds (refer to Section 5.2).
8. Refill and properly inhibit the engine cooling system (refer to *Coolant Specifications (Section 13.3) or Coolant for Detroit Diesel Engines - Form 7SE298).*

.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 below. The normal tolerance for the start-to-open temperature is +2°F or -3°F (+1.11°C or -1.67°C).

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. Series 149 thermostats are designed so that at 3/4 of their stroke coolant flow is not substantially affected so as to cause coolant temperature concerns. Thermostats may be tested on the simple fixture shown (Fig. 4). 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-gauge 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. 3) and the test plate assembly (Fig. 2).

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.
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. 4.

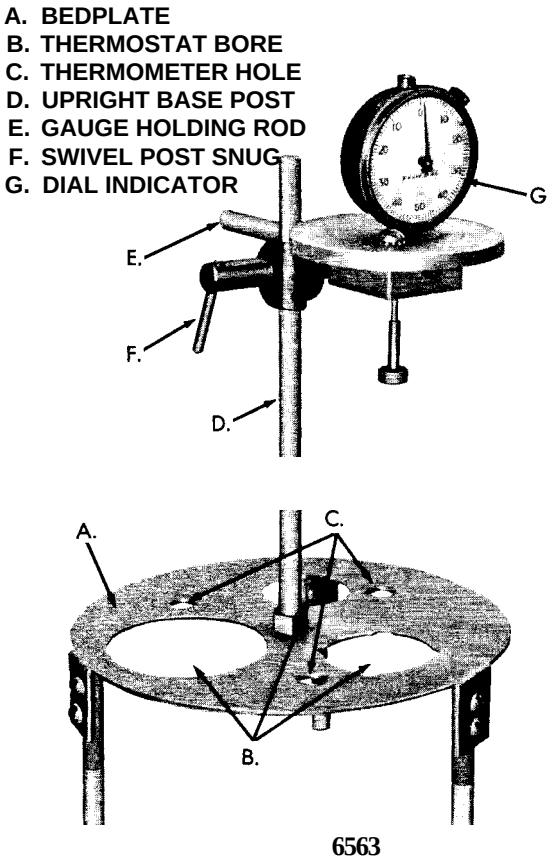


Fig. 2 - Test Plate Assembly

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

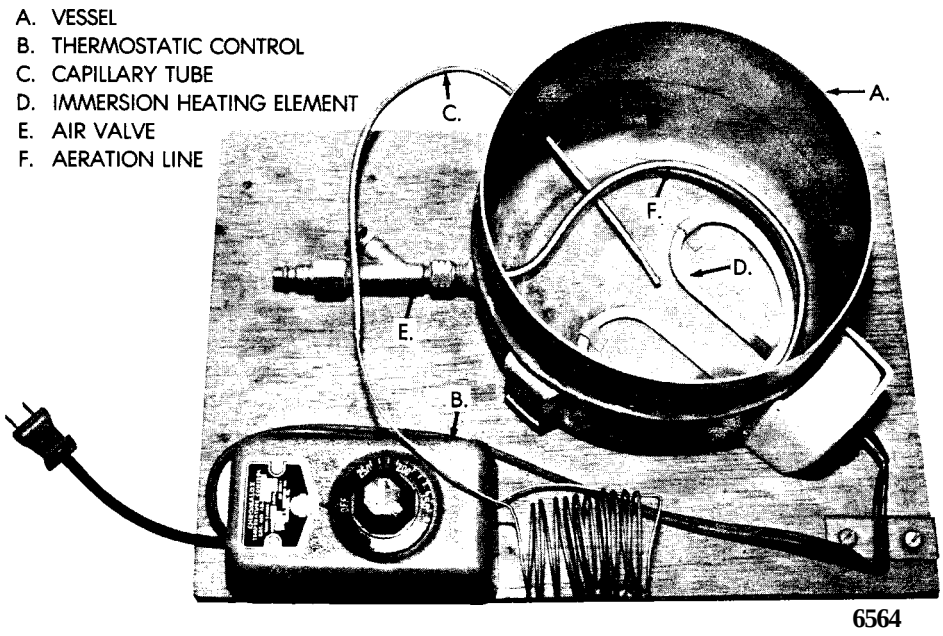


Fig. 3 - Test Vessel and Control

start-to-open temperature of the thermostat. Observe the dial indicator and note the temperature at which the needle just begins to move. This if referred to as the *start-to-open temperature.* The total indicator travel, from start-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.

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.

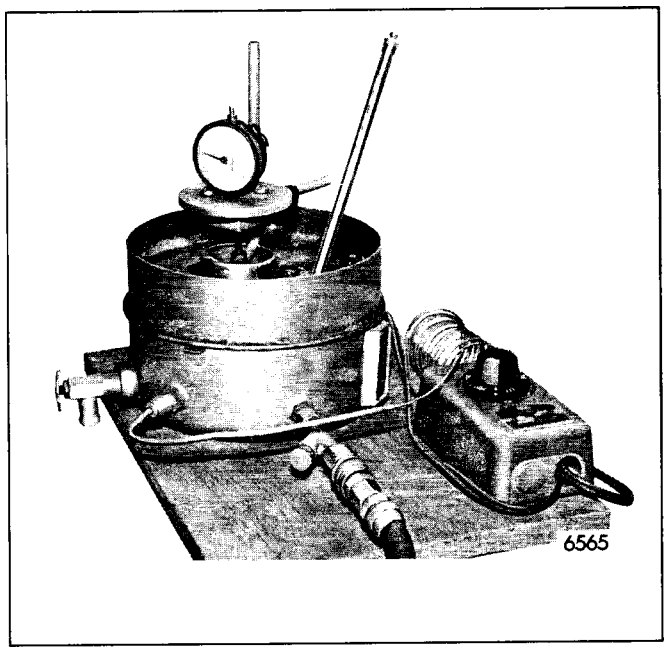


Fig. 4 - Testing a Thermostat in the Test Fixture

.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.

* Available from:

CHEMCENTRAL CORPORATION
7050 West 71st Street
Chicago, Illinois 60638

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb-ft)	INUm	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	INUm
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	i	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

BOLT IDENTIFICATION CHART

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD	lb-ft	N«m
Fresh water pump shaft locknut	7/16-20	40-45	54-61
Fan shaft locknut		195-205	265-278
Raw water pump drive gear locknut	5/8-18	25-30	34-41

STUD TORQUE SPECIFICATIONS

APPLICATION	STUD	lb-ft	N*m
Water pump body stud	3/8-16	20-30	27—41

SERVICE TOOLS

TOOL NAME	TOOL NO.
Belt gage (10 or 18 ribs, L section)	J 33889
Belt gage (8 rib, K section - 10 rib, L section)	J 23586-B
Driver handle	J 7079-2
Impeller slip checking fixture	J 34034
Installer—water pump oil seal	J 8501
Puller—universal	J 24420-B
Seal installer	J 8550
Snap ring pliers	J 4646
Water pump drive gear installer	J 25257

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 the cylinder block by studs, special washers, clamps and nuts.

EXHAUST MANIFOLD (AIR COOLED)

• A two-piece exhaust manifold with metal seal ring and expander (Fig. 1) is used on each side of 8V-engines. Two one-piece exhaust manifolds (Fig. 2) are used on each side of 12V engines. Two one-piece manifolds (Fig. 3) were formerly used on each side of 16V engines. These were replaced by new two-piece manifolds with seals, expanders, and clamps (Fig. 1), effective with unit serial number 16E08115.

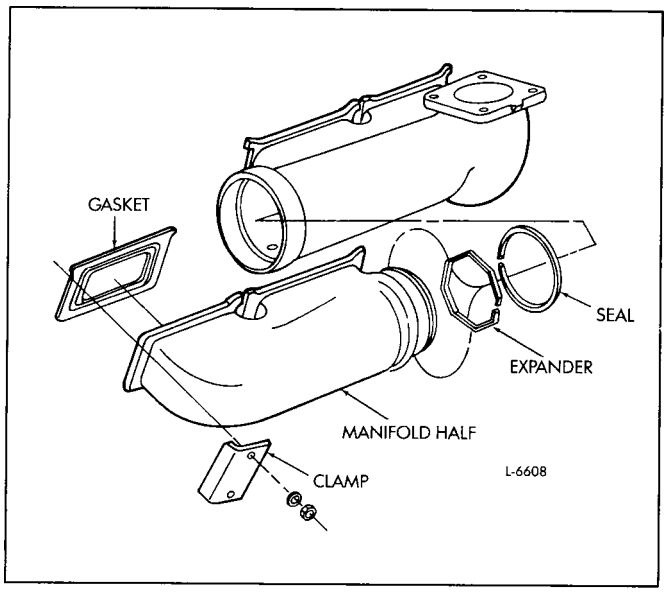


Fig. 1 Typical Two–Piece Exhaust Manifold Mounting

A single " Y" shaped adaptor connects the manifolds to the exhaust piping for each bank on a naturally aspirated engine (Fig. 2). Turbocharged engines utilize an adaptor on each manifold which connects the exhaust manifolds to the turbochargers.

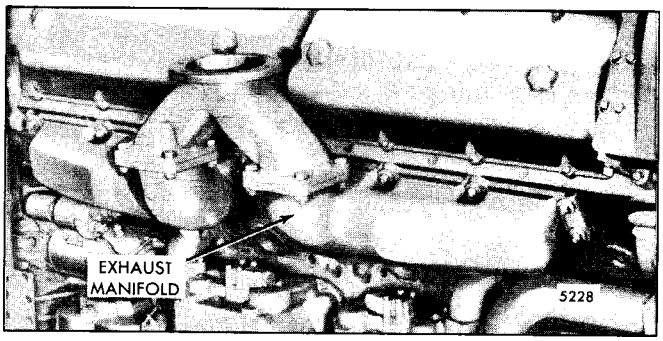


Fig. 2 - Typical One-Piece Exhaust Manifold Mounting

• In 1982, drain holes (Fig. 3) were added to all Series 149 non-marine exhaust manifolds in order to visually detect a *coolant leak and prevent the buildup* of potentially damaging *coolant inside the manifolds.* Effective with engine serial numbers 12E08857 and 16E08747, a new drain plug is factory-installed in the exhaust manifolds of all mine haul engines and is provided as a ship loose item (at 1 per manifold) with all other industrial models. DDC recommends installing these drain plugs in all engine applications (including 8V-149) that can tolerate open exhaust drains.

Remove Exhaust Manifold

1. Disconnect the exhaust pipe or adaptor from the exhaust manifold flange.
2. Loosen and remove the nuts, clamps and special washers which secure the exhaust manifold to the cylinder block. It is suggested that, as a safeguard, one nut and washer be loosened and left on one of the center studs of each manifold or manifold half until all of the other nuts and washers have been removed.
3. Support the manifold(s) and remove the nut(s) and washer(s) from the center stud(s).
4. Lift the manifold(s) away from the cylinder block.
5. Remove the gasket(s).

Inspection

Remove the loose scale and carbon that may have accumulated on the internal walls of the exhaust manifold. It is especially important to clean the manifold used on a turbocharged engine to eliminate the possibility of loose scale entering and damaging the turbocharger.

Before replacing a turbocharger that has experienced compressor turbine wheel damage, always inspect for and remove any debris that may have accumulated in the exhaust manifold. Failure to remove debris can result in damage to the replacement turbocharger.

Check the 1 /8" drain holes (if used) in the manifolds to be sure they are open.

Because some engine applications cannot tolerate open exhaust drains, all drain openings are plugged at the factory. Anyone wishing to utilize the drain hole feature must remove the solid pipe plugs from the manifolds and install a special service only plug which incorporates a 1/8" drilled hole. Through engine testing, the Engineering Department has determined that a 1/8" drilled hole has no significant effect on engine performance.

NOTICE: A drain hole larger than the 1/8" drilled hole may affect engine performance.

Those wishing to add this preventive maintenance feature to engines currently in service may modify their one-piece exhaust manifolds by drilling 1/8" holes in the locations shown in Fig. 3. Position the holes in the approximate center of the manifold in the logitudinal direction and at the lowest point in the transverse direction. Thread holes with 1/8" NPSF tap and install service-only exhaust manifold drain plugs which incorporate a 1/8" drilled hole.

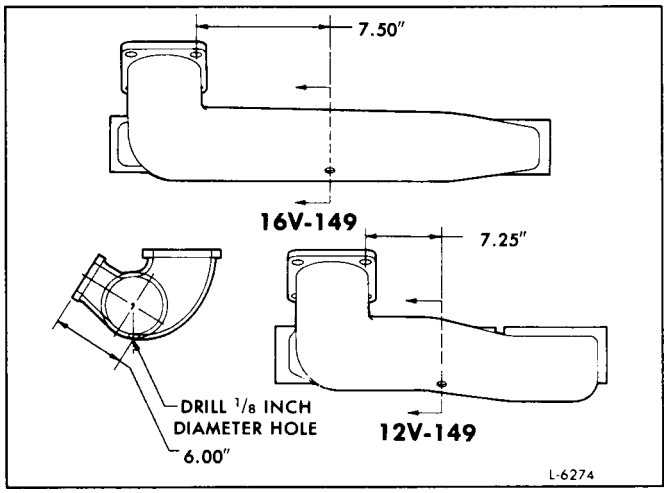


Fig. 3 - Exhaust Manifold Drain Hole Location

The exhaust manifolds and turbocharger exhaust inlet adaptors have been revised to provide a centrally located exhaust outlet connection. The exhaust manifold gasket and manifold attaching clamp have also been revised to improve sealing.

Check the flatness of each manifold. Flatness must be held at .005" to ensure proper sealing at the mating surface to the cylinder block. If the flange faces require milling, remove only the minimum amount of material necessary. To maintain sufficient end clamping, the height of the end clamp support legs should be reduced by an amount equal to that removed from the flange faces.

When replacing an exhaust manifold on a naturally aspirated engine, the current front and rear manifolds on the same cylinder bank must be used together with the revised gasket and clamp.

When replacing an exhaust manifold or an exhaust inlet adaptor on a turbocharged engine, both the current adaptor and manifold must be used together with the revised gasket and clamp.

Fig. 4 - Former and Current Exhaust Manifold Gaskets

Install Exhaust Manifold

- 1. Place a new, all-metal gasket over the studs (Fig. 4). When the current all-metal gasket is used, all studs will be the same length. Omit the beveled washer on the end studs when the new end clamp (Fig. 5) is used.
2. On 8V and 16V engines equipped with two-piece exhaust manifolds, install the expander and seal ring in the groove in the manifold, then assemble the two halves.
3. Position the exhaust manifold over the studs and up against the gasket.
4. Install the special washers so that the outer diameter will rest on the manifold and the crown is toward the nut. Then, install the two end clamps and attaching nuts on the studs. When an all-metal gasket is used on a 16V engine equipped with a one-piece exhaust manifold, use new end clamps or former clamps that have been reworked (Fig. 5).
5. Draw the manifold against the gasket, starting with the center nut. Tighten the nuts with stud nut wrench J 26816 to 50-55 lb—ft (68-75 N'm) torque.
6. Connect the exhaust pipe or adaptor to the exhaust manifold flange. Tighten the 5/8"—18 outlet flange nuts to 103-110 lb—ft (140-149 N-m) torque. Do not allow exhaust piping to impose excessive loads on the turbocharger.
7. Inspect exhaust outlet piping for dents, holes and potential sources of water infiltration such as loose clamps or deteriorated seals. Repair or replace, if necessary.

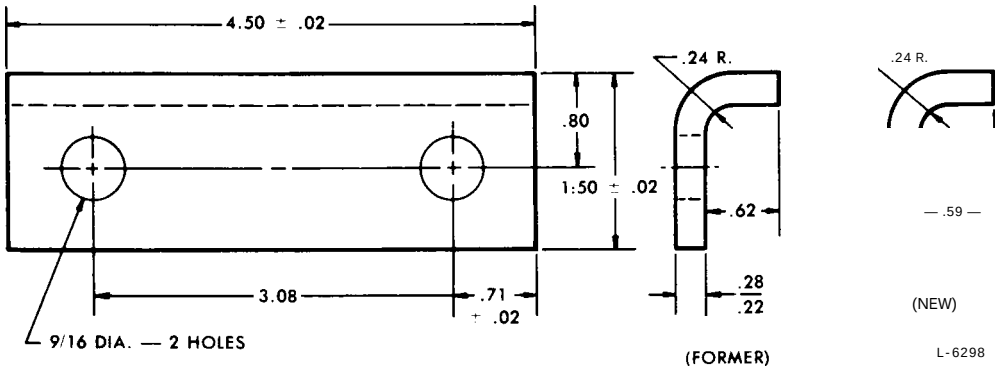


Fig. 5 - Former and Current End Clamps Used on One-Piece Exhaust Manifold

EXHAUST MANIFOLD (WATER COOLED)

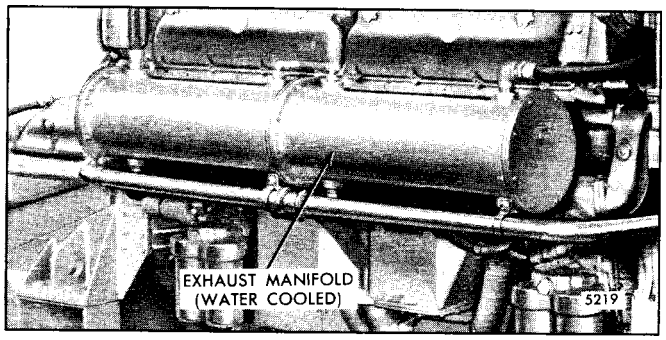


Fig. 1 - Water Cooled Exhaust Manifold Mounting (Naturally Aspirted Engines)

Water cooled exhaust manifolds are generally used on marine units, and some enclosed stationary installations, where the temperature of the engine room would raise the engine operating temperature above acceptable limits.

• The two-piece bolt-together water cooled exhaust manifold (Fig. 1) is designed with an integral water jacket surrounding the exhaust chamber. A portion of the engine coolant is bypassed from the rear of the water manifold into the rear exhaust manifold and is discharged from the front of the rear manifold into the rear of the front manifold. Coolant exits from the front of this manifold to different locations, depending on the application. A drain cock is installed in the bottom of each manifold for draining the water jacket. Manifolds may also have a center drain cock to check the exhaust path for the presence of water.

• One-piece water-cooled exhaust manifolds (Fig. 2) have a cast-in water jacket surrounding the exhaust chamber. A drain cock is normally installed in the bottom of the manifold(s) for draining the water jacket. On engines using one-piece water-cooled manifolds, the coolant flow is as follows:

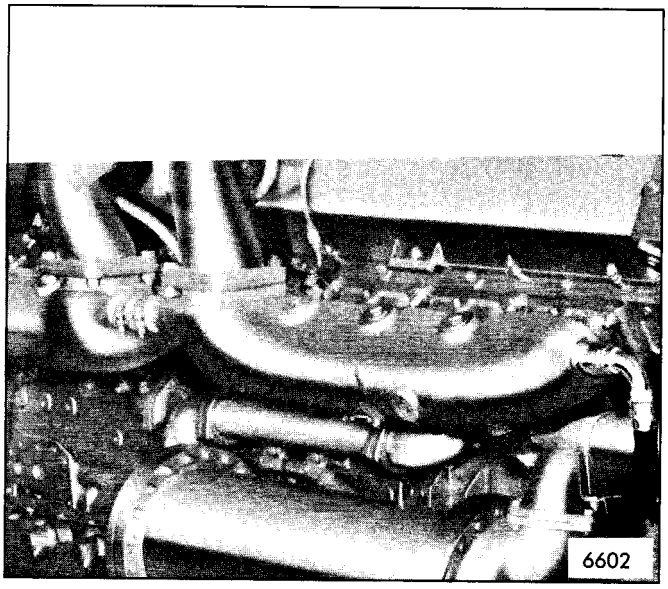


Fig. 2 - Water Cooled Exhaust Manifold Mounting (Turbocharged Engines)

8V Engines

Coolant flows from hoses on each side of the block into water inlet elbows at the front of the manifolds. After passing through the exhaust manifolds, the coolant exits through hoses routed to the water manifolds, then flows from the water manifolds through the thermostat housings and into the heat exchanger.

12V Engines

Left bank: Coolant flows from the heat exchanger into the left-bank thermostat housing and then into the left-bank water manifold. Coolant exits through a hose at the rear of the water manifold and enters the rear of the left-bank exhaust manifold. From here it passes through a connector into the front manifold and exits out a hose routed back to the heat exchanger.

Right bank: Coolant flows from a hose on the side of the block into the front of the right-bank exhaust manifold, passes through a connector into the rear exhaust manifold, and exits through a hose routed to the rear of the water manifold. After flowing through the water manifold, it enters the thermostat housing and returns to the heat exchanger.

16V Engines

Coolant flows from hoses on each side of the block into water inlet elbows in the front manifold. Coolant from each front manifold flows through connecting hoses into each rear manifold. The coolant exits through hoses routed to the rear of the water manifolds, then flows through the thermostat housings and into the heat exchanger.

Refer to *Troubleshooting* in Section 5.0 for combustion gas leakage into the cooling system.

Remove Exhaust Manifold

Because of the weight of the water cooled exhaust manifold, care should be taken to provide adequate support and means of removing and installing the manifolds on the engine.

Two-Piece Bolt Together Manifolds

1. Drain the cooling system.
2. Disconnect the water inlet and the water outlet tubes from the exhaust manifolds.
3. Disconnect the tubes or hoses connecting the manifolds.
4. Loosen and remove the nuts, two clamps and special washers which secure the exhaust manifold to the cylinder block. It is suggested that, as a safeguard, one

nut and washer be loosened and left on one of the center studs until all other nuts and washers have been removed.

5. Support the manifold and remove the nut and washer from the center stud.
6. Lift the manifold off the studs and away from the cylinder block.
7. Remove the manifold gaskets.

Inspection

Remove the loose scale and carbon that may have accumulated on the internal walls of the exhaust manifold. It is especially important to clean the manifold used on a turbocharged engine to eliminate the possibility of loose scale entering and damaging the turbocharger.

Before replacing a turbocharger that has experienced compressor turbine wheel damage, always inspect for and remove any debris that may have accumulated in the exhaust manifold. Failure to remove debris can result in damage to the replacement turbocharger.

Install Exhaust Manifold

1. On all engines, place a new, all-metal gasket over the studs (Fig. 3).

Fig. 3 - Former and Current Exhaust Manifold Gaskets

2. Position one of the exhaust manifolds over the studs and up against the gasket.
3. Install the special washers so that the outer diameter will rest on the manifold and the crown is toward the nut. Then, install the nuts on the studs.

NOTICE: When an all-metal gasket is used on an engine, use new end clamps or former clamps that have been reworked (Fig. 4).

.4. Draw the manifold against the gasket, starting with the center nut. *When installing'two-piece, bolt-together manifolds,* tighten the nuts with stud nut wrench J 26816 to 50-55 lb—ft (68-75 N*m) torque.

When installing one-piece cast manifold, tighten the 5/8"-18 center stud nut and the 5/8"—11 bolts to 103-110 lb—ft (140-149 N*m) torque.

5. Install a new center gasket and attach the remaining manifold, if removed.
6. If the exhaust flange was removed from the manifold, install the flange, using a new gasket.
7. Connect the exhaust pipe to the flange. Tighten the 5/8"—11 outlet flange nuts to 103-110 lb-ft (140-149 N*m) torque.
8. Connect the water inlet and outlet tubes to the manifold.

NOTICE: Do not allow exhaust piping to impose excessive loads on the turbocharger.

9. Inspect exhaust outlet piping for dents, holes and potential sources of water infiltration such as loose clamps or deteriotated seals. Repair or replace, if necessary.
10. Fill the cooling system and check for leaks.

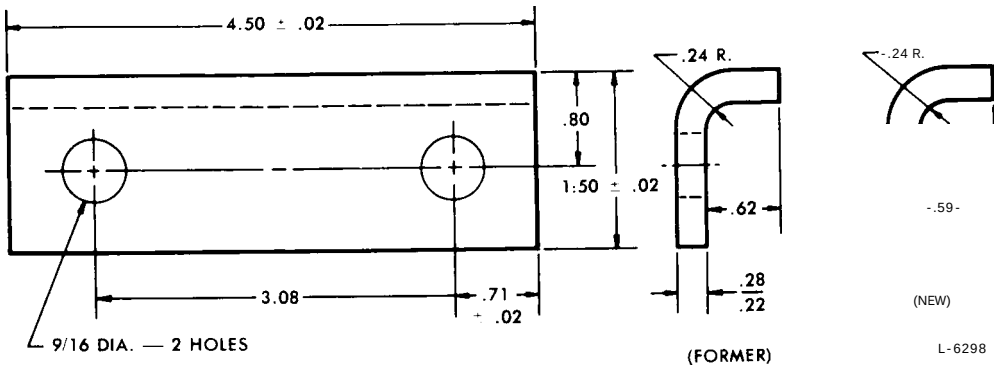


Fig. 4 - Former and Current Exhaust Manifold End Clamps

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.

BATTERY-CHARGING ALTERNATOR

The battery-charging circuit consists of an alternator, battery (Section 7.2), and the wiring. The battery-charging alternator (Fig. 1) 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.

HINGE-MOUNTED ALTERNATOR (BELT-DRIVEN)

The hinge-mounted alternating current self-rectifying alternator, mounted at the rear of the engine, 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.

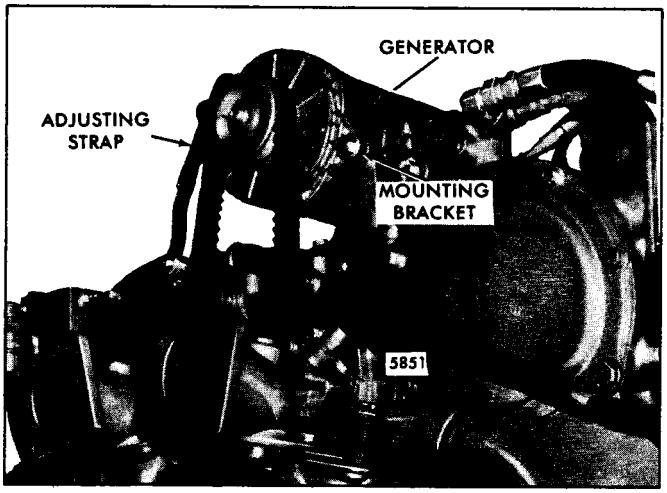


Fig. 1 - Typical Hinge-Mounted Alternator

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.

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. 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. 2).

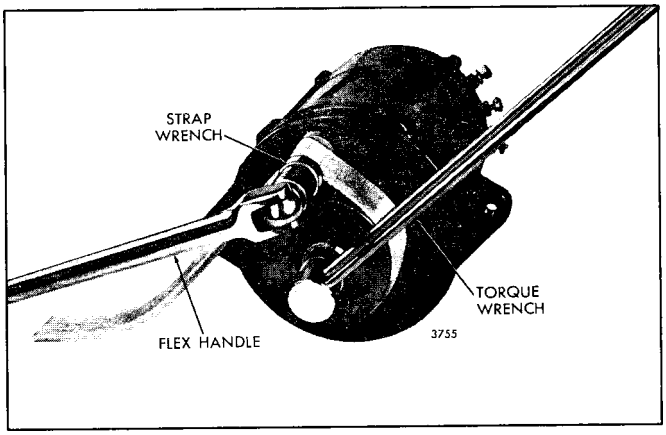


Fig. 2 - Tightening Alternator Pulley Retaining Nut

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. 2).

   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.

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 the 7/16"-14 mounting bolts to 46-50 lb—ft (62-68 N*m) torque and the 1/2"-13 mounting bolts to 60-70 lb—ft (81-95 N*m) torque.

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.

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.

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)	
		ABOVE 32°F (0°C)	BELOW 32°F (0°C)
8V-149 12V-149, 16V-149	24V, 32V 24V#, 32V#	950	1250

#Two cranking motors. Battery recommendation is for each motor.

• 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 # ST 1201) 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.

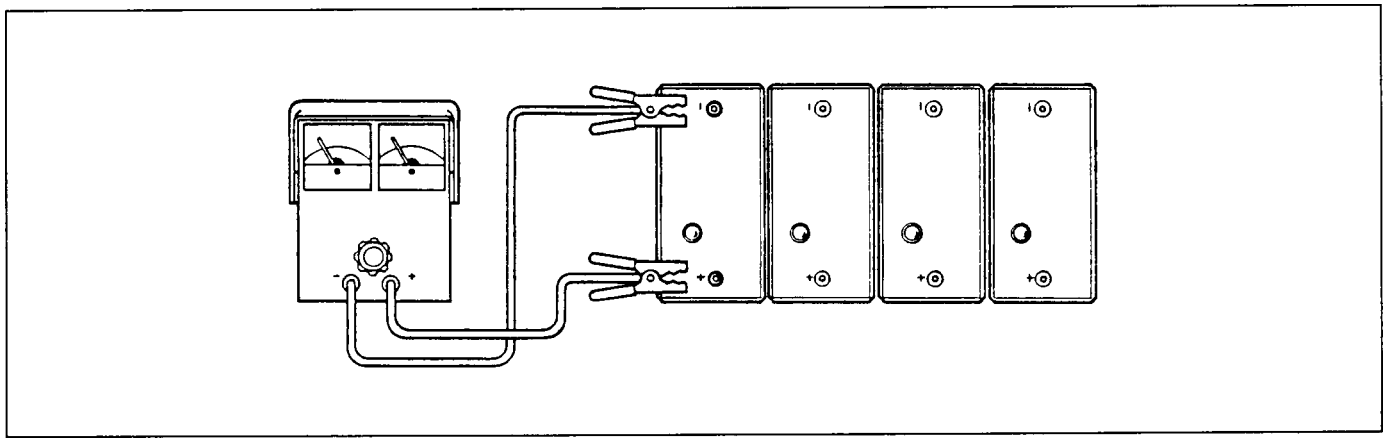


Fig. 2 - Battery Testing

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 (2 1.1°C)	9.6
50°F (10.0°C)	9.4
30°F (1.1 1°C)	9.1
1 5°F (-9.44°C)	8.8
0°F (-1 7.8°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 # ST 1201) 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 (1 5.6°C)	9.5
50°F (10.0°C)	9.4
40°F (4.44°C)	9.3
30°F (1.1 1°C)	9.1
20°F (-6.67°C)	8.9
10°F (-1 2.2°C)	8.7
0°F (-1 7.8°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

• Starting motors are mounted on the flywheel housing (Fig. 1). One starting motor is used on 8V engines, and two motors are used on 12V and 16V engines. When the starting circuit is closed, a small drive pinion on the armature shaft of each starter 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 pinions to prevent the armatures from overspeeding and damaging the starting motors. To accomplish this, the starting motors are equipped with heavy-duty overrunning clutches.

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

A solenoid switch, mounted on the starting motor housing, operates the overrunning clutch drive by linkage and a shift lever (Fig. 2). When the starting switch is engaged, the solenoid is energized and shifts the starting motor pinion into mesh with the flywheel ring gear and closes the main contacts within the solenoid. Once engaged, the clutch will not disengage during intermittent engine firing. To protect the armature from excessive speed when the engine starts, the clutch “overruns”, or turns faster than the armature, which permits the pinion to disengage itself from the flywheel ring gear.

The solenoid plunger and shift lever on this type of starting motor are totally enclosed to protect them from dirt, water and other foreign material.

An oil seal, between the shaft and the lever housing, and a linkage seal prevents the entry of transmission oil into the main frame of the starting motor and solenoid case, allowing the motor to be used on wet clutch applications.

The nose housing on the starting motor can be rotated to obtain a number of different solenoid positions with respect to the mounting flange. The nose housing, on starters equipped with the heavy-duty clutch, is attached to the lever housing by six bolts located around the outside of the housing. When repositioning of the solenoid is required on a service replacement starting motor, proceed as follows:

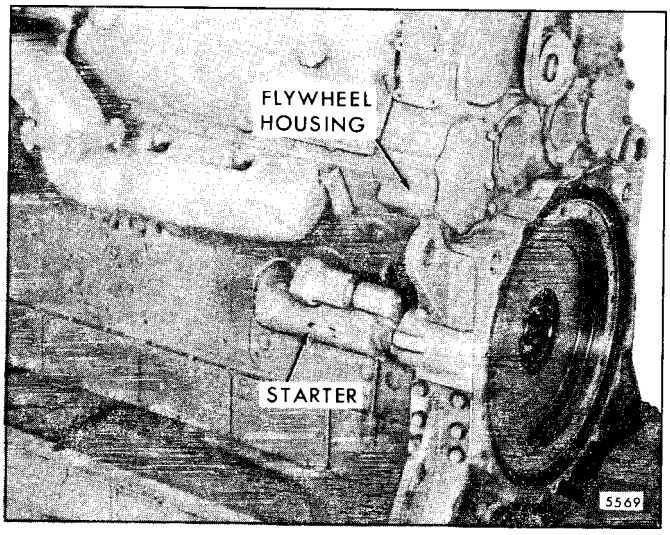


Fig. 1 - Starting Motor Mounting

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

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.

4. Tighten the screws to 13-17 lb—ft (18-23 N*m) torque.

Lubrication

• Starting motors are permanently lubricated at time of manufacture, and no further lubrication is required.

Remove Starting Motor

Failure of a 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.

   NOTICE: 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.

4. Check the starting motor in accordance with the Delco-Remy “Cranking Circuit” maintenance handbook.

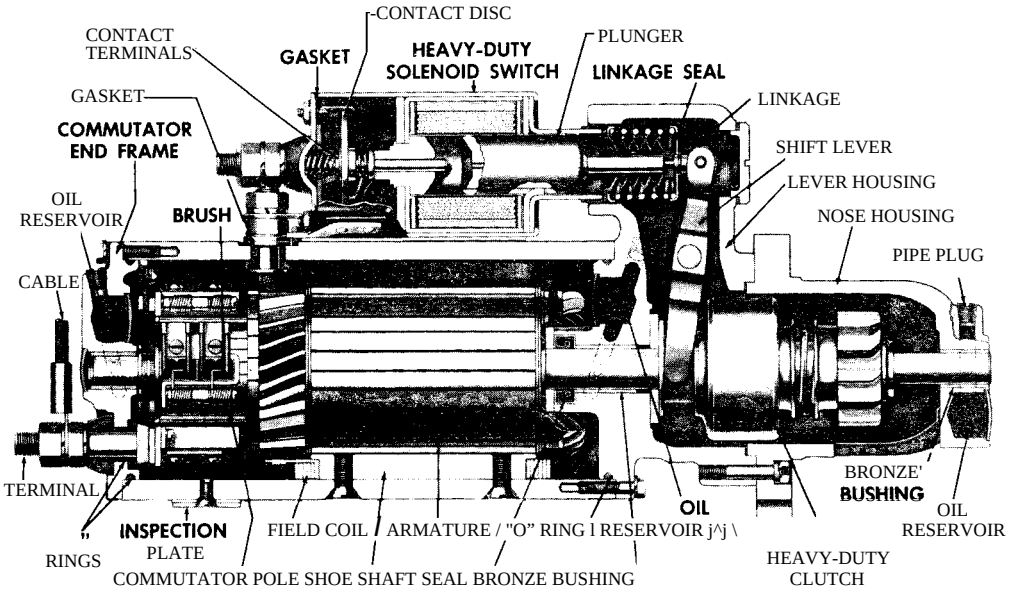


Fig. 2 - Cross-Section of Starting Motor with Heavy-Duty Drive

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.

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

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.

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

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.

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 taken during removal and installation of the part to avoid twisting the rubber diaphragm. 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.

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

To prevent damage to the gage assembly from vibration, the capillary tube must be securely fastened to the engine the full length with suitable clips at intervals of 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

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

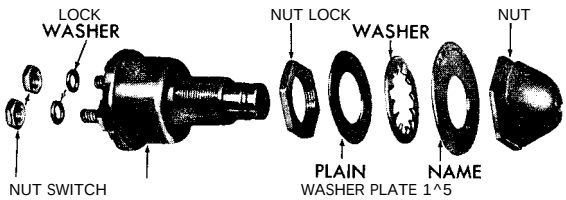


Fig. 1 - Typical Starting Switch Assembly

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 is used to energize the starting motor (Fig. 1). Starting switches may vary in design and their contacts must be rated sufficiently to carry the starter solenoid current.

> **NOTICE:** Tighten the 5/8”-32 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 down the engine. 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.

> **NOTICE:** When an emergency shutdown is necessary on a current engine with the spring loaded fuel injector control tube (one adjustment screw) the stop knob should be pulled **immediately** and held 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.

Emergency Stop Knob (Engines 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.

.CRANKCASE PRESSURE MONITOR

Effective with engines built approximately March 1 of 1984, a new crankcase pressure monitor is used on all Series 149 engines. The new monitor (Fig. 2) is larger than the former monitor and is mounted on the engine front cover.

The crankcase pressure monitor is used to detect excessive crankcase pressure which may be caused by internal engine malfunction. Early detection of an internal malfunction may prevent catastrophic engine damage.

The monitor senses excessive crankcase pressure by means of a diaphragm connected to a microswitch (see Fig. 3). There are three contacts in the microswitch: *common, normally open, and normally closed.* Depending on the application, these contacts may be used as required to activate an alarm system or a shutdown device and/or remove the load from the engine (for example, inhibit electric drive propulsion) when excessive crankcase pressure is detected. Detroit Diesel Corporation has determined that reducing or eliminating load from the engine will reduce the possibility of catastrophic engine damage until engine shutdown can be accomplished.

The microswitch in the monitor is activated when crankcase pressure exceeds 4.5 + .5 inches of water (1.0 to 1.2 kPa) and remains activated even when pressure is reduced. The monitor is reset by removing the safety cover and pushing in the reset button.

> **CAUTION: The crankcase pressure monitor is mounted on the engine front cover and is near the engine cooling fan and belt drives. To avoid personal injury, the engine must be shut down before resetting the monitor.**

Overhaul Procedure

Detroit Diesel Corporation recommends overhauling the current monitor at normal engine overhaul intervals or if a malfunction (failure to reset, for example) should occur.

> **CAUTION: To avoid personal injury and/or engine damage caused by accidental start-up, disconnect the battery cables or the air starter system before removing or installing the crankcase pressure monitor.**

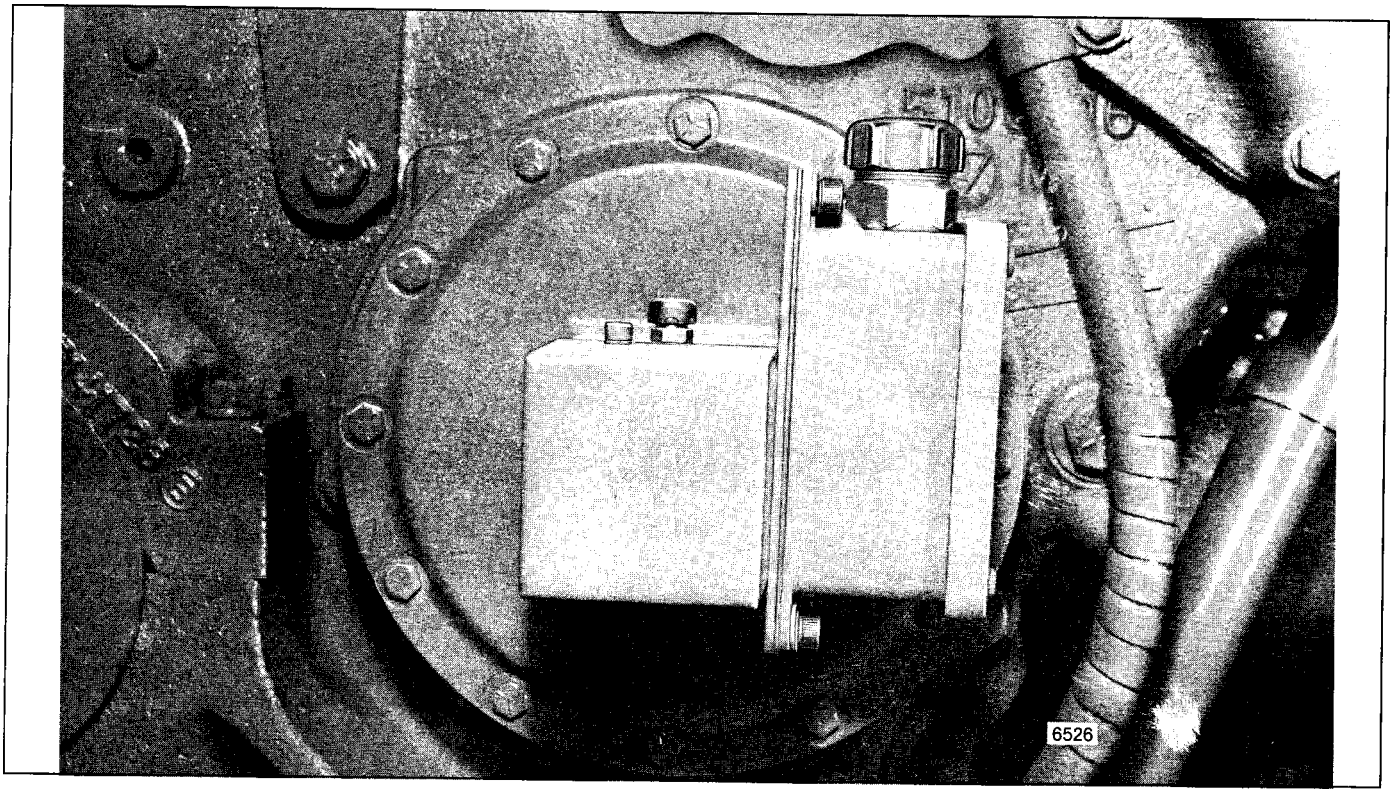


Fig. 2 - Crankcase Pressure Monitor Installed on Front Cover

1. Detach the wiring and remove crankcase pressure monitor from engine. Plug conduit connector hole, and clean all exterior surfaces with solvent or suitable engine degreaser.

2. Wipe or blow dry and place unit, large flange down, on flat, clean surface.

3. Refer to Fig. 4 and remove button cover (17) and terminal box cover (34). Discard screws (1), washers (2), and cover (17).

4. Remove four screws and washers (33 & 32). Remove terminal box (45).

5. Remove two screws and washers (28 & 27), and remove switch plate assembly (26).

6. Remove two screws (18) and withdraw stem assembly (4). Set crankcase tag (3) aside.

7. Remove screw (43) in center of button (42). Remove button and spring (41). Remove stem (38) from guide flange (40). Remove old O-ring (39) and discard. Clean all parts, install new O-ring (39) and reassemble, putting Loctite 271 (or equivalent) on screw (43), and greased O-ring (39) on stem.

8. Remove two #6-32 nuts (30) and washers (29, 36) from screws (22). Remove and discard microswitch assembly (35) and spring (24).

9. Drive out lever retaining pin (25). Discard lever (23) and pin (25).

10. Install new lever (23) and pin (25), with flat side facing up, away from switch.

11. Install new microswitch assembly (35) using screws (22) and washers (29, 36) and nuts (30). Make sure spring (24) is between switch body and lever, over stem of switch. Letter-marked side of switch should face out (be visible).

12. Remove four socket head 1/4" - 20 screws (5) and hold housing assemblies (6 & 7) to upper cover (11).

13. Remove housing assembly (7) and keep the 3 balls (8) for ball retainer (21) removal.

14. Remove ball retainer (21) using tool J 35352-2. With the balls in place, install the tool to engage the balls in the slots of the tool. Turn counterclockwise to remove. Discard the balls.

15. Remove O-ring (20) from ball retainer (21) and replace with new O-ring (20), lightly greased.

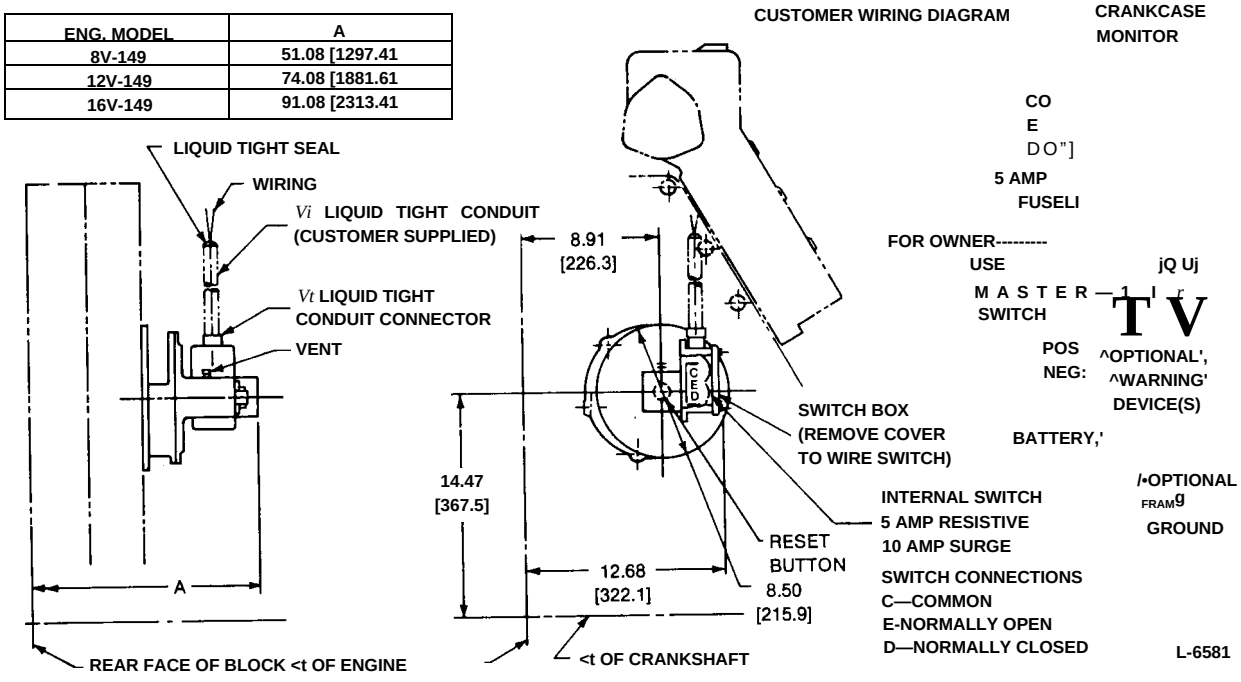


Fig. 3 - Crankcase Pressure Monitor Installation Schematic

16. Place ball retainer (21) into housing (19) by the reverse of step 14, tighten firmly and lock thread joint with punch mark.

17. Place new balls (8) into ball retainer (21) with grease.

18. Remove spring (10) from base of unit and discard.

19. Remove 12 screws (9) from base and separate the two halves (11, 16).

20. Remove diaphragm assembly (14) with gaskets (13) and ball cage (12) attached.

21. Remove 3 small screws (15) from underside of plate to release ball cage (12) from diaphragm. Discard diaphragm.

22. Clean ball cage (12) and install with 3 screws onto new diaphragm assembly (14).

23. Install new gaskets (13) to both sides of diaphragm assembly (14) and place on base. Align holes.

24. Place upper cover (11) on diaphragm assembly (14) and base (16), aligning all gasket and component holes.

25. *Start* 12 screws (9) into base (16) through cover (11), gasket (13) and diaphragm (14).

26. Insert alignment tool J 35352-1 through the cover into the diaphragm-ball cage assembly (12 and 13).

27. Tighten 12 screws (9) and remove the tool.

28. Place new spring (10) into base, around ball cage (12).

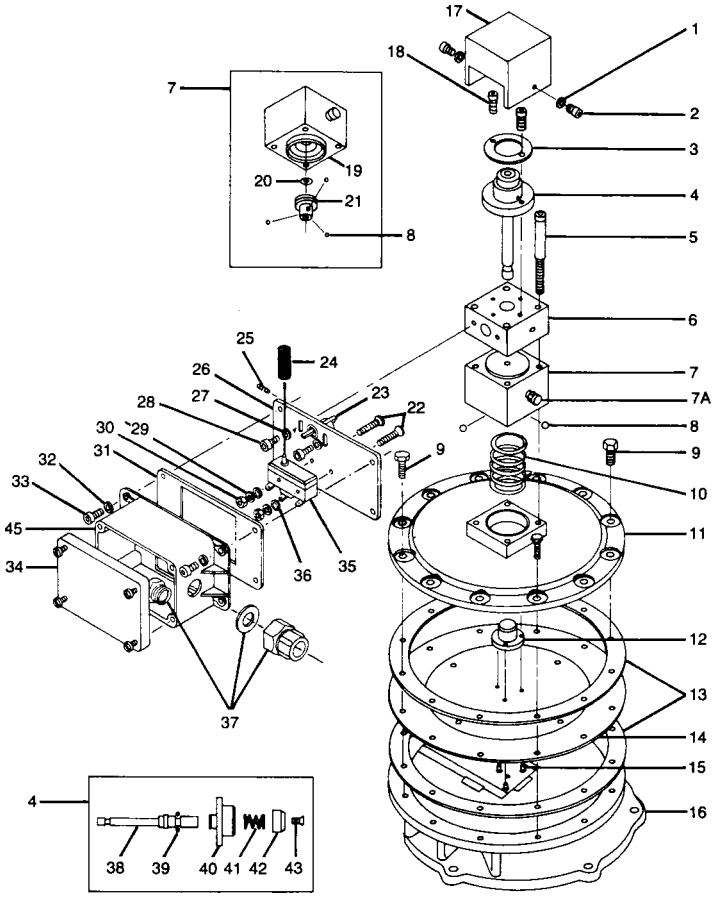
29. Place housing assemblies (6 & 7) onto base, being careful not to displace balls (8). Note correct orientation and drop 4 screws (5) into place.

30. Install alignment tool J 35352-3 through center of housing assembly (6). Insert any slender rod (3/16 dia. or smaller) through hole in bottom of base (16) and press lightly until alignment tool seats fully. Tighten 4 screws (5) securely.

31. Depress slender rod again (from step 30). Insert stem assembly (4), install crankcase tag (3) over top of stem assembly (4), and fasten all to housing assembly (6) with two screws (18).

32. Place screws (28) through switch plate (26), noting orientation shown in Fig. 4 and being careful to place end of lever (23 - opposite switch) above collar on stem (38). This may require movement of stem assembly. Press button (42) in slightly.

33. Test the monitor for proper operation.



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LEGEND

1. Washer Lock (2 req)*	11. Upper Cover (half)	23. Lever*	35. Micro-Switch Assy.*
2. ScrewSockethead(2req)*	12. Ball Cage	24. Compression Spring*	36. Washer (2 req)
3. Crankcase Tag	13. Gasket (2 req)*	25. Lever Retaining Pin*	37. Conduit Connector
4. Stem Assy	14. Diaphram Assembly*	26. Switch Plate	38. Stem
5. Sockethead Screws 1/4x20 (4 req)	15. Screw (3 req)	27. Washer (2 req)	39. "0"Ring*
6. Housing Assy (block)	16. Base (half) (mounting)	28. Screw (2 req)	40. Guide Flange
7. Housing Assy	17. Button Cover*	29. Washer (2 req)	41. Spring
7A. Vent*	18. Screw (2 req)*	30. Nut 6x32 (2 req)	42. Button
8. Ball (3 req)*	19. Housing	31. Gasket, Terminal Box	43. Screw (1 req)
9. Screw (12 req)	20. "O" Ring*	32. Washer (4 req)	44. Spring
10. Spring*	21. Ball Retainer	33. Screw (4 req)	45. Terminal Box
	22. Screw (2 req)	34. Terminal Box Cover	

'THESE COMPONENTS ARE INCLUDED IN MONITOR OVERHAUL KIT 8928694.

Fig. 4 - Crankcase Pressure Monitor Exploded View

Test Procedure (Bench)

Mechanical Test

A. With button (42) out (visible red band), switch (35) circuit should be closed across terminals "C" and "E" (see Fig. 3).

B. Push button in to latch (may have to hold in to permit full latching). When latched, normally opened contacts of switch, "C" and "E", should be open.

C. To trip device on bench, insert slender rod (3/16" dia. or smaller) through hole in bottom center of base (16) and lightly depress until device trips (switch should operate). Reset by pushing button (42) until it latches again.

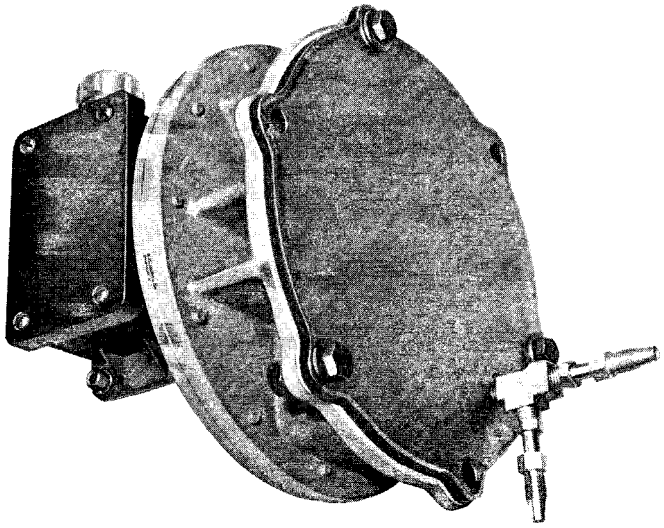


Fig. 5 - Cover Plate, Gasket, Bolts, and "T" Fitting Installed on Monitor

Pressure Test

A. Bolt cover plate (part no. 5139582) and gasket (part no. 5139583) onto mounting flange and thread a “Y” or “T” fitting into the 1/8" NPT hole in plate (Fig. 4). Attach two tight-fitting hoses to each leg of the “Y” or “T” fitting. Connect one hose to a water manometer capable of measuring 10 inches of H_20.

B. To test, connect the other hose to a low air pressure source (0 - 1 0 inches water). Slowly increase pressure until the manometer reaches a pressure that trips the latch. Button (42) will pop out showing the red band. The pressure increase will cause the water in the manometer to go up in one tube and go down in the other tube. Add the numbers at the water level (Meniscus) in each tube to obtain the number of inches of water (pressure). As the pressure increases to the specified trip pressure (4.0 to 5.0 inches), the diaphragm in the crankcase monitor will start to move. As it moves, the pressure in the manometer will drop off a little. When the button pops out, the pressure will drop off to zero. The diaphragm should start to move at 4.0 to 5.0 inches of water. If the manometer pressure builds up to 4.0 to 5.0 inches of water, then drops off until the button pops out, the crankcase monitor is operating correctly.

34. Attach new button cover (17) to housing (16), with screws (2) and washers (1).

35. Attach terminal box (45) to plate (26) with 4 screws and washers (32 & 33). Make sure terminal box gasket (31) is in place.

36. If the screws holding the terminal box cover (34) are tight, overhaul of the monitor is complete.

Test Procedure (On The Engine)

To ensure efficient crankcase pressure monitor operation, Detroit Diesel Corporation recommends testing it every 500 hours in its particular application on the engine. Use this procedure:

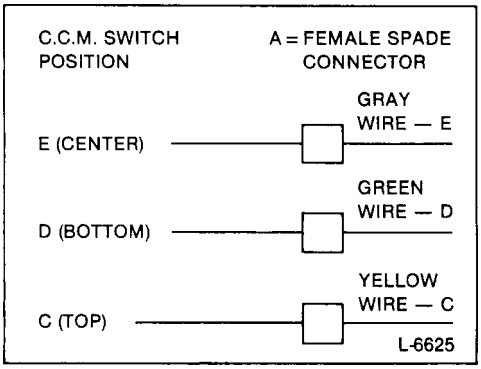
1. Block off one rocker cover breather.

2. Connect one end of a hose to a water manometer and the other end to either of the two remaining rocker cover breathers.

3. Attach a hose with a shut-off valve to the one remaining breather.

4. Start the engine and, after bringing it up to no-load speed, begin closing the shut-off valve. As crankcase pressure increases, the diaphragm in the crankcase monitor will start to move. When crankcase pressure builds up to the specified trip pressure (4.0 - 6.0 inches of water on the manometer), the crankcase monitor should activate.

NOTICE: Due to variations in measuring devices, level of engine condition, and rate of pressure buildup, 4.0 - 6.0 inches of water is acceptable for monitor trip point when checking monitors in the field.



NOTE: IMPROPER INSTALLATION OF WIRES CAN LOG THE FOLLOWING FAULT CODES:

81 VOLTAGE LOW
82 VOLTAGE HIGH
84 MONITOR TRIPPED (HIGH CRANKCASE PRESSURE)

Fig. 6 - Monitor Wiring Schematic - DDC II Equipped Engines

When the monitor is activated on mechanical unit injector-equipped engines, there will be a momentary decrease in crankcase pressure. The reset button on the crankcase monitor should also pop out and an electrical signal should be generated by the crankcase monitor micro-switch, activating the alarm system and/or shutdown system. (The micro-switch lead wires may be wired either normally open or normally closed, depending on application requirements).

When the monitor is activated on DDC II-equipped engines, there will be a momentary decrease in crankcase pressure. The reset button should also pop out, the "Check Engine" and "Stop Engine" lights should be illuminated, and active *Code 84* should be logged.

NOTICE: Improper installation of wires will log fault codes. Refer to Fig. 6 for proper wiring.

Any crankcase pressure monitor that fails to activate should be repaired or replaced.

The crankcase pressure monitor must be reset after completing the test. To reset the monitor, remove the safety cover and push in the reset button. Hold the button in for 3 to 5 seconds to ensure proper reset. The button will remain in the depressed position when properly reset (the red band will not show).

NOTICE: On DDC II-equipped engines, clear all codes from the historical codes with the DDR (Diagnostic Data Reader) tool J 36500.

CAUTION: Because the crankcase pressure monitor is mounted on the engine front cover and is near the engine fan and drive belts, *the engine must be shut down before resetting the monitor.* Failure to observe this precaution may result in personal injury.

TACHOMETER DRIVE

A tachometer drive is attached to the right bank camshaft gear drive flange or the right bank idler gear and extends through an adaptor attached to the flywheel housing cover (tachometer drive cover), Figs. 7 and 8.

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

1. Disconnect the tachometer drive cable from the tachometer drive cable adaptor.
2. Loosen the "A" clamp or the two attaching bolts and remove the tachometer drive cable adaptor and shaft assembly.
3. Remove the tachometer drive cover and gasket from the flywheel housing.
4. Remove the two attaching bolts and the driven tachometer adaptor from the camshaft gear drive flange or the idler gear.

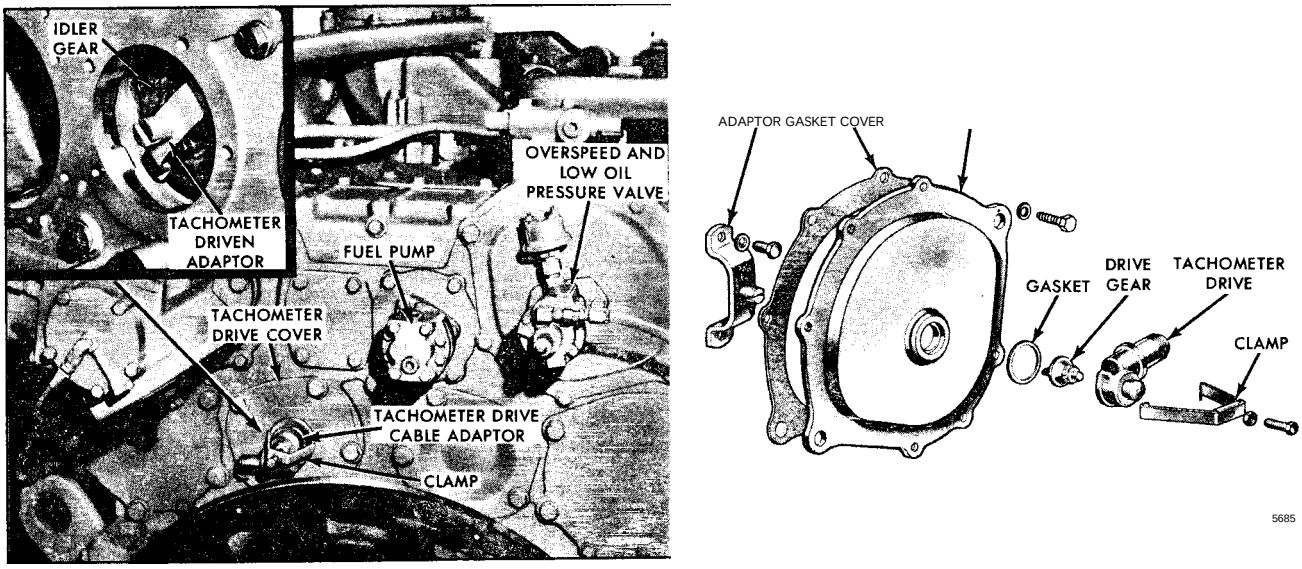


Fig. 7 - Tachometer Drive (Single Outlet)

Install Tachometer Drive

1. Attach the driven tachometer adaptor with two attaching bolts to the camshaft gear drive flange or the idler gear. Tighten the bolts.
2. Use a new gasket and install the tachometer drive cover and attaching bolts. Tighten the bolts.
3. Install the tachometer drive cable adaptor and shaft assembly. Install the “A” clamp or two attaching bolts and tighten the clamp nut or bolts.
4. Attach the tachometer drive cable.

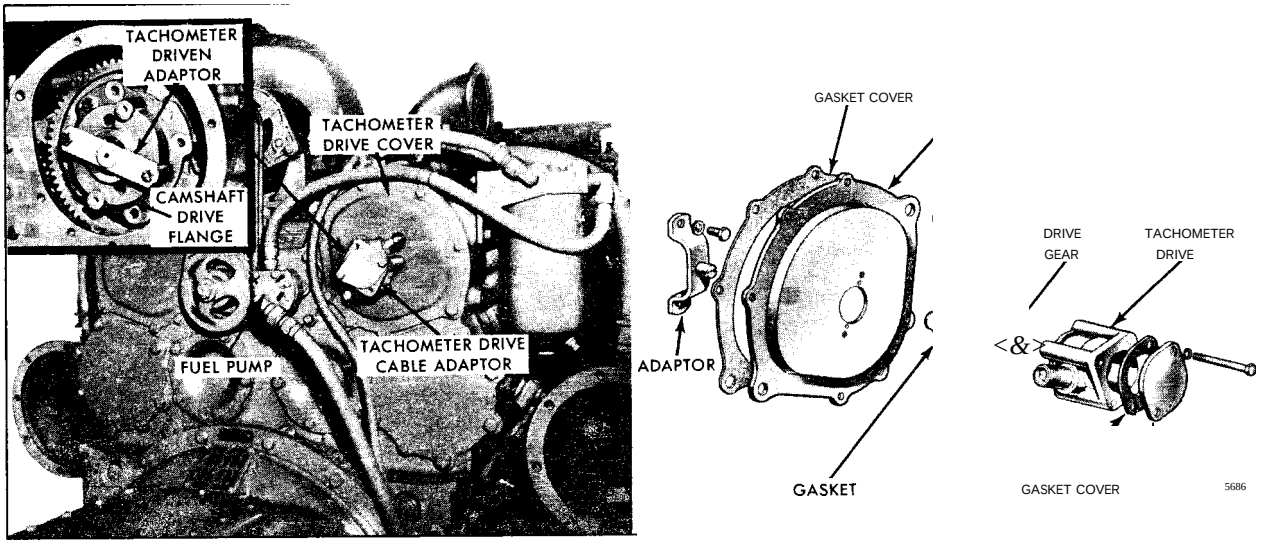


Fig. 8 - Tachometer Drive (Double Outlet)

ENGINE PROTECTIVE SYSTEMS

MANUAL SHUTDOWN SYSTEM

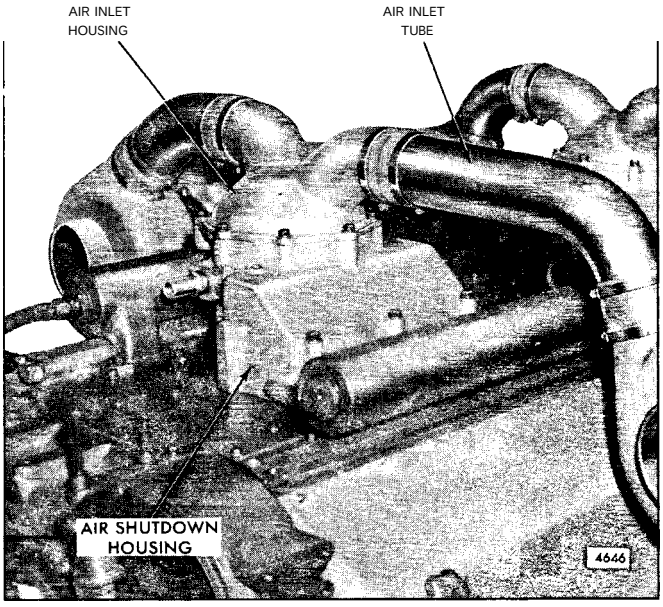


Fig. 1 - Typical Air Shutdown Housing Mounting

A manually operated emergency engine shutdown system, consisting of air shut-off valves mounted in the air shutdown housing and a suitable operating mechanism, 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 the engine to overspeed, use of the shutdown will prevent damage to the engine by cutting off the air supply and thus stopping the engine.

The air shutdown housing(s) is mounted over the blower(s) on the air box cover (Fig. 1).

The air shut-off valves are retained in the open position by a latch. A cable assembly or solenoid is used to trip the latch. Pulling the emergency shutdown knob all the way out will stop the engine. After the engine stops, the operator must push the emergency shutdown knob all the way in and manually reset the air shut-off valves before the engine can be started again.

When service of the shutdown system is required, refer to Section 3.3.

AUTOMATIC ELECTRICAL SHUTDOWN SYSTEM

The automatic electrical shutdown system shown in Fig. 2 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, one 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.

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 in the cylinder block to approximately 203°F (96°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 element and a micro-switch. The element contacts a copper plug (heat probe) which extends into the exhaust manifold outlet. Engine coolant is directed over the temperature sensing element of the switch and should the coolant temperature in the cylinder block exceed approximately 203°F (96°C), the element will close the contacts in the micro-switch and energize the shutdown circuit. If a loss of coolant occurs, the heat of the exhaust gases will be transmitted through the copper plug to the temperature-sensing element and cause the shutdown circuit to be activated.

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

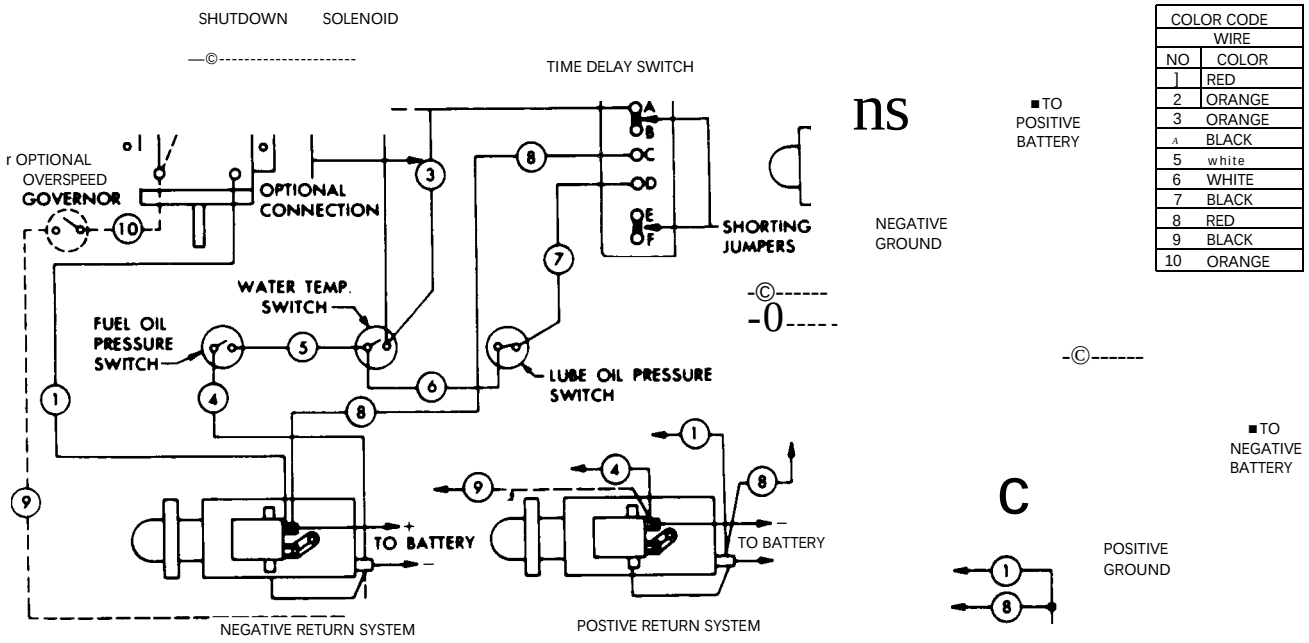


Fig. 2 - Typical Automatic Electrical Shutdown System Diagram

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

Some engines are equipped with an electrically operated automatic shutdown system which incorporates a solid state time delay switch (Fig. 2).

Since the fuel pressure builds up rapidly, the fuel oil pressure switch could close before the lubricating oil pressure switch opens, thereby stopping the engine. The time delay switch, however, delays operation of the solenoid for three to ten seconds to enable the lubricating oil pressure to build up and open the oil pressure switch contacts.

When the lubricating oil pressure falls below 1 0 + 2 psi (69 ± 14 kPa), the contacts in the oil pressure switch used in this system will close and current will flow to the time delay switch. The few seconds required to heat the time delay switch provides sufficient delay to avoid stopping the engine 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.

Solid State Time Delay Switch

A bench test procedure for the solid state time delay switch is as follows:

1. Refer to Fig. 2 and remove the time delay switch from the engine.
2. Refer to Fig. 3 and install the jumper straps on terminals A to B and E to F.
3. Install a positive battery lead to terminal A.
4. Install a negative battery lead to one side of a 12 volt light.
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 terminal D or the switch is closed, the lamp should light in 8 to 10 seconds. If not, the time delay switch must be replaced.

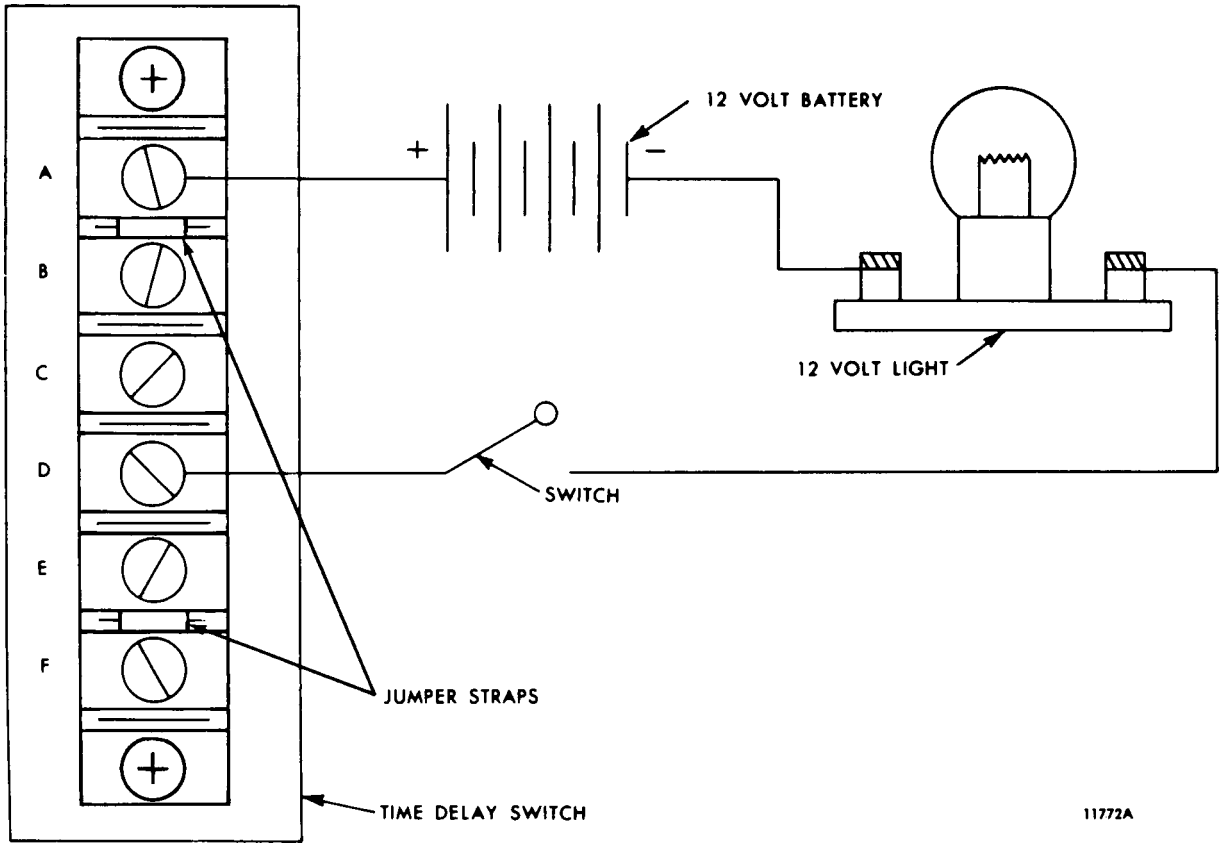


Fig. 3 - Solid State Time Delay Switch Testing Diagram

ALARM SYSTEMS

Electrical alarm systems (Figs. 1 and 2) are used to warn the operator of abnormal operating conditions such as low oil pressure, high water temperature, or a loss of either water or oil.

A typical system consists of a fuel oil pressure switch, a temperature switch and adaptor assembly mounted on the exhaust manifold, a low oil pressure and overspeed valve, a lubricating oil pressure switch, an alarm, and sometimes a relay.

Operation

The fuel oil pressure switch automatically turns the alarm system on and off. When it is open, the alarm is off. The switch is open when the fuel pressure is less than the switch setting which is stamped on the switch cover.

Coolant protection is obtained with an exhaust probe and adaptor assembly and a temperature switch. In this system, the engine coolant is circulated around the switch power element to prevent the switch from being activated by the heat transfer from the exhaust probe. Therefore, an alarm will occur under load if coolant flow through the adaptor is interrupted for any reason. The switch will also operate when the engine coolant discharge temperature exceeds 200-205°F (93-96°C).

The oil pressure switch, mounted in the low oil pressure and overspeed valve, will close to sound the alarm when the engine oil pressure drops below the safe operating pressure. The switch can also detect engine overspeed. Engine oil is supplied to the valve. Should the engine oil pressure drop below a safe operating value, above 1200 rpm, the valve will operate, dropping the oil pressure at the switch which completes the circuit and sounds the alarm. Below 1200 rpm, the oil pressure switch will close whenever the oil pressure is less than the switch setting. Engine overspeed is detected by the operation of the valve, which results in the oil switch closing. The travel of the piston in the valve, which is adjustable, controls the overspeed setting. The relay is used to prevent damage to the pressure and temperature switches should the current to operate the alarm device be too high. Should the alarm be activated for any reason, stop the engine immediately and check the cause before starting the engine again.

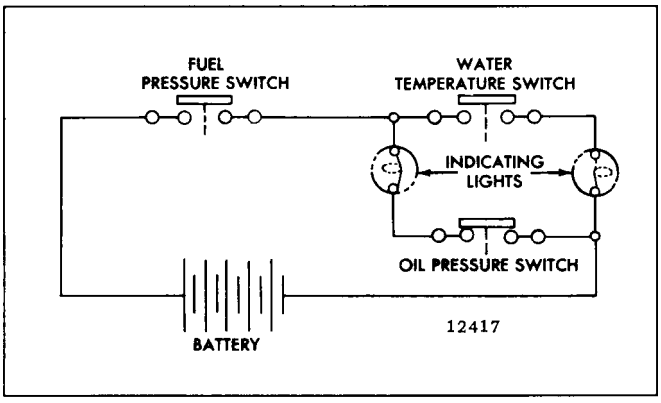


Fig. 1 – Typical Alarm Wiring Diagram

TESTING PROTECTION DEVICES

In a properly maintained installation, the protection devices seldom have cause to operate. Therefore, it is advisable to check to be sure that they will function when needed. It is important that the engine be thoroughly warmed up when checking any device on the engine. Prior to checking the protection devices, the alarm device and wiring should be checked. This is done by placing a jumper wire across the oil pressure switch terminals and operating the engine at rated speed. Failure to obtain an alarm is an indication of a faulty alarm, faulty wiring or inoperative fuel oil pressure switch.

Checking Pressure Switches

A calibrated 0-100 psi (0-689 kPa) pressure gage and a continuity checker are required to check the pressure switches. The pressure switches can be checked on the engine. However, if a regulated air supply is available, it is recommended that they be checked off the engine. Whether checking the switches on or off the engine, the concept of testing is the same. Use the continuity checker to observe when the switch operates and use the pressure gage to determine the pressure at the switch when it operates.

NOTICE: The pressure setting and type of switch (“make” or “break”) are stamped on the switch cover.

“Make” switches close with increasing pressure and “break” switches open with increasing pressure. The switches should operate at the pressure setting stamped on the switch. Normal tolerances for the switches are ± 1 psi (+ 6.9 kPa) for switches stamped up to and including 5 psi (34.5 kPa) and+ 2 psi (± 13.8 kPa) from 7-30 psi (48.3-207 kPa). The switches have been adjusted and sealed at the factory; therefore, it is recommended that faulty switches be replaced.

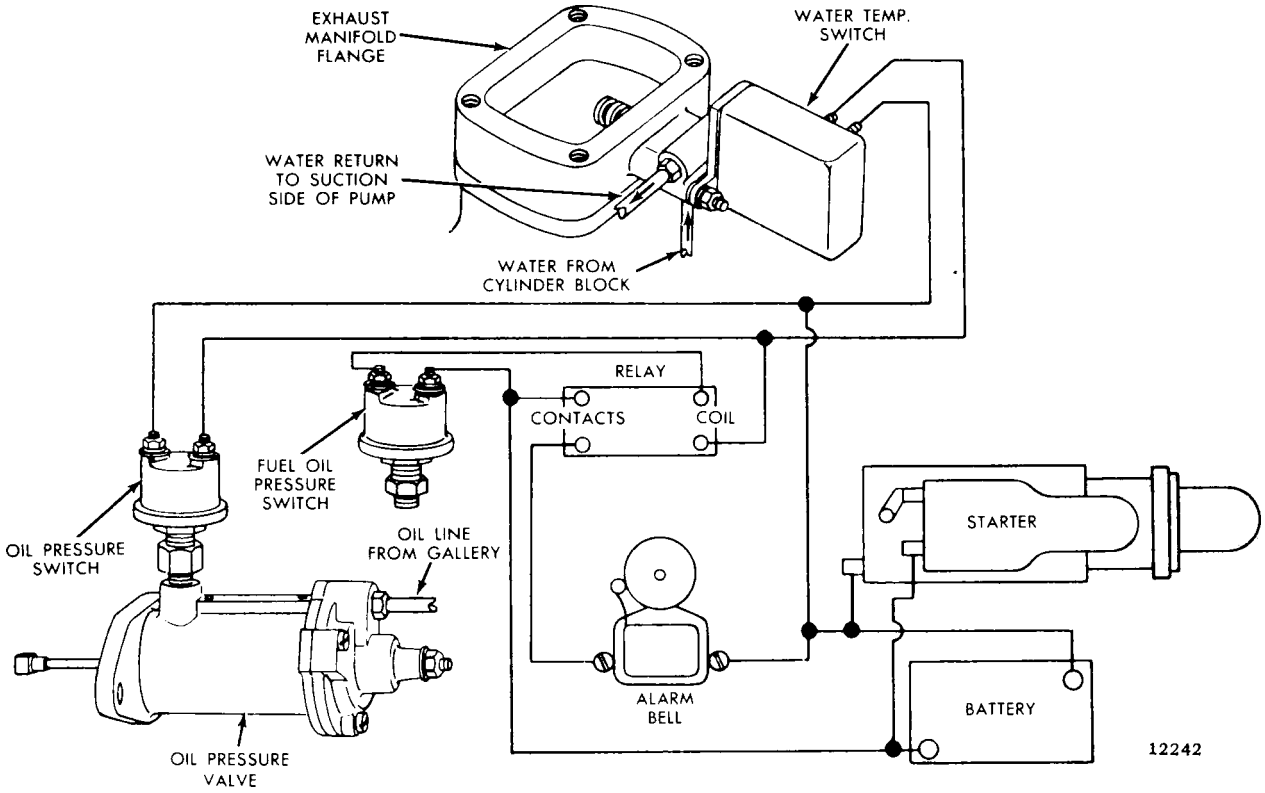


Fig. 2 - Schematic Drawing of Typical Alarm System

Checking Operation Of Temperature Switch

There are several methods for checking the performance of the temperature switch (Fig. 3). The method selected will be determined by the circumstances. Approved methods for checking the operation of the temperature switch are as follows:

1. Remove the temperature switch and immerse the switch sensing element to the switch mounting base in a container of water or ethylene glycol that is agitated and heated. Operation of the switch can be noted with a continuity checker and an accurate thermometer. The switch should operate at 203° + 2°F (95°+ 1°C).

   NOTICE: The temperature of the fluid in the container should be increased slowly after the temperature reaches about 190°F (88°C). Increasing the temperature too rapidly will indicate a false high reading for the switch because the switch will have insufficient time to reach the fluid temperature.

2. Stop coolant flow to the switch and operate the engine at rated speed and no-load. The switch should operate in about one to three minutes and can be noted by operation of the alarm.

   NOTICE: Restore normal coolant circulation to the switch after completing this test. Operation of the switch without coolant and high exhaust temperatures over a period of time will destroy it.

3. In some applications, it may be practical to reduce the effectiveness of the cooling system so that, with the engine operated at rated speed and no-load or a light

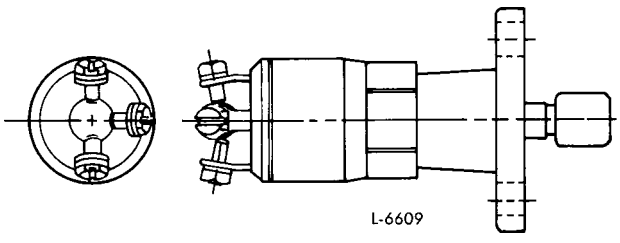


Fig. 3 - Water Temperature Switch

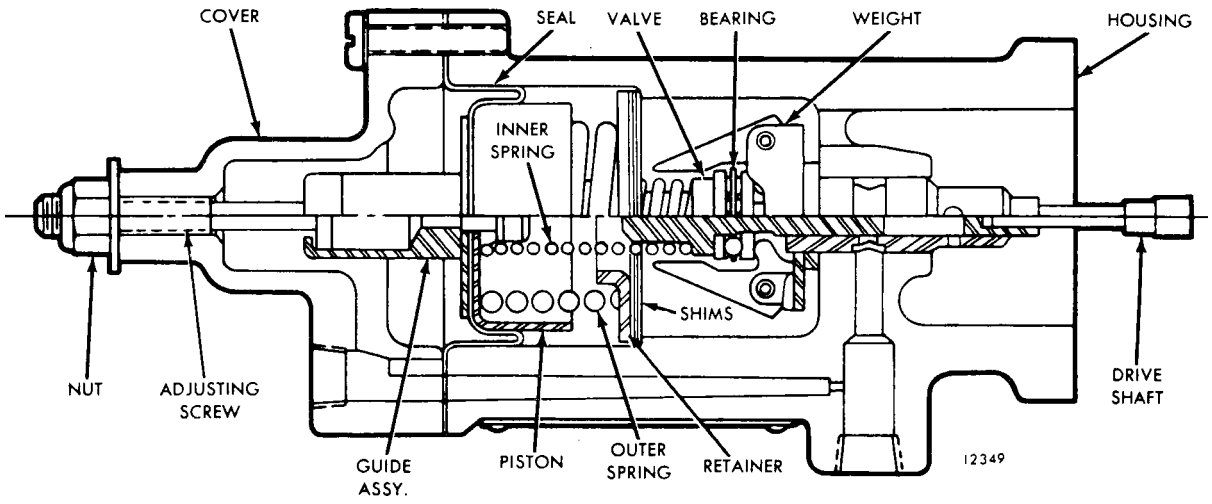


Fig. 4 - Low Oil Pressure and Overspeed Valve

load, the engine coolant temperature can be increased to 208°F (97°C). For example, the air circulation to the radiator on units with suction fans can be stopped by placing sheets of cardboard over the radiator, or on units with blower fans, the fan belts can be loosened so that the fan does not operate.

After reducing the coolant system effectiveness, remove the radiator cap and insert an accurate steel jacketed thermometer. Then operate the engine at rated speed and enough load to gradually increase the temperature until the switch operates.

NOTICE: Do not exceed 210°F (99°C) when performing this test. The switch should operate at 204°F±4° (95.2°C± 2.2°). This procedure will not work for units using water as a coolant at altitudes above 1000 feet (305 metres). This is because the water will boil below the switch setting at the higher altitudes. For these circumstances, the radiator pressure cap must be maintained.

The engine temperature gage, if it is determined to be accurate, can be used in this test. After completion of the test, immediately restore the engine cooling system to normal and operate the engine at rated speed and no-load until normal engine operating temperature is reached.

Temperature Switch Adjustment

The temperature switch setting can be changed by turning the element into or out of the mounting base. Turning the element into the base lowers the setting and turning the element out raises the setting. Total range of adjustment is about 10°F (5.56°C).

NOTICE: Torque should only be applied to the element at the wrench flats provided on the element. Failure to do this can result in the switch becoming inoperative due to damage to the element. After completing the switch adjustment, torque the element lock nut to 40-50 in-lbs (5-6 N.m).

Exhaust Probe And Adaptor Assembly, Plunger And Spring

These parts should normally require no maintenance. Flowever, when installing a new switch or a readjusted switch, check to make sure the plunger is free. It is possible that deposits from the cooling system can build up and freeze the plunger. If this has happened, replace the probe and adaptor assembly, spring and plunger. A frozen plunger can either interfere with the element or there can be a gap between it and the element, both of which can destroy the effectiveness of the switch.

Checking Low Oil Pressure And Overspeed Valve

The only adjustment that can be made for the low oil pressure and overspeed valve is the overspeed setting (Fig. 4). The overspeed setting is normally set 15% above rated speed, and is adjusted by loosening the speed adjusting screw lock nut and turning it in to increase the setting or out to lower the setting. The operation of the valve can be easily checked by first noting the projection of the speed adjusting screw beyond the cover and then lowering the overspeed setting. The speed adjusting screw can be backed out 3/4 inch. An alarm should be obtained with the screw backed out when the engine is operated at rated speed. Failure to obtain an alarm is an indication of a faulty valve. Return the speed adjusting screw to its original position after completing this test.

OVERSPEED GOVERNORS

Certain engines are equipped with an electric overspeed governor to prevent excessive engine speeds. The governor is adjustable in the full-load engine speed range. The electric overspeed governor is mounted on the flywheel housing and is driven by the engine camshaft or the accessory drive gear. The governor is connected electrically to a solenoid which actuates the shutdown mechanism on the air inlet housing or actuates a warning device.

ELECTRIC OVERSPEED GOVERNOR (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.

   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.

   NOTICE: 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.

   NOTICE: 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.

   NOTICE: 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.

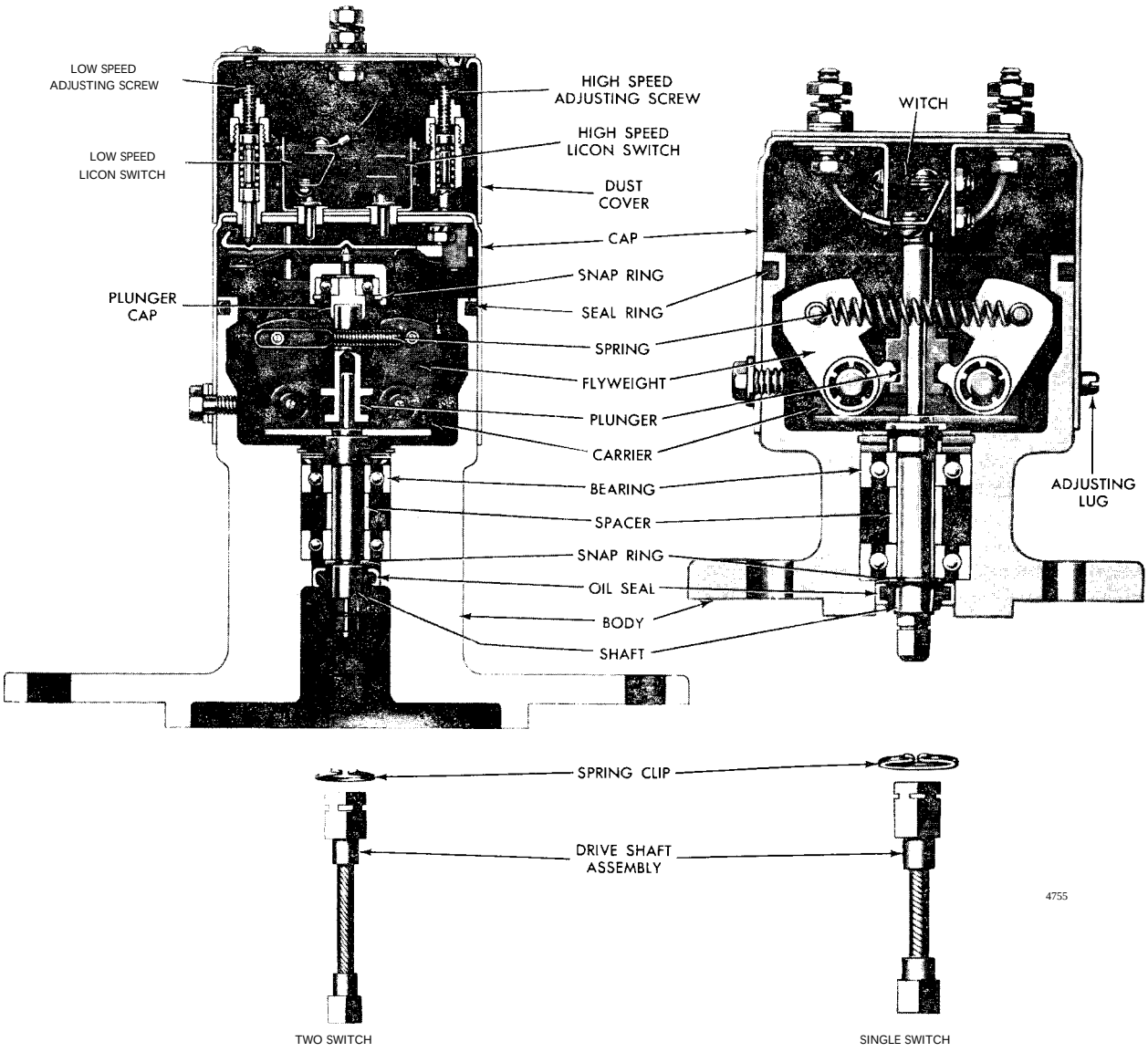


Fig. 1 - Electric Overspeed Governors

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 oil 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 OVERSPEED GOVERNOR (SINGLE SWITCH)

The Series GYA Synchro-Start overspeed governor (Fig. 1) is 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 5,000 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, otherwise serious damage, to not only the engine but also to the governor, may be incurred since the governor is not designed to operate above its tripping speed.

POWER GENERATOR

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

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

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

POWER GENERATOR FOR STATIONARY APPLICATIONS

Remove Power Generator

1. Attach a crane or hoist to support the generator.
2. Remove the engine starting motor(s).
3. Install engine barring tool J 22582 in place of the starting motor.
4. Remove the flywheel housing plugs adjacent to the starting motor opening on each side of the housing.
5. Rotate the crankshaft until one of the dowels is visible through the plug hole. Mark this area for ease of alignment upon reinstallation. A can of spray paint can be used for this purpose. Rotate the crankshaft to gain access to the coupling attaching bolts and remove them through the openings in the flywheel housing.

. 6. Remove the bolts and lock washers or stud nuts which attach the generator frame to the flywheel housing adaptor. Remove bolts attaching the generator to the base. Then back the generator away from the engine, using pry bars or jack screws if necessary.

NOTICE: The drive coupling assembly used between the engine crankshaft and the generator armature has been doweled, machined and balanced as a complete assembly and no attempt should be made to interchange parts with those of another assembly.

Install Power Generator

Check the engine crankshaft for distortion at the rear connecting rod journal counterweights **before** and **after** installing the power generator. Refer to Section 1.3 for the procedure.

1. If not previously removed, remove the plugs adjacent to the starting motor on each side of the flywheel housing.
2. Install the crankshaft portion of the drive coupling assembly on the crankshaft. Special attention should be paid to the position of the staggered locating dowels. Each dowel must be in the same position as removed (refer to Item 5 under *Remove Power Generator).*

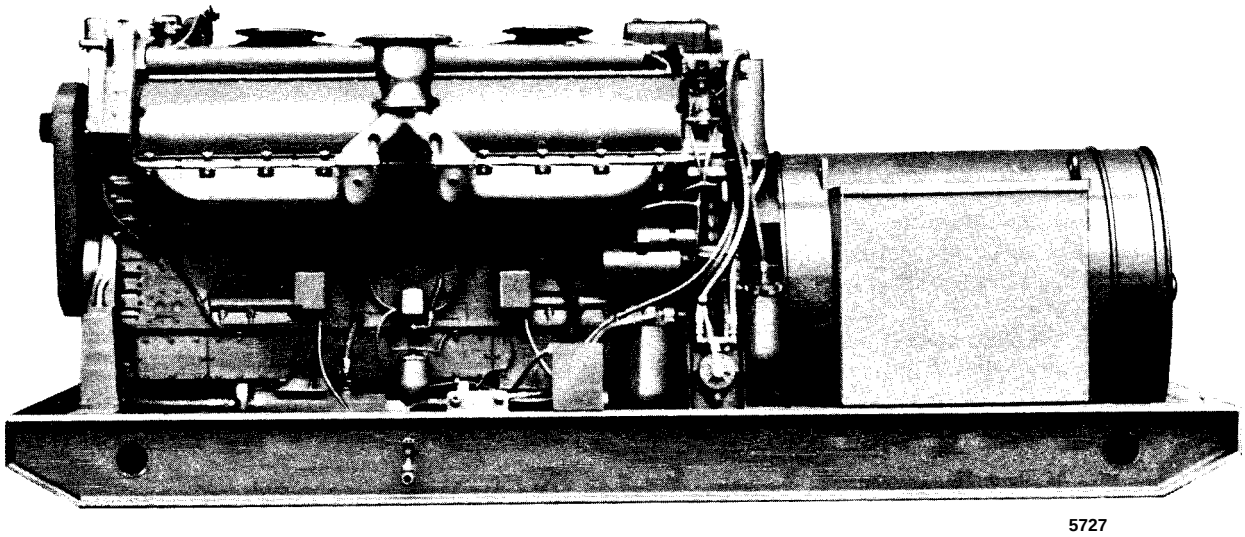


Fig. 1 - Typical Power Generator Mounting

NOTICE: If the dowels are not in the same position as removed, severe damage to the coupling can result when the coupling is assembled.

3. If the generator coupling has been removed from the engine, apply a small amount of International Compound No. 2, or equivalent, to the bolt threads and install the 5/8"-18 x 4" self-locking coupling bolts, being sure to install the scuff plate between the coupling and the bolt heads. Tighten the bolts to 180-190 lb-ft (244-258 N«m) torque.

4. Install the generator portion of the coupling to the generator armature, again paying special attention to the position of the staggered dowel holes and making certain that the holes are in the same position as the dowels on the crankshaft portion of the coupling.

NOTICE: Be sure to follow any special installation instructions of the generator manufacturer.

5. Apply a small amount of International Compound No. 2, or equivalent, to the threads and install the 5/8"-18 x 2 1/2" self-locking bolts and hardened washers. Tighten the bolts to 180-190 lb-ft (244—258 N«m) torque.

6. Apply a small amount of International Compound No. 2, or equivalent, to the threads of the 5/8"-11 x 1 7/8" studs and assemble them in the generator frame. Position three studs on each side to match with the spot faced holes in the flywheel housing adaptor.

7. Tighten the studs to 137-148 lb-ft (186-200 N*m) torque. Check the stud extension above the generator frame. The studs should not extend beyond 7/8".

8. Use a crane or hoist to raise the generator so that the centerline of the armature is slightly above the center line of the crankshaft.

   a. Move the generator toward the engine until the chamfer on the armature coupling begins to engage the chamfer on the crankshaft portion of the coupling, at approximately the 12 o'clock position. Align each of the dowels in the crankshaft coupling so that they will engage in their respective dowel holes in the generator adaptor.

   b. Continue moving the generator towards the engine until full engagement of the dowels is attained. It may be necessary to raise or lower the generator slightly to engage the generator to the flywheel housing attaching studs, which will start to engage shortly after the dowels engage. It may also be necessary to rotate the crankshaft so that the dowel holes are properly aligned.

9. Install the stud nuts as the studs begin to extend beyond the flywheel housing adaptor. With the generator in position against the engine, check the flywheel housing plug hole to make certain the dowel pin has not been pushed through the crankshaft coupling (this could result in a broken casting) during generator installation. Use a depth gage to check the position of the dowel relative to the rear face of the crankshaft coupling. If the dowel pin does not extend at least 1/2" below the rear of the crankshaft coupling, the generator armature coupling may not be properly supported. Both dowel pins should be checked for proper engagement.

10. Apply a small amount of International Compound No. 2, or equivalent, to the threads and install the 5/8"-ll x 1 7/8" bolts through the flywheel housing adaptor to the generator and tighten them and the six stud nuts to 137-147 lb-ft (186-200 N*m) torque.

11. Apply a small amount of International Compound No. 2, or equivalent, on the threads and install the 5/8"—11 x 2 1/2" self-locking bolts and hardened washers to attach the crankshaft coupling to the armature adaptor.

NOTICE: Do not install the bolts part way, but snug them up to prevent lockup when the crankshaft is rotated.

12. After all of the bolts are assembled, tighten them progressively to 137-147 lb-ft (186-200 N*m) torque.

13. Rotate the crankshaft one full revolution and inspect the coupling and adaptor through the flywheel housing openings for proper assembly. A mirror inserted into the flywheel housing openings will facilitate this inspection.

14. Remove the barring tool and install the starter(s) and the flywheel housing plugs.

TRACTION GENERATOR FOR ELECTRIC DRIVE VEHICLES

Remove Generator

1. Attach a crane or hoist to support the generator.
2. Remove the engine starting motor(s).
3. Install engine barring tool J 22582 in place of the starting motor.
4. Remove the flywheel housing plugs adjacent to the starting motor opening on each side of the housing.
5. Rotate the crankshaft until one of the dowels is visible through the plug hole. Mark this area for ease of alignment upon reinstallation. A can of spray paint can be used for this purpose. Rotate the crankshaft to gain access to the twelve coupling attaching bolts and remove them through the openings in the flywheel housing.
6. Remove the ten 5/8"—11 bolts and lock washers and the six stud nuts which attach the generator frame to the flywheel housing adaptor. Remove the six nuts while backing the generator away from the engine, using pry bars or jack screws if necessary.

NOTICE: The drive coupling a'.?,embly used between the engine crankshaft and the generator armature has been doweled, machined and balanced as a complete assembly and no attempt should be made to interchange parts with those of another assembly.

Install Generator

Before and after installing the generator in an electric drive vehicle, it is essential that the axial end play and axial alignment of the crankshaft and generator be maintained within limits. This will prevent possible thrust washer damage due to insufficient crankshaft end play and assure generator-to-engine alignment to avoid overloading and subsequent damage to the rear main bearings and outboard support bearing.

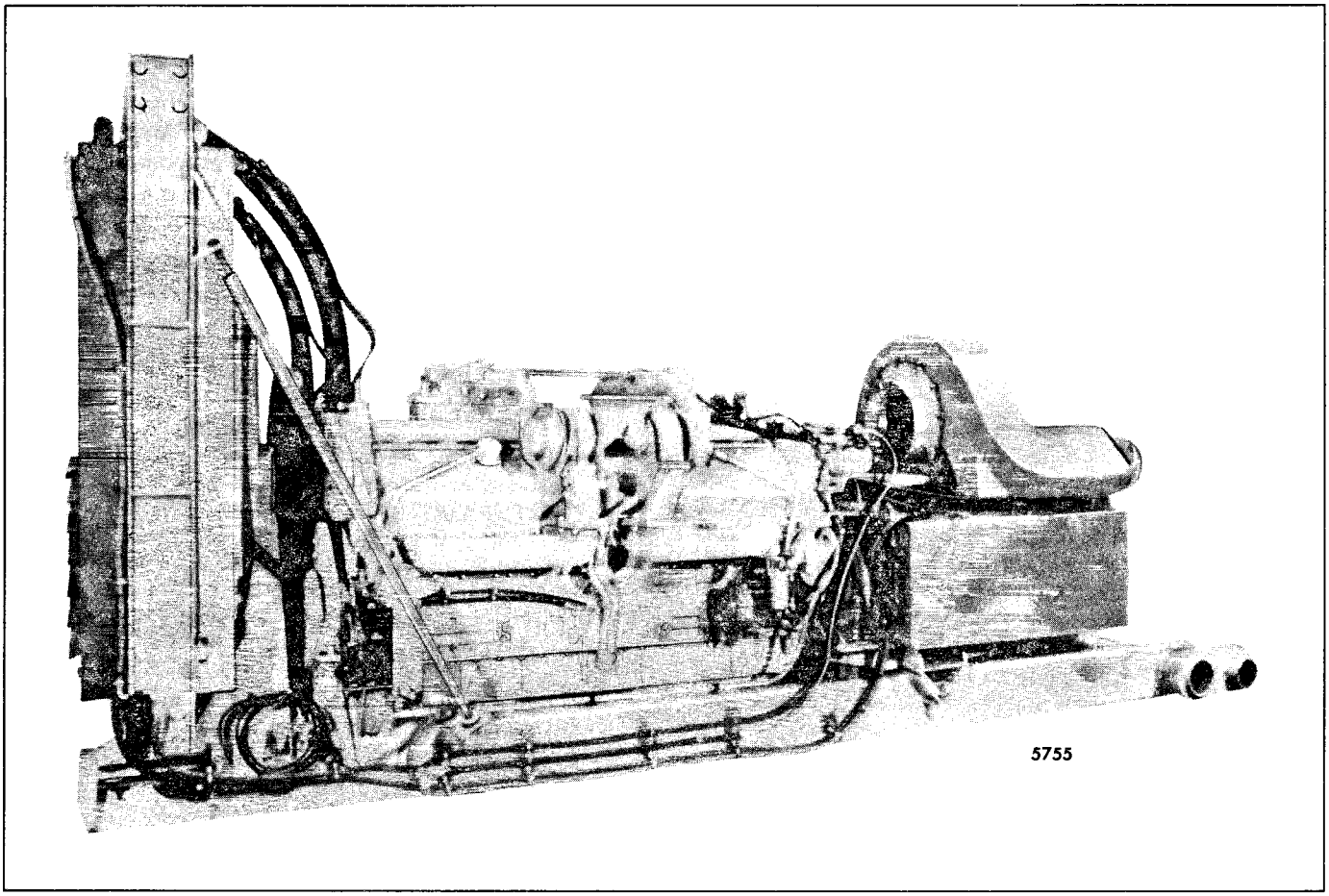


Fig. 2 – Typical Mounting of Traction Generator

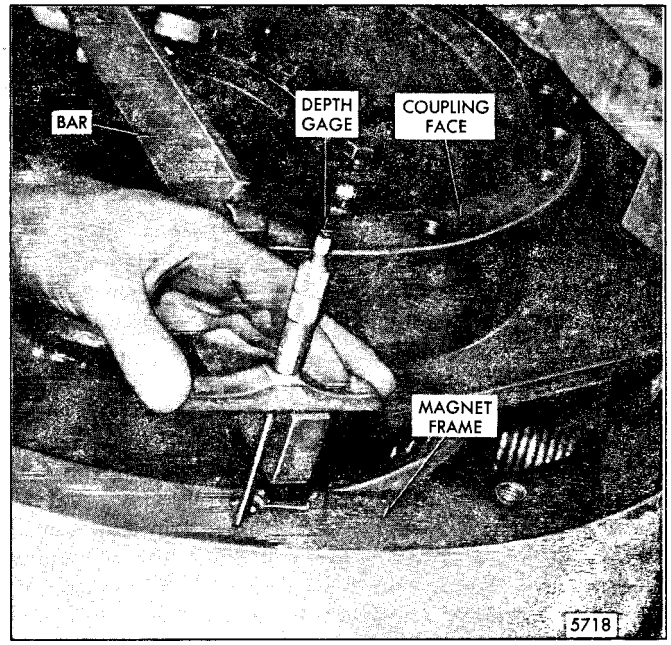


Fig. 3 - Measuring Distance from Generator Coupling Face to Magnet Face

The following procedure ensures that crankshaft and generator end play will be within specifications and that the generator armature and magnet frame will be in alignment with the crankshaft.

Check Engine

1. Check and record the crankshaft end play (refer to Section 1.3). The specified end play is ,004"-.014" with new parts or a maximum of .018" with used parts.

2. Position the rear outboard bearing support in the flywheel housing (refer to Section 1.3.5.2).

3. Check the coupling assembly runout (refer to Section 1.4). The maximum allowable runout is .011" when measured using a dial indicator between the coupling-to-generator bolt holes and the outside diameter of the coupling assembly.

4. Check the flywheel housing face and bore runout (refer to Section 1.5). The maximum total indicator reading must not exceed .013" for either the housing face or the bore runout.

5. Check the flywheel housing adaptor face and bore runout (refer to Section 1.5.1). Maximum total indicator reading must not exceed .026" for either the adaptor face or the bore. This check need not be performed on Terex/Titan vehicles because the Delco generator does not utilize the adaptor ring.

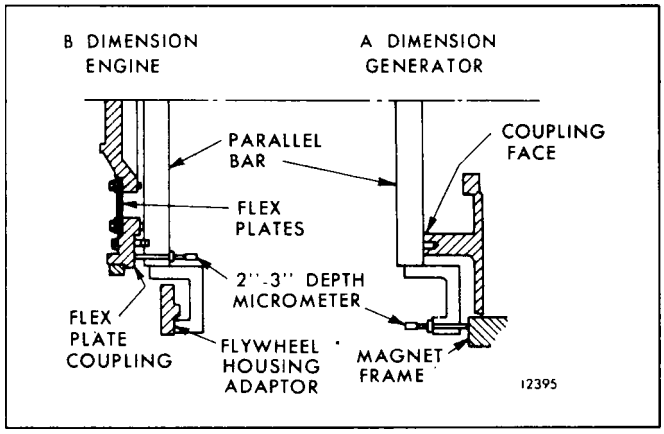


Fig. 4 - Determining Shims Required Between Engine and Generator

Clean Mating Faces

Thoroughly clean the generator magnet face, the generator coupling face, the engine flywheel housing adaptor face and the flexible drive coupling face. Any nicks or burrs should be stoned smooth.

Shimming Generator To Engine Coupling (G.E. Generator)

This check need not be performed on Terex/Titan applications. The Delco generator used on Terex/Titan applications does not require the use of generator-to-engine shims.

Consult the generator manufacturer's specifications for normal end play tolerances and the method of measurement. In the absence of the manufacturer's method, proceed as follows:

1. Support the generator with a crane or hoist and sling. Then hang the generator in a vertical position with the rear end down. Be sure the generator is centered by shimming the four flange radius corners for equal clearance at all four locations.

2. Attach a magnetic base dial indicator to the generator magnet frame and set the pointer on the coupling adaptor surface. Adjust the dial indicator to read zero. Pull the generator armature straight upward and record the end play observed on the dial indicator.

3. Lower the armature toward the commutator end as far as the rear bearing will permit. Place a parallel steel bar across the generator coupling face and measure the distance between the coupling face and the magnet frame face with a depth gage (Fig. 3). Take four readings 90° apart and record the average of the readings. To center the ball bearings in the race seat, it is necessary to add one-half of the end play measured to the total distance determined. Record the average adjusted measurement (dimension "A" on Fig. 4).

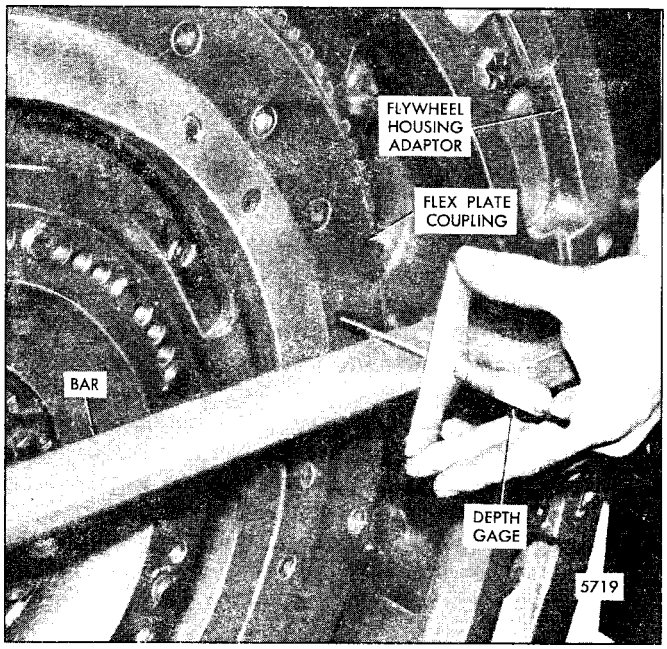


Fig. 5 - Measuring Distance from Flywheel Housing Adaptor to Engine Flex Plate Coupling

4. Center the crankshaft end play and measure from the flywheel housing adaptor to the engine flexible plate coupling mating face using a parallel bar and depth gage (Fig. 5). Obtain four readings 90° apart and record the average measurement (dimension “B” on Fig. 4).

Truck Manufacturer	Housing (16 Bolt)	Rotor/Flywheel (12 Bolt)
	Thickness	Thickness
Unit Rig	.005 .010 .020 .040 .060	.005 .010 .020
Wabco	.004 .007	.004 .007
Euclid	.003 .011/.009 .022/.018	.003 .011/.009 .022/.018

Shims are available from the truck manufacturer

TABLE 1 - G.E. A-1 5 Generator

5. If the generator measurement “A” exceeds engine measurement “B”, shim between the generator magnet frame face and the flywheel housing adaptor face by the difference between these dimensions, with an allowable .002" tolerance (Fig. 6).

6. If the engine measurement “B” is greater than the generator measurement “A”, shim between the generator adaptor face and the engine flexible coupling plate face by the difference between these dimensions, with an allowable .002" tolerance (Fig. 7). See Table 1 for required shims.

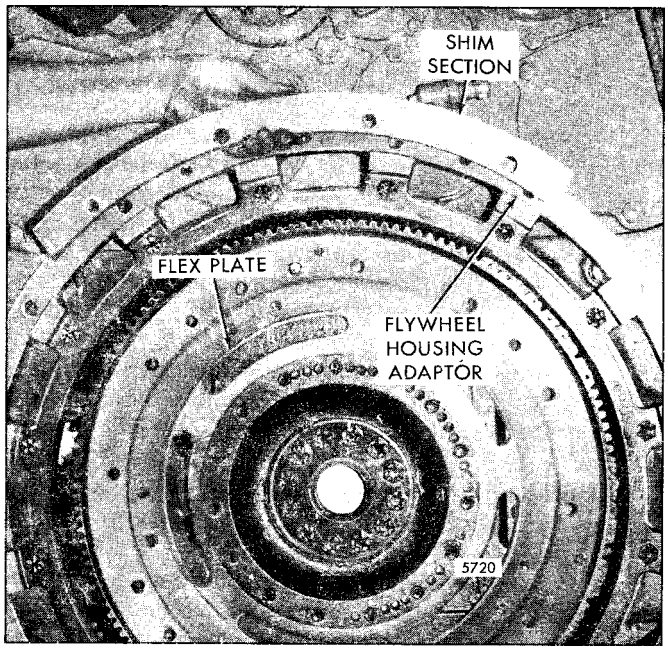


Fig. 6 - Installing Engine Flywheel Housing Adaptor Shim Section

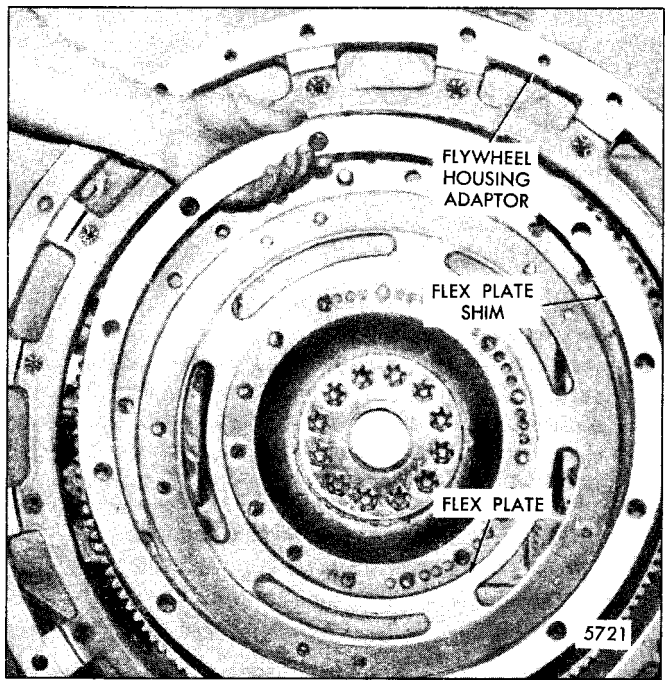


Fig. 7 - Installing Engine Flex Coupling Shim

Shimming Generator Or Engine Mount

Various types of generator-to-engine mount systems are used by the various OEM's and some may require shimming under the engine or generator supports to maintain the correct crankshaft-to-generator relationship. Correct alignment is required to prevent placing excessive loads on the crankshaft main bearings and the rear outboard support bearing.

THREE-POINT (CRADLE) MOUNT

The cradle mount system incorporates a support bracket attached to each side of the engine and generator as a unit. When assembled properly, this system generally does not require shimming to maintain engine-to-generator alignment because it effectively supports the entire rear of the engine and generator as a single unit.

FIVE POINT MOUNT

The five point mount system with separate mounts attached to both rear engine flywheel housing supports and both of the generator mounts at each side will usually require shimming to maintain generator to engine alignment. Shims may be necessary either at the generator mount or the engine mount.

Attach Generator To Engine

The generator must be attached with the module frame out of the vehicle chassis and the engine sitting horizontal in the module. The clamp joint achieved by the mating parts maintains generator alignment during vehicle operation.

EUCLID

1. Install the right and left side arms to the module frame at the six-bolt horizontal flange, but do not fully tighten the bolts.

2. With the engine installed into the module frame and secured at the front engine trunnion mount, temporarily support the rear of the engine with suitable floor jacks from below or a chain hoist from above so that the side arm-to-flywheel housing bolts can be installed. Attach side arms to the flywheel housing, but do not fully tighten the bolts.

   NOTICE: Do not remove support from the rear of the engine. The engine must remain supported until the generator has been fully coupled to the engine and secured to the module.

3. Using the 3 lifter brackets provided, lift the generator into position. The top front lifter bracket should be equipped with an adjustable member such as a come-along and the side lifting members should be of equal length to ensure that the generator is evenly balanced and can be adjusted squarely to the flywheel housing.

   NOTICE: The generator should be supported by a stable overhead crane or hoist. Wheeled lifting devices or equipment are not recommended.

4. Carefully move the generator horizontally into place and engage the coupling assembly dowel pins into the generator drive ring. Install the engine adaptor ring-to-generator outer case bolts, but do not tighten fully. Allow a slight clearance between the generator and engine adaptor ring. Insert a feeler gage between the engine adaptor ring and generator to ensure equal clearance 360° around the adaptor ring. Adjust the generator position with the lifting equipment to obtain an equal clearance 360° around the adaptor ring.

   NOTICE: Once equal clearance has been achieved, do not disturb the engine or generator support until the entire alignment procedure has been completed.

5. Torque the adaptor ring-to-generator outer case bolts alternately in a criss-cross pattern. Install side arm-to-generator bolts, but do not tighten fully.

   NOTICE: If side arm-to-generator bolts will not engage with the generator, reposition the module frame. Under no circumstances should the engine or generator support be moved.

6. Move the right and left side arms in tight against the generator and flywheel housing pads. Properly tighten and torque the side arm-to-generator and side arm-to-flywheel housing pad bolts. Properly tighten and torque the side arm-to-module frame bolts. Install and properly tighten and torque engine coupling-to-generator drive ring bolts. Refer to the necessary Euclid service manuals for the applicable torque values.

7. Lift the rear of the module frame to support the engine/generator assembly and remove the equipment used for alignment purposes.

   NOTICE: An improper unloading sequence can result in generator-to-engine misalignment.

8. Use care when handling the completed module. Never lift it by the engine/generator lifter brackets, since engine/generator misalignment may result. The completed module should always be lifted by the module frame only.

9. Check the crankshaft end play with a magnetic base dial indicator at the front of the crankshaft damper. Engine crankshaft end play should be a minimum of .004" and will not normally change from the original reading in Step 1 under *Check Engine.*

   NOTICE: Do not pry against the damper(s) because dents will render it ineffective and cause subsequent crankshaft damage.

10. If end play cannot be obtained, repeat Steps 2 through 7. The generator may not be aligned correctly and maybe restricting the movement of the crankshaft.

11. If end play still cannot be obtained, the generator to engine coupling may have been shimmed incorrectly and this procedure must be repeated.

12. Rotate the crankshaft one full revolution and listen for any unusual noises caused by moving components contacting stationary parts. The crankshaft and armature should rotate without excessive effort.

13. Operate the engine and attached generator on the module and check for excessive vibration.

UNIT RIG

1. Perform Steps 1 thru 5 under *Check Engine* and Clean Mating Faces.

2. With the engine installed into the module frame and secured at the front engine trunnion mount, temporarily support the rear of the engine with suitable jacks from below or a chain hoist from above. Install and properly tighten and torque the engine flywheel housing-to-module frame bolts.

3. Using the 3 lifter brackets provided, lift the generator into position. The top front lifter brackets should be equipped with an adjustable member such as a come-along and the side members should be of equal length to ensure that the generator is evenly balanced and can be adjusted squarely to the flywheel housing.

   NOTICE: The generator should be supported by a stable overhead crane or hoist. Wheeled lifting devices or equipment are not recommended.

4. Carefully move the generator horizontally into place and engage the coupling assembly dowel pins into the generator drive ring. Install the engine adaptor ring-to-generator outer case bolts, but do not fully tighten. Allow a slight clearance between the generator and engine adaptor ring. Insert a feeler gage between the engine adaptor ring and generator to ensure equal clearance 360° around the adaptor ring. Adjust the generator position with the lifting equipment to obtain an equal clearance 360° around the adaptor ring.

   NOTICE: Once equal clearance has been achieved, do not disturb the engine or generator support until the entire alignment procedure has been completed.

5. Torque the adaptor ring-to-generator outer case bolts alternately in a criss-cross pattern. Install side arm-to-engine and generator bolts and properly tighten and torque.

6. Install and properly tighten and torque the engine coupling-to-generator drive ring bolts. Refer to the necessary Unit Rig service manuals for the applicable torque values.

7. Support the engine/generator assembly by lifting the rear of the module frame by the cradle arms at the points which suspend the module in the vehicle. Remove the equipment used for alignment purposes.

   NOTICE: An improper unloading sequence can result in generator-to-engine misalignment.

8. Use care when handling the completed module. Never lift it by the engine/generator lifter brackets, since engine/generator misalignment may result. The completed module should always be lifted by the module frame only.

9. Check the crankshaft end play with a magnetic base dial indicator at the front of the crankshaft damper. Engine crankshaft end play should be a minimum of .004" and will not normally change from the original reading in Step 1 under *Check Engine.*

   NOTICE: Do not pry against the damper(s) because dents will render it ineffective and cause subsequent crankshaft damage.

10. If end play cannot be obtained, repeat Steps 2 through 7. The generator may not be aligned correctly and may be restricting the movement of the crankshaft.

11. If end play still cannot be obtained, the generator-to-engine coupling may have been shimmed incorrectly, and the shimming procedure must be repeated.

12. Rotate the crankshaft one full revolution and listen for any unusual noises caused by moving components contacting stationary parts. The crankshaft and armature should rotate without excessive effort.

13. Operate the engine and attached generator on the module and check for excessive vibration.

WABCO (THREE-POINT MOUNT)

1. Perform Steps 1 thru 5 under *Check engine* and *Clean Mating Faces.*

2. With the engine installed into the module frame and secured at the front engine trunnion mount, temporarily support the rear of the engine with suitable floor jacks from below or with a chain hoist from above.

   NOTICE: Do not remove the support from the rear of the engine. The engine must remain supported until the generator has been fully coupled to the engine and secured to the module.

3. Using the 3 lifter brackets provided, lift the generator into position. The top front lifter bracket should be equipped with an adjustable member such as a come-along and the side lifting members should be of equal length to ensure that the generator is evenly balanced and can be adjusted squarely to the flywheel housing.

   NOTICE: The generator should be supported by a stable overhead crane or hoist. Wheeled lifting devices or equipment are not recommended.

4. Carefully move the generator horizontally into place and engage the coupling assembly dowel pins into the generator drive ring. Install the adaptor ring-to-generator outer case bolts, but do not tighten fully. Allow a slight clearance between the generator and engine adaptor ring. Insert a feeler gage between the engine adaptor ring and generator to ensure equal clearance 360° around the adaptor ring. Adjust the generator position with the lifting equipment to obtain an equal clearance 360° around the adaptor ring.

   NOTICE: Once equal clearance has been achieved, do not disturb engine or generator support until the entire alignment procedure has been completed.

5. Torque the adaptor ring-to-engine and generator outer case bolts alternately in a criss-cross patern.

6. Install and properly tighten and torque engine coupling-to-generator drive ring bolts. Refer to the necessary Wabco service manuals for the applicable torque values.

7. Install and properly tighten the cradle arms-to-module connecting bolts. Lift the rear of the module frame to support the engine/generator assembly and remove the equipment used for alignment purposes.

   NOTICE: An improper unloading sequence can result in generator-to-engine misalignment.

8. Use care when handling the completed module. Never lift it by the engine/generator lifter brackets, since engine/generator misalignment may result. The completed module should always be lifted by the module frame only.

9. Check the crankshaft end play with a magnetic base dial indicator at the front of the crankshaft damper. Engine crankshaft end play should be a minimum of .004" and will not normally change from the original reading in Step 1 under *Check Engine.*

   NOTICE: Do not pry against the damper(s), because dents will render it ineffective and cause subsequent crankshaft damage.

10. If end play cannot be obtained, repeat Steps 2 through 7. The generator may not be aligned correctly and may be restricting the movement of the crankshaft.

11. If end play still cannot be obtained, the generator-to-engine coupling may have been shimmed incorrectly and the shimming procedure must be repeated.

12. Rotate the crankshaft one full revolution and listen for any unusual noises caused by moving components contacting stationary parts. The crankshaft and armature should rotate without excessive effort.

13. Operate the engine and attached generator on the module and check for excessive vibration.

WABCO (FIVE-POINT MOUNT)

1. Perform Steps 1 thru 5 under *Check Engine* and *Clean Mating Faces.*

2. Support the module frame with suitable blocks at the front and rear module-to-truck support points.

3. Install the engine into the module frame and properly tighten and torque the front engine trunnion mount-to-front module engine bracket bolts and module frame support bracket-to-flywheel housing bolts.

4. Using the 3 lifter brackets provided, lift the generator into position. The top front lifter bracket should be equipped with an adjustable member such as a come-along and the side lifting members should be of equal length to ensure that the generator is evenly balanced and can be adjusted squarely to the flywheel housing.

   NOTICE: The generator should be supported by a stable overhead crane or hoist. Wheeled lifting devices or equiipment are not recommended.

5. Carefully move the generator horizontally into place and engage the coupling assembly dowel pins into the generator drive ring. Install the engine adaptor ring-to-generator outer case bolts, but do not tighten fully. Allow a slight clearance between the generator and engine adaptor ring. Insert a feeler gage between the engine adaptor ring and generator to ensure equal clearance 360° around the adaptor ring. Adjust the generator position with the lifting equipment to obtain an equal clearance 360° around the adaptor ring.

   NOTICE: Once equal clearance has been achieved, do not disturb engine or generator support until the entire alignment procedure has been completed.

6. Torque the adaptor ring-to-generator outer case bolts alternately in a criss-cross pattern. Place shims under generator mounting pad. Install and properly tighten and torque engine coupling-to-generator drive ring bolts. Refer to the necessary Wabco service manuals for applicable torque values.

   NOTICE: If the generator brackets cannot be installed, shims will have to be placed under the flywheel housing-to-module frame support brackets. To accomplish this, the generator must be uncoupled from the engine and then reattached, repeating Steps 2 through 5.

7. Use care when handling the completed module. Never lift it by the engine/generator lifter brackets, since engine/generator misalignment may result. The completed module should always be lifted by the module frame only.

8. Check the crankshaft end play with a magnetic dial indicator at the front of the crankshaft damper. Engine crankshaft end play should be a minimum of .004" and will not normally change from the original reading in Step 1 under *Check Engine*.

   NOTICE: Do not pry against the damper(s), because dents will render it ineffective and cause subsequent crankshaft damage.

9. If end play cannot be obtained, repeat Steps 2 thru 6. The generator may not be aligned correctly and may be restricting the movement of the crankshaft.

10. If end play still cannot be obtained, the generator-to-engine coupling may have been shimmed incorrectly, and the shimming procedure must be repeated.

11. Rotate the crankshaft one full revolution and listen for any unusual noise caused by rotating components contacting stationary parts. The crankshaft and armature should rotate without excessive effort.

12. Operate the engine and attached generator on the module and check for excessive vibration.

TITAN/TEREX 33-15

This procedure requires the use of alignment studs which are available from Delco Products. The use of these studs will improve alignment of the generator drive disc in the pilot of the engine flywheel.

1. Perform Steps 1 thru 4 under *Check Engine* and *Clean Mating Faces.*

2. With the engine installed into the module frame and secured at the front engine trunnion mount, temporarily support the rear of the engine with suitable floor jacks from below or with a chain hoist from above so that a clearance of l/4"-3/8" exists between the rear engine mounting brackets and the engine/generator support brackets.

3. Position the generator coupling and engine flywheel so that the holes, indicated by an “X” on Figure 8, are horizontal.

4. Screw the two alignment studs into the flywheel at locations “X-X” until the polished section of the stud is within 1/16" of the flywheel face.

   NOTICE: The holes indicated by “X-X” must be horizontal.

5. Using the lifter brackets provided, lift the generator into position. The top front lifter bracket should be equipped with an adjustable member such as a come-along and the side members should be of equal length to ensure that the generator is evenly balanced and can be adjusted squarely to the flywheel housing.

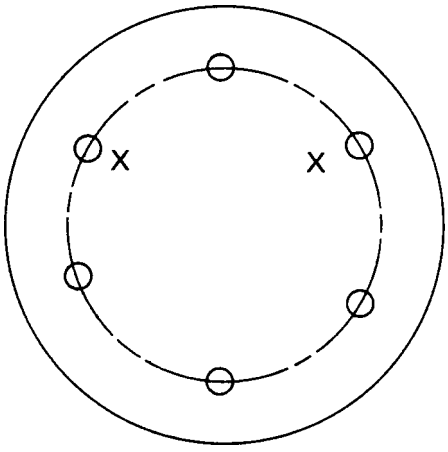


Fig. 8 - Location of Alignment - Stud Holes

NOTICE: The generator must be supported by a stable overhead crane or hoist. Wheeled lifting devices or equipment are not recommended.

6. Carefully move the generator horizontally into place and engage the flywheel studs into the generator driving discs. Install the flywheel housing-to-generator frame bolts, but do not tighten fully. Allow a slight clearance between the generator frame and flywheel housing. Insert a feeler gage between the flywheel housing and generator frame to ensure equal clearance 360° around the flywheel housing.

NOTICE: Once equal clearance has been achieved, do not distrub engine or generator support until the entire alignment procedure has been completed.

7. Torque the flywheel housing-to-generator frame bolts alternately in a criss-cross pattern.

8. Loosen the bolts between the engine/generator support brackets and the module frame, allowing the support brackets to be raised to contact the generator mounting feet.

9. Measure the gap between the rear engine mounting bracket and the engine generator support bracket adjacent to each of the mounting bolts. Install the appropriate shim pack per bolt, insert the bracket bolts and properly tighten and torque.

10. Lift the rear of the module frame to support the engine/generator assembly and remove the equipment used for alignment purposes.

NOTICE: An improper unloading sequence can result in generator-to-engine misalignment.

11. Install the flywheel bolts through the generator coupling and into the flywheel. Properly tighten and torque. Remove the two alignment studs and install and torque the two remaining bolts.

12. Use care when handling the completed module. Never lift it by the engine/generator lifter brackets, since engine/generator misalignment may result. The completed module should always be lifted by the module frame only.

13. Check the crankshaft end play with a magnetic base dial indicator at the front of the crankshaft damper. Engine crankshaft end play should be a minimum of .004" and will not normally change from the original reading in Step 1 under *Check Engine.*

NOTICE: Do not pry against the damper(s), because dents will render it ineffective and cause subsequent crankshaft damage.

14. If end play cannot be obtained, repeat Steps 2 thru 11. The generator may not be aligned correctly and may be restricting the movement of the crankshaft.

15. If end play still cannot be obtained, the generator-to-engine coupling may have been shimmed incorrectly, and the shimming procedure must be repeated.

16. Rotate the crankshaft one full revolution and listen for any unusual noises caused by rotating components contacting stationary parts. The crankshaft and armature should rotate without excessive effort.

17. Operate the engine and attached generator on the module and check for excessive vibration.

SHOP NOTES - TROUBLESHOOTING - SPECIFICATIONS

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.
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.

   NOTICE: 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. Replace 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 200°-210°F (93°-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.

   NOTICE: The boiling point of water lowers approximately 2° for each 1,000 foot rise in altitude. As an example, water boils at approximately 203°F (95°C) at 5,000 feet and at 195°F (91°C) at 9,000 feet altitude. It is necessary to retain the radiator pressure cap on engines which operate in excess of 1,000 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 200°-210°F (93°-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.

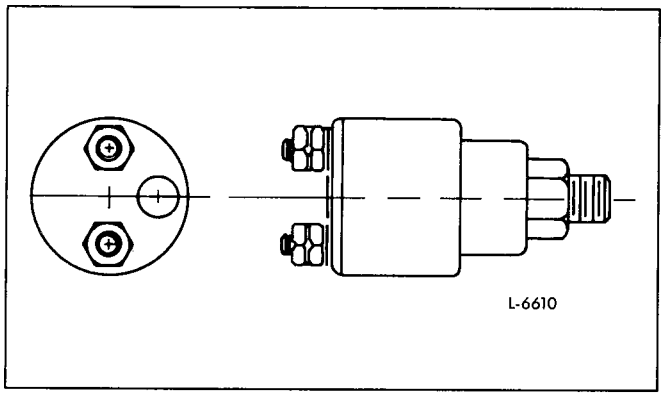


Fig. 1 – Fuel Oil Pressure Switch

Fuel Oil Pressure Switch

The fuel oil pressure switch is set to make contact at an increasing fuel pressure of 20 psi (138 kPa), and 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.

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.
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.

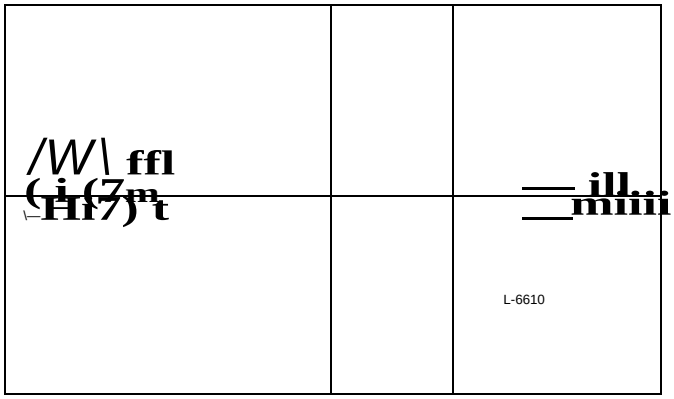


Fig. 2 - Lubricating Oil Pressure Switch

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

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, 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 8 to 10 seconds. If not, the time delay switch must be replaced.

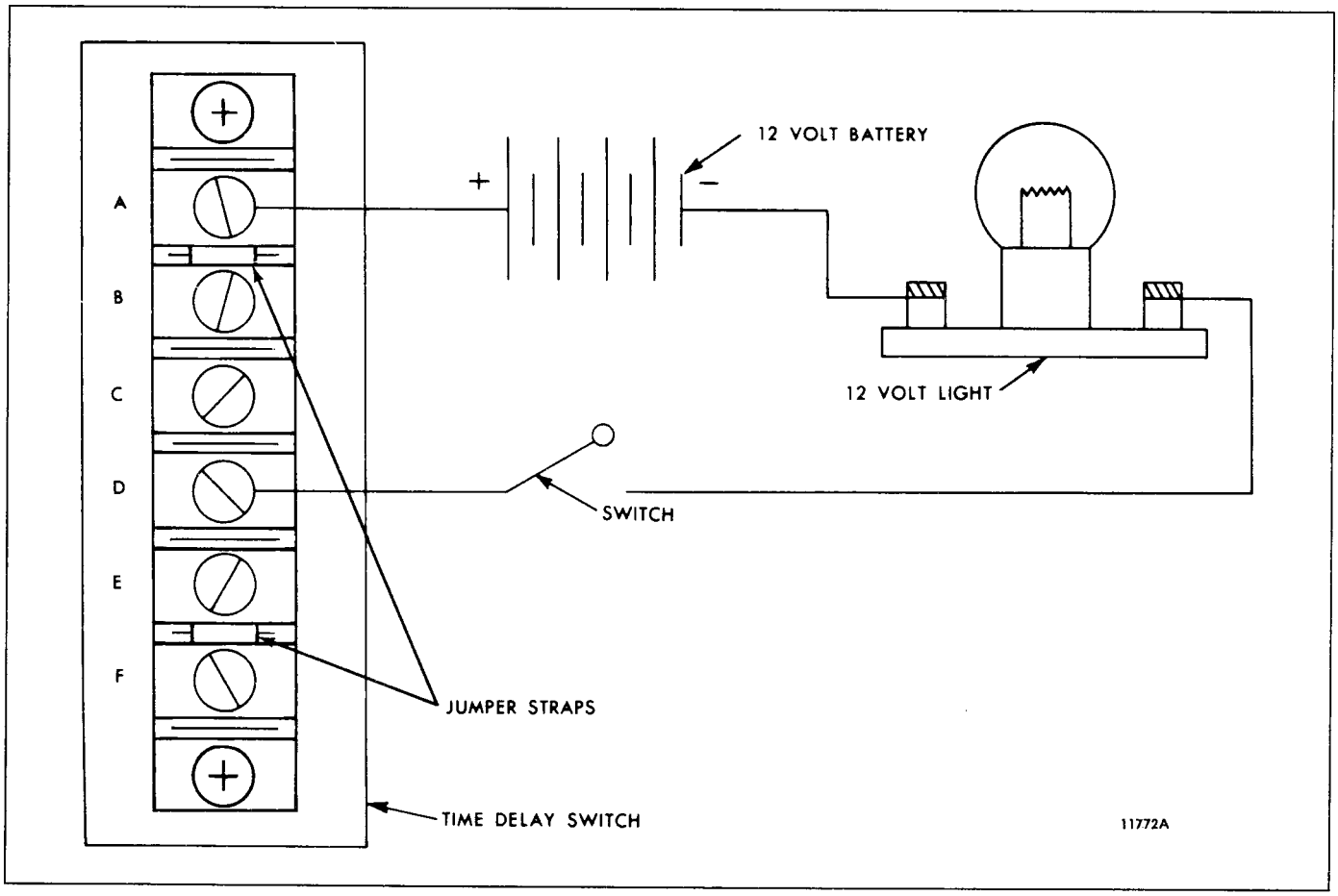


Fig. 3 – Time Delay Switch Testing Diagram

MOUNTING THE STARTER AUXILIARY MAGNETIC SWITCH

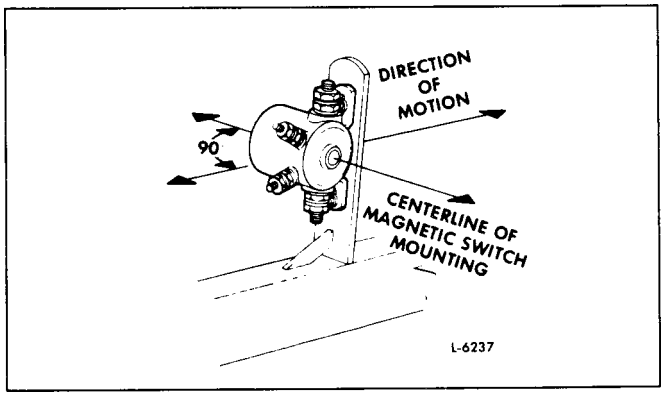


Fig. 4 - Starter Auxiliary Magnetic Switch Mounting

On certain locomotives and off-highway haul trucks equipped with Detroit Diesel engines and Delco-Remy starter auxiliary magnetic switches, a no-start condition 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. 4):

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.
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.

Alow 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)	N*m	THREAD SIZE	280M OR BETTER TORQUE (lb—ft)	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
''s' Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
jjC Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
—[1] Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

BOLT IDENTIFICATION CHART