SERIES 53 ENGINES

DETROIT DIESEL
OPERATORS MANUAL

SERVICE AND PARTS INFORMATION

OPERATORS MANUAL

SERIES 53 ENGINES

DETROIT DIESEL ENGINE DIVISION
GENERAL MOTORS CORPORATION
DETROIT, MICHIGAN, 48228

Form 6SE 337 (Rev. 2-69)
Printed in U.S.A.

TO THE OPERATOR

This manual contains instructions on the operation and preventive maintenance of your Detroit Diesel engine. Sufficient descriptive material, together with numerous illustrations is included to enable the operator to understand the basic construction of the engine and the principles by which it functions. This manual does not cover engine repair or overhaul.

Whenever possible, it will pay to rely on an authorized Detroit Diesel Service Outlet for all your service needs from maintenance to major parts replacement. There are over 1200 authorized service outlets in the U.S. and Canada. They stock factory original parts and have the specialized equipment and personnel with technical knowledge to provide skilled and efficient workmanship.

The operator should familiarize himself thoroughly with the contents of the manual before running an engine, making adjustments, or carrying out maintenance procedures.

The information, specifications and illustrations in this publication are based on the information in effect at the time of approval for printing. Generally, this publication is reprinted annually. It is recommended that users contact an authorized Detroit Diesel Service Outlet for information on the latest revision.

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DESCRIPTION

PRINCIPLES OF OPERATION

The Diesel Principle

The diesel engine is an internal combustion power unit in which the heat of fuel is converted into work within the cylinder of the engine.

In this type of engine, air alone is compressed in the cylinder. Then, after the air has been compressed, a charge of fuel is sprayed into the cylinder and ignition is accomplished by the heat of compression.

The Two-Cycle Principle

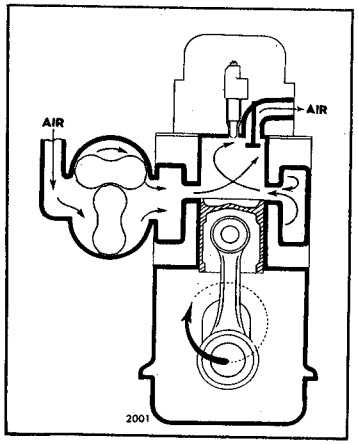


Fig. 1 - Scavenging

In the two-cycle engine, intake and exhaust take place during part of the compression and power strokes respectively, as shown in Figures 1 through 4. In contrast, a four-cycle engine requires four piston strokes to complete an operating cycle; thus during one half of its operation, the four-cycle engine functions merely as an air pump.

A blower forces air into the cylinders for expelling exhaust gases and to supply the cylinders with fresh air for combustion. The cylinder wall contains a row of ports which are above the piston when it is at the bottom of its stroke. These ports admit the air from the blower into the cylinder as soon as the rim of the piston uncovers the ports, as shown in Fig. 1.

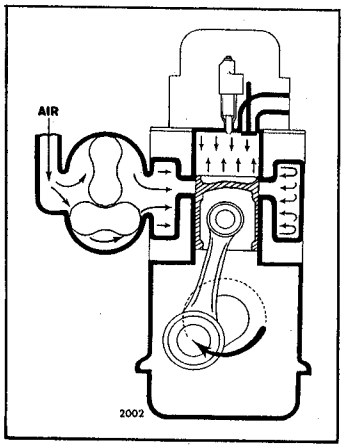


Fig. 2 - Compression

The unidirectional flow of air toward the exhaust valves produces a scavenging effect, leaving the cylinders full of clean air when the piston again covers the inlet ports.

As the piston continues on the upward stroke, the exhaust valves close and the charge of fresh air is subjected to compression, as shown in Fig. 2.

Shortly before the piston reaches its highest position, the required amount of fuel is sprayed into the combustion chamber by the unit fuel injector, as shown in Fig. 3. The intense heat generated during the high compression of the air ignites the fine fuel spray immediately and combustion continues until the injected fuel has been burned.

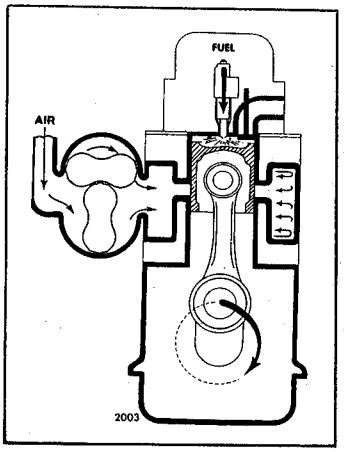


Fig. 3 - Power

The resulting pressure forces the piston downward on its power stroke. The exhaust valves are again opened when the piston is about half way down, allowing the burned gases to escape into the exhaust manifold as shown in Fig. 4. Shortly thereafter, the downward moving piston uncovers the inlet ports, and the cylinder is again swept with clean scavenging air, as shown in Fig. 1. This entire combustion cycle is completed in each cylinder for each revolution of the crankshaft or, in other words, in two strokes; hence, it is a "two-stroke cycle".

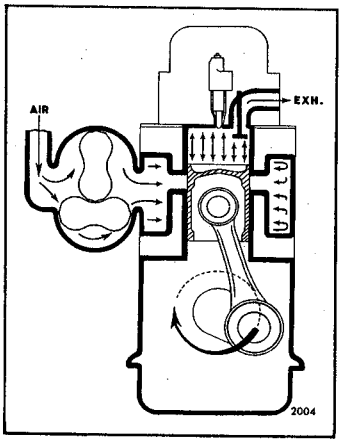


Fig. 4 - Exhaust

GENERAL DESCRIPTION

The two-cycle diesel engines covered in this manual have the same bore and stroke and many of the major working parts such as injectors, pistons, connecting rods, cylinder liners and other parts are interchangeable.

The In-line engines, including the inclined marine models, have standard accessories such as blower, water pump governor and fuel pump, which on some models may be located on either side of the engine regardless of the direction the crankshaft rotates. Further flexibility in meeting installation requirements is achieved with the cylinder head which can be installed to accommodate the exhaust manifold on either side of the engine.

The V-type engines use many In-line engine parts, including the 3-53 and 4-53 cylinder heads. The blower is mounted on top of the engine between the two banks of cylinders and is driven by the gear train. The governor is mounted on the rear end of the 6V-53 blower and on the front end of the 8V-53 blower.

The meaning of each digit in the model numbering system is shown in Figs. 5 and 6. The letter L or R indicates left or right-hand engine rotation as viewed from the front of the engine. The letter A,B,C or D designates the blower and exhaust manifold location on the In-line engines as viewed from the rear of the engine while the letter A or C designates the location of the oil cooler and starter on the V-type engines.

The engines are equipped with an oil cooler (not required on certain 2-cylinder models) replaceable element type lubricating oil filter, fuel oil strainer and filter, an air cleaner or silencer, a governor, a heat exchanger and raw water pump or fan and radiator, and a starting motor.

Full pressure lubrication is supplied to all main connecting rod, and camshaft bearings, and to other moving parts.

Oil is drawn by suction from the oil pan through the intake screen and pipe to the oil pump where it is pressurized and delivered to the oil filter and the oil cooler. From the oil cooler, the oil enters oil galleries in the cylinder block and cylinder head for distribution to the main bearings, connecting rod bearings, camshaft bearings, rocker arm mechanism and other functional parts.

The cooling system has a centrifugal water pump which circulates the engine coolant through the oil cooler and water jackets. The engine temperature is regulated by a thermostat(s).

Fuel is drawn from the supply tank through the fuel strainer and enters a gear type fuel pump at the inlet side. Upon leaving the pump under pressure, the fuel is forced through the fuel filter into the inlet manifold where it passes through fuel pipes into the inlet side of the fuel injectors. The fuel is filtered through elements in the injectors and then atomized through small spray tip orifices into the combustion chamber.

Air for scavenging and combustion is supplied through an air cleaner or silencer by a blower.

The engine may be started by either a hydraulic or an electric starting system.

The engine speed is regulated by an engine governor which may be a limiting speed mechanical, variable speed mechanical or hydraulic governor depending upon the engine application.

5043-5101

SERIES 53	NUMBER OF CYLINDERS	APPLICATION DESIGNATION	BASIC ENGINE ARRANGEMENTS * (see below)	DESIGN VARIATION	SPECIFIC MODEL NUMBER AND STARTER—BLOWER ARRANGEMENT

APPLICATION DESIGNATION

5042-5100	MARINE
5043-5100	FAN TO F/W—INDUSTRIAL
5044-5100	POWER-BASE
5045-5100	GENERATOR
5047-5100	FAN TO F/W—VEHICLE

DESIGN VARIATION

5043-5000	"N" ENGINE
5043-5100	2 VALVE HEAD
5043-5200	4 VALVE HEAD
5042-2302	TURBOCHARGER

STARTER—BLOWER ARRANGEMENT

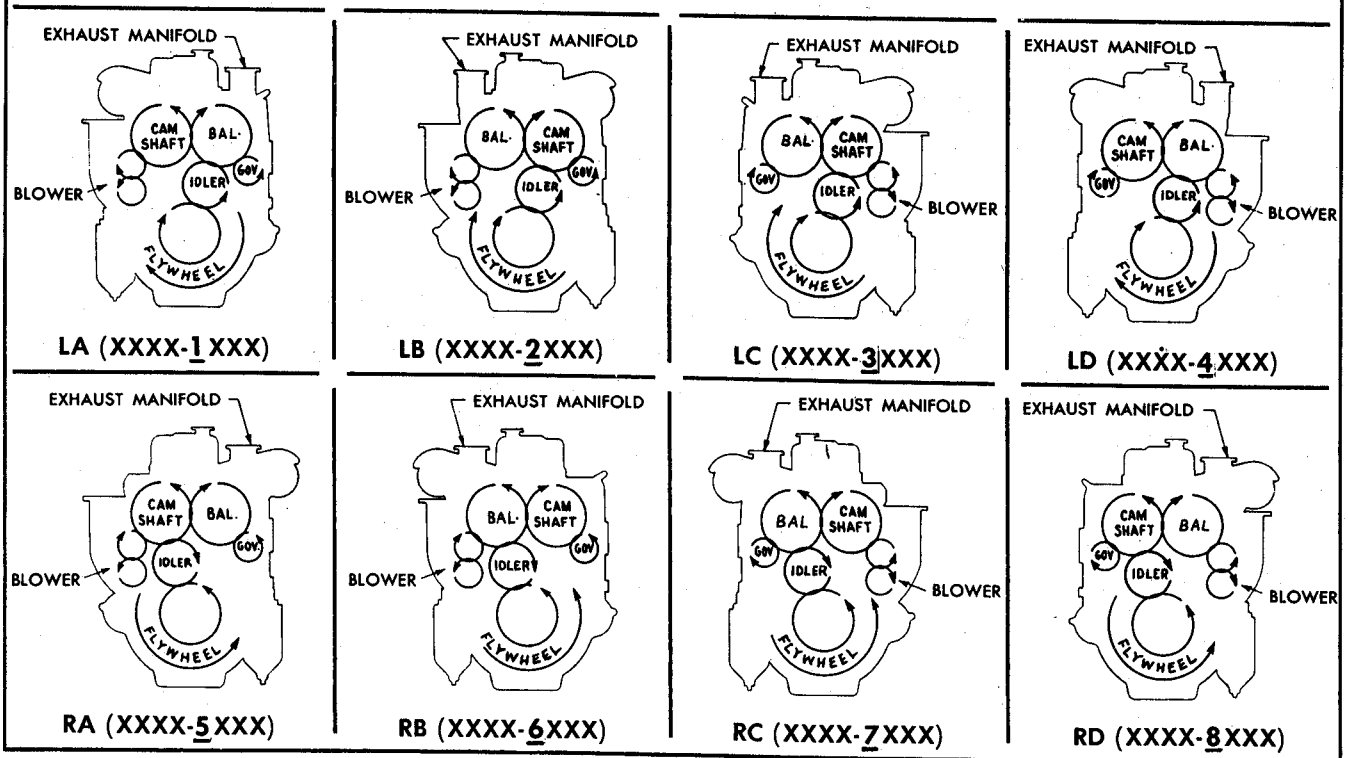
Odd number in last digit designates starter opposite blower.

Even number in last digit designates starter same side as blower.

* 2, 3, 4-53 BASIC ENGINE ARRANGEMENTS

Rotation: R-(right) and L-(left) designates rotation as viewed from the end of the engine opposite the flywheel.

Type: A-B-C-D designates location of exhaust manifold and blower as viewed from the flywheel end of the engine.



ALL ABOVE VIEWS FROM REAR (FLYWHEEL) END OF ENGINE

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Fig. 5 - In-Line Engine Model Description, Rotation and Accessory Arrangement

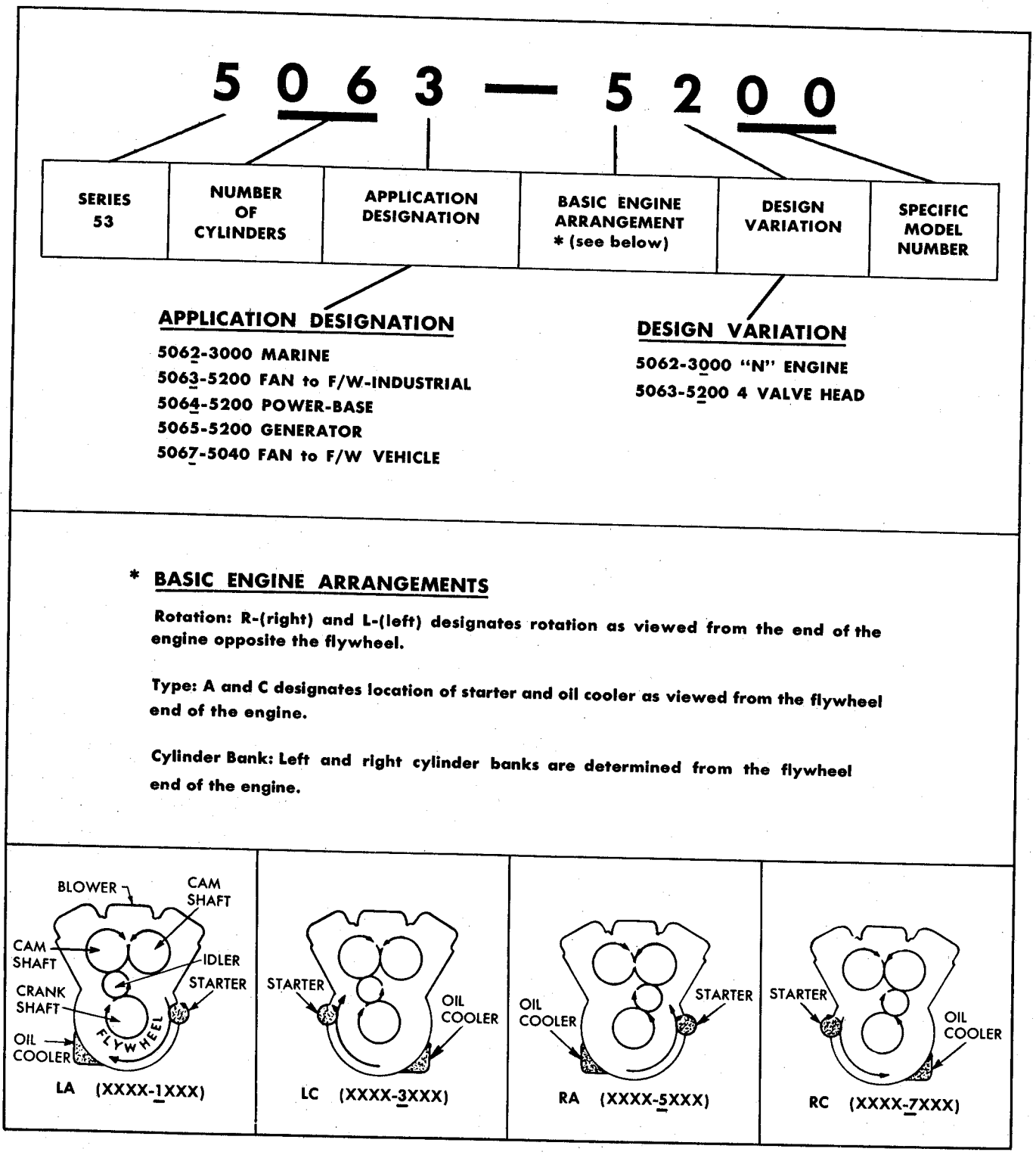


Fig. 6 - 6V or 8V Engine Model Description, Rotation and Accessory Arrangement

GENERAL SPECIFICATIONS

	2-53	3-53	4-53	6V-53	8V-53N
Number of Cylinders	2	3	4	6	8
Bore	3.875 in.	3.875 in.	3.875 in.	3.875 in.	3.875 in.
Stroke	4.5 in.	4.5 in.	4.5 in.	4.5 in.	4.5 in.
Compression Ratio (Nominal) (Standard Engines)	17 to 1	17 to 1	17 to 1	17 to 1	—
Compression Ratio (Nominal) ("N" Engines).		21 to 1	21 to 1	21 to 1	21 to 1
Total Displacement - Cubic Inches	106.2	159.3	212.4	318.6	424.8
Firing Order - R. H. Rotation	1-2	1-3-2	1-3-4-2	1L-3R-3L-2R-2L-1R	1L-3R-3L-4R-4L-2R-2L-1R
Firing Order - L. H. Rotation	—	1-2-3	1-2-4-3	1L-1R-2L-2R-3L-3R	—
Number of Main Bearings	3	4	5	4	5

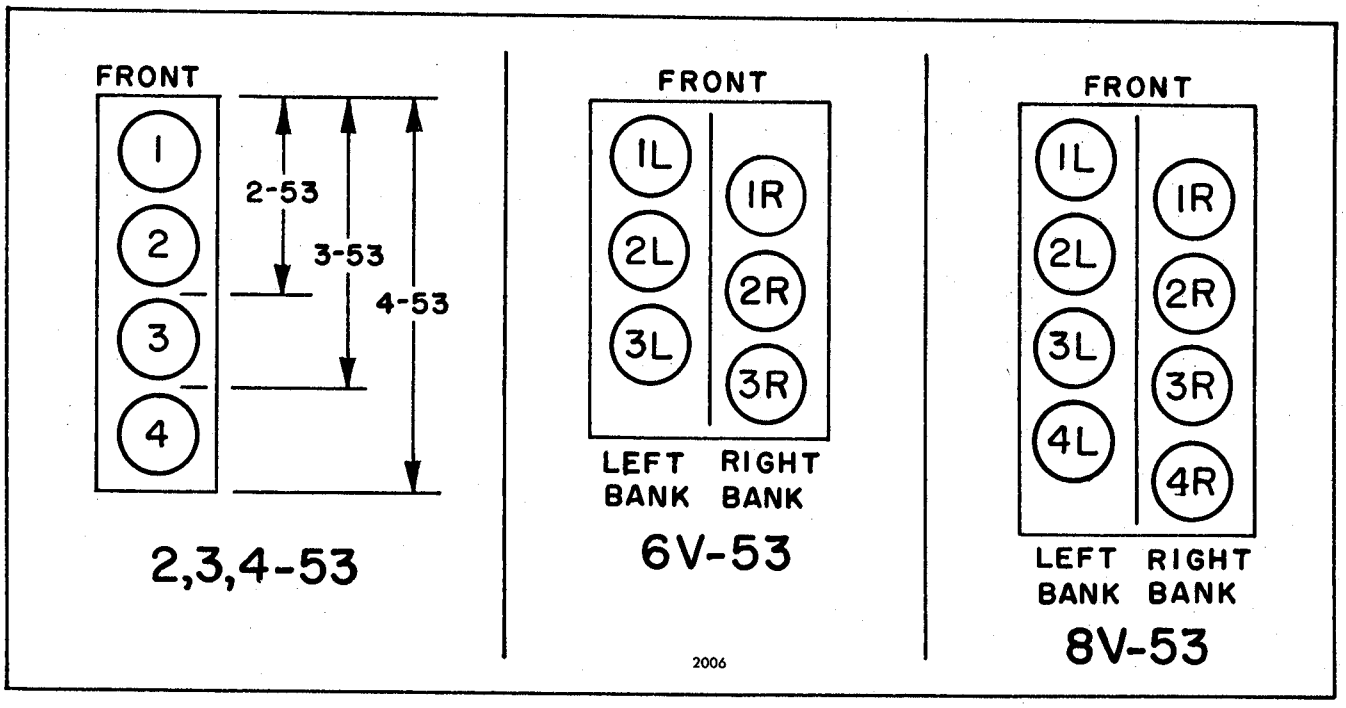


Fig. 7 - Series 53 Cylinder Arrangement

ENGINE MODEL AND SERIAL NUMBER DESIGNATION

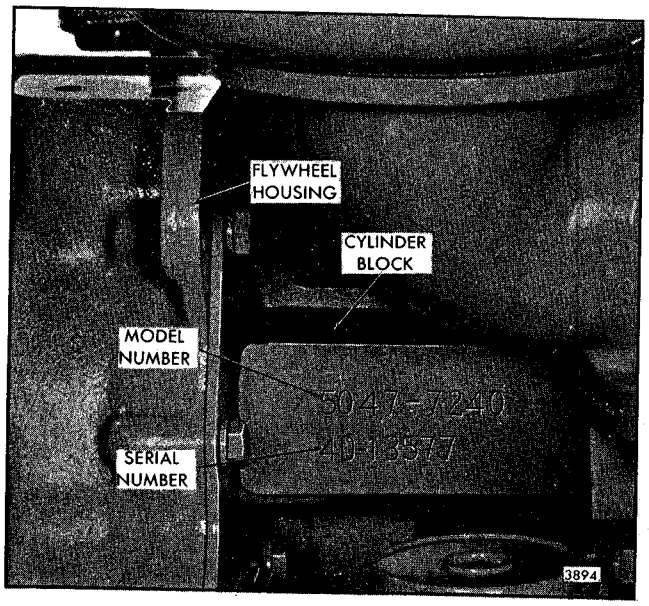


Fig. 8 - Typical Model and Serial Numbers as Stamped on Cylinder Block (In-Line Engine)

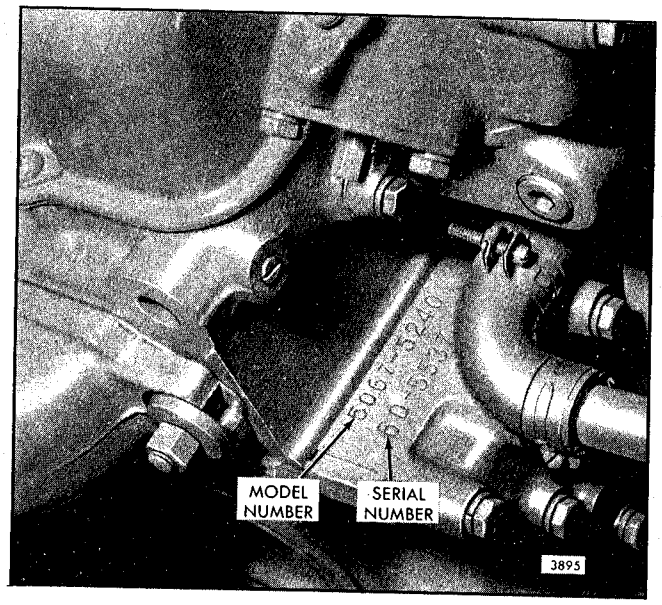


Fig. 9 - Typical Model and Serial Numbers as Stamped on Cylinder Block (6V-53 Engine)

On the In-line engines, the model number and serial number are stamped on the right-hand side of the cylinder block in the upper rear corner (Fig. 8). The model number and serial number on the V-type engines are located on the top right-hand front corner of the cylinder block, as viewed from the rear of the engine (Fig. 9).

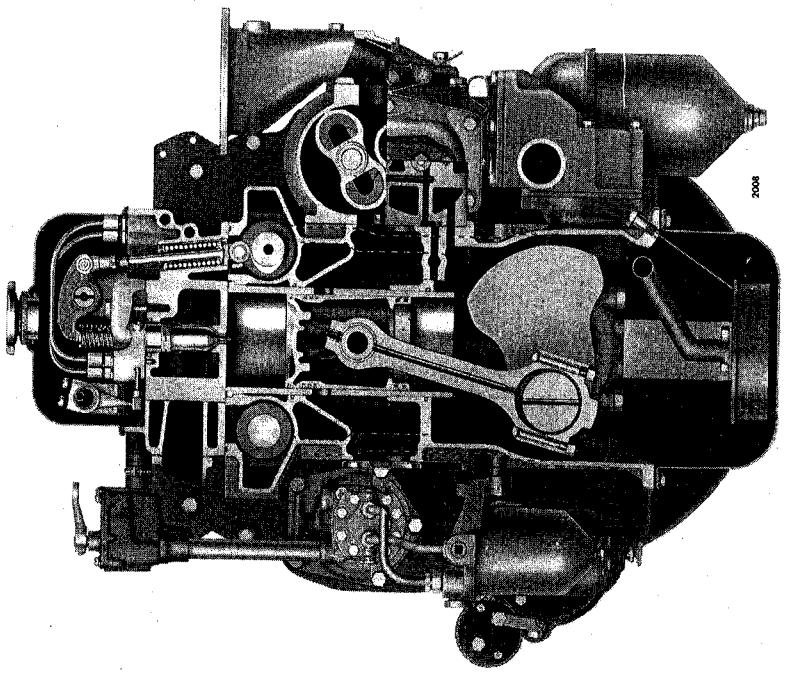
Engines with optional equipment have an option plate attached to one of the valve rocker covers. The engine serial number and model number are also stamped on this plate.

Power take-off assemblies, torque converters, hydraulic marine gears, etc., may also carry name plates pertaining to the particular assembly to which they are attached. The information on these name plates is useful when ordering parts for these assemblies.

BUILT-IN PARTS BOOK

Beginning on page 115 of this manual is complete information on Detroit Diesel's BUILT-IN PARTS BOOK. It is recommended that the engine user be familiar with the purpose of this feature in order to take full advantage of the information provided on the engine option plate.

Numerous exploded view type illustrations are included also to assist the user in identifying and ordering service parts.



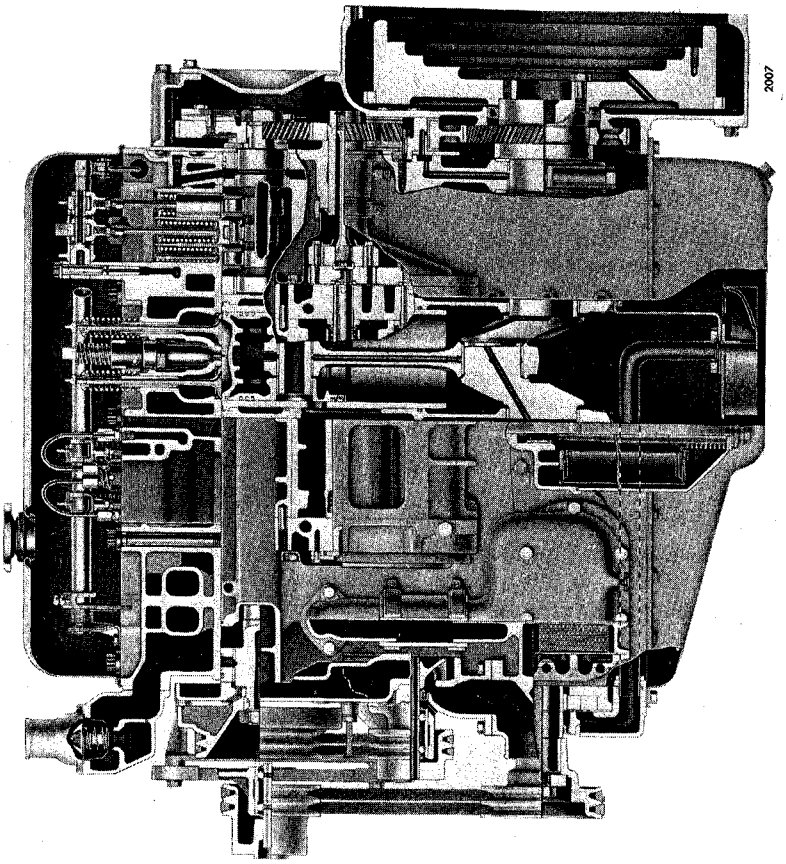


Fig. 10 - Cross Section Views of a Typical In-Line Engine

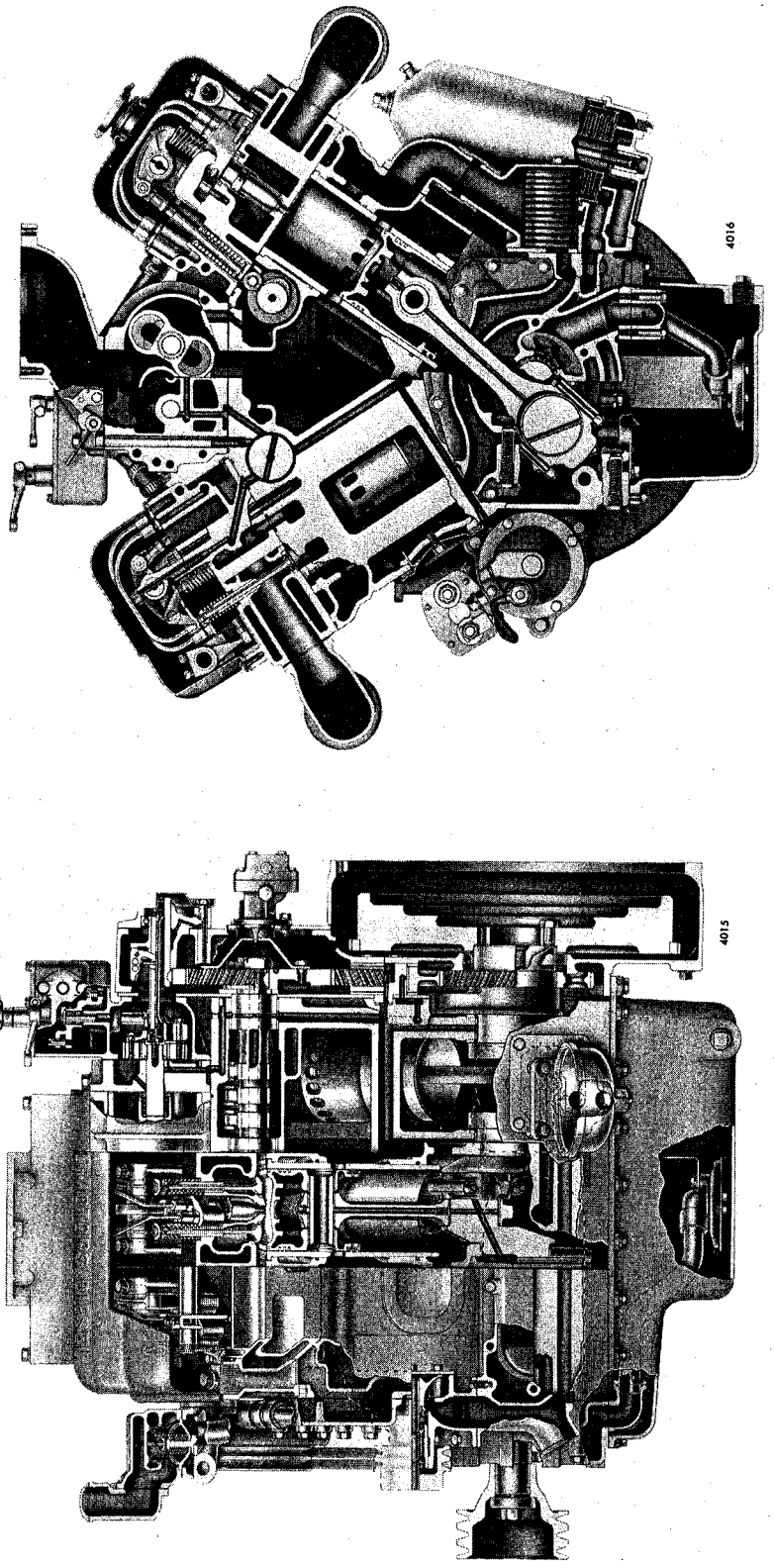
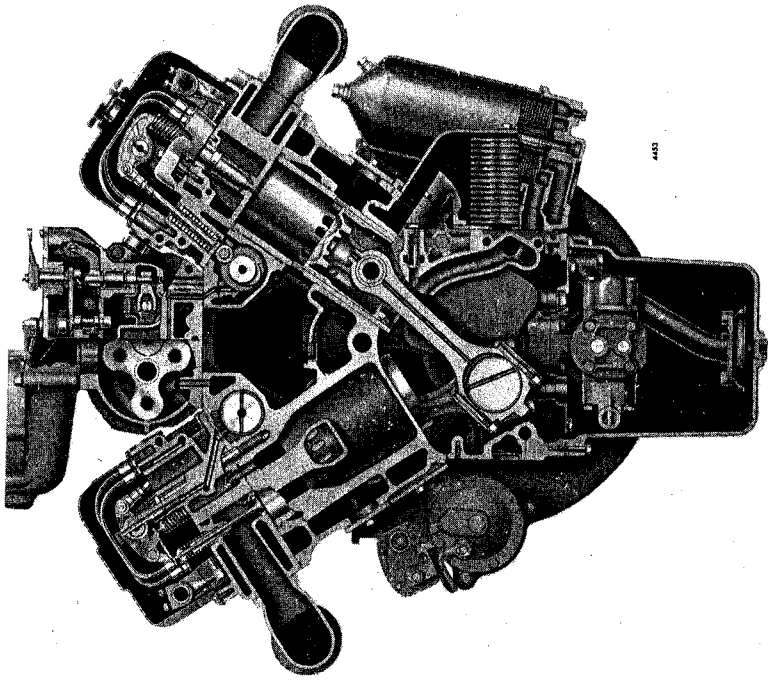


Fig. 11 - Cross Section Views of a Typical 6V-53 Engine



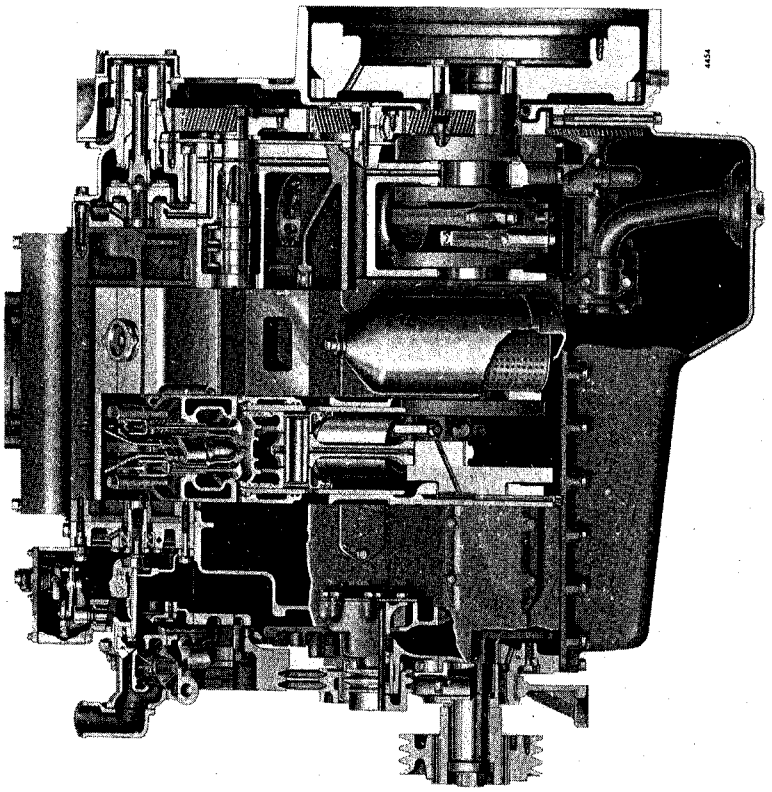


Fig. 12 – Cross Section Views of 8V-53 Engines

ENGINE SYSTEMS

The Series 53 engines incorporate four basic systems which direct the flow of fuel, air, lubricating oil, and engine coolant.

A brief description of each of these systems, and their components, maintenance and adjustment procedures are given in this manual.

FUEL SYSTEM

The fuel system (Figs. 1 and 2) consists of fuel injectors, fuel pipes, fuel manifolds (integral with the cylinder head), fuel pump, fuel strainer, fuel filter, and the necessary connecting fuel lines.

On In-line engines a restricted fitting is located in the cylinder head fuel return manifold outlet to maintain pressure within the fuel system. On V engines this restricted fitting is located in the left cylinder head.

Fuel is drawn from the supply tank through the fuel strainer and enters the fuel pump at the inlet side. Upon leaving the pump under pressure, the fuel is forced through the fuel filter and into the fuel inlet manifold where it passes through fuel pipes into the inlet side of each fuel injector. The fuel is filtered through elements in the injectors and atomized through small spray tip orifices into the combustion chamber. Surplus fuel, returning from the injectors, passes through the fuel return manifold and connecting fuel lines back to the fuel tank.

The continuous flow of fuel through the injectors helps to cool the injectors and remove air from the fuel system.

A check valve may be installed between the fuel strainer and the source of supply as optional equipment to prevent fuel drain back when the engine is not running.

Fuel Injector

The fuel injector combines in a simple unit all of the parts necessary to provide complete and independent fuel injection at each cylinder. The injector creates the high pressure necessary for fuel injection, meters the proper amount of fuel, atomizes the fuel, and times the injection into the combustion chamber.

Since the injector is one of the most important and carefully constructed parts of the engine, it is recommended that the engine operator replace the injector as an assembly if it is not operating properly. Authorized Detroit Diesel Service Outlets are properly equipped to service injectors.

Remove Injector

An injector may be removed and replaced in the following manner:

1. Remove the valve rocker cover.
2. Disconnect the fuel pipes from both the injector and the fuel connectors.
3. Immediately after removing the fuel pipes, cover the injector inlet and outlet fittings with shipping caps to prevent dirt from entering.
4. Turn the crankshaft manually in the direction of engine rotation or crank the engine with the starting motor, if necessary, until the rocker arms for the particular cylinder are aligned in a horizontal plane.

   CAUTION: If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation as the bolt will be loosened. Remove the starting motor and use a pry bar

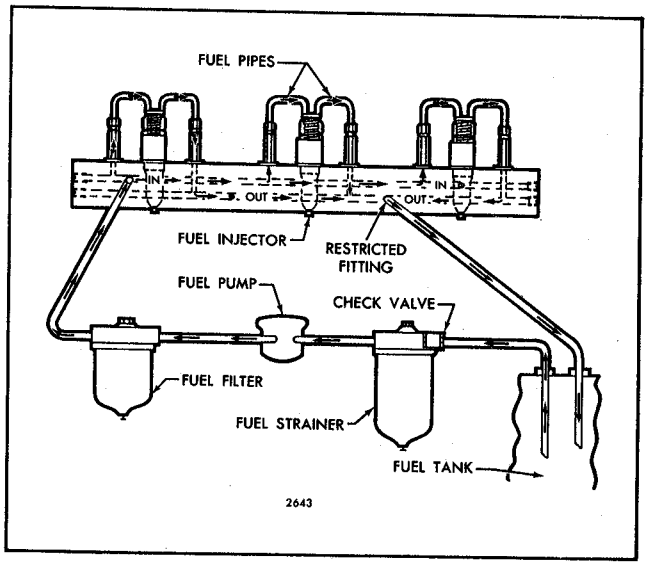


Fig. 1 - Schematic Diagram of Typical Fuel System—In-Line Engine

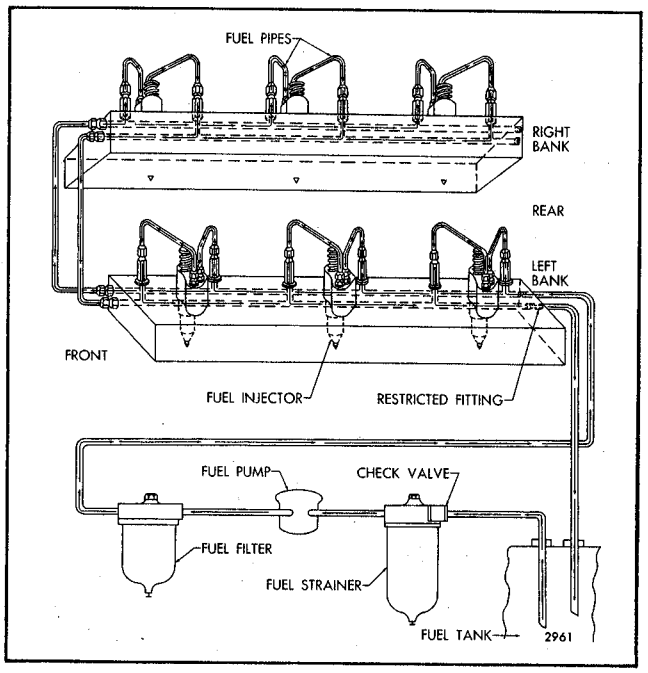


Fig. 2 - Schematic Diagram of Typical Fuel System—V-type Engine

against the teeth of the flywheel ring gear to turn the crankshaft.

5. Remove the two rocker shaft bracket bolts and swing the rocker arm assembly away from the injector and valves.

6. Remove the injector clamp bolt, washer and clamp.

7. Loosen the inner and outer adjusting screws on the injector rack control lever and slide the lever away from the injector.

8. Free the injector from its seat as shown in Fig. 3 and lift it from the cylinder head.

9. Cover the injector hole in the cylinder head to keep foreign particles out of the cylinder.

Install Injector

Before installing an injector, be sure the beveled seat of the injector tube is free from dirt particles and carbon deposits.

A new or reconditioned injector may be installed by reversing the sequence of operations given above for removal.

CAUTION: On four valve cylinder heads, there is a possibility of damaging the exhaust valves if the exhaust valve bridge is not resting on the ends of the exhaust valves when tightening the rocker shaft bracket bolts. Therefore, note the position of the exhaust valve bridge before, during and after tightening the rocker shaft bracket bolts.

Do not tighten the injector clamp bolt to more than 20-25 lb-ft torque, as this may cause the moving parts of the injector to bind. Tighten the rocker arm bracket bolts to 50-55 lb-ft torque.

Align the fuel pipes and connect them to the injector and the fuel connectors. Use socket J 8932-01 and a torque wrench to tighten the fuel pipe nuts to 12-15 lb-ft torque.

CAUTION: Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared ends of the fuel pipes and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

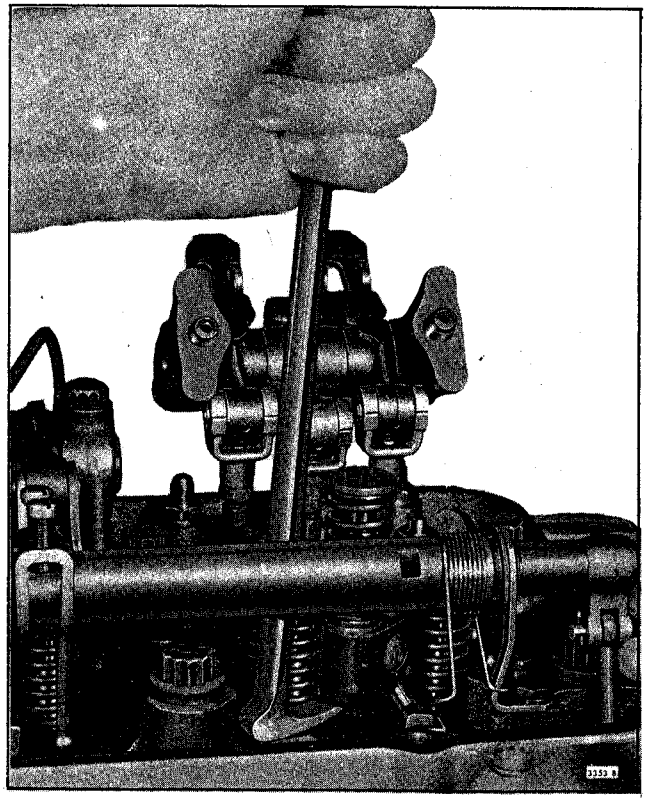


Fig. 3 - Removing Injector from Cylinder Head

Time the injector, position the injector rack control lever and adjust the exhaust valve clearance (cold setting) as outlined in the engine tune-up procedure. If all of the injectors have been replaced, perform a complete tune-up on the engine.

Fuel Pump

A positive displacement gear type fuel pump is used on the In-line and V-type engines. The pump is attached to the governor or blower on the In-line engines and to the flywheel housing on the V-type engines.

A spring-loaded relief valve, incorporated in the pump body, normally remains in the closed position, operating only when the pressure on the outlet side (to the fuel filter) becomes excessive due to a plugged filter or fuel line. The valve will open at a pressure of approximately 65 to 70 lbs per sq. in. and allow the fuel to return, through a passage in the pump body, from the pressure side to the suction side of the pump.

The fuel pump incorporates two oil seals. Two tapped holes are provided in the underside of the pump body, between the oil seals, to permit a drain tube to be attached. If fuel leakage exceeds one drop per minute, the seals must be replaced. An authorized Detroit Diesel Service Outlet is properly equipped to replace the seals.

Fuel pumps are furnished in either left or right hand rotation according to the engine model, and are stamped RH and LH. These pumps are not interchangeable, and cannot be rebuilt to operate in an opposite rotation.

Fuel Strainer and Fuel Filter

A replaceable element type fuel strainer and fuel filter (Fig. 4) are used in the fuel system to remove impurities from the fuel. The strainer removes the larger particles and the filter removes the small foreign particles.

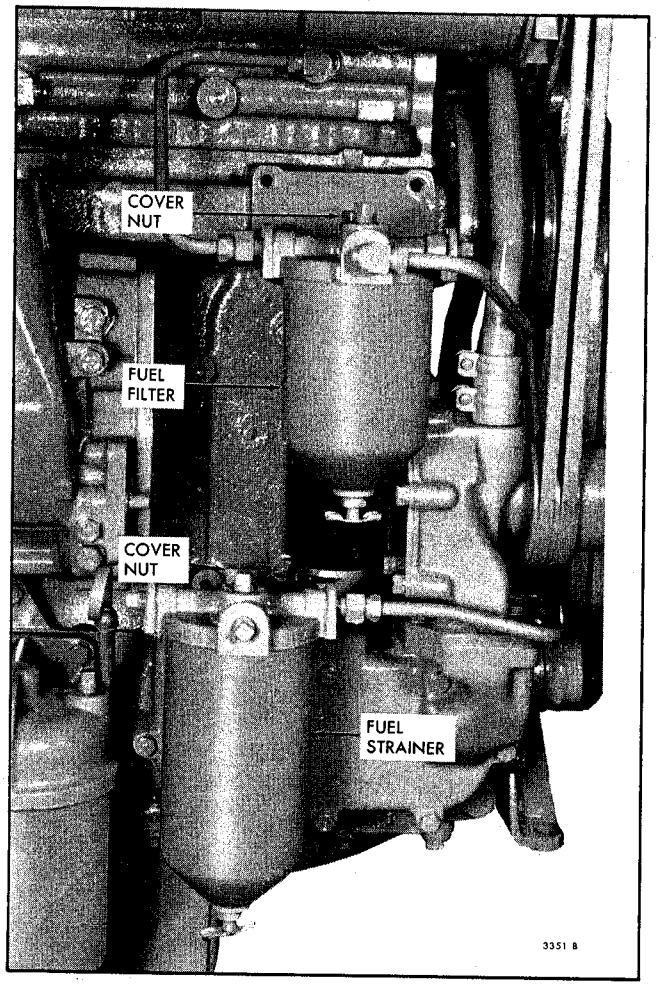


Fig. 4 - Typical Fuel Strainer and Filter Mounting

The fuel strainer and fuel filter are basically identical in construction, both consisting of a cover, shell and replaceable element. Since the fuel strainer is placed between the fuel supply tank and fuel pump, it functions under suction; the fuel filter, which is installed between the fuel pump and fuel inlet manifold in the cylinder head, operates under pressure.

Replace the elements as follows:

1. With the engine shut down, place a suitable container under the fuel strainer or filter and open the drain cock. The fuel will drain more freely if the cover nut is loosened slightly.

2. Support the shell, unscrew the cover nut and remove the shell and element.

3. Remove and discard the element and gasket. Clean the shell with fuel oil and dry it with a cloth or compressed air.

4. Place a new element, which has been thoroughly soaked in clean fuel oil, over the stud and push it down on the seat. Close the drain cock and fill the shell approximately two-thirds full with clean fuel oil.

5. Affix a new shell gasket, place the shell and element into position under the cover and start the cover nut on the shell stud.

6. Tighten the cover nut only enough to prevent fuel leakage.

7. Remove the plug in the strainer or filter cover and fill the shell with fuel. Fuel system primer J 5956 may be used to prime the fuel system.

8. Start and operate the engine and check the fuel system for leaks.

Fuel Tank

Refill the fuel tank at the end of each day's operation to reduce condensation.

> **CAUTION:** A galvanized steel tank should never be used for fuel storage because the fuel oil reacts chemically with the zinc coating to form powdery flakes which quickly clog the fuel strainer and filter and damage the fuel pump and the fuel injectors.

AIR SYSTEM

In the scavenging process used in the Series 53 engines, and illustrated in Figs. 5 and 6, a charge of air is forced into the cylinders by the blower and thoroughly sweeps out all of the burnt 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, each cylinder is filled with fresh, clean air which provides for efficient combustion.

The air, entering the blower from the air silencer or air cleaner, is picked up by the blower rotor lobes and carried to the discharge side of the blower. 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 liner creates a uniform swirling motion to the intake air as it enters the cylinder. This motion persists throughout the compression stroke and facilitates scavenging and combustion.

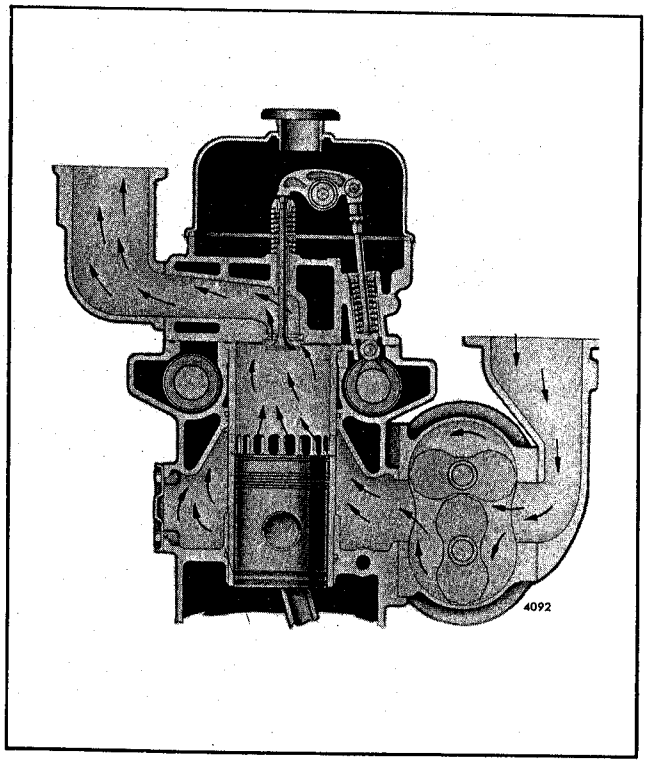


Fig. 5 - Air Intake System Through Blower and Engine (In-line Engine)

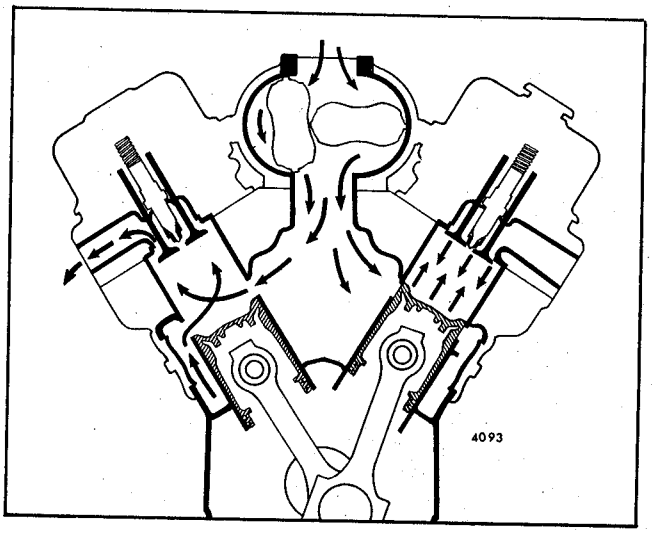


Fig. 6 - Air Intake System Through Blower and Engine (6V-53 Engine)

Air Cleaners

Several types of air cleaners are available for use with industrial engines. The light-duty oil bath air cleaner is used on most models and a heavy-duty oil bath or a dry type air cleaner may be installed where the engine is operating in heavy dust concentrations.

The air cleaners are designed for fast, easy disassembly to facilitate efficient servicing.

The oil bath air cleaner consists of the body and fixed filter assembly which filters the air and condenses the oil from the air stream so that only dry air enters the engine. The condensed oil is returned to the cup where the dirt settles out of the oil and the oil is recirculated. A removable element assembly incorporated in the heavy-duty oil bath air cleaners removes a major part of the dust from the air stream thereby decreasing the dust load to the fixed element. An inner cup, which can be removed from the outer or oil cup, acts as a baffle in directing the oil laden air to the element and also controls the amount of oil in circulation and meters the oil to the element. The oil cup supports the inner cup and is a reservoir for oil and a settling chamber for dirt.

Maximum protection of the engine against dust and other forms of air contamination is possible if the air cleaner is serviced at regular intervals. The light-duty oil bath air cleaner, Fig. 7, should be serviced as follows:

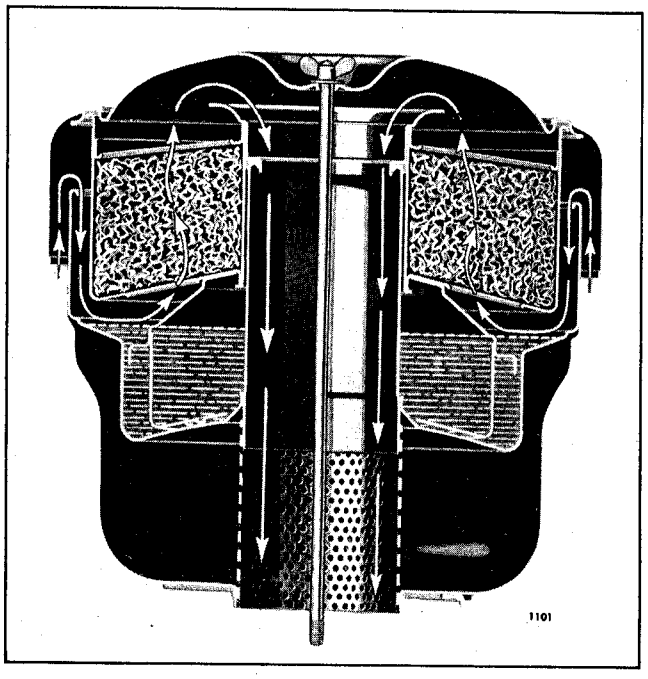


Fig. 7 - Oil Bath Air Cleaner and Silencer Assembly - Light-Duty

1. Loosen the wing bolt and remove the air cleaner assembly from the air inlet housing. The cleaner may then be separated into two sections; the upper section or body assembly contains the filter element, the lower section consists of the oil cup, removable inner cup or baffle and the center tube.

2. Soak the body assembly and element in fuel oil to loosen the dirt; then flush the element with clean fuel oil and allow it to drain thoroughly.

3. Pour out the oil, separate the inner cup or baffle from the oil cup, remove the sludge and wipe the baffle and outer cup clean.

4. Push a lint-free cloth through the center tube to remove dirt or oil.

5. Clean and check all the gaskets and sealing surfaces to ensure air tight seals.

6. Refill the oil cup to the oil level mark only, install the baffle, and reassemble the air cleaner.

7. Check the air inlet housing before installing the air cleaner assembly on the engine. The inlet will be dirty if air cleaner servicing has been neglected or if dust laden air has been leaking past the air cleaner to air inlet housing seals.

8. Make sure that the air cleaner is seated properly on the inlet housing and the seal is installed correctly. Tighten the wing bolt until the air cleaner is securely mounted.

The heavy-duty oil bath air cleaner, Fig. 8, should be serviced as follows:

1. Loosen the wing nuts and detach the lower portion of the air cleaner assembly.

2. Remove the detachable screen by loosening the wing nuts and rotating the screen one-quarter turn.

   One of the most important steps in properly cleaning the tray type oil bath air cleaner is a step that is most overlooked. Unless the filter tray is thoroughly cleaned, satisfactory per-

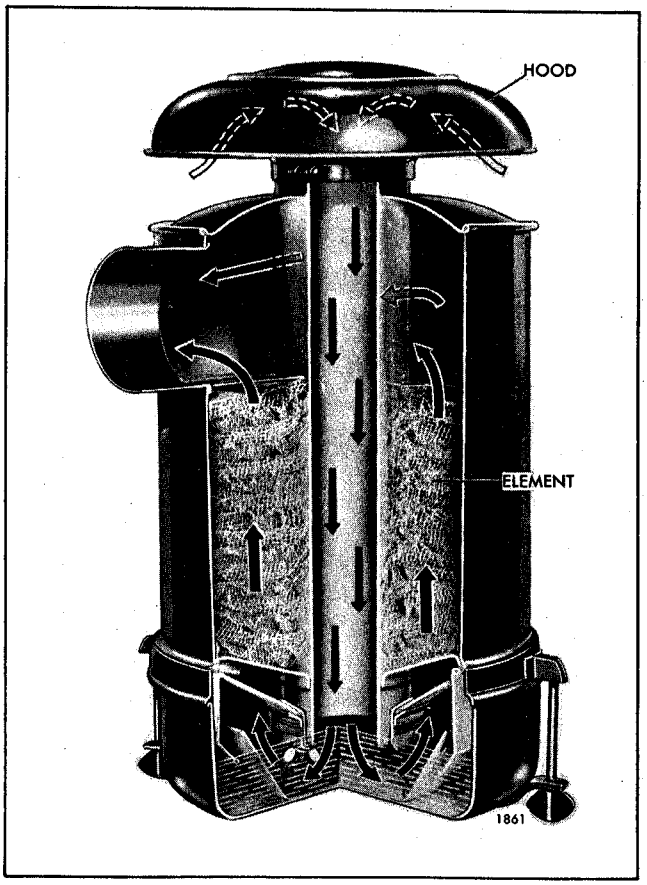


Fig. 8 - Oil Bath Air Cleaner and Silencer Assembly - Heavy-Duty

formance of any engine cannot be realized. The presence of fibrous material found in the air is often underestimated and is the main cause of the malfunctioning of heavy-duty air cleaners. This material comes from plants and trees during their budding season and later from air born seed from the same sources. Figure 10 illustrates the severity of plugging in a tray that is 50% plugged. The solid black areas in the mesh are accumulations of this fibrous material. When a tray is plugged in this manner, washing in a solvent or similar washing solution will not clean the tray satisfactorily. It must be blown out also with high pressure air or steam to remove the material that accumulates between the layers of screening. When a clean tray is held up to the light an even pattern of light should be visible. It may be necessary, only as a last resort, to burn off the lint. Extreme care must be taken to prevent melting the galvanized coating in the tray screens. Some trays have equally spaced holes in the retaining baffle. Check to make sure that they are clean and open. Illustrated in Fig. 9 is a thoroughly cleaned tray. The dark spots in the mesh indicate the close overlapping of the mesh and emphasize the need for using compressed air or steam. It is suggested that users of heavy-duty air cleaners have a spare tray on hand to replace the tray that requires cleaning. Having an extra tray available makes for better service and the dirty tray can be cleaned thoroughly as recommended. Spare trays are well worth their investment.

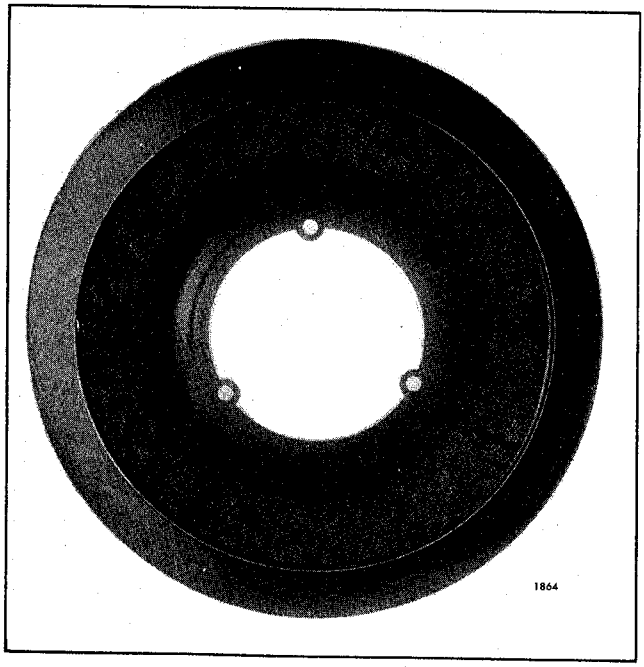


Fig. 9 - Air Cleaner Tray (Clean)

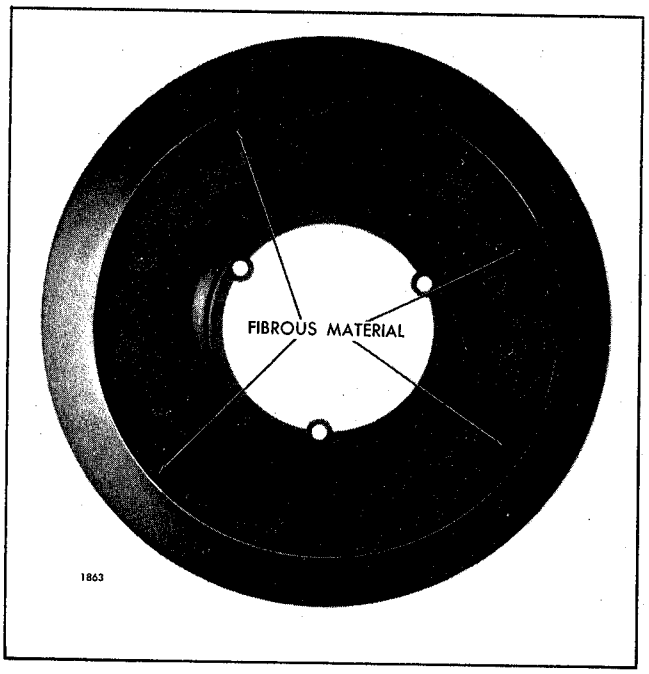


Fig. 10 - Air Cleaner Tray (50% Plugged)

3. Pour out the oil, separate the inner cup or baffle from the oil or outer cup, remove the sludge and wipe the baffle and outer cup clean.

4. Clean and inspect the gaskets and sealing surfaces to ensure an air tight seal.

5. Reinstall the baffle in the oil cup and refill to the proper oil level with the same grade of oil being used in the engine.

6. Remove hood and clean by brushing, or by blowing out with compressed air. Push a lint-free cloth through the center tube to remove dirt or oil from the walls.

7. Inspect the lower portion of the air cleaner body and center tube each time the oil cup is serviced. If there are any indications of plugging, the body assembly should be removed from the engine and cleaned by soaking and then flushing with clean fuel oil. Allow the unit to drain thoroughly.

8. Place the removable element in the body assembly. Install the body if it was removed from the engine for servicing.

9. Install the outer cup and baffle assembly. Be sure the cup is tightly secured to the assembly body.

All oil bath air cleaners should be serviced as operating conditions warrant. At no time should more than 1/2" of "sludge" be allowed to form in the oil cup or the area used for sludge deposit, nor should the oil cup be filled above the oil level mark with clean oil.

The United Specialties dry type air cleaner shown in Fig. 11 consists of a body, dust unloader and element clamped to a base.

Air is drawn through the cleaner intake pipe and is automatically set into a circular motion. This positive spinning of the dirty air "throws out" the heavier particles of dust and dirt where they are collected in the dust port and then expelled through the dust unloader. The circular action continues even during low air intake at engine idle speeds.

The United Specialties dry type air cleaner should be serviced as operating conditions warrant, as follows:

1. Loosen the clamp screw and check the dust unloader for obstruction or damage.

2. Unlock the spring clamps that hold the cleaner body to the cleaner base which is bolted to the air inlet housing. Remove the body and then remove the element from the cleaner base.

3. The paper pleated air cleaner element can be cleaned as follows:

   a. For a temporary expedient in the field, tap the side or end of the element carefully against the palm of your hand.

      CAUTION: Do not tap the element against a hard surface. This could damage the element.

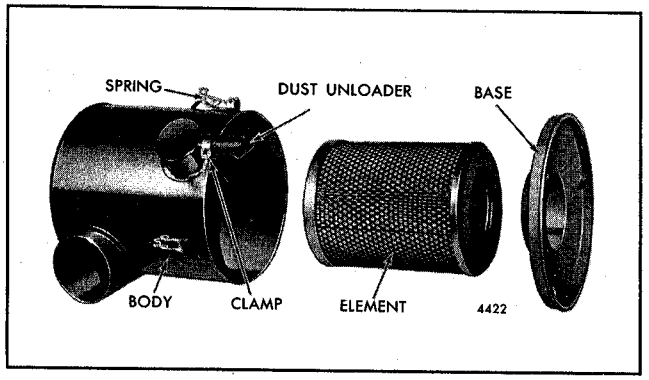


Fig. 11 - United Specialities Dry Type Air Cleaner

   b. Compressed air can be used when the major contaminant is dust. The compressed air (not to exceed 100 psi) should be blown through the element in a direction opposite to the normal air flow. Insert the nozzle inside of the element and gently tap and blow out the dust with air. When cleaning the dust from the outside of the element hold the nozzle at least 6" from the element.

   c. Wash the element if compressed air is not available, or when the contaminant is carbon, soot, oily vapor, or dirt which cannot be removed with compressed air.

      Agitate the element in warm water containing a non-sudsing detergent.

      CAUTION: Do not use water hotter than your hand can stand; solvents or oil; fuel oil or gasoline.

      Preceding the washing, it helps to direct air (not exceeding 100 psi) through the element in a direction opposite to the normal air flow to dislodge as much dust as possible. Reverse flush with a stream of water (not exceeding 40 psi until the water runs clean) to rinse all loosened foreign material from the element. Shake out excess water from the element and allow to dry thoroughly.

      CAUTION: Do not attempt to remove excess water by using compressed air.

4. Inspect the cleaned element with a light bulb after each cleaning for damage or rupture. The slightest break in the element will admit sufficient air borne dirt to cause rapid failure of piston rings. If necessary, replace the element.

   Inspect the gasket on the end of the element. If the gasket is damaged or missing replace the element.

5. Install element on base with gasket side of element down against base. Place body over element and base and tighten spring clamps by hand.

   Replace element after 10 washings or 1 year of service, whichever comes first, or any time damage is noted.

   Install dust unloader and tighten clamp.

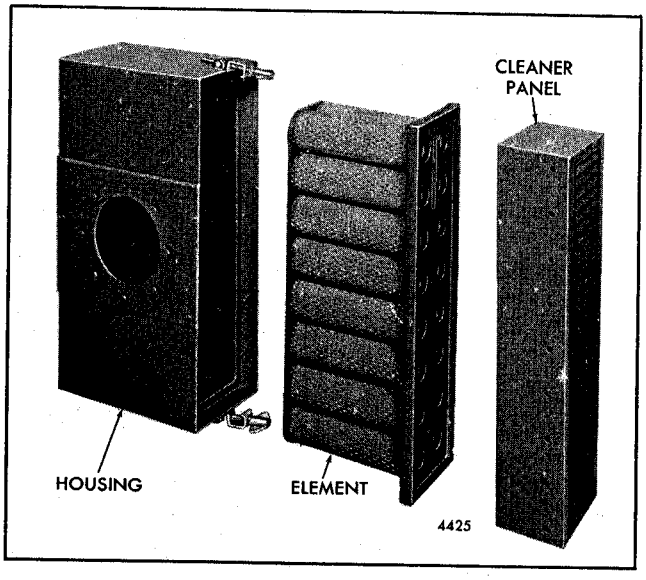


Fig. 12 - Farr Dry Type Air Cleaner

The Farr dry type air cleaner illustrated in Fig. 12 is designed to provide highly efficient air filtration under all operating conditions and is not affected by engine speed. The cleaner assembly consists of a cleaner panel with a replaceable impregnated paper filter element.

The cleaner panel and replaceable filter element are held together in a steel housing with fasteners.

The deflector vanes impart a swirling motion to the air entering the air cleaner and centrifuge the dust particles against the walls of the tubes. The dust particles are then carried to the dust bin at the bottom of the cleaner by approximately 10% bleed-off-air and are finally discharged into the atmosphere.

The cleaner panel is fully effective at either high or low velocities.

The remainder of the air in the cleaner reverses direction and spirals back along the discharge tubes again centrifuging the air. The filtered air then reverses direction again and enters the replaceable filter element through the center portion of the discharge tubes. The air is filtered once more as it passes through the pleats of the impregnated paper element before leaving the outlet port of the cleaner housing.

The cleaner panel tends to be self-cleaning. However, it should be inspected and any accumulated foreign material removed during the periodic replacement of the impregnated paper filter element. Overloading of the paper element will not cause dirt particles to by-pass the filter and enter the engine, but will result in starving the engine for air.

The filter element should be replaced as operating conditions warrant as follows:

1. Loosen the wing nuts on the fasteners and swing the retaining bolts away from the cleaner panel.

2. Lift the cleaner panel away from the housing and inspect it. Clean out any accumulated foreign material.

3. Withdraw the paper filter element and discard it.

4. Install a new filter element.

5. Install the cleaner panel and secure it in place with the fasteners.

Air Silencer

The air silencer is bolted to the intake side of the blower housing. The silencer has a perforated steel partition welded in place parallel with the outside faces, enclosing flame proof, felted cotton waste which serves as a silencer for air entering the blower.

While no servicing is required on the air silencer proper, it may be removed when necessary to replace the air intake screen (refer to Preventive Maintenance Chart). This screen is used to filter out any large foreign particles which might seriously damage the blower assembly.

Air Box Drains

During normal engine operation, water vapor from the air charge, as well as a slight amount of fuel and lubricating oil fumes, condense and settle on the bottom of the air box. This condensation is removed by the air box pressure through air box drain tubes mounted on the side of the cylinder block.

One drain tube is used on the In-line engines, and two drain tubes are used on the V-type engine, at the rear end of cylinder block.

The air box drains should be open at all times. With the engine running, a periodic check is recommended for air flow from the air box drain tubes. Liquid accumulation on the bottom of the air box, indicates a drain tube may be plugged. Such accumulations can be seen by removing the cylinder block air box cover(s) and should be wiped out with rags or blown out with compressed air. Then remove drain tubes and connectors from the cylinder block and clean them thoroughly.

Some engines are equipped with an air box drain check valve. Refer to the Lubrication and Maintenance section of this manual for service instructions.

Crankcase Ventilation

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

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

Some engines are equipped with a breather assembly which is mounted on the rocker cover. Other units employ a breather assembly mounted on the flywheel housing or incorporated in the engine front cover.

The wire mesh pad (element) in the breather assemblies should be cleaned if excessive crankcase pressure is observed. If it is necessary to clean the element, remove the breather housing from the flywheel housing, or remove the engine front cover (V-type engines) and wash the element in fuel oil, blow it dry with compressed air, and then reinstall the element and breather assembly on the engine.

LUBRICATING SYSTEM

The Series 53 engine lubricating systems, illustrated in Figs. 15, 16 and 17 include an oil intake screen and tube assembly, an oil pump, a pressure regulator, a full flow oil or by-pass filter with by-pass valve, and an oil cooler with a by-pass valve.

Lubricating oil from the pump passes from the lower front cover through short gallery passages in the cylinder block. From the block, the oil flows to the full flow oil filter, then through the oil cooler if required, and back into the front engine cover and cylinder block oil galleries for distribution to the various engine bearings. The drains from the cylinder head(s) and other engine parts lead back to the oil pan.

Oil pressure is regulated by a pressure relief valve mounted in the engine front cover. Oil cooler and oil filter by-pass valves prevent the stoppage of oil flow if these items become plugged.

Oil Filters

Each engine is equipped with a full-flow type, lubricating oil filter. If additional filtering is required, a by-pass type oil filter may also be installed.

All of the oil supplied to the engine passes through the full-flow filter that removes the larger foreign particles without restricting the normal flow of oil.

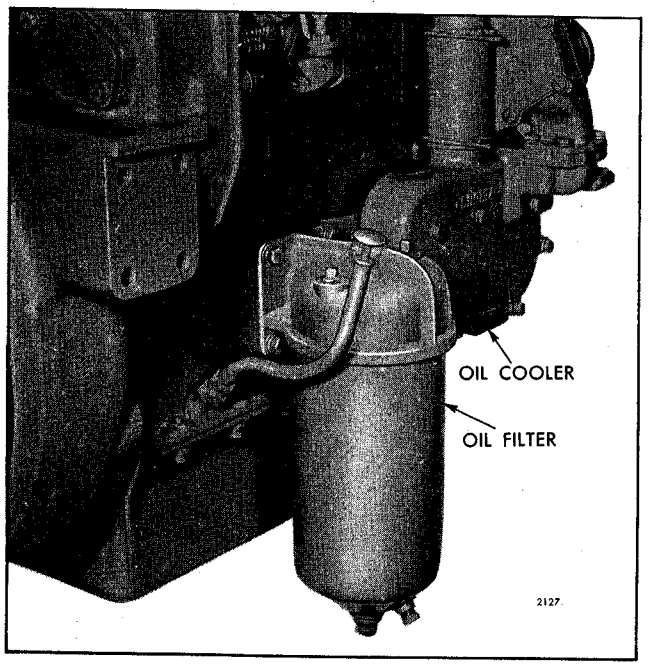


Fig. 13 - Typical In-Line Engine Oil Filter Mounting

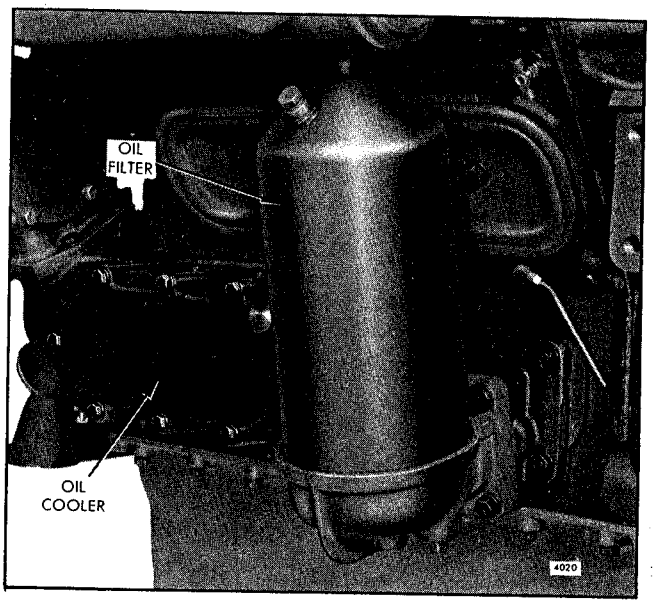


Fig. 14 - Typical V-Type Engine Oil Filter Mounting

The by-pass filter assembly, when used, continually filters a portion of the lubricating oil that is being bled off the oil gallery when the engine is running. Eventually all the oil passes through the filter, filtering out minute foreign particles that may be present.

The full flow and by-pass filter elements should be replaced each time the engine oil is changed; as follows:

1. Remove the drain plug and drain the oil (Figs. 13 and 14).
2. The filter shell, element and stud may be detached as an assembly, after removing the center stud from the base. Discard the gasket.
3. Clean the filter base.
4. Discard the used element, wipe out the filter shell and install a new element on the center stud.
5. Place a new gasket in the filter base, position the shell and element assembly on the gasket and tighten the center stud carefully to prevent damaging the gasket or center stud.
6. Install the drain plug and after the engine is started, check for oil leaks.

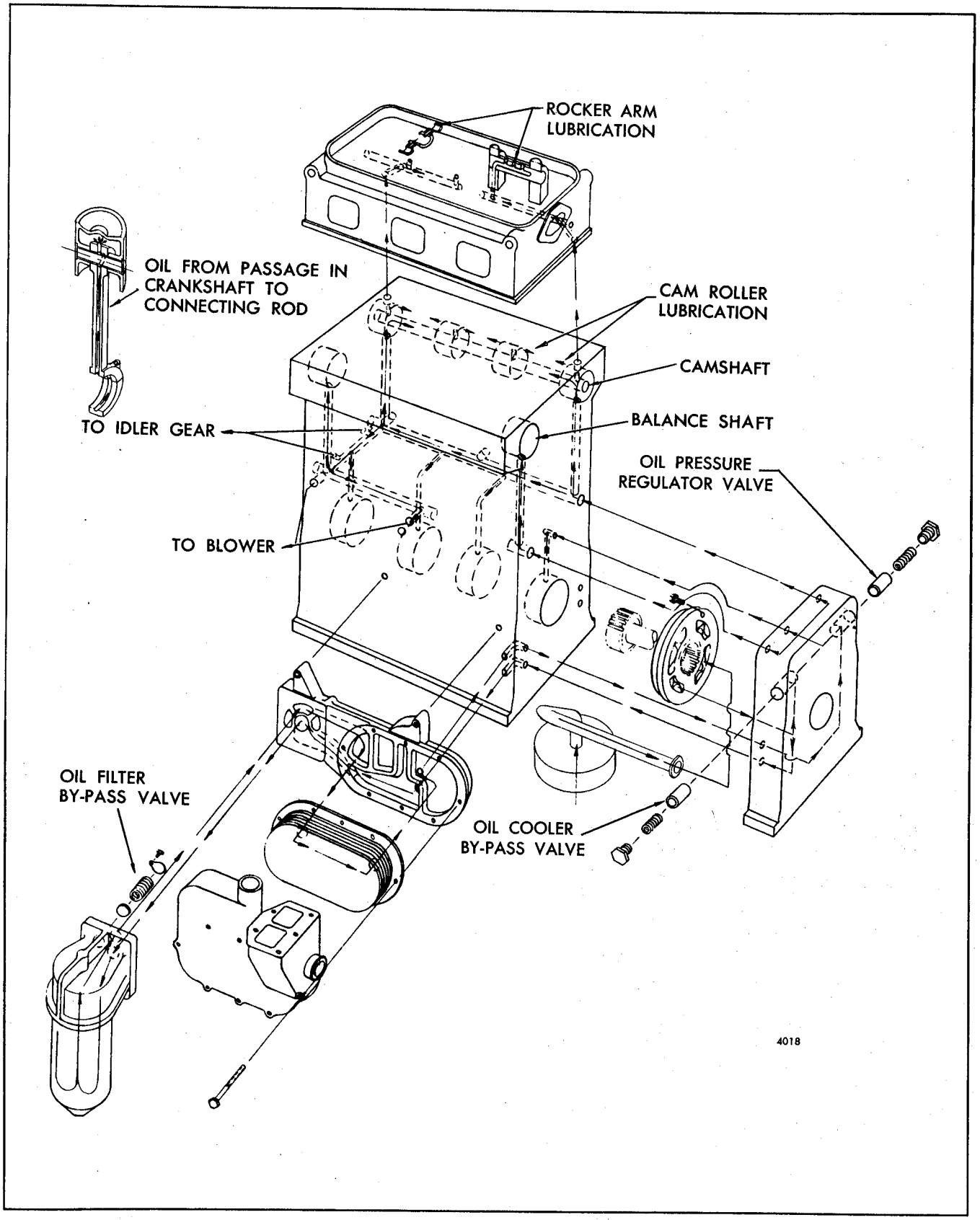


Fig. 15 - Schematic Diagram of Typical In-Line Engine Lubricating System

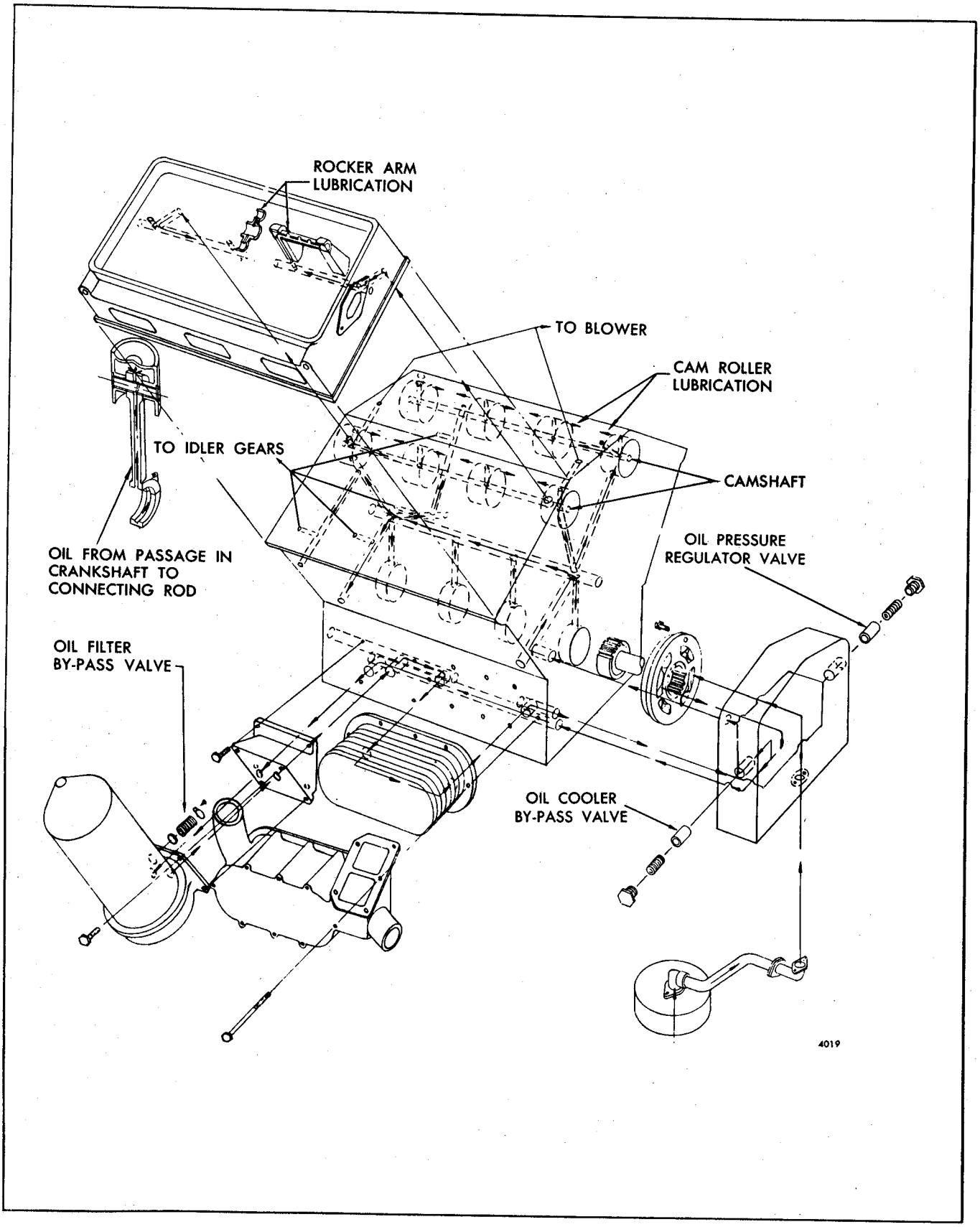


Fig. 16 - Schematic Diagram for 6V-53 Lubricating System

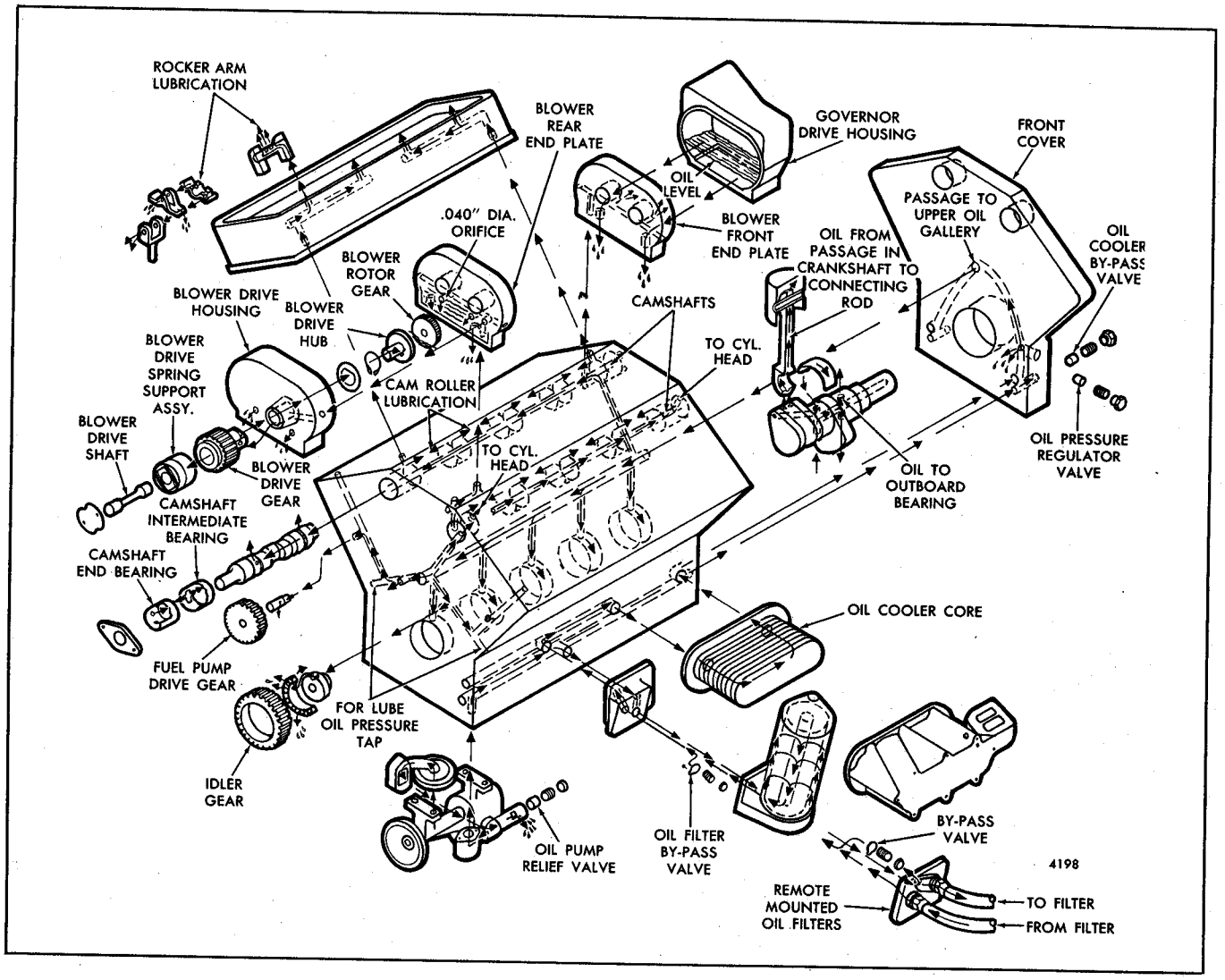


Fig. 17 - Schematic Diagram of Typical 8V Engine Lubrication System

COOLING SYSTEM

One of three different types of cooling systems are used on a Series 53 engine: radiator and fan, heat exchanger and raw water pump, and keel cooling. A centrifugal type water pump is used to circulate the engine coolant in each system. Each system incorporates thermostats to maintain a normal operating temperature of 160°-185°F. Typical engine cooling systems are shown in Figs. 18 and 19.

Radiator and Fan Cooling

The engine coolant is drawn from the bottom of the radiator core by the water pump and is forced through the oil cooler and into the cylinder block. The coolant circulates up through the cylinder block into the cylinder head, then to the water manifold and thermostat housing. From the thermostat housing, the coolant returns to the radiator where it passes down a series of tubes and is cooled by the air stream created by the fan.

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

Heat Exchanger Cooling

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

While passing through the core of the heat exchanger, the coolant temperature is lowered by raw

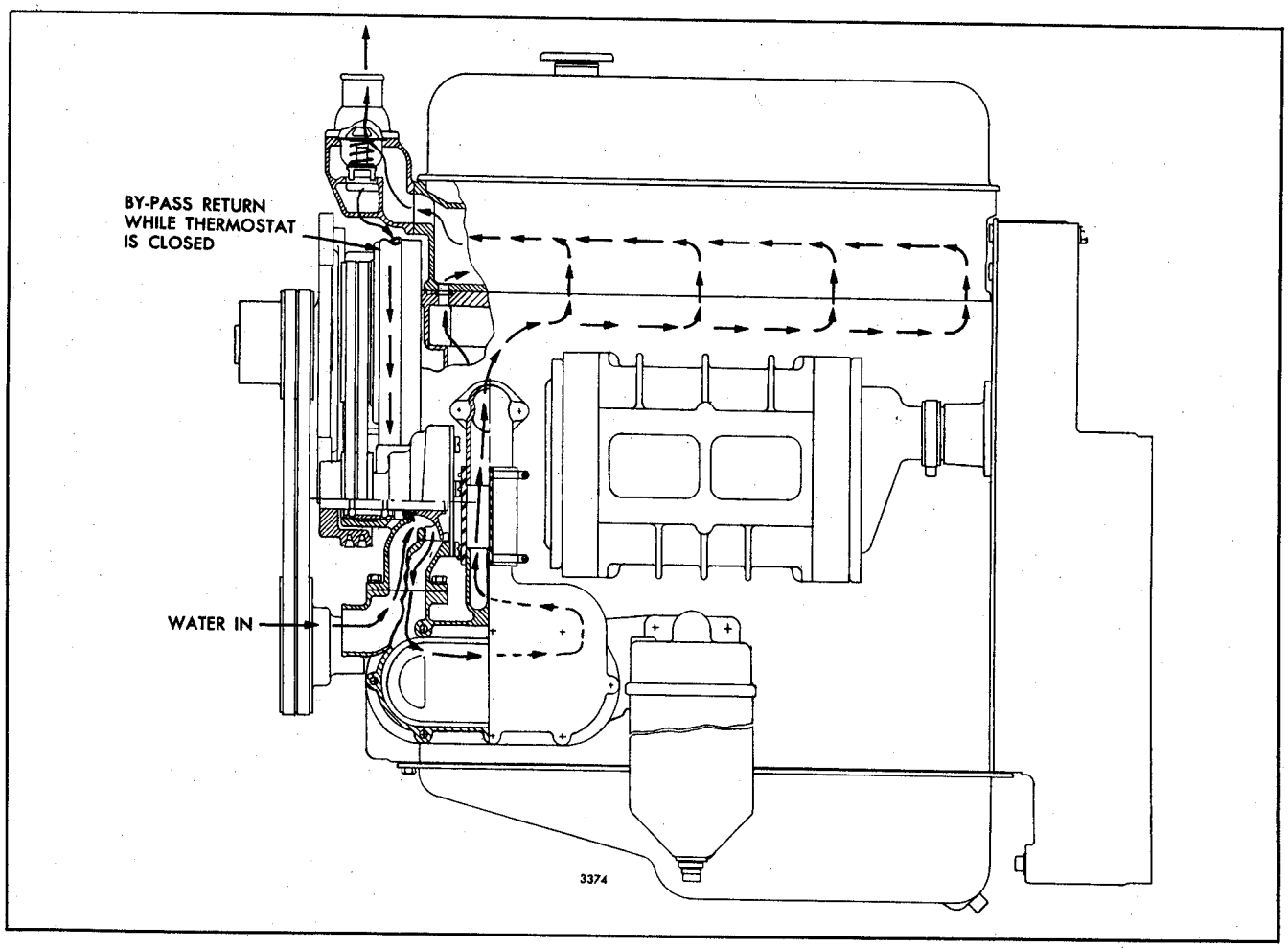


Fig. 18 - Typical Cooling System for In-Line Engine

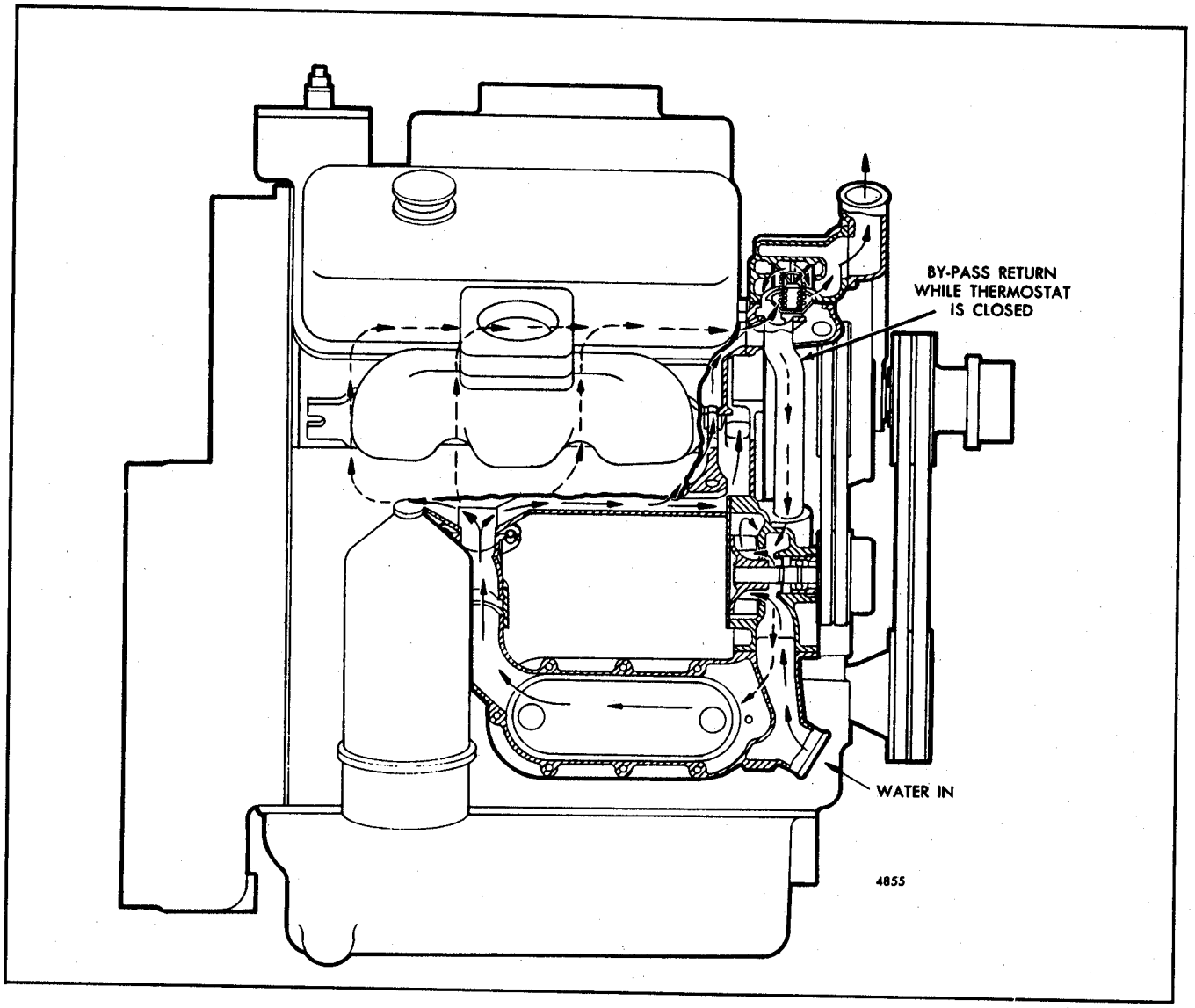


Fig. 19 - Typical Cooling System for V-Type Engine

water, which is drawn by the raw water pump from an outside supply. The raw water enters the heat exchanger at one side and is discharged at the opposite side.

To protect the heat exchanger element from electrolytic action, a zinc electrode is located in both the heat exchanger inlet elbow and the raw water pump inlet elbow and extends into the raw water passage.

The length of time a heat exchanger will function satisfactorily before cleaning will be governed by the kind of coolant used in the engine and the kind of raw water used. Soft water plus rust inhibitor or high boiling point type antifreeze should be used as the engine coolant.

When foreign deposits accumulate in the heat exchanger, to the extent that cooling efficiency is impaired, such deposits can, in most instances, be removed by circulating a flushing compound through the fresh water circulating system without removing the heat exchanger. If this treatment does not restore the engine's normal cooling characteristics, contact an authorized Detroit Diesel Service Outlet.

Keel Cooling

The keel cooling system is similar to the heat exchanger system, except that the coolant temperature is reduced in the keel cooler. In this system, the coolant is drawn by the circulating pump from the bottom of the expansion tank through the engine oil cooler. From the cooler the flow is the same as

in the other systems. Upon leaving the thermostat housing, the coolant is by-passed directly to the bottom of the expansion tank until the engine operating temperature, controlled by the thermostat, is reached. As the engine temperature increases, the coolant is directed to the keel cooler, where the temperature of the coolant is reduced before flowing back to the expansion tank.

Cooling System Capacity

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

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

To obtain the complete amount of coolant in the cooling system of a unit the additional capacity of the radiator, hoses, etc. must be added to the capacity of the basic engine. The capacity of radiators and related equipment should be obtained from the equipment supplier.

Corrosion Inhibitor

A soluble oil type corrosion inhibitor should be added to the water in the cooling system during the summer. Corrosion inhibitors coat the metal surfaces within the water jackets with a thin film which prevents the oxygen in the water or in the system from coming in contact with the surfaces and forming rust.

When a soluble oil type corrosion inhibitor is used, its quantity should not exceed 1% of the total cooling system water capacity. Should a loss of coolant develop as a result of a leak, a proper proportion of inhibitor must be mixed with water before adding the make-up solution to the coolant in the system to prevent any lowering of the concentration. However, if water in the cooling system boils off, the concentration of inhibitor will become too great and a possibility of thickening or congealing may occur. In this case, only water must be added to the cooling system to reduce the concentration to normal.

Water filters, available with summer and winter type elements, remove dirt or other gritty substances in the cooling system. They also inhibit scale deposit and rust formation and reduce electrolytic action between dissimilar metals. When a permanent type antifreeze containing a corrosion inhibitor is used in cold weather or a corrosion inhibitor is used with water in the summer a winter type filter element, which contains no inhibitor, should be installed to prevent possible reaction with the type of corrosion preventive normally used in the summer type filter element. Engines equipped with a filter and conditioner need not be flushed; however, when the cooling system is drained, the filter should be thoroughly cleaned and a new element installed. Prior to the initial installation of a cooling system filter and conditioner, the cooling system should be thoroughly cleaned and flushed, so as to start out with a clean cooling system.

Antifreeze Solutions

High boiling point type antifreeze solutions are used in diesel engines during the winter because of the high coolant temperature encountered in their operation. Alcohol base antifreeze has too low a boiling point. An alcohol base antifreeze solution protecting a unit to -20°F. would begin to boil at 180°F.; a high boiling point type ethylene glycol antifreeze solution protecting a unit to -20°F. would begin to boil at 223°F.

Most high boiling point type antifreeze solutions include a corrosion inhibitor which will protect the cooling system through the winter season. No additives should be added to a system that is protected by this antifreeze solution. In the spring, the antifreeze solution should be drained and discarded.

The use of glycol ether antifreeze solutions should be approached with some caution. Before adding a glycol ether antifreeze solution to an engine that has been in service for a time, the entire cooling system should be drained and flushed with clean water and chemically cleaned, making sure to follow the cleaner manufacturer's instructions closely.

> **NOTE:** The corrosion inhibitor in a used antifreeze solution will not be of sufficient strength to protect the system from corrosion the following winter. The addition of a corrosion inhibitor to an antifreeze solution to permit reuse could cause a reaction within the solution. A precipitation could result and clog the cooling passages, necessitating extensive engine and radiator cleaning.

If the engine is protected by a water filter and conditioner, a winter element must be installed if a permanent antifreeze solution is to be used in the cooling system. The winter filter element contains no corrosion inhibitor and must not be used in the summer. The Perry winter water filter and conditioner element is identified by the letters PAF ("Permanent Antifreeze").

Each time the filter element is changed, buff the lower corrosion resistor plate until it is bright. This plate will periodically pit and erode to the extent that replacement will be necessary.

Flushing

The cooling system should be flushed each spring and fall. The flushing operation cleans the system of antifreeze solution in the spring and removes the summer rust inhibitor in the fall, preparing the cooling system for a new solution. The flushing operation should be performed as follows:

1. Drain the previous season's solution from the engine.
2. Refill the cooling system with soft clean water. If the engine is hot, fill slowly to prevent rapid cooling and distortion of the engine castings.
3. Start the engine and operate it for 15 minutes to circulate the water thoroughly.
4. Drain the cooling system completely.
5. Refill the system with the solution required for the coming season.

Cooling System Cleaners

If the engine overheats and the fan belt tension and water level are satisfactory, it will be necessary to clean and flush the entire cooling system. Scale formation should be removed by using a quality descaling solvent. Immediately after using the solvent, neutralize the system with the neutralizer. It is important that the directions printed on the container of the descaling solvent be thoroughly read and followed.

After the solvent and neutralizer have been used, completely drain the engine and radiator and flush with clean water. Then, fill the system with the coming season's cooling solution.

> **CAUTION:** Whenever water is added to a hot engine, it must be done slowly to avoid distortion and possible cracking of engine castings, resulting from too rapid cooling.

Water Softener

The use of clean soft water in the cooling system will eliminate the need for using a descaling solution. Hard mineral laden water should be made soft by using water softener chemicals before it is poured into the cooling system. These water softeners modify the minerals in the water and greatly reduce or eliminate the formation of scale.

A clean cooling system will reduce engine wear and increase the satisfactory engine operating time between engine overhauls. Thus, when operating within the proper engine temperature range and not exceeding the recommended horsepower output of the engine, all engine parts will be within the normal operating temperature range and at the proper operating clearances.

Drain Cooling System

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

Drain cocks or plugs are located on each side of the 4, 6V and 8V-53 cylinder blocks. The 2 and 3-53 cylinder blocks have a drain cock or plug located on the side of the block opposite the oil cooler.

> **IMPORTANT:** Drain cocks or plugs on both sides of the engine must be opened to drain the engine completely.

In addition to the drains on the cylinder blocks, the In-line engines have a drain cock located on the bottom of the oil cooler housing. The V-type engines have two drain cocks that must be opened when draining the system. Radiators, etc., that do not have a drain cock, are drained through the oil cooler housing drain.

To insure 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 cooling system.

The exhaust manifolds of marine engines are cooled by the same coolant used in the engine. Whenever the engine cooling system is drained, each exhaust manifold drain cock, located on the bottom near the exhaust outlet, must be opened.

Raw water pumps are drained by loosening the cover attaching screws. It may be necessary to tap the raw water pump cover gently to loosen it. After the water has been removed tighten the screws.

Before starting an engine fill the cooling system completely. If the unit has a raw water pump it should also be primed, since operation without water may cause impeller failure.

Fresh Water Pump

A centrifugal-type fresh water pump is mounted on top of the engine oil cooler housing, either on the right-hand or left-hand side of the engine, depending upon the engine model and rotation. It circulates the coolant through the oil cooler, cylinder block, cylinder head(s) and either a heat exchanger or a radiator.

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

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

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

Contact an authorized Detroit Diesel Service Outlet if more information is needed.

Raw Water Pump

The raw water pump (Figs. 20 and 21) is a positive displacement pump, used for circulating raw water through the heat exchanger to lower the temperature of the engine coolant. It is driven by a coupling from the end of the camshaft.

Seal failure is readily noticed by a flow of water visible at the openings in the raw water pump housing, located between the pump mounting flange and the inlet and outlet ports. These openings must remain open at all times.

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

1. Remove the cover and gasket.

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

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

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

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

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

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

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

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

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

   b. Place the seal ring securely in the ferrule, and with the carbon seal and washer correctly positioned against the ferrule, slide the ferrule over the shaft and against the seal seat. Use care to ensure the seal ring

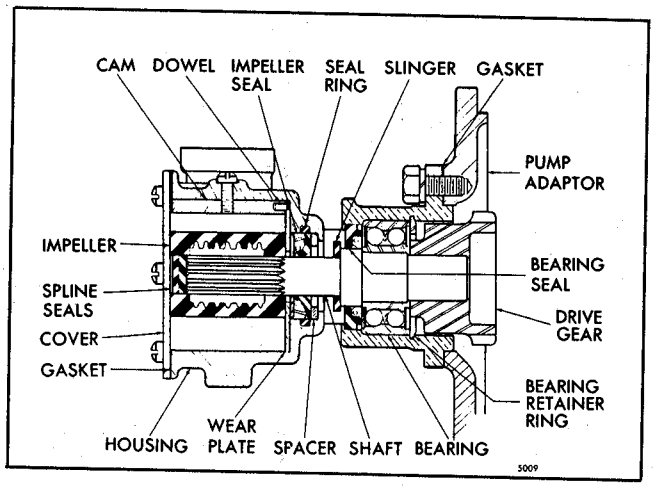


Fig. 20 - Raw Water Pump used on In-Line Engine

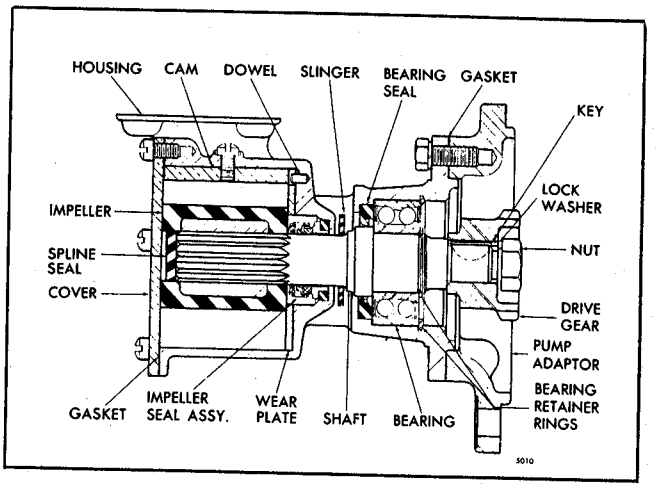


Fig. 21 - Raw Water Pump used on V-Type Engine

is contained within the ferrule so that it grips the shaft.

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

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

7. Install the cam and wear plate assembly.

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

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

9. Compress the impeller blades to clear the offset cam and press the impeller on the splined shaft. The blades must be correctly positioned to follow the direction of rotation.

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

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

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

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

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

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

ENGINE EQUIPMENT

INSTRUMENT PANEL, INSTRUMENTS AND CONTROLS

The instruments generally required in the operation of a diesel engine consist of an oil pressure gage, water temperature gage, ammeter and a mechanical tachometer. Also, closely related and usually installated in the general vicinity of these instruments are certain controls consisting of an engine starter switch, an engine stop knob, an emergency stop knob and, on certain applications, the engine hand throttle.

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 under Running in the Engine Operating Instructions, the unit should be stopped and the cause of low oil pressure determined and corrected before the engine is started again.

Water Temperature Gage

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

Ammeter

An ammeter is incorporated 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 charge rate to the battery. The ammeter will not show zero charge rate since the regulator voltage is set higher than the battery voltage. The small current registered prevents rapid brush wear in the battery-charging generator. If lights or other electrical equipment are connected into the circuit, the ammeter will show discharge when these items are operating and the engine speed is reduced.

Tachometer

A mechanical tachometer is driven by the engine and registers the speed of the engine in revolutions per minute (rpm).

Engine Starting Motor Switch

The engine starting motor switch is used to energize the starting motor. As soon as the engine starts, release the switch.

The starting switch is mounted on the instrument panel with the contact button extending through the front face of the panel. A nut and flat washer at the front and a lock washer, plain washer and nut at the back of the panel secure the switch in place.

The starting switch is serviced as an assembly. When occasion requires, the switch should be removed and a new switch installed.

Stop Knob

A stop knob is used on most applications to shut the engine down. When stopping an engine, the 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, the stop knob should be pulled and held until the engine stops. Pulling on the stop knob manually places the injector racks in the "no-fuel" position. The stop knob should be returned to its original position after the engine stops.

Emergency Stop Knob

In an emergency, or if after pulling the engine stop knob the engine continues to operate, the emergency stop knob may be pulled to stop the engine. The emergency stop knob, when pulled, will trip the air shut-down valve located between the air inlet housing and the blower and shut off the air supply to the engine. Lack of air will prevent further combustion of the fuel and stop the engine.

The emergency stop knob must be pushed back in after the engine stops so the air shut-down valve can be opened for restarting after the malfunction has been corrected.

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 SHUT-DOWN AND ALARM SYSTEMS

MANUAL SHUT-DOWN SYSTEM

A manually operated air shut-off valve is mounted in the air intake to enable the operator to stop the engine in the event the engine continues to operate after the governor is placed in the NO-FUEL position. The air shut-off valve is held in the open position by a latch assembly. A Bowden wire is used to enable the operator to remotely trip the latch assembly. After the engine stops, the emergency shut-down knob must be pushed all the way in and the latch assembly manually reset before restarting the engine.

AUTOMATIC MECHANICAL SHUT-DOWN SYSTEM

Some Series 53 engines use a mechanical shut-down system to stop the engine in case an abnormal condition such as high engine coolant temperature, low engine lubricating oil pressure, or engine overspeeding arises. The components of the shut-down system are schematically illustrated in Fig. 1. In this shut-down system a coolant temperature sensing valve adaptor and plug assembly is mounted on the exhaust manifold with the plug extending into the manifold. Coolant from the engine is directed through the adaptor assembly, in which the bulb of the temperature sensing valve assembly is located, to the suction side of the water pump. Oil under pressure from the engine is directed through a restricted fitting to a "T" connection. One line from the "T" is connected to the temperature sensing valve assembly and the other line leads to the oil pressure bellows. A line attached to the discharge side of the temperature valve directs any oil that passes through the valve to the engine crankcase. Oil under pressure entering the oil pressure bellows, works through the bellows against a spring, overcomes the spring tension and permits the latch to retain the air shut-down valve assembly in the open position. Should the oil pressure drop below a predetermined value, the spring in the oil pressure bellows will release the latch permitting the air shut-down valve to close, stopping the engine. The

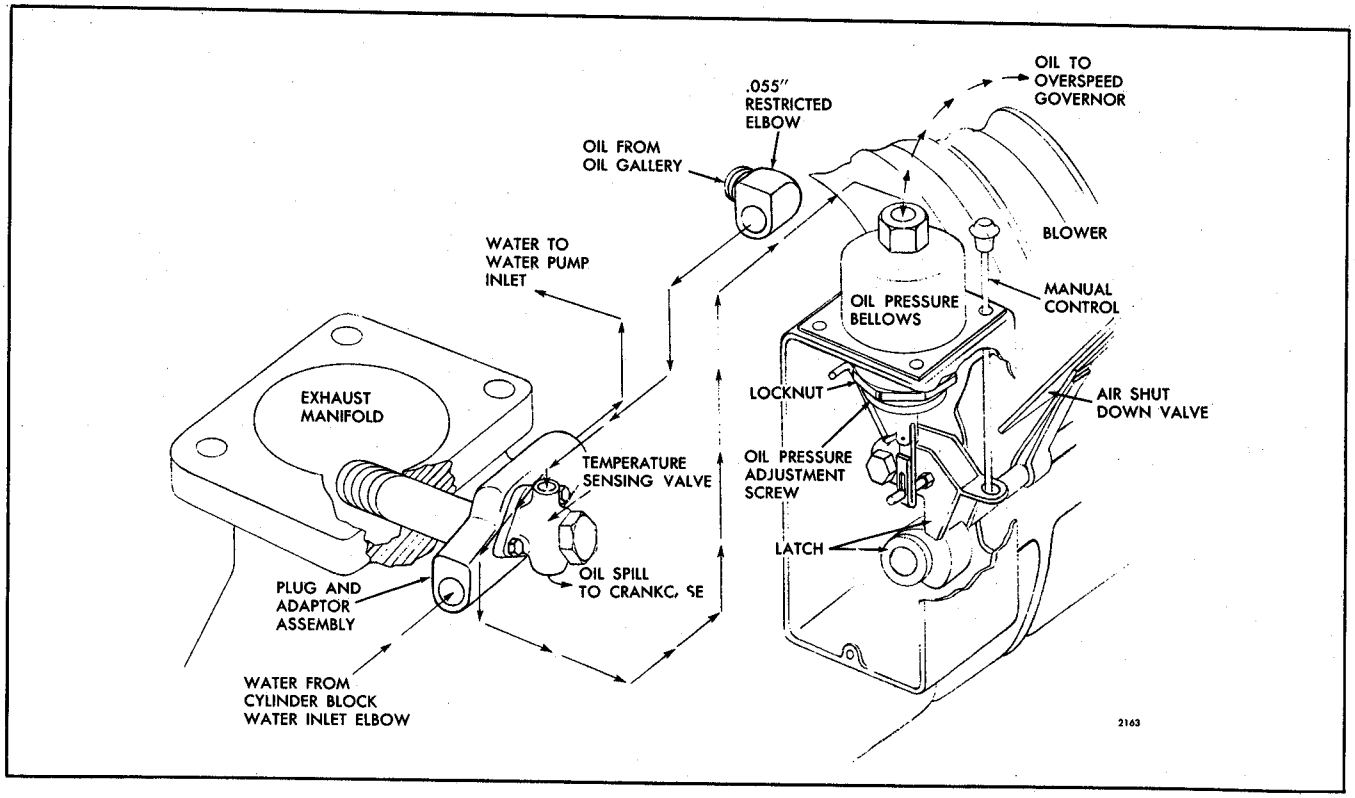


Fig. 1 - Mechanical Shut-down System Schematically Illustrated

oil pressure bellows can be adjusted to release the latch at pressures ranging from approximately 5 to 25 psi.

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

Operation

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

During operation, should the oil pressure drop below the setting of the pressure sensitive bellows, the spring within the bellows will release the latch permitting the air shut-down valve to close, stopping the engine.

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

Also, if the engine loses coolant, the plug extending into the exhaust manifold will heat up and radiate heat to the temperature sensitive valve assembly which will operate and shut the engine down.

Some Series 53 engines are equipped with an over-speed governor, in addition to the two aforementioned devices.

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

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

AUTOMATIC ELECTRICAL SHUT-DOWN SYSTEM

The automatic electrical shut-down 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 shut-down solenoid to release the air shut-down latch and stop the engine.

Operation

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

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

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

The water temperature switch consists of a temperature-sensing valve and a micro-switch. The valve contacts a copper plug (heat probe) which extends into the exhaust manifold outlet. Engine water is directed over the power element of the valve and should the water temperature exceed approximately 203°F., the valve will close the con-

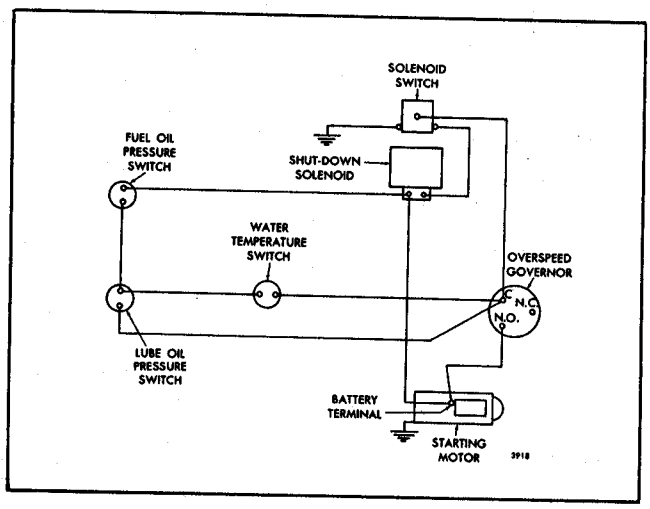


Fig. 2 - Automatic Electrical Shut-Down System Diagram

tacts in the micro-switch and energize the shut-down circuit. If a loss of water occurs, the heat of the exhaust gases will be transmitted through the copper plug to the temperature-sensing valve and cause the shut-down circuit to be activated.

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

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

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

Some engines are equipped with an electrically operated automatic shut-down system which incorporates a hot wire relay (Fig. 3).

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

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

The high water temperature switch, similar in appearance to the pressure switches, is installed in the side of the thermostat housing. The switch contacts close when the water temperature reaches approximately $205^{\circ}F$.

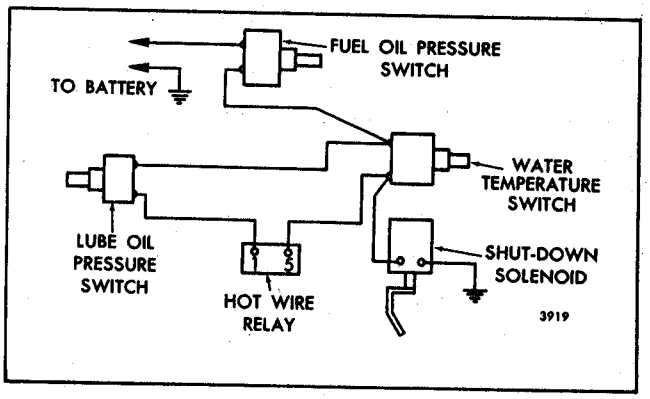


Fig. 3 - Automatic Electrical Shut-Down System Incorporating Hot Wire Relay

ALARM SYSTEM

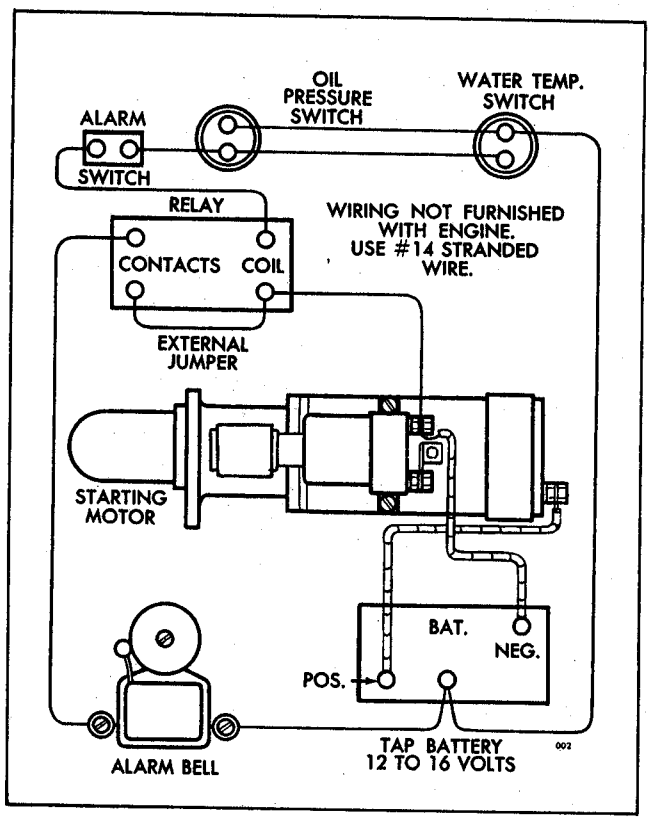


Fig. 4 - Alarm System Wiring Diagram

The alarm system shown in Fig. 4 is similar to the automatic electrical shut-down system, but uses a warning bell in place of the air shut-down valve solenoid. The bell warns the engine operator if the engine coolant overheats or the oil pressure drops below the safe operating limit.

When the engine is started and the oil pressure is sufficient to open the oil pressure switch contacts (opening pressure is stamped on the switch cover), the alarm switch must be turned on manually to put the system in operation. The water temperature switch is normally open. Should the engine coolant exceed 205 ± 5°F., the water temperature switch will close the electrical circuit and sound the alarm bell. Likewise, if the oil pressure drops below the setting of the oil pressure switch, the switch will close and cause the bell to ring. The bell will continue to ring until the engine operator turns the alarm switch off. The alarm switch must also be turned off before a routine stop since the decreasing oil pressure will close the oil pressure switch and cause the bell to ring.

If the alarm bell rings during engine operation, stop the engine immediately and determine the cause of the abnormal condition. Make the necessary corrections before starting the engine again.

GOVERNORS

Horsepower requirements of an engine may vary continually due to the fluctuating loads; therefore, some means must be provided to control the amount of fuel required to hold the engine speed reasonably constant during such load fluctuations. To accomplish this control, one of the three types of governors available are used on Series 53 engines. Installations requiring maximum and minimum speed control, together with manually controlled intermediate speeds, ordinarily use a limiting speed mechanical governor. Applications requiring a near constant engine speed, under varying load conditions, that may be changed by the operator, are equipped with a variable speed mechanical governor. The hydraulic governor is used where uniform engine speed is required under varying load conditions with a minimum speed droop.

Lubrication

The governors are lubricated by oil splash from the engine gear train. Oil entering the governor is directed by the revolving governor weights to the various moving parts requiring lubrication.

Service

Governor difficulties are usually indicated by speed variations of the engine. However, speed fluctuations are not necessarily caused by the governor and, therefore, when improper speed variations become evident, the unit should be checked for excessive load, misfiring, or bind in the governor operating linkage. If none of these conditions are contributing to faulty governor operation, contact an authorized Detroit Diesel Service Outlet.

TRANSMISSIONS

POWER TAKE-OFF

The direct drive power take-off unit is attached to either an adaptor (front power take-off) or the engine flywheel housing (rear power take-off). Each power take-off unit has a single-plate clutch. A dry-disc type clutch facing is used. The drive shaft is driven by the clutch assembly. This shaft is supported by a single-row ball bearing mounted in the flywheel or the adaptor and two tapered roller bearings mounted in the clutch housing.

Clutch Adjustment

These instructions refer to field adjustment for clutch facing wear. Frequency of adjustment depends upon the amount and nature of the load. To ensure longest facing life and best clutch performance, the clutch should be adjusted before slippage occurs.

When the clutch is properly adjusted, a heavy pressure is required at the outer end of the hand lever to move the throwout linkage to the "over center" or locked position.

Adjust the clutch as follows:

1. Disengage the clutch with the hand lever.
2. Remove the inspection hole cover to expose the clutch adjusting ring.
3. Remove the clutch adjusting ring spring lock; then, turn the clutch adjusting ring counterclockwise to tighten the clutch as shown in Fig. 5. While making this adjustment, prevent the clutch from turning by holding the clutch drive shaft.

   When the clutch is properly adjusted, the approximate pressure required at the outer end of the hand lever to engage the clutch is shown in the following table.

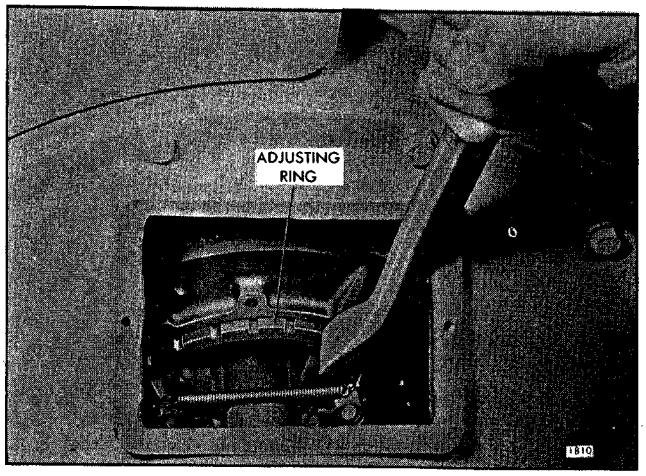


Fig. 5 - Adjusting Power Take-Off Assembly

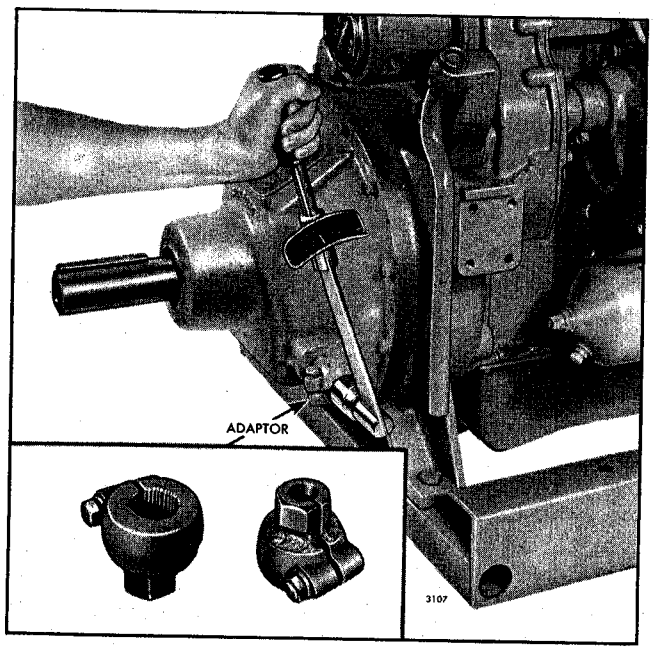


Fig. 6 - Checking Power Take-Off Clutch Adjustment with a Torque Wrench and an Adaptor

Clutch Diameter	Hand Lever Length	Pressure lbs.	Torque Wrench lb-ft
8"	15-1/2"	55	56-63
10"	15-1/2"	80	87-94
*11-1/2"	15-3/8"	100	129
11-1/2"	20"	105	112-120

*Twin Disc Clutch

A suitable spring scale may be used to check the pounds pressure required to engage the clutch.

However, the most accurate method of checking the clutch adjustment is shown in Fig. 6.

To fabricate an adaptor, saw the serrated end off a clutch hand lever; weld a nut (1-1/8" across hex) on it; then, saw a slot in the nut. See Fig. 6.

When checking the clutch adjustment with a torque wrench, engage the clutch slowly, noting the torque, just before the clutch engages (goes over center). The specified torque is shown in the table.

4. Install the clutch adjusting ring spring lock. Be sure that the ends of the spring lock register with the notches in the adjusting ring.

5. Install the inspection hole cover.

CAUTION: The thrust load on the bronze clutch release bearing should be kept at an absolute minimum. Therefore, the hand lever should be positioned on the shaft as near the 12 o'clock or 6 o'clock position as possible. The 9 and 3 o'clock positions are to be avoided.

TORQMATIC CONVERTER

A Torqmatic converter transfers and multiplies the torque of the prime mover by the action of oil within the converter. The Torqmatic converter, in addition to possessing this torque multiplying characteristic, operates as a fluid coupling. The converter transmits power from the prime mover to automotive or stationary equipment and will automatically adjust the output torque to the load requirements.

Torqmatic converters can be obtained in various combinations with the following features: automotive or industrial shaft, hydraulically operated lock-up clutch, manual input disconnect clutch, hydraulically operated output disconnect clutch, and an accessory drive for either a governor or tachometer.

The Torqmatic converter transmits or multiplies the twisting force of a diesel engine by the use of oil instead of by the use of gears. The oil level should be checked daily, also check for external oil leaks. If your model is equipped with an input disconnect clutch, additional checks or service may be necessary, either daily, or at intervals determined by the type of service in which the equipment is being used.

Input disconnect clutches should be adjusted as outlined under power take-off clutch adjustment.

Consult an authorized Detroit Diesel Service Outlet for major repairs or reconditioning of a Torqmatic converter.

WARNER MARINE GEAR

The Warner Hydraulic Marine Gear assembly consists of a hydraulically operated multiple disc clutch in combination with a hydraulically actuated reversing gear train, an oil pressure regulator, an oil sump independent of the engine oil system and an oil cooler mounted on the engine.

Oil pressure for the operation of the marine gear is provided by an oil pump incorporated within the gear housing and driven continuously while the engine is running. The oil is delivered under pressure from the pump to a combination marine gear control valve and pressure regulator valve.

The pressure regulator valve maintains constant pressure over a wide speed range and the control valve directs the oil under pressure to either the forward or reverse piston cylinder. The operating oil pressure range for the marine gear at operating speed is 120 to 140 psi and the maximum oil temperature is 225°F. Minimum oil pressure is 100 psi at idle speed (600 rpm).

Shifting from forward to reverse drive through neutral may be made at any speed; however, it is advisable to shift at low speeds, below 1000 engine rpm, to avoid damage to the engine, reverse gear or shaft.

The marine reverse and reduction gear is lubricated by pressure and splash. The quantity of oil in the marine gear will vary with the inclination of the engine and must be properly maintained to the FULL mark on the dipstick to ensure satisfactory operation.

It is recommended that vessels utilizing a marine gear have a suitable locking device or brake to prevent rotation of the propeller shaft when the vessel is not under direct propulsion. If the marine gear is not in operation and the forward motion of the vessel causes the propeller shaft to rotate, lubricating oil will not be circulated through the gear because the oil pump is not in operation. Overheating and damage to the marine gear may result unless rotation of the propeller shaft is prevented.

Consult an authorized Detroit Diesel Service Outlet for major repairs or reconditioning of the marine gear.

STARTING SYSTEMS

ELECTRICAL STARTING SYSTEM

The electrical system generally consists of a battery-charging generator, a starting motor, voltage regulator, storage battery, starter switch and the necessary wiring. Additional electrical equipment may be installed on the engine unit at the option of the owner.

Starting Motor

The starting motor used on Series 53 engines has a Sprag Overrunning Clutch. Pressing the starting switch engages the starting motor pinion with the teeth of the flywheel ring gear and energizes the starting motor. The starting motor drives the pinion and rotates the engine. When the engine begins to operate, the Sprag Clutch permits the pinion to overrun on its shaft, until the starting switch is released, and prevents overspeeding the starting motor.

Starter Switch

The starting motor switch is serviced as an assembly. When required, the entire switch should be replaced. However, be sure to check the possibility of loose connections or battery trouble before replacing the switch.

Generator

The battery-charging generator provides the electrical current for maintaining the storage battery in a charged condition and for other electrical requirements.

Regulator

A voltage regulator is introduced into the electrical system to regulate the voltage and current output of

the battery-charging generator and to maintain a fully charged storage battery.

Storage Battery

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

The battery has three major functions:

1. It provides a source of electrical power 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 of the unit exceed the output of the generator.

The battery is a perishable item which requires periodic servicing. A properly cared for battery will give long and trouble-free service.

1. Check the level of the electrolyte regularly. Add water if necessary, but do not overfill. Overfilling can cause poor performance or early failure.
2. Keep the top of the battery clean. When necessary, wash with a baking soda solution and rinse with fresh water. Do not allow the soda solution to enter the cells.
3. Inspect the cables, clamps and hold-down bracket regularly. Clean and re-apply a light coating of grease when needed. Replace corroded, damaged parts.
4. Use the standard, quick in-the-unit battery test as the regular service test to check battery condition.
5. Check the electrical system if the battery becomes discharged repeatedly.

If the unit is to be stored for more than 30 days, remove the battery. The battery should be stored in a cool, dry place. Keep the battery fully charged and check the level of the electrolyte regularly.

The Lubrication and Preventive Maintenance section of this manual covers the servicing of the starting motor and generator.

Consult an authorized Detroit Diesel Service Outlet for information regarding the electrical system.

HYDRAULIC STARTING SYSTEM (HYDROSTARTER)

The Hydrostarter System schematically illustrated in Fig. 7 is a complete hydraulic system for starting internal combustion engines. The system is automatically recharged after each start, and can be manually recharged. The starting potential remains during long periods of inactivity, and continuous exposure to hot or cold climates has no detrimental effect upon the Hydrostarter system. Also, the Hydrostarter torque for a given pressure remains substantially the same regardless of the ambient temperature.

The Hydrostarter System consists of a reservoir (95), an engine driven charging pump (120), a hand pump (55), a piston type accumulator (100), a starting motor (1) and connecting hoses and fittings.

Operation

Hydraulic fluid flows by gravity, or a slight vacuum, from the reservoir to either the engine driven pump or the hand pump inlet. Fluid discharging from either pump outlet at high pressure flows into the accumulator and is stored at 3250 psi under the pressure of compressed nitrogen gas.

When the starter is engaged with the engine flywheel ring gear and the control valve is opened, fluid under pressure is forced out of the accumulator, by the expanding nitrogen gas, and flows into the starting motor which rapidly accelerates the engine to a high cranking speed. The used fluid returns directly to the reservoir from the starter.

The engine driven charging pump runs continuously during engine operation and automatically recharges the accumulator. When the required pressure is attained in the accumulator, a valve within the pump body opens and the fluid discharged by the pump is by-passed to the reservoir. The system can be shut down and the pressure in the accumulator will be maintained.

The precharge pressure of the accumulator is the pressure of the nitrogen gas with which the accumulator is initially charged. This pressure must be checked before the system pressure is raised for the initial engine start. To check the precharge pressure, open the relief valve (73), on the side of the hand pump, approximately 1/2 turn, allow-

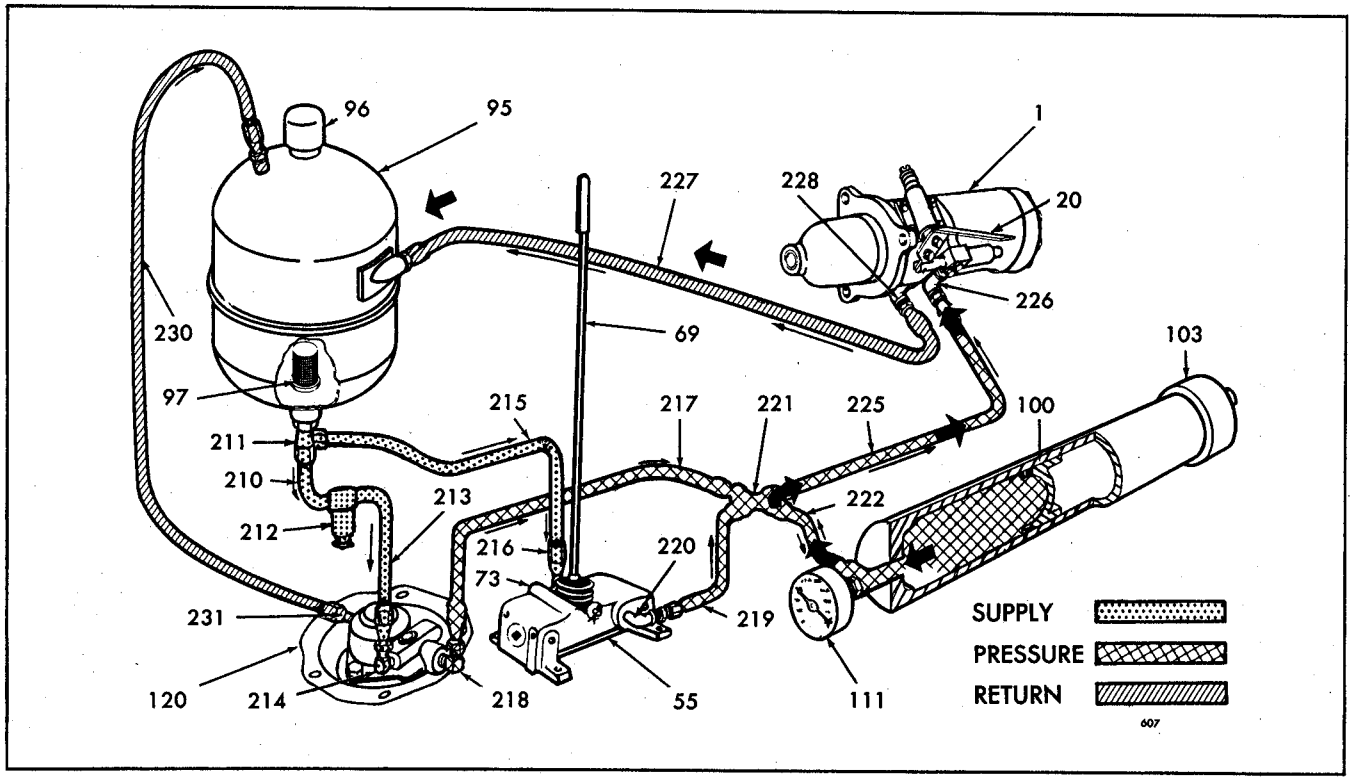


Fig. 7 - Schematic Diagram of Hydrostarter System Showing Oil Flow

1. Motor--Starting
20. Lever--Control (Handle)
55. Pump--Hand
69. Handle--Pump
73. Valve--Relief
95. Reservoir
96. Cap--Filler
97. Screen
100. Accumulator
103. Cap
111. Gage
120. Pump--Direct Engine Driven Hydrostarter Charging
210. Hose--Supply-Reservoir to Filter
211. Tee
212. Filter--Supply Hose to Engine Pump
213. Hose--Supply-Filter to Engine Pump
214. Elbow--Pump Inlet (Driven)
215. Hose--Supply-Tee to Hand Pump
216. Elbow--Pump Inlet (Hand)
217. Hose--Pressure-Engine Pump to Accumulator
218. Elbow--Pump Outlet (Driven)
219. Hose--Pressure-Hand Pump to Accumulator
220. Elbow--Pump Outlet (Hand)
221. Cross
222. Hose--Cross to Accumulator
225. Hose--Pressure-Accumulator to Starting Motor
226. Elbow--Pressure-Inlet Starting Motor
227. Hose--Return-Starter Motor to Reservoir
228. Elbow--Return-Starter Motor to Reservoir
230. Hose--Return-Engine Pump to Reservoir
231. Elbow--Return-Engine Pump to Reservoir

ing the pressure gage (111) to return to zero. Close the relief valve and pump several strokes on the hand pump. The gage should show a rapid pressure rise from zero to the nitrogen precharge pressure, where it will remain without change for several additional strokes of the pump.

Initial Engine Start

Use the hand pump (55), to raise the accumulator pressure. An accumulator pressure of 1500 psi when the ambient temperature is above 40°F. will provide adequate cranking to start the engine. Between 40°F. and 0°F., 2500 psi should be sufficient. Below 0°F., the accumulator should be charged to the maximum recommended pressure. Although the Hydrostarter cranks the engine faster than other starting systems, starting aids should be used in cold weather.

NOTE: Use the priming pump to make sure the filters, lines, manifolds, and injectors are full of fuel before attempting to start the engine.

For ambient temperatures below 40°F., use a fluid starting aid. Add the starting fluid just prior to moving the Hydrostarter lever and during the cranking cycle as required. Do not wait to add the starting fluid after the engine is turning over, otherwise the accumulator charge may be used up before the engine can start. In this case, the accumulator charge must be replaced with the hand pump.

With the engine controls set for start (throttle at least half-open), push the Hydrostarter control lever (20), to simultaneously engage the starter pinion with the flywheel ring gear and to open the control valve. Close the valve quickly when the

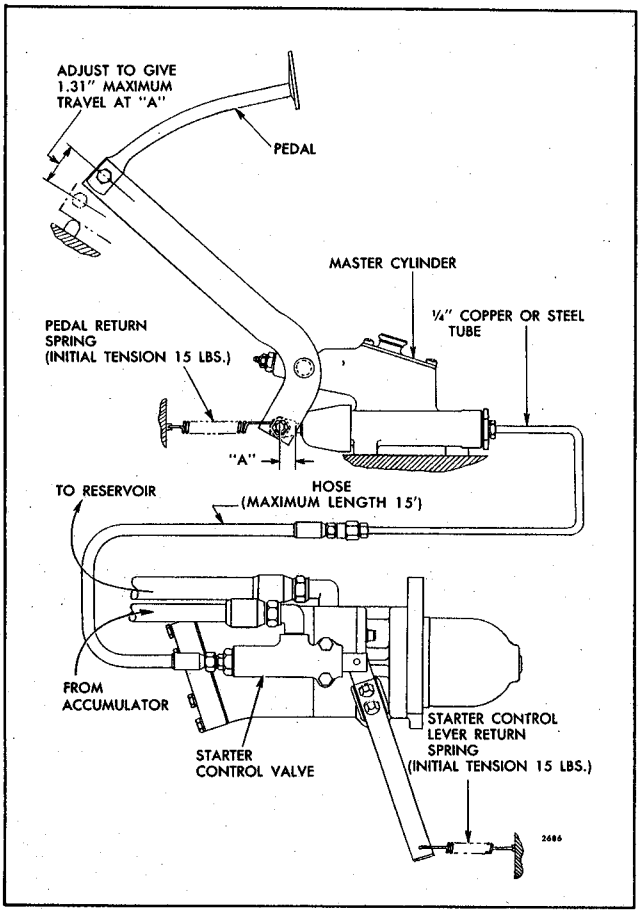


Fig. 8 - Hydrostarter Remote Control System

engine starts, to conserve the accumulator pressure and to prevent excessive overrunning of the starter drive clutch assembly.

Remote Control System

The Hydrostarter remote control system (Fig. 8) consists of a master cylinder, a pedal, a lever arm, two springs, and a flexible hose. It is an independent hydraulic system using diesel fuel oil as a hydraulic fluid to actuate the Hydrostarter control valve by means of the pedal operated master cylinder.

The master cylinder is connected to the control valve on the Hydrostarter by a flexible hose. Pressing on the pedal forces the fluid through the line to the control valve which engages the starter pinion with the engine flywheel ring gear. Release the pedal as soon as the engine starts.

Springs are used to return the master cylinder pedal and the Hydrostarter control lever to the off position.

Filling

Remove the filler cap from the reservoir and add a sufficient quantity of hydraulic fluid (a mixture of 75% diesel fuel and 25% SAE 10 or 30 lubricating oil) to fill the system.

The required amount of hydraulic fluid will vary depending upon the size of the reservoir, length of hydraulic hoses, size and number of accumulators. The reservoirs are available in 10, 12 and 16 quart capacities. In a 10 quart capacity reservoir, add approximately 8 quarts of hydraulic fluid, approximately 10 quarts in a 12 quart reservoir and approximately 14 quarts in a 16 quart reservoir.

> **NOTE:** When the accumulator is charged to 3000 psi and all hoses are filled, there should be enough hydraulic fluid remaining in the reservoir to completely cover the screen in the bottom of the reservoir.

Purging

A by-pass valve is located on the inlet side of the hand pump. Loosen the lock nut and rotate this valve approximately one turn counterclockwise with a screw driver. Operate the hand pump for 12 to 15 complete strokes. Do not pump too rapidly. Close the by-pass valve tightly and tighten lock nut.

1. Move the starter control lever to engage the pinion with the flywheel and open the control valve. While holding the lever in this position, operate the hand pump until the starter has turned several revolutions. Close the control valve. Loosen the swivel hose fitting at the discharge side of the engine driven pump about two turns. Operate the hand pump to force air out until oil begins to appear at the loose fitting. Tighten the swivel hose fitting and pressurize the system with the hand pump sufficiently to start the engine.

2. Perform the initial starting instructions under Preparation for Starting Engine First Time. Then, with the engine running at least 1500 rpm, purge the engine driven pump of air. Break the hose connection at the discharge side of the engine driven pump until a full stream of oil is discharged from the pump. Connect the hose to the pump and alternately loosen and tighten the swivel fitting on the discharge hose until the oil leaking out, when the fitting is loose, appears to be free of air bubbles. Tighten the fitting securely and observe the pressure gage. The pressure should rise rapidly to the accumulator precharge pres-

sure (1250 psi at 70°F.), then increase slowly, reaching 2900 to 3300 psi.

3. After the pressure has stabilized near 3000 psi, examine all the high pressure lines, connections and fittings for leaks.

4. The engine driven pump must by-pass oil to the reservoir when the accumulator pressure reaches 2900-3300 psi. To determine whether the pump by-pass valve is operating properly, remove the reservoir filler cap, disconnect the pump by-pass hose at the reservoir, and hold the hose over the open reservoir filler spout. An occasional spurt of oil may be emitted from the hose prior to by-passing. When the by-pass valve opens, a full and continuous stream of oil will flow from the hose. Reconnect the hose to the reservoir and install the filler cap.

5. Fill the reservoir to the proper level.

The Hydrostarter remote control system may be purged of air as follows:

1. Fill the master cylinder with fuel oil.

2. Loosen the hose fitting at the Hydrostarter control valve.

3. Actuate the master cylinder pedal until all the air is discharged from the system and a solid stream of fuel oil is being discharged with each stroke.

   NOTE: Replenish the fluid in the master cylinder as required during the purging operation.

4. Tighten the hose fitting and check for leaks.

Consult an authorized Detroit Diesel Service Outlet for any information relating to the Hydrostarter System.

COLD WEATHER STARTING AIDS

When starting an internal combustion engine in cold weather, a large part of the energy of combustion is absorbed by the pistons, cylinder walls, engine coolant, and in overcoming friction.

In the diesel engine, air alone is compressed in the cylinder; then, after the air has been compressed, a charge of fuel is sprayed into the cylinder and ignited by the heat of compression. This temperature becomes high enough under ordinary operating conditions, but may not be sufficiently high at extremely low outside temperatures to ignite the fuel charge.

Fluid Starting Aid

The fluid starting aid, illustrated in Fig. 9, is designed to inject a highly volatile fluid into the air intake system at low ambient temperatures to assist in igniting the fuel oil injected. The fluid is contained in suitable capsules to facilitate handling.

The starting aid consists of a cylindrical capsule container with a screw cap, inside of which a sliding piercing shaft operates. A tube leads from the capsule container to a hand operated pump and another tube leads to the atomizing nozzle threaded into a tapped hole in the air inlet housing.

The capsule container should be mounted in a vertical position and away from any heat.

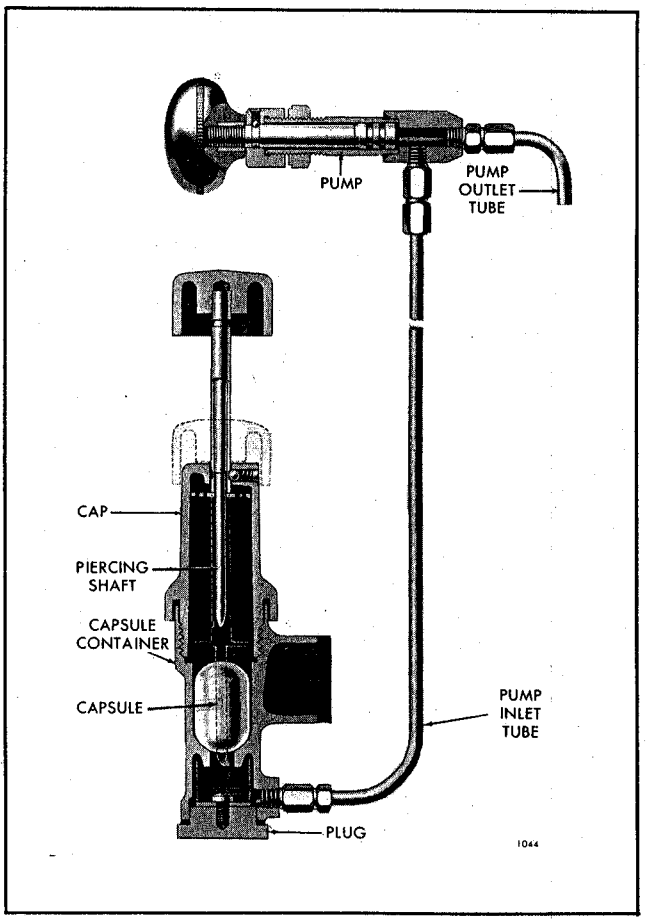


Fig. 9 - Typical Fluid Starting Aid

The fluid starting aid may be operated as follows:

1. Remove the threaded cap and insert a fluid capsule in an upright position within the container.

   CAUTION: The starting fluid is toxic and inflammable. Use caution when handling.

2. Pull the piercing shaft all the way out and install and tighten the cap on the container.

3. Push the piercing shaft all the way down. This will rupture the capsule and fill the container with the starting fluid.

4. Move the engine throttle to the maximum speed position.

5. Engage the starter and at the same time pull the pump plunger all the way out. Push the plunger in slowly forcing the starting fluid through the atomizing nozzle into the air intake. Continue to push the pump in until the engine starts. If the plunger is not all the way in when the engine starts, push it in slowly until it locks in the IN position.

6. Unscrew the cap and remove the capsule. Do not leave the empty capsule in the container.

7. Replace the cap on the capsule container and make sure the piercing shaft is all the way down.

The cold weather fluid starting aid will require very little service. Replace the piston seal packing if the pump leaks. If there is an excessive resistance to pumping, the nozzle may be plugged. Remove the nozzle and clean it.

Pressurized Cylinder Starting Aid

Start the engine during cold weather, using the "Quick Start" starting aid system (Fig. 10) as follows:

1. Press the engine starter button.

2. Pull out the "Quick Start" knob for one or two seconds, then release it.

3. Repeat the procedure if the engine does not start on the first attempt.

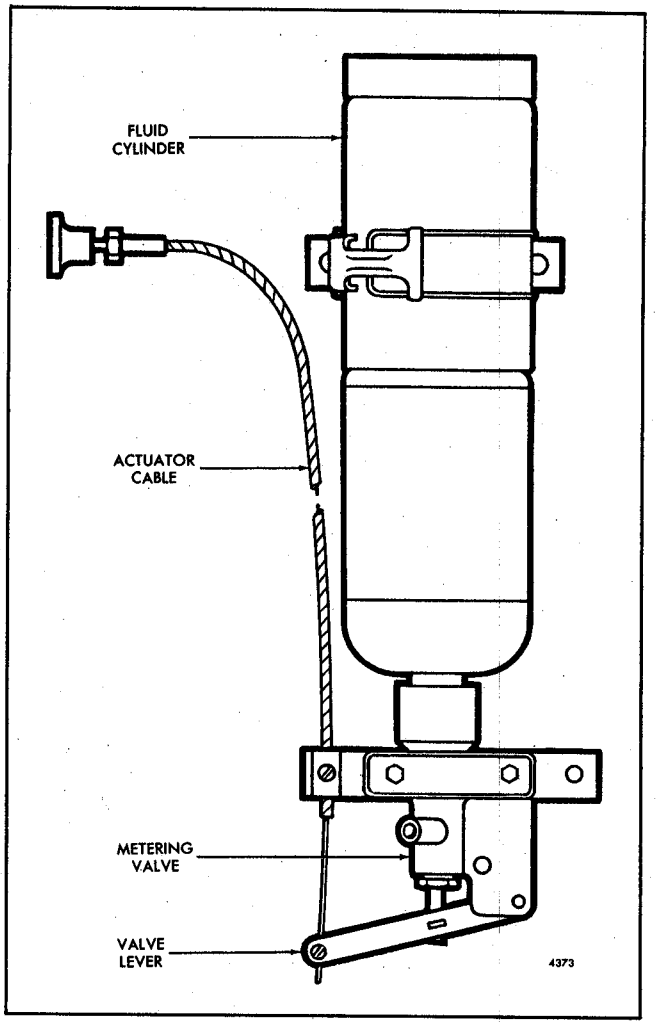


Fig. 10 - "Quick Start" Assembly

CAUTION: Do not crank the engine more than 30 seconds at a time when using an electric starting motor. Always allow one minute intervals between cranking attempts to allow the starting motor to cool.

Periodically perform the following service items to assure good performance:

1. Remove the fluid cylinder and lubricate the valve around the pusher pin under the gasket with a few drops of oil.

2. Lubricate the actuator cable.

3. Actuate the valve with the cable to distribute the oil on the cable and allow the oil to run down through the valve.

4. Remove any dirt from the orifice by removing the air inlet housing fitting, the orifice block and the screen and then blow air through the orifice end only.

5. Assemble and tighten the air inlet housing fitting to the actuator valve and tube.

6. Check for leakage of fluid (fogging) on the outside of the engine air inlet housing by actuating the starting aid while the engine is stopped. If fogging occurs, disassemble and retighten the air inlet housing fitting to the housing.

   CAUTION: Do not actuate the starting aid more than once with the engine stopped. OVER-LOADING THE ENGINE AIR BOX WITH THIS HIGH VOLATILE FLUID COULD RESULT IN A MINOR EXPLOSION.

7. Check the fluid cylinder for hand tightness.

OPERATING INSTRUCTIONS

ENGINE OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME

The operator should read and follow these instructions before attempting to start the engine.

> **NOTE:** When preparing to start a new or overhauled engine or an engine which has been in storage, perform all of the operations listed below. Before a routine start (at each shift), see Daily Operations in the Lubrication and Preventive Maintenance Chart.

Air Cleaner

If the engine is equipped with oil bath air cleaner(s) fill the air cleaner oil cup to the proper level with engine lubricating oil. DO NOT OVERFILL.

Cooling System

Install all the drain cocks in the cooling system. Drain cocks are removed for shipping.

Open the cooling system vents, if unit is so equipped.

Remove the filler cap and fill the cooling system with clean, soft water or a protective solution consisting of high boiling point antifreeze if the engine will be exposed to freezing temperatures. Keep the liquid level about 2 inches below the filler neck to allow for fluid expansion.

Use a quality rust inhibitor if water only is used in the cooling system.

Close the cooling system vents after filling.

On a marine engine, prime the raw water pump by removing the priming cap on the outlet elbow and filling the pump with water to the level of the outlet elbow flange. Open the sea cocks in the raw water system.

Lubrication System

The lubricating oil on the upper parts of new or overhauled engines, and engines which have been in storage, may not be enough when the engine is started. It is recommended that the upper engine parts be prelubricated by removing the valve rocker cover and pouring approximately two quarts of the same oil used in the crankcase over the rocker arms and push rods.

Fill the engine crankcase to the proper level with the heavy duty lubricating oil specified under Lubricating Oil Specifications.

Check the oil level in the crankcase with the dipstick on the side of the engine. Remove the dipstick, wipe the lower end with a clean cloth, insert and remove it again to check the oil level. Keep the oil at the proper level.

Turbocharger

Disconnect the turbocharger oil inlet line and pump clean engine oil into the turbocharger, thus making sure the bearings are oiled for the initial start.

Transmission

Fill the hydraulic marine gear, Torqmatic Converter or reduction gear to the proper level with the lubricant specified under Lubrication and Preventive Maintenance.

Fuel System

Fill the fuel tank with the fuel specified under Diesel Fuel Oil Specifications.

If the unit is equipped with a fuel valve, it must be opened.

To ensure prompt starting, the fuel system between the pump and the fuel return manifold should be filled with fuel. If the engine has been out of service for a considerable length of time the filter between the fuel pump and the injectors should be primed. The filter may be primed by removing the plug in the top of the filter cover and slowly filling the filter with fuel.

In addition to the above, on an engine equipped with a Hydrostarter, use a priming pump to make sure fuel lines, manifolds, and injectors are full of fuel before attempting to start the engine.

> **NOTE:** The fuel system of a new engine is filled with fuel before leaving the factory. If the fuel is still in the system when preparing to start the engine, priming should be unnecessary.

Lubrication Fittings

Fill all the grease cups and lubricate at all fittings with all purpose grease. Apply lubricating oil to

the throttle linkage and other moving parts and fill the hinged cap oilers with a hand oiler.

Drive Belts

Adjust all drive belts as recommended under Lubrication and Preventive Maintenance.

Storage Battery

Check the battery; the top should be clean and dry, the terminals tight and protected with a coat of petroleum jelly and the electrolyte must be at the proper level.

> **NOTE:** When necessary, check the battery with a hydrometer; the reading should be 1.265 or higher. However, hydrometer readings should always be corrected for the temperature of the electrolyte.

Clutch

Disengage the clutch, if the unit is so equipped.

Generator Set

A generator set should be connected and grounded in accordance with the applicable local electrical codes.

The instructions for connecting the load terminals are contained in the generator connection diagram or control cabinet wiring diagram.

> **CAUTION:** The base of a generator set must be grounded.

STARTING

Before starting the unit for the first time, perform the operations listed under Preparation For Starting Engine First Time.

Before a routine start, see Daily Operations in the Lubrication and Preventive Maintenance Chart.

If a manual or an automatic shut-down system is incorporated in the unit, the control must be set in the open position before starting the engine.

The engine will require the use of a cold weather starting aid if the ambient temperature is below 40°F. Refer to Cold Weather Starting Aids.

Initial Engine Start (Electric)

Start an engine equipped with an electric starting motor as follows: Set the throttle in the IDLE position. Press the starting motor switch firmly. If the engine fails to start within 30 seconds, release the starting switch and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

> **CAUTION:** To prevent serious damage to the starter, if the engine does not start, do not press the starter switch again while the starter motor is running.

Initial Engine Start (Hydrostarter)

An engine equipped with a Hydrostarter may be started as follows:

Raise the Hydrostarter accumulator pressure with the hand pump until the gage reads as indicated in the chart.

Ambient Temperature	Pressure Gage Reading
Above 40°F.	1500 psi
40°F. to 0°F.	2500 psi
Below 0°F.	3300 psi

Use the priming pump to make sure the filter, lines, manifolds and injectors are full of fuel.

Set the engine controls for starting--throttle at least half open.

Push the Hydrostarter control lever, to simultaneously engage the starter pinion with the flywheel ring gear and to open the control valve. Close the valve as soon as the engine starts, to conserve the accumulator pressure and to avoid excessive over-running of the starter drive clutch assembly.

RUNNING

Oil Pressure

Observe the oil pressure gage immediately after starting the engine. If there is no oil pressure indicated within 10 to 15 seconds, stop the engine and check the lubricating system. The minimum oil pressure should be at least 30 psi at 1800 rpm for a two-valve head engine or 2200 rpm for a four-valve head engine. The oil pressure at normal operating speed should be 40-50 psi.

Warm-Up

Run the engine at part throttle and no-load for approximately five minutes, allowing it to warm up, before applying a load. If the engine is operating a power generator, refer to the warm-up procedure for a power generator unit.

If the unit is operating in a closed room, start the room ventilating fan or open the windows, as weather conditions permit, so ample air is available for the engine.

Inspection

While the engine is running at operating temperature, check for water, fuel or lubricating oil leaks. Tighten the line connections where necessary to stop leaks.

Temperature

Normal engine coolant temperature is 160° to 185°F.

Crankcase

If the engine crankcase was refilled, stop the engine after normal operating temperature has been reached; allow the oil to drain back into the crankcase and check the oil quantity. Add oil, if necessary, to bring it to the proper level on the dipstick.

Use only the heavy-duty lubricating oils as specified under Lubricating Oil Specifications.

Clutch

Do not engage the clutch at engine speeds over 1000 rpm.

Cooling System

Remove the radiator or heat exchanger tank cap SLOWLY after the engine has reached normal operating temperature and check the engine coolant level. The coolant level should be near the top of the opening. If necessary, add clean soft water or a high boiling point type antifreeze.

Marine Gear

Check the marine gear oil pressure. The operating oil pressure range for the marine gear at operating speed is 120 to 140 psi and the minimum oil pressure is 100 psi at idle speed (600 rpm).

Avoid Unnecessary Engine Idling

During long engine idling periods, the engine coolant temperature will fall below the normal operating range. The incomplete combustion of fuel in a cold engine will cause crankcase dilution, formation of lacquer or gummy deposits on the valves, pistons and rings and rapid accumulation of sludge in the engine.

NOTE: When prolonged engine idling is necessary, maintain at least 800 rpm.

STOPPING

Throttle

Release the load and decrease the engine speed. Allow the engine to run at half speed or lower with no-load for four or five minutes before closing the throttle and stopping the engine. If the engine is operating a power generator, refer to the stopping procedure for a power generator unit.

Fuel System

If the unit is equipped with a fuel valve, close it. Fill the fuel tank; a full tank minimizes condensation.

Exhaust System

If a drain or valve is used in the exhaust line or silencer, open it to drain the condensation.

Cooling System

Drain the cooling system if it is not protected with antifreeze and freezing temperatures are expected. Leave the drains open. Open the raw water drains of a heat exchanger cooling system.

Crankcase

Check the oil level in the crankcase with the dipstick. Add oil, if necessary, to bring it to the proper level.

Marine Gear

Check and, if necessary, replenish the oil supply in the marine gear.

Clean Engine

Clean and check the engine thoroughly to make certain it will be ready for the next run.

Refer to Lubrication and Preventive Maintenance and perform all the daily maintenance operations. Also, perform the operations required for the number of hours or miles the unit has been in operation.

Make the necessary adjustments and minor repairs to correct difficulties which became apparent to the operator during the last run.

ALTERNATING CURRENT POWER GENERATOR UNIT OPERATING INSTRUCTIONS

These instructions cover the fundamental procedures for operating an alternating current power generator unit. The operator should read these instructions before attempting to operate the unit.

PREPARATION FOR STARTING

Before attempting to start a new or an overhauled engine or an engine which has been in storage, perform all of the operations listed under Preparation for Starting Engine First Time. Before a routine start see Daily Operations in the Lubrication and Preventive Maintenance Chart.

In addition to the Engine Operation Instructions, the following instructions also apply when operating an alternating current power generator unit.

1. Check the interior of the generator for dust or moisture. Blow out dust with low pressure air (25 psi maximum). If there is moisture on the interior of the generator, it must be dried before the unit is started.

2. The air shut-down valve located in the air inlet housing must be in the open or reset position.

3. Refer to Fig. 1 and place the circuit breaker in the OFF position.

4. If the unit is equipped with synchronizing lamps, place the lamp switch in the OFF position.

5. Turn the voltage regulator rheostat knob counterclockwise to its lower limit.

6. Make sure the power generator unit has been cleared of all tools or other objects which might interfere with its operation.

STARTING

If the unit is located in a closed space, start the ventilating fan or open the doors and windows, as weather permits, to supply ample air to the engine.

The engine may require the use of a cold weather starting aid if the ambient temperature is below 40°F. Refer to Cold Weather Starting Aids.

Press the throttle button and turn the throttle control (Fig. 1) counterclockwise to a position mid-

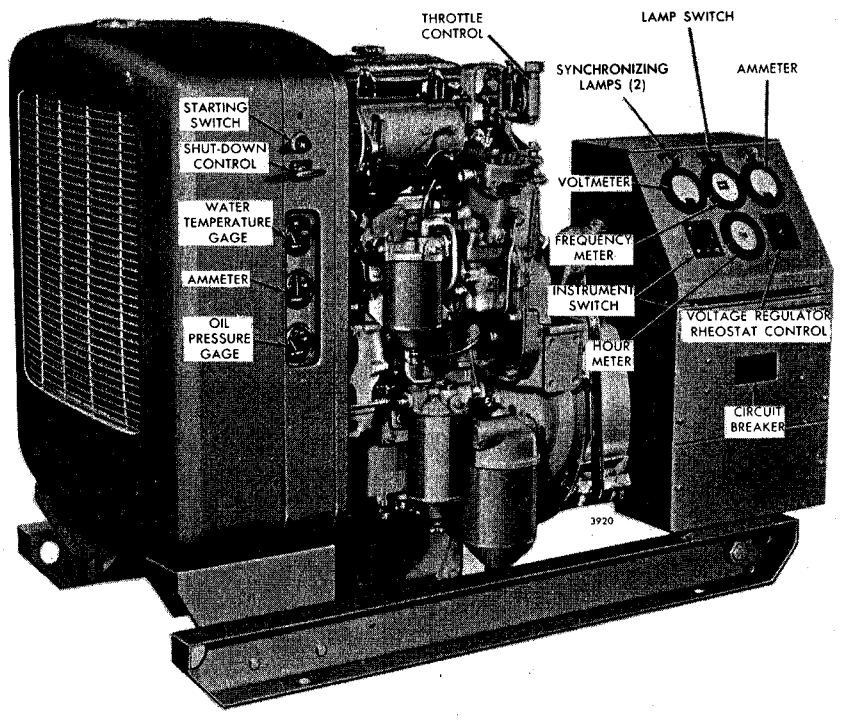


Fig. 1 - Location of Controls on Power Generator Unit

way between RUN and STOP. Then, press the starting switch firmly.

If the engine fails to start within 30 seconds, release the starting switch and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

> **CAUTION:** To prevent serious damage to the starter, if the engine does not start, do not press the starting switch again while the starter motor is rotating.

RUNNING

Oil Pressure

Observe the engine oil pressure gage immediately after starting the engine. If there is no oil pressure indicated within 10 to 15 seconds, stop the engine and check the engine lubricating system.

Warm-Up

Operate the engine at the rated speed to warm-up the engine, and then apply the load to the unit. The warm-up period may be omitted and a load applied to the unit, if circumstances require it as soon as the engine oil pressure stabilizes.

Inspection

While the engine is running at operating temperature, check for water, fuel or lubricating oil leaks. Tighten line connections where necessary to stop leaks.

Engine Crankcase

If the engine crankcase was refilled, and the power supply from the unit is not immediately needed, stop the engine, after it has been running approximately fifteen minutes. Allow approximately five minutes for the oil to drain back to the crankcase. Then, check the oil level. Add oil, if necessary, to bring it to the proper level on the dipstick.

Use only the heavy-duty lubricating oils as specified under Lubricating Oil Specifications.

Cooling System

Remove the radiator or heat exchanger tank cap SLOWLY and check the engine coolant level. The coolant level should be near the top of the opening. If necessary, add clean soft water or a high boiling point type antifreeze.

PREPARING UNIT FOR LOAD

After the engine is warmed up (or the oil pressure has stabilized) prepare the unit for load as follows:

1. Bring the engine up to the rated speed.
2. Turn the instrument switch to the desired position.
3. Turn the voltage regulator rheostat knob slowly in a clockwise direction to raise the voltage, while watching the voltmeter, until the desired voltage is attained.
4. If the power generator unit is equipped with a frequency meter, adjust the engine speed with the vernier throttle knob until the desired frequency is indicated on the meter.
5. Make sure all power lines are clear of personnel, then place the circuit breaker control in the ON position.

> **NOTE:** Perform Step 5 only if the unit is not being paralleled with an existing power source. If the unit is being paralleled with a power source already on the line, read and follow the instructions under Paralleling before turning the circuit breaker control to the ON position.

PARALLELING

If the load conditions require an additional unit to be placed on the line, the following instructions will apply to power generator units of Equal Capacity, with one unit in operation on the line.

1. Prepare the unit to be paralleled as outlined under Preparation For Starting, Starting, Running and items 1 through 4 under Preparing Unit for Load.
2. Check the voltmeter (Fig. 1); the voltage must be the same as the line voltage. Adjust the voltage regulator rheostat control if the voltages are not the same.
3. Place the synchronizing lamp switch, of the power unit to be paralleled, in the ON position.
4. Turn the vernier throttle knob until both units are operating at approximately the same frequency as indicated by the slow change in the brilliancy of the synchronizing lamps.
5. When the synchronizing lamps glow and then go out at a very slow rate, time the dark interval. Then, in the middle of this interval turn the circuit breaker control to the ON position. This places the incoming power unit on the line, with no load. The proper share of the existing load must now be placed on this unit.

6. The division of the kilowatt load between the alternating current generators operating in parallel depends on the power supplied by the engines to the generators as controlled by the engine governors and is practically independent of the generator excitation. Divide the kilowatt load between the units by turning the vernier throttle knob counterclockwise on the incoming unit and clockwise on the unit that has been carrying the load (to keep the frequency of the units constant) until both ammeters read the same, indicating that each unit is carrying its proper percentage of the total K.W. load.

7. The division of the reactive KVA load depends on the generator excitation as controlled by the voltage regulator. Divide the reactive load between the units by turning the voltage regulator rheostat control on the incoming unit (generally clockwise to raise the voltage) until the ammeters read the same on both units and the sum of the readings is minimum.

   NOTE: The units are equipped with a resistor and current transformer connected in series with the voltage coil of the regulator (cross-current compensation) which equalizes most but not all of the reactive KVA load between the generators.

8. When the load is 80 per cent power factor lagging (motor and a few lights only), turn the vernier throttle knob on the incoming unit until the ammeter on that unit reads approximately 40 per cent of the total current load.

9. Rotate the voltage regulator rheostat control on the incoming unit clockwise to raise the voltage until the ammeters read the same on both units.

   NOTE: If a load was not added during paralleling, the total of the two ammeter readings should be the same as the reading before paralleling. Readjust the voltage regulator rheostat on the incoming unit, if necessary.

10. To reset the load voltage, turn the voltage regulator rheostat controls slowly on each unit. It is necessary to turn the controls the same amount and in the same direction to keep the reactive current equally divided.

Power generator units with different capacities can also be paralleled by dividing the load proportionately to their capacity.

STOPPING

The procedure for stopping a power generator unit or taking a unit out of parallel are as follows:

1. Turn off all the load on the generator when stopping a single engine unit.

   Shift the load from the generator when taking a unit out of parallel operation by turning the vernier throttle knob (Fig. 1) until the ammeter reads approximately zero.

2. Place the circuit breaker control in the OFF position.

3. Turn the voltage regulator rheostat control in a counterclockwise direction to the limit of its travel.

4. Press the throttle button and turn the throttle control to STOP to shut-down the engine.

   NOTE: When performing a tune-up on a unit that will be operated in parallel with another unit, adjust the speed droop as specified in Engine Tune-Up.

LUBRICATION AND PREVENTIVE MAINTENANCE

To obtain the long life and the best performance from a Detroit Diesel engine, the Operator must adhere to the following schedule and instructions on lubrication and preventive maintenance.

The daily instructions pertain to routine or daily starting of a unit and not to a new unit or one that has not been operated for a considerable period of time. For new or stored units, carry out instructions given under PREPARATION FOR STARTING ENGINE FIRST TIME under OPERATING INSTRUCTIONS.

The time intervals given in the chart on the following page are actual operating hours of a unit. If the lubricating oil is drained immediately after a unit has been run for some time, most of the sediment will be in suspension and, therefore, will drain readily.

All authorized Detroit Diesel Service Outlets are prepared to service units with the viscosity and grade of lubricants recommended on the following pages.

LUBRICATION AND PREVENTIVE MAINTENANCE CHART	Time Interval								
Item Operation Hours / Miles	Daily	8 / 240	50 / 1,500	100 / 3,000	200 / 6,000	300 / 9,000	500 / 15,000	1,000 / 30,000	2,000 / 60,000
LUBRICATION SYSTEM									
1. Engine Oil	X								
2. Oil Filter *									
COOLING SYSTEM									
3. Coolant and Filter	X						X	X	
4. Hoses							X		
5. Radiator								X	
6. Heat Exchanger							X	X	
7. Raw Water Pump	X								
FUEL SYSTEM									
8. Fuel Tank	X						X		
9. Fuel Strainer & Filter	X					X			
AIR SYSTEM									
10. Air Cleaners		X			X		X		
11. Air Box Drains							X	X	
12. Crankcase Breather								X	
13. Blower Screen								X	
ELECTRICAL SYSTEM									
14. Starting Motor *									
15. Battery-Charging Generator				X	X		X		X
16. Battery				X					
MISCELLANEOUS									
17. Tachometer Drive				X					
18. Throttle Controls					X				
19. Engine Tune-Up *									
20. Fan Bearings* and Drive Belts					X				
21. Power Generator				X		X			
22. Power Take-off		X	X				X		
23. Torqmatic Converter	X		X				X		
24. Marine Gear	X				X				
25. Hydrostarter System									X
26. Air Compressor Air Strainer					X				
27. Shut-Down System						X			
28. Turbocharger	X								

*See items on following pages.

ITEM 1

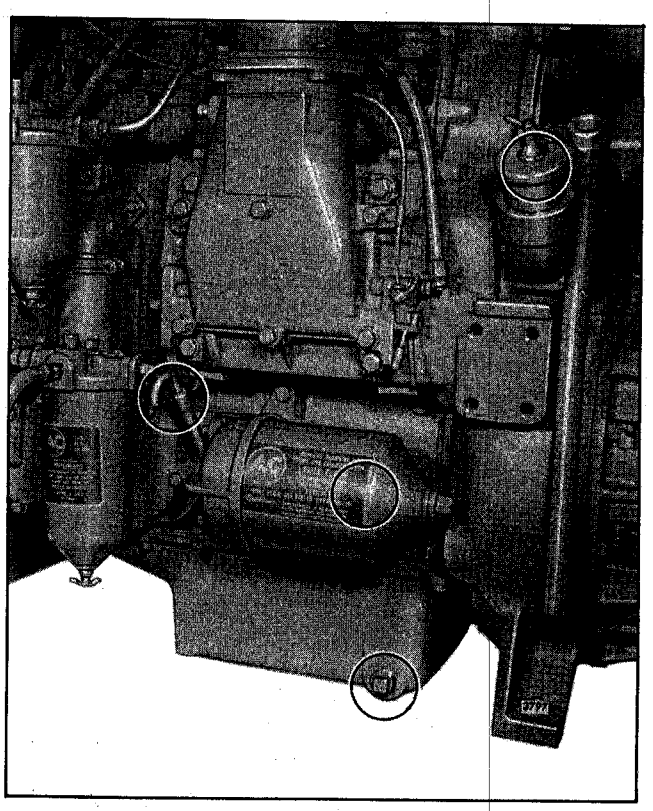
Check the oil level daily before starting the engine. Add oil, if necessary, to bring it to the proper level on the dipstick.

Select the proper grade of oil in accordance with the instructions in the Lubricating Oil Specifications.

It is recommended that new engines be started with 100 hour oil change periods. For highway vehicles, this corresponds to approximately 3,000 miles, and for city-service vehicles approximately 1,000 - 2,000 miles. The drain interval may then be gradually increased, or decreased, following the recommendations of an independent oil analysis laboratory, or oil supplier (based upon the oil sample analysis) until the most practical oil change period has been established.

ITEM 2

Install new engine oil filter elements and gaskets each time the engine oil is changed. Check for oil leaks after starting the engine. If the engine is equipped with a governor oil filter, change the element every 1,000 hours or 30,000 miles.



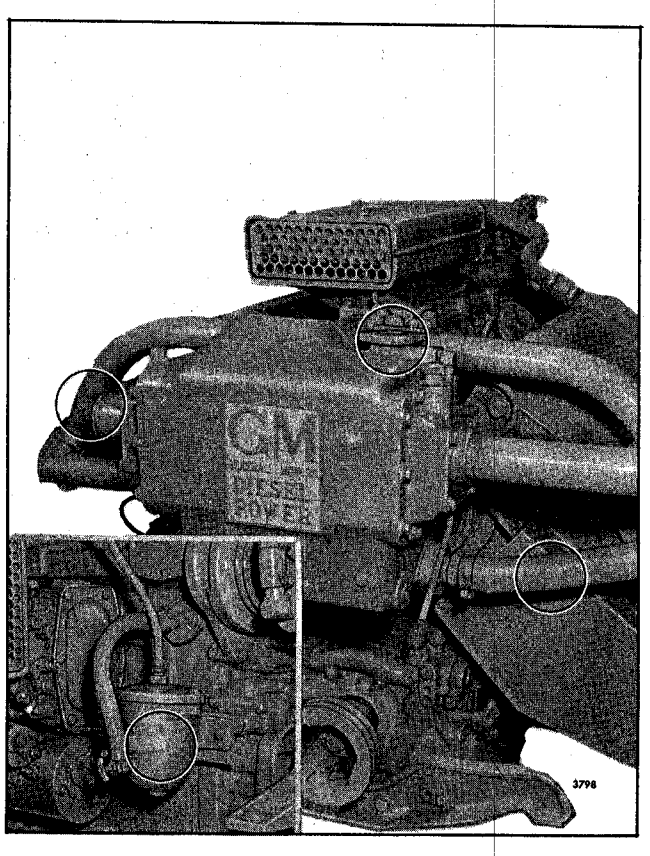
Items 1 and 2

ITEM 3

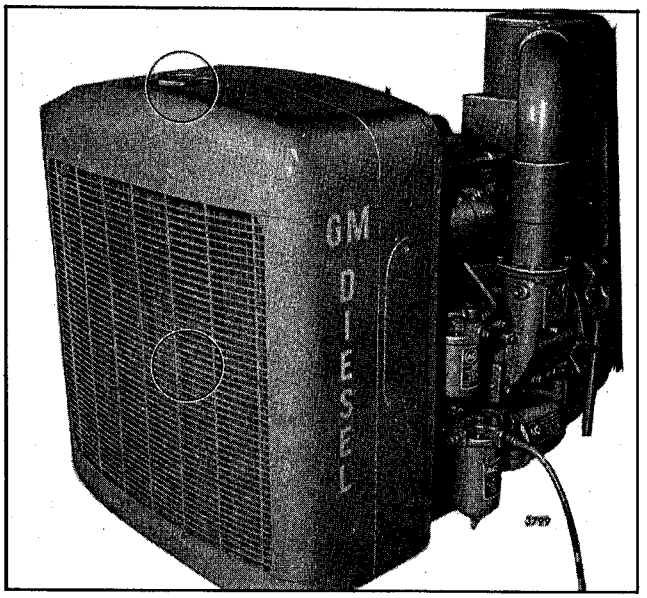
Check the coolant level daily and maintain it near the top of the heat exchanger tank or the radiator upper tank.

Clean the cooling system every 1,000 hours or 30,000 miles, using a good radiator cleaning compound in accordance with the instructions on the compound container. After cleaning, rinse the cooling system thoroughly with fresh water; then, fill the system with soft water, adding a good grade of rust inhibitor or a high boiling point type antifreeze. With the use of a proper antifreeze or rust inhibitor, this interval may be lengthened until, normally, this cleaning is done only in the spring or fall. The length of this interval will, however, depend upon an inspection for rust or other deposits on the internal walls of the cooling system. When a thorough cleaning of the cooling system is required, it should be reverse flushed.

If the engine is protected by a Perry water filter and conditioner, a winter filter element identified with the letters PAF (permanent antifreeze) must be used if a permanent antifreeze solution is to be used in the cooling system. The winter filter element contains no corrosion inhibitor and must not be used in the summer. The water filter elements (summer and winter) should be changed every 500 hours or 15,000 miles.



Items 3 and 4



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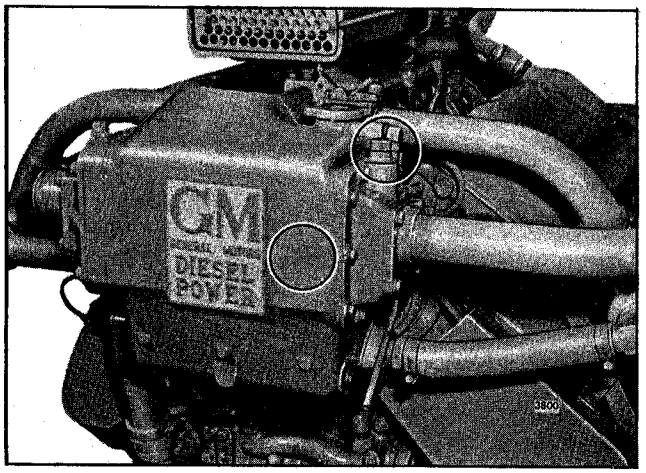

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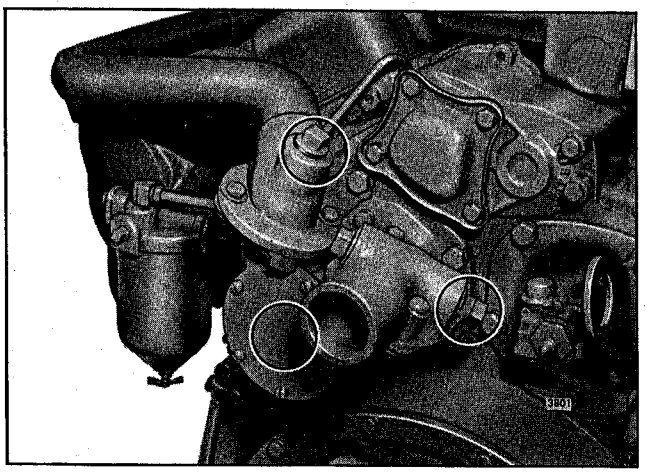


Item 7

Also, buff the lower corrosion resistor plate until it is bright each time the element is changed, or replace the plate if excessive metal loss is evident. This plate will periodically pit to the extent that it must be replaced.

ITEM 4

Inspect all of the cooling system hoses at least once every 500 hours or 15,000 miles for signs of deterioration. Replace the hoses if necessary.

ITEM 5

Inspect the exterior of the radiator core every 1,000 hours or 30,000 miles and, if necessary, clean it with a quality grease solvent such as Oleum and compressed air. It may be necessary to clean the radiator more frequently if the engine is being operated in dusty or dirty areas.

ITEM 6

Every 500 hours, drain the water from the heat exchanger raw water inlet and outlet tubes. Then, remove the zinc electrode 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.

Drain the cooling system, disconnect the raw water pipes at the outlet side of the heat exchanger and remove the retaining cover every 1,000 hours and inspect the heat exchanger core. If a considerable amount of scale or deposits are present, contact an authorized Detroit Diesel Service Outlet.

ITEM 7

Check the prime on the raw water pump; the engine should not be operated with a dry pump. Prime the raw water pump, if necessary, by removing the pipe plug provided in the pump inlet elbow and adding water.

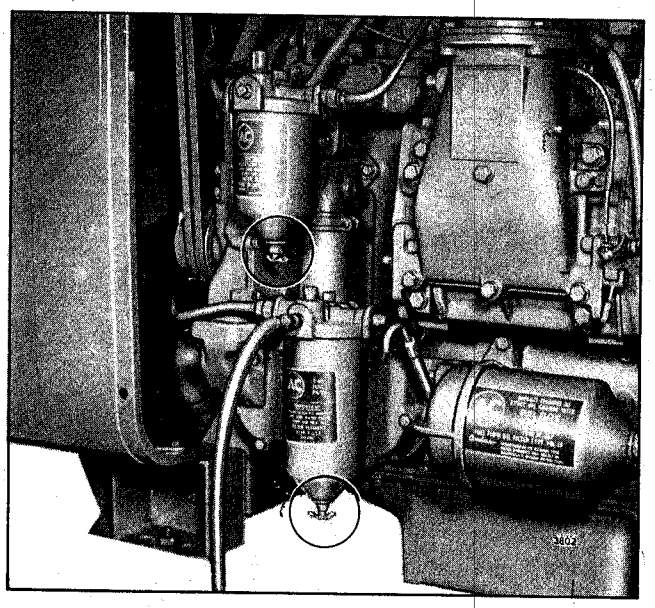
ITEM 8

Keep the fuel tank filled to minimize condensation. Select the proper grade of fuel in accordance with the Diesel Fuel Oil Specifications. Open the drain at the bottom of the fuel tank every 500 hours or 15,000 miles to drain off any water or sediment.

ITEM 9

Drain approximately one-fourth pint of fuel to remove sediment and water from the strainer and the filter daily by opening the drain cock in the bottom of each shell. Install new elements every 300 hours or 9,000 miles or when plugging is indicated.

A method of determining when elements are plugged to the extent that they should be changed, is based on the fuel pressure at the cylinder head fuel inlet manifold and the inlet restriction at the fuel pump. In a clean system, the maximum pump inlet restriction must not exceed 6 inches of mercury. At normal operating speeds (1800-2800 rpm) the fuel pressure is 45 to 70 psi. Change the fuel filter elements whenever the inlet restriction (suction) at the fuel pump reaches 12 inches of mercury at normal operating speeds (1800-2800 rpm) and whenever the fuel pressure at the inlet manifold falls to 45 psi.



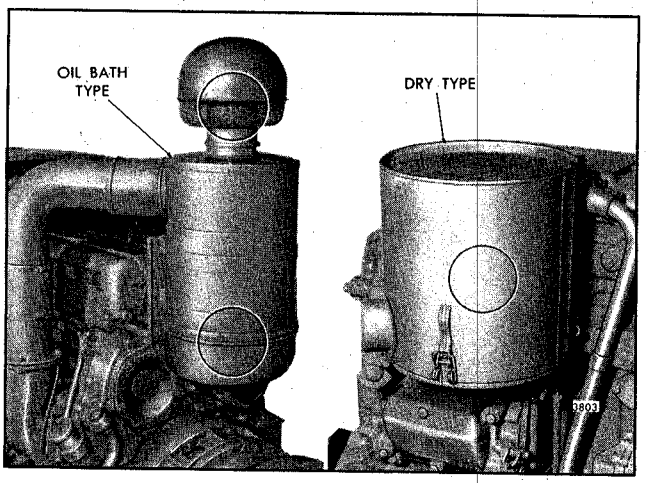
Item 9

ITEM 10

Remove the dirty oil and sludge from the air cleaner cups and center tubes every 8 hours (every 6,000 miles for highway vehicle engines), or less if operating conditions warrant. Wash the cups and elements in clean fuel oil and refill the cups to the level mark with the same grade of heavy duty oil as used in the engine. The frequency of servicing may be varied to suit local dust conditions.

It is recommended that the body and fixed element in the heavy-duty oil bath type air cleaner be serviced every 500 hours, 15,000 miles, or as conditions warrant.

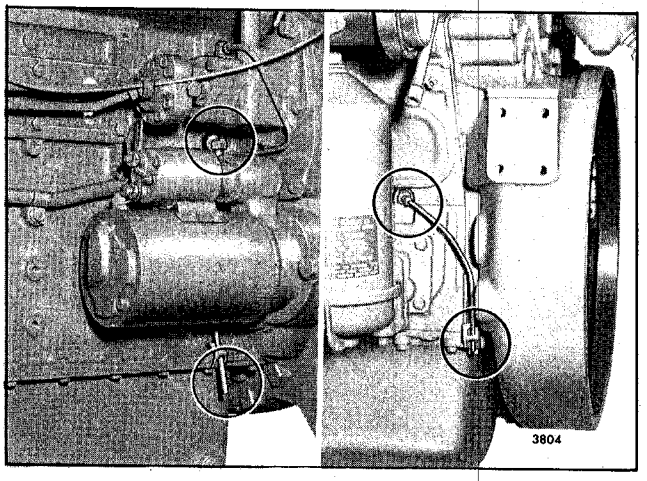
Clean or replace the element in the dry-type air cleaner when the air intake restriction reaches the maximum inches of water given in the Air Intake Restrictions chart in the Trouble Shooting section; or when indicated by an air cleaner restriction indicator. Refer to the appropriate instructions in the Air System section for servicing the dry-type air cleaner.



Item 10

ITEM 11

With the engine running, check for flow of air from the air box drain tubes every 1,000 hours or 30,000 miles. If the tubes are clogged, remove, clean, and reinstall the tubes. The air box drain tubes should be cleaned periodically even though a clogged condition is not apparent. If the engine is equipped with an air box drain tank, drain the sediment periodically. If the engine is equipped with an air box drain check valve, replace the valve every 500 hours or 15,000 miles.



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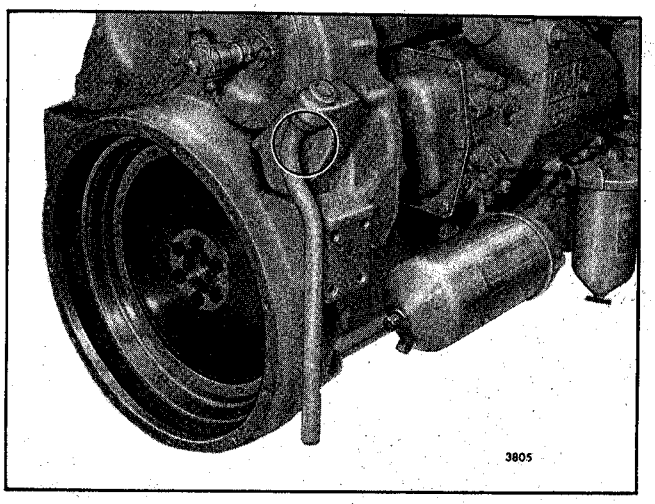

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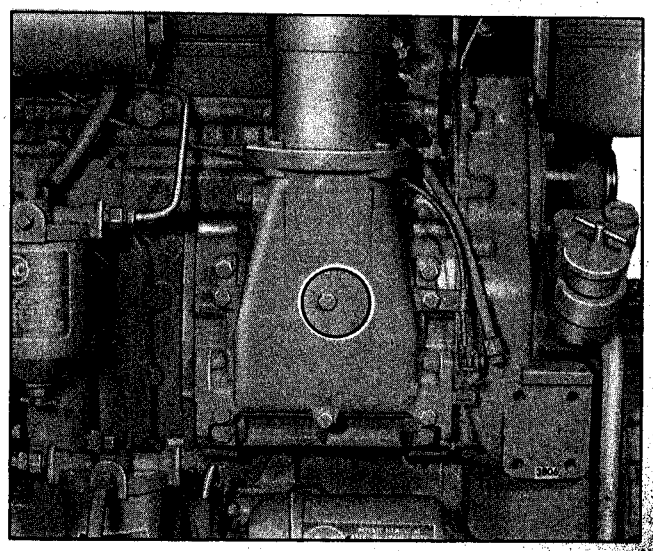

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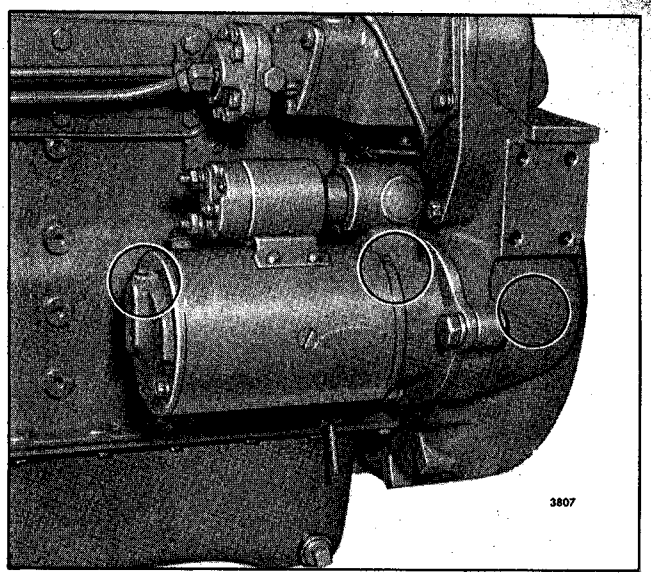


Item 14

ITEM 12

Clean the crankcase breather, if it is mounted on the flywheel housing, every 1,000 hours or 30,000 miles. Remove the crankcase breather from the engine and wash the steel mesh pad in fuel oil and dry it with compressed air. This cleaning period may be reduced or lengthened according to severity of service.

ITEM 13

Inspect the blower screen and gasket assembly every 1,000 hours or 30,000 miles and, if necessary, clean the screen in fuel oil and dry it with compressed air. Reinstall the blower screen and gasket assembly with the screen side toward the blower.

ITEM 14

The electrical starting motor is lubricated at the time of original assembly. Oil can be added to the oil wicks, which project through each bushing and contact the armature shaft, by removing the pipe plugs on the outside of the motor. The wicks should be lubricated whenever the starting motor is taken off the engine or disassembled.

The Sprag overrunning clutch drive mechanism should be lubricated with a few drops of light engine oil whenever the starting motor is overhauled.

ITEM 15

Lubricate the generator bearings or bushings with 5 or 6 drops of engine oil at the hinge cap oiler every 200 hours or 6,000 miles. Generators equipped with grease cups should have the caps turned down one full turn every 100 hours or 3,000 miles of operation. The grease cups should be kept filled with Delco-Remy Cam and Ball Bearing Lubricant or its equivalent. Care should be taken to avoid excessive lubrication since this may cause lubricant to be forced onto the commutator where it would gum and cause poor commutation. Such a condition results in reduced generator output and increased commutator and brush wear.

Some generators have a built-in supply of grease, while others use sealed bearings. In these latter two cases, additional lubrication is not necessary.

On DC generators, inspect the commutator and brushes every 500 hours or 15,000 miles. Examine the commutator and brushes every 2,000 hours or 60,000 miles and clean the commutator, if necessary, with No. 00 sandpaper or a brush seating stone. After cleaning, reseat the brushes and blow out the dust.

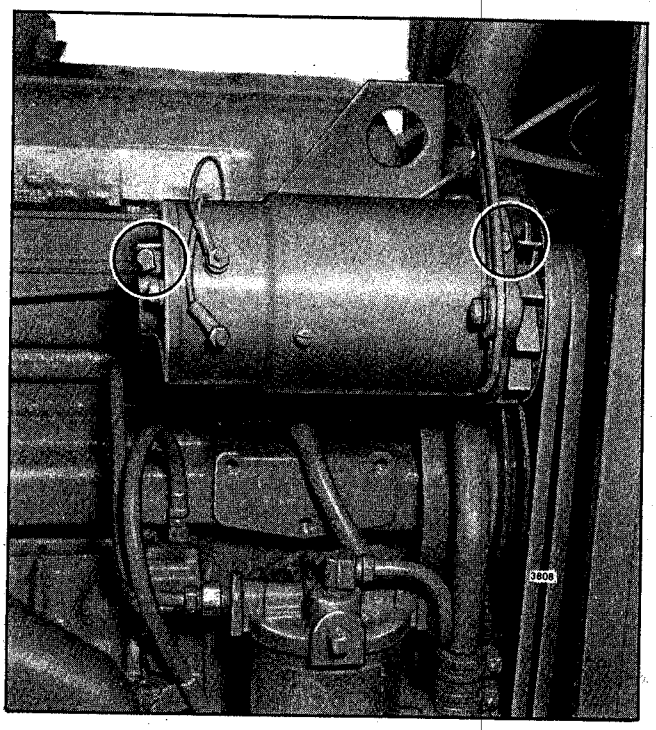
On AC generators, the slip rings and brushes can be inspected through the end frame assembly. If the slip rings are dirty, they should be cleaned with 400 grain or finer polishing cloth. Never use emery cloth to clean slip rings. Hold the polishing cloth against the slip rings with the generator in operation, and blow away all dust after the cleaning operation. If the slip rings are rough or out of round, replace them.

ITEM 16

Check the specific gravity of the electrolyte in each cell of the battery every 100 hours or 3,000 miles. In warm weather, however, it should be checked more frequently due to a more rapid loss of water from the electrolyte. The electrolyte level should be maintained in accordance with the battery manufacturer's recommendations.

ITEM 17

Lubricate the tachometer drive every 100 hours or 3,000 miles with an all purpose grease at the grease fitting. At temperatures above + 30°F., use a No. 2 grade grease. Use a No. 1 grade grease below this temperature.



Item 15

ITEM 18

Lubricate the throttle control mechanism every 200 hours or 6,000 miles with an all purpose grease. At temperatures above + 30°F., use a No. 2 grade grease. Use a No. 1 grade grease below this temperature. Lubricate all other control mechanisms as required with engine oil.

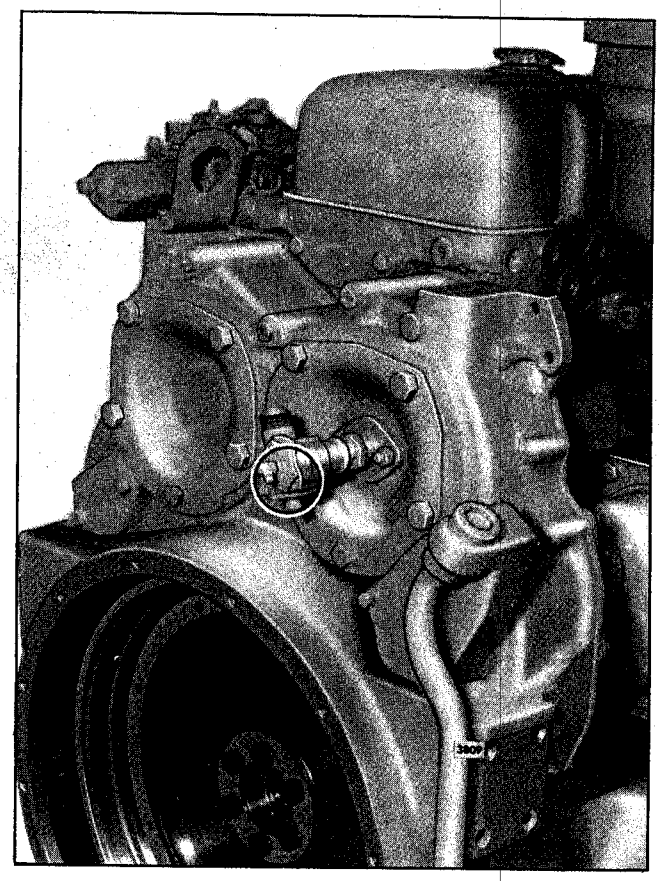
ITEM 19

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, no tune-up should be needed. Minor adjustments in the valve and injector operating mechanisms, governor, etc. should only be required periodically to compensate for normal wear on parts.

ITEM 20

New drive belts will stretch after the first few hours of operation. Therefore, retighten new fan drive, pump drive, and battery-charging generator drive belts after 1 hour or 30 miles and again after 8 hours or 240 miles of operation. Thereafter, check the tension of the drive belts every 200 hours or 6,000 miles and adjust, if necessary. Too tight a belt is destructive to the bearings of the driven part; a loose belt will slip.

Replace all belts in a set when one is worn. Single belts of similar size should not be used as a substitute for a matched belt set; premature belt wear



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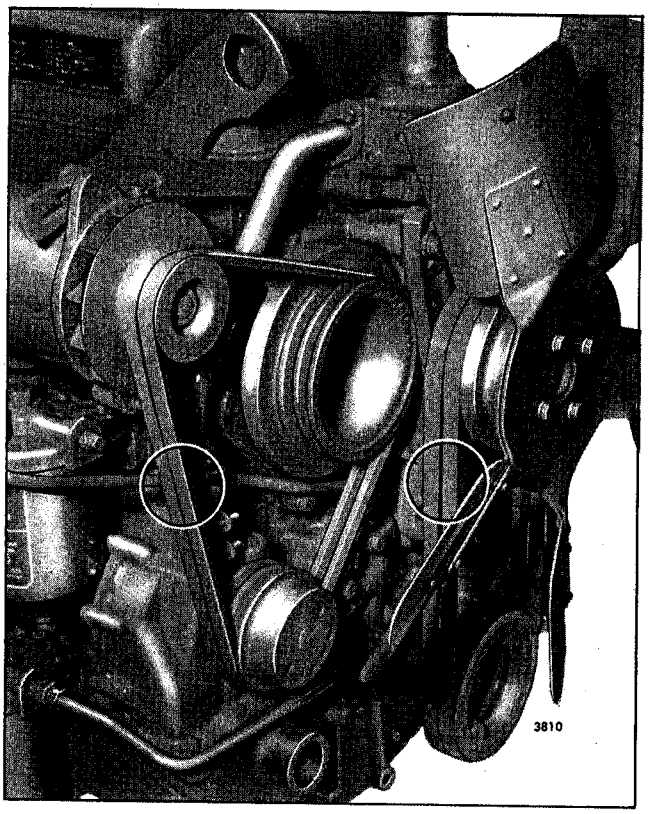

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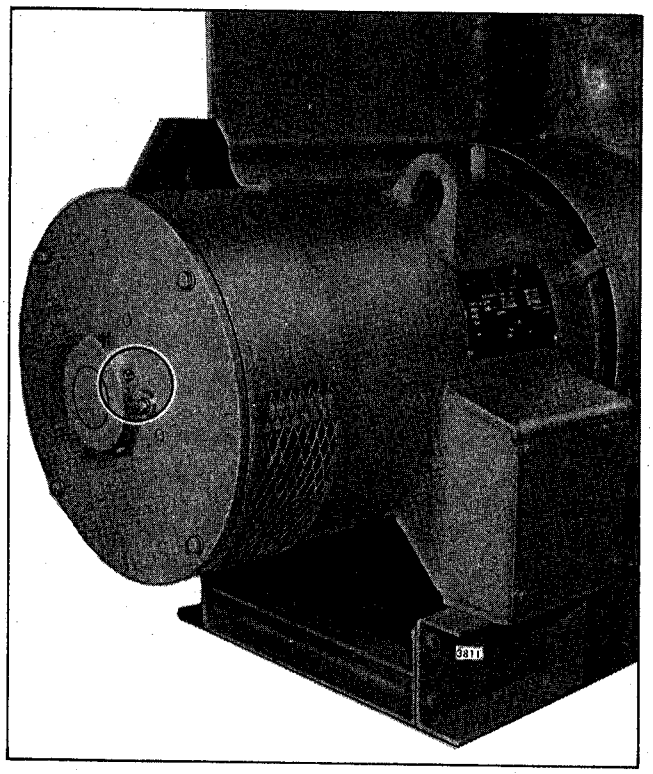


Item 21

can result because of belt length variation. All belts in a matched set are within .032" of their specified center distances.

NOTE: When installing or adjusting an accessory drive belt(s), be sure the bolt at the accessory adjusting pivot point is properly tightened, as well as the bolt in the adjusting slot.

Adjust the belt tension so that a firm push with the thumb, at a point midway between two pulleys, will depress the belt 1/2" to 3/4". If a belt tension gage such as BT-33-73F or equivalent is available, adjust the belt tension as outlined in the following chart.

BELT TENSION CHART (lbs/belt)

Model	Fan Drive		Generator Drive		
	2 or 3 belts	Single belt	Two 3/8" or 1/2" belts	One 1/2" belt	One Wide belt
2,3,4-53	40-50	-	40-50	50-70	40-50
6,8V-53	60-80	80-100	40-50	50-70	40-50
All	For 3-point or triangular drive use a tension of 90-120.				

Every 2500 hours or 75,000 miles, the fan bearing hub assemblies used in radiator cooled engines should be cleaned, inspected and repacked with grease. Repack the hub assemblies using ball or straight roller bearings with Chevron BRB No. 2 grease or a suitable Lithium base multi-purpose grease. Hub assemblies with tapered roller bearings should be repacked with Shell Alvania No. 2 grease, or equivalent.

ITEM 21

The power generator requires lubrication at only one point, the ball bearing in the end frame. Some are lubricated with engine oil and some are lubricated with grease.

If the bearing is oil lubricated, check the oil level in the sight gage every 300 hours; change the oil every six months. Use the same grade of oil as specified for the engine. Maintain the oil level to the line in the sight gage. DO NOT OVERFILL. After adding oil, recheck the oil level after running the generator for several minutes.

If the bearing is grease lubricated, a new generator has sufficient grease for three years of normal service. Then, it should be lubricated at one year intervals. To grease the generator, remove both filler and relief plugs on the side and the bottom of the bearing reservoir. Add grease until new grease appears at the relief plug opening. Run the generator a few minutes, to vent the excess grease; then reinstall the plugs.

The following greases, or their equivalents, are recommended:

Keystone 44H	Keystone Lubrication Co.
BRB Lifetime	Socony Vacuum Oil Co.
NY and NJ F926 or F927	NY and NJ Lubricant Co.

After 100 hours on new brushes, or brushes in generators that have not been in use over a long period, remove the end frame covers and inspect the brushes, commutator, and collector rings. If there is no appreciable wear on the brushes, the inspection interval may be extended until the most practicable period has been established (not to exceed six months). To prevent damage to the commutator or the collector rings, do not permit the brushes to become shorter than 3/4 inch.

Keep the generator clean inside and out. Before removing the end frame covers, wipe off the loose dirt. The loose dirt and dust may be blown out with low pressure air (25 psi maximum). Remove all greasy dirt with a cloth.

ITEM 22

Lubricate all the power take-off bearings with an all purpose grease such as Shell Alvania No. 2 or its equivalent. Lubricate sparingly to avoid getting grease on the clutch facings.

Remove the cover from the side of the clutch housing and lubricate the clutch release sleeve bearing through the fitting every 8 hours.

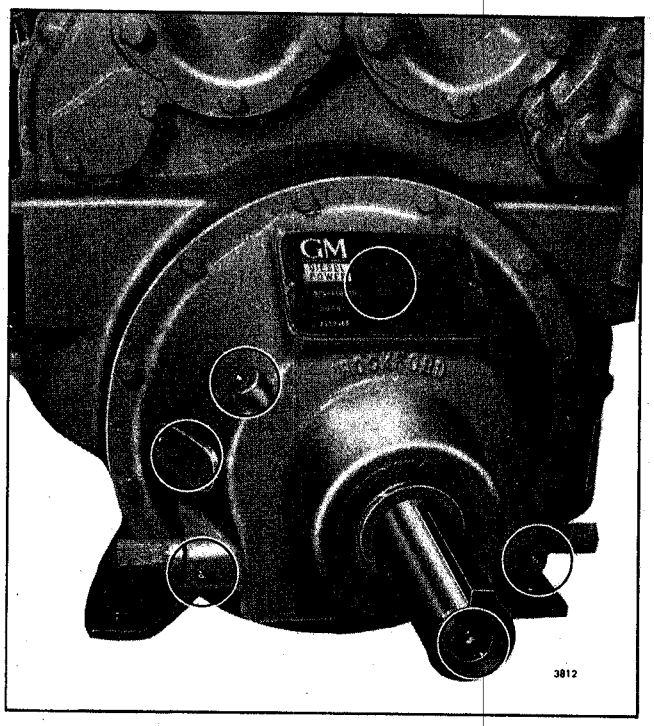
Lubricate the power take-off main bearing every 50 hours. Frequency of lubrication will depend on the working conditions of the bearing, shaft speeds, and bearing loads. It may be necessary to lubricate this bearing more often than every 50 hours. Lubricate the front power take-off clutch pilot ball bearing through the fitting in the outer end of the drive shaft every 50 hours. One or two strokes with a grease gun should be sufficient.

Remove the inspection hole cover and oil the clutch release levers and link pins sparingly every 500 hours. Lubricate the clutch release shaft through the grease fittings on the front of the housing every 500 hours.

Check the clutch facing for wear every 500 hours. Adjust the clutch if necessary.

ITEM 23

Check the oil level in the Torqmatic Converter daily. The oil level must be checked while the converter is operating, the engine idling and the oil is up to operating temperature (approximately 200°F). If the converter is equipped with an input disconnect clutch, the clutch must be engaged.



Item 22

The oil level should be maintained at the proper level on the dipstick. If required, add hydraulic transmission fluid type "C-1" or automatic transmission fluid Type A, suffix A (see chart). Use heavy duty SAE 10 oil only if these fluids are not available. Do not OVERFILL the converter, as too much oil will cause foaming and high oil temperature.

The oil should be changed every 500 hours of operation. Also, the oil should be changed whenever it shows traces of dirt or effects of high operating temperature as evidenced by discoloration or strong odor. If the oil shows metal contamination, contact an authorized Detroit Diesel Service Outlet. Under severe operating conditions, the oil should be changed more often.

The converter oil breather, located on the oil level indicator (dipstick), should be cleaned each time the converter oil is changed. This can be accomplished by allowing the breather to soak in a solvent; then drying it with compressed air.

The full-flow oil filter element should be removed, the shell cleaned, and a new element and gasket installed each time the converter oil is changed.

Lubricate the input clutch release bearing and ball bearing every 50 hours with an all purpose grease. Two grease fittings are provided on the clutch housing. This time interval may vary depending upon the operating conditions. Over-lubrication will cause grease to be thrown on the clutch facing, causing the clutch to slip.

Prevailing Ambient Temperature	Recommended Oil Specification
Above -10°F.	Hydraulic Transmission Fluid, Type C-1
-10°F. to -25°F.	Automatic Transmission Fluid, Type A, Suffix A Identification*
Below -25°F.	Hydraulic Transmission Fluid, Type C-1 or Automatic Transmission Fluid, Type A, Suffix A Identification*

NOTE: Auxiliary preheat required to raise temperature in sump and external circuit to appropriate temperature.

*The term "Suffix A Identification" refers to the Armour Qualification Number used to identify approved "Type A" Fluids that meet their latest specifications. Example "AQ-ATF-696A"-"Type C-1" fluids are not tested by the Armour Foundation, therefore they will not bear a Qualification Number.

ITEM 24

Use the same SAE viscosity lubricating oil in the Warner Marine Gear that is used in the engine.

Start and run the engine at idle speed for a few minutes to fill the lubrication system. Stop the engine. Then, immediately, after stopping the engine, check the oil level in the marine gear. Bring the oil level up to the proper level on the dipstick. Do not overfill.

Check the marine gear oil level daily.

Change the oil every 200 hours. After draining the oil from the unit. clean the removable oil screen thoroughly before refilling the marine gear with oil.

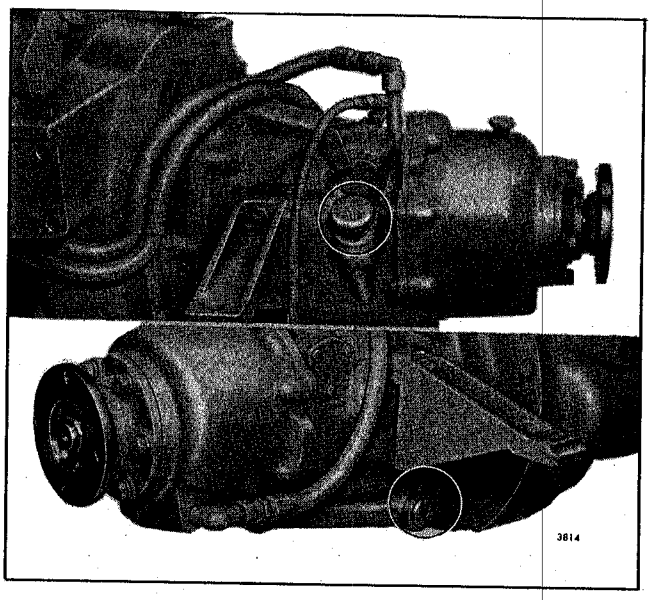
In a Twin Disc Marine Gear, use the same grade of oil as used in the engine. When refilling after an oil drain, bring the oil up to the proper level on the dipstick (approximately 5 qts.). Start and run the engine and reverse gear for a few minutes to be sure the oil cooler and oil cooler supply and return lines are full of oil. Stop the engine. Then, after approximately five minutes, check the oil level again. Add oil as required to bring it to the proper level on the dipstick.

Check the marine gear oil level daily.

Change the oil every 200 hours. Remove and clean the oil inlet strainer screen after draining the oil and before refilling the marine gear. The strainer is located in the sump at the lower end of the pump suction line.

ITEM 25

On units equipped with a Hydrostarter, inspect the system periodically for leaks. Primarily, examine



Item 24

the high pressure hoses, connections, fittings and the control valve on the starter. Make certain the oil level in the reservoir is sufficient to completely cover the filter element at the bottom of the tank. Make this check after the accumulator is charged and the engine driven pump is by-passing oil to the reservoir.

Remove the Hydrostarter motor from the engine every 2,000 hours and apply a coating of Lubriplate, Type 130-AA, or equivalent, on the drive clutch pinion to make sure the clutch slides freely while compressing the spring. Also apply Lubriplate or equivalent on the fingers of the clutch and on the spool of the clutch yoke engaged by the fork. This lubrication period may be reduced or lengthened according to the severity of service.

Before removing the Hydrostarter, release the pressure in the system, using the relief valve in the hand pump; then, remove the three bolts which retain the starting motor to the flywheel housing.

Remove the starter from the flywheel housing without disconnecting the hydraulic hoses. This will prevent dirt and air from entering the hydraulic system.

Remove the pipe plug from the starter drive housing and saturate the shaft oil wick with engine oil. Reinstall the plug.

After lubricating, replace the starter and recharge the accumulator with the hand pump.

Every 2,000 hours, or as conditions warrant, drain the reservoir and remove the screen from the bottom of the reservoir. Flush out the reservoir and clean the reservoir screen and reservoir filler cap.

Remove the bowl and element from the filter and wash them in clean fuel oil and reassemble.

Drain the remaining hydraulic fluid from the system by disconnecting the hoses from the Hydrostarter components. Reconnect all the hydraulic hoses.

NOTE: Make sure the hoses and fittings are clean before any connections are made.

Fill the Hydrostarter system with new clean fluid (a mixture of 75% diesel fuel and 25% SAE 10 or 30 lubricating oil). Purge the Hydrostarter system of air as outlined under Filling and Purging in Hydraulic Starting System.

On units with a remote starting device, check the fluid level in the master cylinder every 2,000 hours and refill with the same diesel fuel used by the engine. Lubricate the master cylinder pedal periodically with all purpose grease.

ITEM 26

To clean either the hair or polyurethane type air compressor air strainer element, saturate and squeeze it in fuel oil, or any other cleaning agent that would not be detrimental to the element, until dirt free. Then dip the element in lubricating oil and squeeze it dry before placing it back in the air strainer.

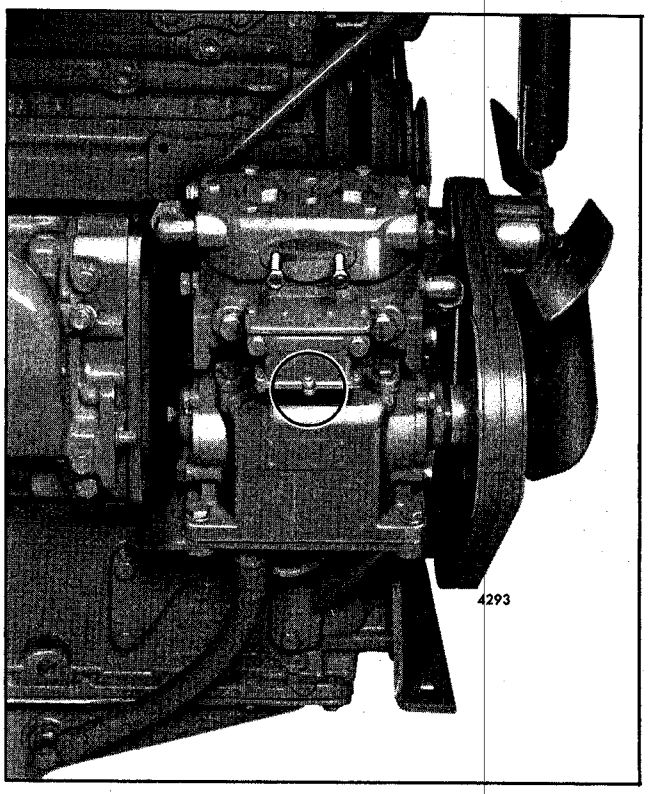
For replacement of the air strainer element, contact the nearest Bendix Westinghouse dealer; replace with the polyurethane element, if available.

ITEM 27

Check the shut-down system every 300 operating hours or each month to be sure it will function when needed. Refer to the Engine Shut-down and Alarm Systems.

ITEM 28

There is no scheduled interval for performing an inspection on the Airesearch turbocharger. As long as the turbocharger is operating satisfactorily and there is no appreciable loss of power, only a periodic inspection is necessary.



Item 26

DIESEL FUEL OIL SPECIFICATIONS

The quality of the fuel oil used for high-speed diesel engine operation is a major factor in satisfactory engine performance and life. The fuel oils selected must be clean, completely distilled, stable, and non-corrosive. Enlist the aid of your supplier in obtaining proper fuel oil. The responsibility for clean fuel lies with the fuel supplier as well as with the operator.

DISTILLATION RANGE, CETANE NUMBER, AND SULFUR CONTENT are three of the most important properties in the selection of diesel fuels for optimum combustion and minimum wear. Engine speed, load, and atmospheric temperature influence the selection of the fuels with respect to distillation range and cetane number. THE SULFUR CONTENT OF THE FUEL MUST BE AS LOW AS POSSIBLE, to avoid excessive deposit formation and premature wear.

Diesel fuels are generally marketed according to ASTM DESIGNATION D975 and only distillate fuels No. 1D and 2D are considered satisfactory for Detroit Diesel engines. These fuels should not be confused with the domestic type furnace oils ASTM D396 which have similar properties but are not always satisfactory for engine use due to their varying composition, cetane number, and distillation range.

As a guide to the selection of the proper fuel oil for various applications refer to the Fuel Oil Selection Chart and the ASTM Classification.

ASTM Classification of Diesel Fuel Oils

	No. 1-D	No. 2-D
Flash Pt.; °F Min.	100	125
Carbon Residue; %	0.15	0.35
Water and Sediment; (% by Volume) Max.	Trace	0.10
Ash; % by Wt.; Max.	0.01	0.02
Distillation, °F 90% Pt.; Max.	550	640
Min.	-	540
Viscosity at 100°F; centistokes Min.	1.4	2.0
Max.	2.5	4.3
Sulfur; % Max.	0.5	0.7
Cetane No; Min.	40	40

Engine operation at altitudes above 5000 feet requires use of next lighter class of fuel oil than would normally be used.

During cold weather engine operation, the "cloud point" (the temperature at which wax crystals begin to form in the fuel oil) should be 10°F. below the lowest expected fuel temperature to prevent clogging of the fuel filters by wax crystals.

At temperatures below -20°F. consult an authorized Detroit Diesel Service Outlet, since particular attention must be given the cooling system, lubricating system, fuel system, electrical system, and cold weather starting aids for efficient engine operation.

FUEL OIL SELECTION CHART

Type of Engine Service	Typical Application	General Fuel Classification	Final Boiling Point (Max.)	Cetane Number (Min.)	Sulfur Content (Max.)
Light load and speed with considerable idling.	City Buses	No. 1-D	550°F	45	0.30%
Light load and speed.	Generator sets, Industrial and Automotive Equipment in city and suburban operation.	Winter No. 1-D	550°F	45	0.30%
		Summer No. 1-D	600°F	40	0.50%
Medium load and speed.	Marine Pleasure Craft, Tractors, Industrial equipment.	Winter No. 1-D	600°F	45	0.50%
		Summer No. 2-D*	675°F	40	0.50%
Heavy load and high speed with idling.	Highway Trucks	Winter No. 2-D*	675°F	45	0.50%
		Summer No. 2-D*	675°F	40	0.50%
Heavy load and high speed.	Heavy Duty Off-the-road Equipment, Trucks, Tractors	No. 2-D*	675°F	45	0.50%

*NOTE: For most satisfactory engine life, use only those No. 2-D diesel fuel oils containing 0.50% or less sulfur. Where minimum exhaust smoke is required or where long periods of idling or cold weather conditions below 32°F. are encountered, the more volatile or light distillate fuels are recommended.

BREAK-IN OILS AND ADDITIVES

The use of proprietary blends of supplementary additive or concentrates such as engine oil supplements, break-in oils, tune-up compounds and friction reducing compounds is not recommended in lubricating oils used in Detroit Diesel engines unless given official Detroit Diesel part numbers and made available for use in appropriate service applications.

DIESEL LUBRICATING OIL SPECIFICATIONS

OIL QUALITY

There are hundreds of commercial crankcase oils marketed today. Lubricants marketed for heavy duty diesel service consist of refined crude oil to which has been added additives compounded to meet the desired engine performance levels. Oil additive selection is based on evaluations conducted by the oil supplier; therefore, satisfactory OIL QUALITY is the responsibility of the oil supplier. (The term oil supplier is applicable to refiners, blenders and rebranders of petroleum products, and does not include distributors of such products.) Experience has shown that oil performance in commercial heavy duty diesel service applications varies from brand to brand.

Obviously engine manufacturers or users cannot completely evaluate the hundreds of commercial oils; therefore, the selection of a suitable lubricant in consultation with a reliable oil supplier, strict observance of his oil change recommendations (used oil sample analysis can be of value), and proper filter maintenance will provide your best assurance of satisfactory oil performance.

Detroit Diesel lubricant recommendations are based on general experience with current lubricants of various types and give consideration to the commercial lubricants presently available.

RECOMMENDATION

MIL-L-2104B Lubricants

Detroit Diesel engines have given optimum performance and experienced the longest service life with the MIL-L-2104B, SAE-30 oils evaluated by Detroit Diesel. MIL-L-2104B oils have superseded the older MIL-L-2104A and Supplement 1 oils. MIL-L-2104B, SAE-30 oils should be used during run-in prior to initial oil drain and are recommended for continued use thereafter. Contact a reliable oil supplier and obtain his assurance that his product has been tested and given good performance in Detroit Diesel engines. You may wish to request the oil supplier to show the performance results of his product in Detroit Diesel engines. An SAE-30 oil of MIL-L-2104B performance level is recommended for year-round use. The use of lower viscosity oils or multigrade products will usually result in less than nominal engine life.

MIL-L-45199 (Series 3) Lubricants

The use of Low Ash Series 3 oils (sulfated ash less than 1.85 percent by weight - A.S.T.M. designation D-874) may be necessary if the continued use of high sulfur fuel is unavoidable. Low ash Series 3 oils are premium priced products and may be desired by the user in preference to MIL-L-2104B oils. Consult a reliable oil supplier, obtain assurance that his products have been tested in Detroit Diesel engines, and select the best performer for optimum engine life.

Low ash Series 3 oils do NOT have to meet any specific military low temperature performance requirements; therefore, they may NOT perform as well as MIL-L-2104B lubricants in cold climates.

The older high ash Series 3 oils should NOT be used in Detroit Diesel engines as they tend to deposit heavy ash on valve faces and head inserts resulting in channelling, guttering, and short engine life.

Supplement 1 Lubricating Oils

Supplement 1 lubricating oils have been superseded by MIL-L-2104B lubricants and S-1 oils are gradually becoming unavailable. However, where a history of satisfactory performance of a specific S-1 oil has been experienced, it can still be used.

MIL-L-2104A Lubricating Oils

This military specification is obsolete.

Multigrade Lubricating Oils

Multigrade oils are NOT recommended. The use of an SAE-30 grade is desirable for year-round use when cold starting can be accomplished. Multigrade oils should be considered only as the "last resort" to facilitate starting when prolonged exposure to temperatures below freezing is unavoidable and adequate starting aids are unavailable.

Experience clearly indicates that multigrade oils are NOT comparable to SAE-30 lubricants for heavy duty diesel service. Cylinder liner scuffing, liner port and ring groove deposit levels are all greater using multigrade lubricants. This results in shortened engine life.

COLD WEATHER OPERATION

Cold weather starting will be facilitated when immersion type electrical coolant heaters can be used. Other practical considerations, such as the use of batteries, cables and connectors of adequate size, generators or alternators of ample capacity, proper setting of voltage regulators, ether starting aids, oil and coolant heater systems, and proper fuel selection will accomplish starting with the use of SAE-30 oil. For complete cold weather starting information, consult an Authorized Detroit Diesel Service Outlet.

OIL CHANGES

It is recommended that new engines be started with 100 hour oil change periods. For highway vehicles this corresponds to approximately 3,000 miles, and for "city-service" vehicles approximately 1,000-2,000 miles. The drain interval may then be gradually increased, or decreased with experience on a specific lubricant while also considering the recommendations of the oil supplier (analysis of the drained oil can be helpful here) until the most practical oil change period for the particular service has been established.

Solvents should not be used as flushing oils in running engines. Dilution of the fresh refill oil supply can occur which may be detrimental.

OIL FILTRATION

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. Since abrasive dust, metal particles and carbon material accumulate in the lubricating oil during engine operation, the oil filter elements must be replaced each time the oil is changed.

> **NOTE:** The manufacturer's warranty applicable to Detroit Diesel engines provides in part that the provisions of such warranty shall not apply to any engine unit which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow the manufacturer's lubricating recommendations indicated above may not be within the coverage of the warranty.

ENGINE TUNE-UP PROCEDURES

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, no tune-up should be needed. Minor adjustments in the valve and injector operating mechanisms, governor, etc. should only be required periodically to compensate for normal wear on parts.

Three types of governors are used. Since each governor has different characteristics, the tune-up procedure varies accordingly. The three types are:

1. Limiting speed mechanical.
2. Variable speed mechanical.
3. Hydraulic.

The mechanical engine governors are identified by a name plate attached to the governor housing. The letters D.W.-L.S. stamped on the name plate denote a double weight limiting speed governor. A single weight variable speed governor name plate is stamped S.W.-V.S.

Normally, when performing a tune-up on an engine in service, it is only necessary to check the various adjustments for a possible change in the settings. However, if the cylinder head, governor, or injectors have been replaced or overhauled, then certain preliminary adjustments are required before the engine is started.

The preliminary adjustments consist of the first four items in the tune-up sequence. The procedures are the same except that the valve clearance is greater for a cold engine.

To tune-up an engine completely, all of the adjustments are made by following the applicable tune-up sequence given below after the engine has reached the normal operating temperature. Since the adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

Tune-Up Sequence for Mechanical Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the governor gap.
4. Position the injector rack control levers.
5. Adjust the maximum no-load speed.
6. Adjust the idle speed.
7. Adjust the buffer screw.
8. Adjust the throttle booster spring (variable speed governor only).

Tune-Up Sequence for Hydraulic Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the fuel rod.
4. Position the injector rack control levers.
5. Adjust the load limit screw.
6. Adjust the speed droop.
7. Adjust the maximum no-load speed.

NOTE: Use new valve rocker cover gasket(s) after each tune-up.

EXHAUST VALVE CLEARANCE ADJUSTMENT

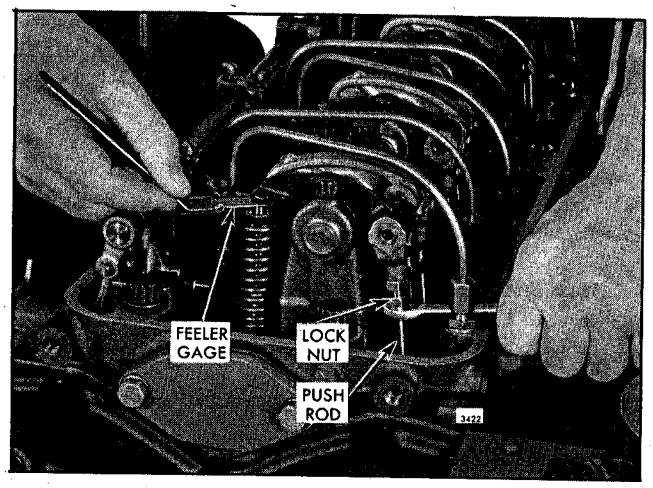


Fig. 1 - Adjusting Valve Clearance (Two-Valve Cylinder Head)

The correct exhaust valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine.

Insufficient valve clearance can result in loss of compression, misfiring cylinders, and eventually burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, especially in the low speed range.

Whenever the cylinder head is overhauled, the exhaust valves reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must first be adjusted to the cold setting to allow for normal expansion of the engine parts during the engine warm-up period. This will ensure a valve setting which is close enough to the specified clearance to prevent damage to the valves when the engine is started.

All of the exhaust valves may be adjusted, in firing order sequence, during one full revolution of the crankshaft. Refer to the general specifications at the front of the manual for the engine firing order.

TWO VALVE CYLINDER HEADS

Cold Engine

1. Clean the loose dirt from the exterior of the engine and remove the valve rocker cover(s).

2. Place the speed control lever in the idle speed position. If a stop lever is provided, secure it in the no-fuel position.

3. Rotate the crankshaft, manually or with the starting motor, until the injector follower is fully depressed on the cylinder to be adjusted.

   CAUTION: If a wrench is used on the crankshaft bolt, do not turn the engine in a left-hand direction of rotation as the bolt will be loosened.

4. Loosen the push rod lock nut.

5. Place a .012" feeler gage, J 9708, between the valve stem and the rocker arm (Fig. 1). Adjust the push rod to obtain a smooth pull on the feeler gage.

6. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the lock nut with a 1/2" wrench.

7. Recheck the clearance. At this time, if the adjustment is correct, the .010" gage will pass freely between the end of the valve stem and the rocker arm and the .012" gage will not pass through.

8. Check and adjust the remaining valves in the same manner as outlined above.

Hot Engine

Maintaining normal engine operating temperature is particularly important when making the final valve clearance adjustment. If the engine is allowed to cool off before setting any of the valves, the clearance, when running at full load, may become insufficient.

With the engine at normal operating temperature (160°-185°F.), recheck the exhaust valve clearance with feeler gage J 9708. At this time, if the valve clearance is correct the .008" gage will pass freely between the end of the valve stem and the rocker arm and the .010" gage will not pass through. Readjust the push rod, if necessary.

Use new gaskets when installing the valve rocker cover(s).

FOUR VALVE CYLINDER HEADS

Cold Engine

1. Clean the loose dirt from the exterior of the engine and remove the valve rocker cover(s).

2. Place the speed control lever in the idle speed position. If a stop lever is provided, secure it in the no-fuel position.

3. Rotate the crankshaft until the injector follower is fully depressed on the cylinder to be adjusted.

   CAUTION: If a wrench is used on the crankshaft bolt, do not turn the engine in a left-hand direction of rotation as the bolt will be loosened.

4. Loosen the push rod lock nut.

5. Place a .027" feeler gage, J 9708, between the end of one valve stem and the rocker arm bridge (Fig. 2). Adjust the push rod to obtain a smooth pull on the feeler gage.

6. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the lock nut with a 1/2" wrench.

7. Recheck the clearance. At this time, if the adjustment is correct, the .025" gage will pass freely between the end of one valve stem and the rocker arm bridge, and the .027" gage will not pass through. Readjust the push rod if necessary.

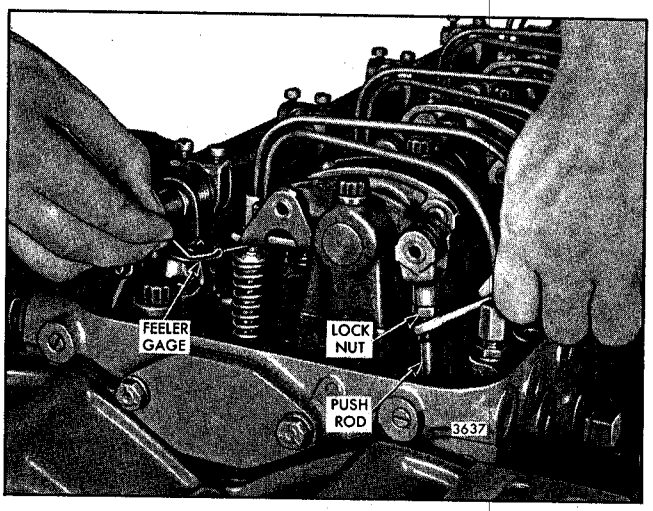


Fig. 2 - Adjusting Valve Clearance (Four-Valve Cylinder Head)

Hot Engine

Maintaining normal engine operating temperature is particularly important when making the final valve clearance adjustment. If the engine is allowed to cool off before setting any of the valves, the clearance, when running at full load, may become insufficient.

With the engine at normal operating temperature (160°-185°F.), recheck the exhaust valve clearance with gage J 9708. At this time, if the valve clearance is correct, the .023" gage should pass freely between the end of one valve stem and the rocker arm bridge and the .025" feeler gage should not. Readjust the push rod, if necessary.

Use new gaskets when installing the valve rocker cover(s).

FUEL INJECTOR TIMING

To time a fuel injector properly, the injector follower must be adjusted to a definite height in relation to the injector body.

All of the injectors can be timed, in firing order sequence, during one full revolution of the crankshaft.

Time Fuel Injector

1. Clean the loose dirt from the exterior of the engine and remove the valve rocker cover(s).

2. Place the speed control lever in the idle speed position. If a stop lever is provided, secure it in the no-fuel position.

3. Rotate the crankshaft, manually or with the starting motor, until the exhaust valves are fully depressed on the particular cylinder to be timed.

   CAUTION: If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation or the bolt will be loosened.

4. Place the small end of the injector timing gage (see table below for correct timing gage) in the hole provided in the top of the injector body, with the flat of the gage toward the injector follower as shown in Fig. 3.

Injector	Timing Dimension	Tool Number
35 (Reefer Car)	1.508	J 8909
35	1.484	J 1242
40	1.484	J 1242
45	1.484	J 1242
S40	1.460	J 1853
S45	1.460	J 1853
S50	1.460	J 1853
L40	1.460	J 1853
N40	1.460	J 1853
N45	1.460	J 1853
N50	1.460	J 1853

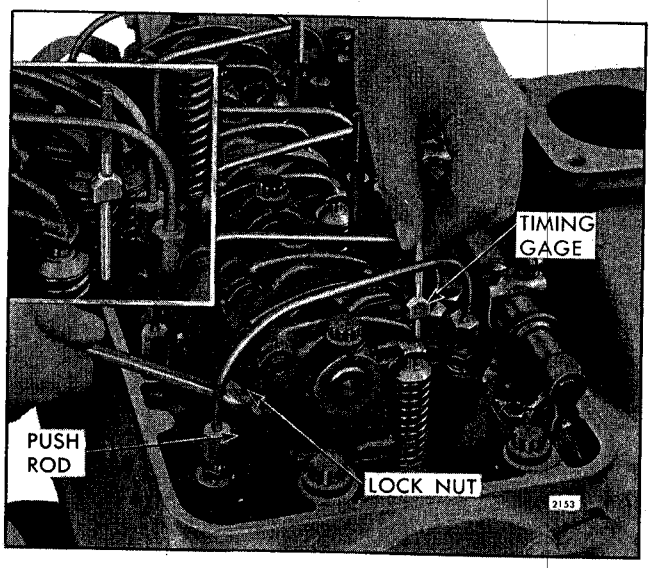


Fig. 3 - Timing Fuel Injector

5. Loosen the push rod lock nut.

6. Turn the push rod and adjust the injector rocker arm until the extended part of the gage will just pass over the top of the injector follower.

7. Hold the push rod and tighten the lock nut. Check the adjustment and readjust, if necessary.

8. Time the remaining injectors as outlined above.

9. Use new gaskets when installing the valve rocker cover(s).