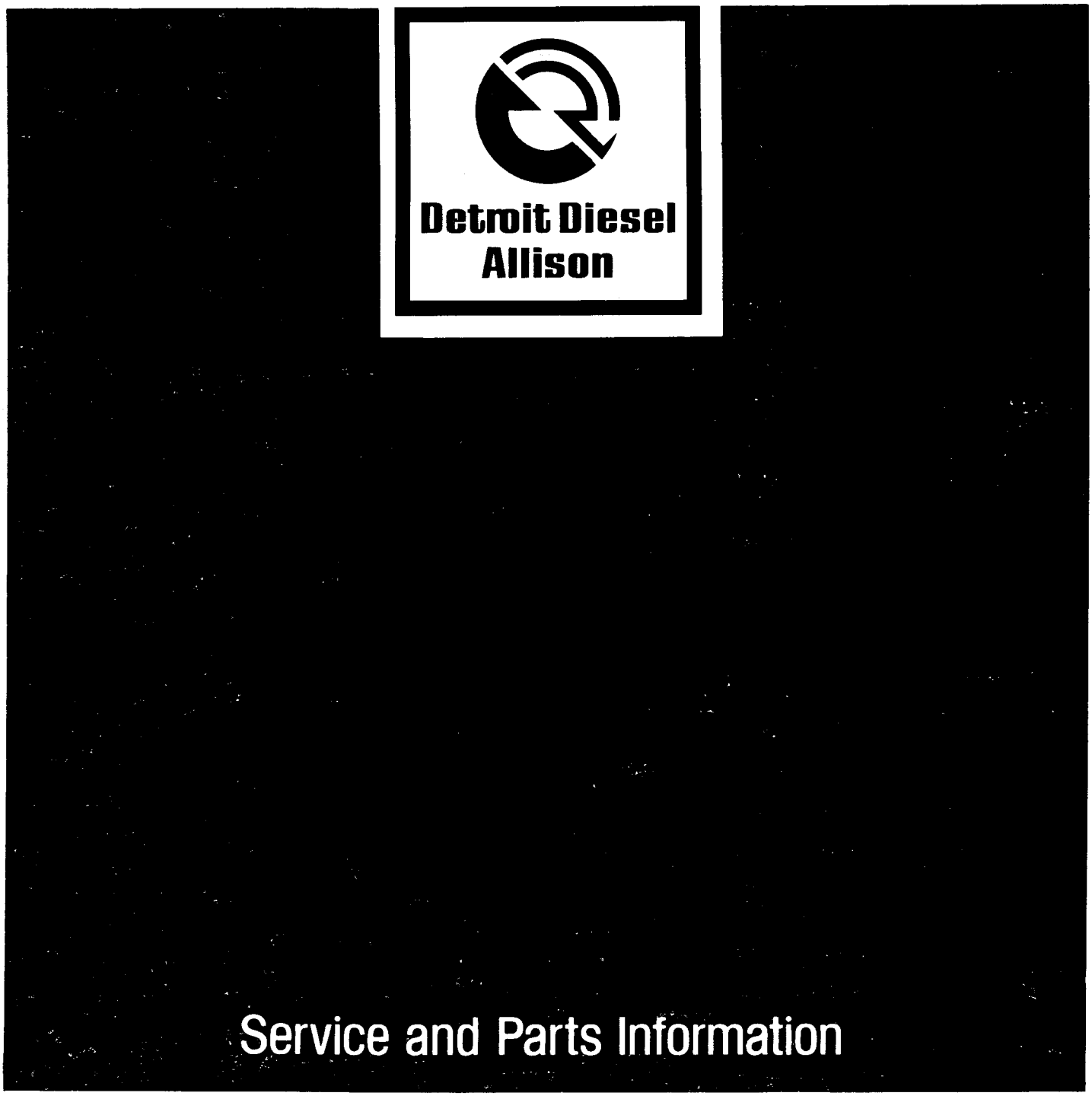
Detroit Diesel Engines

In-Line 71 Operators Manual



Service and Parts Information

6SE329 (Rev. 7/77)

Operators Manual

In-Line 71 Engines

Detroit Diesel Allison
Division of General Motors Corporation
Detroit, Michigan 48228

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 Allison Service Outlet* for all your service needs from maintenance to major parts replacement. There are over 1500 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 Allison Service Outlet* for information on the latest revisions. The right is reserved to make changes at any time without obligation.

WARRANTY

The applicable engine warranty is contained in the form entitled POLICY ON OWNER SERVICE, available from authorized Detroit Diesel Allison Service Outlets.

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DESCRIPTION

PRINCIPLES OF OPERATION

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

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 ignition is accomplished by the heat of compression.

The Two-Cycle Principle

In the two-cycle engine, intake and exhaust take place during part of the compression and power strokes respectively, as shown in Fig. 1. 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 is provided to force air into the cylinders for expelling the exhaust gases and to supply the cylinders with fresh air for combustion. The cylinder wall contains a row of ports that 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 (scavenging).

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. 1 (compression).

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. 1 (power). The intense heat generated during the high compression of the air ignites the fine fuel spray immediately. The combustion continues until the fuel injected has been burned.

The resulting pressure forces the piston downward on its power stroke. The exhaust valves are again opened when the piston is about halfway down, allowing the burned gases to escape into the exhaust manifold as shown in Fig. 1 (exhaust). Shortly thereafter, the downward moving piston uncovers the inlet ports and the cylinder is again swept with clean scavenging air. 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".

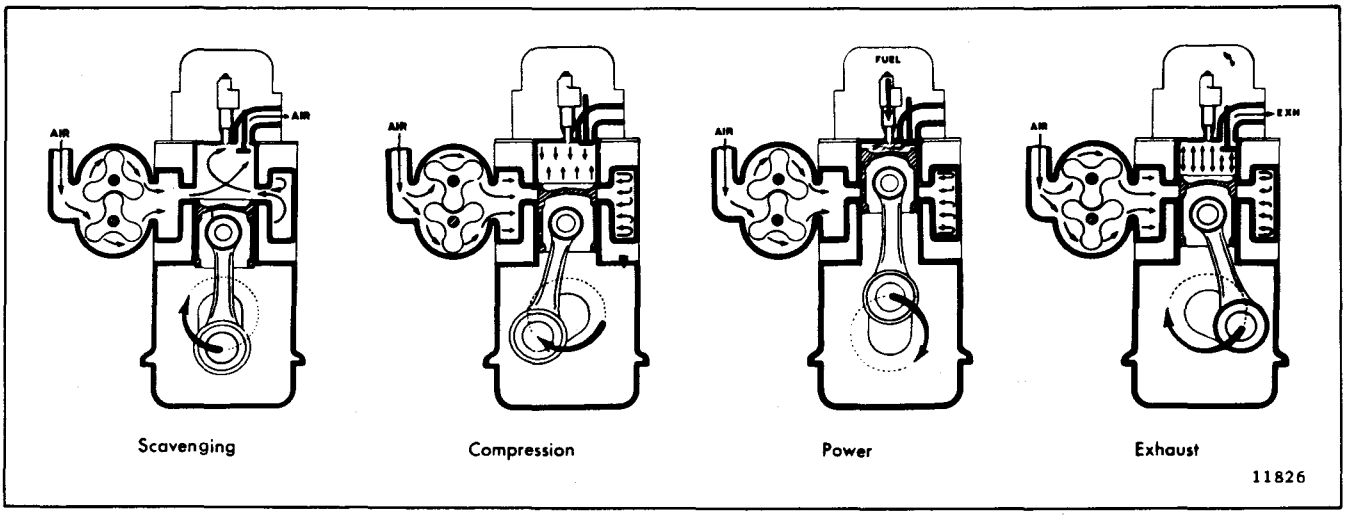


Fig. 1 - The Two-Stroke Cycle

GENERAL DESCRIPTION

The two-cycle engines covered in this manual are produced in three, four and six-cylinder models having the same bore and stroke and many of the major working parts such as injectors, pistons, connecting rods, cylinder liners and other parts that are interchangeable.

The blower, water pump, governor and fuel pump form a group of standard accessories which can be located on either side of the engine, regardless of the direction of rotation. Further flexibility in meeting installation requirements can be had by placing the exhaust manifold and the water outlet manifold on either side of the engine (Fig. 2). This flexibility in the arrangement of parts is obtained by having both the cylinder block and the cylinder head symmetrical at both ends and with respect to each other.

The meaning of each digit in the model numbering system is shown in Fig. 2. 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 as viewed from the rear of the engine.

Each engine is equipped with an oil cooler, lubricating oil filter, fuel oil strainer, fuel oil filter, air cleaner or silencer, governor, heat exchanger and raw water pump or fan and radiator, and starting motor.

Full pressure lubrication is supplied to all main, connecting rod and camshaft bearings, and to other moving parts within the engine. A gear type pump draws oil from the oil pan through an intake screen, through the oil filter and then to the oil cooler. From the oil cooler, the oil enters a longitudinal oil gallery in the cylinder block where the supply divides; a portion entering the by-pass filter, if used, and then draining back into the oil pan, part going to the cam and balance shaft end bearings and cylinder head, with the remainder going to the main bearings and connecting rod bearings via the drilled crankshaft.

Coolant is circulated through the engine by a centrifugal-type water pump. Heat is removed from the coolant, which circulates in a closed system, by the heat exchanger or radiator. Control of the engine temperature is accomplished by a thermostat which regulates the flow of the coolant within the cooling system.

Fuel is drawn from the supply tank through a strainer by a gear-type fuel pump. It is then forced through a filter and into the fuel inlet gallery in the cylinder head and to the injectors. Excess fuel is returned to the supply tank through the fuel outlet gallery and connecting lines. Since the fuel is constantly circulating through the injectors, it serves to cool the injectors and also carries off any air in the fuel system.

Air for scavenging and combustion is supplied by a blower which pumps air into the engine cylinders via the air box and cylinder liner ports. All air entering the blower first passes through an air cleaner or silencer.

Engine starting is provided by either a hydraulic or electric starting system. The electric starting motor is energized by a storage battery. A battery-charging generator, with a suitable voltage regulator, serves to keep the battery charged.

Engine speed is regulated by a mechanical or hydraulic type engine governor, depending upon the engine application.

GENERAL SPECIFICATIONS

	3-71	4-71	6-71
Number of Cylinders	3	4	6
Bore	4.25 in. (108 mm)	4.25 in. (108 mm)	4.25 in. (108 mm)
Stroke	5 in. (127 mm)	5 in. (127 mm)	5 in. (127 mm)
Compression Ratio (nominal)(Standard Engines)	17 to 1	17 to 1	17 to 1
Compression Ratio (Nominal)("N" Engines)	18.7 to 1	18.7 to 1	18.7 to 1
Total Displacement - cubic inches	213	284	426
Total Displacement - litres	3.49	4.66	6.99
Firing Order - R.H. Rotation	1-3-2	1-3-4-2	1-5-3-6-2-4
Firing Order - L.H. Rotation	1-2-3	1-2-4-3	1-4-2-6-3-5
Number of Main Bearings	4	5	7

1 0 6 5 - 7 0 0 1

SERIES 71 IN-LINE ENGINE	NUMBER OF CYLINDERS	APPLICATION DESIGNATION (see below)	BASIC ENGINE ARRANGEMENT AND DRIVE SHAFT ROTATION (see below)	DESIGN VARIATION (see below)	SPECIFIC MODEL NUMBER

APPLICATION DESIGNATION:

1062-7001	MARINE
1063-7001	INDUSTRIAL F-F
1064-7001	POWER-BASE
1065-7001	GENERATOR
1067-7001	VEHICLE F-F
1068-7001	SPECIAL

DESIGN VARIATIONS

1062-7001	4 VALVE HEAD ("N ENGINE)
1062-7101	2 VALVE HEAD ENGINE
1062-7201	4 VALVE HEAD ("E" ENGINE)
1062-7301	TURBOCHARGED ENGINE
1062-7501	CUSTOMER SPEC. ENGINE

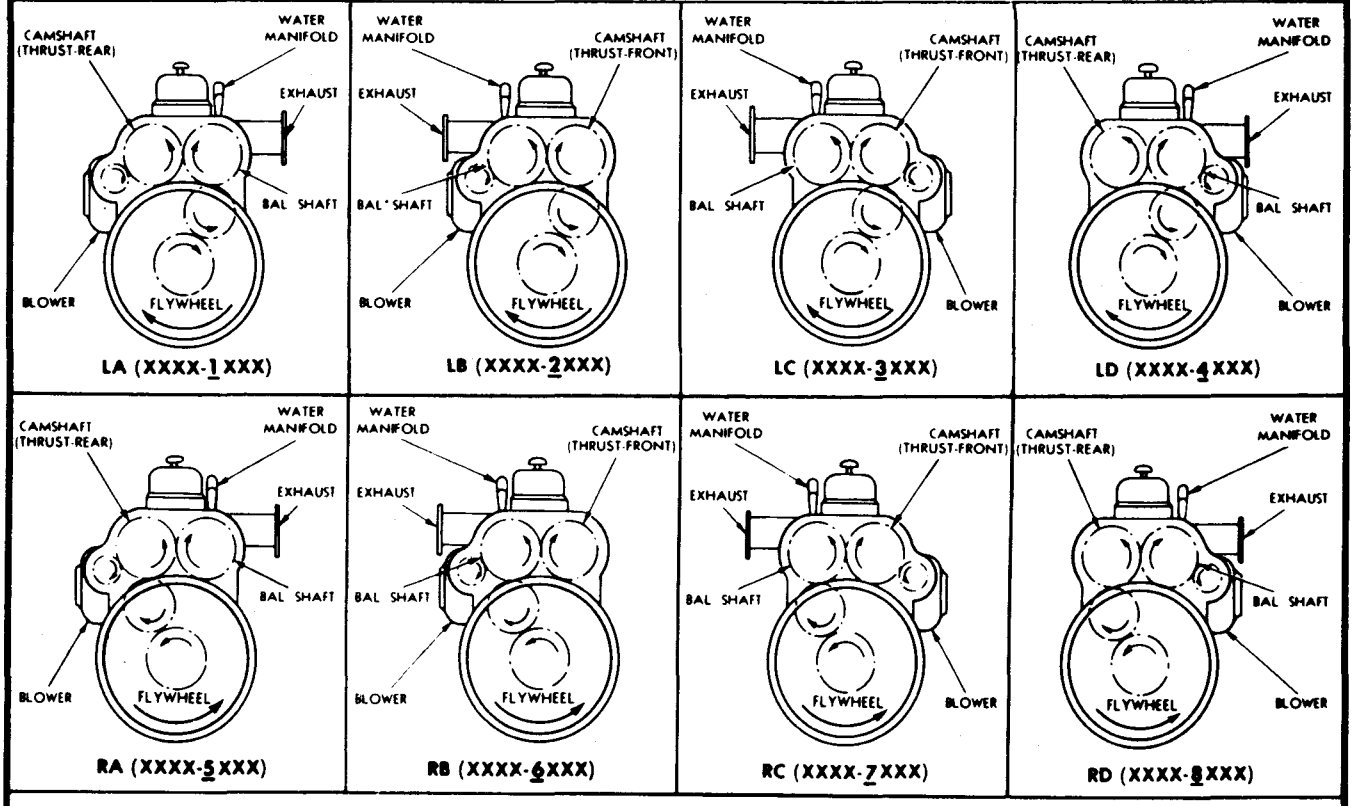
BASIC ENGINE ARRANGEMENTS:

Rotation: L (left) and R (right) designates rotation viewed from the front of the engine. Type A-B-C-D designates the accessory arrangements.

DRIVE SHAFT ROTATION

11220001 LEFT-HAND
11222001 RIGHT-HAND

Shaft rotation on multiple units is determined from the rear of the unit.



ALL VIEWS FROM FLYWHEEL REAR END OF ENGINE
ENGINE ROTATION DETERMINED BY VIEWING ENGINE FROM BALANCE WEIGHT COVER (FRONT) END 11827

Fig. 2 - Model Numbering (Current Engines), Rotation and Accessory Arrangements

ENGINE MODELS

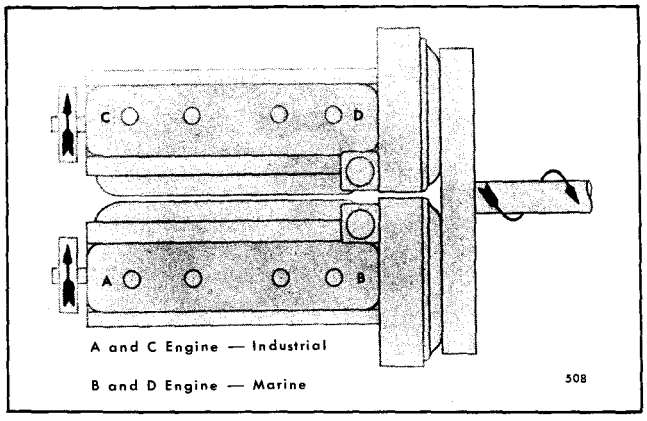


Fig. 3 - Typical Twin Engine Unit

Flexibility in the location of the basic engine accessories (such as the blower, governor, water outlet manifold and exhaust manifold) and a wide range of power take-offs and reduction gears makes it possible to provide a suitable unit to fulfill any requirement.

In addition to single engine models, the Series 71 twin and quad multiple engine units are designed to deliver increased power to a single drive shaft.

Each engine making up a multiple engine unit may be in use or cut out as desired through their individual control levers. Thus, flexibility in power output is possible by varying from idling speed on one engine to full throttle on all engines as the load demands.

A and C engines are used in the twin and quad industrial units and B and D engines are used in twin and quad marine units. Left-hand (LH) rotation is obtained at the power drive shaft with the arrangement shown in Figs. 3 and 4. Right-hand (RH) rotation at the power drive shaft is attained by reversing engine rotation with the same arrangement as shown in Figs. 3 and 4.

The tandem twin marine model, shown in Fig. 5, uses an RA and an LC engine. The accessories and throttle controls are mounted on the inboard side and the exhaust manifold is mounted on the outboard side. On starboard units the drive shaft turns clockwise and on port units the drive shaft turns counterclockwise.

The marine inclined engine is available in two models (RB and LD), each with its own reduction gear and propeller shaft.

The accessories, throttle controls and exhaust manifold are mounted on the inboard side of both models. The propeller shaft on starboard units turns in a clockwise direction and on the port units it turns counterclockwise.

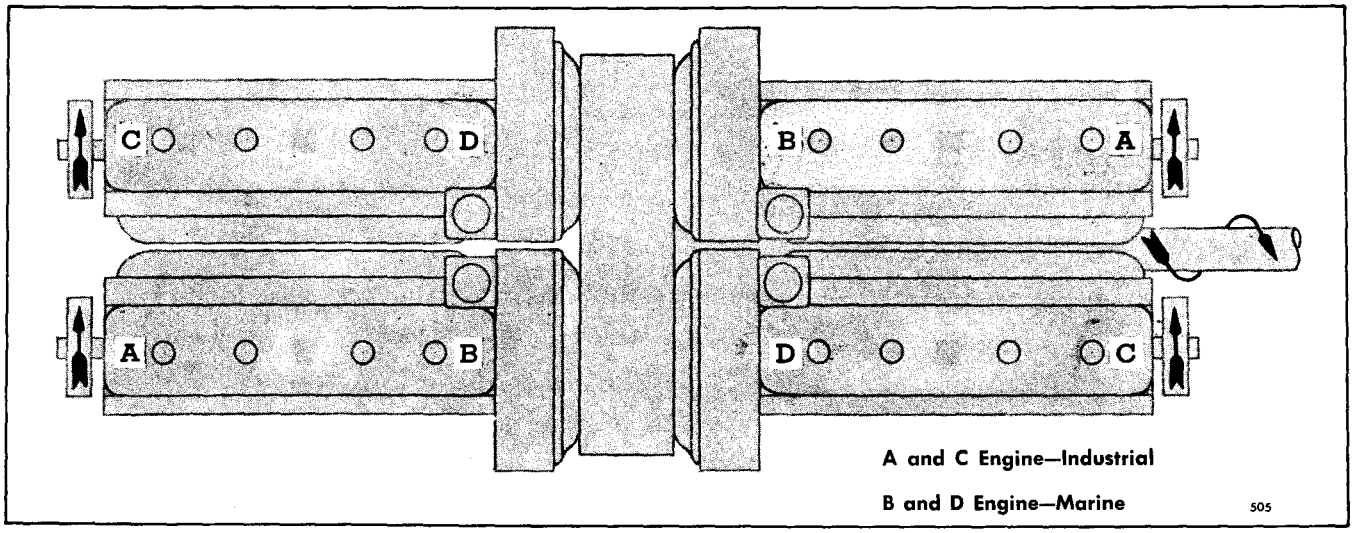


Fig. 4 - Typical Quad Engine Unit

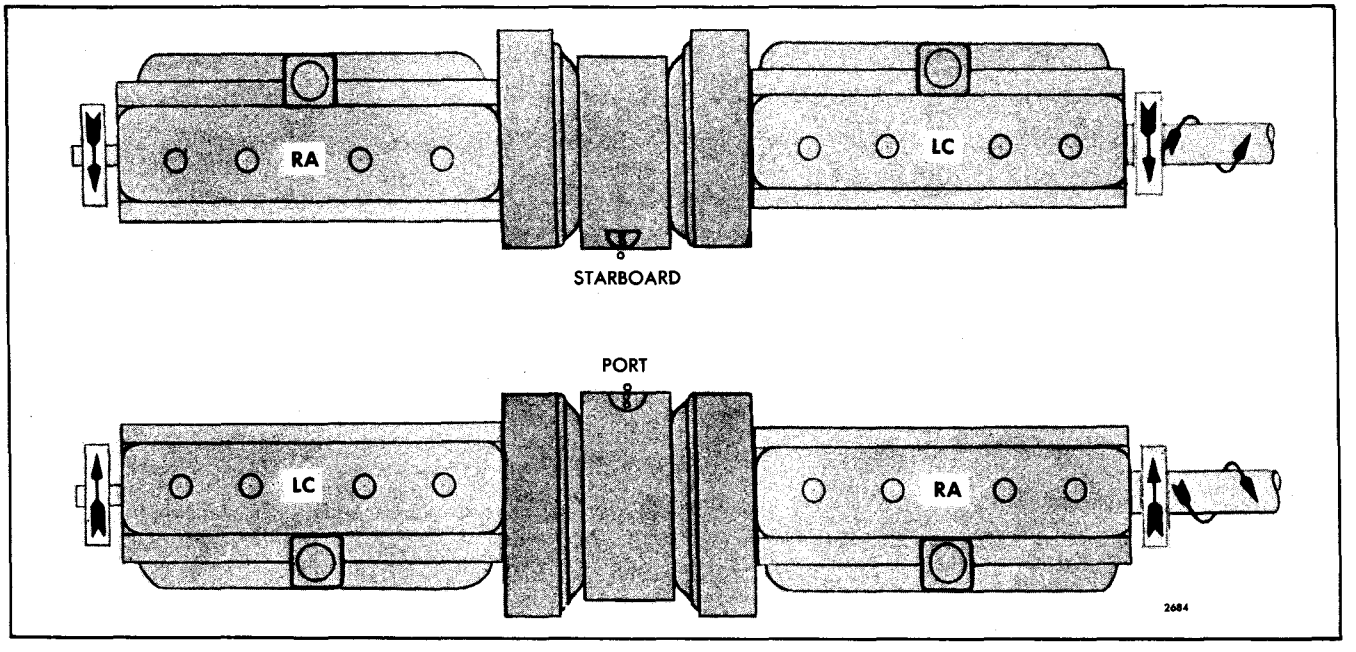


Fig. 5 - Typical Tandem Engine Unit

ENGINE MODEL AND SERIAL NUMBER DESIGNATION

Engine Model and Serial Numbers

On all current Series 71 engines, the engine serial number and the engine model number are stamped on the cylinder block (Figs. 6 and 7). The engine serial number and model number are also stamped on the Option Plate (when used) attached to the valve rocker cover.

Engine Serial Number

Effective with August, 1948 engines, the engine serial number is prefixed by numerals indicating the number of cylinders and the letter "A" which designates a Series 71 engine.

Engine Model Number

Current Series 71 engines are identified by an eight digit model number (Fig. 2). The engine model number 1065-7001 illustrated is interpreted as follows: Series 71 In-line engine (1), six-cylinder (06), generator set (5), right-hand rotation with "C" accessory arrangement (7), four-valve head "N" engine (0) and specific model variation No. 1 (01).

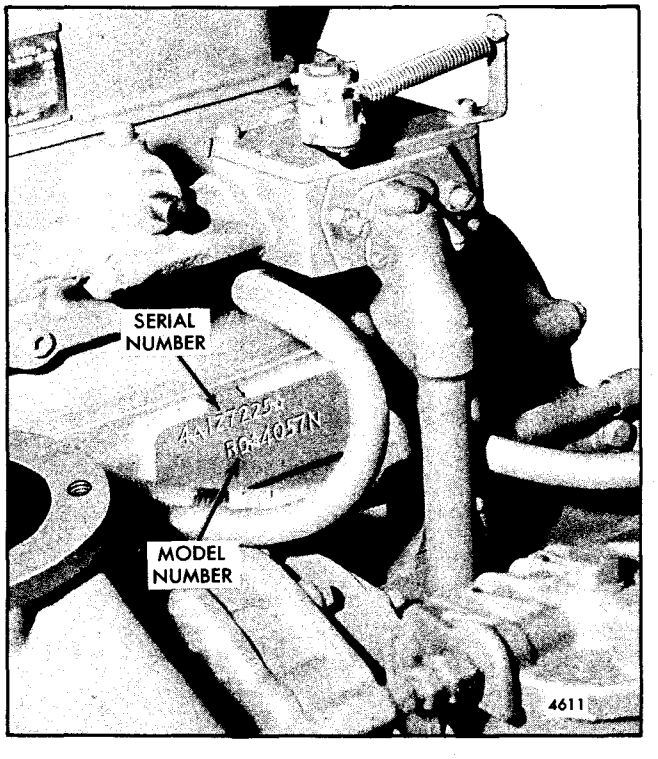


Fig. 6 -Typical Engine Serial Number and Model Number As Stamped on Cylinder Block (Former Engines)

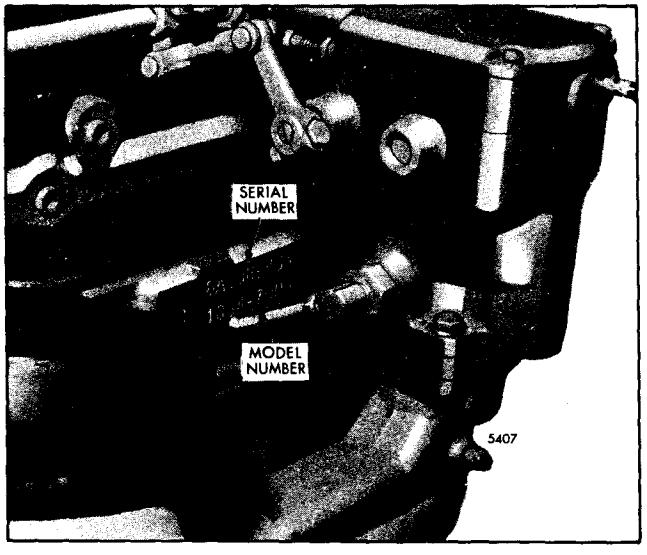


Fig. 7 - Typical Engine Serial Number and Model Number As Stamped on Cylinder Block (Current Engines)

Option Plate

An option plate, attached to the valve rocker cover (only one valve rocker cover of a multiple engine unit), is stamped with the engine serial number and model number and, in addition, lists any optional equipment used on the engine (Fig. 8).

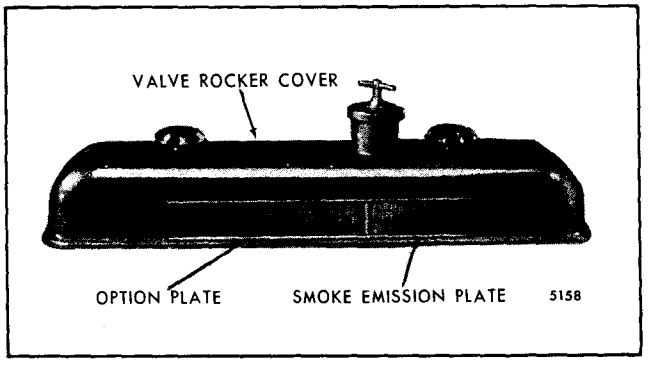


Fig. 8 - Option Plate

With any order for parts, the engine model number and serial number must be given. In addition, if a type number is shown on the option plate covering the equipment required, this number should also be included on the parts order.

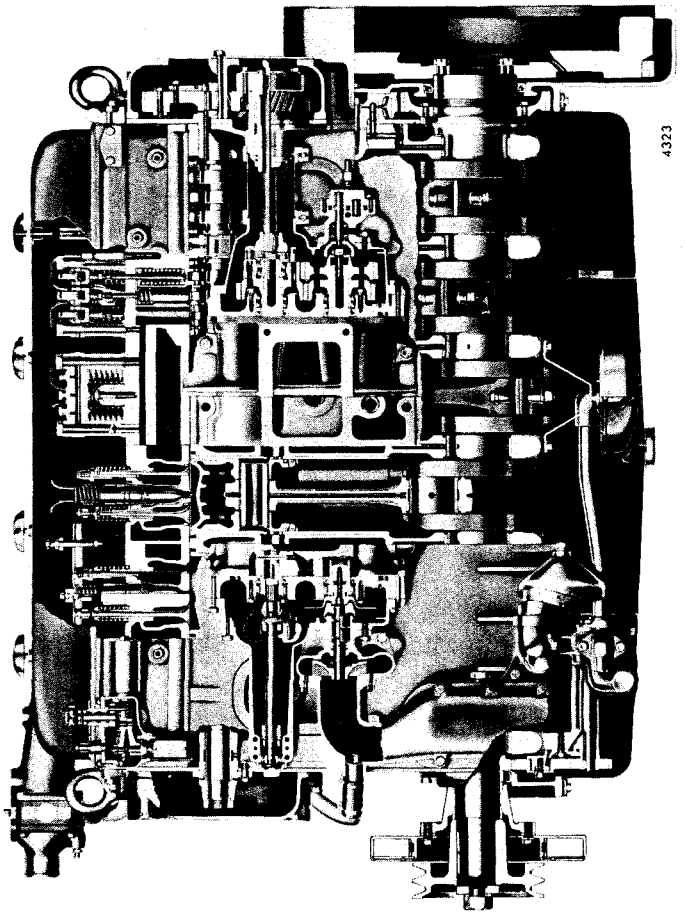
All groups of parts used on a unit are standard for the engine model unless otherwise listed on the option plate.

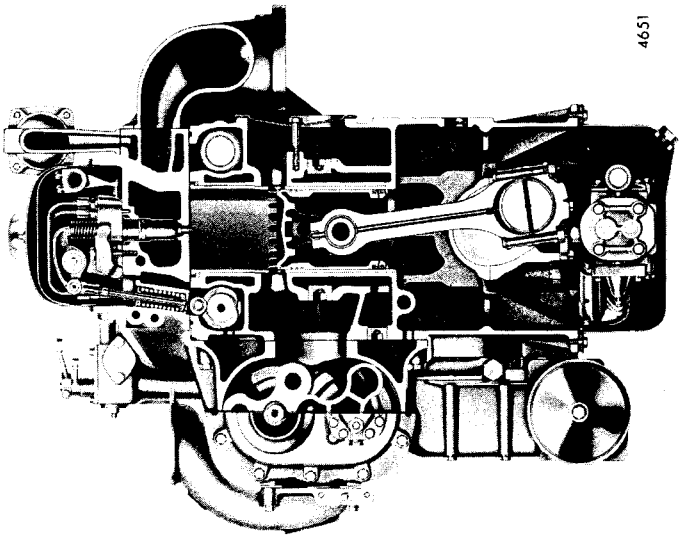
Additional information regarding power take-offs, torque converters, marine gears, etc. may be obtained from the name plate attached to the particular accessory.

BUILT-IN PARTS BOOK

The *Built-In Parts Book* is an anodized aluminum plate (Option Plate) that fits into a retainer on the engine valve rocker cover and contains the necessary information required when ordering parts. It is recommended that the engine user read the section on the *Built-In Parts Book* in order to take full advantage of the information provided on the engine option plate.

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





Cross Section Views of Typical In-Line Engine

ENGINE SYSTEMS

The In-line 71 Detroit Diesel 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, and the necessary maintenance and adjustment procedures are given in this manual.

FUEL SYSTEM

The fuel system, illustrated in Fig. 1, consists of the fuel injectors, fuel pipes, fuel pump, fuel strainer, fuel filter, and the necessary connecting fuel lines.

A restricted elbow is located in the outlet manifold to maintain pressure in the fuel system between the inlet and the outlet fuel passages.

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.

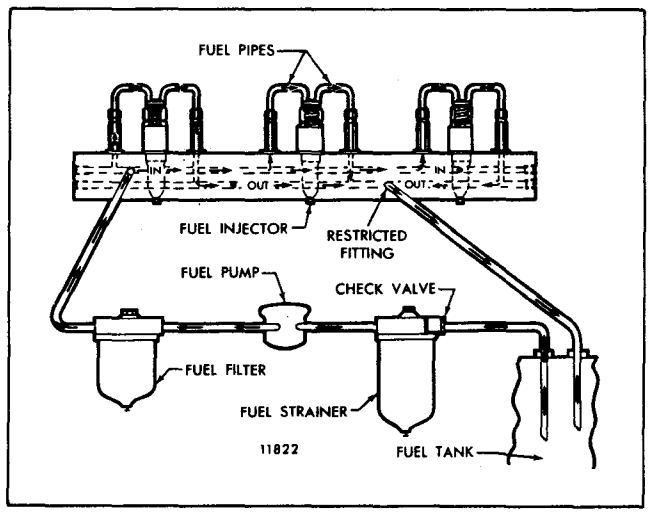


Fig. 1 - Schematic Diagram of Typical Fuel System

Fuel Injector

The fuel injector combines in a single 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 Allison Service Outlets* are properly equipped to service injectors.

Remove Injector

An injector may be removed in the following manner:

1. Remove the valve rocker cover.

2. Disconnect the fuel pipes from both the injector and the fuel connectors.

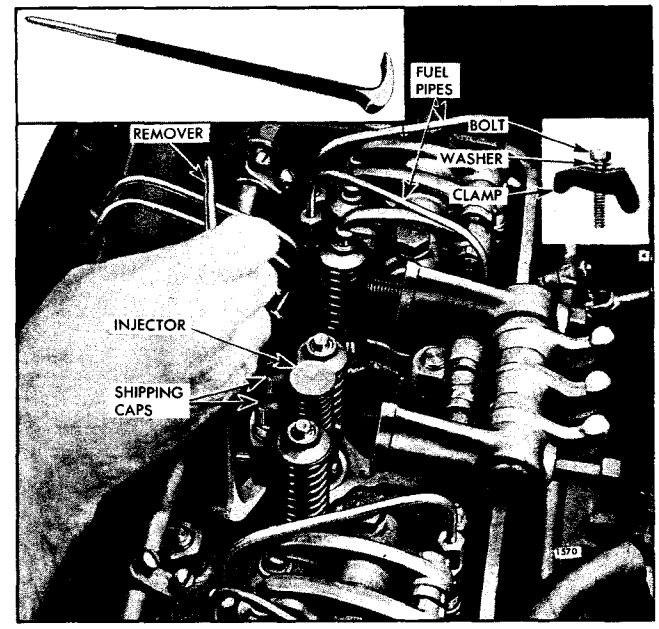


Fig. 2 - Removing Injector from Cylinder Head

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. Either remove the starting motor or the pipe plug in the flywheel housing and use a pry bar 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. 2 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 for removal.

Be sure the fuel injector is filled with fuel oil. If necessary, add clean fuel oil at the inlet filter until it runs out the outlet filter.

Do not tighten the injector clamp bolt to more than 20-25 lb-ft (27-34 Nm) torque, as this may cause the moving parts of the injector to bind. Tighten the rocker shaft bolts to 90-100 lb-ft (122-136 Nm) 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 (16-20 Nm) 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.

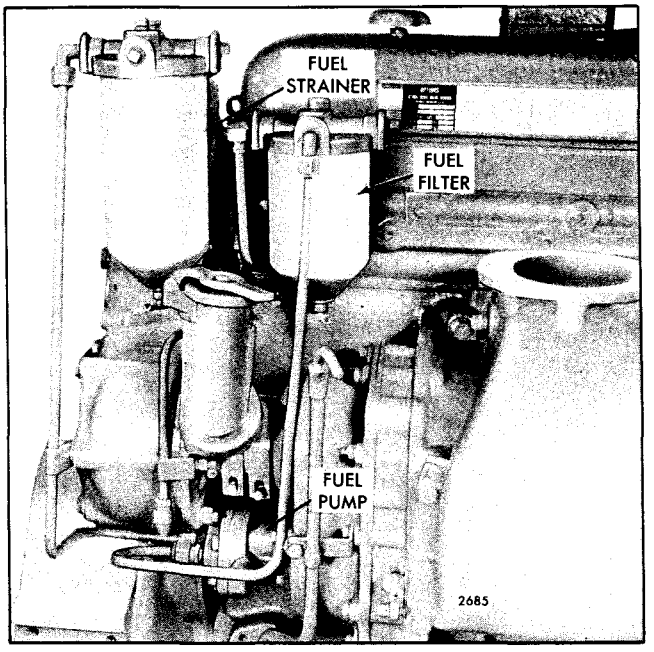


Fig. 3 - Fuel Pump, Fuel Strainer and Fuel Filter Mounting

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 (Fig. 3) is attached to the blower and driven off the rear end of the lower blower rotor.

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 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 Allison 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 (Figs. 1 and 3) 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.

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 the fuel pump, it functions under suction; the fuel filter, which is installed between the fuel pump and the 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 clean lintless 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.

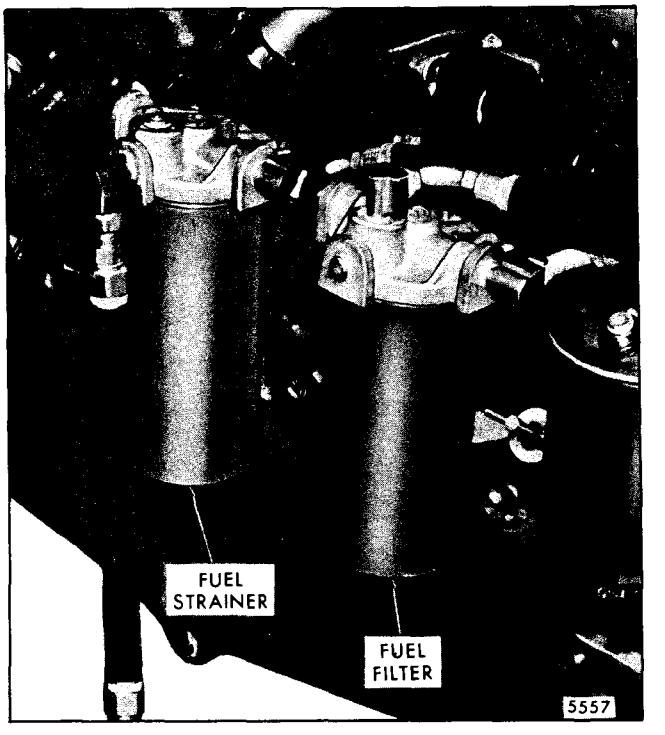


Fig. 4 - Typical Spin-On Fuel Filter and Strainer Mounting

Spin-On Type Fuel Filter

A spin-on type fuel strainer and fuel filter (Fig. 4) is used on certain engines. The spin-on filter cartridge consists of a shell, element and gasket combined into a unitized replacement assembly. No separate springs or seats are required to support the filters.

The filter covers incorporate a threaded sleeve to accept the spin-on filter cartridges. The word "Primary" is cast on the fuel strainer cover and the word "Secondary" is cast on the fuel filter cover for identification.

No drain cocks are provided on the spin-on filters. Where water is a problem, it is recommended that a water separator be installed. Otherwise, residue may be drained by removing and inverting the filter. Refill the filter with clean fuel oil before reinstalling it.

A 1" diameter twelve-point nut on the bottom of the filter is provided to facilitate removal and installation.

Replace the filter as follows:

1. Unscrew the filter (or strainer) and discard it.

2. Fill a new filter replacement cartridge about two-thirds full with clean fuel oil. Coat the seal gasket lightly with clean fuel oil.

3. Install the new filter assembly and tighten it to two-thirds of a turn beyond gasket contact.

4. Start the engine and check for leaks.

Fuel Tank

Refill the fuel tank at the end of each day's operation to prevent condensation from contaminating the fuel.

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 injectors.

AIR SYSTEM

In the scavenging system used in two-cycle engines and illustrated in Fig. 5, a charge of air, forced into the cylinders by the blower, sweeps all of the exhaust gases out through the exhaust valve ports, leaving the cylinders filled with fresh air for combustion at the end of each upward stroke of the pistons. This air also helps 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 blower supplies fresh air required for combustion and scavenging. Two hollow three-lobe rotors are closely fitted in the blower housing which is bolted to the cylinder block. The revolving motion of these rotors pulls fresh air through the air cleaner or air silencer and provides a continuous and uniform displacement of air in each combustion chamber. The continuous discharge of fresh air from the blower creates a pressure in the air box (air box pressure).

Air Cleaners

Several types of air cleaners are available for use with industrial engines. The light duty oil bath air cleaner illustrated in Fig. 6 is furnished on most models and a heavy duty oil bath type (Fig. 7) or a heavy duty 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. 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 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.

The dry type air cleaner consists of a removable cover attached to the air cleaner body which contains a replaceable paper filter cartridge and a dust cup. Air entering the dry type air cleaner is given a centrifugal precleaning by a turbine-type vane assembly. Air rotates at high speed around the filter element throwing the dust to the outside where it flows down the wall of the body and is ejected into a dust cup. The dust cup is baffled to prevent the re-entry of the dust. The pre-cleaned air passes through the paper filter and enters the engine.

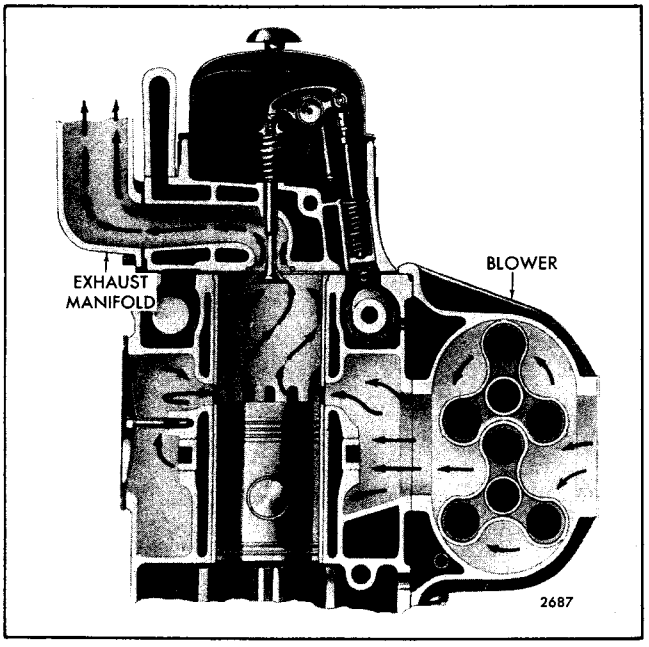


Fig. 5 - Air Intake System Through Blower and Engine

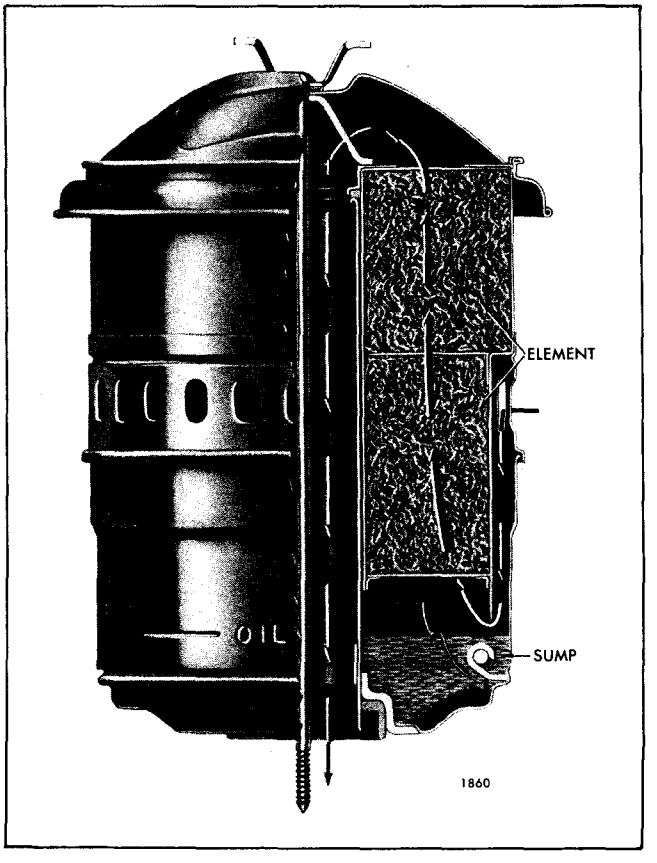


Fig. 6 - Light Duty Oil Bath Air Cleaner Assembly

The *light duty* oil bath air cleaner (Fig. 6) should be serviced as follows:

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 of 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.

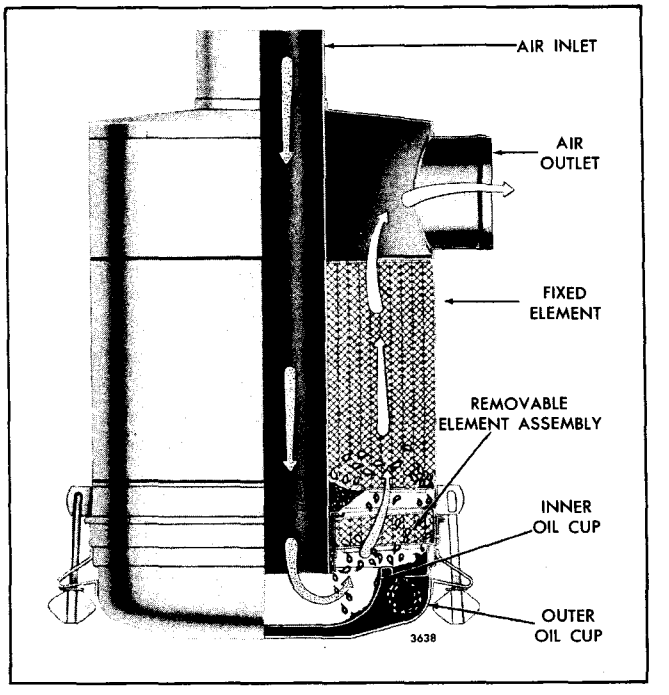


Fig. 7 - Heavy Duty Oil Bath Air Cleaner Assembly

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 the 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. 7) should be serviced as follows:

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

2. Lift out the removable element assembly and hold it up to a light. An even, bright pattern of light through the wire element indicates it is clean. Even a partially plugged element must be cleaned with a suitable solvent or fuel oil and blown out with compressed air to remove any dirt, lint or chaff.

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. 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 and cleaned by soaking and then flushing with clean fuel oil. Allow the unit to drain thoroughly.

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

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

The *dry type* Donaldson "Cyclopac" air cleaner (Fig. 8) consists of a cover assembly, body, element assembly and baffle.

The fins on the element give high speed rotation to the intake air, which separates a large portion of the dust from the air by centrifugal action. The plastic fins, the element and the gasket make up a single replaceable element assembly.

The dust is swept through a space in the side of the baffle and collects in the lower portion of the body. The dust remaining in the pre-cleaned air is removed by the element.

The dry type cleaner *cannot be used* where the atmosphere contains oil vapors, or fumes from the breather can be picked up by the air cleaner.

The air cleaner should be serviced, as operating conditions warrant, as follows:

1. Loosen the cover bolt and remove the cover and bolt as an assembly.

2. Remove the element assembly and baffle from the cleaner body.

3. Remove the dust and clean the cleaner body thoroughly.

4. The paper pleated element assembly can be cleaned as follows:

NOTE: The pre-cleaning fins are not removable.

a. The element can be dry cleaned by directing clean air up and down the pleats on the clean air side of the element.

CAUTION: Air pressure at the nozzle of the air hose must not exceed 100 psi (689 kPa). Maintain a reasonable distance between the nozzle and the element.

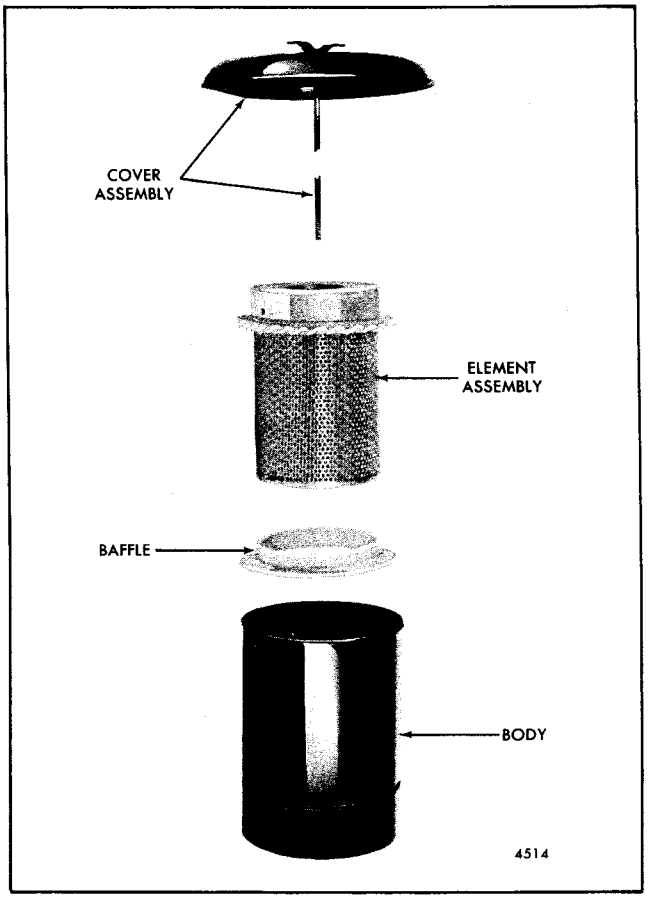


Fig. 8 - Dry Type Air Cleaner

b. To wash the element, use Donaldson Filter Cleaner. Proportions are 2 ounces of cleaner to 1 gallon of water. For best mixing results, use a small amount of cool tap water then add it to warm (100 °F or 39 °C) water to give the proper proportion. Soak the element for 15 minutes; then rinse it thoroughly with clean water from a hose (maximum pressure 40 psi or 276 kPa). Air dry the element completely before reusing (a fan or air draft may be used, but *do not heat* the element to hasten drying).

c. Inspect the cleaned element with a light bulb after each cleaning. Thin spots, pin holes, or the slightest rupture will admit sufficient airborne dirt to render the element unfit for further use and cause rapid failure of the piston rings. Replace the element assembly if necessary.

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

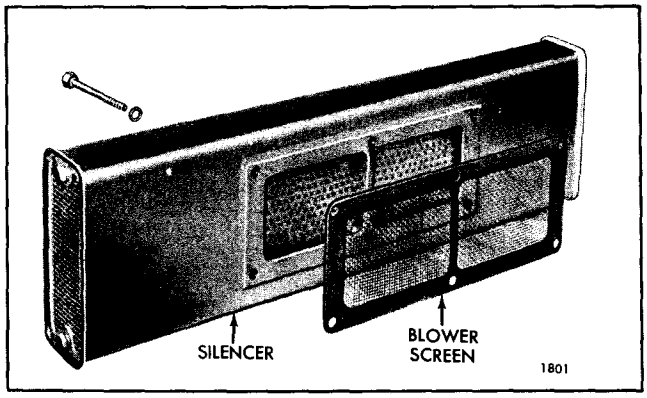


Fig. 9 - Blower Air Inlet Silencer Assembly

5. Reassemble the air cleaner in reverse order of disassembly. Replace the air cleaner body gasket, if necessary.

CAUTION: Do not use oil in the bottom of the cleaner body.

Air Silencer

The air silencer (Fig. 9), used on some marine engines, 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 blower screen. This screen is used to prevent foreign objects from entering the blower.

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, condenses and settles on the bottom of the air box. This condensation is removed

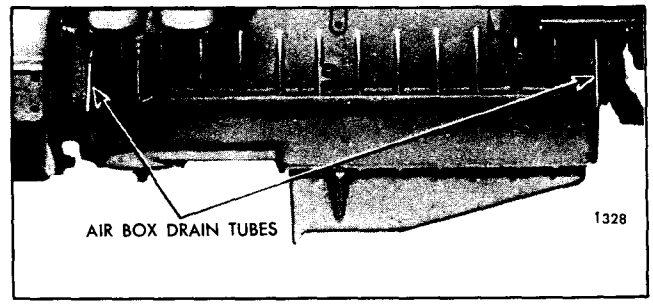


Fig. 10 - Air Box Drain Tubes

by the air box pressure through air box drain tubes (Fig. 10) mounted on the side of the cylinder block.

The air box drains must 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 the drain tubes and connectors from the cylinder block and clean them thoroughly.

Crankcase Ventilation

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

A slight pressure is maintained within the engine crankcase and injector compartment by the seepage of a small amount of air past the piston rings.

Crankcase ventilation is accomplished by the air seepage past the piston rings sweeping up through the flywheel housing and balance weight cover into the valve and injector rocker arm compartment where it is expelled through a vent pipe attached to the rocker cover or the governor. Certain engines use a breather attached to the side of the cylinder block.

LUBRICATING SYSTEM

The lubricating oil system is schematically illustrated in Fig. 11. This system consists of an oil pump, oil cooler, a full-flow oil filter, by-pass valves at the oil cooler and filter and pressure regulator valves at the pump and in the cylinder block main oil gallery. Positive lubrication is ensured at all times by this system. A by-pass oil filter may also be incorporated into the lubricating system at the owner's option.

Oil for lubricating the connecting rod bearings, piston pins, and for cooling the piston head, is provided through the drilled hole in the crankshaft from the adjacent forward main bearings. The gear train is lubricated by the overflow of the oil from the camshaft pocket through a connecting passage into the flywheel housing. A certain amount of oil spills into the flywheel housing from the camshaft, balance shaft, and idler gear bearings. The blower drive gear bearing is lubricated through an external pipe from the rear horizontal oil passage of the cylinder block.

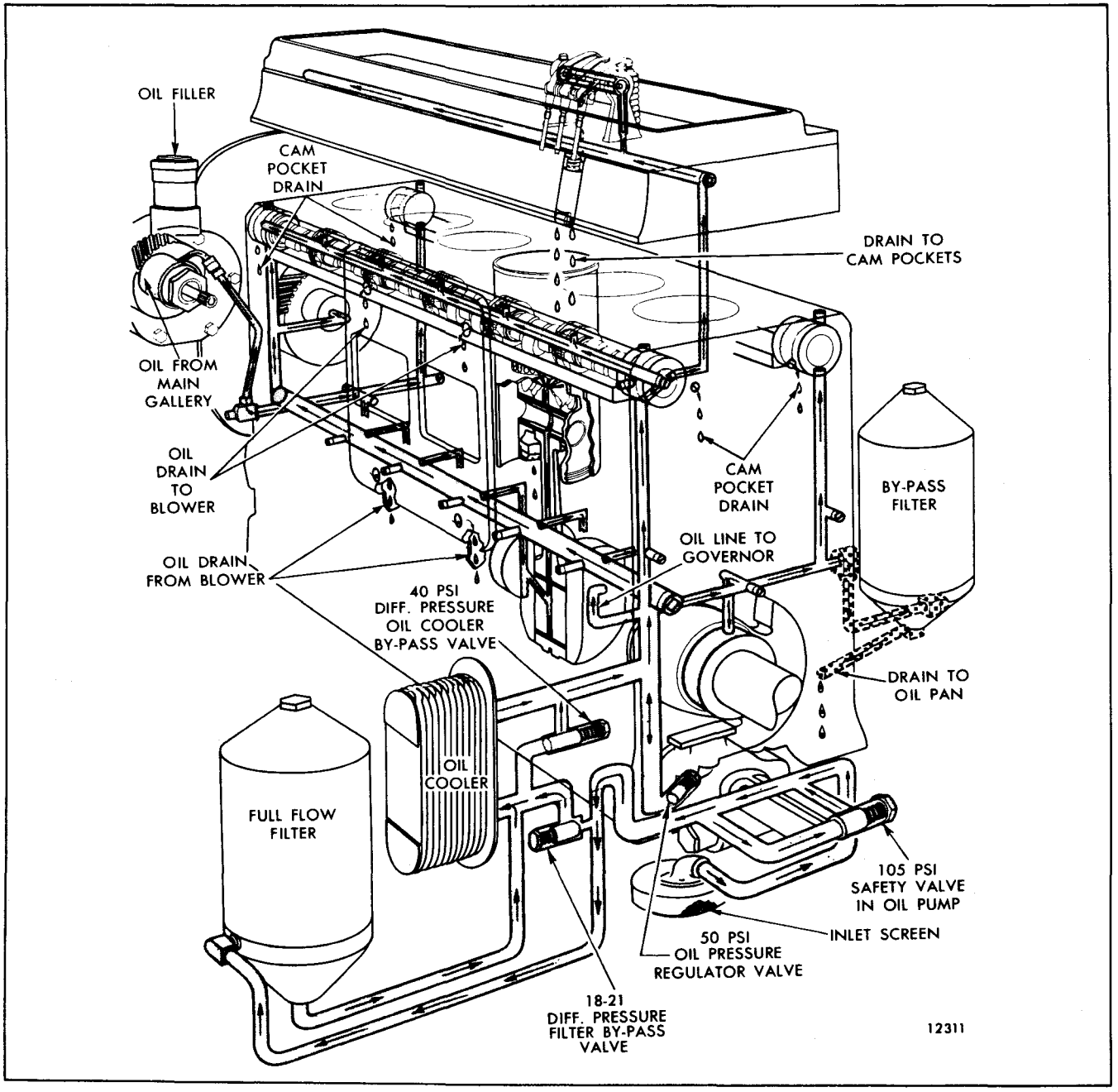


Fig. 11 - Schematic Diagram - Typical Lubricating System

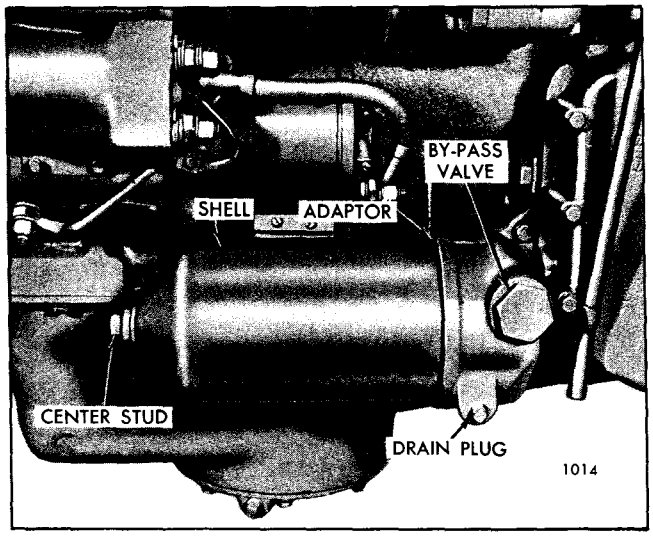


Fig. 12 - Typical Full Flow Filter Mounting

Oil from the cam pocket enters the blower and overflows through two holes, one at each end of the blower housing, providing lubrication for the blower drive gears at the rear end and for the governor mechanism at the front.

Oil Filters

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

The full-flow filter assembly can be remotely mounted or mounted on the engine as shown in Fig. 12. A by-pass valve, which opens at 18 to 21 psi (124 to 145 kPa), is located in the filter adaptor to ensure engine lubrication in the event the filter should become plugged.

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.

The by-pass filter assembly (Fig. 13), 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.

Some engines may be equipped with a by-pass filter assembly consisting of two filter elements, each enclosed in a shell which is mounted on a single

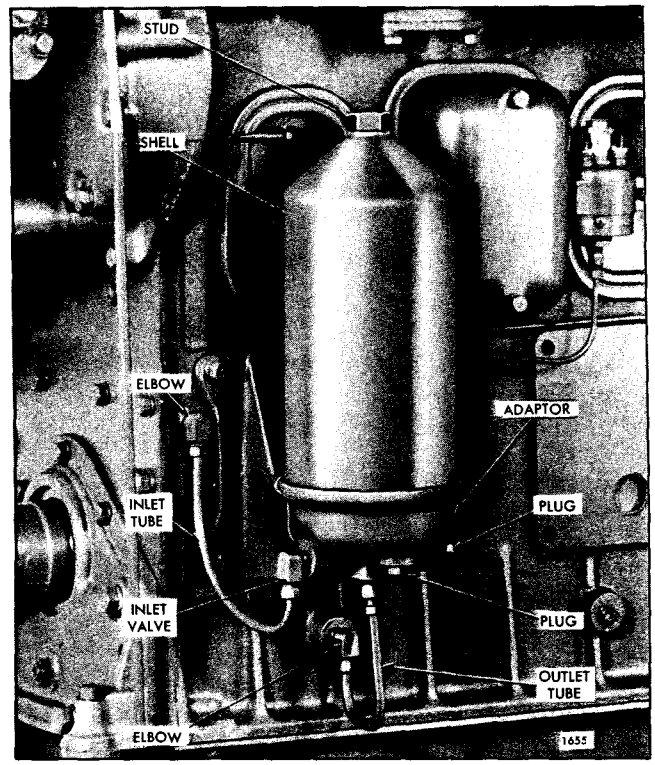


Fig. 13 - Typical Lubricating By-Pass Oil Filter Mounting

adaptor. An oil passage in the filter adaptor connects the two annular spaces surrounding both filter elements.

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.

2. The filter shell, element and stud may be detached as an assembly, after removing the center stud from the adaptor. Discard the gasket.

3. Clean the filter adaptor.

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 adaptor, 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.

COOLING SYSTEM

The In-line 71 engines employ three different types of cooling systems: 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 (71-85 ° C).

Radiator and Fan Cooling

A typical radiator and fan cooling system is illustrated in Fig. 14. 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.

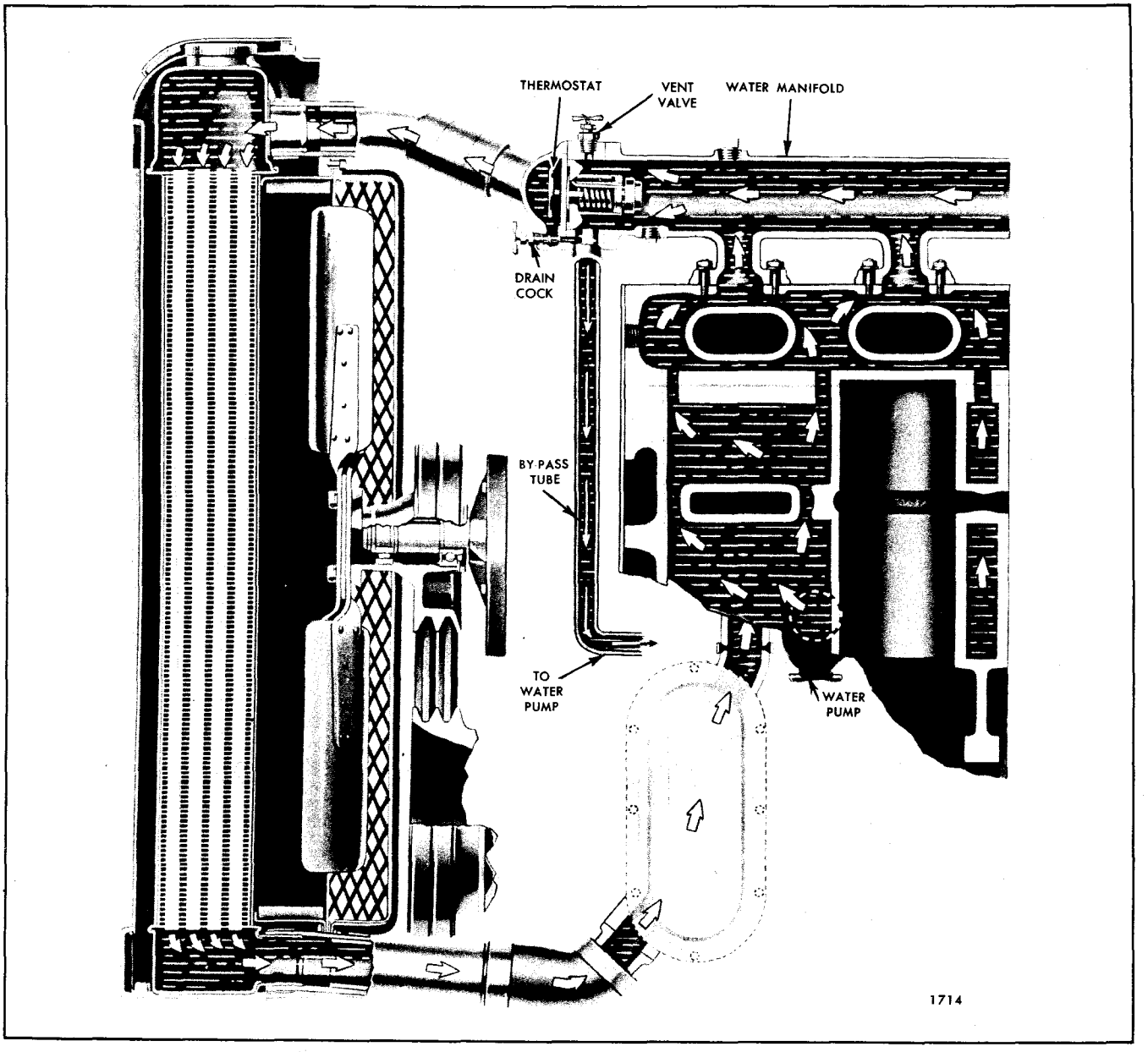


Fig. 14 - Typical Engine Cooling System with Radiator and Fan

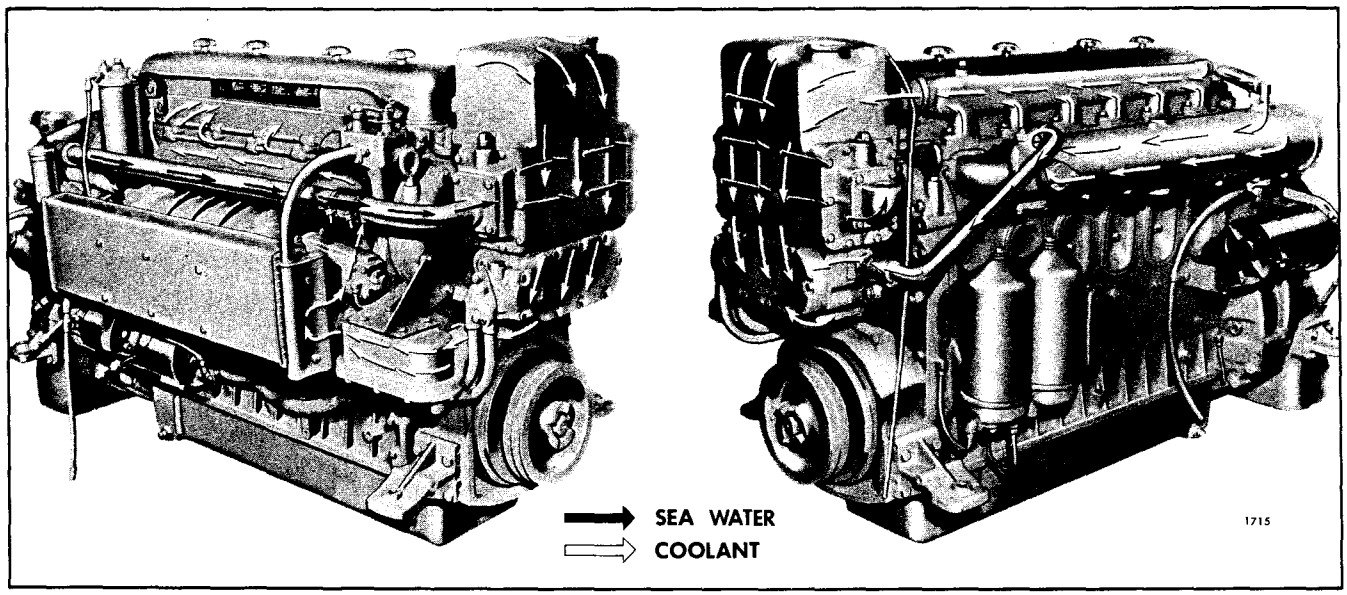


Fig. 15 - Water Circulation Through Heat Exchanger

When starting a cold engine or when the coolant is below operating temperature, the coolant is restricted at the thermostat housing and a by-pass tube provides water circulating within the engine during the warm-up period.

Heat Exchanger Cooling

The heat exchanger cooling system is illustrated in Fig. 15. In this system, the coolant is drawn by the circulating pump from the bottom of the expansion tank through the reverse gear oil cooler and engine oil cooler (on six cylinder engine units, circulation is first through the engine oil cooler, then the reverse gear 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 and oil coolers or by-passes the heat exchanger and oil coolers and flows directly to the water pump, depending on the coolant temperature.

While passing through the core of the heat exchanger, the coolant temperature is lowered by raw water, which is drawn by the raw water 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 governored 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

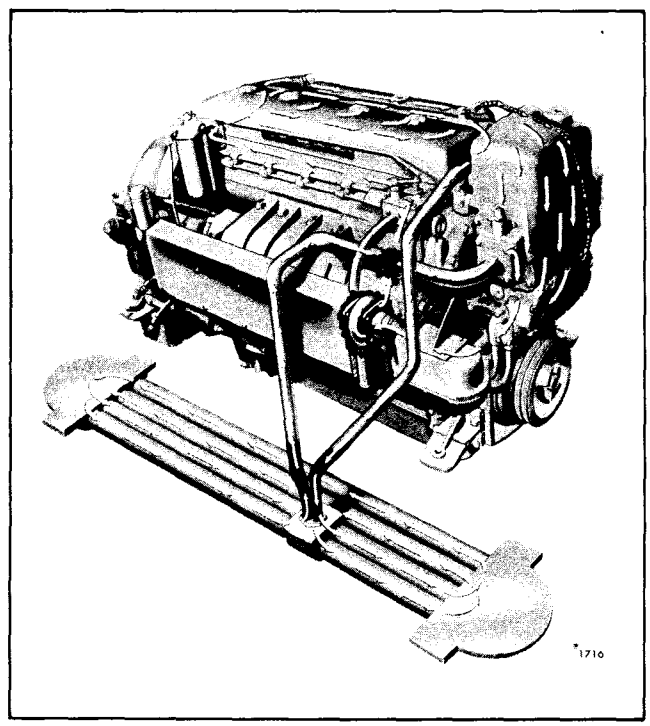


Fig. 16 - Water Flow in Keel Cooled Engine

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 Allison Service Outlet.*

Keel Cooling

The keel cooling system, illustrated in Fig. 16, 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 reverse gear oil cooler and engine oil cooler (on six cylinder engine units circulation is first through the engine oil cooler, then the reverse gear oil cooler). From the coolers, 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.

ENGINE COOLING SYSTEM MAINTENANCE

Engine Coolant

The function of the engine coolant is to absorb the heat, developed as a result of the combustion process in the cylinders, from the component parts such as exhaust valves, cylinder liners, and pistons which are surrounded by water jackets. In addition, the heat absorbed by the oil is also removed by the engine coolant in the oil-to-water oil cooler.

For the recommended coolant, refer to the *Engine Coolant* Section.

Cooling System Capacity

The capacity of the basic engine cooling system (cylinder block, cylinder head, thermostat housings, and oil cooler housing) is shown in Table 1:

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

Cooling System Capacity Chart (Basic Engine)		
Engine	Gallons	Litres
3-71	2-1/2	9
4-71	3-1/2	13
6-71	5-1/2	21

TABLE 1

Fill Cooling System

Before starting the engine, close all of the drain cocks and fill the cooling system with water. If the unit has a raw water pump, it should also be primed, since operation without water may cause impeller failure.

The use of clean, soft water will eliminate the need for de-scaling solutions to clean the cooling system. A hard, mineral-laden water should be made soft by using water softener chemicals before it is poured into the cooling system.

These water softeners modify the minerals in the water and greatly reduce or eliminate the formation of scale.

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

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

Drain Cooling System

Drain the coolant by opening the drain cocks in the water outlet elbow, oil cooler housing, the fresh water pump, heat exchanger, radiator and, on certain engines, the water hole cover located on the blower side toward the rear of the cylinder block. Components

of the cooling system that do not have a drain cock, are drained through the oil cooler housing drain cock.

Remove the cooling system filler cap to permit the coolant to drain completely from the system.

To ensure that all of the coolant is drained completely from a unit, all cooling system drains should be opened. Should any water that may be trapped in the cylinder block or radiator freeze, it will expand and may cause damage. When freezing weather is expected, drain a unit not adequately protected by antifreeze. Leave all drain cocks open until refilling the cooling system.

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

Drain raw water pumps 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 drained, tighten the screws.

Flushing Cooling System

Flush the cooling system 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 thoroughly circulate the water.

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 water level and fan belt tension are satisfactory, it will be necessary to clean and flush the entire cooling system. Scale formation should be removed by using a quality de-scaling solvent. Immediately after using the solvent, neutralize the system with a 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, drain the engine and radiator and flush it with clean water. Then fill the system with the proper cooling solution.

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

Reverse-Flushing

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

The radiator is reverse-flushed as follows:

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

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

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

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

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

> **CAUTION:** Apply air gradually. Do not exert more than 20 psi (138 kPa) air pressure. Too great a pressure may rupture a radiator tube.

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

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

1. Remove the thermostat and the water pump.

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

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

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

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

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

Miscellaneous Cooling System Checks

In addition to the above cleaning procedures, the other components of the cooling system should be checked periodically to keep the engine operating at peak efficiency. The thermostat and the radiator pressure cap should be checked and replaced, if found defective. The cooling system hoses should be inspected and any hose that feels abnormally hard or soft should be replaced immediately.

Also check the hose clamps to make sure they are tight. All external leaks should be corrected as soon as detected. The fan belt must be adjusted to provide the proper tension, and the fan shroud must be tight against the radiator core to prevent re-circulation of air which may lower cooling efficiency.

Water Pump

The centrifugal type water pump is mounted at the front of the engine and is driven by the blower.

A seal in the pump prevents the coolant from escaping and passing along the shaft. A worn seal will be evident by leakage of coolant through the drain hole provided in the pump housing. Should coolant leakage occur, contact an authorized *Detroit Diesel Allison Service Outlet* for service.

Raw Water Pump

A positive displacement raw water pump, driven by a coupling from the camshaft or balance shaft, circulates raw water through the heat exchanger to lower the temperature of the engine coolant.

The impeller (Fig. 17) is self-lubricated by the water pumped and should be primed before starting the engine.

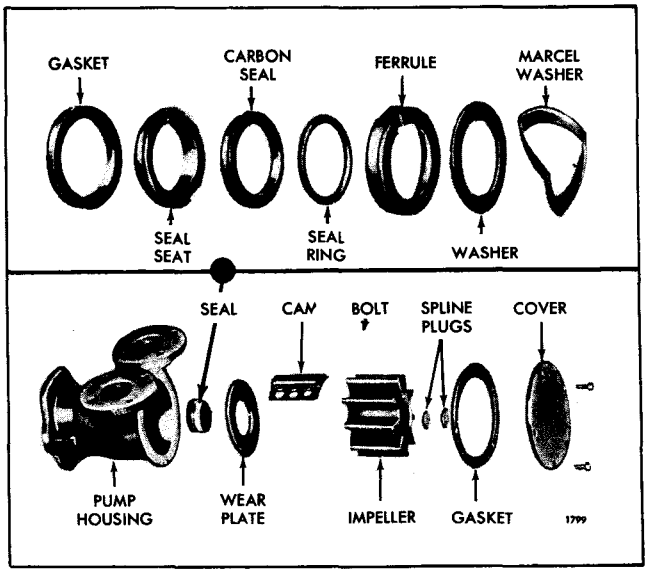


Fig. 17 - Raw Water Pump Details and Relative Location of Parts

Rubber spline plugs have been inserted between the end of the drive shaft and cover to reduce the possibility of foreign material working into the splines and causing wear.

Note that the end cover is marked to show the outlet port for RH rotation and the outlet port for LH rotation. Follow these markings when installing the raw water pump to assure proper direction of flow. Also, when installing the inlet elbow or outlet elbow, be sure to use two flat washers on the bolt being installed in the blind hole in the pump housing.

A rotary type seal assembly prevents any leakage along the shaft.

A raw water pump seal failure is readily noticeable by the leakage of water from the openings in the pump housing. These openings, which are located between the pump mounting flange and the inlet and outlet ports, must remain open at all times.

It is possible to replace seal parts and the impeller without removing the pump from the engine.

Use care to prevent scratching the lapped surface of the seal seat or that portion of the shaft which the seal contacts.

The raw water pump seal parts and impeller may be removed and replaced as follows:

1. Remove the cover screws and lift the cover and gasket from the housing (Fig. 17). Note the position of the impeller blades to facilitate reassembly.

2. Grasp a blade at each side of the impeller with pliers and pull the impeller from the shaft. The spline plugs will come out with the impeller.

3. Remove the spline plugs by pushing a screw driver through the impeller from the opposite end.

CAUTION: If the impeller is reusable, care should be exercised to prevent damage to the splined surfaces.

4. Inspect the bond between the neoprene and the metal of the impeller. Check the impeller blades. If they have a permanent set, a new impeller should be used. If the impeller area which rides on the wear plate is damaged, the impeller should be replaced.

5. Insert two wires (each with a hook at one end) between the housing and seal, with the hooks over the edge of the carbon seal. Then, pull the seal assembly from the shaft.

6. The seal seat and gasket may be removed in the same manner.

7. Remove the cam bolt and cam.

8. Remove the wear plate and check it for wear and burrs. If the plate is worn or burred, it may be reversed.

9. Install the wear plate. There is a dowel in the pump body, and the wear plate is notched to ensure correct installation.

10. Hold the cam in position and install the cam bolt.

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

12. 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. Be sure the seal ring is correctly contained within the ferrule so that it grips the shaft.

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

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

15. Turn the engine over a few revolutions to position the impeller blades properly. Install the spline plugs.

16. Use a new gasket and install the cover on the housing.

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 (4 ° C).

The synthetic rubber impeller must be used when the pump operates with water over 40 ° F (4 ° C).

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

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

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

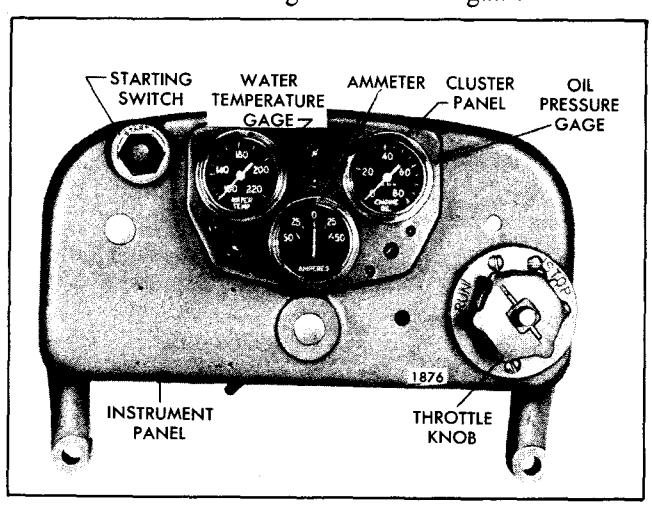


Fig. 1 - Typical Instrument Panel

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, then 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 Switch

The engine starting switch is mounted on the instrument panel with the contact button extending through the front face of the panel. The switch is used to energize the starting motor. As soon as the engine starts, release the switch.

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.

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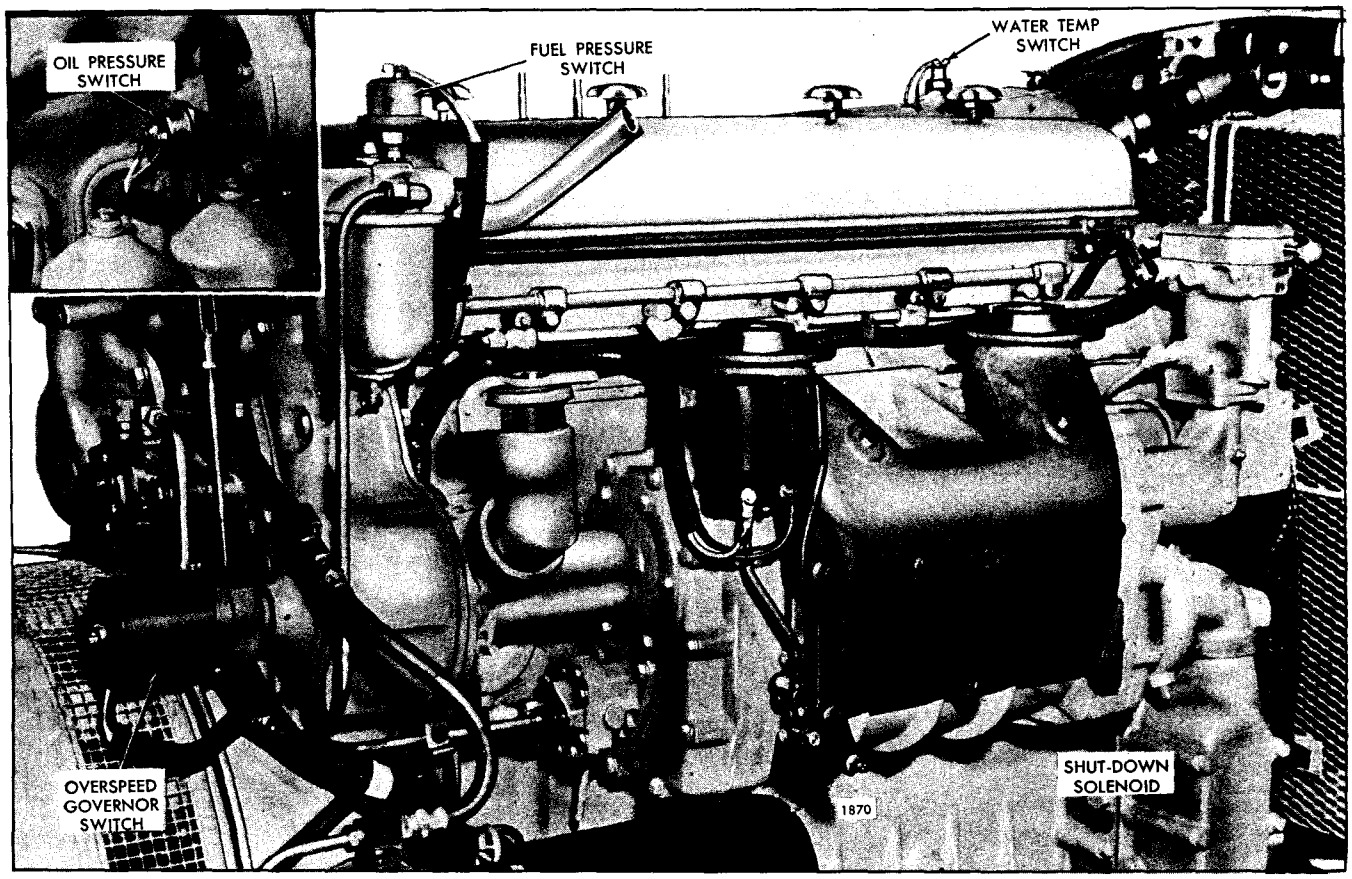

Fig. 3 - Typical Installation of Electrically Operated Shutdown Device

lubricating oil pressure switch and the fuel pressure switch during the starting and stopping of the engine.

The fuel pressure switch is normally a closed type switch connected in the electric circuit to the shutdown solenoid in series with the lubricating oil pressure switch and a hot wire relay. It is calibrated to close at fuel pressures which prevail at engine speeds of approximately 700 rpm. When the engine speed is above 700 rpm, the fuel pressure switch closes, completing the electrical circuit to the lubricating oil pressure switch.

When the engine speed is below 700 rpm, the fuel pressure switch is open and the electrical circuit to the lubricating oil pressure switch is broken. Thus the shutdown solenoid is not exposed to current when the engine is not running, and it will not be energized during normal starting and stopping of the engine.

For service on the shutdown system, contact an authorized *Detroit Diesel Allison Service Outlet.*

ALARM SYSTEM

The alarm system (Fig. 4) is similar to the automatic shutdown system previously described, but does not include the automatic shutdown feature incorporating the electrical solenoid. A bell is used in place of the solenoid in the alarm system or the bell may be added to the automatic shutdown system. The alarm bell warns the engine operator if there is a drop in oil pressure, or if the engine coolant temperature is excessive.

A manually operated alarm switch is incorporated into the system and must be turned *OFF* before stopping the engine to prevent ringing the alarm bell. This switch must be turned *ON* after the engine is started so that the alarm system will operate in case of a malfunction.

The oil pressure and water temperature switches are similar to the switches used in the automatic shutdown device.

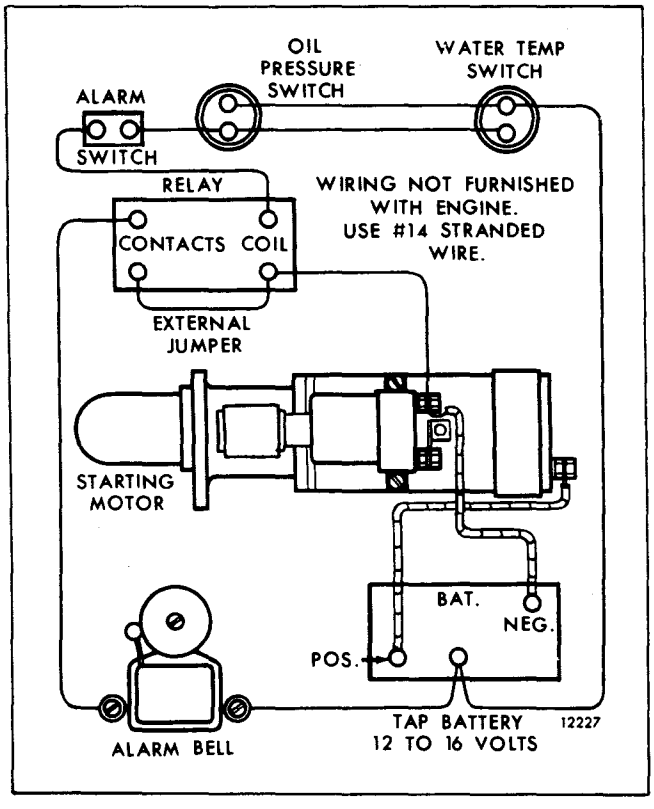

Fig. 4 - Alarm System Wiring Diagram

An overspeed governor may also be installed in the alarm system as optional equipment.

STARTING SYSTEMS

ELECTRICAL STARTING SYSTEM

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

Starting Motor

The electric starting motor has an overrunning clutch drive or a Bendix drive assembly. Bendix drive starters are generally used on applications where automatic starting is required, such as standby generator sets. The overrunning clutch drive starters have the solenoid mounted on the starter and have a totally enclosed shifting mechanism.

Starter Switch

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

Battery-Charging Alternator

A battery-charging alternator is introduced into the electrical system to provide a source of electrical current for maintaining the storage battery in a charged condition and to supply sufficient current to carry any other electrical load requirements up to the rated capacity of the alternator.

Alternator Precautions

Precautions must be taken when working on or around an alternator. The diodes and transistors in the

alternator circuit are very sensitive and can be easily destroyed.

Avoid grounding the output wires or the field wires between the alternator and the regulator. Never run an alternator on an open circuit.

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

Accidentally reversing the battery connections must be avoided.

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

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

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

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

Never attempt to polarize an alternator. Polarization is not necessary and is harmful.

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

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

Regulator

A regulator is incorporated in the electrical system to regulate the voltage and current output of the battery-charging alternator and to help 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 alternator.

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 engine 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 alternator.

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

HYDRAULIC STARTING SYSTEM (HYDROSTARTER)

The hydrostarter system schematically illustrated in Fig. 5 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, an engine-driven charging pump, a hand pump, a piston type accumulator, a starting motor 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 (22 393 kPa) 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 initally 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, on the side of the hand pump, approximately 1/2 turn, allowing the pressure gage 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.

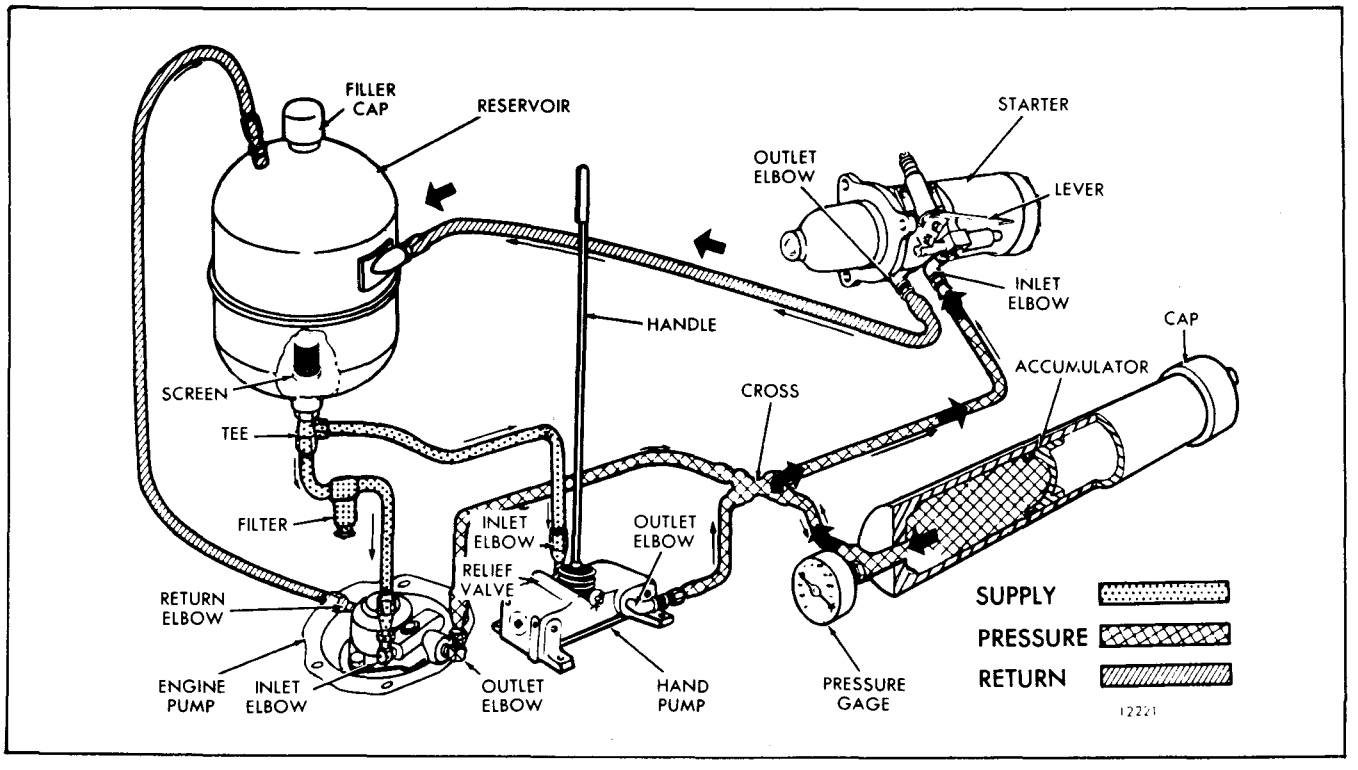

Fig. 5 - Schematic Diagram of Hydrostarter System Showing Oil Flow

Initial Engine Start

Use the hand pump to raise the accumulator pressure. An accumulator pressure of 1500 psi (10 335 kPa) when the ambient temperature is above 40° F (4° C) will provide adequate cranking to start the engine. Between 40° F (4° C) and 0° F (-18° C), 2500 psi (17 225 kPa) should be sufficient. Below 0° F (-18° C), 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 (4° C), 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 to simultaneously engage the starter pinion with the flywheel ring gear and to open the control valve. Close the valve quickly when the engine starts, to conserve the accumulator pressure and to prevent excessive overrunning of the starter drive clutch assembly.

Three different basic types of flywheel ring gear are used -- no chamfer, Bendix chamfer, and Dyer chamfer on the gear teeth. Some difficulty may be encountered in engaging the starter pinion with the Dyer chamfered ring gears. When this happens, it is necessary to disengage and re-engage until the starter pinion is cammed in the opposite direction enough to allow the teeth to mesh.

Remote Control System

The hydrostarter remote control system (Fig. 6) 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 hose to the control valve which engages the starter pinion with the engine flywheel ring gear. Release the pedal as soon as the engine starts.

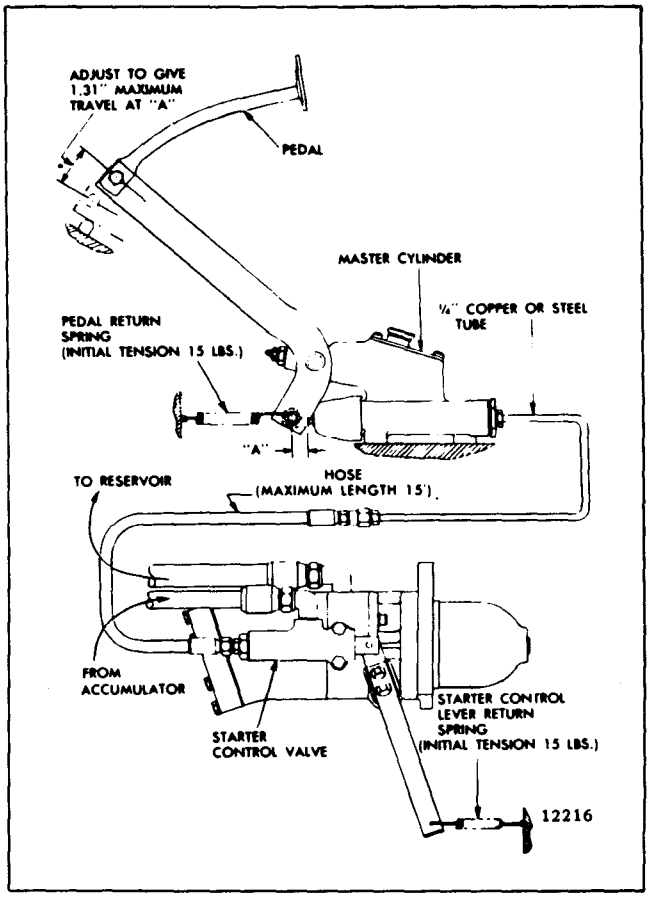

Fig. 6 - Hydrostarter Remote Control System

The hydrostarter motor is equipped with a control valve that incorporates a threaded valve housing plug with a 1/8"-27 tapped hole in the center for installation of the flexible hose. A 1/8"-27 pipe plug is installed when the remote control system is not used.

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 and the size and number of accumulators. The reservoirs are available in 10, 12, 16 and 23 quart (9, 11, 15 and 22 litres) capacities. In a 10 quart (9 litres) capacity reservoir, add approximately 8 quarts (8 litres) of hydraulic fluid, 10 quarts (9 litres) in a 12 quart (11 litres) reservoir, 14 quarts (13 litres)

in a 16 quart (15 litres) reservoir or 21 quarts (20 litres) in a 23 quart (22 litres) reservoir.

NOTE: When the accumulator is charged to 3000 psi (20 670 kPa) 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 the 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 pressure (1250 psi or 8 613 kPa at 70°F or 21°C), then increase slowly, reaching 2900 to 3300 psi (19 981 to 22 737 kPa).

3. After the pressure has stabilized near 3000 psi (20 670 kPa) examine all of the high pressure hoses, 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 (19 981 - 22 737 kPa). 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 of 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.

LUBRICATION AND PREVENTIVE MAINTENANCE

Inspect the system periodically for leaks. Primarily, examine the high pressure hoses, connections, fittings, and the control valve on the starter. Make certain that the oil level in the reservoir is sufficient to completely cover the screen 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.

Every 2000 hours, or as conditions warrant, drain the reservoir and remove the screen. Flush out the reservoir and clean the screen and filler cap. Then reinstall the screen.

Remove the bowl and element from the filter in the engine-driven pump supply hose. Wash the bowl and element in clean fuel oil and reassemble the filter.

Release the pressure and drain the remaining hydraulic fluid from the system by disconnecting the hoses from the hydrostarter components. Then reconnect all of the hydraulic hoses.

CAUTION: The oil pressure in the system must be released prior to servicing the hydrostarter motor or other components to prevent possible injury to personnel or equipment.

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

Fill the hydrostarter system with new clean fluid.

Lubrication

Remove the hydrostarter from the engine every 2000 hours for lubrication. Before removing the hydrostarter, release the pressure in the system by means of the relief valve in the hand pump. Then remove the three bolts that retain the starting motor to the flywheel housing. Remove the starting motor without disconnecting the hydraulic oil hoses. This will prevent dirt and air from entering the hydraulic system.

Apply a good quality, lightweight grease on the drive clutch pinion to make sure the clutch will slide freely while compressing the spring. Also apply grease to the fingers of the clutch fork 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.

Remove the pipe plug from the starting motor drive housing and saturate the shaft oil wick with engine oil. Then reinstall the plug.

After lubricating, install the starting motor on the flywheel housing and recharge the accumulator with the hand pump.

On engines equipped with a hydraulic remote control system, lubricate the shaft in the master cylinder through the pressure grease fitting every 2000 hours.

Cold Weather Operation

Occasionally, when an engine is operated in regions of very low temperatures, the starter drive clutch assembly may slip when the starter is engaged. If the clutch slips, proceed as follows:

1. Release the oil pressure in the system by opening the relief valve in the hand pump.

> **CAUTION:** The oil pressure in the system must be released prior to servicing the hydrostarter motor or other components to prevent possible injury to personnel or equipment.

2. Disconnect the hydraulic hoses from the starting motor.

3. Remove the three retaining bolts and lock washers and withdraw the starting motor from the flywheel housing.

4. Disassemble the starting motor.

5. Wash the hydrostarter drive clutch assembly in clean fuel oil to remove the old lubricant.

6. When the clutch is free, apply SAE 5W lubricating oil.

7. Reassemble the starting motor and reinstall it on the engine. Then attach a tag to the starter noting the lubricant used in the clutch.

8. Recharge the accumulator with the hand pump.

Marine Application

In addition to the normal hydrostarter lubrication and maintenance instructions, the following special precautions must be taken for marine installations or other cases where equipment is subject to salt spray and air, or other corrosive atmospheres:

1. Clean all exposed surfaces and apply a coat of zinc-chromate primer, followed by a coat of suitable paint.

2. Apply a liberal coating of Lubriplate, type 130AA, or equivalent, to the following surfaces.

   a. The exposed end of the starter control valve and around the control shaft where it passes through the clutch housing.

   b. The exposed ends of the hand pump cam pin.

3. Operate all of the moving parts and check the protective paint and lubrication every week.

Consult an authorized *Detroit Diesel Allison Service Outlet* for any information relating to the hydrostarter system.

COLD WEATHER STARTING AIDS

In a diesel engine, the fuel injected into the combustion chamber is ignited by the heat of the air compressed into the cylinder. However, when starting an engine in extremely cold weather, a large part of the energy of combustion is absorbed by the pistons and cylinder walls and in overcoming the high friction created by the cold lubricating oil.

When the ambient temperature is low, it may be necessary to use an air heater or a starting fluid to assist ignition of the fuel.

> **NOTE:** Starting aids are NOT intended to correct for a low battery, heavy oil, or other conditions which cause hard starting. They are to be used only when other conditions are normal, but the air temperature is too cold for the heat of compression to ignite the fuel-air mixture.

FLUID STARTING AID

The fluid starting aid (Fig. 7) 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. This 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 the 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.

Start the engine, using the fluid starting aid, 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.

Service

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.

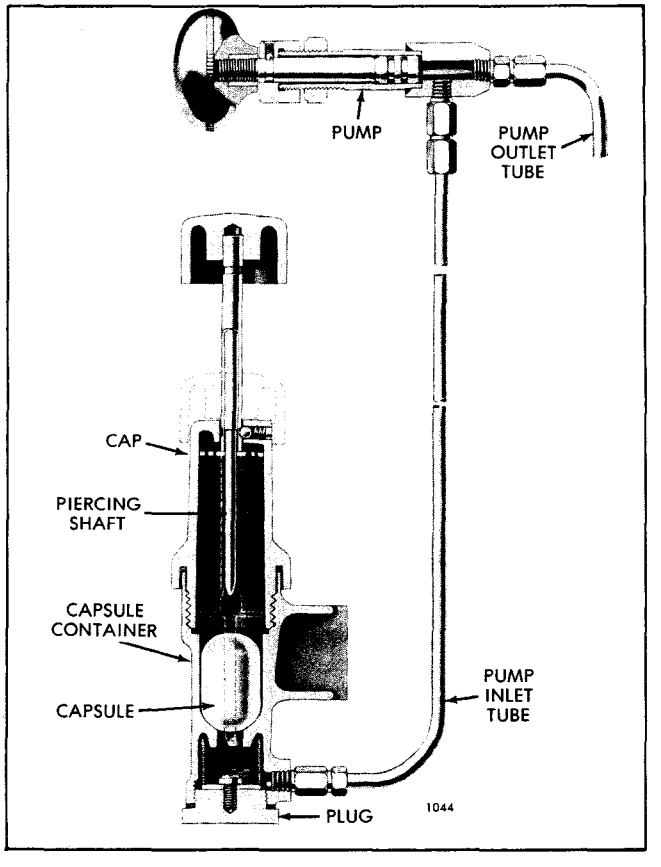

Fig. 7 - Typical Fluid Starting Aid

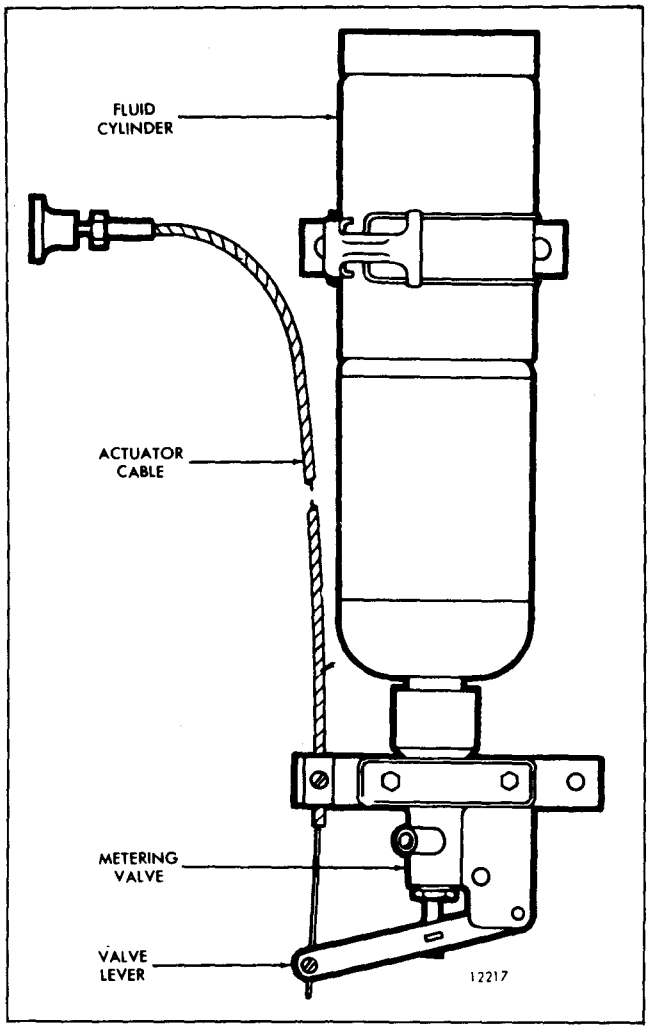

Fig. 8 - Quick Start Assembly

PRESSURIZED CYLINDER STARTING AID

Start the engine during cold weather, using the "Quick Start" starting aid system (Fig. 8) as follows:

1. Press the engine starter button.

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

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

> **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.

Service

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. 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.

GOVERNORS

Engine Governors

Horsepower requirements of an engine may vary continually due to the fluctuating loads; therefore, a 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 four types of governors is used on the engine, depending upon the application. Installations requiring maximum and minimum speed control, together with manually controlled intermediate speeds, ordinarily use a single or double-weight type 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 a uniform engine speed is required, under varying load conditions, with a minimum speed droop. Engines, subjected to varying load conditions that require automatic fuel compensation to maintain constant engine speed in a range somewhat higher or lower than the rated full-load speed, are equipped with a constant speed mechanical governor.

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.

Lubrication

Surplus oil from the cylinder head provides lubrication for the parts in the mechanical governor control housing. Oil picked up from a reservoir in the blower front end plate by a slinger attached to the lower rotor shaft provides lubrication for the governor weights and weight carrier. Some engines have a line carrying oil under pressure, through a restricted fitting, to the weight housing, providing additional lubrication.

The hydraulic governor is lubricated by oil under pressure from the engine.

Service

Fluctuations of the engine speed usually indicates governor malfunction. However, these fluctuations can also be caused by an excessive load on the engine, misfiring, or binding linkage. Contact an authorized *Detroit Diesel Allison Service Outlet* for information regarding governors.

Output Shaft Governors

On certain applications equipped with a Torqmatic converter, it is sometimes desirable to maintain a constant output shaft speed regardless of the engine speed or load fluctuations. To acquire the necessary results, a governor driven by the output shaft is installed in conjunction with an engine governor. This governor is called an output shaft governor and may be mechanical or hydraulic.

The output shaft governor controls the engine governor (usually a limiting speed type) in the engine speed range between idle and maximum speed. The engine speed is prevented from going below idle or exceeding the maximum speed setting by the engine governor. The following governor combination may be employed:

1. A mechanical output shaft governor and mechanical engine governor with the necessary connecting linkage.

2. A hydraulic output shaft governor and a mechanical engine governor with the necessary connecting linkage.

3. A dual hydraulic output shaft engine governor.

Service

Refer to the *Engine Tune-Up Procedures* for any adjustments to the output shaft governors or contact an authorized *Detroit Diesel Allison Service Outlet* for information regarding output shaft governors.

TRANSMISSIONS

This manual includes information on the lubrication and preventive maintenance of the transmissions. It also includes adjustment procedures covering some of the more common power transmissions.

Problems relating to the repair and overhaul of these transmissions should be referred to an authorized *Detroit Diesel Allison Service Outlet.*

POWER TAKE-OFF ASSEMBLIES

The front and rear power take-off units are basically similar in design, varying in clutch size to meet the requirements of a particular engine application.

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 or double plate clutch. The drive shaft is driven by the clutch assembly and is supported by a pilot bearing in the flywheel or the adaptor and by 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 a long clutch facing life and the best 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 8", 11-1/2" and 14" diameter clutches as follows:

1. Disengage the clutch with the hand lever.

2. Remove the inspection hole cover to expose the clutch adjusting ring.

3. Rotate the clutch, if necessary, to bring the clutch adjusting ring lock within reach.

4. On the 8" and 11-1/2" diameter clutches, remove the clutch adjusting ring spring lock screw and lock from the inner clutch pressure plate and adjusting ring. Then, while holding the clutch drive shaft to prevent the clutch from turning, turn the clutch adjusting ring counterclockwise as shown in Fig. 9 and tighten the clutch until the desired pressure on the outer end of the hand lever, or at the clutch release shaft (Fig. 11) is obtained, as shown in the table.

5. On the 14" diameter single and double plate clutches, raise the end of the adjusting ring lock up out of the splined groove in the hub of the outer clutch pressure plate. Then, while holding the clutch drive shaft to prevent the clutch from turning, turn the clutch adjusting ring clockwise as shown in Fig. 10 and tighten the clutch until the desired pressure on the outer end of the hand lever, or at the clutch release shaft (Fig. 11), is obtained as shown in the table.

6. Install the clutch adjusting ring spring lock on the 8" and 11-1/2" diameter clutches. The ends of the lock must engage the notches in the adjusting ring. On the 14" diameter clutch, reinstall the end of the adjusting ring lock in one of the splined grooves in the hub of the outer pressure plate. Then install the inspection hole cover.

When properly adjusted, the approximate pressure required at the outer end of the hand lever to engage the various diameter clutches is shown in Table 1. These specifications apply only with the hand lever which is furnished with the power take-off.

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

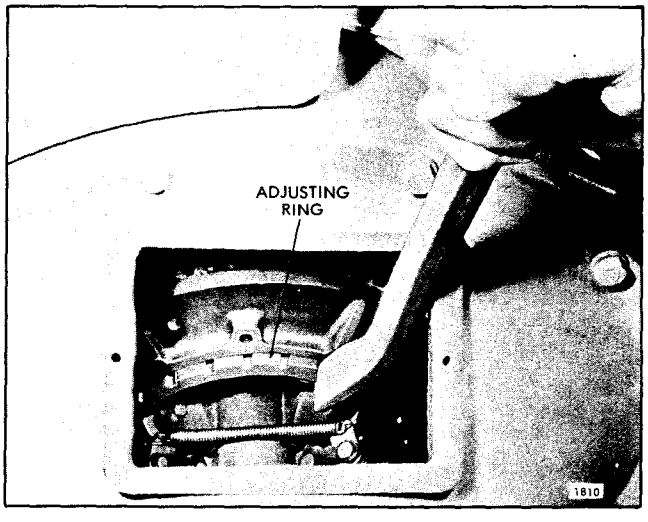

Fig. 9 - Power Take-Off Showing Typical 8" and 11-1/2" Diameter Clutch Adjustment Ring

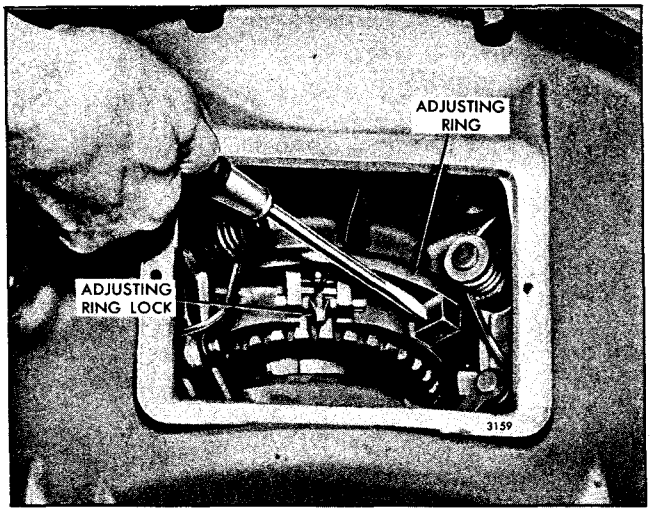

Fig. 10 - Power Take-Off Assembly Showing 14" Diameter Clutch Adjustment Ring

However, a more accurate method of checking the clutch adjustment is with a torque wrench as shown in Fig. 11.

To fabricate an adaptor, saw the serrated end off of a clutch hand lever and weld a 1-1/8" nut (across the hex) on it as shown in Fig. 11. Then saw a slot through the nut.

When checking the clutch adjustment with a torque wrench, engage the clutch slowly and note the amount of torque immediately before the clutch engages (goes over center). The specified torque is shown in Table 1.

The facings of the clutch discs wear only along the area where they contact the pressure plates during engagement. The area on each side of the disc beyond the pressure plates does not wear proportionately, thus resulting in a ridge. This ridge on three segment clutches can complicate the job of making an adjustment inasmuch as the top segment tends to drop down when the engine is stopped. This drop lets the ridge locate between the pressure plates. The drive ring cannot be properly adjusted to the recommended engaging pressure with the disc so positioned. The condition can result in excessive slippage and a need for early clutch facing replacement.

Make a final clutch adjustment check with the engine running, to make sure the adjustment was not made against the ridge. The procedure is outlined below:

1. Start the engine and operate it at idling speed (approximately 500 rpm) with the clutch disengaged.

Clutch Dia.	Hand Lever Length	Pressure		Torque	
		psi	kPa	lb-ft	Nm
8"	15-1/2"	55	379	56-63	76-85
8"	20"	40	276	56-63	76-85
11-1/2"	20"	65	448	94-100	127-136
11-1/2"	25"	50	345	94-100	127-136
14"	25"	75	517	132-149	179-202

TABLE 1

The speed will be sufficient to move the segments out to operating position.

2. Check the pounds pressure required to engage the clutch. The engagement pressure should be the same as that following the adjustment. If the clutch engages at a lower pressure, the adjustment was probably made against the unworn portion of the facing.

3. Stop the engine and readjust the clutch, making sure all disc segments are properly positioned. Install the inspection hole cover.

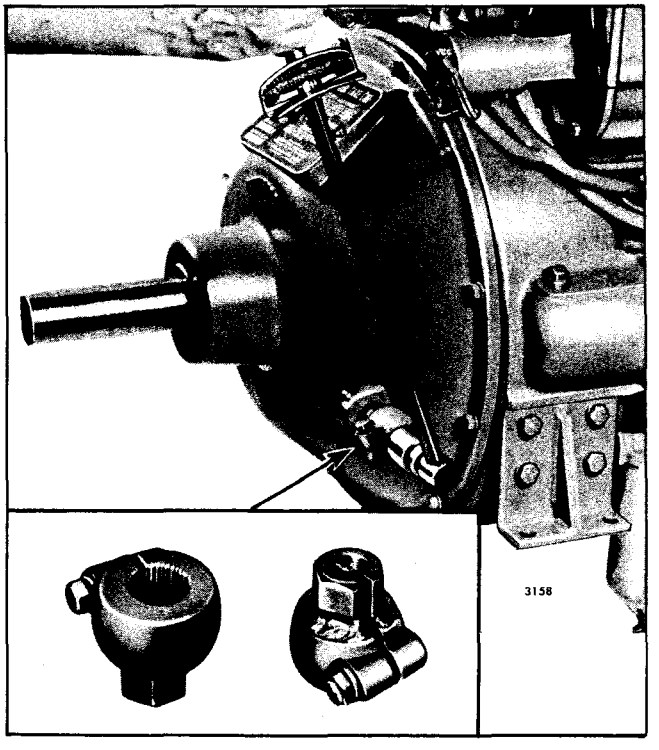

Fig. 11 - Power Take-Off Clutch Adjustment Check with Torque Wrench and Adaptor

POWER TRANSFER GEAR

The twin engine transfer gear is connected to the engines through mechanical clutches on industrial units or hydraulic marine gears on marine units.

The power of the two engines is transmitted through the clutches or hydraulic marine gears to the drive gears, then through a common driven gear to the power driven shaft.

In normal usage, the two clutches used on twin units are operated simulaneously and the engines perform as a single power plant. However, each engine has its own shifting mechanism permitting one or both engines to be cut out, thus providing a unit power output varying from idling speed on one engine to full throttle on both engines.

Each clutch is controlled by a hand lever mounted on a shaft common to the two levers. The shaft is supported in a bracket which in turn is bolted to the side of the gear box.

When a clutch is engaged, the lockout latch rests on the lever quadrant, and when the clutch is disengaged this latch enters a notch in the quadrant. If one engine is stopped and the other engine is in operation, the clutch on the shut-down engine must be disengaged and the latch lever should be locked out by removing the pin in the lockout latch.

Clutch Adjustment

The clutches used in twin industrial units require no adjustment. However, when the facings on the clutch disc are worn so the over-all thickness of the disc and facings is less than 11/32", the disc assembly should be changed.

Clutch Control Adjustment

If the clutch control links are replaced or the adjustment changed, readjust the clutch control as follows:

1. With the clutches engaged, connect each control link at the clutch shift lever with the pin.

2. Set both hand levers in a vertical position.

3. Loosen the lock nut and adjust the clevis on each link so a clevis pin will slip into place through the clevis and lever.

4. Lock the clevis pins with cotter pins.

REDUCTION GEAR FOR MARINE SIDE-BY-SIDE TWIN UNITS

Two hydraulic marine gears are mounted on the forward side of the reduction gear used with side-by-side twin marine units. Each reverse gear drive shaft is splined to and drives a pinion gear. The two pinion gears mesh with a common power driven gear which is bolted to a driven shaft. A flange is provided at the rear end of the power driven shaft for installing a propeller shaft.

REDUCTION GEAR FOR MARINE TANDEM TWIN UNITS

A hydraulic marine gear is mounted on the front and rear of the reduction gear used with tandem twin marine units. Each reverse gear drive shaft is splined to and drives a pinion gear. The two pinion gears mesh with a common power driven gear which is bolted to a driven shaft. A flange is provided at the rear end of the power driven shaft for installing a propeller shaft.

QUAD REDUCTION GEAR

The individual clutch housings of the four engines in an industrial quad unit are attached to a reduction gear assembly. Two clutch housings pilot into and are secured to the front of the reduction gear housing and two housings are attached in the same way to the rear. The clutch housings also pilot into and are bolted to the flywheel housing of each engine.

The marine quad unit has a similar reduction gear, differing only in certain internal details. On these quad units, the engines are connected to the reduction gear assembly by hydraulic reverse gears.

TORQMATIC MARINE GEAR

The Torqmatic marine gear is used on the single and multiple engine marine units. When used on the single engine units, the marine gear consists of a reverse gear section and a reduction gear section. This gear is produced in "M" and "MH" models, each being available in several gear ratios. These two models are basically similar.

The oil for operating the hydraulic clutches and for lubricating the reverse gear is contained in the reverse gear sump and is circulated throughout the system by a hydraulic oil pump mounted on the flywheel housing and driven from the blower drive shaft through a flexible coupling.

The oil pressure ranges for the marine gear at forward operating speed are 130 to 155 psi (896 to 1068 kPa) and 100 to 150 psi (758 to 1034 kPa) in reverse. The average operating oil temperature is 200° F (93° C) in forward and a maximum of 250° F (121° C) in reverse.

A strainer is used between the oil sump and the pump to remove harmful solids. The oil passes from the pump through a cooler to the control valve. From the control valve, the oil operates the forward or reverse clutch pistons and sprays oil into the reduction gear housing to lubricate the gear.

The constant flow control valve, incorporated with a pressure relief valve, controls the amount of oil pumped through the hydraulic system and is sensitive only to engine speed and operates independently of the pressure relief valve section which controls the pressure within the complete hydraulic system.

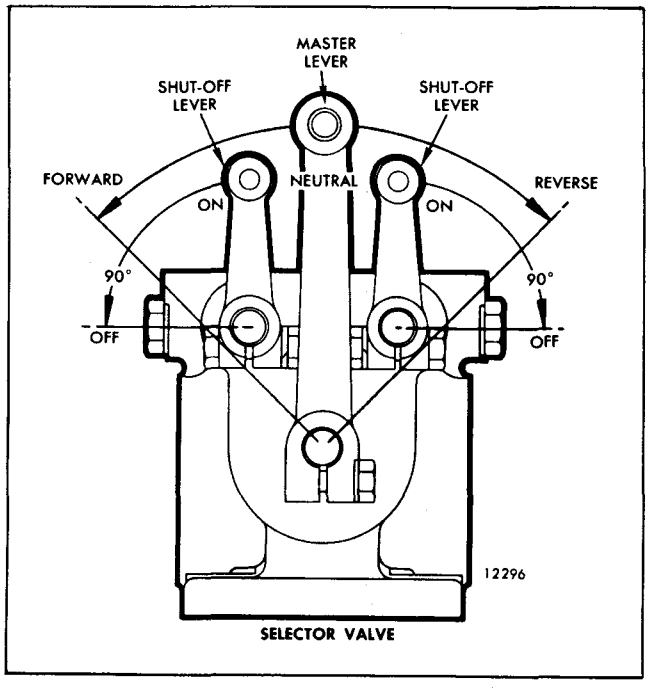

Fig. 12 - Operation of Selector Valve on Multiple Engine Units

When the engine is in operation, the moving parts of the marine reverse gear are pressure lubricated while the reduction gear assembly is splash lubricated.

Shifting from forward to reverse drive through neutral may be made at any speed; however, it is advisable to shift at low engine speeds. For longest clutch life, reduce the engine speed to idle, make the shift and then increase the engine speed.

The marine gear selector control valve assembly on the multiple engine units is provided with several levers (Fig. 12). The master control lever engages all of the marine gears in forward or reverse simultaneously. The smaller levers, one for each engine of the unit, operate the shut-off control valves for controlling the flow of oil to each individual engine marine gear. These levers are normally set in a vertical position ("on" position). To shut down one engine for service work or to conserve on power in a light-load situation, place the master control lever in the neutral position and then turn the shut-off lever for that engine to the "off" position (90 degrees toward the engine). With the shut-off lever in the "off" position, the marine gear for that engine is locked out of engagement. The other engines can then continue to supply power to the gear box.

> **CAUTION:** When the shut-off lever is turned to the *off* position, lock it in that position by wire or some other means to prevent vibration from moving it back up to the *on* position. This caution applies particularly when work is being done on the engine.

It is recommended that all sailing vessels and boats utilizing Torqmatic marine gears (single or twin screw installations) have a locking (brake) devise to prevent the propeller shaft from rotating while the sailing vessel is operating under sail, or the boat is operating with one engine shut down, or being towed.

With the engine shut down and the marine gear oil pump not operating, it cannot circulate lubricating oil through the reverse gear. Therefore, overheating and damage to the marine gear is possible unless the rotation of the propeller shaft is prevented.

If the clutches cannot be engaged hydraulically, in an emergency, the forward drive may be engaged with three bolts as follows:

1. Remove the large pipe plug from the forward face of the flywheel housing.

2. With the throttle in the *STOP* position, rotate the flywheel until one of the bolts aligns with the opening in the flywheel housing.

3. Remove the bolt from the flywheel.

4. Remove and save the jam nut, and replace the bolt finger-tight.

5. Remove and reinstall the remaining two bolts in the same manner.

6. Start at the first bolt and tighten all three bolts uniformly, thereby locking the clutch plate between the piston and the drive plate. Install the pipe plug in the flywheel housing.

NOTE: To prevent binding between the piston and the bore in the flywheel, the emergency engagement bolts must be tightened uniformly.

CAUTION: To prevent damaging the gear, do not use the reverse drive when the engagement bolts are engaged.

IMPORTANT: To reduce the possibility of overheating, add an additional gallon of oil if the forward clutch is engaged with the emergency engagement bolts and the hydraulic pump is inoperative.

MODEL HJ1 PARAGON MARINE REVERSE AND REDUCTION GEAR

The Paragon hydraulic marine gear is a self-contained assembly consisting of a hydraulically operated multiple disc clutch which is combined with a hydraulically actuated reversing gear train, an oil pressure regulator, an independent oil sump and a coolant jacket integral with the marine gear housing.

The oil pressure necessary for the operation of the marine gear is provided by an oil pump which is incorporated in the gear housing and driven continuously while the engine is running. The oil is delivered under pressure from the pump to a pressure relief valve and control valve.

The relief valve maintains a 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 90 to 150 psi (621 to 1034 kPa) and the maximum oil temperature is 250° F (121° C).

Water is circulated through a cored passage in the reverse gear housing to cool the gear oil.

The shift from forward to reverse drive through neutral may be made at any engine speed; however, to avoid possible damage to the engine, reverse gear or shaft, shift at a speed below 1000 rpm.

The marine reverse and reduction gear uses the same oil that is used in the engine and is pressure and splash lubricated. The quantity of oil in the marine gear will vary with the inclination of the different engine installations.

TORQMATIC CONVERTERS

The Torqmatic converter is a self contained unit which transfers and multiplies the torque of the prime mover. This unit transmits the power through the action of oil instead of through gears and in addition to multiplying the torque also acts as a fluid coupling between the engine and the equipment to be powered. The converter will automatically adjust the output torque to load requirements.

There are various combinations of Torqmatic Converters with features such as: an automotive or industrial flange on the shaft, a hydraulically operated lock-up clutch, a manual input disconnect clutch, and an accessory drive for either a governor or tachometer.

Check the oil level daily and, if the converter is equipped with an input disconnect clutch, additional checks and service will be necessary daily or at intervals determined by the type of operation.

Adjust the disconnect clutches as outlined under power take-off clutch adjustment.

Contact an authorized *Detroit Diesel Allison Service Outlet* for information on Torqmatic converters.

TORQMATIC MARINE GEAR

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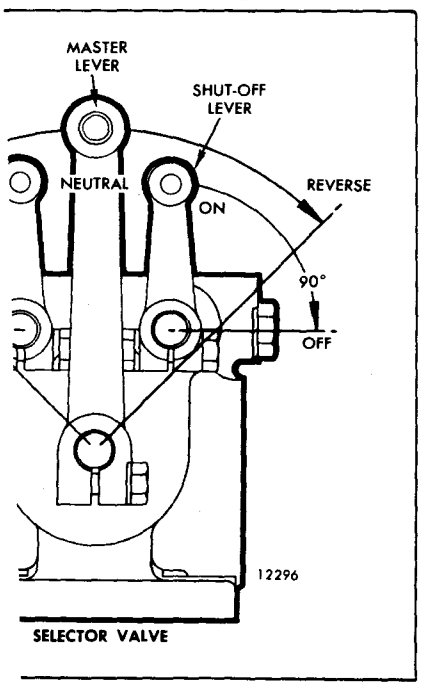


:ration of Selector Valve on tiple Engine Units

pressure relief valve, controls the amount of oil pumped through the hydraulic system and is sensitive only to engine speed and operates independently of the pressure relief valve section which controls the pressure within the complete hydraulic system.

When the engine is in operation, the moving parts of the marine reverse gear are pressure lubricated while the reduction gear assembly is splash lubricated.

Shifting from forward to reverse drive through neutral may be made at any speed; however, it is advisable to shift at low engine speeds. For longest clutch life, reduce the engine speed to idle, make the shift and then increase the engine speed.

The marine gear selector control valve assembly on the multiple engine units is provided with several levers (Fig. 12). The master control lever engages all of the marine gears in forward or reverse simultaneously. The smaller levers, one for each engine of the unit, operate the shut-off control valves for controlling the flow of oil to each individual engine marine gear. These levers are normally set in a vertical position ("on" position). To shut down one engine for service work or to conserve on power in a light-load situation, place the master control lever in the neutral position and then turn the shut-off lever for that engine to the "off" position (90 degrees toward the engine). With the shut-off lever in the "off" position, the marine gear for that engine is locked out of engagement. The other engines can then continue to supply power to the gear box.

> **CAUTION:** When the shut-off lever is turned to the *off* position, lock it in that position by wire or some other means to prevent vibration from moving it back up to the *on* position. This caution applies particularly when work is being done on the engine.

It is recommended that all sailing vessels and boats utilizing Torqmatic marine gears (single or twin screw installations) have a locking (brake) devise to prevent the propeller shaft from rotating while the sailing vessel is operating under sail, or the boat is operating with one engine shut down, or being towed.

With the engine shut down and the marine gear oil pump not operating, it cannot circulate lubricating oil through the reverse gear. Therefore, overheating and damage to the marine gear is possible unless the rotation of the propeller shaft is prevented.

If the clutches cannot be engaged hydraulically, in an emergency, the forward drive may be engaged with three bolts as follows:

OPERATING INSTRUCTIONS

ENGINE OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME

Before starting an engine for the first time, carefully read and follow the instructions listed below and in the *Engine Tune-Up Procedure.* Attempting to run the engine before studying these instructions may result in serious damage to 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.*

Cooling System

Install all of the drain cocks or plugs in the cooling system (drain cocks are removed for shipping).

Open the cooling system vents, if the engine 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 type antifreeze, if the engine will be exposed to freezing temperatures (refer to *Engine Coolant).* Keep the liquid level about two inches below the filler neck to allow for fluid expansion.

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

Close the vents, if used, after filling the cooling system.

On marine installations, prime the raw water cooling system and open any sea cocks in the raw water pump intake line. Prime the raw water pump by removing the pipe plug or electrode provided in the pump outlet elbow and pour water in the pump.

> **CAUTION:** Failure to prime the raw water pump may result in damage to the pump impeller.

Lubrication System

The lubricating oil film on the rotating parts and bearings of a new or overhauled engine, or one which has been in storage, may be insufficient for proper lubrication when the engine is started for the first time.

It is recommended that the engine lubricating system be charged with a pressure prelubricator, set to supply a minimum of 25 psi (172 kPa) oil pressure, to ensure an immediate flow of oil to all bearings at the initial engine start-up. The oil supply line should be attached to the engine so that oil under pressure is supplied to the main oil gallery.

With the oil pan dry, use the prelubricator to prime the engine with sufficient oil to reach all bearing surfaces. Use *heavy-duty* lubricating oil as specified under *Lubricating Oil Specifications.* Then remove the dipstick, wipe it with a clean cloth, insert and remove it again to check the oil level in the oil pan. Add sufficient oil, if necessary, to bring it to the full mark on the dipstick. Do not overfill.

If a pressure prelubricator is not available, fill the crankcase to the proper level with *heavy-duty* lubricating oil as specified under *Lubricating Oil Specifications.* Then pre-lubricate the upper engine parts by removing the valve rocker cover and pouring lubricating oil, of the same grade and viscosity as used in the crankcase, over the rocker arms.

Turbocharger

Disconnect the tubocharger oil inlet line and pour approximately one pint of clean engine oil in the line, thus making sure the bearings are lubricated for the initial start. Reconnect the oil line.

Air Cleaner

If the engine is equipped with oil bath air cleaners, fill the air cleaner oil cups to the proper level with clean engine oil. *Do not overfill.*

Transmission

Fill the transmission case, marine gear or torque converter supply tank to the proper level with the lubricant specified under *Lubrication and Preventive Maintenance.*

Fuel System

Fill the 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, fill the fuel system between the pump and the fuel return manifold with fuel. If the engine has been out of service for a considerable length of time, prime the filter between the fuel pump and the injectors. 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 the fuel lines and the injectors are full of fuel before attempting to start the engine.

NOTE: The fuel system 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 grease cups and lubricate at all fittings with an 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.

Generator Set

Where applicable, fill the generator end bearing housing with the same lubricating oil as used in the engine.

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

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

Clutch

Disengage the clutch, if the unit is so equipped.

STARTING

Before starting the engine 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 shutdown system is incorporated in the unit, the control must be set in the open position before starting the engine. The blower will be seriously damaged if operated with the air shut-off valve in the closed position.

Starting at air temperatures below 40°F (4°C) requires the use of a cold weather starting aid. See *Cold Weather Starting.*

The instructions for the use of a cold weather fluid starting aid will vary dependent on the type being used. Reference should be made to these instructions before attempting a cold weather start.

CAUTION: Starting fluid used in capsules is highly inflammable, toxic and possesses anesthetic properties.

Initial Engine Start (Electric)

Start an engine equipped with an electric starting motor as follows: Set the speed control lever at part throttle, then bring it back to the desired no-load speed. In addition, on mechanical governors, make sure the stop lever on the governor cover is in the *run* position. On hydraulic governors, make sure the stop knob is pushed all the way in. Then 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.

On twin or quad units, move the master throttle lever to the *idle* position and engage the starting motors one at a time.

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

Initial Engine Start (Hydrostarter)

Start an engine equipped with a hydrostarter as follows:

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

Raise the hydrostarter accumulator pressure with the hand pump until the gage reads as indicated in Table 1.

Ambient Temperature	Pressure Gage Reading	
	psi	kPa
Above 40° F (4° C)	1500	10-335
40° F to 0° F (4° to -18° C)	2500	17-225
Below 0° F (-18° C)	3300	27-737

TABLE 1

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

NOTE: During cold weather, add starting fluid at the same time the hydrostarter motor lever is moved. Do not wait to add the fluid after the engine is turning over.

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 pressure indicated within 10 to 15 seconds, stop the engine and check the lubricating oil system. The normal and minimum oil pressures are shown in Table 2.

OIL PRESSURE

Engine	3, 4, 6-71		71N		71M		71T	
Speed (rpm)	psi	kPa	psi	kPa	psi	kPa	psi	kPa
1200 Normal	30-60	207-414	30-60	207-414	–	–	–	–
Minimum	18	124	18	124	–	–	–	–
1500 Normal	–	–	–	–	–	–	35-60	241-414
Minimum	–	–	–	–	–	–	23	159
1800 Normal	38-60	262-414	38-60	262-414	38-60	262-414	40-60	276-414
Minimum	27	186	27	186	27	186	28	193
2000 Normal	–	–	–	–	–	–	40-60	276-414
Minimum	–	–	–	–	–	–	30	207
2100 Normal	40-60	276-414	40-60	276-414	40-60	276-414	40-60	276-414
Minimum	30	207	30	207	30	207	30	207
2300 Normal	40-60	276-414	–	–	40-60	276-414	40-60	276-414
Minimum	30	207	–	–	30	207	30	207

TABLE 2

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 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 coolant, fuel or lubricating oil leaks. Tighten the line connections where necessary to stop leaks.

Engine Temperature

Normal engine coolant temperature is 160° to 185° F (71° to 85° C).

Crankcase

If the engine crankcase was refilled, stop the engine after normal operating temperature has been reached, allow the oil to drain (approximately 20 minutes) back into the crankcase and check the oil level. Add oil, if necessary, to bring it to the proper level on the dipstick.

Use only the *heavy duty* lubricating oil specified under *Lubricating Oil Specifications.*

Clutch

Do not engage the clutch (with a sintered iron clutch plate) at engine speeds over 850 rpm. A clutch with an asbestos or vegetable fiber material clutch plate must not be engaged at 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.

Transmission

Check the marine gear oil pressure. The Torqmatic marine gear oil pressure taken at the control valve assembly for the hydraulic system is between 130 to 155 psi (896 to 1068 kPa) in forward and 110 to 150 psi (758 to 1034 kPa) in reverse.

Turbocharger

Make a visual inspection of the turbocharger for leaks and excessive vibration. Stop the engine immediately if there is an unusual noise in the turbocharger.

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

Normal Stopping

1. Release the load and decrease the engine speed. Put all shift levers in the *neutral* position.

2. Allow the engine to run at half speed or slower with no load for a short time, then move the stop lever to the *stop* position to stop the engine.

Emergency Stopping

If the engine does not stop after using the normal stopping procedure, pull the *Emergency Stop* knob all the way out. This control cuts off the air to the engine. Do not try to restart again until the cause for the malfunction has been found and corrected.

CAUTION: The emergency shutdown system should never be used except in an emergency. Use of the emergency shutdown can cause oil to be sucked past the oil seals and into the blower housing.

The air shut-off valve, located on the blower air inlet housing, must be reset by hand and the *Emergency Stop* knob pushed in before the engine is ready to start again.

Fuel System

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

Exhaust System

Drain the condensation from the exhaust line or silencer.

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. Add oil, if necessary, to bring it to the proper level on the dipstick.

Transmission

Check and, if necessary, replenish the oil supply in the transmission.

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 of the daily maintenance operations. Also perform the operations required for the number of hours or miles the engine 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 SET OPERATING INSTRUCTIONS

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

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 Operating Instructions* the following instructions also apply when operating an alternating current power generator set.

1. Before the first start, check the generator main bearing oil reservoir. If necessary, add sufficient lubricating oil of the same grade that is used in the engine crankcase to bring it to the proper level on the sight gage. *Do not overfill.*

2. Check the interior of the generator for dust or moisture. Blow out dust with low pressure air (25 psi or 172 kPa maximum). If there is moisture on the interior of the generator, it must be dried before the set is started. Refer to the appropriate *Delco Products Maintenance Bulletin.*

3. The overspeed trip solenoid lever located at the air inlet housing must be in the open or reset position.

4. Refer to Fig. 1 and place the circuit breaker (10) in the *OFF* position.

5. Place the field switch (7) in the *OFF* position.

6. Place the synchronizing lamp switch (6) in the *OFF* position.

7. Place the voltage regulator switch (3) in the *OFF* or *MANUAL* position.

8. Turn the field rheostat knob (8) clockwise to its lower limits.

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

STARTING

If the generator set is operated 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 (4 ° C). Refer to *Cold Weather Starting Aids.*

Press the throttle button (15) and turn the throttle control (16), Fig. 1, counterclockwise to a position midway between *RUN* and *STOP.* Then press the starter button (18) firmly.

If the engine fails to start within 30 seconds, release the starter button 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 starting motor is rotating.

RUNNING

If the oil pressure is observed to be normal, increase the throttle setting to cause the engine to run at its synchronous speed.

PREPARING GENERATOR FOR LOAD

After the engine has warmed up (or the oil pressure has stabilized), prepare the generator set for load as follows:

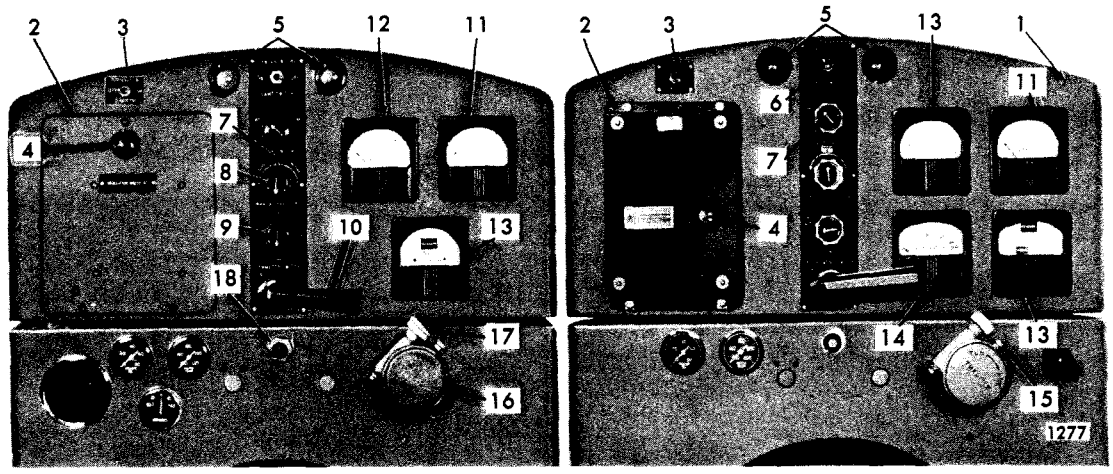
1. Bring the engine up to rated speed. Then place the field switch (7), Fig. 1, in the *ON* position.

2. Turn the voltage regulator switch (3) *ON.*

3. Turn the instrument selector switch (9) to the desired position.

4. Turn the field rheostat (8) slowly in a counterclockwise direction to raise the voltage, while watching the voltmeter, until the rheostat reaches the end of its travel. The voltage regulator will take control of the generator voltage as the field rheostat reaches the end of its travel.

5. If the power generator unit is equipped with a



1. Cabinet--Control
2. Regulator--Voltage
3. Switch--Voltage Regulator
4. Control--Voltage Regulator Rheostat
5. Lamps--Synchronizing
6. Switch--Synchronizing Lamp
7. Switch--Field
8. Control--Manual Field Rheostat
9. Switch--Selector
10. Control--Circuit Breaker
11. Ammeter
12. Voltmeter
13. Frequency Meter
14. Kilowatt Meter
15. Button--Throttle
16. Control--Throttle
17. Knob--Vernier Throttle
18. Switch--Engine Starting

Fig. 1 - Typical Alternating Current Generator Control Cabinets

frequency meter, adjust the engine speed with the vernier throttle knob (17) until the desired frequency is indicated on the meter.

6. Adjust the voltage regulator rheostat (4) to obtain the desired voltage.

7. Make sure all power lines are clear of personnel, then place the circuit breaker control (10) in the *ON* position.

> **NOTE:** Perform Step 7 only if the set is not being paralleled with an existing power source. If the set 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 set to be placed on the line, the following instructions will apply to power generator sets of *equal capacity,* with one set in operation on the line.

1. Prepare the set to be paralleled as outlined under *Preparation For Starting, Starting, Running* and Items 1 through 6 under *Preparing Set For Load.*

2. Check the voltmeter (12), Fig. 1; the voltage must be the same as the line voltage. Adjust the voltage regulator rheostat control (4) if the voltages are not the same.

3. Place the synchronizing lamp switch (6), of the generator set to be paralleled, in the *ON* position.

4. Turn the vernier throttle knob (17) until both sets are operating at approximately the same frequency, 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 set on the line with no load. The proper share of the existing load must now be placed on this set.

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 sets by turning the vernier throttle knob (17) counterclockwise on the incoming set and clockwise on the set that has been carrying the load (to keep the frequency of the sets constant) until both kilowatt meters indicate that each set is carrying its proper percentage of the total K.W. load. Refer to Item 8 if the sets are not equipped with kilowatt meters.

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 sets by turning the voltage regulator rheostat control on the incoming set (generally counterclockwise to raise the voltage) until the ammeters read the same on both sets and the sum of the readings is minimum.

NOTE: The generator sets 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 unity power factor (lighting and a few small motors only) follow the instructions in Item 6 above until both ammeters read the same.

9. When the load is 80 per cent power factor lagging (motor and a few lights only), turn the vernier throttle knob (17) on the incoming set until the ammeter on that set reads approximately 40 per cent of the total current load.

10. Rotate the voltage regulator rheostat control (4) on the incoming set (generally counterclockwise to raise the voltage) until the ammeters read the same on both sets.

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 (4) on the incoming set, if necessary.

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

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

STOPPING

The procedure for stopping a power generator set or taking a set out of parallel is as follows:

1. Turn off all of the load on the generator when stopping a single engine unit. Shift the load from the generator when taking a set out of parallel operation by turning the vernier throttle knob (17), Fig. 1, until the ammeter (11) reads approximately zero.

2. Place the circuit breaker control (10) in the *OFF* position.

3. Turn the field rheostat (8) to the fully clockwise position.

4. Turn the voltage regulator switch (3) to the *OFF* position.

5. Place the field switch (7) in the *OFF* position.

6. Press the throttle button (15) and turn the throttle control (177) to *STOP* to shut down the engine.

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

DIRECT CURRENT POWER GENERATOR SET OPERATING INSTRUCTIONS

These instructions cover the fundamental procedures for operating a direct current power generator set. The operator should read these instructions before attempting to operate the set.

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 Operating Instructions,* the following instructions also apply when operating a direct current power generator set.

1. Before the first start, check the generator main bearing oil reservoir. If necessary add sufficient lubricating oil, of the same grade that is used in the engine crankcase, to bring it to the proper level on the sight gage. *Do not overfill.*

2. Check the interior of the generator for dust or moisture. Blow out dust with low pressure air (25 psi or 172 kPa maximum). If there is moisture on the interior of the generator, it must be dried before the set is started. Refer to the appropriate *Delco Products Maintenance Manual.*

3. The overspeed trip solenoid lever located at the air inlet housing must be in the open or reset position.

4. Refer to Fig. 2 and place the circuit breaker (6) in the *OFF* position.

5. Place field switch (5) in the *OFF* position.

6. Place the ground lamp switch (4) in the *OFF* position.

7. Turn the manual field rheostat control (2) counterclockwise to its lowest limit.

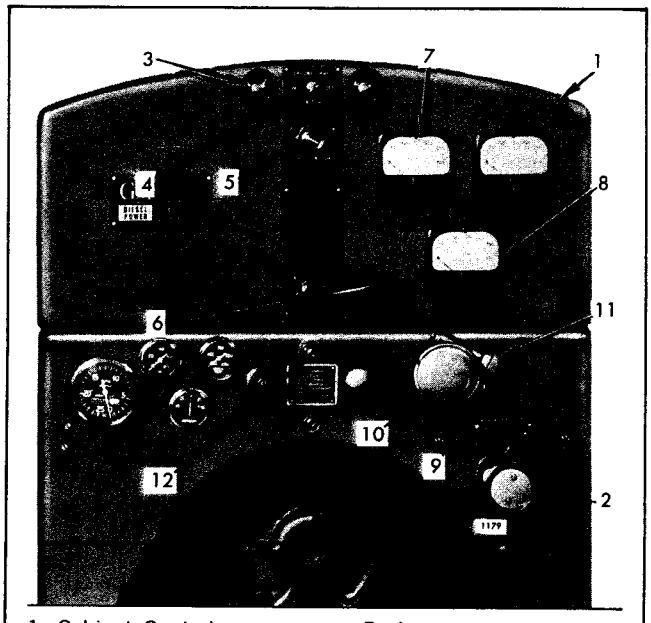
8. Make sure the power generator set has been cleared of all tools or other objects which might interfere with its operation.

STARTING

If the generator is operated in a closed space, start the ventilating fan or open the doors and windows, as weather conditions permit, 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 (4° C). Refer to *Cold Weather Starting Aids.*

Press the throttle button (9) and turn the throttle control (10), Fig. 2, counterclockwise to a position midway between *RUN* and *STOP.* Then press the starter button (12) firmly.



1. Cabinet--Control
2. Control--Manual Field Rheostat
3. Lamp--Ground
4. Switch--Ground Lamp
5. Switch--Field
6. Control--Circuit Breaker
7. Ammeter
8. Voltmeter
9. Button--Throttle
10. Control--Throttle
11. Knob--Vernier Throttle
12. Switch--Engine Starting

Fig. 2 - Typical Control Cabinet

If the engine fails to start within 30 seconds, release the starter button 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 button again while the starting motor is rotating.

RUNNING

If the oil pressure is observed to be normal, increase the throttle setting to cause the engine to run at its synchronous speed.

PREPARING SET FOR LOAD

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

1. Rotate the throttle control (10), Fig. 2, counterclockwise to the *RUN* position.

2. Turn the vernier throttle knob (11) and adjust the engine speed approximately 50 rpm above the rated full-load speed.

NOTE: The speed droop is set at the factory and adjustment should be unnecessary. However, if required, reset the speed droop as outlined under *Engine Tune-Up.*

3. If the set is equipped with a field switch (5), turn it to *ON.*

4. Observe the voltmeter (8) and turn the manual field rheostat control (2) to the desired voltage.

5. Make sure all power lines are clear of personnel, then place the circuit breaker control (6) in the *ON* position.

NOTE: Perform Step 5 only if the set is not being paralleled with an existing power source. If the set 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.

Check the electrical circuit occasionally with the ground lamps. While the set is in operation, turn the ground lamp switch *ON.* If both lamps are dim and of equal brilliance, the circuit is satisfactory. If one lamp remains dark and the other is bright, a ground exists in one of the power leads.

PARALLELING

If the load conditions require an additional set to be placed on the line, the following instructions will apply to power generator sets equipped with equalizer connections only. Do not attempt to parallel sets without equalizer connections.

On "flat compound wound" two-wire direct current generators, it is necessary to connect the equalizer leads together for stable operation. The equalizer cables should have a current carrying capacity equal to or larger than the cables necessary to carry the required load. On generators equipped with a three-wire system, a two-pole knife switch must be placed in the equalizer lines.

Do not use parallel operation if one set is capable of carrying the required load, as both engine and generator operate more efficiently when operating alone at full load.

1. Prepare the set to be paralleled as outlined under *Preparation For Starting, Starting, Running* and Items 1 through 4 under *Preparing Set for Load.*

2. Adjust the speed to *no-load* operating speed with the vernier throttle knob (Fig. 2).

3. Adjust the manual field rheostat control (2) of the incoming set until the voltage is the same as the existing line voltage.

4. Close the switch in the equalizer lines and then place the circuit breaker control (6) in the *ON* position.

5. Adjust the manual field rheostat control to divide the line load equally.

STOPPING

The procedures for stopping a power generator set or taking a set out of parallel is as follows:

1. Turn off all of the load on the generator when stopping a single engine generator set. Shift the load from the generator when taking a set out of parallel operation by turning the manual field rheostat control (2), Fig. 2, until the ammeter (7) reads approximately zero.

2. Place the circuit breaker control (6) in the *OFF* position.

3. Open the switch in the equalizer lines.

4. Turn the manual field rheostat control counterclockwise to the lowest position.

5. Press the throttle button (9) and turn the throttle control (10) to *STOP* to shut down the engine.

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

LUBRICATION AND PREVENTIVE MAINTENANCE

To obtain the best performance and long life 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 an engine and not to a new engine or one that has not been operated for a considerable period of time. For new or stored engines, carry out the 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 or miles of an engine. If the lubricating oil is drained immediately after an engine has been run for some time, most of the sediment will be in suspension and, therefore, will drain readily.

All authorized *Detroit Diesel Allison 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								
	Hours	8	50	100	200	300	500	1,000	2,000
Item Operation	Miles Daily	240	1,500	3,000	6,000	9,000	15,000	30,000	60,000
1. Engine Oil	X								
2. Oil Filter*									
3. Coolant and Filter	X						X	X	
4. Hoses							X		
5. Radiator								X	
6. Heat Exchanger Electrodes and Core							X	X	
7. Raw Water Pump	X								
8. Fuel Tank	X						X		
9. Fuel Strainer and Filter						X			
10. Air Cleaners		X					X		
11. Air Box Drains								X	
12. Ventilating System								X	
13. Blower Screen								X	
14. Starting Motor*									
15. Battery-Charging Alternator				X	X		X		X
16. Battery				X					
17. Tachometer Drive				X					
18. Throttle and Clutch Controls					X				
19. Engine Tune-Up*									
20. Drive Belts					X				
21. Overspeed Governor							X		
22. Fan Hub Bearings*									
23. Shut-Down System						X			
24. Hydrostarter System*									
25. Air Compressor Air Strainer					X				
26. Turbocharger*									
27. Power Generator				X		X			
28. Power Take-Off		X	X				X		
29. Torqmatic Converter	X		X				X	X	
30. Torqmatic Marine Gear	X				X				
31. Paragon Marine Gear	X				X				
32. Reduction Gear (Single Engine)		X	X				X	X	
33. Reduction Gear (Multiple-Industrial)	X							X	
34. Reduction Gear (Multiple-Marine)	X				X				
35. Transmission (Railcar)	X							X	
36. Oil Filter (Railcar)*									

* 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.

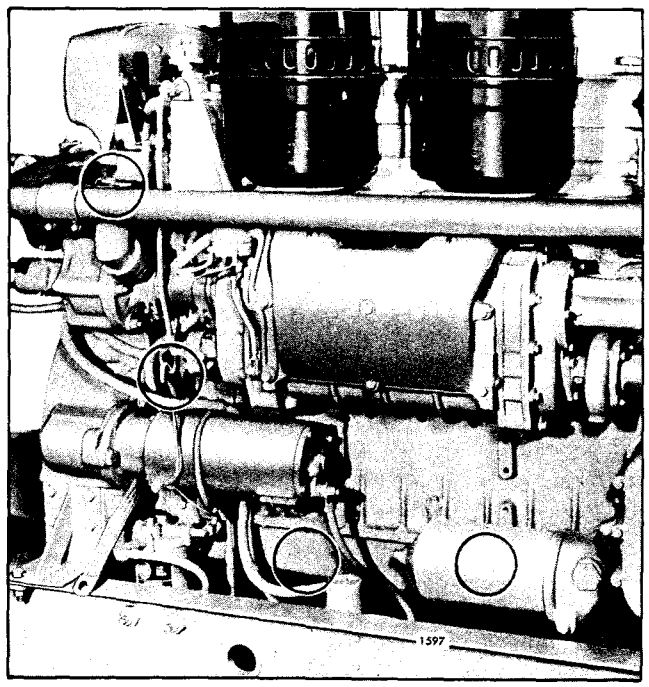
Select the proper grade of oil in accordance with the instructions given in the *Lubricating Oil Specifications.*

It is recommended that new engines be started with 100 hour oil change periods. The drain interval may then be gradually increased, or decreased, following the recommendations of an independent oil analysis laboratory or the oil supplier (based upon the oil sample analysis) until the most practical oil change period has been established.

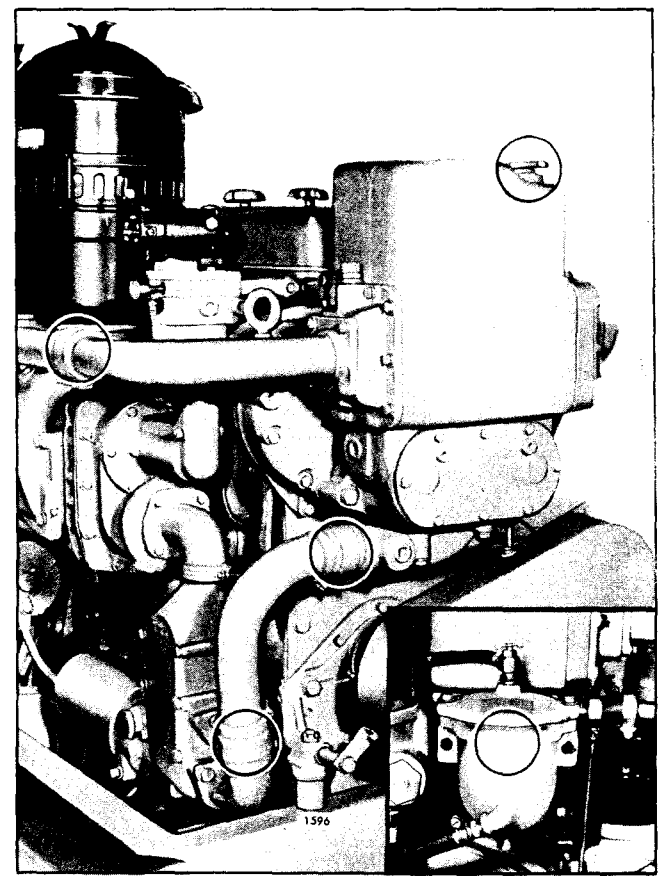
Item 2

Change the engine oil filter elements and gaskets each time the engine oil is changed. Any deviation, such as changing filters every other oil change, should be based on a laboratory analysis of the drained oil and used filter elements to determine if such practice is practical for proper protection of the engine.

Make a visual check of all lubricating oil lines for wear and chafing. If any indication of wear is evident, replace the oil lines and correct the cause.



Items 1 and 2



Items 3 and 4

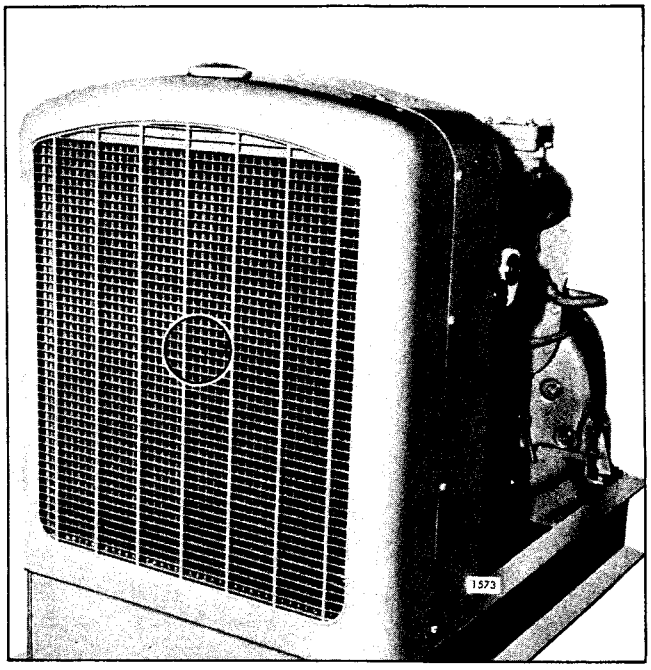
If the engine is equipped with a governor oil filter, change the element every 1,000 hours.

Item 3

Check the coolant level daily and maintain it near the top of the heat exchanger tank or 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 container. After the cleaning operation, 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 (refer to *Engine Coolant).* 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 cooling system is protected by a coolant filter



Item 5

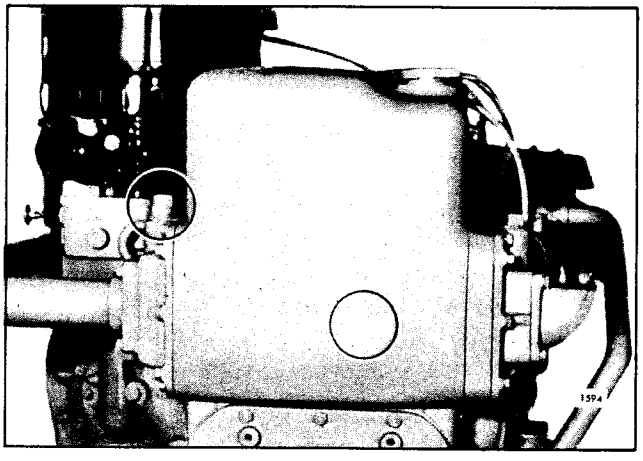
and conditioner, the filter element should be changed every 500 hours or 15,000 miles.

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



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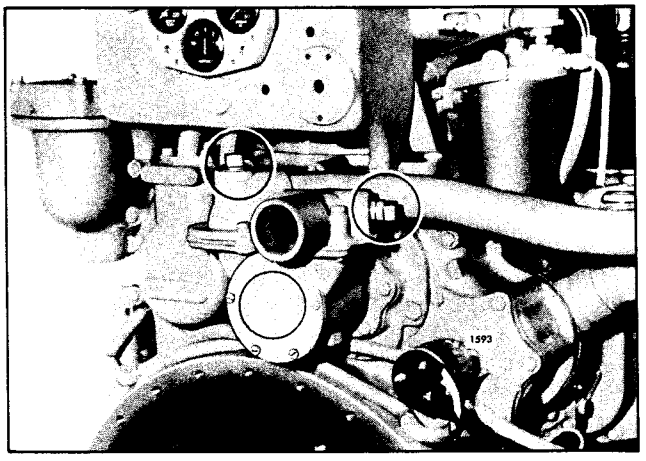


Item 7

hours or 30,000 miles and, if necessary, clean it with a quality grease solvent such as Oleum and dry it with compressed air. *Do not use fuel oil, kerosene or gasoline.* It may be necessary to clean the radiator more frequently if the engine is being operated in extremely 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 electrodes from the inlet side of the raw water pump and the heat exchanger. Clean the electrodes with a wire brush or, if worn excessively, replace with new electrodes. To determine the condition of a used electrode, strike it sharply against a hard surface; a weakened electrode will break.

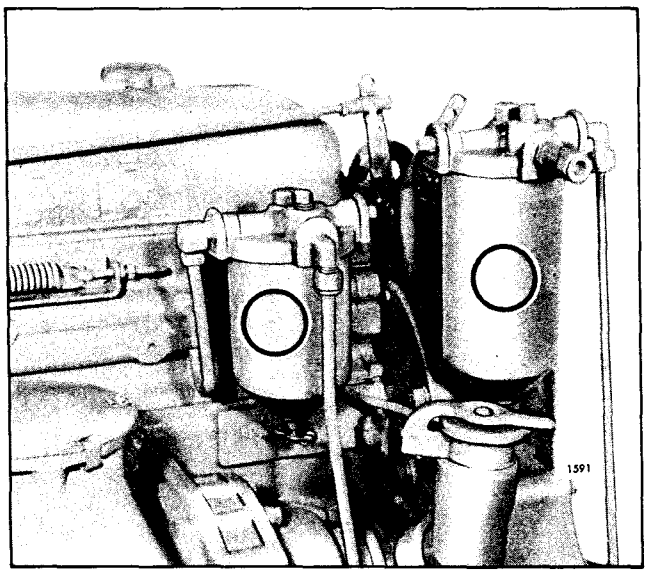
Drain the cooling system, disconnect the raw water pipes at the outlet side of the heat exchanger and remove the retaining cover every 1,000 hours and inspect the heat exchanger core. If a considerable amount of scale or deposits are present, contact a *Detroit Diesel Allison Service Outlet.*

Item 7

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

Item 8

Keep the fuel tank filled to reduce condensation to a minimum. Select the proper grade of fuel in accordance with the *Diesel Fuel Oil Specifications.*



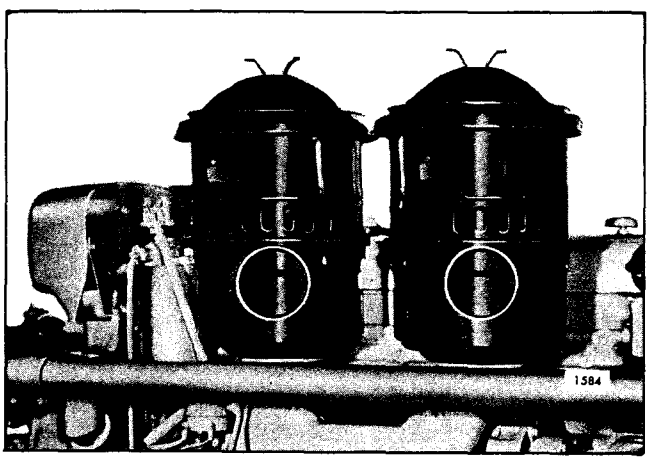
Item 9

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

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 (1600-2100 rpm), the fuel pressure is 45 to 70 psi (310 to 483 kPa). Change the fuel filter



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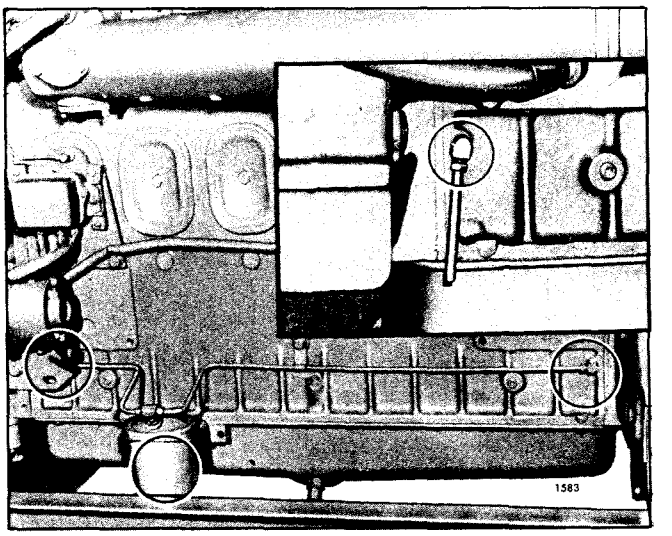


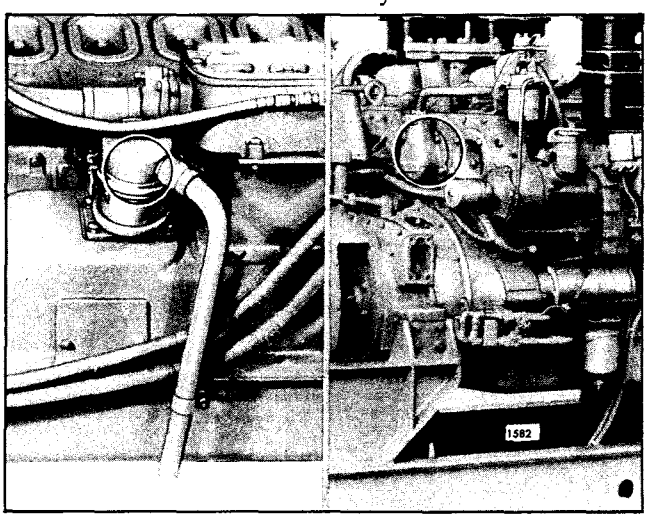
Item 11

elements whenever the inlet restriction (suction) at the fuel pump reaches 12 inches of mercury at normal operating speeds and whenever the fuel pressure at the inlet manifold falls to 45 psi (310 kPa).

Item 10

Remove the dirty oil and sludge from the oil bath type air cleaner cups and center tubes every 8 hours, 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 and viscosity *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



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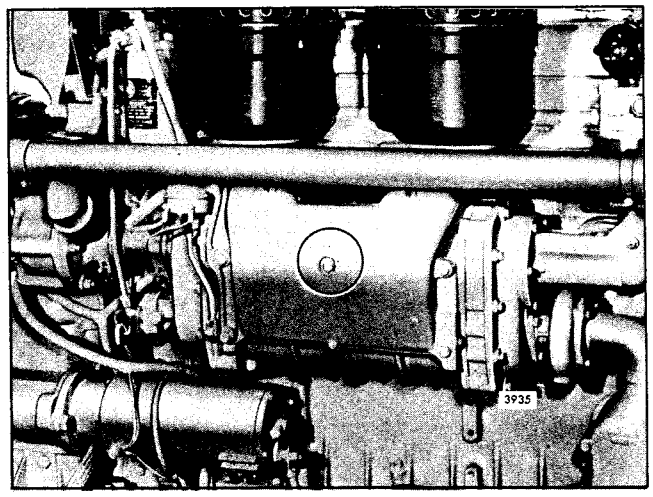


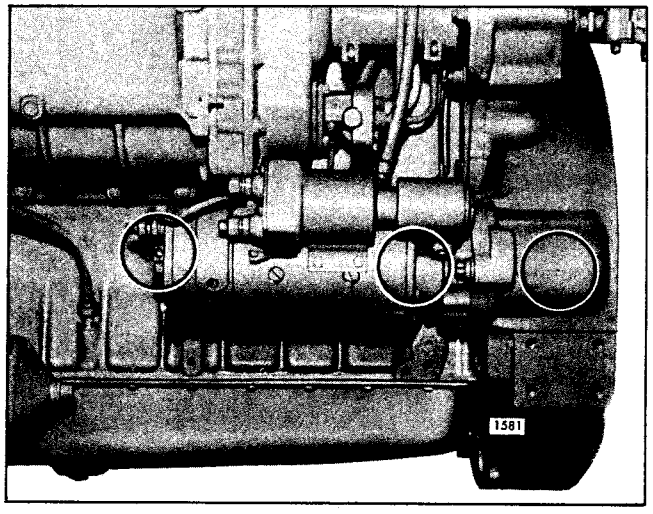
Item 13

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 Donaldson "Cyclopac" air cleaner when the restriction indicator instrument indicates high restriction or when a water manometer reading at the air inlet housing indicates the maximum allowable air inlet restriction. Refer to the instructions in the *Air System* section for the servicing of the dry type air cleaner.

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



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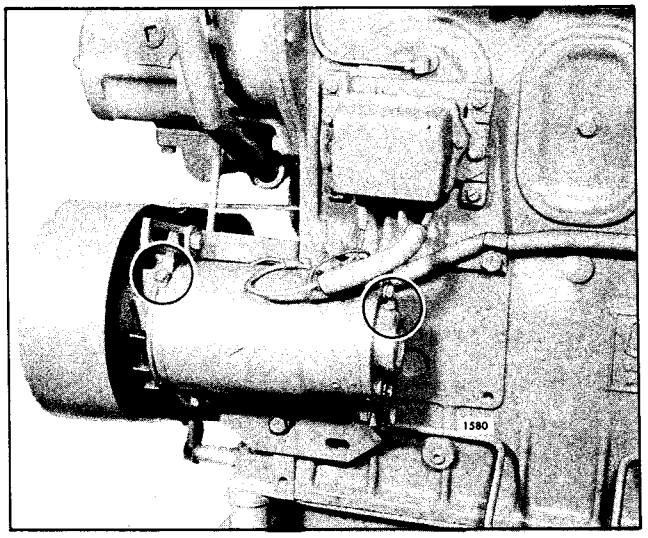


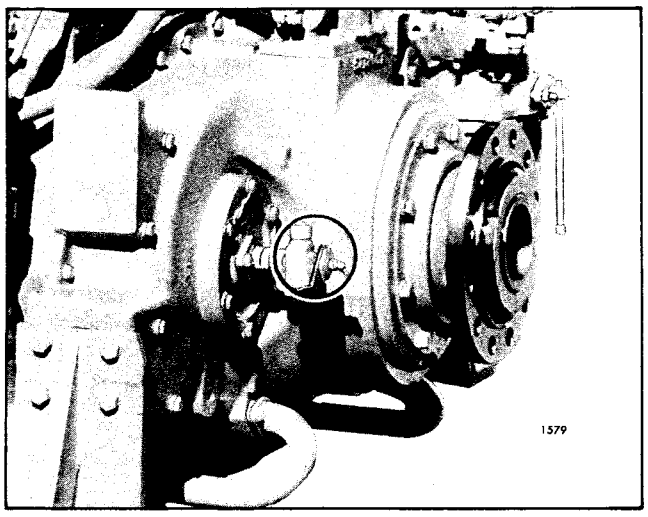
Item 15

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.

Item 12

Remove the externally mounted crankcase breather assembly every 1,000 hours or 30,000 miles and wash the steel mesh pad in clean fuel oil. This cleaning period may be reduced or lengthened according to severity of service.

Clean the breather cap, mounted on the valve rocker cover, in clean fuel oil every time the engine oil is changed.



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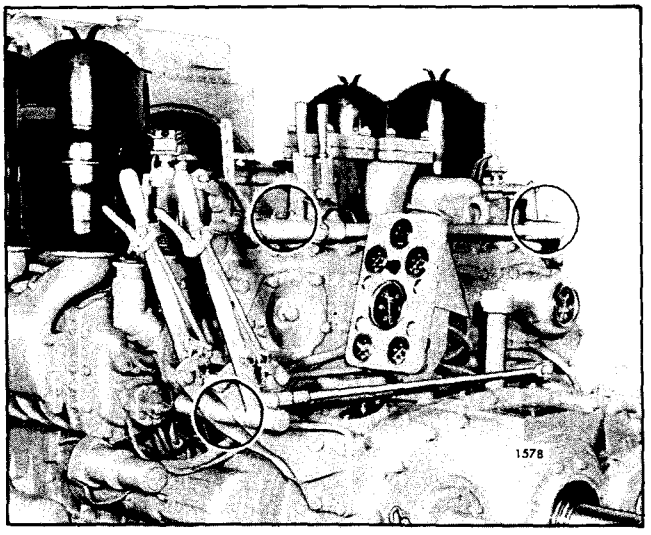


Item 18

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. Install the screen and gasket assembly with the screen side of the assembly toward the blower. Inspect for evidence of blower seal leakage.

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 battery-charging alternator bearings or bushings with 5 or 6 drops of engine oil at the hinge cap oiler every 200 hours or 6,000 miles.

On early generators equipped with grease cups, turn the cups down one full turn every 100 hours or 3,000 miles of operation. Keep the grease cups filled with *Delco-Remy Cam and Ball Bearing Lubricant,* or equivalent. Avoid excessive lubrication since this may cause lubricant to be forced onto the commutator.

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

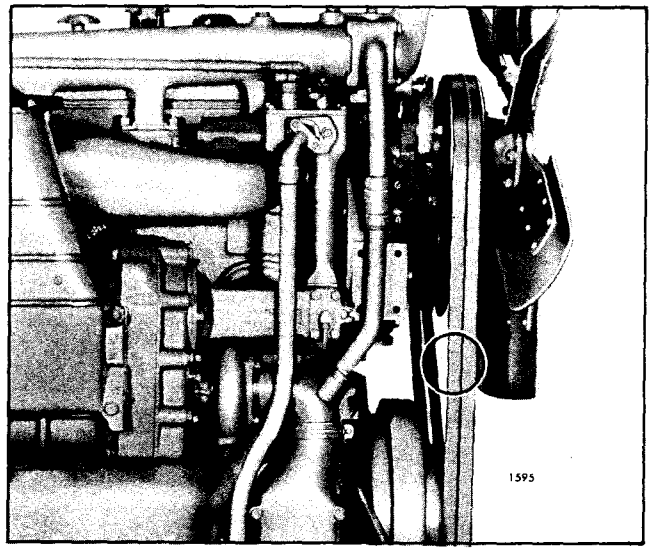
On D.C. generators, inspect the commutator and brushes every 500 hours or 15,000 miles. Clean the commutator every 2,000 hours or 60,000 miles, if necessary, with No. 00 sandpaper or a brush seating stone. After cleaning, reseat the brushes and blow out the dust.

On A.C. generators (alternators), 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 the slip rings. Hold the polishing cloth against the slip rings with the alternator in operation and blow away all dust after the cleaning operation. If the slip rings are rough or out of round, replace them.

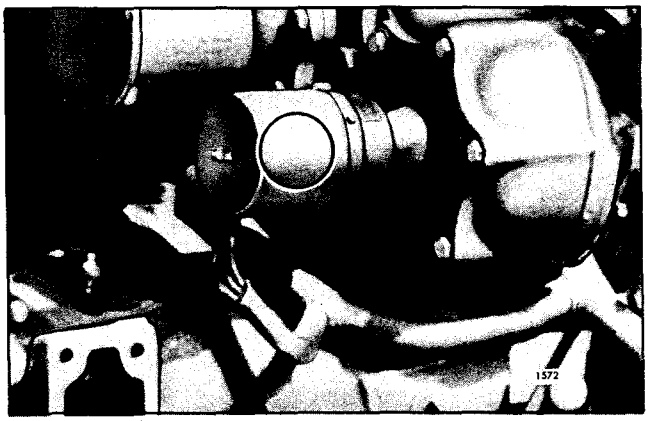
Inspect the terminals for corrosion and loose connections and the wiring for frayed insulation.

Item 16

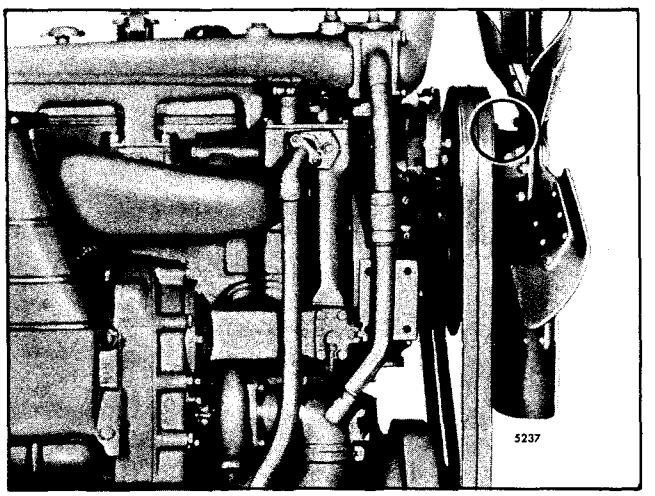
Check the specific gravity of the electrolyte in each cell of the battery every 100 hours or 3,000 miles. In warm weather, however, it should be checked more frequently due to a more rapid loss of water from the electrolyte. The electrolyte level should be maintained in accordance with the battery manufacturer's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



Item 20



Item 21



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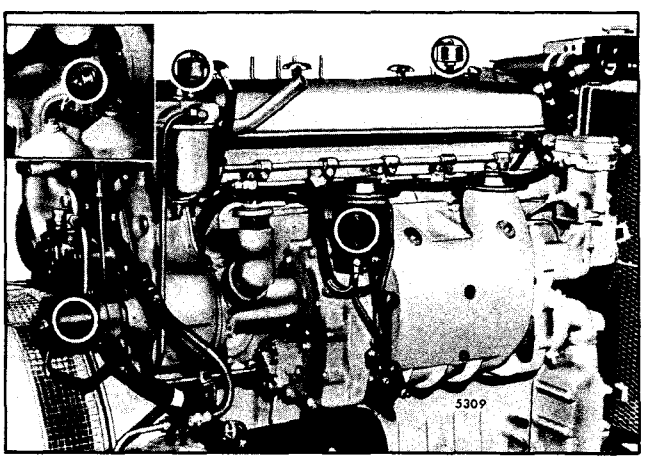


Item 23

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 (−1°C), use a No. 2 grade grease. Use a No. 1 grade grease below this temperature.

Item 18

Lubricate the throttle control mechanism every 200 hours or 6,000 miles with an all purpose grease. At temperatures above +30°F (−1°C), use a No. 2 grade grease. Use a No. 1 grade grease below this temperature. Lubricate the clutch control levers and 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 standard V-belts will stretch after the first few hours of operation. Run the engine for 15 *seconds* to seat the belts, then readjust the tension. Check the belts and tighten the fan drive, pump drive, battery-charging alternator and other accessory drive belts after 1/2 hour or 15 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 can result

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, 4-71	50-60	80-100	40-50	50-70	40-50
6-71	60-80	80-100	40-50	50-70	40-50
All	For 3 point or triangular drives use a tension of 90-120.				

*Belt tension is 60 ± 10 lbs. for a single premium high capacity belt (.785" wide) used to drive a 12 cfm air compressor.

BELT TENSION CHART (lbs/belt)

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

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

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

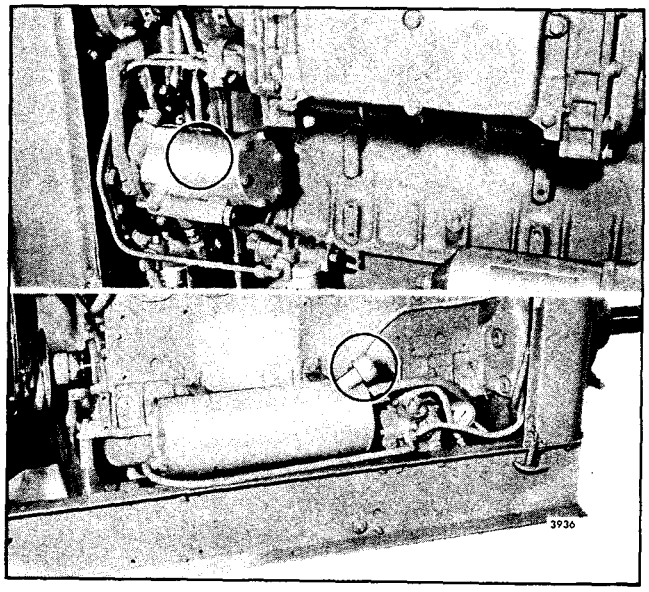
Tighten the 7/16"-14 (300M) pivot bolt to 72-77 lb-ft (98-104 Nm) torque. Tighten the 7/16"-14 (280M) pivot bolt to 46-50 lb-ft (62-68 Nm) torque.

Item 21

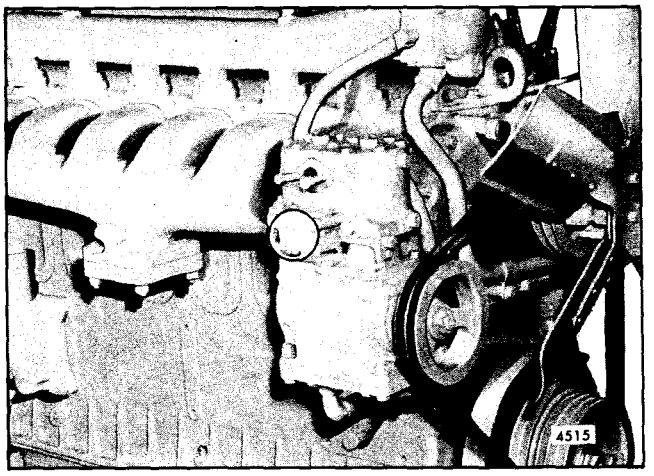
Lubricate the overspeed governor, if it is equipped with a hinge-type cap oiler or oil cup, with 5 or 6 drops of engine oil every 500 hours. Avoid excessive lubrication and do not lubricate the governor while the engine is running.

Item 22

If the fan bearing hub assembly is provided with a grease fitting, use a hand grease gun and lubricate the bearings with one shot of Texaco Premium RB grease, or an equivalent Lithium base multi-purpose grease, every 20,000 miles (approximately 700 hours).



Item 24



Item 25

Every 75,000 miles or 2500 hours, clean, inspect and repack the fan bearing hub assembly with the above recommended grease.

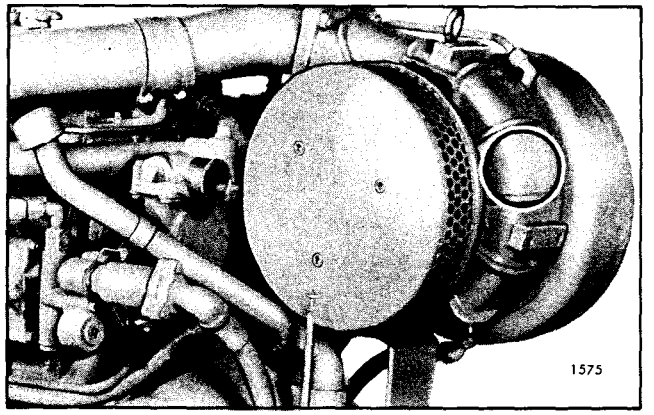
At a major engine overhaul, remove and discard the bearings in the fan hub assembly. Pack the hub assembly, using new bearings, with Texaco Premium RB grease or an equivalent Lithium base multi-purpose grease.

Item 23

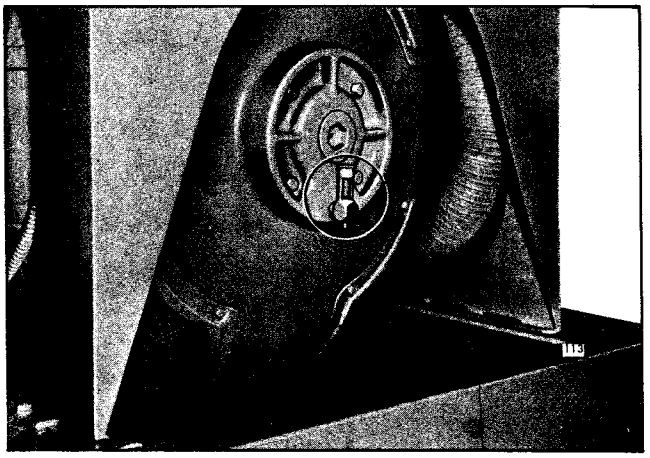
Check the shutdown system every 300 operating hours or each month to be sure it will function when needed.

Item 24

On engines equipped with a hydrostarter, refer to *Lubrication and Preventive Maintenance* of the hydrostarter in the *Engine Equipment* section.



Item 26



Item 27

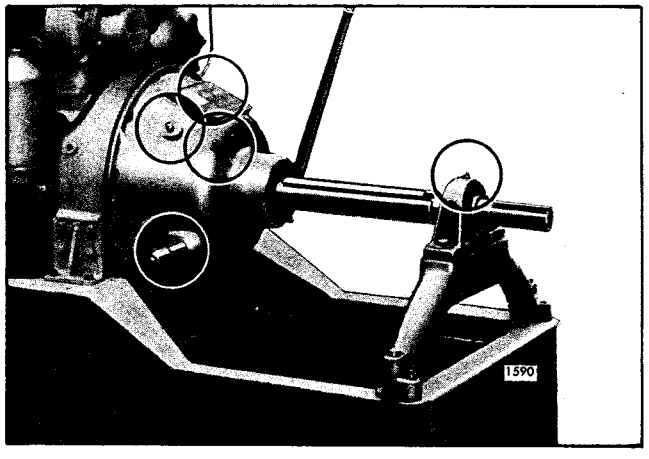
Item 25

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 it 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 26

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, no vibration or unusual noise and no oil leaks, only a periodic inspection is necessary.



Item 28

Item 27

The power generator requires lubrication at only one point -- the ball bearing in the end frame.

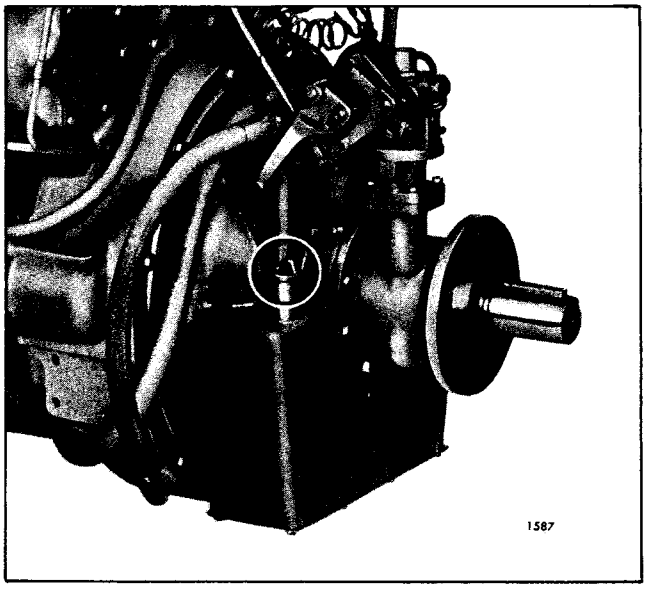
If the bearing is oil lubricated, check the oil level in the sight gage every 300 hours; change the oil every six months. Use the same grade and viscosity *heavy-duty* oil as specified for the engine. Maintain the oil level to the line on the sight gage. *Do not overfill.* After adding oil, recheck the 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. Thereafter, it should be lubricated at one year intervals. To lubricate the bearing, remove the 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.

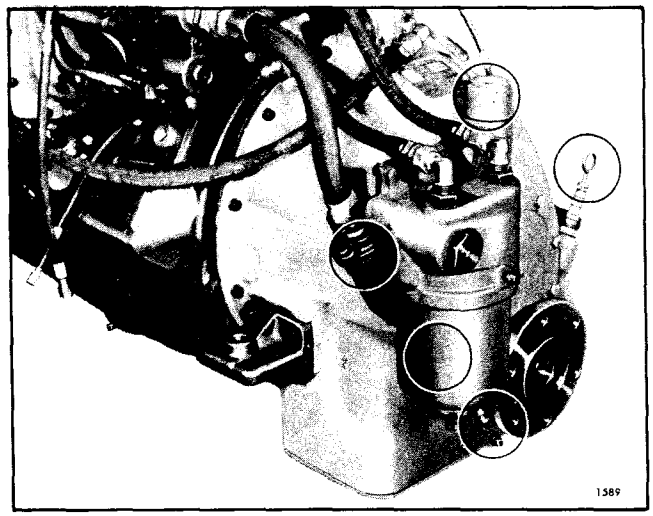
The following greases, or their equivalents, are recommended:

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



Item 29



Item 30

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 or 172 kPa maximum). Remove all greasy dirt with a cloth.

Item 28

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

Open the cover on the side of the clutch housing (8" and 10" diameter clutch) and lubricate the clutch release sleeve collar through the grease fitting every 8 hours. On the 11-1/2" diameter clutch, lubricate the collar through the fitting on the side of the clutch housing every 8 hours.

Lubricate the clutch drive shaft pilot bearing through the fitting in the outer end of the drive shaft (8" and 10" diameter clutch power take-offs) every 50 hours of operation. One or two strokes with a grease gun should be sufficient. The clutch drive shaft pilot bearing used with the 11-1/2" diameter clutch power take-off is prelubricated and does not require lubrication.

Lubricate the clutch drive shaft roller bearings through the grease fitting in the clutch housing every 50 hours under normal operating conditions (not continuous) and more often under severe operating conditions or continuous operation.

Lubricate the clutch release shaft through the fittings at the rear of the housing every 500 hours of operation.

Lubricate the clutch levers and links sparingly with engine oil every 500 hours of operation. Remove the inspection hole cover on the clutch housing and lubricate the clutch release levers and pins with a hand oiler. To avoid getting oil on the clutch facing, do not over lubricate the clutch release levers and pins.

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

Item 29

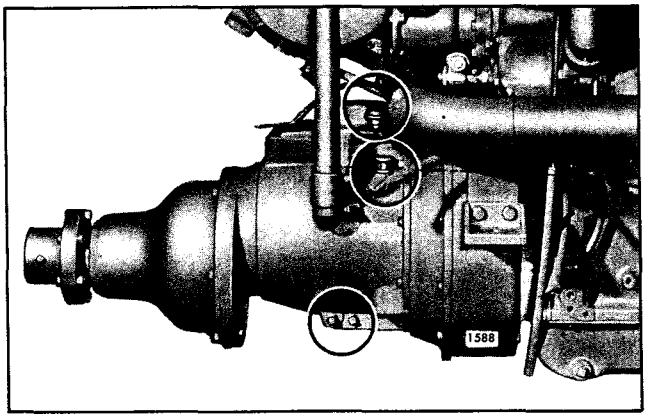
Check the oil level in the Torqmatic converter and supply tank daily. The oil level must be checked while the converter is operating, the engine idling and the oil is up to operating temperature (approximately 200° F or 93° C). If the converter is equipped with an input disconnect clutch, the clutch must be engaged.

Check the oil level after running the unit a few minutes. The oil level should be maintained at the proper level on the dipstick. If required, add hydraulic transmission fluid type "C-2" (see chart). *Do not overfill* the converter as too much oil will cause foaming and high oil temperature.

The oil should be changed every 500 hours for Series 300 converters and every 1,000 hours for Series 400 through 900 converters. 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 Allison Service Outlet* as this usually requires disassembly. Under severe operating conditions, the oil should be changed more often.

Prevailing Ambient Temperature	Recommended Oil Specification
Above - 10°F. (-12C)	Hydraulic Transmission Fluid, Type C-2.
Below - 10°F. (-12C)	Hydraulic Transmission Fluid, Type C-2. Auxiliary preheat required to raise temperature in the sump to a temperature above -10°F. (-12C)

OIL RECOMMENDATIONS



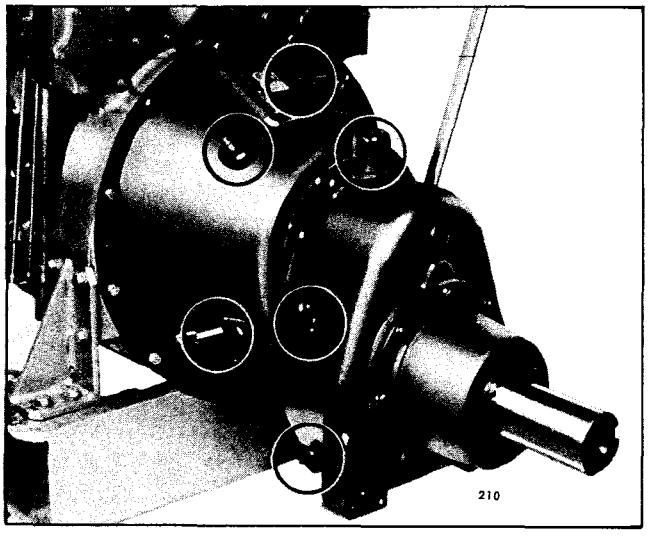
Item 31

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 and the front disconnect clutch drive shaft bearing every 50 hours with an all purpose grease. 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.

The strainer (in the Torqmatic transmission) and the hydraulic system filters should be replaced or cleaned with every oil change.



Item 32

Item 30

Check the oil level daily in the Torqmatic marine gear, with the controls in neutral and the engine running at idle speed. Add oil as required to bring it to the proper level on the dipstick. Use the same grade and viscosity *heavy-duty* oil as used in the engine. Drain the oil every 200 hours and flush the gear with light engine oil.

NOTE: Series 3 oil should not be used in the marine gear.

When refilling after an oil drain, bring the oil up to the proper level on the dipstick (approximately 6 quarts (6 litres) in the M type and 8 quarts (8 litres) in the MH type gear). Start and run the engine at light load for three to five minutes. Then put the controls in neutral and run the engine at idle speed and check the oil level again. Bring the oil level up to the proper level on the dipstick.

Every time the marine gear oil is changed, remove the oil strainer element, rinse it thoroughly in fuel oil, dry it with compressed air and reinstall it. Also replace the full-flow oil filter element every time the marine gear oil is changed.

Item 31

Check the Paragon marine gear oil level daily. To properly check the oil, operate the engine for two minutes at idle speed. Then stop the engine and add oil as required to bring it to the proper level on the dipstick.

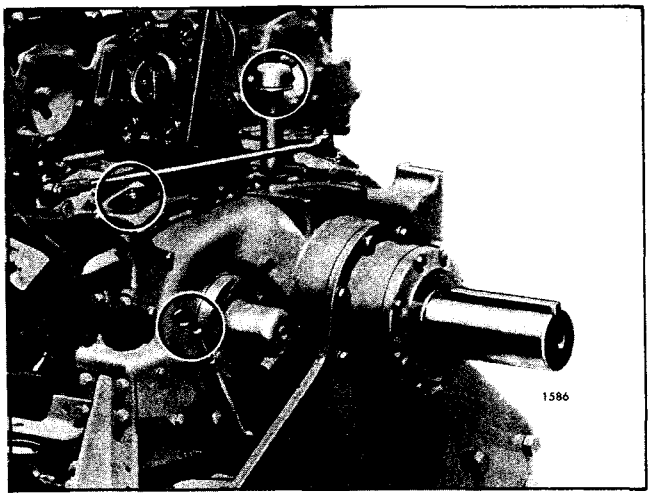
Change the oil every 200 hours. The oil may be drained by removing the drain plug in the bottom of the reverse gear housing and in the bottom of the reduction gear housing or with a hand operated sump pump.

Refill the marine gear to the proper level with the same grade and viscosity *heavy-duty* oil as used in the engine crankcase, operate the engine with a light load for 3 minutes, stop the engine and check the oil. Add oil as required to bring it to the proper level.

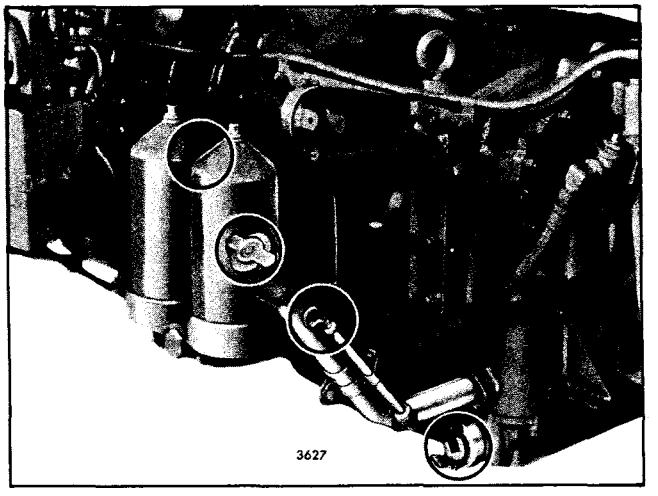
Item 32

ROCKFORD REDUCTION GEAR:

Check the oil level in the reduction gear every 8 hours and add oil as required to bring the oil to the proper



Item 33

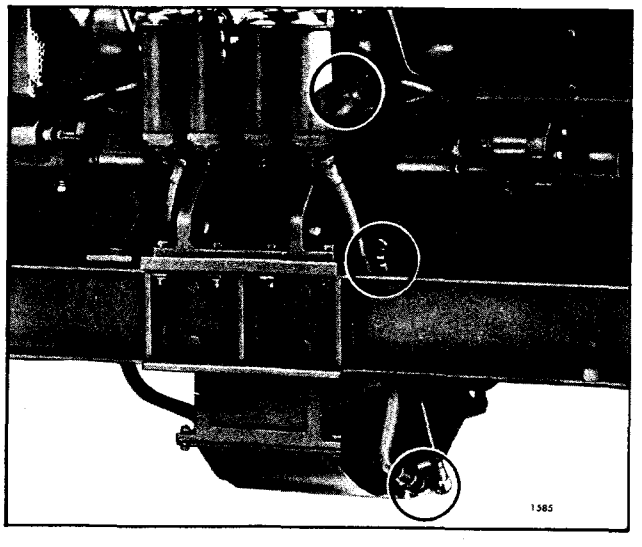


Items 35 and 36

level on the dipstick. Drain the oil every 1,000 hours, flush the housing with light engine oil and refill to the proper level with the same grade and viscosity *heavy-duty* oil as used in the engine. This oil change period should be reduced under severe operating conditions.

Lubricate the clutch release bearing through the grease fitting on the side of the housing every 8 hours of operation. The clutch release bearing in the 18" diameter clutch is pre-lubricated and is not provided with a grease fitting, since no further lubrication is required. Lubricate the front reduction 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.



Item 34

Item 33

Check the oil level daily in the power transfer or reduction gear of multiple engine industrial units. Add oil as required to bring it up to the proper level on the dipstick.

Drain the oil every 1,000 hours, flush with a light engine oil and refill to the proper level on the dipstick with the same grade and viscosity *heavy-duty* oil as used in the engine.

Item 34

Check the oil level daily with the gear in operation. Add oil as required to bring it to the proper level on the dipstick. Use the same grade and viscosity *heavy-duty* oil as used in the engine.

NOTE: Series 3 oil should not be used in the reduction gear.

Drain the oil every 200 hours of operation and flush the gear housing with a light engine oil.

Every time the oil is changed, remove the element from each oil strainer, rinse it thoroughly in clean fuel oil, dry it with compressed air and reinstall it. Also install new full-flow oil filter elements and gaskets each time the oil is changed.

Refill the reduction gear with oil and bring it to the proper level on the dipstick. Then start and run the engines at light load for three to five minutes to fill the

system with oil. With the engines running and the gear operating, check the reduction gear oil level. Add oil, if necessary, to bring it to the proper level on the dipstick. *Do not overfill.*

Item 35

Check the transmission oil level daily with the engine stopped and, if necessary, add oil to bring it to the proper level on the dipstick.

Change the transmission oil every 30,000 car miles (1,000 hours) of operation. Drain the oil by removing the drain plug in the sump pan directly under the oil filler pipe. Use hydraulic transmission fluid, Type "C-2". Run the unit a few minutes to fill the lubrication system. Then check the oil level immediately after stopping the engines to avoid a false reading due to the oil drain back from the converter. Add oil to bring it to the proper level on the dipstick.

Item 36

Install new oil filter elements and gaskets every time the transmission oil is changed. Check for oil leaks after starting the engine.

DETROIT DIESEL FUEL OIL SPECIFICATIONS

GENERAL CONSIDERATIONS

The quality of fuel oil used for high-speed diesel engine operation is a very important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust.

Fuel selected should be completely distilled material. That is, the fuel should show at least 98 percent by volume recovery when subjected to ASTM D-86 distillation. Fuels marketed to meet Federal Specification VV-F-800 (grades DF-1 and DF-2) and ASTM Designation D-975 (grades 1-D and 2-D) meet the completely distilled criteria. Some of the general properties of VV-F-800 and ASTM D-975 fuels are shown below.

FEDERAL SPECIFICATION & ASTM DIESEL FUEL PROPERTIES

Specification or Classification Grade	VV-F-800 DF-1	ASTM D-975 1-D	VV-F-800 DF-2	ASTM D-975 2-D
Flash Point, min.	104° F 40° C	100° F 38° C	122° F 50° C	125° F 52° C
Carbon Residue (10% residuum), % max.	0.15	0.15	0.20	0.35
Water & Sediment, % by vol., max.	0.01	trace	0.01	0.05
Ash, % by wt., max.	0.005	0.01	0.005	0.01
Distillation Temperature, 90% by vol. recovery, min.	—	—	—	540°F (282°C)
max.	572°F (300°C)	550°F (288°C)	626°F (330°C)	640°F (338°C)
End Point, max.	626°F (330°C)	—	671°F (355°C)	—
Viscosity 100°F (38°C)				
Kinematic, cs, min.	1.4	1.4	2.0	2.0
Saybolt, SUS, min.	—	—	—	32.6
Kinematic, cs, max.	3.0	2.5	4.3	4.3
Saybolt, SUS, max.	—	34.4	—	40.1
Sulfur, % by wt., max.	0.50	0.50	0.50	0.50
Cetane No.	45	40	45	40

Residual fuels and domestic furnace oils are not considered satisfactory for Detroit Diesel engines; however, some may be acceptable. (See "DETROIT DIESEL FUEL OIL SPECIFICATIONS.")

NOTE: Detroit Diesel Allison does not recommend the use of drained lubricating oil as a diesel fuel oil. Furthermore, Detroit Diesel will not be responsible for any engine detrimental effects which it determines resulted from this practice.

All diesel fuel oil contains a certain amount of sulfur. Too high a sulfur content results in excessive cylinder wear due to acid build-up in the lubricating oil. For most satisfactory engine life, fuels containing less than 0.5% sulfur should be used.

Fuel oil should be clean and free of contamination. Storage tanks should be inspected regularly for dirt, water or water-emulsion sludge, and cleaned if contaminated. Storage instability of the fuel can lead to the formation of varnish or sludge in the tank. The presence of these contaminants from storage instability must be resolved with the fuel supplier.

DETROIT DIESEL FUEL OIL SPECIFICATIONS

Detroit Diesel Allison designs, develops, and manufactures commercial diesel engines to operate on diesel fuels classified by the ASTM as Designation D-975 (grades 1-D and 2-D). These grades are very similar to grades DF-1 and DF-2 of Federal Specification VV-F-800. Residual fuels and furnace oils, generally, are not considered satisfactory for Detroit Diesel engines. In some regions, however, fuel suppliers may distribute one fuel that is marketed as either diesel fuel (ASTM D-975) or domestic heating fuel (ASTM D-396) sometimes identified as furnace oil. In this case, the fuel should be investigated to determine whether the properties conform with those shown in the "FUEL OIL SELECTION CHART" presented in this specification.

The "FUEL OIL SELECTION CHART" also will serve as a guide in the selection of the proper fuel for various applications. The fuels used must be clean, completely distilled, stable, and non-corrosive. DISTILLATION RANGE, CETANE NUMBER, and SULFUR CONTENT are three of the most important properties of diesel fuels that must be controlled to insure optimum combustion and minimum wear. Engine speed, load, and ambient temperature influence the selection of 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, premature wear, and to minimize the sulfur dioxide exhausted into the atmosphere.

To assure that the fuel you use meets the required properties, enlist the aid of a reputable fuel oil supplier. The responsibility for clean fuel lies with the fuel supplier as well as the operator.

During cold weather engine operation, the cloud point (the temperature at which wax crystals begin to form in diesel fuel) should be 10°F (6°C) below the lowest expected fuel temperature to prevent clogging of the fuel filters by wax crystals.

At temperatures below −20°F (−29°C), consult an authorized Detroit Diesel Allison service outlet, since particular attention must be given to the cooling system, lubricating system, fuel system, electrical system, and cold weather starting aids for efficient engine starting and operation.

FUEL OIL SELECTION CHART

Typical Application	General Fuel Classification	Final Boiling Point	Cetane No.	Sulfur Content
		(Max)	(Min)	(Max)
City Buses	No. 1-D	550°F (288°C)	45	0.30%
All Other Applications	Winter No. 2-D	675°F	45	0.50%
	Summer No. 2-D	675°F (357°C)	40	0.50%

NOTE: When prolonged idling periods or cold weather conditions below 32°F (0°C) are encountered, the use of lighter distillate fuels may be more practical. The same consideration must be made when operating at altitudes above 5,000 ft.

DETROIT DIESEL LUBRICATING OIL SPECIFICATIONS

GENERAL CONSIDERATIONS

All diesel engines require heavy-duty lubricating oils. Basic requirements of such oils are:

Lubricating Quality

High Heat Resistance

Control of Contaminants

LUBRICATING QUALITY. The reduction of friction and wear by maintaining an oil film between moving parts is the primary requisite of a lubricant. Film thickness and its ability to prevent metal-to-metal contact of moving parts is related to oil viscosity. The optimums for Detroit Diesel engines are SAE 40 or 30 weight.

HIGH HEAT RESISTANCE. Temperature is the most important factor in determining the rate at which deterioration or oxidation of the lubricating oil will occur. The oil should have adequate thermal stability at elevated temperatures, thereby precluding formation of harmful carbonaceous and/or ash deposits.

CONTROL OF CONTAMINANTS. The piston and compression rings must ride on a film of oil to minimize wear and prevent cylinder seizure. At normal rates of consumption, oil reaches a temperature zone at the upper part of the piston where rapid oxidation and carbonization can occur. In addition, as oil circulates through the engine, it is continuously contaminated by soot, acids, and water originating from combustion. Until they are exhausted, detergent and dispersant additives aid in keeping sludge and varnish from depositing on engine parts. But such additives in excessive quantities can result in detrimental ash deposits. If abnormal amounts of insoluble deposits form, particularly on the piston in the compression ring area, early engine failure may result.

Oil that is carried up the cylinder liner wall is normally consumed during engine operation. The oil and additives leave carbonaceous and/or ash deposits when subjected to the elevated temperatures of the combustion chamber. The amount of deposits is influenced by the oil composition, additive content, engine temperature, and oil consumption rate.

DETROIT DIESEL LUBRICATING OIL SPECIFICATIONS

OIL QUALITY

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.)

There are hundreds of commercial crankcase oils marketed today. Obviously, engine manufacturers or users cannot completely evaluate the numerous commercial oils. The selection of a suitable lubricant in consultation with a reliable oil supplier, observance of his oil drain recommendations (based on used oil sample analysis and experience) and proper filter maintenance, will provide the best assurance of satisfactory oil performance.

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

RECOMMENDATION

Detroit Diesel engines have given optimum performance and experienced the longest service life with the following oil performance levels having the ash and zinc limits shown:

Former Military Identification	API Letter Code Service Classification	SAE Grade
MIL-L-2104B/1964MS *	CC/SC	40 or 30 •
Supplement 1 **	CB	40 or 30 •

*Military Specification MIL-L-2104B is obsolete and new developed products can no longer be qualified to meet this performance level. However, many lubricants formulated to meet the performance criteria of MIL-L-2104B/1964MS are still being marketed. Detroit Diesel engines have given optimum performance and experienced the longest service life using MIL-L-2104B/1964MS lubricants. The majority of MIL-L-2104B/1964MS lubricants have a sulfated ash content between 0.55 and 0.85 percent by weight.

**Supplement 1 oils have a history of very satisfactory performance in Detroit Diesel engines. Supplement 1 oils have a relatively low ash content. However, the Supplement 1 oil specification is obsolete and new products cannot be qualified to meet this performance level. Some older formulations are still distributed and used by Detroit Diesel engine customers.

•SAE 40 grade oil has performed satisfactorily and is recommended in Detroit Diesel engines. Obviously, the expected ambient temperatures and engine cranking capability must be considered by the engine owner/operator when selecting the proper grade of oil. Only when the ambient temperatures and engine cranking capabilities result in difficult starting should SAE 30 grade oil be used.

ASH LIMIT

The sulfated ash (ASTM D-874) limit of all the lubricants recommended or selected as alternates for use in Detroit Diesel engines shall not exceed 1.000 percent by weight, except lubricants that contain only barium detergent-dispersant salts where 1.500 percent by weight is allowed. Lubricants having a sulfated ash content between 0.55 and 0.85 percent by weight have a history of excellent performance in Detroit Diesel engines. Lubricants having a sulfated ash content greater than 0.85 percent by weight are prone to produce greater deposit levels in the ring belt and exhaust valve areas of the engine.