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Detroit Diesel Engines

In-Line 71 Operators Manual

Detroit Diesel Allison

Service and Parts Information

SAFETY IS YOUR BUSINESS

Safety, based on technical skill and years of experience, has been carefully built into your Detroit Diesel engine. Time, money and effort have been invested in making your diesel engine a safe product. The dividend you realize from this investment is your personal safety.

It should be remembered, however, that power-driven equipment is only as safe as the man who is at the controls. You are urged, as the operator of this diesel engine, to keep your fingers and clothing away from the revolving "V" belts, gears, blower, fan, drive shafts, etc.

A serviceman can be severely injured if caught in the pulleys, belts or fan of an engine that is accidentally started. To avoid such a misfortune, disconnect the battery from the starting system by removing one or both of the battery cables. With the electrical circuit disrupted, accidental contact with the starter button will not produce an engine start.

An accident can be prevented with your help.

6SE329 (REV. 12/81)

Operators Manual

In-Line 71 Engines

Detroit Diesel Allison
13400 W. Outer Drive
Detroit, Michigan 48228

NOTE:
Additional copies of this service manual may be purchased from Detroit Diesel Allison Distributors. See your yellow pages—under Engines, Diesel.

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 fron maintenance to major parts replacement. Authorized service outlets in the U.S. and Canada 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 the 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 WARRANTY INFORMATION ON DETROIT DIESEL ENGINES, 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".

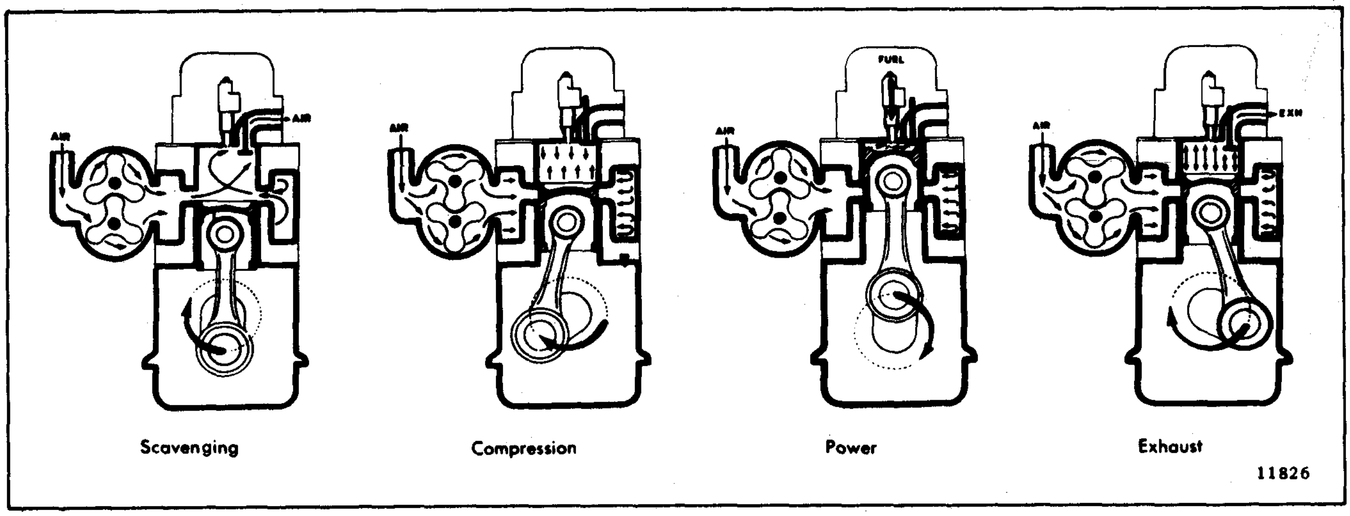


Fig. 1 - The Two-Stroke Cycle

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 bypass 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 alternator, with a built-in 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
Type	2 Cycle	2 Cycle	2 Cycle
Number of Cylinders	3	4	6
Bore (inches)	4.25	4.25	4.25
Bore (mm)	108	108	108
Stroke (inches)	5	5	5
Stroke (mm)	127	127	127
Comp. Ratio (Nominal)(Std. Engines)	17 to 1	17 to 1	17 to 1
Comp. 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 - liters	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

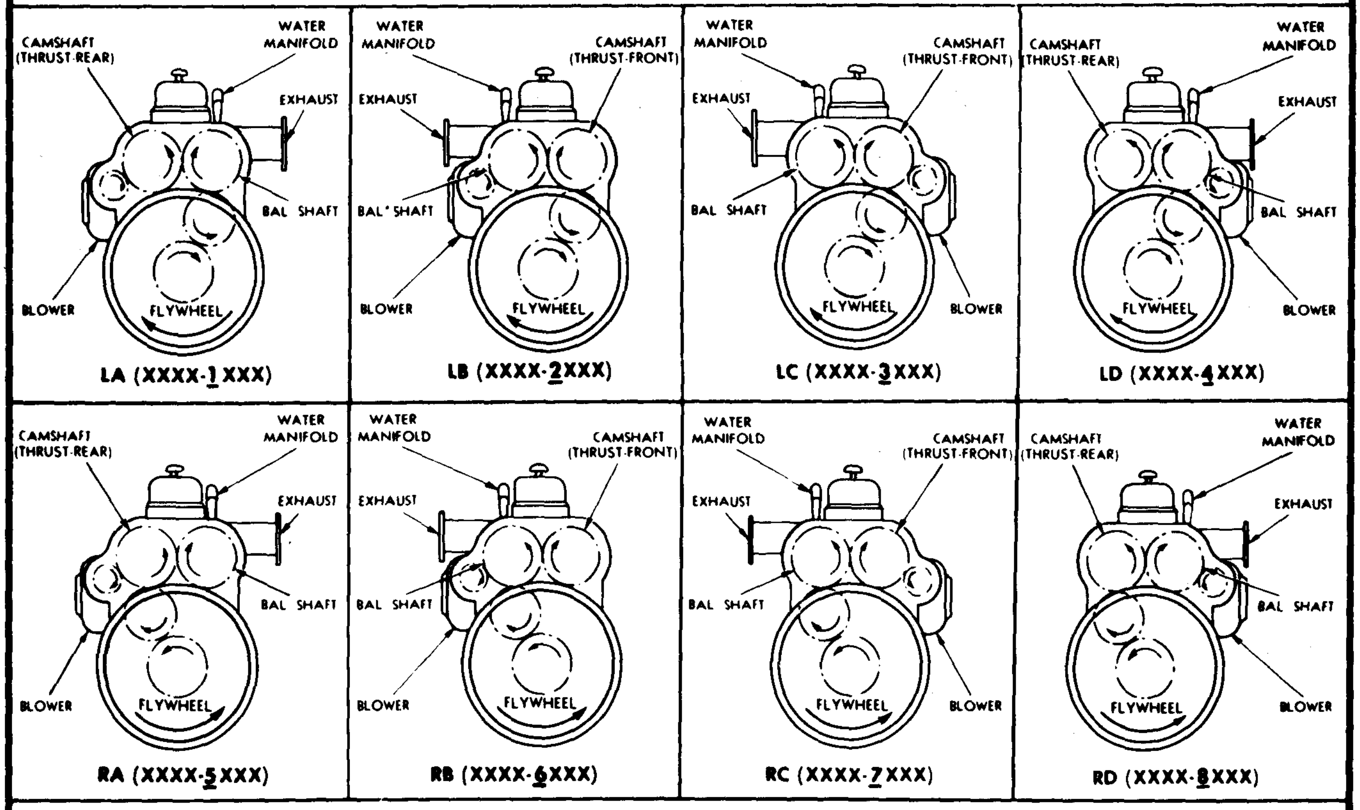
BASIC ENGINE ARRANGEMENTS:

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
11229001 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

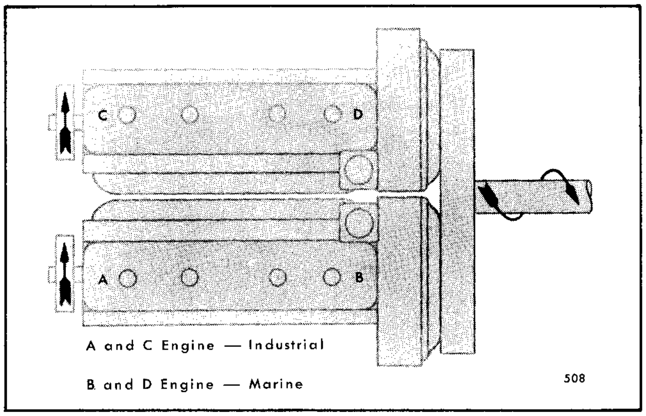


Fig. 3 - Typical Twin Engine Unit

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.

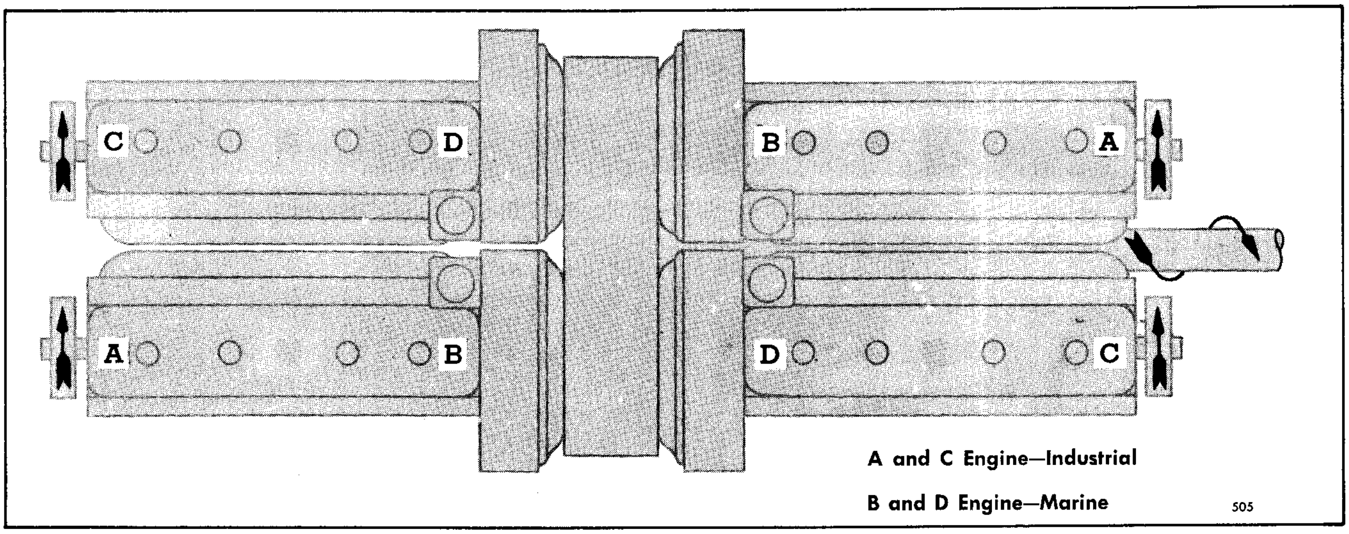


Fig. 4 - Typical Quad Engine Unit

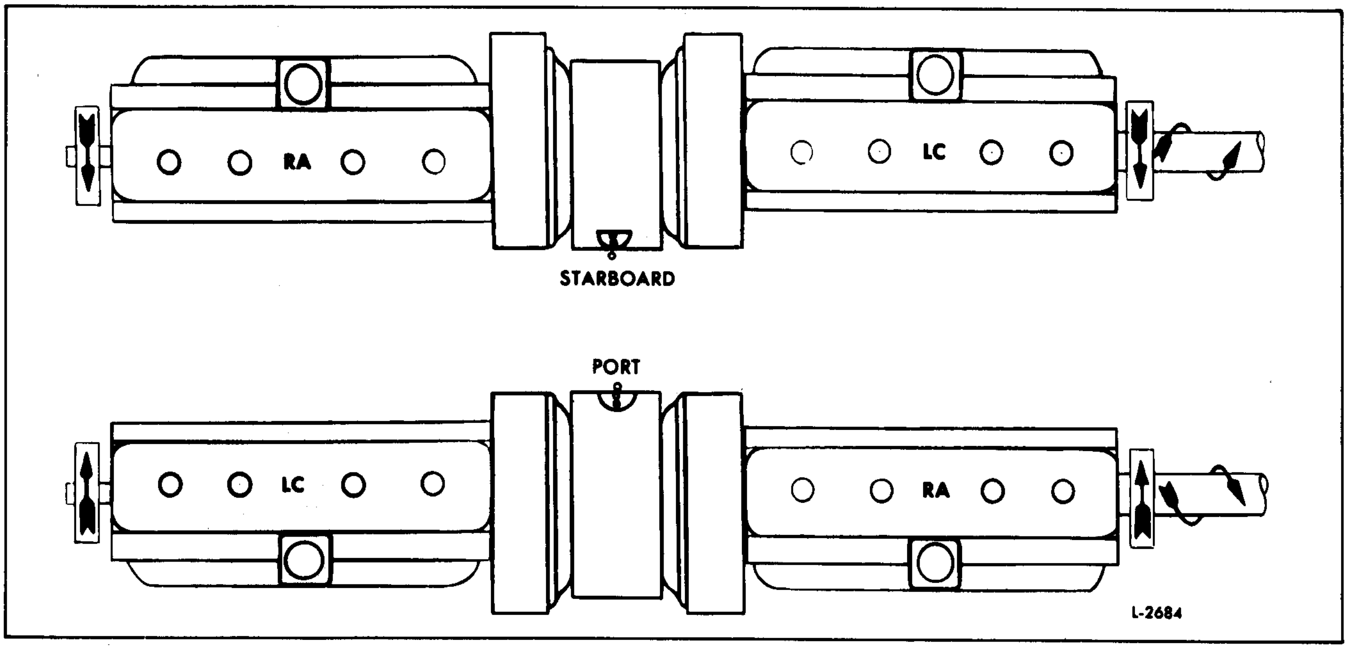


Fig. 5 - Typical Tandem Engine Unit

ENGINE MODEL AND SERIAL NUMBER DESIGNATION

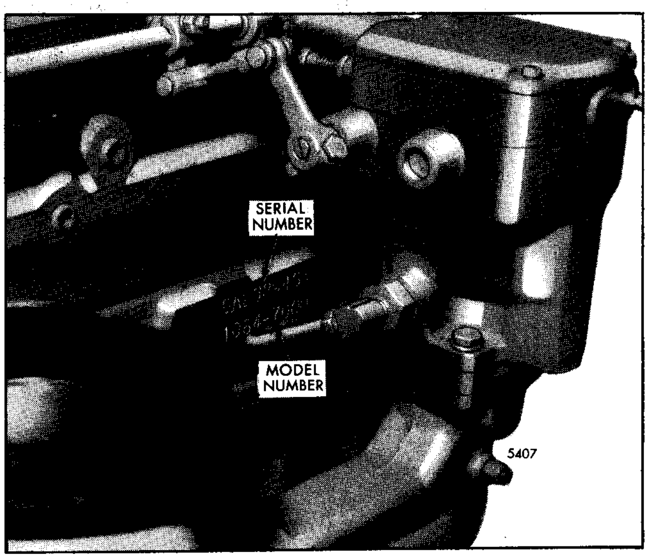


Fig. 6 - Typical Engine Serial Number and Model Number As Stamped on Cylinder Block

The engine serial number and the engine model number are stamped on the cylinder block (Fig. 6).

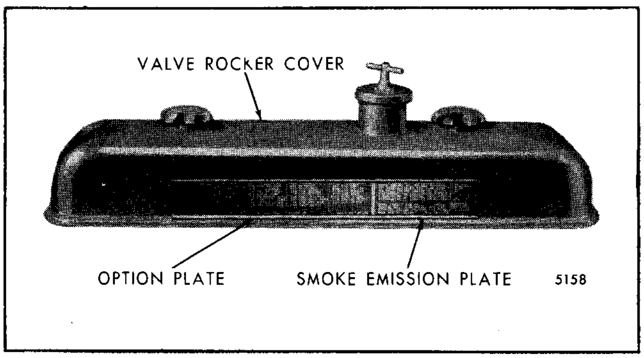


Fig. 7 - Option Plate

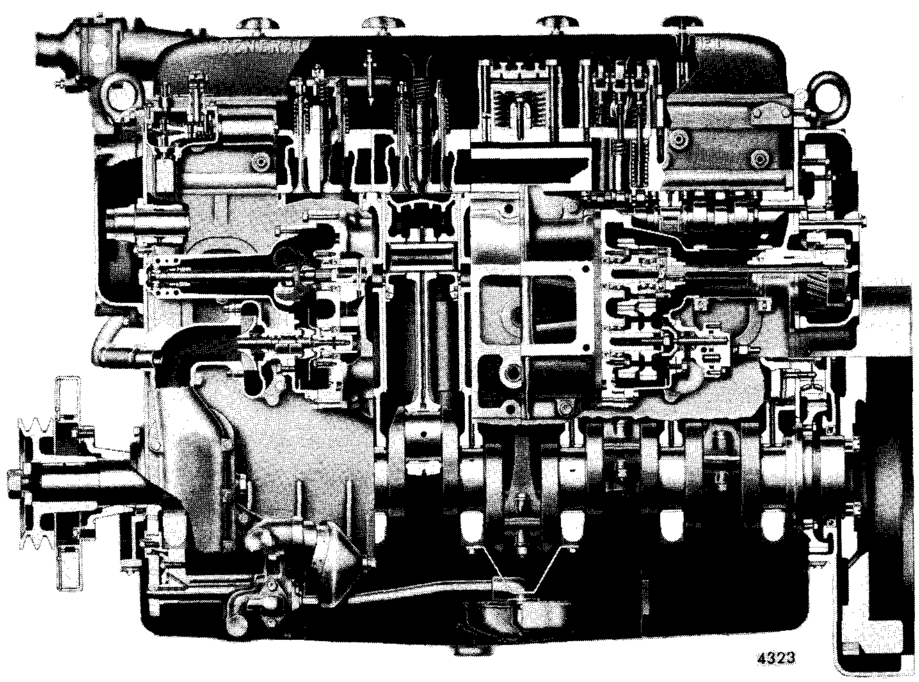
An option plate, attached to the valve rocker cover (only one valve rocker cover of a multiple engine unit), is stamped with the engine serial number and model number and, in addition, lists any optional equipment used on the engine (Fig. 7).

Power take-off assemblies, torque converters, marine gears, etc. may also carry name plates. The information on these name plates should be included when ordering replacement parts for these assemblies.

BUILT-IN PARTS BOOK

The *Built-In Parts Book* is a photoetched aluminum plate (Option Plate) that fits into a holding channel 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.



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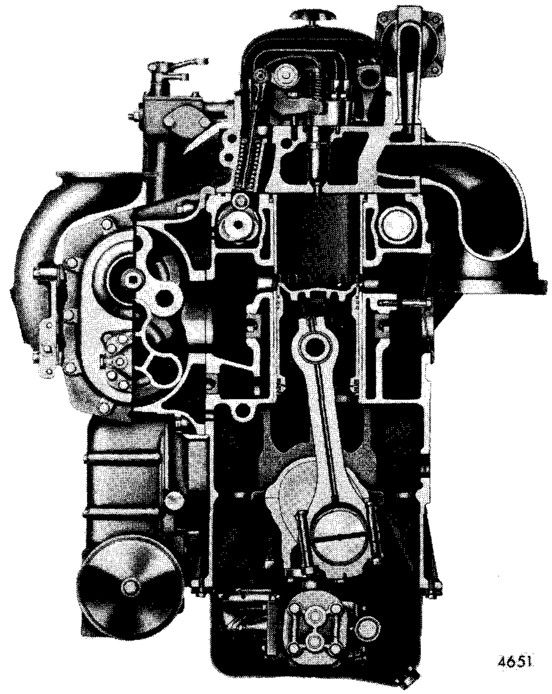

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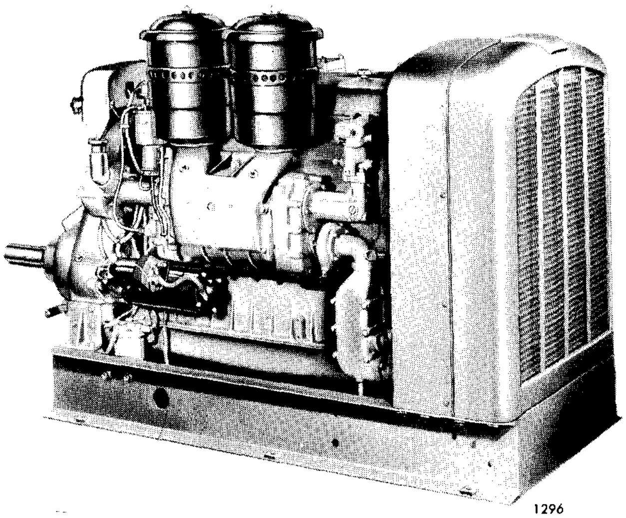
Cross Section Views of Typical In-Line Engine



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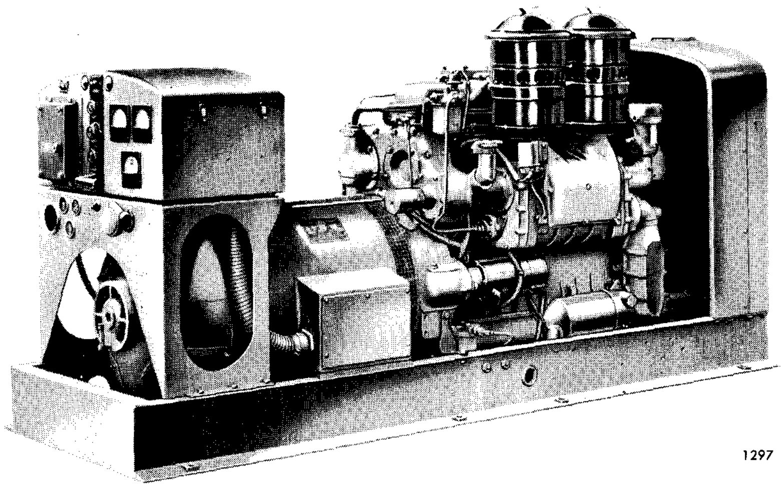
Typical Industrial Power Take-Off Unit



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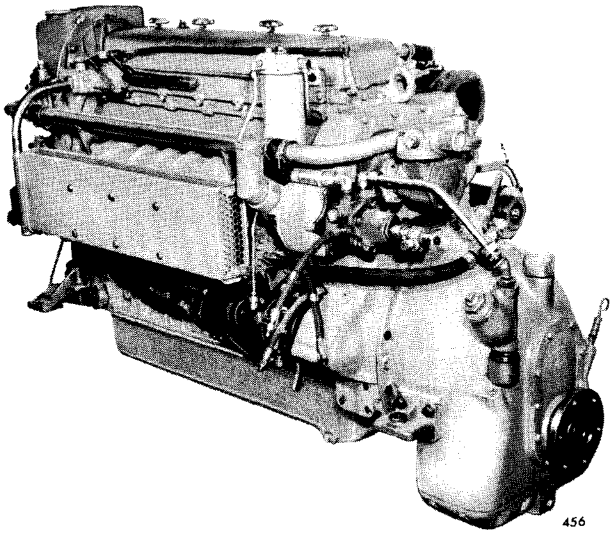
Typical Power Generator Unit



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Typical Marine Propulsion Unit

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.

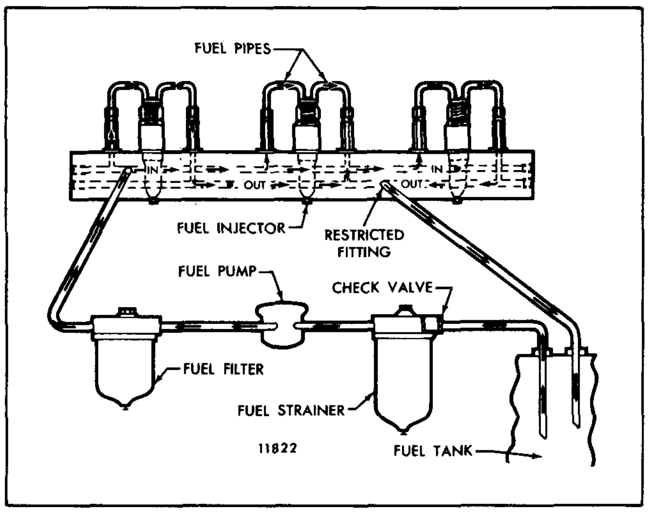


Fig. 1 - Schematic Diagram of Typical Fuel System

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.

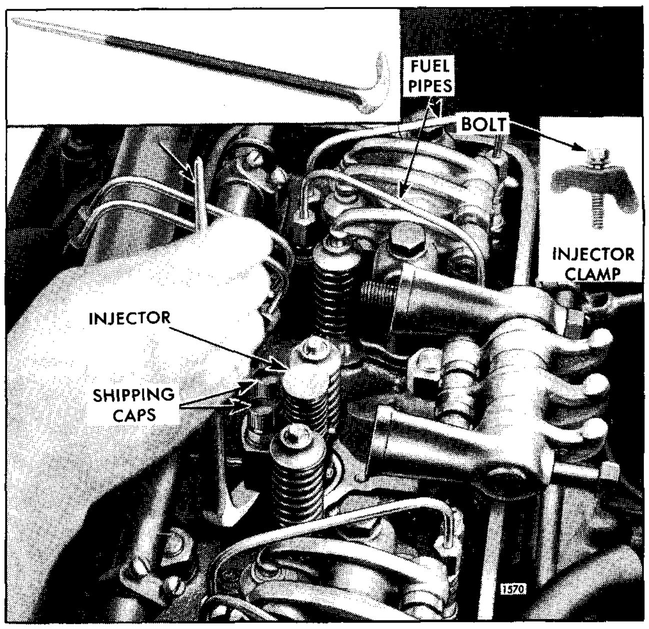


Fig. 2 - Removing Injector from Cylinder Head

Remove Injector

An injector may be removed in the following manner:

1. Clean and remove the valve rocker cover.

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

3. Immediately after removing the fuel pipes, cover the injector inlet and outlet fittings with shipping caps to prevent dirt from entering.

4. Turn the crankshaft manually in the direction of engine rotation or crank the engine with the starting motor, if necessary, until the rocker arms for the particular cylinder are aligned in a horizontal plane.

> **NOTE:** 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 assmebly 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.

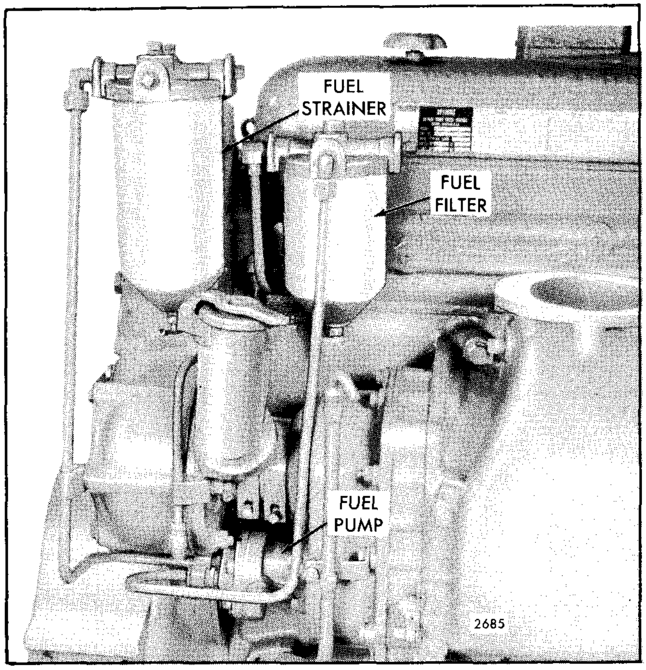


Fig. 3 - Fuel Pump, Fuel Strainer and Fuel Filter Mounting

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.

> **NOTE:** 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.

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

Fuel Pump

A positive displacement gear type fuel pump is attached to the blower and driven off the rear end of the lower blower rotor (Fig. 3).

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 Filter (Bolt-On Type)

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.

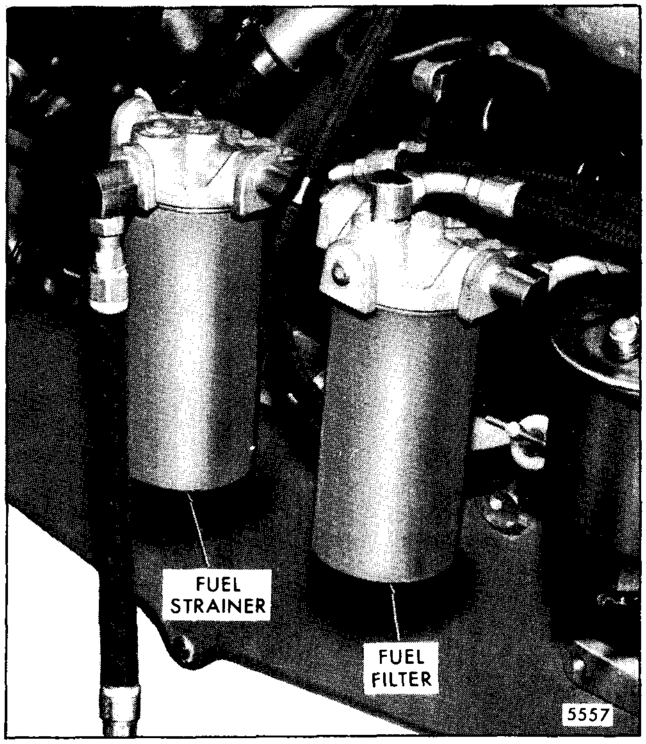


Fig. 4 - Typical Spin-On Fuel Filter and Strainer Mounting

Fuel Strainer and Filter (Spin-On Type)

A spin-on type fuel strainer and fuel filter is used on certain engines (Fig. 4). 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 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 one-half 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.

> **NOTE:** 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.

Engine Out of Fuel

The problem in restarting the engine after it has run out of fuel stems from the fact that after the fuel is exhausted from the fuel tank, fuel is then pumped from the primary fuel strainer and sometimes partially removed from the secondary fuel filter before the fuel supply becomes insufficient to sustain engine firing. Consequently, these components must be refilled with fuel and the fuel pipes rid of air in order for the system to provide adequate fuel for the injectors.

When an engine has run out of fuel, there is a definite procedure to follow for restarting the engine.

1. Fill the fuel tank with the recommended grade of fuel oil. If only partial filling of the tank is possible, add a minimum of ten gallons (38 litres) of fuel.

2. Remove the fuel strainer shell and element from the strainer cover and fill the shell with fuel oil. Install the shell and element.

3. Remove and fill the fuel filter shell and element with fuel oil as in Step 2.

4. Start the engine. Check the filter and strainer for leaks.

> **NOTE:** In some instances, it may be necessary to remove a valve rocker cover and loosen a fuel pipe nut in order to bleed trapped air from the fuel system. Be sure the fuel pipe is retightened securely before replacing the rocker cover.

Primer J 5956 may be used to prime the entire fuel system. Remove the filler plug in the fuel filter cover and install the primer. Prime the system. Remove the primer and install the filler plug.

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 (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.

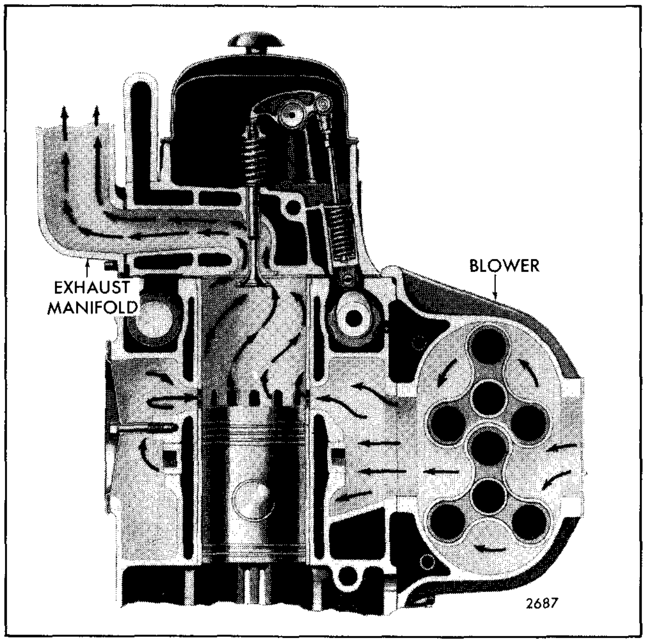


Fig. 5 - Air Intake System Through Blower and Engine

Oil Bath Air Cleaners

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.

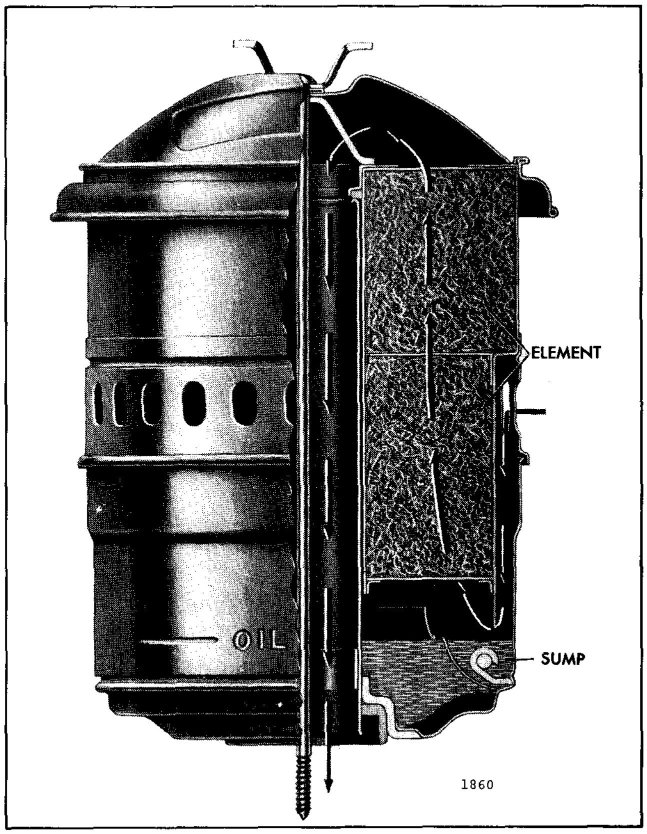


Fig. 6 - Light Duty Oil Bath Air Cleaner Assembly

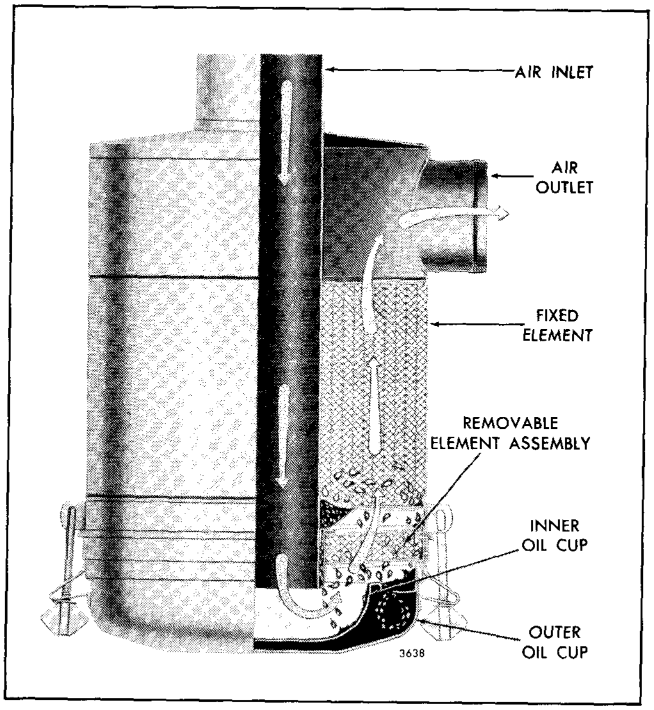


Fig. 7 - Heavy Duty Oil Bath Air Cleaner Assembly

Service the *light duty* oil bath air cleaner as follows (Fig. 6):

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.

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.

Service the *heavy duty* oil bath air cleaner as follows (Fig. 7):

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.

Dry-Type Air Cleaners

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 reentry of the dust. The pre-cleaned air passes through the paper filter and enters the engine.

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

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.

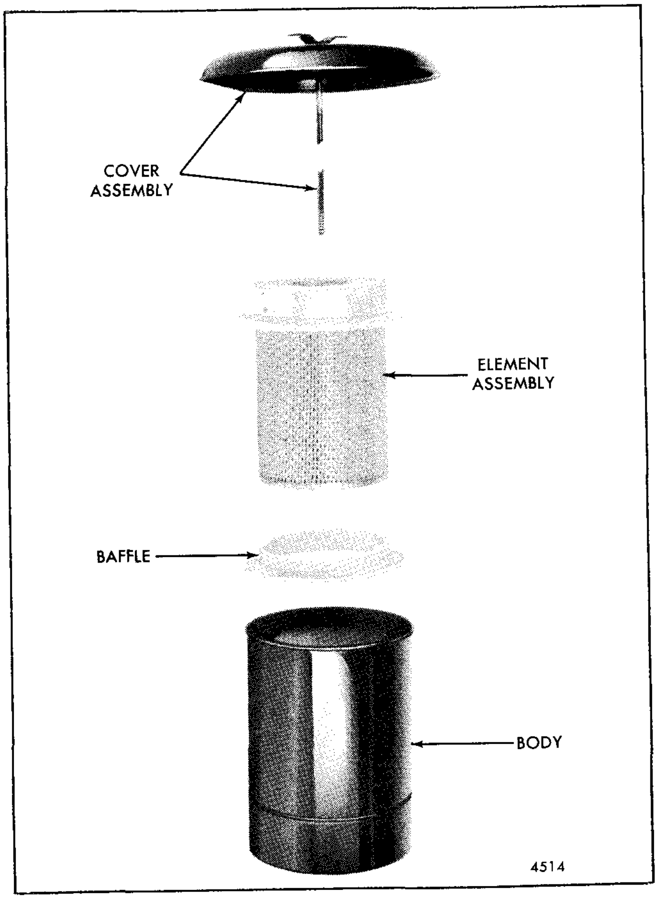


Fig. 8 - Dry Type Air Cleaner

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.

NOTE: 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.

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.

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

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

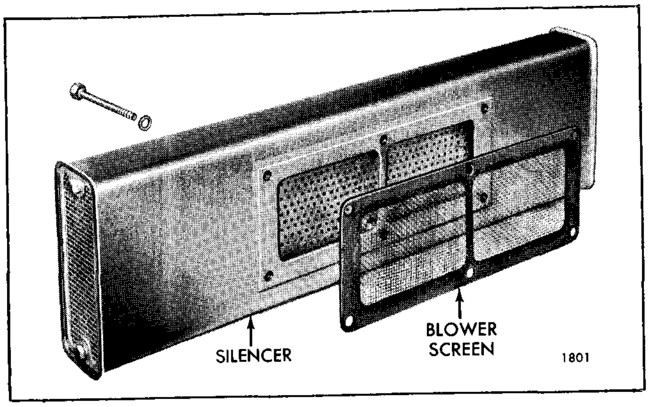


Fig. 9 - Blower Air Inlet Silencer Assembly

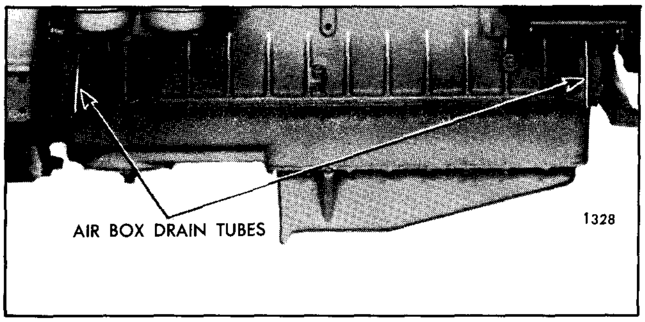


Fig. 10 - Air Box Drain Tubes

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

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 schematically illustrated in Fig. 11 consists of an oil pump, oil cooler, a full-flow oil filter, bypass 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 bypass 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.

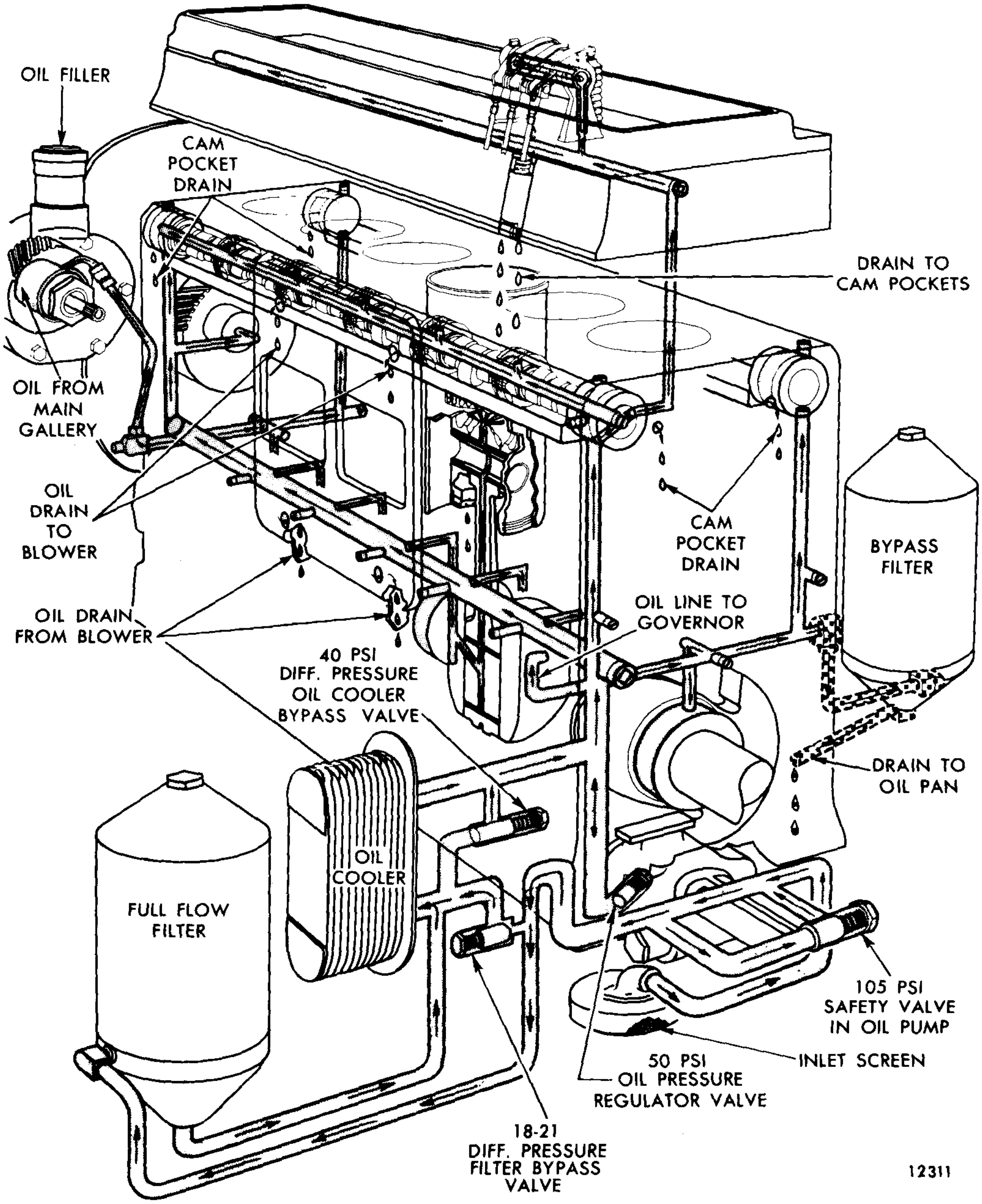


Fig. 11 - Schematic Diagram - Typical Lubricating System

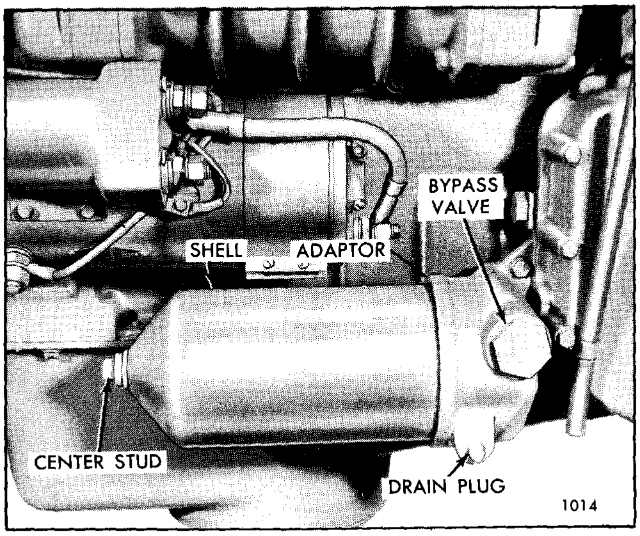


Fig. 12 - Typical Full Flow Filter Mounting

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 bypass 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 bypass 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 bypass 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 bypass filter assembly consisting of two filter elements, each enclosed in a shell which is mounted on a single adaptor. An oil passage in the filter adaptor connects the two annular spaces surrounding both filter elements.

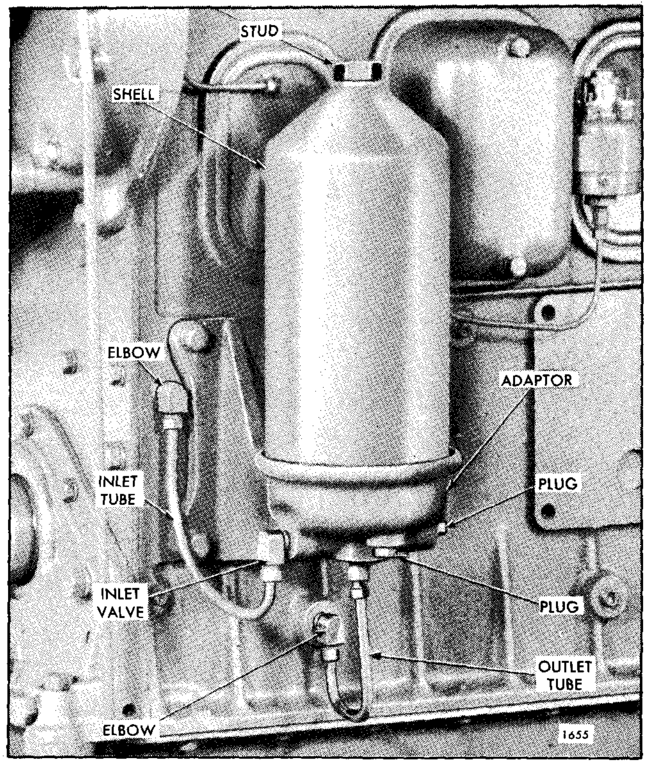


Fig. 13 - Typical Lubricating Bypass Oil Filter Mounting

The full-flow and bypass 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.

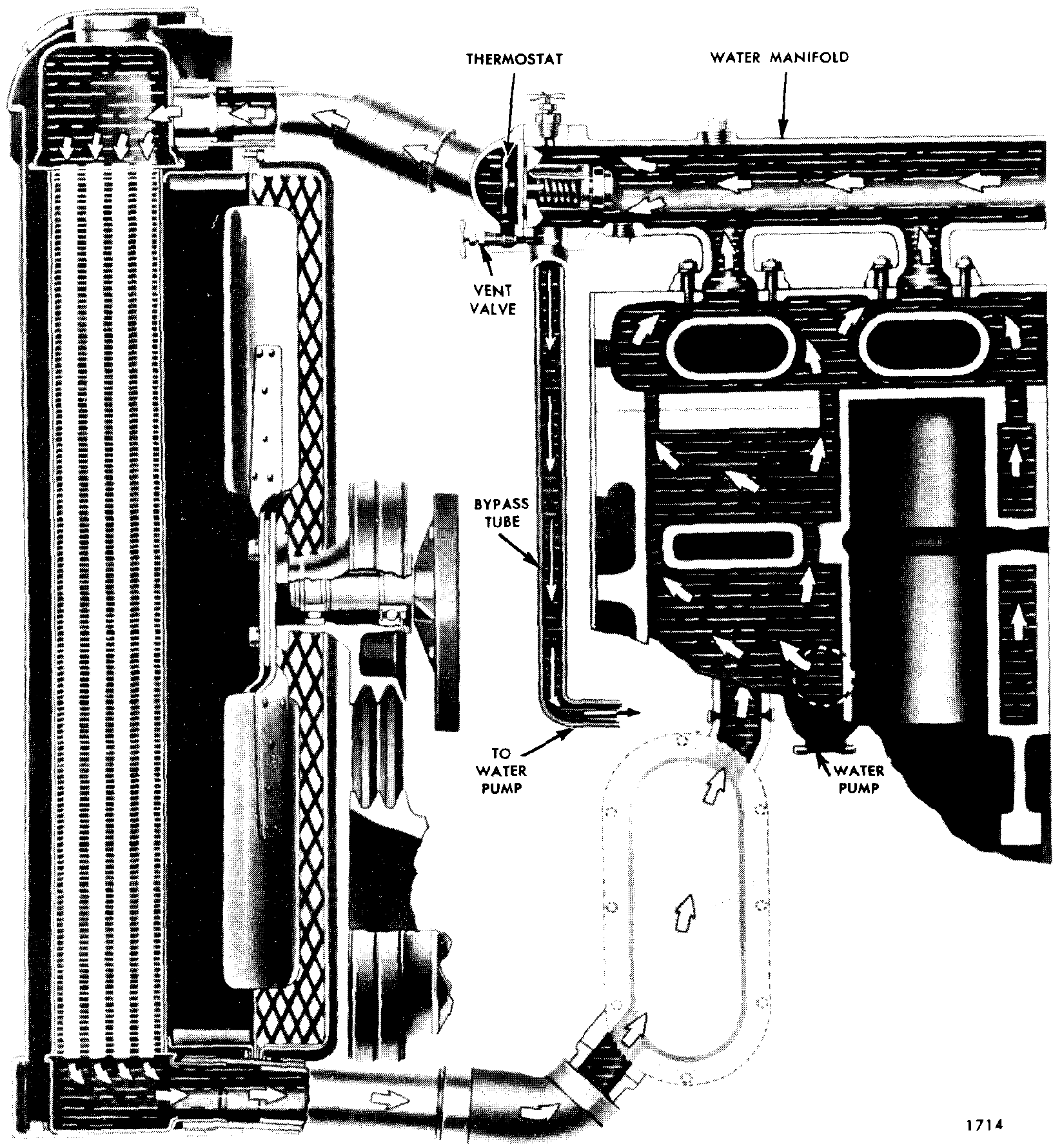


Fig. 14 - Typical Engine Cooling System with Radiator and Fan

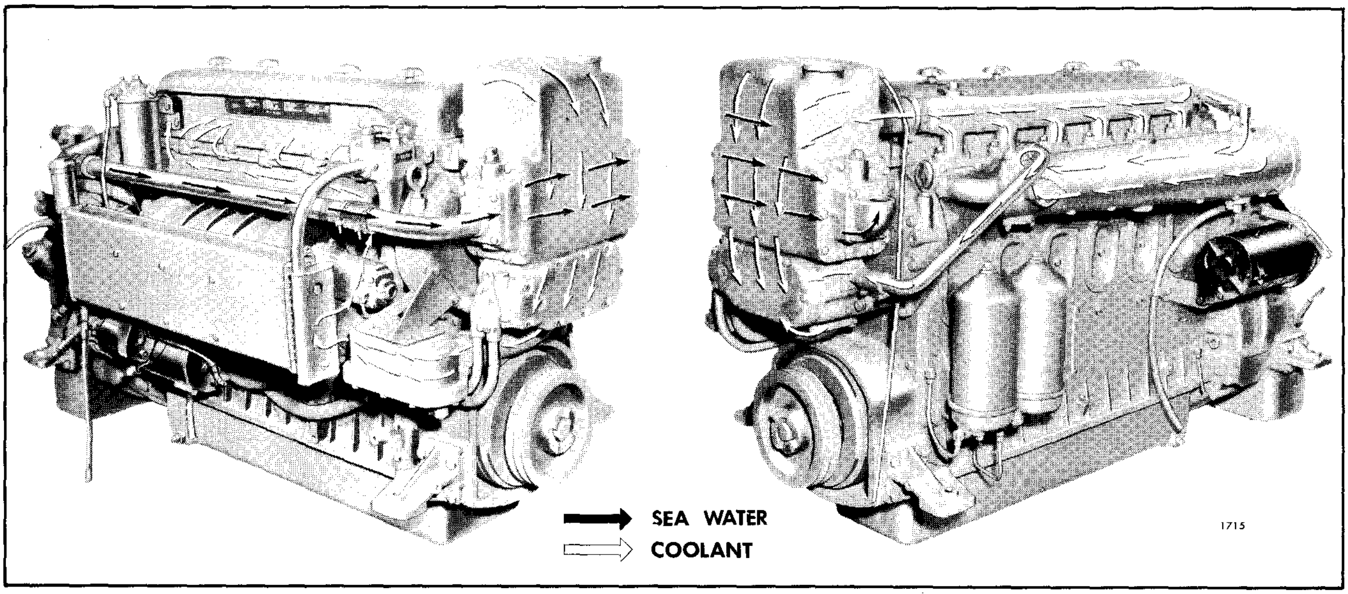


Fig. 15 - Water Circulation Through Heat Exchanger

When starting a cold engine or when the coolant is below operating temperature, the coolant is restricted at the thermostat housing and a bypass 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 bypasses 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

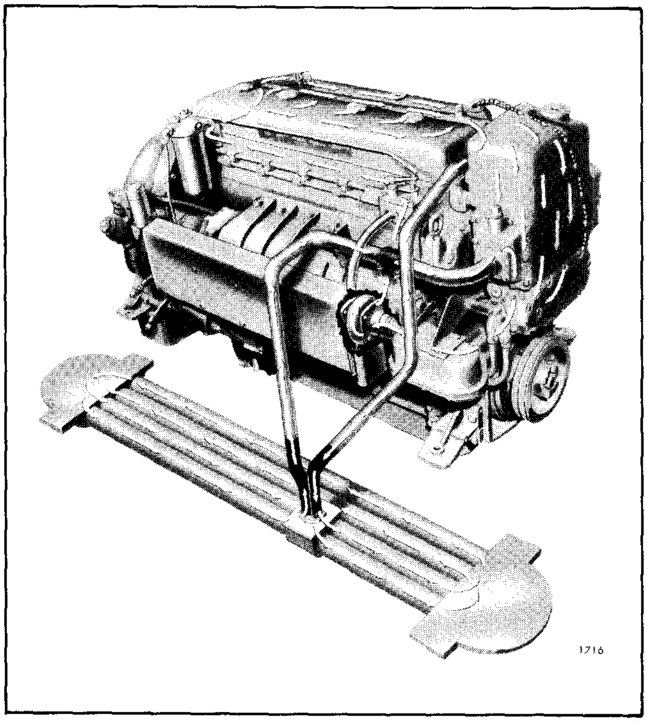


Fig. 16 - Water Flow in Keel Cooled Engine

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 bypassed 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 descaling 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.

> **NOTE:** 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.

> **NOTE:** 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 recirculation 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.

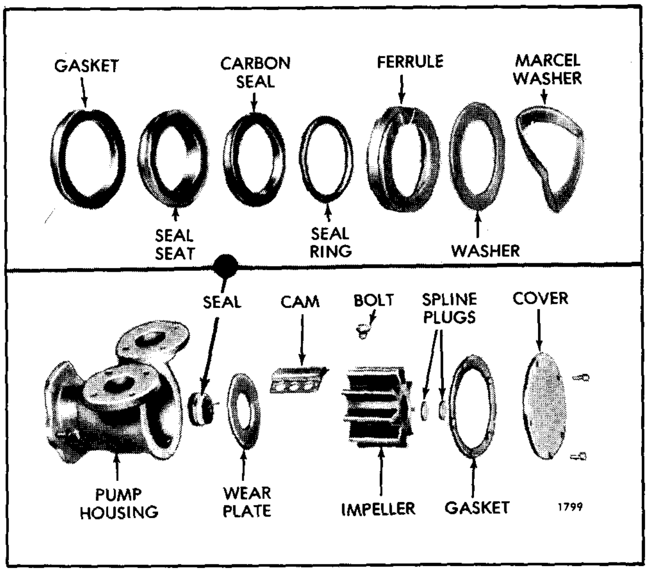


Fig. 17 - Raw Water Pump Details and Relative Location of Parts

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.

NOTE: 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 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 (Fig. 1). 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.

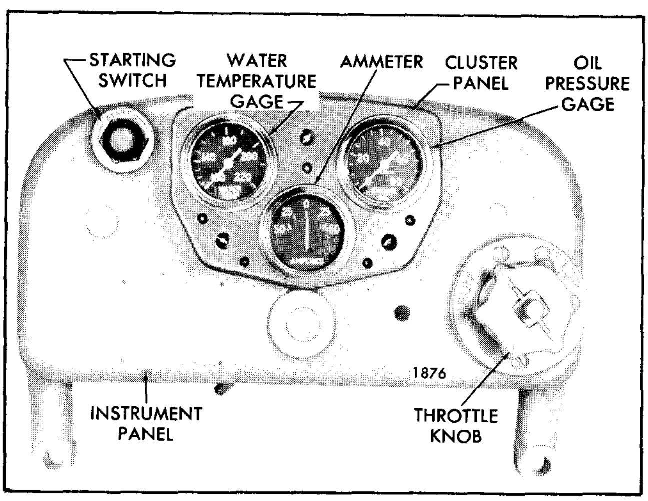


Fig. 1 - Typical Instrument Panel

Water Temperature Gage

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

Ammeter

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

Tachometer

A tachometer, driven by the engine, 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 down the engine. 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.

NOTE: When an emergency shut down is necessary on an engine the stop knob should be pulled immediately, and held until the engine stops.

Emergency Stop Know (Engine with Air Shutoff Valve)

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

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

Throttle Control

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

ENGINE PROTECTIVE SYSTEMS

MANUAL SHUTDOWN

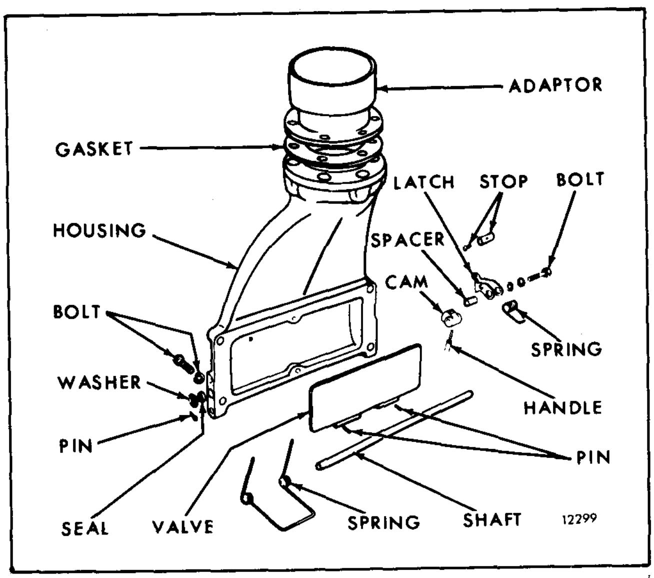


Fig. 2 - Typical Manual Shutdown and Relative Location of Parts

A manually operated emergency engine shutdown device enables the engine operator to stop the engine in the event an abnormal condition should arise (Fig. 2). If the engine continues to run after the engine throttle is placed in the *no-fuel* position, or if combustible liquids or gases are accidentally introduced into the combustion chamber causing overspeeding of the engine, the shutdown device will prevent damage to the engine by cutting off the air supply and thus stopping the engine. The shutdown device consists of a flap valve mounted in the air inlet housing and a suitable operating mechanism.

The manually operated shutdown device is operated by a knob located on the instrument panel and connected to a latch on the valve shaft by a Bowden wire or cable assembly. Pulling the shutdown knob all the way out will stop the engine. Push the knob all the way in and manually reset the air shutdown device in the shutdown housing before the engine is started again.

AUTOMATIC MECHANICAL SHUTDOWN

A mechanical type shutdown system is used on certain models to prevent damage to the engine in case of an emergency. This system makes use of an air valve in the air system. The air valve automatically closes if the engine overspeeds, overheats or loses oil pressure.

Operation

By pulling the control knob from the instrument panel, a cam comes in contact with the starter button, energizing the starting motor.

When the engine starts, the control knob is released after the oil pressure has built up and forced the latch into position to hold the air valve open. If the engine overheats, the water temperature bellows will expand, releasing the air damper and allowing it to close. If the engine loses oil pressure or overspeeds, the oil pressure bellows will contract, releasing the latch which allows the air damper to close.

AUTOMATIC MECHANICAL SHUTDOWN

(Temperature-Sensing Valve Type)

The automatic mechanical shutdown system is designed to stop the engine if there is a loss of oil pressure, loss of engine coolant, overheating of the engine coolant or overspeeding of the engine. Engine oil pressure is utilized to activate the components of the system.

A coolant temperature-sensing valve and an adaptor and copper plug assembly are mounted on the exhaust manifold outlet. The power element of the temperature-sensing valve is placed against one end of the copper plug, and the other end of the plug extends into the exhaust manifold. Engine coolant is directed through the adaptor and passes over the power element of the valve. Engine oil, under pressure, is directed through a restricted fitting to the temperature-sensing valve and to an oil pressure actuated bellows located on the air shutdown housing.

The pressure of the oil entering the bellows overcomes the tension of the bellows spring and permits the latch to retain the air shutoff valve in the open position. If the oil pressure drops below a predetermined value, the spring in the bellows will release the latch and permit the air shutoff valve to close and thus stop the engine.

The overspeed governor (Fig. 3) used on certain applications, consists of a valve actuated by a set of spring-loaded weights. Engine oil is supplied to the valve through a connection in the oil line between the bellows and the temperature-sensing valve. An outlet in the governor valve is connected to the engine oil sump. Whenever the engine speed exceeds the overspeed governor setting, the valve (actuated by the governor weights) is moved from its seat and permits the oil to flow to the engine sump. This decreased the oil pressure to the bellows, thus actuating the shutdown mechanism and stopping the engine.

Some engines are equipped with a low oil pressure and overspeed valve assembly (Fig. 4). The valve assembly consists of a pair of springs, an oil piston, an oil dump valve, and an air piston. The springs establish a force which is imposed on the dump valve and air piston. Air box pressure, which is dependent on engine speed, is used to maintain a balance between the secondary spring and the engine speed. If the oil pressure decreases to the balance point, the air box pressure will move the valve to the dump position, thus lowering the oil pressure to the bellows and actuating the shutdown mechanism. Overspeed control is obtained through a cam which controls the travel of the oil piston and establishes the maximum force that can be imposed on the valve and air piston. When air box pressure exceeds this force, the valve will open and permit the oil to flow to the engine crankcase. The resulting decrease in oil pressure will activate the shutdown mechanism.

A restricted fitting, which will permit a drop in oil pressure great enough to actuate the shutdown mechanism, is required in the oil line between the cyliner block oil gallery and the shutdown sensing devices.

Operation

To start an engine equipped with a mechanical shutdown system, first manually open the air shutoff valve and then press the engine starting switch. As soon as the engine starts, the starting switch may be released, but the air shutoff valve must be held in the open position until the engine oil pressure increases sufficiently to permit the bellow to retain the latch in the open position.

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

If the engine coolant overheats, the temperature-sensing valve will open and permit the oil in the protective system to flow to the engine crankcase.

The resulting decrease in oil pressure will actuate the shutdown mechanism and stop the engine. Also if the engine loses its coolant, the copper plug will be heated up by the hot exhaust gases passing over it and cause the temperature- sensing valve to open and actuate the shutdown mechanism.

Whenever the engine speed exceeds the overspeed governor setting, the oil in the line flows to the sump, resulting in a decrease in oil pressure. The oil pressure bellows then releases the latch and permits the air shutoff valve to close.

If the overspeed valve assembly is used, a decrease in

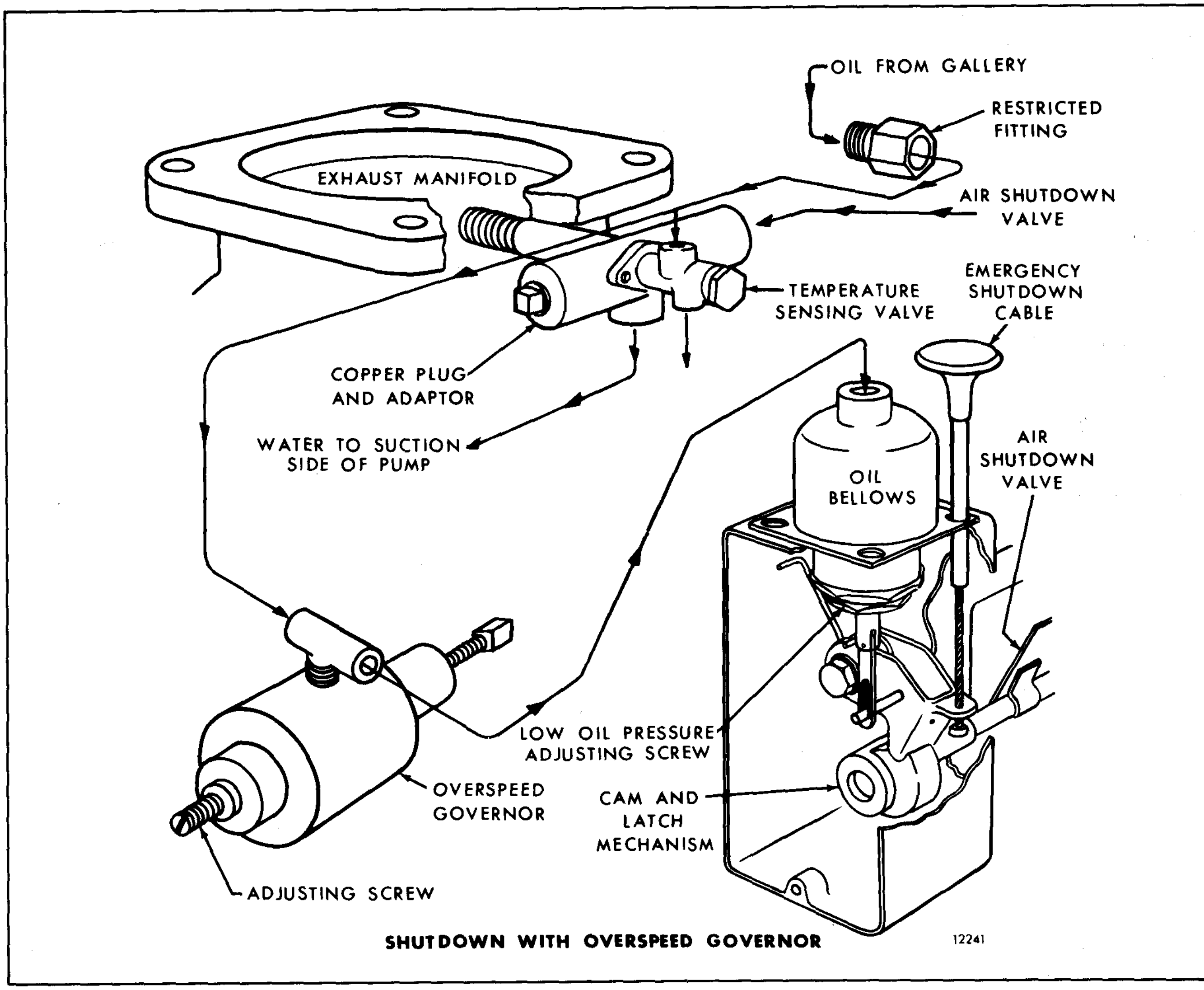


Fig. 3 - Schematic Drawing of Automatic Mechanical Shutdown System with Overspeed Governor

the oil pressure will reduce the spring tension in the valve and cause the air box pressure to open the dump valve and actuate the shutdown mechanism. If the engine speed increases, the air box pressure and oil pressure will also increase. However, since the travel of the oil piston is limited by the speed adjusting sleeve, the air box pressure will overcome the spring tension on the dump valve and actuate the shutdown mechanism.

When an engine is stopped by the action of the shutdown system, the engine cannot be started again until the particular device which actuated the shutdown mechanism has returned to its normal position. The abnormal condition which caused the engine to stop must be corrected before attempting to start it again.

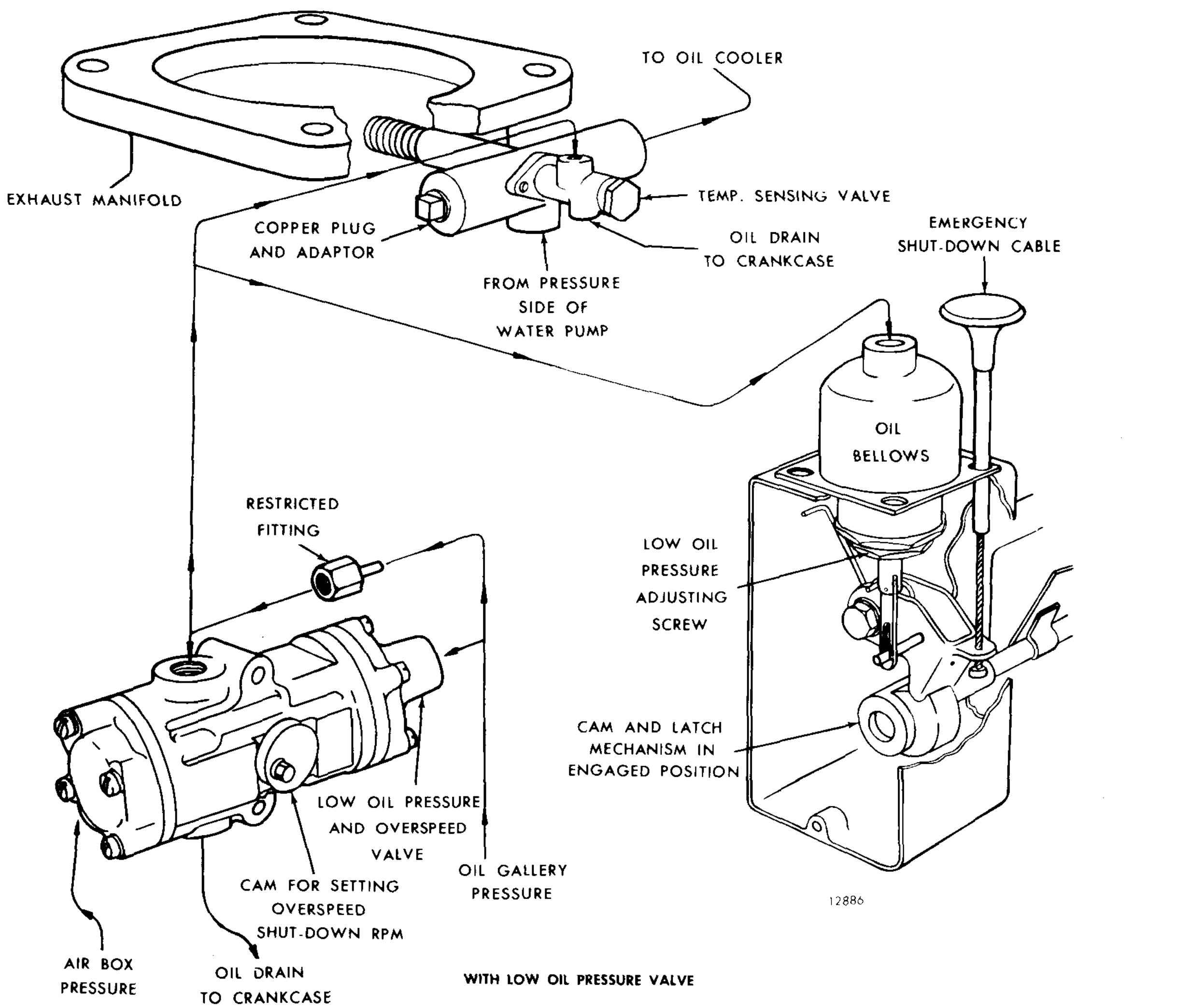


Fig. 4 - Schematic Drawing of Automatic Mechanical Shutdown System with Low Oil Pressure and Overspeed Valve

AUTOMATIC ELECTRICAL SHUTDOWN

The electrically operated automatic shutdown includes a fuel pressure switch, a lubricating oil pressure switch, a water temperature switch and a shutdown solenoid (Fig. 5).

An overspeed governor switch may be employed separately or in conjunction with the above electrical shutdown system.

A hot wire relay or a solid state time delay switch may be introduced into the electrical shutdown system to prevent the fuel oil pressure switch from closing before the lubricating oil pressure switch opens, which would cause a shutdown of the engine.

When the engine is not running, the fuel oil pressure switch is open, the lubricating oil pressure switch is closed and the water temperature switch is open.

After starting the engine, the lubricating oil pressure switch contacts are open when the oil pressure is 10 psi (69 kPa) or higher (approximately 700 rpm), and the fuel oil pressure switch contacts are closed when the fuel oil pressure is 20 psi (138 kPa) or greater (approximately 800 rpm). The electrical circuit of this

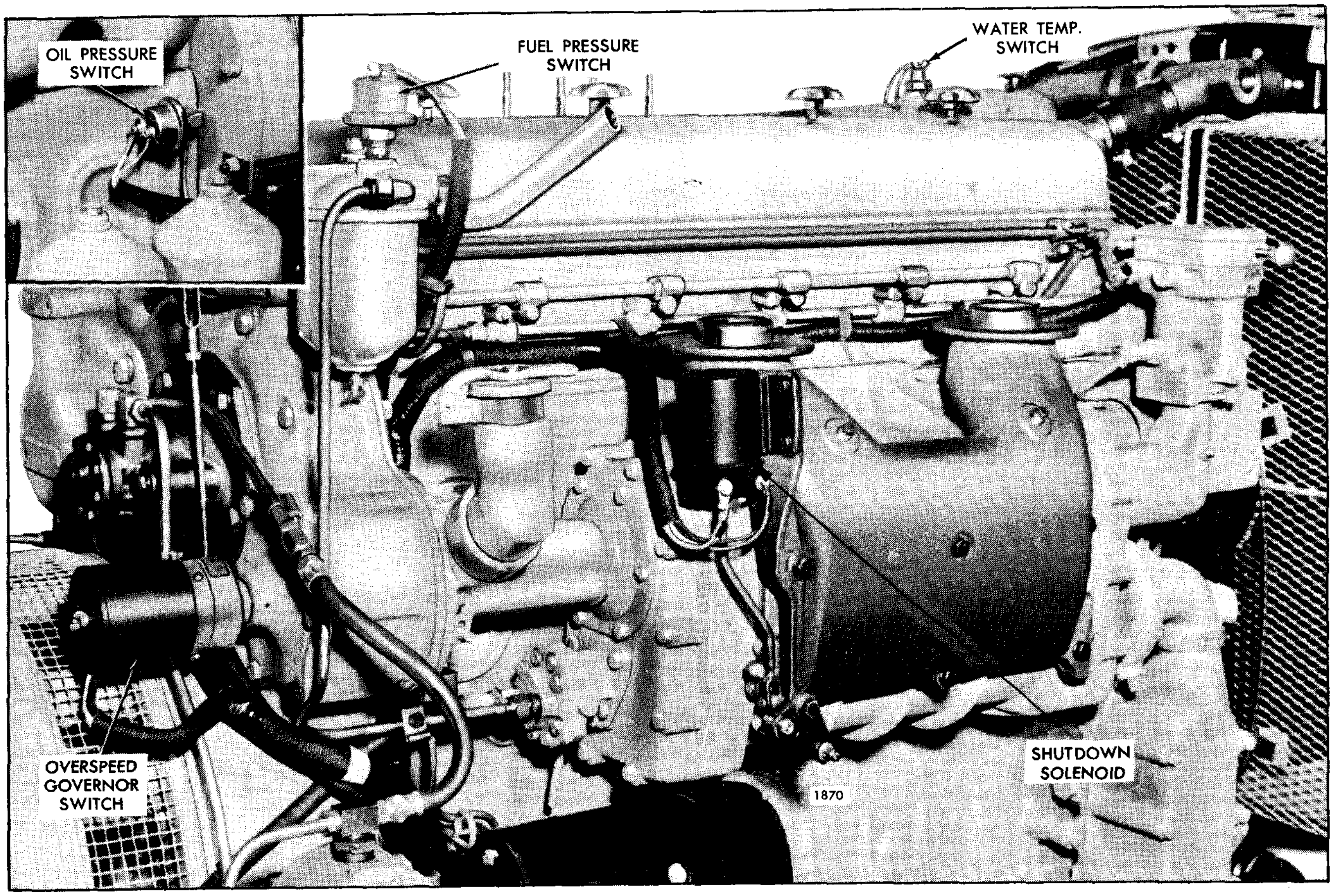


Fig. 5 - Typical Installation of Automatic Shutdown Device

system is so arranged that the closing of the fuel pressure switch energizes the entire system, and at anytime thereafter, the closing of either the lubricating oil pressure switch or water temperature switch, will cause the shutdown to operate. When the engine starts, the fuel pressure increases so rapidly that the fuel pressure switch contacts close before the lubricating oil pressure reaches 10 psi (69 kPa). This condition would cause the engine to shutdown, except for the introduction of a hot wire relay or a solid state time delay switch into the circuit. This relay or time delay switch delays the energizing of the shutdown solenoid by 3 to 10 seconds, enabling the lubricating oil pressure to exceed 10 psi (69 kPa), thereby opening the lubricating oil pressure switch and preventing the energizing of the circuit. When the engine has reached normal operating speed, the fuel oil pressure switch is closed and the lubricating oil pressure switch is open.

When the lubricating oil pressure falls below 10 ±2 psi (69 ±14 kPa), the oil pressure switch closes and current flows to the hot wire relay or time delay switch which must be heated by the current to complete the circuit to the solenoid. The few seconds required to heat the hot wire relay or time delay switch provides sufficient delay to avoid engine shutdown when low oil pressure is caused by a passing condition such as an air bubble or by the temporary overlap in the operation of the lubricating oil pressure switch and fuel pressure during starting and stopping of the engine.

The high water temperature switch is connected in parallel with the lubricating oil pressure switch and normally remains open, closing only when the engine coolant temperature exceeds 200 ±5°F (93 ±3°C) thus energizing the shutdown solenoid.

The overspeed governor is driven by the blower drive shaft. If the engine speed exceeds the speed which has been established by the engine governor, the overspeed governor switch is actuated, causing the shutdown solenoid to close the shutdown valve.

When the engine is shut down, as described above, the fuel oil pressure switch opens, thus breaking the circuit and eliminating the possibility of damage due to continued exposure to current.

Time Delay Switch

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

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

Fuel Oil Pressure Switch

From the above description, it can be seen that the fuel oil pressure switch is the controlling switch of the system, since this switch controls the flow of current to the other two switches. As previously stated, the fuel oil pressure switch is set to make contact when the fuel pressure reaches 20 psi (138 kPa), and the phrase "20-MAKE" is stamped on the switch cover.

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

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

Lubricating Oil Pressure Switch

The lubricating oil pressure switch is similar to the fuel oil pressure switch, except that the fuel oil pressure switch is of the "make" type while the lubricating oil pressure switch is of the "break" type. In other words, the lubricating oil pressure switch is calibrated to break contact when the lubricating oil pressure increases to 10 psi (69 kPa). The phrase "10-BREAK" is stamped on the switch cover.

As the lubricating oil pressure increases, when the engine starts, the diaphragm in the switch body expands and forces the plunger upwards. Since the bottom of the adjusting screw bears against the plunger and the adjusting screw is attached to the bracket which controls the upper breaker point arm, the arm is also forced upwards. When the lubricating oil pressure increases to 10 psi (69 kPa), the points separate. However, as previously described, current flows to the lubricating oil pressure switch only after the fuel oil pressure switch closes, at which time the points of the lubricating oil pressure switch are open. If the lubricating oil pressure decreases to 10 psi (69 kPa) during operation, the breaker point will close and either the alarm bell or the shutdown solenoid will be energized.

Water Temperature Switch

The terminals of the water temperature switch are connected into the shutdown system, and when the engine circulating water temperature reaches 205 $\pm 5°$F (96 $\pm 3°$C), the switch closes and completes the shutdown or alarm system.

As the water temperature increases, a plunger rises and contacts a wheel which is attached to the switch actuating lever. A further increase in water temperature forces the contact end of the actuating lever upwards. When the water temperature reaches 205 $\pm 5°$F (96 $\pm 3°$C), this lever forces the switch button upwards into the switch block thus closing the switch. Since this lever is spring loaded, the contact end of the lever moves away from the switch button as the water temperature decreases.

If the engine has been stopped by any of the above mentioned switches, the shutdown valve must be reset in the open position before the engine can be started.

SHUTDOWN SYSTEM FOR DIRECT MOUNTED TURBOCHARGED ENGINES

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

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

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

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

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

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

The customer is required to provide the mounting support brackets.

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

ALARM SYSTEM

The alarm system is similar to the automatic shutdown system previously described, but does not include the automatic shutdown feature incorporating the electrical solenoid (Fig. 6). The 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 is 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.

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

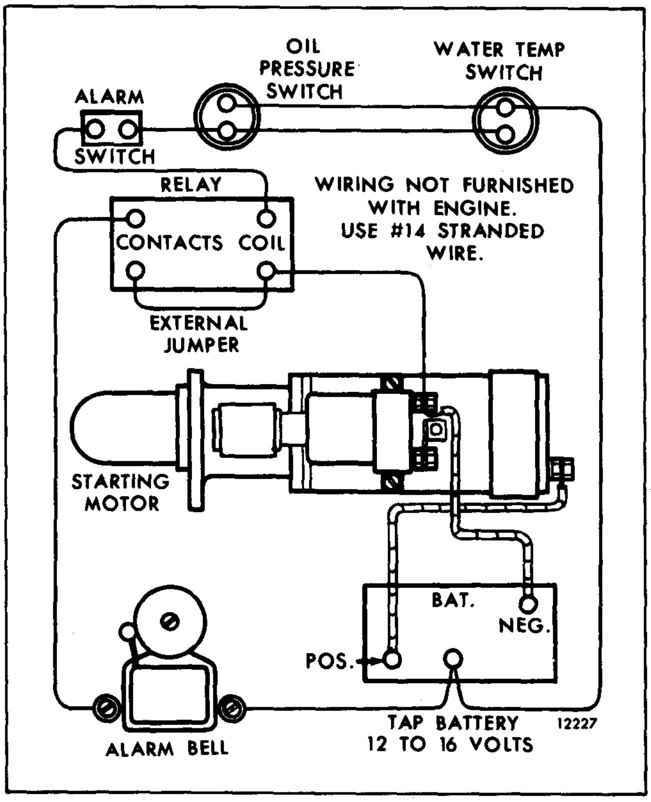


Fig. 6 - Alarm System Wiring Diagram

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 reapply 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.

CAUTION: Explosive gas may remain in or around the battery for several hours after it has been charged. Sparks or flame can ignite this gas causing an explosion which could shatter the battery. Flying pieces of the battery structure and splash of electrolyte can cause personal injury.

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.

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 (Fig. 7). Tighten the clutch until the desired pressure on the outer end of the hand lever, or at the clutch release shaft (Fig. 9), is obtained as shown in Table 1.

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 (Fig. 8). Tighten the clutch until the desired pressure on the outer end of the hand lever, or at the clutch release shaft (Fig. 9), is obtained as shown in Table 1.

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. However, a more accurate method of checking the

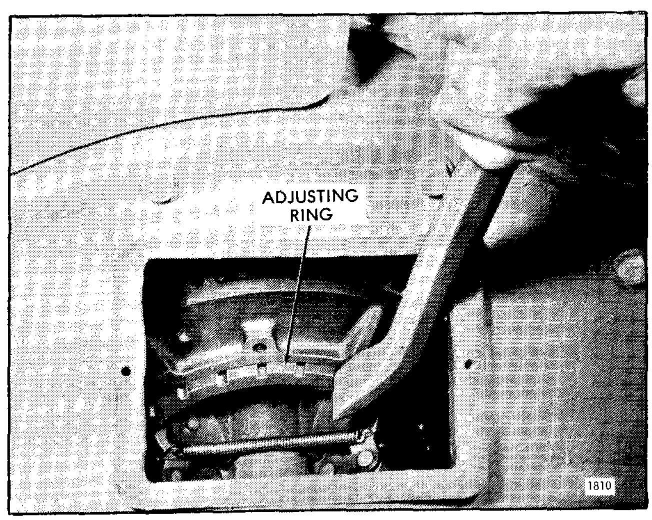


Fig. 7 - Power Take-Off Showing Typical 8" and 11-1/2" Diameter Clutch Adjustment Ring

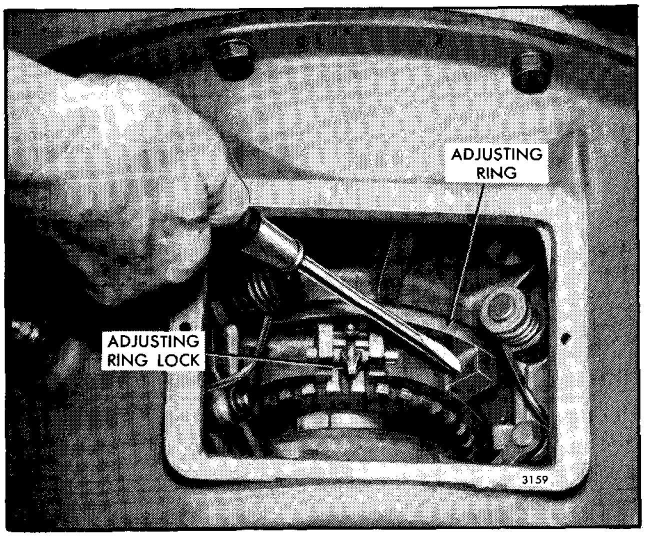


Fig. 8 - Power Take-Off Assembly Showing 14" Diameter Clutch Adjustment Ring

However, a more accurate method of checking the clutch adjustment is with a torque wrench as shown in Fig. 9.

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. 9. 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:

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

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

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.

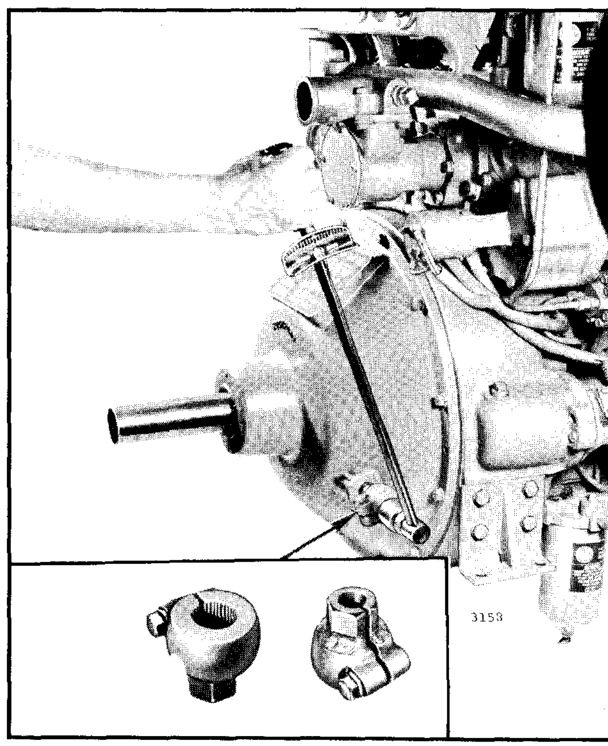


Fig. 9 - Power Take-Off Clutch Adjustment Check with Torque Wrench and Adaptor

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.

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 110 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.

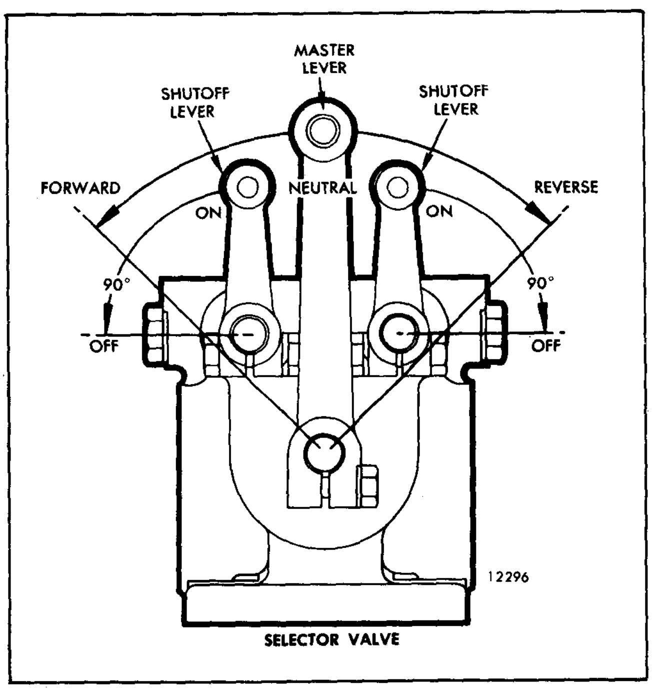


Fig. 10 - Operation of Selector Valve on Multiple Engine Units

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.

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. 8). 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 shutoff 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 shutoff lever for that engine to the "off" position (90 degrees toward the engine). With the shutoff 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 shutoff 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. 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. To prevent binding between the piston and the bore in the flywheel, the emergency engagement bolts must be tightened uniformly. Do not use the reverse drive when the engagement bolts are engaged. Install the pipe plug in the flywheel housing.

> **NOTE:** 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.

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 lockup 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.

OPERATING INSTRUCTIONS

ENGINE OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME

The operator should read and follow these instructions before attempting to start the engine. 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 water and an ethylene glycol base 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.

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.

> **NOTE:** 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 *Lubrication 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 *Lubrication 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

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

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

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

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

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

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

Fuel System

Fill the tank with the fuel specified under *Fuel 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 (except for fan hub pulley fitting--refer to *Preventive Maintenance*) 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.

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.*

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 grade and viscosity lubricating oil as used in the engine.

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

> **NOTE:** 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 shutdown valve in the closed position.

The engine may require the use of a cold weather starting aid if the ambient temperature is below 40°F (4°C).

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.

NOTE: 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.

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 1.

Warm-Up

Run the engine at part throttle and no-load for approximately five minutes, allowing it to warm-up before applying the 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.

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 1

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 160-185 °F (71-85 °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 *Lubrication 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 (refer to *Engine Coolant*).

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

To stop an engine (normal or emergency) equipped with the spring-loaded (one screw) design injector control tube, pull the governor stop lever to the stop position. If an engine equipped with the non-spring loaded (two screw) design injector control tube 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 cuase for the malfunction has been found and corrected.

> **NOTE:** 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 shutdown 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.

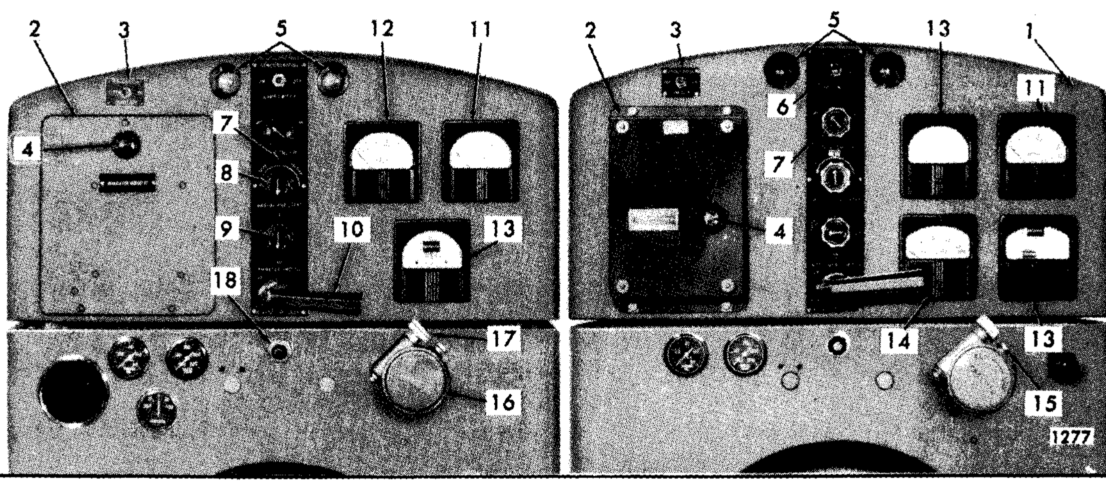
5. Place the field switch (7) in the *off* position.

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.



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

Fig. 1 - Typical Alternating Current Generator Control Cabinets

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).

Press the throttle button (15) and turn the throttle control (16) counterclockwise to a position midway between *run* and *stop* (Fig. 1). 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.

> **NOTE:** 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) in the *on* position (Fig. 1).

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 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); the voltage must be the same as the line voltage (Fig. 1). 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), until the ammeter (11) reads approximately zero (Fig. 1).

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 (16) 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.

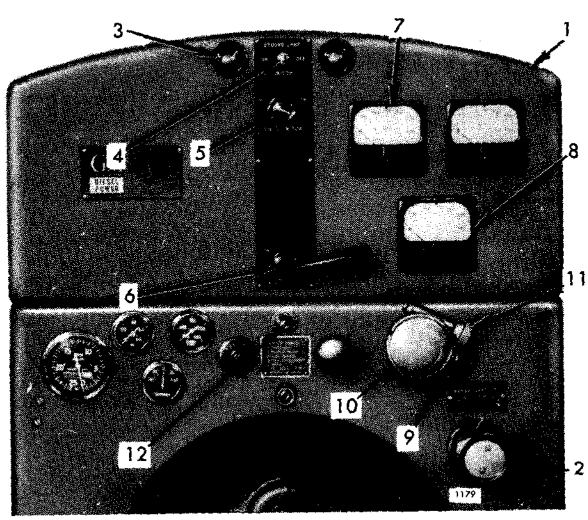
7. Turn the manual field rheostat control (2) counterclockwise to its lowest limit.

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.

Press the throttle button (9) and turn the throttle control (10) counterclockwise to a position midway between *run* and *stop* (Fig. 2). 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.

NOTE: 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) counterclockwise to the *run* position (Fig. 2).

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) until the ammeter (7) reads approximately zero (Fig. 2).

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

The *Lubrication and Preventive Maintenance Schedule* is intended as a guide for establishing a preventive maintenance schedule. The suggestions and recommendations for preventive maintenance should be followed as closely as possible to obtain long life and best performance from a Detroit Diesel engine. The intervals indicated on the chart are time or miles of actual operation.

MAINTENANCE SCHEDULE EXPLANATION

The time or mileage increments shown apply only to the maintenance function described. These functions should be co-ordinated with other regularly scheduled 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* in Section 4.

INDUSTRIAL OFF HIGHWAY AND MARINE — HRS.	TIME INTERVALS DLY.	8	50	100	150	200	300	500	700	1,000	2,000
MILES		240	1,500	3,000	4,500	6,000	9,000	15,000	20,000	30,000	60,000
1. — Lubricating Oil	X				X						
2. — Fuel Tank	X							X	X		
3. — Fuel Lines	X										
4. — Cooling System	X								X	X	
5. — Turbocharger	X										
6. — Battery				X							
7. — Tachometer Drive				X							
8. — Air Cleaners		X						X			
9. — Drive Belts		X				X					
10. — Air Compressor						X			X		
11. — Throttle and Clutch Controls						X					
12. — Lubricating Oil Filter								X		X	
13. — Fuel Strainer and Filter							X				
14. — Coolant Filter								X			
15. — Starting Motor*											
16. — Air System									X		
17. — Exhaust System									X		
18. — Air Box Drain Tube										X	
19. — Emergency Shutdown									X		
21. — Radiator									X		
22. — Shutter Operation									X		
23. — Oil Pressure									X		
24. — Overspeed Governor								X			
26. — Throttle Delay*											
27. — Battery-Charging Alternator						X					
28. — Engine and Transmission Mounts											X
29. — Crankcase Pressure											X
30. — Air Box Check Valves*											
31. — Fan Hub*									X		
32. — Thermostats and Seals									X		
33. — Blower Screen										X	
34. — Crankcase Breather										X	
36. — Engine Tune-Up*											
37. — Heat Exchanger Electrodes								X		X	
38. — Raw Water Pump	X										
39. — Power Generator				X			X				
40. — Power Take-Off		X	X					X			
41. — Marine Gear	X					X				X	
42. — Torqmatic Converter	X		X					X		X	
43. — Reduction Gear (Single Engine)		X	X					X		X	
44. — Reduction Gear (Multiple-Ind.)	X									X	
45. — Reduction Gear (Multiple-Marine)	X					X					
47. — Transmission (Railcar)	X									X	
48. — Oil Filter (Railcar)										X	

*See Item

Item 1 - Lubricating Oil

Check the lubricating oil level with the engine stopped.. If the engine has just been stopped, wait approximately twenty minutes to allow the oil to drain back to the oil pan. Add the proper grade oil as required to maintain the correct level on the dipstick. Refer to *Lubrication Specifications* in this section.

NOTE: Oil may be blown out through the crankcase breather if the crankcase is overfilled.

Make a visual check for oil leaks around the filters and external oil lines.

Change the lubricating oil at intervals shown in Table 1.

ENGINE OIL CHANGE INTERVALS

Service Application	Max. Engine Oil Change Interval		
	Diesel Fuel Sulfur Content % by Wt. Max.		
	0 to .50	0.51 to 0.75	0.76 to 1.00
Industrial & Marine	150 Hours	30 Hours	15 Hours*

*These oil change intervals are based upon worst case with chrome-faced rings. Oil change periods with plasma rings can be established by oil analysis.

TABLE 1

The drain interval may be established on the recommendations of an independent oil analysis laboratory or the oil supplier (based upon the used oil sample analysis) until the most practical oil change period has been determined. Select the proper grade of oil in accordance with the instructions given in the *Lubrication Specifications* in this section.

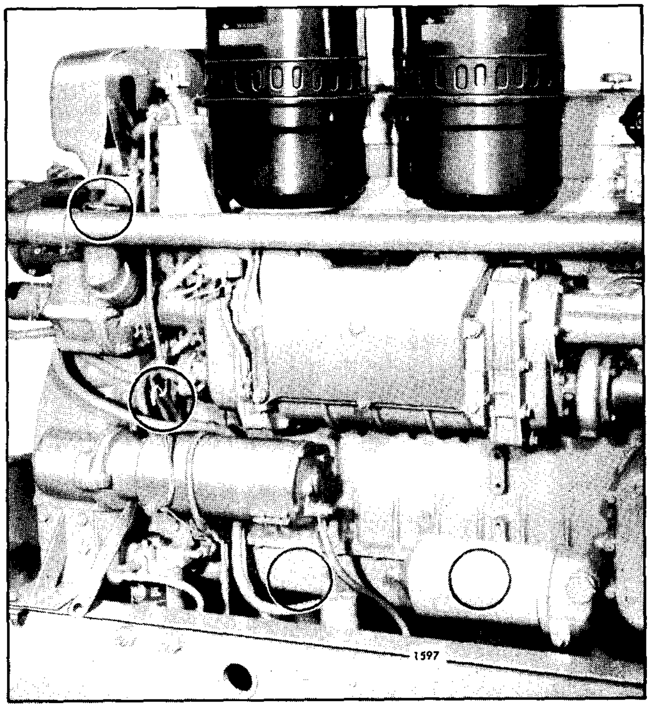
NOTE: If the lubricating oil is drained immediately after an engine has been run for some time, most of the sediment will be in suspension and will drain readily.

Item 2 - Fuel Tank

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

Open the drain at the bottom of the fuel tank every 500 hours or 15,000 miles to drain off any water and/ or sediment.

Every 12 months or 20,000 miles (700 hours) tighten all fuel tank mountings and brackets. At the same time, check the seal in the fuel tank cap, the breather hole in the cap and the condition of the crossover fuel line. Repair or replace the parts as necessary.



Items 1 and 12

Diesel Fuel Contamination

The most common form of diesel fuel contamination is water. Water is harmful to the fuel system in itself, but it also promotes the growth of mircobiological organisms (microbes). These microbes clog fuel filters with a "slime" and restrict fuel flow.

Water can be introduced into the fuel supply through poor maintenance (loose or open fuel tank caps), contaminated fuel supply or condensation.

Condensation is particularly prevalent on units which stand idle for extended periods of time, such as marine units. Ambient temperature changes cause condensation in partially filled fuel tanks.

Water accumulation can be controlled by mixing isopropyl alcohol (dry gas) into the fuel oil at a ratio of one pint per 125 gallons fuel (or 0.10% by volume).

Marine units in storage are particularly susceptible to mircobe growth. The mircobes live in the fuel-water interface. They need both liquids to survive. These microbes find excellent growth conditions in the dark, quiet, non-turbulent nature of the fuel tank.

Microbe growth can be eliminated through the use of commerically available biocides. There are two basic types on the market.

1. The water soluble type treats *only the tank* where it is introduced. Microbe growth can start again if fuel is transferred from a treated to an untreated tank.

2. The diesel fuel soluble type, such as "Biobor" manufactured by U.S. Borax or equilvalent, treats *the fuel* itself and therefore the entire fuel system.

Marine units, or any other application, going into storage should be treated as follows: Add the biocide according to the manufacturer's instructions. This operation is most effective when performed as the tank is being filled. Add dry gas in the correct proportions.

If the fuel tanks were previously filled, add the chemicals and stir with a clean rod.

Item 3 - Fuel Lines

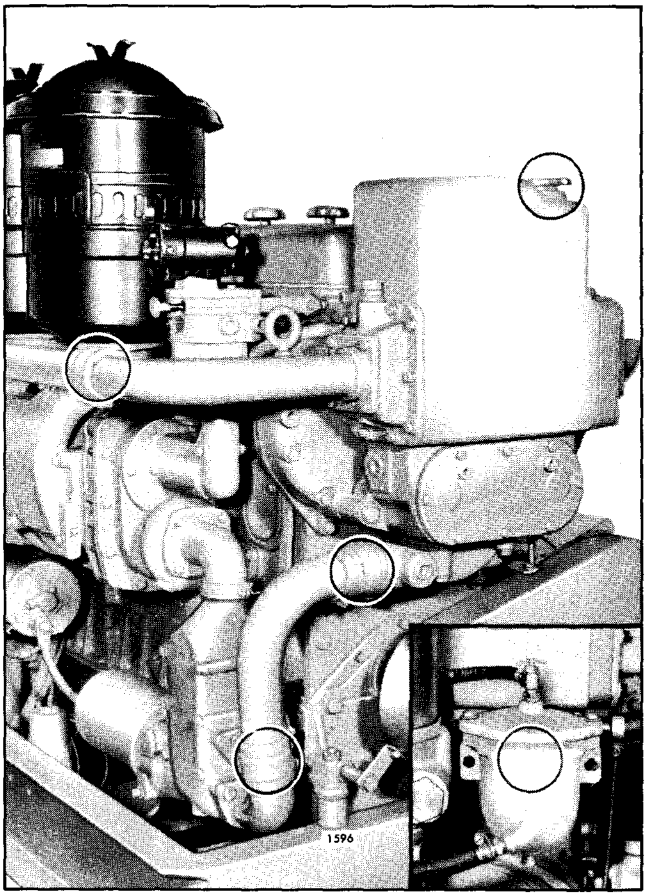
Make a visual check for fuel leaks at the crossover lines and at the fuel tank suction and return lines. Since fuel tanks are susceptible to road hazards, leaks in this area may best be detected by checking for accumulation of fuel under the tanks.

Item 4 - Cooling System

Check the coolant level daily and maintain it near the top of the heat exchanger tank or radiator upper tank. Add coolant as necessary. *Do not overfill.*

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 an ethylene glycol base antifreeze (refer to *Engine Coolant* in this section). 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.

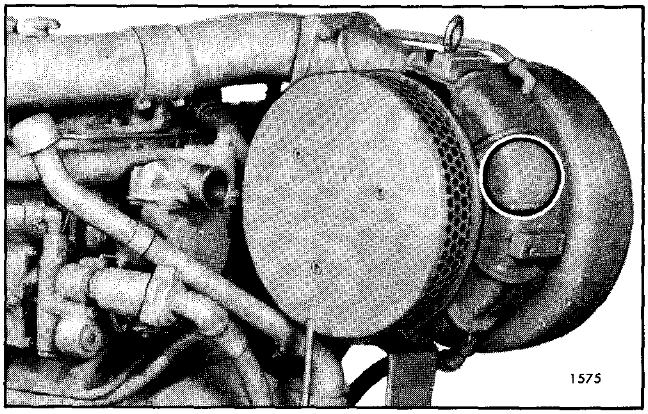
The coolant circulated through the intercoolers on a turbocharged intercooler engine is protected by a 20 mesh cone-shaped water filter (screen). The filter is located at the water connection in the water pump-to-engine oil cooler tube. The filter should be inspected for damage or clogging when the cooling system is cleaned. Disconnect the flexible water hose at the water connection and remove and clean the filter. If



Items 4 and 14

necessary, replace the filter. Reinstall the water filter (screen) in the water connection.

Inspect all of the cooling system hoses at least once every 700 hours or 20,000 miles for signs of deterioration. Replace the hoses if necessary.



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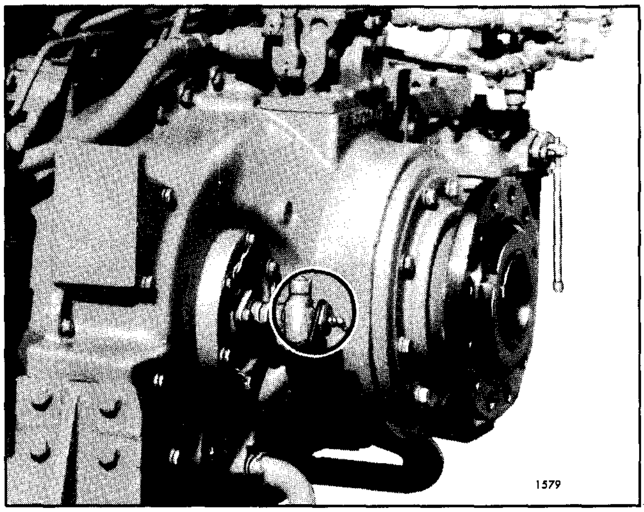


Item 7

Item 5 - Turbocharger

Inspect the mountings, intake and exhaust ducting and connections for leaks. Check the oil inlet and outlet lines for leaks or restrictions to oil flow. Check for unusual noise or vibration and, if excessive, remove the turbocharger and correct the cause.

Item 6 - Battery

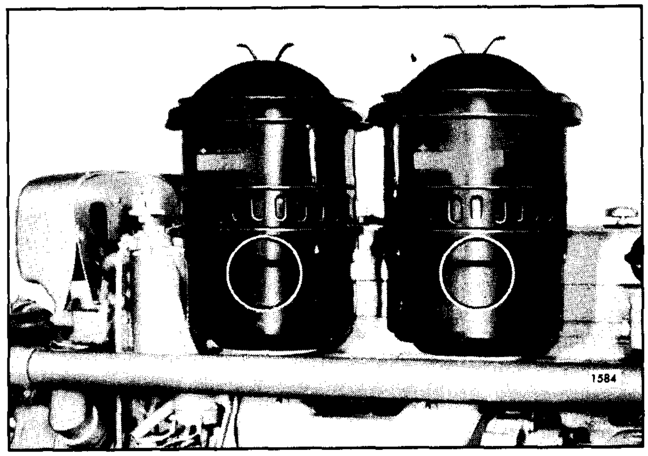
Check the specific gravity of the electrolyte in each cell of the battery every 100 hours or 3,000 miles. In warm weather, however, it should be checked more frequently due to a more rapid loss of water from the electrolyte. The electrolyte level should be maintained in accordance with the battery manufacturer's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

Item 7 - Tachometer Drive

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 8 - Air Cleaner

Under no engine operating conditions should the air inlet restriction exceed 25 inches of water (6.2 kPa) for non-turbocharged engines or 20 inches of water (5.0 kPa) for turbocharged engines. A clogged air cleaner element will cause excessive intake restriction and a reduced air supply to the engine.



Item 8

Oil Bath

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. If heavy rain or snow has been encountered, check the air cleaner for an accumulation of water.

Remove and steam clean the air cleaner element and baffle annually.

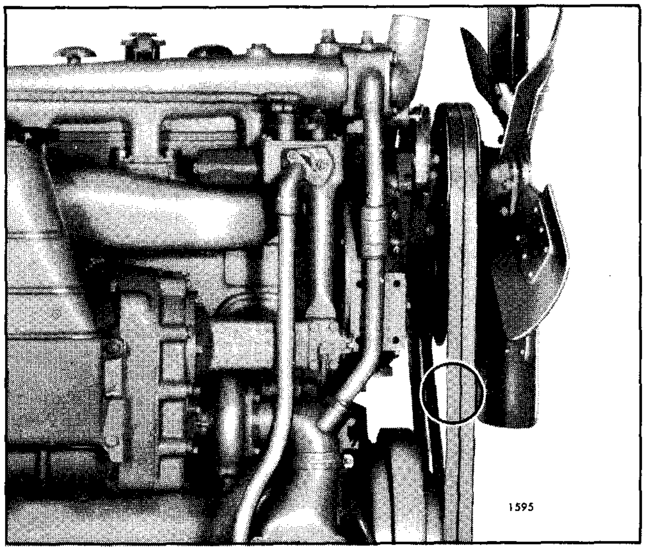
It is recommended that the body and fixed element in the heavy-duty oil bath type air cleaner be serviced every 500 hours or 15,000 miles or as conditions warrant.

Dry Type

Dry type elements used in off-highway applications should be discarded and replaced with new elements after one year of service or when the maximum allowable air intake restriction has been reached (see Section 13.2), whichever comes first. In cases where the air cleaner manufacturer recommends cleaning or washing off-highway elements, the maximum service life is still one year or maximum restriction. Cleaning, washing and inspection must be done per the manufacturer's recommendations. Secondary (safety) elements should **not** be cleaned or reused. Inspection and replacement of the cover gaskets must also be done per the manufacturer's recommendations.

Item 9 - Drive Belts

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



Item 9

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 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, J 23600-B or equivalent is available, adjust the belt tension as outlined in the chart.

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 6-71	50-60 60-80	80-100 80-100	40-50 40-50	50-70 50-70	40-50 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 bolt (.785" wide) used to drive a 12 cfm air compressor.

BELT TENSION CHART (lbs/belt)

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.

Item 10 - Air Compressor

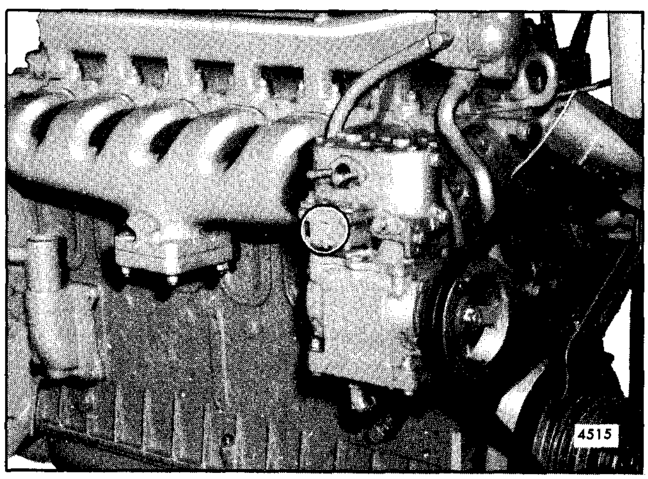
Remove and clean all air compressor air intake parts every 200 hours or 6,000 miles. To clean either the hair or polyurethane type air compressor air strainer element, saturate and squeeze it in fuel oil, or any other cleaning agent that would not be detrimental to the element, until dirt free. Then 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.

Every 12 months or 20,000 miles (700 hours) tighten the air compressor mounting bolts. If the air compressor is belt driven, check the belts for proper tension.

Item 11 - Throttle and Clutch Controls

Every 200 hours or 6,000 miles lubricate the limiting speed governor speed control shaft. Remove the plug in the end of the shaft and install a temporary grease fitting. Then remove the governor cover to obtain a visual indication when greasing is complete. Use an all purpose grease (No. 2 grade) at temperatures +30 °F (−1 °C) and above. At temperatures below this use a No. 1 grade grease. After greasing the shaft remove the fitting and install the plug and governor cover using a new cover gasket.



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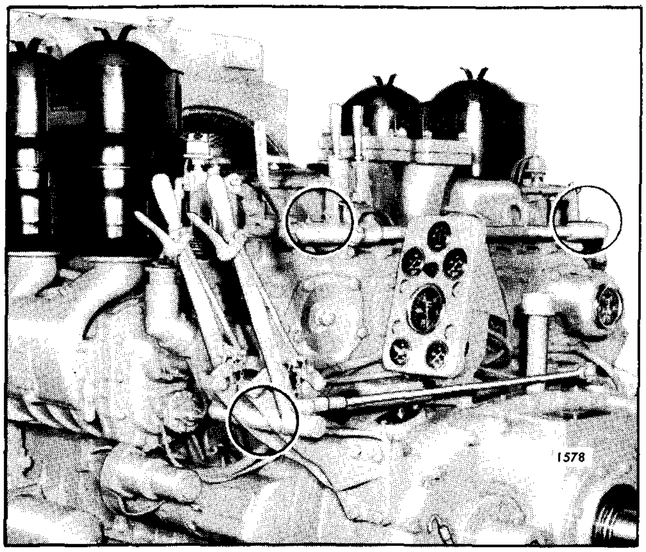


Item 11

Lubricate the clutch control levers and all other control mechanisms, as required, with engine oil.

Item 12 - Lubricating Oil Filter

Install new oil filter elements and gaskets at a *maximum* of 500 hours or each time the engine oil is changed, whichever occurs first. Any deviation, such as changing filters every other oil change, should be based on a laboratory analysis of the drained oil and the 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.

When the engine is equipped with a turbocharger:

1. Disconnect the oil inlet (supply) line at the bearing (center) housing.

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

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

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

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

If the engine is equipped with a governor oil filter, change the element every 1,000 hours or 30,000 miles.

Check for oil leaks after starting the engine.

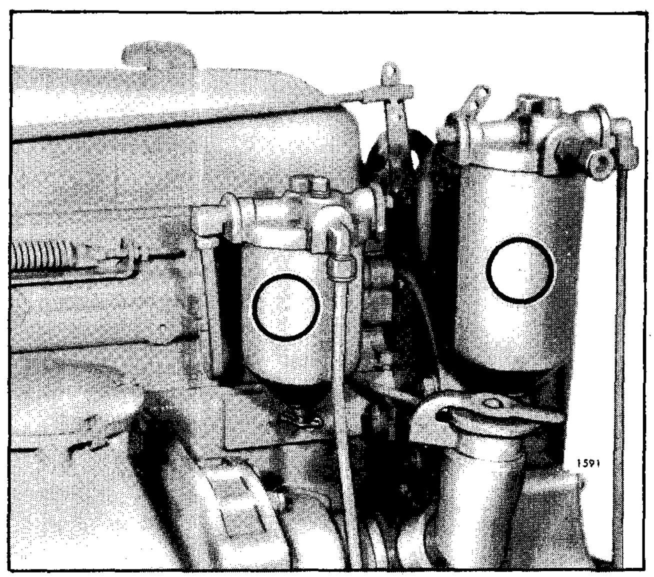
Item 13 - Fuel Strainer and Filter

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 (20.3 kPa). At normal operating speeds (1600-2100 rpm), the fuel pressure is 45 to 70 psi (310 to 483 kPa). Change the fuel filter elements whenever the inlet restriction (suction) at the fuel pump reaches 12 inches of mercury (41 kPa) at normal operating speeds and whenever the fuel pressure at the inlet manifold falls to 45 psi (310 kPa).

Item 14 - Coolant Filter

If the cooling system is protected by a coolant filter and conditioner, the filter element should be changed every 500 hours or 15,000 miles. Select the proper coolant filter element in accordance with the instructions given under *Engine Coolant* in this section. Use a new filter cover gasket when installing the filter



Item 13

element. After replacing the filter and cover gasket, start the engine and check for leaks.

Item 15 - Starting Motor

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 16 - Air System

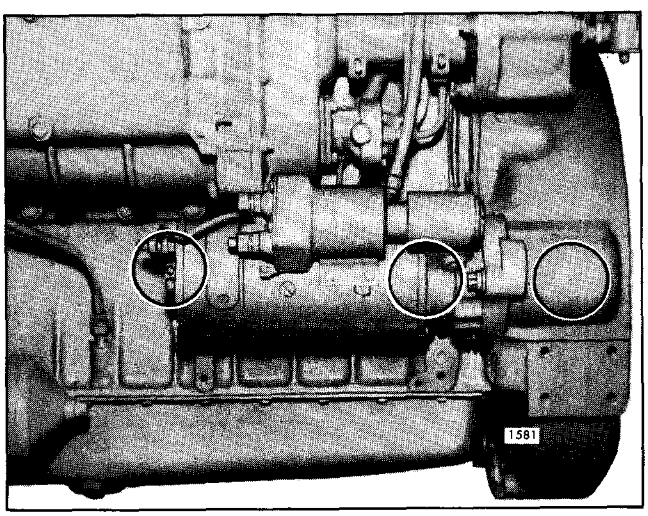
Check all of the connections in the air system to be sure they are tight. Check all hoses for punctures or other damage and replace, if necessary.

Item 17 - Exhaust System

Check the exhaust manifold retaining nuts, exhaust flange clamp and other connections for tightness. Check for proper operation of the exhaust pipe rain cap, if one is used.

Item 18 - Air Box Drain Tube

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



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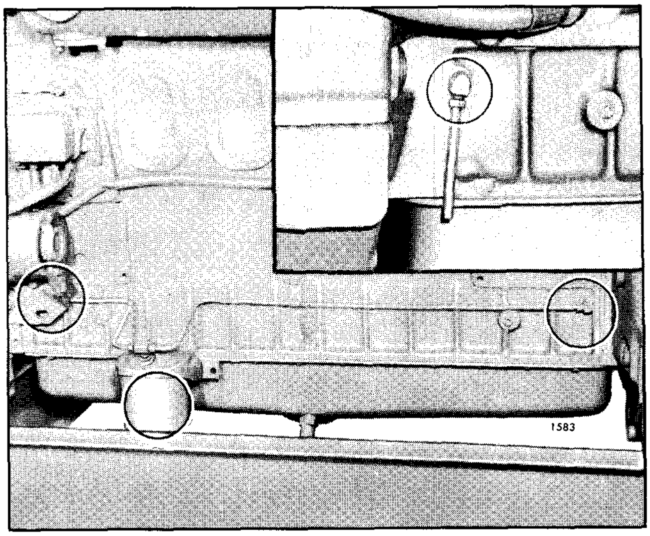
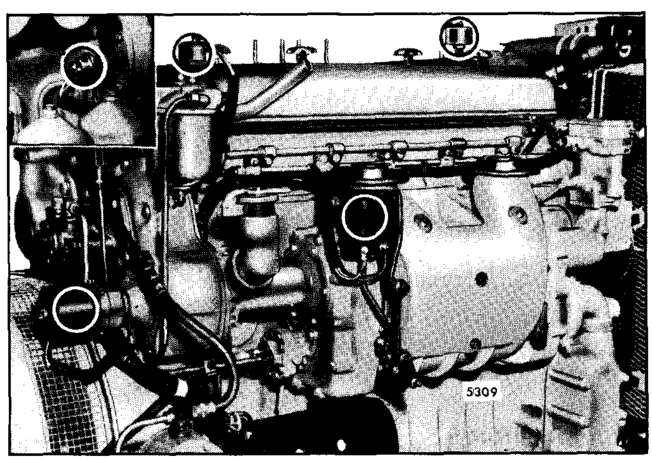


Item 18

If the engine is equipped with an air box drain tank, drain the sediment periodically.

Item 19 - Emergency Shutdown

With the engine running at idle speed, check the operation of the emergency shutdown every 700 hours or 20,000 miles. Reset the air shutdown valve in the open position after the check has been made.



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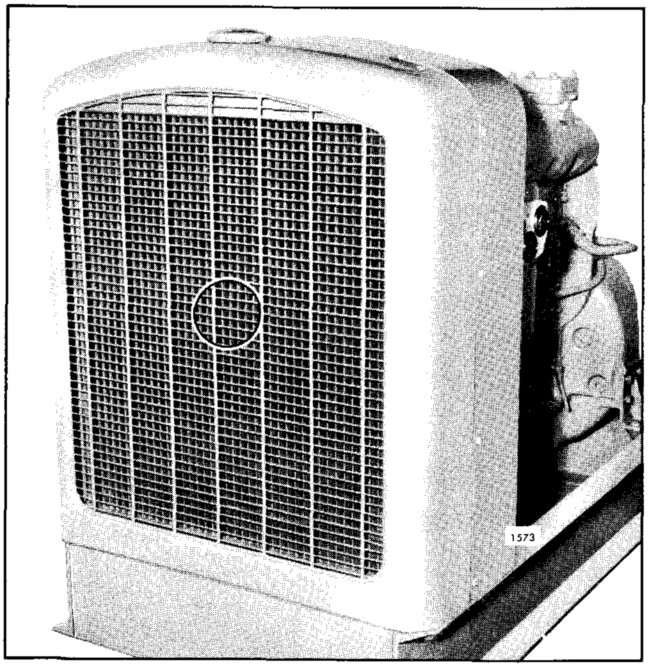


Item 21

Item 21 - Radiator

Inspect the exterior of the radiator core every 700 hours or 20,000 miles and, if necessary, clean it with a quality grease solvent such as mineral spirits 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 22 - Shutter Operation

Check the operation of the shutters and clean the linkage and controls.

Item 23 - Oil Pressure

Under normal operation, oil pressure is noted each time the engine is started. In the event the engine is equipped with warning lights rather than pressure indicators, the pressure should be checked and recorded every 700 hours or 20,000 miles.

Item 24 - Overspeed Governor

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 or 15,000 miles. Avoid excessive lubrication and do not lubricate the governor while the engine is running.

Item 26 - Throttle Delay

Inspect and adjust, if necessary, every 30 months or 50,000 miles.

The throttle delay system limits the amount of fuel injected during acceleration by limiting the rate of injector rack movement with a hydraulic cylinder. The initial location of this cylinder must be set with the proper gage to achieve the appropriate time delay (Section 6).

Inspect the check valve by filling the throttle delay cylinder with diesel fuel and watching for valve leakage while moving the throttle from the idle to the full-fuel position.

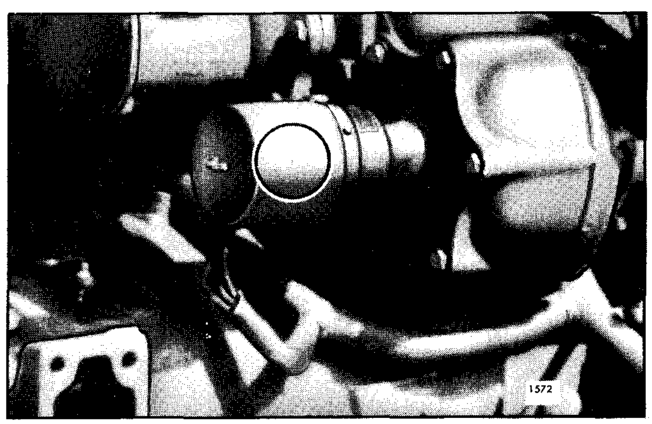
Item 27 - Battery-Changing Alternator

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

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.

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

On 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.



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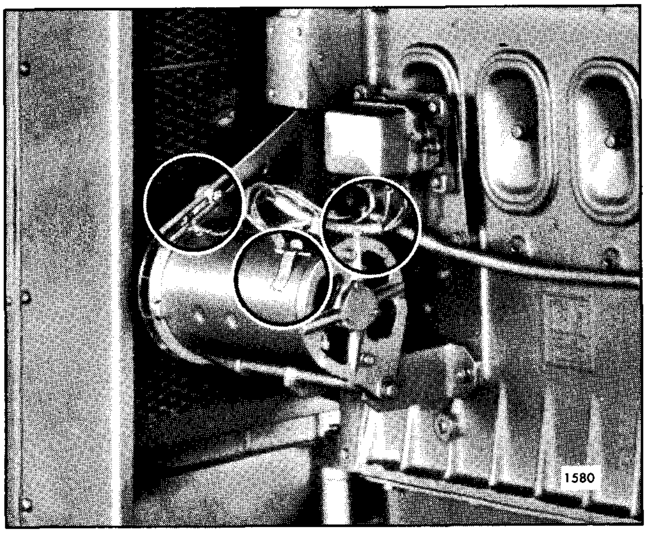

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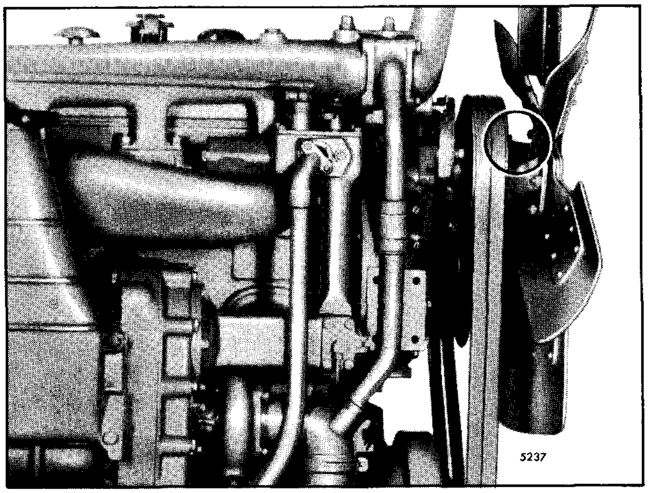


Item 31

Item 28 - Engine and Transmission Mounts

Check the engine and transmission mounting bolts and the condition of the mounting pads every 2000 hours or 60,000 miles. Tighten and repair as necessary.

Item 29 - Crankcase Pressure

Check and record the crankcase pressure every 2000 hours or 60,000 miles.

Item 30 - Air Box Check Valves

Every 100,000 miles or approximately 3000 hours remove, clean in solvent and blow out lines with compressed air. Inspect for leaks after servicing.

Item 31 - Fan Hub

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).

Every 4000 hours clean, inspect and repack the fan bearing hub assembly with the above recommended grease.

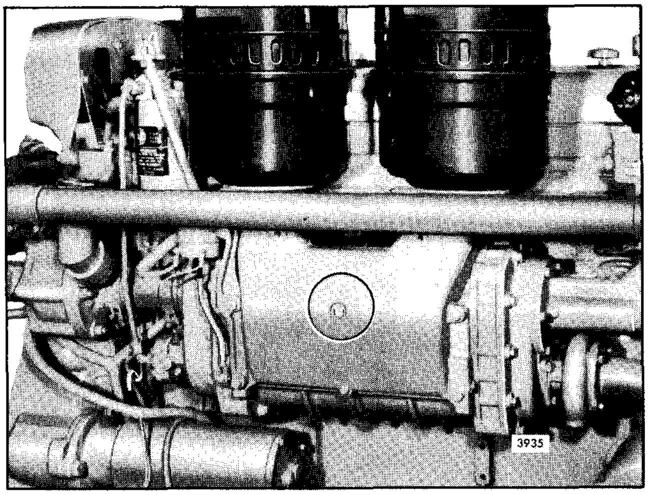
At a major engine overhaul, remove and discard the bearings in the fan hub assembly. Pack the hub assembly, using new bearings, with Texaco Premium RB grease or an equivalent Lithium base multi-purpose grease.

Item 32 - Thermostats and Seals

Check the thermostats and seals (preferably at the time the cooling system is prepared for winter operation). Replace the seals if necessary.

Item 33 - Blower Screen

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 33

Item 34 - Crankcase Breather

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.

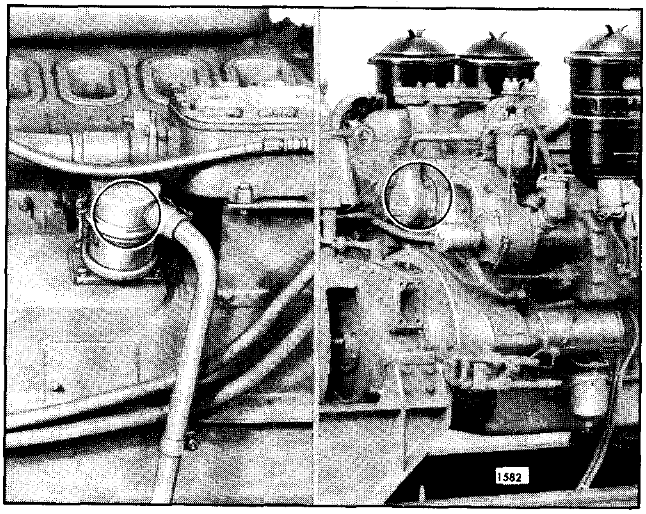
Item 36 - Engine Tune-Up

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 37 - Heat Exchanger Electrodes and Core

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



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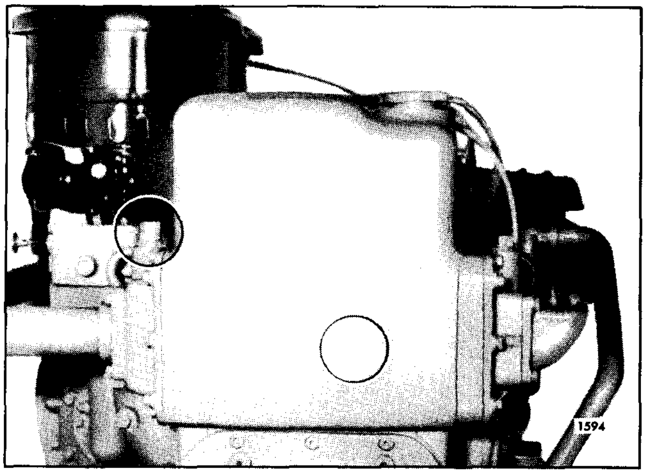


Item 37

amount of scale or deposits are present, contact a *Detroit Diesel Allison Service Outlet.*

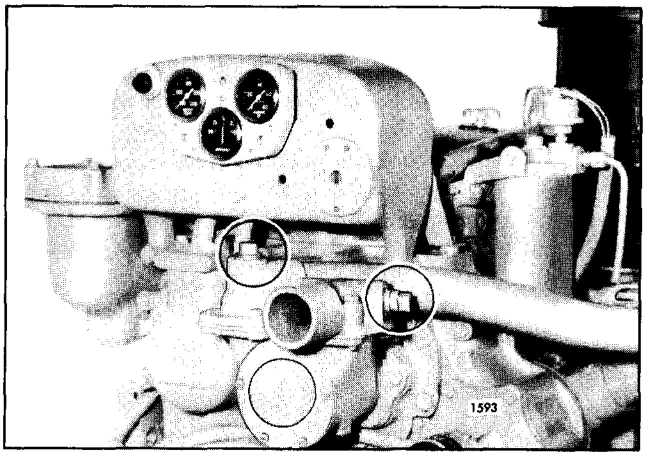
Item 38 - Raw Water Pump

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 39 - Power Generator

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



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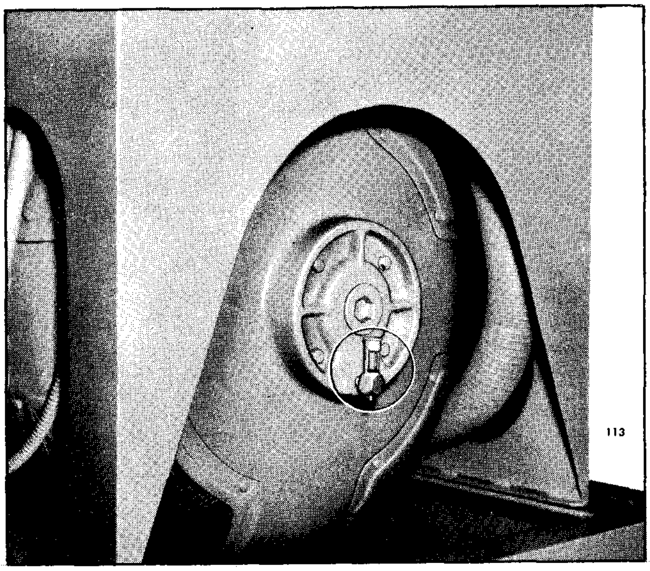


Item 39

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.

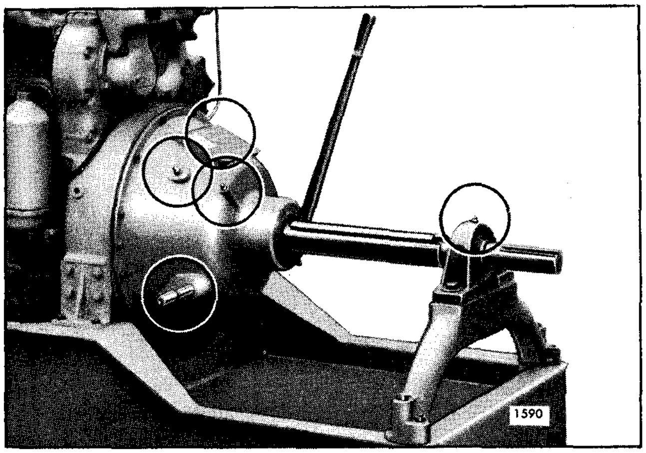
If the bearing is grease lubricated, a new generator has sufficient grease for three years of normal service. Thereafter, it should be lubricated at one year intervals. To lubricate the bearing, remove the filler and relief plugs on the side and the bottom of the bearing reservoir. Add grease until new 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 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 40

Item 40 - Power Take-Off

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 41 - Torqmatic Marine Gear

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.

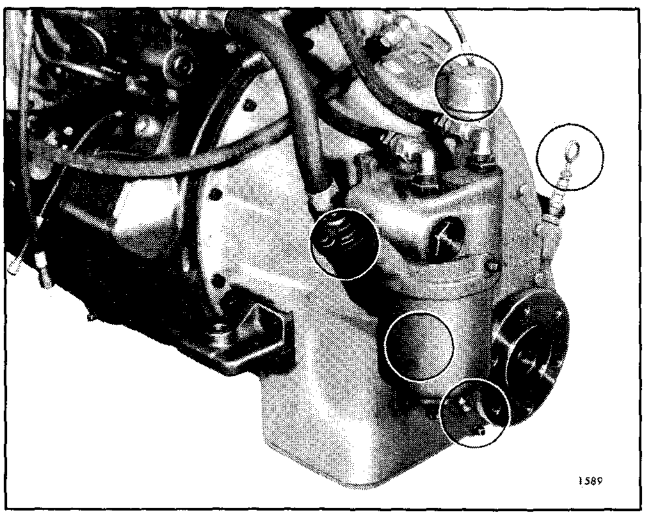
When refilling after an oil drain, bring the oil up to the proper level on the dipstick - approximately 6 quarts (5.7 liters) in the M type and 8 quarts (7.6 liters) in the MH type gear. Start and run the engine at light load for three to five minutes. Then put the controls in neutral and run the engine 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 42 - Torqmatic Converter

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



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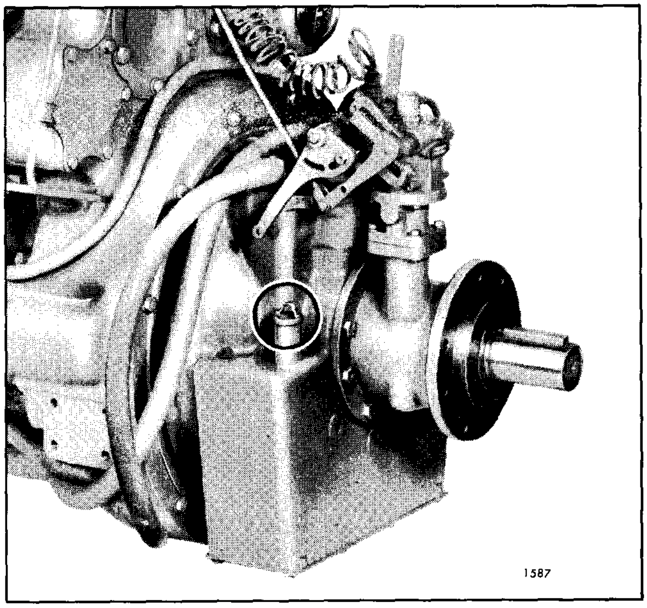

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minutes. The oil level should be maintained at the proper level on the dipstick. If required, add hydraulic transmission fluid type "C-2" (see chart). *Do not overfill* the converter as too much oil will cause foaming and high oil temperature.

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

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.

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 43 - Reduction Gear (Single Engine)

ROCKFORD REDUCTION GEAR:

Check the oil level in the reduction gear every 8 hours or 240 miles and add oil as required to bring the oil to the proper level on the dipstick. Drain the oil every 1,000 hours or 30,000 miles, 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 or 15,000 miles. Lubricate the clutch release shaft through the grease fittings on the front of the housing every 500 hours or 15,000 miles.

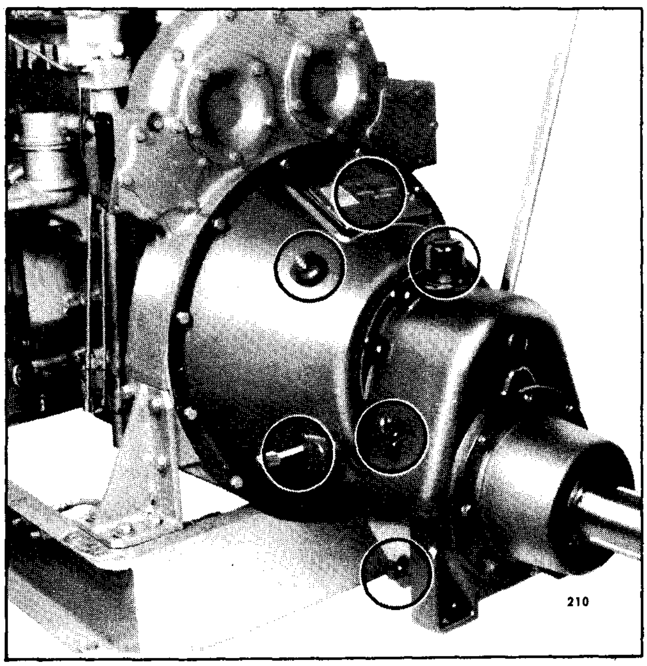
Item 44 - Reduction Gear (Multiple-Industrial)

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 45 - Reduction Gear (Multiple-Marine)

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.



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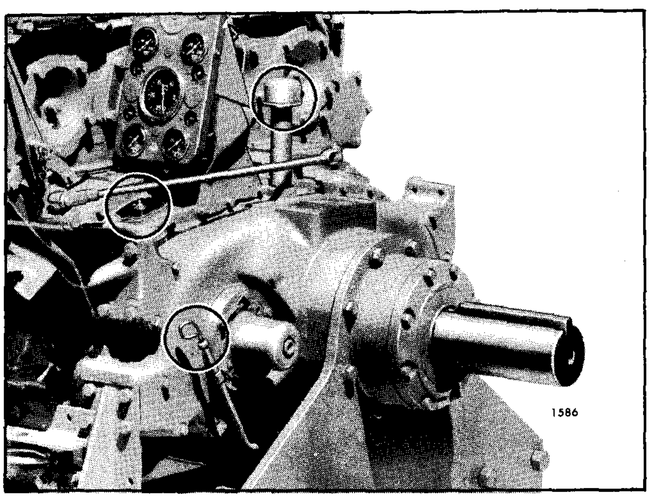

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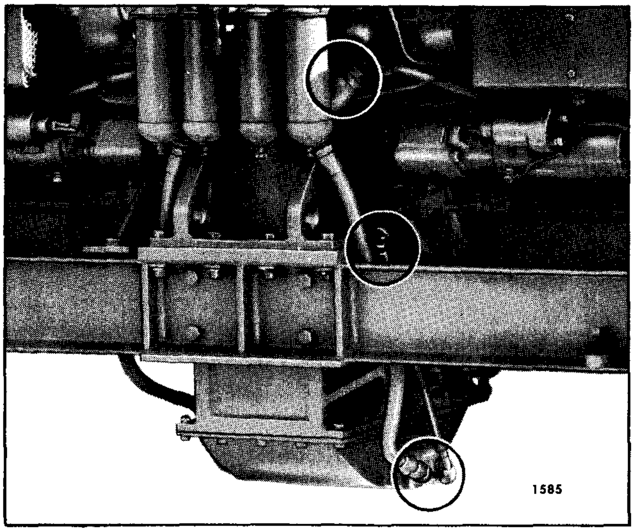


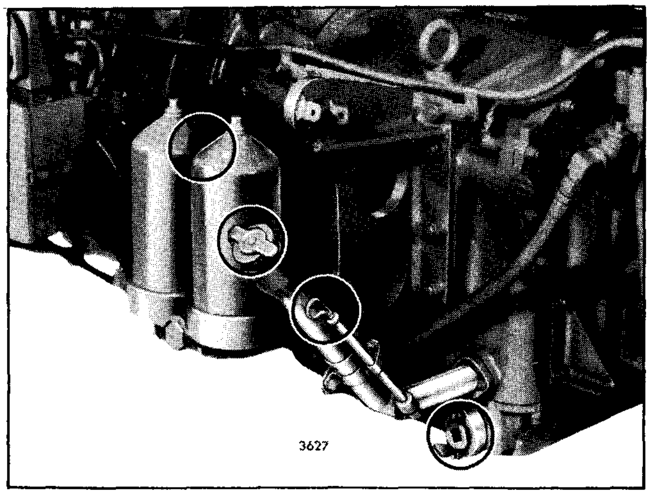
Item 45

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.*



Items 47 and 48

Item 47 - Transmission (Railcar)

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 48 - Oil Filter (Railcar)

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

FUEL OILS FOR DETROIT DIESEL ENGINES

DIESEL FUEL OILS 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 emission levels.

COMPLETELY DISTILLED FLUID

Fuel selected should be completely distilled material. That is, the fuel should show at least 98% 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. The differences in properties of VV-F-800 and ASTM D-975 fuels are shown in the following table.

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, cSt, min.	1.4	1.4	2.0	2.0
Saybolt, SUS, min.	—	—	—	32.6
Kinematic, cSt, 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

FUEL CLEANLINESS

Fuel oil should be clean and free of contamination. Storage tanks and stored fuel 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.

FUEL SULFUR CONTENT

The *sulfur content* of the fuel should be as low as possible to avoid premature wear, excessive deposit formation, and minimize the sulfur dioxide exhausted into the atmosphere. Limited amounts can be tolerated, but the amount of sulfur in the fuel and engine operating conditions can influence corrosion and deposit formation tendencies.

The deleterious effect of burning high sulfur fuel is reflected in Detroit Diesel lube oil change interval recommendations. Detroit Diesel recommends that the Total Base Number (TBN-ASTM D-664) of the lube oil be monitored frequently and that the oil drain interval be drastically reduced. Consult the FUEL OIL SELECTION CHART.

IGNITION QUALITY-CETANE NUMBER

There is a delay between the time the fuel is injected into the cylinder and the time that ignition occurs. The duration of this delay is expressed in terms of *cetane number* (rating). Rapidly ignited fuels have high cetane numbers; e.g., 50. Slowly ignited fuels have low cetane numbers; e.g., 40 or less. The lower the ambient temperature, the greater the need for a fuel that will ignite rapidly; i.e., high cetane.

Difficult starting may be experienced if the cetane number of the fuel is too low. Furthermore, engine knock and puffs of white smoke may be experienced during engine warmup especially in severe cold weather when operating with a low cetane fuel. If this condition is allowed to continue for any prolonged period, harmful fuel derived deposits will accumulate within the combustion chamber. Consult the FUEL OIL SELECTION CHART.

DISTILLATION END POINT

Fuel can be burned in an engine only after it has been vaporized. The temperature at which fuel is completely vaporized is described as the *distillation end point* (ASTM D-86). The distillation (boiling) range of diesel fuels should be low enough to permit complete vaporization at combustion chamber temperatures. The combustion chamber temperature depends on ambient temperature, engine speed, and load. Mediocre to poor vaporization is more apt to occur during severe cold weather and/or prolonged engine idling and/or light load operation. Therefore, engines will show better performance operating under the conditions described above when lower distillation end point fuels are used. Consult the FUEL OIL SELECTION CHART.

CLOUD POINT

The *cloud point* is that temperature at which wax crystals begin to form in diesel fuel. The selection of a suitable fuel for low temperature operability is the responsibility of the fuel supplier and the engine user. Consult the FUEL OIL SELECTION CHART.

FUEL OIL SELECTION CHART

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

*No. 2-D diesel fuel may be used in city coach engine models that have been certified to pass Federal and California emission standards.

Note 1: The cloud point should be 10°F (6°C) below the lowest expected fuel temperature to prevent clogging of the fuel filters by wax crystals.

Note 2: 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 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.

Burner fuels (furnace oils or domestic heating fuels) generally require an open flame for satisfactory combustion. The ignition quality (cetane rating) of burner fuels (ASTM D-396) is poor when compared to diesel fuels (ASTM D-975).

In some regions, however, fuel suppliers may distribute one fluid that is marketed as either diesel fuel (ASTM D-975) or domestic heating fuel (ASTM D-396) sometimes identified as burner, furnace, or residual fuel. Under these circumstances, the fuel should be investigated to determine whether the properties conform with those indicated in the FUEL OIL SELECTION CHART.

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, Sulfur Content, and Cloud Point* are four of the most important properties of diesel fuels that must be controlled to insure satisfactory engine operation. Engine speed, load, and ambient temperature all influence the selection of diesel fuels with respect to distillation range and cetane number.

All diesel fuels contain a certain amount of sulfur. Too high a sulfur content results in excessive cylinder wear. For most satisfactory engine life, fuels containing less than 0.5% sulfur should be used.

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 in order to prevent clogging of the fuel filters by wax crystals.

A reputable fuel oil supplier is the only one who can assure you that the fuel you receive meets the *Distillation End Point, Cetane Number, Sulfur Content, and Cloud Point* property limits shown in the FUEL OIL SELECTION CHART. The responsibility for clean fuel and fuel that meets Detroit Diesel Allison specifications lies with the fuel supplier as well as the operator.

At temperatures below +32°F (0°C) particular attention must be given to cold weather starting aids for efficient engine starting and operation.

NUMEROUS FUELS BURNED IN DDA ENGINES

Numerous fuels meeting the properties shown in the FUEL OIL SELECTION CHART may be used in Detroit Diesel engines. The table (top, right) shows some of the alternate fuels (some with sulfur and/or cetane limits) that have been burned in Detroit Diesel engines. Among these are No. 1 and No. 2 diesel fuels, kerosene, aviation turbine (jet) fuels, and burner fuels.

FUELS BURNED IN DETROIT DIESEL ENGINES

ASTM Designation	Federal Standard	Military Spec.	NATO Code	Grade	Description/Comments
D-975				1-D 2-D	Diesel Fuel
D-396				1, 2	Burner Fuel (Furnace Oil) ***Caution: If Used, The Max. Sulfur Content Allowed Is 0.50 WT. % and the Minimum Cetane No. Is 45. (See Fuel Oil Selection Chart).***
	VV-F-800		F-54	1, 2	DF-1 Winter Grade, DF-2 Regular Grade
	VV-F-800		F-56		DF-A (Arctic Grade). Limited Supply For Military.
		MIL-T-5624		JP-5	Kerosene
D-1655		MIL-T-83133	F-34	JP-8	Jet A-1, Kerosene Type Plus Special Anti-Icer
D-1655			F-35		Jet A, Kerosene
		MIL-F-16884	F-76	DFM	Diesel Fuel - Marine (DFM). ***Caution: If Used, The Max. Sulfur Content Allowed Is 0.50 WT. %.***
		MIL-F-5161		JP-6	Referee Grade JP-5 Type Jet Fuel. Limited Quantities Supplied To Military Only.

PROPOSED ASTM D-975, GRADE 3-D

Detroit Diesel Allison does NOT recommend the use of proposed grade 3-D diesel fuel in any of its engines. This grade of fuel has been proposed to, but not accepted by, the American Society for Testing and Materials (ASTM).

The proposed grade 3-D is undesireable in that it possesses poor ignition quality (i.e., lower cetane), allows greater sulfur content (up to 0.70% by weight), allows the formation of more carbon deposits (Conradson carbon residue), and allows the blending of heavier, more viscous boiling point fractions that are difficult to burn. The latter tend to increase combustion chamber deposits. This type of fuel usually manifests poor cold weather properties (wax formation tendencies). In addition, the poor ignition quality adversely affects noise and emission levels.

A comparison of ASTM D-975 grade 2-D and the proposed grade 3-D fuel properties is shown in the following table.

COMPARISON OF ASTM D-975 GRADE 2-D AND PROPOSED GRADE 3-D PROPERTIES

Property	Grade Recommended 2-D	Grade Not Recommended 3-D
Cetane No., Min.	40.0	37.0
Sulfur, WT. %, Max.	0.50	0.70
Carbon Residue On 10% Residuum, %, Max.	0.35	0.40
Viscosity @ 40° Celsius, Centistokes	1.9 - 4.1	2.0 - 7.0
Distillation deg. Celsius (Fahrenheit) 90% Recovery, Max.	338 (640)	360 (680)

USING DRAINED LUBE OIL IN DIESEL FUEL

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

BURNING MIXTURES OF ALCOHOL, GASOLINE, GASOHOL OR DIESOHOL WITH DIESEL FUEL

Alcohol, gasoline, gasohol, or diesohol should never be added to diesel fuel. An explosive and fire hazard exists if these blends are mixed and/or burned. See DIESEL FUEL LINE DE-ICER below.

DIESEL FUEL LINE DE-ICER

Very small amounts of isopropyl alcohol (isopropanol) may be used to preclude fuel line freeze-up in winter months. No more than ONE PINT of isopropyl alcohol should be added to 125 GALLONS of diesel fuel for adequate protection.

LUBRICATING OILS FOR DETROIT DIESEL ENGINES

DIESEL LUBRICATING OILS GENERAL CONSIDERATIONS

All diesel engines require heavy-duty lubricating oils. Basic requirements of such oils are lubricating quality, high heat resistance, and 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 compositon, additive content, engine temperature, and oil consumption rate.

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.

It should be noted that lube oil manufacturers may reformulate an oil while maintaining the same API classification, or may reformulate to a new API classification and continue the brand name designation. For example, SE oils being reformulated to SF letter code classification may perform differently after this reformulation. A close working relationship with the lube oil manufacturer should be maintained so that any reformulation can be reviewed and decision made as to its affect on continued satisfactory performance.

COLD WEATHER OPERATION

Two important considerations relate to satisfactory operation under cold ambient temperature conditions. These are: (1) the ability to crank the engine fast enough to secure starting, and (2) providing adequate lubrication to internal wearing surfaces during starting and warm-up. Once started and warmed up, external ambient temperatures have little effect on internal engine temperatures. Both cold weather considerations can be adequately met through proper lube oil selection and the use of auxiliary heat prior to starting. Auxiliary heat can be used in the form of jacket water and oil pan heaters, hot air space heaters applied to engine compartments, or some combination of these.

Proper oil selection and oil heat can assure lubricant flow immediately upon starting. Improper oil selection and oil heat may result in starting with cold oil congealed in the oil pan, and little or no oil flow for lubricating internal parts once the engine has started.

Proper oil selection and jacket water heating can assure cranking capability by maintaining an oil film on cylinder walls and bearing surfaces in a condition which provides low friction, and hence, less cranking effort to achieve cranking speeds necessary for reliable starting. Improper oil selection and jacket water heating may result in congealed oil films on cylinder walls and bearing surfaces, which result in high friction loads and more cranking effort than is available, thus preventing sufficient cranking speeds to assure reliable starting.

LUBE OIL SPECIFICATIONS

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 2-cycle engines have provided optimum performance and experienced the longest service life operating with lubricating oils meeting the following ash limits, zinc requirements, oil performance levels, viscosity grades, and evidence of satisfactory performance.

Sulfated Ash Limit (ASTM D-874)

The sulfated ash content of the lubricant shall not exceed 1.000% by weight, except lubricants that contain only barium detergent-dispersant salts where 1.5% by weight is allowed. Lubricants having a sulfated ash content between 0.55% and 0.85% by weight, have a history of excellent performance in Detroit Diesel engines. Lubricants having a sulfated ash content exceeding 0.85% by weight, are prone to produce greater deposit levels in the piston ring grooves, exhaust valve faces and seats.

Zinc Content
The zinc content (zinc diorganodithiophosphate) of all the lubricants recommended for use in Detroit Diesel 2-cycle engines shall be a minimum of 0.07% by weight. This requirement is waived where single grade SAE 40, intermediate viscosity index lubricants qualified for use in Electro-Motive Division (EMD) diesel engines are used.

VISCOSITY GRADE AND OIL PERFORMANCE LEVEL

Single Grade SAE 40 & SAE 30 Lubricants
Single grade SAE 40 and SAE 30 grade lubricants are preferred and recommended for use in all Detroit Diesel 2-cycle engines provided they meet the sulfated ash and zinc content requirements indicated above and any of the oil performance levels shown in Table L-1. EVIDENCE OF SATISIFACTORY PERFORMANCE (see section under this title) is desired where new formulation SAE 40 or SAE 30 oils will be used. Selection of the appropriate viscosity grade is shown in Table L-2.

Multigrade Lubricants
Multigrade oils have not provided performance comparable to SAE-40 or SAE-30 lubricants in some engine service applications. Because of this experience, the use of 15W-40 and all other multigrade oils is not recommended for Series 149 engines, and restrained usage in Series 53, 71 and 92 engines is advised.

If the use of a 15W-40 multigrade oil in Series 53, 71 or 92 engines is being considered, it must meet the CD/SE oil performance level shown in Table L-1. Table L-2 indicates that 15W-40 multigrades may be selected when ambient temperatures are at, or less than, freezing. However, because our experience has disclosed that the performance of straight grade oils has been superior to multigrade oils in some service applications, Detroit Diesel recommends that the user obtain proven service experience and evidence of satisfactory performance supplied by the lube oil manufacturer or follow the guidelines in the section entitled, "EVIDENCE OF SATISFACTORY PERFORMANCE." Upon request, the Detroit Diesel Allison Regional Office will counsel with customers in selecting a lubricating oil that will be suitable for their specific needs.

Other Multigrade Oils
Detroit Diesel Allison *does not recommend* the use of 10W-30, 10W-40, 20W-40 or any other multigrade oils in 2-cycle engines. As previously indicated, 15W-40 oils are the only lubricants that should be considered if prolonged severe cold, ambient temperatures, are expected.

EVIDENCE OF SATISFACTORY PERFORMANCE

It is recommended that evidence of satisfactory lubricant performance in Detroit Diesel 2-cycle engines be obtained from the oil supplier prior to procurement. Controlled oil performance evaluations in field test engines are recommended. The type of field test used by the oil supplier depends on the Series engine in which the candidate oil will be used and the service application. This information is summarized in Table L-3. The candidate test oil-operated engines should all operate for the mileage/hours indicated. Fuel and lube oil consumption should be monitored during the test period. Any serious mechanical problems experienced should be recorded. All of the oil test engines should be disassembled at the conclusion of the oil test period and inspected. The following oil performance parameters should be compared:

- Ring sticking tendencies and/or ring conditions
- Piston skirt scuffing and cylinder liner wear and scuffing
- Exhaust valve face and seat deposits
- Piston pin and connecting rod bushings (Note: Trunk pistons used in Series 53 engines)
- Overall valve train and bearing wear levels.

USED LUBE OIL ANALYSIS PROGRAM

A used lube oil analysis program should be conducted in conjunction with the oil performance field test. In order to determine the condition of the lube oil that will prevail when subjected to various engine operational modes in specific service applications, it is recommended that frequent oil samples be investigated. This subject is more comprehensively addressed in the OIL CHANGES section below.

OIL CHANGES

Table L-4 shows the initial oil drain intervals for all Series 2-cycle engines used in the various service applications. Oil drain intervals in all service applications may be increased or decreased with experience using a specific lubricant. Detroit Diesel Allison recommends the use of a controlled, used lube oil analysis monitoring program. This is especially prudent when extended oil drain intervals (e.g., 100,000 miles) are being considered. The frequency at which used lube oil samples are obtained may be scheduled for the same period as when other preventive maintenance is conducted. For example, a used lube oil sample for analysis may be obtained every 10,000 miles when engines are brought in for fuel and coolant filter replacement. Table L-5 shows the routine specific laboratory tests that are recommended. Sometimes further confirmatory tests are required, especially when fuel and/or coolant dilution is suspected. Table L-5 indicates the routine and confirmatory tests recommended. The lube oil should be drained if any of the maximum tolerable warning limits are exceeded.

THE INFLUENCE OF DIESEL FUEL SULFUR CONTENT ON LUBE OIL CHANGE INTERVALS

Table L-4 shows the reduced oil drain intervals that are recommended if the use of high sulfur fuel is unavoidable. The use of diesel fuels having a sulfur content exceeding 0.50% by weight can have a negative effect on piston ring life and lube oil deposit levels. For this reason, it is recommended that oil drain intervals be drastically shortened to minimize the adverse effect of acid build-up in the lubricant. These relatively short oil drain intervals may be altered if a lubricant with high alkaline reserve (i.e., high TBN - ASTM D-664) and low sulfated ash (i.e., less than 1.000% by weight - ASTM D-874) can be obtained. Table L-5 indicates that the TBN of the used oil should never be less than 1.0 (ASTM D-664). If laboratory analysis reveals that the TBN is less than 1.0, this is an indication that the acceptable drain interval has been exceeded.

MIL-L-46167 ARCTIC LUBE OILS FOR NORTH SLOPE AND OTHER EXTREME SUB-ZERO OPERATIONS

Lubricants meeting this specification are used in Alaska and other extreme sub-zero locations. Generally, they may be described as 5W-20 multigrade lubricants made up of synthetic base stock and manifesting low volatility characteristics. Although they have been used successfully in some severe cold regions, Detroit Diesel Allison does not consider their use as desirable as the use of SAE-40 or SAE-30 oils with auxiliary heating aids. For this reason, they should be considered only where engine cranking is a severe problem and auxiliary heating aids are not available on the engine.

EMD (RR) OILS

Lubricants qualified for use in Electro-Motive Division (EMD) diesel engines may be used in Detroit Diesel 2-cycle engines provided the sulfated ash (ASTM D-874) content does not exceed 1.000% by weight. These lubricants are frequently desired for use in applications where both Detroit Diesel and Electro-Motive powered units are operated. These fluids may be described as SAE-40 lubricants that possess medium Viscosity Index properties and do not contain any zinc additives.

SYNTHETIC OILS

Synthetic lubricants may be used in Detroit Diesel 2-cycle engines provided the ash limit, zinc requirements, and specified oil performance levels (for example, CD/SE or MIL-L-2104B, etc.) shown elsewhere in this specification are met. Viscosity grades SAE-40 or SAE-30 are recommended.

LUBE OIL FILTER CHANGE INTERVAL

Full-Flow Filters

A full-flow filtration system is used in all Detroit Diesel 2-cycle engines. To ensure against physical deterioration of the filter element, it should be replaced at a maximum of 25,000 miles for on-highway vehicles. For all other applications, the filter should be replaced at a maximum of 500 hours.

By-Pass Filters

Auxiliary by-pass lube oil filters are not required on Detroit Diesel 2-cycle engines.

OIL CHANGE INTERVAL BASED ON SURVEY OF SATISFIED END USERS

A number of successful Detroit Diesel (2-cycle engine) customers in numerous service applications do not utilize oil analysis procedures. They prefer conservative lube oil drain and filter change intervals.

Lubricant and filters were changed based on experience, and the customer felt he saved money in eliminating costly lube oil analysis programs. Naturally, Detroit Diesel supports the lube oil and filter change practices used in these successful service operations.

Highway Truck Service Application

Oil Change Interval	20,000 Miles
Filter Change Interval	20,000 Miles

Large 149 Series Engines Powering Off-Road Equipment (Construction & Mine Site Service Applications)

Oil Change Interval	150 Hours
Filter Change Interval	300 Hours

City Transit Coaches

Oil Change Interval	12,500 Miles
Filter Change Interval	25,000 Miles

Pickup & Delivery Metro Area Truck Service

Oil Change Interval	12,000 Miles
Filter Change Interval	24,000 Miles

Stationary (Usually Stand-By) Engines

Oil Change Interval	150 Hours or One Year
Filter Change Interval	300 Hours or One Year

LUBE OIL PERFORMANCE LEVELS

API Letter Code Service Classification	Military Specification	SAE Grade
CB	MIL-L-2104A (Supplement 1)	40 or 30
CC	MIL-L-2104B	40 or 30
CD	MIL-L-45199B (Series 3)	40 or 30
CC/SE	MIL-L-46152	40 or 30
CD/SC	MIL-L-2104C	40 or 30
Numerous Combinations of Above	Single Grade Universal No MIL-Spec.	40 or 30
CD/SE	Multigrade Universal No MIL-Spec.	15W-40

Table L-1

VISCOSITY GRADE SELECTION

AMBIENT TEMPERATURE degrees Celsius	AMBIENT TEMPERATURE degrees Fahrenheit	RECOMMENDATIONS PRIMARY	SECONDARY	THIRD
↑	↑	SAE 40	SAE 30	None
10	50			
↕	↕	SAE 40 Plus Starting Aids	SAE 30 Usually Unaided	None
0	32			
↕	↕	SAE 40 Plus Starting Aids	SAE 30 Plus Starting Aids	15W-40 Usually Unaided
18	0			
↓	↓	SAE 40 Plus Starting Aids	SAE 30 Plus Starting Aids	15W-40 Plus Starting Aids

Table L-2

INDIVIDUAL USER SERVICE APPLICATION LUBE FIELD TESTING

Engine Series	Service Application	Test Duration	No. Engines on Candidate Test Oil	No. Sister Engines on Reference Baseline SAE 40 or SAE 30
53	Pickup & Delivery Metro Area	50,000 Miles	5	5
71 & 92	Hwy. Truck 72,000 Lbs. GCW	200,000 Miles	5	5
149	Off Road Rear Dump 120 Ton	10,000 Hours	3*	3

*Single Grade Only - No Multigrades Recommended For Series 149 Engines

Table L-3

LUBE OIL DRAIN INTERVAL				
		Max. Lube Oil Drain Interval*		
		Diesel Fuel Sulfur Content Wt. %		
Service Application	Engine Series	0 to 0.50	0.51 to 0.75	0.76 to 1.00
Hwy. Truck (Long Distance Hauls) and Inter-City Buses	71 & 92	100,000 Miles**	20,000 Miles	10,000 Miles
City Transit Coaches and Pickup and Delivery Truck Service (Stop-And-Go Short Distance	53, 71, 92	12,500 Miles	2,500 Miles	1,250 Miles
Industrial and Marine	53, 71, 92	150 Hours	30 Hours	15 Hours +
Large Industrial and Marine	149	(NA) 500 Hours	100 Hours	50 Hours +
		(T) 300 Hours	60 Hours	30 Hours +

*Maximum lube oil drain intervals must be based on the laboratory test results obtained from used lube oil samples.

**If supported by oil analysis at 10,000 mile intervals or when recommended fuel filter maintenance is performed.

+These oil change intervals are based upon worst case with chrome-faced rings. Oil change periods with plasma-faced rings can be established by oil analysis.

Table L-4

USED LUBE OIL ANALYSIS WARNING VALUES	ASTM Designation	Limits	Routine Or Confirmatory
Pentane Insolubles, Wt. %, Max.	D-893	1.00	Routine
TGA Carbon (Soot) Content, Wt. %, Max.	None	0.80	Routine
Viscosity at 100°F, SUS	D-445		Routine
% Max. Increase	&	40.00	
% Max. Decrease	D-2161	15.00	
Iron Content, PPM., Max.	None	150.00	Routine
Total Base Number (TBN), Min.	D-664	1.00	Routine
Water Content, Vol. %, Max.	D-95	0.30	Confirmatory
Flash Point, °F, Max. Reduction	D-92	40.00	Confirmatory
Fuel Dilution, Vol. %, Max.	—	2.50	Confirmatory
Glycol Dilution, PPM., Max.	D-2982	1000.00	Confirmatory
Sodium Content, PPM., Max. Allowed Over Lube Oil Baseline	—	50.00	Routine
Boron Content, PPM., Max. Allowed Over Lube Oil Baseline	—	20.00	Routine

Table L-5

MISCELLANEOUS FUEL AND LUBRICANT INFORMATION

ENGINE OIL CLASSIFICATION SYSTEM

The American Petroleum Institute (API), the Society of Automotive Engineers (SAE), and the American Society for Testing and Materials (ASTM) jointly have developed the present commercial system for designating and identifying motor oil classifications. The table in this section shows a cross-reference of current commercial and military lube oil identification and specification systems.

PUBLICATION AVAILABLE SHOWING COMMERCIAL "BRAND" NAME LUBRICANTS

A list of "brand" name lubricants distributed by the majority of worldwide oil suppliers can be purchased from the Engine Manufacturers Association (EMA). The publication is titled *EMA Lubricating Oils Data Book for Heavy-Duty Automotive and Industrial Engines.* The publication shows the brand names, oil performance levels, viscosity grades, and sulfated ash contents of most "brands" marketed.

ENGINE MANUFACTURERS ASSOCIATION
111 EAST WACKER DRIVE
CHICAGO, ILLINOIS 60601

Upon request, the Detroit Diesel Allison Regional Office will counsel with customers in selecting a lubricating oil that will be suitable for their specific needs.

STATEMENT OF POLICY ON FUEL AND LUBRICANT ADDITIVES

In answer to requests concerning the use of fuel and lubricating oil additives, the following excerpt has been taken from a policy statement of General Motors Corporation:

"It has been and continues to be General Motors policy to build motor vehicles that will operate satisfactorily on the commercial fuels and lubricants of good quality regularly provided by the petroleum industry through retail outlets."

Therefore, Detroit Diesel Allison does not recommend the use of any supplementary fuel or lubricant additives. These include all products marketed as fuel conditioners, smoke suppressants, masking agents, reodorants, tune-up compounds, top oils, break-in oils, graphitizers, and friction-reducing compounds.

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

CROSS REFERENCE OF LUBE OIL CLASSIFICATION SYSTEM

API CODE LETTERS	COMPARABLE MILITARY OR COMMERCIAL INDUSTRY SPECIFICATION
CA	MIL-L-2104A
CB	Supplement 1
CC	MIL-L-2104B (See Note Below)
CD	MIL-L-45199B (Series 3)
‡	MIL-L-46152 (Supersedes MIL-L-2104B Military Only)
□	MIL-L-2104C (Supersedes MIL-L-45199B for Military Only)
SA	None
SB	None
SC	Auto Passenger Car 1964 MS Oils - Obsolete System
SD	Auto Passenger Car 1968 MS Oils - Obsolete System
SE	Auto Passenger Car 1972 MS Oils - Obsolete System
SF	Auto Passenger Car 1980 Production

‡ Oil performance meets or exceeds that of CC and SE oils.

□ Oil performance meets or exceeds that of CD and SC oils.

NOTE: MIL-L-2104B lubricants are obsolete for military service applications only.
MIL-L-2104B lubricants are currently marketed and readily available for commercial use.

Consult the following publications for complete descriptions:

1. Society of Automotive Engineers (SAE) Technical Report J-183a.
2. Federal Test Method Standard 791a.

ENGINE COOLANT

The coolant provides a medium for heat transfer and controls the internal temperature of the engine during operation. In an engine having proper coolant flow, the heat of combustion is conveyed through the cylinder walls and the cylinder head into the coolant. Without adequate coolant, normal heat transfer cannot take place within the engine, and engine temperature rapidly rises. In general, water containing various materials in solution is used for this purpose.

The function of the coolant is basic to the design and to the successful operation of the engine. Therefore, coolant must be carefully selected and properly maintained.

COOLANT REQUIREMENTS

Coolant solutions must meet the following basic requirements:

1. Provide for adequate heat transfer.

2. Provide a corrosion-resistant environment within the cooling system.

3. Prevent formation of scale or sludge deposits in the cooling system.

4. Be compatible with the cooling system hose and seal materials.

5. Provide adequate freeze protection during cold weather operation.

The first four requirements are satisfied by combining a suitable water with reliable inhibitors. When freeze protection is required, a solution of suitable water and an antifreeze containing adequate inhibitors will provide a satisfactory coolant. Ethylene glycol-based antifreeze is recommended for use in Detroit Diesel engines.

WATER

Any water, whether of drinking quality or not, will produce a corrosive environment in the cooling system, and the mineral content may permit scale deposits to form on internal cooling system surfaces. Therefore, water selected as a coolant must be properly treated with inhibitors to control corrosion and scale deposition.

To determine if a particular water is suitable for use as a coolant when properly inhibited, the following characteristics must be considered: the concentration of chlorides and sulfates, total hardness and dissolved solids.

Chlorides and/or sulfates tend to accelerate corrosion, while hardness (percentage of magnesium and calcium salts broadly classified as carbonates) causes deposits of scale. Total dissolved solids may cause scale deposits, sludge deposits, corrosion or a combination

	PARTS PER MILLION	GRAINS PER GALLON
Chlorides (Maximum)	40	2.5
Sulfates (Maximum)	100	5.8
Total Dissolved Solids (Maximum)	340	20
Total Hardness (Maximum)	170	10

TABLE 1

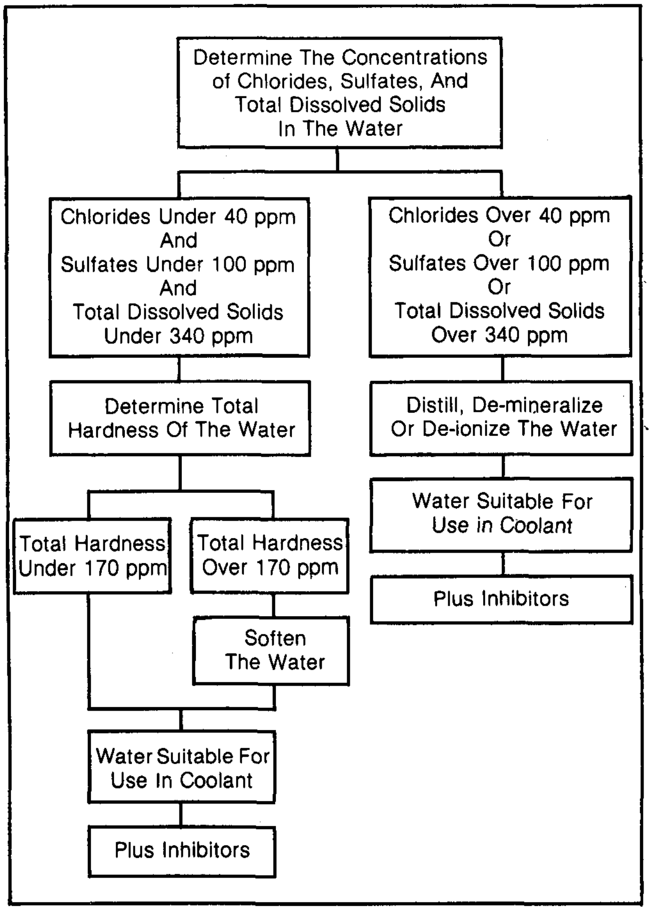


TABLE 2

of these. Chlorides, sulfates, magnesium and calcium are among the materials which make up dissolved solids. Water, within the limits specified in Table 1 is satisfactory as an engine coolant when proper inhibitors are added. The procedure for evaluating water intended for use in a coolant solution is shown in Table 2.

CORROSION INHIBITORS VITAL

A corrosion inhibitor is a water-soluble chemical compound which protects the metallic surfaces of the cooling system against corrosive attack. Some of the more commonly used corrosion inhibitors are chromates, borates, nitrates, nitrites and soluble oil. (Soluble oil is not recommended as a corrosion inhibitor). Depletion of all types of inhibitors occurs through normal operation. Therefore, strength levels must be maintained by the addition of inhibitors at prescribed intervals.

The importance of a properly inhibited coolant cannot be overstressed. A coolant which has insufficient inhibitors, the wrong inhibitors, or-worse-no inhibitors at all invites the formation of rust and scale deposits within the cooling system. Rust, scale, and mineral deposits can wear out water pump seals and coat the walls of the cylinder block water jackets and the outside walls of the cylinder liners. As these deposits build up, they insulate the metal and reduce the rate of heat transfer. For example, a 1/16" deposit of rust or scale on 1" of cast iron is equivalent to 4-1/4" of cast iron in heat transferability (Fig. 1).

An engine affected in this manner overheats gradually over a period of weeks or months. Liner scuffing, scoring, piston seizure and cylinder head cracking are the inevitable results. An improperly inhibited coolant

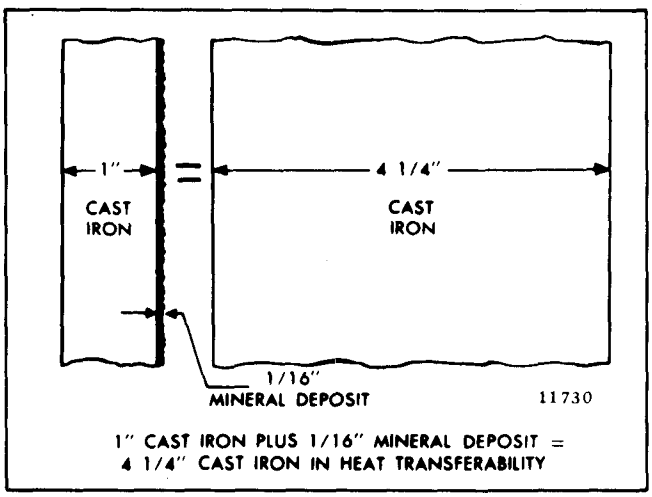


Fig. 1 - Heat Transfer Capacity

can also become corrosive enough to "eat away" coolant passages and seal ring grooves and cause coolant leaks to develop. If sufficient coolant accumulates on top of a piston, a hydrostatic lock can occur while the engine is being started. This, in turn, can result in a bent connecting rod. An improperly inhibited coolant can also contribute to *cavitation erosion*. Cavitation erosion is caused by the collapse of bubbles (vapor pockets) formed at the coolant side of an engine component. The collapse results from a pressure differential in the liquid caused by the vibration of the engine part. As bubbles collapse, they form pin points of very high pressure. Over a period of time, the rapid succession of millions of tiny bursting bubbles can wear away (erode) internal engine surfaces.

Components such as fresh water pump impellers and cylinder liners are especially susceptible to cavitation erosion. In extreme cases their surfaces can become so deeply pitted that they appear to be spongy, and holes can develop completely through them.

Chromates

Sodium chromate and potassium dichromate are two of the best and most commonly used *water* system corrosion inhibitors. Care should be exercised in handling these materials due to their toxic nature.

Chromate inhibitors should *not* be used in antifreeze solutions. Chromium hydroxide, commonly called "green slime", can result from the use of chromate inhibitors with antifreeze. This material deposits on the cooling system passages and reduces the heat transfer rate (Fig. 1) which results in engine overheating. Engines which have operated with a chromate-inhibited water must be chemically cleaned before the addition of antifreeze. A commercial heavy duty descaler should be used in accordance with the manufacturer's recommendation for this purpose.

Soluble Oil

Soluble oil has been used as a corrosion inhibitor for many years. It has, however, required very close attention relative to the concentration level due to adverse effects on heat transfer if the concentration exceeds 1% by volume. For example: 1.25% of soluble oil in the cooling system increases fire deck temperatures 6% and a 2.50% concentration raises fire deck temperature up to 15%. *Soluble oil is not recommended as a corrosion inhibitor.*

Non-Chromates

Non-chromate inhibitors (borates, nitrates, nitrites, etc.) provide corrosion protection in the cooling system with the basic advantage that they can be used with either water or a water-and-antifreeze solution.

INHIBITOR SYSTEMS

An inhibitor system is a combination of chemical compounds which provide corrosion protection, pH control and water-softening ability. Corrosion protection is discussed under the heading *Corrosion Inhibitors Vital.* The pH control is used to maintain an acid-free solution. The water-softening ability deters formation of mineral deposits. Inhibitor systems are available in various forms such as coolant filter elements, liquid and dry bulk inhibitor additives and as an integral part of antifreeze.

Coolant Filter Elements

Replaceable elements are available with various chemical inhibitor systems. Compatibility of the element with other ingredients of the coolant solution cannot always be taken for granted.

Problems have developed from the use of the magnesium lower support plate used by some manufacturers in their coolant filters. The magnesium plate will be attacked by solutions which will not be detrimental to other metals in the cooling system. The dissolved magnesium will be deposited in the hottest zones of the engine where heat transfer is most critical. The use of an aluminum or zinc support plate in preference to magnesium is recommended to eliminate the potential of this type of deposit.

High chloride coolants will have a detrimental effect on the water-softening capabilities of systems using ion-exchange resins. Accumulations of calcium and magnesium ions removed from the coolant and held captive by the zeolite resin can be released into the coolant by a regenerative process caused by high chloride-content solutions.

Bulk Inhibitor Additives

Commercially packaged inhibitor systems are available which can be added directly to the engine coolant or to bulk storage tanks containing coolant solution. Both chromate and non-chromate systems are available and care should be taken regarding inhibitor compatibility with other coolant constituents.

Non-chromate inhibitor systems are recommended for use in Detroit Diesel engines. These systems can be used with either water or water-and-antifreeze solutions and provide corrosion protection, pH control and water softening. Some non-chromate inhibitor systems offer the additional advantage of a simple on-site test to determine protection level. Since they are added directly to the coolant, require no additional hardware or plumbing.

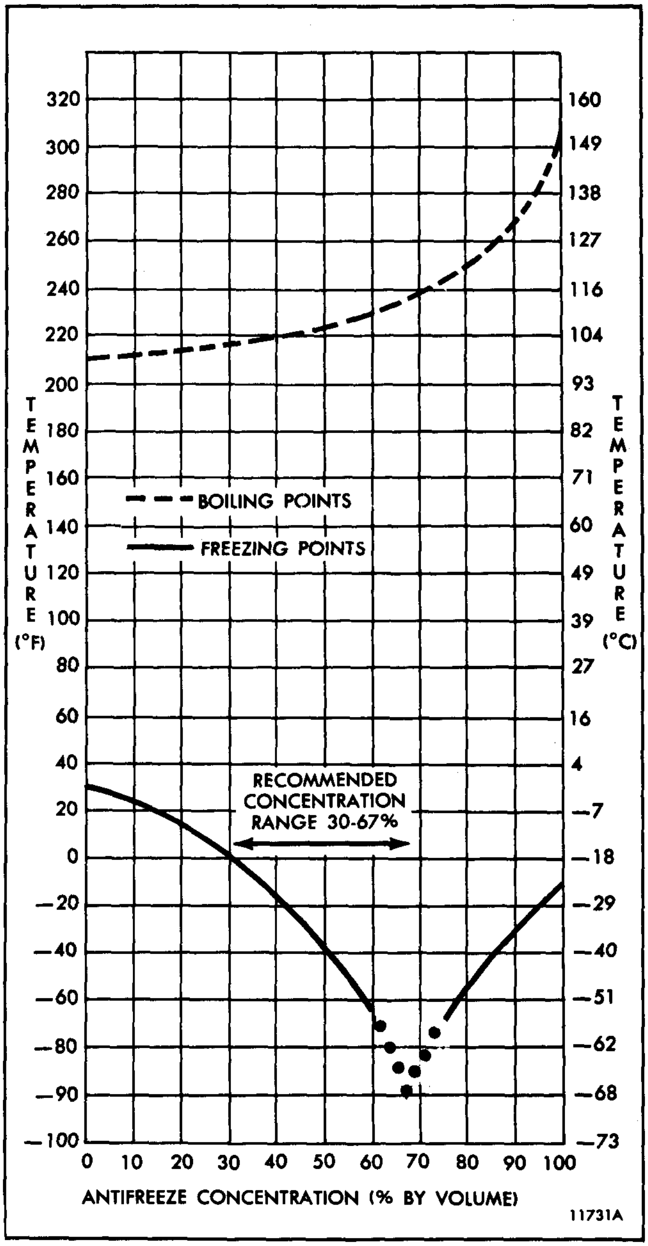


Fig. 2 - Coolant Freezing and Boiling Temperatures vs. Antifreeze Concentration (Sea Level)

All inhibitors become depleted through normal operation and additional inhibitor must be added to the coolant at prescribed intervals to maintain original strength levels. Always follow the supplier's recommendations on inhibitor usage and handling.

TEST STRIPS

Some chemical manufacturers have developed *test strips* for use with their antifreeze or coolant additives. These test strips are used to measure the freeze protection and/or inhibitor strength of ethylene glycol-based antifreeze. To avoid a false reading caused by variations in reserve alkalinity, Detroit Diesel Allison suggests using test strips that measure depletable inhibitor concentration directly. *Do not use one manufacturer's test strips to measure the chemical content of another's antifreeze and/or inhibitors.* Always follow the manufacturer's recommended test procedures.

ANTIFREEZE

When freeze protection is required, an antifreeze meeting GM specification 1899M must be used. An inhibitor system is included in this type of antifreeze and no additional inhibitors are required on initial fill if a minimum antifreeze concentration of 30% by volume is used. Solutions of less than 30% concentration do not provide sufficient corrosion protection. Concentrations over 67% adversely affect freeze protection and heat transfer rates (Fig. 2).

Ethylene glycol base antifreeze is recommended for use in all Detroit Diesel engines. Methyl alcohol base anitfreeze is not recommended because of its effect on the non-metallic components of the cooling system and because of its low boiling point. Methoxy propanol base antifreeze is not recommended for use in Detroit Diesel engines due to the presence of fluoroelastomer seals in the cooling system.

Before installing ethylene glycol base antifreeze in a unit that has previously operated with methoxy propanol, the entire cooling system should be drained, flushed with clean water, and examined for rust, scale contaminants, etc. If deposits are present, the cooling system must be chemically cleaned with a commerical grade heavy-duty descaler.

The inhibitors in antifreeze should be replenished at approximately 500 hour intervals or by test with a non-chromate inhibitor system. Commercially available inhibitor systems may be used to reinhibit antifreeze solutions.

Sealer Additives

Antifreeze with sealer additives is not recommended for use in Detroit Diesel engines due to plugging possibilities throughout various areas of the cooling system, including cooling system bleed holes and water pump drain holes.

GENERAL RECOMMENDATIONS

All Detroit Diesel engines incorporate pressurized cooling systems which permit operation at temperatures higher than non-pressurized systems. It is essential that these systems be kept clean and leak-free, that filler caps and pressure relief mechanisms be correctly installed at all times and that coolant levels be properly maintained.

Always maintain engine coolant at the proper level. A low coolant level allows the water pump to mix air with the coolant. Air bubbles in the coolant can "insulate" the cylinder walls, preventing normal heat transfer. An abnormally low coolant level can cause the water pump to become (:air-bound," a condition in which it works feverishly but pumps nothing. Without proper heat transfer, silicone elastomer head-to-block water hole seals can deteriorate and cylinder components can expand so that pistons rapidly cut through the lubricant on the liner walls. Scuffing and piston seizure may follow.

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

An engine may contain the correct amount of properly inhibited coolant, but still fail to adequately cool the engine. In cases where this occurs, other causes of low coolant flow, either engine or cooling system related, should be investigated.

1. Always use a properly inhibited coolant.

2. Do not use soluble oil.

3. Maintain the prescribed inhibitor strength.

4. Always follow the manufacturer's recommendations on inhibitor usage and handling.

5. If freeze protection is required, use a solution of water and antifreeze meeting GM specification 1899M.

6. Reinhibit antifreeze with a recommended non-chromate inhibitor system.

7. Do not use a chromate inhibitor with antifreeze.

8. Do not use methoxy propanol base antifreeze in Detroit Diesel engines.

9. Do not mix ethylene glycol base antifreeze with methoxy propanol base antifreeze in the cooling system.

10. Do not use antifreeze containing sealer additives.

11. Do not use methyl alcohol base antifreeze.

12. Use extreme care when removing the radiator pressure-control cap.

ENGINE TUNE-UP PROCEDURES

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

The type of governor used depends upon the engine application. Since each governor has different characteristics, the tune-up procedure varies accordingly. The following types of governors are used:

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

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

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

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

> **NOTE:** If a supplementary governing device, such as the throttle delay mechanism, is used, it must be disconnected prior to the tune-up. After the governor and injector rack adjustments are completed, the supplementary governing device must be reconnected and adjusted.

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

The tune-up procedures apply to the individual engines of multiple engine units as well as to the single engine units. However, the throttle linkage of multiple engine units must be adjusted after the individual engines have been tuned-up.

Use a new valve rocker cover gasket after the tune-up is completed.

Tune-Up Sequence for Mechanical Governor

Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover, the serviceman must determine that the injector racks move to the no-fuel position when the governor stop lever is placed in the stop position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

> **CAUTION:** An overspeeding engine can result in engine damage which could cause personal injury.

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

Tune-Up Sequence for Hydraulic Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the fuel rod.
4. Position the injector rack control levers.
5. Adjust the load limit screw.
6. Compensation adjustment (PSG governors only).
7. Adjust the speed droop.
8. Adjust the maximum no-load speed.

EXHAUST VALVE CLEARANCE ADJUSTMENT

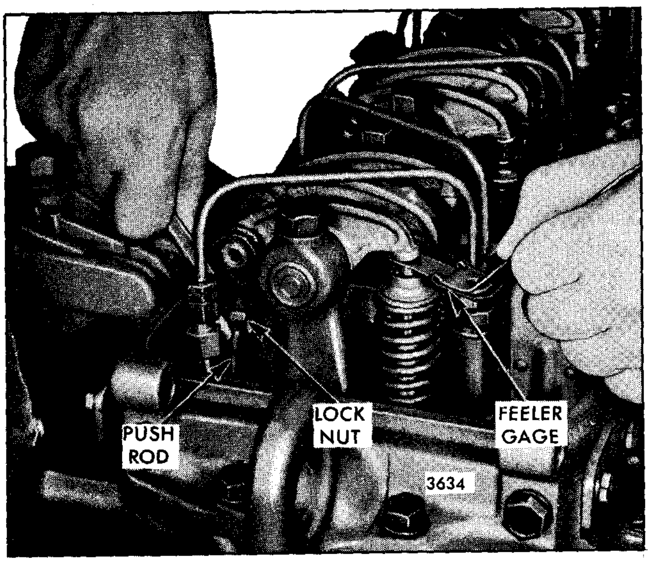


Fig. 1 - Adjusting Valve Clearance

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

Insufficient valve clearance can result in loss of compression, misfiring cylinders and, eventually, burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, increased valve face wear and valve lock damage.

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

ENGINES WITH TWO VALVE CYLINDER HEADS

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

Valve Clearance Adjustment (Cold Engine) 100°F (38°C) or less

1. Remove the loose dirt from the valve rocker cover and remove the cover.

2. Place the governor speed control lever in the *idle* speed position. If a stop lever is provided, secure it in the *stop* position.

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

> **NOTE:** 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 because the bolt may be loosened.

4. Loosen the exhaust valve rocker arm push rod locknut.

5. Place a .012" ±.004" feeler gage (J 9708-01) between the valve stem and the rocker arm (Fig. 1). Adjust the push rod to obtain a smooth "pull" on the feeler gage.

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

7. Recheck the clearance. At this time, if the adjustment is correct, the .011" feeler gage will pass freely between the valve stem and the rocker arm, but the .013" gage will not pass through. Readjust the push rod, if necessary.

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

Exhaust Valve Clearance Adjustment (Hot Engine)

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

1. With the engine at normal operating temperature (160-185°F or 71-85°C), recheck the exhaust valve clearance with feeler gage J 9708-01. At this time, if the valve clearance is correct, the .008" feeler gage will pass freely between the valve stem and the rocker arm and the .010" feeler gage will not pass through. Readjust the push rod, if necessary.

2. After the exhaust valve clearance has been adjusted, check the fuel injector timing.

ENGINES WITH FOUR VALVE CYLINDER HEADS

The exhaust valve bridges must be adjusted and the adjustment screws locked securely at the time the cylinder head is installed on the engine. Until wear occurs, no further adjustment is required on the exhaust valve bridges. When wear is evident, make the necessary adjustments as outlined below.

Valve Bridge Adjustment

1. Remove the loose dirt from the valve rocker cover and remove the cover. Remove the injector fuel pipes and the rocker arm retaining bolts. Move the rocker arms away from the exhaust valve bridges.

2. Remove the exhaust valve bridge (Fig. 2).

3. Place the valve bridge in a vice or bridge holding fixture J 21772 and loosen the locknut on the bridge adjusting screw.

> **NOTE:** Loosening or tightening the locknut with the bridge in place may result in bending the bridge guide or the rear valve stem.

4. Install the valve bridge on the bridge guide.

5. While firmly pressing straight down on the pallet surface of the bridge, turn the adjusting screw clockwise until it just touches the valve stem. Then turn the screw an additional 1/8 to 1/4 turn clockwise and tighten the locknut finger tight.

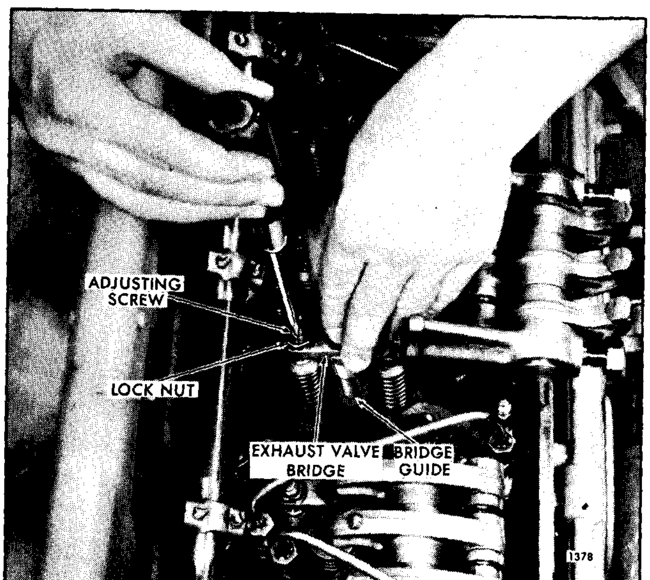


Fig. 2 - Valve Bridge Adjustment

6. Remove the valve bridge and place it in a vise. Hold the screw from turning with a screwdriver and tighten the locknut on the adjustment screw. Complete the operation by tightening the locknut with a torque wrench to 20-25 lb-ft (27-34 Nm) torque, being sure that the screw does not turn.

7. Lubricate the valve bridge guide and valve bridge with engine oil.

8. Reinstall the valve bridge in its *original* position.

9. Place a .0015" feeler gage (J 23185) under each end of the valve bridge. When pressing down on the pallet surface of the valve bridge, both feeler gages must be tight. If both feeler gages are not tight, readjust the adjusting screw as outlined in Steps 5 and 6.

10. Adjust the remaining valve bridges as outlined above.

11. Swing the rocker arm assembly into position being sure the valve bridges are properly positioned on the rear valve stems. This precaution is necessary to prevent valve damage due to mislocated valve bridges.

12. Tighten the rocker arm bracket bolts to 90-100 lb-ft (122-136 Nm) torque.

13. Align the fuel pipes and connect them to the injectors and the fuel connectors. Use socket J 8932 to tighten the connectors to 12-15 lb-ft (16-20 Nm) torque.

> **NOTE:** 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.

The exhaust valve bridge balance should be checked when a general valve adjustment is performed. After the bridges are balanced, adjust the valve clearance at the *push rod only*.

Do not distrub the exhaust valve bridge adjusting screw.

All of the exhaust valves may be adjusted, in firing order sequence, during one full revolution of the crankshaft. Refer to *General Specifications - Section 1* for the engine firing order.

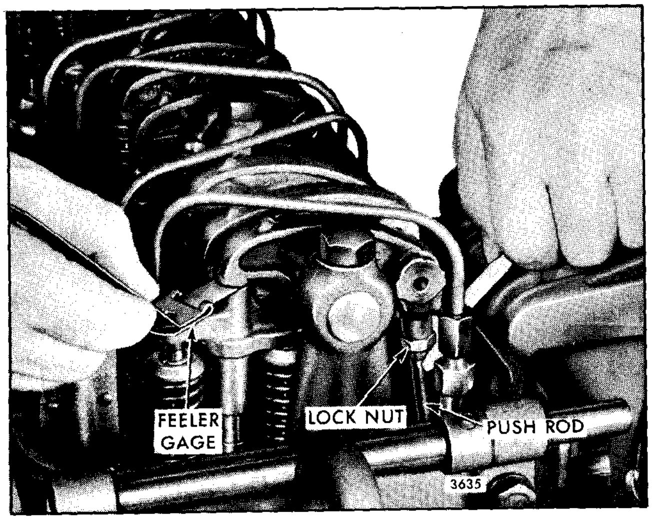


Fig. 3 - Adjusting Valve Clearance

Valve Clearance Adjustment (Cold Engine) 100°F (38°C) or less

1. If not done previously, clean the loose dirt from the exterior of the engine and remove the valve rocker covers. Then cover any drain cavities in the cylinder head to prevent foreign material from entering.

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

3. Rotate the crankshaft, with engine barring tool J 22582 or with the starting motor, until the injector follower is fully depressed on the cylinder to be adjusted.

> **NOTE:** If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the engine in a left-hand direction of rotation because the bolt may be loosened.

4. Loosen the exhaust valve rocker arm push rod locknut.

5. Place a .016" ±.004" feeler gage (J 9708-01) between the valve bridge and the valve rocker arm pallet (Fig. 3). Adjust the push rod to obtain a smooth "pull" on the feeler gage.

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

7. Recheck the clearance. At this time, if the adjustment is correct, the .015" gage will pass freely between the valve bridge and the rocker arm pallet, but the .017" gage will not pass through. Readjust the push rod, if necessary.

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

Exhaust Valve Clearance Adjustment (Hot Engine)

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

1. With the engine at normal operating temperature (160-185°F or 71-85°C), recheck the exhaust valve clearance with feeler gage J 9708-01. At this time, if the valve clearance is correct, the .013" feeler gage will pass freely between the valve bridge and the rocker arm pallet, but the .015" feeler gage will not pass through. Readjust the push rod, if necessary.

2. After the exhaust valve clearance has been adjusted, check the fuel injector timing.

FUEL INJECTOR TIMING

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

All of the injectors can be timed, in firing order sequence, during one full revolution of the crankshaft. Refer to *General Specifications* - Section 1, for the engine firing order.

Time Fuel Injector

After the exhaust valve clearance has been adjusted, time the fuel injectors as follows:

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

2. Rotate the crankshaft, by using the starting motor or engine barring tool J 22582, until the exhaust valves are fully depressed on the particular cylinder to be timed.

> **NOTE:** 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 because the bolt may be loosened.

3. Place the small end of the injector timing gage (refer to the chart for the correct timing gage) in the hole provided in the top of the injector body. The flat of the gage should be toward the injector follower (Fig. 4).

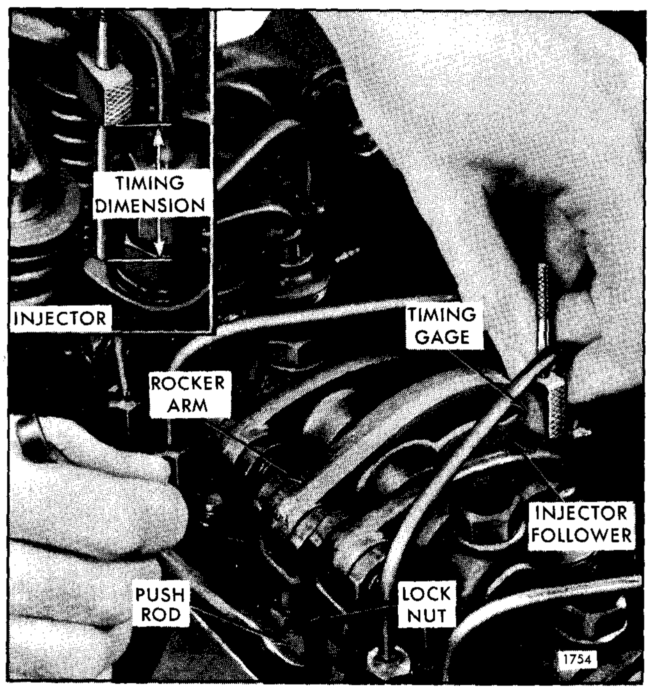


Fig. 4 - Timing Fuel Injector

4. Loosen the injector rocker arm push rod locknut.

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

6. Hold the push rod and tighten the locknut. Check the adjustment and, if necessary, readjust the push rod.

7. Time the remaining injectors in the same manner as outlined above.

8. If no further engine tune-up is required install the valve rocker cover, using a new gasket.

Injector	Timing Dimension	Timing Gage	Camshaft Timing
GENERATOR SET APPLICATIONS			
All	1.460"	J 1853	Standard
ALL OTHER APPLICATIONS			
71N5	*1.460"	J 1853	*Standard
N55	*1.460"	J 1853	*Standard
N60	*1.460"	J 1853	*Standard
N65 (White Tag)	1.460"	J 1853	Standard
N65 Turbo (Brown Tag)	1.484"	J 1242	Standard
N65 Non-Turbo (Brown Tag)	**1.484"	J 1242	**Advanced
HN65	1.460"	J 1853	Standard
N70 Turbo	1.460"	J 1853	Standard
N70 Non-Turbo	1.460"	J 1853	Advanced
N75 Turbo	1.460"	J 1853	Standard
N80 Turbo	1.484"	J 1242	Standard
N80 Non-Turbo	**1.484"	J 1242	**Advanced
N90	1.460"	J 1853	

*Use 1.484" timing gage (J 1242) when engine has advanced camshaft timing. Correct to standard camshaft timing and 1.460" injector timing at first opportunity to be consistent with current production build.

**Use 1.460" timing gage (J 1853) when engine has standard camshaft timing. Correct to advanced camshaft timing and 1.484" injector timing at first opportunity.

NOTE: Advanced camshaft timing is indicated by "ADV—GT—ADV—CAM" stamped on lower right hand side of option plate.

INJECTOR TIMING GAGE CHART (Needle Valve)

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

The governor is mounted on the front end of the blower and is driven by the upper blower rotor.

After adjusting the exhaust valves and timing the fuel injectors, adjust the limiting speed mechanical governor and position the injector rack control levers.

> **NOTE:** Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, reconnect and adjust the supplementary governing device.

Adjust Governor Gap (Single Weight Governor)

With the engine stopped and at normal operating temperature, adjust the governor gap as follows:

1. Remove the governor high-speed spring retainer cover.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut (Fig. 8).

3. Start the engine and loosen the idle speed adjusting screw locknut. Then adjust the idle screw to obtain the desired engine idle speed (Fig. 8). Hold the screw and tighten the locknut to hold the adjustment.

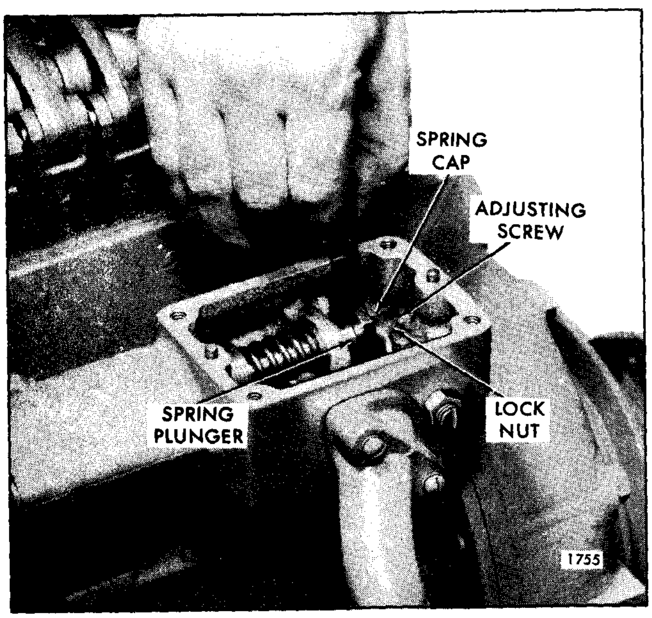


Fig. 1 - Adjusting Gap (Single Weight Governor) using Tool J 5407

> **NOTE:** Limiting speed governors used in turbocharged engines include a starting aid screw threaded into a boss on the governor housing.

4. Stop the engine. Clean and remove the governor cover and lever assembly. If not previously done, remove the valve rocker cover. Discard the gasket.

5. Remove the fuel rod from the differential lever and the injector control tube lever.

6. Check the gap between the low-speed spring cap and the high-speed spring plunger with gage J 5407 (.170") as shown in Fig. 1.

> **NOTE:** Be sure the external starting aid screw (if used) is backed out far enough to make it ineffective when making this adjustment.

7. If required, loosen the locknut and turn the gap adjusting screw until a slight drag is felt on the gage.

8. Hold the adjusting screw and tighten the locknut.

9. Recheck the gap and readjust if necessary.

10. Install the fuel rod between the governor and injector control tube lever.

11. Use a new gasket and install the governor cover and lever assembly.

Adjust Governor Gap (Double-Weight Governor)

With the engine stopped and at normal operating temperature, adjust the governor gap as follows:

1. Remove the governor high-speed spring retainer cover.

2. Backout the buffer screw until it extends approximately 5/8" from the locknut (Fig. 8).

3. Start the engine and loosen the idle speed adjusting screw locknut. Then adjust the idle screw to obtain the desired engine idle speed (Fig. 2). Hold the screw and tighten the locknut to hold the adjustment.

> **NOTE:** Limiting speed governors used in turbocharged engines include a starting aid screw threaded into a boss on the governor housing.

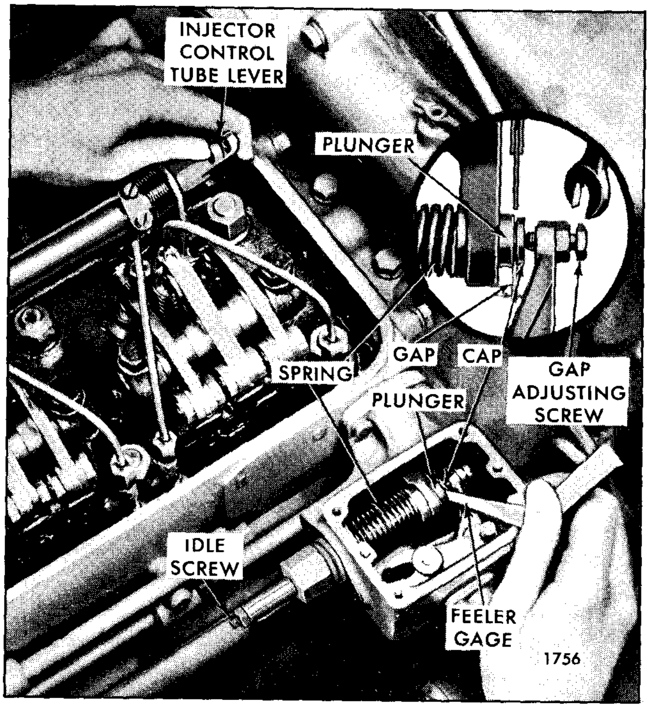


Fig. 2 - Adjusting Gap (Double-Weight Governor) using Tool J 3172

4. Stop the engine. Clean and remove the governor cover and lever assembly. If not previously done, remove the valve rocker cover. Discard the gasket.

5. Remove the fuel rod from the differential lever and the injector control tube lever (Fig. 3).

6. Start and run the engine between 1100 and 1300 rpm by manual operation of the control tube lever.

NOTE: Do not overspeed the engine.

7. Check the gap between the low-speed spring cap and the high-speed spring plunger with a feeler gage (Fig. 2). The gap should be .002"-.004". If the gap setting is incorrect, reset the gap adjusting screw.

8. On governors without the starting aid screw, hold the gap adjusting screw and tighten the locknut.

9. Recheck the governor gap with the engine operating between 1100 and 1300 rpm. Readjust, if necessary.

10. Stop the engine and install the fuel rod between the differential lever and the control tube lever.

11. Use a new gasket and install the governor cover and lever assembly. Tighten the screws.

Position Injector Rack Control Levers

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

The engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever and one screw and locknut to keep each injector rack properly positioned.

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the maximum speed position.

2. Governor low-speed gap closed.

3. High-speed spring plunger on the seat in the governor control housing.

4. Injector racks in the full-fuel position.

Adjust the No. 1 injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers (Fig. 3).

1. Disconnect any linkage attached to the governor speed control lever.

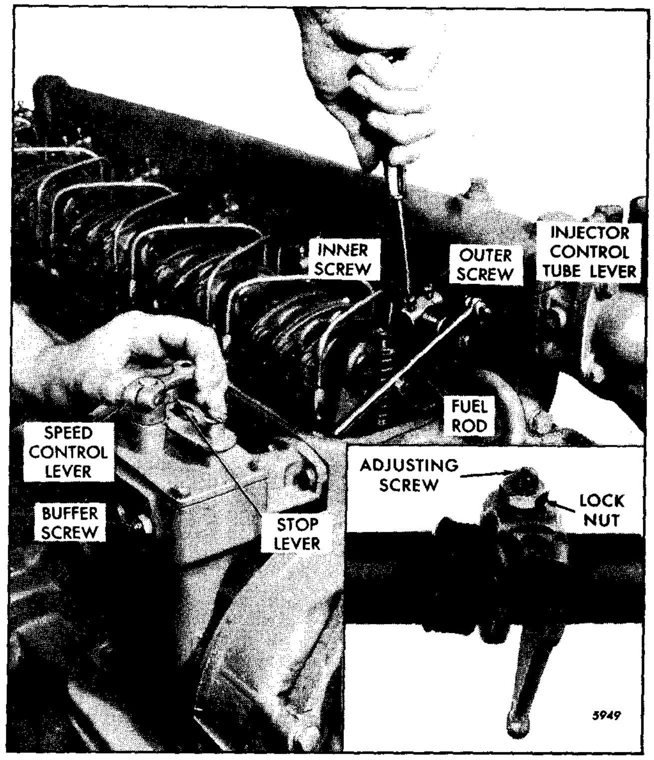


Fig. 3 - Positioning No. 1 Injector Rack Control Lever

2. Turn the idle speed adjusting screw until 1/2" of the threads (12-14 threads) project from the locknut when the nut is against the high-speed plunger (Fig. 2). This adjustment lowers the tension of the low-speed spring so it can be easily compressed. This permits closing the low-speed gap without bending the fuel rods or causing the *yield mechanism springs to yield or stretch.*

NOTE: A false full fuel rack setting may result if the idle speed adjusting screw is not backed out as noted above.

Injector racks must be adjusted so that the effort to move the throttle from the idle speed position to the maximum speed position is uniform. A sudden increase in effort can result from:

a. Injector racks adjusted too tight, not allowing the speed control lever to reach the end of its travel.

b. Binding of the fuel rod.

c. Failure to back out idle screw.

3. Back out the buffer screw approximately 5/8", if it has not already been done.

4. Loosen all of the adjusting screws and locknuts. Be sure all of the injector rack control levers are free on the injector control tube.

NOTE: On engines equipped with a yield link type fuel rod, attach a small "C" clamp at the shoulder of the rod to prevent the yield spring from compressing while adjusting the injector rack control levers.

5. Move the speed contro: lever to the maximum speed position and hold it in that position with light finger pressure (FIg. 3). Tighten the adjusting screw of the No. 1 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 1 injector rack in the full-fuel position.

Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

NOTE: The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

6. To be sure of the proper rack adjustment, hold the speed control lever in the maximum speed position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack (Fig. 4). Hold the speed control lever in the maximum speed position and using a screwdriver, press downward on the injector control rack. The rack should tilt downward and when the pressure of the screwdriver is released, the control rack should "spring" back upward (Fig. 5).

If the rack does not return to its original position, it is too loose. To correct this condition, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is too tight if, when moving the speed control lever from the idle speed position to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (as determined by the stop under the governor cover). This will result in a step-up in effort required to move the speed control lever to the end of its travel. To correct this condition, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

7. To adjust the remaining injector rack control levers, remove the clevis pins from the fuel rod at the injector control tube levers. Hold the injector control rack in the full-fuel position by means of the lever on the end of the control tube and proceed as follows:

a. Tighten the adjusting screw of the No. 2 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

NOTE: Over tightening of the injector rack control tube lever adjusting screws during

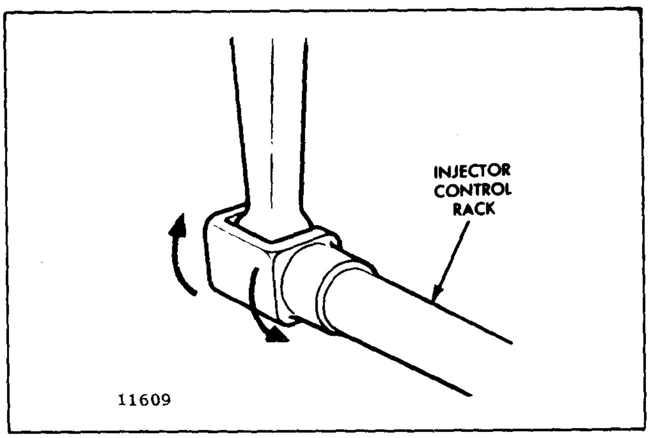


Fig. 4 - Checking Rotating Movement of Injctor Control Rack

installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Verify the injector rack adjustment of No. 1 as outlined in Step 6. If No. 1 does not "spring" back upward, turn the No. 2 adjusting screw counterclockwise slightly until the No. 1 injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 1 and No. 2 injectors. Turn clockwise or counterclockwise the No. 2 injector rack adjusting screw until both No. 1 and No. 2 injector racks are in the full-fuel position when the locknut is securely tightened.

c. Adjust the remaining injectors using the procedures outlined in Step "B" always verifying proper injector rack adjustment.

8. Position the remaining injector rack control levers.

9. Connect the fuel rod to the injector control tube lever.

10. Turn the idle speed adjusting screw until it projects 3/16" from the locknut, to permit starting the engine.

NOTE: Remove the "C" clamp from the fuel rod on units equipped with a yield link.

11. Adjust the starting aid screw (Turbocharged engines).

a. With the engine *stopped,* place the governor stop lever in the *run* position and the speed control lever in the *idle speed* position.

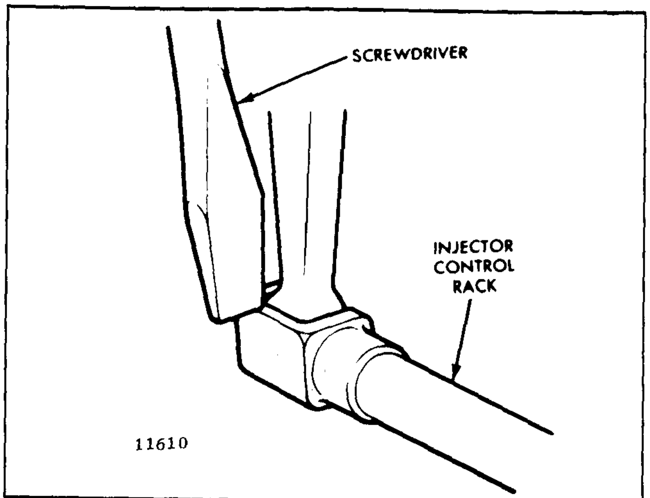


Fig. 5 - Checking Injector Control Rack "Spring"

b. Adjust the starting aid screw to obtain the required setting between the shoulder on the injector rack clevis and the injector body (Fig. 6). Select the proper gage and measure the setting at any convenient cylinder. When the starting aid screw is properly adjusted, the gage should have a small clearance of 1/64" in the space along the injector rack shaft between the rack clevis and the injector body.

c. After completing the adjustment, hold the starting aid screw and tighten the locknut.

d. Check the injector rack clevis-to-body clearance after performing the following:

1. Position the stop lever in the *run* position.

2. Move the speed control lever from the *idle speed position to the maximum speed* position.

3. Return the speed control lever to the *idle speed* position.

Movement of the speed control lever is to take-up the clearance in the governor linkage. The injector rack clevis-to-body clearance can be increased by turning the starting aid screw farther in against the operating shaft lever or reduced by backing it out.

NOTE: The starting aid screw will be ineffective if the speed control lever is advanced toward wide open throttle during start-up.

12. Use a new gasket and reinstall the valve rocker cover.

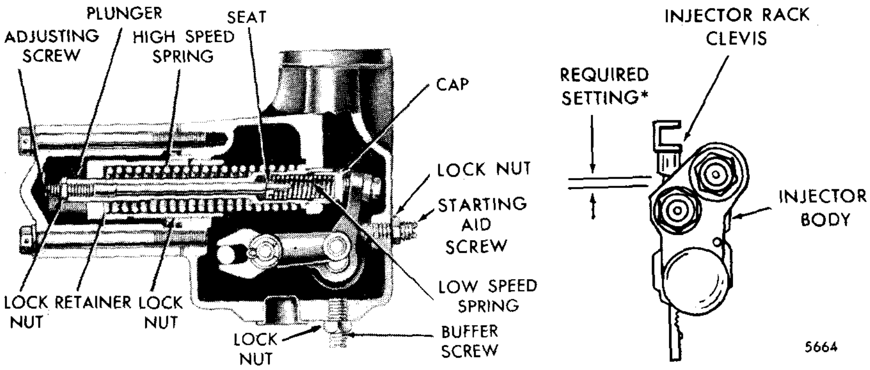
Adjust Maximum No-Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the option plate, set the maximum no-load speed as follows:

NOTE: Be sure the buffer screw projects 5/8" from the locknut to prevent interference while adjusting the maximum no-load speed.

1. Loosen the spring retainer locknut and back off the high-speed spring retainer approximately five turns (Fig. 7).

2. With the engine running at operating temperature and no-load, place the speed control lever in the full-fuel position. Turn the high-speed spring retainer until the engine is operating at the recommended no-load speed position.



INJECTOR	GAGE SETTING*	TOOL NUMBER
N65	.385″	J 24882
N70	.385″	J 24882
N75	.385″	J 24882
N80	.385″	J 24882
N90	.454″	J 23190
C65	.385″	J 24882
7C70	.385″	J 24882
7C75	.385″	J 24882
7E50	.345″	J 24889
7E55	.345″	J 24889
7E60	.345″	J 24889
7E65	.385″	J 24882
7E75	.385″	J 24882
71B5	.345″	J 24889
B55	.345″	J 24889
B60	.345″	J 24889
7G65	.385″	J 24882
7G70	.385″	J 24882
7G75	.385″	J 24882

Fig. 6 - Adjusting Starting Aid Screw (Turbocharged Engines)

3. Hold the high-speed spring retainer and tighten the locknut using spanner wrench J 5345-5.

Adjust Idle Speed

With the maximum no-load speed properly adjusted, adjust the idle speed as follows:

1. Remove the spring housing to uncover the idle speed adjusting screw.

2. With the engine running, at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw until the engine operates at approximately 15 rpm below the recommended idle speed (Fig. 8).

3. Hold the idle screw and tighten the locknut.

4. Install the high-speed spring retainer and tighten the two bolts.

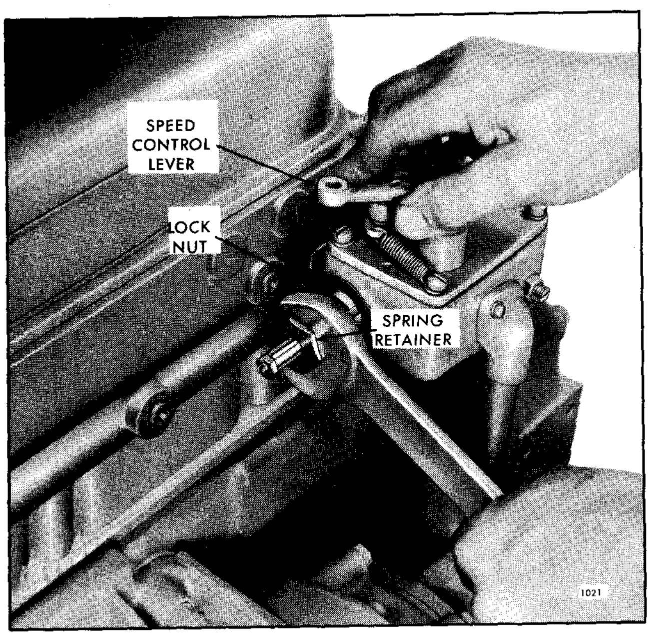


Fig. 7 - Adjusting Maximum No-Load Speed

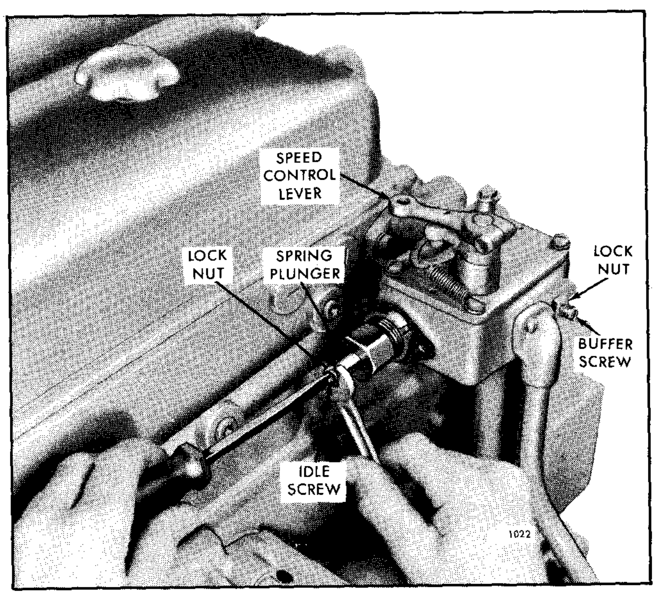


Fig. 8 - Adjusting Engine Idle Speed

Adjust Buffer Screw

With the idle speed properly set, adjust the buffer screw as follows:

1. With the engine running at normal operating temperature, turn the buffer screw in so it contacts the differential lever as lightly as possible and still eliminates engine roll (Fig. 8).

NOTE: Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2. Recheck the maximum no-load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.

3. Hold the buffer screw and tighten the locknut.

MECHANICAL OUTPUT SHAFT GOVERNOR AND LINKAGE ADJUSTMENT

A Pierce mechanical governor is used to maintain a near constant output shaft speed on engines equipped with a torque converter. The governor may be mounted at the front of the engine (Fig. 1) and driven by a flexible shaft from the converter output shaft, or may be mounted on the torque converter and gear driven from the output shaft (Fig. 2).

Lubrication for the direct driven governor is provided by an external oil line from the torque converter. The engine mounted governor is lubricated by engine oil contained within the governor housing. The governor sump is filled through the hinged cap oiler until the oil begins to drip out of the oil level hole. After filling, a plug is installed in the oil level hole to prevent leakage.

The output shaft governor is connected to the engine governor by control rods and levers (Figs. 1 and 2). The control rod end ball joints are sealed assemblies and do not require lubrication. However, the throttle control shaft bearings should be lubricated periodically with all purpose grease through the grease fittings. Other moving parts of the control linkage should be lubricated with engine oil.

The centrifugal force of the revolving output shaft governor flyweights is converted into linear motion which is transmitted through a riser, thrust bearing, operating fork, and rocker shaft to an external speed adjusting spring. The speed of the torque converter output shaft is governed by the tension of the speed adjusting spring. This spring tension is established by the operator when he moves the output shaft governor speed adjusting lever to the desired speed setting.

The engine governor operating lever is positioned by the operator to limit the maximum fuel input to the engine. For most purposes, such as drag line and shovel operation, the lever is advanced to its maximum position to permit the output shaft governor to obtain full power from the engine. The lever may be used as an overrule lever when performing such jobs as laying of structural steel. A spring is used to return the lever to the idle position. Travel of the governor operating lever is limited by a stop (bolt).

The engine governor throttle control lever is pinned to the throttle shaft. The engine governor operating lever is mounted below the throttle control lever and rides on the throttle shaft boss on the governor cover. The output shaft governor lever is mounted above the throttle control lever and is retained on the shaft by a snap ring. A stop pin, pressed into the throttle control lever, transmits movement of the output shaft governor lever and/or engine governor operating lever through the throttle control lever to the injector racks. The torsion spring, used to retain the throttle control lever stop pin against the output shaft governor lever, yields to permit the governor operating lever to move the throttle control lever toward the idle position, regardless of the position of the output shaft governor lever. A slot in the underside of the governor cover

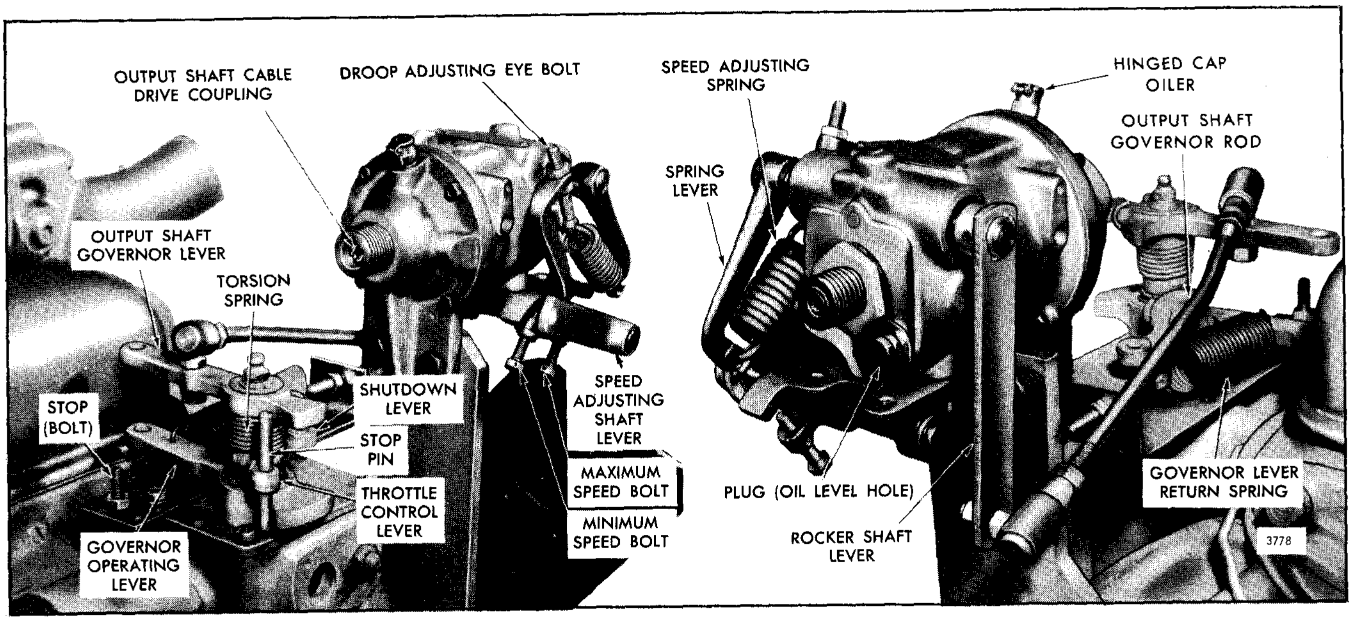


Fig. 1 - Flexible Shaft Driven Output Shaft Governor and Linkage

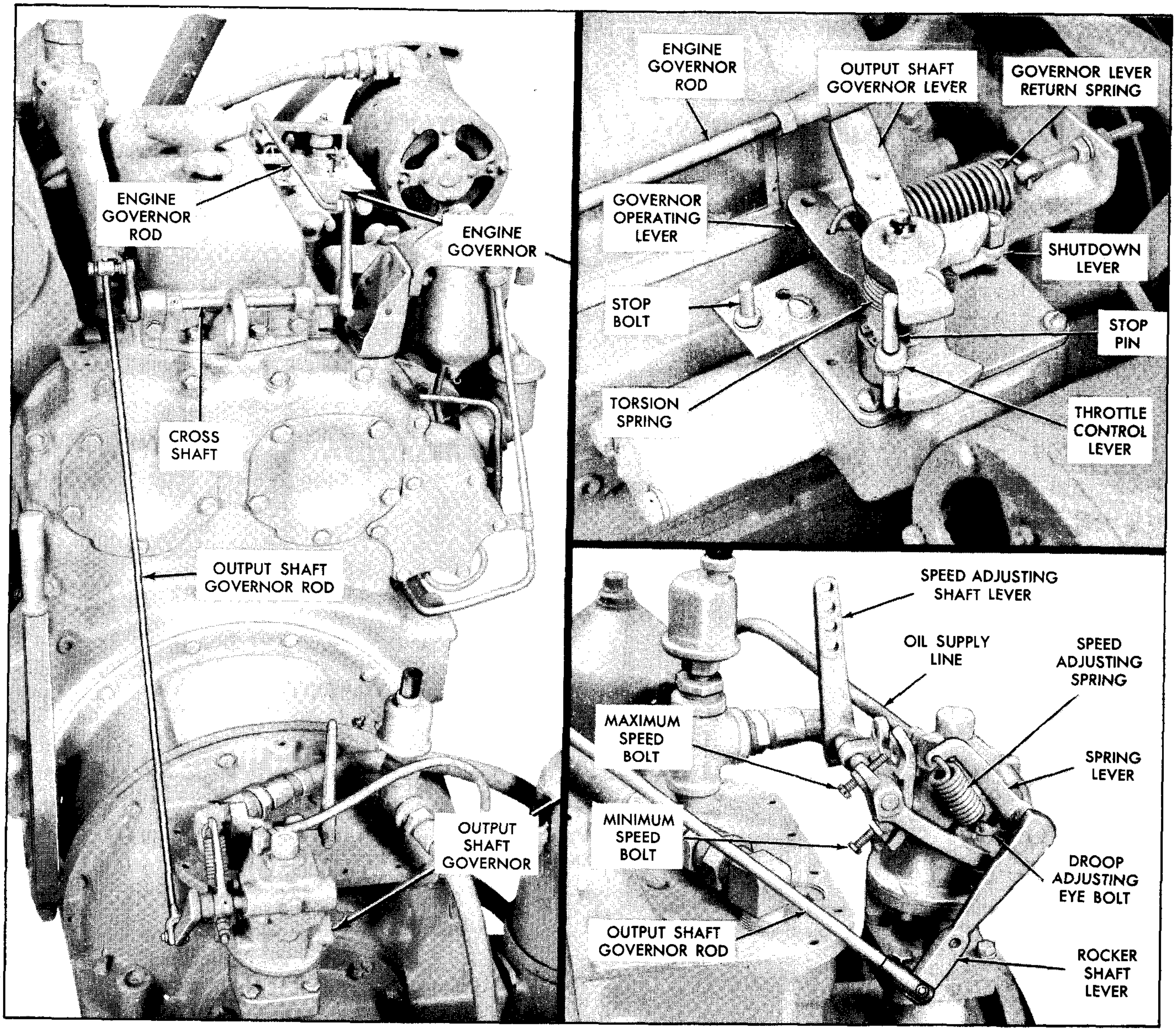


Fig. 2 - Gear Driven Output Shaft Governor and Linkage

hub limits the travel of the throttle control lever in both its maximum and minimum speed positions.

Movement of the output shaft governor speed adjusting lever is limited by the maximum and minimum speed adjusting bolts.

The engine shutdown lever is connected through a shaft to another lever, under the governor cover, which bears against the pin in the differential lever. To stop the engine, the shutdown lever is used to move the differential lever to the no-fuel position.

Operation

When the output shaft governor speed adjusting lever is advanced, the tension on the speed adjusting spring is increased. The force resulting from the increased spring tension is transmitted through the rocker shaft lever and control linkage to the throttle control lever which advances the injector racks. Engine speed increases, as a result of the increased fuel, until the output shaft governor weight force is sufficient to balance the increased spring tension. The weights then move against the spring and reduce the injector rack fuel setting to an amount sufficient to maintain the higher engine speed setting.

Should the operator move the speed adjusting shaft lever to a decreased speed position, the tension on the speed adjusting spring will decrease and the governor weights will overcome the spring tension and move the rocker shaft lever to a decreased fuel position. The engine speed will be reduced until the force of the output shaft governor weights equals the tension of the speed adjusting spring. The engine will then operate at the desired reduced engine speed.

When a load is applied to the unit, the output shaft slows down and the force exerted by the governor flyweights is reduced, allowing the spring to move the rocker shaft lever to an increased fuel position to provide sufficient power to equal the new load.

When the load on the unit is removed, the output shaft speed will increase and the force exerted by the governor flyweights will increase, overcoming the spring tension and moving the rocker shaft lever to a decreased fuel position to reduce the power to match the reduced load.

Tune-Up

Adjust the exhaust valve clearance, time the injectors and adjust the engine and output shaft governors as follows:

1. Adjust the exhaust valve clearance and time the fuel injectors.

2. Disconnect the output shaft governor rod and the linkage to the engine governor operating lever. Then adjust the engine governor as outlined under *Limiting Speed Mechanical Governor and Injector Rack Control Adjustment*.

> **NOTE:** Set the no-load engine speed to that specified on the engine option plate. The no-load speed varies with the converter used and the maximum output shaft speed setting.

3. Reconnect the linkage to the governor operating lever and check the total travel of the operating lever. The lever should move to the stop (bolt) in one direction and the governor lever return spring should move the lever, in the other direction, until the throttle control lever reaches the end of its travel.

4. Move the governor operating lever to the maximum speed position (against the stop bolt).

5. Move the output shaft governor rocker shaft lever to the maximum fuel position and retain it by moving the speed adjusting lever to the full-speed position. Then move the output shaft governor lever and the throttle control lever together to the maximum speed position and retain them there.

> **NOTE:** This operation closes the low speed gap which may require more torque than is available from the torsion spring between the above two levers. Thus, it is important that they be held together, permitting no space between the throttle control lever pin and the arm of the output shaft governor lever.

6. Adjust the flexible-shaft driven output shaft governor rod length until it will just slide into the inner hole of the output shaft governor lever (Fig. 1). Then increase the length of the rod until there is approximately .020" clearance between the stop pin and the output shaft governor lever, and the bend in the rod is positioned as shown in Fig. 1. Tighten the adjustment.

To adjust the linkage between the output shaft governor (mounted on the torque converter) and the engine governor, loosen the output shaft governor rod clamping bolt in the ball joint in the rear cross shaft lever (Fig. 2). Next, move the output shaft governor rod until there is approximately .020" clearance between the stop pin and the output shaft governor lever. Then tighten the clamping bolt securely.

> **NOTE:** The engine governor control rod is connected to the outer bolt hole in the output shaft governor lever on units equipped with a rear mounted output shaft governor.

7. Adjust the governor operating lever return spring by retaining the rocker shaft lever in the full-speed position and increasing the tension on the spring by adjusting the eyebolt and nuts, until the tension of the torsion spring is overcome and the throttle control lever is moved against its stop in the idle position.

8. Move the output shaft governor speed adjusting lever to the minimum speed position and start the engine.

9. Advance the output shaft governor speed adjusting lever to the desired maximum output shaft speed and adjust the maximum speed adjusting bolt to retain the lever.

10. Move the output shaft governor speed adjusting shaft lever to the desired minimum speed position and adjust the minimum speed adjusting bolt to retain the lever.

11. Recheck the output shaft maximum and minimum speeds and readjust the position of the speed adjusting bolts, if necessary.

12. To check the unit for stability as affected by governor speed droop, move the speed adjusting shaft lever, with the engine operating at no load, to the maximum speed position. Then move the output shaft

governor rod to cause a speed decrease of several hundred rpm. Release the rod and check for hunting when the governor returns the engine to the maximum speed setting. If the engine stabilizes in less than three surges, the droop may be set too high; if the engine does not stabilize in five surges, the droop may be set too low. Set the speed droop as follows:

a. If the engine hunts less than three surges, back off the inner speed adjusting spring eyebolt nut one full turn and tighten the outer nut one turn to retain the adjustment. If the engine hunts more than five surges, back off the outer speed adjusting spring eyebolt nut one full turn and tighten the inner nut one turn to retain the adjustment.

NOTE: The eye of the bolt must be in a horizontal plane to avoid twisting the spring.

b. Reset the maximum engine no-load speed, if necessary, as outlined in Steps 9 and 10.

c. Recheck the speed droop. The engine speed should be stable when the governor droop is 7-1/2% to 10% of the full-load speed. For example, at an output shaft speed setting of 1800 rpm full load, the output shaft speed droop should be 150 to 200 rpm. Therefore, the no-load output shaft speed should be set at 1950 to 2000 rpm.

VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

The single-weight governor is mounted on the front of the blower and is driven by the upper blower rotor.

After adjusting the exhaust valves and timing the fuel injectors, adjust the variable speed mechanical governor and position the injector rack control levers.

> **NOTE:** Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, reconnect and adjust the supplementary governing device.

Adjust Governor Gap

With the engine stopped and at normal operating temperatures, adjust the governor gap as follows:

1. Disconnect any linkage attached to the governor levers.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut.

3. Clean and remove the governor cover and valve rocker cover. Discard the gasket.

4. Place the speed control lever in the *maximum* speed position (Fig. 1).

5. Insert a .006" feeler gage between the spring plunger and the plunger guide (Fig. 1). If required, loosen the locknut and turn the adjusting screw in or out until a slight drag is noted on the feeler gage.

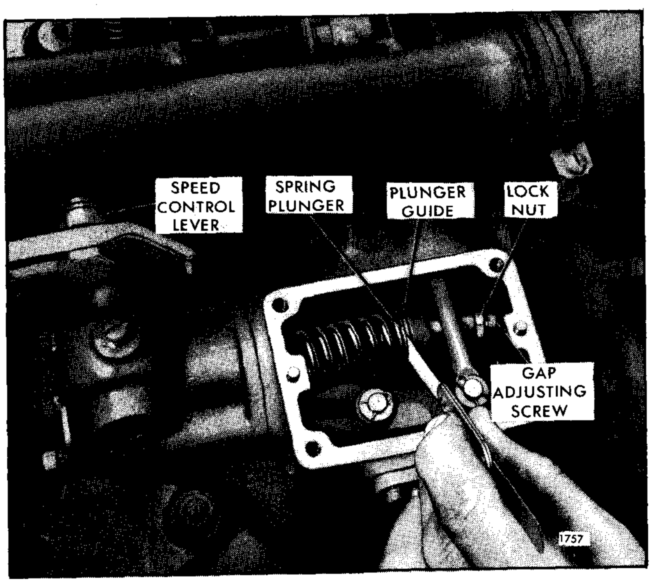


Fig. 1 - Adjusting Governor Gap

6. Hold the adjusting screw and tighten the locknut. Check the gap again and, if necessary, readjust.

7. Secure the governor cover to the governor housing with three regular screws, one special screw and lock washers.

8. Hook the torsion retracting spring on the special cover screw and the stop lever (Fig. 2).

Position Injector Rack Control Levers

The position of the injector rack control levers must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

The engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever and one screw and locknut to keep each injector rack properly positioned.

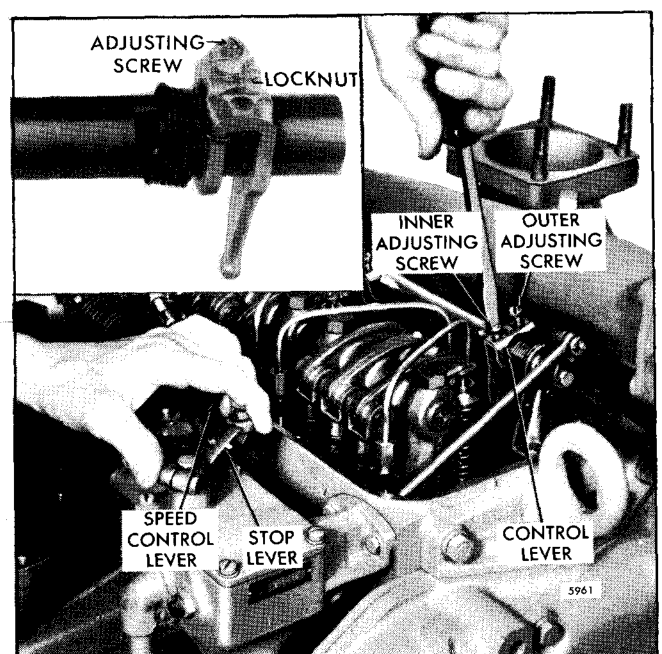


Fig. 2 - Positioning No. 1 Injector Rack Control Lever

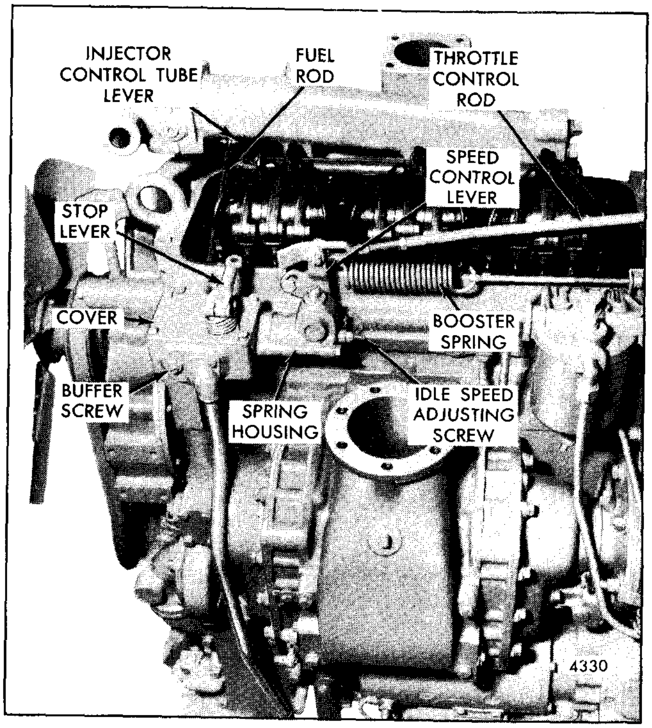


Fig. 3 - Buffer and Idle Speed Adjusting Screw

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the maximum speed position.

2. Stop lever in the *run* position.

3. High-speed spring plunger on the seat in the governor control housing.

4. Injector fuel control racks in the full-fuel position.

NOTE: The cross link equalizer spring must be removed from multiple engine units before performing the individual engine tune-up.

Adjust the No. 1 injector rack control lever (Fig. 2) first, to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect any linkage attached to the stop lever.

2. Loosen all of the adjusting screws and locknuts (Fig. 2). Be sure all of the injector rack control levers are free on the injector control tube.

3. Move the speed control lever to the full-fuel position.

4. Move the stop lever to the *run* position and hold it in that position with light finger pressure. Tighten the adjusting screw of the No. 1 injector rack control lever

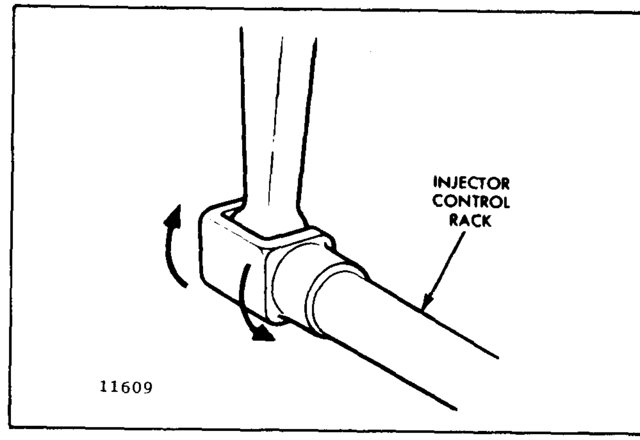


Fig. 4 - Checking Rotating Movement of Injector Control Rack

until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (Fig. 2). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 1 injector rack in the full-fuel position.

NOTE: Overtightening the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

4. To be sure of proper rack adjustment, hold the stop lever in the *run* position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack when the stop lever is in the *run* position (Fig. 4). Hold the stop lever in the *run* position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward and, when the pressure of the screwdriver is released, the control rack should "spring" back upward (Fig. 5).

If the rack does not return to its original position, it is too loose. To correct this condition, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is too tight if, when moving the stop lever from the *stop* to the *run* position, the injector rack becomes tight before the stop lever reaches the end of its travel. This will result in a step-up in effort required to move the stop lever to the end of its travel. To correct this condition, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

5. To adjust the remaining injector rack control levers, remove the clevis pin from the fuel rod and the injector control tube lever, hold the injector control racks in the full-fuel position by means of the lever on the end of the control tube and proceed as follows:

a. Tighten the adjusting screw of the No. 2 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

NOTE: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Verify the injector rack adjustment of No. 1 as outlined in Step 4. If No. 1 does not "spring" back upward, turn the No. 2 adjusting screw counterclockwise slightly until the No. 1 injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 1 and No. 2 injectors. Turn clockwise or counterclockwise the No. 2 injector rack adjusting screw until both No. 1 and No. 2 injector racks are in the full-fuel position when the locknut is securely tightened.

c. Adjust the remaining injectors using the procedures outlined in Step "B" always verifying proper injector rack adjustment.

6. When all of the injector rack control levers are adjusted, recheck their settings. With the control tube lever in the full-fuel position, check each control rack as in Step 4. All of the control racks must have the same "spring" condition with the control tube lever in the full-fuel position.

7. Insert the clevis pin in the fuel rod and the injector control tube lever.

8. Use a new gasket and reinstall the valve rocker cover.

Adjust Maximum No-Load Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the engine option plate, set the maximum no-load speed as outlined below:

Full-Load Speed	Stops	Shims
1200 to 1425 rpm	2	Up to .325"
1426 to 1825 rpm	1	Up to .325"
1826 to 2100 rpm	0	Amount required to get necessary speed

TABLE 1 - TWO VALVE CYLINDER HEADS

Start the engine and, after it reaches normal operating temperature, determine the maximum no-load speed of the engine with an accurate hand tachometer. Then stop the engine and make the following adjustments, if required:

1. Refer to Fig. 3 and disconnect the booster spring.

2. Remove the variable speed spring housing and the variable speed spring plunger from inside the spring housing.

3. Refer to Table 1 and Fig. 6 and determine the stops or shims required for the desired full-load speed for engines with two valve cylinder heads. *A split stop can only be used with a solid stop.*

Refer to Table 2 and determine the stops or shims required for the desired full-load speeds for engines with four valve cylinder heads.

4. Install the variable speed spring plunger and housing and tighten the two bolts. Start the engine and recheck the maximum no-load speed.

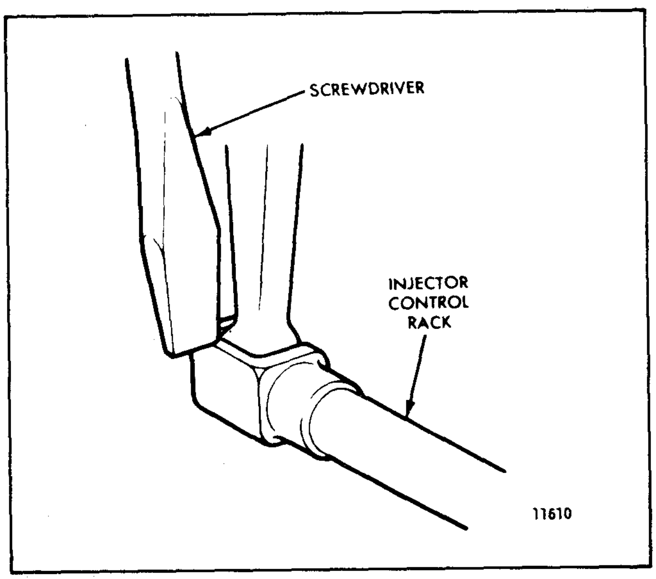


Fig. 5 - Checking Injector Control Rack Movement

Full-Load Speed	Stops	Shims
1450 to 1650 rpm	2	Amount required to get necessary speed
1651 to 2150 rpm	1	
2151 to 2300 rpm	0	

TABLE 2 - FOUR VALVE CYLINDER HEADS

5. If required, add shims to obtain the necessary operating speed. For each .001" shim added, the operating speed will increase approximately 1 rpm. If the maximum no-load speed is raised or lowered more than 50 rpm by the installation or removal of the governor shims, the governor gap should be rechecked.

NOTE: Governor stops are used to limit the compression of the governor spring which determines the maximum speed of the engine.

If readjustment of the governor gap is required, the position of the injector racks must be rechecked.

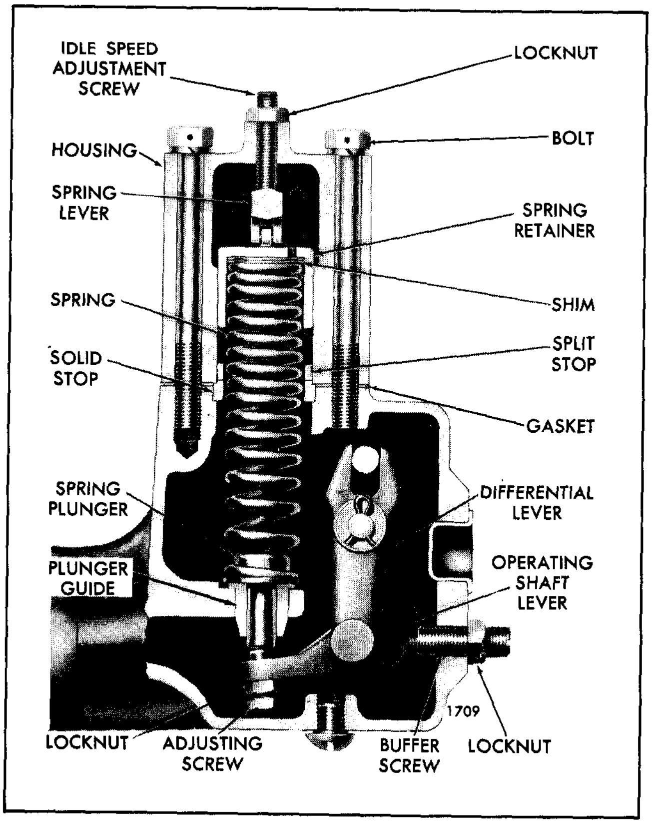


Fig. 6 - Location of Stops and Shims

Adjust Idle Speed

With the maximum no-load speed properly adjusted, adjust the idle speed as follows:

1. Place the speed control lever in the idle position and the stop lever in the *run* position.

2. With the engine running at normal operating temperature, back out the buffer screw to avoid contact with the differential lever.

3. Loosen the locknut and turn the idle speed adjusting screw until the engine is operating at approximately 15 rpm below the recommended idle speed. The recommended idle speed is 500-600 rpm, but may vary with special engine applications.

4. Hold the idle speed adjusting screw and tighten the locknut.

Adjust Buffer Screw.

With the idle speed set at approximately 15 rpm below the recommended idle speed, the buffer screw may be set as follows:

1. With the engine running at normal operating temperature, turn the buffer screw *in* so that it contacts the differential lever as lightly as possible and still eliminates engine roll.

NOTE: Do not increase the engine speed more than 15 rpm with the buffer screw.

2. Hold the buffer screw and tighten the locknut.

Adjust Booster Spring

With the engine idle speed adjusted, adjust the booster spring as follows:

1. Move the speed control lever to the idle speed position.

2. Refer to Fig. 3 and loosen the booster spring retaining nut on the speed control lever. Loosen the nut and locknut on the eye bolt at the opposite end of the booster spring.

3. Move the spring retaining bolt in the slot of the speed control lever until the center of the bolt is on or slightly over center toward the idle position of an imaginary line through the bolt, lever shaft and eye bolt. Hold the bolt and tighten the locknut.

4. Start the engine and move the speed control lever to the maximum speed position and release it. The speed

control lever should return to the *idle* speed position. If it does not, reduce the booster spring tension. If it does, continue to increase the spring tension until the point is reached where it will not return to idle. Then reduce the spring tension until the point is reached where it will not return to idle. Then reduce the spring tension until the lever does not return to idle and tighten the lock nut on the eye bolt. This setting will result in the minimum force required to operate the speed control lever.

SUPPLEMENTARY GOVERNING DEVICE ADJUSTMENT

ENGINE LOAD LIMIT DEVICE

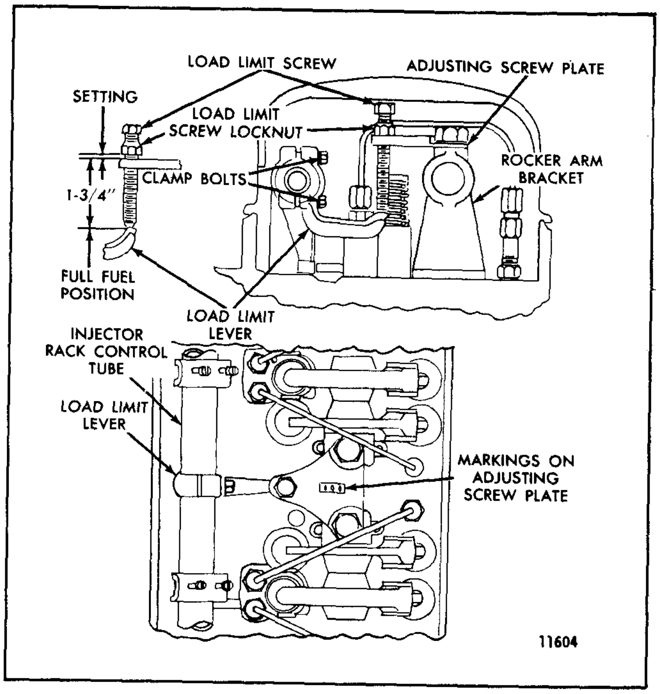


Fig. 1 - Engine Load Limit Device

Engines with mechanical governors may be equipped with a load limit device to reduce the maximum horsepower (Fig. 1).

This device consists of a load limit screw threaded into a plate mounted between two adjacent rocker arm shaft brackets and a load limit lever clamped to the injector control tube.

The load limit device is located between the No. 1 and No. 2 cylinders of a three cylinder engine, between the No. 2 and No. 3 cylinders of a four cylinder engine or between the No. 3 and No. 4 cylinders of a six cylinder engine.

When properly adjusted for the maximum horsepower desired, this device limits the travel of the injector control racks and thereby the fuel output of the injectors.

Adjustment

After the engine tune-up is completed, make sure the load limit device is properly installed as shown in Fig. 1. Make sure the counterbores in the adjusting screw plate are up. The rocker arm shaft bracket bolts which fasten the adjusting screw plate to the brackets are tightened to 75-85 lb-ft (102-115 Nm) torque. All other rocker arm shaft bracket bolts are tightened to 90-100 lb-ft (122-136 Nm) torque. Then adjust the load limit device as follows:

1. Loosen the load limit screw locknut and remove the screw.

2. Loosen the load limit lever clamp bolts so the lever is free to turn on the injector rack control tube.

3. With the screw out of the plate, adjust the load limit screw locknut so the bottom of the locknut is 1 3/4" from the bottom of the load limit screw (Fig. 1) for the initial setting.

4. Thread the load limit screw into the adjusting screw plate until the locknut *bottoms* against the top of the plate.

5. Hold the injector rack control tube in the full-fuel position and place the load limit lever against the bottom of the load limit screw. Then tighten the load limit lever clamp bolts.

6. Check to ensure that the injector racks will just go into the full-fuel position -- readjust the load limit lever if necessary.

7. Hold the load limit screw to keep it from turning, then *set* the locknut until the distance between the bottom of the locknut and the top of the adjusting screw plate corresponds to the dimension (or number of turns) stamped on the plate. Each full turn of the screw equals .042", or .007" for each flat on the hexagon head.

   NOTE: If the plate is not stamped, adjust the load limit screw while operating the engine on a dynamometer test stand and note the number of turns required to obtain the desired horsepower. Then stamp the plate accordingly.

8. Thread the load limit screw into the plate until the locknut *bottoms* against the top of the plate. Be sure the nut turns with the screw.

9. Hold the load limit screw to keep it from turning, then tighten the locknut to secure the setting.

THROTTLE DELAY MECHANISM

The throttle delay mechanism is used to retard full-fuel injection when the engine is accelerated. This reduces exhaust smoke and also helps to improve fuel economy.

The throttle delay mechanism is installed between the No. 1 and No. 2 cylinders on the cylinder head (Fig. 2). It consists of a special rocker arm shaft bracket (which incorporates the throttle delay cylinder), a piston, throttle delay lever, connecting link, orifice plug, ball check valve and U-bolt.

A yield lever and spring assembly replaces the standard lever and pin assembly on the front end of the injector control tube.

Operation

Oil is supplied to a reservoir above the throttle delay cylinder through an orifice plug in the drilled oil passage in the rocker arm shaft bracket (Fig. 2). As the injector racks are moved toward the no-fuel position, free movement of the throttle delay piston is assured by air drawn into the cylinder through the ball check valve. Further movement of the piston uncovers an opening which permits oil from the reservoir to enter the cylinder and displace the air. When the engine is accelerated, movement of the injector racks toward the full-fuel position is momentarily retarded while the piston expels the oil from the cylinder through an orifice. To permit full accelerator travel, regardless of the retarded injector rack position, a spring loaded yield lever and spring assembly replaces the standard lever on the front end of the injector control tube.

Inspection

The throttle delay bracket has a closer tolerance on the piston and cylinder bore. The check valve has a nylon check ball. When inspecting the throttle delay hydraulic cylinder, it is important that the ckeck valve be inspected for wear.

To inspect the check valve, fill the throttle delay cylinder with diesel fuel oil and watch for check valve leakage while moving the engine throttle from the idle position to the full-fuel position. If more than a drop of leakage occurs, replace the check valve.

Adjustment

Whenever the injector rack control levers are adjusted, disconnect the throttle delay mechanism by loosening the U-bolt which clamps the lever to the injector control tube. After the injector rack control levers have been positioned, the throttle delay mechanism must be

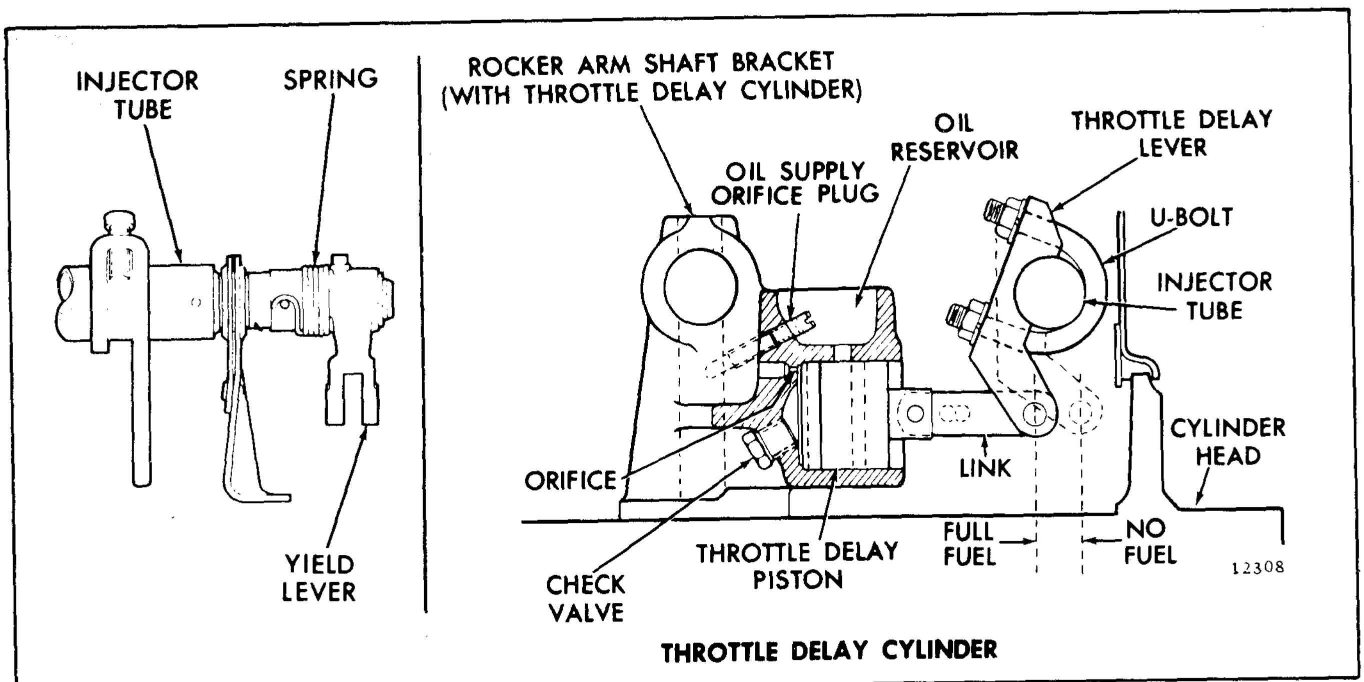


Fig. 2 - Throttle Delay Cylinder and Yield Link

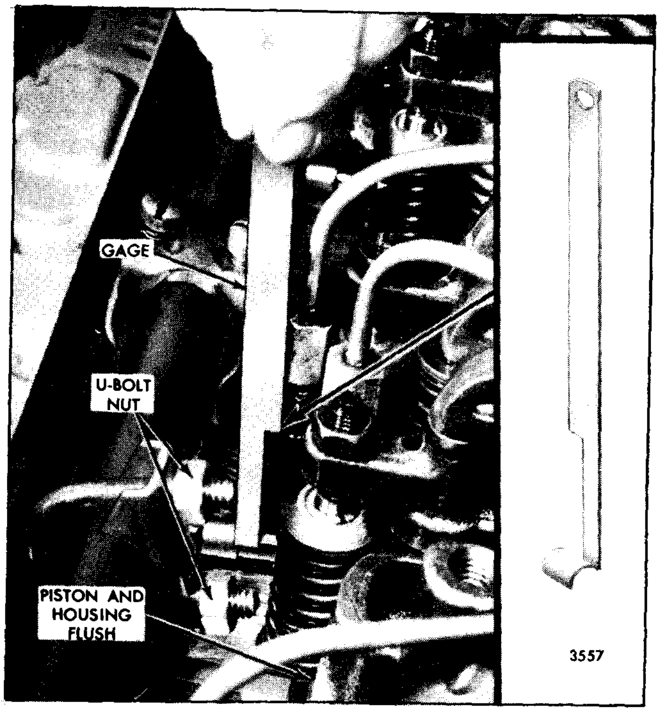


Fig. 3 - Adjusting Throttle Delay Cylinder

readjusted. With the engine stopped, proceed as follows:

1. Refer to Fig. 3 and insert gage J 25559 (.570" gage length) between the injector body and the shoulder on the injector rack clevis of the injector nearest to the throttle delay cylinder.

2. Hold the governor throttle in the maximum speed position. This should cause the injector rack to move toward the full-fuel position and against the gage.

3. Insert the pin gage J 25558 (.072" diameter setting end) in the cylinder fill hole.

4. Rotate the throttle delay lever in the direction shown in Fig. 2 until further movement is limited by the piston contacting the pin gage.

5. Tighten the U-bolt nuts while exerting a slight amount of torque on the lever, in the direction of rotation. Be careful not to bend the gage or damage the piston by using excessive force.

6. Check the setting as follows:

a. Remove the pin gage.

b. Attempt to reinstall the pin gage (.072" diameter). It should not be possible to reinsert the gage without moving the injector racks towards the no-fuel position.

c. Reverse the pin gage to the .069" diameter end and insert it in the cylinder fill hole. It should enter the cylinder without resistance.

NOTE: If the .072" diameter end of the gage enters the fill hole (Step 6b), increase the torque on the upper U-bolt nut. If the .069" diameter will not enter the fill hole (Step 6c) without resistance, increase the torque on the lower U-bolt nut.

7. Release the governor throttle and remove the timing gage and pin gage.

8. Move the injector control tube assembly from the no-fuel to the full-fuel position to make sure there is no bind.

9. Refer to Section 5 for maintenance.

FUEL SHUTOFF AIR CYLINDER ASSEMBLY

An air cylinder is mounted at the rear of the cylinder head on some engines to move the injector fuel control racks to the no-fuel position to stop the engine (Fig. 4). The air cylinder permits the use of a governor with a single control lever, eliminating the need of an off-on lever and the necessary operating linkage.

The use of the air cylinder on an engine with a limiting speed governor requires a yielding fuel control rod (Fig. 5). An engine equipped with an air cylinder and a fuel modulating governor (Figs. 6 and 7) does not require the yielding rod because the torsion spring within the governor will perform the same purpose.

Operation

The fuel shutoff cylinder is actuated by air pressure. The air enters the cylinder and forces the piston forward, thus overcoming the tension of the air cylinder spring; the yielding fuel rod is used to move the injector fuel control racks to the no-fuel position, shutting the engine down. When the air pressure is released, the spring within the air cylinder moves the piston to the end of its travel away from the engine allowing the yielding rod to expand, moving the injector racks into the full-fuel position required for engine starting.

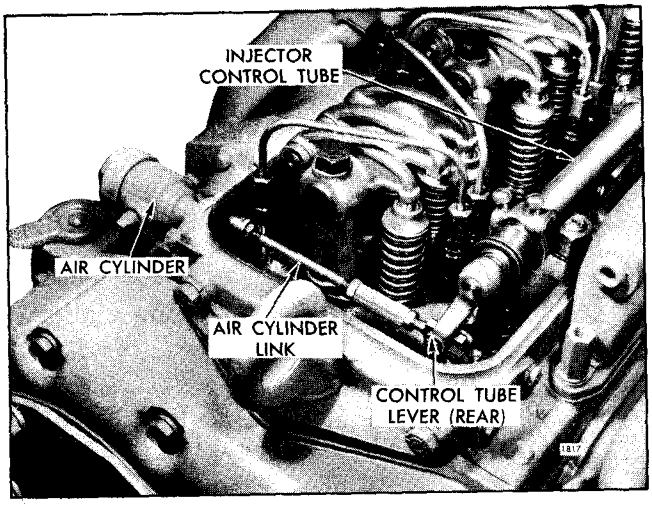


Fig. 4 - Air Cylinder Used with Limiting Speed Governor

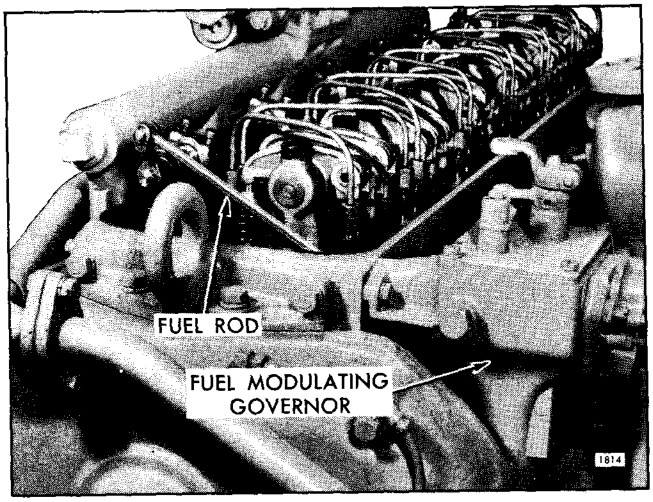


Fig. 6 - Standard Fuel Rod Used with Fuel Modulating Governor

Adjust Air Cylinder Linkage

After completing adjustment of the governor, adjust the linkage between the fuel shutoff cylinder and the injector control tube lever as follows:

1. Place the governor speed control lever in the maximum speed position. Movement of the control lever will move the injector racks to the full-fuel position.

2. Loosen the locknuts on the air cylinder link (Fig. 4) and lengthen the rod by turning the turnbuckle until the end of the slot contacts the pin in the end of the control tube lever. Then shorten the rod one complete turn of the turn buckle and tighten the locknuts.

Adjusting the rod in this manner will permit the governor to move the injector control racks into the full-fuel position without coming to the end of the slot in the air cylinder link.

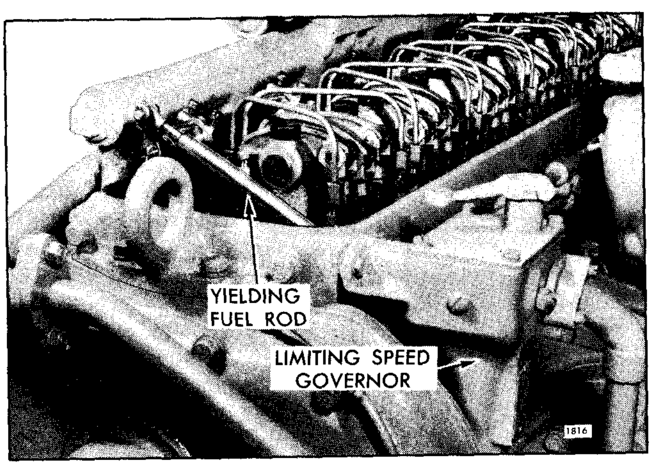


Fig. 5 - Yielding Fuel Rod Used with Limiting Speed Governor

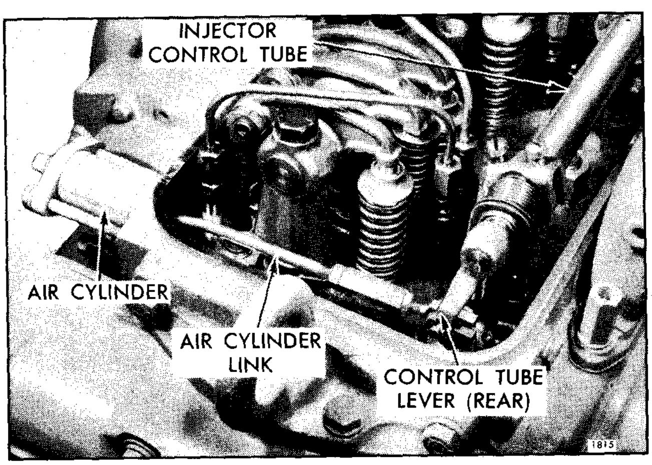


Fig. 7 - Air Cylinder Used with Fuel Modulating Governor

ADJUSTMENT OF MECHANICAL GOVERNOR SHUTDOWN SOLENOID

When a governor shutdown solenoid is used on an engine equipped with a mechanical governor, the governor stop lever must be properly adjusted to match the shutdown solenoid plunger travel.

The solenoid plunger can be properly aligned to the governor stop lever as follows:

1. Remove the bolt connecting the rod end eye (variable speed governor) or the right angle clip (limiting speed governor) to the stop lever (Figs. 8 and 9). Align and clamp the lever to the shutdown shaft in such a way that, at its mid-travel position, it is perpendicular to the solenoid plunger. This assures that the linkage will travel as straight as possible. The solenoid plunger has available 1/2" travel which is more than adequate to move the injector control racks from the full-fuel to the complete no-fuel position and shutdown will occur prior to attaining complete travel.

2. With the stop lever in the *run* position, adjust the rod end eye or right angle clip for minimum engagement on the solenoid plunger when the connecting bolt is installed. The oversize hole in the eye or clip will thereby permit the solenoid to start closing the air gap, with a resultant build-up of pull-in force prior to initiating stop lever movement.

3. The bolt through the rod end eye or the right angle clip should be locked to the stop lever and adjusted to a height that will permit the eye or clip to float vertically. The clearance above and below the eye or clip and the bolt head should be approximately 1/32" minimum.

> **NOTE:** The locknut can be either on top of or below the stop lever.

4. Move the lever to the *stop* position and observe the plunger for any possible bind. If necessary, loosen the mounting bolts and realign the solenoid to provide free plunger motion.

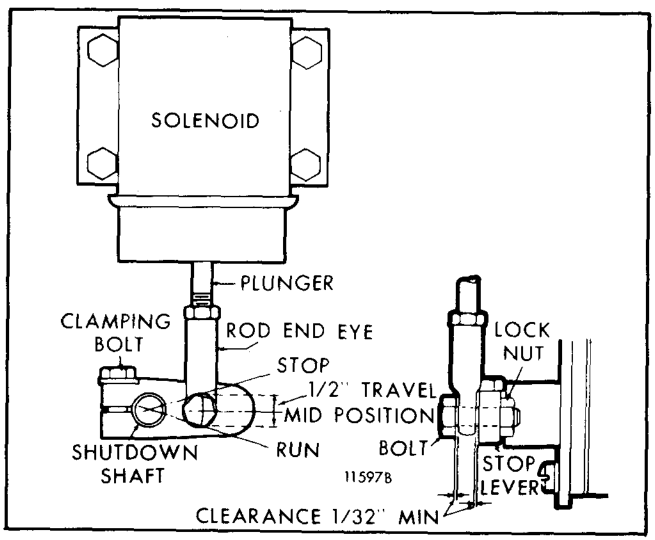


Fig. 8 - Typical Variable Speed Governor Lever Position

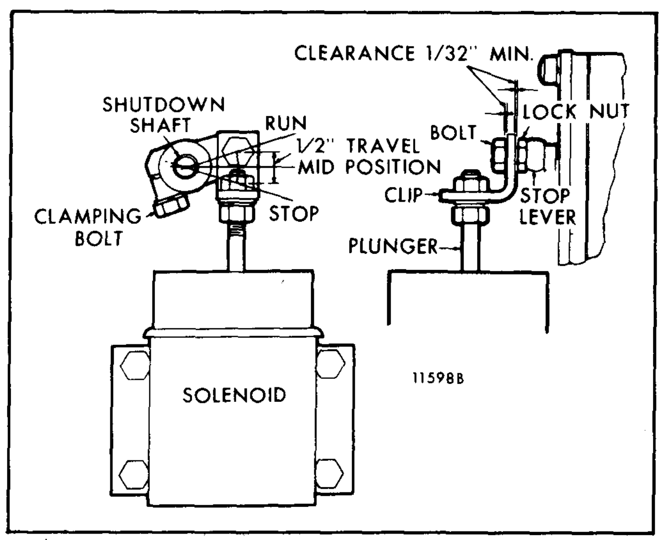


Fig. 9 - Typical Limiting Speed Governor Lever Position

HYDRAULIC SG GOVERNOR AND INJECTOR CONTROL RACK ADJUSTMENT

After adjusting the exhaust valves and timing the fuel injectors, adjust the hydraulic governor and injector rack control levers.

Adjust Fuel Rod

To be sure of a full travel between no-fuel and full-fuel adjust the fuel rod as follows:

1. Remove the governor cover and the valve rocker cover, then loosen all the injector rack control lever adjusting screws and locknuts (Fig. 2). Be sure all of the control levers are free on the injector control tube.

2. Loosen the fuel rod locknut and remove the fuel rod knob (Fig. 1).

3. Turn the locknut until 3/16" of the fuel rod extends beyond the nut. Hold the locknut in position with a wrench and install the fuel rod knob. Use a suitable wrench to tighten the knob against the locknut.

Position Injector Rack Control Levers

After the fuel rod is properly adjusted, adjust the rack control levers in the no-fuel position as follows:

1. Adjust the No. 1 injector rack control lever by tightening the adjusting screw until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (Fig. 2). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 1 injector rack in the full-fuel position.

2. Pull the fuel rod out and check for 1/32" to 1/16" movement.

If the movement exceeds the distance specified, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

If the movement is less than the distance specified, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

3. Disconnect the fuel rod from the injector control tube lever.

4. Manually hold the No. 1 injector rack control lever in the full-fuel position and tighten the adjusting screw (Fig. 2) of the No. 2 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

NOTE: Overtightening the injector rack control lever adjusting screws can result in damage to

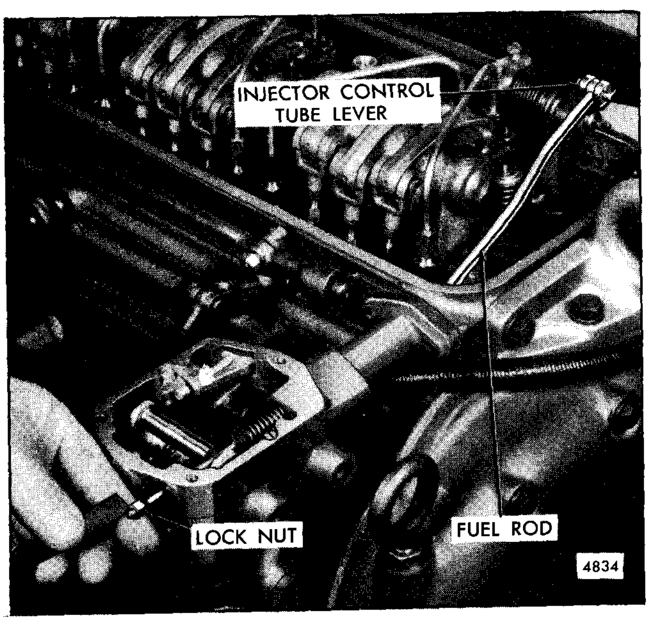


Fig. 1 - Adjusting Fuel Rod

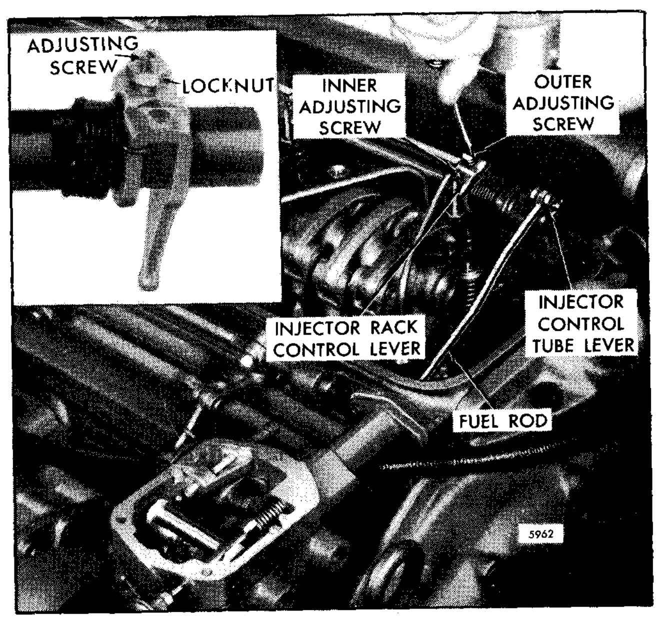


Fig. 2 - Positioning No. 1 Injector Rack Control Lever

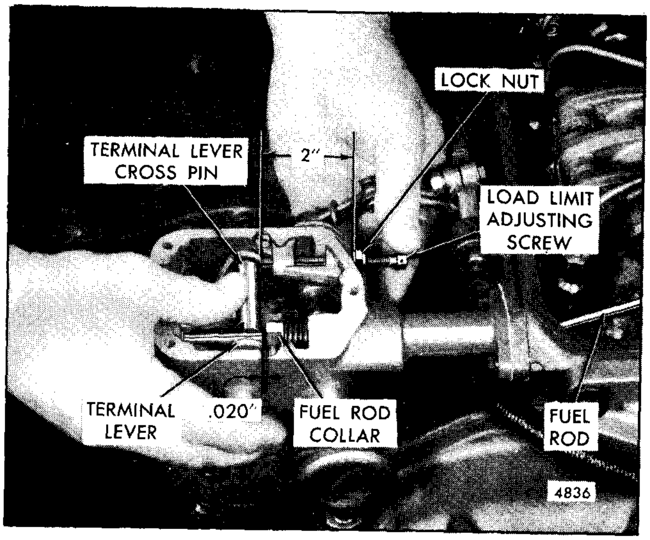


Fig. 3 - Adjusting Load Limit

the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

5. Recheck the No. 1 injector fuel rack to make sure that it has remained snug on the ball end of the rack control lever while adjusting the No. 2 injector rack. If the rack of No. 1 injector has become loose, loosen the locknut and turn the adjusting screw on the No. 2 injector rack control lever clockwise a slight amount and retighten the locknut.

When the settings are correct, the racks of both injectors must be snug on the ball end of the respective rack control levers.

6. Position the remaining injector rack control levers as outlined in Steps 4 and 5.

When the settings are correct, the racks of all of the injectors must be snug on the ball end of the rack control levers when the control tube lever is held in the full-fuel position.

7. Reconnect the fuel rod to the injector control tube lever.

Adjust Load Limit

The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the load limit screw should be readjusted.

With the injector rack control levers properly adjusted, the load limit may be set as follows:

1. Loosen the load limit screw locknut (Fig. 3) and adjust the load limit screw to obtain a distance of approximately 2" from the outside face of the boss on the governor sub-cap to the end of the screw.

2. Place the fuel rod and terminal lever in the full-fuel position (Fig. 3).

3. Turn the load limit screw until a .020" space exists between the fuel rod collar and the terminal lever, then hold the screw and tighten the locknut.

Adjust Speed Droop

The purpose of adjusting the speed droop is to establish a definite engine speed at no load with a given speed at rated full load.

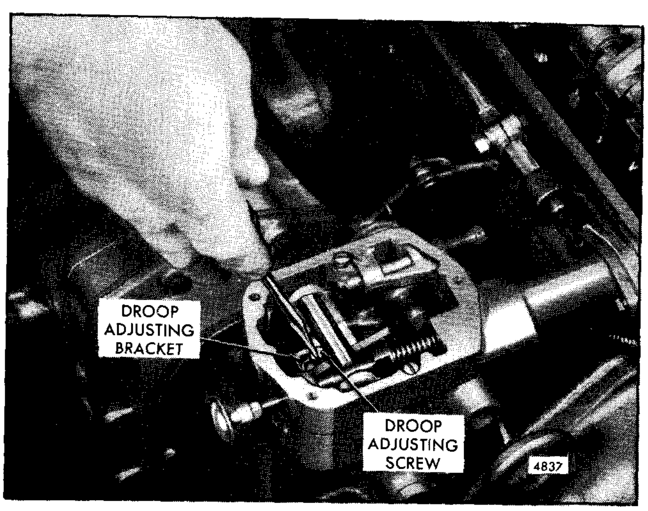


Fig. 4 - Adjusting Speed Droop

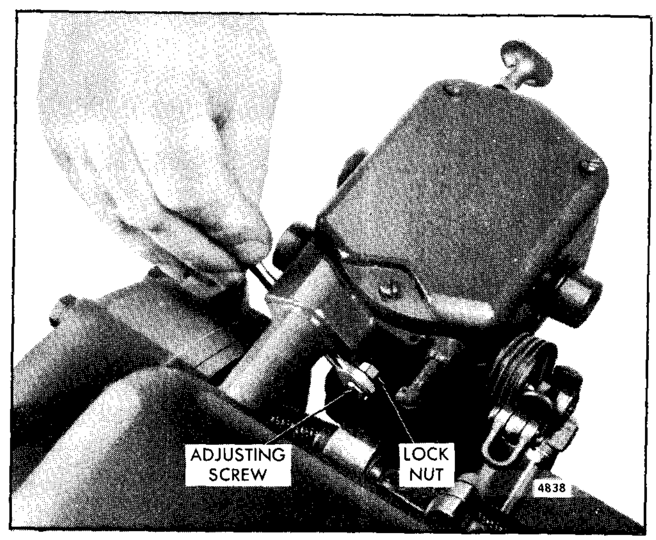


Fig. 5 - Adjusting Maximum No-Load Speed

The governor is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs, the speed droop should be readjusted.

Use an accurate tachometer to determine the engine speed.

When a full rated load on the unit is established and the fuel rod, injector rack control levers and load limit have been adjusted, the speed droop may be adjusted as follows:

1. Start the engine and operate it at approximately one-half the rated no-load speed until the lubricating oil has had an opportunity to warm-up.

> **NOTE:** When the engine lubricating oil is cold, the governor regulation may be erratic. The regulation should become increasingly stable as the temperature of the lubricating oil increases.

2. Stop the engine and remove the governor cover.

3. Loosen the locknut and back off the maximum speed adjusting screw approximately 3/8" (Fig. 5).

4. Refer to Fig. 4 and loosen the speed droop adjusting screw. Move the speed droop adjusting bracket so the screw is midway between the ends of the slot in the bracket. Tighten the screw. Be sure the bracket remains on the shoulder of the terminal lever.

5. With the throttle in the *run* position, adjust the speed until the engine is operating at 5% above the recommended full-load speed.

6. Apply the full rated load on the engine and readjust the engine speed to the correct full-load speed.

7. Remove the rated load and note the engine speed after the speed has stabilized under no load. If the speed droop is correct, the engine speed will be approximately 5% higher than the full-load speed.

If the speed droop is too high, stop the engine, loosen the screw again and move the speed droop adjusting bracket *in* (toward the engine). Tighten the screw. To increase the speed droop, move the droop adjusting bracket *out* (away from the engine).

If the speed droop in the governors of power generator engines are not the same, the electrical load will not be equally divided when the generators are operated in parallel.

The speed droop bracket in the governor of each engine must be adjusted to obtain the desired variation between the engine no-load and full-load speeds shown in Table 1.

Full Load	No-Load
50 cycles 1000 rpm	52.5 cycles 1050 rpm
60 cycles 1200 rpm	62.5 cycles 1250 rpm
50 cycles 1500 rpm	52.5 cycles 1575 rpm
60 cycles 1800 rpm	62.5 cycles 1875 rpm

TABLE 1

The recommended speed droop at full load for power generator sets operating in parallel is 50 rpm (2-1/2 cycles) at 1000 and 1200 rpm. For generator sets operating at 1500 and 1800 rpm, the speed droop should be 75 rpm (2-1/2 cycles). The speed droop may be varied to suit the particular application.

Adjust Maximum No-Load Speed

After the speed droop is properly adjusted, set the maximum no-load speed as follows:

1. Loosen the maximum speed adjusting screw locknut and back the adjusting screw out three turns.

2. With the engine operating at no-load, adjust the engine speed until the engine is operating at approximately 8% higher than the rated full-load speed.

3. Turn the maximum speed adjusting screw in lightly until contact is felt with the linkage in the governor (Fig. 5).

4. Hold the adjusting screw and tighten the locknut.

5. Install the governor cover.

Governors With Synchronizing Motor

Some hydraulic governors are equipped with a reversible electric synchronizing motor mounted on the governor cover.

The adjustments on a governor equipped with a synchronizing motor are the same as on a governor without the motor. However, the governor cover and motor assembly must be removed when setting the engine speed droop (except on a governor equipped with an external droop adjustment). The cover and motor must be reinstalled to check the speed droop.

HYDRAULIC WOODWARD PSG GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

Adjust engines with hydraulic governor assemblies after adjusting the exhaust valves and timing the fuel injectors as follows:

Adjust Fuel Rod

1. Remove the governor cover. Refer to Fig. 1 and loosen all of the injector rack control lever adjusting screws and locknuts. Be sure all of the control levers are free on the injector control tube.

2. Loosen the fuel rod locknut and remove the fuel rod knob.

3. Turn the locknut to a position so that 13/16" of the fuel rod extends beyond the nut. Install the fuel rod knob and tighten the locknut.

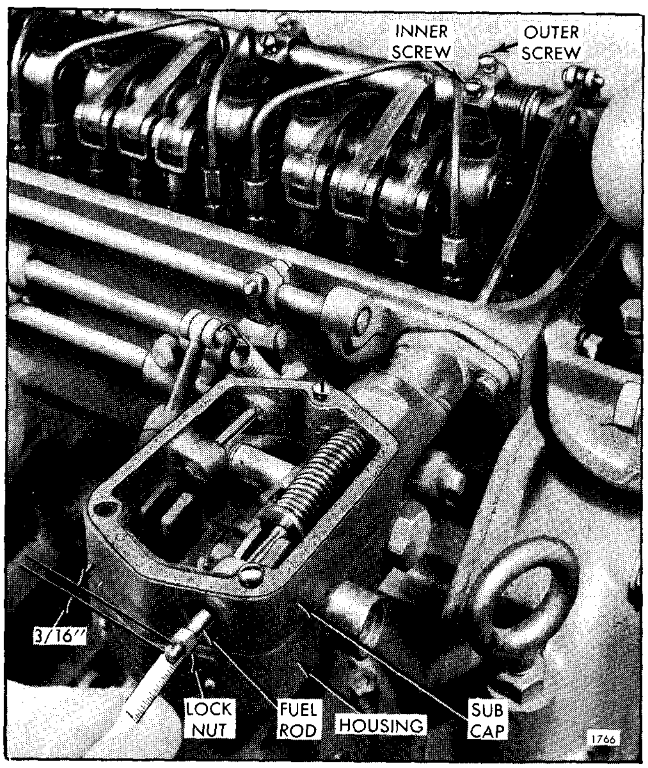


Fig. 1 - Adjusting Fuel Rod

Position Injector Rack Control Levers

With the fuel rod properly adjusted, the rack control levers may be adjusted as follows:

1. Adjust the No. 1 injector rack control lever by tightening the adjusting screw until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (Fig. 2). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 1 injector rack in the full-fuel position.

2. Pull out on the fuel rod and check for 1/32" to 1/16" movement.

If the movement exceeds the distance specified, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

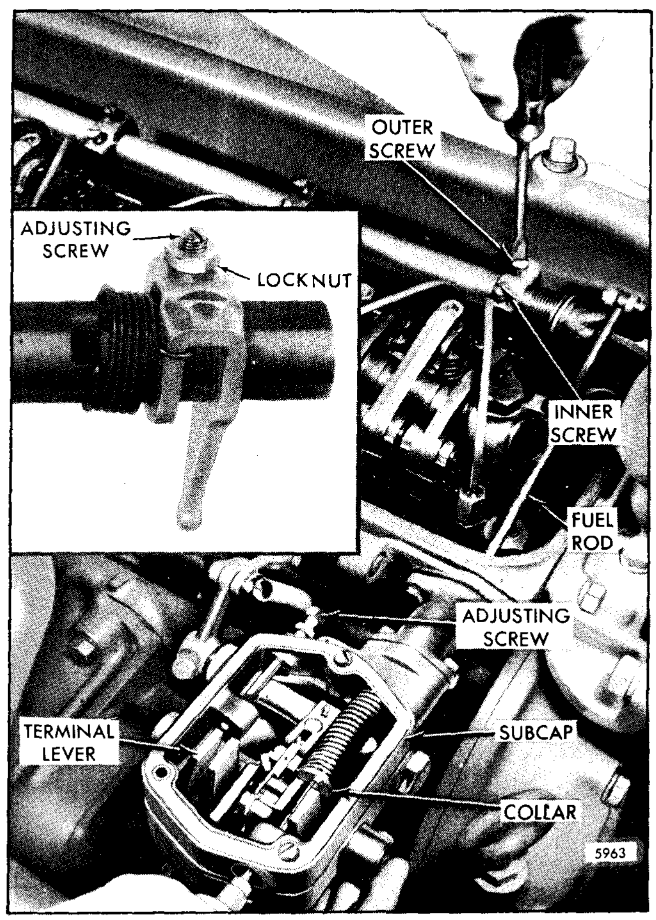


Fig. 2 - Positioning No. 1 Injector Rack

If the movement is less than the distance specified, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

3. Disconnect the fuel rod from the injector control tube lever.

4. Hold onto the clevis at the end of the injector control tube and position the No. 1 injector in the full-fuel position and tighten the adjusting screw of the No. 2 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

> **NOTE:** Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

5. Make sure the rack remains snug on the pin of the rack control lever at the No. 1 injector.

If the rack of the No. 1 injector has become loose, loosen the locknut and turn the adjusting screw on the No. 2 injector rack control lever clockwise a slight amount and retighten the locknut.

When the settings are correct, the rack of both injectors must be snug on the pin of their respective rack control levers.

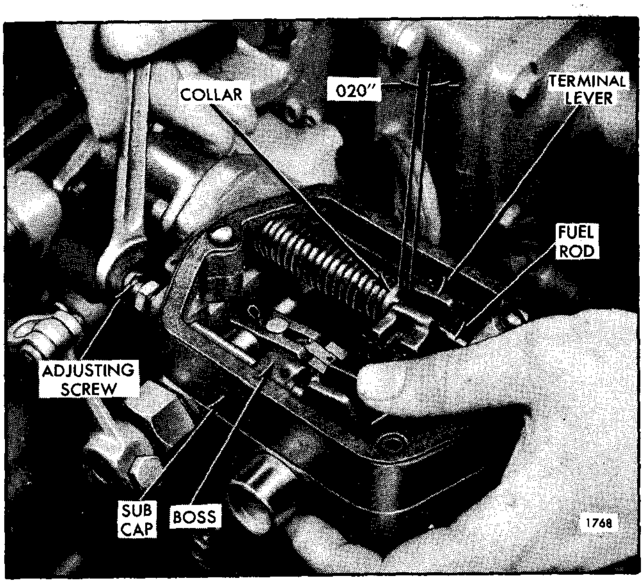


Fig. 3 - Setting Maximum Fuel Adjusting Screw (Load Limit)

6. Position the remaining rack control levers as outlined in Steps 4 and 5.

When the settings are correct, the racks of all injectors must be snug on the pins of the rack control levers when the control tube lever is held in the full-fuel position.

Adjust Load Limit

The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the load limit screw should be readjusted.

With the injector rack control levers properly adjusted, the load limit may be set as follows:

1. Place the fuel rod and the terminal lever in the full-fuel position as shown in Fig. 3.

2. Loosen the locknut and turn the adjusting screw until a .020" space exists between the fuel rod collar and the terminal lever. Hold the screw and tighten the locknut.

Compensation Adjustment

After the temperature of the engine and the oil supplied to the governor have reached their normal operating values, adjust the governor compensation without load on the engine as follows:

1. Open the compensating needle valve (Fig. 6) two or three turns with a screwdriver and allow the engine to "hunt" or "surge" for about one-half minute to bleed trapped air from the governor oil passages.

2. Gradually close the needle valve until "hunting" just stops. Do not go beyond this position. Check the amount of needle valve opening by closing the valve completely, noting the amount required to close. Open the valve to the previously determined opening at which "hunting" stopped. Test the action by manually disturbing the engine speed. The engine should return promptly to the original steady speed with only a small overshoot. The correct needle valve setting will be between 1/8 and 1/2 turn open.

It is desirable to have as little compensation as possible. Closing the needle valve farther than necessary will make the governor slow to return to normal speed after a load change.

Adjust Speed Droop

The purpose of adjusting the speed droop is to establish a definite engine speed at no load with a given speed at rated full load.

The governor droop is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs, the speed droop should be readjusted.

The best method of determining the engine speed is by the use of an accurate hand tachometer.

If a full rated load on the unit can be established, the fuel rod, injector control rack levers and load limit have been adjusted, the speed droop may be adjusted as follows:

1. Start the engine and run it at approximately one-half the rated no-load speed until the lubricating oil temperature stabilizes.

NOTE: When the engine lubricating oil is cold, the governor regulation may be erratic. The regulation should become increasingly stable as the temperature of the oil increases.

2. With the engine stopped, remove the governor cover.

3. Loosen the locknut and back off the maximum speed adjusting screw approximately 3/8" (Fig. 5).

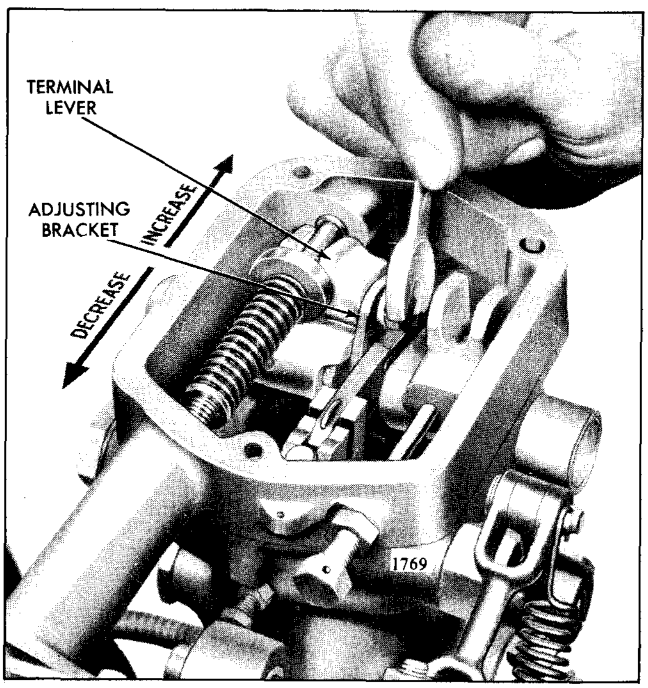


Fig. 4 - Adjusting Speed Droop

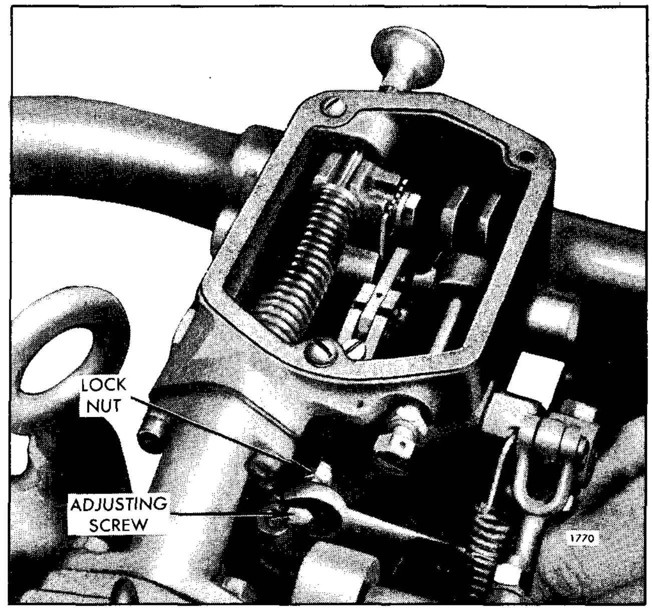


Fig. 5 - Setting Maximum Speed Adjusting Screw

4. Refer to Fig. 4 and loosen the droop adjusting bolt. Move the bracket so that the bolt is midway between the ends of the slot in the bracket. Tighten the bolt. Be sure the bracket remains on the shoulder of the terminal lever.

5. With the throttle in the *run* position, adjust the engine speed until the engine is operating at 3% to 5% above the recommended full-load speed.

6. Apply the full rated load on the engine and adjust the engine speed to the correct full-load speed.

7. Remove the rated load and note the engine speed after the speed stabilizes under no load. If the speed droop is correct, the engine speed will be approximately 3% to 5% higher than the full-load speed.

If the speed droop is too high, stop the engine and again loosen the bolt and move the droop adjusting bracket *in* toward the engine. Tighten the bolt. To increase the speed droop, move the droop adjusting bracket *out*, away from the engine.

The speed droop in governors which control engines

Full-Load	No-Load
50 cycles 1000 rpm	52.5 cycles 1050 rpm
60 cycles 1200 rpm	62.5 cycles 1250 rpm
50 cycles 1500 rpm	52.5 cycles 1575 rpm
60 cycles 1800 rpm	62.5 cycles 1875 rpm

TABLE 1

driving generators in parallel should be identical, otherwise the electrical load will not be equally divided.

Adjust the speed droop bracket in each engine governor to obtain the desired variation between the engine no-load and full-load speeds shown in Table 1.

The recommended speed droop of generator sets operating in parallel is 50 rpm (2 1/2 cycles) for units operating at 1000 and 1200 rpm and 75 rpm (2 1/2 cycles) for units operating at 1500 and 1800 rpm full load. This speed droop recommendation may be varied to suit the individual application.

A single engine unit equipped with an isochronous type hydraulic governor may operate at a constant frequency by setting the governor droop to zero. However, when operating generator sets in parallel, the governor of each unit must be set with an equal amount of droop for stable operation and proper division of the load.

If required, the zero droop setting may be carried out by performing Steps 1 through 7 as outlined, except adjust for zero droop instead of 3% to 5% as stated.

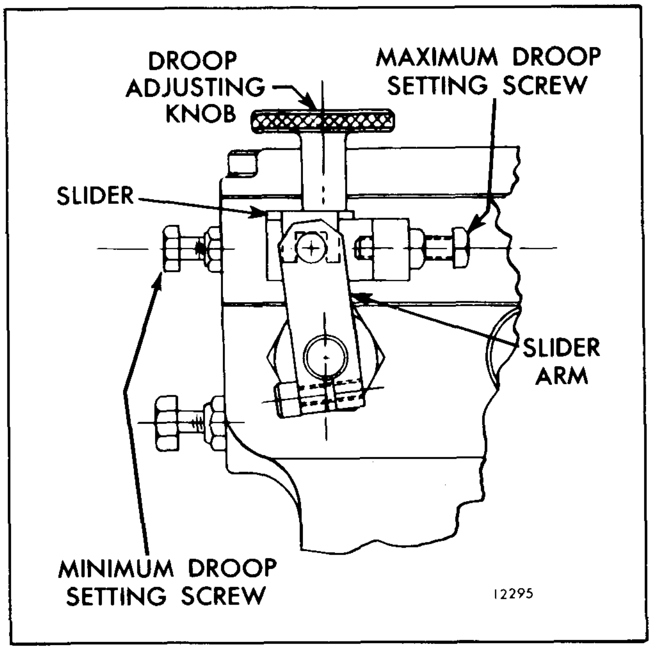


Fig. 6 - External Droop Control on PSG Isochronous Governor

Adjust Maximum No-Load Speed

With the speed droop properly adjusted, set the maximum no-load speed as follows:

1. Loosen the locknut and back out the maximum speed adjusting screw three turns.

2. With the engine operating at no-load, adjust the engine speed until the engine is operating at approximately 10% higher than the rated full-load speed.

3. Turn the maximum speed adjusting screw in lightly until contact is felt with the linkage in the governor (Fig. 5).

4. Hold the screw and tighten the locknut. Install the governor cover.

Governors With Synchronizing Motor

Some hydraulic governors are equipped with a reversible electric synchronizing motor mounted on the governor cover.

The adjustments on a governor equipped with a synchronizing motor are the same as on a governor without the motor. However, the governor cover and motor assembly must be removed when setting the engine speed droop (except on a governor equipped with an external droop adjustment). The cover and motor must be reinstalled to check the speed droop.

Governors with External Droop Control

Some PSG governors have an external adjustable droop control to enable droop adjustment without the removal of the governor cover. Units having a governor with this feature may be paralleled with another unit that is operating at constant frequency (zero droop). The incoming unit should have its droop bracket set in the maximum position while it is being paralleled and while operating in parallel. When it is desired to stop the unit operating at constant frequency, the load should be shifted to the incoming unit and its governor droop bracket moved to zero droop. The outgoing unit can then be adjusted to maximum droop, removed from the line and stopped. The incoming unit will now be carrying the load and operating at constant frequency (zero droop).

Adjustment of governor droop by the external adjustable droop control should be performed as follows:

1. Start the engine, and run it at approximately one-half the rated full-load speed until the lubricating oil temperature stabilizes.

2. Remove the load from the engine.

3. Back off the needle valve to release any air that may be trapped in the system. Turn the needle valve in slowly to reduce governor hunting. The correct needle valve setting will be between 1/8 and 1/2 turn open.

4. Back out the minimum and maximum droop setting screws.

5. Loosen the droop adjusting knob (Fig. 6) and move the slider all the way in toward the engine and then tighten the knob.

6. Loosen the locknut on the maximum speed adjusting screw and turn the screw out until 5/8" of the threads are exposed.

7. With the engine operating at the recommended full-load speed, apply the full rated load and recheck the engine speed. If required, readjust the engine to full-load speed by means of the synchronizing motor.

8. Remove the load and note the engine speed. If the zero droop setting is correct, the engine speed will remain constant. If the engine speed is higher, loosen the droop adjusting knob and set the slider to a reduced droop position.

9. When the desired minimum droop setting is reached, loosen the locknut and turn the minimum droop setting screw inward until it contacts the droop linkage within the governor. This will be felt by a step-up of resistance while turning the adjusting screw. Lock the adjusting screw.

10. Loosen the droop adjusting knob and slide the droop bracket in a direction to increase the droop. Perform Steps 7 and 8 to check the droop until the desired maximum droop is attained.

11. When the desired maximum droop setting is reached, loosen the locknut and turn the maximum droop setting screw inward until it contacts the droop slider arm. Lock the adjusting screw.

12. Recheck the minumum and maximum droop setting as outlined in Steps 7 and 8 and adjust the adjustment screws, if necessary, until the correct settings are attained.

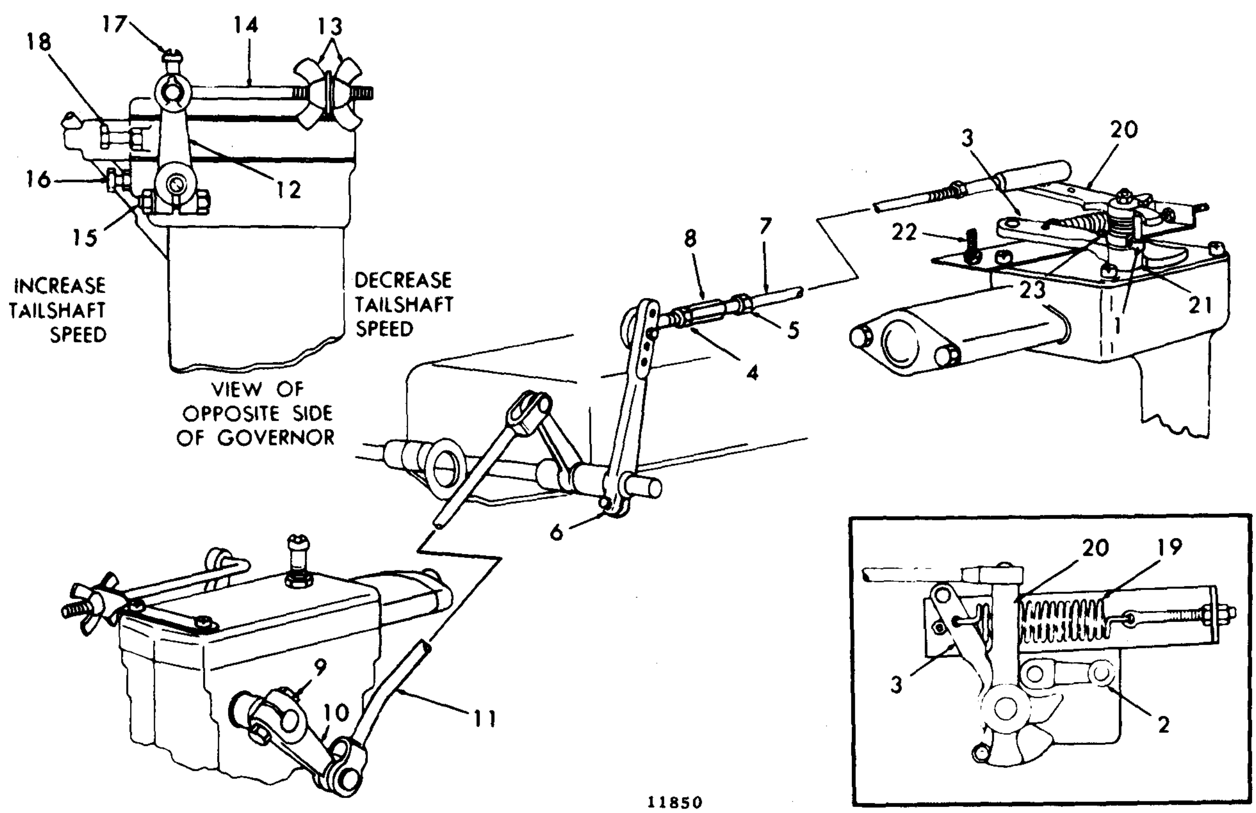
13. Adjust the maximum no-load speed.

HYDRAULIC OUTPUT SHAFT GOVERNOR AND LINKAGE ADJUSTMENT

A hydraulic governor is used to maintain a near constant output shaft speed on engines equipped with a Series 500 or larger Torqmatic converter. The governor is mounted on the converter and gear driven from the output shaft.

The output shaft governor is connected to the engine governor by control rods and levers (Figs.1 and 2). The control rod end ball joints are sealed assemblies and do not require lubrication. However, the throttle control shaft bearings should be lubricated periodically with all purpose grease through the grease fittings. Other moving parts of the control linkage should be lubricated with engine oil.

In most applications, such as drag line and shovel operation, it is desirable to have the output shaft governor control the fuel input to maintain a relatively constant output shaft speed. The output shaft speed will be constant up to full power of the engine, except for the amount of governor droop. The speed setting of the engine governor must be sufficiently higher than the speed setting of the output shaft governor so the engine governor will not reduce the fuel input to the engine before full power is required by the output



1 Lever--Throttle Control
2 Lever--ShutDown
3 Lever--Governor Operating
4 Lock Nut--Turnbuckle
5 Lock Nut--Turnbuckle
6 Lever--Throttle Control Rear Cross-Shaft
7 Rod--Engine Governor
8 Turnbuckle
9 Bolt
10 Lever--Output Shaft Governor Control
11 Rod--Output Shaft Governor
12 Lever--Speed Control
13 Wing Nuts--Speed Adjusting
14 Link--Sliding
15 Bolt
16 Screw--Maximum Speed Limit Adjusting
17 Screw--Minimum Speed Limit Adjusting
18 Screw--Maximum Fuel Adjusting
19 Spring--Governor Lever Return
20 Lever--Output Shaft Governor
21 Pin--Stop
22 Bolt--Stop
23 Spring--Torsion

FIG. 1 - Hydraulic Output Shaft Governor and Linkage (Type A)

shaft governor. As load is applied to the output shaft, the output shaft speed will decrease gradually up to the amount of the output shaft governor droop at full load. At the same time, the engine speed will gradually increase until full load is reached.

In some types of operation, such as laying of structural steel, it is desirable to operate the unit with a very low output shaft speed. This speed could be so low that the output shaft governor ball head assembly would not actuate the governor pilot valve and spring seat assembly. In such applications, the engine governor operating lever (6), Fig. 1, or the remote throttle control lever (1), Fig. 2, used as an overrule lever, can be moved toward the idle speed position sufficiently to provide the desired low output shaft speed. Output shaft speeds down to zero can be obtained through this type of engine governor control. The engine governor would maintain control unless the output shaft speed increased to the speed setting of the output shaft governor.

Two types of governor control linkages are in use. The adjustment procedure for each type is outlined in the following paragraphs.

Adjustments (Type A - Fig. 1)

The engine governor throttle control lever (Fig. 1) is pinned to the throttle shaft. The engine governor operating lever is mounted below the throttle control lever and rides on the throttle shaft boss on the governor cover. The output shaft governor lever is mounted above the throttle control lever and is retained on the shaft by a snap ring. A stop pin, pressed into the throttle control lever, transmits movement of the output shaft governor lever and/or engine governor operating lever through the throttle control lever to the injector racks. The torsion spring, used to retain the throttle control lever stop pin against the output shaft governor lever, yields to permit the governor operating lever to move the throttle control lever toward the idle position, regardless of the position of the output shaft governor control lever. A slot in the underside of the governor cover hub limits the travel of the throttle control lever in both the maximum and minimum speed positions.

The engine shutdown lever is connected through a shaft to another lever, under the governor cover, which bears against the pin in the differential lever. To stop the engine, the shutdown lever is used to move the differential lever to the no-fuel position.

The following linkage and governor adjustments should be made with the engine stopped, after the limiting speed engine governor has been adjusted as outlined in **Hydraulic Governor** section under *Position Injector Rack Control Levers.*

1. Connect the linkage to the governor operating lever and check the total travel of the lever (Fig. 1). The lever should move to the stop bolt in one direction and the governor lever return spring should move the lever, in the other direction, until the throttle control lever reaches the end of its travel.

2. Move the governor operating lever to the maximum speed position (against the stop bolt).

3. Move the output shaft governor control lever to the full-fuel position and retain it by moving the speed control lever to the maximum speed position. Then move the output shaft governor lever (on the engine governor cover) and the throttle control lever together to the maximum speed position and retain them there.

> **NOTE:** This operation closes the low speed gap (in the engine governor) which may require more torque than is available from the torsion spring between the two levers. Thus, it is important that they be held together, permitting no space between the throttle control lever pin and the arm of the output shaft governor lever.

4. To adjust the linkage between the output shaft governor and the engine governor, loosen the output shaft governor rod clamping bolt in the ball joint in the rear cross-shaft lever. Next, move the output shaft governor rod until there is approximately .020" clearance between the stop pin and the output shaft governor lever. Then tighten the clamping bolt securely.

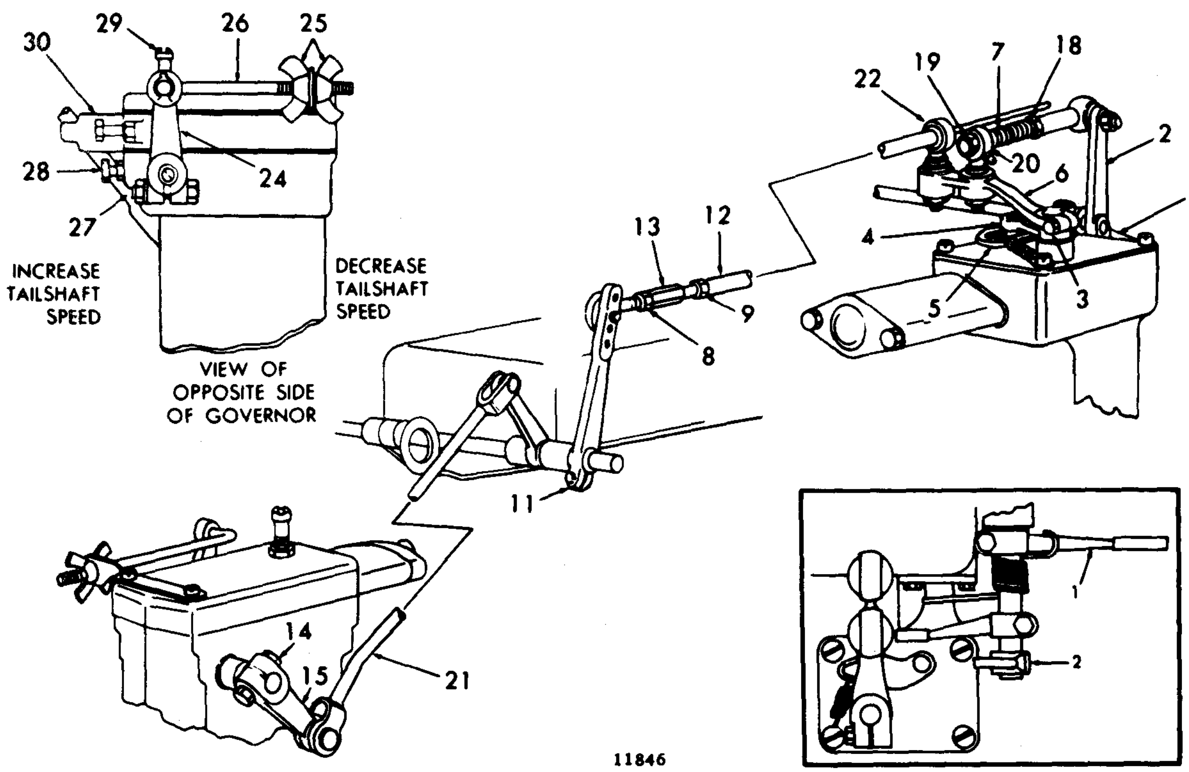
> **NOTE:** The engine governor control rod is connected to the outer bolt hole in the output shaft governor lever.

5. To adjust the governor operating lever return spring, retain the output shaft governor control lever in the full-fuel position and increase the tension on the spring by adjusting the eyebolt and lock nuts until the tension of the torsion spring is overcome and the throttle control lever is moved against the stop in the idle position.

Final Adjustments

Move the output shaft governor lever in the idle speed position and start the engine.

After the engine reaches normal operating temperature, advance the output shaft governor speed control lever to the maximum speed position and check the



1 Lever--Remote Throttle Control
2 Lever--Governor Throttle Control
3 Bolt
4 Lever--Governor Stop
5 Cam--Governor
6 Lever--Governor Speed Control
7 Spring--Repulsing
8 Lock Nut--Turnbuckle
9 Lock Nut--Turnbuckle
11 Lever--Throttle Control Rear Cross-Shaft
12 Rod--Throttle
13 Turnbuckle
14 Bolt
15 Lever--Output Shaft Governor Control
18 Lock Nut
19 Bolt--Spring
20 Bearing--Rod End
21 Rod--Throttle
22 Bearing--Rod End
24 Lever--Speed Control
25 Wing Nuts--Speed Adjusting
26 Link--Sliding
27 Bolt
28 Screw--Maximum Speed Limit Adjusting
29 Screw--Minimum Speed Limit Adjusting
30 Screw--Maximum Fuel Adjusting

Fig. 2 - Hydraulic Output Shaft Governor and Linkage (Type B)

Torqmatic converter output shaft speed. This speed will vary depending upon engine application.

If it is necessary to adjust the output shaft speed, loosen the wing nuts on the sliding link and move the speed control lever to increase or decrease the speed as needed.

The output shaft governor is driven through the converter and there is a high droop. Therefore, the no-load speed setting should be at least 150 rpm higher than the desired full-load speed setting. Tighten the wing nuts after completing the adjustment.

NOTE: Do not set the Torqmatic converter output shaft speed in excess of the speed specified by the equipment manufacturer, to prevent damage to the driven machinery.

It will be noted during engine operation that the minimum droop will vary between 150 and 175 rpm. If the droop requires adjustment, move the droop bracket (inside the output shaft governor) to decrease or increase the amount of droop.

NOTE: To compensate for the output shaft speed droop, the engine no-load speed must be set approximately 175 rpm above the required engine full-load speed.

Move the output shaft governor speed control lever to the idle speed position and adjust the idle speed by means of the minimum speed limit adjusting screw.

The maximum fuel adjusting screw and the maximum speed limit adjusting screw are not used and should be backed out to prevent interference.

Adjustments (Type B - Fig. 2)

The following linkage and governor adjustments should be made with the engine stopped and after the limiting speed engine governor has been adjusted as outlined under *Limiting Speed Mechanical Governor and Injector Rack Control Adjustment.*

1. Place the remote throttle control lever (1) in the maximum speed position (Fig. 2).

2. Move the governor speed control lever (6) and governor stop lever (4) into the "idle" notch in the governor cam (5). The repulsing spring (7) should be fully compressed when the stop lever reaches the "idle" notch of the governor cam.

If the repulsing spring is not fully compressed, loosen the bolt (3) in the governor speed control lever and move the lever until the spring is compressed.

If the repulsing spring becomes fully compressed before the governor stop lever reaches the "idle" notch in the governor cam, loosen the bolt (3) in the governor speed control lever and manually move the stop lever into the "idle" notch.

3. Hold the governor stop lever (4) halfway between the idle and maximum speed positions and loosen the lock nuts (8) and (9). Adjust the turnbuckle (13) so the rear cross-shaft lever (11) is vertical.

4. Loosen the bolt (14) and remove the output shaft governor control lever (15). Place the governor stop lever (4) into the idle position by moving the rear cross-shaft lever (11) and reinstall the output shaft governor control lever.

> **NOTE:** Move the rear cross-shaft lever (11) into the maximum speed position and check to see that there is no binding between the clevis on the end of the throttle rod (21) and the output shaft governor control lever (15).

5. Move the governor stop lever (4) into the maximum speed position in the governor cam (5) and check to see that there is 1/32" to 1/16" clearance between the rod end bearing (20) and the hex head of the spring bolt (19). If the clearance is not correct, loosen the lock nut and adjust the spring bolt.

6. Manually hold the governor stop [illegible] position. Loosen the lock nuts [illegible] the turnbuckle (13) until the shoulder on the throttle rod (12) just contacts the rod end bearing (22) and holds the stop lever in the idle position.

Final Adjustments

Place the remote throttle control lever (1) in the "mid-position", then start the engine. After the engine reaches normal operating temperature, place the remote throttle control lever in the maximum speed position and check the Torqmatic converter output shaft speed. This speed will vary depending upon engine application requirements.

If it is necessary to adjust the output shaft speed, loosen the wing nuts on the sliding link as needed and move the speed control lever to increase or decrease the speed.

The Torqmatic converter hydraulic output shaft governor is driven through the torque converter and there is a high droop. Therefore, the no-load setting should be at least 150 rpm higher than the desired full-load setting. Tighten the wing nuts after completing the adjustment.

> **NOTE:** Do not set the output shaft speed in excess of the speed specified by the equipment manufacturer, to prevent damage to the driven machinery.

During engine operation, it will be noted that the minimum droop will vary between 150 and 175 rpm. If the droop requires adjustment, move the droop bracket (inside the hydraulic output shaft governor) to decrease or increase the amount of droop.

> **NOTE:** To compensate for the output shaft speed droop, the engine no-load speed must be set approximately 175 rpm above the required engine full-load speed.

In the application of a hydraulic governor, the maximum fuel adjusting screw (30) and the maximum speed limit adjusting screw (28) are not used and therefore should be backed out to prevent any interference.

DUAL HYDRAULIC WOODWARD SGT GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

A dual hydraulic governor assembly is used with certain torque converter applications. This governor consists of two sets of flyweights and pilot valve assemblies that are interconnected to operate a single servo piston. One set of flyweights is driven by the engine. The other set is driven through a flexible shaft by the output shaft. The governor assembly used on a particular engine may have either single (Fig. 1) or dual (Fig. 3) speed control levers.

The single-lever type governor control lever is attached to the output shaft governor speed adjustment shaft (Fig. 1). The engine governor and the output shaft governor speed adjusting shaft arms are linked together by a "slip-joint" link (Fig. 2).

On the single lever type governor, the control lever has two distinct arcs of travel. In the first arc of travel (used to obtain the desired engine speed), the control lever moves the engine governor speed adjusting shaft arm to a point between the engine idle and maximum speed positions. In the second arc of travel (used to set the desired output shaft speed, the pin located at the lower end of the output shaft governor speed adjusting shaft arm "picks-up" the output shaft governor floating lever assembly. The movement of the governor control lever in the second arc of travel is opposed by the "slip-joint" linkage spring.

The dual lever type governor assembly has one of the two control levers attached to the engine governor speed adjusting shaft, used to control the engine governor. The other control lever is attached to the output shaft governor speed adjusting shaft, need to control the output shaft governor.

The path of oil within both types of governor assemblies is from the pump through the engine

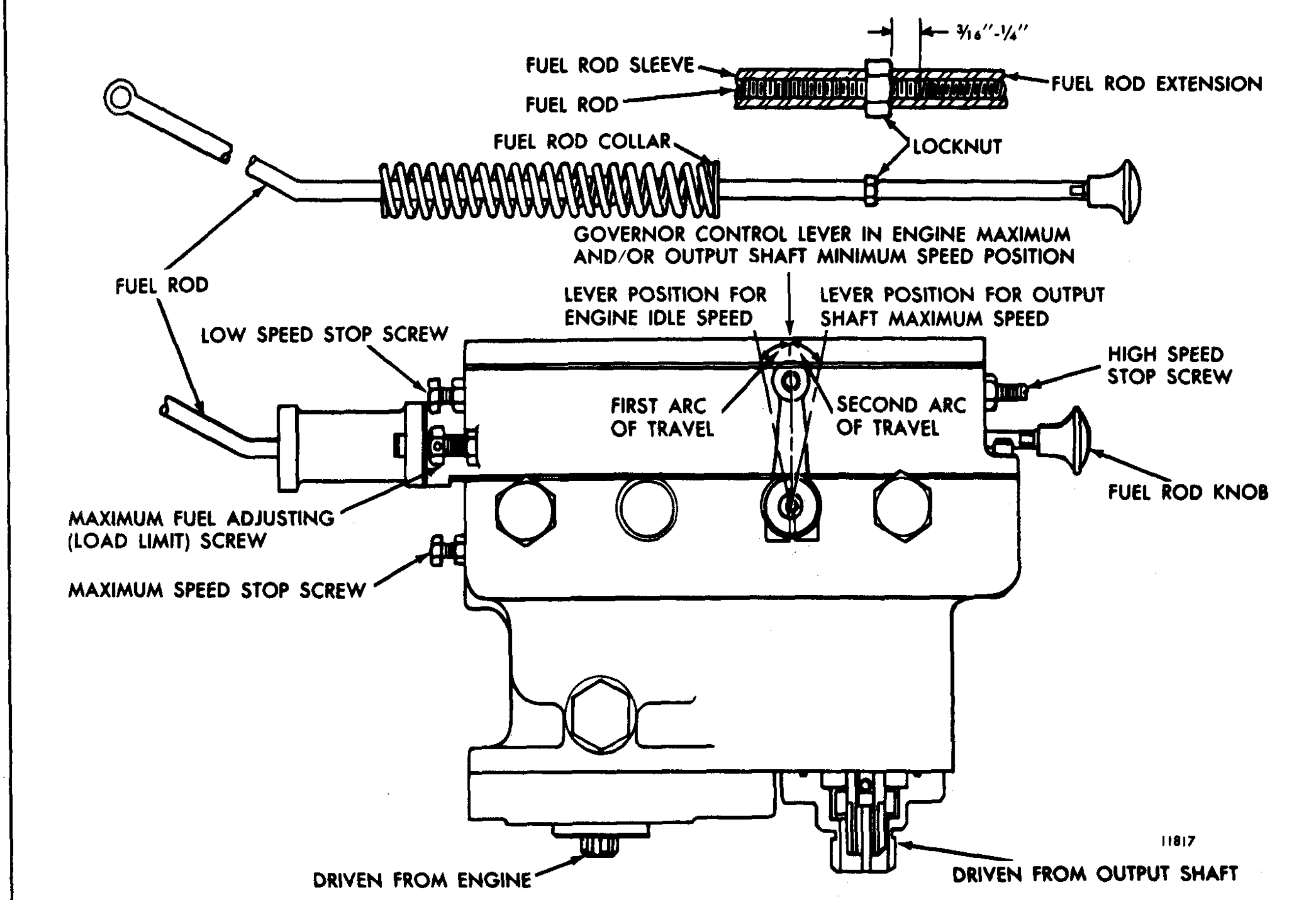


Fig. 1 - Single Lever Dual Hydraulic Governor

governor pilot valve to the output shaft governor pilot valve, then to a single common servo piston. The servo piston operates a terminal lever which in turn controls the position of the fuel rod connected to the injector racks.

The engine governor no-load speed setting must be equal to the lo-load output shaft speed setting plus the amount of engine speed increase over output shaft speed plus the engine governor droop.

To stop the engine, pull outward (away from the engine) on the fuel rod knob.

Adjustments

Make the follwoing linkage and governor adjustments with the engine stopped. Before adjusting the governor, be sure that adjustment is necessary. The injector racks, injector control tube and remote throttle control linkage should be checked for freedom of movement, excess play or binding. Adjustments should be made only after the engine has reached normal operating temperature.

Fuel Rod Adjustment (Engine Stopped)

Figs. 2 and 4 give the nomenclature of the parts in their approximate location and relation of each other. The following adjustments are made with the rocker valve cover off.

1. Loosen the adjusting screws and locknuts in all of the injector rack control levers so that all of the levers move freely.

2. Remove the governor cover.

3. Loosen the fuel rod locknut and unscrew the shutdown knob and rod extension (insert of Figs. 1 and 3).

4. Turn the locknut so that 3/16" to 1/4" of the fuel rod extends beyond the nut.

5. Replace the fuel rod extension and knob and tighten the extension against the locknut.

Position Injector Rack Control Levers (Engine Stopped)

After the fuel rod is properly adjusted, adjust the injector rack control levers as follows:

1. Adjust the No. 1 injector rack control lever by tightening the adjusting screw until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 1 injector rack in the full-fuel position.

2. Pull the fuel rod out and check for 1/16" movement.

If the movement exceeds the distance specified, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

If the movement is less than the distance specified, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

3. Remove the clevis pin and disconnect the fuel rod from the injector control tube lever.

4. Holding on to the clevis at the end of the injector control tube, position the No. 1 injector in the full-fuel position and screw the adjusting screw of the No. 2 injector down until the rack tightens on the pin of the rack control lever. This may be felt at the clevis end by a slight movement as contact is made.

5. Recheck the No. 1 injector rack to make sure that it has remained snug on the ball end of the injector rack control lever while adjusting the No. 2 injector rack. If the rack of the No. 1 injector has become loose, turn the adjusting screw on the No. 2 injector rack control lever clockwise a slight amount. Tighten the locknut.

When the settings are correct, the racks of both injectors must be snug on the ball end of their respective rack control levers.

Position the remaining injector rack control levers as outlined in Steps 4 and 5.

6. Connect the fuel rod to the injector control tube lever and replace the clevis pin; the clevis pin must rotate freely. Replace the valve rocker cover.

Adjust Load Limit

The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the load limit screw should be adjusted.

With the injector rack control levers properly adjusted, the load limit may be set as follows:

1. Place the fuel rod and the terminal lever in the full-fuel position (some improvised method may be

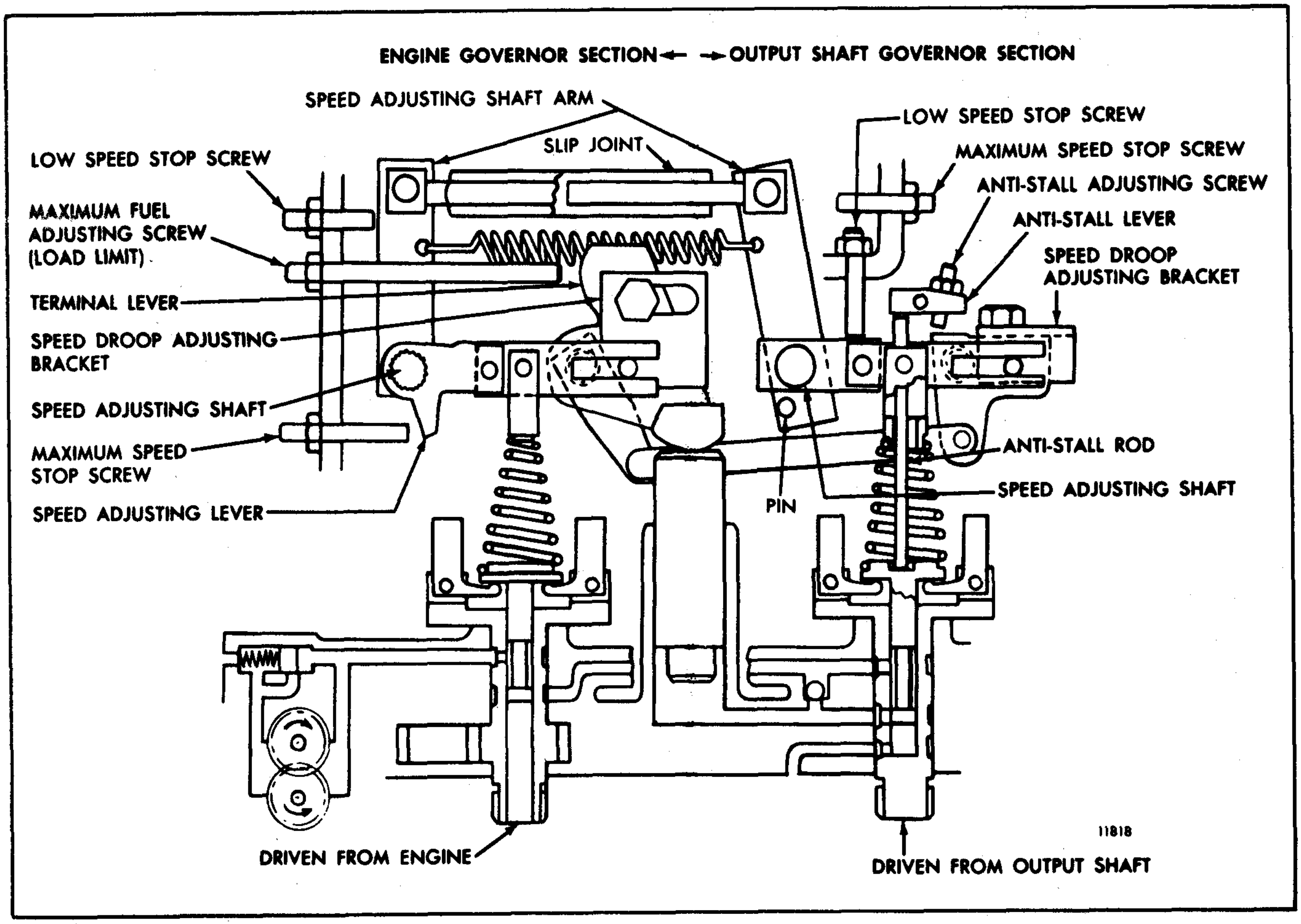


Fig. 2 - Schematic Diagram of Single Lever Dual Governor

employed to hold the fuel rod in the full-fuel position).

2. Loosen the locknut on the load limit adjusting screw. Turn the adjusting screw until a .020" gap exists between the terminal lever and the fuel rod collar.

3. Release the fuel rod and tighten the locknut. Clearance must not exceed .020" to obtain full-fuel position off the injector racks.

Adjust Engine Governor (Engine Stopped)

1. Loosen the locknut and back out the output shaft governor maximum speed stop screw until it extends approximately 1" from the face of the locknut when the nut is tight against the housing (Fig. 2).

2. Back out the output shaft governor anti-stall adjusting screw until it projects 1/2" above the anti-stall lever.

3. Loosen the output shaft governor low speed stop screw locknut and turn the screw until it projects 5/16" above the upper face of the locknut when the nut is tight against the governor body.

The weights of the output shaft governor ballhead assembly should be fully collapsed. This ensures control of the engine by the engine governor since tension on the output shaft governor speeder spring will hold the output shaft governor pilot valve plunger in an open position, thus permitting the oil passing through the engine governor pilot valve to actuate the servo piston.

4. Disconnect the output shaft governor flexible drive shaft at the governor.

5. Position the engine governor droop adjusting bracket so the adjusting screw is an equal distance from either end of the slot.

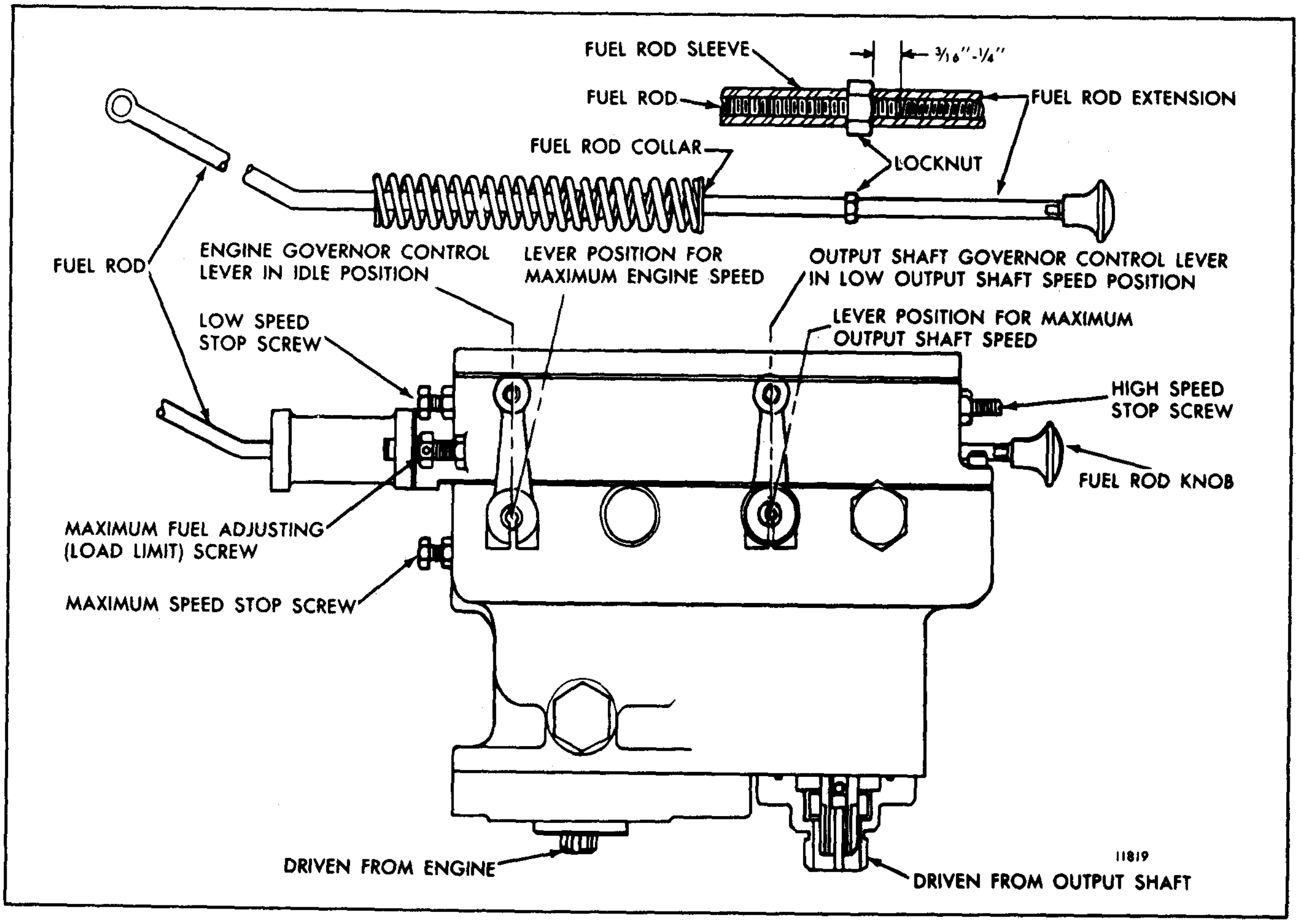


Fig. 3 - Two Lever Dual Hydraulic Governor

Adjust Engine Governor (Engine Running)

1. Start and warm up the engine.

2. Loosen the locnut on the engine governor maximum speed stop screw and back out the screw until it projects 5/8" from the face of the locknut when the nut is tight against the governor body (Figs. 1 and 2).

3. Position the engine governor control lever, using the remote throttle control, so the engine is running at the specified maximum no-load speed shown on the engine name plate. Then turn the maximum speed stop screw in until it contacts the speed adjusting lever. Tighten the locknut.

4. Loosen the locknut on the engine governor low speed stop screw and turn the screw until it projects 3/4" from the governor body when the nut is tight against the governor body.

5. Position the engine governor speed control lever, using the remote throttle control, so the engine is running at the specified no-load idle speed. Then turn the low speed stop screw until it contacts the governor speed adjusting shaft arm. Tighten the locknut.

NOTE: The idle speed should be 500 rpm or more.

6. Adjust the governor speed droop bracket, if necessary, to obtain the minimum droop to stabilize the engine. A decreasing engine speed as load is picked up and an increasing speed as load is dropped off is called the droop. Insufficient droop will cause "hunting" or "surging" and will result in an unstable engine. It must be remembered, however, that a stable engine may surge three or four times before stabilizing. Moving the droop bracket toward the engine decreases and away from the engine increases the amount of droop. Stop the engine.

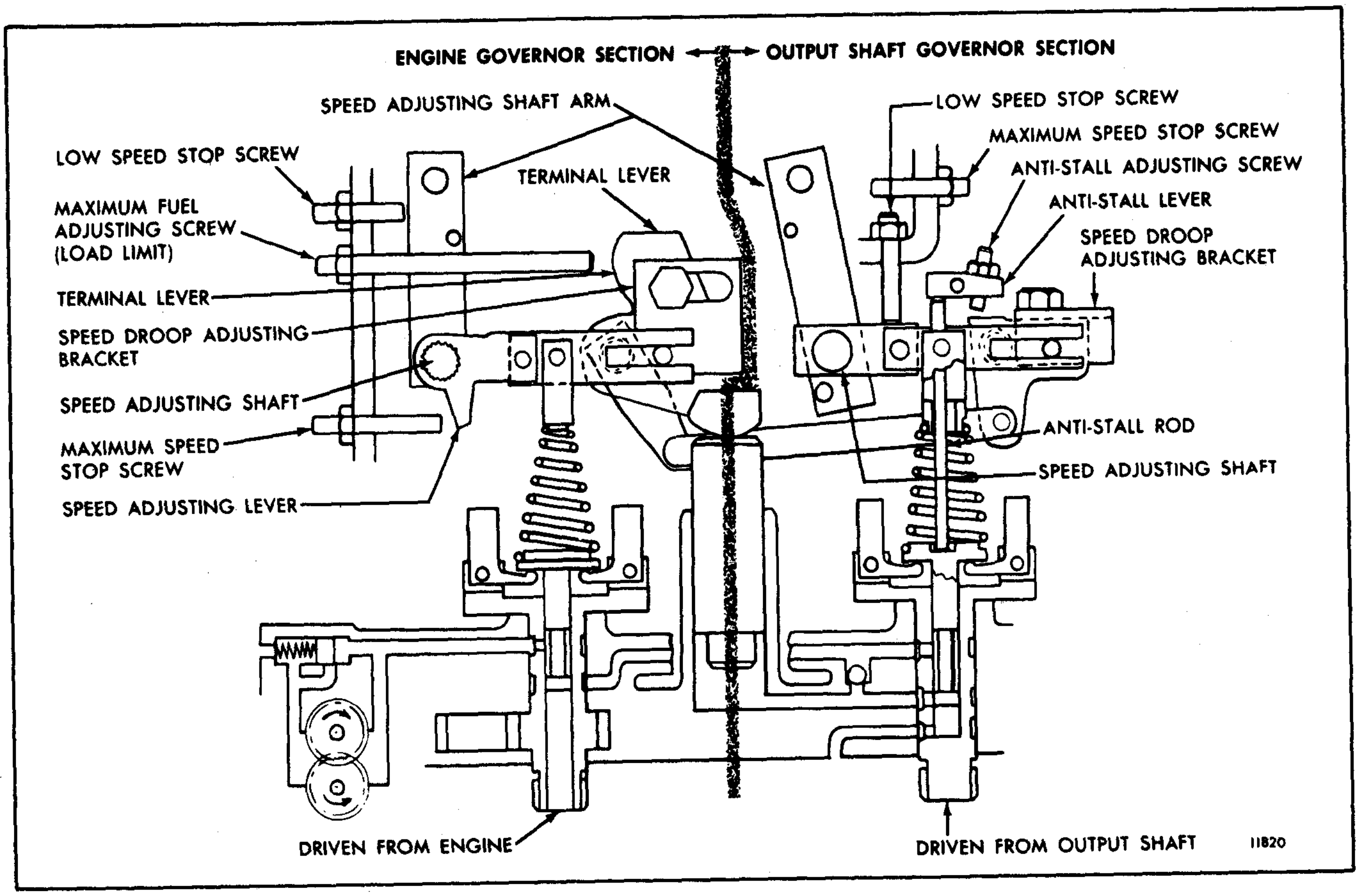


Fig. 4 - Schematic Diagram of Two Lever Dual Governor

Adjust Output Shaft Governor (Engine Running)

1. Connect the flexible drive shaft to the output shaft governor. Start the engine and make sure the ball head assembly of the output shaft governor is turning.

2. Adjust the output shaft governor speed droop bracket, if necessary, to stabilize the engine. Moving the bracket toward the engine decreases the droop and moving the bracket away from engine increases the amount of droop.

3. On single lever type governor assemblies, position the governor control lever, using the remote throttle control, in the output shaft minimum speed position.

On dual lever type governor assemblies, position the output shaft governor control lever, using the remote throttle control, in the low output shaft speed position (Fig. 3).

Dual governor assemblies with the "single" control lever incorporating the "slip-joint" linkage may have the linkage adjusted to provide a "lag" or "dwell" between the throttle position at which the no-load maximum engine speed is reached and the throttle position at which the output shaft speed begins to increase (as the governor control lever is moved toward the output shaft maximum speed position). This "lag" is usually governed by the type of application (or provided for the convenience of the operator) and permits movement of the control lever toward full output shaft position, for a short distance, without a corresponding change in output shaft speed. The "slip-joint" may be lengthened or shortened by loosening the locknut and turning the turnbuckle until the desired adjustment is made. Lengthening the linkage will decrease and shortening the linkage will increase the "lag".

4. On single lever type governor assemblies, position the governor control lever, using the remote throttle control, so that the output shaft is running at the maximum speed desired (usually shown on one of the unit name plates); then run in the output shaft governor maximum speed stop screw until it contacts the output shaft governor speed adjusting shaft arm. Tighten the locknut.

On dual lever type governor assemblies, position the output shaft governor control lever, using the remote throttle control, so that the output shaft is running at the maximum speed desired (usually shown on one of the unit name plates). Then turn in the output shaft governor maximum speed stop screw until it contacts the output shaft governor speed adjusting shaft arm. Tighten the locknut.

5. Loosen the output shaft governor low speed stop screw locknut and back out the screw until the desired minimum output shaft no-load speed is obtained. Tighten the locknut.

6. On single lever type governor assemblies, position the governor control lever, using the remote throttle control, in the minimum speed position. Then turn in the anti-stall screw (Fig. 2) until the anti-stall lever just contacts the anti-stall rod. This can be checked by lightly pressing the outer end of the anti-stall lever (side opposite screw) with a screwdriver. The screw will be adjusted correctly when a slight increase in output shaft speed is noted when the lever is depressed slightly with a screwdriver.

On dual lever type governor assemblies, position the output shaft governor control lever, using the remote throttle control, in the minimum speed position. Then turn in the anti-stall screw until the anti-stall lever just contacts the anti-stall rod. This can be checked by lightly pressing the outer end of the anti-stall lever (side opposite screw) with a screwdriver. The screw will be adjusted correctly when a slight increase in output shaft speed is noted when the lever is depressed slightly with a screwdriver.

7. Replace the governor cover.

STORAGE

PREPARING ENGINE FOR STORAGE

When an engine is to be stored or removed from operation for a period of time, special precautions should be taken to protect the interior and exterior of the engine, transmission and other parts from rust accumulation and corrosion. The parts requiring attention and the recommended preparations are given below.

It will be necessary to remove all rust or corrosion completely from any exposed part before applying a rust preventive compound. Therefore, it is recommended that the engine be processed for storage as soon as possible after removal from operation.

The engine should be stored in a building which is dry and can be heated during the winter months. Moisture absorbing chemicals are available commercially for use when excessive dampness prevails in the storage area.

TEMPORARY STORAGE (30 days or less)

To protect an engine for 30 days or less, proceed as follows:

1. Drain the engine crankcase.

2. Fill the crankcase to the proper level with the recommended viscosity and grade of oil.

3. Fill the fuel tank with the recommended grade of fuel oil. Operate the engine for two minutes at 1200 rpm and no load.

> **NOTE:** Do not drain the fuel system or the crankcase after this run.

4. Check the air cleaner and service it, if necessary, as outlined under *Air System* - Section 2.

5. If freezing weather is expected during the storage period, add an ethylene glycol base antifreeze solution in accordance with the manufacturer's recommendations. Drain the raw water system and leave the drain cocks open.

> **NOTE:** If an antifreeze solution is not to be used during this storage period, the coolant system should be flushed with a good rust inhibitor to prevent rusting of the outside diameter of the cylinder liners (refer to *Engine Coolant* - Section 5).

6. Clean the outside of the engine (except the electrical system) with fuel oil and dry it with compressed air.

7. Seal all of the engine openings. The material used for this purpose must be waterproof, vaporproof and possess sufficient physical strength to resist puncture and damage from the expansion of entrapped air.

8. Store the engine in a building which is dry and can be heated during the winter months. Moisture-absorbing chemicals are available commercially for use when excessive dampness prevails in the storage area.

An engine prepared in this manner can be returned to service in a short time by removing the seals at the engine openings, checking the engine coolant, fuel oil, lubricating oil, transmission and priming the raw water pump, if used.

EXTENDED STORAGE (more than 30 days)

To prepare an engine for extended storage, (more than 30 days), follow this procedure:

1. Drain the cooling system and flush with clean, soft water. Refill with clean, soft water and add a rust inhibitor to the cooling system (refer to *Corrosion Inhibitor* under *Engine Coolant*).

2. Remove, check and recondition the injectors, if necessary, to make sure they will be ready to operate when the engine is restored to service.

3. Reinstall the injectors, time them and adjust the exhaust valve clearance.

4. Circulate the coolant by operating the engine until normal operating temperature (160-185°F or 71-85°C) is reached.

5. Stop the engine.

6. Drain the engine crankcase, then reinstall and

tighten the drain plug. Install new lubricating oil filter elements and gaskets.

7. Fill the crankcase to the proper level with a 30 weight preservative lubricating oil MIL-L-21260B, Grade 2.

8. Drain the fuel tank. Refill with enough clean fuel oil to permit the engine to operate for about ten minutes.

9. Drain and disassemble the fuel filter and strainer. Discard the used elements and gaskets. Wash the shells in clean fuel oil and insert new elements. Fill the cavity between the element and shell about two-thirds full of fuel oil and reinstall on the engine. If spin-on fuel filters and strainers are used, discard the used cartridges, fill the new ones two-thirds full of fuel oil and reinstall on the engine.

10. Operate the engine for five minutes to circulate the clean fuel oil throughout the engine.

11. Refer to *Air System* and service the air cleaner.

12. MARINE GEAR

a. Drain the oil completely and refill with clean oil of the recommended grade and viscosity. Remove and clean or replace the strainer and filter elements.

b. Start and run the engine at 600 rpm for 10 minutes to coat all of the internal parts of the marine gear with clean oil. Engage the clutches alternately to circulate clean oil through all of the moving parts.

NOTE: The performance of this step is not necessary on torque converter units.

13. TORQMATIC CONVERTER

a. Start and operate the engine until the temperature of the converter oil reaches 150 °F (66 °C).

b. Stop the engine, remove the converter drain plug and drain the converter.

c. Remove the filter element.

d. Start the engine and stall the converter for **twenty seconds** at 1000 rpm to scavenge the oil from the converter. *Due to lack of lubrication, do not exceed the 20 second limit.*

e. Install the drain plug and a new filter element.

f. Fill the converter to the proper operating level with a commercial preservative oil which meets specification MIL-L-21260B, Grade 2. Oil of this type is available from the major oil companies.

g. Start the engine and operate the converter for at least 10 minutes at a minimum of 1000 rpm. Engage the clutch, then stall the converter to raise the oil temperature to 225 °F (107 °C).

NOTE: Do not allow the oil temperature to exceed 225 °F (107 °C). If the unit does not have a temperature gage, *do not stall the converter for more than thirty seconds.*

h. Stop the engine and allow the converter to cool to a temperature suitable to the touch.

i. Seal the breather and all of the exposed openings with moisture proof tape.

j. Coat all exposed, unpainted surfaces with preservative grease. Position all of the controls for minimum exposure and coat them with grease. The external shafts, flanges and seals should also be coated with grease.

14. POWER TAKEOFF

a. Use an all purpose grease such as Shell Alvania No. 2, or equivalent, and lubricate the clutch throwout bearing, clutch pilot bearing, drive shaft main bearing, clutch release shaft and the outboard bearings (if so equipped).

b. Remove the inspection hole cover on the clutch housing and lubricate the clutch release lever and link pins with a hand oiler. *Avoid getting oil on the clutch facing.*

c. If the unit is equipped with a reduction gear, drain the gear box and flush with light engine oil. If the unit is equipped with a filter, clean the shell and replace the filter element. Refill the gear box to the proper level with the grade of oil indicated on the name plate.

15. TURBOCHARGER

Since turbocharger bearings are pressure lubricated through the external oil line leading from the engine cylinder block while the engine is operating, no further attention is required. However, the turbocharger air inlet and turbine outlet connections should be sealed off with moisture resistant tape.

16. Apply a *non-friction* rust preventive compound to all exposed parts. If convenient, apply the rust preventive compound to the engine flywheel. If not, disengage the clutch mechanism to prevent the clutch disc from sticking to the flywheel.

NOTE: Do not apply oil, grease or any wax base compound to the flywheel. The cast iron will absorb these substances which can "sweat" out during operation and cause the clutch to slip.

17. Drain the engine cooling system.

18. Drain the preservative oil from the engine crankcase. Reinstall and tighten the drain plug.

19. Remove and clean the battery and battery cables with a baking soda-water solution and rinse with fresh water. Do not allow the soda solution to enter the battery. Add distilled water to the electrolyte, if necessary, and fully charge the battery. Store the battery in a cool (never below 32 °F or 0 °C) dry place. Keep the battery fully charged and check the level and the specific gravity of the electrolyte regularly.

20. Insert heavy paper strips between the pulleys and belts to prevent sticking.

21. Seal all engine openings, including the exhaust outlet, with moisture resistant tape. Use cardboard, plywood or metal covers where practical.

22. Clean and dry the exterior painted surfaces of the engine and spray with a suitable liquid automobile body wax, a synthetic resin varnish or a rust preventive compound.

23. Protect the engine with a good weather-resistant tarpaulin and store it under cover, preferably in a dry building which can be heated during the winter months.

Detroit Diesel Allison does not recommend the outdoor storage of engines (or transmission). Nevertheless, DDA recognizes that in some cases outdoor storage may be unavoidable. If units must be kept out-off-doors, follow the preparation and storage instructions already given. Protect units with quality, weather-resistant tarpaulins (or other suitable covers) arranged to provide air circulation.

NOTE: *Do not use plastic sheeting for outdoor storage.* Plastic is fine for indoor storage. When used outdoors, however, enough moisture can condense on the inside of the plastic to rust ferrous metal surfaces and pit aluminum surfaces. If a unit is stored outside for any extended period of time, severe corrosion damage can result.

The stored engine should be inspected periodically. If there are any indications of rust or corrosion, corrective steps must be taken to prevent damage to the engine parts. Perform a complete inspection at the end of one year and apply additional treatment as required.

PROCEDURE FOR RESTORING AN ENGINE TO SERVICE WHICH HAS BEEN IN EXTENDED STORAGE

1. Remove the covers and tape from all of the openings of the engine, fuel tank and electrical equipment. *Do not overlook the exhaust outlet.*

2. Wash the exterior of the engine with fuel oil to remove the rust preventive.

3. Remove the rust preventive from the flywheel.

4. Remove the paper strips from between the pulleys and the belts.

5. Remove the drain plug and drain the preservative oil from the crankcase. Reinstall the drain plug. Then refer to *Lubrication System* in the *Operating Instructions* and fill the crankcase to the proper level with the recommended grade of lubricating oil.

6. Fill the fuel tank with the fuel specified under *Fuel Specifications.*

7. Close all of the drain cocks and fill the engine cooling system with clean soft water and a rust inhibitor. If the engine is to be exposed to freezing temperatures, fill the cooling system with a solution of water and ethylene glycol base antifreeze (refer to *Engine Coolant*).

8. Install and connect the battery.

9. Service the air cleaner as outlined under *Air System.*

10. POWER GENERATOR

Prepare the generator for starting as outlined under *Operating Instructions.*

11. MARINE GEAR

Check the Marine gear; refill it to the proper level, as necessary, with the correct grade of lubricating oil.

12. TORQMATIC CONVERTER

a. Remove the tape from the breather and all of the openings.

b. Remove all of the preservative grease with a suitable solvent.

c. Start the engine and operate the unit until the temperature reaches 150°F (66°C). Drain the preservative oil and remove the filter. Start the engine and stall the converter for twenty seconds at 1000 rpm to scavenge the oil from the converter.

NOTE: A Torqmatic converter containing preservative oil should only be operated enough to bring the oil temperature up to 150°F (66°C).

d. Install the drain plug and a new filter element.

e. Refill the converter with the oil that is recommended under *Lubrication and Preventive Maintenance.*

13. POWER TAKE-OFF

Remove the inspection hole cover and inspect the clutch release lever and link pins and the bearing ends of the clutch release shaft. Apply engine oil sparingly, if necessary, to these areas.

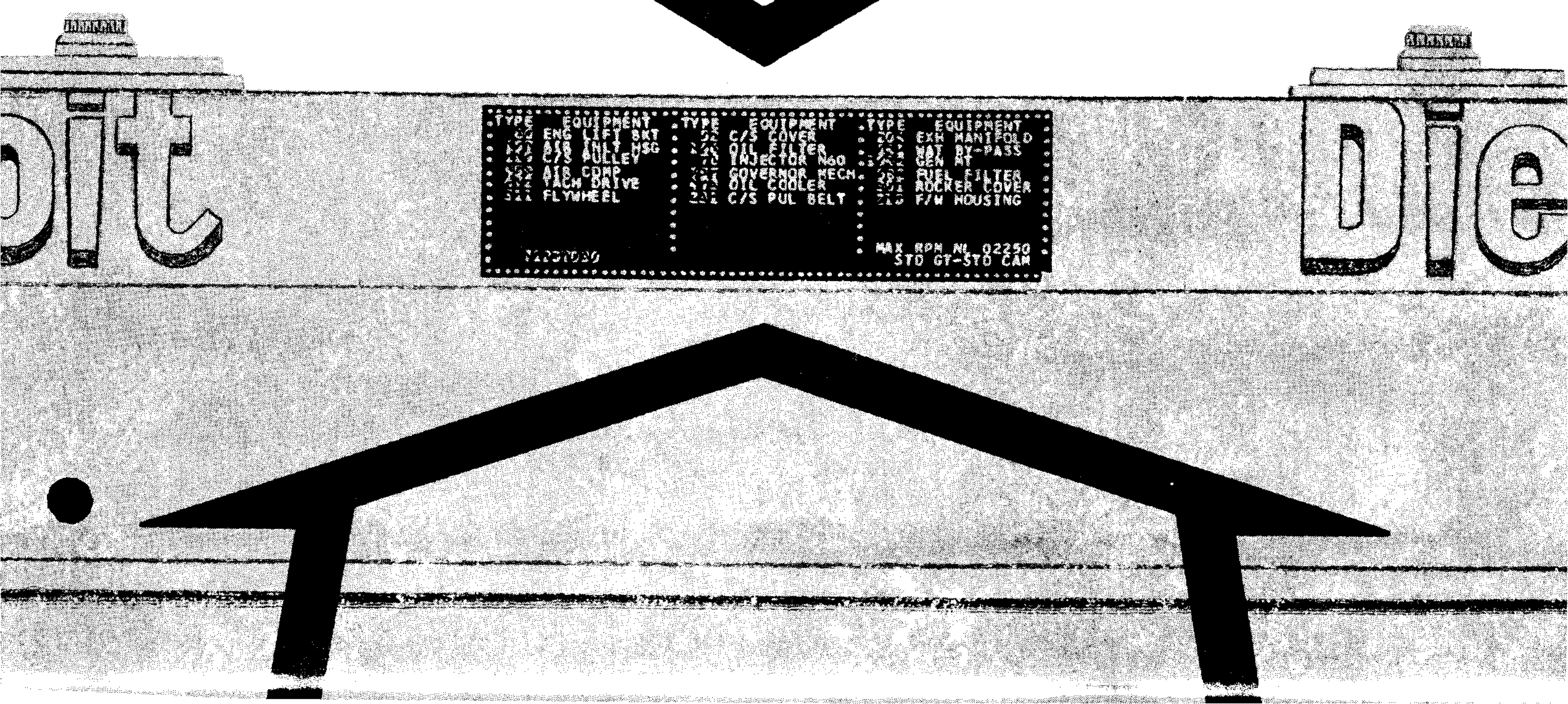
14. TURBOCHARGER

Remove the covers from the turbocharger air inlet and turbine outlet connections. Refer to the lubricating procedure outlined in *Preparation for Starting Engine First Time* under *Operating Instructions.*

15. After all of the preparations have been completed, start the engine.

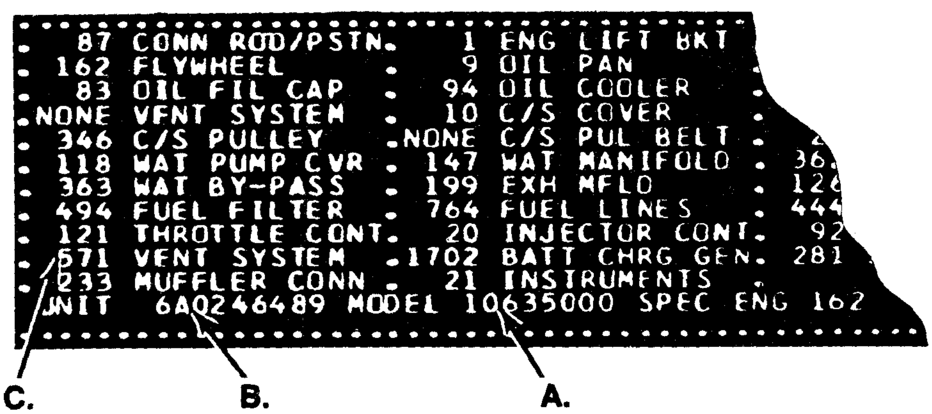
NOTE: Before subjecting the engine to a load or high speed, it is advisable to check the engine tune-up.

BUILT-IN PARTS BOOK for DETROIT DIESEL ENGINES



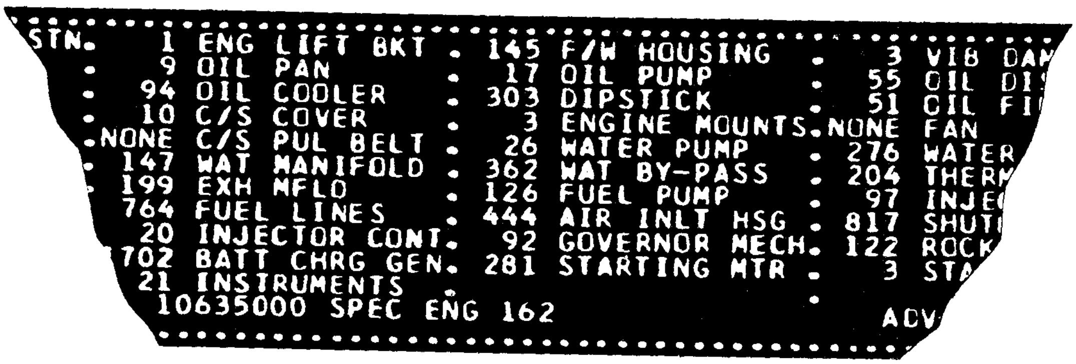
Progress in industry comes at a rapid pace. In order for the engine manufacturer to keep pace with progress he needs a versatile product for the many models and arrangements of accessories and mounting parts needed to suit a variety of equipment. In addition, engine refinements and improvements are constantly being introduced. All of this dynamic action must be documented so that the equipment can be serviced if and when it's needed. It is fully documented in the manufacturer's plant and in dealer Parts Departments with Master Files and adequate supporting records. But, what about YOU the user of this equipment? You have neither the time nor the inclination to ferret out specific part number data. What is the answer? – It is Detroit Diesel's exclusive BUILT-IN PARTS BOOK which is furnished with each engine. It takes the form of an "Option Plate" mounted on the rocker cover of the engine. With it, ordering parts becomes as simple as A, B, C. You have merely to provide the Dealer with . . .

A. The "Model" number **B.** The "UNIT" number **C.** The "TYPE" number



From that much information, the dealer with his complete records on all engine models, can completely interpret your parts requirements.

What is this "built-in" book? It is a photo etched aluminum option plate that fits into a holding channel on the engine rocker cover.



SHOWN IN COLUMNS, the type numbers and equipment descriptions represent specific groups of functionally related parts installed on the engine as optional equipment. The components making up these groups are found in the parts catalog microfiche under the "type" number of the appropriate equipment category.

The engine unit and model numbers appear at the bottom of the plate, as shown on the preceding page, along with the governed maximum rpm, no-load setting, and engine timing.

All engine components are divided into groups of functionally related parts. A complete listing of the twelve major groups and their many subgroups is shown below.

GROUP NOMENCLATURE

1.0000 ENGINE (less major assemblies)
- 1.1000 Cylinder Block
- 1.1000A Air Box Drains
- 1.2000 Cylinder Head
- 1.2000A Engine Lifter Bracket
- 1.3000 Crankshaft
- 1.3000A Crankshaft Front Cover
- 1.3000B Vibration Damper
- 1.3000C Crankshaft Pulley
- 1.3000D Crankshaft Pulley Belt
- 1.4000A Flywheel
- 1.5000A Flywheel Housing
- 1.5000B Flywheel Housing Adaptor
- 1.6000 Connecting Rod and Piston
- 1.7000 Camshaft and Gear Train
- 1.7000A Balance Weight Cover
- 1.7000B Accessory Drive
- 1.8000 Valve and Injector Operating Mechanism
- 1.8000A Rocker Cover

2.0000 FUEL SYSTEM
- 2.1000A Fuel Injector
- 2.2000 Fuel Pump
- 2.2000A Fuel Pump Drain
- 2.3000A Fuel Filter
- 2.4000 Fuel Manifold and/or Connections
- 2.5000A Fuel Lines
- 2.6000A Fuel Tank
- 2.7000A Mechanical Governor
- 2.8000A Hydraulic Governor
- 2.9000 Injector Controls
- 2.9000A Throttle Controls

3.0000 AIR SYSTEM
- 3.1000A Air Cleaner and/or Adaptor
- 3.2000A Air Silencer
- 3.3000A Air Inlet Housing
- 3.4000 Blower
- 3.4000A Blower Drive Shaft
- 3.5000A Turbocharger

4.0000 LUBRICATING SYSTEM
- 4.1000A Oil Pump
- 4.1000B Oil Distribution System
- 4.1000C Oil Pressure Regulator
- 4.2000A Oil Filter
- 4.3000A Oil Filter Lines
- 4.4000A Oil Cooler
- 4.5000A Oil Filler
- 4.6000A Dipstick
- 4.7000A Oil Pan
- 4.8000A Ventilating System

5.0000 COOLING SYSTEM
- 5.1000 Fresh Water Pump
- 5.1000A Fresh Water Pump Cover
- 5.2000A Water Outlet Manifold and/or Elbow
- 5.2000B Thermostat
- 5.2000C Water By-pass Tube
- 5.3000A Radiator
- 5.3000B Water Connections
- 5.4000A Fan
- 5.4000B Fan Shroud
- 5.5000A Heat Exchanger or Keel Cooling
- 5.6000A Raw Water Pump
- 5.7000A Water Filter

6.0000 EXHAUST SYSTEM
- 6.1000A Exhaust Manifold
- 6.2000A Exhaust Muffler and/or Connections

7.0000 ELECTRICAL-INSTRUMENTS
- 7.1000A Battery Charging Generator
- 7.2000B Automatic Starting
- 7.3000A Starting Motor
- 7.4000A Instruments
- 7.4000B Tachometer Drive
- 7.4000C Shut-off or Alarm System
- 7.5000A Power Generator
- 7.6000A Control Cabinet
- 7.7000A Wiring Harness
- 7.8000A Air Heater

8.0000 POWER TAKE-OFF
- 8.1000A Power Take-off and/or Clutch
- 8.3000A Torque Converter
- 8.3000B Transmission Lines

9.0000 TRANSMISSION AND PROPULSION
- 9.1000A Hydraulic Marine Gear
- 9.3000A Power Transfer Gear
- 9.4000 Transmission-Highway
- 9.7000 Transmission-Off-highway

10.0000 SHEET METAL
- 10.1000A Engine Hood

11.0000 ENGINE MOUNTING
- 11.1000A Engine Mounting and Base

12.0000 MISCELLANEOUS
- 12.2000A Bilge Pump
- 12.3000A Vacuum Pump
- 12.4000A Air Compressor
- 12.5000A Hydraulic Pump
- 12.6000A Gasoline Starter
- 12.6000B Air Starter
- 12.6000C Cold Weather Starting Aid
- 12.6000D Hydraulic Starter
- 12.6000E Hydraulic Starter Accessories

Within each of these sub-groups, various designs of similar equipment are categorized as "Types" and identified by a Type Number.

The Distributor/Dealer has an Index for each engine model. The Index lists all of the "Standard" and "Standard Option" equipment for that model.

DETROIT DIESEL 71 MPC 1064-7000 (RD)

STANDARD AND STANDARD OPTION EQUIPMENT

GROUP NAME	GROUP NO.	TYPE
CYLINDER BLOCK	1.1000	4
AIR BOX DRAINS	1.1000A	1
CYLINDER HEAD	1.2000	17
ENGINE LIFTER BRACKET	1.2000A	2
CRANKSHAFT	1.3000	4
CRANKSHAFT FRONT COVER	1.3000A	2
VIBRATION DAMPER REFER TO OPTION PLATE	1.3000B	NONE
CRANKSHAFT PULLEY	1.3000C	177
CRANKSHAFT PULLEY BELT	1.3000D	245
FLYWHEEL	1.4000A	170
FLYWHEEL HOUSING (SAE #1)	1.5000A	23
CONNECTING ROD AND PISTON	1.6000	101
CAMSHAFT AND GEAR TRAIN	1.7000	18
BALANCE WEIGHT COVER	1.7000A	25
VALVE OPERATING MECHANISM	1.8000	21
ROCKER COVER	1.8000A	122
FUEL INJECTOR N60	2.1000A	78
FUEL PUMP	2.2000	76
FUEL PUMP DRAIN	2.2000A	2
FUEL FILTER	2.3000A	273
FUEL MANIFOLD CONNECTIONS	2.4000	52

NOTE The Distributor/Dealer uses his model index to interpret the standard equipment. The plate, therefore, lists only the non-standard or choice items.

So, from the plate, give the dealer the

A—Model No. ____________
B—Unit No. ____________
***C—Type No.** ____________

*(If not shown, indicate "NONE". The dealer knows the "standard" for the model).

FOP READY REFERENCE, Transfer the information on the Option Plate to this record.

MODEL NO.__________ **UNIT NO.**__________

EQUIPMENT	TYPE	EQUIPMENT	TYPE	EQUIPMENT	TYPE
Engine Base		Water Bypass Tube		Battery Chrg. Generator	
Engine Lifter Brkt.		Thermostat		Starter	
Flywheel Housing		Water Filter		Hyd. Starter Acces.	
Vibration Damper		Exhaust Manifold		Starting Aid	
Flywheel		Air Cleaner or Silencer		Marine Gear	
Flywheel Hsg. Adptr.		Fuel Pump		Torque Converter	
Oil Pan		Injector		Torque Converter Lines	
Oil Pump		Blower		Muffler & Conn.	
Oil Distribution		Blower Drive Shaft		Engine Hood	
Dipstick		Fuel Filter		Wiring Harness	
Oil Pan Drain Tube		Fuel Lines		Instruments	
Oil Filler Tube or Cap		Air Inlet Housing		Tach. Drive	
Oil Cooler		Alarm or Shutoff		Radiator	
Oil Filter		Overspeed Governor		Heat Ex. or Keel Cooling	
Oil Lines		Throttle Controls		Raw Water Pump	
Ventilating System		Injector Controls		Power Generator	
Crankshaft Cover		Governor Mech or Hyd		Control Cabinet	
Balance Wgt. Cover		Engine Mounts		Cylinder Head	
Fan		Power Take-off		Conn Rod & Piston	
Crankshaft Pulley		Hydraulic Pump		Valve Mechanism	
Crankshaft Pulley Belt		Air Compressor		Fuel Manifold Conn	
Fan Shroud		Camshaft & Gear Train			
Water Connections		Rocker Cover			
Water Pump Cover		Accessory Drive			
Water Manifold					

OTHER USEFUL INFORMATION:

Each fuel and lube oil filter on your engine has a decal giving the service package part number for the element. It is advisable to have your own personal record of these part numbers by filling in the chart provided below:

TYPE	LOCATION	PACKAGE PART NO.
Fuel Strainer		
Fuel Filter		
Lube Oil Filter Full-Flo		
Lube Oil Filter By-Pass*		

*Not Standard

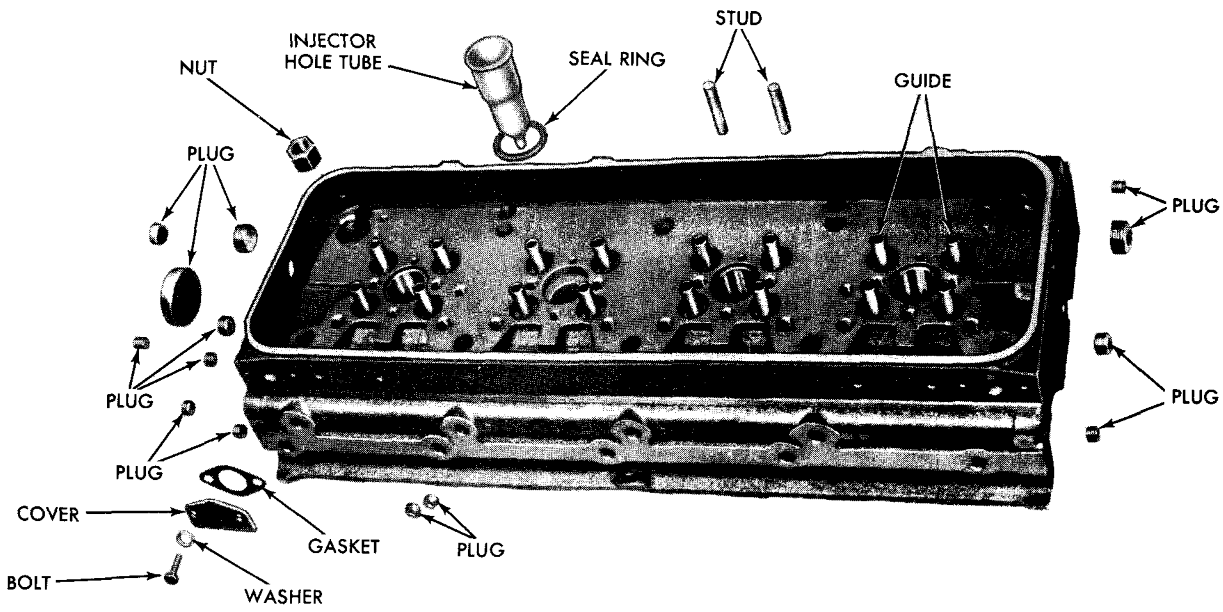
AIR CLEANER

If dry-type, indicate make and number of filter element:

____

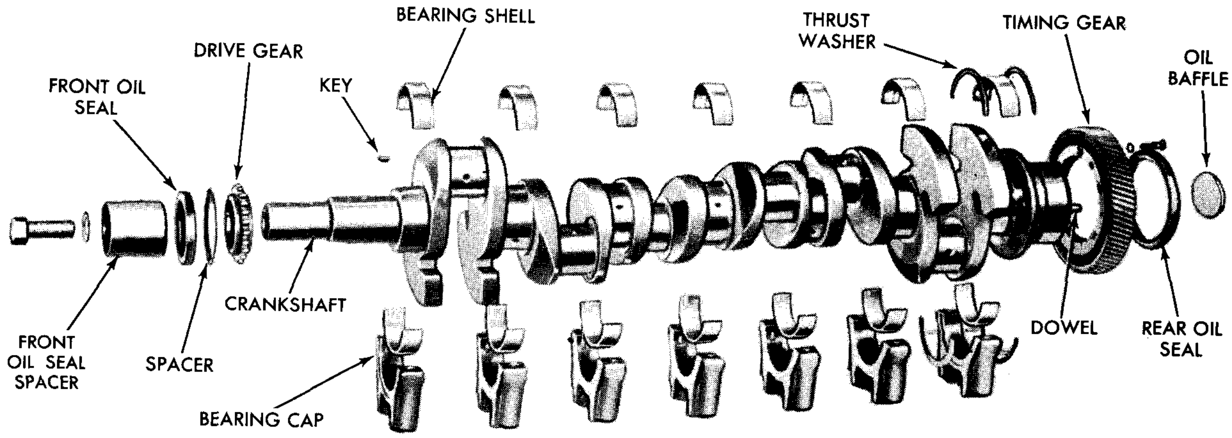
____

Wet type, indicate capacity__________qts.



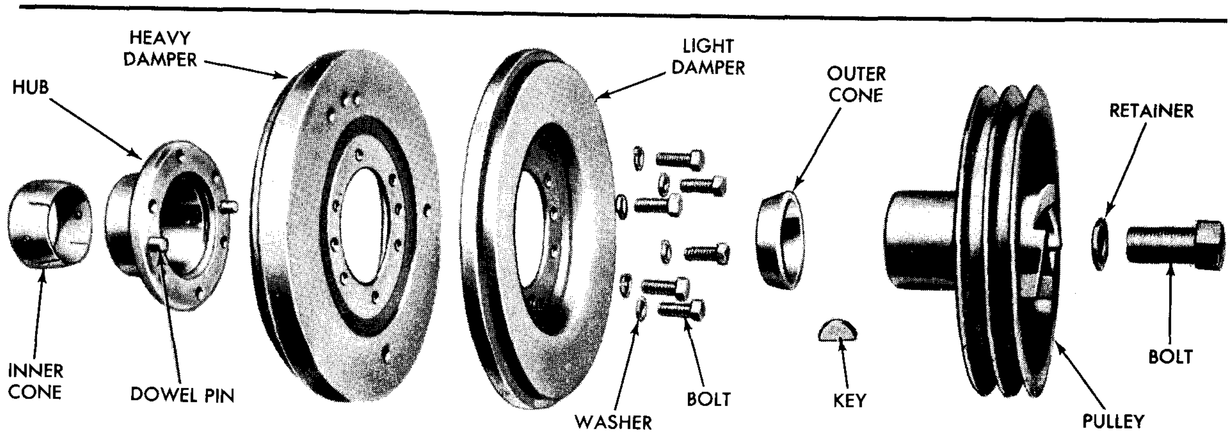
4 VALVE CYLINDER HEAD

P 614B



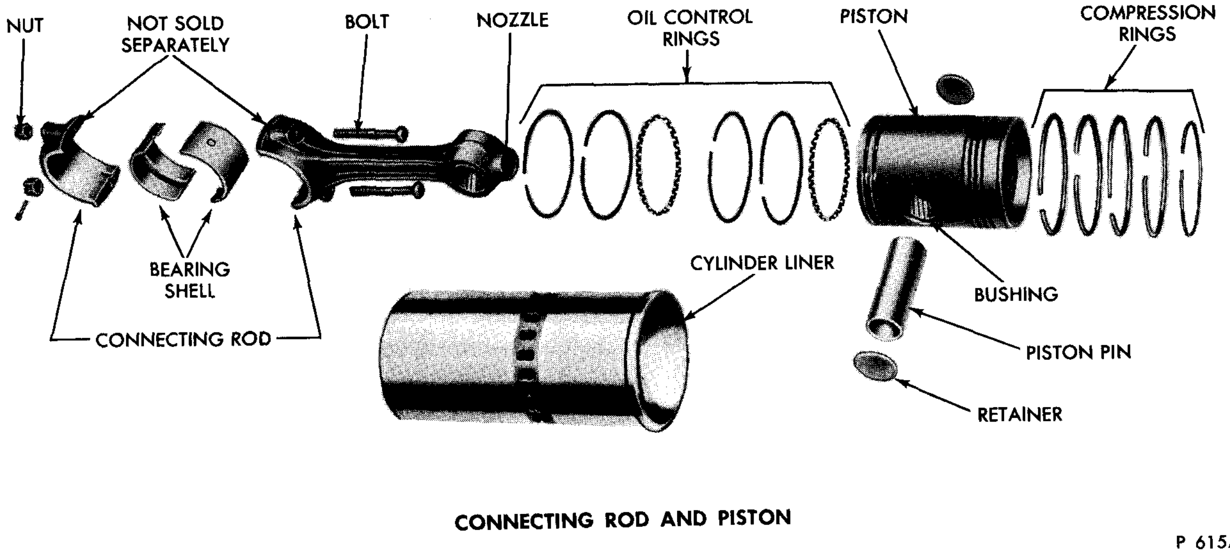
CRANKSHAFT

P 614A

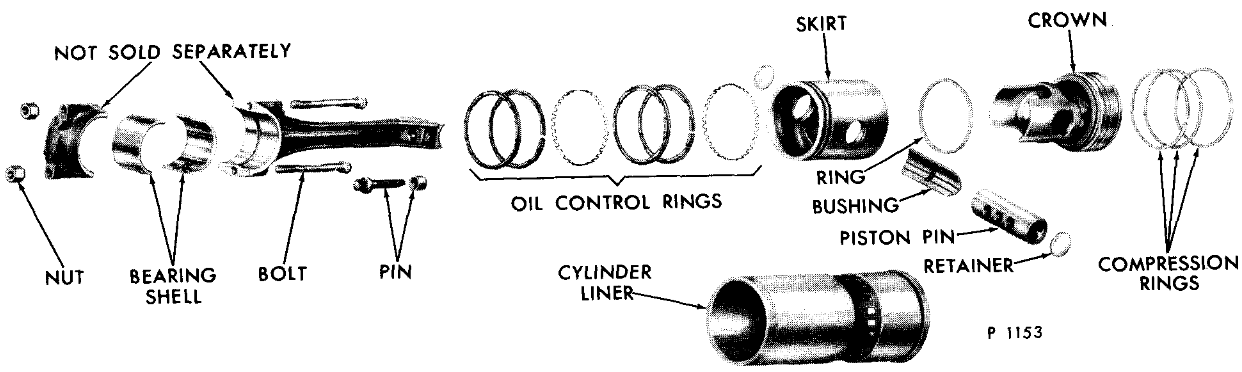


CRANKSHAFT PULLEY, VIBRATION DAMPER AND HUB

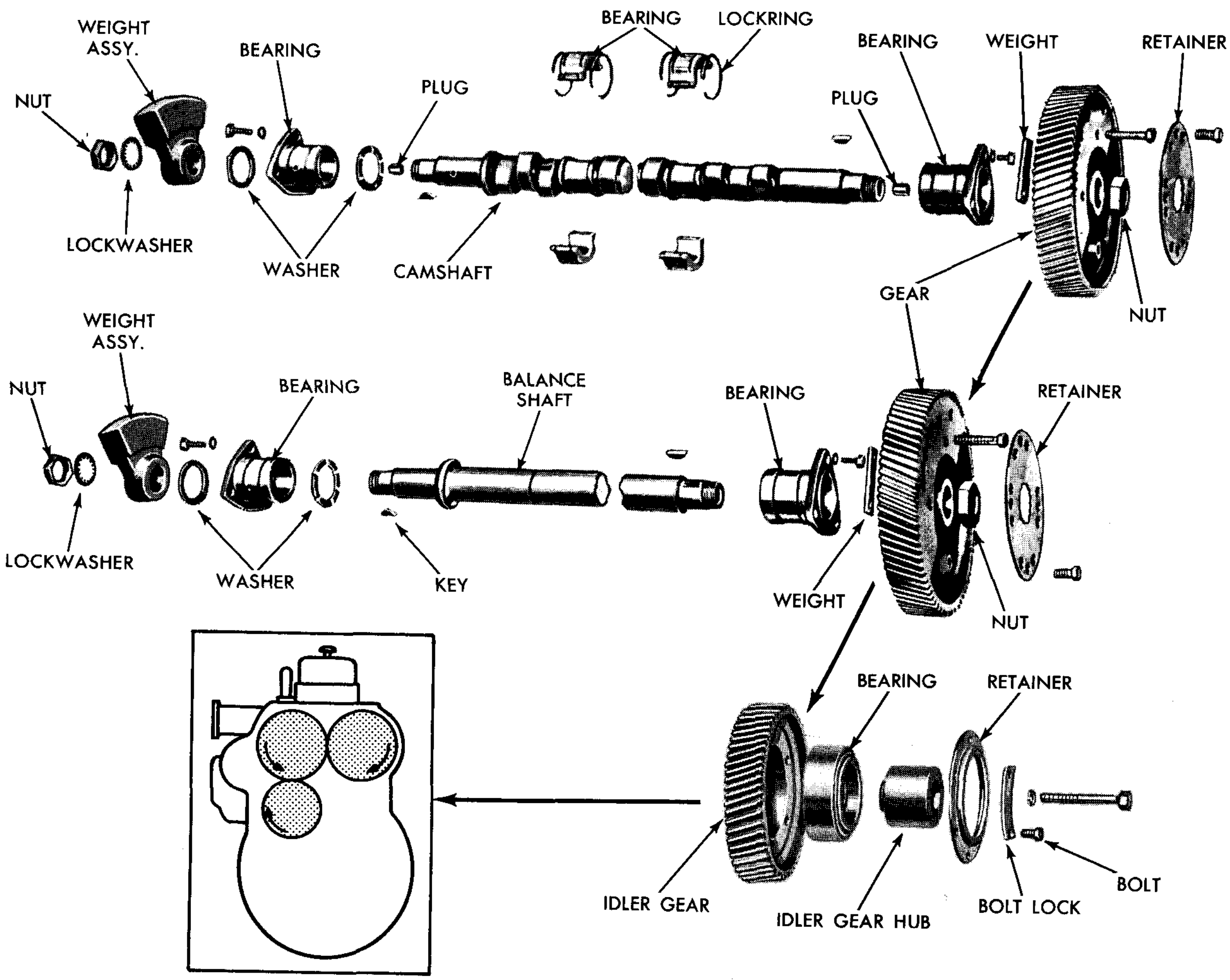
P 614



CONNECTING ROD AND PISTON

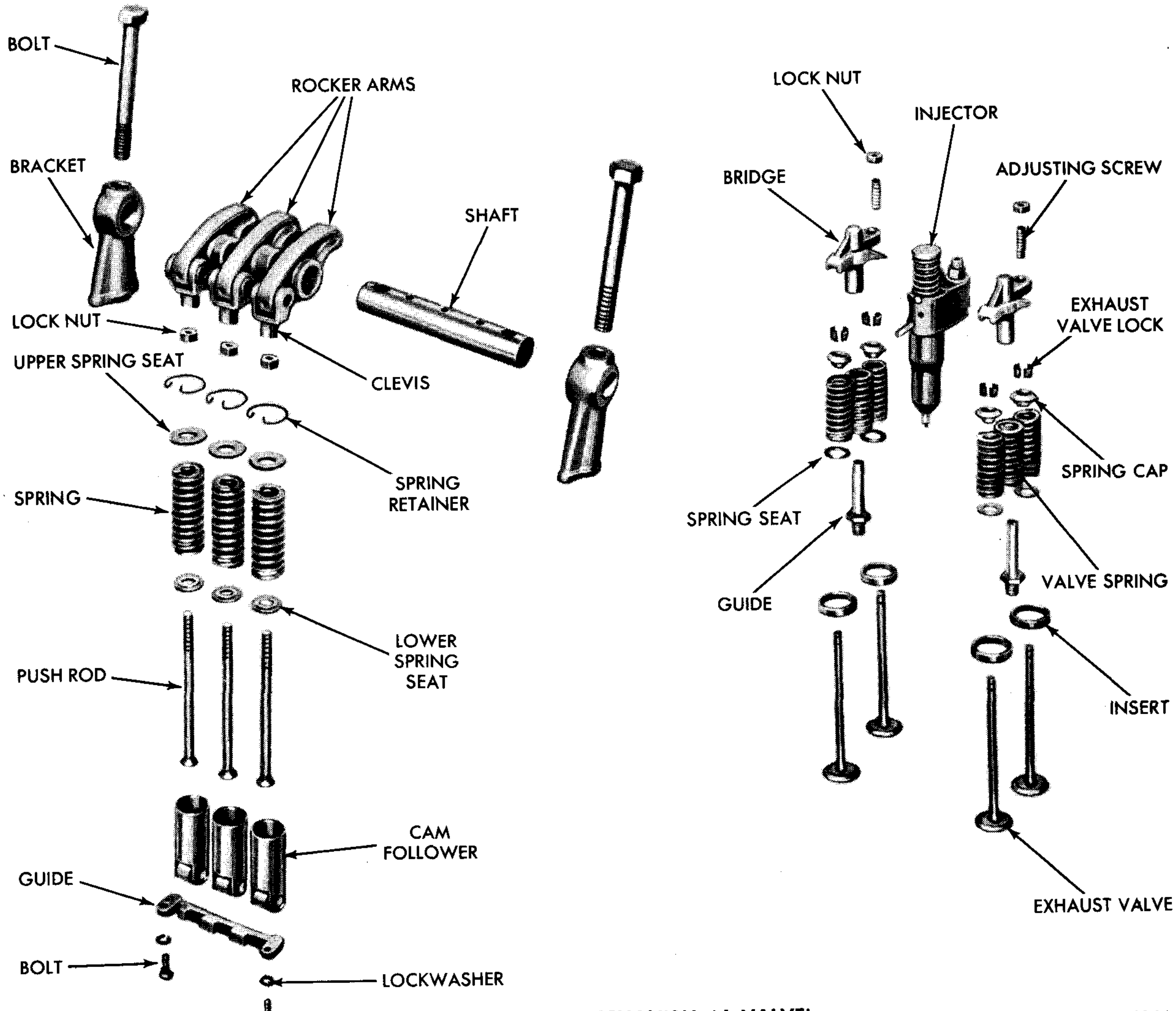


CONNECTING ROD AND CROSS-HEAD PISTON



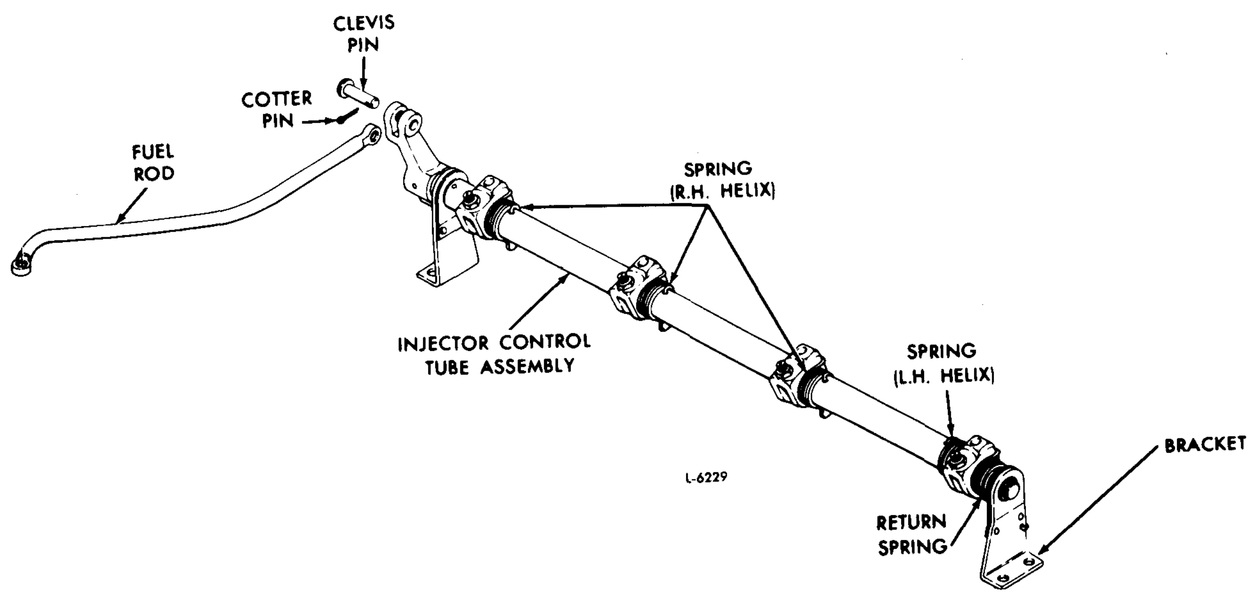
CAMSHAFT AND GEAR TRAIN

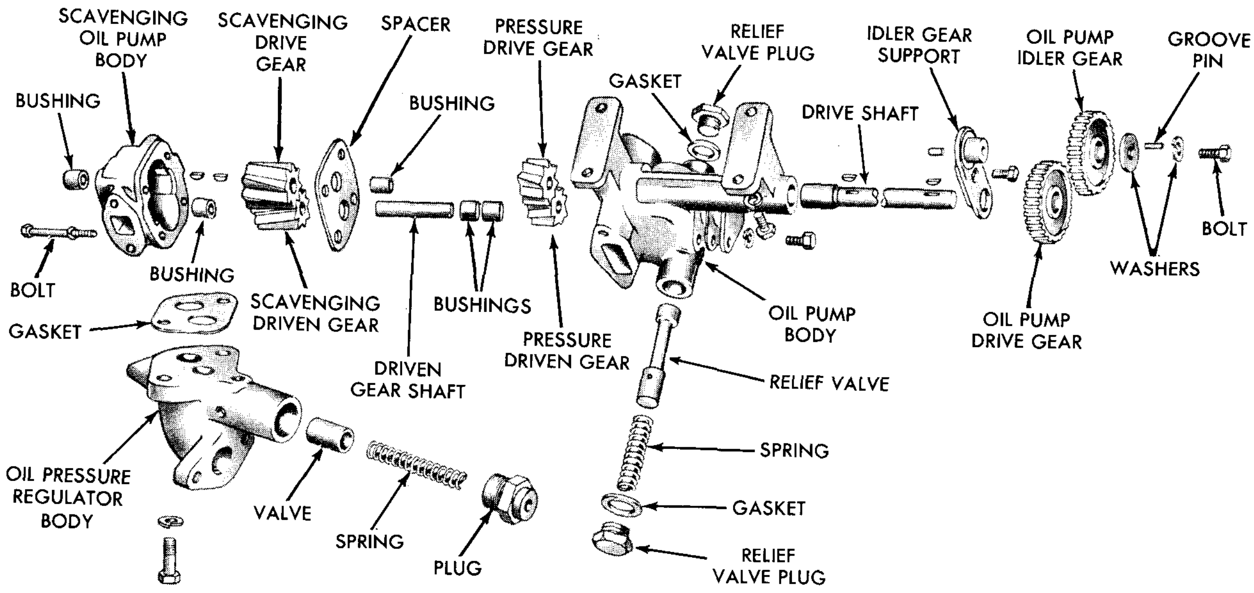
P 615



VALVE OPERATING MECHANISM (4 VALVE)

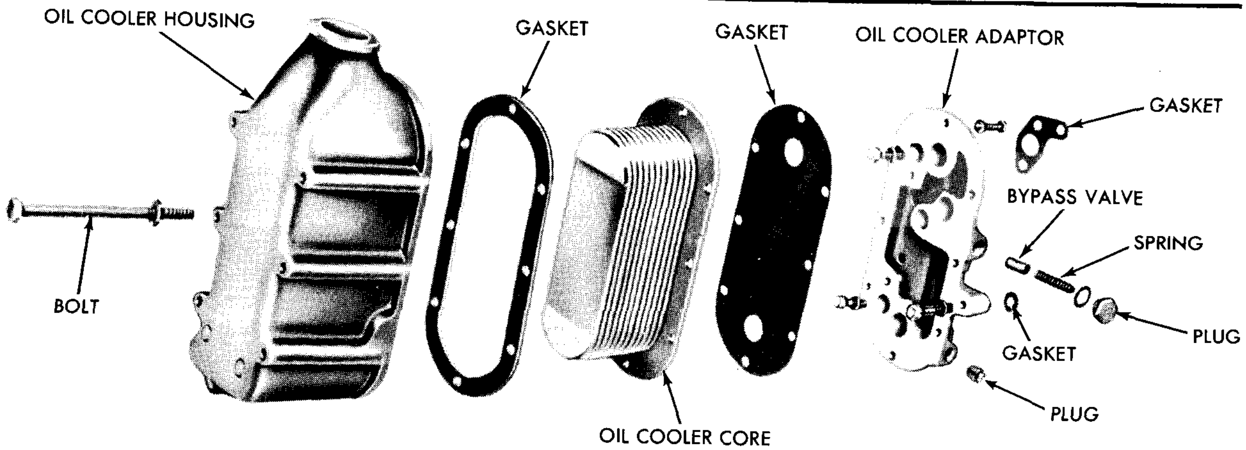
P 616A





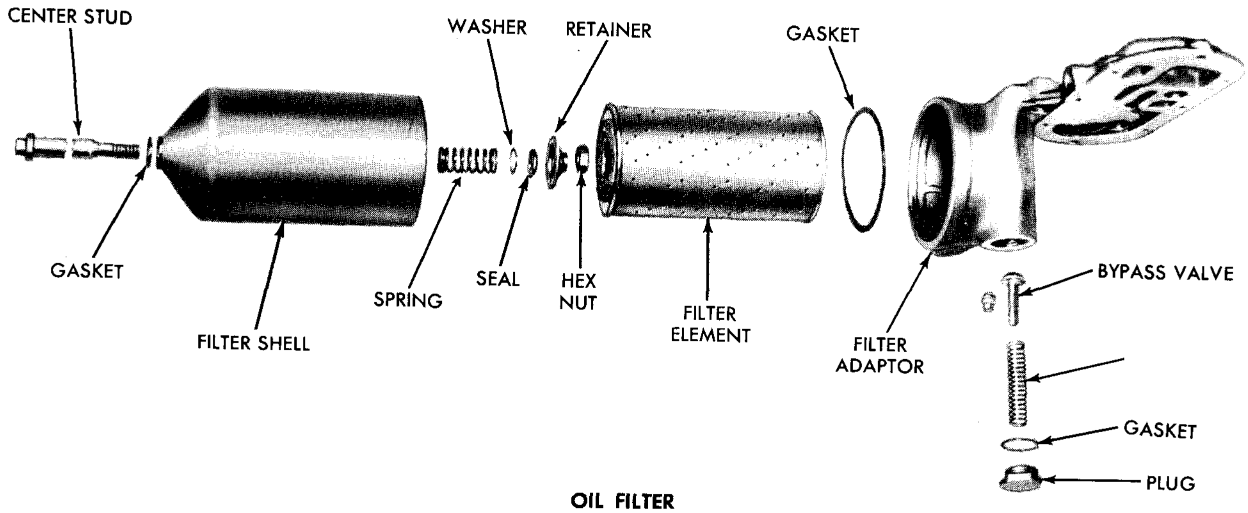
LUBRICATING OIL PUMP

P 622B



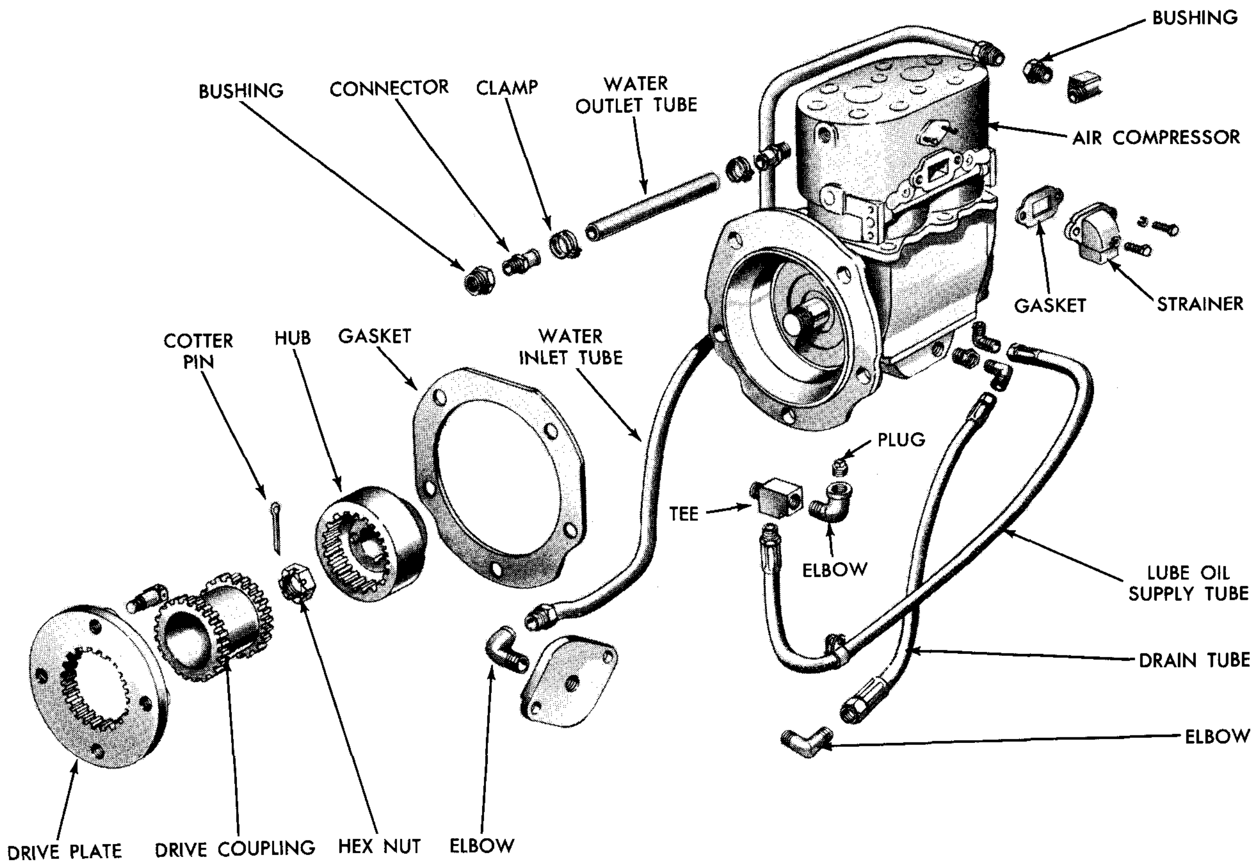
OIL COOLER

P 622A

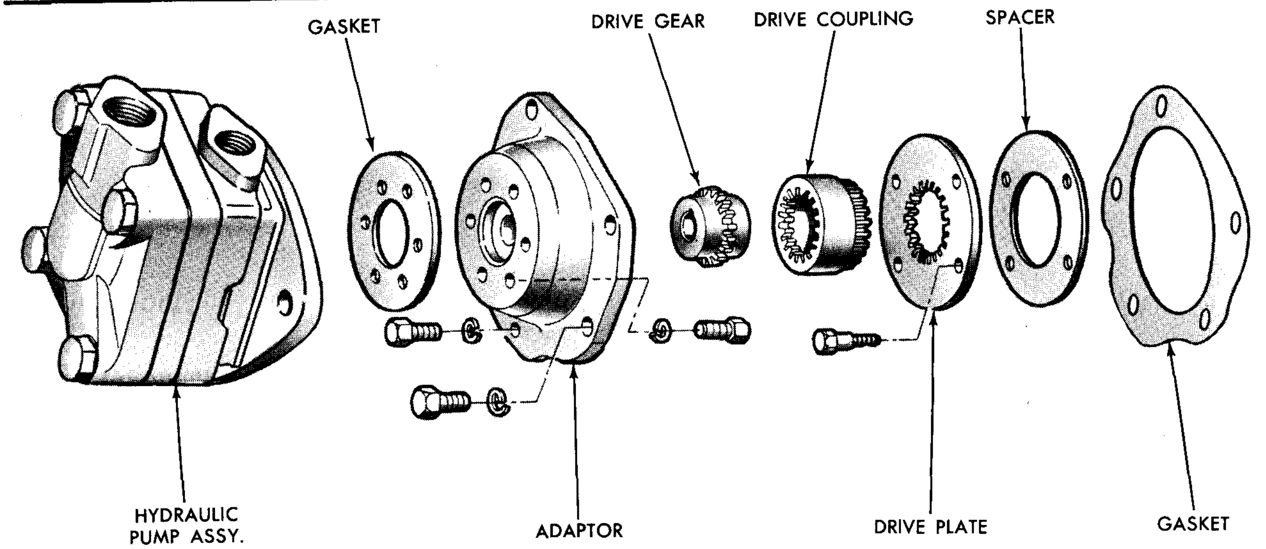


OIL FILTER

P 622

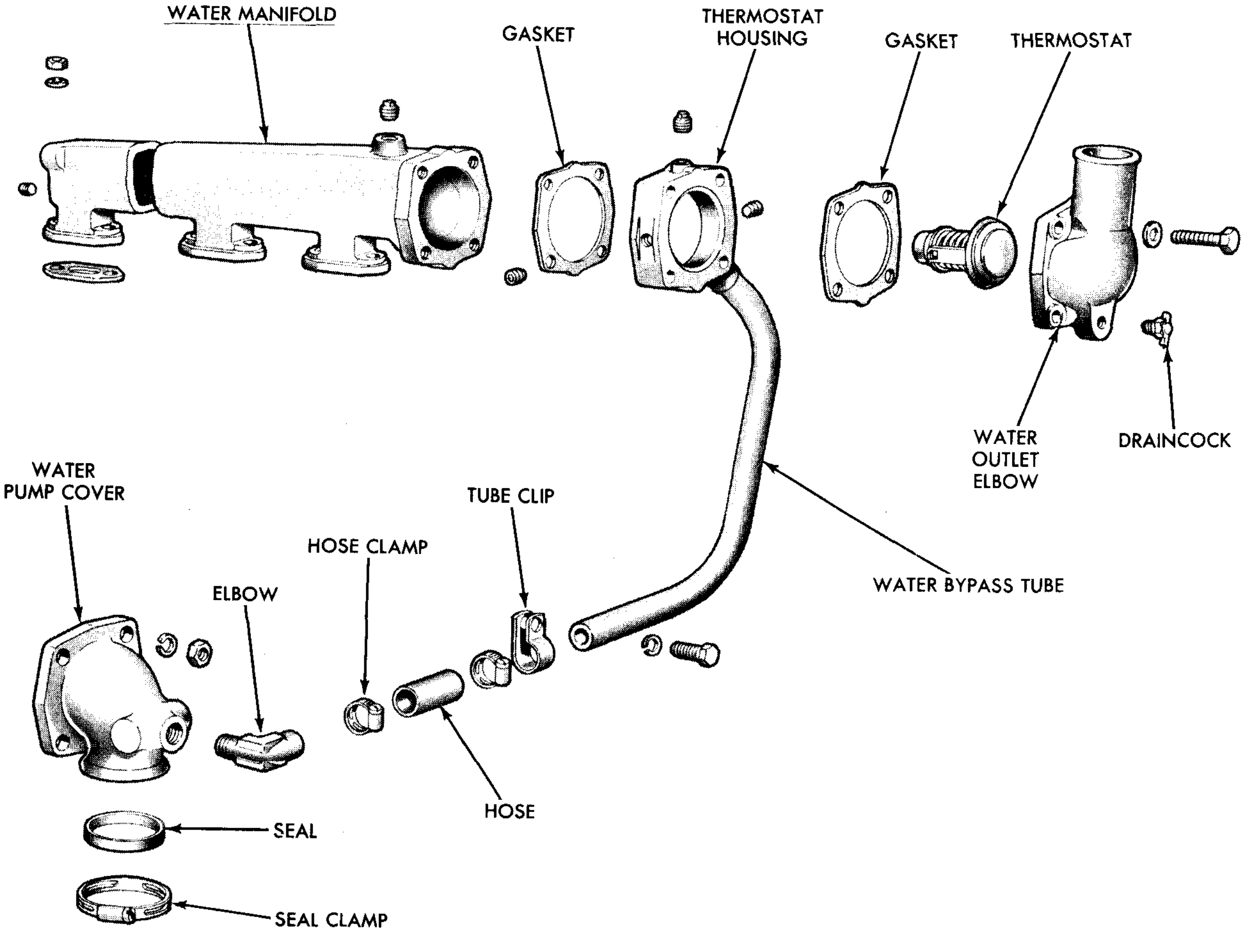


AIR COMPRESSOR AND DRIVE



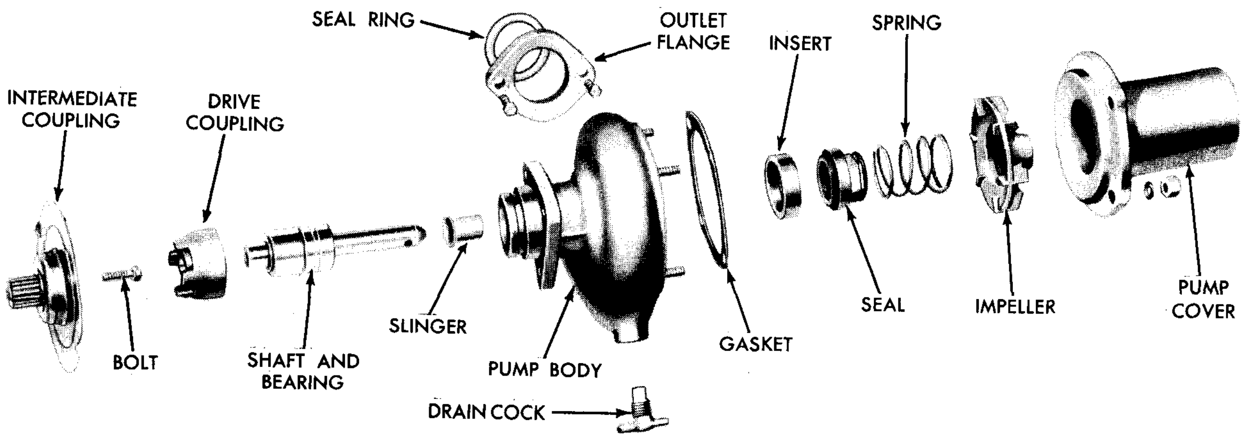
HYDRAULIC PUMP AND DRIVE

P 618



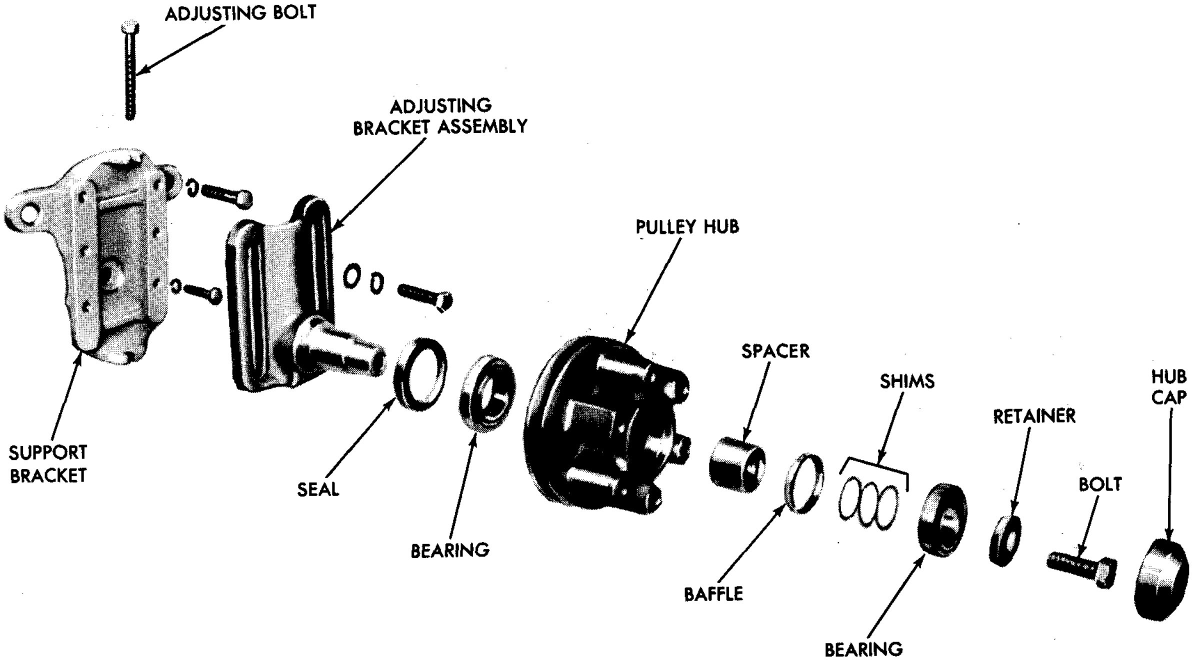
COOLING SYSTEM

P 620A



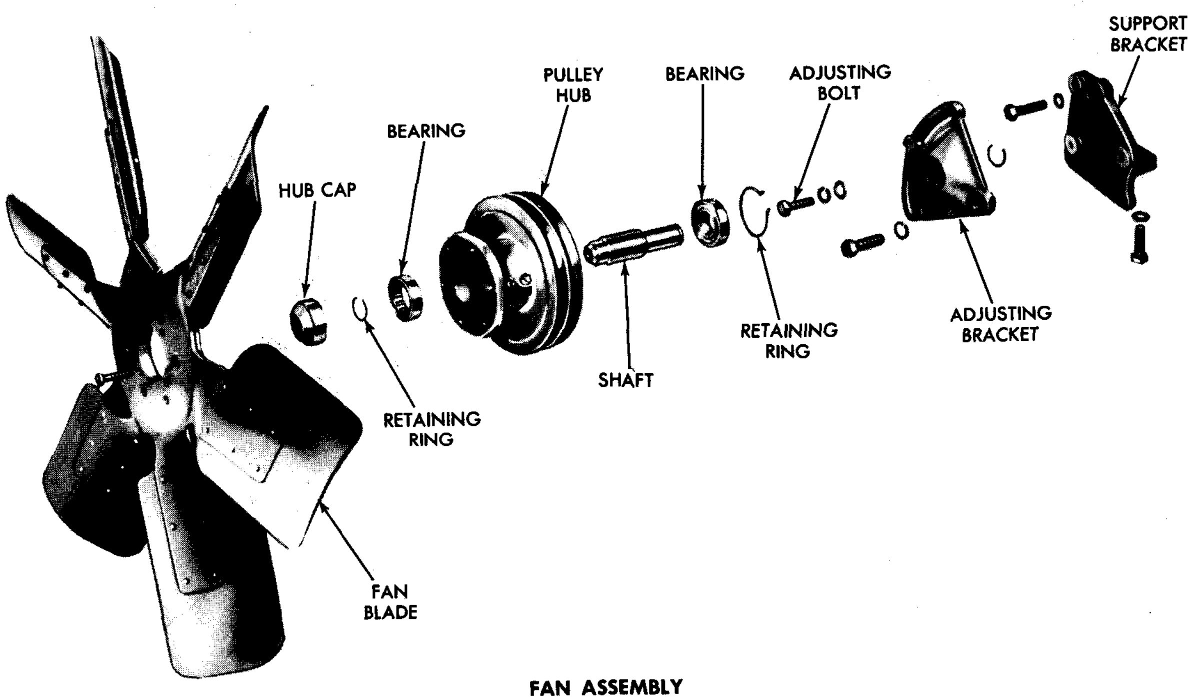
FRESH WATER PUMP

P 620



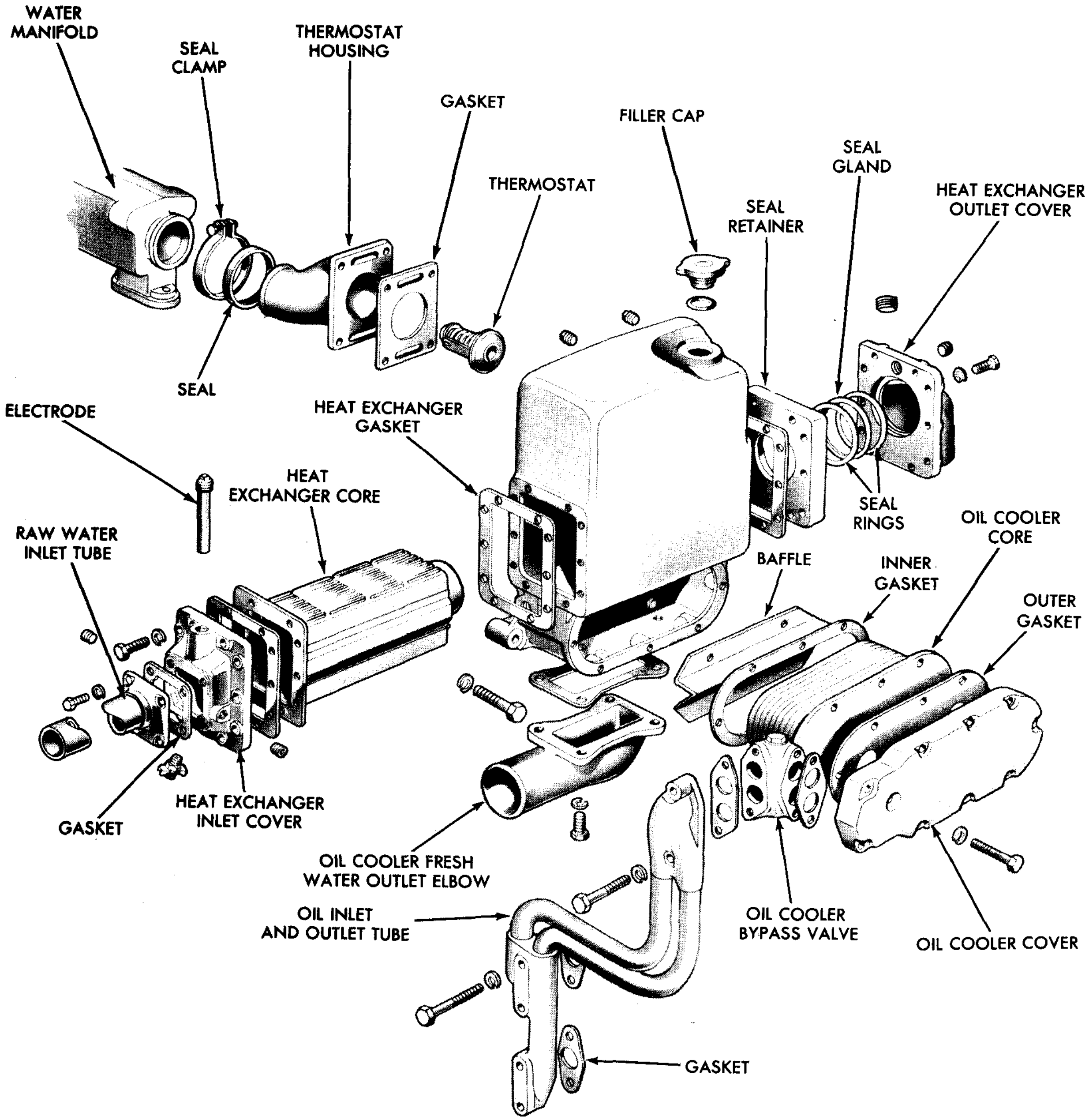
FAN MOUNT

P 619A



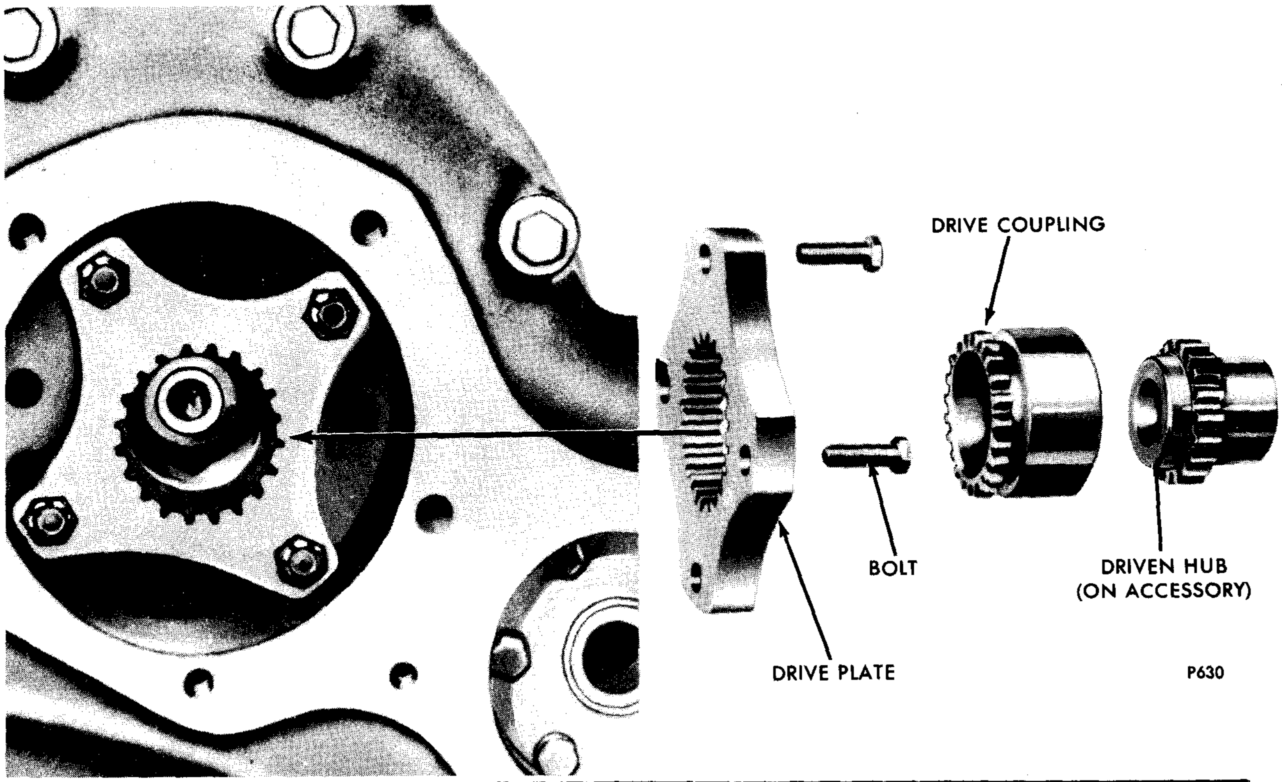
FAN ASSEMBLY

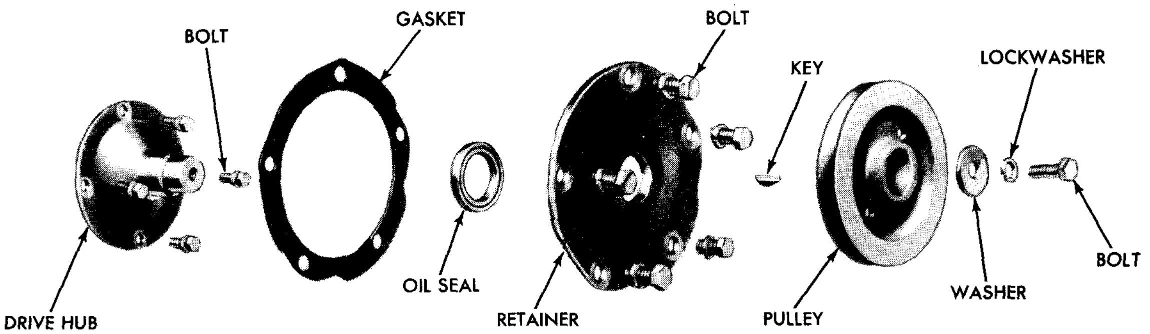
P 619



HEAT EXCHANGER

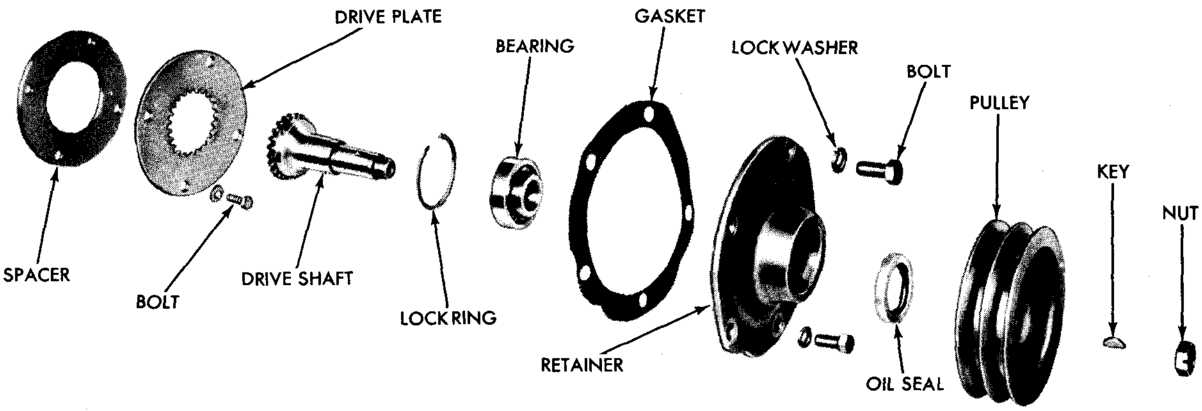
P 621





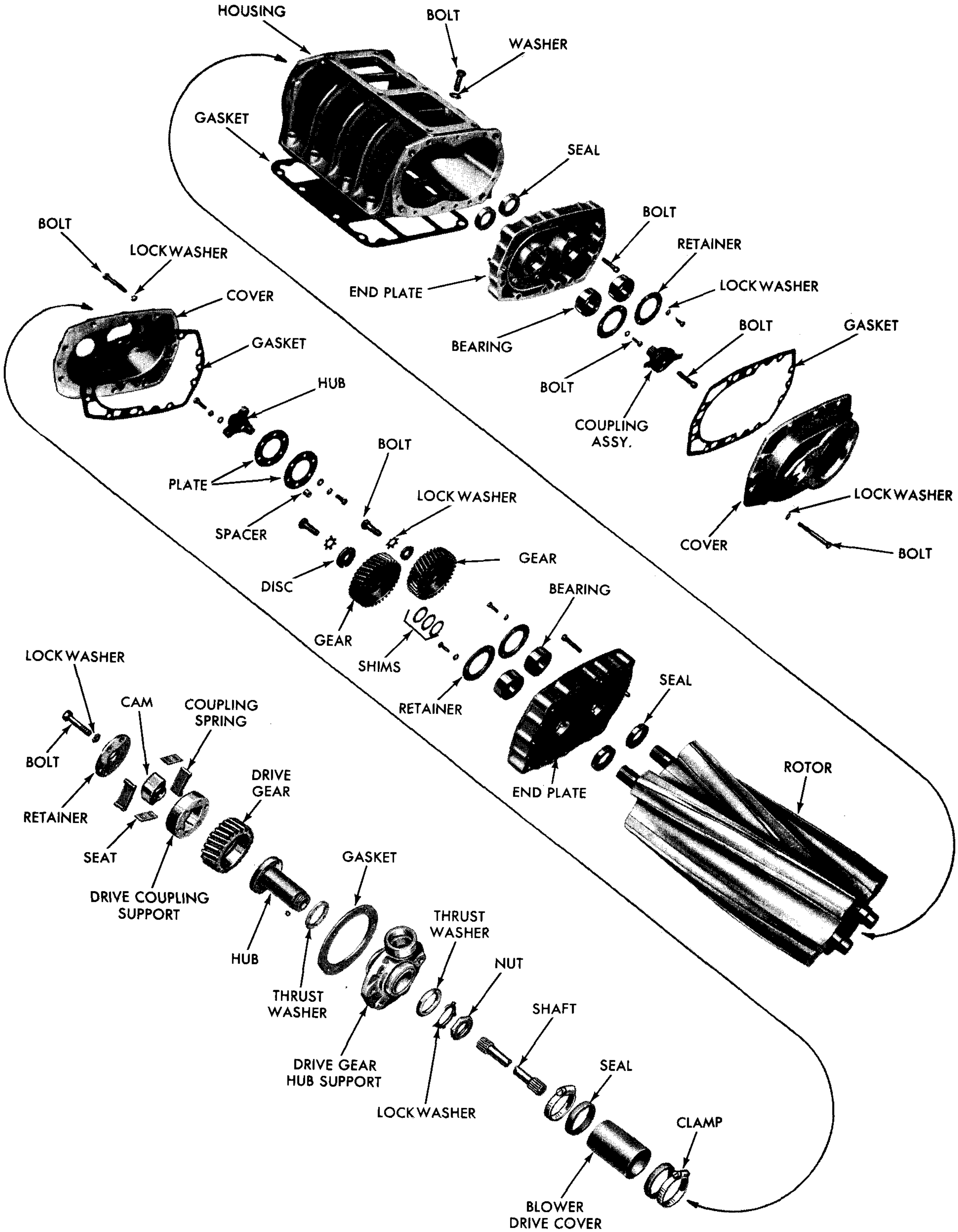
ACCESSORY DRIVE FOR BELT DRIVEN ACCESSORY (DRIVE HUB TYPE)

P 617A



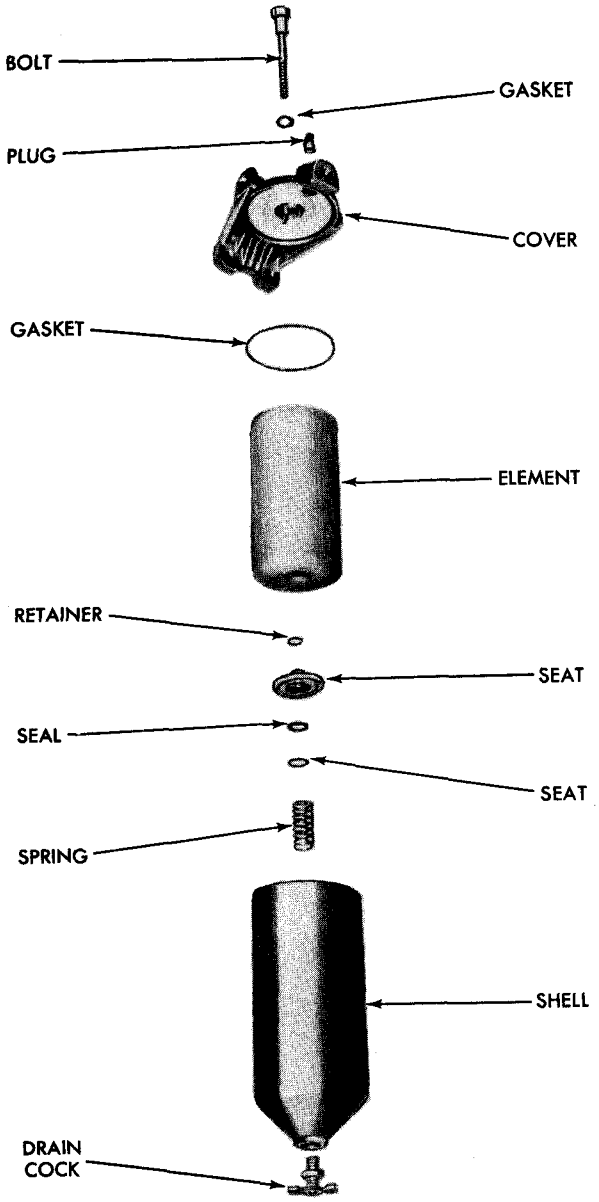
ACCESSORY DRIVE FOR BELT DRIVEN ACCESSORY (DRIVE PLATE TYPE)

P 617

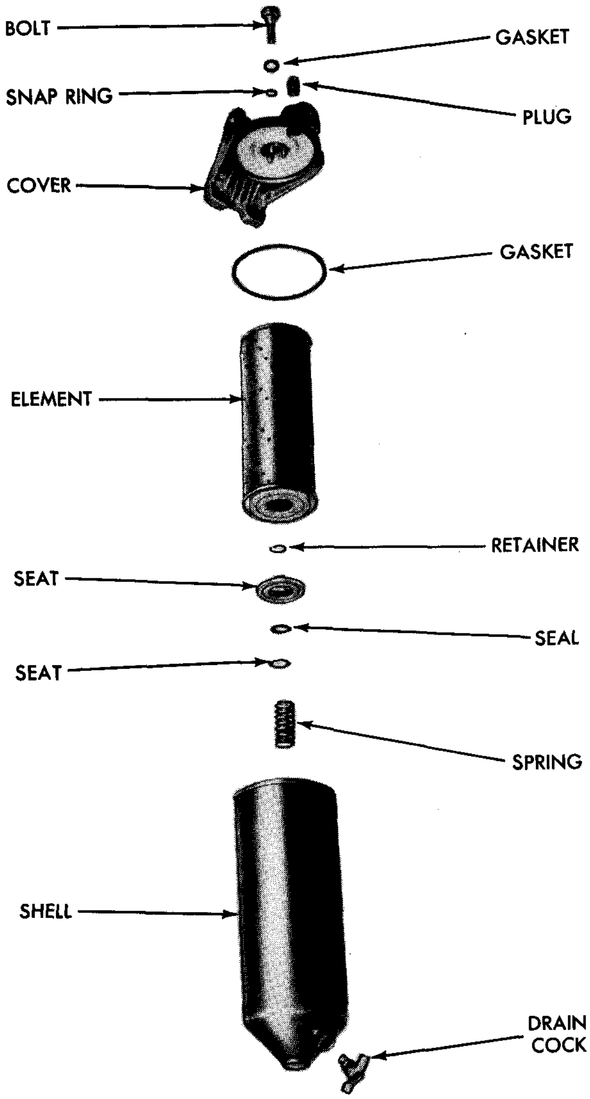


BLOWER ASSEMBLY AND DRIVE

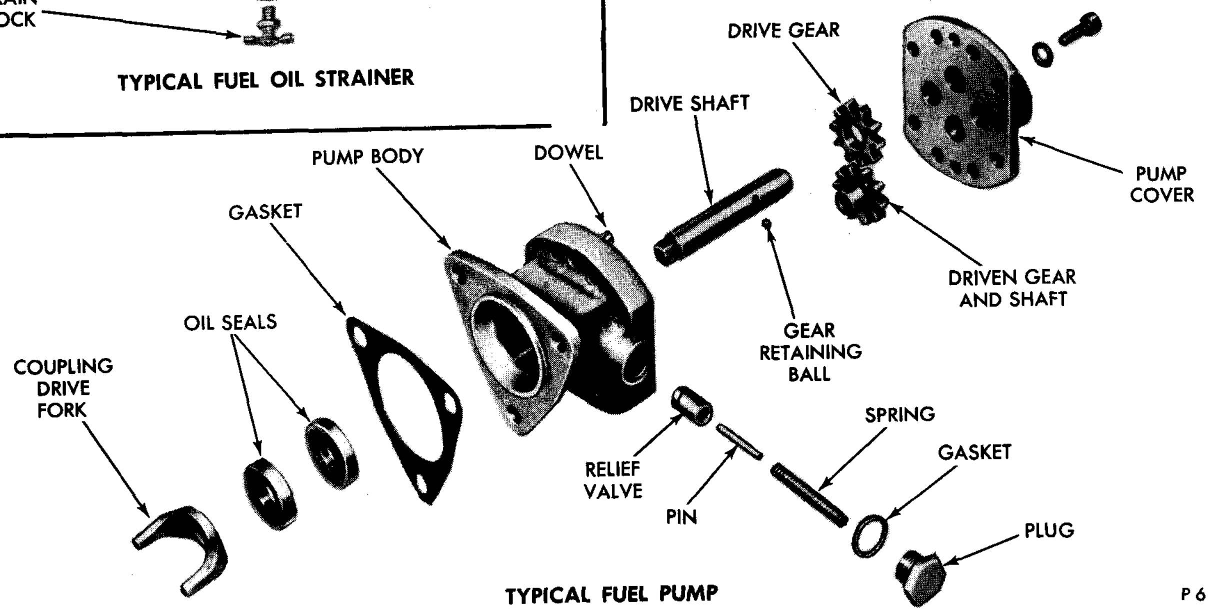
P 623



TYPICAL FUEL OIL STRAINER

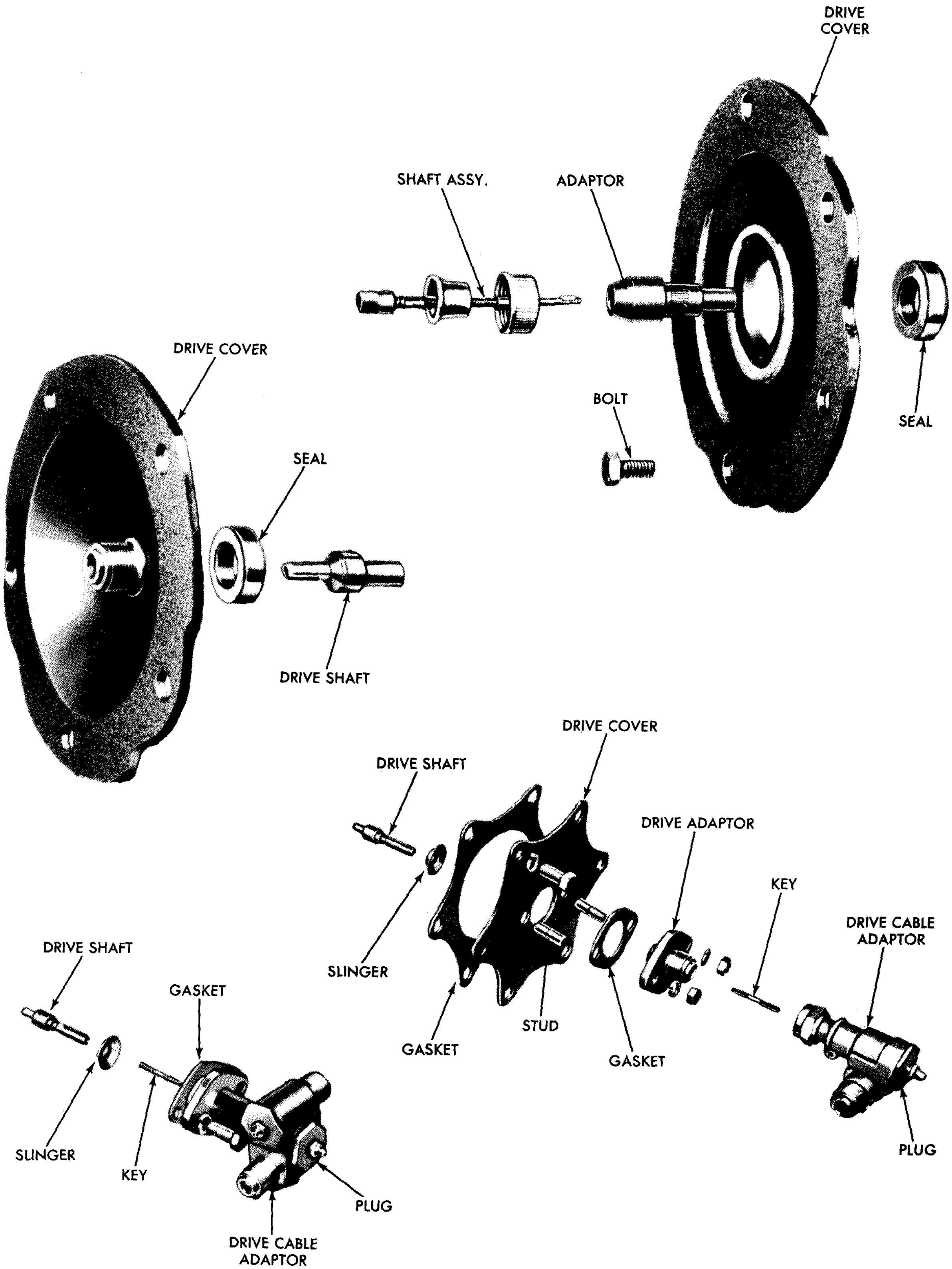


TYPICAL FUEL OIL FILTER



TYPICAL FUEL PUMP

P624



TACHOMETER DRIVE COVERS AND ADAPTORS

P 625

OWNER ASSISTANCE

The satisfaction and goodwill of the owners of Detroit Diesel engines are of primary concern to Detroit Diesel Allison and its authorized service outlets. We recognize, however, that despite the best intentions of everyone concerned, misunderstandings may occur. Normally, any such situation that arises in connection with the sale, operation or service of your engine will be handled by the authorized service outlets in your area (check the Yellow Pages for the Detroit Diesel Allison Service Outlet nearest you).

To further assure your complete satisfaction, we have developed the following three-step procedure to be followed in the event you have a problem that has not been handled satisfactorily.

Step One - **Discuss your problem with a member of management from the authorized service outlet.** Frequently, complaints are the result of a breakdown in communication and can quickly be resolved by a member of management. If you have already discussed the problem with the Sales or Service Manager, contact the General Manager. If your problem originates with a dealer, explain the matter to a management member of the distributorship with whom the dealer has his service agreement.

Step Two - When it appears that your problem cannot readily be resolved at the distributor level without additional assistance, **contact the responsible Detroit Diesel Allison Regional Office in your area** listed below:

Eastern Region
Suite 202
10 Parsonage Road
Edison, New Jersey 08817, U.S.A.
Phone: (201) 246-5070
Regional Manager: S. F. Zappia
Service Manager: D. P. Friedrich

Great Lakes Region
Garrison Place
19855 West Outer Drive
Dearborn, Michigan 48124, U.S.A.
Phone: (313) 565-0411
Regional Manager: E. C. Enlow
Service Manager: R. Schwaller

Southwestern Region
General Motors Bldg.
130 E. Carpenter Freeway
Irving, Texas 75062, U.S.A.
Phone: (214) 659-5070
Regional Manager: E. A. Wilson
Service Manager: W. C. Kaphengst

Western Region
Suite 232
2659 Townsgate Road
Westlake Village, California 91361, U.S.A.
Phone: (213) 997-5405
Regional Manager: G. J. Dunneback
Service Manager: W. K. Clark, Jr.

Southeastern Region
5730 Glenridge Drive, N.E.
Atlanta, Georgia 30328, U.S.A.
Phone: (404) 252-3310
Regional Manager: L. R. Kirby
Service Manager: B. D. Robison, Jr.

Midwestern Region
Suite 618
2021 Spring Road
Oakbrook, Illinois 60521, U.S.A.
Phone: (312) 654-6619
Regional Manager: C. O. Zimmerman
Service Manager: R. A. Galloway

Northwestern Region
Suite 2700
39465 Paseo Padre Parkway
Fremont, California 94538, U.S.A.
Phone: (415) 498-5200
Regional Manager: C. G. Good, Jr.
Service Manager: J. T. Hunt

Canada
Diesel Division - GM of Canada Ltd.
P.O. Box 5990
600 Clarke Road
London, Ontario N5V 3K5, Canada
Phone: (519)452-5000
Telex: 064-5850
TWX; 610-352-0269
Manager: W. Bedford
Service Manager: H. Marienfeldt

Asia/Pacific Region
Detroit Diesel Allison - Australia
Div. of GM - Holden's Ltd.
Princes Highway, P.O. Box 163
Dandenong, Victoria 3175
Australia
Phone: 03-792-01111
Telex: 30792, Melbourne
Regional Manager: J. McGranaghan
Sales & Service Manager: T. E. Kendrick

Latin America Region
Detroit Diesel Allison
Gables Center, Suite 321
95 Merrick Way
Coral Gables, Florida 33144, U.S.A.
Phone: (305)446-4900
Telex: 810-848-9061
Regional Manager: R. D. Daugherty
Sales & Service Manager: J. O. Wine

European Region
Detroit Diesel Allison - Europe
Div. of GM Continental, S.A. Nederland
Parmentierplein 1, 3088 GN Rotterdam
Mail: P.O. Box 5061
3008 AB Rotterdam, Netherlands
Phone: 010-290-000
Telex: 28355 GMCNL
Regional Manager: H. Veldhuizen
Service Manager: T. F. Chope

Middle East/Africa Region
Detroit Diesel Allison
Athens Towers, Messoghion 2/4
Suite 705
Athens 610, Greece
Phone: 7785-344 or 7706-669 or 7787-281
Telex: 215759 DDA
Regional Manager: R. L. Riddell
Service Manager: R. B. Golding

Prior to this call, have the following information available:

- Name and location of distributor or dealer.
- Type and make of equipment.
- Engine model and serial number.
- Engine delivery date and accumulated miles or hours of operation.
- Nature of problem.
- Chronological summary of unit's history.

Step Three - If you are still not satisfied, **present the entire matter in writing or by phone to the Product Headquarters:**

Diesel Operations - J. E. Frederickson, Manager Customer Services, Detroit Diesel Allison, 13400 W. Outer Drive, Detroit, Michigan 48228, Phone (313) 592-5608.

The inclusion of all pertinent information will assist the product headquarters in expediting the handling of the matter. If an additional review by the product headquarters of all the facts involved indicates that some further action can be taken, the Regional Office will be so instructed.

If at this point your problem is still not resolved to your satisfaction, call or write:

J. P. Lewis, Manager, Diesel Engine Service, Detroit Diesel Allison, 13400 W. Outer Drive, Detroit, Michigan 48228, U.S.A., Phone: (313)592-7279.

When contacting the Regional Office or product headquarters, please keep in mind that ultimately your problem will likely be resolved at the distributorship or dealership using their facilities, equipment and personnel. Therefore, it is suggested that you follow the above steps in sequence when experiencing a problem.

Your purchase of a Detroit Diesel Allison product is greatly appreciated, and it is our sincere desire to assure complete satisfaction.

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Service and Parts Information