Detroit Diesel Engines

V-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.

An accident can be prevented with your help.

6SE323 (Rev. 12/78)

Operators Manual

V-71 Engines

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

Printed in U.S.A

TO THE OPERATOR

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

Whenever possible, it will pay to rely on an authorized *Detroit Diesel Allison Service Outlet* for all your service needs from maintenance to major parts replacement. 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 this publication are based on the information in effect at the time of approval for printing. Generally, this publication is reprinted annually. It is recommended that users contact an authorized *Detroit Diesel Allison Service Outlet* for information on the latest revision. The right is reserved to make changes at any time without obligation.

WARRANTY

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

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DESCRIPTION

PRINCIPLES OF OPERATION

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

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

The Two- Cycle Principle

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

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

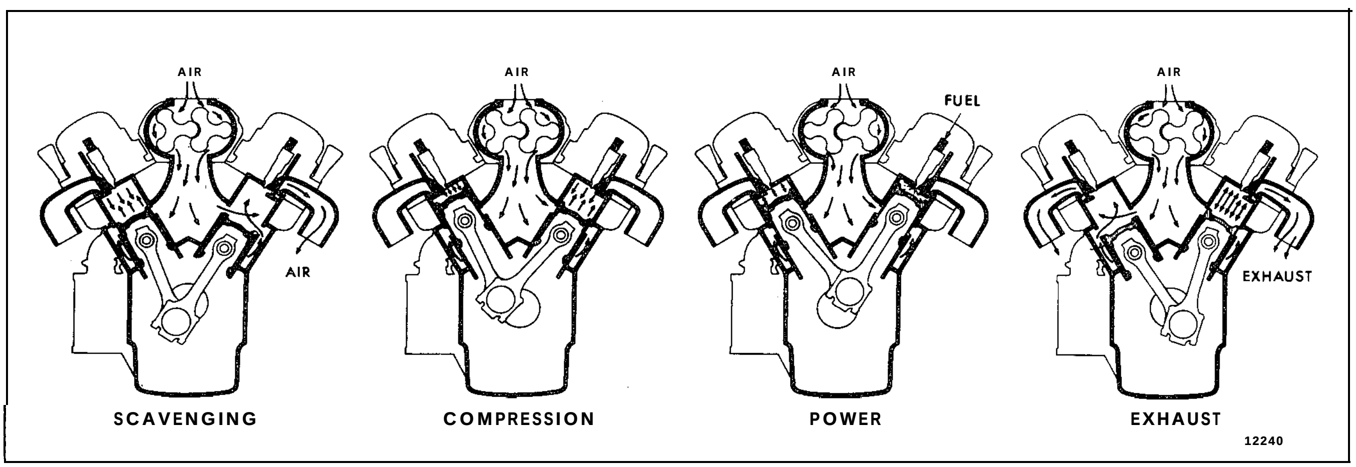


Fig. 1 - The Two-Stroke Cycle

GENERAL DESCRIPTION

The V-71 engines (6, 8, 12 and 16 cylinder models) covered by this manual have the same bore and stroke and use many of the same parts.

All cylinder blocks are symmetrical in design thus permitting oil cooler or starter installation on the same side or on opposite sides of the engine, depending upon the installation requirements. The engines are built with right-hand or left-hand crankshaft rotation. For example, the crankshaft in an RC engine, viewed from the flywheel end, will rotate counterclockwise, the oil cooler will be mounted on the right-hand side of the engine and the starter will be on the left-hand side of the engine (Fig. 2).

There are eight basic engine models. 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 location of the starter and oil cooler as viewed from the rear (flywheel) end. For the meaning of each digit in the model numbering system, refer to Fig. 2.

The engines are normally equipped with an oil cooler, lubricating oil filter(s), fuel oil strainer, fuel oil filter, air cleaner(s) or silencer(s), governor, heat exchanger and raw water pump or fan and radiator, and a starter.

Fuel is drawn from the supply tank and through a strainer by a gear-type fuel pump, then it is forced through the filter and the fuel inlet manifolds in the cylinder heads to the injectors. Excess fuel is returned to the supply tank via the return fuel manifolds and connecting lines. Since fuel is constantly circulating through the injectors, it serves to cool the injectors and carry off any air in the fuel system.

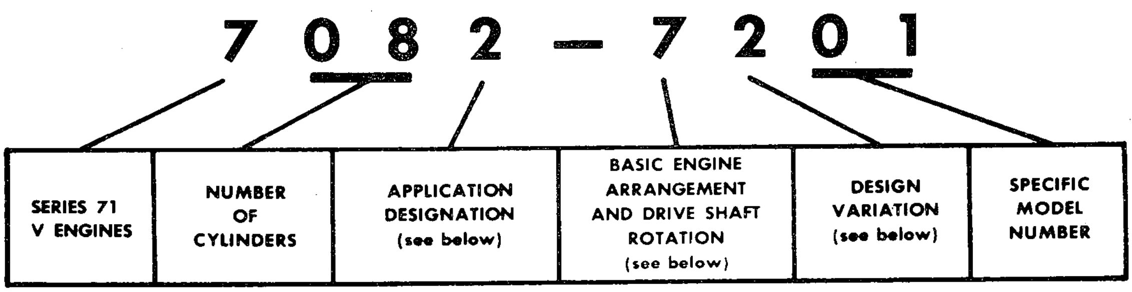
Air for scavenging and combustion is supplied by a blower(s) which pumps air into the engine cylinders via the air box and cylinder liner ports. All air entering the blower(s) first passes through an air cleaner or silencer.

Full pressure lubrication is supplied to all main, connecting rod and camshaft bearings, and to other moving parts of the engine. A gear-type pump draws oil from the oil pan through an intake screen and delivers it to the oil filter(s) and then to the oil cooler(s). From the oil cooler(s) the oil flows through passages that connect with the oil galleries in the cylinder block and cylinder heads for distribution to the bearings, rocker arm mechanism and other functional parts.

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 either a radiator or heat exchanger. Control of the engine temperature is accomplished by thermostats that regulate the flow of the coolant within the cooling system.

Engine starting is provided by either a hydraulic or an electrical starting system.

Engine speed is controlled by a governor. Some engines have a mechanical limiting speed governor, some a mechanical variable speed governor, and other engines use a limiting speed or a variable speed hydraulic governor. The engine application determines which type of governor is used.



APPLICATION DESIGNATION:

7082-7200	MARINE
7083-7200	INDUSTRIAL F-F
7084-7200	POWER-BASE
7085-7200	GENERATOR
7087-7200	VEHICLE F-F
7088-7200	SPECIAL

BASIC ENGINE ARRANGEMENTS:

Rotation: L (left) and R (right) designates rotation viewed from the front of the engine.

Type: A-B-C-D designates location of starter and oil cooler as viewed from the rear (flywheel) end.

Cylinder Bank: Left and right cylinder banks are determined from rear of engine.

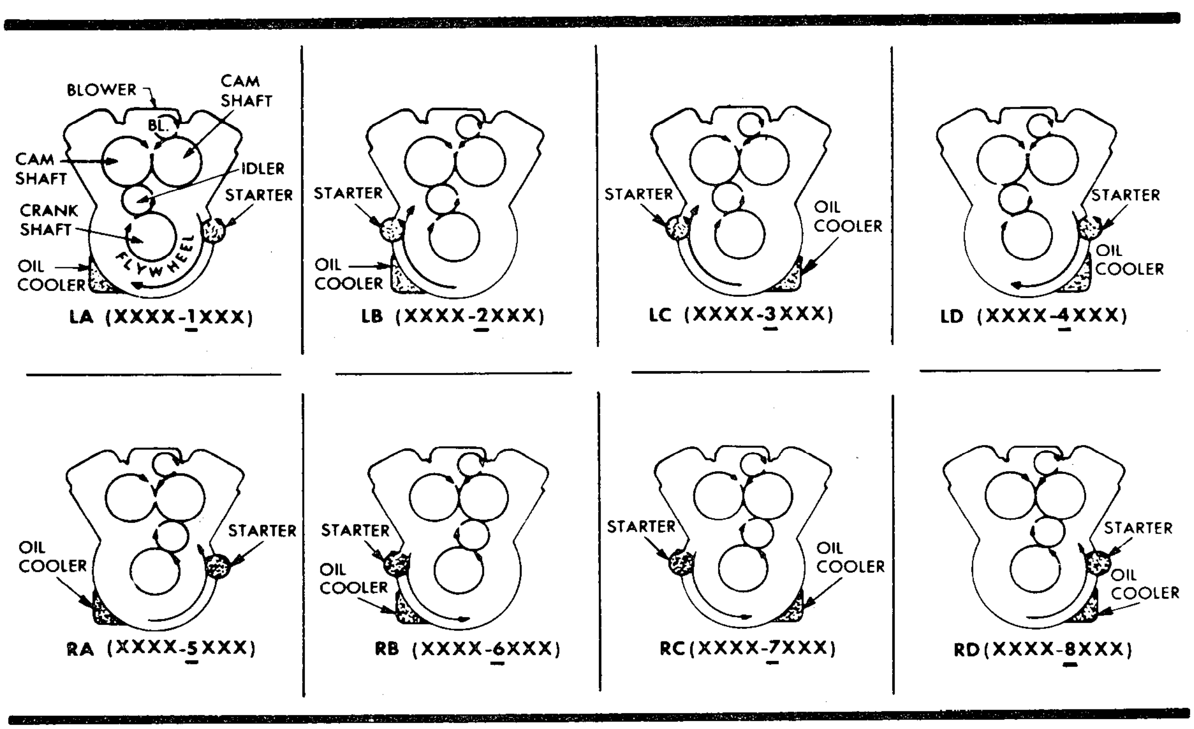
DESIGN VARIATION:

7082-7000	V-71 "N" ENGINE
7082-7100	2 VALVE HEAD ENGINE
7082-7200	4 VALVE HEAD ENGINE
7082-7300	TURBOCHARGED ENGINE
7082-7400	AFTERCOOLED ENGINE
7082-7500	CUSTOMER SPEC. ENGINE

DRIVE SHAFT ROTATION:

7242-0200	LEFT-HAND
7242-9200	RIGHT-HAND

Drive shaft rotation: shaft rotation on multiple units is determined from the rear of the unit.



ALL ABOVE VIEWS FROM REAR OF ENGINE 11473

Fig. 2 – Model Description, Rotation, and Accessory Arrangement

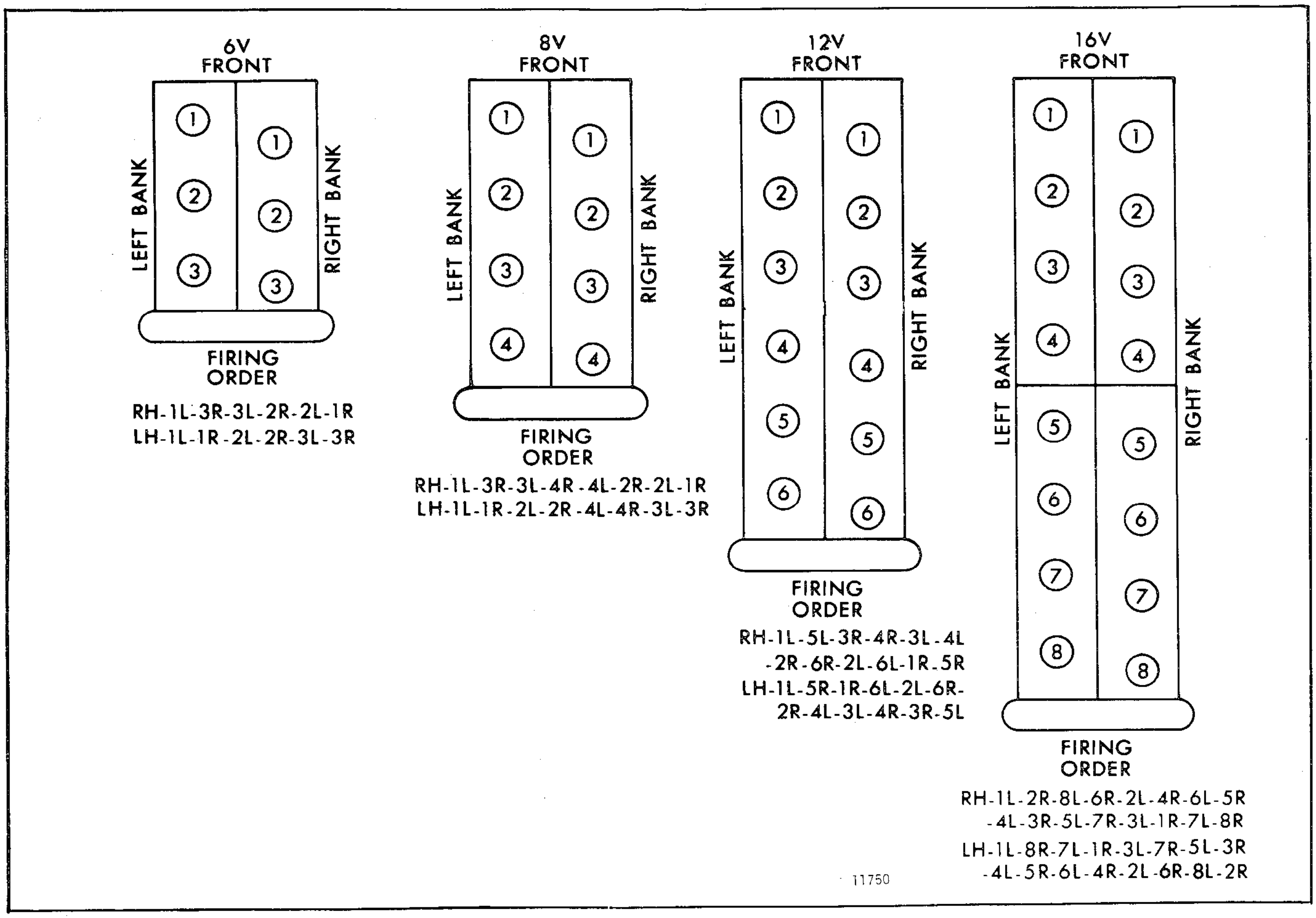


Fig. 3 – V-71 Cylinder Designation and Firing Order

GENERAL SPECIFICATIONS

	6V	8V	12V	16V
Type	2 Cycle	2 Cycle	2 Cycle	2 Cycle
Number of Cylinders	6	8	12	16
Bore (inches)	4.25	4.25	4.25	4.25
Bore (mm)	108	108	108	108
Stroke (inches)	5	5	5	5
Stroke (mm)	127	127	127	127
Compression Ratio (Nominal)(Standard Engines)	17 to 1	17 to 1	17 to 1	17 to 1
Compression Ratio (Nominal)("N" Engines)	18.7 to 1	18.7 to 1	18.7 to 1	18.7 to 1
Total Displacement – cubic inches	426	568	852	1136
Total Displacement – litres	6.99	9.32	13.97	18.63
Number of Main Bearings	4	5	7	10

ENGINE MODEL AND SERIAL NUMBER DESIGNATION

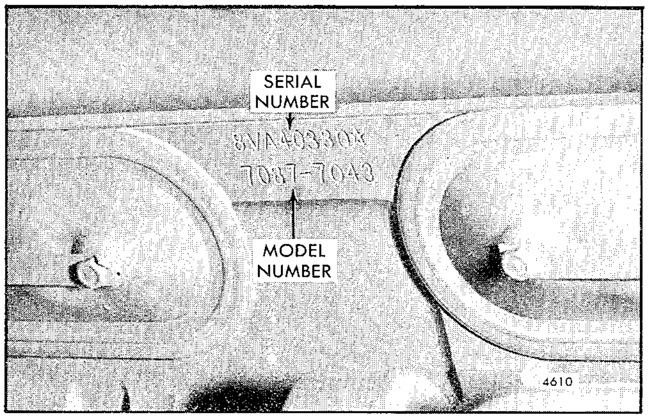


Fig. 4 – Typical Engine Serial Number and Model Number as Stamped on Cylinder Block

The engine serial number and model number are stamped on the right-hand side of the cylinder block (Fig. 4).

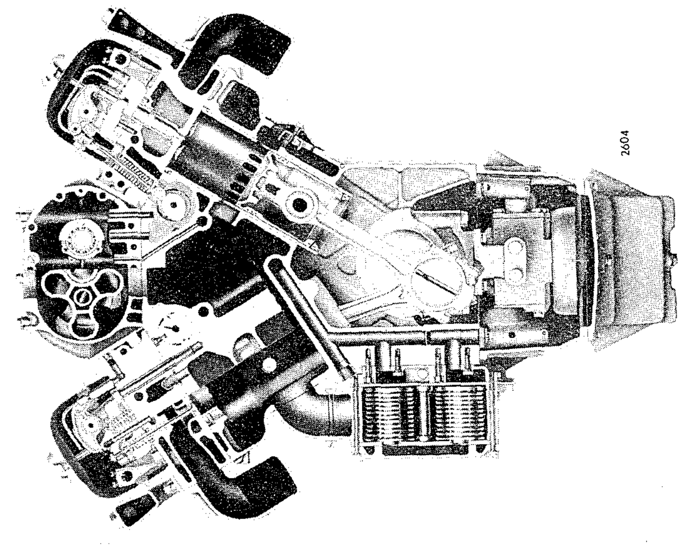
Engines with optional equipment have an option plate attached to one of the valve rocker covers. The engine serial number and model number are also stamped on this plate.

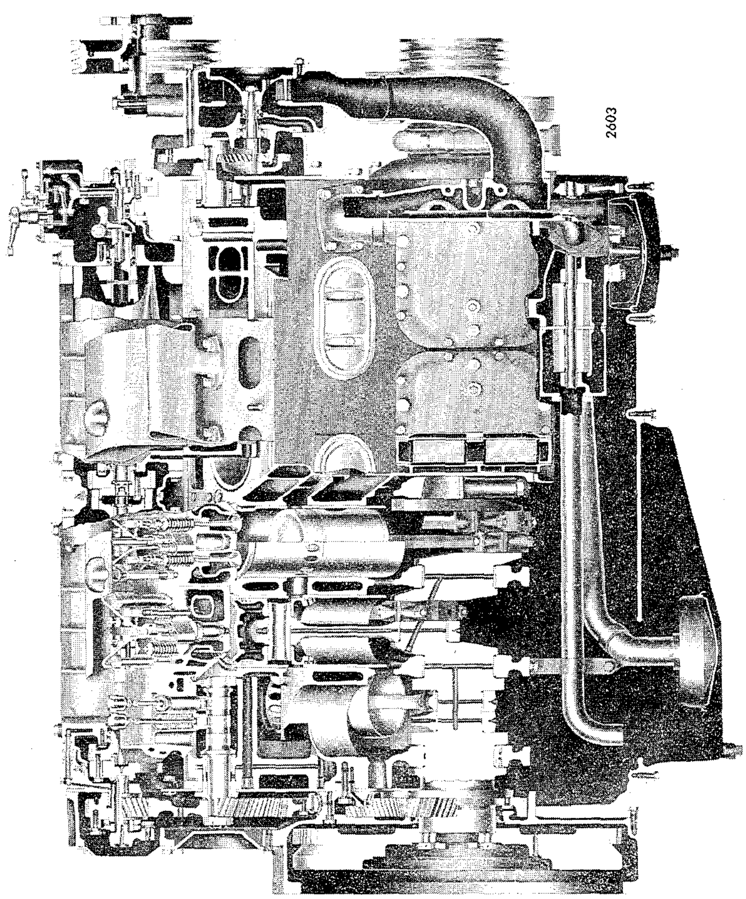
Power take-off assemblies, torque converters, hydraulic marine gears, etc. may also carry name plates pertaining to the particular assembly to which they are attached. The information on these name plates should be included when ordering parts for these assemblies.

BUILT-IN PARTS BOOK

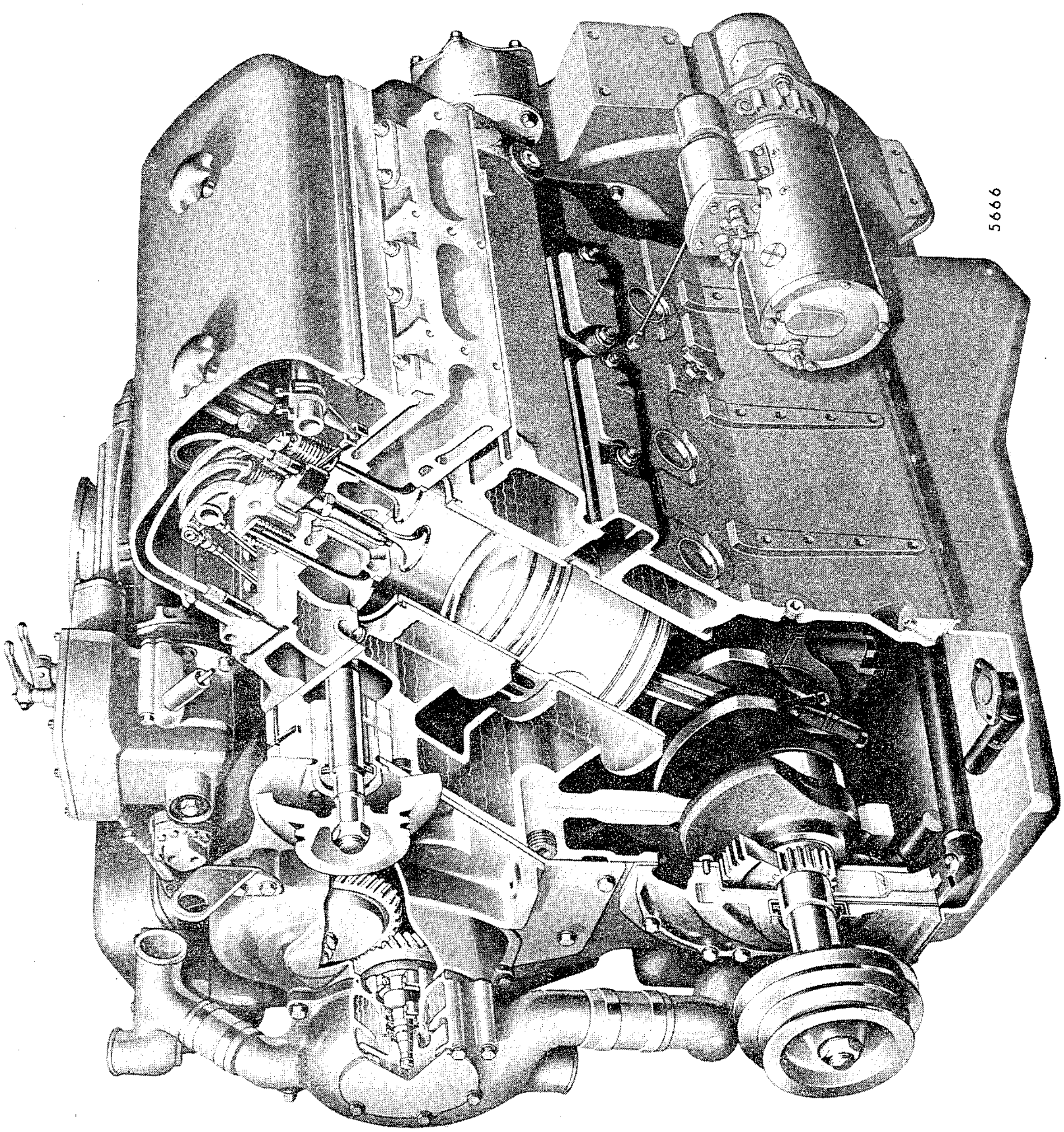
The *Built-In Parts Book* is a photo etched aluminum plate that fits into a holding channel on the engine valve rocker cover and contains the necessary information required when ordering parts. It is recommended that the engine user read the section on the *Built-In Parts Book* in order to take full 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.

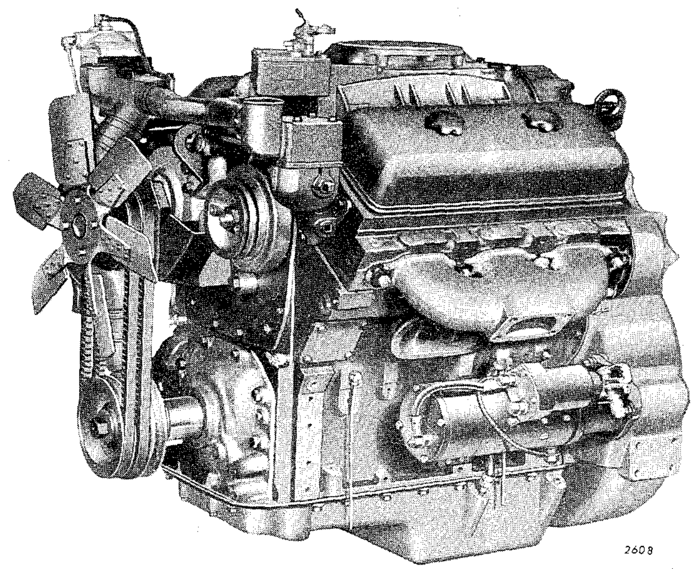




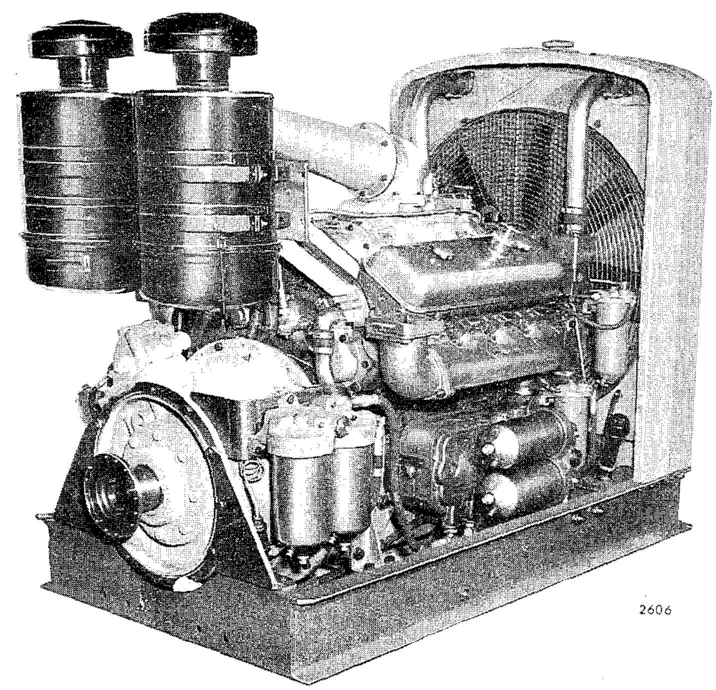
Cross Section Views of a Typical V-71 Engine



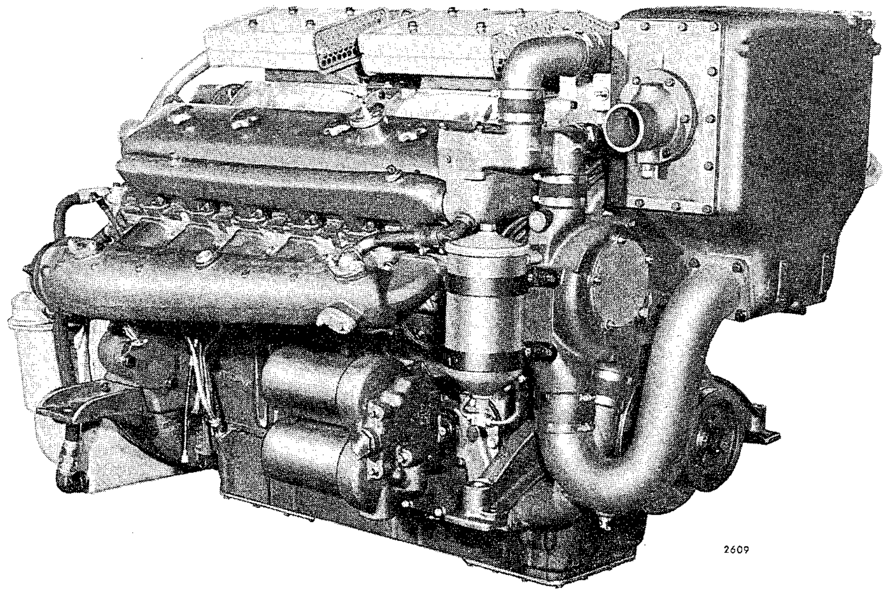
Three-Quarter Cutaway View of V-71 Engine



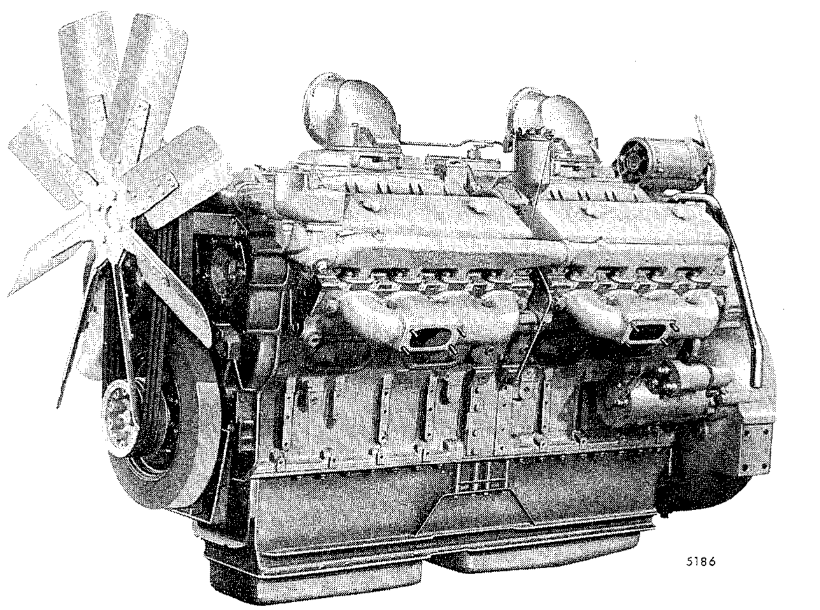
Typical Fan-to-Flywheel Unit (6V)



Typical Industrial Torque Converter Unit (8V)



Typical Marine Propulsion Engine (12V)



Typical Fan-to-Flywheel Engine (16V)

ENGINE SYSTEMS

The V-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 (Fig. 1) consists of the fuel injectors, fuel pipes, fuel pump, fuel strainer, fuel filter and the necessary connecting fuel lines.

A restricted fitting is located in the outlet passage in one of the cylinder heads on 6, 8 and 12V engines to maintain pressure in the fuel system. Two of the cylinder heads on 16V engines have a restricted fitting.

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

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

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

Fuel Injector

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

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

Remove Injector

An injector may be removed in the following manner:

1. Remove the valve rocker cover.

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

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.

> **IMPORTANT:** 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 may be loosened. Either

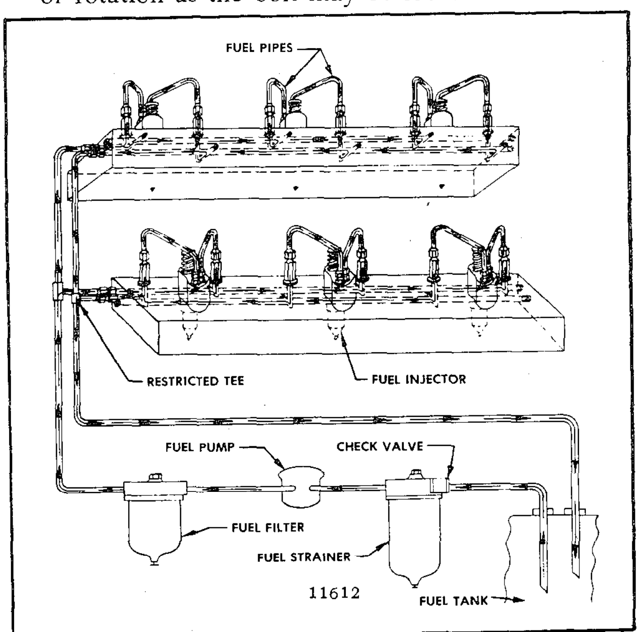


Fig. 1 - Schematic Diagram of Typical Fuel System

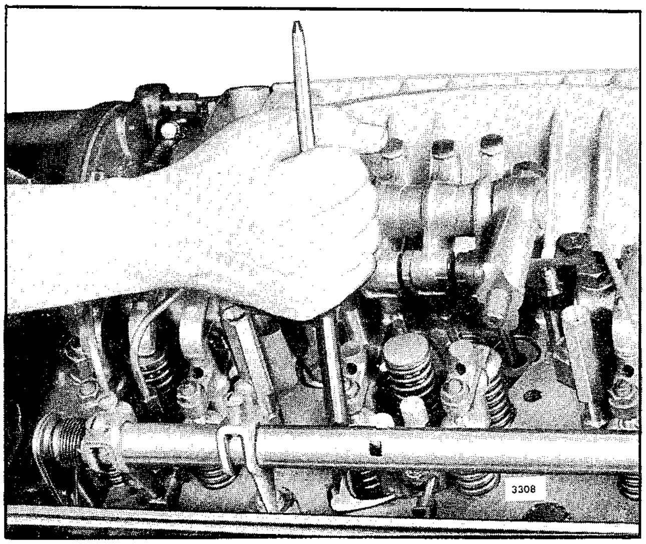


Fig. 2 - Removing Injector from Cylinder Head

remove the starting motor or the pipe plug in the flywheel housing and use a pry bar against the teeth of the flywheel ring gear to turn the crankshaft.

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

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

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

8. Free the injector from its seat as shown in Fig. 2 and lift it from the cylinder head.

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

Install Injector

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

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

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

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

Align the fuel pipes and connect them to the injector and the fuel connectors. Use socket J 8932-01 and a torque wrench to tighten the fuel pipe nuts to 12-15 lb-ft (16-20 Nm) torque.

> **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 front end of the blower.

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.

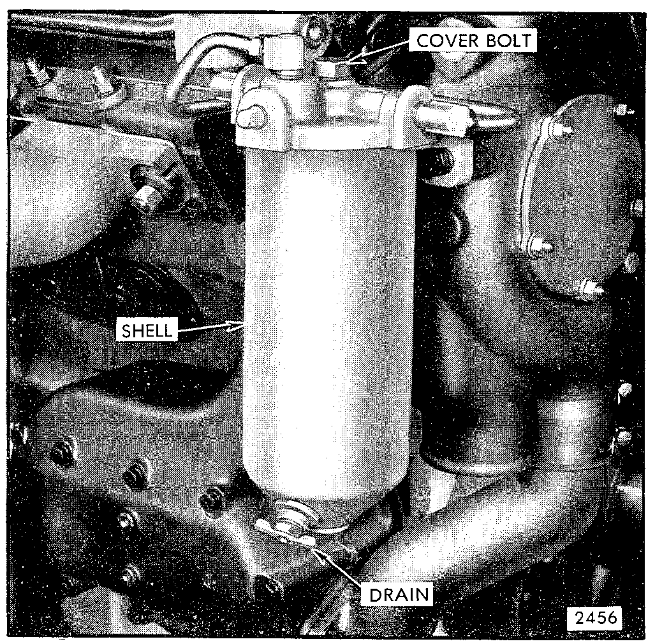


Fig. 3 - Typical Fuel Filter Mounting

The fuel pump incorporates two oil seals. Two tapped holes are provided in the underside of the pump body to permit draining off any leakage of oil.. 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.

The fuel pump used on the V-71 engines is a left-hand rotating pump. Regardless of engine rotation, the pump will always rotate in a left-hand direction.

Fuel Strainer and Fuel Filter

A replaceable element type fuel strainer and fuel filter (Figs. 1 and 3) are used in the fuel system to remove impurities from the fuel. The strainer removes the larger foreign 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 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.

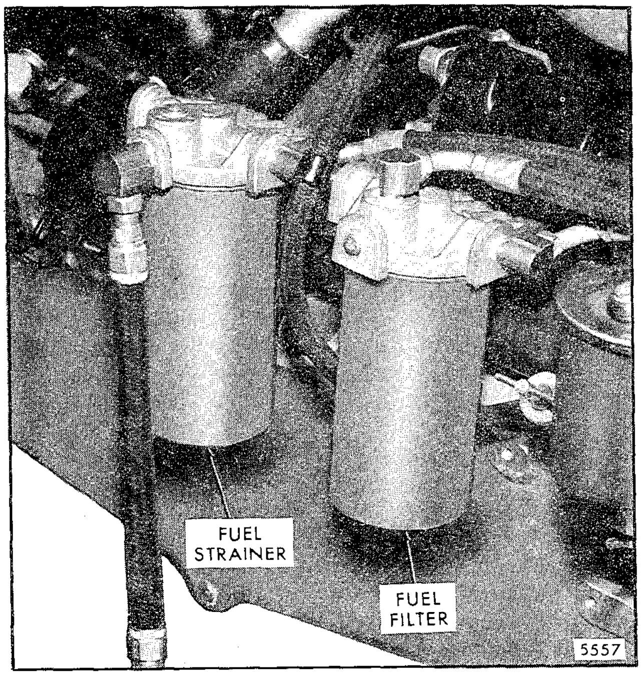


Fig. 4 - Typical Spin-On Fuel Filter Mounting

Spin-On Type Fuel Filter

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

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

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

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

Replace the filter as follows:

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

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

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

4. Start the engine and check for leaks.

Fuel Tank

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

> **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(s), 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 to cool the internal engine parts, particularly the exhaust valves. At the beginning of the compression stroke, each cylinder is filled with fresh, clean air which provides for efficient combustion.

The blower(s) supplies fresh air required for combustion and scavenging. The hollow three-lobe rotors are closely fitted into the blower housing(s) which is bolted to the cylinder block. The revolving motion of these rotors pulls fresh air through the air cleaner or 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).

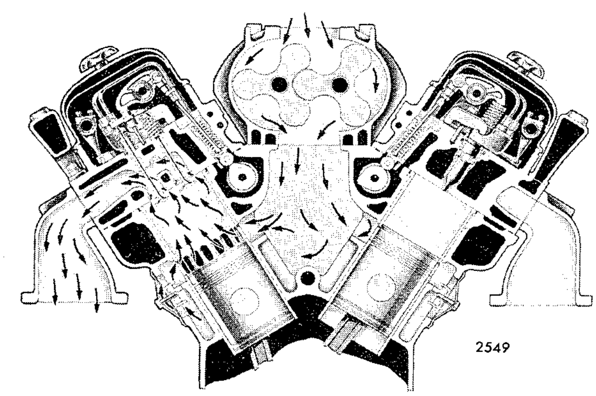


Fig. 5 – Air Intake System Through Blower and Engine

OIL BATH TYPE AIR CLEANERS

Several types of air cleaners are available for use with the V-71 engines. The light duty oil bath air cleaner (Fig. 6) is used with some marine models and a light or heavy-duty oil bath air cleaner (Fig. 7) is available for industrial engines. Some engines are equipped with a heavy-duty dry type air cleaner or a two-stage dry type air cleaner (Fig. 8). The air cleaners are designed for fast, easy disassembly to facilitate efficient servicing. Maximum protection of the engine against dust and other forms of air contamination is possible if the air cleaner is serviced at regular intervals.

The oil bath air cleaner consists of the body and fixed filter assembly which filters the air and condenses the oil from the air stream so that only dry air enters the engine. The condensed oil is returned to the cup where the dirt settles out of the oil and the oil is recirculated. A removable element assembly incorporated in the heavy-duty oil bath air cleaners removes a major part of the dust from the air stream thereby decreasing the dust load to the fixed element. An inner cup, which can be removed from the outer 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.

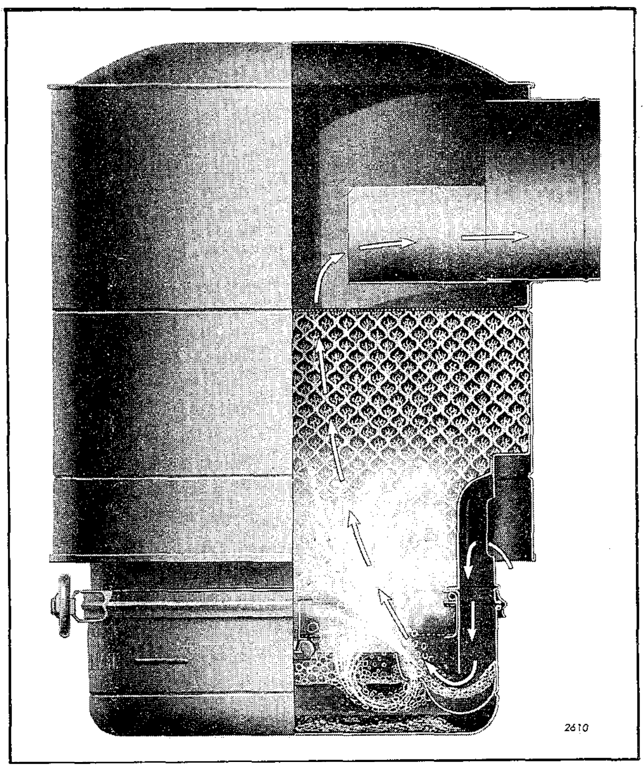


Fig. 6 - Typical Light-Duty Air Cleaner

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

1. Loosen the wing bolt and remove the air cleaner assembly from the air inlet housing. The cleaner may then be separated into two sections; the upper section or body assembly contains the filter element and 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.

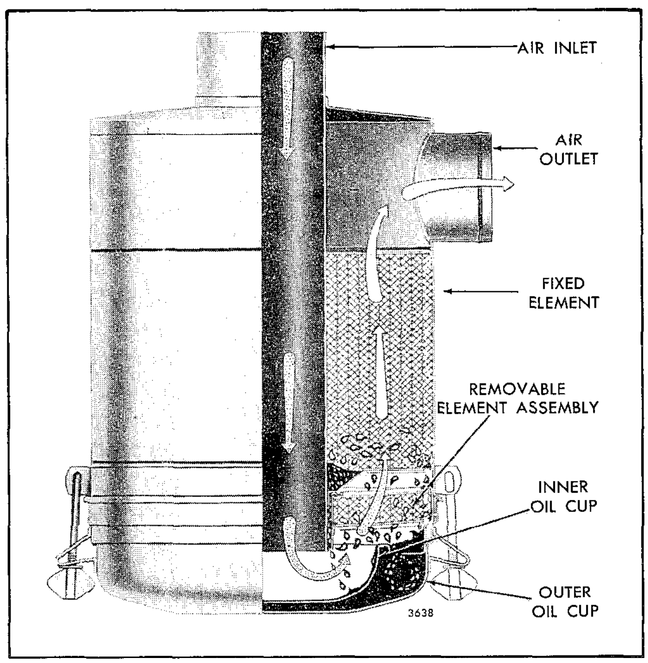


Fig. 7 - Heavy-Duty Oil Bath Air Cleaner

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 (Fig. 7) as follows:

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

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

3. Pour out the oil, separate the inner cup or baffle from the 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 as 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.

HEAVY-DUTY DRY-TYPE AIR CLEANER

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

Some air cleaners are equipped with an indicator which will aid in determining the servicing requirements.

Service the *dry-type* air cleaner as follows:

1. Loosen the wing bolt and remove the air cleaner assembly from the air inlet housing.

2. Detach the cover and wing bolt and remove the element. Then empty and wipe the dust cup clean.

3. Clean the filter element as follows: If the element is dry and dusty, use compressed air. The air should be blown through the element opposite to the normal direction of air flow.

4. If the element is oily or has soot deposits, use a water hose (less than 40 psi or 276 kPa) and wash with warm water and a non-sudsing detergent. Dry the element thoroughly.

5. Reassemble all of the air cleaner parts, place the assembly on the air inlet housing and secure it with the wing bolts.

TWO-STAGE DRY-TYPE AIR CLEANER

The dry-type air cleaner illustrated in Fig. 8 is designed to provide highly efficient air filtration under all operating conditions and is not affected by engine speed. The cleaner assembly consists of a centrifugal air cleaner in series with a replaceable impregnated paper filter element. The dust collected in the centrifugal cleaner is exhausted by connecting the dust bin to an exhaust gas aspirator. The centrifugal cleaner and replaceable filter element are held together in a steel housing. Positive sealing between the two elements and the housing is provided by rubber gaskets. The steel housing incorporates filter fasteners, mounting flanges and an outlet for the filtered air.

Operation

The deflector vanes (Fig. 9) impart a swirling motion to the air entering the air cleaner and centrifuge the dust particles against the walls of the tubes. The dust particles are then carried to the dust bin at the bottom of the cleaner by approximately 10% bleed-off air and are finally discharged into the atmosphere through an exhaust gas aspirator.

The exhaust gas aspirator is connected into the exhaust system of the engine (Fig. 10). A flexible hose carries the dust particles from the cleaner dust bin to the aspirator where the waste energy of the exhaust gases draws the dust-laden bleed-off air out and discharges it

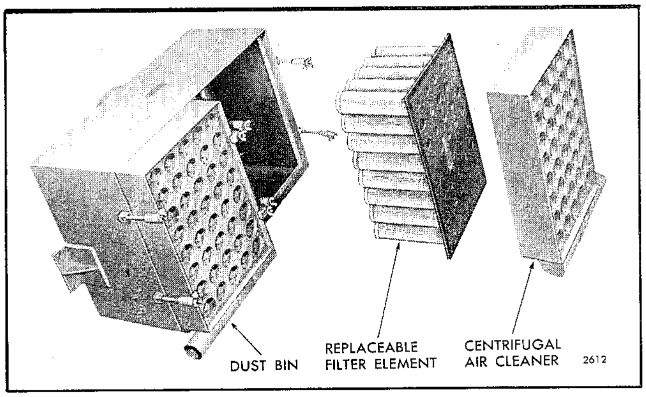


Fig. 8 - Dry Type Air Cleaner

into the atmosphere along with the engine exhaust gases. Approximately 90% of the total dust load is disposed of in this manner. The centrifugal air cleaner is fully effective at either high or low velocities.

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

An air cleaner restriction indicator (Fig. 10) may be attached near the outlet side of the cleaner. As the restriction in the cleaner increases, suction created will pull the indicator plunger upward. A brightly colored card, attached to the plunger and visible through a small window in the indicator, will indicate the relative amount of air restriction in the cleaner. When the card is fully visible, the air cleaner should be cleaned and

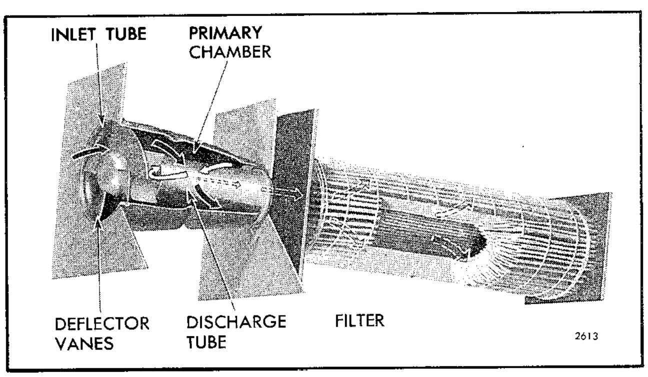


Fig. 9 - Flow of Air Through Filter Element Segment

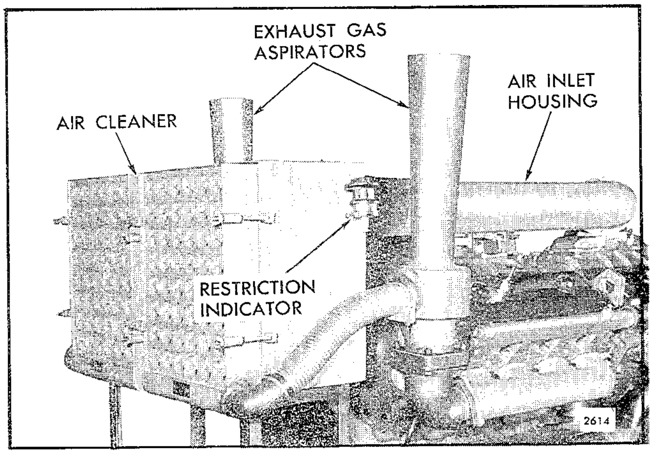


Fig. 10 - Typical Dry Type Air Cleaner Mounting

the indicator reset by pushing the plunger all the way up and then releasing it.

Service

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

The filter element may be replaced as follows:

1. Disconnect the flexible aspirator hose at the dust bin of the air cleaner.

2. Loosen the wing nuts on the filter fasteners and swing the retaining bolts away from the cleaner.

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

4. Withdraw the paper filter element and discard it.

5. Install a new filter element. New sealing gaskets are provided with the element to insure a positive air seal at all times.

6. Install the cleaner and secure it in place with the fasteners.

7. Connect the aspirator hose to the dust bin, making sure the connection is air tight.

AIR SILENCER

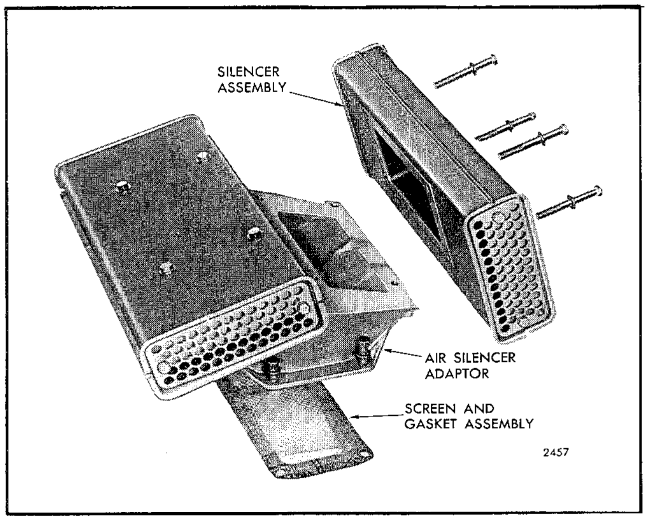


Fig. 11 - Silencer Assembly

The air silencer (Fig. 11), used on some marine models, is bolted to the air intake side of the blower housing. The silencer has a perforated steel partition welded in place parallel with the outside faces, enclosing flame proof, felted cotton waste which serves as a silencer for air entering the blower.

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

AIR BOX DRAINS

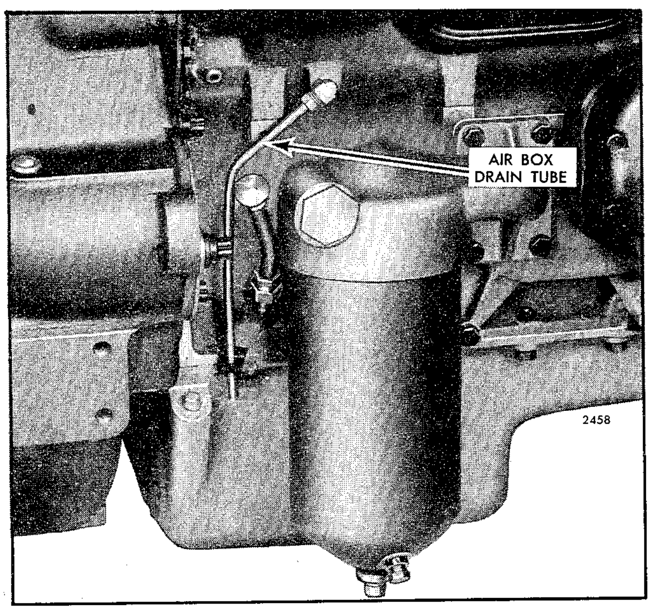


Fig. 12 - Air Box Drains

In normal operation, a slight amount of vapor from the air condenses and settles at the bottom of the air box. This condensation is drained through air box drain tubes (Fig. 12) which direct the expelled air and vapor down and away from the engine.

Air box drains must be open at all times, otherwise water and oil may accumulate in the air box and be drawn into the cylinders with the incoming fresh air. Therefore, periodic checks should be made to ensure they are open. Remove the air box covers and examine the air box floor for oil or an accumulation of water. If oil or water is found, wipe the air box dry with clean rags and remove and clean the air box drain tubes.

CRANKCASE VENTILATION

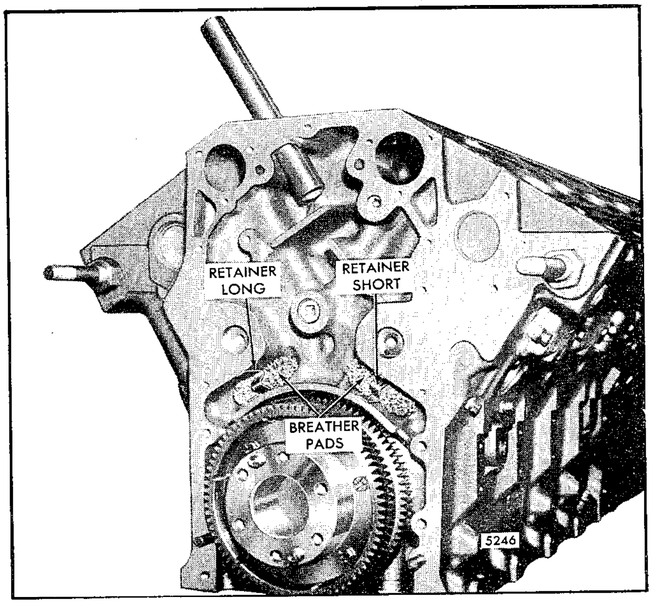


Fig. 13 - Breather Pads and Retainers Installed in Cylinder Block

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

Breathing is through two openings in the rear main bearing bulkhead of the crankcase, which connects to a chamber. Two crimped-steel mesh breather pads, which cover the openings (Fig. 13), filter out the oil as the vapors pass into the chamber.

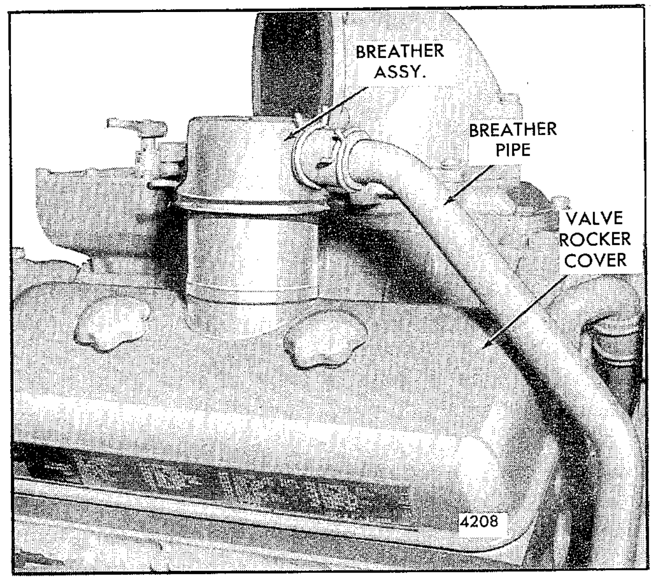


Fig. 14 - Typical Mounting of Breather Assemly on Valve Rocker Cover

A breather pipe is pressed into or flange mounted on top of the cylinder block to provide an exit for the crankcase vapors.

Some engines have an additional breather assembly mounted on the flywheel housing or on one of the valve rocker covers (Fig. 14).

LUBRICATING SYSTEM

The lubricating oil systems schematically illustrated in Figs. 15, 16 and 17 consist of an oil pump, oil cooler, a full-flow oil filter, by-pass valves at the oil cooler and filter and pressure regulator valves at the pump and in the cylinder block main oil gallery. Positive lubrication is ensured at all times by this system. A by-pass oil filter may also be incorporated into the lubricating system at the owner's option.

Oil for lubricating the connecting rod bearings and 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 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 and idler gear bearings. The blower drive gear is lubricated from the rear of the blower.

The oil pump on the 6 and 8V engines is driven by a pump drive hub on the front end of the crankshaft and consists of a large and small spur gear meshing in a cavity inside the crankshaft cover.

The gear-type oil pump used on the 12 and 16V engines is mounted on the main bearing caps. The pump on the 12V engine is driven from the front end of the crankshaft and on the 16V engine the pump, which is mounted on the No. 9 and 10 main bearing caps, is driven from the rear end of the crankshaft.

The pressure regulator valve, located at the end of a vertical oil gallery in the front of the cylinder block, maintains a stabilized oil pressure. The 16V engine has two pressure regulator valves located at the ends of

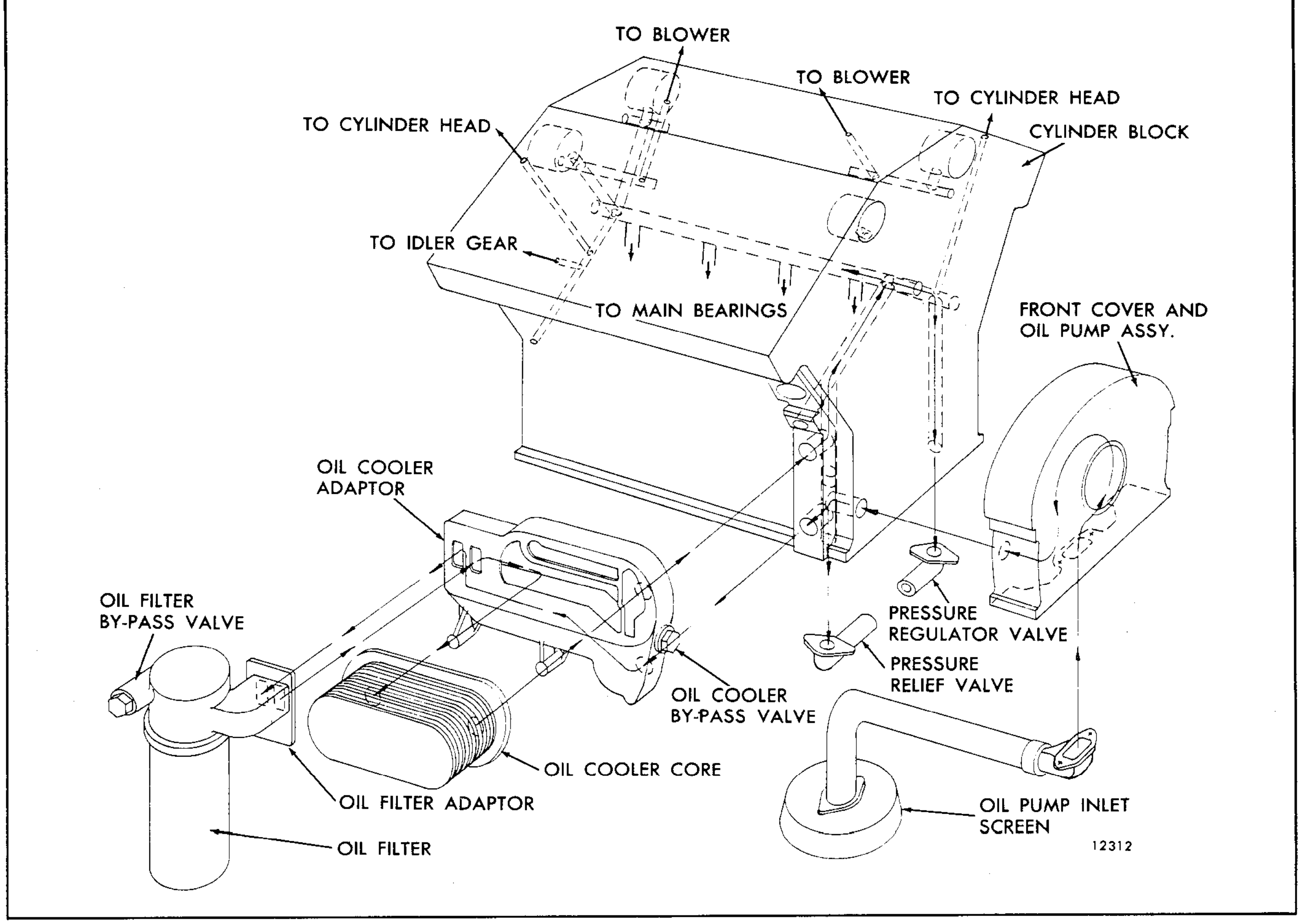


Fig. 15 - Schematic Diagram of Typical 6V and 8V Lubricating Systems

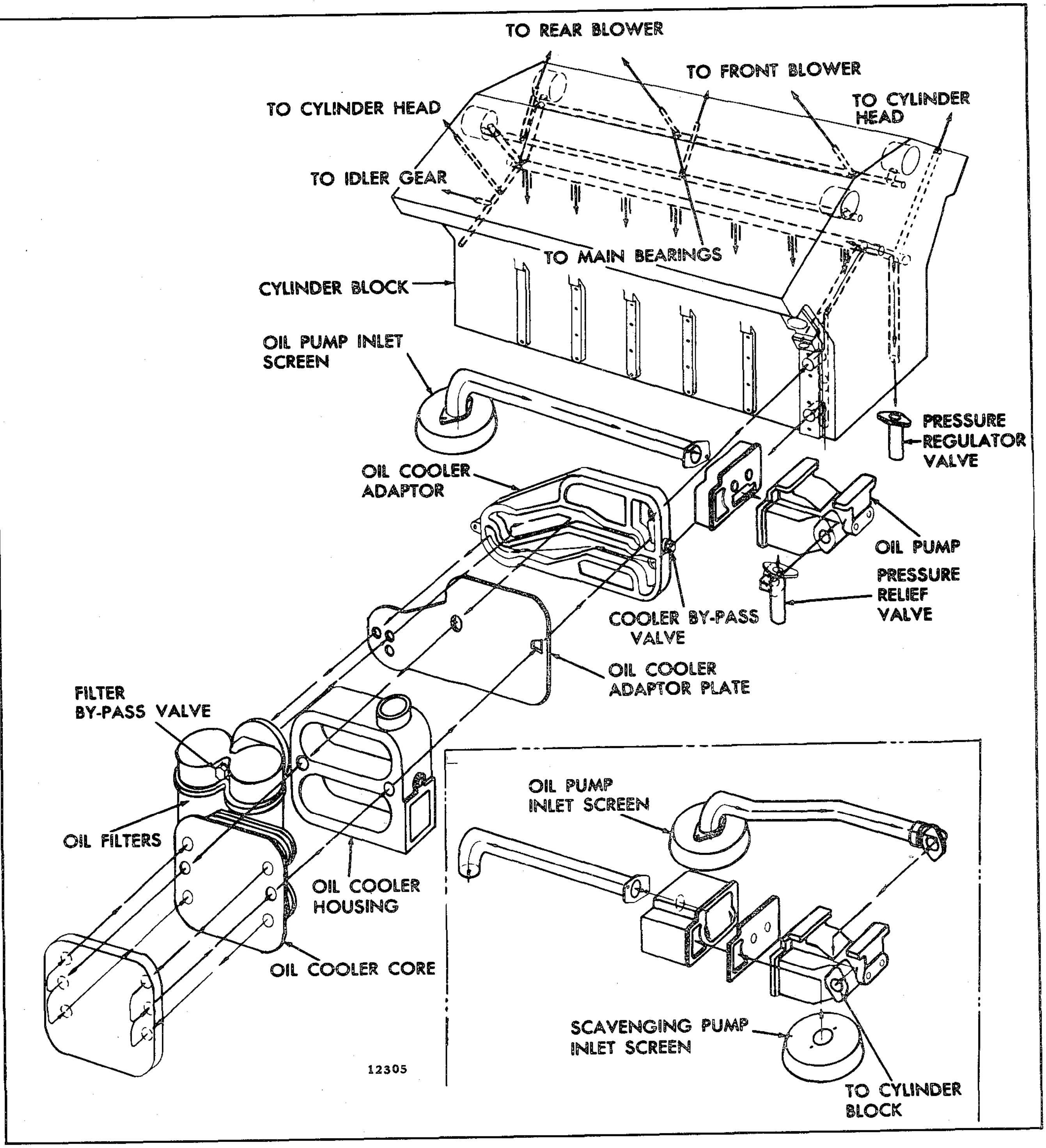


Fig. 16 - Schematic Diagram of Typical 12V Lubricating Systems

the vertical oil galleries. When the oil pressure at the regulator valve(s) exceeds 50 psi (345 kPa), the valve(s) open and discharge the excess oil to the sump.

Oil Filters

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

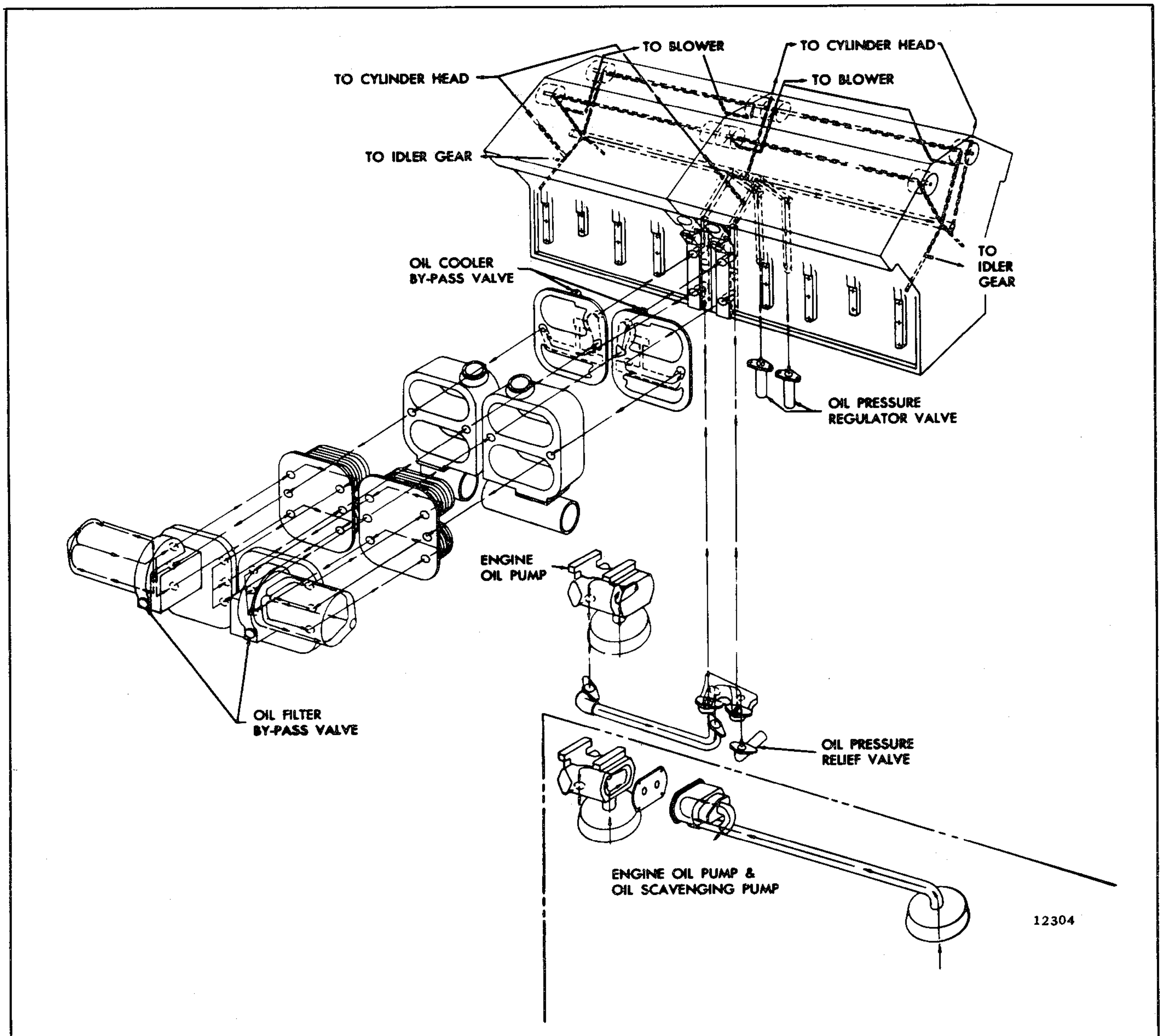


Fig. 17 - Schematic Diagram of Typical 16V Lubrication System

type oil filter may also be installed. The full-flow filter assembly can be remotely mounted or mounted on the engine as shown in Fig. 18. A by-pass valve, which opens at 15 psi (103 kPa), is located in the filter base to ensure engine lubrication in the event the filter should become plugged.

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

The by-pass filter assembly, 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 of the oil passes through the filter, filtering out minute foreign particles that may be present.

Some engines may be equipped with a by-pass filter assembly consisting of two filter elements, each enclosed in a shell which is mounted on a single base. An oil passage in the filter base connects the two annular spaces surrounding both filter elements.

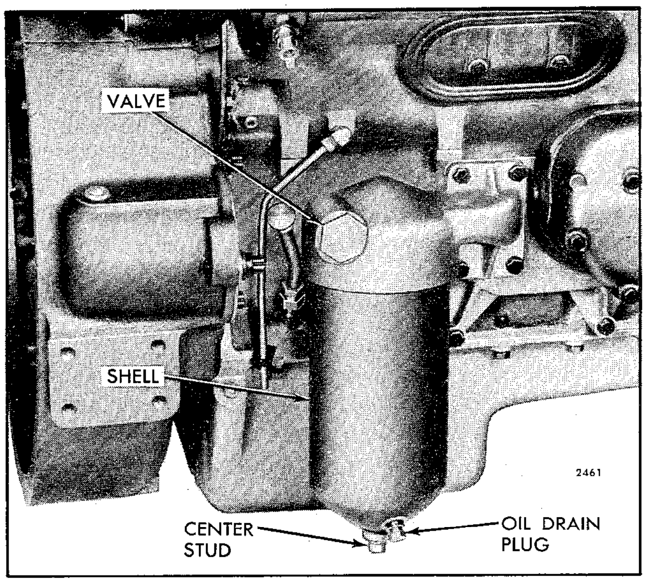


Fig. 18 - Typical Full-Flow Filter Mounting

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

1. Remove the drain plug and drain the oil (Fig. 18).

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

3. Clean the filter base.

4. Discard the used element, wipe out the filter shell and install a new element on the center stud.

5. Place a new gasket in the filter base, position the shell and element assembly on the gasket and tighten the center stud carefully to prevent damaging the gasket or center stud.

6. Install the drain plug and, after the engine is started, check for oil leaks.

COOLING SYSTEM

To effectively dissipate the heat generated by the engine, one of three different types of cooling systems is used on a V-71 engine; radiator and fan, heat exchanger and raw water pump, or keel cooling. Each system is provided with a centrifugal type water pump that circulates the engine coolant. Each system incorporates thermostats to maintain a normal engine operating temperature of 160-185°F (71-85°C). A typical cooling system is illustrated in Fig. 19.

Radiator and Fan Cooling

Coolant is drawn from the lower portion of the radiator by the water pump and is forced through the oil cooler housing and into the cylinder block. From the cylinder block the coolant passes up through the cylinder heads and, when the engine is at normal operating temperature, through the thermostat housings and into the upper portion of the radiator. Then the coolant passes down a series of tubes where the coolant temperature is lowered by the air stream created by the revolving fan.

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

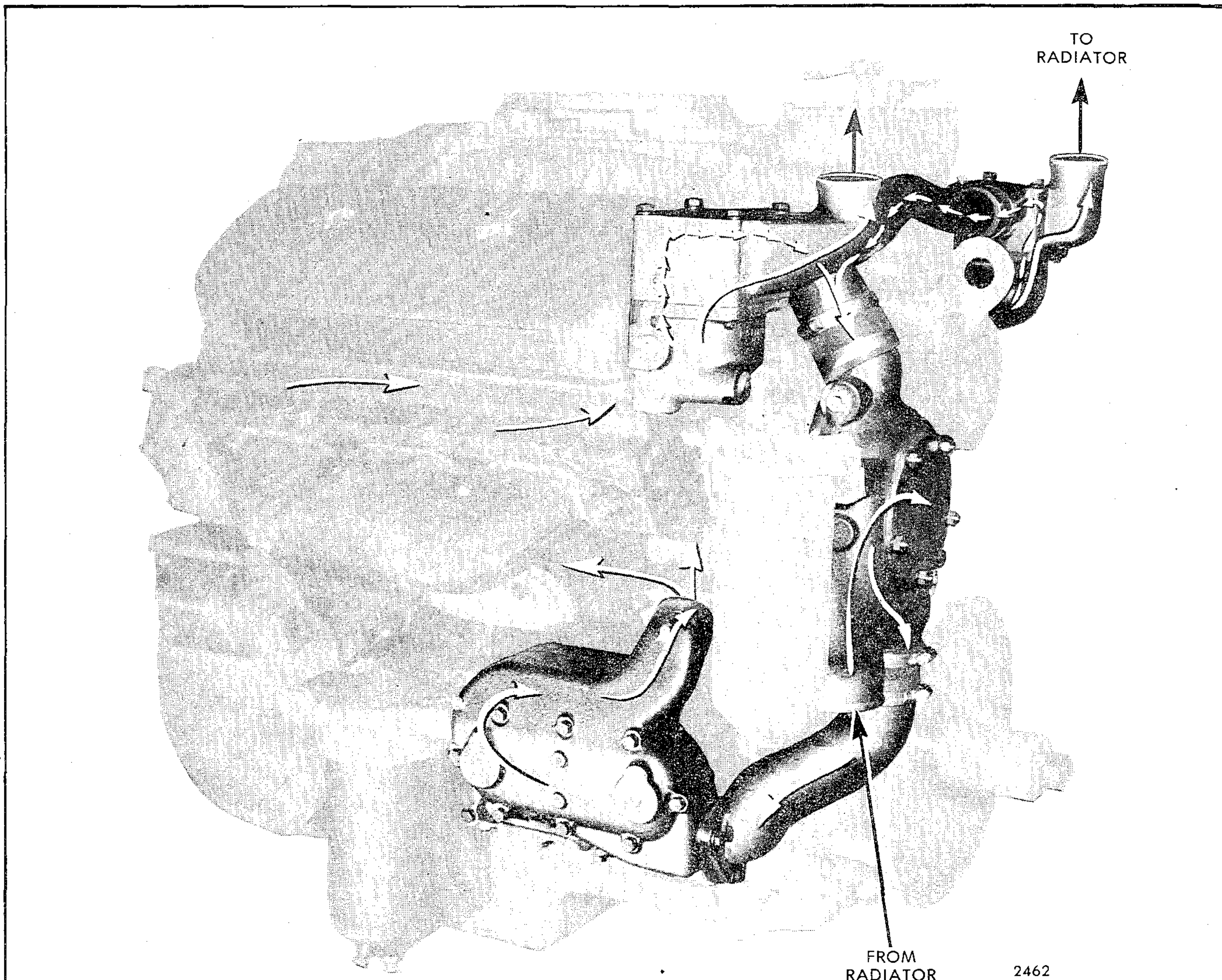


Fig. 19 - Cooling System

Heat Exchanger Cooling

In the heat exchanger cooling system, the coolant is drawn by the fresh water pump from the heat exchanger and is forced through the engine oil cooler, cylinder block, cylinder heads, exhaust manifolds and to the thermostat housings. A by-pass tube from the thermostat housings to the inlet side of the water pump permits circulation of the coolant through the engine while the thermostats are closed. When the thermostats open, the coolant can flow through the heat exchanger and then, after being cooled, to the engine fresh water pump for re-circulation.

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 governed by the kind of coolant used in the engine and the kind of raw water used. Soft water plus rust inhibitor or high boiling point type antifreeze should be used as the engine coolant.

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

Keel Cooling

In the keel cooling system, the coolant is drawn by the fresh water pump from the keel cooler and is forced through the engine oil cooler, cylinder block, cylinder heads, exhaust manifolds and to the thermostat housings. A by-pass tube from the thermostat housings to the inlet side of the water pump permits circulation of coolant through the engine while the thermostats are closed. When the thermostats open, the coolant can flow through the keel cooling coils and then to the suction side of the fresh water pump for re-circulation.

The heat of the engine coolant is transferred through the coils of the keel cooler to the surrounding water.

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 cylinder, 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 cooler.

COOLING SYSTEM CAPACITY
(BASIC ENGINE)

Engine	*WBP Block	
	gallons	litres
6V	7	27
8V	7-3/4	29
12V	13-3/4	52
16V	19-3/4	75
**16VTI	22	83

*Water-below-port cylinder block
**Estimated

TABLE 1

For the recommended coolant, refer to the section on *Engine Coolant.*

Cooling System Capacity

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

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

Fill Cooling System

Before starting the engine, close all of the drain cocks and fill the cooling system with water. If the unit has a raw water pump, it should also be primed, since operation without water may cause impeller failure. The use of clean, soft water will eliminate the need for de-scaling solutions to clean the cooling system. A hard, mineral-laden water should be made soft by using water softener chemicals before it is poured into the cooling system. These water softeners modify the minerals in the water and greatly reduce or eliminate the formation of scale.

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

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

Drain Cooling System

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

Drain cocks are located on each side of the cylinder block at both the front and rear of the engine. The drain cocks at the rear of the engine are below the exhaust manifold. The front surface of the cylinder block has drain cocks on each side above the engine front cover.

In addition to the drains on the block, the oil cooler housing has a drain cock at the extreme bottom. Radiators and other components that do not have a drain cock are drained through the oil cooler housing drain cock.

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

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

Raw water pumps are drained by loosening the cover attaching screws and tapping the cover gently to loosen it. After the water has drained, tighten the screws.

Flushing Cooling System

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

1. Drain the previous season's solution from the engine.

2. Refill the cooling system with soft clean water. If the engine is hot, fill slowly to prevent rapid cooling and distortion of the engine castings.

3. Start the engine and operate it for 15 minutes to circulate the water thoroughly.

4. Drain the cooling system completely.

5. Refill the system with the solution required for the coming season.

Cooling System Cleaners

If the engine overheats, and the fan belt tension and water level have been found to be satisfactory, clean and flush the entire cooling system. Remove scale formation by using a reputable and safe de-scaling solvent. Immediately after using the de-scaling solvent, neutralize the system with the neutralizer. It is important that the directions printed on the container of the de-scaler be thoroughly read and followed.

After the solvent and neutralizer have been used, completely drain the engine and radiator and reverse-flush before filling the system.

Reverse-Flushing

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

The radiator is reverse-flushed as follows:

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

2. Attach a hose at the top of the radiator to lead water away from the 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 30 psi (207 kPa) air pressure. Too great a pressure may rupture a radiator tube.

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

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

1. Remove the 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 cooling system hoses, thermostats and radiator pressure cap should be checked and replaced if found to be defective.

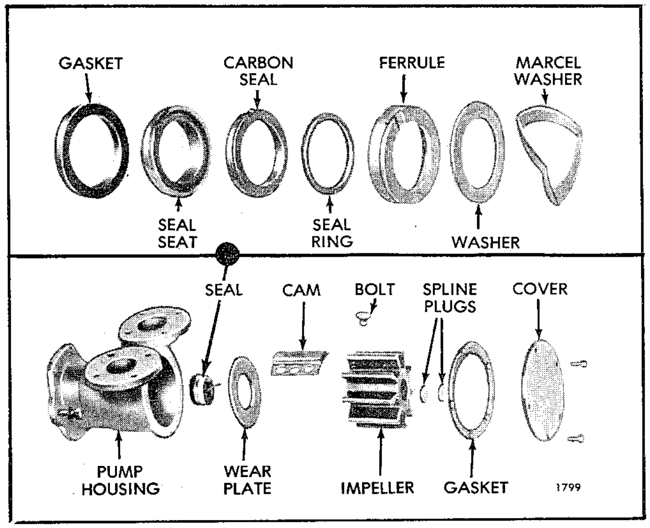


Fig. 20 – Raw Water Pump Details and Relative Location of Parts

When water connection seals and hoses are installed, be sure the connecting parts are properly aligned and the seal or hose is in its proper position before tightening the clamps. All external leaks should be corrected as soon as detected.

The fan belt must be checked and adjusted, if necessary, to provide the proper tension and the fan shroud must be tight against the radiator core to prevent re-circulation of air which may lower the cooling efficiency.

Water Pump

The centrifugal type water pump is mounted on the engine front cover and is driven by a front camshaft gear. This pump circulates the engine coolant through the cylinder block, cylinder head, heat exchanger or radiator and the oil cooler.

The pump consists of a bronze impeller secured to a stainless steel shaft with a lock nut. A gear is pressed on the opposite end of the shaft and the shaft turns on two ball bearings. An oil seal is used ahead of the front bearing and a spring-loaded face type water seal is used in back of the impeller. The pump ball bearings are lubricated with oil splashed by the water pump gear.

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

Raw Water Pump

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

The impeller (Fig. 20) is self-lubricated by the water pumped and should be primed before starting the engine.

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. 20). 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).

ENGINE EQUIPMENT

INSTRUMENT PANEL, INSTRUMENTS AND CONTROLS

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

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

Oil Pressure Gage

The oil pressure gage registers the pressure of the lubricating oil in the engine. As soon as the engine is started, the oil pressure gage should start to register. If the oil pressure gage does not register at least the minimum pressure listed under *Running* in the *Engine Operating Instructions*, the engine should be stopped and the cause of low oil pressure determined and corrected before the engine is started again.

Water Temperature Gage

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

Ammeter

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

Tachometer

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

Engine Starting Switch

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

Stop Knob

A stop knob is used on most applications to shut the engine down. When stopping an engine, the speed should be reduced to idle and the engine allowed to operate at idle for a few minutes to permit the coolant to reduce the temperature of the engine's moving parts. Then the stop knob should be pulled and held until the engine stops. Pulling on the stop knob manually places the injector racks in the "no-fuel" position. The stop knob should be returned to its original position after the engine stops.

NOTE: When an emergency shutdown is necessary on a current engine with the spring

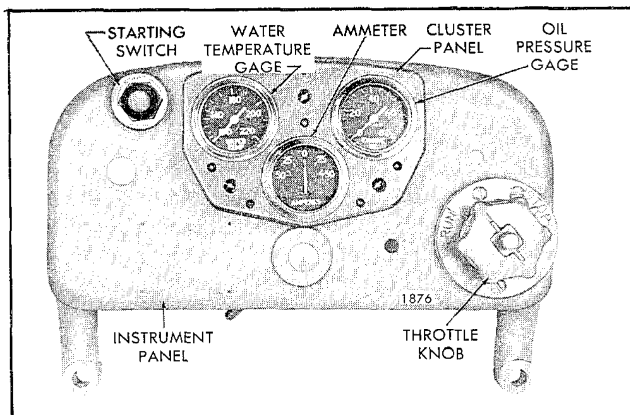


Fig. 1 - Typical Instrument Panel

loaded fuel injector control tubes (one adjusting screw) the stop knob should be pulled immediately and held until the engine stops.

Emergency Stop Knob (Engine with Air Shutdown Valves)

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

The emergency stop knob must be pushed back in after the engine stops so the air shut-off 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 SYSTEM

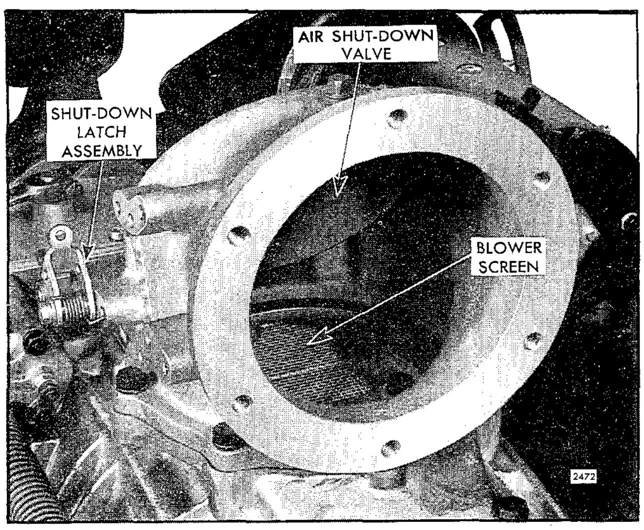


Fig. 2 - Manually Operated Emergency Engine Shutdown Valve Mounting

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

The air shut-off valve is retained in the open position by a latch. A wire or cable assembly is used to trip the latch. Pulling the emergency shutdown knob all the way out will stop the engine. After the engine stops, the operator must push the emergency shutdown knob all the way in and manually reset the air shut-off valve before the engine is started again.

AUTOMATIC MECHANICAL SHUTDOWN SYSTEM

The automatic mechanical shutdown system (Fig. 3) 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 inlet housing.

The pressure of the oil entering the bellows overcomes the tension of the bellows spring and permits the latch to retain the air shut-off valve in the open position. If the oil pressure drops below a predetermined value, the spring in the bellows will release the latch and

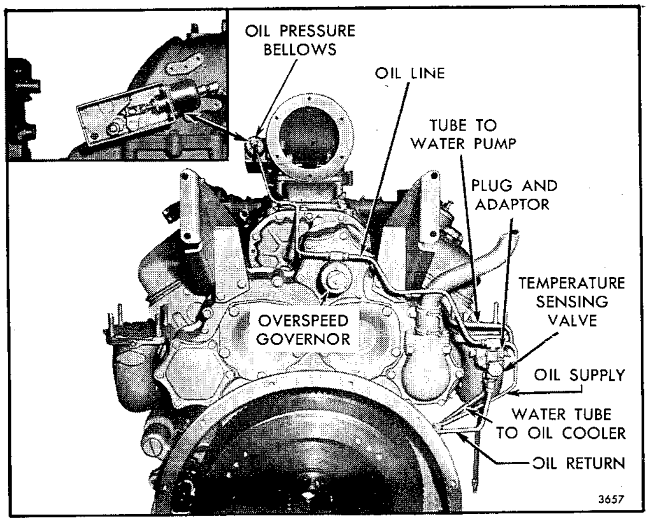


Fig. 3 - Automatic Mechanical Shutdown System Mounting

permit the air shut-off valve to close and thus stop the engine.

The overspeed governor (Fig. 4), 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 decreases the oil pressure to the bellows, thus actuating the shutdown mechanism and stopping the engine.

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 cylinder block oil gallery and the shutdown sensing devices.

Operation

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

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.

Adjustment

The only adjustments necessary in the mechanical shutdown system are the low oil pressure setting of the bellows and the overspeed setting of the overspeed governor or overspeed valve assembly. Replace the temperature-sensing valve when operation is unsatisfactory.

To adjust the low oil pressure setting of the bellows, start and run the engine until the normal operating temperature (160-185 °F or 71-85 °C) has been reached and the oil pressure has stabilized. Then reduce the engine speed slowly until the bellows disengages the latch on the air shut-off valve and stops the engine. Note the oil pressure at which the shut down occurred. The oil pressure at disengagement should be 5-10 psi (35-69 kPa) at 450-600 rpm; 10-15 psi (69-103 kPa) at 601-1400 rpm; or 15-20 psi (103-138 kPa) at 1401 and above rpm. If adjustment is necessary, loosen the lock nut on the bellows and turn the adjusting screw clockwise to increase the oil pressure setting or counterclockwise to decrease the setting. Hold the adjusting screw and tighten the lock nut when the proper setting has been obtained.

> **NOTE:** Set the bellows disengagement pressure as near as possible to the high end of the pressure range for the low engine speed specified for the engine. For an engine equipped with a dual speed governor, set the

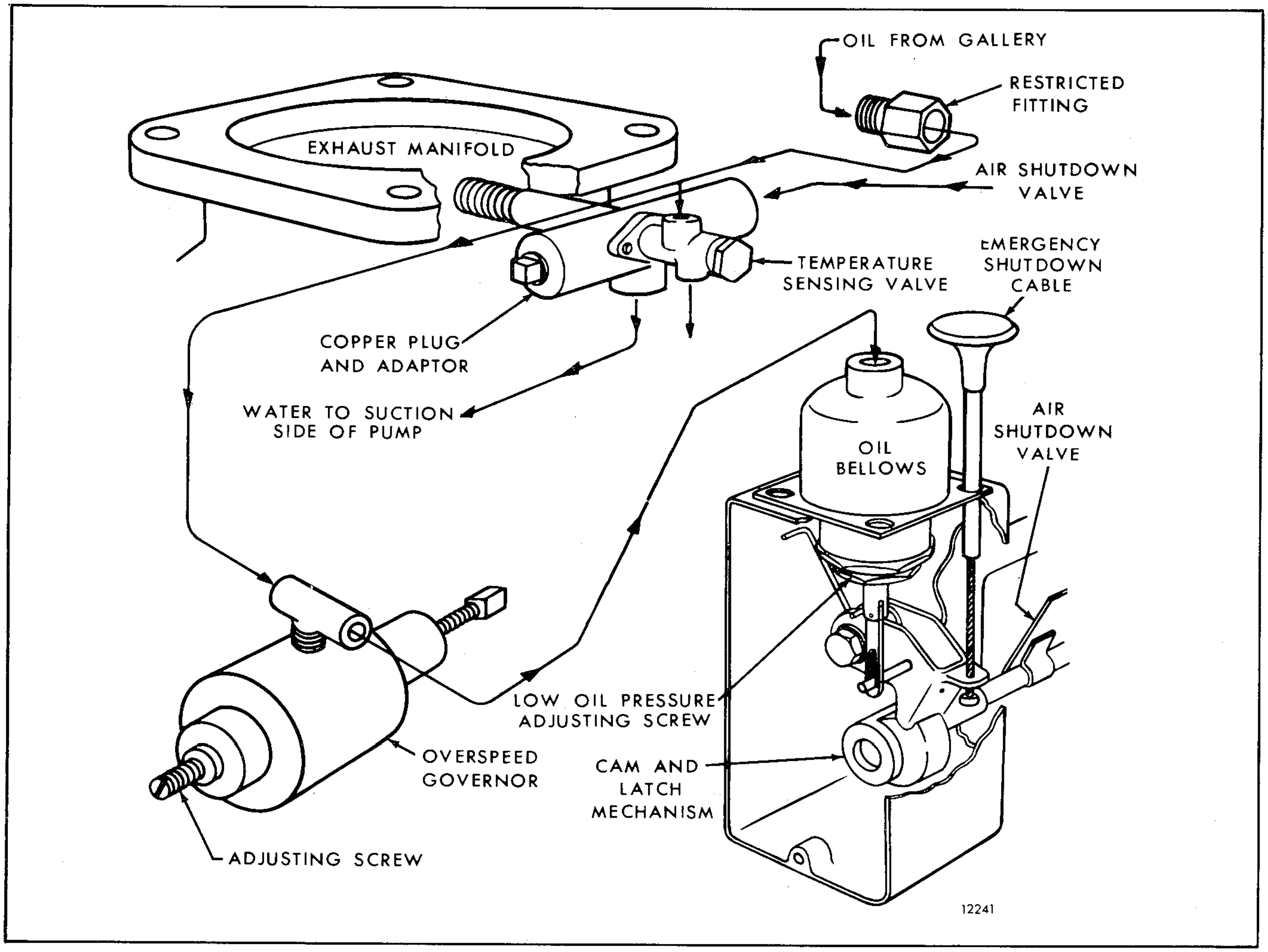


Fig. 4 - Schematic Drawing of Automatic Mechanical Shutdown System with Overspeed Governor

bellows disengagement at the lower setting of the engine governor.

Check the operation of the engine coolant temperature-sensing valve by placing a cover over the radiator while the engine is operating at part load and note the coolant outlet temperature at which the bellows disengages the air shutdown latch. The air shut-off valve should close and stop the engine within a temperature range of 200-210 °F (93-99 °C). If the engine is not shut down in this range, replace the temperature-sensing valve. If the engine is shut down below 200 °F (93 °C), check the coolant flow through the plug and adaptor assembly and, if circulation is satisfactory, replace the temperature-sensing valve.

NOTE: If a premature engine shutdown occurs, check the copper plug. A spring and plunger assembly are used with the current type plug to provide an unobstructed flow of coolant over the temperature-sensing valve element.

The temperature-sensing valve can be bench tested by attaching an air hose (40 psi or 276 kPa air supply) to the oil inlet side and installing a tube from the outlet side to a can of water. Then immerse the power element of the valve in a container of water that is heated and agitated. Check the temperature of the water with a thermometer. Apply air to the valve. The valve should be open, as indicated by the flow of air, at a water temperature of 195-206 °F (91-95 °C).

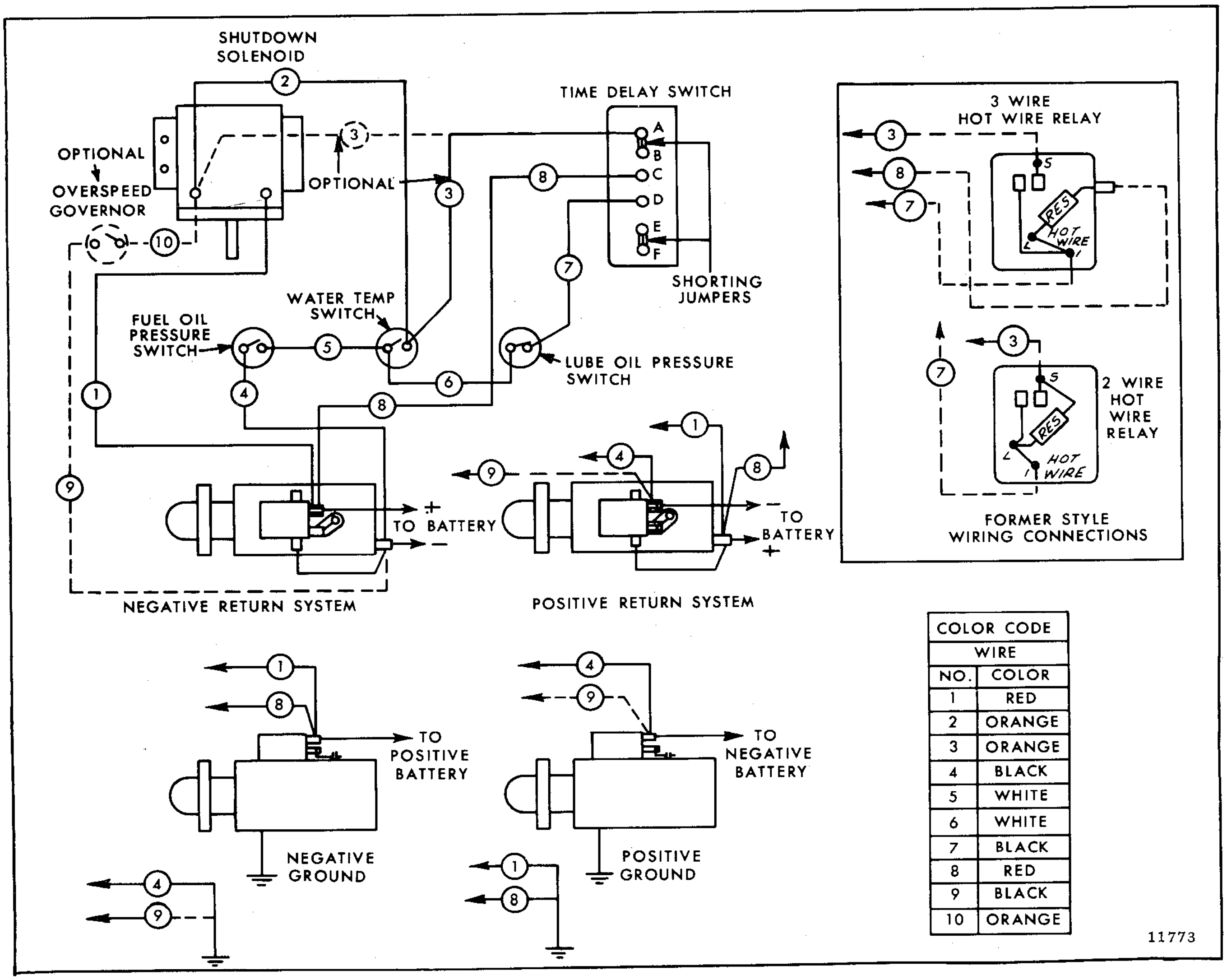
To adjust the overspeed governor, start and run the engine until normal operating temperature is reached. Then increase the engine speed to the desired overspeed shutdown speed. At this speed, the bellows should disengage the air shutdown latch and stop the engine. If necessary, adjust the overspeed governor setting by loosening the lock nut on the adjusting screw at the rear of the governor and turn the screw clockwise to increase the shutdown speed or counter-clockwise to decrease the shutdown speed. Then tighten the lock nut, while holding the adjusting screw, when the proper setting is obtained.

AUTOMATIC ELECTRICAL SHUTDOWN SYSTEM

The automatic electrical shutdown system shown in Fig. 5 protects the engine against a loss of coolant, overheating of the coolant, loss of oil pressure, or overspeeding. In the event one of the foregoing conditions arises, a switch will close the electrical circuit and energize the solenoid switch, causing the shutdown solenoid to release the air shutdown latch and stop the engine.

Operation

The electrical circuit is de-energized under normal operating conditions. When the engine is started, one oil pressure switch opens when the oil pressure reaches approximately 5 psi (35 kPa) and the fuel oil pressure switch closes at approximately 20 psi (138 kPa) fuel pressure. As the engine speed increases, the second oil pressure switch opens at approximately 27 psi (186 kPa) and at 1000–1100 rpm, the No. 1 switch in the overspeed governor will close. The water temperature switch remains open.



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

Fig. 5 – Automatic Electrical Shutdown System Diagram

If the oil pressure drops below 27 psi (186 kPa), the oil pressure switch will close the circuit and energize the shutdown solenoid. This will activate the shutdown mechanism and stop the engine.

A loss of coolant or an increase in coolant temperature to approximately 203° F (94° C) will close the contacts in the water temperature switch, thus closing the electrical circuit and activating the shutdown mechanism.

The water temperature switch consists of a temperature-sensing valve and a micro-switch. The valve contacts a copper plug (heat probe) which extends into the exhaust manifold outlet. Engine water is directed over the power element of the valve and should the water temperature exceed approximately 203° F (94° C), the valve will close the contacts in the micro-switch and energize the shutdown circuit. If a loss of water occurs, the heat of the exhaust gases will be transmitted through the copper plug to the temperature-sensing valve and cause the shutdown circuit to be activated.

If the engine speed exceeds the high speed setting of the overspeed governor, the No. 2 governor switch will close and activate the shutdown mechanism.

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

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

Some engines are equipped with an electrically operated automatic shutdown system which incorporates a hot wire relay and one oil pressure switch (Fig. 5).

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

When the lubricating oil pressure falls below 10 ± 2 psi (69 ± 14 kPa), the contacts in the oil pressure switch used in this system will close and current will flow to the hot wire relay. The few seconds required to heat the hot wire relay provides sufficient delay to avoid an engine shut down when low oil pressure is caused by a temporary condition such as an air bubble or a temporary overlap in the operation of the oil pressure switch and the fuel oil pressure switch when starting or stopping the engine.

Depending upon the particular shutdown system used, the high water temperature switch may be installed in one of the openings in the water manifold, or the temperature-sensing valve and micro-switch unit may be installed in the exhaust manifold outlet.

In some electrical shutdown applications, the temperature-sensing valve and the copper plug used in the mechanical shutdown system is utilized. The lubricating oil pressure switch is installed in the oil line to the valve. When an increase in water temperature causes the valve to open and permits the oil to flow back to the crankcase, the resulting decrease in oil pressure will close the oil pressure switch and energize the electrical shutdown circuit. Low engine oil pressure will also cause the contacts in the oil pressure switch to close and energize the shutdown circuit.

ALARM SYSTEM

The alarm system shown in Fig. 6 is similar to the automatic electrical shutdown system, but uses a warning bell in place of the air shut-off valve solenoid. The bell warns the engine operator if the engine coolant overheats or the oil pressure drops below the safe operating limit.

When the engine is started and the oil pressure is sufficient to open the oil pressure switch contacts (opening pressure is stamped on the switch cover), the alarm switch must be turned on manually to put the system in operation. The water temperature switch is normally open. Should the engine coolant exceed 200-205° F (93-95° C), the water temperature switch will close the electrical circuit and sound the alarm bell.

Likewise, if the oil pressure drops below the setting of the oil pressure switch, the switch will close and cause the bell to ring. The bell will continue to ring until the engine operator turns the alarm switch off. The alarm switch must also be turned off before a routine stop since the decreasing oil pressure will close the oil pressure switch and cause the bell to ring.

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

An alarm bell may be connected to the electrical shutdown system as shown in Fig. 7. In this system, if

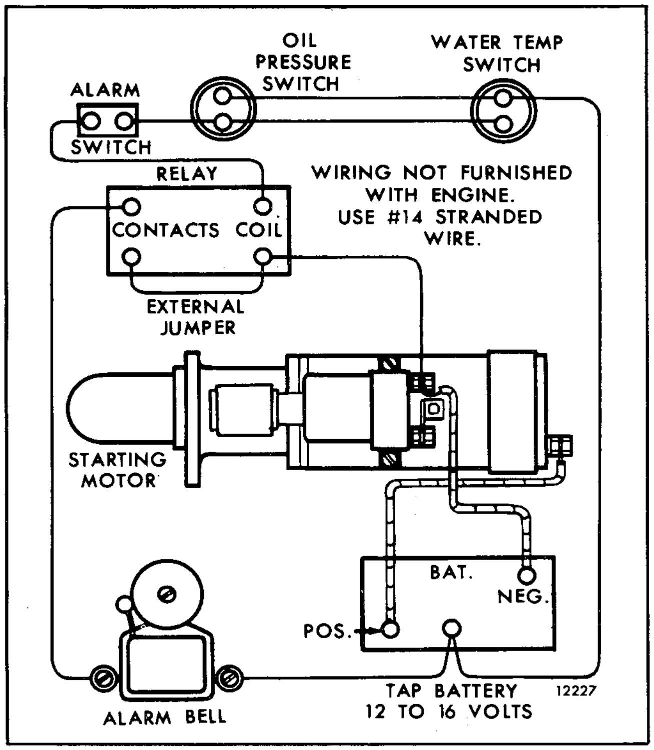


Fig. 6 - Alarm System Wiring Diagram

an abnormal condition occurs, the engine will be stopped automatically and the alarm bell will ring to notify the operator. The bell will continue to ring until the operator pushes the reset button on the drop relay.

The alarm system illustrated in Fig. 8 utilizes the temperature-sensing valve and the low oil pressure and overspeed valve used in the mechanical shutdown system.

When the engine is started, the oil pressure switch will open when the oil pressure reaches 10 psi (69 kPa) and the fuel oil pressure switch will close when the fuel pressure reaches 20 psi (138 kPa). If overheating or loss of engine coolant occurs, the temperature-sensing valve will open and permit the oil to flow to the crankcase. The resulting drop in oil pressure will permit the contacts in the oil pressure switch to close and complete the electrical circuit to the alarm bell. A loss of engine oil pressure or overspeeding of the engine will cause the oil pressure and overspeed valve to open and activate the alarm system. Once the alarm system is activated, the bell will continue to ring until the engine operator stops the engine.

During a routine engine shut down, the decreasing

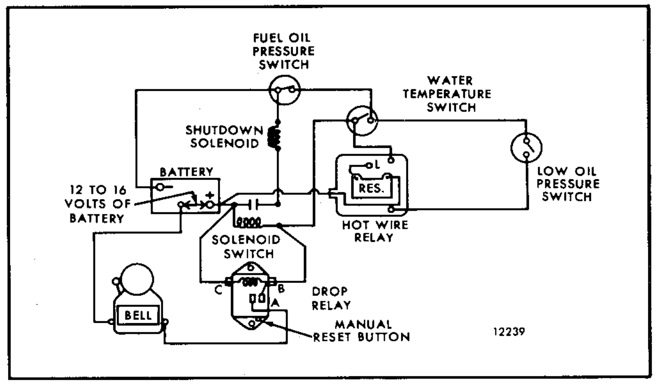


Fig. 7 - Alarm Bell Connected to Electrical Shutdown System

fuel pressure causes the fuel pressure switch to open the electrical circuit before the decreasing oil pressure can activate the alarm system.

On 16V-71 engines, coolant protection is also obtained through an exhaust probe and adaptor assembly and a temperature switch. In this system, the engine coolant is circulated around the switch power element to prevent the switch from being activated by the heat transfer from the exhaust probe. Therefore, an alarm will occur if coolant flow through the adaptor is interrupted for any reason. The switch will also operate when the engine coolant discharge temperature exceeds 200-205 °F (93-95 °C).

The oil pressure switch, mounted in the low oil pressure and overspeed valve (Fig. 8), will be activated to sound the alarm when the engine oil pressure drops below the safe operating pressure. The switch will also detect an engine overspeed. Engine oil is supplied to the valve. Should the engine oil pressure drop below a safe operating value, above 1200 rpm, the valve will operate, dropping the oil pressure at the switch which completes the circuit and sounds the alarm. Below 1200 rpm the oil pressure switch will close whenever the oil pressure is less than the switch setting.

Engine overspeed is detected by the operation of the valve which results in the oil switch closing. The travel of the piston in the valve, which is adjustable, controls the overspeed setting.

The relay is used to prevent damage to the pressure and temperature switches should the current to operate the alarm device be too high.

Should the alarm be activated for any reason, the engine should be stopped immediately and the cause found and corrected before the engine is started again.

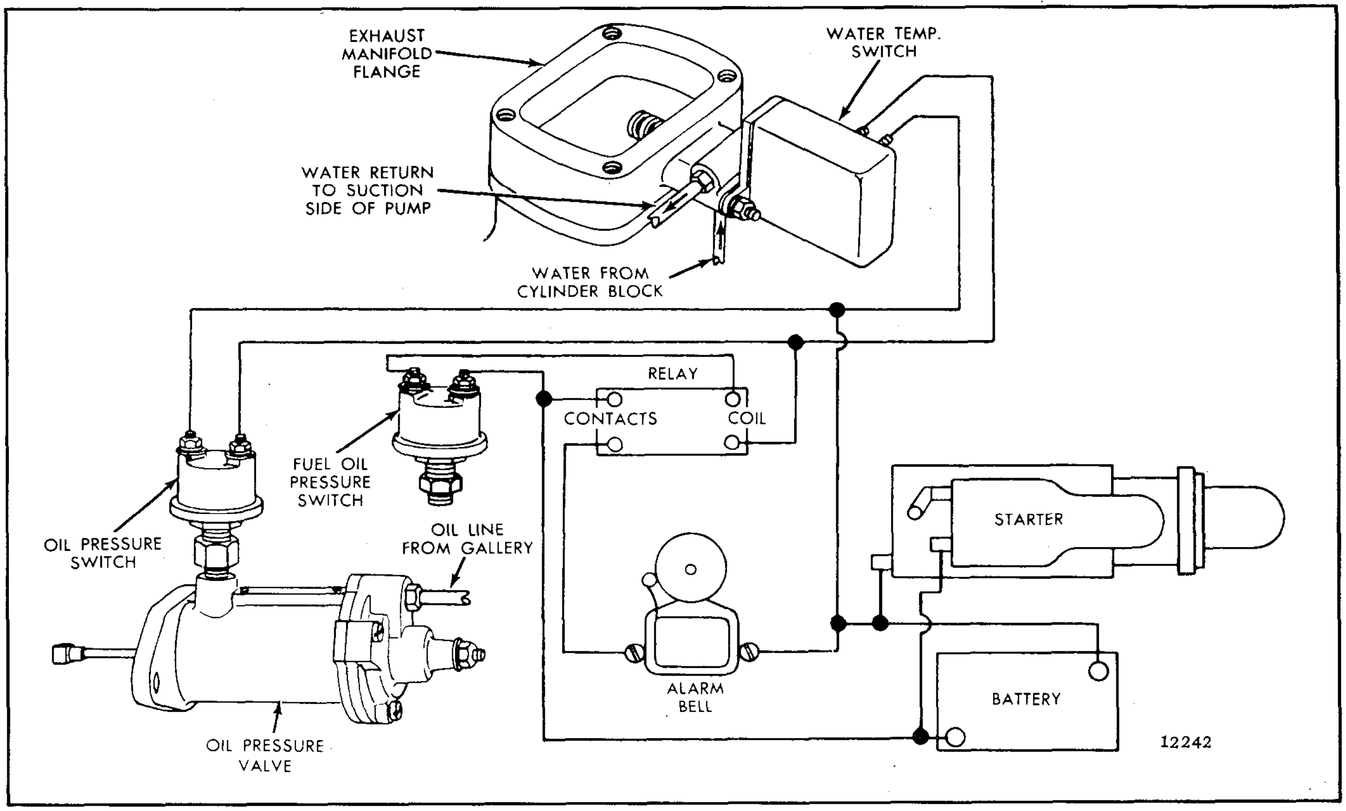


Fig. 8 - Alarm System with Mechanical Sensing Units

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 A.C. generator (alternator). The diodes and transistors in the alternator circuit are very sensitive and can be easily destroyed.

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

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

Accidentally reversing the battery connections must be avoided.

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

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

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

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

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

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

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

Regulator

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

Storage Battery

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

The battery has three major functions:

1. It provides a source of electrical power for starting the engine.

2. It acts as a stabilizer to the voltage in the electrical system.

3. It can, for a limited time, furnish current when the electrical demands of the unit exceed the output of the alternator.

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

1. Check the level of the electrolyte regularly. Add water if necessary, but do not overfill. Overfilling can cause poor performance or early failure.

2. Keep the top of the battery clean. When necessary, wash with a baking soda solution and rinse with fresh water. Do not allow the soda solution to enter the cells.

3. Inspect the cables, clamps and hold-down bracket regularly. Clean and re-apply a light coating of grease when needed. Replace corroded, damaged parts.

4. Use the standard, quick in-the-unit battery test as the regular service test to check battery condition.

5. Check the electrical system if the battery becomes discharged repeatedly.

> **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.

COLD WEATHER STARTING AIDS

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

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

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

FLUID STARTING AID

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

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

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

Start the engine, using the fluid starting aid, as follows:

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

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

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

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

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

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

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

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

Service

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

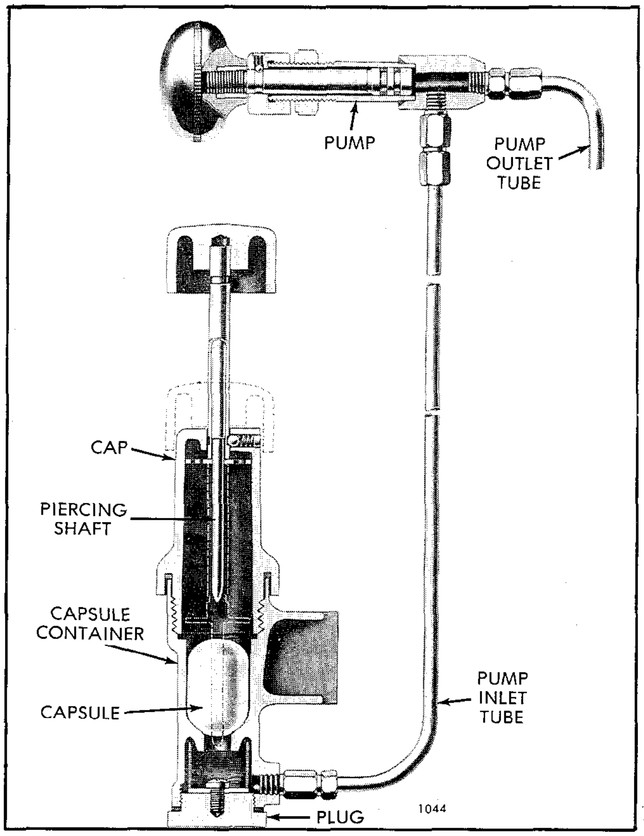


Fig. 9 - Typical Fluid Starting Aid

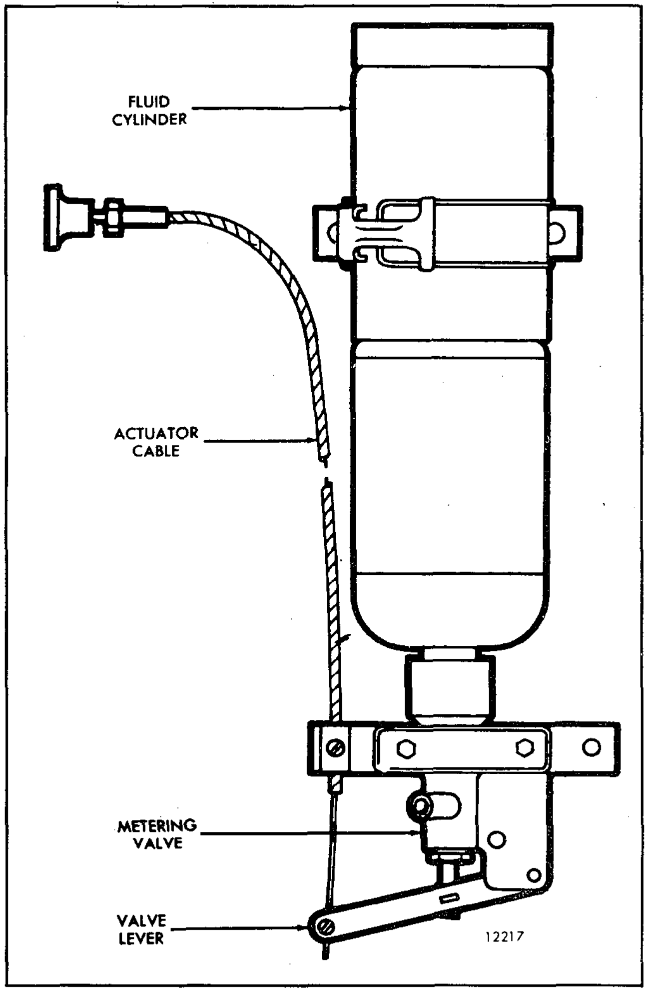


Fig. 10 - Quick Start Assembly

PRESSURIZED CYLINDER STARTING AID

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

1. Press the engine starter button.

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

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

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

Service

Periodically perform the following service items to assure good performance:

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

2. Lubricate the actuator cable.

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

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

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

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

> **NOTE:** Do not actuate the starting aid more than once with the engine stopped. *Over-loading the engine air box with this high volatile fluid could result in a minor explosion.*

7. Check the fluid cylinder for hand tightness.

GOVERNORS

Engine Governors

Horsepower requirements of an engine may vary continually due to the fluctuating loads; therefore, a means must be provided to control the amount of fuel required to hold the engine speed reasonably constant during such load fluctuations. To accomplish this control, one of three 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 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.

Lubrication

Mechanical governors are lubricated by oil that is sprayed from an orifice in the front blower end plate. This orifice directs a stream of oil into the revolving governor weights. The weights throw the oil to all moving parts within the governor.

Surplus oil returns to the engine crankcase through connecting passages in the blower and cylinder block.

When an engine equipped with a hydraulic governor is running, oil is supplied under pressure from the engine to the governor and a portion of the oil flows past the power piston and pilot valve plunger to lubricate the moving parts in the governor housing.

Oil which collects on the floor of the governor housing drains into the drive housing, thus providing lubrication for the drive and driven shafts and their bearings. If the engine should fail to supply oil to the governor, the power piston will drop allowing the fuel rod to return to the no-fuel position; thus the hydraulic governor also acts as an automatic shut-down device.

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.

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 power take-off unit is attached to either an adaptor (front power take-off) or the engine flywheel housing (rear power take-off). Each power take-off unit has a single or double plate clutch. The drive shaft is driven by the clutch assembly and is supported by a pilot bearing in the flywheel or the adaptor and by two tapered roller bearings mounted in the clutch housing.

Clutch Adjustment

These instructions refer to field adjustment for clutch facing wear. Frequency of adjustment depends upon the amount and nature of the load.

To ensure a long clutch facing life and the best performance, the clutch should be adjusted before slippage occurs.

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

Adjust the 8 ", 11-1/2 " and 14 " diameter clutches as follows:

1. Disengage the clutch with the hand lever.

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

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

4. On the 8 " and 11-1/2 " diameter clutches, remove the clutch adjusting ring spring lock screw and lock from the inner clutch pressure plate and adjusting ring. Then, while holding the clutch drive shaft to prevent the clutch from turning, turn the clutch adjusting ring counterclockwise as shown in Fig. 11 and tighten the clutch until the desired pressure on the outer end of the hand lever, or at the clutch release shaft (Fig. 14), 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 as shown in Fig. 12 and tighten the clutch until the desired pressure on the

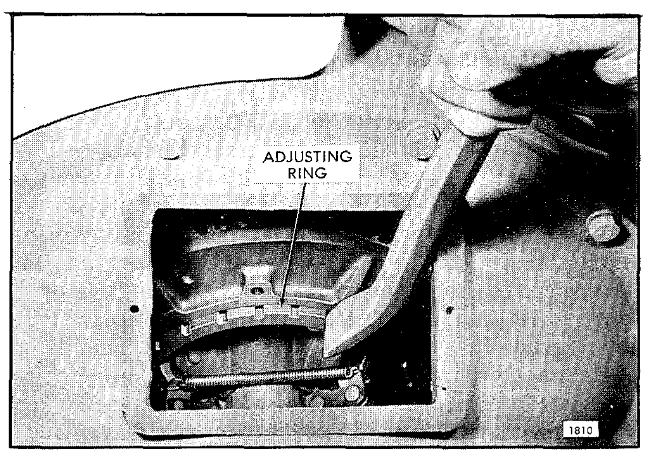


Fig. 11 - Power Take-Off Showing Typical 8 and 11-1/2 Inch Diameter Clutch Adjustment Ring

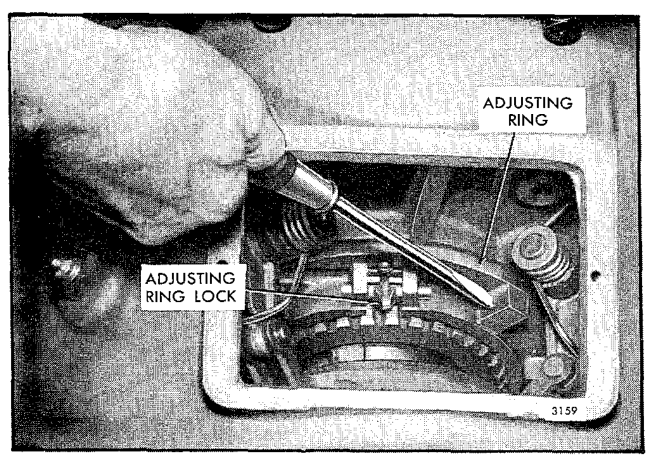


Fig. 12 - Power Take-Off Assembly Showing 14 Inch Diameter Clutch Adjustment Ring

outer end of the hand lever, or at the clutch release shaft (Fig. 14), 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.

Adjust the 18 " diameter clutch as follows:

1. Rotate the clutch, if necessary, to bring the adjustment lock and the pinion within reach through the inspection hole.

2. Loosen the lock bolt and pull the lock out of mesh with the adjusting ring; then, tighten the lock bolt to hold the lock out of the adjusting ring. While holding the clutch drive shaft to prevent the clutch from turning, turn the adjustment pinion clockwise to tighten the clutch as shown in Fig. 13.

3. Loosen the lock bolt and move the lock so it will mesh with the teeth of the adjusting ring, then tighten the lock bolt.

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

Clutch Dia.	Hand Lever Length	Pressure		Torque	
		psi	kPa	lb-ft	Nm
8"	20"	40	276	56-63	76-85
11-1/2"	20"	65	448	94-100	127-36
14"	25"	75	517	132-149	179-202
18"	40-3/8"	90	621	278-298	379-404

TABLE 1

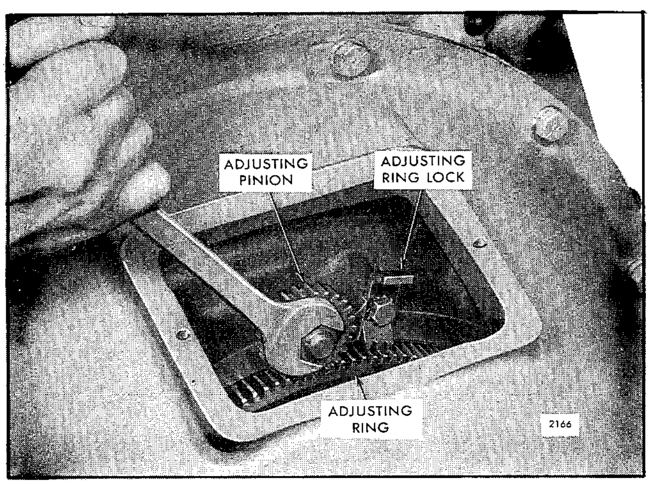


Fig. 13 - Power Take-Off Assembly Showing Method of Adjusting 18 Inch Diameter Clutch

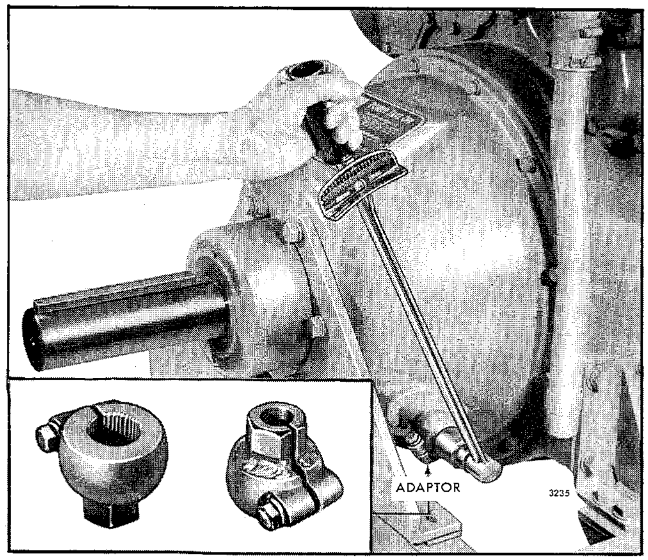


Fig. 14 - Checking Power Take-Off Clutch Adjustment with Torque Wrench and Adaptor

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 clutch adjustment is with a torque wrench as shown in Fig. 14.

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. 14. Then saw a slot through the nut.

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

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

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

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

TORQMATIC MARINE GEAR

The Torqmatic marine gear is used on 6V and 8V single engine marine units and tandem twin marine units. The marine gear consists of a reverse gear section and a reduction gear section. Each marine gear is available in several gear ratios.

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 130-155 psi (896-1068 kPa) and 110-150 psi (758-1034 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.

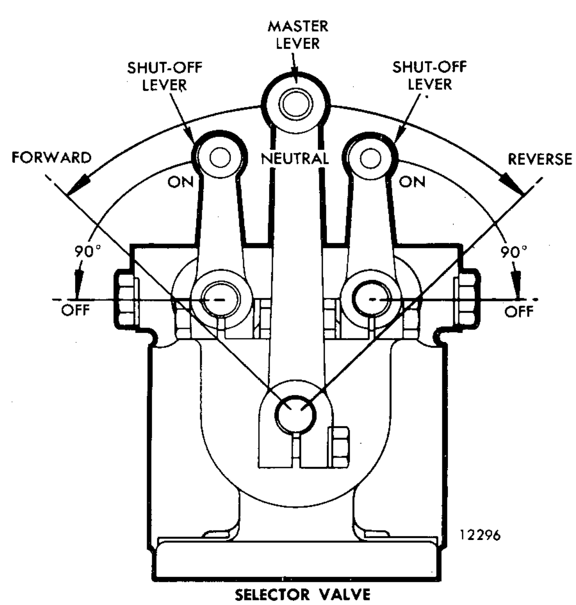


Fig. 15 - Lever Arrangement on Tandem Twin Engine Marine Gear Selector Valve

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 tandem twin marine engine unit is provided with several levers (Fig. 15). The master control lever engages both marine gears in forward or reverse simultaneously. The smaller levers, one for each engine, operate the shut-off control valves for controlling the flow of oil to each individual engine marine gear. These levers are normally set in a vertical position ("on" position). To shutdown one engine for service work or to conserve on power in a light load situation, place the master control lever in the neutral position and then turn the shut-off lever for that engine to the "off" position (90 degrees toward the engine). With the shut-off lever in the "off" position, the marine gear for that engine is locked out of engagement. The other engine can then continue to supply power to the gear box.

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

It is recommended that all sailing vessels and boats utilizing the Torqmatic marine gears (single or twin screw installations) have a locking (brake) device 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 rotation of the propeller shaft is prevented.

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

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

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

3. Remove the bolt from the flywheel.

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

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

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

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

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

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

TWIN DISC MARINE GEAR

A Twin Disc marine gear is used on certain V-71 marine engines. This marine gear has two hydraulically operated multi-disc clutches to provide forward and reverse operation.

The marine gear has an oil sump capacity of approximately six gallons (22.71 litres). An oil pump driven by the reverse shaft operates whenever the engine is operating. This pump draws oil from the sump through a suction strainer, protecting the pump from foreign particles in the oil. The oil discharged from the pump flows through an oil cooler, mounted on the side of the engine, and then returns to the marine gear housing. The oil upon entering the gear housing passes through an integral oil filter and then to the selector valve. A by-pass valve across the filter prevents the stoppage of oil flow to the selector valve in the event the filter becomes clogged.

Some units incorporate a trolling valve which is mounted between the selector valve and the forward clutch. This valve is a relief valve with manual control over the relief valve spring. Movement of the trolling valve by the operator drops the forward clutch operating pressure to a point where the multi-disc clutch plates slip. Further movement of the valve increases the slippage. This permits very low propeller speeds necessary for some fishing operations. The entire oil spill from the trolling valve, in dropping the pressure, is directed through the plates of the forward slipping clutch. This provides a film of oil on which the plates ride and removes any heat generated.

The marine gear is driven by the engine through synthetic rubber caps molded in a gear tooth form. The rubber caps are mounted on the teeth of the spider gear and mesh with the flywheel drive ring. They cushion the drive from the engine to the marine gear.

Emergency Operation

In case of emergency shifting from forward to reverse at higher than normal engine speeds, the selector and pressure regulating valve should have a 1/2 second pause in neutral so that it can control the rate of pressure rise. This causes 3/4 to 1 1/2 second delay before full pressure is applied to the selected clutch. Thus, sudden shock on the gears and shafts is reduced. Complete reversal of the propeller is recommended only at reduced engine speeds.

Emergency Engagement

Should a failure impair the hydraulic system of the marine gear, the desired clutch, either forward or reverse, can be engaged manually. The manual engagement is accomplished by removing three pipe plugs, protruding from the rear of the transmission, in line with the desired clutch to be engaged. Then bar the engine output shaft over until the three emergency engagement bolts are in line with the holes. Alternately tighten the three bolts uniformly until the clutch is locked in engagement. Reinstall the pipe plugs.

The engine, when started with the selector valve in neutral, will drive the propeller through the engaged clutch. No attempt should be made to move the selector valve from the neutral position since engagement of the other clutch may cause damage.

TORQMATIC CONVERTERS

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

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

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

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

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

OPERATING INSTRUCTIONS

ENGINE OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME

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

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

Cooling System

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

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

Loosen the water return line near the top of the turbocharger (if used).

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

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

Tighten the turbocharger water return line.

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 *Lubricating Oil Specifications*. Then remove the dipstick, wipe it with a clean cloth, insert and remove it again to check the oil level in the oil pan. Add sufficient oil, if necessary, to bring it to the full mark on the dipstick. Do not overfill.

If a pressure prelubricator is not available, fill the crankcase to the proper level with *heavy-duty* lubricating oil as specified under *Lubricating Oil Specifications*. Then pre-lubricate the upper engine parts by removing the valve rocker covers 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 the moving parts of the turbocharger center housing be lubricated as follows:

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 psi or 60 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.

Air Cleaner

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

Transmission

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

Fuel System

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

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

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

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

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

Lubrication Fittings

Fill all grease cups and lubricate at all fittings with an all purpose grease. Apply lubricating oil to the throttle linkage and other moving parts and fill the hinged cap oilers with a hand oiler.

Drive Belts

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

Storage Battery

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

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

Generator Set

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

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

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 shut-off valve in the closed position.

NOTE: On engines with dual air shutdown housings, both air shut-off valves must be in the open position before starting the engine.

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

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

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

Initial Engine Start (Electric)

Start an engine equipped with an electric starting motor as follows: Set the speed control lever at part throttle, then bring it back to the desired no-load speed. In addition, on mechanical governors, make sure the stop lever on the governor cover is in the *run* position; on hydraulic governors, make sure the stop knob is pushed all the way in. Then press the starting motor switch firmly. If the engine fails to start within 30 seconds, release the starting switch and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

> **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 pressure should not fall below 25 psi (172 kPa) at 1200 rpm or 30 psi (207 kPa) at 2100 rpm and normal operating pressure should be higher.

Warm-Up

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

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

Inspection

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

Engine Temperature

Normal engine coolant temperature is 160-185 °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 *Lubricating Oil Specifications.*

Clutch

Do not engage the clutch (with a sintered iron clutch plate) at engine speeds over 850 rpm. A clutch with an asbestos or vegetable fiber material clutch plate must not be engaged at speeds over 1000 rpm.

Cooling System

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

Transmission

Check the marine gear oil pressure. The operating oil pressure range at operating speed is 130-155 psi (896-1068 kPa) (Allison Torqmatic gear). The operating oil pressure varies with the different Twin Disc gears as noted in Table 1. Check and, if necessary, replenish the oil supply in the transmission.

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.

Operating Oil Pressure at 180° F (82° C)*									
Marine Gear	Position	†Test rpm	Test Pressure psi	Test Pressure kPa	Marine Gear	Position	†Test rpm	Test Pressure psi	Test Pressure kPa
MG-506 (except	Neutral and				MG-514 (less	Neutral	600	20-65	138-448
1.5:1 and 2:1 ratios)	Engaged	600	280-315	1930-2170	than 4:1 ratio)	Neutral	1800	45-92	310-634
	Neutral and				(shallow case)	Engaged	600	210-235	1447-1619
	Engaged	1800	300-320	2067-2205		Engaged	1800	228-237	1571-1633
	Cruising	Min.	270	1861		Cruising	Min.	215	1481
MG-506 (only	Neutral and				MG-514 (4:1 and	Neutral	600	35-65	241-448
1.5:1 and 2:1 ratios)	Engaged	600	330-365	2274-2515	greater ratio)	Neutral	1800	50-85	379-586
	Neutral and				(deep case)	Engaged	600	187-215	1289-1481
	Engaged	1800	350-370	2412-2550		Engaged	1800	193-220	1330-1516
	Cruising	Min.	335	2308		Cruising	Min.	185	1275
MG-509	Neutral	600	35-70	241-483	MG-521	Neutral	600	45-85	310-586
	Neutral	1800	50-85	345-586		Neutral	1800	75-100	517-689
	Engaged	600	187-215	1289-1481		Engaged	600	180-215	1241-1481
	Engaged	1800	193-220	1330-1516		Engaged	1800	188-220	1296-1516
	Cruising	Min.	165	1137		Cruising	Min.	165	1137
MG-512	Neutral	600	45-70	310-483	MG-527	Neutral	600	45-85	310-586
	Neutral	1800	60-90	414-621		Neutral	1800	65-100	448-689
	Engaged	600	185-215	1275-1481		Engaged	600	180-215	1241-1481
	Engaged	1800	195-220	1344-1516		Engaged	1800	188-220	1296-1516
	Cruising	Min.	185	1275		Cruising	Min.	165	1137
MG-513	Neutral	600	70-110	483-758					
	Neutral	1800	90-130	621-896					
	Engaged	600	230-270	1585-1861					
	Engaged	1800	240-280	1654-1930					
	Cruising	Min.	234	1612					

* Sump or heat exchanger inlet 210° F (99° C) maximum. Normal operating range desired 140-180° F (60-82° C) minimum continuous duty.

† Sump or heat exchanger inlet 225° F (107° C) maximum intermittent permissable in pleasure craft.

TABLE 1 - Twin Disc Marine Gear Operating Conditions

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 four or five minutes, then move the stop lever to the *stop* position to shut down 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 cause 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.

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 dipsticks.

Transmission

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

Clean Engine

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

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

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

ALTERNATING CURRENT POWER GENERATOR SET OPERATING INSTRUCTIONS

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

PREPARATION FOR STARTING

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

In addition to the *Engine Operating Instructions,* the following instructions also apply when operating an alternating current power generator set.

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

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

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

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

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

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

7. Place the voltage regulator switch (3) in the *off* or *manual* position.

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

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

STARTING

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

The engine may require the use of a cold weather starting aid if the ambient temperature is below 40 °F (4 °C). Refer to *Cold Weather Starting Aids.*

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

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

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

RUNNING

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

PREPARING GENERATOR FOR LOAD

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

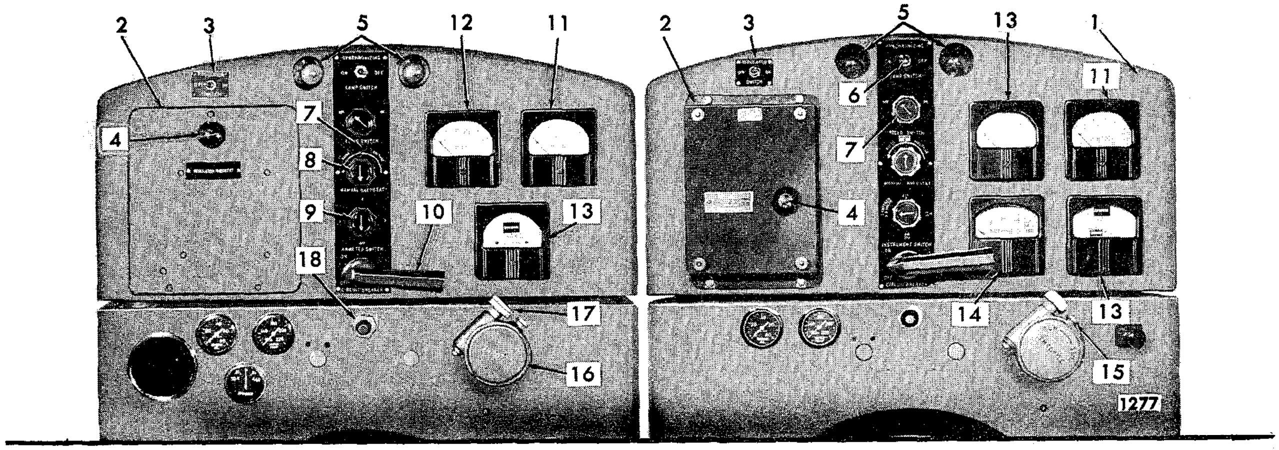
1. Bring the engine up to rated speed. Then place the field switch (7), Fig. 1, in the *on* position.

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

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

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

5. If the power generator unit is equipped with a frequency meter, adjust the engine speed with the



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

Fig. 1 - Typical Alternating Current Generator Control Cabinets

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 paralled 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 Generator for Load*.

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

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

4. Turn the vernier throttle knob (17) until both sets are operating at approximately the same frequency, indicated by the slow change in the brilliancy of the synchronizing lamps.

5. When the synchronizing lamps glow and then go out at a very slow rate, time the dark interval. Then, in the middle of this interval turn the circuit breaker control to the *on* position. This places the incoming set on the line, with no load. The proper share of the existing load must now be placed on this set.

6. The division of the kilowatt load between the alternating current generators operating in parallel depends on the power supplied by the engines to the generators as controlled by the engine governors and is practically independent of the generator excitation. Divide the kilowatt load between the sets by turning the vernier throttle knob (17) counterclockwise on the incoming set and clockwise on the set that has been carrying the load (to keep the frequency of the sets constant) until both kilowatt meters indicate that each set is carrying its proper percentage of the total K.W. load. Refer to Item 8 if the sets are not equipped with kilowatt meters.

7. The division of the reactive KVA load depends on the generator excitation as controlled by the voltage regulator. Divide the reactive load between the sets by turning the voltage regulator rheostat control on the incoming set (generally counterclockwise to raise the

voltage) until the ammeters read the same on both sets and the sum of the readings is minimum.

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

8. When the load is unity power factor (lighting and a few small motors only), follow the instructions in Item 6 above until both ammeters read the same.

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

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

NOTE: If a load was not added during paralleling, the total of the two ammeter readings should be the same as the reading before paralleling. Readjust the voltage regulator rheostat (4) on the incoming set, if necessary.

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

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

STOPPING

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

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

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

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

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

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

6. Press the throttle button (15) and turn the throttle control (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*.

LUBRICATION AND PREVENTIVE MAINTENANCE

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

The daily instructions pertain to routine or daily starting of 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 instructions given under *Preparation for Starting Engine First Time* under *Operating Instructions.*

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

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

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

*See items on following pages **Twin Disc Marine Gear † Allison Torqmatic Marine Gear

Item 1

Check the lubricating oil level with the engine stopped. If the engine has just been stopped, wait approximately twenty mintues to allow the oil to drain back to the oil pan. Add the proper grade oil, as required, to maintain the current level on the dipstick.

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

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

It is recommended that new engines be started with 150 hour oil change periods. The oil drain intervals may be extended, if supported by used oil analysis (refer to *Lubricating Oil Specifications*).

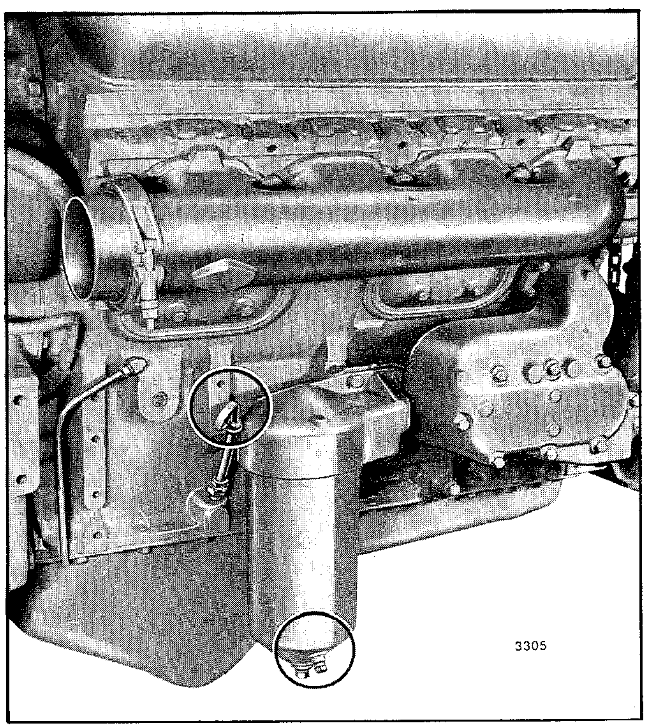
Item 2

Install new oil filter elements and gaskets at a *maximum* of 500 hours or each time the engine oil is changed, whichever occurs first.

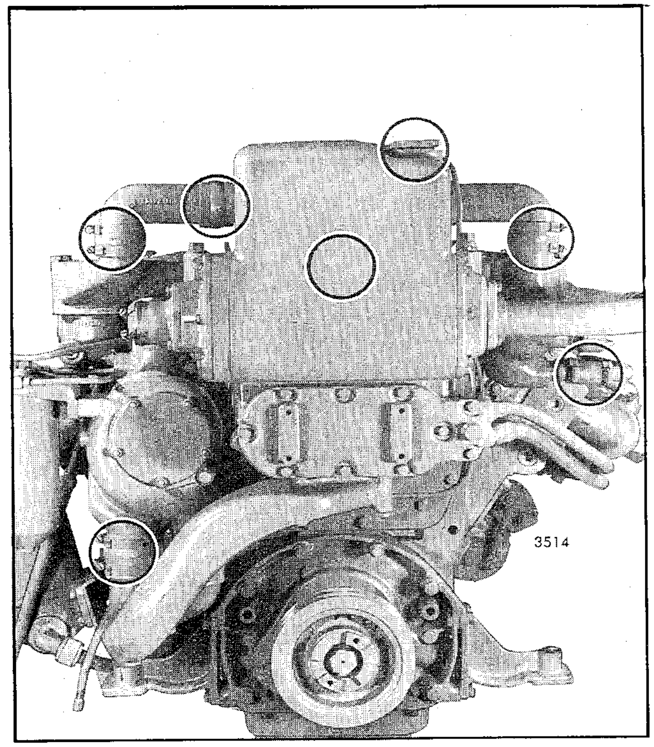
When the engine is equipped with a turbocharger:

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

2. Fill the bearing housing cavity with clean engine oil.



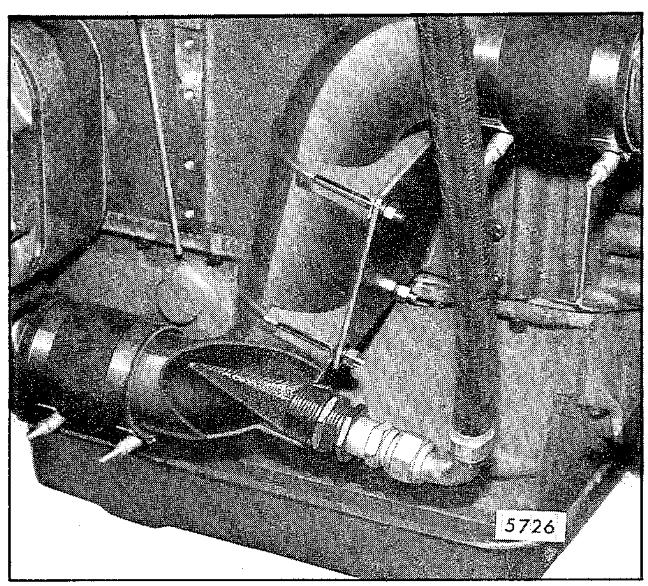
Items 1 and 2



Items 3 and 4

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.



Item 3

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).

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

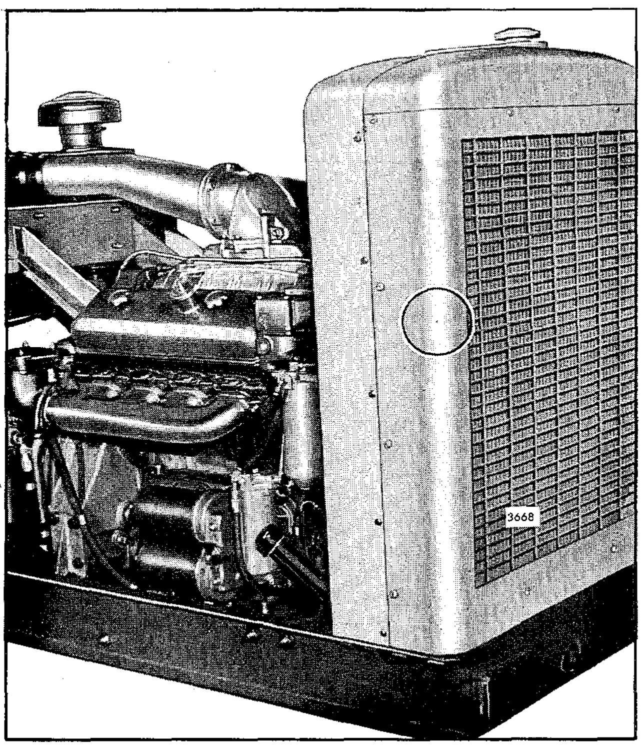
If the engine is equipped with a governor oil filter, change the element every 1,000 hours.

Check for oil leaks after starting the engine.

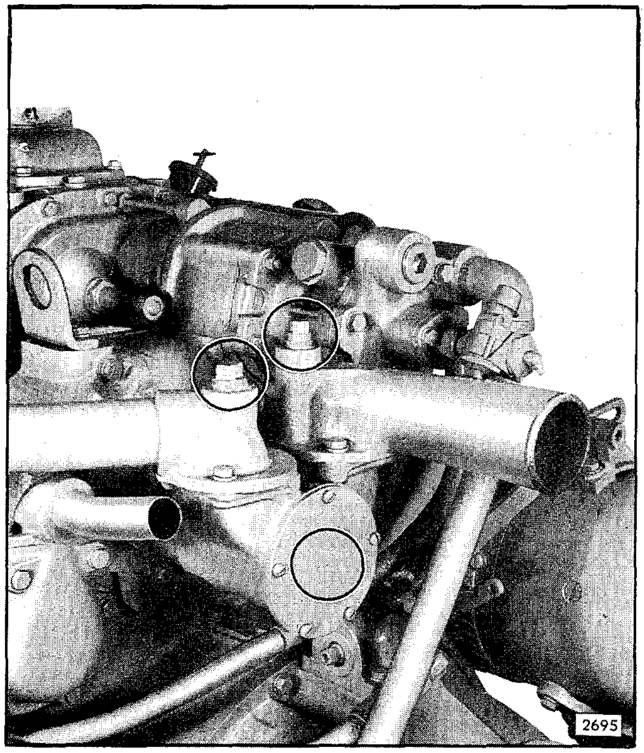
Item 3

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

Clean the cooling system every 1,000 hours or 30,000 miles (48 280 km) using a good radiator cleaning compound in accordance with the instructions on the container. After the cleaning operation, rinse the cooling system thoroughly with fresh water. Then fill the system with soft water, adding a good grade of rust inhibitor or a high boiling point type antifreeze (refer to *Engine Coolant*). With the use of a proper antifreeze or rust inhibitor, this interval may be lengthened until, normally, this cleaning is done only in the spring or fall. The length of this interval will, however, depend upon an inspection for rust or other deposits on the internal walls of the cooling system. When a thorough cleaning of the cooling system is required, it should be reverse flushed.



Item 5



Items 6 and 7

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

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 (24 140 km).

Item 4

Inspect all of the cooling system hoses at least once every 500 hours or 15,000 miles (24 140 km) for signs of deterioration. Replace the hoses if necessary.

Item 5

Inspect the exterior of the radiator core every 1,000 hours or 30,000 miles (48 280 km) 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 dusty or dirty areas.

Item 6

Every 500 hours, drain the water from the heat exchanger raw water inlet and outlet tubes. Then remove the zinc electrodes from the inlet side of the raw water pump and the heat exchanger. Clean the electrodes with a wire brush or, if worn excessively, replace with new electrodes. To determine the condition of a used electrode, strike it sharply against a hard surface; a weakened electrode will break.

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

Item 7

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

Item 8

Keep the fuel tank filled to reduce condensation to a minimum. Select the proper grade of fuel in accordance with the *Diesel Fuel Oil Specifications.* Open the drain at the bottom of the fuel tank every 500 hours or 15,000 miles (24 140 km) to drain off any water or sediment.

Item 9

Install new elements every 300 hours or 9,000 miles (14 484 km) or when plugging is indicated.

A method of determining when elements are plugged to the extent that they should be changed is based on the fuel pressure at the cylinder head fuel inlet manifold and the inlet restriction at the fuel pump. In a clean system, the maximum pump inlet restriction must not exceed 6 inches of mercury. At normal operating speeds (1600-2100 rpm), the fuel pressure is 45 to 70 psi (310-483 kPa). Change the fuel filter elements whenever the inlet restriction (suction) at the fuel pump reaches 12 inches of mercury at normal operating speeds and whenever the fuel pressure at the inlet manifold falls to 45 psi (310 kPa). Refer to Table 1.

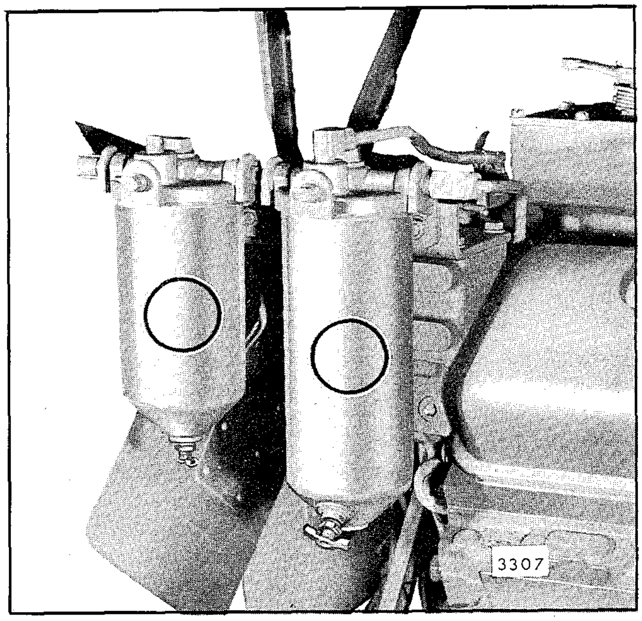
Item 10

Remove the dirty oil and sludge from the oil bath type air cleaner cups and center tubes every 8 hours, or less if operating conditions warrant. Wash the cups and elements in clean fuel oil and refill the cups to the level mark with the same grade and viscosity of *heavy duty* oil as used in the engine. The frequency of servicing may be varied to suit local dust conditions.

It is recommended that the body and fixed element in the heavy-duty oil bath type air cleaner be serviced

Fuel Pressure at Inlet Manifold										
Engine	Speed (rpm)									
	1200		1800		2000		2100		2300	
	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa
V-71, V-71N (6,8,12V) Normal	35-70	241-483	45-70	310-483			45-70	310-483		
8V-71T Normal			45-70	310-483	45-70	310-483			45-70	310-483
12V-71T Normal							45-60	310-414	45-60	310-414
16V-71 Normal	35-70	241-483	45-70	310-483			45-70	310-483		
16V-71N Normal	35-70	241-483	45-70	310-483			45-70	310-483		
16V-71T Except Standby Gen. Set			45-70	310-483	45-70	310-483	45-70	310-483		
16V-71T With Standby Gen. Set			50-70	345-483						

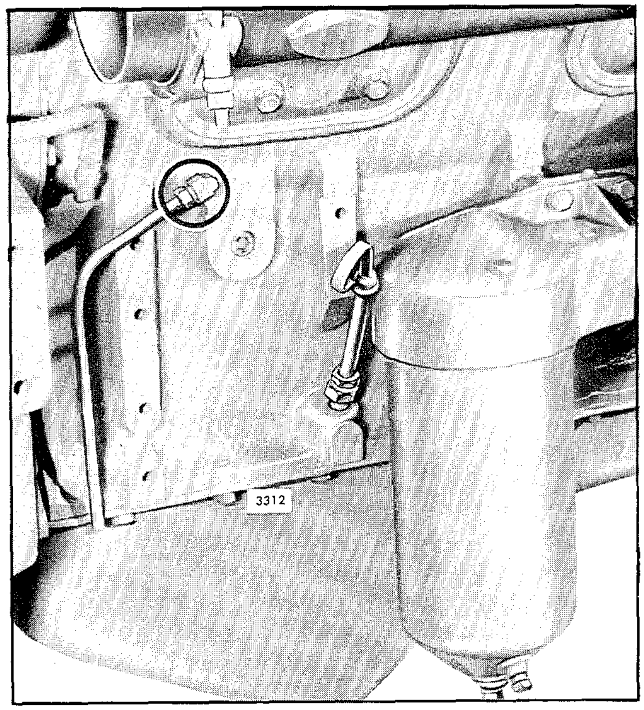
TABLE 1



Item 9

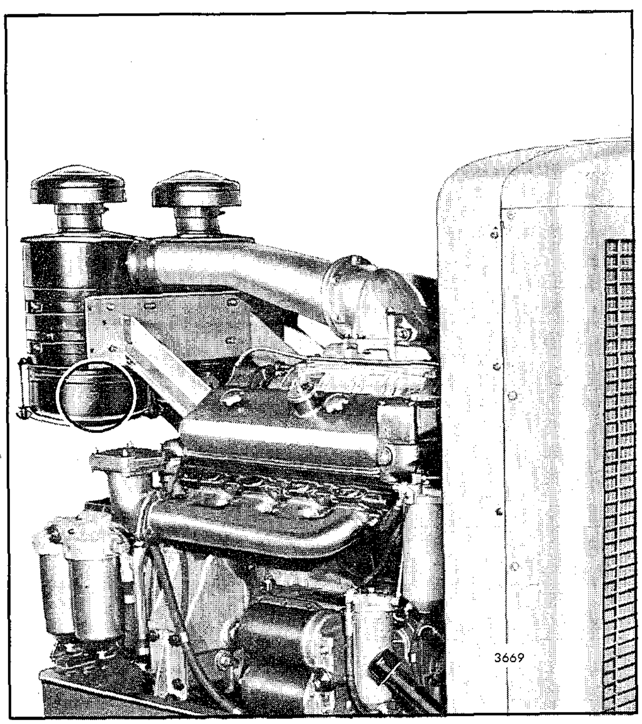
every 500 hours, 15,000 miles (24 140 km) or as conditions warrant.

Clean or replace the element in the dry-type air cleaner when the restriction indicator instrument indicates high restriction or when a water manometer

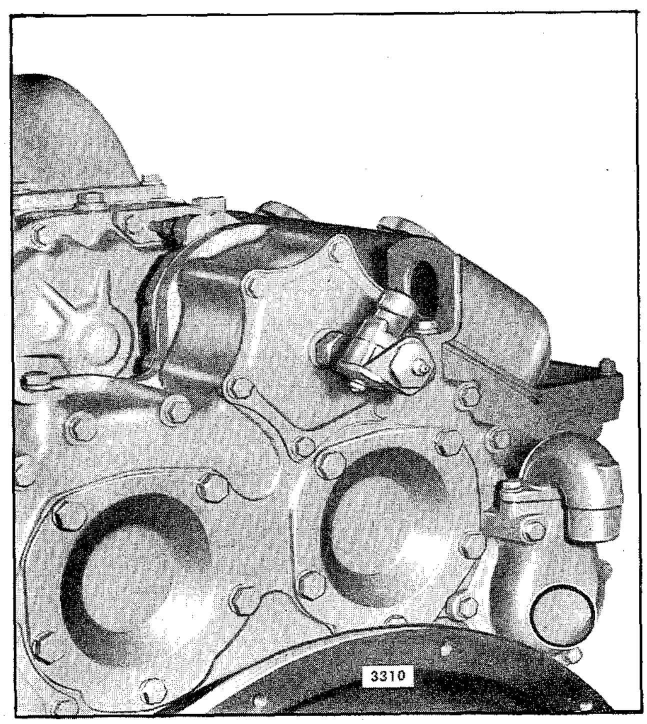


Item 11

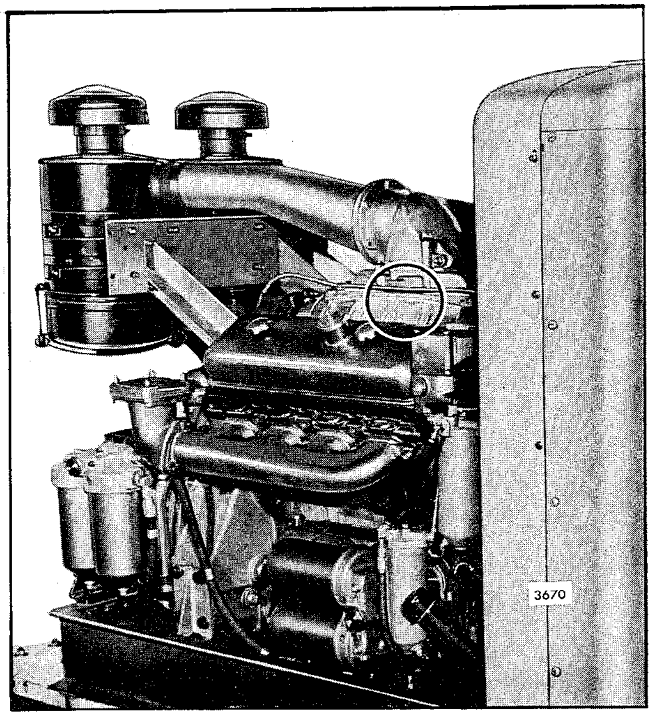
reading at the air inlet housing indicates the maximum allowable air inlet restriction (refer to the *Air Inlet Restriction* chart in the *Trouble Shooting*



Item 10



Item 12

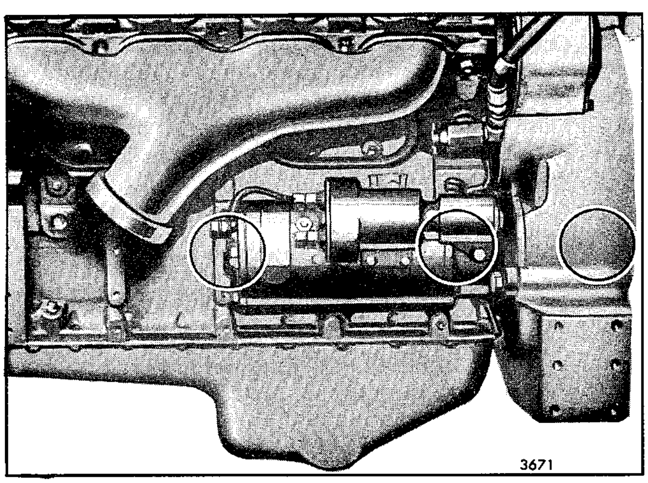


Item 13

section). Refer to the instructions in the *Air System* section for servicing the dry-type air cleaner.

Item 11

With the engine running, check for flow of air from the air box drain tubes every 1,000 hours or 30,000 miles (48 280 km). If the tubes are clogged, remove, clean and reinstall the tubes. The air box drain tubes should be cleaned periodically even though a clogged condition is not apparent. If the engine is equipped



Item 14

with an air box drain tank, drain the sediment periodically.

Item 12

Remove the crankcase breather, if it is mounted on the flywheel housing, every 1,000 hours or 30,000 miles (48 280 km) and wash the steel mesh pad in fuel oil and dry it with compressed air. This cleaning period may be reduced or lengthened according to severity of service.

Clean the internally mounted breather pads at time of engine overhaul, or sooner if excessive crankcase pressure is observed.

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

Item 13

Inspect the blower screen and gasket assemblies (if used) every 1,000 hours or 30,000 miles (42 280 km) and, if necessary, clean the screens in fuel oil and dry them with compressed air. Reinstall the screen and gasket assemblies with the screen side of the assemblies toward the blower. Inspect for evidence of blower seal leakage.

Item 14

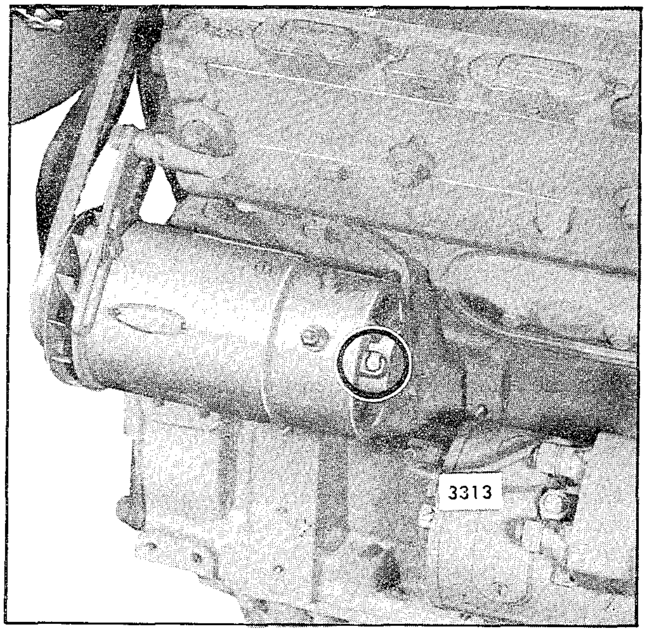
The electrical starting motor is lubricated at the time of original assembly. Oil can be added to the oil wicks, which project through each bushing and contact the armature shaft, by removing the pipe plugs on the outside of the motor. The wicks should be lubricated whenever the starting motor is taken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

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

Item 15

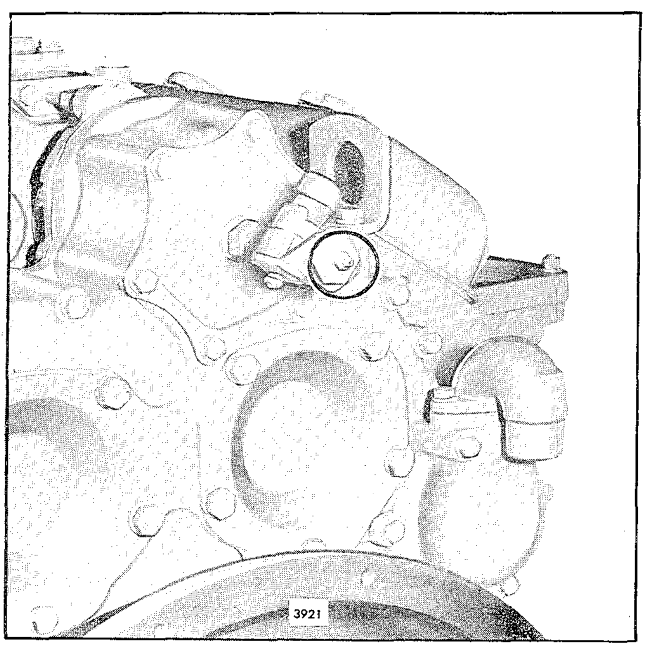
Lubricate the battery-charging alternator bearings or bushings with 5 or 6 drops of engine oil at the hinge cap oiler every 200 hours or 6,000 miles (9 656 km). Some alternators have a built-in supply of grease, while others use sealed bearings. In these latter two cases, additional lubrication is not necessary.

On A.C. alternators, the slip rings and brushes can be

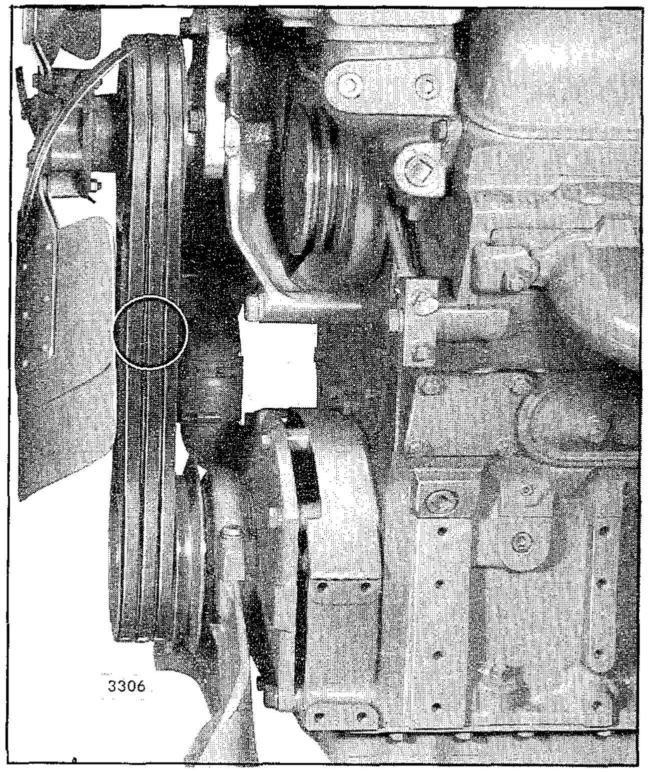


Item 15

inspected through the end frame assembly. If the slip rings are dirty, they should be cleaned with 400 grain or finer polishing cloth. Never use emery cloth to clean the slip rings. Hold the polishing cloth against the slip rings with the alternator in operation and blow away all dust after the cleaning operation. If the slip rings are rough or out of round, replace them. Inspect the terminals for corrosion and loose connections and the wiring for frayed insulation.



Item 17



Item 20

Item 16

Check the specific gravity of the electrolyte in each cell of the battery every 100 hours or 3,000 miles (4 828 km). In warm weather, however, it should be checked more frequently due to a more rapid loss of water from the electrolyte. The electrolyte level should be maintained in accordance with the battery manufacturer's recommendations.

Item 17

Lubricate the tachometer drive every 100 hours or 3,000 miles (4 828 km) with an all purpose grease at the grease fitting. At temperatures above +30 °F (−1 °C), use a No. 2 grade grease. Use a No. 1 grade grease below this temperature.

Item 18

Lubricate the throttle control mechanism every 200 hours or 6,000 miles (9 656 km) with an all purpose grease at the grease fittings. At temperatures above +30 °F (−1 °C), use a No. 2 grade grease. Use a No. 1 grade grease below this temperature. Lubricate all other control mechanisms, as required, with engine oil.

"V" and "POLY V" BELT TENSION TABLE (1 lbs/belt)

Model	Fan Drive			Alternator or Generator Drive		
	10 Rib (L) Poly V Belt	2 or 3 Belts	Single Belt	Two 3/8" or 1/2" Belts	One 1/2" Belt	8 Rib (K) Poly V Belts
6, 8V-71		60-80	80-100	40-50	50-70	110-130
12V-71		70-90		40-50	50-70	
16V-71	310-360	90-120		40-50	50-70	

Belt tension is 50-70 for a single premium high capacity belt (.785" wide) used to drive a 12 cfm air compressor.

Adjust all V-belts with belt tension gage BT-33-73 FA or equivalent.

Adjust all Poly V-belts with belt tension gage *BT-33-AE6-40A (Burroughs) or equivalent J23586 (Kent Moore) *Range 60-400 lbs

TABLE 2

Item 19

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, a complete tune-up is not required. Minor adjustments in the valve and injector operating mechanisms and governor should only be required periodically to compensate for normal wear on parts.

Item 20

New standard V-belts will stretch after the first few hours of operation. Run the engine for 15 *seconds* to seat the belts, then re-tension them. Retighten the fan drive, pump drive, battery-charging alternator and other accessory drive belts after 1/2 hour or 15 miles (24 km) and again after 8 hours or 240 miles (386 km) of operation. Thereafter, check the tension of the drive belts every 200 hours or 6,000 miles (9 656 km) 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 or equivalent is available, adjust the belt tension as outlined in Table 2.

> **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.

Adjust Poly-V Fan Belt (16V-71)

The fan belt should be neither too tight nor too loose. Carelessness in making a belt adjustment can be dangerous. Too tight a belt imposes an undue load on the fan bearings and shortens the life of the belt. Too loose a belt allows slippage and lowers the fan speed, causes excessive belt wear and leads to overheating of the cooling system.

Before a Poly-V belt is installed, it is very important that the crankshaft pulley (10 grooves) and the fan drive pulley (11 grooves) are in alignment. The extra groove in the fan drive pulley can be on the inside or the outside of the pulley, depending upon alignment requirements.

Misalignment between the crankshaft pulley and the fan drive pulley cannot be more than .009 " per inch of center line distance. A straight line can be determined by placing a straight edge on the rims of the pulleys. A spacer is available to facilitate pulley alignment, if necessary. The spacer mounts between the crankshaft pulley and the vibration damper hub.

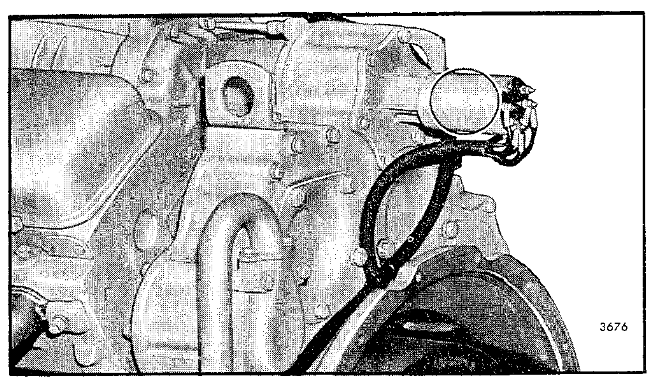
Poly-V belts require a special procedure for proper belt tension.

1. After the belts have been initially adjusted, run the engine under a light load for one-half hour.

2. Stop the engine and check the belt tension with the belt "hot"; use belt tension gage BT-33-86AE6-40A, or equivalent, which has a range of 60 to 400 pounds.

3. If the tension value is not between 280 and 360 pounds, re-adjust the belt tension.

> **NOTE:** Because the allowable load the crankshaft bearing can carry is critical, do not exceed the maximum tension value of 360 pounds.



Item 21

4. Run the engine at full load for eight hours and then recheck the belt tension.

5. If the belt tension is too tight or too loose, keep the gage in place and adjust the belt tension, to the prescribed value, at the accessory mounting or adjusting bolts. Retighten all of the bolts to the proper torque.

6. The belt tension should be rechecked every 200 hours of engine operation and readjusted, if necessary.

Item 21

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

Item 22

If the fan bearing hub assembly is provided with a grease fitting, use a hand grease gun and lubricate the bearings with one shot of Texaco Premium RB grease, or an equivalent Lithium base multi-purpose grease, every 20,000 miles or 32 187 km (approximately 700 hours).

Every 75,000 miles (approximately 4,000 hours) clean, inspect (replace if necessary) and repack the fan bearing hub assembly with the above recommended grease.

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

Item 23

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

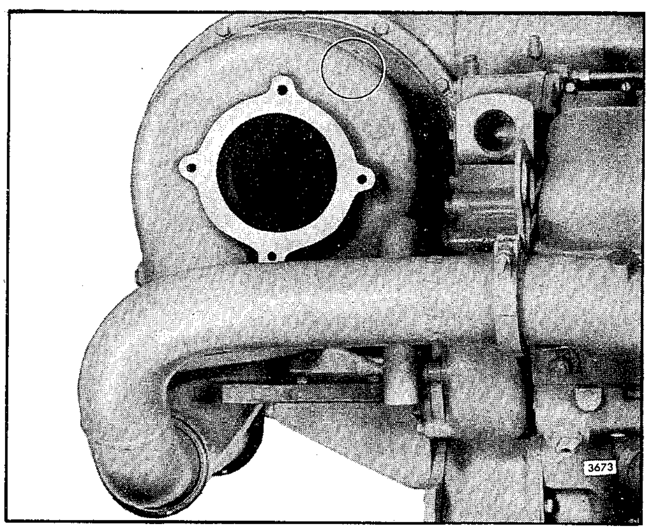
Item 24

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

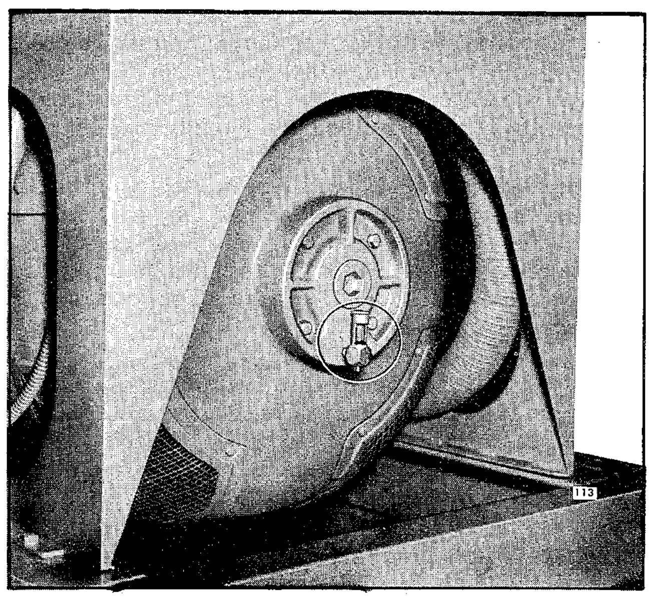
For replacement of the air strainer element, contact the nearest Bendix Westinghouse dealer; replace with the polyurethane element, if available.

Item 25

There is no scheduled interval for performing an inspection on the turbocharger. As long as the turbocharger is operating satisfactorily and there is no appreciable loss of power, no vibration or unusual noise and no oil leaks, only a periodic inspection is necessary. When service is required, contact an authorized *Detroit Diesel Allison Service Outlet*.



Item 25



Item 27

Item 26

Check the fan drive fluid level every 75,000 to 100,000 miles (120 701 to 160 934 km) to avoid improper operation and damage to the drive components.

The modulated fan drive has an inspection plug for checking the fluid level.

1. Check the fan drive fluid level after the unit has been idle for at least 1/2 hour.

2. Turn the fan drive so that the inspection plug is 3/4 " below the horizontal center line, then allow the silicone fluid to drain down an additional five minutes.

3. Remove the inspection plug. If fluid begins to flow from the inspection hole, the drive has sufficient fluid. Replace the inspection plug.

4. If the fluid does not flow from the hole, proceed as follows:

   a. Rotate the fan drive downward and observe when the fluid begins to flow from the hole. If it is necessary to lower the drain hole more than 2 " below the horizontal center line, the fan drive should be removed from the engine, disassembled and inspected for possible damage to the components.

   b. Turn the fan drive back so the inspection hole is 3/4 " below the horizontal center line and add fluid until the overflow point is reached. Replace the inspection plug.

NOTE: Use only the manufacturer's Special 20 Cenistroke fluid.

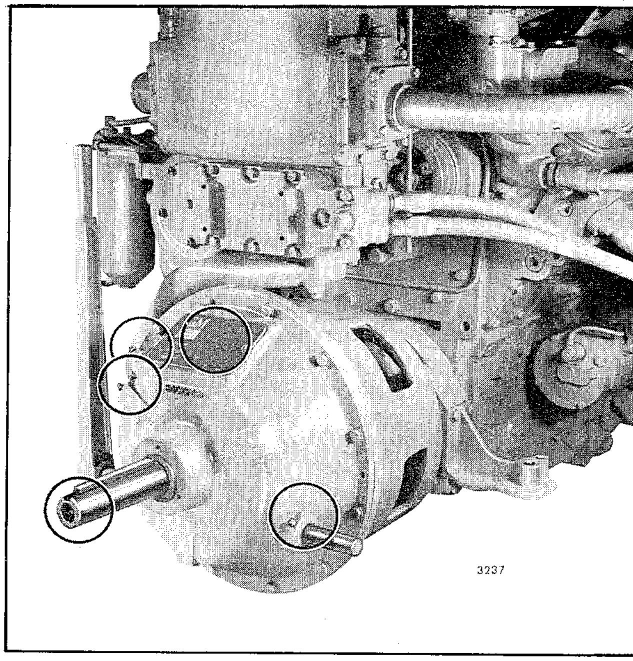
The fan drive bearing should be lubricated with a medium consistency silicone grease (Dow Corning No. 44, or equivalent). The bearing is lubricated through a grease fitting in the drive housing hub.

Item 27

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

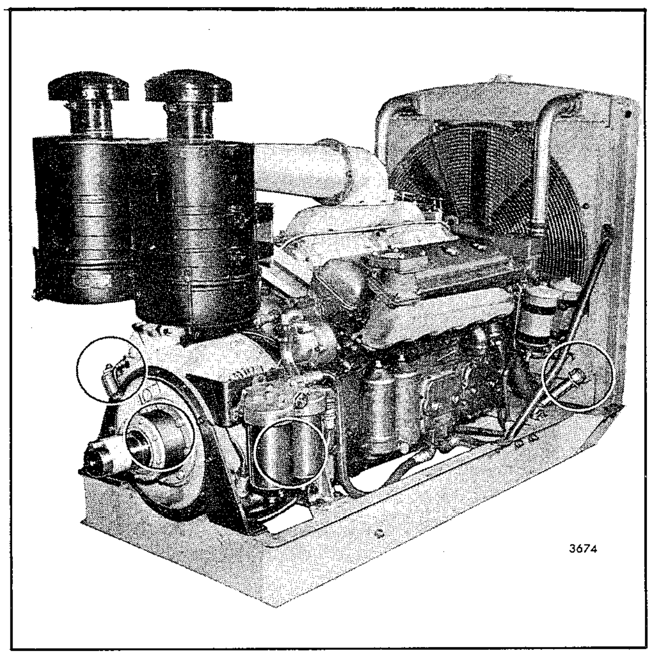
If the bearing is oil lubricated, check the oil level in the sight gage every 300 hours; change the oil every six months. Use the same grade and viscosity *heavy-duty* oil as specified for the engine. Maintain the oil level to the line on the sight gage. *Do not overfill.* After adding oil, recheck the oil level after running the generator for several minutes.

If the bearing is grease lubricated, a new generator has sufficient grease for three years of normal service.



Item 28

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.



Item 29

The following greases, or their equivalents, are recommended:

Keystone 44H ....Keystone Lubrication Co.
BRB Lifetime ....Socony Vacuum Oil Co.
NY and NJ926 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 28

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

Lubricate the clutch release bearing and the disconnect mechanical rear drive shaft shielded bearing every 8 hours. 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 power take-off main bearing, also the outboard bearing if the unit is so equipped, every 50 hours. Frequency of lubrication will depend on the working conditions of the bearing, shaft speeds and bearing loads. It may be necessary to lubricate this bearing more often than every 50 hours. Lubricate the front power take-off clutch pilot ball bearing through the fitting in the outer end of the drive shaft every 50 hours. One or two strokes with a grease gun should be sufficient.

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

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

OIL RECOMMENDATIONS

Prevailing Ambient Temperature	Recommended Oil Specification
Above −10°F (−23°C)	Hydraulic Transmission Fluid, Type C-2.
Below −10°F (−23°C)	Hydraulic Transmission Fluid, Type C-2. Auxiliary preheat required to raise temperature in the sump to a temperature above −10°F. (−23° C)

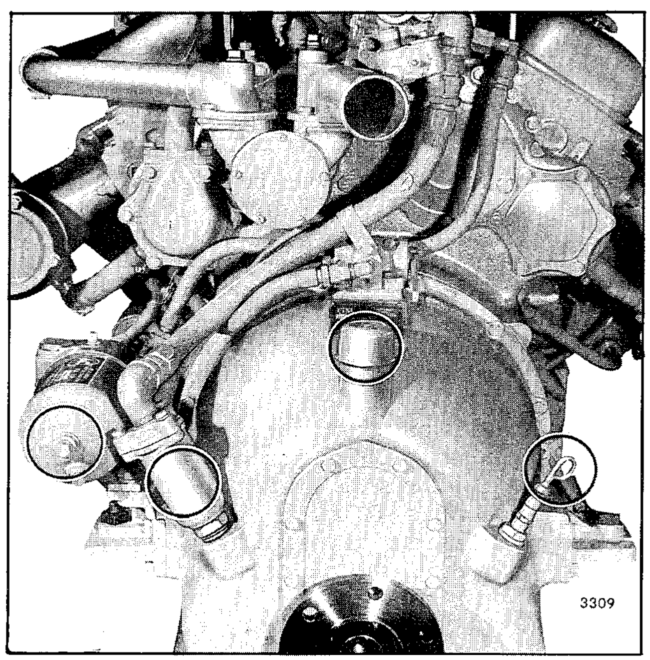
TABLE 3

Item 29

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

Check the oil level after running the unit a few minutes. The oil level should be maintained at the proper level on the dipstick. If required, add hydraulic transmission fluid type "C-2" (see Table 3). *Do not overfill* the converter as too much oil will cause foaming and high oil temperature.

The oil should be changed 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



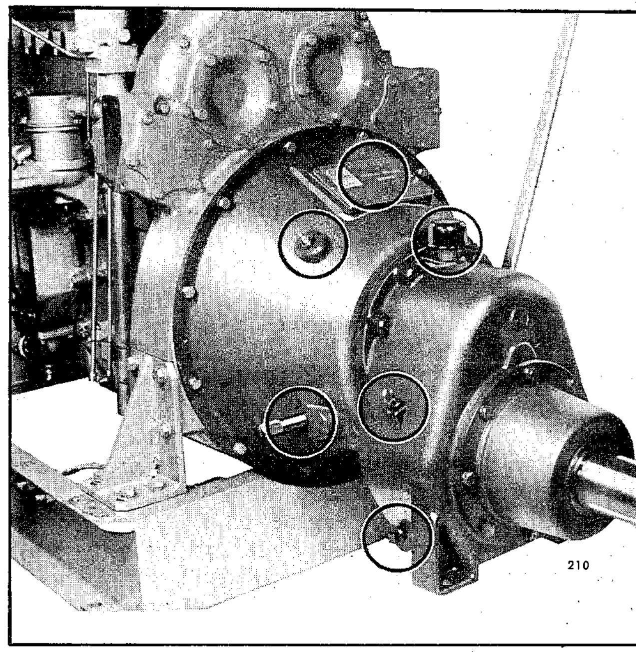
Item 30

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 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.

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 31

Item 30

TORQMATIC MARINE GEAR (6 and 8V):

Check the oil level daily in the 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 oil of the same *heavy duty* grade and viscosity that is used in the engine. Drain the oil every 200 hours and flush the gear with light engine oil.

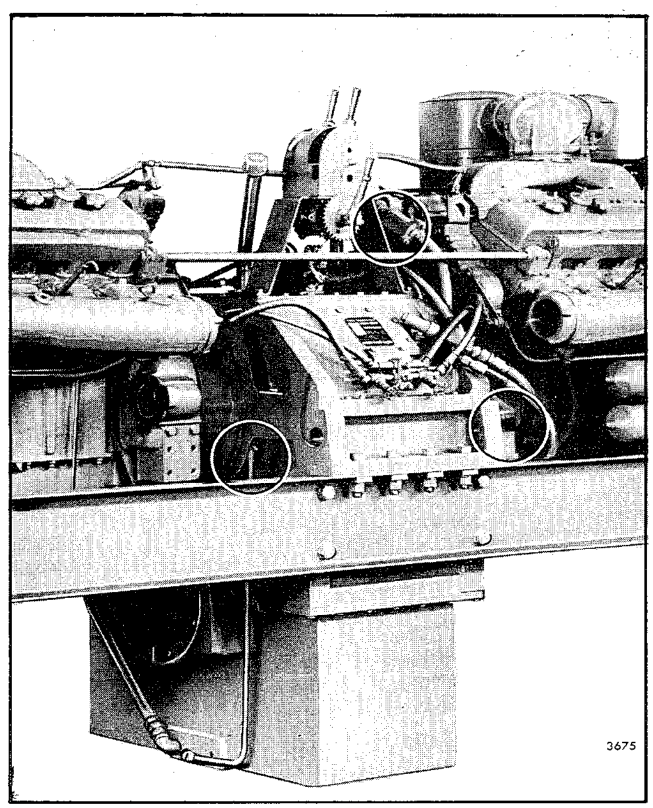
NOTE: Series 3 oil should not be used in the marine gear.

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

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

TWIN DISC MARINE GEAR:

Check the oil level daily. Check the oil level with the engine running at low idle speed and the gear in neutral. Keep the oil up to the proper level on the dipstick. Use oil of the same *heavy-duty* grade and viscosity that is used in the engine.



Item 32

Change the oil and the oil filter element every 1,000 hours. After draining the oil, thoroughly clean the removable oil screen and breather. Reinstall the breather and refill the marine gear with oil up to the full mark on the dipstick. Start the engine and, with the gear in neutral, run the engine at idle speed for three to five minutes. Then stop the engine and check the oil level. If necessary, add oil to bring it up to the full mark on the dipstick.

Item 31

ROCKFORD REDUCTION GEAR:

Check the oil level in the reduction gear every 8 hours and add oil as required to bring it to the proper level on the dipstick. Drain the oil every 1,000 hours, flush the housing with light engine oil and refill to the proper level with the same grade and viscosity *heavy duty* oil that is used in the engine. This oil change period should be reduced under severe operating conditions.

Lubricate the clutch release bearing through the grease fitting on the side of the housing every 8 hours of operation. The clutch release bearing in the 18 ″ diameter clutch is pre-lubricated and is not provided with a grease fitting, since no further lubrication is required. Lubricate the front reduction clutch pilot ball bearing through the fitting in the outer end of the drive shaft every 50 hours. One or two strokes with a grease gun should be sufficient.

Remove the inspection hole cover and oil the clutch release levers and link pins sparingly every 500 hours.

Lubricate the clutch release shaft through the grease fittings on the front of the housing every 500 hours.

Item 32

REDUCTION GEAR (24V and 32V):

The oil level in the reduction gear should be checked while the gear is in operation. Keep the oil level at the operating level on the dipstick.

Drain the oil every 200 hours of operation. Flush with light engine oil and refill to the proper level on the dipstick (approximately 21 gallons or 79 litres).

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

Use oil of the same *heavy duty* grade and viscosity that is used in the engine.

Every time the oil is changed, remove the element from each oil strainer and rinse it thoroughly in clean fuel oil, dry it with compressed air and reinstall.

The filter element of each marine gear oil filter should be removed, the element shell cleaned, and a new element and gasket installed every time the reduction gear oil is changed.

When refilling after an oil drain, bring the oil up to the proper level on the dipstick. Then run the engines to fill the system with oil. Check the oil level on the reduction gear with the engines and gear operating. Bring the oil level up to the proper level on the dipstick. *Do not overfill.*

DETROIT DIESEL FUEL — LUBRICATING OIL SPECIFICATIONS

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.

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. Some of the general properties of VV-F-800 and ASTM D-975 fuels are shown below.

FEDERAL SPECIFICATION & ASTM DIESEL FUEL PROPERTIES

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

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

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

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

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

DETROIT DIESEL FUEL OIL SPECIFICATIONS

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

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

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

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

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

FUEL OIL SELECTION CHART

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

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

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 15W-40, or SAE 40 or 30 weight.

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

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

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

DETROIT DIESEL LUBRICATING OIL SPECIFICATIONS

OIL QUALITY

OIL QUALITY is the responsibility of the oil supplier. (The term *oil supplier* is applicable to refiners, blenders, and rebranders of petroleum products, and does not include distributors of such products.)

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

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

RECOMMENDATION

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

15W-40 MULTIGRADE LUBE OIL

Detroit Diesel Allison now approves and recommends the use of the new generation 15W-40 lubricating oils, providing the following ash limits, zinc requirements, oil performance levels, and conditions are met:

1. The sulfated ash (ASTM D-874) 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.
2. The lubricant shall meet the performance requirements shown in API Service Classifications CD/SE.
3. The zinc content (zinc diorganodithiophosphate) of all the lubricants recommended for use in Detroit Diesel engines shall be a minimum of 0.07% by weight. However, the zinc requirement is waived where EMD lubricants are used.
4. Evidence of satisfactory performance in Detroit Diesel engines has been shown to the customer and to Detroit Diesel Allison by the oil supplier.

10W-30, 20W-40 & OTHER MULTIGRADE OILS

Detroit Diesel Allison does *NOT* approve any multigrade oils, except the new generation 15W-40 lubricants previously described. Although lubricants such as 10W-30 and 20W-40 are commercially available, the performance of their additive systems has not been demonstrated in Detroit Diesel engines. Since properties such as sulfated ash are affected in formulating these multigrade compounds, their use cannot be approved.

SAE-40 & SAE-30 SINGLE GRADE LUBRICANTS

Detroit Diesel Allison continues to approve SAE-40 and SAE-30 lube oils, providing they meet the 1.000% maximum sulfated ash limit, the 0.07% by weight minimum zinc content, and the following API Service Classifications:

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/SC	MIL-L-2104C	40 or 30
CD	MIL-L-45199B (Series 3)	40 or 30
CC/SE	MIL-L-46152	40 or 30
Numerous	Universal	40 or 30

MIL-L-46167 ARCTIC LUBE OILS FOR NORTH SLOPE & 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 15W-40 (new generation), 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 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 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 15W-40 or SAE-40 or SAE-30 are recommended.

EVIDENCE OF SATISFACTORY PERFORMANCE

Detroit Diesel Allison has referred to evidence of satisfactory performance in its lubricant specifications. Detroit Diesel Allison uses controlled field test oil evaluation programs to determine the performance of lubricants. The following briefly describes one method Detroit Diesel Allison uses to evaluate lubricating oil performance. This method may be used as a guideline for oil suppliers with candidate lubricants for Detroit Diesel engines.

1. Select five (5) highway truck (72,000 lbs. GCW) units in the same fleet powered by Detroit Diesel engines. Operate these on the candidate 15W-40 motor oil for 200,000 miles.
2. Select five (5) "sister" highway trucks in the same fleet to operate on a reference SAE-30 or SAE-40 grade lubricant having a history of good performance in Detroit Diesel engines.
3. *Operate the ten (10) oil test engines for 200,000 miles each.* Monitor the oil and fuel consumption during the test period. Record any serious mechanical problems experienced. Disassemble all ten (10) engines at the conclusion of the 200,000 mile period and compare the following:
   - Ring sticking tendencies and/or ring conditions.
   - Piston skirt and cylinder liner scuffing.
   - Exhaust valve face and stem deposits.
   - Overall wear levels.
4. The results obtained from a new candidate 15W-40 lubricant should be comparable to or better than those obtained from SAE 30 or 40 oils.

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 below shows a cross-reference of current commercial and military lube oil identification and specification systems.

CROSS REFERENCE OF LUBE OIL CLASSIFICATION SYSTEM

APIC 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 B)
‡	MIL-L-46152 (supersedes MIL-L-2104B for 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

‡ 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.

OIL CHANGES

Oil change intervals are dependent upon the various operating conditions of the engines and the sulfur content of the diesel fuel used. Oil drain intervals in all service applications may be increased or decreased with experience using a specific lubricant, while also considering the recommendations of the oil supplier. Generally, the sulfur content of diesel fuels supplied throughout the U.S.A. and Canada are low (i.e., less than 0.5% by weight — ASTM D-129 or D-1552 or D-2622). Fuels distributed in some overseas locations may contain higher concentrations of sulfur, the use of which will require reduced lube oil drain intervals.

Highway Trucks & Inter-City Buses (Series 71 and 92 Naturally Aspirated and Turbocharged Engines)

For highway trucks and buses, used for inter-city operation, the oil change interval is 100,000 miles. The drain interval may be extended beyond this point if supported by the results obtained from used lube oil analysis; it is recommended that you consult with your lube oil supplier in establishing any drain interval exceeding 100,000 miles.

City Transit Coaches and Pick-Up and Delivery Truck Service (Series 53, 71 and 92 Naturally Aspirated and Turbocharged Engines)

For city transit coaches and pick-up and delivery truck service, the oil change interval is 12,500 miles. The oil drain interval may be extended beyond 12,500 miles if supported by used oil analyses.

Industrial and Marine
(Series 53, 71, and 92 Naturally Aspirated and Turbocharged Engines)

Series 53, 71, and 92 engines, in industrial and marine service, should be started with 150-hour oil change periods. The oil drain intervals may be extended if supported by used oil analyses.

Large Industrial and Marine
(Series 149 Naturally Aspirated and Turbocharged Engines)

The recommended oil change period for naturally aspirated Series 149 engines is 500 hours, while the change period for turbocharged Series 149 engines is 300 hours. These drain intervals may be extended if supported by used oil analyses.

Used Lube Oil Analysis Warning Values

The presence of ethylene glycol in the oil is damaging to the engine. Its presence and need for an oil change and for corrective maintenance action may be confirmed by glycol detector kits which are commercially available.

Fuel dilution of the oil may result from loose fuel connections or from prolonged engine idling. A fuel dilution exceeding 2.5% of volume indicates an immediate need for an oil change and corrective maintenance action. Fuel dilution may be confirmed by ASTM D-322 test procedure performed by oil suppliers or independent laboratories.

In addition to the above considerations, if any of the following occur, the oil should be changed:

1. The viscosity at 100° F. of a used oil sample is 40% greater than the viscosity of the unused oil measured at the same temperature (ASTM D-445 and D-2161).
2. The iron content is greater than 150 parts per million.
3. The coagulated pentane insolubles (total contamination) exceed 1.00% by weight (ASTM D-893).
4. The total base number (TBN) is less than 1.0 (ASTM D-664). Note: The sulfur content of the diesel fuel used will influence the alkalinity of the lube oil. With high sulfur fuels, the oil drain interval will have to be shortened to avoid excessive acidity in the lube oil.

LUBE OIL FILTER ELEMENT CHANGES

Full-Flow Filters

A full-flow oil filtration system is used in all Detroit Diesel 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 or at each oil change period, whichever occurs first. For all other applications, the filter should be replaced at a *maximum* of 500 hours or at each oil change period, whichever occurs first.

By-Pass Filters

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

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

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.

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

SERVICE AND INSPECTION INTERVALS

Generally, operating conditions will vary for each engine application, even with comparable mileage or hours and therefore, maintenance schedules can vary. A good rule of thumb for piston ring, and liner inspections, however, would be at 45,000 miles or 1500 hours for the first such inspection and at 30,000 miles or 1000 hour intervals thereafter.

ENGINE COOLANT

Engine coolant is considered as any solution which is circulated through the engine to provide the means for heat transfer from the various engine components. 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

A suitable coolant solution 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 operating conditions dictate the need for freeze protection, a solution of suitable water and a permanent type antifreeze containing adequate inhibitors will provide a satisfactory coolant.

WATER

Any water, whether of drinking quality or not, will produce a corrosive environment in the cooling system. Also, scale deposits may form on the internal surfaces of the cooling system due to the mineral content of the water. 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, sulfates, total hardness and dissolved solids. Chlorides and/or sulfates tend to accelerate corrosion, while hardness (percentage of magnesium and calcium present) causes deposits of scale. Total dissolved solids may cause scale deposits, sludge deposits, corrosion or a combination of these. Chlorides, sulfates, magnesium and calcium are among but not necessarily all the materials which make up dissolved solids. Water, within the limits specified in Tables 1 and 2 of Figure 1, is satisfactory as an engine coolant when proper inhibitors are added.

CORROSION INHIBITORS

A corrosion inhibitor is a water soluble chemical compound which protects the metallic surfaces of the

TABLE 1

	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

Refer to Table 2 for evaluation of water intended for use in a coolant solution.

TABLE 2

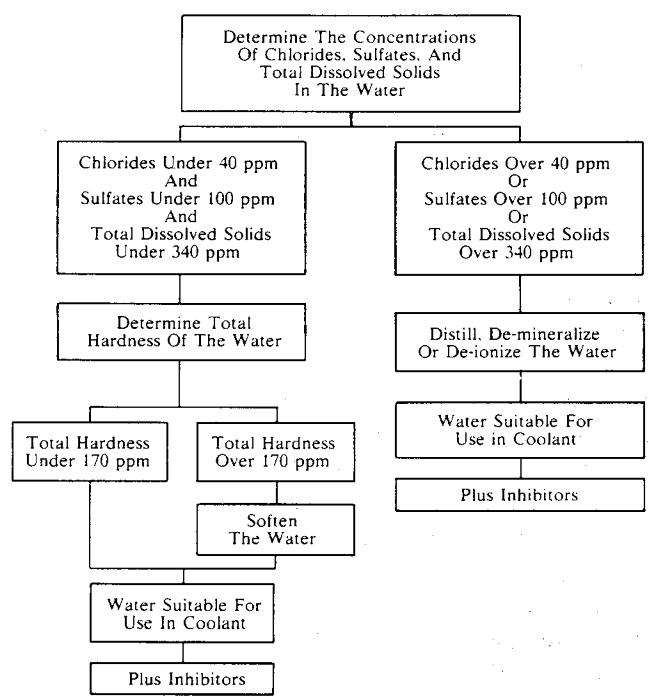


Fig. 1 - Water Characteristics

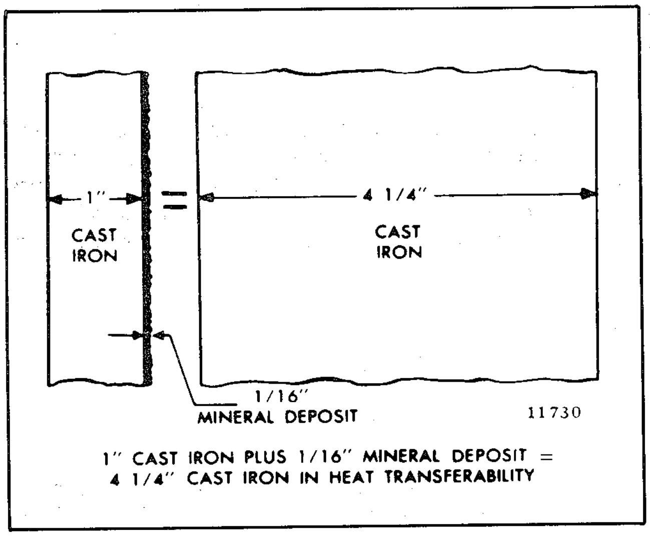


Fig. 2 - Heat Transfer Capacity

cooling system against corrosive attack. Some of the more commonly used corrosion inhibitors are chromates, borates, nitrates, nitrites and soluble oil. Depletion of all types of inhibitors occur through normal operation. Therefore, strength levels must be maintained by the addition of inhibitors at prescribed intervals. Always follow the supplier's recommendations on inhibitor usage and handling.

Chromates

Sodium chromate and potassium dichromate are two of the best and most commonly used *water* system corrosion inhibitors. However, the restrictive use of these materials, due to ecology considerations, has de-emphasized their use in favor of non-chromates. Care should be exercised in handling these materials due to their toxic nature.

Chromate inhibitors should *not* be used in permanent type antifreeze solutions. Chromium hydroxide, commonly called "green slime", can result from the use of chromate inhibitors with permanent type antifreeze. This material deposits on the cooling system passages, reducing the heat transfer rate (Fig. 2), and results in engine overheating. Engines which have operated with a chromate-inhibited water must be chemically cleaned before the addition of permanent type antifreeze. A commercial heavy duty de-scaler 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: 1-1/4% of soluble oil in the cooling system increases fire deck temperatures 6% and a 2-1/2% 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 permanent type antifreeze solution.

INHIBITOR SYSTEMS

An inhibitor system (Fig. 3) is a combination of chemical compounds which provide corrosion protection, pH control and water softening ability. Corrosion protection has been discussed under the heading *Corrosion Inhibitors.* 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 permanent 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 manufacturer's 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

Inhibitor or Inhibitor System	Corrosion Inhibitor Type	Inhibitor Compatability		
		Complete Inhibitor System	Water	Ethylene Glycol Base Antifreeze
Sodium chromate	Chromate	No	Yes	No
Potassium dichromate	Chromate	No	Yes	No
Perry filter elements:				
5020 (Type OS)	Chromate	Yes	Yes	Yes
S-453 (Spin-on)	Chromate	Yes	Yes	Yes
S-373 (Spin-on)	Non-chromate	Yes	Yes	Yes
5070 (Type OS)	# Non-chromate	Yes	Yes	Yes
S-473 (Spin-on)	# Non-chromate	Yes	Yes	Yes
Lenroc filter element	Non-chromate	Yes	Yes	Yes
Fleetguard filter elements:				
DCA (Canister)	Non-chromate	Yes	Yes	Yes
DCA (Spin-on)	Non-chromate	Yes	Yes	Yes
AC filter elements:				
DCA (Canister)	Non-chromate	Yes	Yes	Yes
DCA (Spin-on)	Non-chromate	Yes	Yes	Yes
Luber-Finer filter elements:				
LW-4739 (Canister)	Non-chromate	Yes	Yes	Yes
LFW-4744 (Spin-on)	Non-chromate	Yes	Yes	Yes
Nalcool 2000 (Liquid)	Non-chromate	Yes	Yes	Yes
Perry LP-20 (Liquid)	Non-chromate	Yes	Yes	Yes
Sy-Cool (Liquid)	Non-chromate	Yes	Yes	Yes
Lubercool (Liquid)	Non-chromate	Yes	Yes	Yes
DuBois Chemicals IWT-48 (Liquid	Non-Chromate	Yes	Yes	Yes
Norman Chemicals C15 (Liquid)	Non-Chromate	Yes	Yes	Yes
Aqua-Tane (Liquid)	Non-Chromate	Yes	Yes	Yes

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

Fig. 3 - Coolant Inhibitor Chart

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 permanent type 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 and, since they are added directly to the coolant, require no additional hardware or plumbing.

ANTIFREEZE

When freeze protection is required, a permanent type antifreeze 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. 4).

Methoxy propanol base antifreeze is not recommended for use in Detroit Diesel engines due to the presence of fluoroelastomer (Viton 'O') seals in the cooling system. Before installing ethylene glycol base antifreeze in an engine 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 commercial grade heavy-duty de-scaler.

Ethylene glycol base antifreeze is recommended for use in Series 71 Detroit Diesel engines. Methyl alcohol antifreeze is *not* recommended because of its effect on the non-metallic components of the cooling system and because of its low boiling point.

The inhibitors in permanent type antifreeze should be replenished at approximately 500 hour or 20,000 mile intervals with a non-chromate inhibitor system. Commercially available inhibitor systems may be used to re-inhibit antifreeze solutions.

Sealer Additives

Several brands of permanent antifreeze are available with sealer additives. The specific type of sealer varies with the manufacturer. Antifreeze with sealer additives is *not recommended* for use in Detroit Diesel engines due to possible plugging throughout various areas of the cooling system.

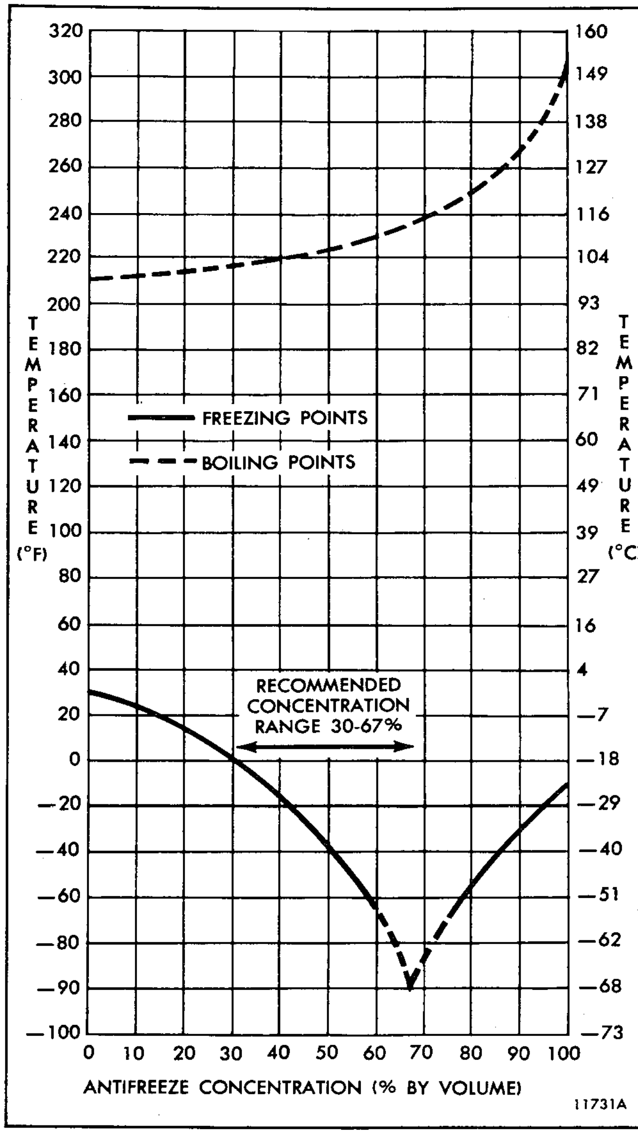


Fig. 4 - Coolant Freezing and Boiling Temperatures Vs Antifreeze Concentration (Sea Level)

GENERAL RECOMMENDATIONS

All Detroit Diesel engines incorporate pressurized cooling systems which normally operate 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.

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.

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, always use a permanent type antifreeze.

6. Re-inhibit antifreeze with a recommended non-chromate inhibitor system.

7. Do not use a chromate inhibitor with permanent type 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 an 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.

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

1. Limiting speed mechanical.

2. Variable speed mechanical.

3. Variable speed hydraulic.

4. Limiting speed hydraulic.

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

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

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

To tune-up an engine completely, all of the adjustments, except the valve bridge adjustment on four valve cylinder heads, are made by following 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.

> **NOTE:** The exhaust valve bridges on the four valve cylinder head are adjusted at the time the cylinder head is installed on the engine and, until wear occurs, no further adjustment is required. When wear is evident, perform a complete valve bridge adjustment as outlined on the following pages.

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 new valve rocker cover gaskets after the tune-up is completed.

Tune-Up Sequence for Mechanical Governors

> **CAUTION:** 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.

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 governor linkage.

4. Position the injector rack control levers.

5. Adjust the load limit screw.

6. Compensation adjustment (PSG governors only).

7. Adjust the governor speed droop.

8. Adjust the maximum no-load speed.

EXHAUST VALVE CLEARANCE ADJUSTMENT

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

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

Whenever the cylinder head is overhauled, the exhaust valves 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

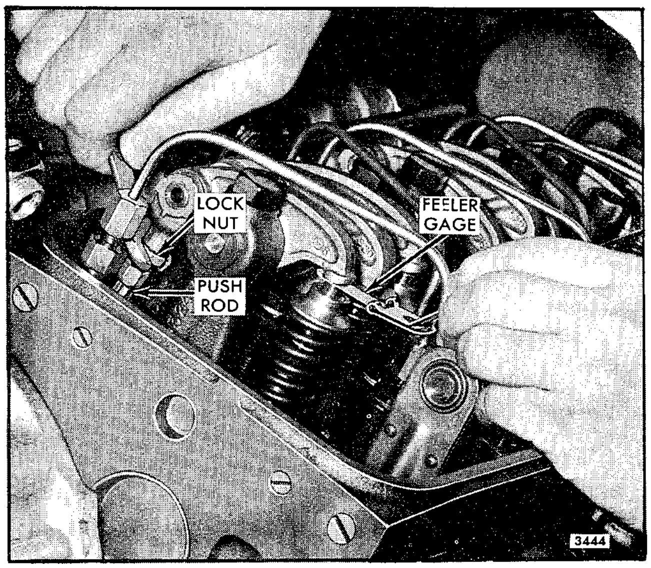


Fig. 1 - Adjusting Valve Clearance

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.

Exhaust Valve Clearance Adjustment (Cold Engine)

1. Place the governor stop lever in the no-fuel position.

2. Clean the loose dirt from the valve rocker covers and remove the covers. Then cover any drain cavities in the cylinder head to prevent foreign material from entering.

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

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

4. Loosen the exhaust valve rocker arm push rod lock nut.

5. Place a .013 " feeler gage, tool J 9708, between the valve stem and the rocker arm (Fig. 1). Adjust the push rod to obtain a smooth "pull" on the feeler gage.

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

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

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.

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

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.

Exhaust Valve Bridge Adjustment

1. Remove the loose dirt from the valve rocker covers and remove the covers. Remove the injector fuel pipes and the rocker arm bracket bolts. Move the rocker arms away from the exhaust valve bridge.

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

3. Place the bridge in a vise or holding fixture J 21772 and loosen the lock nut on the bridge adjusting screw.

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

4. Install the 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 lock nut finger tight.

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

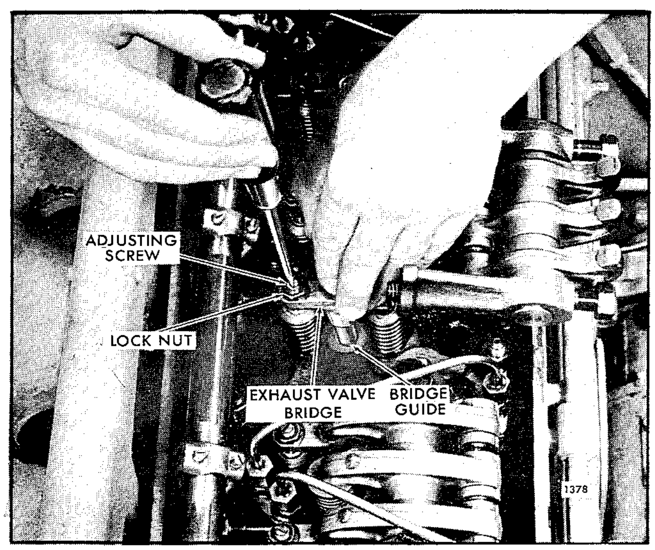


Fig. 2 - Bridge Balancing Adjustment

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

8. Reinstall the bridge in its original position.

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

10. Adjust the remaining bridges as outlined above.

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

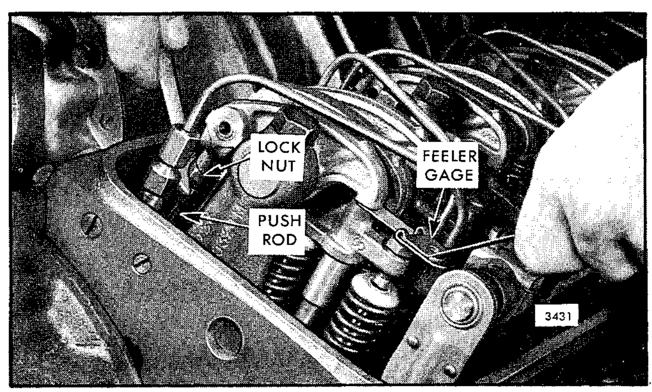


Fig. 3 - Adjusting Valve Clearance

Exhaust Valve Clearance Adjustment (Cold Engine)

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.

1. Place the governor stop lever in the no-fuel position.

2. Clean the loose dirt from the valve rocker covers and remove the covers. Then cover any drain cavities in the cylinder head to prevent foreign material from entering.

> **NOTE:** On certain 12V turbocharged engines, it is necessary to remove the air inlet housing to remove the rocker covers.

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

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

4. Loosen the exhaust valve rocker arm push rod lock nut.

5. Place a .017 ″ feeler gage, J 9708, 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 lock nut with a 1/2 ″ wrench.

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

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. 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 ″ 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.

TIMING FUEL INJECTOR

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 the *General Specifications* at the front of the manual for the engine firing order.

Use the proper timing gage as indicated in Table 1.

Time Fuel Injector

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

1. Place the 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.

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

3. Place the small end of the injector timing gage in the hole provided in the top of the injector body, with the flat of the gage toward the injector follower (Fig. 4).

4. Loosen the exhaust valve rocker arm push rod lock nut.

5. Turn the push rod and adjust the injector rocker

Injector Timing Gage Chart (Needle Valve)

Injector	Timing Dimension	Timing Gage	Camshaft Timing
Generator Sets			
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 (N/A) (brown tag)	**1.484"	J 1242	**Advanced
HN65	1.460"	J 1853	Advanced
N70 Turbo	1.460"	J 1853	Standard
N70 N/A	1.460"	J 1853	Advanced
N75 N/A	1.484"	J 1242	Advanced
N75 Turbo	1.460"	J 1853	Standard
N80 Turbo	1.484"	J 1242	Standard
N80 N/A	**1.484"	J 1242	**Advanced
N90	1.460"	J 1853	Standard

N/A—Naturally aspirated engines.
*Use 1.484" timing gage (J1242) 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-CAM-TIMING" stamped on lower right-hand side of option plate.

TABLE 1

arm until the extended part of the gage will just pass over the top of the injector follower.

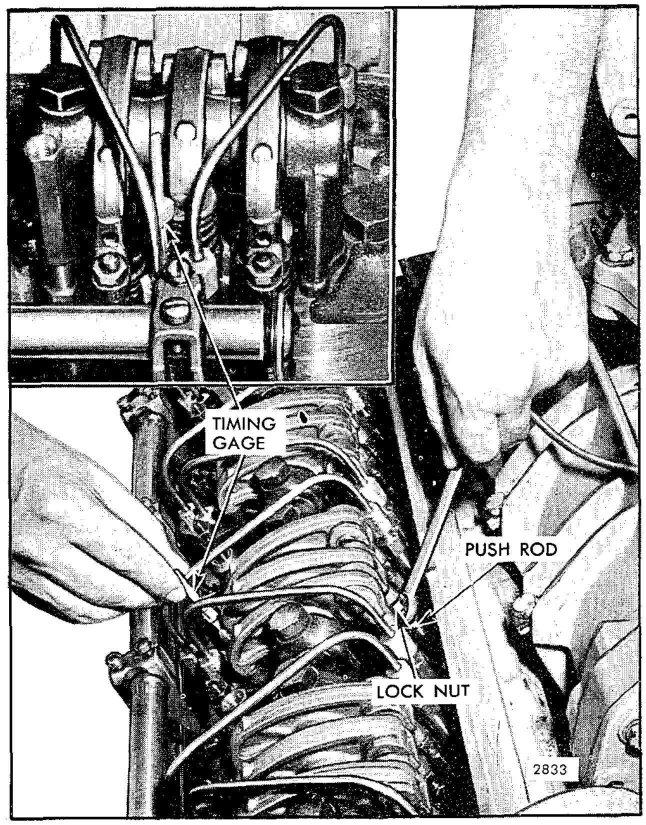


Fig. 4 - Timing Fuel Injector

6. Hold the push rod and tighten the lock nut. 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, use new gaskets and install the valve rocker covers.

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

6, 8 and 12V-71 ENGINES

Two types of limiting speed mechanical governors are used. The difference between each type of governor is in the high-speed spring retainer and spring housing assembly. Certain engines use the standard limiting speed governor while some engine applications use the dual-range limiting speed governor. The only variation in the tune-up procedure between each type of governor is in the setting of the maximum no-load speed.

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

> **NOTE:** Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device, such as throttle delay mechanism and back out the starting aid screw.

After the adjustments are completed, reconnect and adjust the supplementary governing device.

Adjust Governor Gap

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

> **NOTE:** If the governor gap adjustment is to be made with the engine in the vehicle, it is suggested that the fan assembly be removed due to the closeness of the fan blades to the engine governor.

1. Remove the high-speed spring retainer cover.

2. Back out the buffer screw until it extends approximately 5/8 " from the lock nut (Fig. 10).

3. Start the engine and loosen the idle speed adjusting screw lock nut. Then adjust the idle screw to obtain the desired engine idle speed. Hold the screw and tighten the lock nut to hold the adjustment.

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

4. Stop the engine, clean and remove the governor cover and lever assembly and the valve rocker covers. Discard the gaskets.

5. Start and run the engine between 1100 and 1300 rpm by manual operation of the differential lever.

> **NOTE:** Do not overspeed the engine.

6. Check the gap between the low-speed spring cap and the high-speed spring plunger (Fig. 1) with a feeler gage. The gap setting should be .002 "-.004 ". If the gap setting is incorrect, reset the gap adjusting screw. If the setting is correct, the .002 "-.004 " movement can be seen by placing a few drops of oil into the governor gap and pressing a screw driver against the gap adjusting screw. Movement of the cap toward the plunger will force the oil from the gap in the form of a small bead.

7. On governors without the starting aid screw, hold the gap adjusting screw and tighten the lock nut.

8. Recheck the gap with the engine running between 1100 and 1300 rpm and readjust if necessary.

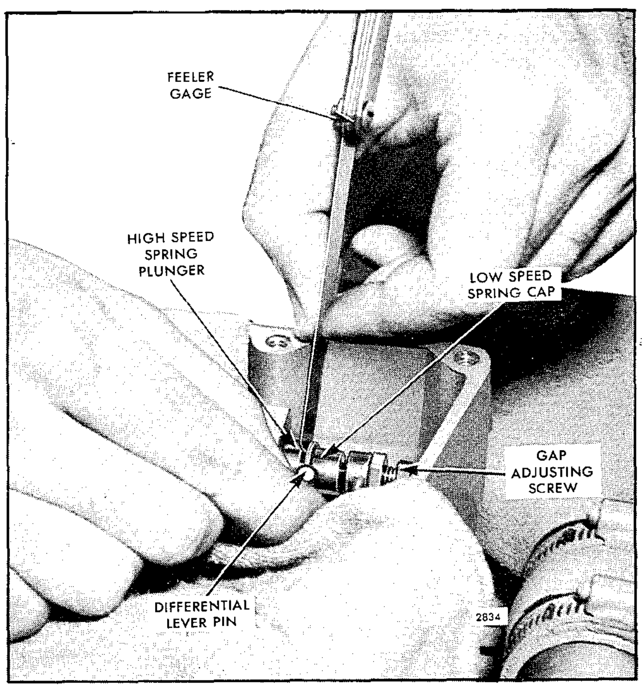


Fig. 1 - Adjusting Governor Gap

9. Stop the engine and, using a new gasket, install the governor cover and lever assembly. Tighten the screws.

Position Injector Rack Control Levers

> **NOTE:** To ensure proper injector control rack adjustment, the injector racks must be adjusted with the yield link and governor cover that are to be used with the governor.

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.

Current engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever and only one screw and lock nut to keep each injector rack properly positioned. Adjust the single screw and lock nut on each injector rack control lever the same as for the two screw rack control lever.

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 fuel control racks in the full-fuel position.

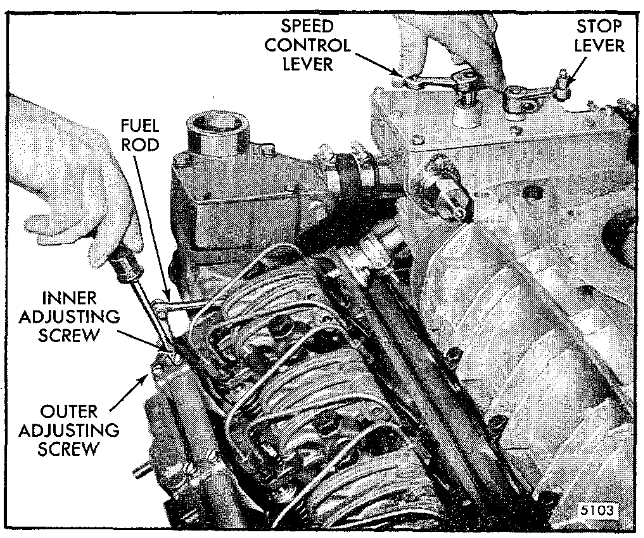


Fig. 2 - Positioning No. 1 Injector Rack Control Lever (Two Screw Assembly)

The letters R and L indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. The cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 1L injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

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

2. Turn the idle speed adjusting screw until there is no tension in the idle spring.

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

> **NOTE:** 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.*

Injector racks must be adjusted so 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 causing the yield link to separate.

b. Binding of the fuel rods.

c. Failure to back out idle screw.

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

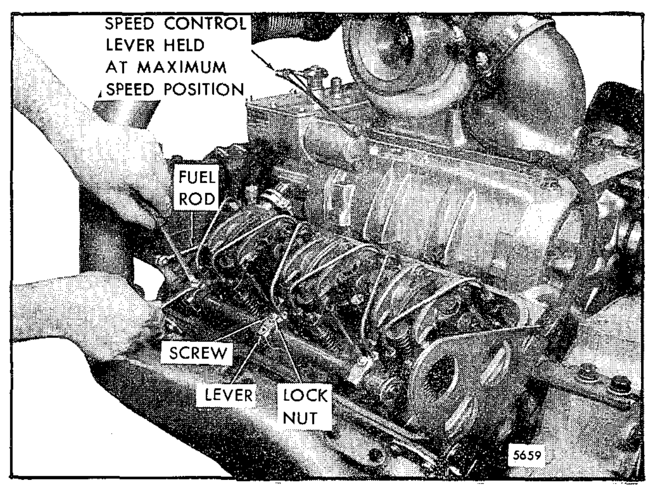


Fig. 3 - Positioning No. 1 Injector Rack Control Lever (One Screw and Lock Nut Assembly)

4. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

5. Loosen all of the inner and outer injector rack control lever adjusting screws (former engines) or adjusting screw and lock nut (current engines) on both cylinder heads. Be sure all of the injector rack control levers are free on the injector control tubes.

6. Move the speed control lever to the maximum speed position; hold it in that position with light finger pressure.

a. On the current spring-loaded injector control tubes, tighten the adjusting screw of the No. 1L 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 (Fig. 3). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw lock nut. This will place the No. 1L injector rack in the full fuel position.

b. On the former two screw injector control tubes, turn the inner adjusting screw of the No. 1L injector rack control lever down until a slight movement in the control tube lever is observed or a step-up in effort to turn the screwdriver is noted (Fig. 2). This will place the No. 1L injector rack in the full-fuel position. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

NOTE: 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 in-lbs (3-4 Nm).

IMPORTANT: 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.

7. 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 screw driver 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 screw driver, press downward on the injector control rack. The rack should tilt downward (Fig. 5) and when the pressure of the screw driver is released, the control rack should "spring" back upward.

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

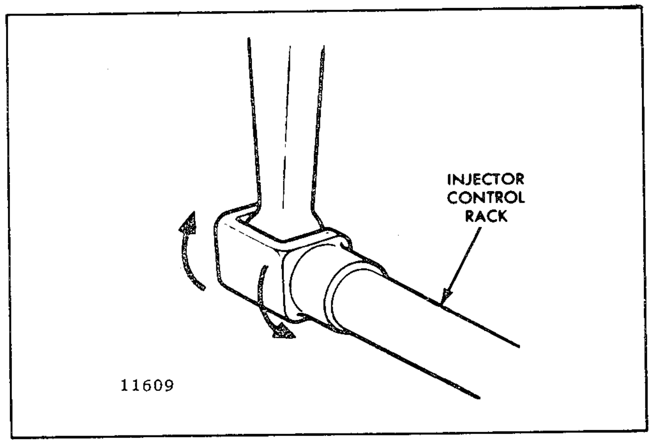


Fig. 4 - Checking Rotating Movement of the Injector Control Rack

On former engines, back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly.

The setting is too tight if, when moving the speed control lever from the no-speed 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 on current engines, loosen the lock nut and turn the adjusting screw counterclockwise a slight amount and retighten the nut. On former engines, back out the inner adjusting screw slightly and tighten the outer adjusting screw slightly.

8. Remove the clevis pin from the fuel rod and the left bank injector control tube lever.

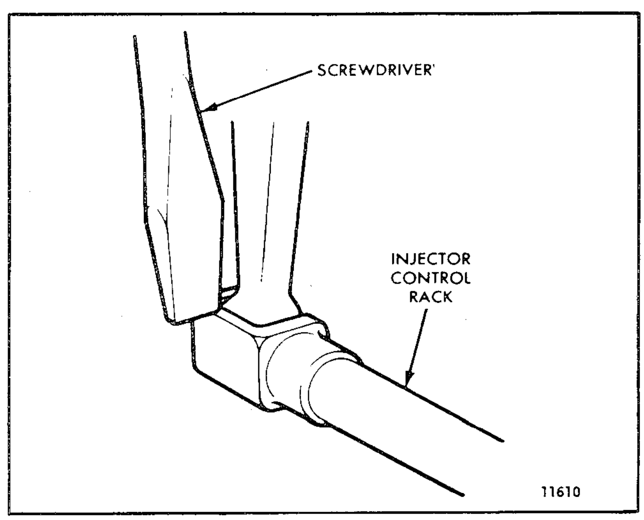
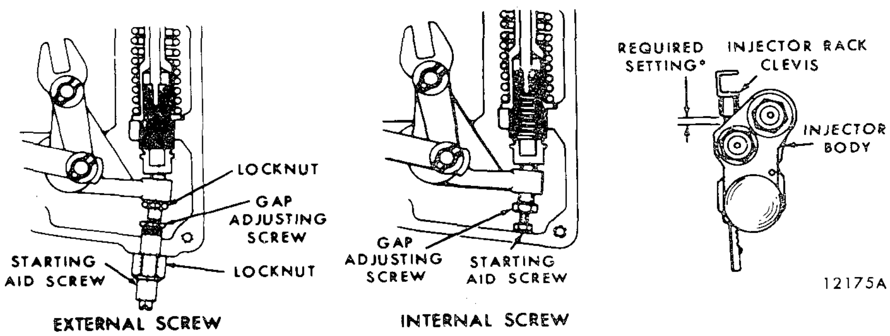


Fig. 5 - Checking Injector Control Rack "Spring"



INJECTOR	GAGE SETTING*	TOOL NUMBER
S80	.345"	J 24889
N60	.345"	J 24889
N65	.385"	J 24882
N70	.385"	J 24882
N75	.385"	J 24882
N80	.385"	J 24882
N90	.454"	J 23190
C65	.385"	J 24882
C80	.385"	J 24882
7A50	.345"	J 24889
7A55	.345"	J 24889
7A60	.345"	J 24889
7A65	.385"	J 24882
7A70	.385"	J 24882
7A75	.385"	J 24882

Fig. 6 - Starting Aid Screw Adjustment

9. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the No. 1R injector rack control lever as previously outlined in Step 6 for the No. 1L injector rack control lever.

10. Insert the clevis pin in the fuel rod at the left bank injector control tube lever. Verify the adjustments for the No. 1L and 1R injector racks are equal. To do this, move the speed control lever to the maximum speed position. Rotate the clevis pins at the injector control tube levers and note the drag or resistance to rotate the pins. This resistance or drag should be equal for both pins. If the drag is not equal, turn the No. 1R injector rack adjusting screw (inner screw, former engines) clockwise to increase drag on the right bank clevis pin or counterclockwise to decrease the pin drag. Adjust No. 1R adjusting screw and lock (inner screw, former engines) securely to ensure equal drag for both clevis pins.

11. To adjust the remaining injector rack control levers, remove the clevis pins from the fuel rod at the injector control tube levers, hold the left bank injector control racks in the full fuel position by means of the lever on the end of the control tube and proceed as follows.

On current spring-loaded injector control tubes:

a. Tighten the adjusting screw of the No. 2L 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 lock nut.

b. Verify the injector rack adjustment of No. 1L as outlined in Item 7. If No. 1L does not "spring" back upward, turn the No. 2L adjusting screw counterclockwise slightly until the No. 1L injector rack returns to its full fuel position and secure the adjusting screw lock nut. Verify proper injector rack adjustment for both No. 1L and No. 2L injectors. Turn clockwise or counterclockwise the No. 2L injector rack adjusting screw until both No. 1L and No. 2L injector racks are in the full fuel position when the lock nut is securely tightened.

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

On former two screw injector control tubes:

a. Turn down the inner adjusting screw of the injector rack control lever until the screw bottoms (injector control rack in the full-fuel position).

b. Turn down the outer adjusting screw of the injector rack control lever until it bottoms on the injector control tube.

c. While still holding the control tube lever in the full-fuel position, adjust the inner and outer adjusting screws to obtain the same condition as outlined in Step 7. Tighten the screws.

IMPORTANT: Once the No. 1L and No. 1R injector rack control levers are adjusted, do not try to alter their settings. All adjustments are made on the remaining control racks.

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 **in-lbs** (3-4 Nm).

12. 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 7. All of the control racks must have the same "spring" condition with the control tube lever in the full-fuel position.

13. Insert the clevis pin in the fuel rod and the injector control tube levers.

14. Turn the idle speed adjusting screw in until it projects 3/16 " from the lock nut, to permit starting the engine.

15. On current turbocharged engines, adjust the external starting aid screw as follows:

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

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 " (.397 mm) 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 lock nut.

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.

NOTE: 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 gap adjusting screw, or reduced by backing it out.

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

16. On early turbocharged engines, adjust the internal starting aid screw, if used, as follows:

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

b. Hold the gap adjusting screw, to keep it from turning, and adjust the starting aid screw to obtain the required setting between the shoulder on the injector rack clevis and the injector body (Fig. 6). The setting is measured at the No. 3R injector rack clevis.

c. 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* position to the *maximum* speed position.

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

NOTE: Movement of the governor speed control lever is to take-up clearances in the governor linkage. The clevis-to-body clearance can be increased by backing out the starting aid screw or reduced by turning it farther into the gap adjusting screw.

d. Start the engine and re-check the running gap (.002 "-.004 ") and, if necessary, reset it and re-position the injector racks. Then stop the engine.

e. Use a new gasket and replace the governor cover and lever assembly. Tighten the screws.

17. Use new gaskets and replace the valve rocker covers.

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 engine option plate, set the maximum no-load speed as follows:

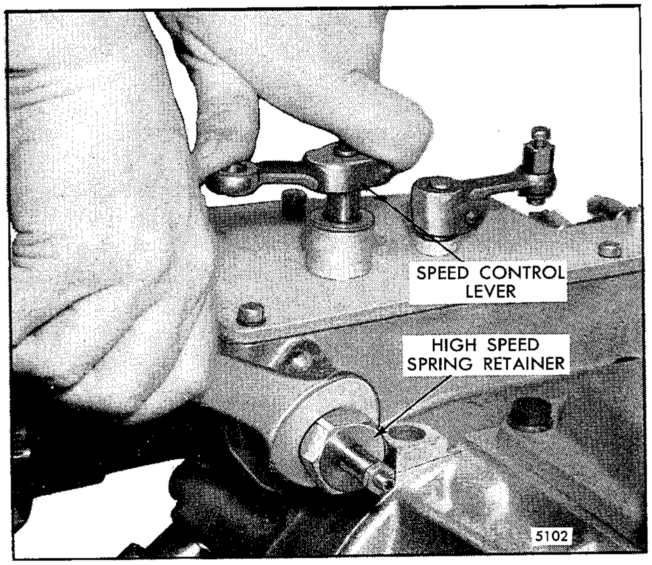


Fig. 7 - Adjusting Maximum No-Load Speed

STANDARD GOVERNOR

After positioning the injector rack control levers and setting the idle speed, set the maximum engine speed as follows:

> **NOTE:** Be sure the buffer screw (or fast idle air cylinder) projects 5/8 " from the lock nut to prevent interference while adjusting the maximum no-load speed.

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

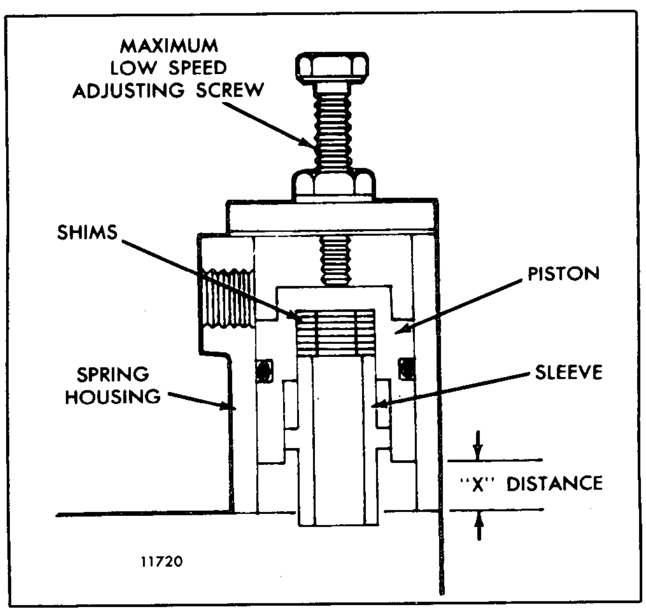


Fig. 8 - Dual Range Governor Spring Housing Assembly (Sectional View)

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

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

DUAL HIGH-SPEED RANGE GOVERNOR

After positioning the injector control levers, set the maximum engine speeds.

> **NOTE:** Be sure the buffer screw (or fast idle air cylinder) projects 5/8 " from the lock nut to prevent interference while adjusting the maximum no-load speeds.

With the spring housing assembly mounted on the governor, the piston and sleeve assembled with four .100 " shims and ten .010 " shims and the low maximum speed screw extending from the spring housing approximately 1-1/4 ", proceed as follows:

> **NOTE:** Do not apply air or oil pressure to the governor until performing Step 1f.

1. Set the high maximum no-load engine speed:

a. Start and warm-up the engine. Then position the

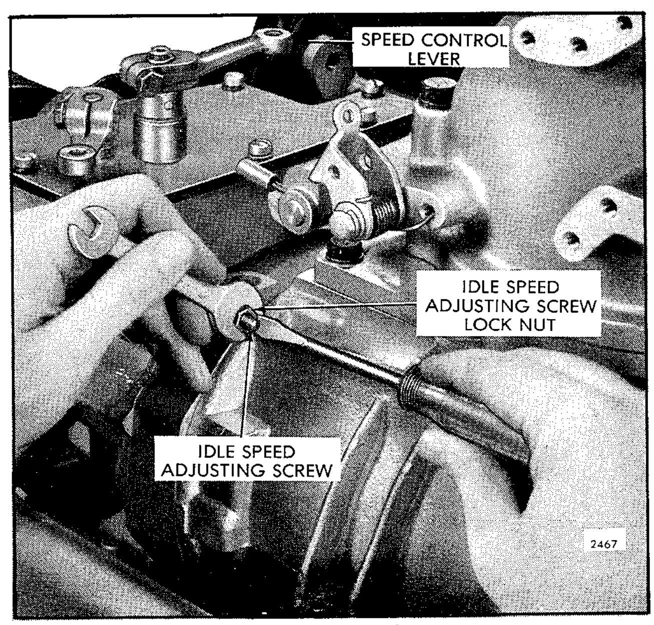


Fig. 9 - Adjusting Engine Idle Speed

speed control lever in the maximum speed position.

b. Turn the low maximum speed adjustment screw in until the high maximum speed desired is obtained.

c. Stop the engine and remove the spring housing assembly.

d. Note the distance ("X" distance, Fig. 8) the piston is from the bottom of the spring housing when it is against the low maximum speed screw, then remove the sleeve from the piston.

IMPORTANT: Do not permit the seal ring on the piston to slide past the air inlet port, since the seal ring will be damaged.

NOTE: When checking this distance, the piston should be held tight against the adjustment screw of the cover that is held in position, with its gasket, against the end of the spring housing.

e. Remove a quantity of shims, from the shims within the piston, equal to the distance noted in Step d.

f. Start the engine and position the speed control lever in the maximum speed position and apply air or oil pressure to the governor and note the engine speed.

g. Remove the air or oil pressure from the governor and stop the engine. Then install or remove shims as required to obtain the correct high maximum no-load speed. Removing shims will decrease the engine speed and adding shims will increase the engine speed.

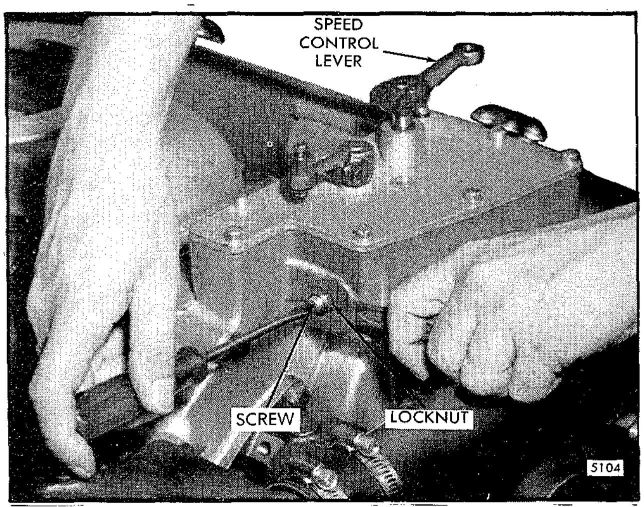


Fig. 10 - Adjusting Buffer Screw

NOTE: Each .010 " shim removed or added will decrease or increase the engine speed approximately 10 rpm.

2. Set the low maximum no-load engine speed:

a. Adjust the low maximum speed adjusting screw, with the speed control lever held in the maximum speed position, until the desired low maximum speed is obtained. Turn the screw in to increase or out to decrease the engine speed.

b. Recheck the engine speed and readjust, if necessary.

3. Check both the high maximum and low maximum engine speeds. Make any adjustment that is necessary as outlined in Steps 1 and 2.

Adjust Idle Speed

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

1. 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 (Fig. 9) until the engine operates at approximately 15 rpm below the recommended idle speed.

IMPORTANT: It may be necessary to use the buffer screw to eliminate engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8 ").

2. Hold the idle screw and tighten the lock nut.

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

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. 10).

IMPORTANT: 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 out the buffer screw until the increase is less than 25 rpm.

3. Hold the buffer screw (or fast idle air cylinder) and tighten the lock nut.

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

16V-71 ENGINE

The governor (Fig. 1) on the 16V engine is mounted on and driven from the front end of the rear blower.

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and 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.

If the engine or governor has been overhauled, or the injector control linkage has been disturbed, the control link levers in the governor housing and auxiliary control link housing must be aligned before proceeding with the engine tune-up. Refer to Fig. 2 and position the control link levers as follows:

1. Disconnect the linkage to the governor speed control lever and stop lever.

2. Remove the covers from the governor housing and auxiliary control link housing.

3. Disconnect the adjustable link from the lever in the auxiliary control link housing.

4. Remove the connecting pin from the auxiliary governor control link lever.

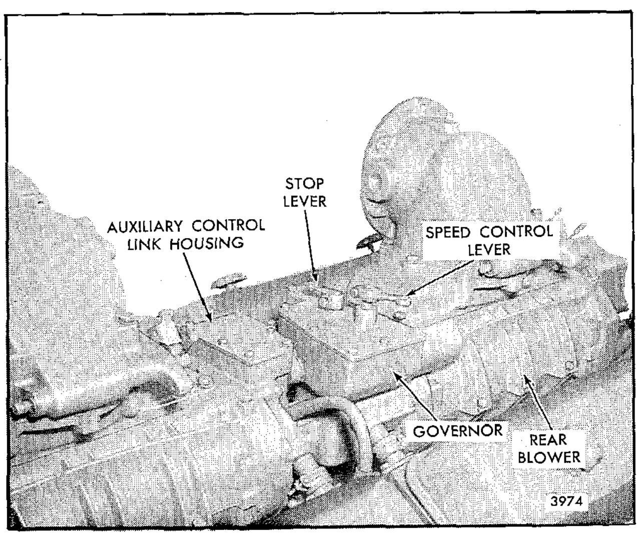


Fig. 1 - Governor Mounting

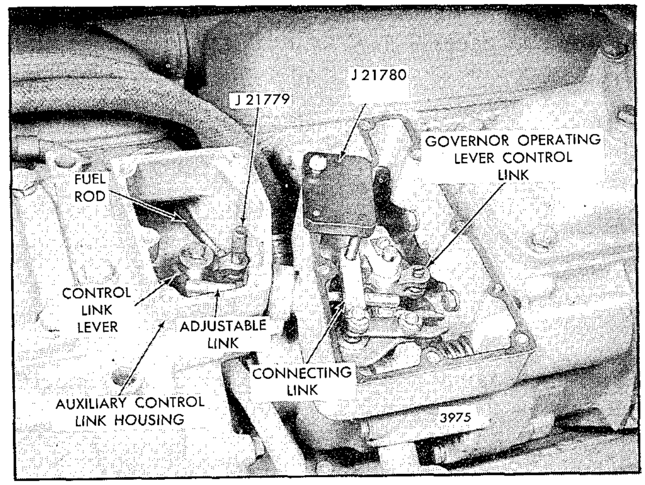


Fig. 2 - Control Link Levers in Position

5. Install gage J 21779 so it extends through the lever and fuel rod and into the gage hole in the bottom of the housing. With the gage in place, the auxiliary control link lever will be in the mid-travel position.

6. Remove the connecting pin from the control link lever in the governor housing and install gage J 21780. Install the gage so the pin extends through the connecting link, control lever and fuel rod and the governor housing dowel pin extends into the small hole in the gage. Then install a governor cover bolt as shown in Fig. 2 to lock the gage in place. With gage

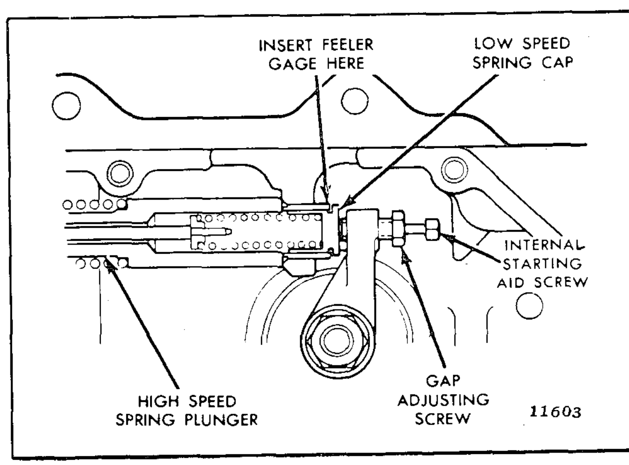


Fig. 3 - Governor Gap Adjustment

J 21780 in place, the governor control link lever will be in the mid-travel position and parallel to the auxiliary control link lever.

7. Adjust the length of the adjustable connecting link to retain the lever positions obtained in Steps 5 and 6 and install the link.

8. Remove gages J 21779 and J 21780 and reinstall the control link lever connecting pins.

9. Install the governor housing and auxiliary control link housing covers.

Proceed with the governor and injector rack control adjustment.

Adjust the Governor Gap

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

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

2. Back out the buffer screw (Fig. 10) until it extends approximately 5/8 " from the lock nut.

3. Start the engine and loosen the idle speed adjusting screw lock nut and adjust the idle screw (Fig. 9) to obtain the desired idle speed. Hold the screw and tighten the lock nut to hold the adjustment.

IMPORTANT: Current governors include a starting aid screw threaded into the governor housing.

NOTE: The recommended idle speed is 400-450 rpm, but may vary with special engine applications.

4. Stop the engine. Clean and remove the governor cover and lever assembly and the valve rocker covers. Discard the gaskets.

5. Start and run the engine between 800 and 1000 rpm by manual operation of the differential lever.

NOTE: Do not overspeed the engine.

6. Check the gap between the low-speed spring cap and the high-speed spring plunger (Fig. 3) with a .0015 " feeler gage. If the gap setting is incorrect, reset the gap adjusting screw. If the setting is correct, the .0015 " movement can be seen by placing a few drops of oil into the governor gap and pressing a screw driver against the gap adjusting screw. Movement of the cap toward the plunger will force the oil from the gap in the form of a small bead.

7. Hold the gap adjusting screw and tighten the lock nut.

8. Recheck the gap and readjust, if necessary.

9. Stop the engine and, using a new gasket, install the governor cover and lever assembly.

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.

Certain engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever and only one screw and lock nut to keep each injector rack properly positioned. Adjust the single screw and lock nut on each injector rack control lever the same as for the two screw rack control lever (refer to Fig. 3 for 6, 8 and 12V-71 engine governor). 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.

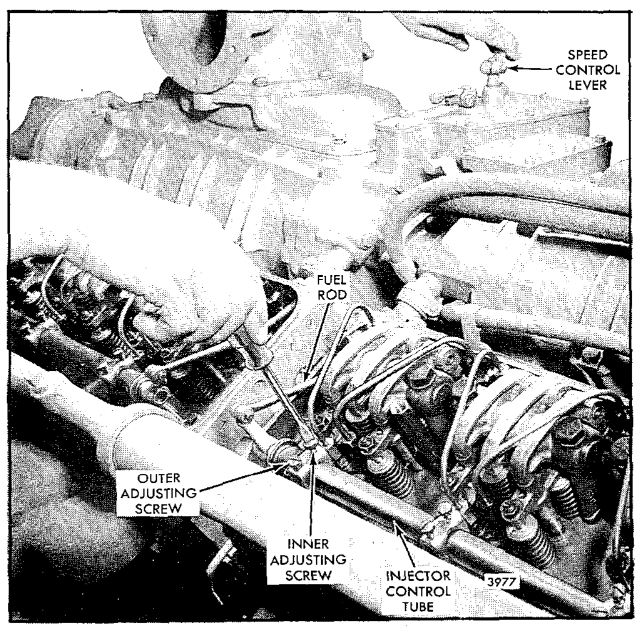


Fig. 4 - Positioning No. 4L Injector Rack Control Lever (Two Screw Assembly)

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

The letters R and L indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 4R injector rack control lever first to establish a guide for adjusting the remaining right bank injector rack control levers.

1. Adjust the idle speed adjusting screw until 1/2 " of the threads (12-14 threads) project from the lock nut when the nut is against the high-speed spring plunger.

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

NOTE: This adjustment lowers the tension on 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.

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

3. Loosen all of the inner and outer injector rack control lever adjusting screws on both cylinder banks. Be sure all of the levers are free on the injector control tubes.

4. Check for any bind in the governor control tube linkage by moving the linkage through its full range of travel.

5. Remove the clevis pins which attach the right rear bank and both left bank fuel rods to the injector control tube levers.

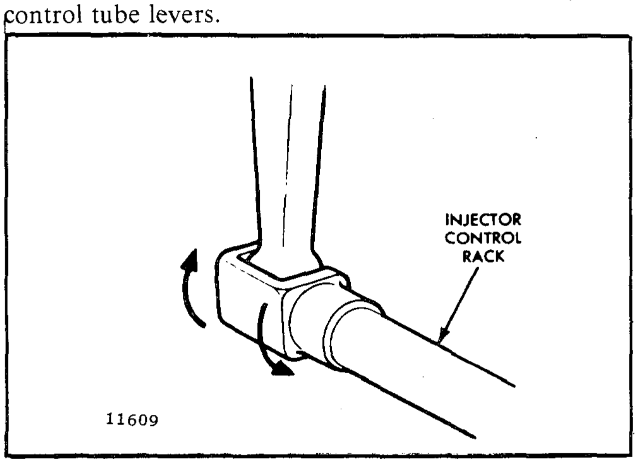


Fig. 5 - Checking Rotating Movement of Injector Control Rack

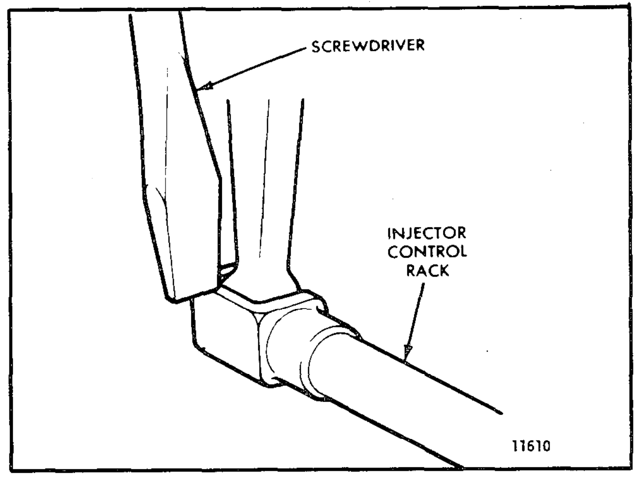


Fig. 6 - Checking Injector Control Rack "Spring"

6. Move the speed control lever to the maximum speed position.

7. Hold it with light finger pressure (Fig. 4) and adjust the No. 4R injector rack by turning the inner adjusting screw down until a slight movement of the control tube is observed or a step-up in effort to turn the screw driver is noted. This will place the rack in the full-fuel position. Turn the outer adjusting screw until it bottoms lightly on the control tube. Then tighten both the inner and outer adjusting screws alternately.

NOTE: Care should be taken to avoid setting the rack too tight, causing the fuel rod to bend.

NOTE: 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 **in-lb(3-4 Nm).**

IMPORTANT: 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.

8. 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 screw driver or finger tip and note "rotating" movement of the injector control rack (Fig. 5). Hold the speed control lever in the maximum speed position and, using a screw driver, press downward on the injector control rack. The rack should tilt downward (Fig. 6) and when the pressure of the screw driver is released, the control rack should "spring" back upward.

If the rack does not return to its original position, it is too loose. To correct this condition, back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly.

The setting is too tight if, when moving the speed control lever from the no-speed 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, back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly.

9. Remove the fuel rod-to-control tube lever clevis pin from the right front bank fuel rod and install it on the right rear bank fuel rod and adjust the No. 5R injector rack as outlined in Steps 5, 6 and 7.

10. Repeat Step 9 for adjustment of the No. 4L and 5L injector racks. When the settings are correct, the No. 4R, 5R, 4L and 5L injector racks will be snug on the ball end of the control levers when the injectors are in the full-fuel position.

11. With the fuel rod disconnected from the injector control tube lever, adjust the remaining injector rack control levers on the right front bank. Hold the No. 4R injector rack in the full-fuel position by means of the control tube lever and turn the inner adjusting screw of the No. 3R injector rack control lever until the injector rack has moved into the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

> **NOTE:** 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 **in-lb (3-4 Nm).**

12. Recheck the No. 4R injector rack to be sure it has remained snug on the ball end of the injector rack control lever. If the rack of the No. 4R injector has become loose, back off the inner adjusting screw slightly on the No. 3R injector rack control lever and tighten the outer adjusting screw. When the settings are correct, both injector racks must respond in the same manner on the ball ends of the control levers when the injector control tube lever is held in the full-fuel position.

13. Position the remaining injector rack control levers on the right front cylinder bank as outlined in Steps 11 and 12.

14. Adjust the remaining injector rack control levers on the right rear, left front and left rear cylinder banks in the same manner as outlined in Steps 11, 12 and 13.

15. Install the four fuel rod-to-control tube lever clevis pins and check the adjustment of the injector rack control levers.

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

17. Use new gaskets and replace the valve rocker covers.

Adjust Starting Aid Screw

The starting aid screw (Fig. 7) is threaded into the governor housing of current engines and into the governor gap adjusting screw of early engines. This screw is adjusted to position the injector racks at less than full fuel when the governor speed control lever is in the idle position. The reduced fuel makes starting easier and reduces the amount of smoke on start-up.

> **IMPORTANT:** The effectiveness of the starting aid screw will be eliminated if the speed control lever is advanced to wide open throttle during starting.

After the normal governor *running* gap of .0015 " has been set and the injector racks positioned, adjust the starting aid screw.

1. On current turbocharged engines, adjust the external starting aid screw as follows:

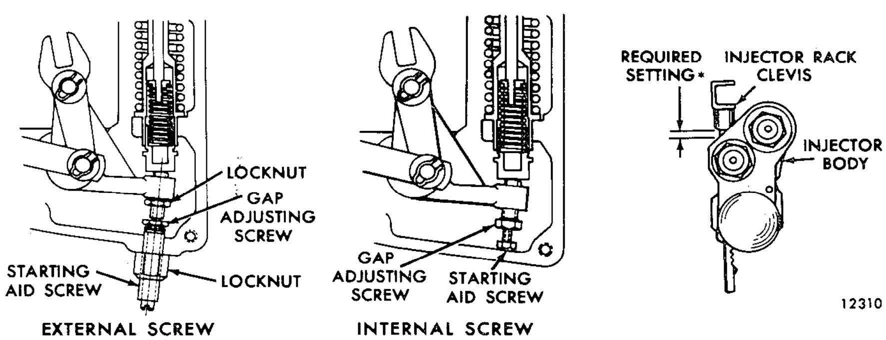
a. With the engine *stopped,* place the governor stop lever in the *run* position and the speed control lever in the *idle speed* position.

b. Adjust the starting aid screw to obtain the required setting between the shoulder on the injector rack clevis and the injector body (Fig. 7). 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 " (.397 mm) 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 lock nut.

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

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



INJECTOR	GAGE SETTING *	TOOL NUMBER
S 80	.345"	J 24889
N 60	.345"	J 24889
N 65	.385"	J 24882
N 70	.385"	J 24882
N 75	.385"	J 24882
N 80	.385"	J 24882
N 90	.454"	J 23190
C 65	.385"	J 24882
C 80	.385"	J 24882
M 70	.385"	J 24882
M 95	.454"	J 23190

Fig. 7 - Starting Aid Screw Adjustment

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.

NOTE: 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 gap adjusting screw, or reduced by backing it out.

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

2. On early turbocharged engines, adjust the internal starting aid screw, as follows:

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

b. Hold the gap adjusting screw, to keep it from turning, and adjust the starting aid screw to obtain the required setting between the shoulder on the injector rack clevis and the injector body (Fig. 7). The setting is measured at the No. 3R injector rack clevis.

c. 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* position to the *maximum speed* position.

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

NOTE: Movement of the governor speed control lever is to take-up clearances in the governor linkage. The clevis-to-body clearance can be increased by backing out the starting aid screw or reduced by turning it farther into the gap adjusting screw.

d. Start the engine and re-check the running gap (.0015 ") and, if necessary, reset it and re-position the injector racks. Then stop the engine.

e. Use a new gasket and replace the governor cover and lever assembly. Tighten the screws.

3. Use new gaskets and replace the valve rocker covers.

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

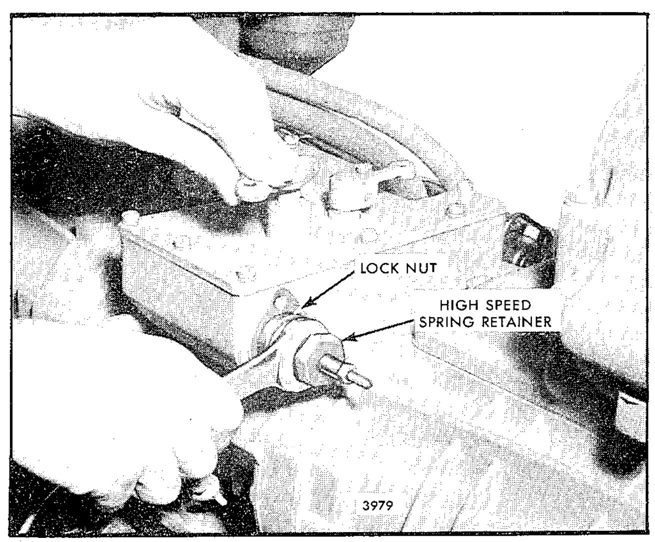


Fig. 8 - Adjusting Maximum No-Load Speed

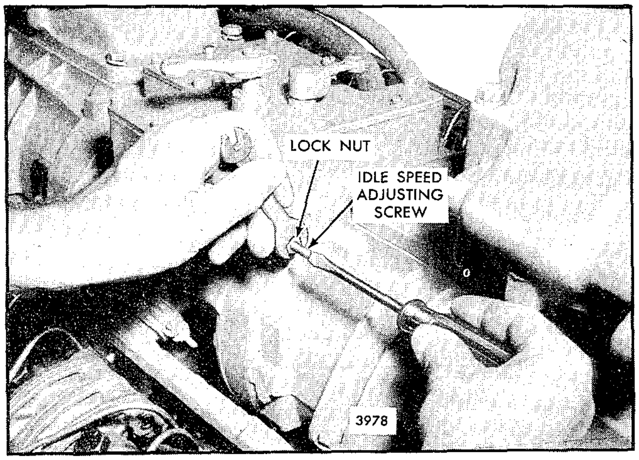


Fig. 9 - Adjusting Engine Idle Speed

on the option plate, set the maximum no-load speed as follows:

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

1. Loosen the spring retainer lock nut (Fig. 8) and back off the high-speed spring retainer approximately five turns.

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

3. Hold the high-speed spring retainer and tighten the lock nut.

Adjust Idle Speed

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

1. 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 (Fig. 9) until the engine is operating approximately 15 rpm below the recommended idle speed.

IMPORTANT: It may be necessary to use the buffer screw to eliminate the engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8 ").

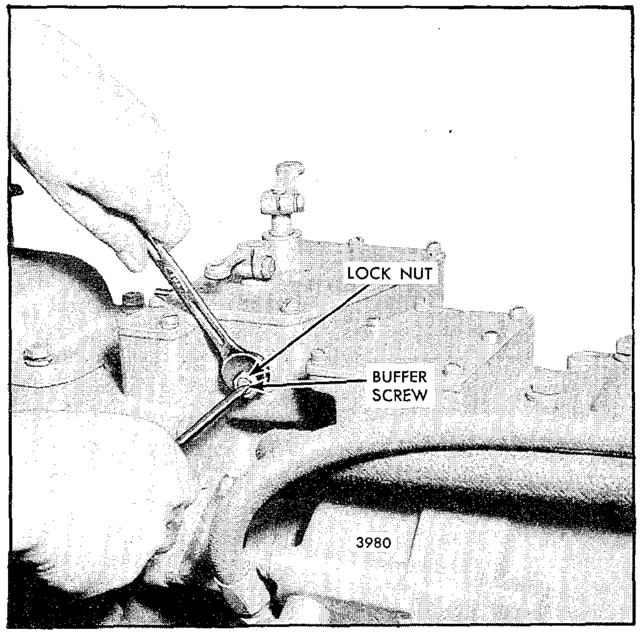


Fig. 10 - Adjusting Buffer Screw

NOTE: The recommended idle speed is 400-450 rpm, but may vary with certain engine applications.

2. Hold the idle screw and tighten the lock nut.

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

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 the engine roll (Fig. 10).

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 lock nut.

LIMITING SPEED MECHANICAL GOVERNOR

(Fast Idle Cylinder)

The limiting speed governor equipped with a fast idle air cylinder is used on certain engines where the engine powers both a vehicle and auxiliary equipment.

The fast idle system consists of a fast idle air cylinder installed in place of the buffer screw and a throttle locking air cylinder mounted on a bracket fastened to the governor cover (Fig. 1). An engine shutdown air cylinder, if used, is also mounted on the governor cover.

The fast idle air cylinder and the throttle locking air cylinder are actuated at the same time by air from a common air line. The engine shutdown air cylinder is connected to a separate air line.

The air supply for the fast idle air cylinder is usually controlled by an air valve actuated by an electric solenoid. The fast idle system should be installed so that it will function only when the parking brake system is in operation to make it tamper-proof.

The accelerator-to-governor throttle linkage is connected to a yield link so the operator cannot overcome the force of the air cylinder holding the speed control lever in the idle position while the engine is operating at the single fixed high idle speed.

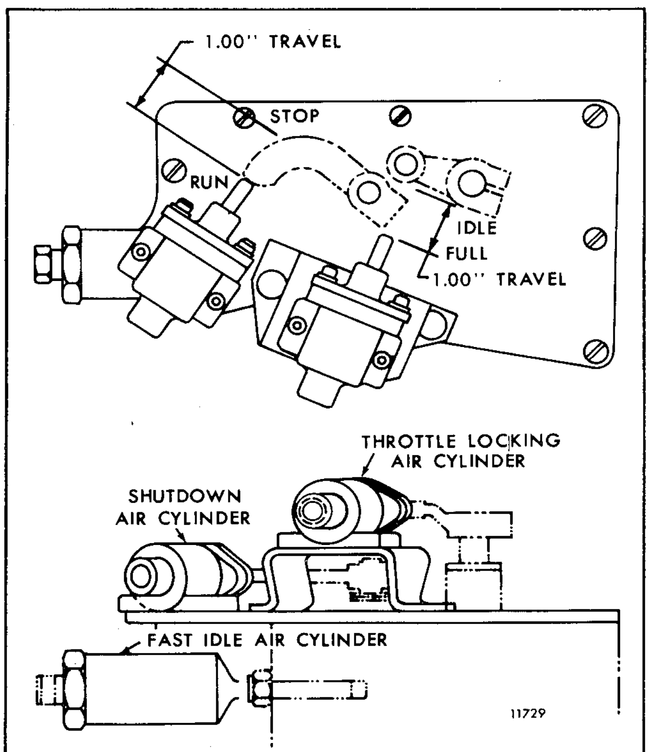


Fig. 1 - Governor with Fast Idle Cylinder

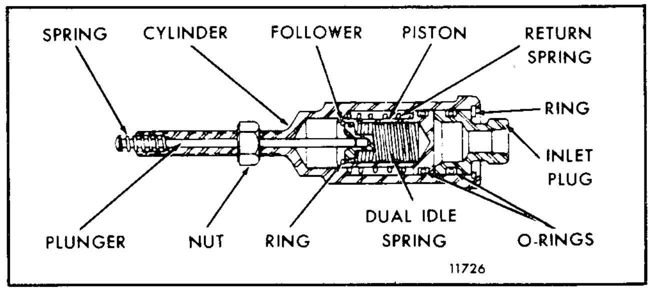


Fig. 2 - Fast Idle Air Cylinder

Operation

During normal operation, the governor functions as a limiting speed governor.

For operation of auxiliary equipment, the vehicle is stopped and the parking brake set. Then, with the engine running, the low-speed switch is placed in the ON position. When the fast idle air cylinder is actuated, the force of the dual idle spring (Fig. 2) is added to the force of the governor low-speed spring, thus increasing the engine idle speed.

The governor now functions as a constant speed governor at the high idle speed setting, maintaining a near constant engine speed regardless of the load within the capacity of the engine. The fast idle system

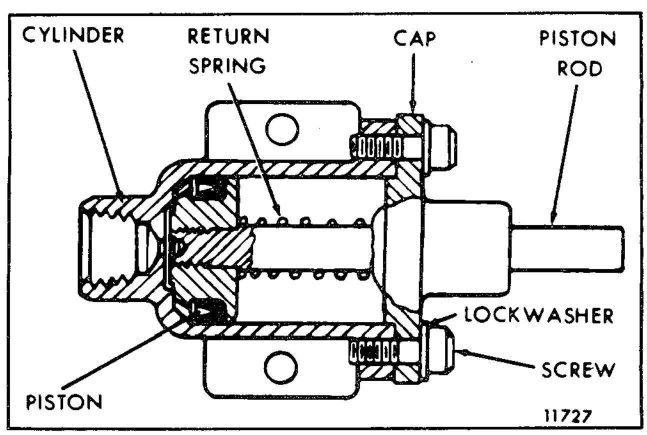


Fig. 3 - Throttle Locking Air Cylinder

provides a single fixed high idle speed that is not adjustable, except by disassembling the fast idle air cylinder and changing the dual idle spring. As with all mechanical governors, when load is applied, the engine speed will be determined by the governor droop.

Adjust Governor

Before adjusting the governor gap, back out the de-energized fast idle air cylinder until it will not interfere with the governor adjustments. After the normal idle speed setting is made, adjust the de-energized fast idle air cylinder as follows:

1. Turn in the fast idle cylinder assembly until an increase of idle speed is noted. The increase in idle speed should not exceed 15 rpm. Tighten the fast idle jam nut.

2. Lock the governor throttle in the idle position and apply full shop air pressure to the fast idle air cylinder. The engine idle speed must increase from 325 to 500 rpm ± 50 rpm, depending on the original idle speed setting and fast idle spring used.

The throttle locking air cylinder is adjusted on its mounting bracket so it will lock the throttle in the idle position when it is activated, but will not limit the throttle movement when not activated.

VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

6, 8 and 12V ENGINES

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

After adjusting the exhaust valves and timing the fuel injectors, adjust the variable speed mechanical governor and 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 temperature, 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 lock nut.

3. Clean and remove the governor cover and valve rocker covers. Discard the gaskets.

4. Place the speed control lever in the maximum speed position.

5. Insert a .006" feeler gage between the spring plunger and the plunger guide as shown in Fig. 1. If required, loosen the lock nut and turn the adjusting screw until a slight drag is noted on the feeler gage.

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

7. Use a new gasket and install the governor cover. Tighten the screws.

Position Injector Rack Control Levers

The position of the injector control rack 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.

Certain engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever and only one screw and lock nut to keep each injector rack properly positioned. Adjust the single screw and lock nut on each injector rack control lever the same as for the two screw rack control lever.

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 is within .005" to .007" of its seat in the governor control housing.

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

The letters R and L indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. The cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the

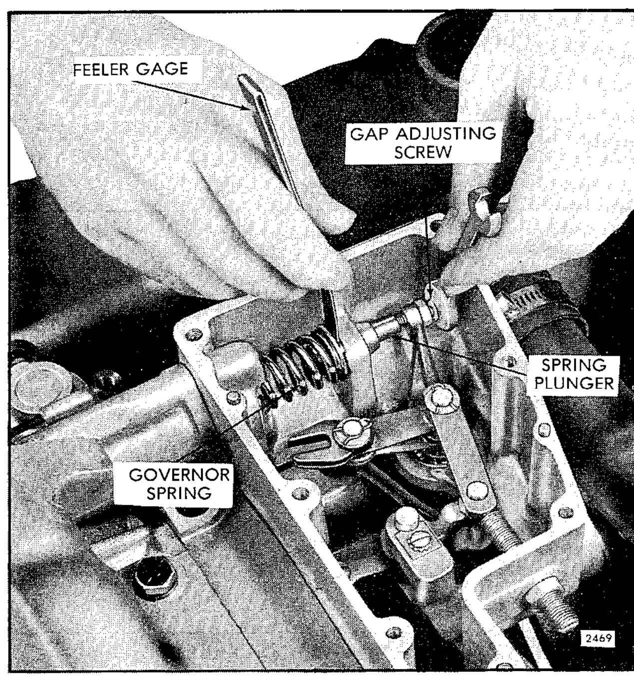


Fig. 1 – Adjusting Governor Gap

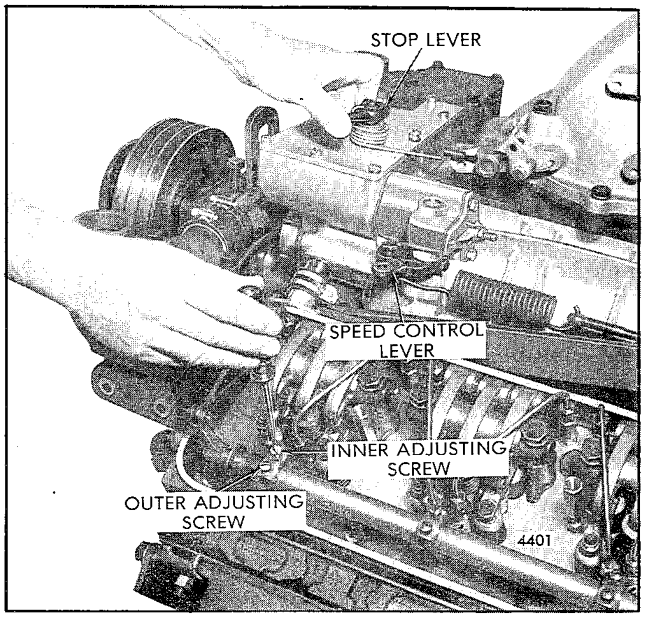


Fig. 2 - Positioning No. 1 Injector Rack Control Lever

No. 1L injector rack control lever first to establish a guide for adjusting the remaining control levers.

1. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

2. Loosen all of the inner and outer injector rack control lever adjusting screws on both injector control tubes. Be sure all of the injector rack control levers are free on the injector control tubes.

3. Move the speed control lever to the maximum speed position.

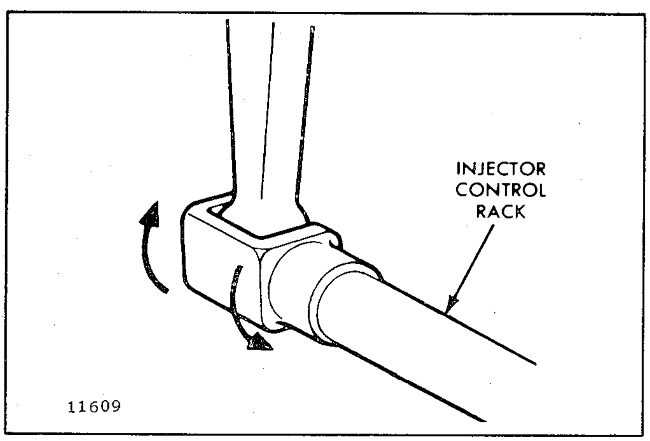


Fig. 3 - Checking Rotating Movement of Injector Control Rack

4. Move the governor stop lever to the "run" position and hold it in that position with light finger pressure. Turn the inner adjusting screw of the No. 1L injector rack control lever down until a slight movement in the governor stop lever is noted. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws (Fig. 2).

NOTE: 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 **in-lbs** (3-4 Nm).

IMPORTANT: 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.

5. To be sure of the proper rack adjustment, hold the stop lever in the run position and press down on the injector rack with a screw driver or finger tip and note "rotating" movement of the injector control rack (Fig. 3) when the stop lever is in the run position. Hold the stop lever in the run position and, using a screw driver, press downward on the injector control rack. The rack should tilt downward (Fig. 4) and when the pressure of the screw driver is released, the control rack should "spring" back upward.

If the rack does not return to its original position, it is too loose. To correct this condition, back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly.

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, back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly.

NOTE: 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 **in-lbs** (3-4 Nm).

6. Remove the clevis pin from the fuel rod and the left bank injector control tube lever.

7. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the 1R injector rack control lever as previously outlined in Step 4.

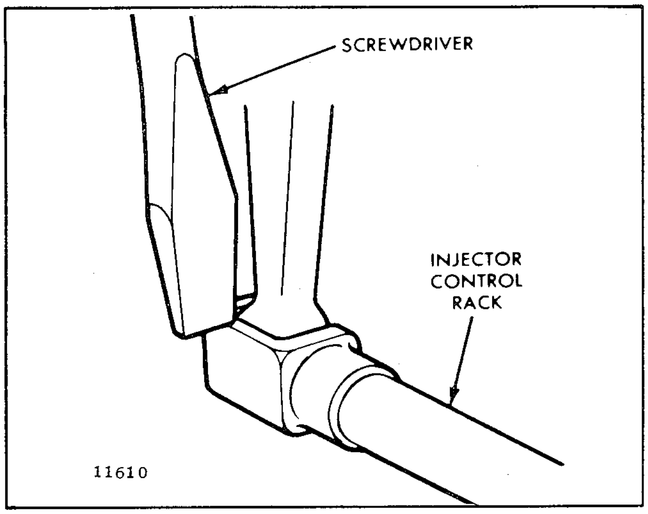


Fig. 4 - Checking Injector Control Rack "Spring"

8. Insert the clevis pin in the fuel rod and the left bank injector control tube lever. Repeat the check on the 1L and 1R injector rack control levers as outlined in Step 5. Carefully observe and eliminate any deflection which occurs at the bend in the fuel rod where it enters the cylinder head.

9. To adjust the remaining injector rack control levers, remove the clevis pin from the fuel rods and the injector control tube levers, 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. Turn down the inner adjusting screw of the injector rack control lever until the screw bottoms (injector control rack in the full-fuel position).

b. Turn down the outer adjusting screw of the injector rack control lever until it bottoms on the injector control tube.

c. While still holding the control tube lever in the full-fuel position, adjust the inner and outer adjusting screws to obtain the same condition as outlined in Step 5. Tighten the screws.

NOTE: Once the No. 1L and No. 1R injector rack control levers are adjusted, do not try to alter their settings. All adjustments are made on the remaining control racks.

10. 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 5. All of the control racks must have the same "spring" condition with the control tube lever in the full-fuel position.

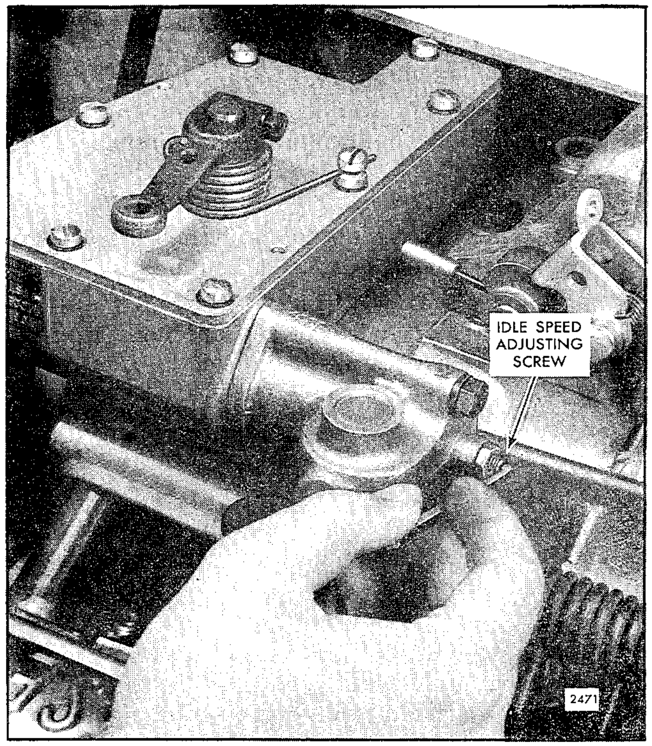


Fig. 5 - Adjusting Idle Speed

11. Insert the clevis pin in the fuel rods and the injector control tube levers.

12. Use new gaskets and install the valve rocker covers.

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 engine option plate, set the maximum no-load speed as outlined below.

Start the engine and, after it reaches normal operating temperature, use an accurate hand tachometer to

Variable Speed Governor Adjustment		
Full-Load Speed*	Stops	Shims
1200-1750	2	Up to .325"
1750-2100	1	in shims
2000-2300	0	maximum

*No-load speed is 125-200 rpm above full-load speed depending upon engine application.

TABLE 1

determine the maximum no–load speed of the engine. Then stop the engine and make the following adjustments, if required:

1. Disconnect the booster spring and the stop lever spring.

2. Remove the variable speed spring housing and the spring retainer from the governor housing.

3. Refer to Table 1 and determine the stops or shims required for the desired no–load speed.

4. Install the variable speed spring retainer and housing and tighten the two bolts.

5. Connect the booster spring and the stop lever spring. Start the engine and recheck the maximum no–load speed.

6. If required, add or remove shims to obtain the necessary operating speed. For each .001″ shim added, the operating speed will increase approximately 1 rpm.

> **IMPORTANT:** If the maximum no–load speed is raised or lowered more than 50 rpm by the installation or removal of shims, recheck the governor gap. If readjustment of the governor gap is required, the position of the injector racks must be rechecked.

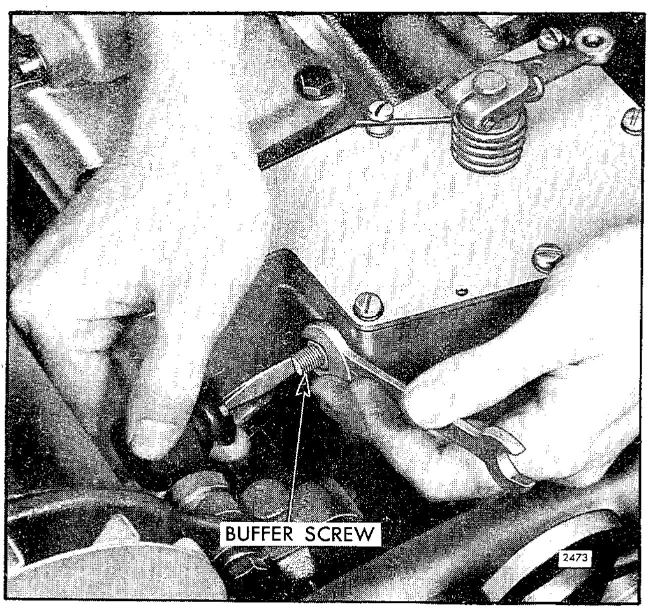


Fig. 6 – Adjusting Buffer Screw

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

Adjust Idle Speed

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

1. Place the stop lever in the "run" position and the speed control lever in the "idle" 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 lock nut and turn the idle speed adjusting screw (Fig. 5) until the engine is operating at approximately 15 rpm below the recommended idle speed.

> **NOTE:** The recommended idle speed is 550 rpm, but may vary with special engine applications.

4. Hold the idle speed adjusting screw and tighten the lock nut.

Adjust Buffer Screw

1. With the engine running at normal operating temperatures, turn the buffer screw "in" (Fig. 6) so

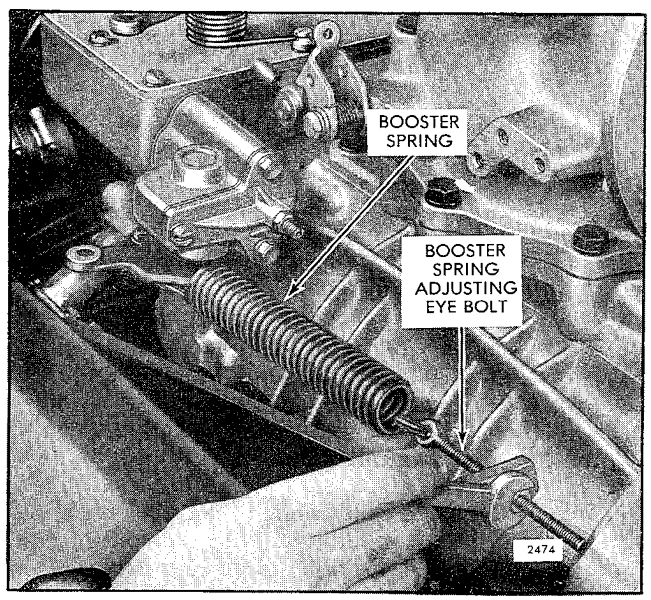


Fig. 7 – Adjusting Booster Spring

that it contacts the differential lever as lightly as possible and still eliminates engine roll.

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

2. Hold the buffer screw and tighten the lock nut.

Adjust Booster Spring

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

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

2. Refer to Fig. 7 and loosen the booster spring retaining nut on the speed control lever. Loosen the lock nuts on the eye bolt at the opposite end of the booster spring.

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

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 position. If it does not, reduce the tension on the booster spring. If it does, continue to increase the spring tension until the point is reached that it will not return to idle. Then reduce the tension until it does 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.

5. Connect the linkage to the governor levers.

VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

16V-71 ENGINE

The governor (Fig. 1) on the 16V engine is mounted on and driven from the front end of the rear blower.

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

If the engine or governor has been overhauled, or the injector control linkage has been disturbed, the control link levers in the governor housing and auxiliary control link housing must be aligned before proceeding with the engine tune-up. Refer to Fig. 2 and position the control link levers as follows:

1. Disconnect the linkage to the governor speed control and stop levers.

2. Remove the covers from the governor housing and auxiliary control link housing.

3. Disconnect the adjustable link from the lever in the auxiliary control link housing.

4. Remove the connecting pin from the auxiliary governor control link lever.

5. Install gage J 21779 so it extends through the lever and fuel rod and into the gage hole in the bottom of the housing. With the gage in place, the auxiliary control link lever will be in the mid-travel position.

6. Remove the connecting pin from the control link lever in the governor housing and install gage J 21780. Install the gage so the pin extends through the connecting link, control lever and fuel rod and the governor housing dowel pin extends into the small hole in the gage. Then install a governor cover bolt as shown in Fig. 2 to lock the gage in place. With gage J 21780 in place, the governor control link lever will be in the mid-travel position and parallel to the auxiliary control link lever.

7. Adjust the length of the adjustable connecting link to retain the lever positions obtained in Steps 5 and 6 and install the link.

8. Remove gages J 21779 and J 21780 and reinstall the control link lever connecting pins.

9. Install the governor housing and auxiliary control link housing covers.

Proceed with the governor and injector rack control adjustment.

Adjust Governor Gap

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

1. Clean and remove the governor cover and the valve rocker covers. Discard the gaskets.

2. Back out the buffer screw until it extends approximately 5/8″ from the lock nut.

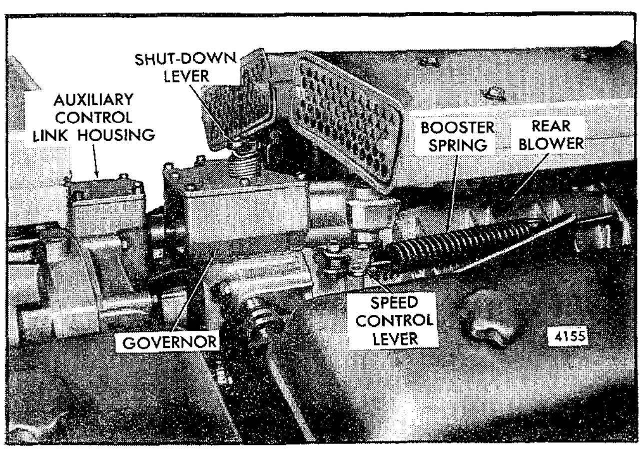


Fig. 1 - Governor Mounting

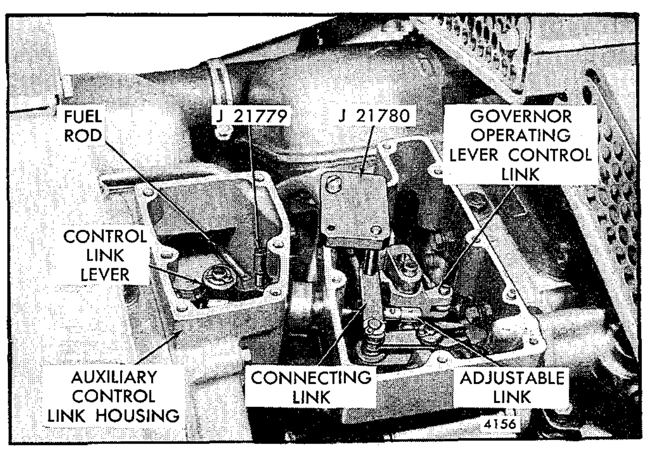


Fig. 2 - Control Link Levers In Position

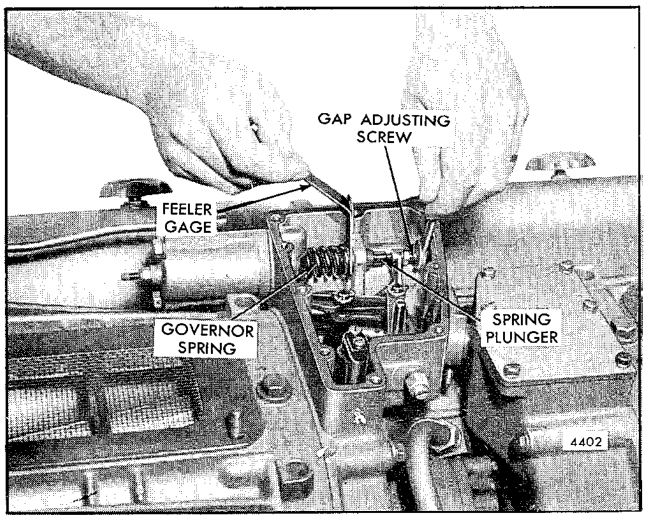


Fig. 3 - Adjusting Governor Gap

3. Place the speed control lever in the maximum speed position.

4. Insert a .006″ feeler gage between the spring plunger and the plunger guide as shown in Fig. 3. If required, loosen the lock nut and turn the adjusting screw until a slight drag is noted on the feeler gage.

5. Hold the adjusting screw and tighten the lock nut. Check the gap and readjust if necessary.

6. Use a new gasket and install the governor cover.

Position Injector Rack Control Levers

The position of the injector control rack 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.

Certain engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever and only one screw and lock nut to keep each injector rack properly positioned. Adjust the single screw and lock nut on each injector rack control lever the same as for the two screw rack control lever.

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 is within .005″ to .007″ of its seat in the governor control housing.

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

The letters R and L indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 4R injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Remove the clevis pins which attach the right rear bank and both left bank fuel rods to the injector control tube levers.

2. Loosen all of the inner and outer injector rack control lever adjusting screws on both cylinder banks. Be sure all of the levers are free on the injector control tubes.

3. Move the speed control lever to the maximum speed position.

4. Move the stop lever in the RUN position and hold it in that position with a light finger pressure. Turn the inner adjusting screw of the No. 4R injector rack control lever down until a slight movement of the stop lever is noted (Fig. 4). Turn down the outer adjusting screw until it bottoms lightly on the control tube. Then

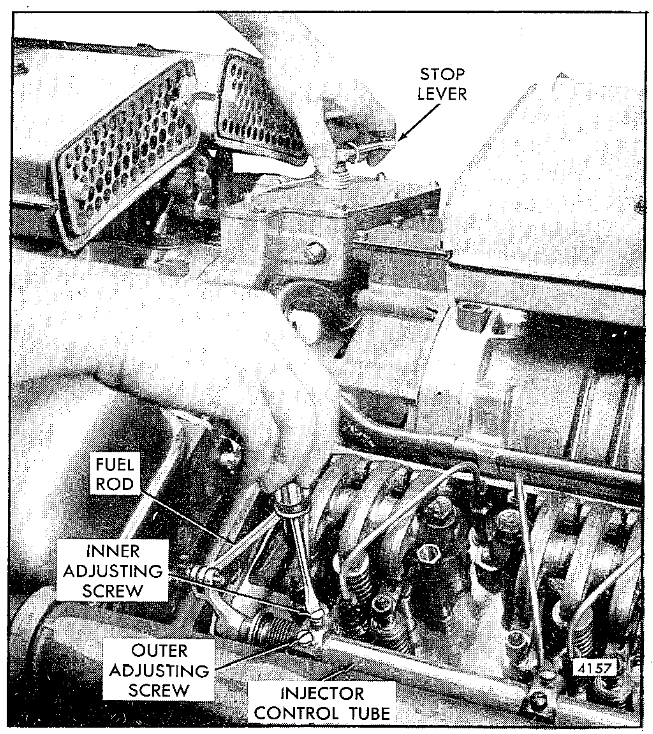


Fig. 4 - Positioning No. 4R Injector Rack Control Lever

alternately tighten both the inner and outer adjusting screws.

NOTE: 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 **in–lbs** (3–4 Nm).

IMPORTANT: 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.

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

If the rack does not return to its original position, it is too loose. To correct this condition, back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly.

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, back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly.

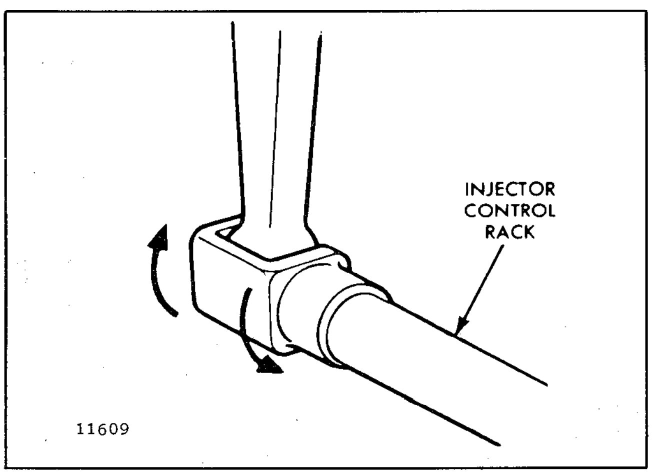


Fig. 5 – Checking Rotating Movement of Injector Control Rack

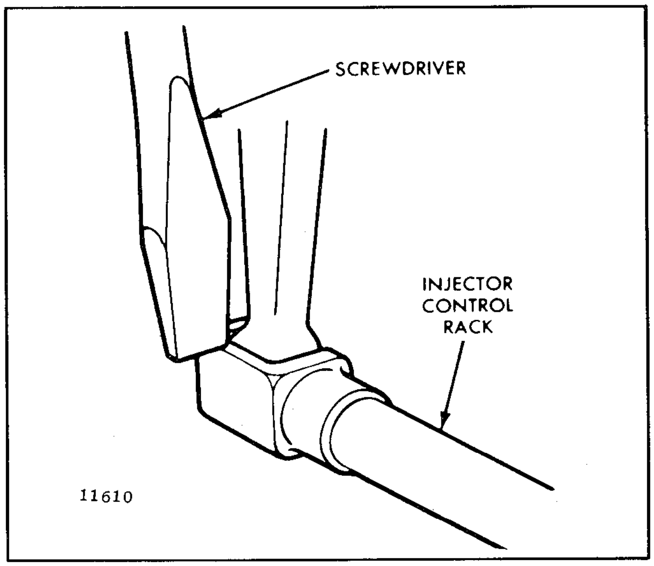


Fig. 6 – Checking Injector Control Rack "Spring"

6. Remove the fuel rod–to–control tube lever clevis pin from the right front bank fuel rod and install it on the right rear bank fuel rod and adjust the No. 5R injector rack as outlined in Steps 4 and 5.

7. Repeat Step 6 for adjustment of the No. 4L and 5L injector racks. When the settings are correct, the No. 4R 5R, 4L and 5L injector racks will be snug on the ball end of the control levers when the injectors are in the full–fuel position.

8. With the fuel rod disconnected from the injector control tube lever, adjust the remaining injector rack control levers on the right front bank. Hold the No. 4R injector rack in the full–fuel position by means of the control tube lever and turn the inner adjusting screw of the No. 3R injector rack control lever until the injector rack has moved into the full–fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

NOTE: 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 **in–lbs** (3–4 Nm).

9. Recheck the No. 4R injector rack to be sure it has remained snug on the ball end of the injector rack control lever. If the rack of the No. 4R injector has become loose, back off the inner adjusting screw slightly on the No. 3R injector rack control lever and

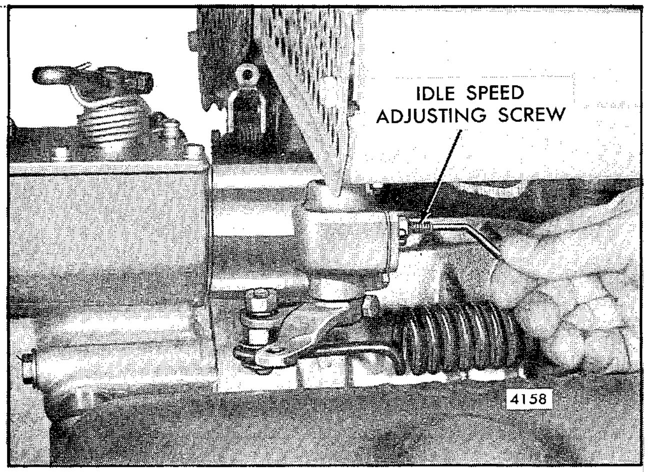


Fig. 7 – Adjusting Idle Speed

tighten the outer adjusting screw. When the settings are correct, both injector racks must respond in the same manner on the ball ends of the control levers when the injector control tube lever is held in the full–fuel position.

10. Position the remaining injector rack control levers on the right front cylinder bank as outlined in Steps 8 and 9.

11. Adjust the remaining injector rack control levers on the right rear, left front and left rear cylinder banks in the same manner as outlined in Steps 8, 9 and 10.

12. Install the four fuel rod–to–control tube lever clevis pins and check the adjustment of the injector rack control levers.

13. Use new gaskets and install the valve rocker covers.

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

Variable Speed Governor Adjustment		
Full-Load Speed*	Stops	Shims
1200-1750	2	Up to .325"
1750-2100	1	in shims
2100-2300	0	maximum

*No-load speed is 150-225 rpm above full-load speed depending upon engine application.

TABLE 1

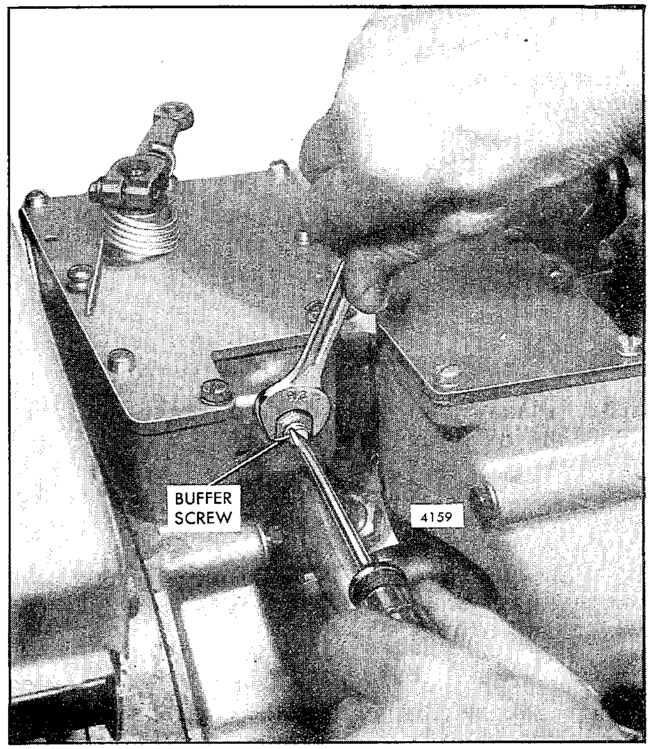


Fig. 8 – Adjusting Buffer Screw

not exceed the recommended no–load speed as given on the engine option plate, set the maximum no–load speed as outlined below.

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

1. Disconnect the booster spring and the stop lever spring.

2. Remove the variable speed spring housing and the spring retainer from the governor housing.

3. Refer to Table 1 and determine the stops or shims required for the desired no–load speed.

4. Install the variable speed spring retainer and housing and tighten the two bolts.

5. Connect the booster spring and the stop lever spring. Start the engine and recheck the maximum no–load speed.

6. If required, add or remove shims to obtain the necessary operating speed. For each .001" shim added, the operating speed will increase approximately 1 rpm.

IMPORTANT: If the maximum no-load speed is raised or lowered more than 50 rpm by the installation or removal of shims, recheck the governor gap. If readjustment of the governor gap is required, the position of the injector racks must be rechecked.

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

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 lock nut and turn the idle speed adjusting screw (Fig. 7) until the engine is operating at approximately 15 rpm below the recommended idle speed.

NOTE: The recommended idle speed is 550 rpm, but may vary with special engine applications.

4. Hold the idle speed adjusting screw from turning and tighten the lock nut.

Adjust Buffer Screw

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

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

2. Hold the buffer screw from turning and tighten the lock nut.

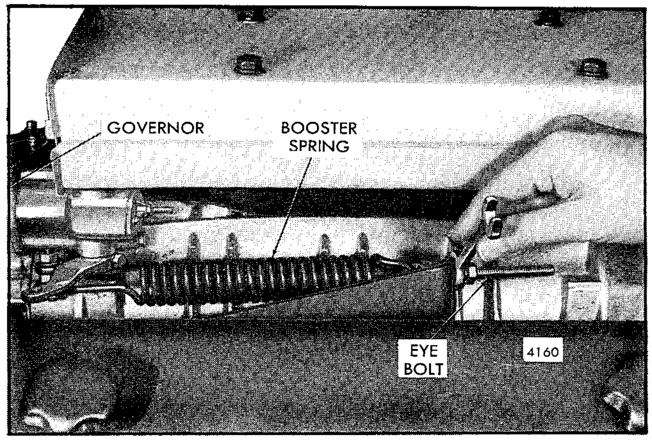


Fig. 9 – Adjusting Booster Spring

Adjust Booster Spring

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

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

2. Refer to Fig. 9 and loosen the nut on the booster spring retaining bolt on the governor speed control lever. Loosen the lock nuts on the eye bolt at the opposite end of the booster spring.

3. Move the bolt in the slot of the speed control lever until the center of the bolt is on or slightly over center (toward the idle speed position) of an imaginery line through the bolt, lever shaft and eye bolt. Hold the bolt from turning and tighten the lock nut.

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 position. If it does not, reduce the spring tension. If the lever does return to the idle position, increase the tension of the spring until the lever will not return to idle. Then reduce the tension until the lever will return to idle and tighten the lock nut on the eye bolt. This setting will result in a minimum force required to operate the speed control lever.

SUPPLEMENTARY GOVERNING DEVICE ADJUSTMENT

ENGINE LOAD LIMIT DEVICE

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

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 on *each* cylinder bank of a 6V engine, between the No. 2 and No. 3 cylinders on *each* cylinder bank of an 8V engine, or between the No. 3 and No. 4 cylinders on *each* cylinder bank of a 12V engine. On the 16V engine, four load limit devices are used (one on each cylinder head): between the No. 2 and No. 3 cylinder and between the No. 6 and No. 7 cylinder on each bank.

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 devices are properly installed as shown in Fig. 1. Make sure the counterbores in the adjusting screw plates 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 or 122–136 Nm torque). Then adjust the load limit device, on each cylinder head, as follows:

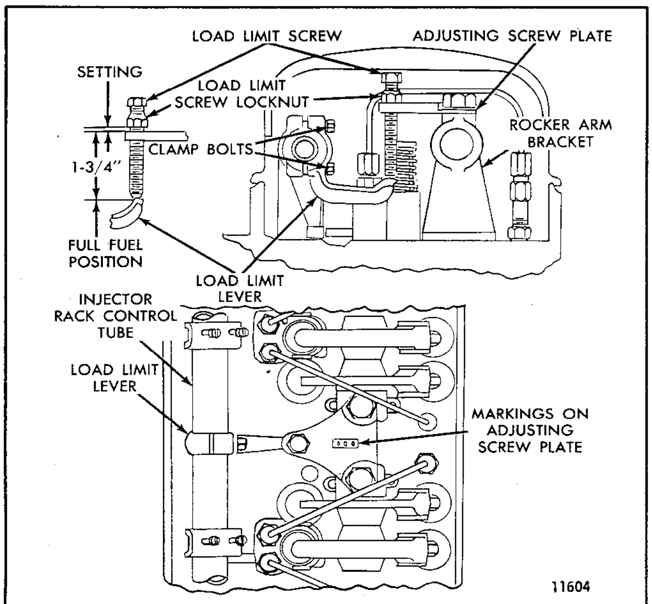


Fig. 1 – Engine Load Limit Device

1. Loosen the load limit screw lock nut 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 screw lock nut so the bottom of the lock nut 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 lock nut *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 lock nut until the distance between the bottom of the lock nut 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 lock nut *bottoms* against the top of the plate.

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

POWER CONTROL DEVICE

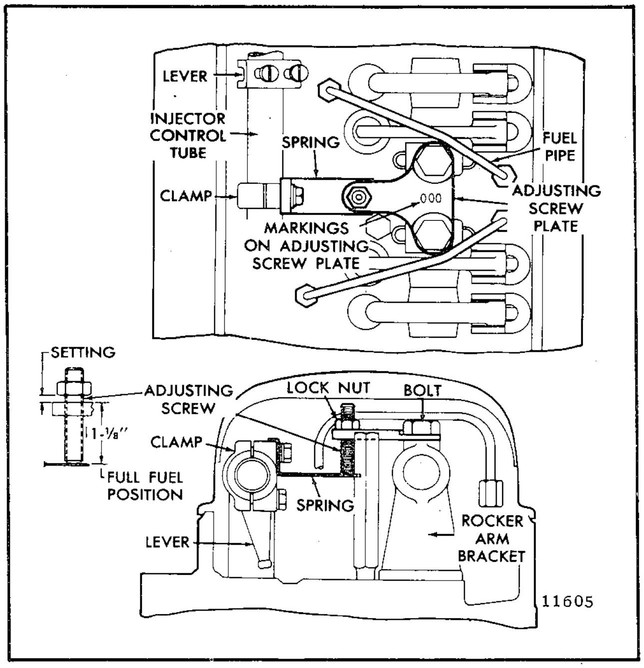


Fig. 2 – Power Control Device

The power control (torque limiting) device (Fig. 2) is used to limit the maximum horsepower output at the wheels without diminishing the performance at lower speeds where full power may be required. It limits the horsepower at, or just below, the normal full-load governed speed. These limiting characteristics are proportionately lessened as the engine speed is reduced and the horsepower required is reduced.

This device, one on each cylinder bank, consists of an adjusting screw threaded into a plate mounted between two adjacent rocker arm shaft brackets and a spring attached to a clamp on the injector control tube.

NOTE: The rocker arm shaft bracket bolts that retain the adjusting screw plates 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.

The power control device is located between the No. 1 and No. 2 cylinders on *each* cylinder bank of a 6V engine, between the No. 2 and No. 3 cylinders on *each* cylinder bank of an 8V engine, or between the No. 3 and No. 4 cylinders on *each* cylinder bank of a 12V engine.

Adjustment

After the engine tune-up is completed, adjust the power control device on both cylinder banks as follows:

1. Place the vehicle on a chassis dynamometer and check the maximum wheel horsepower.

2. Loosen the power control spring attaching bolts. Then adjust both springs until they project parallel to the cylinder heads when the injector control racks are held in the full-fuel position. Tighten the spring attaching bolts to 7-9 lb-ft (10-12 Nm) torque to retain the adjustment.

3. Set each power control device, while holding the injector control racks in the full-fuel position, by turning the adjusting screw down (clockwise) until it just touches the spring and the lock nut is tight against the plate. Then release the injector control racks.

NOTE: Wipe the oil from each spring and the bottom of each adjusting screw so the point of contact can be seen readily.

IMPORTANT: Steps 2 and 3 must be completed on both cylinder banks before proceeding with Step 4.

4. Start the engine. Then, with the engine running at full governed speed, check the horsepower. If necessary, re-adjust the screws to obtain the specified horsepower. Turn the screws down to decrease the horsepower; turn the screws up to increase the horsepower. When the desired wheel horsepower is obtained, hold the screws from turning and tighten the lock nuts.

NOTE: If a dynamometer is not available, back up the lock nuts the distance stamped on the plates. Then turn the screws and lock nuts down together until the lock nuts *bottom* on the plates. Hold the screws from turning and tighten the lock nuts.

THROTTLE DELAY MECHANISM

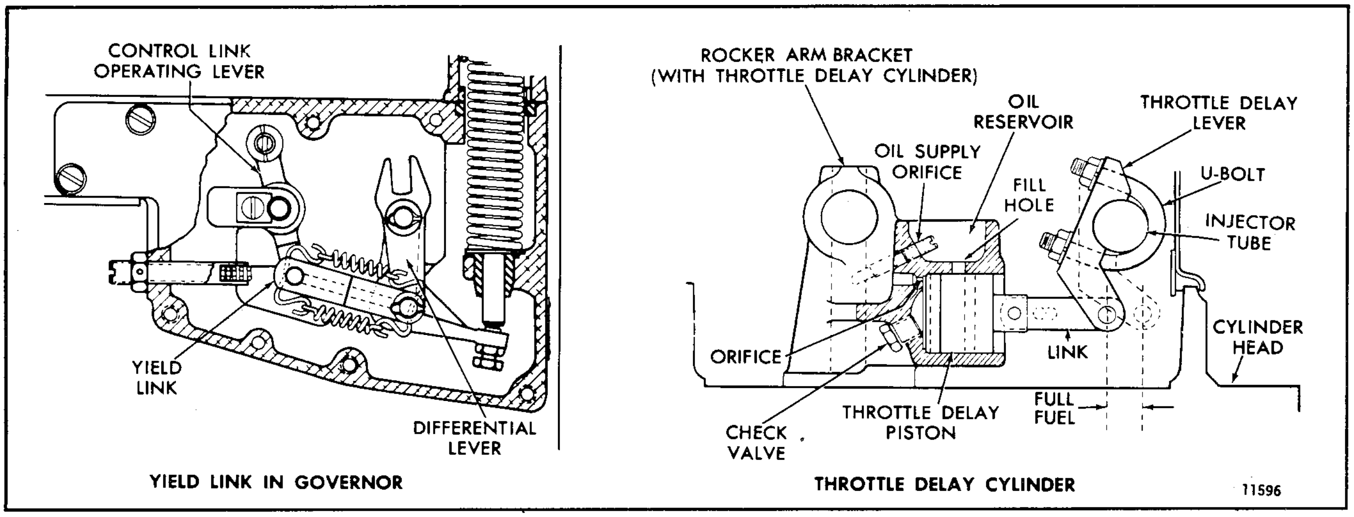


Fig. 3 - Throttle Delay Cylinder and Yield Link

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 (Fig. 3) is installed between the No. 1 and No. 2 cylinders on the right-bank cylinder head. 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 link replaces the standard operating lever connecting link in the governor.

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. 3). 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 link replaces the standard operating lever connecting link in the governor.

Inspection

When inspecting the throttle delay hydraulic cylinder it is important that the check valve be inspected for wear. Replace the check valve if necessary.

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.

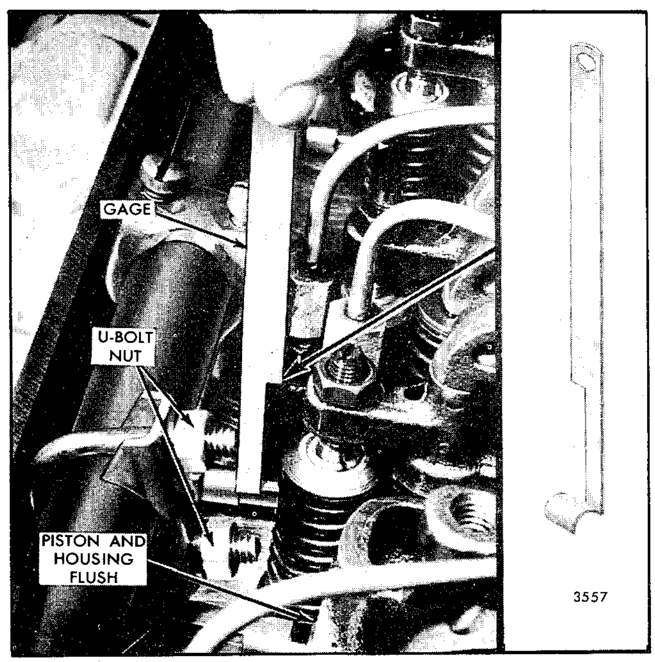


Fig. 4 - Adjusting Throttle Delay Cylinder

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 re-adjusted. With the engine stopped, proceed as follows:

1. Refer to Fig. 4 and insert gage J 23190 (.454" setting) between the injector body and the shoulder on the injector rack. Then exert a light pressure on the injector control tube in the direction of full fuel.

2. Align the throttle delay piston so it is flush with the edge of the throttle delay cylinder.

3. Tighten the U-bolt on the injector control tube and remove the gage.

4. Move the injector rack from the no-fuel to the full-fuel position to make sure it does not bind.

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. 5 and 6). 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 lock nut 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.

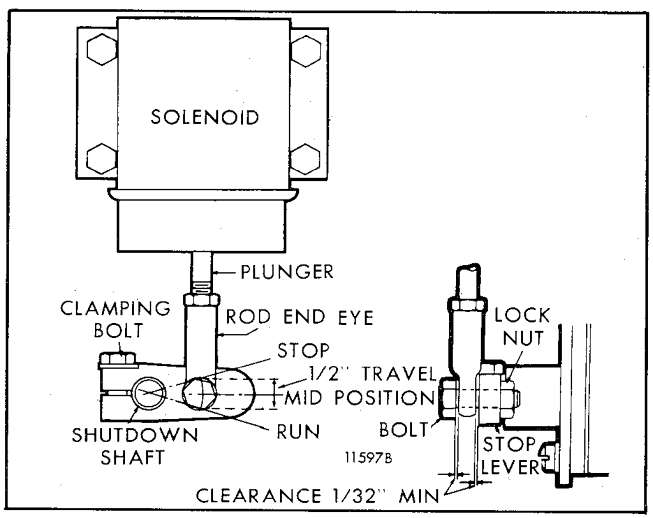


Fig. 5 - Typical Variable Speed Governor Lever Position

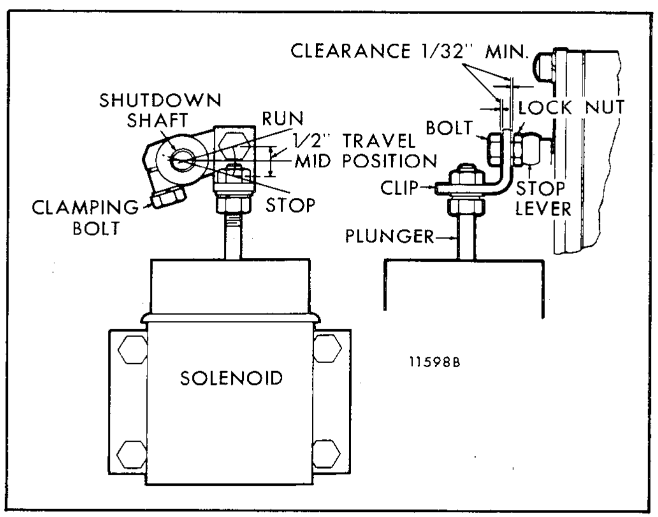


Fig. 6 - Typical Limiting Speed Governor Lever Position

VARIABLE SPEED HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

6, 8 and 12V ENGINES

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor linkage (Fig. 1) and position the injector rack control levers.

Adjust Governor Linkage and Position Injector Rack Control Levers

1. Clean and remove the valve rocker cover from each cylinder head. Discard the gaskets.

2. Loosen all of the inner and outer injector rack control lever adjusting screws. Be sure all of the control levers are free on the control tubes.

3. Disconnect the vertical link assembly from the governor operating lever and the bell crank.

4. Loosen the bolt and slide the governor operating lever from the serrated shaft.

5. Place the bolt (removed from the lower end of the vertical link) through the bell crank and into the recessed hole in the governor drive housing.

6. Adjust the No. 1R injector rack by turning the inner adjusting screw down until it bottoms on the control tube (Fig. 2). Turn down the outer adjusting screw until it also bottoms on the control tube. Then alternately tighten both the inner and outer adjusting screws.

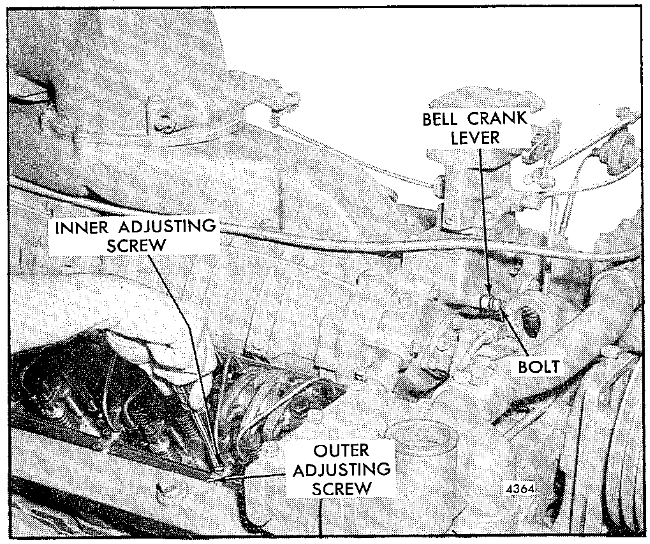


Fig. 2 - Positioning No. 1R Rack Control Lever

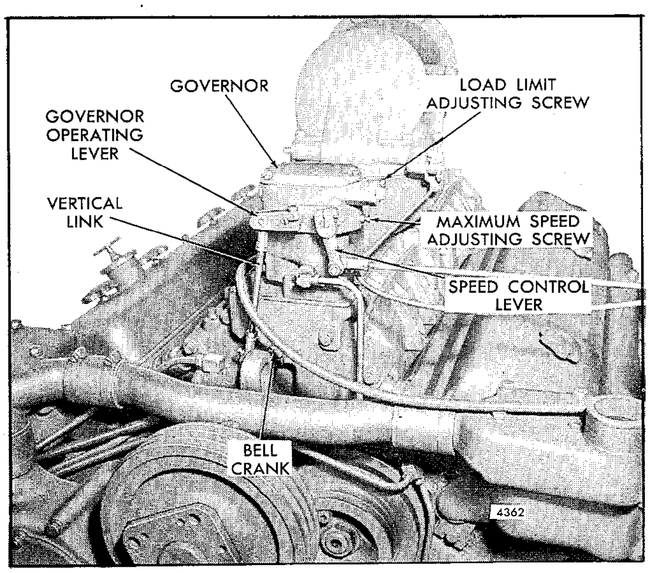


Fig. 1 - Hydraulic Governor Mounted on Engine

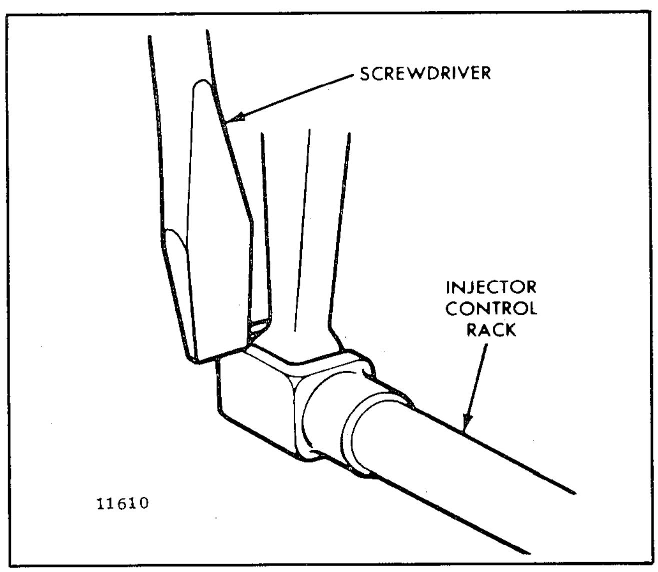


Fig. 3 - Checking Injector Rack "Spring"

NOTE: Care should be taken to avoid setting the racks too tight and causing the fuel rod to bend.

7. To be sure the rack control lever is properly adjusted, press down on the injector rack with a screw driver or finger tip (Fig. 3). A light pressure should cause the rack to rotate. The rack is sufficiently tight if the rack returns or springs back to its original position when the pressure is removed. The rack is too tight if a heavy pressure is required to rotate the rack.

8. Adjust the No. 1L injector rack control lever as outlined in Steps 6 and 7.

9. Check the adjustment on the 1R and 1L injector rack control levers. If the setting is correct, the injector racks will be in the full–fuel position and snug on the ball end of the control levers.

10. To adjust the remaining injector rack control levers, hold the No. 1L injector rack in the full–fuel position by means of the lever on the end of the control tube assembly. Turn down the inner adjusting screw of the No. 2L injector rack control lever until the injector rack has moved into the full–fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

NOTE: 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 **in–lbs** (3–4 Nm).

11. Recheck the No. 1L injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while positioning the No. 2L injector rack. If the rack of the No. 1L injector has become loose, back off the inner adjusting screw slightly on the No. 2L injector rack control lever. Tighten the outer adjusting screw. When the settings are correct, both injector racks must respond in the same manner on the ball end of their respective rack control levers as previously outlined in Step 7.

12. Position the remaining injector rack control levers on the left and right cylinder heads as outlined in Steps 10 and 11. When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube lever is held in the full–fuel position.

13. Remove the bolt from the recessed hole in the drive housing and install linkage gage J 21304 (Fig. 4).

14. Replace the governor operating lever on the serrated shaft so that the bolt hole is lined up within the proper lines on the gage (Fig. 5). The type of governor (SGX or PSG) will determine the proper position of the lever.

15. Remove the gage.

16. Move the bell crank lever to the no–fuel position.

17. Adjust the length of the vertical link so that the bolt holes of the levers and the centers of the rod end bearings are lined up (Fig. 6).

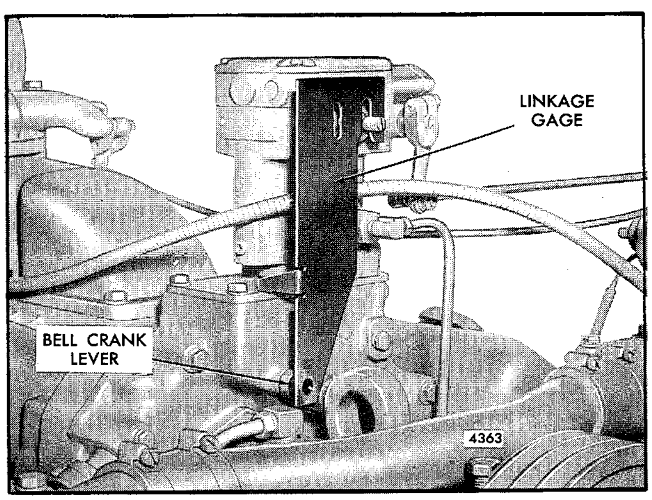


Fig. 4 – Linkage Gage in Position

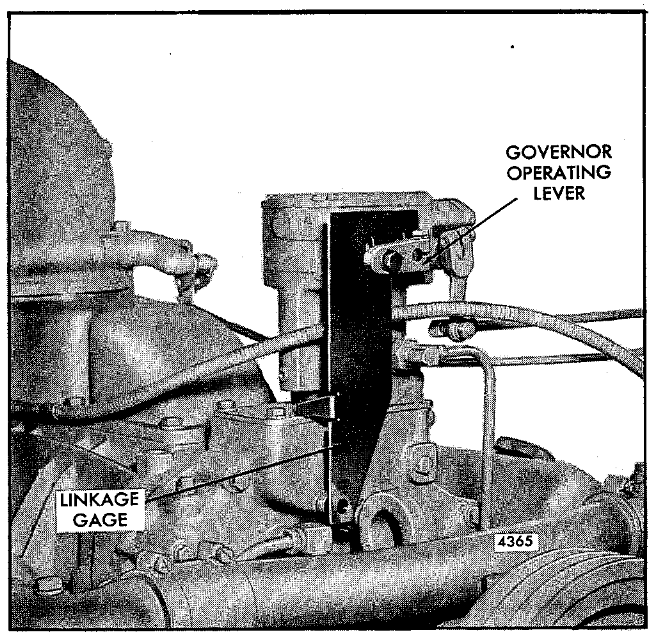


Fig. 5 – Governor Operating Lever in Position

18. Replace the two bolts in the levers and tighten the bolts.

19. Remove the governor cover.

20. With the load limit screw backed all the way out, retain the governor operating lever in the full-fuel position. The governor terminal lever should touch the boss in the governor housing (Fig. 7). Adjust the vertical link so that all of the injector racks are in the full-fuel position, then tighten the rod end lock nuts securely.

21. Use a new gasket and install a valve rocker cover on each cylinder head.

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 re-positioned, the load limit screw should be re-adjusted.

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

1. With the governor cover off and the load limit screw lock nut loosened, adjust the 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. Then place and retain the governor operating lever in the full-fuel position as shown in Fig. 7.

NOTE: Do not overstress the linkage.

2. Turn the load limit adjusting screw until a .020″ space exists between the fuel rod collar and the terminal lever. If the adjustment cannot be made with a feeler gage, turn the load limit adjusting screw (with the lock nut tight enough to eliminate slack in the threads) inward until the injector racks just loosen on the ball end of the control levers.

3. Release the governor operating lever and hold the adjusting screw while tightening the lock nut. Then install the governor cover and tighten the screws.

Compensation Needle Valve Adjustment (PSG Governor)

Start the engine and, after the engine reaches normal operating temperature, adjust the governor compensation needle valve (without load on the engine) as follows:

1. Open the compensation needle valve (Fig. 11) two or three turns and allow the engine to "hunt" or "surge" for about one-half minute to bleed any air which may be trapped in the governor oil passages.

2. Gradually close the valve until the "hunting" just stops. Check the amount of valve opening by closing the valve completely and noting the number of turns

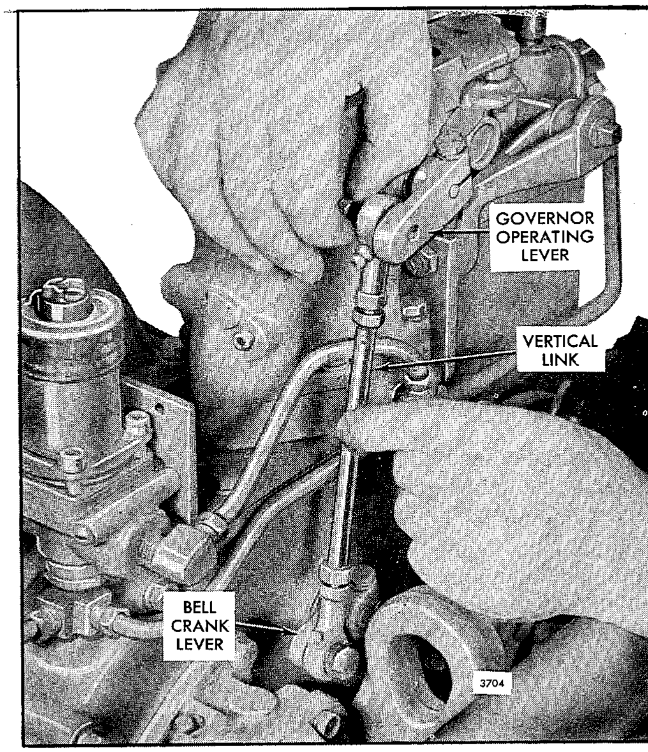


Fig. 6 - Adjusting Vertical Link

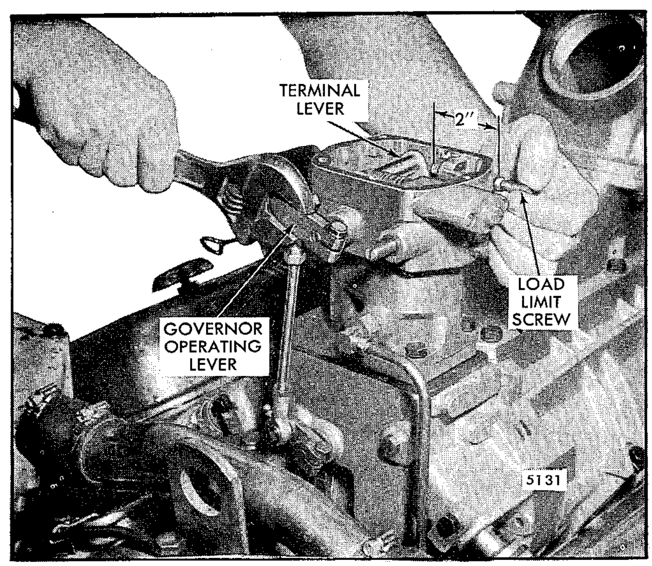


Fig. 7 - Adjusting Load Limit Screw

required to close it. Open the valve to the previously determined position at which the "hunting" stopped. Test the action of the governor by manually disturbing the engine speed. The engine should return promptly to the original steady speed with only a small overshoot. The correct valve setting will be between 1/8 and 1/2 turn open. Closing the valve farther than necessary will make the governor slow in returning the engine to normal speed after a load change.

Adjust Governor Speed Droop

INTERNAL DROOP ADJUSTMENT

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 speed droop is set at the factory and further adjustment should be unnecessary. However, if the governor has been overhauled, the speed droop must be readjusted.

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

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

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

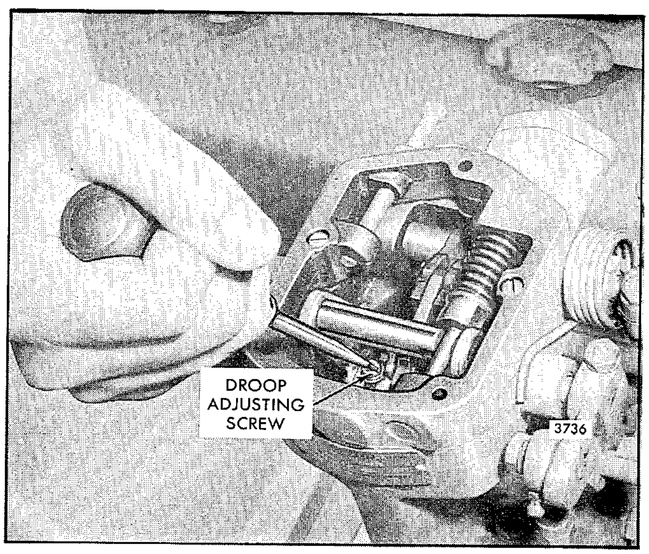


Fig. 8 – Adjusting Speed Droop

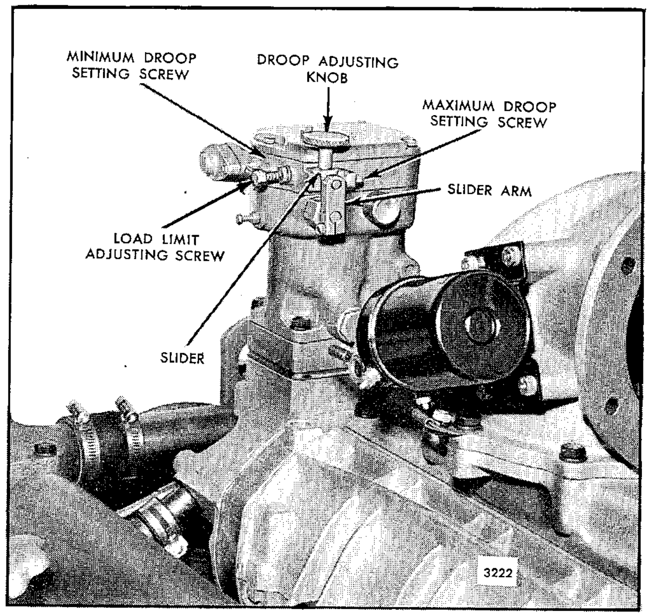


Fig. 9 – External Droop Control on PSG Isochronous Governor

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

2. Stop the engine and remove the governor cover.

3. Loosen the lock nut and back off the maximum speed adjusting screw approximately 5/8".

4. Loosen the droop adjusting screw. Move the droop bracket so that the screw is midway between the ends of the slot in the bracket. Tighten the screw (Fig. 8).

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 readjust the engine speed to the correct full-load speed.

7. Remove the rated load and note the engine speed

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

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, loosen the droop adjusting screw and move the adjusting bracket IN toward the center of the governor. Tighten the screw. To increase the speed droop, move the bracket OUT, away from the center of the governor.

The speed droop in governors which control engines driving generators in parallel must be identical, otherwise the electrical load will not be equally divided.

Adjust the speed droop bracket in each governor to obtain the desired variation between engine no-load and full-load speeds. The recommended speed droop for generator sets operating in parallel is 50 rpm (2-1/2 cycles) for units operating at 1,000 and 1,200 rpm, and 75 rpm (2-1/2 cycles) for units operating at 1,500 and 1,800 rpm (Table 1). However, this speed droop recommendation may be varied to suit the individual application.

EXTERNAL DROOP CONTROL

Some PSG type governors are equipped with an external adjustable droop control (Fig. 9). This permits the speed droop to be adjusted without removing the governor cover. With this feature, a unit can be paralleled with another unit that is operating at constant frequency (zero droop). The incoming unit must 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, shift the load to the incoming unit and move the governor droop bracket to zero droop. Then adjust the outgoing unit to maximum droop, remove it from the line and stop the engine. The incoming unit will now be carrying the load and operating at constant frequency (zero droop).

Adjust the governor speed droop as follows:

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

2. Remove the load from the engine.

3. Back off the compensation 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.

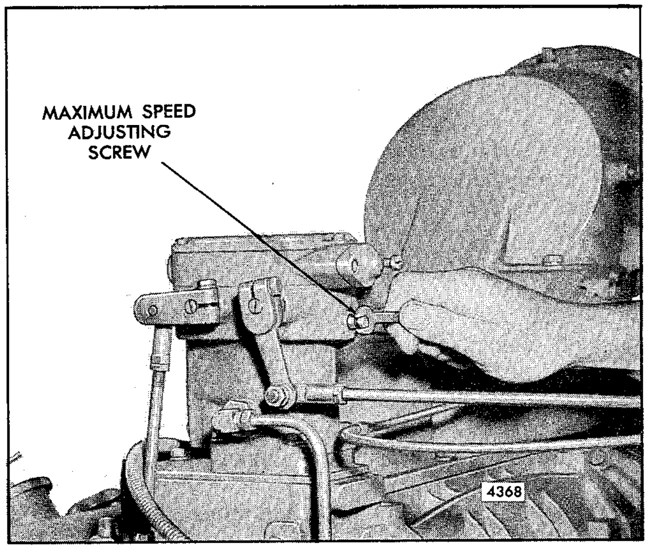


Fig. 10 - Adjusting Maximum No-Load Engine Speed

5. Loosen the droop adjusting knob and move the slider all the way in toward the center of the governor. Then tighten the knob.

6. Loosen the lock nut on the maximum speed adjusting screw (Fig. 10) and turn the screw out until 5/8" of the threads are exposed.

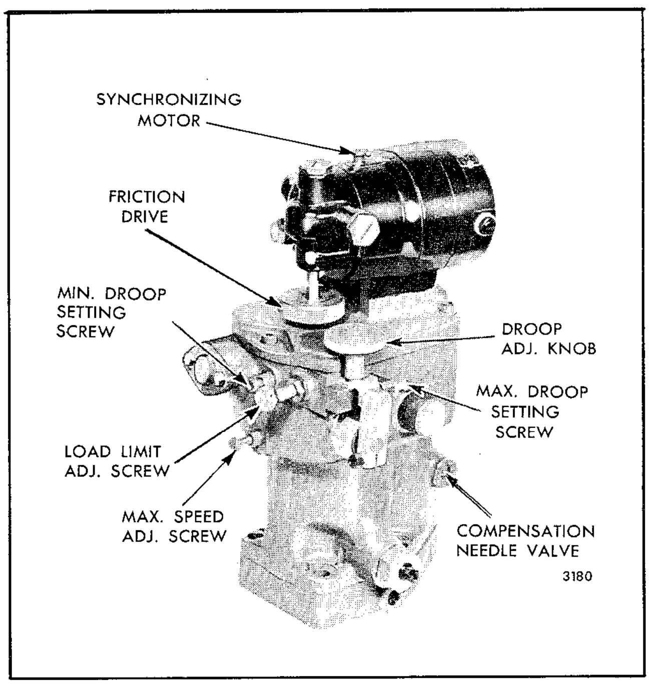


Fig. 11 - Typical Synchronizing Motor Mounting

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.

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 lock nut 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 in this position.

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 speed droop is attained.

11. When the desired maximum droop setting is reached, loosen the lock nut and turn the maximum droop setting screw inward until it contacts the droop slider arm. Lock the adjusting screw in this position.

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

Adjust Maximum No-Load Speed

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

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

2. Turn the maximum speed adjusting screw (Fig. 10) in until the screw contacts the throttle linkage internally, limiting the maximum speed of the engine at 8% above the rated full-load speed.

3. Hold the screw and tighten the lock nut.

Governors with Synchronizing Motor

Some hydraulic governors are equipped with a reversible electric synchronizing motor (Fig. 11) 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.

VARIABLE SPEED HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

16V-71 ENGINE

The governor on the 16V engine is mounted on and driven from the front end of the rear blower (Fig. 1). The governor-to-injector control tube linkage is shown in Fig. 2.

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

Adjust Governor Linkage and Position Injector Rack Control Levers

1. Clean and remove the valve rocker cover from each cylinder head. Discard the gaskets.

2. Loosen all of the inner and outer injector rack control lever adjusting screws. Be sure all of the control levers are free on the control tubes.

3. Remove the vertical link assembly from the governor operating lever and the bell crank lever.

4. Loosen the bolt and slide the governor operating lever from the serrated shaft.

5. Place the bolt (removed from the lower end of the vertical link) through the bell crank and into the recessed hole in the governor drive housing (Fig. 3).

6. Adjust the No. 4R injector rack by turning the inner adjusting screw down until it bottoms on the control tube (Fig. 4). Turn down the outer adjusting screw until it also bottoms on the control tube. Then tighten both the inner and outer adjusting screws alternately.

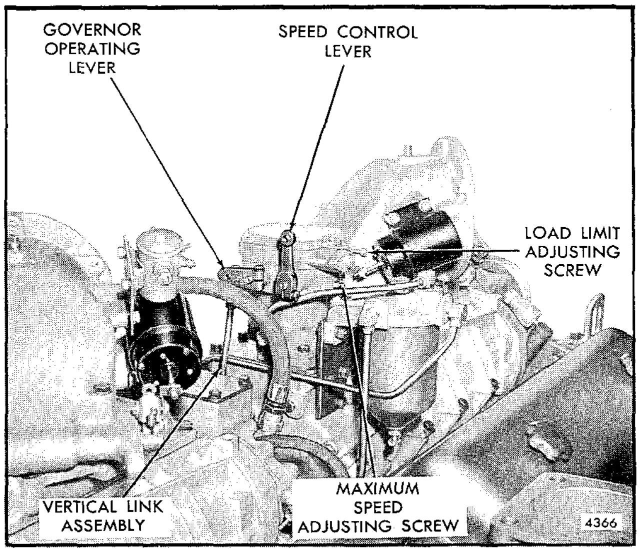


Fig. 1 - Hydraulic Governor Mounting

NOTE: Care should be taken to avoid setting the racks too tight, causing the fuel rod to bend.

7. To be sure the rack control lever is properly adjusted, press down on the injector rack with a screw driver or finger tip (Fig. 5). A light pressure should cause the rack to rotate. The rack is sufficiently tight if the rack returns to its original position when the pressure is removed. The rack is too tight if a heavy pressure is required to rotate the rack.

8. Adjust the 5R, 4L and 5L injector rack control levers as outlined in Steps 6 and 7. When the settings are correct, all four of the injector racks will be snug on the ball end of the control levers when the injectors are in the full-fuel position.

9. To adjust the remaining injector rack control levers on the right front bank, hold the 4R injector rack in the full-fuel position by means of the lever on the control tube assembly and turn down the inner adjusting screw of the 3R injector rack control lever until the injector rack has moved into the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

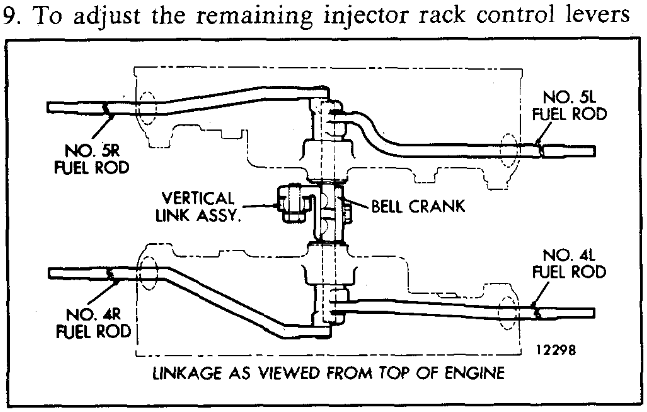


Fig. 2 - Governor to Injector Rack Control Linkage

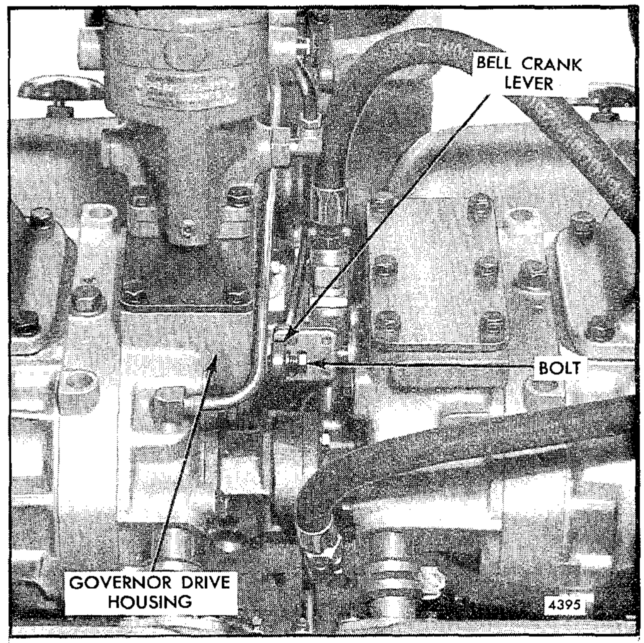


Fig. 3 - Bolt in Position through Bell Crank Lever

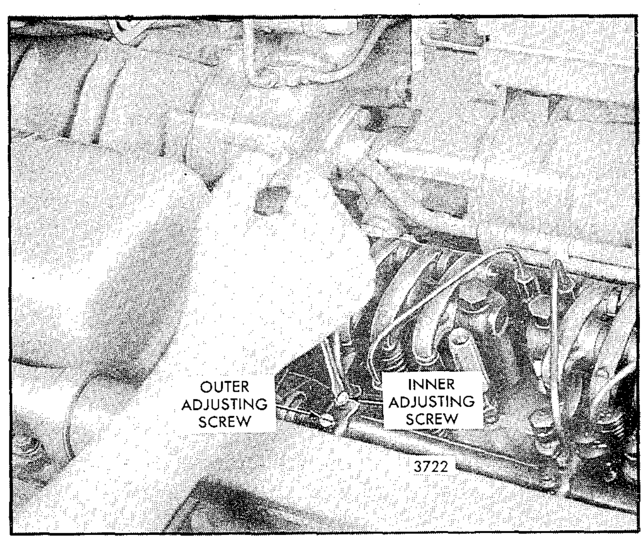


Fig. 4 - Positioning No. 4R Injector Rack Control Lever

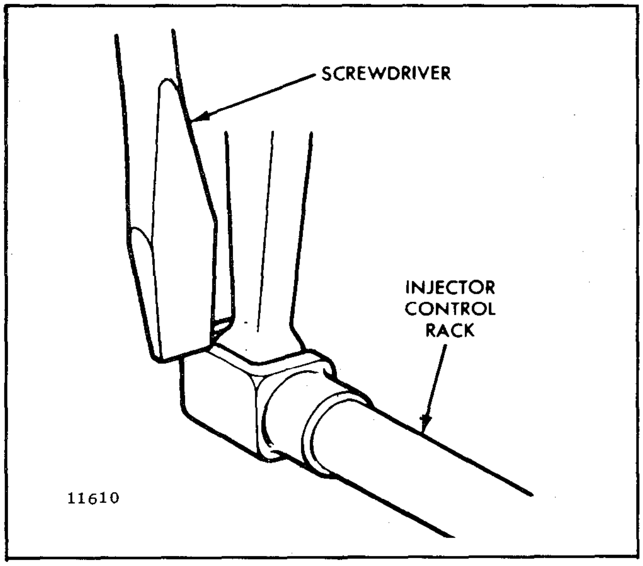


Fig. 5 - Checking Injector Rack "Spring"

NOTE: 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 **in-lbs** (3-4 Nm).

10. Recheck the No. 4R injector rack to be sure that it has remained snug on the ball end of the injector rack control lever. If the rack of No. 4R injector has become loose, back off the inner adjusting screw slightly on the 3R injector rack control lever. Tighten the outer adjusting screw. When the settings are correct, both injector racks must respond in the same manner on the ball ends of their respective rack control levers as previously outlined in Step 7.

11. Position the remaining injector rack control levers on the right front cylinder head as outlined in Step 9. When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube lever is held in the full-fuel position.

12. Adjust the remaining injector rack control levers on the right rear, left front, and left rear cylinder heads in the same manner as outlined in Steps 9, 10 and 11.

13. Remove the bolt from the recessed hole in the drive housing and install linkage gage J 21304.

14. Replace the governor operating lever on the serrated shaft so that the bolt hole is lined up within the proper lines on the gage. The type of governor

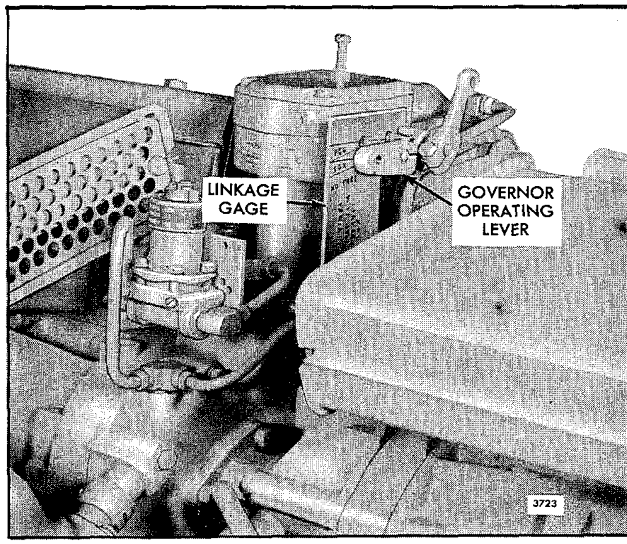


Fig. 6 - Governor Operating Lever in Position

(SGX or PSG) will determine the proper position of the lever (Fig. 6).

15. Remove the gage.

16. Move the bell crank lever to the no-fuel position.

17. Adjust the length of the vertical link so that the bolt holes of the levers and the centers of the rod end bearings are lined up (Fig. 7).

18. Replace the two bolts in the levers and tighten the bolts.

19. Remove the governor cover.

20. With the load limit screw backed all the way out, retain the governor operating lever in the full-fuel position. The governor terminal lever should touch the boss on the governor housing. Adjust the vertical link so that all of the injector racks are in the full-fuel position, then tighten the rod end lock nuts securely.

21. Use a new gasket and install the valve rocker cover on each cylinder head.

Adjust Load Limit

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

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

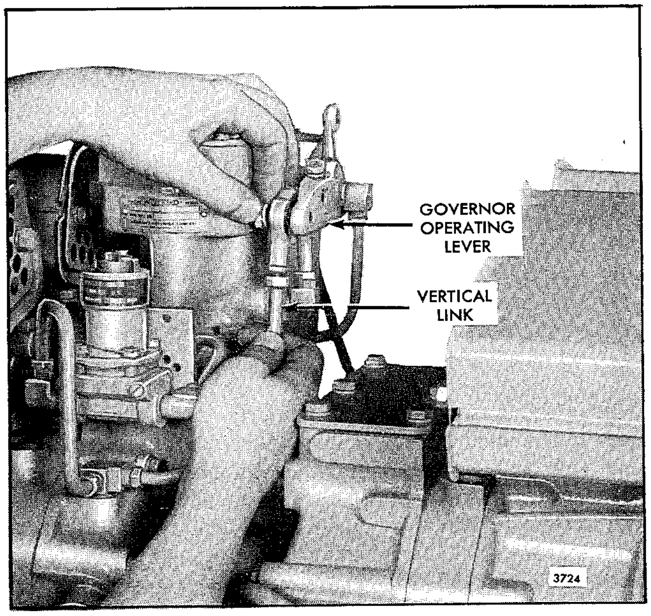


Fig. 7 - Adjusting Vertical Link

1. With the governor cover off and the load limit screw lock nut loosened, place and retain the governor operating lever in the full-fuel position as shown in Fig. 8.

NOTE: Do not overstress the linkage.

2. Turn the load limit adjusting screw until a .020" space exists between the fuel rod collar and the terminal lever. If the adjustment cannot be made with a feeler gage, turn the load limit adjusting screw (with the lock nut tight enough to eliminate any slack in the threads) in until the injector racks just loosen on the ball end of the control levers.

3. Release the governor operating lever and hold the adjusting screw while tightening the lock nut. Then install the governor cover and tighten the screws.

Compensation Needle Valve Adjustment (PSG Governor)

Start the engine and, after the engine reaches normal operating temperature, adjust the governor compensation needle valve, without load on the engine, as follows:

1. Open the valve (Fig. 10) two or three turns and allow the engine to "hunt" or "surge" for about one-half minute to bleed any air which may be trapped in the governor oil passages.

2. Gradually close the valve until the "hunting" just stops. Check the amount of valve opening by closing the valve completely and noting the number of turns required to close it. Open the valve to the previously determined position at which the "hunting" stopped. Test the action of the governor by manually disturbing the engine speed. The engine should return promptly to the original steady speed with only a small overshoot. The correct valve setting will be between 1/8 and 1/2 turn open. Closing the valve farther than necessary will make the governor slow in returning the engine to normal speed after a load change.

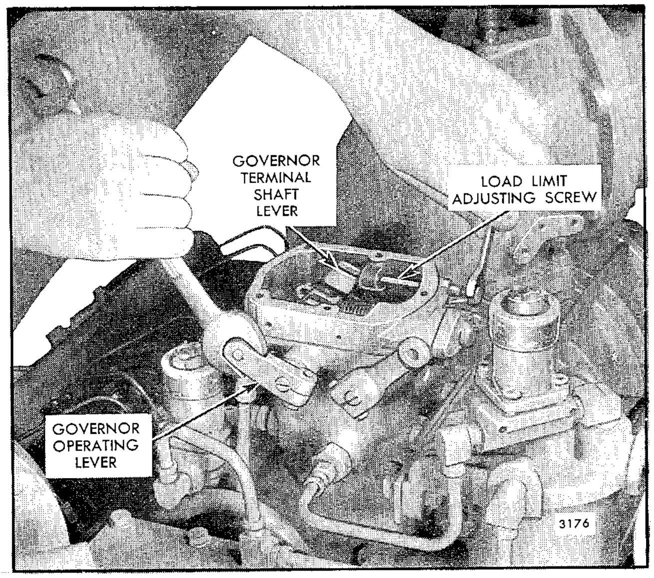


Fig. 8 - Adjusting Load Limit Screw

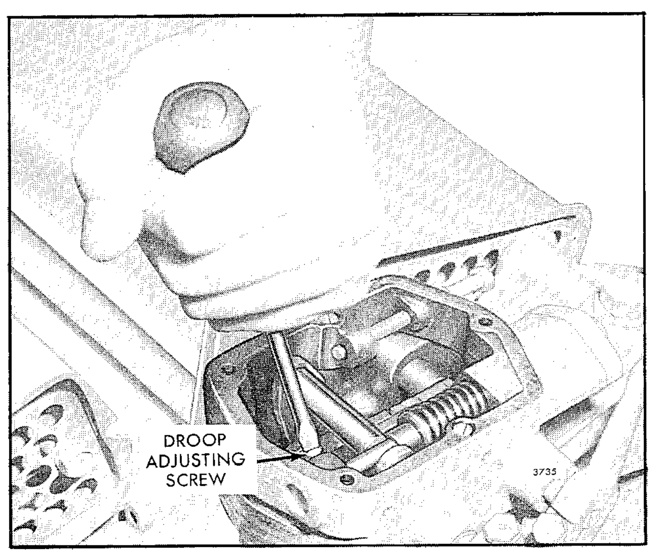


Fig. 9 - Adjusting Speed Droop

Adjust Governor Speed Droop

INTERNAL DROOP ADJUSTMENT

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

The governor speed droop is set at the factory and further adjustment should be unnecessary. However, if the governor has been overhauled, the speed droop must be readjusted.

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

If a full rated load can be established on the unit, and the fuel rods, injector rack control levers and the load limit have been adjusted, set the speed droop 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. Regulation will become increasingly stable as the temperature of the oil increases.

2. Stop the engine and remove the governor cover.

3. Loosen the lock nut and back off the maximum speed adjusting screw approximately 5/8″.

4. Loosen the droop adjusting bolt on former units or the screw on current units (Fig. 9). Move the droop bracket so that the screw is midway between the ends of the slot in the bracket. Tighten the screw.

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 readjust 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.

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

If the speed droop is too high, stop the engine, loosen the droop adjusting screw and move the adjusting bracket IN toward the center of the governor. Tighten the screw. To increase the speed droop, move the bracket OUT, away from the center of the governor.

The speed droop in governors which control engines driving generators in parallel must be identical, otherwise the electrical load will not be equally divided.

Adjust the speed droop bracket in each governor to obtain the desired variation between engine no–load and full–load speeds. The recommended speed droop for generator sets operating in parallel is 50 rpm (2–1/2 cycles) for units operating at 1,000 and 1,200 rpm, and 75 rpm (2–1/2 cycles) for units operating at 1,500 and 1,800 rpm (Table 1). However, this speed droop recommendation may be varied to suit the individual application.

EXTERNAL DROOP CONTROL

Some PSG type governors are equipped with an external adjustable droop control (Fig. 10). This permits the speed droop to be adjusted without removing the governor cover. With this feature, a unit can be paralleled with another unit that is operating at constant frequency (zero droop). The incoming unit must 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, shift the load to the incoming unit and move the governor droop bracket to zero droop. Then adjust the outgoing unit to maximum droop, remove it from the line and stop the engine. The incoming unit will now be carrying the load and operating at constant frequency (zero droop).

Adjust the governor speed droop as follows:

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

2. Remove the load from the engine.

3. Back off the compensation 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. 10) and

move the slider all the way in toward the center of the governor. Then tighten the knob.

6. Loosen the lock nut 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.

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 lock nut and turn the minimum droop setting screw in 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 in this position.

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 speed droop is attained.

11. When the desired maximum droop setting is reached, loosen the lock nut and turn the maximum droop setting screw in until it contacts the droop slider arm. Lock the adjusting screw in this position.

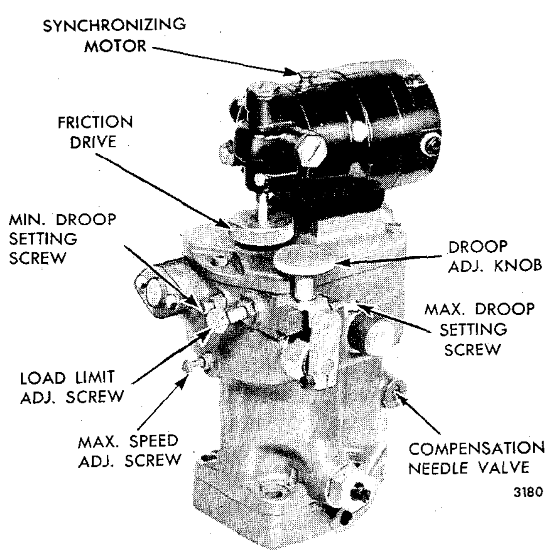


Fig. 10 - Typical Synchronizing Motor Mounting

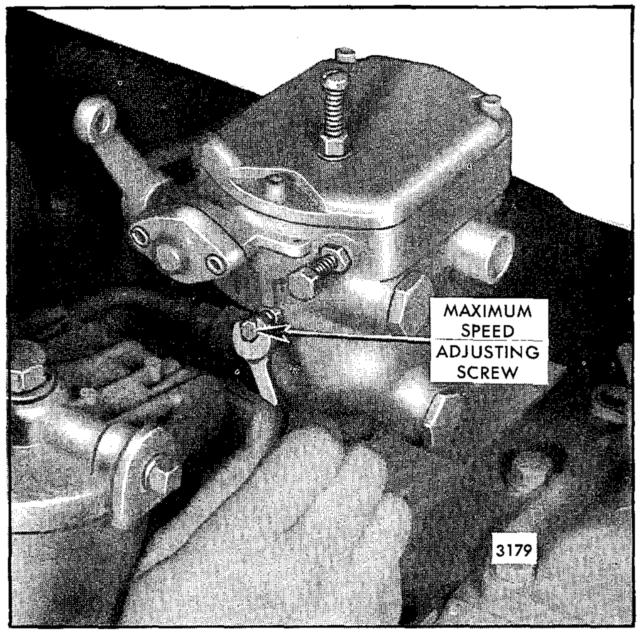


Fig. 11 - Adjusting Maximum No-Load Engine Speed

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

Adjust Maximum No-Load Speed

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

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

2. Turn the maximum speed adjusting screw (Fig. 11) in until the screw contacts the throttle linkage internally, limiting the maximum speed of the engine at 8% above the rated full-load speed.

3. Hold the screw and tighten the lock nut.

Adjust Low-Speed Stop Screw

The low-speed stop screw (Fig. 12) projects from the top of the governor cover. This screw is used to establish an idle speed setting when the throttle is moved to the **idle/neutral** position on marine units,

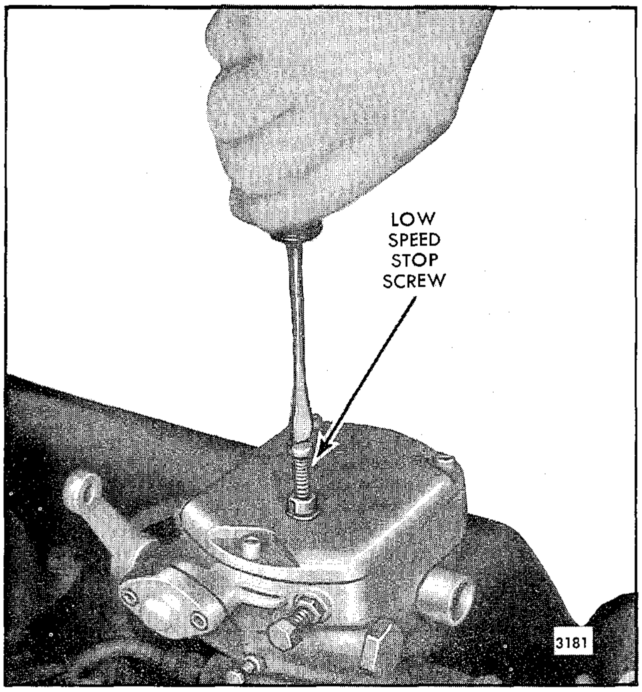


Fig. 12 - Adjusting Low-Speed Stop Screw

thus preventing false engine shutdowns. To establish the desired engine idle speed, proceed as follows:

1. Loosen the lock nut and back out the low speed stop screw.

2. Start the engine and carefully reduce the speed with the throttle until the desired idle speed is established.

3. Turn the low-speed stop screw down until the engine speed just begins to increase.

4. Tighten the lock nut to secure the stop screw in place.

NOTE: The marine engine is stopped when the solenoid in the oil dump line from the governor servo-piston is energized.

Governors with Synchronizing Motor

Some hydraulic governors are equipped with a reversible electric synchronizing motor (Fig. 10) 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 the external droop adjustment). The cover and motor must be reinstalled to check the speed droop.

LIMITING SPEED HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

16V-71 ENGINE

The governor on the 16V engine is mounted on and driven from the front end of the rear blower (Fig. 1). The governor to injector rack control linkage is shown in Fig. 2.

The objectives of the tune-up are (1) to adjust the linkage so the injector racks will be at the full-fuel position when the terminal lever shaft pointer indicates exactly 18°, (2) to set the band-level so the governor will place the pointer at exactly 18° just below full-load speed and, (3) to adjust the speed droop, idle speed and maximum no-load speed.

Prior to starting the tune-up, remove the governor control housing cover and turn the buffer screw out until it clears the differential lever approximately 1/4 inch, when the speed control lever is in the idle position. Then hold the speed control lever in the maximum speed position and move the governor operating lever to check the travel of the terminal shaft lever as indicated by the pointer.

The pointer should move from 0° to 36° (on some governors, the pointer may not quite reach 36°). Next, check to be sure that the pointer is exactly at zero when the linkage is in the no-fuel position. If not, adjust the pointer or the terminal lever shaft position indicator plate (scale).

The pointer is attached to a metal ring which is secured to the terminal shaft by a set screw (Fig. 3). To make the zero adjustment, loosen the set screw and, with the linkage in the no-fuel position, set the pointer at exactly zero. Then tighten the set screw.

After the zero adjustment is completed, to make sure the shaft is assembled correctly, reach in behind the differential lever in the governor control housing and force the governor operating lever upward until the pointer is aligned exactly with the 18° mark (Fig. 6). The pointer should be vertical; if it is approximately 1/16" off vertical, the shaft is probably out one serration. To make the necessary correction, remove

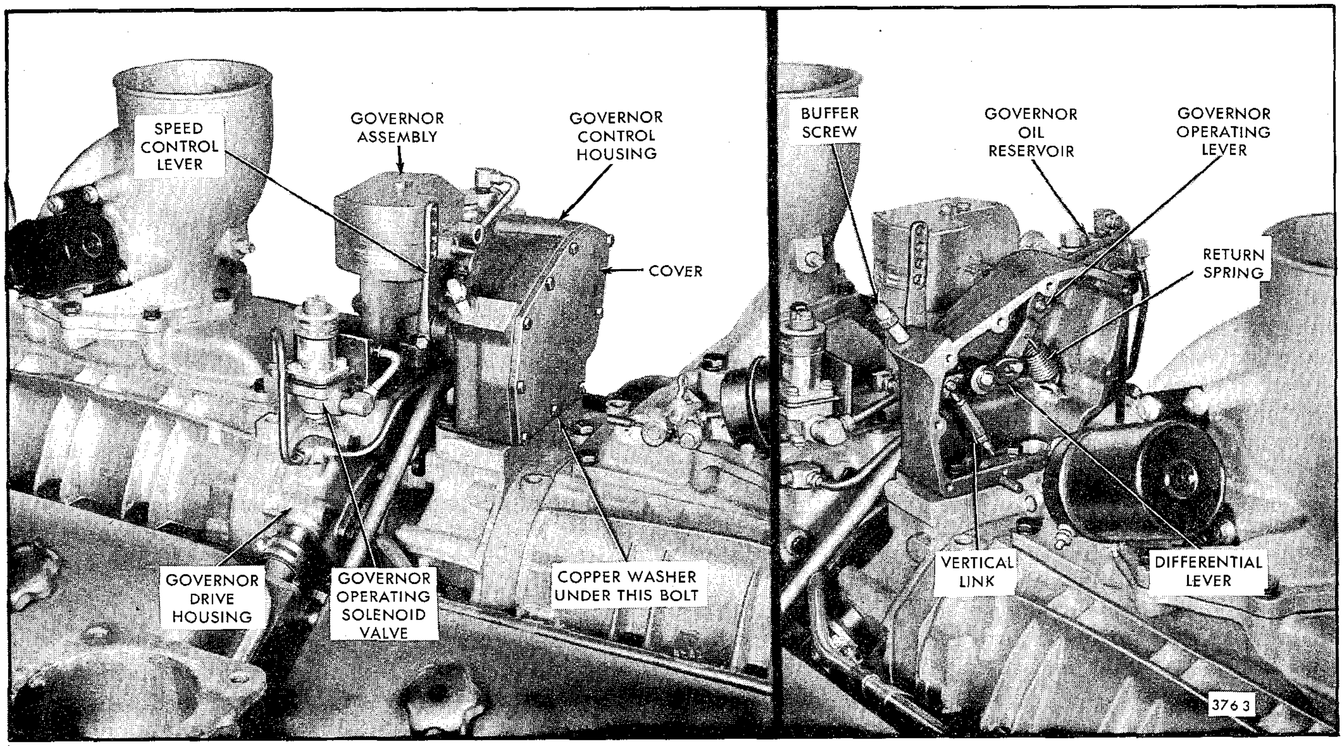


Fig. 1 - Governor Mounting and Linkage in the Control Housing

the sub-cap (refer to *Adjust Maximum No-Load Speed*), then remove the cotter pin from the shaft and make a careful visual check of the alignment of the holes in the terminal lever and the shaft. If they are not in alignment, remove the shaft and reinstall it so the holes are in perfect alignment. Then install the cotter pin and sub-cap.

Then, after adjusting the exhaust valves and timing the injectors, position the injector rack control levers, adjust the governor linkage and adjust the governor.

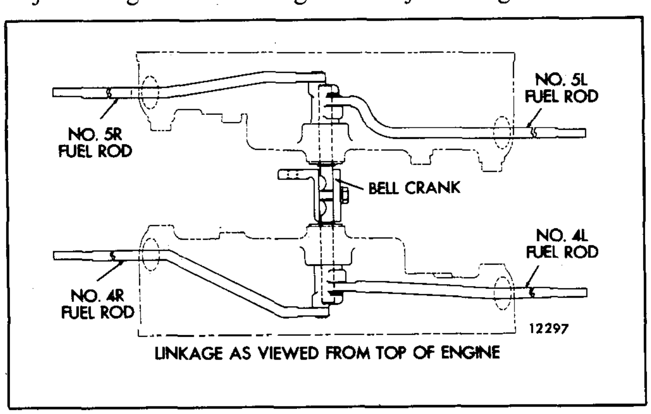


Fig. 2 - Governor-to-Injector Rack Control Linkage

Position Injector Rack Control Levers and Adjust Governor Linkage

1. Clean and remove the valve rocker cover from each cylinder head.

2. Loosen all of the inner and outer injector rack

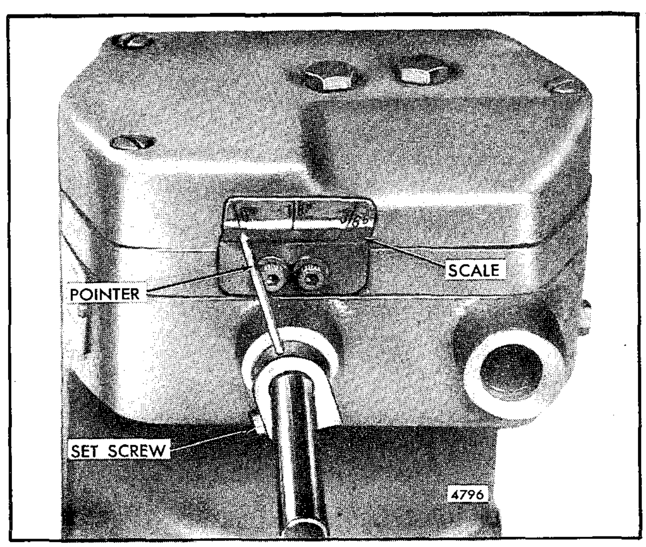


Fig. 3 - Governor Pointer and Scale

control lever adjusting screws. Be sure all of the control levers are free on the control tubes.

3. Disconnect the upper end of the adjustable vertical link (Fig. 1) from the differential lever pin.

> **NOTE:** Stuff a clean rag in the opening to prevent the clip or washer from dropping into the engine.

4. Place linkage gage J 21351 in position so the pin in the gage enters the hole in the bell crank lever and the tangs on each side of the gage rest on top of the governor drive housing cover (Fig. 4). The gage holds the linkage in the full-fuel position while the injector racks are being adjusted.

5. Adjust the 4R injector rack by turning the inner adjusting screw down until a slight movement of the control tube is observed or a step-up in effort is noted (Fig. 5). This will place the rack in the full-fuel position. Turn the outer adjusting screw down until it bottoms slightly on the control tube. Then alternately tighten both the inner and outer adjusting screws.

> **NOTE:** If the injector rack is set too tight, it will cause the fuel rod to bend.

6. To be sure the injector rack control lever is properly adjusted, press down on the injector rack with a screw driver or finger tip. A light pressure should cause the rack to rotate. The rack is sufficiently tight if it returns to its original position when the pressure is removed. The rack is too tight if a heavy pressure is required to rotate it.

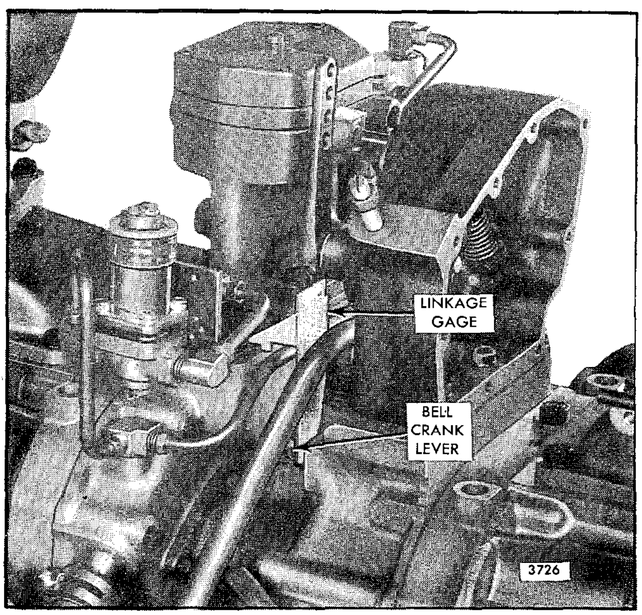


Fig. 4 - Linkage Gage in Position

7. Adjust the 5R, 4L and 5L injector rack control levers as outlined in Steps 5 and 6. When the settings are correct, all four of the injector racks will be snug on the ball end of the control levers when the injectors are in the full-fuel position. The linkage gage may be removed at this time.

8. To adjust the remaining injector rack control levers on the right front bank, hold the 4R injector rack in the full-fuel position, by means of the control tube lever, and turn down the inner adjusting screw of the 3R injector rack control lever until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

> **NOTE:** 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 **in-lbs** (3-4 Nm).

9. Recheck the 4R injector rack to be sure it has remained snug on the ball end of the injector rack control lever. If the 4R injector rack has become loose, back off the inner adjusting screw slightly on the 3R injector rack control lever and tighten the outer adjusting screw. When the settings are correct, both

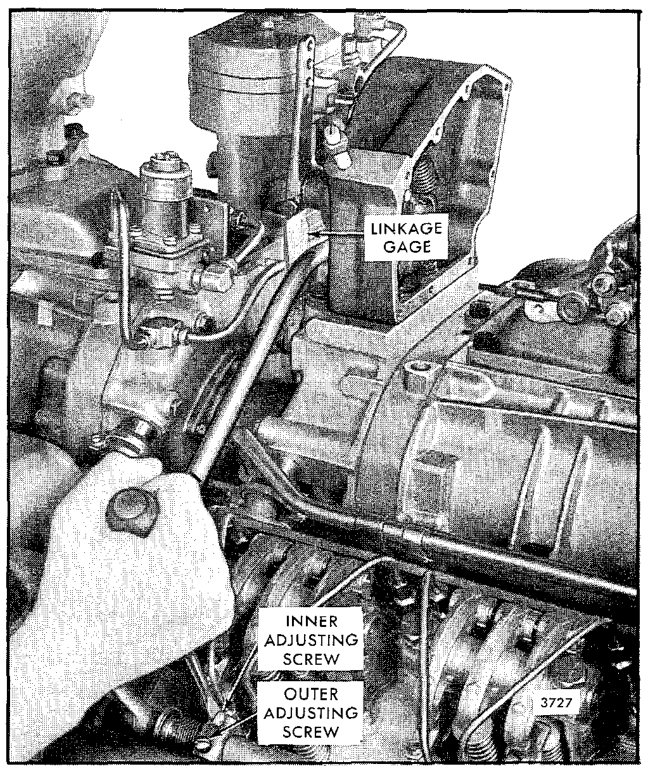


Fig. 5 - Positioning No. 4R Injector Rack Control Lever

injector racks must respond in the same manner on the ball ends of their respective rack control levers as in Step 6.

10. Position the remaining injector rack control levers on the right front cylinder head in the same manner. When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube is in the full-fuel position.

11. Adjust the remaining injector rack control levers on the right rear, left front, and left rear cylinder heads in the same manner as in Steps 8, 9 and 10.

12. Reconnect the upper end of the adjustable vertical link on the differential lever pin and secure it in place with the washer and clip.

13. To be sure that the governor flyweights will be in the vertical position throughout the intermediate speed range (between idle speed and full-load speed), adjust the vertical link as follows.

a. Loosen and back off the two turnbuckle lock nuts two or three turns.

b. Secure the speed control lever in the maximum speed position.

c. Reach in behind the differential lever in the governor control housing and force the governor operating lever upward until the governor pointer is aligned exactly with the 18° mark (Fig. 6). Hold the lever in this position.

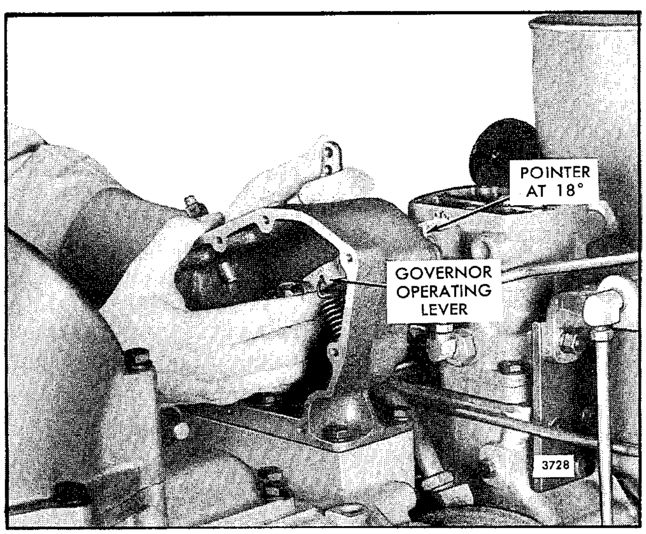


Fig. 6 - Moving Operating Lever

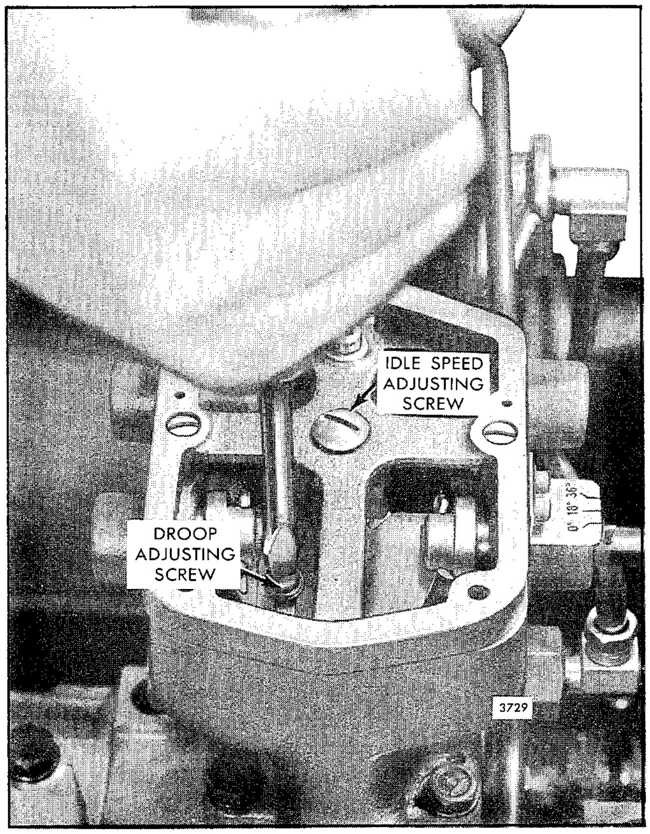


Fig. 7 - Adjusting Speed Droop

NOTE: It is very important that the force to move the pointer to 18° be applied to the governor operating lever rather than to the differential lever. This is necessary to ensure that the terminal lever pin is tight against the upper side of the slot in the differential lever just as it is when the engine is running under governor control.

d. Adjust the length of the vertical link, by means of the turnbuckle, so the injector racks are in the full-fuel position. Then tighten the lock nuts.

e. Recheck to determine if the pointer still points to exactly 18° when the injector racks are at the full-fuel position. Readjust the vertical link, if necessary.

f. Release the speed control lever. With the lever in the idle speed position, the pointer should be at approximately 18°.

14. Use a new gasket and install the valve rocker cover on each cylinder head.

Adjust Governor Speed Droop

1. Remove the governor cover.

2. Set the governor speed droop bracket at its mid-position (Fig. 7). After the other adjustments are made, the speed droop may be increased if the engine speed is unstable.

Preliminary Band-Level Adjustment

The band-level adjustment corresponds to the gap adjustment on a mechanical limiting speed governor. In the low idle speed range, the governor pointer will be between the 18° and 36° marks. As the speed is increased, by moving the speed control lever, the pointer will gradually approach 18° and should be exactly at 18° just below the full-load speed of the engine. After full load is reached, the pointer will move rather rapidly until at the no-load speed it will indicate a position approximately half way between the 18° and 0° marks.

If the pointer is above 18° just below the full-load speed of the engine, the band-level is too low; if the pointer is below 18°, the band-level is too high. Perform a preliminary band-level adjustment as follows:

1. Hold the linkage so the pointer indicates 18°.

2. With a long thin screw driver, pry one of the flyweights outward with a light force (Figs. 8 and 9). It should reach a vertical position. If not, proceed with Step 3.

> **NOTE:** The position of the flyweights determines the position of the pilot valve plunger, which controls the flow of oil to the servo piston. If the flyweights are too far in, the plunger will not close off the ports and oil will flow to the servo piston. This will cause the terminal lever to move the pointer beyond 18° and result in excessive speed when the engine is started. When the flyweights are too far out, the plunger moves up and dumps the oil from the servo piston. This causes the terminal lever to drop below the 18° position and will result in difficulty in starting the engine or in attaining speed.

3. Loosen the band-level pivot arm lock screw and turn the band-level adjusting nut (Figs. 8 and 10) clockwise to raise the band-level or counter-clockwise to lower the band-level. Tighten the lock screw to draw the pivot arm assembly in place. Then check the adjustment as described in Step 2. Readjust the band-level, if necessary.

> **CAUTION:** Turning the band-level adjusting nut does not in itself complete the adjustment. The lock screw must be tightened to draw the pivot arm assembly into the new position, especially if the nut was turned down.

Adjust Idle Speed

There should be approximately 1/16" clearance between the bottom of the idle speed adjusting screw head and the plunger directly under the screw head (Fig. 8).

1. Close the governor operating solenoid valve switch, if a normally open type valve is used.

2. Start the engine.

> **NOTE:** Stop the engine if the speed starts to increase above idle speed while the speed control lever is in the idle position. Raise the band-level again until the speed remains at idle.

3. If the engine stalls with the speed control lever in the idle position, turn the idle screw down (clockwise) 1/4 turn or until the engine will continue running.

4. Hold the speed control lever in the idle position. Then turn the idle speed adjusting screw (Figs. 8 and 10) in or out until the desired idle speed is obtained.

Set Band-Level at 18°

1. Gradually move the speed control lever from the idle to maximum speed position and while doing this, observe the movement of the pointer and also record the top no-load speed. The normal movement of the pointer in response to the speed control lever travel should be as follows:

a. During the first 100 or 200 rpm increase above idle speed, the pointer should move from approximately midway between 18° and 36° to slightly above 18°. Then, as the speed increases on up to approximately 300 rpm below the top no-load speed, the pointer should move slightly until it is exactly at 18°. From full-load speed up to no-load speed, the pointer should move from 18° to nearly midway between 18° and 0°.

b. If the pointer indicates more than 18° at approximately 300 rpm below the top no-load speed, the band-level is too low. The adjusting nut should be turned clockwise, in small increments, until the pointer indicates exactly 18° at the above speed.

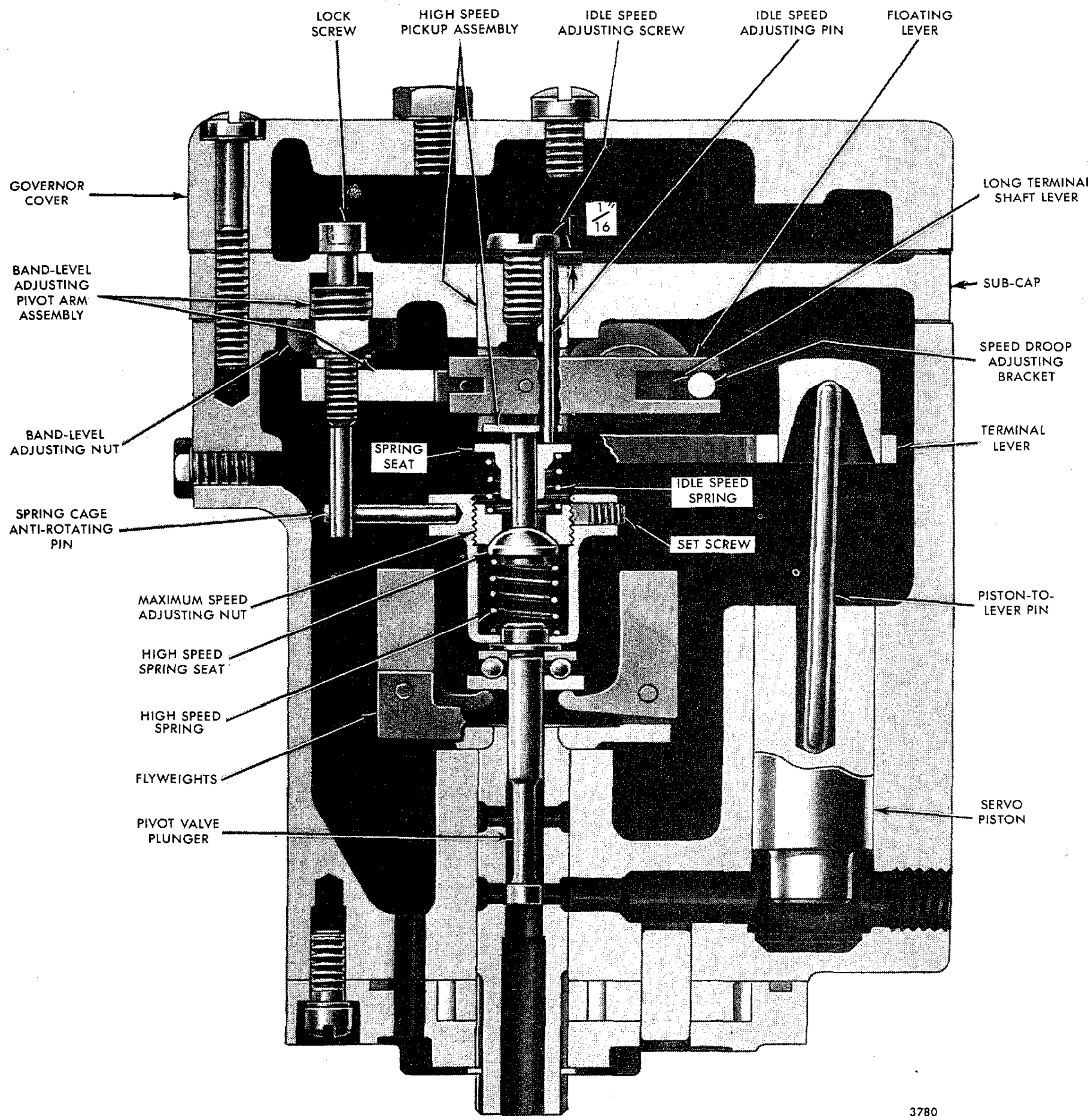


Fig. 8 – Cross-Section of Limiting Speed Hydraulic Governor for 16V Engine

c. If the pointer indicates less than 18° at approximately 300 rpm below the top no-load speed, the band-level is too high. The adjusting nut should be turned counterclockwise, in small increments, until the pointer indicates exactly 18° at the above speed. If the band-level is too high , the engine speed may fall several hundred rpm below the top no-load speed even though the speed control lever is in the maximum speed position.

d. Reset the idle speed, if the band-level has been changed.

Adjust Maximum No-Load Speed

1. Remove the sub-cap assembly, including the idle speed spring. Since the sub-cap is dowelled to the governor housing, removal will be made easier by

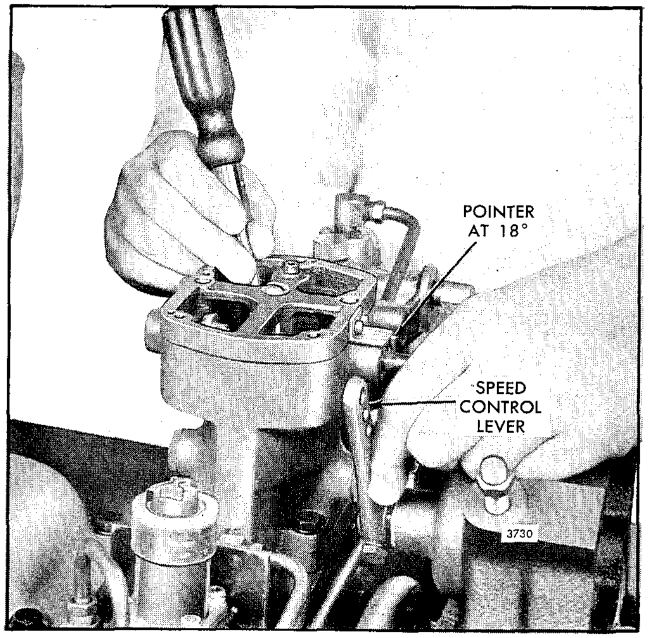


Fig. 9 - Moving Flyweight with Screw Driver

moving the linkage so the pointer is near the 36° mark.

NOTE: Hold the idle speed spring seat or spring with your finger, as shown in Fig. 11, to prevent it from falling into the governor housing.

2. Loosen the small set screw (on the side opposite the anti-rotating pin) in the high speed spring cage with a 5/64" Allen wrench (Figs. 8 and 12).

3. Turn the high speed adjusting nut up to decrease or down to increase the speed (Fig. 13).

NOTE: A 1/6th turn of the nut changes the speed 30-40 rpm. Use a 1/4" Allen wrench (the end of the wrench should be ground flat or slightly concave).

4. Tighten the small set screw to lock the adjusting nut in place.

5. Check to make sure the idle speed adjusting pin is in position and place the idle speed spring against the spring seat. Then, holding the spring in place with your finger (Fig. 11) and holding the linkage so the pointer is near the 36° mark, install the sub-cap

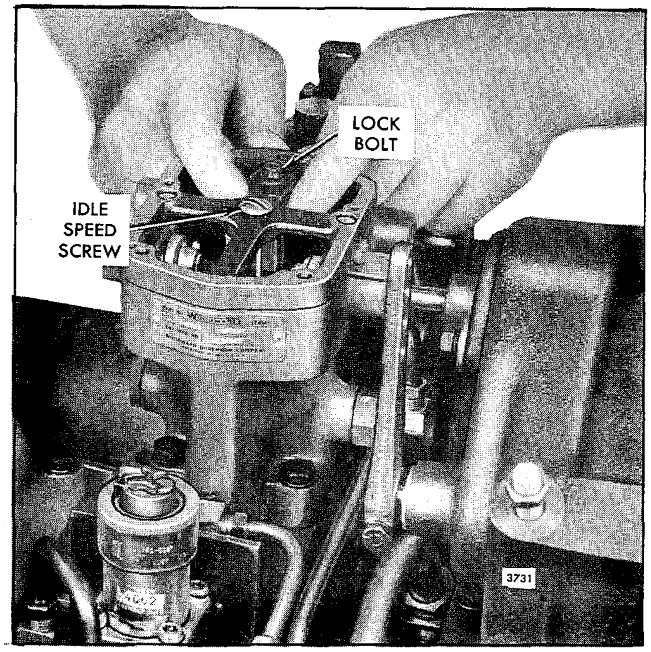


Fig. 10 - Adjusting Band-Level

assembly. Make sure the pin in the speed droop adjusting bracket enters the slot in the floating lever.

6. Reset the band-level adjustment.

7. Reset the idle speed.

8. Check the maximum speed.

9. Check the engine speed by suddenly moving the speed control lever from idle to maximum. If the engine speed does not stabilize after two to four surges, move the droop bracket outward. Recheck the idle and maximum speeds.

10. Install the governor cover and tighten the screws.

Adjust Buffer Screw

The purpose of the buffer screw adjustment is to prevent the injector racks from going all the way to the no-fuel position and causing the engine to stall.

1. With the warm engine at idle, turn the buffer screw in until it just touches the lower left end of the differential lever. Then, back off three complete turns and tighten the lock nut.

2. Install the cover on the governor control housing.

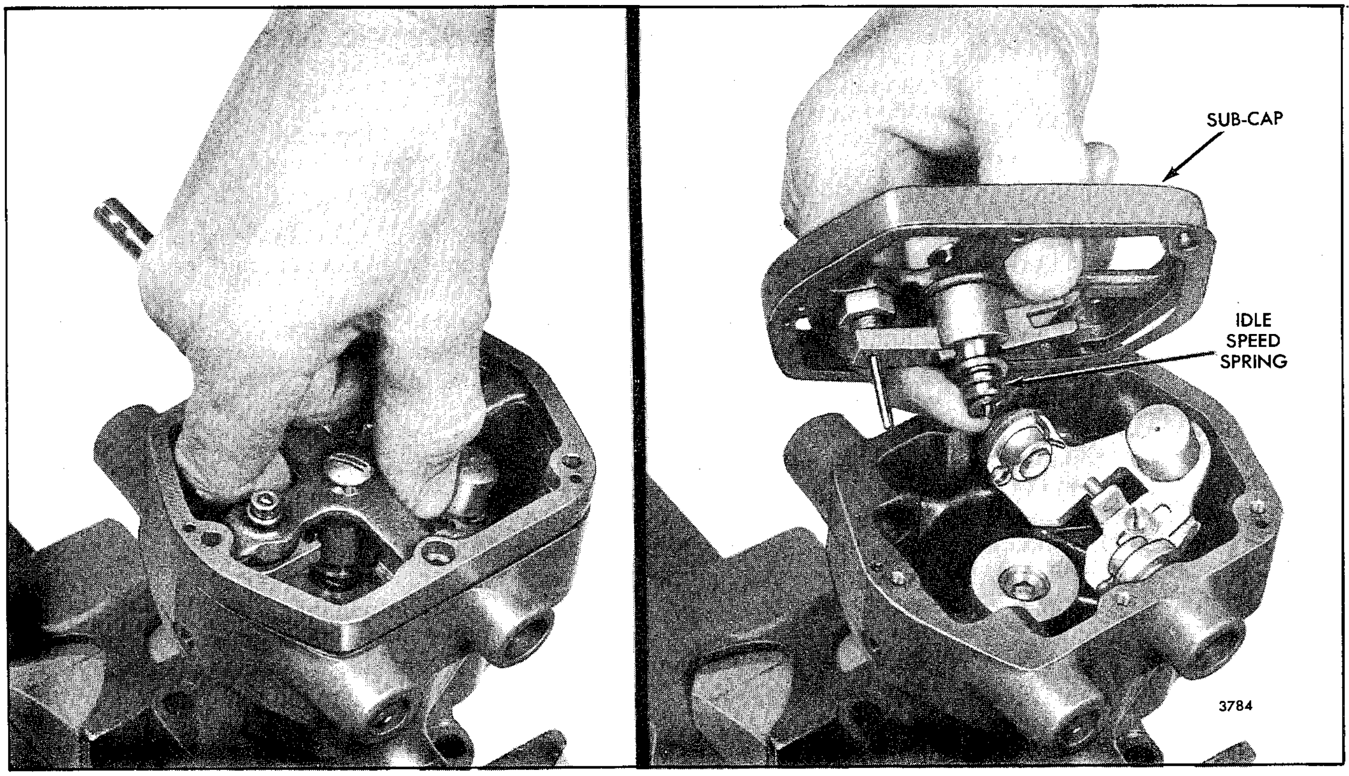


Fig. 11 - Removing or Installing Governor Sub-Cap Assembly

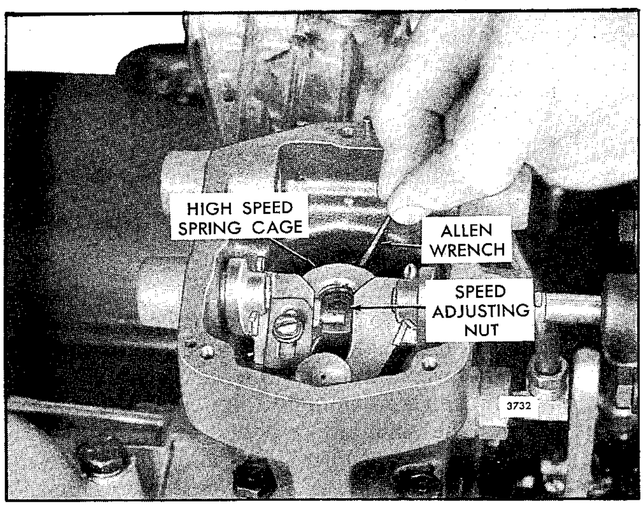


Fig. 12 - Loosening Allen Screw on Spring Cage

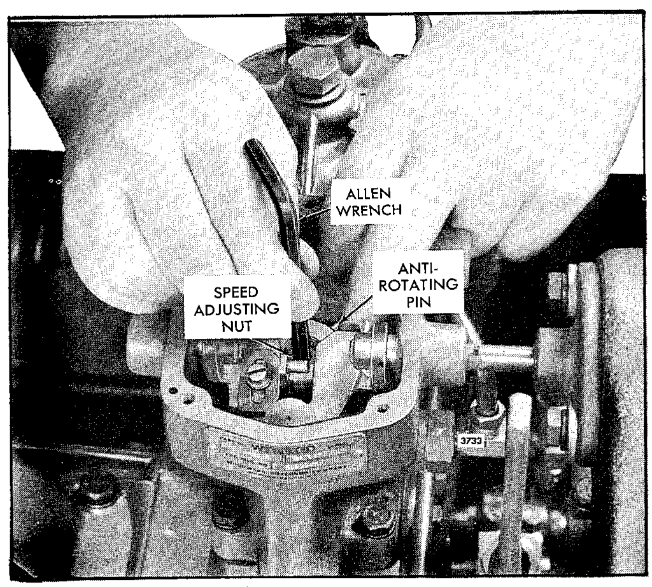


Fig. 13 - Turning High Speed Adjusting Nut

HYDRAULIC GOVERNOR (EG-B ELECTRIC) AND INJECTOR RACK CONTROL ADJUSTMENT

6, 8 and 12V ENGINES

The Woodward EG–B2C series governor (Fig. 1) is of the electric type. It can be operated as an isochronous (zero speed droop) governor or as a speed droop governor. As an isochronous governor installed on an engine operating alone, it will maintain a constant speed for all loads within the capacity of the engine, except momentarily at the time a load change occurs. Paralleled with other EG–governors, it will render proportional load division with isochronous control. Paralleled with dissimilar governors or with an infinite bus (i.e., commercial power), the EG–B2C governor can be operated as a conventional speed droop governor, and the load carried by the engine will be a function of the governor speed setting and speed droop setting.

The governor consists essentially of three separate assemblies: a control box, a speed adjusting potentiometer, and a hydraulic actuator. A resistor box assembly is required when the control box receives load signals from an engine driven alternator.

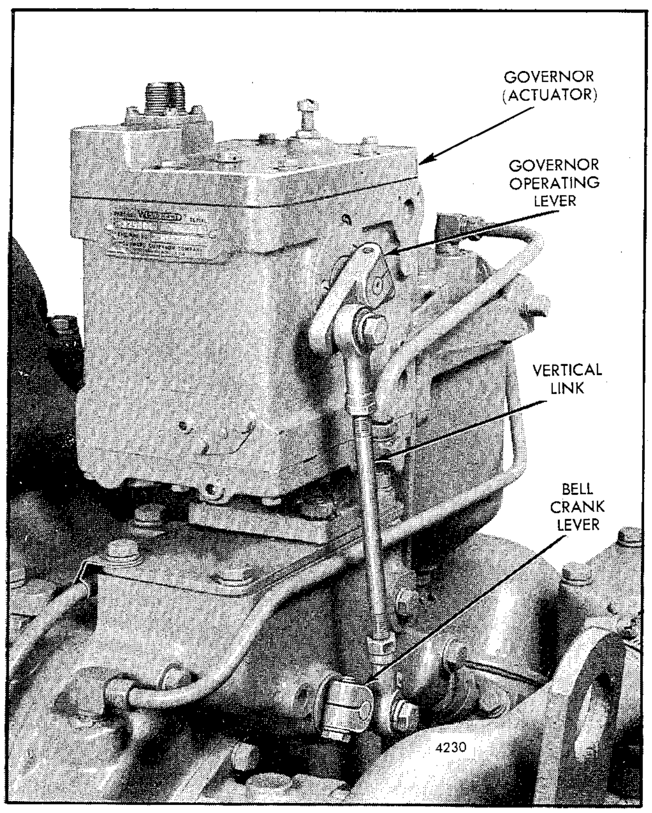


Fig. 1 - Governor Mounted on Engine

The output signal of the control box serves as the input signal to the hydraulic actuator; the actuator in turn controls the fuel to the engine.

The EG–B hydraulic actuator has a centrifugal head assembly to control the engine during starting; also, it will limit the maximum engine speed if the control box signal is interrupted or if it fails in such a manner as to call for maximum fuel.

Used with the control box, the EG–B actuator provides, in effect, two governors in one: an electric governor and a centrifugal governor, each independently capable of positioning the terminal (output) shaft. During normal operation, the electric governor controls fuel to the engine. The actuator is adjusted so that, if the electric control signal is interrupted, the electric section moves the fuel linkage to maximum fuel. When the speed reaches the level for which the centrifugal governor is set (always a level higher than that for which the electric governor is set), this section assumes and maintains control of the engine. Speed can then be reduced, if desired, by lowering the speed setting on the centrifugal governor. Should the control box fail in such a way as to emit a continuous signal calling for a decrease in fuel, the unit would shut down.

The essential element of the electric section of the actuator is an electro–hydraulic transducer which directs pressure oil to and from the power piston which actuates the fuel mechanism. The transducer consists of a polarized magnet to which is attached the pilot valve plunger controlling oil flow to and from the power piston. The solenoid responds to the push–pull output of the electric control box and, in so doing, moves the pilot valve plunger up or down. Through connecting linkage, the power piston moves the terminal (output) shaft of the actuator. The engine fuel linkage attaches to the actuator terminal shaft.

The governor (actuator) uses oil from the engine lubrication system.

For more detailed information on the electrical section and on servicing the EG–B2C governor, refer to the Woodward Governor Company's Bulletins 37709 and 37706 (also 37702 for type EG–B1 governor).

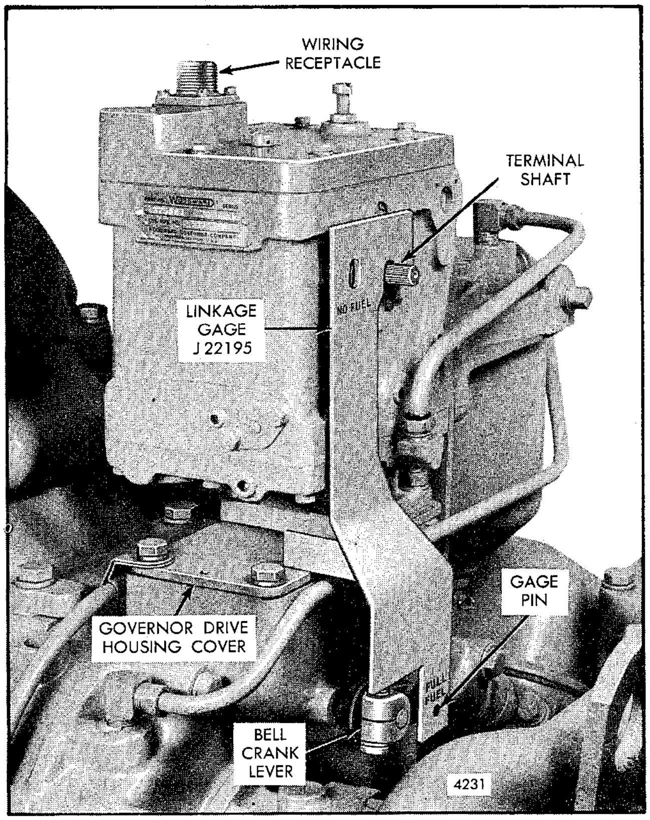


Fig. 2 – Linkage Gage in Position

Position Injector Rack Control Levers and Adjust Governor Linkage

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

The position of the injector control 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 letters R and L indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 1R injector rack control lever first to establish a guide for adjusting the remaining levers.

1. Clean and remove the valve rocker covers.

2. Loosen all of the inner and outer injector rack control lever adjusting screws on both injector control tubes. Be sure all of the injector rack control levers are free on the control tubes.

3. Remove the vertical link assembly (Fig. 1) from the governor operating lever and the bell crank lever.

4. Loosen the clamping bolt and slide the governor operating lever from the governor terminal shaft.

5. Place the linkage gage J 22195 over the governor terminal shaft and insert the gage pin in the bell crank lever bolt hole (Fig. 2). The tang on the side of the gage should just touch the top of the governor drive housing when the gage is properly positioned. The gage will hold the injector control racks in the full–fuel position while the levers are being adjusted.

6. Remove the clevis pin from the fuel rod and the left cylinder bank injector control tube lever.

7. Turn the inner adjusting screw of the No. 1R injector rack control lever down (Fig. 3) until a slight movement of the control tube is observed, or a step–up in effort to turn the screw driver is noted. This will place the No. 1R injector rack in the full–fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector tube. Then alternately tighten both the inner and outer adjusting screws.

NOTE: Avoid setting the rack too tight, causing the fuel rod to bend.

8. To be sure the control lever is properly adjusted, press down on the injector rack with a screw driver or finger tip. The setting is sufficiently tight if the rack returns to its original position when the pressure is released.

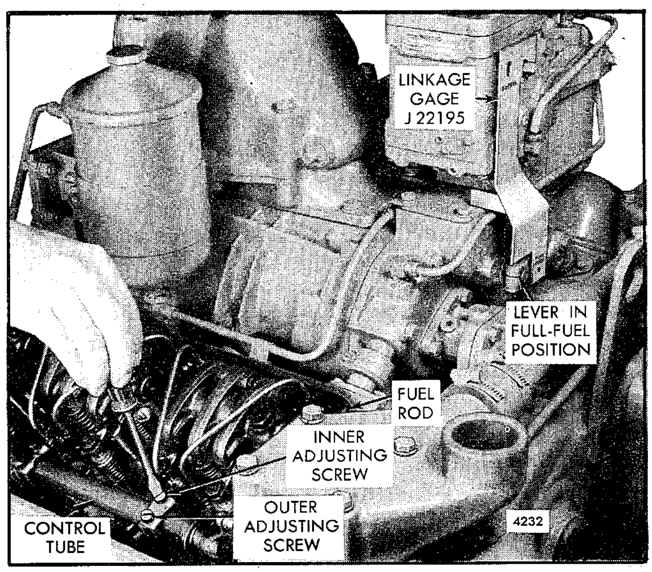


Fig. 3 – Positioning No. 1R Injector Rack Control Lever

9. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

10. Install the clevis pin in the fuel rod and the left cylinder bank injector control tube lever. Then position the No. 1L injector rack control lever as outlined in Steps 7 and 8.

11. Install the clevis pin in the fuel rod and the right cylinder bank injector control tube lever. Recheck the No. 1R and 1L injector rack control levers as in Step 8. Check for and eliminate any deflection in the fuel rods. If the settings are correct, both injector racks will be in the full-fuel position and snug on the ball end of the control levers.

12. Manually hold the No. 1R injector rack in the full-fuel position by means of the injector control tube lever. Turn down the inner adjusting screw of the No. 2R injector rack control lever until the injector rack moves into the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

NOTE: 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 **in-lbs** (3-4 Nm).

13. Recheck the No. 1R injector rack to be sure it has remained snug on the ball end of the rack control lever while positioning the No. 2R injector rack. If the rack of No. 1R injector has become loose, back off the inner adjusting screw on the No. 2R injector rack control lever slightly and tighten the outer adjusting screw. When the settings are correct, both injector racks will respond in the same manner on the ball end of their respective rack control levers.

14. Position the remaining injector rack control levers on the right and left bank cylinder heads as outlined in Step 12. When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube levers are held in the full-fuel position.

15. Turn the terminal shaft clockwise to the no-fuel position. Then place the governor operating lever on the terminal shaft so that the bolt hole in the lever is aligned with the center of the slot in the linkage gage (Fig. 4). Remove the gage and tighten the clamping bolt on the lever.

16. Move the bell crank lever to the no-fuel position.

17. Adjust the length of the vertical link so the bolt holes in the two levers and the rod end bearings in the vertical link are in alignment.

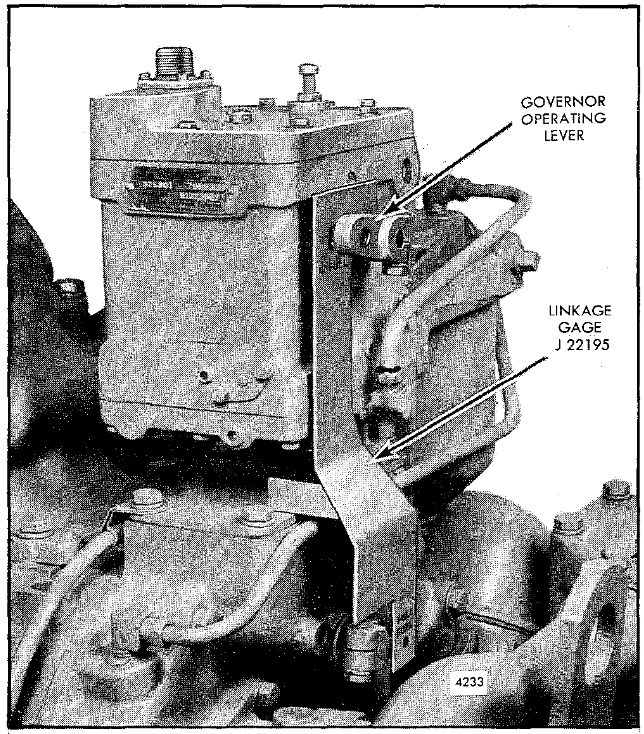


Fig. 4 - Governor Operating Lever in Position

18. Install and tighten the vertical link attaching bolts.

19. As an additional check, the governor operating lever should be in a position indicating maximum on the dial indicator (Fig. 6), when the injector rack control levers are in the full-fuel position. If not, readjust the vertical link.

20. Use a new gasket and install the valve rocker cover on each cylinder head.

Governor Adjustments

The centrifugal governor section of the actuator has three operating adjustments.

1. *Speed setting:* An external adjustment used to set the speed at which the centrifugal governor will control.

2. *Speed droop:* An internal adjustment used to permit parallel operation of units controlled by the centrifugal governor.

3. *Needle Valve:* An external adjustment used to stabilize the centrifugal governor.

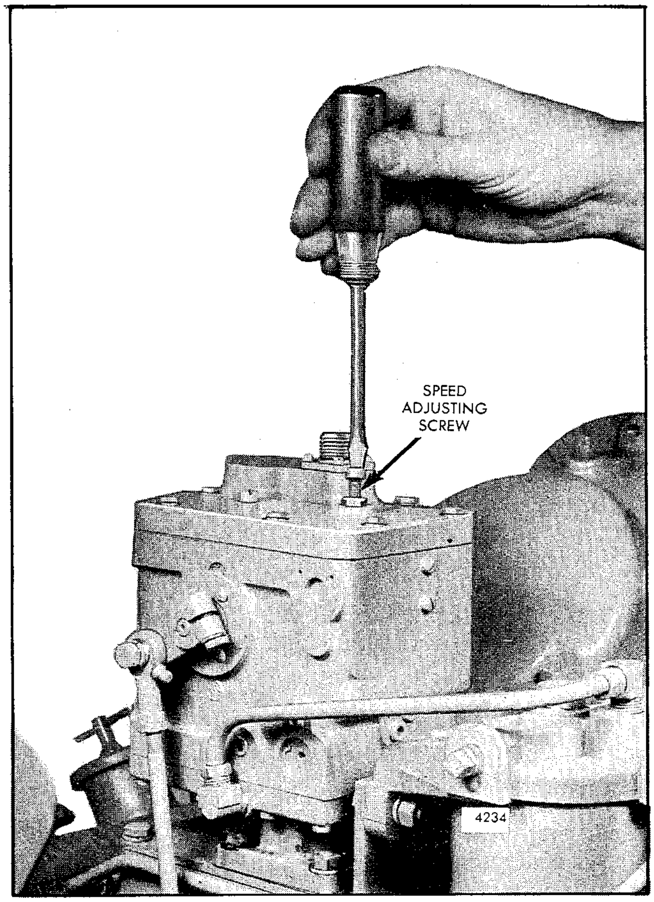


Fig. 5 – Adjusting Maximum No–Load Engine Speed

Once set, these adjustments do not usually require further adjustment.

Adjust Maximum No-Load Speed

When shipped from the factory, the speed adjusting screw is set for a speed approximately 4–1/2% above rated speed at no–load (the usual factory droop setting of 3% will reduce the speed to approximately 1–1/2% above rated speed at full travel of the centrifugal governor power piston). With the speed adjusting screw at this setting during normal operation (i.e., with the electric section controlling), the centrifugal governor power piston will be held in its maximum fuel position.

If adjustment of the maximum no–load speed is required, proceed as follows:

1. Disconnect the wiring at the receptacle on the governor cover.

2. Start the engine and run it at no–load.

3. Turn the speed adjusting screw (Fig. 5) until the desired speed is obtained. Turning the screw counterclockwise will decrease the speed setting.

Adjust Needle Valve

When starting the engine for the first time, eliminate any air which may be trapped in the actuator oil passages as follows:

1. Open the needle valve of the centrifugal governor section (Fig. 6) until the engine hunts or surges. After a half minute, gradually close the needle valve until the engine speed just stabilizes. Closing the needle valve farther than necessary will make the governor slow to return to normal speed after a load change. Never close the needle valve tight.

2. Test the action by manually disturbing the speed of the engine. The engine should promptly return to its original steady–state speed with only a small overshoot or undershoot.

Speed Droop Adjustment

The governor is set with approximately 3% droop when shipped from the factory. When the electric governor section is controlling the engine, the speed

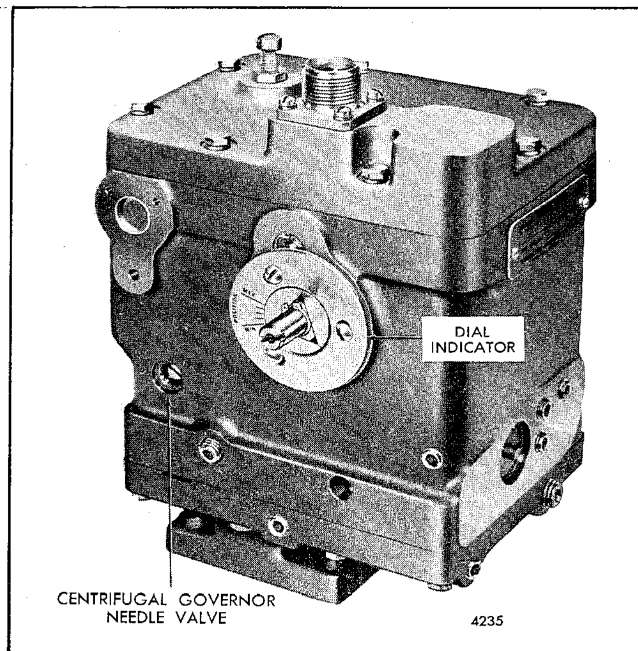


Fig. 6 – Location of Centrifugal Governor Needle Valve

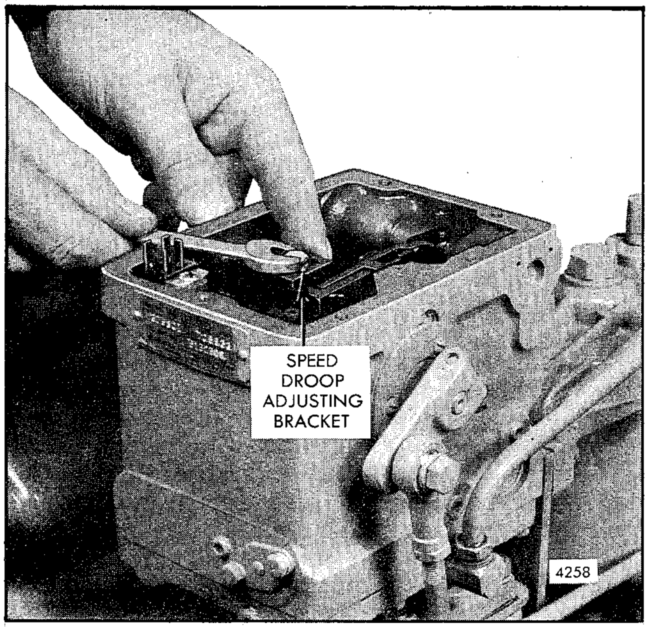


Fig. 7 – Adjusting Speed Droop

droop adjustment has no effect on operation and should be left as factory set. When, for some reason, the centrifugal governor section is controlling the engine, the speed droop setting can be adjusted, if necessary, to suit the operating requirements. The governor should never be set at "zero" droop unless the unit is maintaining the frequency of paralleled alternators or is operating as a single, isolated unit.

Not more than one unit in a system of paralleled alternators with engines controlled by centrifugal governors can be operated on "zero" droop.

If necessary, adjust the speed droop as follows:

1. Start the engine and run it at approximately half-load until the lubricating oil temperature is stabilized; governor regulation will become more stable as the oil temperature increases.

2. Stop the engine and remove the actuator cover.

3. Loosen the speed droop adjusting bracket screw and move the bracket (Fig. 7) slightly to obtain the desired droop; moving the bracket toward the flyweight end of the actuator will increase the droop. Tighten the screw.

4. Install the actuator cover and, with the engine running, adjust the speed until the engine is operating at the desired speed above the rated full-load speed.

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

6. Remove the rated load and note the engine speed after it stabilizes under no load. If necessary, stop the engine, remove the actuator cover and readjust the speed droop bracket.

After the engine tune-up is completed, reconnect the electrical circuit of the governor at the receptacle on the actuator cover. If necessary, refer to the Woodward Governor Company's Bulletin 37709 for the procedures to be followed in checking the electrical system.

16V ENGINE

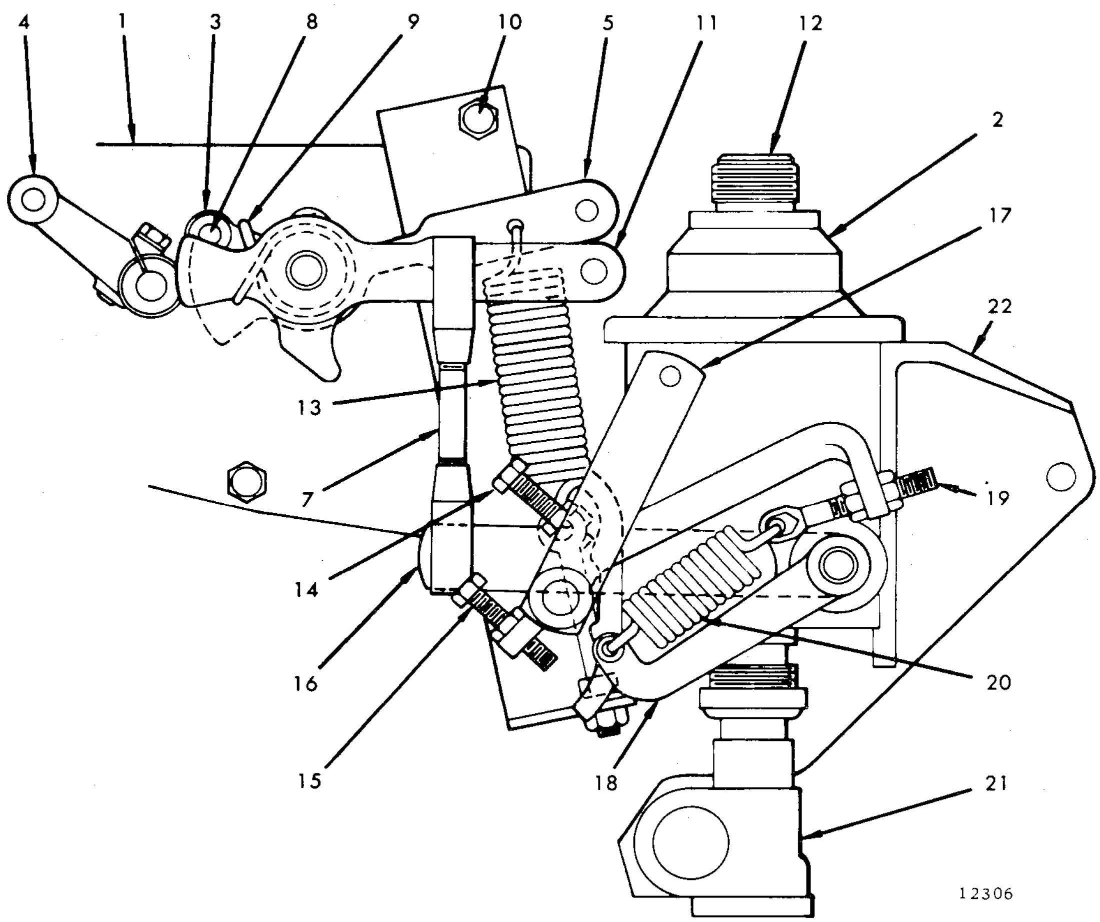
The tune-up procedure for a 16V engine equipped with the EG-B electric governor is similar to the procedure used on the 6, 8 or 12V engines. To position the injector rack control levers, use the same linkage gage (J 22195) but follow the procedure outlined in the variable speed hydraulic governor (6, 8 and 12V) or in the variable speed hydraulic governor (16V). The governor adjustments, however, are the same as on the 6, 8 and 12V engines.

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 is mounted at the front of the engine (Fig. 1) and driven by a flexible shaft from the converter output shaft.

The output shaft 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 oil level should be checked every 8 service hours and changed every 500 hours.

The output shaft governor is connected to the engine governor by control rods and levers as illustrated in Fig. 1. The control rod end ball joints are sealed assemblies and do not require lubrication. Other moving parts of the control linkage should be lubricated with engine oil.



1. Governor--Engine
2. Governor--Output Shaft
3. Lever--Throttle Control
4. Lever--Shutdown
5. Lever--Engine Governor Operating
7. Rod--Output Shaft Governor
8. Pin--Stop
9. Spring--Torsion
10. Bolt (Stop)
11. Lever--Output Shaft Governor
12. Drive--Flexible Shaft
13. Spring--Governor Lever Return
14. Bolt--Minimum Speed Adjusting
15. Bolt--Maximum Speed Adjusting
16. Lever--Rocker Shaft
17. Lever--Speed Adjusting
18. Lever--Spring
19. Eyebolt--Droop Adjusting
20. Spring--Speed Adjusting
21. Drive--Tachometer
22. Bracket--Output Shaft Governor Mounting

Fig. 1 - Mechanical Output Shaft Governor and Linkage

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 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.

If the operator moves 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 fuel injectors and adjust the engine and output shaft governors as follows:

1. Adjust the exhaust valve clearance and time the 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 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 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 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. Tighten the adjustment.

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 eye bolt 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:

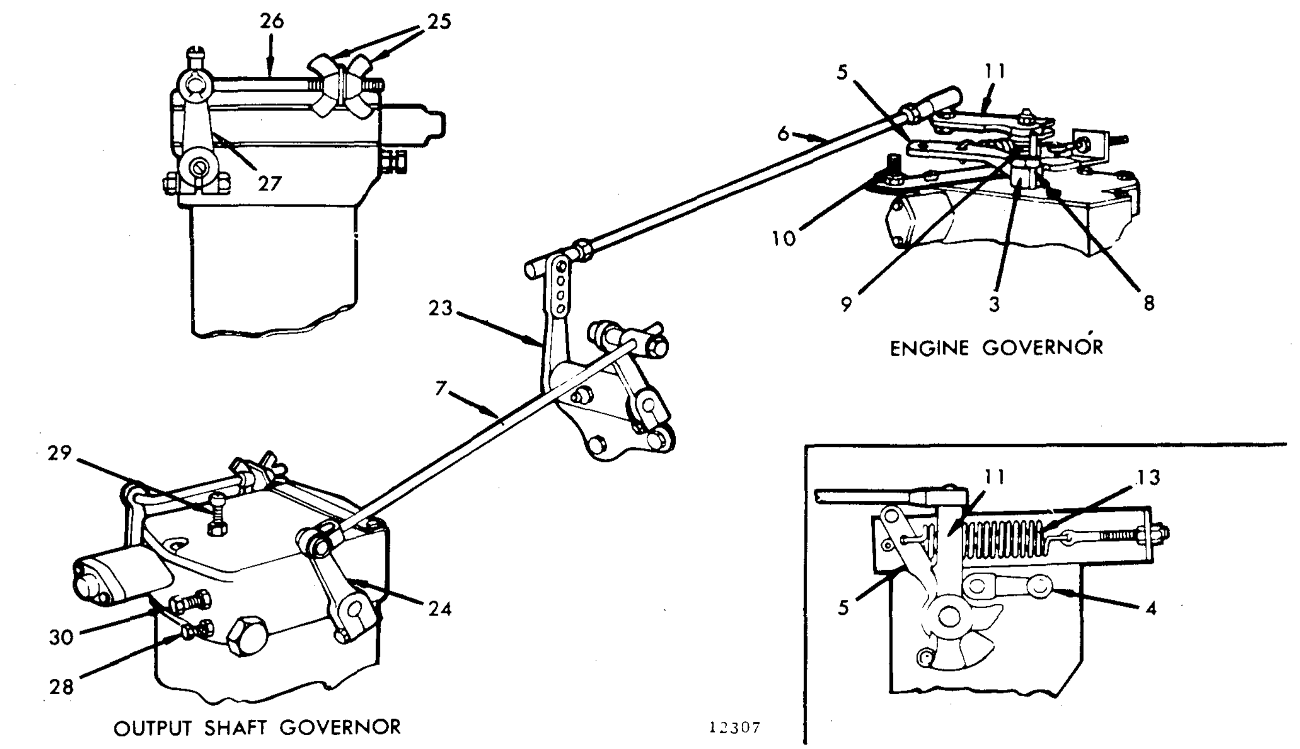
a. If the engine hunts less than three surges, back off the inner speed adjusting spring eye bolt nut one full turn and tighten the inner nut one turn to retain the adjustment. If the engine hunts more than five surges, back off the outer speed adjusting spring eye bolt nut one full turn and tighten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

HYDRAULIC OUTPUT SHAFT GOVERNOR AND LINKAGE ADJUSTMENT



3. Lever--Throttle Control
4. Lever--Shutdown
5. Lever--Engine Governor Operating
6. Rod--Engine Governor
7. Rod--Output Shaft Governor
8. Pin--Stop
9. Spring--Torsion
10. Bolt (Stop)
11. Lever--Output Shaft Governor
13. Spring--Governor Lever Return
23. Lever--Throttle Control Rear Cross Shaft
24. Lever--Output Shaft Governor Control
25. Wing Nut--Speed Adjusting
26. Link--Sliding
27. Lever--Speed Control
28. Screw--Maximum Speed Limit Adjusting
29. Screw--Minimum Speed Limit Adjusting
30. Screw--Maximum Fuel Adjusting

Fig. 1 - Hydraulic Output Shaft Governor and Linkage

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 (Fig. 1). The control rod end ball joints are sealed assemblies and do not require lubrication. 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 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, 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.

Adjustments

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 and after the limiting speed engine governor has been adjusted.

1. Connect the linkage to the governor operating lever and check the total travel of the 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.

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 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 eye bolt 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 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.

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 a temporary period of time, 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*.

5. If freezing weather is expected during the storage period, add a high boiling point type antifreeze solution in accordance with the manufacturer's recommendations. Drain the raw water system and leave the drain cocks open.

6. Clean the entire exterior of the engine (except the electrical system) with fuel oil and dry it with air.

7. Seal all of the engine openings. The material used for this purpose must be water proof, vaporproof and possess sufficient physical strength to resist puncture and damage from the expansion of entrapped air.

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 (30 days or more)

When an engine is to be removed from operation for an extended period of time, prepare it as follows:

1. Drain and thoroughly flush the cooling system with clean, soft water.

2. Refill the cooling system with clean, soft water.

3. Add a rust inhibitor to the cooling system (refer to *Corrosion Inhibitor* under *Cooling System).*

4. Remove, check and recondition the injectors, if necessary, to make sure they will be ready to operate when the engine is restored to service.

5. Reinstall the injectors in the engine, time them, and adjust the valve clearance.

6. Circulate the coolant through the entire system by operating the engine until normal operating temperature is reached (160–185° F or 71–85° C).

7. Stop the engine.

8. Remove the drain plug and completely drain the engine crankcase. Reinstall and tighten the drain plug. Install new lubricating oil filter elements and gaskets.

9. Fill the crankcase to the proper level with a 30-weight preservative lubricating oil MIL-L-21260, Grade 2 (P10), or equivalent.

10. Drain the engine fuel tank.

11. Refill the fuel tank with enough rust preventive fuel oil such as American Oil Diesel Run-In Fuel

(LF 4089), Mobil 4Y17, or equivalent, to enable the engine to operate 10 minutes.

12. Drain the fuel filter and strainer. Remove the retaining bolts, shells and elements. 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 the same rust preventive compound as used in the fuel tank and reinstall the shell.

13. Operate the engine for 10 minutes to circulate the rust preventive throughout the engine.

14. Refer to *Air System* and service the air cleaner.

15. MARINE GEAR

a. Drain the oil completely and refill with clean oil of the proper viscosity and grade as is recommended. Remove, clean or replace the strainer and replace the filter element.

b. Start and run the engine at 600 rpm for 10 minutes so that clean oil can coat all of the internal parts of the marine gear. Engage the clutches alternately to circulate clean oil through all of the moving parts.

16. TORQMATIC CONVERTER

a. Start the engine and operate it until the temperature of the converter oil reaches 150 °F (66 °C).

b. Remove the 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 Government specifications MIL-L-21260, Grade 1. 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 permit the converter to cool to a temperature suitable to touch.

i. Seal all of the exposed openings and the breather 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.

17. POWER TAKE-OFF

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 and flush the gear box 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.

18. TURBOCHARGER

The turbocharger bearings are lubricated by pressure through the external oil line leading from the engine cylinder block while performing the previous operations above and no further attention is required.

19. Apply a *non-friction* rust preventive compound, to all exposed parts. If it is 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.

20. Drain the engine cooling system.

21. The oil may be drained from the engine crankcase if so desired. If the oil is drained, reinstall and tighten the drain plug.

22. Remove and clean the battery and battery cables

with a baking soda solution and rinse them 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.

23. Insert heavy paper strips between the pulleys and belts to prevent sticking.

24. Seal all of the openings in the engine, including the exhaust outlet, with moisture resistant tape. Use cardboard, plywood or metal covers where practical.

25. Clean and dry the exterior painted surfaces of the engine. Spray the surfaces with a suitable liquid automobile body wax, a synthetic resin varnish or a rust preventive compound.

26. Cover the engine with a good weather-resistant tarpaulin or other cover if it must be stored outdoors. A clear plastic cover is recommended for indoor storage.

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. Reinstall the valve rocker covers.

2. Remove the covers and tape from all of the openings of the engine, fuel tank and electrical equipment. *Do not overlook the exhaust outlet.*

3. Wash the exterior of the engine with fuel oil to remove the rust preventive.

4. Remove the rust preventive from the flywheel.

5. Remove the paper strips from between the pulleys and the belts.

6. 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.

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

8. 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, add a high boiling point type antifreeze solution to the cooling system (the antifreeze contains a rust inhibitor).

9. Install and connect the battery.

10. Service the air cleaner as outlined under *Air System.*

11. POWER GENERATOR

Prepare the generator for starting as outlined under *Operating Instructions.*

12. MARINE GEAR

Check the Marine gear; refill it to the proper level, as necessary, with the correct grade of lubricating oil.

13. 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.*

14. 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.

15. TURBOCHARGER

a. Thoroughly clean the area around the turbocharger air inlet tube and the oil inlet line.

b. Disconnect the air inlet tube from the compressor housing.

c. Disconnect the oil inlet line from the top of the center housing.

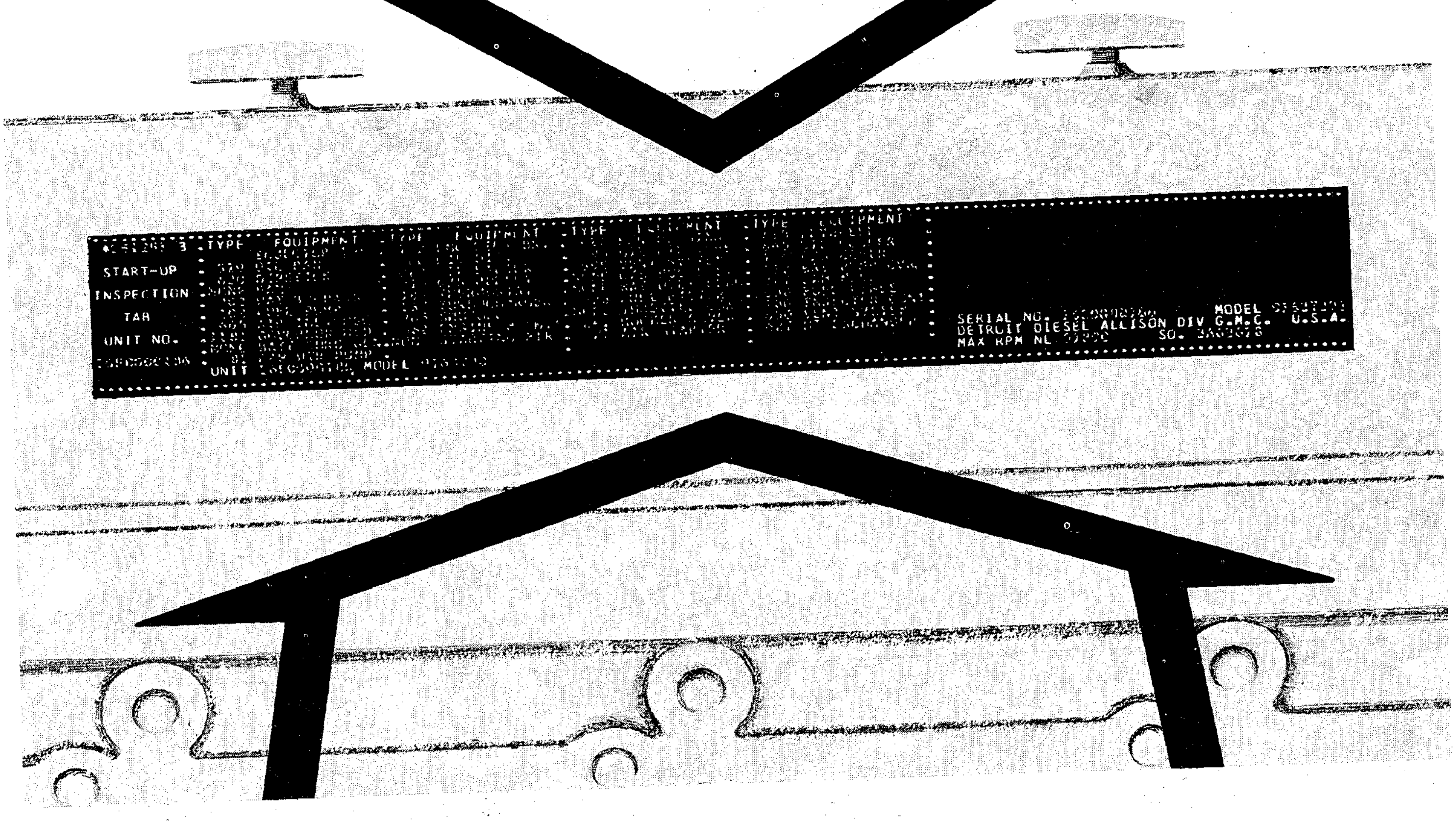
d. Pour approximately four ounces of lubricating oil in the oil inlet opening of the center housing. Reach in through the air inlet opening in the compressor housing and turn the rotating assembly by hand to coat the bearings, thrust ring and thrust washer with oil. Then fill the oil inlet line with engine oil.

e. Connect the oil inlet line to the top of the center housing. Then connect the air inlet tube to the compressor housing.

16. After all of the preparations have been completed, start the engine. The small amount of rust preventive compound which remains in the fuel system will cause a smoky exhaust for a few minutes.

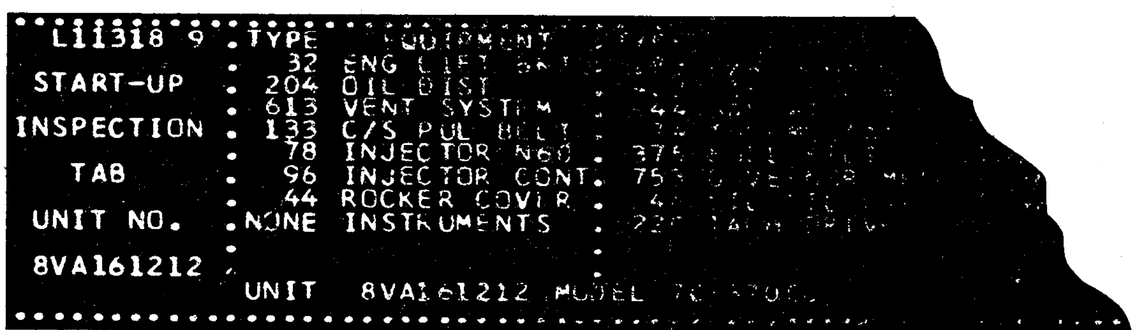
NOTE: Before subjecting the engine to a load or high speed, it is advisable to check the engine tune-up.

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 . . .

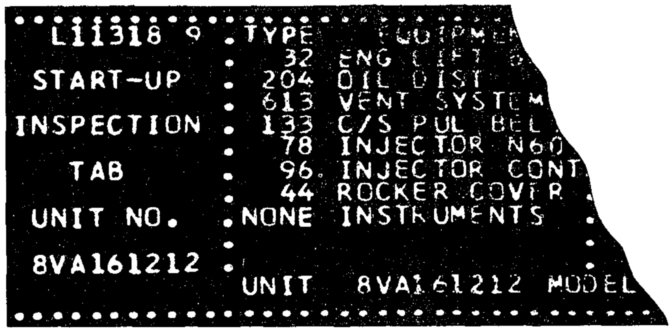
A. The "Model" number **B.** The "UNIT" number **C.** The "TYPE" number



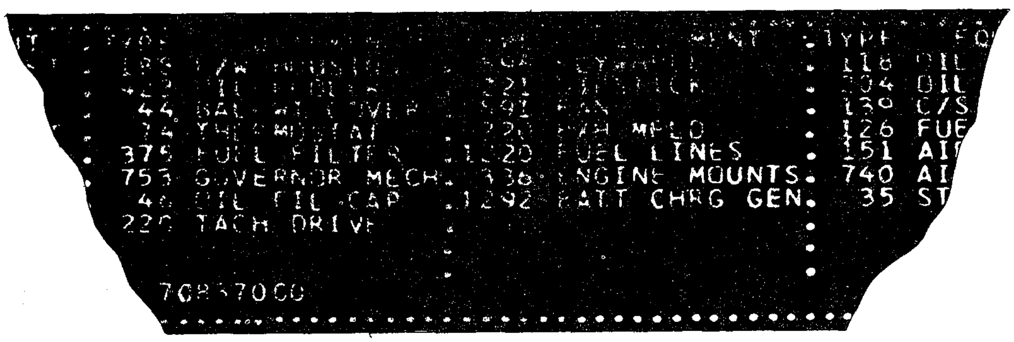
C. B. A.

From that much information, the dealer with his complete records on all engine models, can completely interpret your parts requirements.

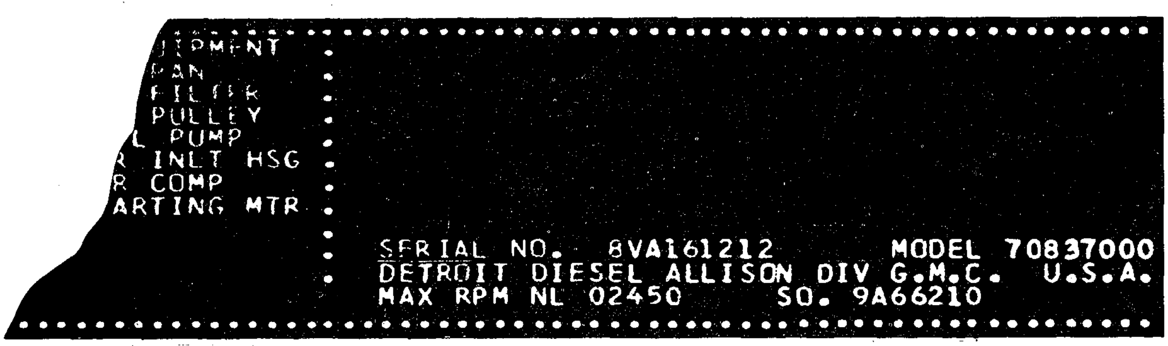
What is this "built-in" book? It is a photo etched aluminum plate that fits into a holding channel on the engine rocker cover.



ON THE LEFT SIDE of the plate is the Start-up Inspection Tab which is removed by the dealer when he has completed the inspection.



NEXT is the type number and the equipment description. On the left is the type number. The type number designates all service parts applicable to the equipment. On the right is a brief description of the equipment.



ON THE RIGHT SIDE of the plate is shown the model number, serial number and the related governor setting.

All engine components are divided into groups of functionally related parts. A complete listing of the twelve major groups and their many sub-groups 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 V-71 MPC 7064-7002 (RC)

STANDARD AND STANDARD OPTION EQUIPMENT

GROUP NAME	GROUP NO.	TYPE
CYLINDER BLOCK	1.000	34
AIR BOX DRAINS (WATER BELOW PORT BLOCK)	1.1000A	103
CYLINDER HEAD	1.2000	27
ENGINE LIFTER BRACKET	1.2000A	37
CRANKSHAFT	1.3000	23
CRANKSHAFT PULLEY	1.3000C	134
FLYWHEEL	1.4000A	170
FLYWHEEL HOUSING (SAE #1)	1.5000A	188
CONNECTING ROD AND PISTON THRU 6VA-034891	1.6000	88
CONNECTING ROD AND PISTON EFF. WITH 6VA034892	1.6000	137
CAMSHAFT AND GEAR TRAIN	1.7000	38
BALANCE WEIGHT COVER	1.7000A	19
VALVE OPERATING MECHANISM	1.8000	24
ROCKER COVER	1.8000A	43
FUEL INJECTOR N55	2.1000A	77
FUEL PUMP THRU 6VA-61547	2.2000	71
FUEL PUMP EFF. WITH 6VA-61548	2.2000	126
FUEL FILTER	2.3000A	360
FUEL MANIFOLD CONNECTORS	2.4000	55
FUEL LINES	2.5000A	1265
GOVERNOR, MECHANICAL	2.7000A	753
INJECTOR CONTROLS	2.9000	95

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).

FOR 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

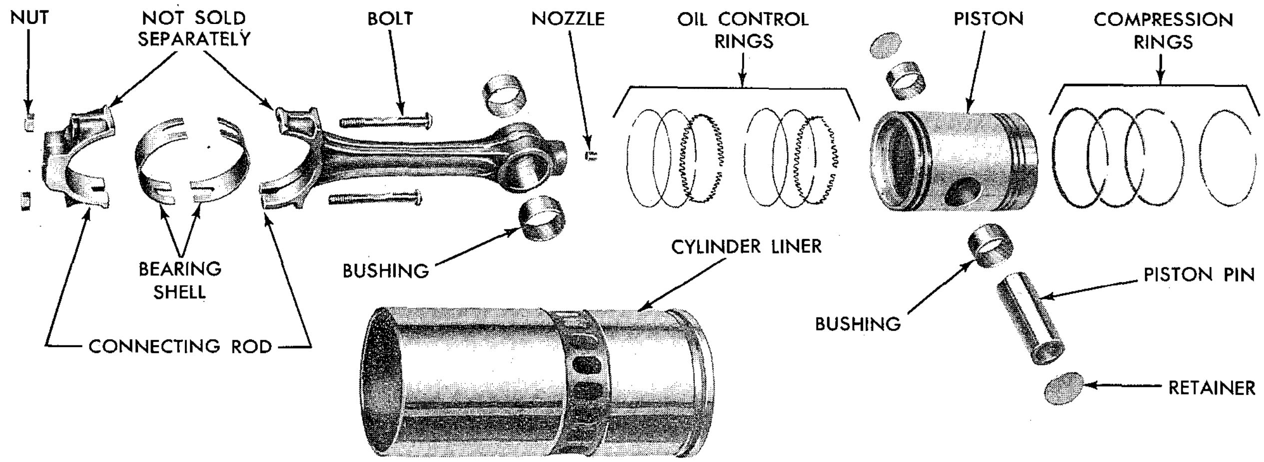
AIR CLEANER

If dry-type, indicate make and number of filter element:

____

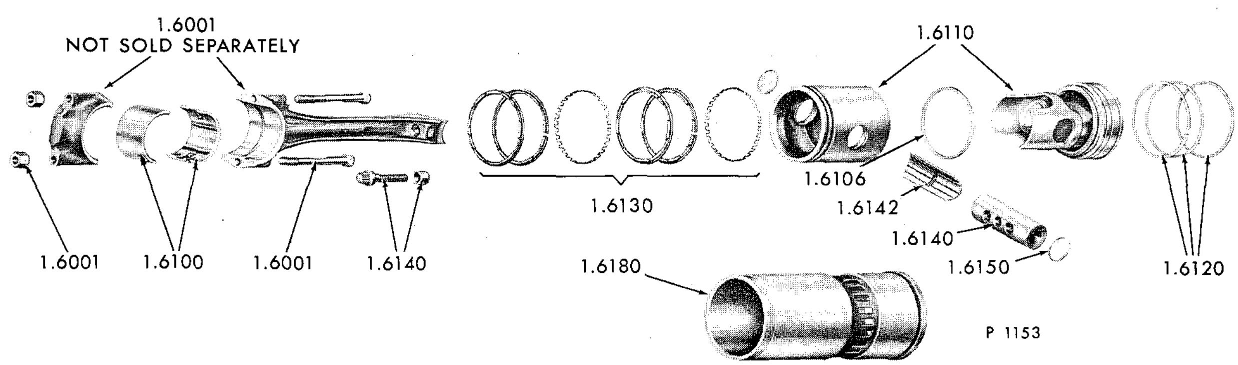
____

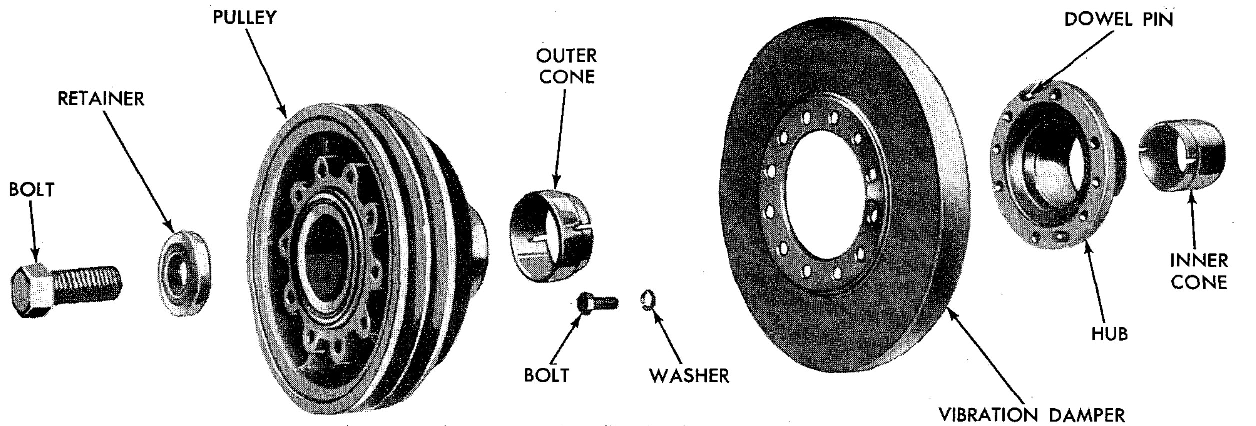
Wet type, indicate capacity__________qts.



CONNECTING ROD AND PISTON

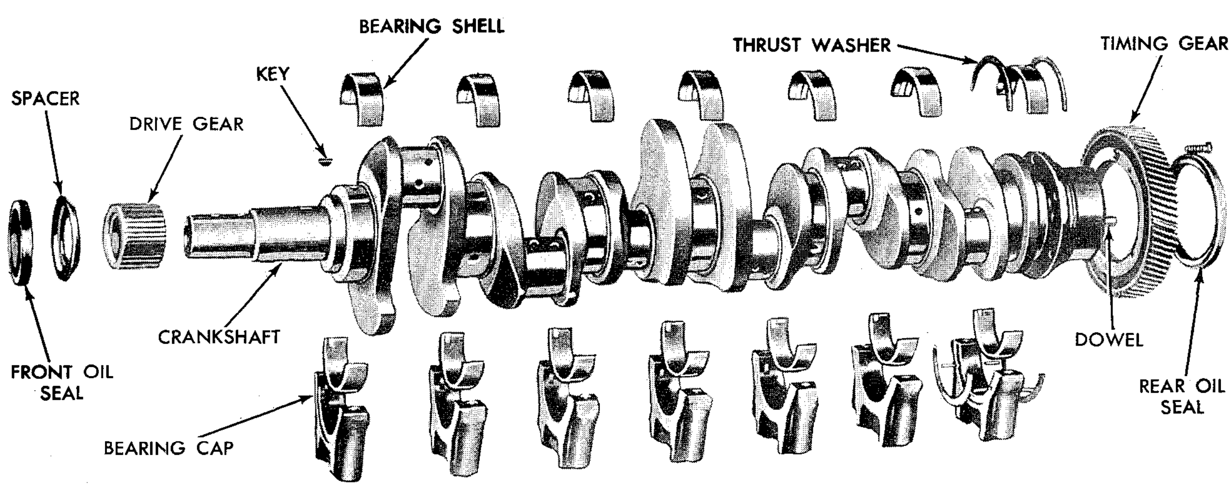
P 607B





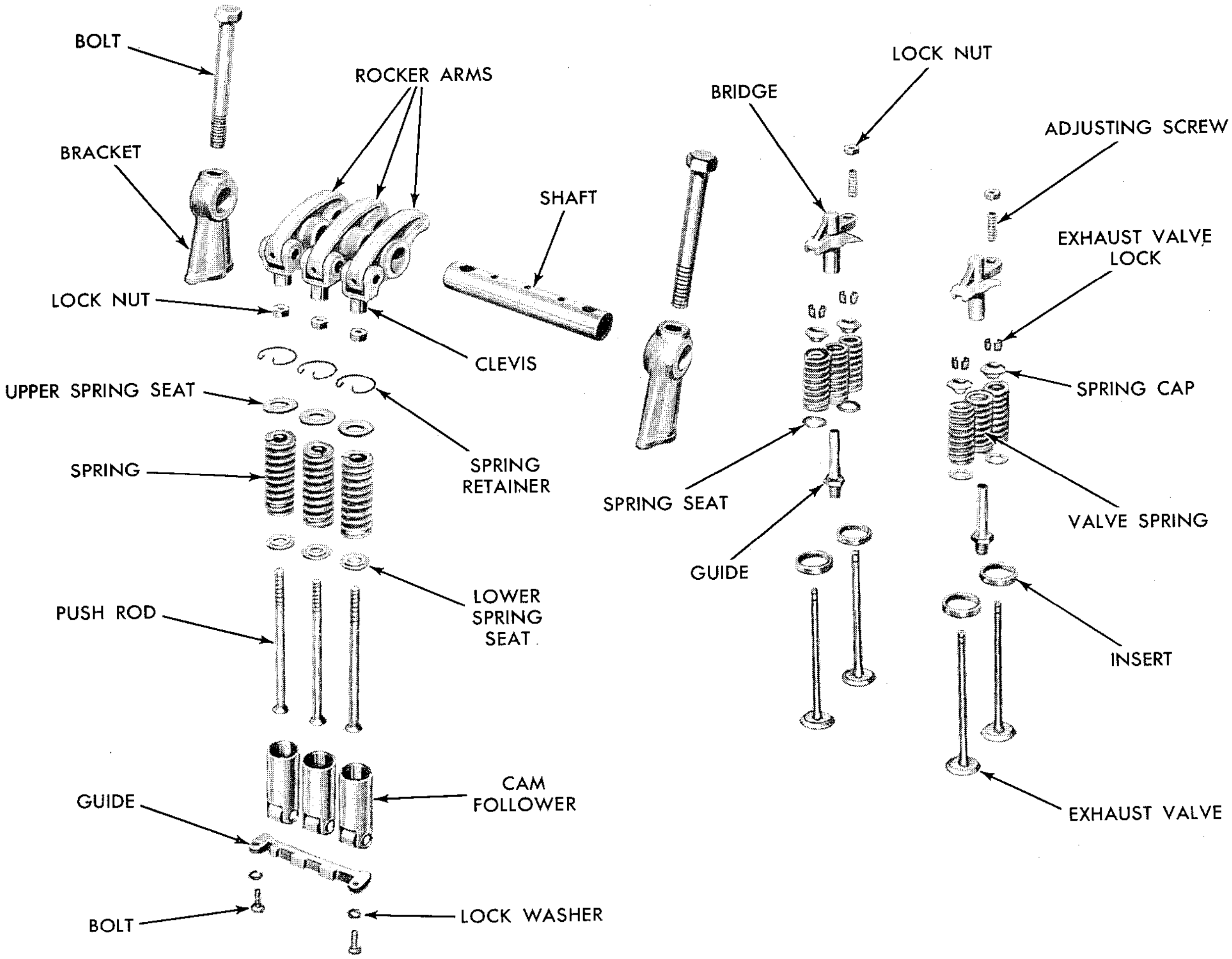
CRANKSHAFT PULLEY, VIBRATION DAMPER AND HUB

P 607A



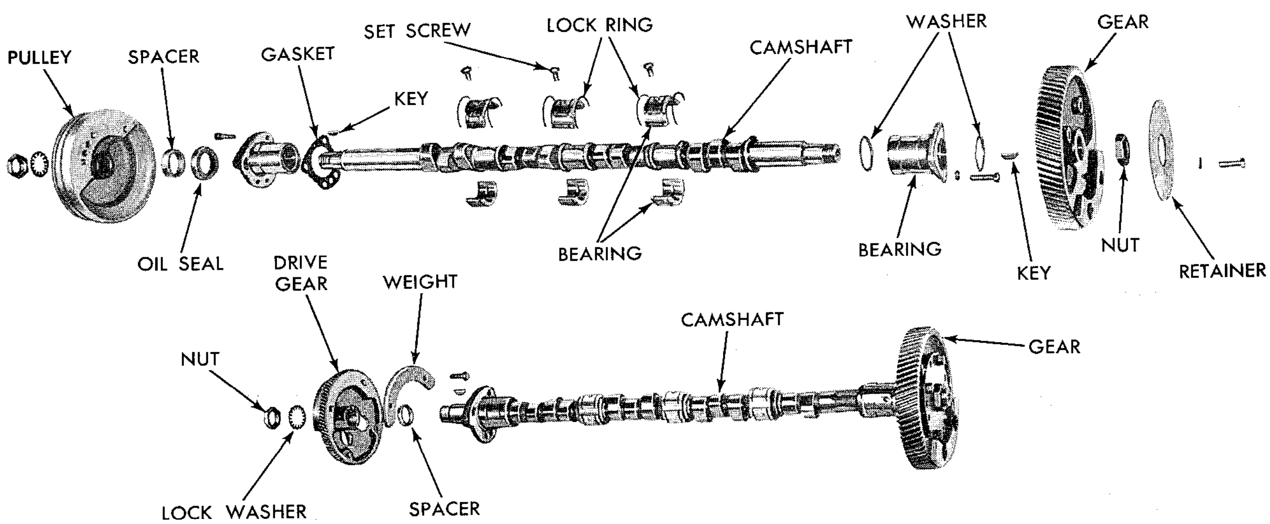
CRANKSHAFT

P 607



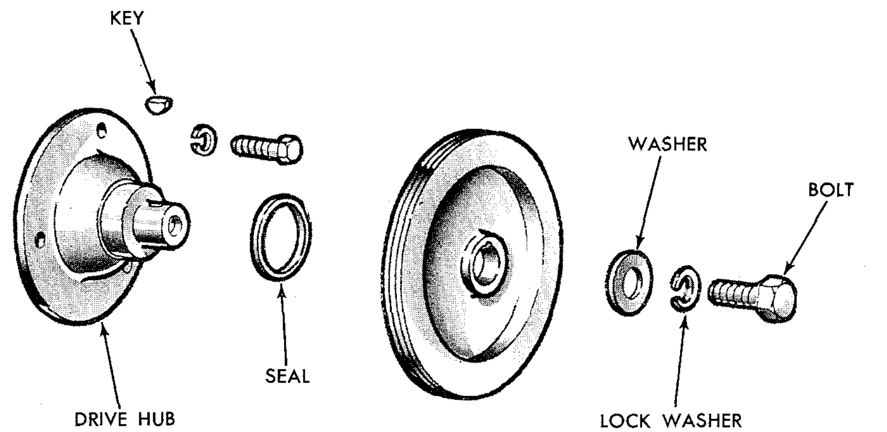
VALVE OPERATING MECHANISM (4 VALVE)

P 600A



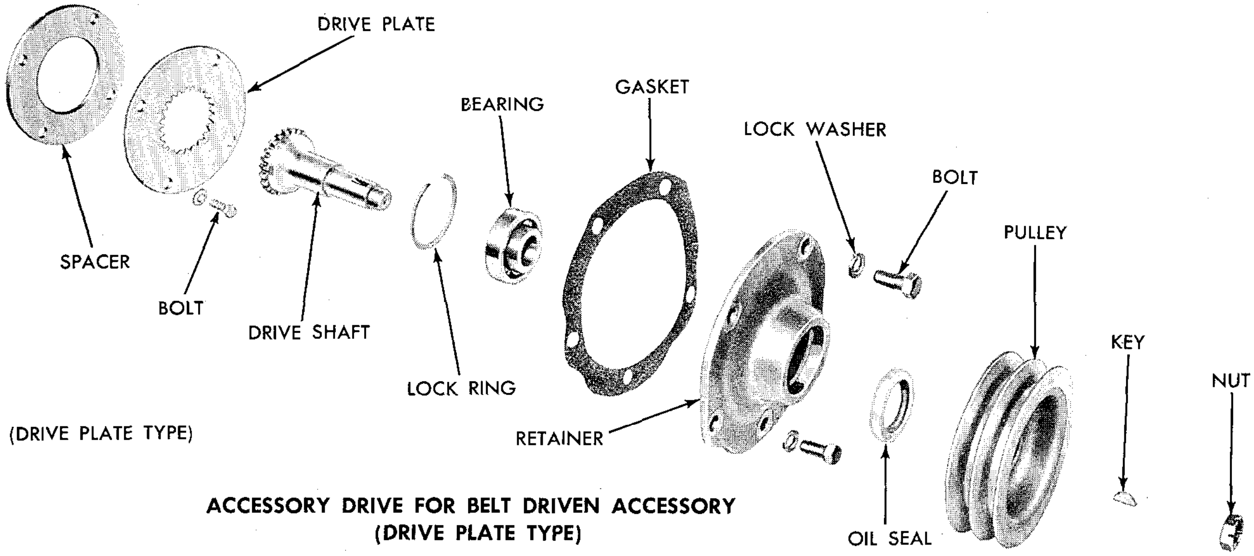
CAMSHAFT AND GEARS

P 600



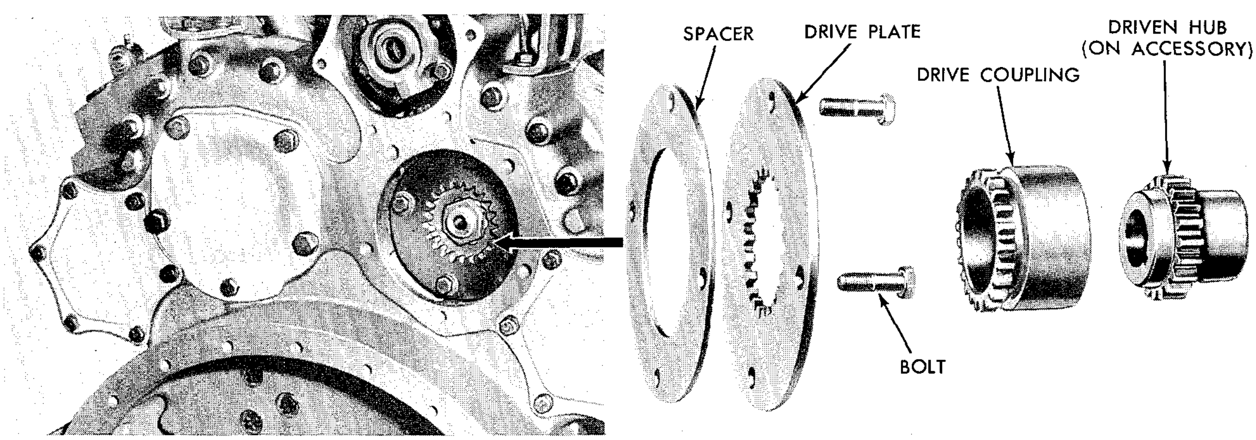
ACCESSORY DRIVE FOR BELT DRIVEN ACCESSORY (FRONT MOUNTED TYPE)

P 609B



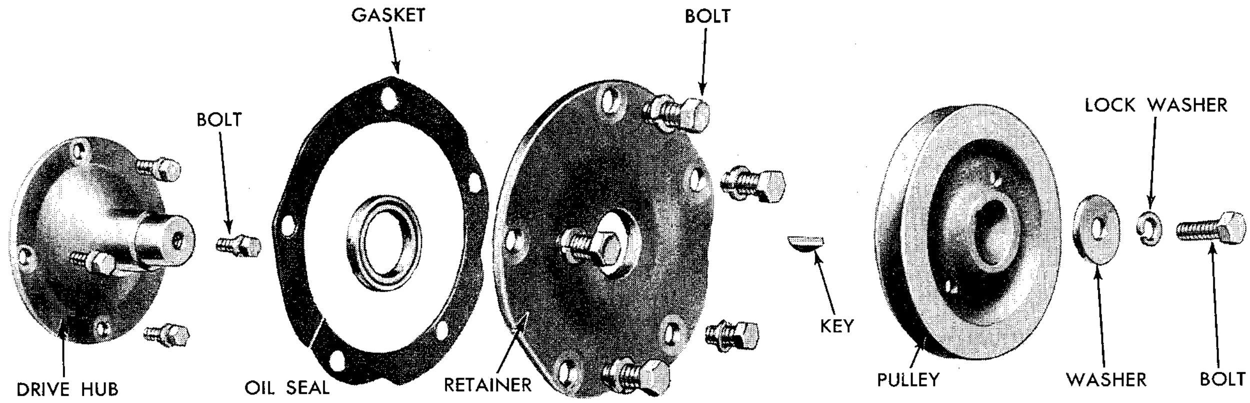
ACCESSORY DRIVE FOR BELT DRIVEN ACCESSORY (DRIVE PLATE TYPE)

P 609A



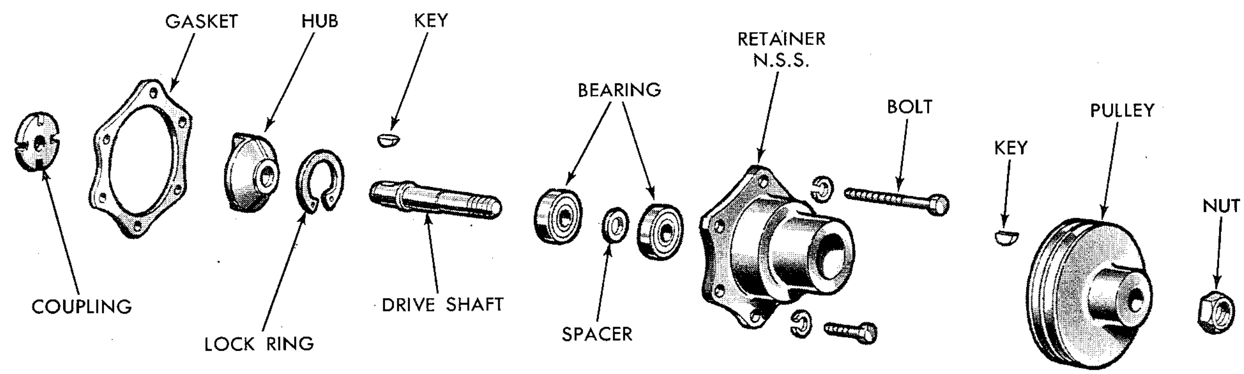
ACCESSORY DRIVE FOR DIRECT DRIVEN ACCESSORY (CAMSHAFT GEAR)

P 609



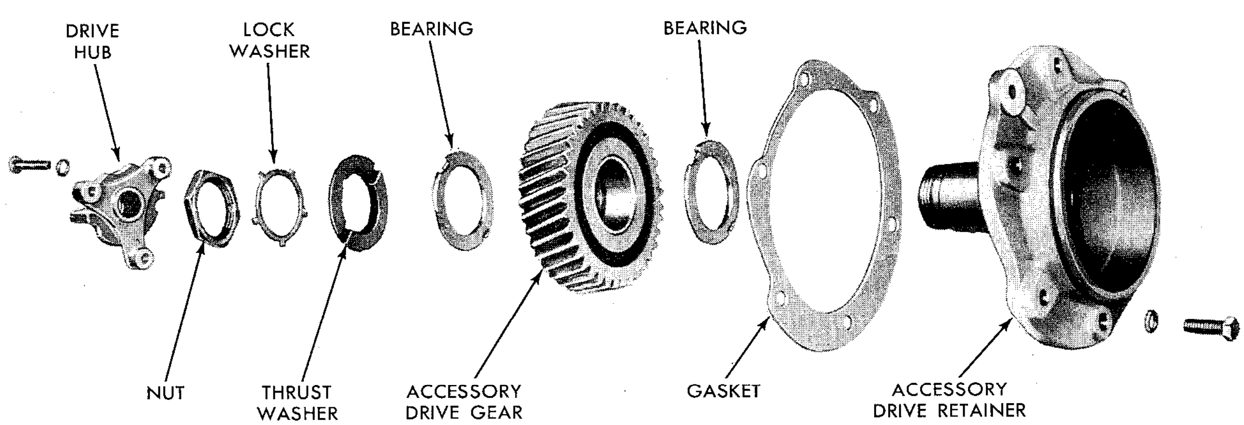
ACCESSORY DRIVE FOR BELT DRIVEN ACCESSORY (DRIVE HUB TYPE)

P 603B



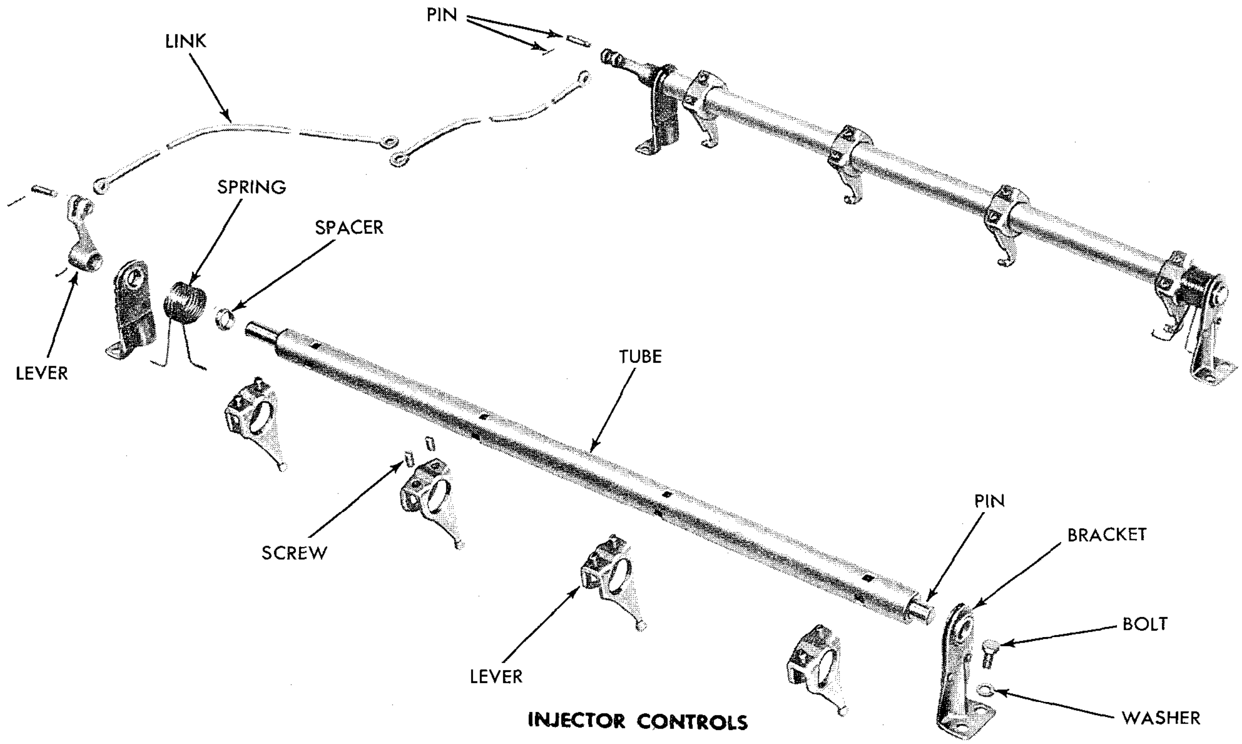
ACCESSORY DRIVE FOR BELT DRIVEN ACCESSORY (DRIVE DISC COUPLING TYPE)

P 603A

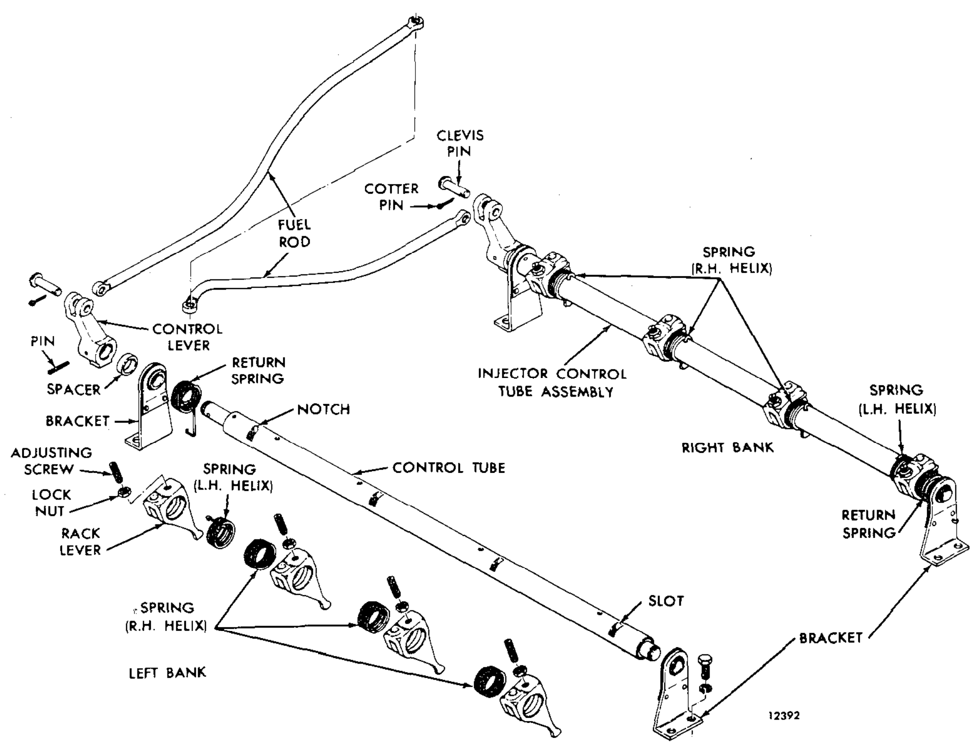


ACCESSORY DRIVE FOR BELT DRIVEN ACCESSORY (ACCESSORY GEAR)

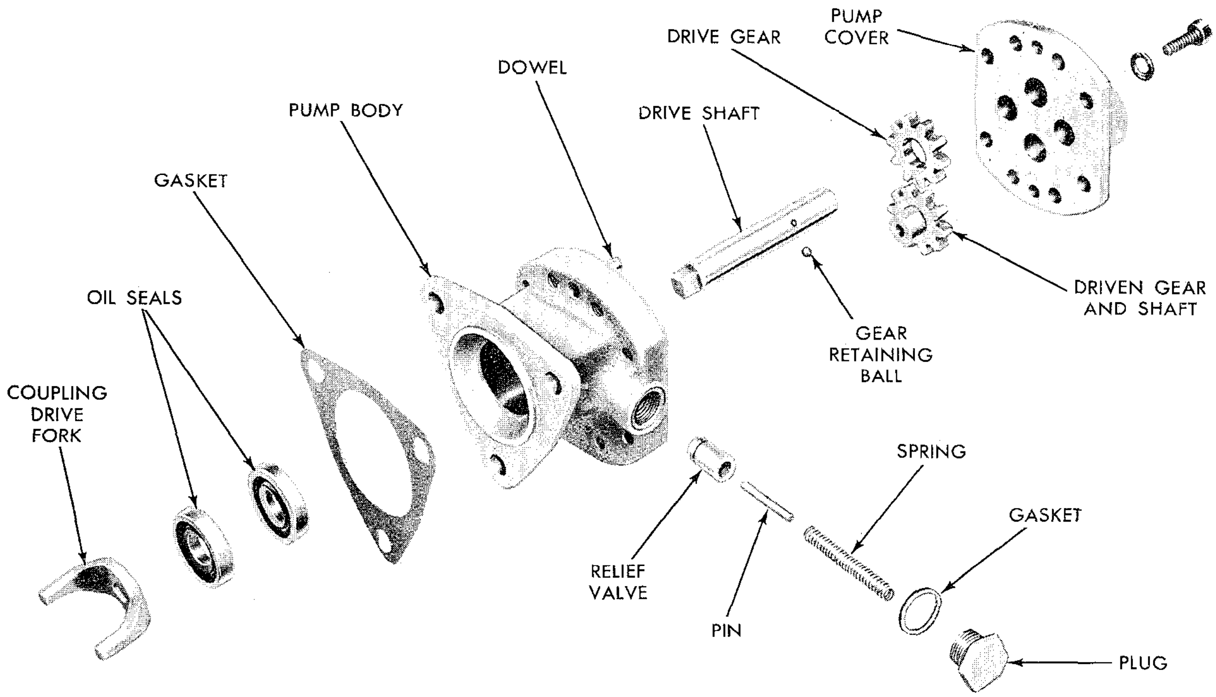
P 603



INJECTOR CONTROLS
(Non–Spring Loaded)

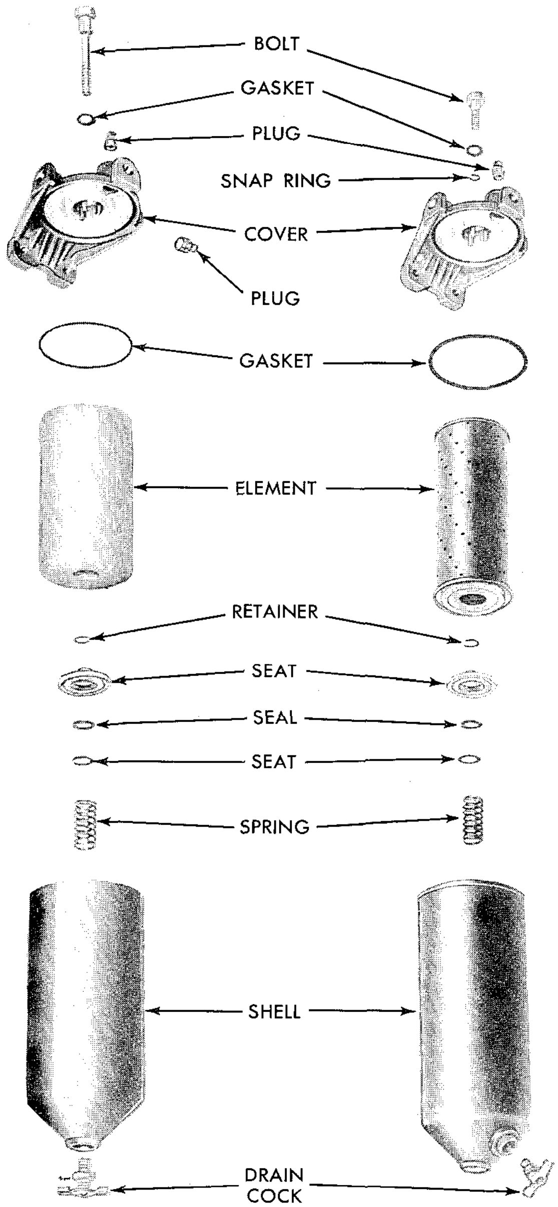


Spring- Loaded Injector Controls



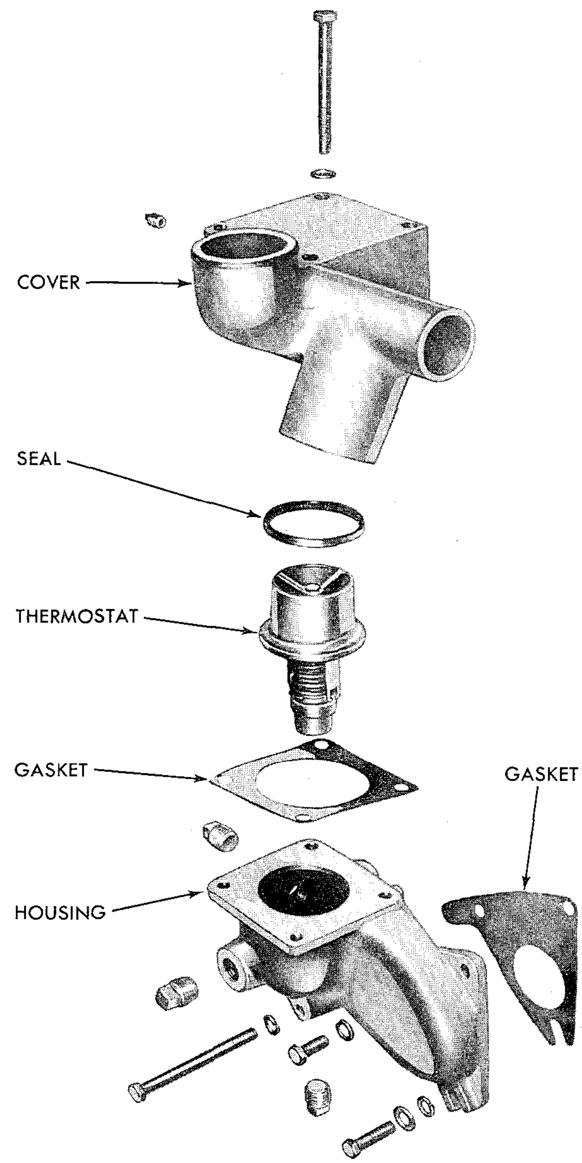
TYPICAL FUEL PUMP

P 602



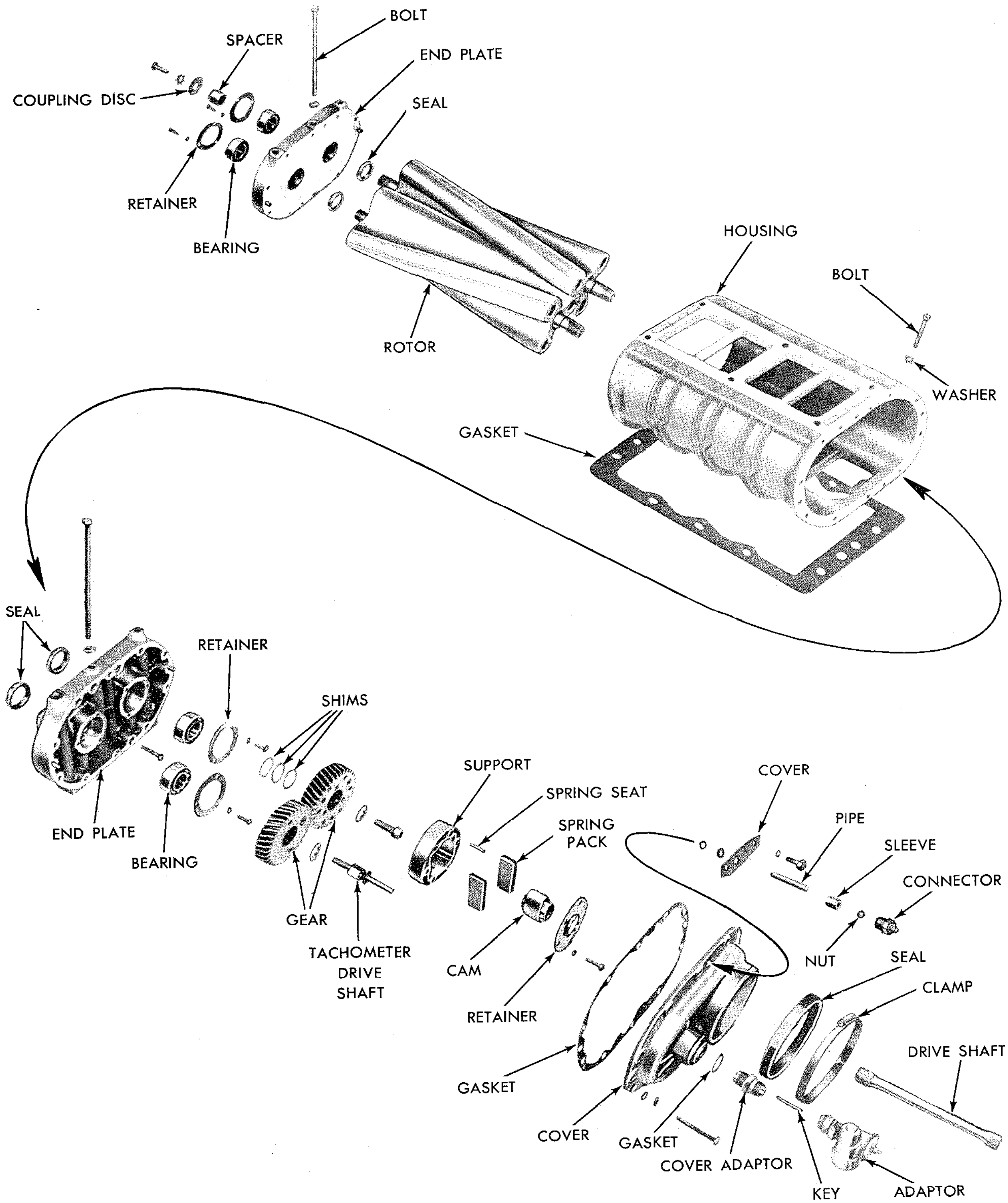
TYPICAL FUEL OIL STRAINER **TYPICAL FUEL OIL FILTER**

P 601A



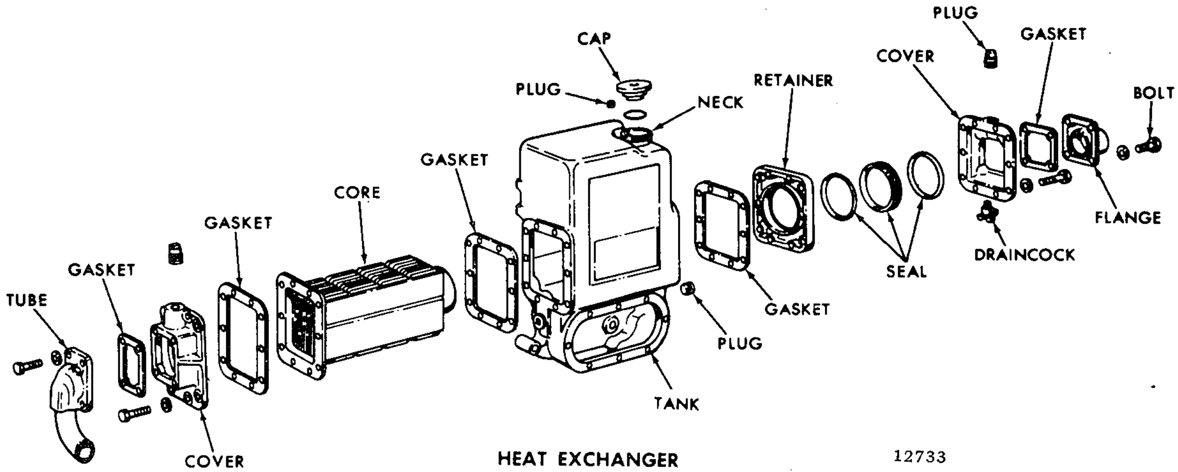
THERMOSTAT HOUSING

P 601


BOLT
SPACER
END PLATE
COUPLING DISC
SEAL
RETAINER
BEARING
HOUSING
BOLT
ROTOR
WASHER
GASKET
SEAL
RETAINER
SHIMS
SUPPORT
COVER
SPRING SEAT
SPRING PACK
PIPE
END PLATE
SLEEVE
BEARING
CONNECTOR
GEAR
TACHOMETER DRIVE SHAFT
CAM
NUT
SEAL
CLAMP
RETAINER
DRIVE SHAFT
GASKET
COVER
GASKET
COVER ADAPTOR
KEY
ADAPTOR

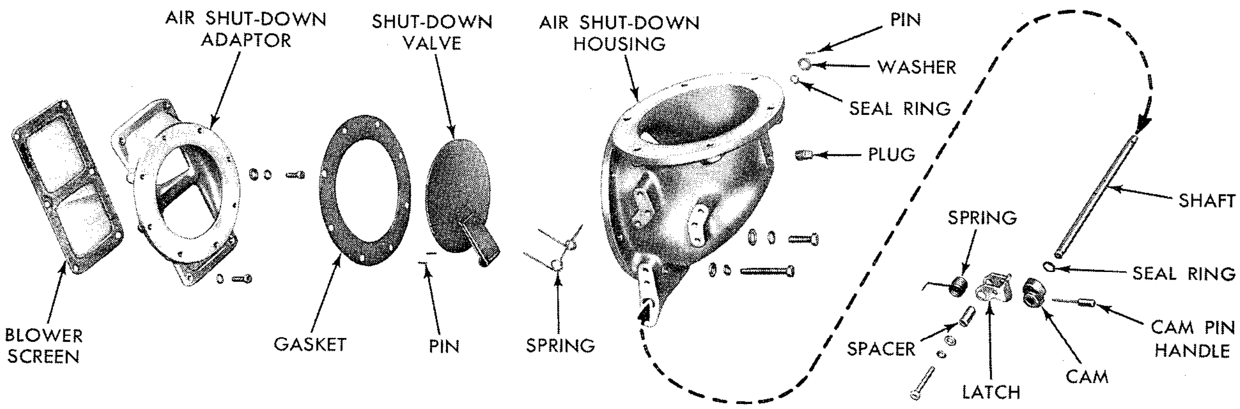
BLOWER

P 606



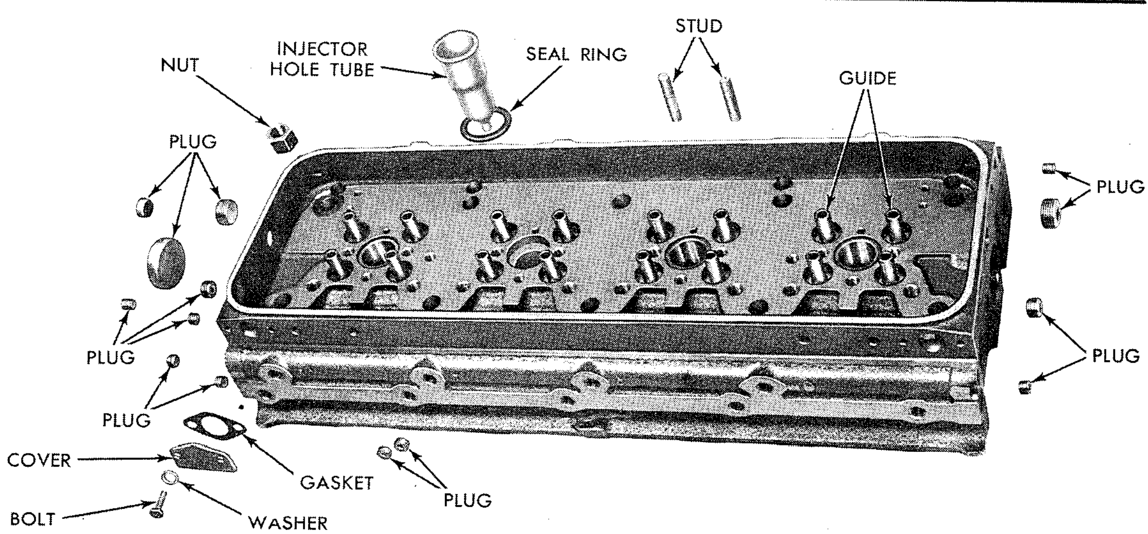
HEAT EXCHANGER

12733



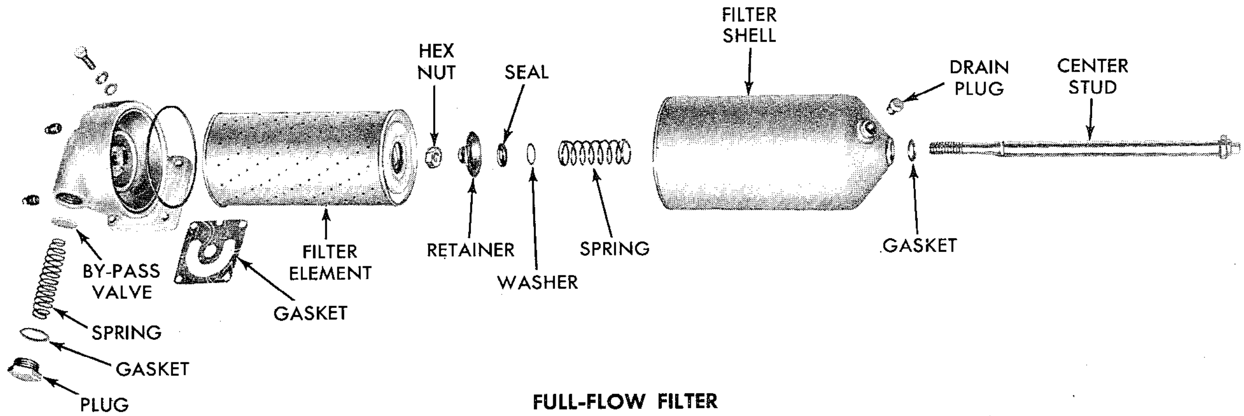
AIR SHUT-DOWN HOUSING

P 604A



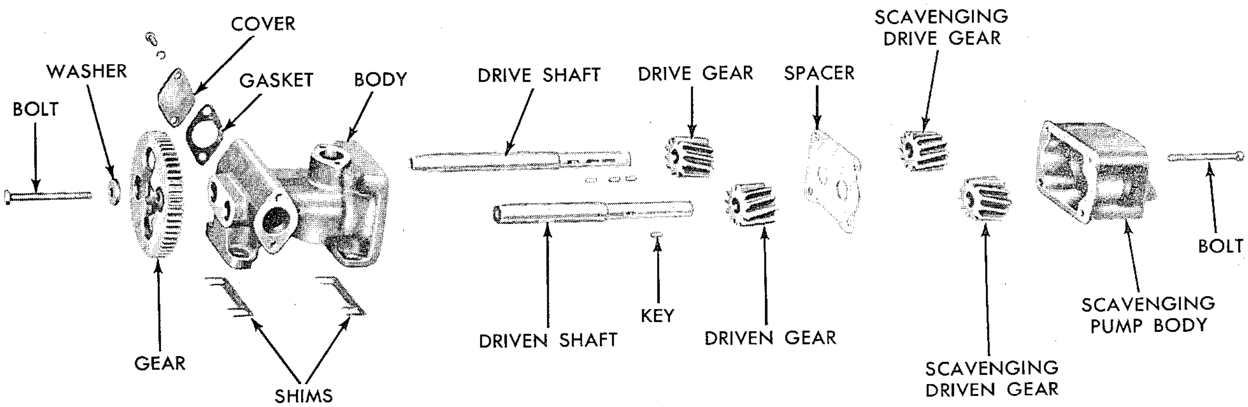
4 VALVE CYLINDER HEAD

P 604



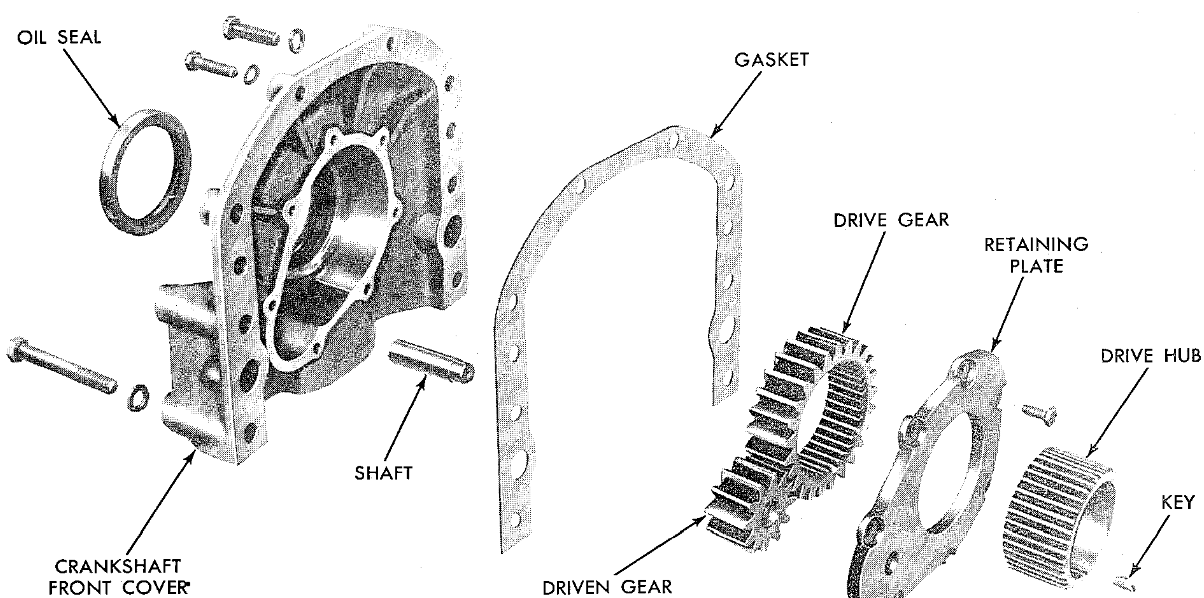
FULL-FLOW FILTER

P 605B



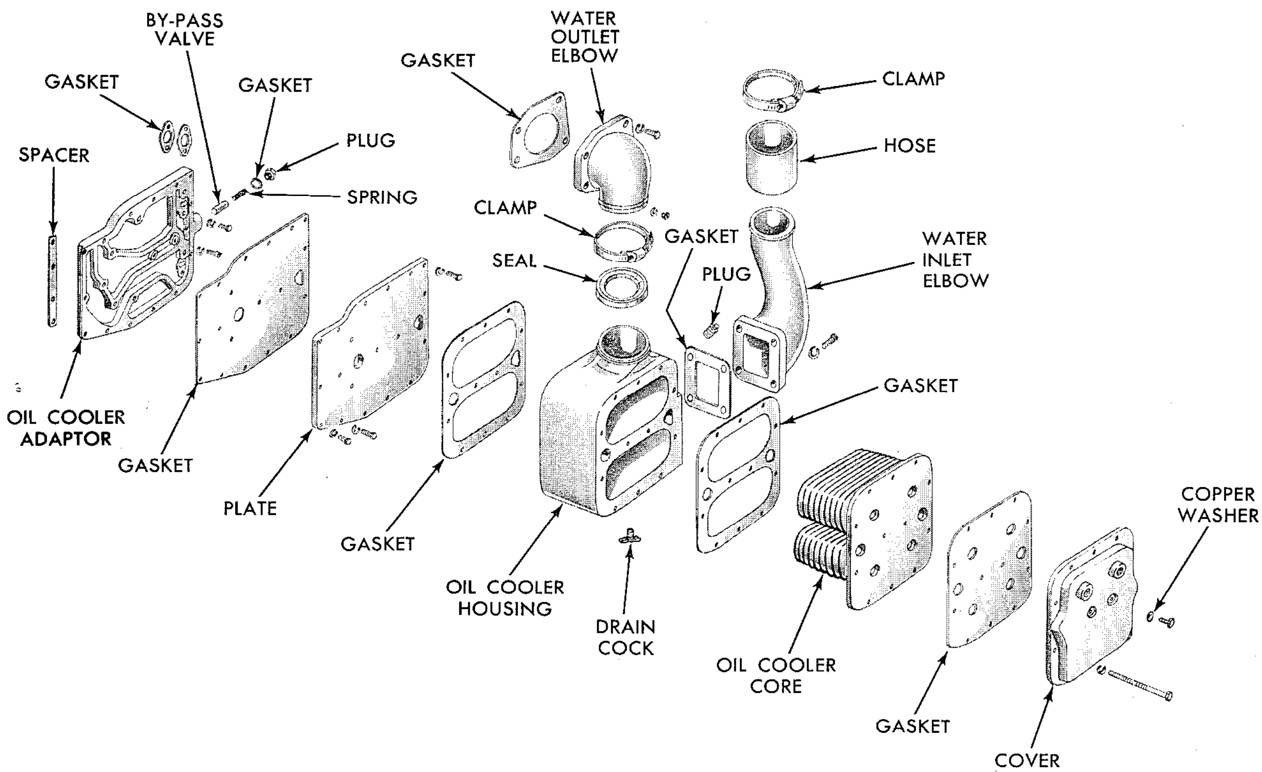
LUBRICATING OIL PUMP

P 605A



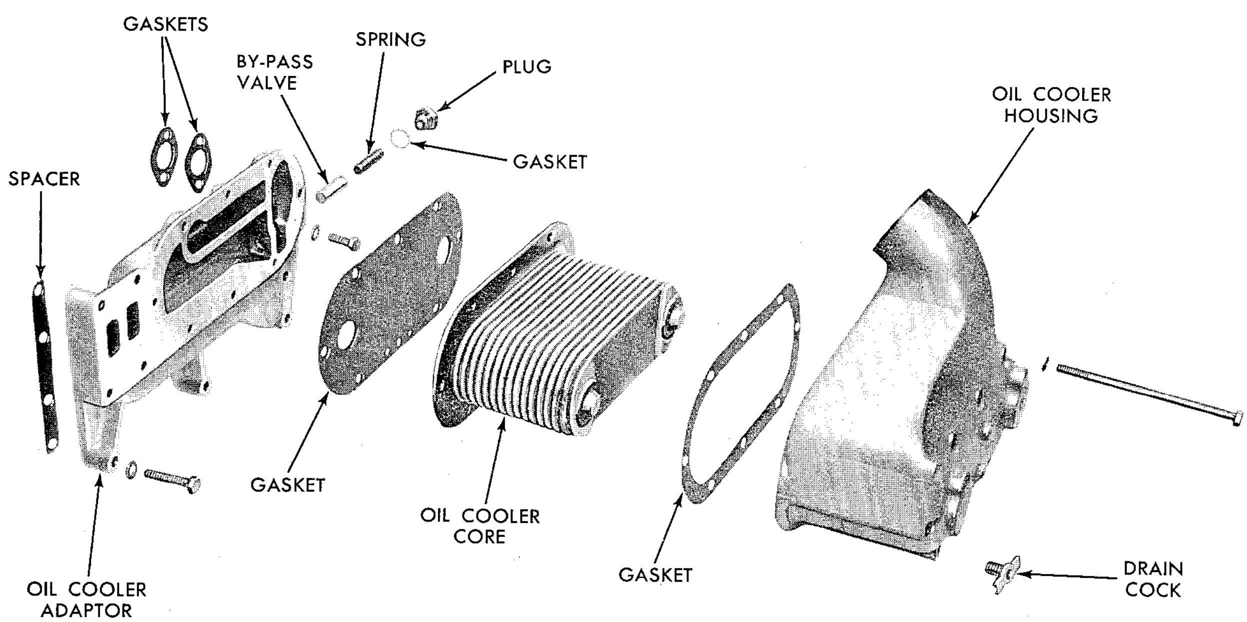
LUBRICATING OIL PUMP (6V OR 8V ENGINES)

P 605



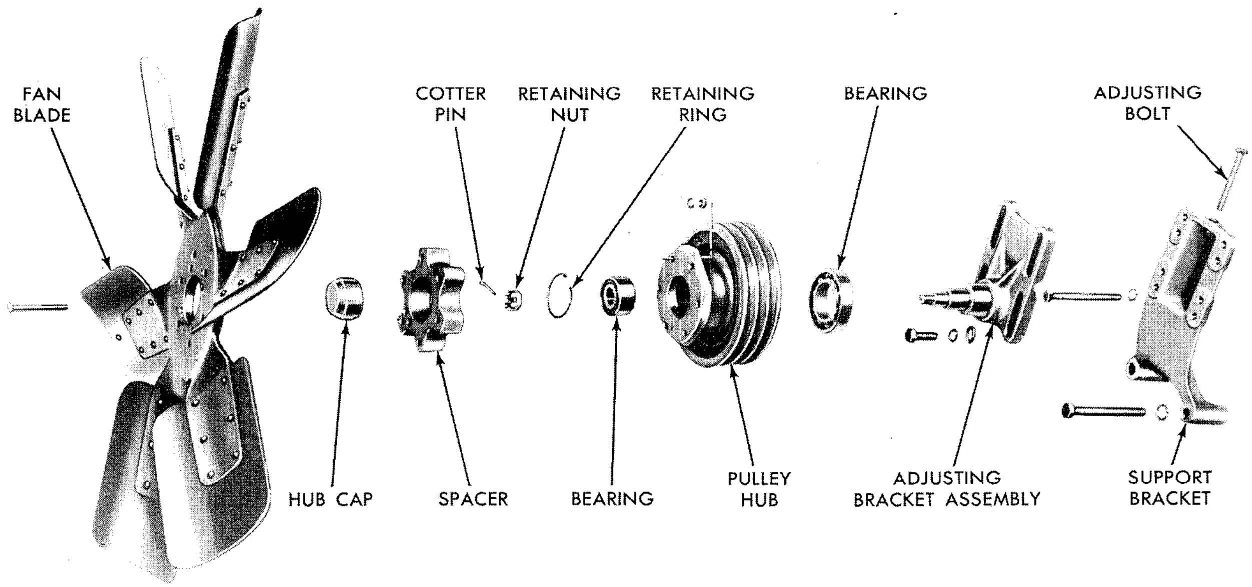
TWIN PLATE OIL COOLER

P 608B



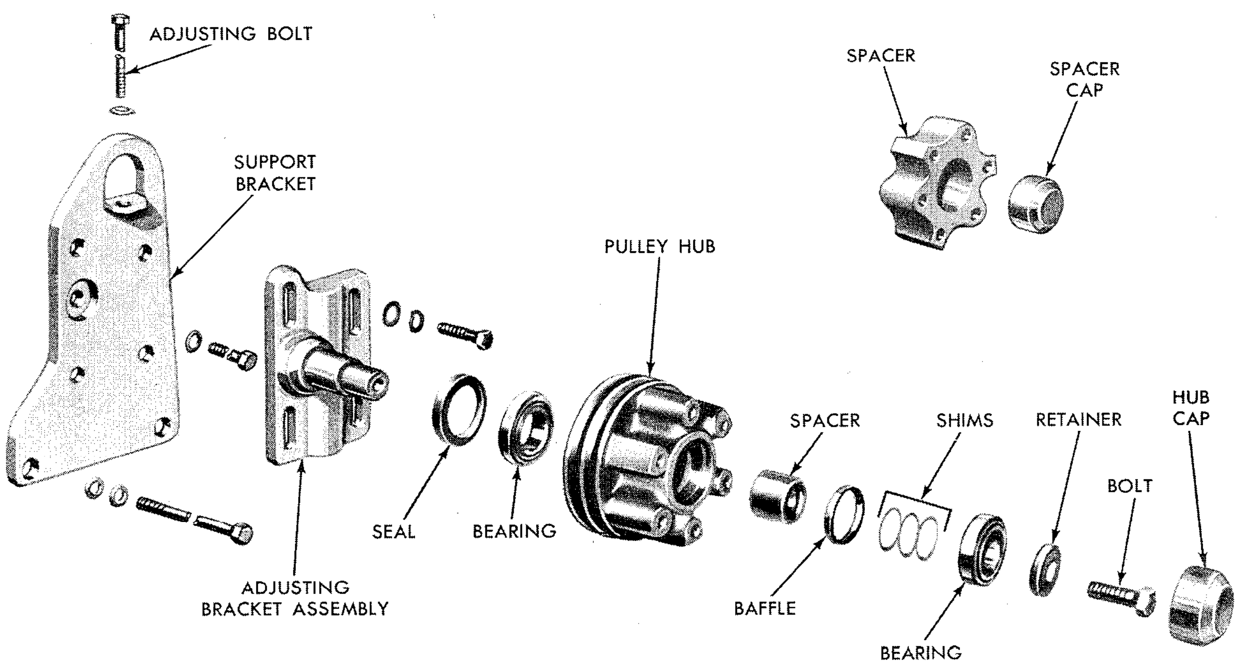
OIL COOLER

P 608



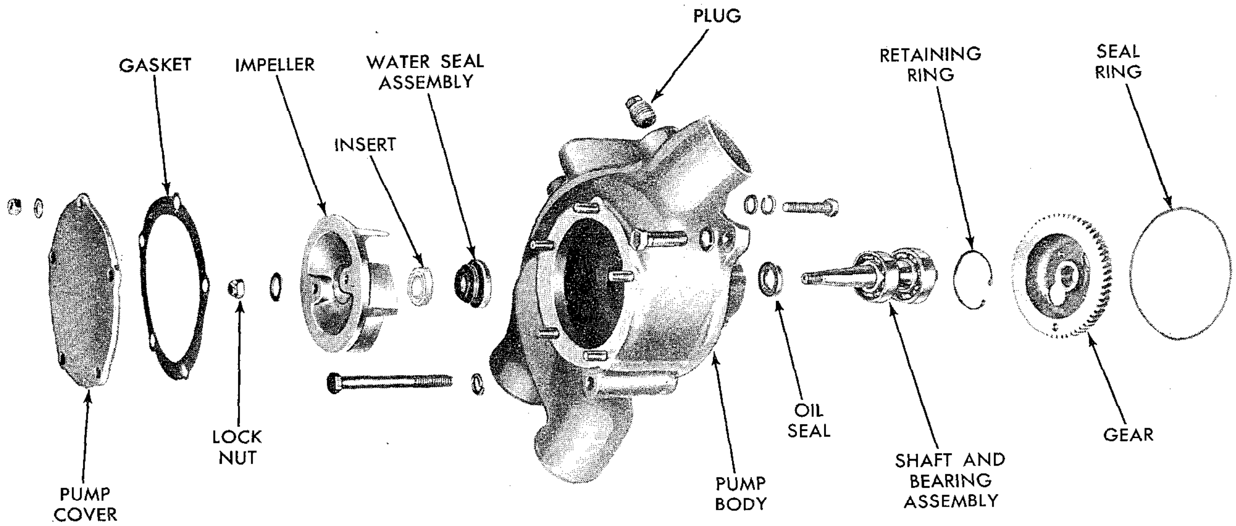
FAN ASSEMBLY

P 610A



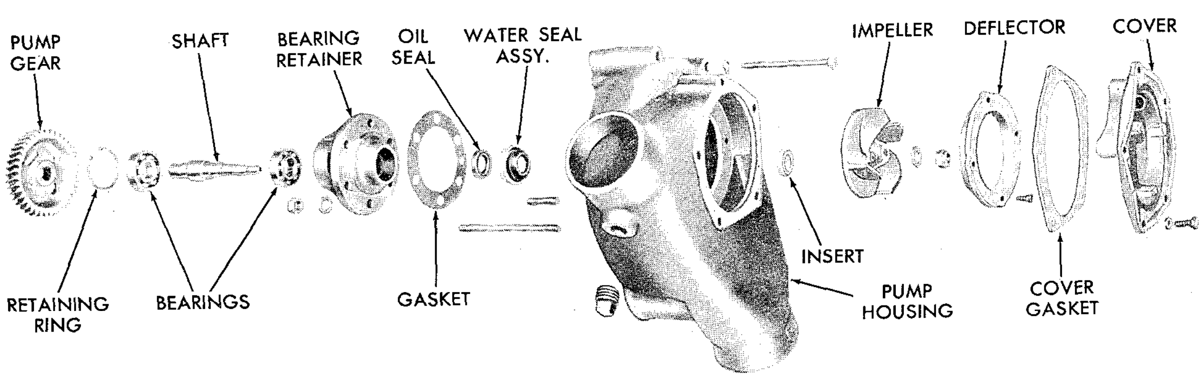
FAN MOUNT

P 610



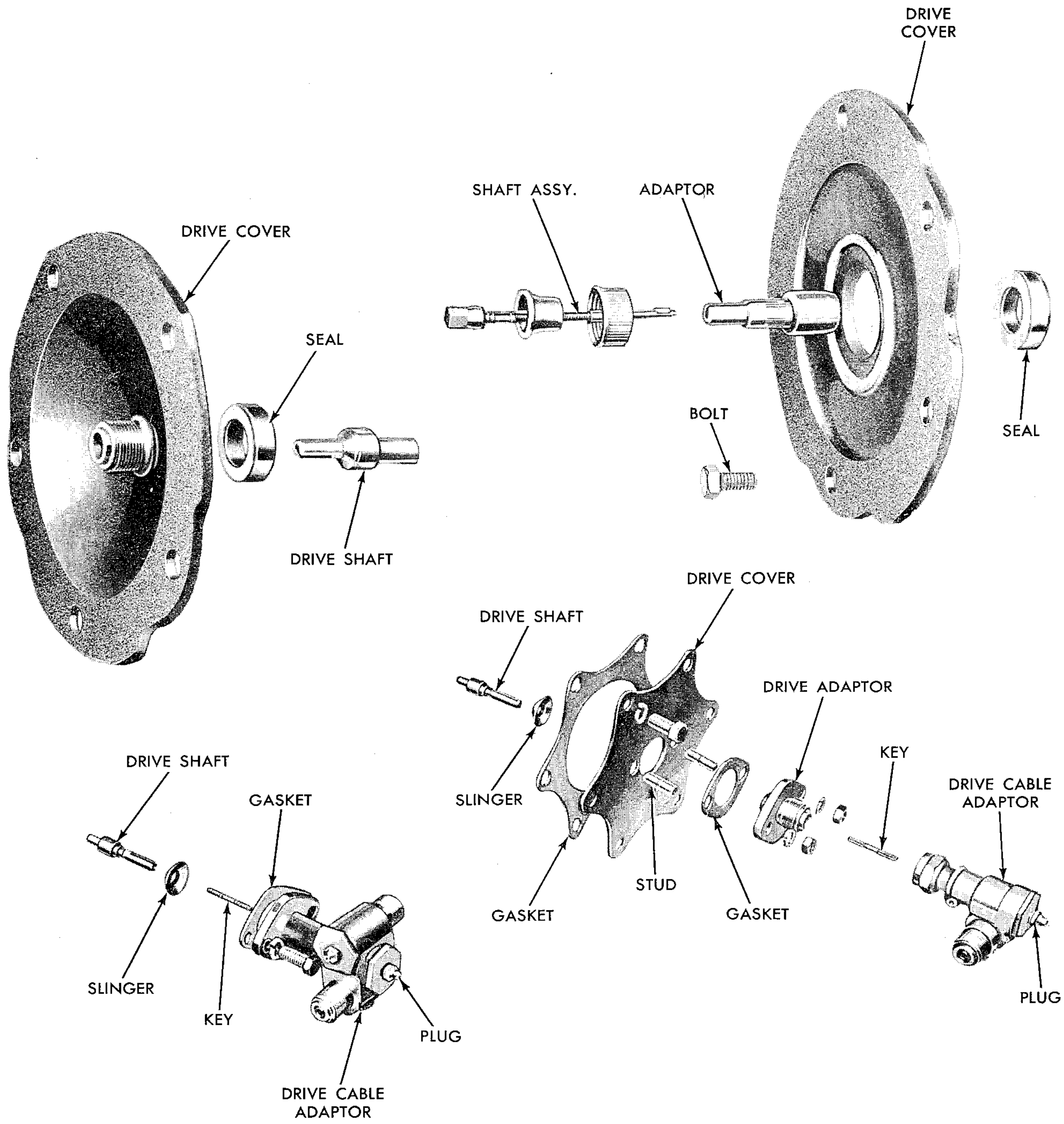
FRESH WATER PUMP (6, 8, 12V)

P 612A



FRESH WATER PUMP (16V)

P 612



TACHOMETER DRIVE COVERS AND ADAPTORS

P 611

OWNER ASSISTANCE

The satisfaction and goodwill of the owners of Detroit Diesel engines are of primary concern to the Detroit Diesel Allison Division, its distributors and their dealers.

As an owner of a Detroit Diesel engine, you have a complete network of over 2300 Detroit Diesel Allison Distributors and Dealers in the U.S. and Canada, plus many outlets worldwide that are prepared and anxious to meet your parts and service needs:

Expert service by trained personnel.

Emergency service 24 hours a day.

Complete parts support, including reliabilt components.

Sales teams to help determine your power requirements.

Product information and literature.

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 distributor or dealer 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 distributorship or dealership.** 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 Detroit Diesel Allison Regional Office nearest you** listed below:

Eastern Region
Suite 202
10 Parsonage Road
Edison, New Jersey 08817
Phone: (201) 246-5074
Regional Manager: S. F. Zappia
Service Manager: D. P. Friedrich

Southeastern Region
5730 Glenridge Drive, N.E.
Atlanta, Georgia 30328
Phone: (404) 252-3310
Regional Manager: L. R. Kirby
Service Manager: B. D. Robison, Jr.

Great Lakes Region
Garrison Place
19855 Outer Drive
Dearborn, Michigan 48124
Phone: (313) 565-0411
Regional Manager: A. W. Christy
Service Manager: R. Schwaller

Midwestern Region
Suite 618
2021 Spring Road
Oak Brook, Illinois 60521
Phone: (312) 654-6619
Regional Manager: C. O. Zimmerman
Service Manager: T. F. Chope

Southwestern Region
Suite 130
2655 Villa Creek Drive
Dallas, Texas 75234
Phone: (214) 241-7721
Regional Manager: E. A. Wilson
Service Manager: W. C. Kaphengst

Northwestern Region
Suite 2700
39465 Pasco Padre Parkway
Freemont, California 94538
Phone: (408) 255-7700
Regional Manager: W. C. Edwards
Service Manager: J. P. Miles

Western Region
Suite 823
Crocker Bank Building
15760 Ventura Blvd.
Encino, California 91436
Phone: (213) 981-7300
Regional Manager: G. J. Dunneback
Service Manager: W. K. Clark, Jr.

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 Home Office:**

Diesel Operations - J. E. Fisher, Manager Customer Services, Detroit Diesel Allison, 13400 W. Outer Drive, Detroit, Michigan 48228, Phone (313) 592-5608.

Canada Operations - E. A. Kobe, Manager of Product Service, Diesel Division, General Motors of Canada, Ltd., P.O. Box 5990, 847 Highbury Avenue, London, Ontario N6A 4L6, Phone (519) 455-7110.

If an additional review by the Home Office 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, Diesel Operations (313) 592-7279; D. F. Downham, Sales Manager, Diesel Operations (313) 592-7276.

When contacting the Regional or Home Office, please keep in mind that ultimately your problem will likely be resolved at the distributorship or dealership utilizing their facilities, equipment and personnel. Therefore, it is suggested that you follow the above steps in sequence when experiencing a problem.

ALPHABETICAL INDEX

Detroit Diesel Engines

V-71 Operators Manual

Detroit Diesel Allison

Service and Parts Information