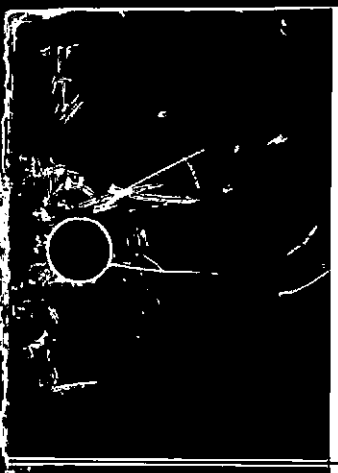

Cummins Diesels

V12 series

Operation and Maintenance Manual

Cummins Engine Company, Inc.
Bulletin 983596A, Copyright 5-1967
Columbus, Indiana, U. S. A.

Operation and Maintenance Manual

Cummins Diesel V12 Series

Foreword

This manual is applicable to all V12 Series Cummins Diesels currently being produced by Cummins Engine Company, Inc. It contains instructions for operators that will enable them to get the best service from their engines. Before operating engine become familiar with procedures described.

Maintenance section is for men who are responsible for upkeep and availability of engine on the job. Maintenance program is simple, realistic, easy to control and profitable to practice.

This is an operation and maintenance manual; repair operations should be performed by specially trained personnel. Trained personnel are available at all Cummins Distributor and Dealer locations.

Full repair Shop Manuals may be purchased from a Cummins Distributor at a nominal cost if you are equipped to do your own repair work.

Cummins Engine Company, Inc.
Columbus, Indiana, U. S. A.

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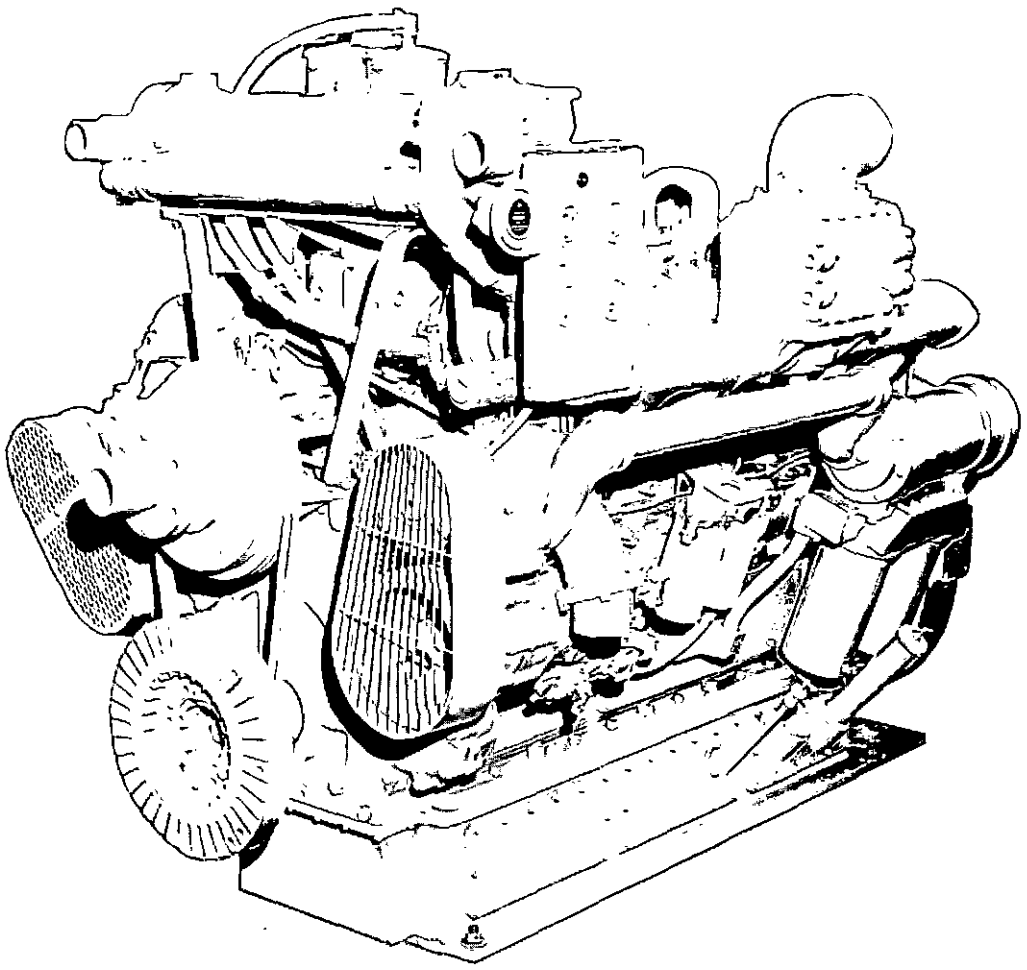
Engine Ratings—V12



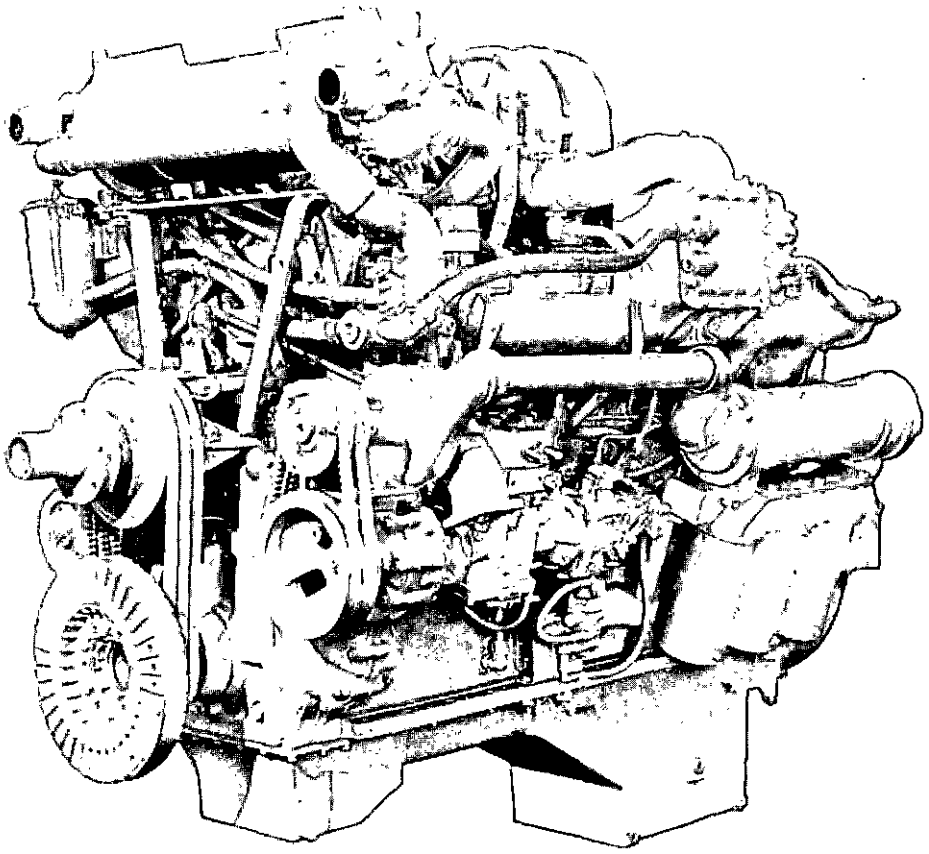
V12-525 ENGINE MODEL

Table 1: Cummins V12 Series Naturally Aspirated Engines

Engine Model	Bore & Stroke In. [mm]	Displ. Cu. In. [cu cm]	Max. Torque @ RPM Ft-Lb [kg m]	Max. HP @ RPM
NVH-450	5⅛ x 6 [127.1250 x 142.4]	1486 [24,351.2306]	1190 @ 1480 [164.5770]	450 @ 2100
V12-525	5½ x 6 [139.7 x 142.4]	1710 [28,021.9410]	1445 @ 1500 [199.8435]	525 @ 2100

Note: Horsepower ratings (stated in U. S. values) established at 29.92 In./Hg. barometric pressure (sea level), 60° F [15.5° C] air intake temperature, dry air. Derate naturally aspirated engines 3% for each 1000 ft [304.800 m] above sea level and 1% for each 10° F [5.56°C] rise in air temperature.

Engine Ratings—VT12



VT12-700 ENGINE MODEL

Table 2: Cummins V12 Series Turbocharged Engines

Engine Model	Bore & Stroke In. [mm]	Displ. Cu. In. [cu cm]	Maximum Altitude Ft [m]	Max. Torque @ RPM Ft-Lb [kg m]	Max. Hp @ RPM	Begin Derate @ Ft [m] Altitude
VT12	5⅛ x 6 [127.1250 x 142.4]	1486 [24,351.2306]	6000 [1828.8000]	1630 [225.4290] @ 1500	600 @ 2100	6000 (T-590) [1828.8000]
VT12-635	5½ x 6 [139.7 x 142.4]	1710 [28,021.9410]	11,000 [3352.8000]	1750 [242.0250] @ 1500	635 @ 2100	11,000 (T-590), 12,000 (T-50) [3352.8000] [3657.6000]
VT12-700	5½ x 6 [139.7 x 142.4]	1710 [28,021.9410]	8500 [2590.8000]	1920 [265.5360] @ 1500	700 @ 2100	8500 T-590), 11,000 (T-50) [2590.8000] [3352.8000]

1. *Horsepower ratings (stated in U. S. values) established at 29.92 In./Hg. barometric pressure (sea level), 60° F [15.5° C]* air temperature, dry air.
2. Turbocharged engines are derated 4% for each 1000 ft [304.800 m] altitude above maximum altitude stated above and 1% for each 10° F [5.56°C] air temperature rise above 100° F [37.8°C].

Operating Principles

The most satisfactory service can be expected from a Cummins Diesel Engine when operation procedures are based upon a clear understanding of engine working principles. Each part of engine affects operation of other working parts and of engine as a whole. Cummins Diesel Engines treated in this manual are four-stroke-cycle, high-speed, full-diesel engines. Horsepower ratings and other engine specifications for each model are tabulated on preceding pages.

Cummins Diesel Engine

Cummins Diesel Cycle

Diesel engines differ from other internal combustion engines in a number of ways. Compression ratios are higher than in spark-ignited engines. The charge taken into combustion chamber through intake consists of air only — with no fuel mixture. Injectors receive low-pressure fuel from fuel pump and deliver it into individual combustion chambers at right time in equal quantity and proper condition to burn. Ignition of fuel is caused by heat of compressed air in combustion chamber.

It is easier to understand function of engine parts if it is known what happens in combustion chamber during each of four piston strokes of the cycle. The four strokes and the order in which they occur are: Intake Stroke, Compression Stroke, Power Stroke and Exhaust Stroke.

Intake Stroke

During intake stroke, piston travels downward; intake valves are open, and exhaust valves are closed.

The downstroke of piston permits air from outside to enter cylinder through open intake valve ports. On engines where used, turbocharger increases air pressure in engine intake manifold and forces it into cylinder.

The intake charge consists of air only with no fuel mixture.

Compression Stroke

At end of intake stroke, intake valves close and piston starts upward on compression stroke. The exhaust valves remain closed.

At end of compression stroke, air in combustion chamber has been forced by piston to occupy a space about one-fifteenth as great in volume as it occupied at beginning of stroke. Thus, compression ratio is 15:1, or directly in proportion to amount air in combustion chamber is compressed.

Compressing air into a small space causes temperature of that air to rise. Near end of compression stroke, pressure of air above piston is approximately 500 to 600 psi [35.1500 to 42.1800 kg/sq cm] and temperature of that air is approximately 1000° F [537.7° C].

During last part of compression stroke and early part of power stroke, a small metered charge of fuel is injected into combustion chamber.

Almost immediately after fuel charge is injected into combustion chamber, fuel is ignited by hot compressed air and starts to burn.

Power Stroke

During power stroke, piston travels downward and both intake and exhaust valves are closed.

By the time piston reaches end of compression stroke, burning fuel causes a further increase in pressure above piston. As more fuel is added and burns, gases get hotter and expand more to push piston downward and add impetus to crankshaft rotation.

Exhaust Stroke

During exhaust stroke, intake valves are closed, exhaust valves are open, and piston is on upstroke.

Burned gases are forced out of combustion chamber through open exhaust valve ports by upward travel of piston.

Proper engine operation depends upon two things — first, compression for ignition; and second, that fuel be measured and injected into cylinders in proper quantity at proper time.

Fuel System

The PT fuel system is used exclusively on Cummins Diesels. The identifying letters, "PT," are an abbreviation for "pressure-time."

The operation of Cummins PT Fuel System is based on the principle that volume of liquid flow is proportionate to fluid pressure, time allowed to flow and size of passage liquid flows through. To apply this simple principle to Cummins PT Fuel System, it is necessary to provide:

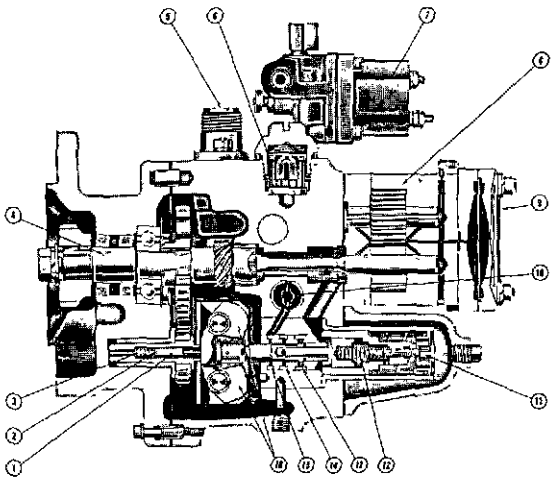
1. A fuel pump to draw fuel from supply tank and deliver it to individual injectors for each cylinder.
2. A means of controlling pressure of fuel being delivered by fuel pump to injectors so individual cylinders will receive right amount of fuel for power required of engine.
3. Fuel passages of proper size and type so fuel will be distributed to all injectors and cylinders with equal pressure under all speed and load conditions.
4. Injectors to receive low-pressure fuel from fuel pump and deliver it into individual combustion chambers at right time, in equal quantity and proper condition to burn.

The PT fuel system consists of fuel pump, supply and drain lines and passages, and injectors. There are two types of PT fuel systems. The first type — commonly called PT (type G) — is shown in Fig. 1-1. The second type — called PT (type R) — is shown in Fig. 1-3.

Designations PT (type G) and PT (type R) are for "Governor-Controlled" and "Pressure-Regulated" respectively. Hereafter, these designations will be used to describe both fuel system and fuel pump.

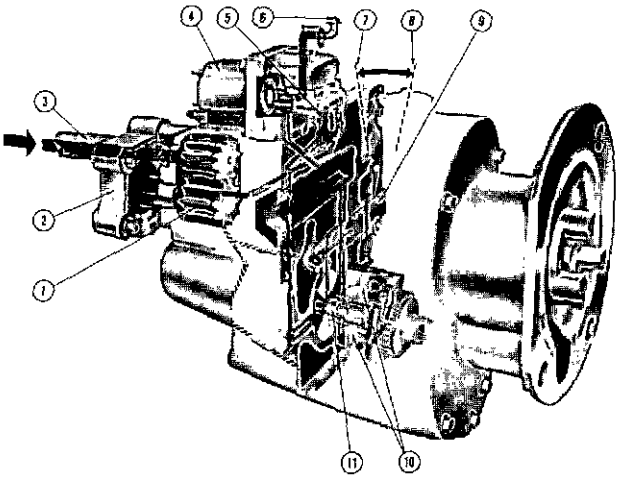
Fuel Pump

The fuel pump is coupled to compressor or fuel pump drive which is driven from engine gear train. Fuel pump main shaft turns at engine crankshaft speed, and drives gear pump, governor and tachometer shaft.



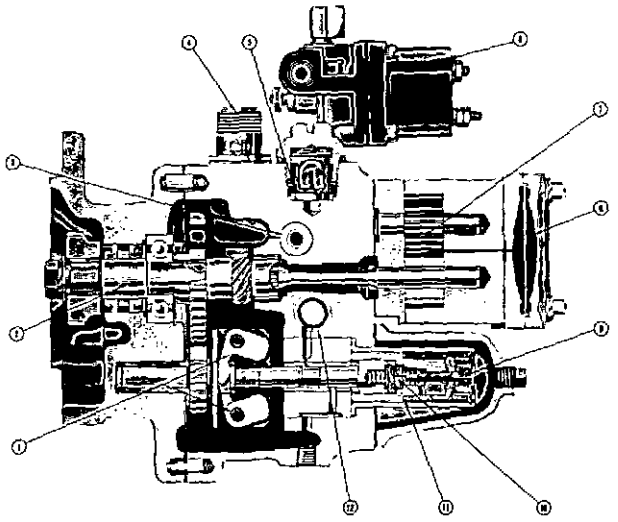
① GOVERNOR ASSIST PLUNGER
② SHIMS
③ GOVERNOR ASSIST SPRING
④ MAIN SHAFT
⑤ TACHOMETER SHAFT
⑥ FILTER SCREEN
⑦ SHUT-DOWN VALVE
⑧ GEAR PUMP
⑨ PULSATION DAMPER
⑩ THROTTLE SHAFT
⑪ IDLE ADJUSTING SCREW
⑫ IDLE SPRING
⑬ GEAR PUMP PRESSURE
⑭ FUEL MANIFOLD PRESSURE
⑮ IDLE PRESSURE
⑯ GOVERNOR WEIGHTS

Fig. 1-1. PT (type G) fuel pump cross-section FWC-5



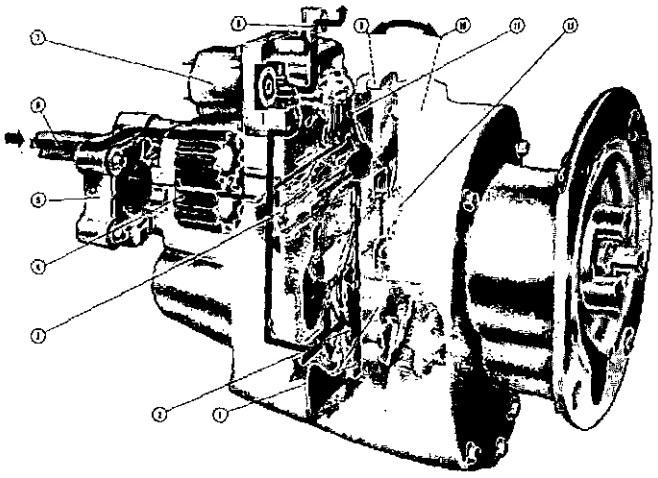
① GEAR PUMP
② PULSATION DAMPER
③ FROM TANK
④ SHUT-DOWN VALVE
⑤ FILTER SCREEN
⑥ TO INJECTORS
⑦ IDLE
⑧ FULL
⑨ THROTTLE SHAFT
⑩ GOVERNOR WEIGHTS
⑪ GOVERNOR PLUNGER

Fig. 1-2. PT (type G) fuel pump flow FWC-6



① GOVERNOR WEIGHTS
② MAIN SHAFT
③ PRESSURE REGULATOR
④ TACHOMETER CONNECTION
⑤ FILTER SCREEN
⑥ SHUT-DOWN VALVE
⑦ GEAR PUMP
⑧ PULSATION DAMPER
⑨ IDLE SPEED SCREW
⑩ IDLE SPRINGS
⑪ MAXIMUM SPEED SPRING
⑫ THROTTLE SHAFT

Fig. 1-3. PT (type R) fuel pump cross-section FWC-3



① GOVERNOR WEIGHTS
② GOVERNOR PLUNGER
③ PRESSURE REGULATOR
④ GEAR PUMP
⑤ PULSATION DAMPER
⑥ FROM TANK
⑦ SHUT-DOWN VALVE
⑧ TO INJECTORS
⑨ IDLE
⑩ FULL
⑪ FILTER SCREEN
⑫ THROTTLE SHAFT

Fig. 1-4. PT (type R) fuel pump flow FWC-4

PT (type G) Fuel Pump

PT (type G) fuel pump can be identified by absence of return line at top of fuel pump. The pump assembly is made up of three main units.

1. Gear pump, which draws fuel from supply tank and forces it through pump filter screen to governor.
2. Governor, which controls flow of fuel from gear pump, as well as maximum and idle engine speeds.
3. Throttle, which provides a manual control of fuel flow to injectors under all conditions in operating range. The location of fuel pump components is indicated in Fig's. 1-1 and 1-3.

PT (type R) Fuel Pump

PT (type R) fuel pump can be identified easily by presence of a fuel return line from top of fuel pump housing to supply tank.

The pump assembly is made up of four main units:

1. Gear pump, which draws fuel from supply tank forcing it through pump filter screen into pressure regulator valve.
2. Pressure regulator, which limits pressure of fuel to injectors.
3. Throttle, which provides a manual control of fuel flow to injectors under all conditions in operating range.
4. Governor assembly, which controls flow of fuel from idle to maximum governed speed.

Gear Pump And Pulsation Damper

Gear pump and pulsation damper located at rear of fuel pump perform same function on both PT (type G) and PT (type R) fuel pumps.

Gear pump is driven by pump main shaft and contains a single set of gears to pick up and deliver fuel throughout fuel system. A pulsation damper mounted to gear pump contains a steel diaphragm which absorbs pulsations and smoothes fuel flow through fuel system. From gear pump, fuel flows through filter screen and:

1. In the PT (type G) fuel pump, to governor assembly as shown in Fig. 1-2.
2. In the PT (type R) fuel pump, to pressure regulator assembly as shown in Fig. 1-4.

Pressure Regulator

The pressure regulator, used only in PT (type R) fuel pump,

functions as a by-pass valve to regulate fuel pressure to injectors. By-passed fuel flows back to suction side of gear pump. See Fig. 1-4.

Throttle

In both fuel pumps, throttle provides a means for operator to manually control engine speed above idle as required by varying operating conditions of speed and load.

In PT (type G) fuel pump, fuel flows through governor to throttle shaft. At idle speed, fuel flows through idle port in governor barrel, past throttle shaft. To operate above idle speed, fuel flows through main governor barrel port to throttling hole in shaft.

In PT (type R) fuel pump, fuel flows past pressure regulator to throttle shaft. Under idling conditions, fuel passes around shaft to idle port in governor barrel. For operation above idle speed, fuel passes through throttling hole in shaft and enters governor barrel through main fuel port.

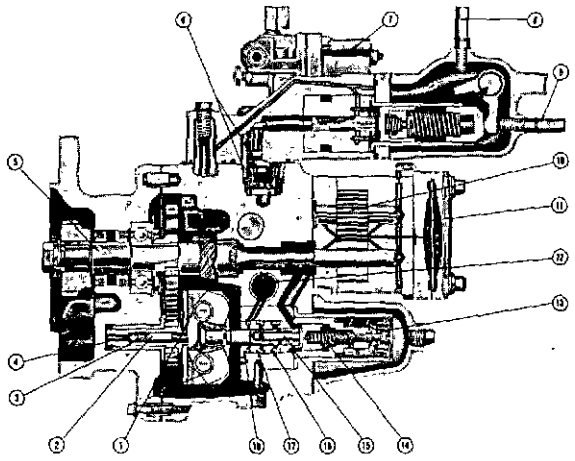
Governors

Idling and High-Speed Mechanical Governor: The mechanical governor, sometimes called "automotive governor", identical on both PT (type G) and PT (type R) fuel pumps, is actuated by a system of springs and weights, and has two functions. First, the governor maintains sufficient fuel for idling with throttle control in idle position; second, it cuts off fuel to injectors above maximum rated rpm. The idle springs in governor spring pack position governor plunger so idle fuel port is opened enough to permit passage of fuel to maintain engine idle speed.

During operation between idle and maximum speeds, fuel flows through governor to injectors in accordance with engine requirements as controlled by throttle and limited by size of idle spring plunger counterbore on PT (type G) fuel pumps and pressure regulator of PT (type R) fuel pumps. When engine reaches governed speed, governor weights move governor plunger, and fuel passages to injectors are shut off. At the same time another passage opens and dumps fuel back into main pump body. In this manner engine speed is controlled and limited by governor regardless of throttle position. Fuel leaving governor flows through shutdown valve, inlet supply lines and on into injectors.

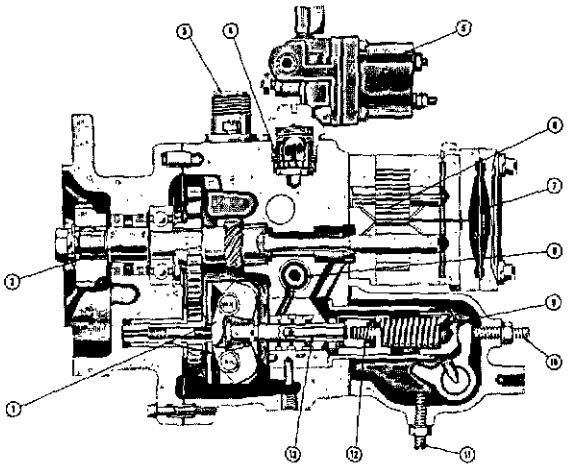
PT (type G) Variable-Speed Governors

There are two mechanical variable speed governors used with PT (type G) fuel pump. The "Mechanical Variable Speed (MVS)" governor which is mounted directly on top of, or remotely near, the fuel pump; and "Special Variable Speed (SVS)" governor which is a special spring-pack assembly at lower rear of fuel pump. See Fig's. 1-5 and 1-6.



① GOVERNOR WEIGHTS
② GOVERNOR ASSIST PLUNGER
③ SHIMS
④ GOVERNOR ASSIST SPRING
⑤ MAIN SHAFT
⑥ FILTER SCREENS
⑦ SHUT-DOWN VALVE
⑧ MAXIMUM SPEED SCREW
⑨ IDLE SPEED SCREW
⑩ GEAR PUMP
⑪ PULSATION DAMPER
⑫ THROTTLE SHAFT
⑬ IDLE ADJUSTING SCREW
⑭ IDLE SPRING
⑮ GOVERNOR PLUNGER
⑯ GEAR PUMP PRESSURE
⑰ FUEL MANIFOLD PRESSURE
⑱ IDLE PRESSURE

Fig. 1-5. PT (type G) fuel pump with MVS governor FWC-9



① GOVERNOR WEIGHTS
② MAIN SHAFT
③ TACHOMETER CONNECTION
④ FILTER SCREEN
⑤ SHUT-DOWN VALVE
⑥ GEAR PUMP
⑦ PULSATION DAMPER
⑧ THROTTLE SHAFT
⑨ GOVERNOR SPRING
⑩ IDLE SPEED ADJUSTING SCREW
⑪ MAXIMUM SPEED ADJUSTING SCREW
⑫ IDLE SPRING
⑬ GOVERNOR PLUNGER

Fig. 1-6. PT (type G) fuel pump with SVS governor FWC-10

Mechanical Variable Speed (MVS) Governor

This governor supplements standard automotive governor to meet the requirements of machinery on which engine must operate at a constant speed, but where extremely close regulation is not necessary.

Adjustment for different rpm can be made by means of a lever control or adjusting screw. At full-rated speed, this governor has a speed droop between full-load and no-load of approximately eight percent. A cross section of this governor is shown in Fig. 1-5.

As a variable-speed governor, this unit is suited to varying speed requirements of cranes, shovels, etc., in which same engine is used for propelling unit and driving a pump or other fixed-speed machine.

As a constant-speed governor, this unit provides control for pumps, nonparalleled generators and other applications where close regulation (variation between no-load and full-load speeds) is not required.

The (MVS) governor assembly mounts atop fuel pump, and fuel solenoid is mounted to governor housing. See Fig. 1-5. The governor also may be remote mounted.

Fuel from fuel pump body enters variable speed governor housing and flows to governor barrel and plunger. Fuel flows past plunger to shut-down valve and on into injector according to governor lever position, as determined by operator.

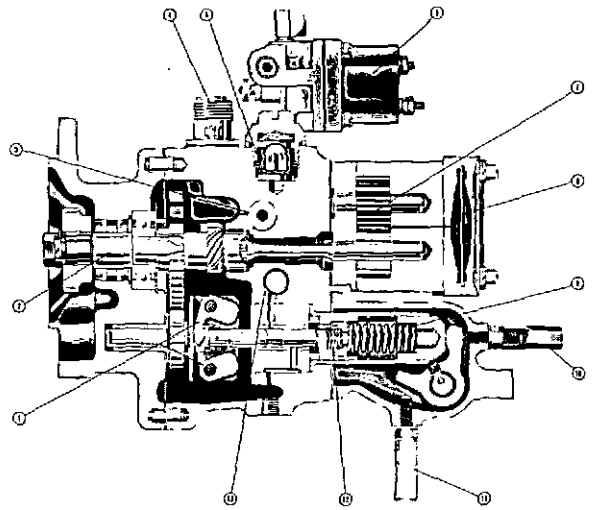
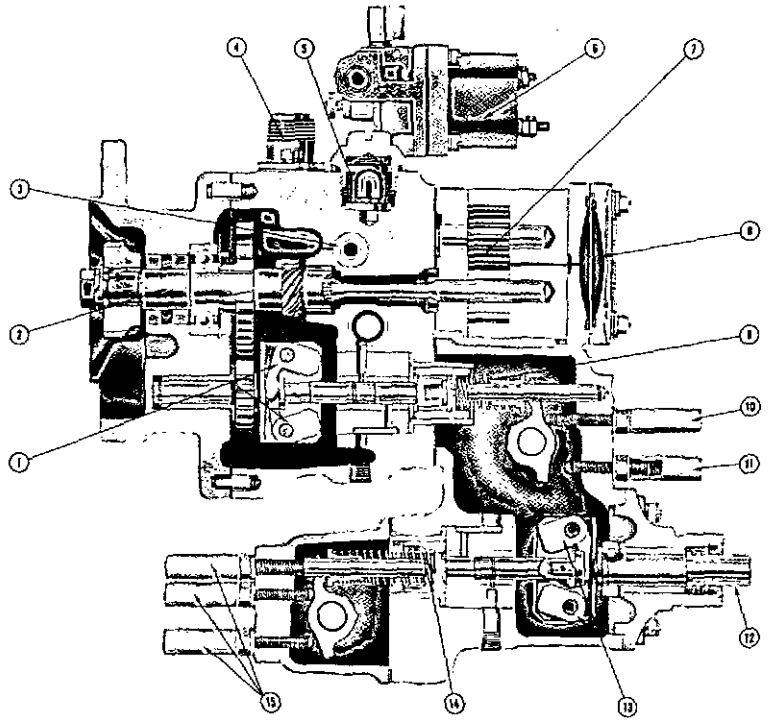
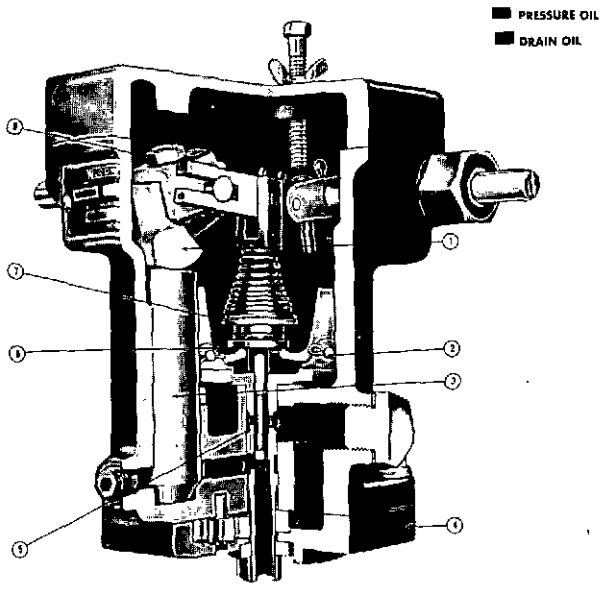


Fig. 1-7. PT (type R) fuel pump with MVS governor FWC-7



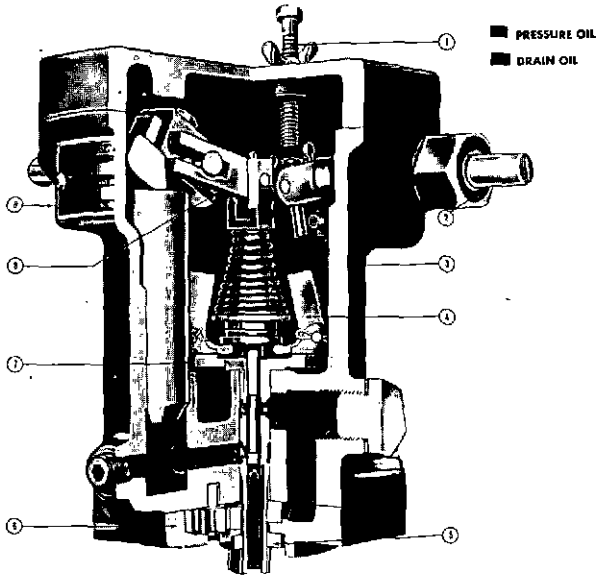
① GOVERNOR WEIGHTS
② MAIN SHAFT
③ PRESSURE REGULATOR
④ TACHOMETER CONNECTION
⑤ FILTER SCREEN
⑥ SHUT-DOWN VALVE
⑦ GEAR PUMP
⑧ PULSATION DAMPER
⑨ ENGINE PRIMARY GOVERNOR SPRING
⑩ ENGINE IDLE SPEED SCREW
⑪ ENGINE MAXIMUM SPEED SCREW
⑫ AUXILIARY UNIT DRIVE CABLE CONNECTION
⑬ AUXILIARY GOVERNOR WEIGHTS
⑭ AUXILIARY GOVERNOR SPRING
⑮ AUXILIARY GOVERNOR SPEED-ADJUSTING SCREWS

Fig. 1-8. Cross-section torque converter governor, PT (type R) fuel pump FWC-8



① TERMINAL LEVER
② BALLARM PIN
③ SERVO MOTOR PISTON
④ GOVERNOR BASE
⑤ PILOT VALVE PLUNGER
⑥ THRUST BEARING
⑦ SPRING SEAT
⑧ SPEED DROP ADJUSTING SCREW

Fig. 1-9. Load off, increased speed, hydraulic governor FWC-1



① LOW LIMIT ADJUSTING SCREW
② SPEED ADJUSTING SHAFT
③ GOVERNOR CASE
④ BALL ARM
⑤ DRIVE SHAFT COLLAR
⑥ PUMP GEAR
⑦ BALLHEAD
⑧ FLOATING LEVER
⑨ NAME PLATE

Fig. 1-10. Load on, decreased speed, hydraulic governor FWC-1

The variable-speed governor cannot produce engine speeds in excess of automotive governor setting. The governor can produce idle speeds below automotive pump idle speed setting, but should not be adjusted below automotive fuel pump speed setting when operating as a combination automotive and variable-speed governor.

Special-Variable Speed (SVS) Governor

The SVS governor provides many of the same operational features of MVS governor, but is limited in application. An overspeed stop should be used with SVS governors in unattended applications; in attended installations, a positive shutdown throttle arrangement should be used if no other overspeed stop is used.

Marine applications require automotive throttle of fuel pump to be locked open during operation and engine speed control is maintained through SVS governor lever. Also, only PT (type B) injectors should be used in marine engines equipped with the SVS governed fuel pump.

Power take-off applications use SVS governor lever to change governed speed of engine from full-rated speed to an intermediate power take-off speed. During operation as an automotive unit, SVS governor is in high-speed position. See operation instructions for further information.

Hydraulic governor applications, not having variable-speed setting provisions, use the SVS governor to bring engine speed down from rated speed for warm-up at or slightly above 1000 RPM.

PT (type R) Mechanical Variable-Speed Governor

On some applications this governor replaces standard automotive governor to meet requirements of machinery on which engine must operate at a constant speed, but where extremely close regulation is not necessary.

Adjustment for different rpm can be made by means of a lever control or adjusting screw. At full-rated speed, this governor has a speed droop between full-load and no-load of approximately eight percent. A cross section of this governor is shown in Fig. 1-7.

As a variable-speed governor, this unit is suited to varying speed requirements of cranes, shovels, etc., in which same engine is used for propelling unit and driving a pump or other fixed-speed machine.

As a constant-speed governor, this unit provides control for pumps, nonparalleled generators and other applications where close regulation (variation between no-load and full-load speeds) is not required.

PT (type R) Torque Converter Governor

A PT (type R) fuel pump is usually supplied when a torque

converter is used to connect the engine with its driven unit. An auxiliary governor may be driven by torque converter output shaft to exercise control over engine governor and to limit converter output shaft speed. The engine governor and converter governor must be adjusted to work together.

The PT torque-converter governor consists of two mechanical variable-speed governors in series — one driven by engine and the other by converter. Fig. 1-8.

The engine governor, in addition to giving a variable engine speed, acts as an over-speed and idle-speed governor while the converter driven governor is controlling the engine. Each governor has its own control lever and speed adjusting screws.

The converter-driven governor works on same principle as standard engine governor except it cannot cut off fuel to idle jet in engine-driven governor. This insures that if converter tailshaft overspeeds, it will not stop engine.

Hydraulic Governor

Hydraulic governors are used on stationary power applications where it is desirable to maintain a constant speed with varying loads.

The Woodward SG Hydraulic Governor uses lubricating oil, under pressure, as an energy medium. It is supplied from a sump on governor drive housing. For oil viscosity, see Page 3-2.

The governor acts through oil pressure to increase fuel delivery. An opposing spring in governor control linkage acts to decrease fuel delivery.

In order that its operation may be stable, speed droop is introduced into governing system. Speed droop means the characteristic of decreasing speed with increasing load. The desired magnitude of this speed droop varies with engine applications and may easily be adjusted to cover a range of approximately one-half of one percent to seven percent.

Assume a certain amount of load is applied to the engine. The speed will drop, flyballs will be forced inward and will lower pilot valve plunger. This will admit oil pressure underneath power piston, which will rise. The movement of power piston is transmitted to terminal shaft by terminal lever. Rotation of terminal shaft causes fuel setting of engine to be increased. Fig's. 1-9 and 1-10.

Injectors

The injector provides a means of introducing fuel into each combustion chamber. It combines the acts of metering, timing and injection. Two types of injectors — flanged and cylindrical — are found in V12 Series engines.

Flanged Injector

Fuel is supplied to and drained from flanged injectors through external fuel lines and connections as shown in Fig.1-11. From inlet connection, fuel flows down inlet passage of injector, around injector plunger between body and cup, up drain passage to drain connections and lines where it returns to supply tank.

As plunger rises, metering orifice is uncovered and part of fuel is metered into cup. At same time, the rest of fuel flows out of drain orifice. The amount of fuel passing through metering orifice and into cup is controlled by fuel pressure. Fig. 1-11.

During injection, plunger is forced downward until metering orifice is closed and fuel in cup is injected into cylinder. While plunger is seated, all fuel flow through injector stops. Fig. 1-13.

Injectors contain an adjustable orifice or selected inside diameter orifice plug in inlet passage which regulates fuel flow into injector.

Cylindrical Injector

When cylindrical injectors are used, fuel supply and drain is accomplished through internal drilled passages in cylinder head. Fig. 1-12. A radial groove around each injector mates with drilled passages in cylinder head and admits

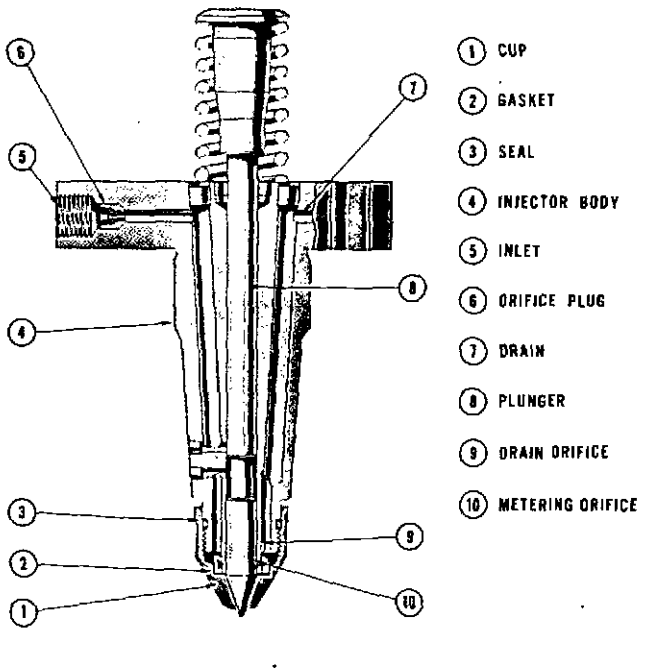


Fig. 1-11. Cross-section, flanged PT injector FWC-11

fuel through an adjustable (adjustable by burnishing to size at test stand) orifice plug in injector body. A fine mesh screen at fuel inlet orifice of each injector provides final fuel filtration.

Fuel flows from a connection atop fuel pump shut-down valve through a supply line into lower drilled passage in cylinder head at front of engine. A second drilling in head is aligned with upper injector radial groove to drain away excess fuel. A fuel drain at flywheel end of engine allows return of unused fuel to fuel tank.

Fuel grooves around injectors are separated by "O" rings which seal against cylinder head injector bore. Fig. 1-14. This forms a leak-proof passage between injectors and cylinder head injector bore surface.

The injector contains a ball check valve. As injector plunger moves downward to cover feed openings, an impulse pressure wave seats ball and at the same time traps a positive amount of fuel in injector cup for injection. As the continuing downward plunger movement injects fuel into combustion chamber, it also uncovers drain opening and ball rises from its seat. This allows free flow through injector and drain for cooling purposes. Fig. 1-15.

Fuel Lines, Connections And Valves

Supply And Drain Lines

On engines using flanged injectors, fuel is supplied through a single tube to fuel supply manifold. The drain manifold returns fuel, that is not injected, to supply tank through a drain line located at rear of the engine.

The PT (type R) fuel pump has a drain line returning from top of pump to supply tank. This line is not necessary with the PT (type G) pump. Fig. 1-12.

Connections

Flanged injectors are connected to supply and drain manifolds through connections. The inlet connection contains

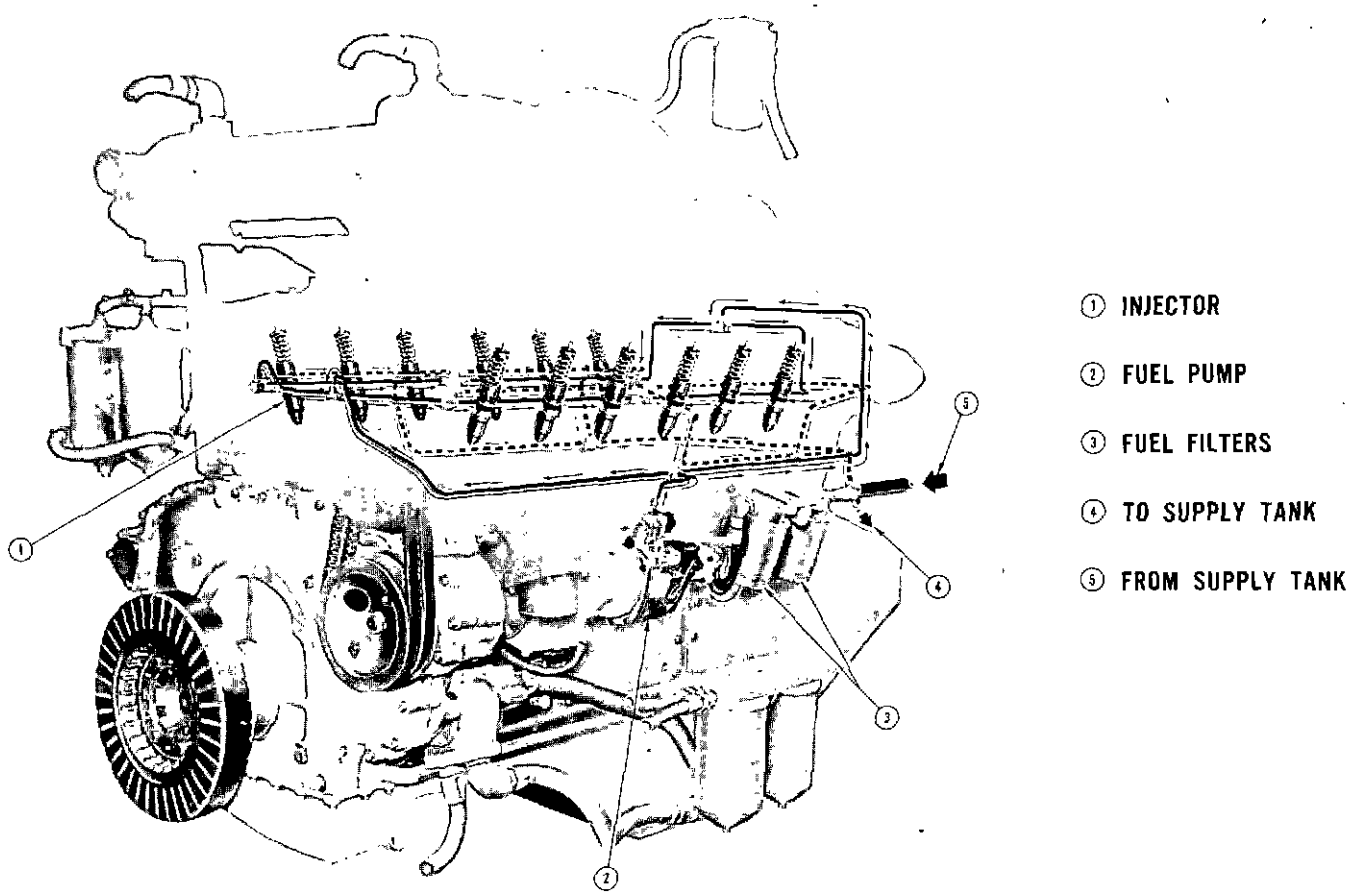


Fig. 1-12. Fuel flow diagram, V-12 5½ inch bore engine with external lubricating oil pump FWC15

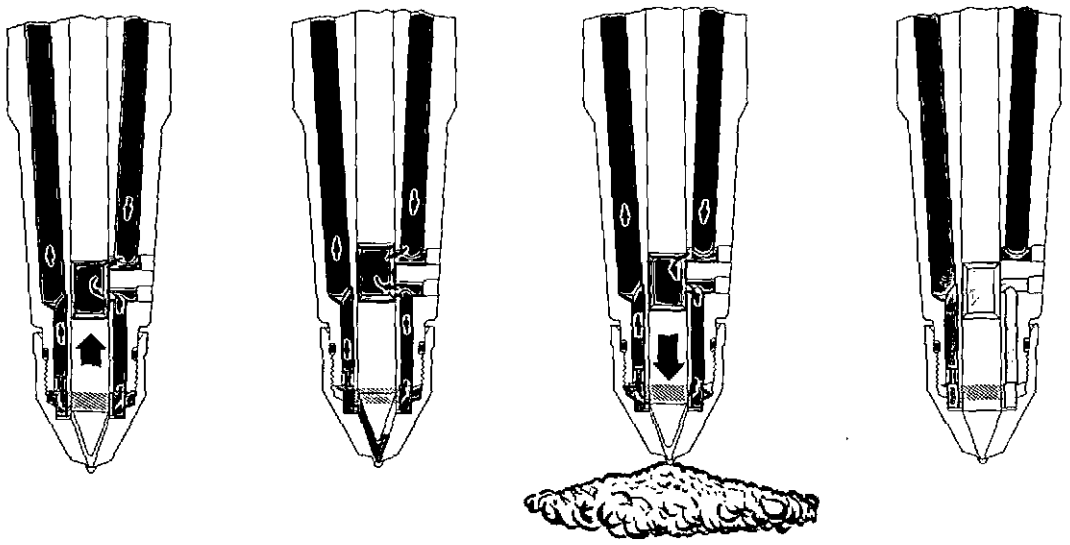


Fig. 1-13. Fuel injection cycle, flanged PT injector FWC-11

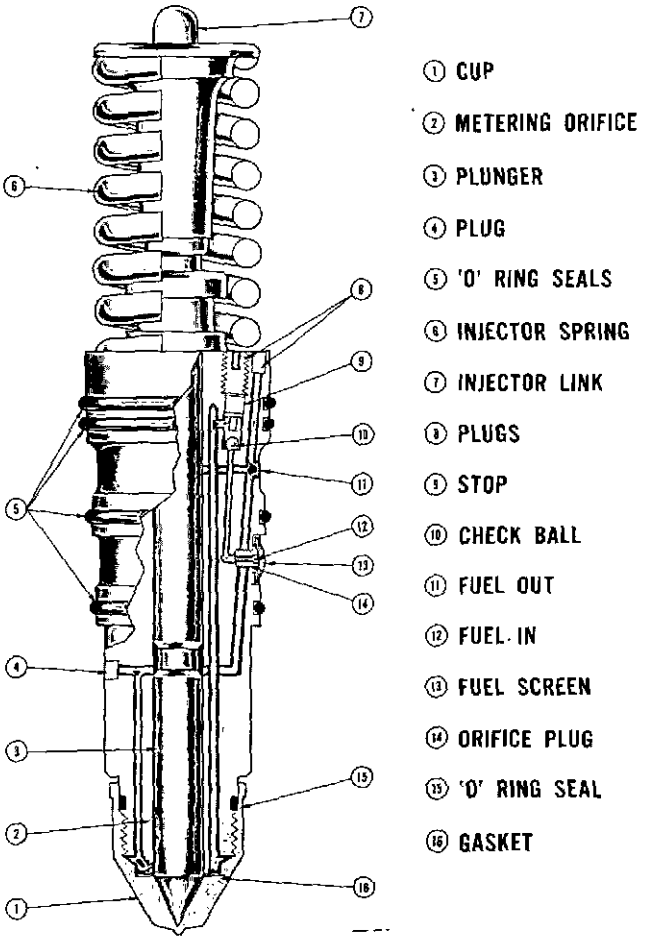


Fig. 1-14. Cross section, cylindrical PT (type B) injector FWC-14

a fine mesh screen which acts as a final filter before fuel enters combustion chamber.

V12 engines using cylindrical injectors have fuel lines between heads to bridge gap between each cylinder head supply and drain passage. Fig. 1-12.

Shut-Down Valve

Either a manual or electric shut-down valve is used on Cummins fuel pumps.

With a manual valve, control lever must be fully clockwise or open to permit fuel flow through valve.

With electric valve, manual control knob must be fully counterclockwise to permit solenoid to open valve when "switch key" is turned on. For emergency operation in case of electrical failure, turn manual knob clockwise to permit fuel to flow through valve.

Aneroid

The aneroid control, Fig. 1-16, provides a fuel by-pass system that responds to air manifold pressure and is used on some turbocharged engines whenever close control of exhaust smoke is desirable.

The aneroid limits fuel pressure to injectors when accelerating engine from speeds below normal operating speed range, and while air intake manifold air pressure is not sufficient for complete combustion. Air intake manifold pressure rises with turbocharger speed, which is a product of exhaust gas energy and is resultingly low at low engine speed and exhaust gas output.

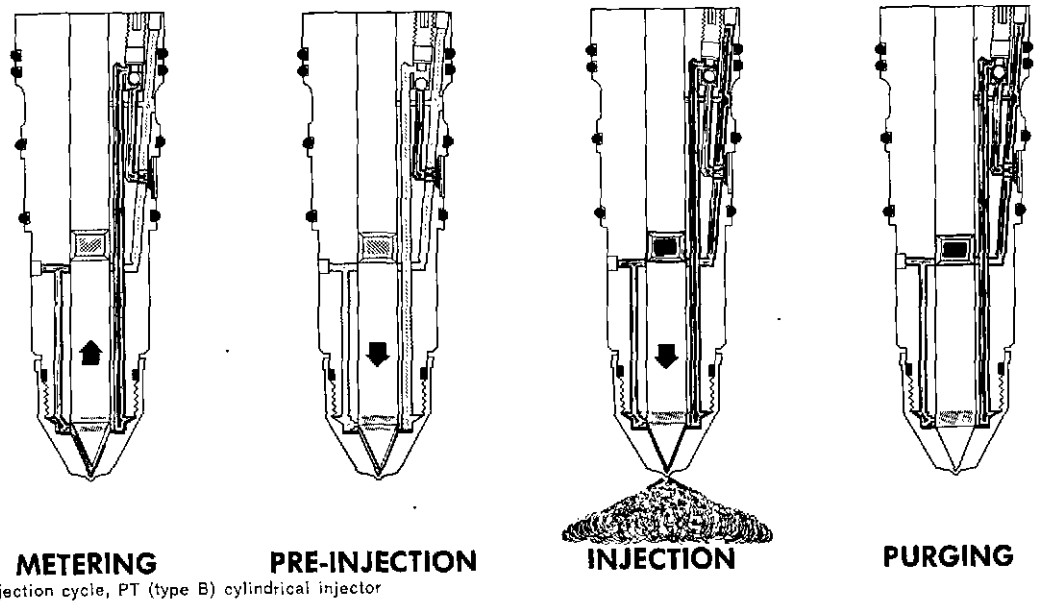


Fig. 1-15. Fuel injection cycle, PT (type B) cylindrical injector

FWC-14

Note: Aneroid is not required on turbocharged V12 engines using T-50 turbochargers.

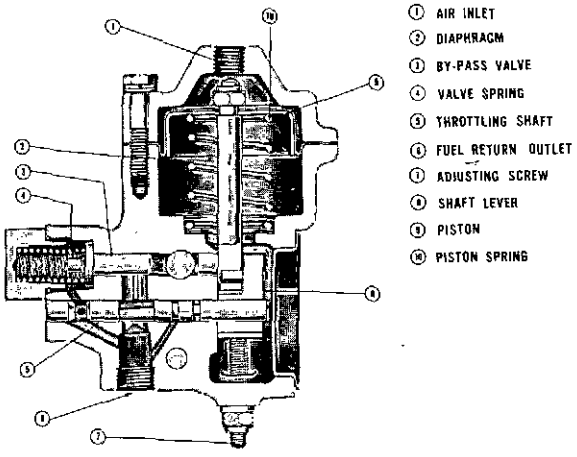


Fig. 1-16. Aneroid control cross-section

AWC-2

Lubricating System

Cummins V12 Series engines are pressure lubricated, pressure being supplied by a gear-type lubricating oil pump.

A by-pass valve is provided in full-flow oil filter(s) as insurance against interruption of oil flow by a dirty or clogged element.

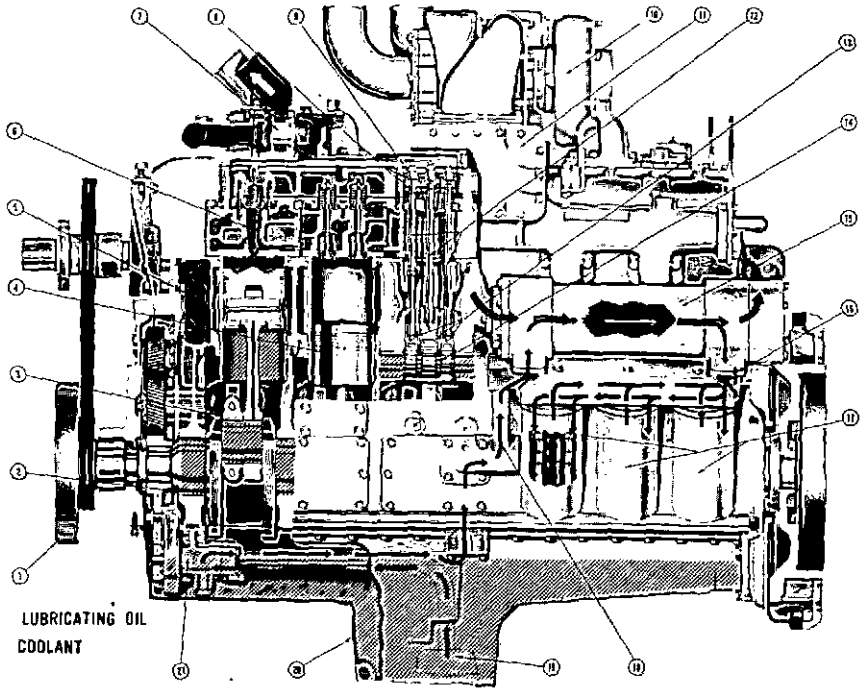
1. Oil is drawn into pump through an oil line to oil pan sump. A screen in sump strains the oil. Fig. 1-17.
2. Oil flow from pump is:

a. External lubricating oil pump and cooler in Vee: from pump to full-flow filters to cooler then to oil headers in block.

b. External lubricating oil pump and external cooler (cooler not in Vee) mounted transversely at front at top of engine or along side of engine: from pump to cooler to full-flow filters, then to oil headers in block.

c. Internal lubricating oil pump and cooler mounted on side of engine in combination with filter head and filters: from pump to cooler to full-flow filters, then to oil headers in block.

3. Oil headers, drilled full length of block on each side, deliver oil to moving parts within engine.
4. Oil pipes — or a combination of pipes and passages — carry oil from camshaft to upper rocker housings; various drillings through block, crankshaft, connecting rods and rocker levers complete oil circulating system.
5. On engines equipped with oil-cooled pistons, oil headers are drilled the length of block on each side; headers supply oil to spray nozzles, which direct oil to piston skirts.
6. Lubricating oil pressure is controlled by a regulator located in the lubricating oil pump.



① VIBRATION DAMPER
② MAIN BEARING
③ CONNECTING ROD BEARING
④ PISTON
⑤ COOLANT PASSAGE
⑥ INJECTOR
⑦ THERMOSTAT
⑧ VALVE ROCKER LEVERS
⑨ INJECTOR ROCKER LEVER
⑩ T-590 TURBOCHARGER
⑪ INTER-COOLER/AIR INTAKE MANIFOLD
⑫ PUSH TUBES
⑬ TAPPETS
⑭ CAMSHAFT
⑮ OIL COOLER
⑯ OIL TO ENGINE
⑰ FULL-FLOW OIL FILTERS
⑱ OIL TO COOLER
⑲ OIL SUCTION
⑳ LUBRICATING OIL PAN
㉑ LUBRICATING OIL PUMP

Fig. 1-17. Lubricating oil and coolant flow — side view

LWC-14

Cooling System

Coolant is circulated by a centrifugal-type water pump mounted at front of engine and driven by an idler gear from right-hand camshaft gear or by belts from accessory drive. Fig. 1-17 and 1-18.

Coolant is drawn from radiator or heat exchanger by water pump and circulated as follows:

a. With lubricating oil cooler in Vee: coolant flows from water pump to oil cooler and water header simultaneously, then through block, cylinder heads and exhaust manifolds.

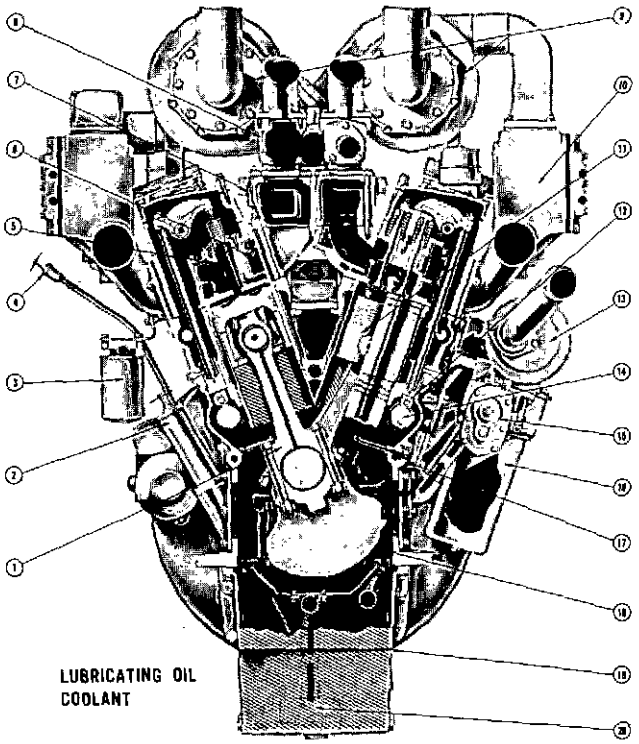
b. External lubricating oil cooler (not in Vee): coolant flows from water pump to water header, through block, cylinder heads and exhaust manifolds to oil cooler.

c. External lubricating oil cooler, cooler in combination with filter head and full-flow filters: coolant flows from water pump to oil cooler to water header, through block and cylinder heads and exhaust manifolds.

Note: Heat exchangers, marine type (oil coolers and coolant section in one unit), coolant flow as in (b) above; both sections cooled by sea water circulated by sea water pump.

Note: From return header (exhaust manifold) coolant goes to thermostat housing where it is directed to radiator for cooling, or, if it has not been heated sufficiently to actuate thermostats, it is directed through a by-pass tube to water pump for recirculation.

The engine coolant is cooled by a radiator or by heat exchangers, depending on type of installation. An oil cooler is always used on V12 engines.



① CONNECTING ROD
② OIL FILLER
③ TURBOCHARGER FILTER
④ OIL DIPSTICK
⑤ INJECTOR
⑥ COOLANT PASSAGE
⑦ EXHAUST MANIFOLD
⑧ THERMOSTAT HOUSING
⑨ T-590 TURBOCHARGERS
⑩ INTER-COOLER/AIR INTAKE MANIFOLD
⑪ PISTON
⑫ TAPPET
⑬ OIL COOLER
⑭ CAMSHAFT
⑮ FUEL PUMP
⑯ FULL-FLOW OIL FILTER
⑰ PISTON-COOLING NOZZLE
⑱ OIL TO COOLER AND ENGINE
⑲ LUBRICATING OIL PAN
⑳ OIL SUCTION

Fig. 1-18. Lubricating oil and coolant flow — end view

LWC-13

Air System

The intake air should always be routed through an air cleaner (or air silencers). The cleaner may be mounted on engine or equipment and may be either oil bath, paper element or composite type depending upon engine application. Air is routed from air cleaner directly to intake air manifold, or turbocharger if engine is a turbocharged model.

The turbochargers force additional air into combustion chambers so engine can burn more fuel and develop more horsepower than if it were naturally aspirated.

Turbocharger

The turbocharger consists of a turbine wheel and a centrifugal blower, or compressor wheel, separately encased but mounted on and rotating with a common shaft.

The power to drive turbine wheel — which in turn drives compressor — is obtained from energy of engine exhaust gases. Rotating speed of turbine changes as energy level of gas changes so engine is supplied with enough air to burn fuel for its load requirement. Fig. 1-19.

Air Compressor

The Cummins Air Compressor is a single-cylinder unit driven from engine by integral crankshaft and accessory drive or by belt. Lubrication is received from engine lubrication system, with oil carried by internal drillings or external lines. The cylinder head is cooled by engine coolant. Operating functions are as follows:

Air Intake

Air is drawn into compressor from a separate filter or from engine air system after air cleaner or silencers. As piston moves down, a partial vacuum occurs above it. The difference in cylinder pressure and atmospheric pressure forces inlet valve down from its seat, allowing air to flow through intake port and into cylinder. When piston has reached the bottom of its stroke, spring pressure is sufficient to overcome lesser pressure differential and forces valve against its seat. Fig. 1-20.

Compression

When piston starts its upward stroke, the increased pressure of air in cylinder and head forces outlet valve away from its seat. The compressed air then flows through outlet ports and into air tank as piston continues its upward stroke. On piston down-stroke, exhaust valve closes and intake valve opens except during unloading period.

Unloading

When pressure in air tank is at a predetermined level, air pressure is applied to top of unloader cap by a compressor governor. This pressure forces cap down and seals off intake passage. When pressure in air tank drops, cap returns to its upper position and intake and compression sequences begin once again.

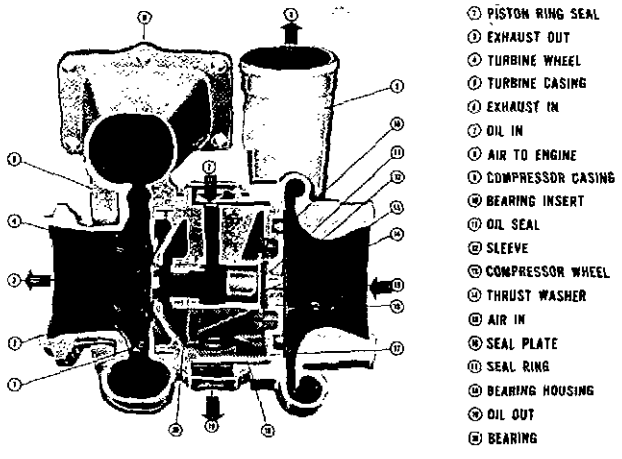


Fig. 1-19. T-50 turbocharger cross-section AWC6

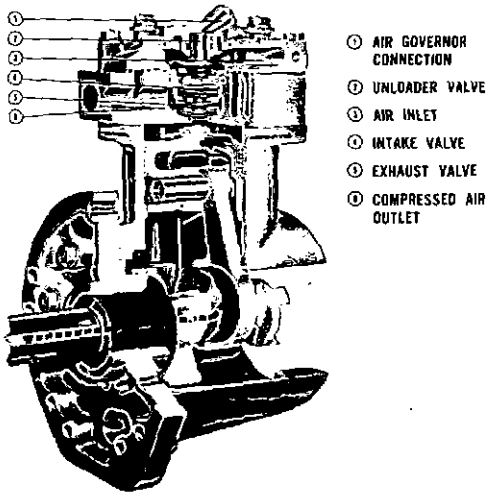


Fig. 1-20. Cummins air compressor AWC1

Operating Instructions

The engine operator assumes responsibility of engine care while it is being worked. This is an important job and one that will determine to a large degree the extent of profit from operation. There are comparatively few rules which operator must observe to get best service from the Cummins Diesel. However, if any of these rules are broken, a penalty is certain to follow. The penalty may be in lack of work accomplished because of lowered engine efficiency, or it may be in down time and costly repair bills resulting from premature engine failure.

General—All Applications

New Engine Break-In

Cummins engines are run-in on dynamometers before being shipped from factory and are ready to be put to work in applications such as emergency generator sets, fire pump engines and turbine-starting engines. In other applications, engine can be put to work, but operator has an opportunity to establish conditions for optimum service life during initial 100 hours of service by:

1. Operating as much as possible in half to three-quarter throttle or load range.
2. Avoiding operation for long periods at engine idle speeds, or at maximum horsepower levels in excess of five minutes.
3. Developing the habit of watching engine instruments closely during operation and letting up on throttle if oil temperature reaches 250°F [121.1°C] or coolant temperature exceeds 190°F [87.8°C].
4. Operating with a power requirement that allows acceleration to governed speed when conditions require more power.

Pre-Starting Instructions — First Time

Priming Fuel System

1. Prime fuel pump before starting engine for first time. Remove plug next to tachometer drive — PT (type G) pump — and fill with clean fuel oil meeting the specifications outlined on Page 3-1. On all PT fuel pumps fill gear pump through suction fitting with clean lubricating oil to aid in faster pick-up of fuel. If fuel filter is "dry", fill with clean fuel oil before starting engine.
2. Check fuel tanks. There must be an adequate supply of good grade, clean, No. 2 diesel fuel in tanks. See "Fuel Oil Specifications," Page 3-1.
3. If injector and valve adjustments have been disturbed by any maintenance work, check to be sure they have been properly adjusted before starting engine.

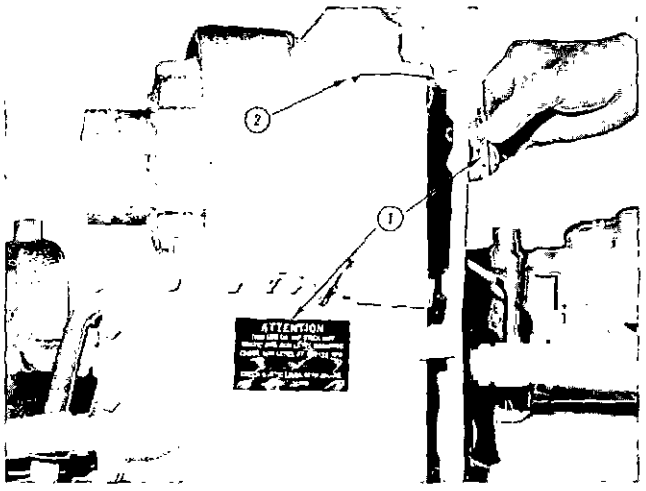


Fig. 2-1. Checking engine oil level V41817

Priming Lubricating System

1. Fill crankcase to "L" (low) mark on dipstick. See Page 3-2.

   Note: Most dipsticks have dual marking(s), with high- and low-level marks; static oil marks on one side, engine running at low idle speed marks on opposite side. Be sure to use proper scale. Fig. 2-1.
2. Remove pipe plug from lubricating oil filter head for paper element filters.
3. Connect a hand- or motor-driven priming pump line from source of clean lubricating oil (see Page 3-2) to oil plug boss.
4. Prime until a 30 psi [2.1090 kg/sq cm] minimum pressure is obtained.
5. Crank engine for at least 15 seconds while maintaining external oil pressure at minimum of 15 psi [1.0545 kg/sq cm].
6. Remove external oil supply and replace plug in oil filter head.

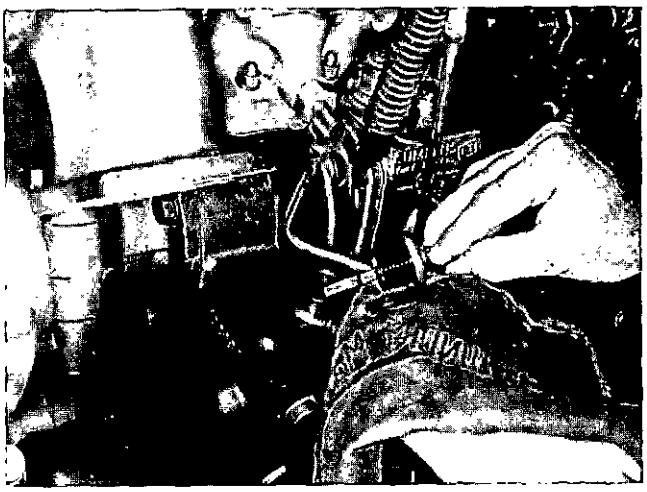


Fig. 2-2. Checking hydraulic governor oil level V41802

7. *Fill crankcase, through filler tube(s), to "H" (high) mark on* dipstick with oil meeting specifications shown on Page 3-2. No change in oil viscosity or type is needed for new or newly rebuilt engines.

   Caution: After engine has run a few minutes, it will be necessary to add lubricating oil to compensate for that absorbed by filter element(s) and oil cooler.

Check Hydraulic Governor

1. Many engines used in stationary power applications are equipped with hydraulic-governed fuel pumps. This governor uses lubricating oil as an energy medium. For governor *oil viscosity, see Page 3-2.*
2. *Oil level in governor sump must be at full mark on dipstick.* Fig. 2-2.

Normal-Daily Checks

Check Oil Level

1. *A dipstick oil gauge is located on side of engine. The dip*stick supplied with engine has an "H" (high) and "L" (low) level mark to indicate lubricating oil supply. Dipstick must be kept with oil pan, or engine, with which it was originally supplied. Cummins oil pans differ in capacity with different type installations and oil pan part numbers.

   Note: Most dipsticks have dual markings, with high- and low-level marks; static marks on one side, engine running at low idle speed marks on opposite side. Be sure to use *proper scale.*
2. *Keep oil level as near high mark as possible.*

Caution: Never operate engine with oil level below low-level mark, or above high-level mark.

Check Air Connections

Check air connections to compressor and air equipment, if used, and to air cleaners.

Check Engine Coolant Supply

1. Remove radiator or heat exchanger cap and check engine coolant supply. Add coolant as needed to completely fill system.
2. Make visual check for leaks.
3. There are several recognized methods of protecting engine cooling systems from rust and corrosion. These methods are described on Page 3-4.

Check Fuel Supply And Connections

1. Fill fuel tanks with fuel meeting specifications on Page 3-1.
2. Visually check for evidence of external fuel leakage at fuel connections. Tighten fuel manifold fittings; tighten flanged injector fuel connections to 20/25 in.-lb [0.2300/0.2875 kg m].
3. On engines with internal fuel passages in head, check fuel *supply line at front and rear of engine.*

Starting The Engine

Starting requires only that clean air and fuel be supplied to combustion chamber in proper quantities at correct time.

Normal Starting Procedure

Prelube Engine

If fuel system is equipped with overspeed stop, push "Reset" button before attempting to start engine.

1. On units equipped with air activated prelube device, open air valve for 10 to 12 seconds to activate piston in prelube device which will lubricate all moving parts in engine prior to engaging starter.
2. Set throttle for idle speed.
3. Disengage driven unit or make sure main disconnect switch is open.

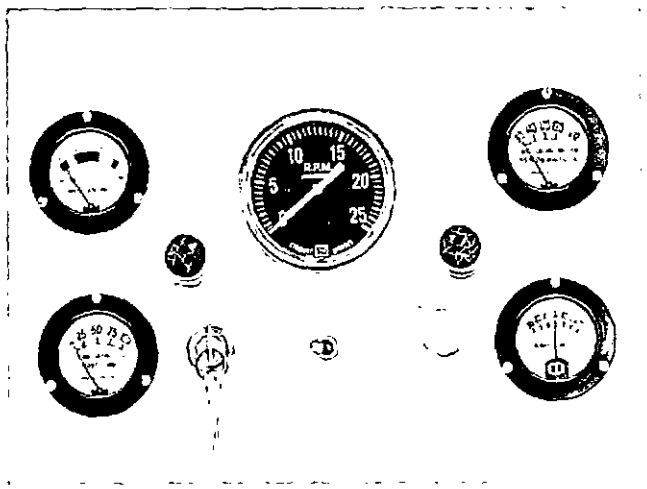


Fig. 2-3. Instrument panel, power unit N11808

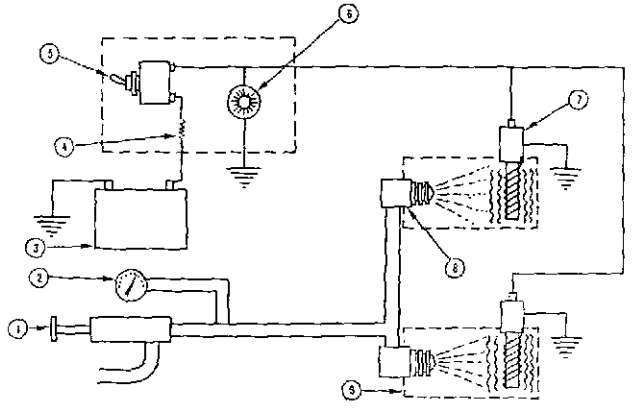


Fig. 2-4. Preheater wiring diagram V41803

4. Open manual fuel shut-down valve, if engine is so equipped. Electric shut-down valves operate automatically.
5. Pull the compression release.
6. Press starter button or turn switch-key to "start" position.

   Note: A manual over-ride knob provided on forward end of electric shut-down valve allows valve to be opened in case of electric power failure. To use, open by turning fully clockwise.

   Caution: To prevent permanent cranking motor damage, do not crank engine for more than 30 seconds continuously. If engine does not fire within first 30 seconds, wait one to two minutes before recranking.

7. After three or four seconds of cranking, close compression release and continue to crank until engine fires.
8. On some generator sets where main generator current is used to actuate pump shut-down valve, start engine by using manual over-ride button and then disengage button to allow engine safety circuit to take over pump and engine control. This arrangement is usually used with air starting systems.
9. Release lever quickly at instant engine starts. Make certain lever returns to "off" position.

Use Preheater For Cold-Weather Starting

To aid in starting engine when temperature is 50° F [10° C] or below, an intake air preheater is available. The preheater equipment consists of a hand-priming pump (1, Fig. 2-4) to pump fuel into intake manifold (9), a glow plug (7) which is electrically heated by battery (3), and a switch (5) to turn on glow plug. Fuel burns in intake manifold and heats intake air.

Caution: Do not use ether in conjunction with preheater.

To use preheater for cold starting:

1. Set throttle in idle position. Do not accelerate engine during starting procedure.
2. Turn glow plug toggle switch to "ON" position. Red indicator light (6) must be on.
3. After red light has been on for 20 seconds, start cranking engine. As soon as engine begins rotating, operate preheater priming pump to maintain 80 to 100 psi [5.6240 to 7.0300 kg/sq cm] fuel pressure. Use of primer before the 20-second interval will wet glow plug and prevent heating.

   Note: On engine equipped with an oil pressure safety switch, fuel by-pass switch must be in "start" position before operating priming pump. Hold fuel by-pass switch in "start" position until engine oil pressure reaches 7 to 10 psi [0.4921 to 0.7030 kg/sq cm]; then, move to "run" position.

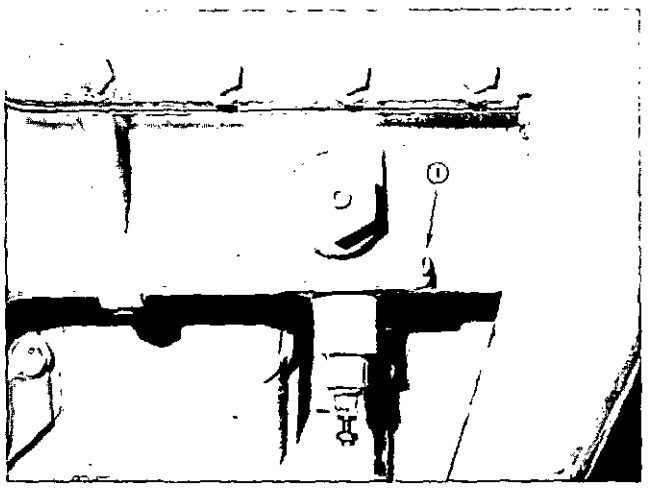


Fig. 2-5. Glow plug inspection hole V41818

4. If engine does not start within 20 seconds, stop cranking. Wait 30 seconds and repeat cranking operation.
5. After engine starts, pump primer slowly to keep engine idling smoothly. In cold weather this may require 4 to 5 minutes, or longer. Do not accelerate engine.
6. When engine has warmed up so it does not falter between primer strokes, stop pumping. Close and lock primer. Turn off glow plug toggle switch. (Red indicator light will go out.)

Failure To Start

1. If engine gives no indication of starting during first three full strokes of preheater pump, touch-check intake manifold for heat. If there is no heat, check electric wiring. If wiring is all right, remove ⅛" pipe plug (1, Fig. 2-5) from manifold near glow plug and check flame while a helper performs the preceding Steps 2, 3 and 4.
2. If no flame is observed, close glow plug manual switch 15 seconds and observe glow plug through ⅛" pipe plug hole. Glow plug should be white hot: if not, connect glow plug to a 6- or 12-volt (as used) source and check amperage which should be 30/32 (minimum). If glow plug is all right, check manual switch and resistor, if used, and replace if necessary.

Other Cold-Starting Aids

Use Of Ether Without Metering Equipment

If engine is not equipped with a preheater arrangement, two men can use the following method to start engine:

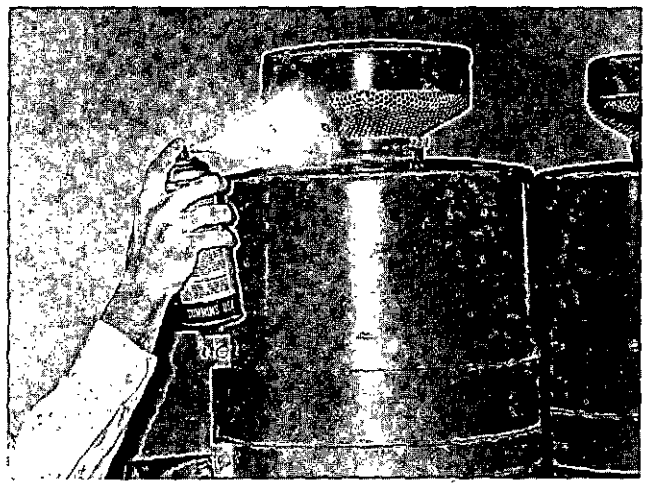


Fig. 2-6. Ether spray application V41805

Caution: Never handle ether near an open flame. Never use it with preheater or flame thrower equipment. Do not breathe the fumes.

1. Pour three tablespoonfuls of ether on a cloth; hold cloth close to air cleaner intake while second man cranks engine.

   Caution: Be sure cloth is outside air cleaner and cannot be drawn into engine.

2. As an alternate method, spray ether into air cleaner intake while second man cranks engine. Fig. 2-6.

   Caution: Use of too much ether will cause excessively high pressures and detonation.

3. Ether fumes will be drawn into intake air manifold and cold engine should start without difficulty.

Warm Up Engine Before Applying Load

When engine is started, it takes a while to get lubricating oil film re-established between shafts and bearings and between pistons and liners. The most favorable clearances between moving parts are obtained only after all engine parts reach normal operating temperature.

Avoid seizing pistons in liners and running dry shafts in dry bearings by bringing engine up to operating speed gradually as it warms up. Allow engine to run at 800 to 1000 rpm for some 4 to 5 minutes or preferably until water temperature reaches 140° F [60° C] before engaging the load. During the next 10 to 15 minutes, or until water temperature reaches 160°/165° F [71.1°/73.9° C], operate at partial load at approximately 75% of governed rpm.

Engine Speeds

It is necessary in some applications to reduce engine horsepower and rpm due to load or climatic conditions under which engine operates.

Operation of an engine at its maximum rating for prolonged periods will reduce engine life.

Operate At Reduced RPM For Continuous-Duty Or Cruising

When operating engine in a continuous-duty situation and engine is rated at maximum horsepower and rpm such as powering a boat, or running continuous-operation generators, etc., maintain engine rpm at approximately 85 percent of rated rpm (approximately 1750/1800 rpm). This will give adequate power as well as economical fuel consumption.

Engine governors are normally set for reduced rpm or fuel pump at reduced fuel rate for continuous-duty operation. If

engine is applied under these conditions constantly, see later paragraphs.

Governed Speeds

All Cummins engines are equipped with governors to prevent speeds in excess of maximum or predetermined lower speed rating.

The governor has two functions: First, it provides exact amount of fuel needed for idling when throttle is in idling position. Second, it overrides throttle and shuts off fuel if engine rpm exceeds maximum rated speed.

Many engines, such as generator sets, are set at other values due to equipment being powered or loads applied to equipment and engine.

Instrument Panels

Operate By The Instruments

It makes no difference whether an engine is in a boat or on some other type operation; operator must use the panel board instruments. The instruments show at all times how to get most satisfactory service from any engine.

Use Tachometer

Governed engine speed is maximum rpm which a properly adjusted governor will allow engine to turn under full load.

Never override governor, or allow engine to exceed governed rating during operation.

Operate at partial throttle in continuous-duty situations to give required torque with tachometer showing rpm approximately 15 percent below governed speed.

Oil Temperature Gauge Indicates Best Operating Range

The oil temperature gauge normally should read between 180° F [82.2° C] and 200° F [93.3° C] for best lubrication. Under full-load conditions, a temperature of 225° F [107.2° C] for a short period is not to be considered cause for alarm.

Caution: Any sudden increase in oil temperature, which is not caused by load increase, is warning of possible mechanical failure and should be investigated at once.

During warm-up period, apply load gradually until oil temperature reaches 140° F [60° C]. While oil is cold it does not do a good job of lubricating. Continuous operation with oil temperatures much below 140° F [60° C] increases likelihood of crankcase dilution and acids in the lubricating oil which quickly accelerate engine wear.

Keep Water Temperature Between 165° F [73.9° C] And 195° F [90.6° C]

A water temperature of 165° F to 195° F [73.9° to 90.6° C] is best assurance that cylinder liners are heated to proper temperature to support good combustion and that working parts of engine have expanded evenly to most favorable oil clearances. See "Engine Warm-Up."

Engine should be warmed up slowly before applying full load so pistons will not expand too fast for cylinder liners. Most cases of piston and liner scoring start with throwing full load on a cold engine.

When water temperature is too low, cylinder walls retard heating of air during compression and delay ignition. This causes incomplete combustion, excessive exhaust smoke and high fuel consumption.

Keep thermostats in engine summer and winter, avoid long periods of idling, and do whatever else is required to keep water temperatures to a minimum of 165° F [73.9° C]. If necessary in cold weather, use radiator shutters or cover a part of the radiator to prevent overcooling.

Overheating problems require mechanical correction. It may be caused by loose water pump belts, a clogged cooling system or heat exchanger, or insufficient radiator capacity. Report cases of overheating to maintenance department for correction; 200° F [93.3° C] maximum engine coolant temperature should not be exceeded.

Keep An Eye On The Oil Pressure Gauge

The oil pressure gauge indicates any drop in lubricating oil supply or mechanical malfunction in the lubricating oil system. Operator should note loss of oil pressure immediately and shut down engine before bearings are ruined.

Normal Operating Pressures are:

At Idle .....15 psi [1.0545 kg/sq cm] (Min.)

At Rated Speed .....40 psi [2.8120 kg/sq cm] (Min.)

Note: Individual engines may vary from above normal pressures. Observe and record pressures when engine is new to serve as a guide for indication of progressive engine condition.

Observe Engine Exhaust

Engine exhaust is a good indicator of engine operation and performance. A smoky exhaust may be due to a poor grade of fuel, dirty air cleaner, overfueling or poor mechanical conditions.

If engine exhaust is smoky, corrective action should be taken.

Maximum Horsepower Requirements

Maximum horsepower is attained only at maximum, or governed, engine rpm. Whenever engine rpm is pulled down by overload, horsepower is lost and continues to be lost as long as the engine continues to lose rpm. When full horsepower is needed, operate the engine near the governor. This rule applies to any kind of application.

Increase Engine RPM When More Power Is Needed

One rule sums up all rules for proper operation to give the power needed and best performance from the equipment:

Always operate so power requirements will allow engine to accelerate to, or maintain, governed rpm when advancing to full throttle.

When more torque or power is required, bring engine speed near governor. This will produce additional horsepower needed.

High Altitude Operation

Engines lose horsepower when operated at high altitude because the air is too thin to burn as much fuel as at sea level. This loss is about 3 percent for each 1000 ft [304.8000 m] of altitude above sea level for a naturally aspirated engine. An engine will have a smoky exhaust at high altitude unless a lower power requirement is used so engine will not demand full-fuel from the fuel system. Smoke wastes fuel, burns valves and exhaust manifolds, and "carbons up" piston rings and injector spray holes. See "Engine Ratings" for altitude ratings for VT12 engines.

Engine Shut-Down

Let Engine Idle A Few Minutes Before Shutting It Down

It is important to idle an engine 3 to 5 minutes before shutting it down to allow lubricating oil and water to carry heat away from combustion chamber, bearings, shafts, etc. This is especially important with turbocharged engines.

The turbocharger contains bearings and seals that are subject to high heat of combustion exhaust gases. While engine is running, this heat is carried away by oil circulation, but if the engine is stopped suddenly, turbocharger temperature may rise as much as 100° F [37.8° C]. The results of extreme heat may be seized bearings or loose oil seals.

Do Not Idle Engine For Excessively Long Periods

Long periods of idling are not good for an engine because operating temperatures drop so low the fuel may not burn completely. This will cause carbon to clog the injector spray holes and piston rings.

If engine coolant temperature becomes too low, raw fuel will wash lubricating oil off cylinder walls and dilute crankcase oil so all moving parts of the engine will suffer from poor lubrication.

If engine is not being used, shut it down.

Turn Switch Key To "Off" Position To Shut Down Engine

The engine can be shut down completely by turning off switch key on installations equipped with an electric shut-down valve, or by pulling the manual shut-down lever.

Turning off switch key which controls electric shut-down valve always stops engine unless over-ride button on shut-down valve has been locked in open position. If manual over-ride on electric shut-down valve is being used, turn button fully counterclockwise to stop engine. Refer to "Normal Starting Procedure," Page 2-2. Valve cannot be reopened by switch key until after engine comes to complete stop.

Caution: Never leave switch key or over-ride button in valve-open or run position when engine is not running. With overhead tanks this could allow fuel to drain into cylinders causing hydraulic lock.

Do Not Use Compression Release Lever To Stop Engine

V12 Series engines are equipped with a compression release lever. Pulling this lever lifts the intake valve push tubes and opens the valves. The push tubes are pulled from their sockets and extensive wear on balls and sockets will result from using compression release to stop engine.

The compression release lever can be used as an aid in cranking, before starting, or while making injector and valve adjustments, but not to stop the engine.

Stop Engine Immediately If Any Parts Fail

Practically all failures give some warning to operator be-

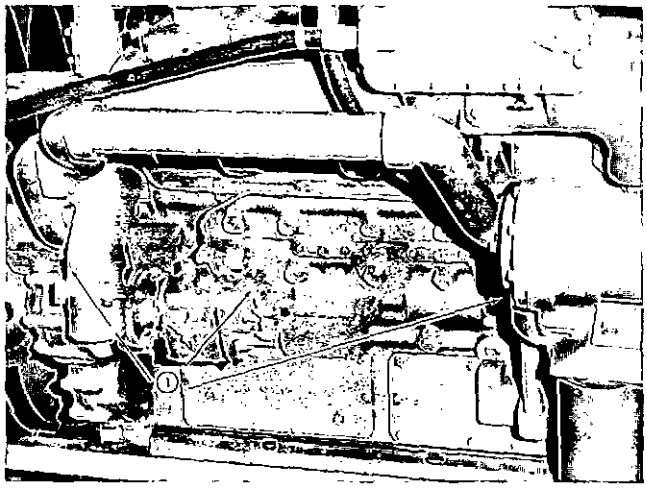


Fig. 2-7. Drain points V40033

fore parts fail and ruin engine. Many engines are saved because alert operators heed warning signs (sudden drop in oil pressure, unusual noises, etc.) and immediately shut down engine. A delay of ten seconds after a bearing failure causes a knock may result in a ruined crankshaft or allow a block to be ruined by a broken connecting rod.

Never try to make the next trip or another load after engine indicates that something is wrong. It does not pay!

Cold-Weather Protection

1. For cold-weather operation, use of permanent-type ethylene glycol-base antifreeze with rust inhibitor additives is recommended. See Page 3-4.
2. To completely drain cylinder block and head, open petcock (1, Fig. 2-7) or remove drain plug on water pump, and both banks of cylinder block at the front and rear of engine. If an air compressor, oil cooler, heat exchanger or other "water-cooled" accessory is used, open petcock on unit. Failure to drain any of these units may cause serious damage in freezing weather.

Operator's Daily Report

Make A Daily Report Of Engine Operation To Maintenance Department

The engine must be maintained in top mechanical condition if operator is to get most satisfaction from its use. Engine adjustments, etc., are the work of maintenance department. However, the maintenance department needs daily running reports from operator to make necessary adjustments in time allotted and to make provisions for more extensive maintenance work as reports indicate necessity.

Comparison and intelligent interpretation of daily report along with a practical follow-up action will eliminate practically all operating failures and emergency repairs. Report to maintenance department any of following conditions:

1. Low lubricating oil pressure.
2. Low power.
3. Abnormal water or oil temperature.
4. Unusual engine noise.
5. Excessive smoke.

Vehicular Applications

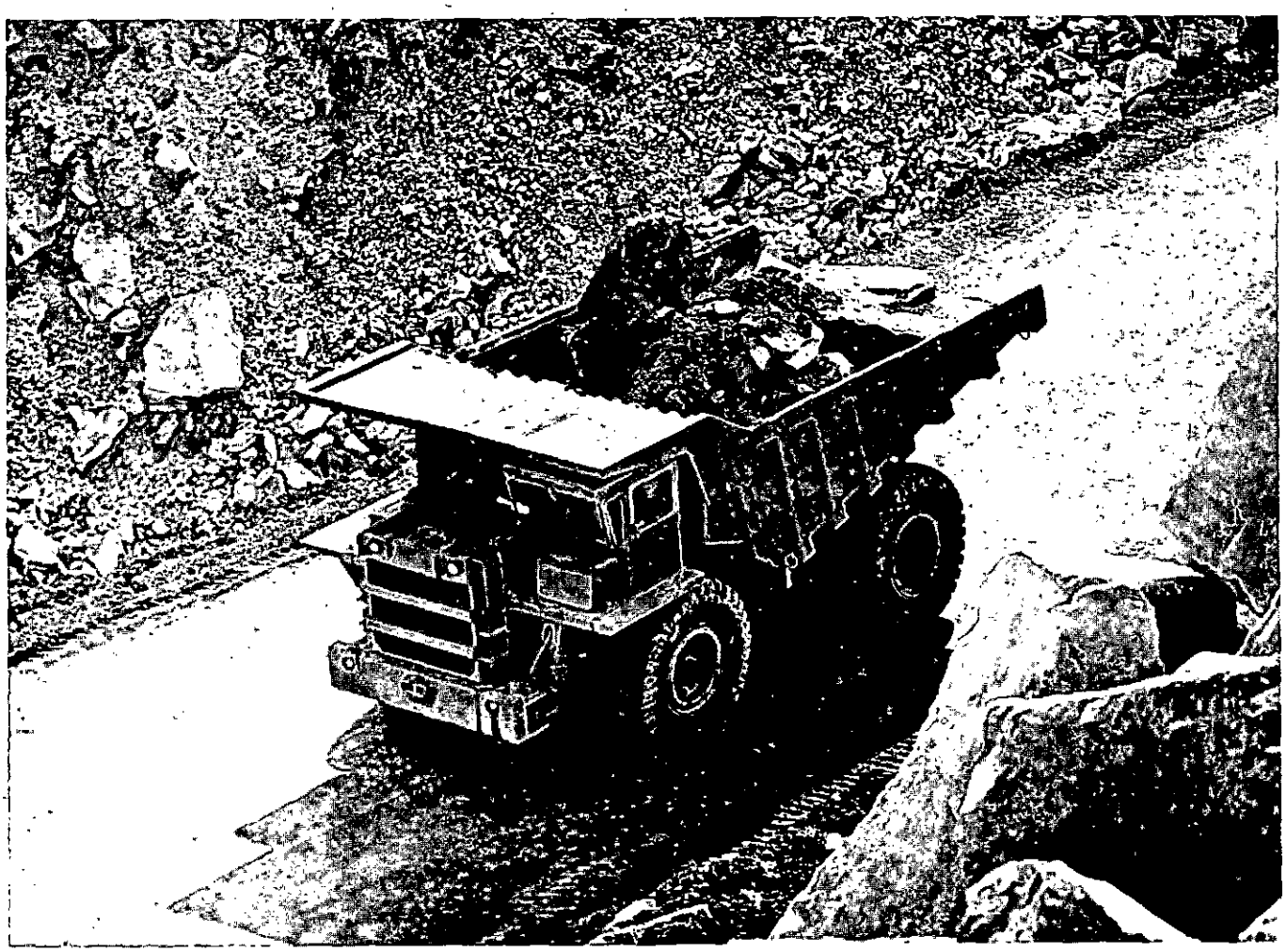


Fig. 2-8. Typical vehicular installation V41807

Engine break-in, before starting and general operational procedure follows that previously described. Additional items, applying to other applications, follow.

Apply Load Gradually

Always engage load in a gear low enough to allow acceleration to governed rpm. The operator should become familiar with transmission and gear train used in vehicle before starting engine. Many power train options are available due to variety of applications in which V12 Series engines are used. Several of these power trains require full throttle at all times, some require vehicle to come to a complete stop before shifting gears, and on some you can catch a gear while engine is decelerating. You may have a power-shifted or mechanical-shifted transmission, used with or without a single stage or three-stage torque converter, with or without a variable rear axle ratio, with or without a lockup feature in torque converter; or you may have an electric power train which could have an electric motor in each driving wheel. Sometimes you must clutch a transmission once to change gears or you may have to double clutch transmission to change into another gear, or you might not even have a clutch.

As you can readily see, the operation of any one of the above combinations would differ greatly from any other combination, and should be driven accordingly. Do not skip gears.

Shock loads take their toll of tires and transmissions as well as being hard on engine. Apply load gradually.

Operate At Reduced RPM For Cruising

When operating a vehicle on level ground hold engine rpm at approximately 85 percent of governed rpm. See Pages 5 and 6. This will give adequate power for cruising and economical fuel mileage. The engine will be operating in proper range and will not be working hard.

Use Tachometer

Governed engine speed is maximum rpm which a properly adjusted governor will allow engine to turn under full-load.

Never override governor, or allow engine to exceed governed rating while out of gear, operating at partial load, or driving downhill.

Shift To Lower Gear When Load Pulls Down Engine RPM

If grade gets steeper and load starts to pull down engine rpm, treat that part of grade like another hill and shift to a still lower gear or range. Fig. 2-9.

Do not pull down engine rpm more than 10 to 20 percent.

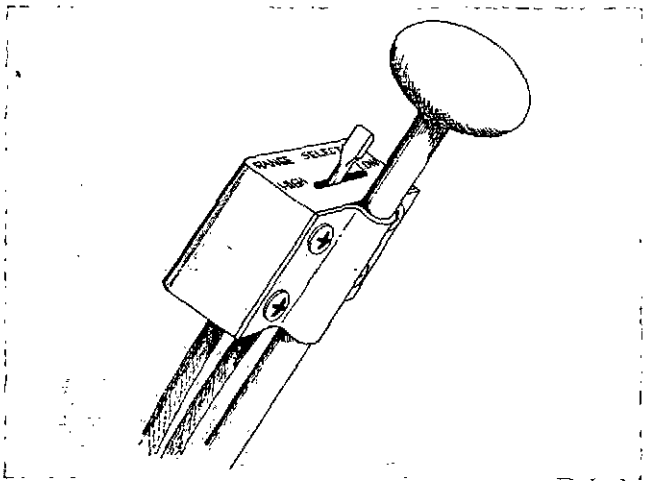


Fig. 2-9. Change gears for more power V41808

The practice of shifting gears, when used, — next to safety observance — is the most important phase of good engine operation.

When approaching a hill, more torque at the wheels is required. Shift to a lower gear and "rev up" engine near governor. This will give additional horsepower needed without loss of speed.

Downhill Operation

The Cummins diesel is effective as a brake on downhill grades, but care must be exercised not to overspeed the engine going downhill. Fig. 2-10. The governor has no control over engine speed when it is being pushed by loaded vehicle.

Never turn off switch key while going downhill. With engine still in gear, fuel pressure will build up against shutdown valve and may prevent it from opening when switch key is turned on.

Use Brake As Needed To Prevent Excessive Engine Speeds

Use a combination of brakes, gears and any other mechanism available on vehicle to keep it under control at all times, and to keep engine speed below rated governed rpm.

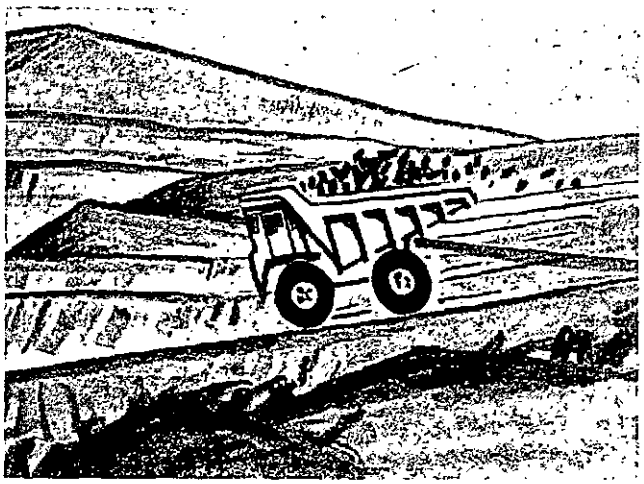


Fig. 2-10. Down-hill operation V41809

Generator Applications

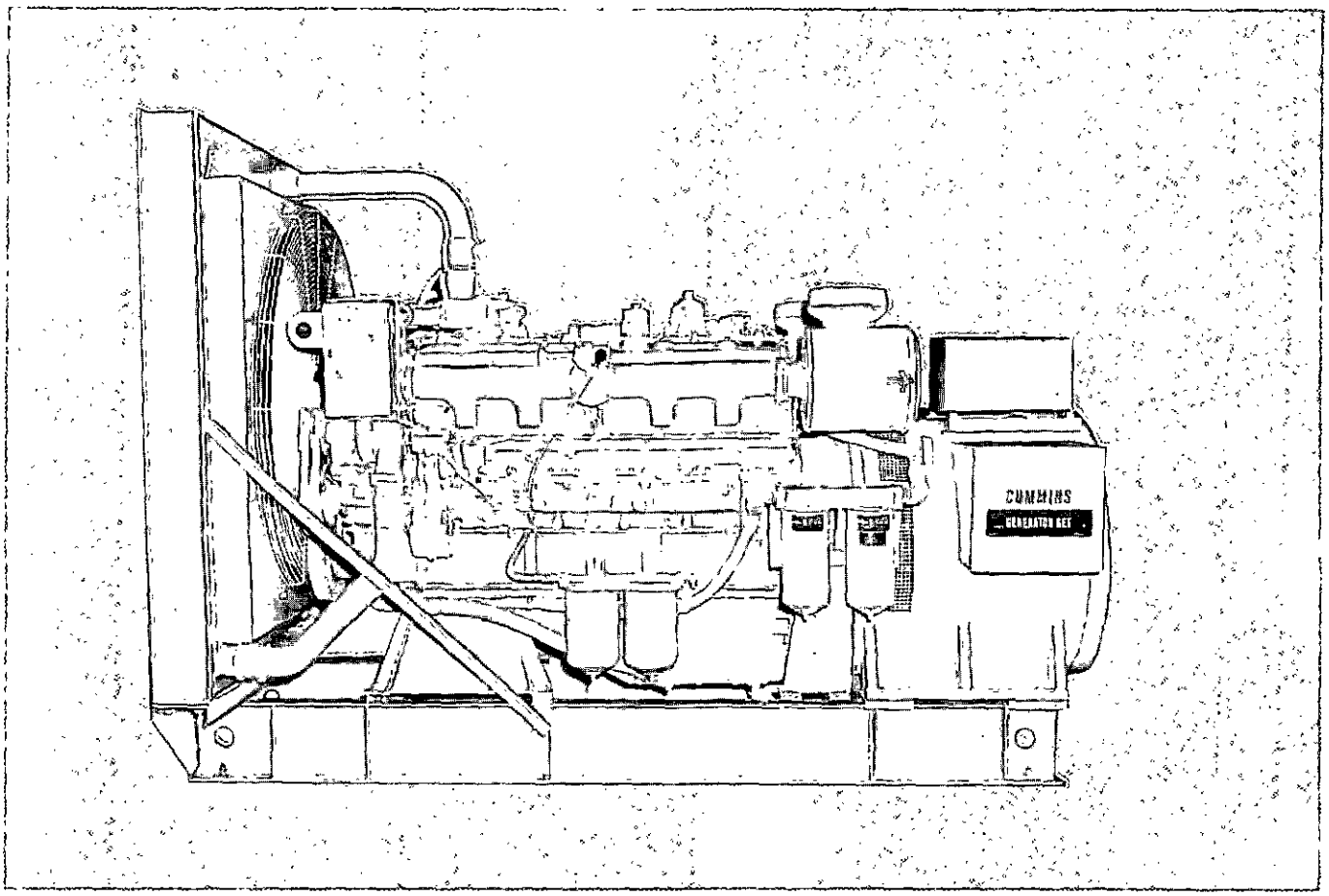


Fig. 2-11. Typical generator set

V41810

In addition to general operating instructions, perform following.

Before starting:

1. Open main power disconnect switch from load line.
2. Check electrical connections.
3. Lubricate generator end bearing as stated on generator.

Starting Procedure

On some generator sets where main generator current is used to actuate pump shut-off valve, start engine by using manual override button, and then disengage button to allow engine safety circuit to take over pump and engine control. This arrangement is usually used with air starting systems.

Operation

1. Bring engine to desired operating rpm.

   Caution: Make sure all power lines and control stations are clear of personnel.

2. Engage disconnect switch and adjust load bank.

Generator Set — Parallel Operation

In many cases where electric power is required, it may be advantageous to install two or more smaller generator sets instead of one single set of higher rating. Table 2-1. This condition also exists when it becomes necessary to increase the capacity of existing plant by adding generator sets. When two or more generators are connected and operated together in such a way that they deliver electric energy to system, they are said to be operating in parallel. Parallel operation is considered successful when generators deliver energy to external system without delivering energy to each other.

To be suitable for parallel operation, generation equipment selected must meet the following requirements:

1. The generator voltage and frequency ratings must be the same for all sets.
2. The generators should have approximately the same waveform. Similar waveshapes are readily obtainable if machines are of similar type.
3. The generators should have similar voltage regulation characteristics.
4. The driving engines should have the same speed regulation characteristics. The governors should be adjusted to give same speed droop when applying or removing the load.

Connections

1. When two or more power units are to be operated in parallel, they must be tied together electrically and connected to the load system. This interconnection is referred to as "the bus."
2. The connecting cables or bus must be installed between the corresponding line terminals of each power unit. Thus L-1 on one unit will be connected to L-1 on the second unit, L-2 to L-2 and L-3 to L-3, etc. On 3-phase, 4-wire units, the L-0 terminals will also be connected together.

   Caution: Both sets must be connected to a common ground. This is most readily achieved by running a No. 12 or larger wire from the grounding terminal on the housing of one set to the grounding terminal on the other set. This wire should be protected from mechanical damage. It need not be insulated.
3. Bar positions on set's reconnection panels must be connected in the same way so output voltage of both sets will be the same.
4. Power units which are suitable for parallel operation will be equipped with necessary cross current compensation equipment to assure proper parallel operation.

Initial Operation

Generator Test

Before operating power units in parallel, each generator and regulator should be checked by starting and operating each unit individually.

1. Check engine, battery, generator and connecting cables in accordance with operating procedure for single-unit operation outlined in the technical manual for the set in use.

   Caution: When conducting these preliminary tests never close the main switches (or contactors) of both sets at the same time.
2. Check operation of voltage regulators of each of the sets as described in technical manual and adjust as described therein, if necessary.

Speed Droop Check

Since it is important that both engines have the same speed droop characteristics, each set should be checked individually for speed droop and the governors adjusted, if necessary. This may be accomplished by using any load which does not exceed the rating of a single set. When a dummy load is not available, use of the end item as a load is permissible. Loads which vary, such as tracking antennas, should be avoided but acquisition antennas running at constant speed are acceptable loads.

1. Start one machine and adjust to standard no-load speed (62 cycles for 60 cycle machines and 415 cycles for 400 cycle machines).
2. Adjust set to rated voltage operating under automatic voltage regulator control. Load set with as much steady state load as is available, up to the rated capacity of the machine.
3. Determine frequency at which the set is operating under load.
4. Shut down first machine and repeat steps 1 and 2 above, on second machine.
5. In accordance with instructions contained in technical manual, adjust governor droop characteristic of second machine so set will be operating at same frequency as first machine when loaded with same load.

Preliminary Tests

Before operating two sets in parallel the first time, two preliminary electrical tests should be made.

Phase Rotation Test

Only generators connected together with proper phase ro-

tation (phase sequence) can be operated in parallel.

1. Connect units to bus as directed in paragraph "Connections" above.
2. Start both units leaving main switch or contactor on both sets open.
3. Adjust voltage on both sets to rated value by means of automatic voltage regulator rheostat.
4. Adjust both sets to same frequency (no-load).
5. Close main switch on one set and turn on synchronizing lamp switch on other machine.
6. If the phase sequence on both generators is the same, both synchronizing lights will light and go dark simultaneously. If the machines do not have the same phase sequence, at no time will both lamps be dark simultaneously; instead, the lamps in the different legs will darken successively. In the latter case, the phase rotation of the machines can be matched by interchanging two (any two) cables at the one-load terminal panel.

Caution: Never work on load or bus lines unless both sets are shut down.

Cross Current Compensation

When two generators are operated in parallel, supplying a load whose power factor is other than unity, each generator must supply its proper share of reactive (wattless) KVA. If one generator carries more than its share of wattless current, overheating of the generator may take place. The voltage regulator functions to hold the voltage constant. In addition, when sets are operated in parallel, the voltage regulators function to provide proper division of wattless KVA load between generators. They also serve to prevent useless circulating current from flowing between the two machines. For these purposes, cross current compensation equipment is provided with the regulators.

Polarity Test

Proper functioning of cross current compensating equipment depends on connections to current transformers being made correctly. If polarity of transformer secondaries is incorrect, the compensation will aggravate current unbalance instead of restoring proper division.

To determine if connections are correct:

1. Start both machines as directed in "Preliminary Tests" above. Close parallel operation (cross current compensator) switches on both sets and adjust voltage and frequency.
2. Adjust speed of either set so synchronizing lights blink slower and slower (about once every two seconds). When both lights are dark, close the circuit breaker.

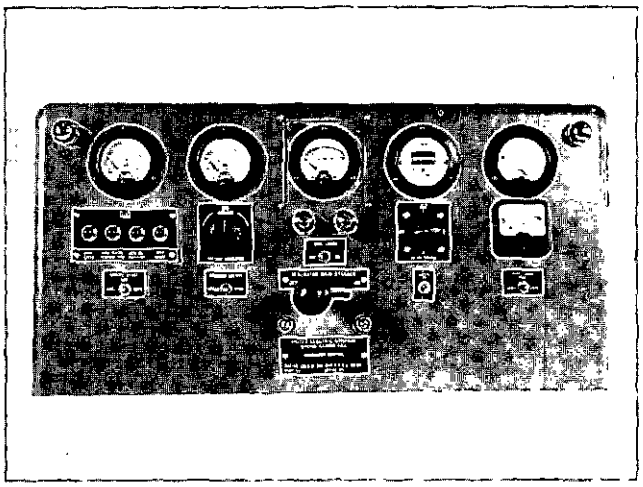


Fig. 2-12. Typical switch gear control panel V41811

3. Some circulating current will flow between the two machines as indicated on the ammeters. If it does not or if it is very great, turn voltage regulator rheostat on either set to cause about 10 percent of rated current to flow between the sets.
4. Turn off parallel operation (cross current compensating switch) on one set. If the current rises, the circuit is connected correctly. If the current falls, the leads to the current transformer secondaries must be reversed on that set.
5. Repeat operation on second machine.

Adjustment

1. After the proper polarity of the compensation circuit has been established, the amount of compensation should be adjusted. For single, non-parallel operation, voltage regulator can be adjusted for a negligible voltage drop. As soon as compensation is connected in the regulator circuit, a drop in AC voltage, held by voltage regulator, is introduced when a load with a power factor other than unity is applied or increased during operation. Depending upon how much resistance is used across current transformers, AC voltage will drop from 2 to 5 percent when load varies from zero to rated load. It should be noted that voltage drop due to compensation will only occur when the load has a power factor other than unity; on unity power factor (pure resistance) loads, this compensation drop is negligible.
2. Increasing compensating resistance will increase compensating effect toward equalizing the division of current between generators, but at the same time the voltage drop will increase which is an undesirable effect. Therefore, it is advisable to use just enough compensation to obtain satisfactory parallel operation. Generally, parallel operation is considered successful if the differences between the currents of the two generators (as indicated by the load ammeter) is less than 10 percent of the rated current

of one machine when the load is anything from 20 percent to 100 percent of rated load.

3. The compensating resistor (or resistors) are set at the factory for load and power factor conditions normally encountered in the field. This setting will usually provide satisfactory parallel operation and will eliminate cross currents. Voltage drop during parallel operation will be negligible. It is recommended the setting of the compensating resistor not be changed unless the load conditions are so abnormal the compensation is inadequate. Once set and found satisfactory, the resistor setting should be left unchanged.

Synchronizing

Once preliminary tests have been performed and adjustments made, settings will remain correct as long as the respective wire and cable connections remain unchanged. It is not necessary to make these tests every time the alternators are to be paralleled. It is, however, necessary to synchronize each and every time the generators are to be paralleled.

1. Make sure both main switches (breakers or contactors) are open.
2. Start both sets and adjust to frequency, without load, by adjusting governor controls. (Normally this setting will be about 62 cycles for 60-cycle sets and 415 cycles for 400-cycle sets.)
3. Operate both sets on their automatic voltage regulators. Adjust both sets to the same voltage.
4. Throw both cross current compensation (parallel operation) switches to "ON" position.
5. Close breaker on one of the sets.
6. Turn on synchronizing lamp switch on the other set. The synchronizing lamps will flash on and off rapidly at a frequency depending on difference in speeds of two units.
7. Adjust speed of unit whose breaker is open until lamps flash on and off slowly (about once every two seconds). After making a speed adjustment it may be necessary to wait a few seconds until lamp fluctuations slow down.
8. When the lamps are dark, close the main breaker of the set.
9. Open synchronizing lamp switch.

Note: The above procedure can be followed if one of the sets is already on the line. Follow above directions with loaded set taken to be the one with closed main switch.

Load Division

After units are operating in parallel, load should be divided proportionately to generator ratings. In case of addition of a set to one already carrying a load, this involves shifting of part of the load to the second generator. In case of two units of the same size, each should carry half of the load. On AC generators, load can be shifted from one generator to another only by speed control, not by manipulating voltage regulator rheostat. Such manipulation will only change power factor of generator and hence current output of the machines, causing undesirable cross current.

1. Increase the load on machine with the lesser amount of total load by increasing governor throttle control. This increase will be indicated on the wattmeter.
2. When two loads are correct as indicated by the wattmeters, check frequency as indicated on either sets' frequency meter. If frequency is too high, it will be necessary to readjust both the governor controls to feed less fuel to the machines. Conversely, if the combined speed is too low, opening the governor controls on both machines will increase the frequency. When raising or lowering the frequency, care must be taken to readjust load division so wattmeter readings are equal (or proportional to set size if sets are not the same size).

Eliminating Wattless Current

After KW load has been proportionally divided, the reactive (wattless) load should also be divided proportionally. Assuming that both generators have the same rating, both generators should show same load amperes. This indicates cross currents and should be eliminated by adjustment of voltage regulator rheostats on the sets.

1. Slowly turn voltage adjusting knob on one of the units first clockwise, then counterclockwise. One movement or the other should result in decreasing ammeter readings. Adjust until both ammeters are at the lowest point at which they both read the same value on similar sets. On different size sets, the proportional load division described previously will have to be considered.
2. After adjustment, it may be found the output voltage is too high or too low. If too low, turn the voltage regulator rheostat on one of the sets up slightly and repeat the operation of the preceding paragraph using the rheostat on the other set for balancing. Conversely, if the voltage is too high, turn down one of the rheostats and balance with the other.

Adjustments

Once proper load distribution between the units is established, little or no adjustment of the load distribution should be required when the load is increased or decreased. Such adjustments as may be necessary should be carried out as indicated in the preceding paragraphs. Proportional division of the KW load is assured by the speed regulation characteristics of the units. The proportional division of the wattless load will be maintained by the cross current compensation feature of the voltage regulators.

Table 2-1: Standard Generator Set Application Specifications

Engine Model	50 Cycle				60 Cycle			
	Stand By		Prime Power		Stand By		Prime Power	
	KW	RPM	KW	RPM	KW	RPM	KW	RPM
NVH-450	265	1800	225	1800	220	1800	187	1800
V12-525	300	1800	250	1800	250	1800	208	1800
VT12-600	200	1200	175	1200				
VT12-600	350	1800	300	1800	292	1800	250	1800
VT12-700	250	1200	225	1200				
VT12-700	400	1800	350	1800	333	1800	292	1800

Removing A Generator From The Line

To remove a generator operating in parallel, reduce the load carried by that machine by manipulating the speed control until the KW indication on the wattmeter is very small, then open the main switch or contactors on that machine. Turning the speed control in the decrease speed direction will decrease the load carried by that generator.

Marine Applications

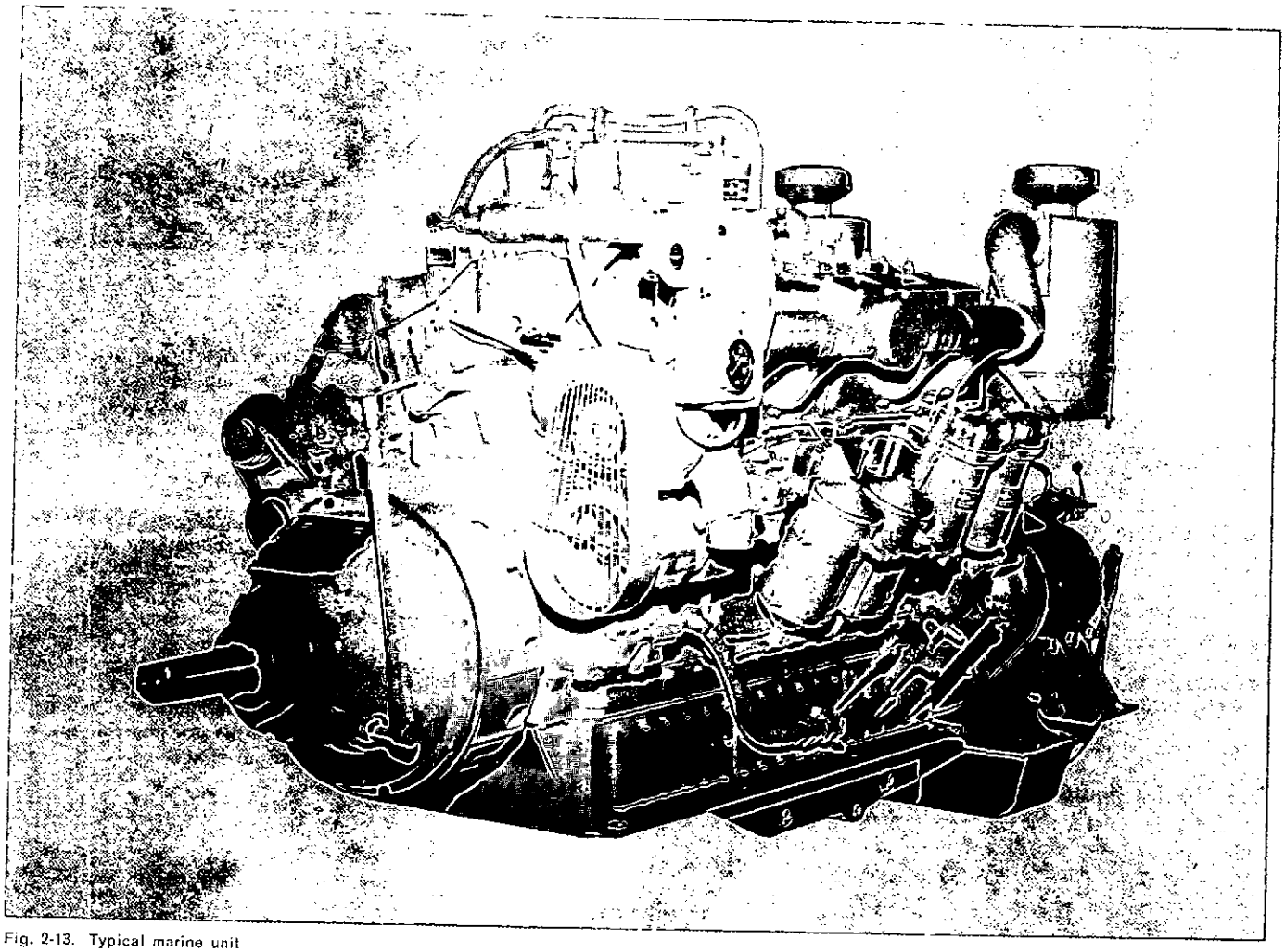


Fig. 2-13. Typical marine unit

V41812

Pleasure boat and work boat engines are rated at a different horsepower output and speed (rpm) for the same model engine, due to continuous duty requirements of work boat. Refer to Table 2-2. Engine break-in, pre-starting checks and operation follow "General Operating Instructions" and include specific instructions listed below.

Prestarting Checks

Check marine gear oil level. The marine gear is a separate unit and carries its own lubrication. Fill housing through filler tube to high-level mark on dipstick gauge with correct viscosity of oil according to specification plate on gear housing.

Check Fresh-Water System

Fill fresh-water expansion tank of heat exchanger with clean fresh water or antifreeze to about one inch from top of tank. This will allow room for expansion when coolant gets warm and eliminates overflow.

Table 2-2: Cummins Marine Diesels

Model	Pleasure boat intermittent duty Bhp-rpm	Work boat continuous duty Bhp-rpm
NVH-450-M	450 @ 2100	290 @ 1800
V12-525-M	525 @ 2100	370 @ 1800
VT12-M	600 @ 2100	390 @ 1800
VT12-700-M	700 @ 2100	455 @ 1800
VT12-825-M	825 @ 2100	535 @ 1800

Open Seacocks

Open seawater inlet and outlet valves to permit seawater flow through heat exchanger.

Starting Procedure

Place marine gear in neutral position and follow general starting procedure and other instructions as follows:

Check Marine Gear Oil Level

Check oil level of marine gear daily. Keep oil level as near "H" mark as possible. Use type and grade of oil specified in marine gear manufacturer's manual.

Note: *Never operate marine gear with oil level below the* "L" mark or above the "H" mark on the dipstick.

Operate By Instruments

1. Tachometer. Do not operate engine above governed rpm. Excessive engine speeds are dangerous and may lead to engine failure.
2. Oil temperature gauge. The oil temperature gauge may read as high as 225° F [107.2° C] with engine at sustained load operation. Under heavy load conditions, lubricating oil temperature may reach 250° F [121.1° C] for a short period. However, a sudden increase, in oil temperature, which is not caused by load increase, is a warning of possible mechanical failure and should be investigated at once.
3. Coolant temperature gauge. A minimum temperature of 165° F [73.9° C] indicates cylinder liners are heated to proper temperature to support good combustion. Engines should be warmed up slowly before applying full-load so pistons will not expand faster than cylinder liners. Piston and liner scoring is often caused by operating at full-load while engine is cold. When coolant temperature is too low, cylinder walls retard heating of air during compression, thereby delaying ignition. This causes delayed combustion, excessive smoke and high fuel consumption.

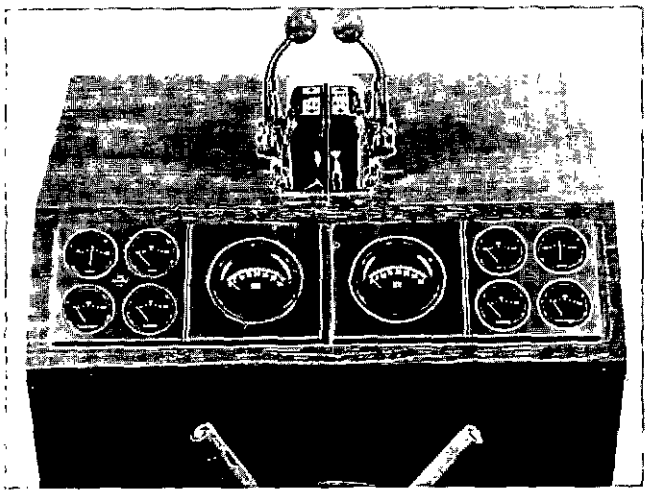


Fig. 2-14. Marine unit instrument panel N11817

Properly operating thermostats are necessary both summer and winter. Avoid long periods of idling and do whatever else is required to keep water temperatures up to minimum of 165° F [73.9° C]. Over-heating problems usually require mechanical corrections. They may be caused by a worn water pump, a clogged cooling system, worn sea water pump, clogged sea water inlet or outlet.

4. Oil pressure gauge. The oil pressure gauge indicates lubricating oil pressure. Shut down engine immediately at loss of oil pressure. Under full load conditions, oil pressure may drop to 40 psi [2.8120 kg/sq cm] and oil temperature may reach 250° F [121.1° C] for a short period. This is not cause for alarm.

Caution: Any sudden increase in oil temperature, which is not caused by load increase, is a warning of possible mechanical failure and should be investigated at once.

Marine Gear

Movement of a single lever on control valve to neutral, forward or reverse controls marine gear operation. If so desired, control lever may be interlocked with throttle; therefore, marine gear may be shifted to forward or reverse before throttle is moved from idle position and returned to neutral when throttle is closed. The use of an interlock system is mandatory when pilot house control is used and no engineer is present in engine room.

Check Marine Gear Oil Pressure

If unit is being operated first time, remove pipe plug and attach oil pressure gauge to control valve. Refer to gear manufacturer's manual for specific pressure.

Clutch slippage can be corrected by adjusting oil pump

pressure regulator by adding or removing washer atop pressure regulator spring.

Check Marine Gear For Oil Leaks

Check all hose line connections, fittings, hose, gaskets and oil seals for leaks. If oil seal at rear of gear housing is leaking, tighten bearing retainer cap capscrews.

Check For Misalignment Or Binding

Marine Gear, crankshaft and propeller shaft should have been correctly aligned during initial installation, but if gear becomes overheated or if "hot spots" are detected under full-load condition, it is an indication of gear misalignment or of incorrect bearing or gear clearances. Correct as necessary.

Caution: Never shift control lever to any position with engine running faster than idle speed.

Operating Procedure

1. Operate pleasure craft at 85% of governed rpm for cruising.
2. Operate with a power requirement that will permit marine unit to reach governed rpm under loaded condition. See Table 2-2.

PT (type G) Fuel Pumps With SVS Governor

1. The engine is operated by means of SVS governor lever and "automotive" throttle is set in wide open position during operation.
2. The engine must contain a fuel pump with special limited by-pass governor plunger to prevent "under-shoot" during deceleration, and the fuel pump does not require a torque spring.
3. An overspeed stop must be used in unattended applications, and in attended installations the "automotive" throttle should be set so it will act as a positive shut-down, if no other overspeed stop is used.

Caution: When automotive throttle is used as a positive shutdown, it must not be used except in an emergency to shut down the engine; at all other times the throttle should remain in wide open position.

Industrial Applications

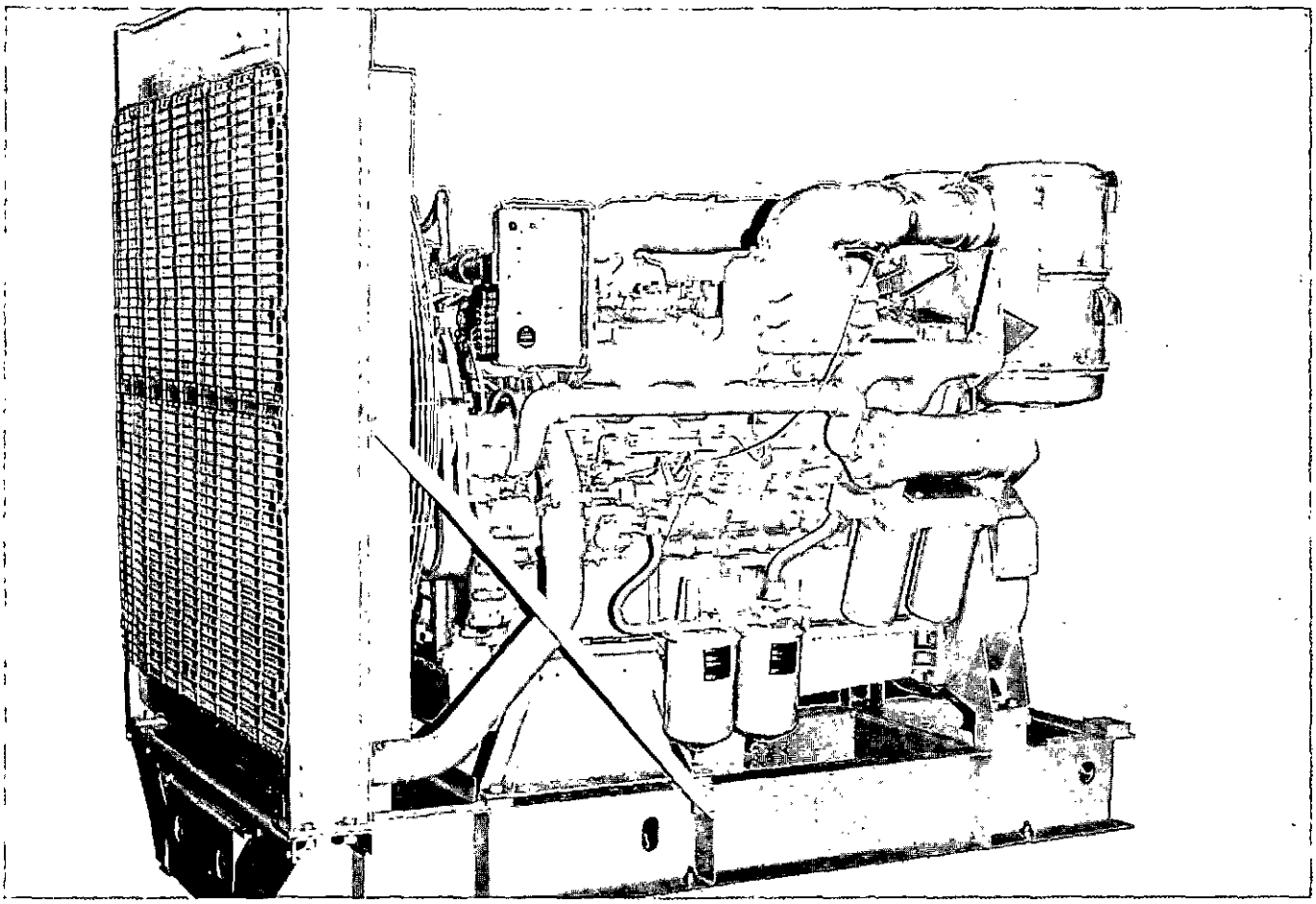


Fig. 2-15. Typical industrial unit

V41813

Engine break-in, prestarting checks and operation follow "General Operating Instructions" and include additional specific instructions listed below.

Prestarting Checks

1. Check torque converter oil level, when used; maintain oil level as near as possible to "H" (high) level mark on dipstick. Fill converter with grade of oil listed on torque converter specification plate.
2. On stationary units check for proper alignment of engine to driven unit.

Operation

1. Observe torque converter temperature gauge. Operating range is 180° F to 230° F [82.2° C to 110° C]. Temperature should not be allowed to exceed 250° F [121.1° C].
2. Observe torque converter oil pressure gauge. Operate with pressure as specified by converter manufacturer listed on converter specification plate.

Hydraulic Governor Applications With SVS Governor PT (type G) Fuel Pump

1. SVS governor is used in combination with hydraulic governor in industrial installations to bring engine speed down from rated, where it is normally maintained by hydraulic governor, for engine warm-up.
2. Idle speed, or warm-up, should be set at 1000 rpm or above with the SVS governor.

Table 2-3: Industrial Power Unit Specifications

Model	Max. HP @ RPM	Cont. HP @ RPM
V12-525	525 @ 2100	361 @ 1800
VT12-600	600 @ 2100	410 @ 1800
VT12-700	700 @ 2100	475 @ 1800

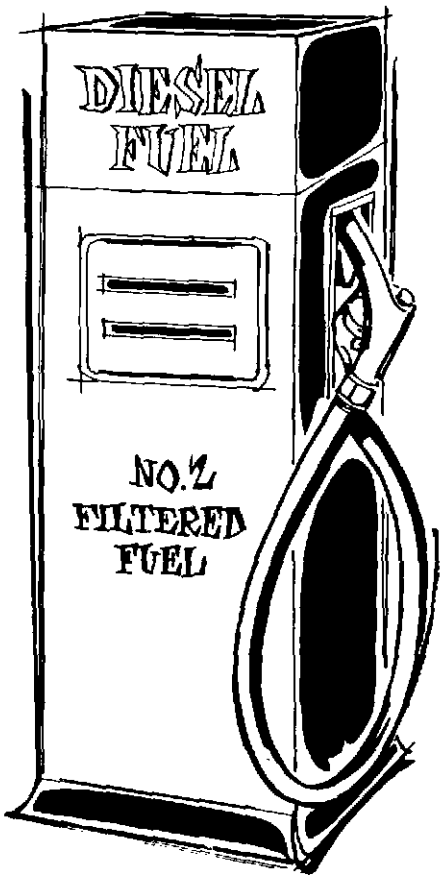
Table 2-4: Torque Converter Power Unit Specifications

Model	Max. HP. @ RPM (sea level, 60° F [15.6° C])	Approximate Converter Output at 500 Ft [152.4000 m], 85° F [29.4° C]	
		Max. HP.	Cont. HP.
V12-525-TC	525 @ 2100	387	340
VT12-600-TC	600 @ 2100	458	390
VT12-700-TC	700 @ 2100	535	455

Specifications

Providing and maintaining an adequate supply of clean, high-quality fuel, lubricating oil, grease and coolant in an engine is one way of insuring long life and satisfactory performance.

Fuel Oil Specifications

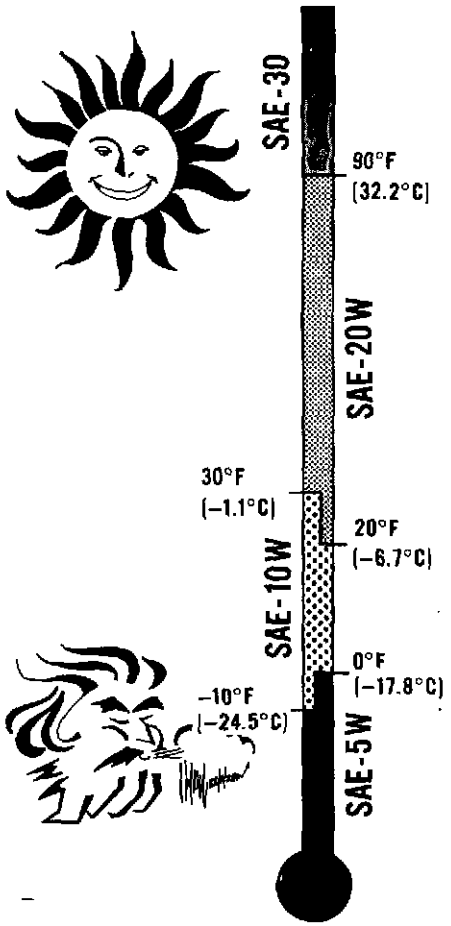


Fuel oil serves two purposes in a Cummins Diesel: It supplies the energy for the work done by the engine and it lubricates many of the fuel system parts. Fuel oil, commonly referred to as No. 2 Diesel Fuel, should be a neutral distillate petroleum oil, free from suspended matter, and not a mixture of light oil and heavy residue.

Physical and chemical properties should meet the following requirements:

Viscosity @ 100°F.	Centistokes: 2.4 to 5.0, or Saybolt Universal: 34 to 42.
Gravity	30 to 42 degrees A.P.I. at 60°F.
Cetane Number	40 minimum except that in warm weather and where no starting difficulties are encountered, the cetane number may be lower.
Pour Point	10°F. below lowest temperature expected.
Bottom Sediment and Water	Not to exceed .05% of weight.
Distillation	At least 10% should distill below 460°F. At least 90% should distill below 675°F. End point should not exceed 725°F. Minimum recovery 98%.
Conradson Carbon Residue	Not to exceed .25% on 10% bottoms.
Ash	Not to exceed .02% of weight.
Sulphur	Not to exceed 1% of weight.
Copper Strip Corrosion	Must pass test 3 hours @ 122°F.

Lubricating Oil Specifications



Cummins Engine Company, Inc., recommends that owners of Cummins Diesels give special consideration to use of heavy-duty oils developed for use in diesel engines. Under normal conditions, the oil used should meet the requirements of U. S. Military Specifications Mil-L-2104-A. The responsibility for meeting these specifications, the quality of the product and its performance must necessarily rest with the oil supplier. Cummins Engine Company, Inc., does not recommend any specific brand of lubricating oil. Many brands which meet specifications following are listed in the "Lubricating Oils for Industrial Engines" booklet published by The Internal Combustion Engine Institute (Room 1516 - 201 N. Wells Street, Chicago, Illinois 60606).

Mil-L-2104-A and/or British Defense Spec. DEF-2101B

Recommended for engines operating under normal conditions and where sulphur content of the diesel fuel is from 0.5% to 1% content by weight.

Supplement 1 (SI)
Recommended where a fuel with a corrosive sulphur content in excess of 1% is used. These oils have a higher additive level than Mil-L-2104-A.

Mil-L-2104-B

These oils meet or exceed the levels of Supplement 1 oils and may be used in Cummins Engines to provide additional sludge and rust protection.

Series 3 (Mil-L-45199)

These are premium oils and are not required for Cummins Engines except under very unusual operating conditions. Do not use in applications where exhaust valve deposits are encountered.

Viscosity Recommendations

Except in extreme climates most engine operation will be in the range of — 10° F [— 23° C] to 90° F [32.2° C]; oil viscosity should be as follows:

SAE 10W — temperatures consistently between — 10° F [— 23° C] and 30° F [— 1.1° C].

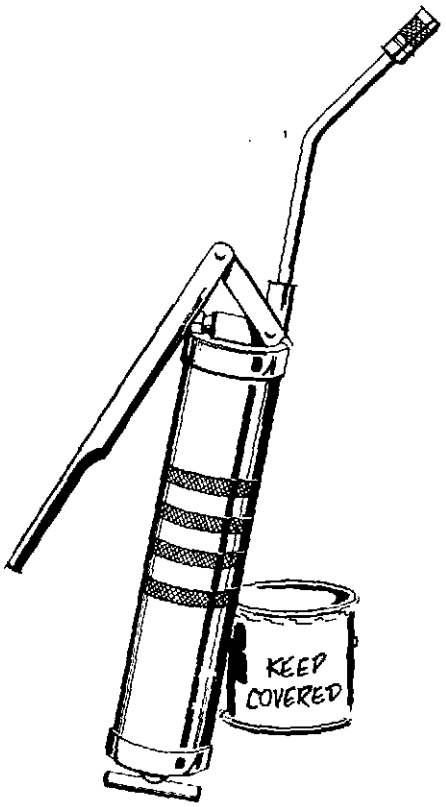
SAE 20—temperatures consistently between 20° F [—6.7° C] and 90° F [32.2° C].

SAE 30 — temperatures above 90° F [32.2° C].

Where temperatures are not above 0° F [— 17.8° C], SAE 5W oils meeting the requirements of Mil-L-10295 may be used. However, in heavily loaded applications it may be necessary to use one grade heavier oil to maintain minimum recommended oil pressures of engine being operated.

Oil which is best for general operation is also best for the "break-in" period. No change in oil viscosity or type is needed for new or newly rebuilt engines. Do not mix brands or grades of oil in the engine. Choose carefully the best oil available and continue to use that brand consistent with above conditions and engine wear.

Grease Specifications



Longer service, less maintenance and more effective lubrication are possible when a high-quality engine accessory grease is used. Cummins Engine Company, Inc., recommends use of grease meeting the specifications of Mil-G-3545, excluding those of sodium or soda soap-type thickeners. Contact your lubricant supplier for grease meeting these specifications.

High-Temperature Performance		
Dropping point, °F	ASTM D 2265	350 min.
Bearing life, hours at 300°F, 10,000 rpm	*FTM 331	600 min.
Low-Temperature Properties		
Torque, GCM	ASTM D 1478	
Start at 0°F		15,000 max.
Run at 0°F		5,000 max.
Rust Protection and Water Resistance		
Rust test	ASTM D 1743	Pass
Water resistance, %	ASTM D 1264	20 max.
Stability		
Oil separation, % 30 Hours @ 212°F	*FTM 321	5 max.
Penetration		
Worked	ASTM D 217	250-300
Bomb Test, PSI Drop	ASTM D 942	
100 Hours		10 max.
500 Hours		25 max.
Copper Corrosion	*FTM 5309	Pass
Dirt Count, Particles/cc	*FTM 3005	
25 Micron +		5,000 max.
75 Micron +		1,000 max.
125 Micron +		None
Rubber Swell	*FTM 3603	10 max.

*Federal Test Method Standard No. 791a.

Caution: Do not mix grades or brands of grease as damage to bearings may result. Excessive lubrication is as harmful as inadequate lubrication.

Coolant Specifications

Water should be clean and free of any corrosive chemicals such as chlorides, sulphates and acids. It should be kept slightly alkaline with pH value in range of 8.3 to 9.5. Any water which is suitable for drinking can be treated as described in the following paragraphs for use in an engine.

Install and/or maintain the Cummins Corrosion Resistor on the engine. The resistor by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically. In addition, a sacrificial metal plate arrests pitting of metals in the system by electro-chemical action. *The resistor is available from any Cummins Distributor or Dealer.*

In Summer (No Anti-freeze)

1. Use the corrosion resistor with chromate element(s), Part No. 132732. Do not use elements 168481 (PAF) with plain water.
2. Replace corrosion resistor element(s) as recommended in Section 5 of this manual.
3. If no corrosion resistor is used, add ½ oz [14.1747 g] chromate compound in the system for every U.S. gal [3.785 lit] of water or until the coolant mixture meets requirements indicated in Section 5 under "Check Engine Coolant".

In Winter (Using Anti-freeze)

1. Select an anti-freeze known to be satisfactory for use with the chromate element of the corrosion resistor and continue to use the 132732 resistor element(s) or;
2. If you are not sure the anti-freeze is compatible with the chromate resistor element 132732:

a. Use anti-freeze, in percentage to prevent freezing, with PAF (168481) element(s) in the corrosion resistor.

b. Use only anti-freeze, with compounded inhibitors, in proper percentage and follow anti-freeze supplier's recommendation to prevent corrosion.

c. Check corrosion control by draining a sample of coolant from the system as described under "Check Engine Coolant".

d. If there has been a loss of corrosion control, change anti-freeze.

Caution: Never use soluble oil in the cooling system when a Corrosion Resistor is being used.

Trouble Shooting

Trouble shooting is an organized study of the problem and a planned method of procedure for investigation and correction of the difficulty. The chart on the following page includes some of the problems that an operator may encounter during the service life of a Cummins Diesel Engine.

Cummins Diesel Engines

The chart does not give all the answers for correction of problems listed, but it is meant to stimulate a train of thought and indicate a work procedure directed toward the source of trouble. To use the trouble-shooting chart, find the complaint at top of chart; then follow down that column until you come to a black dot. Refer to left of dot for the possible cause.

Think Before Acting

Study the problem thoroughly. Ask these questions:

1. What were the warning signs preceding the trouble?
2. What previous repair and maintenance work has been done?
3. Has similar trouble occurred before?
4. If the engine still runs, is it safe to continue running it to make further checks?

Do Easiest Things First

Most troubles are simple and easily corrected; examples are "low-power" complaints caused by loose throttle linkage or dirty fuel filters, "excessive lube oil consumption" caused by leaking gaskets or connections, etc.

Always check the easiest and obvious things first; following this simple rule will save time and trouble.

Double-Check Before Beginning Disassembly Operations

The source of most engine troubles can be traced not to one part alone but to the relationship of one part with another. For instance, excessive fuel consumption may not be due to an incorrectly adjusted fuel pump, but instead to a clogged air cleaner or possibly a restricted exhaust passage, causing excessive back pressure. Too often, engines are completely disassembled in search of the cause of a certain complaint and all evidence is destroyed during disassembly operations. Check again to be sure an easy solution to the problem has not been overlooked.

Find And Correct Basic Cause Of Trouble

After a mechanical failure has been corrected, be sure to locate and correct the cause of the trouble so the same failure will not be repeated. A complaint of "sticking injector plungers" is corrected by replacing the faulty injectors, but something caused the plungers to stick. The cause may be improper injector adjustment, or more often, water in the fuel.

TROUBLE SHOOTING

CUMMINS ENGINES

CAUSES	Complaints: Hard Starting or Failure to Start	Engine Misses	Excessive Smoking at Idling	Excessive Smoke Under Load	Low Power or Loss of Power	Cannot Reach Governed RPM	Low Air Output	Excessive Fuel Consumption	Poor Deceleration	Erratic Idle Speeds	Engine Dies	Surging at Governed RPM	Excessive Lube Oil Consumption	Crankcase Sludge	Dilution	Low Lubricating Oil Pressure	Coolant Temperature too Low	Coolant Temperature too High	Lube Oil too Hot	Piston, Liner and Ring Wear	Worn Valves and Journals	Fuel Knocks	Mechanical Knocks	Gear Train Whine	Excessive Engine Vibration
AIR SYSTEM																									
Restricted Air Intake	●		●	●			●																		
High Exhaust Back Pressure			●	●			●										●								
Thin Air In Hot Weather or High Alt.			●	●																					
Air Leaks Between Cleaner & Engine																				●	●	●			
FUEL SYSTEM																									
Out of Fuel or Fuel Shut-Off Closed	●									●															
Poor Quality Fuel	●	●	●	●			●			●												●			
Air Leaks In Suction Lines	●	●		●					●		●											●			
Restricted Fuel Lines: Stuck Drain Valve	●	●	●	●	●	●		●	●																
External or Internal Fuel Leaks								●							●										
Plugged Injector Spray Holes	●	●	●	●	●			●		●															
Broken Fuel Pump Drive Shaft	●										●														
Scored Gear Pump or Worn Gears	●				●																				
Loose Injector Inlet or Drain Connection	●														●										
Wrong Injector Cups			●	●	●			●																	
Cracked Injector Body or Cup								●							●										
Mutilated Injector Cup "O" Ring								●							●										
Throttle Linkage					●	●																			
Incorrectly Assembled Idle Springs									●	●															
Governor Weights Assembled Incorrectly											●														
High-Speed Governor Set Too Low					●	●																			
Water in Fuel	●	●				●					●														
LUBRICATING SYSTEM																									
External and Internal Oil Leaks													●	●											
Dirty Lube Oil Strainer													●							●	●				
Faulty Cylinder Oil Control			●	●									●	●						●					
Clogged Oil Drillings																				●	●	●			
Oil Suction Line Restriction															●					●	●	●			
Faulty Oil Pressure Regulator															●										
Crankcase Low or Out of Oil															●			●		●	●	●			
Wrong Grade Oil for Weather Conditions													●		●										
COOLING SYSTEM																									
Insufficient Coolant															●			●	●						
Worn Water Pump															●			●	●						
Faulty Thermostats														●	●		●	●	●						
Damaged Water Hose															●			●	●						
Loose Fan Belts															●			●	●						
Radiator Shutters Stuck Open														●			●								
Clogged Water Passages															●			●	●						
Internal Water Leaks															●										
Clogged Oil Cooler															●				●						
Radiator Core Openings Dirty															●			●	●						
Air in Cooling System															●			●	●						
Exterior Water Leaks															●			●	●						
Insufficient Radiator Capacity															●			●	●						
OPERATION AND MAINTENANCE PRACTICES																									
Dirty Filters and Screens					●									●						●	●	●			
Long Idle Periods	●	●	●	●	●									●	●										
Engine Overloaded				●				●							●			●	●	●	●	●	●		
Lube Oil Needs Changing														●						●	●	●			
Engine Exterior Caked with Dirt															●			●	●						
MECHANICAL ADJUSTMENTS OR REPAIR																									
Gasket Blow-by or Leakage			●	●	●										●										
Faulty Vibration Damper																							●		●
Unbalanced or Loose Flywheel																							●		●
Valve Leakage	●	●			●																●				
Broken or Worn Piston Rings			●	●	●									●						●			●		
Incorrect Bearing Clearances					●			●								●					●		●	●	
Excessive Crankshaft End Clearance																					●		●	●	
Main Bearing Bore Out of Alignment																					●		●		●
Engine Due for Overhaul	●		●	●	●			●						●		●				●	●	●	●	●	●
Damaged Main or Rod Bearings																●					●		●		
Broken Tooth In Gear Train																							●	●	
Excessive Gear Back Lash																							●	●	
Misalignment Engine to Driven Unit								●													●			●	●
Loose Mounting Bolts																							●		●
Incorrect Valve and Injection Timing	●		●	●	●																●	●			
Worn or Scored Liners or Pistons			●	●	●									●						●			●		
Injectors Need Adjustment		●	●	●	●			●		●	●	●										●			

Maintenance Operations

Maintenance is the key to lower operating costs. A diesel engine — like any other engine — requires regularly scheduled maintenance to keep it running efficiently. Most diesel engines are purchased and used for the sake of revenue. Any failure or loss of efficiency reduces revenue as well as requiring additional funds for repair.

Investigate any successful operation where engines are used and you will find a good, regularly scheduled maintenance program in effect.

Maintenance Schedule

Preventive maintenance performed on schedule is the easiest, as well as the least expensive, type of maintenance. It permits maintenance department to do work in the shop on schedule, rather than on the job under poor working conditions and at inconvenient hours.

Accessories must have a place in maintenance schedule the same as basic engine, for an accessory failure may put entire engine out of operation.

A Good Maintenance Schedule Depends On Engine Application

Actual operating environment of engine must govern establishment of maintenance schedule. Some engines operate under rather clean conditions, some under moderately dusty conditions and others under severely dusty or dirty conditions, and each type operation must be analyzed as maintenance schedule is established. A look at suggested check sheet, on the opposite page, indicates some checks (shown by shaded boxes) may have to be performed more often under heavy dust or other special conditions. The schedule is also dependent upon amount of work being done which can best be determined by amount of fuel being burned. A record of gallons of fuel used is the best yardstick to be used in establishing an accurate regular maintenance schedule.

Hours of operation may be used for the same purpose; in so doing you should determine amount of fuel used per hour during normal operation. For example, if the average fuel consumption of a V12 engine is 15 to 20 gallons [56.8 to 75.7 liters] per hour the "B" check would be made every 3750 to 5000 gal. [14193.0000 to 18925.0000 liters] of fuel or approximately every 250 hours of operation.

Extending Maintenance Schedule

Any change of established maintenance schedule should be preceded by a complete re-analysis of the operation. A lubricating oil analysis should be the major factor used in establishing original maintenance schedule and it should be studied before making any change in or extending schedule periods. In extremely dirty and under severe operating conditions, scheduled maintenance period may even need reducing. Again, operation should be re-analyzed and a lubricating oil analysis should be made. Extending or reducing schedule period should be done only after a complete study, basically, the same as used in establishing original maintenance schedule period. Lubricating oil analysis is described on Page 5-11.

Using Suggested Schedule Check Sheet

The maintenance schedule check sheet (on next page) is designed as a guide until you have adequate experience to establish a schedule to meet your specific operation.

A detailed list of component checks is provided through several check periods; also a suggested schedule basis is given for gallons of fuel used and/or hours of operation.

Your maintenance schedule should be established using the check sheet as a guide; the result will be an excellent maintenance program to fit your specific operation.

The check sheet shown can be reproduced by any printer to provide forms for your use. The person making each check can then indicate directly on the sheet (in the blank or shaded box following the operation) that he has completed the operation. When a complete column (under A, B, C etc.) of checks is indicated, the engine will be ready for additional service until the next check is due.

Maintenance Operations Summary Sheet

The maintenance operations summary sheet (at the end of this section) is designed to be used to summarize scheduled maintenance checks for a specific engine, by unit or engine serial number. The summary sheet records operation or check performed, fuel used, mechanic, labor costs, parts used, etc. A complete record of this type is essential

Maintenance Schedule

CHECK SHEET FOR ALL MODELS

EQUIPMENT NO. _____ ENGINE SERIAL NO. _____

MECHANIC _____ MILEAGE, HOURS, GALLONS _____

TIME SPENT _____ CHECK PERFORMED _____

PARTS ORDER NO. _____ DATE _____

As Applicable To Your Unit — Check Each Operation As Done			A	B	C	D	E	F
Suggested Engine Maintenance Interval	Naturally Aspirated	Hours Operation	Daily	250	500	1000	2000	6000
	Turbocharged	Hours Operation	Daily	250	500	1000	2000	6000
	Naturally Aspirated	Gal's Fuel Used	Daily	3750	7500	15,000	30,000	90,000
	Turbocharged	Gal's Fuel Used	Daily	5000	10,000	20,000	40,000	120,000
If Different From Suggested — Insert Your Actual Interval ➡								
Check or Operation	**Engine Application**							
Check Operators Report	All							
Check Leaks and Correct	All							
Check Engine Oil Level	All							
Check Coolant Level	All							
Fill Fuel Tanks	All							
Check Oil Bath Air Cleaner Oil	All							
Clean Pre-Cleaner Dust Pan	Industrial							
Check Marine Gear Oil Level	Marine							
Check Sea Water Pump Oil Level	Marine							
Check Converter Oil Level	Industrial							
Lubricate P.T.O. Bearing	Industrial/Marine							
Drain Sediment From Fuel Filter	All		*					
Clean Dry-Type Air Cleaner Element	All		*					
Change Oil Bath Air Cleaner Oil	All		*					
Change Engine and Aneroid Oil	All							
Change Engine (Full Flow) and Turbocharger Filter	All							
Record Oil Pressure	All							
Lubricate Electrical Equipment	All							
Change Marine Gear Oil, Clean Strainer	Marine							
Check Hydraulic Governor Oil Level, Change Filter	Industrial							
Change Engine By-Pass Oil Filter Element	All			**				
Clean Fuel Tank Breather, Drain Sediment	Industrial/Marine			*				
Check Air and Vent Piping Connections	All			*				
Change Fuel Filter and Check Restriction	All							
Check and Adjust Belt Tension	All							
Change Corrosion Resistor Element/Check Coolant	All							
Check Heat Exchanger Zinc Plugs	Marine							
Change Converter Oil Filter, Clean Strainer	Industrial				*			
Check Inlet Air Restriction	All				*			
Replace Dry-Type Air Cleaner Element	All				*			
Clean Oil Bath Air Cleaner Tray Screen	All				*			
Clean/Change Crankcase Breather Element	All				*			
Clean Air Compressor Breather	All				*			
Check Cooling System Thermal Controls	All							
Check Fan Hub and Drive Pulley	All							
Clean Electrical Units/Tighten Connections	All							
Check Turbocharger For Oil Leaks	All							
Tighten Turbocharger Manifold Mountings	All							
Check Sea Water Pump	Marine							
Clean Aneroid Air Filter	All					*		
Clean Oil Bath Air Cleaner	All					*		
Lubricate Water Pump and Fan Hub	All							
Clean Fuel Pump Screen	All							
Adjust Valves and Injectors	All							
Check Fuel Manifold Pressure	All							
Clean Turbocharger Compressor Side	All							
Check Turbocharger Bearing	All							
Check Alternator/Generator Brushes/Commutator	All							
Check Starting Motor Brushes/Commutator	All							
Steam Clean Engine	All							
Tighten Engine Mountings	All							
Check Engine Blow-By	All							
Check Crankshaft End Clearance	All							
Check Vibration Damper	All							
Change Hydraulic Governor Oil	Industrial							
Clean Cooling System	All		Spring and Fall					
Check Engine Preheater	All		Spring and Fall					
Check Clutch Adjustment	All		As Required					
Clean Injectors and Inlet Screens	All		As Required					

Major Inspection—Perform Using Engine Shop Manual Wear Limits As Guide

Notes: * Under extremely dusty conditions perform at the more frequent interval shown.
** All other than Cummins Fleetguard element.

to perform a thoroughly efficient cost record of the operation.

Maintenance — Standby Service Engines

For units in standby service, or when hours of operation fall far below those listed, adjust the maintenance schedule accordingly as follows and with due consideration:

1. Monthly perform A checks.
2. Every 3 months, perform B checks.
3. Every 6 months, perform C checks.
4. Yearly, perform D checks.

Lubricating oil standing in engines that are used infrequently or are in storage between seasons may tend to oxidize and require changing even though it is not dirty. Laboratory testing is the best way to determine whether oil or fuel is oxidizing under these conditions, and we suggest that oil be checked regularly. After several tests it will be possible to schedule oil changes where the oil is not actually being contaminated due to dirt.

Units in standby service should be started once each week in locations where ambient temperature remains below 70°F [21.1°C] and contains a high percentage of humidity. Start engine and bring unit up to normal operating temperature and run for approximately thirty minutes. Check electrical equipment for corrosion on all relays and switch terminals. Check controls for leaks and proper operation.

With units in locations where ambient temperature is normally above 70° F [21.1° C], perform starting procedure as above once every two weeks.

The above procedures are only recommendations; therefore, the operator must take into consideration the environment of his particular unit installation.

A—Maintenance Checks

Check Operator's Report (A Check)

Check operator's daily or trip reports, and investigate and correct reported cases of:

1. Low lubricating oil pressure.
2. Low power.
3. Abnormal water or oil temperature.
4. Unusual engine noises.
5. Excessive smoke.
6. Observe all instruments and gauges (with coolant temperatures in operating range) with engine running at most applicable speed; take any corrective action required.

Check Oil Leaks And Correct (A Check)

Check for evidence of external oil leakage. Tighten capscrews, fittings, connections or replace gaskets as necessary to correct. Check oil dipstick (1, Fig. 5-1) and filler tube caps (2). See that they are tightened securely.

Check Fuel Leaks And Correct (A Check)

1. Check for evidence of fuel leakage.

a. Check fuel pump and filter.

b. Check fuel supply line and connections at fuel tank, fuel filter and fuel pump.

c. Check fuel inlet tube and connections at fuel pump shutdown valve.

d. Check all fuel supply and drain lines, connections and fittings on cylinder heads.

e. Check fuel lines and tubing between engine and fuel tank(s).

2. If there are indications of air leaks on suction side of fuel pump, check for air leaks by placing a sight gauge (1, Fig. 5-2) in the line between fuel filter(s) and pump. Bubbles over ½ in. [1.270 cm] long or "milky" appearance indicates an air leak. Find and correct.

Check Coolant Leaks And Correct (A Check)

Check for evidence of external coolant leakage. Tighten capscrews, hose clamps, fittings and connections or replace gaskets or hose as necessary to correct.

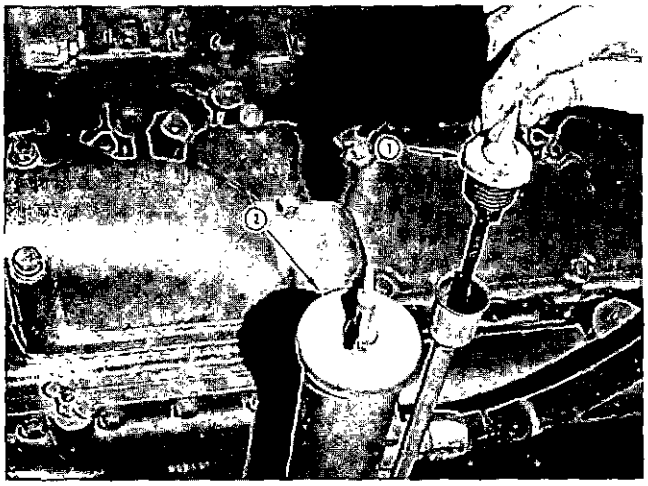


Fig. 5-1. Lubricating oil filler tube V40736

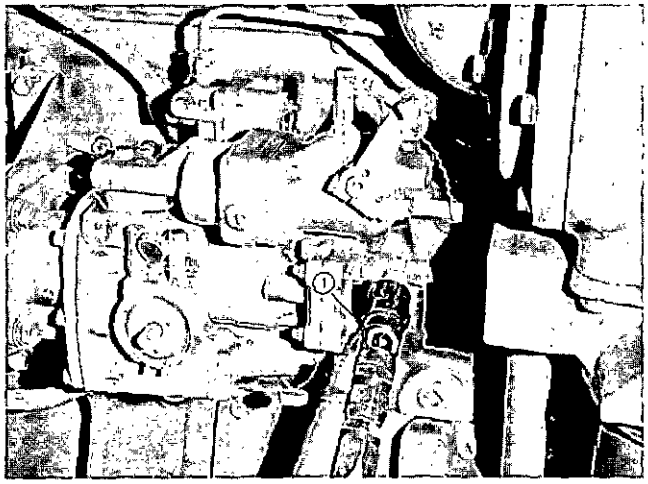


Fig. 5-2. Sight gauge in fuel suction line V41923

Check Air Connections (A Check)

Visually check air system connections for leaks or damage while making other visual checks.

The diesel engine requires hundreds of gallons (liters) of air for every gallon (liter) of fuel that it burns. For engine to operate efficiently, engine must breathe freely; intake and exhaust systems must not be restricted.

Valves, pistons and rings must seal properly against compression and combustion pressures.

The amount of fuel that can be burned and power developed is as dependent upon air as fuel. If there is too little air to burn all the fuel, the excess fuel causes a smoky exhaust — high exhaust temperatures and a loss of horsepower.

Wasted fuel is not the only loss caused by incomplete combustion. The excess fuel washes lubricating oil off cylinder walls resulting in seized pistons and bearing failures. Carboned injector cup spray holes and stuck piston rings are other troubles which result from insufficient air. Dirty air cleaner elements, leaky valves, worn rings, damaged silencers and air piping that is too small or with sharp bends are common causes of air restriction. Therefore, it is necessary to perform air system maintenance regularly as follows.

When engines operate under extremely dusty conditions, adjust the maintenance intervals to those indicated by shaded blocks in the check sheet on Page 4-2.

Engine Oil Level (A Check)

1. Check oil level with dipstick oil gauge located on the engine. For accurate readings, oil level should not be checked for approximately 30 minutes after engine shutdown. Keep dipstick with the oil pan with which it was originally shipped. Keep oil level as near "H" mark as possible. Fig. 2-2.

   Note: Some dipsticks have dual markings, with high- and low-level marks: static oil marks on one side, engine running at low idle speed marks on opposite side. Be sure to use proper scale.

   Caution: Never operate the engine with oil level below the "L" mark or above the "H" mark.

2. Add oil as necessary of the same quality and brand as already in engine. See Page 3-2.

Lubricating oil performs four functions in an engine:

1. Reduces friction (heat and wear) by providing a film between bearing surfaces.
2. Scavenges by picking up carbon and other small particles, carrying them to the oil filter where they are taken out of circulation.
3. Cools pistons, liners and bearings and absorbs heat from the engine. This heat is then dissipated by radiation from the pan and by an oil cooler. It is important that air be free to flow around the oil pan.
4. Completes the seal of rings to pistons and cylinder walls.

There are two broad classes of lubrication failures:

1. Those caused by running an engine without or low on oil, resulting in seizures of pistons or bearings within minutes.
2. Failures due to poor or marginal lubrication, from low oil pressure, dilution, partially clogged oil passages and dirty or clogged lubricating oil filters or improper clearances.

Fill Cooling System (A Check)

Keep cooling system completely filled. Check coolant level daily or at each fuel fill point. Investigate for cause of coolant loss. Recheck the level after engine reaches normal operating temperature. At operating temperature the thermostat is open and water is free to circulate to all parts of the system and fill all air pockets. Requirements of a good coolant are described on Page 3-4.

Many operators have been shocked to find water in crankcase and to learn it got there through "pin holes" or pitted areas that started on water side of cylinder liners.

This "eating away of metal" or corrosion, as it is commonly called, is likely to occur in any heating or cooling system. Corrosion may or may not be associated with iron rust, and as a result may not show up in the coolant.

Research has shown there are many causes of corrosion and among the most serious are acid, salt or aeration of the coolant. Acid and salt can be controlled by a properly maintained corrosion resistor as described in the following paragraphs entitled "Check Engine Coolant (C Check)".

Aeration refers to air bubbles which may be drawn into radiator core tubes, then into water pump and engine. The worst effect of aeration is loss of water pump prime due to an accumulation of air resulting in complete flow stoppage. Entrained air promotes accelerated internal corrosion. Entrained air in coolant will increase the temperature differential from combustion gases to water due to reduction in heat transfer.

An open (non-baffled) radiator top tank is often the cause of air entering the system. Due to high velocity of coolant entering top tank, the surface becomes very agitated and tends to draw air into core tubes along with coolant. It is very difficult on many units to completely fill cooling system at initial fill; this is due to trapping of air in pockets in engine or other parts of the system. The system should be bled of air or refilled after a short period of operation to purge air from the coolant.

Fill Fuel Tanks (A Check)

Always filter or strain fuel before or while putting it in tank. See "Fuel Oil Specifications", Page 3-3.

In cold weather, water which accumulates in the fuel system will sometimes freeze and block the supply of fuel.

This condition can be prevented by adding one quart of denatured alcohol to each 50 gal. [189.250 lit.] of fuel oil. This not only prevents the water from freezing, but allows it to go into solution with the alcohol and fuel oil so it can pass through the fuel system and be "burned" without doing any damage.

Fuel should always be strained or filtered before being put into the supply tank. This will lengthen the life of the engine fuel filter and reduce the chances of dirt getting into the fuel pump.

Fuel filter elements are designed to trap dirt and sediment that has entered the fuel system. A filter that has been allowed to become dirty and clogged from overuse will be more of a handicap than help to an engine. It will allow damaging sediment and dirt to circulate through the fuel system and will restrict the flow of fuel, thus reducing horsepower output.

Excessive amounts of water in the fuel will cause rusting and corrosion in the injectors as well as to fuel pump shafts, bearings and other parts. In some sections it is difficult to purchase fuel which does not contain some water. Normal condensation, either in the storage tank or in the fuel tank, increases water content. This water, of course, must be filtered out or drained off before it gets into the fuel pump. The life of a fuel pump and injectors can be considerably extended if the operator takes the precaution of draining about a cup of fuel from the lowest point in the fuel system before starting the engine each day.

Drain plugs are located in the bottom of some fuel filter cases, and in the sump of the fuel supply tank. More condensation of water vapor occurs in a partially filled fuel tank than in a full one. Therefore, fuel supply tanks should be kept as nearly full as possible. Warm returning fuel from the injectors heats the fuel in the supply tank. If the fuel level is low in cold weather, the upper portion of the tank not being heated by returning fuel tends to increase condensation. In warm weather both the supply tank and fuel are warm. In the night, however, the cool air lowers the temperature of the tank much more rapidly than the temperature of the fuel. Again this tends to increase condensation.

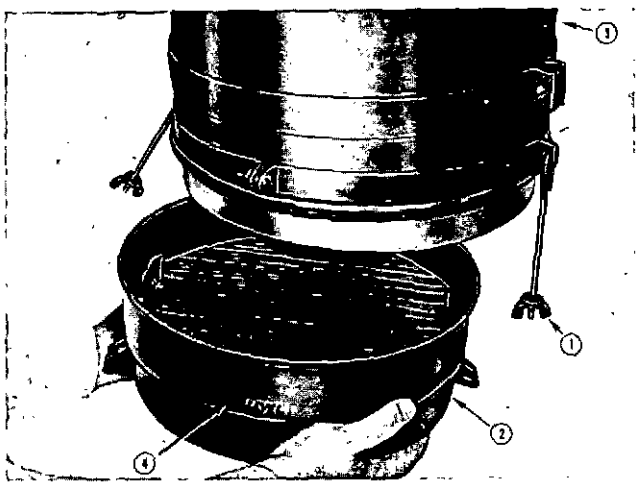


Fig. 5-3. Oil level in air cleaner N11001

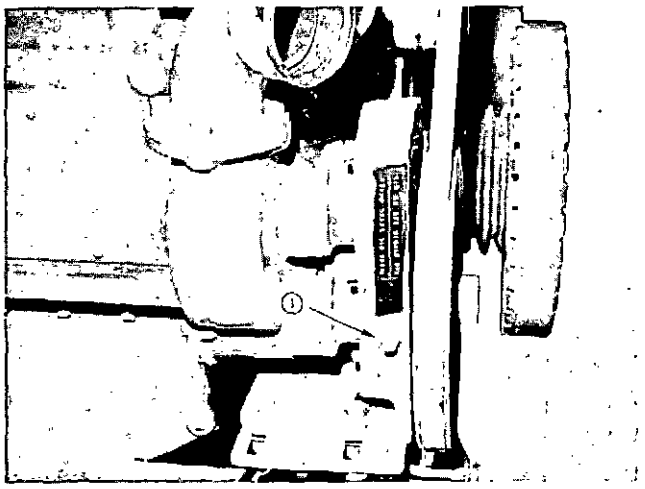


Fig. 5-4. Check oil level in sea water pump V41819

Check Air Cleaner Oil Level (A Check)

Daily, check oil level (4, Fig. 5-3) in oil bath air cleaner (3) to be sure oil level in oil cup (2) is at indicated mark. To remove oil cup, loosen wing nuts (1). During wet weather and in winter months, excessive moisture in air cleaner oil sometimes causes cleaner to become flooded and results in oil pullover or plugging of the bottom air cleaner screen. Add or change oil as necessary. This is especially important if oil bath cleaner is the only cleaner on the engine.

Clean Pre-Cleaner And Dust Pan (A Check)

On engines working under extremely dirty conditions an air pre-cleaner may be used. Clean pre-cleaner jar and dry-type air cleaner dust pans daily or oftener as necessary depending on operating conditions.

Check Marine Gear Oil Level (A Check)

Check oil level of marine gear daily. Keep oil level as near "H" mark as possible.

Note: Never operate marine gear with oil level below the "L" mark or above the "H" mark on the dipstick.

Check Sea Water Pump Oil Level (A Check)

Check oil level by removing plug (1, Fig. 5-4). Fill with hypoid SAE 90 oil when pump with oil sump is used.

Check Converter Oil Level (A Check)

Different models of equipment may vary in the manner in which oil level check is made — either with a dipstick, a level plug or a petcock. Oil level should be maintained at full. If needed, add oil according to oil specifications on nameplate.

1. Cold Check:

   The cold check (engine not running) insures there is sufficient oil in system to start engine — especially if equipment has been standing idle for a long period of time. Be sure oil is at high level.

2. Hot Check:

   The hot check should be made at operating temperature, with the engine running from 600 to 1000 rpm and with the transmission in neutral range.

3. If the converter is operating in combination with a Torqumatic transmission, the oil level check is made at the transmission.

Lubricate Power Take-Off And Clutch Throw-Out Bearing (A Check)

Power Take-Off

Apply a small amount of any high-grade soda base, short fiber, heat resistant, gun lubricant grease once a day through fitting on tapered part of housing to throw-out collar.

Manual Spring-Loaded Input Disconnect Clutch

Approximately once a week, lubricate the release bearings with two "shots" from a grease gun using above grease. Two grease fittings are usually provided atop the clutch housing.

B—Maintenance Checks

Drain Sediment From Filter (B Check)

Perform at A Check under extremely dusty conditions.

1. *Open drain cocks (1, Fig. 5-5), if used, at bottom of fuel* filter case and drain out any accumulated water and sediment. Tighten the drain cock. If drain plug is used, tighten to 5 to 10 ft lb [0.6915/1.3830 kg m].
2. Unscrew throw-away type elements (without drain cock); dump water and sediment. Fill new element with clean fuel and replace.

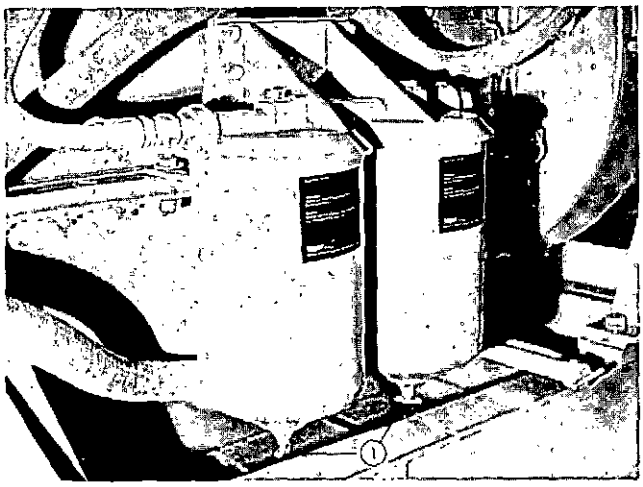


Fig. 5-5. Open drain cocks in fuel filter

Clean Dry-Type Cleaner Element (B Check)

Perform at A Check under extremely dusty conditions.

The paper element (6, Fig. 5-6) in a dry-type air cleaner (3) may be cleaned several times by using a compressed air jet to blow off dirt. Do not hold air jet too close to paper element or damage to element will result. Wing nut (1) secures bottom cover (2) to housing with center bolt (4). When installing element, make sure it seats on gasket at air cleaner outlet end (7).

Caution: Holes in element of a dry-type air cleaner render cleaner inoperative. Do not use damaged cleaner element.

Clean Composite And Cyclonic Dry-Type Cleaner Element (B Check)

Perform at A Check under extremely dusty conditions.

Composite cleaners combine a centrifugal cleaning stage with a paper filter element. Fig's. 5-7 and 5-8.

Air enters cleaner through an inlet on side of cleaner and passes into a tube. Vanes on tube impart a cyclonic twist to air which throws dust particles to the outside.

The separated dust collects in pan (2, Fig. 5-7) at bottom of cleaner while clean air passes up through center of tube to a paper filter (4, Fig. 5-7) (3, Fig. 5-8). The paper filter then removes any small dust particles remaining in the air. Before disassembly, wipe dirt from cover and upper portion of air cleaner. To clean composite-type:

1. Loosen clamps and remove cover (1, Fig. 5-7).
2. *Unscrew wing bolt holding inner cover and element in po-*

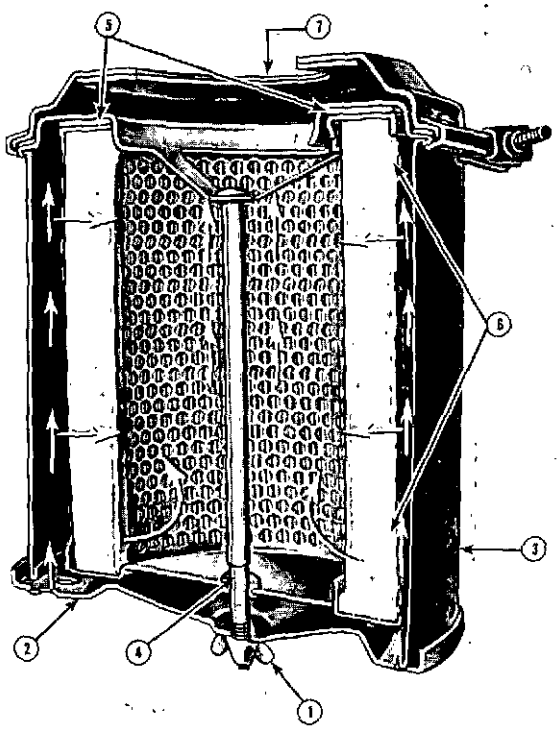


Fig. 5-6. Air cleaner — dry type N11003

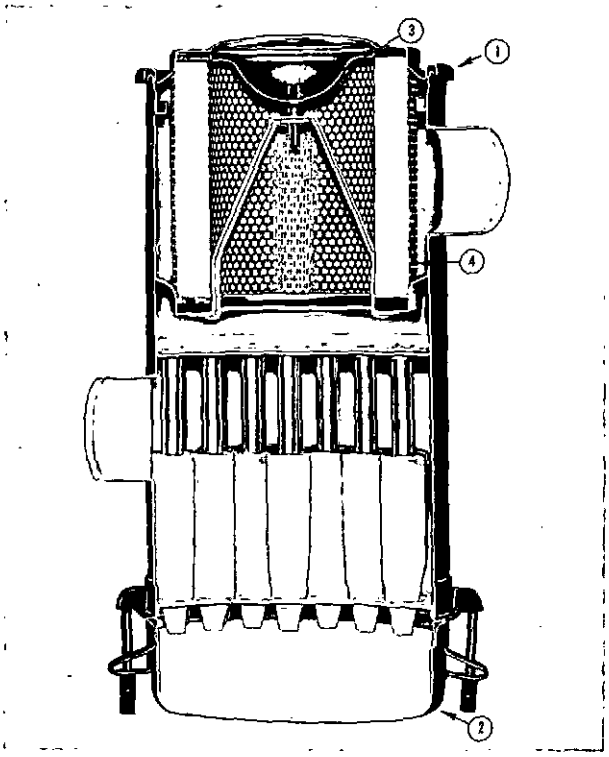


Fig. 5-7. Air cleaner — composite type V11004

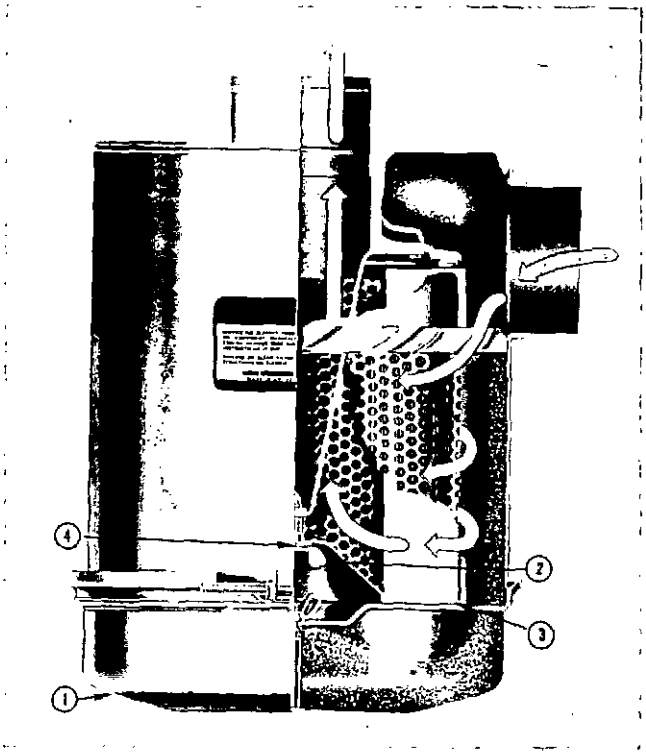


Fig. 5-8. Air cleaner — centrifugal type V11005

sition; remove element carefully so loose dirt will not fall into chamber (3, Fig. 5-7) (2, Fig. 5-8).

3. Remove dust cup (2, Fig. 5-7) (1, Fig. 5-8) and clean.
4. Tap side or bottom ring of element with palm of hand or soft hammer.
5. Blow out element from clean air side with compressed air.

Caution: Air pressure should not be more than 100 psi [7.0310 kg/sq cm] to avoid rupturing element. Do not concentrate air pressure in one spot.

6. Wash element with non-sudsing household detergent and warm water, preferably 120/140° F [48.9/60.0° C]. Dry with compressed air, approximately 40 psi [2.8124 kg/sq cm].
7. Remove retainer clamp. Separate upper and lower bodies; remove "O" ring.
8. Hold element up to light and inspect tubes for dust deposits. Remove dust with stiff fiber brush.
9. Inspect gaskets and "O" rings; discard if worn or mutilated.
10. Inspect element after cleaning to be sure there are no holes in filter.
11. Position upper body with gasket on lower body; secure with retainer clamp.
12. Install element and inner cover in position.
13. Be sure gasket washer is in place under wingnut before tightening.
14. Install cover.
15. Install dust cup.

Cartridge-Type Air Cleaner (B Check)

1. The best method to tell when to change any dry-type air cleaner is by use of a Filter Restriction Indicator which clearly indicates when the element is loaded. Fig. 5-25. Other indications are a loss of engine power or excessive smoke in exhaust gases.
2. Cartridge changes can be scheduled, but due to wide variations in dust and weather conditions, even in the same location, changing "as required" is usually more economical.
3. The Filter Restriction Indicator, Fig. 5-24, signals when to change cartridges. The flag in window gradually rises as cartridge loads with dirt. Do not change cartridge until flag reaches top and locks in position. When locked, flag will remain up after engine is shut down. Change cartridge when flag locks at top. After changing cartridge reset indicator by pushing Re-Set Button. Push button all the way in firmly, then release. If button sticks, repeat pushing slowly.
4. Loosen wing nuts (4, Fig. 5-9) on air cleaner housing (3). Loosen "U" bolt clamp securing pre-cleaner to aspirator tubing. Remove pre-cleaner panel (1).

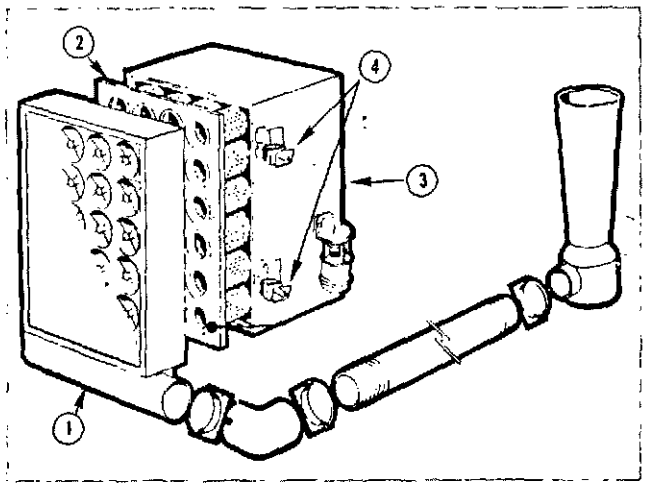


Fig. 5-9. Air cleaner — cartridge type N21017

5. To remove dirty Pamic cartridge (2) insert fingers in cartridge opening using a "bowling ball grip". Loosen all four corners of cartridge, one at a time, by pulling straight out. With larger cartridges it may be necessary to break seal along edges of cartridge. After seal has been broken pull cartridge straight out and slightly up so cartridge will clear sealing frame and edges of air cleaner housing.

6. Clean pre-cleaner openings of all soot, oil film and any other objects that may have become lodged in the openings. Remove any dust or dirt that may be in lower portion and aspirator tubing. Inspect inside of air cleaner housing to be sure it is free of all foreign material.

7. Inspect dirty cartridge for soot or oil. If there is soot inside Pamic tubes check for leaks in engine exhaust system, exhaust "blow-back" into air intake and exhaust from other equipment. If cartridge appears "oily" check for fumes escaping from crankcase breather. Excessive oil mist shortens life of any dry-type cartridge. Trouble shooting before new cartridge is placed in air cleaner can appreciably lengthen cartridge life.

8. It is not recommended to clean and reuse cartridge. Considerable laboratory testing shows shaking, washing, rapping or blowing out with compressed air can cause cracks or ruptures in paper filter cartridges and would permit wear-causing dirt particles to enter engine. If a failure occurs, there is no way of discovering it until the cartridge is changed again.

9. Inspect flexible hose or tubing and clamps to be sure all fittings are air tight.

10. Inspect each new filter cartridge for shipping damage before installing.

11. To install a new cartridge, hold cartridge in the same manner as when removing it from housing. Insert clean cartridge into housing; avoid hitting cartridge tubes against sealing flange on edges of air cleaner housing.

12. Since cleaner requires no separate gaskets or seals, care must be taken when inserting cartridge to insure a proper seat within air cleaner housing. Firmly press all edges and corners of cartridge with fingers to effect a positive air seal against sealing flange of housing. Under no circumstances should cartridge be pounded or punched in the center with the fist to effect a seal.

13. Replace pre-cleaner panel and tighten wing nuts. Assemble aspirator tube to pre-cleaner panel and tighten "U" bolt.

14. Care should be taken to keep leaves, rags or side curtains from obstructing cleaner face. Obstructing air intake can result in reverse exhaust flow through the bleed line and damage to cartridge.

15. Be sure Service Indicator is re-set before starting engine, if this accessory is used.

Change Oil Bath Air Cleaner Oil (B Check)

Perform at A Check under extremely dusty conditions.

Before dirt build-up reaches ½ inch, remove oil cup from cleaner. Discard oil and wash cup in cleaning solvent or fuel oil.

Fill oil cup to level indicated by bead on its side with clean, fresh oil and assemble to cleaner. Oil of the same grade as that in crankcase should be used in cleaner; however, in extremely cold weather a lighter grade may be necessary. A straight mineral, non-foaming detergent, or non-foaming additive oil may be used in oil bath air cleaners.

Caution: Never use crankcase drainings.

Table 5-1: Suggested Initial Oil And Filter Change Periods

Filtering Arrangement	Fuel Consumed U. S. Gal. [Lit.]	Hours Operated
Full-Flow Paper Element Only	3750/5000 [14,193.8000/18,925.000]	250
Full-Flow Paper and By-Pass	6000/8000 [22,610.000/30,280.000]	400

Note: 3750/5000 U.S. gal = 4503/6005 U.K. gal
6000/8000 U.S. gal = 7205/9607 U.K. gal

Engine Oil Change (B Check)

The kind of oil used (Mil-L-2104A, Supplement 1, Mil-L-2104B, etc.), the efficiency of the filtering system and condition of the engine must be considered in determining when to change oil. Currently, two levels of filtering effi-

ciency are being used on Cummins V12 engines; therefore, this must be taken into consideration.

The following schedule can be lengthened or may even, in rare cases, be reduced, based on oil analysis and other closely controlled tests, such as filter restriction measurement.

Factors to be checked and the limits for oil analysis are listed below. The oil change at the "B check" as shown in the maintenance check chart on Page 5-2 is for average conditions which closely follows that indicated as "Full-Flow Paper Element Only" above.

Lubricating Oil Analysis

The most satisfactory method for determining when to change lubricating oil is by oil analysis using laboratory tests. Fig. 5-10. After several test periods, a time interval (gallons fuel consumed, hours, weeks, etc.) for the oil change can be established; however, a new series of tests should be run if filters, oil brands or grades are changed.

In the beginning, tests should be made each 200 gal. [757 lit.] fuel consumed (after the first 800 gal. [3028 lit], or 20 hours (after the first 100 hours) until the analysis indicates the first oil change is necessary. Repeat analysis cycle until a definite pattern is established.

Wide variations in different brands of lubricating oil make it profitable to contact the oil supplier to assist in the development of the oil change period because he knows best the factors peculiar to his brand or brands of oil.

Analysis Test For Lubricating Oil

Following is a suggested list of lubricating oil properties which should be checked during laboratory analysis. The suggested methods are fully described in the American Society for Testing Materials Handbook.

Oil Property	Test Number
Viscosity at 100° and 200° F [37.8° and 93.3° C]	ASTM-D445
Sediment	ASTM-D893
Water	ASTM-D95
Acid and Base Number	ASTM-D664

General Limits For Oil Change

1. Minimum Viscosity (dilution limit): Minus one SAE grade from oil being tested or point equal to a minimum containing five percent by volume of fuel oil.
2. Maximum Viscosity: Plus one SAE grade from oil being tested, or ten percent increase at 210° F [98.9° C] or 25 percent increase at 100° F [37.8° C].
3. Sediment Content: Normal pentane insoluble 1.0 to 1.5 percent. Benzine insoluble 0.75 to 1.0 percent.
4. Acid Number: Check with your oil supplier as this value differs with each oil brand and grade.
5. Water Content: 0.2 percent maximum.
6. Additive Reduction: 25 percent maximum.

Caution: If the above tests indicate presence of any bearing metal particles, or if found in filters, the source should be determined before a failure results.

The efficiency of any maintenance program can only be judged on the basis of failures prevented or intercepted before engine or unit is damaged.

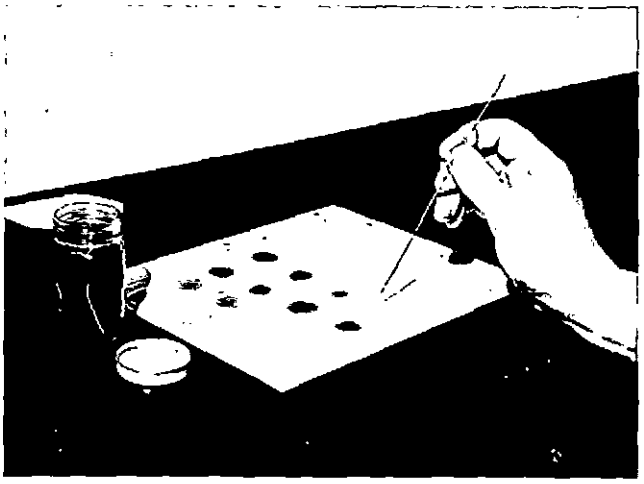


Fig. 5-10. A typical lubricating oil analysis test N11945

Fig. 5-11. Fill aneroid with oil V41022

Change Oil In Aneroid Control (B Check)

1. Remove plug from bottom of aneroid control and drain oil.
2. Replace drain plug and remove filter or pipe plug at hole *marked "Lub Oil".*
3. *Fill aneroid with clean engine lubricating oil through hole* until oil fills to hole level. Fig. 5-11. Reinstall filter or pipe plug.

Change Engine Full-Flow Filter Element (B Check)

1. Remove drain plug(s) from filter case(s) and allow oil to drain.
2. Loosen center capscrew(s) and remove filter case(s) from filter head.
3. Withdraw filter element Fig. 5-12, inspect, then discard.

a. *Inspect for metal particles.* ***If metal is found, a check of connecting rods and main bearings should be made at once.***

b. If element is relatively clean it may be possible to lengthen change periods.

c. If element is clogged the change period should be shortened. Oil pressure drop reading across filters is the best way to determine change periods. Pressure drop from inlet to outlet side of filter should not exceed 10 psi [0.7030 kg/*sq cm] with* 140° F [60° C] *oil and engine* at high-idle speed.

4. Remove seal ring from filter head and discard.
5. Clean filter case thoroughly.
6. Check to make sure element end seals are in place and install new element over spring support assembly.
7. Position new seal ring in place; assemble filter case to *head and tighten center capscrew to* 25/35 ft-lb [6.915/9.681 kg m].
8. Check oil level. Run engine and check for leaks.
9. Recheck engine oil level; add oil as necessary to bring oil level to "H" mark on dipstick.

Note: Always allow oil to drain back to oil pan before checking level.

Change Turbocharger Oil Filter (B Check)

The throw-away type turbocharger oil filter prevents clogging of the T-590 turbocharger oil supply orifice. T-50 turbochargers do not require use of a separate turbocharger filter.

Change filter at each oil change or install a pressure gauge in the filter outlet line and change filter when gauge indicates a 15 psi [1.0546 kg/sq cm] lower pressure than oil *pressure on inlet side.*

To change element:

1. Unscrew element and discard. Fig. 5-13.
2. Clean filter head with solvent that is not harmful to aluminum.
3. Inspect head for cracks and distorted threads; discard if damaged.
4. Coat gasket and fill new element with clean engine lubricating oil.
5. Install element to head; tighten until gasket contacts head.

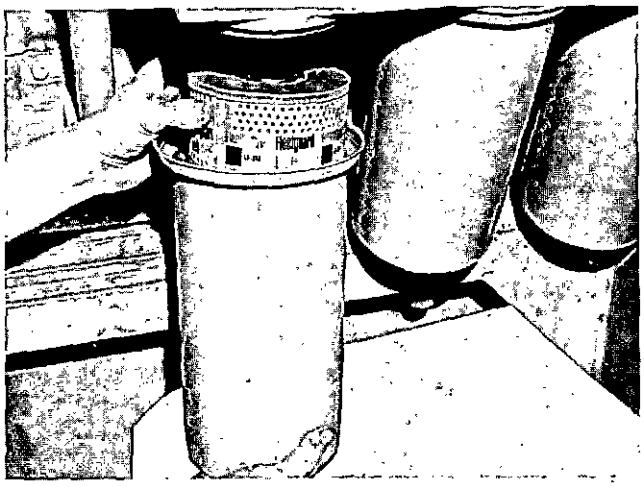


Fig. 5-12. Removing paper element lubricating oil filter(s) V40737

Fig. 5-13. Removing turbocharger oil filter V40738

6. Rotate element an additional one-half to three-fourths turn to seal gasket. Do not overtighten.

   Caution: Do not attempt to use substitute elements. Element threads and filter paper are of a special design.

7. Reconnect oil supply and discharge lines, if previously removed.

   Caution: Make sure oil supply line to filter is connected at opening marked "in". Reversing connections will lead to turbocharger failure.

Record Oil Pressure (B Check)

Start the engine and operate at 800 to 1000 rpm until the oil temperature gauge reads 140° F [60° C]. Reduce engine speed to idle and record oil pressure. A comparison of pressure at idling speed with previous readings will give an indication of progressive wear of lubricating oil pump, bearings, shafts, etc. These readings are more accurate and reliable when taken immediately after an oil change.

Lubricate Generator (B Check)

Lubricate generator by adding five or six drops of SAE 20 lubricating oil to oil cup, Fig. 5-14, or by turning down grease cup a maximum of one turn.

Caution: Avoid over-lubrication; it is harmful to insulation.

If no cups are present, unit contains sealed bearings and requires no lubrication.

When a generator filter is used, clean filter screen at each lubrication period. Remove filter screen and wash in an approved cleaning solvent; blow dry with compressed air and reassemble.

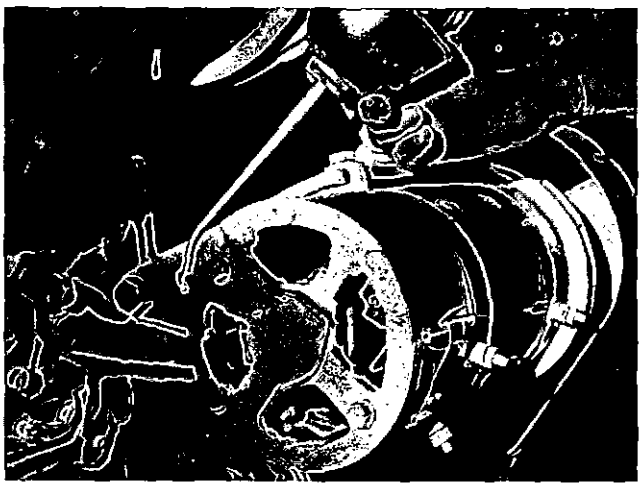


Fig. 5-14. Lubricate generator V41304

Lubricate Cranking Motor (B Check)

Electric

Add five or six drops of clean SAE 30 lubricating oil to cranking motor bearings.

Air

Air cranking motor may be equipped with grease fittings, felt wicks with outer grease cups or air line lubricators. Follow manufacturer's recommendation for procedure, interval and lubricant specification.

Change Marine Gear Oil (B Check)

1. Remove drain plug from bottom of gear housing and drain oil, or pump from sump, or follow manufacturer's recommendations.
2. Reinstall drain plug and fill marine gear to "H" level on dipstick with lubricant as specified by the gear manufacturer.

   Note: On some gears the inspection plate must be removed to fill gear, while others have an oil filler spout.

Clean Marine Gear Oil Strainer (B Check)

1. Disconnect oil hose and remove capscrews securing cover to housing; slide out strainer assembly and discard gasket.
2. Wash strainer in an approved solvent and dry thoroughly.
3. Assemble strainer to cover and position assembly in housing with new gasket; secure with capscrew and connect all hose.

Check Hydraulic Governor Oil Level (B Check)

If engine has a hydraulic governor, use clean lubricating oil of same grade as used in engine in governor sump.

Keep level half-way up on inspection glass or to high-level mark on dipstick oil gauge. Fig. 2-2.

Change Hydraulic Governor Oil Filter (B Check)

Some engines have hydraulic governors which are lubricated from the engine oil supply and utilize a filter. Change filter every 200 hours or install a pressure gauge in the filter outlet line and change filter when gauge indicates a pressure drop of 7 psi [0.49217 kg/sq cm] or more across filter head at engine governed speed.

To change element:

1. Unscrew element and discard.
2. Clean filter head in solvent that is not harmful to aluminum.
3. Inspect head for cracks and distorted threads; discard if damaged.
4. Coat gasket atop new element with clean lubricating oil and fill element.
5. Install element to head; tighten until gasket contacts head.
6. Rotate element an additional one-half turn to seal gasket. Do not overtighten.

Caution: Do not attempt to use substitute elements. Element threads and filter paper are of a special design.

Change By-Pass Filter Element (B Check)

Change Cummins Fleetguard (LF-750) by-pass filter elements on engine so equipped as follows:

1. Remove drain plug (5, Fig. 5-15) from bottom of housing and drain oil.
2. Remove clamping ring capscrew (1) and lift off cover (2).
3. Unscrew upper support hold-down assembly (3); lift out element (4) and hold-down assembly. Discard element.
4. Clean housing and hold-down assembly in solvent; clean orifice (6) in standpipe.
5. Inspect hold-down assembly spring and seal. Replace if damaged.
6. Inspect drain plug and connections. Replace plug.
7. On the Cummins Fleetguard by-pass filter, check orifice plug (6) inside oil outlet connection or standpipe; blow out with air jet to make sure orifice is open and clean.
8. Check filter cover "O" ring (7). Replace if damaged or deteriorated.
9. Install new element in housing.
10. Replace upper support hold-down assembly in filter and tighten down to stop.
11. Position "O" ring seal on housing flange.

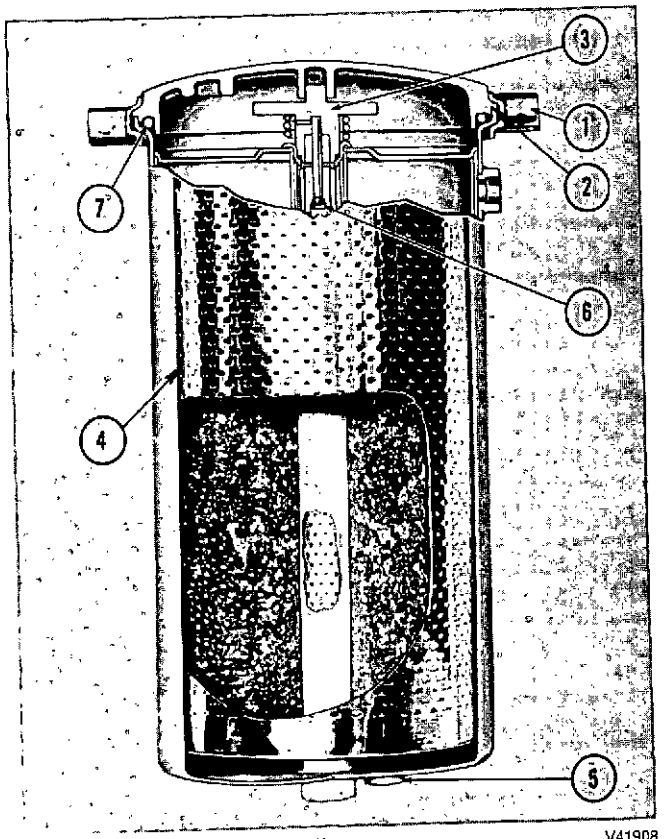


Fig. 5-15. By-pass filter cross-section V41908

12. Install cover and clamping ring; tighten capscrew until clamping lugs come together.
13. Add enough extra oil to crankcase to fill case and element. (Approximately 2.9 gal [10.9775 lit] per filter.)

Caution: Never use a by-pass filter in place of a full-flow filter.

Clean Fuel Tank Breather(s) And Drain Sediment From Tank(s) (B Check)

1. Clean tank breather(s) in cleaning solvent and dry with compressed air.
2. Loosen fuel tank drain cock(s) or plug(s) and drain approximately 1 cup of fuel. Close drain cock(s) or plug(s).

C—Maintenance Checks

Check Air And Vapor Line Connections (C Check)

Perform at B Check under extremely dusty conditions.

Check all air and vapor lines and connections from compressor, rocker housing cover and cylinder head for leaks, breaks, stripped threads, etc.; correct as needed.

In cold weather, condensed moisture in air tanks and lines may freeze and make brakes or cranking motors useless.

Drain air tanks to keep all water out of brake system.

Check Air Piping (C Check)

Perform at B Check under extremely dusty conditions.

Check air intake piping from air cleaner to intake manifolds. Check for loose clamps or connections, cracks, punctures, or tears in hose or tubing, collapsing hose, or other damage. Tighten clamps or replace parts as necessary to insure an airtight air intake system. Make sure that all air goes through air cleaner. Fig. 5-16.

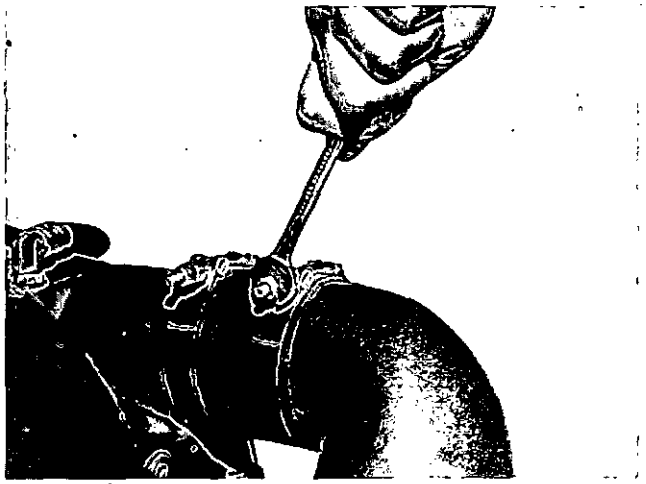


Fig. 5-16. Check air intake piping V41023

Change Fuel Filter Element (C Check)

Double element (throw-away) fuel filters are used. Under normal working conditions and with proper storage of fuel, filter should be changed every 7500 gal [28,387.500 lit] of fuel used.

The most accurate method of determining element change period is by measurement of fuel restriction as outlined below.

Check Fuel Restriction

To check restriction, connect ST-434 Vacuum Gauge to fuel pump as shown in Fig. 5-17 using special adapter furnished. If restriction reads 8 to 8.5 in. [20.320 to 21.590 cm] vacuum while engine is running at full speed and load, change element or remedy other sources of restriction. When restriction becomes as great as 10 or 11 in. [25.400 or 27.940 cm] vacuum, engine will lose power.

Change element as described below.

Replaceable Element

1. Open drain cock(s) in bottom of filter case(s) and drain contents. (1, Fig. 5-18.)

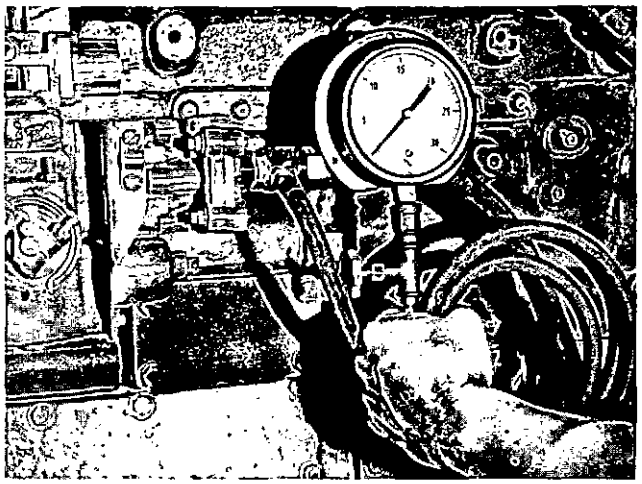


Fig. 5-17. Checking fuel filter restriction V414211

2. *Loosen nut(s) at top of fuel filter(s). Take out dirty elements,* clean filter case(s) and install new element(s). Fig. 5-18.
3. Install new gasket(s) in filter head(s) and assemble case(s) and element(s). Tighten center bolt(s) to 20/25 ft-lb [2.766/3.4575 kg m] with a torque wrench. Fill filter case(s) with clean fuel to aid in faster pick-up of fuel.
4. Check fittings in filter head(s) for leaks. Fittings should be tightened to 30/40 ft-lb [4.1490/5.5320 kg m].

Throw-Away Type Filter

1. *Unscrew combination case(s) and element(s); discard.* (1, Fig. 5-19.)

   Note: On elements that do not have integral "O" ring seal(s), install new "O" ring(s) before installing element(s).
2. Fill element(s) with clean fuel.
3. Install new element(s); tighten by hand until seal touches *filter head. Tighten an additional one-half to three-fourths* turn.

   Caution: Mechanical tightening will distort or crack filter head(s).

Check And Adjust Belt Tension (C Check)

The service life of belts used to drive fans, water pumps and generators/alternators can be greatly extended by proper installation, adjustment and maintenance practices. Neglect or improper procedures often lead to problems of cooling or bearing failures, as well as short belt life. Following are the most important rules to be observed to extend belt life.

Installation

1. Always shorten distance between pulley centers so belt can be installed without force. Never roll or tighten a belt over the pulley and never pry it on with a tool such as a screwdriver. Either of these methods will damage belts and cause early failure. Diagonal cuts on a failed belt indicate that the failure was caused by rolling a tight belt over the pulley. Cuts from prying a belt in place may be either diagonal or vertical.
2. Always replace belts in complete sets to prevent early failure and to provide efficient operation. Belt riding depth should not vary over $\frac{1}{16}$ in. [1.587 mm] on matched belt sets.
3. *Pulley misalignment must not exceed $\frac{1}{16}$ in. [1.587 mm] for* each ft [0.3048 m] of distance between pulley centers.
4. Belts should not bottom on pulley grooves nor should they protrude over $\frac{3}{32}$ in. [2.381 mm] above top edge of groove.
5. Do not allow belts to rub any adjacent parts.

Belt Tension

1. Tighten belts until a reading of 90 to 110 lb is indicated on *ST-968 Belt Tension Gauge. Fig. 5-20.*
2. If belt tension gauge is not available, tighten belts so pressure of index finger will depress belt as shown in Table 5-2. The index finger should be extended straight down from hand; in this manner, force will be approximately 13 lb [5.8968 kg] deflection (A, Fig. 5-21) per ft [0.3048 m] of span (B).

Readjusting New Belts

All new belts will loosen after running for an hour or more

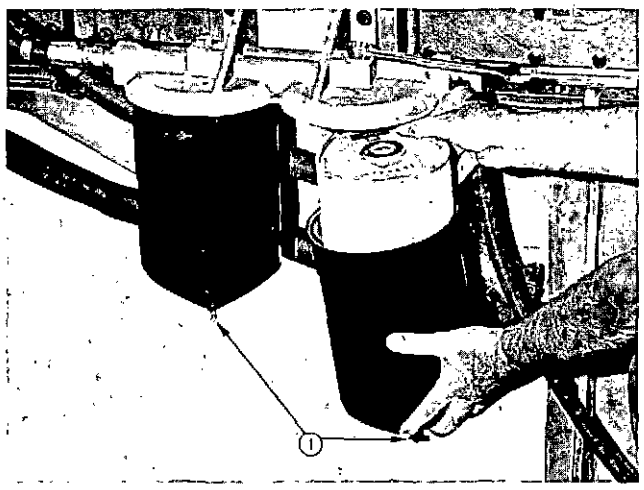


Fig. 5-18. Replaceable element fuel filter V40040

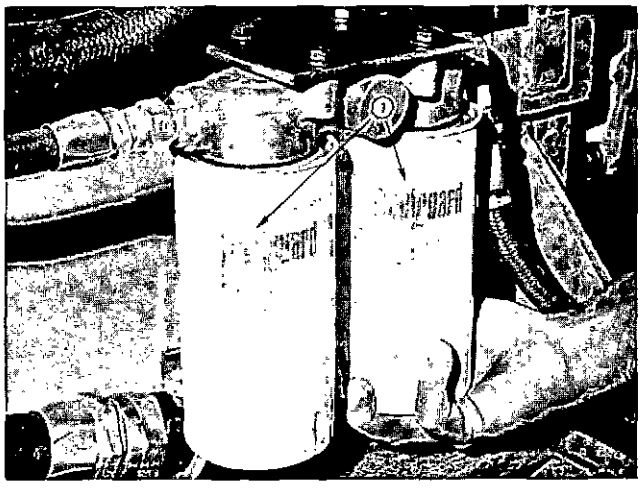


Fig. 5-19. Removing throw-away type fuel filter V41925

and must be readjusted. Readjust as described under "Belt Tension".

Table 5-2: Belt Tension — in. [mm]

Belt Width	Deflection Per Ft [0.3048] of Span
1/2 [12.700]	13/32 [10.318]
11/16 [17.462]	13/32 [10.318]
3/4 [19.050]	7/16 [11.112]
7/8 [22.225]	1/2 [12.700]
1 [25.400]	9/16 [14.287]

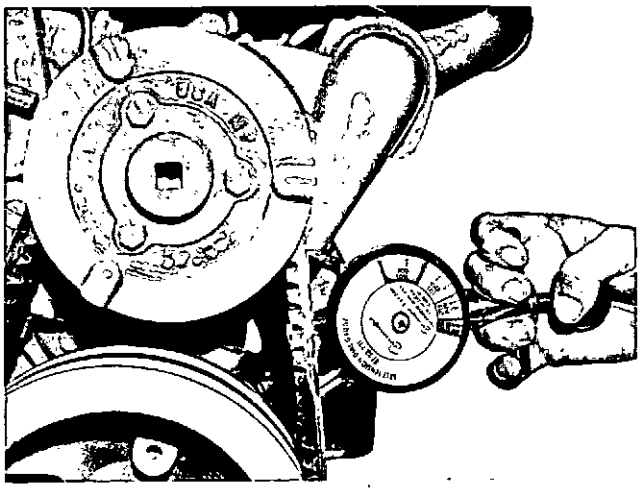


Fig. 5-20. Checking belt tension with ST-968 gauge V41922

Belt Care Or Maintenance

Belts often slip or squeak because of glaze that forms due to dirt or steam cleaning.

To clean a belt, wipe it with approved belt lubricant or hydraulic brake fluid. Cleaning in this manner will eliminate most cases of squeaking.

Do not tighten belt beyond figures given to eliminate belt squeak. Squeak does not necessarily mean belt slippage. Tightening to excess may damage bearings as well as belts.

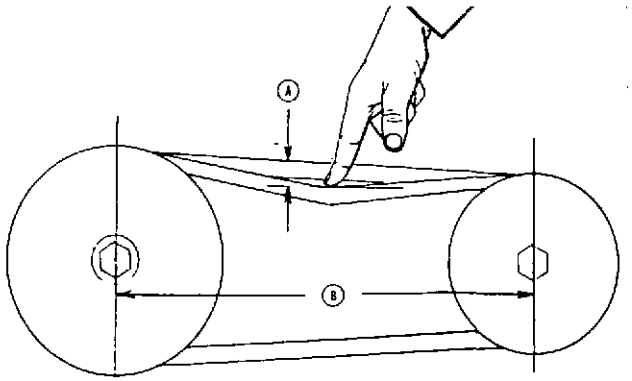


Fig. 5-21. Checking belt tension manually N11471

Change Corrosion Resistor (C Check)

Change corrosion resistor element at each "C" check unless facilities are available for testing. See "Check Engine Coolant", following. Change element when concentration drops below 100 grains per gal [3.785 lit].

Selection of element to be used should be based upon "Coolant Specifications", Section 3.

Note: Whenever a cooling system is changed from one element formula to the other, the system must be drained and flushed.

To Change Element(s):

1. Close shut-off valves on inlet and drain lines. Unscrew drain plug at bottom of housing.
2. Remove cover capscrews and cover(s). Fig. 5-22.
3. Remove plate(s) securing element(s); lift element(s) from housing(s) and discard. Remove plate(s) below element(s).
4. Lift spring(s) from housing(s).
5. Polish plates. If less than half of metal plates can be exposed by polishing, install new plates.

Fig. 5-22. Changing corrosion resistor elements V40820

6. Replace spring(s) and lower plate(s).
7. Remove new element(s) from transparent bags; install element(s) in housing(s). Fig. 5-22.
8. Replace upper plate(s), gasket(s) and cover(s).
9. Replace drain plug(s) and open shut-off valves in inlet and drain lines.

Keel Cooling Or Heat Exchanger Systems

1. Determine complete capacity of cooling system over and above that of engine itself.
2. Add ½ oz. of Nalco 38, Dearborn Formula 517 or equivalent chromate treatment for each gal [3.785 lit] of water over that stated in Step 1.
3. Start unit and check pH value and chromate concentration after solution is thoroughly mixed.
4. The corrosion resistor will maintain proper chromate concentration for systems up to 30 to 36 gal [115.550 to 136.260 lit] of coolant capacity. If above this capacity, it is recommended that treated "make-up" coolant be added to the system. See "Check Engine Coolant" preceding.

Check Engine Coolant (C Check)

Periodic tests of engine coolant should be made to insure the frequency of corrosion resistor servicing or concentration of chromate is adequate to control corrosion for specific condition of operation. In cases where "make-up" water must be added frequently, we suggest that a supply of water be treated and added as necessary. (See "Keel Cooling" preceeding).

When using plain water in a cooling system with a corrosion resistor (with chromate-type element) or when treating with chromate compounds, the concentration of effective inhibitor dissolved in coolant can be measured by the color comparison method. Cummins Coolant Checking Kit ST-993 is available from Cummins Distributors for this check. Fig. 5-23.

Most commercially available antifreezes contain a coloring dye that renders the color comparison method ineffective. When colored antifreezes are present in the coolant, effective control of corrosion can be determined by inspecting coolant for accumulation of reddish-brown or black finely granulated dirt. A small amount of corrosion produces significant quantities of these corrosion products; therefore, if corrosion resistor servicing is adjusted at the first indication of increased accumulation of these products, actual corrosion will be limited to a negligible amount.

Examine sump of corrosion resistor for these "dirt" materials at time of servicing or inspect for them in a small sample of coolant drained from bottom of radiator after allowing coolant to settle.

Note: Use of chromate compound, added to the coolant without a corrosion resistor, with antifreeze is not recommended.

pH Value Test:

1. Separate tubes marked "pH" are furnished in the test kit. Select a tube and fill to mark with coolant to be checked.
2. Add eight drops of pH Reagent to tube and mix thoroughly.
3. Insert tube in comparator, hole marked "pH".
4. Compare color of test sample with color standards on either side. Preferred range is 8.3 to 9.5.
5. Wash out test tubes after each test and keep reagent container caps in place.

Chromate Concentration Test:

1. Draw sample of coolant and pour into tube marked "chromate".
2. Insert sample into comparator, hole marked "chromate".
3. Compare color of test sample with color standards on either side. Preferred range is 100 to 150 grains per gal [3.785 lit] or 1700 to 2500 parts per million (ppm).
4. Wash out test tubes after each test.

Adjusting Coolant To Specifications

If above tests indicate coolant is outside specifications,

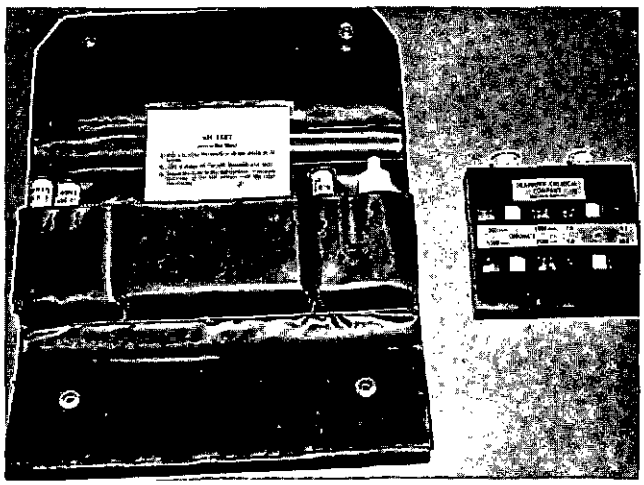


Fig. 5-23. Checking coolant — ST-993 N11946

make an adjustment immediately to prevent corrosion.

If Cummins Corrosion Resistor is used change element(s) and run engine four to six hours; then, check coolant again; in extreme cases it may be necessary to change element(s) a second time. However, the latter condition may be due to larger coolant system than corrosion resistor was designed to treat; note reference on resistor label.

Table 5-3: Comparison Units Chromate Concentration

Ounces Per Gallon	Parts Per Million	Grains Per Gallon
0.16	850	50
0.32	1700	100
0.50	2550	150

If chromate compounds are used, add enough compound to bring concentration to proper level. Normal usage is ½ oz. [218.75 grains] chromate for each 1 gal [3.785 lit] coolant.

Check Heat Exchanger Zinc Plugs (C Check)

Check zinc plugs in heat exchanger and change, if badly erroded. Frequency of change depends upon chemical reaction of raw water circulated through heat exchanger.

Change Converter Oil Filter And Screens (C Check)

Change Converter Oil

Oil should be changed every "C" check in the hydraulic system, or oftener, depending on operating conditions. Also the oil must be changed whenever it shows traces of dirt or the effects of high operating temperature evidenced by discoloration or strong odor.

Change Converter Filter And Screen

The hydraulic system filter should be changed every oil change and the strainer thoroughly cleaned.

D—Maintenance Checks

Check Inlet Air Restriction (D Check)

Perform at C Check under extremely dusty conditions.

The best method for determining dry-type air cleaner maintenance periods is through air restriction checks.

Check Air Inlet Restriction At Engine

1. On naturally aspirated engines attach vacuum gauge or water manometer in the middle of the intake manifold or on air intake piping. When located in air intake piping, adapter must be perpendicular to air flow and not more than 6 in. [152.4 mm] from air intake manifold connection.
2. On turbocharged engines, attach checking fixture one pipe diameter upstream from turbocharger in a straight section of tubing.
3. Idle engine until normal operating temperature is reached.
4. Operate engine at rated speed, full-load and observe reading from vacuum gauge or manometer. Air restriction must not exceed 25 in. [635.0 mm] of water or 1.8 in. [45.720 mm] of mercury.
5. If air restriction exceeds 25 in. [635.0 mm] of water or 1.8 in. [45.720 mm] of mercury:

a. Clean or replace dry-type cleaner element.

b. Replace damaged air piping, rain shield or housing.

c. Remove excessive bends or other source of restriction in air piping.

Check Air Inlet Restriction At Cleaner

Air restriction readings may be taken at air cleaner outlet pipe. The adapter must be mounted perpendicular to air flow, and restriction must not exceed 20 in. [508.0 mm] of water or 1.5 in. [38.100 mm] of mercury when checked at this location.

A mechanical restriction gauge is available to indicate excessive air restriction. This gauge can be mounted in air cleaner outlet or on vehicle instrument panel. The gauge shows completely red in indicator window (1, Fig. 5-24), plunger (2), when restriction reaches 20 in. [508.0 mm] of water.

Vacuum switches are available which actuate a warning light on instrument panel when air restriction becomes excessive. Items required for installation are:

1. Electric source (1, Fig. 5-25).
2. Air piping with fitting for switch (2).
3. Vacuum switch (3).
4. Red indicator light (4).

Note: Air restriction checks should not be used to determine maintenance periods for oil-bath air cleaners. Before dirt build-up reaches ½ in. [12.700 mm] maximum height, perform maintenance as described under "Change Air Cleaner Oil".

Replace Dry-Type Cleaner Element (D Check)

Perform at C Check under extremely dusty conditions.

Elements that have been cleaned several times will finally clog and air flow to engine will be restricted. After cleaning, check restriction as previously described and replace element if necessary.

Holes, loose end seals, dented sealing surfaces and other forms of damage require immediate element replacement.

Replace paper element in all dry-type air cleaners when

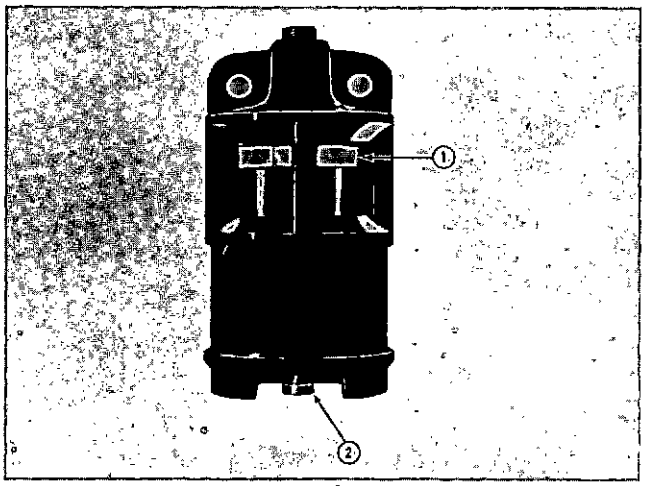


Fig. 5-24. Air inlet restriction gauge CGS-20

breaks appear or if air restriction is still excessive after element has been cleaned. To change element:

1. Remove cover; lift out element. Do not allow dust from element to fall back into air cleaner. Discard element.
2. Inspect "O" rings or gaskets. Replace as needed.
3. Insert new element and tighten cover securely.

Clean Tray Screen (D Check)

Perform at C Check under extremely dusty conditions.

Immerse tray screen (1, Fig. 5-26) in kerosene or cleaning solvent.

Slosh screen up and down several times. Dry thoroughly with compressed air, and reassemble to air cleaner.

Note: If tray screen is extremely dirty or coated with varnish, it may be necessary to singe the screen with a flame. Be careful not to melt tin plate on screens.

Clean Crankcase Breather (D Check)

Perform at C Check under extremely dusty conditions.

Wire Mesh Element

Clean breather element in cleaning solvent and dry with compressed air. Wipe out breather housing. Soak element in oil; drain out excess. Check gasket; replace if damaged. Fig. 5-27.

Clean Air Compressor Breather (D Check)

Perform at C Check under extremely dusty conditions.

Three types of breathers are available to provide filtered air for air compressor when intake line is not connected to engine air intake system.

When used, service breathers regularly as follows.

Bendix-Westinghouse Paper Element

Remove the breather cover and element. Fig. 5-29. Clean by reverse flushing with compressed air; reassemble on compressor. Discard element if damaged or unsuitable for cleaning.

Bendix-Westinghouse Sponge

Remove breather from air compressor. Disassemble breath-

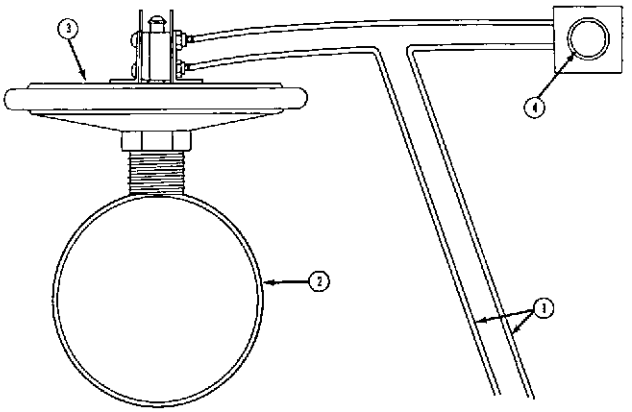


Fig. 5-25. Vacuum switch to check air inlet restriction N21905

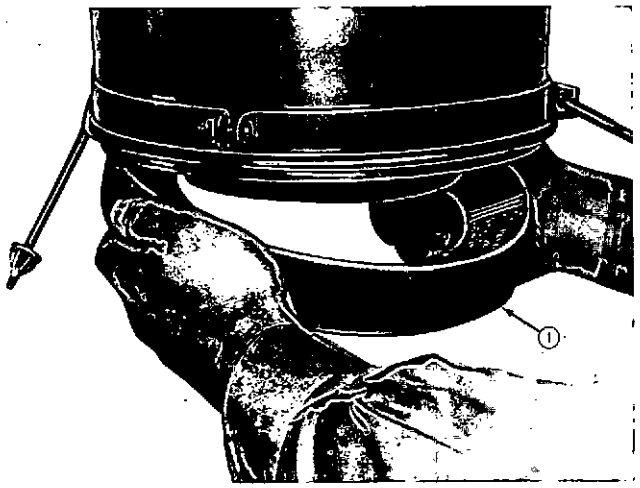


Fig. 5-26. Removing tray screen N11002

Fig. 5-27. Clean crankcase breather — mesh element V40313

er, wash all metal parts in solvent and blow dry with compressed air. Wash element in solvent; using a squeezing action, remove all solvent from element; dip in clean engine oil and squeeze excess oil from element.

Bendix-Westinghouse Oil Bath

Unsnap spring clips and remove oil cup. Wash in solvent, dry, replenish with oil to level mark and reassemble. Use clean oil, same grade as used in crankcase.

Every other service period, unscrew wing nut on top and remove filter element. Wash in solvent, dry and reassemble to cover.

Cummins Paper

A light-weight, self-contained air cleaner with "paper element" is optional on Cummins air compressor. Clean element at each "D" maintenance check. Remove wing nut securing front cover to body. Lift off front cover and element. Inspect paper element before cleaning by reverse flow of compressed air; discard if damaged or unsuitable for cleaning. Fig. 5-28.

Caution: Do not rupture filter element.

Clean the body and front cover with a clean cloth. With rubber gasket on center bolt, place element in front cover and assemble over center bolt; secure with wing nut.

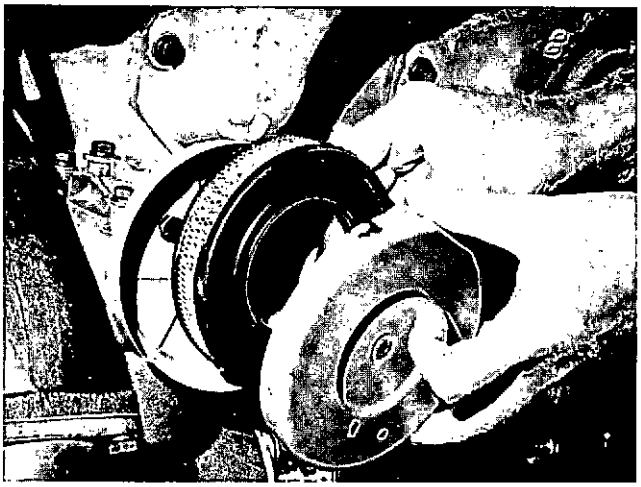


Fig. 5-28. Cummins air compressor breather — paper element V414209

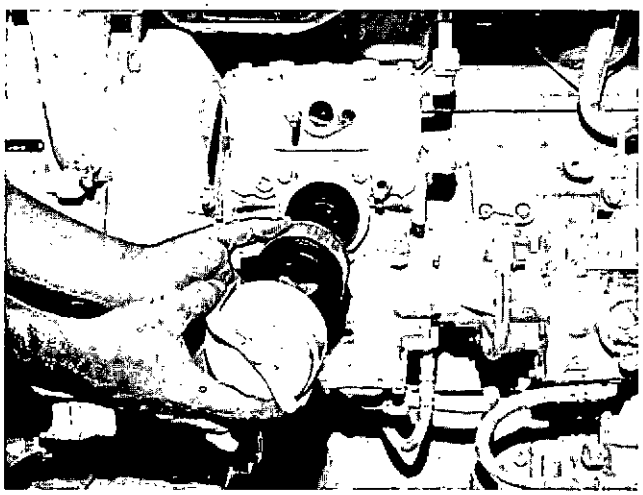


Fig. 5-29. Bendix-Westinghouse air compressor breather V414210

Check Thermal Controls (D Check)

Thermostat

Most Cummins Engines are equipped with either medium 170/185°F [76.7/85.0°C] or low 160/175°F [71.1/79.4°C] and in a few cases high-range 180/195° F [82.2/90.6° C] thermostats, depending on engine application.

The lower value indicates where thermostat starts to open and the higher value where it is fully open. Check stamp-

Table 5-4: Thermal Control Settings

Unit	Settings with 170/185° F [76.7/85.0° C] Thermostats		Settings with 160/175° F [71.1/79.4° C] Thermostats	
	Start-Open	Stop-Close	Start-Open	Stop-Close
Thermatic Fan	195°F [90.6°C]	180°F [85.0°C]	185°F [85.0°C]	170°F [76.7°C]
Shutterstat	190°F [87.8°C]	182°F [83.3°C]	180°F [82.2°C]	172°F [77.8°C]
Shutterstat with Thermatic Fan	180F° [82.2°C]	172°F [77.8°C]	170°F [76.7°C]	162°F [72.2°C]

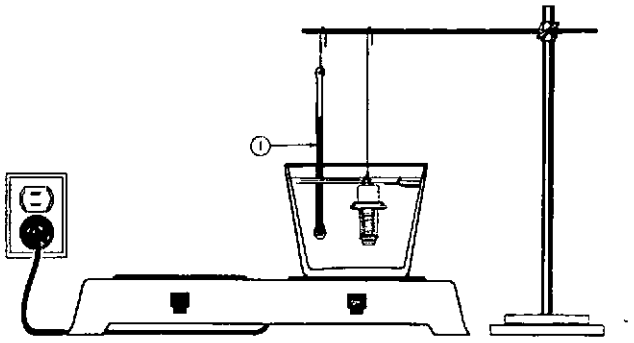


Fig. 5-30. Testing thermostat N10809

ing on thermostat; install same range new thermostat as that removed.

The opening and closing of thermostats can be checked against a thermometer reading (1, Fig. 5-30) while immersed in water as the water is brought up to temperature by heating.

Other Thermal Controls

Shutterstats and thermatic fans must be set to operate in same range as thermostat with which they are used. Table 5-4 gives settings for shutterstats and thermatic fans as normally used. The 180/195° F [82.2/90.6° C] thermostats are used with shutterstats only that are set to close at 187° F [86.1° C] and open at 195° F [90.6° C].

Check Fan Hub And Drive Pulley (D Check)

Check fan hub and drive pulley to be sure they are securely mounted.

Tighten fan capscrews each "D" check. Check drive pulley for looseness or wobble and, if necessary, remove fan and hub and tighten shaft nut. Tighten bracket capscrews.

Clean Dust From Alternator/Generator And Cranking Motor (D Check)

Dust and dirt, if allowed to accumulate in generator/alternator and cranking motor, will cause excessive wear of bearings, brushes and commutator.

Remove cover band and blow out dust and dirt with compressed air.

Clean And Tighten Electric Connections (D Check)

Hard starting is often traceable to loose or corroded battery connections. A loose connection will overwork generator/alternator and regulator and shorten their life.

1. Add water (distilled) to battery cells as required. Check solution level every 15 days during hot weather, every 30 days during cold weather; keep solution filled to 3/8 in. above separator plates.
2. Remove corrosion from around terminals, then coat with petroleum jelly.
3. Keep connections clean and tight. Prevent wires and lugs from touching each other or any metal except screw terminals to which they are attached.
4. Replace broken or worn wires and their terminals.
5. Have battery tested periodically. Follow battery manufacturer's instructions for maintenance.

Check For Oil Leaks At Turbochargers (D Check)

Check both intake and exhaust sides of turbochargers for "wet" oil. If oil is present, be sure that it is not caused by worn rings or an oil-over condition from the air cleaner. Check hose, tubing and connections for leaks and tighten or replace as necessary.

Tighten Manifold Nuts Or Capscrews (D Check)

Check exhaust and intake manifolds mounting hardware for tightness; correct deficiencies as required.

Tighten Turbocharger Mounting Nuts (D Check)

Tighten all turbocharger mounting capscrews and nuts to be sure that they are holding securely. Tighten mounting bolts and supports so vibration will be at a minimum. Fig. 5-31.

Check Sea Water Pump (D Check)

Maintenance and service periods for sea water pump must

Fig. 5-31. Tighten turbocharger mounting nuts V40049

necessarily be adjusted to agree with the type of application to which it is subjected. Fig. 5-4.

If coolant being pumped through sea water pump is relatively free of sediment, corrosive chemicals, foreign material and abrasives such as sand or mud, normal maintenance periods are sufficient.

Accelerated maintenance periods are necessary to compensate for undesirable operating conditions.

1. Check all pipes and fittings for leaks. Tighten as necessary.
2. Remove cover plate to drain pump.
3. Slide out rubber impellers and check for cracks, breaks or damage. Install new impellers if necessary.

   Note: If impeller is subjected to extreme temperatures, either hot or cold, impeller life is shortened and inspection periods must be adjusted accordingly.
4. Clean out all sediment.
5. Install new cover plate gasket and install cover on pump. 0.015 in. [0.3810 mm] gasket should be used to maintain proper impeller-to-cover clearance.
6. The sea water pump is self-priming.

E—Maintenance Checks

Clean Aneroid Air Filter (E Check)

Perform at D Check under extremely dusty conditions.

At each "E" check, remove filter and reverse flush with compressed air; it is not necessary to disassemble filter.

Clean Oil Bath Air Cleaner (E Check)

Perform at D Check under extremely dusty conditions.

Steam Cleaning

Steam clean oil-bath air cleaner main body screens. Direct steam jet from air outlet side of cleaner to wash dirt out in opposite direction of air flow.

Solvent Bath Cleaning

This method of cleaning requires a 55 gal [219.175 lit] drum and a source of air pressure. Any good commercial solvent may be used.

1. Steam clean exterior of cleaner.
2. Remove air cleaner oil cup.
3. Clamp hose with air line adapter to air cleaner outlet.
4. Submerge air cleaner in solvent.
5. Introduce air into unit at 3/5 psi [0.21093/0.35155 kg/sq cm] and leave in washer 10 to 20 minutes.
6. Remove cleaner from solvent and steam clean thoroughly to remove all traces of solvent.
7. Dry thoroughly with compressed air.

   Caution: Failure to remove solvent may cause engine to overspeed until all solvent is sucked from cleaner.

8. If air cleaner is to be stored, dip in lubricating oil to prevent rusting of screens.

   Note: If screens cannot be thoroughly cleaned by either method, or if body is pierced or otherwise damaged, replace with new air cleaner.

Lubricate Water Pump And Fan Hub (E Check)

1. The water pump and fan hub contain plugs (1 and 2, Fig. 5-32) through which grease may be applied; give one "shot" (approx. 1 tablespoon) each "E" check.

   Caution: Remove grease fittings and install pipe plugs after applying grease to prevent expelling grease during operation.

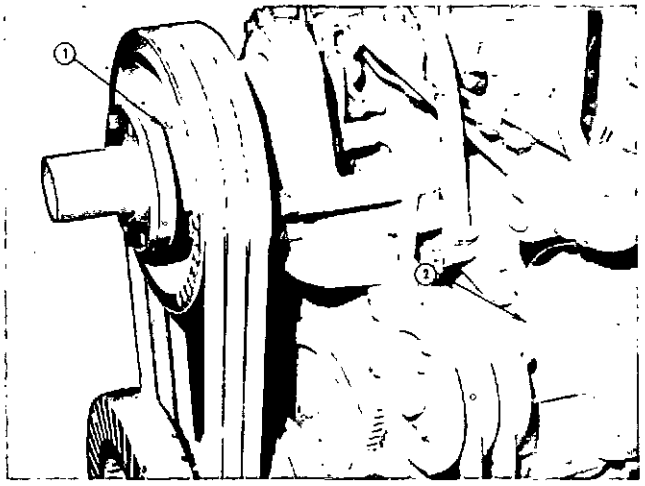


Fig. 5-32. Fan hub and water pump lubricating point V40821

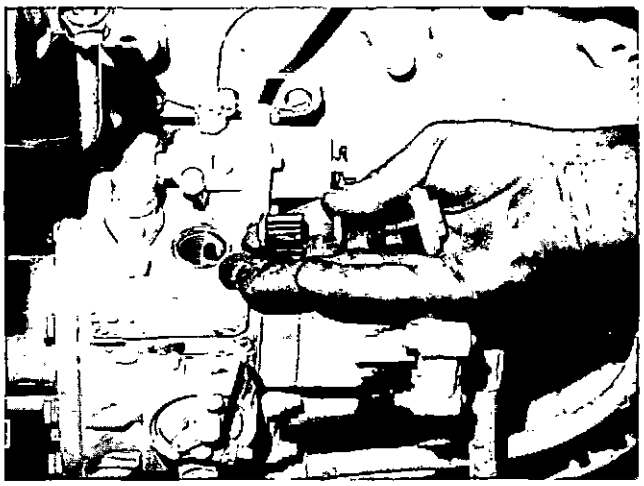


Fig. 5-33. Fuel pump filter screen V41911

2. Completely disassemble, clean and inspect at each third "E" check. Pack bearings and fill water pump and fan hub bearing cavities ½ to ⅔ full of grease meeting specifications shown on Page 3-3.

Clean Fuel Pump Screen And Magnet (E Check)

PT Fuel Pump

Remove and clean fuel pump filter screen at each "E" check. To clean filter screen:

1. Loosen and remove cap at top of fuel pump. Remove spring. Lift out filter screen assembly. Fig. 5-33.
2. Remove top screen retainer from filter screen assembly.

   Note: Some filter screens do not contain a magnet. If not, magnet can be obtained from any Cummins distributor. Magnetic action will remove any ferrous metal particles that may enter fuel system.
3. Clean screen and magnet in cleaning solvent and dry with compressed air.
4. Replace screen retainer and install filter screen assembly in fuel pump with hole down. Replace spring on top of filter screen assembly.
5. Replace cap, tighten to 20/25 ft-lb [2.7660/3.4575 kg m].

PT (type G) Fuel Pump With MVS Governor

1. Remove filter cap and dynaseal from governor housing. See Fig. 5-34.
2. Remove "O" ring retainer, "O" ring, screen and spring from filter cap.
3. Using a screwdriver or wire hook, remove bottom screen and magnet assembly from fuel pump housing. Remove screen retainer.
4. Clean parts as described above.
5. Install screen retainer and place bottom screen assembly in fuel pump housing with removable end up.
6. Install spring, large coil first, in filter cap; install upper screen, closed end first, in cap and snug against spring.
7. Install new "O" ring on "O" ring retainer; insert in filter cap, "O" ring first.
8. Install filter cap and dynaseal in governor housing; tighten cap to 20/25 ft-lb [2.7660/3.4575 kg m] with torque wrench and screwdriver adapter.

Adjust Injectors And Valves (E Check)

It is essential that injectors and valves be in correct adjustment at all times for engine to operate properly. This controls engine breathing and fuel delivery to the cylinders. Adjust valves and injectors at "E" checks. Final adjustment must be made when engine is at operating temperature. Injectors must always be adjusted before valves. The procedure is as follows:

Time Mark Alignment

1. Pull compression release lever back and block in open position to lift all intake valves. This allows crankshaft to be rotated without working against compression.
2. Bar engine in direction of rotation until No. 1-6L VS mark appears. See Fig. 5-35 for location of valve set marks. In this position, both intake and exhaust valves must be closed for cylinder No. 1, on engine left bank. (Remove block from compression release before setting valves.)

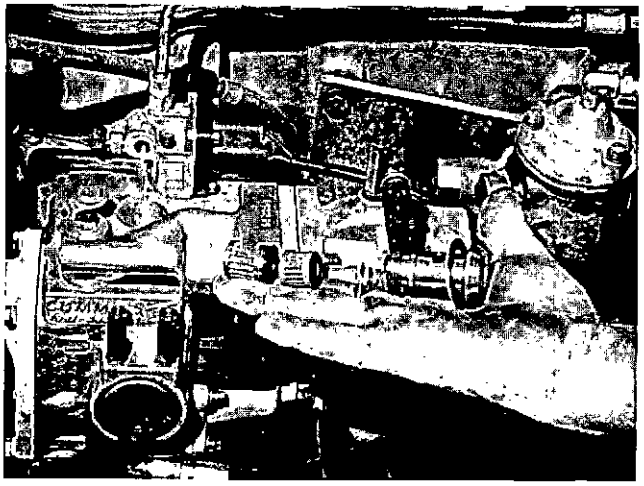


Fig. 5-34. Fuel pump screens — PT (type G) fuel pump with MVS governor V41912

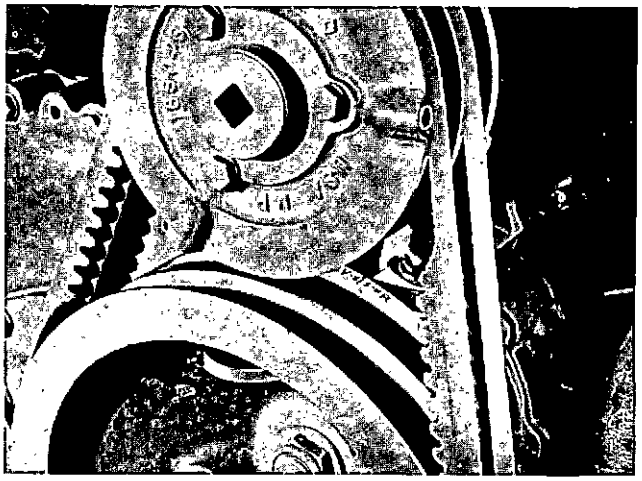


Fig. 5-35. Valve set marks V41484

3. Adjust injector plunger, then crossheads and valves of first cylinder as explained in succeeding paragraphs. Turn crankshaft in direction of rotation to next VS mark corresponding to firing order of engine and corresponding cylinder will be ready for adjustment.

Engine Firing Order

Right Hand —
1L-6R-2L-5R-4L-3R-6L-1R-5L-2R-3L-4R

Left Hand —
1L-4R-3L-2R-5L-1R-6L-3R-4L-5R-2L-6R

Note: Number one L and one R cylinders on V12 engines are at gear case end of engine.

5. Continue turning crankshaft in direction of rotation and making adjustments until all injectors and valves have been correctly adjusted.

Note: Two complete revolutions of crankshaft are needed to set all injector plungers and valves. Injector and valves can be adjusted for only one cylinder at any one "VS" setting.

Injector Plunger Adjustment

The injector plungers of all engines must be adjusted with an in.-lb torque wrench to a definite torque setting. Snap-On Model TQ12B or equivalent torque wrench and a screwdriver adapter can be used for this adjustment. Fig. 5-36.

1. Turn adjusting screw down until plunger contacts cup and advance an additional 15 degrees to squeeze oil from cup.

2. Loosen adjusting screw one turn; then, using a torque wrench calibrated in in.-lb and a screwdriver adapter, tighten the adjusting screw to values shown in Table 5-5 for cold setting and tighten the locknut. Table 5-6. After all injectors and valves are adjusted and engine has been started and warmed up to 140° F [60.0° C] oil temperature, reset the injectors to the warm setting.

Table 5-5: Injector Plunger Adjustment Torque

Oil Temperature 70° F [21.1° C]	Oil Temperature 140° F [60° C]
48 in.-lb [0.5520 kg m]	60 in.-lb [0.6900 kg m]

3. Hold injector adjusting screw and tighten injector locknuts to values indicated in Table 5-6. Where ST-669 is used nut torque is reduced to compensate for additional torque arm length. Fig. 5-37.

Table 5-6: Injector And Valve Locknut Torque

With ST-669	Without ST-669
60/70 ft-lb [8.298/9.681 kg m]	70/80 ft-lb [9.681/11.064 kg m]

Crosshead Adjustments

V12 Series engines have four-valve heads; it is necessary to adjust the crossheads before making valve adjustments. Fig. 5-38.

1. Loosen valve crosshead adjusting screw locknut and back off screw one turn.

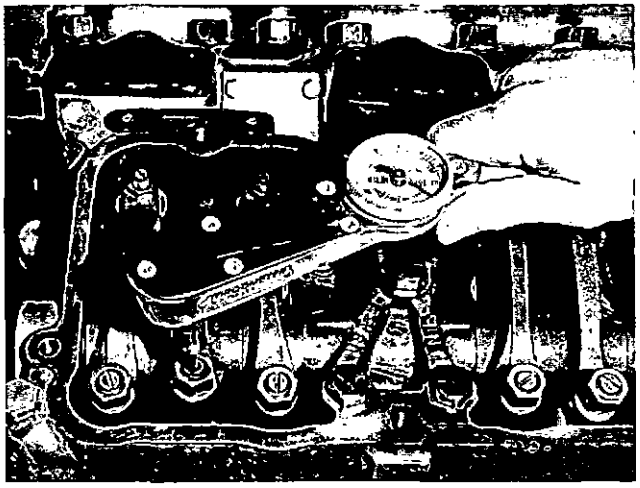


Fig. 5-36. Adjusting injector plungers V414190

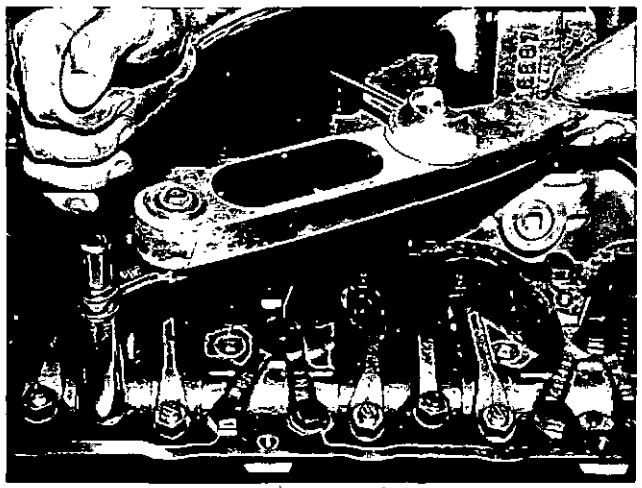


Fig. 5-37. Tightening injector adjusting screw locknut V414201

2. Use light finger pressure at rocker lever contact surface to hold crosshead in contact with valve stem (without adjusting screw). Fig. 5-38.
3. Turn down crosshead adjusting screw until it touches valve stem.
4. With new crossheads and guides, advance screw an additional one-third of one hex (20°) to straighten stem in guide and compensate for slack in threads. With worn crossheads and guides, it may be necessary to advance screw as much as 30° to straighten stem in guide.
5. Hold adjusting screw in this position and torque locknut to 25/30 ft-lb [3.4575/4.1490 kg m].
6. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.020 in. [0.5080 mm] clearance at this point.

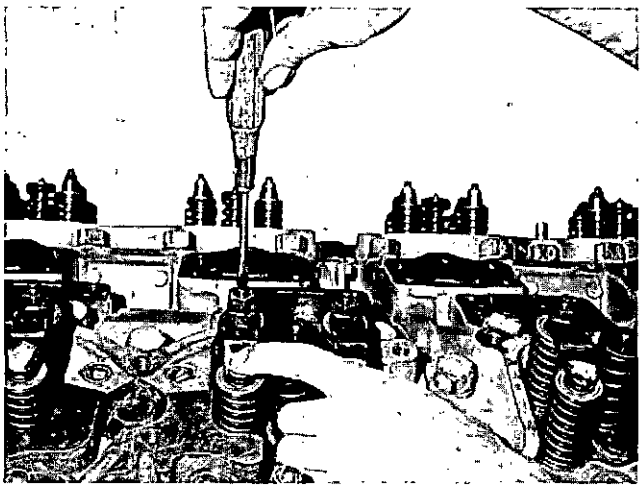


Fig. 5-38. Adjusting crossheads V414163

Valve Adjustment

The same engine position used in adjusting injectors is used for setting intake and exhaust valves.

1. While adjusting valves make sure compression release is in running position.
2. Loosen locknut and back off adjusting screw. Insert feeler gauge between rocker lever and top of crosshead. Turn screw down until lever just touches gauge and lock adjusting screw in this position with the locknut. Fig. 5-39. Torque locknut to values indicated in Table 5-6; note Step 3 under "Injector Plunger Adjustment".
3. Always make final valve adjustment after injectors are adjusted and with the engine at operating temperature. Valve clearances are shown in Table 5-7.

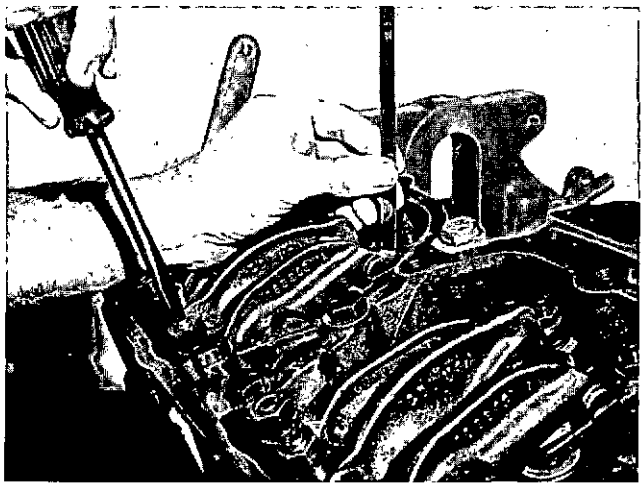


Fig. 5-39. Adjust valves V414193

Table 5-7: Valve Clearance — In. [mm]

Intake Valves Oil Temperature		Exhaust Valves Oil Temperature	
70°F [21.1°C]	140°F [60°C]	70°F [21.1°C]	140°F [60°C]
0.016 [0.4064]	0.014 [0.3556]	0.029 [0.7366]	0.027 [0.6858]

Check Fuel Manifold Pressure (E Check)

1. Check maximum fuel manifold pressure with ST-435. Remove plug from shut-down valve and connect gauge line. Run engine up until governor "cuts in" and check maximum pressure reached. Compare with previous readings to determine if fuel pressure output is satisfactory. Normally this check is required only if loss of power is suspected. Fig. 5-40.

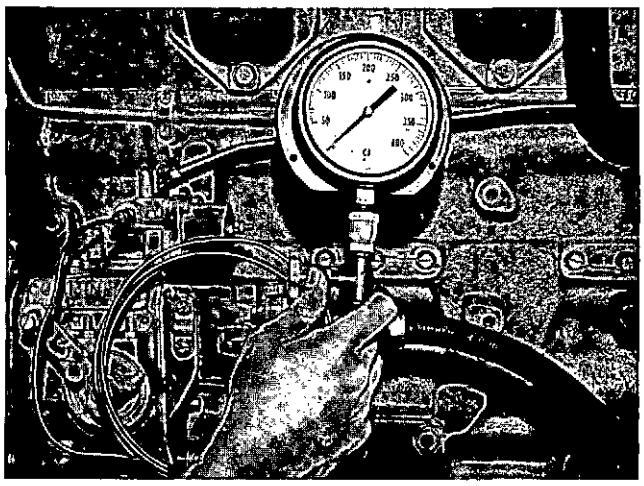


Fig. 5-40. Checking fuel manifold pressure V41021

Caution: Aneroids (when used) on turbocharged engines must be disconnected to reach maximum fuel pressure during the short acceleration period.

2. Always make above checks on a hot engine and operate engine for a minimum of five minutes between checks to clear system of air.

Clean Turbocharger Compressor Wheel And Diffuser (E Check)

Keep compressor wheel and diffuser clean for best turbocharger performance. Any build-up of dirt on compressor wheel will restrict air flow and cause rotor imbalance.

At every "E" check, clean compressor wheel and diffuser as follows:

1. Remove intake piping, air cleaner piping and support bracket if used from turbocharger.
2. Loosen and remove capscrews, lockwashers and plain washers from plate. Remove front plate to expose compressor wheel and diffuser. Fig. 5-41.

   Note: On T-50 turbocharger, loosen and remove V-clamp between housings. Pull T-50 compressor housing.
3. Use a good carbon-removing solvent and a brush with nylon or hog bristles to clean compressor wheel and diffuser. Never use a solvent that may attack aluminum and result in an unbalanced compressor wheel.
4. If unit is very dirty when front plate or compressor housing is removed, remove turbocharger from engine.
5. Immerse compressor wheel end of turbocharger in cleaning fluid to diffuser plate face; allow to soak. Do not rest weight of turbocharger on compressor wheel or on end of shaft.
6. Dry unit thoroughly with compressed air. Reassemble front plate to turbocharger.

   Note: On the T-50 turbocharger, install compressor housing and V-clamp. Tighten V-clamp capscrew to 32/36 in.-lb [0.3680/0.4140 kg m]; do not overtighten.

Check Turbocharger Bearing Clearance (E Check)

Check bearing clearances every "E" check. This can be done, without removing turbocharger from engine, by using a dial indicator (1, Fig. 5-42) to indicate end-play of rotor shaft and a feeler gauge to indicate radial clearance.

Checking Procedure

1. Remove exhaust and intake piping from turbocharger to expose ends of rotor assembly.

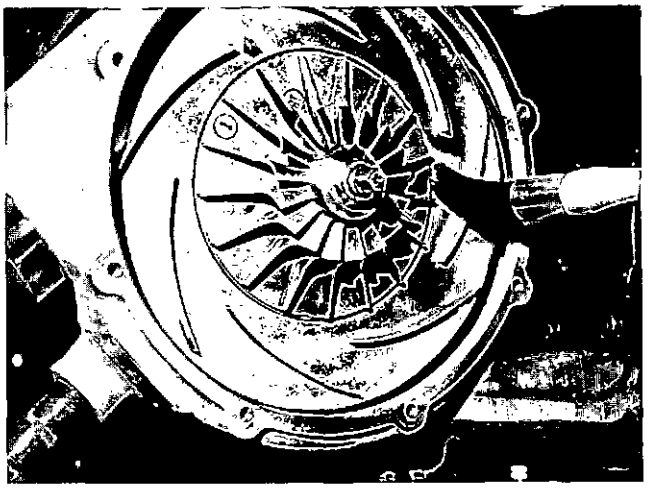


Fig. 5-41. Cleaning T-590 turbocharger V41919

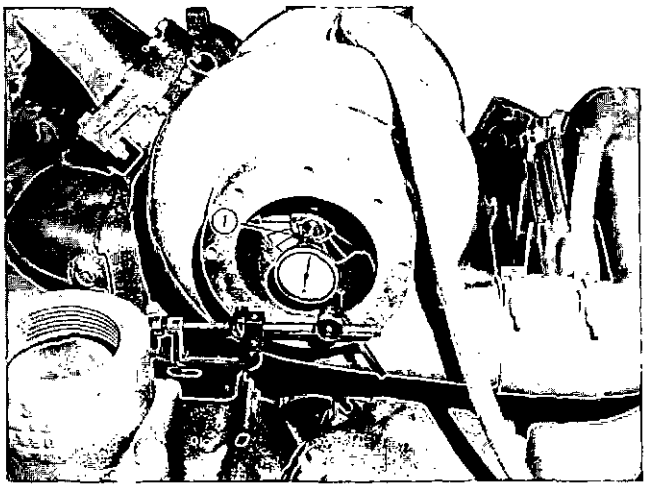


Fig. 5-42. Checking turbocharger bearing clearance V41024

2. Remove one capscrew from front plate (compressor wheel end) and replace a long capscrew. Attach an indicator to the long capscrew and register indicator point on end of rotor shaft. Push shaft from end-to-end, making note of total indicator reading. Move indicator point to end of shaft and check end-play of rotor assembly. See Table 5-8 for limits.
3. Check radial clearance on compressor wheel only. Note that limits in Table 5-8 are minimum figures.

Table 5-8: Turbocharger Bearing Clearances — In. [mm]

Turbocharger Model	Radial Clearance Minimum	Radial Clearance Maximum	End Clearance Minimum	End Clearance Maximum
T-50	0.005 [0.1270]	0.015 [0.3810]	0.006 [0.1524]	0.019 [0.4826]
T-590	0.008 [0.2032]	——	0.003 [0.0762]	0.011 [0.2794]

4. If end clearance exceeds limits shown above, remove turbocharger from engine and replace with a new or rebuilt unit.

Check Alternator/Generator And Cranking Motor Brushes And Commutators (E Check)

Failure of an alternator/generator or cranking motor may cause unit downtime and nearly always results in expensive replacement.

1. Clean dirty commutators with No. 00 sandpaper, never with emery cloth.
2. Replace worn brushes. If brushes wear rapidly, check brush spring tension (1, Fig. 5-43) or high mica on the commutator. Check generator manufacturer's specifications for spring tension data. Check out-put and action of an ammeter indicator after brush replacement.
3. Shorts and incorrect polarization (on generators) can be detected at the ammeter. Incorrect polarization is indicated by minus reading when generator is turned. Take unit to an electric service station for immediate correction.

Steam Clean Engine (E Check)

There are many reasons why exterior of engine should be kept clean. Dirt from the outside will find its way into fuel and lubricating oil filter cases and into rocker housings when covers are removed unless dirt is removed first.

Steam is the most satisfactory method of cleaning a dirty engine or piece of equipment. If steam is not available, use mineral spirits or some other solvent to wash the engine.

All electrical components and wiring should be protected from the full force of the steam jet.

Tighten Mounting Bolts And Nuts (E Check)

Mounting bolts will occasionally work loose and cause supports and brackets to wear rapidly. Tighten all mounting bolts or nuts and replace any broken or lost bolts or capscrews.

Check Engine Blow-By (E Check)

Engine blow-by, or escape of combustion gases past pistons and liners, is usually caused by worn or stuck piston rings, worn cylinder liners or worn pistons.

Blow-by can be detected by running engine and observing gas escape from lubricating oil filler hole with cap or breather open or removed. There is always some vapor or gas escape at this point due to heated oil and piston

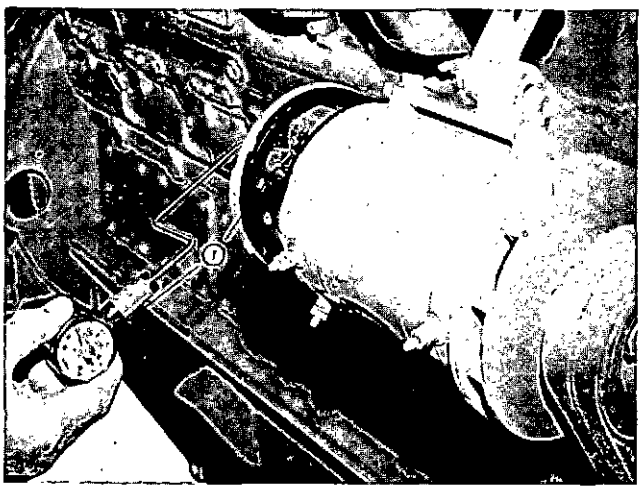


Fig. 5-43. Checking generator brush spring tension V41926

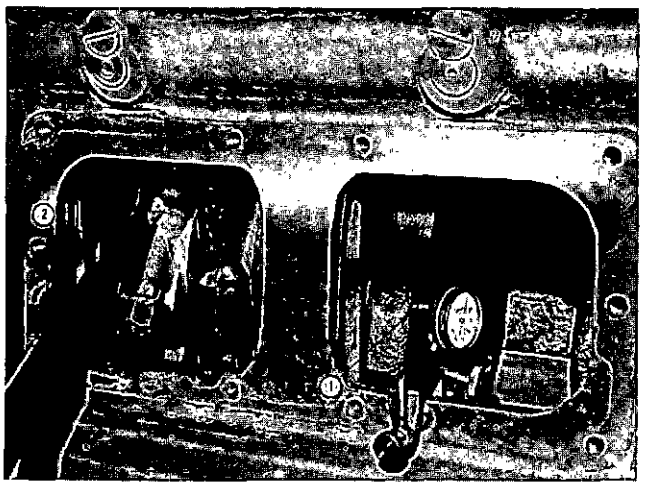


Fig. 5-44. Checking crankshaft end clearance V41924

movement, but distinct puffs indicate blow-by. Experience and comparison with other units operating at same speed are needed to make a conclusion to extent of blow-by. Normally, excessive blow-by is accompanied by oil consumption.

Cummins Distributors are equipped to check engines for blow-by under loaded conditions, with special tools, to determine if blow-by is excessive.

Check Crankshaft End Clearance (E Check)

The crankshaft of a new engine must have end clearance as listed in Table 5-9. A worn engine must not be operated with more than worn limit end clearance shown in same table. If engine is disassembled for repair, install new thrust rings if wear results in end clearance in excess of 0.022 in. [0.5588 mm].

The check can be made by attaching an indicator (1, Fig. 5-44) to rest against flywheel/crankshaft while prying (2) against a crankshaft throw through an inspection hole if the oil pan is not removed. End clearance must be present with engine mounted in unit and assembled to transmission or converter.

Table 5-9: Crankshaft End Clearance — In. [mm]

New Minimum	*New* Maximum	*Operating* Worn Limit
0.006 [0.1524 mm]	0.013 [0.3302 mm]	0.026 [0.6604 mm]

Check Vibration Damper Alignment (E Check)

Damper hub (1, Fig. 5-45) and inertia member (2) are stamped with an index mark (3) to permit detection of movement between the two components.

Inspect damper every "E" check. There should be no relative rotation between hub and inertia member resulting from engine operation.

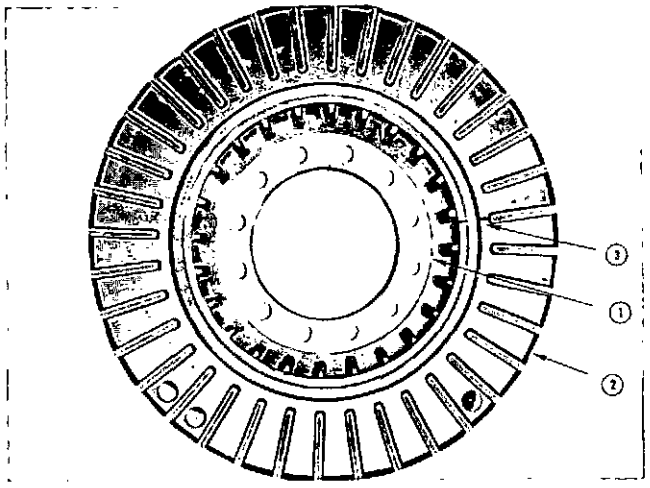


Fig. 5-45. Vibration damper alignment marks V40147

Change Hydraulic Governor Oil (E Check)

Change oil in the hydraulic governor sump at each "E" check.

Use the same grade oil as used in engine. See "Lubricating Oil Specifications," Page 3-1.

Note: When temperatures are extremely low, it may be necessary to dilute lubricating oil with enough fuel oil or other special fluid to insure free flow for satisfactory governor action.

Clean Cooling System (Spring And Fall)

The cooling system must be clean to do its work properly.

Scale in the system slows down heat absorption from water jackets and heat rejection from radiator. Use clean water that will not clog any of the hundreds of small passages in radiator or water passages in block. Clean radiator cores, heater cores, oil cooler and block passages that have become clogged with scale and sediment by chemical cleaning, neutralizing and flushing.

Chemical Cleaning

The best way to insure an efficient cooling system is to prevent formation of rust and scale by using a Cummins Corrosion Resistor, but if they have collected, the system must be chemically cleaned. Use a good cooling system cleaner such as sodium bisulphate or oxalic acid followed by neutralizer and flushing.

Pressure Flushing

Flush radiator and block when anti-freeze is added or removed, or before installing a Corrosion Resistor on a used engine.

When pressure flushing radiator, open upper and lower hose connections and screw radiator cap on tight. Remove thermostats from housing and flush block with water. Use hose connections on both upper and lower connections to make the operation easier. Attach flushing gun nozzle to lower hose connection and let water run until radiator is full. When full, apply air pressure gradually to avoid damage to the core. Shut off air and allow radiator to refill, then apply air pressure. Repeat until water coming from radiator is clean.

Sediment and dirt settle into pockets in block as well as radiator core. Remove thermostats from housing and flush block with water. Partially restrict lower opening until block fills. Apply air pressure and force water from lower opening. Repeat process until stream of water coming from block is clean.

Check Preheater (Spring And Fall)

1. Inspect wiring; remove ⅛ in. pipe plug from manifold near glow plug and check flame while a helper performs preheating operation. See Page 2-3.
2. If no flame is observed, remove and replace with new or tested parts.

Check Power Take-Off Clutch Adjustment (As Required)

If clutch does not pull, heats or operating lever jumps out, clutch must be adjusted. To adjust clutch, remove hand hole plate in housing and turn clutch until adjusting lockpin can be reached.

Disengage adjusting lockpin and turn adjusting yoke or ring to right, or clockwise, until operating lever requires a distinct pressure to engage. A new clutch generally requires several adjustments until friction surfaces are worn in.

Clean Injector Inlet Screens (As Required)

On external fuel line engines, each fuel inlet connection has a fine mesh screen (1, Fig. 5-46) at the large end.

To clean: Remove the strainer screen; wash in solvent and dry with compressed air. Reassemble as removed.

Clean And Calibrate Injectors (As Required)

Clean and calibrate injectors as required to prevent restriction of fuel delivery to combustion chambers. Because of the special tools required for calibration, most owners and fleets find it more economical to let a Cummins Distributor do the cleaning and calibration operations.

Normally, it is necessary to clean and calibrate injectors when there is an indication of low power, excessive smoke and when adjustment does not bring engine performance back to normal.

To clean and calibrate injectors, refer to Bulletin No. 983536.

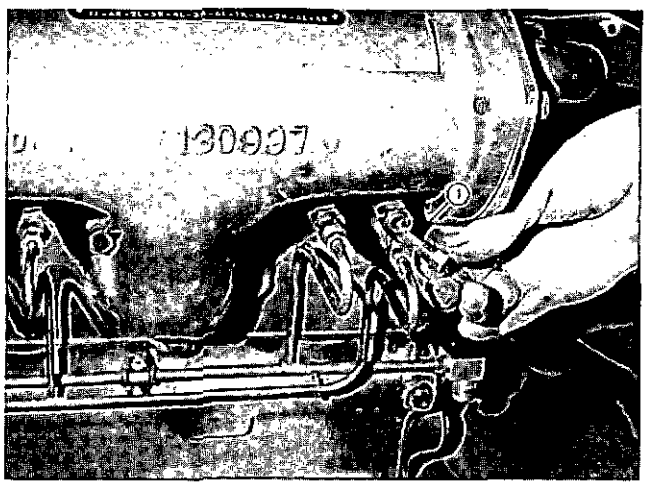


Fig. 5-46. Clean injector inlet screens V40602

F—Maintenance Checks

After engine has had four "E" checks, it should have an "F" check or major inspection to determine whether it may be operated for another service period, or whether it should be overhauled. Oil consumption, oil pressure at idling, dilution and other signs of wear should be analyzed as part of the inspection.

Since major inspection requires partial disassembly of engine, it should be done only in a well-equipped shop by mechanics thoroughly familiar with worn replacement limits and with disassembly and assembly procedures. This information is available in all Cummins Shop Manuals which can be purchased from any Cummins Distributor.

Inspect following items at this period:

Main and Connecting Rod Bearing Shells

Crankshaft Journals

Camshaft Lobes

Cylinder Heads (Grind Valves)

Cylinder Liners

Pistons and Rings

Fuel Pump (Calibrate)

Injectors (Clean and Calibrate)

Oil Cooler (Clean)

Turbocharger Bearing Clearances

Air Compressor

Alternator/Generator and Cranking Motor

Intake and Exhaust System (Clean and Correct Leaks)

Parts which are worn beyond worn replacement limits at this inspection should be replaced with new or rebuilt parts or units.

Engine Rebuild

If, during major inspection, it is determined crankshaft journals or any other engine parts are worn beyond worn replacement limits, engine should be removed and completely rebuilt.

After an engine has been rebuilt it is essentially a new engine and should be treated as such. By treating rebuilt engine like a new engine and by following preventive maintenance schedule, the same dependable service can be expected from engine that it gave during its first service period.

Maintenance Operations Summary Sheet

Information should be collected from each maintenance check sheet and consolidated on a single summary sheet such as shown on the next page. Each engine thus has an established history and cost records can be computed quickly. A review of summary sheet will then tell you which operations can be reduced or increased to make maintenance program more effective, resulting in more efficiency from engine at lower cost. A potential failure caught before it happens provides savings to engine owner and a ready-for-service unit for operator.

CUMMINS

MAINTENANCE OPERATIONS SUMMARY

ENGINE SERIAL NO.____________

EQUIPMENT NO.____________

NOTE: INCLUDE SUMMARY OF DAILY "A" REPORTS PERFORMED BETWEEN "B" OPERATIONS IN NEXT "B" REPORT.

	OPERATIONS		DUE	PERFORMED	DATE	MECHANIC	LABOR	PARTS		FUEL	LUBE OIL	TIME LOST	EMERGENCY REPAIRS			REMARKS
	CHECKS	FUEL GALLONS	GALLONS or HOURS	GALLONS or HOURS			HOURS	REQ. NO.	COST	GALLONS	QUARTS	HRS. OUT OF SERVICE	LABOR	PARTS	TIME LOST – HOURS	ACCIDENTS – CAUSE OF FAILURE – MAJOR ITEMS REPLACED, ETC.
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	C															
	B															
	D															
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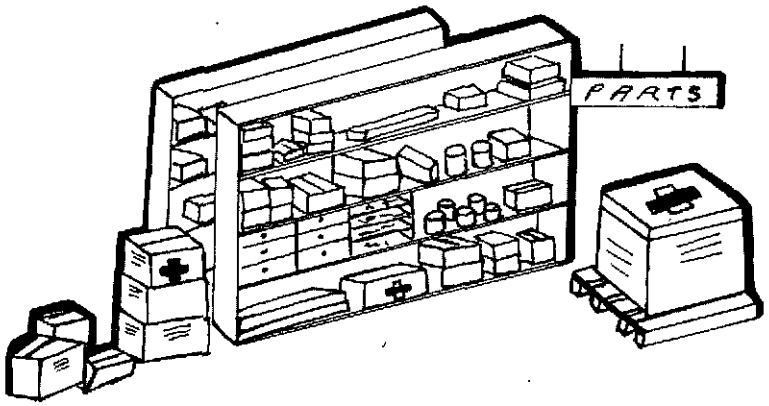
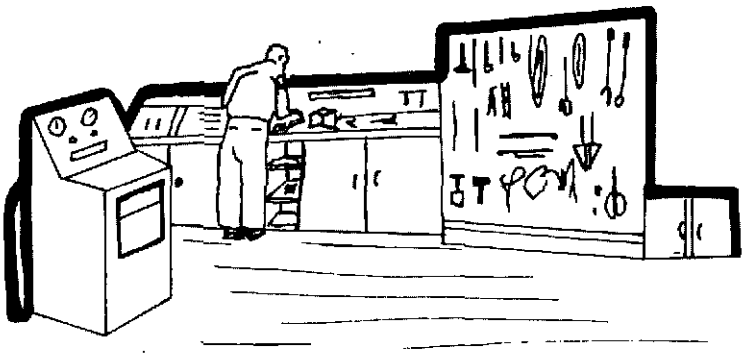


Parts

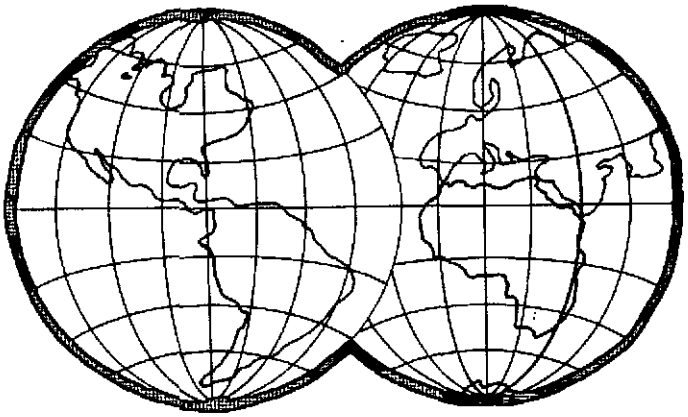
Genuine Cummins service parts are of the same high quality as those used on the original engine so your engine will continue to give good service after any repair or maintenance.

These parts are available only from authorized Cummins Distributors and Dealers, and we urge you to make full use of their parts stocking facilities.



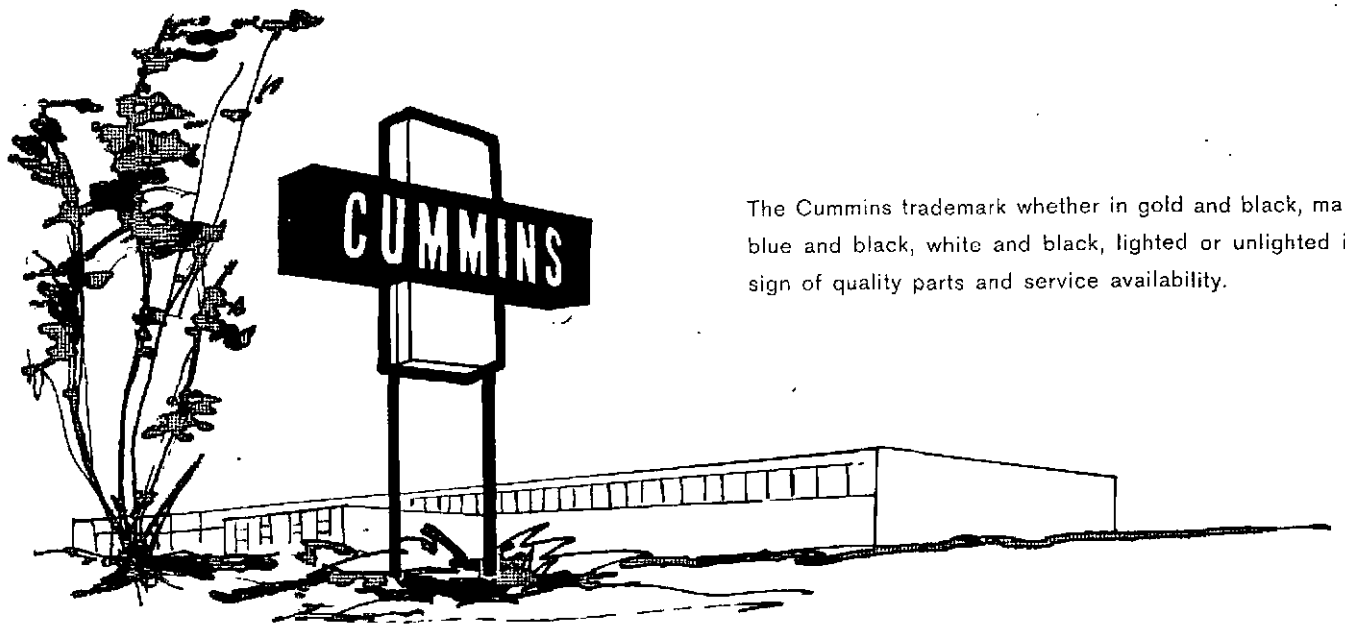
Service

Trained servicemen, special tools and equipment (where required) and an active interest in each customer will make you immediately aware that service is the by-word of the Cummins Distributor and Dealer Organization.



Location

The Cummins Distributor and Dealer Organization reaches to the "far corners" of the world and points in between. Each Distributor or Dealer is a respected businessman from the locality which he serves; this is an important reason why Cummins Service has gained such an outstanding reputation. For assistance in selecting new engine power, parts and service; see your nearest Cummins Distributor or Dealer.



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Bulletin No. 983596-A 3/67 Printed in U.S.A.