OPERATION AND MAINTENANCE

CUMMINS

H and NH SERIES DIESEL ENGINES

BULLETIN NO. 983373-A

PRICE $1.50

CUMMINS ENGINE COMPANY, INC. • COLUMBUS, INDIANA, U.S.A.

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Foreword

This manual is applicable to all 4 and 6-cylinder, 4⅞" and 5⅛" bore Cummins Diesels. It contains instructions for operators and maintenance mechanics that will enable them to get the best service from their engines. Before operating the engine or attempting any engine adjustments, familiarize yourself with the procedures described.

This is an operation and maintenance manual; no unit rebuilding instructions are included. Rebuild operations should be performed in a well-equipped shop by mechanics trained for rebuild work.

Your Cummins Distributor is equipped to do rebuild work, or if you are equipped to do your own rebuilding, you can purchase the H and NH Shop Manual from your Cummins Distributor.

CUMMINS ENGINE COMPANY, INC.

COLUMBUS, INDIANA, U.S.A.

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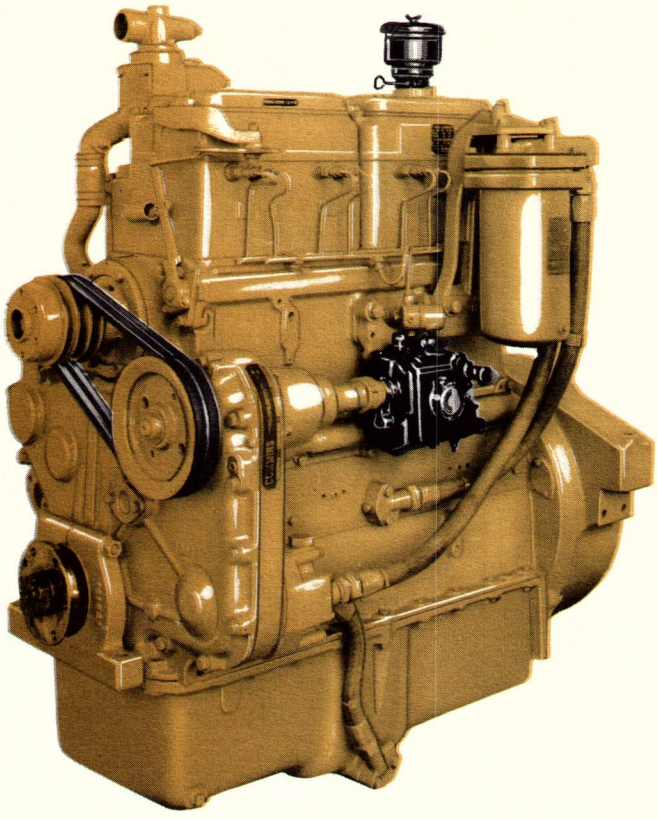


Fig. 1. HRC-4 Diesel Engine—Fuel pump side

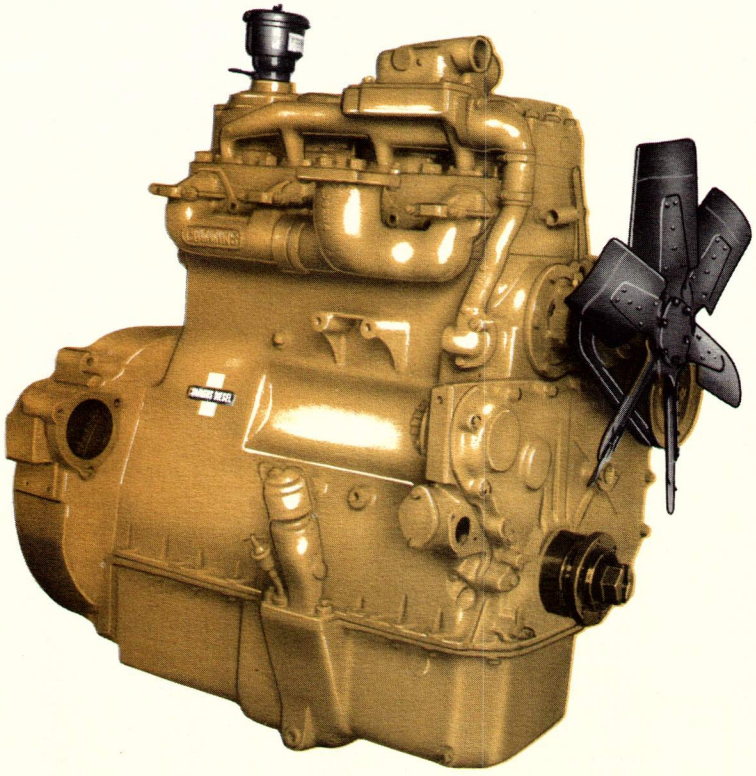


Fig. 2. NHC-4 Diesel Engine—Manifold side

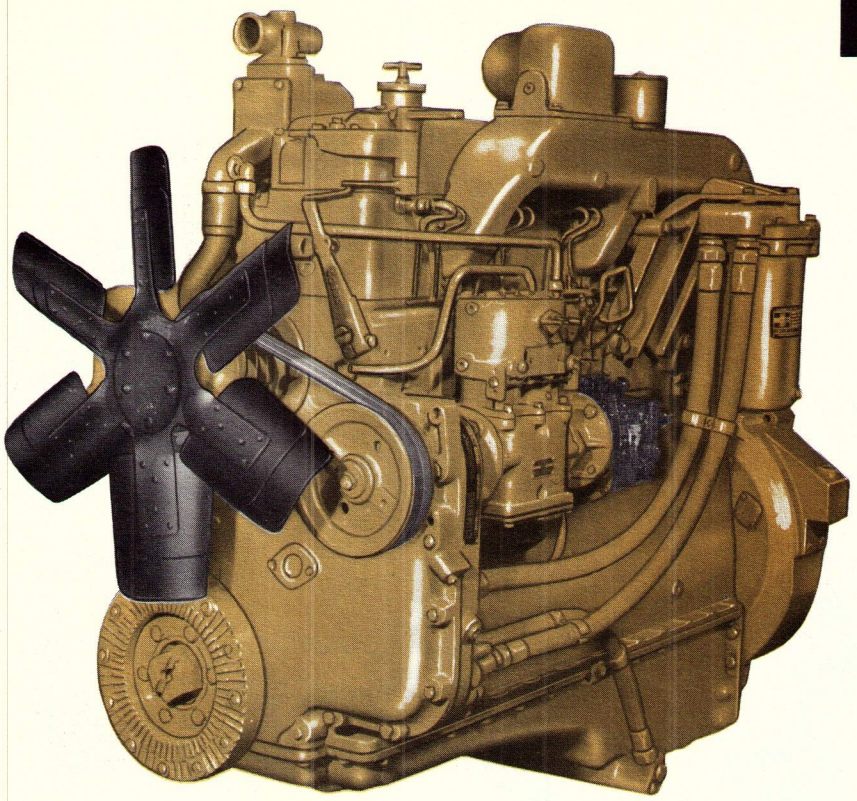


Fig. 3. NH-195 (IOL) Diesel Engine—Fuel pump side

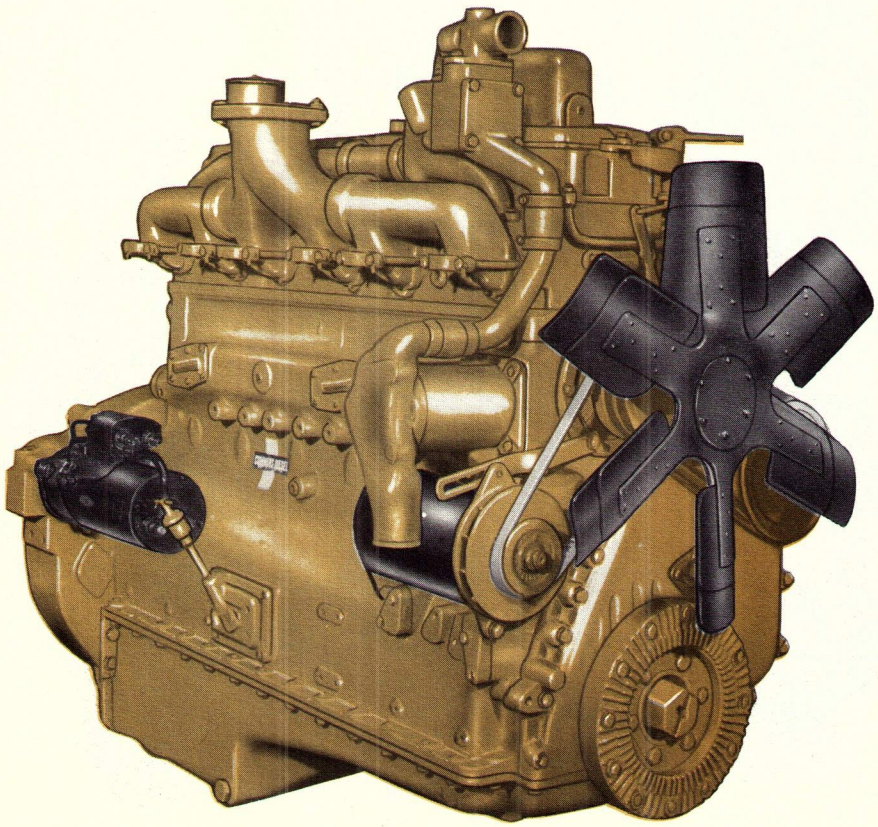


Fig. 4. NH-220 (IOL) Diesel Engine—Manifold side

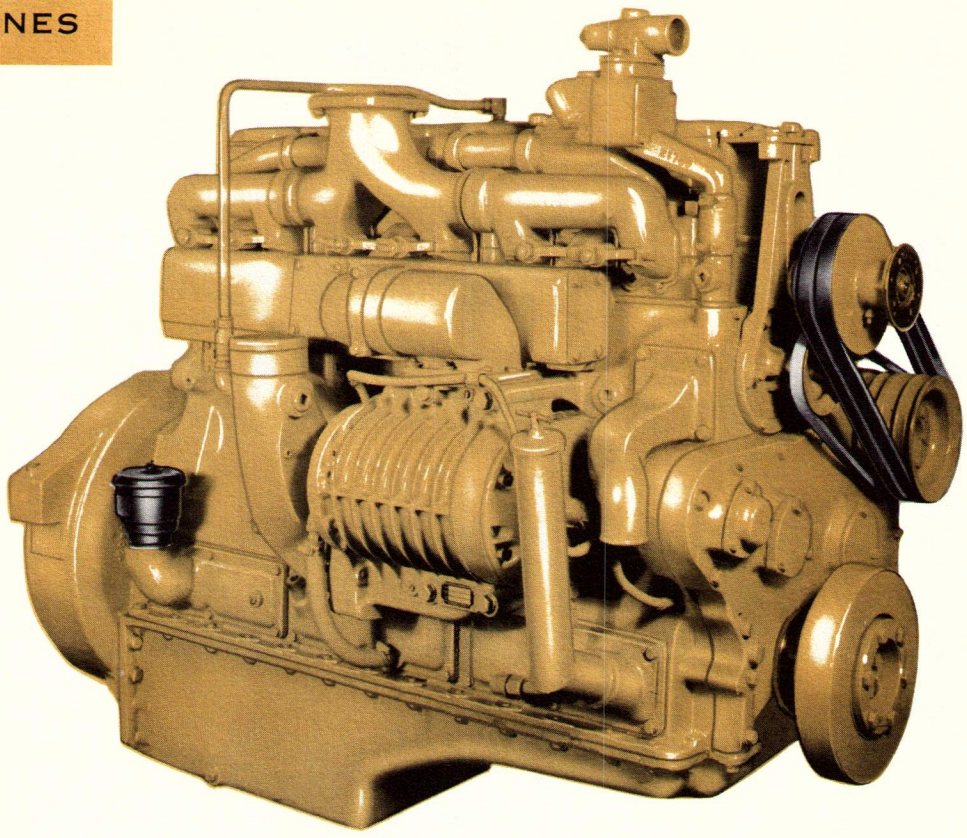


Fig. 5. HBS-6 Diesel Engine—Supercharger side

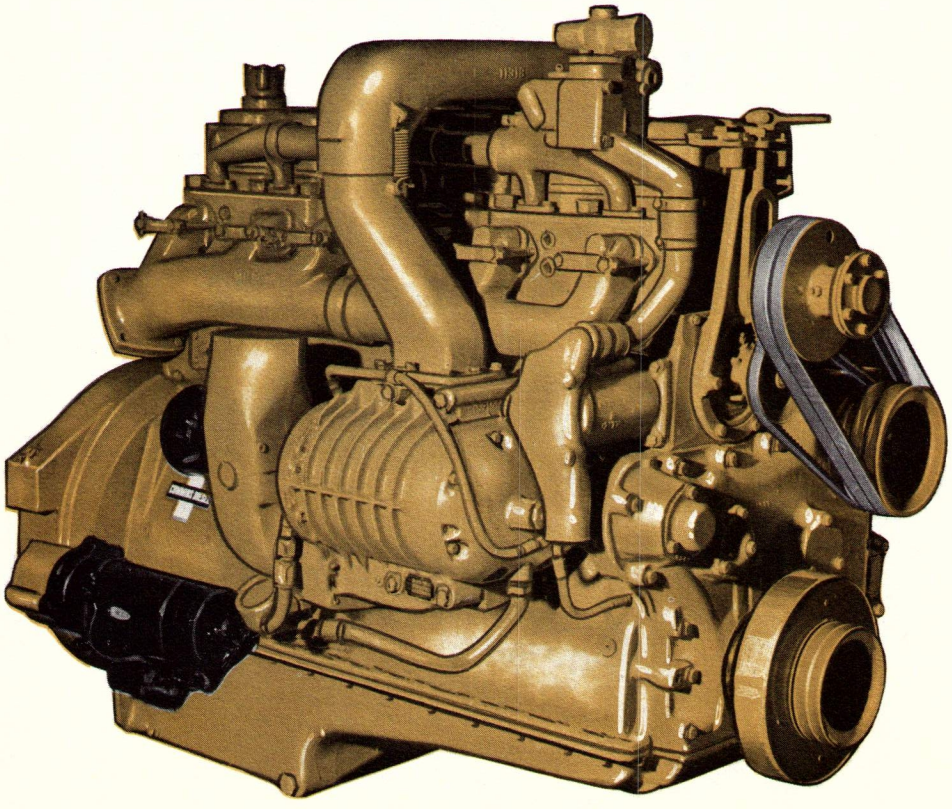


Fig. 6. NHRS-6 (IOL) Diesel Engine—Supercharger side

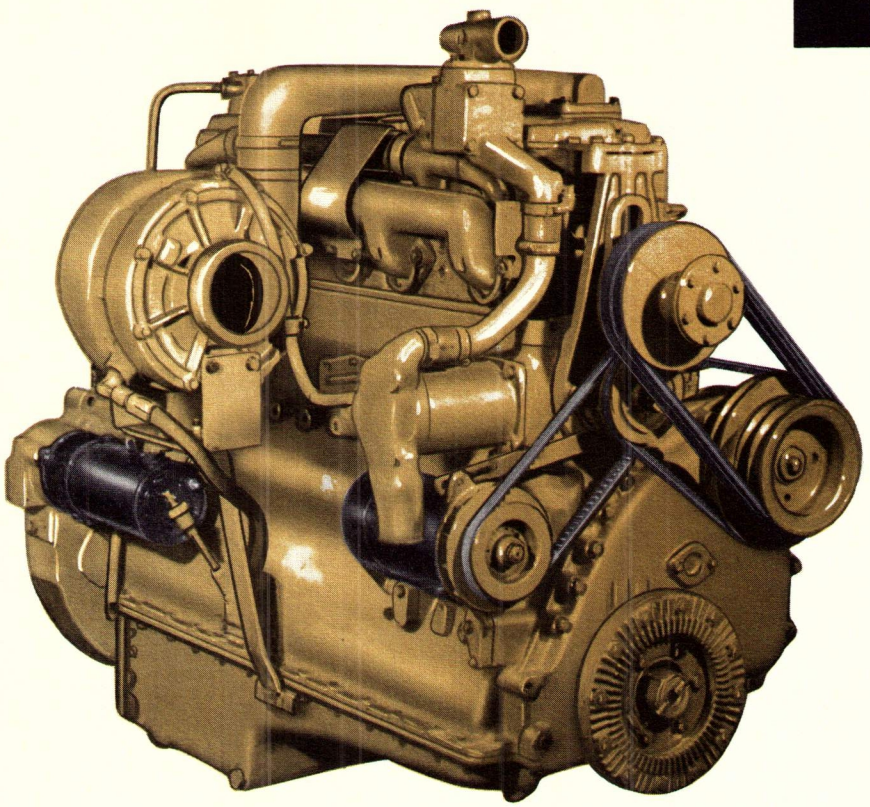


Fig. 7. NRTO-6 (IOL) Diesel Engine—Turbocharger side

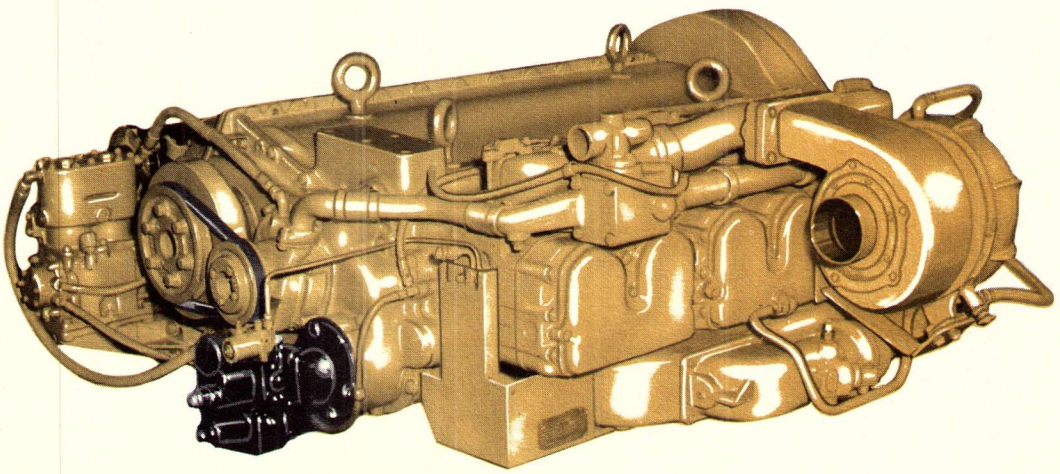


Fig. 8. NHHT-6 Diesel Engine—Front view

CUMMINS

H and NH SERIES DIESEL ENGINES

Section I

The most satisfactory service can be expected from a Cummins Diesel Engine when the operation and maintenance procedures are based upon a clear understanding of the engine working principles. Each part of the engine affects the operation of every other working part and of the engine as a whole.

Cummins H and NH Series 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 at the end of this Section.

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 the combustion chamber through the intake consists of air only — with no fuel mixture. Injectors receive low pressure fuel from the fuel pump and deliver it into the individual combustion chambers at the right time in equal quantity and proper condition to burn. Ignition of fuel is caused by the heat of the compressed air in the combustion chamber.

We can better understand the function of engine parts if we know what happens in the combustion chamber during each of the 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 the intake stroke, the piston travels downward, the intake valve is open, and the exhaust valve is closed. Some engines have dual intake and exhaust valves as indicated on Page 1-11.

The downstroke of the piston permits air from outside to enter the cylinder through the open intake

valve port. On engines where used, the supercharger or turbocharger increases air pressure in the engine intake manifold and forces it into the cylinder.

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

COMPRESSION STROKE:

At the end of the intake stroke, the intake valve closes and the piston starts upward on the compression stroke. The exhaust valve remains closed.

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

Compressing the air into a small space causes the temperature of that air to rise. Near the end of the compression stroke, the pressure of the air above the cylinder is approximately 500 to 600 pounds per square inch and the temperature of that air is approximately 1000° F.

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

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

POWER STROKE:

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

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

EXHAUST STROKE:

During the exhaust stroke, the intake valve is closed, the exhaust valve is open, and the piston is on its upstroke.

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

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

THE LUBRICATING SYSTEM

The working parts of the Cummins Diesels are lubricated by force feed. The force is supplied by a gear-type lubricating pump. Oil is held in the sump in the oil pan and it is drawn from this sump by the lubricating oil pump. It is delivered to all working parts of the engine through lubricating oil lines and the oil header, the latter being drilled the full length of the block.

The oil header, oil pipes leading to the upper rocker housings, various drillings through the block, crankshaft and rocker levers complete the oil circulating passages.

Lubricating oil is forced from the crankshaft to lubricate the main and connecting rod bearings. Lubricating oil pressure is controlled by a regulator in the oil pump.

Filters, strainers and screens are provided throughout the lubricating system for proper cleaning of the lubricating oil.

The air compressor and supercharger or turbocharger receive pressure lubrication from the engine oil supply.

The injector plunger in the injector and the working parts in the fuel pump are lubricated by fuel oil. The fuel oil used for lubrication of the injector plunger is returned to the fuel tank through drain lines. On hydraulic-governed fuel pumps, lubricating oil of the same grade as used in the engine is carried in the governor drive housing for governor lubrication.

The cross-section figures, Pages 1-3 and 1-4, show oil flow direction and the various units provided to clean and cool hot oil and maintain a constant pressure of 30/50 psi in the header at governed engine rpm.

A by-pass valve is provided in the oil strainer as insurance against interruption of oil flow by a dirty or clogged strainer element.

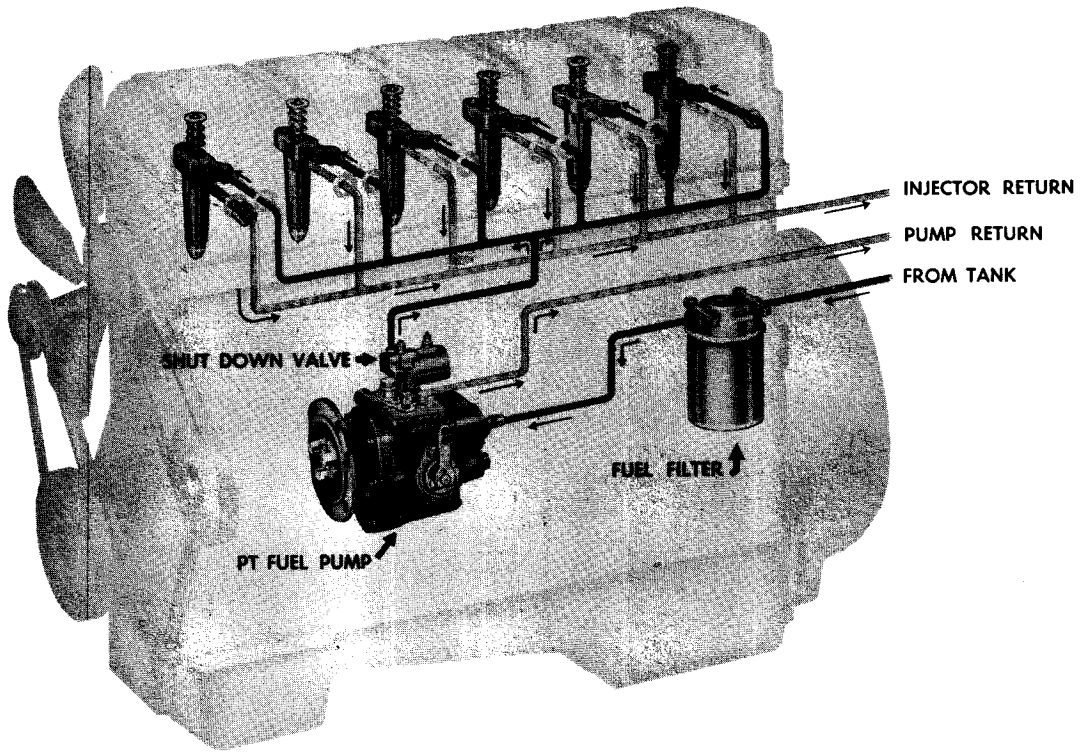


Fig. 1-1. PT fuel system — Fuel flow diagram

THE FUEL SYSTEM

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

The principle of the PT Fuel System is based on the fact that by changing the pressure of a liquid flowing through a pipe you change the amount of liquid coming out of the open end. Increasing the pressure increases the flow or the amount of liquid delivered, and vice versa. In applying this simple principle to the diesel fuel system it is necessary to provide:

1. A fuel pump to draw fuel from the fuel tank and deliver it to individual injectors for each cylinder.
2. A means of controlling the pressure of the fuel being delivered by the fuel pump to the injectors so the individual cylinders will receive the right amount of fuel for the power required of the engine.
3. Fuel passages of the proper size and type so that the 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 the fuel pump and deliver it into the individual combustion chambers at the right time, in equal quantity and proper condition to burn.

The PT fuel system consists of the fuel pump (with governor), the supply and drain lines, and the injectors. Each is described in detail in the following paragraphs.

FUEL PUMP:

The fuel pump is made up of three main units:

1. A gear pump which draws fuel from the supply tank and delivers it under pressure through the pump and supply lines to the individual injectors.

2. The pressure regulator which limits the pressure of the fuel to the injectors.
3. The governor and throttle which act independently of the pressure regulator to control fuel pressure to the injectors.

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

The location of these units in the fuel pump housing is indicated in Figs. 1-2 and 1-3.

Gear Pump:

The gear pump is located at the rear of the fuel pump and is driven by the main shaft. This unit consists of a single set of gears to pick-up and deliver fuel throughout the fuel system. From the gear pump, fuel flows through the filter screen and to the pressure regulator. Fuel flow is shown in Fig. 1-4.

Pressure Regulator:

The pressure regulator is a by-pass valve to regulate the fuel, under pressure, supplied to the injectors. By-passed fuel flows back to the suction side of the gear pump.

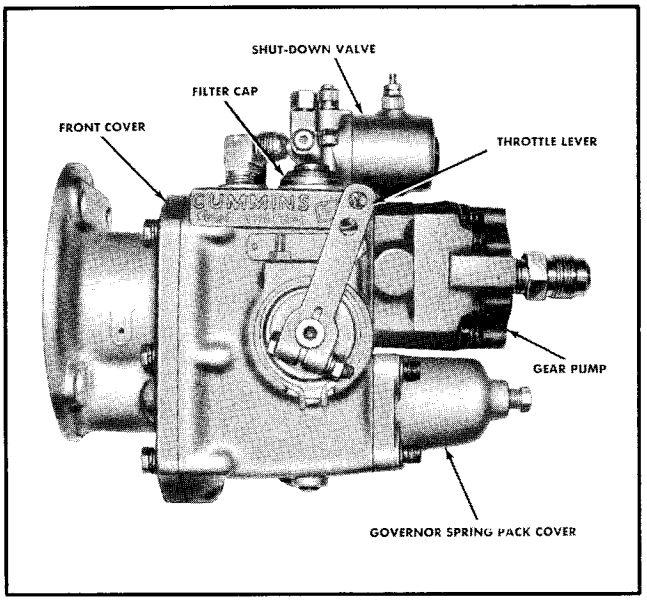


Fig. 1-2. Fuel pump units

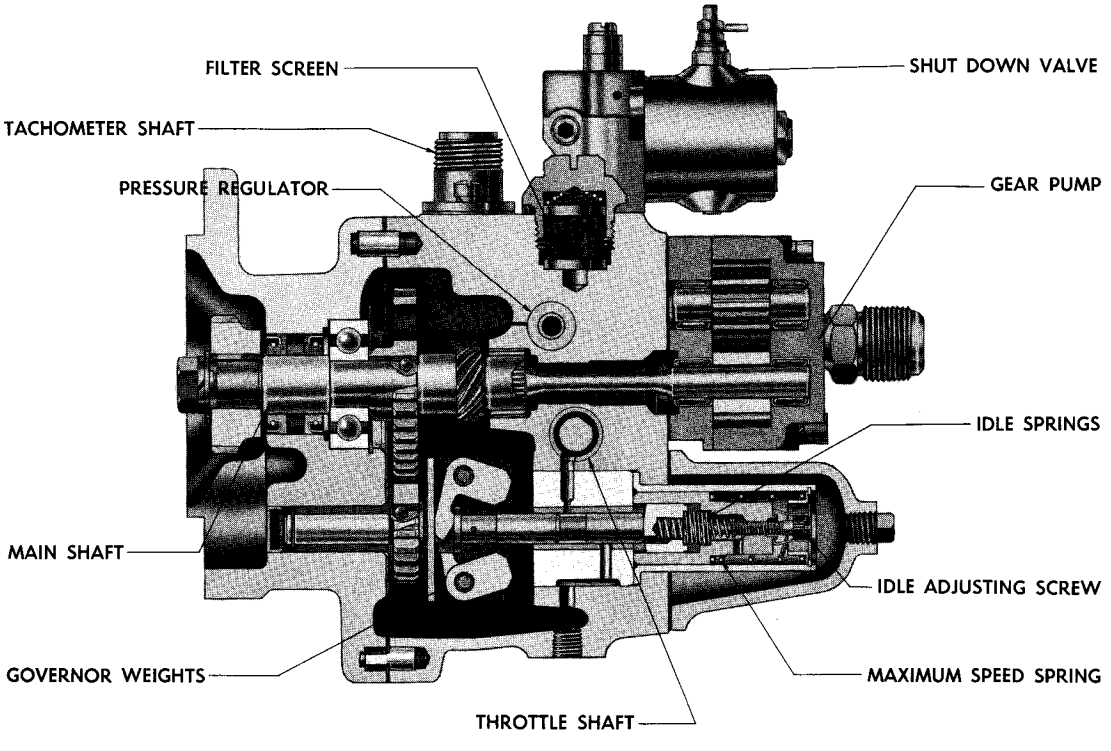


Fig. 1-3. Cross section PT pump with idling and high-speed mechanical governor

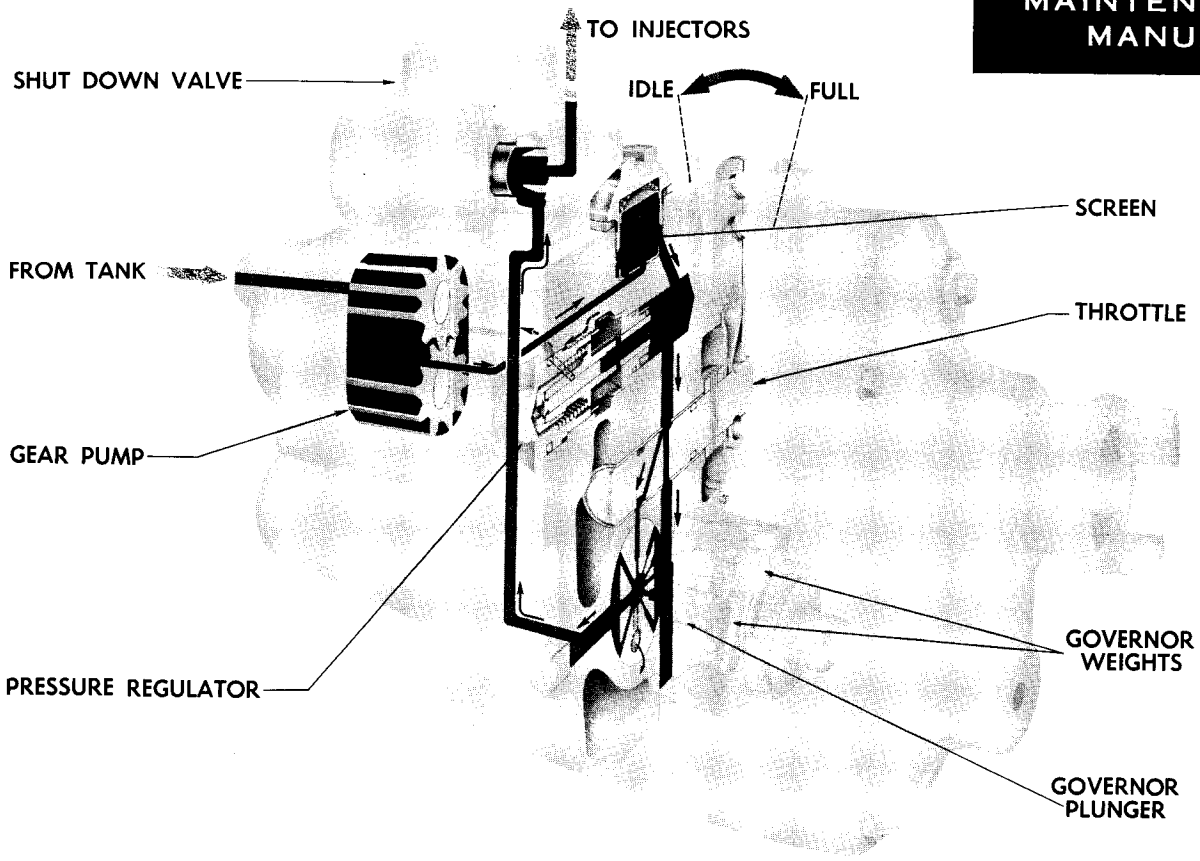


Fig. 1-4. Fuel flow through the fuel pump

Throttle:

Fuel for the engine flows past the pressure regulator to the throttle shaft. Idle fuel passes through the shaft idle port to the idle jet in the governor. For operation above idle, fuel passes through the throttling hole in the shaft and enters the governor through the primary jets.

Governors:

Idling and High-Speed Mechanical Governor: Mechanical governor action is provided by a system of springs and weights, and has two functions. First, the governor maintains sufficient fuel for idling with the throttle control in idle position; and second, it cuts off fuel above maximum rated rpm. The idle springs in the governor spring pack position the governor plunger so the idle fuel jet is opened enough to permit passage of fuel to maintain engine idle speed.

During operation between idle and maximum speeds, fuel flows through the governor to the injectors in accord with the engine requirements as controlled by the throttle and limited by the pressure regulator. When the engine reaches governed speed, the governor weights move the governor plunger, and fuel passages to the fuel supply manifold are shut off. At the same time another passage opens and dumps the fuel to the supply manifold back into the main pump body. In this manner engine speed is controlled and limited by the governor regardless of throttle position. Fuel leaving the governor travels through the shut-down valve, inlet supply lines and on into the injectors.

Variable-Speed Mechanical Governor: This governor is designed to meet the requirements of machinery on which the 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 the varying speed requirements of cranes, shovels, etc., in which the same engine is used for propelling the unit and driving a pump or other fixed-speed machine.

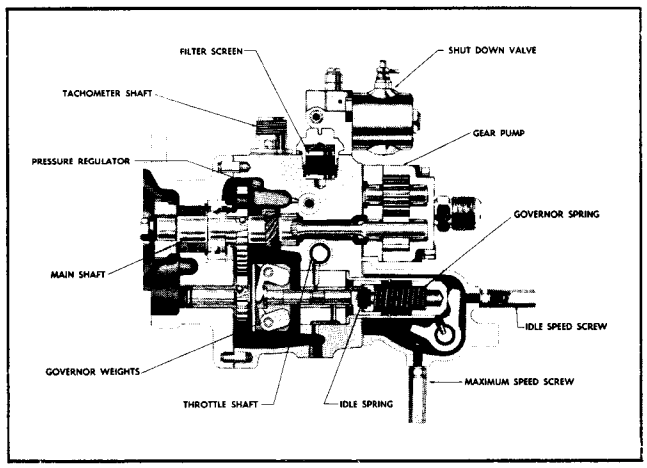


Fig. 1-5. Flange-mounted fuel pump with variable-speed governor

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.

Torque Converter Governor: When a torque converter is used to connect the engine with its driven unit, an auxiliary governor may be driven off the torque converter output shaft to exercise control over the engine governor and to limit converter output shaft speed. The engine governor and the 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 the engine and the other by the converter. Figs. 1-5 and 1-6.

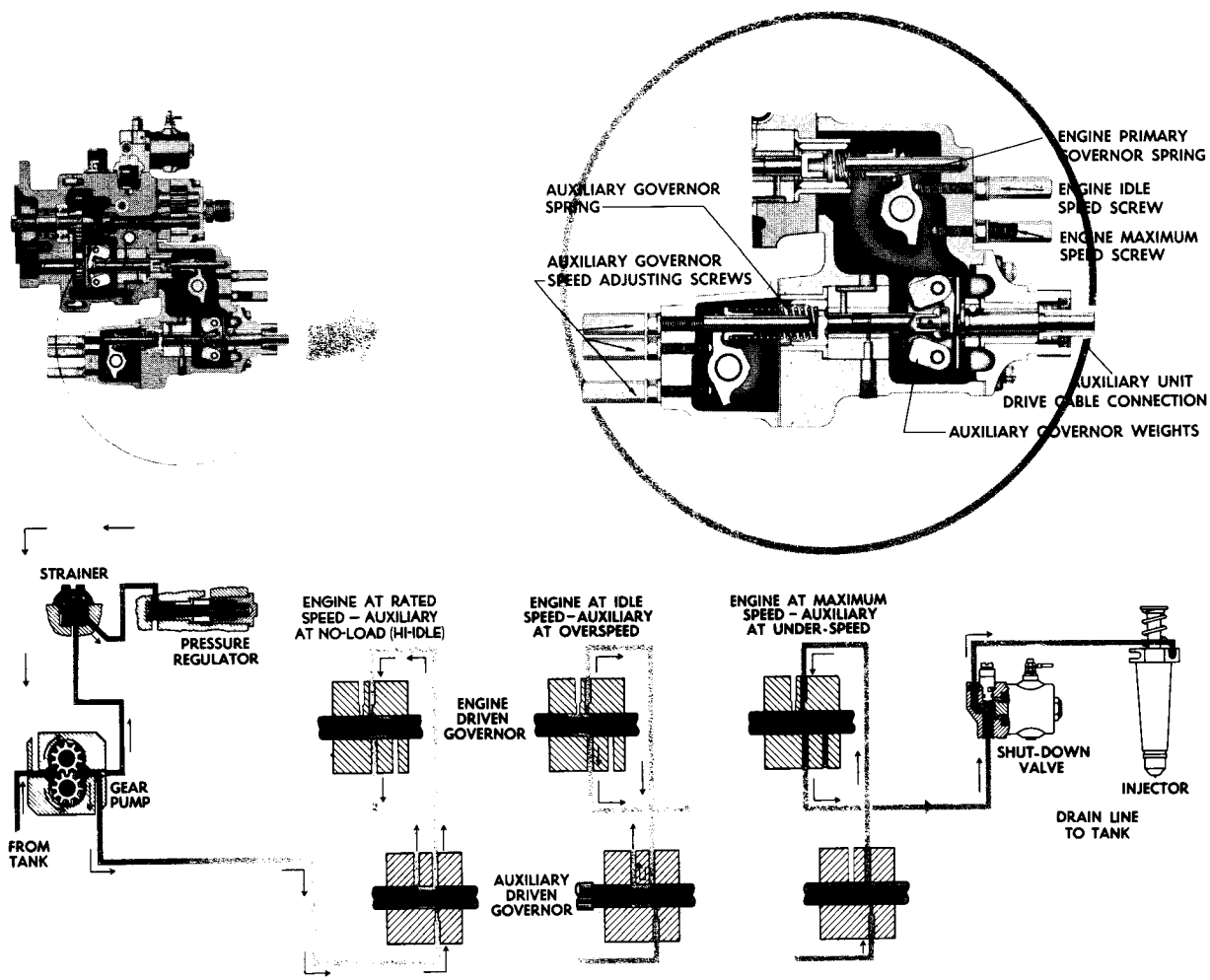


Fig. 1-6. Cross section and fuel flow through torque convertor governor and fuel pump

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

Fig. 1-6 shows the position of the governor plungers under different engine and converter speed conditions.

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 the governor drive housing.

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

In order that its operation may be stable, speed droop is introduced into the 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 that a certain amount of load is applied to the engine. The speed will drop, the flyballs will be forced inward and will lower the pilot valve plunger. This will admit oil pressure underneath the power piston, which will rise. The movement of the power piston is transmitted to the terminal shaft by the terminal lever. Rotation of the terminal shaft causes the fuel setting on the engine to be increased. Fig. 1-7.

INJECTORS:

Fuel circulates through the injector at all times except during a short period following injection into the cylinder. From the inlet connection, fuel flows down the inlet passage of the injector, around the injector plunger, between the body end and cup, up the drain passage to the drain connections and manifold and back to the supply tank.

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

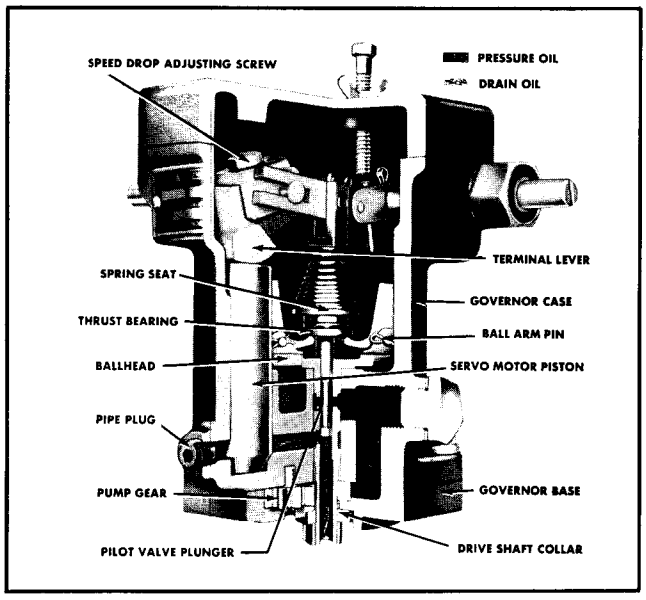


Fig. 1-7. Load off, speed increased position

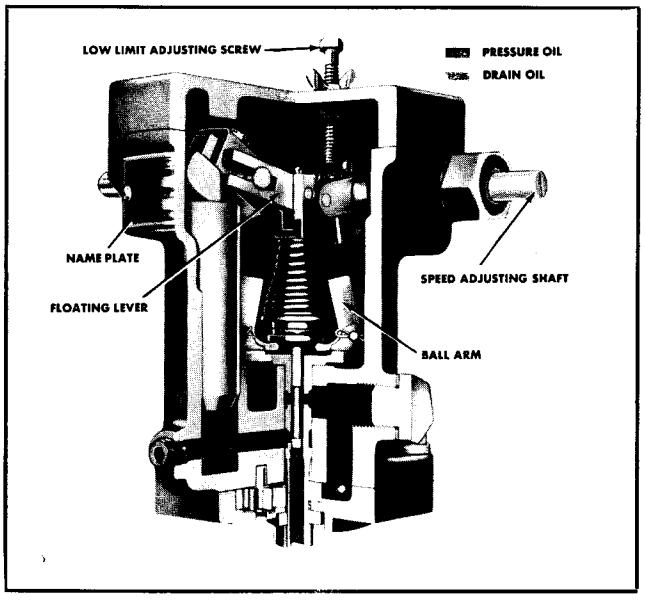


Fig. 1-8. Load on, speed decreased position

During injection, the plunger is forced downward until the metering orifice is closed and the fuel in the cup is injected into the cylinder. While the plunger is seated all fuel flow through the injector stops. Fig. 1-9.

Some injectors contain adjustable injector bodies. A selected orifice plug in the inlet passage regulates fuel flow to the injector.

FUEL LINES AND VALVES:

Shut-Down Valve:

Manual Type: The shut-down valve, located on top of the fuel pump, cuts off fuel supply and is used to shut down the engine. When the plunger is pushed in, the fuel passage to the injectors is open; as it is pulled out, the fuel passage is closed. It is important to keep the valve pulled out in the "off" position whenever the engine is not running.

Electric Solenoid Type: The electric solenoid shut-down valve permits the fuel to be shut off or turned on through the use of a switch key similar to that used in automotive ignition systems.

Supply Lines:

Fuel supply lines must be held to a specified size to insure an even pressure and supply of fuel to each injector. From the supply lines, fuel enters the inlet connection to the injector. Fig. 1-1.

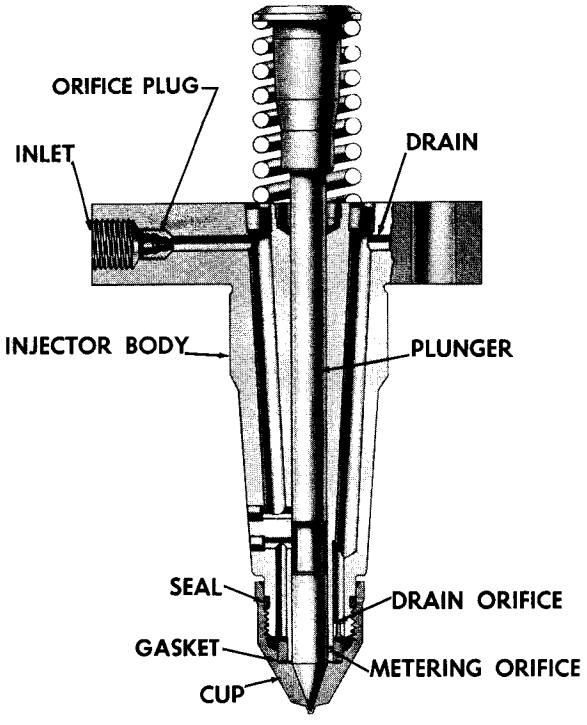


Fig. 1-9. Injector cross section

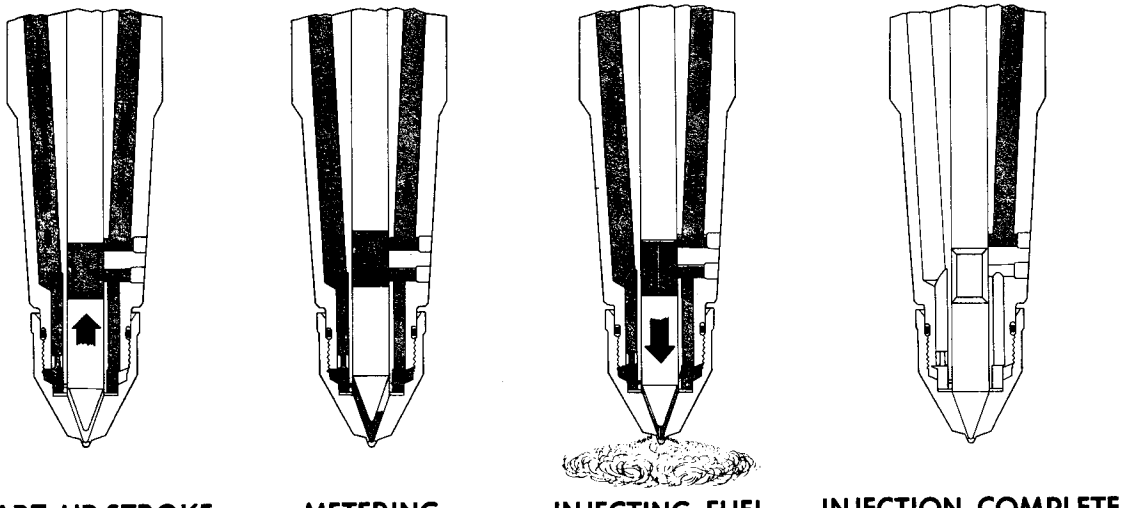


Fig. 1-10. Fuel injection cycle

Inlet Connections:

The inlet connections between the fuel supply manifold and the injectors contain fine mesh screens at the large or cage end. The screen is the last protection against dirt entering the injector. There are no check valves in the inlet connection used in the PT fuel system. Fig. 1-1.

Drain Lines:

Not all fuel entering the injector is burned in the cylinder. Part of it circulates through the injector and is returned to the supply tank through the drain fittings, manifold and line. The drain lines must be ample size to provide free drainage to the fuel tank.

THE COOLING SYSTEM

Water is circulated by a centrifugal-type water pump mounted on the gear cover end of the engine and driven by belts from the accessory drive.

The water circulates around the wet-type cylinder liners, through the cylinder head and around the injector sleeves. The injector sleeves in which the injectors are mounted are made of copper for fast dissipation of heat. Discharge connections between the heads are provided by a water manifold. The water manifold houses a single thermostat to control engine operating temperature.

The engine coolant is cooled by a radiator or by heat exchangers, depending on the type of installation. In some cases, the heat exchanger and oil cooler are built as one unit. Oil coolers are provided for all NH Series engines except the NH-180 engine.

Where heat exchangers are used, a sea water pump is mounted on the engine.

THE AIR SYSTEM

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

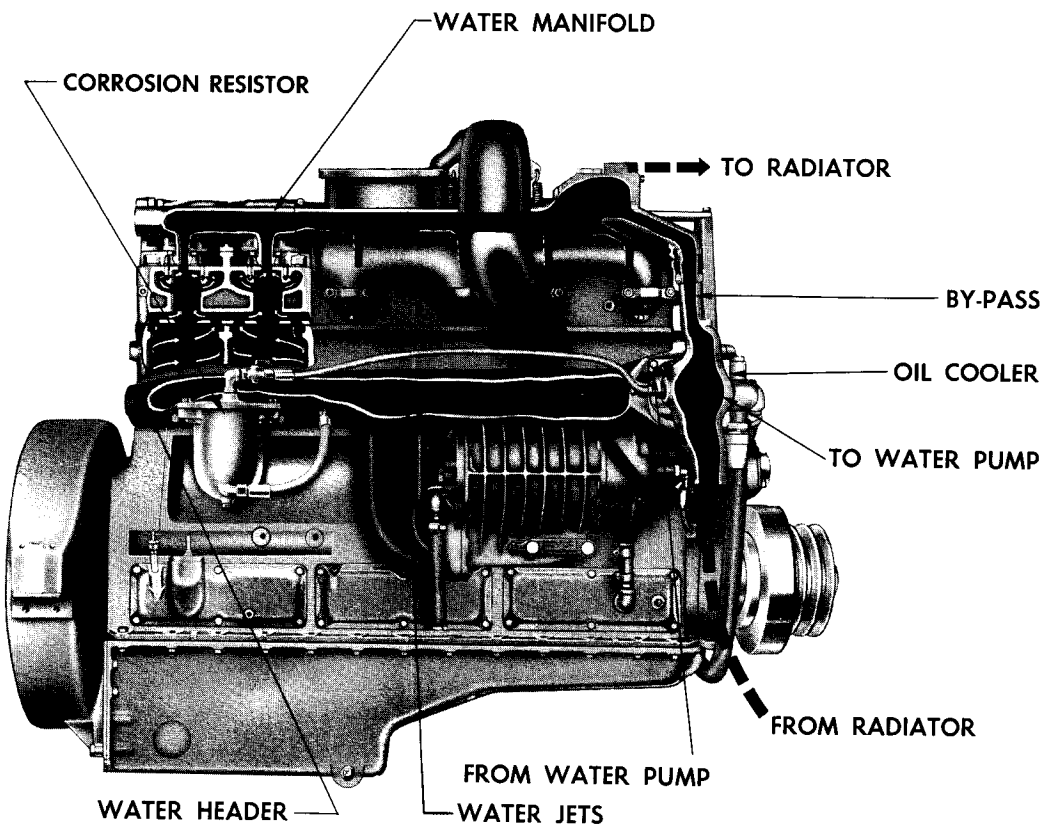


Fig. 1-11. NHS engine cooling system

The HS, HRS, NHS, and NHRS engines have superchargers; the NT, NTO, NRT, and NRTO engines are equipped with turbochargers.

SUPERCHARGER:

A supercharger is a gear-driven air pump which employs rotors to force air into the engine cylinders. The supercharger is driven from the engine crankshaft through a gear train turning at about 1.8 times engine speed. Fig. 1-12.

TURBOCHARGER:

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

The power to drive the turbine wheel (which in turn drives the compressor) is obtained from the energy of the exhaust gases. The rotating speed of the turbine changes as the energy level of the exhaust gas changes so the engine is supplied with enough air to burn the fuel for its load requirement. Fig. 1-13.

NOTE: On turbocharged engines equipped with water cooled exhaust manifolds never operate the engine with the manifold "dry." This will result in overspeeding and eventual turbocharger failure.

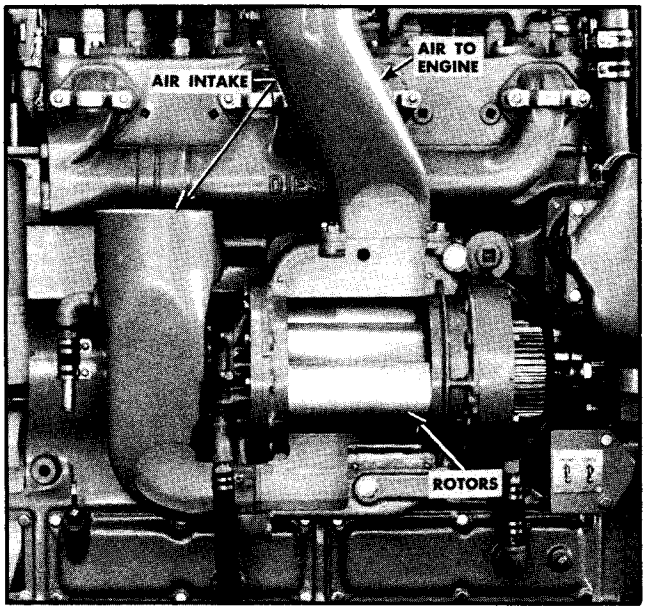


Fig. 1-12. Cutaway view of supercharger

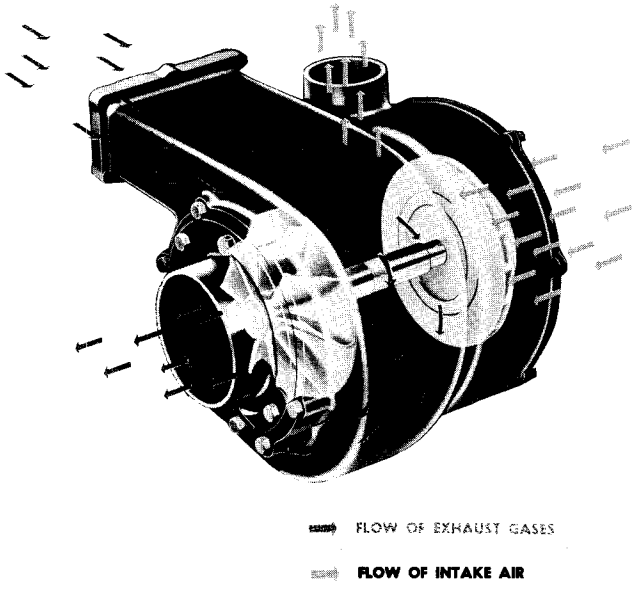


Fig. 1-13. Cutaway view of turbocharger

BASIC ENGINE MODELS TREATED IN THIS MANUAL

ENGINE MODELS	Engine Breathing	Number Cylinders	Bore & Stroke	Cu. In. Displ.	Valves per Cylinder	Maximum HP @ RPM
Vertical Models:						
H-6	Natural	6	4⅞ x 6	672	2	160 @ 1800
HS-6	Supercharged	6	4⅞ x 6	672	2	210 @ 1800
HRC-4	Natural	4	5⅛ x 6	495	2	115 @ 1800
*HR-6	Natural	6	5⅛ x 6	743	2	175 @ 1800
HRF-6	Natural	6	5⅛ x 6	743	2	190 @ 2000
HRS-6	Supercharged	6	5⅛ x 6	743	2	240 @ 1800
NHC-4	Natural	4	5⅛ x 6	495	4	130 @ 2000
*NH-180	Natural	6	4⅞ x 6	672	4	180 @ 2100
*NH-195	Natural	6	4⅞ x 6	672	4	195 @ 2100
*NH-220	Natural	6	5⅛ x 6	743	4	220 @ 2100
NHS-6	Supercharged	6	5⅛ x 6	743	4	290 @ 2100
*NHRS-6	Supercharged	6	5⅛ x 6	743	4	320 @ 2100
NT-4	Turbocharged	4	5⅛ x 6	495	4	165 @ 2000
NT-180	Turbocharged	4	5⅛ x 6	495	4	180 @ 2100
NT-200	Turbocharged	4	5⅛ x 6	495	4	200 @ 2100
*NT-6	Turbocharged	6	5⅛ x 6	743	4	250 @ 2100
*NTO-6	Turbocharged	6	5⅛ x 6	743	4	262 @ 2100
*NRT-6	Turbocharged	6	5⅛ x 6	743	4	300 @ 2100
*NRTO-6	Turbocharged	6	5⅛ x 6	743	4	335 @ 2100
NFT-6	Turbocharged	6	5⅛ x 6	743	4	375 @ 2300

* These engines also available in horizontal models.

Notes:

1. Naturally-aspirated and supercharged engine horsepower ratings are for standard test conditions at sea level and 60° F. intake air temperature. These engines should be derated 3% for each 1,000 feet increase in altitude and 1% for each 10 degrees air temperature increase.

2. NT engine horsepower rating is for operation up to 12,000 feet altitude. Derate 3% for each 1,000 feet over 12,000 feet altitude.

3. NTO engine horsepower rating is for operation up to 10,000 feet altitude. Derate 3% for each 1,000 feet altitude.

4. NRT engine horsepower rating is for operation up to 12,000 feet altitude. Derate 3% for each 1,000 feet over 12,000 feet altitude.

5. NRTO engine horsepower rating is for operation up to 5,000 feet altitude. Derate 1.5% for each 1,000 feet over 5,000 feet, and 3% for each 1,000 feet over 12,000 feet altitude.

6. NFT engine horsepower rating is for operation up to 2,000 feet altitude. Derate 2% for each 1,000 feet over 2,000 feet.

CUMMINS

H and NH SERIES DIESEL ENGINES

Section II

OPERATING INSTRUCTIONS

The operator of the engine assumes the 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 the operation.

There are comparatively few rules which the operator must observe to get the 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.

NEW ENGINE BREAK-IN

The way you operate your new engine during the first 50 to 100 hours' service will have an important effect on the life of the engine and its parts. Its moving parts are closely fitted for long service, and even though all Cummins engines are run on a dynamometer for several hours before they leave the factory, an additional period may be required before uniform oil films are established between all mating parts.

During the first 50 to 100 hours' service:

1. Operate most of the time at one-half to three-quarters throttle. Do not operate at maximum horsepower for more than five or ten minutes at a time.
2. Do not idle the engine for long periods, because this will cause cylinder walls to glaze before the piston rings seat properly, and the engine will continue to use too much lubricating oil.
3. Keep a close watch on your instruments. Back off on throttle if oil temperature reaches 200° F. or if water temperature exceeds 185° F.
4. Drive in a gear low enough so you can accelerate under any condition.

PREPARATION FOR STARTING

CHECK LUBRICATING OIL SUPPLY:

1. A dip stick oil gauge is located on the side of the engine. The dip stick supplied with the engine has a high "H" and low "L" level mark to indicate lubricating oil supply. The dip stick must be kept with the

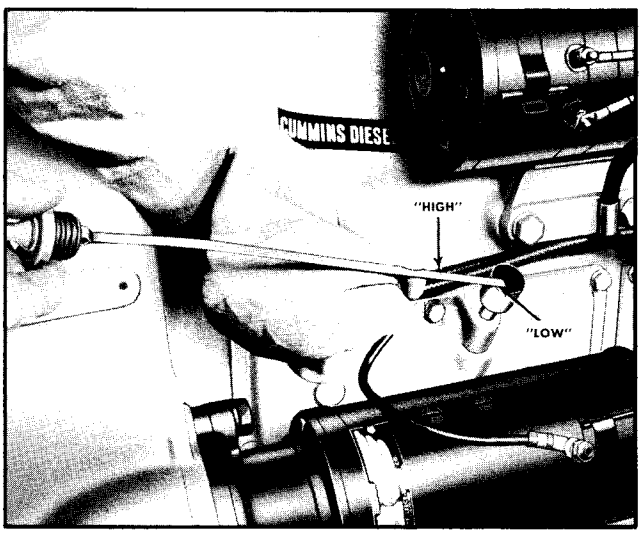


Fig. 2-1. Checking lubricating oil supply

oil pan, or engine, with which it was originally supplied. Cummins oil pans differ in capacity with different type installations and oil pan parts numbers.

2. Keep oil level as near the high level mark as possible. Never operate the engine with oil level below the low level mark.

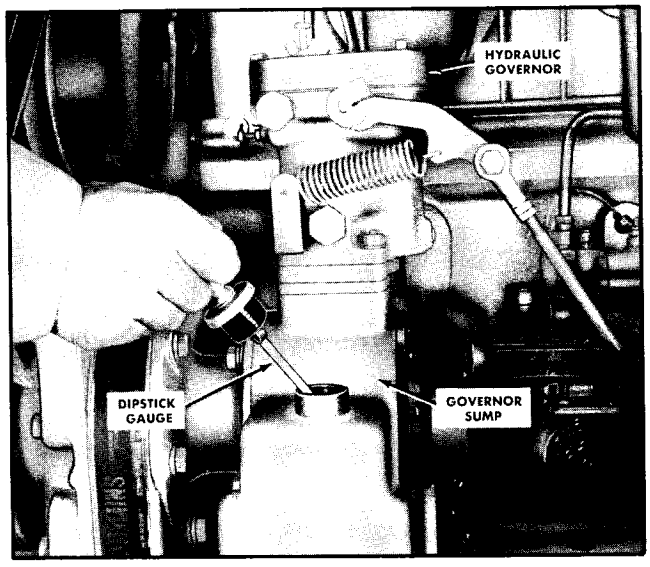


Fig. 2-2. Hydraulic governor

CHECK HYDRAULIC GOVERNOR:

1. Many engines used in stationary power applications are equipped with hydraulic-governed fuel pumps. This governor uses lubricating oil (of the same weight as used in the engine) as an energy medium.

2. Oil level in governor sump must be at full mark on dipstick. Fig. 2-2.

CHECK AIR CONNECTIONS:

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

CHECK ENGINE COOLANT SUPPLY:

1. Remove the radiator cap and check the engine coolant supply. Add coolant as needed to completely fill the system.

2. There are several recognized methods of protecting engine cooling systems from rust and corrosion. These methods are described on Page 3-17 under "Coolant Treatment."

CHECK INJECTOR PLUNGER AND VALVE ADJUSTMENTS:

If valve and injector adjustments have been disturbed by any maintenance work, it is important that they be properly adjusted before starting the engine. Otherwise, adjustments are required only at every fourth oil change, or every "D" check.

CHECK FUEL SUPPLY AND CONNECTIONS:

Make sure there is an adequate supply of good clean No. 2 diesel fuel. See "Fuel Oil Specifications," Page 3-14.

STARTING THE ENGINE

There is no mystery about starting a Cummins Diesel Engine. Starting requires:

1. An air supply to the combustion chambers.
2. A fuel supply to the combustion chambers.
3. Compression of the air for ignition.

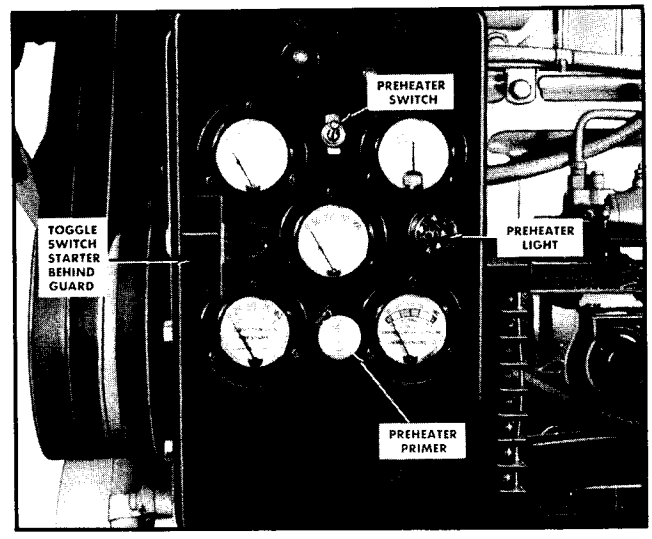


Fig. 2-3. Instrument panel

NORMAL STARTING PROCEDURE:

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

1. Set throttle for idle speed.
2. Release the clutch.
3. Open manual fuel shut-off valve, if not equipped with automatic valve.
4. Pull the compression release (if so equipped).
5. Press starter button or turn switch-key to "start" position. A manual over-ride button is provided

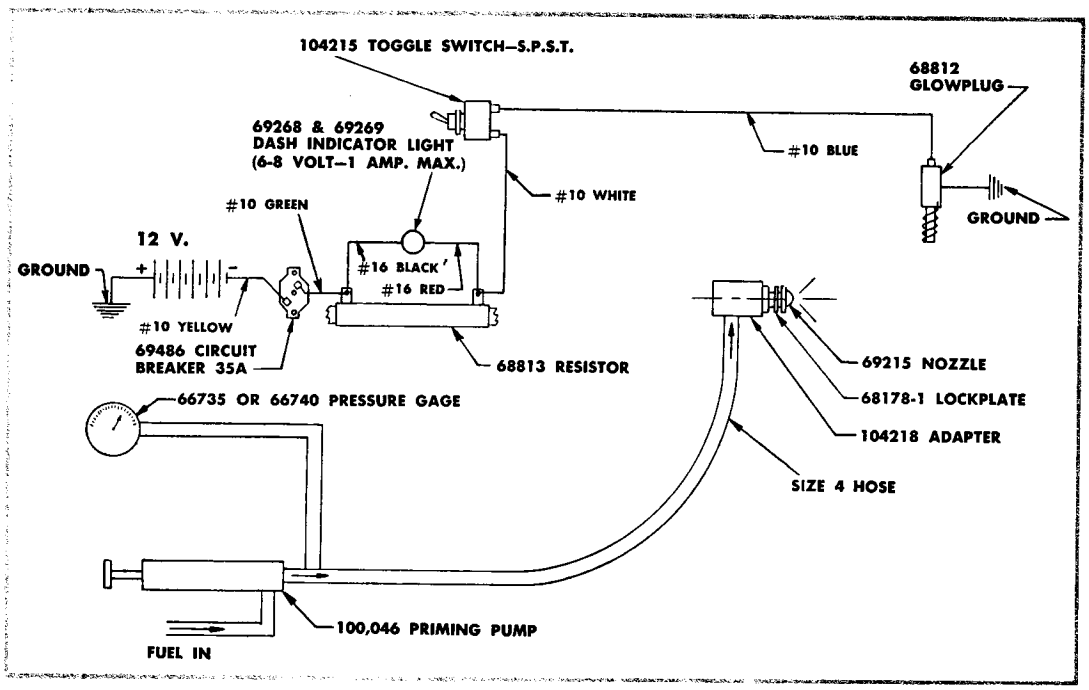


Fig. 2-4. Preheater wiring diagram

on the forward end of the electric shut-down valve above the fuel pump. It allows the valve to be opened in case of electric power failure. To use, push in button and lock by turning to right.

6. After three or four seconds of cranking, close the compression release (if so equipped) and continue to crank until the engine fires.

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

CAUTION: DO NOT CRANK ENGINE FOR MORE THAN 30 SECONDS CONTINUOUSLY OR YOU MAY BURN OUT THE CRANKING MOTOR. IF ENGINE DOES NOT FIRE WITHIN THE FIRST 30 SECONDS, WAIT TWO TO FIVE MINUTES BEFORE RE-CRANKING.

USE THE PREHEATER FOR COLD WEATHER STARTING:

To aid in starting the engine when the temperature is 50° F. or below, an intake air preheater is supplied as standard equipment on all supercharged and turbo-charged engines. The preheater equipment consists of a hand-priming pump to pump fuel into the intake manifold, a glow plug electrically heated by the battery, and a switch to turn on the glow plug when fuel is pumped into the intake manifold. The fuel burns in the intake manifold and heats the intake air.

CAUTION: DO NOT USE ETHER IN CONJUNCTION WITH THE PREHEATER.

To use the preheater for cold starting follow this starting procedure:

1. Set throttle in idle position. *Do not accelerate engine during the starting procedure.*
2. Turn glow plug toggle switch on "ON" position. Red indicator light must be on.
3. After red light has been on for 20 seconds, start cranking the engine. As soon as engine begins rotating, operate the preheater priming pump to maintain 40 to 60 psi 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, the fuel by-pass switch must be in "start" position before operating priming pump.

4. If engine does not start within 20 seconds, stop cranking. Wait 30 seconds and repeat cranking operation.

NOTE: On engines with an oil pressure safety switch, hold the fuel by-pass switch in "start" position until engine oil pressure reaches 7 to 10 psi; then, move to "run" position.

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 the 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 the engine gives no indication of starting during the first three full strokes of the preheater pump, check the intake manifold for heat. If there is no heat, check electric wiring. If wiring is all right, remove ⅛" pipe plug 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. The glow plug should be white hot; if not, connect glow plug to a six-volt source and check amperage which should be 30 (minimum). If glow plug is all right, check manual switch and resistor and replace if necessary.

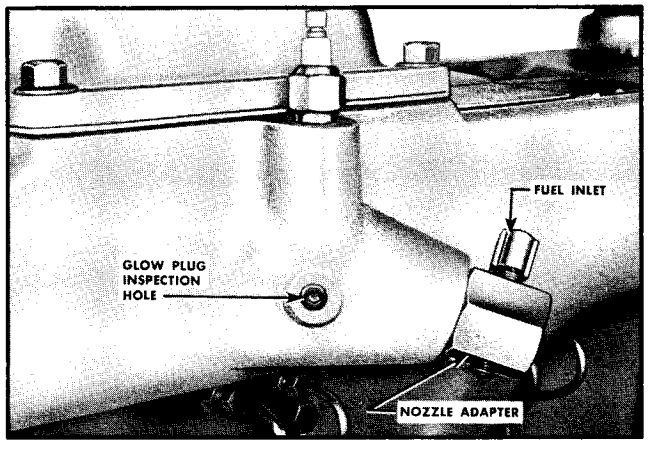


Fig. 2-5. Glow plug inspection hole

OTHER COLD STARTING AIDS:

Ether-Compound Metering Equipment:

This consists of a metering chamber for ether compound capsules and controls to release the starting compound during cranking.

The metering chamber is installed to release the starting fluid between the air cleaner and the supercharger on supercharged engines. On non-supercharged engines, the metering chamber releases the fluid to the air intake manifold. To start engines equipped with this cold starting aid:

1. Close shut-off cock. If properly installed, the spring will hold it closed.

2. Remove cap and insert capsule of starting fluid.

3. Push cap down sharply to puncture capsule and tighten one-fourth turn.

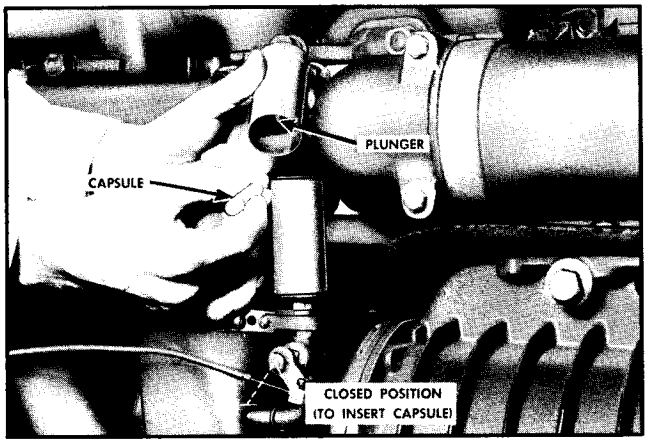


Fig. 2-6. Ether compound metering equipment

4. Wait 30 seconds before engaging starter.

5. Engage starter and, while engine is being cranked, open the shut-off valve.

CAUTION: DO NOT OPEN THE VALVE BEFORE CRANKING THE ENGINE OR THE ENTIRE AMOUNT OF FLUID WILL DRAIN INTO THE INTAKE AIR BEFORE CRANKING, AND THERE WILL BE ONE EXCESSIVELY HEAVY CHARGE INSTEAD OF THE METERED AMOUNTS WHICH STARTING REQUIRES.

6. After engine has started and all fluid has drained out of chamber, close the valve to prevent leakage of dusty air into the engine.

7. Remove and discard empty capsule, and reassemble empty primer.

Use of Ether Without Metering Equipment:

If the engine is not equipped with a preheater arrangement or ether compound metering equipment, the following method can be used to start the engine:

CAUTION: NEVER HANDLE ETHER NEAR AN OPEN FLAME. NEVER USE IT WITH PREHEATER OR FLAME THROWER EQUIPMENT. DO NOT BREATHE THE FUMES.

1. Two men will be required for this operation; one will crank the engine while the other applies ether to the intake air.

2. Pour two or three tablespoonfuls of ether on a cloth and hold the cloth close to the air cleaner while another operator cranks the engine.

CAUTION: DO NOT USE TOO MUCH ETHER. THIS WILL CAUSE EXCESSIVELY HIGH PRESSURES AND DETERIORATION.

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

CAUTION: BE SURE CLOTH IS OUTSIDE THE AIR CLEANER AND CAN NOT BE DRAWN INTO THE ENGINE.

ENGINE WARM UP

WARM UP ENGINE BEFORE APPLYING LOAD:

When the engine is started, it takes a while to get the 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 the engine up to operating speed gradually as it warms up. Allow the engine to run at 800 to 1000 rpm long enough to bring water temperature to at least 130° F. before engaging the load. During this time make all the necessary outside checks; load distribution, brakes, fifth wheel, air and electric couplings, tires, etc. During the next 10 to 15 minutes, or until water temperature reaches 160°/165° F. operate at partial load and at not more than 1600 rpm.

APPLY LOAD GRADUALLY:

Always engage the load in a gear low enough to allow you to accelerate to governed rpm, then catch the next gear as you decelerate. Do not skip gears.

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

ENGINE SPEEDS

OPERATE AT REDUCED RPM FOR CONTINUOUS-DUTY:

When operating the engine in a continuous-duty situation, such as, cruising on a level highway, powering a boat or running continuous-operation generators, maintain engine rpm at approximately 85 percent of governed rpm. See Table. This will give you adequate power for continuous-duty operation and economical fuel consumption.

Engine governors are set for reduced rpm for continuous-duty operation.

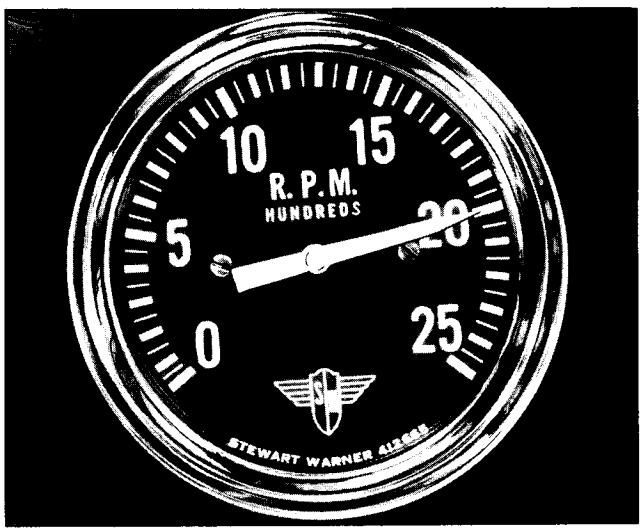


Fig. 2-7. Cruise at 85% governed rpm

Governed Speeds:

All Cummins engines are equipped with governors to prevent speeds in excess of maximum ratings.

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

TABLE: ENGINE SPEEDS

	Governed Full Load RPM	Cruising or Continuous Duty RPM
H-4	1800	1500 to 1550
HR(C)-4	1800	1500 to 1550
H-6	1800	1500 to 1550
HS-6	1800	1500 to 1550
HR-6	1800	1500 to 1550
HRF-6	2000	1700
HRS-6	1800	1500 to 1550
NHC-4	2000	1700
NT-4	2000	1700
NT-180	2100	1750 to 1800
NT-200	2100	1750 to 1800
NH-180	2100	1750 to 1800
NH-195	2100	1750 to 1800
NH-220	2100	1750 to 1800
NHS-6	2100	1750 to 1800
NHRS-6	2100	1750 to 1800
NT-6	2100	1750 to 1800
NTO-6	2100	1750 to 1800
NRT-6	2100	1750 to 1800
NRTO-6	2100	1750 to 1800

THE INSTRUMENT PANEL

OPERATE BY YOUR INSTRUMENTS:

It makes no difference whether your engine is in a truck, in a boat or on some other type operation; you need to use the panel board instruments. The instruments tell you at all times what you need to do to get the most satisfactory service from your engine.

USE THE TACHOMETER:

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

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

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

Most of your operation will be of this kind. The engine will not be working hard and you will be operating in the easy-shift range.

Many trucks are geared for higher maximum road speeds than schedules require, so drivers can cruise in high gear and at reduced engine rpm. This is good practice as long as the engine pulls its load at partial throttle.

THE OIL TEMPERATURE GAUGE INDICATES BEST OPERATING RANGE:

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

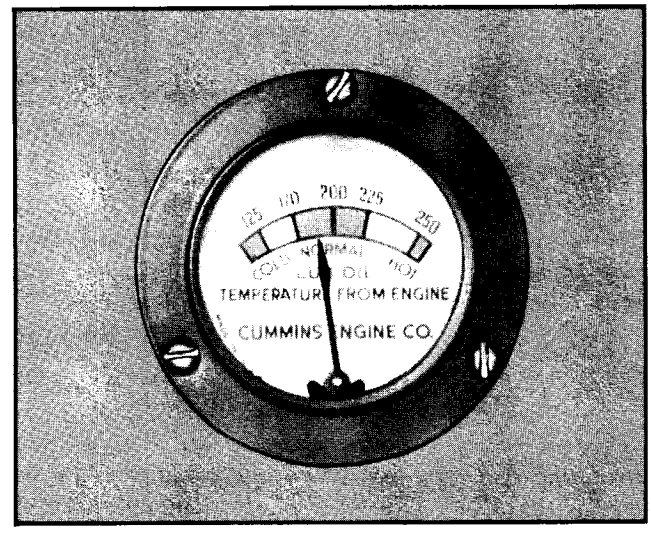


Fig. 2-8. Oil temperature

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

During warm-up period, apply load gradually until oil temperature reaches 170° F. While oil is cold it does not do a good job of lubricating. Also, if you operate continuously with oil temperatures much below 170° F., you are likely to have crankcase dilution and acids in the lubricating oil which will accelerate wear tremendously.

KEEP WATER TEMPERATURE BETWEEN 165°F. AND 185°F.:

A water temperature of 165° F. to 185° F. is the best assurance that cylinder liners are heated to the proper temperature to support good combustion, and that working parts of the engine have expanded evenly for the most favorable oil clearances.

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

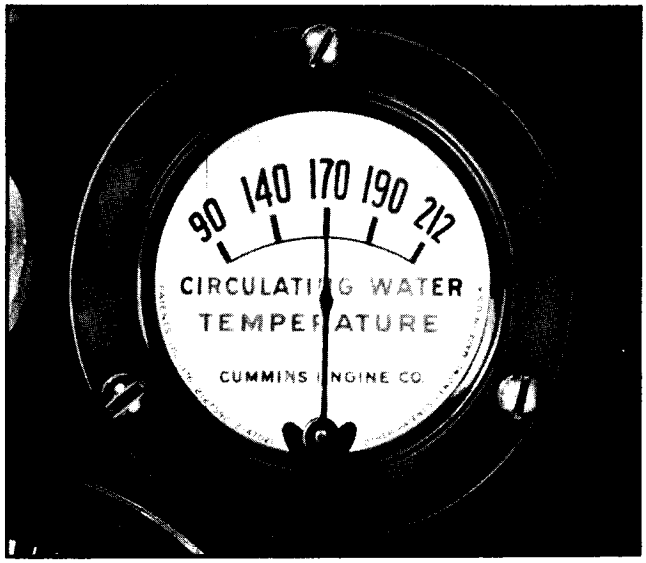


Fig. 2-9. Water temperature

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

Keep thermostats in the engine summer and winter, avoid long periods of idling, and do whatever else is required to keep water temperatures up to a minimum of 165° F. 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 insufficient radiator capacity. Report cases of overheating to the maintenance department for correction.

KEEP AN EYE ON YOUR OIL PRESSURE GAUGE:

Your oil pressure gauge indicates when the lubricating oil supply is low. A good operator will note loss of oil pressure immediately and shut down the engine before the bearings are ruined.

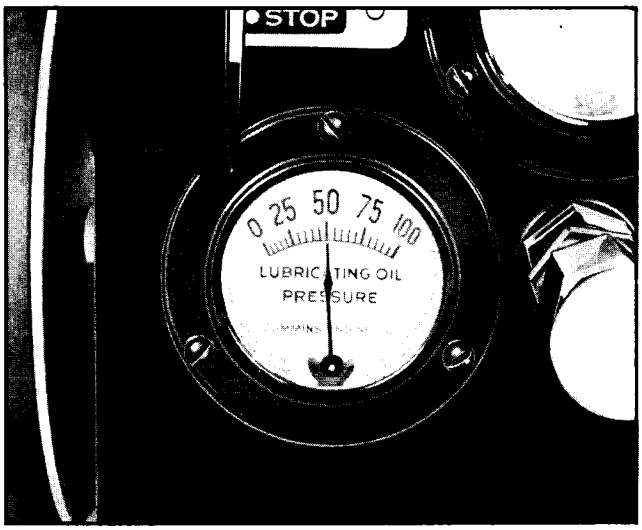


Fig. 2-10. Oil pressure

Normal pressures are:

Idle Pressure	5-15 psi
Operating Pressure	30-75 psi

OBSERVE ENGINE EXHAUST:

Your 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 your engine exhaust is smoky, shift to a lower gear.

MAXIMUM HORSEPOWER REQUIREMENTS

Maximum horsepower is attained only at maximum, or governed, engine rpm. Whenever you pull down engine rpm by overload you start losing horsepower, and you continue to lose it as long as the engine continues to lose rpm. When you need full horsepower, operate your engine near the governor. This rule applies to any kind of application.

Torque converters and combinations of electric generators and motors often are applied to transmit power from the engine to its driven unit. When properly applied, these devices automatically compensate for load changes by trading shaft speed for increased torque without allowing engine rpm to be pulled down by more than 10% to 15%.

WHEN YOU NEED MORE POWER SHIFT TO A LOWER GEAR AND INCREASE ENGINE RPM:

One rule sums up everything you need to know about proper gear selection to give you the power you need and best performance from your equipment:

Always operate in a gear low enough to allow the engine to accelerate to, or maintain, governed RPM when you advance to full throttle.

When you require more torque or power, shift to lower gear and rev up the engine near the governor. This will give you the additional horsepower you need.

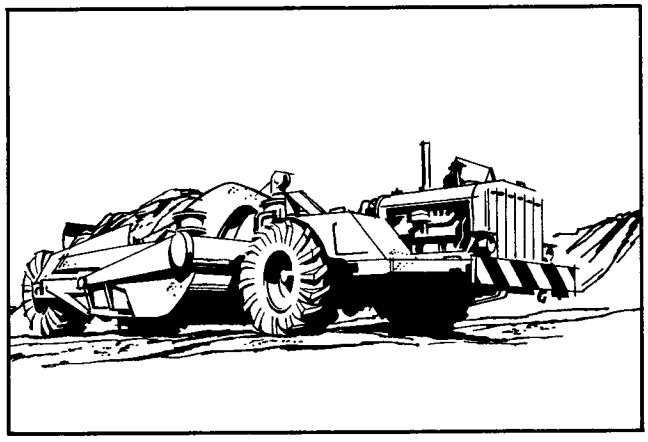


Fig. 2-11. Change gears for more power

SHIFT TO A LOWER GEAR WHEN THE LOAD PULLS DOWN ENGINE RPM AS MUCH AS 10%:

If the grade gets steeper and load starts to pull down engine rpm, just treat that part of the grade like another hill and shift to a still lower gear.

Never allow engine rpm to drop more than 10 percent below the governor at full-throttle before you start shifting. If you cannot catch the next gear at the 10 percent drop, let up on the throttle until you get the right rpm for the shift, but at full-throttle do not pull down engine rpm more than 10 percent.

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

HIGH ALTITUDE OPERATION

Your engine loses horsepower when you operate at high altitude because the air is too thin to burn as much fuel as at sea level. The loss is about 3 percent for each 1,000 feet of altitude. See Page 1-11.

OPERATE IN LOWER GEARS AT HIGH ALTITUDE:

Your engine will have a smoky exhaust at high altitude unless you use a gear low enough so your 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. Shift gears as needed to avoid smoking, and to avoid overspeeding of turbocharger. See Page 1-11.

DOWN-HILL OPERATION

Your Cummins Diesel is effective as a brake on downhill grades, but do not overspeed the engine going downhill. The governor has no control over engine speed when it is being pushed by the loaded vehicle.

Never turn off the switch key while going down hill because, with the engine still in gear, fuel pressure will build up against the shut-off valve and may prevent it from opening when the switch key is again turned on.

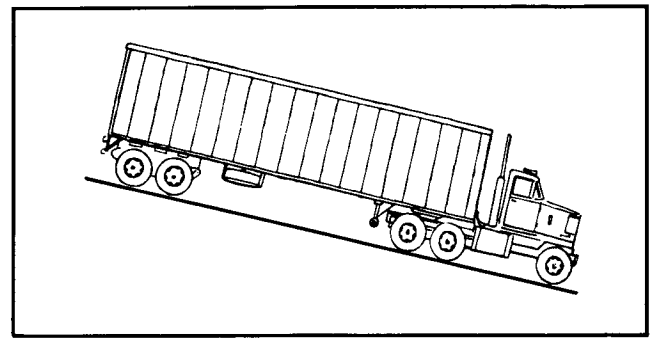


Fig. 2-12. Down-hill operation

USE BRAKES AS NEEDED TO PREVENT EXCESSIVE ENGINE SPEEDS:

Use a combination of brakes and gears to keep the vehicle under control at all times, and to keep engine rpm below its rated governed rpm.

ENGINE SHUT-DOWN

LET THE 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 the combustion chamber, bearings, shafts, etc.

The turbocharger is the one unit containing bearings and seals that is subject to the high heat of combustion exhaust gases.

While the engine is running, the heat is carried away by oil and water circulation, but if the engine is stopped suddenly, the temperature of the turbocharger may rise as much as 100° F. above that reached during operation. The results of the extreme heat may be seized bearings or loose oil seals.

DO NOT IDLE THE ENGINE FOR EXCESSIVELY LONG PERIODS:

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

If engine coolant remains cold, 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 you are not using the engine, shut it down.

TURN SWITCH KEY TO "OFF" POSITION TO SHUT DOWN THE ENGINE:

The engine can be shut down completely by turning off the switch key on installations equipped with an electric solenoid valve, or by pulling out 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. Refer to "Normal Starting Procedure," Page 2-2. Valve can not be reopened by switch key until after engine comes to complete stop.

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

DO NOT USE THE COMPRESSION RELEASE LEVER TO STOP THE ENGINE:

Most H and NH Series engines are equipped with a compression release lever. Pulling this lever lifts the intake valve push rods and opens the valves. The push rods are pulled from their sockets and extensive wear on the balls and sockets will result from using the compression release to stop the 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 THE ENGINE IMMEDIATELY IF ANY PARTS FAIL:

Practically all failures give some warning to the operator before the parts "let go" and ruin the engine. Many engines are saved because alert operators heed warning signs (sudden drop in oil pressure, unusual noises, etc.) and immediately shut down the engine. A delay of ten seconds, after a bearing failure causes a knock, may result in a ruined crankshaft. Five seconds delay may be enough to cause a block to be perforated by a broken connecting rod.

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

COLD WEATHER PROTECTION

ANTI-FREEZES:

For cold weather operation, the use of permanent-type (ethylene-glycol) antifreeze with rust inhibitor is recommended.

DRAINING CYLINDER BLOCK:

To completely drain the cylinder block and head, open the petcock on the manifold side of the cylinder

block at the rear of the engine. If an air compressor is used, open the petcock beside the breather. On engines equipped with water-cooled turbochargers, make sure to drain turbocharger.

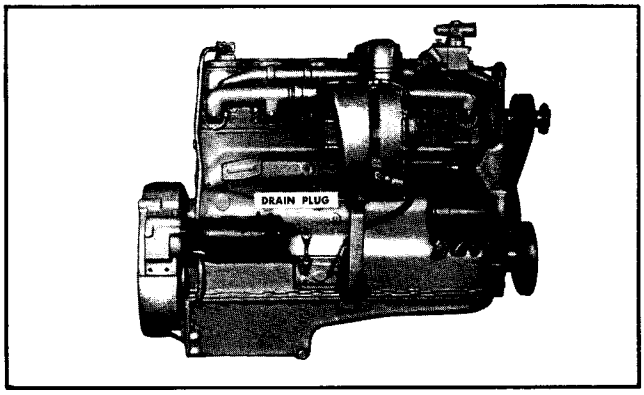


Fig. 2-13. Plug for draining cylinder block

OPERATOR'S DAILY REPORT

MAKE A DAILY REPORT OF ENGINE OPERATION TO THE MAINTENANCE DEPARTMENT:

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

Comparison and intelligent interpretation of the day by day report will make it possible to eliminate practically all road failures and emergency repairs.

Report to the maintenance department any of the following conditions:

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

GENERATOR SETS — 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 unit of higher rating. This condition also exists when it becomes necessary to increase the capacity of the 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 the system they are said to be operating in parallel. Parallel operation is considered successful when the generators deliver energy to the external system without delivering energy to each other.

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

1. The generator voltage and frequency ratings must be the same for all units.
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 the 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 L3 to L3, 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 the sets' reconnection panels must be connected in the same way so that the 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 the 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 the voltage regulators of each of the sets as described in the 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, the use of the end item as a load may be resorted to if it is possible to put a steady load on the generator. 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 the 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 the instructions contained in the technical manual, adjust the governor droop characteristic of the second machine so that the set will be operating at the same frequency as the first machine when loaded with the same load.

PRELIMINARY TESTS:

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

Phase Rotation Test:

Only generators connected together with the proper phase rotation (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 the 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 pane.

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 currents from flowing between the two machines. For these purposes, cross current compensation equipment is provided with the regulators.

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

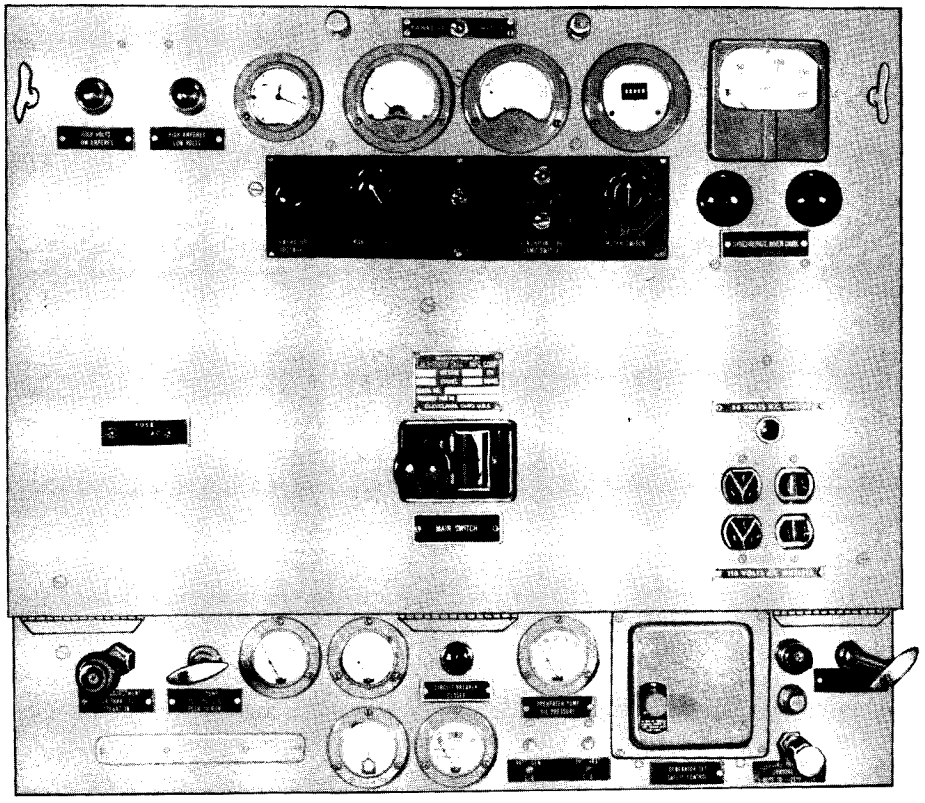


Fig. 2-14. Typical switch gear control panel

To determine if the connections are correct:

1. Start both machines as directed in "Preliminary Tests" above. Close the parallel operation (cross current compensator) switches on both sets and adjust voltage and frequency.

2. Adjust speed of either set so that synchronizing lights blink slower and slower (about once every two seconds). When both lights are dark, close the open breaker.

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 the voltage regulator rheostat on either set to cause about 10 percent of rated current to flow between the sets.

4. Turn off the 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, the voltage regulator can be adjusted for a negligible voltage drop. As soon as compensation is connected in the regulator circuit, a drop in the ac voltage, held by the 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 the current transformers, the ac voltage will drop from 2 to 5 percent when the 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 the compensating resistance will increase the 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. The voltage drop during parallel operation will be negligible. It is recommended that the setting of the compensating resistor not be changed unless the load conditions are so abnormal that the compensation is inadequate. Once set and found satisfactory the resistor setting should be left unchanged.

SYNCHRONIZING:

Once the preliminary tests have been performed and adjustments made, the 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. (Nominally 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 the "ON" position.

5. Close the breaker on one of the sets.

6. Turn on the synchronizing lamp switch on the other set. The synchronizing lamps will flash on and off rapidly at a frequency depending on the difference in speeds of the two units.

7. Adjust the speed of the unit whose breaker is open until the 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 up.

8. When the lamps are dark, close the main breaker of the set.

9. Open the synchronizing lamp switch.

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

LOAD DIVISION:

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

1. Increase the load on the machine with the lesser amount of the total load by increasing the governor throttle control. This increase will be indicated on the wattmeter.

2. When the two loads are correct as indicated by the wattmeters, check the frequency as indicated on either sets' frequency meter. If the frequency is too high, it will be necessary to readjust both 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 the load division so that the wattmeter readings are equal (or proportional to set size if the sets are not the same size).

ELIMINATING WATTLESS CURRENT:

After the 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 the same load amperes. This indicates cross currents and should be eliminated by adjustment of the voltage regulator rheostats on the sets.

1. Slowly turn the voltage adjusting knob on one of the units first clockwise, then counterclockwise. One movement or the other should result in decreasing the 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 that 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 the 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.

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 contactor on that machine. Turning the speed control in the *decrease* speed direction will decrease the load carried by that generator.

CUMMINS

H and NH SERIES DIESEL ENGINES

Section III

MAINTENANCE OPERATIONS

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

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

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

THE MAINTENANCE SCHEDULE MUST FIT THE JOB

The maintenance schedule on the next page is based on engine work output as measured by its fuel consumption. It also has been adapted to a suggested schedule of "hours" or "miles" of operation.

A maintenance schedule based on fuel consumption is the most accurate because the amount of wear in an engine is proportional to the work performed. Work is measured in horsepower and is obtained from the fuel that is burned. Therefore, based on your particular operation you may find it desirable to reduce or extend the number of miles or hours between maintenance operations.

PREVENTIVE MAINTENANCE SHOULD BE APPLIED TO ALL THE ENGINE SYSTEMS

By necessity, all engine owners practice preventive maintenance to some degree. To be effective and profitable, the maintenance program must apply to all the engine systems, and maintenance work must be performed before the engine is damaged by unfavorable conditions resulting from lack of maintenance.

Preventive maintenance consists of doing the things that will prevent on-the-job failures and expensive progressive damage to the unit. Maintenance work is profitable work.

MAINTENANCE SCHEDULE FOR H AND NH SERIES ENGINES

Engine Serial No. _____ **Mileage or Hours** _____

Check Being Made _____ **Time Spent on Check** _____

Date _____ **Parts Order No.** _____

Mechanic _____

		Check As Performed		GALLONS FUEL CONSUMED				
				500	1000	2000	4000	16000
				HOURS				
				120	240	480	960	4800
				MILEAGE				
			Daily	3000	6000	12000	24000	96000
		✓	A	B	C	D	E	
LUBRICATING SYSTEM	Check Oil Level		●	●	●	●	●	
	Check Leaks and Correct		●	●	●	●	●	
	Change Oil			●	●	●	●	
	Clean Filter Element (Screen Type)			●	●	●	●	
	Change Filter Element (Bag Type)			●	●	●	●	
	Record Oil Pressure			●	●	●	●	
	Lubricate Generator			●	●	●	●	
	Change Oil in Aneroid Control			●	●	●	●	
	Lubricate Cranking Motor				●	●	●	
	Change By-Pass Filter Element				●	●	●	
	Lubricate Water Pump and Fan Hub					●	●	
	Flush Crankcase						●	
FUEL SYSTEM	Fill Fuel Tanks		●	●	●	●	●	
	Check Leaks and Correct		●	●	●	●	●	
	Drain Sediment from Filter and Tanks			●	●	●	●	
	Check Hydraulic Governor Oil Level			●	●	●	●	
	Change Filter Element					●	●	
	Clean Injectors (Reverse Flushing)					●	●	
	Adjust Injectors and Valves					●	●	
	Clean Injector Inlet Screens					●	●	
	Clean Fuel Pump Screen					●	●	
	Check Fuel Rate					●	●	
	Change Hydraulic Governor Oil						●	
COOLING SYSTEM	Fill Cooling System		●	●	●	●	●	
	Check Leaks and Correct		●	●	●	●	●	
	Check and Adjust Belt Tension				●	●	●	
	Check Corrosion Resistor				●	●	●	
	Check Thermal Controls					●	●	
	Check Engine Coolant					●	●	
	Check Fan Hub and Drive Pulley					●	●	
	Clean Cooling System				SPRING & FALL			
AIR SYSTEM	Check Air Cleaner Oil Level		●	●	●	●	●	
	Clean Pre-Cleaner		●	●	●	●	●	
	Check Air and Vapor Line Connections		●	●	●	●	●	
	Clean Dry-Type Cleaner Element			●	●	●	●	
	Change Air Cleaner Oil			●	●	●	●	
	Clean Crankcase Breather (Oil Bath Type)		*	●	●	●	●	
	Clean Crankcase Breather (Horsehair Element)		*	●	●	●	●	
	Change Crankcase Breather (Paper Element)		*	●	●	●	●	
	Clean Air Compressor Breather		*	*	●	●	●	
	Clean Tray Screen			*	●	●	●	
	Check Air Piping			*	●	●	●	
	Check for Oil Leaks at Supercharger or Turbocharger					●	●	
	Tighten Turbocharger Mounting Nuts					●	●	
	Check Inlet Air Restriction				*	*	●	
	Replace Dry-Type Cleaner Element					*	●	
	Steam Clean Oil-Bath Air Cleaner					*	●	
	Clean Aneroid Air Filter					*	●	
	Tighten Manifold Nuts or Cap Screws						●	
	Clean Turbocharger Impeller and Diffuser						●	
	Check Turbocharger Bearing Clearances						●	
OTHER	Check Operator's Report		●	●	●	●	●	
	Retighten Cylinder Head Capscrews (See Page 4-11)			●				
	Blow Dust from Generator and Cranking Motor					●	●	
	Clean and Tighten Electric Connections					●	●	
	Check Generator Brushes and Commutator					●	●	
	Steam Clean Engine					●	●	
	Tighten Mounting Bolts and Nuts					●	●	
	Check Engine Blow-By					●	●	
	Check Crankshaft End Clearance						●	

MAJOR INSPECTION SEE PAGE 3-27

SCHEDULED MAINTENANCE OPERATIONS

The material in this maintenance section is so arranged that you can immediately set up your maintenance program and follow the procedures step by step. The instructions are complete for each operation and the necessary forms are shown which you may have your printer reproduce.

The maintenance schedule form on the facing page lists the operations for each engine system in progressive form. You can have your local printer reproduce this sheet at very little expense so you can use it as a check-off form for all periodic inspections.

Engines in off-highway equipment should be serviced more often than highway applications, as indicated by the asterisks in the schedule.

MAINTENANCE OPERATIONS:

The maintenance operations are described for each system following the reproduction of that portion of the chart starting with Page 3-4.

Space is provided above the letters heading each check column for gallons fuel consumed, mileage or hour intervals corresponding to schedule you use in your operation. For example, if your average mileage is 6 mpg, the "B" check should be made at 3,000 miles and you would insert 3,000 above the "B", etc.

This section should be studied carefully by the maintenance mechanic until he is familiar with the procedure; afterward, he will use the form only as a check-off sheet.

MAJOR INSPECTION:

After 16,000 gallons fuel consumption, or equivalent mileage, the engine should be given a major inspection. This is not considered routine maintenance, and for that reason, it is described separately on Page 3-27.

ENGINE MAINTENANCE OPERATIONS SUMMARY:

The summary sheet shown on Page 3-28 has space provided for the complete maintenance data to be obtained from the maintenance schedule form and all other expense items forms.

This record will show complete operating expense for the engine through 32,000 gallons fuel consumption. The record will show the value of the preventive maintenance program.

LUBRICATING SYSTEM MAINTENANCE

	OPERATION	✓	A	B	C	D	E
LUBRICATING SYSTEM	Check Oil Level		●	●	●	●	●
	Check Leaks and Correct		●	●	●	●	●
	Change Oil			●	●	●	●
	Clean Filter Element (Screen Type)			●	●	●	●
	Change Filter Element (Bag Type)			●	●	●	●
	Record Oil Pressure			●	●	●	●
	Lubricate Generator			●	●	●	●
	Change Oil in Aneroid Control			●	●	●	●
	Lubricate Cranking Motor				●	●	●
	Change By-Pass Filter Element				●	●	●
	Lubricate Water Pump and Fan Hub					●	●
	Flush Crankcase						●

Perform the operations at the intervals shown in the chart above. The instructions follow the same order as listed in the chart.

CHECK OIL LEVEL:

The dip stick oil gauge located on the side of the engine has a high "H" and a low "L" level mark to indicate lubricating oil supply. The dip stick must be kept with the oil pan, or engine, with which it was originally supplied. Cummins oil pans differ in capacity with different type installations and oil pan parts numbers.

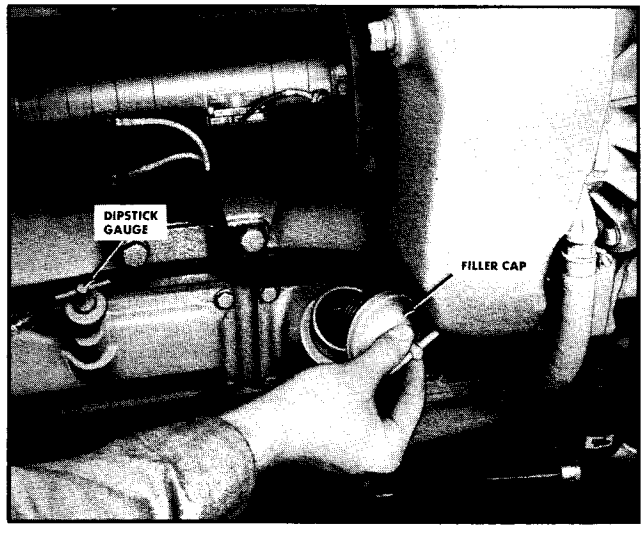


Fig. 3-1. Lubricating oil filler tube

Keep oil level as near the high level mark as possible, and never operate the engine with oil level below the low level mark.

CHECK LEAKS AND CORRECT:

Check for evidence of external oil leakage. Tighten capscrews, fittings, connections, or replace gaskets as necessary to correct.

CHANGE OIL:

The kind of oil used, the efficiency of the filtering system and the condition of the engine must be considered in determining when the oil needs changing. NOTE: The schedule for oil changes at 500 gallons fuel consumption is based on crankcase and filter capacity of 5 to 7 gallons.

This period can be extended under favorable operating conditions to a *maximum* of 1000 gallons fuel consumed when both full-flow and by-pass filters are used, and crankcase and filter capacity is 10 gallons, or more.

The safest method for determining oil change period is by lubricating oil analysis. See "Lubricating Oil Specifications," Page 3-8.

CLEAN FILTER ELEMENT: (Screen-Type)

1. Loosen the capscrew at the bottom of the strainer case and lower the case to remove the case and strainer assembly.

CAUTION: DO NOT LOSE THE NEOPRENE SEAL RING.

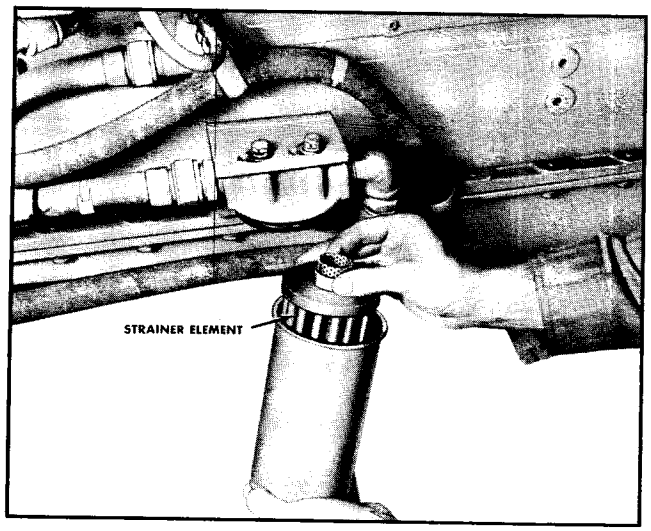


Fig. 3-2. Removing screen-type strainer element

2. Lift the strainer pack assembly from the capscrew and case. Plug the open tube ends of the strainer with cork stoppers to keep dirt out of the strainer pack assembly.

3. Inspect the dirty element for the amount of dirt or sludge collected, and metal particles, bearing metal, grit, etc. If the strainer is packed full of dirt and sludge, it has probably been inoperative and this is a definite indication of poor operating conditions or inadequate maintenance.

4. If the dirty element contains any bearing metal, it is an indication of a possible bearing failure in the near future. *This calls for an immediate inspection of the connecting rod and main bearing shells.*

5. Clean the assembly by washing in a satisfactory cleaner. Drain or blow off cleaning fluid.

6. Clean the inside of the case thoroughly in solvent and dry with compressed air. The capscrew has a retainer ring to prevent the washer and spring from being lost. Do not remove the capscrew, ring, washer or spring.

7. Remove the cork stoppers and reassemble the strainer in proper order as removed.

8. Make sure the rubber seal ring between case and cover is in good condition.

9. Fill strainer case with clean lubricating oil. This will aid in priming the lubricating system.

10. Tighten the capscrew to 75 to 100 inch pounds. *Extreme tightening will distort the case and cut the rubber seal ring.*

NOTE: Many operators find it profitable to carry an extra strainer element in stock as a service replacement unit and allow the dirty element to soak in solvent overnight. This saves cleaning time.

CHANGE FILTER ELEMENT: (Bag-Type)

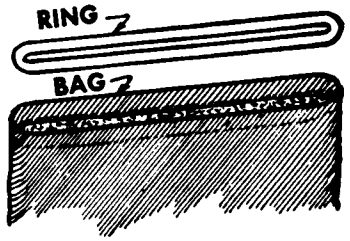
1. Remove the strainer element from the case. With clean cloths — not waste — wipe the case clean.

2. Turn the used bag inside out and inspect for bearing metal, grit, etc. If metal is found in the bag, an inspection of connecting rod and main bearings should be made at once.

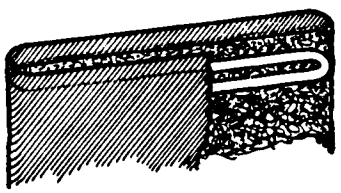
CAUTION: DO NOT ATTEMPT TO WASH USED STRAINER BAGS.

3. Wash all parts thoroughly except the bags. Inspect the spool gasket, bag clamp, and spacer mat. If they are not in good condition, replace them with new parts.

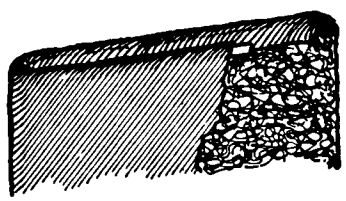
4. Install a new strainer bag as shown in the sketches which follow:



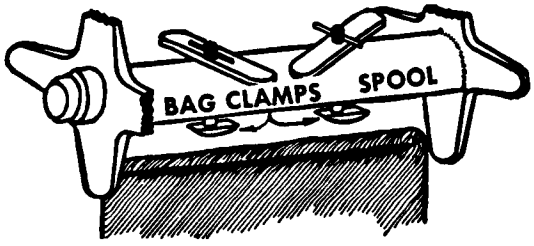
Bag and ring ready for assembling



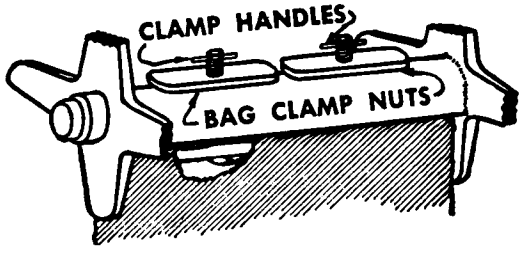
Place ring inside of bag.



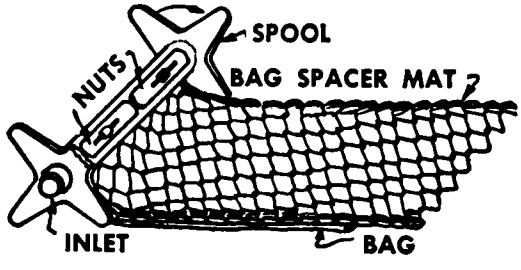
Fold top of bag inward over ring about ½" starting with the ends and then the sides.



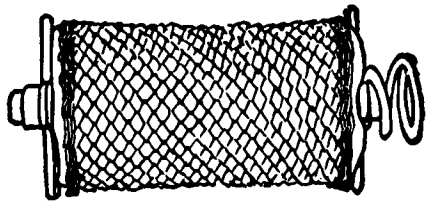
Before applying bag to spool, turn bag-clamps lengthwise so that they will enter bag opening. Install gasket.



Hold bag firmly against spool and give ¼ turn to bag clamp handles which brings them into lengthwise position. Hold handles thus while turning bag clamp nuts to a hand tight lengthwise position.



With inlet end facing you, place spool with bag on a clean flat surface, then lay bag spacer mat on bag making sure they are flat and that the left end of the mat comes up close to the spool. Then roll mat with bag around spool clockwise. The spacer mat must protrude 1½ to 2 inches after the mat and spool are rolled together.



Assembled filtering element ready to insert into shell.

RECORD OIL PRESSURE:

Start the engine and bring up speed and temperatures slowly until the oil temperature gauge reads 140° F. and record the 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:

Use SAE 20 lubricating oil to lubricate the battery charging generator bearings. Fig. 3-3. Avoid over oiling which would damage wire insulation.

CHANGE OIL IN ANEROID CONTROL:

1. At each "B" check, remove the plug from the bottom of the aneroid control and drain the oil.
2. Replace drain plug, and loosen vent line.

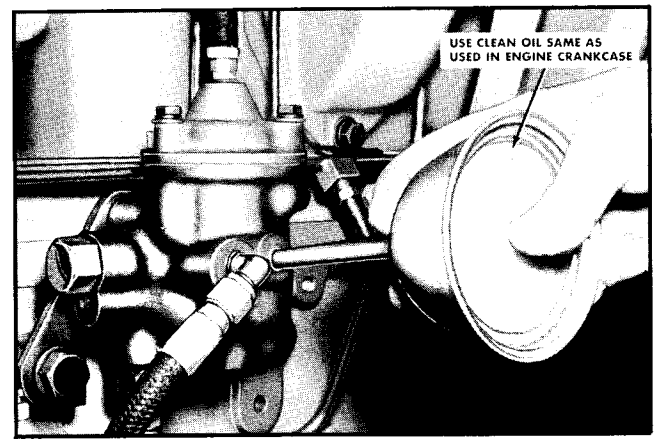


Fig. 3-3. Fill aneroid with lubricating oil

3. Fill control with clean engine lubricating oil through the vent tube hole (until oil fills to vent plug hole level) and reinstall vent tube.
4. On aneroid controls with an air filter mounted in the vent line tap, remove filter and fill with oil; replace filter.
5. Latest aneroids have a special boss for mounting the air filter; fill aneroid through oil cup mounted in old vent line tap.

LUBRICATE CRANKING MOTOR:

Add a few drops of clean SAE 30 weight lubricating oil to the bearings of the cranking motor.

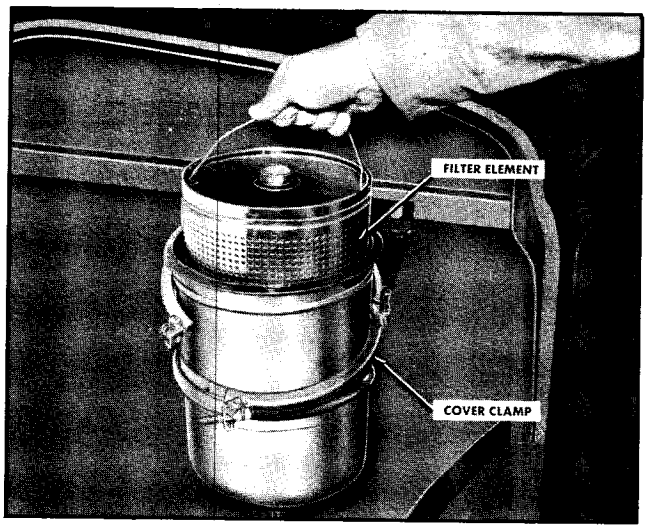


Fig. 3-4. By-pass filter element

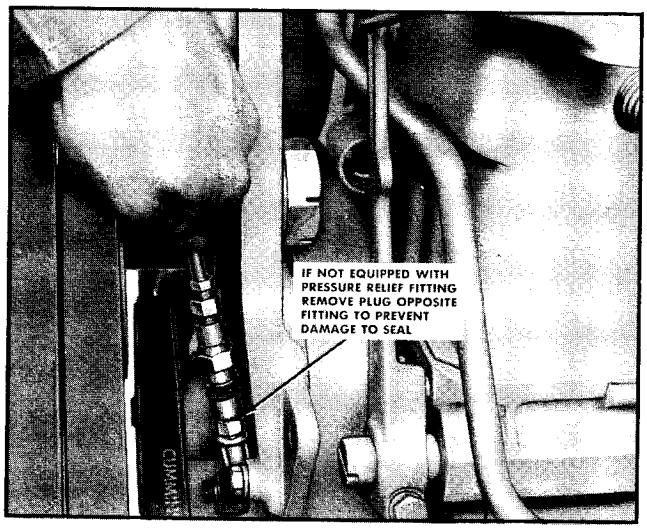


Fig. 3-5. Lubricate water pump

CHANGE BY-PASS FILTER ELEMENT:

If the engine is equipped with a by-pass filter the element should be changed as follows:

1. Remove drain plug from bottom of housing and drain oil.
2. Remove clamping ring capscrew and lift off the cover.
3. Unscrew T-handle pack holddown assembly and lift out pack or packs.
4. Clean housing and replace drainplug.
5. Install new pack or packs.
6. Replace T-handle pack holddown assembly in filter and tighten down to stop. Inspect the T-handle assembly to see that the metering hole in the orifice plug is open.
7. Check to see that the "O" ring gasket is clean and in position on the housing flange. Replace "O" ring if damaged.
8. Replace cover and clamping ring and tighten down the capscrew until the clamping lugs come together.
9. Add an extra three and one-half gallons of oil to the crankcase to fill the filter case and element.
10. Loosen the vent plug in the cover and start the engine. Close vent plug when oil reaches vent.

LUBRICATE WATER PUMP AND FAN HUB:

Pressure-relief fittings are provided to grease the water pump and protect the seal from damage due to pressure from the grease pump. Use lithium-soap-base ball bearing grease.

The fan-hub bearing is prepacked with grease at assembly; add grease as necessary at each "D" check. At time of the frame overhaul, the fan hub should be disassembled and the bearings cleaned and repacked with fresh grease.

FLUSH CRANKCASE:

1. At the "E" check, inspect the condition of the upper rockers and crankcase for sludge. Normally, if a good grade of heavy-duty oil has been used and operating temperatures have been kept in the correct range, there should be no sludge and crankcase flushing will not be needed.
2. If inspection shows a large amount of sludge, the crankcase should be flushed with a mixture of five gallons of clean fuel oil and one-half to one gallon clean lubricating oil, or as much more flushing oil as is needed to bring and keep the level in the operating range.
3. Dirty lubricating oil filter elements should be removed before flushing.
4. Lubricating oil strainer elements should be changed or cleaned before and after flushing. If the engine is equipped with a Nugent bag-type strainer, use a special strainer bag saved just for flushing operations.

5. The radiator should be covered while running the engine at 800 to 900 rpm for approximately 15 minutes to bring the water temperature up to about 190° F. Sludge is heavy and gummy, and the flushing oil must be hot to cut it thoroughly.

6. Allow the flushing oil to drain at least 30 minutes. Unless all fuel oil used for flushing is drained from the engine and oil pan, it will dilute the new lubricating oil. A gooseneck tube attached to a hand suction pump should be inserted through the oil pan drain plug hole to pump all flushing oil from the oil pan unless the pan is the type that drains completely.

7. Install new filter pack (if by-pass filter is used) and fill the crankcase with the proper grade lubricating oil. Three and one-half gallons of oil are needed to fill by-pass filter and housing.

LUBRICATING OIL SPECIFICATIONS

Lubricating oil used in Cummins engines should be oils represented by the oil supplier as meeting the quality requirements of U. S. Military Specifications Mil-L-2104A. The responsibility for meeting these specifications, the quality of the product, and its performance in service must necessarily rest with the oil supplier. Cummins Engine Company, Inc. does not recommend any specific brand of lubricating oil.

As a general reference, the Internal Combustion Engine Institute (Chicago 6, Illinois) has published (in their booklet, "Lubricating Oils For Industrial Engines") several hundred oil brand names which meet the performance level and are satisfactory for use in Cummins engines. Those brands are listed as Mil-L-2104A oils. In the same booklet, "Supplement 1" and "Series 3" oils are listed which meet more severe lubrication requirements.

Mil-L-2104A oils are satisfactory for normal service in Cummins engines, but under adverse conditions of low temperature, frequent starting and stopping, or high-sulphur content fuel it may be advisable to use "Supplement 1" or "Series 3" oil. Contact your oil supplier for his recommendations.

VISCOSITY:

Viscosity of lubricating oil used in crankcase should be as follows:

SAE No. 10W when ambient temperature is below 32° F.
SAE No. 20 when ambient temperature is 32° F. to 90° F.
SAE No. 30 when ambient temperature is above 90° F.

No change in oil viscosity or type is needed for new or newly rebuilt engines. Oil which is best for general operation is also best for the "break-in."

Different brands or grades of lubricating oil should never be mixed in the crankcase. It is best to choose carefully the best oil available and continue to use that brand in the proper grade or weight, consistent with weather conditions and engine wear.

	OPERATION	√	A	B	C	D	E
FUEL SYSTEM	Fill Fuel Tanks		●	●	●	●	●
	Check Leaks and Correct		●	●	●	●	●
	Drain Sediment from Filter and Tanks			●	●	●	●
	Check Hydraulic Governor Oil Level			●	●	●	●
	Change Filter Element					●	●
	Clean Injectors (Reverse Flushing)					●	●
	Adjust Injectors and Valves					●	●
	Clean Injector Inlet Screens					●	●
	Clean Fuel Pump Screen					●	●
	Check Fuel Rate					●	●
	Change Hydraulic Governor Oil						●

Perform the operations at the intervals shown in the chart above. The instructions folllow the same order as listed in the chart.

FILL FUEL TANKS:

Do not miss an opportunity to filter or strain the fuel before or while putting it in the tank.

See "Fuel Oil Specifications," Page 3-14.

CHECK LEAKS AND CORRECT:

1. Check for evidence of external fuel leakage. Tighten capscrews, fittings, and connections, or replace gaskets as necessary to correct.
2. Check for air leaks in fuel system by placing a sight gauge in the line between fuel filter and pump. Bubbles over ½-inch long or "milky" appearance indicates an air leak. Find and correct.

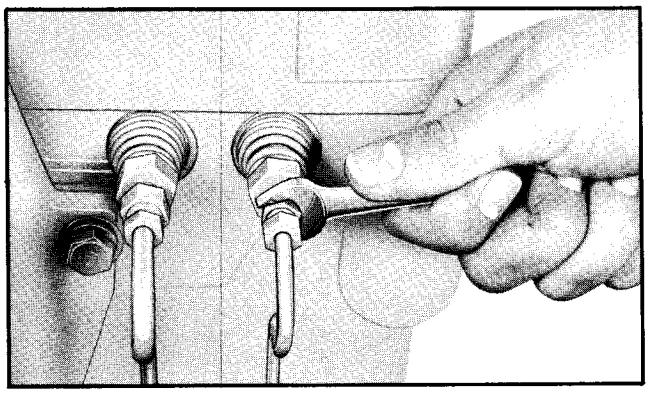


Fig. 3-6. Tightening inlet connection

DRAIN SEDIMENT FROM FILTER AND TANKS:

Loosen the drain cock at the bottom of the fuel filter case and drain out any accumulated water and sediment.

Tighten the drain cock and refill the filter case with clean fuel.

CHECK HYDRAULIC GOVERNOR OIL LEVEL:

If the fuel pump has a hydraulic governor, clean lubricating oil of the same grade as used in the engine must be carried in the governor sump.

The level should be maintained half-way up on the inspection glass or to high level on dip-stick oil gauge.

CHANGE FILTER ELEMENT:

Ordinarily, the element should be changed at 2000 gallons fuel consumption. This is not always necessary, however, if the restriction on the inlet side of the pump is satisfactory.

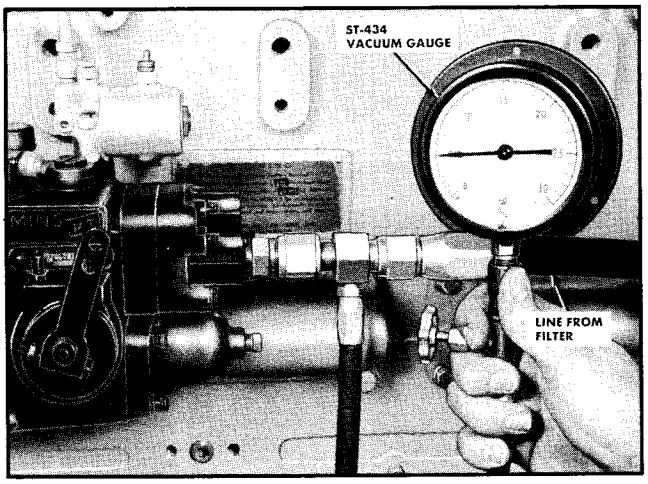


Fig. 3-7. Checking fuel restriction

To check restriction, connect ST-434 vacuum gauge to the pump as shown (Fig. 3-7) using the special

adapter furnished. If restriction reads 8 to 8.5 inches vacuum while engine is running at idle speed, no-load, change element or remedy other sources of restriction. When restriction becomes as great as 10 or 11 inches vacuum, the engine will lose power.

Change elements as described below.

Replaceable Element:

1. Loosen the hex nut at the top of the fuel filter. Take out the dirty element, clean the filter case, and install a new element.

Fig. 3-8. Changing fuel filter element

2. Install a new gasket in the filter head and assemble case and element. Tighten center bolt to 20/25 ft. lbs. with a torque wrench. Fill filter case with clean fuel to aid in faster pick-up of fuel pump.

3. Check fittings in filter head for leaks. Fittings should be tightened to 30/40 ft. lbs.

Throw-away Element:

1. Unscrew combination case and element; discard.

NOTE: On elements that do not have an integral "O" ring seal, install new "O" ring before installing element.

2. Install new case and element; tighten by hand until seal touches filter head. Tighten an additional 45° to 90°.

CAUTION: MECHANICAL TIGHTENING WILL DISTORT OR CRACK FILTER HEAD.

CLEAN INJECTORS:

Injectors should be cleaned regularly so that fuel delivery to the combustion chambers will not be restricted.

Each 2000 gallons, carbon accumulation should be removed from the metering orifice by reverse flushing. It should be performed on a warm engine as follows:

1. Loosen all injector adjusting screws one turn from bottom or one and one-fourth turns from set position. Lock with the jam nut.

NOTE: An alternate method which makes it easier to start the engine is to loosen three injector adjusting screws at a time and perform the flushing operation in two steps.

2. Start the engine and accelerate with *maximum* throttle from idle to high-idle 10 to 15 times.
3. Readjust injectors to standard settings.

When the injector is set with the adjusting screw backed off, the metering orifice will not be closed during injection. High injection pressure will force some of the fuel to back-flow through the orifice and remove carbon deposits.

Starting will be difficult, and the engine will smoke badly and be sluggish during this maintenance operation.

If this method is not effective, remove injectors and clean in a good carbon solvent. Refer to PT Fuel System Shop Manual for cleaning procedure.

See Page 4-9 for removal and installation of injectors.

ADJUST INJECTORS AND VALVES:

It is essential that injectors and valves be in correct adjustment at all times for the engine to operate properly. One controls engine breathing; the other controls fuel delivery to the cylinders.

Adjust valves and injectors at "D" and "E" checks. Final adjustment must be made when the engine is at operating temperature. Injectors should always be adjusted before valves. The procedure is as follows:

1. Pull the compression release lever back and block in the open position. This lifts all intake valves and makes it possible to turn the crankshaft without working against compression.

2. Bar engine in direction of rotation until the "1-6VS" mark on the fan drive pulley is in line with the timing mark on the gear case cover (see Fig. 3-9). On horizontal model engines the valve set marks are on the vibration damper flange. In this position, both intake and exhaust valves will be closed for No. 1 cylinder.

3. Adjust injector plunger, then valves of No. 1 cylinder as explained in succeeding paragraphs under "Adjust Injector Plungers" and "Adjust Valve Clearance." Turn crankshaft in direction of rotation to the next VS mark corresponding to firing order of the engine "2-5VS", and the cylinder ready for adjustment will be No. 5.

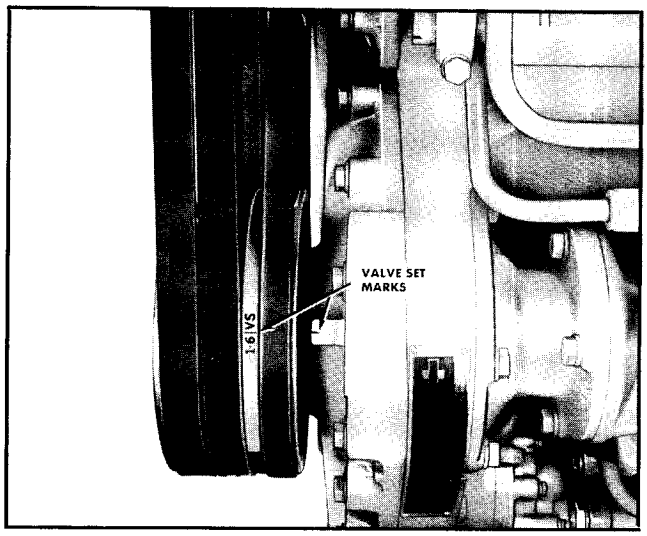


Fig. 3-9. Valve set timing marks

4. Firing order is as follows:

ENGINE FIRING ORDER

Six Cylinder Engines:
Right Hand — 1-5-3-6-2-4
Left Hand — 1-4-2-6-3-5
Four Cylinder Engines:
Right Hand — 1-2-4-3
Left Hand — 1-3-4-2

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 the 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.

6. On engines without compression releases, turn each intake valve adjusting screw down one turn from adjusted *position before* making the adjustment. Then, adjust injectors and valves on each cylinder in manner described above.

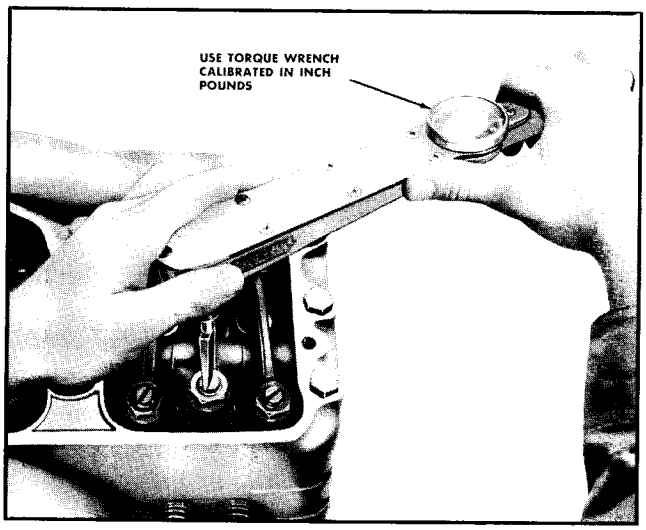


Fig. 3-10. Adjusting injector plunger

Adjust Injector Plungers:

The injector plungers of all engines are to be adjusted with a torque wrench to a definite torque setting. Snap-On Model TQ12B or equivalent torque wrench and a screw driver adapter can be used for this adjustment.

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 inch-pounds and a screw driver adapter, tighten the adjusting screw to the figures shown for cold setting and tighten the lock nut. After all valves and injectors are adjusted and engine has been started and warmed up to 140° F., reset the injectors to the warm setting.

INJECTOR ADJUSTMENT

Cold Setting 70° F.	Warm Setting 140° F.	Applicable Engines
60 in./lbs.	72 in./lbs.	* All *Preceding* Engine Serial No. 226953
48 in./lbs.	60 in./lbs.	* All *After* Engine Serial No. 226953

* *In some cases, engine timing changes in the field will necessitate lower adjustment torque values.* CHECK INJECTOR ADJUSTMENT PLATE ON ENGINE FOR CORRECT VALUES.

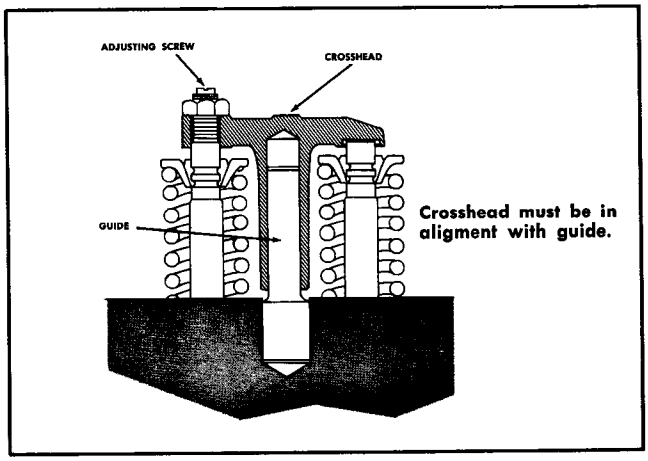


Fig. 3-11. Alignment of crosshead stem and guide

Valve Crosshead Adjustment:

Four valve heads have crossheads to operate valves in pairs. It is necessary to adjust the crossheads before making valve adjustments.

Following are instructions for proper adjustment and tightening of the screw and lock nut, using a torque wrench:

A. Loosen valve crosshead adjusting screw lock nut and back off screw one turn.

B. Use light finger pressure at the rocker lever contact surface to hold crosshead in contact with valve stem nearest the push rod.

C. Turn adjusting screw down until it contacts its mating valve stem.

D. For new crossheads and guides, advance adjusting screw one-third of one hex (20 degrees) to straighten the stem in its guide and to compensate for slack in threads. With worn crossheads and guides, it may be necessary to advance the screw as much as 30 degrees in order to straighten the stem in its guide.

E. Hold the adjusting screw in this position and tighten lock nut to 25-30 foot-pounds torque.

F. Check clearance between crosshead and valve spring retainer with a wire gauge. There should be a minimum of .020 inch clearance at this point.

Adjust Valve Clearance:

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

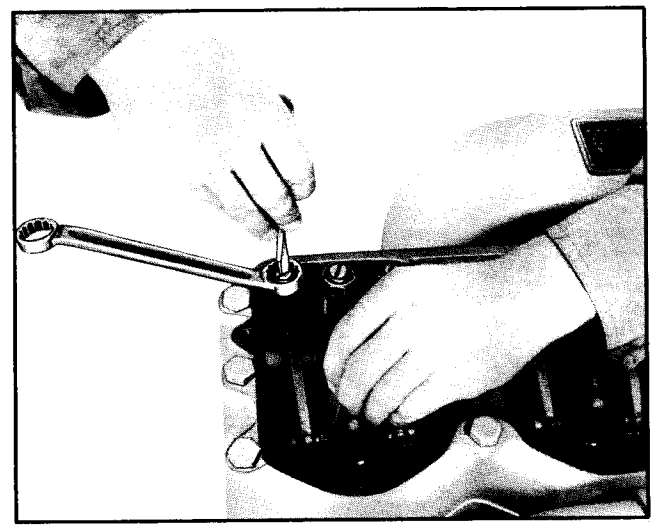


Fig. 3-12. Adjusting valves

1. While adjusting valves, make sure that the compression release, on those engines so equipped, is in the running position.

2. Loosen the locknut and back off the adjusting screw. Insert the feeler gauge between the rocker lever and top of the valve stem or crosshead, and turn the screw down until the lever just touches the gauge. Lock the adjusting screw in this position with the jam nut. Fig. 3-12.

3. Always make final valve adjustment after injectors are adjusted and with the engine at operating temperature. Valve clearances are shown in the table.

TABLE — VALVE ADJUSTMENT
(Set with injector plungers adjusted)

Engine Model	Intake Valves Cold	Intake Valves Hot	Exhaust Valves Cold	Exhaust Valves Hot
All H Series naturally aspirated	.016	.014	.024	.022
All H Series supercharged	.018	.016	.030	.028
All NH Series	.016	.014	.029	.027

CLEAN INJECTOR INLET SCREENS:

Each fuel inlet connection has a fine mesh screen at

the large end. This screen is the last protection against dirt entering the injector.

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

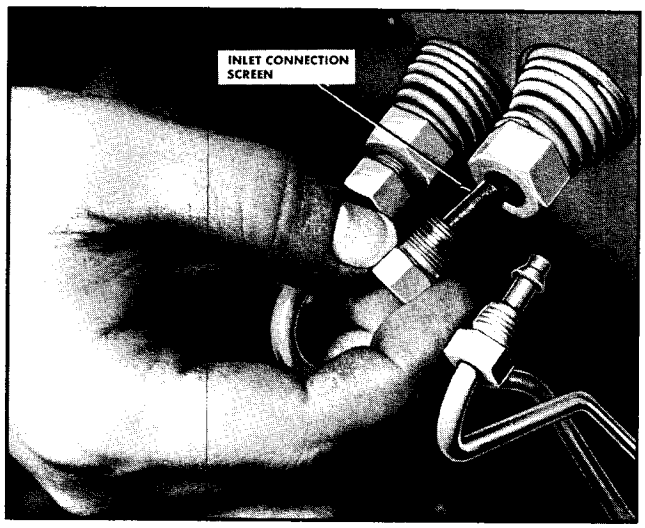


Fig. 3-13. Injector inlet screen

CLEAN FUEL PUMP SCREEN:

The fine mesh fuel filter screen in the fuel pump should be removed and cleaned each 2000 gallons fuel consumed to prevent unnecessary wear and loss of power. A clogged filter screen will cut down fuel delivery to the engine.

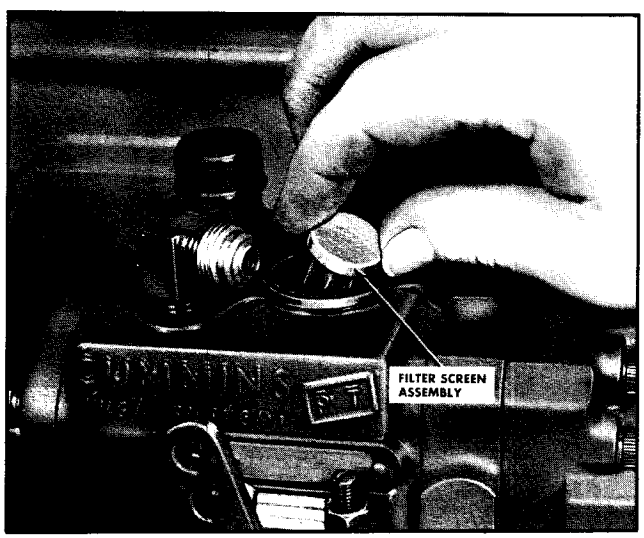


Fig. 3-14. Strainer screen in fuel pump

The filter screen is located under the large cap on the top of the fuel pump. See Fig. 3-14. Loosen the cap and lift out the spring and screen assembly. The screen can be separated from one of the screen retainers for easy cleaning, the other retainer is soldered to the screen. Replace the screen and retainer (the retainer with the hole goes down) after cleaning. The spring is assembled on the screen assembly; the cone end of the spring may be assembled either up or down. Cap must be tightened to 20/25 ft. lb. with a torque wrench; excessive tightening is not required.

CHECK FUEL RATE:

The best way to check pump settings is on a fuel pump test stand; however, where a test stand is not available, a pump can be checked on the engine. The most accurate check with the pump on an engine is made while operating at full-load and rated speed using an engine dynamometer and a full-flow meter available as service tool, ST-502.

A less accurate method is to take "snap readings" of fuel manifold pressure with ST-435 pressure gauge while accelerating the engine from idling to governed rpm. (While operating in this manner maximum fuel manifold pressure will be reached.)

Checking Fuel Rate in Pounds per Hour:

1. Make sure fuel filter is new or not offering more than 8 inches water restriction as measured by a vacuum gauge.

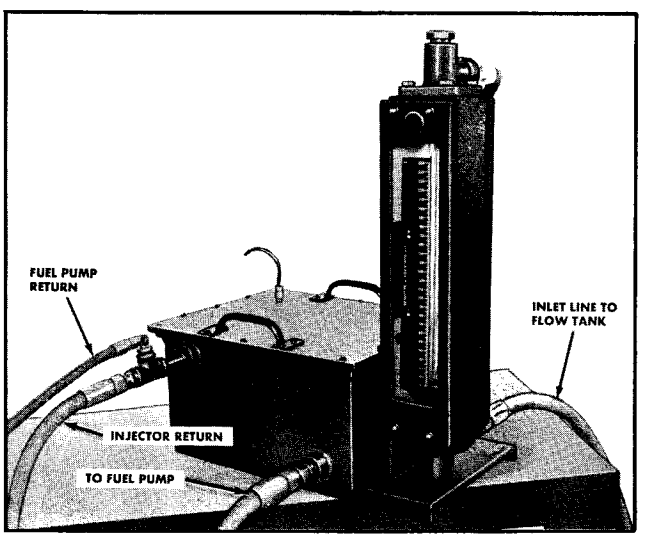


Fig. 3-15. Checking fuel rate with ST-502 meter

2. Adjust valves and injectors.

3. Attach ST-502 Flow Meter to fuel supply line between fuel pump and tank.

4. Read fuel rate at top of float on ST-502 while engine is pulling full load on a dynamometer.

5. If rate is different than specified adjust by adding or removing shims under the nylon adjusting plunger.

Checking Maximum Fuel Manifold Pressure:

1. To check maximum manifold pressure, connect ST-435 to the pump shut-off valve. Remove the pipe plug from the shut-off valve to connect the pressure gauge line. Fig. 3-16. At governed speed (just before the governor cuts in) the maximum manifold pressure will be attained.

2. Adjust the maximum manifold pressure by adding or removing shims from under the nylon fuel adjusting plunger in the by-pass valve plunger. Take care not to lose the small lock-washer which fits between the fuel adjusting plunger and the plunger cap.

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

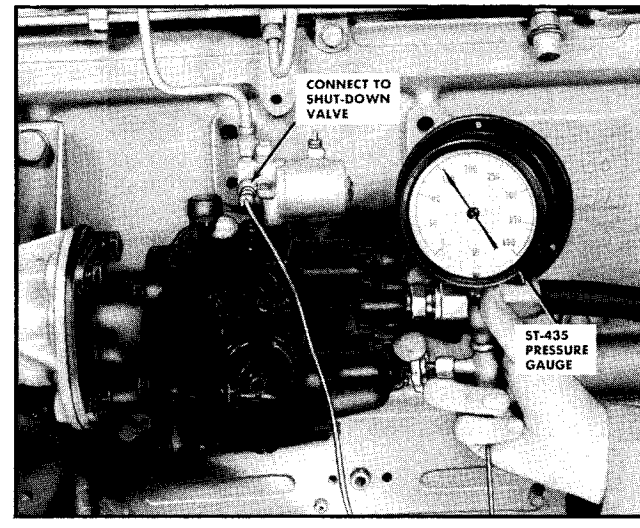


Fig. 3-16. Checking fuel manifold pressure

CHANGE HYDRAULIC GOVERNOR OIL:

If the fuel pump has a hydraulic governor, maintain oil level between marks on dipstick gauge.

Change the oil in the governor at each "E" check. Use the same grade oil in the hydraulic governor as used in the engine.

FUEL OIL SPECIFICATIONS

Fuel oil serves two purposes in your Cummins Diesel. It supplies the energy for the work done by the engine and it lubricates many of the fuel system parts.

Fuel oil 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.

COOLING SYSTEM MAINTENANCE

	OPERATION	✓	A	B	C	D	E
COOLING SYSTEM	Fill Cooling System		●	●	●	●	●
	Check Leaks and Correct		●	●	●	●	●
	Check and Adjust Belt Tension				●	●	●
	Check Corrosion Resistor				●	●	●
	Check Thermal Controls					●	●
	Check Engine Coolant					●	●
	Check Fan Hub and Drive Pulley					●	●
	Clean Cooling System		SPRING & FALL				

Perform the operations at the intervals shown in the chart above. The instructions follow the same order as listed in the chart.

FILL COOLING SYSTEM:

Keep the cooling system completely filled. *Check the coolant level daily or at each fuel stop. Investigate for cause of coolant loss.* Recheck the level after the 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.

CHECK LEAKS AND CORRECT:

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

CHECK AND ADJUST BELT TENSION:

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

Installation:

Always shorten distance between pulley centers so the 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. Both 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.

Fan Belt Tension:

Tighten fan belts so that the pressure of the index finger will depress the belt as shown in the table.

TABLE

Fan Belt Tension

Belt Width	Deflection per ft. of Span
1/2"	3/8"
11/16"	15/32"
3/4"	7/16"
7/8"	3/8"
1"	11/32"

The index finger should be extended straight down from the hand; in this manner, the force will be approximately 13 pounds.

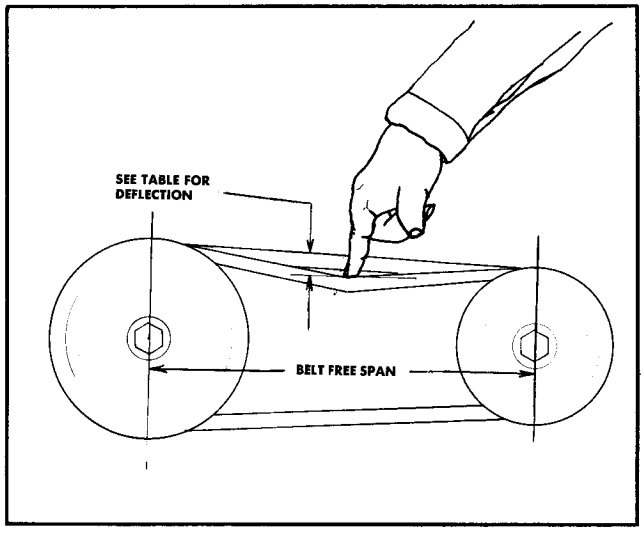


Fig. 3-17. Fan belt tension

Re-Tensioning New Belts:

All new belts will loosen after running for an hour or more and must be retensioned. If the belt can be pushed down ⅛ inch more than recommended, retension as described under "Fan Belt Tension".

Belt Care or Maintenance:

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

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

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

CHECK CORROSION RESISTOR:

Each 6000 miles or 240 hours of operation, check the coolant chromate circulation to determine if the Corrosion Resistor element should be changed. See procedure on Page 3-18. Change element when concentration drops below 1700 parts per million.

At each change of the element, check the magnesium waste plate in the Corrosion Resistor (when used). Buff or polish this plate to remove scale and deposits so that the metal is exposed. Replace this plate when it becomes pitted to the extent that less than 50 per cent of the metal surface can be polished.

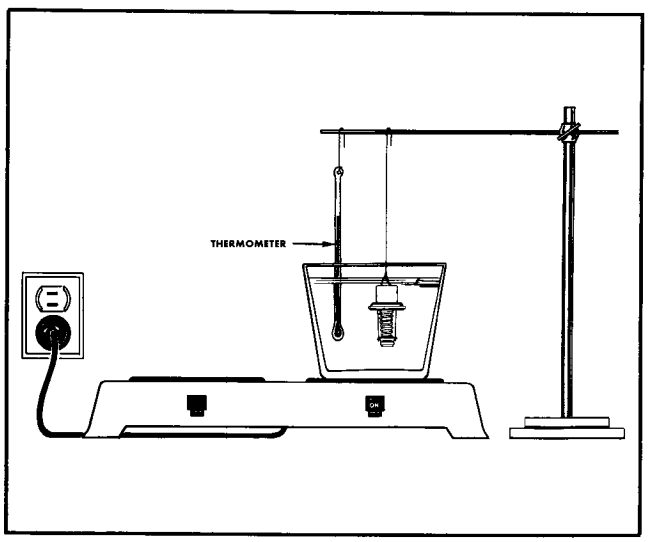


Fig. 3-18. Test thermostat

CHECK THERMAL CONTROLS:

Cummins H and NH Series engines are equipped with either high or low range thermostats, depending on engine application.

Low-range thermostats start to open at 160° F. and are fully open at 175° F. High-range thermostats start to open at 170° F. and are fully open at 185° F. Check stamping on thermostat; install same range new thermostat as that removed.

The opening and closing of thermostats can be checked against a thermometer while immersed in water as the water is brought up to temperature by heating. Fig. 3-18.

Shutterstats, when used with standard thermostats and without thermatic fans, should be set to open at 180° F. and to close at 172° F.

Thermatic fans, where used, should start at 185° F. and shut off at 170° F.

Shutterstats, when used with thermatic fan, should open at 170° F. and close at 162° F.

CHECK ENGINE COOLANT:

Diligent maintenance of the engine cooling system is necessary to enable the system to cool the engine, and to prevent corrosion within the water jacket. Maintenance involves mechanical corrections for loose belts, etc., and water testing and treatment to prevent rust and corrosion.

Requirements of a Good Coolant:

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 8.5 to 10.5.

Any water which is suitable for drinking can be treated as described in the following paragraphs to make it suitable for use in an engine.

Coolant Treatment:

Following are two effective methods of treating engine coolant to prevent corrosion:

1. Install and maintain a Cummins Corrision Resistor. This is a unit which by-passes a small amount of coolant from the system through a filtering and treating device. It softens water, neutralizes acidity and protects against corrosion by the use of a replaceable chemically-activated filtering element. In addition the unit contains a sacrificial metal plate which arrests

pitting of metals in the system by electro-chemical action. It is available as extra equipment from your Cummins Dealer and easily installed on any Cummins engine. It can be used with or without anti-freeze.

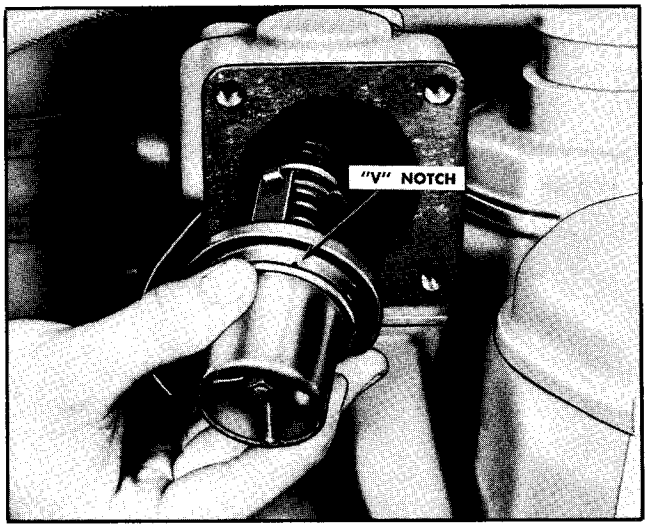


Fig. 3-19. Installing thermostat

2. The second best method of treating coolant to prevent corrosion requires a summer and winter treatment as follows:

In Summer: Use one ounce of chromate compound for every two or three gallons of water. This is equivalent to 1700 to 2500 parts per million.

In Winter: Use ethylene-glycol base anti-freeze in the percentage required for winter protection. You can use anti-freeze with Cummins Corrosion Resistor, but not with any other type inhibitor.

Testing Engine Coolant:

If the cooling system in your engine is being protected by either one of the two methods recommended, it should be tested regularly for each of the following conditions:

pH Value: The test kit is pHydrion wide range test paper and dispenser (ABpH 1-11). The kit can be purchased from the Harshaw Scientific Company which has branches in Cleveland, Cincinnati, Detroit, Houston, Los Angeles, and Philadelphia, or from other companies furnishing chemical supplies. The cost is nominal (approximately $1.50) for a plastic dispenser and two 15-foot rolls of test paper. Check the engine coolant following the manufacturer's directions supplied with the kit.

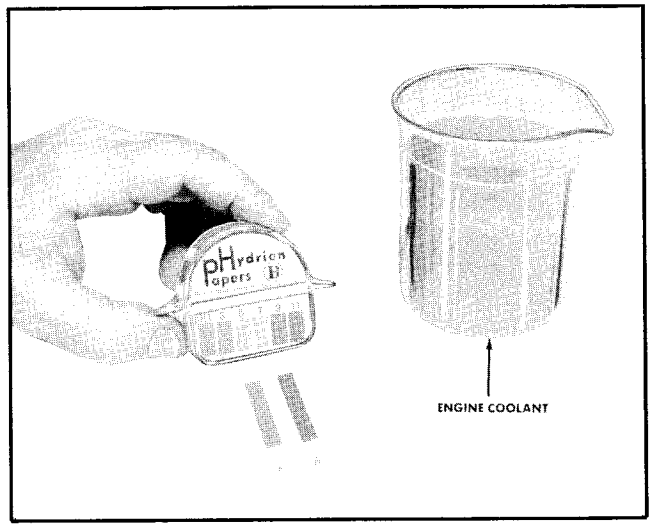


Fig. 3-20. pHydrion test paper

Chromate Concentration: A color comparator kit provides an easy and accurate check of chromate concentration in any cooling system protected by Cummins Corrosion Resistor, or by chromate compounds. A good comparator, called "The Dearborn Cooling Water Treatment Comparator," is manufactured and sold by Dearborn Chemical Company, Merchandise Mart Plaza, Chicago 54, Illinois.

Testing is accomplished by comparing the color of a sample with standards supplied in the kit. Chromate concentration should be kept between 1700 and 2500 parts per million.

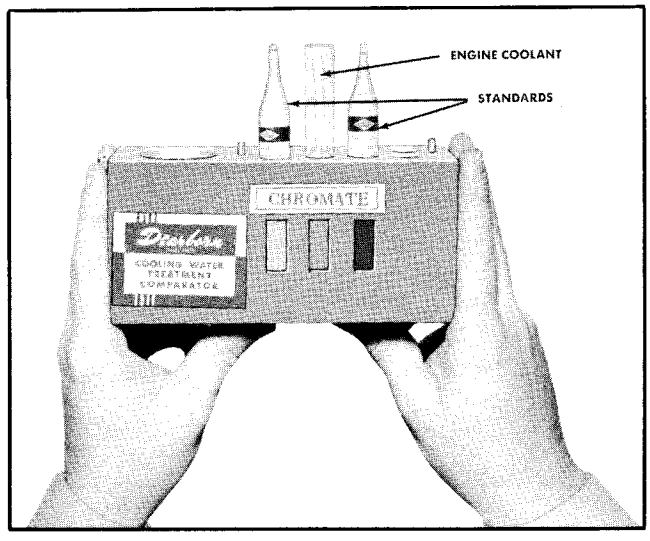


Fig. 3-21. Checking chromate concentration

Adjusting Coolant to Specifications:

If the tests indicate that the coolant has a pH value below 8.5 or that the chromate concentration is below 1700 parts per million, and adjustment should be made immediately to prevent corrosion. The correction necessary depends upon which method of protection is being used in the cooling system.

If the Cummins Corrosion Resistor is used, change the element, run the engine four to six hours; then, check again.

If chromate compounds are used, add enough compound to bring the concentration between 1700 and 2500 parts per million.

CHECK FAN HUB AND DRIVE PULLEY:

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

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

CLEAN COOLING SYSTEM — SPRING AND FALL:

The cooling system must be clean to do its work well. Scale in the system slows down heat absorption from water jackets and heat rejection from the radiator. Use clean water which will not clog any of the hundreds of small passages in the radiator or the water passages in the block.

Clean out radiator cores, heater cores, heat exchanger, and block passages which 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 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

The radiator and block should be flushed when antifreeze is added or removed, or before installing a corrosion resistor on a used engine.

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

Sediment and dirt settles into pockets in the block as well as in the radiator core. Remove thermostats from housing and flush the block with water. The lower opening should be partially restricted until the block fills up. Apply air pressure and force the water from the lower opening. Repeat the process until the stream of water coming from the block is clean.

AIR SYSTEM MAINTENANCE

	OPERATION	✓	A	B	C	D	E
AIR SYSTEM	Check Air Cleaner Oil Level		●	●	●	●	●
	Clean Pre-Cleaner		●	●	●	●	●
	Check Air and Vapor Line Connections		●	●	●	●	●
	Clean Dry-Type Cleaner Element			●	●	●	●
	Change Air Cleaner Oil			●	●	●	●
	Clean Crankcase Breather (Oil Bath Type)		*	●	●	●	●
	Clean Crankcase Breather (Horsehair Element)		*	●	●	●	●
	Change Crankcase Breather (Paper Element)		*	●	●	●	●
	Clean Air Compressor Breather		*	*	●	●	●
	Clean Tray Screen			*	●	●	●
	Check Air Piping			*	●	●	●
	Check for Turbocharger/Supercharger Oil Leaks					●	●
	Tighten Turbocharger Mounting Nuts					●	●
	Check Inlet Air Restriction				*	*	●
	Replace Dry-Type Cleaner Element					*	●
	Clean Aneroid Air Filter					*	●
	Steam Clean Oil-Bath Air Cleaner					*	●
	Tighten Manifold Nuts or Capscrews						●
	Clean Turbocharger Impeller and Diffuser						●
	Check Turbocharger Bearing Clearances						●

When engines operate under extremely dusty conditions, the operations followed by asterisks in the chart above should be performed at the more frequent intervals as indicated.

CHECK AIR CLEANER OIL LEVEL:

Daily or at each trip, check oil level in the oil bath air cleaner to be sure that level is at indicated mark. Add oil if necessary. This is especially important if the oil bath cleaner is the only cleaner on the engine.

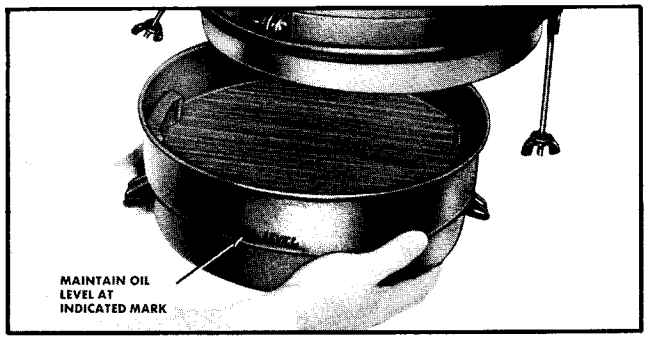


Fig. 3-22. Oil level in air cleaner

CLEAN PRE-CLEANER.

On engines working under extremely dirty conditions an air pre-cleaner may be used. Clean daily or oftener as necessary dependent on operating conditions.

CHECK AIR AND VAPOR LINE CONNECTIONS:

All air and vapor lines and connections from compressor, supercharger, rocker housing cover, and cylinder heads should be checked and corrected as needed.

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

Air tanks should be drained and all water must be kept out of the brake system.

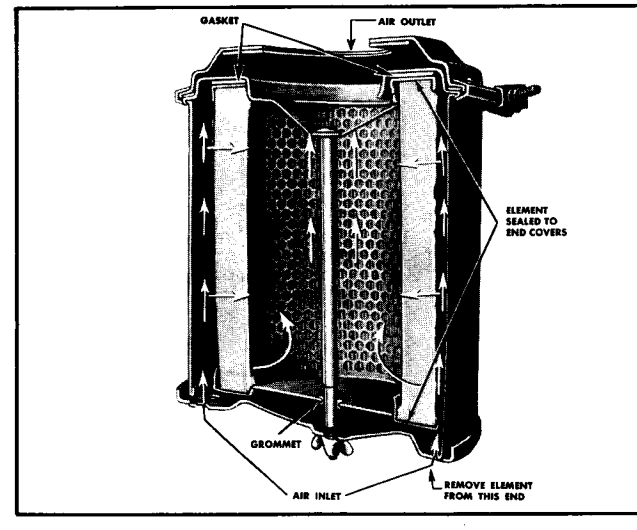


Fig. 3-23. Cross section of dry-type air cleaner

CLEAN DRY-TYPE CLEANER ELEMENT:

The paper element in a dry-type air cleaner may be cleaned several times by using a compressed air jet to blow off the dirt. Be sure that you do not hold the jet too close to the paper element or you may tear it.

When you install the element, make sure it seats on the gasket at the air cleaner outlet end. Fig. 3-23.

CAUTION: ANY HOLES IN THE ELEMENT OF A DRY-TYPE AIR CLEANER RENDER THE CLEANER INOPERATIVE AND DAMAGE TO THE ENGINE WILL RESULT.

CHANGE AIR CLEANER OIL:

Fill the oil cup to the level indicated by the bead on its side with clean, fresh oil and assemble to cleaner. An oil of the same grade as that in the crankcase should be used in the cleaner; however, in extremely cold weather a lighter grade may be necessary. Some detergent, or additive, oils tend to foam in the air cleaner and for this reason it is recommended that a straight mineral oil be used.

CAUTION: NEVER USE CRANKCASE DRAININGS.

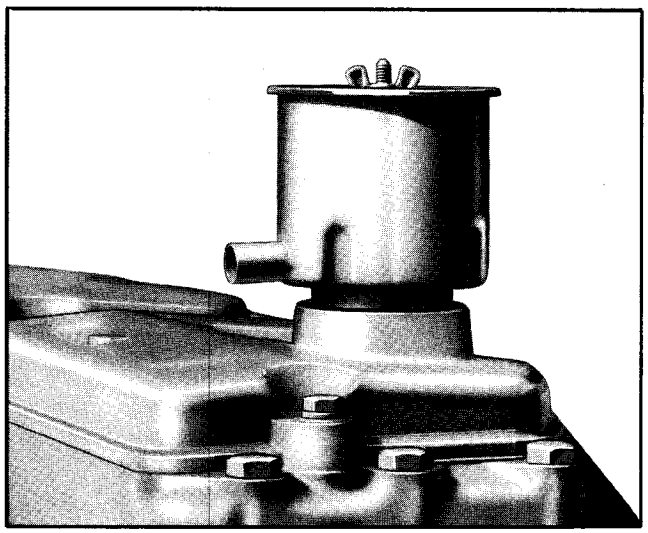


Fig. 3-24. Crankcase breather

CLEAN CRANKCASE BREATHER:

Oil Bath Type:

Immerse the breather in kerosene or cleaning solvent. Wash thoroughly. Dry with compressed air. Fill the breather oil cup to the level indicated with oil of the same grade as used in the engine.

Horsehair Element:

Crankcase breathers with horsehair elements are used on turbocharged engines. Clean element by washing in cleaning solvent and drying with compressed air.

CHANGE CRANKCASE BREATHER:

Paper Element:

Dry-type crankcase breathers containing a chemically-treated paper element are used on naturally-aspirated engines. DO NOT ATTEMPT TO CLEAN ELEMENT OR TO USE ON ENGINES WITH PRESSURIZED SYSTEMS. ELEMENTS MUST BE REPLACED NEW. Fig. 3-24.

CLEAN AIR COMPRESSOR BREATHER:

Two types of breathers are furnished to provide clean, filtered air for the air compressor. They should be serviced regularly at each oil change period as follows:

Mesh Type:

Remove the breather from the air compressor. Disassemble the breather completely and wash all parts

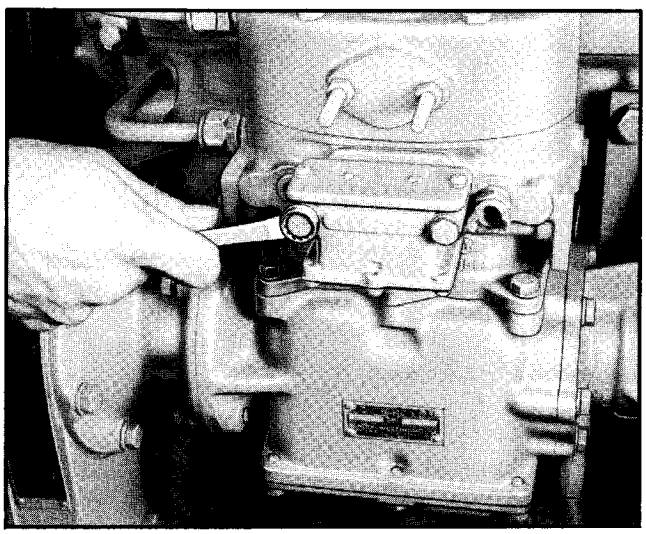


Fig. 3-25. Air compressor breather

in solvent. Dry with compressed air, reassemble, and install on compressor. Oil the mesh element very lightly with SAE 20 oil to aid in capturing dirt particles.

Oil Bath Type:

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

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

CLEAN TRAY SCREEN:

Immerse the tray screen in kerosene or cleaning solvent. Slosh the screen up and down several times. Dry thoroughly with compressed air, and reassemble to air cleaner.

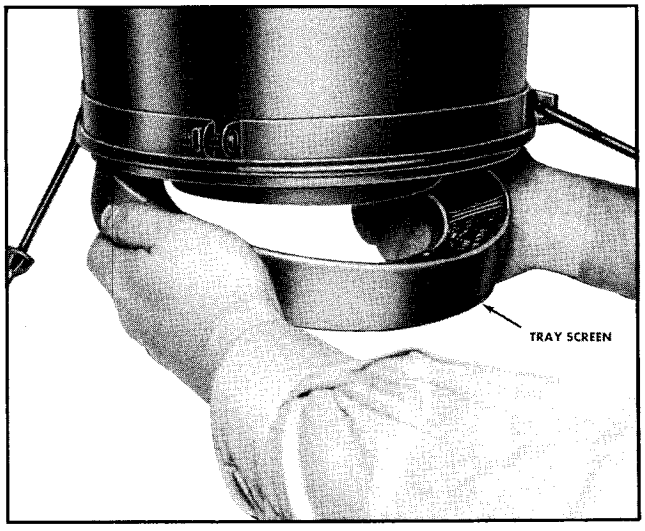


Fig. 3-26. Tray screen in oil bath cleaner

NOTE: If the 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 the tin plate on the screens.

CHECK AIR PIPING:

Check air intake piping from air cleaner to intake manifold. Check for loose clamps or connections, cracks, punctures, or tears in hoses or tubing, collapsing hoses, or other damage. Tighten clamps or replace parts as necessary to insure an airtight air intake system. *Make sure that all air goes through the air cleaner.*

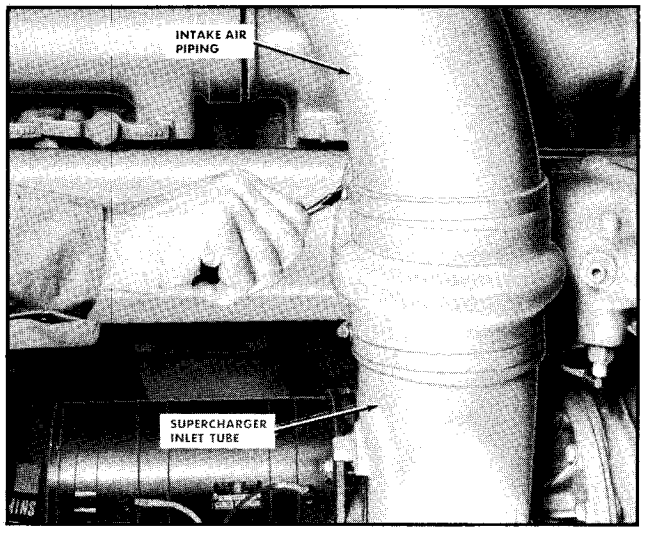


Fig. 3-27. Air inlet piping

CHECK FOR OIL LEAKS AT SUPERCHARGER OR TURBOCHARGER:

Supercharger:

Remove the supercharger outlet connection and visually check the ends of the rotors and case for evidence of oil leakage from supercharger seals. Rotors will always show some oil from the vapor tube which is connected to a rocker housing cover. Only the appearance of "wet" oil at the ends of the rotors, and excessive oil consumption should be cause for changing supercharger seals.

Check supercharger lubricating oil lines and connections for leaks and correct as needed.

Turbocharger:

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

TIGHTEN TURBOCHARGER MOUNTING NUTS:

Tighten all turbocharger mounting capscrews and nuts to be sure that they are holding securely. Tighten

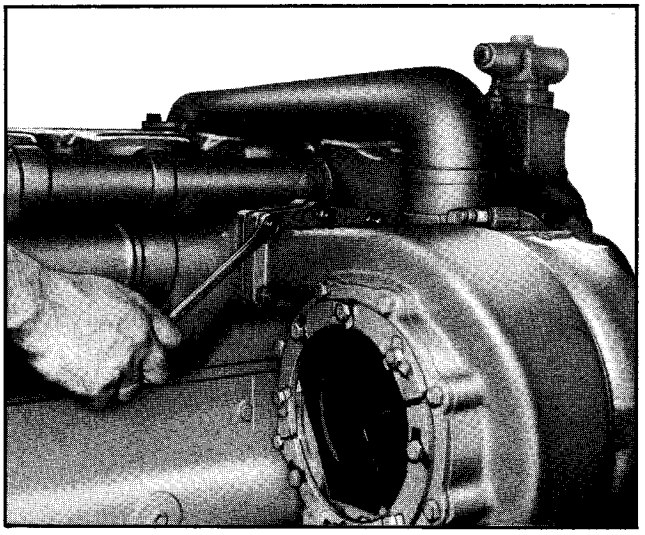


Fig. 3-28. Turbocharger mounting nuts

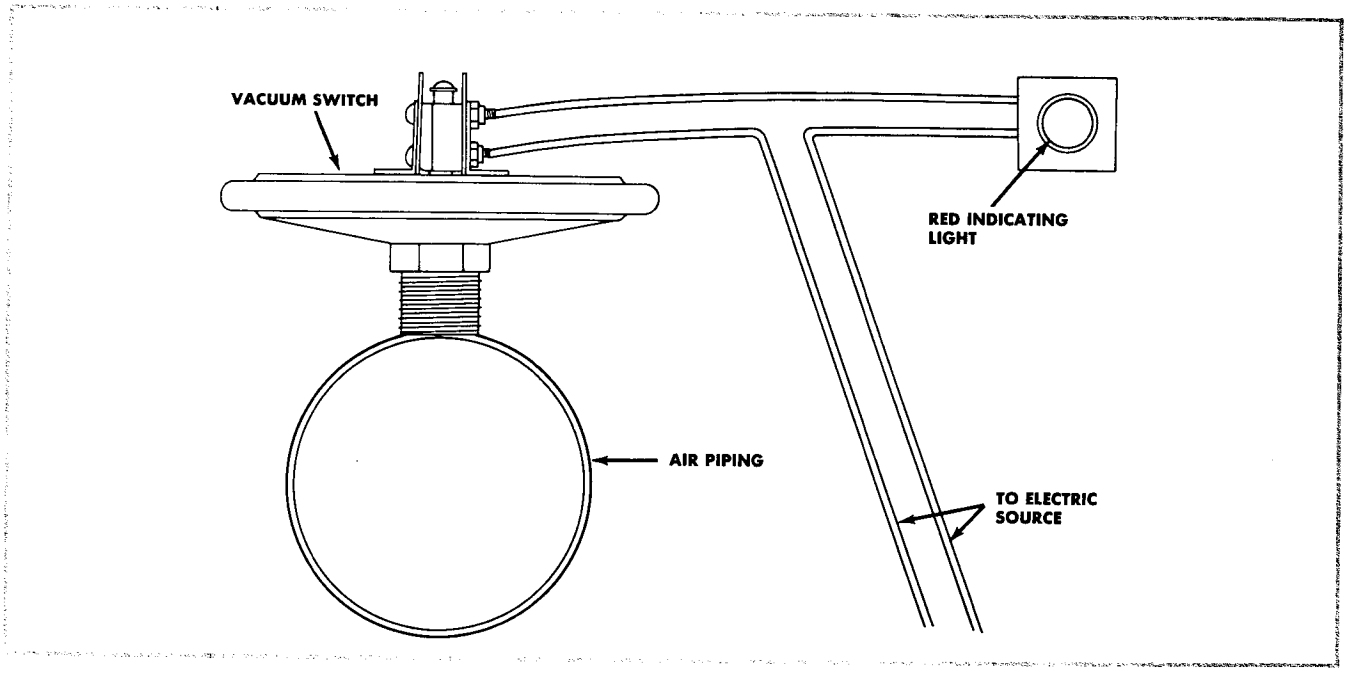


Fig. 3-29. Vacuum switch to check inlet air restriction

mounting bolts and brace rods so that vibration will be at a minimum.

CHECK INLET AIR RESTRICTION:

When the engine is pulling full load, the inlet air restriction in the intake manifold should not exceed 20 inches water as measured with a manometer or vacuum switch.

The manometer or vacuum switch must be located on the intake manifold or on the piping between air cleaner and manifold. The vacuum switch is recommended because it automatically closes an electric circuit and causes a red light on the instrument panel to glow when air restriction becomes excessive. Vacuum switches are available as optional parts from your Cummins Distributor.

If restriction exceeds permissible limits, correct as follows:

1. Clean or replace dry-type air cleaner element, or steam clean the element in the oil-bath air cleaner.
2. Repair or replace any dented or mashed air cleaner piping, rain shield or housing.

REPLACE DRY-TYPE CLEANER ELEMENT:

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

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

CLEAN ANEROID AIR FILTER:

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

STEAM CLEAN OIL-BATH AIR CLEANER:

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

If the screens cannot be thoroughly cleaned at this time or if the body has been pierced or otherwise severely damaged, replace the air cleaner.

TIGHTEN MANIFOLD NUTS OR CAPSCREWS:

Exhaust, intake and water manifolds should be checked for tightness and corrected as required.

CLEAN TURBOCHARGER IMPELLER AND DIFFUSER:

The impeller and diffuser must be kept clean for best turbocharger performance. Any build-up of dirt on the impeller will choke off the air flow and it can cause rotor imbalance.

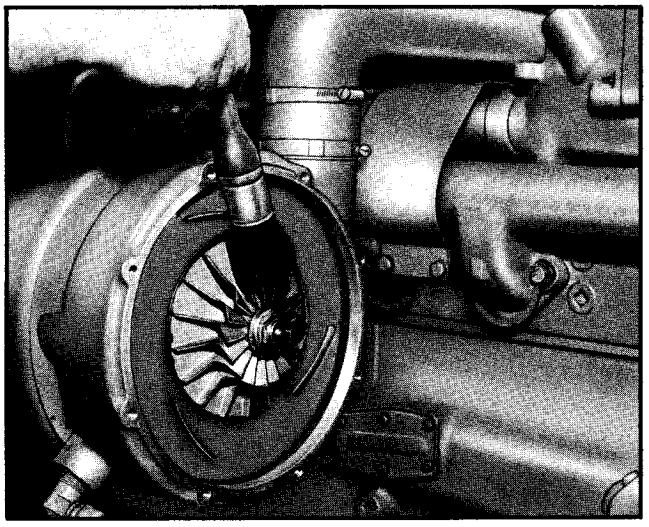


Fig. 3-30. Cleaning turbocharger impeller

At every "E" check, clean the impeller and diffuser as follows:

1. Remove the intake piping, air cleaner piping and turbo support bracket from the turbocharger.

2. Loosen and remove the eight capscrews, lock washers and plain washers from the plate. Remove the front plate to expose the impeller and diffuser.

3. Use a good carbon solvent cleaner but *never* use a caustic solution or any other type that may attack aluminum, as this will either weaken the impeller or destroy its balance. Never use a wire brush or scraper; a brush with nylon or hog bristles is preferable.

4. If the unit is found to be very dirty when the front plate is removed, remove the turbocharger from the engine.

5. With the front plate removed, immerse the impeller end of the turbocharger into the cleaning fluid to the face of the diffuser plate and allow to soak. Do not rest the weight of the turbocharger on the impeller or on the end of the shaft.

6. Dry the unit thoroughly with a compressed air jet. Reassemble the front plate to the turbocharger.

CHECK TURBOCHARGER BEARING CLEARANCES:

Bearing clearances should also be checked every "E" check. This can be done without removing the turbocharger from the the engine, by using a dial indicator to indicate the side and end-play of the rotor shaft.

Checking Procedure:

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

2. Fasten a dial indicator to the turbine casing and place the indicator point against the hub of the turbine wheel. Then by forcing the turbine wheel up and down, or side-wise, note the total indicator reading.

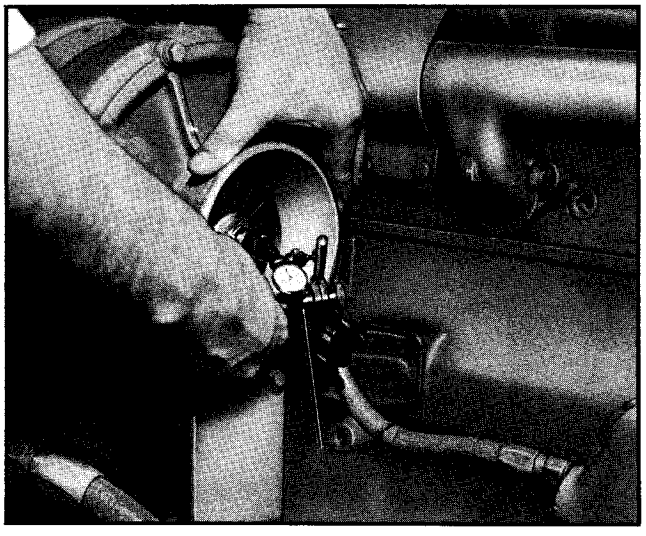


Fig. 3-31. Check bearing clearance

3. Remove one of the eight capscrews from the front plate (impeller end) and replace with a long capscrew. Attach an indicator to the long capscrew and register the indicator point against the flat on the end of the rotor shaft. Push the shaft side-wise, or up and down, making note of the total indicator reading. Move the indicator point to the end of the shaft and check end-play of rotor assembly.

4. Compare readings with limits shown:

	Min.	Max.
Radial Clearance		
(Total Indicator Reading)		**.010**
Rotor End-Play	**.006**	**.014**

If radial or end clearance exceeds the maximum limits shown above, the turbocharger should be removed from the engine and replaced by a new or rebuilt unit.

OTHER MAINTENANCE

	OPERATION	√	A	B	C	D	E
OTHER	Check Operator's Report		●	●	●	●	●
	Retighten Cylinder Head Capscrews (1st "B" Only)			●			
	Blow Dust from Generator and Cranking Motor					●	●
	Clean and Tighten Electric Connections					●	●
	Check Generator Brushes and Commutator					●	●
	Steam Clean Engine					●	●
	Tighten Mounting Bolts and Nuts					●	●
	Check Engine Blow-By					●	●
	Check Crankshaft End Clearance						●

Perform the operations at the intervals shown in the chart above. The instructions follow the same order as listed in the chart.

CHECK OPERATOR'S REPORT:

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

1. Low lubricating oil pressure.
2. Low fuel pressures.
3. Abnormal water or oil temperature.
4. Unusual engine noises.
5. Excessive smoke.

RETIGHTEN CYLINDER HEAD CAPSCREWS:

On a new engine, or at any time after the cylinder head has been removed, retighten cylinder head capscrews or nuts at the first "B" check. This applies to engines with steel-asbestos gaskets only. Following is the current procedure:

1. Be sure that capscrew holes or studs are clean.
2. Lubricate capscrew or stud threads with clean lubricating oil. Do not use grease or Lubriplate.
3. Install capscrews or stud nuts to finger tightness.
4. Tighten in sequence shown in Fig. 3-32 in 150 foot-pound steps with torque wrench until all capscrews or stud nuts have been tightened to 430/450 foot-pounds.
5. Run engine until oil and water temperatures reach 140° F. to 160° F., then tighten stud nuts or capscrews at the first oil change only.

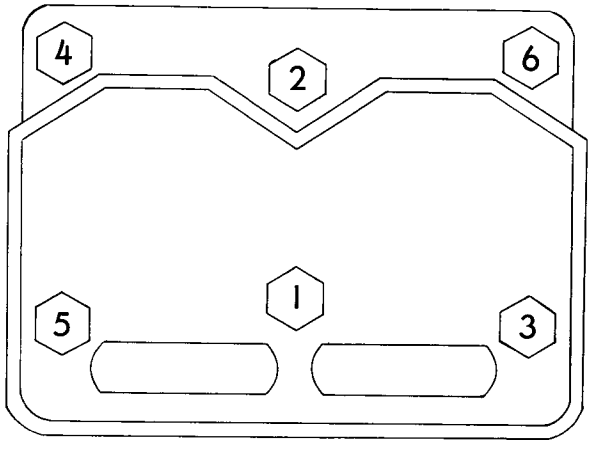


Fig. 3-32. Sequence for tightening head capscrews

BLOW DUST FROM GENERATOR AND CRANKING MOTOR:

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

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

CLEAN AND TIGHTEN ELECTRIC CONNECTIONS:

Poor starting conditions are often traceable to loose or corroded battery connections. A loose connection will overwork the generator and regulator and shorten their life.

1. Add water to battery cells to keep tops of plate covered.

2. Remove corrosion from and around terminals, then coat with vaseline.

3. Keep connections clean and tight. Prevent wire and lugs from touching each other or any metal except screw terminals to which they are attached.

4. Replace broken or worn out wires and their terminals.

5. Have battery tested periodically by a competent agency for any faults. Follow battery manufacturer's instructions for maintenance.

CHECK GENERATOR BRUSHES AND COMMUTATOR:

The failure of a generator may cause unit downtime and nearly always results in expensive replacement.

Dirty commutators should be cleaned with No. 00 sandpaper; *never with emery cloth.*

Replace worn brushes. If brushes wear rapidly, check for incorrect brush spring tension or high mica on the commutator. Check generator output and action of ammeter indicator after brush replacement.

Shorts and incorrect polarization can be detected at the ammeter. Incorrect polarization is indicated by minus reading when generator is turned. Take unit to electric service station for quick correction.

STEAM CLEAN ENGINE:

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 down the engine.

Generator and cranking motor openings and wiring should be protected from the full force of the steam jet.

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

TIGHTEN MOUNTING BOLTS AND NUTS:

Mounting bolts will occasionally work loose and cause the 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:

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

NOTE: On supercharged and turbocharged engines, the breather hole nearest the center rocker lever housing cover stud is closed with socket head plug. Make sure that this plug is in place before you decide the engine has blow-by.

Blow-by can be detected by running the engine and observing the gas escape from the lubricating oil filler hole with the cap or breather removed. There will always be some gas escape at this point when the lubricating oil is up to operating temperature due to heat and piston movement, but distinct puffs indicate blow-by. Experience and comparison with other units operating at the same speed are needed to make a conclusion as to the extent of blow-by. Real blow-by is always accompanied by excessive lubricating oil consumption. It can be corrected only by installing new rings, pistons, or liners as needed.

CHECK CRANKSHAFT END CLEARANCE:

The crankshaft of a new or newly rebuilt engine must have a minimum of .007 end clearance. A worn engine should not be operated with more than .035 crankshaft end clearance Fig. 3-33.

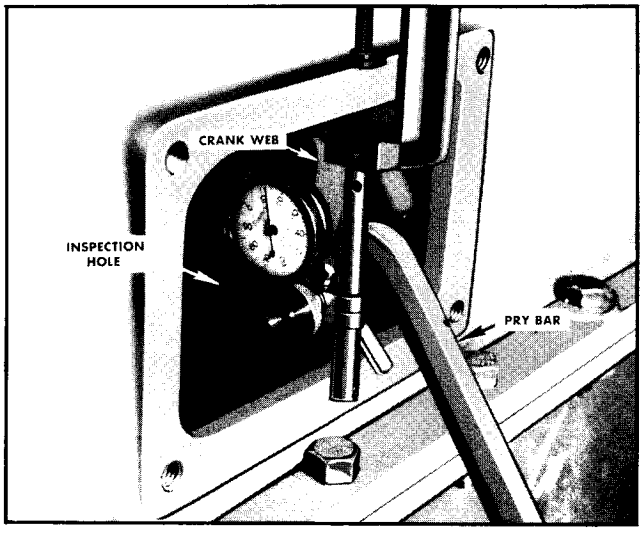


Fig. 3-33. Crankshaft end clearance

The check can be made by attaching an indicator to rest against the flywheel or end of the crankshaft while prying against a crankshaft throw through an

inspection plate, (Fig.3-33) if the oil pan is not removed. End clearance must be present with engine mounted to its driven unit.

Insufficient end clearance will cause excessive wear of the crankshaft flange and thrust bearings. It often results in bearing and engine failure.

Excessive thrust bearing or flange wear is generally caused by poor mounting of driven unit or by riding the clutch or other poor operating practices. End clearance in excess of .035" may result in bossing of connecting rods in pistons.

MAJOR INSPECTION

After 16,000 gallons fuel consumption, the engine should have a major inspection to determine whether it is in condition for another service period, or whether it should be overhauled. Oil consumption, oil pressure at idling, dilution and other signs of wear should be considered as part of the inspection.

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

The items which should be inspected at this period are the following:

Main and Connecting Rod Bearing Shells

Crankshaft Journals

Camshaft Lobes

Cylinder Heads (Grind Valves)

Cylinder Liners

Pistons and Rings

Fuel Pump (Calibrate)

Injectors (Clean)

Supercharger Seals and Bearings

Oil Cooler (Clean)

Turbocharger Bearing Clearances

Air Compressor, or Vacuum Pump

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 OVERHAUL

If during the major inspection it is determined that crankshaft journals or many of the other engine parts are worn beyond the worn replacement limits, the engine should be removed from the equipment and be completely rebuilt.

The overhaul or complete rebuild must be performed in a well-equipped shop by well-trained mechanics. Your Cummins Distributor has the special tools and the up-to-date information necessary to rebuild the engine to factory specifications.

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

ENGINE MAINTENANCE OPERATIONS SUMMARY

ENGINE SERIAL 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	MILEAGE or HOURS	MILEAGE or HOURS			HOURS	REQ. NO.	COST	GALLONS	QUARTS	HRS. OUT OF SERVICE	LABOR	PARTS	TIME LOST—HRS.	ACCIDENTS — CAUSE OF FAILURE — MAJOR ITEMS REPLACED, ETC.
	B	500														
	C	1000														
	B	1500														
	D	2000														
	B	2500														
	C	3000														
	B	3500														
	E	4000														
	B	4500														
	C	5000														
	B	5500														
	D	6000														
	B	6500														
	C	7000														
	B	7500														
	E	8000														
	B	8500														
	C	9000														
	B	9500														
	D	10000														
	B	10500														
	C	11000														
	B	11500														
	E	12000														
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	B	30500														
	C	31000														
	B	31500														
	G	32000														
TOTALS																

Fig. 3-34. Maintenance operations summary form

CUMMINS

H and NH SERIES DIESEL ENGINES

Section IV

ENGINE UNIT REPLACEMENTS

The design of Cummins engines makes it possible to replace worn units with new or rebuilt units within a few hours so you can get the engine back on the job quickly.

For all unit rebuilding and installation of other units and parts, see your nearest Cummins Distributor. He is equipped to rebuild your engine or engine unit. If you have the facilities to do your own overhaul work, he can supply you with the complete instructions contained in the H & NH Series Shop Manual. Through the use of the shop manual, factory approved service tools and trained mechanics, your rebuilt engine should perform as well as a new one.

Use only genuine Cummins parts in Cummins engines. Years have been spent in developing and testing these parts — each one in relation to its mating parts. Your Cummins engine deserves the best replacement parts and *these are genuine Cummins parts.*

Always provide a clean place to work and clean the outside of the engine before you remove any units. More engine failures are caused by dirt than from any other cause.

Use the proper tools for the job. Good work is impossible with poor or improper tools.

Protect all machined surfaces from contact with other rough parts. Protect parts which are to be stored with an oil or grease film.

CLEAN ENGINE EXTERIOR

After removal of generator, cranking motor and other electric equipment, but before removal of remaining units, the engine should be thoroughly cleaned with a steam jet. The time spent in cleaning will be made up quickly during disassembly.

A portable, fuel-oil or electric-heated steam cleaner is very satisfactory for general use on Cummins engines. This type cleaner can be used either in the cleaning room or in the yard.

In addition to actual time saved by engine cleaning, the quality of work will be improved.

GENERATOR

REMOVAL:

1. Disconnect the wiring leads from the generator terminals.

2. Remove the capscrews from the generator bracket and lift the generator and bracket from the engine.

3. Remove the bracket from the generator.

INSTALLATION:

1. Make sure the generator is the same type and rating as the one removed.

2. Mount the generator to the bracket. If the bracket does not have the word "Top" cast on it, be sure to mount the generator so the top generator-to-bracket mounting holes are closer to the horizontal center line of the bracket. Failure to do so will throw the generator lubricating oil cup and oil passages out of position.

3. Install the rubber buffer between the generator coupling and the drive coupling and connect the two units. Fig. 4-1. Mount the generator and bracket assembly to the cylinder block.

4. Replace generator wiring leads to proper terminals.

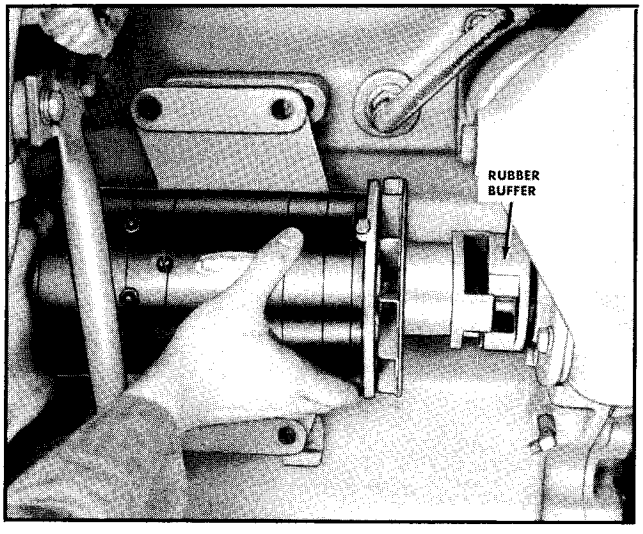


Fig. 4-1. Mounting generator

CRANKING MOTOR

REMOVAL:

1. Disconnect the wiring leads from the cranking motor terminals.

2. Remove the three capscrews holding the cranking motor and mounting spacer to the flywheel housing and lift out.

INSTALLATION:

1. Check cranking motor to see if it is the same type as removed. Cranking motors are designed with different type drives and must be used with a matching flywheel ring gear. Thus, it is important to replace them with the same type.

2. Assemble spacer to cranking motor.

3. Mount cranking motor to flywheel housing with three capscrews. Fig. 4-2.

4. Replace the wiring leads to the cranking motor terminals.

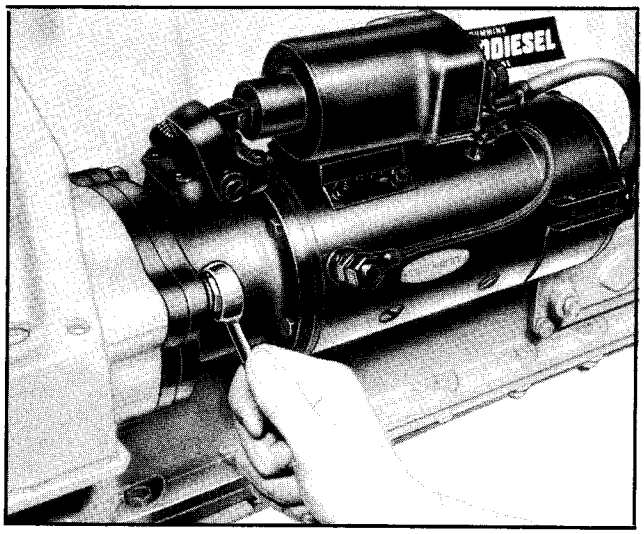


Fig. 4-2. Mounting starter

CORROSION RESISTOR

Many engines are equipped with a corrosion resistor. A single resistor is used on engines having cooling system capacities of 20/25 gallons; for larger systems, twin resistors are used.

REMOVAL:

1. Close shut-off valves in inlet and outlet lines; remove drain plug in resistor housing and drain coolant.
2. Disconnect inlet and outlet lines.
3. Remove capscrews securing corrosion resistor to engine block or mounting bracket.

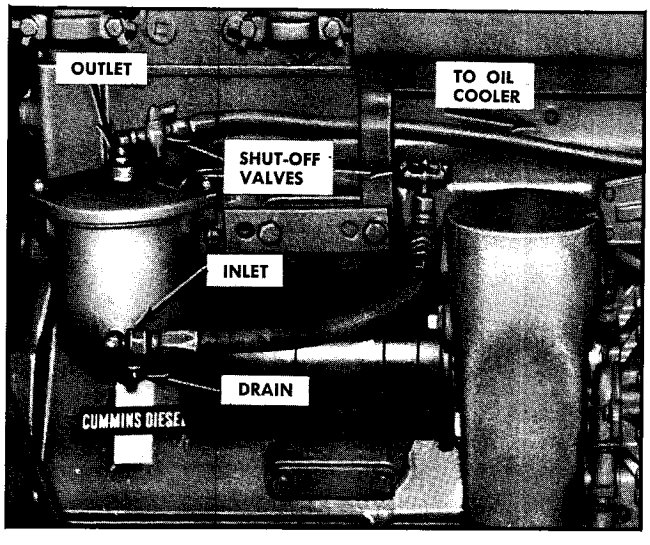


Fig. 4-3. Corrosion resistor

INSTALLATION:

1. Select location so that resistor will be grounded and inlet line will be less than 18 inches in length.
2. Secure resistor to engine or mounting bracket with capscrews.
3. Attach inlet and outlet lines. The inlet line connects the resistor to the pressure side of the water pump. The outlet line connects to the suction side of the water pump. Check table below for correct hose and valve sizes.

	LENGTH	HOSE SIZE	I.D.	VALVE SIZE
INLET LINE:	Under 12"	No. 8 Flexible Wire Braided	13/32"	3/8"
	12" to 18"	No. 10 Flexible Wire Braided	1/2"	1/2"
	Over 18"	5/8" Heater Hose	5/8"	1/2"
OUTLET LINE:	As Necessary	No. 6 Flexible Wire Braided	5/16"	3/8"

4. Open shut-off valves; start engine and check for leaks.
5. After a few minutes, check resistor head temperature to see if coolant is circulating. If resistor head is cold, disconnect outlet line to bleed off air. Recheck for circulation.
6. For service instructions, see Page 3-18.

THERMOSTAT

REMOVAL:

1. Disconnect hose from water outlet connection on thermostat housing. Disconnect and remove air compressor water lines, if present. On turbocharged engines, disconnect turbocharger water outlet line at housing.
2. Remove four capscrews holding thermostat housing to cylinder head water outlet connection and separate the two units. On turbocharged engines, lift the housing from the water by-pass coupling. Remove thermostat. Remove and discard gasket.

INSTALLATION:

1. Install new or tested thermostat as shown in Fig. 4-4., using new gasket. If a turbocharged engine, use new rubber O-ring on water by-pass coupling.

Install thermostat with "V" notch at top to vent as much air as possible. *Failure to do so may result in an air lock and incomplete coolant circulation.*

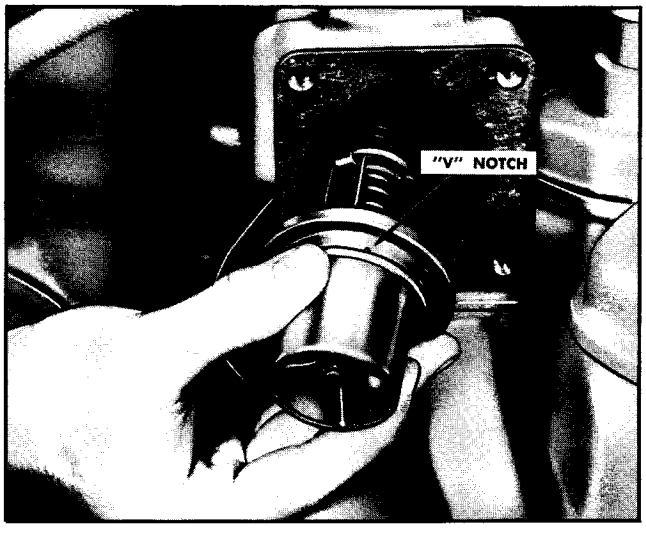


Fig. 4-4. Thermostat installation

2. Install four capscrews and washers and tighten securely. Connect air compressor water lines, if present. Connect water outlet hose and tighten clamp.

3. After filling cooling system, open drain cock at top of thermostat housing to bleed out air.

WATER PUMP

REMOVAL:

Fan and Pulley:

1. Remove the fan from the fan pulley.

2. Loosen the adjusting screw and remove the fan hub, pulley and belts from the mounting bracket.

Fan Bracket and Water Pump:

1. Remove the bell crank arrangement when used, from the rocker housing and compression release lever.

2. Loosen and remove the capscrews that hold the fan bracket support to the rocker housing.

3. The fan bracket on many engines is also a clamp ring to secure the water pump. Loosen the six capscrews in the clamp ring.

4. Using a screw driver in the holes provided in the water pump housing, turn the water pump to the lowest point of its eccentric to loosen the water pump belt.

5. Remove the water pump belt, fan bracket and support.

6. Remove the water pump from the cylinder block.

INSTALLATION:

Fan Bracket and Water Pump:

1. Place the water pump clamp ring and gasket on the water pump.

2. Assemble the drive belt on the water pump pulley and water pump drive pulley.

3. Turn the water pump to the low point of its eccentric and install in place in the cylinder block. Secure lightly with capscrews and lock-washers. Fig. 4-5.

4. Insert a large screw driver in the holes provided in the water pump and turn the water pump on its eccentric counter-clockwise to tighten the belt. Refer to page 3-16.

5. Tighten capscrews in the clamp ring.

6. Secure the fan bracket support to the rocker housing with capscrews and lockwashers.

Belt Adjustment:

Refer to Page 3-16.

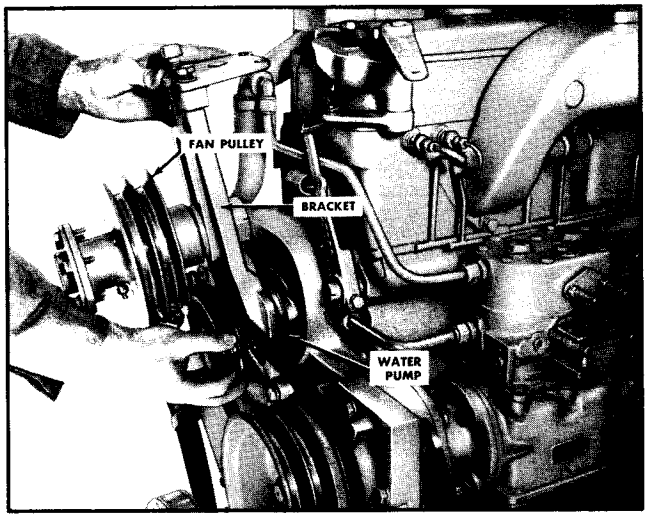


Fig. 4-5. Mounting water pump and fan bracket

Fan and Fan Pulley:

1. Assemble the belts over the fan pulley and fan drive pulley.

2. Assemble the fan pulley to the water pump bracket.

CAUTION: AVOID STRETCHING THE BELTS. LOOSEN THE ADJUSTING SCREW UNTIL THE BELTS GO INTO POSITION.

3. Tighten the adjusting screw to get proper tension on the drive belts and tighten hub to bracket. Pack the fan hub bearings with a good grade ball-bearing grease.

4. Assemble fan and dirt exclusion plate to fan hub.

TURBOCHARGER

All production model Cummins turbochargers are now oil cooled. The removal and installation instructions given below apply only to the oil-cooled type. For information on water-cooled turbochargers, refer to Turbocharger Manual.

REMOVAL:

1. Disconnect oil lines.

2. Loosen intake and discharge air connections.

3. Remove mounting bracket stud nuts and turbocharger to exhaust-manifold capscrews. Lift off turbocharger.

INSTALLATION:

1. Check position of lubricating oil drain (large boss). Oil drain must always be down or within 45° of that position when turbocharger is mounted on the engine. Fig. 4-6.

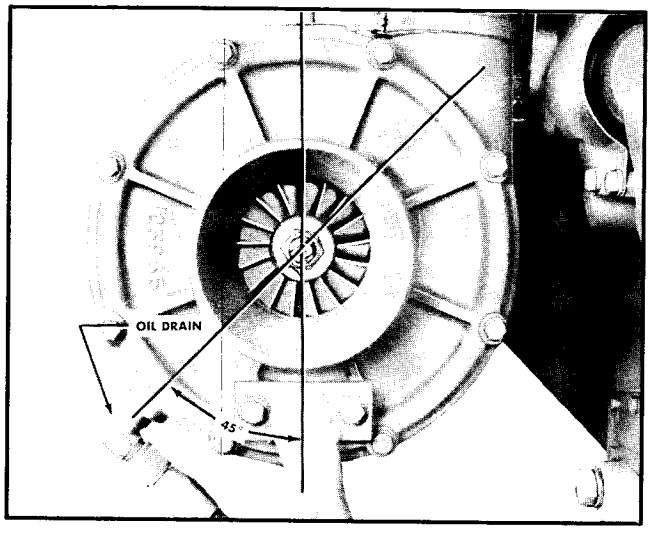


Fig. 4-6. Oil drain position

2. Install gasket and turbocharger to exhaust manifold.

3. Secure mounting bracket to turbocharger casing. Fig. 4-7.

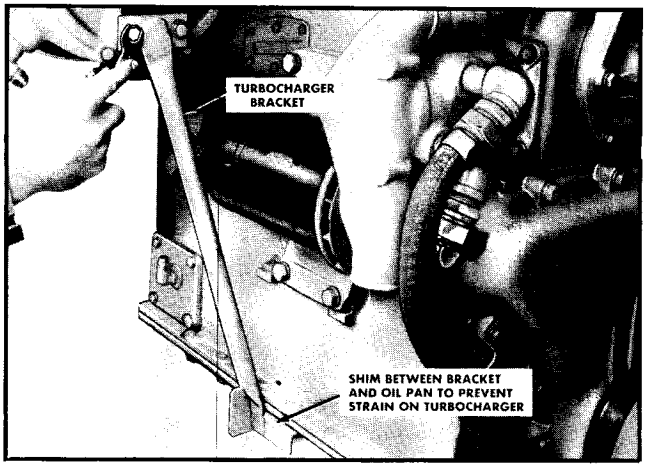


Fig. 4-7. Turbocharger support bracket

4. Connect oil inlet line from top of turbocharger to oil cooler or rear of block.

5. Connect oil drain line from large boss on side of turbocharger to the crankcase. Fig. 4-8.

6. Install hose from blower outlet to intake manifold connection.

7. Install air cleaner and exhaust piping. *Do not carry the exhaust piping weight on the turbocharger.*

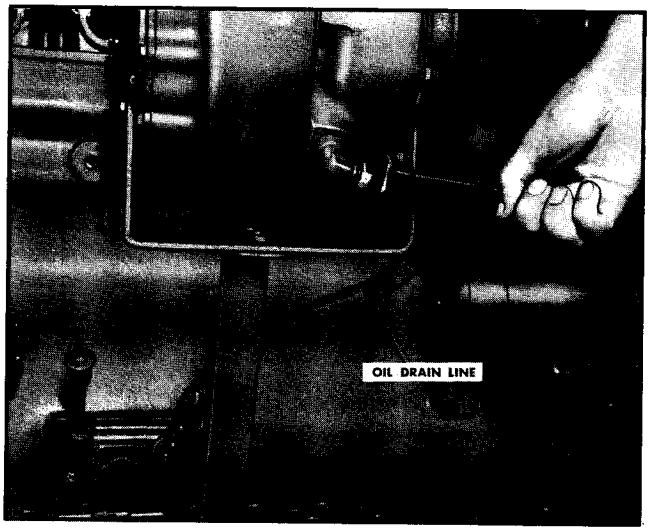


Fig. 4-8. Connecting drain line

TURBOCHARGER LINE SIZES

Oil Inlet 5/16" I. D. Oil Drain 1/2" I. D.

SUPERCHARGER

REMOVAL:

1. Remove four capscrews which secure the connection to the intake manifold. Using a screw driver, pry the springs from the supercharger connection at the outlet. Springs are used at this connection to prevent distortion of the supercharger when the connection is installed. Tape the connection opening in the supercharger to prevent entry of foreign objects.

2. Remove heat shield and supercharger outlet.

3. Remove oil filter tube and cover plate from cylinder block.

4. Disconnect and remove lubricating oil supply and drain lines from the supercharger and hand hole covers.

5. While supporting the supercharger to keep it from falling, remove the mounting capscrews from the supercharger and cylinder block.

6. Disengage the supercharger coupling from the drive unit and lift from engine.

NOTE: NHHS superchargers are flange-mounted to the gear case and cover.

INSTALLATION:

1. Keep ports covered at all times before final assembly of the inlet and outlet ends of the manifold to

the supercharger. Masking tape may be used. Do not stuff rags into the inlet or outlet ports at any time as they might be left there on assembly to the engine.

2. Assemble the supercharger inlet and outlet connections to the supercharger. Use hug-nuts and flat washers to secure connections in place.

3. Lift the supercharger to the engine and engage the coupling to the drive unit. Fig. 4-9.

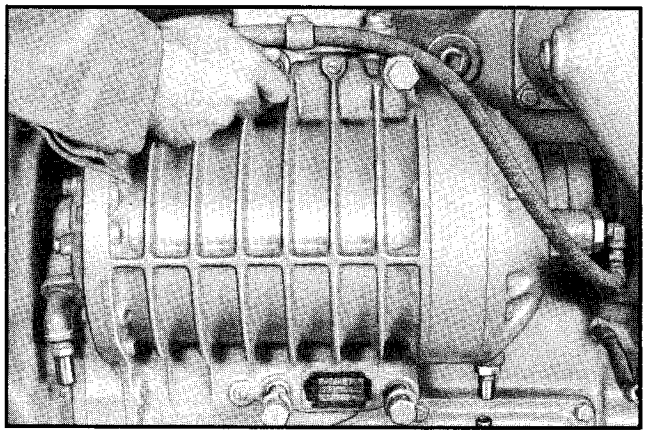


Fig. 4-9. Installing supercharger

4. Start the upper left and lower right bolts to support the supercharger.

5. Start and tighten the upper right and lower left support bolts. The upper right and lower left bolt holes in the supercharger are reamed holes and fit the support bolts snugly. A slight coating of oil on the bolts will ease their installation.

6. Tighten the other two support bolts. *Care should be taken against extreme tightening which will result in distortion in the housing, causing the rotors to scrape.*

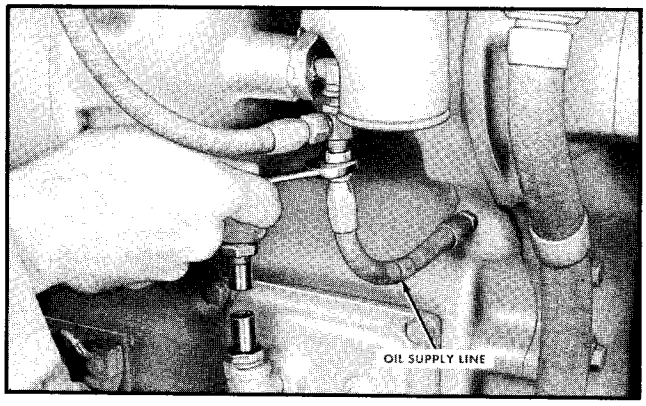


Fig. 4-10. Installing oil supply line

7. Place rubber buffer in generator drive coupling and mount generator.

8. Install lubricating oil supply and drain lines to the supercharger and hand hole covers. Fig. 4-10.

OIL COOLER

REMOVAL:

1. Remove water and oil connections.

2. Loosen four capscrews and remove the oil cooler from the cylinder block. Fig. 4-11.

3. Screw two 10/32-inch capscrews into the tapped holes provided in the element and pull the element from the housing.

4. Discard old "O" rings.

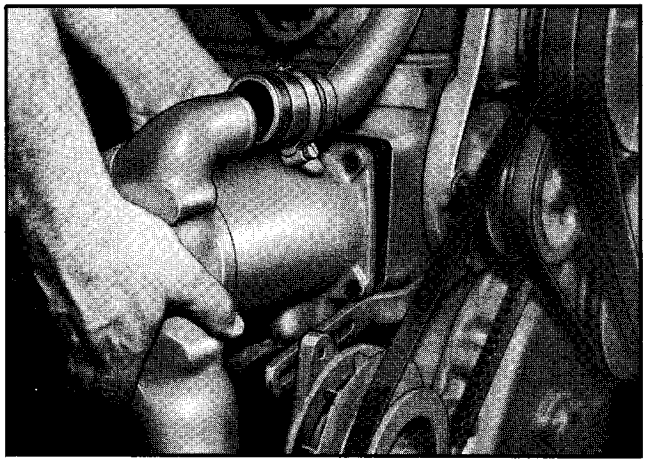


Fig. 4-11. Removing oil cooler

CLEANING:

Tube Bundle Element:

1. The element may be cleaned in any solvent that will dissolve the oil film and sludge.

CAUTION: DO NOT USE ANY SOLVENT THAT IS HARMFUL TO COPPER OR TRY TO USE ANY MECHANICAL CLEANING METHOD SUCH AS SCRAPING.

2. Finish cleaning by blowing through the bundle with compressed air.

Housing:

Clean the housing casting with solvent and compressed air.

INSTALLATION:

1. Place a new rubber "O" ring in the groove at the bottom of the housing. Make sure the ring is free of cuts, nicks, etc., and is not twisted.

2. Lubricate the ring thoroughly with a good grade of ball-bearing grease.

3. Push the element into the housing by hand, taking care to align the index marks on the housing and element. Fig. 4-12.

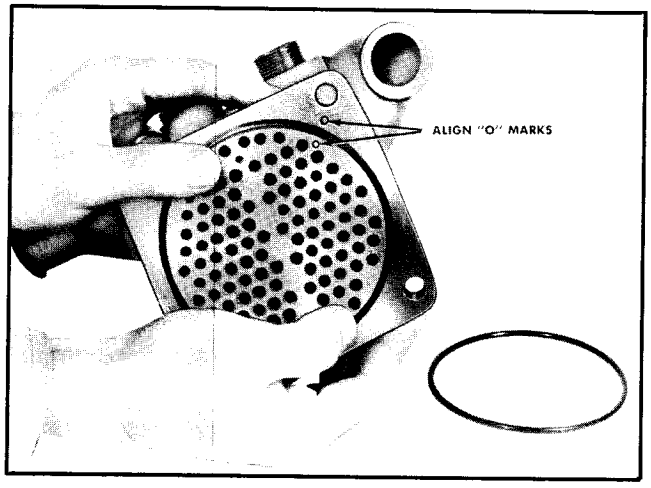


Fig. 4-12. Installing tube bundle element

4. Install another new "O" ring around the top of the element by pressing it in place with a wooden block so that equal pressure is applied to the ring throughout its circumference.

5. Place a steel retainer ring over the rubber "O" ring.

6. Install a new gasket and secure the assembled cooler to the cylinder block with four capscrews.

NOTE: On some blocks with a casting date before July 1, 1957, the block water passage may be larger than the element diameter. In that case, use an oil cooler plate in addition to the steel retainer ring in Step 5.

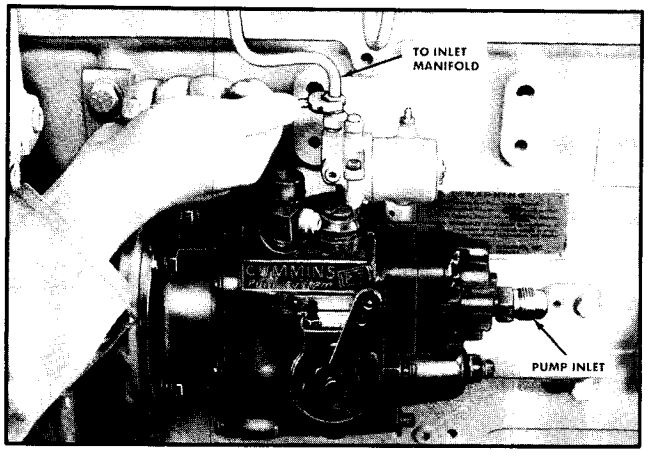


Fig. 4-13. Disconnecting fuel lines

FUEL PUMP

REMOVAL:

The fuel pump is flange-mounted to the accessory drive on the gear housing or to the rear of the air compressor.

1. Remove fuel line connecting fuel pump and inlet manifold. Fig. 4-13.

2. Disconnect fuel pump inlet and drain lines.

3. Disconnect throttle linkage.

4. Remove four stud nuts or capscrews, lockwashers, and flatwashers holding pump to accessory drive or to compressor and remove fuel pump from engine. Remove the rubber coupling from the drive unit.

INSTALLATION:

1. Install fuel pump to accessory drive or to compressor with new gasket and rubber buffer in position. Place flatwashers, lockwashers, and nuts over the four studs and tighten. Fig. 4-14.

NOTE: The fuel pump is mounted to Cummins air compressors with lockwashers and capscrews.

2. Connect the pump drain and inlet-to-fuel-tank lines.

3. Install fuel line from pump to fuel inlet manifold.

4. Connect the throttle linkage to the pump.

ADJUSTMENTS:

1. Fuel-rate calibration is discussed on Page 3-13.

2. Governor adjustments are described on Page 4-14 to 4-16.

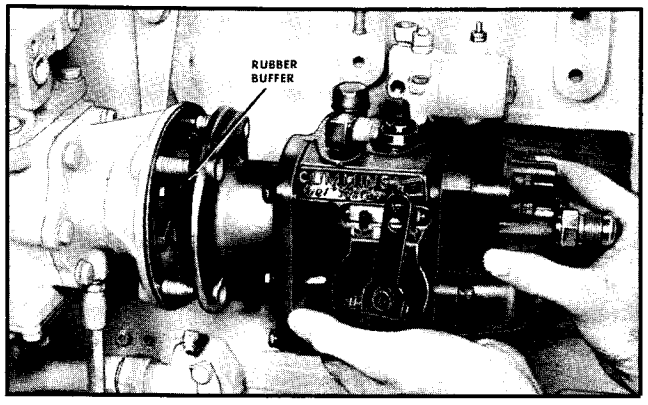


Fig. 4-14. Mounting fuel pump

AIR COMPRESSOR

Two types of air compressors are now in use on Cummins engines. The instructions for the removal and installation of each type is found below.

CUMMINS:
REMOVAL:

The Cummins air compressor is flange-mounted to the gear case and is gear-driven off the camshaft.

1. Remove capscrew, lock washer and washer securing accessory drive pulley to compressor crankshaft; using puller, remove pulley from crankshaft.

CAUTION: REPLACE CAPSCREW IN END OF CRANKSHAFT TO PREVENT DAMAGE TO THREADS.

2. Remove accessory drive pulley key.
3. On internal oil line engines only, remove oil slinger from crankshaft before proceeding.
4. Remove fuel pump as described on Page 4-7. Discard gasket.
5. Disconnect all air, water and oil lines from compressor.
6. Remove capscrews and lock washers mounting compressor support to gear case. If compressor is bracket mounted, remove capscrews and lock washers securing compressor to bracket.
7. Lift compressor from engine; discard gasket.

CAUTION: DO NOT LOSE COUPLING RETAINER PLATE AND RUBBER BUFFER FROM FUEL PUMP END OF CRANKSHAFT.

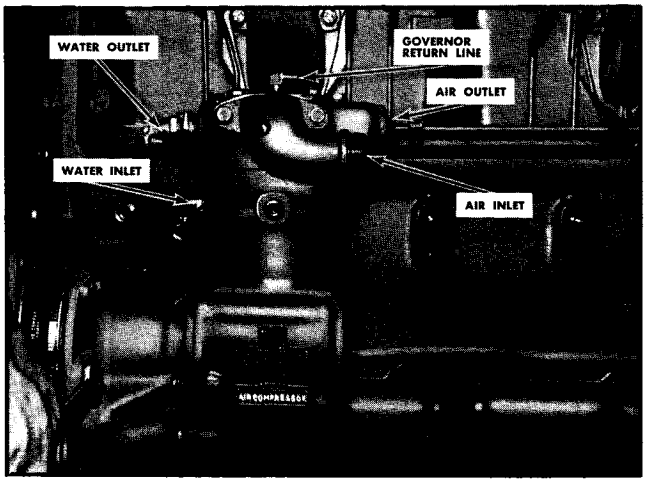


Fig. 4-15. Cummins air compressor, installed

INSTALLATION:

1. Using a new gasket, install compressor to gear case; secure with lock washers and capscrews. Fig. 4-15.

CAUTION: TIMING MARKS ON COMPRESSOR DRIVE GEAR AND CAMSHAFT GEAR MUST BE INDEXED.

2. Connect all air, water and oil lines to the compressor.
3. If removed, install coupling retainer plate and rubber buffer on fuel pump end of crankshaft.
4. Using a new gasket, install fuel pump. See Page 4-7.
5. On internal oil line engines, slide oil slinger on crankshaft.
6. Install accessory drive pulley key in crankshaft by tapping into place with plastic mallet.
7. Remove large capscrew from end of crankshaft. Install accessory drive pulley on crankshaft with puller. Secure with washer, lock washer and capscrew.

BENDIX-WESTINGHOUSE:
REMOVAL:

The air compressor is flange mounted to the accessory drive and is driven by a splined-sleeve type drive coupling from the accessory drive shaft.

1. Remove the fuel pump as described on Page 4-7. Disconnect the oil inlet line from the air compressor drive and fuel pump flange.
2. Remove the oil drain tube from the bottom of the compressor. Disconnect the water inlet and outlet tubes and the air outlet tubing from the compressor.
3. Remove the two capscrews holding the compressor support to the cylinder block and the four capscrews holding the air compressor to the accessory drive. Fig. 4-16.
4. Remove the compressor and splined coupling. Discard the old gasket.

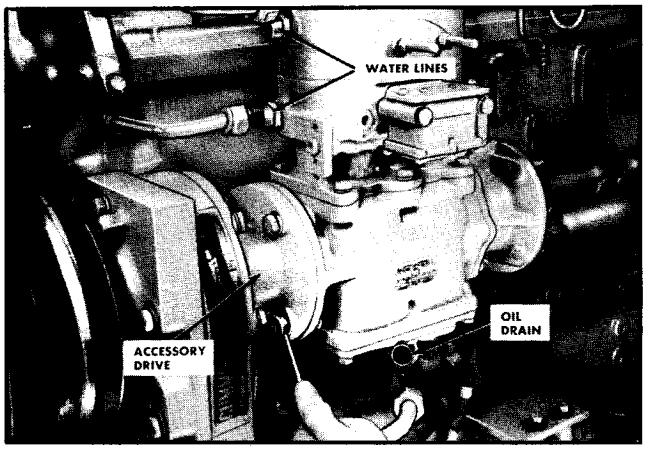


Fig. 4-16. Removing air compressor

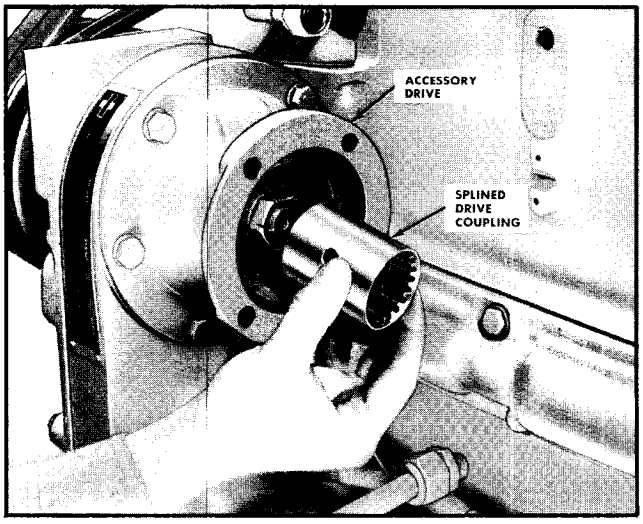


Fig. 4-17. Installing splined coupling

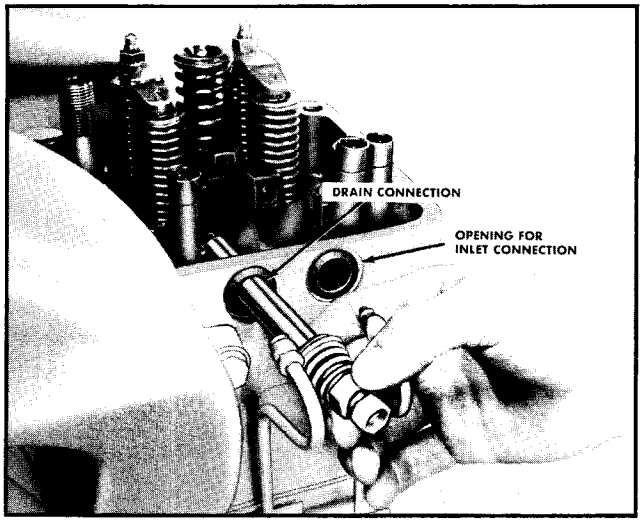


Fig. 4-18. Removing fuel drain connection

INSTALLATION:

1. Assemble splined coupling to compressor. Fig. 4-17. Assemble air compressor to accessory drive using a new gasket. Install and tighten the four capscrews and lockwashers.

2. Attach compressor support to block with two capscrews, lockwashers, and flatwashers.

3. Connect all water, air and oil lines, or tubing.

4. Install fuel pump as described on Page 4-7.

INJECTORS

REMOVAL:

1. Remove the three capscrews and washers from the rocker cover and lift it from the rocker housing.

2. Remove fuel inlet and drain lines to injector connections.

3. Remove the fuel inlet and drain connections from the injector body. Fig. 4-18.

4. Loosen injector locknut and unscrew the adjusting screw until the push tube can be disengaged.

5. Disengage the push tube and tip back the rocker lever until the injector can be removed.

6. Remove hold-down capscrews and lift injector from the cylinder head.

CAUTION: DO NOT BRUISE THE INJECTOR TIP.

INSTALLATION:

1. Make sure the same type injectors are put in as taken out.

2. Wrap a clean cloth around a wooden stick and clean-out the injector sleeve. The injector sleeves are made of copper and are closely machined to seal the injector cup. Never use a screw driver or any metal object for this operation. Fig. 4-19.

3. Place the injector in its proper position in the cylinder head being very careful not to hit or damage the injector tip.

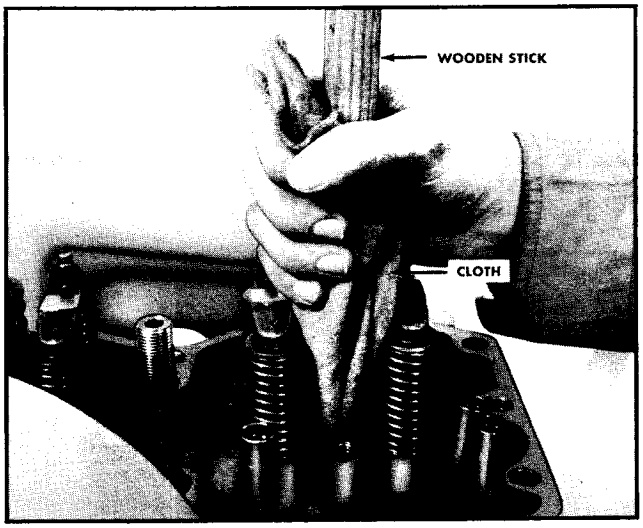


Fig. 4-19. Cleaning injector sleeve

4. Start, but do not tighten, the injector hold-down capscrews.

5. In order to align the injectors before tightening hold-down capscrews, screw in the inlet and drain connections about three turns.

6. Oil the injector hold-down capscrews and tighten to 10 to 12 foot-pounds with a torque wrench. Fig. 4-20. Excessive tightening will distort the valve seats and will crack the cylinder head.

NOTE: Injector hold-down capscrews now contain a nylon insert that acts as a lock. These capscrews may be reused 5 to 10 times before the effectiveness of the insert is impaired. Nylock capscrews should be tightened to 12/14 ft. lbs. with a torque wrench.

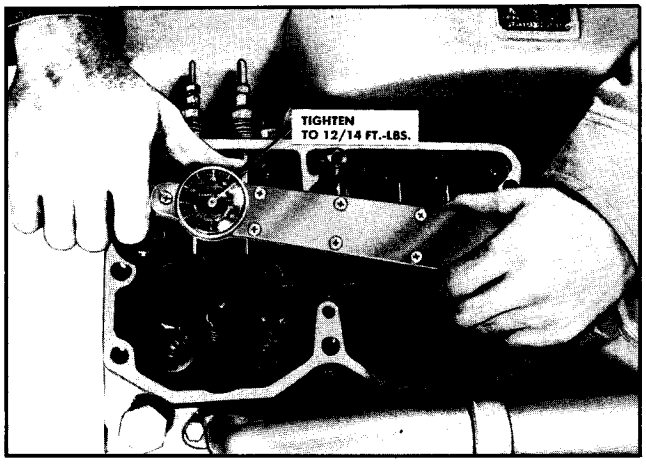


Fig. 4-20. Tightening hold-down capscrews

7. Tighten inlet and drain connections to 20 to 25 foot-pounds with a torque wrench.

8. Assemble injector rocker lever to injector push tube.

9. Adjust injectors and valves as outlined on Page 3-10.

10. Install rocker-lever cover.

CYLINDER HEAD

REMOVAL:

Supercharger Outlet Connection:

1. Loosen and remove the capscrews, nuts and washers that secure the supercharger outlet connections (on supercharged and turbocharged engines only).

2. Remove the fuel connection from the intake manifold connection.

3. Remove the capscrews and lockwashers from the intake manifold connection and the engine intake manifold. Lift off the intake manifold connection.

CAUTION: INLET AND OUTLET CONNECTIONS SHOULD BE KEPT COVERED WITH PLATES OR GUMMED PAPER TO KEEP OUT FOREIGN OBJECTS. DO NOT STUFF RAGS INTO THE PORTS.

Intake and Exhaust Manifolds:

Remove the capscrews and lockwashers at each intake and exhaust port. Lift the intake and exhaust manifolds from the engine.

Water Manifold:

Remove the two capscrews from the water by-pass connection. Then remove the two capscrews from each foot of the water manifold and lift the manifold assembly from the engine. Fig. 4-21.

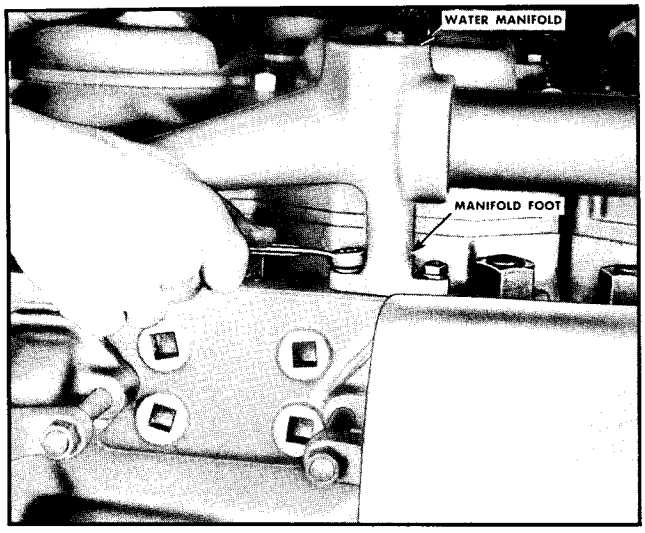


Fig. 4-21. Removing water manifold

Rocker Housing Covers and Housings:

1. Remove the rocker housing covers by taking out the three capscrews holding each cover to the housing.

2. Remove the lubriciating oil pipe cap and gasket.

3. Remove the seven capscrews from each rocker housing and lift separately from the engine by grasping the end of each injector rocker.

Push Rods:

Remove the push rods by lifting them from their sockets.

Injectors and Connections:

1. Unscrew and remove the fuel lines and fuel inlet and drain connections.

2. After removing the injector hold-down capscrew, lift the injector from the cylinder head.

CAUTION: DO NOT BRUISE THE INJECTOR TIP.

3. Put injectors and inlet connections in order so they may be replaced together.

Cylinder Heads:

Remove the cylinder-head capscrews with a heavy-duty socket wrench. Lift the heads from the engine.

CAUTION: DO NOT LET MACHINED SURFACES BECOME SCRATCHED OR MARRED IN ANY WAY.

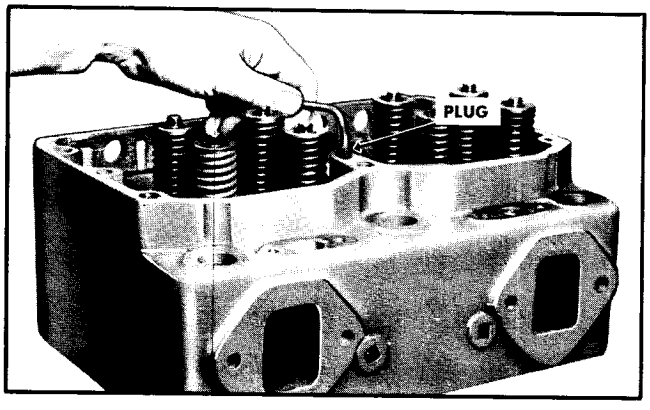


Fig. 4-22. Breather hole in cylinder head

INSTALLATION:

Cylinder Heads:

1. Make sure that cylinder heads on naturally-aspirated engines have the top breather hole open. Supercharged or turbocharged engines must have this breather hole plugged with a ⅛ inch pipe plug. The breather hole is located at the top of the cylinder head between the center stud holes. Fig. 4-22.

2. Wipe clean the mating surfaces of the cylinder block and the cylinder head.

3. Place grommet retainers in water passages in block, small end up. Fig. 4-23.

4. Lay gasket on flat surface; press grommets into place by hand. Fig. 4-23.

CAUTION: AVOID ALL CONTACT BETWEEN GROMMETS AND FUEL OR LUBE OIL TO PREVENT DAMAGE DUE TO SWELLING.

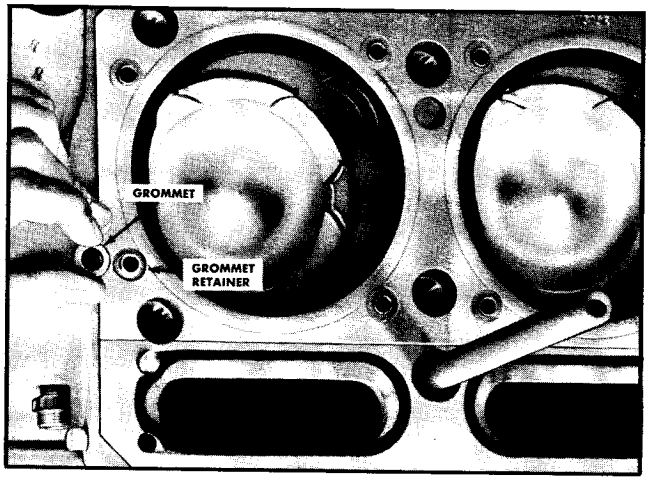


Fig. 4-23. Install grommet retainers and grommets

5. Install head gasket, stamped word "TOP" to top, over oil pipes. Be careful not to dislodge grommets as gasket is lowered over grommet retainers.

6. Examine oil pipe bore on milled surface of cylinder head for counterbore. If the head is counterbored at this point, install cork washer on each oil pipe. If the counterbore occurs at the top surface of the head, install washer on the oil pipe after the cylinder heads have been placed on the block. All current production heads are counterbored at the top surface for these washers.

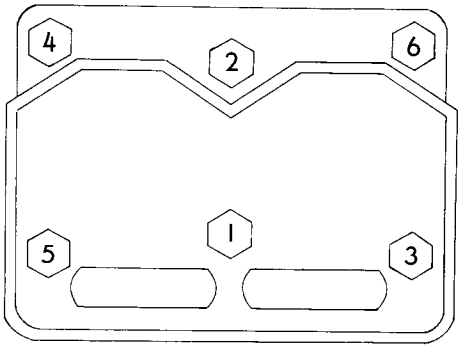


Fig. 4-24. Sequence for tightening cylinder head capscrews

7. Oil cylinder head capscrews and tighten each slightly in the correct order as shown in Fig. 4-24. Continue tightening in rotation and in 100 foot-pound steps with a torque wrench until all capscrews have been tightened to 430/450 foot-pounds.

CAUTION: RETORQUE CAPSCREWS AFTER 50 HOURS OR 2000 MILES OPERATION WHEN STEEL-ASBESTOS GASKETS ARE USED. THIS IS NOT NECESSARY WITH STEEL-PLATE GASKETS.

Injectors and Fuel Connections:

Refer to Page 4-9, "Injector Installation".

Push Rods:

Insert the push rods for the injector, intake and exhaust valves for each cylinder into the sockets of the cam follower levers. The injector push rod is the largest and goes in the middle socket. The intake push rods have collars to match with the milled lift of the compression release.

Cross Heads:

On 4-valve engines, assemble the cross heads with the adjusting screw toward the water manifold. For adjustment see Page 3-12.

Rocker Arm Housing:

1. Install a new rocker housing gasket over the capscrews to the cylinder heads.
2. Loosen the locknuts and back off the rocker arm adjusting screws two or three turns. While holding the rocker arms in place, assemble each housing in place with the ball ends of the rocker arms fitting into their respective push rod sockets.
3. Place a new gasket on each lubricating oil pipe and tighten down the caps. Fig. 4-25.
4. Replace and tighten the capscrews.

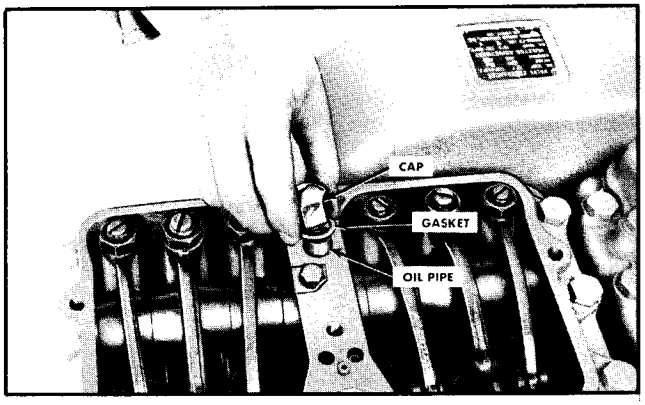


Fig. 4-25. Lubricating oil pipe cap

Rocker Housing Covers:

1. Install the rocker housing covers to the rocker housing and secure with the three capscrews and washers.
2. Assemble the breather (if used) to the rocker housing cover.

Valve and Injector Adjustments:

Make valve and injector adjustments as explained on Page 3-10.

Water Manifold:

Cement a new gasket to each manifold foot and secure the manifold to the cylinder heads.

Intake and Exhaust Manifold:

1. Install the intake and exhaust manifolds with new gaskets.
2. Tighten capscrews or stud nuts securely, beginning at center and working toward the ends.

CAUTION: KEEP EXPOSED OUTLETS COVERED UNTIL CONNECTED TO MATING PART.

Supercharger Air Outlet Connection:

1. Install a new rubber pack ring and gasket.
2. Assemble connection in place and secure with capscrews and washers.
3. Assemble fuel line connection to preheater nozzle.

Mounting of several units on the horizontal engines differ slightly from the vertical engines. Replacement should be made as follows:

REMOVAL:

1. Disconnect all fuel lines to and from the fuel pump.

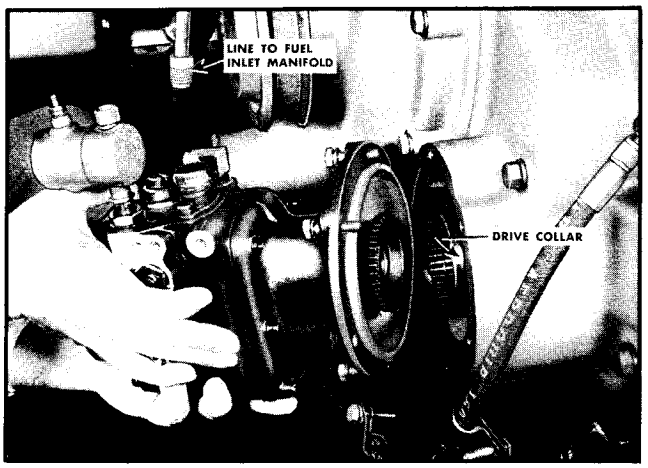


Fig. 4-26. Fuel pump assembly

2. Loosen the six capscrews from the front pump cover and slide the pump away from the gear case cover. Fig. 4-26.

3. Slide the coupling collar off the drive gear.

4. Cover pump connections to prevent entrance of dirt.

INSTALLATION:

1. Place the pump coupling drive collar over the engine drive gear.

2. Place the fuel pump in position, use a new gasket on the gear case, and secure with capscrews.

3. Connect fuel lines.

REMOVAL:

1. Disconnect the hose leading to the radiator and to the water manifold.

2. Remove water pump pulley capscrews and remove belt.

3. Loosen the water pump mounting capscrews — to the gear cover — and pull out the pump.

INSTALLATION:

1. Install a new gasket on the water pump and mount on the gear cover.

2. Install the belt over the pulley on the vibration damper and pulley-half on the water pump. Install the remaining half of the pump pulley using shims to adjust belt to proper tension. Fig. 4-27. Refer to Page 3-16 for belt adjustments.

3. Connect hose connections to the pump.

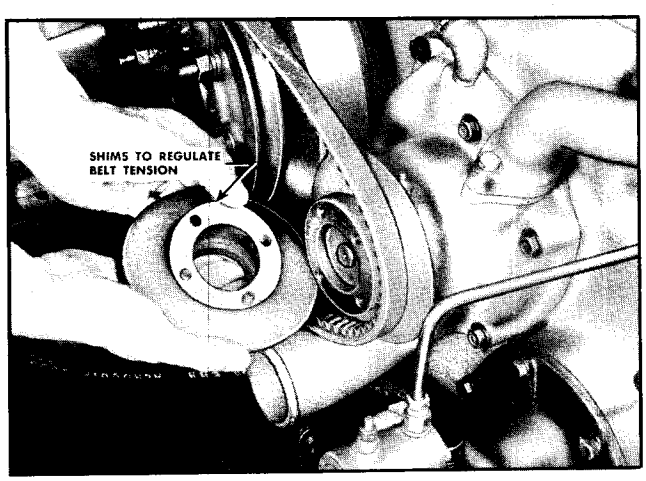


Fig. 4-27. Water pump pulley shims

FOUR-CYLINDER ENGINES

[illegible] BALANCER

REMOVAL:

1. Remove oil pan.

2. Loosen the eight capscrews which hold the front drive assembly and the balancer assembly to the cylinder block. Fig. 4-28.

3. Both front drive assembly and balancer are doweled to the block. Disengage from dowels and remove from block as one unit to avoid strain on spline coupling shaft.

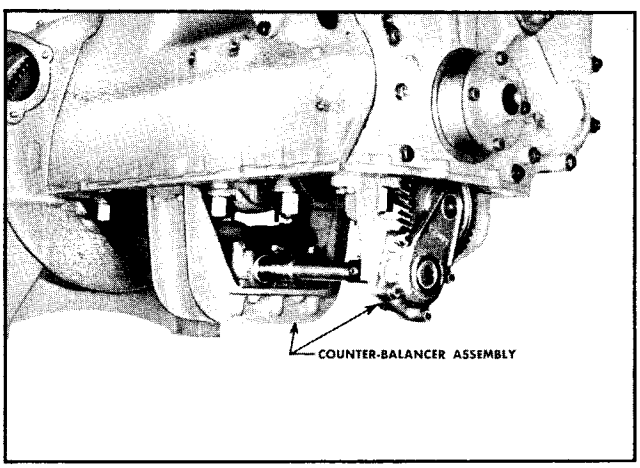


Fig. 4-28. Balancer assembly

INSTALLATION:

1. Bar engine over to No. 1 T.C. In this position the "A" timing mark on the crankshaft gear will be in position to mesh with the "A" timing mark on the balancer idler gear. See Fig. 4-30.

2. The timing marks on the balancer gears, Fig. 4-29, must be engaged as shown in Fig. 4-30, with the counter weights down.

3. The splined drive between the balancer drive and weight assemblies has one wide spline to prevent improper timing, provided Steps 1 and 2 have been performed correctly.

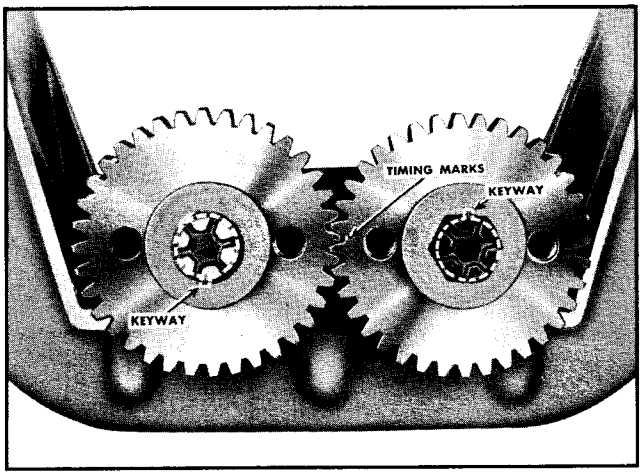


Fig. 4-29. Balancer timing marks

4. Assemble units to the engine with timing marks engaged as shown in Fig. 4-29. If this is not done correctly serious damage may result.

CAUTION: IF THE "B" MARKS ARE NOT IN LINE THE BALANCER IS NOT IN TIME. THIS POSITION OCCURS ONLY ONCE IN NINE REVOLUTIONS.

5. Install the oil pan, using a new gasket, to the engine.

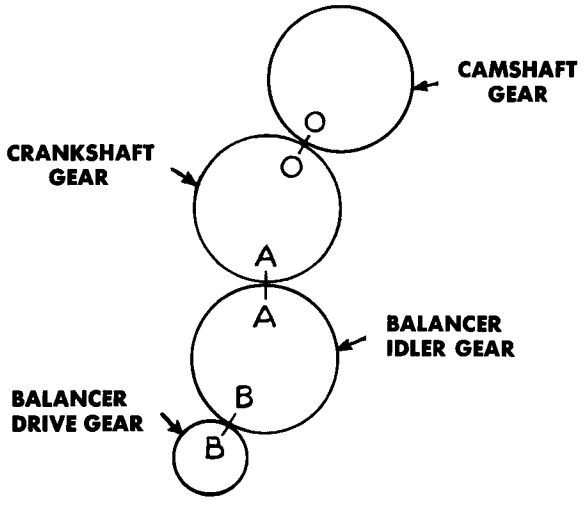


Fig. 4-30. Gear train timing marks

GOVERNOR ADJUSTMENTS

STANDARD HIGH-SPEED GOVERNOR:

High Speed Adjustment:

Maximum engine speed is adjusted by adding or removing shims under the high-speed governor spring. Normally, this adjustment is made on the fuel pump test stand as the fuel pump is calibrated.

Idle Speed:

1. Warm up engine to 140° F. oil temperature; then, shut-off or let it idle.

2. Remove pipe plug from spring pack cover. Fig. 4-31.

3. The idle adjustment screw is held in position by a spring clip. Turn screw "in" to increase, or "out" to decrease the speed. Idle speed should be set 40 to 50 rpm lower than desired if the adjustment is made with

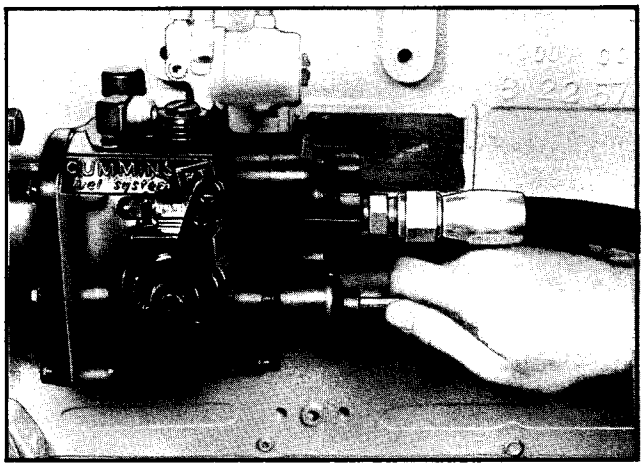


Fig. 4-31. Setting idle speed

the engine running. With the engine running, air collects in the spring pack housing and speed change results when the housing fills with fuel.

4. Replace pipe plug.

VARIABLE-SPEED GOVERNOR:

Both the maximum and idle adjusting screws are located on the governor cover. To adjust:

1. Loosen the adjusting screw locknut.

2. Screw adjusting screw "in" or "out" to get speeds required. Fig. 4-32.

3. Tighten adjusting screw locknut.

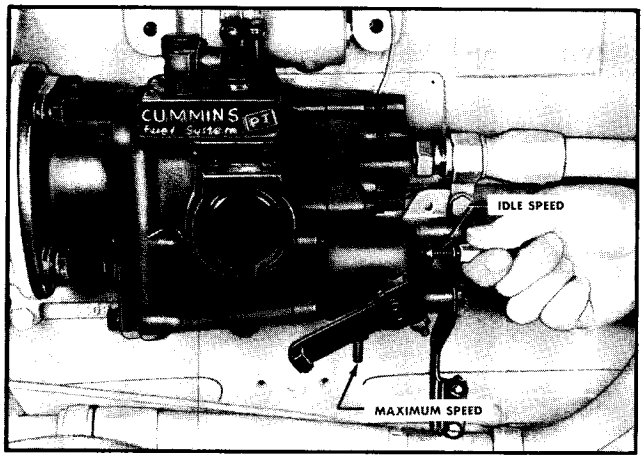


Fig. 4-32. Adjusting screws, variable speed governor

PT TORQUE CONVERTER GOVERNOR:

1. Disconnect the torque-converter governor flexible drive cable, or declutch the converter from the engine so the engine governor will have complete control of the engine. Disconnect the drive cable at the converter to prevent the cable whipping.

2. Hold the converter lever in clockwise position and turn in converter governor idle screw "C" (Fig. 4-33) until you are sure the spring is compressed. Turn adjusting screw out; then, back in slowly to check this adjustment.

3. Start the engine and rotate the engine governor lever in clockwise direction; then, set engine idle speed by adjusting idle screw "A" to get 515 to 700 rpm. See Fig. 4-33.

4. Set approximate engine maximum no-load speed by adjusting maximum speed screw "B" while holding engine governor lever against its stop; turn lever in counterclockwise direction. See Fig. 4-33.

5. Stop the engine and engage the torque-converter clutch or connect the flexible drive cable to the torque-converter governor. Make sure that engagement is made so that the torque converter drives the governor. The flexible cable should have 10", or larger, radius bends for satisfactory service life.

6. Start the engine and bring speed up to 1000 rpm with engine governor lever.

7. Increase engine speed until it reaches rated speed of converter tailshaft.

8. Decrease speed at torque-converter governor by adjusting screw "C" (out) until converter speed can be

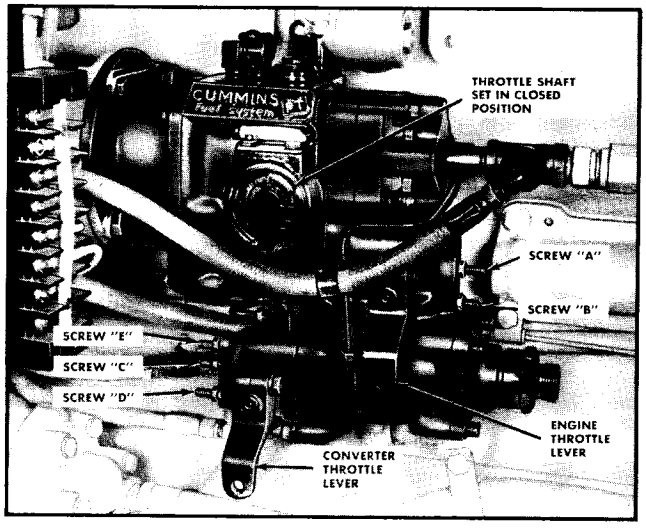


Fig. 4-33. PT Pump with torque converter governor

controlled by the converter governor lever; turn lever in a counterclockwise direction.

9. Advance engine governor to maximum speed position.

10. If the unit has a single speed setting:
   a. Adjust screw "C" to get rated no-load tailshaft speed of converter. Fig. 4-33.
   b. Adjust screw "D" until converter governor lever is locked in place. Fig. 4-33.

11. If the unit has a two-speed setting:
   a. Adjust screw "C" to get no-load tailshaft speed of converter. Fig. 4-33.
   b. Adjust screw "D" until you reach maximum converter speed desired. Fig. 4-33.

Adjustments For Minimum Fuel:

1. Operate the engine at full-speed, no-load, with tailshaft governor in operation.

2. Loosen screw "C", Fig. 4-33, and back out approximately ¾ inch.

3. Move the converter governor-throttle-lever counterclockwise until engine speed is reduced to 400 rpm. Hold in this position.

4. Loosen screw "E" and turn clockwise approximately 1/16 inch, until engine speed begins to increase to approximately 450 rpm.

5. Lock screw "E" in position and readjust screw "C" as described previously.

Stall Speed Settings:

Where a given speed is important with converter output shaft stalled, check as follows:

Stall the converter and check the engine speed:

1. If engine rated speed is excessive, adjust the engine governor maximum-speed adjusting screw "B", or if governor adjustment does not affect the unit, decrease fuel delivery.

2. If engine speed is low, adjust the engine-governor maximum-speed adjusting screw "B" or if the governor adjustment does not affect the unit, the fuel delivery must be increased. Check fuel delivery on a pump test stand.

Adjustments For Unstable Speeds:

1. Start with minimum output-shaft speed setting; then, loosen pump throttle screws and adjust so the throttle shaft turns in counterclockwise direction until engine speed increases 10 to 15 rpm. Continue throttle screw adjustment one-half turn or approximately 10 to 20 rpm more and lock in place. *Make this check with a hot engine only.*

a. If throttle leakage is too high, the engine will tend to over-speed after the load is released and engine rpm will stay up.

b. If throttle leakage is too low, the engine speed will surge or be unstable at half or no-load.

2. If necessary readjust converter-governor speed-adjusting screws as described in steps 10 or 11 (Page 4-15.) to get maximum speed of the unit.

Changing Speed-Droop Converter Governor:

Due to the variety of applications, converter ratios, and operator preference for different operating characteristics, the converter governor spring furnished in the fuel pump may not give the desired speed droop. Speed droop is controlled by changing springs; the springs listed in the following table give a full droop range, with the top spring giving the most droop and those following correspondingly less.

CONVERTER GOVERNOR SPRINGS

Part Number	*Color Code*
109690	Pink
109689	Gray
109688	Brown
70822	Green
109687	Yellow
109686	Blue
70821	Green and White
107787	Yellow & Blue
101002	White
110461	Purple
110460	Orange
105422	Black
118935	Orange & White

CUMMINS

H and NH SERIES DIESEL ENGINES

Section V

The term "trouble shooting" means locating the basic cause of the difficulty so that when repairs are made there will be no repetition of the failure. Trouble shooting, in most cases, is very simple. In the majority of problems the only requirement is a knowledge of the construction of the units and the principles of its operation. Knowing these two factors, anyone who is qualified to make repairs on the unit can start at the beginning and follow through each step in the functioning of each part until the cause of the trouble is found.

Trouble shooting is nothing more nor less than an organized study of the problem and a planned method of procedure for the investigation and correction of the difficulty. The following chart includes some of the most common complaints that may be encountered during the service life of your diesel engine.

The chart does not give all the answers for correction of the complaints listed, but it is meant to stimulate a train of thought and indicate a work procedure directed to the source of the trouble.

THINK BEFORE YOU ACT:

Study the problem thoroughly. Ask these questions:

What were the warning signs preceding the trouble?

What previous repair and maintenance work has been done?

Has similar trouble occured before?

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 most obvious things first; you will save time and trouble.

DOUBLE-CHECK BEFORE YOU BEGIN DISASSEMBLY OPERATIONS:

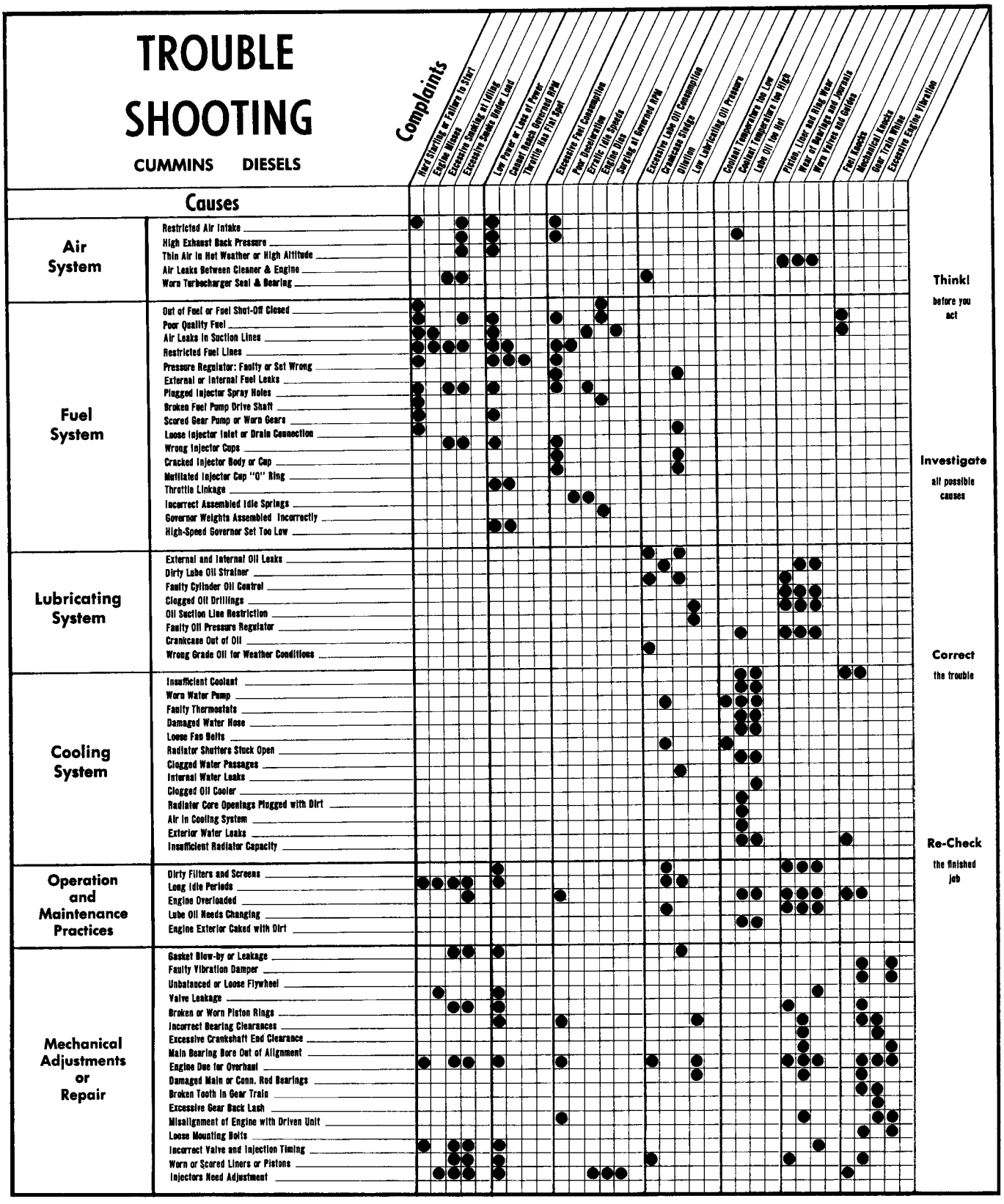
The source of most engine troubles can be traced not to one part alone but to the relationship of one part with another. Too often, engines are completely disassembled in search of the cause of a certain complaint and all evidence is destroyed during disassembly operations. Check again to be sure you have not missed an easy solution to the problem.

FIND AND CORRECT THE BASIC CAUSE OF THE TROUBLE:

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

TROUBLE SHOOTING

CUMMINS DIESELS



CUMMINS

H and NH SERIES DIESEL ENGINES

Section VI

Cummins H and NH Series engines are full-diesel, 4-stroke-cycle type with overhead valves. Fuel specifications are listed on Page 3-14 and lubricating oil specifications on Page 3-8. Horsepower ratings for each model engine are listed on Page 1-13.

Firing order for 4-cylinder right-hand and left-hand engines is 1-2-4-3 and 1-3-4-2 respectively. For 6-cylinder engines, the firing order is 1-5-3-6-2-4 (right hand) and 1-4-2-6-3-5 (left hand).

Detailed engine specifications and dimensions are listed in the following chart and tables.

PART OR LOCATION	NEW DIMENSIONS Minimum	NEW DIMENSIONS Maximum	WORN REPLACEMENT LIMIT
CAMSHAFT			
Journal Diameter	1.997	1.998	1.996
CONNECTING ROD			
Center to Center	11.998	12.000	Same
Crankpin Bore	3.2722	3.2732	Same
Piston Pin Bushing	2.001	2.0015	2.0025
Bore Misalignment — Bend	.000	.004 in 12"	.004 on ST-227
Bore Misalignment — Twist	.000	.010 in 12"	.010 on ST-227

PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
CRANKSHAFT			
Main Journals	4.499	4.500	4.497
Rod Journals	3.124	3.125	3.122
Fillet Radii	.1725	.1955	Same
Main Bearings — Copper Lead			
Shell Thickness	.1230	.12375	.1215
Journal Clearance	.0015	.005	.007
End Clearance	.007	.013	.022
Tightening	Template Method		
.010, .020, .030 and .040 undersize main bearing shells are available.			
Con. Rod Bearings — Copper Lead			
Shell Thickness	.07225	.073	.070
Journal Clearance	.0015	.0045	.007
Tightening	Template Method		
.010, .020, .030, and .040 undersize connecting rod shells are available.			
CYLINDER BLOCK			
Liner Counterbore Depth	.434	.435	.435
Protrusion of Liner Flange Above Block	.004	.006	.004
Main Bearing Bore	4.749	4.750	Same
Camshaft Bushings I.D.	1.9990	2.0000	2.0035
Cylinder Liners — I.D. "H"	4.876	4.877	4.881
Cylinder Liners — I.D. "NH" (Chrome)	5.125	5.128	5.131
Cast Iron Liners — I.D.	5.1245	5.1260	5.130
CYLINDER HEAD			
Intake and Exhaust Valve Seat Angle	30°	30°	30°
Valve Guide Bore — 2-valve heads	.4995	.5005	.5015
Valve Guide Bore — 4-valve heads	.4045	.4062	.407
Valve Crosshead Guide — 4-valve heads	.3755	.376	.378
Injector Tip Protrusion Through Head	.040	.055	.065
Tighten Head Stud Nuts or Capscrews			
Steel Asbestos Gasket	430	450	
Valve Clearance	Intake		Exhaust
H, HR, HRFB	.014		.022
HS, HRS	.016		.028
NH(S), NHRS, NHHRS	.014		.027
EXHAUST BACK PRESSURES			
Maximum Permissible — Inches of Mercury			
Naturally Aspirated Engines		1.0	
Turbocharged and Supercharged Engines		1.5	

PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
FLYWHEEL HOUSING			
Bore Run-out	.000	.004	.004
Face Run-out	.000	.008	.008
Clutch Pilot Bearing Bore Run-out	.000	.004	.004
Clutch Drive Ring Pilot Bore	.000	.004	.004
Clutch Face	.000	.005	.005
INJECTORS			
Hold-down Capscrews	10 ft. lbs.	12 ft. lbs.	
Hold-down Capscrews (Nylock)	12 ft. lbs.	14 ft. lbs.	
Adjustment	Refer to Page 3-10.		
INLET CONNECTIONS			
Tighten to	20 ft. lbs.		
LUBRICATING OIL PRESSURES			
Idling to Governed Speed (Normal)	5/15 psi	55 psi	
Normal at Governed Speed	30 psi	50 psi	
OIL PAN			
Capacity	2½ gal. (According to Installation)	12 gal.	
PISTON			
Ring Groove Clearance	Wedge Type Keystone Rings		
Piston Pin Bore (at 70° F.)			
Aluminum Pistons	1.9987	1.9991	2.000
Cast Iron Pistons	1.9994	1.9996	2.0005
Piston Pin	1.9988	1.9990	1.9978
Ring Gap Clearances (with new liners)			
42360, 41878, 65327	.015	.025	
100233, 104200	.017	.027	
42330, 42035, 43421	.013	.023	
9236-2, 42331, 65325, 65326	.010	.018	
60471, 61263, 65354	.010	.020	
115990	.018	.032	
.010, .020, .030 and .040 oversize pistons and rings are available for H and NH engines.			

PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
THERMOSTATS			
LOW RANGE:			
Thermostat Starts to Open at	160° F.		
Completely Open at	175° F.		
HIGH RANGE:			
Thermostat Starts to Open at	170° F.		
Completely Open at	185° F.		
ROCKER LEVER HOUSING AND LEVERS			
Shaft	1.123	1.1235	1.122
Bushings	1.1245	1.1255	1.1265
CAM FOLLOWER LEVERS AND HOUSING			
Shaft	.7485	.749	.748
Bushings	.7495	.7505	.7515

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