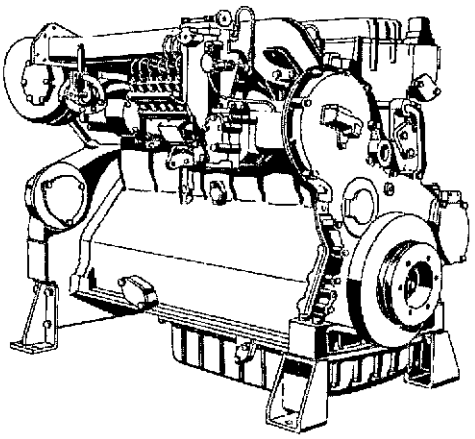
FORM 33511-2

OPERATION AND MAINTENANCE INSTRUCTIONS

CATERPILLAR
D333 ENGINE



SERIAL NUMBERS
58B1-UP

Caterpillar Tractor Co., General Offices, Peoria, Illinois. • Caterpillar Americas Co., Peoria, Illinois. • Caterpillar Overseas S.A., Geneva. • Caterpillar of Australia Pty. Ltd., Melbourne. • Caterpillar Brasil S.A., São Paulo. • Caterpillar Tractor Co. Ltd., Glasgow. • Caterpillar of Canada Ltd., Toronto. • Caterpillar France S.A., Grenoble. • Caterpillar (Africa) (Pty.) Ltd., Johannesburg. • Caterpillar Mexicana S.A. de C.V., Monterrey.

Warranty

Caterpillar Tractor Co. warrants products sold by it for six (6) months after date of delivery to the initial user, subject to the succeeding provisions hereof. This warranty is limited to the repair or replacement, as Caterpillar Tractor Co. may elect, at one of its factories designated by it, of such parts as shall appear to it, upon inspection, to have been defective in material or workmanship, but does not include any installation or transportation costs. No warranty is made with respect to items made by others (except items made by direct or indirect subsidiaries of Caterpillar Tractor Co.) when such items are warranted by their respective makers or when they are supplied by Caterpillar Tractor Co. on special order. No other warranty of any kind is made or authorized by Caterpillar Tractor Co., and no recommendation of items made by others shall imply or constitute any warranty with respect to such items.

T54255

Foreword

Caterpillar products are a result of advanced engineering, skilled manufacturing, and the finest materials metallurgical science can select. Thousands of satisfying, economical working hours are built into each machine.

Whether or not the owner derives the maximum service from his machine depends largely on the care exercised in its operation and maintenance. This book is written to give the operator essential information regarding the day-to-day operation, lubrication and adjustment of the machine. Careful adherence to these instructions will result in assured economy.

More and more Caterpillar owners are depending upon their dealer for service other than the care and adjustments described in this book. This practice is recommended because Caterpillar dealers have stocks of genuine Caterpillar parts and are equipped with tools designed and built by Caterpillar. Their servicemen are factory-trained and are kept closely informed by the factory regarding advanced methods of servicing Caterpillar products — thus, in all ways they are equipped to render the best of service.

T20841

Avoid Accidents

Most accidents, whether they occur in the air, in industry, on the farm, at home, on the highways, or at sea, are caused by someone's failure to follow simple and fundamental safety rules or precautions. For this reason most accidents can be prevented by recognizing the real cause and doing something about it before the accident occurs.

Regardless of the care used in the design and construction of any type of equipment, there are many conditions that cannot be completely safeguarded against without interfering with reasonable accessibility and efficient operation.

A careful operator is the best insurance against an accident.

The complete observance of one simple rule would prevent many thousands of serious injuries each year. That rule is: "Never attempt to clean, oil or adjust a machine while it is in motion."

Altitude Operation

MODEL	NO. OF CYL.	BORE	STROKE

ENGINE SERIAL NO.	
NO LOAD ENGINE R.P.M.	
FULL LOAD ENGINE R.P.M.	
RACK SETTING	
H.P. SETTING AT SEA LEVEL	
INJECTION TIMING	
LIFTER SETTING AT T.C.	
BILL OF MAT'L OR ESO NO.	

WARNING - TURBOCHARGED ENGINES ONLY - ENGINE HAS BEEN CORRECTLY SET TO OPERATE AT ALTITUDE LIMIT SHOWN.

			FT. OR BELOW

GOVERNOR AND TURBOCHARGER ARE SEALED. DO NOT CHANGE RACK SETTING, TURBINE NOZZLE OR ENGINE SPEED WITHOUT PROPER INSTRUCTIONS. THE RACK SETTING MUST BE CHANGED BY YOUR CATERPILLAR DEALER BEFORE OPERATING AT A HIGHER ALTITUDE AS SERIOUS DAMAGE OR INJURY MAY RESULT DUE TO TURBOCHARGER OVERSPEEDING.

REFER TO OPERATION AND MAINTENANCE INSTRUCTIONS FOR HIGH ALTITUDE OPERATION. T43141

WARNING PLATE LOCATED ON THE SIDE OF THE FUEL FILTER HOUSING

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See page 32 for additional information about safe altitude operation.

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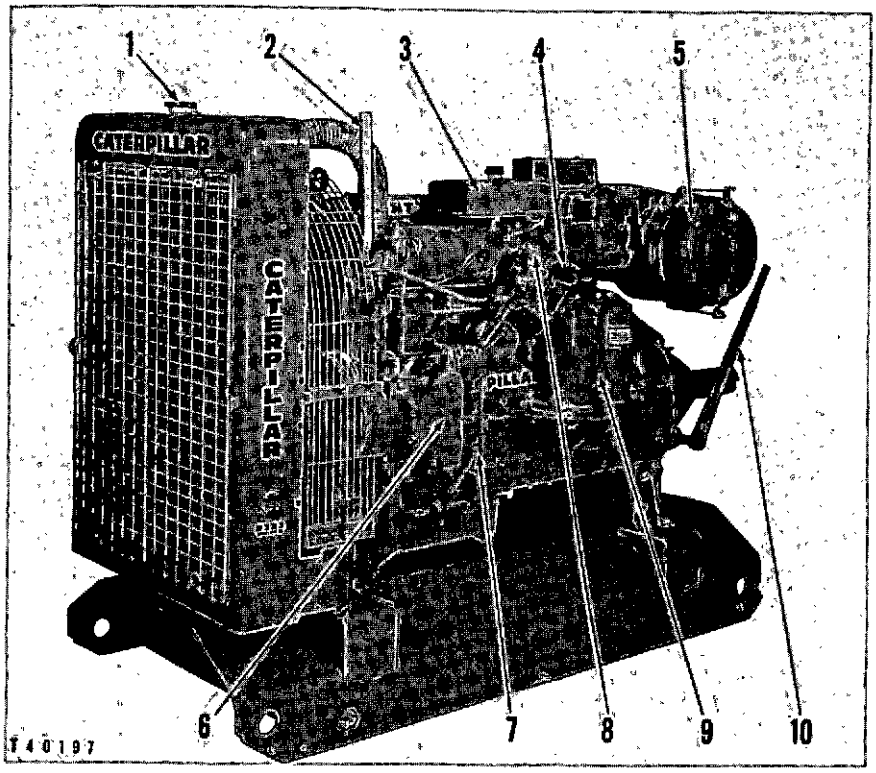
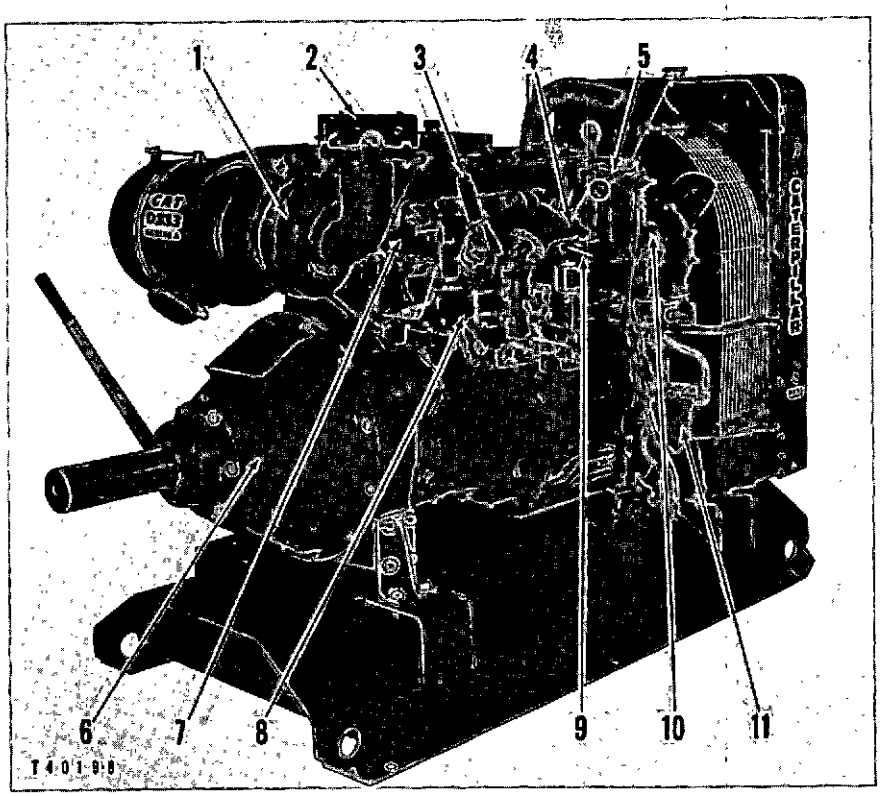


D333 ENGINE — LEFT FRONT VIEW

1–Radiator filler cap. 2–Starting engine exhaust pipe. 3–Starting engine fuel tank. 4–Crankcase lubricating oil filler cap. 5–Diesel engine air cleaner. 6–Crankcase lubricating oil cooler. 7–Crankcrase lubricating oil level gauge. 8–Crankcase breather. 9–Crankcase lubricating oil filter. 10–Enclosed flywheel clutch control lever.



D333 ENGINE — RIGHT REAR VIEW

1–Turbocharger. 2–Diesel engine gauge panel. 3–Governor control lever. 4–Fuel injection pump housing. 5–Final fuel filter. 6–Enclosed flywheel clutch. 7–Diesel engine compression release lever. 8–Starting engine clutch and starter pinion control lever. 9–Starting engine recoil starter. 10–Starting engine magneto switch. 11–Primary fuel filter.

Installation Instructions

There are a number of factors that warrant careful consideration when installing an engine. Careful thought and planning on installation details can pay dividends in increased engine life and successful operation. Attention should be given to installation details that will make operation and maintenance easy, such as ample clearance around walls and surrounding machinery, accessibility for adjustment and maintenance, and proper provision for draining crankcase oil. The following comments will touch briefly on some of the more important factors, but for more specific recommendations, it is suggested that your Caterpillar dealer be consulted.

COOLING

Probably the most important consideration is that of making sure the engine will cool properly. Various types of cooling may be used sucessfully, the choice being governed by the type of engine application and local conditions. Cooling, however, is a complete subject within itself and is not covered in this book. Contact your Caterpillar dealer to obtain complete installation details. Following are certain fundamentals which can be mentioned.

In the initial planning of the installation, it is assumed that the most satisfactory cooling system was selected. If it is to be a permanent installation, a heat exchanger or cooling tower was probably chosen. With either type of these installations a water cooled oil cooler is used. Normally, a permanent installation in a building would be cooled by means other than a radiator. If it is a portable unit, a radiator system will probably be used.

On heat exchanger and cooling tower installations, it is important to be sure that there is a sufficient flow of raw water at low enough temperatures to cool the engine properly. The piping should be carefully checked to be sure there are no air pockets that will restrict the flow of water and, if necessary, vents should be installed. It should be kept in mind, however, that very few vents will be needed if the piping is properly installed. Flexible connections should be used to keep engine vibrations from being transmitted to the cooling water piping.

On radiator-cooled installations, the engine should always be placed so that the flow of air through the radiator is in the same direction as the prevailing wind. Strong cross winds materially reduce the cooling capacity by cutting down the amount of air the fan can force through the radiator. On installations where the engine powers a machine that stirs up quantities of dust, such as rock crushers, it is advisable to locate the engine so that air passing through the radiator will be as free of dust as possible. Any accumulation of dust, dirt or lint on the radiator reduces cooling capacity.

Two or more radiator-cooled engines operated together should be so arranged that the discharged hot air from one engine does not pass through the radiator of the other. Each engine should be able to pass unheated air through its radiator.

CAUTION

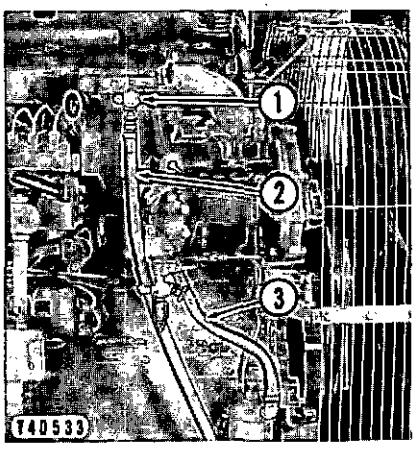
Various packaging materials must be removed before operating the engine to prevent damage. Inspect the engine for shipping straps, brackets, bolts, skids and coverings to be sure they have all been removed before operation of the engine.

EXHAUST LINES

Flexible connections should be used to prevent transmission of engine vibrations to exhaust piping. Flexible metal tubing is geneally recommended for the exhaust connections at the engine. The exhaust outlet should be protected from the weather so that rain and snow cannot enter the line and get into the engine. The exhaust lines should be as short as possible. Long exhaust lines or lines with several bends should be of increased diameter so as not to create excessive back pressure. The back pressure should never exceed 15 inches of water on a new installation when measured with a manometer at the exhaust connection of the engine. Exhaust from the starting engine should be carried in a separate line and not connected into the diesel exhaust line.

FUEL LINES

Flexible fuel lines **(2)** and **(3)** are recommended on all permament installations. On power units where the fuel tank is not installed at the factory, connect a fuel line from the diesel fuel tank to the fuel transfer pump flexible line **(3)**. The transfer pump will lift fuel the height of 12



FLEXIBLE FUEL LINES

1–Adapter. 2–Flexible fuel return line. 3–Flexible fuel supply lines.

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feet through no more than 50 feet of pipe. Also, remove the cork and connect a return line from the fuel filter adapter (1) to the diesel fuel tank. It is essential that there be no air leaks in the suction system. Even a small leak will destroy the suction lift of the transfer pump.

CAUTION

Do not connect a line between the adapter (1) and the fuel inlet to the fuel transfer pump as this may cause the system to become air bound. If a pipe plug is installed in place of the cork or if the return tube is too small, fuel pressure will burst the housing.

BASE

A chart is available that gives the necessary dimensions for making an engine installation. A concrete base may be constructed which will be satisfactory for all average conditions. Where the soil is sandy or extremely wet, the concrete base should be proportionately increased in size both in length and width, to secure a firm and solid foundation. Reinforcing bars should be used to strenghten the walls especially at the corners.

Provisions should be made for draining the crankcase, either by providing a small pit for a container near the drain plug, or by extending the pipe and installing a shut-off valve close to the engine.

CORRECT AIR CLEANING IS NECESSARY

Caterpillar air cleaners are designed to remove all harmful elements from the air entering the engine. Dutsy atmospheric conditions will cause frequent servicing and short element life. Precleaners are available to provide reasonable service periods and element life. Air inlet extensions can be utilized to provide cleaner air to the air cleaner. Your Caterpillar dealer has additional information.

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Lubrication Instructions

Electric set generator information is covered in the Operation and Maintenance Instruction Book for the generator.

SERVICE METER

The Service Meter is located at the right front corner of the engine on the front of the timing gear housing. It is geared to the engine, and when the crankshaft turns as many revolutions as are made in an hour at average operating speed on an average job application, the dial advances one number. There are some applications that will result in either a lower or higher than normal average engine speed. Under these conditions, the advance in the Service Meter reading will differ from the number of clock hours of operation.

The purpose of the Service Meter is to indicate when to perform the recommended maintenance and lubrication operations. The established intervals in the lubrication chart and maintenance instructions are given in service hours, so daily readings will tell when to service the engine. Rely on the Service Meter and not on the clock to measure service intervals.

SERVICE METER

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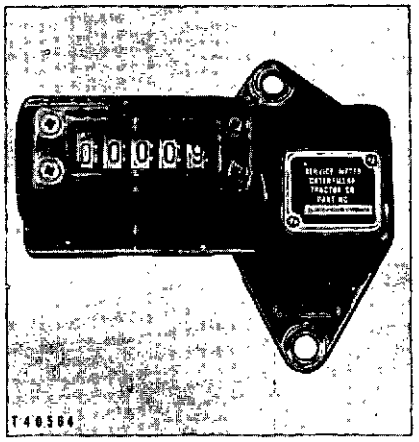

GENERAL LUBRICATING INFORMATION

Naturally, any precautions taken during cold weather to house the engine, cover it with a tarpaulin, or warm it before starting, will cause more rapid oil distribution and contribute to quicker starting.

Lubricate all miscellaneous points, not equipped with fittings, with crankcase lubricating oil every 50 service hours.

It is extremely important in handling the oil to keep it clean. Every precaution should be taken to use only clean filler cans and funnels and to be sure that all dirt is removed from the filler cap before it is taken off

for filling. The operator should take every precaution to prevent dirt from getting into any system to extend the life of the engine.

Careful attention to the following information on lubricants and their proper selection will add much to performance, economy and long life of your engine. The lubrication chart specifies the lubricants to be used, the points to be serviced and the intervals of servicing according to service hours.

DESCRIPTION OF LUBRICANTS

The lubricants recommended for use in this engine can be identified by the sub-headings preceding their descriptions that follow: The proper selection of one of these types of crankcase lubricating oils, and SAE grade of oils can be made from the information in the topic, TYPE OF LUBRICANTS AND SAE GRADES TO USE.

Crankcase Lubricating Oils

Superior Lubricants (Series 3): These are additive-type oils that have been identified as meeting a rigid, high quality standard and certified for use in all Caterpillar Diesel Engines. See your Caterpillar dealer for brand names of products conforming to this specification.

MIL-L-2104A Specification Oils: These oils are additive-type but are milder than Superior Lubricants (Series 3) Oils. They can be used as specified for various compartments satisfactorily. Your oil supplier is familiar with those oils meeting the MIL-L-2104A Specification.

Lubricating Grease

Ball and Roller Bearing Lubricant: This lubricant is a mixture of mineral oil and metallic soaps. Use No. 2 grade for most temperatures. For extremely low temperatures use No. 0 or No. 1 grade.

This grease can be applied to all bearings points — plain bearings, ball bearings and roller bearings — where equipped with hydraulic pressure fittings or when bearings are hand packed.

Use only a high grade short fiber grease. This grease must be satisfactory in anti-friction bearings at speeds up to 3000 RPM at a maximum temperature of 300° F. It is a grease with sufficient adhesive qualities to cling to the bearings in all extremes of high and low operating temperatures.

Type of Lubricants and SAE Grades to Use

The grade of oil is classified in terms of viscosity (fluidity or flow ability) and is identified with numbers called SAE numbers. The lower SAE numbers are more fluid and flow more readily than do those with the higher numbers within the same series.

To determine if the oil in the compartments will flow in cold weather, remove the oil level gauge before starting and if the oil will flow off, the oil is fluid enough to circulate properly.

The oil that has been diluted for cold weather starting should be drained and replaced with undiluted oil at the end of the cold season when dilution is no longer required.

The oil specification chart will aid in the proper oil grade selection for the various compartments. The proper SAE grade of oil to select is determined by the amospheric temperature at which the machine **is started.** However, during operation SAE 10W can be used successfully in the diesel engine crankcase when atmospheric temperatures are as high as 70° F.

OIL SPECIFICATION CHART

Compartment	SAE GRADE OF OIL TO USE AT STARTING ATMOSPHERIC TEMPERATURE			
	Above +32°F.	+32°F. to +10°F.	+10°F. to −10°F.	−10°F and Lower
Diesel Engine Crankcase	Superior Lubricants (Series 3)			
	SAE 30	SAE 10W*	SAE 10W*	**Dilute SAE 10W
†Starting Engine Crankcase	Superior Lubricants (Series 3) or MIL-L-2104A			
	SAE 10W	SAE 10W	SAE 10W	**Dilute SAE 10W

*In seasons or locations where starting atmospheric temperatures are below 32°F., SAE 10W oil should be used to insure free circulation, even though daytime operating temperatures may rise as high as 70°F.

**In lower temperatures it may be necessary to dilute oil with kerosene so it will be fluid enough to insure free circulation. This should be done before stopping, then operate the engine for a few minutes to mix kerosene and oil. Evaporation in the engine crankcase under steady operation may make it necessary to again add kerosene to maintain proper fluidity.

†Disregard the starting engine SAE grade of oil recommendations if the starting engine lubricating oil system is interconnected with the diesel engine lubricating oil system.

Diesel Engine Crankcase Lubricating Oil Change Periods

The crankcase lubricating oil change periods for these engines have been carefully established for the purpose of protecting the service life of the engine as economically as possible.

Change the oil and filter elements after the first 10 service hours of operation of a reconditioned engine.

DIESEL ENGINE CRANKCASE LUBRICATING OIL CHANGE PERIOD CHART
USE ONLY SUPERIOR LUBRICANTS (Series 3)

FUEL SULPHUR CONTENT	OIL CHANGE PERIOD*	FILTER CHANGE PERIOD
0.4% or less	125 Service Hrs.	125 Service Hrs.
0.4% to 1.0%**	50 Service Hrs.	50 Service Hrs.

*Regardless of time operated, the crankcase oil and filter elements should be changed at least every six months.

**Reduce crankcase oil and filter element change periods one half when sulphur content is greater than 1.0%.

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LUBRICATION CHART
CATERPILLAR
DIESEL D333 ENGINE

The folded page is arranged for two purposes:

First, it is a complete outline of all information required to lubricate the engine.

Second, the illustration and identification of points of lubrication can be used with the detailed illustration and information on the pages following the chart as a reference for lubrication and service information.

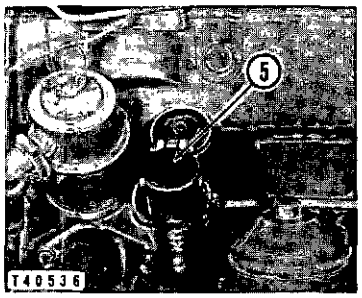
CO Crankcase Lubricating Oil

1

DIESEL ENGINE CRANKCASE

Use Superior Lubricants (Series 3) Only

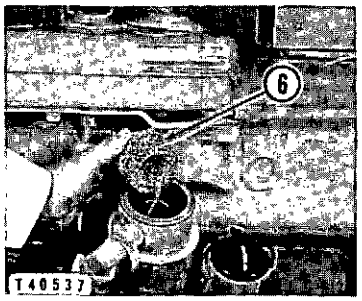
After draining crankcase refill at (5) and start the diesel engine. Run engine for two minutes then add oil to bring level to "full" mark on *gauge, while engine is running.*



1

DIESEL ENGINE CRANKCASE

Wash breather element (6) each time crankcase oil is drained and reinstall it.



Lubrication of Attachments

The following list of identifying letters, names of attachments requiring lubrication, and type of lubricant required will help in lubrication of attachments.

Identification Of Points Of Lubrication, Lubricant To Apply And Interval Of Service

CO Crankcase Lubricating Oil **BR** Ball and Roller Bearing Lubricant

Point and Identification		Lubricant	SERVICE HOURS 10	50	125	250	1000	2000
A.	Starting Engine Crankcase	**CO**			†C	†C		
B.	Electric Starting Motors	**CO**	See detailed instructions on page 14.					
C.	Air and Electric Starting Motor Drive End Bearings	**CO**						L
D.	Air Starting Motor Oiler	**CO**	X					
E.	Enclosed Clutch Shift Collar Shaft	**CO**		L				
F.	Tachometer Drive	**BR**			L			
G.	Charging Generator	**BR**	See detailed instructions on page 15.					
H.	Enclosed Clutch Shift Collar and Shaft Bearings	**BR**	L	L				
I.	Enclosed Clutch Pilot Bearing	**BR**			L			
J.	Air Starting Motor Gear Drive and Plain End	**BR**	See detailed instructions on page 16.					

Key to Symbols X—CHECK, ADD OIL IF NECESSARY L—LUBRICATE
†—DEPENDING ON DUST CONDITIONS C—CHANGE

STARTING ENGINE CRANKCASE OIL FILTER INSTRUCTIONS

FOR D330 AND D333 INDUSTRIAL ENGINES

Starting Engine Crankcase Lubricating Oil System

(For Later Engines Equipped with a Filter)

Oil, which is picked up from the starting engine oil pan suction bell by the starting engine oil pump, flows to the crankshaft front main bearing and to the camshaft oil manifold. A portion of the oil is diverted to the starting engine oil filter located on the side of the starting engine. The oil enters the filter case on the outside of the element, flows through the element, and returns to the crankcase through the filter stem and dump line.

The filter base contains a pressure control valve which prevents oil from entering the oil filter until normal engine oil pressure is attained. Another valve is located inside the filter which opens when the filter becomes clogged and by-passes the oil to the filter stem and dump line.

The starting engine oil filter should be replaced periodically. See the LUBRICATION INSTRUCTIONS section of this book.

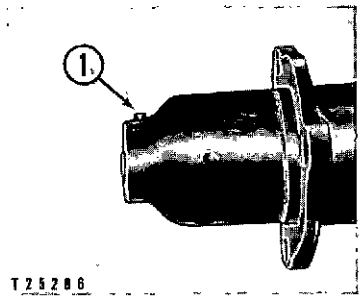
CO Crankcase Lubricating Oil

STARTING ENGINE CRANKCASE

Later Machines

Starting engines with separate lubrication systems can be identified by the separate breather and oil filler opening, the crankcase oil level gauge and the redesigned crankcase oil pan.

ings of a type that make lubrication necessary only when the starter is disassembled for cleaning or servicing. Two or three drops of oil for each bearing is sufficient.



C

AIR AND ELECTRIC STARTING MOTOR DRIVE END BEARINGS

Both air and electric starting motors for the diesel engine have bearings in the drive end that require lubrication every 2000 service hours, or whenever the motor is removed for any reason.

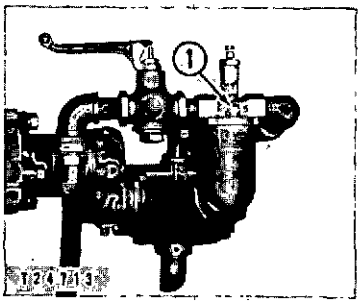
To lubricate remove the starting motor and the plug (1). Saturate the wick with Crankcase Lubricating Oil. Reinstall the plug and starting motor.

CO Crankcase Lubricating Oil

D

AIR STARTING MOTOR OILER

Every 10 service hours check oil level in oiler by removing plug (1). Keep oiler filled at all times.



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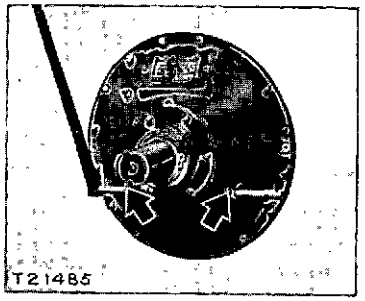
ENCLOSED CLUTCH SHIFT COLLAR SHAFT

Lubricate shift collar shaft bearings every 50 service hours.

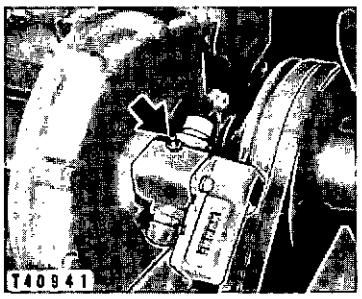


BR Ball and Roller Bearing Lubricant

F

TACHOMETER DRIVE

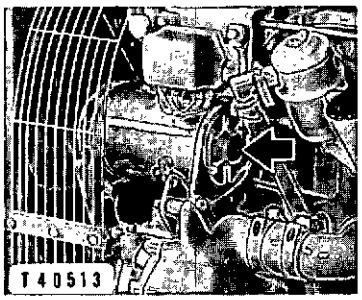
Every 125 service hours lubricate the tachometer drive with 5 strokes.



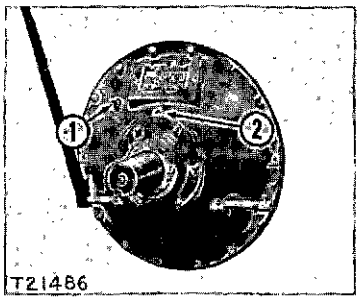
G

CHARGING GENERATOR

Generators have bearings packed with Ball and Roller Bearing Lubricant making lubrication necessary only when the generator is disassembled for cleaning or servicing.



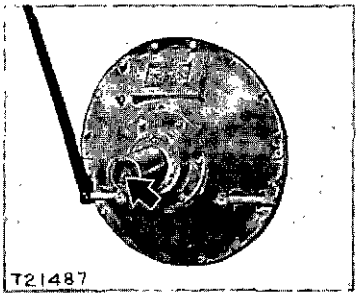
BR Ball and Roller Bearing Lubricant



H

ENCLOSED CLUTCH SHIFT COLLAR AND SHAFT BEARINGS

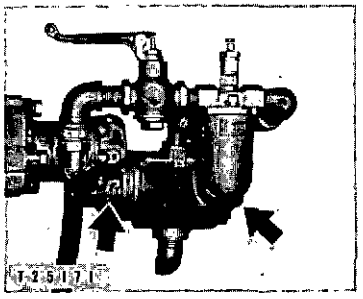
Lubricate shift collar through fitting (1) every 10 service hours, and shaft bearing through fitting (2) every 50 service hours.



I

ENCLOSED CLUTCH *PILOT BEARING*

Lubricate clutch pilot bearing sparingly every 125 service hours.



J

AIR STARTING MOTOR GEAR DRIVE AND PLAIN END

Air starting motor gear drive and plain end bearing compartments are packed at the time of assembly and require no periodic lubrication. If the motor is disassembled for any reason, No. 1 Ball and Roller Bearing Lubricant should be used to fill the compartments.

Operation Instructions

Electric set generator information is covered in the Operation and Maintenance Instruction Book for the generator.

PREPARING THE ENGINE FOR USE

New Engine Initial Service: The first duty of anyone charged with the care and operation of an engine is to give it a detailed inspection, and to lubricate all parts as directed in the LUBRICATION INSTRUCTIONS section of this book.

Fill the diesel fuel tank, taking care no dirt, water, or other foreign substances are admitted with the fuel. Give particular attention to the details of fuel handling as outlined under the topic, CARE OF THE FUEL SUPPLY.

Fill the starting engine fuel tank with gasoline if engine is so equipped.

Fill the cooling system with clean soft water and rust inhibitor, or with the correct antifreeze solution if temperatures below freezing are likely to be encountered. See the topic, COOLING SYSTEM.

New Engine Recheck: After the first 100 to 125 service hours of operation, tighten the diesel engine cylinder head bolts and the exhaust manifold stud nuts. Tighten the tubocharger mounting bolts, the starting engine head bolts and carburetor mounting stud nuts if the diesel engine is so equipped.

When the diesel engine and starting engine cylinder head bolts are tightened, the cylinder head gasket is compressed and the valve clearances are changed. Adjust the valve clearance as described in the topic, DIESEL ENGINE VALVE CLEARANCE ADJUSTMENT and STARTING ENGINE VALVE CLEARANCE ADJUSTMENT.

New Operator's Responsibility: The operator who is given the responsibility of care and operation of an engine already in service, should first, check it for necessary lubrication, fuel supply and coolant in the cooling system. Second, the engine should have any necessary adjustments made to obtain satisfactory performance.

STARTING THE ENGINE

There are four methods available for starting the diesel engine, gasoline starting engine, electric starting, air starting and hydraulic starting. Hydraulic starting instructions are packaged with the Operation and Maintenance Instructions if the diesel engine is so equipped. Gasoline engine, electric and air starting information is covered in the following topics.

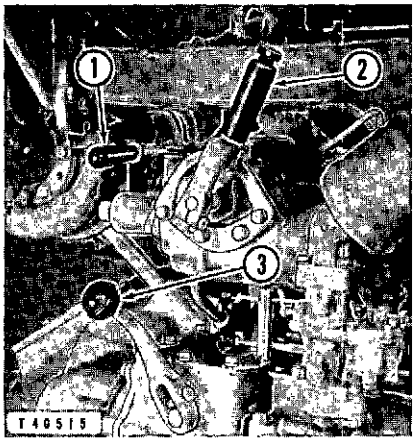
Before Starting: Be sure to check the crankcase oil level in the diesel engine to make sure the oil is considerably above the "add oil" mark on the gauge.

Disengage the flywheel clutch or remove any load possible from the engine, then start the engine as described in one of the following topics, whichever applies, GASOLINE STARTING ENGINE, DIRECT ELECTRIC STARTING or AIR STARTING.

Gasoline Starting Engine

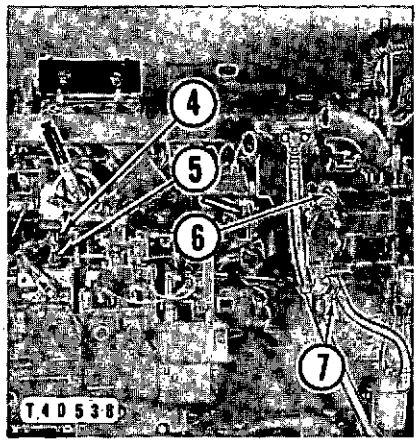
Position Controls for Starting: Before attempting to start the starting engine, position the controls of the diesel and starting engine as follows:

1. Move the compression release lever **(1)** to the START position.
2. Move the governor control lever **(2)** to the shut-off position so the fuel injection pumps are closed.



POSITIONING CONTROL LEVERS

1–Compression release lever in start position. 2–Governor control lever in the shut-off position. 3–Starting engine clutch and starter pinion lever.



POSITIONING CONTROLS FOR STARTING ENGINE

4–Choke control. 5–Throttle control. 6–Magneto switch. 7–Starting engine fuel valve.

3. See that the starting engine clutch and starter pinion lever **(3)** is toward the rear of the engine.
4. Open the starting engine fuel valve **(7)** by turning the fuel valve control in the counterclockwise direction.
5. Pull out the starting engine choke control **(4)**.
6. Pull out the starting engine throttle control **(5)** to the 1/4 to 1/2 open position.
7. Turn ON the magneto switch **(6)**.
8. Push in the reset piston to reset the oil pressure shut-off, if so equipped.

Starting the Starting Engine: After positioning the control correctly, the starting engine may be started as follows:

1. Grasp the starting engine recoil starter and spin the starting engine with a quick pull on the cable. With a firm grasp on the handle allow the cable to rewind slowly.

STARTING ENGINE RECOIL STARTER

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2. Push in the choke control when the engine will run without choking. Temperature and altitude will vary the length of time it is necessary to have the choke on. Actual experience in starting will determine this interval.
3. **When the engine starts keep the speed low until the crankcase lubricating oil has a chance to get warm and better lubricate the engine.**

Helpful suggestions for starting the starting engine in cold weather are in the topic, OPERATING IN COLD WEATHER.

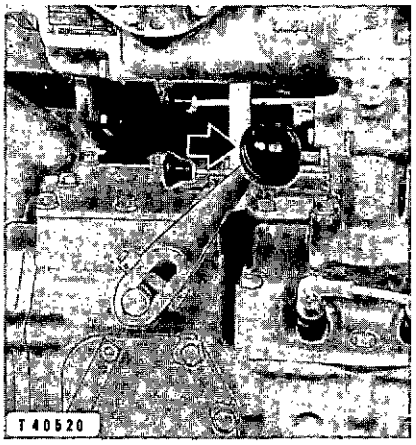
Operating Starting Engine Electric Starter: Place the diesel and starting engine controls in the same position as described in the preceding topic. Then start the starting engine with the electric starter as follows:

1. Press the electric starter switch to crank the engine. Do not run the starter for more than thirty seconds at a time. Then allow two minutes for cooling before using it again. If the electric starter pinion disengages for any reason before the engine starts, release the starter switch and wait until the starting motor stops turning and the engine stops "rocking" before again pressing the starter switch.
2. As soon as the engine starts release the starter switch.

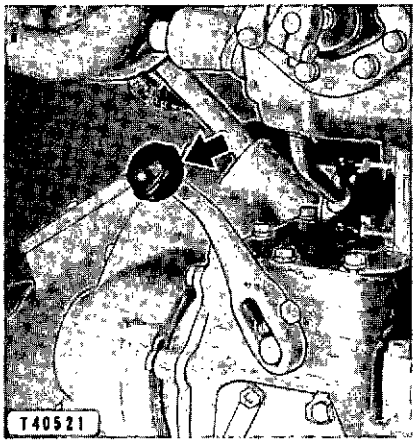
Starting the Diesel Engines

1. Check to see that the starting engine is running smoothly at high idle.

2. Move the clutch and starter pinion control lever slowly forward as far as it will go to release the clutch, apply the clutch brake and engage the pinion.



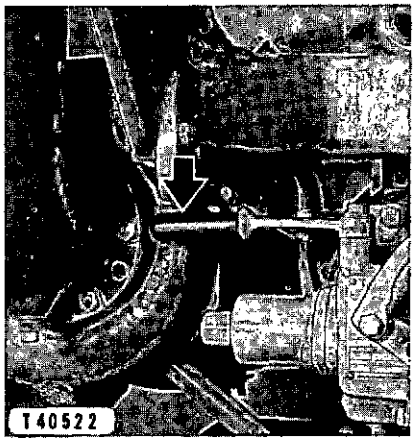
CLUTCH AND STARTER PINION CONTROL LEVER IN PINION ENGAGED POSITION



CLUTCH AND STARTER PINION CONTROL LEVER IN CLUTCH ENGAGED POSITION

3. Move the clutch and starter pinion control lever to the rear as far as it will go to engage the clutch.

4. Move the compression release lever to the RUN position as soon as the starting engine is cranking the diesel engine at normal cranking speed.



COMPRESSION RELEASE LEVER IN THE RUN POSITION

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Actual experience will determine the length of time necessary to crank the diesel engine to warm it sufficiently to assure easy starting.

5. Move the governor control lever to approximately half engine speed position.

GOVERNOR CONTROL LEVER IN APPROXIMATELY HALF ENGINE SPEED POSITION FOR STARTING

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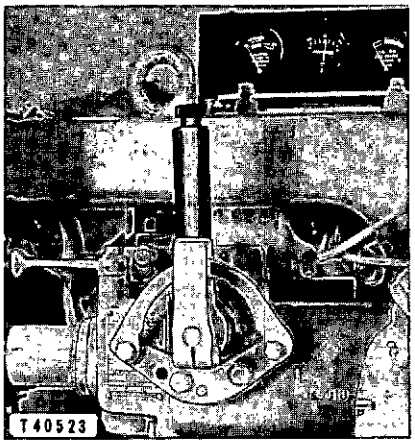


After the engine starts, reduce the engine speed to low idle until the oil pressure gauge indicates normal oil pressure. When the gauge indicates normal oil pressure, the engine should be allowed to run for five minutes with the governor control lever at approximately half engine speed position before applying the load. During this period the engine gauges should be observed for proper readings as explained in the topic, GAUGES.

If the diesel engine is thoroughly heated but does not start, make an inspection to see that everything is correctly set for starting. If smoke has been coming from the diesel exhaust, fuel has been reaching the cylinders. If no smoke has been evident when the governor control lever was in the run position, check the fuel supply. If the diesel fuel tank is empty or the fuel tank valve is closed, it will be necessary to prime the system as outlined under the topic, PRIMING THE FUEL SYSTEM. In case there may be water or dirt in the fuel system, or if the fuel injection equipment is suspected, see the topic, FUEL INJECTION EQUIPMENT.

NOTE

The starting engine clutch and starter pinion control lever must always be in the clutch engaged position whenever the diesel engine is running. The will enable the starter pinion to automatically disengage from the diesel engine ring gear.

6. Stop the starting engine by closing the valve in the starting engine fuel tank line and allow the starting engine to burn all the fuel in the carburetor. Then turn OFF the magneto switch.

Direct Electric Starting

Diesel engine electric starting can be used successfully in atmospheric or engine room temperatures of 50° F. (10° C.) or above **without** the use of a starting aid. **It is not advisable** to use electric starting in temperatures below 50° F. (10° C.) without the use of a starting aid. See the topic, OPERATING STARTING AIDS. Even when a starting aid is used in temperatures below 32° F. (0° C.), it is advisable to use crankcase lubricating

oil of a lower viscosity in the engine crankcase to reduce the cranking effort required. See the topic, TYPE OF LUBRICANTS AND SAE GRADES TO USE.

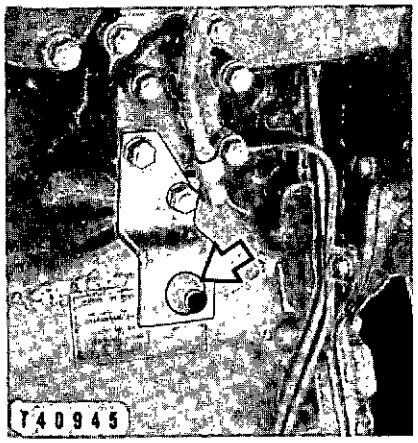
The engine must be kept in the best mechanical condition possible, the batteries kept fully charged and all terminals kept clean and tight for satisfactory performance of the starting system in lower atmospheric or room temperatures. In extremely cold temperatures any use of an acceptable means of heating the engine will make starting easier.

Position Controls for Starting: Before attempting to start the diesel engine the control should be correctly positioned as follows:

1. Normally, the compression release lever remains in the run position unless it is desired to turn the engine for some purpose other than starting.
2. Move the governor control lever to approximately half engine speed position.
3. Push in the reset piston to reset the oil pressure shut-off if so equipped.

Starting the Diesel Engine: After positioning the controls correctly, the diesel engine may be started as follows:

1. Press the starter switch to crank the diesel engine against compression.



ELECTRIC STARTER SWITCH

2. If the engine does not start within a few seconds, shut off the fuel supply by moving the governor control to the shut-off position but continue to crank the engine for about ten seconds before returning the governor control to its original position.
3. If the diesel engine fails to start within **thirty seconds**, release the starter switch and wait **two minutes** to allow the electric starting motor to cool before using it again.
4. If the electric starting motor pinion disengages for any reason before the engine starts, release the starter switch and wait until the electric starting motor stops rotating and the diesel engine stops "rocking".
5. As soon as the engine starts, release the starter switch.

After the engine starts, reduce the engine speed to low idle until the oil pressure gauge indicates normal oil pressure. When the gauge indicates normal oil pressure, the engine should be allowed to run for five minutes with the governor control lever at approximately half engine speed position before applying the load. During this period the engine gauges should be observed for proper readings as explained in the topic, GAUGES.

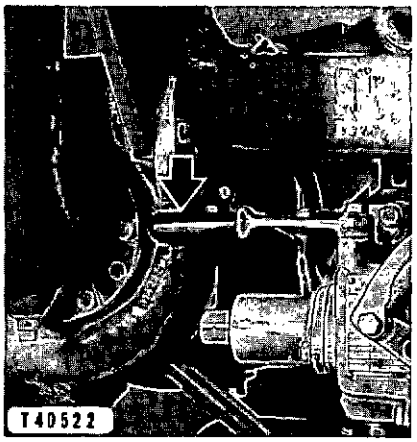
Air Starting

Diesel engine air starting **can** be used successfully in atmospheric or engine room temperatures of 32° F. (0° C.) or above without the use of a starting aid. **It is not advisable** to use air starting in temperatures below 32° F. (0° C.) without the use of a starting aid. See the topic, OPERATING STARTING AIDS. Even when a starting aid is used in temperatures below 32° F. (0° C.), it is advisable to use crankcase lubricating oil of a lower viscosity in the engine crankcase to reduce the cranking effort required. See the topic, TYPE OF LUBRICANTS AND SAE GRADES TO USE.

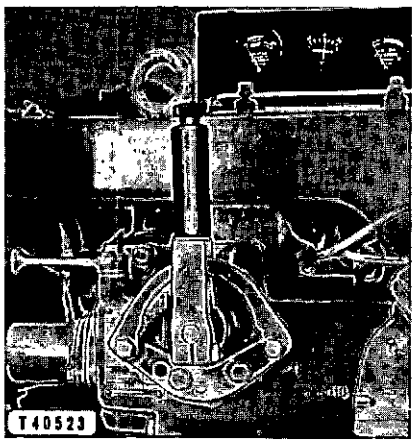
An installation with 250 pounds air pressure in a 10 cubic feet air receiver should provide an adequate volume of air for starting the diesel engine. The air pressure should be regulated to 100 pounds pressure before the air enters the control valve.

Position Controls for Starting: Before attempting to start the diesel engine the controls should be correctly positioned as follows:

1. Normally the compression release lever remains in the run position unless it is desired to crank the engine for some purpose other than starting.
2. Move the governor control lever to approximately half engine speed position.
3. Push in reset piston to reset the oil pressure shut-off, if so equipped.



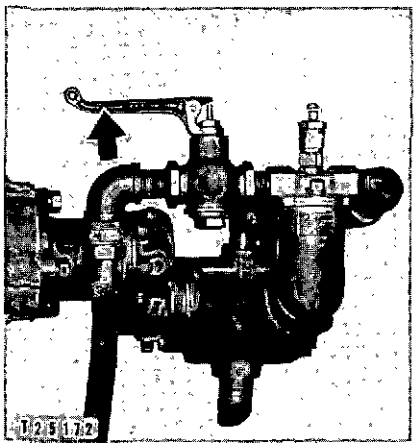
COMPRESSION RELEASE LEVER IN RUN POSITION



GOVERNOR CONTROL LEVER IN APPROXIMATE HALF ENGINE SPEED POSITION FOR STARTING

Starting the Diesel Engine: After positioning the controls correctly, the diesel engine may be started as follows.

1. Pull up the air valve control to crank the engine against compression.



AIR VALVE CONTROL

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2. If the engine does not start in a few seconds, continue to crank the diesel engine but shut off the fuel supply by moving the governor control lever to the shut-off position for about ten seconds to clear the cylinders of raw fuel.
3. If the air starting motor pinion disengages for any reason before the engine starts, release the air valve control and wait until the engine stops "rocking."

After the engine starts, reduce the engine speed to low idle until the oil pressure gauge indicates normal oil pressure. When the gauge indicates normal oil pressure, the engine should be allowed to run for five minutes with the governor control lever at approximately half engine speed position before applying the load. During this period the engine gauges should be observed for proper readings as explained in the topic, GAUGES.

OPERATING STARTING AIDS

Starting the diesel engine at temperatures above 50° F. (10° C.) using electric starting, or 32° F. (0° C.) using air starting, may be accomplished without the use of starting aids as instructed in the preceding topics.

When using the electric or air starting motor in lower temperatures, the glow plug starting aid, an ether aid, or both should be used.

Pressure ether dispensers are commercially available and engine mounted ether dispensers are available and can be used as an aid in low temperature starting. Starting aids may also be used with the gasoline starting engine method of starting, however, only experience can determine the temperatures at which the starting aid should be used.

STARTING AID CHART

STARTING TEMPERATURE	STARTING METHOD	STARTING AID	HEATING TIME TO USE AND/OR ETHER AID
Above 50°F.	Electric	None	None
	Air or Gasoline	None	None
Between 50°F. and 32°F.	Electric	Glow Plugs	1 Minute
		Ether	Ether Aid
	Air or Gasoline	None	None
Between 32°F. and 0°F.	Electric	Ether	Ether Aid
		Glow Plugs and Ether	1 to 2 Minutes and Ether Aid
	Air or Gasoline	Glow Plugs	1 to 3 Minutes
		Ether	Ether Aid
		Glow Plugs and Ether	1 to 2 Minutes and Ether Aid
Between 0°F. and −10°F.	Electric, Air or Gasoline	Ether	Ether Aid
		Glow Plugs and Ether	3 to 5 Minutes and Ether Aid
Below −10°F.	Air or Gasoline	Glow Plugs or Ether, or Both	Heat cooling system and crankcase oil

The controls should be positioned as instructed in the topic covering the method of starting to be used, and the following additional instructions should be carefully followed. This will permit the quickest possible start and conserve the battery or air supply. See the STARTING AID CHART.

When using glow plugs with either electric or air starting, and the engine fails to start after 10 seconds of cranking, the START switch or air valve control should be released, but continue to hold the HEAT switch ON for about 30 seconds before cranking the engine again. When the starting motor is cranking, the battery efficiency is reduced and the glow plugs cool. Reheating them after 10 seconds of cranking makes the glow plugs more effective and conserves the battery or air supply.

When the engine starts release the START switch but continue to hold the HEAT switch ON for a few seconds, or a period long enough to assure that the engine will continue to run.

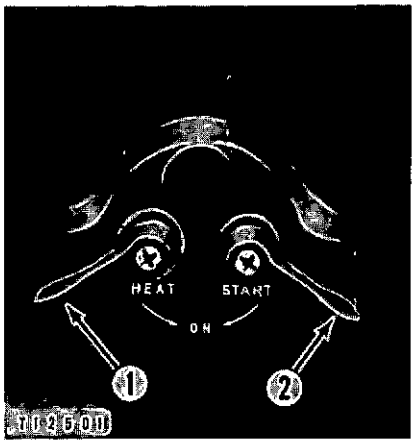
Do not turn the glow plug switch ON while the engine is warm and running.

When using ether for starting, continue cranking until the engine starts. However, do not run the **electric** starting motor for more than 30 seconds at a time, then allow 2 minutes intermission before using it again.

Starting Between 50° F. and 32° F.

The use of starting aids between these temperatures is needed only when electric starting is used to start the diesel engine.

1. Move the HEAT switch **(1)** to the ON position for the length of time necessary. See the STARTING AID CHART.



CONTROL SWITCHES

1–HEAT switch. 2–START switch.

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NOTE

Each glow plug uses approximately 5 or 10 amperes while the HEAT switch is in the ON position. This is actually a small amount in comparison to the starting load that is imposed on the battery when the START switch is ON.

2. Move the START switch **(2)** to the ON position or press the starter switch.
3. If the diesel engine fails to start within **thirty seconds**, release the starter switch and wait **two minutes** to allow the electric starter to cool before using it again.
4. If the electric starter pinion is disengaged for any reason before the engine starts, wait until the electric starter stops rotating and the engine stops "rocking" before again using the starter switch.

If a pressurized ether dispenser is to be used as a starting aid, move the START switch **(2)** to the ON position or press the starter switch. While the electric starter is turning the diesel engine, carefully spray ether toward the air cleaner inlet until the engine starts. If the diesel engine fails to start within **thirty seconds,** release the starter switch and wait **two minutes** to allow the electric starter to cool before using it again.

NOTE

Use only enough ether to start the diesel engine or keep it running if the engine starts to stall.

After the engine starts, reduce the engine speed to low idle until the oil pressure gauge indicates normal oil pressure. When the gauge indicates normal oil pressure, the engine should be allowed to run for five minutes with the governor control lever at approximately half engine speed position before applying the load. During this period the engine gauges

should be observed for proper readings as explained in the topic, GAUGES.

Starting Between 32° F. and −10° F.

Starting between 32° F. (10° C.) and −10° F. (−23.3° C.), using either electric or air starting, may be accomplished with the use of starting aids in the following manner.

1. Move the HEAT switch to the ON position for the length of time necessary. See the STARTING AID CHART.

NOTE

Each glow plug uses approximately 5 or 10 amperes while the HEAT switch is in the ON position. This is actually a small amount in comparison to the starting motor load imposed on the battery when the START switch is ON.

2. Move the START switch to the ON position, press the starter switch or pull up on the air valve control to crank the engine.

While the starter is turning the diesel engine, carefully spray ether toward the air cleaner inlet until the engine starts. If the electric starter is being used to start the diesel engine and the engine fails to start in thirty seconds, release the starter switch and wait two minutes to allow the electric starter to cool before using it again.

NOTE

Use only enough ether to start the diesel engine or keep it running if the engine starts to stall.

After the engine starts, reduce the engine speed to low idle until the oil pressure gauge indicates normal oil pressure. When the gauge indicates normal oil pressure, the engine should be allowed to run for five minutes with the governor control lever at approximately half engine speed position before applying the load. During this period the engine gauges should be observed for proper readings as explained in the topic, GAUGES.

Starting Below −10° F.

When starting in temperatures below −10° F. (−23.3° C.), the coolant in the cooling system and crankcase lubricating oil should be warmed. When heating the cooling system in these lower temperatures, the coolant should be maintained between +15° F. (−9.5° C) and +30° F. (−1° C.) for easy cranking, quicker starting and rapid oil distribution.

When electric starting is used, oversize or paralleled batteries may be required to maintain cranking speeds.

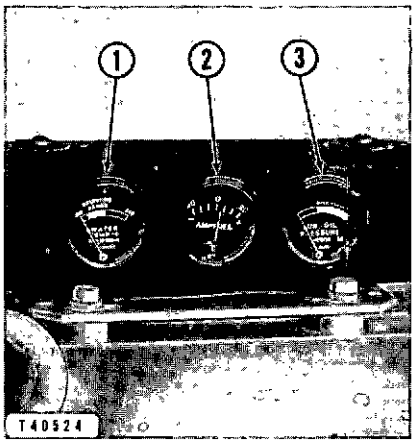
GAUGES

After the engine starts and at frequent intervals while the engine is operating, the engine gauges should be observed for proper readings as explained in the following paragraphs.

Oil Pressure Gauge: Immediately after the engine has started, check the crankcase lubricating oil pressure gauge **(3)** to see that it is registering. When the engine is running at rated engine speed the gauge should register in the OPERATING RANGE. A lower pressure reading is normal at low idling speeds. If no pressure is indicated, investigate at once.

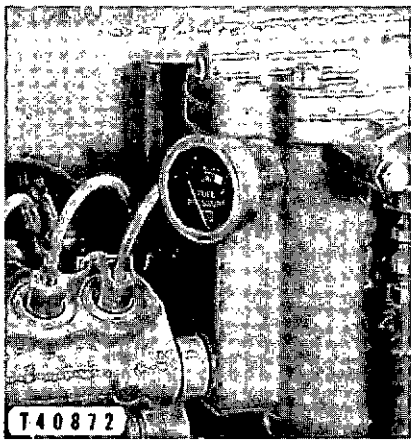
Water Temperature Gauge: The indicator on the water temperature gauge **(1)** should register in the OPERATING RANGE. The water temperature regulators within the diesel engine cooling system are designed to give an approximate minimum coolant temperature of 160° F. (71° C.). The maximum operating temperature will vary according to the air temperature and load factor, but should never exceed boiling temperature at the prevailing altitude.

Ammeter: The ammeter **(2)** should be checked to see that the indicator is registering in the charging range (indicator on the + side of zero). If the indicator registers in the discharging range (indicator on the — side of zero) investigate at once.



GAUGES

1–Water temperature gauge. 2–Ammeter. 3–Crankcase lubricating oil pressure gauge.



FUEL PRESSURE GAUGE

Fuel Pressure Gauge: The indicator on the fuel pressure gauge should register in the NORMAL (white) range. See the topic, FUEL SYSTEM.

STARTING THE LOAD

When the engine has run long enough to warm up, move the governor control lever to the full governed speed position to bring the engine to operating speed and apply the load.

GOVERNOR CONTROL LEVER *IN FULL SPEED* POSITION

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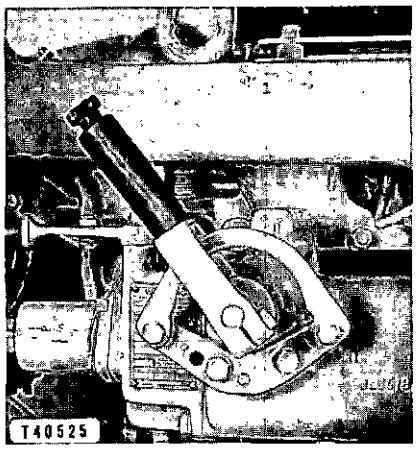

STOPPING THE LOAD

For a temporary stop — that is, when it becomes necessary to stop transmitting power — remove the load and move the governor control lever to reduce the engine speed. Reduce engine speed as described in the topic, STOPPING THE DIESEL ENGINE.

Long periods of running the engine with the clutch disengaged is not recommended. Either the clutch should be engaged or the engine stopped.

STOPPING THE DIESEL ENGINE

Correctly stopping the diesel engine will allow some of the hot areas in the engine to gradually cool, thus extending engine service life. The correct diesel engine stopping procedure is as follows:

1. After the normal load is removed from the engine allow it to idle five minutes with the governor control lever at half engine speed position.
2. Reduce engine speed to low idle speed and allow the engine to run for thirty seconds.
3. Stop the diesel engine while it is running at low idle speed by moving the governor control lever to the shut-off position. Do not accelerate the engine speed above low idle before stopping the engine.

If the engine must stand without shelter, cover the exhaust pipe (including starting engine exhaust pipe if so equipped) to exclude rain or snow. If the temperature is below freezing, or if freezing weather is expected before the engine will be started again, check to see that the cooling system is adequately protected against freezing. See the topic, COOLING SYSTEM, for information about anti-freeze solutions and cooling system draining.

DAILY CARE

Attention should be given to the operations mentioned in this topic, every 10 service hours or daily, whichever occurs first.

A daily check of the engine should be made to see if there are any loose nuts, bolts or parts worn to such an extent that they are no longer serviceable. If corrective steps are taken immediately upon discovery of loose or worn parts, fewer enforced stops and more economical operations will result! Points to be checked daily, or every 10 service hours, are as follows:

1. Exhaust manifold, air cleaner connections, the turbocharger mounting stud nuts and connections between the air cleaner and turbocharger, inspect for tightness.
2. Cooling system, clean trash from radiator core and add coolant or anti-freeze if necessary.
3. Fuel pressure gauge, inspect with engine running to see that indicator is not in red range.
4. Diesel engine air cleaner, with engine stopped, inspect for dirt in cleaner body, when operating conditions are extremely dusty.
5. Turbocharger, check to see that no vibration or excessive noise is present. The "muffled high pitched whine" is the normal sound. If turbocharger is defective it will usually be noisy only under load.

Fill the diesel fuel tank at the end of the day's run. See the topic, CARE OF THE DIESEL FUEL TANK for other periodic care.

Dirt should not be allowed to accumulate on the engine. A few minutes spent daily in keeping it clean are well repaid in improved appearance, and greater ease and safety in operation and maintenance.

STARTING IN COLD WEATHER

If the diesel engine is in good mechanical condition, and the precautions necessary for cold weather operation are taken, ordinary cold weather will not cause difficulty in starting or loss of efficiency.

Lubricants: As the starting atmospheric temperatures become lower, where warm housing facilities are not available, lubricants of lower viscosity should be used. See the topic, TYPE OF LUBRICANTS AND SAE GRADES TO USE.

Coolant: When the temperature is below freezing, sufficient anti-freeze solution should be used in the cooling system to prevent freezing. See the topic, COOLING SYSTEM.

The liquid in the cooling system may be warmed to make starting easier and quicker. When warming anti-freeze solutions, keep away from flames, as some of these solutions are inflammable. Avoid getting the solution hot, and even a warm solution should be poured very slowly into a cold cooling system to prevent damage by sudden expansion.

Fuel: Fuel must be "free flowing" enough to flow readily through the fuel lines at the lowest temperatures at which the engine will be started and operated. For additional information on this subject, see the topic, FUELS.

Electrical Equipment: During cold weather, more attention should be given the condition of the battery. It should be tested frequently and charged as often as necessary to insure sufficient power for starting. All switches and connections in the electrical system should be inspected and kept in good condition to prevent losses through improper contact. See the topic, BATTERY.

Starting the Starting Engine: If the engine has been standing without shelter in extremely cold weather, the following suggestions will materially assist starting.

It is very important to keep low viscosity crankcase lubricating oil up to the full mark on the gauge in the diesel engine crankcase to provide proper lubrication when starting. Refer to the topic, TYPE OF LUBRICANTS AND SAE GRADES TO USE.

Crank the starting engine several revolutions with the ignition switch OFF, the choke ON, the throttle slightly open and the starting engine clutch disengaged. This will prime the engine and better distribute oil to the bearings and cylinder walls.

Sometimes moisture, or fuel which has not vaporized, collects on the starting engine spark plugs. They may be dried out by removing them and pouring gasoline over the electrodes. Ignite the gasoline and allow it to burn. **Use care to prevent fire.**

Pouring a small amount of gasoline on the electrodes before they are replaced in the engine is more effective in promoting combustion than priming the cylinders with gasoline. A small amount of gasoline in the cylinders will remove the film of oil from the cylinder walls and interfere with compression.

Follow the starting procedure covered in the topics, GASOLINE STARTING and either MANUAL STARTING or ELECTRIC STARTING whichever applies.

When the engine starts, keep the engine speed low until the crankcase lubricating oil has a chance to get warm and better lubricate the engine.

Starting the Diesel Engine: It is very important to keep low viscosity crankcase lubricating oil up to the full mark on the gauge in the diesel engine crankcase to provide proper lubrication when starting. Refer to the topic, TYPE OF LUBRICANTS AND SAE GRADES TO USE.

In cold weather, if the pinion clashes and will not engage with the ring gear, proceed as follows:

1. Stop the starting engine after the lubricating oil is thoroughly warm.
2. *Engage the starter pinion by moving the clutch and starter pinion* control forward as far as it will go. (It may be necessary to rotate the starter pinion by the use of the electric starter or hand recoil starter.)
3. Restart the starting engine.
4. With the starting engine running at high idle speed, engage the starting engine clutch, by moving the control lever toward the rear, to start the diesel engine.

STORAGE

Lubricate all points mentioned in the lubrication chart if the engine is to be stored or left standing for any length of time. This will protect against rusting.

Starting Engine and Diesel Engine: If the engine is to be stored or left standing for a long period of time, the lubricating oil may drain away from the cylinder walls and piston rings. This lack of lubricant permits the rings and liners to rust. It also permits unnecessary wear caused by metal-to-metal contact between the pistons, rings and liners when the engine is started before fresh oil has reached these surfaces. The lack of lubricant may not cause any noticeable change in engine operation after it has been started but it does contribute to shorter engine life.

The oil film should be renewed once a week by running the starting engine and diesel engine until they are thoroughly warm. This will circulate the oil and prevent rusting from condensation.

Cooling System: If the temperature will be below freezing, the cooling system should be drained if the system has not been serviced as instructed in the topic, COOLING SYSTEM.

Battery: Periods of two weeks or more when the engine is not operated necessitates provisions being made to keep the battery charged. This may be done by running the engine once a week or taking the battery to your Caterpillar dealer for charging.

ALTITUDE OPERATION

The maximum turbocharger speed is determined by the fuel rack setting, the high idle speed, the turbine nozzle and the altitude at which the engine is operated. The rack and high idle speed settings have been established to permit the engine to be operated at the altitude marked

on the warning plate located on the side of the fuel filter housing. The turbine nozzle is the same for all altitudes, but the engine fuel rack setting and high idle speed vary with altitude. If the fuel rack setting is greater than specified for the altitude at which the engine is being operated or the high idle speed is too high, **serious damage or injury due to turbocharger overspeeding may result.**

The maximum altitude at which the engine may be operated at the present setting is marked on the warning plate. The governor housing and turbocharger are sealed for your protection. **Changes to the turbocharger, fuel rack setting, or high idle speed should be made only by your Caterpillar dealer.**

The engine can be operated at a lower altitude than marked on the warning plate without danger of turbocharger overspeeding, but with slightly less than maximum performance, however the fuel rack setting must be changed when operated at a lower altitude to get full power. **When operated at a higher altitude, the fuel rack setting must be changed by your Caterpillar dealer.** After making any changes, new altitude limit will be marked on the warning plate and the governor housing will be resealed for your protection. This will assure you that correct settings have been made.

IMPORTANT: Consult your Caterpillar dealer before operating at a higher altitude than marked on the warning plate.

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Maintenance Instructions

Electric set generator information is covered in the Operation and Maintenance Instruction Book for the generator.

The foregoing paragraphs have been devoted to instructions which are necessary for day-to-day operation of the engine. The following topics give detailed instructions regarding the care and adjustment of the various parts.

AIR CLEANERS

These dry type air cleaners are to be used without oil.

Regular service intervals, along with close visual inspection of the dry type air cleaner, are necessary for proper cleaning of the engine inlet air. The service interval will vary with the weather and working conditions. During dry, dusty months where dust conditions are severe, it will be necessary to service the air cleaner frequently. In damp weather and other conditions of little or no dust, the service interval can be extended.

Diesel Engine Dry Type Air Cleaner

To extend the service life of the element, the exhaust and air cleaner inlet pipes should be arranged so that exhaust and/or oil fumes do not enter the engine air cleaner.

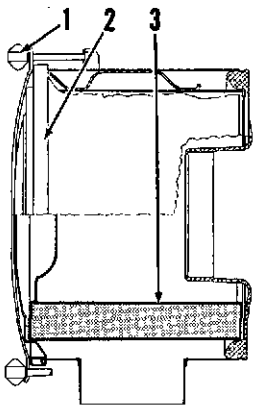
Visual inspection of the gaskets and seals is important in keeping dust from by-passing the air cleaner. Air leakage can upset proper air cleaner action. If the condition of any of the replaceable seals and gasket is questionable, replace them. If the sealing ends of the filter element or the element pleats are damaged, replace the element.

Filter Element: Every 50 to 250 service hours, in average operating conditions, remove the filter element for inspection and cleaning. This period may be extended in clean atmosphere and can only be determined by experience. **Never service the air cleaner while the engine is running.**

An extra filter element should be kept on hand for replacement or for use in the air cleaner while the element that was removed is being cleaned.

If desired, the air cleaner service periods can be determined by measuring the air cleaner restriction with a manometer, a vacuum gauge or with the installation of an Air Cleaner Service Indicator in the air transfer pipe between the air cleaner and turbocharger. The air cleaner should be serviced when the restriction reaches 30 inches of water when measured with a manometer or vacuum gauge or when the red piston locks in the "up" position on an Air Cleaner Service Indicator. All checks are to be made at rated speed and full load. This measurement of restriction should be made with an element that shows no evidence of damage to the sealing surfaces or resin impregnated cellulose material.

Excessive engine exhaust smoke and/or loss of power may indicate the need for servicing the air cleaner.



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DRY TYPE AIR CLEANER

1–Wing nut. 2–End cover. 3–Filter element.

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To remove the filter element **(3)**, loosen the two wing nuts **(1)**, remove the end cover **(2)** and the filter element.

Remove any dirt which has accumulated in the bottom of the case.

The end cap of the filter element can be damaged by bumping or tapping. Bent and/or dented end caps cannot seal properly and will allow unfiltered air to enter the engine cylinders causing premature engine wear.

To service the filter element proceed as follow:

1. Clean the filter element using one of the following methods:
   a. Using clean, dry air, at a pressure not to exceed 100 PSI, proceed as follows:

      Direct air against the inside of the element to loosen any imbedded dirt. Best results can be obtained by moving the air hose so that air is directed along the complete length of each pleat.

      Blow off loose dirt by directing air against the outside of the element.

      Repeat this procedure until the element is clean. Make certain that no dirt is inside the element.

   b. Using clean water, at a pressure not to exceed 40 PSI, proceed as follows:

      Direct water against the inside of the element to loosen any imbedded dirt. Best results can be obtained by using a water hose without a nozzle and moving it so that water is directed along the complete length of each pleat.

      Wash off loose dirt by directing water against the outside of the element.

      Repeat this procedure until the element is clean. Make certain that no dirt is inside the element, and thoroughly dry the element before installing it.

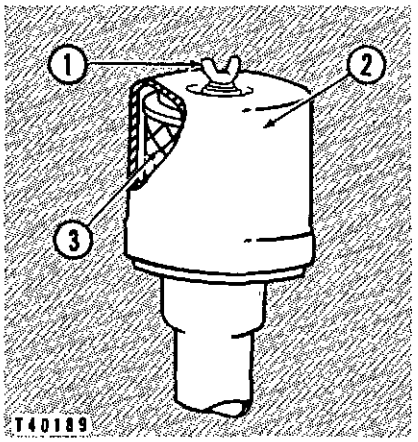
c. Some oily and/or sooty deposits can be removed by washing the element in a solution of warm water and a good household non-sudsing detergent. Rinse with clean water and dry as in "b" above.

2. Inspect the element and if it is damaged, install a new element.
3. Thoroughly clean all parts of the air cleaner. Inspect all replaceable gaskets and seals and replace with new ones if the old ones are damaged.
4. Assemble the air cleaner. This air cleaner requires no oil.

If after cleaning, the engine exhaust smoking and/or loss of power has not been corrected, or the restriction has not been reduced, replace with a new Caterpillar element.

Replace the filter element at least once a year.

Starting Engine Dry Type Air Cleaner



STARTING ENGINE AIR CLEANER
1–Wing nut. 2–Case. 3–Filter element.

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Filter Element: Every 250 service hours, clean the filter element. Hard starting and/or loss of speed and power may indicate the need for servicing the air cleaner.

To remove the filter element, unscrew the wing nut **(1)**, remove the air cleaner case **(2)** and the filter element **(3)**.

To service the element, direct clean dry air under pressure (not to exceed 100 PSI) from a hose held against the inside of the element. Blow off any loose dirt on the outside of the element. Do not let any dust collect inside the element.

While the element is removed, inspect and clean all parts of the air cleaner before reassembling it.

If the element is damaged or if after cleaning, the engine is hard to start and/or loss of speed and power has not been corrected, install a new Caterpillar element.

Replace the filter element at least once a year.

TURBOCHARGER

General: The engine is equipped with a turbocharger which is driven by exhaust gases. The turbocharger is attached to the diesel engine exhaust manifold.

SCHEMATIC OF EXHAUST GAS TURBOCHARGING SYSTEM

1–Exhaust manifold. 2–Inlet manifold. 3–Engine cylinder. 4–Air inlet. 5–Compressor. 6–Turbine. 7–Exhaust gas discharge.

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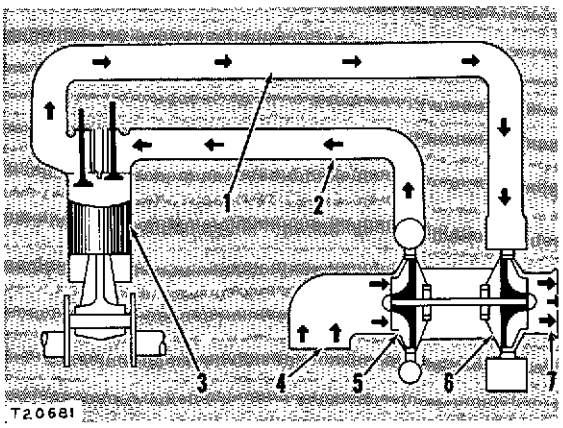
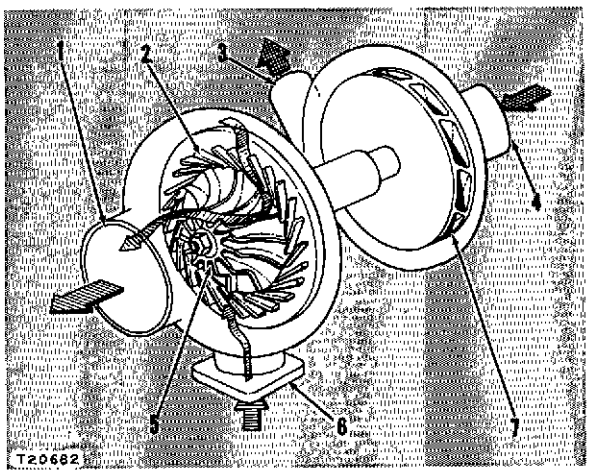


On engines not equipped with turbochargers air enters the cylinder under approximately atmospheric pressure when the piston travels downward on the inlet stroke. When the turbocharger is used, the air in the inlet manifold is under greater pressure than atmospheric, and air is forced into the cylinders, thus permitting more fuel to be burned. This results in greater horsepower output than from an engine of the same dimension that it not equipped with a turbocharger.



TURBOCHARGER EXHAUST GAS AND AIR FLOW

1–Exhaust gas outlet. 2–Turbine nozzle. 3–Compressed air discharge. 4–Air inlet. 5–Turbine wheel. 6–Exhaust gas inlet. 7–Compressor impeller.

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The turbocharger is constructed with such close limits of balance and clearances that foreign particles may affect its operation. If any unusual sound or vibration resulting from the turbocharger operation is noticed, the engine should be stopped and the turbocharger inspected by your Caterpillar dealer. Whenever a turbocharger is removed from an engine,

the exhaust and inlet manifolds and oil line openings should be covered to prevent entrance of dirt.

CRANKCASE LUBRICATING OIL SYSTEM

The crankcase lubricating oil flows from the oil pump, located in the crankcase, to the oil cooler where it is cooled; then flows to the oil filter base, through the filter and then is distributed to the bearings and all points of lubrication in the engine.

The oil is cleaned by a full-flow filtering system. The filter, located on the right side of the engine, is installed in the main pressure line so that the entire pump capacity is put through it.

The turbocharger is lubricated with oil supplied from the diesel engine crankcase lubricating oil system. A valve is used to assure rapid distribution of crankcase lubricating oil to the turbocharger when the engine is being started. The valve is in the lubricating oil system between the crankcase lubricating oil pump and the oil cooler. After lubricating the turbocharger bearings, the oil then returns to the diesel engine crankcase by gravity.

Engines before 58B577 are not equipped with a valve in the lubricating oil system between the crankcase lubricating oil pump and the oil cooler unless a "Turbocharger Oil Lines and Valve Group" has been added.

The crankcase lubricating oil filter should be replaced periodically. See the LUBRICATION INSTRUCTIONS section of this book.

FUELS

As a source of power the diesel engine has two outstanding advantages over the gasoline engine. The first is its lower rate of fuel consumption—and second its ability to use less expensive fuels. In selecting a fuel, it should be pointed out that distillates are especially desirable because, in refining, they are heated to a vaporous state and condensed in another container; thus, all the sediment and residue remain in the still. Always buy the **lowest priced distillate fuel giving satisfactory operation.**

In the United States and Canada, there are two general classes of fuel available for diesel engines. The American Society for Testing Materials (ASTM) has established these classes in their specifications. One class is that marketed as fuel oil (domestic furnace oil); the other is that marketed as diesel fuel oil. No. 2 fuel oil and No. 2D diesel fuel oil are recommended for use in Caterpillar Diesel Engines. More expensive "premium" fuel such as No. 1 fuel oil and No. 1D diesel fuel oil are not necessary or recommended for normal operating conditions.

There is considerable variation in the composition of fuels distributed under the No. 2 grade classifications. For desirable engine service, it is most important to give special attention to pour point, cloud point, filterability, sulphur content and cetane number of the fuel.

Pour Point: The pour point of the fuel has no effect on engine performance, so long as the fuel is fluid enough to flow from the diesel fuel tank to the engine fuel transfer pump. The pour point of the fuel should be at least 10° F. below the lowest atmospheric temperature at which the engine must start and operate. This will generally provide a fuel that will flow readily from the fuel tank to the engine fuel transfer pump. In subzero (—18° C.) weather it may be necessary to use No. 1 fuel oil or No. 1D diesel fuel oil to obtain unusually low pour point fuels.

Cloud Point: Cloud point is a low temperature property frequently not reported in fuel characteristics. It is the temperature at which wax crystals become visible, and it is generally above the pour point of the fuel. The cloud point should be below the lowest atmospheric temperature at which the engine will be operated so the filter will not be plugged with the wax formation.

Filterability: A good clean fuel should contain no more than .1% sediment and water. Dirty fuels lead to early filter plugging and in addition, with some fuels, fuel stability and fuel compatibility can result in the formation of gums and resins which will also reduce filter life.

Sulphur Content: As the sulphur content of the fuel increase, the oil change periods should be reduced as indicated in the topic, DIESEL ENGINE CRANKCASE LUBRICATING OIL CHANGE PERIODS.

Cetane Number: This is an indication of a fuel's ignition quality and should never be less than 35 for Caterpillar Engines. A higher cetane number is required at higher altitudes and for easier starting at low temperatures.

There is no world-wide standardization of diesel fuels and the ASTM classifications are not used in many export territories. Therefore, for best results, consult your Caterpillar dealer because he is familiar with fuels that are marketed in his particular area. He will be glad to advise you.

CARE OF THE FUEL SUPPLY

Keep the Fuel Clean: Too much emphasis cannot be placed on the importance of using only clean diesel fuel.

It is important to buy clean fuel, and keep it clean. The best fuel can be rendered unsatisfactory by inadequate storage facilities or careless handling. The clearance between the fuel injection pump plunger and the barrel is very small, actually less than .0001 inch (0.00254 mm.), which makes it evident that the invisible particles of dirt which might pass through the filters can damage these finely finished parts.

Effort should be constantly expended to prevent contamination of the fuel. Important steps are to use clean containers and funnels and to reduce the number of times the fuel must be handled. When the fuel can be delivered by the distributor to fuel storage tanks and then pumped from the fuel storage tank to the diesel fuel tank, the handling is reduced to a minimum.

Since natural settling is an effective method of cleaning diesel fuel the fuel should be allowed to stand at least 24 hours in the fuel storage tank after the tank has been filled before fuel is transferred to the diesel fuel tank. Be sure to drain all water and sediment that has settled to the bottom of the tank before the tank is refilled. Occasionally, drain all of the fuel and clean the tank thoroughly.

CARE OF THE DIESEL FUEL TANK

Fill the diesel fuel tank at the end of the day, because the incoming fuel will drive out the moisture-laden air and prevent condensation. Every 125 service hours before starting the engine, open the drain cock under the diesel fuel tank and drain off any sediment or water which may have accumulated. The strainer in the diesel fuel tank filler opening should be removed and cleaned regularly. Remove the retainer ring and lift out the strainer.

FUEL SYSTEM

The fuel flows from the diesel fuel tank through the fuel line, and the primary fuel filter, if the engine is so equipped, to the fuel transfer pump. The fuel transfer pump supplies fuel under pressure to the fuel filter housing, the filter removes the dirt and other foreign particles. From here the fuel is supplied to the fuel pump manifold for the individual fuel injection pumps. The fuel injection pumps meter and force the fuel through the fuel injection lines and the fuel injection valves in the cylinder head, into the precombustion chambers where it is ignited and passed into the main combustion chamber or cylinder.

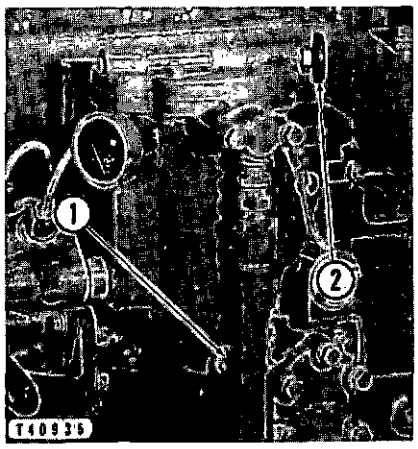
The primary fuel filter in the fuel system is for the purpose of straining out foreign material from the fuel before it enters the fuel transfer pump.

As either the metallic filter element in the primary filter or the resin impregnated cellulose material type fuel filter element in the final fuel filter housing gradually becomes clogged with foreign material, the position of the fuel gauge indicator will work back from the original position in the NORMAL (white) range, to the CAUTION (green) range and later into the OUT (red) range. When the indicator shows in the OUT (red) range, the primary filter element should be removed and washed. If the indicator still shows in the OUT (red) range, the resin impregnated cellulose material type fuel filter element should be replaced.

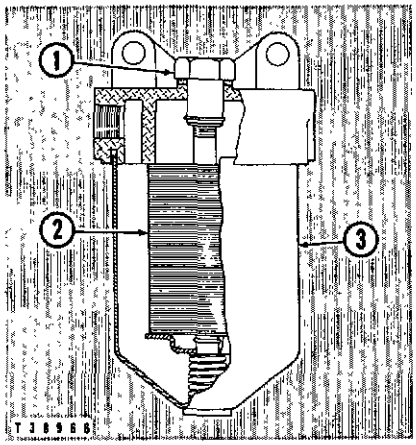
Primary Fuel Filter

Every 50 service hours remove and clean the filter element.

To remove the filter element **(2)**, stop the engine and shut off the diesel fuel tank valve. Loosen the nut **(1)** on the filter cover and lower the filter case **(3)**. Remove the element and wash in clean kerosene or diesel fuel. Reinstall the element.



DRAINING FUEL FILTER HOUSING
1–Vent valve. 2–Drain plug.



PRIMARY FUEL FILTER
1–Nut. 2–Filter element. 3–Filter case.

Final Fuel Filter

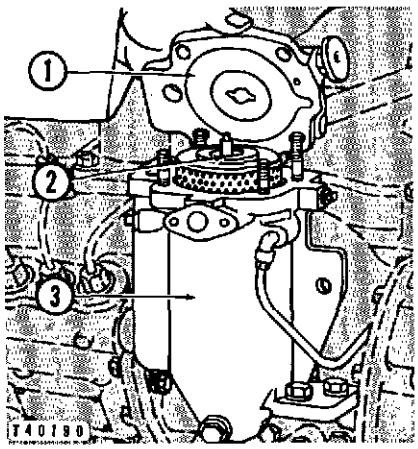
Draining Fuel Filter Housing: Every 50 service hours, or even as often as daily during extremely low temperatures, drain the filter housing of sediment and water which settles to the bottom of the compartment. Close the diesel fuel valve at the fuel tank, remove the filter housing drain plug **(2)** and open the vent valve **(1)** in the housing. Replace the drain plug and prime the system. See the topic, PRIMING THE FUEL SYSTEM.

Fuel Filter Elements: The fuel filter elements are of the resin impregnated cellulose material type. When the pleated elements have collected enough contamination to interfere with engine performance, they must be replaced with new elements. These elements will continue to collect particles until fuel will no longer flow through them at a rate to maintain maximum engine performance. They will not discharge their burden into the clean fuel; this is prevented by the fine grade filter media around the perforated metal core.

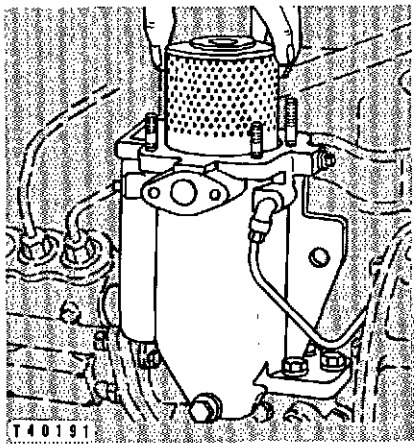
The resin impregnated cellulose material type filter element collects and holds contaminants and cannot be washed or otherwise restored.

Removing Used Filter Element: To remove the used filter element proceed as follows:

1. Close the diesel fuel tank valve.
2. Remove the filter housing drain plug.
3. Open the filter housing vent.
4. Thoroughly clean the top of the cover and around the edges of the gasket joint and cover to prevent dirt from dropping into the filter housing when the cover is removed.
5. Remove the fuel filter cover **(1)** from the housing **(3)**.
6. Lift the filter element out of the housing. The rod and rod spring may be lifted out of the housing to permit the inside of the housing to be thoroughly cleaned if so desired.



REMOVING FUEL FILTER COVER
1–Fuel filter cover. 2–Rod.
3–Filter housing.



REMOVING FUEL FILTER ELEMENT

Installing Filter Element in Housing: To install the element in the housing proceed as follows:

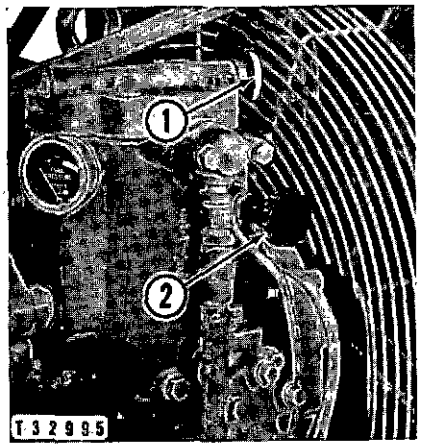
1. If the rod and rod spring have been removed from the housing, replace the spring and then rod **(2)** in the housing. Make certain the rod end enters the drilled hole in the bottom of the housing and that the spring is piloted on the boss of the housing and rod.
2. Place the filter element over the rod.
3. Place a new gasket on the filter housing.
4. Replace the filter cover **(1)**.

Keep a New Filter Element On Hand: An extra filter element should be kept on hand for replacement. Always keep the element wrapped and in its original carton to insure against dust and dirt accumulation which will shorten the life of the element if it gets on the outside or may cause damage to the fuel injection equipment if it gets on the inside.

PRIMING THE FUEL SYSTEM

Any time the fuel flow is broken and air is allowed to get into the fuel system, the fuel system must be primed. If air is left in the lines, the fuel system may become air bound, resulting in inability to start the diesel engine or the misfiring of one or more cylinders.

1. Check to see that the diesel fuel tank valve is open.
2. Move the governor control lever to the shut-off position so the fuel injection pumps are closed.
3. Open the fuel filter vent valve **(1)** and pump the fuel priming pump **(2)**, if so equipped, in and out until a steady stream of fuel comes from the tube leading from the filter housing.



PRIMING THE FUEL SYSTEM

1–Fuel filter vent valve.
2–Fuel priming pump.

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4. Open and close the vent valve **(1)** several times in succession, while pumping, to be sure all air is bled from the system.

If diesel engine is equipped with a gasoline or air starting system and does not have a fuel priming pump, open and close the vent valve while the starting engine is cranking the diesel engine.

FUEL INJECTION EQUIPMENT

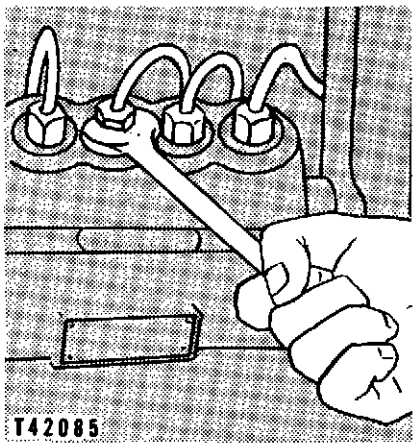
When improper fuel injection is affecting the diesel engine operation, a systematic check should be made to determine the cause. The most likely cause is dirt or water in the fuel. Drain the sediment from the diesel fuel tank and drain the fuel filter housing. Check the fuel pressure gauge as mentioned in the topic, FUEL SYSTEM. Replace the filter element if necessary. Then prime the fuel system until clean fuel passes through the vents on the fuel injection pumps. If the fuel system is air bound, priming the system will overcome the difficulty.

When the engine is running irregularly, and smoking, a fuel injection valve may not be spraying the fuel properly.

As the clearance between the plunger and the barrel of a fuel injection pump increases, due to wear, fuel leakage occurs. When the leakage increases to the point where insufficient fuel is injected into the cylinder, a loss of power is noticeable. With the loss of power, hard starting is also encountered.

Fuel Injection Valves

Testing Fuel Injection Valves: Whenever an engine performs in such a manner that a fuel injection valve is suspected of causing trouble, test all fuel injection valves. To test the injection valves loosen the fuel injection line nuts at the fuel injection pumps, one at a time, while the engine is



LOOSENING FUEL INJECTION LINE NUT TO TEST VALVE

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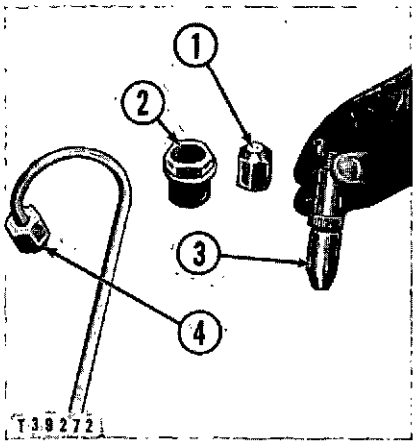
running. When a nut is loosened and the exhaust smoking is completely or partially eliminated and the irregularity in running is not affected, this identifies the defective valve and a new one should be installed in that cylinder. These valves can be tested by your Caterpillar dealer.

Removing Fuel Injection Valves: Before removing a valve clean the dirt from around the valve and connections.

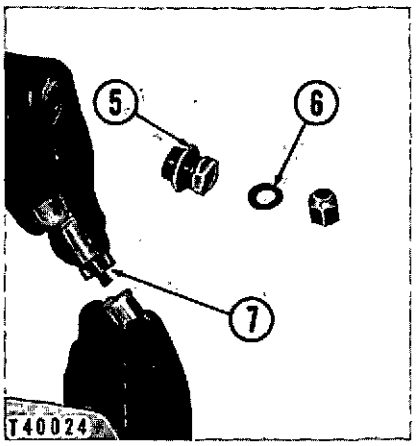
Loosen the fuel injection line at pump and disconnect it from the valve. Immediately install plug **(4)** to prevent dirt from entering the fuel injection line. Remove the valve retainer nut **(2)** and lift out the fuel injection nozzle assembly **(3)** and body as a unit.

If the fuel injection valve will not be immediately installed, the cap **(1)** should be put on the valve body, to prevent dirt from entering the valve assembly.



REMOVING FUEL INJECTION VALVE

1–Cap. 2–Retainer nut. 3–Fuel injection nozzle assembly. 4–Plug.



INSTALLING FUEL INJECTION VALVE

5–Large seal. 6–Small seal. 7–Injection valve body.

Installing Fuel Injection Valves: Before installation of a fuel injection valve, be sure the wrench is clean. Put the dust cover on the valve body *as soon as possible to prevent dirt entering the fuel passage. Install the* fuel injection valve in the following manner:

1. Screw the valve body **(7)** into the fuel injection valve nozzle assembly **(3)** only finger tight. The threads of the body and nozzle assembly are made to fit loosely. The clearance between the threads provides a passage for the fuel to enter the nozzle assembly from the body.

2. Insert the nozzle assembly and valve body as a unit into the precombustion chamber opening. Turning the body in a clockwise direction and at the same time pressing down will assure alignment of the serrations.

3. Install a new large seal **(5)** on the retainer nut. A light coating of lubricant on the seal will permit it to seat properly.

4. Tighten the retainer nut to prevent leaks between the nozzle assembly and the nozzle assembly seats. A torque of 100 to 110 pounds feet is adequate to tighten the retainer nuts.

5. Place a new small seal **(6)** over the threads on the top of the valve body and on the retainer nut .

6. Connect the fuel injection lines and tighten the nuts.

Fuel Injection Pumps

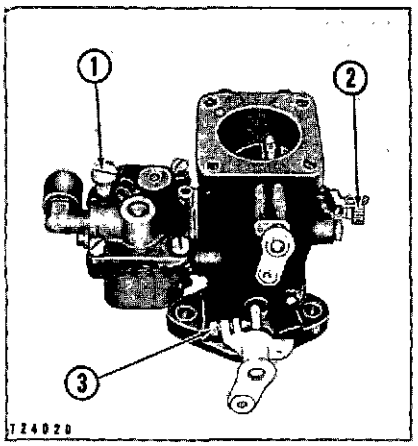
Testing Fuel Injection Pumps: It is not usual for one pump on an engine to require replacement unless all the pumps are worn. Worn fuel injection pumps will result in loss of power and hard starting. When loss of power and hard starting is accompanied with a clear exhaust, good compression and no blow-by gases from the crankcase breather it indicates worn injection pumps. The tools and information required to service and check fuel injection pumps are available at your Caterpillar dealer.

STARTING ENGINE FUEL SYSTEM

Keeping the starting engine fuel tank filled will prevent condensation in the tank. Periodically drain any water which may have accumulated in the starting engine fuel tank sediment bowl. Check the carburetor for proper adjustment every 500 service hours.

Carburetor Adjustment: To obtain an approximate carburetor adjustment, turn the adjusting screws gently against their seals. Then back off the high speed mixture adjusting screw **(1)** one turn from the closed position and the low speed mixture adjusting screw **(2)** one half turn from the closed position.

A more accurate adjustment can be made with the engine running at full governed speed by turning the high speed mixture adjusting screw **(1)** out to make the mixture richer or in to make it leaner. Adjust this screw to a point that will give the greatest amount of power with a clear exhaust. Turn the low speed mixture adjusting screw **(2)** until the engine will idle regularly at slow speed without emitting black smoke from the exhaust. Turn this screw in to make the mixture richer or out to make it leaner. Turn the idling speed control screw **(3)** to the left (out) to decrease idling speed or to right (in) to increase the speed.



CARBURETOR ADJUSTMENT

1–High speed mixture adjusting screw.
2–Low speed mixture adjusting screw.
3–Idling speed control screw.

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Sediment Bowl Filter and Fuel Line Screen: The sediment bowl **(1)** collects water and sediment that may be in the fuel. To remove the collected water and sediment, close the valve **(2)** under the fuel tank and remove the bowl by unscrewing the nut **(4)** that clamps it to the body of the valve. Unscrew the edge-type filter **(5)** and shake it in kerosene or some noninflammable cleaning fluid. When the bowl is replaced see that the gasket **(3)** is clean, is in the correct position, and not broken.

STARTING ENGINE SEDIMENT BOWL FILTER

1–Sediment bowl. 2–Valve. 3–Gasket. 4–Nut. 5–Edge-type filter element.

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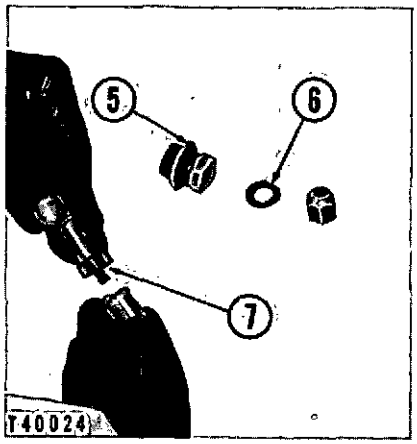
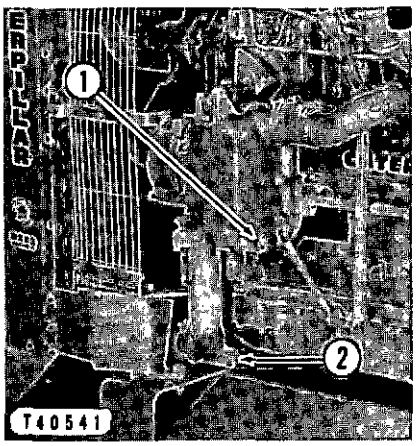


COOLING SYSTEM

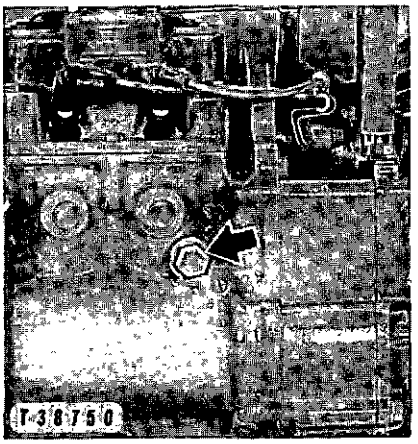
Coolants: Water used in the cooling system should be soft, or as free as possible from scale forming minerals. Treat the available water with Caterpillar Rust Inhibitor. The use of this rust inhibitor in the cooling system will prevent the formation of rust. It will also retard, and in some cases completely eliminate mineral deposits within the engine. Most commercial anti-freeze solutions contain rust inhibitors, therefore, it is not necessary to use rust inhibitors with those anti-freeze solutions which do contain inhibitors. Your Caterpillar dealer stocks Caterpillar Rust Inhibitor in convenient one quart cans. Directions for its use are printed on each can.

When the temperature is below freezing sufficient anti-freeze should be used in the cooling system to prevent freezing. Various anti-freeze mixtures such as ethylene glycol (Prestone, GM., Permaguard, Zerex, etc.), denatured ethyl alcohol, methanol (synthetic wood or methyl alcohol) and glycerine are all suitable for use. Alcohol can be used successfully but, because it readily evaporates at the normal operating temperature of the diesel engine, the solution should be tested frequently—even daily—and kept up to correct strength. This loss by evaporation is objectionable **but the temperature regulators should not be removed.** Doing so might make the solution run cooler and save the alcohol, but it is not desirable for good performance. It is essential, therefore, that the coolant be tested frequently to assure adequate protection.

Draining: The cooling system is drained by removing the plug **(2)** in the pipe between the radiator and oil cooler and by removing the oil cooler drain plug **(1)** on the left side of the diesel engine. If the diesel engine is equipped with a starting engine, remove the starting engine block drain plug to drain the water from both the starting engine and the



COOLING SYSTEM DRAIN PLUGS
1–Oil cooler drain plug.
2–Radiator drain plug.



STARTING ENGINE BLOCK DRAIN PLUG

diesel engine. This should be done at the end of the day's run when all the material is in suspension and will drain with the liquid.

Cleaning the Cooling System: An occasional washing of the cooling system may be necessary to remove the dirt and sediment which accumulates. The frequency of washing will depend on the amount of foreign material present in the water used in the system.

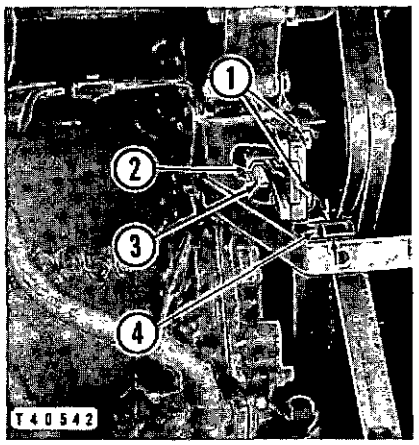
To wash the system, run the engine until the liquid in the cooling system is at operating temperature, and the loose foreign material is stirred up. Then stop the engine, and drain as quickly as possible before the sediment has time to settle. Close the drain and pour in kerosene equal to about one-tenth the capacity of the cooling system and fill the remainder with a solution of one-half pound (226.8 grams) of washing soda to each gallon (3.8 liters or .8 Imp. Gal.) of water. Run the engine for about one-half hour, and again drain and flush the system with clean water. Comercially available cooling system cleaners may be used.

FAN BELT ADJUSTMENT

The fan belts should be checked every 250 service hours for proper adjustment.

If the fan belts are operated too loose, they will slap against the pulleys, causing unnecessary wear to the belt and possibly slipping to the extent that the engine will overheat. If the belts are too tight, unnecessary stresses are placed upon the fan bearings and belts, which might shorten the life of both. Correct adjustment exists when the belts can be pushed inward ½ inch (1.27 cm.) with an approximate force of 25 pounds exerted midway between the pulleys as shown at **(4)**. Whenever the belts can be pushed inward ¾ inch (1.9 cm.), adjust them.

When a belt, or belts, need replacing, a matched set which is available from your Caterpillar dealer should be used. Always install a matched set — never only one.



FAN BELT ADJUSTMENT

1–Retaining nuts. 2–Locknut. 3–Adjusting screw. 4–Correct adjustment ½ inch (1.27 cm.) slack at this point.

◆

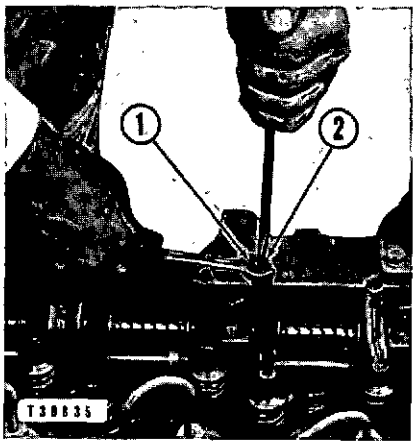
Adjusting Belts: Loosen the two retaining nuts **(1)** which hold the idler hub bracket to the timing gear cover. Loosen the locknut **(2)** on the adjusting screw **(3)** and turn the screw until the belts can be pushed inward approximately ½ inch (1.27 cm.), as shown at **(4)**. Recheck the adjustment after tightening the locknut and bracket retaining nuts.

DIESEL ENGINE VALVE CLEARANCE ADJUSTMENT

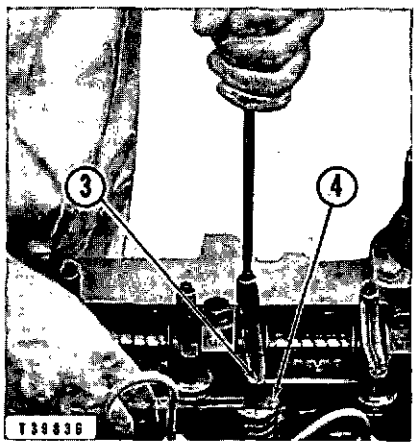
The initial valve clearance adjustment should be made after the first 100 to 125 service hours of operation. Thereafter, the clearances should be checked and adjusted if necessary after every 500 service hour operating interval.

The valve clearance adjustment should be made while the engine is hot, either while the engine is running or before it has been stopped twenty minutes after having run long enough to thoroughly warm up. If the adjustment with the engine stopped is not completed during this twenty minute interval, start the engine and allow it to warm up. The valve clearance adjustment must be made or the clearances checked, with the compression release lever in the run position.

To Adjust: Loosen the valve adjusting screw locknut **(1)**, turn the adjusting screw **(2)** to allow a thickness gauge **(4)** to pass between the top of the valve stem **(3)** and the end of the valve rocker at the correct clearance. Set this clearance at .015 inch (0.38 mm.) for inlet and .025 inch (0.64 mm.) for exhaust valves. Tighten the adjusting screw locknut **(1)** and check the adjustment.



LOOSENING LOCKNUT
1–Locknut. 2–Adjusting screw.



ADJUSTING VALVE CLEARANCE
3–Valve stem. 4–Thickness gauge.

If the adjustment is made with the engine stopped, turn the engine until the valve closes and push rod is at its lowest point.

The compression release clearance is not adjustable but it should be checked when the valve clearances are checked. The normal clearance

between the inlet valve rocker and flat of the compression release shaft is about .060 inch (approximately .15 cm.). If the clearance does not come close see your Caterpillar dealer.

Check Valve Rotators: Valve rotators are located below the valve springs next to the cylinder head. Check the valve rotators with the engine running after valve clearance adjustment check has been made to see if the valves rotate. The rotating of the valves decreases carbon build up and uneven wear, thereby increasing the life of the valves. To check, draw a pencil line on the valve retainer and observe the valve rotation. If the valves do not turn the valve rotators should be replaced. See your Caterpillar dealer.

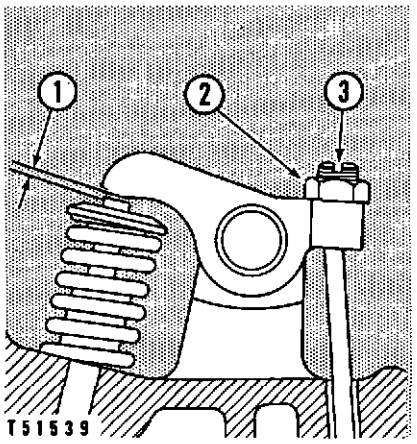
STARTING ENGINE VALVE CLEARANCE ADJUSTMENT

The initial valve clearance adjustment should be made after the first 100 to 125 service hours of operation. Thereafter the clearance should be checked and adjusted, if necessary, after every 500 service hours.

The valve clearance adjustment should be made while the engine is **cold.**

For valve adjustment proceed as follows:

1. Disconnect all linkage from the carburetor and remove the carburetor and the air cleaner as an assembly.
2. Remove the valve cover.
3. Turn the engine with the starting cable until the valve closes and the push rod is at its lowest point.
4. Loosen the locknut **(2)** and with an off-set screwdriver turn the adjusting screw **(3)** to allow a thickness gauge of the correct thickness to pass between the top of the valve stem and the valve rocker arm at **(1)**.
5. The correct clearance between the top of the valve stem and the rocker arm, for both the exhaust and inlet valves is .010 inch (.25 mm.).
6. Tighten the locknut and check the adjustment.
7. Install the valve cover, carburetor and air cleaner.



ADJUSTING VALVE CLEARANCE

1–Valve clearance for inlet and exhaust valves is .010 inch (.25 mm.). 2–Locknut. 3–Adjusting screw.

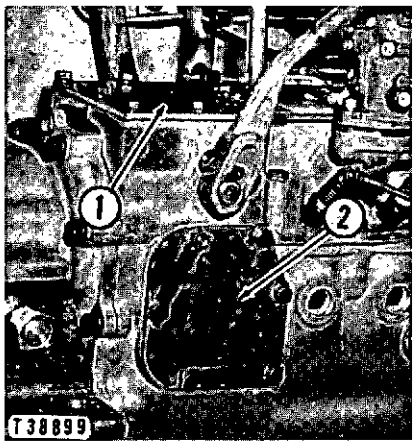
◆

STARTING ENGINE CLUTCH AND CLUTCH BRAKE

If the starting engine clutch slips, the starting engine clutch should be adjusted and the clutch brake adjustment checked.

Adjusting the Starting Engine Clutch: The starting engine clutch must be engaged when making clutch adjustment. To adjust the clutch proceed as follows:

1. Turn the magneto switch OFF.
2. Remove the side cover **(2)** and the top cover **(1)**, taking care not to damage the gaskets.



STARTING ENGINE CLUTCH COVERS

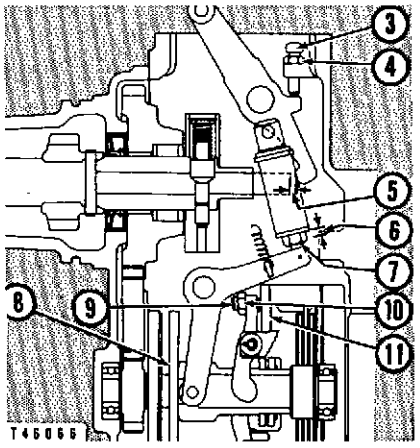
1–Top cover. 2–Side cover.

◆

CAUTION

Attach a cord or wire to **all tools** to aid in their removal should they be accidentally dropped into the compartment.

3. Engage the starter pinion and re-engage starting engine clutch.
4. Pull the recoil starter mechanism as required to move the flywheel and clutch to positions where the locknuts **(10)** on the adjusting screws **(9)** in each of the three clutch arms may be loosened through the access opening in the side of the housing.
5. Move the clutch brake pressure plate **(8)** as far to the right as possible. A 3/16 inch hexagonal wrench inserted in the hollow end of the adjusting screws is used to adjust each of the three adjusting screws until a clearance of .030 to .040 inch (.76 to .92 mm.), measured with a thickness gauge, is obtained between the spherical end of the adjusting screws **(9)** and the plate **(11)**. Tighten the locknuts and recheck the clearance. If new clutch plates have been installed the clearance should be .050 inch (0.132 cm.) to provide clearance as the plates mate during oil soak-up and run-in.



STARTING ENGINE CLUTCH AND CLUTCH BRAKE

3–Screw. 4–Locknut. 5–Clearance. 6–Vertical travel. 7–Locknut. 8–Pressure plate (brake). 9–Adjusting screws. 10–Locknuts. 11–Plate (clutch).

◆

Adjusting the Starting Engine Clutch Brake: If the starting engine pinion gear clashes with the diesel engine ring gear, when the clutch and pinion lever is moved to clutch brake and pinion engaged position, the clutch brake should be adjusted.

The starting engine clutch must be engaged when making clutch brake adjustments. To adjust the clutch brake proceed as follows:

1. Proceed as in steps 1 through 2 of the previous topic, ADJUSTING THE STARTING ENGINE CLUTCH.
2. Through the opening at the top of the housing, loosen locknut **(4)** and turn screw **(3)** until the pinion engagement lever touches the shaft and there is no clearance at **(5)**. To obtain the correct clearance at **(5)**, turn screw **(3)** counterclockwise one and one-half turns. Tighten locknut **(4)**.
3. Pull the recoil starter mechanism as required to move the flywheel and clutch to a position where a thickness gauge or wedge may be placed between the spherical head of the adjusting screw **(9)** and the plate **(11)** to remove only the "free play" of the clutch arms.
4. Move the starter pinion and clutch control lever from the clutch engaged position (as far down as possible) until spring resistance is encountered and measure the vertical travel **(6)** of the linkage assembly. The correct free travel or play of this linkage is .030 inch (.076 cm.).
5. If the measurement of linkage assembly travel is not approximately 1/32 inch, turn the locknut **(7)** clockwise to decrease and counterclockwise to increase the amount of linkage assembly travel.
6. Remove the thickness gauge or wedge from the clutch arm and replace the top and side covers.

SPARK PLUG ADJUSTMENT

The spark plugs should be examined every 1000 service hours. The gap

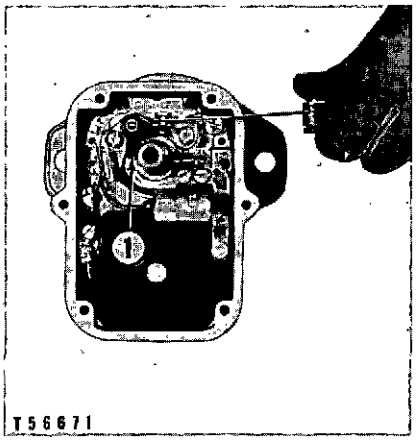
may be kept at approximately .030 inch (0.76 mm.). Measure this gap with a thickness gauge. To adjust the gap, bend the outer electrode.

STARTING ENGINE MAGNETO

Do Not Lubricate the Magneto at Any Point: The bearings are packed with a ball and roller bearing grease when assembled, and this should be replaced only when the magneto is taken to your Caterpillar dealer for checking or reconditioning.

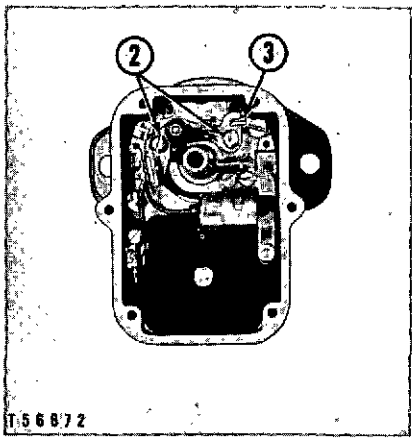
Checking Contact Point Opening: Every 1000 service hours check the contact point opening.

To check, first remove the distributor cap which is held in place by three screws. Care should be taken in removing the cap not to damage the gasket. Clean any carbon dust from the inside of the plate and any carbon track from the rotor using a soft cloth, dampened with a non-inflammable cleaning fluid. Remove the distributor rotor, then turn the engine until the contact bumper block **(1)** is on one of the highest elevations of the cam. Check the clearance with a thickness gauge between the contact points as illustrated. This clearance should be .015 inch (.38 mm.).



CHECKING CONTACT POINT OPENING

1–Contact point bumper block on one of the highest elevations of the cam.



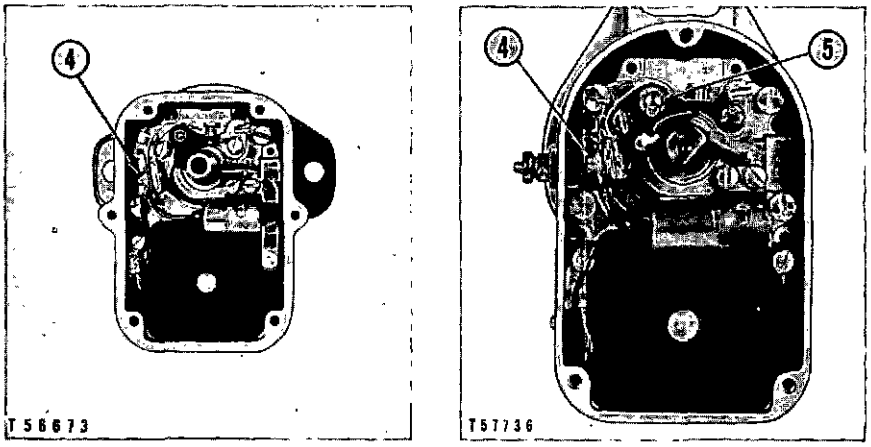
ADJUSTING CONTACT POINT OPENING

2–Bracket fastening screws.
3–Slot.

Adjusting Contact Point Openings: Loosen bracket fastening screws **(2)** which hold the adjustable contact point bracket and move the bracket by inserting a screwdriver in slot **(3)** and turn either clockwise or counter-clockwise until the correct point opening is obtained. Then tighten the fastening screws and recheck the adjustment.

To Remove the Contact Points: To remove the contact points on later magnetos remove the spring clamp screw **(4)** and bracket fastening screws **(2)** used in adjusting the contact point opening.

To remove the contact points on earlier magnetos, remove spring clamp screw **(4)**, lock and washer **(5)** and the bracket fastening screws **(2)** used in adjusting contact point opening.



REMOVING CONTACT POINTS
(Later Magneto) (Earlier Magneto)
4–Spring clamp screw. 5–Lock and washer.

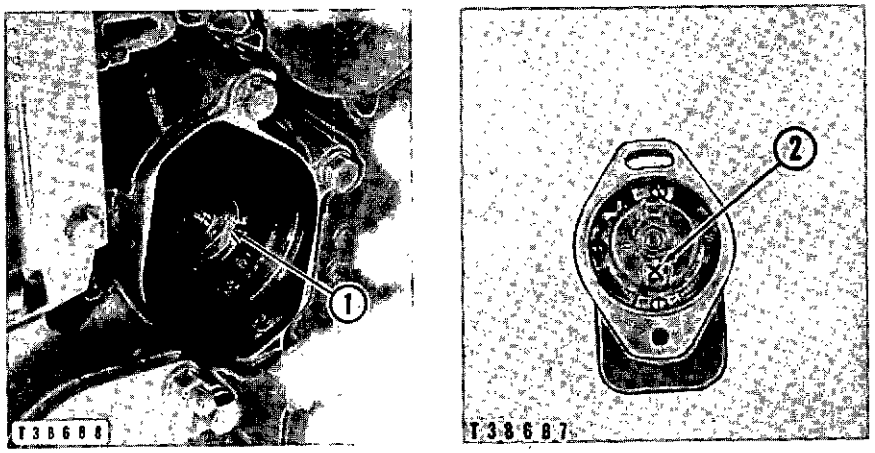
Testing: A magneto can be tested when coupled to the engine. Remove the cable from a spark plug (rotate the terminal to facilitate removal), insert a 1/4 inch (6 mm.) bolt or similar metal object into the terminal to contact the wire, and hold the terminal so the end of the bolt is 1/8 inch (3.17 mm.) away from the metal base of the spark plug. Turn the magneto switch ON and crank the engine. If no spark occurs between the bolt and the spark plug base, disconnect the switch wire from the terminal on the magneto and test again. If a spark now occurs with the switch wire removed, the wire from the magneto to the switch has become grounded or the switch requires replacement. If, with the switch wire off, the magneto still does not fire, remove the magneto as instructed in the next paragraph and take it to your Caterpillar dealer for testing.

To Remove the Magneto for Testing: Disconnect the cables from the magneto. (One of the cables should be tagged or marked in some convenient manner which will designate the proper position of the cables.) Remove the two bolts that hold the magneto to the timing gear cover and lift off the magneto.

To Time the Magneto to the Engine: To time the magneto to the engine proceed as follows:

1. Locate the "X" mark **(1)** on the starting engine magneto drive.

2. Turn the magneto impulse coupling until the "X" mark **(2)** on the tang is in such a position as to line up with the mark on the magneto drive.
3. Install the magneto with the "X" marks together and tighten the bolts.



TIMING MARKS

1–Mark "X" on magneto drive. 2–Mark "X" on the impulse coupling tang.

To Reinstall Magneto Wires: To reconnect the magneto wires proceed as follows:

1. Place the spark plug wire from number 1 cylinder (the cylinder farthest away from the flywheel) into the top wire receptacle of the magneto cap.
2. Install the other spark plug wire.
3. Reconnect ground wire.

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Attachment Instructions

Attachments are available from your Caterpillar dealer. Many of these attachments will add to operator comfort and convenience as well as increase the usefulness of your engine.

FLYWHEEL CLUTCH

To Test the Adjustment: Pull the clutch lever to the engaged position. For a desirable adjustment the lever should engage with a distinct snap, and should require a reasonably hard pull.

Enclosed Type Clutch

Clutch Adjustment: Remove the inspection cover and turn the adjusting ring **(2)** until the adjusting lock pin **(1)** can be reached. Push in the lock pin and tighten the clutch by turning the ring to the right or clockwise until the lock pin drops into the next notch. Test the adjustment by engaging the clutch. If one notch gives too loose an adjustment, and the other gives a slightly tight adjustment, use the tighter adjustment. Replace the inspection cover.

ENCLOSED CLUTCH ADJUSTMENT

1–Adjusting lock pin. 2–Adjusting ring.

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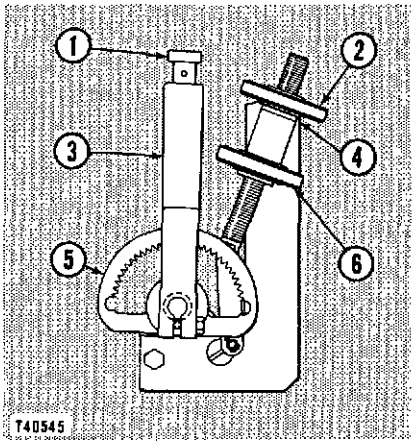
VERNIER GOVERNOR CONTROL

The vernier type governor control provides a means of adjusting engine speed to the exact speed desired. This is particularly desirable when paralleling electric sets and when loading engines that are operating in parallel. To move the governor control lever **(3)** to a position on quadrant **(5)** for the approximate engine speed required, push in knob **(1)** on control lever **(3)** and move the lever to that approximate position. To make slight engine speed changes, turn the adjusting nuts to unlock the adjustment. Turn the lower adjusting nut **(6)** clockwise to increase speed and counterclockwise to decrease engine speed. Lock the adjustment when the diesel engine is running at the desired speed by turning the upper



VERNIER GOVERNOR CONTROL

1–Knob. 2–Upper adjusting nut. 3–Governor control lever. 4–Yoke. 5–Quadrant. 6–Lower adjusting nut.

◆

adjusting nut **(2)** against the yoke **(4)** locking the adjustment. To stop the diesel engine, push in the knob on the governor control lever and move the lever all the way forward to shut off the fuel injection pumps, stopping the engine.

AIR STARTING MOTOR OILER

The air starting motor oiler automatically meters oil into the air system in the form of a fine fog to lubricate the air motor vanes when the air control valve is opened. An air director tube (venturi tube) located in the air passage of the oiler body **(3)** delivers air pressure above the oil in bowl **(4)**. Oil flows from the bowl through a tube and drilled passage in oiler body **(3)** into the air stream and then to the motor.

The oiler is designed to operate satisfactorily in a perpendicular position as long as the bowl is kept filled with lubricant. The oiler should be regulated to meter about four drops of oil per minute to the air stream.

Oil drips into the air stream only when air passes through the oil to the air motor.

To regulate the drops of oil from the oiler.

1. Crank the engine with the compression release lever in the start position and the governor control in the shut-off position.
2. Turn valve needle **(1)** counterclockwise to increase or clockwise to decrease the amount of oil.
3. While cranking the engine watch the sight feed glass **(5)** to see the oil dripping.

If the oiler becomes clogged or cannot be adjusted to deliver the proper quantity of oil, remove top plug **(2)** and valve needle **(1)** from the plug. Lift the oil drip gland out of the body and wash it in kerosene or some non-inflammable cleaning fluid. Be sure the oil passage is open in both the body and drip gland before reinstalling the top plug. If it is

suspected that dirt or sludge has accumulated in bowl **(4)** remove the bowl and clean it thoroughly in kerosene or some non-inflammable cleaning fluid and blow out the passages in the body with compressed air.

AIR STARTING MOTOR OILER

1–Valve needle. 2–Top plug. 3–Oiler body. 4–Bowl. 5–Sight feed glass.

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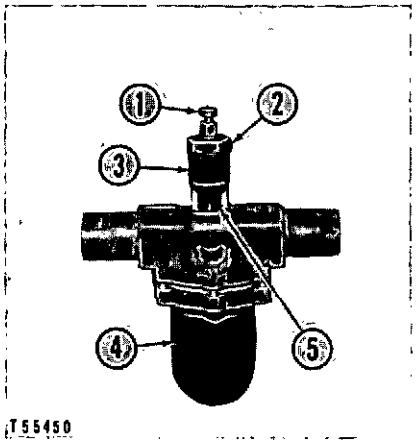


T55450

ELECTRICAL SYSTEM

The basic electrical system is composed of the following:

1. Battery.
2. Generator.
3. Generator regulator.
4. Wiring.

These components functioning together produce and store the electricity necessary for operating the electrical equipment on the machine and each is dependent upon the others for satisfactory operation. In the event of failure or improper operation it is essential to check the entire electrical system, as a defect in one component can cause damage to another.

The topics which follow describe the proper maintenance of the components to assure satisfactory operation of the electrical system.

Battery

Every 50 service hours, or more often when continuous operation without the use of the battery is encountered, the following attention should be given to the battery to insure high efficiency and maximum operating life.

Testing: The battery should be tested with a hydrometer and kept to a specific gravity of 1.250 or above. Always test a battery for degree of charge before adding water. The specific gravity between the cells should be within .025. A dangerously low point of charge is indicated by a hydrometer reading of 1.150 which will permit the battery to freeze. A specific gravity of 1.250 will permit the battery to withstand temperatures as low as —60° F. without freezing.

Water Addition: The water level should be maintained 3/8 inch (9.5 mm.) above the separators or insulators by addition of distilled water or "approved water" (water free from impurities by analysis). Do not overfill or underfill the cells of the battery as either has a detrimental effect on battery life.

Charging: The charging rate is correct when the battery maintains a minimum of specific gravity of 1.250 and does not require the addition of more than 1 ounce of water per cell week or 50 service hours.

When there is evidence of either overcharging or undercharging, the cause should be found and corrected as soon as possible to protect the service life of the battery. See the topics, GENERATOR, GENERATOR REGULATOR and WIRING.

Cleanliness: Keep the top of the battery clean and dry to prevent current losses and keep the terminals clean and tight. To clean corrosion from the battery terminals, scrub them with a weak solution of bicarbonate of soda (baking soda) and water. Dry the battery thoroughly, then coat the terminals with lubricant to prevent corrosion. Keep the battery securely fastened in its compartment at all times.

Installation: When installing a battery in its compartment fasten it securely and be sure to attach the cables to the correct battery terminals. Incorrect grounding of the battery will reverse the polarity of the electrical system and cause damage to the generator regulator. See the topic, GENERATOR REGULATOR.

Generator

Never operate a generator with an open circuit between it and the battery.

General Reconditioning: Every 2000 service hours, the generator should be removed and the commutator and brushes checked for glaze or darkening. At the same time the generator should be completely disassembled, washed and have all worn parts replaced. It is suggested that this cleaning and reconditioning be entrusted to your Caterpillar dealer.

Generator Removal: Remove all wires from the generator and tag them so that they may be connected correctly when the generator is reinstalled. Remove the bolts or stud nuts that hold the generator in position and lift off the generator.

Generator Installation: Whenever a generator is installed, or reconnected to the generator regulator, it must be polarized **before** starting the engine. Follow the instructions carefully to prevent damage to the generator, generator regulator or both, due to incorrect polarizing.

1. Place the generator in position and install the bolts or stud nuts.
2. Connect all wires to the generator, regulator and battery. See the topic, WIRING.

3. Polarize the generator.

Polarizing Delco-Remy Generators: Turn the disconnect switch ON, if engine is so equipped. Connect a jumper wire momentarily between the regulator terminals marked BAT and GEN. Make sure all connections are clean and tight. See the topics, BATTERY, GENERATOR REGULATOR and WIRING.

Generator Regulator

The generator regulator is adjusted at the factory for average operating conditions. The regulator may have to be readjusted to provide the proper charging rate for the particular operating conditions of the machine. In case of failure of either the regulator or generator, both units should be taken to your Caterpillar dealer, where the output of the generator can be checked and the regulator adjusted accordingly.

Charging Rate: The normal function of the generator regulator is to adjust the generator charging rate by sensing the degree of charge in the battery. As the battery becomes fully charged, the charging rate should drop until the ammeter indicates a rate only perceptibly above zero.

When improper charging of the battery is encountered, the entire electrical system should be carefully checked. Loose or dirty connections, worn or broken wires, or a faulty generator can prevent a good regulator from functioning properly. See the topics, BATTERY, GENERATOR, and WIRING.

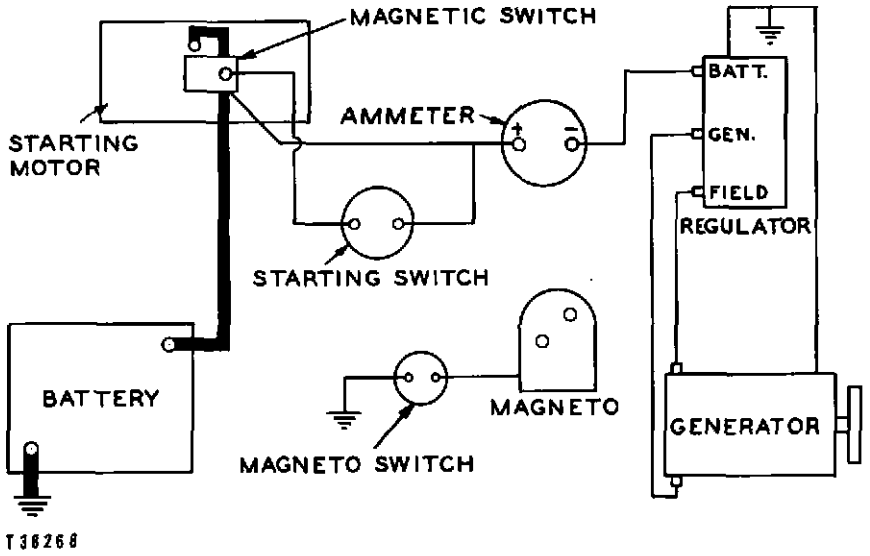
Polarity: Electrical systems may have either the positive or negative terminals grounded. When connecting the battery, be sure to ground the same battery terminal that was originally grounded. On new installations or where the battery grounding is questioned, check the generator regulator to determine the polarity of the system. The battery must be grounded as indicated on the regulator or damage will result.

The voltage and polarity of the electrical system are marked either on the cover or on the base of the regulator near a mounting hole. These marks may appear in any of the following forms: "24 VOLTS - NEGATIVE GROUND," "24V - NEG," or "24 V N." Similar marks are used for other voltages and for POSITIVE ground systems.

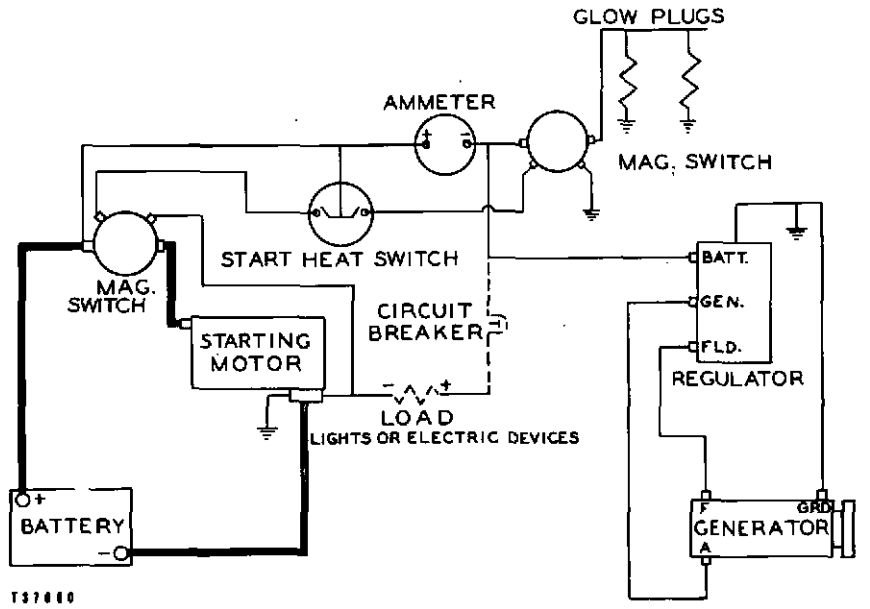
Wiring

The wiring forms an important part of the electrical system and care should be used to protect it from damage. When the electrical system is being serviced, check the wiring for loose or dirty connections, worn insulation or broken wires. Inspect the battery terminals and cables. Poor connections or wiring can cause trouble or damage in other parts of the electrical system. See the topics, BATTERY, GENERATOR and GENERATOR REGULATOR.

Wiring Diagrams: The diagrams are furnished so that when it becomes necessary to disturb the electrical equipment for purpose of reconditioning or parts replacement, reassembling may be accomplished without difficulty. The battery terminal to be grounded is determined by the generator regulator. See the topic, GENERATOR REGULATOR.



WIRING DIAGRAM FOR 12 VOLT SYSTEM
WITH ELECTRIC START STARTING ENGINE



WIRING DIAGRAM FOR ENGINES EQUIPPED WITH 24 VOLT SYSTEM WITH
DIRECT ELECTRIC START AND GLOW PLUGS

ELECTRIC STARTER

No periodic service is indicated for the brushes and bearings between general reconditioning periods. The brushes should be inspected after removal of the starter from the engine and removal of the commutator end bearing frame. Replace worn brushes.

Most starting motors have three bearings which should be lubricated with crankcase lubricating oil. When plugs and wicks are provided, remove the plugs and saturate the wicks with oil when the starting motor is reconditioned or removed. When wicks are not provided apply two or three drops of oil to the bearings when the starter motor is disassembled for reconditioning. Overlubrication of the commutator end bearing may cause gum to build up on the commutator and cause poor commutation.

General Reconditioning: Approximately every 4,000 service hours, the starter should be removed so that it may be completely disassembled, washed and have all parts replaced that show evidence of being unsatisfactory for reason of wear. Do not use a degreaser or high temperature cleaning method when cleaning parts of the starter or overrunning clutch. If the overrunning clutch turns roughly when rotated in the overrunning direction or slips in the cranking direction, after the clutch has been washed, it must be replaced with a new clutch. It is suggested that cleaning and reconditioning be entrusted to your Caterpillar dealer.

GLOW PLUGS

Diesel engines which depend upon electric cranking systems require certain aids when starting in lower temperatures. These engines are equipped with a glow plug in each combustion chamber, which when energized by an electric current, gives off heat to the combustion chamber. It is recommended that the glow plugs be used to assist starting in temperatures below 50° F.

Maintenance: If it is suspected that the glow plugs are not correctly assisting in starting, the system should be checked for defective glow plugs. The ammeter should be observed when making this check to show that each glow plug uses approximately 5 or 10 amperes, whichever applies for a 24 or 12 volt system respectively.

An ammeter of sufficient capacity should be connected to the magnetic switch on the glow plug side, and the HEAT and START switch moved to the HEAT position. A reading on the ammeter should be approximately equal to the number of glow plugs in the system multiplied by 5 or 10 whichever applies for a 24 or 12 volt system respectively. Any reading that varies appreciably from this may indicate one or more defective glow plugs.

To locate the defective glow plug or plugs, check each glow plug separately by removing the leads from the glow plugs one at a time with the HEAT and START switch in the HEAT position. **Reconnect the lead to**

the plug before removing the lead from the next glow plug to be checked. When a lead is removed from a glow plug, with no variation shown on the ammeter, it can be assumed that the plug is defective and should be replaced.

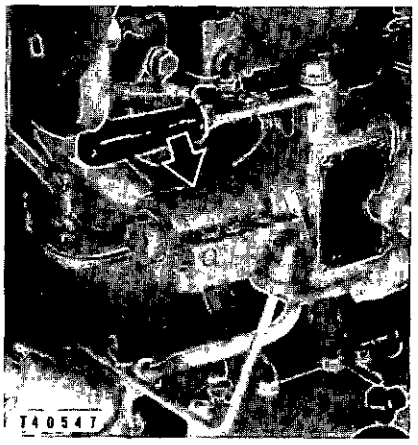
To remove a defective glow plug, disconnect the lead from the glow plug. Unscrew the glow plug from the precombustion chamber.

Apply anti-seizure compound to the threads of the new glow plug and install the glow plug into the precombustion chamber tightening it to a *torque of 10 to 12 pounds feet.*

GLOW PLUG

SAFETY SHUT-OFF CONTROLS

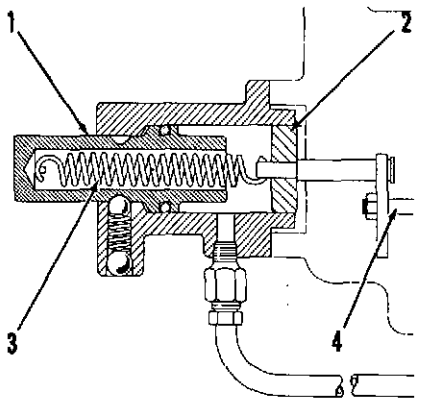
The purpose of the safety shut-off controls is to provide means of automatically stopping the engine to prevent damage when the lubricating oil pressure becomes dangerously low or excessively high cooling system temperatures occur.



OIL PRESSURE SHUT-OFF CONTROL

The oil pressure shut-off is mounted at the rear of the governor housing. Oil pressure lines between the engine oil pressure system, and the oil pressure and water temperature shut-offs constitute the oil pressure arrangement of the safety shut-off controls.

Oil Pressure Shut-off: When the engine is running and the lubricating oil pressure is normal, oil is forced by the crankcase lubricating oil pump through oil lines to the oil pressure shut-off control. Engine oil pressure to the shut-off control pushes control piston **(2)** forward and at the same time pushes reset piston **(1)** rearward to the latched position. Spring **(3)** is now in tension and is connected to the diesel engine fuel rack. Should



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OIL PRESSURE SHUT-OFF CONTROL

1–Reset piston. 2–Control piston. 3–Spring. 4–Rack bolt.

◆

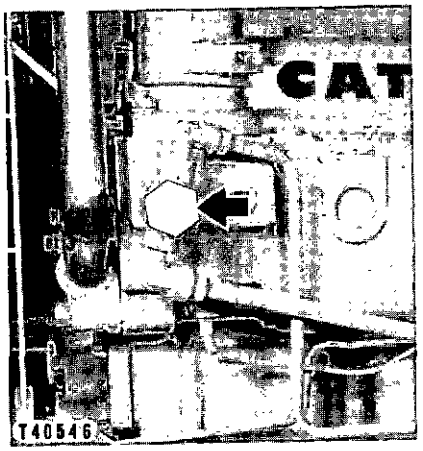
oil pressure become dangerously low, the oil pressure exerted on control piston **(2)** will diminish allowing spring **(3)** to draw rack bolt **(4)** back shutting off the fuel injection pumps, stopping the engine.

Reset Piston: To start the diesel engine, after the engine has stopped for any reason, reset piston **(1)** must be pushed in to release the shut-off control from the rack. The governor control lever, when moved, can now control the rack and open up the fuel injection pumps for starting the engine. After the engine starts, oil pressure will force the reset piston back into the latched position. The shut-off control mechanism can now function properly.

CAUTION

Before attempting to start an engine that has been stopped by the safety shut-off control, determine the reason for the engine being stopped and correct it before attempting to start the engine. After starting, if sufficient oil pressure is not developed, it is possible for the engine to run but the safety shut-off control will be inoperative. Therefore, **immediately after starting check to make sure the reset piston moves out to the latched position.**

Water Temperature Shut-off: The water temperature shut-off in itself is a control valve for the oil pressure shut-off, as it is actually the oil pres-



WATER TEMPERATURE SHUT-OFF

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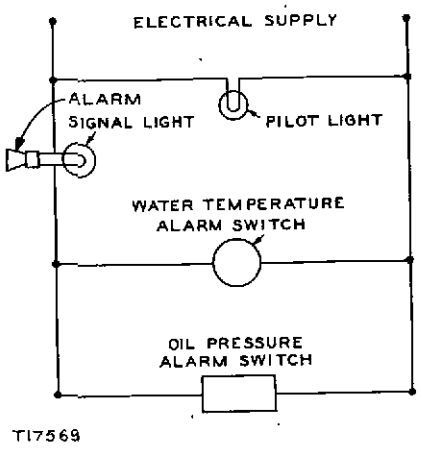
sure shut-off that functions to stop the engine. The water temperaure shut-off is used only with the oil pressure shut-off.

SAFETY ALARM SWITCHES

The engine may be equipped with a water temperature alarm switch and an oil pressure alarm switch. A signal light, horn or bell or a combination can be placed in the circuit so that the operator will be warned in case the water temperature or oil pressure reaches dangerous levels. The operator can then shut down the engine and correct the difficulty. For further information see your Caterpillar dealer.



TYPICAL SAFETY ALARM CIRCUIT

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Water Temperature Alarm Switch

The water temperature alarm switch is located on the right side of the engine at the front, in the cylinder head. The rise in engine water temperatures causes the metallic coil to expand, operating a single throw, mag-

netic switch. This switch is open during cold and normal water temperature ranges. When excessive temperatures are reached the switch is closed thus sounding the alarm.

The switch is designed to be installed in series with an alarm switch or relay switch having a rating not to exceed the maximum as follows:

1. In circuits of single phase, 115 volts alternating current, connected directly to the alarm, 5 amperes.
2. In circuits of single phase, 230 volts alternating current, connected directly to the relay, 2.5 amperes.
3. In circuits up to 600 volts alternating current, where another switch (relay) is operated, 1 ampere.
4. In circuits of 125 volts, where a direct current relay is employed, .5 ampere.
5. In circuits of 250 volts, where a direct current relay is employed, .25 ampere.

Oil Pressure Alarm Switch

The oil pressure alarm switch may be mounted either at the rear of the engine above the flywheel housing or in the lubricating oil junction block on the left side at the rear of the engine. When the engine oil pressure drops to the danger point a diaphragm actuates the contact points thus closing the circuit to sound the alarm.

The switch is designed to be installed in series with alarm or relay switch having a rating not to exceed the maximum as follows:

1—Circuits of 115 volts, alternating current, 15 amperes.

2—Circuits of 230 volts, alternating current, 14 amperes.

3—Circuits of 6 to 32 volts, direct current, 14 amperes.

4—Circuits of 115 volts, direct current, 6.5 amperes.

5—Circuits ot 230 volts, direct current, 3.3 amperes.

Electric Tachometer

The electric tachometer is waterproof and designed to give trouble free long life performance. If the electric tachometer is not operating properly, contact your Caterpillar dealer.

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FORM 33511-2

9-62
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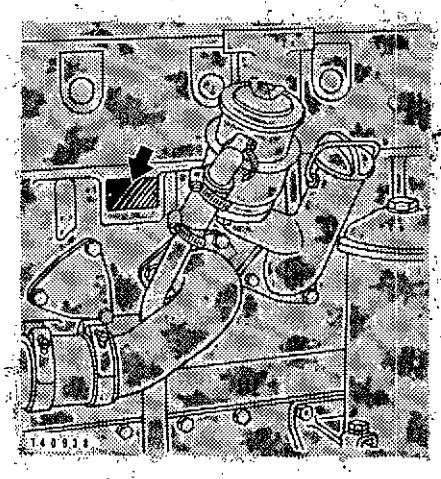
Capacities

Approximate Quantities

	U.S. Measure	Imperial Measure	Metric Measure Liters
Crankcase Lubricating Oil System:			
Diesel Engine	22 qt.	18.36 qt.	20,82
Starting Engine	4 qt.	3.3 qt.	3,8
Cooling System:			
Engine Only	17.6 qt.	14.66 qt.	16,65
With Radiator	33.6 qt.	27.59 qt.	30,07

Location of Serial Number



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Diesel Engines - - - - Tractors - - - - Motor Graders
- - - - - - - Earthmoving Equipment - - - - - - -

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