

FOREWORD

This Operation Guide contains both operation instructions and lubrication and maintenance information. Application of this information should give maximum performance and life of the engine, and minimize the costs of engine operation.

Caterpillar engines are found in many applications. Therefore, the illustrations in this Guide are typical and may not be of your specific engine or application.

Familiarize yourself with the components installed on your engine as described in the instructions. Some components described in the instructions may not be on your engine or installation.

Continuing improvement and advancement of product design may cause changes to your engine which may not be included in this publication. Each publication is reviewed and revised, as required, to update and include these changes in later editions.

Whenever a question arises regarding your Caterpillar product, or this publication, please consult your Caterpillar dealer for the latest available information.

The services of authorized Caterpillar dealers are recommended. Your dealer is staffed with trained personnel who are equipped with proper tools, necessary Caterpillar parts, and are trained in the latest service procedures.

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NOTICE!

TO THE DELIVERING DEALER—

THE WARRANTY COVERAGE ON CATERPILLAR ENGINES VARIES BY APPLICATION

To ensure the proper warranty coverage is extended to the owner of this engine, fill out the attached card COMPLETELY and ACCURATELY and return to CATERPILLAR.

The warranty period will start on the DELIVERY DATE entered below.

An Engine Warranty Information Card must be prepared by the OEM or Caterpillar dealer when delivering the engine to the user.

A card must be prepared for each new or remanufactured Caterpillar engine except for new engines installed in new on-highway trucks.

USER'S REFERENCE INFORMATION

DELIVERY DATE _____

ENGINE SERIAL NO. _____

DELIVERING DEALER'S NAME AND ADDRESS:

ARRANGEMENT NO. _____

MODIFICATION NO. _____

REMANUFACTURED ENGINE
 REFERENCE SERIAL NO. _____

VEHICLE MILES _____
 OR
 HOURS _____

SIGNATURE OF DELIVERING DEALER'S REPRESENTATIVE

FOLD AND DETACH HERE.



ENGINE WARRANTY INFORMATION CARD

SOLD TO: _____
 NAME

 ADDRESS

 CITY STATE ZIP

ENGINE MODEL	ENGINE SERIAL NUMBER	DELIVERY DATE

IF ELECTRIC SET, IS IT L PRIME OR M STAND-BY?

SOLD BY: 1. CATERPILLAR DEALER
 2. OEM DEALER

 DEALER'S NAME

DID THIS ENGINE REPLACE ANOTHER ENGINE?	CURRENT VEHICLE
YES <input type="checkbox"/> NO <input type="checkbox"/>	MILES _____ OR HOURS _____

MANUFACTURER'S EQUIPMENT IDENTIFICATION

 TYPE MACHINE

 MODEL SERIAL NUMBER

APPLICATION (check PRIMARY application only)

- A MARINE
- B DREDGE
- C POWERING AGRICULTURAL VEHICLE
- D AGRICULTURAL – OTHER
- E POWERING ON-HIGHWAY VEHICLE
- F PETROLEUM – DRILL RIG
- G PETROLEUM – OTHER
- H LOCOMOTIVE
- J POWERING OFF-HIGHWAY TRUCK
- K OTHER:

SIGNATURE OF DELIVERING DEALER'S REPRESENTATIVE

 PLEASE SPECIFY

(PLEASE TYPE OR PRINT)

NOTE

When mailing from locations in the U.S.A., use the card below which requires no postage.

When mailing from other locations, use the similar card, attached to Form 83996, and mail it to the appropriate address listed above that card.

In the United States —

All OEM's, except those who manufacture on-highway trucks, should include the foreign version of the Engine Warranty Information Card with their equipment shipped overseas. The foreign version of the Engine Warranty Information Card, Form 83996, may be obtained through your Caterpillar dealer or by written request to Caterpillar at the address shown below.

Additional copies of the domestic Engine Warranty Information Card, Form 83995, may be obtained through your Caterpillar dealer or by written request to:

CATERPILLAR TRACTOR CO.
Miscellaneous Orders, AB5C
100 NE Adams Street
Peoria, IL 61629

Please be sure to reference the appropriate form number.

FIRST CLASS
PERMIT NO. 385
PEORIA, ILLINOIS

BUSINESS REPLY MAIL

NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY



CATERPILLAR TRACTOR CO.

100 N.E. Adams Street
Peoria, Illinois 61602, U. S. A.

ATTN: Warranty & Data Div.
AB5A



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USER'S REFERENCE INFORMATION

DELIVERY DATE _____

ENGINE SERIAL NO. _____

DELIVERING DEALER'S NAME AND ADDRESS:

ARRANGEMENT NO. _____

MODIFICATION NO. _____

REMANUFACTURED ENGINE
REFERENCE SERIAL NO. _____

VEHICLE MILES _____

OR

HOURS _____

SIGNATURE OF DELIVERING DEALER'S REPRESENTATIVE

FOLD AND DETACH HERE.



ENGINE WARRANTY INFORMATION CARD

SOLD TO: _____

NAME

ADDRESS

CITY

STATE

ZIP

SOLD BY: 1. CATERPILLAR DEALER

2. OEM DEALER

DEALER'S NAME

MANUFACTURER'S EQUIPMENT IDENTIFICATION

TYPE MACHINE

MODEL

SERIAL NUMBER

SIGNATURE OF DELIVERING DEALER'S REPRESENTATIVE

ENGINE MODEL	ENGINE SERIAL NUMBER	DELIVERY DATE

IF ELECTRIC SET, IS IT L PRIME OR M STAND-BY?

DID THIS ENGINE REPLACE ANOTHER ENGINE?	CURRENT VEHICLE MILES
YES <input type="checkbox"/> NO <input type="checkbox"/>	_____
	OR
	HOURS _____

APPLICATION (check PRIMARY application only)

- A MARINE
 B DREDGE
 C POWERING AGRICULTURAL VEHICLE
 D AGRICULTURAL - OTHER
 E POWERING ON-HIGHWAY VEHICLE
 F PETROLEUM - DRILL RIG
 G PETROLEUM - OTHER
 H LOCOMOTIVE
 J POWERING OFF-HIGHWAY TRUCK
 K OTHER: _____

PLEASE SPECIFY

PLEASE TYPE OR PRINT

**WHEN MAILING FROM THIS COUNTRY
OR AREA**



**ADDRESS TO THIS CATERPILLAR
LOCATION**



UNITED STATES (use postage paid card in Engine Operation Guide)	CATERPILLAR TRACTOR CO. 100 N.E. ADAMS STREET PEORIA, ILL. 61629
EUROPE AFRICA NEAR EAST	CATERPILLAR OVERSEAS S.A. POST OFFICE BOX 408 1211 GENEVA 3 SWITZERLAND
AUSTRALIA PAPUA NEW GUINEA NEW ZEALAND NEW CALEDONIA — FIJI	CATERPILLAR OF AUSTRALIA LTD. POST OFFICE BOX 35 NIDDRIE VICTORIA, AUSTRALIA 3042
FAR EAST (EXCEPT JAPAN)	CATERPILLAR FAR EAST LTD. 31ST FLOOR, GAMMON HOUSE 12, HARCOURT ROAD HONG KONG, B.C.C.
JAPAN	CATERPILLAR MITSUBISHI LTD. 3700, TANA SAGAMIHARA-SHI, KANAGAWA-KEN 229 JAPAN
BRASIL	CATERPILLAR BRASIL S.A. CAIXA POSTAL 8239 SAO PAULO BRAZIL
CANADA CENTRAL AMERICA MEXICO SOUTH AMERICA (EXCEPT BRASIL)	CATERPILLAR AMERICAS CO. 100 N.E. ADAMS STREET PEORIA, ILL. 61629 U.S.A.

3304-3306 INDUSTRIAL ENGINE OPERATION INSTRUCTIONS

GENERAL

Proper engine operation and maintenance are essential for long engine life and maximum performance. The basic operation and periodic maintenance procedures are outlined in this OPERATION GUIDE. Before starting the engine, familiarize yourself with these procedures.

Your Caterpillar dealer is available for troubleshooting, testing and servicing when required.

SAFETY PRECAUTIONS

Safety is basically common sense. Some general safety precautions are listed below. However, each installation has its own peculiarities which cannot always be predicted and may not be covered by these rules. Past experience and common sense are needed in addition to these safety precautions. Lack of attention to safety can result in serious accidents. Be alert. Watch for hazards. Use preventive measures. Correct deficiencies promptly.

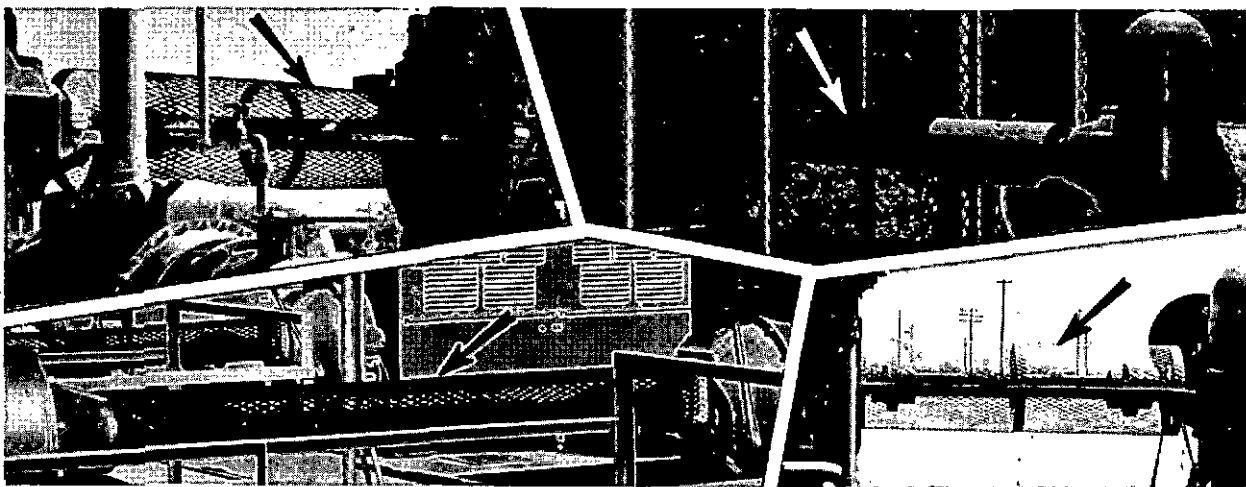
The following safety precautions are a general guide to safe operation:

1. Install guards over all exposed rotating parts. If guards are missing, inadequate or in need of repair, repair or replace them as soon as possible.

2. Wear ear protective devices if working inside an enclosed engine room with engine running.
3. Wear a safety hat when working in the area of overhead equipment.
4. Do not wear loose clothing whenever working around engines or machinery.
5. Keep the engine room and floor clean. Wipe up spilled oil or fuel promptly.
6. Keep batteries in a well ventilated area.

Hydrogen gas, which is present in the area of the batteries, is highly explosive. Do not smoke around batteries.

7. Provide adequate and pollution free waste oil disposal.
8. Store oily rags in fireproof containers. Don't leave rags on an engine.
9. Remove all tools, electrical cords and other loose items from the engine before starting.
10. Disconnect and tape the battery ground lead before working on an engine. Be sure an automatic start-stop system cannot operate and start the engine while working on it.



11. Never start, nor attempt to run, an engine with the governor linkage disconnected.
12. Never try adjusting or repairing either the engine, or the driven equipment, while the engine is running.

Safety is EVERYONE'S Business!

ENGINE HORSEPOWER RATINGS

There are two general horsepower ratings for industrial engines and two for electric set engines. They are: intermittent or continuous; standby or prime. These ratings are the recommended engine horsepower settings based upon load requirements and type of operation.

Continuous Rating:

The horsepower and speed capability of the engine which can be used without interruption or load cycling.

Intermittent Rating:

The horsepower and speed capability of the engine which can be utilized for about one hour, followed by about one hour of operation at or below the continuous rating.

CAUTION

If an engine is set for an intermittent rating and is operated for long periods of time at constant full load, the engine life will be shortened.

Prime Rating:

The horsepower and speed capability of the engine which can be used for continuous electrical service.

Standby Power:

The horsepower and speed capability of the engine which can be used for continuous electrical service during interruption of normal power.

Contact your Caterpillar dealer if there is doubt as to which rating the engine has.

CAUTION

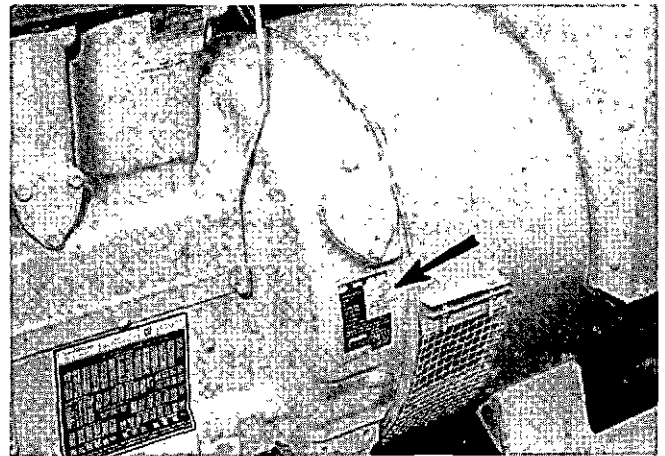
Horsepower settings should only be done by authorized personnel.

ALTITUDE DERATING

The fuel system settings and altitude limits are stamped on the engine information plate. When an engine is moved to a higher altitude, these settings must be changed by your Caterpillar dealer in order to prevent damaging the turbocharger, and to provide maximum engine efficiency.

If the engine is moved to a lower altitude than that which is stamped on the engine information plate, the engine can be operated safely, but it will deliver less than rated horsepower.

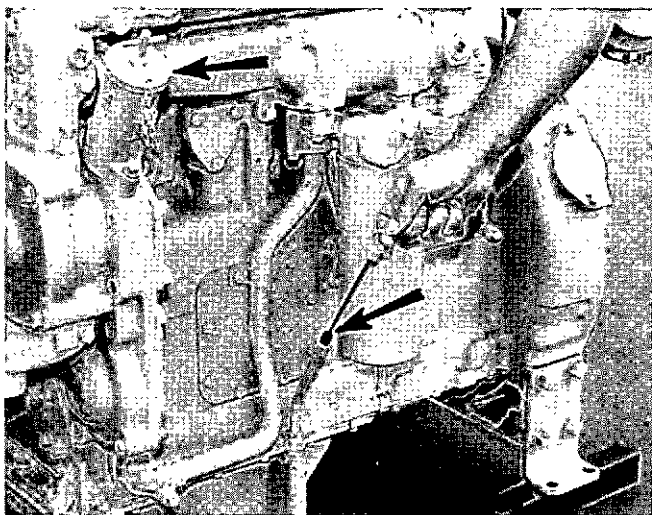
The information plate is attached to the engine flywheel housing.



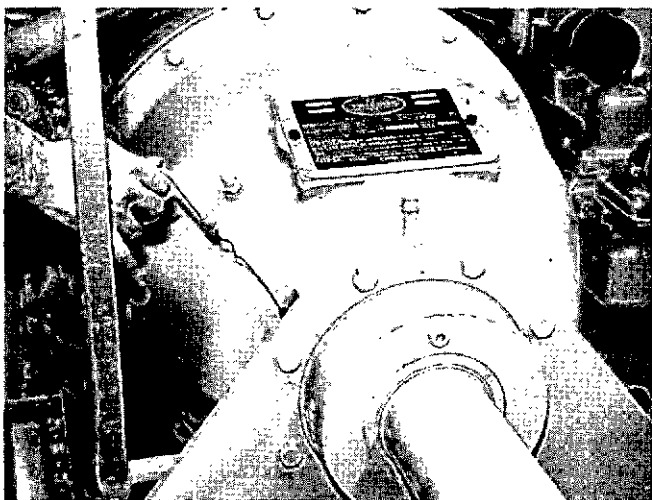
INDUSTRIAL ENGINE OPERATION INSTRUCTIONS

PRE-START CHECKS AND PROCEDURES

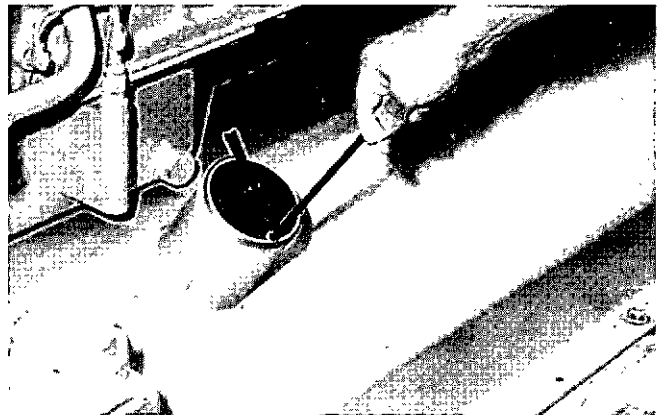
1. Make a "walk-around" check of the engine and components. Correct minor problems before they develop into major repair jobs.
2. Check the crankcase oil level. Maintain the oil level between the ADD and FULL marks on the ENGINE STOPPED side of the dipstick. See the LUBRICATION AND MAINTENANCE CHART for proper type and viscosity of oil to use.



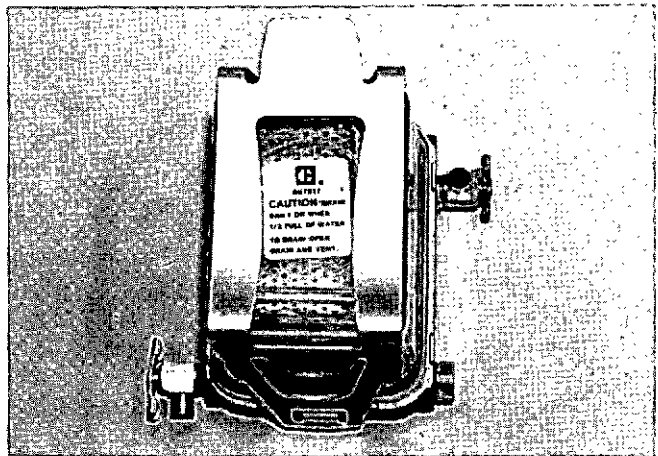
3. Check oil level(s) on driven equipment. Add oil as required. Do not overfill.



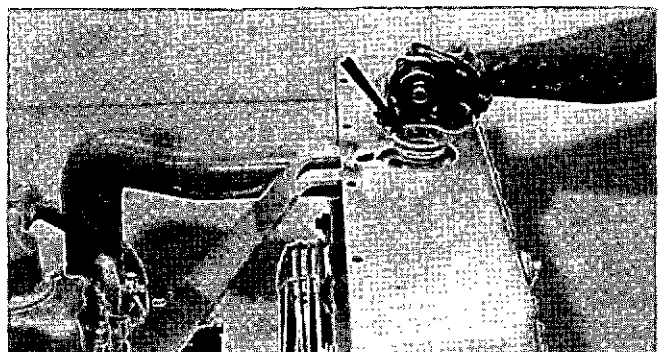
4. Check the fuel tank level. See the LUBRICATION AND MAINTENANCE CHART for proper fuel to use.



5. If the fuel system is equipped with a water separator, observe the glass housing and drain any water present. See the LUBRICATION AND MAINTENANCE PROCEDURES, topic FUEL SYSTEM, for the draining procedure.



6. Check the engine jacket coolant level. The coolant level must be within 1/2 inch of the base of the fill pipe. See the LUBRICATION AND MAINTENANCE CHART for proper make-up coolant to use.

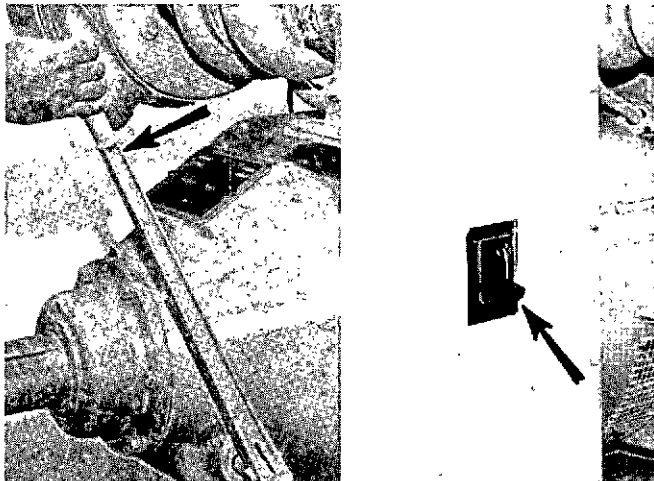


7. Open the sea water valve (if so equipped) on the engine jacket heat exchanger system.
8. Reset shutoff devices. See the topic, ATTACHMENTS, Emergency Shutoff Devices and Alarms.
9. Open the fuel supply valve.

CAUTION

The fuel return line must be open to prevent engine damage.

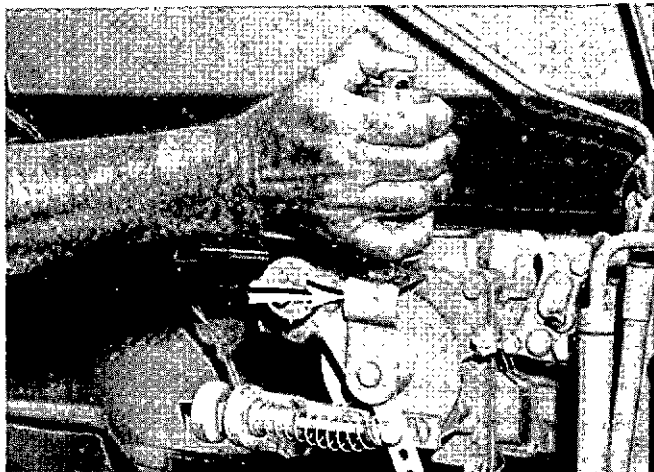
10. If air has entered the fuel system, prime the fuel system. See the LUBRICATION AND MAINTENANCE PROCEDURES topic, Priming the Fuel System.
11. Disconnect any battery charger which is not protected against starting motor drain.
12. Disengage the clutch on mechanical driven equipment, or open the circuit breaker on an electric set.



CAUTION

Do not start an engine under load.

13. Move the governor control lever to half engine speed position or to speed limiter stop.



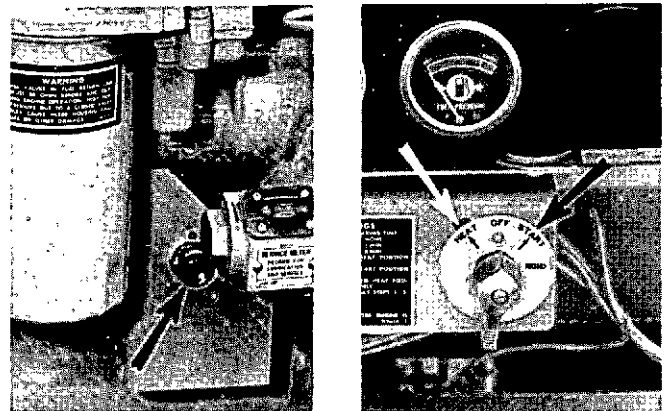
STARTING THE ENGINE

Electric Starting (Industrial Engines):

1. Use starting aids if required. See the topic, Cold Weather Starting.
2. Push the START button; or turn the HEAT-START switch to the START position, depending upon the control the engine has. Release the control as soon as the engine starts.

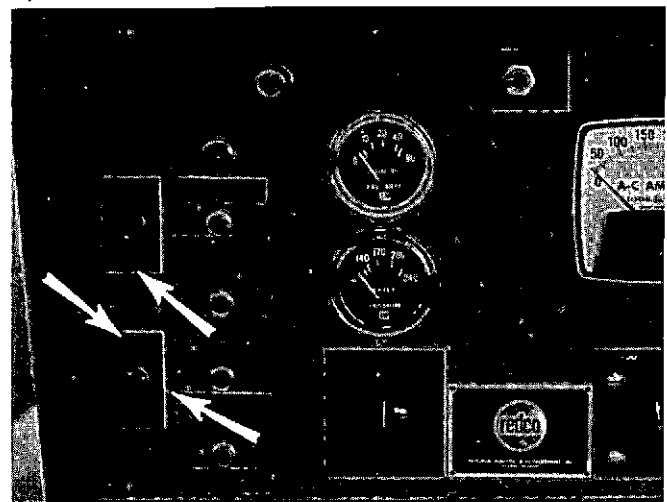
CAUTION

Do not engage the starter when the flywheel is moving.



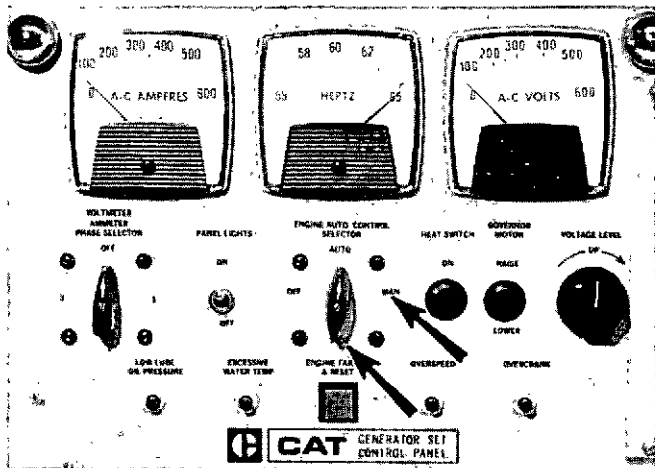
Electric Starting (Generator Set with "Redco" Panel):

1. Place the AUTO-MAN switch in the MAN (manual) position.
2. Move the ON-OFF-STOP switch to the ON position to start the engine. Cranking period should be less than 30 seconds.
3. As soon as the engine starts, move the switch to the OFF position. (The OFF position stops the starting motor; the STOP position stops the engine.)



Electric Starting (Generator Set with "CAT" Panel):

1. Turn the ENGINE AUTO. CONTROL SELECTOR to the MAN (manual) position. The starter motor will crank the engine until it starts, and then will stop. (The STOP position stops the engine).



If the engine is equipped with a Woodward PSG Governor, see the topic, WOODWARD GOVERNOR for the governor operation instructions.

If the engine fails to start in 10 seconds, move the governor control lever to the fuel off position, then continue to crank for 10 seconds. This will clear the cylinders of unburned fuel.

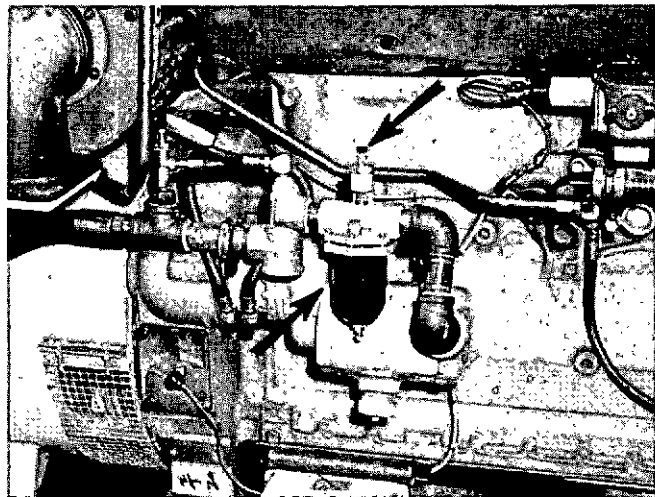
If the engine fails to start after 30 seconds of cranking, allow the starter to cool for 2 minutes before repeating the starting procedure.

CAUTION

NEVER use starting aids when the engine is warm and running.

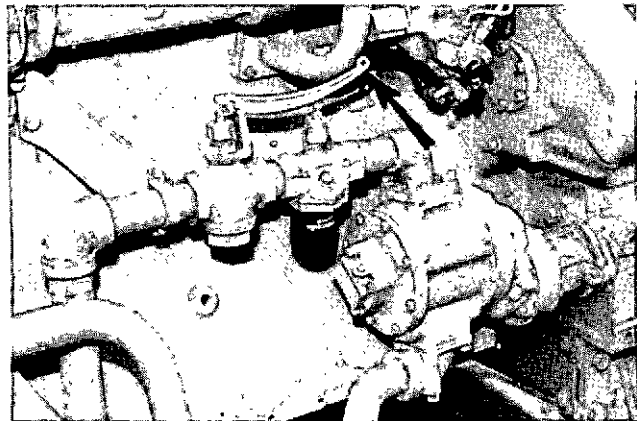
Air Starting:

1. Open and close the bleed valve on the bottom of the air tank to drain condensation and oil carryover.
2. Check the air supply pressure. The air start must have 100 PSI (7 kg/cm²) to operate properly.
3. Check the oil level in the oiler jar. Keep jar at least half full. Add oil if necessary. See the LUBRICATION AND MAINTENANCE CHART for the proper oil to use.



4. Push the air valve downward to crank the engine. As soon as the engine starts, release the valve.

For earlier engines, pull the air valve handle upward to crank the engine. Release the valve when the engine starts.



COLD WEATHER STARTING

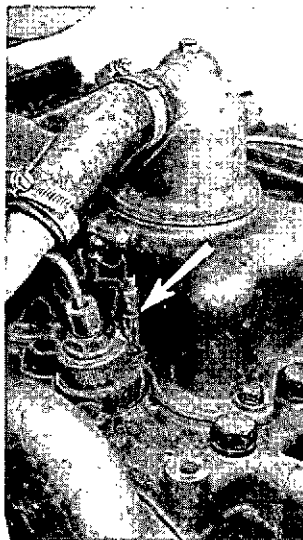
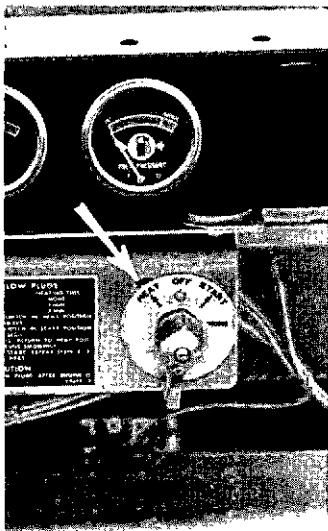
STARTING TEMPERATURE	STARTING AID	HEATING TIME
Above 60°F (15°C)	None	None
60°F to 32°F (15°C to 0°C)	Glow Plugs	1 Minute
32°F to 0°F (0°C to -20°C)	Glow Plugs	2 Minutes
Below 0°F (-20°C)*	Glow Plugs & Starting Fluid	3 Minutes

*Heating of jacket water and/or crankcase oil; and/or use of extra battery capacity may be required.

Many variables can affect cold weather starting. Use the above chart as a guide, but actual experience will determine when aids are necessary and how they should be used. One or more of the following starting aids may be on your engine.

Glow Plugs (Attachment)

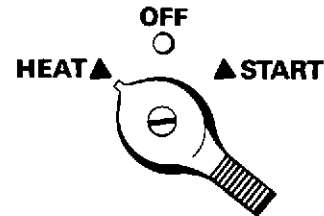
Use glow plugs before cranking the engine, immediately after the engine has started, and until the engine is running smoothly.



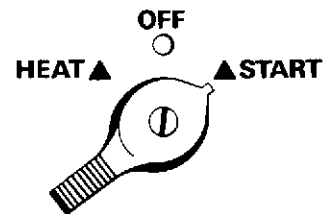
Operation:

1. Perform the PRE-START CHECKS AND PROCEDURES.

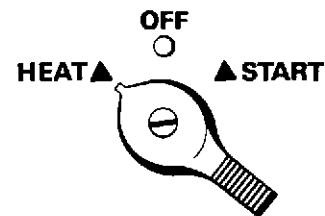
2. Push in and turn the HEAT-START switch to the HEAT position and hold for the approximate heating time shown in the Cold Weather Starting Chart.



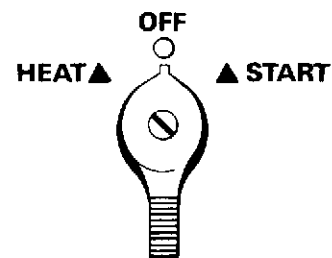
3. Turn the HEAT-START switch to the START position.



4. As soon as the engine starts, turn the HEAT-START switch to the HEAT position. Hold the switch in this position until the engine is running smoothly.



5. Release the switch.



CAUTION
NEVER use glow plugs when the engine is warm and running.

Starting Fluid

CAUTION

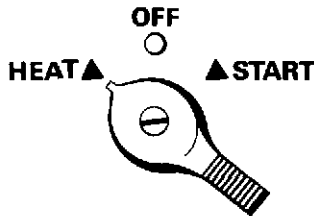
Spray starting fluid only while cranking the engine.

If starting fluid is sprayed into an engine that is running, the fluid would cause severe preignition in all cylinders until the fluid is consumed.

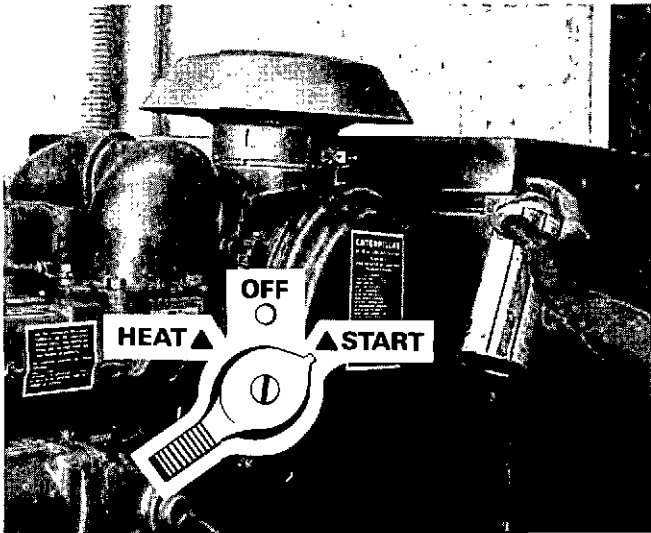
WARNING

Starting fluid is volatile and must be stored away from heat and direct sunlight. If an aerosol container is used, follow the instructions on the container.

1. Heat the glow plugs for the approximate heating time shown in the Cold Weather Starting Chart.



2. Turn the HEAT-START switch to the START position. While cranking, discharge a quick spray of starting fluid into the air inlet or air cleaner.



3. If necessary, repeat the procedure.
4. After the engine starts, it may be necessary to return the HEAT-START switch to the HEAT position until the engine runs smoothly. Then release the switch.

ATTACHMENT

Jacket Water Heater

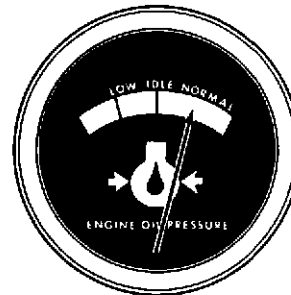
In very low temperatures, the lubricating oil must be warmed to allow starting. A jacket water heater can maintain the jacket water temperature at approximately 90°F (32°C). The warm jacket water will keep the oil in the upper part of the engine block warm enough to flow when starting.

Dipstick Oil Heater

Contact your Caterpillar dealer before installing a dipstick crankcase oil heater.

AFTER ENGINE STARTS

1. Observe the oil pressure gauge immediately after starting.



CAUTION

If oil pressure is not indicated, stop the engine and have necessary repairs made.

WARNING

Stop the engine if any repairs or adjustments are required. Do not work on machinery while the engine is running.

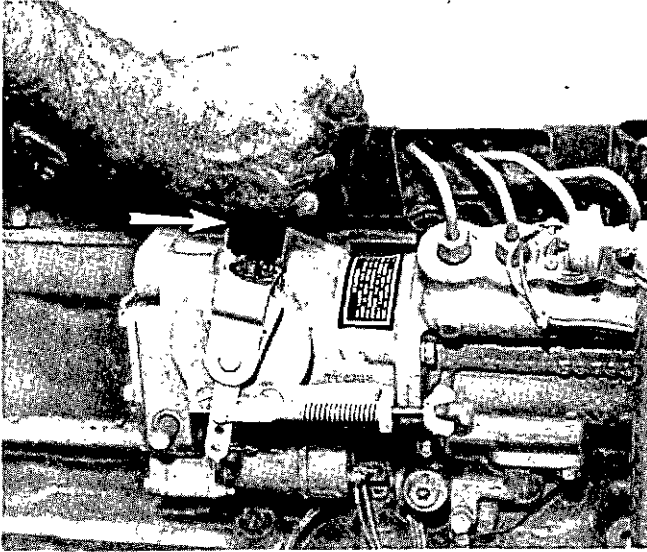
2. Move the governor control to low idle, allow the engine to warm (usually several minutes). Make another "walk-around" inspection for leaks, etc.

STARTING THE LOAD

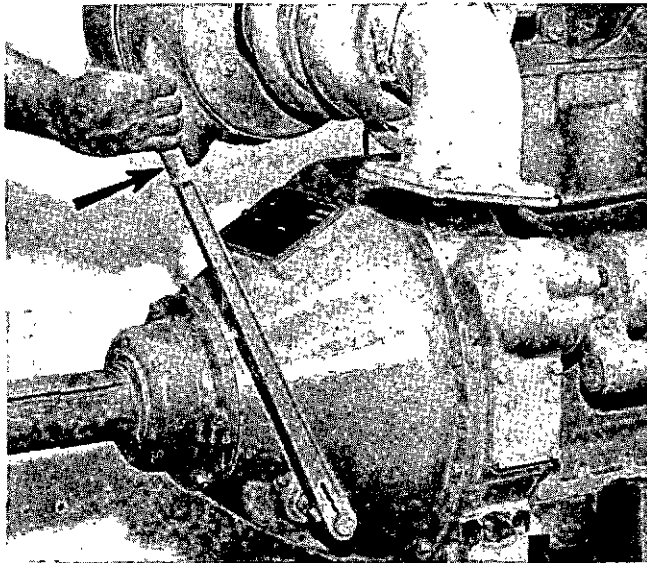
Driven Equipment Without Load:

To engage the driven equipment with no load:

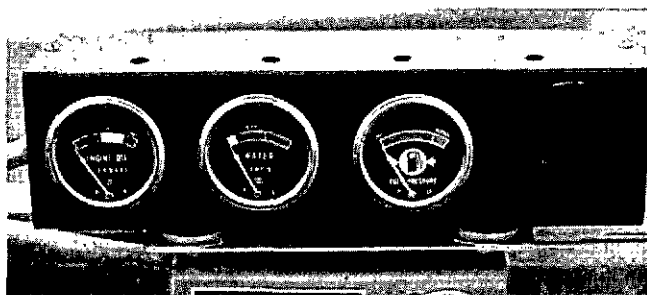
1. Move the governor control to half engine speed.



2. Engage the driven equipment with no load on the equipment.



3. Check the engine gauges.



4. Move the governor control to high idle (full load) position.
5. Apply the load to the driven equipment.

Driven Equipment With Load:

1. Move the governor control to half engine speed. Check the engine gauges.
2. Move the governor control to high idle (full load) position.
3. Engage the loaded driven equipment.

INSTRUMENT PANEL GAUGES

After the engine starts, and at frequent intervals while the engine is operating, the gauges should be observed. Determine the normal reading for each gauge. Investigate the cause whenever there is a significant change in the reading.

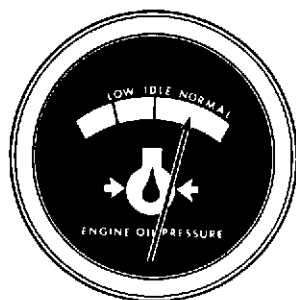
Your engine may be equipped with calibrated gauges. Periodic monitoring and recording of the gauge readings will provide a history of the engine's performance. A change in a reading will indicate a related problem is developing. Have the necessary repairs made before the failure and the resulting unexpected downtime occurs.

CAUTION

If a large quantity of oil or water is lost in a short period of time — as when the line ruptures — manually shut down the engine immediately. If the oil or water levels are allowed to go below the ADD levels, the safety shutoff devices will not protect your engine.

Engine Oil Pressure:

Oil pressure will be greatest after starting a cold engine. Oil pressure will decrease as the engine warms while idling. As the engine speed is increased to full load speed, oil pressure will increase into the NORMAL range and stabilize.



If the gauge reading fluctuates:

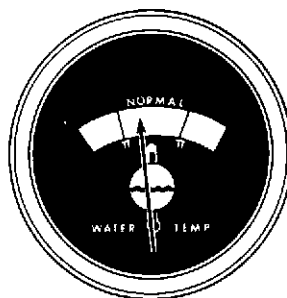
1. Remove the load.
2. Reduce engine speed to low idle.
3. Check the oil level. Maintain the oil level between the ADD and FULL mark on the ENGINE RUNNING side of the dipstick. If the reading continues to fluctuate, call your Caterpillar dealer.

CAUTION

If oil pressure drops rapidly at rated speed, stop the engine immediately.

Engine Coolant Temperature:

The temperature of the coolant may vary according to load, but should never exceed the boiling temperature for the pressurized system being used.



If the engine operates with the indicator in the HOT range and steam becomes apparent:

1. Reduce the load and speed.
2. Inspect for pressure steam or water leaks. Determine if the engine must be shut down immediately; or if the engine can be safely cooled by reducing the load.

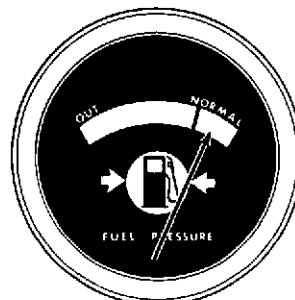
CAUTION

Do not add cold water to a hot engine: Cracking of engine components may occur. Allow the engine to cool, then add coolant.

The engine operating temperature should be approximately 200°F (95°C). If the temperature gauge reading registers in, or near, the cold range — approximately 170°F (75°C):

1. Check the temperature regulators for proper temperature range; and replace if necessary.
2. Check the water temperature gauge for accuracy.
3. Determine if the radiator is overcooled, and if radiator shutters are required.

Fuel Pressure:

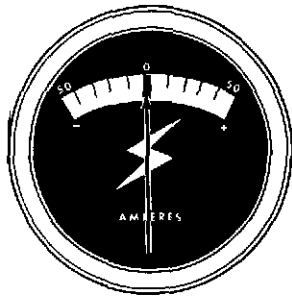


The fuel filter gauge indicates pressure of the filtered fuel. If the fuel filter gauge registers in the OUT range, clean the primary fuel filter if so equipped, and install a new fuel filter. See the LUBRICATION AND MAINTENANCE PROCEDURES topic, Fuel Filters.

In cold weather, paraffin crystals can form in the fuel and plug the fuel filter. If this occurs, use a fuel that has a lower CLOUD POINT. See your fuel distributor.

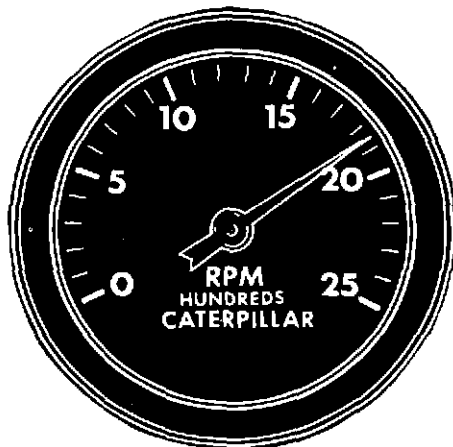
Ammeter:

The ammeter should indicate, just to the right of zero (in the "+" range), when the engine is warm and running at rated speed. If the gauge registers to the left (in the "-" range) as the engine speed is increased, determine and correct the cause.



Tachometer:

The tachometer indicates engine RPM. When the governor control lever is moved to the full speed position without load, the engine is running at high idle. When the governor control lever is moved to the full speed position and load is applied, the engine will slow slightly to full load speed. The high idle RPM and the full load RPM are stamped on the engine information plate. The engine can be operated between these two speed limits for long periods of time.

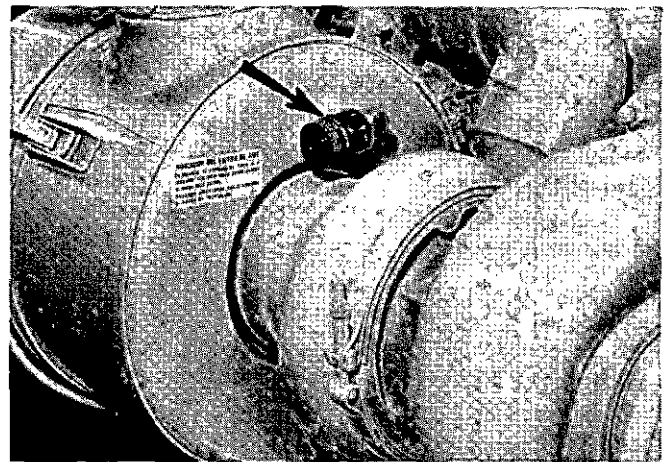


If the engine speed drops below full load speed with the governor control lever positioned in the full load position, the engine will be operating in a lug condition; see the topic, LUGGING.

INDICATORS

Air Cleaner Service Indicator:

Periodically check the air cleaner service indicator. If the red piston remains in the visible position, the air cleaner element requires servicing. See the LUBRICATION AND MAINTENANCE PROCEDURES topic, Air Cleaner Service Indicator.



ENGINE OPERATION

Full Load Operation:

The governor control lever should remain in the full governed position while operating at full load.

Reduced Load Operation:

If the load varies, or is cyclic, the governor usually will adjust the engine speed as required. If a slower constant speed is desired, move the governor control lever to desired speed position.

CAUTION

Be sure to increase engine speed before increasing the load.

Prolonged operation at low idle or reduced load may cause oil consumption and carboning in the combustion chamber and result in poor performance and a loss of power. Every four hours, load the engine to clear carbon from the combustion chamber.

No Load Operation:

If the load is temporarily removed, engine speed may be reduced by manually moving the governor control. However, the engine may be operated at high idle without causing shortened engine life.

CAUTION

Never operate an electric set below 2/3 full load RPM: Overheating and possible damage could occur to the generator below this RPM.

Lugging:

Lugging can occur at any engine speed and with most applications. Lugging occurs whenever engine speed decreases below full load speed with the governor control at full load speed position; or when an increase in governor control setting will not increase engine speed.

Lugging can damage an engine: Maximum fuel is injected at reduced engine speed; and the water pump, oil pump and fan run slower than required to cool the engine. Certain engine areas will become extremely hot and failure of parts could occur.

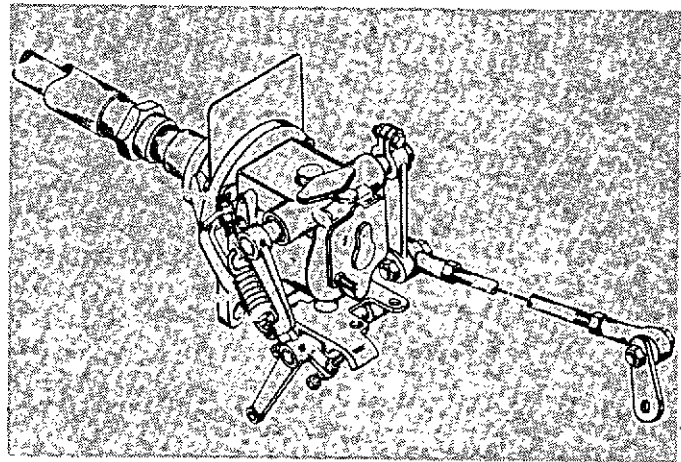
Because maximum engine torque is developed, lugging — if properly used — can be useful. Lugging will not cause damage if the lugging period is short in duration, and if the engine is allowed to cool.

An example of lugging could be a shovel digging through rock and clay. As the bucket is raised, the governor increases engine speed. If the bucket becomes lodged on a rock, the engine speed will drop, but the fuel consumption rate, exhaust temperatures and torque will increase. The operator must determine if either the rock can be loosened in a short period of time, or the bucket should be repositioned and the load reduced. If the rock is to be loosened while in lug condition, the engine must be able to cool in the time it takes to finish the cut, swing and dump the load, and return to the next load.

The temperature gauges for the engine should be closely watched during periods of lugging. If the temperature readings increase, the load must be reduced.

Output Shaft Governor Operation:

If the load can overspeed the torque converter output shaft, an output shaft governor should be installed. The output shaft governor is a speed limiting device.

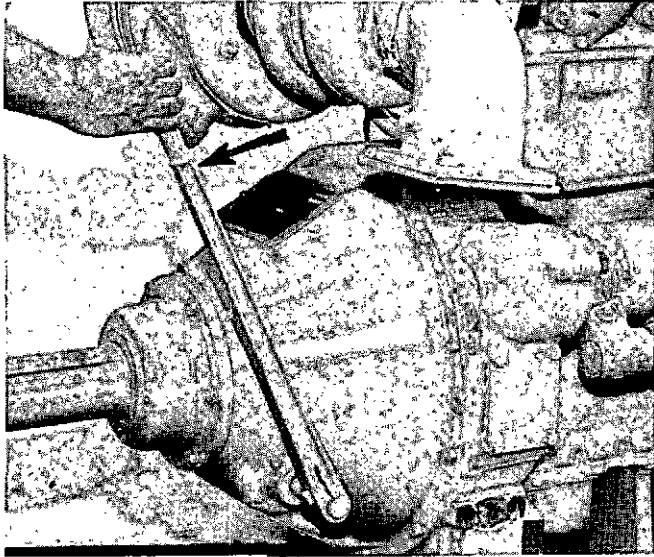


The output shaft governor is installed on the torque converter output shaft. It is connected to the engine governor through a hydraulic servo mechanism. Normally, the engine governor regulates engine speed. If the load is removed and the torque converter output shaft speed exceeds desired operating speed, the output shaft governor will operate the engine governor to reduce the speed of the engine. When the output shaft speed returns to normal operating speed, the engine governor maintains full load engine speed.

STOPPING

Remove the Load:

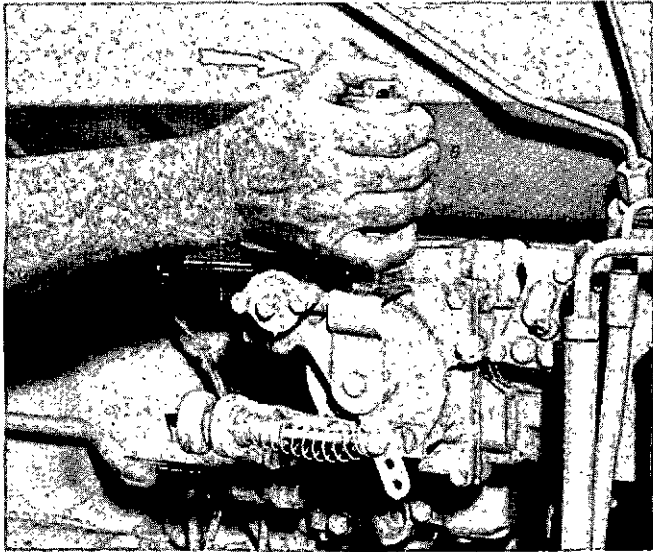
1. Flywheel clutch operation: Quickly pull the clutch lever to the released position.



For electric set operation, see the section AT-TACHMENT, Generator Set Operation.

Allow The Engine To Cool:

1. Reduce engine speed to half speed. Run for 5 minutes to cool the engine.



2. Reduce engine speed to low idle.

3. Check the crankcase oil level while the engine is idling. Maintain the oil level between the ADD and FULL marks on the side of the dipstick stamped CHECK WITH ENGINE RUNNING. See the LUBRICATION AND MAINTENANCE PROCEDURES topic, Diesel Engine Lube Oil.

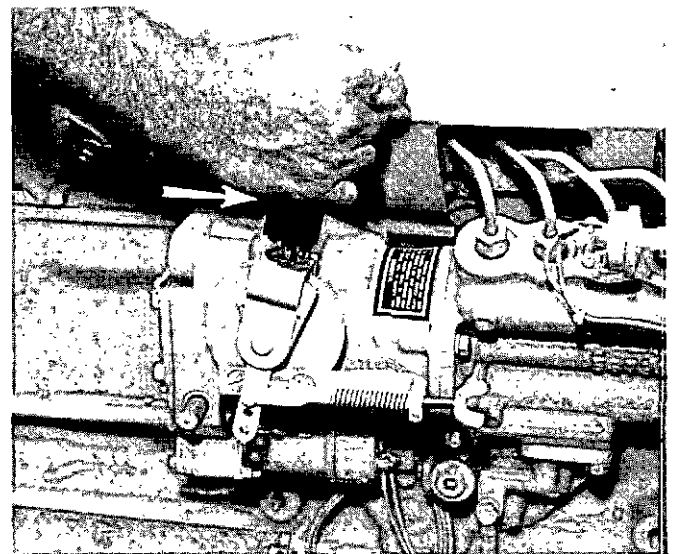


Stop the Engine:

1. Stop the engine by moving the engine governor control to the shutoff position.

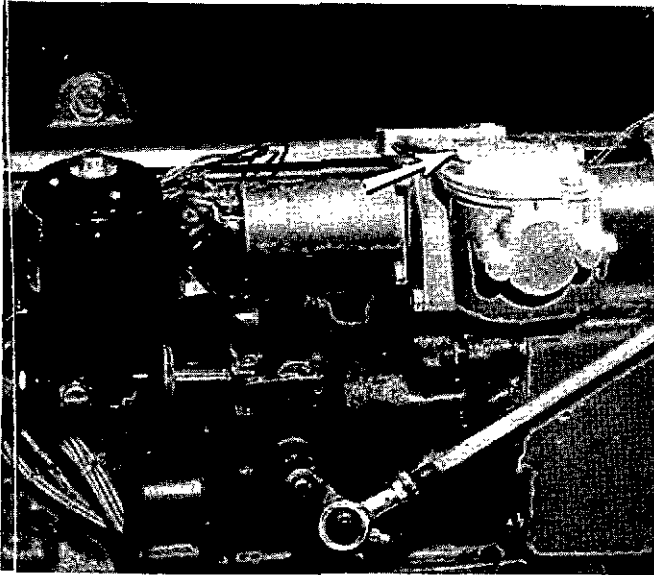
Mechanical Governor Control:

Pull upward on the hand grip, and move the control to the shutoff position.



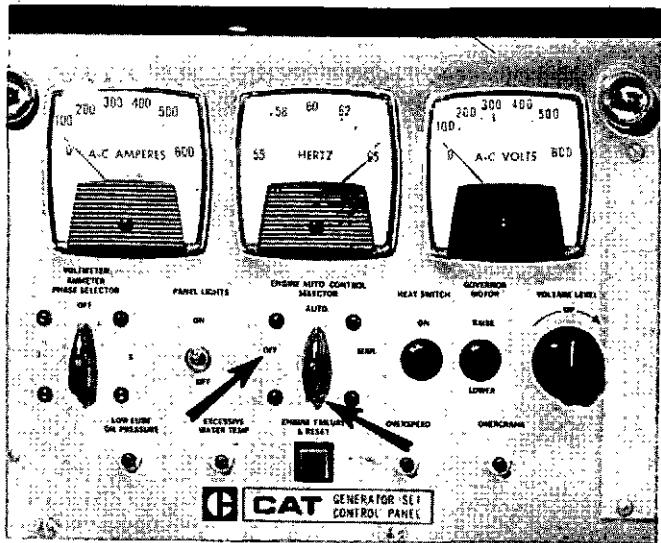
Woodward PSG Governor:

Move the lever forward against the stop; hold the lever until the engine is stopped.



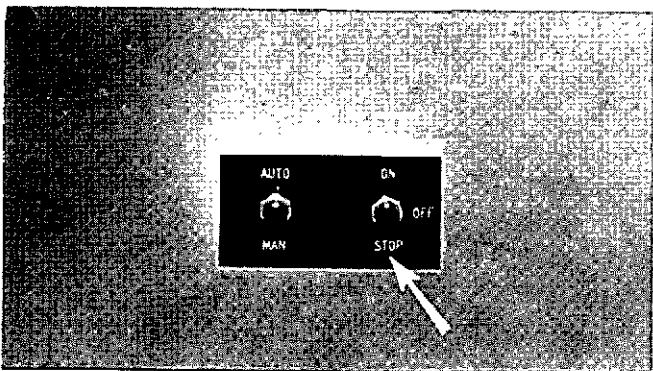
CAT Generator Set Control Panel:

Turn the ENGINE AUTO. CONTROL SELECTOR switch to the OFF or STOP position.



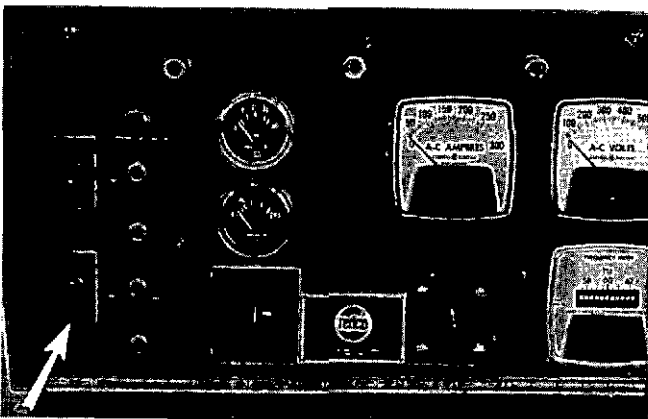
Air Controls:

Push and hold the ON-OFF-STOP switch in the STOP position until the engine stops.



REDCO Generator Set Panel:

Push and hold the ON-OFF-STOP switch in the STOP position until the engine stops.

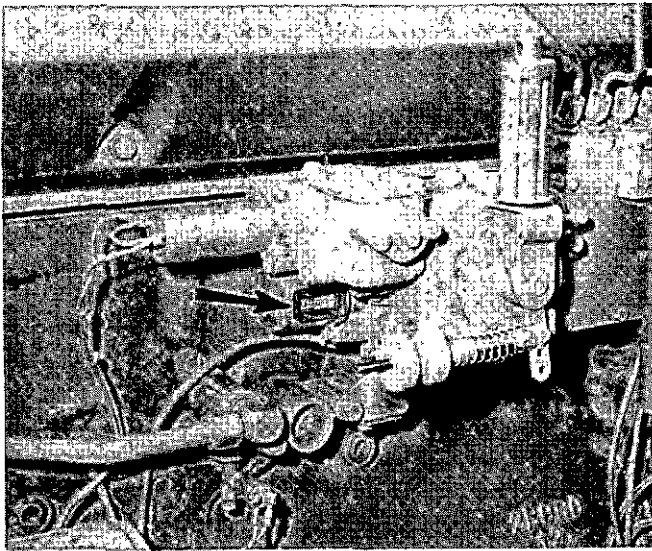


EMERGENCY STOPPING

To stop in an emergency, stop the engine as quickly as possible. How the engine should be stopped depends on where the operator is standing and how the engine is equipped.

AFTER STOPPING CHECKS AND PROCEDURES

1. Fill the fuel tank. See the LUBRICATION AND MAINTENANCE PROCEDURES topic, Fuel Tank.
2. Drain the raw water system if below freezing temperatures are expected; see the topic, Draining Raw Water System in the LUBRICATION AND MAINTENANCE PROCEDURES.
3. If below freezing temperatures are expected, allow the engine jacket water expansion tank to cool; then check the coolant for proper antifreeze protection. Add permanent type antifreeze if required. See the LUBRICATION AND MAINTENANCE PROCEDURES topic, Cooling System.
4. Repair any leaks, correct major adjustments, tighten loose bolts, etc.
5. Observe the Service Meter reading. Perform the periodic maintenance as instructed in the LUBRICATION AND MAINTENANCE CHART.



6. Perform the required maintenance on all other equipment; see the equipment manufacturer's instructions.

STORAGE

If the engine is not started for several weeks, the lubricating oil drains from the cylinder walls and piston rings. This lack of oil permits the piston rings to rust; and causes metal-to-metal contact between the piston rings, the pistons and the cylinder liners when the engine is started. This metal-to-metal contact will result in shorter engine life. To prevent excessive engine wear:

1. Be sure all lubrication points mentioned in the LUBRICATION AND MAINTENANCE CHART are serviced.
2. Once a week, start and run the engine until it is thoroughly warm. For unattended automatic start-stop systems, an engine exerciser can be installed for this purpose.
3. Stop the engine, perform required servicing.
4. Check the cooling system for adequate protection against freezing if freezing temperatures can be expected. A 50-50 solution of permanent type antifreeze and approved water will give protection below -20°F (-29°C).

If it will be impossible to start the engine every week, see your Caterpillar dealer for instructions to prepare your engine for further storage.

ATTACHMENTS

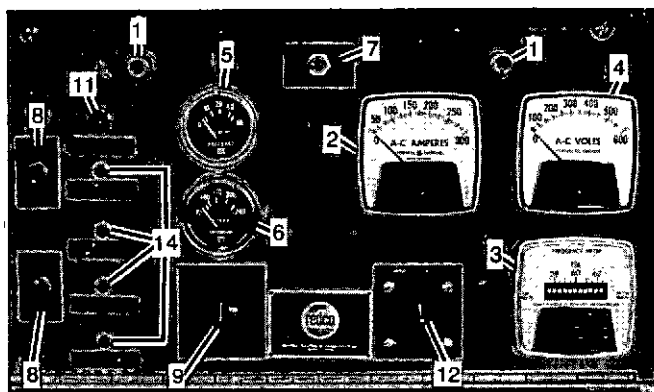
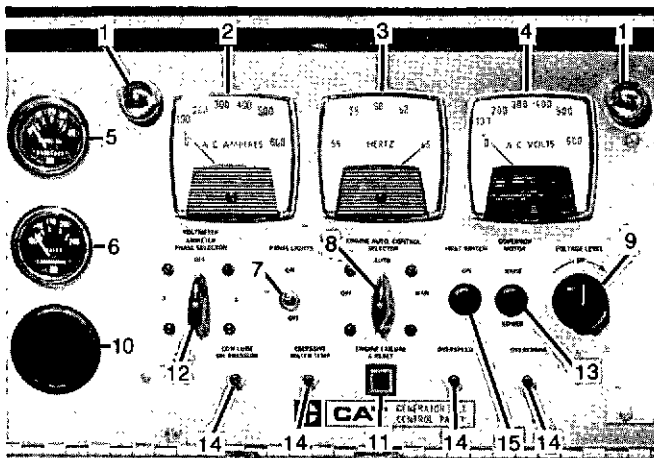
GENERATOR SET CONTROL PANEL

The control panel may be mounted either on top of the generator; or, remote mounted from the generator set. The control panel mounted on top of the generator may be either one of the 2 types shown below. Remote instrument panels will vary depending upon the type of installation.

The ON/OFF Switch (7) controls the Panel Lights (1). Heat Switch (15) operates the glow plugs for cold weather starting. Engine Control Switch (8) allows choosing the method of operation. Gauges (5) and (6) indicate the engine oil pressure and water temperature respectively. DC Ammeter (10) indicates alternator output.

Voltage level control of the generator set is regulated with Rheostat (9). Ammeter Selector Switch (12) allows for Phase T1, T2 or T3 generator output to be indicated on Ammeter (2). This ammeter and Frequency Meter (3) and Voltmeter (4) indicate generator output. Governor Control Raise-Lower Switch (13) controls frequency output.

Engine Failure Light/Reset Switch (11) indicates if an engine fault occurs; and one or more of Indicators (14) will indicate the problem(s). The indicators are activated by low oil pressure, high water temperature, engine overspeed, or excessive cranking while trying to start.

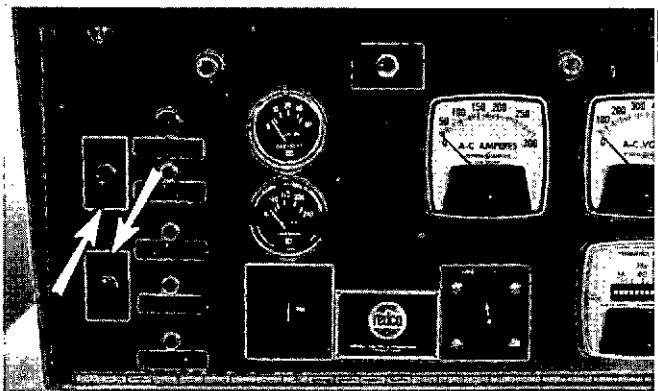
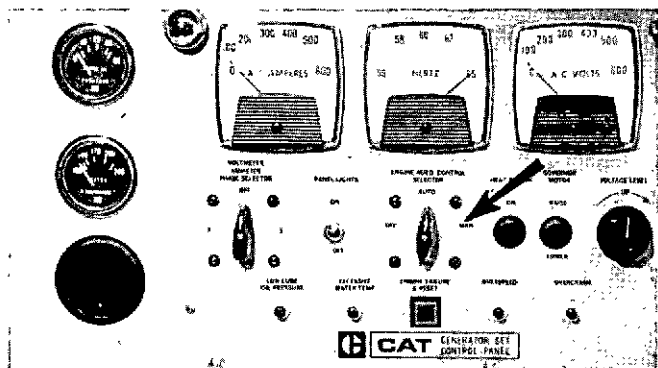


GENERATOR SET OPERATION

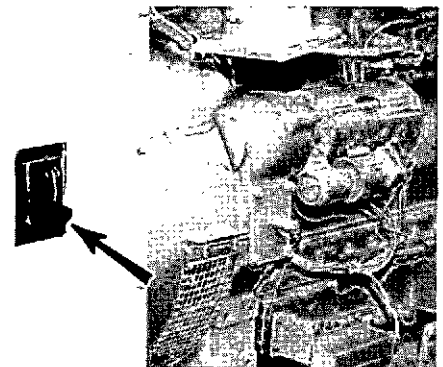
SINGLE UNIT OPERATION

Starting

1. Make all engine pre-start checks.
2. Be sure the main or line circuit breaker is open.
3. Move the Engine Control Switch (8) to the MANUAL position. The starting motor will crank the engine until it starts, the pinion will then disengage from the flywheel and the starting motor will stop.

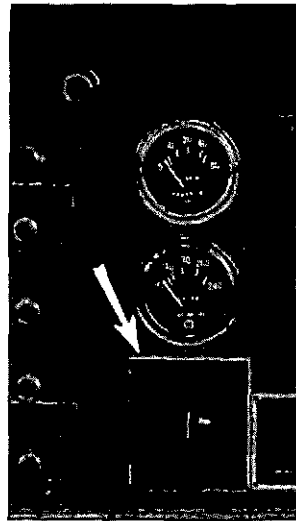
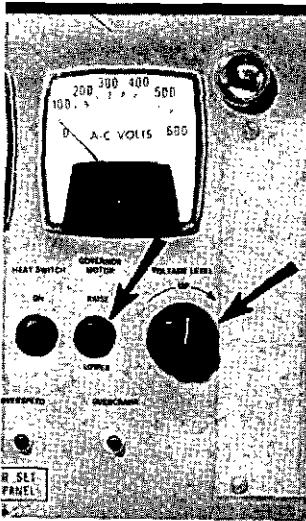


4. Close the main circuit breaker.

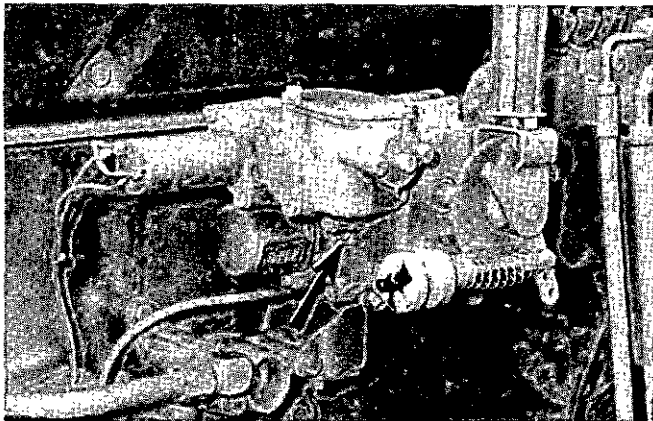


5. Apply the load by increments to maintain a constant frequency level. Do not apply the load in one step.

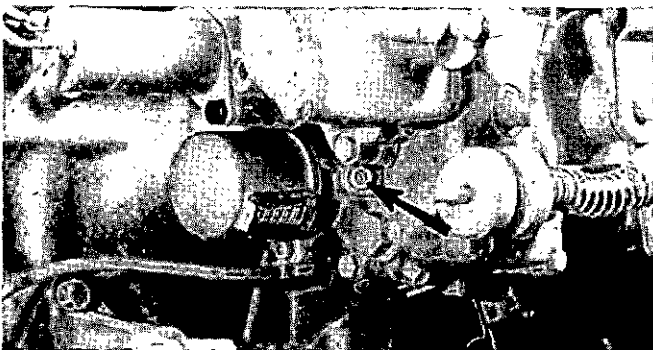
- Adjust the Governor Motor and/or Voltage Level as required to attain the required instrument panel gauge readings.



If the engine surges, an adjustment to the dashpot needle valve can be made on engines equipped with a Sleeve Metering Fuel System.



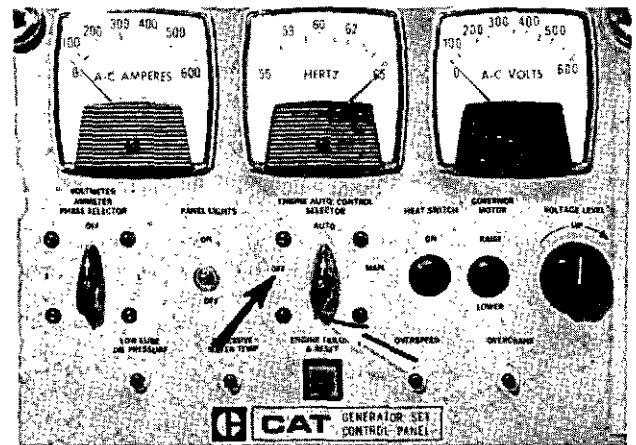
- Turn the needle valve clockwise until it contacts the valve seat.



- Turn the needle valve counterclockwise $\frac{1}{4}$ of a turn (90°).
- Listen to the sound of the engine and make a final adjustment if needed.

Stopping

- Remove the load by increments.
- Open the circuit breaker.
- Reduce the engine speed to low idle and allow the engine to cool by idling for 5 minutes.
- Check the engine oil level while the engine is idling. Maintain the oil level between the ADD and FULL marks on the side of the dipstick stamped CHECK WITH ENGINE RUNNING. See the LUBRICATION AND MAINTENANCE CHART for proper oil to add.
- Move the Engine Control Switch to the OFF or STOP position.



- Fill the fuel tank with the proper fuel. See the LUBRICATION AND MAINTENANCE CHART.
- Complete all of the procedures described in the topic AFTER STOPPING CHECKS AND PROCEDURES in the section, ENGINE OPERATION.

MULTIPLE UNIT OPERATION

Starting

Start each unit as a single unit; see the starting instructions above.

Circulating Currents

When two units are paralleled there will be circulating currents. These currents are not doing useful work, but are flowing between the generators. By determining the total generator amperage and subtracting the amperage going to the load, the amount of circulating current can be determined.

Circulating currents are caused by voltage differences between the two units. As the oncoming generator warms up the circulating current will be reduced.

In a cold unit, circulating current may be as high as 25% of rated amperes without being harmful. Circulating current is part of the total generator current, which must not exceed the rated amperage.

Paralleling

Units may be paralleled at no load or paralleled with units under load. To parallel two or more units the following conditions must be met:

- Same phase rotation.
- Same voltage level.
- Same voltage droop.
- Same frequency.
- Voltages must be in phase.

To make the initial adjustments for the above conditions, see the ELECTRIC SET OPERATION INSTRUCTIONS. After being sure the initial adjustments have been made:

1. Start the unit to be paralleled according to the procedure in the engine operation section.
2. Turn the synchronizer lights on.
3. After the engine has run long enough to warm up, bring it up to synchronous speed (the same frequency as the unit on the line). The synchronizing lights will begin to blink as they approach the same speed.
4. Using the governor control adjust the speed until the lights slowly go on and off together. If the lights blink in sequence, see the ELECTRIC SET OPERATION INSTRUCTIONS; topic, Phase Rotation.

5. Both lights are off when the voltages of the two units are in phase. At this point very quickly close the breaker while both lights are out.

NOTE

The frequency of the incoming unit should be slightly greater than the line frequency. This will allow the incoming unit to assume some of the load.

Load Division

When two units have been paralleled, the load of each generator is determined by their governor control settings. If two units of the same capacity and the same governor characteristics have the same governor control settings, they will share the load equally.

NOTE

The total load must not exceed the capacity of the engines, or the engines will be overloaded.

To transfer the load from one engine to the other:

1. Increase the governor speed control of the incoming unit to the high idle position to assume the load.
2. Reduce the governor speed control of the outgoing unit until the generator amperage is at a minimum. (The amperage may never be zero due to circulating currents.) At this point transfer the load.

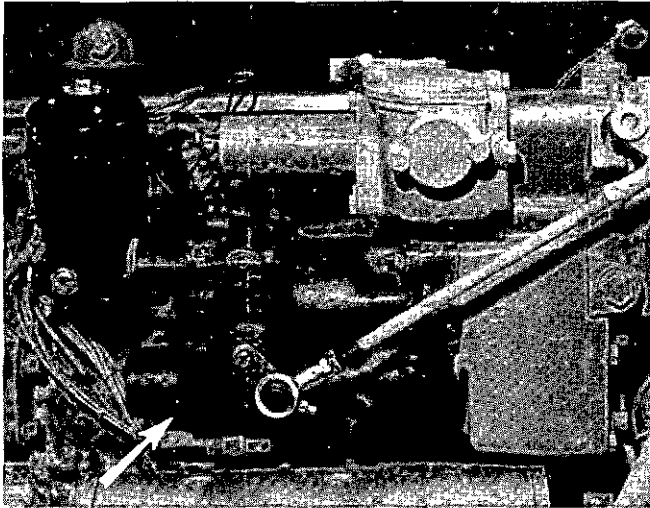
Stopping

To remove a generator from the line do the following:

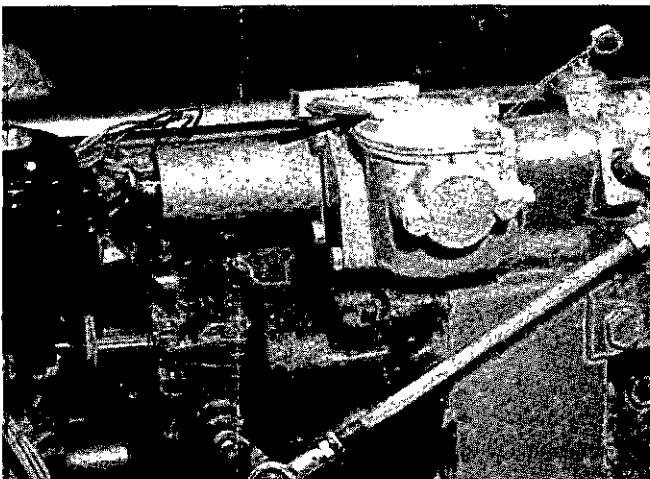
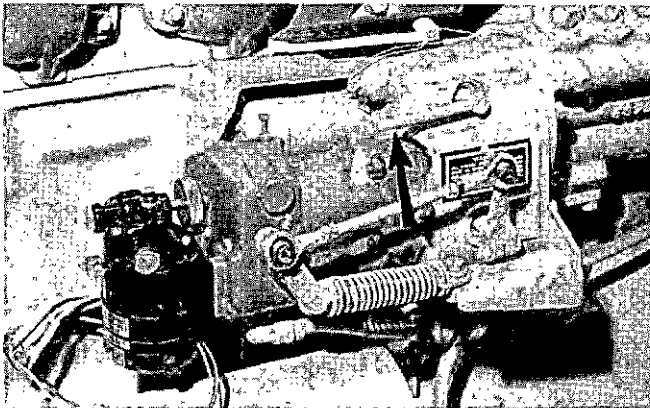
1. Check the load. It must be less than the rated capacity of remaining units.
2. Be sure the neutral of one of the remaining units is grounded.
3. Remove the load from the outgoing unit as described in LOAD DIVISION.
4. Open the circuit breaker.
5. Allow the engine to cool by idling for 5 minutes.
6. Check the engine oil level while the engine is idling. Maintain the oil level between the ADD and FULL marks on the side of the dipstick stamped CHECK WITH ENGINE RUNNING.
7. Stop the engine by moving the engine control switch to the STOP position.

WOODWARD GOVERNORS

Woodward Governors are usually electrically operated from a control panel. The load application is usually a generator set operation similar to that which is described above. On standby sets the governor may be set to operate only at full load speed.



The engine may be stopped manually by moving the hand lever upward or forward, depending upon the installation.



Hold the lever in the stop position until the engine stops.

AUTOMATIC OPERATION

OPERATION

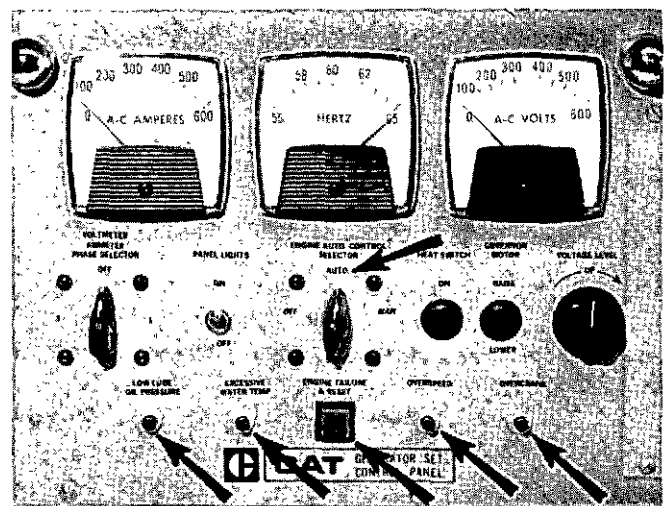
An automatic start-stop system is usually a single unit standby operation whereby the engine must start, pick up the load, operate the load, remove the load and stop with no one in attendance. A control panel with the proper switch gear is needed to start the engine.

The engine mounted control panel discussed in the topic, Single Unit Operation, can be used for this operation.

Starting Conditions

The following conditions must exist for the engine to start unattended:

1. Either the ambient engine room temperature must be at least 70°F (20°C); or, the engine coolant temperature must be at least 90°F (32°C). A jacket water heater can maintain the necessary temperature.
2. The governor control must be set for the full load engine speed position. If the generator set is exercised or operated manually, be sure the throttle setting is returned to full governed position.
3. All switches must be properly set. The engine control switch must be in the "AUTO" position, and all emergency shutoff devices must be in the RUN position.



PROTECTION DEVICES

The engine must be equipped with protection devices to protect the engine while running with no one in attendance.

Alarms and Shutoff Devices

Alarm systems provide either an audible or a visual warning, or both, when certain abnormal operating conditions occur. These conditions can be low fuel supply, low oil pressure, or high engine coolant temperature. The alarm will be activated until the cause for the condition is corrected. The alarm sensor will then return to its normal position, and shut off the alarm circuit.

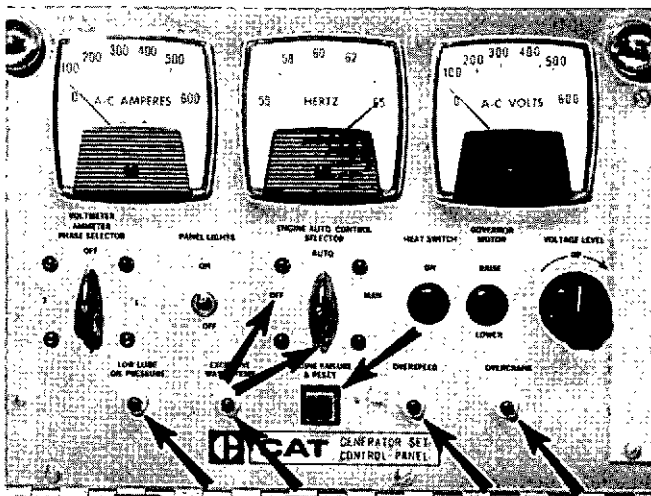
If no action is taken when the alarm is activated for lack of lubrication or coolant, the engine can be damaged. To prevent this from occurring to unattended engines, shutoff devices should also be used.

At a slightly different temperature or pressure range than that which activates the alarm system, the shutoff device stops the engine. The Engine Failure Light on the control panel and one or more of the indicators will either light, or pop out to indicate the problem. Repairs must be made before starting is attempted.

STARTING AFTER A SHUTDOWN

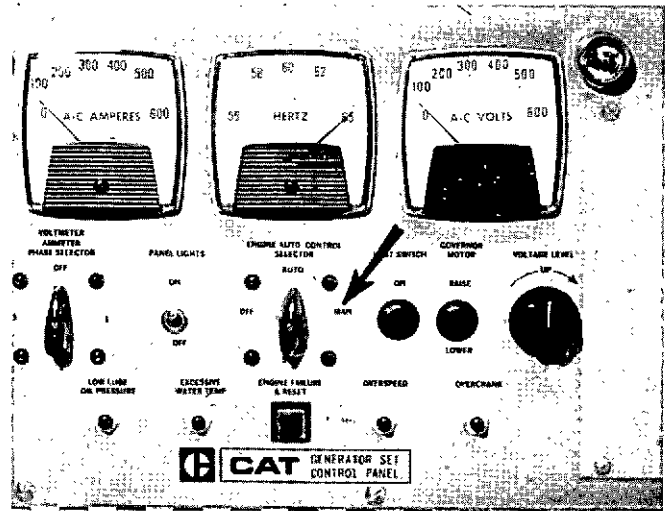
After the repairs have been made:

1. Push in the engine failure light/reset switch.
2. Move the engine control switch to either the STOP or OFF position.

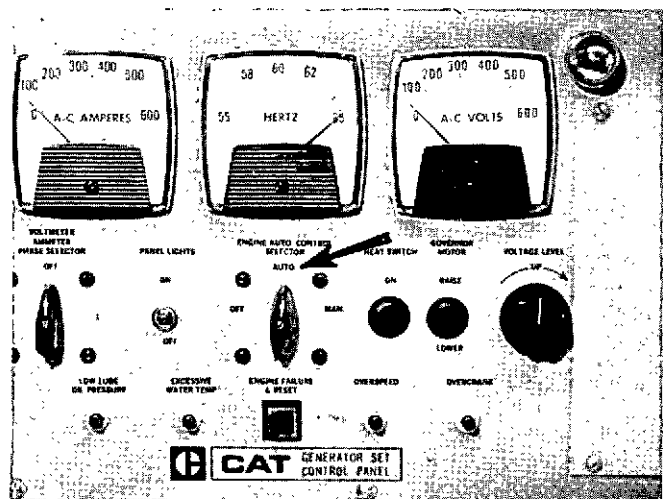


3. Push in or reset the shutdown indicator/light that was tripped.
4. Reset the emergency shutoff device if necessary — see the topic, Emergency Shutoff Devices and Alarms for instructions.

5. Turn the engine control switch to MANUAL position. Operate the generator set to be sure the engine problems are corrected.



6. When engine performance is found to be satisfactory, turn the engine control switch to the STOP or OFF position and stop the engine.
7. Position the governor control in the full load position to allow the engine to start automatically.
8. Turn the engine control switch to the "AUTO" position.



ATTACHMENT TIMERS

Cranking Timer

There are two cranking timers which may be used on an Automatic Start-Stop generator set.

One type allows the engine to crank for 30 seconds. The second type cranks the engine up to 10 seconds for as many as 5 successive starting attempts. If the engine does not start during the specified time period, the fuel will be shut off and a light will indicate a starting failure.

Cooling Timers:

After the commercial power has returned to service, the load is removed from the engine. The engine will continue to run for a period up to 5 minutes. After the engine has cooled, the timer then stops the engine.

ENGINE EXERCISER

At preset times, the exerciser will start, run and stop the engine. This ensures both proper lubrication of all engine parts and proper equipment operation when the standby unit is needed.

Become familiar with all instructions included with the equipment.

GENERATOR STORAGE

When a generator is stored for any length of time, *moisture condenses in the windings. Minimize the condensation by providing a dry storage space.*

To remove moisture caused by high humidity or dampness, *dry the generator by one of the following methods:*

1. Place the generator in an oven and bake at a temperature not above 185°F (85°C) for four hours.

CAUTION

If an oven is used for drying, use a forced air type rather than a radiant type. Radiant ovens can cause localized overheating.

2. Enclose the generator and heating lamps in canvas to raise the temperature. Leave the opening in the top for the moisture to escape.
3. Pass a low voltage current through the windings to raise the temperature of the windings to 185°F (85°C).
4. If there is a possibility that the insulation resistance has deteriorated to a dangerously low level, contact your Caterpillar dealer.

If a brush type generator (SRCR) is to be stored for a prolonged time, lift the brushes off the slip ring to prevent chemical action from damaging the slip ring.

EMERGENCY SHUTOFF DEVICES AND ALARMS

Emergency shutoff devices are either electrically or mechanically operated. Familiarize yourself with the types and locations of the shutoff devices, the conditions which cause each control to function, and the resetting procedure required to start your engine.

CAUTION

Always determine the cause of the shutdown, and have the necessary repairs made before re-starting the engine.

Emergency shutoff controls are for emergency use only. Do not use an emergency shutoff device for a normal stopping procedure.

ELECTRIC SHUTOFF CONTROLS

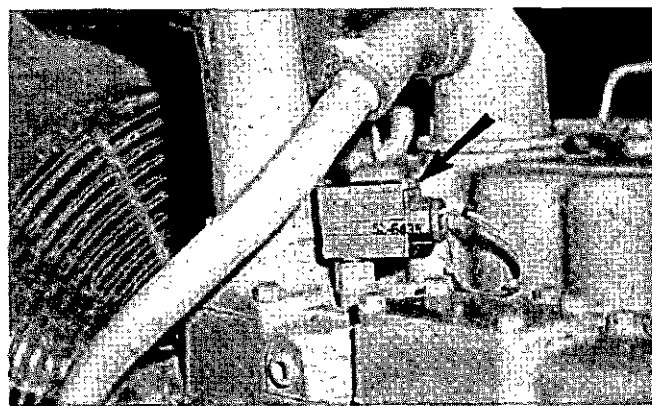
The operation of all electric shutoff controls is similar: A critical operating condition actuates a switch in the sensing unit. The switch closes the circuit to the shutoff solenoid which moves linkage to bypass the fuel to the cylinders; thus stopping the engine. The shutoff control may require resetting before the engine can start.

High Water Temperature Shutoff:

The shutoff switch is located in the water temperature regulator housing. Excessive water temperature closes the switch. No resetting procedure is required: As the coolant cools, the switch opens.

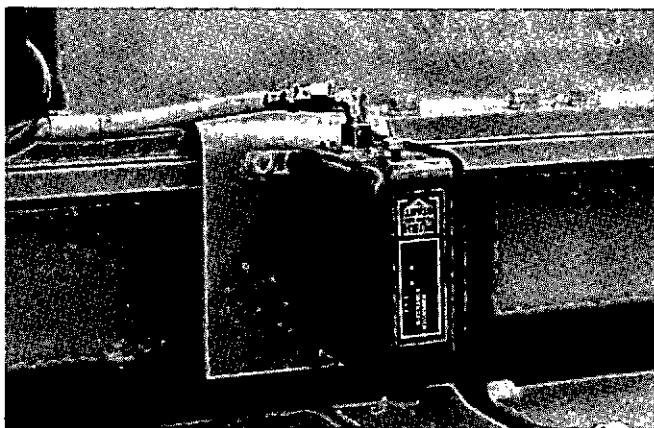
CAUTION

The sensing element must be submerged in the coolant to operate. A low coolant level cannot actuate the shutoff.

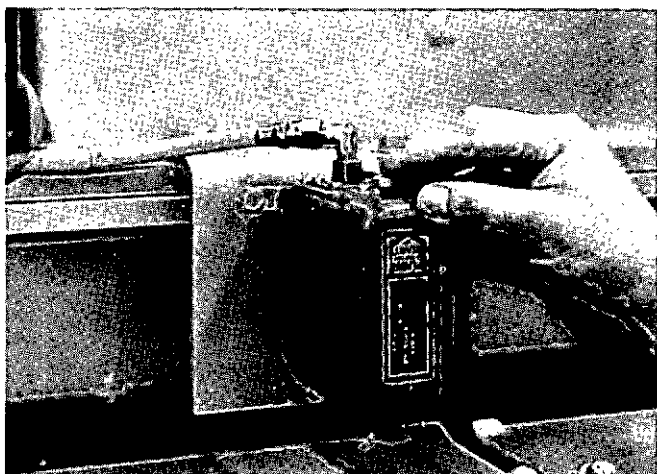


Low Oil Pressure Shutoff Switch:

This device is usually mounted on the side of the engine with oil lines connected to the switch. Low oil pressure closes the switch.



Manually operated systems require resetting by pushing the button until it latches. After the engine starts and develops oil pressure, the oil pressure will push the button to the extended running position.



CAUTION

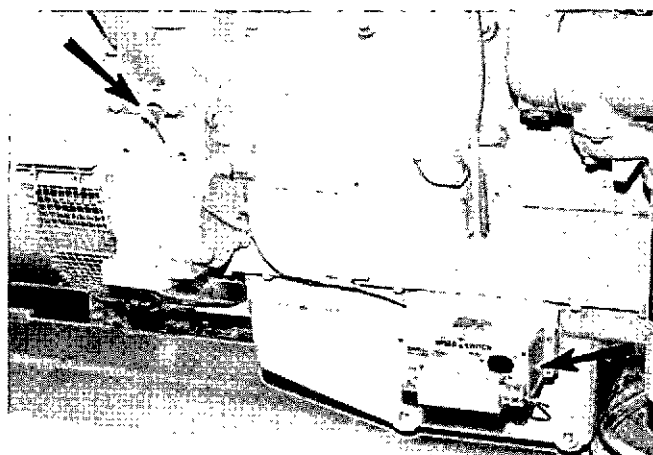
If the reset knob does not move to the extended position after the engine starts, the engine will not be protected by this switch.

If the button remains in the reset position, the engine oil pump is not developing normal oil pressure and a check should be made.

Automatic start-stop systems use a pressure switch which resets itself.

ELECTRONIC OVERSPEED SHUTOFF SWITCH

This switch uses a magnetic pickup mounted in the flywheel housing to sense engine speed.



Overspeed Shutoff:

Should the engine overspeed, the magnetic pick-up will close the circuit to the fuel shutoff solenoid and stop the engine.

The shutoff switch can be checked for proper operation at 75% overspeed condition:

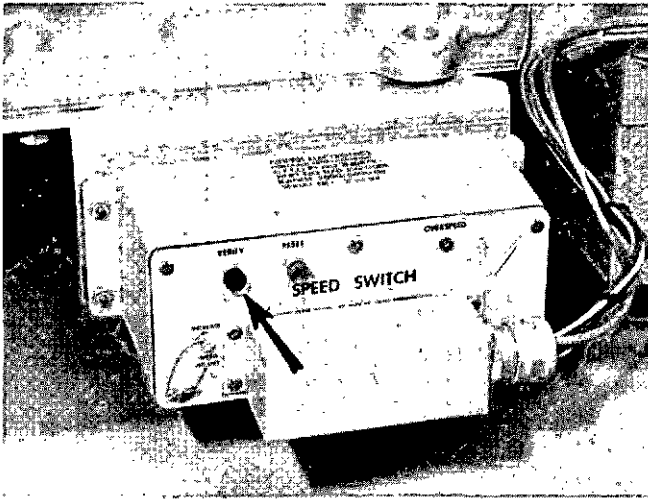
1. Determine the full load RPM of the engine from the serial number plate.
2. Operate the engine at the corresponding speed shown in the OVERSPEED TEST RPM Column of the chart below.

FULL LOAD RPM	OVERSPEED TEST RPM	ACTUAL OVERSPEED RPM
1500	1328	1770
1800	1593	2124
2000	1770	2360
2200	1947	2596

NOTE

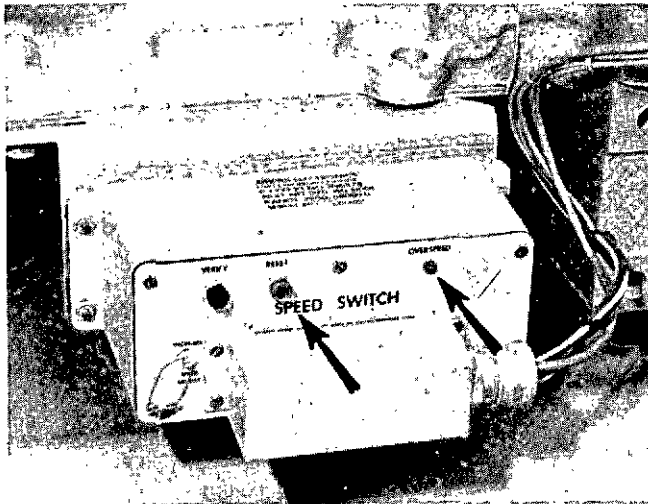
The Overspeed Test RPM is slower than the Full Load RPM:
 $\text{FULL LOAD RPM} \times .885 = \text{OVERSPEED TEST RPM}$

3. While maintaining test RPM, push and hold the VERIFY button. The engine should stop.



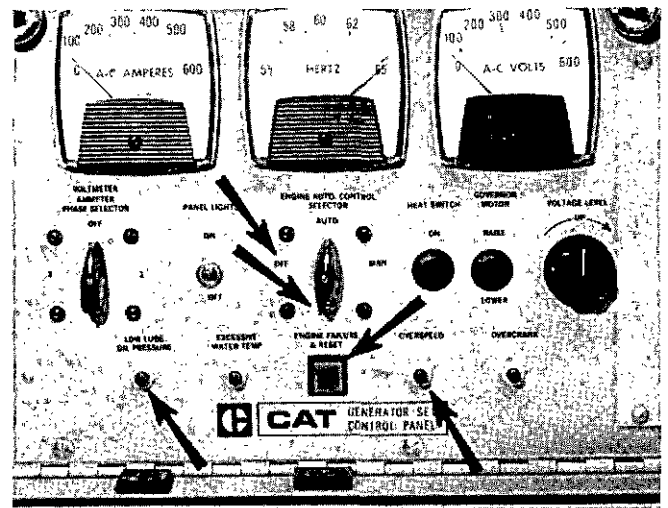
If the engine does not stop at the specified test RPM, contact your Caterpillar dealer.

As the engine stops, the yellow light will light. The RESET button must be pushed before starting the engine.

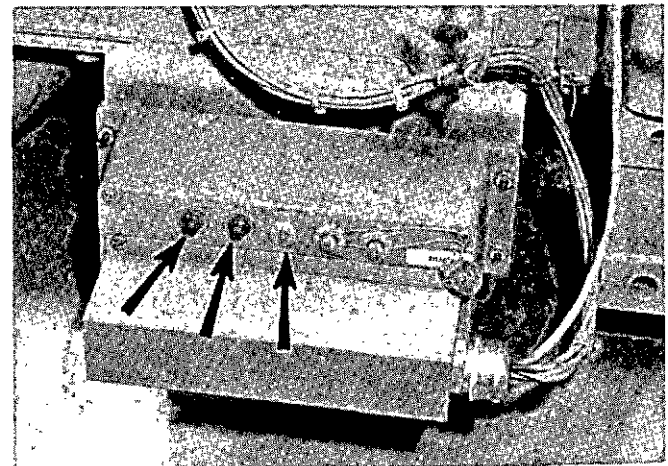


If the engine is equipped with a CAT Generator Set Control Panel, the safety devices on the panel must be reset:

1. Turn the Engine Auto. Control Selector switch to OFF or STOP position.
2. Push the Engine Failure and Reset button in to the reset position.
3. Push in on the OVERSPEED indicator to the reset position.



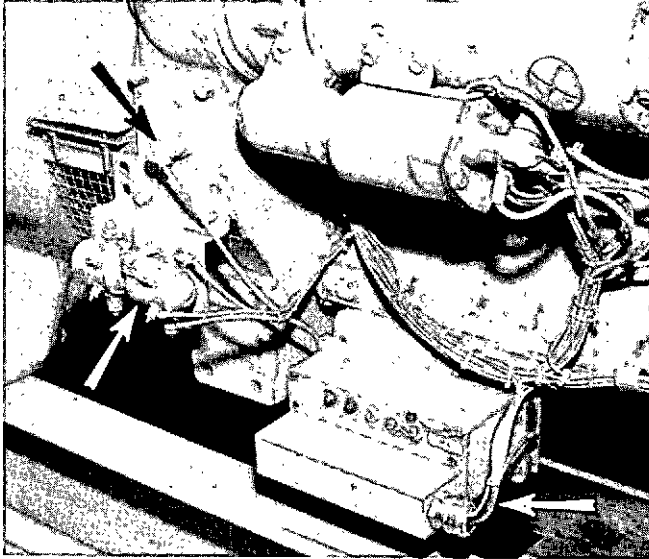
ELECTRONIC OVERSPEED SHUTOFF SWITCH WITH CRANKING TERMINATION



This switch has a 75% VERIFY button, a RESET button and an indicator light similar to the speed switch just discussed. The operation of this portion of the switch is identical in all respects to the one just described.

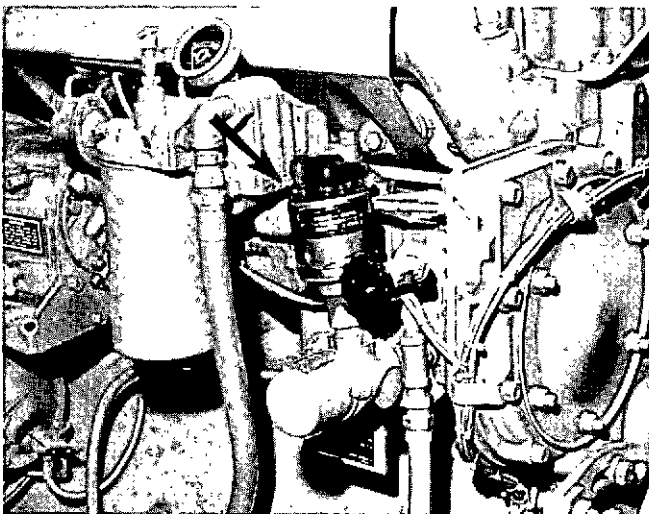
In addition, this switch has a second sensing circuit which prevents the starter pinion from remaining engaged in the flywheel at excessive RPM.

After the starting motor has cranked the engine, the pinion gear can remain engaged with the flywheel as engine speed increases. At 600 RPM, the magnetic pickup opens the circuit to the starter motor which allows the pinion to disengage. The circuit remains open until the flywheel stops. This prevents energizing the starter motor again while the flywheel is turning.

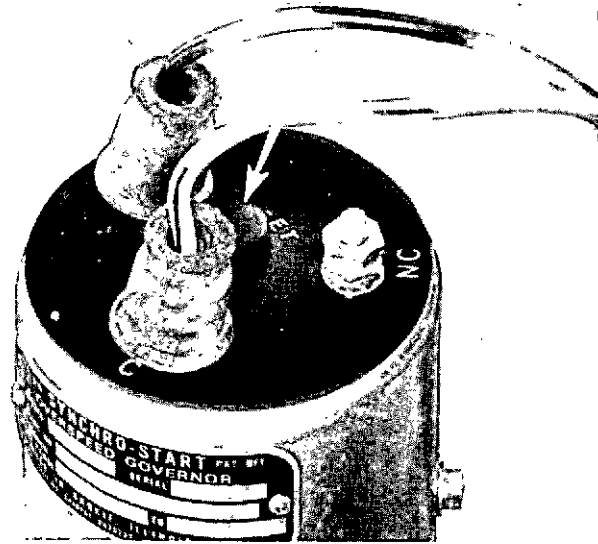


Overspeed Shutoff Switch (Electro-Mechanical):

This switch is mounted either on the tachometer drive or on the governor. Excessive engine speed closes the switch by centrifugal force.



To reset the switch, push the button marked RE-SET. The knob will remain down until the engine overspeeds.



ALARM SWITCHES

Alarm switches are set at a less critical temperature, pressure, or level limit than the comparable shutoff control. The alarm switch warns the operator that an unsafe operating condition is starting to occur. Corrective measures should be taken to avoid possible damage to the engine and/or a possible shutdown of the engine.

CAUTION

It could be hazardous to have the engine stop unexpectedly when engine power is needed. However, if the engine overspeeds, the engine must be stopped immediately.

When the preset temperature, pressure or fluid level occurs, the alarm switch will either turn on a light or an audible alarm. The light or alarm will continue to operate until the condition is corrected. When the condition is corrected the alarm will automatically reset and the light will turn off.

CAUTION

The cause of the shutdown must be investigated and corrected before starting the engine.

Alarm Shutoff Switch:

A switch may be installed in the alarm circuit for silencing the alarm while the engine is stopped for repairs. Before starting be sure the switch is moved to the closed (ON) position and the warning lights are lit.

CAUTION

If the switch is left in the open (OFF) position when the engine is started, the engine will not be protected.

Testing Indicator Lights:

Most control panels are equipped with a test switch. By turning the switch ON, all of the indicator lights can be checked for proper operation. Test the indicator lights periodically, replace burned out light bulbs immediately.

TESTING SHUTOFF DEVICES AND ALARMS

Have all shutoff controls and alarms on the engine checked twice a year by your Caterpillar dealer.

It is important that these controls function properly. Their operating condition can only be checked by simulating extreme operating conditions under controlled testing procedures. To avoid damage to the engine, only authorized personnel should conduct these checks.

DETERMINING CAUSE OF SHUTDOWN

CAUTION

If the engine has been shut down by a safety device, do not start the engine without having the cause of the shutdown corrected.

Low Oil Pressure Checks:

If the low oil pressure shutoff control has stopped the engine, make the following checks:

1. Check the water temperature gauge. Determine if the engine was overheated. Check for external water leaks.

WARNING

Beware of steam or scalding water. Do not attempt to loosen the radiator cap until the temperature gauge indicates the coolant has sufficiently cooled. Then, loosen the cap slowly.

2. Check the oil level. Oil level must be between the ADD and FULL marks on the side of the dipstick stamped CHECK WITH ENGINE STOPPED.
3. If the oil level is below the ADD mark, check for oil spray and/or oil accumulations. Have necessary repairs made. Add oil to the FULL mark on the oil dipstick.
4. Reset the shutoff control.
5. Remove the load and start the engine at its slowest speed.

CAUTION

Be prepared to shut the engine down manually.

6. Listen for unusual sounds or noises. If the engine knocks, stop the engine immediately and contact your Caterpillar dealer.
7. If the engine emits excessive black exhaust or has excessive crankcase pressures, the engine may need reconditioning. Stop the engine and contact your Caterpillar dealer.
8. If the engine runs satisfactorily, observe the oil pressure gauge. If below normal oil pressure is indicated even as engine speed is increased, stop the engine and contact your Caterpillar dealer.
9. If normal oil pressure registers, see if the oil pressure shutoff reset knob has turned to the RUN position. If the knob has not moved, stop the engine. Inspect the shutoff control, the oil line, and the oil pressure gauge. Have necessary repairs made.
10. If the engine operation is satisfactory with both normal oil pressure and the shutoff control in the RUN position, determine if the high water temperature shutoff has stopped the engine.

High Water Temperature Checks — Engine Running:

1. Determine if the load was too great for the engine: Reduce the load and allow the engine to cool while running.

2. If pressure steam or water leaks are visible, remove the load and stop the engine. Have the necessary repairs made.
3. Inspect for collapsing or deteriorated water hoses. Have necessary repairs made.
4. Listen for noisy water pump operation. Have necessary repairs made.
5. Refill the cooling system with either a solution of water and permanent type antifreeze if below freezing temperatures are expected; or with the recommended solution of approved water and Caterpillar Corrosion Inhibitor. Follow the instructions on the container.

⚠ WARNING

DO NOT remove the pressure cap on an overheated engine. The coolant is under pressure; and removing the cap releases the pressure to cause the coolant to flash into steam. Serious flesh burns and engine damage can result. If necessary, reduce pressure in the surge tank by pouring warm water on the tank. Never add cold water to a hot engine.

NOTE

If there is adequate coolant in the cooling system, gradual cooling produced by running the engine at half speed is preferred. This eliminates concentrated hot spots from developing inside the engine. Hot spots can cause failure of internal engine parts.

**High Water Temperature
Checks-Engine Stopped and Cold:**

1. Observe the coolant level. Determine if the coolant has proper antifreeze protection. A 50-50 solution of permanent type antifreeze and approved water will afford protection below -20°F (-29°C).
2. Be sure the raw water valve is open.
3. Test the water pump drive V-belts for proper tension; See the LUBRICATION AND MAINTENANCE PROCEDURES; topic, Fan Belts.
4. Inspect engine room vents and/or louvers. Be sure the engine is receiving sufficient clean, cool air.
5. Be sure the temperature regulators are operating at proper temperature range.
6. Inspect all water hoses carefully for signs of collapsing, and external and internal failures. Replace hoses as required.
7. Have the cooling system cleaned.

CAUTION

If severe or prolonged overheating has occurred, contact your Caterpillar dealer to have your engine checked for possible damage.

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ELECTRIC SET OPERATION INSTRUCTIONS

GENERAL

Proper engine operation and maintenance are essential to long engine life and maximum performance. The essentials for proper operation and normal periodic maintenance are outlined in this guide. However, your Caterpillar dealer is available for troubleshooting and/or repairs when required.

Before starting the engine, familiarize yourself with these procedures. Even though your engine may not be equipped with the exact attachment illustrated, the operating procedures will be similar.

This guide contains information for Caterpillar Statically Regulated Controlled Rectifier (SRCR) and SR 4 generators. Caterpillar SR 4 refers to the brushless type generators. Study the guide carefully and apply the principles to your particular installation.

SAFETY PRECAUTIONS

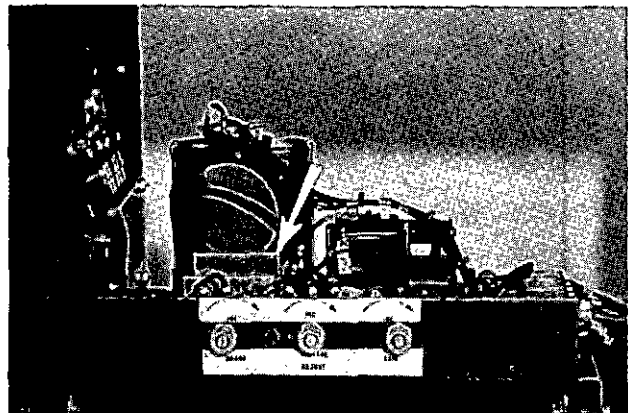
You can do something about safety. Lack of attention to safety can result in: accidents, personal injury, reduction of efficiency and worst of all—loss of life.

Safety is basically common sense. There are standard safety rules but each situation has its own peculiarities which cannot always be covered by rules. Therefore, your experience and common sense will be your best guides to safety. Watch for safety hazards. Correct deficiencies promptly.

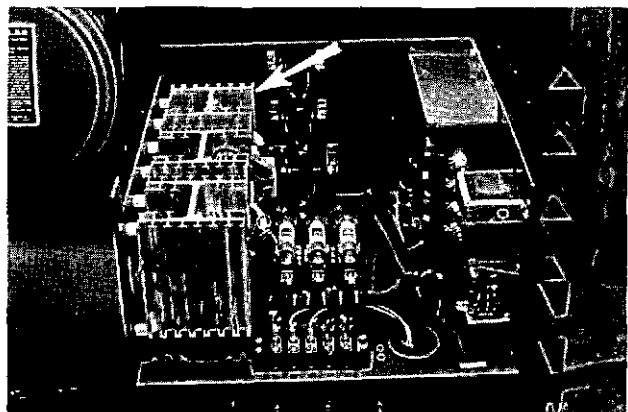
Use the following safety precautions as a general guide to safe operation.

1. Observe NO SMOKING signs.
2. Do not wear loose clothing around machinery.
3. Be sure the engine room is properly ventilated.
4. Do not smoke around batteries. Hydrogen gas generated by charging batteries is explosive. Keep batteries in a well ventilated area.
5. All electrical equipment must be grounded according to local building codes.
6. Remove tools and electrical cords from the engine before starting.
7. All fans, shafts, pulleys, etc. must have guards.
8. Check all connections periodically for tightness and insulation.
9. Never adjust or repair a machine while in operation.

10. Never operate a diesel engine with the governor linkage disconnected. Human reactions are not fast enough to control the fuel rack.
11. Do not touch the heat sink on the generator regulator when the generator is running. It is electrically "hot".



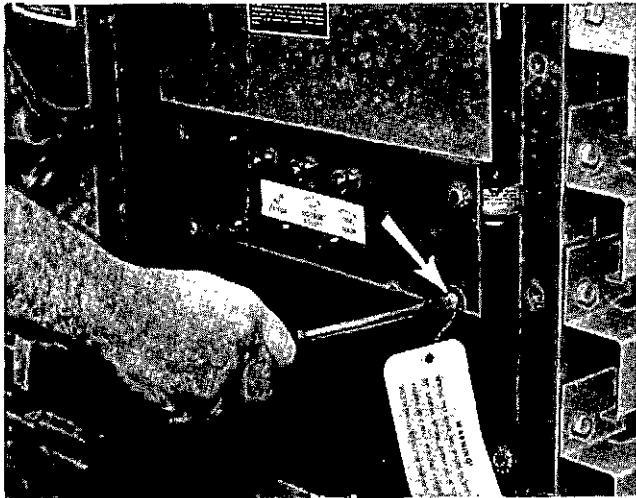
HEAT SINK (SR 4)



HEAT SINK (SRCR)

12. Always disconnect and tape the ground battery lead before working on the electrical system.
13. Be sure the remote starting system is inoperative when the engine is being worked on. Disconnect the starter from the start switch.
14. Always disconnect the engine starter circuit when working on the generator.
15. Keep the engine room and floor area clean.
16. Store oily rags in metal covered containers.
17. Never store flammable liquids near the engine.

- 18. Insulate all connections and disconnected wires.
- 19. Do not use carbon tetrachloride fire extinguishers. Fumes are toxic and the liquid has a deteriorating effect on insulation.
- 20. Do not work on electrically "hot" equipment.



REMOVE SHIPPING SCREWS BEFORE STARTING
(SRCR ONLY)

IDENTIFICATION

Voltage Setting

Generators are set at the factory for the voltage and type of operation specified. Voltage control initial adjustment instructions are located inside the generator exciter and regulator access cover. These instructions are for adjusting the generator output to nameplate ratings. For further adjustments, see page 5 for single and parallel unit operation.

Generator Serial Number

The engine serial number is stamped on the engine information plate and on a plate on the left side of the block toward the rear. The generator serial number is stamped on the generator nameplate and on the right side of the generator frame forward of the terminal box. Requests for information and orders for parts should be accompanied by the engine and generator serial numbers.

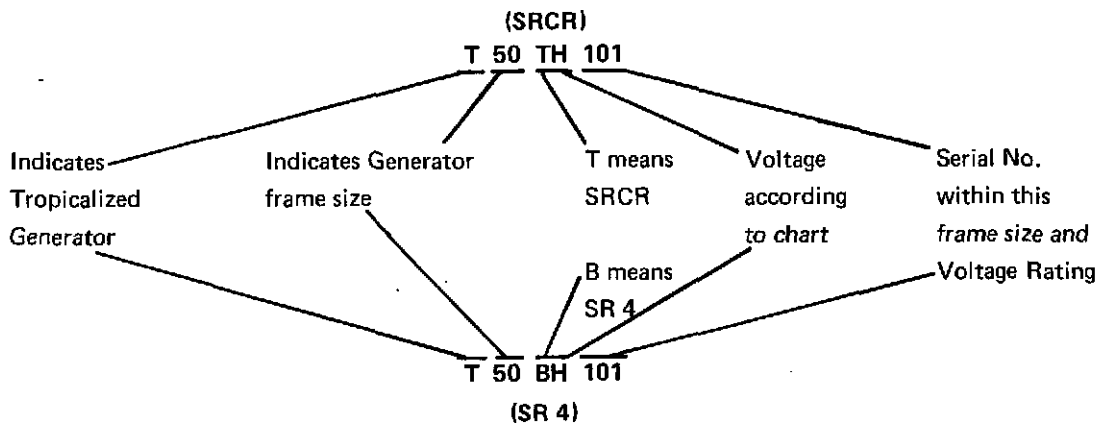
1. The group of numbers before the letters indicates generator frame size. The letter T may appear before the first group of numbers. This indicates a "tropicalized" generator, that has been dipped in epoxy to prevent moisture entrapment in windings.
2. The letter T is the symbol for Caterpillar Statically Regulated Controlled Rectifier generators. The letter B is the symbol for Caterpillar Statically Regulated Brushless Excited generators.
3. The next letter indicates the voltage rating of the generator as follows:

SRCR

L	115-230 volts	60 Hz
	125-250 volts—Single Phase	60 Hz
H	230-460 volts	60 Hz or
	125-216 volts	60 Hz or
	200-400 volts	50 Hz
G	287-575 volts	60 Hz or
	230-460 volts	50 Hz
N	2400 volts	60 Hz

SR 4

L	120-240 volts	60 Hz or
	125-250 volts—Single Phase	60 Hz
S	208-416 volts	60 Hz
H	240-480 volts	60 Hz or
	200-400 volts	50 Hz
G	300-600 volts	60 Hz or
	240-480 volts	50 Hz

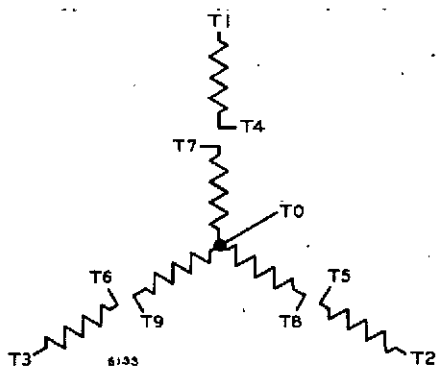


- The last group of numbers are the actual serial numbers of the generator in the frame size and voltage rating. Always use the complete serial number.

Generator Lead Numbering

Each coil lead is marked according to the following diagram.

Numbering is clockwise from the top and from the outside in. Terminal T0 is the neutral lead on all high voltage connections. On low voltage connections T0 is connected with T4, T5, and T6 to form the neutral terminal. The standard generator diagram and the terminal connections are on the nameplate of each generator.



THREE PHASE NEUTRAL CONNECTIONS

Single Units

Three Wire: In a three phase, three wire system, the generator should normally be grounded according to local wiring codes. In some cases, however, it is undesirable to ground the neutral wire. For example, on boats a grounded neutral may increase the problem of electrolysis. In applications where definite measures are taken to prevent grounds to the load leads, an ungrounded neutral can be used. Be sure to check your local wiring codes.

Four Wire: In a three phase, four wire system, the neutral wire should be grounded according to local wiring codes. For only single unit operation, there should never be a need for a disconnect switch, or device, in the neutral line.

Multiple Units

Operation of multiple generators in parallel, having all neutrals grounded, may result in current circulating through the neutral connections. To eliminate the possibility of circulating currents, ground the neutral of only one generator. If multiple generators are alternated on line, a single pole single throw knife switch should be installed in the neutral ground circuit of each generator, so all but one neutral ground circuit can be opened. Be sure one neutral ground circuit is closed.

VOLTAGE CONNECTIONS

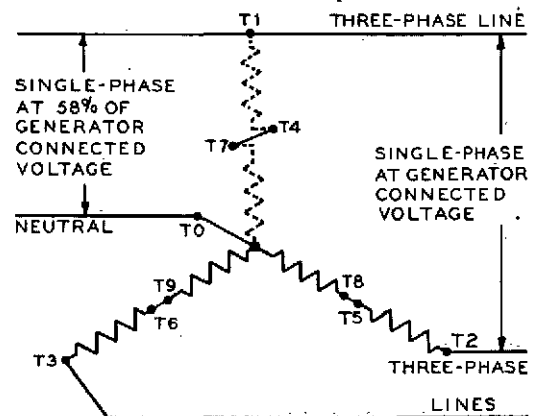
Three Phase

The connections for both high and low voltage are given in the following chart.

The terminals must be connected securely and insulated with a good quality electrical tape.

REQUIRED VOLTAGE	CONNECT LINE LEADS TO			NEUTRAL	CONNECT
3 Phase High Voltage	T1	T2	T3	T0	T4 to T7 T5 to T8 T6 to T9
3 Phase Low Voltage	T1 & T7	T2 & T8	T3 & T9	T4, T5, T6 & T0	T4, T5, T6 & T0 For Neutral

Single Phase Current From A Three-Phase Generator



Three phase and single phase current can be taken simultaneously from a generator connected for three phase service. Connecting any two of the three phase leads will provide single phase current at the same voltage as three phase power. Connecting a three phase lead to neutral will produce current at 58% of the three phase voltage. DO NOT exceed the nameplate current rating for any one phase.

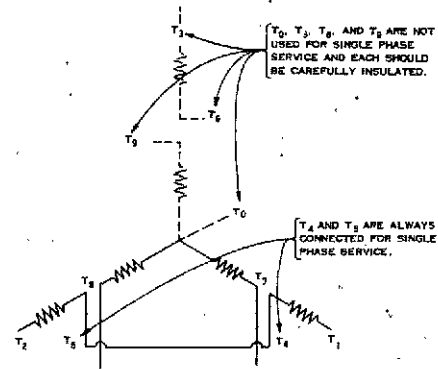
Single Phase

When a generator is connected for single phase operation, do not exceed these limits:

1. The nameplate amperage limits.
2. Fifty-eight percent of the KVA and KW ratings. (The engine will only work about half as hard.)

Three phase (230-460V and 115-230V for SRCR) and (240-460V, 125-250V and 208-416V for SR 4) generators can be connected for two or three wire service at either voltage. When generators are connected for three wire ser-

vice both high and low voltages may be obtained simultaneously without reconnecting the leads. In this case DO NOT ground T0. Generator neutral is not T0 but a point in the windings electrically half way between T1 and T8. This point is not wired to a terminal.



To reconnect the generator for single phase voltage follow the chart. Wrap all connections and unused terminals with a good grade of insulation.

REQUIRED VOLTAGE	CONNECT LINE LEADS TO			CONNECT	TAPE INDIVIDUALLY
Single-Phase 2 Wire Low Voltage	T2 & T8		T1 & T7	T4 & T5	T3 T6 T9 T0
Single-Phase 3 Wire Low/High Voltage	T2	T1 & T8 Neutral	T7	T4 & T5	T3 T6 T9 T0
Single-Phase 2 Wire High Voltage	T2		T7	T1 & T8 T4 & T5	T3 T6 T9 T0

ELECTRIC SET OPERATION

Generator Loading

A three phase load is usually balanced and presents no problem when kept within the amperage limits. However, single phase power taken from a three phase source can be a problem unless the single phase loading is equally distributed.

When a generator is installed or reconnected, be sure the total current in one phase does not exceed the nameplate rating. Each phase should carry the same load, allowing the engine to work at its rated capacity. An electrical unbalance can result in an electrical overload and overheating if one phase exceeds the nameplate amperage.

Power Factor

Power factor may be thought of as the efficiency of the load — the ratio of apparent power to total power. Power factor is expressed as a decimal and denotes that portion of current supplied to a system doing useful work. The portion of current not doing useful work is absorbed in maintaining the magnetic field in motors. This current, although it is called the reactive load, does not require engine horsepower to maintain it. The only horsepower consumed in a reactive load is used to start motors. This is the inrush or starting current.

In most applications electric motors and transformers determine the power factor of the system. Induction motors usually have a .8 power factor. Incandescent lighting is a resistive load of about 1.0 power factor, or unity.

The power factor of a system may be determined by a power factor meter or by calculations. Determine the power requirement in KW by multiplying the power factor by the KVA supplied to the system. As the power factor goes up the total current supplied to a constant power demand will go down. A 100 KW load at .8 power factor will draw more current than a 100 KW load at .9 power factor. A higher power factor increases the possibility of overloading the engine. A lower power factor increases the possibility of overloading the generator.

Low Idle Adjustment

Electric sets require higher low idle setting than do industrial engines. Low idle must not be below 2/3 the full load speed of 60 Hz units (4/5 full load speed of 50 Hz units).

CAUTION

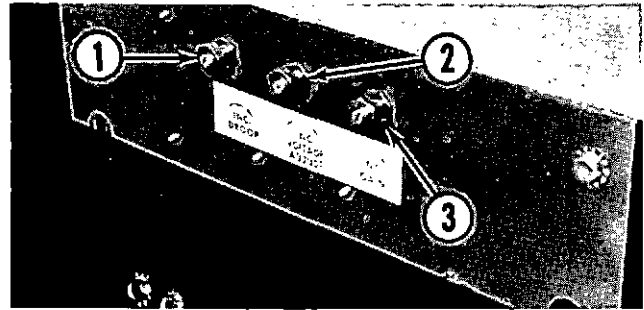
Disconnect the exciter circuit by removing fuses F1 and F2 (on SRCR) or Fuse F1 (on SR 4) before operating the engine below the low idle rating. Failure to do this will result in generator damage.

On electric sets with Woodward governors, there is no low idle stop. On electric sets with mechanical governors and natural gas electric sets, the low idle is set at the factory, and should only be adjusted by your Caterpillar dealer if adjustment is required.

SINGLE UNIT OPERATION

Final adjustments for a new installation are given here.

1. Remove the exciter regulator cover and loosen the locknuts on the voltage level, voltage droop and regulator gain controls.
2. Turn the voltage droop control counterclockwise to zero droop and tighten the locknut.



VOLTAGE ADJUSTMENT CONTROLS

1. Voltage Droop 2. Voltage Level 3. Voltage Gain
3. Run the engine at full governed speed.
4. Using the voltage level control, adjust the open circuit (no load) voltage to equal nameplate voltage.
5. Apply rated load and adjust the governor control for rated speed.
6. Adjust the regulator gain control until the line voltage is equal to rated voltage at rated load.
7. Allow the electric set to operate about one hour until temperature in the generator has stabilized.
8. Repeat steps 4, 5 and 6.
9. Tighten the locknuts on the voltage level and regulator gain controls, and install the exciter-regulator assembly access cover.

The electric set is now properly adjusted for single unit operation.

PARALLEL OPERATION

Preparing a generator for parallel operation requires special attention. Before attempting to parallel units for the first time, all units must be checked to be sure the following three conditions are met:

1. Same phase rotation.
2. Same speed capabilities.
3. Same voltage characteristics.

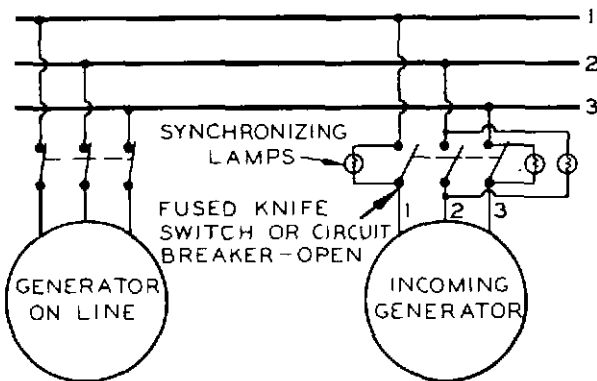
These three conditions may be compared to similar conditions required for engagement of two gears. To mesh as smoothly as possible, two gears must meet the following three conditions:

1. Correct rotation.
2. Same rotation speed.
3. The tooth of one segment must fit the root of the engaging segment.

Phase Rotation

The phase rotation must be the same. A set of three light bulbs is used to determine whether the phase rotation of the incoming unit and the phase rotation of the line are the same.

1. Connect the light bulbs between the generator leads and the corresponding line phase, i.e. terminal 1 to line 1 across the open circuit breaker.
2. Start the units to be paralleled and bring them up to speed. As they approach the same speed the lights will start to blink.



SYNCHRONIZING LIGHTS

- a. If the lights blink in sequence one of the units is connected backward. To correct this remove generator leads 1 and 3 at the circuit breaker and exchange them. This reverses the direction of phase rotation. Line 2 should always be connected to line 2.

WARNING

Never attempt to work on electrically hot wiring. Stop the electric set before rewiring generator leads. Open circuit breakers before working on the equipment which they control.

- b. If lights blink in unison the phase rotation of both engines is the same, and condition 1 has been met.

Engine Speed

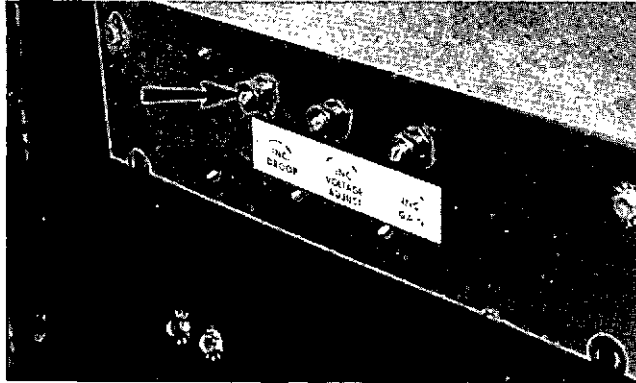
The speed of units to be paralleled must be the same. Speed refers to the alternating current frequency.

1. Allow each electric set to run under load long enough for the internal temperatures to stabilize (about one hour).
2. Adjust the governor control to give rated frequency at full load.
3. Remove the load and check the high idle speed; it should be approximately 3% above full load speed. If these speeds can not be obtained, contact your Caterpillar dealer.
4. For the most consistent results repeat steps 2 and 3. Condition 2 has been met.

Voltage Adjustment

The voltage level and voltage droop adjustments determine the amount of circulating currents between generators. Carefully matched voltage regulator adjustments will reduce the circulating currents. Adjustments to the voltage droop control should be made to give a 2% droop for load of unity power factor (load composed primarily of lighting). Loads of .8 power factor (primarily motors) require a generator voltage droop of about 5%. Voltage droop is expressed as the percentage of voltage change from no load to full load.

1. Remove the exciter-regulator access cover and loosen the locknuts of the voltage level and droop controls and the regulator gain control.
2. Turn the droop control counterclockwise to zero.
3. Run the engine at high idle.
4. Adjust the open circuit voltage level to equal nameplate rated voltage.



DROOP ADJUSTMENT

5. Apply full load and adjust the governor control to the rated full load speed.
6. Adjust the regulator gain control to equal nameplate rated voltage at full speed.
7. Run the electric set at full load until internal temperatures have stabilized (about 1 hour) remove the load and repeat steps 4, 5, and 6.
8. Tighten the locknut on the regulator gain control.
9. With the engine running at high idle, turn the voltage droop clockwise about 1/4 of full range.
10. Readjust the voltage level control until the voltage is about 5% above rated voltage.
11. Apply full load at .8 power factor.

NOTE

If a generator is paralleled with other generators, the voltage droop of each generator must be the same to satisfactorily divide reactive load.

12. Readjust the voltage droop control to get rated voltage with full load at .8 power factor.
13. Repeat steps 10, 11 and 12 until line voltage is equal to nameplate rating at .8 power factor and open circuit voltage is approximately 5% above rated voltage.
14. Tighten the locknuts on all controls and install the access cover. Condition 3 has been met.

Starting Single Unit Operation

1. Make all preliminary engine starting checks.
2. Be sure the main or line circuit breaker is open.
3. Start the engine and allow it to warm up.
4. Close the main circuit breaker.
5. Apply the load. Do not try to apply full load in one move, rather apply the load in increments to maintain system frequency at a constant level.

Stopping

1. Remove the load in increments.
2. Open the circuit breaker.
3. Allow the engine to run for 5 minutes to cool.
4. Stop the engine.

Standby Electric Sets

Most standby units are automatic. They start, pickup the load, run and stop without an operator in attendance. Standby units can not change the governor control setting automatically. The throttle must be preset for the proper operation of that unit. Whenever the set is exercised or operated manually, be sure the throttle setting is correct for automatic operation. Check all switches to see they are properly set: Start Selector Switch in AUTOMATIC position and any Emergency Stop Switches in RUN position.

MULTIPLE UNITS

STARTING — Units are started the same as single units. See page 5, steps 1 – 3.

Paralleling

Units may be paralleled at no load or paralleled with units under load. To parallel two or more units the following conditions must be met:

1. Same phase rotation.
2. Same voltage level.
3. Same voltage droop.
4. Same frequency.
5. Voltages must be in phase.

The first three conditions have been met in the parallel operation. See page 5.

1. Start the unit to be paralleled according to the procedure in the engine operation section.
2. Turn the synchronizer lights on.
3. After the engine has run long enough to warm up, bring it up to synchronous speed (the same frequency as the unit on the line). The synchronizing lights will begin to blink.
4. Using the governor control adjust the speed until the lights blink very slowly.
5. The lights are off when the voltages of the two units are in phase. At this point very quickly close the breaker while the lights are out.

NOTE

The frequency of the incoming unit should be slightly greater than the line frequency. This will allow the incoming unit to assume some of the load rather than add to the system load.

Circulating Currents

When two units are paralleled there will be circulating currents. These currents are not doing useful work, but are flowing between the generators. By determining the total generator amperage and subtracting the amperage going to the load, the amount of circulating current can be determined.

Circulating currents are caused by voltage differences between the two units. As the oncoming generator warms up the circulating current will be reduced.

In a cold unit, circulating current may be as high as 25% of rated amperes without being considered harmful. Circulating current is part of the total generator current which must not exceed the rated amperage.

Load Division

Once two units have been paralleled their share of the load is determined by the governor control setting. If two units of the same capacity and the same governor characteristics have the same governor control settings they will share the load equally.

To transfer the load from one engine to the other follow this procedure:

NOTE

The total load must not exceed the capacity of the engine, or the engine will be overloaded.

1. Increase the governor speed control of the unit to the high idle position to assume the load.
2. Reduce the governor speed control of the outgoing unit until the generator amperage is at a minimum. (The amperage may never be zero due to circulating currents.) At this point transfer the load.

Stopping

To remove a generator from the line do the following:

1. Check the load. It must be less than the rated capacity of remaining units.
2. Be sure the neutral of one of the remaining units is grounded.
3. Remove the load from the outgoing unit as described in LOAD DIVISION.
4. Open the circuit breaker.
5. Allow the engine to cool for 5 minutes.
6. Stop the engine.

GENERATOR STORAGE

When a generator is stored for any length of time moisture condenses in the windings. Minimize the condensation by providing a dry storage space.

To remove moisture caused by high humidity or dampness, dry the generator by one of the following methods:

1. Place the generator in an oven and bake at a temperature not above 185°F (85°C) for four hours.

CAUTION

If an oven is used for drying, use a forced air type rather than a radiant type. Radiant ovens can cause localized overheating.

2. Enclose the generator and heating lamps in canvas to raise the temperature. Leave an opening in the top for the moisture to escape.
3. Pass a low voltage current through the windings to raise the temperature of the windings to 185°F (85°C).


If there is a possibility the insulation resistance has deteriorated to a dangerously low level, contact your Caterpillar Dealer.

If a brush type generator (SRCR) is to be stored for a prolonged time, lift the brushes off the slip ring to prevent chemical action from damaging the slip ring.

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LUBRICATION AND MAINTENANCE CHART

3304

2B4364-UP
4B6032-UP

3306

23C740-UP
66D8891-UP

INDUSTRIAL ENGINES

This LUBRICATION AND MAINTENANCE SCHEDULE lists those items commonly ordered on this engine which require servicing.

The time intervals are based upon the numbers showing on the engine's service meter. Use the daily readings of the Service Meter to determine maintenance intervals. Perform required maintenance at multiples of each unit. "EVERY 10" means perform that maintenance at 10, 20, 30, etc., service meter units. For those areas which require periodic maintenance which cannot be given a definite service hour, see the column "WHEN TO SERVICE".

For items marked (*) see "KEY TO FUELS, LUBRICANTS AND WATER" in this chart. "Page" refers to the page number in the LUBRICATION AND MAINTENANCE PROCEDURES where the service procedure is detailed for that item.

SCHEDULED ITEM	MAINTENANCE	LUBE	PAGE
FREQUENTLY DURING OPERATION			
Observe all gauge readings. Determine the normal reading for each gauge. Note any change from the normal reading; then determine the cause and have necessary repairs made. See the OPERATION INSTRUCTIONS topic: Instrument Panel Gauges.			
EVERY 10 SERVICE METER UNITS OR DAILY			
ENGINE OIL LEVEL—observe dipstick with engine idling, oil hot:	Maintain oil level between the ADD and FULL marks on the dipstick.	CD*	A-1
AIR CLEANER INDICATOR—observe position of indicator piston:	If piston locks in "up" position, service the element. (See Note A).	—	B-1
FUEL TANK—fill:		*	C-1
WATER SEPARATOR—drain water:	If glass becomes clouded, install new glass filter.	—	C-4
COOLANT LEVEL—if filler cap must be removed, observe level with engine stopped and cold:	Maintain level in range above baffle plate and ½ (15 mm) below fill pipe.	*	D-1
—if equipped with water level gauge:	Maintain coolant level between ADD and FULL marks on gauge.	*	D-1
CLUTCH SHIFT COLLAR:	Lubricate 1 fitting—2 strokes.	MPGM*	G-1
EVERY 50 SERVICE METER UNITS			
DUST COLLECTOR CUP—(two stage air cleaner):	Empty dust cup and clean tubes; may be required more often in dusty conditions.	—	B-2
EVERY 125 SERVICE METER UNITS			
FRONT OR REAR CLUTCH—CLUTCH LEVER BEARINGS:	Lubricate—2 strokes each bearing.	MPGM*	G-1
PILOT BEARING:	Lubricate 1 fitting—2 strokes.	MPGM*	G-1
MAIN SHAFT BEARING:	Lubricate 1 fitting—2 strokes.	MPGM*	G-1

SCHEDULED ITEM	MAINTENANCE	LUBE	PAGE
EVERY 250 SERVICE METER UNITS			
ENGINE OIL AND FILTERS:	Turbocharged Engines only—change oil and filters. (See Note B).	CD*	A-1
ENGINE BREATHER:	Clean, use clean solvent.	—	A-2
FAN AND ALTERNATOR BELTS— check wear and belt tension:	Belts should deflect 9/16" to 13/16" (15 to 20 mm) @ 25 lbs. (11 kg) force.	—	D-4
BATTERY ELECTROLYTE LEVEL:	Maintain electrolyte level to base of each vent well.	*	F-1
EVERY 500 SERVICE METER UNITS			
ENGINE OIL AND FILTERS:	Nat. Aspirated Engines only—change oil and filters. (See Note B).	CD*	A-1
ENGINE BREATHER:	Clean, use clean solvent.	—	A-2
JACKET WATER COOLING SYSTEM:	Add cooling system inhibitor. Follow instructions on the container.	*	D-1
RADIATOR FAN:	Lubricate 1 fitting, 2 strokes.	MPGM*	D-5
SRGR GENERATOR SLIP RINGS (2):	Check for discoloration, clean with electrical cleaning solvent.	—	G-2
SRGR GENERATOR BRUSHES:	Measure, install new brushes when less than 9/16" (15 mm).	—	G-3
EVERY 1000 SERVICE METER UNITS OR 6 MONTHS			
FUEL TANK:	Drain water and sediment.	—	C-1
WOODWARD PSG GOVERNOR LINKAGE:	Lubricate 2 fittings—1 stroke each.	MPGM*	C-4
SHUTOFF CONTROLS:	Have operation checked by Caterpillar dealer.	—	G-7
TACHOMETER DRIVE:	Lubricate 1 fitting—1 stroke.	MPGM*	G-7
EVERY 2000 SERVICE METER UNITS OR 1 YEAR			
VALVE LASH—check adjustment, set:	INLET VALVE LASH = .015" (0.38 mm)	—	B-5
	EXHAUST VALVE LASH = .025" (0.64 mm)		
VALVE ROTATORS:	Observe rotation of valves with engine idling.	—	B-8
COOLING SYSTEM:	Clean. Follow instructions in Procedures, or on commercial cleaner container.	*	D-3
ELECTRIC SET GENERATOR:	Remove 2 plugs, install upper fitting, lubricate until old grease appears.	MPGM*	G-5
NON-SCHEDULED ITEMS			
	WHEN TO SERVICE ITEMS	LUBE	PAGE
AIR CLEANER ELEMENT:	Install when air cleaner indicator piston locks "up".	—	B-1
PRIMARY FUEL FILTER:	Clean when FUEL PRESSURE gauge registers OUT.	—	C-1
FUEL FILTER:	Replace when FUEL PRESSURE gauge registers OUT.	—	C-2
FUEL SYSTEM:	Prime after servicing fuel system.	—	C-3
AIR STARTING SYSTEM— COLLECTOR JAR:	Empty when jar is half full. Do not reuse oil.	—	E-1
OILER JAR:	Fill when jar is half empty.	CD*	E-1
OILER FEED:	Adjust when oiler uses more than 4 drops per minute.	—	E-1
BATTERY:	Clean with baking soda when white deposit forms.	—	F-1
GLOW PLUGS:	Replace when ammeter reading is closer than usual to "0" with HEAT-START switch in HEAT position.	—	F-3
CLUTCH ADJUSTMENT:	Adjust when lever no longer "snaps" past center position.	—	G-1

NOTES

- NOTE A:** Service intervals may be shortened in dusty operating conditions. If the exhaust smoke and/or loss of power continues after servicing the air cleaner, discard that element and install a new element. Install a new element at least once a year.
- NOTE B:** This is the normal change interval to use when fuel sulphur content is 0.4% or less. When sulphur content is 0.4% to 1.0%, reduce oil change interval one-half. When sulphur content is above 1.0%, reduce oil change interval to one-fourth the normal interval. Regardless of hours, change oil and filters every 6 months.

*KEYS TO FUELS, LUBRICANTS AND WATER

- FUEL:** Use only distillate fuels (ASTM No. 1 or No. 2 Fuel Oil, or No. 1D or No. 2D Diesel Fuel Oil are examples) with a minimum cetane number of 35. Heavier oil is generally preferable because of its energy content.
- CD:** Use oils which meet Engine Service Classification CD, or MIL-L-2104C, in Caterpillar diesel engine crank-cases and gear compartments.
- MPGM:** Use Multipurpose-type Grease which contains both 3 to 5% molybdenum disulfide conforming to MIL-L-7866, and a suitable corrosion inhibitor. NLGI No. 2 Grade is suitable for most temperatures. NLGI No. 1 or No. 0 are suitable for extremely low temperatures.
- BATTERY WATER:** Add either distilled water; or, odorless, tasteless drinking water. Do not use mineral water, water containing iron, salt water or softened water. Water level must be at base of vent well for each cell.
- ENGINE COOLANT:** When ambient temperatures remain above freezing, use a mixture of Caterpillar Cooling System Conditioner, or equivalent, and clean, odorless, tasteless drinking water. Do not use chemically softened water.
- When operating conditions are severe, or if ambient temperatures are below freezing, use a 50-50 solution of antifreeze and water.
- Drain, flush and fill with new coolant every 2000 Service Meter Units or annually. Coolant change period may be extended to 2 years by adding corrosion inhibitor every 500 Service Meter Units.

3304-3306 ENGINE SPECIFICATIONS

RECOMMENDED OIL VISCOSITIES AT VARIOUS STARTING TEMPERATURES		
COMPONENT	VISCOSITY	TEMPERATURE RANGE
DIESEL ENGINE LUBRICATION SYSTEM	SAE 10W	-20°F to +70°F (-29°C to +21°C)
	SAE 10W/30	-10°F to +90°F (-23°C to +32°C)
	SAE 20W/40	+15°F to +120°F (-9°C to +49°C)
	SAE 30†	+20°F to 120°F (-7°C to +49°C)
	SAE 40	+45°F to +120°F (+7°C to -49°C)
AIR STARTING MOTOR OILER JAR:	SAE 10W	ALL TEMPERATURES

†SAE 40 is preferred above +90°F (32°C).


REFILL CAPACITIES (Approximate):	GALS.	LITRES	IMP. GALS.
3304 ENGINE LUBRICATION SYSTEM:	5	19	4
COOLING SYSTEM (Engine Only):	4.5	17	3.75
3306 ENGINE LUBRICATION SYSTEM:	7.25	27.5	6
COOLING SYSTEM (Engine Only):	5.25	20	4.5

VALVE LASH ADJUSTMENT				
NO. 1 CYLINDER ON COMPRESSION STROKE:			NO. 1 CYLINDER ON EXHAUST STROKE:	
VALVES	ENGINE CYLINDERS		ENGINE CYLINDERS	
	3304	3306	3304	3306
INLET	1-2	1-2-4	3-4	3-5-6
EXHAUST	1-3	1-3-5	2-4	2-4-6

CYLINDERS ARE NUMBERED FROM FRONT TO FLYWHEEL 1-2-3-4; 5-6.

INLET VALVE LASH = .015" (0.38 mm); EXHAUST VALVE LASH = .025" (0.64 mm).



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3304-3306 LUBRICATION AND MAINTENANCE PROCEDURES

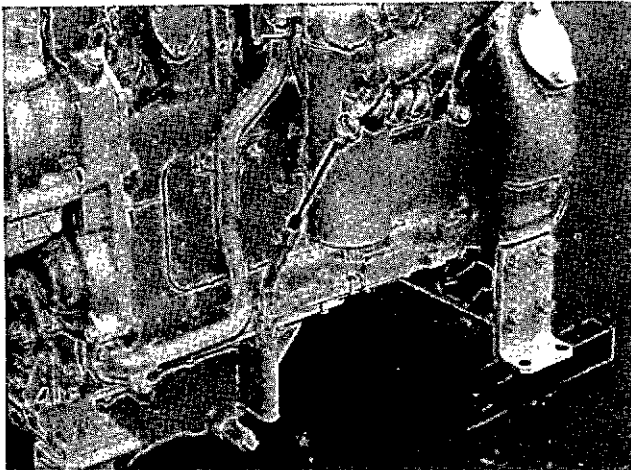
ENGINE LUBRICATION SYSTEM

Checking Oil Level

The dipstick is stamped on both sides of the blade. One side is marked and to be read when checking the oil level with the ENGINE STOPPED. The other side is marked and to be read with the ENGINE IDLING – HOT OIL. Each side is stamped to remind you not to OVERFILL the crankcase with oil.

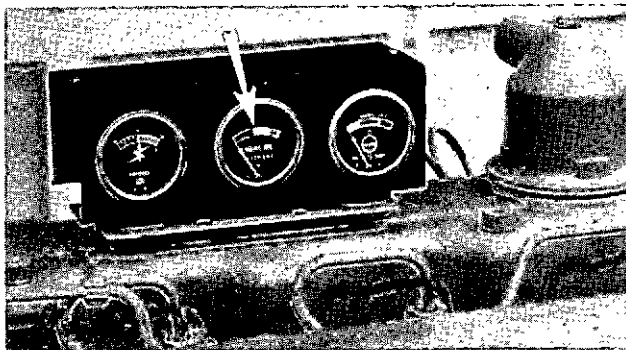
CAUTION

Be sure to read the correct side of the dipstick. The ADD and FULL levels are not the same when checking the oil while stopped or while idling.



Checking Oil Pressure

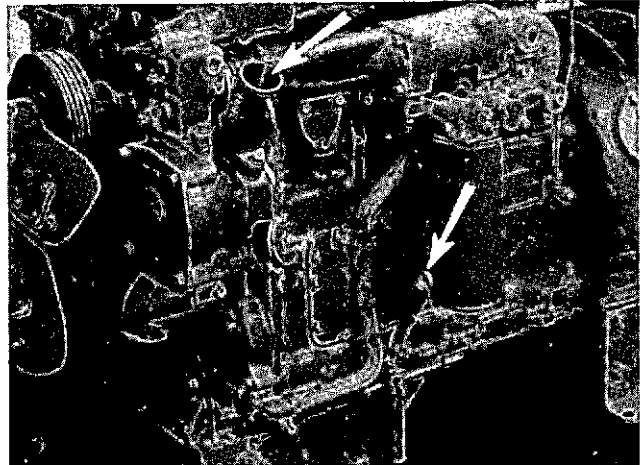
Immediately after starting, and frequently during operation, observe the oil pressure gauge reading. The indicator should register in the NORMAL range.



If the indicator fluctuates or registers below NORMAL range:

1. Move the governor control to low idle position,

2. Check the oil level. Be sure to read the ENGINE IDLING side of the dipstick.
3. Add oil until the oil level is at the FULL mark on the ENGINE IDLING side of the dipstick. Do not overfill.

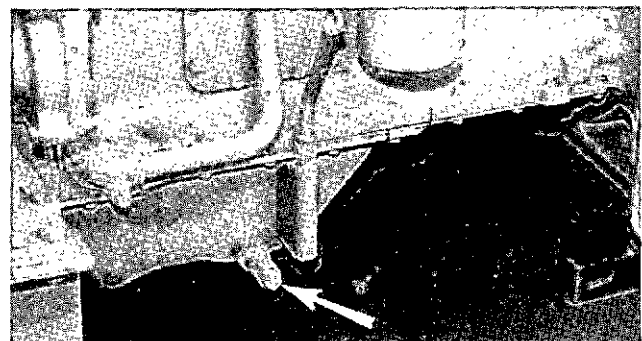


4. Check for oil leaks.
5. If necessary, stop the engine and have repairs made.

Draining Engine Oil

With engine stopped and oil warm:

1. Remove the crankcase oil drain plug.

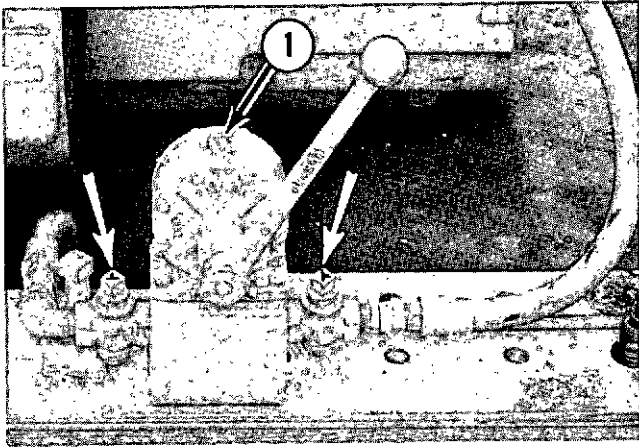


2. Allow the oil to drain.
3. Clean and install the drain plug.

OR, if a sump pump is used:

1. Connect a suitable drain line and container to the pump outlet (1).

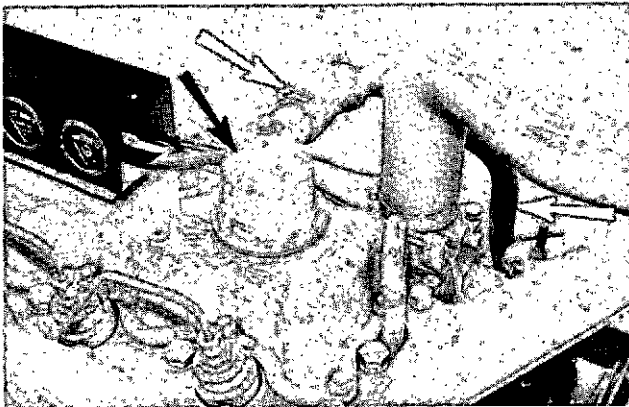
2. With engine stopped and oil warm, open the sump pump valve to the engine crankcase drain line: The two marks on the valve must be turned so that one mark points to the pump, and the second mark points to the engine drain line.



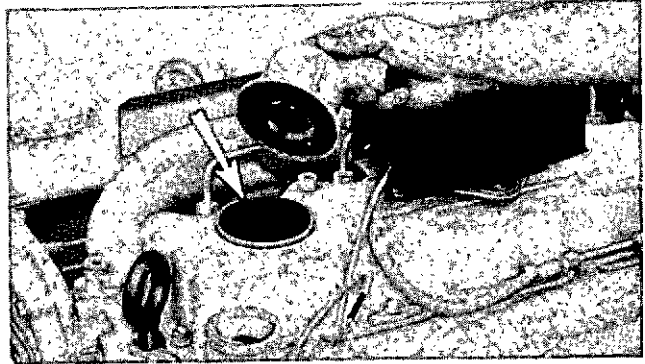
3. Close the valve to the marine gear housing drain: The two marks on this valve must be at right angles to the mark pointing towards the marine gear drain line.
4. Operate the sump pump handle until the crankcase is empty.
5. Close the valve to the engine crankcase drain line.

Cleaning the Breather

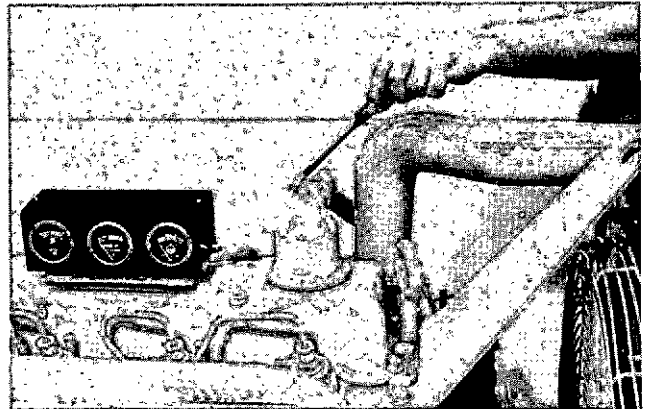
1. Release the hose clamp and disconnect the fumes disposal tube.
2. Remove the breather assembly.



3. Wash the breather in solvent.
4. Allow to drain dry and then wipe.
5. Inspect the gasket. Install a new gasket if necessary.
6. Install the breather.

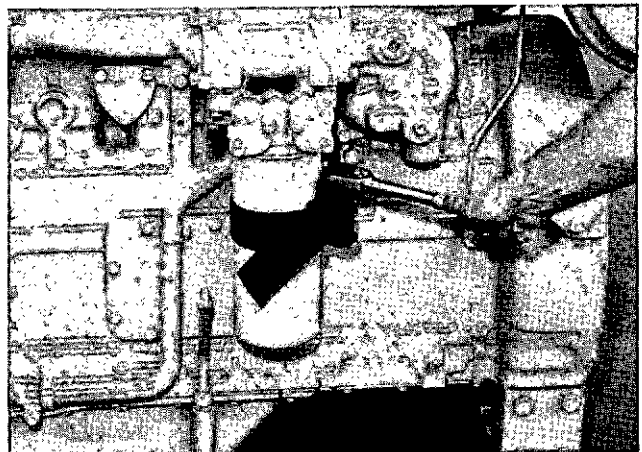


7. Connect the fumes disposal tube.

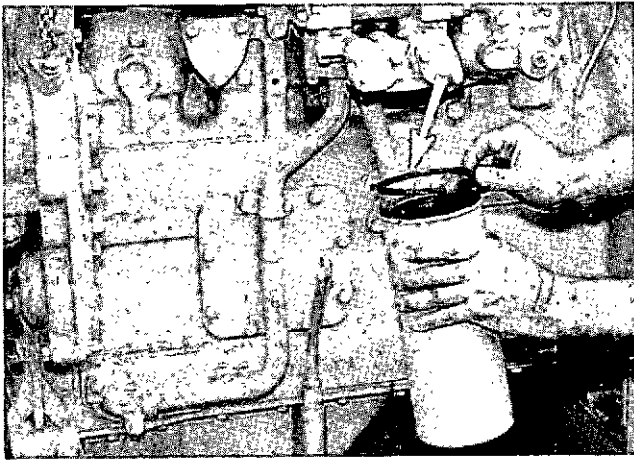


Changing Oil Filter

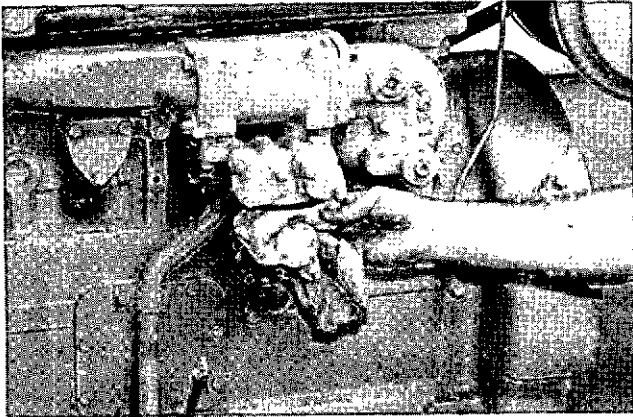
1. Unscrew and remove the filter.



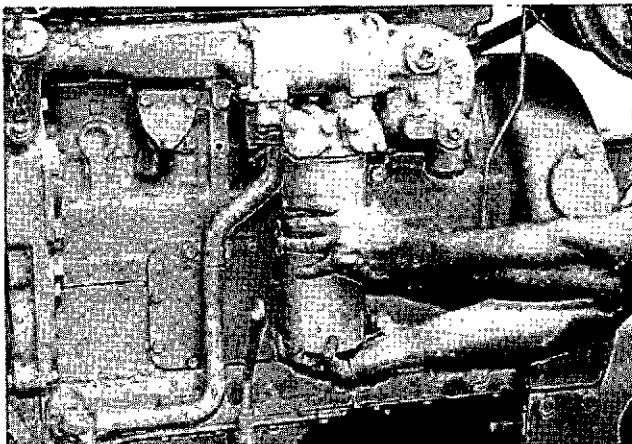
2. Be sure the old filter gasket did not remain attached inside the filter base: Leaking will occur between the new filter gasket and this old gasket.



3. Wipe the filter base.

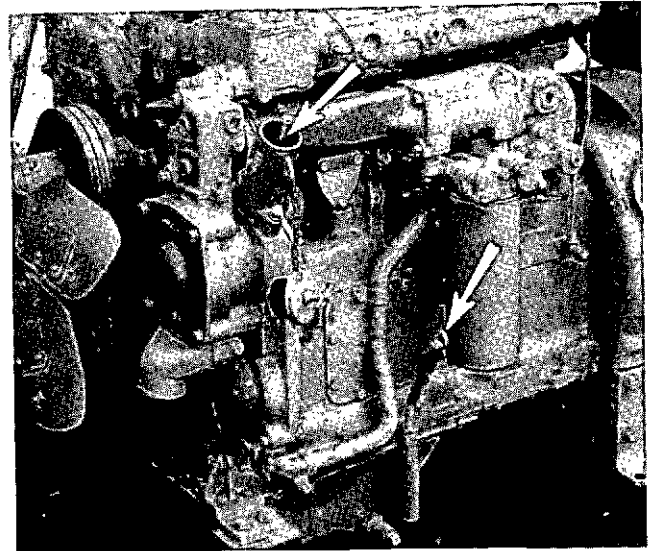


4. Apply a thin coat of clean oil to the gasket of the new filter.
5. Install the new filter: Hand tighten the filter 3/4 turn after the filter gasket contacts the base. Use the rotation index numbers, which are painted on the filter can as a guide for proper tightening.

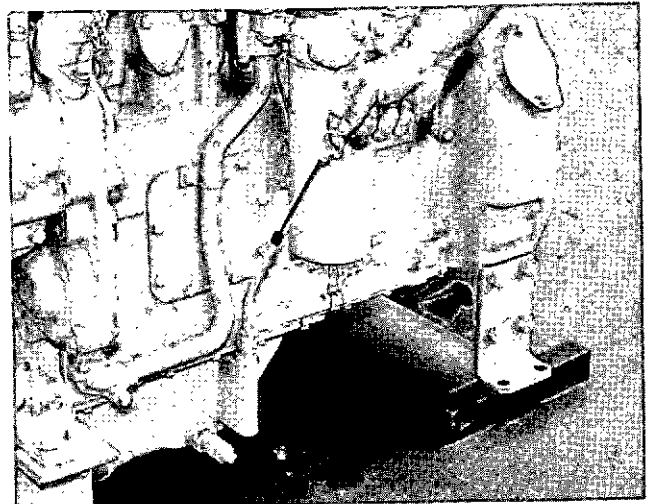


Filling the Crankcase

1. Fill the crankcase to the safe starting range on the ENGINE STOPPED side of the dipstick. See the Lubrication and Maintenance Chart for refill capacity and proper oil viscosity.



2. Start the engine and check for oil leaks.
3. After the engine is warm, check the oil level with the engine idling.



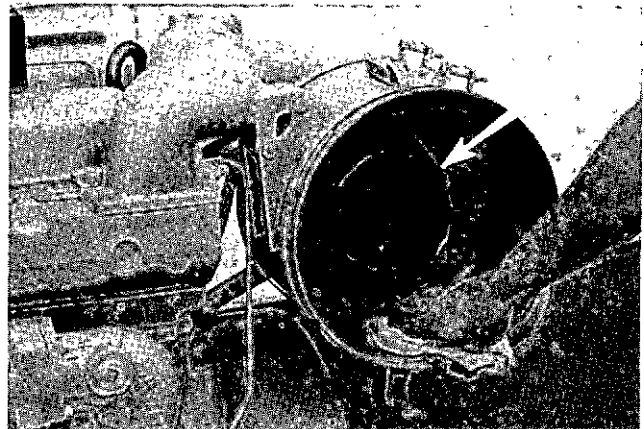
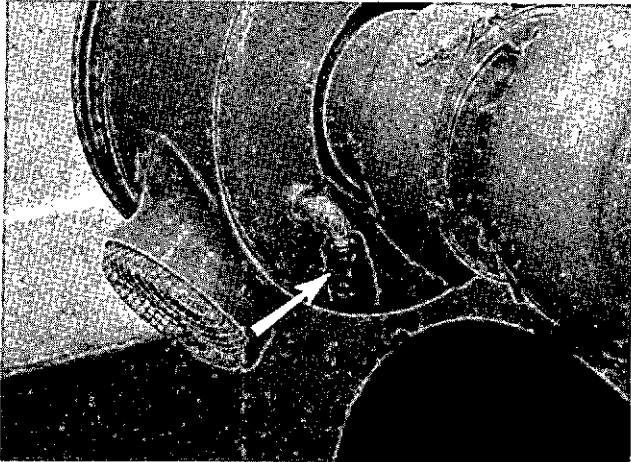
4. Add oil if necessary to maintain the oil level at the FULL mark on the ENGINE IDLING side of the dipstick.

AIR INDUCTION AND EXHAUST SYSTEM

AIR CLEANER SERVICE INDICATOR

Checking Air Cleaner Condition

Before starting the engine, check the window of the indicator. If the red piston is locked in the raised position, service the air cleaner as outlined below.



4. Inspect the replacement element for damage and cleanliness.

NOTE

Have a replacement element on hand to install and use while cleaning the dirty element. This will save you down time.

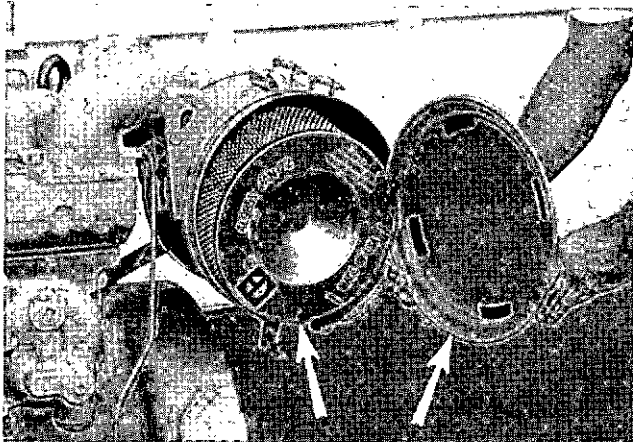
SINGLE STAGE AIR CLEANER

Changing Filter Element

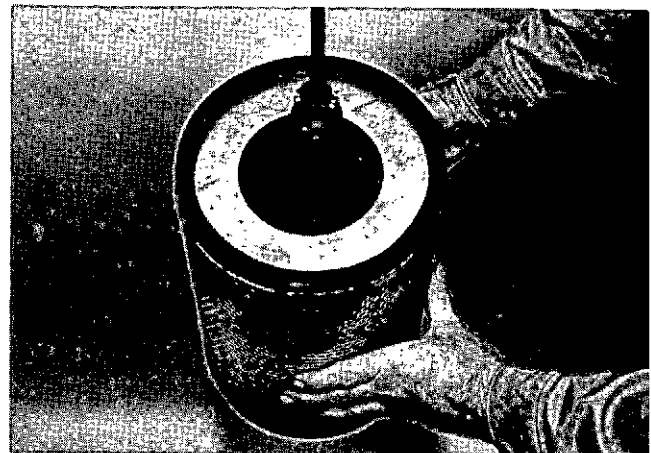
CAUTION

Service the air cleaner with the engine stopped.

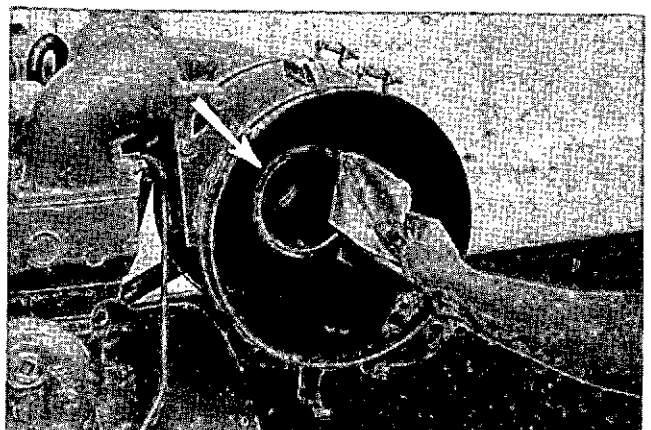
1. Remove the air cleaner cover and element.



2. Cover the air inlet opening to prevent foreign objects from entering the engine.
3. Clean the inside of the air cleaner cover and the air cleaner body.



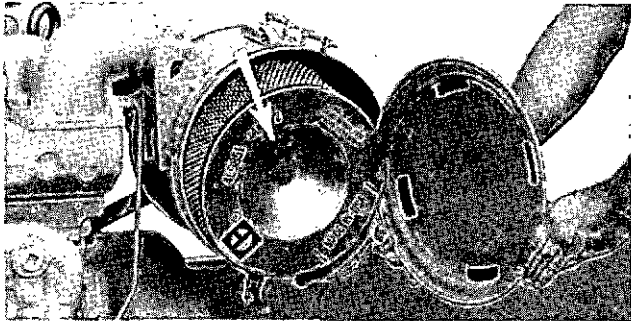
5. Remove the covering from the air inlet opening.



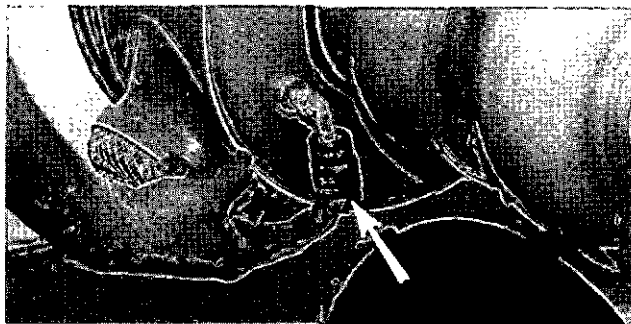
6. Install the element.

CAUTION

Be sure the closed end of the element is facing outward after being installed.



7. Install the air cleaner cover.
8. Reset the service indicator button by pushing upward on the reset button.

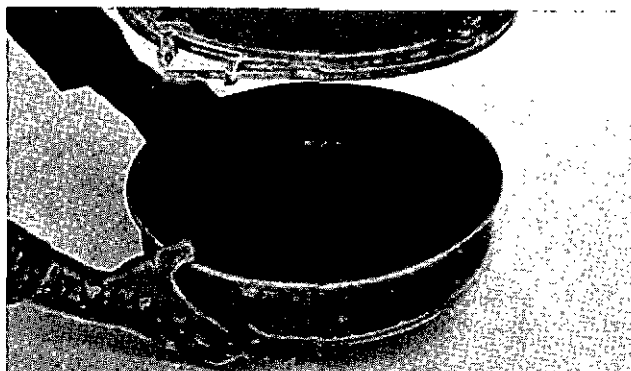


9. Clean the used air cleaner element. See the instructions for cleaning.

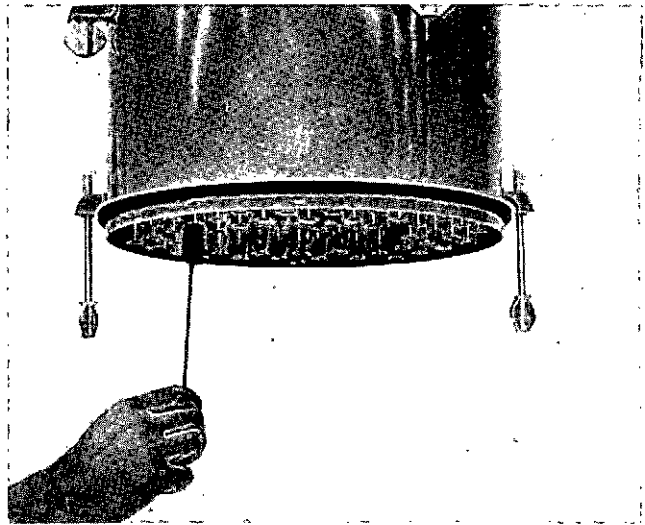
TWO STAGE AIR CLEANER

Emptying Dust Collector Cup

1. Loosen the clamping bolt on the lower body.



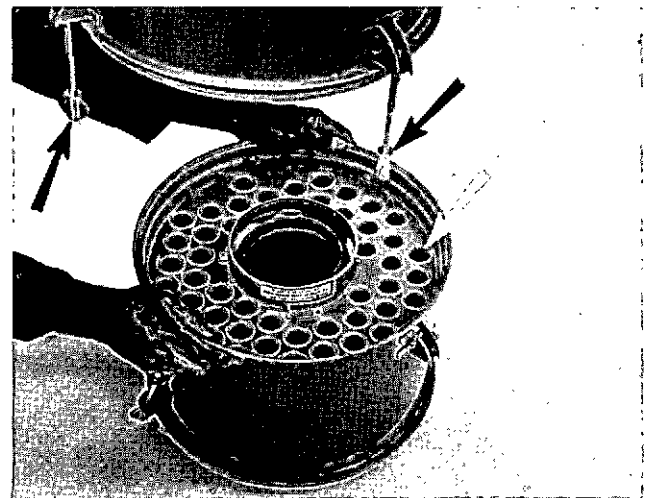
2. Remove and empty the dust collector cup.
3. Inspect the seal in the filter base. Install a new seal if necessary.



4. Clean the tubes with a round brush. Use a brush that will not scratch the plastic, but will remove the dirt.
5. Install the dust collector cup.

Cleaning the Lower Body

1. Remove the dust collector cup.
2. Loosen the clamping bolts on the upper body.
3. Remove the lower body. Clean the tubes from both ends.



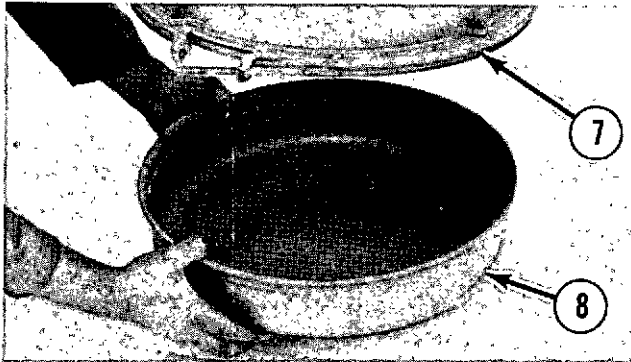
4. Inspect the upper body seal. Install a new seal if the used one is damaged.

Changing Filter Element

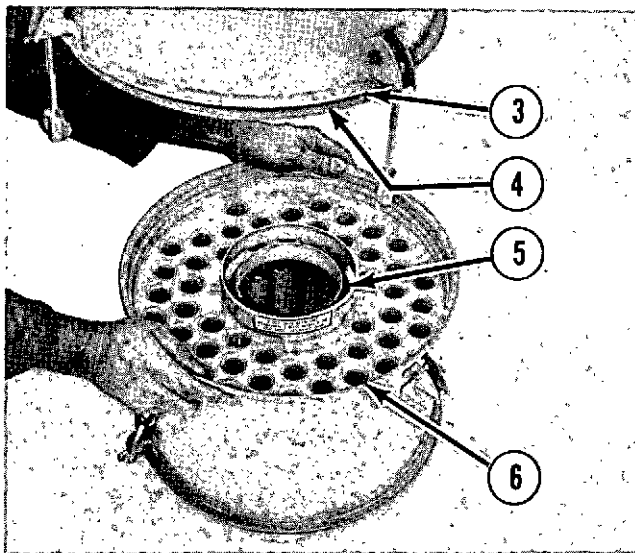
CAUTION

Service the two stage air cleaner with the engine stopped.

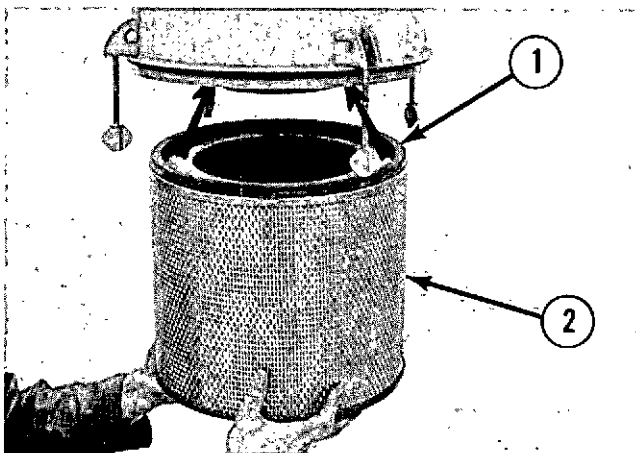
1. Remove the dust collector cup.



2. Remove the lower body. Clean the tubes from both ends.



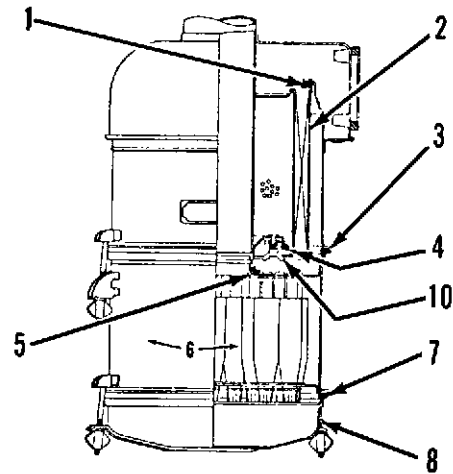
3. Remove the retaining wing nuts and filter element.



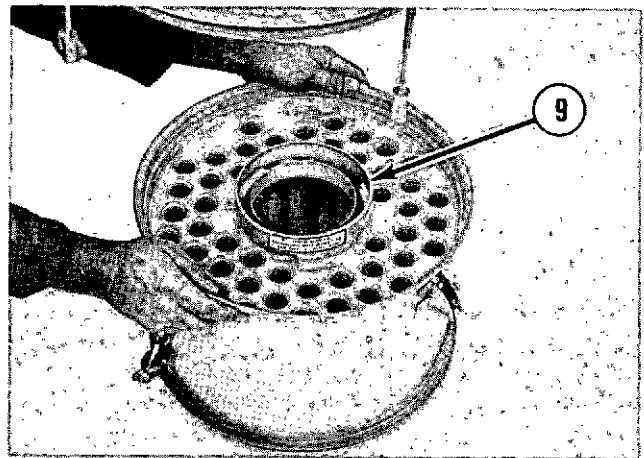
4. Clean all parts of the air cleaner.
5. Inspect seals (3) and (7) and gasket (5). Install new ones if they are damaged.
6. Inspect the replacement element. If the upper seal (1), lower seal (4), or paper pleats are damaged, install a new element.

NOTE

Have a replacement element on hand to install and use while cleaning the dirty element. This will save you down time.



7. Install the filter element and the wing nuts. Tighten the wing nuts to prevent dust from bypassing the filter element.
8. Align the wing nuts so locking ring (9) will slip over the wing nuts at (10) when the lower body is installed. The locking ring prevents the wing nuts from loosening during operation.



9. Be sure upper body seal (3) and lower body gasket (5) are in place. Install the lower body.
10. Install the dust collector cup.

CLEANING FILTER ELEMENTS

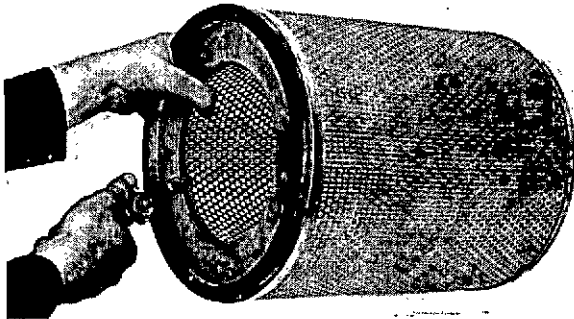
Cleaning Elements With Air

1. Use clean, dry air — 30 psi (2 kg/cm²) maximum. Hold the nozzle at least one inch from the element and at a slight angle.

WARNING

When using pressure air, wear safety glasses and protective clothing. Use no more than 30 psi (2 kg/cm²) pressure.

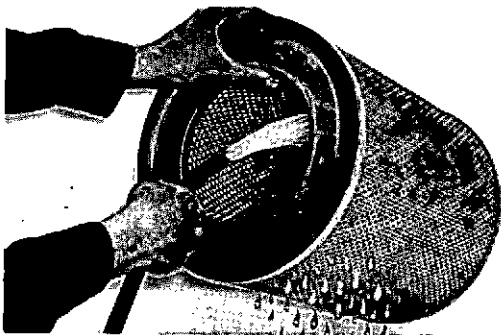
2. Direct the air stream along the complete length of each pleat on the CLEANEST side of the element. (This will loosen the dirt from the dirtier side.)



3. Blow the loosened dirt from the DIRTY side.
4. Direct the air from the CLEAN side through to the DIRTY side to remove dirt blown into the pleating.

Cleaning Elements With Water

1. Use clean water at no more than 40 psi (3 kg/cm²). Do not use a nozzle.
2. Direct the water along the complete length of each pleat on the CLEAN side of the element.

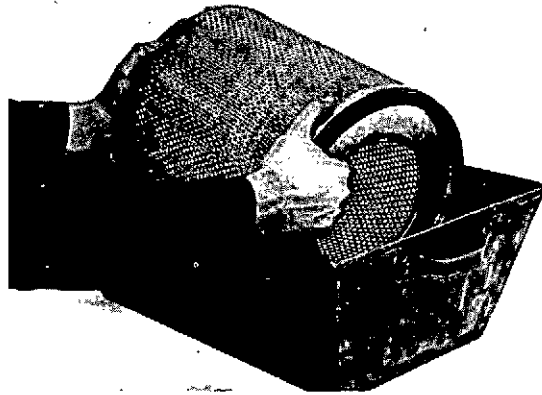


3. Direct water along the complete length of each pleat on the DIRTY side of the element.

4. Rinse the CLEAN side of the element.
5. Allow the cleaned element to dry thoroughly.

Cleaning Elements With Detergent

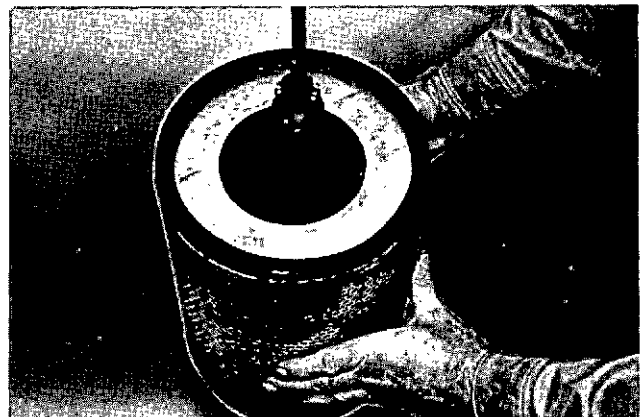
1. Wash both sides of the element in a solution of warm water and non-sudsing detergent.



2. Rinse the CLEANEST side of the element with clean water 40 psi (3 kg/cm²) maximum along the complete length of each pleat.
3. Rinse the opposite side of the element along the complete length of each pleat.
4. Rinse the first side again to remove all loosened dirt.
5. Allow the cleaned element to dry thoroughly.

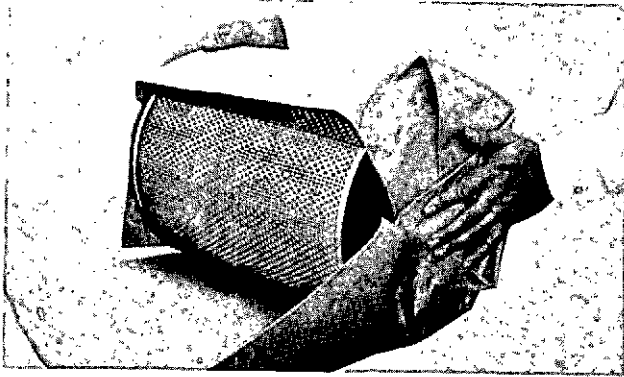
Inspecting Cleaned Elements

Insert a lighted light bulb inside the dried element. Carefully inspect the element for tiny pin points of light. Any light showing indicates the paper has been punctured and will allow dirt to enter the engine.



Storing Cleaned Elements

1. Wrap usable elements in heavy paper.

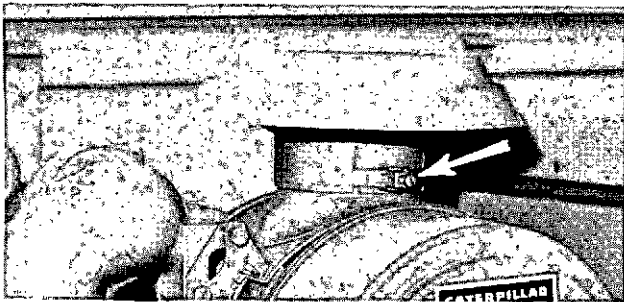


2. Store the wrapped element in a dry, clean place.

DUST COLLECTOR CAP

Servicing Dust Collector Cap

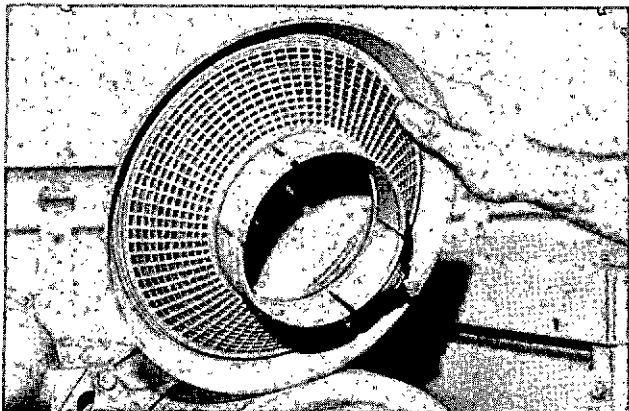
1. Remove the cap from the air cleaner inlet.



2. Clean the bottom grill using pressure air (maximum 30 psi – 2.0 kg/cm²), or low sudsing detergent and water. Install the cap.

WARNING

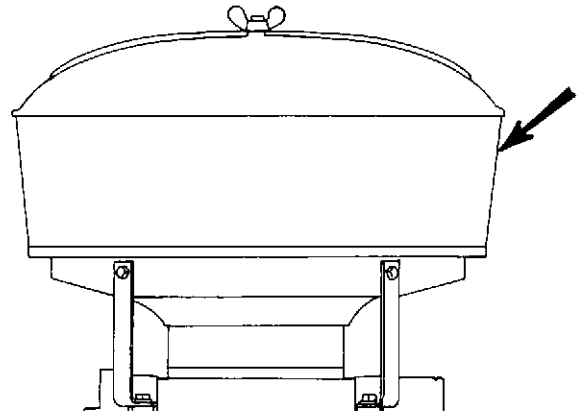
Protective eye glasses must be worn when using pressure air.



PRECLEANER

Servicing Precleaner Dust Collector Body

When the precleaner body is 3/4 full:

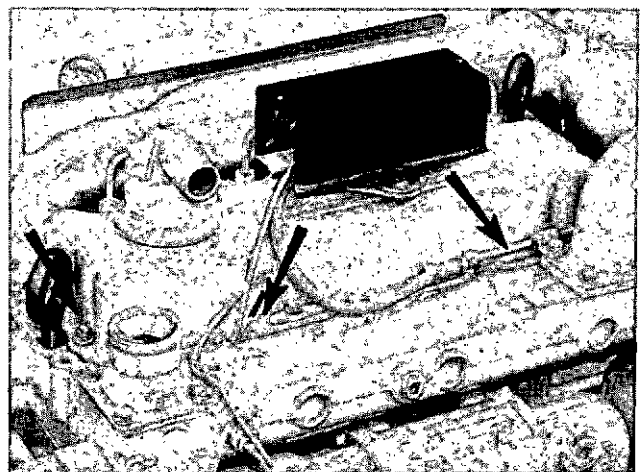


1. Loosen the wing nut and remove the cover.
2. Remove the precleaner body.
3. Empty the dust. If necessary, wash the precleaner body in low sudsing detergent and water.
4. Assemble the body and cover.

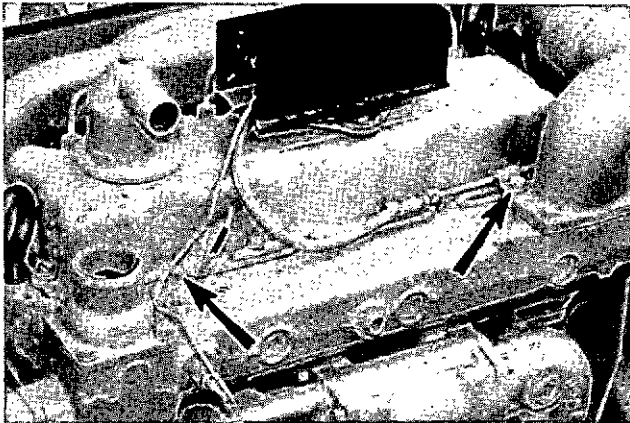
VALVE LASH

Checking and Adjusting Valve Lash

1. Stop the engine.
2. Clean the top of the cylinder head and the base of the valve cover.



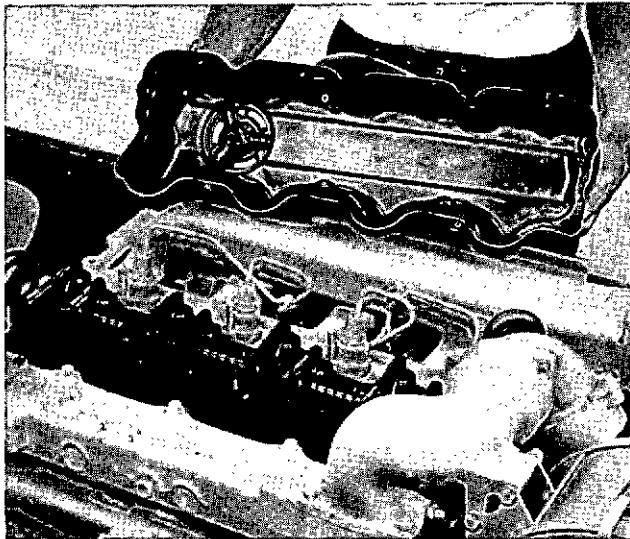
3. Remove the brackets holding the lines to the instrument panel gauges.



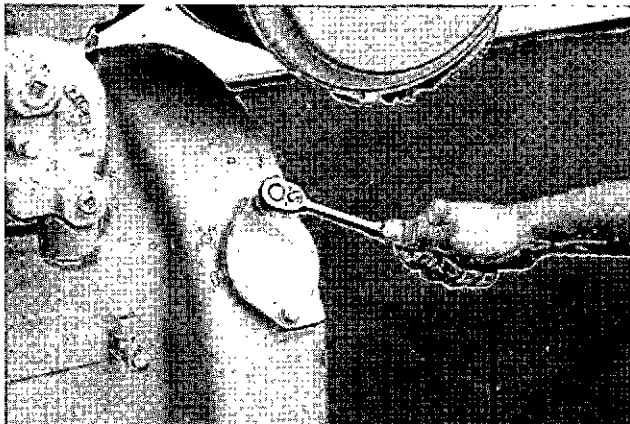
4. Remove the valve cover.

CAUTION

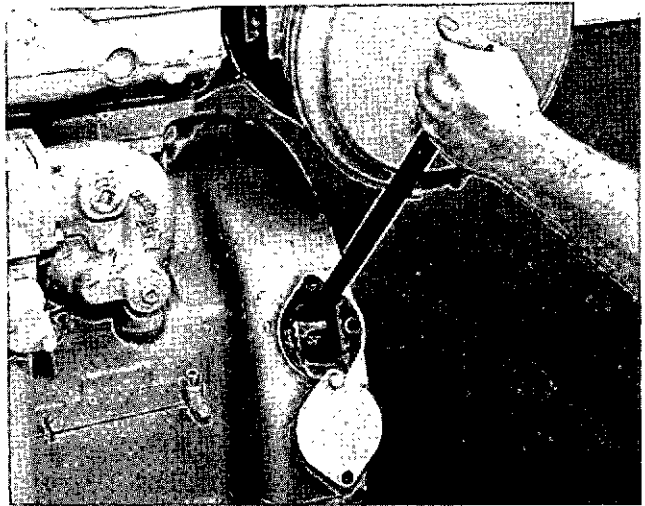
Keep dirt from falling inside the engine block or into the valve mechanism, as the valve cover is removed.



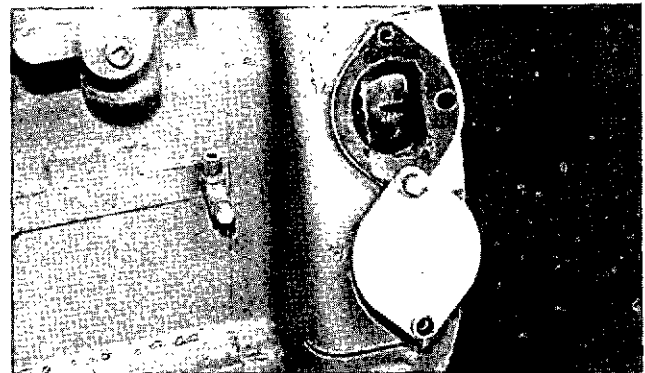
5. Remove the flywheel housing timing cover.



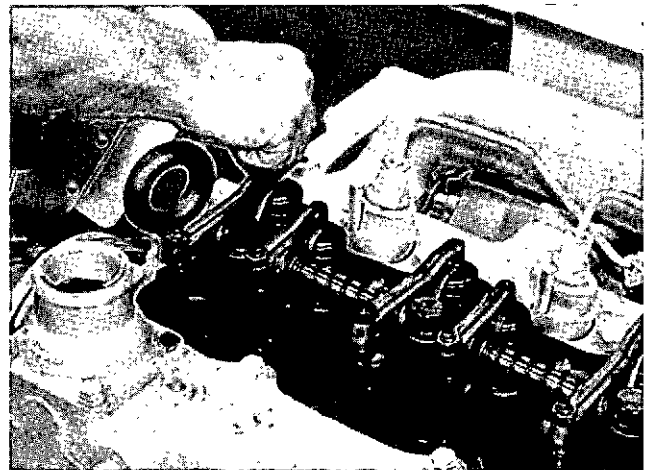
6. Bar the flywheel in the direction of normal rotation.



7. Align the "TC-1" timing mark with the flywheel housing timing pointer.



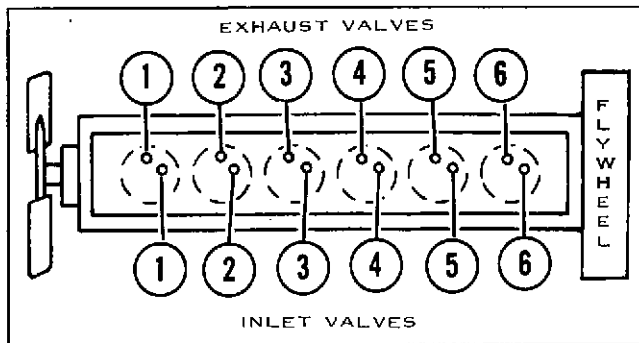
8. Check the No. 1 cylinder rocker arms for movement. Determine if the piston is on COMPRESSION OR EXHAUST STROKE.



NOTE

COMPRESSION STROKE: Both inlet and exhaust valve rocker arms can be easily moved with finger pressure.

EXHAUST STROKE: Only inlet valve rocker arm can be moved freely with finger pressure.



(3306 shown, 3304 is similar)

CYLINDER AND VALVE IDENTIFICATION

- Refer to the tables below, and set only those valves specified in the appropriate table:

COMPRESSION STROKE

VALVES	CYLINDERS	
	3304	3306
INLET	1-2	1-2-4
EXHAUST	1-3	1-3-5

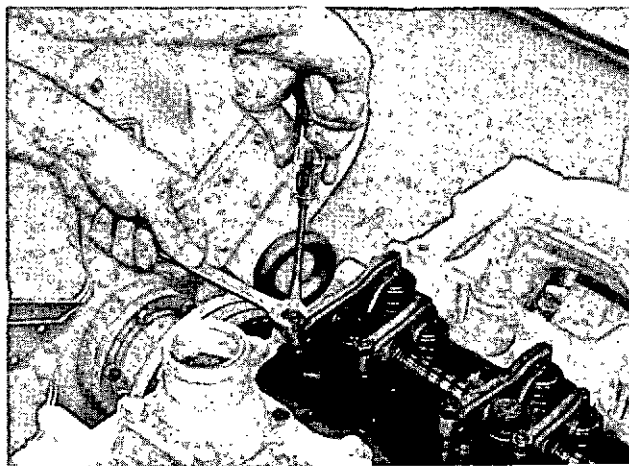
EXHAUST STROKE

VALVES	CYLINDERS	
	3304	3306
INLET	3-4	3-5-6
EXHAUST	2-4	2-4-6

- Bar the flywheel one revolution in the direction of normal rotation and align the flywheel "TC-1" timing mark.
- Check the movement of the rocker arms for cylinder No. 2.
- Set the remaining valves as specified in the remaining table.

Setting Valve Lash

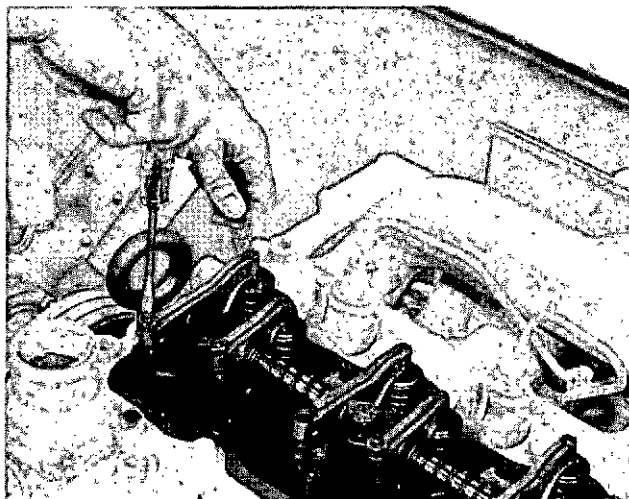
- Loosen the locknut on the adjusting screw.



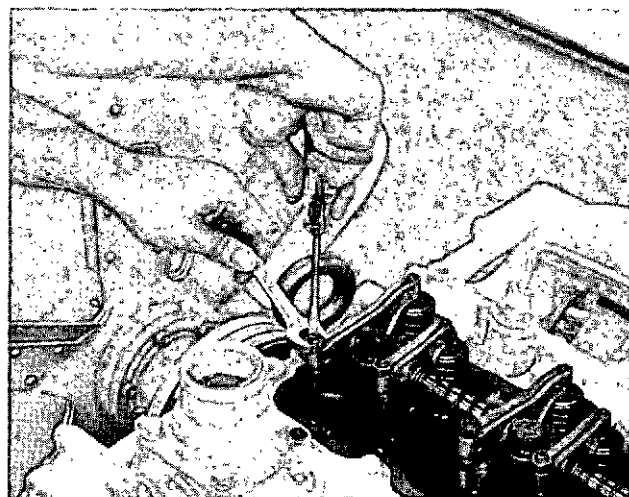
- Turn the adjusting screw to obtain the proper lash.

Exhaust lash = .025" (0,69 mm)

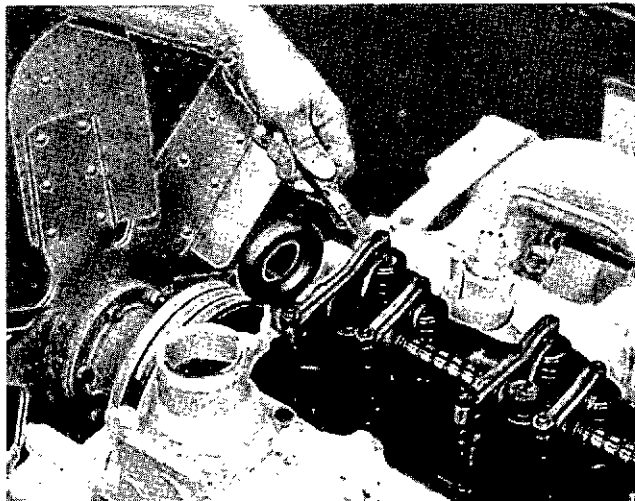
Inlet lash = .015" (0,38 mm)



- Hold the adjusting screw and tighten the locknut.



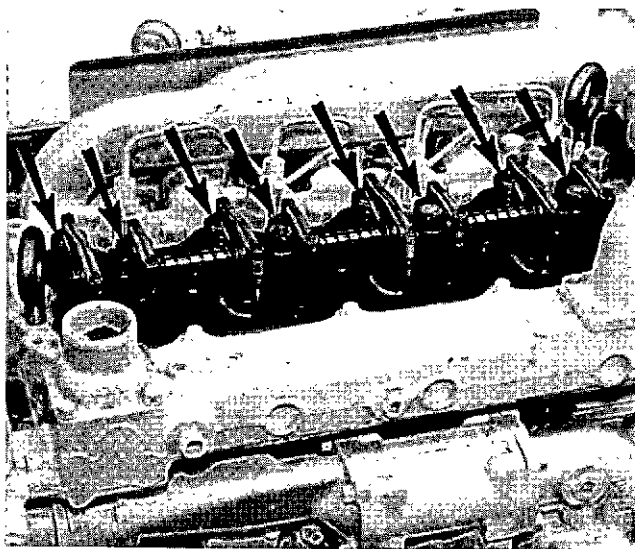
4. Recheck the lash.



Checking Valve Rotation

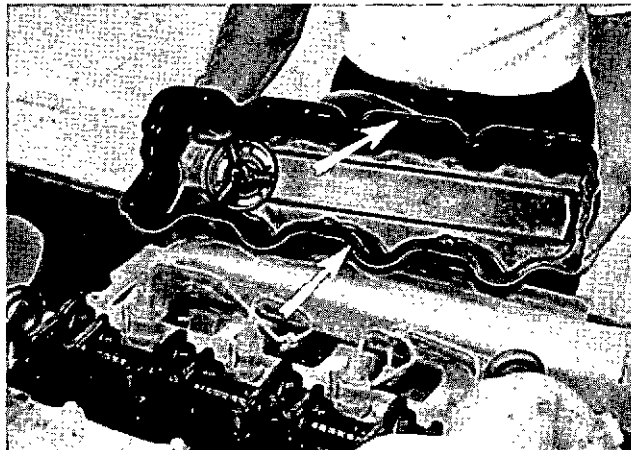
After checking valve lash, and before installing the valve cover:

1. Start the engine.
2. Move the governor control to low idle position.
3. Watch the serrations on each valve retainer. Each valve retainer should turn slightly each time the valve closes.

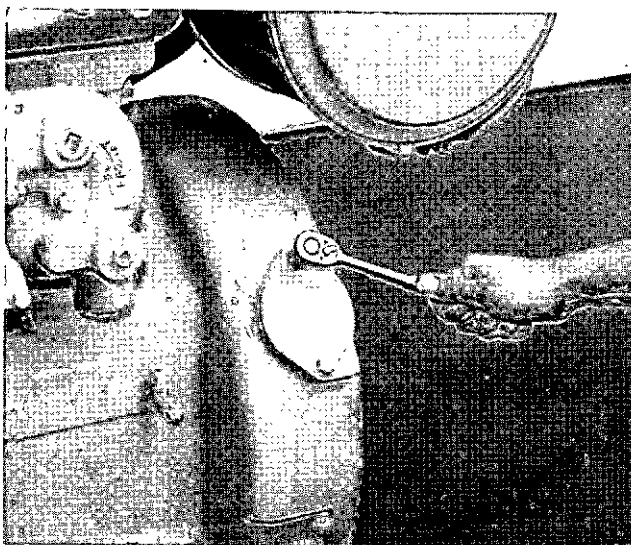


If a valve retainer fails to rotate, call your Caterpillar dealer.

4. Stop the engine.
5. Inspect the valve cover gasket. Install a new gasket if necessary.



6. Install the valve cover.
7. Install the flywheel housing timing cover.



FUEL SYSTEM

FUEL

Diesel Fuel

See the Lubrication and Maintenance Chart for distillate fuel recommendations to use when ordering fuel.

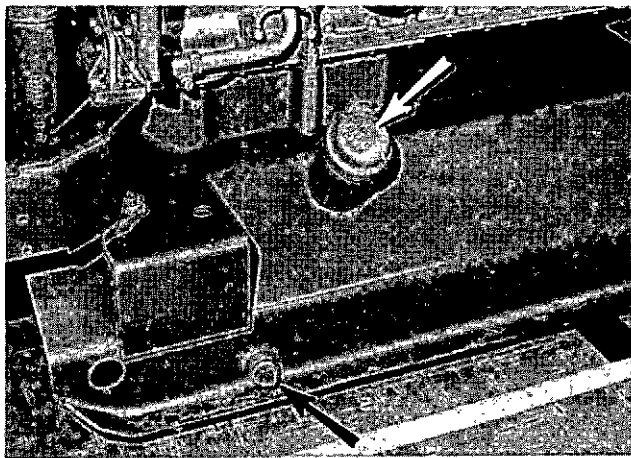
Fuel Tank Maintenance

1. Check the fuel level daily.
2. Fill the fuel tank as required. If possible, fill the tank before evening.

As fuel is used, air with some humidity must replace the fuel in the tank. As the fuel tank cools at night, this moisture may condense on the inside walls of the tank and drop into the remaining fuel and contaminate it.

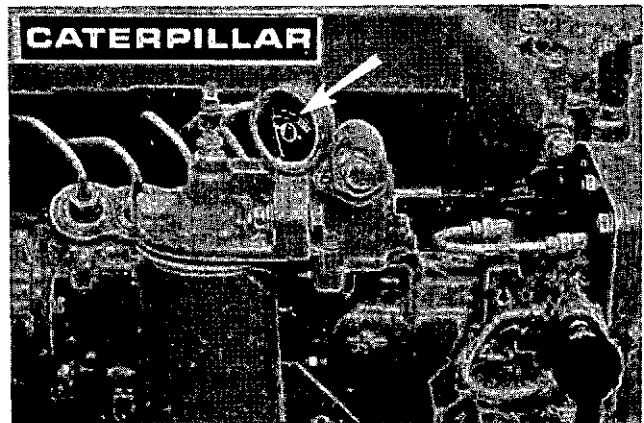
By filling the tank before evening, there will be that much less air and humidity in the tank to condense.

3. Periodically open the fuel tank drain valve. Drain the water and sediment from the fuel tank to prevent fuel contamination, and poor engine performance.



Checking Fuel Pressure

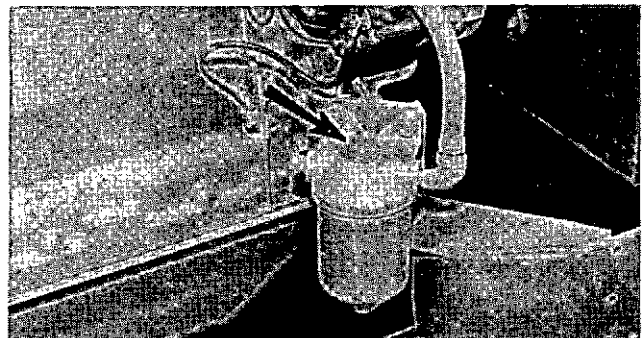
With the engine running, the fuel pressure gauge should register in the NORMAL range. Observe the gauge reading frequently. If the gauge indicates in the OUT range, clean the primary filter element, if so equipped; or change the fuel filter element.



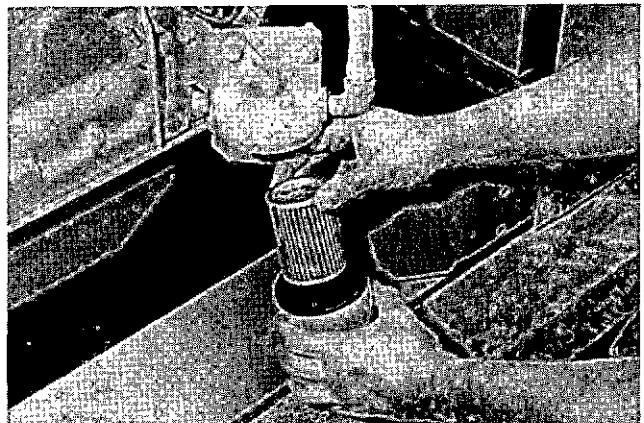
PRIMARY FILTER ELEMENT

Cleaning Primary Fuel Filter

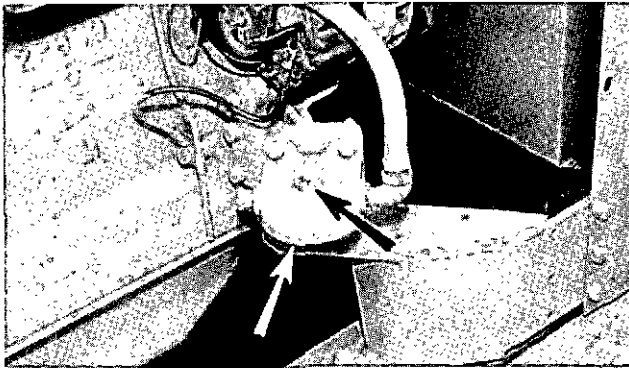
1. Stop the engine.
2. Close the diesel fuel supply line valve.
3. Loosen the cover nut, and remove the housing and element.



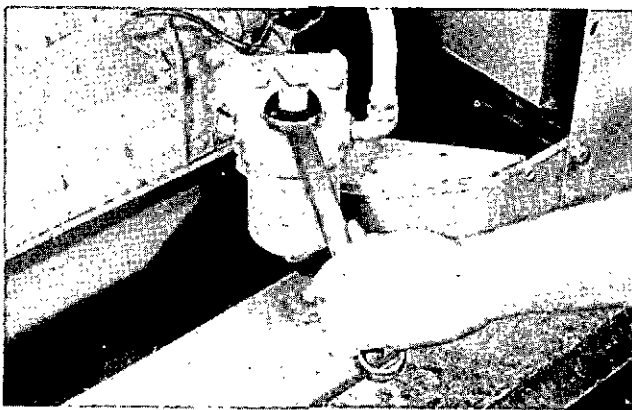
4. Remove the element from the housing; and clean them both in solvent.



5. Inspect the upper and lower cover gaskets. Install new gaskets if necessary.



6. Install the cleaned filter element and case.

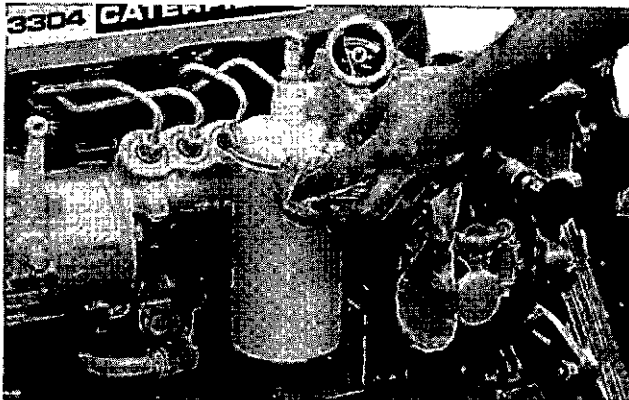


7. Open the fuel supply line valve.
8. Prime the fuel system as instructed.

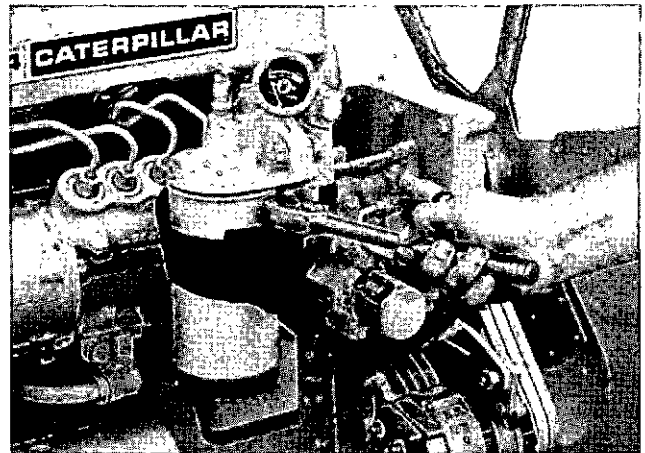
FUEL FILTER

Changing Filter

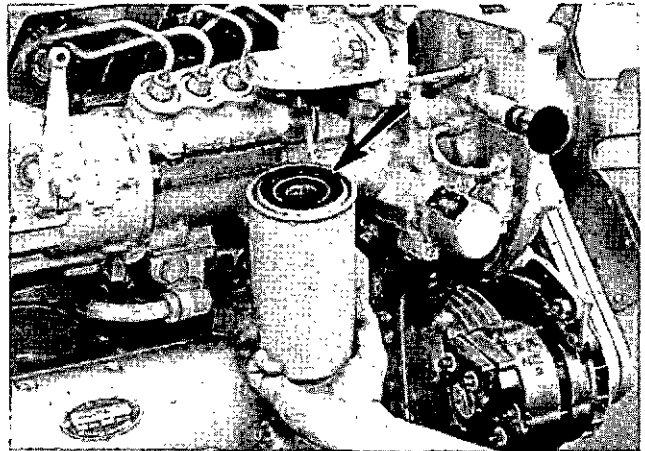
1. Stop the engine.
2. Close the diesel fuel supply valve.
3. Wipe the top of the filter element and filter base.



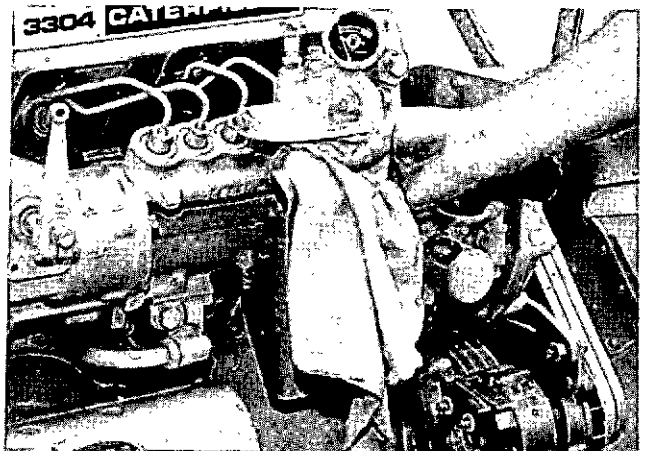
4. Unscrew and remove the filter.



5. Be certain the filter gasket did not remain attached to the filter base: Leaking between the new and old filter gaskets would result.

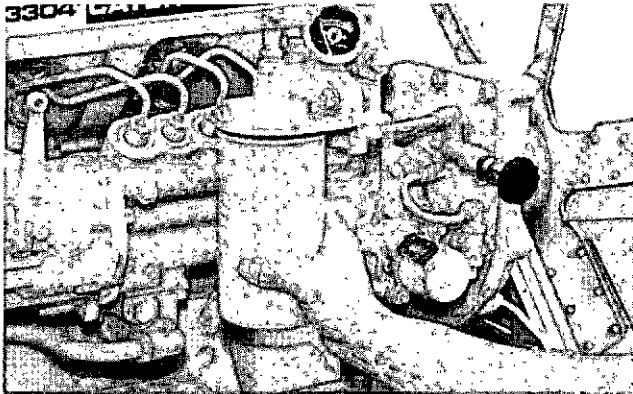


6. Clean the gasket sealing surface of the filter base.



7. Lubricate the new filter gasket with clean diesel fuel.

8. Install the new filter: Hand tighten the filter. When the engine is running, check for fuel leaks; and if necessary, tighten the filter by hand until leaking stops.



9. Open the fuel supply line valve.

10. Prime the fuel system as instructed.

PRIMING PUMP

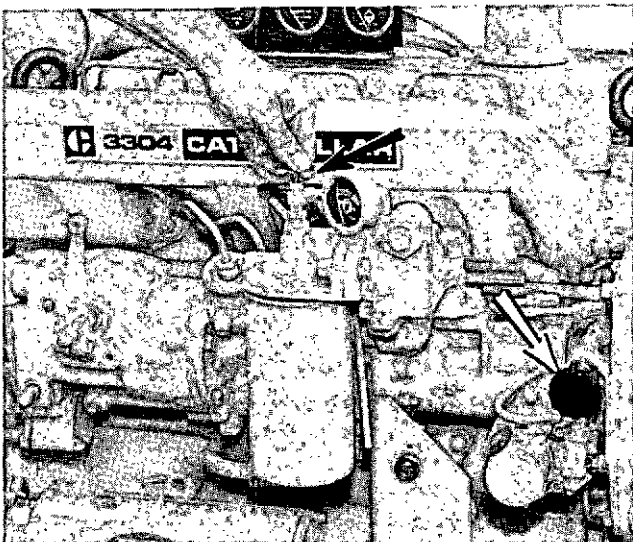
Priming the Fuel System

If air is trapped in the fuel system, the diesel engine will either not start, or will misfire.

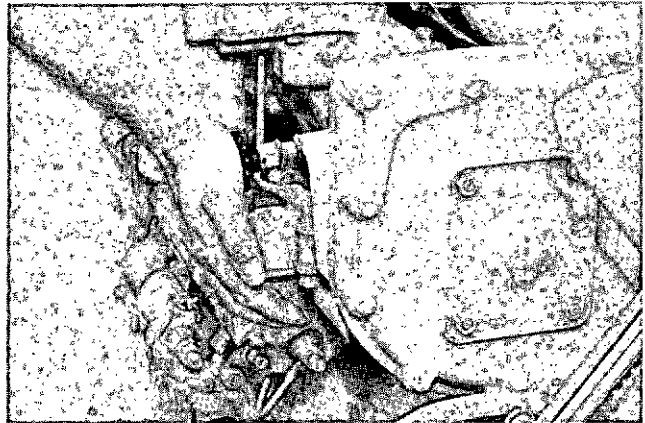
1. Move the governor control lever to the shut-off position.
2. Open the vent valve on top of the filter base.

CAUTION

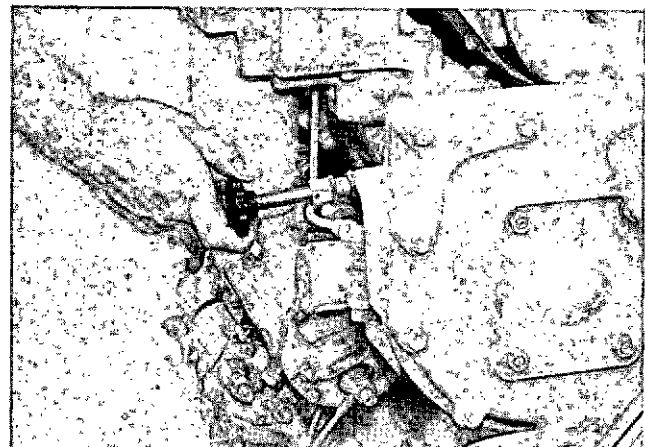
Operate the priming pump only when the vent is open.



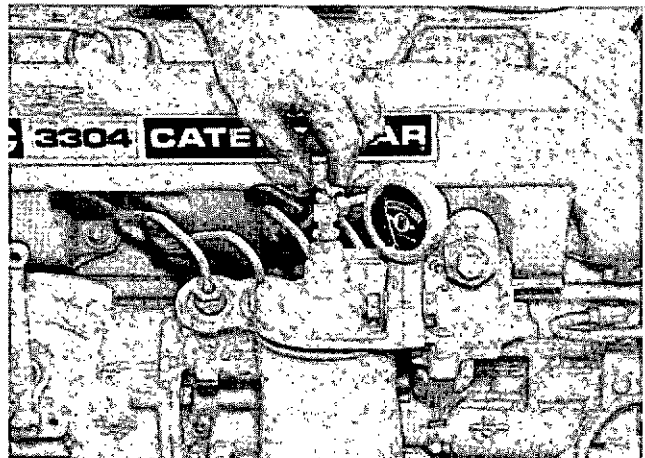
3. Push in on the pump and turn counterclockwise to release the pump from the locked position.



4. Operate the fuel priming pump with rapid strokes until the stream of fuel pumped out is free of air bubbles.



5. Push in on the pump and turn clockwise to lock the pump in the closed position.
6. Close the vent valve.



7. Start the engine.

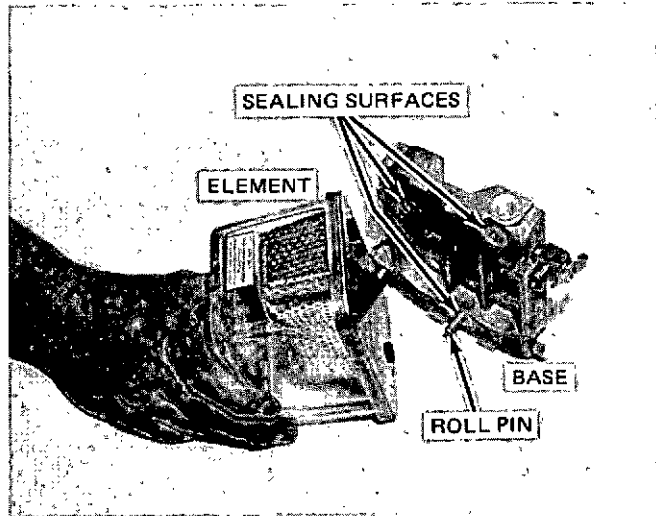
Replacing the Water Separator Filter and Glass Housing Assembly:

When the water level cannot be seen because of the sediment inside the filter housing:

1. Stop the engine and close the fuel supply valve.
2. Clean around the base of the housing.
3. Drain the water and fuel from the housing. Close the vent and fuel valves.
4. Push against the extended tab with the heel of the hand while lifting the tab from the locking slot. Remove the filter and housing assembly and discard it.



5. Clean the three sealing surfaces on the filter mounting base.



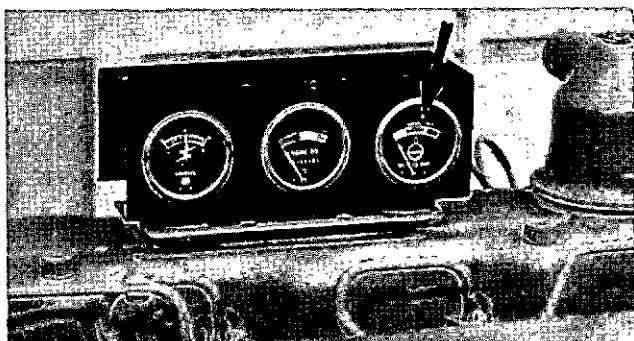
6. Engage the base of the new filter assembly housing on the locating pin and push the housing onto the base.
7. Engage the lower clamp tab with the base; and while pushing on the upper tab with your palm, engage the top tab.
8. Open the fuel supply valve and check for fuel leaks.

COOLING SYSTEM

ENGINE COOLANT

Checking Water Temperature

The water temperature gauge should normally register in the NORMAL range when operating. However, with some systems, as long as the coolant does not boil the cooling system is functioning properly.



1. If the water temperature gauge continually registers near — or in the "HOT" range — without boiling, have the system checked to determine if the cooling system is functioning properly.
2. Check the water temperature gauge reading frequently during operation. Note any deviation from the usual reading.

If the reading is not in the NORMAL operating range, stop the engine and have the engine serviced.

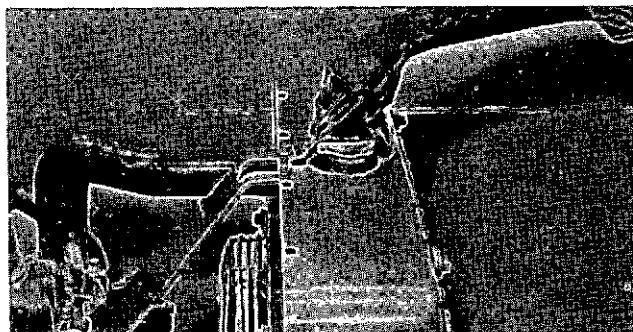
Checking Coolant Level

With the engine stopped:

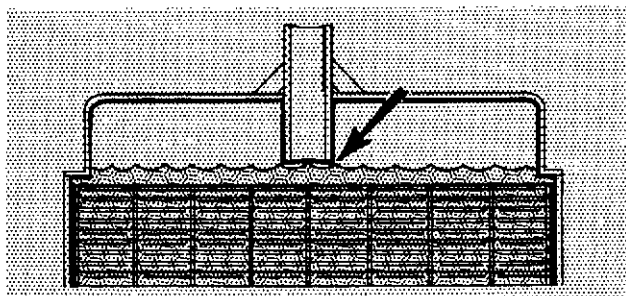
1. Slowly turn the filler cap to the first stop and release pressure.

WARNING

Be careful. If the engine is warm — steam may spray outward under high pressure.



2. Push the cap down; turn until the cap is released.
3. Maintain coolant level to the base of the fill pipe.



4. Make-up coolant should be one of the following, in the order of preference:
 - a. Permanent antifreeze and fresh water solution.
 - b. Drinkable water and rust inhibitor solution.
 - c. Drinkable water.
 - d. Any available fresh water.

(a) Must be used if engine is to be shut down in below freezing weather without draining the coolant. (b) Can only be used when the coolant temperature is above freezing, or if the coolant will be immediately drained after shut down during below freezing temperatures.

(c) or (d) Should only be used as a "temporary fix". As soon as possible, return the system to either (a) or (b).

Draining Radiator

If a permanent antifreeze solution is used in the cooling system, either renew the rust inhibitor every three months by adding Caterpillar Corrosion Inhibitor, or drain and replace the solution yearly.

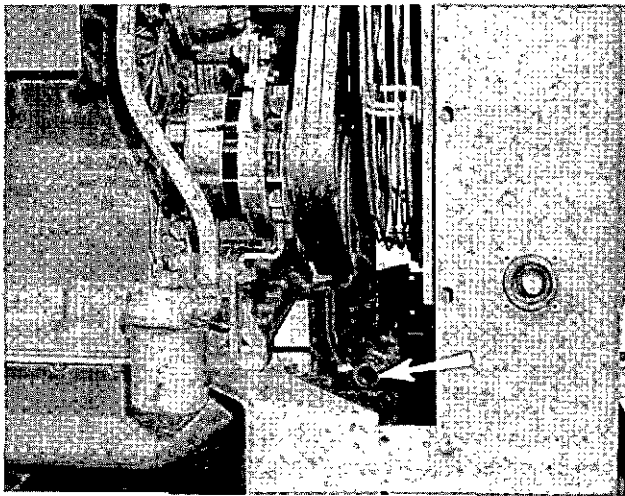
Whenever is it necessary to drain the cooling system:

1. Shut the engine off.
2. Slowly turn the pressure cap until the cap is released.

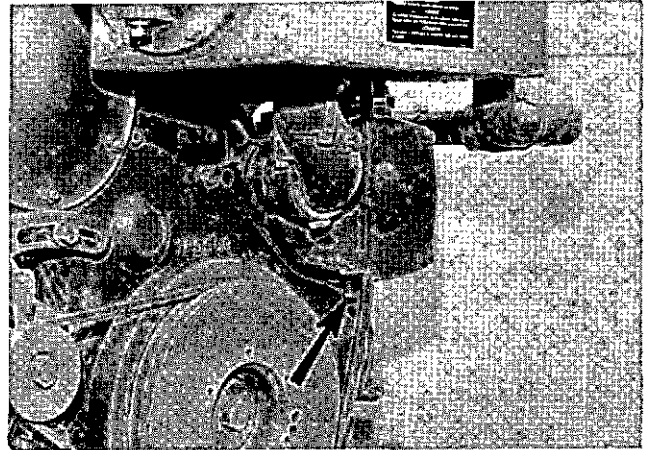
WARNING

Be careful. If the engine is warm — steam may spray outward under high pressure.

3. Open the drain valve to the radiator.

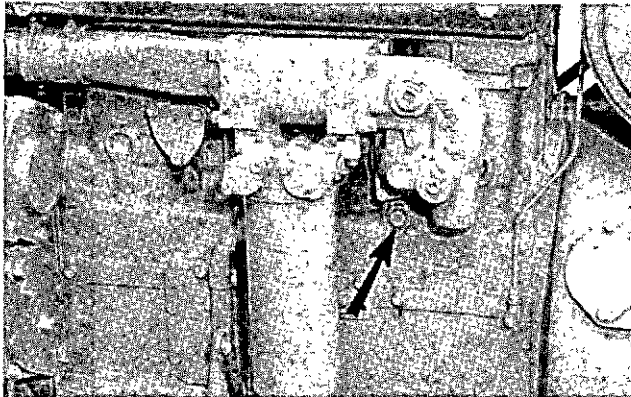


4. Remove the water pump drain plug.

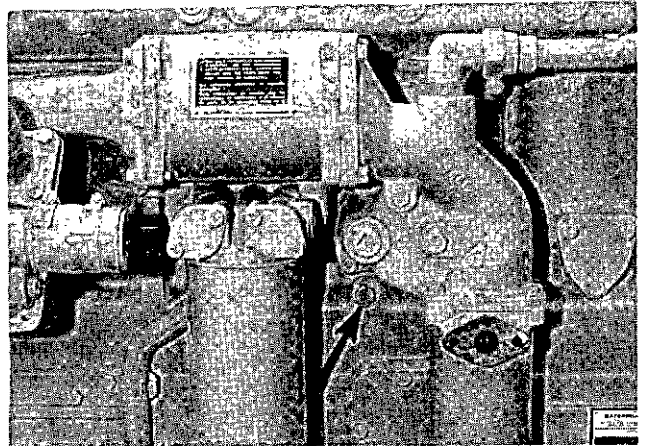


Draining Engine Jacket Water

1. Drain the radiator.
2. Remove the engine block drain plug.



5. Remove the engine block drain plug.



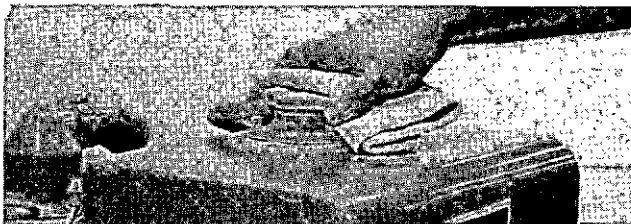
6. Remove the water cooled manifold drain plug.

Draining Marine Engine Jacket Water

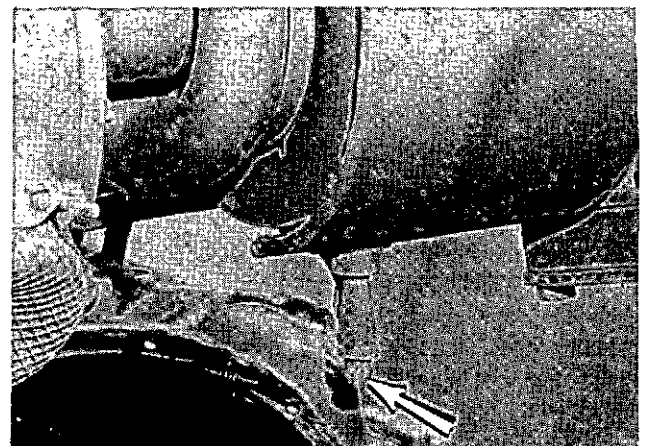
1. Shut the engine off.
2. Slowly turn the pressure cap to the first stop and release pressure.

WARNING

Be careful. If the engine is warm—steam may spray outward under high pressure.



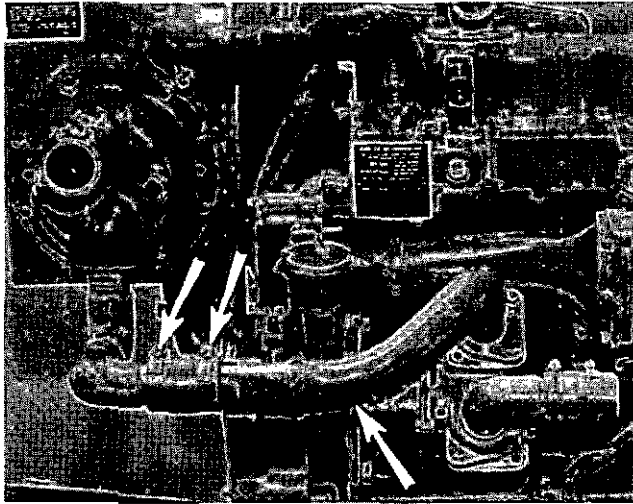
3. Push the cap down and turn until the cap is released.



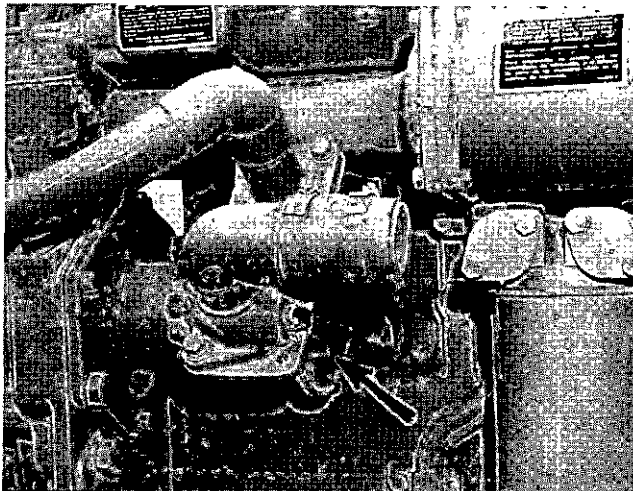
Draining Raw Water System

If ambient temperature may go below freezing, drain the raw water line between the expansion tank and raw water pump:

1. Loosen the hose clamps and hose, or remove the drain plug if so equipped.



2. Remove the cover from the raw water pump.



Filling Cooling System

CAUTION

When filling a cooling system, it is essential air pockets within the system are able to vent to the atmosphere. Air trapped in the system can cause major engine problems.

1. Use water that is low in scale forming minerals. Do not use softened water.
2. While filling the cooling system, stop the filling procedure several times to allow the coolant level to stabilize and expel air from the system.
3. Add coolant until the coolant level reaches the base of the fill pipe. Allow space for coolant expansion.

4. Start the engine and allow it to idle several minutes with the filler cap off. Add coolant as necessary.
5. Install the filler cap.
6. Check the system for leaks. Have the engine cooling system repaired if necessary.

Cleaning Cooling System

To clean the cooling system, any good commercial radiator cleaning solution can be used. Follow the instructions included with the cleaner.

The cooling system can be cleaned using oxalic acid and sodium carbonate as follows:

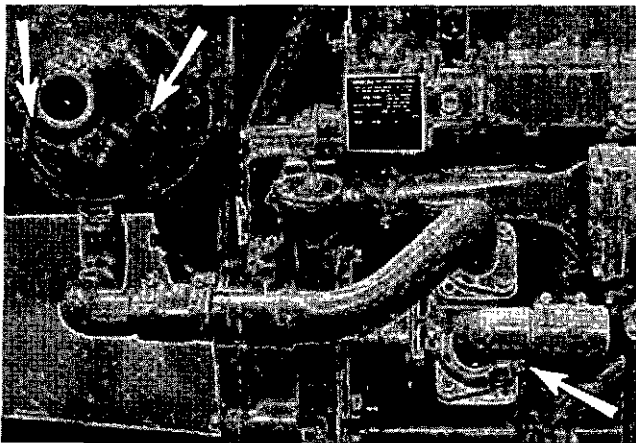
1. Fill the cooling system with a solution of 2 pounds of oxalic acid or sodium bisulphate (NaHSO_4) with every 10 gallons of water (mix 25 grams per liter of water).
2. Start the engine and operate at operating temperatures for 1/2 to 1 hour.
3. Stop the engine and drain the cooling system.
4. Flush the system with clean water until the draining water is clear.
5. Install all drain plugs.
6. Fill with a solution consisting of 1/2 pound of sodium carbonate crystals (Na_2CO_3) with every 10 gallons of water (mix 6 grams per liter of water.)
7. Start and run the engine for 10 minutes.
8. Stop the engine and drain the cooling system.
9. Flush the cooling system with clean water.
10. Install all drain plugs.

ZINC RODS

(Salt Water Operations Only)

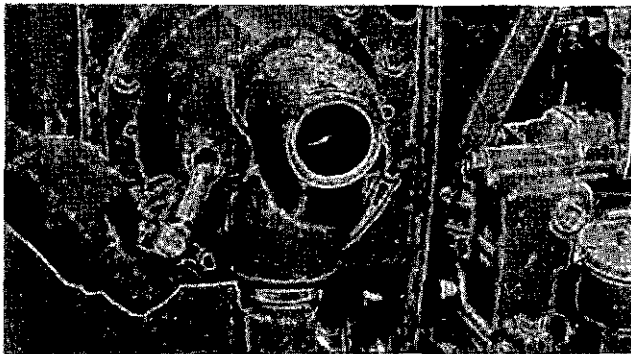
Salt water has a highly corrosive reaction with metal by a chemical action called "electrolysis". To prevent this chemical action taking place, with parts used in the raw water system, zinc plugs are placed in the raw water piping. Zinc is a relatively soft metal which reacts quite readily with the salt water. Thus, by the deterioration of the zinc, the raw water system parts are protected from corrosion.

The zinc rods must be inspected regularly and be replaced as they become deteriorated. The zinc rod plugs are painted red for easy identification.

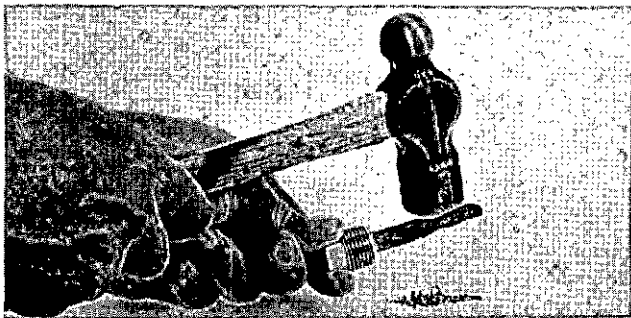


Inspecting Zinc Rods

1. Move the governor control lever to the shut-off position.
2. Remove and inspect all of the zinc plugs. They are painted red for easy identification. Depending upon the engine, their location may be in the oil cooler heat exchanger bonnet, raw water heat exchanger bonnet, aftercooler lines, raw water pump, or in the raw water lines.



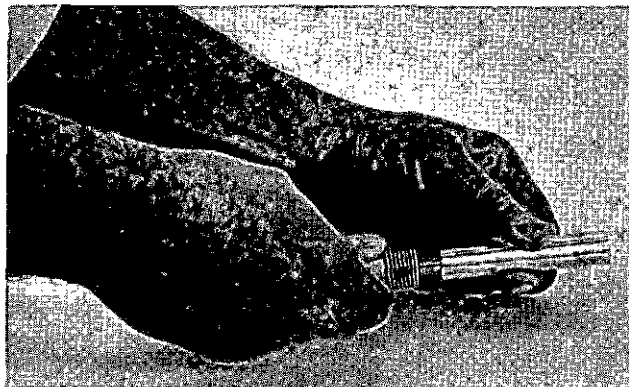
3. Tap the zinc rods lightly with a hammer.



4. Inspect the rods. If a rod has deteriorated, or flakes apart when tapped, install a new zinc rod.

Installing a New Zinc Rod

1. Unscrew or drill the existing rod from the plug base.
2. Install a new rod in the plug base.



3. Install the plug.

ALTERNATOR—FAN BELTS

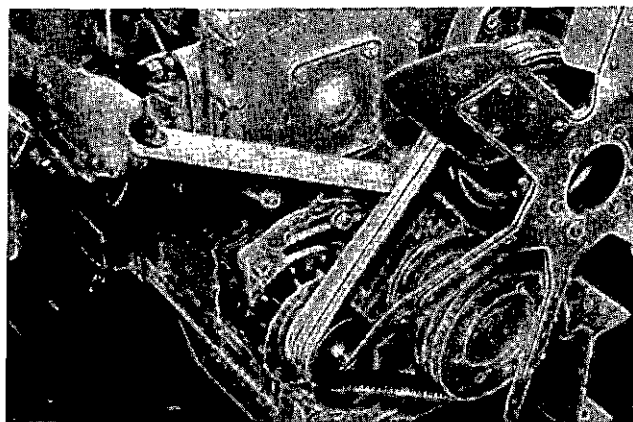
Checking Belt Condition and Tension

1. Check belts for excess wear, fraying and cracking.

NOTE

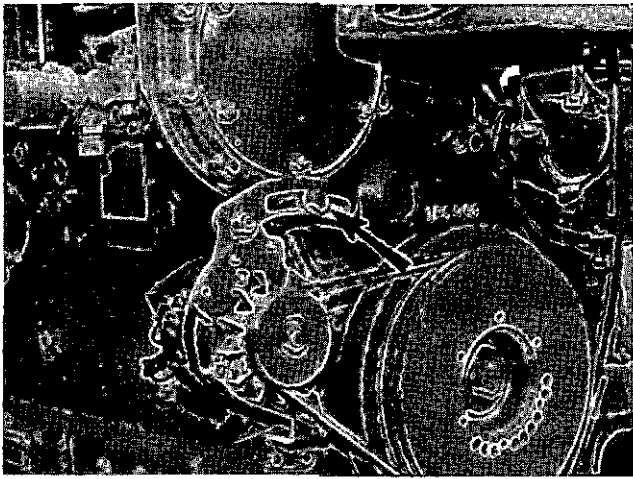
When belt replacement is necessary, belts must be replaced in complete matched sets. Never replace a single belt as the new belt will carry all of the load and fail rapidly.

2. Apply a 25 pound (10 kg) force perpendicular to the belt, midway between the driver and driven pulley. Belt deflection should be $9/16''$ to $13/16''$ (15–20 mm). Adjust the belt tension as required.



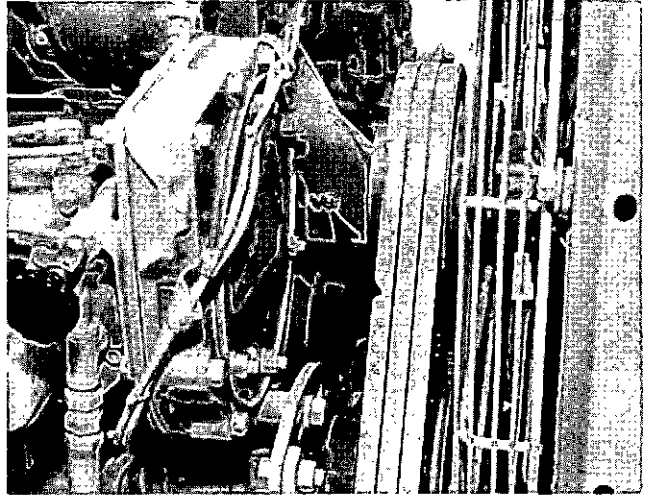
Adjusting Belts

1. Loosen the adjusting bolt in the slotted bracket.

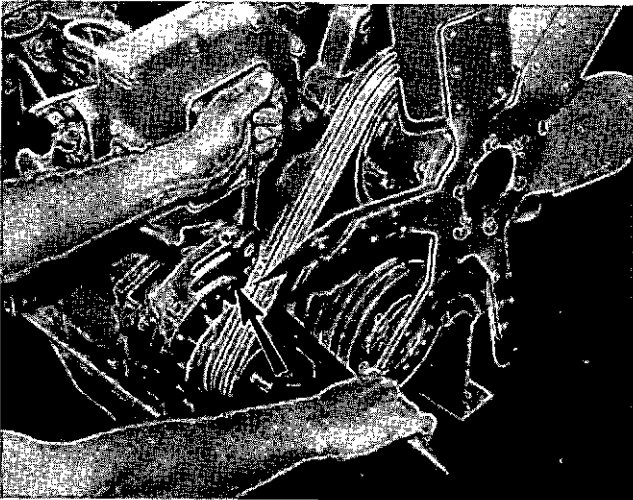


Lubricating Fan Drive

Lubricate the fan drive bearing; 1 or 2 strokes, 1 fitting.

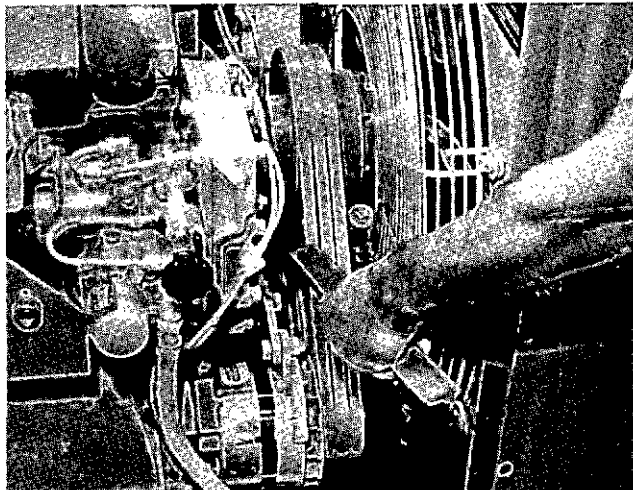


2. By applying pressure to the front housing only of the alternator, as shown, move the alternator outward.



3. When the desired belt deflection is attained, tighten the adjusting bolt.

4. Check belt tension. Adjust if necessary.



AIR STARTING SYSTEM

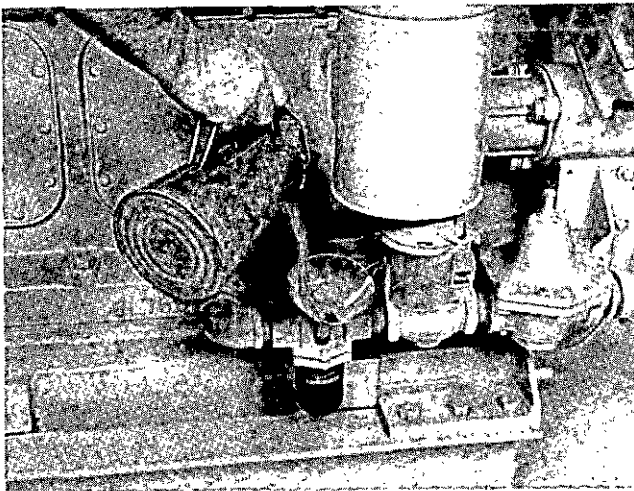
Filling Motor Oiler

The motor oiler lubricates the vanes of the starting motor with a fine oil mist as the motor is operating.

When the oiler jar becomes half empty, remove the oil filler plug and fill the jar with clean oil. Refer to the Lubrication and Maintenance Chart for proper oil.

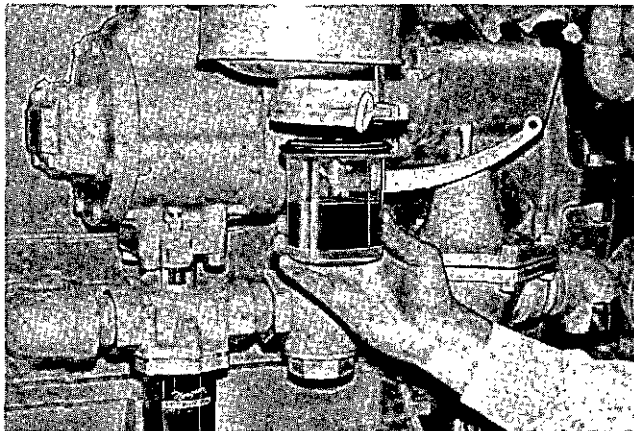
CAUTION

Never allow the jar to become empty. The starting motor will be damaged by lack of proper lubrication.



Emptying Oil Collector Jar

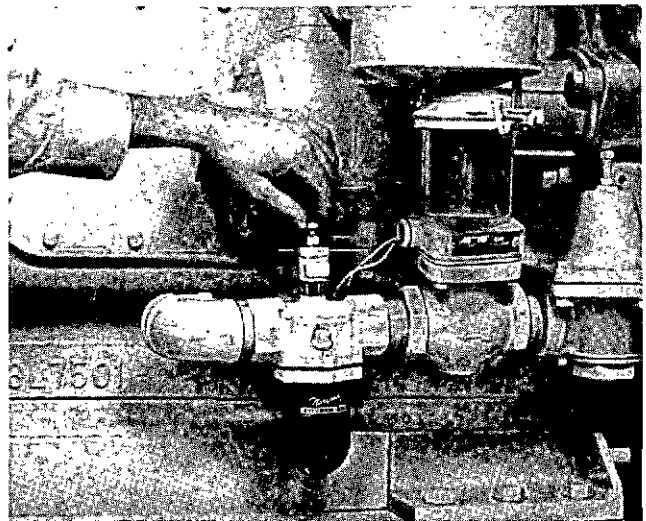
Empty the oil collector jar whenever the jar becomes half full. The collector jar collects both the oil after it has lubricated the starting motor vanes, and the moisture condensation from the compressed air. **Do not fill the oiler jar with this used oil.**



Adjusting Oiler Feed

If necessary, adjust the oiler to release approximately four drops of oil per minute into the starting motor air stream.

1. The engine must be operated long enough to have the oil warm. Then stop the engine.
2. Move the governor control lever to the SHUT-OFF position.
3. Pull up on the air start control lever and crank the engine.
4. Count the drops of oil released per minute into the air stream.
 - a. Turn the needle valve (the uppermost knob on the oiler) counterclockwise to increase the number of drops.
 - b. Turn the needle valve clockwise to decrease the number of drops.



ELECTRICAL SYSTEM

BATTERY

Installing Battery

1. Be sure the battery tray is clean and free of foreign objects.
2. Be sure terminal posts and cable clamps are clean.
3. Place the battery in the tray. Tighten the hold down clamps evenly until the battery is snug. Do not over-tighten.
4. Connect the "hot" terminal first. Be sure the top of the cable terminal is pushed down even with the top of the terminal post. Tighten the clamp firmly.

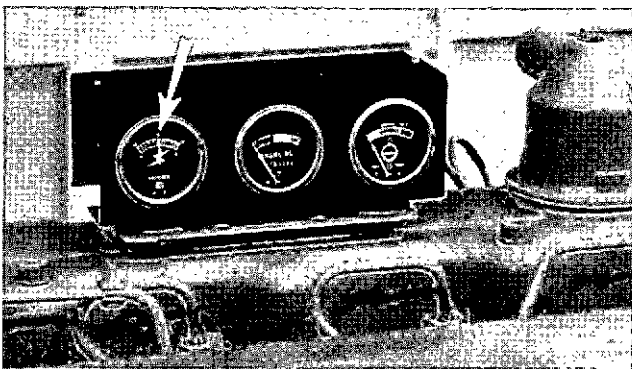
WARNING

Always connect the "hot" terminal first to minimize arcing. Otherwise injury or damage could result.

5. Connect the "grounded" terminal last. Be sure the top of the cable terminal is pushed down even with the top of the terminal post. Tighten the clamp firmly.
6. Apply a thin coating of grease over the cable clamps, terminals and hold down fasteners.

Checking Charge Rate

1. After starting the engine, the ammeter indicator should register to the right of zero, but should never be "pegged".



2. After the engine has been running, the indicator should be just to the right of zero.

If the indicator remains far to the right of zero, or remains to the left of zero with an increase of engine speed, have the electrical charging system checked.

Checking Electrolyte Level

A proper charge rate will require periodic additions of water.

1. Remove each vent cap and check the electrolyte level in each cell.
2. Add water to maintain the electrolyte level to the base of each vent well. Make-up water must be one of the following (in order of preference):
 - a. Distilled water.
 - b. Odorless drinking water.
 - c. Iron free fresh water.
 - d. Any available fresh water.

WARNING

Never add acid or electrolyte solution.

Cleaning Battery

Over a period of time, corrosion will appear on battery terminals, and the top of the battery case will accumulate oil and dirt. To maintain battery efficiency, these accumulations must be removed.

1. Mix a weak solution of baking soda and water.
2. Apply the solution with a clean, nylon bristle brush; avoiding the holes in the vent caps.
3. Allow the baking soda to work on the terminals and battery case for a few minutes. If reaction is fast, a second application may be needed.
4. Thoroughly rinse the battery and battery tray with clean water.
5. Examine. If required, repeat procedures.
6. Inspect cable clamp condition. Replace cables if necessary.

7. Check tightness of cable clamp bolts. They must be tight.
8. Apply grease to the battery cable clamps, terminals and hold down fasteners.

COLD WEATHER BATTERY MAINTENANCE

General Maintenance

1. After adding make-up water, charge the battery. The added water could dilute the electrolyte enough without charging to cause freezing and permanent damage to the battery.
2. Keep the batteries fully charged either by operating the charging system or by using a battery charger.
3. Keep the battery warm when not in use. In an unheated area, the heat from a lighted electric bulb is usually sufficient.

CAUTION

Use only a shop cord with a heavy wire guard around the light bulb.

Do not lay a lighted bulb directly on a battery case; the heat at point of contact could melt the battery case.

Do not lay cloth or flammable material in contact with a lighted bulb; charring and/or fire could result.

4. Use starting aids as instructed for starting the engine.
5. Use booster batteries as required. Connect the batteries as instructed below.
6. If a battery is not going to be used for a period of time, be sure the battery is fully charged while stored. Use a battery hydrometer to check the specific gravity of each cell, and use a battery charger to keep the battery charged. See the instructions below.

Charging the Battery

WARNING

Never smoke near the area where batteries are being charged. Hydrogen gas is given off

at each vent cap during charging. Hydrogen mixed with air is highly explosive.

1. Connect positive charger clamp to positive battery terminal.
2. Connect negative charger clamp to negative battery terminal.
3. Connect charger power cord to proper outlet.
4. Allow battery to charge slowly.

CAUTION

If battery is charged too rapidly, the battery will be damaged.

5. After the battery is charged, disconnect charger power cord from outlet; remove charger clamp from negative battery terminal; remove charger clamp from positive battery terminal.

Testing Electrolyte

NOTE

If the electrolyte level is too low to allow taking a hydrometer reading, add make-up water to the correct level and then charge the battery 2 to 4 hours before taking a reading.

1. Insert the hydrometer tube into a cell. Fill the hydrometer barrel while holding the hydrometer in a vertical position. The float must not drag on the wall of the barrel.

1.250 or above: fully charged battery cell; freezing point @ -60°F (-51°C)
 1.225 – 1.250: half to fully charged battery cell; freezing point @ -40°F (-40°C)
 1.150 – 1.225: low to half charged battery cell; freezing point @ -20°F (-29°C)
 Below 1.150: dead battery cell; freezing point @ $+10^{\circ}\text{F}$ (-12°C)
 1.000: water; freezing point is $+32^{\circ}\text{F}$ (0°C)

2. Read the hydrometer.

NOTE

Specific gravity ranges shown above may vary because of electrolyte temperature, battery construction or strength of electrolyte used in different climate zones.

3. Test each cell in the same manner.

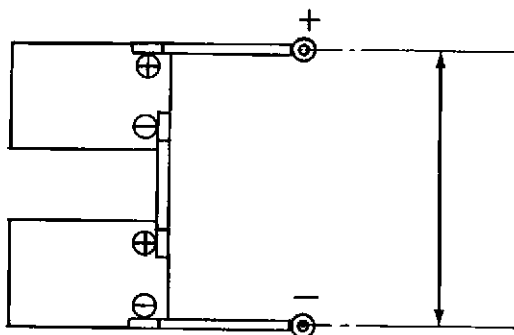
The hydrometer reading is of most importance during cold weather. A low specific gravity reading means the battery has less available power to crank the engine, booster batteries may be required, or the battery may freeze if not charged.

Connecting Booster Batteries

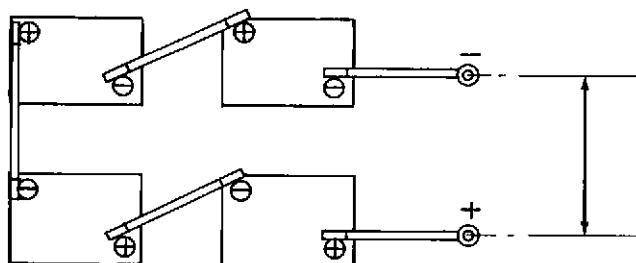
1. Using jumper cables, connect red cable to "hot" terminal of booster battery.
2. Connect black cable to "ground" terminal of booster battery.

CAUTION

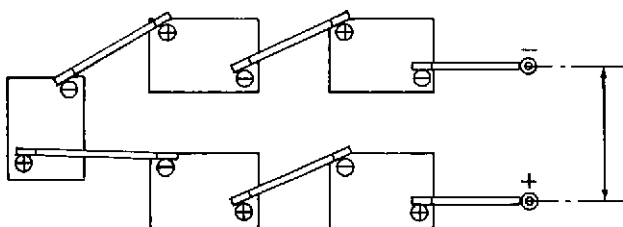
Keep red and black terminals from touching each other.



24 VOLT STARTING USING 12 VOLT BATTERIES



24 VOLT STARTING USING 6 VOLT BATTERIES



30 VOLT STARTING USING 6 VOLT BATTERIES

3. Connect other end of red cable to "hot" terminal of engine battery, and other end of black cable to "ground" terminal of engine battery.
4. Start the engine using starting aids as instructed in the Operation Instructions.

Disconnecting Booster Batteries

As soon as engine starts:

1. Disconnect black jumper cable from engine.
2. Disconnect red jumper cable from engine.
3. Disconnect black cable from booster battery.
4. Disconnect red cable from booster battery.
5. Charge booster batteries to full capacity with a battery charger.

GLOW PLUGS

Testing Glow Plugs

1. Stop the engine.
2. Disconnect the lead harness wire from the magnetic switch.
3. Connect an ammeter of sufficient capacity between the magnetic switch terminal and the lead harness wire.
4. Push in, turn and hold the HEAT-START switch in the HEAT position.
5. The ammeter reading should equal the number of glow plugs multiplied by the amperage of each glow plug.

Calculate the amperage of each glow plug by dividing its wattage by its voltage. These values are stamped on each glow plug. The amperage should be 3.5 amperes to 7 amperes per glow plug, depending upon the engine.

A deviation from the calculated reading will indicate one or more defective glow plugs.

Locating Defective Glow Plugs

1. Push in, turn and hold the HEAT-START switch in the HEAT position. Observe the ammeter reading.

2. Pull the lead from a glow plug. Observe the ammeter reading.

NOTE

If the ammeter reading does not change, the glow plug was not drawing current when connected and can be assumed to be defective. If the ammeter reading decreases, the glow plug is working properly.

3. Release the HEAT-START switch.
4. Connect the lead to the glow plug.
5. Test each glow plug individually.

Installing Glow Plugs

1. Disconnect the lead wire at the defective glow plug.
2. Remove the defective glow plug.
3. Apply anti-seize compound to the threads of the new glow plug.
4. Install the new glow plug and tighten to a torque of 10 to 12 pound-feet (1,38 to 1,66 mkg).
5. Turn the HEAT-START switch to the HEAT position and observe the ammeter reading.
6. Release the switch.
7. Install the lead wire.
8. Turn the HEAT-START switch to the HEAT position. The reading should increase. If the reading is the same, check the glow plug wiring.
9. Disconnect the ammeter.

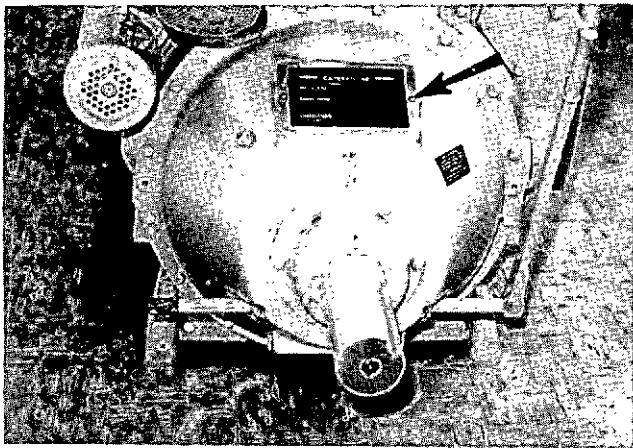
POWER COUPLING SYSTEM

POWER COUPLING SYSTEM FLYWHEEL AND/OR FRONT POWER TAKE-OFF CLUTCHES

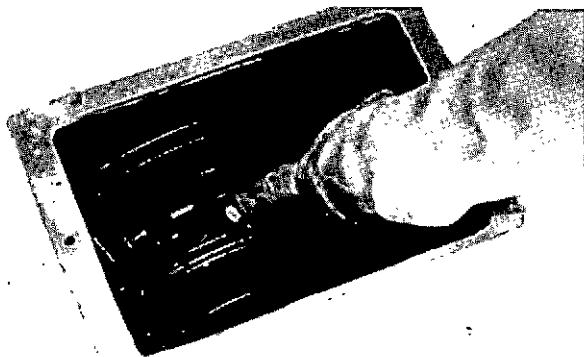
Checking Clutch Adjustment

While engaging the clutch to pick up the load, check the clutch adjustment. The clutch should engage with a hard push and distinct snap. If engagement is "soft", adjust the clutch.

1. Stop the engine and remove the clutch inspection cover.



2. Turn the clutch until the lock pin, engaged in the locking ring, is visible.
3. Pull the lock pin out and rotate the locking ring clockwise until the lock pin pops into the next notch.

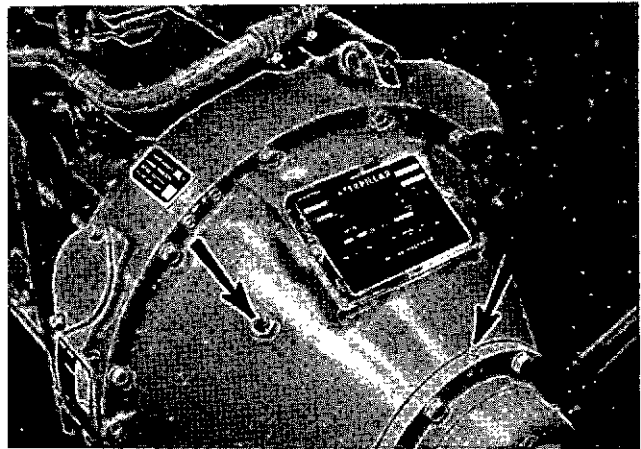


4. Test the clutch adjustment. If still too "soft", rotate the ring to the next notch. If the adjustment is too tight—turn the ring back one notch.
5. Install the cover.

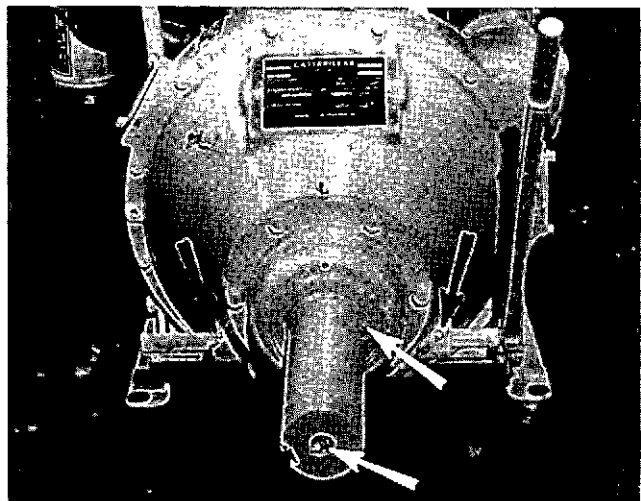
Lubricating the Clutch

Lubricate the clutch bearings with grease, 1 or 2 strokes each fitting.

1. Lubricate the shift-collar bearings sparingly; 1 fitting at top left of center.
2. Lubricate the main shaft bearing; 1 fitting located above the output shaft on the bearing cage.

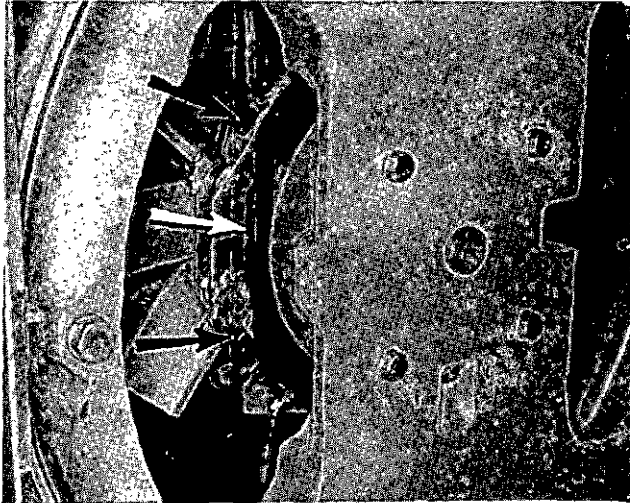


3. Lubricate the shift lever bearings; 1 fitting on each side of the clutch housing.
4. Lubricate pilot bearing; 1 fitting at the end of shaft. If this fitting is not accessible, remove the plug located on the circumference of the shaft near the rear of the housing, and install a fitting.



GENERATOR SET

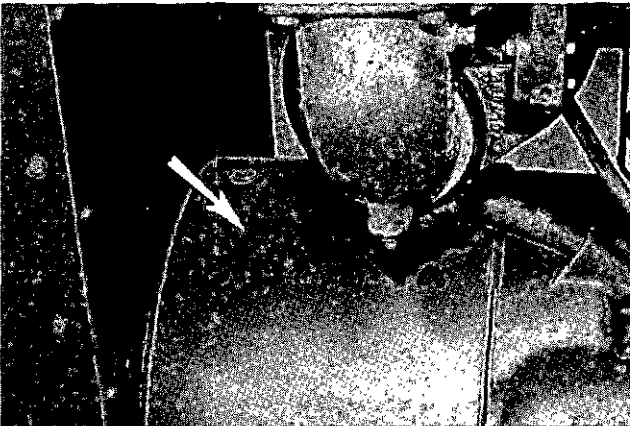
Your engine may be equipped with either a SRCR, or SR4 Generator. The SRCR Generator requires periodic inspections of its 4 brushes and 2 slip rings, and lubrication of the rear bearing.



The SR4 Generator is a brushless design, and therefore requires no periodic maintenance other than lubrication of the rear bearing.



To determine which generator you have, see the serial number stamped on the generator housing. The first group



of numbers of the serial number will be followed by either the letter "T" or "B":

"T" designates SRCR Generator

"B" designates SR4 Generator

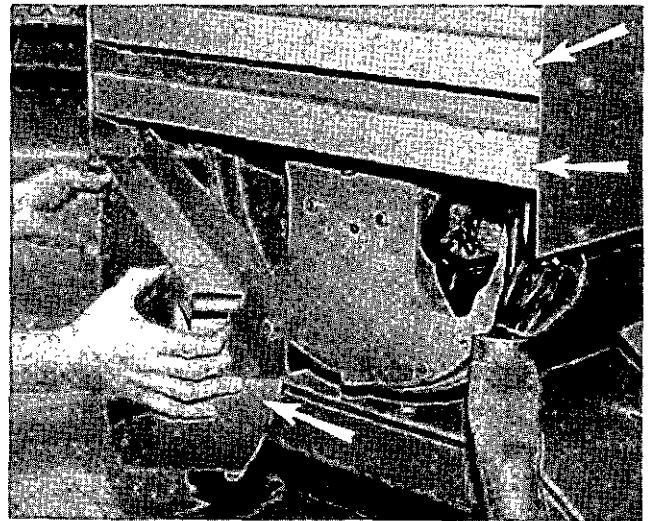
A complete explanation of the numbers and letters of the serial number are found in the Electric Set Operation of the OPERATION GUIDE.

If you have a generator of other than Caterpillar design, see the Manufacturer's Instructions.

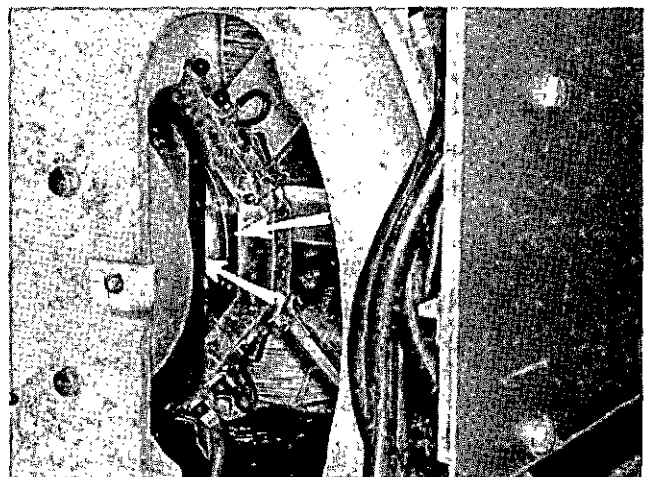
SRCR MAINTENANCE

Inspecting Slip Rings

1. Remove the three lower panels from the rear of the generator housing.



2. Inspect the color of each slip ring.



NOTE

The color may be shiny copper, straw, chocolate or black. The important thing is the color must be uniform to indicate a satisfactory condition.

3. If a ring contains blotches of green, blue or black, clean the ring with an electrical cleaning solvent.

WARNING

Do not use gasoline or carbon tetrachloride. The vapors from carbon tetrachloride can be extremely harmful when inhaled. Either solvent will dissolve insulation.

4. Inspect each ring for pitting, roughness, or eccentric wear. If any of these conditions are present, contact your Caterpillar dealer; the rings must be re-conditioned.
5. If pitting is found, determine if the cause is (a) or (b):
 - a. Check the rating on the generator nameplate. The generator load must be within this rating. Determine if the generator may have been operated in an overload condition.
 - b. Check the brushes for excessive spring tension.

Inspecting Brush Spring Tension

Each brush must move freely within its holder and have enough spring load to prevent brush flotation.

1. Remove the three lower panels from the rear of the generator housing.
2. Using a small spring scale, calibrated in ounces, lift each spring and check the spring tension for each brush.



BRUSH CONTACT AREA		SPRING TENSION		MINIMUM LENGTH	
Inch	mm	Ounce	Gram	Inch	mm
5/8x5/16	16x8	14	400	9/16	14
7/8x5/16	22x8	20	550	9/16	14
1 1/8x1/2	29x13	40	1100	3/4	19

- a. If spring tension is less than shown in the chart: Push the spring forward one notch in the retainer clip. Check the spring tension.



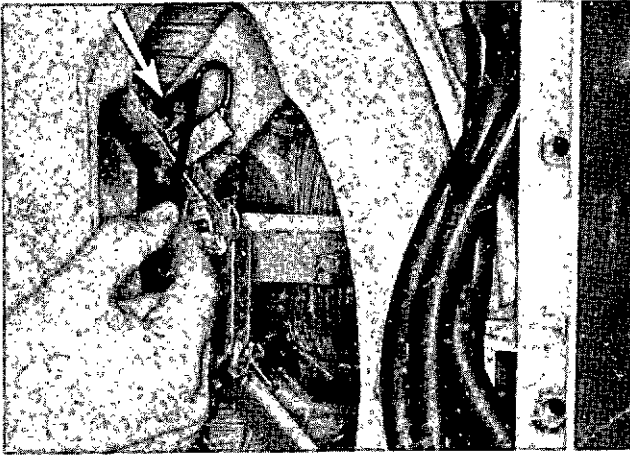
- b. If the spring tension is greater than shown in the chart: Release the spring by one notch. Check the spring tension.
- c. If the spring tension is less than shown in the chart and the spring is in the forward notch, remove the brush and check the brush length.

Removing and Installing Brushes

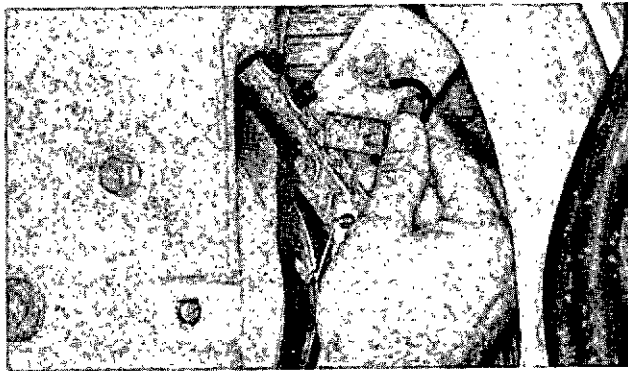
1. Release the spring from the retainer.



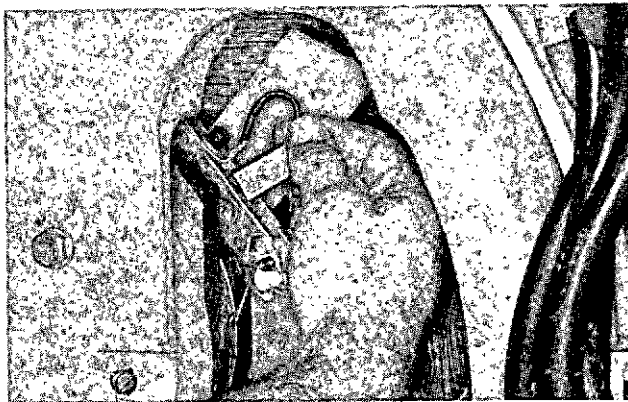
2. Disconnect the lead wire of the brush.



3. Remove and inspect the brush. If the brush length is less than the minimum shown or if badly pitted, install a new brush.



4. Connect the lead wire of the brush.
5. Place the brush in the brush holder. Be sure the brush moves freely in the holder.



6. Cut a strip of "00" sandpaper the width of the brush.

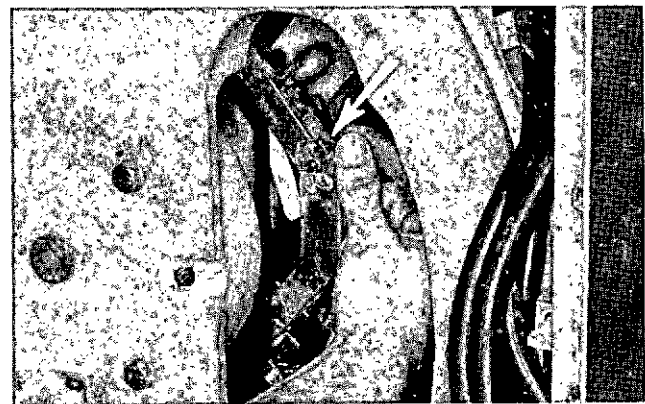
NOTE

Never use emery cloth for this purpose. Emery contains small metallic particles which can damage the copper rings.

7. Place the sandpaper between the brush and slip ring with the abrasive side of the sandpaper against the brush.



8. Place the spring in the middle notch of the retainer.



9. Slowly pull the sandpaper from beneath the brush.



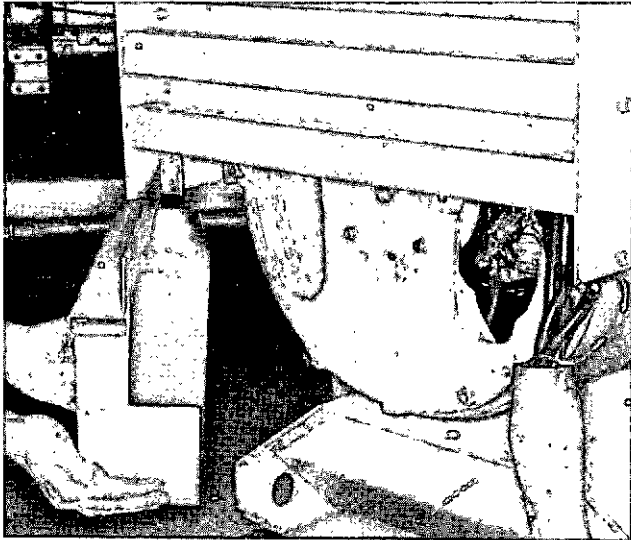
10. Remove all dust with a suction hose. If suction is not available, use a maximum air pressure of 30 psi (2 kg/cm²). Do not use metal tips.

11. Check brush tension and adjust if necessary.
12. Install the three rear panels that were removed.

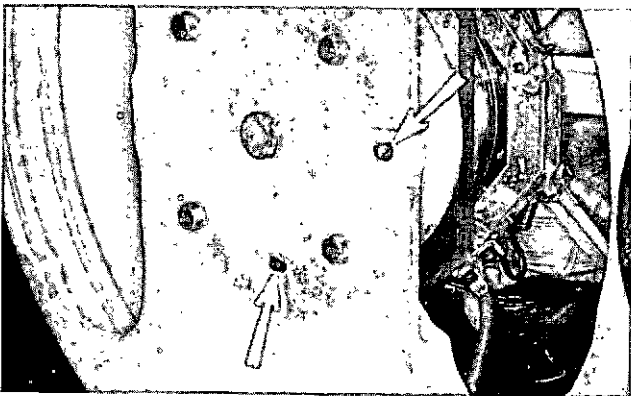
SRCR and SR4 GENERATOR LUBRICATION

Lubricating Generator Rear Bearing

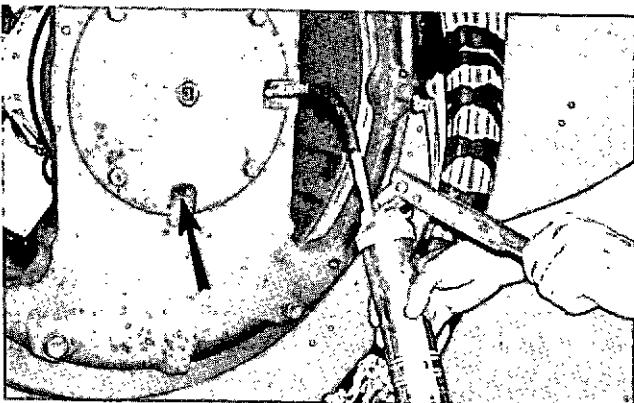
1. Remove the three lower panels from the rear of the generator housing.



2. Remove the upper and lower grease fitting plugs.



3. Install a grease fitting in the upper threaded hole.
4. Lubricate with grease until clean lubricant appears at the lower threaded hole.

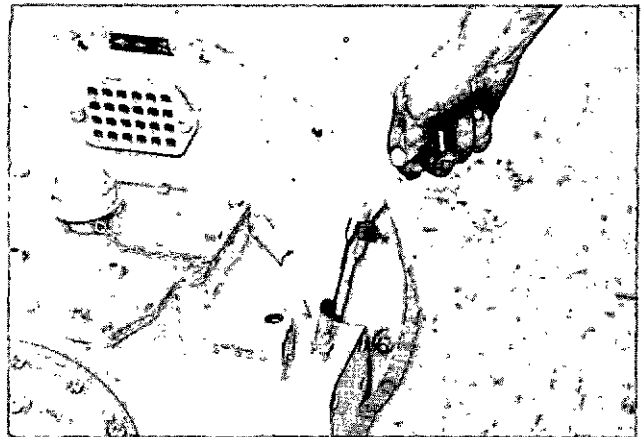


5. Install the lower plug. Wipe off excess grease.
6. Remove the fitting from the upper threaded hole.
7. Start the engine and allow the grease to expand from the upper hole.
8. Stop the engine. Install the plug in the upper hole. Wipe off the excess grease.
9. Install the three panels which were removed.

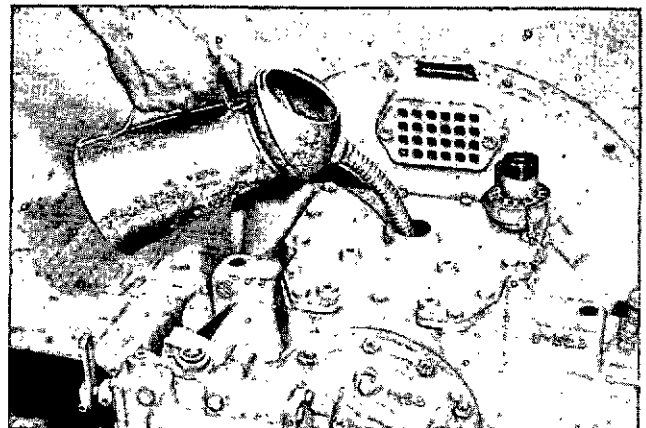
MARINE GEAR

Checking Oil Level

1. Check the oil level with the engine warm, idling, and the clutch engaged.

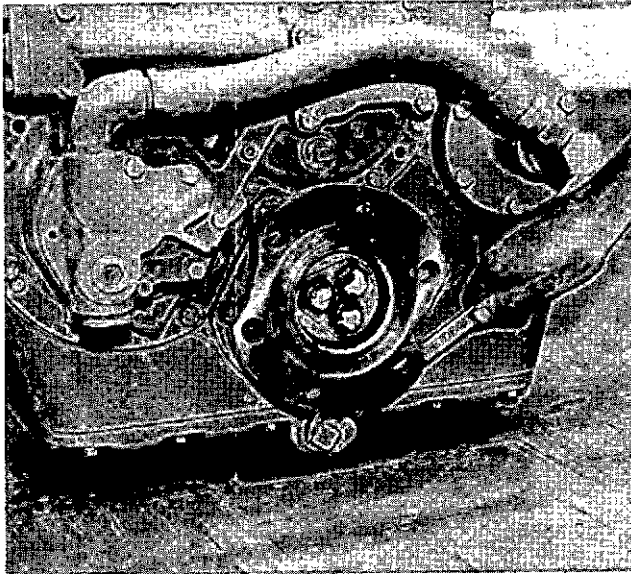


2. Maintain oil level at the FULL mark on the oil level gauge. Add oil through the breather tube on top of the marine gear housing. Refer to Lubrication and Maintenance Chart for proper oil to use.



Draining Lubricating Oil

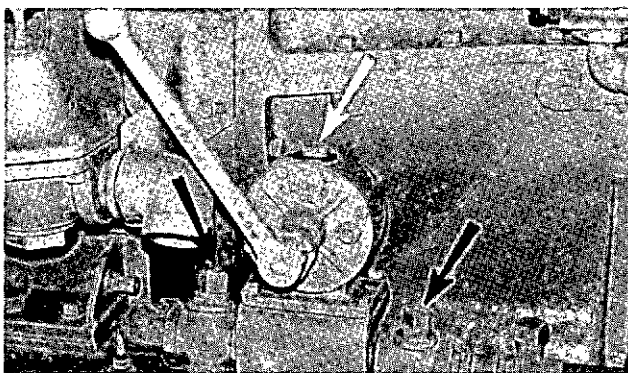
1. Remove the marine gear drain plug, allow the oil to drain.



2. Clean and install the drain plug.

If a sump pump is used:

- a. Connect a drain line to the top outlet of the sump pump.
- b. Be sure the valve on the engine oil pan line is closed. Marks on the valve must be turned at right angles to the direction of the oil line.
- c. Open the valve on the marine gear oil line.

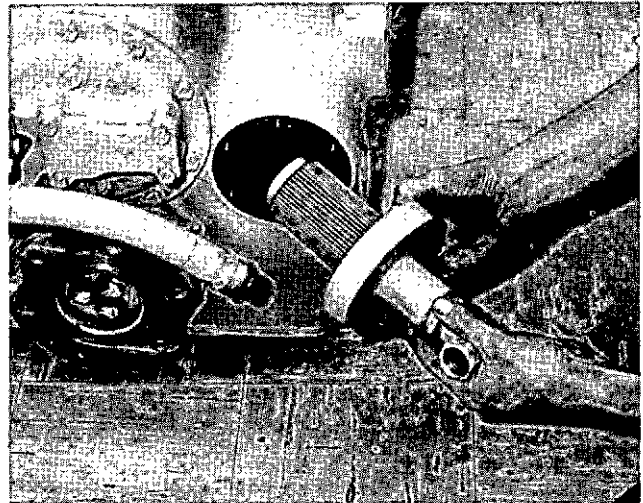


- d. Operate the sump pump handle until the oil is drained.
- e. Close the valve to the marine gear drain line.

Changing Oil Filter Element (509 Marine Gear)

1. Drain the lubricating oil.

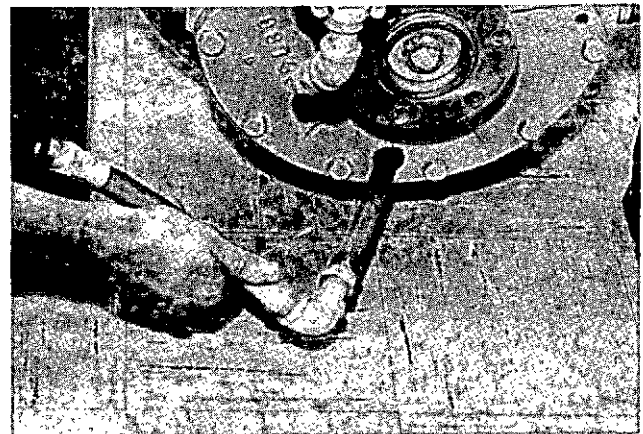
2. Remove the bolts or nuts and remove the cover and filter element. Remove the element.



3. Wash the inside of the housing and the cover.
4. Inspect and install the cover gasket; install a new gasket if necessary.
5. Install new element on cover and install cover and element assembly.

Cleaning Oil Strainer (506 Marine Gear)

1. Remove hose from pump inlet and loosen strainer retaining nut.
2. Remove strainer from housing.



3. Wash the strainer in clean solvent.
4. Inspect the strainer. Use new one if necessary. Install the strainer.

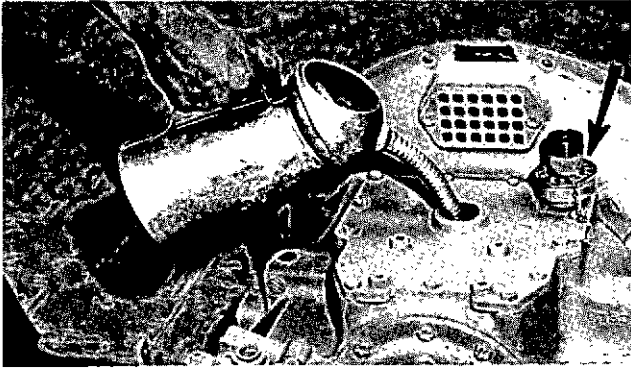
Filling the Lube System

1. Be sure the marine gear drain plug has been installed, or the sump pump valve on the oil line to the marine gear drain line has been closed.

CAUTION

Be sure the valves (one to the marine gear and one to the engine oil pan) are closed. Otherwise, a transfer of oil during operation may occur and damage could result.

2. Fill the marine gear to the FULL mark on the oil level gauge. Refer to the Lubrication and Maintenance Chart for proper oil viscosity and type of oil to use.

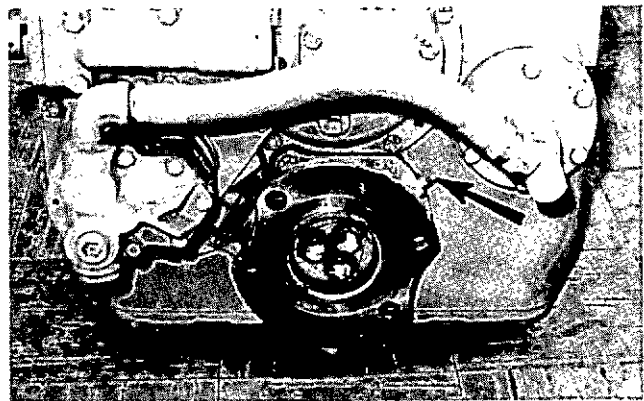


Cleaning the Breather

1. Remove the breather.
2. Wash it in clean solvent.
3. Install the breather.

Lubricating the Output Shaft Seal

Lubricate the output shaft bearing with two or three strokes of MPGM grease while slowly rotating the output shaft.



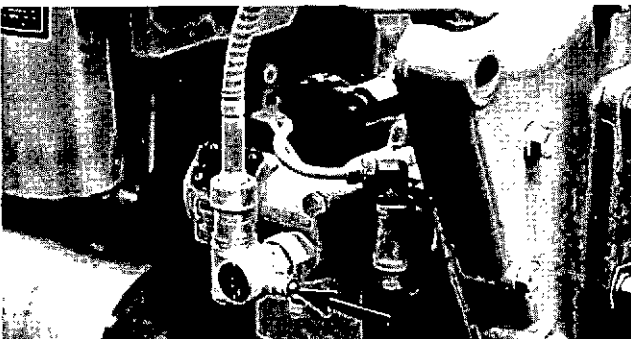
MISCELLANEOUS MAINTENANCE

TACHOMETER DRIVE

Lubricating Angle Adapter

The single tachometer drive does not require additional lubrication.

If equipped with an angle adapter, lubricate the angle adapter with two strokes of MPGM grease.



SAFETY SHUT-OFF CONTROLS

Checking Operation

The safety shut-off controls must be periodically checked to ensure that if an adverse condition arises, the safety shut-off control will shut down the engine.

Because damage could occur to the engine while the checks are being run, have only authorized Caterpillar dealer personnel conduct these tests.

Contact your Caterpillar dealer to have safety shut-off checks made on your engine.

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