OPERATION GUIDE

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LUBRICATION AND MAINTENANCE CHART

LUBRICATION AND MAINTENANCE PROCEDURES

D399 ELECTRIC SET

35B1-UP

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COMPLETE GUIDE
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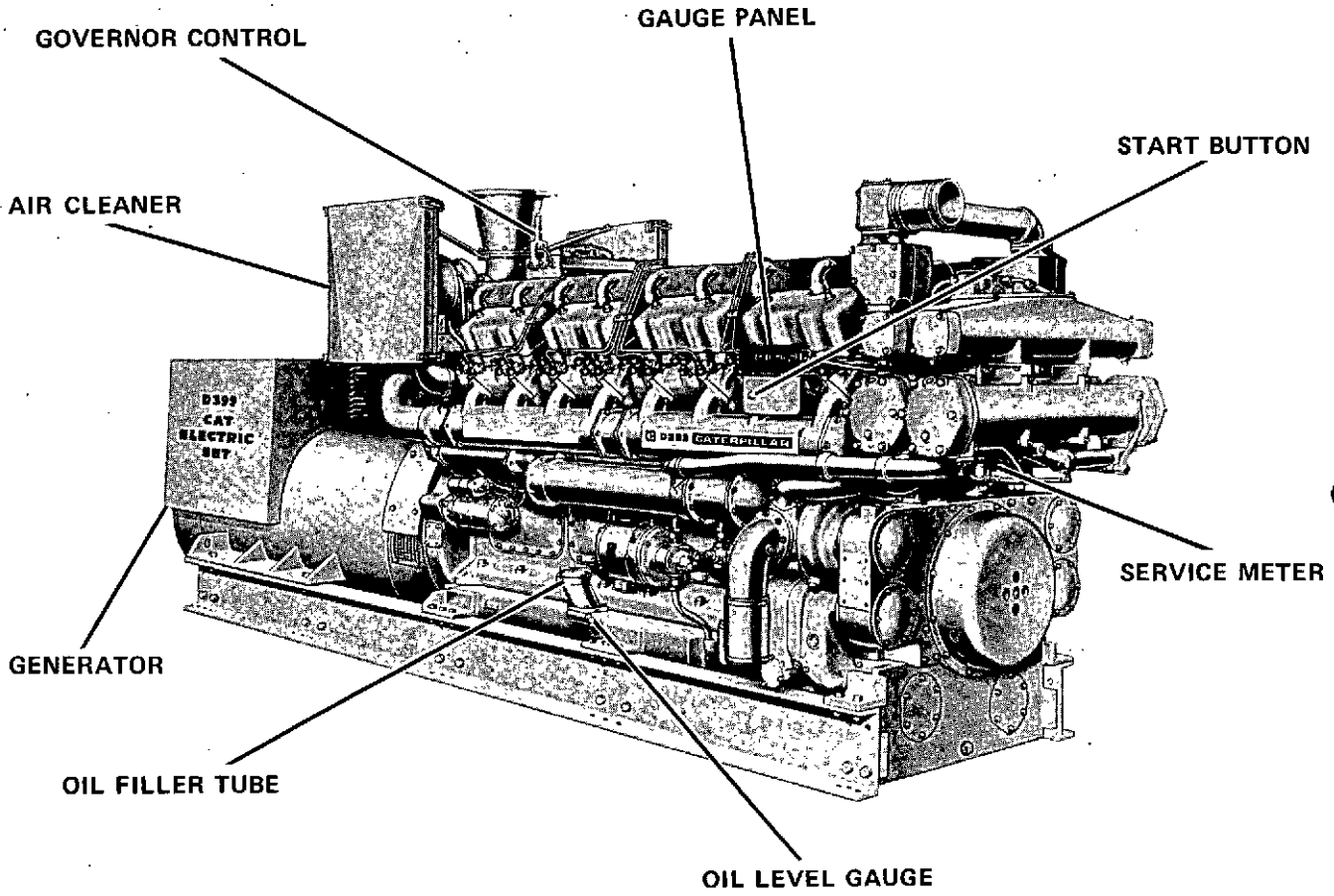


D399 ELECTRIC SET

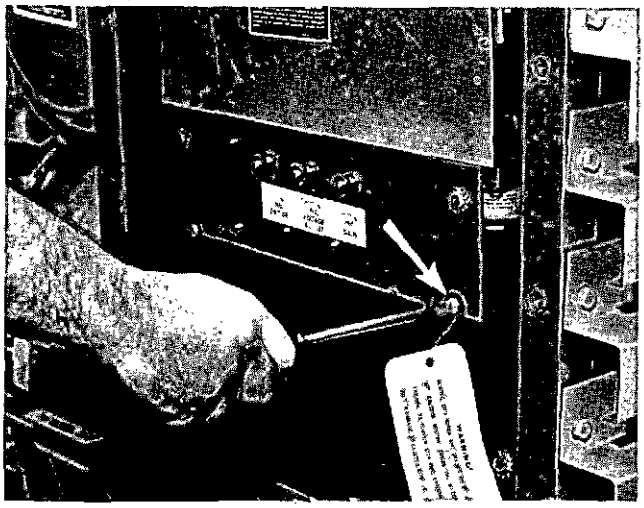
ELECTRIC SET OPERATION

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.



REMOVE SHIPPING SCREWS BEFORE STARTING (SRCR ONLY)

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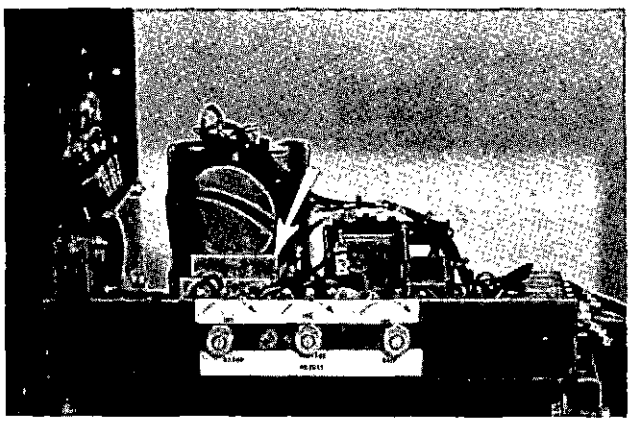
SAFETY PRECAUTIONS

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.

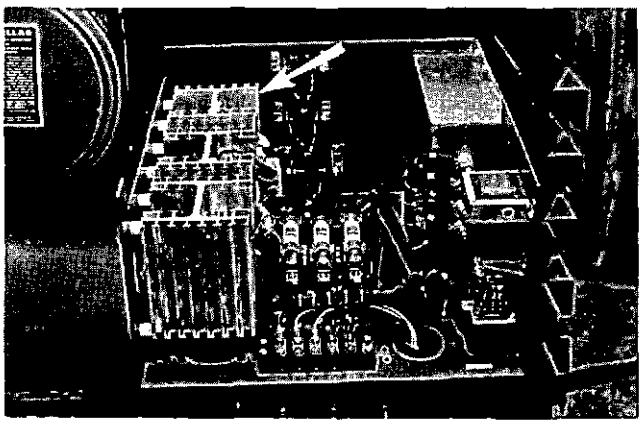
Safety is basically common sense. There are standard safety rules but each situation has its own peculiarities which cannot always be covered by rules. Therefore, your experience and common sense will be your best guides to safety. Watch for safety hazards. Correct deficiencies promptly.

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

1. Never adjust or repair a machine while in operation.
2. All fans, shafts, pulley, etc. must have guards.
3. Do not wear loose clothing around machinery. .
4. Remove tools and electrical cords from the engine before starting.
5. Keep the engine room and floor area clean.
6. Store oily rags in metal covered containers.
7. Never store flammable liquids near the engine.
8. Do not smoke around batteries. Hydrogen gas generated by charging batteries is explosive. Keep batteries in a well ventilated area.
9. Observe NO SMOKING signs.
10. Be sure the engine room is properly ventilated.
11. Always disconnect and tape the ground battery lead before working on the electrical system.



HEAT SINK (SR 4)



HEAT SINK (SRCR)

12. All electrical equipment must be grounded according to local building codes.
13. Be sure the remote starting system is inoperative when the engine is being worked on. Disconnect the starter from the start switch.
14. Never operate a diesel engine with the governor linkage disconnected. Human reactions are not fast enough to control the fuel rack.
15. Do not work on electrically "hot" equipment.
16. Insulate all connections and disconnected wires.
17. Check all connections periodically for tightness and insulation.
18. Always disconnect the engine starter circuit when working on the generator.
19. Do not touch the heat sink on the generator regulator when the generator is running. It is electrically "hot".
20. Do not use carbon tetrachloride fire extinguishers. Fumes are toxic and the liquid has a deteriorating effect on insulation.

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.

SERIAL NUMBER

You can get further information about your generator from your Caterpillar dealer. Requests for information and orders for parts should be accompanied by the engine and generator serial numbers. 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 on the right side of the generator frame forward of the terminal box.

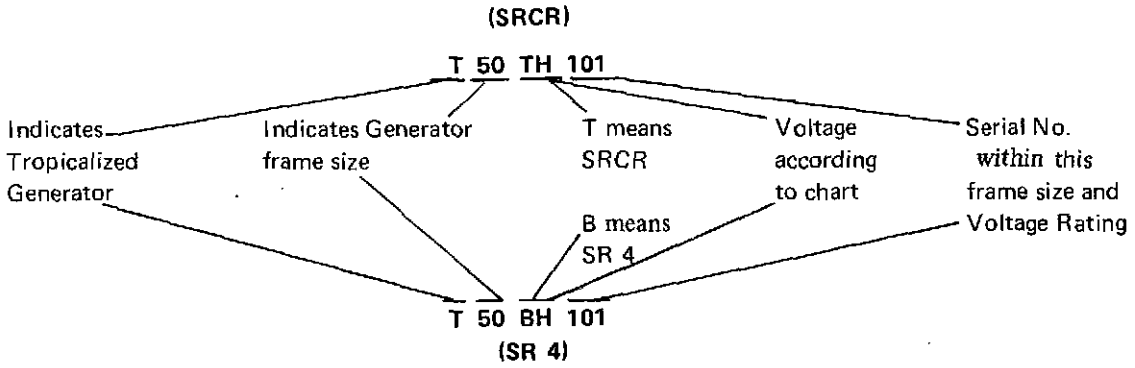
1. The group of numbers before the letters indicates generator frame size. The letter T may appear before the first group of numbers. This indicates a "tropicalized" generator, that has been dipped in epoxy to prevent moisture entrapment in windings.
2. The letter T is the symbol for Caterpillar Statically 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

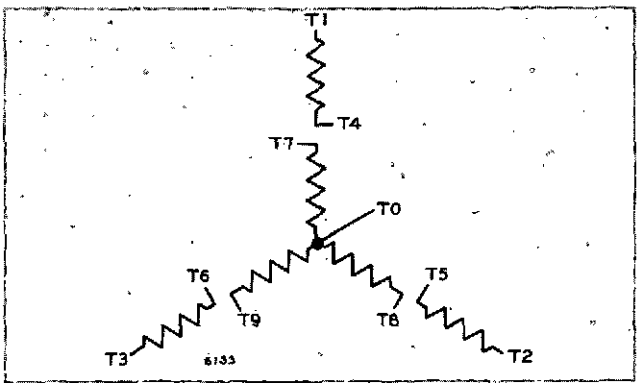


4. The last group of numbers are the actual serial numbers of the generator in the frame size and voltage rating. Always use the complete serial number.

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.

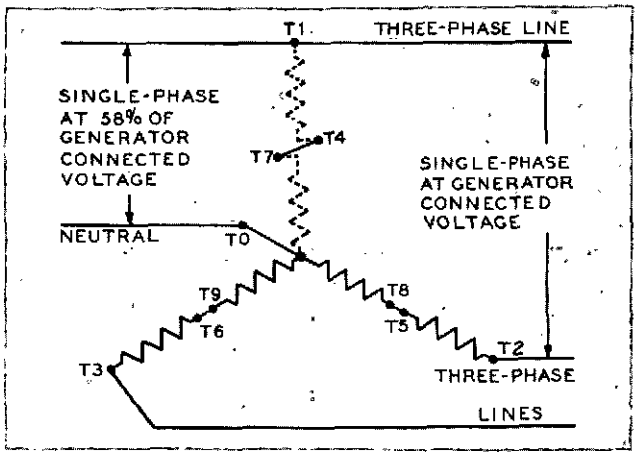
VOLTAGE CONNECTIONS

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

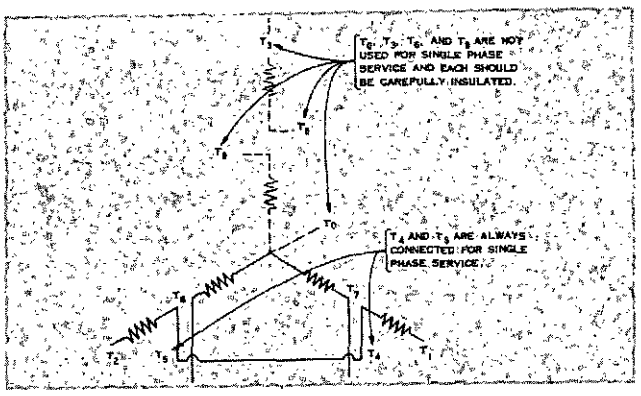
When a generator is connected for single phase operation, do not exceed these limits:

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 (230-460 V and 115-230V for SRCR) and (240-460V, 125-250 and 208-416 for SR 4) genera-

tors can be connected for two or three wire service at either voltage. When generators are connected for three wire service both high and low voltages may be obtained simulaneously 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 INDIVID-UALLY
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

OPERATING

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 settings 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

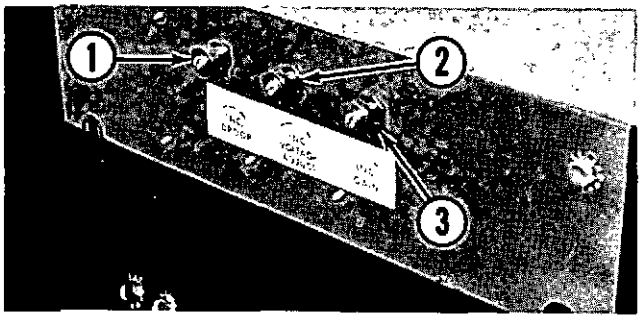
Disconnect the exciter circuit by removing fuses F1 and F2 (on SRCR) or Fuse F1 (on SR4) before operating the engine below the low idle rating. Failure to do this will result in generator damage.

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.
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.



VOLTAGE ADJUSTMENT CONTROLS

1. Voltage Droop
2. Voltage Level
3. Voltage Gain

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.

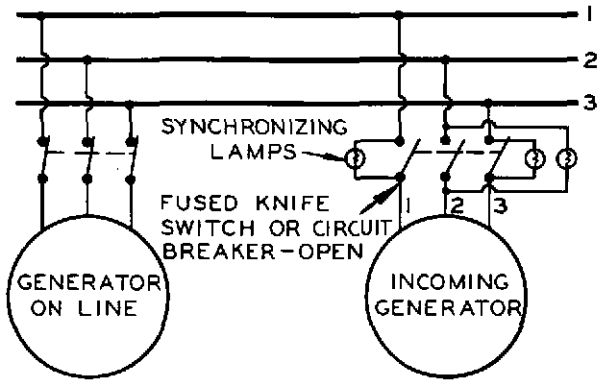
These three conditions may be compared to similar conditions required for engagement of two gears. To mesh as smoothly as possible, two gears must meet the following three conditions:

1. Same direction of 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

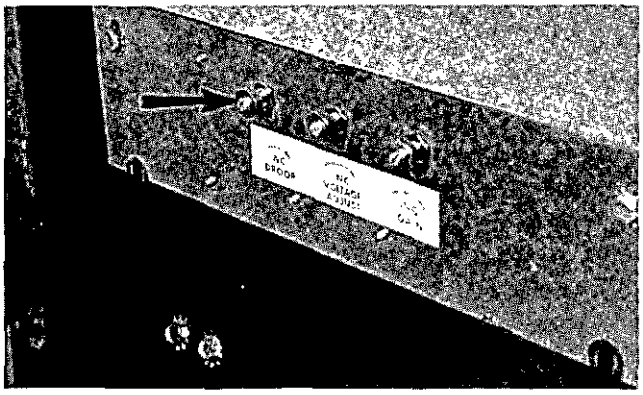
The speed of units to be paralleled must be the same. Speed refers to the alternating current frequency.

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 of 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.

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Engine Operation

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LUBRICATION AND MAINTENANCE CHART

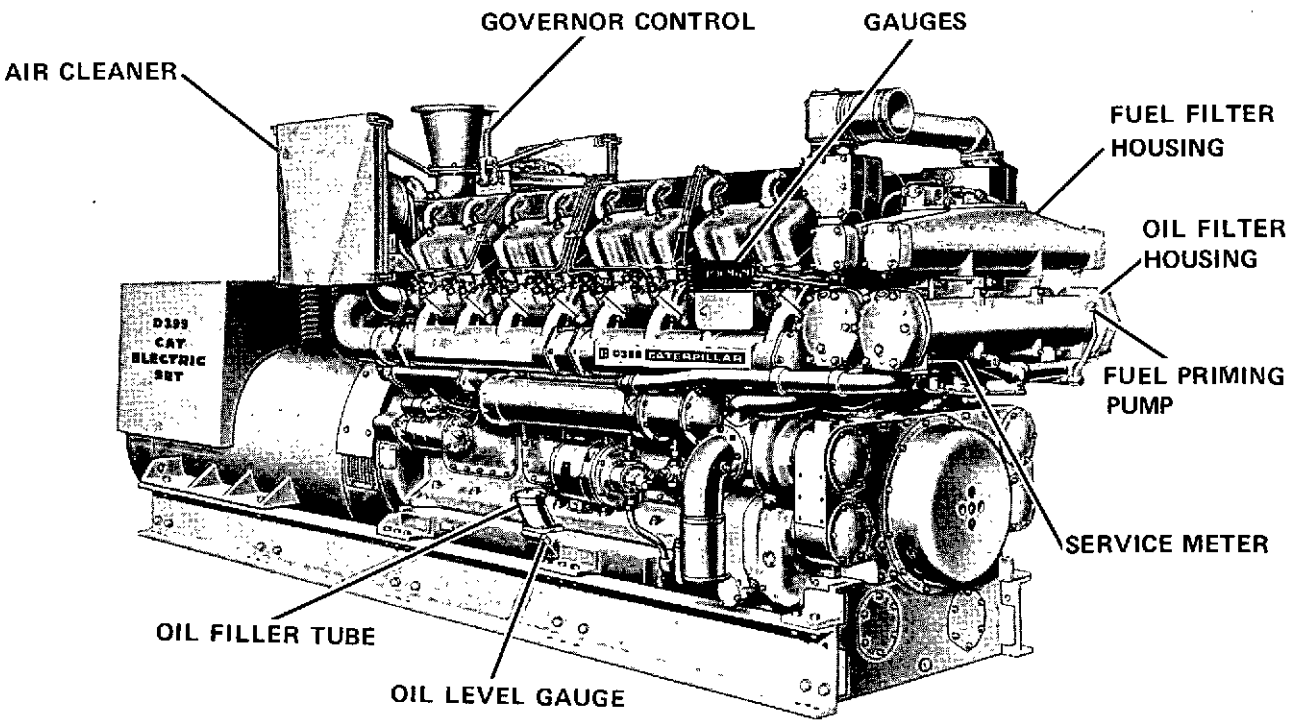
The LUBRICATION AND MAINTENANCE CHART lists all serviceable items which are either standard equipment or attachments commonly ordered on your model of engine.

Items needing periodic maintenance are grouped according to frequency of service. Items needing service as required are grouped according to the general system of which they are a part, and follow the periodic interval items.

The page letter and number in the right hand column of the chart is the reference page for the detailed instructions in the LUBRICATION AND MAINTENANCE PROCEDURES. These procedures are grouped according to the various engine systems, e.g., the Diesel Engine Lubrication System is A, the Air Induction and Exhaust System is B, etc.

The number following the letter indicates the page number within that system, e.g., B-2 is the second page in the Air Induction and Exhaust System.

Items which do not pertain to your engine may be lined out to customize your charts.



D399 ELECTRIC SET

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ITEM	PROCEDURE	Lubricant	Section and Page
FREQUENTLY DURING OPERATION			
Crankcase lube oil pressure	Check oil pressure gauge reading	-	A-1
Fuel pressure gauge	Check fuel pressure gauge reading	-	C-2
Operating water temperature	Check water temperature gauge reading	-	D-1
Battery charge rate	Check ammeter reading	-	F-2
EVERY 10 SERVICE HOURS			
Crankcase lube oil level	Check oil level - fill as required	S3	A-1
Air cleaner - single stage or two stage	Check service indicator - service	-	B-1
Fuel level	Check fuel supply	-	C-1
Day tank	Fill fuel tank	-	C-1
Woodward UG8 Governor	Check oil level	EO	C-3
Cooling system	Check coolant level	-	D-1
EVERY 50 SERVICE HOURS			
Pre-lube pump	Check oil level	EO	A-3
Two-stage air cleaner	Empty dust collector cup	-	B-2
Raw water system	Inspect zinc rods	-	D-5
Batteries	Check electrolyte level	-	F-2
EVERY 250 SERVICE HOURS			
Air cleaner element (See Note 1)	Install replacement filter element	-	B-1, B-2
Fuel filter housing	Drain water and sediment from filter housing	-	C-1
Radiator fan belt	Check belt wear and adjustment	-	D-3
Charging alternator belt	Check belt adjustment	-	F-3
EVERY 500 SERVICE HOURS			
Radiator fan	Lubricate fan bearings	MPG	D-4
Electric set generator	Inspect slip rings and brushes	-	G-2, G-3
EVERY 800 SERVICE HOURS - 110 Gal. Crankcase (See Note 2) **See 1200 Service Hours for 165 Gal. Crankcase**			
Crankcase lube system	Change oil and filter elements	S3	A-1, A-2
Crankcase breathers	Clean breathers	-	A-2
EVERY 1000 SERVICE HOURS			
Fuel tank	Drain water and sediment	-	C-1
Fuel priming pump	Lubricate pump lever bearings	MPG	C-2
Crankshaft coupling for fan drive	Lubricate coupling	MPG	D-5
Shut-off control reset lever	Lubricate reset lever bearing	MPG	H-1
Tachometer drive	Lubricate tachometer drive bearing	MPG	H-1
Safety shut-off controls (or 6 months)	Check operation	-	H-1

LUBRICATING OILS

SUPERIOR LUBRICANTS (SERIES 3): Additive type oils that meet a rigid high quality standard and are certified for use in Caterpillar diesel engines.

MIL-L-2104A or MIL-L-2104B OILS: Additive type oils but milder than Superior Lubricants (Series 3).

Your oil supplier is familiar with oils meeting these requirements.

Use only Superior Lubricants (Series 3) oil in the diesel engine crankcase.

Use Superior Lubricants (Series 3), or oils meeting MIL-L-2104B specifications in all other components.

RECOMMENDED VISCOSITIES AT VARIOUS STARTING TEMPERATURES

COMPONENT	ABOVE 32° (ABOVE 0°C)	32°F TO 10°F (0° TO -12°C)	10°F TO -10°F (-12°C TO -23°C)	BELOW -10°F (BELOW -23°C)
Air starting motor oiler jar	SAE 10W	SAE10W	SAE10W	SAE10W
Diesel engine crankcase	SAE30	SAE10W(1)	SAE 10W	SAE10W(2)
Governor, Woodward UG8 and synchronizing motor	SAE 30	SAE 10W(1)	SAE 10W	SAE 10W
Pre-lube pump reduction gear case	SAE40	SAE20	SAE20	SAE10

(1)SAE 10W oil may be used even if daytime ambient temperatures rise to 70°F (21°C).

(2)It may be necessary to warm the oil so the engine can be cranked and the oil will circulate freely.

LUBRICATING GREASE

Use Multipurpose-type Grease. NLG1 No. 2 Grade is suitable for most temperatures. Use NLG1 No. 0 or No. 1 Grade for extremely low temperatures.

Wipe fittings, covers and plugs before servicing.

VALVE LASH

Exhaust valves	.035 inch (0,9 mm)
Inlet valves	.015 inch (0,4 mm)

REFILL CAPACITIES

	U.S. Gals.	Imp. Gal.	Liters
Diesel engine lubrication system:			
5° maximum tilt oil pan	110	92	416
8° maximum tilt oil pan	165	136	625
Pre-lube pump reduction gear case	.25	.2	1
Cooling system (engine only):	85	71	322
Cooling system (with radiator):	140	117	530

GEG00363

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LUBRICATION AND MAINTENANCE PROCEDURES

ENGINE LUBRICATION SYSTEM

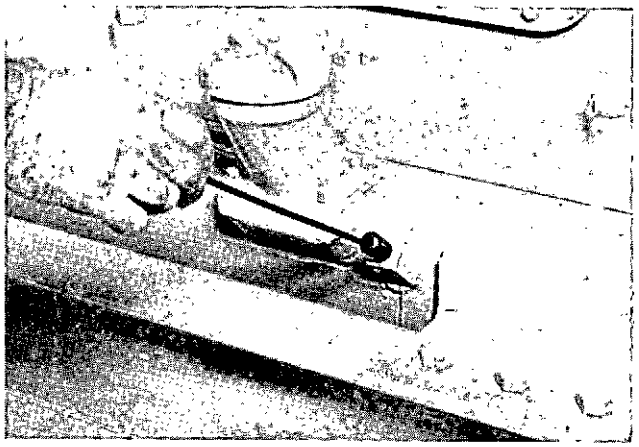
DIESEL ENGINE LUBE OIL

CHECKING OIL PRESSURE GAUGE READING

After starting and during operation, frequently observe the oil pressure gauge. If the gauge indicator registers below "NORMAL", or if the indicator fluctuates, check the oil level and take corrective measures.

CHECKING OIL LEVEL

Check the oil level with the engine idling. Oil level must be between the ADD and FULL marks on the oil level gauge. Add oil as required. See Lubrication and Maintenance Chart for proper oil.

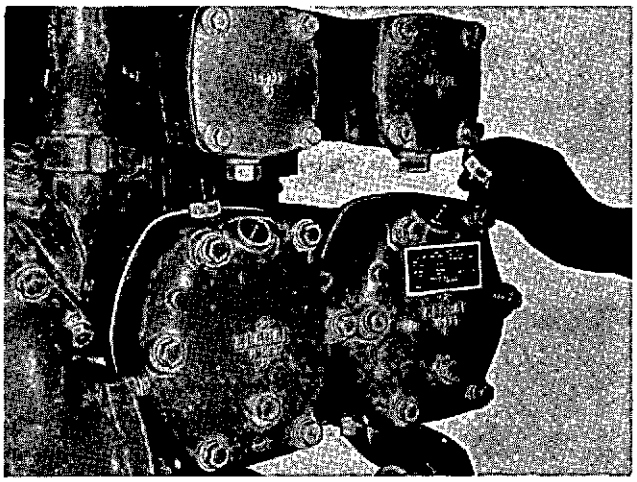


CHECKING CRANKCASE OIL LEVEL

DRAINING CRANKCASE LUBE OIL

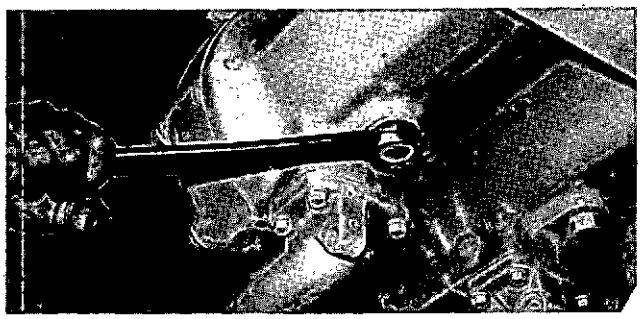
With engine stopped and oil warm:

1. Wipe dirt from each oil filter housing end cover.
2. Remove vent plug from each cover.



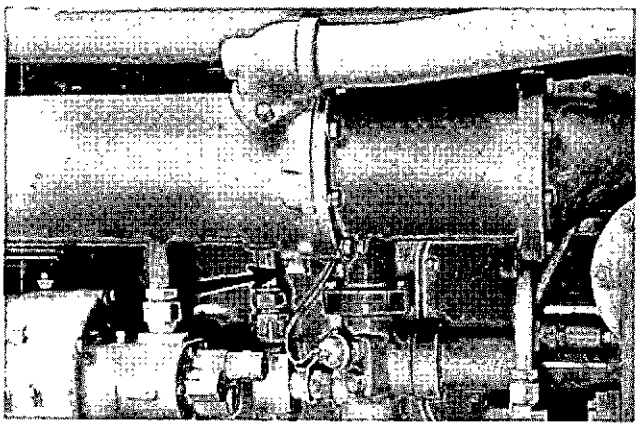
REMOVING OIL FILTER HOUSING VENT PLUGS

3. Remove oil filter housing drain plugs.



REMOVING OIL FILTER DRAIN PLUG

4. Remove the oil cooler drain plug.



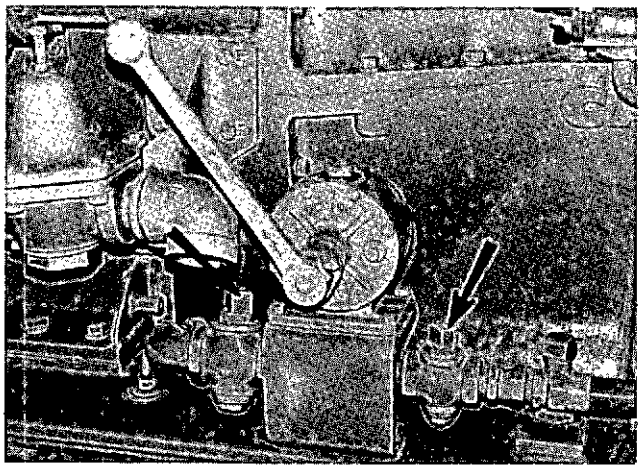
OIL COOLER DRAIN PLUG

5. Remove the oil pan drain plug.

OR If a sump pump is used

a. Connect a suitable drain to the pump outlet.

b. Open the valve to the engine crankcase.



SUMP PUMP VALVES

INDEX
Pg. K-1

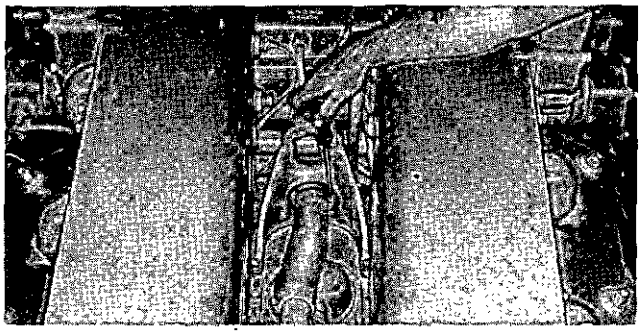
c. Close the valve to the marine gear housing.

d. Operate the sump pump handle until the crankcase is empty.

e. Close the valve to the engine crankcase.

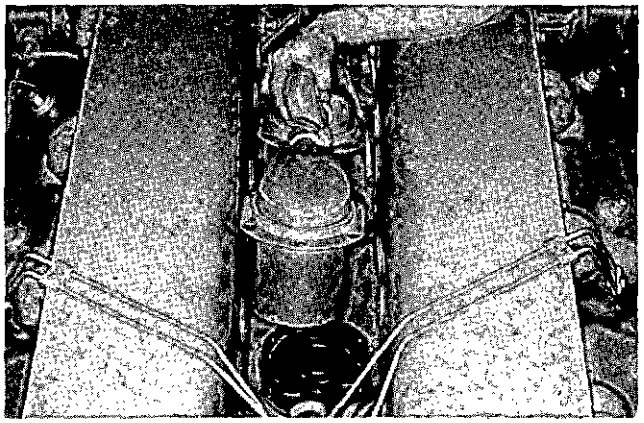
CLEANING BREATHER (S)

1. Loosen front hose clamp. D399 Engine only.



LOOSENING HOSE CLAMP

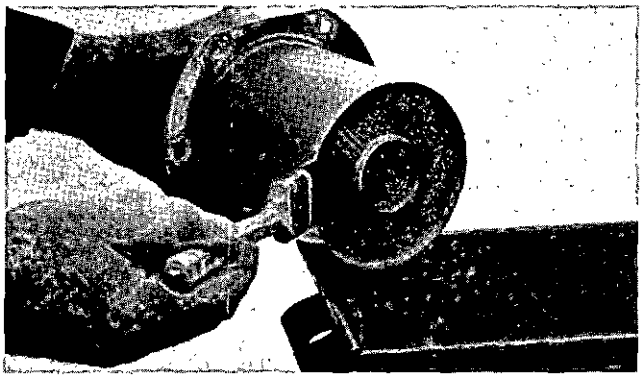
2. Remove breather mounting bolts (all engines). Lift off breather(s).



REMOVING BREATHERS

3. D399 Engine only: Remove and inspect upper and lower hoses from breathers.

4. Wash breather(s) in clean diesel fuel or kerosene.



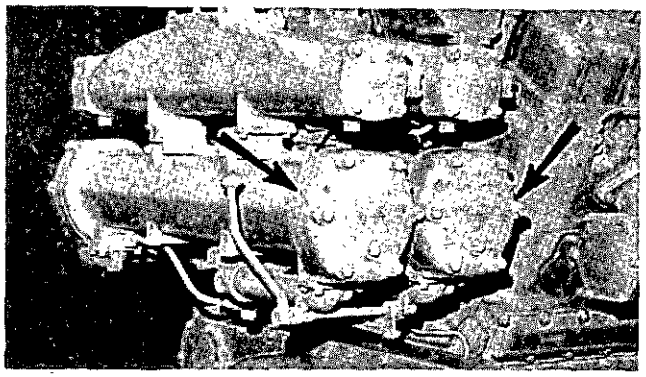
WASHING BREATHER

5. Install breather(s) and lower hose. Install upper hose. Tighten all clamps.

INSTALLING NEW OIL FILTER ELEMENTS

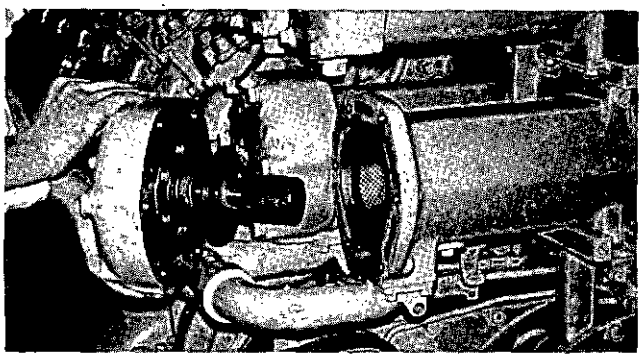
1. Drain the oil filter housing.

2. Remove the "OUTLET" covers (left covers of the oil filter housing when viewed from the flywheel).



OUTLET COVERS

3. Remove the "INLET" covers (right covers when viewed from the flywheel).



INLET COVERS

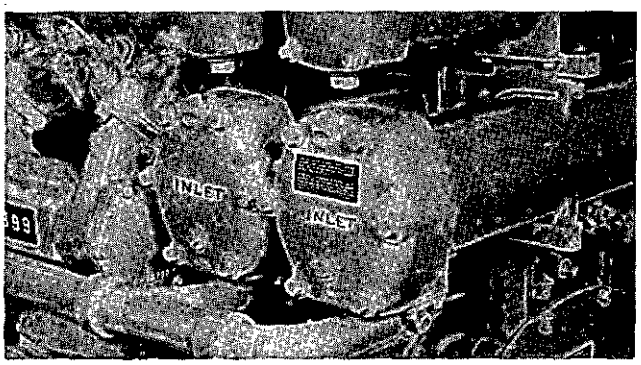
4. Remove all filter elements from the right side. Push the elements through the housing from left to right.

CAUTION

Do not push the elements from right to left. *This will scrape unfiltered oil into the filtered oil passage in the engine.*

5. Wipe the filter housing from left to right.

6. Install the cover marked "INLET" on the right side of the housing.



INSTALLED INLET COVERS

7. Install new filter elements and the "OUTLET" cover.
8. Install all drain plugs that were removed.
9. Fill the filter housing and oil cooler with oil; add the oil through the vent plug openings. See Lubrication and Maintenance Chart for proper oil.
10. Fill the crankcase to the FULL mark on the oil level gauge.
11. Install all vent plugs that were removed.

PRE-LUBE PUMP

D399 Engines only: When the START switch is energized, the pre-lube pump will build up oil pressure in the engine before the starting motors are energized.

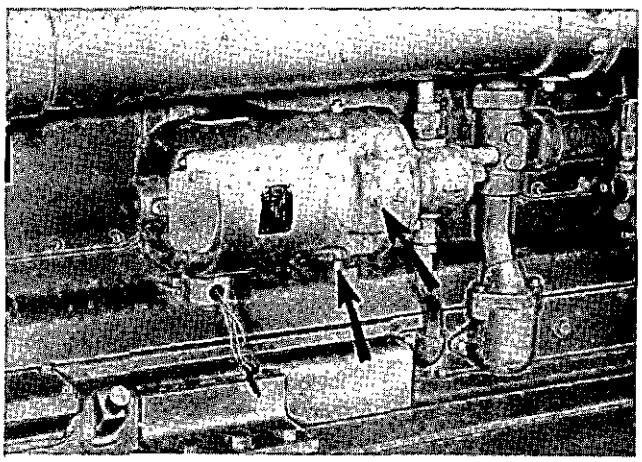
CHECKING PRE-LUBE PUMP OIL LEVEL

Check the pre-lube gear case oil level before starting the diesel engine. Oil level must be between the LOW and HIGH marks on the bayonet gauge. Add oil as required. See Lubrication and Maintenance Chart for proper oil.

CHECKING OIL LEVEL

DRAINING PRE-LUBE PUMP OIL

1. Remove drain plug and drain oil.

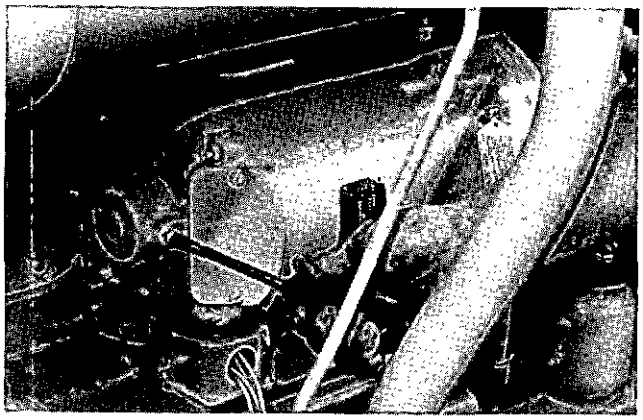


FILLER AND DRAIN PLUGS

2. Flush the gear case with diesel fuel or kerosene.
3. Fill gear case with oil. See Lubrication and Maintenance Chart for proper oil.

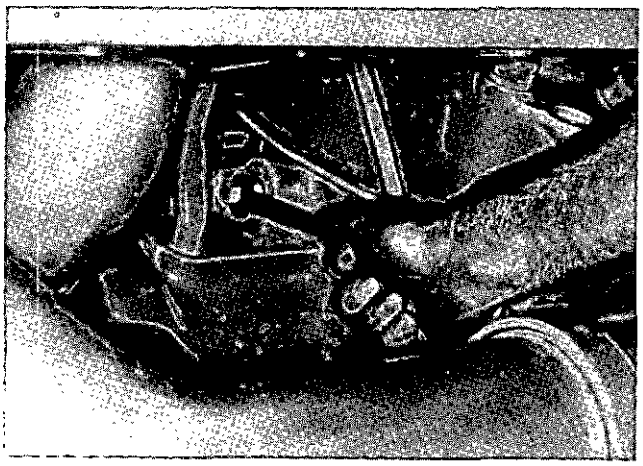
LUBRICATING PRE-LUBE PUMP REAR BEARING

1. Remove the rear bearing grease plug.



REMOVING GREASE PLUG

2. Clean out old grease.
3. Install a grease fitting. Lubricate; see Lubrication and Maintenance Chart for proper grease.
4. Remove the grease fitting.
5. Move the compression release lever to START to prevent the engine from starting.



COMPRESSION RELEASE LEVER (1 each bank)

6. Turn the start switch to START; the running pre-lube pump motor will push the excess grease out the plug hole.
7. Wipe excess grease from outside of motor.
8. Clean and install the grease plug.

AIR INDUCTION AND EXHAUST SYSTEM

AIR CLEANER SERVICE INDICATOR

CHECKING AIR CLEANER SERVICE INDICATOR

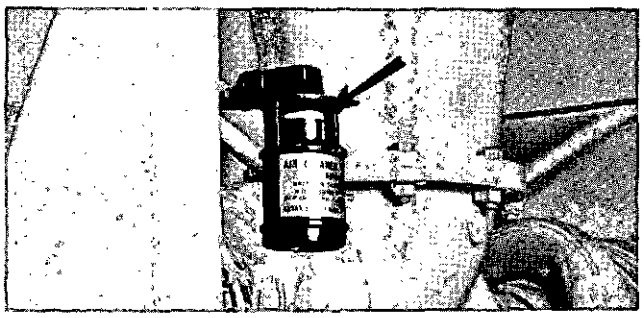
Before starting, check the window of the indicator. If the red piston is locked in the raised position, service the air cleaner as outlined.

NOTE

Have spare elements on hand to install while cleaning used elements.

CAUTION

Service the air cleaner with the engine STOPPED.

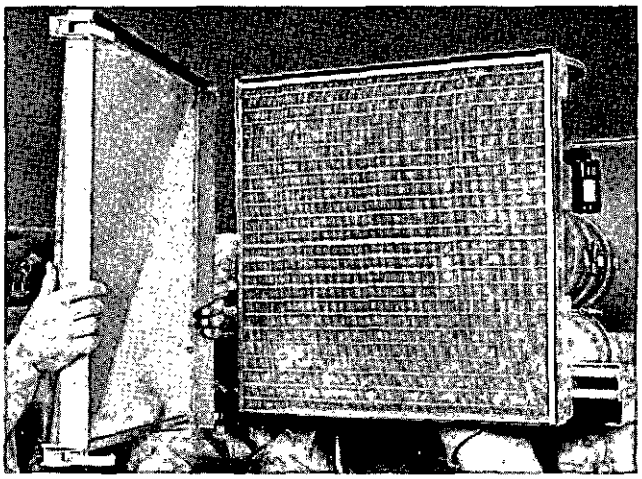


PISTON LOCKED IN RAISED POSITION

SINGLE STAGE AIR CLEANER

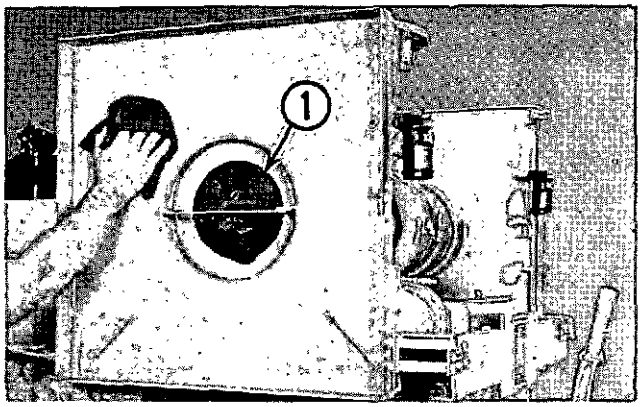
SERVICING SINGLE STAGE AIR CLEANER

1. Remove the air cleaner cover and element.



REMOVING COVER AND FILTER ELEMENT

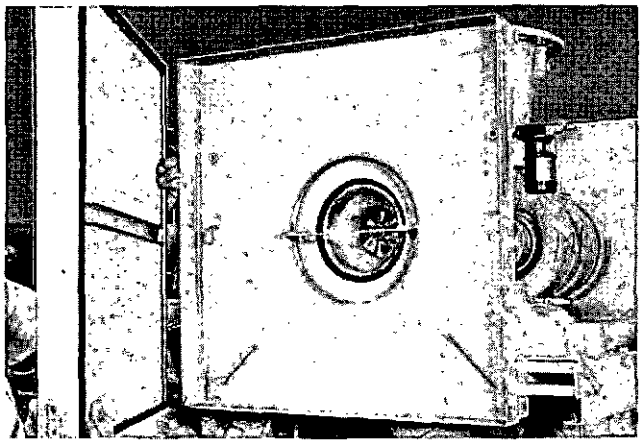
2. Cover the turbocharger air inlet opening to prevent dirt from entering the engine.
3. Clean the inside of the air cleaner cover and the air cleaner body.



CLEANING INSIDE OF AIR CLEANER

1. Air Inlet Cover

4. Inspect the replacement element for damage and dirt.
5. Remove the covering from the turbocharger inlet opening.
6. Install the element.

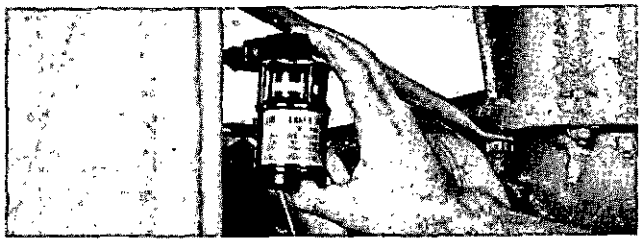


INSTALLING AIR CLEANER ELEMENT

CAUTION

The reinforcing brace across the middle of panel type elements fits over the supporting bar of the turbocharger.

7. Install the air cleaner cover.
8. Reset the service indicator piston by pushing the reset button. (See the instructions for air cleaner element cleaning).

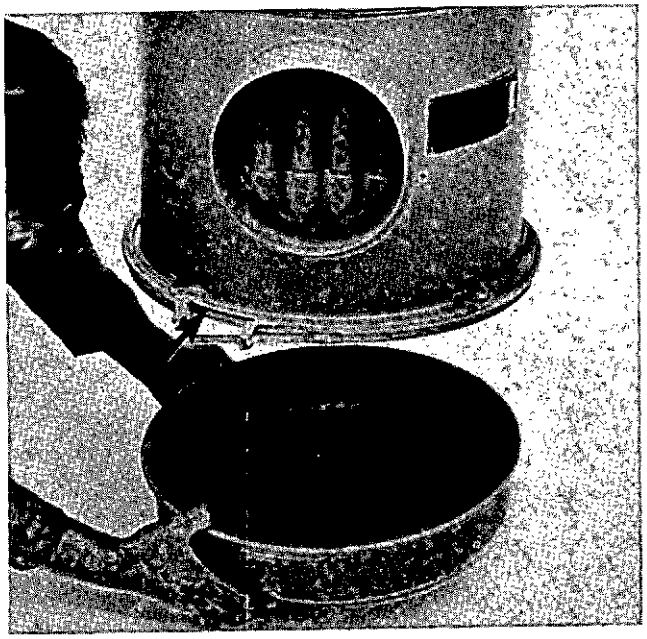


RESETTING AIR INDICATOR PISTON

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 and install the seal; install a new seal if necessary.

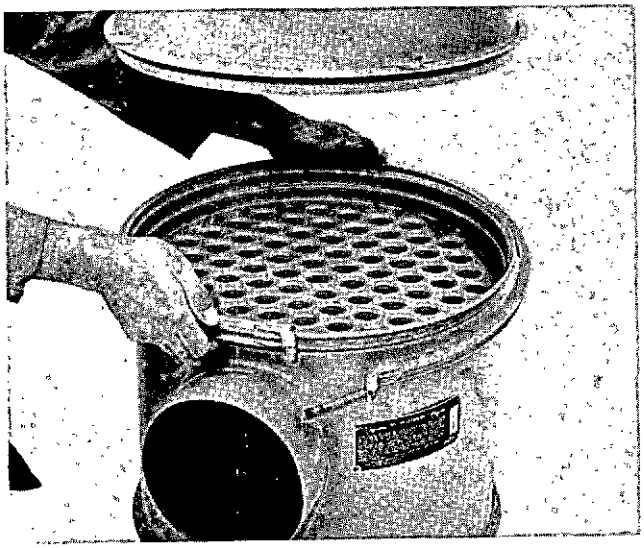


REMOVING DUST CUP

4. Inspect the tubes in the lower body. If dirty, clean the tubes with a round bottle brush.
5. Install the dust collector cup.

CLEANING THE LOWER BODY

1. Remove the dust collector cup.
2. Loosen the clamping bolt on the upper body.

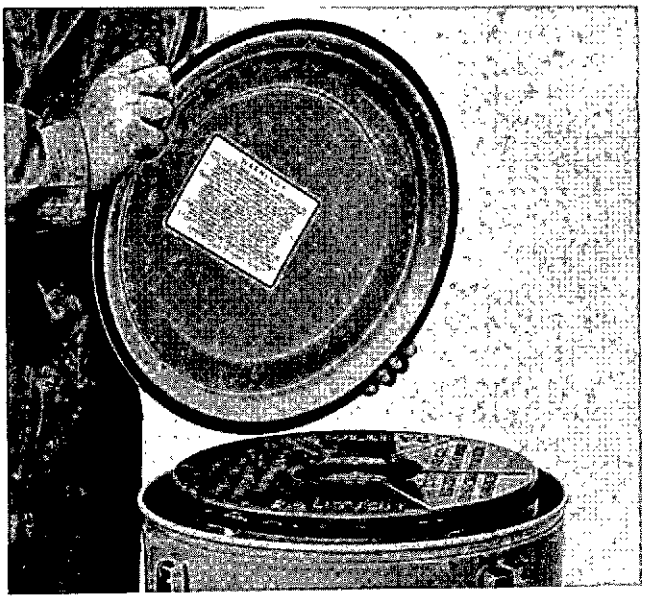


REMOVING LOWER BODY

3. Remove the lower body. Clean the tubes from both ends.
4. Inspect and install the upper body seal. Install a new seal if it is damaged.

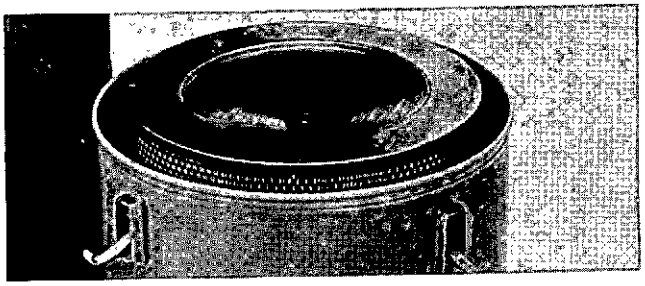
INSTALLING REPLACEMENT FILTER ELEMENT

1. Remove the cover.



REMOVING COVER AND INNER COVER

2. Remove the inner cover and filter element. In cold weather, a stuck inner cover may be removed by warming the air cleaner cover to 70-75°F (21-24°C).



REMOVE ELEMENT

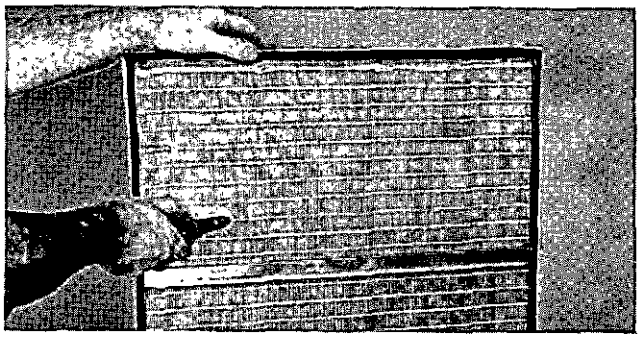
3. Clean all parts of the air cleaner.
4. Inspect the replacement element for damage and cleanliness.
5. Install the element, inner cover, and wing nut. Tighten the wing nut to prevent dust from bypassing the filter element.
6. Install the cover.

If, after servicing the air cleaner, the exhaust smoke and/or loss of power continues; or the service indicator locks in the raised position, discard that element and install a new element. Install a new element at least once a year.

CLEANING USED AIR CLEANER ELEMENTS

CLEANING WITH PRESSURE AIR

1. Use clean, dry air—100 PSI maximum. Hold the nozzle at least one inch from the element and at a slight angle. (A direct blast can rip the pleating.)

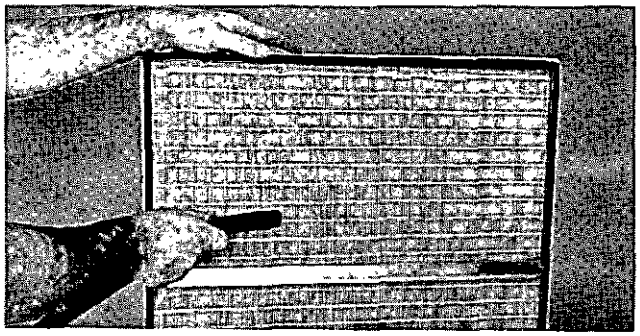


CLEANING ELEMENT WITH AIR

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 WITH WATER

1. Use clean water at no more than 40 PSI. Do not use a nozzle.
2. Direct the water stream along the complete length of each pleat on the CLEAN side of the element.

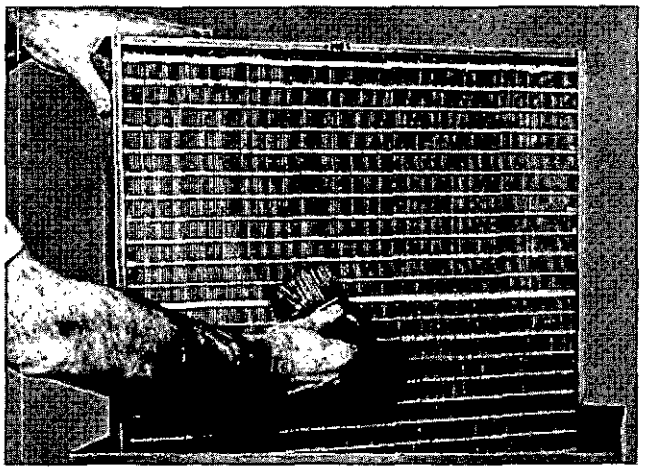


CLEANING ELEMENT WITH WATER

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 WITH DETERGENT

1. Wash both sides of the element in a solution of warm water and non-sudsing household detergent.
2. Rinse the CLEANEST side of the element with clean water (40 PSI maximum) along the complete length of each pleat.

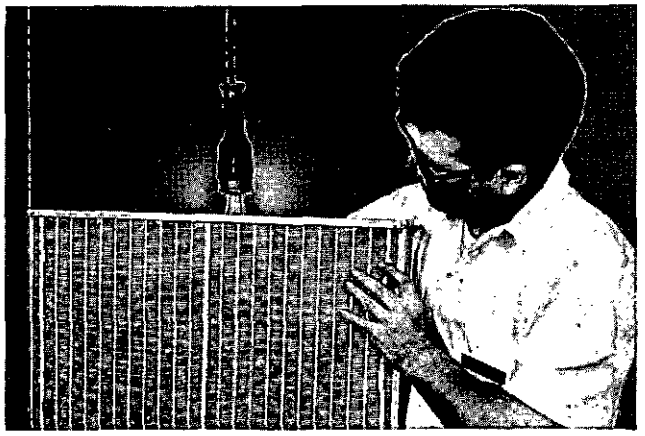


WASHING ELEMENT WITH DETERGENT

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.

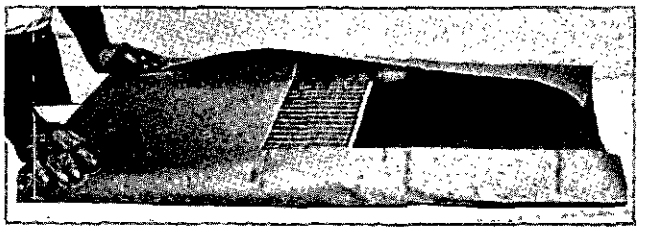
STORING CLEANED ELEMENTS

1. Hold the dried element in front of a lighted electric bulb. Carefully inspect the element for tiny, pinpoints of light. Any light showing indicates a pleat has ruptured and will tear with further use. Discard the element.



INSPECTING ELEMENT

2. Wrap usable elements in heavy paper.



WRAPPING ELEMENT FOR STORAGE

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

PRECLEANER

SERVICING

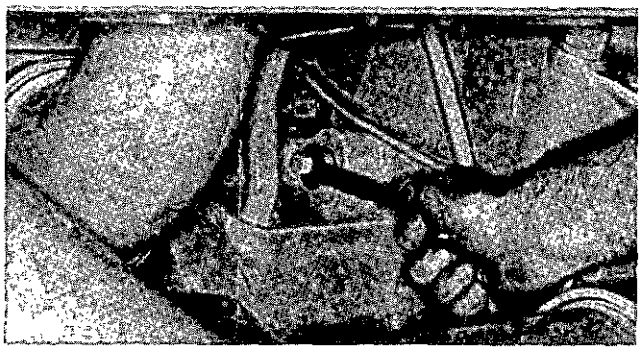
When the precleaner body is 3/4 full, remove and empty the precleaner. Wash the precleaner in water.

ENGINE VALVES

VALVE LASH

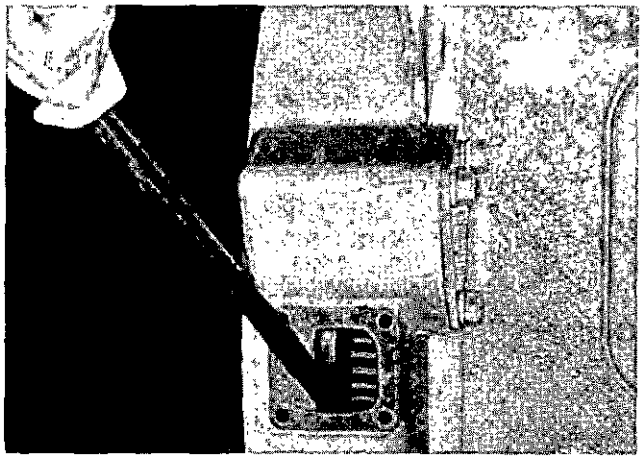
PREPARING TO CHECK ADJUSTMENT

1. Stop the engine. Allow it to cool at least 20 minutes.
2. Remove the flywheel housing timing cover.
3. Wipe dirt from the base of the valve covers.
4. Remove the valve covers.
5. Move both compression release levers to the START position.



COMPRESSION RELEASE LEVER (1 each bank)

6. Determine direction of flywheel rotation. See the decal above the flywheel housing.
7. Bar the flywheel in the direction of normal rotation. Align the "TDC 1" timing mark for your engine, ("TDC 1-7", "TDC 1-11", or "TDC 1-15"), with the timing pointer on the flywheel housing.



BARRING FLYWHEEL

8. Move both compression release levers to the RUN position. This must be done to release the exhaust valves.

NUMBERING OF CYLINDERS

Starting at the front of the engine:

Cylinder 1-3-5-7-9 etc.: Left bank, counting from front to rear.

Cylinder 2-4-6-8-10 etc.: Right bank, counting from front to rear.

LOCATING EXHAUST AND INLET VALVES

Exhaust Valves: Located toward center of vee.

Inlet Valves: Located toward outside of vee.

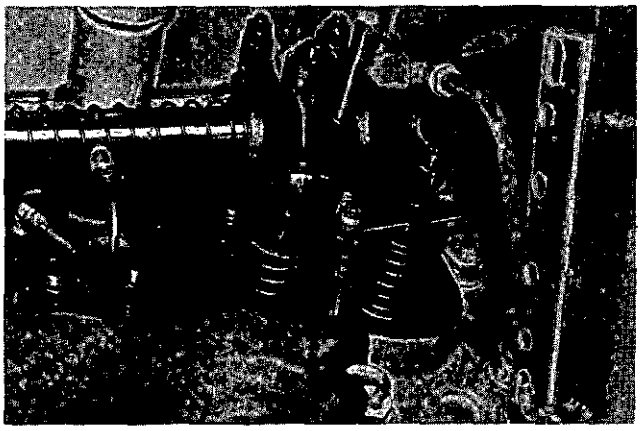
CHECKING ADJUSTMENT

1. Observe the rocker arms for cylinder No. 1. Determine if the piston is on compression or exhaust stroke.

   Compression stroke: Both intake and exhaust valves are closed.

   Exhaust stroke: Intake valve is closed, exhaust valve is opened.

2. With NO 1 CYLINDER ON COMPRESSION STROKE, check the lash of the following valves: Adjust if necessary. See the Lubrication and Maintenance Chart for correct valve lash.



CHECKING VALVE LASH

NO. 1 CYLINDER ON COMPRESSION STROKE COUNTERCLOCKWISE ROTATION - Viewed from Flywheel			
VALVES	D379 CYLINDERS	D398 CYLINDERS	D399 CYLINDERS
Exhaust	1-4-5-8	1-4-5-6-9-12	1-2-3-4-5-6-8-9
Intake	1-2-3-6	1-3-6-7-10-12	1-2-7-8-11-12-13-14

NO. 1 CYLINDER ON COMPRESSION STROKE CLOCKWISE ROTATION - Viewed from Flywheel			
VALVES	D379 CYLINDERS	D398 CYLINDERS	D399 CYLINDERS
Exhaust	1-4-5-8	1-4-5-8-9-12	1-2-3-4-5-6-9-10
Intake	1-3-6-8	1-3-4-6-7-12	1-2-6-7-8-11-13-14

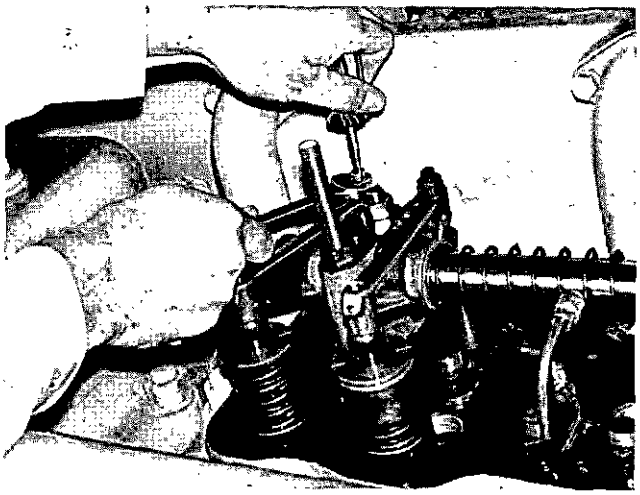
3. Move both compression release levers to START position.
4. Bar the flywheel one revolution in the direction of normal rotation. Align the "TDC 1" timing mark for your engine, ("TDC 1-7", "TDC 1-11" or "TDC 1-15"), with the timing pointer on the flywheel housing.
5. Move both compression release levers to the RUN position.
6. With NO. 1 CYLINDER ON EXHAUST STROKE, check the lash for the following valves. Adjust if necessary. See the Lubrication and Maintenance Chart for correct valve lash.

NO. 1 CYLINDER ON EXHAUST STROKE COUNTERCLOCKWISE ROTATION - Viewed from Flywheel			
VALVES	D379 CYLINDERS	D398 CYLINDERS	D399 CYLINDERS
Exhaust	2-3-6-7	2-3-7-8-10-11	7-10-11-12-13-14-15-16
Intake	4-5-7-8	2-4-5-8-9-11	3-4-5-6-9-10-15-16

NO. 1 CYLINDER ON EXHAUST STROKE CLOCKWISE ROTATION - Viewed from Flywheel			
VALVES	D379 CYLINDERS	D398 CYLINDERS	D399 CYLINDERS
Exhaust	2-3-6-7	2-3-6-7-10-11	7-8-11-12-13-14-15-16
Intake	2-4-5-7	2-5-8-9-10-11	3-4-5-9-10-12-15-16

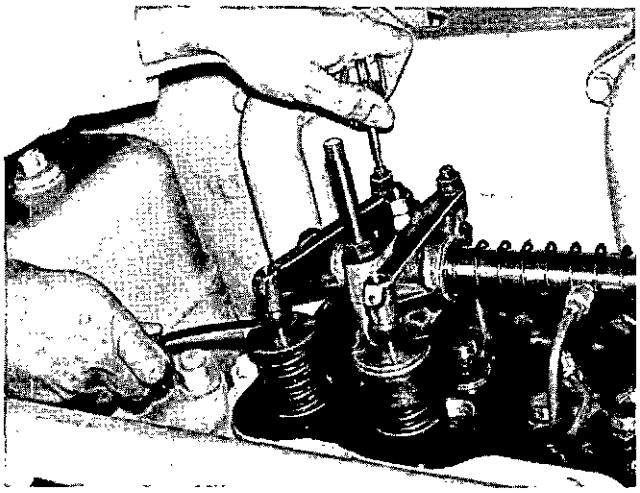
ADJUSTING VALVE LASH

1. Loosen the locknut on the adjusting screw.



LOOSENING LOCKNUT

2. Hold the locknut and turn the adjusting screw to obtain the proper lash.



ADJUSTING VALVE LASH

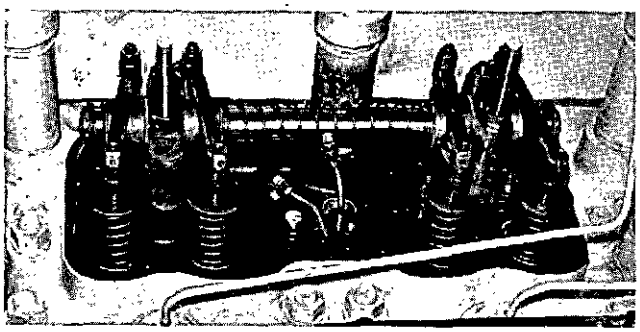
3. Hold the adjusting screw and tighten the locknut.
4. Recheck the lash.

VALVE ROTATORS

CHECKING ROTATION

After checking all valve clearances, and before installing the valve covers:

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.



CHECK VALVES FOR ROTATION

If a valve retainer fails to rotate, contact your Caterpillar dealer. Repairs must be made to prevent burning the valve.

If all valves rotate, proceed as follows:

4. Stop the engine.
5. Inspect and install valve cover gaskets. Install new gaskets if necessary.
6. Install the valve covers.
7. Install the flywheel housing timing cover.

FUEL SYSTEM

FUEL

Check the fuel supply. Order fuel as required. See Lubrication and Maintenance Chart for fuel recommendations.

FUEL TANK

FILLING

Fill the day tank at the end of each day's operation. This helps prevent moisture in the air from condensing on the inside walls of the tank and contaminating the fuel with water.

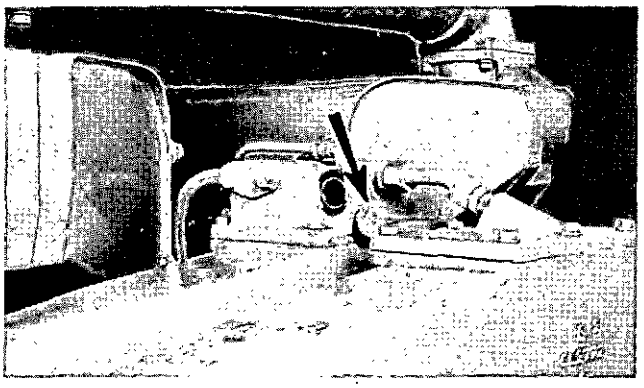
DRAINING WATER AND SEDIMENT

1. Open the fuel tank drain valve and drain water and sediment from fuel tank.
2. Close the drain valve.

FUEL FILTERS

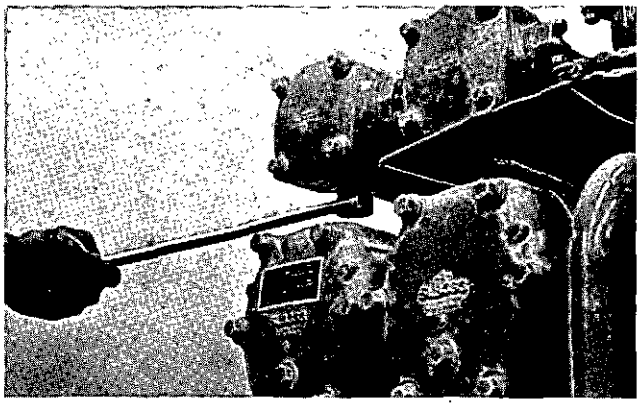
DRAINING WATER AND SEDIMENT

1. Close the fuel supply valve.
2. Open the fuel vent valve, located on top of the fuel filter housing.



FUEL VENT VALVE

3. Remove the fuel drain plugs. Drain water and sediment from filter.

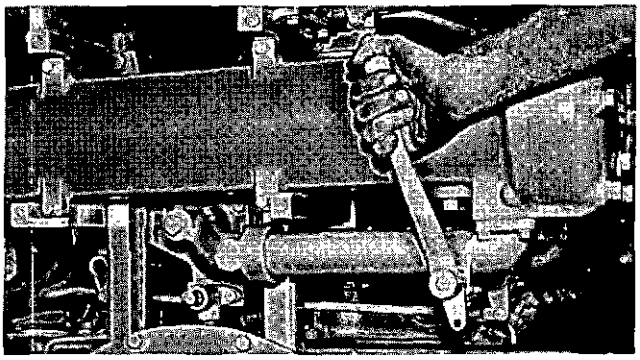


REMOVING FUEL FILTER HOUSING DRAIN PLUGS

4. Install the drain plugs.
5. Close fuel vent valve.
6. Prime the fuel system.

PRIMING THE FUEL SYSTEM

1. Open the fuel supply line valve.
2. Move the governor control lever to the shut-off position.
3. Be sure the fuel vent valve, located on top of the fuel filter housing is open.
4. Operate the priming pump lever until no air bubbles are visible through the circular glass window.



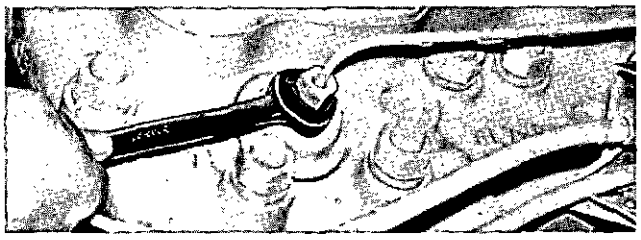
OPERATING FUEL PRIMING PUMP

5. Close the vent valve.
6. Start the engine.

IF THE ENGINE RUNS ROUGH, RELEASE TRAPPED AIR FROM FUEL LINES

With the engine running:

1. Loosen a fuel line—loosen either the line nut at the fuel injection pump, or the line nut at the nozzle.



LOOSENING FUEL LINE NUT

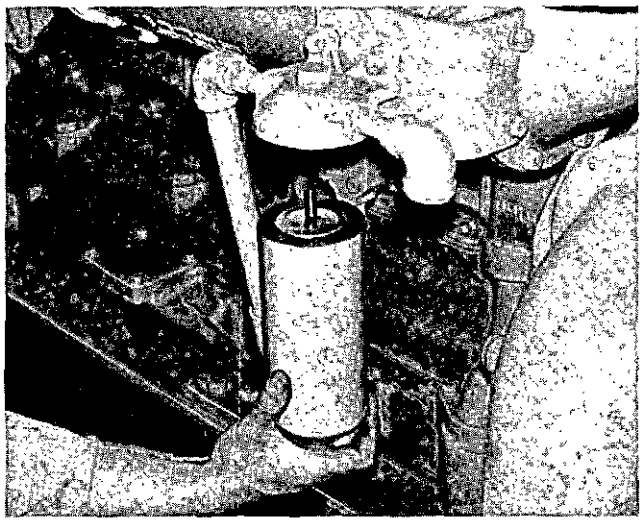
2. Allow the fuel to spurt until the fuel stream is free of air bubbles.
3. Tighten the line nut. Proceed to the next fuel line and repeat the procedure.
4. Continue this procedure for all fuel lines.

CHECKING FUEL PRESSURE GAUGE

With engine running, the fuel pressure gauge should register in the NORMAL range. If the gauge registers in the OUT range, service the fuel filter elements.

CLEANING PRIMARY FILTER ELEMENT

1. Stop the engine.
2. Close the diesel fuel supply line valve.
3. Loosen the nut on the cover and remove the case.

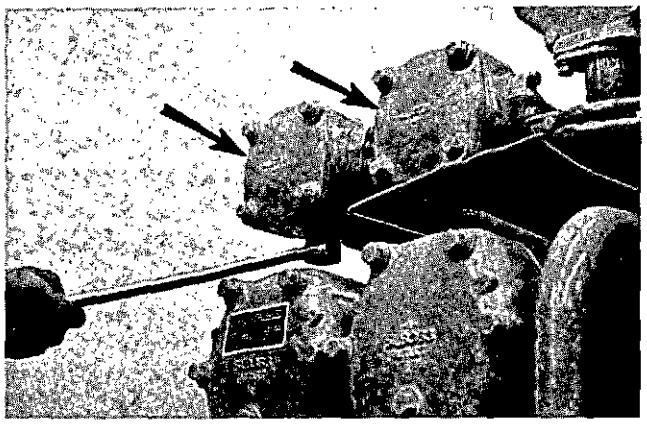


REMOVING PRIMARY FUEL FILTER

4. Remove the filter element. Clean the element and case in kerosene or diesel fuel.
5. Inspect and install the upper and lower cover gaskets. Install new gaskets if necessary.
6. Install the cleaned filter element and case.
7. Open fuel supply line valve.
8. Prime the fuel system.

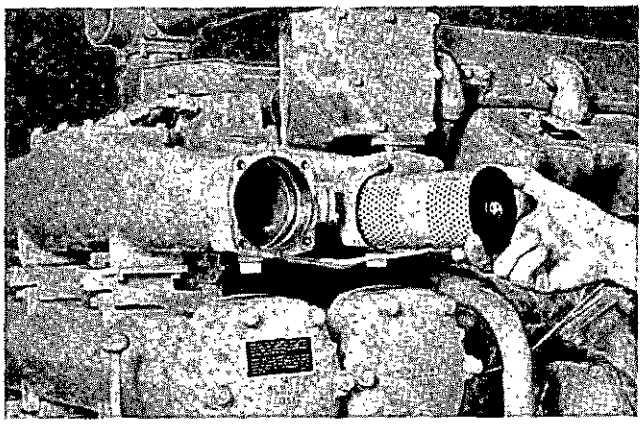
INSTALLING NEW FINAL FUEL FILTER ELEMENTS

1. Close the fuel supply line valve.
2. Open the fuel vent valve located on top of the fuel filter housing.
3. Remove the drain plugs and drain the fuel filter housing(s).
4. Remove the end covers.
5. Remove the filter elements.
6. Wipe sediment from inside the housings.



DRAIN AND REMOVE COVERS

7. Install all drain plugs.
8. Install new elements.



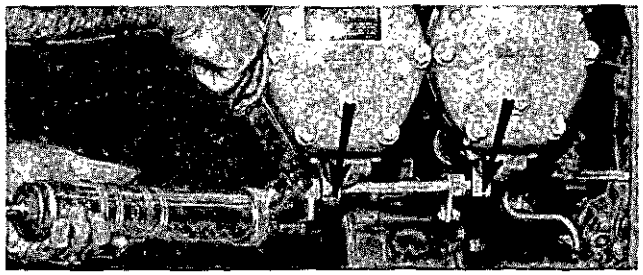
INSTALLING NEW ELEMENTS

9. Inspect and install the cover gaskets. Install new gaskets if necessary.
10. Install the end covers.
11. Open fuel supply line valve.
12. Prime the fuel system.

LUBRICATING THE FUEL PRIMING PUMP BEARINGS

Lubricate the fuel priming pump shaft bearings with grease:

D379 and D398: 1 or 2 strokes, 1 fitting in the lever bearing. D399: 1 or 2 strokes, 2 fittings; 2 bearings supporting the pump lever shafting.

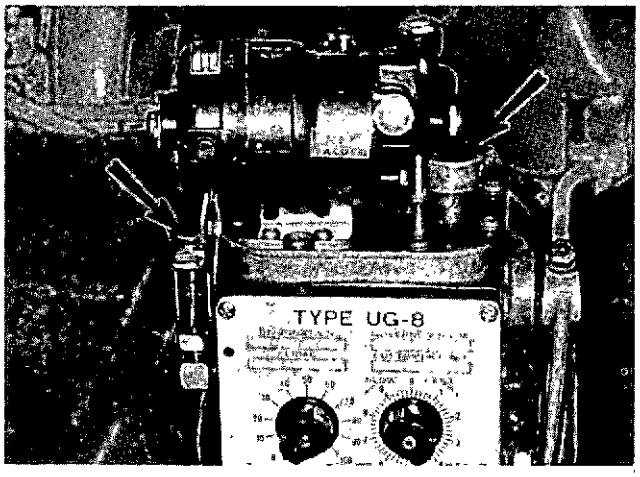


LUBRICATING FUEL PRIMING PUMP BEARINGS

WOODWARD UG8 GOVERNOR

CHECKING GOVERNOR OIL LEVEL

1. Check the governor oil level sight gauge.
2. Maintain the oil level between the ADD and FULL marks. Add oil as required. See Lubrication and Maintenance Chart for proper oil.



CHECKING OIL LEVEL

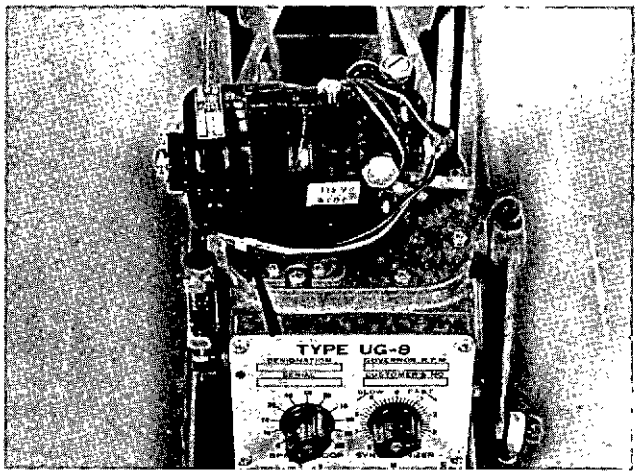
CHANGING GOVERNOR OIL

1. Move the governor control lever to the shut-off position.
2. Shut off the fuel tank fuel supply valve.
3. Disconnect the ground cable from the battery.

WARNING

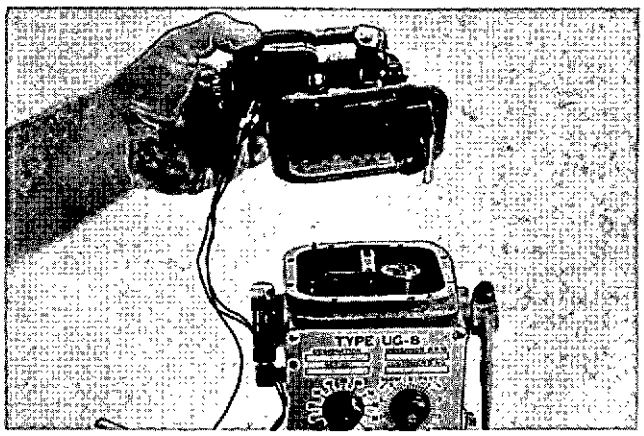
Be sure the engine cannot be started while work is being done. This is very important when the engine is equipped with an Automatic Start-Stop System.

4. Disconnect the governor linkage from the governor.
5. Disconnect the governor synchronizing motor wires.



DISCONNECT SYNCHRONIZING MOTOR

6. Remove the governor from the engine.
7. Remove the governor cover.



REMOVING GOVERNOR COVER

8. Turn the governor upside down and drain the oil.
9. Flush the governor with clean diesel fuel or kerosene.
10. Install the governor on the engine.
11. Fill the governor, with clean oil, to the FULL mark on the sight gauge. See Lubrication and Maintenance Chart for proper oil.
12. Connect the governor linkage.

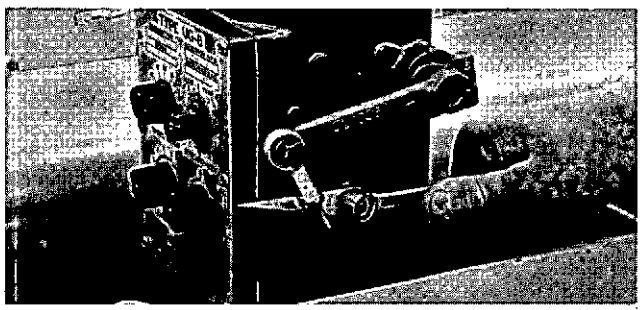
WARNING

Before starting the engine, check to be sure the governor linkage has been connected to the governor.

13. Connect the ground cable to the battery.

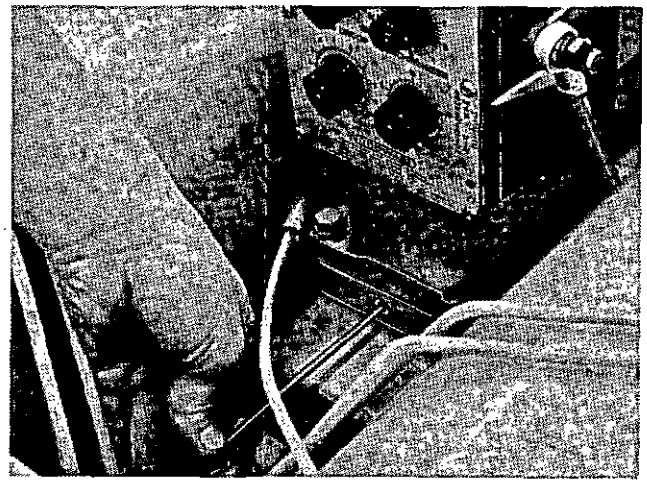
BLEEDING GOVERNOR

1. Start the engine and allow the engine to reach normal operating temperature.
2. Loosen the nut on the side of the governor which holds the compensation adjusting pointer.
3. Manually move the pointer to the extreme upper position and tighten the nut. This will allow the governor to be purged of air.



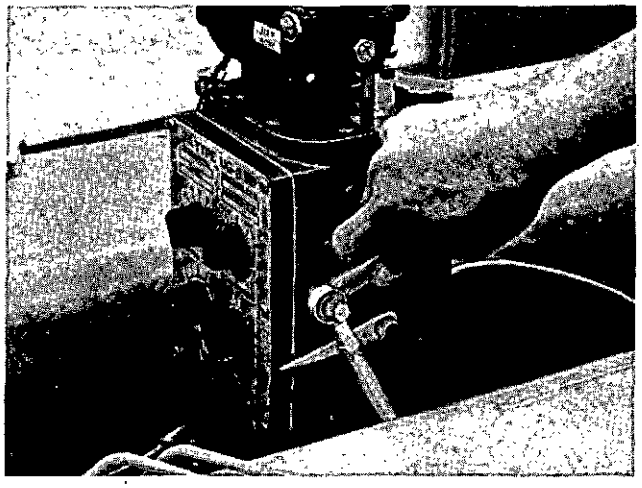
SETTING POINTER AT UPPER POSITION

4. Remove the plug from the base of the governor.
5. Using a wide blade screwdriver, engage the wide shallow screwdriver slot and turn the needle valve 3 or more turns counterclockwise.



OPENING NEEDLE VALVE

6. Allow the engine to surge for approximately 30 seconds.
7. Loosen the nut and move the compensation adjusting pointer to the extreme downward position. Tighten the nut.
8. Slowly turn the needle valve (wide shallow slot) clockwise until the surging stops.
9. It should now take less than one turn from this point to close the valve completely.
10. Open the valve to the same position where the surging had stopped.
11. Manually move the governor linkage to disturb the engine speed.



MANUALLY CHANGING ENGINE SPEED

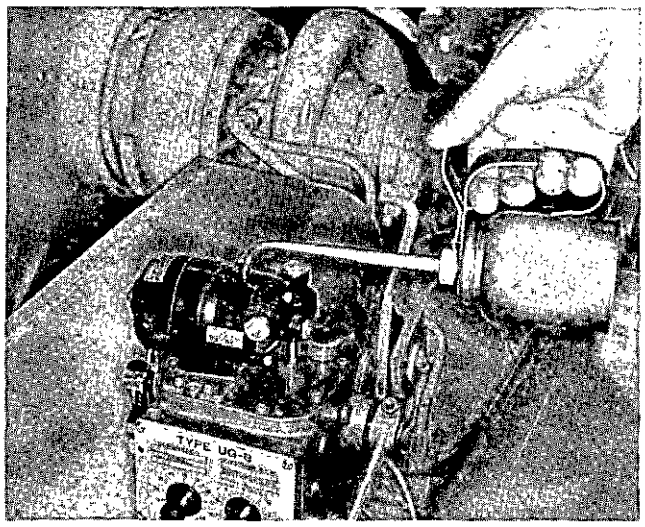
If the engine speed stabilizes, and the needle valve is only 1/2 to 3/4 turn open, the governor is properly adjusted. Install the base plug.

If more than a 3/4 turn is required to stop the engine from surging, proceed with the following steps.

12. Raise the pointer two divisions on the pointer scale.
13. Engage the wide shallow slot and turn the needle valve counterclockwise 3 or more turns.
14. Allow the engine to surge approximately 30 seconds.
15. Gradually turn the needle valve clockwise until surging just stops.
16. Note the portion of a turn required to close the needle valve.
17. Open the valve exactly to the same position surging stopped.
18. Manually move the governor linkage to disturb the engine speed. The engine speed should stabilize with the needle valve opened 1/2 to 3/4 turn.
19. A valve opened less than 1/2 of a turn produces a slow response to load changes. A valve opened more than 3/4 of a turn produces excessive speed response to load change. If the engine does not stabilize between 1/2 to 3/4 turn open, raise the pointer two divisions and repeat steps 12 through 19.
20. When the engine speed stabilizes, install the base plug.

LUBRICATING THE GOVERNOR SYNCHRONIZING MOTOR

Fill the cup on top of the motor with clean oil. See Lubrication and Maintenance Chart for proper oil.



LUBRICATING ELECTRIC MOTOR

COOLING SYSTEM

ENGINE JACKET WATER

CHECKING COOLANT LEVEL

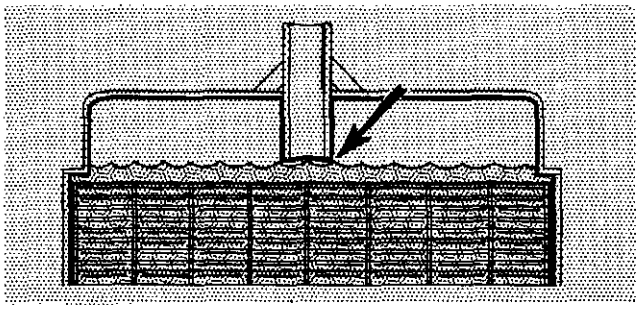
With the engine stopped:

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 level to base of fill pipe. The coolant requires expansion space as it is heated.



PROPER COOLANT LEVEL

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

CHECKING WATER TEMPERATURE GAUGE READING

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. Frequently check the water temperature gauge while operating. Be sure to note any deviation from the normal reading.
3. Whenever the reading changes, investigate the cause and have necessary repairs made.

DRAINING RADIATOR OR EXPANSION TANK

Whenever it is necessary to drain the cooling system for repairs:

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

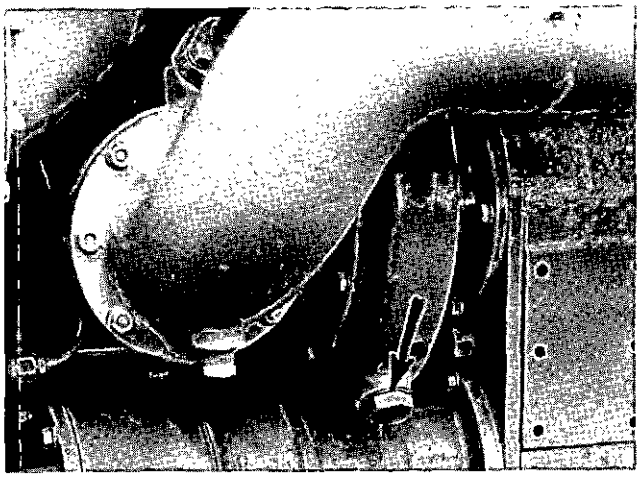
WARNING

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.
4. Open the drain valve on the radiator, if so equipped.

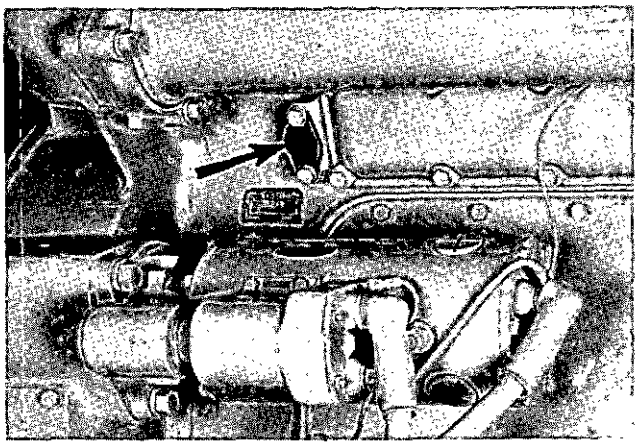
DRAINING COMPLETE COOLING SYSTEM

1. Remove the water pump drain plug.



COOLANT DRAIN

2. Remove the engine block right rear drain cover.

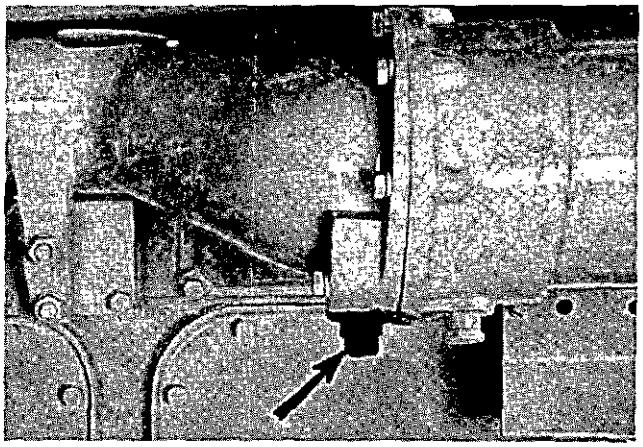


COOLANT DRAIN

3. Remove the drain plug from the rear of the oil cooler support.

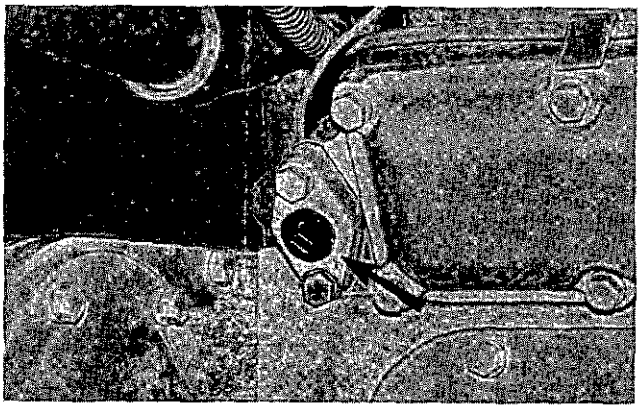
CAUTION

The drain plug on the oil cooler housing drains engine oil.



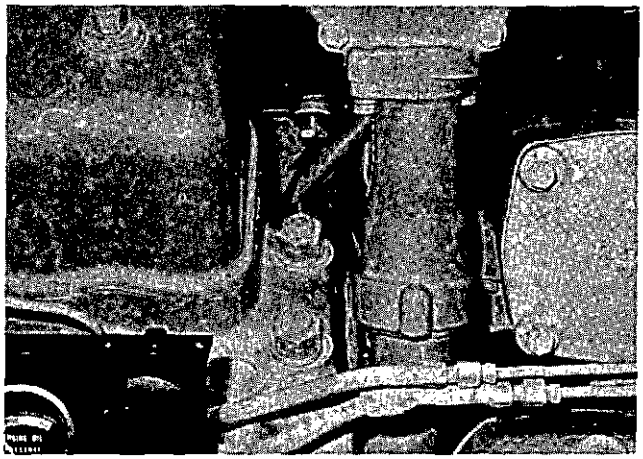
COOLANT DRAIN

4. Remove the engine block left front drain cover.



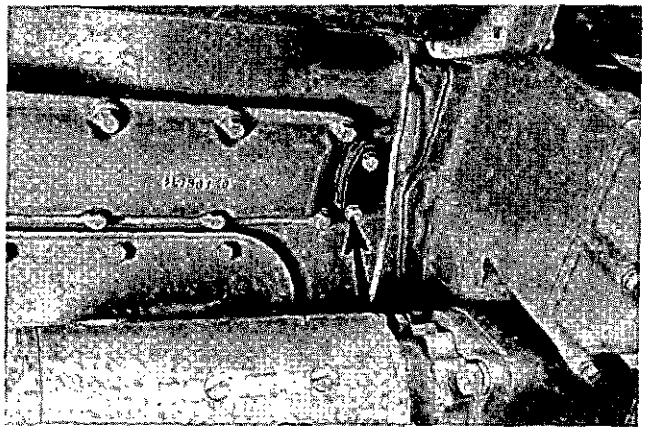
COOLANT DRAIN

5. Remove the left and right manifold water shield drain plugs, located above the rear of the engine block.



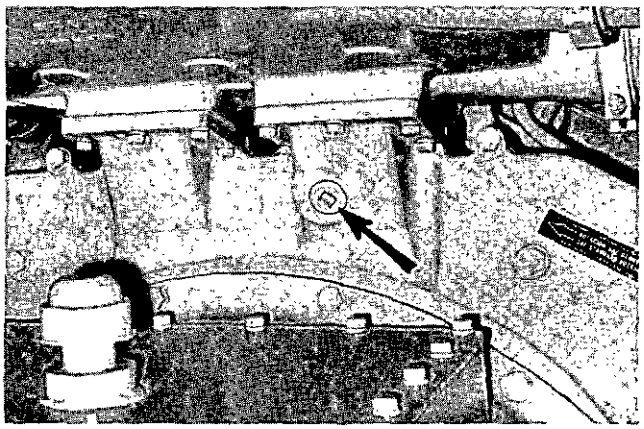
COOLANT DRAIN

6. Remove the engine block left rear drain cover.



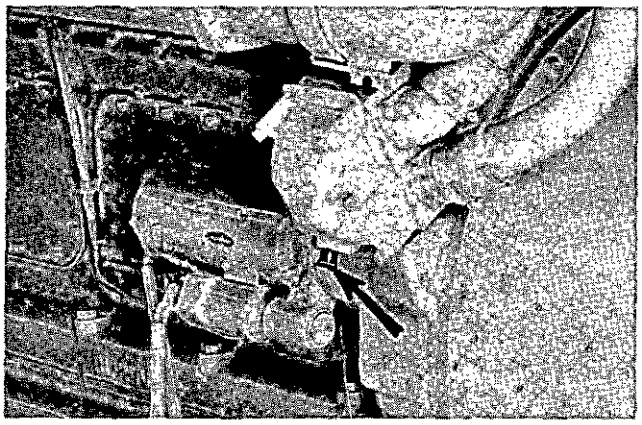
COOLANT DRAIN

7. Remove the aftercooler drain plug.



COOLANT DRAIN

8. Remove the elbow drain plug from the left side of the flywheel housing. Allow the coolant to drain.



COOLANT DRAIN

9. Install all drain covers and plugs. Close the radiator *drain valve.*

FLUSHING 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:

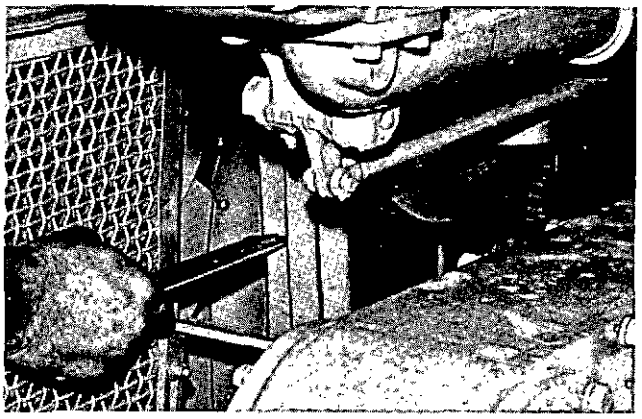
1. Fill the cooling system with a solution consisting of one pound (0,45 kg) of oxalic acid or sodium bisulphate ($NaHSO_4$) with every 5 gallons (19 liters) of water.
2. Start the engine and operate at operating temperatures for 1/2 to 1 hour.
3. Stop the engine and drain the cooling system.
4. Flush 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 (0,23 kg) sodium carbonate crystals (Na_2CO_3, $10H_2O$) with every 10 gallons (38 liters) 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.

FILLING COOLING SYSTEM

1. Add anti-freeze, if required.
2. Fill to correct level with water which is free as possible from scale forming minerals.
3. Start and run engine for 10 minutes.
4. Remove the radiator cap and check the coolant level.
5. Add coolant, if needed, until coolant level is to the bottom of the filler tube.
6. Install the radiator cap.

FAN BELTS AND DRIVE

1. Check belt wear.
2. Apply a 25 pound (10 kg) force, perpendicular to the belt, midway between the driver and driven pulley and measure the belt deflection.



MEASURING BELT DEFLECTION

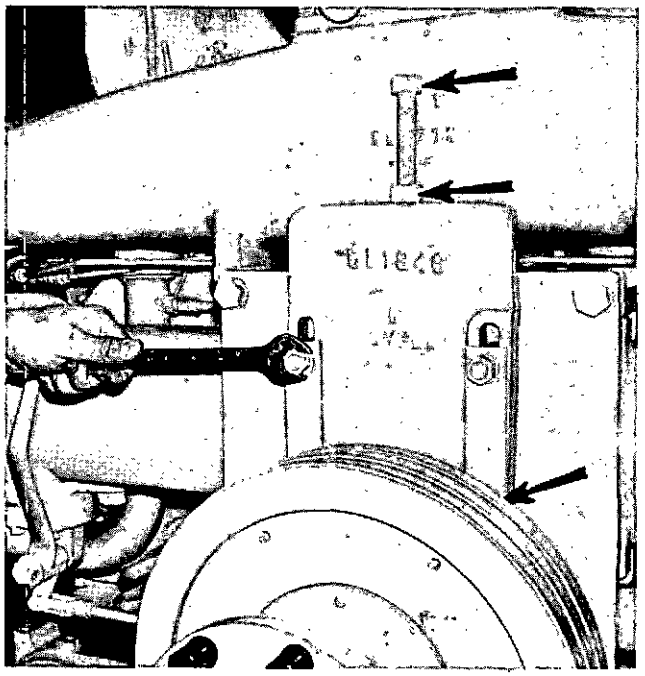
BELT DEFLECTION

ENGINE	DEFLECTION
D379	9/16" to 13/16" (15 to 20mm)
D398	1 1/8" to 1 3/8" (30 to 35mm)
D399	1 1/8" to 1 3/8" (30 to 35mm)

3. If one belt in a set requires replacement, always install a new matched set of belts—never replace just the worn belt. If only the worn belt is replaced, the new belt will be carrying all of the load—as it will not be stretched as much as the older belts—and all of the belts will fail in rapid succession.

ADJUSTING THE D379 FAN BELTS

1. Loosen the four nuts holding the fan plate to the engine block.

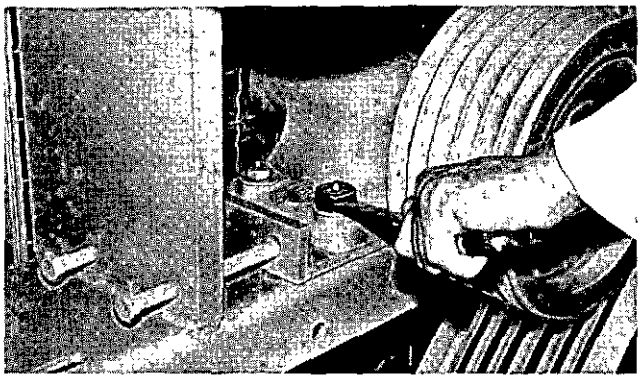


ADJUSTING D379 FAN BELT

2. Loosen locknut. Turn the adjusting screw until belt is adjusted properly.
3. Tighten the four nuts and locknut.
4. Check the belt adjustment.

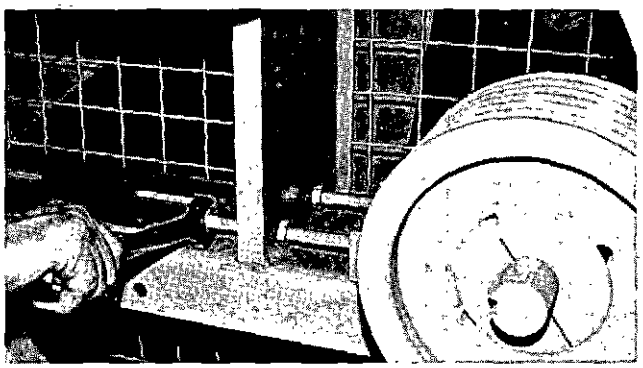
ADJUSTING THE D398 OR D399 FAN BELTS

1. Loosen the idler pillow block mounting bolts.



LOOSENING MOUNTING BOLTS

2. Loosen the locknut on the pillow block positioning screw.
3. Turn the positioning screw until the belt is adjusted properly.

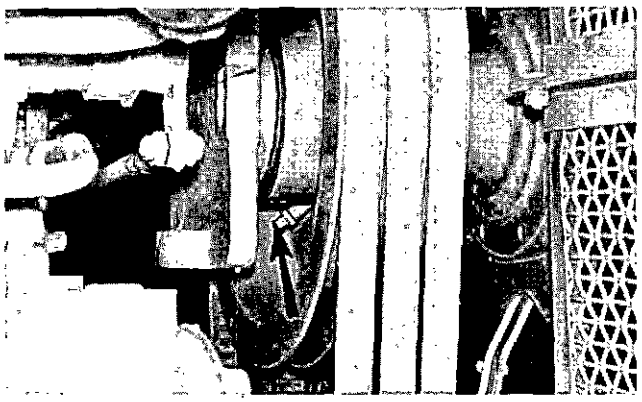


POSITIONING SCREW

4. Tighten the pillow block mounting bolts.
5. Tighten the locknut on the positioning screw.
6. Check the belt adjustment.

LUBRICATING D379 FAN DRIVE

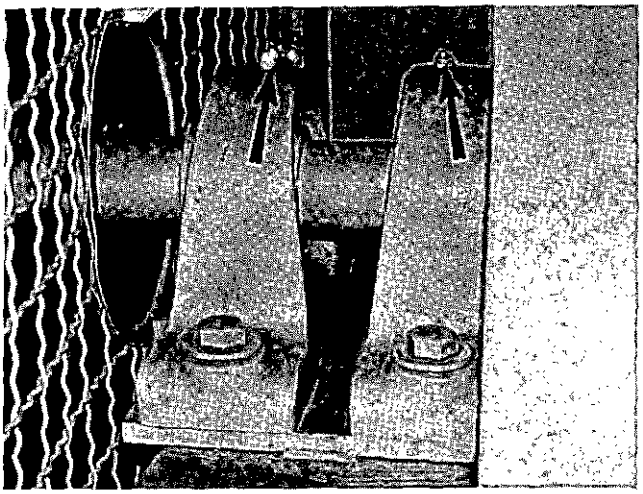
Lubricate the fan drive bearing with grease; 1 or 2 strokes, 1 fitting.



FAN DRIVE BEARING

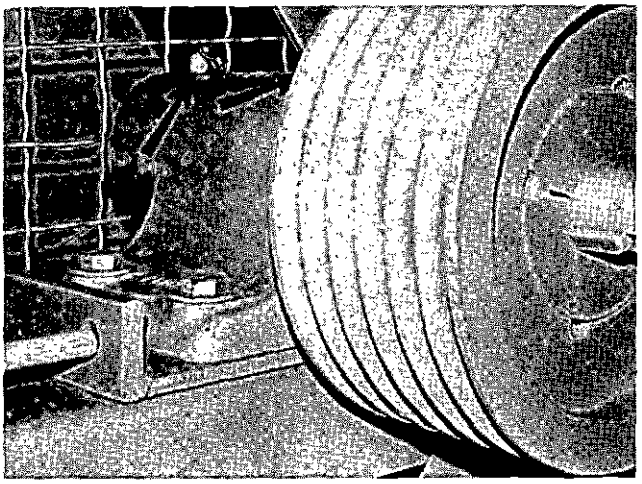
LUBRICATING D398, D399 FAN DRIVE

1. Lubricate the upper pillow block bearings with grease; 1 or 2 strokes, 2 fittings.



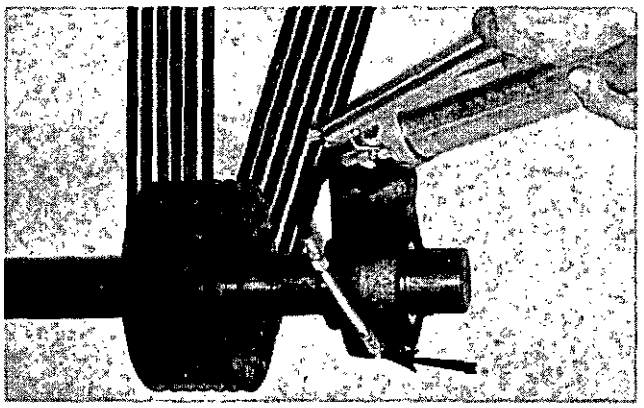
UPPER PILLOW BLOCK BEARINGS

2. Lubricate the idler pillow block bearings with grease; 1 or 2 strokes, 2 fittings.



IDLER PILLOW BLOCK BEARINGS

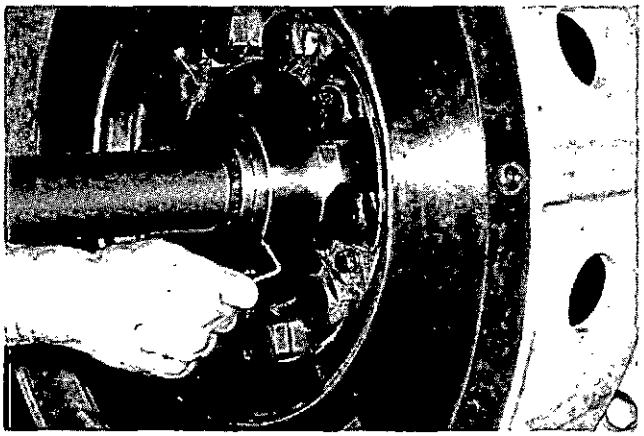
3. D399 Engine only: Lubricate the lower pillow block bearing with grease; 1 or 2 strokes, 1 fitting.



LUBRICATING LOWER PILLOW BLOCK BEARING

LUBRICATING D399 CRANKSHAFT COUPLING

1. Rotate the crankshaft until the two lubricating plugs are 45° from horizontal.
2. Remove the lower plug.
3. Remove the upper plug and install a grease fitting.
4. Lubricate with grease until the grease appears at the lower hole.
5. Remove the fitting, wipe off the excess grease, and install both plugs.



REMOVING LUBRICATING PLUGS ON CRANKSHAFT COUPLING

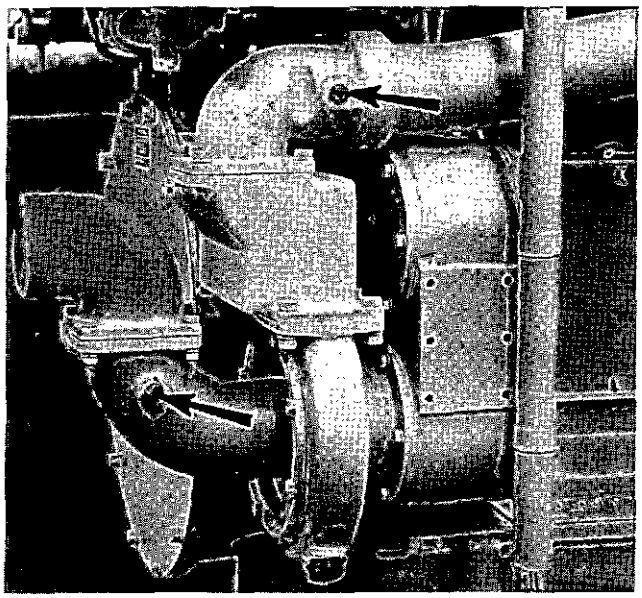
RAW WATER

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.

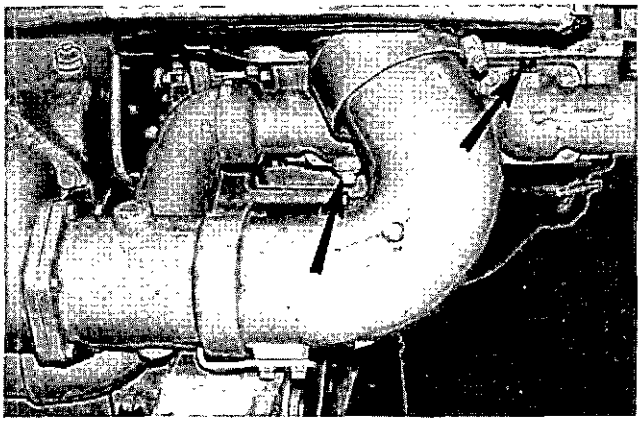
INSPECTING ZINC RODS

1. Move the governor control lever to the shut-off position.
2. Remove the two plugs with zinc rods from the raw water pump and line.



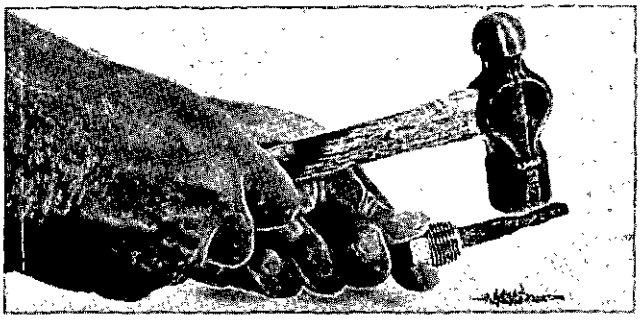
ZINC PLUGS IN RAW WATER PUMP AND LINE

3. Remove the two plugs with zinc rods from the aftercooler line.



ZINC PLUGS IN AFTERCOOLER LINES

4. Tap the zinc rods lightly with a small hammer.



INSPECTING ZINC ROD

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

INSTALLING NEW ZINC ROD

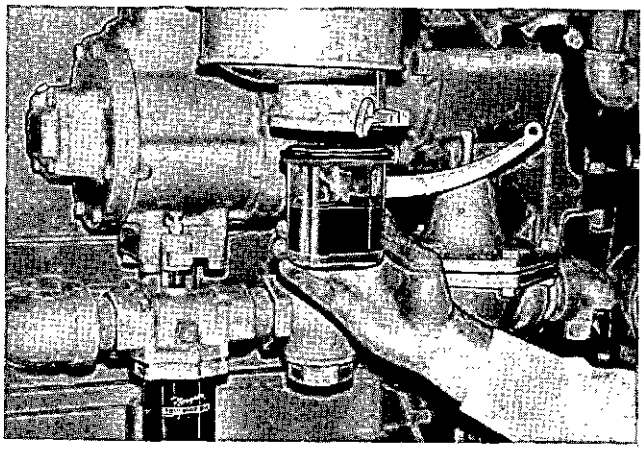
1. Unscrew or drill the existing rod from the plug base.
2. Install a new rod in the plug base.
3. Install the plug.

STARTING SYSTEM

AIR STARTING

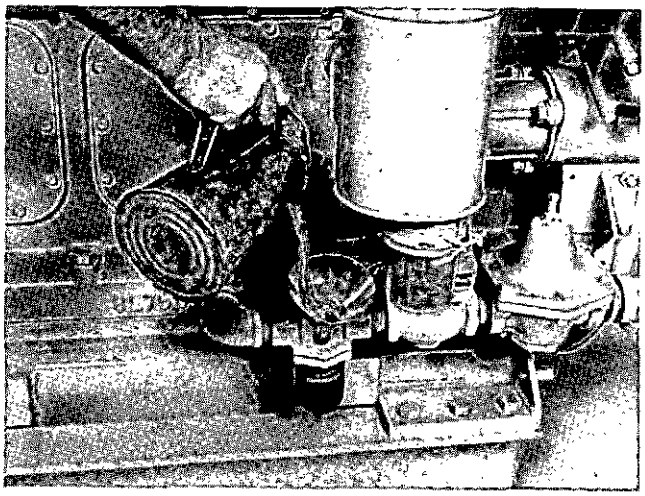
The motor oiler lubricates the vanes of the starting motor with a fine oil mist as the motor is operating.

The collector jar collects both the oil after it has lubricated the starting motor vanes, and the moisture condensation from the compressed air. Empty the collector jar whenever the jar becomes half full.



REMOVING OIL COLLECTOR JAR

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



ADDING OIL TO MOTOR OILER

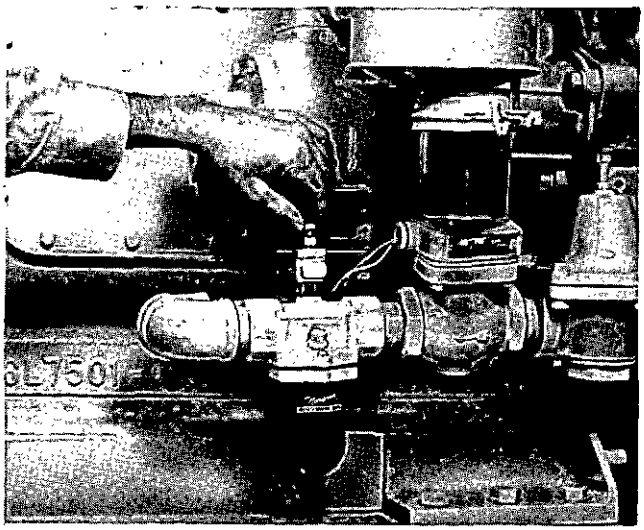
CAUTION

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

ADJUSTING THE AIR STARTING MOTOR OILER FEED

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

1. Move the compression release lever to the START position, and move the governor control lever to the SHUT-OFF position.
2. Pull up on the air start control lever and crank the engine.
3. Count the drops of oil released per minute into the air stream.
   a. Turn the valve needle (the uppermost knob on the oiler) counterclockwise to increase the number of drops.
   b. Turn the valve needle clockwise to decrease the number of drops.



ADJUSTING MOTOR OILER

HYDRAULIC STARTING

RELEASING HYDRAULIC PRESSURE

CAUTION

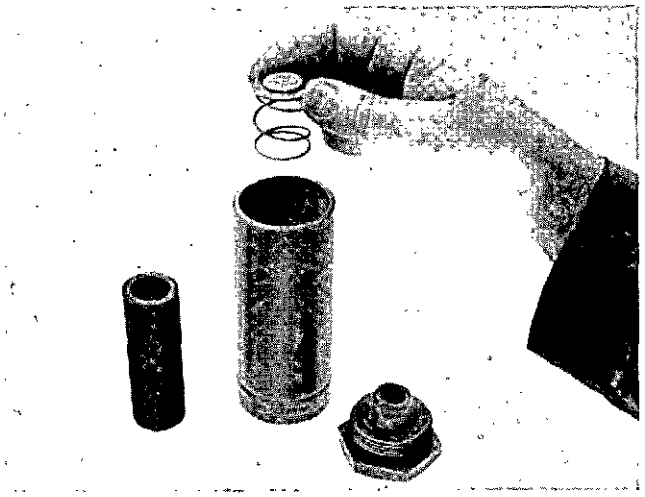
Before disconnecting any part of the hydraulic starting circuit, release all hydraulic pressure.

1. Move the governor control to turn off the fuel.
2. If the engine is equipped with a compression release lever, move the lever to the START position.
3. Engage the hydraulic start control valve.

Hold the control valve in the engaged position until the engine stops. Disengage and engage the control lever several times. The hydraulic gauge must indicate "0 psi" before removing any part.

INSTALLING OIL FILTER ELEMENT

1. Remove the filter cover slowly. Pressure oil may be present.
2. Remove the filter element.
3. Remove the plate and spring.
4. Clean all parts in diesel fuel.
5. Check the cap and housing for damaged threads.
6. Install a new O-ring in the cover.
7. Install the plate, spring, new filter element and cover.



HYDRAULIC STARTER OIL FILTER

ELECTRICAL SYSTEM

BATTERY INSTALLATION

PREPARING DRY CHARGE BATTERIES

One day before installing a new dry charge battery, add the electrolyte solution to each cell.

1. Fill each cell to the bottom of the vent with electrolyte solution.

CAUTION

If the battery is initially filled with water by mistake, the battery is ruined and must be replaced.

2. Allow the battery to sit for several minutes to permit the battery plates to absorb the electrolyte.
3. Add make-up electrolyte solution until the level stabilizes. Once the level stabilizes, never add anything but water.
4. Install the vent caps.
5. Remove the tape covering the vent hole in each cap.
6. Slowly charge the battery on a battery charger until the specific gravity of the solution is at least 1.240 at a temperature of 80°F (27°C).

NOTE

If the electrolyte solution temperature nears 125°F (53°C) reduce the charging rate. Temperature in excess of 125°F (53°C) will ruin the battery.

PREPARING WET CHARGE BATTERIES

The electrolyte solution was added by the manufacturer. Make-up solution must be water; never add electrolyte or acid to a wet charge battery. If necessary, slowly charge the battery before using.

USING A BATTERY CHARGER

A desirable charging rate can be calculated by multiplying the amp-hour rating of the battery by .07 (7%).

Shut off the battery charger before disconnecting the booster charger clamps from the battery terminals. While the battery is charging, hydrogen gas is being given off through each vent cap. When hydrogen gas is mixed with air, the mixture is highly explosive and will explode in the presence of a spark or small flame.

WARNING

Never smoke near the area where batteries are being charged.

INSTALLING BATTERY

1. Be sure the tray is free of objects which may puncture the battery case when the hold down straps are tightened.
2. Be sure terminal posts and cable clamps are clean.
3. Place the battery in the tray. Tighten the hold downs evenly until the battery is snug. Do not overtighten.
4. Connect the "hot" terminal first.
5. Connect the ground terminal last.

CAUTION

Always connect the "hot" terminal first.

When the "hot" terminal is connected first, no arcing can occur if the wrench accidentally contacts both the terminal and the frame or tray. The part that is contacted will take the same polarity as the battery terminal.

By connecting the ground terminal first, the frame or tray is connected to ground. Then, if the wrench accidentally contacts the frame while connecting the "hot" terminal, a circuit is completed through the wrench. A hot spark will occur which could burn the person holding the wrench, or possibly explode the battery if an excess of hydrogen gas is present at any one of the vent holes.

After connecting both cables, apply a thin coating of grease over the cable clamps, terminals and hold down fasteners.

BATTERY MAINTENANCE

TESTING THE ELECTROLYTE SOLUTION

The general condition of a battery can be determined by measuring the specific gravity of the electrolyte solution and adjusting the reading to 80°F (27°C). 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 into a cell. Fill the hydrometer barrel while holding it vertically. The float must not drag on the wall of the barrel.
2. Read the hydrometer:

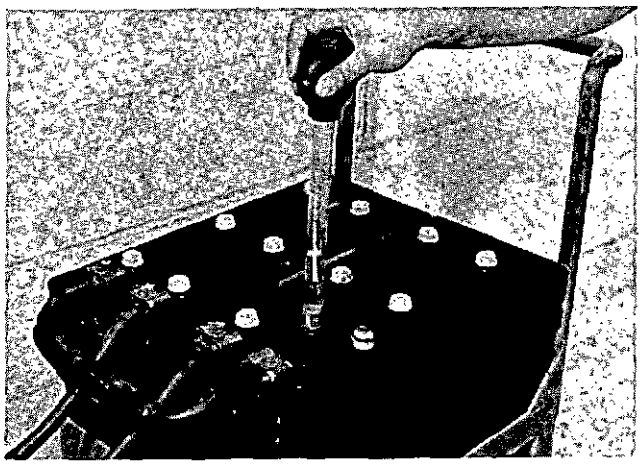
   1.250 or above - fully charged battery cell

   1.250-1.225 - full to half charged battery cell

   1.225-1.150 - half to low charged battery cell

   Below 1.150 - dead cell

   1.000 - water
3. Test each cell in the same manner.



MEASURING SPECIFIC GRAVITY

4. If there is more than .050 (50 gravity points) variation between the highest and lowest reading, the battery should be replaced.
5. Adjust the readings to 80°F (27°C).
   a. For every 10F° (5.5C°) the electrolyte temperature is above 80°F (27°C), add .004 (4 gravity points) to the specific gravity reading.

   Example: *Electrolyte temperature* = 100°F; 38°C
   Corrected temperature = 80°F; 27°C
   Difference: = 20°F; 11°C
   Increments: 10; 5.5
   20 ÷ 10 = 2 ; 11 ÷ 5.5 = 2
   2 x 4 gravity points = 8 gravity points

Add 8 gravity points to your hydrometer reading to obtain *the adjusted reading at* 100°F. *If the uncorrected* hydrometer is 1.240 the corrected reading would be: 1.240 + 8, or 1.248

   b. For every 10F° (5.5C°) the electrolyte temperature is below 80°F (27°C), subtract .004 (4 gravity points) from the specific gravity reading.

   Example: Electrolyte Temperature = 10°F; -13°C
   Corrected temperature = 80°F; 27°C
   Difference = 70°F; 40°C
   Increments: 10; 5.5
   70 ÷ 10 = 7; 40 ÷ 5.5 = 7
   7 x 4 gravity points = 28 gravity points

If the uncorrected hydrometer reading is 1.210 the corrected reading would be 1.210 – 28 = 1.182

The corrected reading is of most importance during cold weather when the hydrometer reading is always corrected to a lower specific gravity reading. A low reading signifies the battery has less available power to crank the engine and that booster batteries may be required.

ADDING MAKE-UP WATER

Check the electrolyte level of each cell and the general condition of the battery.

1. Maintain the electrolyte level to the base of each vent well.
2. The make-up water must be one of the following (in order of preference):
   a. Distilled water.
   b. Odorless, tasteless drinking water.
   c. Iron free water.
   d. Any available water.

WARNING

Never add acid or electrolyte.

READING THE AMMETER

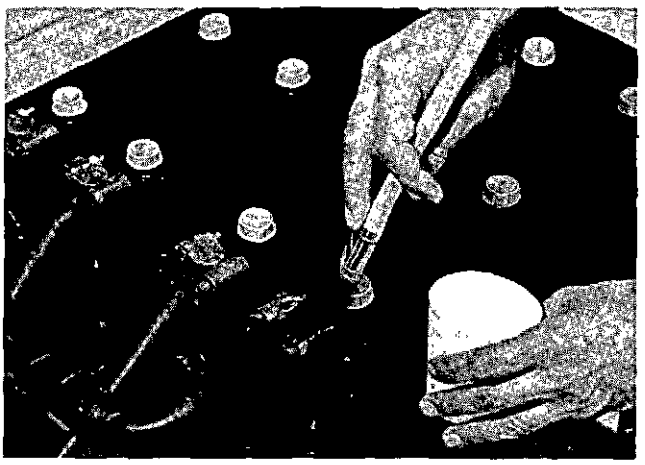
1. After starting the engine, the ammeter indicator should register to the right of zero, but should never be "pegged".
2. After the engine has been running, the indicator should be just to the right of zero.

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

The alternator charging rate maintains the battery's electrolyte specific gravity reading, and the battery's performance. An undercharge rate cannot maintain a desired 1.250 specific gravity reading. An overcharge rate will boil the water from the electrolyte solution. A proper charging rate should require no more than one ounce (30 cc) of water per cell per week to maintain a fully charged battery.

CLEANING BATTERY

1. Mix a weak solution of baking soda and water. Apply the solution with a bristle brush.



CLEANING BATTERY TERMINALS

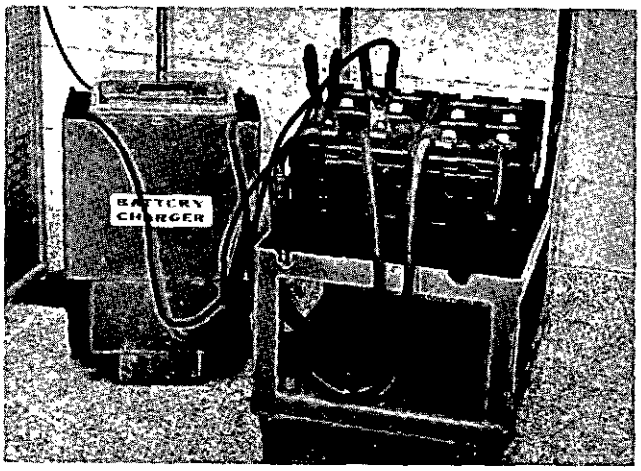
2. Thoroughly rinse the battery and battery tray with clean water.
3. Apply grease to the battery cable clamps and terminals and to all threads.

COLD WEATHER BATTERY MAINTENANCE

The following instructions aid in obtaining maximum performance in cold weather:

1. After adding make-up water, charge the battery.

   The added water will dilute the electrolyte. This will lower the specific gravity of the solution, raise the freezing point of the solution and lower the charge of the battery.



CHARGING A BATTERY

2. Keep the batteries fully charged either by operating the charging system or by using a battery charger.
3. Keep the electrolyte warm when the battery is not in use. The heat from an electric light bulb usually is sufficient.

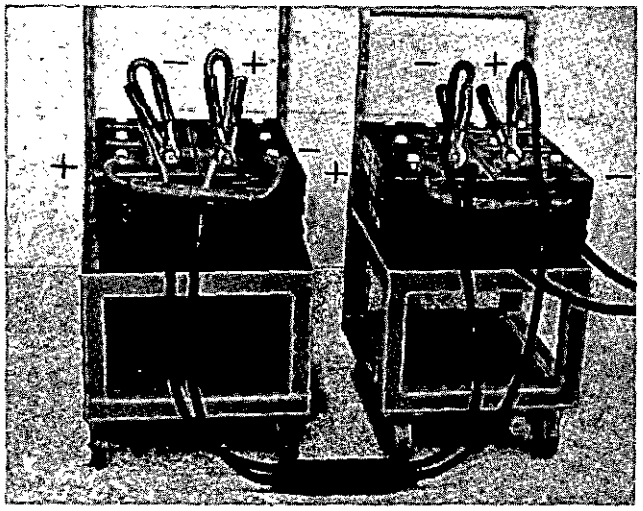
   CAUTION

   Do not lay cloth or any flammable material in contact with a lighted bulb. Charring, or fire, can result.

4. Use starting aids as instructed when starting.
5. Use booster batteries as required. Connect as instructed below.

CONNECTING FIVE 6 VOLT BOOSTER BATTERIES TO OBTAIN 30 VOLT STARTING

1. Using four jumper cables, connect five fully charged 6 volt batteries in series: Connect the positive terminal of one battery to the negative terminal of a second battery.



SERIES CONNECTED BOOSTER BATTERIES CONNECTED IN PARALLEL

2. Using a pair of jumper cables, connect the red jumper cable to the "hot" terminal of the booster batteries.
3. Connect the black jumper cable to the ground terminal of the booster batteries.

   CAUTION

   Keep the red and black cable terminals from touching each other.

4. Connect the other end of the red jumper cable to the "hot" terminal of the engine batteries.
5. Connect the other end of the black jumper cable to the ground terminal of the engine batteries.
6. Start the engine using starting aids as instructed.

REMOVING JUMPER CABLES

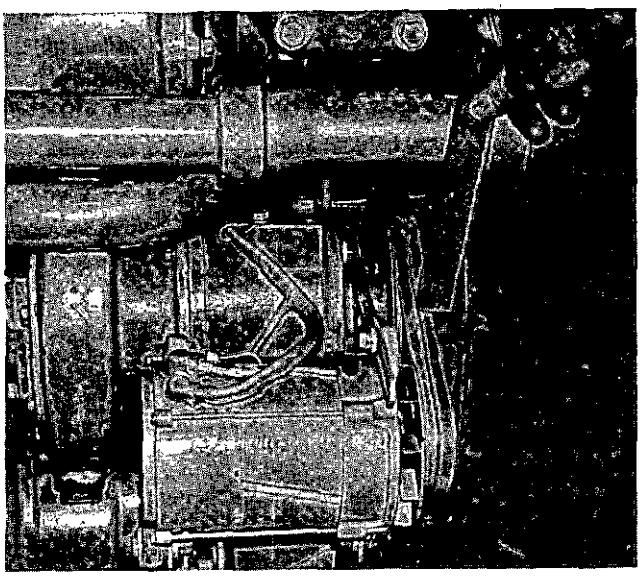
As soon as the engine starts:

1. Disconnect the black jumper cable from the engine battery ground terminal.
2. Disconnect the red jumper cable from the engine battery "hot" terminal.
3. Disconnect the black jumper cable from the booster batteries.
4. Disconnect the red jumper cable from the booster batteries.
5. Disconnect the booster batteries. Charge them to full capacity with a battery charger.

CHARGING ALTERNATOR

CHECKING ALTERNATOR BELTS

1. Check belt wear.
2. Apply a 25 pound (11,34 kg) force, perpendicular to the belt, midway between the driver and driven pulleys. Measure the belt deflection.

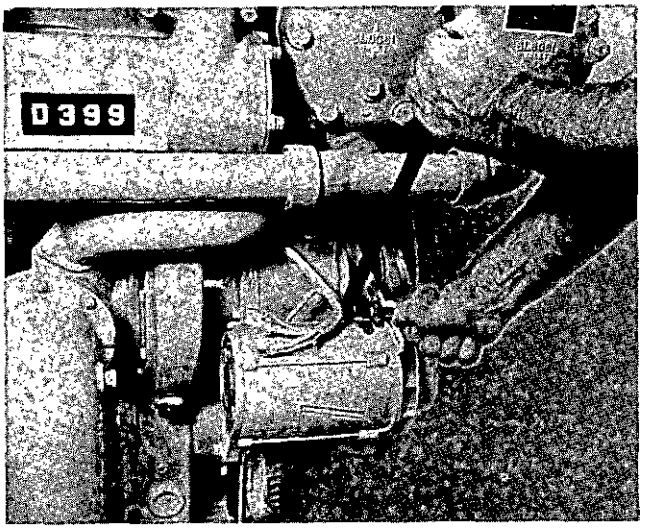


MEASURING BELT DEFLECTION

3. Proper belt deflection is 9/16 to 13/16" (14 to 20 mm). Adjust the belt tension as required.
4. If one belt in a set requires replacement, always install a new matched set of belts—never replace just the worn belt. If only the worn belt is replaced, the new belt will be carrying all of the load—as it will not be stretched as much as the older belts—and all of the belts will fail in rapid succession.

ADJUSTING ALTERNATOR BELTS

1. Remove the belt guard.
2. Loosen the alternator mounting bolts.
3. Push the alternator outward until the belt is properly adjusted.
4. Tighten the mounting bolts.
5. Check the belt adjustment.
6. Install the belt guard.



ADJUSTING BELT

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 be approximately equal to the number of glow plugs multiplied by 5, the *approximate amperage used by each glow plug.*

A deviation of 5 or more amps from this reading may 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 pounds feet.
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 be increased. If the reading is the same, check the glow plug wiring.
9. Disconnect the ammeter.

POWER COUPLING SYSTEM

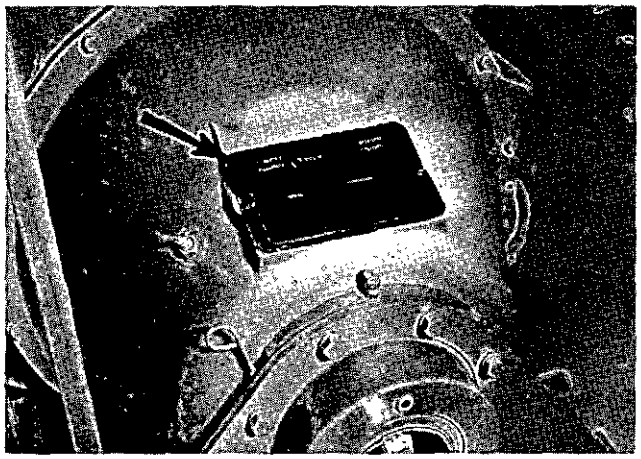
ENCLOSED CLUTCHES AND/OR FRONT POWER TAKE-OFF

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.

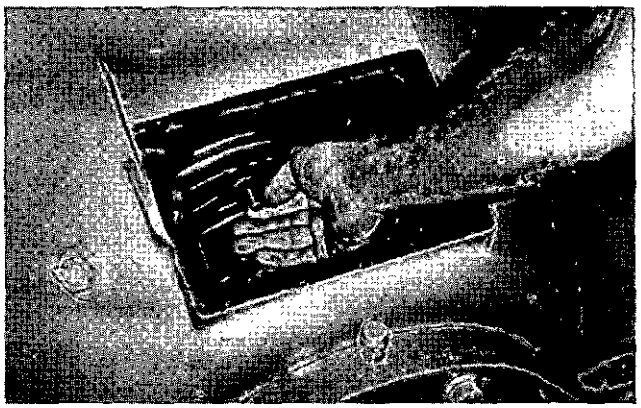
ADJUSTING CLUTCH

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



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.



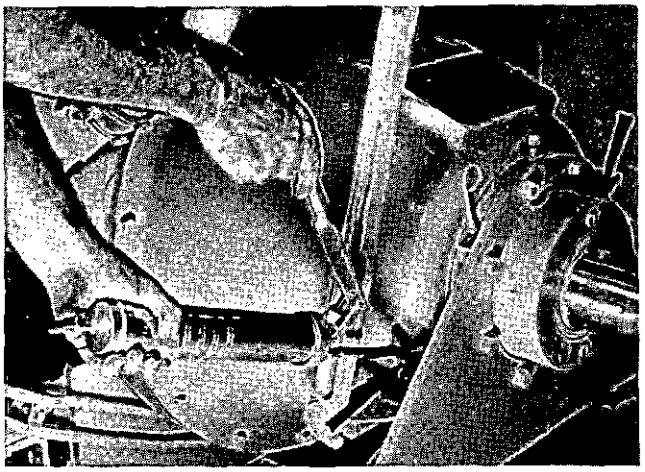
PULLING LOCKING PIN

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 (D379, D398 FLYWHEEL CLUTCHES AND D379, D398 AND D399 FRONT POWER TAKE-OFF CLUTCHES

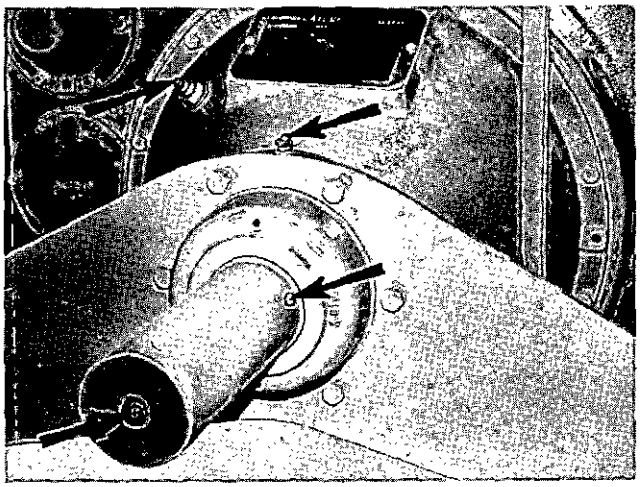
Lubricate the clutch bearings with grease, 1 or 2 strokes each fitting.

1. Lubricate the shift lever bearings; 1 fitting on each side of the clutch housing.



LUBRICATING SHIFT LEVER BEARINGS

2. 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.



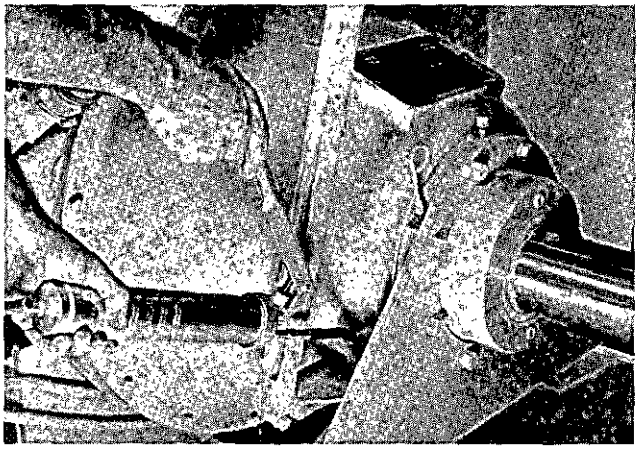
PILOT, SHIFT COLLAR AND SHAFT BEARINGS

3. Lubricate shift-collar and shaft; 1 fitting at top-left of center.
4. D379 and D398 only: Lubricate the shaft bearing 1 fitting on top-rear of housing.

LUBRICATING D399 ENGINE FLYWHEEL CLUTCH

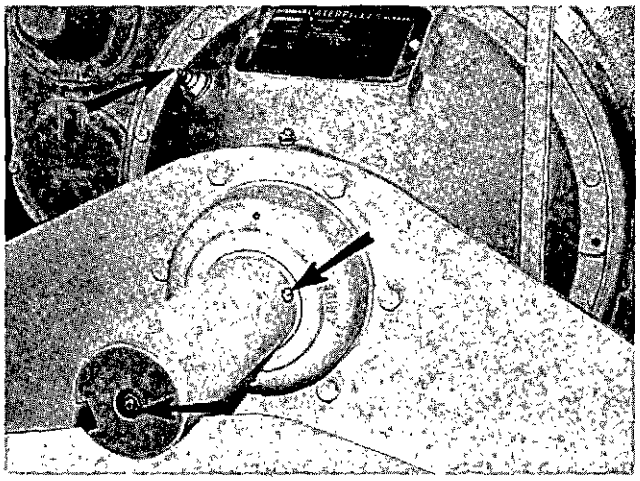
The D399 flywheel clutch main shaft bearing is oil lubricated. The remaining bearings are lubricated with grease.

1. Lubricate the shift lever bearings; 1 fitting on each side of clutch housing.



SHIFT LEVER BEARING

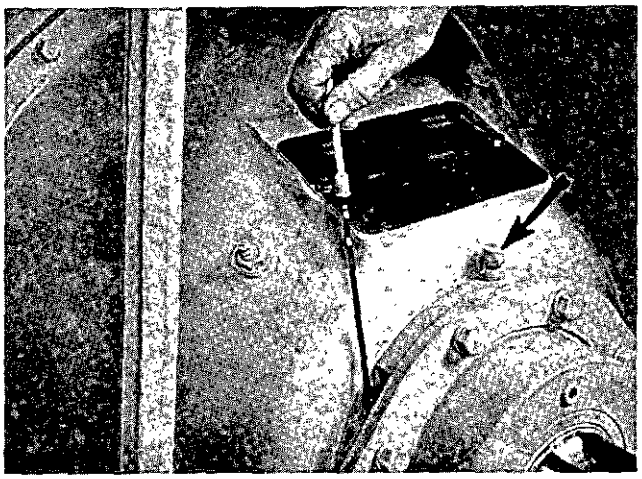
2. Lubricate the pilot bearing; 1 fitting at the end of shaft. If this fitting is not accessible, remove the plug located on the circumference of the shaft near the rear of the housing, and install a fitting.



PILOT AND SHIFT COLLAR BEARINGS

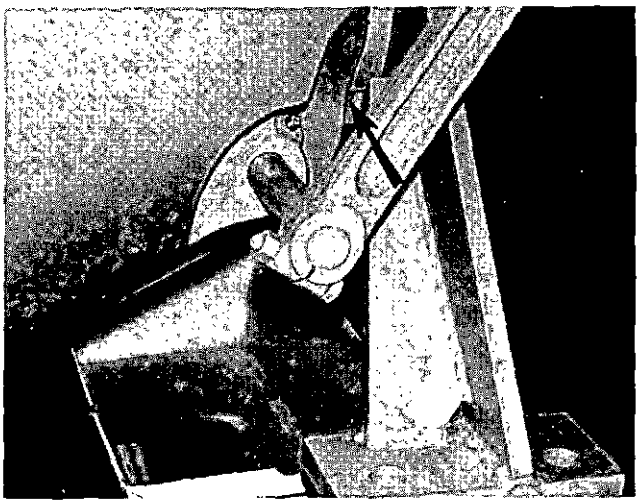
3. Lubricate the shift-collar bearing; 1 fitting at top-left of center.

4. Check the main shaft bearing oil reservoir level with engine stopped. Maintain the oil level at the FULL mark on the oil level gauge. Add oil through the filler tube on top of the bearing cage housing. Refer to Lubrication and Maintenance Chart for proper oil.



CHECKING OIL LEVEL

5. To drain the reservoir: Remove the drain plug located on the lower left side of the shaft bearing reservoir. Drain and install the drain plug. Fill to the FULL mark on the oil level gauge. Install the filler cap.



CLUTCH SHAFT BEARING DRAIN PLUG

ELECTRIC SET GENERATOR

INSPECTING SLIP RING

1. Remove the two lower panels from the rear of the generator housing.
2. Inspect the slip ring color. The slip ring color may be shiny copper to straw, or chocolate to black, but the color must be uniform to indicate satisfactory operation.

If the ring is basically one of the above shades, but contains blotches of green, blue or black, clean the ring with an electrical cleaning solvent.

CAUTION

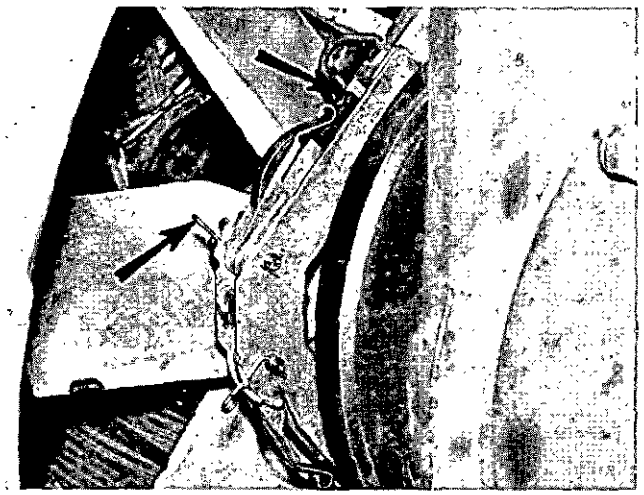
Do not use gasoline or carbon tetrachloride. **Both solvents will dissolve insulation. The vapors from carbon tetrachloride can be harmful when inhaled.**

Green blotches are caused by chlorine vapors, blue blotches are caused by sulphuric fumes, black blotches are caused by oil.

3. Inspect the slip ring for pitting. If the slip rings are rough, pitted, or worn eccentric, contact your Caterpillar dealer. The rings must be reconditioned.
4. Check the following to determine the cause for pitting:
   A. Check the generator nameplate rating. The generator load must be within this rating.
   B. Check the brush tension.

INSPECTING BRUSHES

The brush must move freely within the holder, but with enough spring tension to prevent brush flotation during operation.



CHECKING BRUSH SPRING TENSION

If brush tension is weak, push the spring forward into the next notch. If the spring is in the front notch, remove the brush and check the brush length. If the brush length is less than the minimum required, install a new brush.

Spring Tension	Minimum Length Before Replacement
14 Ounces	9/16 inch *
20 Ounces	9/16 inch *
40 Ounces	9/16 inch *

*15 mm

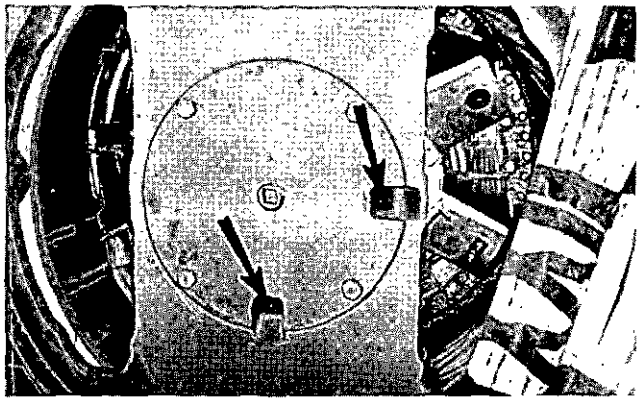
If the spring is moved forward and the brush tension is greater than chart specifications, release the spring one notch. Excessive spring tension will cause excessive brush wear.

INSTALLING NEW BRUSHES

1. Release spring tension.
2. Disconnect the lead wire from the brush and pull the brush from the brush holder.
3. Insert a new brush. Be sure it moves freely in the brush holder. Connect the lead wire.
4. Place a narrow piece of "00" sandpaper between the brush and slip ring with the abrasive surface against the brush. (Never use emery cloth as the emery contains small metallic particles which will damage the copper.)
5. Engage the spring in the middle notch.
6. Slowly pull the sandpaper from beneath the brush.
7. Remove all dust with a suction hose. If suction is not available, use a very low pressure blower. Do not use metal hose tips.
8. Check brush tension.
9. Install the two panels.

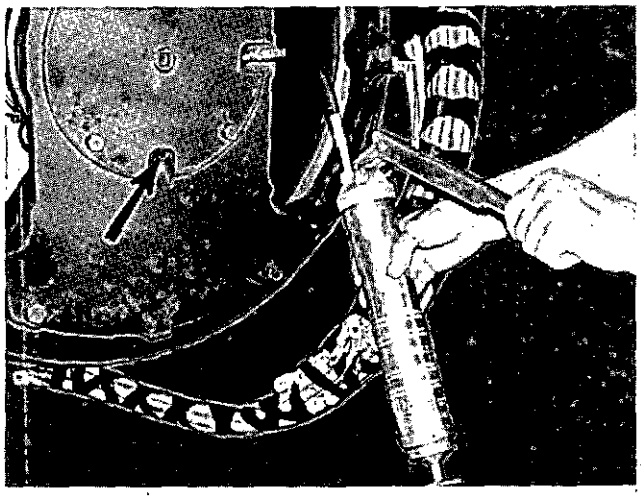
LUBRICATING THE REAR BEARING

1. Remove the two lower panels from the rear of the generator housing.
2. Remove the upper and lower grease fitting plugs.



LUBRICATION PLUGS

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



LUBRICATING BEARING

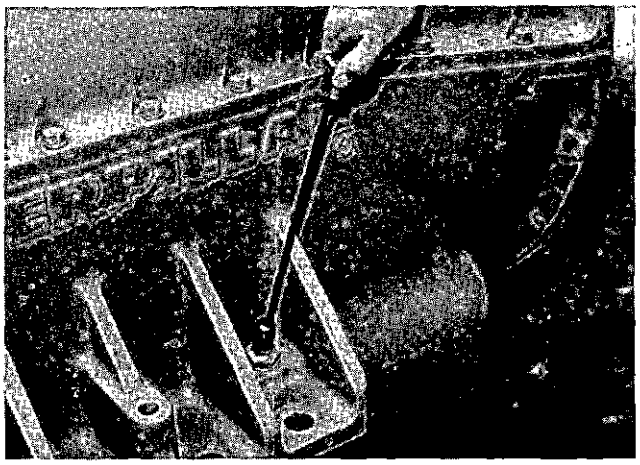
5. Wipe off the excess grease. Install the lower plug.
6. Remove the fitting from the upper threaded hole.
7. Start the engine and allow the grease to expand from the upper hole.
8. Stop the engine. Install the plug in the upper hole and wipe off excess grease.
9. Install the two panels.

MARINE GEAR

FOR OTHER THAN CATERPILLAR MARINE GEARS,
SEE THE MARINE GEAR
MANUFACTURER'S INSTRUCTIONS

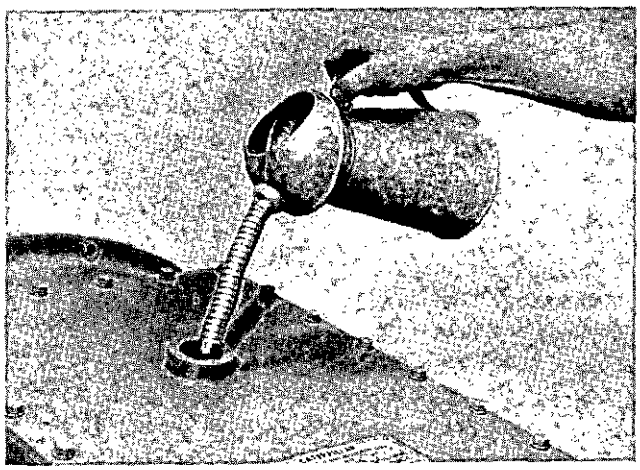
CHECKING OIL LEVEL

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



CHECKING OIL LEVEL

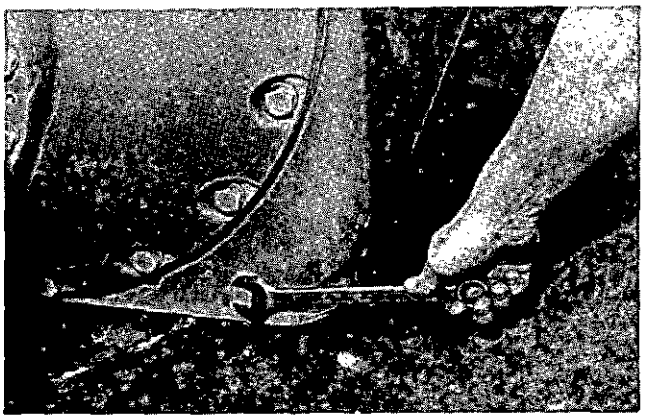
2. Maintain oil level at the FULL mark on the oil level gauge. Add oil through the breather tube on top of the marine gear housing. Refer to Lubrication and Maintenance Chart for proper oil to use.



ADDING OIL

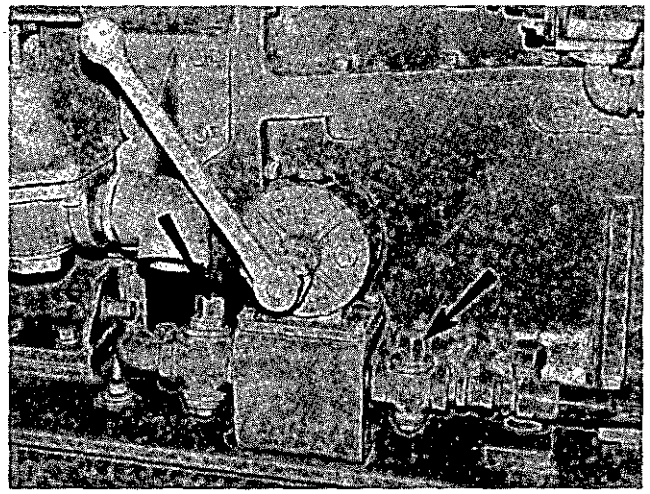
DRAINING LUBRICATING OIL

1. Remove the marine gear drain plug.



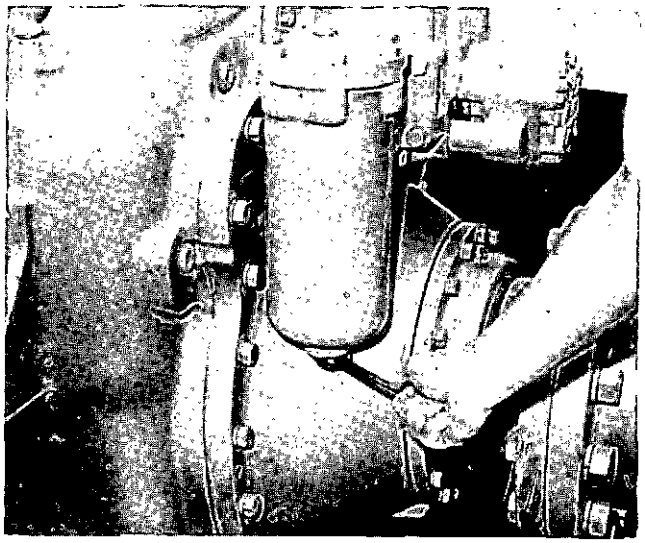
REMOVING DRAIN PLUG

If a sump pump is used:
   a. Connect a drain line to the top outlet of the sump pump.



SUMP PUMP VALVES

   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.
2. Remove the marine gear oil filter housing drain plug.

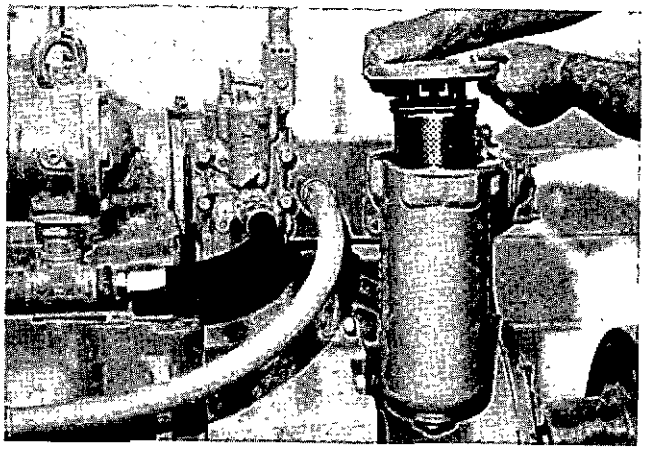


OIL DRAIN

7261 AND 7251 MARINE GEARS

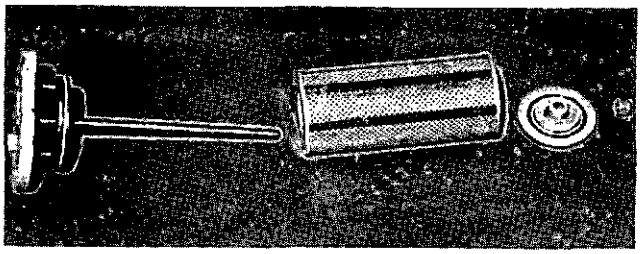
INSTALLING MARINE GEAR OIL FILTER ELEMENT

1. Drain the marine gear lubricating oil.
2. Remove the cover assembly – with filter attached.



REMOVING COVER AND FILTER ELEMENT

3. Remove the nut, retainer, and element from the cover.
4. Clean the filter housing and the cover assembly with clean diesel fuel or kerosene.
5. Inspect the retainer plate seal, and cover seals. Install new seals if necessary.
6. Install a new filter element, the retainer, and nut to the cover assembly. Tighten the nut to 10 ± 2 foot pounds (1,38 mkg).

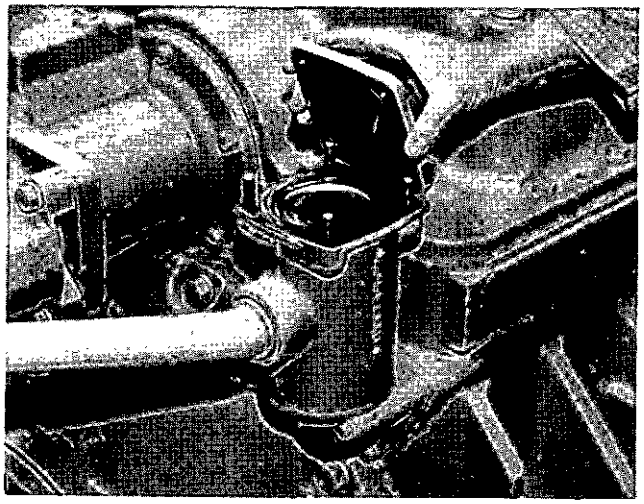


ELEMENT DISASSEMBLED FROM COVER

7. Install element and cover. Tighten all bolts.
8. Install the drain plug.

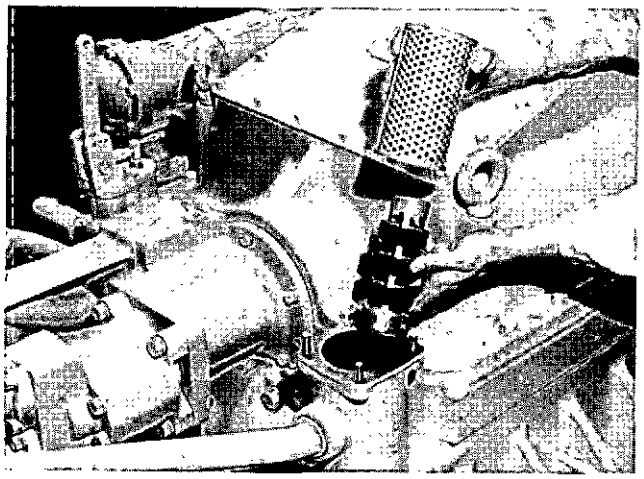
CLEAN MARINE GEAR OIL STRAINER

1. Remove the strainer cover.



REMOVING STRAINER COVER

2. Remove the spring washer, strainer and magnetic screen tube.



REMOVING STRAINER AND MAGNETIC SCREEN TUBE

3. Wash the strainer and magnetic screen tube in clean diesel fuel or kerosene.

If a magnet is broken, install the new magnet properly; the N poles and S poles of the magnets are adjacent to each other so that they repel instead of attract: S - N, N - S, S - N.

4. Inspect the strainer, and the seal in the cover for damage. Obtain new parts if necessary.
5. Install the magnetic core tube, strainer, spring washer, seal and cover.

FILLING THE MARINE GEAR LUBE SYSTEM

1. Install the marine gear drain plug, or close the sump pump valve on the oil line to the marine gear.

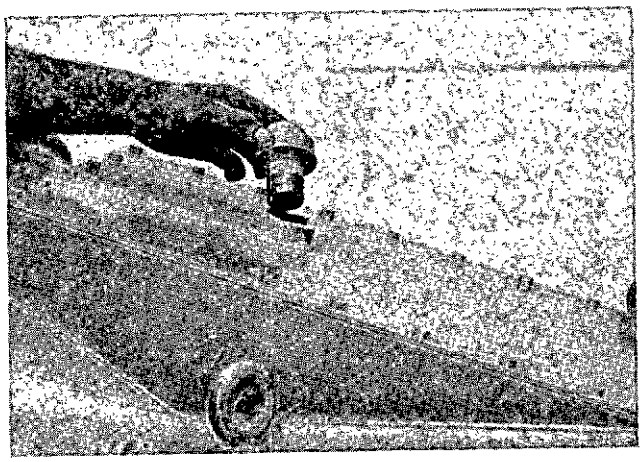
CAUTION

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

CLEANING THE BREATHER

1. Remove the breather.



REMOVING THE BREATHER

2. Wash it in clean diesel fuel or kerosene.
3. Install the breather.

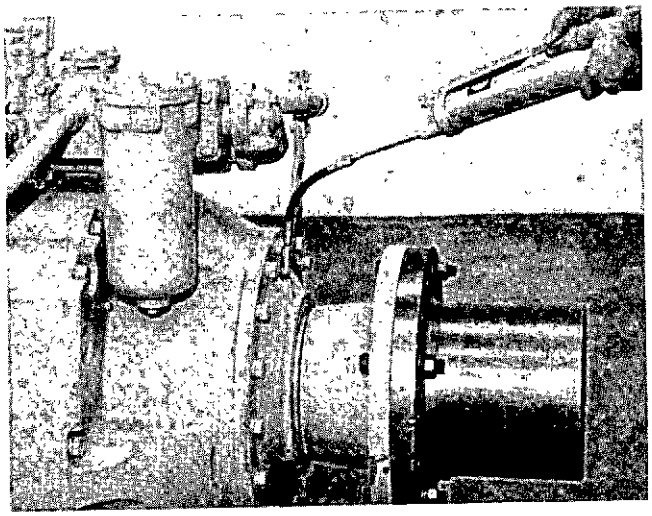
OUTPUT SHAFT SEAL

Lubricate the output shaft seal, 1 fitting at top rear of marine gear. Slowly rotate the output shaft while lubricating the seal.

7241 MARINE GEAR

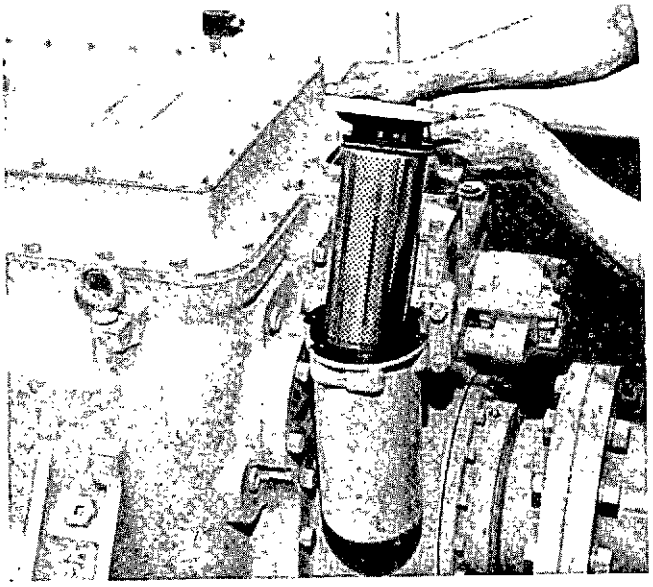
INSTALLING MARINE GEAR OIL FILTER

1. Drain the marine gear lubricating oil.



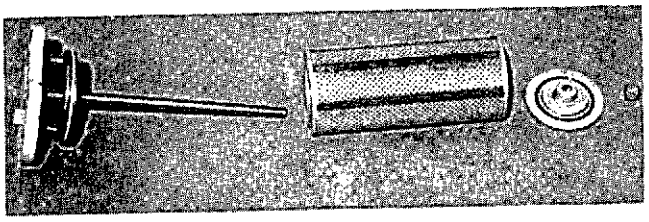
LUBRICATING OUTPUT SHAFT SEAL

2. Remove the cover assembly—with filter attached.



REMOVING COVER AND FILTER ELEMENT

3. Remove the nut, retainer, and element from the cover.



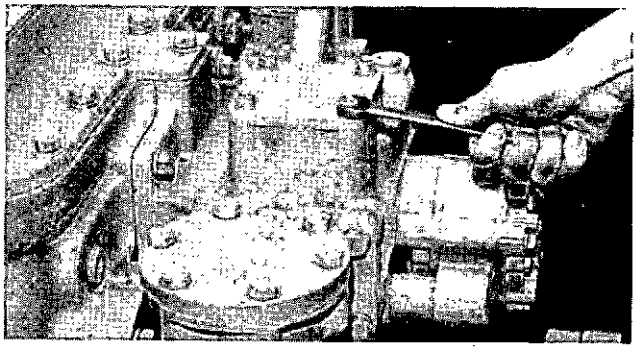
ELEMENT DISASSEMBLED FROM COVER

4. Clean the filter housing and the cover assembly with clean diesel fuel or kerosene.
5. Inspect the retainer plate seal, and cover seals. Install new seals if necessary.

6. Install a new filter element, the retainer, and nut to the cover assembly. Tighten the nut to 10 ± 2 foot pounds (1,38 mkg).
7. Install element and cover. Tighten all bolts.
8. Install the drain plug.

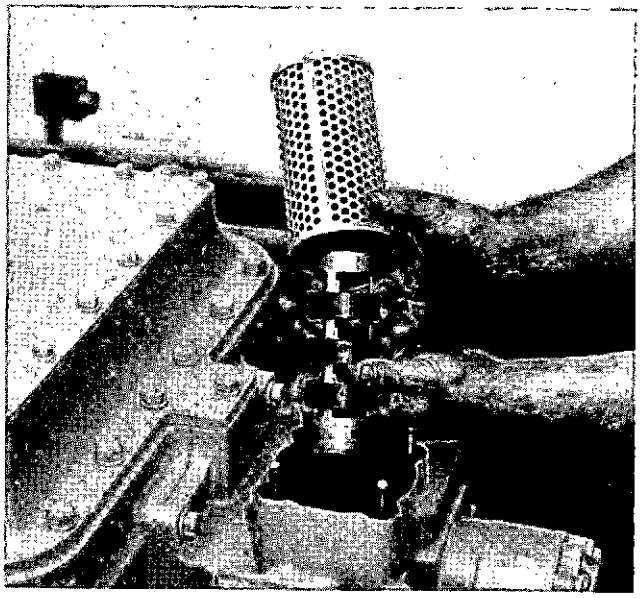
CLEANING MARINE GEAR OIL STRAINER

1. Remove the strainer cover.



REMOVING STRAINER COVER

2. Remove the spring washer, strainer and magnetic screen tube.



REMOVING STRAINER AND MAGNETIC SCREEN TUBE

3. Wash the strainer and magnetic screen tube in clean diesel fuel or kerosene.

   If a magnet is broken, install the new magnet properly; the N poles and S poles of the magnets are adjacent to each other so that they repel instead of attract: S - N, N - S, S - N.

4. Inspect the strainer, and the cover seal for damage. Install new parts if necessary.
5. Install the magnetic core tube, strainer, spring washer, seal and cover.

FILLING THE MARINE GEAR LUBE SYSTEM

1. Install the marine gear drain plug, or close the sump pump valve on the oil line to the marine gear.

CAUTION

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

CLEANING THE BREATHER

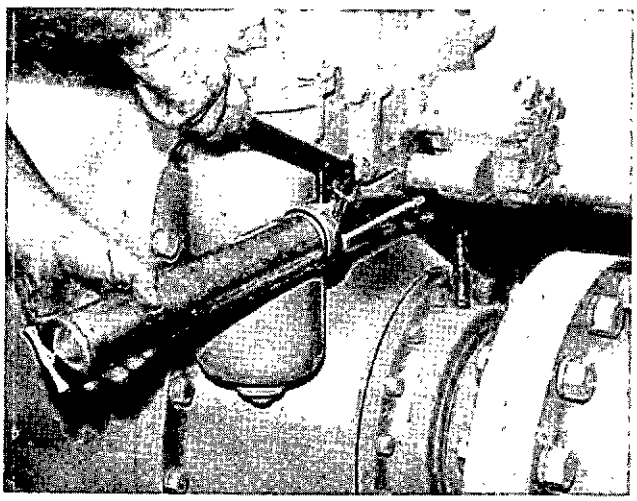
1. Remove the breather.

REMOVING THE BREATHER

2. Wash the breather in clean diesel fuel or kerosene.
3. Install the breather.

OUTPUT SHAFT SEAL

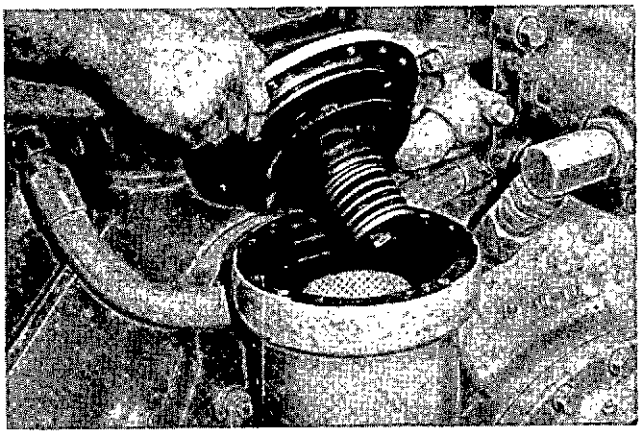
Lubricate the output shaft seal, 1 fitting at top rear of the marine gear. Slowly rotate the output shaft while lubricating the seal.



LUBRICATING OUTPUT SHAFT SEAL

INSTALLING MARINE GEAR OIL FILTER ELEMENT

1. Drain the lubricating oil.
2. Remove the cover, spring, bypass valve and filter element.

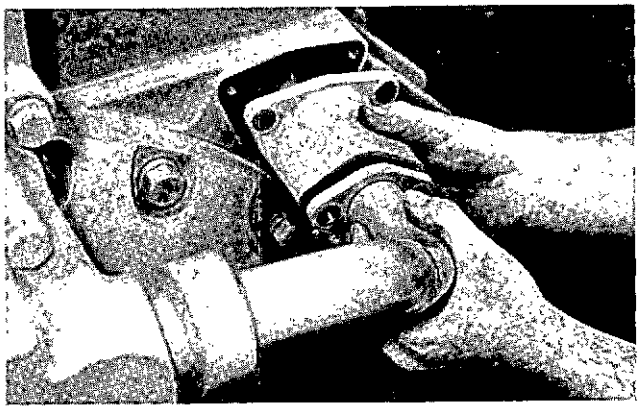


REMOVING COVER AND FILTER ELEMENT

3. Wash the inside of the housing and the cover.
4. Install the housing drain plug.
5. Inspect and install the cover gasket; install a new gasket if necessary.
6. Install a new filter element, the bypass valve, spring, gasket and cover. Tighten all bolts.

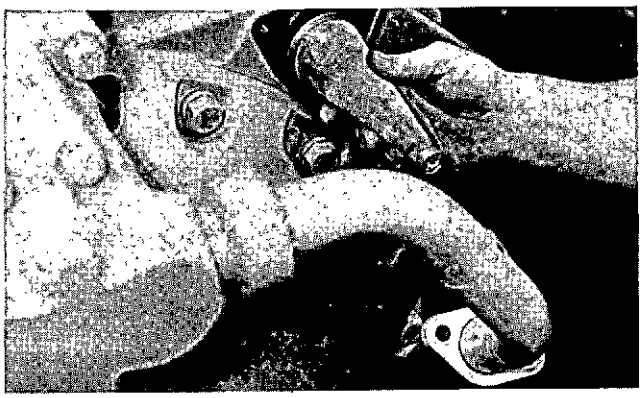
CLEANING MARINE GEAR OIL STRAINER

1. Remove the bolts holding the strainer retaining housing to the rear of the marine gear. (The oil line tube from the oil pump bolts to the retaining housing.)
2. Loosen the bolts holding the oil tube to the retainer. Pull the retainer away from the rear of the marine gear and rotate the tube downward to expose the strainer.



REMOVING STRAINER TUBING AND RETAINER

3. Remove the strainer from the marine gear housing.



REMOVING THE STRAINER

4. Wash the strainer in diesel fuel or kerosene. Inspect and install the strainer.
5. Inspect and install the retainer gasket. Use new gasket if necessary.
6. Rotate the oil tube and retainer into position. Tighten all bolts.

FILLING THE MARINE GEAR LUBE SYSTEM

1. Install the marine gear drain plug, or close the sump pump valve on the oil line to the marine gear.

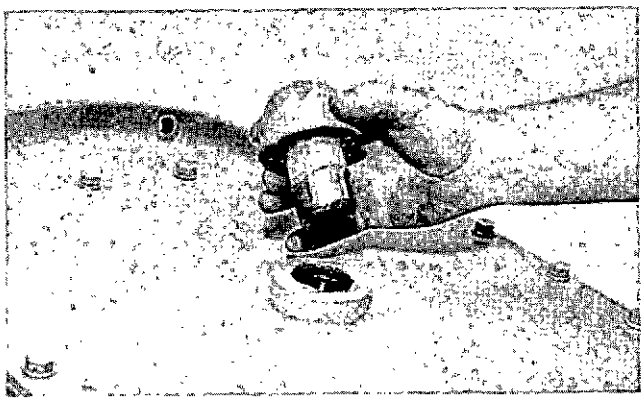
CAUTION

Be sure both 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 Lubrication and Maintenance Chart for proper oil.

CLEANING THE BREATHER

1. Remove the breather.
2. Wash it in clean diesel fuel or kerosene.
3. Install the breather.

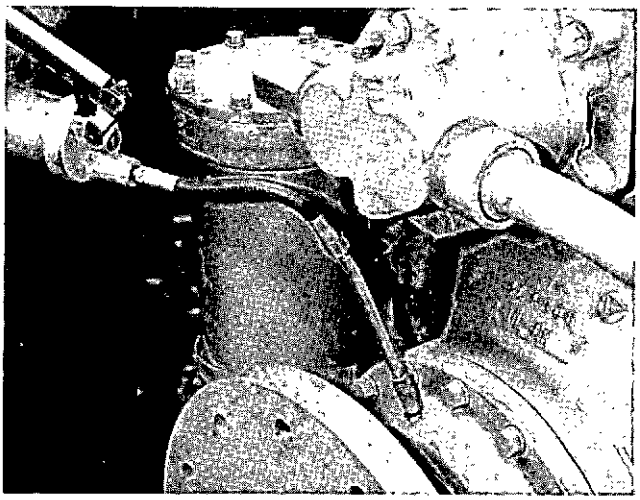


INSTALLING THE BREATHER

OUTPUT SHAFT SEAL

Lubricate the output shaft seal, 1 fitting at top rear of

marine gear. Slowly rotate the output shaft while lubricating the seal.

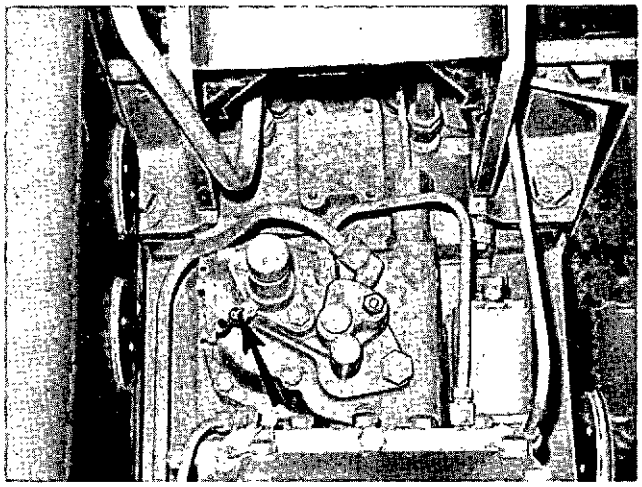


LUBRICATING OUTPUT SHAFT SEAL

MISCELLANEOUS MAINTENANCE

LUBRICATING TACHOMETER DRIVE

Lubricate the tachometer drive bearing with grease; 1 or 2 strokes, 1 fitting.



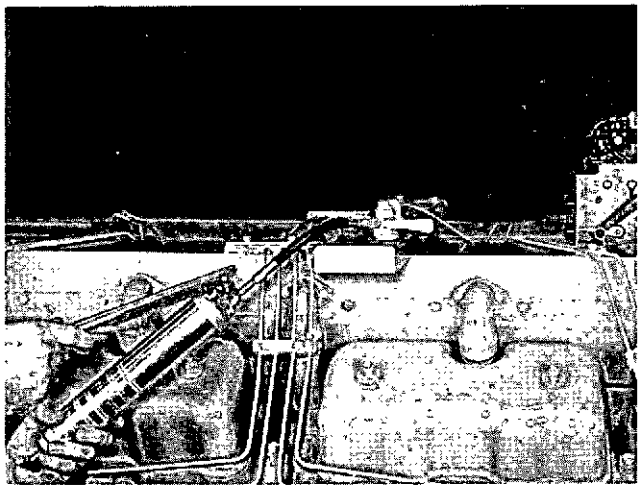
TACHOMETER LUBRICATION FITTING

SAFETY SHUT-OFF CONTROLS

The shut-off controls must be checked to insure proper functioning if and when needed. To prevent damage to your engine while making the required tests, only authorized personnel should perform the checks. Contact your Caterpillar dealer.

LUBRICATING SHUT-OFF CONTROL RESET LEVER

Lubricate the reset lever bearing with grease; 1 or 2 strokes, 1 fitting on lever hub.



LUBRICATING RESET LEVER

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Lubrication and Maintenance Procedures

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ENGINE OPERATION

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.

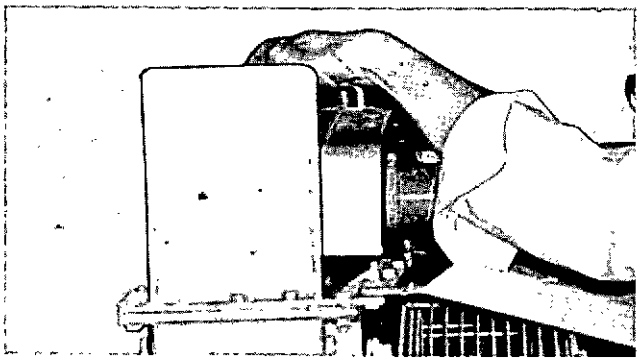
SAFETY PRECAUTIONS

Unlike the old saying "everyone says something about the weather but no one does anything about it," you are in a position to do something about safety. Lack of attention to safety can result in: accidents, personal injury, reduction in 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. Be ever watchful for safety hazards and correct deficiencies promptly.

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

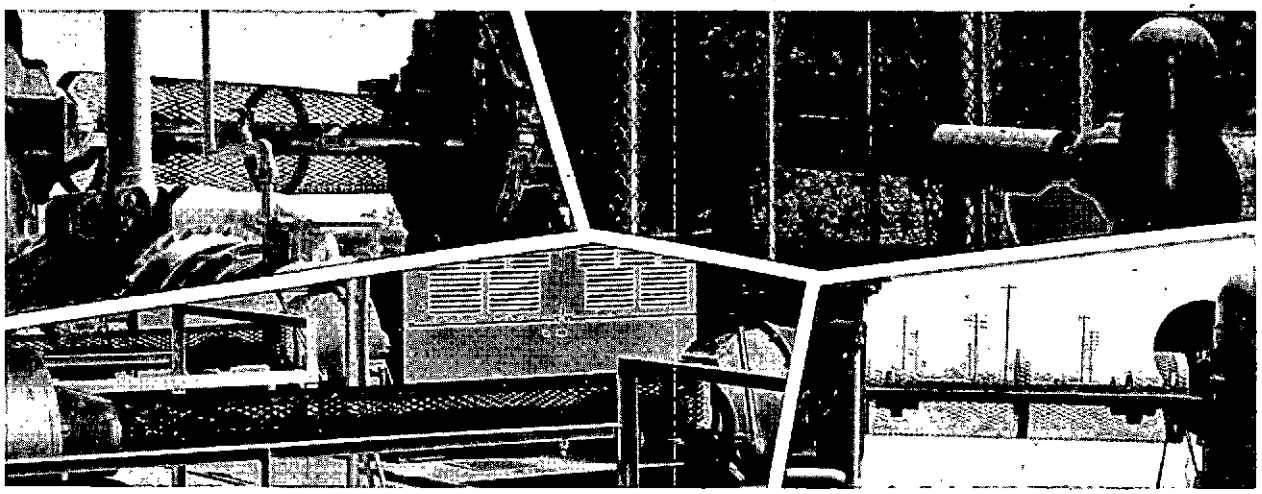
1. Never adjust or repair a machine while it is in operation.
2. Remove all tools and electrical cords before starting.
3. Keep the engine room and floor area clean.
4. Store oily rags in containers.
5. Never store flammable liquids near the engine.
6. Do not smoke around batteries. Hydrogen gas generated by charging is explosive. Keep batteries in a well ventilated area.
7. Observe NO SMOKING signs.



NO LOOSE CLOTHES AROUND MACHINERY

8. Be sure the engine room is properly ventilated.
9. Always disconnect and tape the ground battery lead before working on the electrical system.
10. All electrical equipment must be grounded according to local building ordinances.
11. Be sure an automatic start-stop system is inoperative when the engine or generator is being worked on. Disconnect and tape the ground battery lead.
12. Never operate a diesel engine with the governor linkage disconnected. Human reactions are not fast enough to control the fuel rack.

Remember, safety is everyone's business.



BE SURE GUARDS ARE IN PLACE

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Pg. 10

PERIODS OF LIMITED USE

A prolonged period without use is not good for any piece of machinery. Engines should be started and cycled every week. Load the engine every two weeks to the extent that it would be in normal operation. This is particularly important for standby power. Prolonged idling or running under a reduced load may cause oil consumption and carboning in the combustion chamber and result in poor performance and a loss of power.

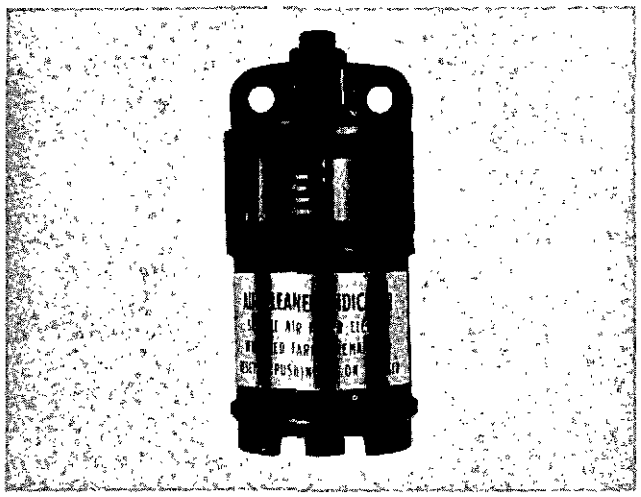
If an engine is going to be put in storage see your Caterpillar dealer for storage instructions.

STARTING

Perform required periodic maintenance before starting the engine. Make a "walk-around" check of the installation. It takes only a few minutes to correct minor discrepancies that can develop into major repair jobs.

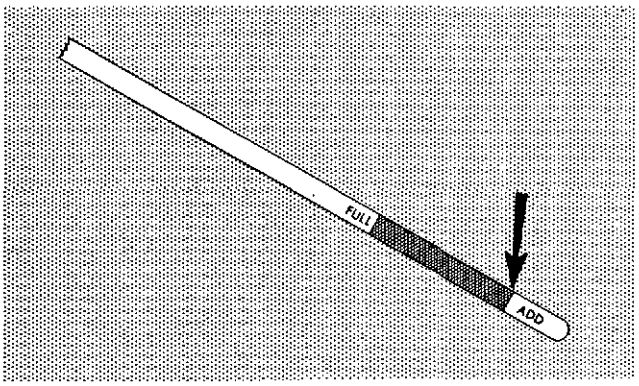
PRE-START CHECKS

1. Check the air cleaner service indicator. If the red piston is locked in the visible position, have the air cleaner serviced.



AIR CLEANER SERVICE INDICATOR

2. Correct any leaks, loose bolts or covers, and obstructions. The fan and radiator must be clear of restrictions.
3. Check the coolant level. The radiator must be full to the bottom of the filler neck.



OIL LEVEL

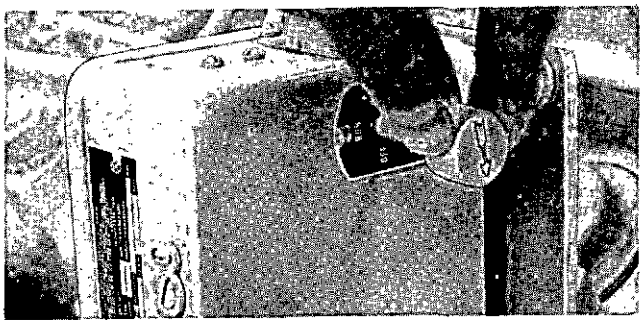
4. The crankcase oil level must be above the ADD mark on the dipstick.
5. Disconnect any battery chargers that are not protected against the starter current drain.
6. All guards must be in place. If guards are inadequate or in need of repair, notify your supervisor.

If an engine has not been run for several weeks, fuel may have drained from or air accumulated in the filter housing. When fuel filters have been changed, some air space will be left in the housing. In these instances, prime the fuel system until pressure registers on the gauge.

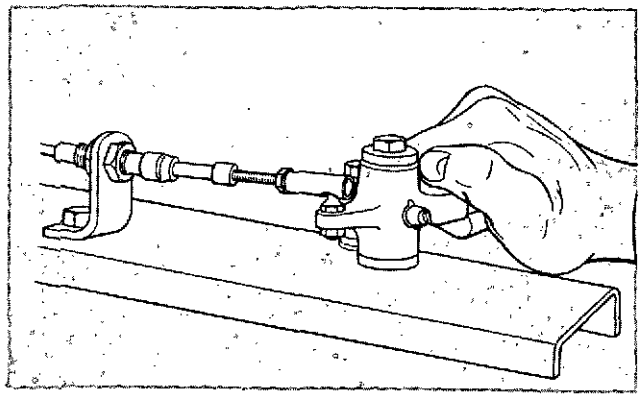
STARTING PROCEDURE

ELECTRIC START

1. Open the raw water valve — if so equipped.
2. *Open the fuel supply valve. The fuel return line must* be open to prevent engine damage.
3. Disengage the clutch or open the circuit breaker. Do not start an engine under load.
4. Move the controls to half engine speed position or to speed limiter stop.
5. Reset any safety devices.



TURN OIL PRESSURE SWITCH OFF



RESET LEVER

Prolonged cranking will energize the mechanical safety shut-off and prevent the engine from starting.

6. Start the engine using starting aids as necessary.
7. If the engine fails to start in a few seconds, move the governor control to the fuel off position and continue to crank for 10 seconds. This clears the engine of unburned fuel.
8. If the engine fails to start after 30 seconds of cranking, allow the starter to cool for two minutes before repeating the starting procedure.

CAUTION

Do not engage the starter when the flywheel is moving.

Clearances and tolerances are designed for operating conditions – including operating temperature. After the engine is started it takes several minutes to establish the lubricating oil film and allow the moving parts to heat up and expand. Loading a cold engine will cause shortened service life; i.e., broken rings, seized pistons, etc. This warm up period allows time for another "walk-around" check for leaks, etc.

WARNING

Do not attempt repairs or adjustments while the engine is running.

If oil pressure fails to register, stop the engine and determine the cause. On units with an oil pressure switch, the reset knob will move from OFF to RUN automatically when oil pressure builds up. If the knob fails to move, stop the engine and determine the cause.

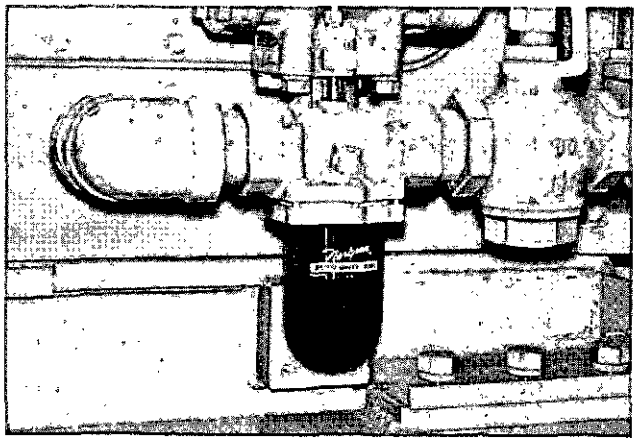
AIR START

Perform all electric starting preliminary checks.

Check the air supply. The air starter must have 100 PSI air pressure to operate properly. The standard air tank stores 10.5 cubic ft. of air at 250 PSI. Pressure is reduced at the air starter motor.

Open bleed valve (on the bottom of the air tank) before starting, to drain condensation and oil carryover.

Fill the oiler. See the Lubrication and Maintenance Chart for proper oil.



AIR STARTER MOTOR OILER

HYDRAULIC START

Perform all electric starting preliminary checks.

Check the hydraulic accumulator pressure – it must be 3000 PSI.

STARTING – D399 ONLY

A prelube system is used to ensure proper lubrication of all major moving parts prior to starting. When the starter switch is moved to the START position, it energizes an electric oil pump. This externally mounted pump takes oil from the crankcase and pumps it through the engine oil passages. A switch in the turbocharger supply line completes the starter circuit when oil pressure reaches 3 PSI. Prelube time will vary with oil temperature. It takes longer to prelube with hot oil. Once the engine starts, the engine driven oil pump provides all lubrication.

COLD WEATHER STARTING

STARTING TEMP.	STARTING AID	HEATING TIME
Above 60°F	None	None
32°F to 60°F	Glow Plugs	1 Minute
32°F to 0°F	Glow Plugs	2 Minutes
Below 0°F	Glow Plugs & Ether	3 Minutes

Starting aids are available for cold weather starting. Many variables effect starting conditions, so only experience can determine when aids are necessary. Use the above chart as a guide.

GLOW PLUGS – Glow plugs supply heat to promote initial combustion in a cold engine. When conditions dictate, use glow plugs before starting and continue to use until the engine runs smoothly.

CAUTION

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

ETHER – Ether is much more volatile than diesel fuel and is used to start combustion of the fuel-air mixture.

WARNING

Ether is volatile and must be stored away from heat and direct sunlight. See the instructions on the container.

Engine mounted either dispensers are available commercially. Aerosol cans can also be used. Point the can opening at the air inlet and give a quick spray while cranking the engine. Too much ether will cause excessively high pressure and detonation. Liquid ether can be used by pouring a small amount on a cloth and holding the cloth in front of the air cleaner while the engine is cranking. Be sure the cloth is outside the air cleaner and cannot be drawn into the engine.

WARNING

DO NOT use ether after the engine has started. DO NOT inhale ether fumes.

In extremely cold climates, additional aids such as water heaters and battery heaters may be used. Contact your Caterpillar dealer before installing submersible crankcase oil heaters.

STOPPING

1. Remove the load from the engine.
2. Allow the engine to run at about half speed for five minutes. This allows internal temperatures to reduce gradually and prevents the loss of coolant by "afterboil".
3. Reduce speed to low idle for about 30 seconds.
4. DO NOT race the engine before shut off. This causes the turbocharger to "coast" without lubrication.
5. Stop the engine.

ATTACHMENTS

GOVERNOR CONTROLS

Various types of governor controls can be installed on engines according to the application. The most common control is direct mechanical. The control may be mounted either on the engine or on a remote control panel. Engine mounted controls normally consist of a positive locking handle connected directly to the governor shaft. Cables and vernier controls mount on the engine or on a control panel.

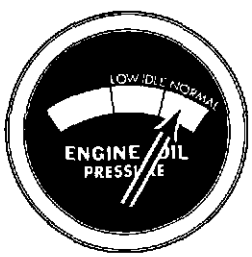
An engine mounted pneumatic cylinder may be used to regulate the speed of one or more units. Synchronous operating speed of parallel or compound units can be regulated with a single pneumatic control lever.

Shutdown controls are used only to stop the engine. Air, oil, cables and/or mechanical shutdowns are commonly used. These devices are connected to a shutdown lever. Shutdown controls allow an engine to be restarted after shutdown without readjusting the speed controls.

On smaller bore engines a solenoid acts directly on the rack.

GAUGES

Gauges provide a "look" inside the engine. Be sure they are in good working order. You can determine what is "normal" operating range by observing the gauges over a period of time. The cause of any sudden or significant change in the readings should be determined and corrected.



OIL PRESSURE

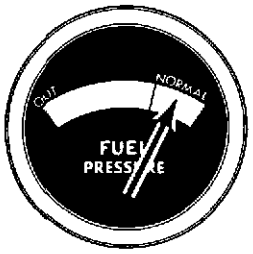
WATER TEMPERATURE

OIL PRESSURE – Oil pressure is normally greatest after starting a cold engine. As the oil warms up the pressure drops. Oil pressure is greater at operating speeds than at low idle. Fluctuating readings can mean air in the oil or a sticking pressure relief valve. Stop the engine immediately if a sudden loss of oil pressure occurs.

WATER TEMPERATURE – The operating temperature is maintained by the water temperature regulator. High coolant temperatures mean the cooling system is not dissipating enough engine heat. Pressurized cooling system gauges are marked with ranges rather than temperatures. If the gauge indicates in the red range, inspect the cooling system.

The minimum operating temperature should not be below the opening temperature of the water temperature regulator.

In cold weather the temperature gauge may fluctuate in or near the cold range. This indicates the engine is being overcooled. In these instances the use of radiator louvers is suggested.



FUEL PRESSURE

AMMETER

FUEL PRESSURE – The fuel pressure gauge indicates the pressure of filtered fuel. As the fuel filters collect dirt, the pressure drops until the gauge registers in the OUT range.

When the temperature is below the cloud point of the fuel, paraffin crystals form. These crystals will plug a fuel filter element. In these cases use a fuel with a cloud point at least 10F° below ambient temperature.

AMMETER – The ammeter should register in the charging range when the engine is running above low idle. If the gauge registers a discharge the engine speed is increased, determine the cause.

AUTOMATIC START-STOP

An automatic start-stop system ensures that power is supplied to a load when the normal power source is interrupted. The cranking panel is the heart of the system and consists of the failure warning system and relays to start and stop the engine. When a power failure occurs the system senses the failure and starts the engine to transfer the load to standby. When power is restored, it senses power restoration and transfers the load from standby and stops the engine. The major use of automatic start-stop systems is standby electric sets and this discussion is limited to that application.

If a power failure occurs, a circuit breaker opens and a set of contacts in the transfer switch closes, completing the circuit to the starter motor. When the engine starts, the starter circuit opens, protecting the starter from overspeed damage.

Since a standby engine is usually unmanned, it is usually protected from mechanical malfunction by a series of electrical safety devices; high water temperature, low oil pressure and engine overspeed. If a fault occurs it energizes one of the shut-off controls and causes the fuel rack to move to the fuel-off position, stopping the engine.

CAUTION

DO NOT use any emergency shut-off control for normal shut down. The emergency shut-off controls are for emergencies only.

An automatic start-stop installation is usually unmanned so starting aids cannot be used. For prompt starting, the jacket water must be 90°F (32°C) or the ambient temperature 70°F (21°C). A jacket water heater is recommended when lower ambient temperatures are encountered.

If the unit has a standard cranking panel the battery and starter are protected from prolonged cranking by a cranking cycle timer. A timer providing five ten-second cranking cycles can be used. Both units have fault indicators which light if the cranking cycle is completed and the engine does not start.

Automatic start-stop units may have a time delay to prevent the standby circuit breaker from closing until the engine has had a few seconds warm up time. A shutdown time delay provides for up to two minutes cool off after the load has been transferred back to normal power source.

A time delay relay in the transfer circuit can be adjusted from 0 to 30 minutes. This delays the transfer from standby back to normal power until the normal power has remained stable for the preset period.

Unattended units may have an exerciser. At a preset time the engine automatically starts and runs, under load if possible, and shuts itself off. This helps to ensure the unit will start and perform as required when necessary.

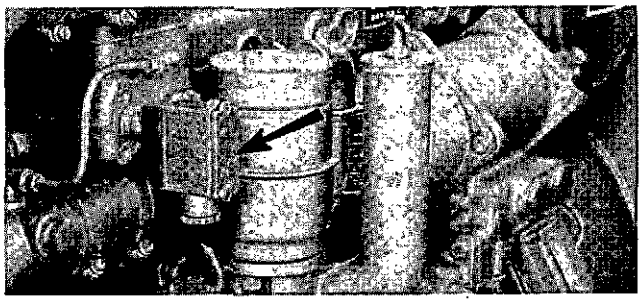
A shutdown timer may also be used with an automatic start-stop system. This provides a two minute cool off period after the load has been removed from the engine. This allows the heat of full load operation to be dissipated gradually.

Many safety circuits have fault lights to aid the operator in locating the cause of the malfunction. These lights are lighted by the safety circuit that is energized by a mechanical fault i.e., high water temperature, low oil pressure, etc.

ELECTRIC SAFETY SHUT-OFF OPERATION

All electric safety shut-offs stop the engine by energizing a solenoid. A microswitch in the sensing unit is actuated by the fault condition and completes the circuit to the solenoid. The solenoid moves the rack to the fuel off position and the engine stops.

A high water temperature shut-off switch is located in the water temperature regulator housing. This unit senses water temperature and protects the engine from damage caused by overheating. As the temperature increases an



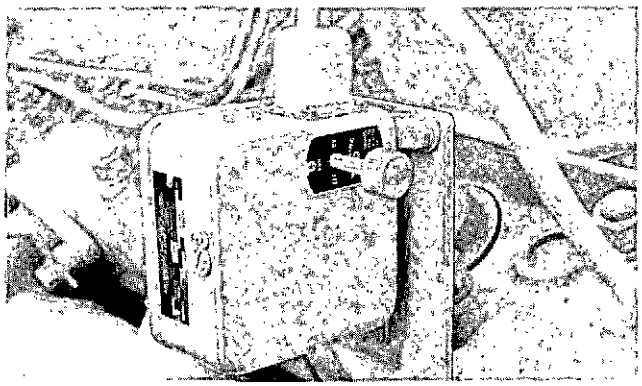
HIGH WATER TEMPERATURE SENDING UNIT

internal element expands to operate a microswitch. The switch energizes a rack solenoid that stops the engine. This unit is not adjustable.

CAUTION

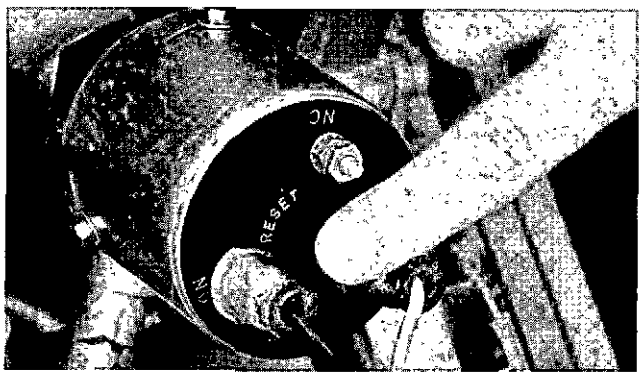
The element must be in contact with the coolant to operate. A low coolant level will not actuate the switch.

An oil pressure switch protects the engine from damage caused by low oil pressure. If oil pressure falls below the safe operating limits, the contacts close and energize the rack solenoid.



OIL PRESSURE SWITCH

The oil pressure switch must be reset before starting the engine. To reset the switch turn the knob counterclockwise to the OFF position. The knob will move to the RUN position when normal oil pressure is reached. The engine can be stopped by turning the knob to the ON position.



PUSH RESET BUTTON

A contactor actuated by a flyweight governor provides overspeed protection for the engine. The governor is mounted on the tachometer drive. If the engine overspeeds, the governor closes the contacts and energizes the rack solenoid. If an overspeed shutdown occurs the overspeed switch must be reset by pushing a button on the microswitch.

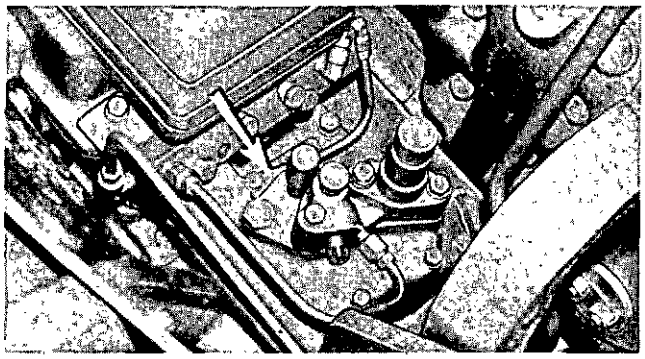
A fuel pressure switch keeps the rack solenoid from staying energized after shutdown. The switch opens the circuit if fuel pressure drops below 3 PSI.

ALARM SWITCH

Alarm switches are available to notify the operator that a fault condition exists. If the oil pressure drops to a dangerous level or the water temperature reaches a high level an alarm is activated. Depending on the system, a light is turned on, or a bell or horn is sounded calling the operator's attention to the problem.

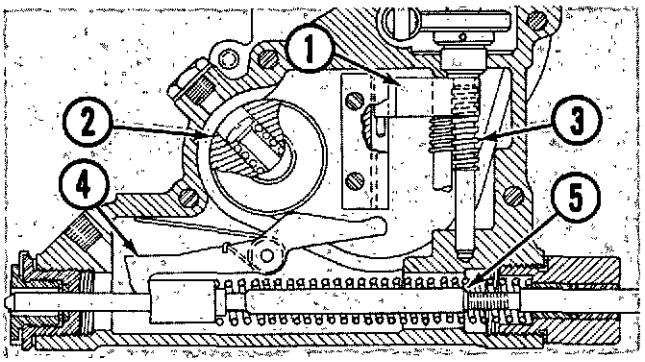
Check these sending units in a manner similar to the safety shut-off components and at the same intervals.

MECHANICAL SAFETY SHUT-OFF



MECHANICAL SHUT OFF

The safety shut-off is a mechanically driven device which protects the engine from overspeed and low oil pressure damage. The shut-off mounts on the governor.

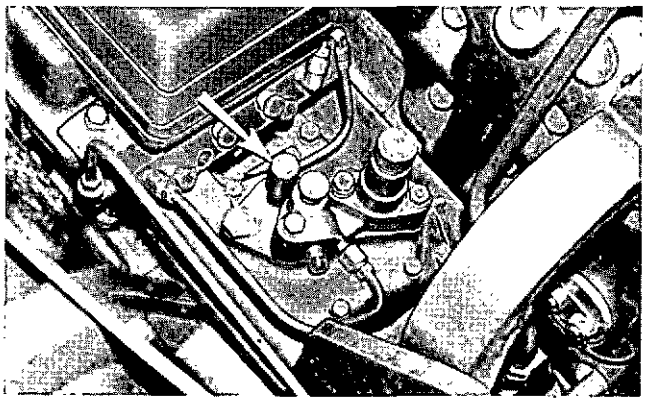


MECHANICAL SHUT OFF CROSS SECTION

1. Worm Shaft
2. Slide
3. Overspeed Carrier
4. Latch
5. Spring-loaded Rod

The slide (2) is held away from the engine driven worm shaft (1) by normal oil pressure. If oil pressure drops below safe operating limits and slide is released and engages with the worm shaft. The slide moves along the shaft to the right until it contacts latch (4) and releases the spring-loaded rod (5). The rod moves the rack to the fuel off position and the engine stops. The oil pressure shut-off is not adjustable.

The overspeed carrier (3) is also engine driven. If the engine overspeeds, centrifugal force moves the spring-loaded weight outward. The weight strikes latch (4) and releases the spring-loaded rod. The rod moves the rack to the fuel off position, and stops the engine.

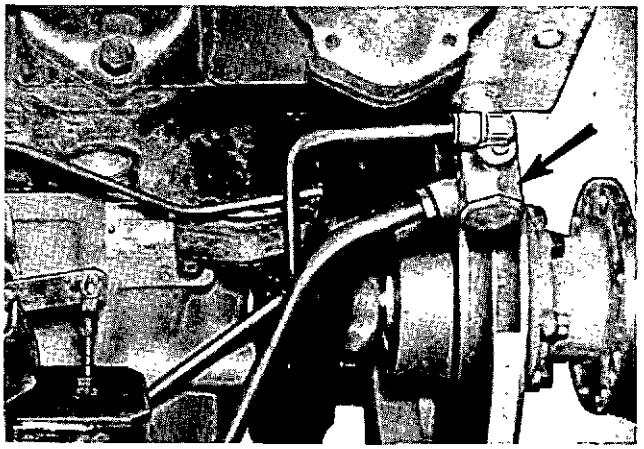


EMERGENCY STOP BUTTON

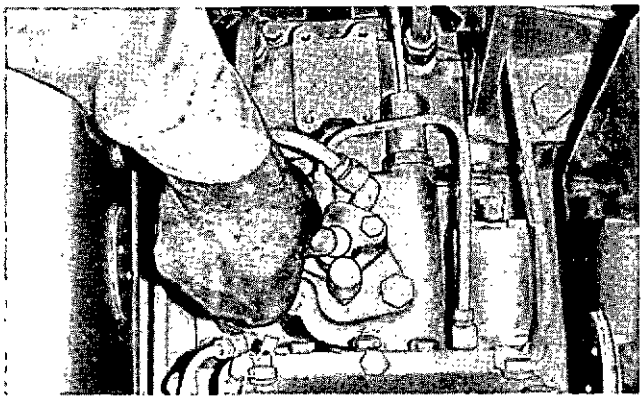
An emergency stop button is provided. Pressing the button causes the overspeed weight to strike the latch and releases the spring-loaded rod. The rod moves the rack to the fuel off position, which stops the engine.

A high water temperature shut-off is available. It is a heat operated dump valve in the water temperature regulator housing. High water temperature opens the valve and dumps pressure oil to the oil pressure shut-off system. The engine stops as if an oil pressure failure had occurred. The high water temperature shut-off is not adjustable.

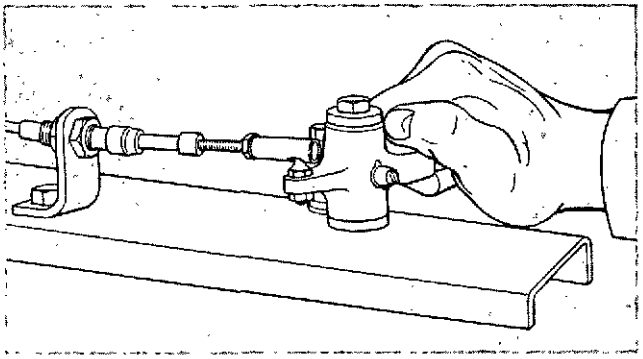
The cause of shut down must be determined before the engine is restarted. See page 8.



HIGH WATER TEMPERATURE SENDING UNIT



PUSH RESET BUTTON

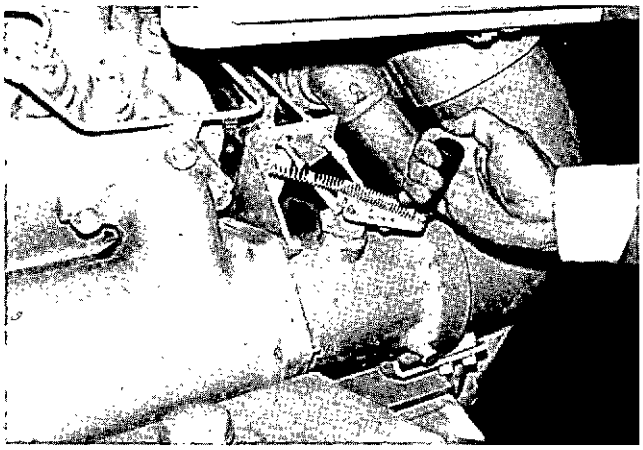


RESET LEVER

After a shut down, the reset button must be pushed before the safety lever is reset. Push the spring-loaded safety lever to reset. The lever will return to its original position. If the lever does not return, check the cable for kinks or internal drag.

AIR SAFETY SHUT-OFF

The air shut-off mechanism functions the same as the mechanical safety shut-off, only the method of stopping the engine differs. Instead of moving the rack to the fuel off position it closes a butterfly valve in the intake manifold. The butterfly stops the air flow to the engine.



RESET AIR SHUT OFF

SAFETY SHUT-OFF TESTING

Safety shut-offs function only when an abnormal condition exists. Because the shut-offs operate only in time of a mechanical emergency, it is impossible to tell if they are in good working order through normal operation. Since it is important they are in working order, have the shut-offs checked periodically by your Caterpillar dealer. See the Lubrication and Maintenance Chart for service intervals.

DETERMINING THE CAUSE OF SHUTDOWN

Anytime an engine is shut down by its safety circuit, the cause must be determined. In some cases the cause will be obvious but often an investigation will have to be made. Do not put the engine back into service without determining and correcting the cause of the shutdown.

HIGH WATER TEMPERATURE

1. Check for water on the floor from spilled or leaking coolant.
2. Check the water temperature gauge for accuracy.

WARNING

DO NOT remove the pressure cap of an overheated unit. The coolant is under pressure and relieving this pressure will cause the coolant to flash into steam. Serious burns and engine damage can result from the escaping coolant. Pressure in a radiator or surge tank may be reduced by pouring warm water on the top tank to condense the steam.

NOTE

If the engine has overheated and is still hot, gradual cooling is best. If there is still adequate coolant in the radiator and circulation can be maintained, start the engine and run it at half speed. This helps eliminate hot spots.

CAUTION

NEVER add cold water to an overheated engine.

3. Check air flow through the radiator and water flow through the heat exchanger.
4. Check air temperature to radiator. Few radiators can adequately cool a fully loaded engine with 125°F (52°C) ambient air.
5. Check for recirculating air currents.
6. Check fan belts for proper tension.
7. See that engine room vents and louvers are open.
8. Check water flow.
9. Check water hoses for leaks. Is the water pump inlet hose collapsed. Hoses have been known to peel off internally and restrict water flow.
10. Determine if flow valves are open.
11. Check water pump drive belts.
12. Check raw water flow to heat exchanger.
13. If the engine is overloaded, overheating can result.

Overheating can cause seals and gaskets to relax and fuel nozzles to change their operating characteristics. If severe or prolonged overheating has occurred, have the engine checked.

LOW OIL PRESSURE

Look for the obvious first.

1. Check the oil level.
2. Check floor for oil from leaks.
3. To determine if low oil pressure was the cause of the shut down, crank the engine with the fuel off. If unusual noises come from the engine, discontinue cranking. If oil pressure fails to build up, and no external leaks are found, the problem is probably internal.

OUTPUT SHAFT GOVERNOR

An Output Shaft Governor governs the speed of a torque converter output shaft. The OPS governor prevents overspeeding driven equipment when the load on the torque converter is reduced. For example; dragline operation, when the bucket breaks out of the bank. As the output shaft speed increases, the flyweights in the governor move outward and cause the fuel rack to be moved in the fuel off direction. The engine speed is automatically reduced and the operator is free to concentrate on maneuvering. When a load is applied to the torque converter, the shaft speed decreases. The flyweights then move inward allowing the rack to move in the fuel on direction and increase the speed.

WOODWARD UG8 GOVERNOR

CONTROLS

SPEED DROOP KNOB – Controls the speed change from no load to full load.

SYNCHRONIZER KNOB – Throttle. Controls engine speed.

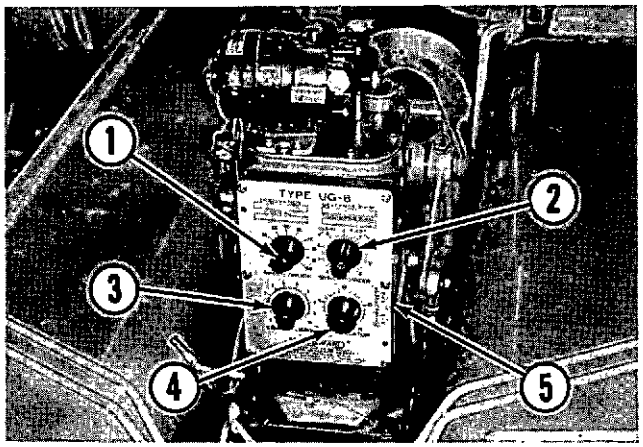
LOAD LIMIT KNOB – Controls the horsepower output of the engine to the nameplate rating. All Caterpillar engines have a separate rack stop to limit maximum output.

SYNCHRONIZER INDICATOR – Indicates how many turns of the synchronizer knob have been made.

LOAD INDICATOR POINTER – Indicates relative load.

STARTING

Make all preliminary starting checks. See page 2.



UG8 GOVERNOR

1. **Speed Droop Knob**
2. **Synchronizer Knob**
3. **Load Limit Knob**
4. **Synchronizer Indicator**
5. **Load Indicator Pointer**

1. Turn the load limit knob until the indicator is between 5 and 7.
2. Turn the synchronizer knob clockwise until the indicator is at 8.
3. Start the engine and run it at 900 RPM for 5 minutes. To adjust speed turn the synchronizer knob.
4. Turn the load limit knob to "10" to carry the load.
5. Turn the synchronizer knob clockwise until the engine runs at full governed speed.
6. Speed droop is dictated by the application.
   A. Single unit application when constant speed or frequency is required, set the speed droop knob to "0".
   B. Parallel operation. When several units are operated in parallel and constant speed or frequency is required, the first unit on the line may be set at "0" droop and additional units set from "30" to "70". If constant speed is not required, set the speed droop from "30" to "70" on all units.
7. Apply the load and readjust the synchronizer knob to obtain the desired division. The load indicator pointer behind the load limit knob indicates the relative load.

When engines are paralleled, individual engine output is controlled by the synchronizer knob. Turn the knob clockwise to assume more of the load.

A synchronizer motor is available for remote speed control. The motor is a split field, series wound reversible type.

STOPPING THE ENGINE

1. Remove the load and move the synchronizer knob counterclockwise to reduce the speed to 900 RPM. Allow the engine to cool for 5 minutes.
2. Stop the engine by turning the load limit knob to "0".

ALTITUDE OPERATION

Turbocharger speed is determined by rack setting, engine high idle speed, turbocharger nozzle, and the altitude at which the engine is operating. The rack setting and altitude limits are stamped on the engine information plate. When an engine is moved to a higher altitude the rack must be reset by your Caterpillar dealer to prevent damage to the turbocharger and provide maximum engine efficiency.

The engine can be operated safely at lower altitudes than specified on the engine information plate, but it will not deliver rated horsepower.

MODEL	NO. OF CYL.	BORE	STROKE
ENGINE SERIAL NO.			
NO LOAD ENGINE R.P.M			
FULL LOAD ENGINE R.P.M.			
RACK SETTING			
H.P. SETTING AT SEA LEVEL			
INJECTION TIMING			
LIFTER SETTING AT T.C.			
BILL OF MATL OR ESO NO.			

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

FT. OR BELOW

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

REFER TO OPERATION AND MAINTENANCE INSTRUCTIONS FOR HIGH ALTITUDE OPERATION.

ENGINE INFORMATION PLATE

INDEX

Engine Operation

CATERPILLAR

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