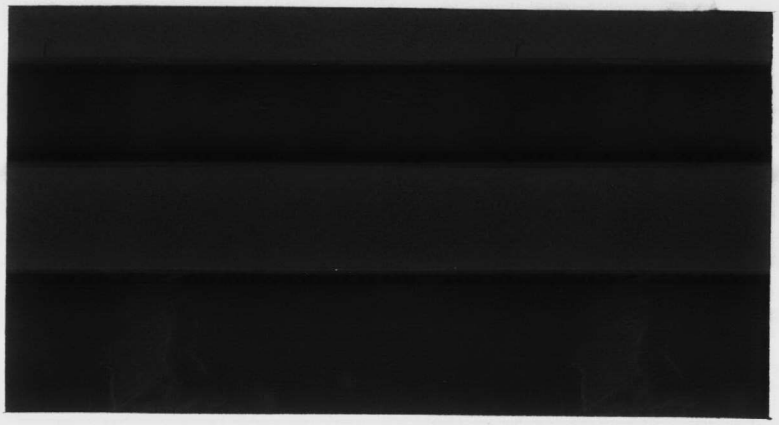
GREGORY POOLE
EQUIPMENT COMPANY

ENGINE DIVISION

Post Office Box 469 • Raleigh, North Carolina 27602 • Telephone (919) 828-0641

CATERPILLAR®



N62470-85-C-6304
REPLACE AUXILIARY ENGINE, TT-38

MCB, CAMP LEJEUNE, NC 28542

Operation & Maintenance

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DESCRIPTION:

Engine

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Confidential Records Management, Inc.
New Bern, NC
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CATERPILLAR

operation

3408/3412
Industrial Engines

3408 - 67U1-UP 3412 - 38S1-UP

01-735-83995-2

NOTICE!

TO THE DELIVERING DEALER —

THE WARRANTY COVERAGE ON CATERPILLAR ENGINES VARIES BY APPLICATION

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

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

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

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

USER'S REFERENCE INFORMATION

DELIVERY DATE _____

DELIVERING DEALER'S NAME AND ADDRESS:

_____

_____

_____

_____

_____

SIGNATURE OF DELIVERING DEALER'S REPRESENTATIVE

ENGINE SERIAL NO. _____

ARRANGEMENT NO. _____

MODIFICATION NO. _____

REMANUFACTURED ENGINE
REFERENCE SERIAL NO. _____

VEHICLE MILES _____
OR
HOURS _____

FOLD AND DETACH HERE.

(PLEASE TYPE OR PRINT)

CATERPILLAR

ENGINE WARRANTY INFORMATION CARD

ENGINE MODEL	ENGINE SERIAL NUMBER	DELIVERY DATE

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

DID THIS ENGINE REPLACE ANOTHER ENGINE?
YES ☐ NO ☐

CURRENT VEHICLE
MILES _____
OR
HOURS _____

SOLD TO: _____
NAME

_____
ADDRESS

_____
CITY STATE ZIP

SOLD BY: ☐ 1. CATERPILLAR DEALER
☐ 2. OEM DEALER

_____
DEALER'S NAME

MANUFACTURER'S EQUIPMENT IDENTIFICATION

_____
TYPE MACHINE

_____
MODEL SERIAL NUMBER

_____
SIGNATURE OF DELIVERING DEALER'S REPRESENTATIVE

APPLICATION (check PRIMARY application only)

- ☐ A MARINE AND SELF PROPELLED DREDGE
- ☐ B DREDGE
- ☐ C POWERING AGRICULTURAL VEHICLE
- ☐ D AGRICULTURAL — OTHER
- ☐ E POWERING ON-HIGHWAY VEHICLE
- ☐ F PETROLEUM — DRILL RIG
- ☐ G PETROLEUM — OTHER
- ☐ H LOCOMOTIVE
- ☐ J POWERING OFF-HIGHWAY TRUCK
- ☐ K OTHER: _____
  PLEASE SPECIFY

NOTE

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

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

In the United States –

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

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

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

Please be sure to reference the appropriate form number.

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IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 385 PEORIA, ILLINOIS

POSTAGE WILL BE PAID BY ADDRESSEE

ATTN: Warranty & Data Div. AB5A

CATERPILLAR TRACTOR CO.

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

01-735-83996-2

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USER'S REFERENCE INFORMATION

DELIVERY DATE _____

DELIVERING DEALER'S NAME AND ADDRESS:

_____

_____

_____

_____

_____

SIGNATURE OF DELIVERING DEALER'S REPRESENTATIVE

ENGINE SERIAL NO. _____

ARRANGEMENT NO. _____

MODIFICATION NO. _____

REMANUFACTURED ENGINE REFERENCE SERIAL NO. _____

VEHICLE MILES _____

OR

HOURS _____

FOLD AND DETACH HERE.

(PLEASE TYPE OR PRINT)

CATERPILLAR

ENGINE WARRANTY INFORMATION CARD

ENGINE MODEL	ENGINE SERIAL NUMBER	DELIVERY DATE

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

DID THIS ENGINE REPLACE ANOTHER ENGINE?

YES ☐ NO ☐

CURRENT VEHICLE MILES _____

OR

HOURS _____

SOLD TO: _____

NAME

_____

ADDRESS

_____

CITY STATE ZIP

SOLD BY: ☐ 1. CATERPILLAR DEALER

☐ 2. OEM DEALER

_____

DEALER'S NAME

MANUFACTURER'S EQUIPMENT IDENTIFICATION

_____

TYPE MACHINE

_____

MODEL SERIAL NUMBER

_____

SIGNATURE OF DELIVERING DEALER'S REPRESENTATIVE

APPLICATION (check PRIMARY application only)

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

PLEASE SPECIFY

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

_____

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ATTN: Service Dept.

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_____

FOREWORD

This Operation Guide contains operation instructions, lubrication and maintenance information and the basic systems operations. Application of this information should help obtain maximum performance and life of the engine; and keep the costs of engine operation to a minimum.

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

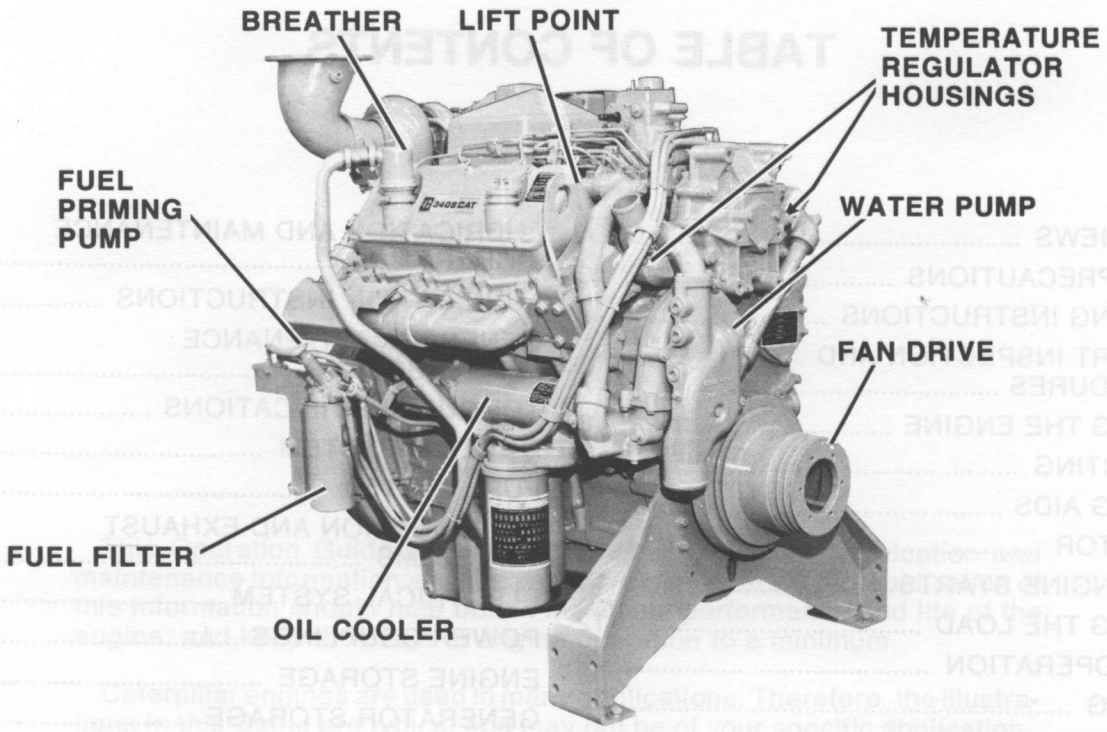
Become familiar with the components installed on your engine as described in the instructions. (Some components described in the instructions may not be on your engine or installation.)

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

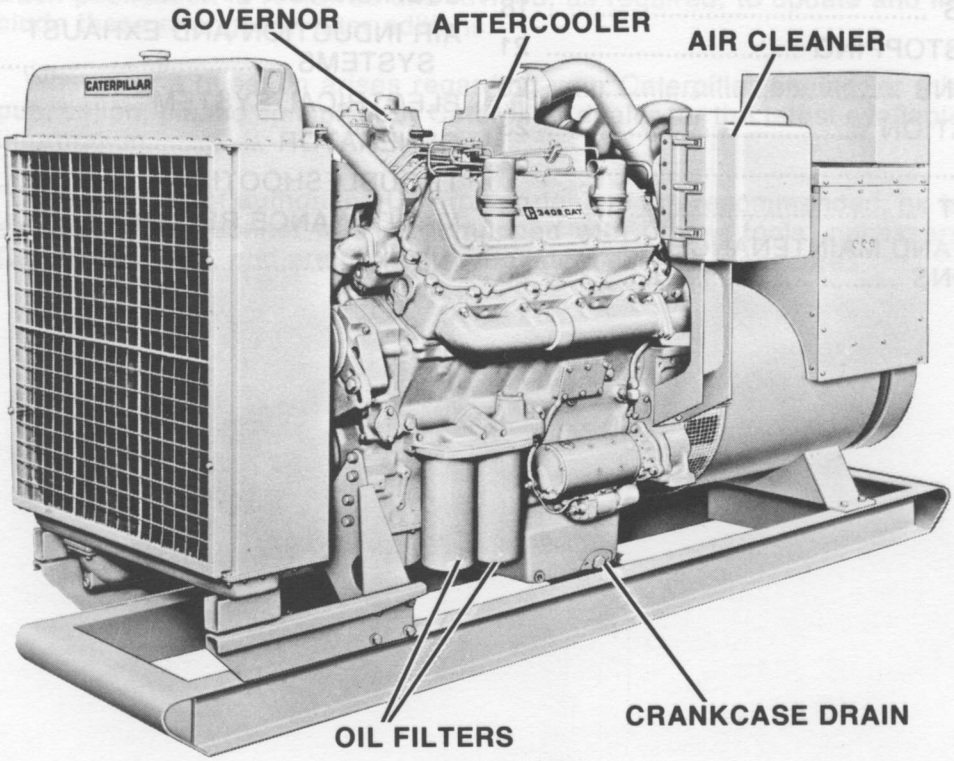
Whenever a question arises regarding your Caterpillar engine, or this publication, please consult your Caterpillar dealer for the latest available information.

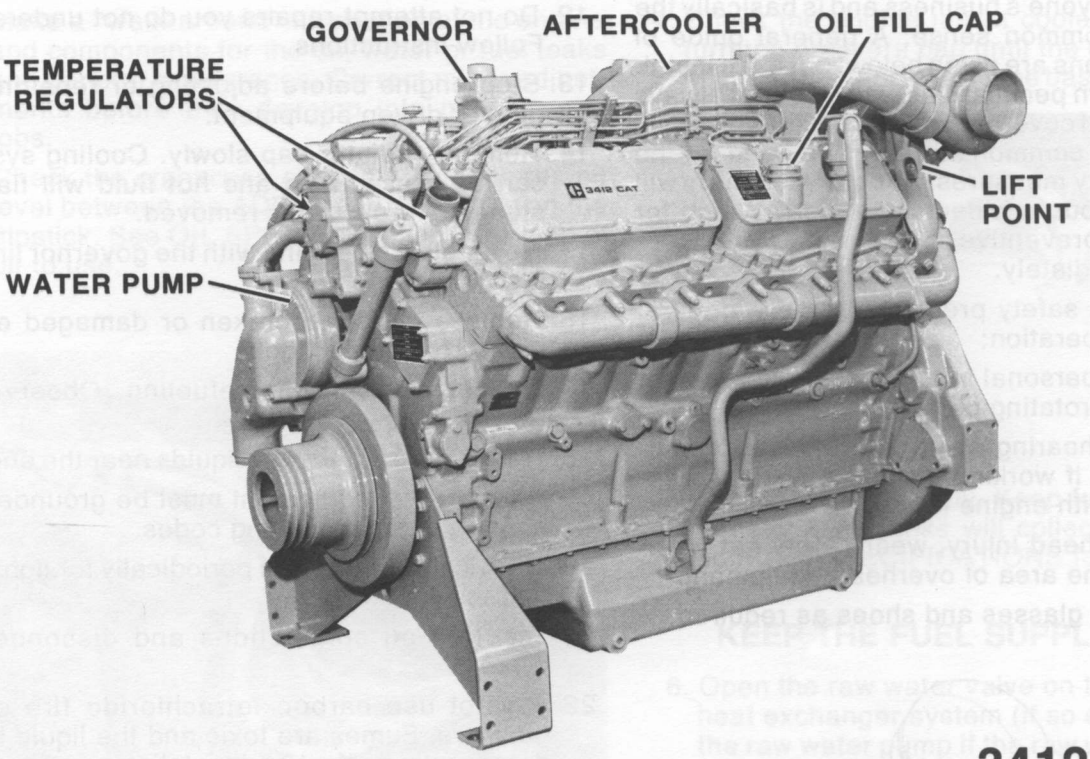
The services of authorized Caterpillar dealers are recommended; he is staffed with personnel who are equipped with proper tools, necessary Caterpillar parts, and are trained in the latest service procedures

TABLE OF CONTENTS

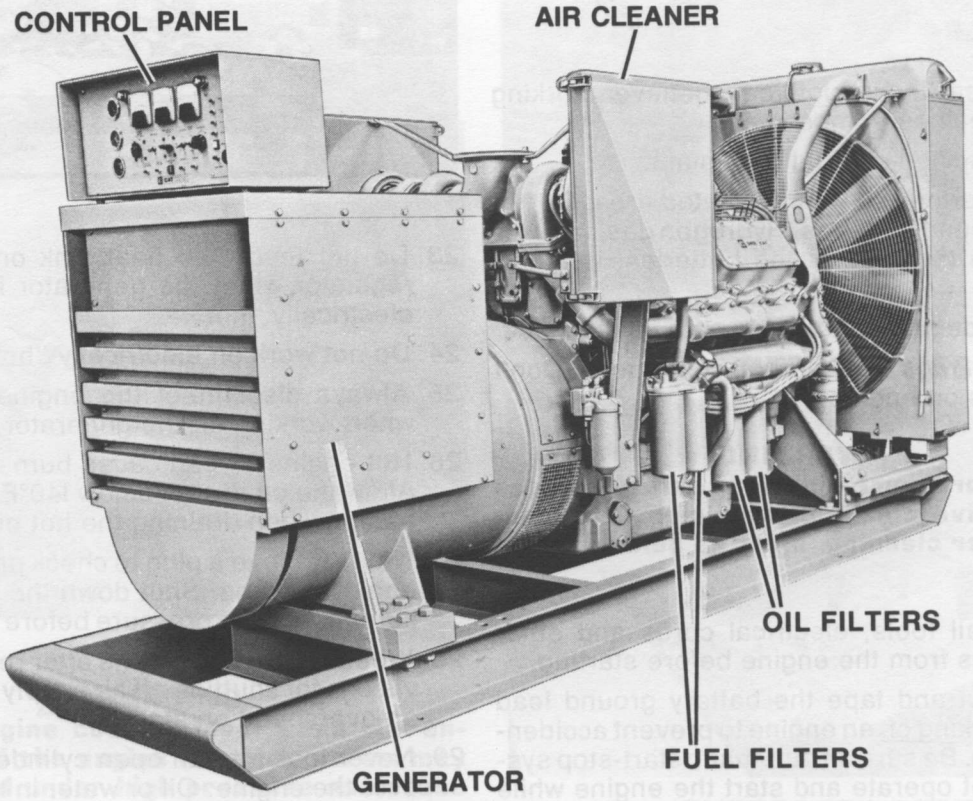


3408 INDUSTRIAL ENGINE





3412 INDUSTRIAL ENGINE

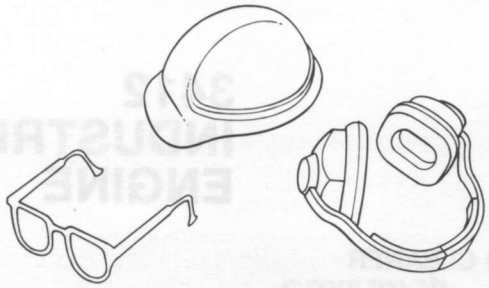


SAFETY PRECAUTIONS

Safety is everyone's business and is basically the use of good common sense. A general guide of safety precautions are given below, but each installation has its own peculiarities which cannot always be predicted and covered by established rules. Past experience and common sense are needed for the necessary safety measures. Attention to safety will help avoid serious accidents. Be alert. Watch for hazards. Use preventive measures. Correct deficiencies immediately.

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

1. To prevent personal injury, install guards over all exposed rotating parts.
2. To prevent hearing damage, wear ear protective devices if working inside an enclosed engine room with engine running.
3. To prevent head injury, wear safety hat when working in the area of overhead equipment.
4. Wear safety glasses and shoes as required.

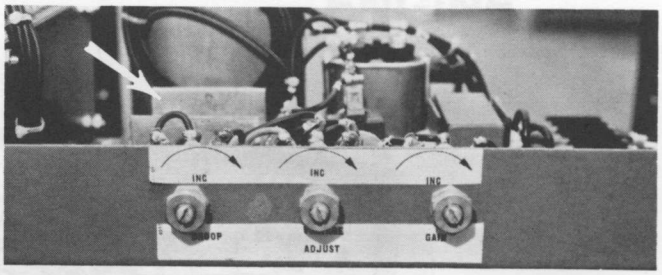


5. Do not wear loose clothing whenever working around engines or machinery.
6. Wipe up spilled oil, fuel or coolant.
7. Keep batteries in a well ventilated area. Do not smoke around batteries. Hydrogen gas, which is present in the area of the batteries, is highly explosive.
8. Provide adequate and safe waste oil disposal.
9. Store oily rags in fireproof containers. Don't leave rags on engine.

⚠ WARNING

When using pressure air, wear safety glasses and protective clothing. Maximum air pressure, used for cleaning, must be below 30 PSI (2 kg/cm²).

10. Remove all tools, electrical cords and other loose items from the engine before starting.
11. Disconnect and tape the battery ground lead before working on an engine to prevent accidental starting. Be sure an automatic start-stop system cannot operate and start the engine while working on it.
12. Do not attempt repairs you do not understand. Follow instructions.
13. Stop engine before adjusting or repairing engine or driven equipment.
14. Remove radiator cap slowly. Cooling systems can be pressurized and hot fluid will flash to steam as pressure is removed.
15. Never start an engine with the governor linkage disconnected.
16. Replace or repair broken or damaged equipment. Use proper tools.
17. Do not smoke while refueling. Observe NO SMOKING signs.
18. Never store flammable liquids near the engine.
19. All electrical equipment must be grounded according to local building codes.
20. Check all connections periodically for tightness and insulation.
21. Insulate all connections and disconnected wires.
22. Do not use carbon tetrachloride fire extinguishers. Fumes are toxic and the liquid has a deteriorating effect on insulation.

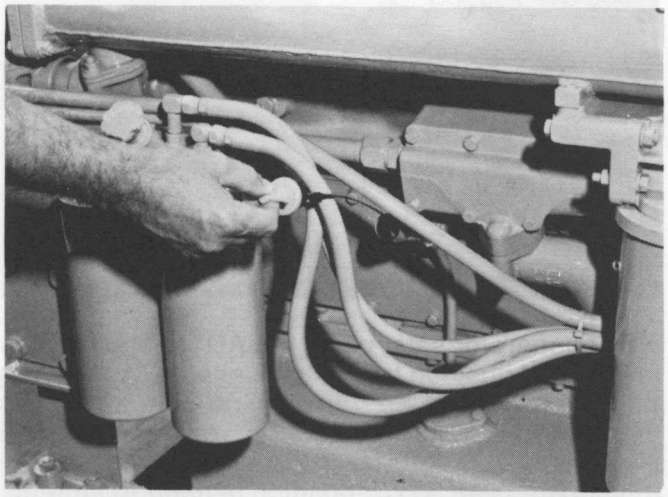


23. Do not touch the heat sink on the generator regulator when the generator is running. It is electrically "hot".
24. Do not work on electrically "hot" equipment.
25. Always disconnect the engine starter circuit when working on the generator.
26. Hot engine oil can cause burns when drained. Allow the oil to cool below 140°F or provide protection when draining the hot oil.
27. Never remove a plug to check pressure with the engine running. Shut down the engine and assure there is no pressure before removing plug.
28. When starting an engine after repair, make provisions for shutting off air supply in case there is an overspeed on start up.
29. Never look into an open cylinder port and turn over the engine. Oil or water in the cylinder will be ejected violently.

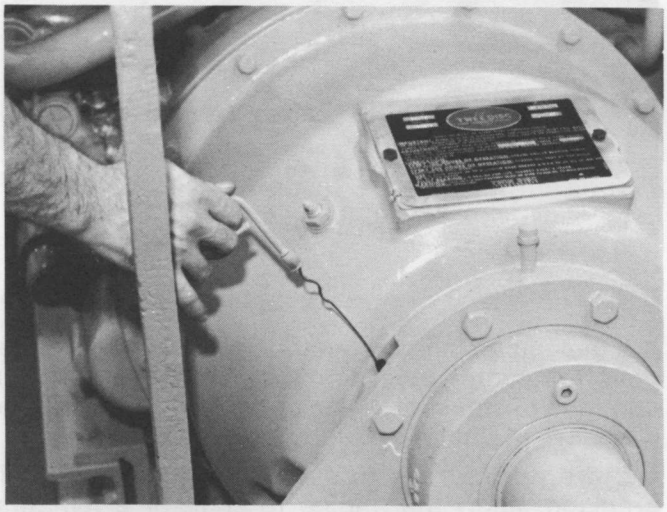
OPERATION INSTRUCTIONS

PRE-START INSPECTION AND PROCEDURES

1. Make a "walk-around" inspection of the engine and components for the oil, water or fuel leaks and general appearance. Correct minor adjustments before they develop into major repair jobs.
2. Check the crankcase oil level. Maintain the oil level between the ADD and FULL marks on the dipstick. See OIL SPECIFICATIONS for type of oil to use.



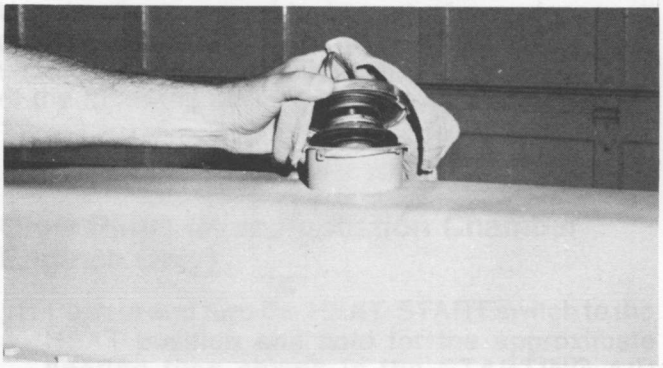
3. Check oil level(s) on driven equipment.



⚠ WARNING

Check the engine coolant level when the engine is cool. If the engine is warm, steam may spray outward under high pressure and cause personal injury.

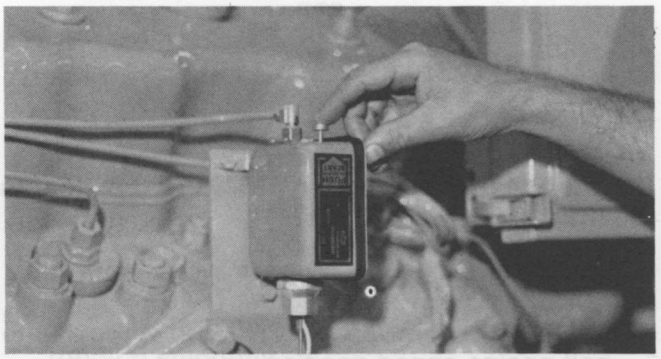
4. Check the engine jacket coolant level. Slowly turn the pressure cap until the cap is removed. Maintain coolant level to the base of the fill pipe.



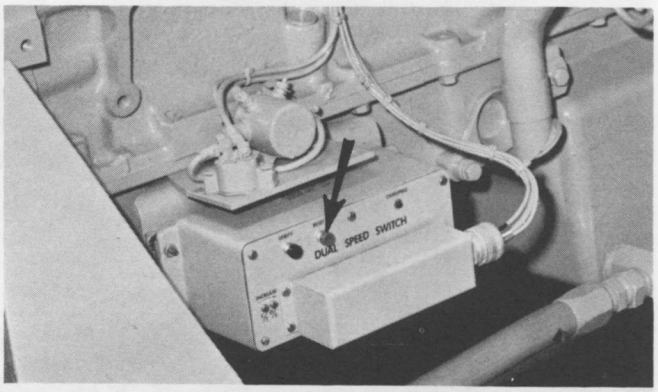
5. Check the fuel supply. Keep fuel tanks full, as partially filled tanks will collect moisture. See the FUEL SPECIFICATIONS for type of fuel.

KEEP THE FUEL SUPPLY CLEAN

6. Open the raw water valve on the engine jacket heat exchanger system (if so equipped). Prime the raw water pump if the raw water system has been drained.
7. Reset shutoff devices. See the topic, ATTACHMENTS, Emergency Shutoff Devices and Alarms.

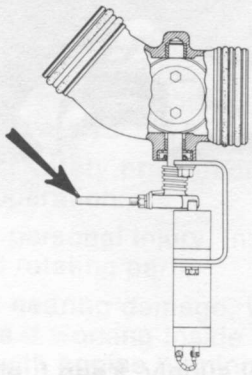


OIL PRESSURE RESET



OVERSPEED RESET

If the engine is equipped with an air safety shutoff control, and was tripped to the shutoff position, reset the latch to the run position.



AIR SHUTOFF RESET

8. Open the fuel supply valve. If the engine has not run for some time it may be necessary to prime the system. See the topic, PRIMING THE FUEL SYSTEM.
9. Disconnect any battery charger which is not protected against starting motor drain.
10. Disengage the clutch, or open the circuit breaker on a generator set.

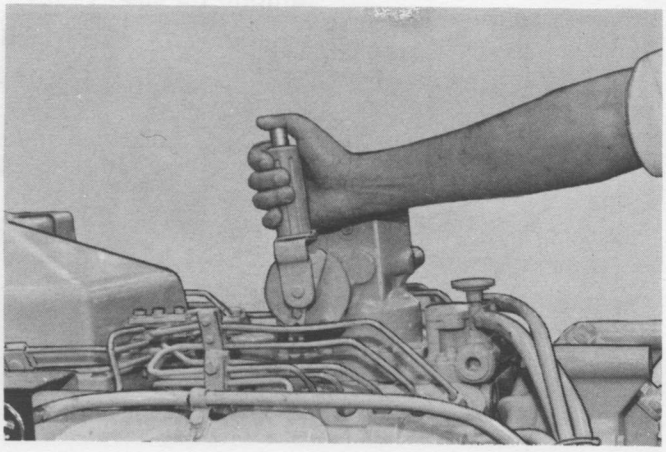
STARTING THE ENGINE

CAUTION

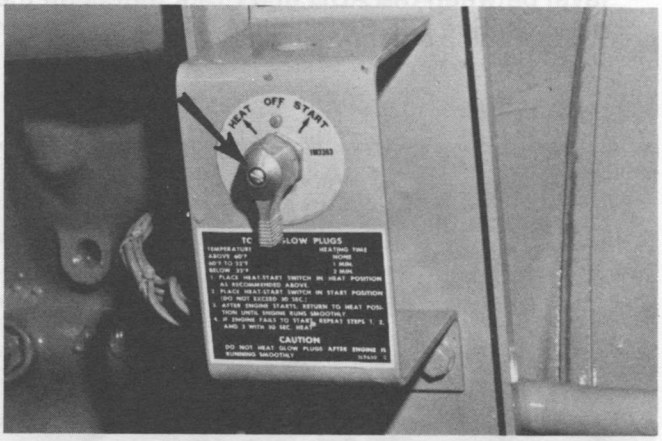
Do not engage the starter when the flywheel is moving.

Electric Starting

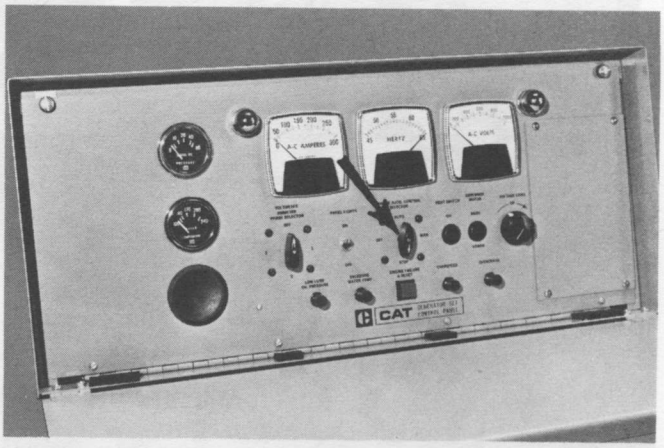
1. Move the governor control lever to approximate half engine speed position.



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



For generator sets, place the AUTO-MAN switch in the MAN position to crank the engine. As soon as the engine starts, and the engine speed reaches 600 rpm and oil pressure is approximately 22 psi (1.5 kg/cm²), the starter motor will disconnect from the circuit. (The STOP position is used to stop the diesel engine.)



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

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

CAUTION

Prolonged cranking at low oil pressure can activate the mechanical safety shut-off. If the reset lever is in the shut-off position, reset the mechanical shut-off control.

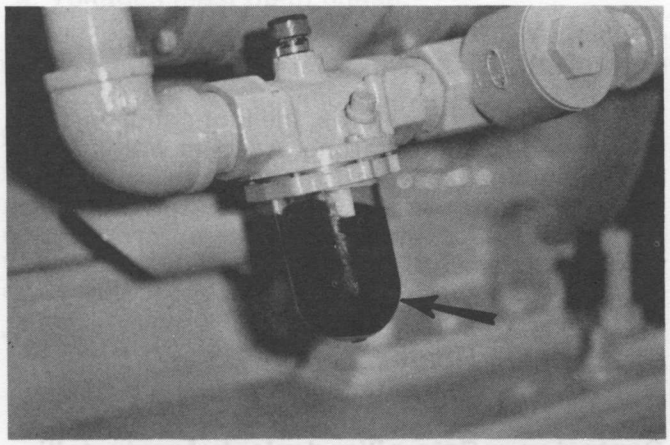
CAUTION

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

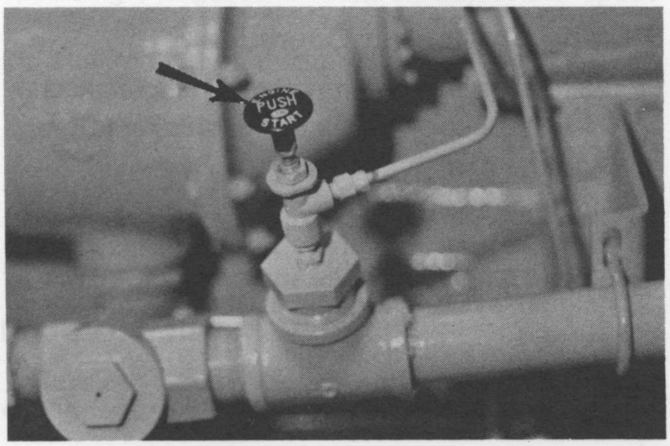
If the engine is equipped with a Woodward PSG Governor, see the topic, WOODWARD GOVERNORS for the governor operation instructions.

Air Starting

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



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

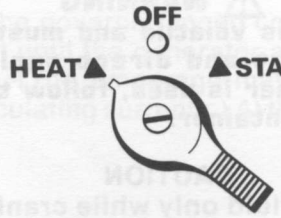


Starting Aids

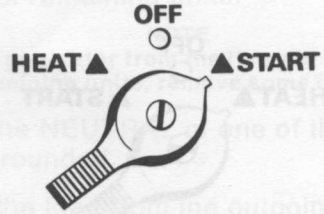
Many variables can affect cold weather starting. Use the chart as a guide, but actual experience will determine when aids are necessary and how they should be used. Your engine may have one or more of the following starting aids:

Glow Plugs (Precombustion Chamber Engines Only)

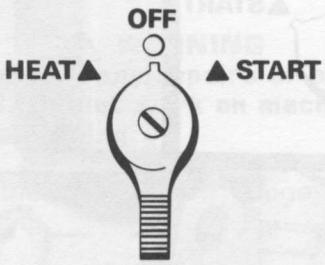
1. Push in and turn the HEAT-START switch to the HEAT position and hold for the approximate heating time shown in the STARTING AID CHART .



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



3. If necessary, when the engine starts turn the HEAT-START switch to the HEAT position. Hold the switch in this position until the engine is running smoothly.
4. Release the switch.



CAUTION

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

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

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

Starting Fluid

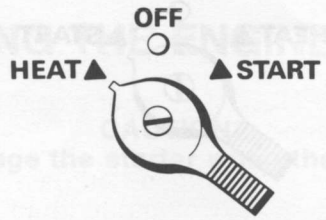
⚠ WARNING

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

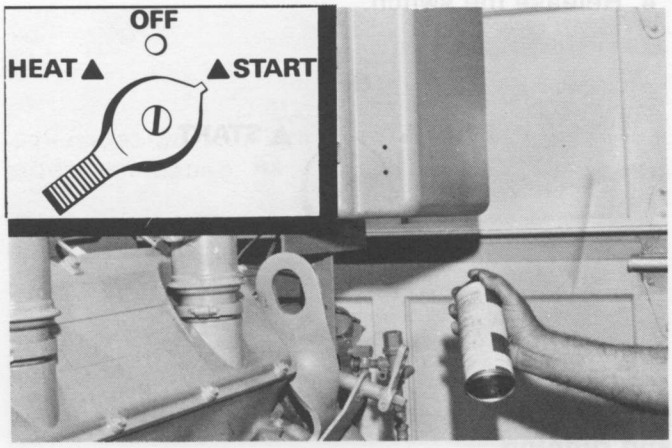
CAUTION

Spray starting fluid only while cranking the engine.

1. Heat the glow plugs (If equipped) for the approximate heating time shown in the STARTING AID CHART.



2. Turn the HEAT-START switch to START position. While cranking, spray starting fluid into the air inlet or air cleaner for approximately 1 second.



CAUTION

Wait at least 2 seconds before spraying starting fluid again.

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

Jacket Water Heater (Attachment)

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

Dipstick Oil Heater

CAUTION

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

GENERATOR

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.

Standby Generator 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.

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 condition is established by "phased" wiring connections of initial installation.

The second and third conditions are usually established by semi-permanent adjustments to the generator controls.

The fourth and fifth conditions are under control of the operation in manual paralleling systems (or under automatic control in automatic paralleling systems).

To Parallel

1. Start the unit to be paralleled.
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.

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 setting they will share the load equally.

To add load to one engine, slowly increase the governor control setting of that engine, or slowly decrease the governor control setting of the engine giving up load.

Load Transfer

At this point open the circuit breaker to remove any remaining load on the outgoing generator set.

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.

NOTE

If removing a generator from the line will cause overloading of the remaining units, remove some of the load first.

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 and Load Transfer.
4. Open the circuit breaker.
5. Run the engine for 5 minutes without a load, to allow it to cool. Stop the engine.

After Engine Starts

⚠ WARNING

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

1. Observe the oil pressure gauge immediately after starting.

CAUTION

If oil pressure is not indicated within 5 seconds, stop the engine and have necessary repairs made.

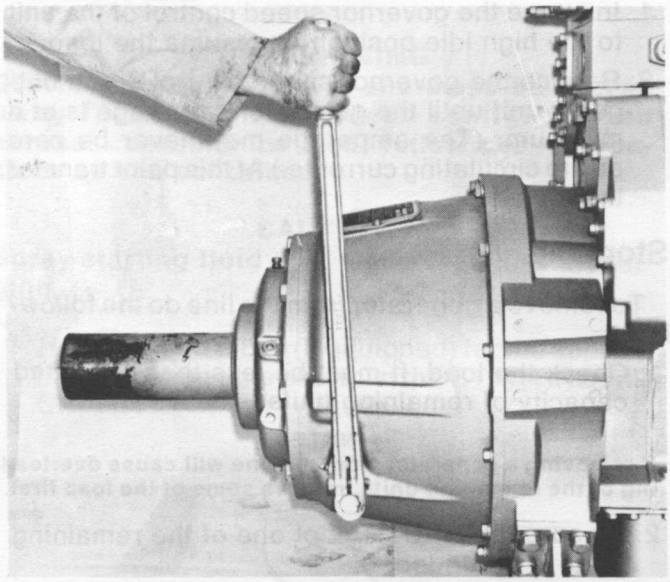
2. Move the governor control to low idle, allow the engine to reach normal operating range (usually several minutes). Make another "walk-around" inspection for leaks, etc.

STARTING THE LOAD

Driven Equipment without Load

To engage the driven equipment before applying load:

1. Move the governor control to half engine speed.
2. Engage the driven equipment without load on the equipment.



3. Make sure the engine and equipment gauges register in the operating range.
4. Move the governor control to high idle (full load) position.
5. Apply the load to the driven equipment.

Driven Equipment With Load

1. Move the governor control to half engine speed. Make sure the engine gauges register in the normal operating range.
2. Move the governor control to high idle (full load) position.
3. Engage the load.

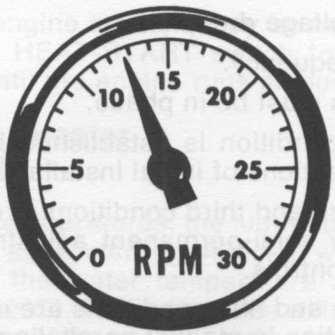
ENGINE OPERATION

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

Gauges

Tachometer

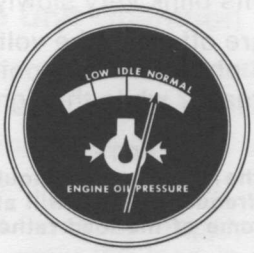
The tachometer indicates engine RPM. The high idle RPM and the full load RPM are stamped on the engine's information plate. The engine can be operated between these two speed limits for long periods of time without shortening engine life. Prolonged operation at high idle with little or no load can cause adverse engine operation.



Engine Oil Pressure

If the gauge reading fluctuates after the load is stable:

1. Remove the load.
2. Reduce engine speed to low idle.
3. Observe the oil level. Maintain the oil level between the ADD and FULL mark on the dipstick. If the reading continues to fluctuate when the oil level is correct, stop engine and call your Caterpillar dealer.



Engine Jacket Water Temperature

The engine should operate within the NORMAL (green) range. If the engine is operating in the (red) range and steam becomes apparent:

1. Reduce the load and engine RPM.
2. Inspect for coolant leaks.
3. Determine if the engine must be shut down immediately; or if the engine can be safely cooled by reducing the load.

See COOLING SYSTEM MAINTENANCE INSTRUCTIONS.

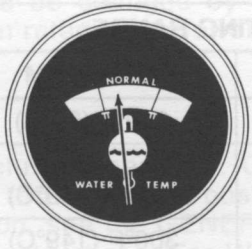
CAUTION

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

If the temperature gauge reading registers in or near the cold range (white) while operating under load:

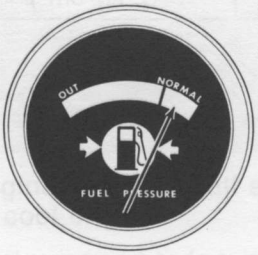
1. Check the water temperature gauge for accuracy.
2. Check the temperature regulators for proper temperature range. Replace regulators if necessary.

See COOLING SYSTEM MAINTENANCE for DETAILS.



Fuel pressure

If the fuel filter gauge registers in the OUT range, clean the primary fuel filter, if so equipped. Install new secondary or final fuel filter elements if gauge still registers OUT. See the FUEL MAINTENANCE INSTRUCTIONS and FUEL SPECIFICATIONS.

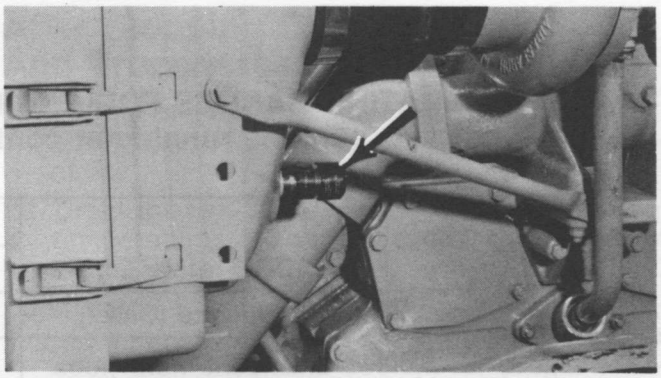


Ammeter:

The ammeter reading is normal when the indicator is at or on the (+) side of zero, when the engine is running at rated speed. If indicator is to the left (−) side of zero, investigate and correct cause.

Air Cleaner Service Indicator

When the gauge indicator locks in the red range, service the air cleaner. With the engine stopped; see AIR INDUCTION AND EXHAUST SYSTEM MAINTENANCE INSTRUCTIONS.



Calibrated Gauges

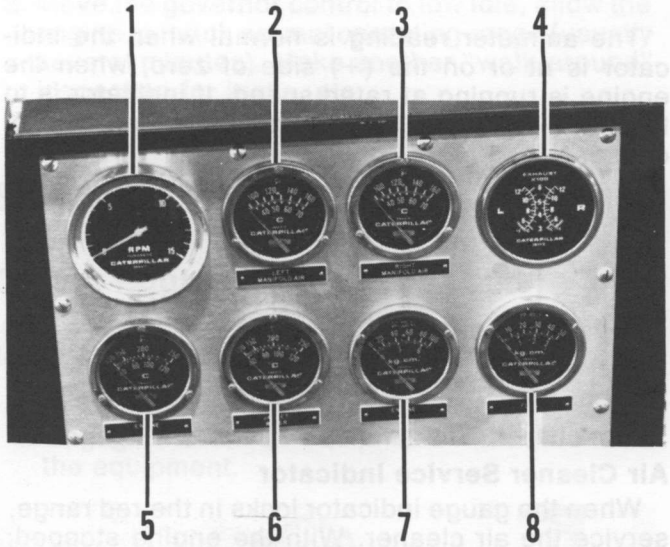
Calibrated gauges are used on some engines to monitor the engine systems. If an abnormal engine condition develops, determine and analyze and correct the cause before a failure and downtime occurs.

The operating limits given in the "OPERATING RANGES FOR ENGINES" chart are based on the engine running at continuous rated speed and load, after warm-up, using SAE 30, oil. If any of the gauges register at or outside the operating limits, investigate and correct any malfunction. See TROUBLESHOOTING GUIDE for guidance.

⚠ WARNING

Shut the engine down if work on or around the engine is required.

DO NOT OPERATE THE ENGINE WITH THE GAUGES REGISTERING AT OR OUTSIDE THE LIMITS.



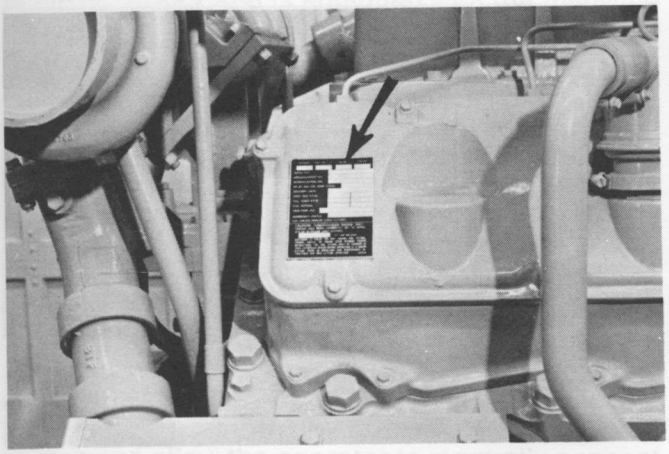
1. Tachometer.
2. Left inlet manifold temperature.
3. Right inlet manifold temperature.
4. Left and right exhaust manifold temepratures.
5. Engine oil temperature.
6. Engine jacket water temperature.
7. Engine oil pressure.
8. Fuel pressure.

OPERATING RANGES FOR ENGINES WITH CALIBRATED GAUGES
(Engine running at continuous rating and load.)

GAUGE	OPERATING RANGE	
	MINIMUM	MAXIMUM
Jacket Water Temperature (Outlet)	172°F (77°C)	210°F (99°C)
Inlet Manifold Air Temperature		
Aftercooled (PC)		300°F (149°C)
Non-aftercooled (DI)		300°F (149°C)
Exhaust Temperature		
Aftercooled (PC)		800°F (427°C)
Non-aftercooled (DI)		800°F (427°C)
Oil Temperature		
Aftercooled (PC)	172°F (77°C)	230°F (110°C)
Non-aftercooled (DI)	172°F (77°C)	230°F (110°C)
Oil Pressure	20 PSI (138 kPa) (1.5 kg/cm²)	62 PSI (427 kPa) (4 kg/cm²)
Fuel Pressure	17 PSI (117 kPa) (1 kg/cm²)	30 PSI (207 kPa) (2 kg/cm²)

Altitude Operation

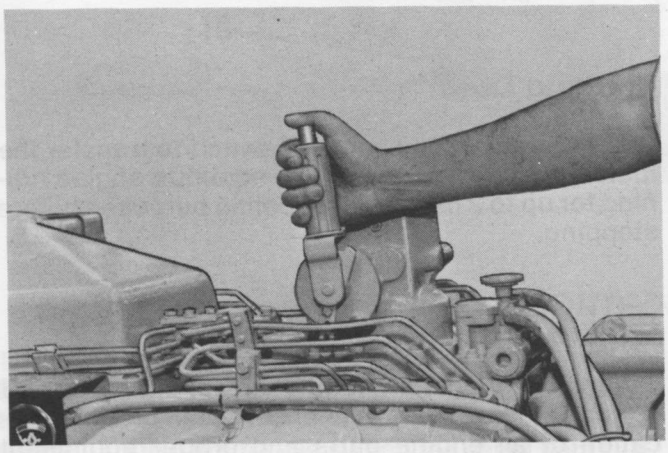
The fuel system settings and altitude limits are stamped on the engine information plate. When an engine is moved to a higher altitude, these settings must be changed by your Caterpillar dealer in order to prevent damaging the turbocharger, and to provide maximum engine efficiency.



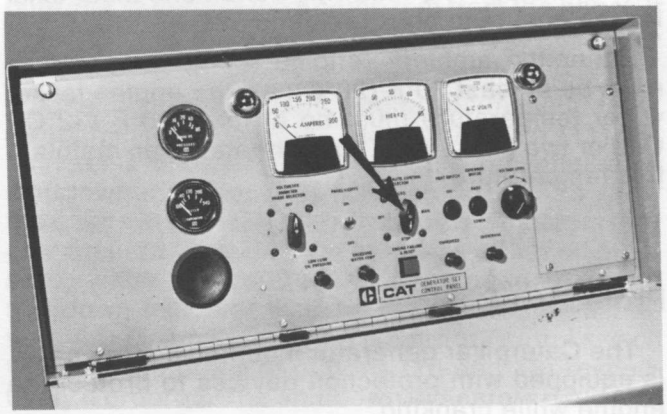
If the engine is moved to a lower altitude than that which is stamped on the engine information plate, the engine can be operated safely; however, it will deliver less than rated horsepower, and the fuel settings should be changed by your Caterpillar dealer to obtain rated horsepower.

Stopping

1. Flywheel clutch operation: Quickly pull the clutch lever to the released position. For electric set operation, see the GENERATOR SET OPERATION instructions. For Woodward Governor operation, see the topic, WOODWARD GOVERNORS, Stopping the Engine.

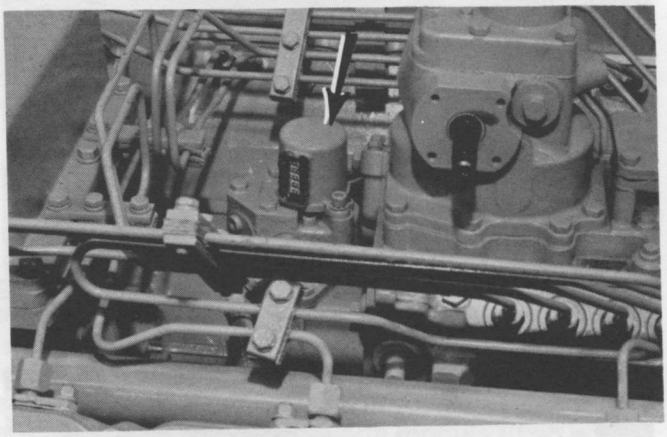


2. Reduce engine speed to half speed. Run for 5 minutes to cool engine.
3. Reduce engine speed to low idle.
4. Observe the crankcase oil level while the engine is idling. Maintain the oil level between the ADD and FULL marks on the side of the dipstick stamped, CHECK WITH ENGINE RUNNING. See the LUBRICATION AND MAINTENANCE SECTION.
5. Stop the engine.



After Stopping Checks And Procedures

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



SERVICE METER

ATTACHMENTS

Automatic Start-Stop

An automatic start-stop system is used when an engine must start when a specific condition occurs with no one in attendance. The engine will start, increase speed, pick-up the load, operate the load until a second condition occurs, remove the load, cool and stop. The following conditions must exist for the engine to start unattended:

Either the ambient (engine room) temperature must be at least 70°F (20°C); or, the engine jacket water temperature must be at least 90°F (32°C). One or two 3 kw jacket water heaters can maintain this temperature.

Protection Devices

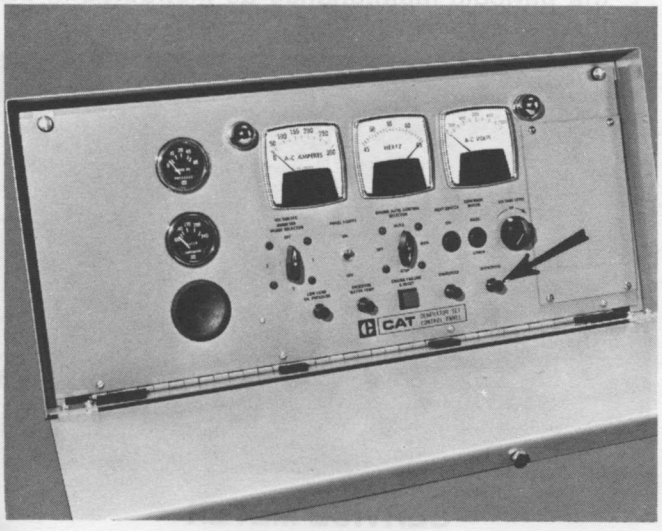
The Caterpillar generator mounted control panel is equipped with protection devices to protect the engine while cranking.

Batteries

Lights or buttons may indicate if a fault has occurred in the battery charging system causing the battery to be either undercharged or overcharged.

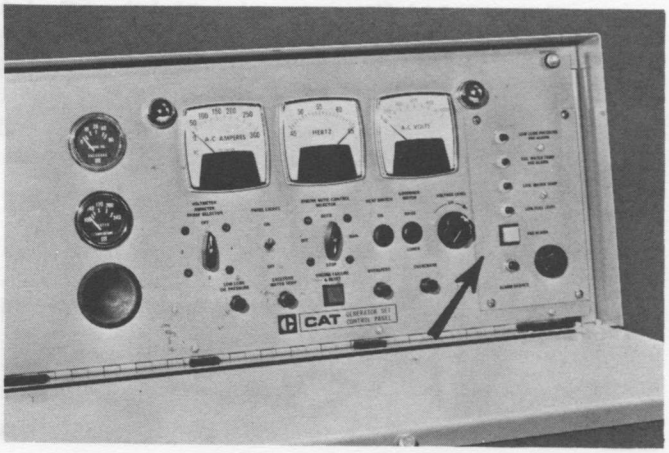
Overcranking

A timer allows the engine to crank either once for 30 seconds, or to crank through 5 ten-second cranking cycles (depending upon the device used) while unattended. If the engine does not start before the time elapsed, the fuel system will be shutoff and a light will indicate a starting failure.



Engine Operation

Prealarm systems provide an audible and/or a visual indication for low oil pressure, high water temperature, low fuel supply or low jacket water temperature before the condition becomes critical. These alarms are self resetting when the condition is corrected.



The engine may also be equipped with shutdown devices. If low oil pressure, high jacket water temperature or an engine overspeed condition occurs, the engine will be shutdown and a corresponding button or light will indicate the cause of the shutdown. These devices must be reset after repairs have been made and before starting. See the topic, EMERGENCY SHUTOFF DEVICES AND ALARMS.

Generator set control panels should be equipped with an ammeter, a frequency meter and a voltmeter. Depending upon the type of operation, the panel may also be equipped with other meters and lights. Know these instruments and their normal readings. They will indicate how the generator set is performing.

Shutting Down

A timer allows the transfer switch to transfer the load to another source and to continue engine running for up to 2 minutes for cooling purposes before stopping.

Engine Exerciser

At preset times, the exerciser will start, run and stop the engine in order to ensure both proper lubrication of all engine parts and proper equipment operation if and when the standby unit is needed.

Become familiar with all instructions included with the equipment.

Woodward Governors

Woodward Governors are usually electrically operated from a control panel.

Generator Set Control Panel

The generator set control panel is located on top of the generator and is equipped with the following controls and gauges:

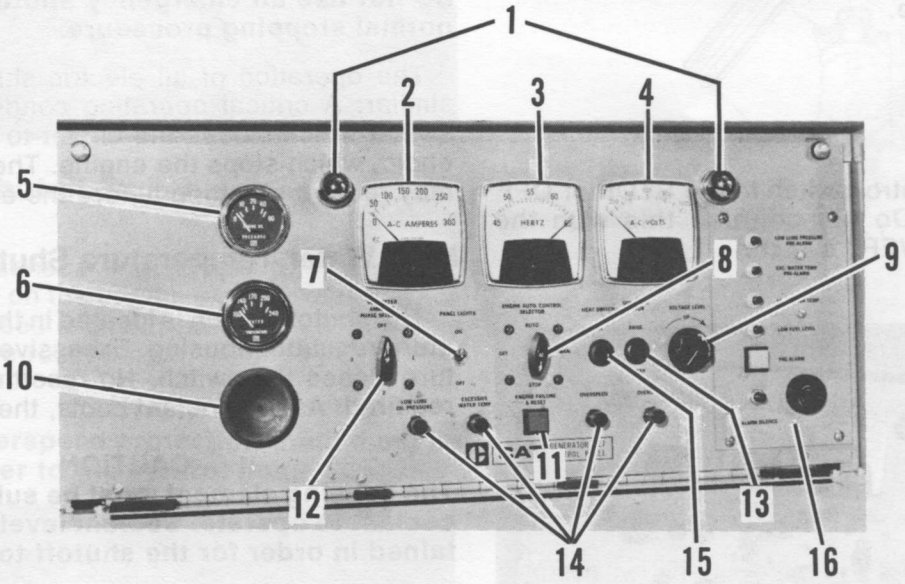
Panel lights (1) are controlled by an ON/OFF switch (7). An ammeter (2), frequency meter (3) and a voltmeter (4) show the output of the generator. Two gauges (5 and 6) show engine oil pressure and water temperature respectively. The ammeter selector switch (12) gives the operator a choice of which phase (T1, T2 or T3) of the generator output the ammeter (2) will show. Voltage level rheostat (9) takes the place of the voltage level rheostat in the generator regulator assembly.

The engine control switch (8) has four positions; MANUAL, AUTOMATIC, STOP and OFF. Placing the control in the MANUAL position will start the engine and allow the operator to manually connect the generator to the load. If the unit is used for standby application with a remote transfer switch, the AUTOMATIC position is used. In this position the engine will automatically start and take up the load when commercial power has stopped. Placing the control in the STOP or OFF position will stop the engine. When in the AUTOMATIC or MANUAL position, the engine will automatically stop if the commercial power has started or if the engne has a fault.

The PSG governor control switch allows the operator to control the engine rpm from the panel. If the engine is equipped with glow plugs, they are controlled by an ON/OFF heat switch (15).

If the engine has a fault, engine failure light/reset switch (11) will operate. The light/switch (11) will activate a shutdown relay to stop the engine. A shutdown indicator (14) will also operate to show the cause of the fault. The shutdown indicators (14) give an indication that the fault was either oil pressure, water temperature or overspeed. A fourth shutdown indicator will show an overcrank condition. A D.C. ammeter and a governor control switch will take the place of buttons (10 and 13) respectively if ordered. The shutdown indicators have four auxiliary contacts; one for each time its shutdown indicator operates. The contacts are connected to a remote annunciator panel if ordered.

The shutdown indicator lights can be checked for malfunction by depressing the shutdown indicators. Replace burned out bulbs immediately.



CONTROL PANEL

1. Panel lights. 2. Alternating current ammeter. 3. Frequency meter. 4. Alternating current voltmeter. 5. Oil pressure gauge. 6. Water temperature gauge. 7. ON/OFF toggle switch for panel lights. 8. Engine control switch. 9. Voltage level rheostat. 10. Button (direct current ammeter if ordered). 11. Engine failure light/reset switch. 12. Ammeter selector switch. 13. Button (governor control switch if engine is equipped with a PSG governor). 14. Shutdown indicator (oil pressure, water temperature, overspeed and overcrank). 15. Button; heat switch (if so equipped). 16. Panel; prealarm module (if so equipped).

Starting The Engine

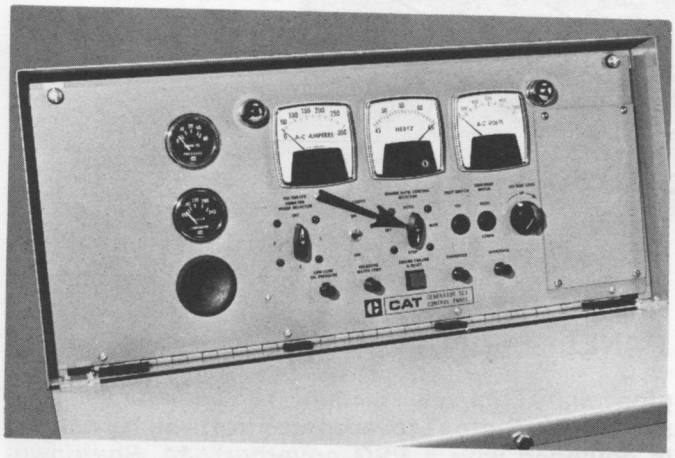
1. Perform all prestart checks outlined previously.
2. Place the CONTROL switch in the MANUAL position to crank the engine.
3. When the engine starts and engine rpm reaches 600 rpm and the oil pressure registers 22 psi (1.5 kg/cm²) the starting motor will automatically disconnect from the start circuit.
4. Start the load.
5. Regulate the engine speed with the RAISE-LOWER switch to the required instrument panel gauge readings.

Stopping The Engine

1. Remove the load. See GENERATOR SET OPERATION instructions if equipped with an electric set generator.
2. Reduce engine speed to low idle: Push down and hold the RAISE-LOWER switch until the engine low idle speed is reached.
3. While the engine is idling, check the engine oil level. Oil level must be maintained between the ADD and FULL marks on the side of the dipstick marked "CHECK WITH ENGINE RUNNING".
4. Stop the engine.

Solenoid Shutoff

a. Move the control switch to the STOP or OFF positions. (Do not confuse this with the "RAISE-LOWER" switch.)



ON-OFF-STOP SWITCH

PSG Governor:

b. Move the shutoff lever forward, or hold the lever up, depending upon installation. Hold the lever in this position until the engine stops.
5. Fill the fuel tank. See the LUBRICATION AND MAINTENANCE section.
6. Drain the raw water system if below freezing temperatures are expected.
7. Observe the Service Meter reading. Perform the periodic maintenance as instructed in the LUBRICATION AND MAINTENANCE CHART.

Emergency Shutoff Devices And Alarms

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

CAUTION

Always determine the cause of the shutdown, and have the necessary repairs made before restarting the engine. See TROUBLESHOOTING GUIDE.

Do not use an emergency shutoff device for a normal stopping procedure.

The operation of all electric shutoff controls is similar: A critical operating condition actuates a switch which closes the circuit to the shutoff solenoid, which stops the engine. The shutoff control may require resetting before the engine can start.

High Water Temperature Shutoff

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

CAUTION

The sensing element must be submerged in the coolant to operate. Coolant level must be maintained in order for the shutoff to operate.

Low Oil Pressure Shutoff Switch

CAUTION

Does not protect system from rapid oil loss, such as line breakage.

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

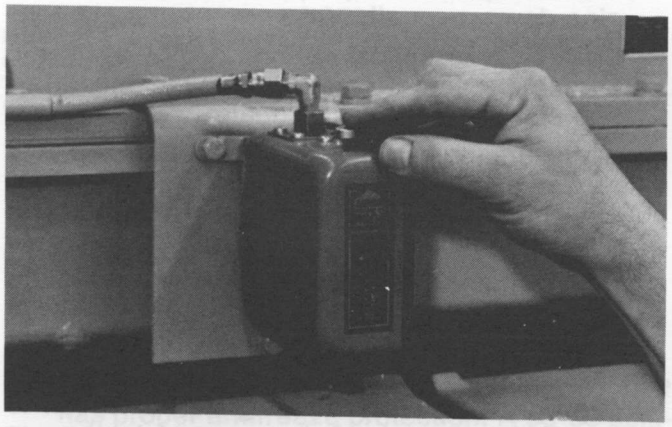
Manually operated systems require resetting of this switch before starting. Automatic start-stop systems use a pressure switch which resets itself.

To reset the switch, push the button until it latches. After the engine starts and develops oil pressure, the button will move to the extended running position.

CAUTION

The button must be in the RUN position to protect the engine.

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

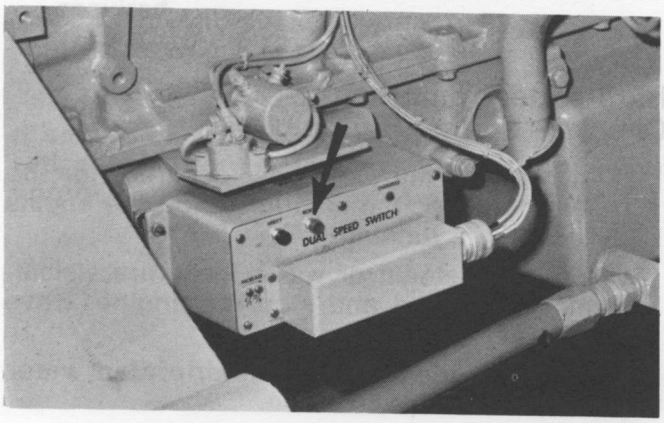


Overspeed Shutoff Switch (Electronic)

This switch senses engine speed. The control box is mounted on the engine block. Excessive engine speed closes a circuit breaker. To reset the switch, push the reset button.

CAUTION

To provide overspeed protection there must be electrical power to the control box.



Fuel/Oil Pressure Switch

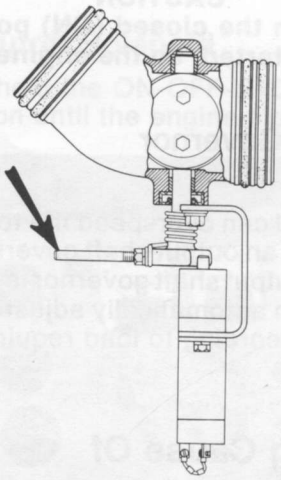
This switch is mounted in the fuel manifold between the outlet side of the fuel filter and the fuel injection pump. Low fuel pressure opens the switch and the electrical circuit to either the shutoff solenoid or the circuit between the alternator and the alternator regulator. While the engine is stopped, open these circuits to prevent the battery from becoming discharged.

This switch can also be used with an electric governor. In this application, oil pressure closes the switch to allow the electric governor to control engine speed.

This switch does not require resetting.

Air Safety Shutoff Control

The air shutoff control is an attachment to the safety shutoff devices. When an emergency conditions occurs, the solenoid pushes the rack into the shutoff position and a solenoid trips a butterfly valve, located in the inlet manifold, to the closed position. The air safety shutoff control must be reset before starting.



Alarm Switches

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

CAUTION

Even though it could be hazardous to have the engine stop unexpectantly, if the engine overspeeds, it should be stopped immediately.

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

CAUTION

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

Testing Indicator Lights

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

Alarm Shutoff Switch

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

CAUTION

Place switch in the closed (ON) position when the engine is started, so the engine will be protected.

Output Shaft Governor Operation

When the load can overspeed the torque converter output shaft, an output shaft governor should be installed. The output shaft governor is a speed limiting device which automatically adjusts engine governor setting according to load requirement.

Determining Cause Of Shutdown

CAUTION

If the engine has been shutdown by a safety device, do not start the engine and place it into service without having the cause of the shutdown investigated and corrected.

Low Oil Pressure Checks

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

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

⚠ WARNING

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

2. Check the oil level. Oil level must be between the ADD and FULL marks on the side of the dipstick stamped CHECK WITH ENGINE STOPPED.
3. If the oil level is below the ADD mark, check for oil spray and/or oil accumulations. If any are found, have the necessary repairs made. Before starting, add oil to the FULL mark.
4. Reset the shutoff control.
5. Remove the load and start the engine at its slowest speed. Be prepared to shut the engine down manually.
6. Be alert for unusual sounds or noises. If the engine knocks, stop the engine immediately and call your Caterpillar dealer.
7. If the engine blows excessive black exhaust or has excessive crankcase blow-by, the engine may need reconditioning. Stop the engine and call your Caterpillar dealer.
8. If the engine runs satisfactorily, observe the oil pressure gauge. If satisfactory pressure is not indicated, shut the engine down; call your Caterpillar dealer.
9. If proper oil pressure is registered, check to see if the reset knob has moved to the run position. If the knob does not move, stop the engine. Check the shutoff control, the oil line, and the oil pressure gauge. Have necessary repairs made.
10. If the oil pressure gauge registers normal oil pressure, if the knob on the shutoff control moves to the run position, and if the engine operation is otherwise satisfactory, determine if the high water temperature shutoff may have shut down the engine.

High Water Temperature Checks—Engine Running

1. Determine if the load was too great for the engine: Reduce the load and allow the engine to cool while running.
2. If pressure steam or water leaks are visible, remove the load and stop the engine. Have necessary repairs made.
3. Check for collapsing or deteriorated water hoses. Have repairs made.

4. Check for noisy water pump operation. Have necessary repairs made.
5. Refill the cooling system with a solution of water and permanent-type antifreeze if below freezing temperatures are expected; or with a solution of approved water and Caterpillar Corrosion Inhibitor or equivalent. Follow the instructions on the container.

⚠ WARNING

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

NOTE

If there is adequate coolant in the cooling system, gradual cooling is preferred by running the engine a half speed. This eliminates hot spots in the engine, and possible failure.

High Water Temperature Checks—Engine Stopped and Cold

1. Check coolant level. Determine if the coolant has proper antifreeze protection. A 50-50 solution of permanent-type antifreeze and approved water will give protection below −20°F (−29°C).
2. Check to be sure the raw water valve has been opened.
3. Check engine room vents and/or louvers. Be sure the engine is receiving sufficient air.
4. Be sure temperature regulators are operating at proper temperature range.
5. Inspect all water hoses carefully for collapsing, external and internal failures. Replace hoses as required.
6. Have the cooling system cleaned.

CAUTION

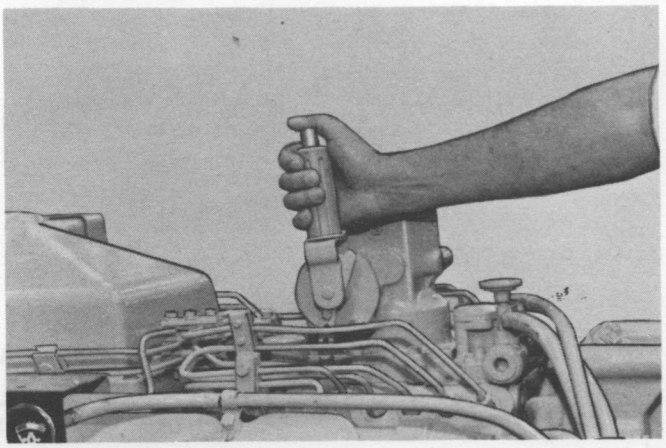
If severe or prolonged overheating has occurred, contact your Caterpillar dealer to have your engine checked for possible damage.

Emergency Stopping

To stop in an emergency:

Mechanical Governor Control

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

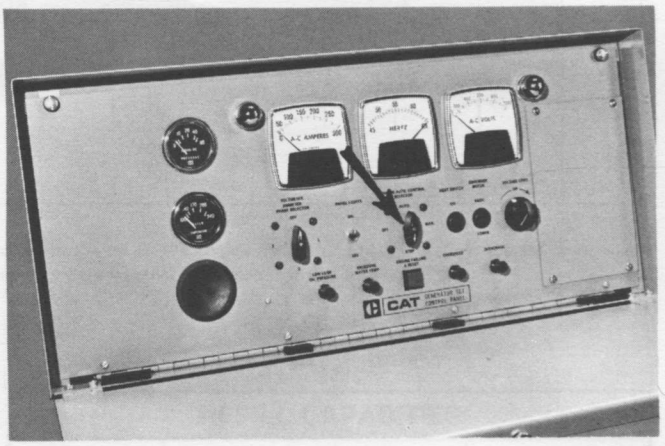


Woodward PSG Governor

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

Electric Shutoff Solenoid

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



Air Controls

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

LUBRICATION SPECIFICATIONS

Crankcase Lubricating Oils

Use oils which meet Engine Service Classification CD or MIL-L-2104C. These are additive-type oils that have been approved for use in Caterpillar Diesel Engines.

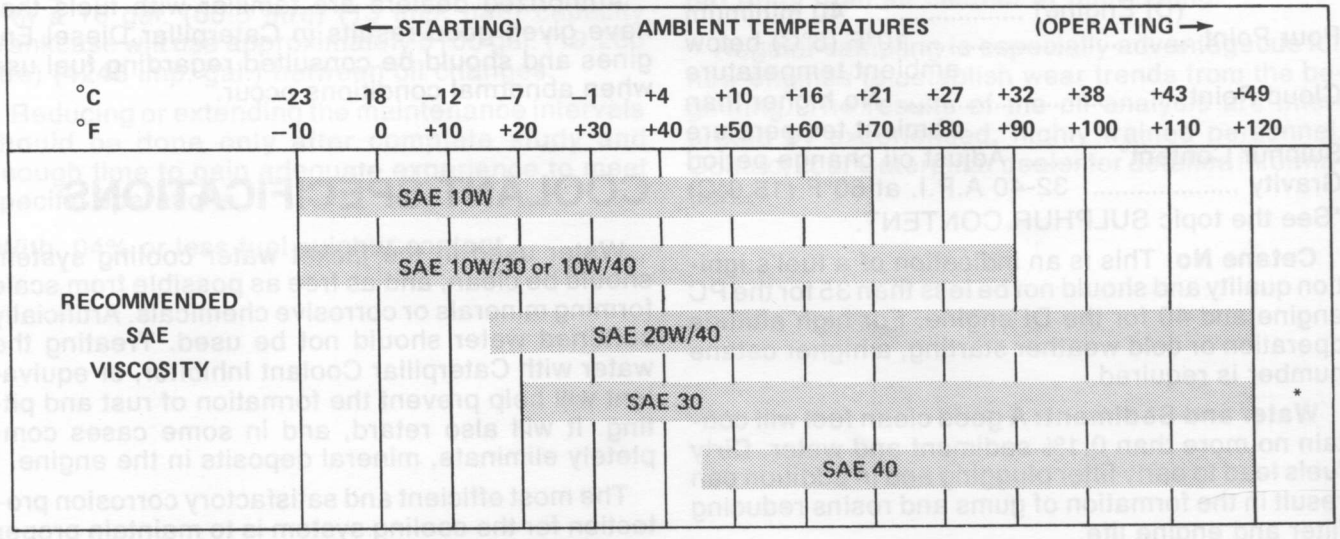
The proper SAE grade of oil to select is determined by the ambient temperature at which the engine is started and the maximum ambient temperature in which the engine will be operating. See chart for recommended viscosity and temperature range.

To determine if the oil in the crankcase will flow in cold weather, remove the oil dipstick before starting. If the oil will flow off, the oil is fluid enough to circulate properly.

Lubricating Grease

Use Multipurpose-type Grease (MPGM) which contains 3-5% molybdenum disulfide conforming to MIL-M-7866, and a suitable corrosion inhibitor. NLGI No. 2 Grade is suitable for most temperatures. Use NLGI No. 0 or No. 1 Grade for extremely low temperatures.

RECOMMENDED ENGINE OIL VISCOSITY



*SAE 40 is preferred for sustained operation above 90°F (32°C).

NOTE: At temperatures below −10°F (−23°C), it may be necessary to warm the oil so the engine can be cranked and allow the oil to circulate freely. For operation in cold temperature see your Caterpillar dealer for cold weather operation instructions.

Air Starting Motor Oiler: Use SAE 10W in all temperatures.

Flywheel Clutch Bearing Reservoir: Use SAE 30 in all temperatures.

REFILL CAPACITIES			
MODEL	U.S. GAL.	LITRE	IMP. GAL.
3408	12	45.5	10
3412	16	60.5	13

FUEL SPECIFICATIONS

No. 2 fuel oil and No. 2D diesel fuel are recommended for use in Caterpillar Diesel Engines. In extreme cold temperatures use No. 1 fuel oil or No. 1D diesel fuel.

In selecting a fuel, note that distillate fuels are especially desirable because the fuel is heated to a vaporous state and condensed, thus eliminating all sediment and residue.

There is considerable variation in the composition of fuels distributed under the No. 2 grade classifications. For desirable engine service it is most important to give special attention to cetane no., water and sediment, pour point, cloud point and sulphur content. USE THE LOWEST PRICE DISTILLATE FUEL WHICH MEETS THE FOLLOWING REQUIREMENTS.

Water and Sediment	0.1% sediment
Cetane No. (PC Engine)	35 minimum
(DI Engine)	40 minimum
Pour Point	10°F (6°C) below ambient temperature
Cloud Point	No higher than abmient temperature
Sulphur Content*	Adjust oil change period
Gravity	32-40 A.P.I. at 60°F (15.6°C)

*See the topic SULPHUR CONTENT.

Cetane No: This is an indication of a fuel's ignition quality and should not be less than 35 for the PC engine and 40 for the DI engine. For high altitude operation or cold weather starting, a higher cetane number is required.

Water and Sediment: A good clean fuel will contain no more than 0.1% sediment and water. Dirty fuels lead to early filter plugging and in addition can result in the formation of gums and resins reducing filter and engine life.

Pour Point: The pour point of the fuel has no effect on engine performance, as long as the fuel is fluid enough to flow from the fuel tank to the engine. The pour point of the fuel should be at least 10°F (6°C) below the lowest atmospheric temperature at which the engine must start and operate. In extremely cold temperatures it may be necessary to use No. 1 fuel oil or No. 1D diesel fuel.

Cloud Point: Cloud point is the temperature at which wax crystals become visible and is generally above the pour point of the fuel. The cloud point should be no higher than the lowest atmospheric temperature at which the engine must start to keep the fuel filter elements from plugging with wax crystals.

Sulphur Content: As sulphur content increases, the crankcase oil change periods should be reduced. Fuel containing 0.4% or less sulphur content, use normal oil change periods. If the fuel contains 0.4% to 1.0% sulphur, oil change periods should be reduced to one-half normal time. If the fuel contains more than 1.0% sulphur, oil change periods should be reduced to one-fourth normal time.

Gravity: Gravity is the measurement of heat units in a certain amount of fuel. The heavier the fuel (the lower the number) the more heat units per volume. If a fuel with a higher A.P.I. gravity is used the power produced will be lower. Select fuels with the lower A.P.I. gravity reading.

Some fuel specifications that meet the above requirements are:

ASTM—D396 - No. 1 & No. 2 fuels (burner fuels)
ASTM—D975 - No. 1D & No. 2D diesel fuel oils
BS2869—Class A1 to Class A2 engine fuels
BS2869—Class C & Class D burner fuels
DIN51601—Diesel fuel
DIN51603—EL heating oil

Authorized dealers are familiar with fuels that have given good results in Caterpillar Diesel Engines and should be consulted regarding fuel use when abnormal conditions occur.

COOLANT SPECIFICATIONS

Water used in the jacket water cooling system should be clean, and as free as possible from scale forming minerals or corrosive chemicals. Artificially softened water should not be used. Treating the water with Caterpillar Coolant Inhibitor, or equivalent will help prevent the formation of rust and pitting. It will also retard, and in some cases completely eliminate, mineral deposits in the engine.

The most efficient and satisfactory corrosion protection for the cooling system is to maintain proper level of coolant inhibitor and antifreeze solution. The use of auxiliary water filters is not recommended.

During freezing weather use the proper permanent type antifreeze and water solution to prevent freezing.

Before placing the engine in operation, make sure a 3% concentration of Caterpillar Corrosion Inhibitor or equivalent has been added to the cooling system. This 3% concentration must be maintained in cooling systems which are filled with water and systems protected with ethylene glycol antifreeze mixture, regardless of antifreeze concentration.

⚠ WARNING

Inhibitors contain alkali. Avoid contact with eyes. To prevent personal injury, avoid prolonged or repeated contact with skin.

LUBRICATION AND MAINTENANCE INSTRUCTIONS

Regular service intervals, along with close daily visual inspection and the adherence to the instructions and schedules, will assure many hours of trouble-free service. If correction steps are taken immediately on discovery of any abnormal condition, fewer forced stops and more economical operation will result.

The Lubrication and Maintenance Chart is intended as a guide and adjustments in the schedule may be necessary, depending on conditions under which the engine is operating. A thorough analysis should be made before adjusting the maintenance schedule.

Some items to consider in establishing a new schedule are: Severe dust or dirty conditions, fuel consumption (a good measurement to establish intervals as it indicates the amount of work performed). As a guideline, the 3408 Engine with a 12 gal. (45 litre) (10 imp. gal.) capacity crankcase will use approximately 4000 gal. (15,000 litre) (3332 imp. gal.) between oil changes.* The 3412 Engine with a 16 gal. (60.5 litre) (13 imp. gal.) capacity crankcase will use approximately 5100 gal. (19,200 litre) (4248 imp. gal.) between oil changes.*

Reducing or extending the maintenance intervals should be done only after complete study and enough time to gain adequate experience to meet specific operations.

*With .04% or less fuel sulphur content.

Caterpillar scheduled oil sampling: Scheduled oil sampling is a program which analyzes oil samples taken from an engine at regular intervals (usually at oil change periods). This oil analysis does not indicate the condition of the oil; but rather, it is a scheduled procedure to determine engine condition at regular intervals by analyzing lubricating oil for foreign and wear particles.

The scheduled oil sampling will give the following benefits:

It assures the owner that maintenance has been performed.

It will show the first signs of excessive wear, meaning a possible upcoming failure, allowing time for a scheduled repair.

It will warn maintenance personnel of improper or lack of maintenance and presence of fuel dilution or antifreeze in oil.

It is particularly helpful in preventing wear due to dirt entry from air cleaner or inlet piping.

Regular sampling is especially advantageous for new engines to establish wear trends from the beginning. The results of the oil analysis are interpreted by experienced, highly trained personnel. Contact your Caterpillar dealer for detailed information.

LUBRICATION AND MAINTENANCE CHART

The LUBRICATION AND MAINTENANCE CHART lists all serviceable items commonly ordered on this engine.

The maintenance time intervals are expressed in Service Meter Units. The Service Meter on the engine shows the total number of units the engine has run. Use the Service Meter readings for determining your maintenance schedules. Perform the maintenance at multiple intervals of the units shown. For example, when the Service Meter shows "100" on the dial, all items listed under "EVERY 10 SERVICE METER UNITS" should be serviced now for the tenth time, and all items under "EVERY 50 SERVICE METER UNITS" should be serviced for the second time.

Diesel fuels, lubricants and coolant make-up water to use are explained in the "Specifications".

SERVICE ITEM	Page No.	SERVICE METER UNITS									
		10	50	125	250	500	1000	2000	4000	Year	As Req.
LUBRICATION											
Check Engine Crankcase Oil Level	28	•									
Lubricate Front Clutch Engaging Collar (2 Strokes)	31	•									
Lubricate Rear Clutch Engaging Collar (2 Strokes)	31	•									
Check Shaft Bearing Reservoir (Rear Heavy Duty Clutch)	31	•									
Lubricate Clutch Control Lever Shaft Bearings (2 Strokes)	31			•							
Lubricate Front and Rear Clutch Pilot and Shaft Bearings (2 strokes)	31			•							
Change Crankcase Oil and Filter	28				Note A						
Lubricate Fan Drive Bearings (2 Strokes)	30				•						
Crankcase Breather, Clean	28					•					
Change Clutch Shaft Reservoir Oil (Heavy Duty Clutch)	31					•					
Lubricate Woodward PSG Governor	30						•				
Lubricate Generator (SR4) Rear Bearing	32							•			
Air Start Oiler Jar, Fill	30										•
Empty Air Start Oil Collector Jar	30										•
COOLING SYSTEM											
Check Engine Coolant Level	36	•									
Inspect Zinc Rods in Raw Water System (Salt Water Only)	40		•								
Clean Radiator Core (External)	37				•						
Inspect Coolant Line Connections and Hoses	39				•						
Check Fan/Alternator Belt Tension and Wear	40				•						
Add Cooling System Inhibitor (Jacket Cooling)	36					•					
Inspect Coolant Pump	40							•			
Inspect Temperature Regulator	39									•	
Clean Cooling System (Internal)	37									•	

SERVICE ITEM	Page No.	SERVICE METER UNITS									
		10	50	125	250	500	1000	2000	4000	Year	As Req.
FUEL SYSTEM											
Fill the Fuel Tank After Stopping	41	•									
Drain Sediment and Water From Fuel Tank	41	•									
Check Fuel Pressure Gauge Reading	41	•									
Wash Primary Filter	42				•						
Replace Final Fuel Filter	42	Note B									
Check/Replace Fuel Injection Nozzles If Necessary	43							•			
AIR INDUCTION AND EXHAUST											
Check Air Cleaner Service Indicator	45	•									
Check/Clean Dust Collector Cap	47	•									
Clean/Replace Air Cleaner Element	46						Note C				
Inspect Manifold and Air Piping for Leaks	50				•						
Adjust Valve Lash (Engine Stopped)	47							•			
Check Valve Rotation (Engine Idling)	50							•			
Inspect/Rebuild Turbocharger	51								•		
ELECTRICAL SYSTEM											
Check Battery Electrolyte	52				•						
Clean Electrical Connections and Battery	52				•						
Inspect Alternator Drive Belt	56				•						
Check Shutoff Controls	Note D					•					
Inspect/Rebuild Alternator	55							•			
Inspect/Rebuild Starter	54								•		
Check Cold Weather Starting Aids	56									•	
POWER COUPLINGS											
Check and Adjust Clutch	57										•

NOTES

NOTE A: This is the normal engine oil change interval to use when fuel sulphur content is 0.4% or less. When sulphur content is 0.4% to 1.0%, reduce oil change interval one-half. When sulphur content is above 1.0%, reduce oil change interval to one-fourth the normal interval. Regardless of hours, change oil filters every 6 months.

NOTE B: Check fuel pressure gauge daily. Replace when FUEL PRESSURE gauge registers OUT or 20 PSI (124 kPa).

NOTE C: The element can be cleaned approximately 3 times. Carefully inspect the element after each cleaning. If engine is not equipped with air cleaner service indicator, check element every 250 Service Meter Units, or more often under dusty conditions. If after servicing the air cleaner, the exhaust smoke and/or loss of power continues, install a new element.

NOTE D: Authorized Caterpillar dealers are equipped with the necessary tools, personnel and procedures to perform these services

LUBRICATION INSTRUCTIONS

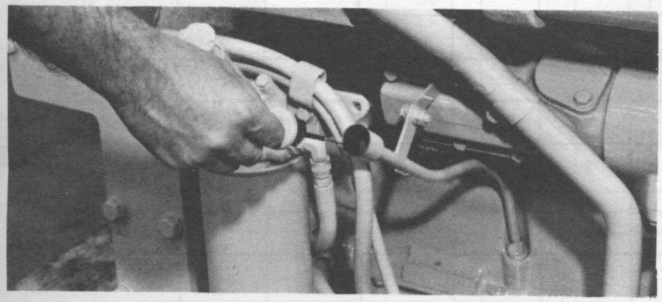
Crankcase Lubrication Oil

The Lubrication and Maintenance Charts list the normal oil change periods as determined by fuel sulphur content. (Make an initial oil and filter change after the first 10 service meter units of operation for reconditioned engines).

See the OIL SPECIFICATIONS to aid in the proper oil SAE viscosity selection. The proper SAE viscosity of oil to select is determined by the ambient temperature at which the engine is started and operated.

Checking Oil Level

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



CAUTION

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

Checking Oil Pressure

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

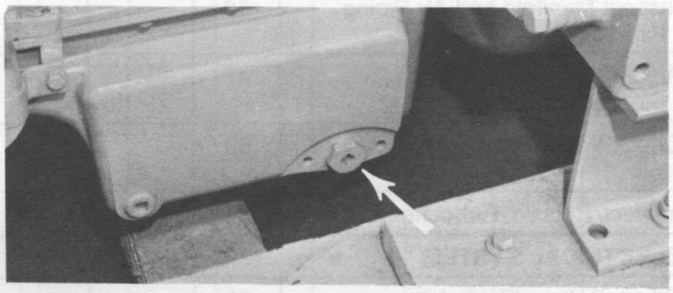
If the indicator fluctuates or registers below NORMAL range:

1. Move the governor control to low idle position.
2. Check the oil level. Be sure to read the ENGINE IDLING side of the dipstick.
3. Add oil until the oil level is at the FULL mark on the ENGINE IDLING side of the dipstick. Do not overfill.
4. Check for oil leaks.
5. If necessary, stop the engine and have repairs made.

Draining Engine Oil

With engine stopped and oil warm:

1. Remove the crankcase oil drain plug.
2. Allow the oil to drain.



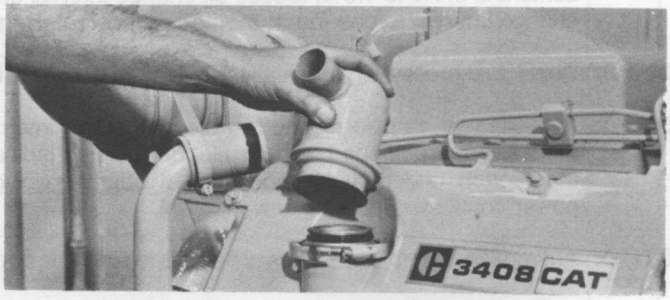
3. Clean and install the drain plug.

OR, if a sump pump is used:

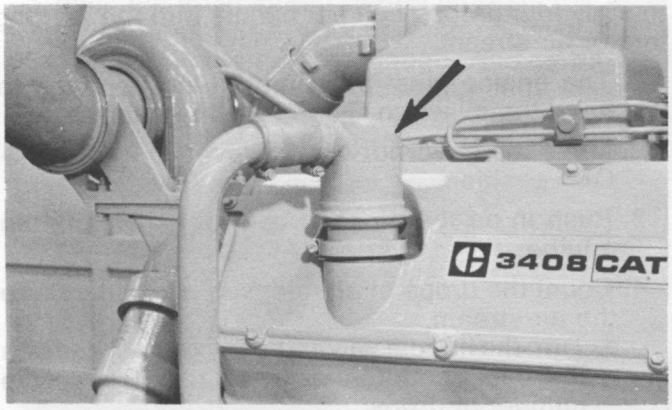
1. Connect a suitable drain line and container to the pump outlet.
2. With engine stopped and oil warm, open the sump pump valve to the engine crankcase drain line: The two marks on the valve must be turned so that one mark points to the pump, and the second mark points to the engine drain line.
3. Operate the sump pump handle until the crankcase is empty.
4. Close the valve to the engine crankcase drain line.

Cleaning the Breather

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



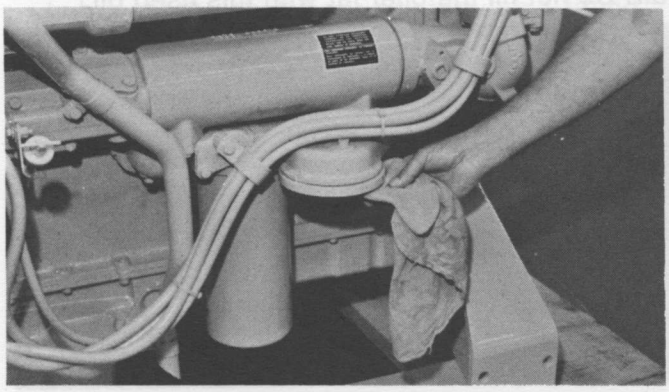
3. Wash the breather in solvent.
4. Allow to drain dry and then wipe.
5. Inspect the gasket. Install a new gasket if necessary.
6. Install the breather.
7. Connect the fumes disposal tube.



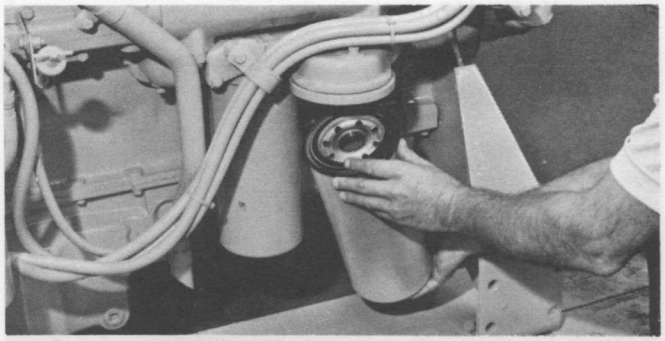
Changing Oil Filter

1. Unscrew and remove the filter.

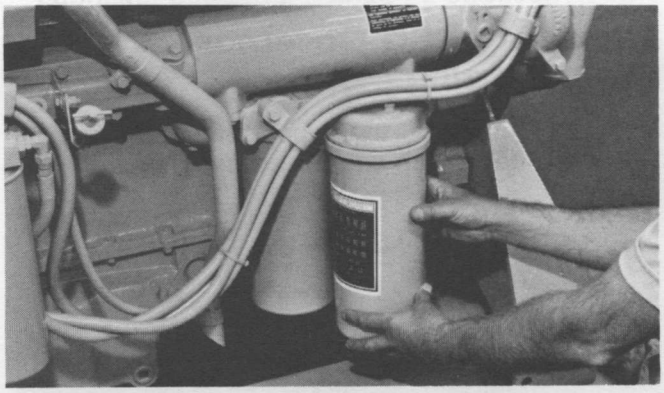
2. Be sure the old filter gasket did not remain attached inside the filter base: Leaking will occur between the new filter gasket and this old gasket.
3. Wipe the filter base.



4. Apply a thin coat of clean oil to the gasket of the new filter.



5. Install the new filter: Hand tighten the filter ¾ turn after the filter gasket contacts the base. Use rotation index numbers, which are painted on the filter can, as a guide for proper tightening.



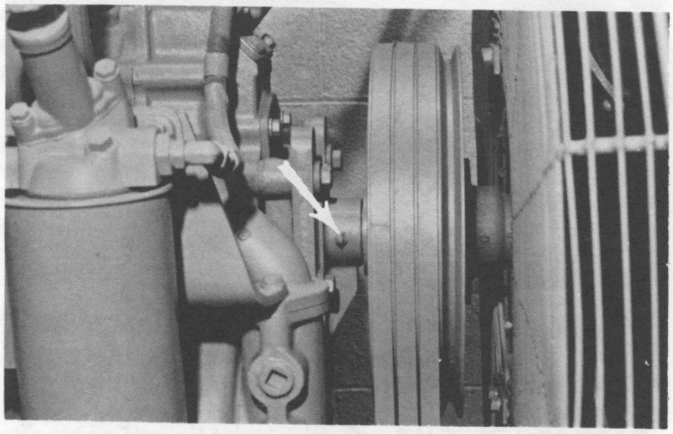
Filling the Crankcase

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

2. Start the engine and check for oil leaks.
3. After the engine is warm, check the oil level with the engine idling.
4. Add oil if necessary to maintain the oil level at the FULL mark on the ENGINE IDLING side of the dipstick.

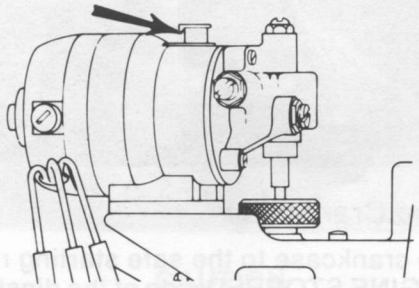
Fan Drive Bearings

Lubricate the fan drive bearings with lubricating grease through one fitting, 1 or 2 strokes.



Woodward PSG Governor Synchronizing Motor

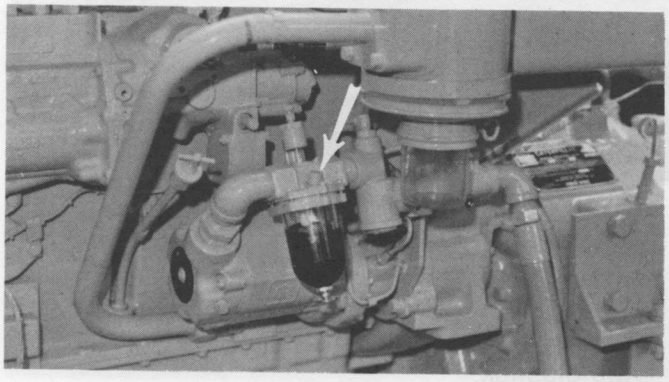
Fill the oil cup on the synchronizing motor with clean engine oil with same viscosity as used in the engine.



Air Starting Motor

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

When the oil jar becomes half empty, remove the oil filler plug and fill the jar with clean engine oil with the same viscosity as used in the engine.



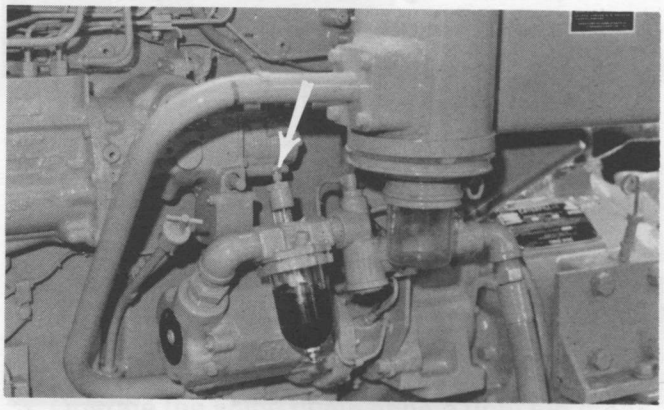
CAUTION

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

Adjusting Oiler Feed

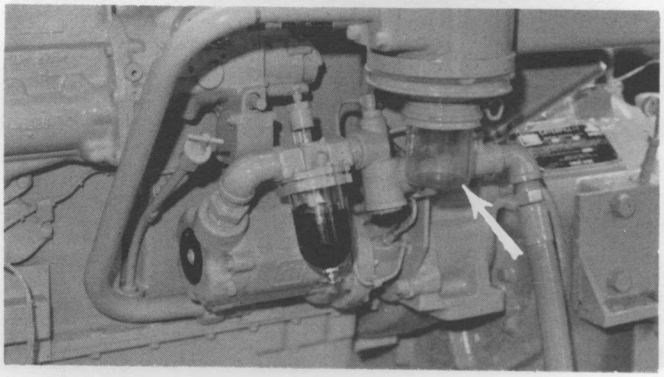
If necessary, adjust the oiler to release approximately four drops of oil per minute into the starting motor air stream.

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



Emptying Oil Collector Jar

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

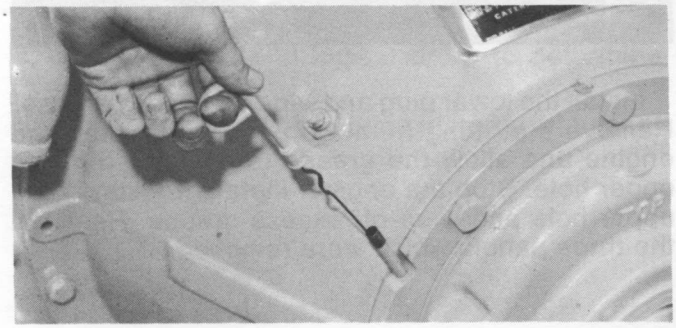


Power Coupling Attachment

Heavy Duty Clutch Main Shaft Bearings

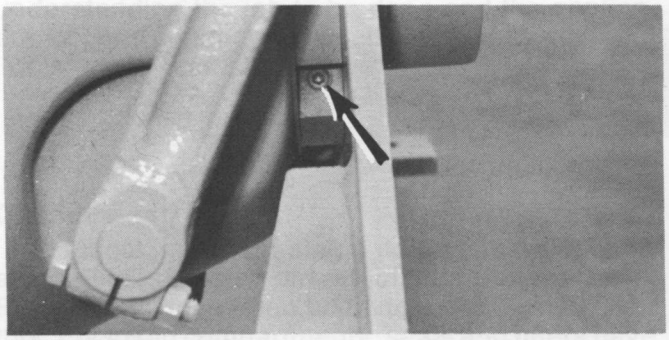
The heavy duty flywheel clutch main shaft bearing is oil lubricated. The remaining bearings are lubricated with grease.

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. Use the same type of oil as used in the engine crankcase. See the OIL SPECIFICATIONS.



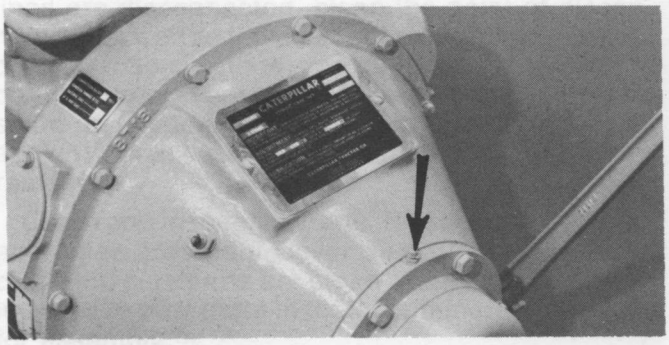
To drain the reservoir:

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.



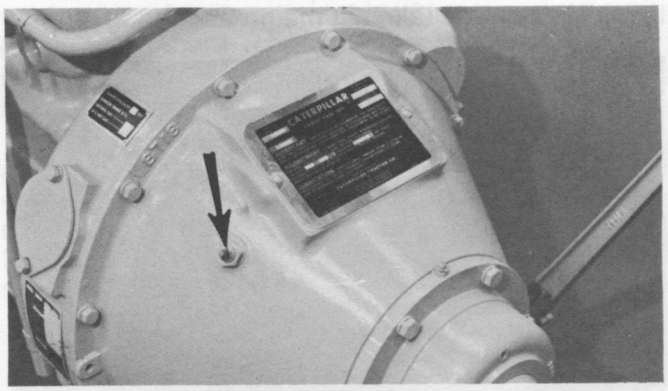
Enclosed Clutch Shaft Bearings (Grease Lubricated)

Lubricate the shaft bearings through 1 fitting.



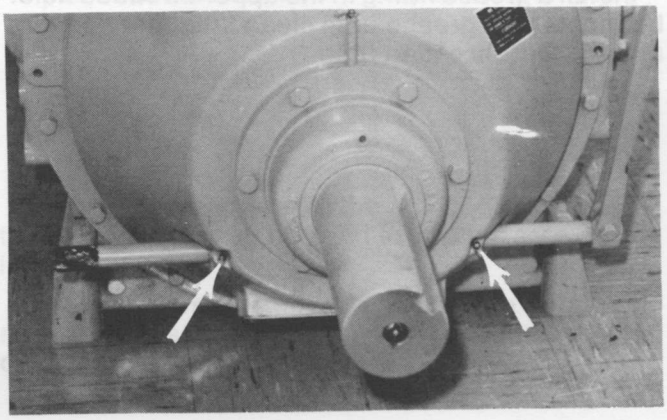
Front/Rear Clutch Engaging Collar

Lubricate through 1 fitting—2 strokes.



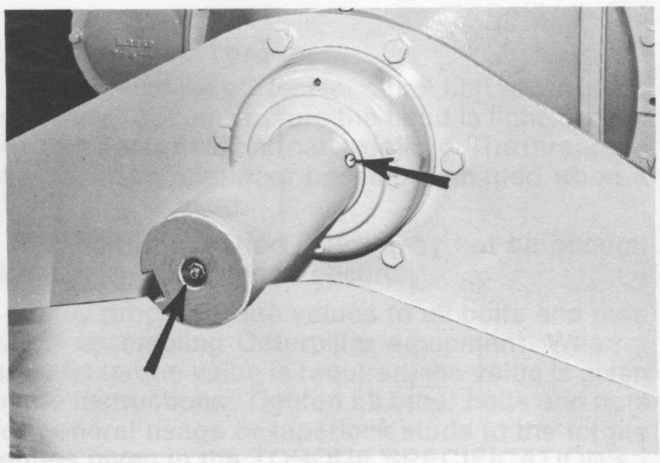
Control Lever Shaft Bearings

Lubricate through 2 fittings—2 strokes.



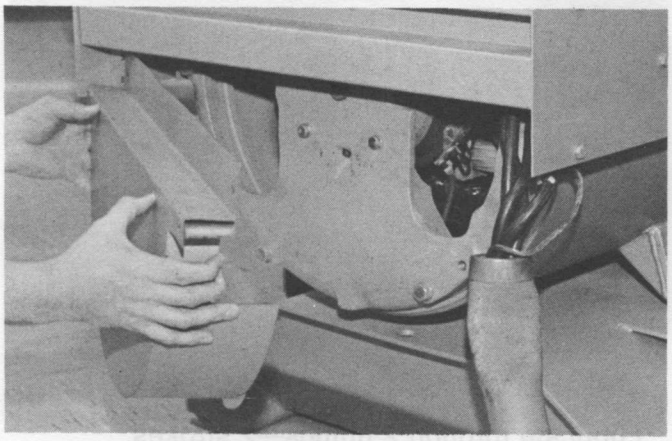
Clutch Pilot Bearing

Lubricate sparingly through 1 fitting on end of shaft. If fitting is not accessible, remove the plug on the circumference of the shaft near the housing and install a grease fitting. Reinstall plug after lubricating.

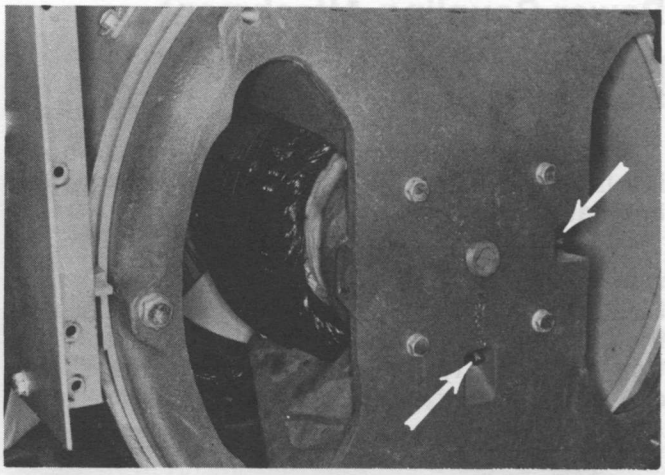


SR4 Generator Rear Bearing

Remove the three lower panels from the rear of the generator and take out the grease fitting plugs.



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



Install the lower plug and wipe off excess grease. Remove the fitting from the upper hole, start the engine and allow the grease to expand from the upper hole. Stop the engine, install the plug in the upper hole and wipe off excess grease. Reinstall the three panels which were removed.

GENERAL MAINTENANCE INSTRUCTIONS

These instructions are a review of many items which a serviceman encounters in servicing and maintaining engines.

Problem Analyzing:

In analyzing a system malfunction, use this systematic procedure to locate and correct the problem.

1. Determine problem.
2. List possible causes.
3. Devise checks.
4. Conduct checks in logical order to determine cause.
5. Consider remaining service life against cost of parts and labor.
6. Make necessary repair.
7. Recheck.

Safety:

Your safety and that of others is always the number one consideration when servicing or maintaining engines. Safety is a matter of thoroughly understanding the job to be done and the application of good common sense. It is not just a matter of "do's" and "don'ts".

Cleanliness:

The most important single item in assuring long engine life is to keep dirt out of vital working parts. Precautions have been taken to safeguard against this. Enclosed compartments, seals and filters have been provided to keep the supply of air, fuel, coolant and lubricants clean. It is important that these safeguards be maintained.

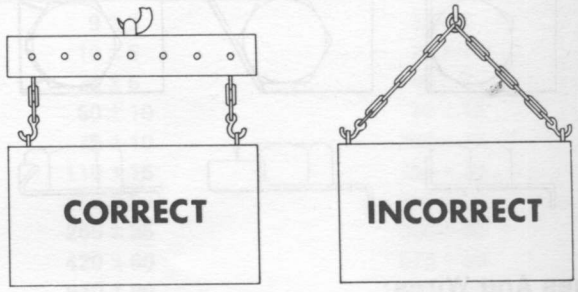
Whenever fuel, lubricating oil, coolant lines or air lines are disconnected, clean the point of disconnection as well as the adjacent area. As soon as the disconnection is made, cap, plug or tape the line or opening to prevent entry of foreign material. The same recommendations for cleaning and covering apply when access covers or inspection plates are removed.

Clean and inspect all parts. Be sure all passages and holes are open. Cover all parts to keep them clean. Be sure parts are clean when they are installed. Leave new parts in their containers until ready for assembly.

Removal And Installation:

Use a hoist to remove heavy components. Lift the engine by using an adjustable lifting beam. All supporting members (chains and cables) should be parallel to each other and as near perpendicular as possible to the top of the object being lifted.

When it is necessary to remove a component on an angle, remember that the capacity of an eyebolt diminishes as the angle between the supporting members and the object becomes less than 90°. Eyebolts and brackets should never be bent and should only have stress in tension.



Some removals require the use of lifting fixtures to obtain proper balance and to provide safe handling.

If a part resists removal, check to be certain all nuts and bolts have been removed and that an adjacent part is not interfering.

Disassembly And Assembly:

When servicing or repairing the engine, complete each step in turn. Do not partially assemble one part and start assembling some other part. Make all adjustments as recommended. Always check the job after it is completed to see nothing has been overlooked.

Bolts And Bolt Torque:

Use bolts of the correct length. A bolt which is too long may "bottom" before the head is tight against the part it is to hold and cause failure. The threads in the assembly can also become damaged when a "long" bolt is used.

If a bolt is too short, there may not be enough threads to hold the part securely.

Apply proper torque values to all bolts and nuts when assembling Caterpillar equipment. When a specific torque value is required, the value is given in the instructions. Tighten all other bolts and nuts for general usage or taperlock studs to the torque values given in the TORQUE SPECIFICATIONS.

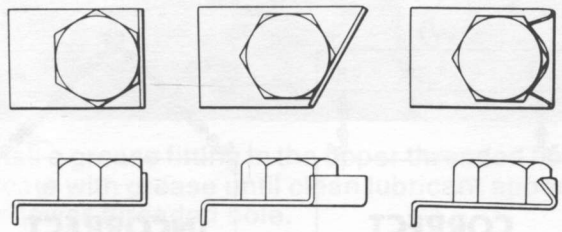
Locks:

Lockwashers, flat metal locks or cotter pins are used to lock nuts and bolts.

Flat metal locks must be installed properly to be effective. Bend one end of the lock around the edge of the part. Bend the other end against one flat surface of the nut or bolt head.

Always install new locks in compartments which house moving parts.

When installing lockwashers on housings made of aluminum, use a flat washer between the lockwasher and the housing.



Lines And Wires:

When removing or disconnecting a group of lines or wires, tag each one to assure proper assembly.

Lubrication:

Where applicable, fill the compartments of the components serviced with the amount, type and grade of lubricant recommended in the Lubrication Instructions.

Rust Preventive Compoung:

Clean the rust preventive compound from all machined surfaces of new parts before installing them.

Shims:

When shims are removed, tie them together and identify them as to location. Keep shims clean and flat until they are reinstalled.

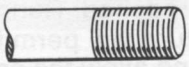
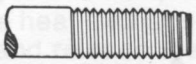
Gaskets:

Be sure the holes in the gaskets correspond with the lubricant passages in the mating parts. If it is necessary to make gaskets, select stock of the proper type and thickness. Be sure to cut holes in the right places. Blank gaskets can cause serious damage.

When removed, always install new cylinder head and manifold gaskets using recommended gasket compound on head gaskets to allow uniform sealing.

GENERAL TIGHTENING TORQUE FOR BOLTS, NUTS AND TAPERLOCK STUDS

The following charts give the standard torque values for bolts, nuts and taperlock studs of SAE Grade 5 or better quality. Exceptions are given in other sections of the Service Manual where needed.

THREAD DIAMETER		STANDARD TORQUE	
inches	**millimeters**	**lb. ft.**	**N·m**
Standard thread 		Use these torques for bolts and nuts with standard threads (conversions are approximate).	
1/4	6.35	9 ± 3	12 ± 4
5/16	7.94	18 ± 5	25 ± 7
3/8	9.53	32 ± 5	45 ± 7
7/16	11.11	50 ± 10	70 ± 15
1/2	12.70	75 ± 10	100 ± 15
9/16	14.29	110 ± 15	150 ± 20
5/8	15.88	150 ± 20	200 ± 25
3/4	19.05	265 ± 35	360 ± 50
7/8	22.23	420 ± 60	570 ± 80
1	25.40	640 ± 80	875 ± 100
1 1/8	28.58	800 ± 100	1100 ± 150
1 1/4	31.75	1000 ± 120	1350 ± 175
1 3/8	34.93	1200 ± 150	1600 ± 200
1 1/2	38.10	1500 ± 200	2000 ± 275
Taperlock stud 		Use these torques for studs with Taperlock threads.	
1/4	6.35	5 ± 2	7 ± 3
5/16	7.94	10 ± 3	15 ± 5
3/8	9.53	20 ± 3	30 ± 5
7/16	11.11	30 ± 5	40 ± 10
1/2	12.70	40 ± 5	55 ± 10
9/16	14.29	60 ± 10	80 ± 15
5/8	15.88	75 ± 10	100 ± 15
3/4	19.05	110 ± 15	150 ± 20
7/8	22.23	170 ± 20	230 ± 30
1	25.40	260 ± 30	350 ± 40
1 1/8	28.58	320 ± 30	400 ± 40
1 1/4	31.75	400 ± 40	550 ± 50
1 3/8	34.93	480 ± 40	650 ± 50
1 1/2	38.10	550 ± 50	750 ± 70

COOLING SYSTEM

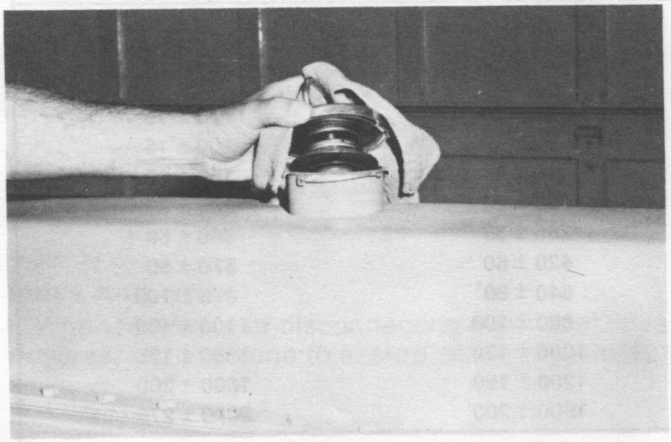
Coolant Level

Check the engine coolant daily with the engine stopped and cool.

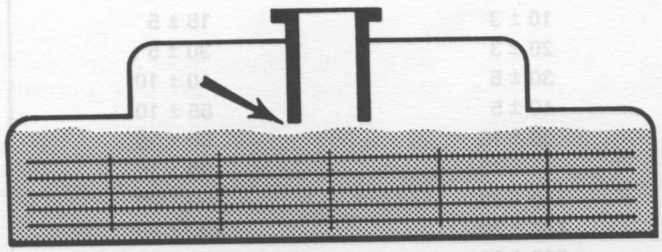
1. Slowly turn the filler cap to the first stop to release pressure.

⚠WARNING
Be careful: If the engine is warm-steam may spray outward under high pressure.

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



3. Maintain coolant level to the base of the fill pipe.



4. Make-up coolant should be with water free as possible from scale forming minerals (not softened water) and a permanent type antifreeze containing rust inhibitor or a solution of water and Caterpillar Corrosion Inhibitor. Follow the recommendations given on the container.

Maintain a 3% concentration of Caterpillar Corrosion Inhibitor.

CAUTION
Do not use with Dowtherm 209.

Make-up water added without the proper proportions of coolant corrosion inhibitor can cause excessive lime deposits and corrosion.

CAUTION
Add coolant slowly to a hot engine to prevent possible cracking or distorting the cylinder head.

If a loss of coolant is noticeable, check for leaks in the system. After filling the system, start the engine and recheck the coolant level after normal operating temperature is reached. Running the engine at operating temperature will permit the temperature regulator to open and allow the coolant to circulate through the entire system and purge air from the engine.

If a permanent antifreeze solution is used in the cooling system, either renew the rust inhibitor every three months by adding Caterpillar Corrosion Inhibitor, or drain the entire cooling system annually and refill with fresh coolant solution.

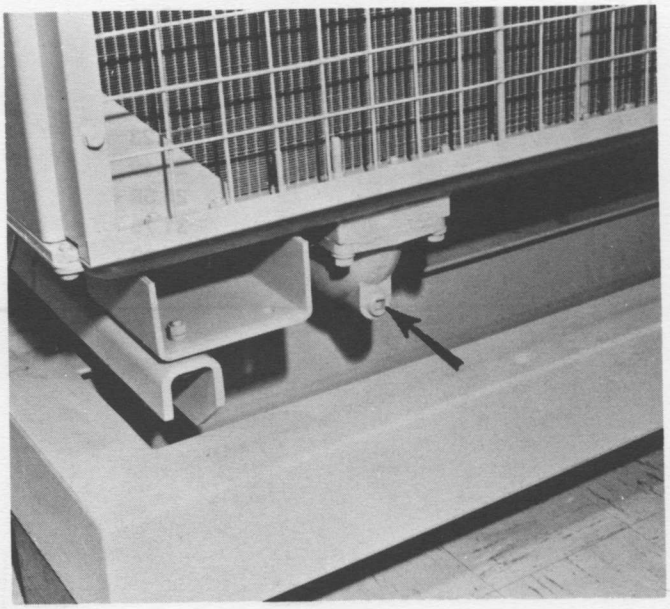
Draining The Cooling System

To clean the cooling system or replace the coolant solution, it is necessary to completely drain the cooling system.

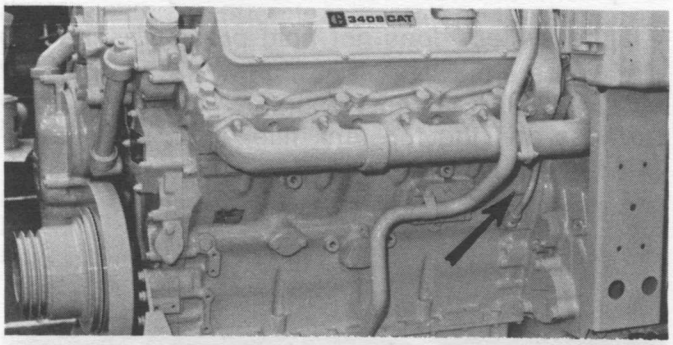
1. Stop the engine.
2. Slowly turn the pressure cap until the cap is removed.

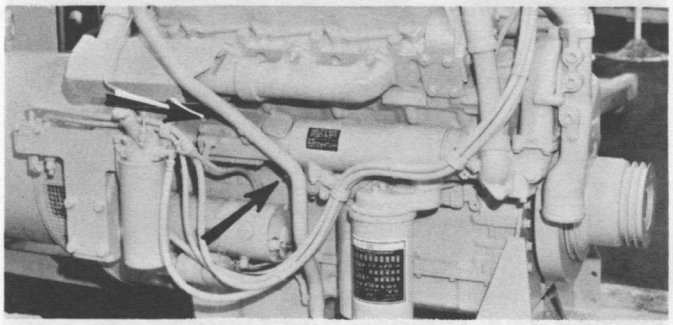
⚠ WARNING
Be careful. If the engine is warm-steam may spray outward under high pressure.

3. Open the radiator drain valve.



4. Remove block and oil cooler drain plugs.





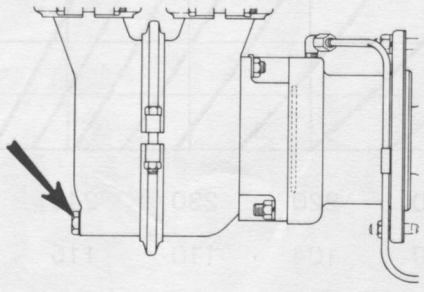
Draining Heat Exchanger Cooling System

1. Stop the engine.
2. Slowly turn the heat exchanger pressure cap to the first stop and release the 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. Remove the drain plugs to drain tank, pump, block and lines.
5. If the ambient temperature is expected to go below freezing, drain the raw water line between the heat exchanger and the raw water pump.



RAW WATER PUMP DRAIN

Cleaning The Radiator (External):

Every 250 hours clean dirt and trash from between the tubes of the radiator which may cause excessively high operating temperature. Wash, brush or blow the dirt out with whichever method is available and most effective.

Cleaning The Cooling System (Internal):

Clean the cooling system periodically. Mineral deposits can cause serious engine damage by retarding the transfer of heat to the coolant. A deposit of lime 1/32 inch thick insulates the same amount as 2 inches of steel, reducing the heat transfer substantially. Loose scale and sediment deposited in the cooling system will reduce circulation, resulting in possible engine damage.

To clean, stop the engine when it is at normal operating temperature and drain as quickly as possible.

Flush thoroughly, then fill with a solution of one pound of Oxalic Acid or Sodium Bisulfate per five gallons of water. Run the engine at operating temperature one-half to one hour, then drain and flush until water is clear. Fill with a solution of one-half pound of Sal Soda per ten gallons of water and run the engine ten minutes. Drain, flush and fill with water, adding coolant conditioner and the desired amount of antifreeze.

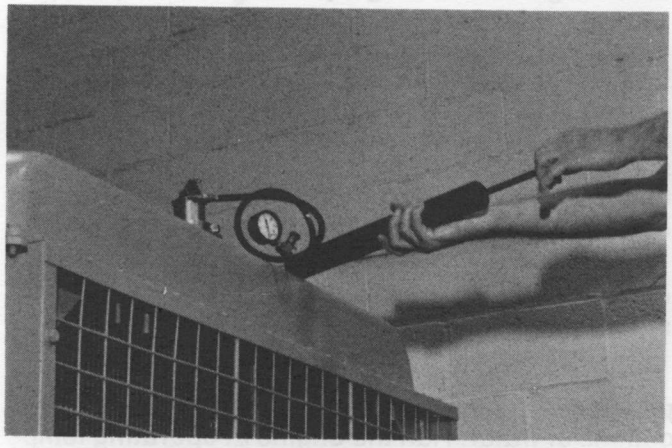
Cooling System Pressure

A pressure relief cap on the radiator or expansion tank controls the pressure of the cooling system and prevents the loss of coolant through the radiator overflow tube.

Pressurizing the cooling system serves two purposes. First, it permits safe operation at coolant temperatures higher than the normal boiling point, providing a margin of cooling for intermittent peak loads. Secondly it prevents cavitation in the water pump, and reduces the possibility of air or steam pockets forming in the coolant passages. Proper operation of the pressure relief cap assembly is essential. A pressure relief cap allows pressure (and some water, if the cooling system is too full) to escape when the pressure in the cooling system exceeds the capacity of the pressure cap. Loss of pressure will cause steam to form when coolant temperature is above the normal boiling point.

The cooling system is designed to work under a pressure of 4-7 PSI (7 PSI is recommended) to allow a high heat transfer for size of radiator and fan combination. In a pressurized system, a leaking radiator cap allows loss of pressure and coolant. For a simple check of cooling system pressure, install a pressure gauge in the radiator top tank and pressurize the system. Do this by either using an air

valve and external air supply, hand pump, or by operating the machine until the coolant reaches operating temperature. System pressure should rise to approximately 7 PSI, and any additional pressure should force air past the relief valve through the overflow opening. Do not allow pressure to exceed 10 PSI. The system should hold a minimum pressure of approximately 7 PSI, and a



PRESSURIZING THE SYSTEM

pressure must remain constant with the air supply shut off or the engine running at a constant temperature.

If the pressure isn't maintained, overflow loss can occur as cooling system temperature rises. Do not remove the cap while the system is at operating temperature. Check coolant level only when cold.

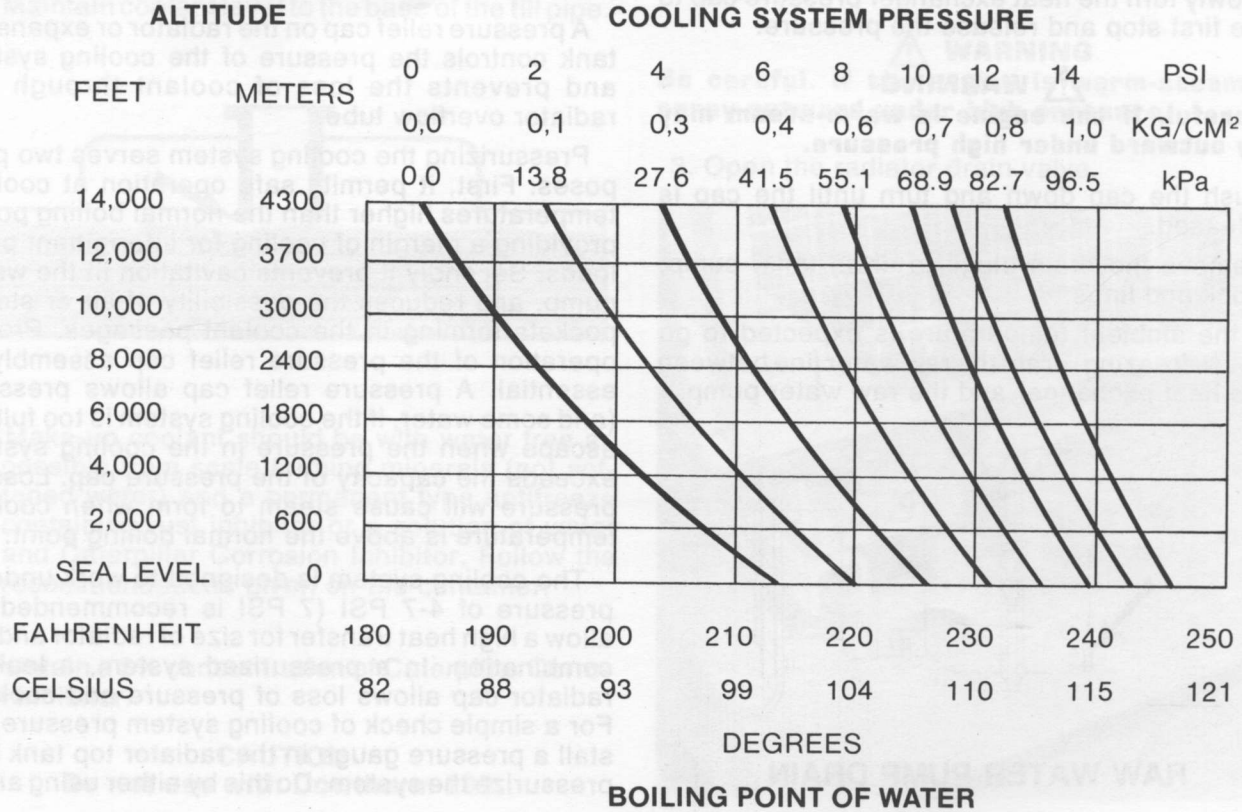
If the system does not hold pressure, find the leak.

Carefully inspect the radiator cap, seals, sealing surfaces and the top tank filler neck surface for damage.

RADIATOR CAP

Testing The Temperature Gauge

Remember that boiling point temperature and pressure go hand-in-hand and neither one can be tested logically without considering the other. For example, the effect of pressurization and altitude on the boiling point of water is shown in the chart.

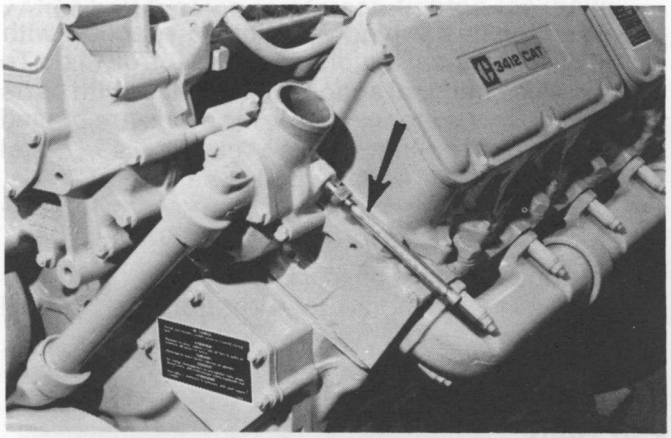


BOILING POINT OF WATER

If overheating and loss of coolant is a problem, a pressure loss in the system could be the cause. If an overheating condition is indicated on the temperature gauge and loss of coolant is not evident, check the accuracy of the temperature gauge. Make this check by installing a thermometer with a suitable bushing into the cylinder head.

Start the engine. Partially cover the radiator to reduce air flow and cooling. The reading on the instrument panel gauge should agree with the reading on the thermometer.

⚠ WARNING
Use CAUTION when working around moving parts with the engine running.

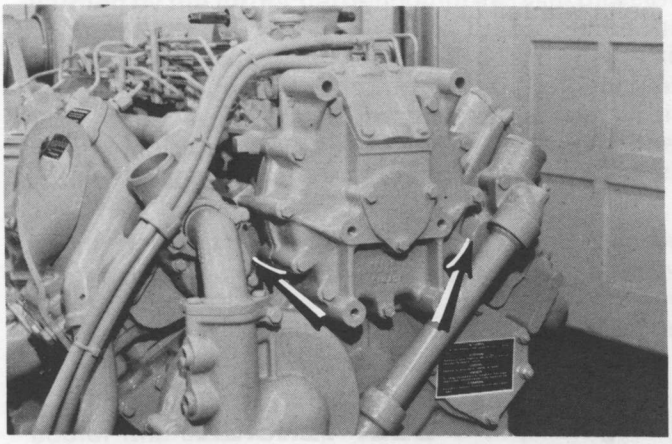


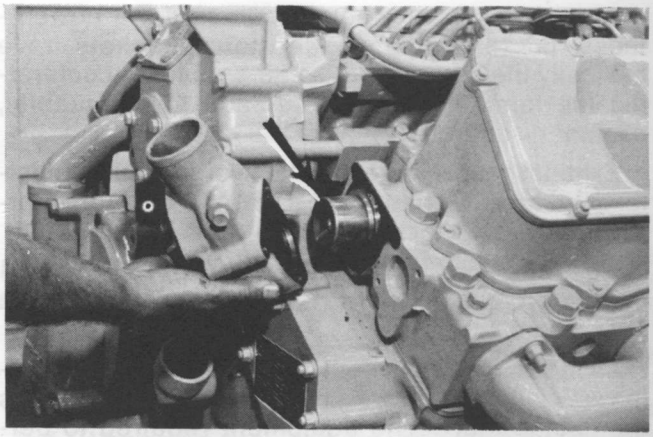
CHECKING COOLANT TEMPERATURE WITH THERMOMETER

Temperature Regulators

There is a temperature regulator located at the front of each cylinder head.

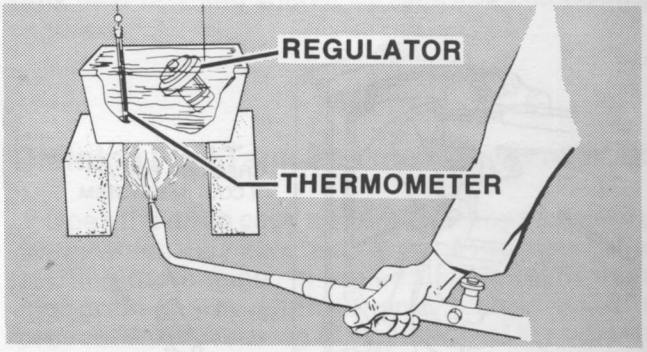
The opening temperature of the regulator (bench test in atmospheric pressure) should be 175 ± 2°F (70 ± 2°C). The regulator should be fully open at approximately 197°F (92°C).





1. Remove the regulator from the housing.
2. Submerge the regulator and a thermometer in a pan of water as shown.
3. Apply heat to the pan and stir the water to maintain uniformity.
4. Observe the opening temperature of the regulator.

If the regulator does not operate correctly, install a new one.



Cooling System Hoses

Inspect all coolant hoses annually and replace if they show signs of cracking or leaking. Periodically replace all hoses, as it is many times difficult to determine the condition of a water hose by visual inspection and feel. Coolant hoses are expendable items and periodic replacement is considered good maintenance practice.

Air, Gases And Steam In The System

Incomplete or improper filling is a major cause of air in the cooling system. Also, leaks in various components such as the aftercooler, and hoses allow air to enter the cooling system, especially on the inlet side of the water pump.

Air in the system produces foaming or aeration and affects water pump performance. The air bubbles insulate various parts of the engine from the coolant, and hot spots form. As the air bubbles cir-

culate or break up, coolant contacts the hot surfaces, creating steam. The steam pockets have basically the same effect as air bubbles, accelerating the formation of more steam. Consequently, coolant discharges through the overflow.

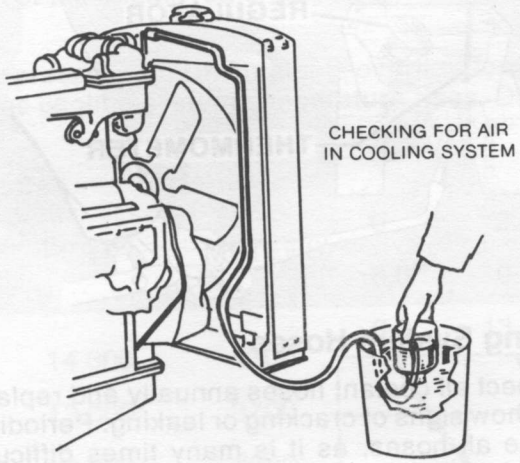
Exhaust gas leakage into the system causes similar conditions. Exhaust gas can enter through internal cracks or defective cylinder head gaskets.

Most of the causes can be checked by a visual inspection, while others require disassembly or a simple test.

Air in the cooling system is one cause of overheating which can be located by a simple test known as the "bottle test". The equipment required to perform such a test consists of a 1 pint bottle, a bucket of water, and a length of hose with an inside diameter large enough to fit over the end of the radiator overflow pipe.

To Test

Fill the cooling system to proper level. Wire open the relief valve in the radiator cap. Install the radiator cap and tighten. Assemble the rubber hose over the end of the overflow pipe.



CHECKING FOR AIR IN COOLING SYSTEM

Start the engine and operate it at high idle speed for at least five minutes after the engine reaches operating temperature. Block off part of the air flow through the radiator to maintain operating temperature. After the temperature has stabilized and all expansion air has vented out, place the loose end of the hose in the water filled bottle which is inverted in the bucket of water. If it takes less than a minute to displace the water in the pint bottle, leakage into the cooling system is excessive.

Loose precombustion chambers, faulty precombustion chamber seals, a loose cylinder head, or a damaged head gasket are possible causes of air in the cooling system. In any case, the cause should be corrected immediately.

Water Pump

The water pump circulates the coolant through the aftercooler and oil cooler, the cylinder block, cylinder head, and radiator. Poor coolant circulation causes overheating. A badly corroded or worn water pump impeller, or even a loose impeller, reduces circulation and efficiency.

Every 2000 hours inspect the water pump and rebuild as necessary, or install a rebuilt pump to reduce downtime to a minimum. Your authorized dealer is familiar with worn replacement limits and with disassembly and assembly procedures.

Raw Water Zinc Rods (Salt Water Only)

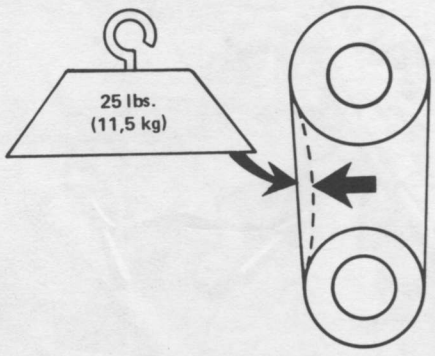
Salt water has a highly corrosive reaction with metal by a chemical action called "electrolysis". To prevent this chemical action taking place, with parts used in the raw water system, zinc plugs are placed in the raw water piping. Zinc is a relatively soft metal which reacts quite readily with the salt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

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

Fan Belts

Examine the drive belts annually for wear and replace if they show signs of wear. Loose or worn pulley grooves cause belt slippage and low fan speed. If fan belts are too loose, they vibrate enough to cause unnecessary wear on the belts and pulleys and possibly slip enough to cause overheating.

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 carry all the load-as it will not be stretched as much as the older belts-and all the belts will fail in rapid succession.



BELT TENSION

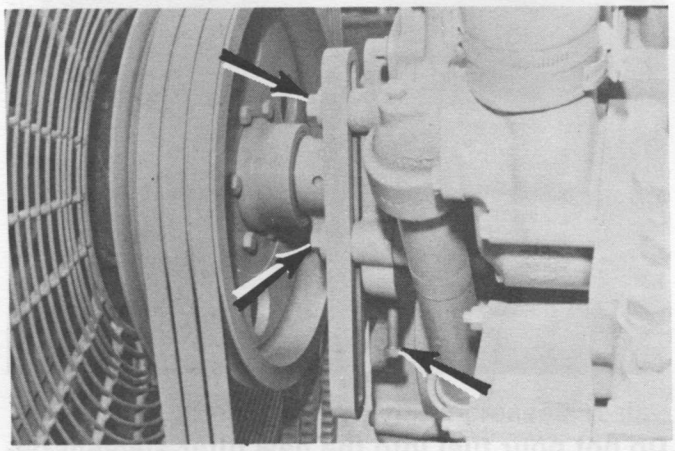
Adjustment:

Check new belts for adjustment after the first 10 hours and every 250 hours thereafter. To check belts-apply 25 lbs. (11.5 kg) force midway between pulleys. Correctly adjusted belts will deflect ½ inch (12.5 mm) to ¾ inch (19 mm) for the first check. Maintain later adjustments at 7/8 inch (23 mm).

To Adjust:

Loosen the lockbolts on the fan pulley adjusting bracket and adjust fan pulley with the adjusting bolt. After belt tension is correct, tighten lockbolts.

Readjust alternator belt tension and tighten adjusting nuts.



Aftercooler

Some engines may be equipped with an aftercooler. The aftercooler is a simple device resembling a small radiator core. Water from the engine passes through the core tubes. Engine inlet air, warmed by the turbocharger compressor is directed through the core and around the tubes. Since the temperature of the water is lower than the air, the air is cooled as it leaves the aftercooler and becomes more dense as it enters the intake manifold. This means more air (oxygen) is available for combustion, resulting in more fuel being burned and more power produced.

One degree increase in inlet air temperature increases exhaust temperature approximately three degrees. Restrictions to either coolant or air flow reduce aftercooler efficiency and severly affect the engine and cooling system.

When engine is being rebuilt, remove the aftercooler and clean core, water and air passages.

FUEL SYSTEM

Care Of The Fuel Supply

Too much emphasis cannot be placed on the importance of using only clean diesel fuel. It is important to buy clean fuel and keep it clean. The best fuel can be rendered unsatisfactory by inadequate storage facilities or careless handling.

Effort should be constantly expended to prevent contamination of the fuel. An important step is to reduce the number of times the fuel must be handled. When the fuel can be delivered by the distributor to storage tanks and then pumped from the storage tank to the diesel fuel tank, the handling is reduced to a minimum.

Care Of The Diesel Fuel Tank

Fill the fuel tank at the end of the day, because the incoming fuel will drive out the moisture-laden air and prevent condensation. The strainer in the fuel tank filler opening should be removed and cleaned regularly.

Draining Fuel Tank Sediment Accumulation

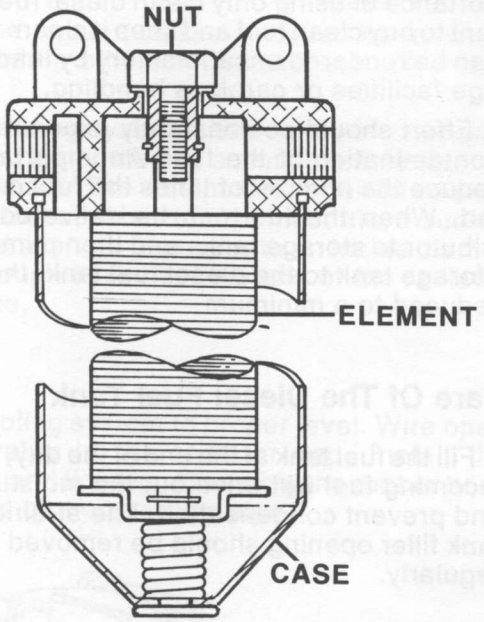
Open the drain cock and drain off any sediment or water which may accumulate in the fuel tank before starting the engine. In temperatures below freezing, drain shortly after the engine has stopped to prevent water freezing in the bottom of the tank and other low points in the system.

Fuel Filtering System

As either the primary fuel filter element or the final fuel filter element gradually become clogged with foreign material, lack of horsepower will be noticed and the position of the fuel gauge indicator will work back from the original position in the NORMAL (green or approximately 30 PSI) range to the OUT (red or approximately 20 PSI) range. Every 250 hours or when the indicator shows in the OUT (red) range, the metallic primary fuel filter element (if equipped) should be removed and washed. If the indicator still shows in the OUT (red) range, the final filter element should be replaced with a Caterpillar filter element. Other make fuel filters may not meet filtering or capacity requirements. See the topics, PRIMARY FUEL FILTER and FINAL FUEL FILTER.

Primary Fuel Filter (Optional)

To remove the filter element, stop the engine and shut off the diesel fuel tank valve. Loosen the nut on the filter cover and lower the filter case. Remove the element and wash in clean solvent or diesel fuel. Reinstall the element.

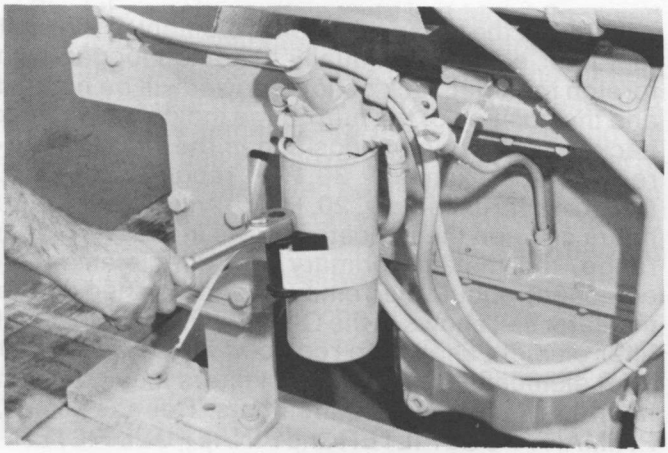


Final Fuel Filter

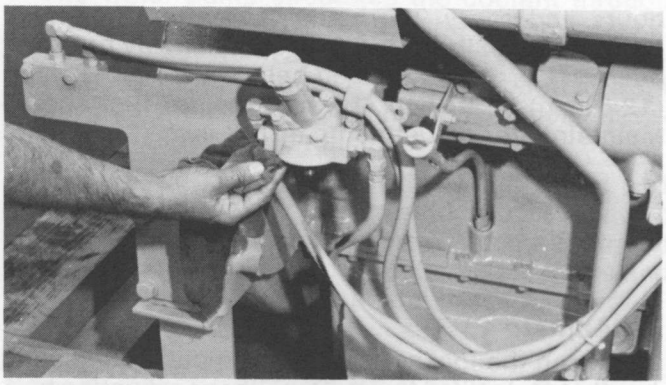
The filter element collects and holds contaminants and cannot be washed or otherwise restored.

To remove the used filter, proceed as follows:

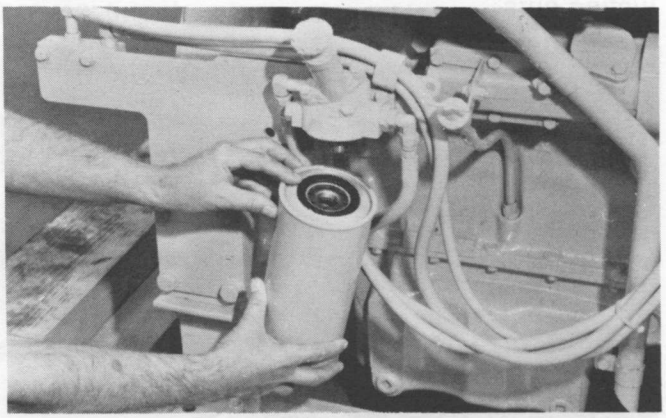
1. Stop the engine and close the diesel fuel line valve (if equipped).
2. Unscrew and remove filter.



3. Clean the gasket sealing surfaces on the filter bases.



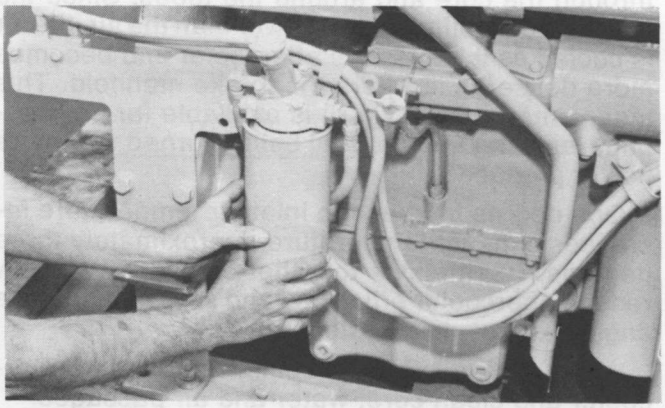
4. Lubricate the new filter gasket with clean diesel fuel.



CAUTION

Do not pour fuel into the new filter element before installing. Prime the system as instructed in the topic, PRIMING THE FUEL SYSTEM.

5. Tighten the filter by hand until the gasket contacts the base, then tighten ½ to ¾ turn more.
6. Start the engine and run at 1000 rpm for several minutes and check for leaks. If the engine fails to start, prime the fuel system. See the topic TO PRIME THE SYSTEM.



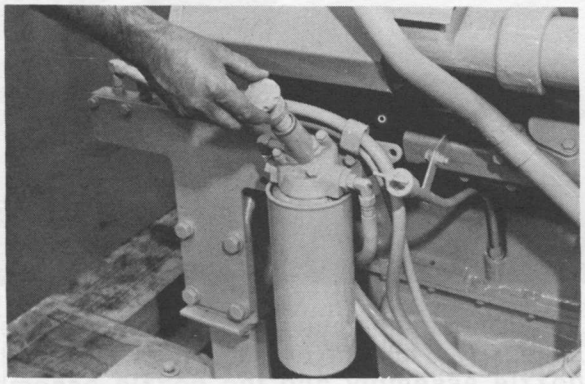
Keep New Fuel Filters On Hand

Extra filters should be kept on hand for replacement. Always keep filters wrapped in their original carton to insure against dust and dirt accumulation which will shorten the life of the filters or may cause damage to the fuel injection equipment.

To Prime The System

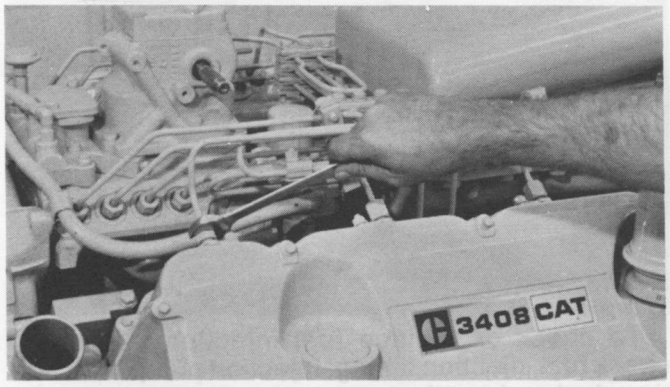
If air is trapped in the fuel system, the diesel engine will either not start, or will misfire. Then it is necessary to prime the system.

The fuel priming pump is mounted on the fuel filter base. If the fuel filter is changed or if the engine has run out of fuel, prime the fuel system as follows:



1. Be sure the fuel line valve is open and the engine shutoff control is off.
2. Unlock the fuel priming pump.
3. Operate priming pump until increased resistance is felt.
4. Lock fuel priming pump.

If the engine fails to start or continues to misfire or smoke, further bleeding is necessary. With engine running, or with the use of the priming pump, loosen fuel line nuts, one at a time, several times in succession and allow fuel to run until free of air bubbles. Tighten fuel line nuts.



LOOSENING FUEL INJECTION LINE TO BLEED SYSTEM

Fuel Injection Equipment

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

If the engine is running irregularly, smoking, or knocking, a fuel injection valve may not be spraying the fuel properly.

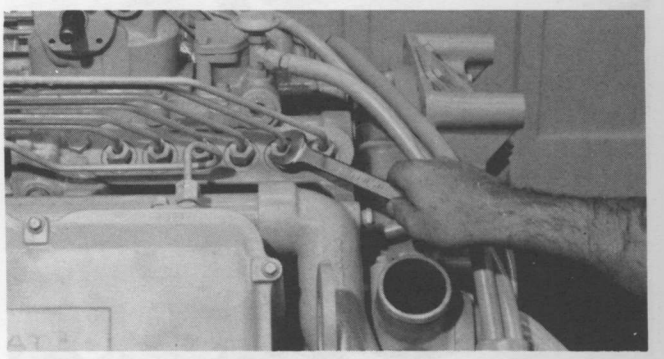
Direct Injection System

The fuel system of direct injection engines is essentially the same as precombustion chamber engines. The absence of the precombustion chamber requires a different fuel nozzle and adapter. Externally the direct injection fuel nozzle resembles the precombustion chamber nozzle except it is longer in length. Nozzle testing and replacement procedure is the same as illustrated for the precombustion chamber engines, except that an extracting tool is used to remove the fuel nozzle and adapter. The seal on the adapter should be inspected and replaced if damaged.

Precombustion Chamber Injection System

Testing Fuel Injection Valves

Whenever an engine performs in such a manner that a fuel injection valve is suspected of causing trouble, test all fuel injection valves. To test the injection valves: Loosen the fuel injection line nut at the fuel injection pumps, one at a time, while the engine is running. When a nut is loosened and the exhaust smoking is completely or partially eliminated and the irregularity in running is not affected,



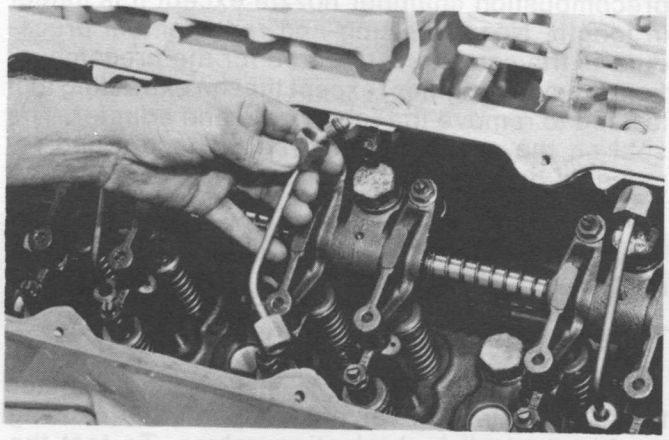
LOOSENING FUEL INJECTION LINE NUT TO TEST VALVE

this identifies the probable location of a defective valve and a new one should be installed in that cylinder to definitely determine if the valve removed was defective. Never wire brush or scrape a fuel injection nozzle assembly as this will damage the finely machined orifice. Your authorized dealer has the proper tools for cleaning and testing fuel injection valves.

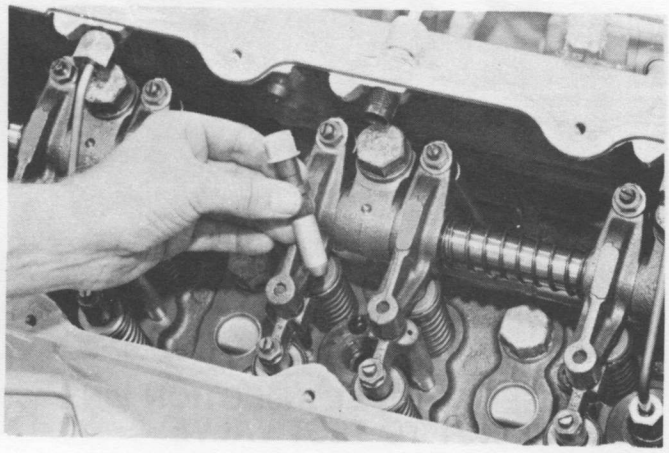
Remove Fuel Injection Valve

Clean dirt from around the valve cover and remove. Before removing an injection valve, clean the dirt from around the valve and line connections. Disconnect the lead wire from the glow plugs. (If so equipped)

Loosen the fuel injection line at the valve housing and disconnect it from the valve. Immediately install plugs to prevent dirt from entering the fuel injection



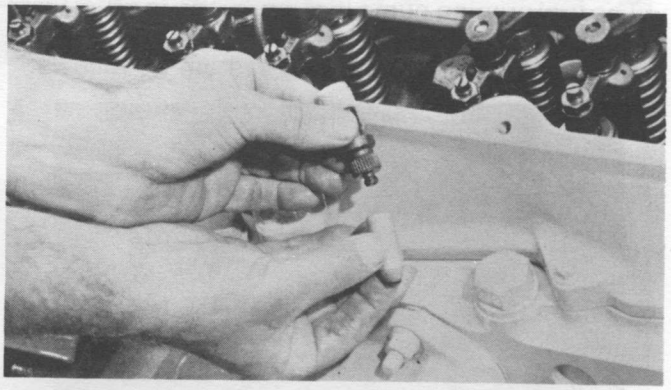
line. Remove the valve retainer nut and lift out the fuel injection nozzle assembly and body as a unit. If the fuel injection valve will not be immediately installed, caps should be put on the valve body to prevent dirt entering the valve assembly.



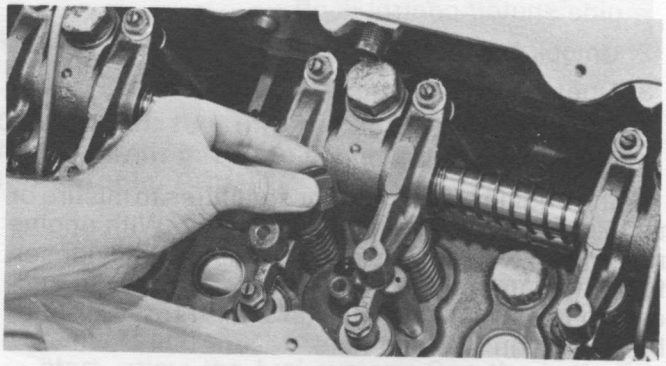
Installing Fuel Injection Valves

Before installation of a fuel injection valve, be sure the wrench is clean. Install the fuel injection valve in the following manner.

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



3. Install the retainer nut and tighten to a torque of 55 lb.ft. (7.6 mkg) to prevent leaks between the nozzle assembly and the nozzle assembly seats.



INSTALLING RETAINER NUT

CAUTION
Do not overtighten. Use torque wrench.

4. Connect the fuel injection line and tighten the nuts.

Fuel Injection Pumps

To check or replace fuel injection pumps, to check fuel injection timing, injection pump lifter setting, fuel rack setting and governor adjustments, it is recommended they be performed by an authorized dealer.

Governor

Check the engine high and low idle RPM at the first oil change period and every 1,250 service hours thereafter. To check, remove tachometer drive cable (or cap) from the tachometer drive housing in front of the fuel pump housing. See the information plate on the engine for engine RPM. It is recommended this adjustment be made by an authorized dealer.

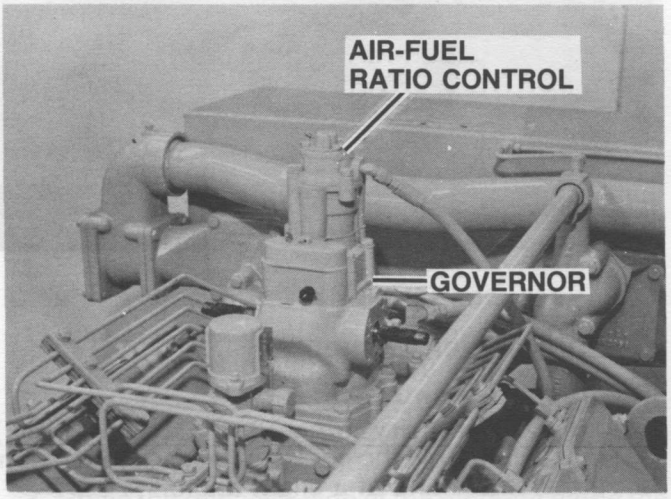
NOTE

Tachometers on the panel are usually not sufficiently accurate to check high and low idle engine RPM. Always use an accurately calibrated tachometer.

Air-Fuel Ratio Control

The air-fuel ratio control is a device to control the smoke emission of an engine during its operation when low inlet manifold pressure exists.

Low inlet manifold pressure occurs during operation at low torque output. During this type of operation the air-fuel ratio control regulates the maximum fuel injected into each cylinder. If the controlling diaphragm within the air-fuel ratio control should rupture, the fuel system will be restricted the same as it would be with low inlet manifold pressure. Slow engine response and low power may indicate a need for adjustment or repair. Authorized dealers are equipped with the necessary tools, personnel and procedures to perform these service.



Air Cleaners (Caterpillar Dry-type Air Cleaners Only)

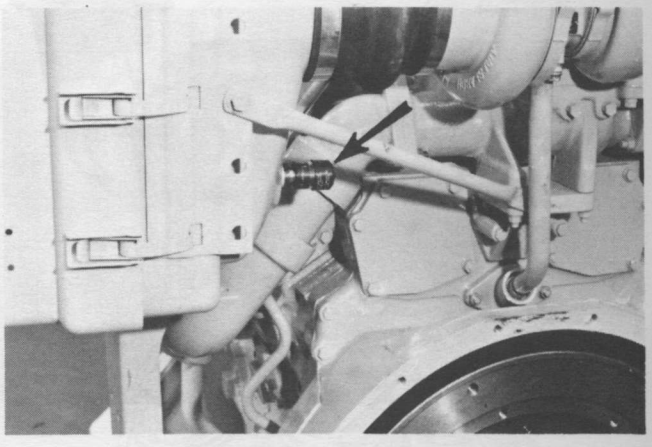
Regular service intervals, along with close visual inspection of the air cleaner, are necessary for proper cleaning of the engine inlet air. The service interval will vary with the weather and working conditions. Where dust conditions are severe, it will be necessary to service the air cleaner frequently.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

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

Visual inspection of the gaskets and seals is important in keeping dust from bypassing the air cleaner. Any dirt allowed to enter, accelerates wear throughout the engine. If the condition of any of the replaceable seals and gaskets is questionable, replace them. If the sealing ends of the filter element or the element pleats are damaged, replace the element.

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

The air service cleaner indicator is connected to the air inlet pipe between the air cleaner and the turbocharger. It contains a red marked piston, which gradually rises with restriction to the air flow. When the entire piston is visible it will lock in this position. This indicates a need for air cleaner service. The piston will remain in this position whether or not the engine is running. After servicing the air cleaner, reset the piston by depressing the plunger in the bottom of the indicator.



AIR CLEANER SERVICE INDICATOR

Excessive engine exhaust smoke and/or loss of power may indicate the need for servicing the air cleaner. Never service the air cleaner while the engine is running.

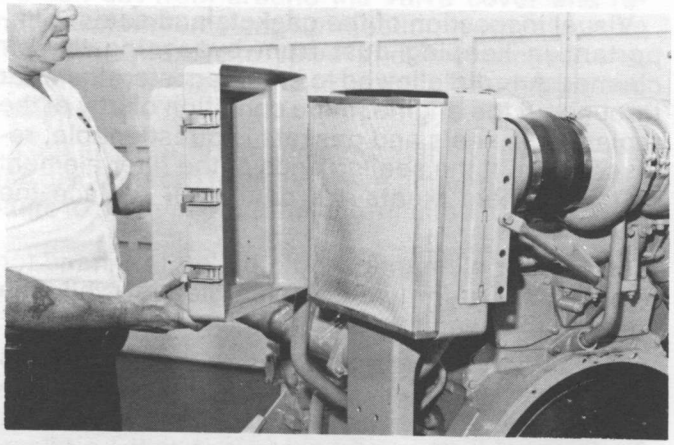
Single Stage Air Cleaner

Changing Filter Element

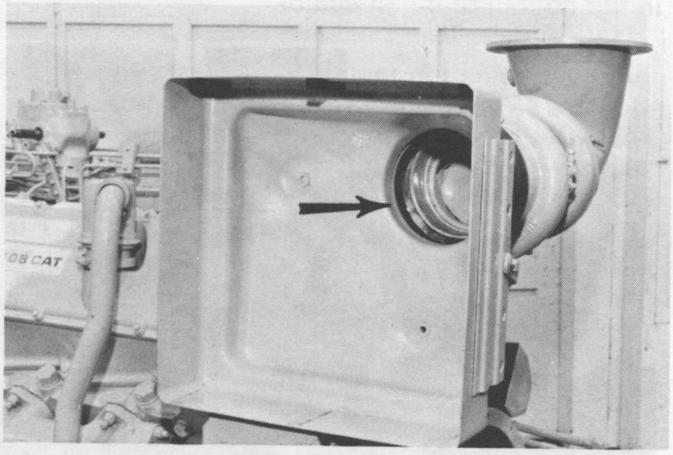
CAUTION

Service the air cleaner with the engine stopped.

1. Remove the air cleaner cover and element.



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



4. Inspect the replacement element for damage and cleanliness.

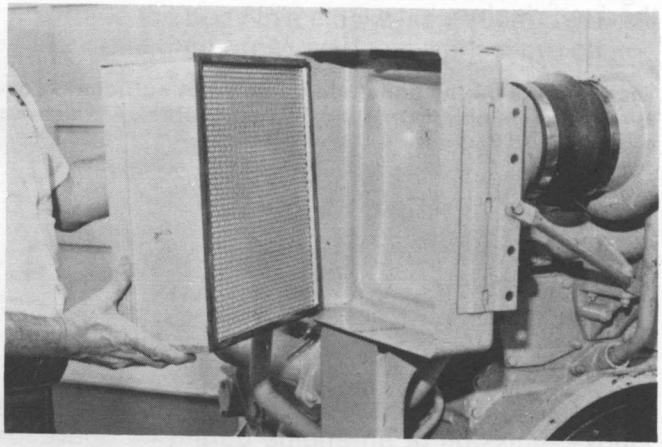
NOTE

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

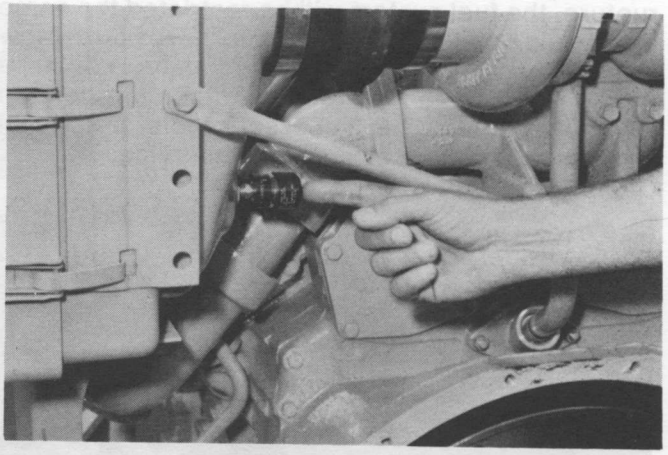
5. Remove the covering from the air inlet opening.
6. Install the element.

CAUTION

Install the air cleaner element as shown in the illustration. Note the arrows indicating air flow on the side of the element, and the position of the gasket.



7. Install the air cleaner cover.
8. Reset the service indicator button by pushing on the reset button.
9. Clean the used air cleaner element. See the instructions for cleaning.



Cleaning Filter Elements

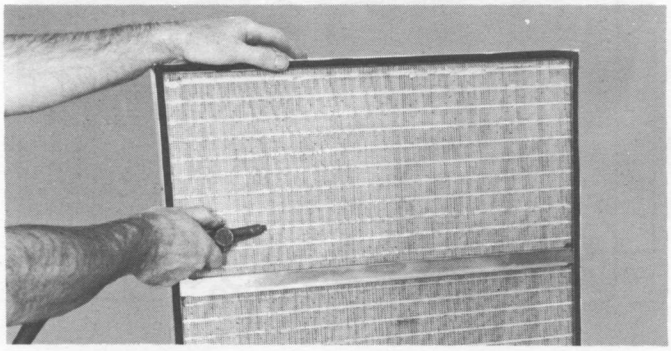
Cleaning Elements With Air

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

⚠ WARNING

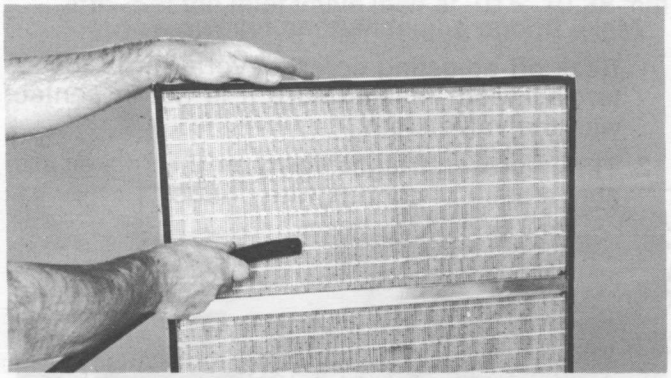
When using pressure air, wear safety glasses and protective clothing. Use no more than 30 PSI (2 kg/cm²) pressure.

2. Direct the air stream along the complete length of each pleat on the CLEANEST side of the element. (This will loosen the dirt from the dirtier side.)
3. Blow the loosened dirt from the DIRTY side.
4. Direct the air from the CLEAN side through to the DIRTY side to remove dirt blown into the pleating.



Cleaning Elements With Water

1. Use clean water at no more than 40 psi (3 kg/cm²). Do not use a nozzle.
2. Direct the water along the complete length of each pleat on the CLEAN side of the element.
3. Direct water along the complete length of each pleat on the DIRTY side of the element.
4. Rinse the CLEAN side of the element.
5. Allow the cleaned element to dry thoroughly.



Cleaning Elements With Detergent

1. Wash both sides of the element in a solution of warm water and non-sudsing detergent.
2. Rinse the CLEANEST side of the element with clean water 40 psi (3 kg/cm²) maximum along with the complete length of each pleat.
3. Rinse the opposite side of the element along the complete length of each pleat.
4. Rinse the first side again to remove all loosened dirt.
5. Allow the cleaned element to dry thoroughly.

Inspecting Cleaned Elements

Place a lighted electric bulb behind the cleaned, dried filter element. Carefully check each pleat for holes or tears. If just one small hole or tear is found, discard that element and install a new element.

Storing Cleaned Elements

1. Wrap usable elements in heavy paper.
2. Store the wrapped element in a dry, clean place.

Dust Collector Cap

Servicing Dust Collector Cap

1. Remove the cap from the air cleaner inlet.
2. Clean the bottom grill using pressure air (maximum 30 psi — 2.0 kg/cm²), or low sudsing detergent and water. Install the cap.

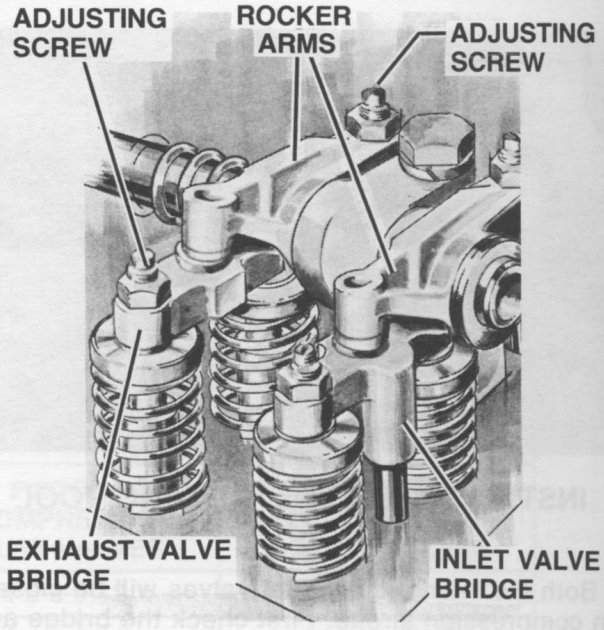
WARNING

Protective eye glasses must be worn when using pressure air.

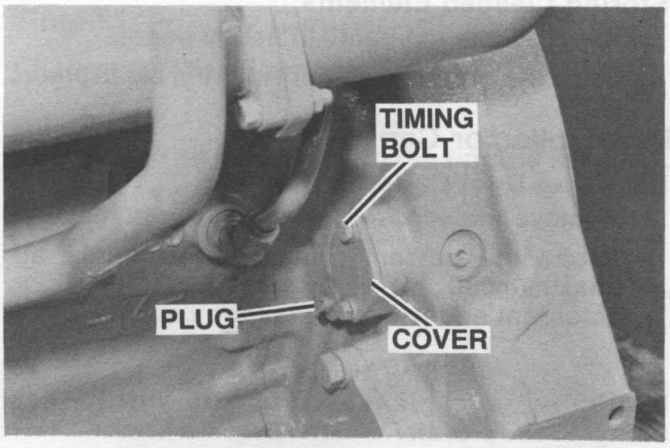
Valve Adjustments

There are two rocker arms per cylinder, one rocker arm for the two exhaust valves and one rocker arm for the two inlet valves. Each pair of valves is connected by a bridge which is actuated by the rocker arm. The valves in each pair are adjusted simultaneously by the adjusting screw in the rocker arm.

Check the bridge and valve adjustment with the engine stopped.



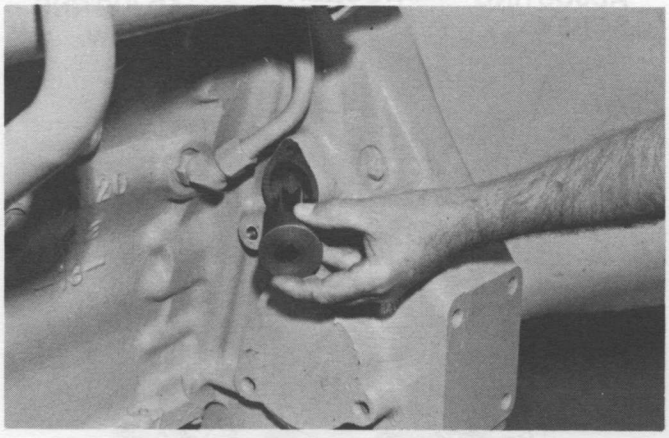
Clean the dirt from the base of the valve covers and then remove covers. Remove the plug from the timing hole, timing bolt and access cover. Rotate the flywheel in the direction of engine rotation until the timing bolt can be installed in the flywheel and the No. 1 piston is on compression stroke.



TIMING BOLT LOCATION

NOTE

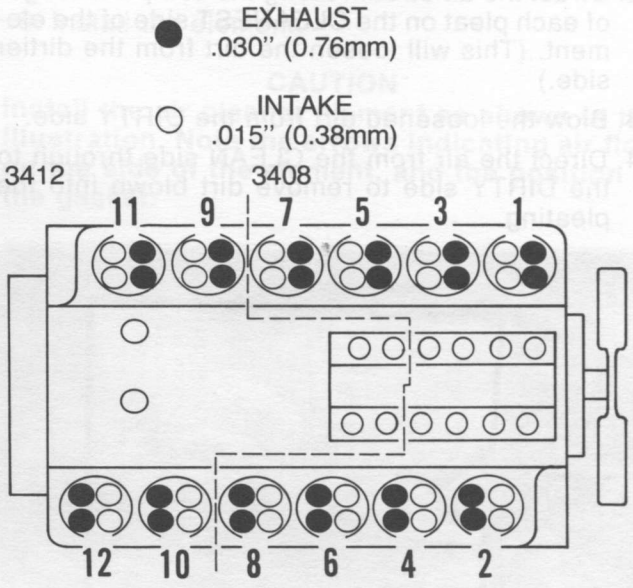
The flywheel can be rotated with an engine turning tool (9S9082). Remove the access cover and install the engine turning tool in the access hole so it engages the flywheel ring gear. Turn with a ratchet handle.



INSTALLING ENGINE TURNING TOOL

Both the inlet and exhaust valves will be closed on compression stroke. First check the bridge adjustment and then the valve lash adjustment.

VALVE LOCATION

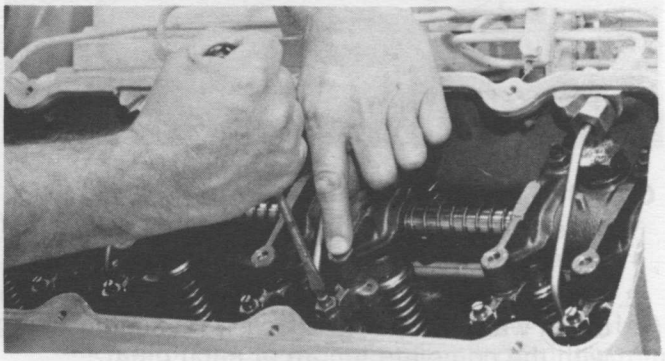


Bridge Adjustment

Check the bridge adjustment screw and locknut for tightness. If the adjusting screw and locknut are tight, proceed with the valve lash adjustment. If the bridge adjusting screw can be turned with a screwdriver without holding the locknut, the bridge requires adjustment. The bridge adjustment must be made before the valve lash is checked for proper clearance.

Make bridge adjustment as follows:

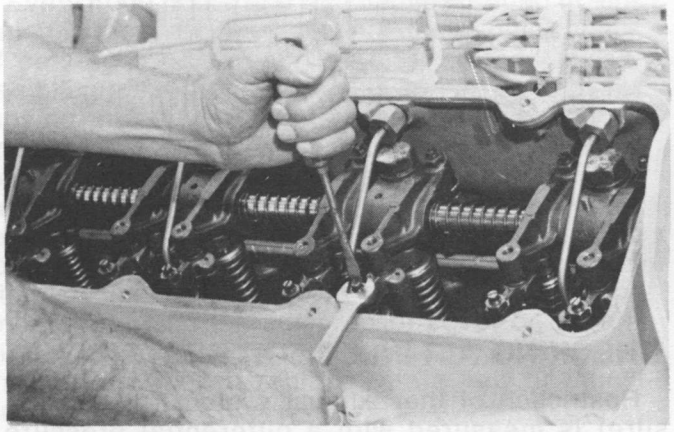
1. Back off adjusting screw several turns (counterclockwise) making sure it is not in contact with the valve stem.
2. Firmly press straight down on the rocker arm above point of contact with bridge.



ADJUSTING BRIDGE

3. Turn the adjusting screw clockwise until contact is made with the valve stem, then turn the adjusting screw an additional 30° or 1/12 turn (½ the distance between the two points on the locknut).

4. Hold the adjusting screw in this position and tighten the locknut to 20 lb. ft. (27.2 N m).

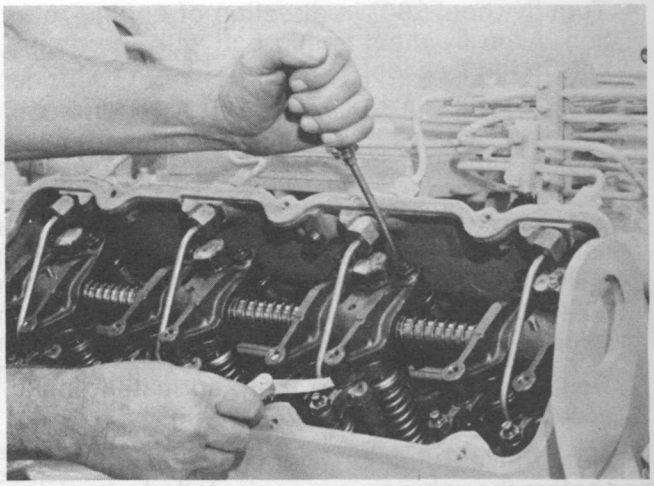


TIGHTENING ADJUSTING SCREW LOCKNUT

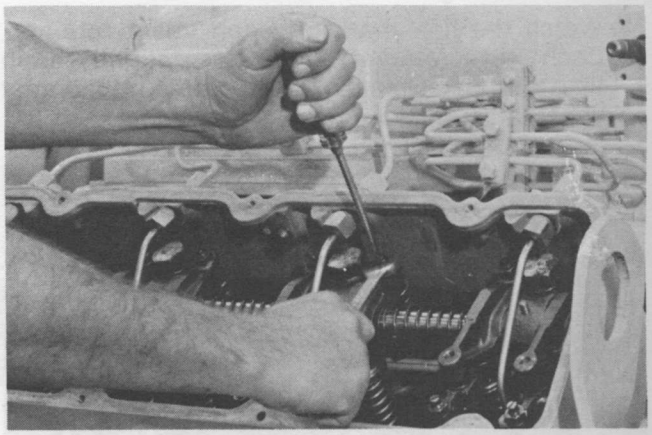
Valve Adjustment

After checking the bridge adjustment, make the valve lash adjustment.

1. With No. 1 piston at TDC on compression, check valve lash between the bridge and rocker arm. See chart for cylinder and valve adjusting sequence.
2. To adjust, loosen valve adjusting locknut and turn adjusting screw to allow feeler gauge to pass between top of bridge and the valve rocker arm. Set the inlet valve lash at .015" (0.38 mm) and exhaust valve lash at .030" (0.76 mm).



3. After proper adjustment, tighten the adjusting screw locknut to 22 lb. ft. (29.9 N·m) and recheck lash clearance.



3408 VALVE ADJUSTING SEQUENCE			
VALVES	LASH	NO. 1 PISTON TDC ON COMPRESSION ADJUST VALVES	NO. 6 PISTON TDC ON COMPRESSION ADJUST VALVES
EXHAUST	.030" (0.76 mm)	1-3-4-8	2-5-6-7
INLET	.015" (0.38 mm)	1-2-5-7	3-4-6-8

3412 VALVE ADJUSTING SEQUENCE			
VALVES	LASH	NO. 1 PISTON TDC ON COMPRESSION ADJUST VALVES	NO. 6 PISTON TDC ON COMPRESSION ADJUST VALVES
EXHAUST	.030" (0.76 mm)	1-4-5-8-9-12	2-3-6-7-10-11
INLET	.015" (0.38 mm)	1-3-4-6-7-12	2-5-8-9-10-11

4. Turn flywheel 360° in direction of engine rotation. Align flywheel timing bolt with the timing hole in the flywheel.

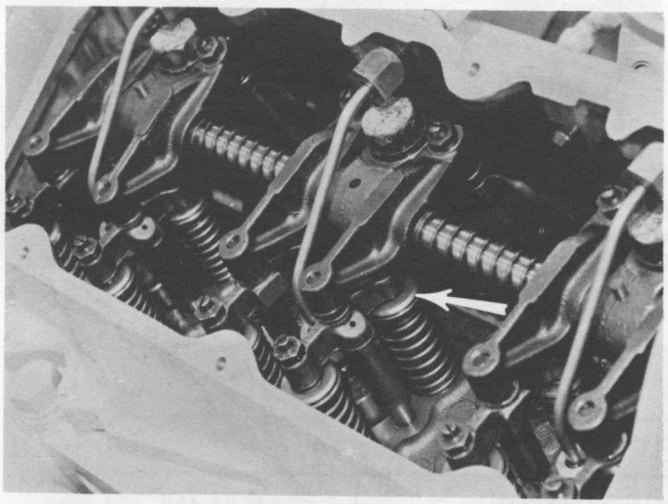
   3408—No. 6 Cylinder will be at TDC on compression stroke (all valves closed)

   3412—No. 11 Cylinder will be at TDC on compression stroke (all valves closed).

5. Check lash and adjust as necessary on all remaining valves, see valve adjusting sequence chart.
6. Tighten locknut and recheck lash clearance.
7. Remove engine turning tool and install timing access cover, timing bolt and plug.

Check Valve Rotation: After checking valve lash and before the valve covers are installed, check the valves for rotation.

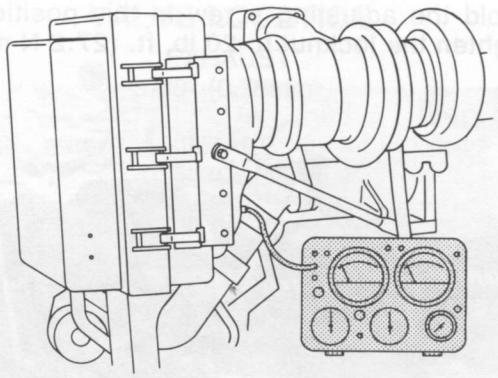
1. Mark a line on each valve retainer.
2. Start the engine and run at low idle.
3. Watch the line mark on each valve retainer. Each valve retainer should turn slightly each time the valve closes. If they do not turn, contact your Caterpillar dealer.



4. Stop the engine.
5. Inspect the valve cover gasket and install a new one as necessary. Install the valve cover.

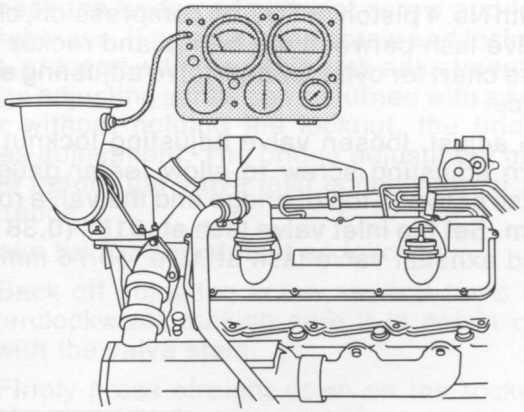
Restriction Of Air Inlet And Exhaust

If an air inlet restriction is suspected in the piping or air filter element, check with a differential pressure gauge or manometer. Remove the air cleaner service indicator and connect differential pressure gauge or manometer in the service indicator connection. The air inlet piping or air cleaner should not restrict air flow more than 30 inches (762 mm) of water difference in pressure.



CHECKING AIR INLET FOR RESTRICTION

Restriction of the exhaust system (back pressure) is measured with a differential pressure gauge or manometer. This pressure difference is measured between the turbocharger outlet and ambient air and should be no more than 20 inches (645 mm) of water. An exhaust pressure tap is provided in the turbocharger outlet elbow. This check should be performed with the engine at operating temperature and developing full rated power.



CHECKING EXHAUST SYSTEM BACK PRESSURE

Crankcase Pressure

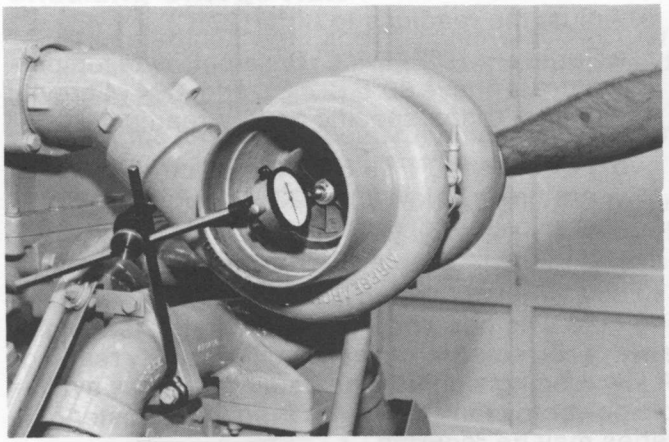
Excessive crankcase pressure can be a result of combustion gas leaking past broken or damaged pistons, worn cylinder liner walls and/or piston rings. This condition will usually be accompanied by irregular engine operation and excess fumes from crankcase breather opening. This pressure can cause the breather element to become restricted in an unusually short time. In addition, it can cause engine oil to leak past gaskets and seals that would function properly under normal conditions.

Turbocharger

Every 4000 hours or if any unusual sound or vibration in the turbocharger is noticed, a quick check of bearing condition can be made without disassembling the turbocharge. This can be done by removing the piping from the turbocharger and inspecting the compressor impeller, turbine wheel and compressor cover. Rotate the compressor and turbine wheel assembly by hand and observe by feeling excess end play and radial clearance. The rotating assembly should rotate freely with no rubbing or binding. If there is any indication of the impeller rubbing the compressor cover or the turbine wheel rubbing the turbine housing, recondition the turbocharger or replace with a new or rebuilt one.

End clearance is best checked with a dial indicator. Attach a dial indicator with the indicator point on the end of the shaft. Move the shaft from one end to end making note of the total indicator reading.

End play should be between .003 in. (0.076 mm) and .008 in. (0.203 mm). If end play exceeds .008 in. (0.203 mm) rebuild or replace the turbocharger. End clearance less than .003 in. (0.076 mm) could indicate build-up on the turbine wheel and should be disassembled for cleaning and inspection.



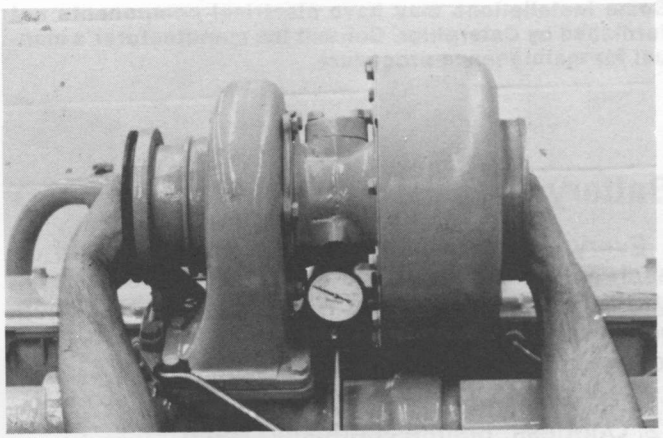
CHECKING TURBOCHARGER ROTATING ASSEMBLY END PLAY

A more reliable check of bearing condition can be made only when the turbocharger is disassembled and the bearings, shaft journal and housing bore diameters can actually be measured. This service is available from an authorized dealer.

Radial clearance can also be checked with a dial indicator. Remove the oil return line from the turbocharger. Attach a dial indicator with an extension indicator point long enough to contact the shaft through the oil return hole. Make sure the contact point is centered on the shaft (highest indicator reading). Raise both ends of the shaft all the way then push down in the opposite direction. Total movement of the indicator should be between .005 in. (0.13 mm) and .009 in. (0.23 mm). If radial clearance exceeds .009 in. (0.23 mm) or minimum clearance is under .005 in. (0.13 mm) the turbocharger should be disassembled and the bearings checked.

NOTE

Care must be taken not to cock the shaft or a false reading will be obtained.



CHECKING THE TURBOCHARGER RADIAL CLEARANCE

If a turbocharger fails, try to determine cause of failure and eliminate before installing a rebuilt or new turbocharger. When installing a new or rebuilt turbocharger always perform the following steps:

A. Inspect the air induction and exhaust system for the presence of foreign particles which could result in repeat failure.
B. Change the air cleaner element.
C. Change the oil filters.
D. Drain and refill the engine crankcase.
E. Pre-lubricate the replacement turbocharger by filling the center housing with oil.

ELECTRICAL SYSTEM

The following topics describe care and maintenance of the electrical system components. These components functioning together produce the energy needed for operating the electrical equipment on the engine and each is dependent upon the others for satisfactory operation. In the event of failure or improper operation, it is essential to check the entire electrical system as a defect in one component can cause damage to another.

Many electrical system problems can be traced to loose or corroded connections. Keep connections tight and make sure the wiring insulation is in satisfactory condition. Most of the electrical system testing can be performed while the components are on the engine. It should be remembered, if a malfunction is found on test, the component must be removed for further testing, repair or replacement.

NOTE
Some installations may have electrical components not furnished by Caterpillar. Consult the manufacturer's manual for maintenance procedure.

Battery

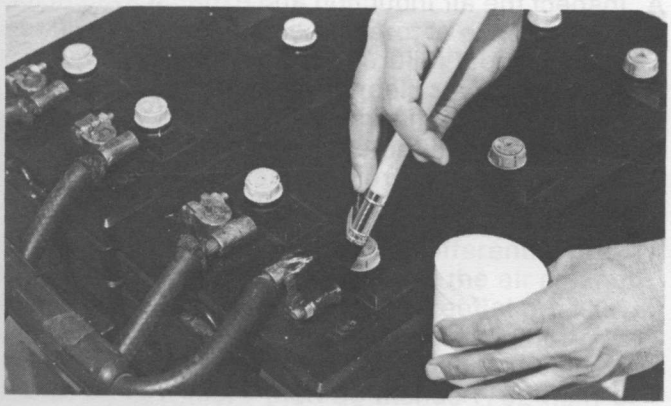
Every 250 hours check the electrolyte level of each cell and the general condition of the battery. Maintain the electrolyte level to the base of each vent well. The make-up water must be one of the following (in order of preference):

1. Distilled water.
2. Odorless, tasteless drinking water.
3. Iron free water.

⚠ WARNING
Never add acid or electrolyte.

Cleaning Battery

Mix a weak solution of baking soda and water. Apply the solution with a soft bristle brush. Be careful not to get cleaning solution into the battery.



CLEANING BATTERY TERMINALS

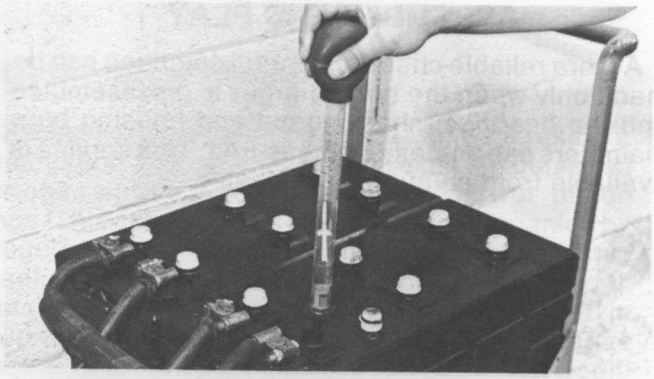
Thoroughly rinse the battery and battery tray with clean water. Apply grease to the battery cable clamps and terminals and to all threads.

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:
   1.265 - 100% charged
   1.225 - 75% charged
   1.190 - 50% charged
   1.155 - 25% charged
   1.120 - Discharged
   1.000 - Water
3. Test each cell in the same manner.
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 10°F (5.5°C) the electrolyte temperature is above 80°F (27°C), add .004 (4 gravity points) to the specific gravity readings.
   b. For every 10°F (5.5°C) the electrolyte temperature is below 80°F (27°C), subtract .004 (4 gravity points) from the specific gravity reading.

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.



TESTING ELECTROLYTE SOLUTION

Installing Battery

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

⚠ WARNING

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

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

Checking Charge Rate

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

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

Charging the Battery

⚠ WARNING

Never smoke near the area where batteries are being charged. Hydrogen gas is given off at each vent cap during charging. Hydrogen mixed with air is highly explosive.

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

CAUTION

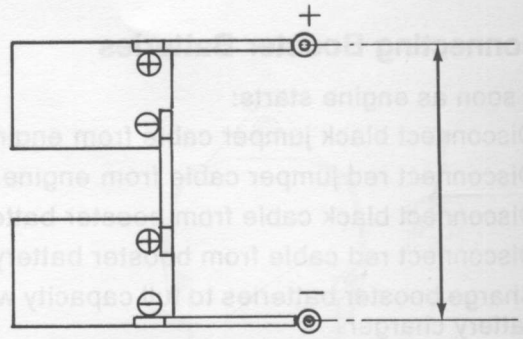
If battery is charged too rapidly, the battery will be damaged.

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

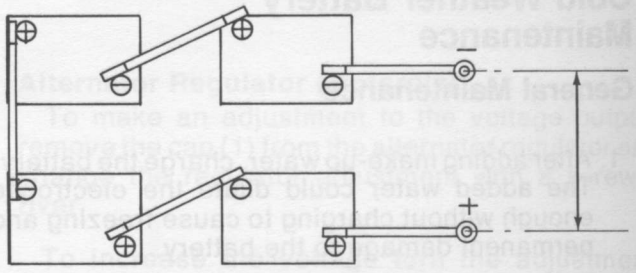
Connecting Booster Batteries

CAUTION

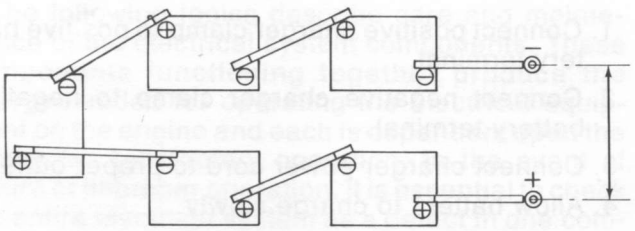
Keep red and black terminals from touching each other.



24 VOLT STARTING USING 12 VOLT BATTERIES



24 VOLT STARTING USING 6 VOLT BATTERIES



30 VOLT STARTING USING 6 VOLT BATTERIES

1. Remove all filler caps from all batteries before connecting jumper cables.
2. Connect red jumper cable to "hot" terminal of booster battery.
3. Connect black cable to "ground" terminal of booster battery.
4. Connect other end of red cable to "hot" terminal of engine battery.
5. Connect other end of black cable to the starter ground terminal, if equipped with a starter to ground cable.

   If the starter is not grounded with a cable, attach the black cable terminal to a good ground on the engine or engine frame, at a point away from, and below the battery.
6. Start the engine using starting aids as instructed in the Operation Instructions.

Disconnecting Booster Batteries

As soon as engine starts:

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

Cold Weather Battery Maintenance

General Maintenance

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

CAUTION

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

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

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

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

Voltage Test (After Load)

A load test should be made on a battery that discharges very rapidly when in use. To do this apply a resistance of three times the ampere/hour rating of the battery across the battery main terminals. Allow the resistance to discharge the the battery for 15 seconds and immediately test the battery voltage. A 6 volt battery in good condition will test 4.5 volts; a 12 volt battery in good condition will test 9 volts and a 24 volt battery will test 18 volts.

Starter

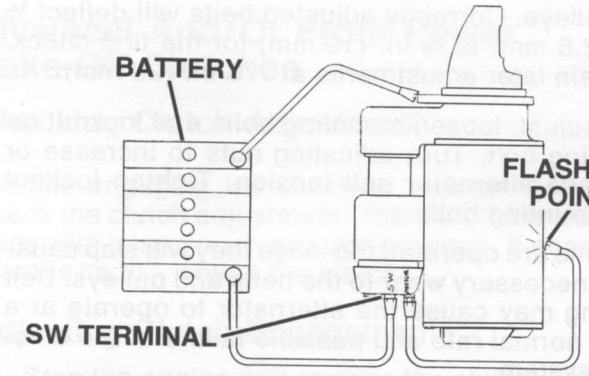
No periodic service is indicated for the electric starter brushes between general reconditioning periods. The brushes should only be inspected after removal of the starter from the engine and removal of the commutator end bearing frame. The electric starter commutator end and drive end bearings are equipped with wicks for lubrication purposes. The wicks should be saturated with oil whenever the electric starter is removed or disassembled.

It is suggested that cleaning and reconditioning be entrusted to your authorized dealer.

Pinion Clearance Adjustment

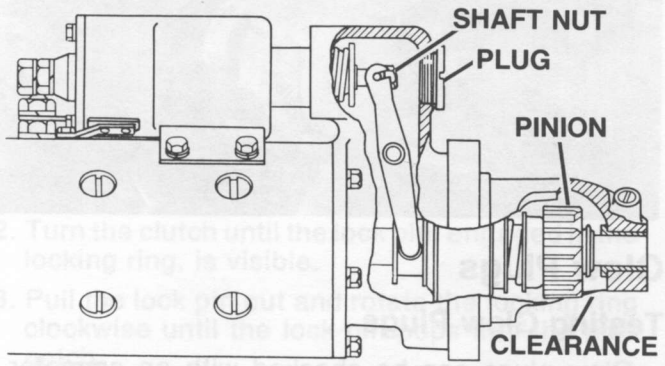
Whenever the solenoid is installed, the pinion clearance should be adjusted. The adjustment should be made with the starting motor removed.

Bench test and adjust the pinion clearance at installation of solenoid as follows:



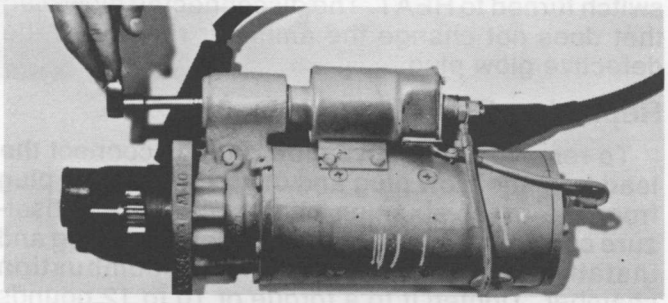
CIRCUIT FOR CHECKING AND ADJUSTING PINION CLEARANCE

1. Install the solenoid without connector from the MOTOR terminal on solenoid to the motor.
2. Connect a battery, of the same voltage as the solenoid, to the terminal marked SW.
3. Connect the other side of battery to ground terminal or to solenoid frame.



ADJUSTING PINION CLEARANCE

4. MOMENTARILY flash a jumper wire from the solenoid terminal marked MOTOR to the frame or ground terminal. The pinion will shift into cranking position and will remain there until the battery is disconnected.
5. Push pinion towards commutator end to eliminate free movement.
6. Pinion clearance should be .36 in. (9.14 mm).
7. Adjust clearance by removing plug and turning shaft nut.



ADJUSTING PINION CLEARANCE

Charging System

Alternator Regulator

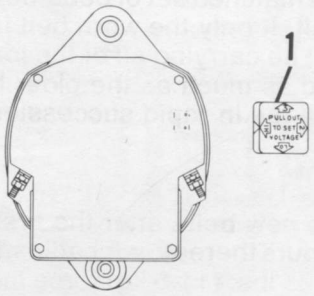
The alternator regulator is adjusted at the factory for average operating conditions and may require readjustment to provide the proper charging rate for the particular operating conditions.

The condition and state of charge of the battery at each regular inspection will indicate if the alternator is operating efficiently. An adjustment is necessary when the battery is always in a low state of charge or an excessive amount of water must be added to the battery (more than one ounce of water per cell per week or per every 50 service hours).

When the alternator is either charging the battery too much or not enough, an adjustment can be made to the alternator charging rate.

Alternator Regulator (Delco-Remy)

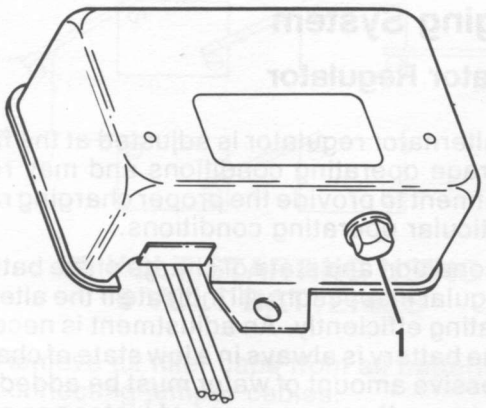
To make an adjustment to the voltage output, remove the voltage adjustment cap (1) from the alternator, turn the cap 90°, and install it again into the alternator. The voltage adjustment cap has four positions: HI, LO, and two positions between the high and the low setting.



Alternator Regulator (Motorola)

To make an adjustment to the voltage output, remove the cap (1) from the alternator regulator and change the regulator adjustment with a screwdriver.

To increase the voltage turn the adjustment screw clockwise. The adjustment screw under the cap (1) has five positions (number 1 is the last position clockwise).



Adjustment Position	1	2	3	4	5
Regulator Voltage	29.25 ± .35	28.6 ± .3	28.0 ± .3	27.4 ± .3	26.8 ± .3

Never operate the charging alternator with an open circuit between it and battery.

CAUTION

Do not attempt to polarize the alternator. If an accidental connection is made between the "+" terminal and either one of the "F" terminals on the alternator, the rectifiers in the alternator and the transistors in the regulator will be damaged.

Alternator Belts

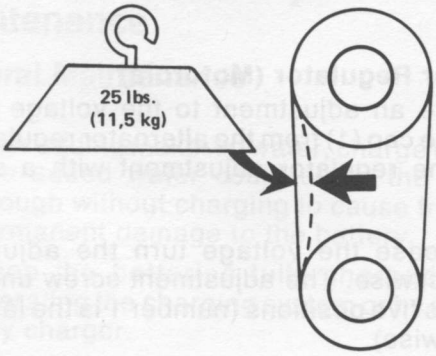
Every 250 hours examine the drive belts for wear and replace if they show signs of wear.

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.

Adjustment

Check the new belts after the first 10 hours and every 250 hours thereafter for adjustment. To check belts-apply 25 lbs. (11.5 kg) force midway between the pulleys. Correctly adjusted belts will deflect ½ in. (12.5 mm) to ¾ in. (19 mm) for the first check. Maintain later adjustments at 7/8 in. (23 mm).

BELT TENSION

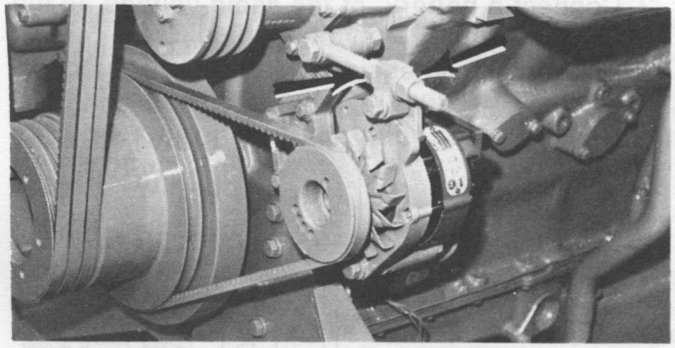


To adjust, loosen mounting bolts and locknut on adjusting bolt. Turn adjusting nuts to increase or decrease alternator belt tension. Tighten locknut and mounting bolts.

If belts are operated too loose they will slap causing unnecessary wear to the belts and pulleys. Belt slipping may cause the alternator to operate at a below normal rate and possible failure of the electrical system.

If the belts are too tight, unnecessary stresses are placed upon the pulley bearings and belts which might shorten the life of both.

ALTERNATOR BELT ADJUSTMENT



Glow Plugs

Testing Glow Plugs

Glow plugs can be checked with an ammeter. Disconnect the wire lead from the glow plug terminal on the HEAT-START switch. Install an ammeter, in series, between the disconnected lead and the terminal on the switch. Observe the ammeter with the HEAT-START switch turned to the HEAT position. Each 12 volt glow plug draws approximately 12.5 amperes. The ampere draw of one glow plug multiplied by the number of engine cylinders will be the total ampere draw of the glow plugs in the engine. A low reading is an indication of one or more defective glow plugs. Disconnect one glow plug lead at a time and observe the ammeter with the switch turned to HEAT. The disconnected glow plug that does not change the ammeter reading is the defective glow plug.

Replacing Glow Plugs

To remove a defective glow plug disconnect the lead from the glow plug and unscrew the glow plug from the precombustion chamber. Apply antiseize compound to the thread of a new glow plug and install the glow plug into the precombustion chamber. Tighten it to a torque of 10 to 12 pounds feet.

POWER COUPLING SYSTEM

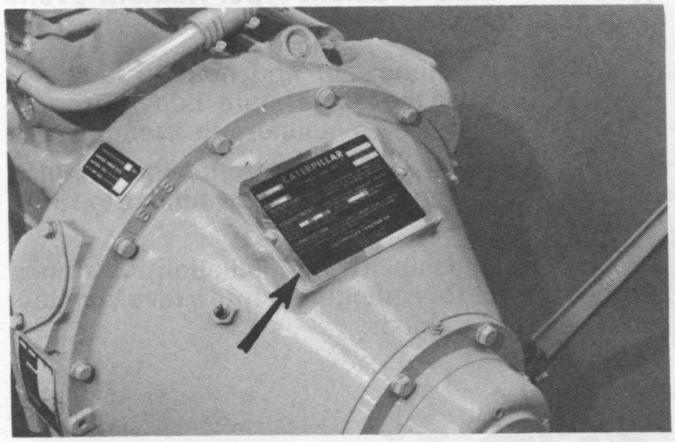
Flywheel And/Or Front Power Take-Off Clutches

Checking Clutch Adjustment

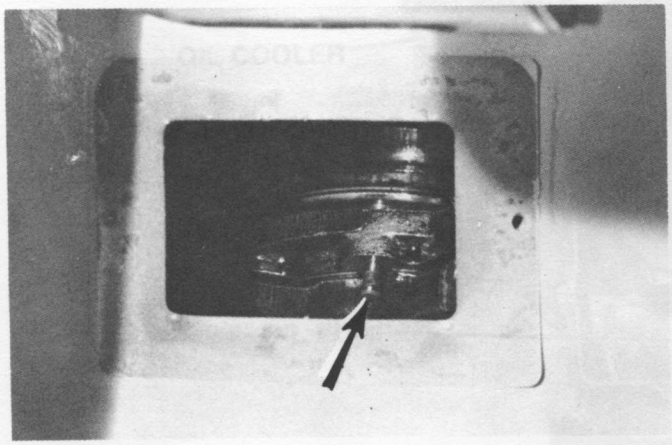
While engaging the clutch to pick up the load, check the clutch adjustment. The clutch should engage with a hard push and distinct snap. If engagement is "soft", adjust the clutch.

Adjusting Clutch Engagement

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



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



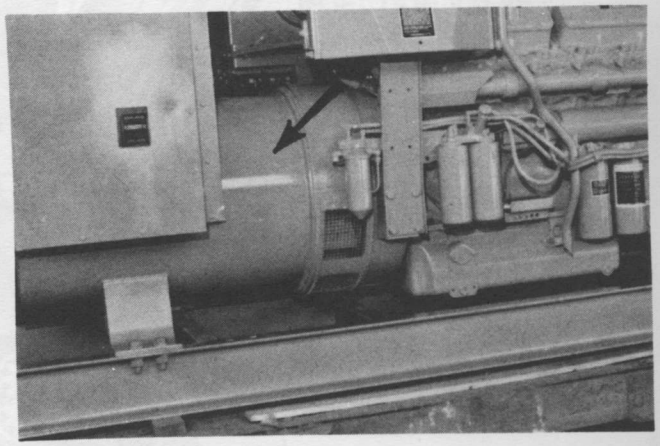
4. Test the clutch adjustment. If still too "soft", rotate the ring to the next notch. If the adjustment is too tight-turn the ring back one notch.
5. Install the cover.

Generator Set

Your electric set engine may be equipped with a Caterpillar SR4 Generator. The SR4 Generator is a brushless design, and therefore requires no periodic maintenance other than lubrication of the rear bearing. See Lubrication Instructions.

The generator serial number is stamped on the generator housing. The first group of numbers, reading from the left, indicates the frame size. Following this number are the letters BS, BH or BG. The letter B indicates the generator is of the SR4 design. The letter S, H or G indicates the voltage rating of the generator. The following numerical digits are the serial number of the generator in that particular frame size and voltage rating. A complete explanation of the numbers and letters in the serial number are found in the GENERATOR SET SYSTEMS OPERATION SECTION. Always use the complete serial number in your communications with your Caterpillar dealer.

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



GENERATOR SERIAL NUMBER LOCATION

STORAGE

Engine Storage

If the engine is not started for several weeks, the lubricating oil drains from the cylinder walls and piston rings. This will result in shorter engine life. To prevent excessive engine wear:

1. Be sure all lubrication points mentioned in the LUBRICATION AND MAINTENANCE CHART are serviced.

2. Once a week, start and run the engine until it is thoroughly warm. For unattended automatic start-stop systems, the engine may have an exerciser for this purpose.

3. Stop the engine, perform required servicing.

4. Check the cooling system for adequate protection if freezing temperatures can be expected. A 50-50 solution of permanent type antifreeze and approved water will give protection below −20°F (−29°C).

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

Generator Storage

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

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

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

CAUTION

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

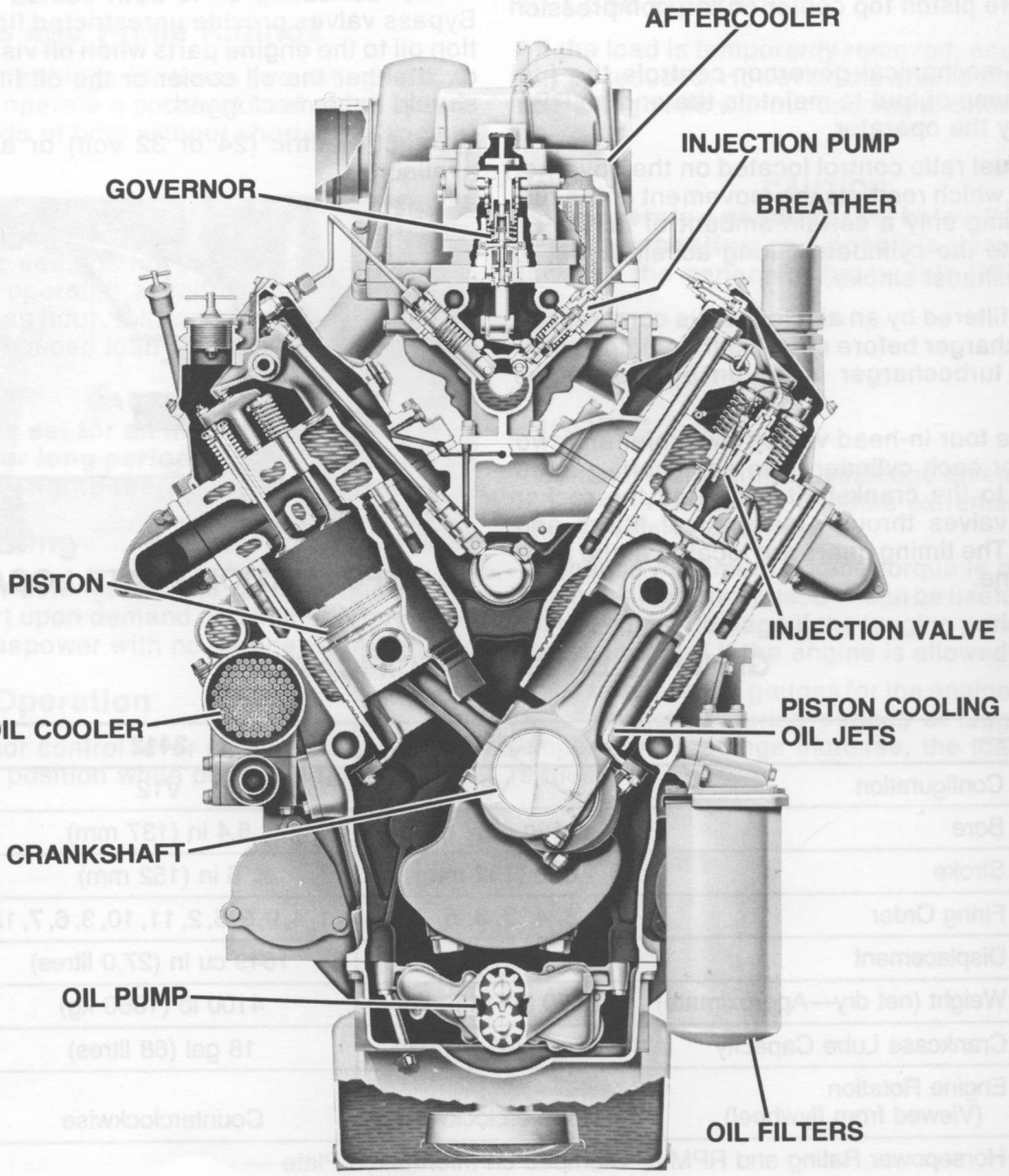
2. Enclose the generator and heating lamps in canvas to raise the temperature. Leave an opening in the top for the moisture to escape.

3. Pass a low voltage current through the windings to raise the temperature of the windings to 185°F (85°C).

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

SYSTEMS OPERATION

To many, the working principle of diesel engine components may not be new; however, the special features of these engines require that the operator and maintenance personnel become acquainted with the systems in order to give the engine the best possible care. Maximum service depends a great deal on a good maintenance schedule, performed by trained personnel, with a thorough understanding of the systems.



GENERAL INFORMATION

For flexibility in meeting various applications and emission requirements, these engines are offered either with direct injection (DI) or with precombustion chamber (PC). Identification of the combustion system used is attached to the fuel injection pump housing.

Individual injection pumps, one for each cylinder, meter and pump fuel under high pressure to an injection valve for each cylinder. An automatic variable timing device advances or retards fuel injection and is regulated by engine speed. The faster the engine turns the earlier the injection must take place before piston top center on the compression stroke.

A hydro-mechanical governor controls the fuel injection pump output to maintain the engine RPM selected by the operator.

The air-fuel ratio control located on the governor is a device which restricts the movement of the fuel rack, allowing only a certain amount of fuel to be injected into the cylinders during acceleration, to minimize exhaust smoke.

Inlet air, filtered by an air cleaner, is compressed by a turbocharger before entering the engine cylinders. The turbocharger is driven by the engine exhaust.

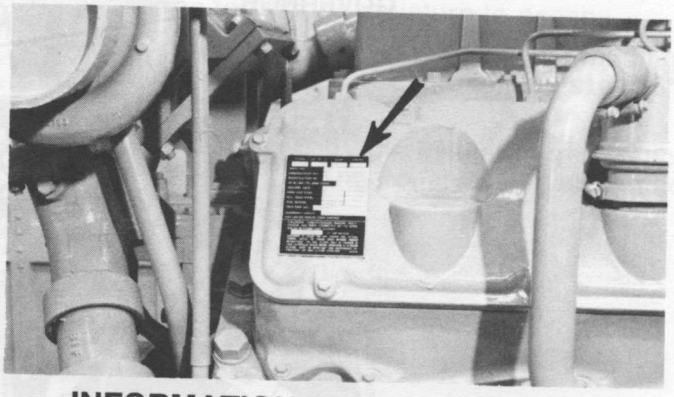
There are four in-head valves (two inlet and two exhaust) for each cylinder. The camshaft, geared and timed to the crankshaft, actuates the rocker arms and valves through mechanical lifters and push rods. The timing gears are located at the front of the engine.

The engine coolant is circulated through the engine by a gear driven water pump located on the right front of the engine. The pump directs coolant to the oil cooler first, then to the engine block and head. One full-flow thermostat in a housing at the front of each cylinder bank provided for quick engine warm-up and allow free circulation of coolant after operating temperature has been reached.

Lubrication for the engine is supplied by a gear-type pump. The pump provides full pressure lubrication to the engine internal and external parts.

The lubricating oil is both cooled and filtered. Bypass valves provide unrestricted flow of lubrication oil to the engine parts when oil viscosity is high or, if either the oil cooler or the oil filter elements should become clogged.

Direct electric (24 or 32 volt) or air starting is available.



INFORMATION PLATE LOCATION

GENERAL ENGINE SPECIFICATIONS

	3408	3412
Configuration	V8	V12
Bore	5.4 in (137 mm)	5.4 in (137 mm)
Stroke	6 in (152 mm)	6 in (152 mm)
Firing Order	1, 8, 4, 3, 6, 5, 7, 2	1, 4, 9, 8, 5, 2, 11, 10, 3, 6, 7, 12
Displacement	1099 cu in (18.0 litres)	1649 cu in (27.0 litres)
Weight (net dry—Approximate)	3150 lb (1430 kg)	4100 lb (1860 kg)
Crankcase Lube Capacity	12 gal (45.5 litres)	18 gal (68 litres)
Engine Rotation (Viewed from flywheel)	Counterclockwise	Counterclockwise
Horsepower Rating and RPM — Stamped on Information Plate —		

NOTE
Specifications were current at time of printing; however, due to continuous testing and improvements, specifications may change without notice

Engine Horsepower Ratings

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

CAUTION

Horsepower settings should only be made by authorized personnel.

Continuous and Prime Ratings

Horsepower settings for these two ratings allow the engine to operate a constant load at full speed for long periods of time without shortening engine life.

Intermittent Rating

Horsepower settings for this rating requires the engine to be operated at full load and speed for periods up to an hour, followed by an equal time of operation at reduced load and speed.

CAUTION

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

Standby Rating

Horsepower settings for this rating requires the engine to start upon demand and immediately supply rated horsepower with no engine warm-up.

Full Load Operation

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

Reduced Load Operation

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

CAUTION

Be sure to increase engine speed before increasing the load.

No Load Operation

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

CAUTION

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

LUGGING

Continuous lugging can damage an engine: Certain engine areas will become extremely hot and failure of parts could occur.

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

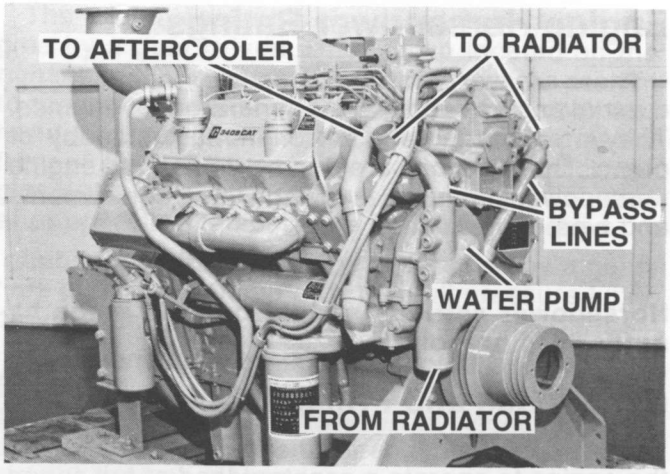
The temperature gauges for the engine should be closely watched during periods of lugging. If the temperature readings increase, the load must be reduced.

COOLING SYSTEM

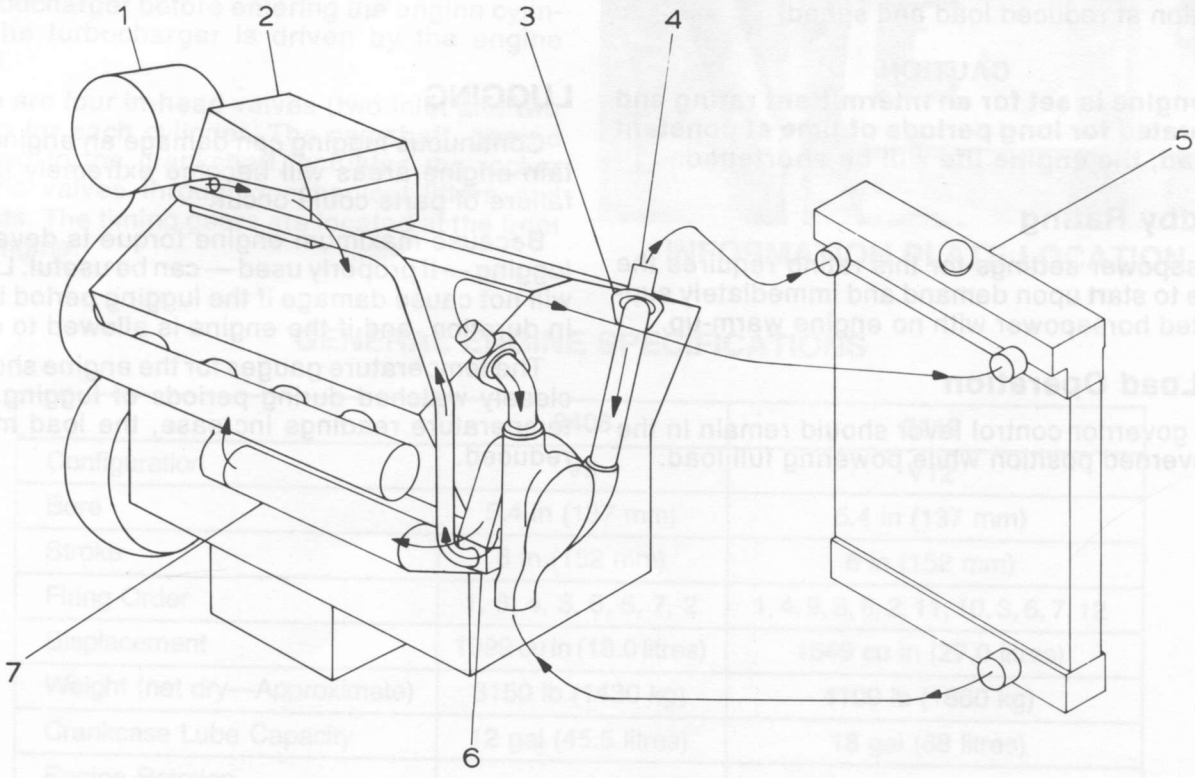
Two basic cooling systems are used on the 3408 and 3412 Industrial Engines; radiator and fan, and heat exchanger with raw water pump. A centrifugal type water pump is used to circulate the engine coolant (jacket water) in each system. Each system uses water temperature regulators to maintain a normal operating temperature. Typical engine cooling systems are shown.

Radiator and Fan Cooling

The engine coolant is drawn from the bottom of the radiator by gear driven pump. The coolant flow is divided at the pump outlet with approximately 75% of the flow directed through the oil cooler and the remainder through a parallel bypass tube, or to the aftercooler if the engine is so equipped. From the oil cooler and aftercooler, coolant is directed to the engine block where it circulates around the cylinder liners into the cylinder heads and water temperature regulator housings.



Each head has a full flow temperature regulator. Until the coolant reaches the temperature required to open the temperature regulator, coolant bypasses the radiator and flows directly back to the pump. When the coolant reaches the temperature required to open the regulator, coolant is then directed through the radiator where it is cooled by air.



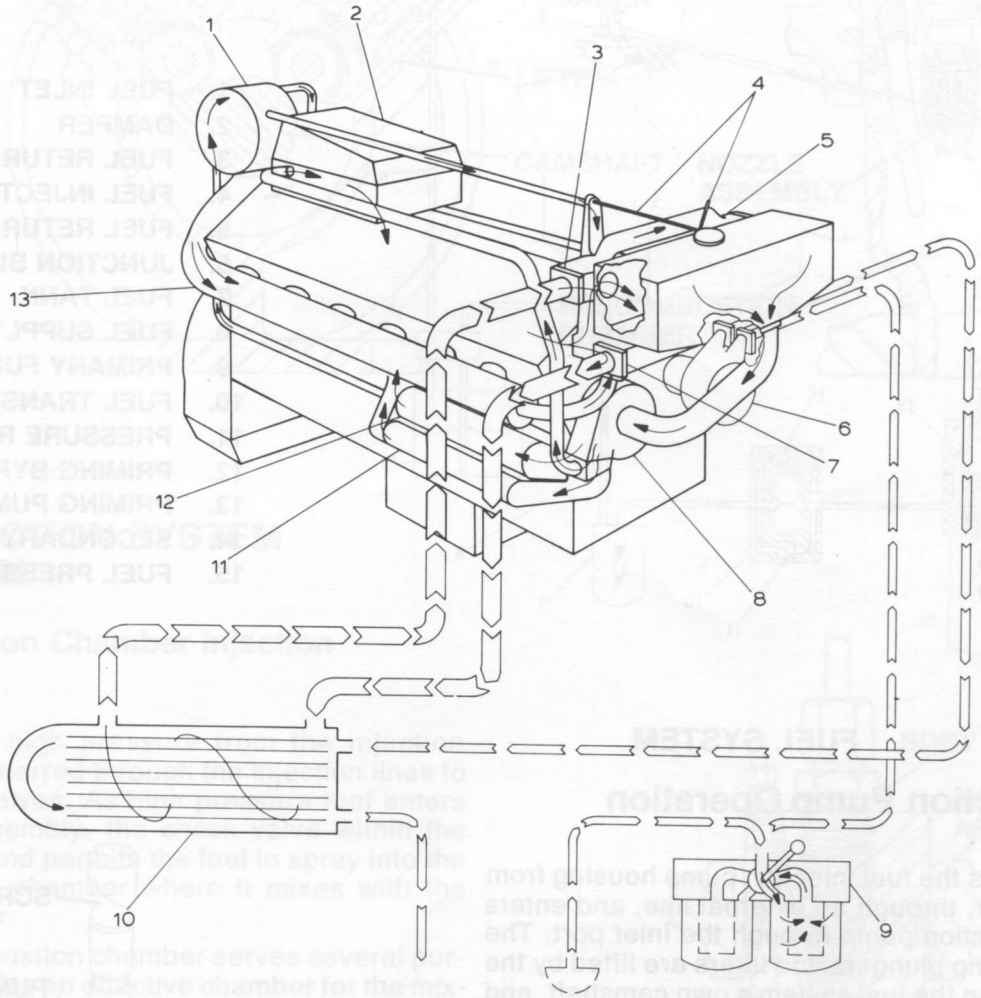
RADIATOR AND FAN COOLING SYSTEM

1. **TURBOCHARGER**
2. **AFTERCOOLER**
3. **WATER TEMPERATURE REGULATOR (BOTH SIDES)**
4. **JACKET WATER OUTLET CONNECTION (BOTH SIDES)**
5. **RADIATOR**
6. **JACKET WATER PUMP**
7. **OIL COOLER**

Heat Exchanger Cooling

The coolant is drawn by the jacket coolant circulating pump, from the bottom of the expansion tank, and pumped through the engine oil cooler, aftercooler and engine, the same as in the radiator/fan system. When leaving the water temperature regulator housing the coolant either passes through the heat exchanger core or bypasses the heat exchanger and flows directly to the pump, depending on the coolant temperature.

As the engine coolant passes through the core of the heat exchanger, the coolant temperature is lowered by the raw water, which is drawn from an outside water supply and circulated around the heat exchanger core by an auxiliary pump.



HEAT EXCHANGER COOLING SYSTEM

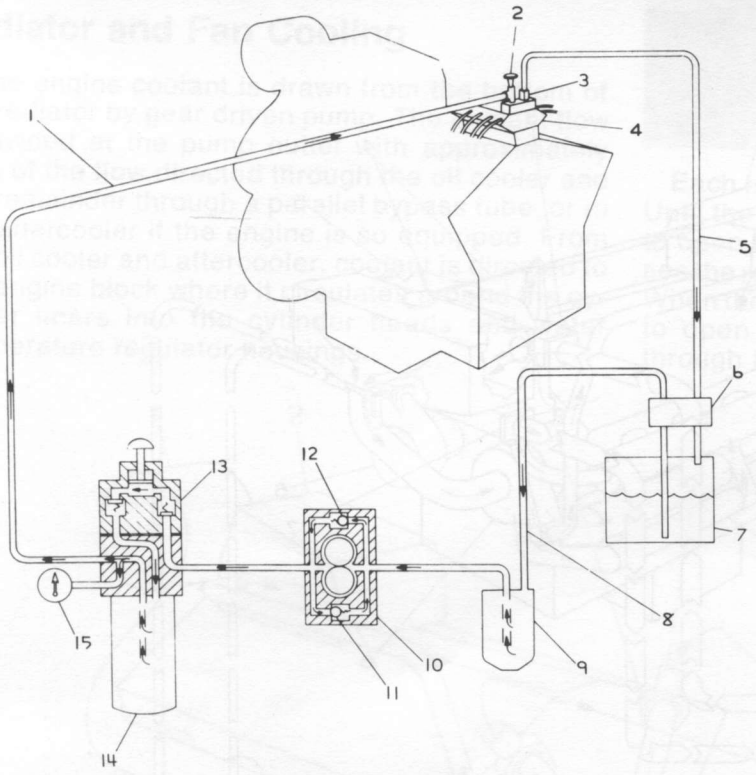
1. WATER COOLED TURBOCHARGER
2. AFTERCOOLER
3. JACKET WATER RETURN CONNECTION (EITHER SIDE)
4. VENT LINES
5. WATER TEMPERATURE REGULATOR (BOTH SIDES)
6. AUXILIARY WATER PUMP
7. JACKET WATER OUTLET CONNECTION (EITHER SIDE)
8. JACKET WATER PUMP
9. DUPLEX STRAINER
10. HEAT EXCHANGER
11. OIL COOLER BYPASS
12. OIL COOLER
13. WATER COOLED MANIFOLD

FUEL SYSTEM

The fuel system consists of the transfer pump, fuel filter, injection pumps, injection lines and nozzles, fuel return line and governor.

The gear type fuel transfer pump is gear driven from the fuel injection pump camshaft. The transfer pump draws fuel from the supply tank through the junction block and primary filter, then delivers it to a filter, and to a manifold in the fuel injection pump housing, which supplies fuel to the individual injection pumps. A return line from the fuel injection pump fuel manifold to the fuel tank provides a constant bypass of fuel.

A priming pump is mounted on the fuel filter base to pressurize the fuel system and to remove the air in the system after servicing the filter, or whenever air is allowed to enter the system. Air is vented by loosening the fuel line nuts one at a time and operating the pump until a stream of fuel, without air bubbles, flows from the fuel lines.



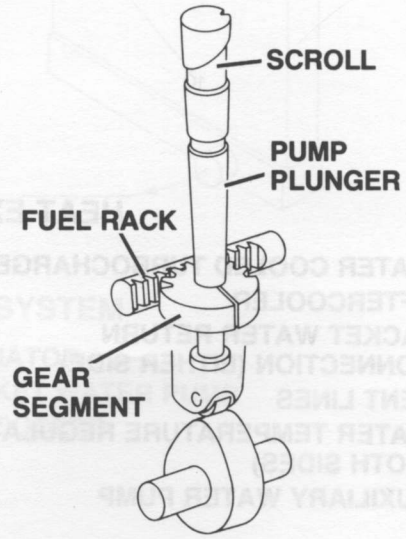
1. FUEL INLET
2. DAMPER
3. FUEL RETURN ORIFICE
4. FUEL INJECTION PUMP
5. FUEL RETURN
6. JUNCTION BLOCK
7. FUEL TANK
8. FUEL SUPPLY LINE
9. PRIMARY FUEL FILTER
10. FUEL TRANSFER PUMP
11. PRESSURE RELIEF VALVE
12. PRIMING BYPASS VALVE
13. PRIMING PUMP
14. SECONDARY FUEL FILTER
15. FUEL PRESSURE GAGE

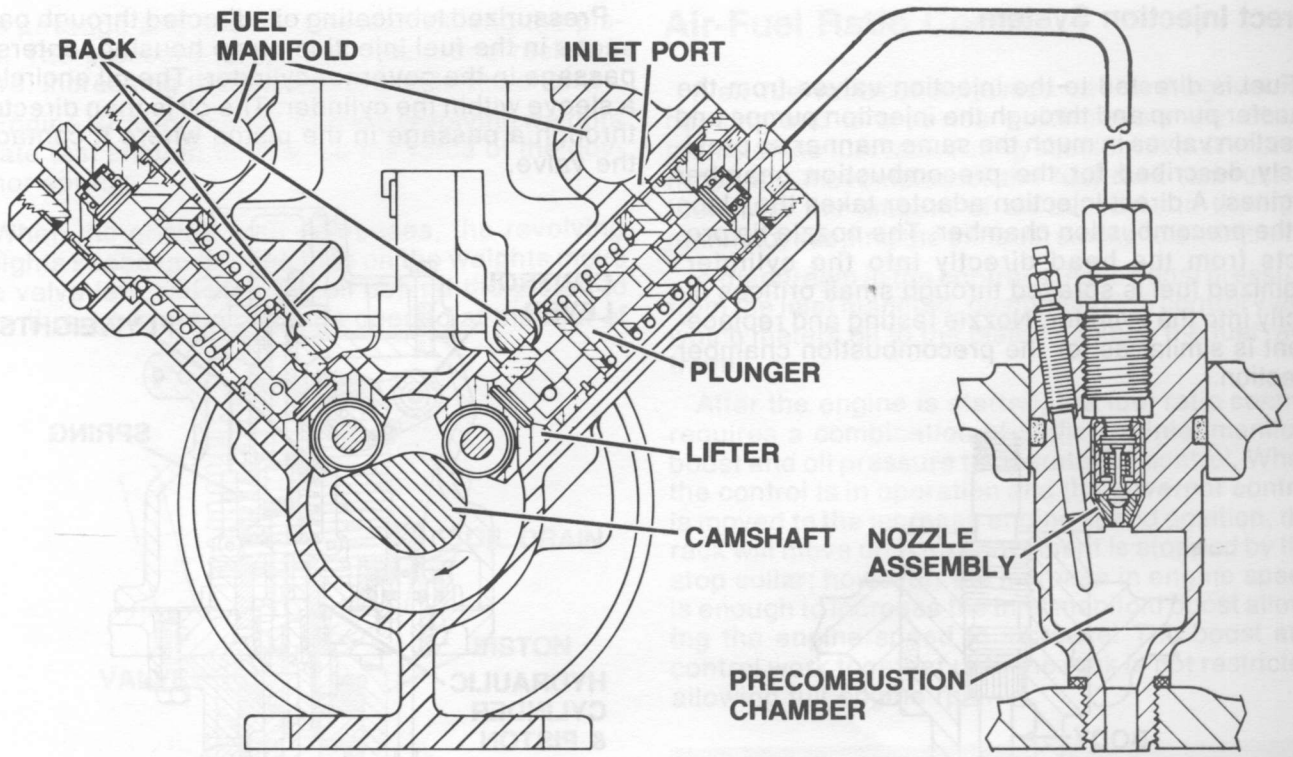
FUEL SYSTEM

Fuel Injection Pump Operation

Fuel enters the fuel injection pump housing from the fuel filter, through an external line, and enters the fuel injection pump through the inlet port. The injection pump plungers and lifters are lifted by the cam lobes, on the fuel system's own camshaft, and always make a full stroke. The lifters are held against the cam lobes by springs. Each pump measures the amount of fuel to be injected into its respective cylinder and delivers it to the fuel injection nozzle.

The amount of the fuel pumped per stroke is varied by turning the plunger in the barrel. The plunger is turned by the governor action through the gear segmented sliding rack, which turns the gear segment on the bottom of the pump plunger. The position of the scroll on the plunger determines the amount of fuel injected into the cylinder.





FUEL INJECTION SYSTEM OPERATION

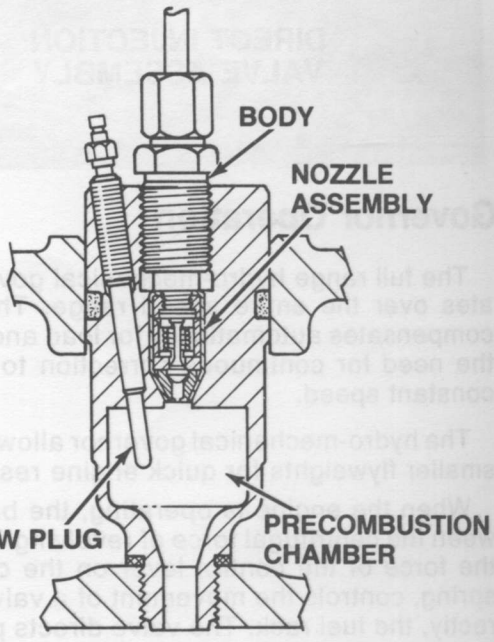
Precombustion Chamber Injection System

Fuel, under high pressure from the injection pumps, is transferred through the injection lines to the injection valves. As high pressure fuel enters the nozzle assembly, the check valve within the nozzle opens and permits the fuel to spray into the precombustion chamber where it mixes with the compressed air.

The precombustion chamber serves several purposes: It provides an effective chamber for the mixing of fuel and air before it enters the cylinder for final combustion, thus permitting the use of a wider range of fuels. It permits the use of easy replaceable fuel nozzles and lends itself to the use of glow plugs to assist in cold weather starting.

These engines can be started in low temperatures with the use of glow plugs, which provide heat for initial ignition of the fuel in the precombustion chamber.

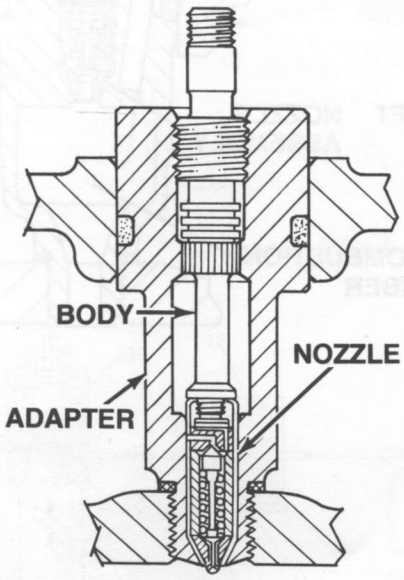
The nozzle assembly which requires no adjustment can be removed and replaced with a new one quickly and economically.



PRECOMBUSTION CHAMBER VALVE ASSEMBLY

Direct Injection System

Fuel is directed to the injection valves from the transfer pump and through the injection pumps and injection valves in much the same manner as previously described for the precombustion chamber engines. A direct injection adapter takes the place of the precombustion chamber. The nozzle tip protects from the head directly into the cylinder. Atomized fuel is sprayed through small orifices directly into the cylinder. Nozzle testing and replacement is similar as for the precombustion chamber injection.



DIRECT INJECTION VALVE ASSEMBLY

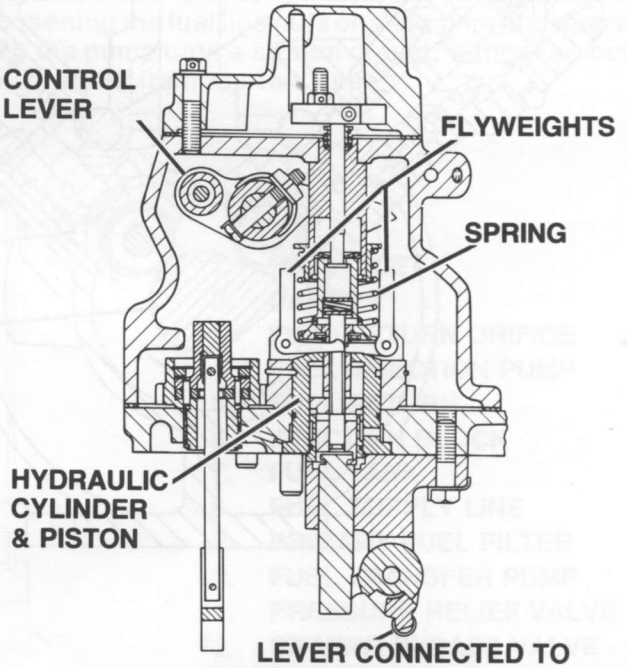
Governor Operation

The full range hydro-mechanical governor operates over the entire speed range. The governor compensates automatically for load and eliminates the need for continuous correction to maintain a constant speed.

The hydro-mechanical governor allows the use of smaller flyweights for quick engine response.

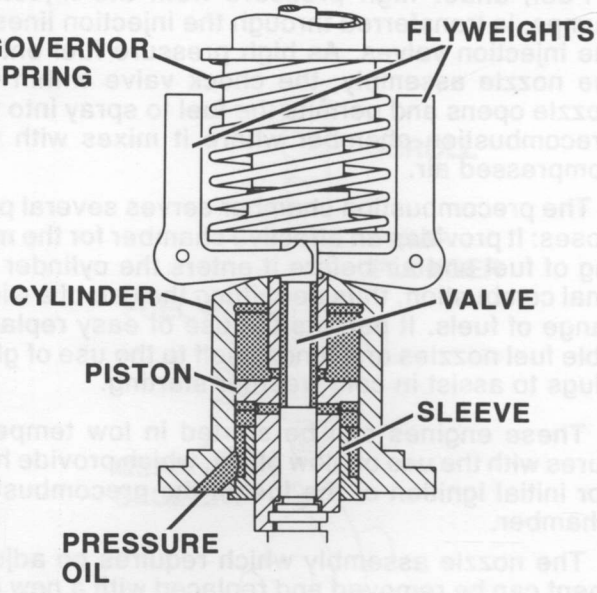
When the engine is operating, the balance between the centrifugal force of revolving weights and the force of the control lever on the compressed spring, controls the movement of a valve and indirectly, the fuel rack. The valve directs pressure oil to either side of a rack positioning piston. Depending on the position of the valve, the rack is moved to increase or decrease the fuel to the engine to compensate for load variation.

Pressurized lubricating oil, directed through passages in the fuel injection pump housing, enters a passage in the governor cylinder. The oil encircles a sleeve within the cylinder. The oil is then directed through a passage in the piston where it contacts the valve.



When the engine load increases, the revolving weights slow down. The weights move toward each other and allow the governor spring to move the valve forward.

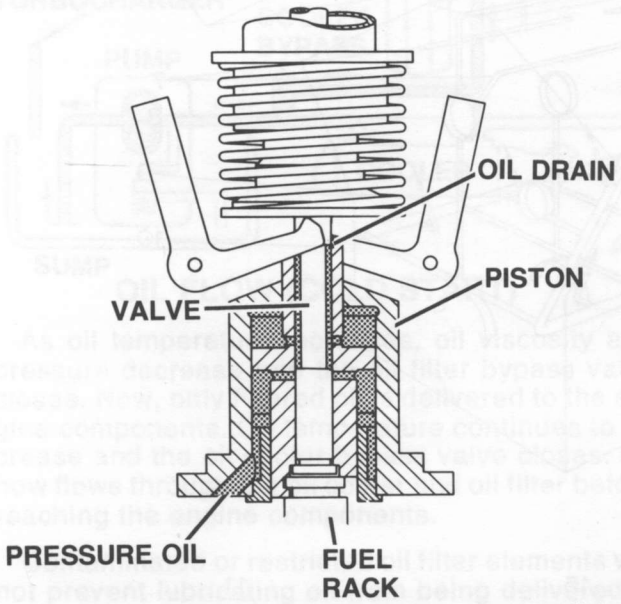
As the valve moves, an oil passage around the piston opens to pressure oil. The oil flows through



this passage and fills the chamber behind the piston. The pressure forces the piston and rack forward, increasing the amount of fuel to the engine.

Engine RPM increases until the revolving weights rotate fast enough to balance the force of the governor spring.

When the engine load decreases, the revolving weights speed up and the toes on the weights move the valve left, allowing the oil behind the piston to flow through a drain passage opened at the rear of



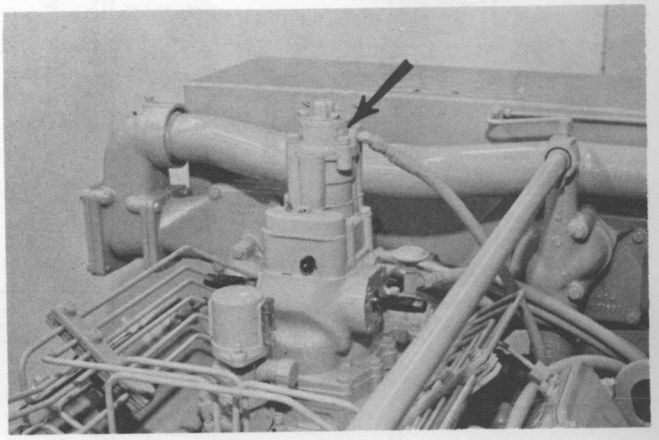
the piston. At the same time, the pressure oil between the sleeve and the piston forces the piston and rack to the left. This decreases the fuel to the engine and the engine slows down. When the force of the revolving weights balances the governor spring force, the RPM of the engine will be the same as before.

Air-Fuel Ratio Control

A air-fuel ratio control is mounted on the governor housing and is a device which resists the movements of the fuel rack during acceleration. It coordinates the movements of the fuel rack (amount of fuel) with the amount of air available in the inlet manifold, keeping the exhaust smoke to a minimum.

A diaphragm in the control senses boost pressure from the inlet manifold, positioning the control valve which meters oil to the piston, limiting the fuel rack travel.

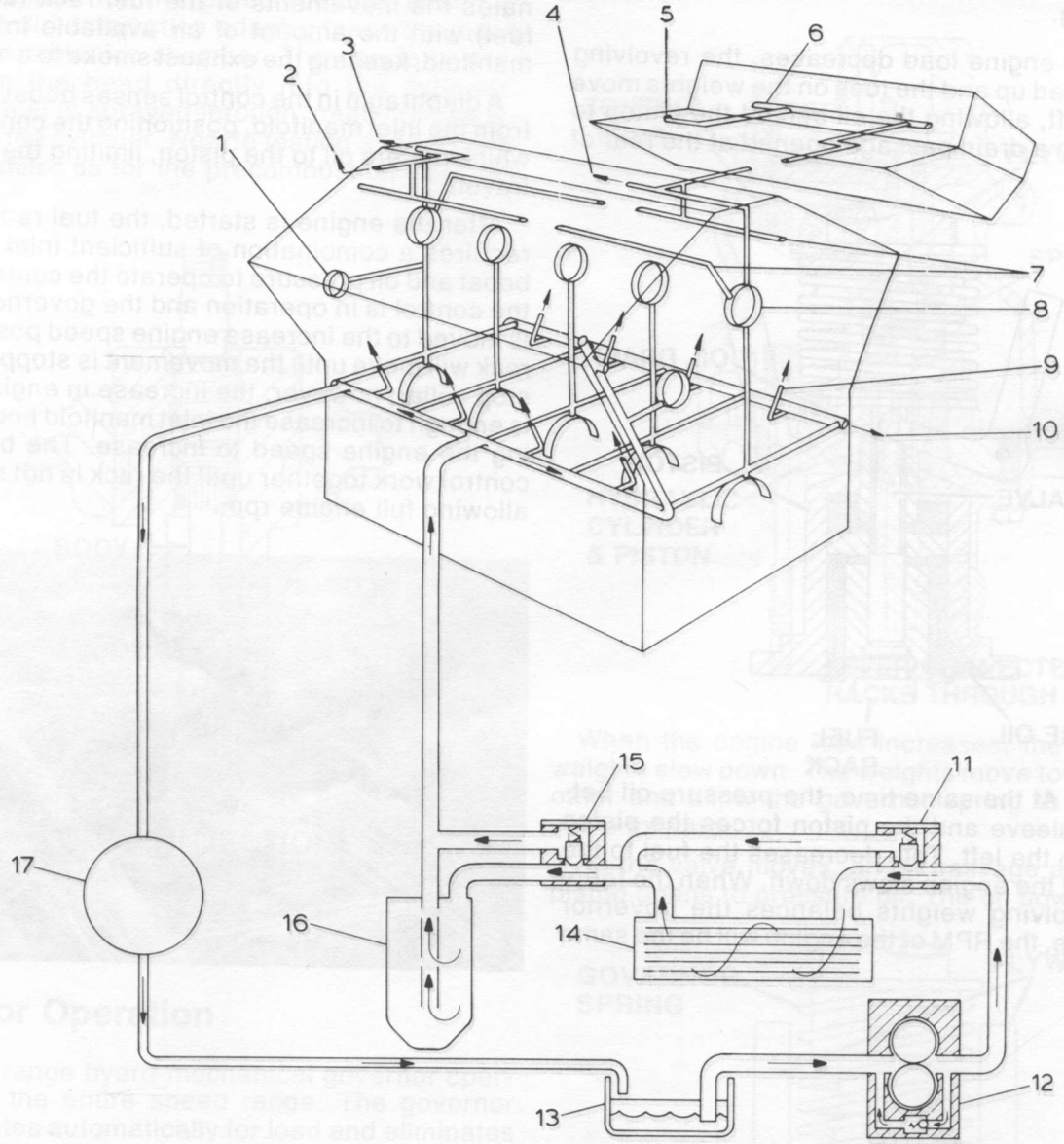
After the engine is started, the fuel ratio control requires a combination of sufficient inlet manifold boost and oil pressure to operate the control. When the control is in operation and the governor control is moved to the increase engine speed position, the rack will move until the movement is stopped by the stop collar; however, the increase in engine speed is enough to increase the inlet manifold boost allowing the engine speed to increase. The boost and control work together until the rack is not restricted allowing full engine rpm.



LUBRICATION SYSTEM

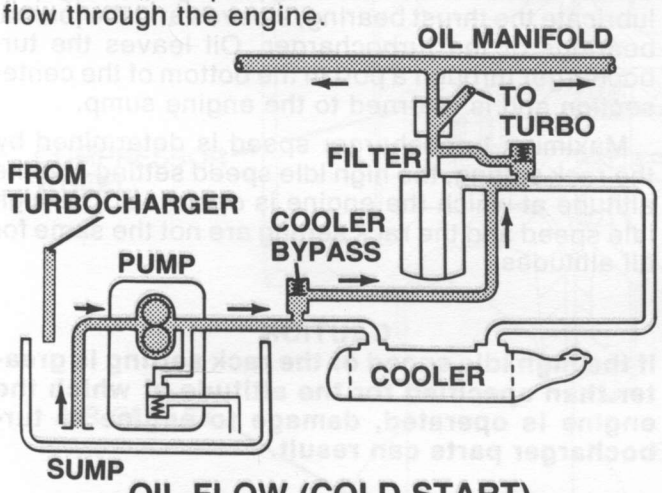
The lubrication system consists of a sump (oil pan), oil pump, oil cooler and oil filters. The engine contains an oil manifold and oil passages to direct lubricant to the various components.

The oil pump draws lubricant from the sump and forces it through the oil cooler, oil filters and then into the oil manifold. Oil flows through connecting passages to lubricate the engine components. A regulating valve in the pump body controls the maximum pressure of the oil from the pump.



1. IDLER GEAR AND BALANCER SHAFT BORE
2. TO ROCKER SHAFT
3. TO FLYWHEEL HOUSING AND AIR COMPRESSOR
4. TO FUEL INJECTION PUMP HOUSING
5. TO AIR-FUEL RATIO CONTROL (IF EQUIPPED)
6. ROCKER SHAFT
7. TO FOLLOWER BORES
8. CAMSHAFT BORE
9. PISTON COOLING
10. TO TIMING GEAR HOUSING
11. COOLER BYPASS
12. OIL PUMP
13. OIL SUMP
14. OIL COOLER
15. FILTER BYPASS
16. OIL FILTER
17. TURBOCHARGER

When the engine is started, the lubricating oil in the pan is cold (thick). This cold oil does not flow immediately through the oil cooler and oil filter. This cold oil forces bypass valves, in the oil cooler and oil filter base, to open and allows an unrestricted oil flow through the engine.



OIL FLOW (COLD START)

As oil temperature increases, oil viscosity and pressure decrease and the oil filter bypass valve closes. Now, only filtered oil is delivered to the engine components. Oil temperature continues to increase and the oil cooler bypass valve closes. Oil now flows through the oil cooler and oil filter before reaching the engine components.

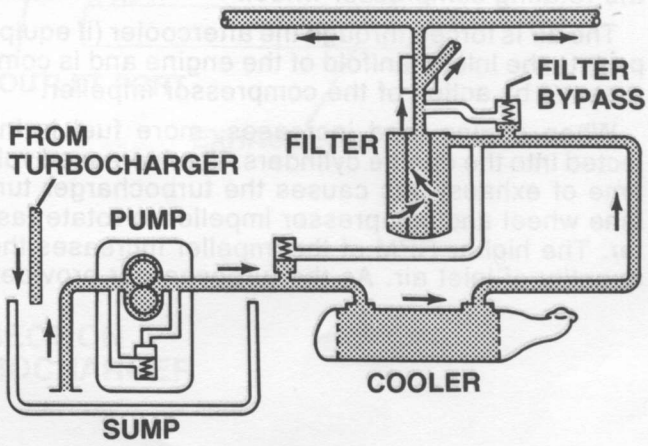
Contaminated or restricted oil filter elements will not prevent lubricating oil from being delivered to the engine components. The oil filter bypass valve will open, allowing oil to bypass the element.

Oil manifolds, cast into the cylinder block, directs lubricant to the main bearings, valve rocker arm shafts, camshaft journals, and the camshaft idler (drive) gears.

Oil spray orifices in the cylinder block spray oil on the underside of the pistons. This cools the pistons and provides lubricant for the piston pins, cylinder walls and piston rings.

The connecting rod bearings receive oil through drilled passages in the crankshaft between the main bearing journals and connecting rod journals.

When the engine is warm and running at rated speed, the oil pressure gauge should register in the "operating range". A lower pressure reading is normal at idling speeds.



OIL FLOW (NORMAL OPERATION)

AIR INDUCTION AND EXHAUST SYSTEMS

The purpose of the air induction system is to provide sufficient clean air to the engine in an efficient, silent manner while the exhaust system discharges exhaust gases as quickly and as silently as possible. Engine horsepower and efficiency will be reduced if either the air inlet or exhaust becomes restricted. Good maintenance practice cannot be over emphasized.

This engine has an exhaust driven turbocharger to provide compacted air to the cylinders.

The exhaust gases enter the turbine housing and are directed through the blades of a turbine wheel, causing the turbine wheel and a compressor wheel to rotate.

Filtered inlet air from the air cleaner is drawn through the air inlet of the compressor housing by the rotating compressor wheel.

The air is forced through the aftercooler (if equipped) to the inlet manifold of the engine and is compressed by action of the compressor impeller.

When engine load increases, more fuel is injected into the engine cylinders. The increased volume of exhaust gas causes the turbocharger turbine wheel and compressor impeller to rotate faster. The higher RPM of the impeller increases the quantity of inlet air. As the turbocharger provides additional inlet air, more fuel can be burned; hence more horsepower derived from the engine.

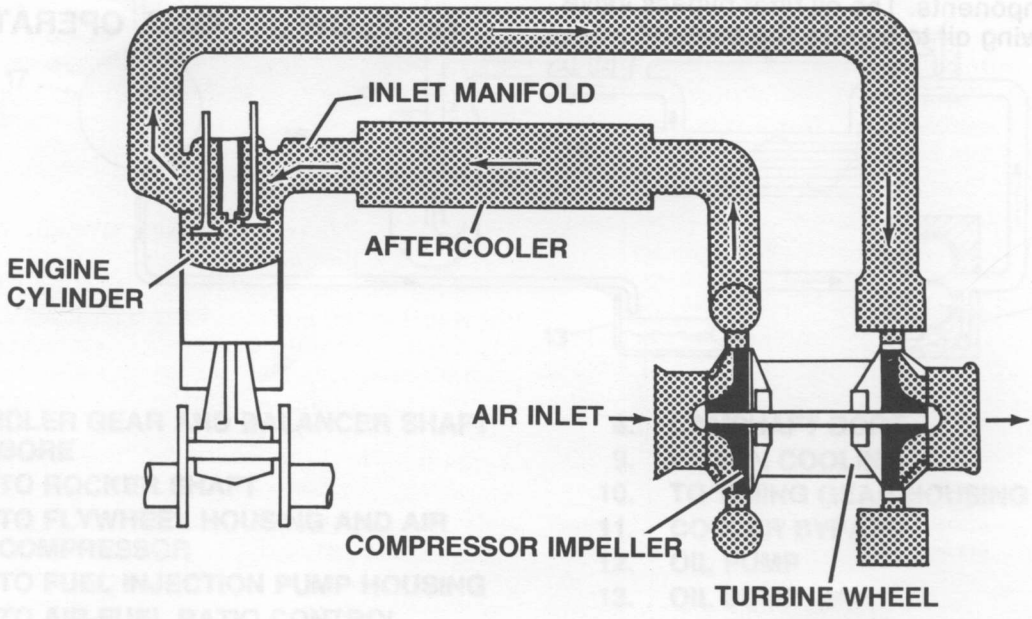
The turbocharger bearings are pressure-lubricated by engine oil. The oil enters the top of the center section and is directed through passages to lubricate the thrust bearing, sleeves and the journal bearings of the turbocharger. Oil leaves the turbocharger through a port in the bottom of the center section and is returned to the engine sump.

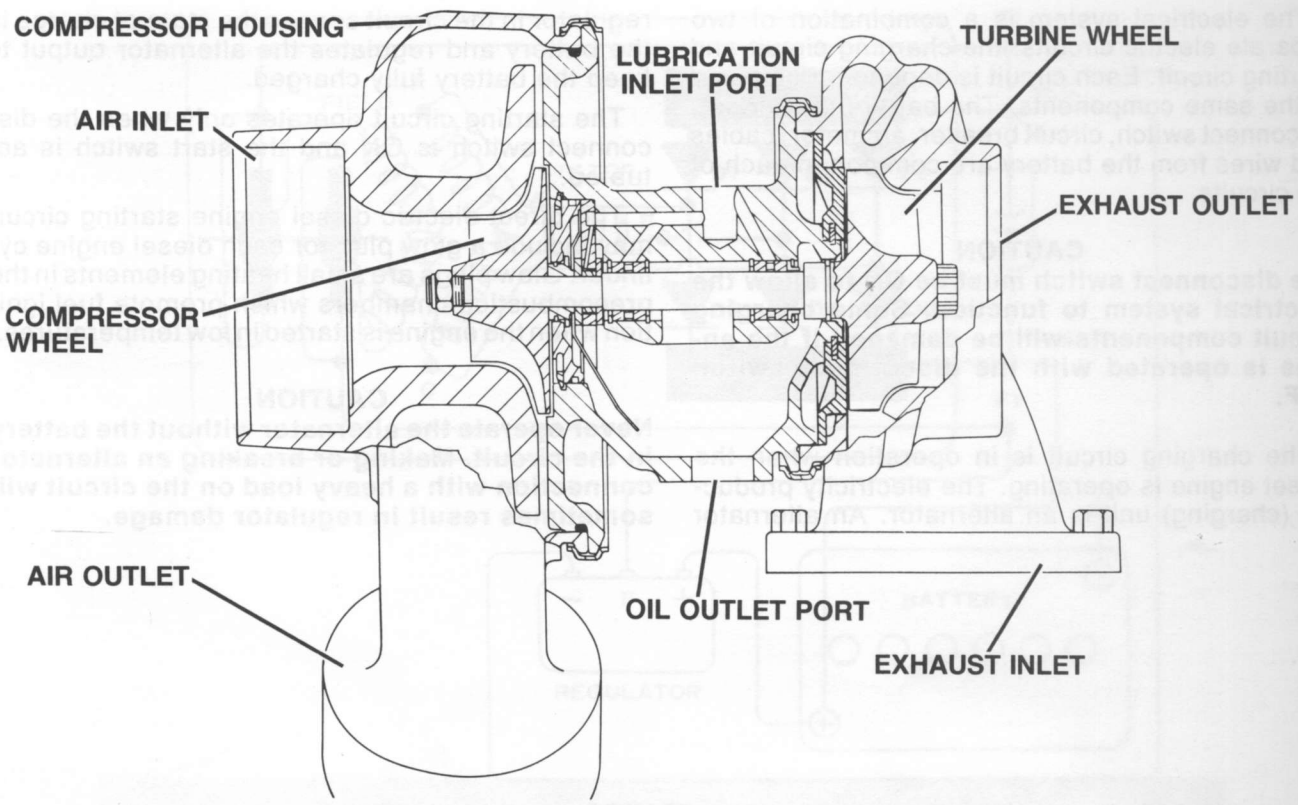
Maximum turbocharger speed is determined by the rack setting, the high idle speed setting and the altitude at which the engine is operated. The high idle speed and the rack setting are not the same for all altitudes.

CAUTION

If the high idle speed or the rack setting is greater than specified for the altitude at which the engine is operated, damage to engine or turbocharger parts can result.

The fuel pump rack has been set by qualified personnel for a particular engine application. The governor housing and turbocharger are sealed to prevent unqualified personnel from tampering with the adjustments.





CROSS SECTION OF THE TURBOCHARGER

The engine can be operated at a lower altitude than specified without danger of engine damage. In this situation the engine will perform at slightly less than maximum efficiency. When operated at a higher altitude, the rack setting and high idle speed setting must be changed.

The principle cause of fouled valves, damaged bearings, worn piston rings and cylinder liners is the entrance of airborne foreign matter into the engine cylinders; therefore it is necessary to incorporate a precision built dry-type or oil bath air cleaner in the system. The intake ducts should be so arranged as to be most convenient to service, but located away from areas of dust and exhaust concentration. The importance of cleaning or filtering the air entering the engine cannot be over-emphasized.

Caterpillar recommends the use of an air cleaner service indicator for dry-type air cleaners. The service indicator senses pressure drop across the air cleaner and a red indicator will remain visible when service is necessary. The service indicator will prevent unnecessary filter changes and reduce maintenance costs while ensuring proper engine operation.

Aftercooled Engines

When the intake air passes through and is compressed by the turbocharger, it becomes heated and becomes less dense. By directing air through the aftercooler located between the turbocharger and the inlet manifold, some of that heat is removed from the air. The aftercooler is a simple device resembling a small radiator core. Coolant from the engine passes through the core tubes and the compressed air is directed around the tubes. Since the temperature of the coolant is lower than the air under loaded conditions, the air is cooled as it leaves the aftercooler. This means more air (oxygen) is available for combustion, resulting in more fuel being burned and more power produced.

ELECTRICAL SYSTEM

The electrical system is a combination of two separate electric circuits: the charging circuit and starting circuit. Each circuit is dependent on some of the same components. The battery (batteries), disconnect switch, circuit breaker, ammeter, cables and wires from the battery are common in each of the circuits.

CAUTION

The disconnect switch must be ON to allow the electrical system to function. Some charging circuit components will be damaged if the engine is operated with the disconnect switch OFF.

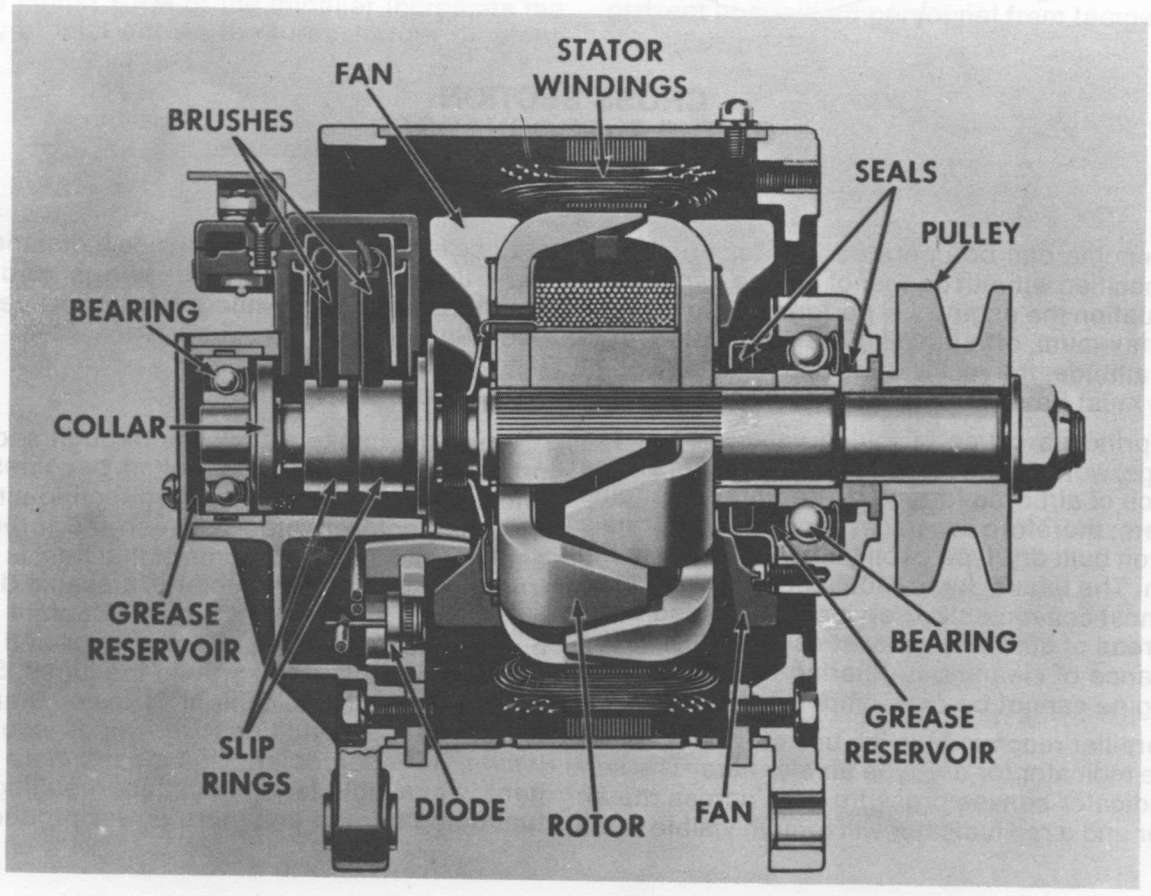
The charging circuit is in operation when the diesel engine is operating. The electricity producing (charging) unit is an alternator. An alternator regulator in the circuit senses the state of charge in the battery and regulates the alternator output to keep the battery fully charged.

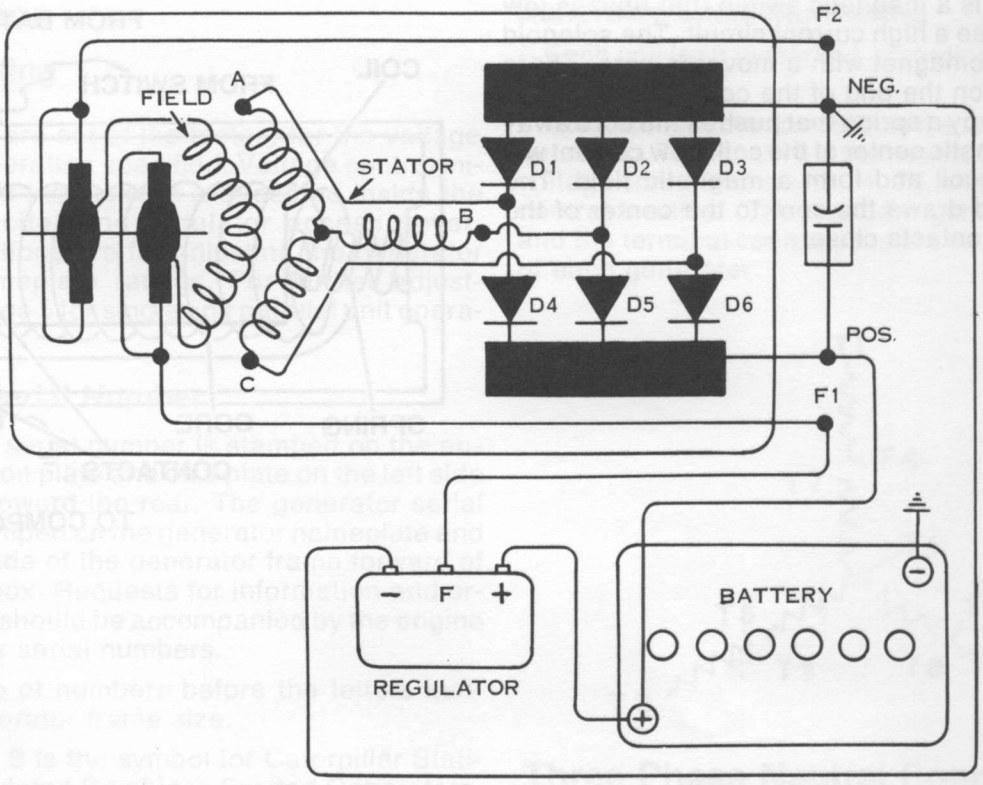
The starting circuit operates only when the disconnect switch is ON and the start switch is actuated.

The direct electric diesel engine starting circuit may include a glow plug for each diesel engine cylinder. Glow plugs are small heating elements in the precombustion chambers which promote fuel ignition when the engine is started in low temperatures.

CAUTION

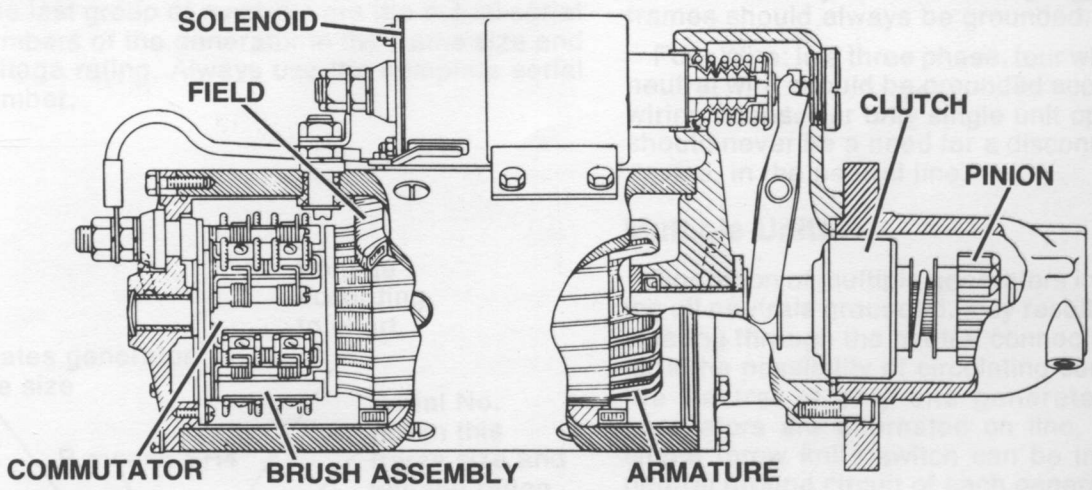
Never operate the alternator without the battery in the circuit. Making or breaking an alternator connection with a heavy load on the circuit will sometimes result in regulator damage.





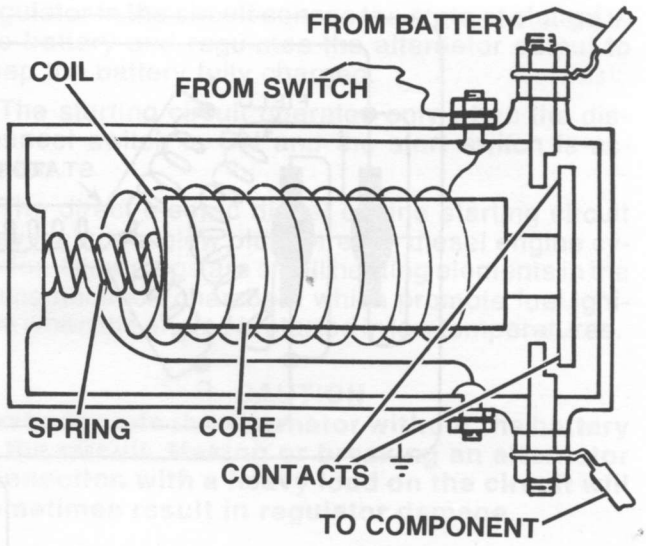
ALTERNATOR CHARGING CIRCUIT (NEGATIVE GROUND SYSTEM ILLUSTRATED)

The starting motor used with direct electric start incorporates a solenoid. The action of the solenoid engages the pinion with the ring gear on the engine flywheel, when the solenoid is energized. The pinion always engages before the electric contacts in the solenoid closes the circuit between the battery and the starting motor. An overrunning clutch protects the starting motor from being over-speeded. Releasing the start-switch disengages the pinion from the ring gear on the flywheel.



24 VOLT STARTING MOTOR

A solenoid is a magnetic switch that utilizes low current to close a high current circuit. The solenoid has an electromagnet with a movable core. There are contacts on the end of the core. The contacts are held open by a spring that pushes the core away from the magnetic center of the coil. Low current will energize the coil and form a magnetic field. The magnetic field draws the core to the center of the coil and the contacts close.



GENERATOR

Identification

Voltage Setting

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

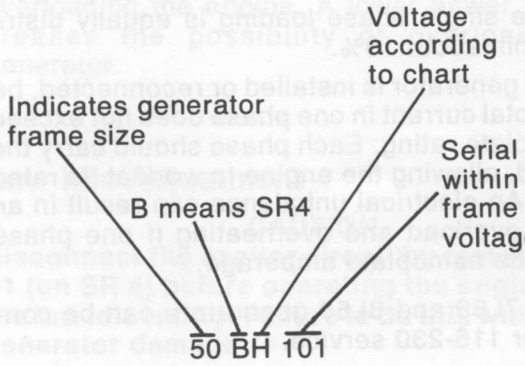
Generator Serial Number

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

1. The group of numbers before the letters indicates generator frame size.
2. 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:

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

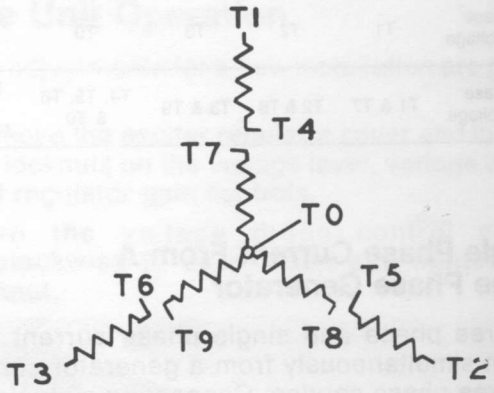
4. The last group of numbers are the actual serial numbers of the generator in the frame size and voltage rating. Always use the complete serial number.



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 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 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. Generator frames should always be grounded.

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 can 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. The switch should be capable of carrying 1.5 times the rated line current of the generator.

Voltage Connections

Three Phase

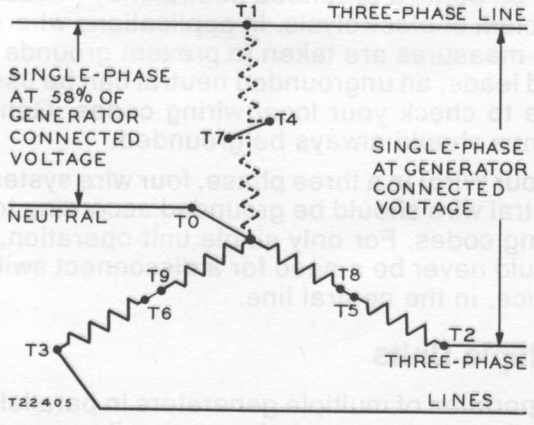
The connections for both high and low voltage are given in the following chart.

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

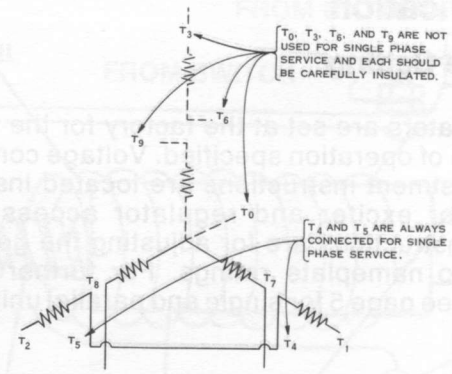
Three phase and single phase current can be taken simultaneously from a generator connected to three phase service. Connecting a single phase lead to any two of the phase leads will provide single phase current at the same voltage as three phase power. Connecting a single phase lead to one phase lead and to neutral will produce current at 58% of the three phase voltage. DO NOT exceed the nameplate current rating for any one phase. Typical commercial voltage designations of this system are 277/480, 230/400, 127/220.



Single Phase

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

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



Three phase (230-460V, 115-230V*, 240-460V, 125-250V and 208-416V) generators 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 simultaneously without reconnecting the leads. In this case DO NOT ground T0. Generator neutral is not T0 but a point in the windings electrically half way between T1 and T8. This point is not wired to a terminal.

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

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

Generator Loading

A three phase load is usually balanced and presents no problem when kept within the rated line amperage limits. However, single phase power taken from a three phase source can be a problem unless the single phase loading is equally distributed within about 10%.

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.

*Only the 7L69 and 8L50 generators can be connected for 115-230 service.

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. Horsepower (KW) consumed in a reactive load is the actual power needed to drive, for example, an electric motor.

At motor start, the inrush current will be very high, usually 6 times the normal running current. However, this current is supplied at a very low power factor, usually around 0.4 to 0.3. As the motor starts and builds up speed, inrush current reduces, but the power factor increases. The actual power (KW), supplied by the engine through the generator, is that which is required to accelerate the motor and its load.

When large motors are started across the generator line leads, high inrush currents will cause generator voltage to fall momentarily. This is called voltage "dip". Normally, voltage "dips" should be limited to about 30%. Voltage "dips" greater than 30% can cause magnetic motor starters to chatter, or drop off the supply line.

Large motors are commonly started through a reduced voltage starter which limits the motor inrush 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

CAUTION

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

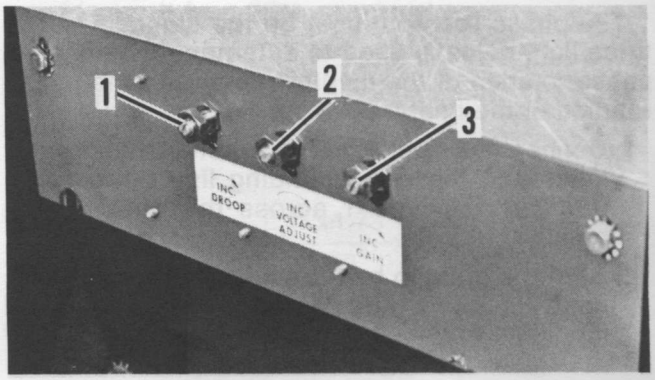
Generator sets require higher low idle setting than do industrial engines. Low idle must not be below 2/3 the full load speed of 60 Hz units (4/5 full load speed of 50 Hz units).

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

Single Unit Operation

Final adjustments for a new installation are given here.

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



VOLTAGE ADJUSTMENT CONTROLS
1. Voltage Droop 2. Voltage Level 3. Voltage Gain

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

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

Parallel Operation

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

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

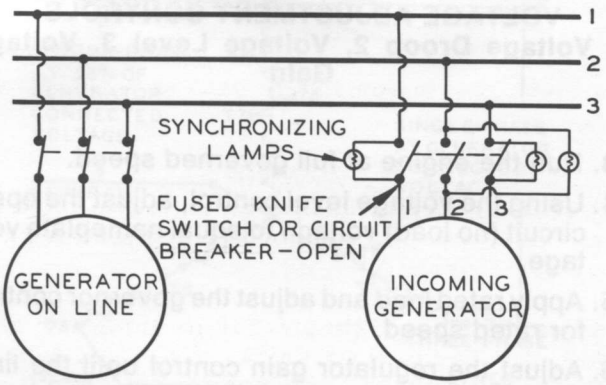
These three conditions may be compared to similar conditions required for engagement of two gears. To mesh as smoothly as possible, two gears must meet the following three conditions:

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

Phase Rotation

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

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



SYNCHRONIZING LIGHTS

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

⚠ WARNING

Never attempt to work on electrically hot wiring. Stop the generator 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

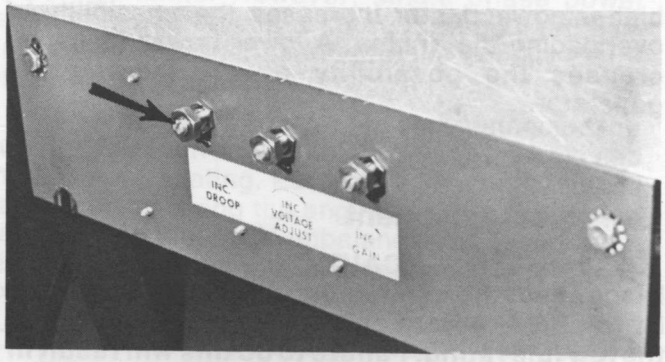
The speed of units to be paralled must be the same. Speed refers to the alternating current frequency.

1. Allow each generator 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), or when adjustment is made with a resistance bank or brine tank. 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.



DROOP ADJUSTMENT

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.
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 generator 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 ¼ 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.

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 Bank Testing

The most popular and inexpensive method used to check generator set power output is the brine tank load test. This simple test uses a salt water solution for a resistive load between the terminals of a generator. The equipment required is relatively easy to acquire and assembly. See your Caterpillar dealer for additional information.

CAUTION

Rated generator KW occurs at 0.8 PF. Therefore, to obtain generator rated KW the line current should be 80% of the nameplate ampere rating of the generator. Operation at full rated current would result in a 25% overload.

For any current reading, the power output of a three phase generator can be calculated using the following formula:

$$KW = \frac{E \times I \times 1.73}{1.000} \times PF$$

Where: KW = Kilowatt output
E = Voltage (average of 3 lines)
I = Amperes (average of 3 lines)
PF = Power Factor

A brine tank or resistance bank is a 1.0 power factor load.

⚠ WARNING

To avoid electrical shock, be sure the tank or any of its metallic support is connected to a good earth ground.

A brine tank test should not be used for any generator above 480 volts. If the generator voltage is greater, use reduction transformers. Avoid any possible flash-over between electrodes and tank.

troubleshooting

INDEX

1. ENGINE FAILS TO START

Possible Causes	Remedy
No Fuel to Engine	Check for empty fuel tank, plugged fuel tank connections, obstructed or kinked fuel suction lines, fuel transfer pump failure, or plugged fuel filters.
Shutoff Solenoid Sticking*	Solenoid must be energized to shut off engine. Actuate the control that operates the shutoff solenoid and listen for a clicking sound. If clicking sound is not evident and engine will not start, remove the solenoid. Again try to start the engine. If the engine starts, the solenoid is bad. Replace the solenoid.
Fuel Transfer Pump	At cranking speed, the fuel transfer pump should supply fuel to the engine at 3 PSI (20 kPa). If fuel pressure is less than 3 PSI (20 kPa), replace the fuel filter. Check for air in fuel system, sticking, binding or defective fuel bypass valve. If pressure is still low, replace the fuel transfer pump.
Engine Improperly Timed	See your authorized dealer.
Glow Plug Failure	Check glow plugs.
Automatic and Safety Shutoff Controls	Check shutoff controls to ensure they are set properly. See Starting Procedures.

*Optional Equipment

2. MISFIRING

Possible Causes	Remedy
Defective Fuel Injection Nozzle or Fuel Pump	Run the engine at the speed where the defect is most pronounced. Momentarily loosen the fuel line nut on the injection pump to "cut out" that cylinder. Check each cylinder in this manner. If one is found where loosening makes no difference in irregular operation, the pump and nozzle for only that cylinder need be treated.
Improper Valve Lash	Set to specified clearance.
Incorrect Fuel Injection Timing	See your authorized dealer.
Low Fuel Supply Pressure	Check fuel supply line for leaks or kinks, air in fuel system, sticking, binding, or defective fuel bypass valve. Replace fuel filter. Check fuel pressure. Fuel transfer pump should supply fuel at 20 to 30 PSI (1.4 to 2.1 kg/cm^2) to the engine when the engine is fully loaded.
Broken or Leaking High Pressure Fuel Line	Replace the line.
Air in Fuel System	Find source of air entry and correct. Bleed system.
Bent or Broken Push Rod	Replace push rod.

3. STALLS AT LOW SPEED

Idle Speed Too Low	See your authorized dealer.
Low Fuel Supply Pressure	Check fuel supply line for leaks or kinks, air in fuel system, sticking, binding, or defective fuel bypass valve. Replace fuel filter. Check fuel pressure. Fuel transfer pump shall supply fuel to 20 to 30 PSI (1.4 to 2.1 kg/cm^2) to the engine when the engine is fully loaded.
Defective Fuel Nozzle	Replace nozzle.
Defective or Damaged Fuel Injection Pumps	Replace damaged or defective parts.*
High Parasitic Loads	Check for excessive loading due to auxiliary attachements.

4. ERRATIC ENGINE SPEED

Governor Control Linkage	Adjust external linkage to obtain sufficient travel. Replace if damaged, bent, or linkage is too short.
Governor Failure	Look for damaged or broken springs, linkage, or other components. Determine if the rack can be moved manually. If any distress is noted in any of these components, replace as necessary.*

*Authorized dealers are equipped with the necessary tools and personnel familiar with disassembly and assembly procedures to perform these services.

5. LOW POWER

Possible Causes	Remedy
Fuel Nozzle Failure	Run the engine at the speed where the defect is most pronounced. Momentarily loosen the fuel line nut on the injection pump to "cut out" that cylinder. Check each cylinder in this manner. If one is found where loosening makes no difference in irregular operation, the pump and nozzle for only that cylinder need be tested.
Poor Quality Fuel	Drain, clean and bleed fuel system. Replace fuel filter. Fill fuel tank with proper grade of fuel.
Turbocharger Carboned or Otherwise Dragging	Inspect and repair or replace turbocharger as necessary.*
Leaks in Air Induction System	Check inlet manifold pressure. Check air cleaner for restriction.
Incorrect Fuel Injection Timing	See your authorized dealer.
Excessive Valve Lash	Set to specified clearance.
Low Fuel Supply Pressure	Check fuel supply line for leaks or kinks, air in fuel system, sticking, binding or defective fuel bypass valve. Replace fuel filter. Check fuel pressure. Fuel transfer pump should supply fuel to 20 to 30 PSI (1.4 to 2.1 kg/cm²) to the engine when the engine is fully loaded.

6. EXCESSIVE VIBRATION

Loose, Worn or Defective Engine Mounts	Tighten all mounting bolts securely. Replace components as necessary.
Loose Pulley and Damper	Retighten.
Loose or Worn Coupling on Driven Equipment	Inspect, align and tighten coupling to driven equipment.
Defective Damper or Pulley	Replace damper or pulley.
Misfiring	See ITEM 2.
Unbalanced Fan Blade	Check by loosening or removing fan belts, and operating engine for "short duration" at affected speed range to see if vibration is still present. If not, replace fan assembly.

7. HEAVY COMBUSTION KNOCK

Possible Causes	Remedy
Air in Fuel System	Bleed air from system.
Defective Fuel Injection Pump Plunger and Barrel Assembly	Replace.*
Defective Fuel Injection Nozzle	Replace.
Incorrect Fuel Injection Timing	See your authorized dealer.*

8. VALVE TRAIN CLICKING NOISE

Excessive Valve Lash	Set to specified clearance.
Broken Valve Spring(s)	Replace valve spring(s) and all other damaged components.*
Insufficient Lubrication	Check lubrication in valve compartment. Should be very wet at all speeds. Oil passages should be cleaned, especially those leading to the cylinder head.

9. OIL IN COOLANT

Failed Oil Cooler Core	Replace oil cooler core.
Failed Head or Spacer Plate Gaskets	Replace head and spacer plate gaskets.
Cracked or Defective Cylinder Block	Replace cylinder block.*
Cracked or Defective Head	Replace cylinder head.

10. MECHANICAL KNOCK

Engine Connecting Rod Bearing Failure	Replace the bearing. Check the connecting rod and crankshaft. Replace if necessary.*
Main Bearing Failure	Replace bearings.*
Damaged Timing Gear Train	Replace components as necessary.*
Broken Crankshaft	Replace crankshaft.*
Fuel Dilution of Crankcase Oil	Correct fuel leakage into crankcase oil.

*Authorized dealers are equipped with the necessary tools and personnel familiar with disassembly procedures to perform these services.

11. EXCESSIVE FUEL CONSUMPTION

Possible Causes	Remedy
Fuel System Leaks	Large changes in fuel consumption may result. Internal leaks will probably be accompanied by low engine oil pressure and increased oil level in the engine oil sump. Replace leaking components.
Fuel and Combustion Knock	Small but measurable increases in fuel consumption may be the result of defective fuel nozzles, misfiring or factors contributing to loss of power. See ITEM 2 and ITEM 5.
Incorrect Fuel Injection Timing	See your authorized dealer.

12. LOUD VALVE TRAIN NOISE

Bent or Broken Valves	Replace damaged parts.*
Broken Camshaft	Replace all damaged parts. Clean engine thoroughly.
Broken or Severely Worn Valve Lifters	Replace camshaft and valve lifters. Check for sticking valves and bent valve stems. Clean engine thoroughly. Set valve lash to specified clearance.

13. EXCESSIVE VALVE LASH

Severely Worn Cam Lobes	Check valve lash. Replace camshaft and followers. Clean engine thoroughly. Set valve lash to specified clearance.
Broken or Severely Worn Valve Lifters	Replace valve lifters. Check camshaft for wear. Check for sticking valves and bent valve stems. Clean engine thoroughly. Set valve lash to specified clearance.
Valve Tip Wear	Set valve lash to specified clearance. If wear is excessive, replace valve.
Moderate Valve Lifter Face Wear	Set valve lash to specified clearance. If wear is excessive, replace valve lifter.
Push Rod Wear	Set valve lash to specified clearance. If wear is excessive, replace push rod.
Rocker Arm Anvil Wear	Set valve lash to specified clearance. If wear is excessive, replace rocker arm.
Insufficient Lubrication	Check lubrication in valve should be very wet at high idle speeds, but only damp at low idle. Oil passages should be cleaned, especially those leading to the cylinder head.

14. VALVE SPRING RETAINER FREE

Possible Causes	Remedy
Broken Keepers	Extensive engine damage may result from dropped valve. Replace all damaged part.*
Broken Valve Spring	Replace valve spring.*
Broken Valve	Replace valve and any other damaged parts.*

15. SLOBBER

Excessive Valve Guide Wear	Recondition cylinder head assembly.*
Excessive Lubricating Oil in Valve Compartment	Check rocker arm shaft and plugs to assure that they are in place.
Worn Piston Rings and/or Liners	Inspect and replace components as necessary.*

16. VALVE LASH CLOSE-UP

Valve Face and/or Seat Wear	Adjust valves to specified clearance. Recondition cylinder head.

17. PREMATURE ENGINE WEAR

Intake Piping Failure (Air Cleaner)	Inspect all gaskets and piping for leaks. Repair all leaks.
Excessive Fuel Dilution of Lubricating Oil	Replace leaking components. This will probably be accompanied by high fuel consumption and low engine oil pressure. Tighten fuel injection line fittings under valve cover.
Dirt in Lubricating Oil	Locate and correct source of dirt entry. Change lubricating oil. Change oil filter.

18. COOLANT IN ENGINE LUBRICATING OIL

Oil Cooler Failure	Replace oil cooler core.
Cylinder Head Gasket Failure	Replace gasket. Maintain proper torque on cylinder head bolts.
Cracked or Defective Cylinder Head	Replace cylinder head.*
Cracked or Defective Cylinder Block	Replace cylinder block.*

*Authorized dealers are equipped with the necessary tools and personnel familiar with disassembly and assembly procedures to perform these serviced.

18. COOLANT IN ENGINE LUBRICATING OIL (Cont'd)

Possible Causes	Remedy
Cylinder Liner Seal Leaking	Replace seals.*
Cracked or Defective Cylinder Liners	Replace cylinder liners.*

19. EXCESSIVE BLACK OR GRAY SMOKE

Insufficient Combustion Air	Check air cleaner for restriction. Check inlet manifold pressure. Inspect turbocharger for proper operation.
Fuel Nozzle Plugged or Leaking	Replace nozzle.
Incorrect Fuel Injection Timing	See your authorized dealer.
Fuel Ratio Control Improperly Adjusted	Adjust fuel ratio control.*

20. EXCESSIVE WHITE OR BLUE SMOKE

Valve Guides Worn	Recondition cylinder head assembly.*
Piston Rings Worn, Stuck or Broken	Replace.*
High Crankcase Oil Level	Avoid overfilling. Determine cause and drain excess oil.
Misfiring	See ITEM 2.
Fuel Injection Pump Timing Wrong	See your authorized dealer.
Air in Fuel System	Bleed fuel system.

21. LOW ENGINE OIL PRESSURE

Engine Oil Diluted with Fuel Oil	Check lip-type seal on fuel transfer pump drive shaft. Drain crankcase and refill with clean lubricant.
Excessive Crankshaft Bearing Clearance	Replace bearings and/or crankshaft.* Check oil filter operation.
Excessive Timing Gear Bearing Clearances	Inspect bearings and replace components as necessary.
Excessive Rocker Arm Bore or Rocker Arm Shaft Wear	Check lubrication. Replace components as necessary.
Defective Oil Pump	Repair or replace.*
Defective Suction Bell	Replace.

21. LOW ENGINE OIL PRESSURE (Cont'd)

Possible Causes	Remedy
Clogged Oil Filter or Cooler	Repair or replace as necessary.
Oil Pump Relief Valve Stuck	Clean valve and housing. Replace if necessary.

22. HIGH LUBRICATING OIL CONSUMPTION

Oil Leaks	Replace gaskets or seals and tighten all connections.
Excessive Oil to Intake	See ITEM 15. Valve Guides.
Excessive Valve Guide Wear	See ITEM 15.
Crankcase Oil Level Too High	Avoid overfilling. Determine cause and drain excess oil.
High Oil Temperature	Check oil cooler bypass valve. Replace if defective. Clean oil cooler core.
Worn Piston Rings and/or Liner	Replace components as necessary.*

23. ABNORMAL ENGINE COOLANT TEMPERATURE

Combustion Gases in Coolant	Determine point at which gases enter the system. Repair or replace components as necessary.
Defective Water Temperature Regulator or Temperature Gauge	Check temperature regulator for proper opening temperature and correct installation. Check temperature gauge. Replace if necessary.
Coolant Level Low	Determine cause—replace leaking gaskets and hoses. Tighten connections. Add coolant.
Air Flow Through Radiator Restricted	Remove all debris from outer surface of radiator.
Defective Water Pump	Check water pump impeller. Repair water pump as necessary.
Radiator Small for Engine Application	Install correct size radiator.
Fan Improperly Positioned in Shroud or Not Shrouded	Position fan correctly.*

*Authorized dealers are equipped with the necessary tools and personnel familiar with disassembly and assembly procedures to perform these services.

23. ABNORMAL ENGINE COOLANT TEMPERATURE

Possible Causes	Remedy
Incorrect Fuel Injection Timing	See your authorized dealer.
Incorrect Water Piping Connections from Engine to Radiator	Check shunt line (if equipped) and vent line for correct installation.

24. STARTING MOTOR FAILS TO CRANK

Low Output from Battery	Check battery and charge or replace.
Defective Wiring or Switch	Repair or replace.
Defective Solenoid	Replace.
Defective Starting Motor	Repair.

25. ALTERNATOR FAILS TO CHARGE

Drive Belt Loose	Adjust belt.
Open or High Resistance in Charging or Ground Return Circuits or Battery Connections	Inspect all cables and connectors. Clean, retighten or replace defective parts.
Excessively Worn, Open or Defective Brushes	Replace brush assembly.*
Open Rotor Field Coil	Replace rotor assembly.*

26. ALTERNATOR CHARGING RATE LOW OR UNSTEADY

Drive Belt Loose	Adjust belt.
Intermittent or High Resistance in Charging or Ground Return Circuits or Battery Connections	Inspect all cables and connectors. Clean, retighten or replace defective parts.
Excessively Worn, Sticky, or Defective Brushes	Replace brush assembly.*
Faulty Regulator	Replace regulator.*
Shorted or Open Rectifier Diodes	Replace defective rectifier diode assembly in alternator.*
Grounded or Shorted Rotor	Replace rotor assembly.*

27. ALTERNATOR CHARGING RATE HIGH

Possible Causes	Remedy
Loose Connections	Tighten connections to alternator and regulator.
Defective Regulator	Replace regulator.

28. ALTERNATOR NOISY

Defective Drive Belt	Replace belt.
Misaligned Belt or Pulley	Align drive pulley, alternator pulley and belt.
Loose Pulley	Tighten pulley nut. If keyway is worn, install a new pulley.
Worn Bearings	Replace bearings.
Shorted Rectifiers in Alternator	Replace diode assembly.*
Armature or Rotor Shaft Bent	Replace component.*

*Authorized dealers are equipped with the necessary tools and personnel familiar with disassembly and assembly procedures to perform these serviced.

MAINTENANCE RECORD

MODEL ______________________________

SERIAL NO. ______________________________

DATE	HOURS	FUEL		LUBE	PARTS		LABOR		DOWN	SERVICE PERFORMED
		QUAN.	COST	OIL	PART	COST	TIME	COST	TIME	

MAINTENANCE RECORD

MODEL ______________________________

SERIAL NO. ______________________________

DATE	HOURS	FUEL		LUBE	PARTS		LABOR		DOWN	SERVICE PERFORMED
		QUAN.	COST	OIL	PART	COST	TIME	COST	TIME	

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Caterpillar Warranty

INDUSTRIAL, AGRICULTURAL, AND MARINE ENGINES, MARINE TRANSMISSIONS AND ELECTRICAL POWER GENERATION PRODUCTS

This warranty applies to the following products delivered to the first user on or after January 1, 1982.

Caterpillar warrants new engines for industrial, agricultural, and marine applications, marine transmissions and electrical power generation products ("products") sold by it (except products installed in on-highway vehicles, in machines manufactured by Caterpillar or in marine pleasure craft sold in the United States of America, to which different warranties apply) to be free from defects in material and workmanship subject to the following provisions.

Warranty Period

The warranty period is 12 months (24 months for standby electric generators and mobile agricultural machines) starting from date of delivery to the first user.

Caterpillar Responsibilities

If a defect in material or workmanship is found during the warranty period Caterpillar will provide through a Caterpillar dealer or other source approved by Caterpillar:

- New or repaired parts at Caterpillar's choice.
- Reasonable and customary labor during normal working hours needed to make the warranty repair.
- Labor needed to disconnect and reconnect the product from its attached equipment, mounting, and support systems.
- Reasonable travel expenses if Caterpillar chooses to perform the repair in the field.
- Usual and customary parts shipping charges to the approved source.
- Lubricating oil, filters, antifreeze and other service items made unusable by the warranty failure.

User Responsibilities

User is responsible for:

- All costs for transporting the product or equipment in which the product is installed.
- Travel expenses for field repair of products in remote places.
- Premium or overtime labor costs.
- Any removal and installation costs beyond those required to disconnect and reconnect the product from its attached equipment, mounting, and support systems.
- Parts shipping charges in excess of those which are usual and customary.
- Costs to investigate performance complaints unless the problem is caused by a defect in Caterpillar material or workmanship.
- Giving timely notice of a warrantable failure and promptly making the product available for repair.

Limitations

Caterpillar is not responsible for failures resulting from:

- Any use or installation which Caterpillar judges improper.
- Attachments, accessory items and parts not sold or approved by Caterpillar.
- Abuse, neglect and improper repair.
- User's unreasonable delay in making the product available after notice, for product improvements ordered by Caterpillar.
- Caterpillar does not warrant items sold by it which are warranted by another maker.

This warranty is expressly in lieu of any other warranties, express or implied, including any warranty of merchantability or fitness for a particular purpose. Remedies under this warranty are limited to the provision of material and services, as specified above. Caterpillar is not responsible for incidental or consequential damages.

As used in this warranty the term "Caterpillar" means Caterpillar Tractor Co. or one of its subsidiaries whichever last sold the product involved.

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maintenance

Recommended Preventive Maintenance Guidelines for Standby Generator Sets

Reference Literature

Operation and Maintenance Guides

3204 Industrial Engine SEBU5851

3208 Industrial & Generator Set Engines SEBU5967

3208 Marine Engine SEBU5988

3304 & 3306 Marine Engines SEBU5559

3304, 3306, 3304B & 3306B Industrial Engines SEBU5779

3406 & 3406B Industrial Engines SEBU5791

3408 & 3412 Industrial Engines SEBU5415

3508, 3512 & 3516 Industrial Engines SEBU5853

D346, D348 & D349 Industrial Engines SEBU5405

D353 Industrial Engine SEBU5364

D353 Marine Engine SEBU5347

D379, D398 & D399 Industrial & Generator Set Engines SEBU5698

D379B, D398B & D399B Marine Engines SEBU5561

Owner's Manuals

3304B & 3306B Marine Engines SEBU5987

3406B Marine Engine SEBU5881

3408 Marine Engine SEBU5454

3412 Marine Engine SEBU5547

3508, 3512 & 3516 Marine Engines SEBU5856

Service Manuals

SR4 Electric Set Generator SENR7958

SR4 Generator (Big) SENR2180

SR4 Generator SENR7968

SR4 and SRCR Generators SEBU5717

SR4 Generators and Control Panel SEBU6051

2301 Electric Governor SENR2928

Introduction

The objective of this publication is to assist users in establishing a Preventive Maintenance Program for Standby Generator Sets or as an aid in evaluating their present programs.

Standby Generator Sets may not be needed very often, but when they are, it is usually under emergency conditions. Maintenance of these standby units is very important. They must always be in excellent operating condition, ready to work under load at any time.

Establishing a Preventive Maintenance Program will provide maximum availability of a standby generator set when needed, longer engine and generator life, and a minimum of expensive repairs.

The recommended weekly maintenance checks can be performed by an operator. All yearly and three year maintenance should be performed by an authorized mechanic or your Caterpillar dealer.

These guidelines are to be used with the Operation and Maintenance guide for your engine. The engine guide will provide the necessary information on how to perform the checks and routine maintenance. Additional information can be obtained from the Generator and Engine Service Manuals, or contact your Caterpillar dealer for assistance.

Inspection and Maintenance Agreements

Your Caterpillar dealer can establish an Inspection and Preventive Maintenance Program for your generator set to provide maximum reliability, increased engine and generator life, and minimize expensive repairs. Contact your Caterpillar dealer for details.

General Recommendations

Safety

Always make repairs with the engine stopped and the starting system disabled. When servicing the generator, make sure that switch gear and automatic transfer switches will not present a shock hazard. Lock them out on the generator being serviced.

Record Keeping

Maintain a log or record keeping system to document all gauge readings, problems, repairs, and maintenance performed on the equipment.

Space Heaters

Moisture is a natural enemy of generators and all electrical equipment. Every effort must be made to keep the generator as dry as possible. Space heaters should be operated inside the generator when it is not in use to maintain the integrity of the generator windings.

⚠ WARNING

The stop-manual-automatic switch on the cranking panel must be set at "stop" position when performing maintenance or repair work on a standby generator set. This prevents the unit from starting if a power failure or voltage drop should occur while working on the unit.

To prevent personal injury due to accidental starting of the engine, disconnect the batteries or disable the starting system before doing maintenance or repair work.

Lock out all switch gear and automatic transfer switches associated with the generator while performing any generator maintenance or repairs. Make sure no shock hazard exists.

Failure to comply could result in personal injury or death.

Preventive Maintenance for Standby Generator Sets To Be Performed By An Authorized Operator

Item	Service
Weekly: Before Starting the Engine	
Walk-Around Inspection	Check the engine, radiator and generator for debris, foreign objects, loose or broken fittings, guards and components. Repair as necessary.
Belts	Inspect for worn, broken or loose belts (alternator, fan, drive, etc.).
Cooling System	Maintain proper coolant level.
Block Heater	Check for proper operation. Maintain 32°C (90°F) coolant temperature in the block at all times.
Air Cleaner Indicator	Check the indicator. Change the air cleaner elements when the indicator diaphragm remains locked.
Engine Crankcase	Check the oil level. Maintain the oil level between the add and full marks on the engine stopped side of the dipstick.
Governor	Check and maintain the oil level (if required).
Fuel System	Check for leaks and drain water separator (if equipped). Keep fuel tank full. Check fuel filter indicator (if equipped).
Air System (If Equipped)	Drain condensate; check air pressure.
Batteries	Maintain electrolyte level, clean batteries if necessary, check for tight connections.
Gauges	Check the condition of all gauges. Repair or replace any broken gauge.
Battery Charger	Check for proper operation.
Generator and Control Panel	Visual inspection – check for loose, broken, or damaged wiring or components.

Preventive Maintenance for Standby Generator Sets To Be Performed By An Authorized Operator

Item	Service
Weekly: With Engine Running	
Start the Engine	The following operational checks are intended to check the generator operation and the engine starting, lubricating and fuel systems as well as overall operation. The checks should take no longer than five (5) minutes to complete. Longer periods of operation are not required. A more beneficial test will be performed annually with the engine operating under load.
Oil Pressure	Check for proper operating oil pressure. Refer to the Operation and Maintenance guide for the correct pressure reading.
Fuel Pressure	Check for proper operating fuel pressure. Refer to the Operation and Maintenance guide for the correct pressure reading.
Engine Crankcase	Check the oil level. Maintain the oil level between the add and full marks on the engine running side of the dipstick. NOTE: This check is not required for 3200 Series Engines.
Frequency (rpm) and Generated Voltage	Check and record readings. NOTE: The operating voltage of a cold (just started) generator will be slightly higher than the operating voltage of a generator that has been under load and warm. The full load voltage of a SR4 Generator will decrease a maximum of 1% when this generator stabilizes at 100°C (212°F). Most of the voltage decrease occurs in about 30 minutes. Generally, temperatures of generators stabilize within two hours.
Radiator Louvers	Check for proper operation (able to open and close freely).
Leaks and Noises	Check for leaks and unusual noises. NOTE: Engine must be stopped before making necessary repairs.
Weekly: After Stopping the Engine	
Automatic Switches (If Equipped)	Check that all switches are in proper position for automatic start.
Fuel Level	Check the fuel level; refill when below three-fourths full.
Battery Charger	Record charging amperage reading.
Malfunctions	Report any malfunction and make necessary repairs.

Preventive Maintenance For Standby Generator Sets To Be Performed By An Authorized Mechanic

Item	Service
Yearly: Before Starting the Engine	
Walk-Around Inspection	Perform all Weekly Before Starting the Engine Preventive Maintenance Procedures. Check the engine, radiator, and generator for debris, foreign objects, loose or broken fittings, guards and components. Repair as necessary.
Cooling System	Check for leaks. Add coolant conditioner (if required).
Fuel System	Drain water and sediment from tank. Change fuel filters.
Air Cleaner Element	Inspect; clean or replace.
Governor	Check and maintain oil level (if required).
Engine Crankcase	Check oil level. Maintain oil level between the add and full marks on the engine stopped side of the dipstick.
Engine Crankcase Breather	Clean.
Valve Lash	Check, adjust if necessary. Refer to the engine Service Manual for proper procedure and settings.
Linkages	Check and adjust all linkages, if necessary. Lubricate all linkage fittings.
Alarms and Shutdown Devices	Check; test for proper operation.
Batteries	Check electrolyte level, clean terminals and connections.
Engine	Wipe down; clean as needed.
Generator NOTE: Refer to the generator Service Manual for information relating to use of the megohmmeter and low resistance readings.	Lubricate bearing; vacuum clean and check wiring of the regulator, exciter and stator. Check generator windings with megohmmeter and record readings for reference. Check operation of space heaters.
Yearly: With Engine Running	
Start the Engine	Check all gauges, oil pressure, fuel pressure, rpm (frequency), generated voltage and engine jacket water temperature, for correct readings.
Engine Crankcase	Check the oil level. Maintain the oil level between the add and full marks on the engine running side of the dipstick.
Radiator Louvers	Check for proper operation (able to open and close freely).
Leaks and Noises	Check for leaks and unusual noises. NOTE: Engine must be stopped before making necessary repairs.
Load Test	Load the engine to minimum of 30% of rated load. Operate at this level for minimum of two hours.
Gauge Readings	After approximately one hour record the readings of all gauges: oil pressure, fuel pressure, oil level, rpm (frequency), generated voltage, service meter, engine jacket water temperature, exhaust temperature (if equipped) and manifold vacuum (if equipped).
Yearly: After Stopping the Engine	
Repair or Adjust	Make any repairs or adjustments to the engine and generator set as necessary.
Engine Crankcase	Change oil; take sample for analysis. Change filters, cut old filter open and inspect for foreign material.
Fuel Level	Record the fuel tank level. Fill if below three-fourths full.
Battery Charger	Record charging amperage reading.
Automatic Switches (If Equipped)	Check that all switches are in proper position for automatic start.

Preventive Maintenance For Standby Generator Sets To Be Performed By An Authorized Mechanic

Item	Service
Every Three Years: Before Starting the Engine	
Before Starting	Perform all Weekly and Yearly Before Starting the Engine Preventive Maintenance procedures.
Cooling System	Drain, clean and flush the cooling system. Replace thermostat(s). Refill with coolant solution and conditioner.
Rubber Hoses and Belts	It is recommended that all hoses and belts be replaced at this time to minimize downtime and additional repair cost of component failures caused by these items.
Batteries	Replace all batteries at this interval.
Turbocharger	Inspect for proper operation. Check the end play and radial clearance on the turbine wheel and shaft.
Engine	Perform a complete engine adjustment and tune-up.
Every Three Years: With Engine Running	
Engine Running	Same as all Yearly With Engine Running Preventive Maintenance procedures.
Exhaust System	Check for leaks. Repair or replace defective components with engine stopped.
Every Three Years: After Stopping the Engine	
After Stopping	Same as all Yearly After Stopping the Engine Preventive Maintenance procedures.

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DESCRIPTION:

Generator

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NEWAGE STAMFORD

'C' Range

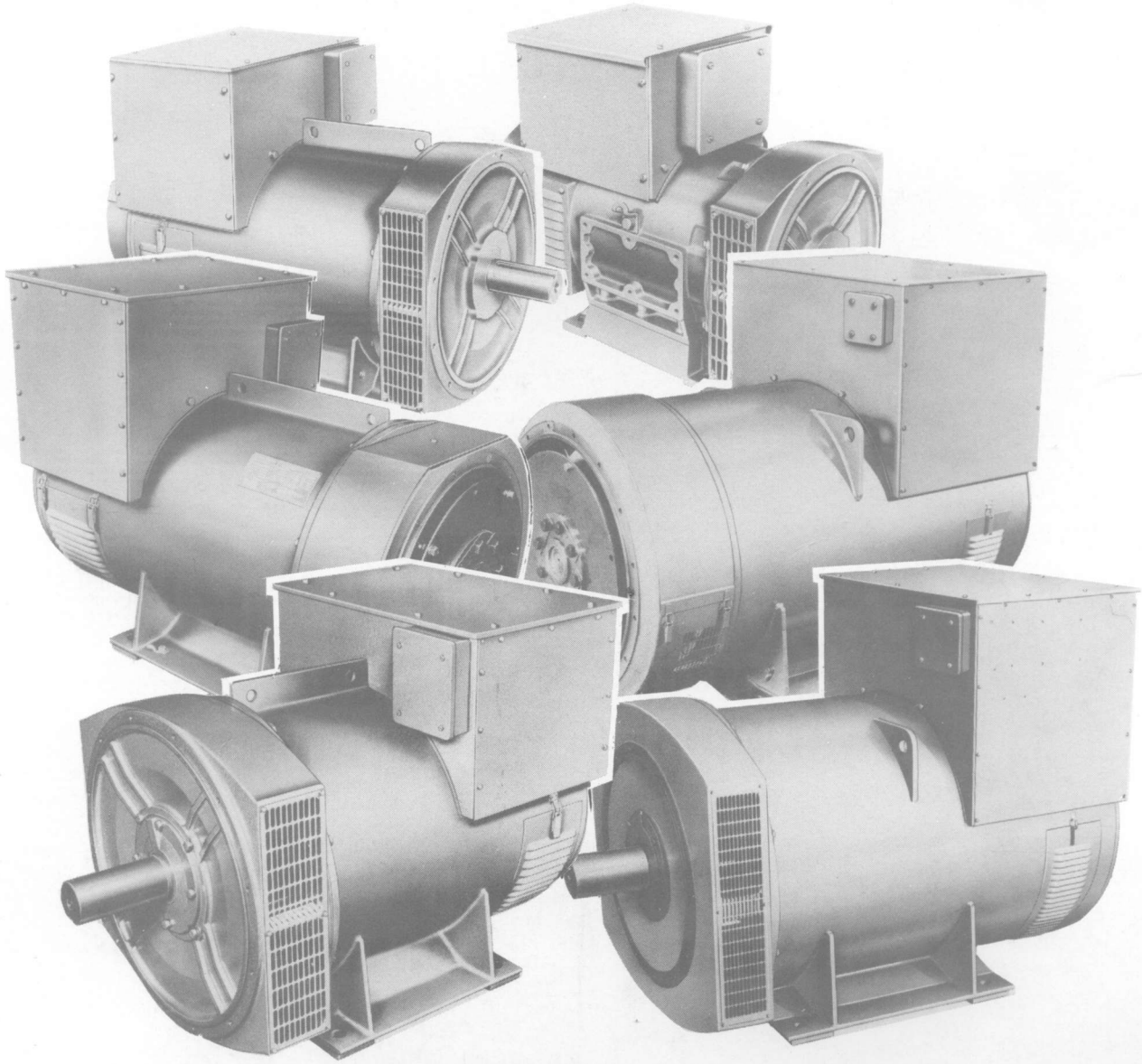
FRAMES 2,3,4,5,6&7

Series 3 A.V.R. Controlled and Permanent Magnet Pilot

Operation & Maintenance Manual

Machine Designations

SC and MSC 234, 334, 434, 534, 634, 734, 636, 736



Publication No. 1H-056 6th. Edition

CONTENTS

SECTION ONE

GENERAL DESCRIPTION

The SC range Stamford a.c. generator is a brushless revolving-field A.V.R.-controlled high-performance machine. All the generators described in this manual incorporate the Stamford Series 3 excitation system, which is powered by a permanent-magnet pilot exciter, providing a virtually constant-voltage excitation source independent of load changes and offering rapid response, good motor-starting characteristics, and positive voltage build-up. Frames 2 - 5 are available only as 4-pole machines, while Frames 6 & 7 are supplied at 4-pole or 6-pole speeds, as required. All the framesizes are available as 3-phase 4-wire machines as standard, but an optional 12-wire reconnection facility is available up to and including the 4-pole SC634A (600/750 kVA 50/60Hz) and the 6-pole SC636B (350/440 kVA 50/60Hz).

STANDARD VOLTAGE AND WINDING SELECTION

4 Wire and 6 Wire Non-Reconnectable			
HZ	**L-L Voltages Wdg. No. 212**	**L-L Voltages Wdg. No. 07**	**L-L Voltages Wdg. No. 18**
50	346-415	440-500	380-460
60	380-480	550-600	460-550

12 Wire Reconnectable L-L Voltages					
Wdg. No.	**Hz**	**Series Star 3 Ph. 4W.**	**Parallel Star 3Ph. 4W.**	**Series Delta 3Ph. 3W. or 1Ph. 2W.**	**Double Delta 1Ph. 3W.**
211	50	346-415	173-208	200-240	200-240
	60	380-480	190-240	220-277	220-277
17	50	440-500	220-250	— — —	— — —
	60	550-600	— — —	— — —	— — —
19	50	380-460	190-230	220-266	220-266
	60	460-480	230-240	266-277	266-277

NOTES: 1. Deratings apply to windings 211 and 212 as follows:-

a) 50Hz. Max. current ratings 380V. (Series Star)
190V (Parallel Star), 220V (Series Delta and Double Delta.)
b) 60Hz. Max. current rating 460V (Series Star)
230V (Parallel Star), 266V (Series Delta and Double Delta)

2. Deratings can apply on certain core sizes and voltages on windings 07, 17, 18, 19. Refer to factory for details.

3. For non-listed voltages or voltage ranges (up to 600V) apply to factory.

MACHINE DESIGNATION

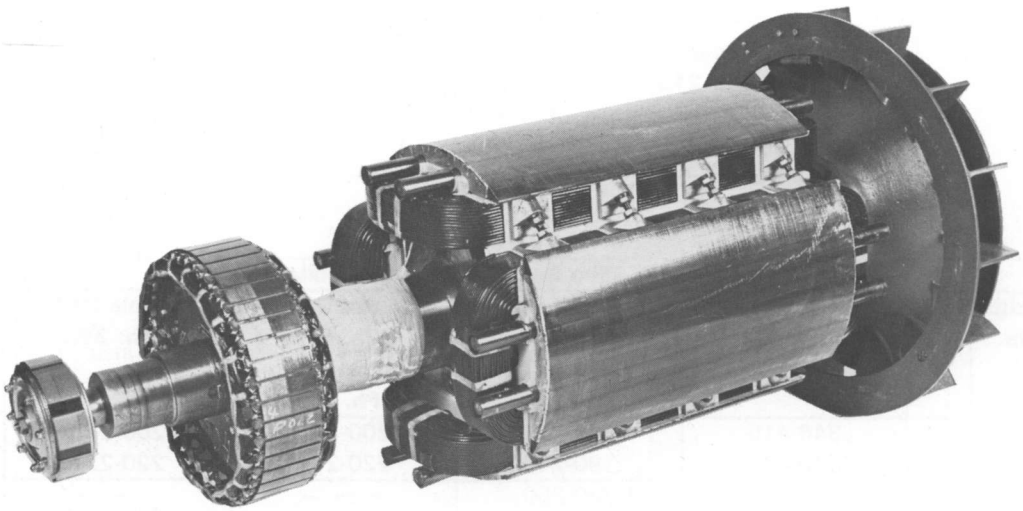
The standard Stamford letter/number coded identification system is used for the whole of the SC range. The first digit after the SC prefix indicates the frame diameter, in this instance 2 to 7; the next digit indicates the excitation system (in this instance 3 only); and the third digit indicates the pole number (4 only, in diameters 2 to 5; 4 or 6 in diameters 6 and 7). The final letter suffix indicates an internal core length, and may be A,B,C,D or E. Marine machines use an overall prefix M.

CONSTRUCTION

The machines are air-ventilated, screen-protected, and drip-proof to IP21 (BS4999 Part 20), and can be in either two-bearing or single-bearing form. Except for Frame 2 (which is of cast-iron construction) all machines have a fabricated steel frame, cast-iron endbrackets, and a large sheet-steel terminal box at the non-drive end.

The stator and rotor cores are produced from low-loss electrical-grade sheet-steel laminations, jig-built and welded under controlled pressure. All the wound components are insulated and impregnated to constitute a Class H(180^{o}C) insulation system.

A high grade precision machined shaft carries the rotor assembly which comprises the generator rotating field system, incorporating a fully interconnected damper winding, the exciter rotor/rotating rectifier system and cooling fan. The rotor is mechanically wedged and supported on the end winding to allow an overspeed of up to 2250 rev/min. On completion the whole rotor assembly, together with the permanent magnet rotor assembly, is dynamically balanced to within precision limits to ensure vibration-free running. The photograph below shows a complete assembly.



Typical 4 Pole Rotor

The rotor is supported by liberally-rated long-life ball bearings. In Frames 2 & 3 these are of the sealed-for-life type; in Frames 4 - 7 cartridge housings, which allow the machine to be dismantled without disturbing the bearings, are fitted.

The bearings are pre-packed with a lithium based grease for a calculated life of 30,000 hours in an ambient of 40^{o}C.

The housing fitted to single bearing machines is designed to prevent bearing 'creep' and also to allow rotor ' end-float' to avoid thrust created by tolerance variations.

The control system comprises a totally enclosed permanent magnet generator mounted externally to the N.D.E. bearing, an AVR mounted from the terminal box in its own totally enclosed compartment and an exciter/rotating rectifier assembly mounted internally to the N.D.E. bearing.

Removable access covers are provided at the D.E. and N.D.E. of the machine. Both side panels and top panel are removable on the terminal box to provide easy access to the output terminals and other ancillary equipment.

SECTION TWO

INSTALLATION

HEALTH AND SAFETY NOTE

Important

British Government Health and Safety at Work Act, 1974

In view of the above Act is it necessary to draw your attention to the following :-

On adaptors/flanges fitted between the a.c. generator and engine the openings must be guarded. Where integral guards are not provided an external protection cover must be fitted.

All a.c. generators are designed with screen protected and drip proof enclosures and as such are not suitable for mounting outdoors unless adequately protected by the use of canopies.

VENTILATION

When installed in a room without special ventilation arrangements it must be ensured that the ambient temperature of the normal operating conditions does not exceed the maximum value for which the machines are designed. (Normally a maximum of $40^{o}C$). Heat dissipation and cooling air requirements are available on request.

INITIAL CHECKS

If it is necessary to store the machine for long periods, the storage accommodation should be clean, dry and well ventilated. We would recommend the use of anti-condensation heaters to ensure that winding insulation is kept in a good condition where machines are stationary for long periods, i.e. standby plant. Before installation of an a.c. generator which has been kept in storage the insulation resistance of the windings should be checked using a megger or similar instrument. It is essential that the automatic voltage regulator (A.V.R.) is completely isolated before testing, otherwise damage to the electronic components may be sustained. If radio interference suppression capacitors have been fitted in the terminal box these should also be disconnected. If the tests show that the insulation resistance is below 0.5 of a megohm, the machine should be dried out and the test made again. With a completely dry machine the resistance value should be at least 2 megohms. The machine windings can be dried out by applying warm air from a fan heater or similar apparatus into the machine openings. Alternatively, the main stator windings may be short circuited, and the generating set run with the exciter stator supplied from a d.c. source. A 12 volt 0.5 amp d.c. supply should be connected to the exciter stator leads, marked X and XX .

WARNING: The short circuit must not be applied with the A.V.R. connected in circuit.

Normally no longer than half an hour will be required for drying out windings in this manner. After this period of time the insulation level should be checked and the drying out procedure repeated if necessary.

VOLTAGE ADJUSTMENT

The machine is factory set to give the optimum performance at the ordered voltage and frequency and no adjustment will normally be required. Should it be necessary to change the voltage from the ordered value, adjustment should be made as follows:-

1. Remove A.V.R. box lid.
2. Adjust VOLTAGE RANGE control to required voltage.
3. Adjust STABILITY CONTROL (only if necessary) until stable operation is obtained "ON" and "OFF" load. Turning control anti-clockwise improves stability.

If a hand trimmer has been supplied for remote voltage control, fine adjustment to the nominal voltage level set by the RANGE control can be made. (See page 35 for details).

UNDER FREQUENCY PROTECTION ADJUSTMENT

This is set for 50 Hz or 60 Hz operation by means of a "JUMPER" lead on the A.V.R. If it is necessary to change this setting appropriate instructions are given on a label fixed to the inside of the A.V.R. box lid.

OVER EXCITATION PROTECTION ADJUSTMENT

This is set for 48v or 60v by means of a "JUMPER" lead on the A.V.R. If it is necessary to change this setting appropriate instructions are given on a label fixed to the inside of the A.V.R. box lid.

OVERVOLTAGE PROTECTION

This is fitted as standard on frames 6 and 7 and can be supplied as an accessory on frames 4 and 5. It comprises an excitation switch and an overvoltage module (O.V.M.) which is factory set to 'trip' at 25% overvoltage. Should it be necessary to change the machine voltage from the ordered values, adjustment to the O.V.M. should be made as given on the accessory sheet Section 6.

EARTHING ARRANGEMENT

On all star connected machines a substantial neutral terminal is provided for connection to the distribution network. This is not connected to the frame of the machine. The a.c. generator frame should, however, be solidly earthed to the generating set bedplate and connected to the common system earth. On generating sets used for mains failure standby special earthing arrangements may be necessary and the local area Electricity Authority or Company should be consulted.

DIRECTION OF ROTATION

All machines are fitted with a radial bladed fan and are suitable for running in either direction of rotation. The standard machine is supplied to give a phase sequence U.V.W. with the machine running clockwise looking at the drive end unless otherwise specified at the time of ordering. If machine rotation is reversed after the machine has been despatched apply to factory for appropriate instructions and wiring diagrams.

MAIN TERMINAL ARRANGEMENT

The main output terminals have been designed to accept cables rated in accordance with normal standard specifications for single or multicore cables, and are based on the use of crimped-type cable terminations.

Frame 2 & 3 — 12-wire reconnectable
The terminal arrangement consists of four stud terminals 10 mm diameter Frame 2 and 12 mm Frame 3.

Frame 4 - 4 and 6 and 12 Wire
Frame 5 - 4 and 6 Wire
The terminal arrangement consists of 4, 12 mm diameter stud terminals capable of accepting one or two cable lugs, having a hole of 14 mm diameter and maximum width of 40 mm.

Frame 5 - 12 Wire
Frame 6 - 4 and 6 Wire
This is provided with 4 terminal bars each 90 mm wide having two holes of 14 mm diameter capable of accepting 3 — 4 cable lugs having holes of 14 mm diameter and maximum width of 40 mm.

Frame 6A/B - 12 Wire
Frame 7 - 4 and 6 Wire
The terminal arrangement consists of 4 terminal bars each 120 mm wide having two holes of 14 mm diameter capable of accepting 3 - 4 cable lugs having holes of 14 mm diameter and a maximum width of 60 mm.

A.C. GENERATOR TO ENGINE ASSEMBLY

Torsional Vibration

Torsional vibrations occur in all engine driven shaft systems and may be of a magnitude to cause damage at certain critical speeds. It is therefore necessary to consider the torsional vibration effect on the a.c. generator shaft and couplings. It is the responsibility of the generator set manufacturer to ensure compatability, and for this purpose drawings showing the shaft dimensions, coupling details and rotor inertias are available for customers to forward to the engine supplier.

Two Bearing Machines

It is beyond the scope of this publication to give guidance on ways and means of a.c. generator installation in great depth due to the many different designs of generating sets and engine configurations. However, it is recommended that the engine/a.c. generator is mounted on a substantial steel bedplate with machine pads to ensure accurate engine/a.c. generator alignment. Where machine faces cannot be accurately achieved, it is necessary to fit shims under the engine/a.c. generator feet to ensure alignment and avoid vibration.

If flexible mountings are used under the bedplate and their position is far removed from the corresponding engine/ a.c. generator feet, a rigid bedplate becomes essential otherwise distortion during running will disturb the alignment or possibly create vibration.

Couplings

A good quality flexible coupling should be fitted and alignment carefully checked, preferably in accordance with the coupling manufacturers' recommendation, to avoid excessive shaft and bearing stresses. In addition a flexible coupling will ensure that in the majority of cases torsional vibration problems will not arise.

Single Bearing Machines

Alignment of single bearing a.c. generators is critical. If necessary, shims should be fitted under the feet to counteract any irregularities in the mounting surfaces.

If there is any doubt about the alignment, the covers at the none-drive end should be removed and the air gap checked with long feeler gauges to ensure uniformity around the periphery of the rotor.

Assembly to Engine

The sequence of assembly to the engine should generally be as follows:

1. Check on engine distance from the flywheel/coupling mating face to engine flywheel housing face. This should be within ± 0.5 mm of nominal dimension. This is necessary to ensure that a thrust is not applied to the a.c. generator bearing or engine bearing.

2. Check that the bolts securing the flexible plates to the shaft are tight and locked into position. Torque tightening is 10 kgf-m (98N-m; 72lbf-ft) for Frames 2 & 3; 48kgf-m (476N-m; 352lbf-ft) for Frames 4 - 6; 84kgf-m (822N-m; 607lbf-ft) for Frame 7.

3. Remove drive end a.c. generator covers for access to coupling and adaptor bolts.

4. Check that coupling discs are central with adaptor spigot. This can be adjusted by the tapered wooden wedges supplied between the fan and adaptor for transit reasons; Alternatively the rotor can be suspended by means of a rope sling through the adaptor opening.

5. Offer the a.c. generator to engine and engage both flexible plates and housing spigots at the same time, finally pulling home by using the housing and coupling bolts.

6. Tighten coupling to flywheel bolts.

7. Remove wooden wedges and check bearing housing gaps (see paragraph 1.)

8. Replace covers, run the machine up to speed and check for excessive vibration.

CAUTION NOTE:

When dismantling a.c. generator from the engine, care should be taken to ensure that the rotor is positioned with a pole at the bottom centre line. This is to avoid any damage to the bearing or exciter by limiting the rotor movement to that of the air-gap.

SECTION THREE

OPERATION OF THE MACHINE

OPERATION

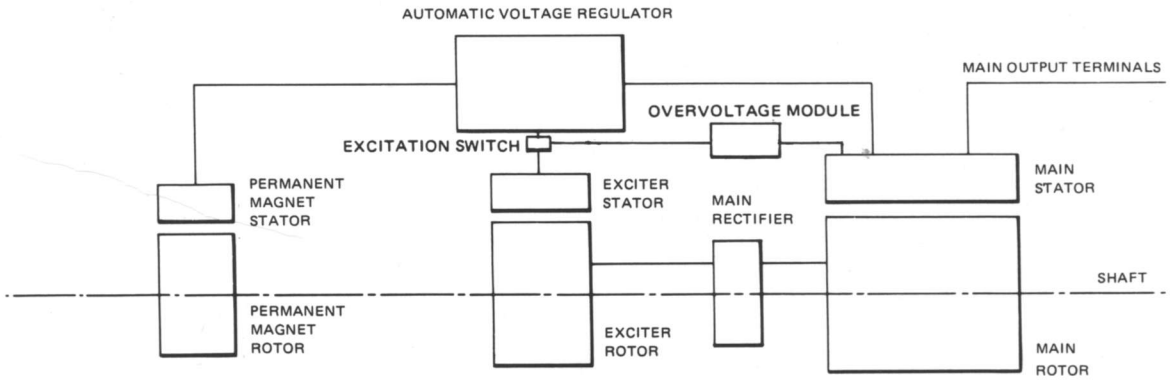


Fig. 1 Block Diagram of Excitation System

The block diagram above indicates the main electrical components and basic interconnections.

Permanent Magnet Exciter

To provide a source of excitation power independent of the main stator winding a rotating field permanent magnet exciter is provided. It is mounted at the non-drive end co-axial with the main shaft. The stator consists of a three phase winding and feeds power to the exciter stator via the automatic voltage regulator. The output of the stator winding is constant at the operational speed of the a.c. generator and is sufficient to give the high forcing excitation required to provide good motor starting characteristics and sustained short circuit current.

Automatic Voltage Regulator (A.V.R.)

The A.V.R. is an all solid state unit utilising high quality printed circuit boards and components. It consists essentially of a power circuit, which rectifies the permanent magnet stator output to provide d.c. power to the main exciter stator, reference and feedback circuits, and a protection circuit. The reference circuit derives an error signal from the main stator output voltage which is used to control the firing angle of a thyristor in the power circuit, thus controlling the power fed to the exciter stator. Large changes in power level to the stator are reflected through the feedback circuit to give high stability during large load changes.

The level of power supplied to the exciter stator controls the output from the 3 phase exciter rotor which is fed via rotating diodes to the main rotor, which in turn controls the output from the main stator windings.

Protection Circuit

As stated previously the P.M. exciter has high excitation forcing capabilities and this can have detrimental effects if the machine is misused or misapplied. Severe damage often results from overloading or by operating the machine into saturation by running at a reduced speed at full voltage. To eliminate these possibilities a protection unit is fitted to de-excite the machine under such conditions. The protection circuit is actuated by main exciter stator voltage level via a timing circuit fed from a potentiometer chain across the exciter stator.

The timing circuit allows high overloads of short duration thereby allowing for motor starting conditions. **Once the protection circuit has been actuated the excitation circuit will remain de-energised until such time as the prime mover is stopped, when the circuit will automatically reset.**

Frequency Sensing Circuit

A frequency sensitive circuit is incorporated into the A.V.R. which functions only when the shaft speed falls below approximately 90% of the rated speed. The voltage then reduces proportionally to any further reduction in speed, thus assisting the prime mover to recover after the application of high starting torque motor loads or high kilowatt load changes. This also provides low speed protection to the main rotor by ensuring the excitation does not exceed the safe operating level at all speeds.

Main Rectifier and Surge Suppressor

The rotating rectifier assembly rectifies the 3 phase A.C. output of the main exciter rotor using 6 silicon diodes mounted on 2 heatsinks forming + ve and –ve plates to feed the main rotor. The diodes are all liberally rated to

withstand the normal overload and short circuit conditions which may arise. However, if the a.c. generator is misused, for example out of phase paralleling, a voltage transient can be fed back to the rectifier assembly from the main rotor due to the current surge produced in the main stator winding. The assembly is fitted with a surge suppressor, which limits its voltage transients to a definite level, thereby providing full protection to the diodes.

Overvoltage Protection

This is fitted as standard on frames 6 and 7 and can be supplied as an accessory on frames 4 and 5.
The system comprises two separate items:—

a. An Overvoltage Module:— Type O.V.M. 1 and
b. An Excitation Switch:— a miniature magnetic circuit breaker fitted with a relay release coil.

The O.V.M. is an electronic protection unit designed for use with Stamford a.c. generators. In conjuction with an excitation switch, the unit provides over-voltage protection to both the a.c. generator and its service load.

The O.V.M. is completely solid-state and is designed for direct machine mounting. Screwdriver adjustments are available for setting both tripping voltage and time delay which is incorporated to prevent nuisance tripping due to transient conditions. (See page 41 for setting up instructions).

When interlinked with the machine windings and the excitation switch supplied, the system acts to de-excite the a.c. generator under overvoltage fault conditions. Provisions are made at the unit's terminals to link further protection modules or external devices. To simplify setting up, a tapped input circuit is provided which allows the unit to be set to nominal +25% without changing the operating voltage of the overall generator system, and without the need for calibrated setting potentiometers.

PERFORMANCE

Voltage Regulation

Voltage regulation is maintained within the limits of **±1½%** from no load to full load including cold to hot variations at any power factor between 0.8 lagging and unity and inclusive of a speed variation of 4½%. If Current Sensing Kit supplied (for improved voltage regulation of **±1%**) see Section Six accessories.

Waveform Distortion, THF and TIF Factors

The total distortion of the voltage waveform with open circuit between phases or between phases and neutral is in the order of **2%.** On a 3 phase balanced harmonic-free load the total distortion is in the order of **3.5%.** Machines are designed to have a THF better than **2%** and a TIF better than **50.**
A 2/3 pitch factor is standard on all stator windings to eliminate 3rd, 9th, 15th..... harmonic voltages on the line-neutral waveform.

Response

Rapid response to transient load changes is a significant performance feature. After the application of full rated load at **0.8** lagging p.f. the output voltage recovers to within **3%** of the steady-state value in **0.25** seconds (Frames 2 & 3), **0.3** seconds (Frames 4 & 5), and **0.35** seconds (Frames 6 & 7).

Motor Starting

A low-power-factor overload equivalent to full-voltage currents of the following values can be sustained for up to **10** seconds: Frames 2 - 4, 3 x f.l.; Frame 5, 2½ x f.l.; Frame 6, 2 x f.l. (Marine, 2½ x f.l.); Frame 7, 1.6 x f.l. (Marine 2 x f.l.). The machines comply with the transient conditions laid down by BS 4999 Part 40 voltage grades VR2.11 to VR2.23 as standard. Check with factory for compliance with grades VR2.31 to VR2.33.

Short Circuit

Up to 3 x f.l. (Frames 2 - 5) or 2½ x f.l. (Frames 6 & 7 — Marine 3 x f.l.) steady-state short-circuit current is available to operate external protective devices, and the internal overexcitation circuit will de-excite the generator after a minimum of 5 seconds to afford external discrimination.

Voltage Build-up

The a.c. generator is fitted with a permanent magnet exciter which ensures voltage build-up from a low speed such that nominal voltage is achieved within a very short period after starting up of the generator set.

Standby Ratings

These are in accordance with NEMA MG1-22.84.

Parallel Operation

The standard machine is fitted with a fully interconnected damper winding and the standard phase sequence is U–V–W when rotating clockwise viewed from the drive end. When paralleling Stamford a.c. generators the neutrals can be connected. When paralleling dissimilar machines it is recommended that the neutrals are not connected as differences in waveform may result in harmonic currents. For types of parallel operation refer to Section - Six Accessories.

AUTOMATIC VOLTAGE REGULATOR TYPES

Two types of A.V.R. can be fitted depending upon the application and performance required:–

Type 1. Two phase sensed Standard on all 4 pole machines.

This is the standard A.V.R. and as the name implies takes its reference from across two phases of the main stator winding. The system provides high performance and the flexibility needed for most generator applications.

Type 2. Three phase sensed. Standard on all 6 pole machines, optional on 4 pole.

This is a special A.V.R. and Three Phase Sensing Unit for special applications and derives its sensing voltage from all 3 phases of the machine. All generators, when an unbalanced load is applied, will result in differences between phase to phase and phase to neutral voltages depending upon the degree of unbalanced load. It is normally accepted that if unbalanced loading can be limited to within 30% the impact on the machine regulation will be marginal on both two phase and three phase sensed A.V.R.'s. If, for any reason, unbalanced loading occurs above this level, the overall regulation will exceed the normal specified limits. On a two phase sensed A.V.R., the phases directly linked with the A.V.R. sensing, will be maintained to close regulating limits but the other phases will float outside the normal regulating limits. By incorporating a three phase sensed A.V.R. overall regulation will not improve but the overall balance around a set point will improve. For example, if the overall voltage regulation is 5% on a two phase sensed A.V.R. the regulation could be all one way, either + 5% or –5% on one of the phases and close to 0% on the other phases. On the three phase sensed A.V.R. although the overall regulation would still be 5%, this would tend to float around the nominal setting to give a regulation of ±2½% between all phases.

A second advantage of three phase sensing is that it provides a more stable reference when operating on thyristor or rectifier loads which, due to the high harmonic content in the current waveform distort the generator waveform. The recommendation is that where high thyristor or rectifier loads are used, the best results will be obtained with a three phase sensed A.V.R.

NOTE: A range of electrical accessories is available for both two phase and three phase sensed A.V.R.'s. see Section 6 for details.

MARINE MACHINES

In order to meet the requirements of marine classifying societies certain modifications to the standard machine are required. From the electrical performance point of view the standard machine is suitable for marine use, but it is necessary to incorporate a shaft manufactured from approved material and to add drip-proofing features to cater for the inclination of the machine in the form of louvred covers on the air outlets. The requirements of most main classifying societies can be met in this way.

SECTION FOUR

SERVICE AND MAINTENANCE

MAINTENANCE

Routine servicing of the a.c. generator is confined to an insulation resistance check on the windings if the machine has not been run for a considerable length of time, and occasional lubrication of the drive end bearing on frames 6 and 7.

Insulation Test

Prior to testing the insulation to earth of the various windings, it is advisable that the A.V.R. is isolated from the windings by disconnecting the push-on terminals. The machine can then be "Meggered" without risk of damaging the control circuits.

PROTECTION CIRCUIT

General Description

Incorporated in the control system of the a.c. generator is a protection circuit, which is activated by the d.c. voltage across the exciter stator. The circuit senses excess excitation voltage, and should this be in excess of 120% of the full load figure of a machine at full temperature rise, a timing circuit is activated and the protection device will de-energise the a.c. generator i.e. the output voltage will collapse. **This condition will continue until the generating set is stopped, which automatically re-sets the control system to normal operation.**

Operation

The overexcitation protection will operate if the generator is significantly overloaded at normal speed; it will also operate, (if the load is high enough, e.g. above about 75%) if the speed is rather less than it should be but not low enough to operate the underspeed protection. If the protection has operated, the possibility of an overload or an underspeed should always be checked before assuming that the machine itself is faulty. The circuit will also operate if any of the internal faults listed in Section A (following) produces an overexcitation.

To check whether the overexcitation protection has operated, shut down the set and then restart. The output voltage should build up rapidly with speed; if it does not or if it is low, or if it collapses after building up, then the machine should be isolated from the system and the following fault-finding procedure should be started.

FAULT FINDING

Fault finding can in practice be greatly simplified by dividing the machine, for check test purposes, into two separate areas, namely (A) the windings and the rotating rectifier and (B) the electronic control system and its wiring.

SECTION A THE WINDINGS AND THE MAIN RECTIFIER ASSEMBLY

Separately Exciting the Machine

The a.c. generator is separately excited to give an indication of the condition of the windings and main rectifier assembly. For the frame sizes covered in this manual a 12 volt d.c. battery supply is sufficient to obtain the full output voltage within + or – 10%, **at no load, with the speed correct at nominal.**

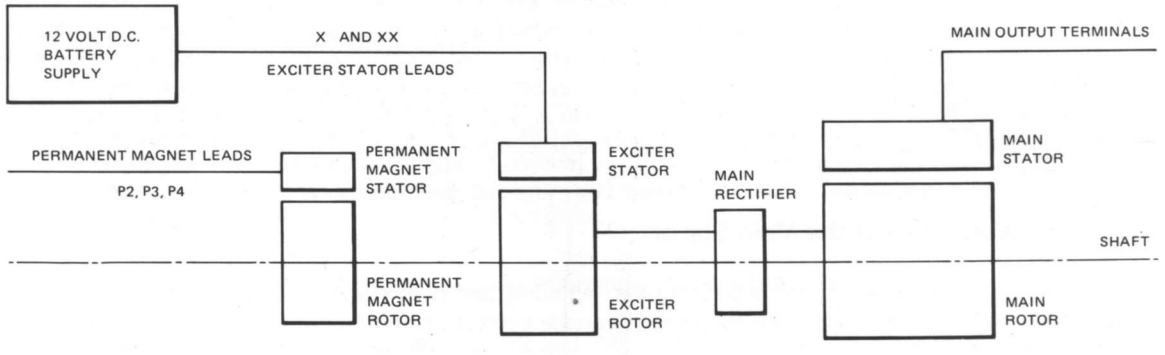


Fig. 2 Method of Separately Exciting the Machine

The d.c. supply is connected to the exciter stator leads marked X and XX , which should be removed from the A.V.R. terminals X and XX respectively. It is also advisable to remove the rest of the push-on terminals from the A,V.R. prior to this test.

With the battery connected to the stator leads, the machine is now run up to full speed (it is essential that the speed is correct for this test), and with a multimeter or voltmeter the following tests are made on the output from the main stator terminals.

Voltage is Balanced and within 10% of the Nominal

This indicates that the exciter windings, main windings and main rectifier diodes are in good working order, and it is therefore not necessary to carry out the following tests up to and including "Main Excitation Windings". Fault finding should continue with test "A.V.R. Sensing Supply from the Main Stator".

Voltage Balance between Phases

The voltages between the three phases, and each phase to neutral, should be balanced, and if an unbalance is shown on any phase of more than 1%, this indicates that a fault exists in the main stator windings. This test should be carried out with all of the customer's external connections removed to eliminate the possibility of external shorts between the machine and the main isolator. Further tests can be made on the resistance values of the stator windings (see Winding Resistance Chart, at the end of this section).

Voltage Balanced but Reading Low when Separately Excited

This indicates that a fault exists in either the main rotating rectifier assembly, or one of the excitation windings i.e. the main rotor and/or the exciter stator and rotor. **First check that the d.c. separate excitation supply is not lower than 12 volts, and that the speed is correct.**

Rectifier Diodes

The diodes on the main rectifier assembly can be checked with a multimeter. The flexible leads connected to each diode should be disconnected at the terminal end, and the forward and reverse resistance checked. A healthy diode will indicate a very high resistance (infinity) in the reverse direction, and a low resistance in the forward direction. A faulty diode will give a full deflection reading in both directions with the test meter on the 10,000 ohms scale, or an infinity reading in both directions.

Replacement of Faulty Diodes (See Figs. 9 and 10)

The rectifier assembly is split into two plates, the positive and negative, and the main rotor is connected across these plates. Each plate carries 3 diodes, the negative plate carrying negative based diodes, and the positive plate carries positive based diodes. Care must be taken to ensure that the correct polarity diodes are fitted to each respective plate. When fitting the diodes to the plates they must be tight enough to ensure a good mechanical and electrical contact, but should not be overtightened. The recommended torque tightening is 4.06 – 4.74 Nm (36 – 42 lbf/in.)

Surge Suppressor

The surge suppressor is a metal-oxide varistor connected across the two rectifier plates to prevent high transient reverse voltages in the field winding from damaging the diodes. This device is not polarised and will show a virtually infinite reading in both directions with an ordinary resistance meter. If defective (normally visible by inspection, since signs of burning will be apparent) it will normally give a full-deflection (short-circuit) reading.

Main Excitation Windings

If after establishing and correcting any fault on the rectifier assembly the output is still low when separately excited, then the main rotor, exciter stator and exciter rotor winding resistances should be checked (see Resistance Charts), as the fault must be in one of these windings. The exciter stator resistance is measured across leads X and XX . The exciter rotor and main rotor resistances, can be obtained from the connections to the main rectifier assembly. The exciter rotor is connected to six studs which also carry the diode lead terminals. The main rotor winding is connected across the two rectifier plates. The respective leads must be disconnected before taking the readings.

A.V.R. Sensing Supply from the Main Stator

The final test which can be made in the separately excited condition is to ensure that the sensing supply from the main stator to the A.V.R. is correct. With the output voltage correct on the main terminals, the voltage across the

A.V.R. leads 2 and 3 should be between 170 – 250 volts a.c. (Two phase sensed) or 10 – 16 volts d.c. (Three phase sensed).

The Permanent Magnet Exciter

The permanent magnet exciter is located on the non-drive end of the main a.c. generator, and is isolated from all other windings, being the main power supply for the A.V.R. For this reason the output from the exciter must be tested independently across its terminals, which are connected to the A.V.R. terminals P2, P3 and P4. These push-on terminals must be disconnected from the A.V.R. and the machine run up to full speed. The output voltage across the leads P2, P3 and P4 should be balanced, and a minimum of 150 volts - 1500 rev/min or 180 volts - 1800 rev/min between terminals. The permanent magnet exciter will produce an output voltage completely independently from the rest of the machine, and has no effect on the separate excitation tests carried out in the previous text.

However, when the machine is controlled by the A.V.R. a fault in this area could result in voltage drift or a loss of voltage completely.

SECTION B THE ELECTRONIC CONTROL SYSTEM

A.V.R.

Should the previous tests prove successful, any faults can now be assumed to be within the voltage control system and its respective wiring. This system can be affected by bad connections, therefore, the wiring between the auxiliary terminals and the A.V.R. push-on terminals should be carefully examined for broken, loose or corroded connections. The sensing circuit leads have been covered in a previous section.

Accessories

Forming an integral part of the electronic circuitry there may be fitted one or more electrical accessory. These items must also be checked for loose, broken or corroded connections, and their resistance values checked. See Section 6 – Accessories.

Overvoltage Protection (Standard on Frames 6 and 7 – Option on Frames 2 and 5).

This must be checked to see if it has operated and if so an attempt should be made to reset the excitation switch. If the switch fails to 'reset' a fault may exist in either the A.V.R. or overvoltage module (O.V.M.). To check the O.V.M., remove the leads from A.V.R. terminals K1 and K2 and replace with a link. If the machine then operates it can be assumed a fault exists in the O.V.M. and/or excitation switch. These should be checked as detailed in Section 6

If no defects are located and the fault still exists, the A.V.R. can be assumed to be faulty, and must be exchanged with a replacement unit. This is a simple operation; (See instructions for "Removal of A.V.R.").

DISMANTLING THE MACHINE

Metric threads are used throughout.

NOTE: On SINGLE BEARING MACHINES before removal from the prime mover, if possible, position the rotor such that a full pole face is at the bottom of the main stator core.

Removal of the A.V.R.

1. Remove A.V.R. box lid complete with 4 captive screws.
2. Remove 4 threaded pillars securing A.V.R.
3. Disconnect all cables to A.V.R.

Removal of the Permanent Magnet Exciter

NOTE: The angular position of the permanent magnet exciter is set during the final electrical test prior to despatch, and a mark indicating the correct position is made on the stator housing and the non-drive endbracket at approximately the 12 o'clock position. It is essential that the stator is returned to exactly the same position when refitting this unit, and therefore before dismantling, this mark must be as clear as possible.

1. Mark the position of the stator housing and remove access cover.
2. Disconnect leads P1 (if fitted) P2, P3 and P4 from the A.V.R. inside terminal box. These leads have in-line connectors making it unnecessary to disconnect at A.V.R.

3. Remove the 4 bolts and clamps retaining the stator housing.

4. Tap the stator housing out of its spigot, and carefully guide the stator leads through the access hole in the non-drive endbracket. As the highly magnetic rotor will attract the stator core, care must be taken to avoid a contact which may damage the windings.

5. Remove the SMALL hexagon nut from the rotor shaft and firmly pull the complete rotor assembly from its location. Keep the rotor clean by avoiding contact with metal dust or particles.

6. Remove the rotor shaft stud from the main shaft, to avoid possible damage when handling the main rotor assembly.

IMPORTANT:

The rotor assembly should under no circumstances be dismantled, or the magnetic properties will be destroyed.

Re-Assembly/Setting Up Procedure – Permanent Magnet Exciter

The angular position of the permanent magnet stator housing is important to the performance of the control system.

Should it be necessary at a later date to rewind or replace (a) the permanent magnet rotor or stator, or, (b) the main stator winding, the following procedure must be adopted to ensure correct operation of the control system.

1. Fit the complete assembly and tighten all bolts ready for normal running.

2. Connect a voltmeter across the main output terminals, such that the reading can be observed while adjusting the permanent magnet position.

3. Run the machine up to full speed and while firmly holding the stator housing in position, loosen the clamp washer bolts approximately one turn, until slight movement is allowed.

   WARNING: Under no circumstances should the permanent magnet stator housing be allowed to move out of its spigot, even slightly, as there is a risk that the stator will foul on the rotor. If there is any doubt, two people should be employed in loosening the bolts and holding the housing in position.

4. Make an identification mark at the 12 o'clock position on the permanent magnet stator housing.

5. Rotate stator housing anti-clockwise until voltmeter reading across output terminals is at a minimum level. Make an identification mark on the endbracket adjacent to the mark on the permanent magnet stator housing.

   NOTE: A. The voltage variation will be approximately 5% from maximum to minimum.

   B. The maximum movement clockwise or anticlockwise is approximately 80 mm (25^{o})

6. Rotate stator housing clockwise until voltmeter reading across output terminals is at a maximum level. Make an identification mark on the endbracket adjacent to the mark on the permanent magnet stator housing.

7. Reset permanent magnet stator housing in the mid position between the two identification marks on the endbracket.

8. This setting will give a good starting off point but fine tuning between the two marks on the endbracket is necessary to achieve the optimum setting for voltage response and voltage regulation.

9. The permanent magnet stator is now positioned correctly for ideal voltage response and regulation. The clamp washers should now be tightened and the position should be marked permanently with a punch or chisel on the endbracket and permanent magnet stator housing.

Removal of the Main Rotor Assembly

NOTE: These instructions apply to both single and two bearing machines unless otherwise stated.

Frames 2 & 3

1. Remove all access covers.

2. Disconnect all auxiliary cables inside terminal box.

3. Remove permanent magnet assembly as described previously.

4. Two Bearing Machines only:- remove screws securing the D.E. endbracket.

4a. Two Bearing Machines only:- position rotor with a full pole face at the bottom and tap endbracket out of its spigot.

4b. Lower rotor on to stator core.

4c. Withdraw D.E. endbracket from bearing.

5. Single Bearing Machines only:- remove screws securing adaptor and tap adaptor out of its spigot.

6. Internal Exciter Machines:- remove N.D.E. bearing cap securing screws and bearing cover.

6a. Remove N.D.E. endbracket securing screws, using 2 of these screws, push endbracket out of its spigot by using the 2 threaded holes in the endbracket flange.

6b. Withdraw N.D.E. endbracket complete with exciter stator.

7. External Exciter Machines:- with external cover removed disconnect main rotor leads from rectifier.

7a. Remove socket head capscrew securing exciter rotor stub shaft.

7b. Withdraw exciter rotor/recitifer/stub shaft assembly.

7c. Remove N.D.E. bearing cap securing screws.

7d. Remove N.D.E. endbracket securing screws, using 2 of these screws, push endbracket out of its spigot. through the 2 threaded holes in the endbracket.

7e. Withdraw N.D.E. endbracket complete with exciter stator.

8. Slide rotor out of stator bore towards the D.E. and withdraw rotor.

NOTE: For removal of rotor **FRAMES SC2/3** it may be necessary to use rope slings as follows:

i. To withdraw the rotor from the stator, it must be lifted by means of rope slings at both ends, and inched out toward the drive end, until half of the main rotor core is protruding out of the stator. At this point it is safe to release the weight from the rope slings.

ii. Tightly bind a rope sling around this portion of the rotor core, and take the weight on this sling.

iii. With both ends of the rotor held, manually slide the rotor out of the stator bore. Care should be taken during this operation to prevent damage to the windings and rectifier assembly by manually guiding the non-drive end of the rotor assembly as it is withdrawn.

9 The sealed-for-life ball bearings are now available for inspection or replacement.

Frames 4–7

1. Remove all access covers and terminal box lid.

2. Disconnect exciter leads X + & XX - at the inline spade connectors inside the terminal box.

3. Remove permanent magnet assembly as described previously.

4. **Two Bearing Machines only — Frames 4 and 5.** Remove the 4 bolts retaining the drive end bearing cartridge housing in the drive endbracket (outer 4 bolts).

Two Bearing Machines only — Frames 6 and 7. Remove the 4 bolts retaining the drive end bearing caps.

5. Remove the 8 bolts holding the drive endbracket to frame.

6. **Two Bearing Machines only.** Position the rotor such that a full pole face is at the bottom of the main stator core.

7. **Two Bearing Machines only.** With rope sling around shaft, supporting rotor weight tap the drive end-bracket out of its spigot.

8. **Two Bearing Machines only.** Lower rotor onto stator core.

9. **Two Bearing Machines only — Frames 4 and 5.** With rope sling around drive endbracket withdraw end-bracket leaving bearing cartridge housing in position.

Two Bearing Machines only — Frames 6 and 7. With rope sling around drive endbracket, withdraw end-bracket over drive end bearing.

10. **Single Bearing Machines only.** With rope sling around drive endbracket tap endbracket out of its spigot.

11. Disconnect leads X and XX from the A.V.R. (inside terminal box) and draw leads back into non-drive endbracket. These leads have in-line connectors making it unnecessary to disconnect at the A.V.R.

12. Remove the 4 bolts retaining the non-drive end bearing cartridge housing in the non-drive endbracket - (outer 4 bolts).

13. Dismantle terminal box by removing side/top covers and support brackets.

14. Remove the 8 bolts holding the non-drive endbracket (4 of these bolts also hold the non-drive end panel of the terminal box).

15. Remove non-drive end panel of terminal box.

16. Insert 2 bolts (M10) in the 2 holes provided for "jacking" purposes, on the endbracket centre line. Screw bolts in until endbracket spigot is clear of locating recess.

17. Carefully tap the whole assembly off the bearing cartridge housing ensuring the endbracket is supported, to prevent the exciter stator from fouling the windings on the exciter rotor.

18. To withdraw the rotor from the stator the rotor must be supported by means of a rope sling at the drive end and eased out of the stator core until half of the main rotor core is protruding out of the stator. At this point it is safe to release the weight from the rope sling.

19. Tightly bind a rope sling around the rotor core and take the weight on the sling.

20. With the rope sling around the rotor core manually guide the rotor assembly out of the stator bore. Care should be taken during this operation to prevent damage to the windings and rectifier assembly by manually guiding the non-drive end of the rotor assembly as it is withdrawn.

WARNING:

The rope sling may not be at the centre of gravity of the rotor, and guidance at the ends of the rotor is essential.

As the rotor is fully withdrawn from the stator core, THE FULL WEIGHT OF THE ROTOR MUST BE SUPPORTED BY THE CRANE. If the rotor core is allowed to drop more than a few millimetres at this point, it will make contact with the stator windings, and may damage them.

Removal of the Bearings

IMPORTANT:

The bearings are enclosed in pre-packed cartridge housings (except the drive end frames 6 and 7) and must not be dismantled unless absolutely necessary, such as for: re-lubrication, replacement of bearings or when a major overhaul is carried out on the prime mover. The bearings assemblies are pre-packed with grease for a calculated life of 30,000 hours in an ambient of 40°C.

NOTE: **Removal of the bearings can be carried out after removal of the main rotor assembly or by removing the endbrackets only. (See instructions previously described).**

Drive End Bearing — Frames 4 and 5.

1. Remove the 4 screws holding bearing cap.
2. Remove cap and "wave" washer.
3. Remove bearing cartridge housing complete with bearing.

Drive End Bearing — Frames 6 and 7.

This bearing is re-greasable and enclosed between standard bearing caps.

Non-drive End Bearing -- All machines.

1. Remove the 4 screws holding bearing cap.

2. Remove cap.

3. Remove circlip (single bearing machines only).

4. Remove bearing cartridge housing complete with bearing.

Lubrication – Frames 4 and 5 and non drive end Frames 6 and 7.

When re-lubricating after 30,000 hours or if replacing the bearings they must be flushed out and re-filled as follows:

Recommended Lubricant: Lithium based grease - Mobilux No. 2 or Shell Alvania R3.

Temperature Range: $-30^{o}C$ to $+120^{o}C$.

Quantity: Frame 4 – 108 millilitres Drive End – 81 millilitres Non-drive end.
Frame 5 – 81 millilitres Drive End or Non-drive end.

Frames 6 and 7 – 81 millimetres Non-drive end.

About a third of the above quantities should be inserted in the bearing, the bearing cap cavity, and the bearing cartridge cavity.

Lubrication – Drive End, Frames 6 and 7;

Recommended lubricant: Lithium based grease – Mobilux No. 2. or Shell Alvania R3.

The bearings are packed with grease and do not normally require greasing more often than once every 4,000 hours running time (six months). When greasing is required ensure that the same grade of grease is used. Any lithium based equivalent grease can be used but this should be carefully checked to avoid mixing dis-similar greases. Care should be taken not to grease too frequently or too liberally as this can lead to overheated bearings.

RE–ASSEMBLY

For re-assembly reverse the dismantling instructions.

WINDING RESISTANCE TABLES
4 POLE

Frame Size	Exciter		Stator Winding (per phase: Star or Series Star)			Rotor
	Stator	Rotor L–L	211 & 212	17 & 07	18 & 19	
2A	27	0.13	0.21	0.30	0.24	0.58
2B	27	0.13	0.15	0.21	0.19	0.65
2C	27	0.13	0.13	0.19	0.15	0.69
2D	31	0.14	0.08	0.12	0.10	0.82
2E	31	0.14	0.06	0.083	0.077	0.93
3AS	37	0.16	0.045	0.064	0.059	1.23
3A	37	0.16	0.041	0.059	0.045	1.34
3B	37	0.16	0.028	0.043	0.033	1.55
3C	37	0.16	0.022	0.031	0.029	1.71
3D	37	0.16	0.019	0.027	0.023	1.88
4A	21	0.17	0.026	0.037	0.034	0.79
4B	21	0.17	0.020	0.029	0.022	0.89
4C	21	0.17	0.017	0.025	0.021	0.93
4D	21	0.17	0.012	0.017	0.015	1.06
4E	21	0.17	0.009	0.013	0.011	1.20
5C	23	0.16	0.0059	0.0095	0.0069	1.55
5D	23	0.16	0.0048	0.0070	0.0059	1.77
5E	23	0.16	0.0036	0.0059	0.0042	1.96
6A	29	0.10	0.0034	0.0050	0.0034	1.37
6B	29	0.10	0.0028	0.0045	0.0030	1.47
6C	29	0.10	0.0021	0.0040	0.0021	1.66
6D	29	0.10	0.0021	0.0036	0.0021	2.31
7A	29	0.13	0.0016	0.0021	0.0016	2.05
7B	29	0.13	0.0012	0.0017	0.0012	2.29
7C	29	0.13	0.0008	0.0013	0.0008	2.71

6 POLE

Frame Size	Exciter		Stator Winding (per phase: Star or Series Star)			Rotor
	Stator	Rotor L–L	211 or 212	17 or 07	18 or 19	
6A	29	0.20	0.0082	0.013/0.014	0.011	1.06
6B	29	0.20	0.0052	0.0094	0.0069	1.27
6C	29	0.20	0.0040	0.0057	0.0056	1.43
6D	29	0.20	0.0030	0.0054	0.0050	1.67
7A	29	0.24	0.0022	0.0041	0.0030	2.20
7B	29	0.24	0.0015	0.0027	0.0020	2.69
7C	26	0.24	0.0012	0.0018	–	3.18

NOTES:

1. **All figures are approximate only.**
2. **Resistances are in ohms and 'cold' (20°C).**
3. **Pilot exciter stator resistance is 4.4 ohms line-to-line (all framesizes).**
4. **For Voltage Range details see p.1.**

SECTION FIVE

RECOMMENDED SPARES/SECTIONAL ARRANGEMENTS/PARTS LISTS

RECOMMENDED SPARES

The following list comprises of replaceable items which can be held by the machine owner for Service and Maintenance requirements.

Description	Quantity per Machine
Bearing Drive End (2 Bearing Machines Only)	1
Bearing Non Drive End	1
Diode (Forward)	3
Diode (Reverse)	3
Automatic Voltage Regulator (A.V.R.)	1 (See Note)
Surge Suppressor	1 (Frames 1 – 3) 1 (Frames 4 – 7)

1. **Machines fitted with three-phase sensing require a special A.V.R.**

2. **Frames 4 - 7 use a larger surge suppressor than that fitted to Frames 1 – 3.**

When ordering spare parts, the following information must be quoted.

1. **Machine Serial Number and type (the serial number can be obtained from the machine nameplate or the drive end of the mainshaft).**

2. **Description of part (obtained from appropriate Operation and Maintenance Manual).**

3. **Quantity required.**

Orders and enquiries for spare parts should be addressed to:

Newage Engineers Limited
Spares Department
P.O. Box 17, Barnack Road
Stamford
Lincolnshire, PE9 2NB, England

Telephone: 0780-62552 Telex 32268 Cables Newage Stamford
or any of our subsidiary companies listed on the back page

A full technical advice and on-site service facility is available from our service department at the above address.

Note: For inboard exciter and two bearing configuration see Fig. 4

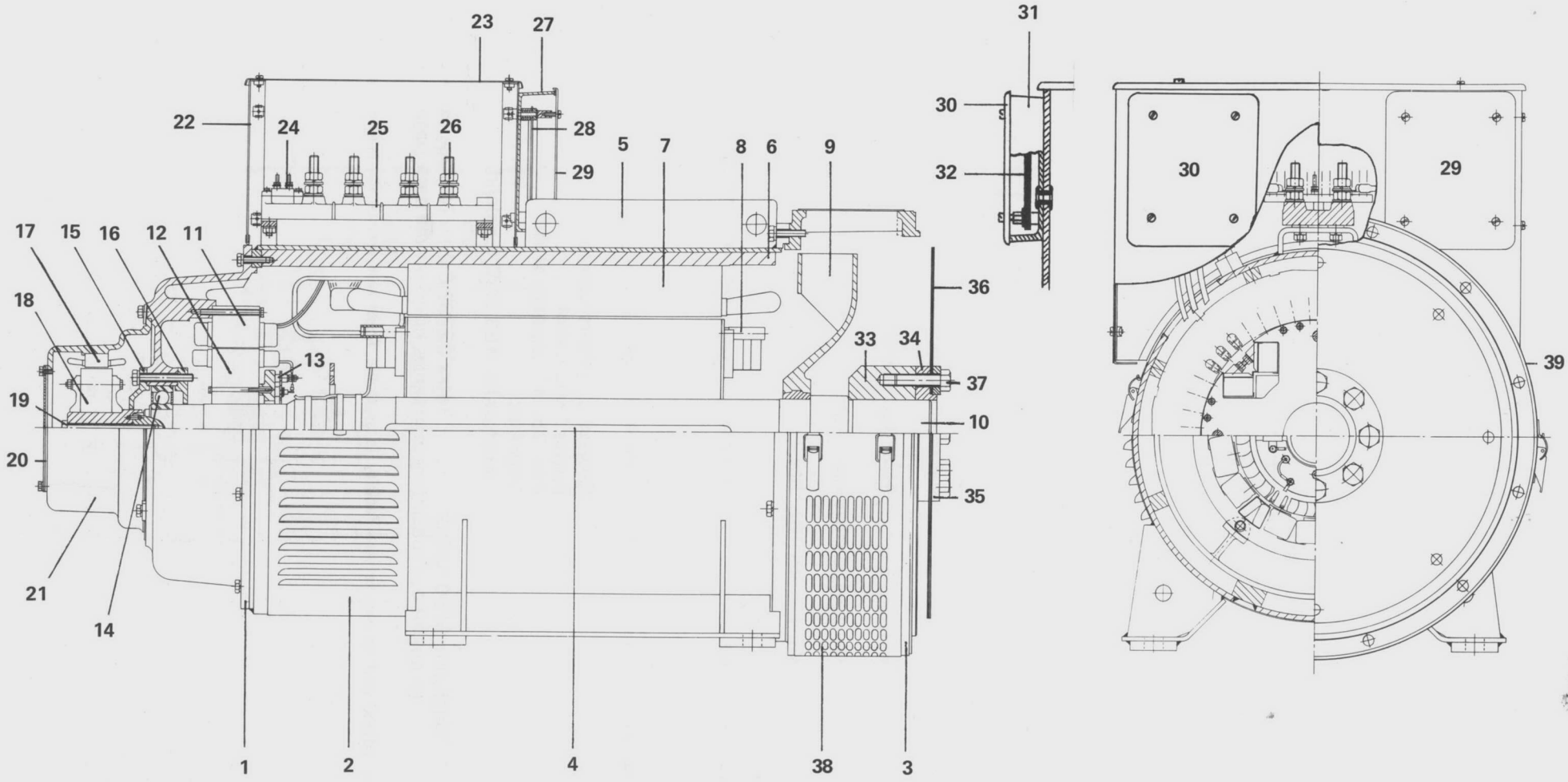


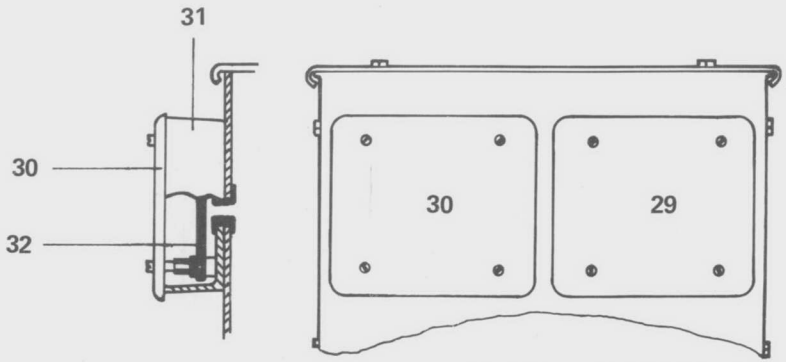
FIG. 3 SC2 - 3 SINGLE BEARING MACHINES (OUTBOARD EXCITER)

PARTS LIST

SC2 - 3 SINGLE BEARING MACHINE (OUTBOARD EXCITER)

Plate Ref	Description	Plate Ref	Description
1	Non drive endbracket	30*	Three phase sensing unit box lid
2	Non drive end louvred cover	31*	Three phase sensing unit box
3	Drive endbracket/adaptor	32*	Three phase sensing unit
4	Main rotor key	33	Coupling hub
5	Lifting lug	34	Coupling spacer
6	Main frame	35	Coupling pressure plate
7	Wound main stator assembly	36	Coupling disc.
8	Wound main rotor assembly	37	Coupling screw
9	Fan	38	Lower drive end cover
10	Shaft	39	Upper drive end cover
11	Wound exciter stator assembly		
12	Wound exciter rotor assembly		
13	Main rectifier assembly		
14	N.D.E. sealed bearing		
15	N.D.E. outer bearing cap		
16	N.D.E. inner bearing cap		
17	Permanent magnet wound stator assembly		
18	Permanent magnet wound rotor assembly		
19	Permanent magnet rotor stud and nut		
20	Permanent magnet end plate		
21	Permanent magnet cover		
22	Terminal box side panel		
23	Terminal box lid		
24	Auxiliary terminal board		
25	Main terminal board		
26	Main terminal board stud and nut		
27	A.V.R. Box		
28	Automatic voltage regulator		
29	A.V.R. box lid		* Optional

Note: For outboard exciter and single bearing configuration see Fig. 3



Position of A.V.R. when three phase sensing unit is fitted

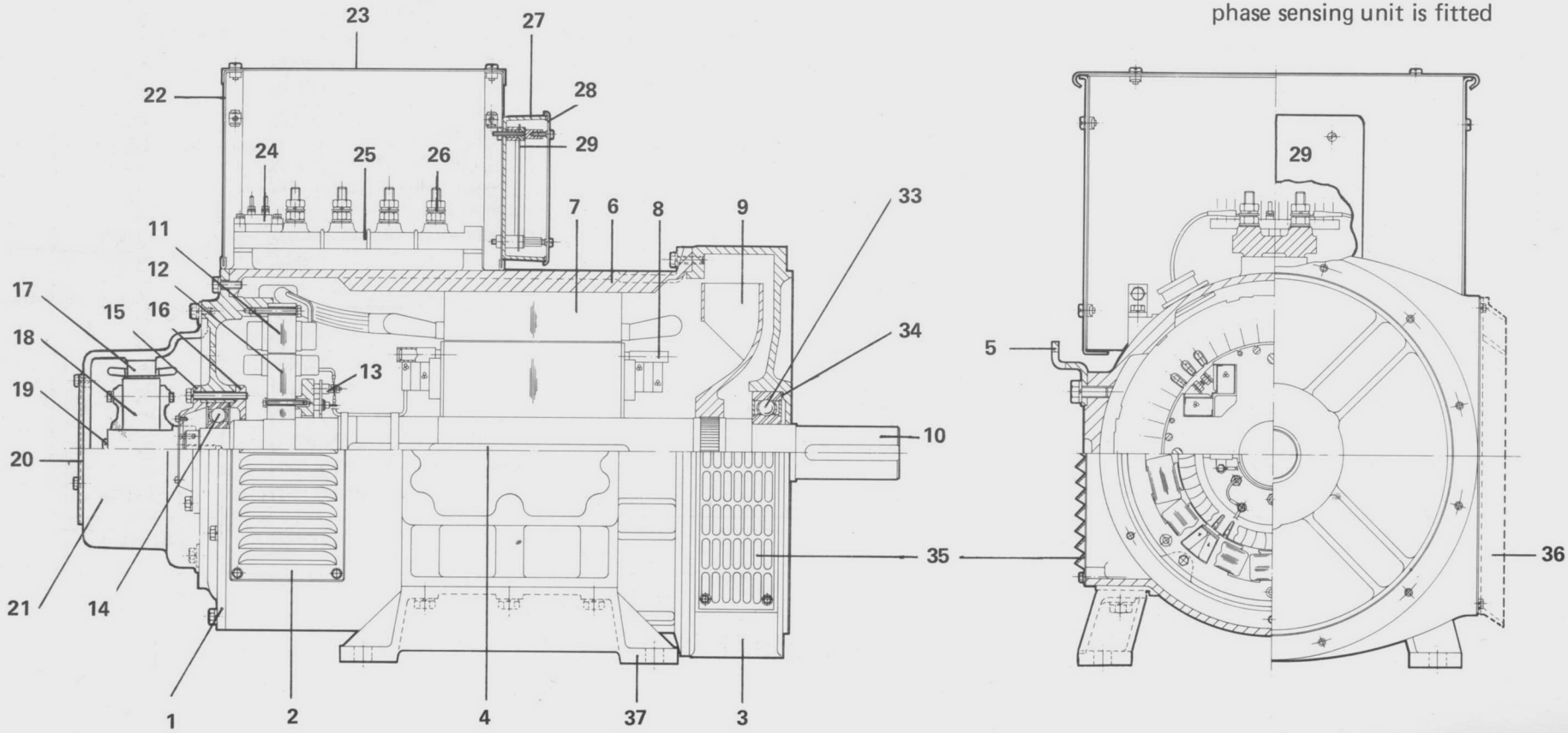


Fig. 4 SC2 - 3 TWO BEARING MACHINE (INBOARD EXCITER)

PARTS LIST

SC2 - 3 TWO BEARING MACHINE (INBOARD EXCITER)

Plate Ref	Description	Plate Ref	Description
1	Non drive endbracket	30*	Three phase sensing unit box lid
2	Non drive end louvred cover	31*	Three phase sensing unit box
3	Drive endbracket/adaptor	32*	Three phase sensing unit
4	Main rotor key	33	Bearing drive end
5	Lifting lug	34	Wave washer
6	Main frame	35	Screen drive end
7	Wound main stator assembly	36	Drive end louvres (when fitted)
8	Wound main rotor assembly	37	Feet
9	Fan		
10	Shaft		
11	Wound exciter stator assembly		
12	Wound exciter rotor assembly		
13	Main rectifier assembly		
14	N.D.E. sealed bearing		
15	N.D.E. outer bearing cap		
16	N.D.E. inner bearing cap		
17	Permanent magnet wound stator assembly		
18	Permanent magnet wound rotor assembly		
19	Permanent magnet rotor stud and nut		
20	Permanent magnet end plate		
21	Permanent magnet cover		
22	Terminal box side panel		
23	Terminal box lid		
24	Auxiliary terminal board		
25	Main terminal board		
26	Main terminal board stud and nut		
27	A.V.R. Box		
28	Automatic voltage regulator		
29	A.V.R. box lid		* Optional

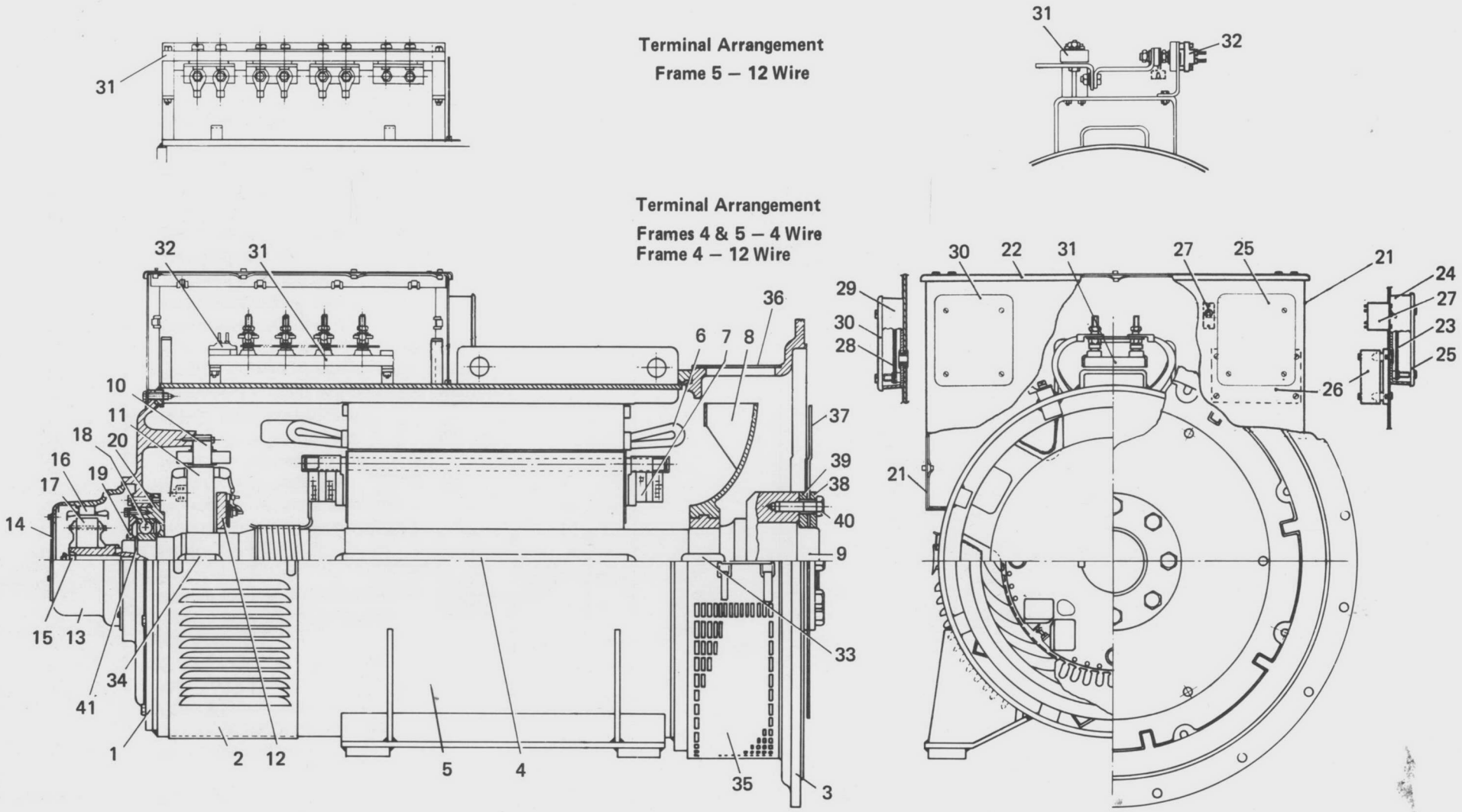


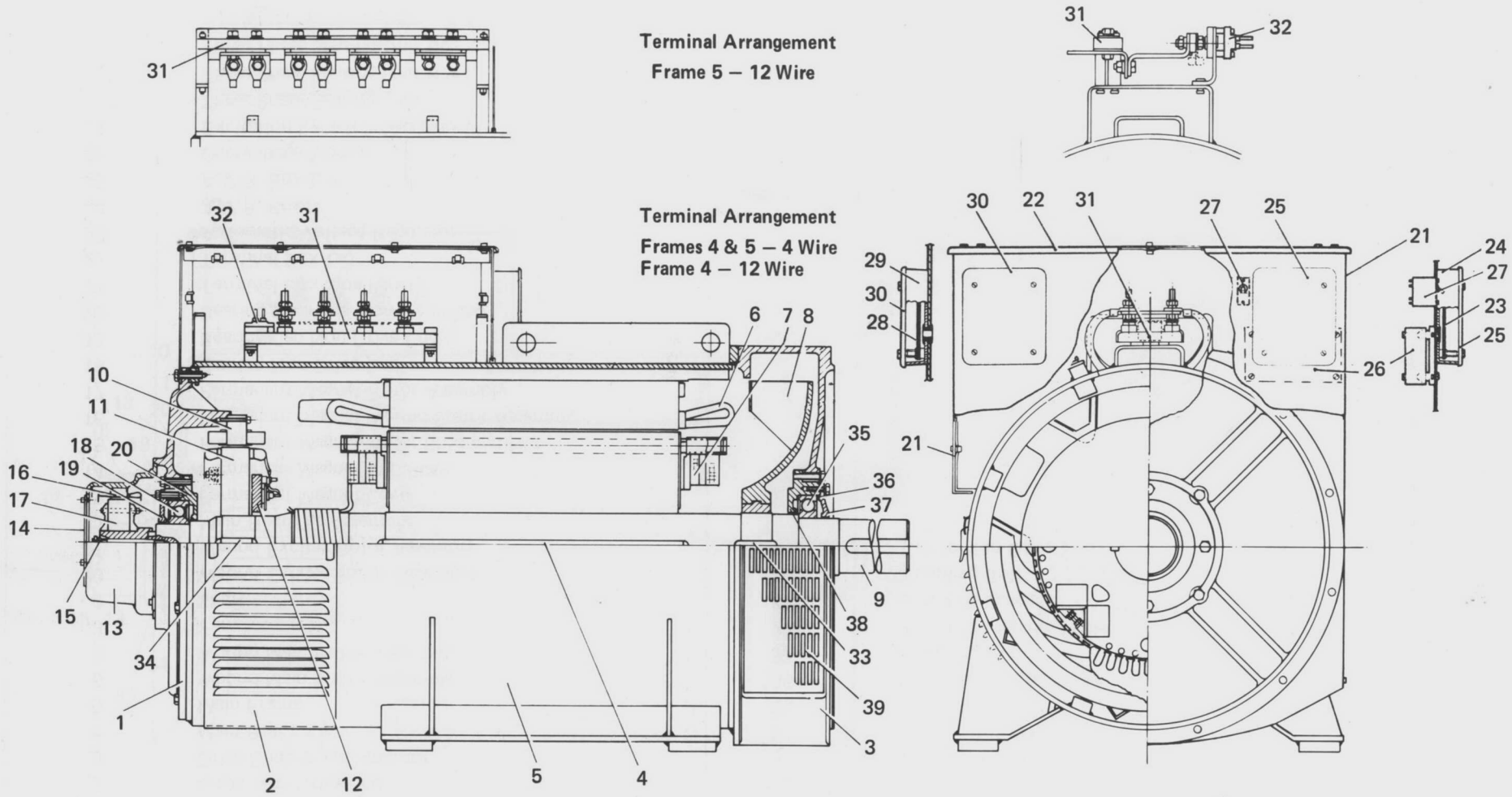
Fig. 5 Single Bearing Machine – Sectional Arrangement

Frames 4 and 5

Single Bearing Parts List

Plate Ref	Description	Plate Ref	Description
1	Non-Drive Endbracket	31	Main Terminal Board
2	Cover Non-Drive End	32	Auxiliary Terminal Board
3	Drive Endbracket/Adaptor	33	Fan Key (Frame 5 only)
4	Main Rotor Key	34	Exciter Rotor Key
5	Main Frame	35	Lower Drive End Cover
6	Wound Main Stator Assembly	36	Upper Drive End Cover
7	Wound Main Rotor Assembly	37	Coupling Disc
8	Fan	38	Coupling Pressure Plate
9	Shaft	39	Coupling Spacer
10	Wound Exciter Stator Assembly	40	Coupling Bolt
11	Wound Exciter Rotor Assembly	41	Circlip Non-Drive End
12	Main Rectifier Assembly		
13	Permanent Magnet Cover		
14	Permanent Magnet End Plate		
15	Permanent Magnet Rotor Stud and Nut		
16	Permanent Magnet Wound Stator Assembly		
17	Permanent Magnet Rotor Assembly		
18	Bearing Non-Drive End		
19	Bearing Cap Non-Drive End		
20	Bearing Cartridge Non-Drive End		
21	Terminal Box Side Panel		
22	Terminal Box Lid		
23	Automatic Voltage Regulator		
24	A.V.R. Box		
25	A.V.R. Box Lid		
26	Overvoltage Module		
27	Excitation Switch (Accessory)		
28*	Three Phase Sensing Unit		
29*	Three Phase Sensing Unit Box		
30*	Three Phase Sensing Unit Box Lid		

* Optional



Frames 4 and 5

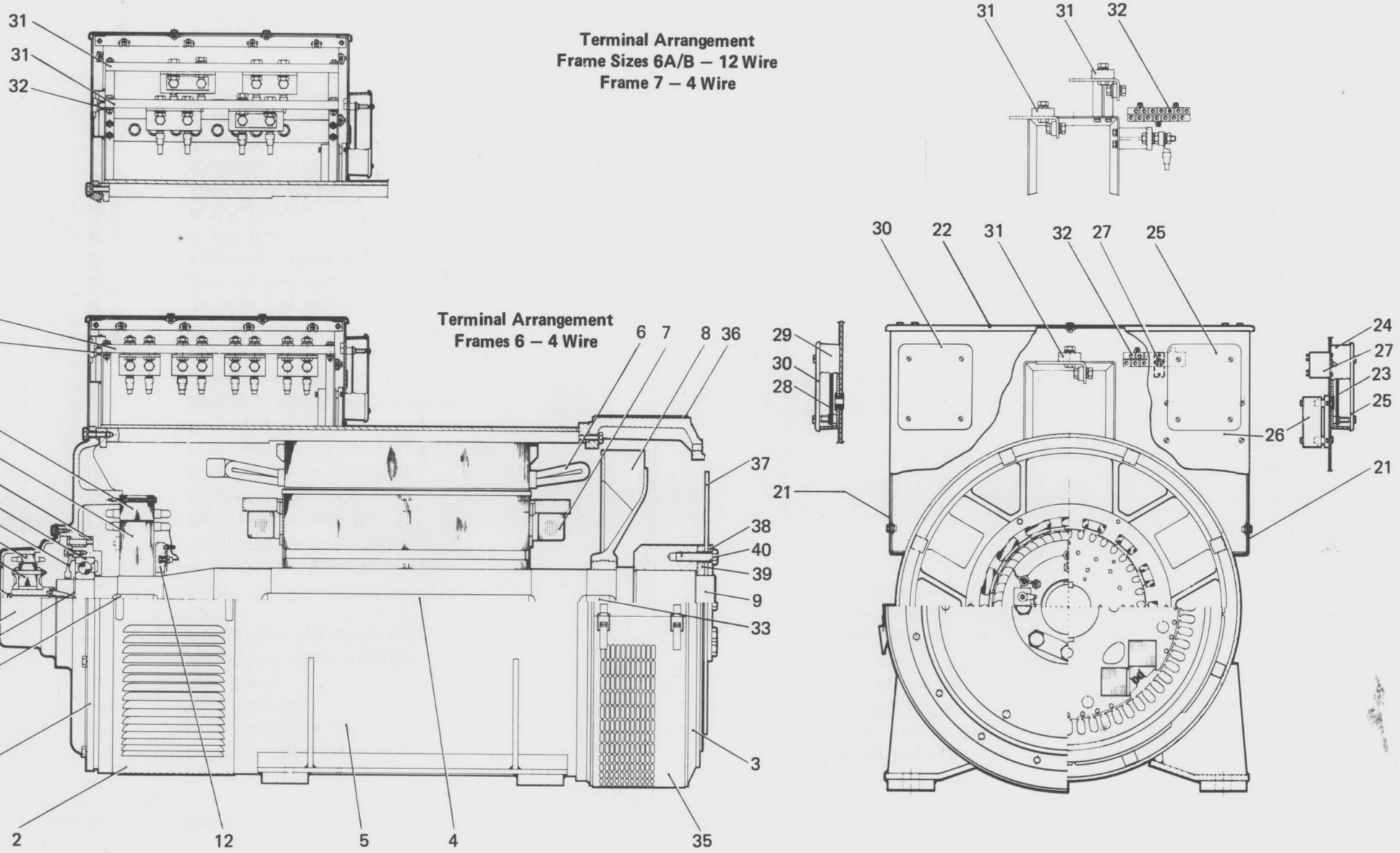
Fig. 6 Two Bearing Machine – Sectional Arrangement

Frames 4 and 5

Two Bearing Parts List

Plate Ref	Description	Plate Ref	Description
1	Non-Drive Endbracket	31	Main Terminal Board
2	Cover Non-Drive End	32	Auxiliary Terminal Board
3	Drive Endbracket	33	Fan Key (Frame 5 only)
4	Main Rotor Key	34	Exciter Rotor Key
5	Main Frame	35	Bearing Drive-End
6	Wound Main Stator Assembly	36	Wave Washer (Bearing Drive-End)
7	Wound Main Rotor Assembly	37	Bearing Cap Drive End
8	Fan	38	Bearing Cartridge Drive End
9	Shaft	39	Screen Drive End
10	Wound Exciter Stator Assembly		
11	Wound Exciter Rotor Assembly		
12	Main Rectifier Assembly		
13	Permanent Magnet Cover		
14	Permanent Magnet End Plate		
15	Permanent Magnet Rotor Stud and Nut		
16	Permanent Magnet Wound Stator Assembly		
17	Permanent Magnet Rotor Assembly		
18	Bearing Non-Drive End		
19	Bearing Cap Non-Drive End		
20	Bearing Cartridge Non-Drive End		
21	Terminal Box Side Panels		
22	Terminal Box Lid		
23	Automatic Voltage Regulator		
24	A.V.R. Box		
25	A.V.R. Box Lid		
26	Overvoltage Module] Accessory		
27	Excitation Switch]		
28*	Three Phase Sensing Unit		
29*	Three Phase Sensing Unit Box		
30*	Three Phase Sensing Unit Box Lid		

* Optional



Frames 6 and 7

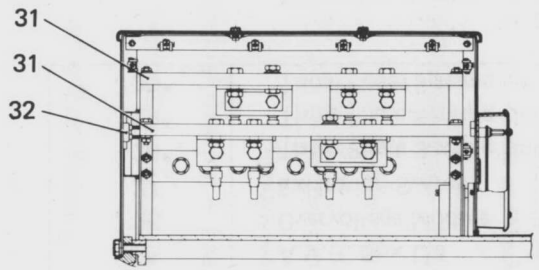
Fig. 7 Single Bearing Machine – Sectional Arrangement

Frames 6 and 7

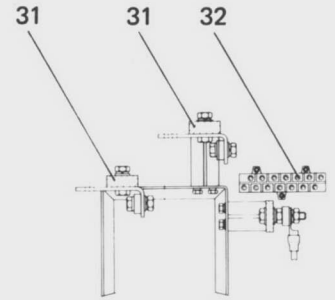
Single Bearing Parts List

Plate Ref	Description	Plate Ref	Description
1	Non-Drive Endbracket	31	Main Terminal Board
2	Cover Non-Drive End	32	Auxiliary Terminal Board
3	Drive Endbracket/Adaptor	33	Fan Key
4	Main Rotor Key	34	Exciter Rotor Key
5	Main Frame	35	Lower Drive End Cover
6	Wound Main Stator Assembly	36	Upper Drive End Cover
7	Wound Main Rotor Assembly	37	Coupling Disc
8	Fan	38	Coupling Pressure Plate
9	Shaft	39	Coupling Spacer
10	Wound Exciter Stator Assembly	40	Coupling Bolt
11	Wound Exciter Rotor Assembly	41	Circlip Non-Drive End
12	Main Rectifier Assembly		
13	Permanent Magnet Cover		
14	Permanent Magnet End Plate		
15	Permanent Magnet Rotor Stud and Nut		
16	Permanent Magnet Wound Stator Assembly		
17	Permanent Magnet Rotor Assembly		
18	Bearing Non-Drive End		
19	Bearing Cap Non-Drive End		
20	Bearing Cartridge Non-Drive End		
21	Terminal Box Side Panel		
22	Terminal Box Lid		
23	Automatic Voltage Regulator		
24	A.V.R. Box		
25	A.V.R. Box Lid		
26	Overvoltage Module		
27	Excitation Switch		
28*	Three Phase Sensing Unit		
29*	Three Phase Sensing Unit Box		
30*	Three Phase Sensing Unit Box Lid.		

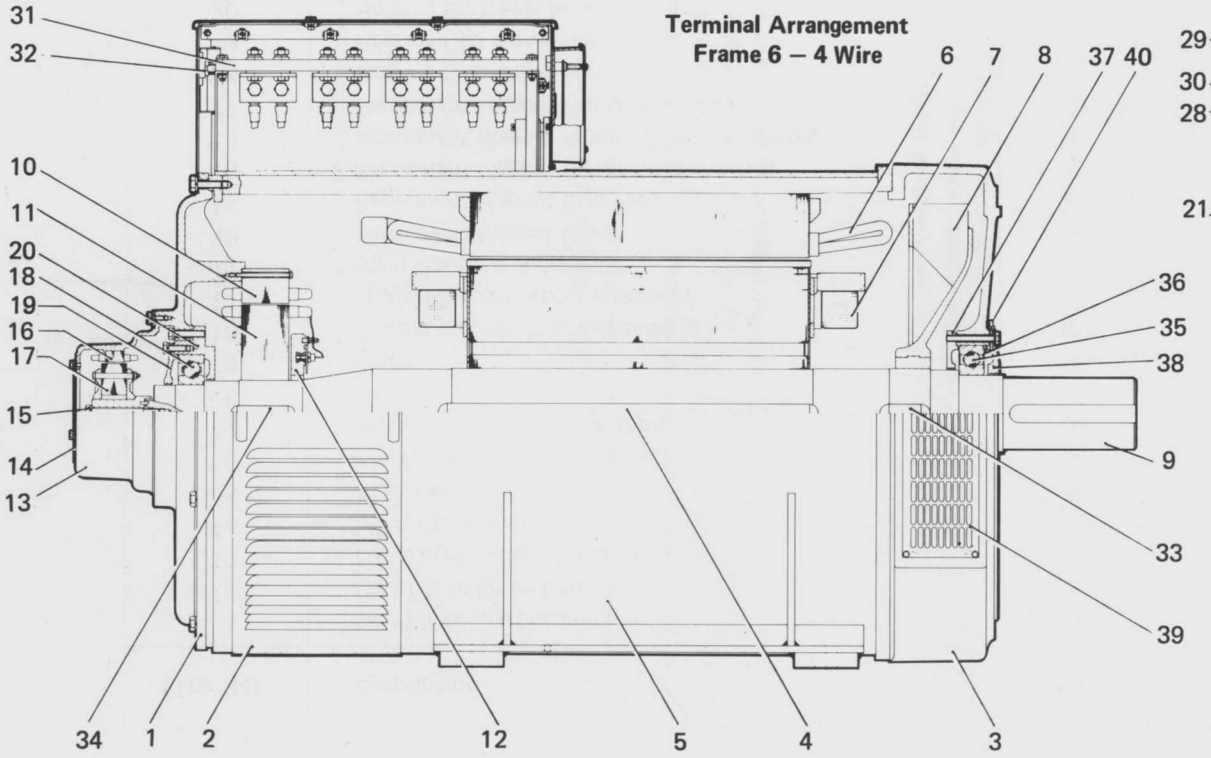
* Fitted as standard on 6 pole machines – optional on 4 pole.

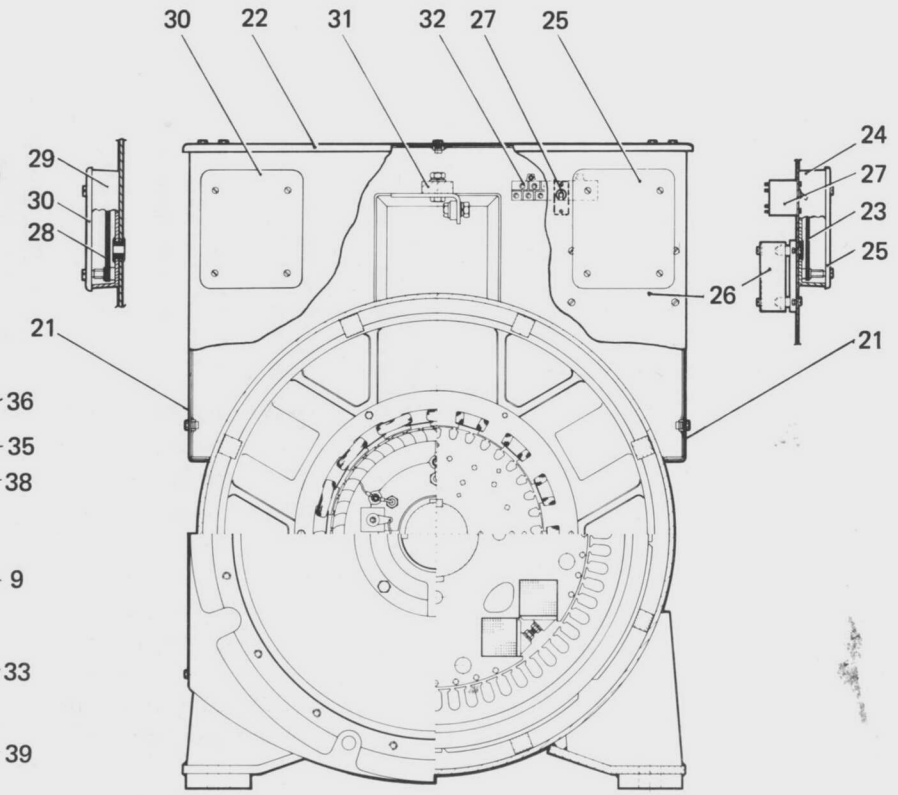


Terminal Arrangement
Frame Sizes 6A/B – 12 Wire
Frame 7 – 4 Wire



Terminal Arrangement
Frame 6 – 4 Wire





Frames 6 and 7

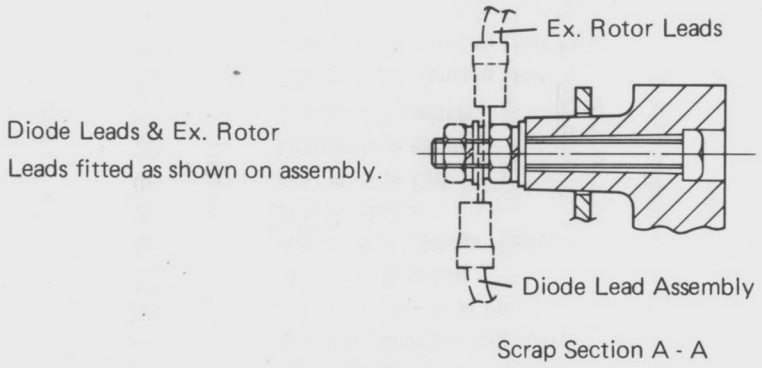
Fig. 8 Two Bearing Machine – Sectional Arrangement

Frames 6 and 7

Two Bearing Parts List

Plate Ref	Description	Plate Ref	Description
1	Non-Drive Endbracket	31	Main Terminal Board
2	Cover Non-Drive End	32	Auxiliary Terminal Board
3	Drive Endbracket	33	Fan Key
4	Main Rotor Key	34	Exciter Rotor Key
5	Main Frame	35	Bearing Drive-End
6	Wound Main Stator Assembly	36	Wave Washer (Bearing Drive-End)
7	Wound Main Rotor Assembly	37	Bearing Cap Inner Drive End
8	Fan	38	Bearing Cap Outer Drive End
9	Shaft	40	Grease Nipple Drive End
10	Wound Exciter Stator Assembly	39	Screen Drive End
11	Wound Exciter Rotor Assembly		
12	Main Rectifier Assembly		
13	Permanent Magnet Cover		
14	Permanent Magnet End Plate		
15	Permanent Magnet Rotor Stud and Nut		
16	Permanent Magnet Wound Stator Assembly		
17	Permanent Magnet Rotor Assembly		
18	Bearing Non-Drive End		
19	Bearing Cap Non-Drive End		
20	Bearing Cartridge Non-Drive End		
21	Terminal Box Side Panel		
22	Terminal Box Lid		
23	Automatic Voltage Regulator		
24	A.V.R. Box		
25	A.V.R. Box Lid		
26	Overvoltage Module		
27	Excitation Switch		
28*	Three Phase Sensing Unit		
29*	Three Phase Sensing Unit Box		
30*	Three Phase Sensing Unit Box Lid		

* Fitted as standard on 6 pole machines — optional on 4 pole.



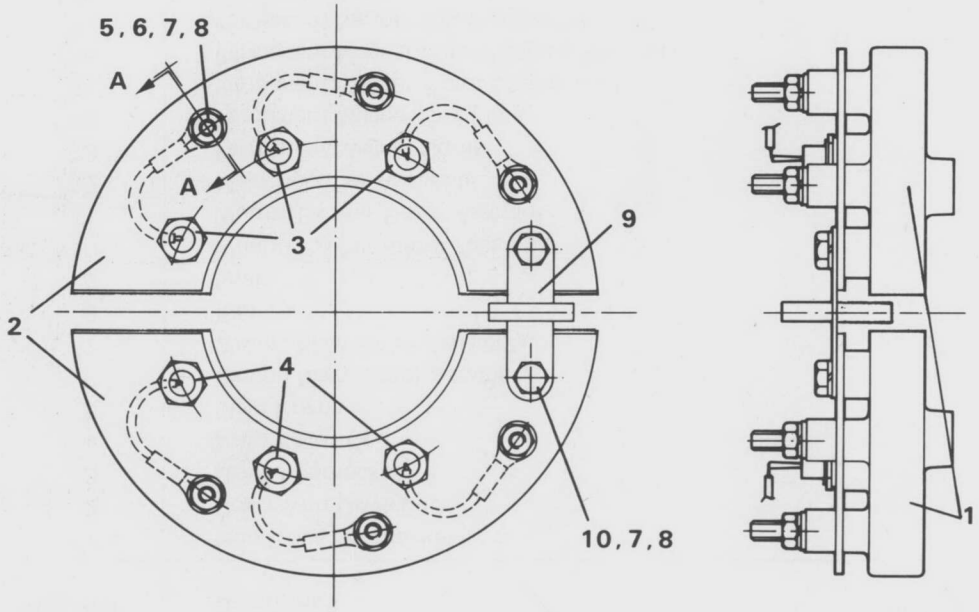


Plate Ref.	Description	Qty
1	Hub (LH/RH)	2
2	Fin	2
3	Diode (forward)	3
4	Diode (reverse)	3
5	Hx. Screw	6
6	Hx. Nut	6
7	Pl. Washer	8
8	SC. L/Washer	8
9	Varistor	1
10	Hx. Screw	2

NOTES:
Fitting of Diodes.

1. Underside of diodes to be smeared with Midland Silicone 'heat sink' compound type MS2623. This compound **must not** be applied to the diode threads.
2. Diodes to be tightened to a torque load of 2.03 - 2.37 N - m.
3. A rectifier assembly must comprise diodes from one manufacturer only.

Fig. 9 SC2 - 3 Split Rectifier Assembly

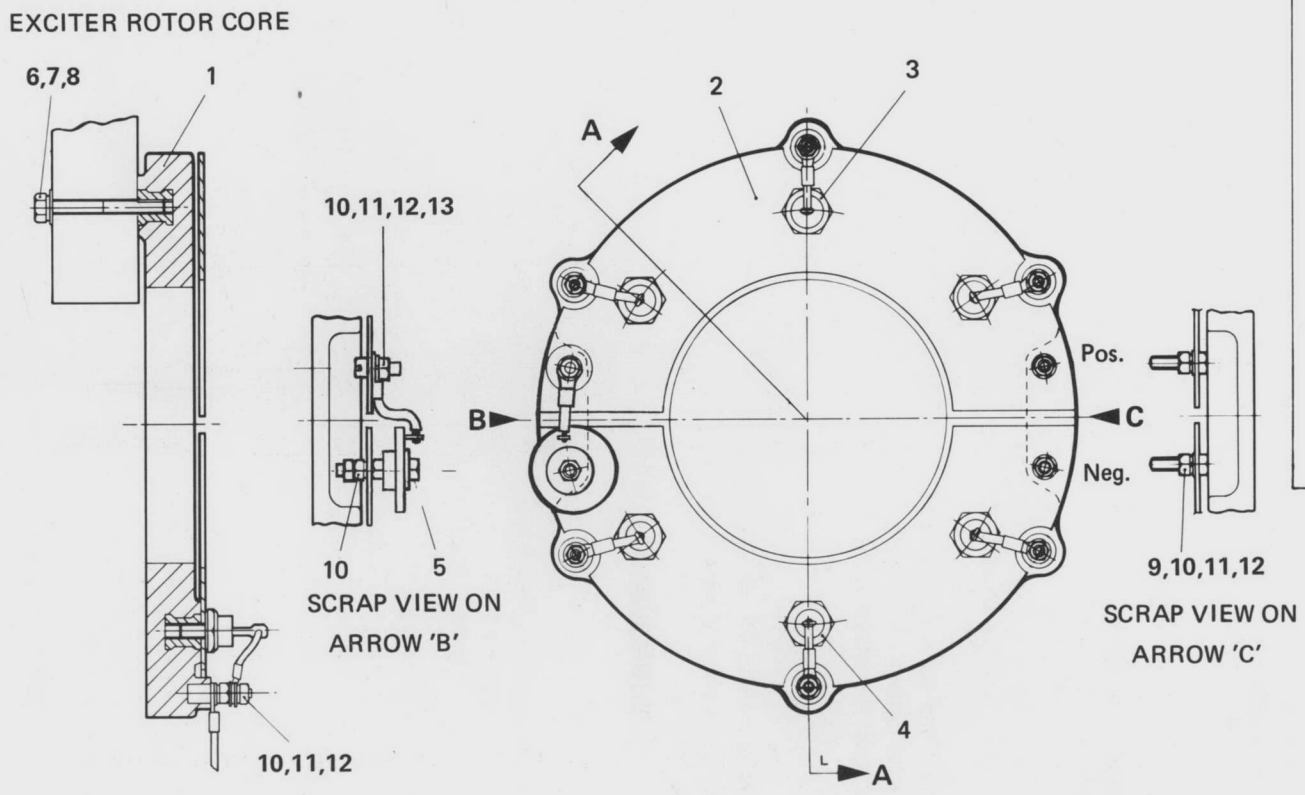


Plate Ref.	Description	Qty
1	Moulded Base	1
2	Fin	2
3	Diode (Forward)	3
4	Diode (Reverse)	3
5	Varistor	1
6	Hexagonal Head Bolt M6 x 65	4
7	Plain Washer M6	4
8	S.C. Lockwasher M6	4
9	Hexagonal Head Screw M5 x 20	2
10	Hexagonal Nut M5	17
11	Plain Washer M5	21
12	S.C. Lockwasher M5	15
13	CH. HD. Screw	1

NOTES:

1. A rectifier assembly **must** comprise diodes from one manufacturer only.
2. 4 Bolts (Plate ref 7) holding the moulding to the exciter core should be given an application of Loctite 241.
3. When fitting replacement diodes the undersides should if possible be smeared with Midland Silicone Heat Sink compound Type MS2623 or similar (available from our Spares Dept.) **IMPORTANT** This compound **MUST NOT** be applied to the diode stud threads.
4. Diode tightening torques: Frames 1 – 3, 2 – 2.4 N-m (18 – 21 lbf-in); Frames 4 – 7, 4 – 4.8 N-m (36 – 42 lbf-in).

Fig. 10 SC4 - 7 Rotating Rectifier Assembly

SECTION SIX

ACCESSORIES

HAND TRIMMER (For remote control)

A remote hand trimmer can be provided to give fine adjustment to the output voltage of approx. 6%. The hand trimmer works in conjunction with the range control fitted to the A.V.R. to give the voltage range specified in Section One. **Resistance value** – 4.7 k ohms.

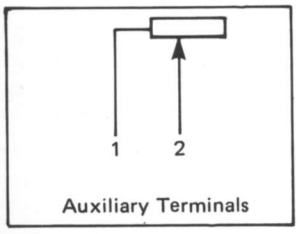


Fig. 11 Wiring details

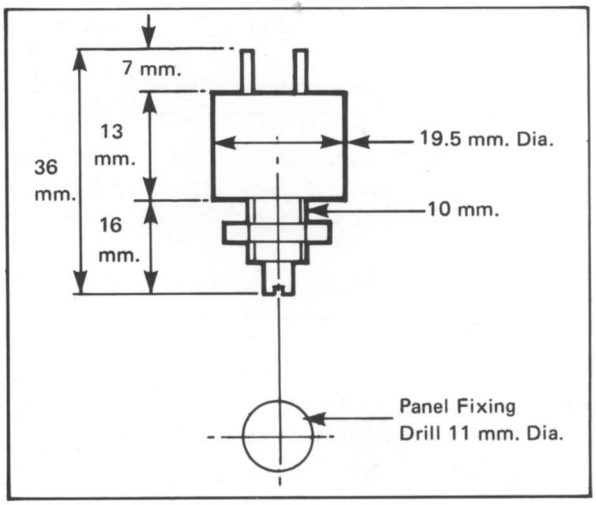


Fig. 12 Fitting details

NOTE: The following accessories are mounted inside the terminal box, the positions are shown on figs. 23 and fig. 24.

PARALLEL OPERATION

There are two important rules to bear in mind when paralleling two or more generators.

1. It is the engine that controls the kW load sharing.

2. It is the generator that controls the kVAr load sharing.

If the engine governors are not electrically interconnected and generator excitation systems are not electrically interconnected, then the larger the engine speed droop when kW load is applied and the larger the generator voltage droop with circulating current, the more flexible and stable the system becomes to obtain load sharing when the generators are in parallel. If closer control of both engine speed and generator voltage is required, then some form of cross connection is required between the governor systems and generator excitation systems.

The standard machine is fitted with a fully interconnected damper winding and the standard phase sequence is UVW when rotating clockwise viewed from the drive end. When paralleling Stamford a.c. generators, the neutrals can be connected but when paralleling dissimilar machines it is recommended that the neutrals are not connected as differences in waveform may result in harmonic currents.

Two paralleling systems can be supplied for the Stamford 'C' range a.c. generators.

Quadrature Droop	– For both similar and dissimilar control systems provided, a droop circuit is fitted to all machines.
Astatic Paralleling (Cross Current Compensation)	– For similar control systems having matching paralleling current transformers and burden resistors.

Quadrature Droop Kit

This is the most widely used and simple of paralleling systems and comprises a current transformer (C.T.)and burden resistor (see Fig. 13). or a current transformer (C.T.) and burden choke (see Fig. 14).

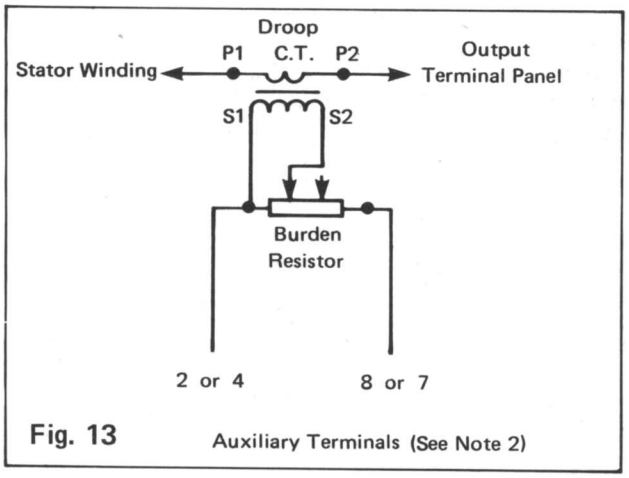


Fig. 13 Auxiliary Terminals (See Note 2)

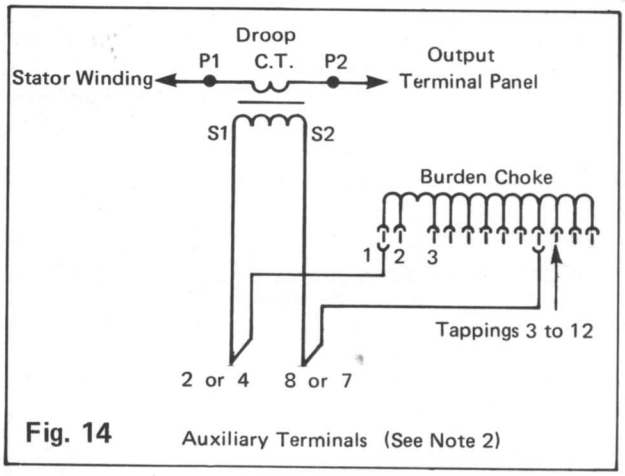


Fig. 14 Auxiliary Terminals (See Note 2)

NOTES:

1. Depending on machine type, one or more main stator winding cables may be connected to each output terminal. Only ONE cable should be passed through the ring-type quadrature-droop current transformer. (See Fig. 18 for CT position and wiring diagram Fig. reference.)

2. Connect resistor or choke to auxiliary terminals 2 & 8 (after removing link) on two-phase-sensed machines and terminals 4 & 7 (after removing link) on three-phase-sensed machines.

Operation

As stated earlier paralleling systems fitted to the generator can only ensure that the excitation system maintains the output voltage to the correct level, gives satisfactory kVAr load sharing, and minimises circulating currents to acceptable levels. The kW load sharing is effected by adjusting the engine throttle/governor setting.

For both two phase and three phase sensed machines the operation is the same in that any circulating current between machines produces a voltage across the burden resistor or choke which directly adds or subtracts from the sensing voltage fed into the A.V.R. This makes the excitation system sensitive to circulating currents and ensures correct sharing of the kVAr load. The larger the droop voltage is set, the more flexible becomes the excitation system to reduce circulating currents and ensure kVAr load sharing. In most cases a 5% droop on the output voltage at full load zero p.f. lag. is satisfactory; this setting increases the voltage regulation by approx. 1% at full load unity p.f. and approx. 3% at full load, 0.8 p.f. When a untiy power factor load (kW) is applied the voltage produced across the burden resistor/choke adds vectorially at right angles to the sensing voltage and has a minimal effect. When the machines are run individually, the droop circuit can be switched out by short-circuiting auxiliary terminals 2 & 8 on the two-phase sensed A.V.R. and 4 & 7 on the three-phase sensed A.V.R. to obtain the normal close regulating characteristics of the machine.

Setting up the droop circuit can be difficult as in most cases only unity p.f. load is available. A simple way of setting up the droop circuit under these conditions is to measure the voltage across the resistor/choke when load is applied; this should be in line with the graph Fig. 15 to obtain approx. 5% droop at full load zero p.f. lag.

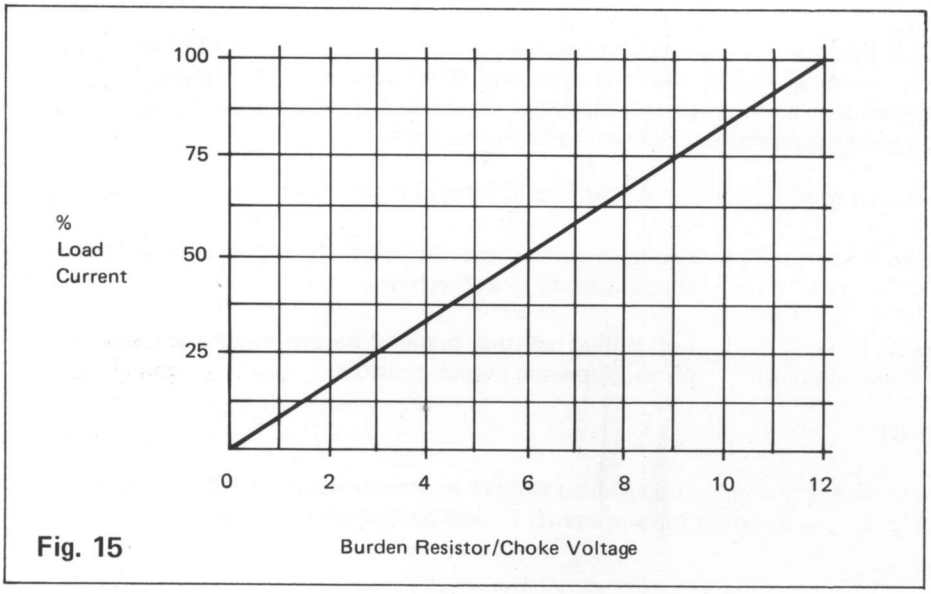


Fig. 15 Burden Resistor/Choke Voltage

The other important factor is to ensure that the voltage produced across the burden resistor/choke adds with the A.V.R. sensing voltage in the correct direction. If for any reason this is reversed, a rising characteristic will result which will give an unstable condition for parallel operation and will produce high circulating currents. This can be checked quite simply by applying a unity p.f. load on each machine separately and measuring the voltage across auxiliary terminals 6 & 2 and 6 & 8 on the two-phase sensed A.V.R. and across auxiliary terminals 6 & 7 and 6 & 4 on the three-phase sensed A.V.R. If the circuit is functioning correctly, the voltage across 6 & 2 should be less than the voltage across 6 & 8 and the voltage across 6 & 7 should be less than the voltage across 6 & 4.

Astatic Paralleling Kit (Cross Current Compensation) Two phase sensed A.V.R. only.

Note: For three phase sensed see enclosure where applicable.

This system can be used to parallel two or more generators with similar excitation control systems whilst maintaining the normal close regulation. The excitation systems are still kVAr-sensitive, and the crossconnection maintains the set output voltage (without deliberate droop) but still ensures satisfactory kVAr load sharing. Any generator can be run singly by shorting out auxiliary terminals 2 & 8.

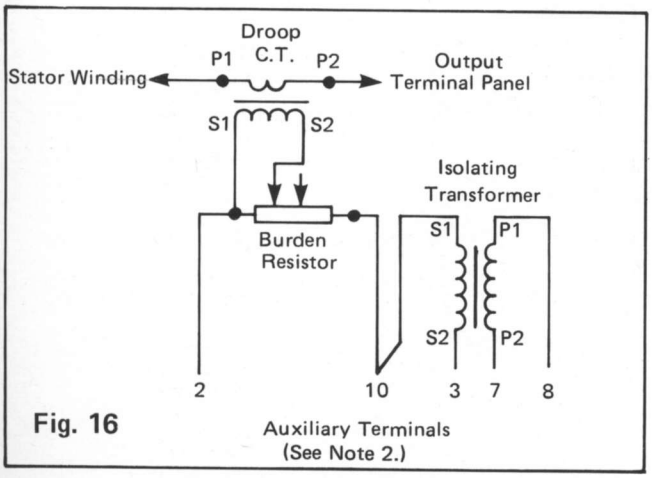


Fig. 16

NOTES:

1. Depending on machine type, one or more main stator winding cables may be connected to each output terminal. Only ONE cable should be passed through the ring-type current transformer. (See Fig. 18 for CT position and wiring diagram Fig. reference.)
2. Remove links 2 – 8 and 3 – 7 before fitting.
3. Not available on Series zig-zag connected machines.

When using astatic droop paralleling machines must be interconnected by cross connecting auxiliary terminals 2 to 10. A typical example is shown in Fig. 17 below.

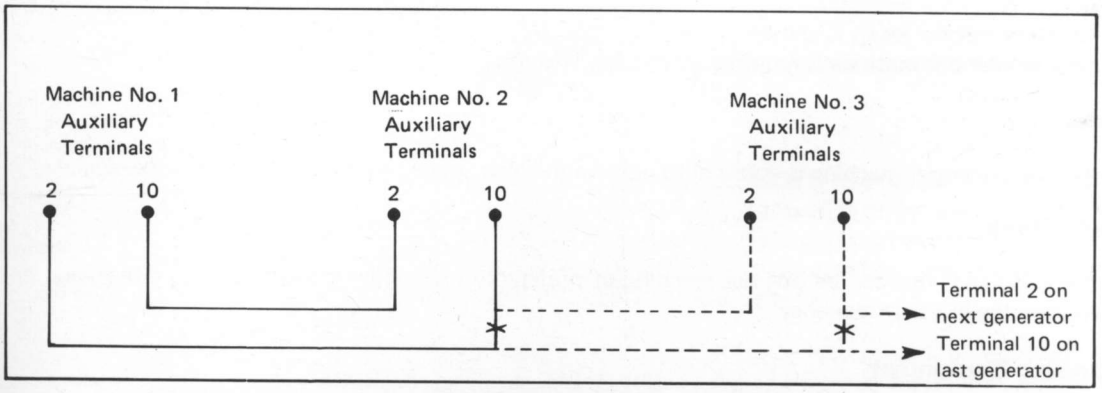


Fig. 17 – Interconnections Between Machines

Resistance Values (Approximate)

Burden Resistor – 215 ohms
Burden Choke – 9 ohms

Droop C.T. – 41 ohms
Isolating Transformer – Primary 494 ohms
Secondary 366 ohms

A.V.R. Type	Stator Connection (Standard phase rotation)	Paralleling			
		Quadrature Droop		Astatic	
		Fig.	C.T. Position	Fig.	C.T. Position
Two Phase Sensed	4 Wire & 6 Wire Star	13	W2	16	W2
	12 Wire Series Star	13	W2	16	W2
	12 Wire Series Delta	13	W2	16	W2
	12 Wire Parallel Star	13	W2	16	W2
	12 Wire Series Zig-Zag Star	14	W2		Not available
Three Phase Sensed	4 Wire & 6 Wire Star	14	V2		See enclosed where applicable
	12 Wire Series Star	14	V2		
	12 Wire Series Delta	13*	W2		
	12 Wire Parallel Star	14	V2		
	12 Wire Series Zig-Zag Star	13*	V2		

Fig. 18 Droop C.T. Positions

NOTES:

1. *For these stator connections the C.T. secondary leads S1 and S2 must be reversed for correct machine operation.

2. Standard phase rotation is U.V.W. when a.c. generator is rotating clockwise viewed at the drive end. For phase rotation U.V.W. when rotating anti-clockwise refer to factory for details.

General Notes on Paralleling

Main Metering Requirements

For successful synchronisation and load sharing between two or more a.c. generators, the following meters and equipment are essential:

Voltmeter

This can be one voltmeter per machine, or one which is switchable to either. The latter is more accurate for initial voltage setting to ensure identical voltages. Another voltmeter may be fitted to the main bus-bars for monitoring the machine on load.

Ammeter

At least one ammeter per machine is required, preferably with phase to phase switching.

Wattmeter

At least one wattmeter per machine is essential to observe the load sharing of the prime movers, i.e. engines.

Frequency Meter

As with the voltmeter, this can be one per machine or preferably one which is switchable to either, and another registering the bus-bar frequency.

Synchronising Equipment

This can comprise either a purpose-built synchronising meter or synchroscope or a system of lamps connected across the synchronising circuit breaker. The lamps can be connected across like phases, i.e. U-U, V-V, and W-W, in which case the lamps will be unlit when the two machines are correctly in phase for synchronising. Alternatively two sets of lamps can be cross-connected, e.g. U-V, V-U, W-W, and the lamps will then be at their brightest at the correct in-phase moment. Each lamp circuit must be rated for at least twice the line-to-neutral voltage, and it is simplest to connect two or three ordinary lamps in series.

Protection Devices

In addition to essential protection devices, i.e. overload circuit breaker, fuses, etc. it is recommended that the breakers have a shunt release coil working in conjunction with a reverse power relay trip. This ensures that, should one of the sets malfunction for any reason, i.e. engine shutdown, voltage drop, etc. the power transferred from the other set, which is now trying to 'motor' the failed plant, will then de-energise the contact breaker and dis-connect the sets.

Setting Up Procedure for Parallel Operation

The droop equipment should be tested and set correctly and the machines can be set for synchronisation as follows:

1. The speed of each set must be adjusted to the nominal frequency of the system, i.e. 50 Hz or 60 Hz.

2. The voltage of each machine can now be set identically on the hand voltage trimmers or A.V.R. range control.

3. The machine should only be paralleled when the difference in frequency between the two sets is small enough to enable the breaker to be closed when the in-phase condition is observed. This is achieved by adjusting the speed of the incoming set to match the set on the bus-bars and the easiest method of speed adjustment is with a governor motor control and a Raise/Lower speed control button.

   Care must be taken to ensure that the machines are exactly in phase before paralleling is attempted, as the forces set up by out of phase paralleling can create severe mechanical and electrical stresses in the sets.

4. As load is applied any discrepancy between the kW meters can be eliminated by slight adjustment of the throttle or governor on one of the machines.

5. With the kW meters sharing load correctly, any discrepancy between the ammeters can be eliminated with slight adjustment of the voltage trimmer on one of the machines.

NOTE: Current discrepancies are due to circulating currents which flow between the sets when there is a difference in excitation levels between the a.c. generators. High circulating currents may be due to a reversal in one of the droop transformers or incorrect adjustment of the droop setting on the burden resistor or choke. In general, when paralleling identical machines, the amount of droop should be approximately equal on all sets.

CURRENT SENSING – IMPROVED VOLTAGE REGULATION KIT

The standard machine is voltage sensed and if required current sensing can be added to make the machine more flexible to improve the voltage regulation where semi-conductor or thyristor loads are used which distort the voltage waveform of the machine. This unit can also be used to bias the sensing circuit of the A.V.R. to overcome voltage drops where long cables between the generator and load are used. The unit consists of a current transformer (C.T.) and a burden resistor (see Fig. 19).

The components are identical to those used for the quadrature droop kit for Parallel Operation, the only difference is that the circuit is arranged to be more sensitive between unity to 0.8 p.f. (lag) loads.

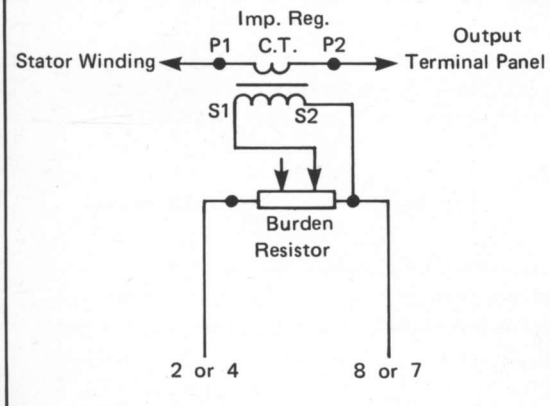


Fig. 19

NOTES:

1. Depending of machine type, one or more main stator winding cables may be connected to each output terminal. Only ONE cable should be passed through the ring-type quadrature-droop current transformer. (See Fig. 20 for CT position and wiring diagram Fig. reference.)

2. Connect to auxiliary terminals 2 – 8 (after removing link) on two phase sensed machines and 4 – 7 (after removing link) on three phase sensed machines.

A.V.R. Type	Stator Connection (Standard phase rotation)	Improved Voltage Regulation	
		Fig.	C.T. Position
Two Phase Sensed	4 Wire & 6 Wire Star	19	V2
	12 Wire – Series Star	19	V2
	12 Wire – Series Delta	19	V2
	12 Wire – Parallel Star	19	V2
	12 Wire – Series Zig-Zag Star	19 *	W2
Three Phase Sensed	4 Wire & 6 Wire Star	19 *	V2
	12 Wire – Series Star	19 *	V2
	12 Wire – Series Delta	19 *	V2
	12 Wire – Parallel Star	19 *	V2
	12 Wire – Series Zig-Zag Star	19 *	U2

Fig. 20 Improved Regulation C.T. Positions

NOTES:

1. *For these stator connections the C.T. secondary leads S1 and S2 must be reversed for correct machine operation.

2. Standard phase rotation is U.V.W. when a.c. generator is rotating clockwise viewed at the drive end. For phase rotation U.V.W. when rotating anti-clockwise refer to factory for details.

Resistance Values

Burden Resistor – 215 ohms

Imp. Reg. C.T. – 41 ohms

R.F.I./E.M.I. – SUPPRESSOR KIT

In cases where R.F.I./E.M.I. levels better than BS800 and VDE class G – N are required, an additional suppressor kit is recommended. The connections are shown below, see Fig. 21.

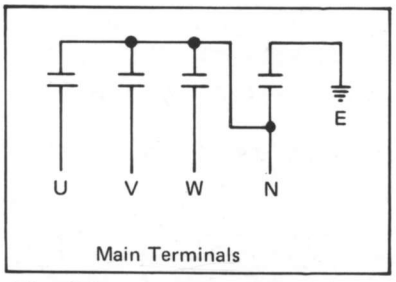


Fig. 21

NOTE: The electrical connections are made automatically when assembling the unit to the moulded type main terminals with the exception of the earth lead. This should be connected to one of the screws holding the terminal panel to the frame.

On the bus-bar terminal arrangement the suppressor kit has 4 flying leads which must be connected to the output terminals and earth.

ANTI–CONDENSATION HEATERS

It is recommended that anti-condensation heaters are fitted on standby applications, marine applications or where the machine is standing idle for long periods of time. The most effective anti-condensation heaters are taped directly to the overhang windings of the stator and as such must be fitted during the winding stage. See Fig. 22. On this basis heaters **must** be specified at time of ordering.

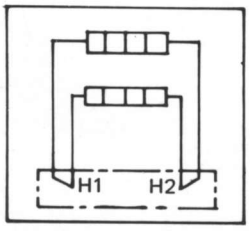
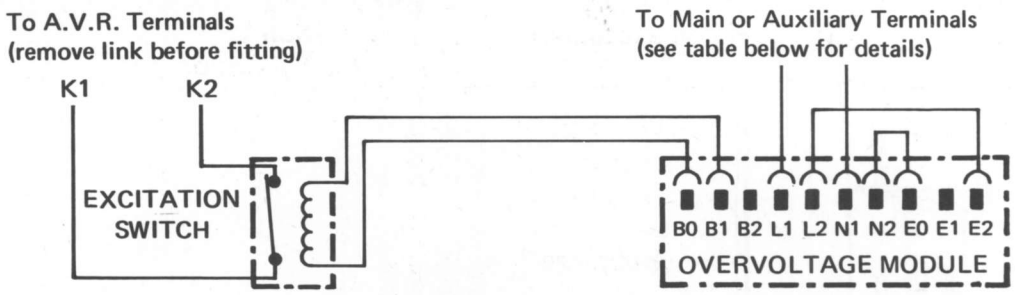


Fig. 22

NOTE: For reasons of safety, all heater leads are terminated in a separate box located on the outside of the main terminal box.

OVERVOLTAGE PROTECTION MODULE (O.V.M.)



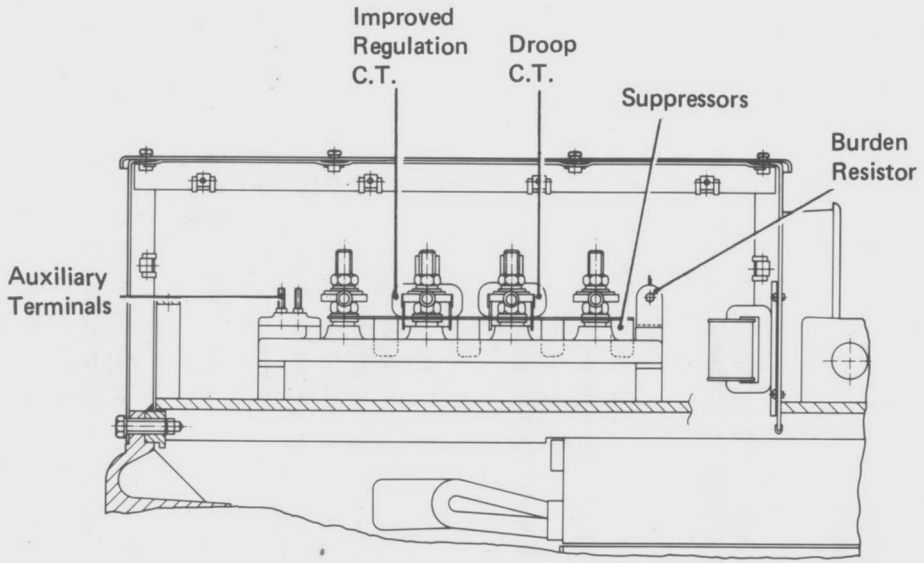
Winding No.	Stator Connection	Freq.	O.V.M. Connections (L1, N1)
12 & 18	Star	50/60	L1 to U – N1 to N
11	Series Star	50/60	L1 to W – N1 to N
	Parallel Star	50/60	L1 to W – N1 to U
	Series Delta	50/60	L1 to W – N1 to U
07	Star	50/60	L1 to Aux. T 6 – N1 to N
17	Series Star	50	L1 to W – N1 to N
	Series Star	60	L1 to Aux. T 6 – N1 to N
	Parallel Star	50/60	L1 to W – N1 to U

Overvoltage Protection

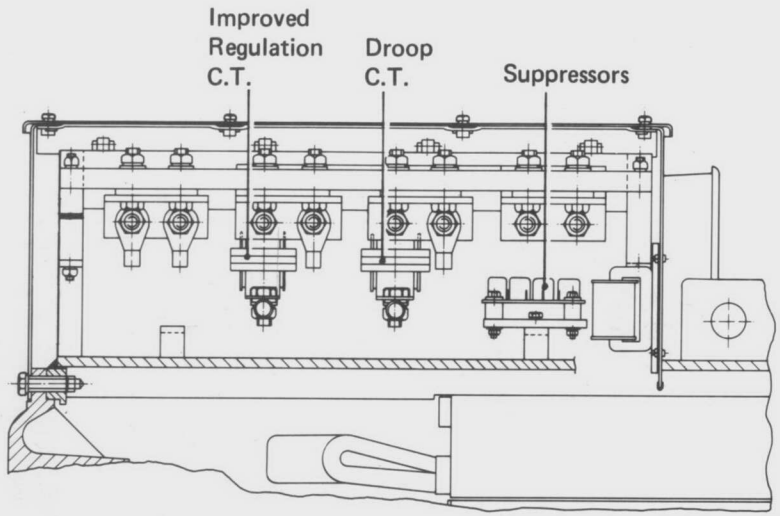
This is fitted as standard on Frames 6 & 7, and can be supplied as an accessory on Frames 2 – 5. It comprises an excitation switch and an overvoltage module (OVM) which is factory-set to trip at 25% overvoltage. Should it be necessary to alter the machine voltage from the originally-ordered value, the OVM should be adjusted as follows.

1. Set the 'volts' setting potentiometer fully clockwise.
2. Move the E2 end of the L2–E2 connecting link to E1.
3. Turn the 'volts' setting potentiometer slowly anti-clockwise until tripping just occurs. The unit is now automatically set to trip at 125% of nominal voltage.
4. Return the E2 end of the L2–E2 link to E2.

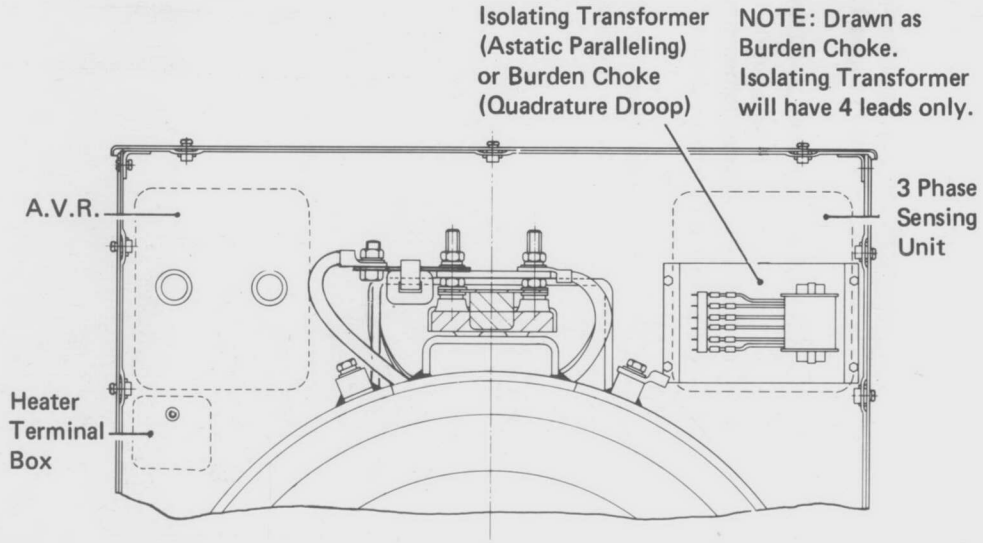
   (The time setting potentiometer has been set on test for about 1 – 1½ seconds delay; turn anti-clockwise to reduce tripping time.)



Frame 4 – 4 and 12 Wire. Frame 5 – 4 Wire



Frame 5 – 12 Wire



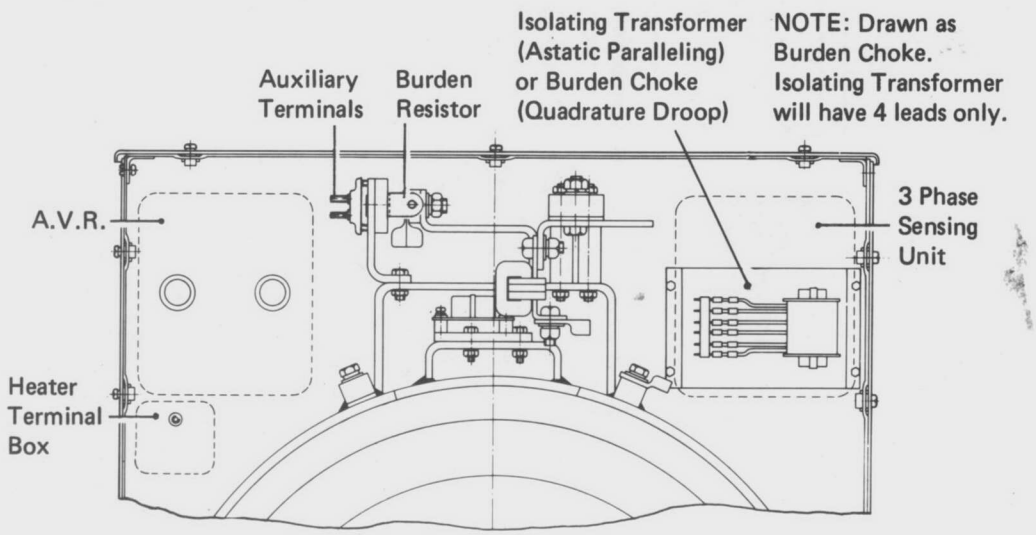
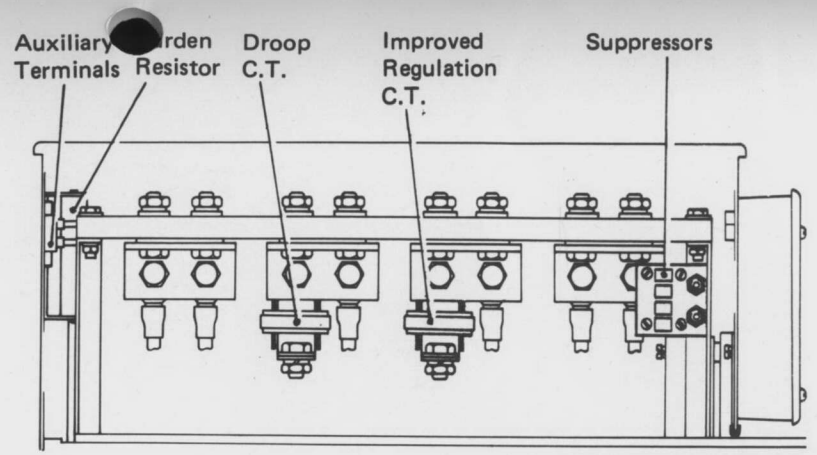
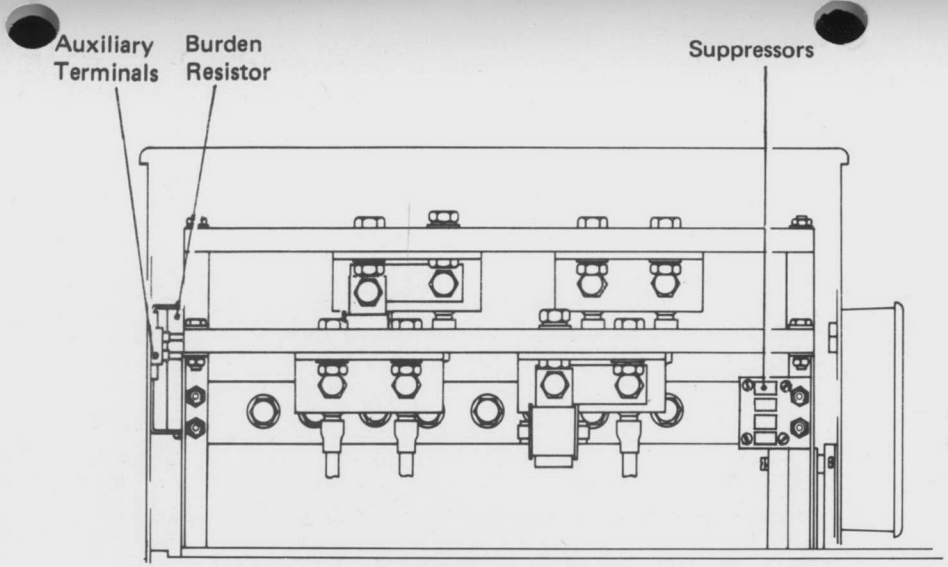


Fig. 23 Frames 4 and 5 Accessory Location Drawings

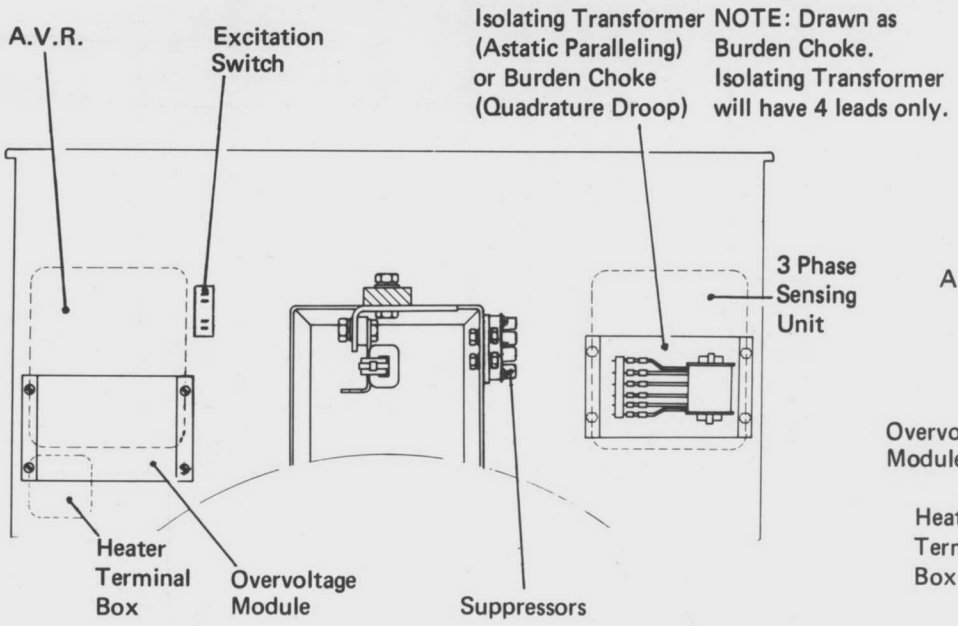


Frame 6 – 4 Wire



Frame Sizes 6A/B – 12 Wire

Frame 7 – 4 Wire



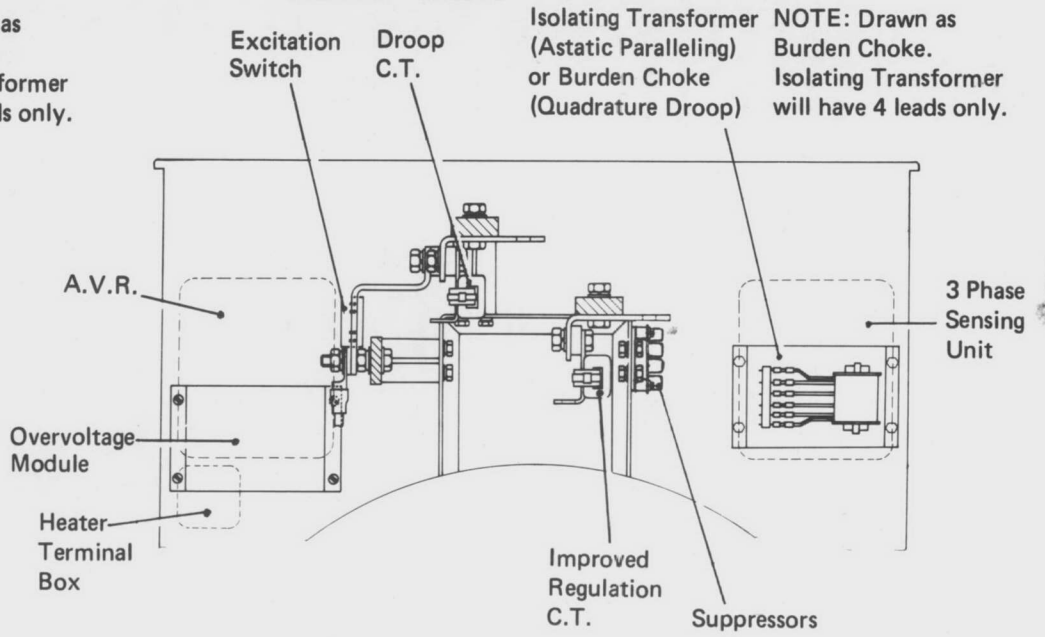


Fig. 24 Frames 6 and 7 Accessory Location Drawings

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Telephone: Toronto (416) 259 3741. Telex: 06-967676.

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Control Panel

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BILL OF MATERIAL

ITEM	QTY.	DESCRIPTION	CATALOG NO.	MFG
	1	Enclosure 20"W x 10"H x 8"D	PB-111,192	Redco
ACA	1	AC Ammeter 3 1/2" 0-800A	016-02AB-LSSN	Crompton
ACV	1	AC Voltmeter 3 1/2" 0-300V	016-02VB-RXRX	Crompton
FM	1	Frequency Meter 3 1/2" 120V/45-65 Hertz	016-41SB-PNAJ	Crompton
RES	1	Resistor (FM)	0217	Ohmite
VAR	1	Voltage Adjust Rheostat	0162	Ohmite
	1	Knob (VAR)	5150	Ohmite
AVS	1	Ammeter/Voltmeter Switch 4-Pos	101904LS	Esco
	1	Nameplate GROUP	#3, 4	Redco
CT-1 2-3	3	Current Transformer 800/5 (Shipped Loose)	C-800	WICC
F1,2 3	3	Fuse 250V 1-Amp	NON-1	Buss
	1	Fuse Block 250V 3-Pole	H25030-3S	U.S.D.C.
TB	1	Terminal Board 10-Point	10-141	C.J.
	1	Assembly Parts	PA-121,454	Redco

AS BUILT NOV. 20. '86

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DWN. KHE DATE 11-12-86
RCD. CK.

REPUBLIC ELECTRIC & DEVELOPMENT CO.
PEORIA, ILLINOIS

TITLE Generator Control

DRAWING NO. PA-126,551

N77472

BILL OF MATERIAL

ITEM	QTY.	DESCRIPTION	CATALOG NO.	MFG
ECS	1	Engine Control Switch 4-Pos	101402A	Esco
PLS	1	Panel Light Switch 1P1T	7500K14	C.H.
ADS	1	Alarm Disconnect Switch 1-N.O.	8411K12	C.H.
ALM	1	Alarm (Sonalert) 24VDC	SC-648	Mallory
FCM	1	Fault Module 24VDC	PA-104,836	Redco
FCM2	1	Fault Module #2 24VDC	PA-124,829	Redco
ENFR	1	Engine Failure Relay 3PDT 24VDC	PA-30044	Redco
RR	2	Run Relay 3PDT 24VDC	PA-30044	Redco
AR	1	Arming Relay 3PDT 24VDC	PA-30044	Redco
ADR	1	Alarm Disconnect Relay 3PDT 24VDC	PA-30044	Redco
	5	Socket 11-Pin	PA-30001	Redco
OCT	1	Timing Module (Overcrank)	PA-30003	Redco
ADT	1	Timing Module (Arming Relay)	PA-30002	Redco
D12	1	Diode	SK-3081	RCA
CCM	1	Timing Module (Crank-Rest-Crank)	1232	PTC
	1	Mounting Track		Curtis
PIL	2	Panel Illumination Light	47-0901-2900-301	Dialco
	2	Lamp 24VDC	6S6	G.E.
TB	1	TERMINAL BOARD 6-POINT	6-141	C.J
TB	3	Terminal Board 10-Point	10-141	C.J.
	1	Nameplate Group	#22, 25A, 26, 27 28, 168, 154, 320 195, 197, 209	Redco

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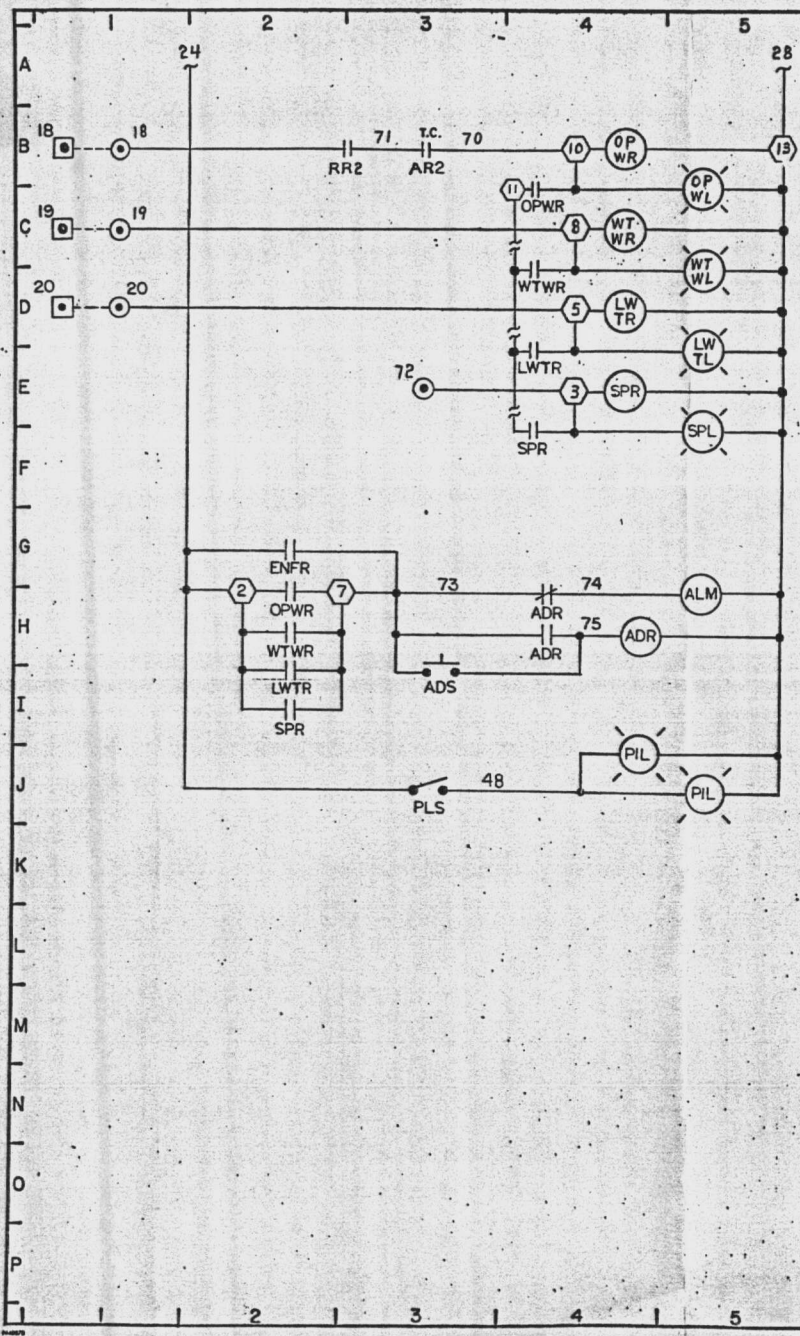
REPUBLIC ELECTRIC & DEVELOPMENT CO. PEORIA, ILLINOIS

TITLE Engine Control

DRAWING NO. PA-126,552

N77472



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ABBREVIATIONS

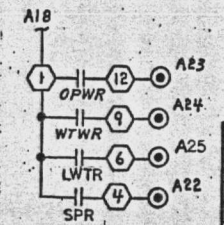
ADR	- ALARM DISCONNECT RELAY
ADS	- ALARM DISCONNECT SWITCH
ALM	- ALARM
AR	- ARMING RELAY
ENFR	- ENGINE FAILURE RELAY
LWTL	- LOW WATER TEMPERATURE LIGHT
LWTR	- LOW WATER TEMPERATURE RELAY
PIL	- PANEL ILLUMINATION LIGHT
OPWL	- LOW OIL PRESSURE WARNING LIGHT
OPWR	- LOW OIL PRESSURE WARNING RELAY
RR	- RUN RELAY
SPL	- SPARE LIGHT
SPR	- SPARE RELAY
WTWL	- EXCESSIVE WATER TEMPERATURE WARNING LIGHT
WTWR	- EXCESSIVE WATER TEMPERATURE WARNING RELAY
PLS	- PANEL LIGHT SWITCH

AS BUILT

NOTES

- ⊙ - TERMINAL BOARD POINTS (PANEL)
- ⊡ - TERMINAL BOARD POINTS (JUNCTION BOX)
- ——— - REDCO WIRING
- — — — - CUSTOMER/USER WIRING
- * - ENGINE MOUNTED
- ⬡ - CONNECTION POINT (FAULT MODULE)

NOV. 20. '86



PRINTS TO	
PRODUCT	
PURCH.	
S/M SHOP	
PANEL TEST BAY	
JOB FILE	

REFERENCE	DRAWINGS

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TITLE: SCHEMATIC-DC

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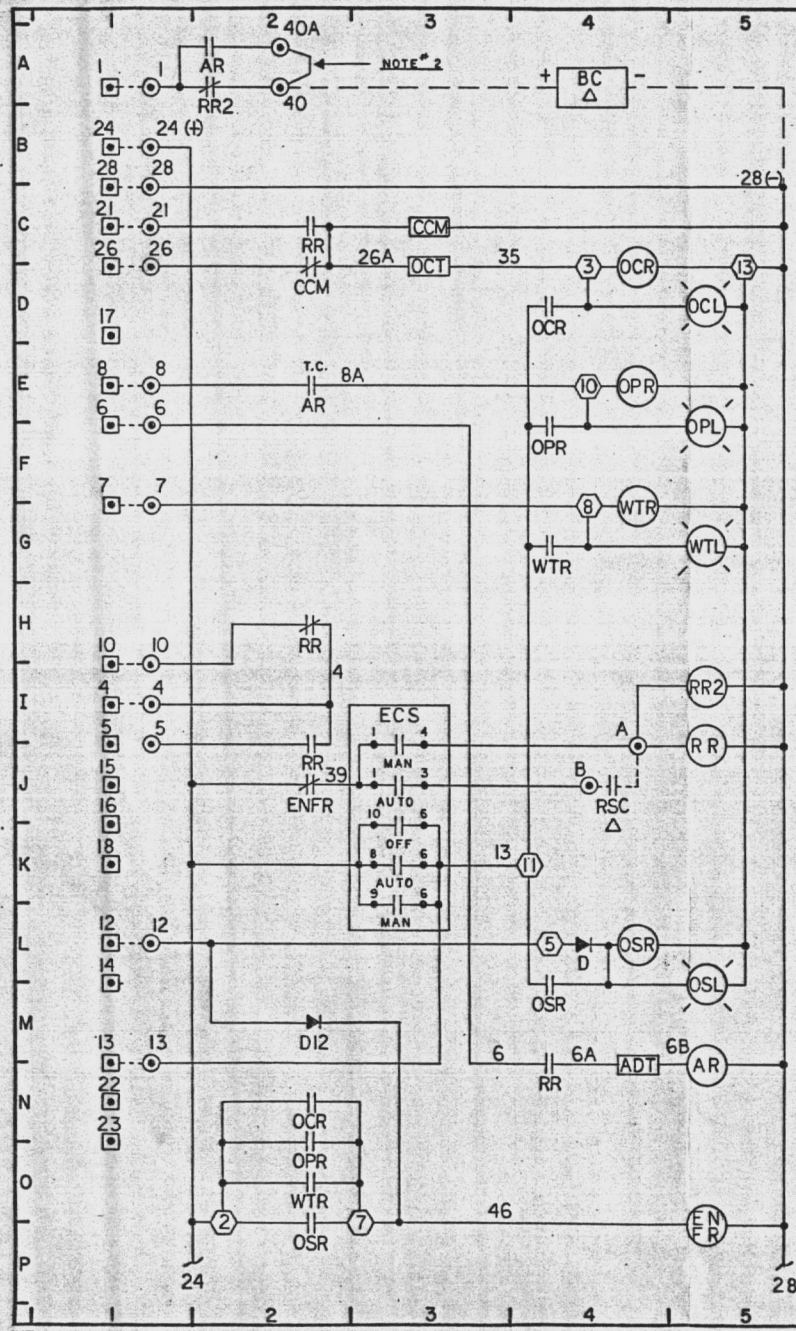

NO.	REVISIONS	DATE

ABBREVIATIONS

ADT	- TIMING MODULE (ARMING DELAY)
AR	- ARMING RELAY
AUTO	- AUTOMATIC POSITION
BC	- BATTERY CHARGER
CCM	- TIMING MODULE (CRANK-REST-CRANK)
D	- DIODE
ECS	- ENGINE CONTROL SWITCH
ENFR	- ENGINE FAILURE RELAY
MAN	- MANUAL POSITION
OCL	- OVERCRANK LIGHT
OCR	- OVERCRANK RELAY
OCT	- OVERCRANK TIMER
OPL	- LOW OIL PRESSURE LIGHT
OPR	- LOW OIL PRESSURE RELAY
OSL	- OVERSPEED LIGHT
OSR	- OVERSPEED RELAY
RR	- RUN RELAY
RSC	- REMOTE START CONTACT CLOSE TO RUN, OPEN TO STOP
WTL	- EXCESSIVE WATER TEMPERATURE LIGHT
WTR	- EXCESSIVE WATER TEMPERATURE RELAY

AS BUILT

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NOTES

- ⊙ - TERMINAL BOARD POINTS (PANEL)
- ⊡ - TERMINAL BOARD POINTS (JUNCTION BOX)
- ——— - REDCO WIRING
- - - - - - CUSTOMER/USER WIRING
- ⬡ - CONNECTION POINT

NOTE #2

REMOVE THIS JUMPER WHEN ENGINE IS SUPPLIED WITH A CHARGING GENERATOR OR ALTERNATOR.

SEE CAT INC. DRAWING #4W9603 SHEET 2 of 3 FOR CONNECTIONS TO JUNCTION BOX

PRINTS TO	
PRODUCT.	
PURCH.	
S/M SHOP	
PANEL TEST BAY	
JOB FILE	

ENERGIZED TO SHUTOFF

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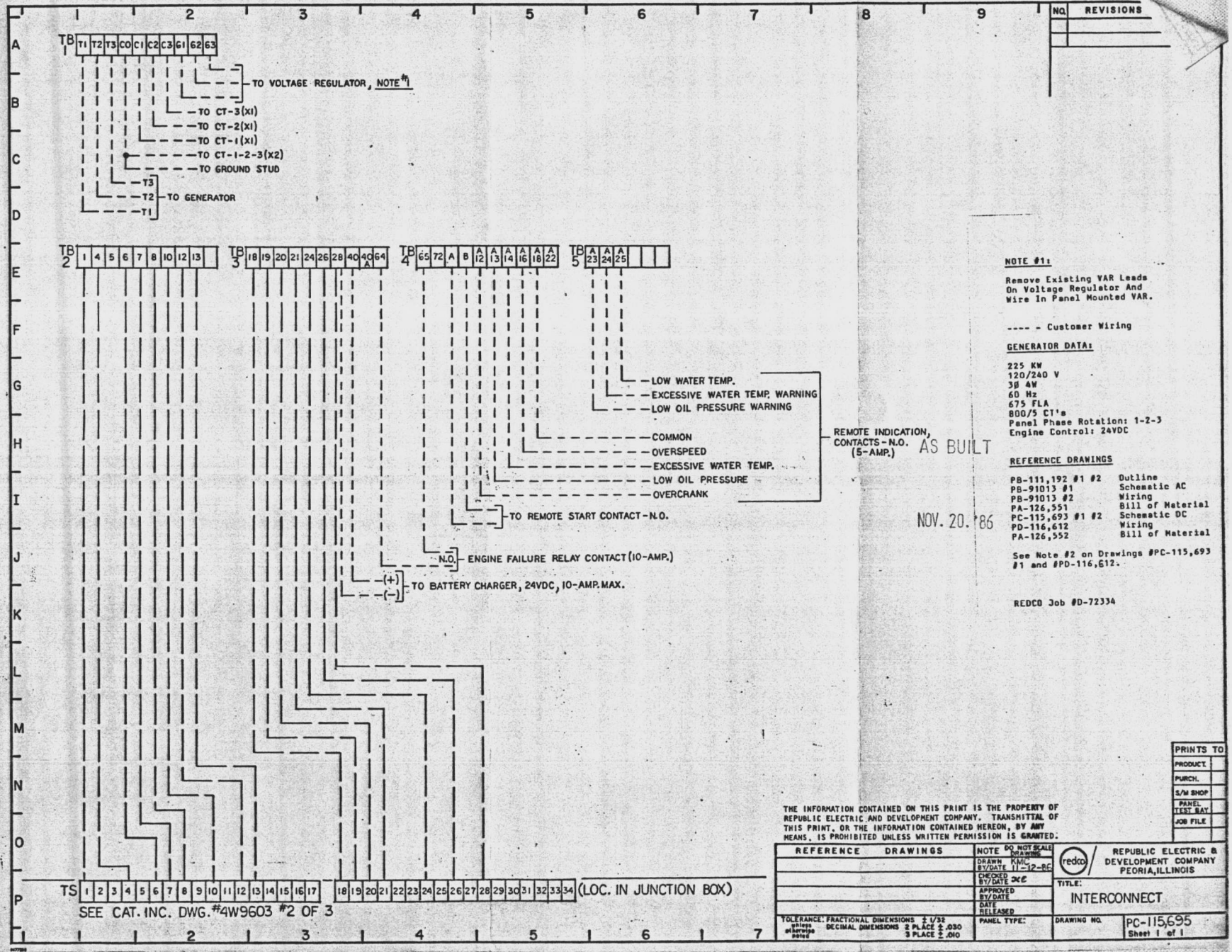
TITLE: SCHEMATIC - DC

DRAWING NO. PC-115,693 Sheet 1 of 2



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NOTE #1:

Remove Existing VAR Leads On Voltage Regulator And Wire In Panel Mounted VAR.

---- - Customer Wiring

GENERATOR DATA:

225 KW
120/240 V
3ϕ 4W
60 Hz
675 FLA
800/5 CT's
Panel Phase Rotation: 1-2-3
Engine Control: 24VDC

REFERENCE DRAWINGS

PB-111,192 #1 #2	Outline
PB-91013 #1	Schematic AC
PB-91013 #2	Wiring
PA-126,551	Bill of Material
PC-115,693 #1 #2	Schematic DC
PD-116,612	Wiring
PA-126,552	Bill of Material

See Note #2 on Drawings #PC-115,693 #1 and #PD-116,612.

REDCO Job #D-72334

PRINTS TO
PRODUCT
PURCH.
S/M SHOP
PANEL TEST BAY
JOB FILE

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	CHECKED BY/DATE JCE
	APPROVED BY/DATE
	DATE RELEASED
TOLERANCE: FRACTIONAL DIMENSIONS ± 1/32 unless otherwise noted; DECIMAL DIMENSIONS 2 PLACE ± .030, 3 PLACE ± .010	PANEL TYPE:

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TITLE: INTERCONNECT

DRAWING NO. PC-115,695 Sheet 1 of 1

PB-

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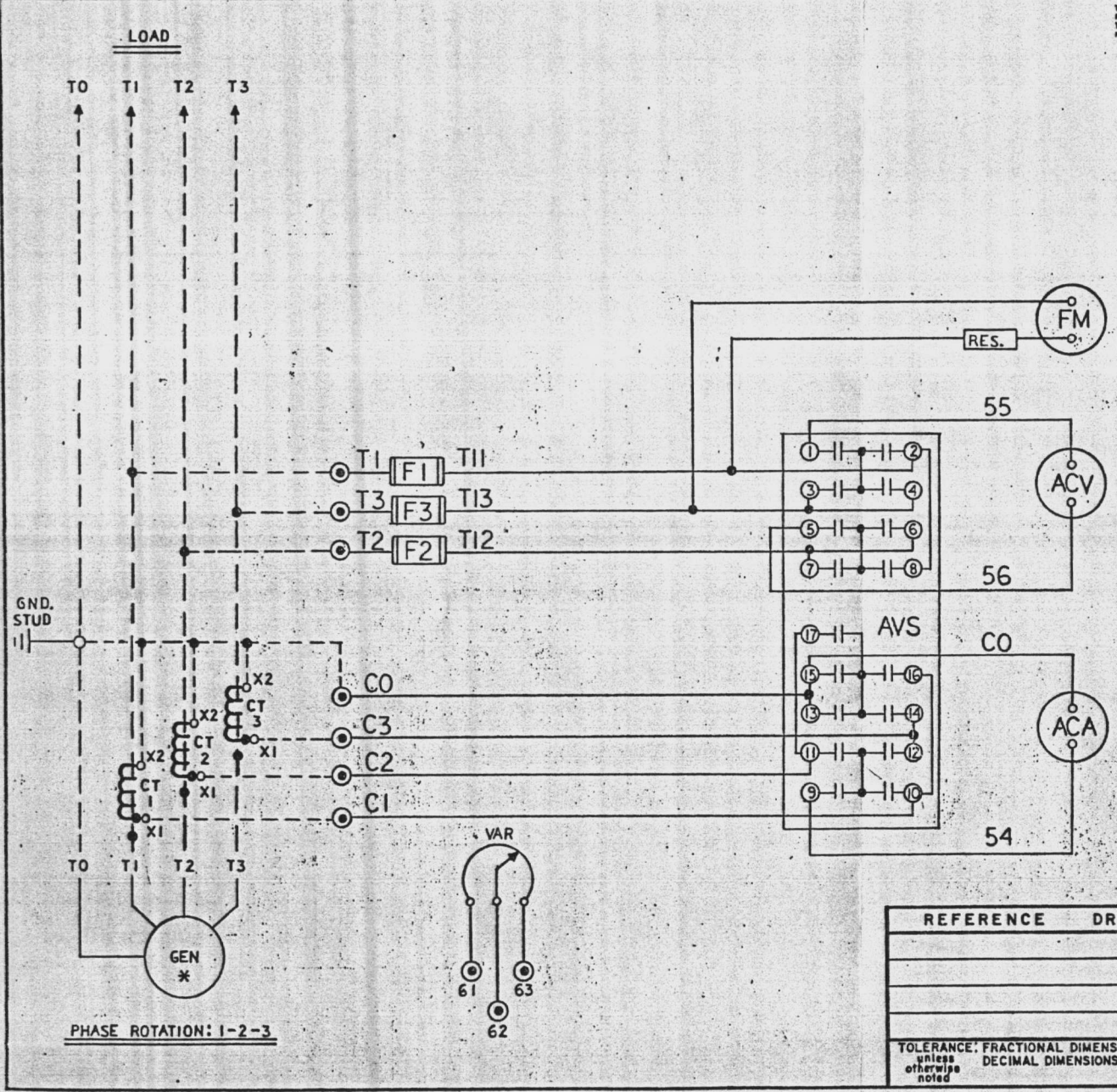


ABBREVIATIONS

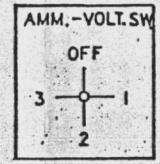
ACA - AC Ammeter
ACV - AC Voltmeter
AVS - Ammeter-Voltmeter Switch
CT - Current Transformer
F - Fuse
FM - Frequency Meter
GEN.. - Generator
GND.STUD - Ground Stud

RES - Resistor
VAR - Voltage Adjust Rheostat

* - Not Supplied By Redco

⊙ - Terminal Board Point
---- - Customer Wiring
——— - REDCO Wiring

AMM.-VOLT.SW



AVS SWITCH CHART

CONTACT	OFF	1	2	3
1		X	X	X
2		X		
3			X	
4				X
5		X	X	X
6		X		
7			X	
8				X
9		X	X	X
10		X		
11			X	
12				X
13	X			
14	X	X	X	
15		X	X	X
16	X		X	X
17	X	X		X

X - INDICATES CONTACT CLOSED

PRINTS TO	
PRODUCT.	
PURCH.	
S/M SHOP	
PANEL TEST BAY	
JOB FILE	

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	DATE RELEASED
TOLERANCE: unless otherwise noted — FRACTIONAL DIMENSIONS ± 1/32; DECIMAL DIMENSIONS 2 PLACE ± .030, 3 PLACE ± .010	PANEL TYPE:

redco / REPUBLIC ELECTRIC & DEVELOPMENT COMPANY PEORIA, ILLINOIS

TITLE: SCHEMATIC - AC

DRAWING NO. PB-91013 Sheet 1 of 2

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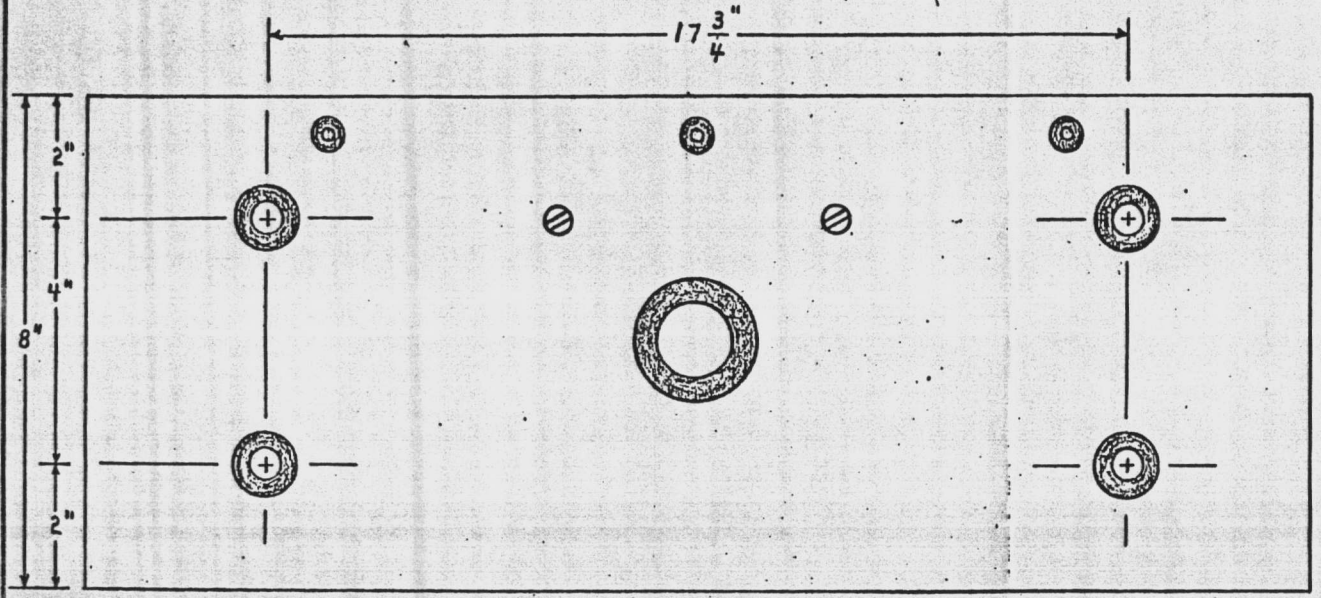

BOTTOM VIEW

ABBREVIATIONS

A	- Indicating Light (Amber)
ACA	- AC Ammeter
ACV	- AC Voltmeter
AVS	- Ammeter-Voltmeter Switch
ALM	- Alarm
ADS	- Alarm Disconnect Switch
ECS	- Engine Control Switch
FM	- Frequency Meter
NP	- Nameplate (Redco)
PIL	- Panel Illumination Light
PLS	- Panel Light Switch
R	- Indicating Light (Red)
VAR	- VOLTAGE ADJUST RHEOSTAT

AS BUILT

INDICATING LIGHTS

1. Overcrank
2. Overspeed
3. High Water Temperature
4. Low Oil Pressure
5. SPARE
6. Low Water Temperature
7. High Water Temperature - Warning
8. Low Oil Pressure - Warning

NOV. 20, 86

PRINTS TO	
PRODUCT	
PURCH.	
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PANEL TEST BAY	
JOB FILE	

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	CHECKED BY/DATE KE	
	APPROVED BY/DATE	
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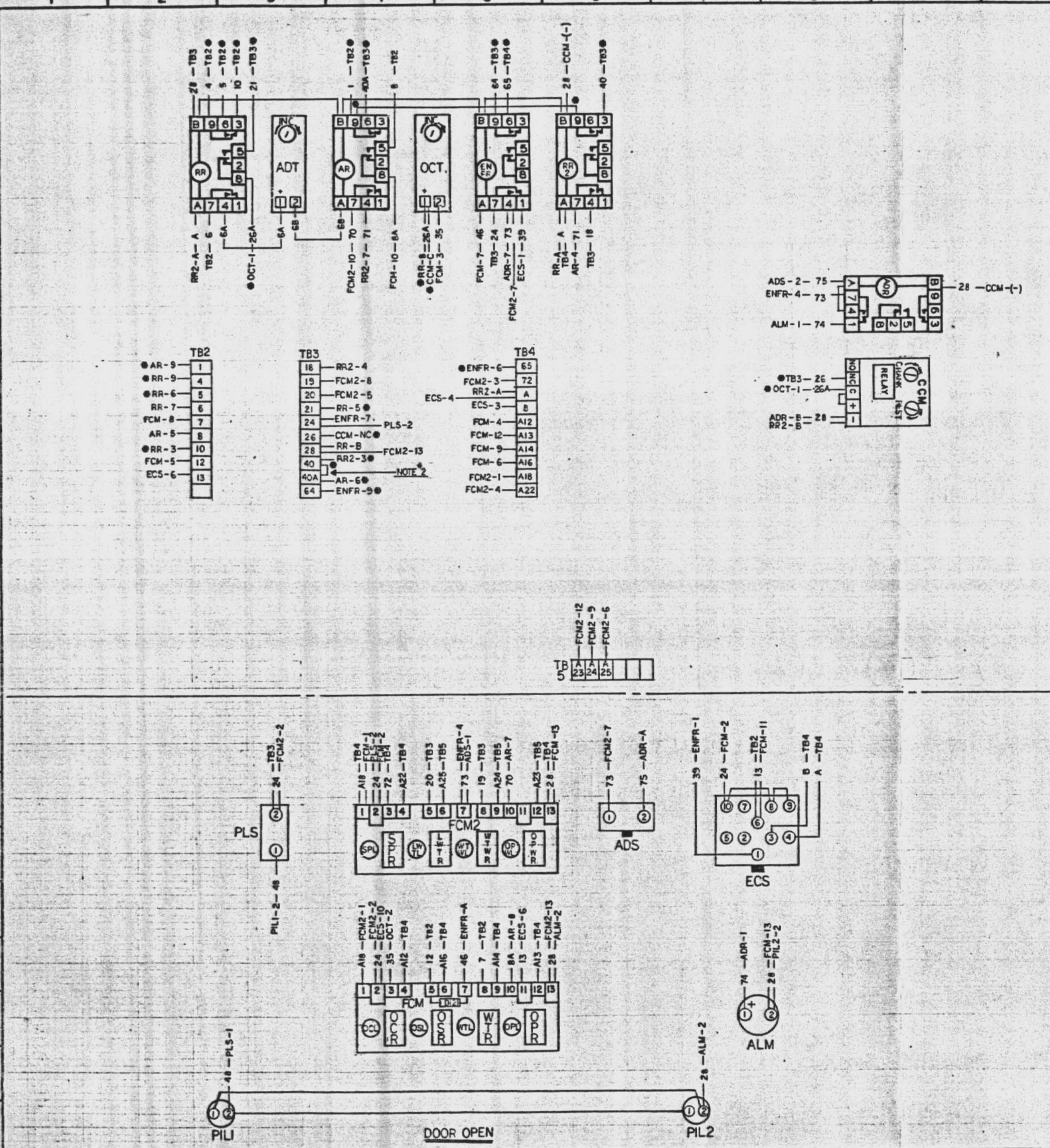
TOLERANCE: unless otherwise noted FRACTIONAL DIMENSIONS ± 1/32; DECIMAL DIMENSIONS 2 PLACE ± .030, 3 PLACE ± .010	PANEL TYPE:	DRAWING NO. PB-111,192 Sheet 2 of 2



AS BUILT

NOV. 20. '86

NOTES:

1. ALL WIRE #20-GA., EXCEPT AS NOTED.
2. REMOVE THIS JUMPER WHEN ENGINE IS SUPPLIED WITH A CHARGING GENERATOR OR ALTERNATOR.
3. ● USE #14-GA. WIRE.

REFERENCE DRAWINGS

REPUBLIC ELECTRIC & DEVELOPMENT COMPANY PEORIA, ILLINOIS

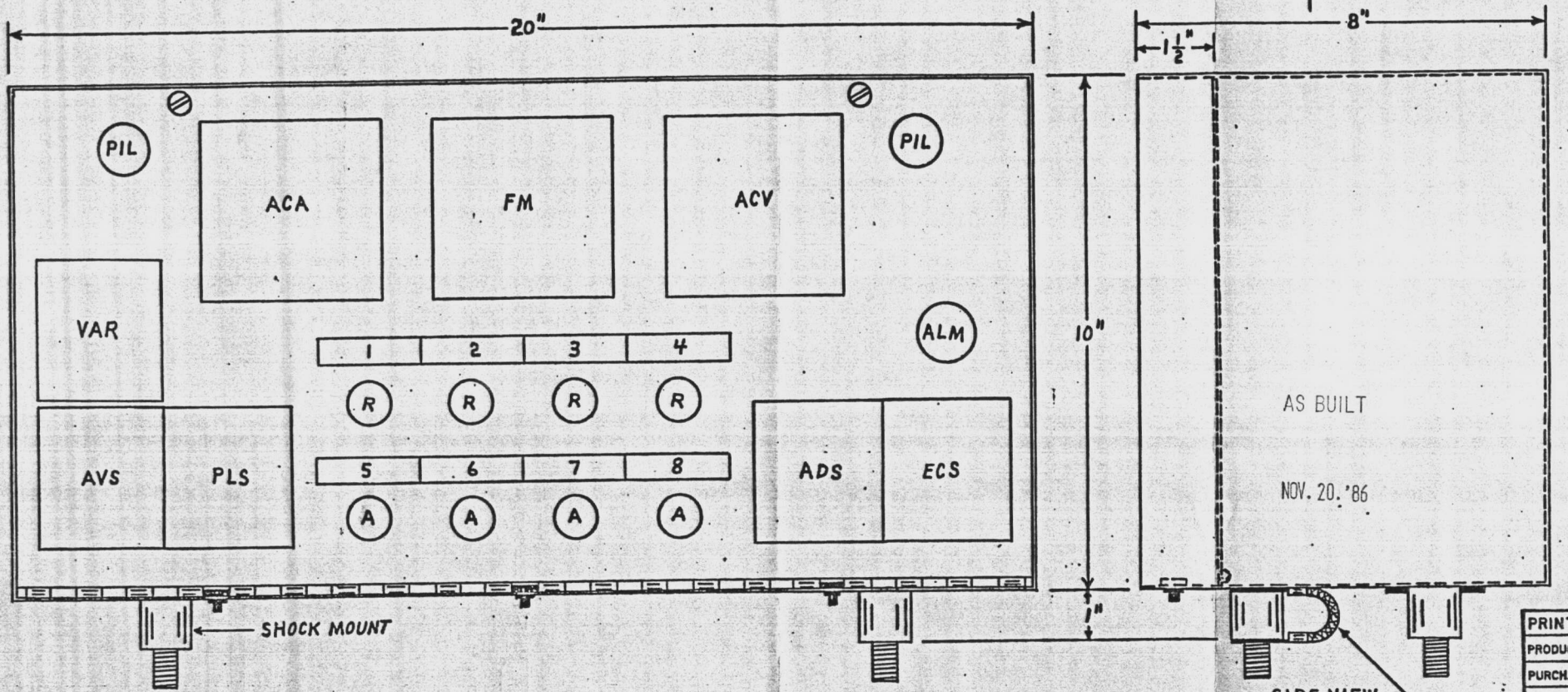
TITLE: WIRING-DC

PD- 116,612

Sheet 1 of 1

PB-

NO.	REVISIONS	DATE



GENERATOR MOUNTED CONTROL PANEL.

Formed Construction, 14-GA.
Door Hinged on Bottom, Screw Secured on Top.
4 - Shock Mounts.

* Plug Buttons.

PAINT: BODY.- CAT. INC. YELLOW
DOOR- BLACK

NOTE: See Page 2 of 2 for List of Abbreviations.

PRINTS TO	
PRODUCT.	
PURCH.	
S/M SHOP	
PANEL TEST BAY	
JOB FILE	

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TITLE: OUTLINE, MCP-PANEL

DRAWING NO. PB-111,192 Sheet 1 of 2

PB-

NO.	REVISIONS	DATE

AVS-8-T11-TB
AVS-7-T12-TB
AVS-4-T13-TB

TB1

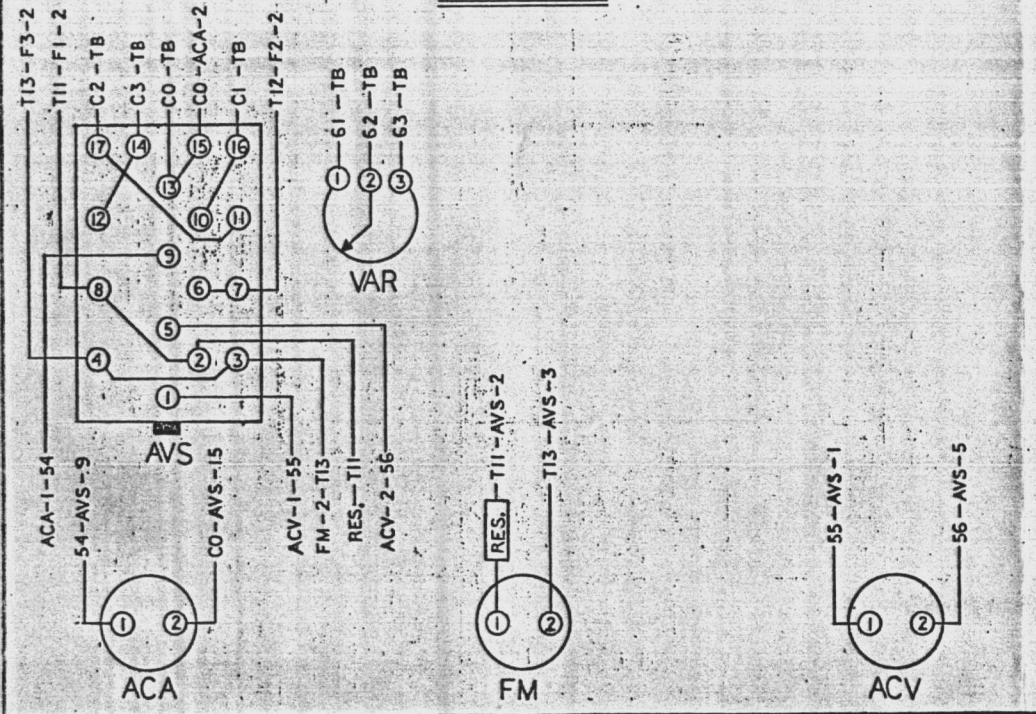
T1	F1-1
T2	F2-1
T3	F3-1
C0	AVS-13
C1	AVS-16
C2	AVS-17
C3	AVS-14
61	VAR-1
62	VAR-2
63	VAR-3

DOOR OPEN

AS BUILT

NOV. 20. '86

NOTE: ALL WIRING #20-GA. AWG.



PRINTS TO	
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PURCH.	
S/M SHOP	
PANEL TEST BAY	
JOB FILE	

REFERENCE DRAWINGS	NOTE DO NOT SCALE DRAWING
	DRAWN KHE BY/DATE 1-30-80
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	APPROVED BY/DATE
	DATE RELEASED
TOLERANCE: unless otherwise noted FRACTIONAL DIMENSIONS ± 1/32; DECIMAL DIMENSIONS 2 PLACE ± .030, 3 PLACE ± .010	PANEL TYPE:

redco

REPUBLIC ELECTRIC & DEVELOPMENT COMPANY
PEORIA, ILLINOIS

TITLE: WIRING-AC

DRAWING NO. PB-91013
Sheet 2 of 2

TAB PLACEMENT HERE

DESCRIPTION:

Battery Charger

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9/08

TECHNICAL INFORMATION

INSTRUCTIONS AND PARTS

FOR

10 AMPERE

12 AND 24 VOLTS
FLOAT-EQUALIZE BATTERY CHARGER

GENERAC CORPORATION
P. O. Box 8
Waukesha, WI 53187

Printed in U.S.A.

Manual Part Number 61555
Revised- 12/14/84

SECTION 1 - INTRODUCTION

1.1- GENERAL

This INSTRUCTIONS AND PARTS MANUAL has been prepared especially for the purpose of familiarizing personnel with the purpose, and installation the applicable equipment. Read the contents of the MANUAL carefully. Comply with all instructions to help avoid misuse or misapplication of the equipment, which might result in injury or damage to equipment and/or property.

1.2- RECEIVING AND HANDLING

Do NOT unpack this equipment until you are ready for installation. Store the equipment in a clean, dry room where it will not be exposed to rain, snow, excessive moisture, extreme cold or heat.

Prior to installing this equipment, clean away all packing material. Any claims for loss or damage that may have occured in transit must be filed by the purchaser with the carrier. Use all necessary precautions to prevent impact damage to equipment.

1.3- EQUIPMENT DESCRIPTION

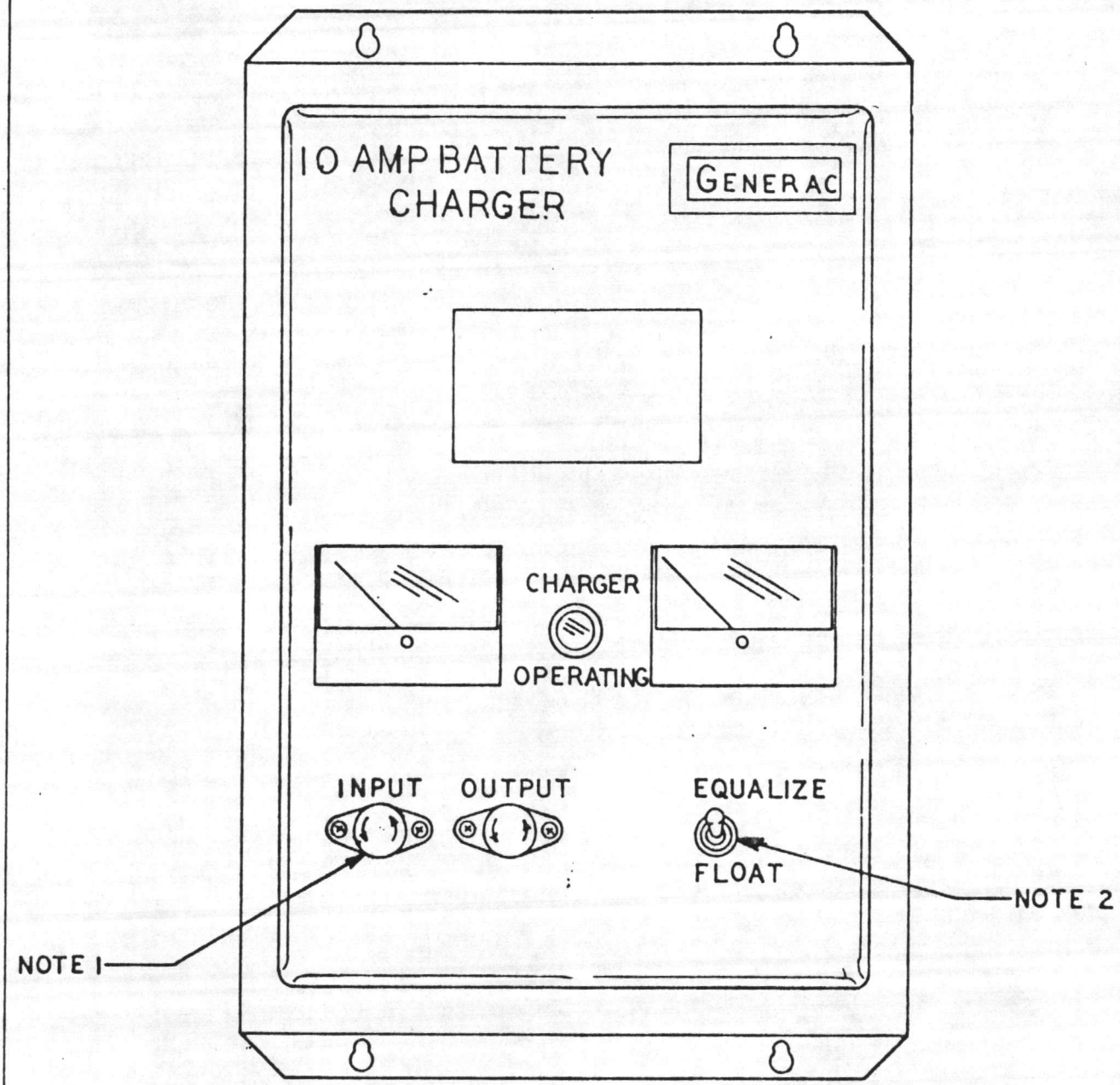
This equipment is a float-equalize type battery charger, with a current rating of 10 DC amperes. This MANUAL covers four basic Battery Charger models, as follows:-

1. **Type 12AF**:- Automatic float-equalize Charger, for use with 12 Volts DC engine electrical systems
2. **Type 12MF**:- Manual float-equalize Charger, for use with 12 Volts DC engine electrical systems
3. **Type 24AF**:- Automatic float-equalize charger, for use with 24 Volts DC engine electrical systems
4. **Type 24MF**:- Manual float-equalize Charger, for use with 24 Volts DC engine electrical systems

1.4- STANDARD FEATURES FOR ALL BATTERY CHARGER MODELS

The following features are included as standard equipment for all 12 and 24 Volts automatic and manual Battery Chargers:-

1. All models or types are rated at 10 DC Amperes of charging current.
2. All models and types are equipped with a DC AMMETER
3. All models and types are equipped with a DC VOLTMETER. On 12 Volts models, the Voltmeter has a range of 0-15 Volts DC; 24 Volts units feature a Voltmeter having a 0-30 Volts range.
4. All Battery Charger models offer a FUSED input and output as standard equipment.
5. All models provide current limiting.
6. All models are powered by a 120 VAC power source, at 50 or 60 Hertz.
7. All models provide remote sensing to improve load regulation.
8. Types 24AF and 24MF include a DC CONVERTER, which provides a 12 Volts DC output for Generator Meter and Control Panel operation.



NOTE 1:- Fuse Rating may differ between Battery Chargers. Input fuse is STANDARD; a CIRCUIT BREAKER is offered as an option.
NOTE 2:- Switch available on MANUAL Battery Chargers only, as well as a TIMER. Automatic Chargers do not require the switch or timer.

Figure 1-1. The 10 Ampere, Float-Equalize Battery Charger

1.5- AVAILABLE OPTIONS

The following options are available:-

1. **AC Circuit Breaker**:- Replaces the standard equipment fuse.
2. **AC Power Failure Relay**:- Proper connection of a warning device (such as a light) to this Relay will signal loss of the 120 VAC power input to the Battery Charger.
3. **Battery Alarm Relays**:- Proper connection of a warning device (such as an advisory light) to the Alarm Relay contacts will signal both a HIGH and a LOW battery voltage condition.
4. **Equalizing Timer**:- A 0-24 hour Equalizing Timer is available on MANUAL Batery Charger models only.

SECTION 2 - BATTERY CHARGER OPERATIONAL ANALYSIS

2.1- GENERAL

Some Generac standby generators utilize diesel engines with a 24 VDC engine electrical system as their "prime mover". The Generac 4.0, 6.4 and 13.3 liter diesel engines all have a 24 VDC engine electrical system. These engines employ two 12 Volts batteries, connected in series, to supply the required 24 VDC output to engine electrical components.

NOTE

At the time of this writing, the 2.2 and 3.0 liter diesel engines used with Generac standby generators were equipped with a 12 VDC engine electrical system. In the future, even those diesel engines may be converted to a 24 VDC electrical system.

Since the Generator's Meter and Control Panel components (DC Control System) requires 12 Volts DC electrical power, the 24 Volts DC output of the engine must be converted to that lower voltage for operation of those components. For that reason, all Type 24MF (manual) and 24AF (automatic) Battery Chargers incorporate a DC CONVERTER. Operation of the 12 and 24 Volts Battery Chargers are identical, except that DC CONVERTER operation must be considered on the 24 VDC units.

2.2- BATTERY CHARGER OPERATION (Figure 2-1)

The Battery Charger is connected to a 120 VAC NORMAL (Utility) power source. Power source voltage (120 VAC) is reduced by the TRANSFORMER and rectified by the silicon full wave RECTIFIERS. Charge rate is controlled by an SCR (Silicone-Controlled-Rectifier). Battery voltage is sensed by the control circuit, which determines how much current the SCR pases. Power to operate the control circuit is obtained from the Transformer.

Battery charge current is monitored by the CIRCUIT BOARD and limited to 11 DC Amperes. Battery charge voltage is 2.17 Volts per cell (13 Volts on the battery) at FLOAT and 2.33 Volts per cell (14 Volts on the battery) at EQUALIZE. The manual version of the Charger will maintain the battery at either 13 or 14 volts, depending on Float-Equalize Switch position (UP for maximum output). In the automatic version, output voltage is determined by charge current. When charge current exceeds approximately 8 DC Amperes, the Charger will automatically switch to the EQUALIZE mode and will then remain in that mode until charge voltage drops below approximately 7 DC Amperes. At that point, the Charger will switch to its FLOAT mode and hold the battery at approximately 13 Volts.

The CIRCUIT BOARD provides the following control points, which are factory set and require no customer adjustment:-

1. FLOAT VOLTAGE setting (2.17 Volts per cell)
2. EQUALIZE VOLTAGE setting (2.33 Volts per cell)
3. CURRENT LIMIT setting (10.5 to 11.5 DC Amperes)
4. FLOAT-EQUALIZE Set Point (automatic models only)

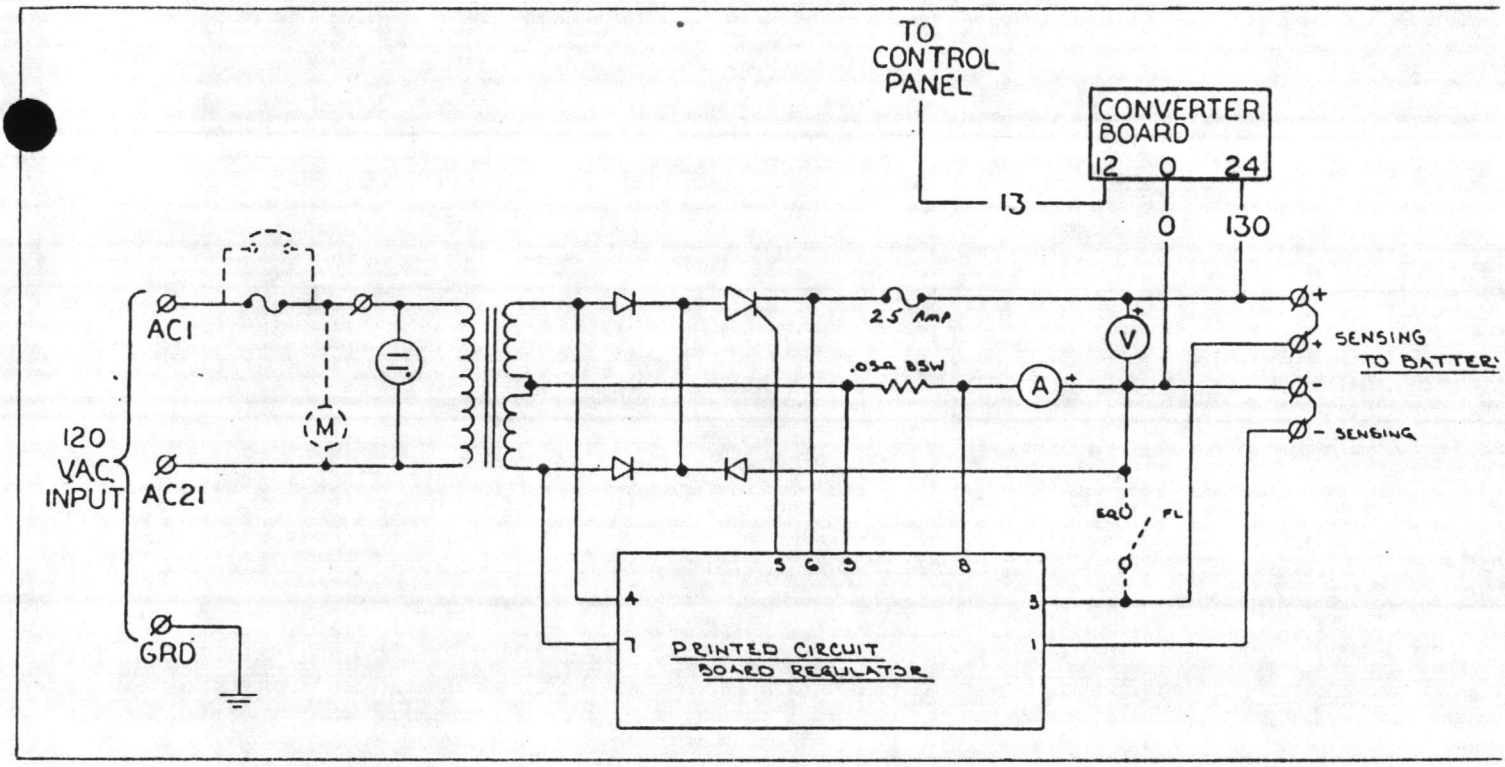


Figure 2-1. Operating Diagram of Battery Charger

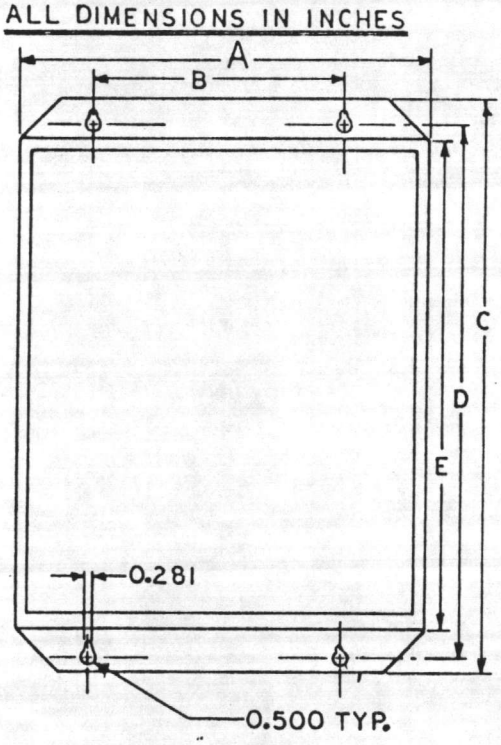
SECTION 3 - BATTERY CHARGER INSTALLATION

3.1- OPERATING LOCATION

Install the battery charger in a vertical position, close to the battery. Maintain a clearance of at least 12 inches (30.48 cm) above and below the Charger, to permit adequate free air flow for cooling the unit. DO NOT locate the Charger in any location that might be subjected to spraying or falling water. NEVER locate the Charger directly above the Battery- corrossive vapors from the battery will damage the unit.

3.2- MOUNTING THE BATTERY CHARGER (Figure 3-1)

See Figure 3-1 for Battery Charger mounting dimensions. Be sure to allow sufficient clearance for opening the Charger cabinet door.



DIMENSION	CHARGER VOLTAGE RATING	
	12 VOLTS	24 VOLTS
A	10.90"	10.90"
B	7.75"	6.75"
C	15.24"	17.24"
D	14.25"	16.25"
E	13.15"	15.15"

Figure 3-1. Battery Charger Mounting Dimensions

3.3- BATTERY CHARGER GROUNDING

Connect the Charger to a grounded, metal, permanent wiring system or route an equipment grounding conductor with the circuit conductors. Connect that grounding conductor to an equipment grounding terminal or to a grounded terminal on the Battery Charger.**ALL BATTERY CHARGER WIRING CONNECTIONS MUST COMPLY FULLY WITH APPLICABLE CODES, STANDARDS AND LAWS GOVERNING SUCH INSTALLATIONS.**

3.3- AC TERMINAL STRIP CONNECTIONS (Figure 3-2, Table 3-1)

DANGER!
Do NOT attempt to connect any 120 VAC power source line to the Battery Charger until AFTER the power is turned OFF at the source.

120 VAC Power Source:- Connect a 3-wire cord set from a 120 VAC NORMAL (Utility) power source circuit to Terminals "1AC", "21AC" and GND (Ground) as shown in Figure 2-2. See Table 3-1.

Terminals "2":- These two terminals are NOT used for customer connections.

Terminals "27", "28" and "29":- Offered as an option with the 10 Ampere Battery Charger is an AC POWER FAILURE RELAY. The Relay will remain energized as long as 120 VAC is applied to the Charger, will de-energize when 120 VAC power is lost. A monitor or advisory light may be connected across Terminals "27" (COMMON) and "28" (Normally Open)- the monitor or light will then come ON when 120 VAC is applied to the Charger. Connection of a monitoring device (or light) across the COMMON (C) and NORMALLY-CLOSED (NC) terminals will cause the monitoring device or light to come ON when 120 VAC power to the Charger is lost.

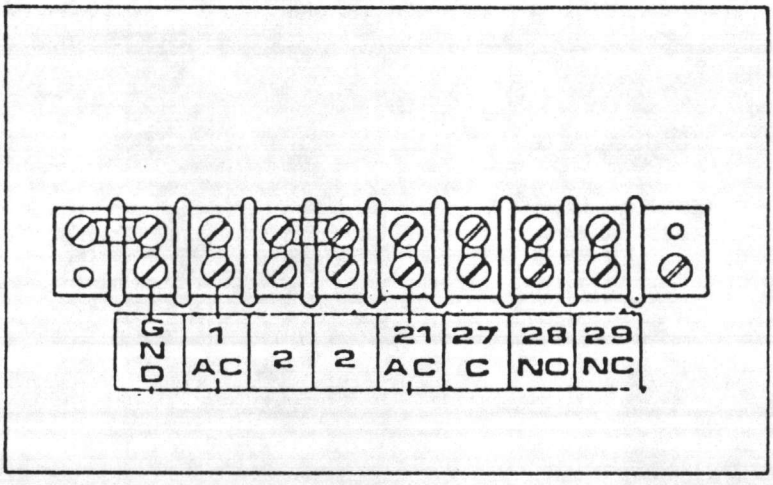


Figure 3-2. AC Terminal Strip Connections In Battery Charger

TERMINAL	MINIMUM WIRE SIZE (COPPER WIRE)	DESIGNATION
GND	As Required	Connect to 120 VAC Power Source GROUND
1-AC	No. 14 AWG	Connect to HIGH side of 120 VAC Power Supply
21-AC	No. 14 AWG	Connect to NEUTRAL side of 120 VAC Power Supply

Table 3-1. AC Terminal Strip Connections

3.3- BATTERY TERMINAL STRIP CONNECTIONS
(Figure 3-3, 3-4, 3-5, and Table 3-2)

A. For Generators Having a Single 12 Volts Battery:- Connect battery posts or terminals to Terminals 0 (-B) and 13 (+B) as shown in Figure 3-3. See Table 3-2 for recommended wire sizes.

NOTE

Terminals 34 (+S) and 35 (-S) are battery voltage sensing terminals. If extremely long wires are required between the battery posts or terminals and Charger Terminals 0 (-B) and 13 (+B), excessive voltage drop and inaccurate sensing may be encountered. For that reason, when wires are extremely long, it is recommended that the terminal strip jumpers be removed and wires connected directly from the battery posts or terminals to Charger Terminals 34 (+S) and 35 (-S). Use COPPER wire having a minimum wire size of No. 24 AWG.

B. For Generators Having Two 12 Volts Batteries Connected in Parallel and No Isolation Diodes:- Make Connections Exactly as outlined for Generator Units having a single 12 Volts battery. See Figure 3-3 and Table 3-2.

C. For Generators with Two 12 Volts Batteries Conected in Series:- This arrangement is used with diesel engines having a 24 VDC engine electrical system. See Figure 3-4 and Table 3-2.

D. For Generator Units Having two 12 Voltys Batteries Connected in Parallel and Separated Electrically by Isolation Diodes:- This arrangement permits cranking and starting power to be taken from one battery and PREHEAT power from the second battery. Connect the Battery Charger to this type of unit as shown in Figure 3-5. Also see Table 3-2.

RATED DC CURRENT	MAXIMUM WIRE LENGTH	WITHOUT REMOTE SENSING		WITH REMOTE SENSING	
		MIN. WIRE SIZE*	TOTAL LOOP DROP	MIN. WIRE SIZE*	TOTAL LOOP DROP
10 DC AMPERES	10 Feet	12 AWG	0.3 Volt	12 AWG	0.3 Volt
	25 Feet	12 AWG	0.8 Volt	12 AWG	0.8 Volt
	50 Feet	8 AWG	0.6 Volt	10 AWG	1.0 Volt

* Wire runs may be TWO of the next smaller even wire size, i.e., use two #12 AWG wires in lieu of #10 AWG wire. Do NOT use aluminum wire.
NOTE:- Wire sizes listed for AC wiring are based on current carrying capacity (ampacity). Battery (DC) wiring sizes are based on wire resistance. Splices or junctions in the wiring path must also be of a low resistance.

Table 3-2. Minimum Recommended Sizes of Copper Wire

3.4- OPTIONAL BATTERY MONITOR CIRCUIT BOARD CONNECTIONS
(Figure 3-6)

An optional BATTERY MONITOR CIRCUIT BOARD is available. This circuit board permits both LOW and HIGH battery voltage conditions to be monitored.

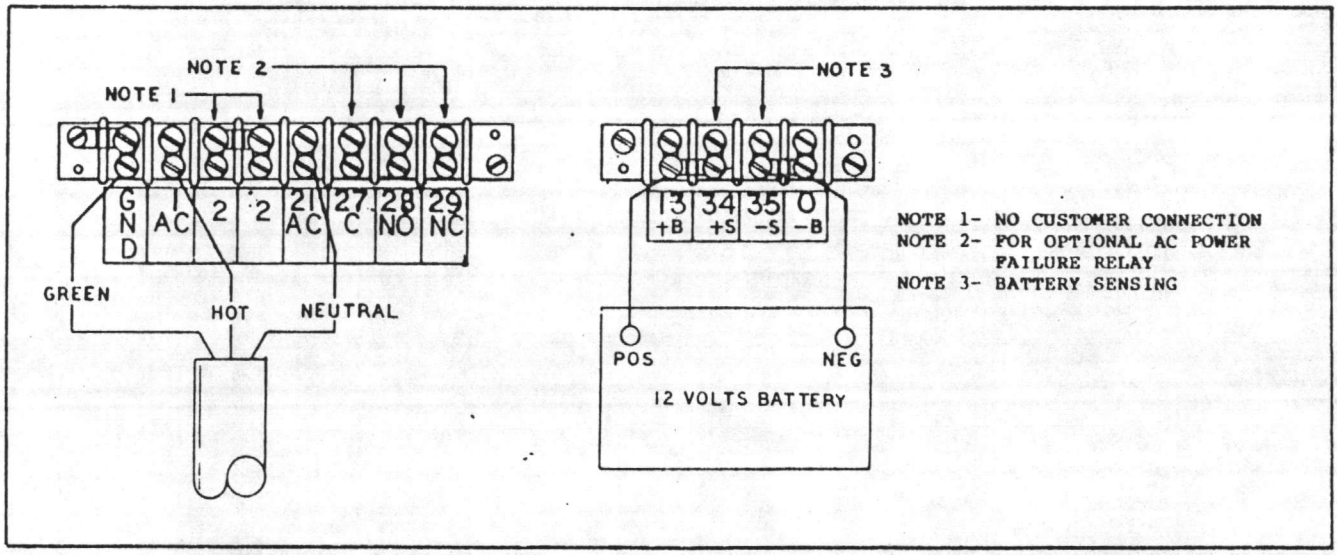


Figure 3-3. Battery Charger Terminal Strip Connections For Generator Units with a Single 12 Volts Battery

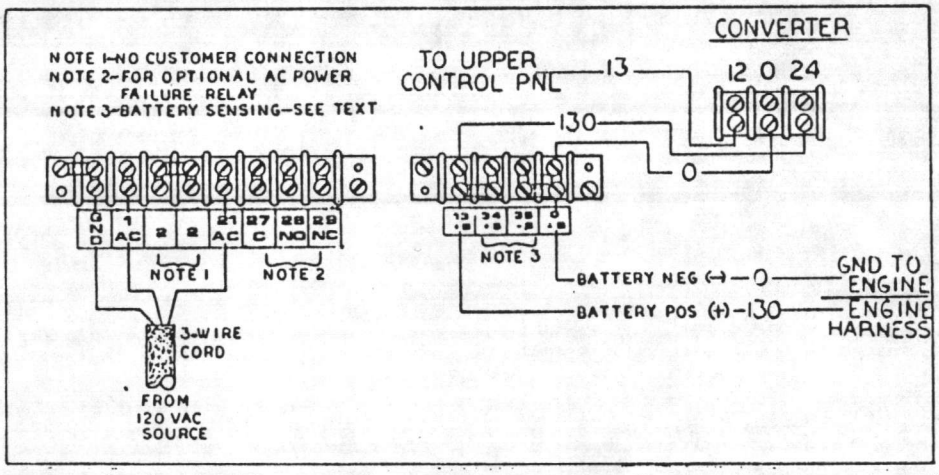


Figure 3-4. Battery Charger Terminal Strip Connections For Generators Having Two 12 Volts Batteries Connected in Series

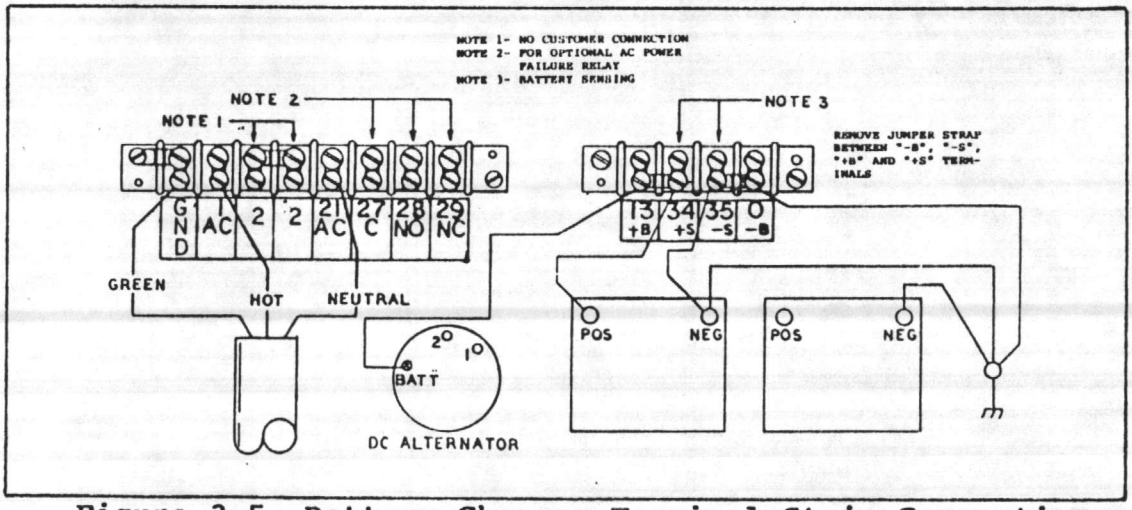


Figure 3-5. Battery Charger Terminal Strip Connections Generator with Two Paralleled Batteries with Isolation Diodes

To turn an advisory light ON when a LOW VOLTAGE condition exists:- Locate the three circuit board terminals under the word "LO". Connect the LOW BATTERY VOLTAGE advisory night across the NORMALLY-CLOSED (NC) and the COMMON (C) terminals.

To turn advisory light OUT under LOW VOLTAGE condition:- Connect an advisory light across the NORMALLY-OPEN (NO) and COMMON (C) terminals.

To turn advisory light ON under a HIGH BATTERY VOLTAGE Condition:- Under the word HI, connect a HIGH BATTERY VOLTAGE light across the NORMALLY-OPEN (NO) and COMMON (C) terminals.

To turn advisory light OUT under a HIGH BATTERY VOLTAGE condition:- Connect HIGH BATTERY VOLTAGE light across the NORMALLY-CLOSED (NC) and COMMON (C) terminals.

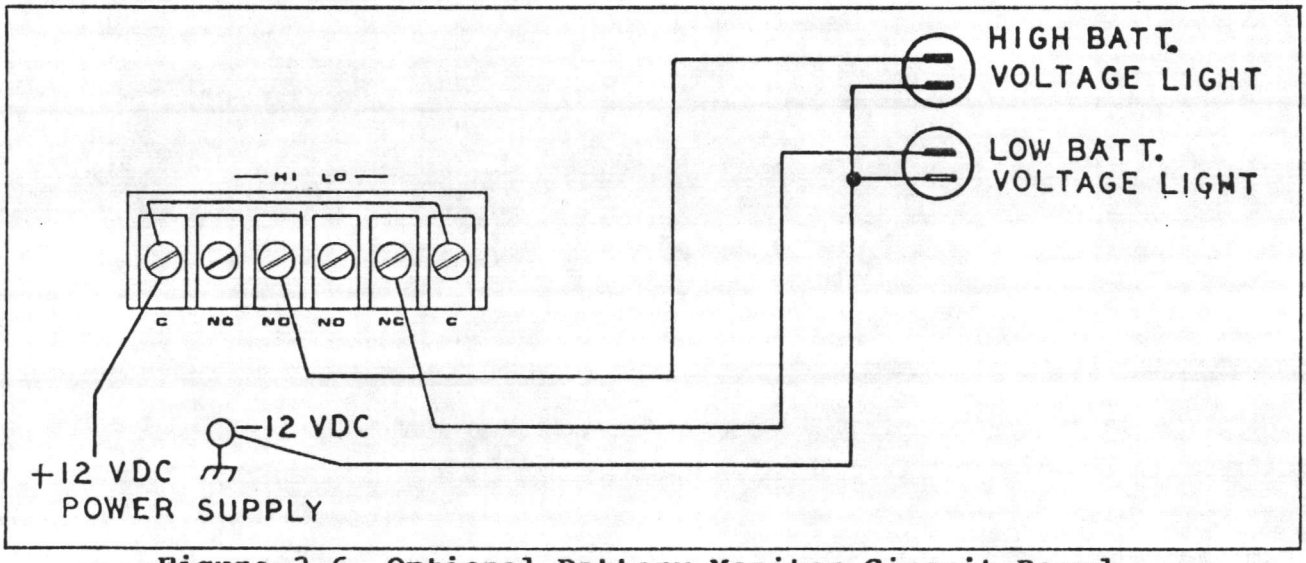
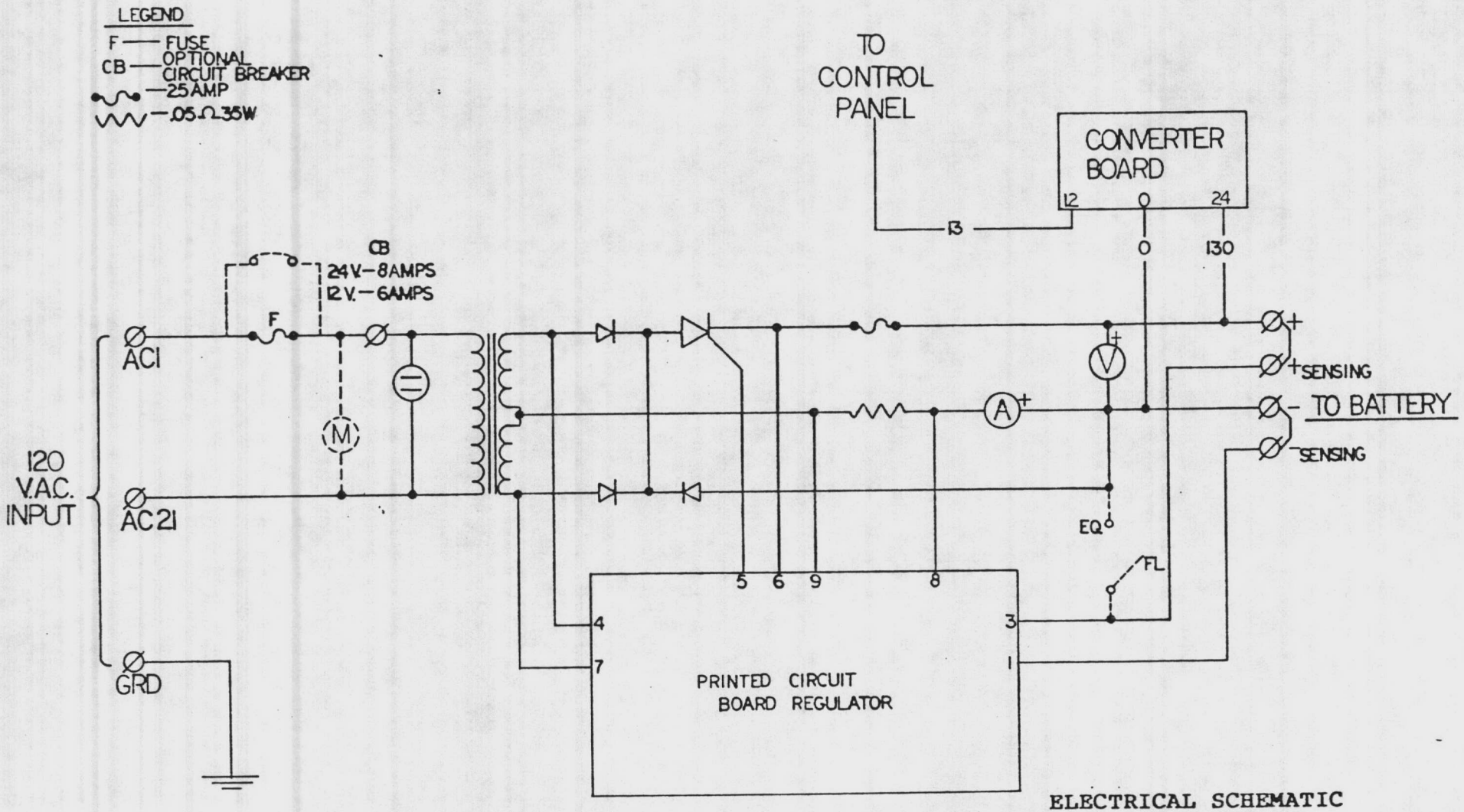
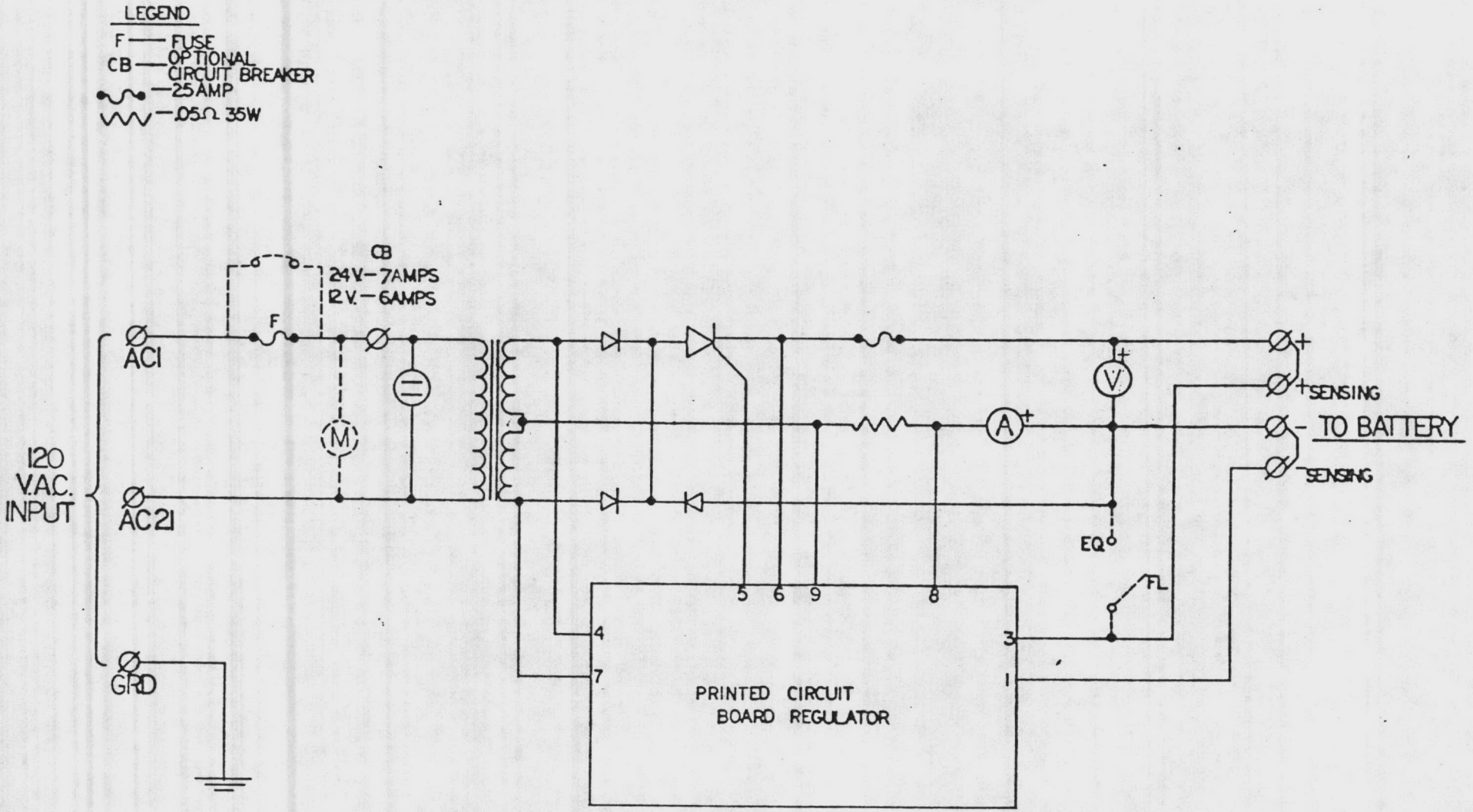


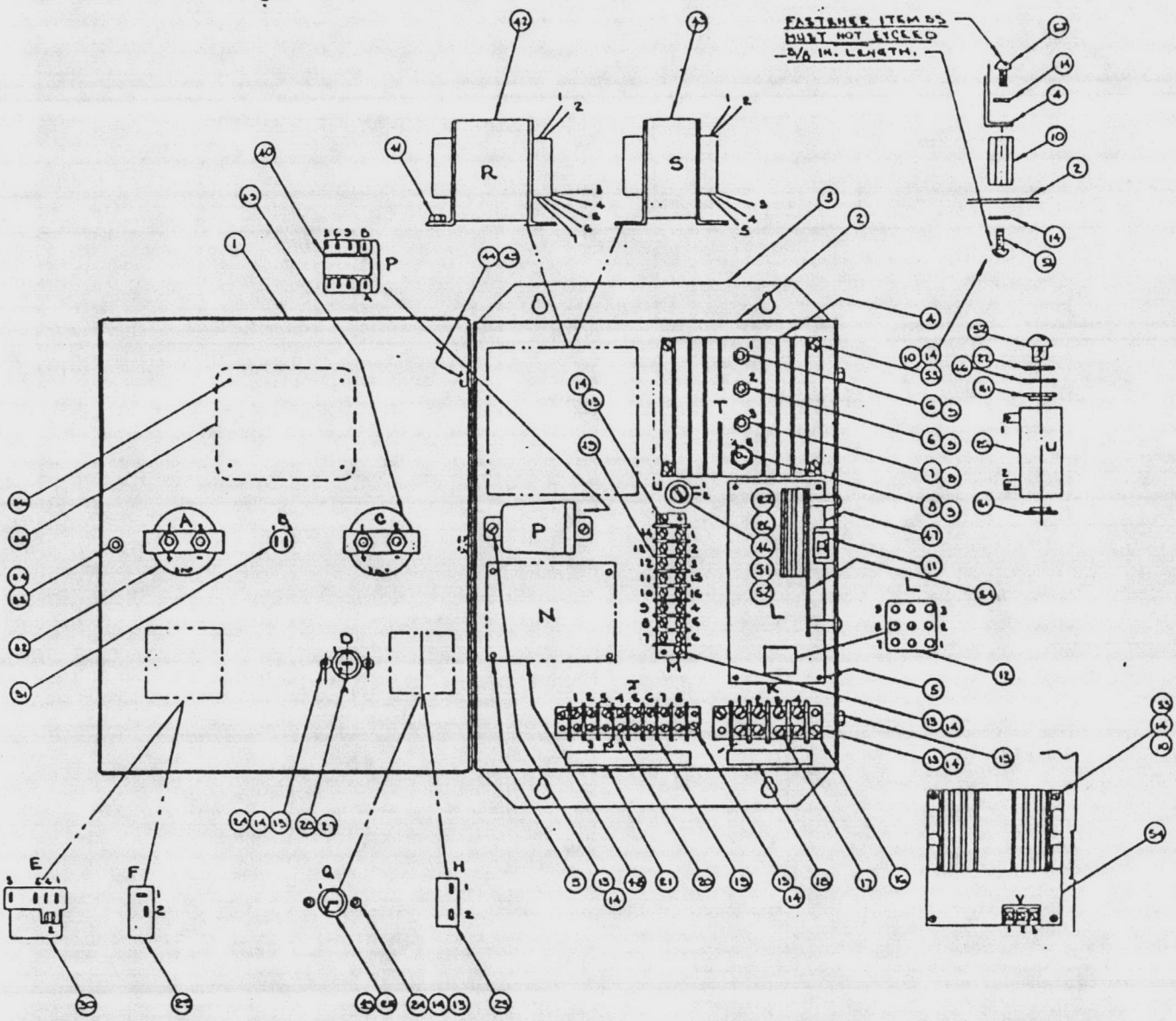
Figure 3-6. Optional Battery Monitor Circuit Board



ELECTRICAL SCHEMATIC
10 Ampere, 24 VDC
Float-Equalize Battery Charger
Drawing Number 66265
Issued- 11/21/84



ELECTRICAL SCHEMATIC
10 AMPERE, FLOAT-EQUALIZE BATTERY CHARGER
Drawing Number 61556
Revised- 09/10/84 (ECO #B-5034-B)



WIRE NUMBER	FROM	TO	WIRE NUMBER	FROM	TO	WIRE NUMBER	FROM	TO
0	A1	C2	2	J4	G1/H1	25	L5	M4
0	A1	K4	4	U1	M13	25	T5	M4
0	T3	K4	3	L4	M14	‡27	P9	J6
*1	J2	B1	++3	T1	M1	‡28	P6	J7
**1	J2	E2	++5	T2	M3	‡29	P3	J8
**1	B1	E2	4	L9	M2	34	L3	K2
1	R1	J2	5	L7	M12	35	L1	K3
2	R2	J3	+6	T1	M15	35	F1/E5	K4
3	R3	M14	+7	T2	M16			
4	R4	M13	8	L8	M5	36	E4/F2	L2
5	R5	M12	8	A2	M8			
6	R6	M11	13	D1	C1	‡1	PA	J2
7	R7	M10	13	K1	C1	‡2	PB	J11
1	S1	J2	21	J5	G2/H2	*2	B2	J10
2	S2	J3	8	U2	M8	**2	H2/G2	E3
3	S3	M14	24	D2	M7	0	N-	K3
4	S4	M13	24	T4	M6	13	N+	K2
5	S5	M12	24	L6	M6	0	V2	A1

* These wires used only when Switch (Item 29) is used
** These wires used only when Timer (Item 30) is used
+ These wires used only when 24V Transformer (Item 42) is used
++ These wires used only when 12V Transformer (Item 43) is used
‡ These wires used only when Relay (Item 40) is used

EXPLODED VIEW AND WIRING DIAGRAM OF BATTERY CHARGER
Drawing Number 61539
Revised- 09/11/84
File #10-84.11

ITEM	PART NUMBER	REQ'D	DESCRIPTION
1	61436-A	1	DOOR- 12AF- Fuse
	61436-B	1	DOOR- 12MF- Timer- Fuse
	61436-C	1	DOOR- 12MF- Fuse and Switch
	61436-E	1	DOOR- 12MF- Timer, Circuit Breaker
	61436-F	1	DOOR- 12MF- Switch and Circuit Breaker
	62030-A	1	DOOR- 24AF- Fuse
	62030-B	1	DOOR- 24MF- Fuse, Timer
	62030-C	1	DOOR- 24MF- Fuse, Switch
	62030-D	1	DOOR- 24AF- Circuit Breaker
	62030-E	1	DOOR- 24MF- Circuit Breaker, Timer
	62030-F	1	DOOR- 24MF- Circuit Breaker, Switch
2	61440	1	WRAPPER ASSEMBLY, Side- 12 Volts Unit
	62028	1	WRAPPER ASSEMBLY, Side- 24 Volts Unit
3	61505	1	PAN, Base- 12 Volts Unit
	62027	1	PAN, Base- 24 Volts Unit
4	61450	1	SINK, Heat
5	40213	12	MOUNT, Circuit Board
6	61529	2	DIODE
7	61530	1	DIODE
8	40081	1	RECTIFIER (SCR)
9	26434	-	GREASE- Silicone
10	62417	8	SPACER, Threaded Nylon- No. 8-32
11	61506	1	FASTENER, Clip
12	61516	1	HOUSING, Socket- 9 Ckt.
13	33515	12	SCREW, Pan Head Machine- No. 8-32 x 5/8"
14	22264	28	WASHER, Lock- No. 8
15	56892	6	SCREW- No. 10
16	39608	1	BLOCK, Terminal- 4-Ckt.
17	23827	2	JUMPER, Terminal Block
18	61518	1	DECAL, Terminal Block
19	57701	2	BLOCK, Terminal- 8 Ckt.
20	46669	2	JUMPER, Terminal Block
21	61519	1	DECAL, Terminal Block- 8 Ckt.
22	22097	1	WASHER, Lock- 1/4"
23	57477	1	BREAKER, Circuit- 6 Ampere, 12 Volts
	56602	1	BREAKER, Circuit- 7 Ampere, 24 Volts
24	22471	4	NUT, Hex- No. 8-32
25	45162	1	HOLDER, Fuse
26	61048	2	RESISTOR- 0.05 Ohms, 35 Watts
27	65378	1	FUSE- 25 Amperes
28	49102	1	HOLDER, Fuse
29	28199	1	SWITCH
30	61524	1	SWITCH, Timer
31	61525	1	LAMP- 125 VAC
32	61526	1	AMMETER
33	29956	1	SCREW, Thumb
34	30864-A	1	RETAINER, Screw
35	61438	1	PLATE, Data
36	29357	1	RIVET- Data Plate
37	28551	1	NAMEPLATE- Generac
38	28552	2	NUT, Speed
39	61527	1	VOLTMETER- 15 Volts (12 Volts Units)
	61528	1	VOLTMETER- 30 Volts (24 Volts Units)
40	61554	1	RELAY- 120 Volts (2PDT)
41	58442	4	SCREW- 1/4"
42	62029	1	TRANSFORMER- 24 Volts
43	61449	1	TRANSFORMER- 12 Volts
44	36701	3	CAPSCREW, Pan Head- No. 10-32 x 1/2"
45	22152	3	WASHER, Lock- No. 10
46	22473	1	WASHER, Flat- 1/4"
47	61442	1	BOARD ASSEMBLY, Printed Circuit- 12MF
	61535	1	BOARD ASSEMBLY, Printed Circuit- 12AF
	61536	1	BOARD ASSEMBLY, Printed Circuit- 24MF
	61537	1	BOARD ASSEMBLY, Printed Circuit- 24AF
48	61521	1	BOARD ASSEMBLY, Printed Circuit- 12 Volts Battery Monitor
	61518	1	BOARD ASSEMBLY, Printed Circuit- 24 Volts Battery Monitor
49	45161	1	FUSE- 6 Ampere (For 12 Volts Charger)
	65379	1	FUSE- 7 Ampere (For 24 Volts Charger)
51	61441	1	WASHER, Step
52	24200	1	SCREW- 1/4"-20 x 2-1/2"
53	23965	16	SCREW, Round Head Machine- No. 8-32 x 3/8"
54	65263	1	CONVERTER- 24 to 12 Volts

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DESCRIPTION:

Bypass Isolation

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Russelectric
WARRANTY

RUSSELECTRIC TRANSFER SWITCHES, BYPASS/ISOLATION SWITCHES, AND POWER CONTROL SYSTEMS CARRY THE INDUSTRY'S BEST WARRANTY

For thirty years, we have built the industry's most dependable power control systems using heavier construction and proven components. We performance test them and rate them conservatively to be sure our customers get **longer life and fewer service problems.**

Now we're backing all this up with the industry's best warranty.

In the United States and Canada, all our products now display the "100+" seal which means they carry our 100 percent unconditional guarantee for two years from the date of shipment...plus our standard warranty covering workmanship and materials for an additional three years.

Simply stated, if anything goes wrong with any of our products during the first two years, we'll either repair them or replace them at no cost for parts or labor.

In addition to this, we have extended our standard warranty for three years beyond the guarantee period for a full five-year total coverage of all Russelectric products.

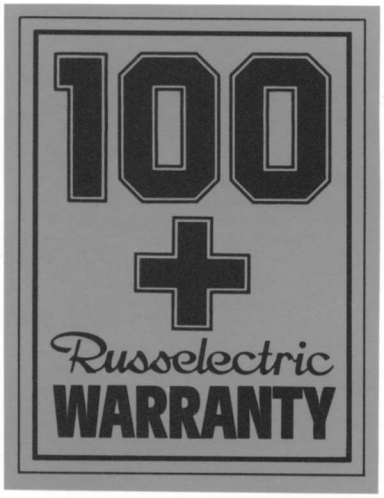
That's how sure we are about the Russelectric Difference.

Russelectric products are fully described in our recently published catalog. To receive a copy, circle the readers' service number or contact us directly.

Russelectric

South Shore Park, Hingham, Massachusetts 02043
Telephone (617) 749-6000 · Telex 94-0328

Raymond G. Russell, founder and president of Russelectric Inc.



In the US and Canada the following warranty has been extended to five years from the date of shipment . . . in addition, for two years from the date of shipment, Russelectric guarantees to repair or replace, at no cost to the customer for parts or labor, any equipment found faulty under the terms of the warranty.

WARRANTY

The Company warrants to the Purchaser that the equipment to be delivered hereunder will be free from defects in material or workmanship and will be of the quality designated or specified in the contract.

This warranty shall apply only to defects appearing within one year from the date of shipment by the Company.

If the equipment delivered hereunder does not meet the above warranty, and if the Purchaser promptly notifies the Company, the Company shall thereupon correct any defect, including nonconformance with the specifications, either (at its option) by repairing any defective or damaged parts of the equipment, or by making available at the Company's plant necessary repaired or replacement parts. The liability of the Company under this warranty (except as to title), or for any loss or damage to the equipment whether the claim is based on contract or negligence, shall not in any case exceed that cost of correcting defects in the equipment as herein provided and upon the expiration of the warranty period all such liability shall terminate. The foregoing shall constitute the exclusive remedy of the Purchaser and the exclusive liability of the Company. This warranty does not apply if the electrical system loads have erratic voltage, frequency or sine wave distortions, due to other installed equipment.

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"power control systems"
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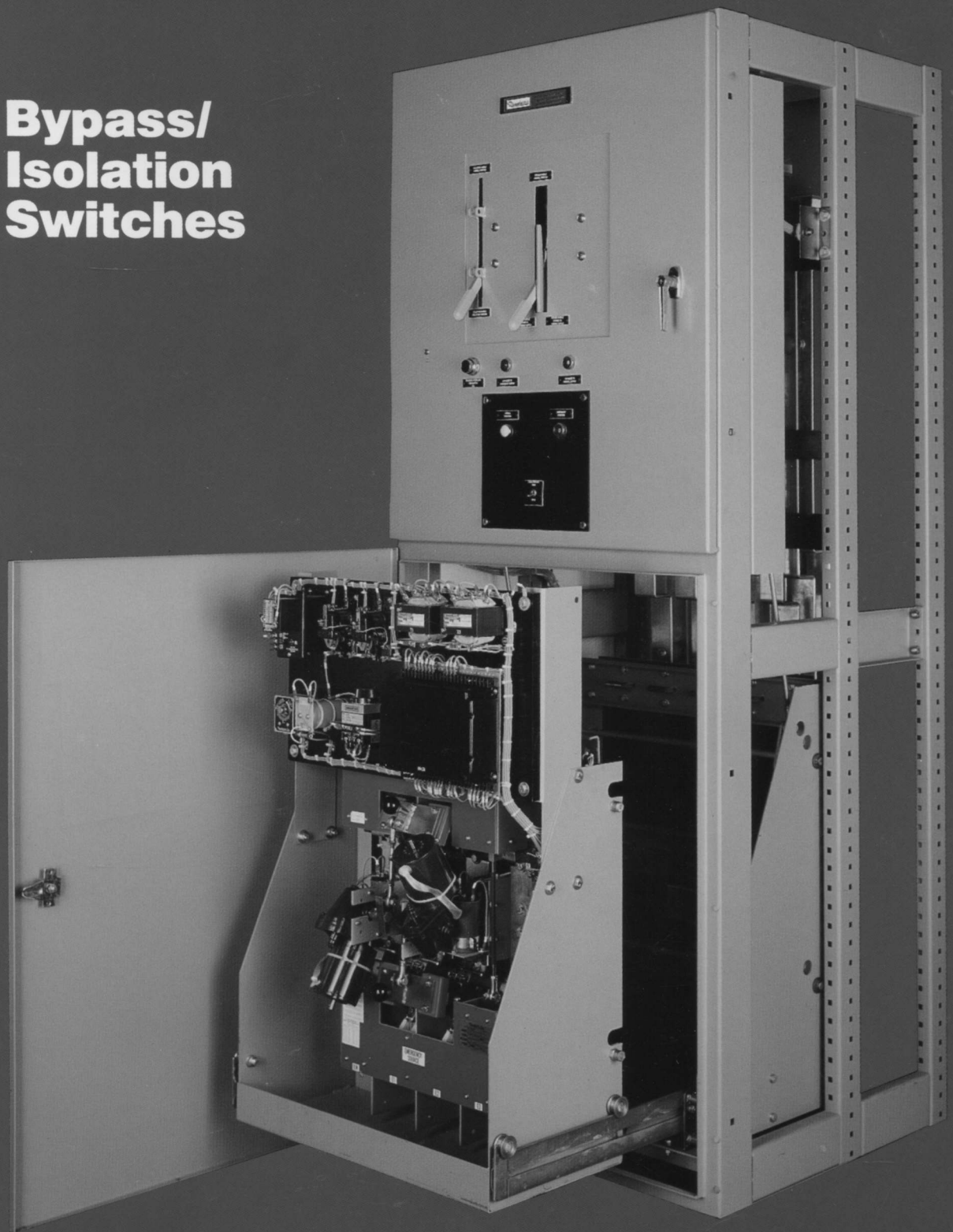
Russelectric

POWER CONTROL SYSTEMS

Bypass/ Isolation Switches



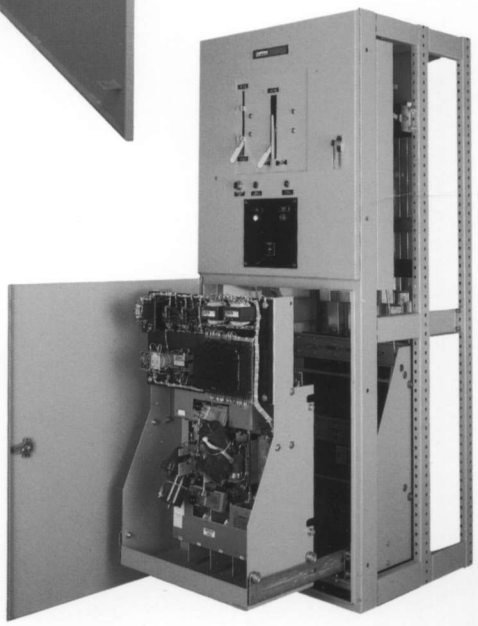
Enclosed Drawout Automatic Transfer Switches and Bypass/Isolation Switches

Russelectric Model RTB switches combine all of the functions of an automatic transfer switch plus a method for bypassing power from the live source to the load in the event the transfer switch is disabled. They also allow the transfer switch to be isolated and deenergized for maintenance, testing, or repair. The automatic transfer switch is either Russelectric Model RMT or RMTD as described on pages 4 through 15.

The bypass/isolation switch is furnished in two basic configurations: one-source and two-source. The one-source design is arranged to bypass either the normal or the emergency power source directly to load (not both). The two-source design is arranged to bypass either the normal or the emergency power source directly to load, at the discretion of the operator.

Five important design advantages of the Russelectric combination automatic transfer bypass/isolation switch are:

1. Operation is possible regardless of the position or condition of the automatic transfer switch.
2. Inherent break-before-make design provides positive assurance against accidental short circuiting of power sources.
3. Quick-break, quick-make contacts and the basic operating mechanisms of the bypass switch are identical to the transfer switch with full load break capability and with the same electrical ratings.
4. True drawout construction allows safe and easy removal of the transfer switch without the need for maintenance personnel to make any electrical or mechanical disconnections.



5. The bypass/isolation switch is fully mechanical and is not dependent upon the operation of relays, interlock circuits, separate load-break contactors, or operator-dependent "dwell times" for safe operation.

Model RTB Specifications

1. General

Each automatic transfer switch (ATS), and its associated bypass/isolation (BPS), shall be mounted in a freestanding enclosure, as shown on the plans, and bussed together with copper bus to provide a complete and pretested assembly. Aluminum bus and/or cable interconnections are not acceptable. Construction shall be such that the contractor need install only the power and control connections.

Bypass/isolation switches shall provide a safe and convenient means for manually bypassing and isolating the automatic transfer switch (ATS), regardless of the position or condition of the ATS, with the ability to be used as an emergency backup system in the event the transfer switch should fail. In addition, the bypass/isolation switch shall be utilized to facilitate maintenance and repair of the automatic transfer switch.

The automatic transfer switch shall be completely isolated from the bypass/isolation switch by means of insulating barriers and separate access doors to positively prevent hazard to operating personnel while servicing the automatic transfer switch.

2. Automatic Transfer Switch

(Insert specification for Model RMT or RMTD here).

3. Bypass/Isolation Switch

Operation of the bypass/isolation switch shall be assured regardless of the position of the automatic transfer switch. Indicating lights shall be provided to show the bypass/isolation switch in bypass position, in fully isolated position, and to indicate source availability. Positive sequencing of all contacts, with no possible intermediate position, shall be accomplished through the manual operators from a dead front location. Electrical testing during maintenance of the automatic transfer switch shall be possible in the bypass position. Inherent double throw (break-before-make) operation shall provide positive assurance against accidental short circuiting of the normal and emergency power sources. Arrangements utilizing interlocking of single-throw devices are not acceptable. The operating speed of the contacts shall be independent of the speed at which the handle is moved. The switch shall be fully manually operated and shall not be dependent upon electrical operators, relays, or interlocks for operation.

The bypass/isolation switch shall be listed by Underwriters Laboratories Inc. under Standard UL-1008 and meet the identical withstand ratings of its associated transfer switch. In addition,

both shall be supplied by the same manufacturer who shall verify that his automatic transfer switch and bypass/isolation switch designs have been in continuous production for not less than five years, with at least ten similar installations operating continuously and successfully for that period of time.

4. Construction

All main contacts and operating linkages shall be identical to the ATS except that the operation shall be manual. the switch shall have the same electrical ratings of ampacity, voltage, short circuit withstand, and temperature rise capability as the associated ATS. The bypass switch shall be the load-break type. The main contacts of the bypass switch shall be mechanically locked in both the normal bypass and emergency bypass positions without the use of hooks, latches, magnets, or springs and shall be silver-tungsten alloy protected by arcing contacts with magnetic blowouts on each pole. The switching mechanism shall provide "quick-break," "quick-make" operation of the contacts.

The primary buswork of the drawout automatic transfer switch shall be connected to the stationary bus stabs in the freestanding cubicle by silver plated, segmented, self-aligning, primary disconnect fingers to facilitate proper alignment between the removable drawout element and the stationary cubicle. The ATS finger assemblies shall be drawn out when the ATS is withdrawn and shall be available for inspection without disturbing or deenergizing the main bus.

Similarly, the secondary control disconnect contacts mounted on the ATS shall be self-aligning and shall plug into the stationary elements mounted on the freestanding cubicle. Separate, manual, secondary control disconnect plugs are not acceptable.

The isolating portion of the bypass/isolation switch shall allow the automatic transfer switch to be disconnected from all sources of power and control with a true drawout configuration which does not require disconnection of any electrical or mechanical device by maintaining personnel. The automatic transfer switch shall be provided with rollers or casters to allow it to be removed from its enclosure simply by rolling it out. Positive mechanical interlocks shall be provided to insure that the bypass/isolation functions can be accomplished without the danger of a short circuit. Overlapping contact bypass/isolation switches, that are dependent upon the position of the automatic transfer switch for proper operation, are not acceptable.

A fourth pole, switched neutral shall be provided if the associated automatic transfer switch is designated as 4-pole. Basic four pole bypass/isolation switch construction shall be identical to the associated automatic transfer switch construction.

Necessary controls shall be provided to ensure that the "engine run" circuit remains closed when the switch is in the by-pass-to-emergency position, even though the associated transfer switch is in the "normal" position or completely removed from the enclosure.

5. Manufacturer

Combination automatic transfer bypass/isolation switches shall be Russelectric Model RTB or approved equal.

Performance Data

Russelectric automatic transfer switches have been subjected to a comprehensive test program to prove conformance with the various performance specifications that are utilized by most consulting electrical engineers and government agencies. The following is a tabulation of the results as of the date of this publication:

UL LISTED WITHSTAND AND CLOSING CURRENT RATINGS IN SYMMETRICAL RMS AMPERES AT 480 VAC

Russelectric switch ampere rating	Test voltage (3 phase)	Russelectric withstand and closing ratings when coordinated with circuit breakers (1.)	Russelectric withstand and closing ratings when coordinated with current limiting fuses (1.)	Maximum fuse size for proper coordination	For comparison the following withstand and closing values are the minimum allowed under UL-1008
100	480	30,000	200,000	300	5,000
150	480	30,000	200,000	300	10,000
225	480	50,000	200,000	1,200	10,000
260	480	50,000	200,000	1,200	10,000
400	480	50,000	200,000	1,200	10,000
600	480	50,000	200,000	1,200	12,000
800	480	50,000	200,000	1,200	16,000
1,000	480	85,000	200,000	3,000	20,000
1,200	480	85,000	200,000	3,000	24,000
1,600	480	85,000	200,000	3,000	32,000
2,000	480	100,000	200,000	3,000	40,000
3,000	480	100,000	200,000	4,000	60,000
4,000	480	100,000	200,000	5,000	80,000

1. Withstand and closing were conducted in accordance with UL-1008 without welding contacts.

OVERLOAD AND ENDURANCE TESTS (3ϕ – 480V)

Russelectric switch ampere rating	Overload Test Amperage (1.)	Endurance Test Amperage (1.) (2.)
100	900	200
150	900	300
225	2,400	450
260	2,400	530
400	2,400	800
600	3,600	1,200
800	4,800	1,600
1,000	7,200	2,400
1,200	7,200	2,400
1,600	9,600	3,200
2,000	12,000	4,000
3,000	18,000	6,000
4,000	24,000	8,000

1. Tests conducted with both normal & emergency energized
2. Tests were conducted for 3000–6000 cycles

ADDITIONAL TEST DATA

Russelectric switch ampere rating	WITHSTANDING CAPABILITY (RMS Amps Symmetrical) Test Parameters 3 Cycles @ 480 Volts 20% P.F.	Test Parameters 10 Cycles @ 480 Volts 20% P.F.
100	16,000	—
150	16,000	—
225	40,000	40,000
260	40,000	40,000
400	40,000	40,000
600	40,000	40,000
800	40,000	40,000
1,000	50,000	50,000
1,200	50,000	50,000
1,600	50,000	50,000
2,000	73,000	—
3,000	61,000	—
4,000	80,000	—

TEMPERATURE RISE TESTS

All test reports include successful completion of post-endurance temperature rise tests with values well within the following published limits.

Terminals—50°C Contacts—65°C
Bus—65°C

DIELECTRIC TESTS

All test reports include post-endurance dielectric tests for 60 cycles, 1000 volts plus twice rated voltage (1960 volts minimum).

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Russelectric Inc.

South Shore Park

Hingham, MA 02043

OPERATION & MAINTENANCE INSTRUCTIONS

RUSSELECTRIC AUTOMATIC

TRANSFER SWITCH

MARKING

PER UNDERWRITERS' LABORATORIES, INC. STANDARD UL-1008

NOTE: A REPRESENTATIVE SAMPLE OF A RUSSELECTRIC AUTOMATIC TRANSFER SWITCH OF THIS TYPE AND RATING HAS BEEN TESTED BY UNDERWRITERS' LABORATORIES, INC., AND WAS FOUND TO MEET THE MINIMUM PERFORMANCE REQUIREMENTS OF UL-1008 FOR EMERGENCY SERVICE AT FULL NAMEPLATE RATING. REFER TO UNDERWRITERS' LABORATORIES, INC. FILE NUMBER E-42157.

THIS TRANSFER SWITCH IS RATED FOR TOTAL SYSTEM TRANSFER, AND IS SUITABLE FOR CONTROL OF MOTORS, ELECTRIC DISCHARGE LAMPS, TUNGSTEN FILAMENT LAMPS AND ELECTRIC HEATING EQUIPMENT WHERE THE SUM OF MOTOR FULL-LOAD AMPERE RATINGS AND THE AMPERE RATINGS OF OTHER LOADS DO NOT EXCEED THE AMPERE RATING OF THE SWITCH, AND THE TUNGSTEN LOAD DOES NOT EXCEED W PERCENT OF THE SWITCH RATING.

THIS TRANSFER SWITCH IS SUITABLE FOR USE ON A CIRCUIT CAPABLE OF DELIVERING NOT MORE THAN 100,000 RMS SYMMETRICAL AMPERES, 480 VOLTS MAXIMUM WHEN USED WITH CLASS X FUSES RATED NOT GREATER THAN 125% OF FULL NAMEPLATE AMPERAGE RATING.

THIS TRANSFER SWITCH IS ADJUSTED TO INITIATE TRANSFER TO THE ALTERNATE SUPPLY WHEN THE NORMAL SOURCE VOLTAGE IS REDUCED TO Z PERCENT OF RATED VOLTAGE, AFTER A TIME DELAY OF Z SECONDS/MINUTES, AND TO INITIATE RETRANSFER TO THE NORMAL SUPPLY WHEN THE NORMAL SOURCE VOLTAGE HAS BEEN RESTORED TO Z PERCENT OF RATED VOLTAGE, AFTER A TIME DELAY OF Z SECONDS/MINUTES.

IT IS RECOMMENDED THAT THIS TRANSFER SWITCH BE TESTED PERIODICALLY, AT LEAST ONCE EVERY MONTH, BY ACTUATING THE LOAD TEST SWITCH, OR BY DISCONNECTING THE NORMAL POWER SOURCE TO THE TRANSFER SWITCH.

△1 AUXILIARY CONTACT RATINGS - 10 AMPERES MIN. AT 120V A.C. UNLESS OTHERWISE NOTED.

△1 THE WIRING SPACES OF THIS SWITCH ARE SUCH THAT ALL POWER TERMINALS ARE SUITABLE FOR USE WITH ALUMINUM CONDUCTORS AS WELL AS COPPER CONDUCTORS.

△1 SWITCHES SHALL BE MARKED CONTROL CIRCUIT TERMINALS SUITABLE FOR COPPER WIRE ONLY.

W - 100% ON SWITCHES TO 400 AMPERES, 30% ON SWITCHES ABOVE 400 AMPERES

Z - FOR VALUES, SEE NOMENCLATURE ON WIRING DIAGRAM

X - 100 & 150 - CLASS J, 225 AMPERES AND ABOVE - CLASS L

WARNING: TO INSURE AGAINST SHOCK OR ACCIDENT, DISCONNECT ALL SOURCES OF SUPPLY BEFORE SERVICING.

NO.	REVISION	DATE	BY	CHKD.
1	AS NOTED --- △1	8/77	RK	

TOLERANCES (EXCEPT AS NOTED)	Russelectric Inc. coordinated power control systems SO. SHORE INDUSTRIAL PARK HINGHAM, MASS.		
DECIMAL ±		SCALE	DRAWN BY / APPROVED BY
FRACTIONAL ±	TITLE: UL DATA SHEET		
ANGULAR ±	DATE: 6/7/72	DRAWING NUMBER: R-1A-3780	1 REV

Russelectric Inc.

"power control systems"

APRIL 1977

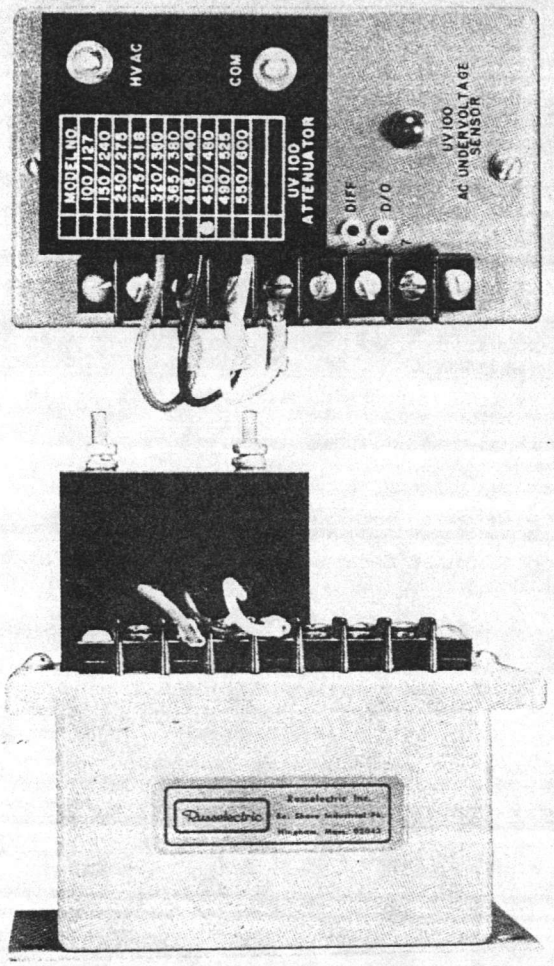
Series UV-100

A.C. UNDERVOLTAGE SENSORS

Bulletin 76A

A.C. UNDERVOLTAGE SENSORS for single and three phase applications

Recognized Components under U.L. File No. E-60150



Features

- reliable solid state design
- integrally mounted long life visual status indicator
- modular construction with interchangeable high voltage attenuators
- 20 year operating life with continuous duty
- packaged in NEMA oil tight housing
- *meets or exceeds new IEEE 2500 volt Surge Withstand Capability Test Requirements
- continuous overvoltage operation to 125% nominal rating
- differential to 1%

General

The Russelectric Series UV-100 Undervoltage Sensors are designed to meet the need for repeatable, close differential sensing of undervoltage conditions on power systems having standard and nonstandard voltages between 100 to 600 VAC RMS. The UV-100 can be utilized to disconnect loads from faulty power sources, actuate signal alarm circuits, operate transfer switches and/or start up standby power systems. It can also be used as an undervoltage detector with automatic lockout feature requiring manual reset.

The basic UV-100 is a single phase undervoltage sensor with isolated Form C output control relay contacts. Three phase sensing is readily accomplished by the use of multiple sensors. Power required for sensor operation is derived from the AC voltage being monitored. Burden is minimal at approximately 3 watts.

Easily adjustable multi-turn tamperproof screwdriver adjustments simplify pickup and dropout settings.

A solid state LED (light emitting diode) indicator illuminates when the applied voltage remains within the normal range following initial energization of the control relay.

A high quality barrier type terminal strip is provided on the main assembly to allow convenient access to all sensor connections except the monitored voltage, which is applied to the top of the attenuator module, where it is isolated from the output circuitry.

Housed in a rugged two-piece NEMA oiltight JIC type metallic enclosure, the basic sensor electronic circuitry is fully protected against hostile industrial and commercial environments.

All circuitry in the main housing is attached to the cover, which is easily removable by means of two standard machine screws.

The housing is furnished with a flat mounting flange having four mounting holes.

The enclosure also serves as a mounting platform for the high voltage attenuator assembly which is completely encapsulated to ensure mechanical rigidity compatible with the high dielectric strength required.

Operation

When the monitored voltage initially exceeds the sensor pickup point, the control relay energizes and the solid state indicator illuminates.

When the voltage being monitored drops below a preset level (dropout voltage) for a period exceeding 0.25 to 0.3 seconds, the solid state indicator light is extinguished and the output control relay is de-energized, transferring external loads up to 10 ampere at 250 VAC resistive. Both the dropout and differential settings are conveniently accessible through the main assembly cover and are independently adjustable to accommodate any AC voltage between 70 to 100% of nominal with standard differentials between 2 and 30%. 1% differential is available for fixed ambient conditions.

The pickup point is determined by the combined settings of the dropout and differential controls.

Operation at or near the pickup and dropout settings is decisive. Built-in minimum fixed hysteresis ensures stable transitions around the specified operating points, even at very close differentials, with freedom from nuisance tripping due to very rapid over and undervoltage transients common to almost all power systems.

UV-100 operation is independent of the frequency of the monitored source voltage over the specified range of 45 Hz to 75 Hz. Other frequencies can be accommodated on special order.

Field Installation

Field installation simply involves connection of the two monitored source conductors to the H.V. attenuator stud terminals and attachment of the external ground and control circuit wiring to the barrier terminal strip.

Design

High quality silicon semiconductors, military type printed circuit board, and other carefully selected components are employed in a reliable electronic design.

The life expectancy for the UV-100 undervoltage sensor is 20 years, based upon continuous operation at normal ambient temperatures and voltages within the limits specified for the units.

Attainment of an operating life of 175,000 hours is based primarily upon careful selection of components, both active and passive, with extremely conservative derating of more severely stressed items such as the semiconductors and capacitors.

Coordinated mechanical and electrical design permits manufacture of the basic modular sensor assembly in a rugged NEMA oiltight JIC housing which is common to all models.

The high voltage attenuator housing attaches to the main assembly by means of three studs accessible on the underside of the cover. The monitored voltage is connected to two 8-32 studs on top of the attenuator housing, with electrical interface between the attenuator and the main assembly accomplished via three short color coded leads connected to the barrier terminal strip on top of the housing.

External ground and output control relay Form C contacts are also available at the barrier terminal strip.

Power line transients are effectively dissipated in the attenuator modules by means of special voltage-dependent symmetrical nonlinear resistors having extremely high peak energy absorption capability.

Further protection has been incorporated into the basic sensor circuitry in the form of additional suppressors, conservatively rated components, and simple straightforward design. The unit is designed to withstand continuous operation at 125 percent of the nominal input voltage.

The UV-100 sensor meets or exceeds the new IEEE 2500 Volt Surge Withstand Capability Specification and is designed to meet both UL and CSA requirements for dielectric strength, endurance, overload capability, temperature, and calibration accuracy.

Calibration

1. For initial calibration, connect an accurate variable voltage AC source to the unit under test. Set the dropout control maximum CCW and the differential control maximum CW.
2. Increase the applied voltage until control relay pickup occurs. Observe the status indicator.
   CAUTION: DO NOT EXCEED SPECIFIED ABSOLUTE MAXIMUM INPUT VOLTAGE VALUE OF UNIT UNDER TEST.
3. Reduce the applied voltage to desired dropout value and rotate dropout control CW while observing status indicator until control relay de-energizes.
4. Increase applied voltage to desired pickup value and rotate differential control CCW while observing status indicator until control relay energizes.
5. Calibration is now complete.

Specifications

Nominal Input Voltage . . . . . 100 to 600 volts RMS (See ordering data.)
Frequency. . . . . 45 to 75 Hz (Special models available for other values.)
Maximum Continuous Input Voltage . . . . . 125% of nominal
Absolute Maximum Input Voltage . . . . . 150 to 750 volts RMS (See ordering data.)
Burden in Normal Mode . . . . . approximately 3 watts
Ambient Temperature Range . . . 0°C (+32°F) to +50°C (+122°F) operating -45°C (-49°F) to +85°C (+185°F) nonoperating or storage
Undervoltage Pickup Range of Adjustability . . . . . 72% to 100% of nominal value
Undervoltage Dropout Range of Adjustability . . . . . 70% to 98% of nominal value
Repetitive Accuracy of Response . . . . . typically ±1% of nominal value over ambient operating temperature range referenced to +25°C
Time Delay on Dropout . . . . . fixed at approximately 0.3 seconds
Status Indicator . . . . . integrally mounted red solid-state L.E.D. (illuminates in normal mode)
Output Control Signal. . . . . Normally energized Form C SPDT Relay contacts 10A 250VAC or 8A 277VAC with 80% P.F.
Overall Dimensions . . . . . 5 1/2" high (13.97CM), 5 1/4" long (13.34 CM), 3 3/16" wide (8.10 CM)
Weight . . . . . 3 lbs. 4 oz. (1.47 kilograms)
Mounting Provisions . . . . . Flat bottom flange with four .25" (6.35 mm) diameter holes rectangularly spaced on a grid 2" (5.08 CM) by 4-3/4" (12.06 CM)

ORDERING DATA

All models listed below are available from stock for immediate delivery and include the basic sensor assembly equipped with proper attenuator calibrated and set to customer specified operating points:

ATTENUATOR ASSEMBLY MODEL NO.	NOMINAL AC LINE RMS VOLTS INPUT RANGE	ABSOLUTE MAXIMUM RMS VOLTS	TYPICAL SYSTEM VOLTAGE VALUES
A2-100/120	100-120	150	100,115,120
A2-150/160	150-160	300	150,160
A2-190/208	190-208	300	190,200,208
A2-216/230	216-230	300	216,220,230
A2-240/277	240-277	390	240,250,260,275,277
A2-290/365	290-365	500	290,318,330,350,360,365
A2-380/400	380-400	630	380,400
A2-416/460	416-460	630	416,433,440,460
A2-480/500	480-500	630	480,490,500
A2-550/600	550-600	750	550,575,600

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Printed in U.S.A.

Russelectric Inc.

"power control systems"

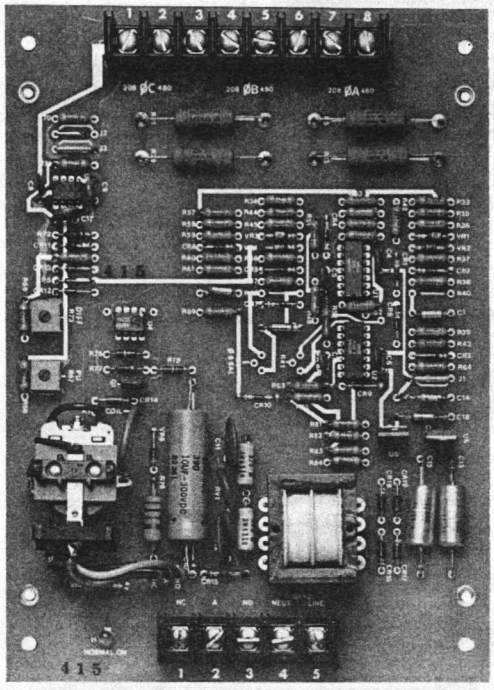
JANUARY 1984

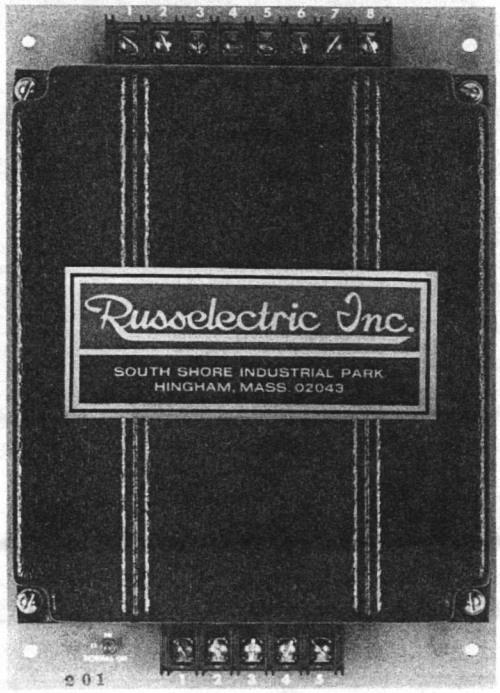
Series UV-300

A.C. UNDERVOLTAGE SENSORS

Bulletin 400

A.C. UNDERVOLTAGE SENSORS for three-phase applications





Features

- Reliable solid state design.
- Integrally mounted, long life visual status indicator.
- Twenty-year operating life with continuous duty.
- Designed to meet or exceed IEEE Standard 472-1974 Surge Withstand Capability Test Requirements.
- Continuous overvoltage operation to 125% nominal rating.
- Differential to 1%.

General

The Russelectric Series UV-300 Undervoltage Sensor was designed to meet the need for repeatable, close differential sensing of undervoltage conditions on three-phase power systems having standard voltages of 208 or 480 VAC RMS. The UV-300 can be utilized to disconnect loads from faulty power sources, actuate signal alarm circuits, operate transfer switches and/or start-up standby power systems.

Unlike most three-phase voltage sensors, this device does not utilize averaging techniques. The relay will de-energize when the voltage of the lowest of the three phases falls below the preset trip point, regardless of the value of the other two-phase voltages.

The UV-300 is a three-phase undervoltage sensor with isolated Form C output control relay contacts.

A solid state LED (light emitting diode) indicator illuminates when the applied voltage remains within the normal range following initial energization of the control relay.

Two high quality barrier-type terminal strips are provided on the assembly to allow convenient access to all sensor connections.

The sensor electronic circuitry is protected against hostile industrial and commercial environments by means of a vacuum-formed cover that is fastened to the circuit board.

Operation

When the monitored voltage initially exceeds the sensor pickup point, the control relay energizes; and the solid state indicator illuminates.

When the voltage being monitored drops below a preset level (dropout voltage) for a period exceeding a predetermined time, the solid state indicator light is extinguished; and the output control relay is de-energized, transferring external loads up to 10 amperes at 250 VAC resistive. Both the pickup and differential settings are accessible by removing the cover and are independently adjustable to accommodate any AC voltage between 75% and 100% of nominal with standard differentials between 2% and 30%. 1% differential is available for fixed ambient conditions.

The dropout point is determined by the combined settings of the pickup and differential controls.

Operation at or near the pickup and dropout settings is decisive. Built-in minimum fixed hysteresis ensures stable transitions around the specified operating points, even at very close differentials, with freedom from nuisance tripping due to very rapid over and undervoltage transients common to almost all power systems.

UV-300 operation is independent of the frequency of the monitored source voltage over the specified range of 45 Hz to 75 Hz. Other frequencies can be accommodated on special order.

Field Installation

Field installation involves simple connection of the three monitored source conductors to the upper terminal strip, a 120 VAC supply on the lower terminal strip, and the control circuit wiring.

Design

High quality silicon semiconductors, military-type printed circuit board, and other carefully selected components are employed in a reliable electronic design.

The life expectancy for the UV-300 undervoltage sensor is twenty years, based upon continuous operation at normal ambient temperatures and voltages within the limits specified for the units.

Attainment of an operating life of 175,000 hours is based primarily upon careful selection of components, both active and passive, with extremely conservative derating or more severely stressed items such as the semiconductors and capacitors.

Power line transient protection has been incorporated into the basic sensor circuitry in the form of suppressors, conservatively rated components, and simple straightforward design. The unit is designed to withstand continuous operation at 125% of the nominal input voltage.

The UV-300 sensor is designed to meet or exceed IEEE Standard 472-1974 Surge Withstand Capability Specification and is designed to meet both UL and CSA requirements for dielectric strength, endurance, overload capability, temperature, and calibration accuracy.

Calibration Procedures

For initial calibration, connect an accurate three-phase variable voltage AC source and a 120 VAC source to the unit under test. Set the pickup and differential controls maximum CW.

CAUTION: DO NOT EXCEED ABSOLUTE MAXIMUM INPUT VOLTAGE OF UNIT UNDER TEST.

Increase applied voltage to the desired pickup point and rotate the pickup control CCW until the control relay energizes.

Decrease the applied voltage to the desired dropout point and rotate the differential control CCW until the control relay de-energizes. Calibration is now complete.

Specifications

* Nominal Input Voltage	208 or 480 Volts RMS
* Frequency	45 to 75 Hz
Maximum Continuous Input Voltage	125% of Nominal Voltage
Absolute Maximum Input Voltage	600 Volts RMS (480 Volt Input)
Burden in Normal Mode	480V = 1 VA/Phase
	208V = .5 VA/Phase
	120V Supply = 4 VA
Ambient Temperature Range	0 °C (+ 32 °F) to + 50 °C (+ 122 °F) Operating
	-40 °C (-40 °F) to + 85 °C (+ 185 °F) Nonoperating or Storage
Undervoltage Pickup Range of Adjustability	75% to 100% of Nominal Voltage
Undervoltage Dropout Range of Adjustability	70% to 98% of Nominal Voltage
Repetitive Accuracy of Response	Typically ± 1% of Nominal Voltage Over
	Ambient Operating Temperature Range Referenced to + 25 °C
Time Delay on Dropout	Fixed at Approximately 75 Milliseconds
Status Indicator	Integrally Mounted Green Solid State LED
	(Illuminates in Normal Mode)
Output Control Signal	Normally Energized Form C SPDT Relay Contacts
	10A 250 VAC or 8A 277 VAC with 80% P.F.
Overall Dimensions	1 3/4 " High (44.5 MM), 8 3/4 " Long (222.3 MM),
	6 1/4 " Wide (158.8 MM)
Weight	1 lb. 4 oz. (.57 Kg)
Mounting Provisions	Four 3/16 " (4.76 MM) Diameter Holes Rectangularly
	Spaced on a Grid 5 5/8 " (142.9 MM) by 7 3/4 " (196.9 MM)

*Other voltages or frequencies available on special order.

Russelectric Inc.

South Shore Park, Hingham, MA 02043 (617) 749-6000 TELEX -94-0328

2M 1-86

Printed in U.S.A.

RUSSELECTRIC AUTOMATIC TRANSFER SWITCHES

Russelectric Automatic Transfer Switches do not require regular maintenance other than an occasional cleaning and visual inspection for condition of contacts, etc. The motor operators are lubricated at the factory, and the gear casings are packed with grease and sealed. Further lubrication throughout the life of the switch is not required. Occasionally, it may be desired to change the setting of time delay relays, or to readjust the setting of the phase failure relays. The procedures for accomplishing this are included in this manual.

Relay Designation and Function

"A" - Control relay energized from normal source through phase failure relays. This relay controls time delays, engine starting circuit (if provided) and the motor operator.

"B" - Phase relay, energized from normal source, this relay detects a low voltage condition, or a voltage failure in the normal source.

"G" - Frequency relay, energized from emergency source. This relay prevents transfer to emergency until emergency source has reached rated voltage and frequency. It is provided as standard when the emergency source is an engine generator set. If the switch is used to select between two sources of prime power, the "G" relay may be designated as "lock out" relay. In this case, the relay monitors voltage, but is not frequency sensitive.

Periodic Cleaning

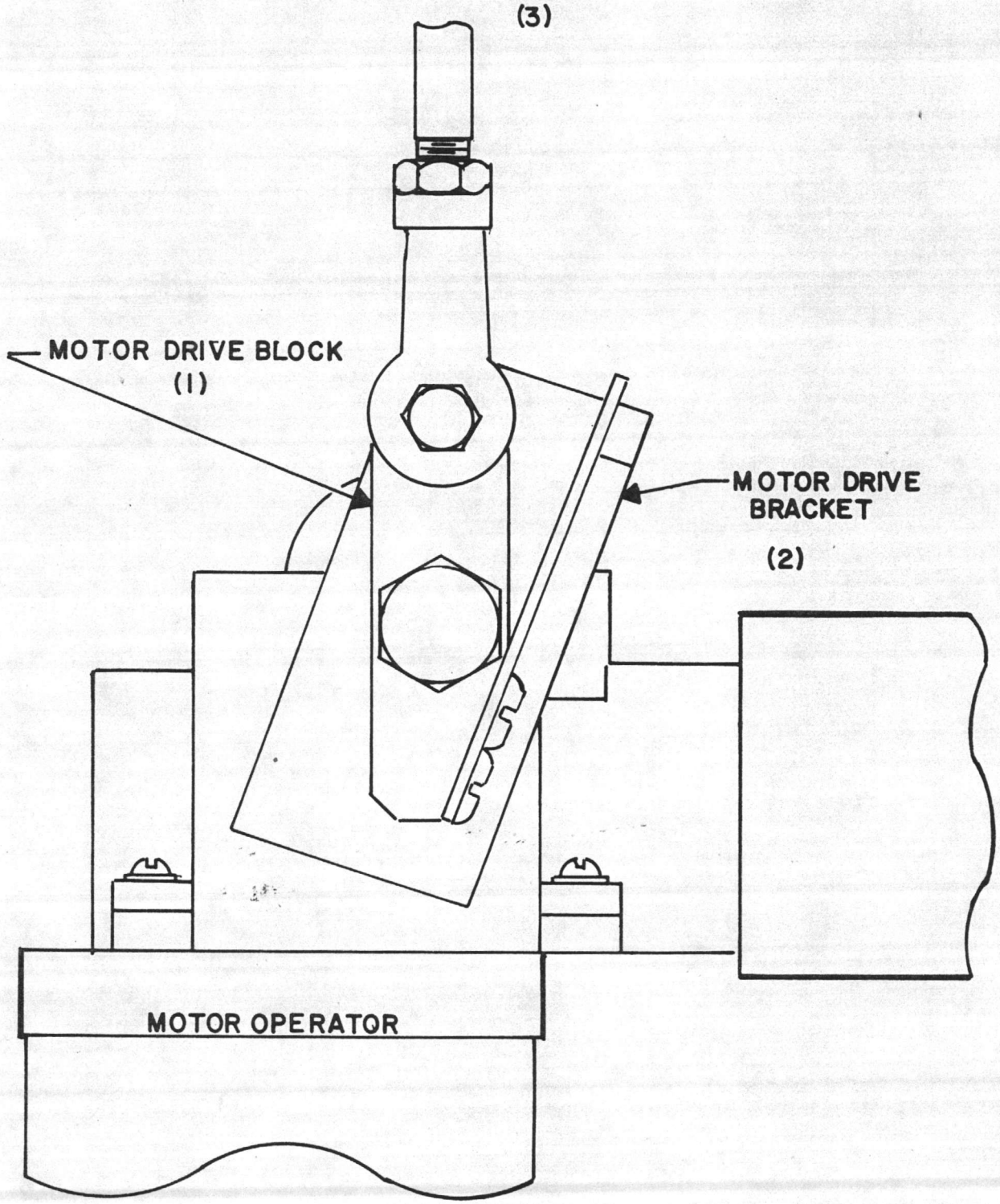
From time to time, the switch should be inspected for cleanliness, and the cabinet and relays should be cleaned by wiping or vacuum cleaning. The relay contacts should be inspected for cleanliness and condition, and should be checked for adjustment periodically. NOTE: If a phase failure (B), control (A), or frequency (G) relay should chatter, hum, or fail to pickup, the problem may be the result of dust or dirt under the armature. There are two suggested methods of correction: (a) run an ordinary calling card or similar piece of thin cardboard between the armature and coil; (b) hold the armature open and direct a jet of pressurized air into the gap.

Adjustment of Relays (See separate instruction sheet.)

Lubrication - Not required.

Manual Operation

(See sketch) Russelectric Automatic Transfer Switches employ an operating mechanism which allows for manual operation in the event of a malfunction. A manual operating handle is provided on the top set of contacts, and the motor drive mechanism is so designed that the drive block (1) may rotate 180° ahead of the drive bracket (2) to allow a manual transfer. It may be necessary for the operator to guide the drive block with his free hand to ascertain that it rotates away from the stop on the drive bracket. CAUTION: If the operator attempts to transfer the switch manually when it is energized, and is already in the correct position, it will immediately retransfer to its original position. The transfer switch should be transferred manually only after the operator has ascertained that a malfunction has occured.



MOTOR DRIVE MECHANISM

"RUSSELECTRIC" AUTOMATIC TRANSFER SWITCHES

FIGURE 1

INSTRUCTION SHEET

"RUSSELECTRIC" CLOSE DIFFERENTIAL PHASE FAILURE RELAYS

Close differential phase failure relays (accessory 4a or 4b) are provided on "Russelectric" Automatic Transfer Switches when it is necessary that the voltage to the load be maintained within close tolerances. Each of these relay assemblies consists of a modified Ward Leonard Bulletin 130 Relay mounted and wired in conjunction with a capacitor, reactor, rheostat, and tap switch. The relays are normally factory set for drop out at 90% of rated voltage, and pick up at 95% of rated voltage. The drop out point is adjustable from approximately 70% to 90%, and the pick up point from approximately 90% to 100% of rated voltage.

The drop out point is adjusted by means of a screwdriver slot in the rheostat shaft. This is the upper adjustment on the Close Differential Relay chasis. The pick up point is adjusted by a black knob on the tap switch, the lower adjustment on the relay chasis. The rheostat shaft is provided with a locking nut, and it is suggested that this nut be re-tightened after final adjustment of the drop out point.

NOTES:

1. THE PICK UP AND DROP OUT POINTS SHOULD NOT BE RE-ADJUSTED EXCEPT BY QUALIFIED PERSONNEL WITH PROPER MEASURING EQUIPMENT.

2. Whenever the drop out point is adjusted, it is necessary to re-adjust the pick up point.

3. If a "Russelectric" Close Differential Relay should chatter, hum, or fail to pick up, the problem may be the result of an undue amount of dirt or dust under the armature. There are two suggested methods of correction:

   a. Run an ordinary calling card or similar piece of thin cardboard between the armature and coil.

   b. Hold the armature open and direct a jet of pressurized air into the gap.

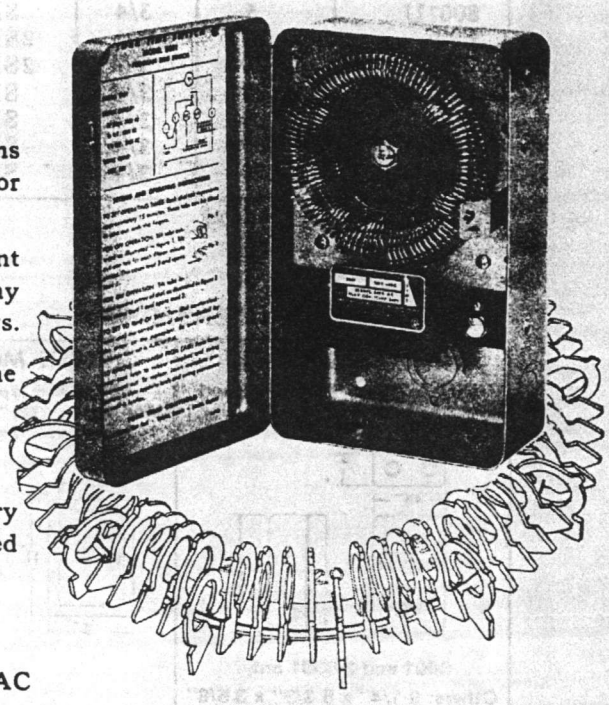
TORK® PRODUCT BULLETIN

No. 180A

July 1971 | 8000 Series

PROGRAM TIME SWITCHES

MODELS: 8001, 8002, 8007, 8007V



MODEL 8001

DESCRIPTION:

Synchronous motor-driven time switch.

24-hour dial has 96 tabs to permit 1 to 48 ON-OFF operations per day, in increments of 15 minutes. Tabs easily tilted in or out manually to set or alter switching programs.

Switch remains in one position (ON or OFF) when adjacent tabs are set alike. New or temporary switching programs may be easily set without disturbing regular automatic settings.

Day omitting device and Reserve Power, to keep dial on time for 36 hours in case of power failure, are optional features.

APPLICATIONS:

Automatic ON-OFF programming of: Ventilating fans, poultry feeding and watering, irrigation, oil field pumping, recorded music, program heating, periodic mixing and agitating.

SPECIFICATIONS:

SWITCH: SPDT: 20 Amps at 120 or 240V AC
5 Amps at 440V

TIMING MOTOR: Heavy duty synchronous, self-starting,
Voltage: 120 or 208-277V, 60 or 50 Hz.
Temperature range: −60° to +150°F.
Power Consumption: 3.7 watts.

DIAL: 24 hour rotation—3 1/4" dia.—clear calibration, with Day and Night zones. Can be turned by hand, without disengaging gears, for accurate setting. Accommodates 96 permanent tabs, which cannot work loose or become lost, each giving a 15-minute increment of either ON or OFF operation. Minimum ON setting: 15-minutes—Maximum ON setting: 23 hours, 45 minutes.

TERMINALS: Terminals can accommodate up to AWG #12 wire. Timing motor terminals separate from switch circuit.

ENCLOSURES: General purpose (NEMA I). Drawn steel, gray baked epoxy enamel, with combination 1/2" and 3/4" K.O.'s on sides, bottom and back. Lockable hasp. Split cover provides exceptional accessibility for wiring and setting. Cover is removable and movement releases from case at finger touch for easy installation.

Also available:

Flush, with lock and key (suffix FL1).
Duplex — 2 standard units in one case, surface (suffix DU).
Weatherproof NEMA III (suffix O).
Bracket mounting — less case, with bracket (specify).

OMITTING DEVICE: 7-spoke wheel marked with days of week — 3 omitting screws (P-14) provided (8007). Standard on 8007 models.

14-spoke wheel marked with days of week — self-retaining screw for each day (8007V).

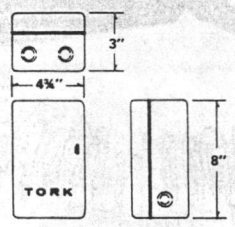
8000 SERIES

Model No.	Amps	H.P.	Switching	Motor Voltage	Feature
8001	20	3/4	SPDT	120V	Daily Operation
2-8001	20	3/4	SPDT	208-277V	Daily Operation
8001U	5	3/4	SPDT	440V/120V Transf.	Daily Operation
8002	20	3/4	2SPDT	120V	Daily Operation
2-8002	20	3/4	2SPDT	208-277V	Daily Operation
8007	20	3/4	SPDT	120V	Can skip 1 to 6 days
8007L*	20	3/4	SPDT	120V	Can skip 1 to 6 days
2-8007	20	3/4	SPDT	208-277V	Can skip 1 to 6 days
8007V	20	3/4	SPDT	120V	Can skip 1 to 13 days

*Reserve Power added. Also available in 24 volt, 60 cycles.

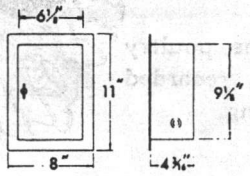
ENCLOSURE DIMENSIONS:

GENERAL PURPOSE
(NEMA Type 1 Surface Mount)

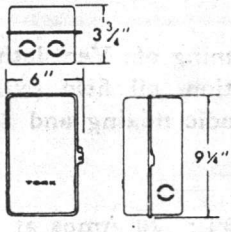


8001 and 2-8001 only.
Others: 9 1/4" x 5 3/8" x 3 5/8"

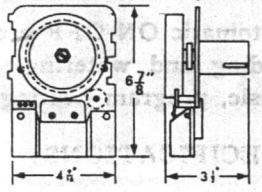
FLUSH MOUNT
(Nema type 1B)
Add letters "FL1" to Cat. No.
Supplied with Lock and Key.



WEATHERPROOF
(Nema Type (III)
Add letter "O" to Cat. No.



MECHANISM ONLY, LESS CASE, WITH MOUNTING BRACKET:
Specify "Less Case, With Mounting Bracket"



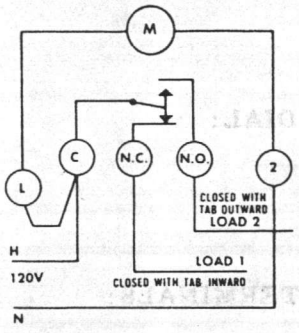
8002 is 7½" high.

SPECIFICATION GUIDE:

The time switches shall be of the program type, capable of programming at 15-minute intervals of the day. Program tabs shall be captive on the dial, and shall be easily set by hand without tools to obtain or to change the desired programming schedule. The switching condition shall be maintained when adjacent tabs are set alike.

The unit shall be powered by a self-starting, enclosed, 120 (or 208-277) volt, synchronous motor capable of continuous accurate operation.

The switch mechanism shall be a self-contained unit rated at not less than 20 amps, 120 volts, single pole, double throw, (or 2SPDT in parallel), and shall be readily replaceable in the field.



FOR 8001 OR 8002 ADD — The time switch shall be similar and equal to (Model 8001) (Model 8002) as manufactured by the Tork Time Controls, Inc.

FOR 8007 ADD — An omitting device shall be furnished as an integral part of the time switch, to enable the switching operation to be skipped for any preselected day or days of the week. The time switch shall be similar and equal to Tork Model 8007.

FOR 8007L ADD — (Same description as for 8007). The unit shall incorporate an integral electrically wound spring reserve power unit, which shall power the clock mechanism for up to 36 hours on a power failure. The time switch shall be similar and equal to Tork Model 8007L.

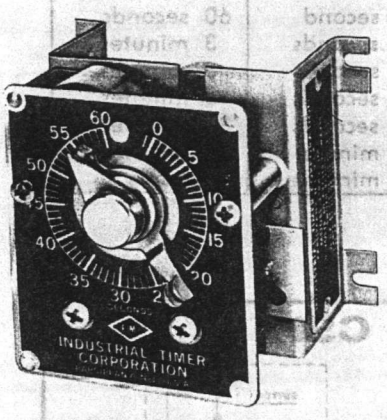
FOR 8001U — The unit shall be furnished with built-in 440/120V transformer to operate timing motor in parallel with 440 volt load. The time switch shall be similar and equal to Tork Model 8001U.

---Distributed By:---

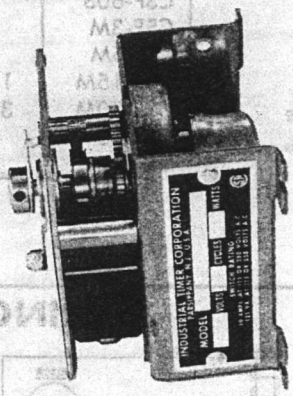
Special Bulletin #307

1 OCT. 1967

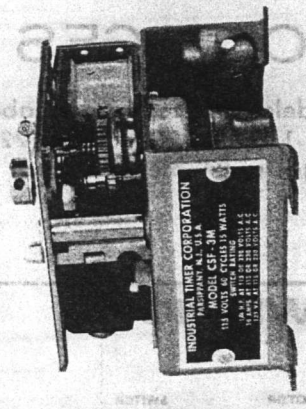
SERIES SF\CSF AUTOMATIC RESET TIME DELAY TIMER



FRONT VIEW



SIDE VIEW SF



SIDE VIEW CSF

DESCRIPTION

The Series SF and CSF are back mounted, extremely compact automatic reset time delay timers featuring technical characteristics normally found in units costing far more than the basic price.

For time cycles of under 60 seconds, the Series SF is offered. This timer incorporates a timer motor employing an internal clutch which permits the timer to automatically reset when power is removed from the sustained start circuit. The SF is available in overall time cycles of 6, 15 and 30 seconds. Full scale reset occurs within 10% of the time cycle or dial setting.
The Series CSF employs an entirely different movement which incorporates an external clutch. The external clutch permits this small timer to be offered in time cycles ranging from 60 seconds to 3 hours in 7 individual time ranges.

The CSF clutch movement incorporates several unique features which assure long life and fail safe reliability. These features are the motor control switch which operates after the timer load switch, permitting the clutch to remain engaged when the timer is in the 'timed out' condition, without damaging the timer motor. Another unique feature is a special shaft friction for additional internal protection. These two features are exclusive with the Series CSF timer.

FUNCTION

The SF and CSF Time Delay Timers provide a pre-set delay between the closing of a circuit L1 and L2, and the subsequent operation of the timer load switch, SPDT. Upon completion of the timed function, the timer stalls at ZERO until power is removed from the start circuit. Upon power removal, the timer automatically resets to the position of the pointer setting, ready for another operation.

Sustained stall at ZERO is a perfectly normal operation and the timer is designed to remain in the 'timed out' condition indefinitely. In the case of the SF type, the synchronous motor develops very little stalling torque, insufficient to damage the motor. The external clutch models, CSF type incorporate a motor control switch which shuts the motor off in the stalled out condition, however the clutch remains energized, therefore the timer can remain in the ZERO condition indefinitely.

U.S. HIGHWAY 287
PARSIPPANY, NEW JERSEY, 07054

INDUSTRIAL TIMER CORPORATION

115 WEST 25th STREET
LOS ANGELES, CALIFORNIA, 90007

A Subsidiary of
General Precision Equipment Corp.

LOAD CONTACTS

Standard load contacts for the SF/CSF timer are totally enclosed SPDT snap action rated at 10 amps. non inductive @ 115/60. Also available are 22 amp. contacts.

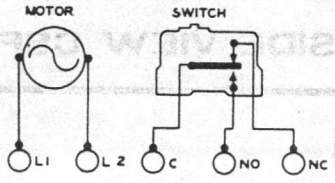
VOLTAGES

The SF/CSF delay timers are available for use on 115/60, 115/50, 220/60 or 220/50 Hz. Other voltages available on special order.

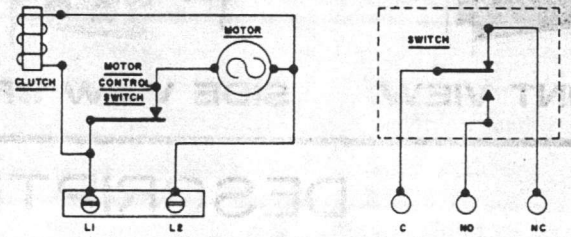
TIME CYCLES

MODEL	MIN. SETTING	MAX. SETTING
SF-6S	¼ second	6 seconds
SF-15S	¼ second	15 seconds
SF-30S	½ second	30 seconds
CSF-60S	1 second	60 seconds
CSF-3M	3 seconds	3 minutes
CSF-5M	5 seconds	5 minutes
CSF-15M	15 seconds	15 minutes
CSF-30M	30 seconds	30 minutes
CSF-60M	1 minute	60 minutes
CSF-3H	3 minutes	3 hours

WIRING SF

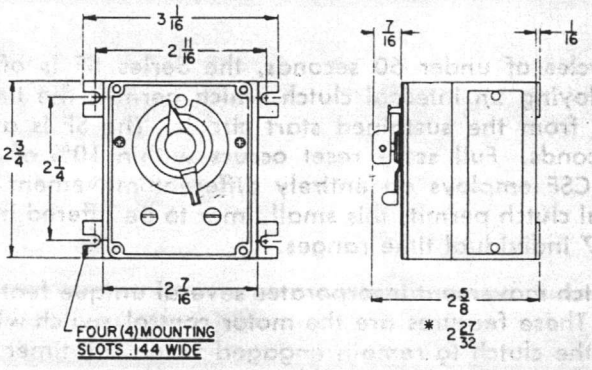


WIRING CSF



LOAD SWITCH OPERATES AT END OF TIME CYCLE

DIMENSIONS



*CSF Models

AVAILABLE ON SPECIAL ORDER

1. Reverse clutch: In this modification the clutch is normally engaged and the timer resets only when power is applied to the clutch circuit. This type of modification is used for safety circuits, or where a momentary power failure should not reset the timer.
2. CUSTOMER DIALS: The SF/CSF is available with special dials designed to the customer specifications.
3. Additional Load Switches: The CSF timer can be supplied with additional load switches; please consult factory for details.

U.S. HIGHWAY 287
PARSIPPANY, NEW JERSEY, 07054

INDUSTRIAL TIMER CORPORATION

115 WEST 25th STREET
LOS ANGELES, CALIFORNIA, 90007

AGASTAT®

7000 Series timing relay

INSTALLATION AND OPERATION

Every AGASTAT timing relay is a precise timing instrument which balances pneumatic, electrical and mechanical forces in a unique design using a minimum of moving parts. Its accuracy and performance to specifications have been carefully tested before shipment. Properly applied, it offers exceptional life expectancy. A few minutes spent in familiarizing yourself with these instructions will help you get the best possible service from this unit in your application.

Because of the skilled calibration and adjustment required on certain components prior to final assembly, we recommend that field servicing be limited to the replacement of the switchblock and coil assemblies, listed below. These have been designed to insure factory-built performance after field servicing without elaborate calibration. In cases where damage or abuse make it impossible to restore satisfactory performance by replacing these assemblies, the unit should be returned to the factory for repair or replacement.

MOUNTING INSTRUCTIONS

A. VERTICAL

Normal mounting for the basic 7000 Series unit is in a vertical position, from the back of the panel. Four 8-32 tapped holes are provided in the back plate, making it interchangeable with earlier models. Mounting screws should not project more than 5/32" into the back of the unit, to prevent internal damage.

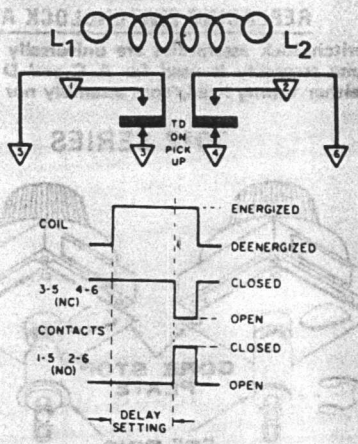
A front mounting bracket and the screws required to attach it to the relay are also supplied with each unit. This extends approximately 3/8" from each side of the unit, and permits installation from the front of the panel.

B. HORIZONTAL/PANELMOUNT

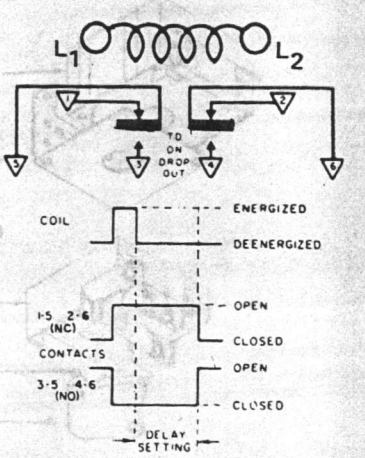
All basic 7000 Series units may be mounted horizontally, or horizontally through a panel with the Panelmount Accessory Kit.

Before mounting the 7000 Series timer for horizontal operation, it is necessary to remove the Position Compensation Spring, which is easily done as follows:
Turn the timer upside down and remove two small screws from the plastic dust cover. As the cover is lifted, the Position Compensation Spring will pop up from the lower spindle collar. Lift off the spring, and replace dust cover.

7012 SERIES



7022 SERIES



AUXILIARY SWITCH ADJUSTMENT

MODEL 7012

INSTANT TRANSFER AUX. SWITCH (CODE L)

Aux. switch should transfer immediately when relay coil is energized, and should reset shortly before solenoid core returns to its normal position, following deenergization. If it fails to reset before end of core's downword stroke, loosen screw in slotted hole of mounting bracket and move switch closer to terminal block.

TWO STEP AUX. SWITCH (CODE T)

Aux. switch contacts should transfer following first delay period after coil energization, and should reset shortly before core returns to its normal position, following coil deenergization. To increase first delay period, increase the distance between actuator screw head and arm by turning it clockwise, using 1/4" open end wrench.*

MODEL 7022

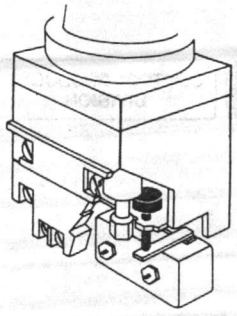
INSTANT TRANSFER AUX. SWITCH (CODE T)

Aux. switch should transfer immediately when relay coil is energized, and should reset shortly before spindle returns to its normal position, following deenergization. To increase aux. switch delay period, increase the distance between actuator screw head and arm by turning it clockwise, using 1/4" open end wrench.

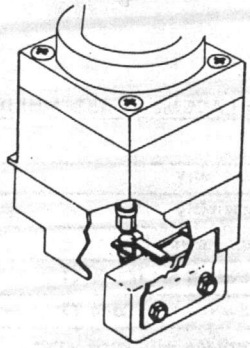
TWO STEP AUX. SWITCH (CODE T)

Check operation as for Instant Transfer, above. Increase first delay period by turning actuator screw clockwise until the desired delay before aux. switch transfer is reached.*

*First delay is independently adjustable, but must be no more than 25% of overall delay. (Recommended max. 30 sec.)



CODE L



CODE T

Coil Data

Coil Part Number	Code Letter	Rated Voltage @ 60 Hz	Operating Voltage Range @ 60 Hz	Rated Voltage @ 50 Hz	Operating Voltage Range @ 50 Hz
2400—	A	120	102 - 132	110	93.5 - 121
	B	240	204 - 264	220	187 - 242
	C	480	408 - 528		
	D	550	468 - 605		
	E	24	20.5 - 26.5		
	F			127	108 - 140
	G			240	204 - 264
	H	12	10.2 - 13.2		
	I	6	5.1 - 6.6		
	J	208	178 - 229		
	K	DUAL VOLTAGE COIL (COMBINES A & B)			

AC SPECIALS L1, L2, etc.

A C Coils (Part No. = 2400 followed by dash and code letter above)

Coil Part Number	Code Letter	Rated Voltage	Operating Voltage Range D C
2410—	M	28	22.5 - 33.5
	N	48	38.5 - 57.5
	O	24	19.2 - 28.8
	P	120	96 - 144
	Q	12	9.6 - 14.4
	R	60	48 - 74
	S	250	200 - 300
	T	550	440 - 660
	U	16	12.8 - 19.2
	V	32	25.6 - 38.4
	W	96	76.8 - 115
	Y	6	4.8 - 7.2
	Z	220	176 - 264

DC SPECIALS X1, X2, etc.

D C Coils (Part No. = 2410 followed by dash and code letter above)

All units draw approximately 8 watts power at rated voltage.

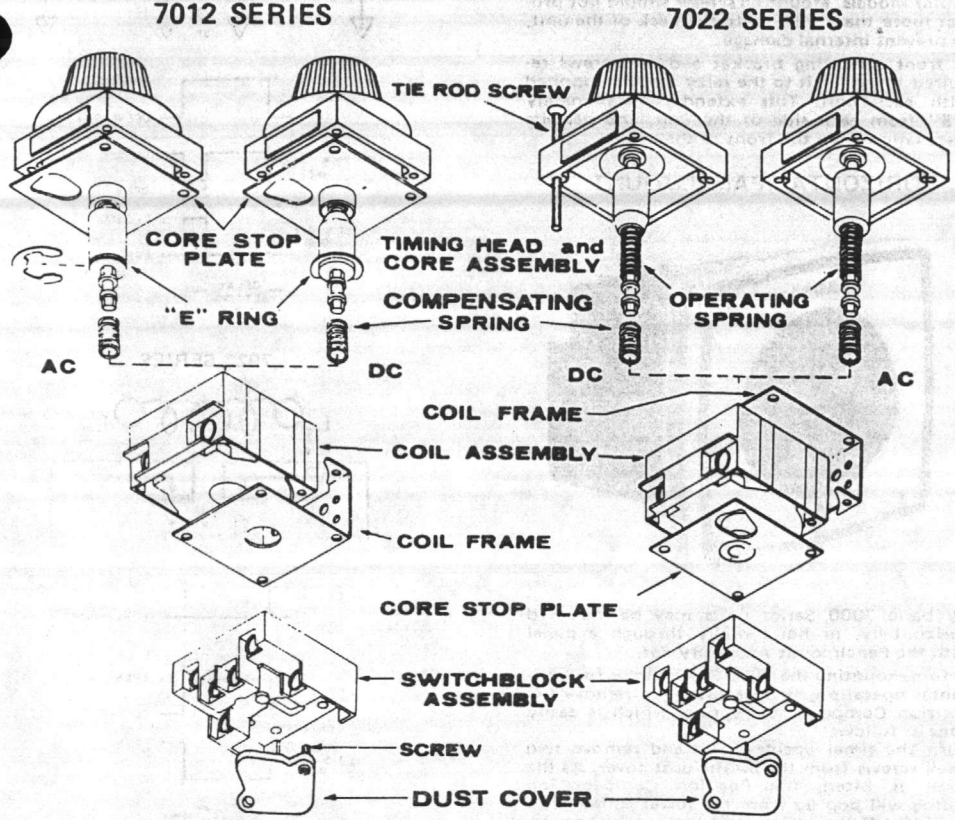
Minimum operating voltages are based on vertically mounted 7012 (on-delay) units. 7012 horizontally mounted or 7022 (off-delay) vertically or horizontally mounted units will operate satisfactorily at minimum voltages approximately 5% lower than those listed.

A C units drop out at approximately 50% of rated voltage. D C units drop out at approximately 10% of rated voltage.

All units may be operated on intermittent duty cycle at voltages 10% above the listed maximums. (Intermittent duty—maximum 50% duty cycle and 30 minutes "on" time.)

REPLACING SWITCHBLOCK AND COIL ASSEMBLIES – MODEL 7012 AND 7022

Switchblock assemblies are universally interchangeable between all standard 7000 Series units. The same assembly is used for A C and D C models for delay on pull-in or delay on dropout service. Neither timing head/core assembly nor coil assembly is interchangeable between A C and D C models.



TIMING RANGES

A	.1 to 1 sec.	F	1 to 10 min.
B	.5 to 5 sec.	H	3 to 30 min.
C	1.5 to 15 sec.	I	6 to 60 min
D	5 to 50 sec.	J	3 to 120 cyc.
E	20 to 200 sec.	K	1 to 300 sec.

Dials are calibrated in time increments covering the range selected. In addition, time-calibrated ranges B through K, provide non-linear adjustment from .2 second to the beginning of the linear zone. For easiest adjustment and lowest cost, the shortest time range suitable for the application should be selected.

CONTACT RATINGS

Contact Capacity in Amperes (Resistive Loads)

Contact Voltage	Min. 100,000 Operations	Min. 1,000,000 Operations
30 vdc	15.0	7.0
110 vdc	1.0	0.5
120 v 60 cps	20.0	15.0
240 v 60 cps	20.0	15.0
480 v 60 cps	12.0	10.0

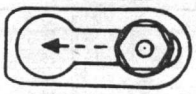
Inductive and capacitive loads should not have inrush currents that exceed five times normal operating load.

Contact rating is UL listed at 120/240 V.A.C., ¼ H.P., 10 A. Resistive; 600 V.A.C., 5A; 30 V.D.C., 15A.

REMOVING SWITCHBLOCK

1. Remove four tie rod screws.
2. Hold timing head and coil assembly in one hand, switchblock in the other.
3. Slide switchblock 1/2" forward of coil assembly to center spindle in large end of keyhole slot in switch blade. (See diagram A).
4. Slowly lift timing head and coil assembly off switchblock, being careful to keep spindle collar away from switchblade while withdrawing it.

REVERSE THIS PROCEDURE TO INSTALL NEW SWITCHBLOCK.



A

REMOVING COIL

Follow steps 1 to 4 above, then:

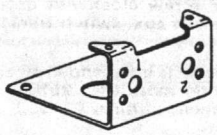
Remove timing head and core assembly. (On Model 7022 units the core stop plate and operating spring are loose pieces, located below the core rather than attached to the timing head and core assembly, as on the Model 7012 units. These two pieces should be removed before removing the coil frame, to prevent loss of the loose spring.)

7012 models require removal of "E" ring from core to permit removing core from coil.

6. Slide off coil frame.

When installing new coil, be sure to replace coil frame with proper side up. Number "1" on back of frame should be up on 7012 (Delay on Pull-in) Models, Number "2" should be up on 7022 (Delay on Drop-out) Models. See Diagram B.

On 7012 models, replace "E" ring in core slot after assembling coil frame to coil.



B

REPLACEMENT ASSEMBLIES

	Part No.
AC Coil Assembly	2400- *
DC Coil Assembly	2410- *
Switchblock Assembly	2412-30
Auxiliary Switch Kit (Code L)	7000-47
Auxiliary Switch Kit (Code T)	2412-121

* Specify voltage with code letter

WARRANTY

The AGASTAT timing relay is warranted against mechanical and electrical defects for a period of one year from date of shipment from factory if it has been installed and used in accordance with factory recommendations. New parts will be furnished free of charge in exchange for parts which have proven defective. The furnishing of these parts shall constitute fulfillment of the Company's obligations and liabilities.

CONTROL PRODUCTS DIVISION

Amerace Corporation
Control Products Division
2330 Vauxhall Road
Union, New Jersey 07083

SR-30

June 1972

Printed in U.S.A.

U.L. MINIMUM ACCEPTABLE SPACINGS FOR OPEN-TYPE TRANSFER SWITCHES

MINIMUM ACCEPTABLE SPACINGS IN INCHES

Potential Involved in Volts		Power Circuits Rated 400 Amperes Maximum and Control Circuits		
		51-150	151-300	301-600
Between any uninsulated live part and an uninsulated live part of opposite polarity	Through Air or Oil	1/8 [a]	1/4	3/8
	Over Surface	1/4	3/8	1/2
Between any uninsulated live part and an uninsulated grounded part other than the enclosure or exposed metal part	Through Air or Oil	1/8 [a]	1/4	3/8
	Over Surface	1/4	3/8	1/2
Between any uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable [b]	Shortest Distance	1/2	1/2	1/2

Potential Involved in Volts		Power Circuits Rated Over 400 Amperes		
		51-150	151-300	301-600
Between any uninsulated live part and an uninsulated live part of opposite polarity	Through Air or Oil	1/2	3/4	1
	Over Surface	3/4	1-1/4	2
Between any uninsulated live part and an uninsulated grounded part, exposed metal part, or the walls of a metal enclosure, including fittings for conduit or armored cable [b]	Through Air or Oil	1/2	1/2	1 [c]
	Over Surface	1/2	1/2	1

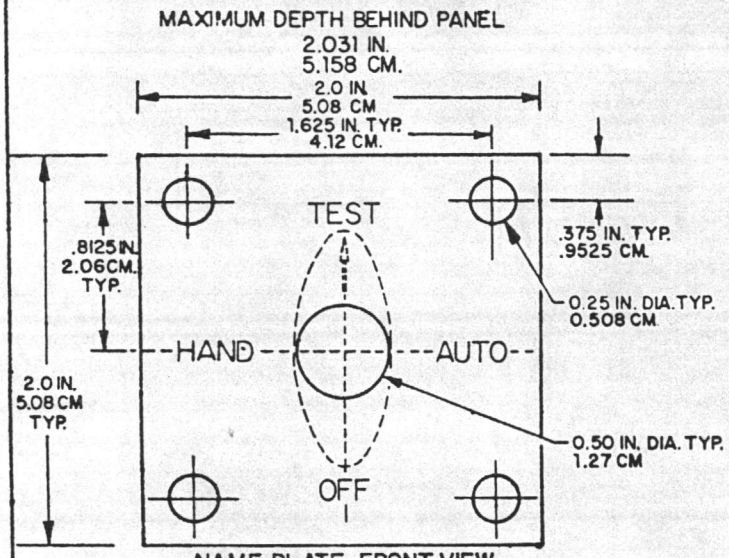
[a] The spacing between wiring terminals of opposite polarity and the spacing between a wiring terminal and a grounded part shall not be less than 1/4 inch if short-circuiting or grounding of such terminals may result from projecting strands of wire.

[b] For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce spacings between the metal piece and uninsulated live parts.

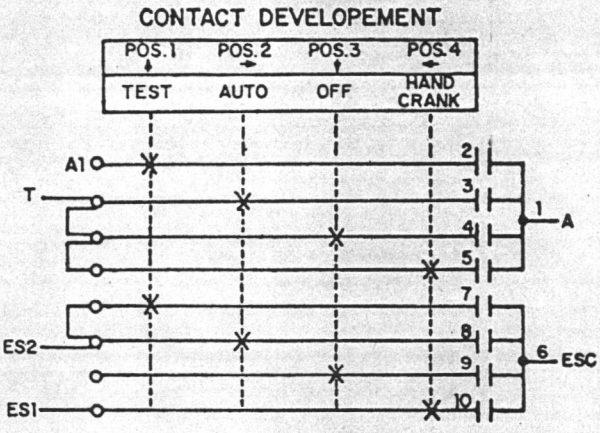
[c] A through-air spacing of not less than 1/2 inch is acceptable (1) at the main terminals, and (2) between grounded dead metal and the neutral of a 277/480 volt, 3 phase, four wire transfer switch.

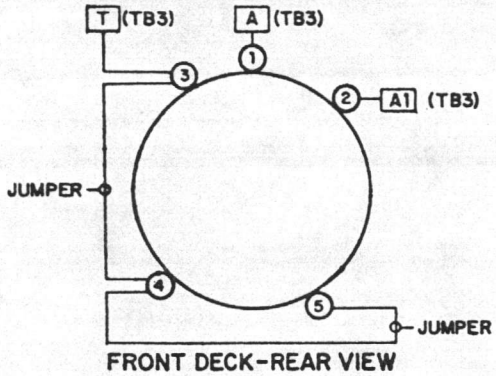
NOTE: ALL "RUSSELECTRIC" OPEN-TYPE AUTOMATIC TRANSFER SWITCHES ARE SUITABLE FOR USE IN UNVENTILATED ENCLOSURES, PROVIDED THE ENCLOSURES COMPLY WITH U.L. STANDARD 508

FOUR POSITION SELECTOR SWITCH (ACC. 12)

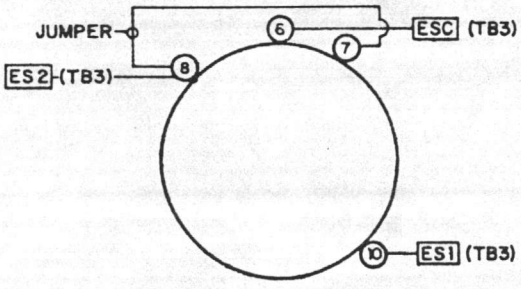


NAME PLATE-FRONT VIEW
AND PANEL DRILLING DETAIL





FRONT DECK-REAR VIEW



REAR DECK-REAR VIEW

INSTALLATION INSTRUCTIONS

1. MOUNT SWITCH IN POSITION SHOWN (REAR VIEW)
2. INSTALL NAMEPLATE AS SHOWN (FRONT VIEW)
3. CONNECT JUMPERS AS SHOWN
4. CONNECT WIRES ESC, ES1, ES2, A, T, & A1 AS SHOWN TO ATS TERMINAL BLOCK TB3

NOMENCLATURE

AUTO - TRANSFER SWITCH WILL START GENERATOR AND TRANSFER UPON NORMAL POWER FAILURE
OFF - ENGINE START SIGNAL DISCONNECTED
HAND - MANUAL STARTING OF ENGINE GENERATOR
TEST - SIMULATES NORMAL POWER FAILURE

ELECTRO SWITCH CAT # 101402A UL LISTED SWITCH

SWITCH RATINGS: 15A 120VAC, 10A 240VAC, 5A 480VAC

NAMEPLATE: BLACK MICARTA ENGRAVED WITH WHITE CORE OR BRASS NAMEPLATE # R-1A-508 ITEM 2

DIMENSIONS AS SHOWN

REF DWG R-1A-329A-1

Russelectric Inc.
SO. SHORE INDUSTRIAL PARK INDUSTRIAL PARK RD. HINGHAM, MASS.

ACCESSORY 12 INSTALLATION DIAGRAM

ESC NO.			
DFTM.		DWG. NO.	REV.
CHKD.			
APPD.		SHEET OF	

AUTOMATIC TRANSFER SWITCH
DUAL MOTOR TYPE RMTD

MANUAL OPERATION

WARNING: DANGEROUS VOLTAGES EXIST INSIDE THE AUTOMATIC TRANSFER SWITCH ENCLOSURE. AS WITH ALL ELECTRICAL EQUIPMENT EXTREME CARE MUST BE TAKEN WHEN OPENING AND ENTERING THESE SECTIONS.

If the automatic transfer switch fails to transfer from one source to the other due to a malfunction in the control circuitry, the switch can be manually operated to transfer the load to the other source.

All Russelectric Transfer Switches are equipped with safe manual operators. The quick break, quick make operation of the transfer switch contacts is independent of the speed of operation of the manual handle and allows maintenance personnel to accomplish safe manual transfers under all load conditions; energized or nonenergized. U.L. Standard 1008 requires that all manufacturers of transfer switches with internal manual operators provide the following markings on the switch enclosure: "WARNING — To reduce risk of electric shock or personal injury, disconnect all sources of supply before servicing".

TRANSFERRING EITHER DIRECTION

1. Open the door of the automatic transfer switch enclosure.

2a. MANUAL OPERATOR KNOB (100A THROUGH 1600A SWITCHES) - (See Figures 1 & 2) Using one hand, firmly push up or pull down as necessary on the manual operator knobs to first open the contacts that are closed, and then close the other set of contacts. NOTE: It may be necessary to rotate the tumbler mechanisms slightly so that the operating arms pivot past the on-center position.

2b. HAND CRANK MECHANISM (2000A THROUGH 4000A SWITCHES)

a. Insert the hand crank into the motor operator for the contacts that are closed. Rotate the hand crank in the direction shown on the motor operator nameplate until the contacts open, then remove the hand crank.

b. Insert the hand crank into the motor operator for the other set of contacts. Rotate the hand crank in the direction shown on the operator nameplate until the contacts close, then remove the hand crank.

3. Close the enclosure door and secure it.

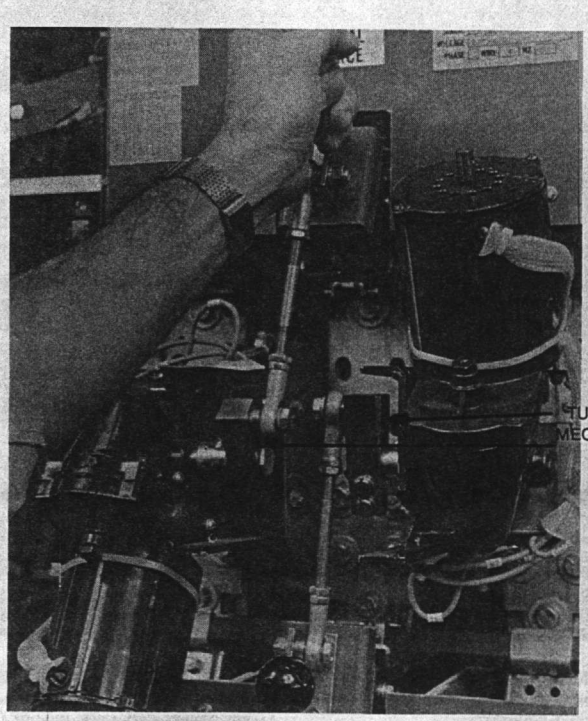


FIGURE 1
UPPER MANUAL OPERATOR KNOB
OPENING/CLOSING TOP CONTACTS

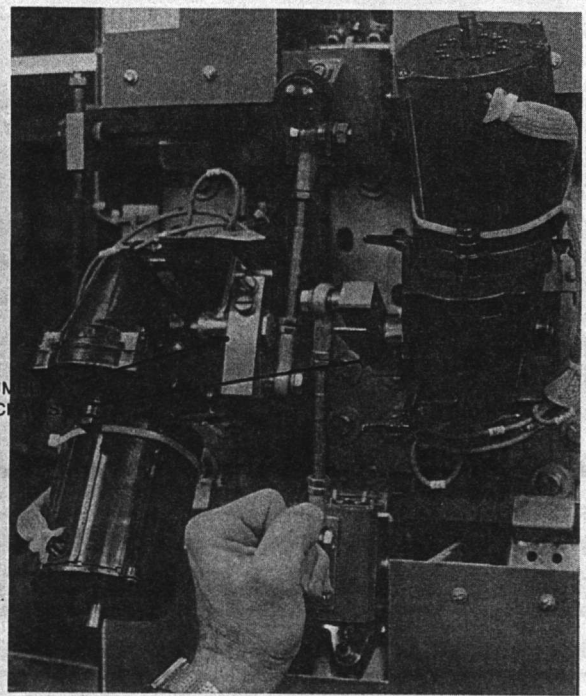


FIGURE 2
LOWER MANUAL OPERATOR KNOB
OPENING/CLOSING BOTTOM CONTACTS

AUTOMATIC TRANSFER SWITCH
SINGLE MOTOR TYPE RMT

MANUAL OPERATION

WARNING: DANGEROUS VOLTAGES EXIST INSIDE THE AUTOMATIC TRANSFER SWITCH ENCLOSURE. AS WITH ALL ELECTRICAL EQUIPMENT EXTREME CARE MUST BE TAKEN WHEN OPENING AND ENTERING THESE SECTIONS.

If the automatic transfer switch fails to transfer from one source to the other due to a malfunction in the control circuitry, the switch can be manually operated to transfer the load to the other source.

All Russelectric Transfer Switches are equipped with safe manual operators. The quick break, quick make operation of the transfer switch contacts is independent of the speed of operation of the manual handle and allows maintenance personnel to accomplish safe manual transfers under all load conditions; energized or nonenergized. U.L. Standard 1008 requires that all manufacturers of transfer switches with internal manual operators provide the following markings on the switch enclosure: "WARNING — To reduce risk of electric shock or personal injury, disconnect all sources of supply before servicing".

TRANSFERRING EITHER DIRECTION

1. Open the door to the automatic transfer switch enclosure.
2. MANUAL OPERATOR KNOB (100A THROUGH 1600A SWITCHES) - (See Figures 1 & 2) Place one hand on the manual operator handle and firmly push up or pull down as necessary to transfer the switch to the opposite position. NOTE: It may be necessary to rotate the tumbler mechanism slightly so that the operating arm pivots past the on-center position.
3. HAND CRANK MECHANISM (2000A THROUGH 4000A SWITCHES) - (See Figure 3) Insert the hand crank into the bottom of the motor operator. Rotate the hand crank in the direction shown on the motor operator nameplate until the switch transfers to the opposite position.
4. Close the enclosure door and secure it.

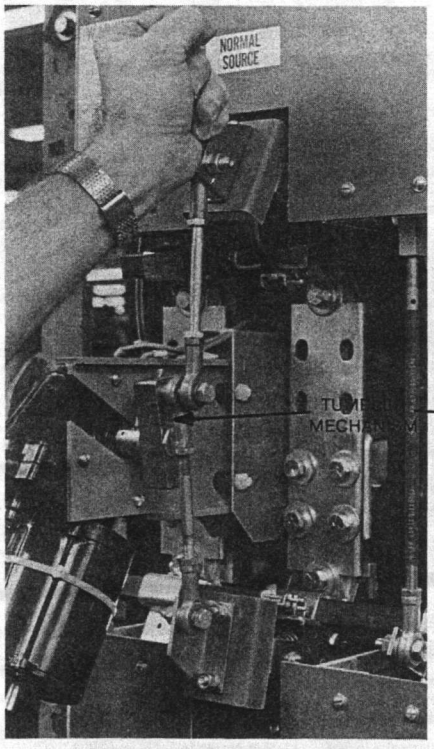


FIGURE 1
OPENING BOTTOM CONTACTS
CLOSING TOP CONTACTS

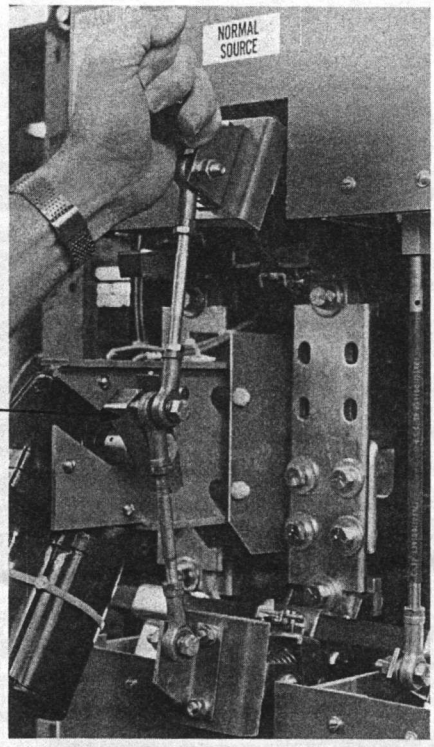


FIGURE 2
OPENING TOP CONTACTS
CLOSING BOTTOM CONTACTS

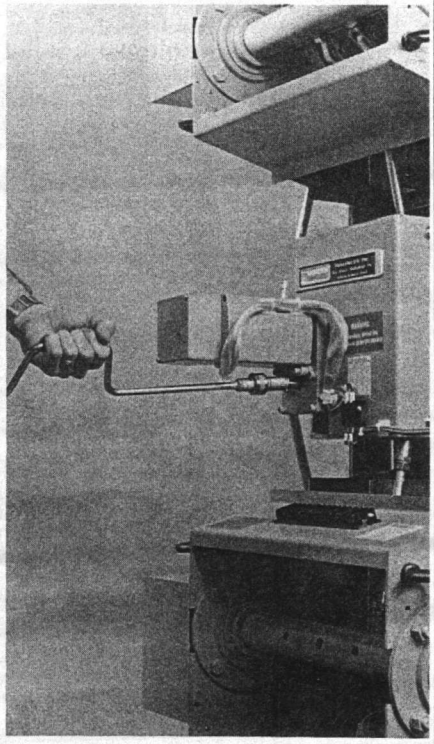


FIGURE 3
HAND CRANK MECHANISM
TRANSFERRING EITHER DIRECTION

SPECIFICATION SHEET

RUSSELECTRIC JOB NO.	13813
NAME OF JOB	CAMP LE JEUNE REPLACE AUXILIARY CAMP LE JEUNE, NORTH CAROLINA
CUSTOMER	GREGORY POOLE EQUIPMENT COMPANY RALEIGH, NORTH CAROLINA
CUSTOMER P.O. NUMBER	ED-04535

ITEM NUMBER	QUANTITY	MARKING
1	1	

DESCRIPTION

RUSSELECTRIC MODEL RTBD8004CEF DUAL MOTOR OPERATED AUTOMATIC TRANSFER SWITCH, RATED 800 AMPERES, FOR USE WITH A 120/240 VOLT AC 3-PHASE, 4-WIRE, 60HZ SERVICE, WITH A SWITCHED NEUTRAL AND A TWO-SOURCE BYPASS/ISOLATION SWITCH ARRANGED TO BYPASS THE LOAD TO EITHER THE NORMAL OR EMERGENCY SOURCE. BOTH UNITS ARE MOUNTED IN A NEMA 1 FREESTANDING ENCLOSURE WITH BARRIERED COMPARTMENTS, AND ARE COMPLETELY INTERCONNECTED AT THE FACTORY.

THE TRANSFER SWITCH PORTION INCLUDES ACCESSORIES AS ITEMIZED ON ACCESSORY LIST.

FOR GENERAL NOTES AND LEGEND REFER TO EDS-190 REV 0

FOR SCHEMATIC DIAGRAM REFER TO SHEET 2

FOR RELAY PLATE WIRING DIAGRAM REFER TO SHEET 3

FOR SWITCH BASE WIRING DIAGRAM REFER TO SHEET 4

FOR SCHEMATIC WIRING DIAGRAM OF THE TWO-SOURCE BYPASS/ISOLATION SWITCH REFER TO SHEET 5

FOR WIRING DIAGRAM FOR THE TWO-SOURCE BYPASS/ISOLATION SWITCH REFER TO SHEET 6

FOR DOOR WIRING DIAGRAM FOR THE TWO-SOURCE BYPASS/ISOLATION SWITCH REFER TO SHEET 7

FOR ACCESSORY LIST REFER TO SHEET 8

OTHER APPLICABLE DRAWINGS:

ENCLOSURE: 13813-1 SHEET 9

INSTALLATION:

REV. NO.	DESCRIPTION	DATE	BY

APPROVED	DATE	REV
MCG 1/17/86	07/15/86	0

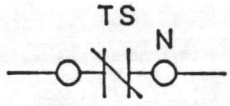
DWG. NO. 13813-1

SHEET 1 OF 9

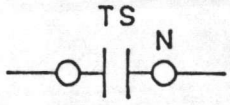
GENERAL NOTES - SCHEMATIC DIAGRAMS

1. ALL CONTACTS SHOWN WITH NORMAL AND EMERGENCY POWER DE-ENERGIZED.
2. DOTTED LINES INDICATE INTERNAL CONNECTIONS WITHIN MCB (MASTER CONTROL BOARD).
3. MCB (MASTER CONTROL BOARD) DWG. #MD-495 REV.4 (OR REV.4A FOR TWO UTILITY OPERATION)

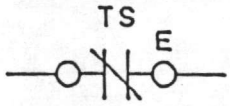
LEGEND



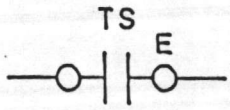
CONTACT ON NORMAL SHAFT CLOSED WHEN SWITCH IS IN NORMAL POSITION -- OPEN WHEN SWITCH IS IN EMERGENCY POSTION.



CONTACT ON NORMAL SHAFT OPEN WHEN SWITCH IS IN NORMAL POSITION -- CLOSED WHEN SWITCH IS IN EMERGENCY POSTION.

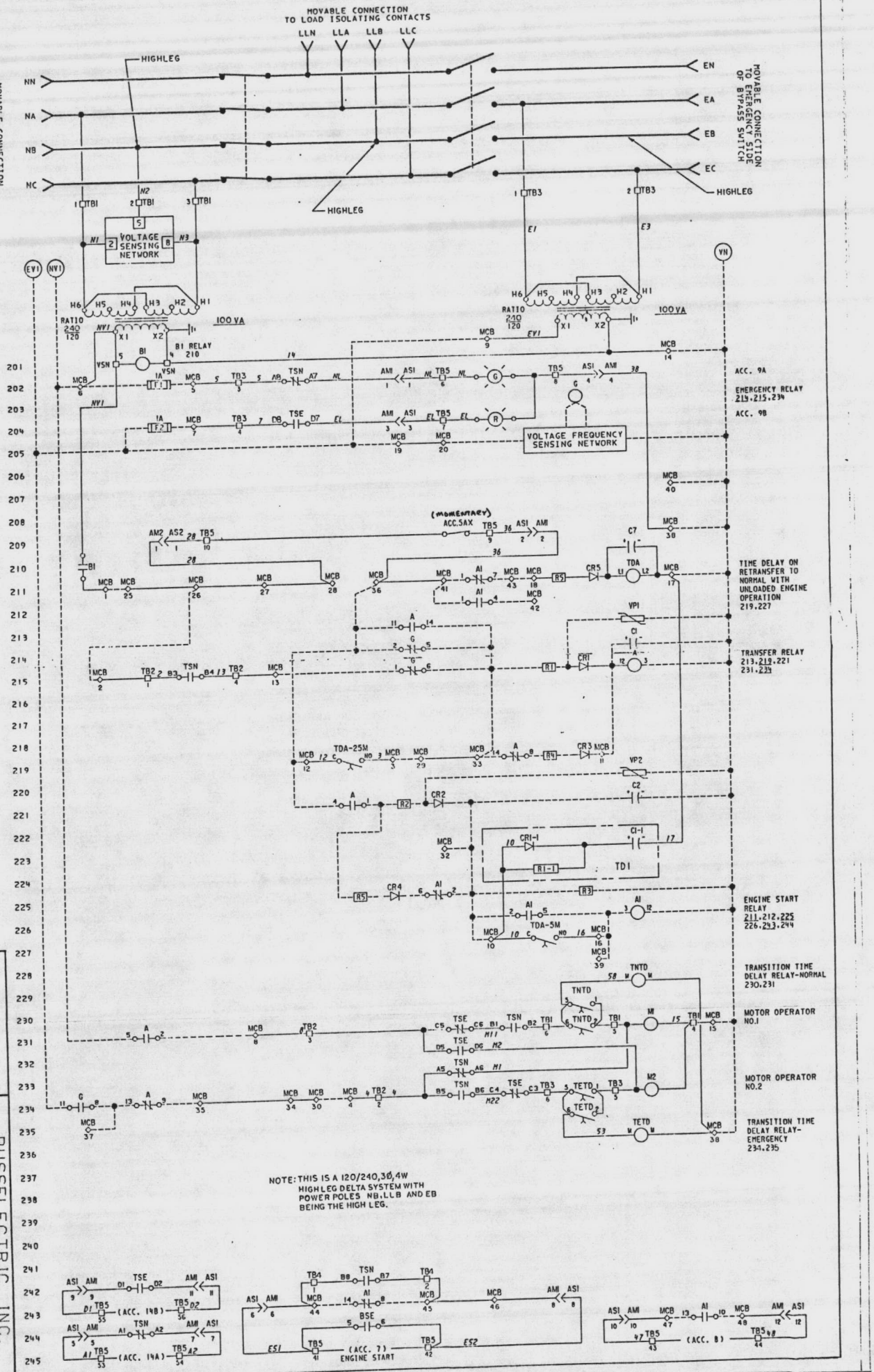


CONTACT ON EMERGENCY SHAFT CLOSED WHEN SWITCH IS IN NORMAL POSITION -- OPEN WHEN SWITCH IS IN EMERGENCY POSTION.



CONTACT ON EMERGENCY SHAFT OPEN WHEN SWITCH IS IN NORMAL POSITION -- CLOSED WHEN SWITCH IS IN EMERGENCY POSTION.

DATE	REV	APPROVED	ATS SCHEMATIC DIAGRAM	
02/25/85	0	MGR	GENERAL NOTES AND LEGEND	PAGE 1 OF 1



FOR GENERAL NOTES AND LEGEND SEE EGS-1-191

NOTE: THIS IS A 120/240,3Φ,4W HIGH LEG DELTA SYSTEM WITH POWER POLES NB,LLB AND EB BEING THE HIGH LEG.

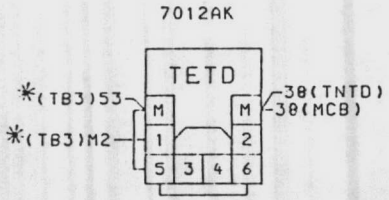
TITLE
SCHEMATIC DIAGRAM
4 POLE ATS
FOR USE WITH LOAD BREAK BYPASS SWITCH
100 - 1600A

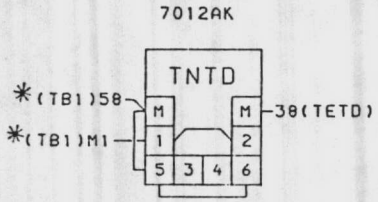
DFTM	[illegible]	7/16/96	DWG. NO.
CHKD	[illegible]	7/17/96	158131-1
APPD	[illegible]	7/17/96	SHEET NO. 2 CONTINUED SHEET NO. 3

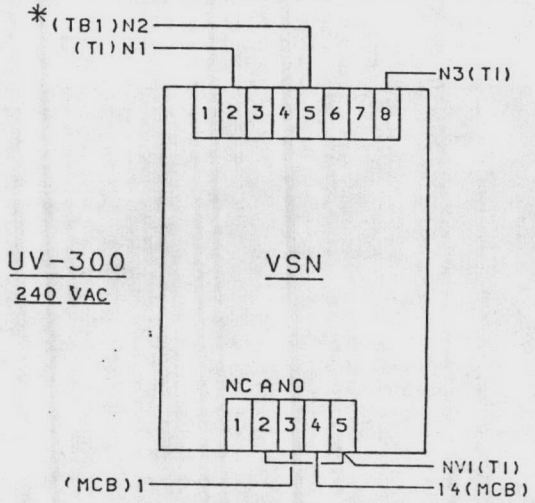
REV. 0

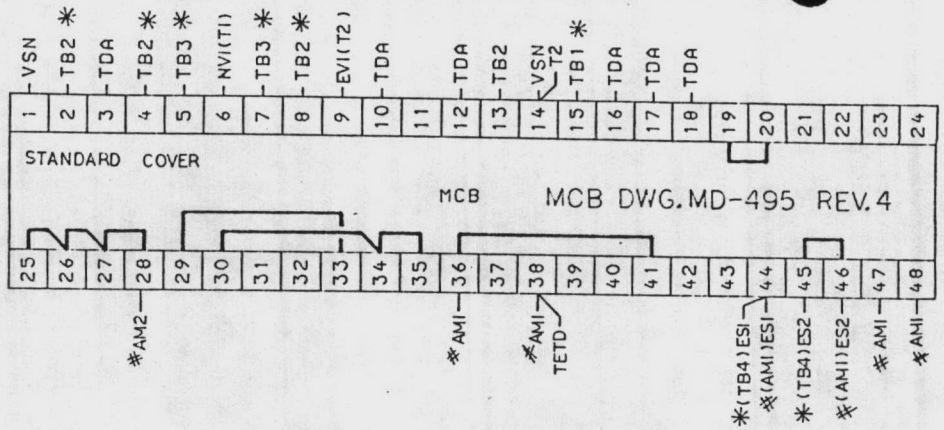
RUSSELECTRIC, INC.
99 INDUSTRIAL PARK ROAD, HINGHAM, MA. 02043

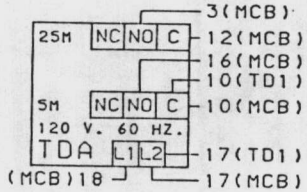
FILE NAME:

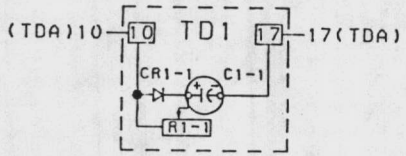


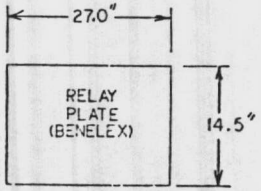




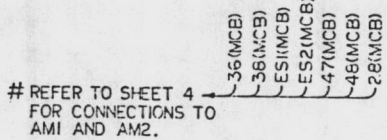


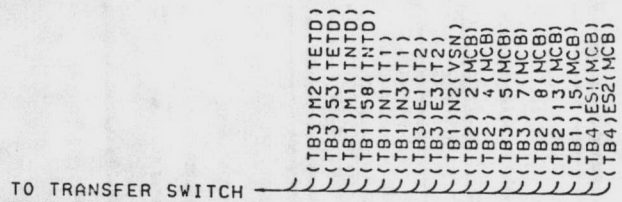






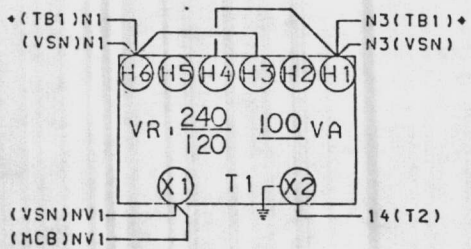
INSULATED MOUNTING PLATE. ALL METAL DEVICE CASES SHALL BE WIRED TO CASE GROUND. (WIRES MARKED 'GRD')

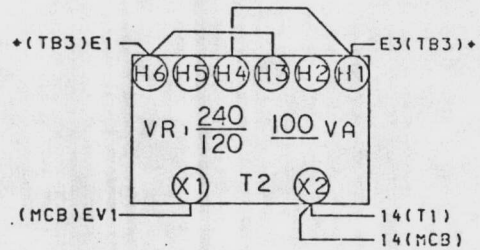




* DENOTES TERMINAL BLOCKS TB1, TB2, TB3, TB4 ARE LOCATED ON TRANSFER SWITCH BASE

NOTE: TRANSFORMERS MOUNTED SIDE BY SIDE ON REAR OF RELAY PLATE.



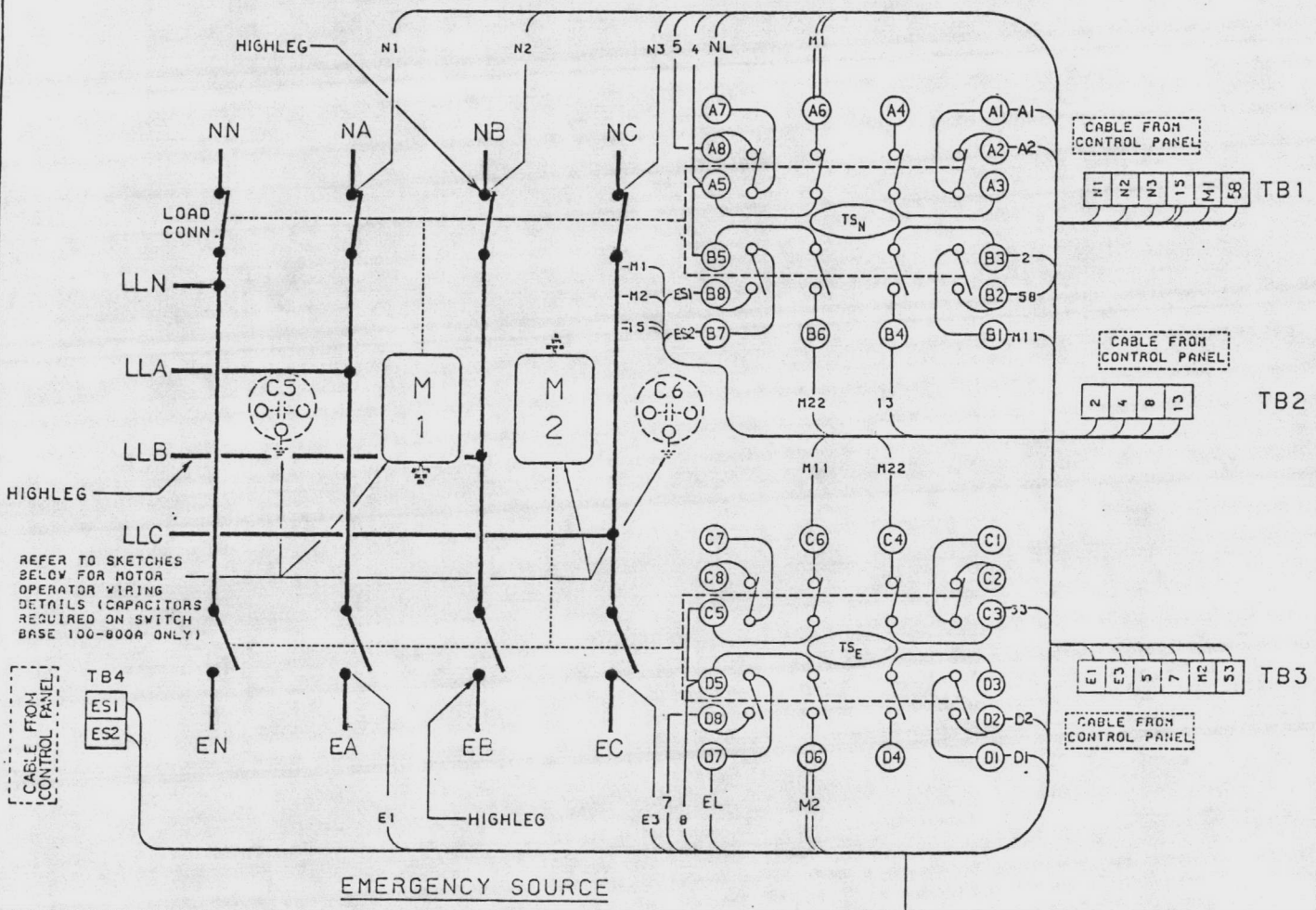


Russelectric Inc.
50. SHORE INDUSTRIAL PARK INDUSTRIAL PARK RD. HINGHAM, MASS.

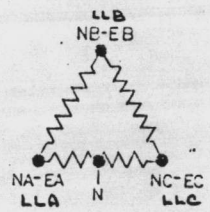
WIRING DIAGRAM — RELAY PLATE

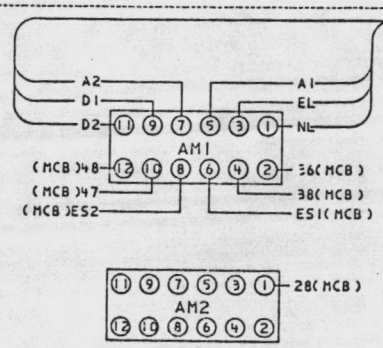
DFTM. 7/16/86		DWG. 13813-1	0
CHKD. 7/17/86		NO.	
APPD. 7/18/86		SHEET 3 OF 9	REV.

TRANSFER SWITCH SECTION

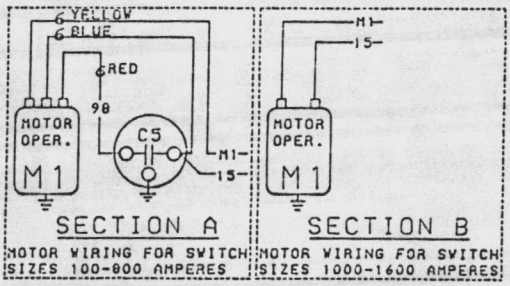


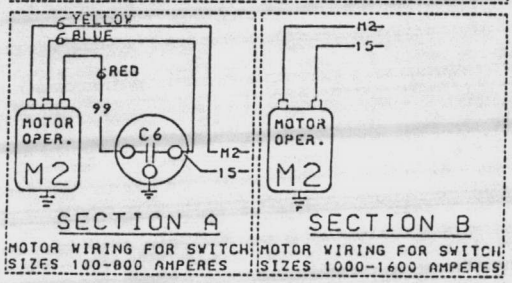
* SWITCH FOR USE WITH TWO-SOURCE BYPASS/ISOLATION SWITCH. TERMINAL CONFIGURATION ARRANGED FOR BUS CONNECTION STRAPS DESIGNED FOR THIS USE. (DRAW OUT TYPE)





MOTOR OPERATOR WIRING DETAILS





NOTE: FOR PHYSICAL DETAILS REFER TO DWG.* MC-434-23

ALL AUXILIARY CONTACTS ARE RATED 25A. AT 150VAC. RESISTIVE

LUG DATA		
STD	OTHER	
	NORMAL	*
	LOAD	*
	EMERGENCY	*
	NEUTRAL	*

TERMINAL CONFIGURATION		RMTD	SOC4CEF
		AMPERES	800
NORMAL	*REAR - TOP	VOLTS	120/240
		PHASE	3
LOAD	*REAR-MIDDLE	WIRE	4
		HERTZ	60
EMERGENCY	*REAR-BOTTOM	NEUTRAL	SWITCHED

RUSSELECTRIC INC.

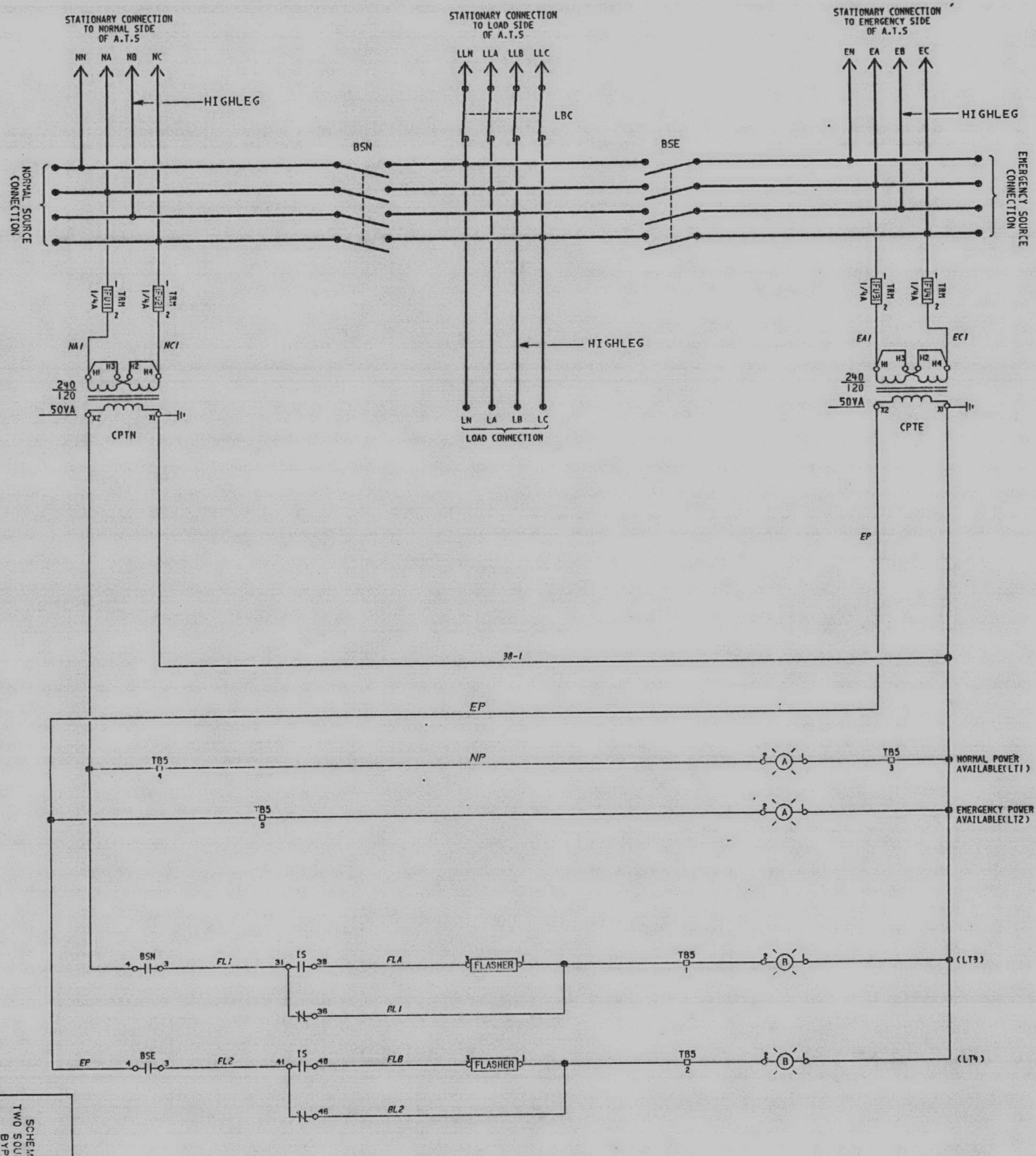
SO. SHORE INDUSTRIAL PARK INDUSTRIAL PARK RD., HINGHAM, MA.

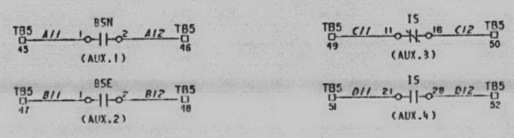
TRANSFER SWITCH WIRING DIAGRAM
100A-1600A

DFTM.	[illegible]	7/16/86	DWG. NO. 13813-1	0
CHKD.	MGR	7/17/86		
APPD.	MGR	7/17/86	SHEET 4 CONT'D ON SHEET 5	REV.

DWG.#-ATS4005-1

FILE/B40051





LT1-AMBER PILOT LIGHT-INDICATES NORMAL POWER AVAILABLE.
LT2-AMBER PILOT LIGHT-INDICATES EMERGENCY POWER AVAILABLE.
LT3-BLUE PILOT LIGHT
CONSTANT-INDICATES LOAD BYPASSED TO THE NORMAL SOURCE.ISOLATING CONTACTS CLOSED-TRANSFER SWITCH ENERGIZED.
FLASHING-INDICATES LOAD BYPASSED TO THE NORMAL SOURCE.ISOLATING CONTACTS OPEN-TRANSFER SWITCH BYPASSED AND ISOLATED.
LT4-BLUE PILOT LIGHT
CONSTANT-INDICATES LOAD BYPASSED TO THE EMERGENCY SOURCE.ISOLATING CONTACTS CLOSED-TRANSFER SWITCH ENERGIZED.
FLASHING-INDICATES LOAD BYPASSED TO THE EMERGENCY SOURCE.ISOLATING CONTACTS OPEN-TRANSFER SWITCH BYPASSED AND ISOLATED.
AUX.1-AUXILIARY CONTACT CLOSED WHEN SWITCH BYPASSED TO THE NORMAL SOURCE.
AUX.2-AUXILIARY CONTACT CLOSED WHEN SWITCH BYPASSED TO THE EMERGENCY SOURCE.
AUX.3-AUXILIARY CONTACT CLOSED WHEN ISOLATING CONTACTS CLOSED.
AUX.4-AUXILIARY CONTACT CLOSED WHEN ISOLATING CONTACTS OPEN.
ALL-AUXILIARY CONTACTS ARE RATED 25 AMP. AT 125VAC RESISTIVE.
CONTACTS SHOWN WITH BYPASS HANDLE AND ISOLATING HANDLE IN NORMAL POSITION.

TITLE
SCHEMATIC DIAGRAM
TWO SOURCE LOAD BREAK
BYPASS SWITCH
FOR USE IN RTB UNIT

RUSSELECTRIC, INC.
99 INDUSTRIAL PARK ROAD, HINGHAM, MA. 02043

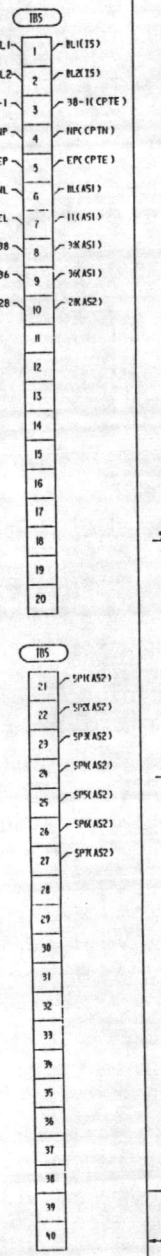
DFTM.	CHKD.	APPD.	DWG. NO.	REV.
96-07-18	7/17/96	7/17/96	13813-1	0

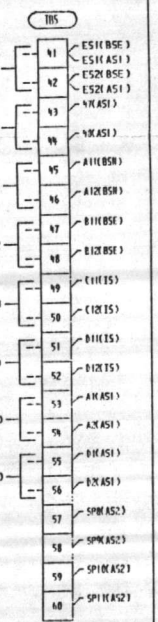
SHEET NO 5 CONT'D.ON SHEET NO. 6

RTB.MAS.4

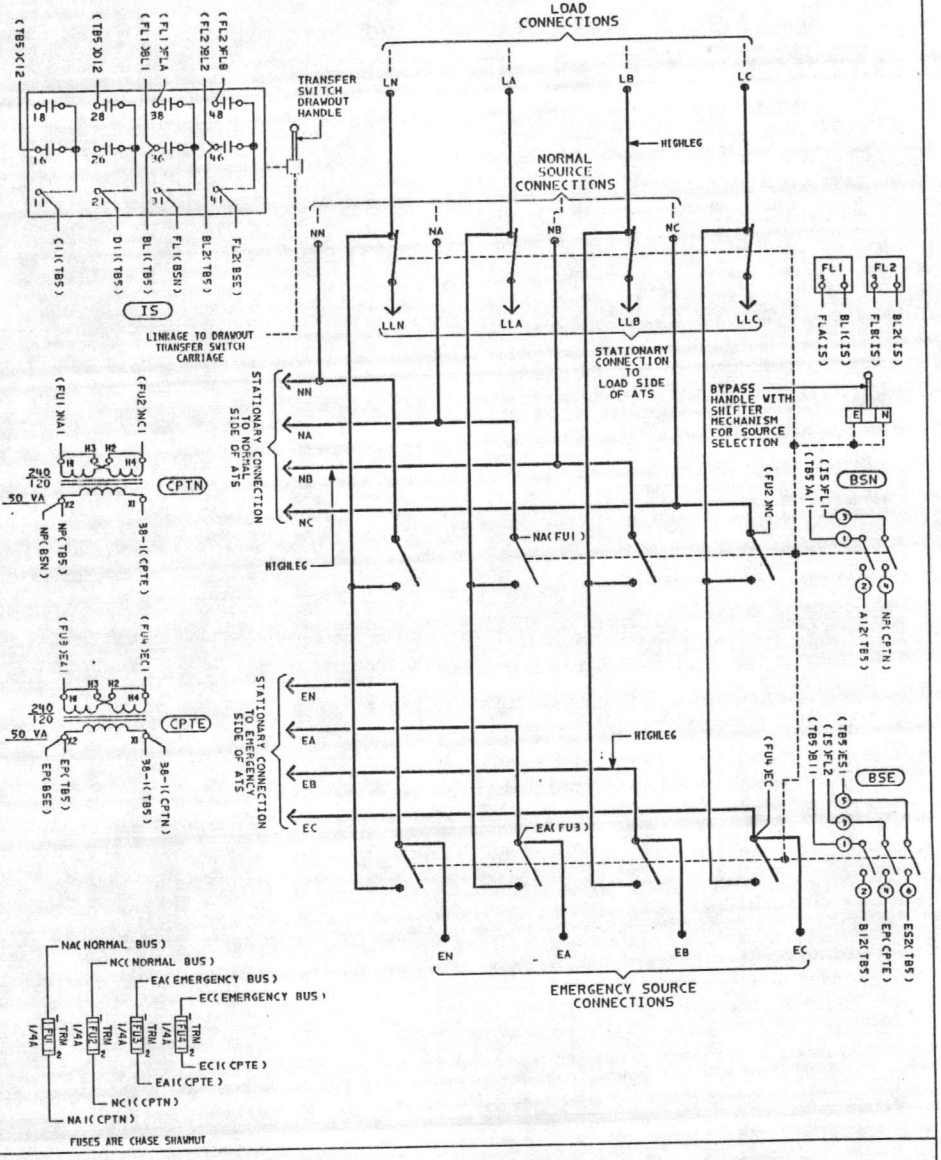
LEFT SIDE-FRONT BARRIER

WIRES TERMINATE ON DEVICES MOUNTED ON DOOR. SEE SHEET 7

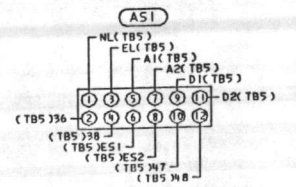




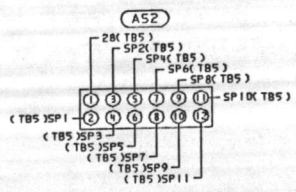
BYPASS SWITCH CUBICLE FRONT VIEW



MID BARRIER FRONT VIEW



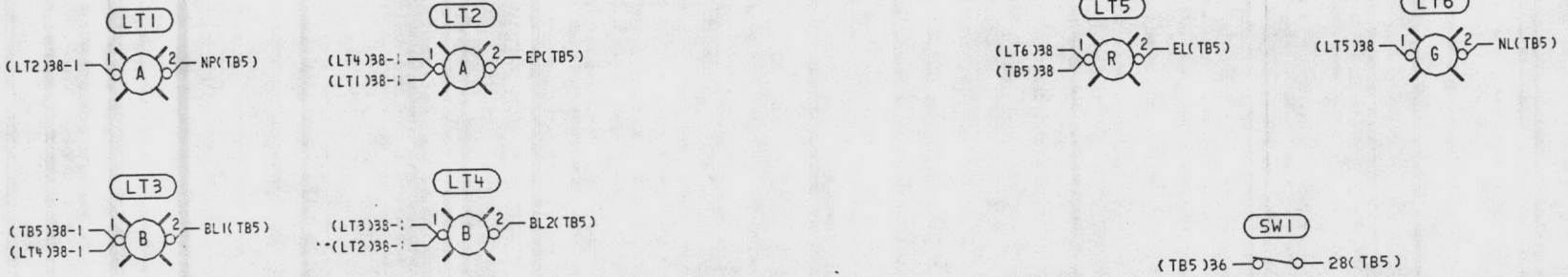
"AS" DEVICES ARE STATIONARY AUXILIARY PLUGS MOUNTED TO THE MID BARRIER AND MATE WITH "AM" AUXILIARY PLUGS MOUNTED ON REMOVABLE TRANSFER SWITCH CHASSIS.



TITLE: WIRING DIAGRAM TWO SOURCE LOAD BREAK BYPASS SWITCH FOR USE IN RTB UNIT

RUSSELECTRIC, INC. 99 INDUSTRIAL PARK ROAD, HINGHAM, MA. 02043

DFT'M	DWN	86-07-18	
CHK'D			
APP'D			
		DWG. NO.	13813-1
		SHEET NO 6 CONT'D ON SHEET NO. 7	
		REV.	0



ACCESSORY PLATE
(REAR VIEW)

DOOR
(REAR VIEW)

TITLE	RUSSELECTRIC, INC. 99 INDUSTRIAL PARK ROAD, HINGHAM, MA. 02043				
DOOR WIRING DIAGRAM	DFT'M.	BKM	86-07-15	DWG. NO. 13813-1	0
	CHK'D.	MGE	7/17/86		
	APP'D.	MGE	7/17/86	SHEET NO 7 CONT'D.ON SHEET NO. 8	REV.

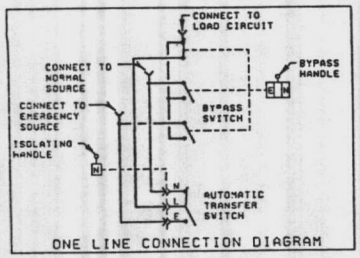
ACCESSORY LIST

ACC.NO.	FUNCTION	DEVICE
* DENOTES ACCESSORIES CONTAINED INTERNALLY IN MASTER CONTROL BOARD (MCB)		
STD	CLOSE DIFFERENTIAL SOLID STATE ADJUSTABLE VOLTAGE SENSING NETWORK ENERGIZED FROM NORMAL PHASE VOLTAGE, WITH RELAY B1 SET TO PICK UP AT 90% OF RATED VOLTAGE, DROP OUT AT 80%.	VSN
STD	TRANSFER RELAY ENERGIZED FROM NORMAL SOURCE.	A*
STD	ENGINE START CONTROL RELAY ENERGIZED FROM NORMAL SOURCE.	A1*
1d	TIME DELAY TO OVERRIDE MOMENTARY NORMAL SOURCE POWER OUTAGES TO DELAY ENGINE START SIGNAL AND TRANSFER SWITCH OPERATION. ADJUSTABLE 0.5-3 SECONDS, FACTORY SET AT 3 SECONDS.	TD-1
2d	TIME DELAY RELAYS TO CONTROL CONTACT TRANSITION TIME ON TRANSFER TO EITHER SOURCE, AIR DIAPHRAGM TYPE, ADJUSTABLE 1-300 SECONDS, FACTORY SET AT 3 SECONDS	TNTD TETD
3c	TIME DELAY ON RETRANSFER TO NORMAL. MOTOR DRIVEN TYPE, ADJUSTABLE 0-25 MINUTES, FACTORY SET AT 5 MINUTES. WITH ENGINE OVERRUN TO PROVIDE FIXED 5 MINUTE UNLOADED ENGINE OPERATION AFTER RETRANSFER TO NORMAL.	TDA
5ax	LOAD TEST SWITCH TO SIMULATE NORMAL POWER FAILURE. (MOMENTARY TYPE)	ACC.5ax
7	CONTACT TO CLOSE ON FAILURE OF NORMAL SOURCE TO INITIATE ENGINE STARTING OR OTHER CUSTOMER FUNCTIONS.	ACC.7
8	CONTACT TO OPEN ON FAILURE OF NORMAL SOURCE TO INITIATE ENGINE STARTING OR OTHER CUSTOMER FUNCTIONS.	ACC.8
9a	GREEN PILOT LIGHT TO INDICATE SWITCH IN NORMAL POSITION.	ACC.9a
9b	RED PILOT LIGHT TO INDICATE SWITCH IN EMERGENCY POSITION.	ACC.9b
14a	AUXILIARY CONTACT CLOSED IN NORMAL POSITION. QUANTITY OF 1 WIRED TO TERMINAL STRIP TB5 ON RTB FRAMEWORK.	ACC.14a
14b	AUXILIARY CONTACT CLOSED IN EMERGENCY POSITION. QUANTITY OF 1 WIRED TO TERMINAL STRIP TB5 ON RTB FRAMEWORK.	ACC.14b
21	RELAY TO PREVENT TRANSFER TO EMERGENCY UNTIL VOLTAGE AND FREQUENCY OF GENERATING PLANT HAVE REACHED 90% OF RATED VALUE.	G*

DWG. NO. 13813-1

APPROVED	DATE	REV
MGR 7/17/86	07/15/86	0

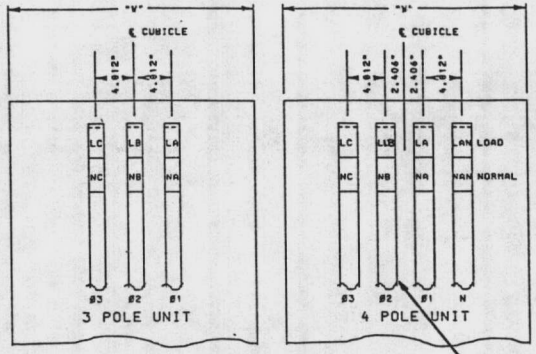
SHEET 8 OF 9



ONE LINE CONNECTION DIAGRAM

NOTES

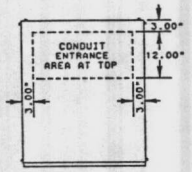
1. ENCLOSURES TO BE FABRICATED FROM FORMED CHANNEL FRAMEWORK WITH CODE GAUGE SHEET STEEL REMOVABLE SIDES AND REAR SHEETS. ALL STEEL PARTS SHALL BE PREPARED FOR PAINTING BY A FIVE STEP CLEANING, PHOSPHATIZING AND SEALING PROCESS. THE PARTS SHALL THEN BE PAINTED ASA #61 GRAY, UTILIZING POLYESTER POWDER COATING APPLIED BY THE ELECTROSTATIC METHOD AND CURED IN A BAKING OVEN. THIS FINISH IS SUITABLE FOR OUTDOOR, AS WELL AS INDOOR APPLICATIONS.
2. ALL CABLE CONNECTORS SHALL BE MECHANICAL TYPE SUITABLE FOR CU/AL CABLE. IF SIZES OTHER THAN THOSE SPECIFIED ARE REQUIRED, CONSULT FACTORY. ENCLOSURE SIZE MAY CHANGE.
3. SOLID NEUTRAL BAR PROVIDED WITH 3 POLE SWITCHES BEING USED IN A 3 PHASE 4 WIRE SYSTEM. 4 POLE SWITCHED NEUTRAL SWITCHES DO NOT REQUIRE A SOLID NEUTRAL.
4. ALL BUS SHALL BE PLATED COPPER.
5. UNIT IS SHIPPED AS TWO SEPARATE ITEMS WITH DRAWOUT ATS REMOVED FROM MAIN UNIT.
6. AUTOMATIC TRANSFER SWITCHES WITH EXTERNAL MANUAL OPERATOR REQUIRE COVER PLATE OVER THIS DEVICE. EXTERNAL MANUAL OPERATOR IS NOT FURNISHED UNLESS CALLED FOR IN ACCESSORY LIST FOR A GIVEN ORDER.



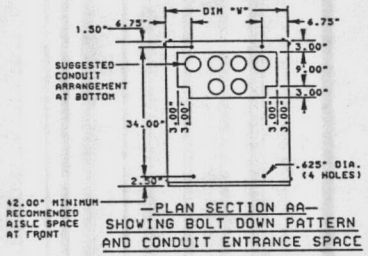
—PARTIAL REAR VIEWS—
SHOWING BUS MARKINGS
(CABLE CONNECTORS NOT SHOWN)

SCHEDULE

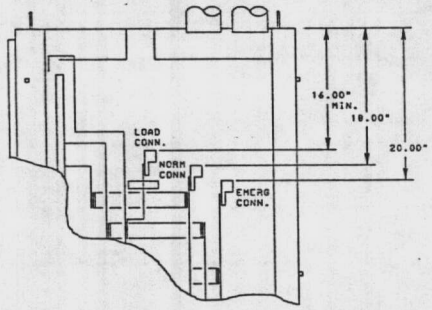
NO. OF POLES	SWITCH SIZE AMPS.	DIM. "W"	CABLE CONNECTION SIZE NORMAL, EMERGENCY & LOAD PER PHASE & NEUTRAL SEE NOTE NO.2	GROUND	ESTIMATED NET WEIGHT(LBS.)
3	400	32.00"	(1)#4-600 MCM OR (2)1/0-250 MCM	(1)#14-1/0	1550
3	600	32.00"	(2)#4-500 MCM	(2)#6-250 MCM	1600
3	800	32.00"	(2)#4-600 MCM OR (4)1/0-250 MCM	(2)#6-250 MCM	1650
4	400	36.00"	(1)#4-600 MCM OR (2)1/0-250 MCM	(1)#14-1/0	1650
4	600	36.00"	(2)#4-500 MCM	(2)#6-250 MCM	1700
4	800	36.00"	(2)#4-600 MCM OR (4)1/0-250 MCM	(2)#6-250 MCM	1750



—TOP VIEW—



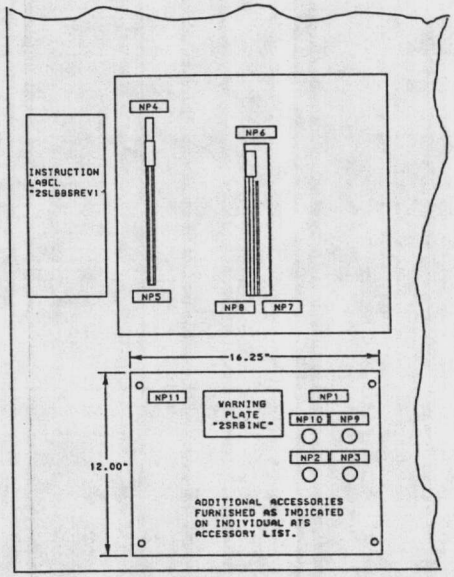
—PLAN SECTION AA—
SHOWING BOLT DOWN PATTERN
AND CONDUIT ENTRANCE SPACE



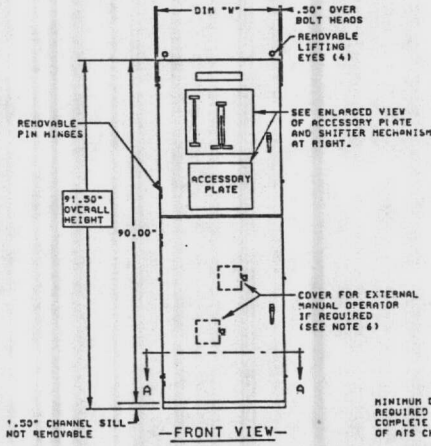
—ENLARGED VIEW—
BUS TAKE OFF DETAILS

NAMEPLATE LEGEND

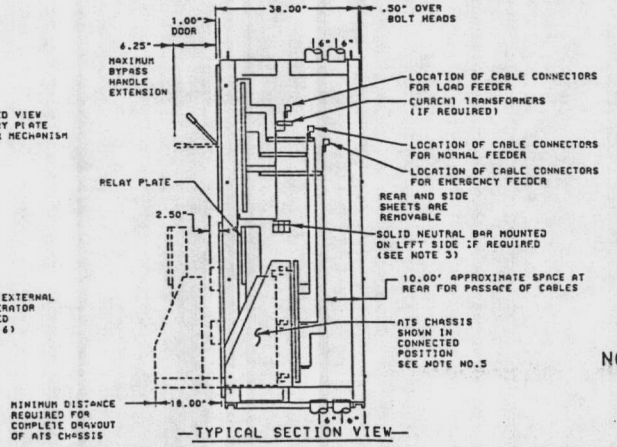
N.P. NO.	INSCRIPTION
NP1	BYPASS SWITCH
NP2	BYPASS TO EMERGENCY SUPPLY
NP3	BYPASS TO NORMAL SUPPLY
NP4	ISOLATING HANDLE NORMAL POSITION
NP5	ISOLATING HANDLE ISOLATING POSITION
NP6	BYPASS HANDLE NORMAL POSITION
NP7	BYPASS HANDLE BYPASS TO NORMAL SUPPLY
NP8	BYPASS HANDLE BYPASS TO EMERGENCY SUPPLY
NP9	NORMAL POWER AVAILABLE
NP10	EMERGENCY POWER AVAILABLE
NP11	AUTOMATIC TRANSFER SWITCH



—ENLARGED VIEW OF—
ACCESSORY PLATE AND SHIFTER MECHANISM



—FRONT VIEW—



—TYPICAL SECTION VIEW—

REAR OR SIDE ACCESS REQUIRED.
CONSULT FACTORY IF FRONT ACCESSIBLE ONLY.

NOTE: THIS IS A 120/240, 3Ø, 4W HIGHLEG DELTA SYSTEM WITH POWER POLES NB, LLB AND EB BEING THE HIGHLEG.

CERTIFIED DRAWING FOR:
CUSTOMER: GREGORY POOLE EQUIPTMENT CO.
INSTALLATION: CAMP LE JEUNE REPLACE AUX.
RUSSELECTRIC S.O. NO. 13813
ITEM NO. 1
SWITCH SIZE AND POLES 800A - 4POLE
ATS MODEL RMT OR (RMTD)
CERTIFIED BY: MGC DATE: 7/17/86

RUSSELECTRIC INC.
SO. SHORE INDUSTRIAL PARK INDUSTRIAL PARK RD. HINGHAM, MA.
TWO-SOURCE BY-PASS ISOLATION SWITCH
NEMA 1 ENCLOSURE TOP AND/OR BOTTOM CONDUIT ENTRANCE
400A THRU 800A 3P & 4P RMT OR (RMTD)
(REAR OR SIDE ACCESS)

DFTM. GM	7/16/86	DWG. NO. 13813-1		0
CHKD. MF	7/17/86			
APPD. MF	7/17/86	SHEET 9 OF 9		REV.

TB-D-1145-3 REV.2

FILE: T1'458-4