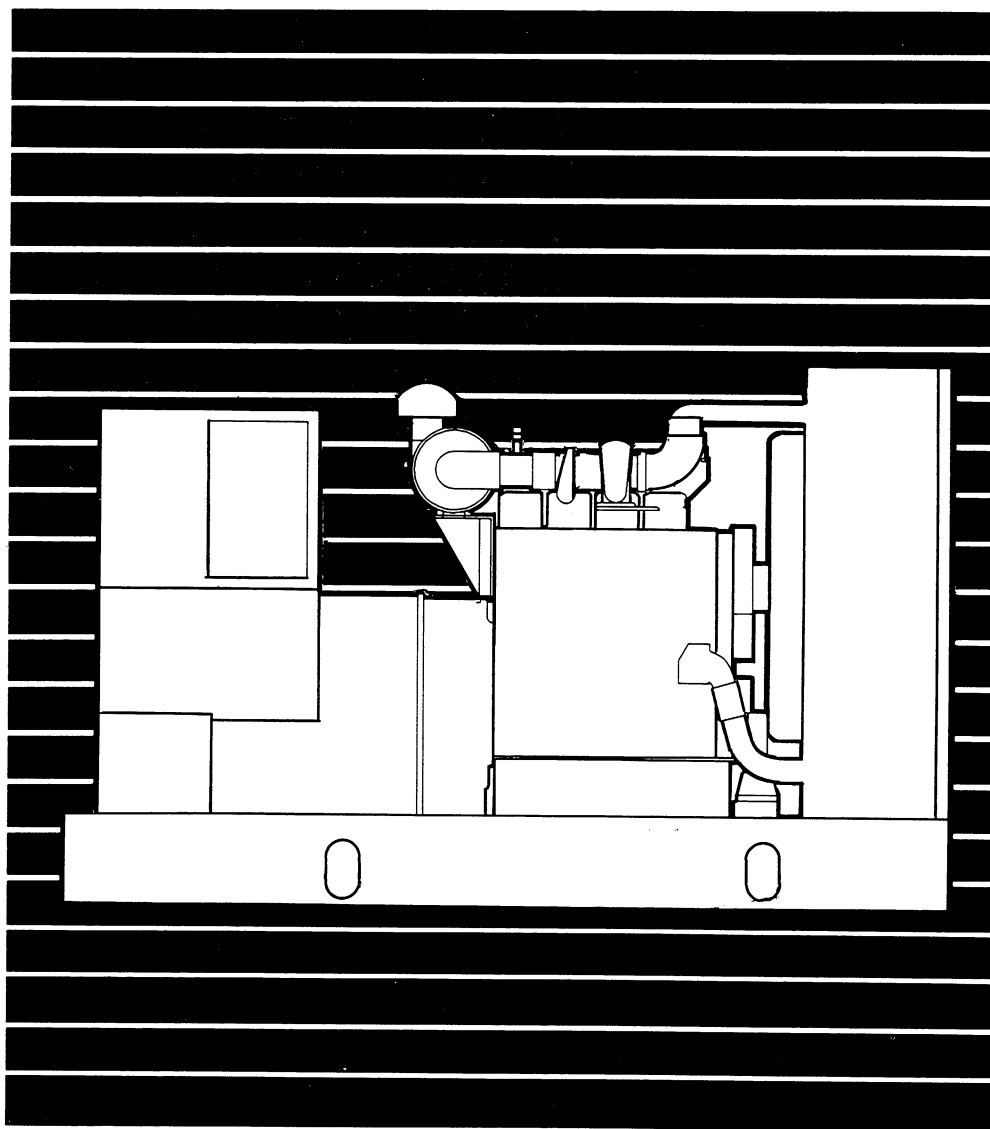




Service Manual Control and Generator

4BT3.9-GC, 6BT5.9-GC, 6CT8.3-GS/GC, 6CTA8.3-GS/GC GENERATOR SETS



Safety Precautions

Before operating the generator set, read the Operator's Manual and become familiar with it and the equipment. Safe and efficient operation can be achieved only if the equipment is properly operated and maintained. Many accidents are caused by failure to follow fundamental rules and precautions.

The following symbols, found throughout this manual, alert you to potentially dangerous conditions to the operator, service personnel, or the equipment.

⚠ DANGER *This symbol warns of immediate hazards which will result in severe personal injury or death.*

⚠ WARNING *This symbol refers to a hazard or unsafe practice which can result in severe personal injury or death.*

⚠ CAUTION *This symbol refers to a hazard or unsafe practice which can result in personal injury or product or property damage.*

FUEL AND FUMES ARE FLAMMABLE. Fire and explosion can result from improper practices.

- DO NOT fill fuel tanks while engine is running, unless tanks are outside the engine compartment. Fuel contact with hot engine or exhaust is a potential fire hazard.
- DO NOT permit any flame, cigarette, pilot light, spark, or other ignition source near the generator set or fuel tank.
- Fuel lines must be adequately secured and free of leaks. Fuel connection at the engine should be made with an approved flexible line. Do not use copper piping on flexible lines as copper will become brittle if continuously vibrated or repeatedly bent.
- Be sure all fuel supplies have a positive shutoff valve.
- Do not smoke while servicing lead acid batteries. Lead acid batteries emit a highly explosive hydrogen gas that can be ignited by electrical arcing or by smoking.

EXHAUST GASES ARE DEADLY

- Provide an adequate exhaust system to properly expel discharged gases. Visually and audibly inspect the exhaust daily for leaks per the maintenance schedule. Ensure that exhaust manifolds are secure and not warped. Do not use exhaust gases to heat a compartment.
- Be sure the unit is well ventilated.

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Keep your hands, clothing, and jewelry away from moving parts.
- Before starting work on the generator set, disconnect starting batteries, negative (-) cable first. This will prevent accidental starting.

- Make sure that fasteners on the generator set are secure. Tighten supports and clamps, keep guards in position over fans, drive belts, etc.
- Do not wear loose clothing or jewelry in the vicinity of moving parts, or while working on electrical equipment. Loose clothing and jewelry can become caught in moving parts. Jewelry can short out electrical contacts and cause shock or burning.
- If adjustment must be made while the unit is running, use extreme caution around hot manifolds, moving parts, etc.

ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Remove electric power before removing protective shields or touching electrical equipment. Use rubber insulative mats placed on dry wood platforms over floors that are metal or concrete when around electrical equipment. Do not wear damp clothing (particularly wet shoes) or allow skin surface to be damp when handling electrical equipment.
- Use extreme caution when working on electrical components. High voltages can cause injury or death. DO NOT tamper with interlocks.
- Follow all applicable state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician. Tag open switches to avoid accidental closure.
- DO NOT CONNECT GENERATOR SET DIRECTLY TO ANY BUILDING ELECTRICAL SYSTEM. Hazardous voltages can flow from the generator set into the utility line. This creates a potential for electrocution or property damage. Connect only through an approved isolation switch or an approved paralleling device.

GENERAL SAFETY PRECAUTIONS

- Coolants under pressure have a higher boiling point than water. DO NOT open a radiator or heat exchanger pressure cap while the engine is running. Allow the generator set to cool and bleed the system pressure first.
- Provide appropriate fire extinguishers and install them in convenient locations. Consult the local fire department for the correct type of extinguisher to use. Do not use foam on electrical fires. Use extinguishers rated ABC by NFPA.
- Make sure that rags are not left on or near the engine.
- Remove all unnecessary grease and oil from the unit. Accumulated grease and oil can cause overheating and engine damage which present a potential fire hazard.
- Keep the generator set and the surrounding area clean and free from obstructions. Remove any debris from the set and keep the floor clean and dry.
- Do not work on this equipment when mentally or physically fatigued, or after consuming any alcohol or drug that makes the operation of equipment unsafe.

Important Safety Precautions

Read and observe these safety precautions when using or working on electric generators, engines and related equipment. Also read and follow the literature provided with the equipment.

Proper operation and maintenance are critical to performance and safety. Electricity, fuel, exhaust, moving parts and batteries present hazards that can cause severe personal injury or death.

FUEL, ENGINE OIL, AND FUMES ARE FLAMMABLE AND TOXIC

Fire, explosion, and personal injury can result from improper practices.

- Used engine oil, and benzene and lead, found in some gasoline, have been identified by government agencies as causing cancer or reproductive toxicity. When checking, draining or adding fuel or oil, do not ingest, breathe the fumes, or contact gasoline or used oil.
- Do not fill tanks with engine running. Do not smoke around the area. Wipe up oil or fuel spills. Do not leave rags in engine compartment or on equipment. Keep this and surrounding area clean.
- Inspect fuel system before each operation and periodically while running.
- Equip fuel supply with a positive fuel shutoff.
- Do not store or transport equipment with fuel in tank.
- Keep an ABC-rated fire extinguisher available near equipment and adjacent areas for use on all types of fires except alcohol.
- Unless provided with equipment or noted otherwise in installation manual, fuel lines must be copper or steel, secured, free of leaks and separated or shielded from electrical wiring.
- Use approved, non-conductive flexible fuel hose for fuel connections. Do not use copper tubing as a flexible connection. It will work-harden and break.

EXHAUST GAS IS DEADLY

- Engine exhaust contains carbon monoxide (CO), an odorless, invisible, poisonous gas. Learn the symptoms of CO poisoning.
- Never sleep in a vessel, vehicle, or room with a genset or engine running unless the area is equipped with an operating CO detector with an audible alarm.
- Each time the engine or genset is started, or at least every day, thoroughly inspect the exhaust system. Shut down the unit and repair leaks immediately.

- Warning: Engine exhaust is known to the State of California to cause cancer, birth defects and other reproductive harm.

Make sure exhaust is properly ventilated.

- Vessel bilge must have an operating power exhaust.
- Vehicle exhaust system must extend beyond vehicle perimeter and not near windows, doors or vents.
- Do not use engine or genset cooling air to heat an area.
- Do not operate engine/genset in enclosed area without ample fresh air ventilation.
- Expel exhaust away from enclosed, sheltered, or occupied areas.
- Make sure exhaust system components are securely fastened and not warped.

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not remove any guards or covers with the equipment running.
- Keep hands, clothing, hair, and jewelry away from moving parts.
- Before performing any maintenance, disconnect battery (negative [-] cable first) to prevent accidental starting.
- Make sure fasteners and joints are secure. Tighten supports and clamps, keep guards in position over fans, drive belts, etc.
- If adjustments must be made while equipment is running, use extreme caution around hot manifolds and moving parts, etc. Wear safety glasses and protective clothing.

BATTERY GAS IS EXPLOSIVE

- Wear safety glasses and do not smoke while servicing batteries.
- Always disconnect battery negative (-) lead first and reconnect it last. Make sure you connect battery correctly. A direct short across battery terminals can cause an explosion. Do not smoke while servicing batteries. Hydrogen gas given off during charging is explosive.
- Do not disconnect or connect battery cables if fuel vapors are present. Ventilate the area thoroughly.

DO NOT OPERATE IN FLAMMABLE AND EXPLOSIVE ENVIRONMENTS

Flammable vapor can be ignited by equipment operation or cause a diesel engine to overspeed and become difficult to stop, resulting in possible fire, explosion, severe personal injury and death. **Do not operate diesel equipment where a flammable vapor environment can be created by fuel spill, leak, etc., unless equipped with an automatic safety device to block the air intake and stop the engine.**

HOT COOLANT CAN CAUSE SEVERE PERSONAL INJURY

- Hot coolant is under pressure. Do not loosen the coolant pressure cap while the engine is hot. Let the engine cool before opening the pressure cap.

ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not service control panel or engine with unit running. High voltages are present. Work that must be done while unit is running should be done only by qualified service personnel.
- Do not connect the generator set to the public utility or to any other electrical power system. Electrocutation can occur at a remote site where line or equipment repairs are being made. An approved transfer switch must be used if more than one power source is connected.
- Disconnect starting battery (negative [-] cable first) before removing protective shields or touching electrical equipment. Use insulative mats placed on dry wood platforms. Do not wear jewelry, damp clothing or allow skin surface to be damp when handling electrical equipment.
- Use insulated tools. Do not tamper with interlocks.
- Follow all applicable state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician. Tag open switches to avoid accidental closure.
- With transfer switches, keep cabinet closed and locked. Only authorized personnel should have cabinet or operational keys. Due to serious shock hazard from high voltages within cabinet, all service and adjustments must be performed by an electrician or authorized service representative.

If the cabinet must be opened for any reason:

1. Move genset operation switch or Stop/Auto/Handcrank switch (whichever applies) to Stop.
2. Disconnect genset batteries (negative [-] lead first).
3. Remove AC power to automatic transfer switch. If instructions require otherwise, use extreme caution due to shock hazard.

MEDIUM VOLTAGE GENERATOR SETS (601V TO 15kV)

- Medium voltage acts differently than low voltage. Special equipment and training are required to work on or around medium voltage equipment. Operation and maintenance must be done only by persons trained and qualified to work on such devices. Improper use or procedures will result in severe personal injury or death.
- Do not work on energized equipment. Unauthorized personnel must not be permitted near energized equipment. Induced voltage remains even after equipment is disconnected from the power source. Plan maintenance with authorized personnel so equipment can be de-energized and safely grounded.

GENERAL SAFETY PRECAUTIONS

- Do not work on equipment when mentally or physically fatigued or after consuming alcohol or drugs.
- Carefully follow all applicable local, state and federal codes.
- Never step on equipment (as when entering or leaving the engine compartment). It can stress and break unit components, possibly resulting in dangerous operating conditions from leaking fuel, leaking exhaust fumes, etc.
- Keep equipment and area clean. Oil, grease, dirt, or stowed gear can cause fire or damage equipment by restricting airflow.
- Equipment owners and operators are solely responsible for operating equipment safely. Contact your authorized Onan/Cummins dealer or distributor for more information.

KEEP THIS DOCUMENT NEAR EQUIPMENT FOR EASY REFERENCE.

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Section 1. Introduction

ABOUT THIS MANUAL

This manual provides troubleshooting and repair information regarding the controls and generators used on the B and C series of generator sets. For further operation, service, and troubleshooting information regarding engine components, refer to support manuals specific to your generator set.

Study this manual carefully and observe all warnings and cautions. Be sure to review *Safety Precautions*, inside front cover. Using the generator set properly and following a regular maintenance schedule is important to obtain longer unit life, better performance, and safer operation.

For proper replacement parts identification, refer to appropriate parts manual supplied with unit.

Repair information in this manual for printed circuit board components other than fuses is not extensive; doing so requires well trained, qualified personnel with the proper equipment. Application of meters or hot soldering irons to printed circuit boards by other than qualified personnel can cause unnecessary and expensive damage. Repair of the printed circuit boards is not recommended except by the factory.

CAUTION *High voltage testing or high potential (or Megger) testing of generator windings can cause damage to solid state components. Isolate these components before testing.*

For any operation, maintenance, or troubleshooting information beyond the scope of this manual, refer to other manuals received with the unit, or contact your distributor.

TEST EQUIPMENT

Most of the test procedures in this manual can be performed with an AC/DC multimeter such as a Simpson Model 260 VOM or a digital VOM. Some other instruments to have available are:

- Battery Hydrometer
- Tachometer or Frequency Meter
- Jumper Leads
- Wheatstone Bridge or Digital Ohmmeter
- Variac
- Load Test Panel
- Megger or Insulation Resistance Meter

HOW TO OBTAIN SERVICE

Always give the complete Model and Serial number of the generator set as shown on the nameplate (Figure 1-1) when seeking additional service information or replacement parts. The nameplate is located on the side of the generator output box.

WARNING *Incorrect service or replacement of parts can result in severe personal injury or death, and/or equipment damage. Service personnel must be qualified to perform electrical and mechanical service. Read and follow Safety Precautions, inside front cover.*

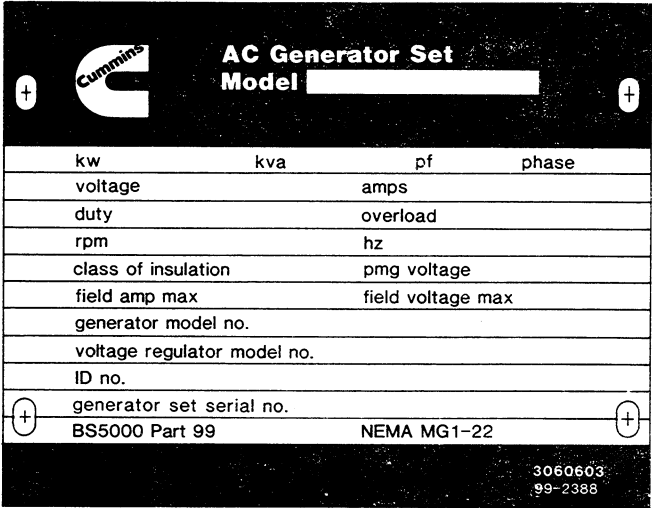


FIGURE 1-1. NAMEPLATE

CONTROLS AND GENERATORS OVERVIEW

General

Depending on the customer order, the control options and generator type may differ. Read through this manual to identify the control options, and generator type. A more in-depth description of the control and generator components follow in the *Controls* and *Generators* sections. Read this information well and understand the function of each component.

Also, periodically review this manual and the unit Operator's Manual when no fault condition is present. You will want to become familiar with the generator set component locations, their proper operation and interaction with other components in order to be effective troubleshooting a fault condition, if one occurs.

Control Panel

The control panel is mounted inside the front portion of the generator output box with vibration isolators on both top and bottom. The controls are separated into a DC panel for monitoring the engine and an AC panel for monitoring the generator. See Figure 1-2 and section 2.

Generator

The generators fitted to this series of generator sets are of two types; the standard non-PMG, and an optional Permanent Magnet Generator (PMG).

Both types of generators are controlled by an Automatic Voltage Regulator (AVR). The AVR's are of two types and are installed at the factory to match unit order. The AVR's are mounted on the inside, back wall of the control panel. The PMG generator can be identified by the Automatic Voltage Regulator used inside control panel. See Figure 1-2 and section 3.

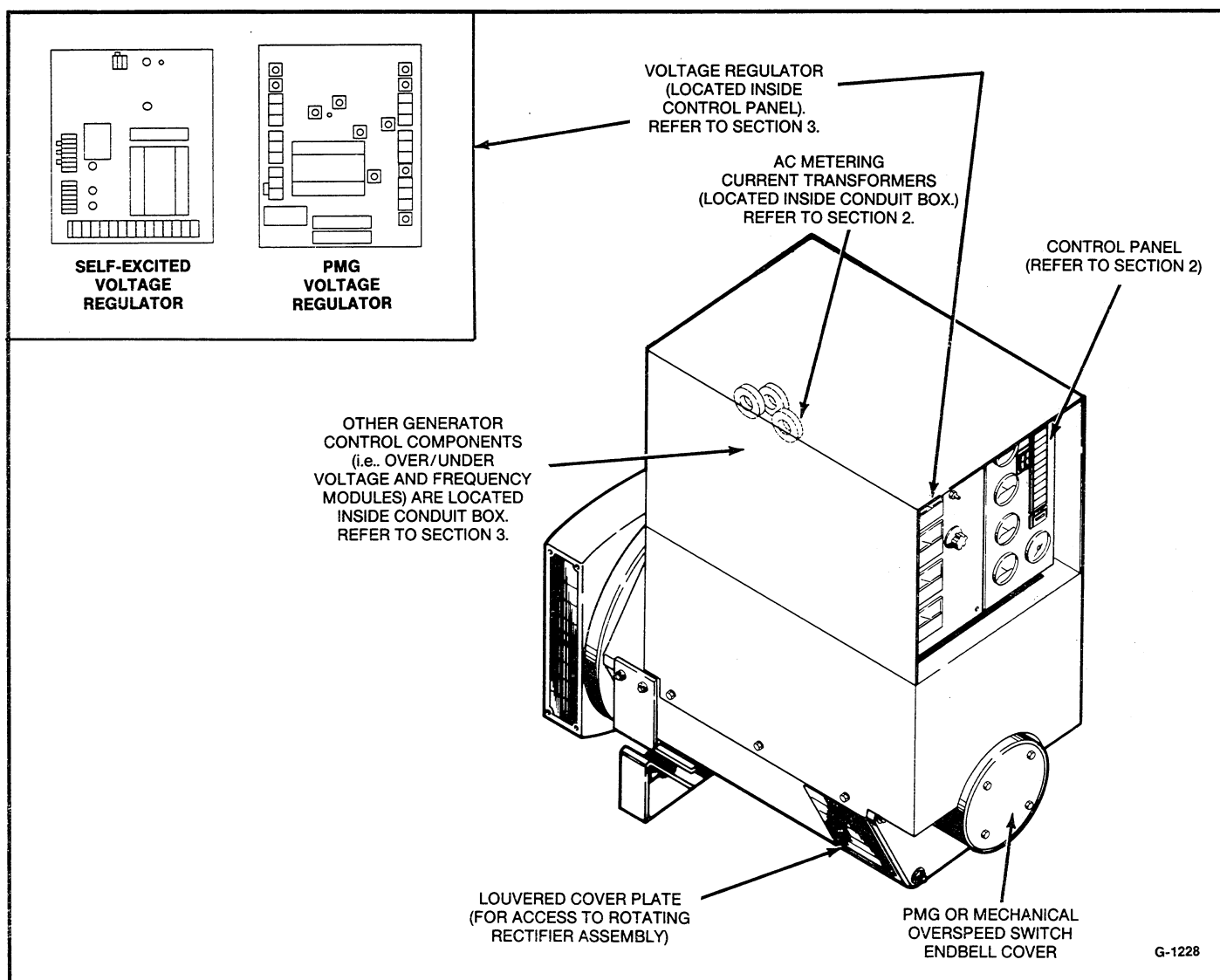


FIGURE 1-2. TYPICAL GENERATOR AND CONTROLS

Section 2. Controls

GENERAL

Depending on customer order, the control configuration and options may differ. This section identifies the control configurations used; Detector-7 and Detector-12 (NPFA) DC Panel, and AC Panel options.

The control panels are separated into an AC panel for monitoring the generator (if equipped with meter options), and a DC panel for monitoring the engine. Review Figure 2-1 to identify the control configuration and options, and refer to Control Descriptions that follow for further information.

CONTROL DESCRIPTIONS

AC Panel

The following describes the function and operation of the optional AC panel for monitoring the generator. Review the following component descriptions and Figure 1.

AC Voltmeter (Optional): Dual range instrument indicating generator AC voltage. Measurement range in use shown on indicator light.

AC Ammeter (Optional): Dual range instrument indicates AC generator line current. Measurement range in use shown on indicator lamps.

Frequency Meter (Optional): Indicates generator output frequency in hertz. It can be used to check engine speed (each hertz equals 30 r/min).

Wattmeter (Optional): Continuously gives reading of the generator output in kilowatts.

Voltage Adjust (Optional): Rheostat providing approximately plus or minus three percent adjustment of the rated output voltage.

Upper and Lower Scale Indicator Lamps (Optional): Indicates which scale to use on the AC voltmeter and AC ammeter.

Phase Selector Switch (Optional): Selects phases of generator output to be measured by AC voltmeter and AC ammeter.

Field Breaker (Optional): Provides generator exciter and regulator protection from overheating in the event of an overvoltage fault condition.

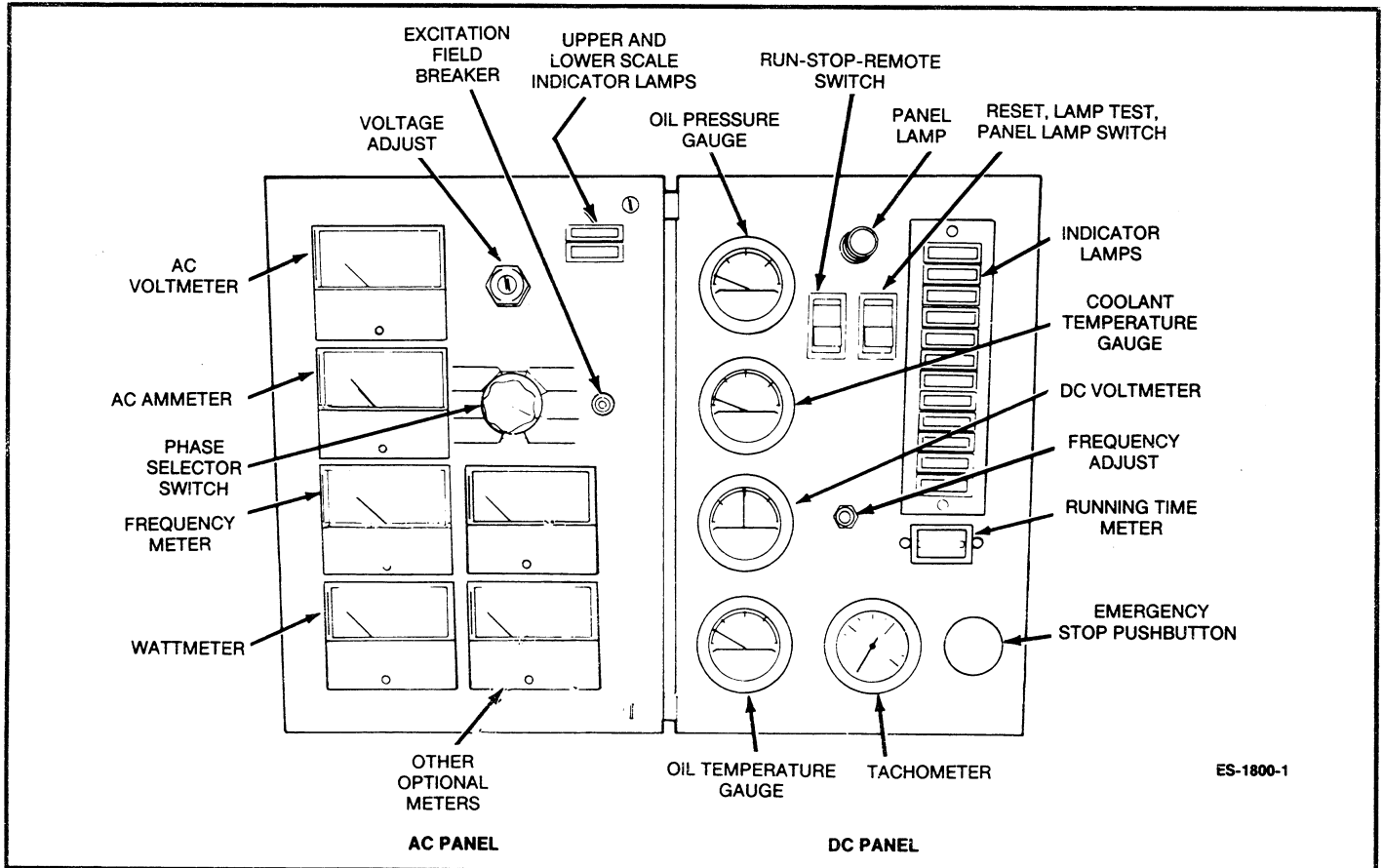


FIGURE 2-1. CONTROLS (Detector-12 and AC Meter Options Shown)

DC Panel

The following describes the function and operation of the DC panel components. The Detector-7 panel is standard, and the Detector-12 panel includes options to more effectively monitor the generator set and ancillary equipment during operation. Both controls include pre-alarm monitoring to inform the operator that a shutdown circumstance might occur if attention is not given to an aspect of engine operation soon. Review the following component descriptions and Figure 2-1.

Panel Lamp: Illuminates control panel.

Oil Pressure Gauge: Indicates pressure of lubricating oil in engine (wired to a sensor unit located on the engine).

Water Temperature Gauge: Indicates temperature of circulating coolant in engine (wired to a sensor unit located on the engine).

DC Voltmeter: Indicates the battery condition. Proper reading should be approximately 26 to 28 volts when set is running.

Tachometer (Optional): Provides constant monitoring of engine r/min.

Oil Temperature Gauge (Optional): Indicates temperature of lubricating oil in engine (wired to a sensor unit located on the engine).

Run-Stop-Remote Switch: Starts and stops the unit locally, or from a remote location that is wired to the control engine monitor board.

Reset, Lamp Test, Panel Lamp Switch: Resets the fault circuit only when the Run-Stop-Remote switch is in the Stop (Reset) position. Tests fault lamps and turns on the control panel lamp.

Frequency Adjust (Optional): Potentiometer providing engine speed adjustment to achieve proper AC frequency.

Running Time Meter: Registers the total number of hours the unit has run. Use it to keep a record of periodic servicing. Time is cumulative; meter cannot be reset.

Emergency Stop Pushbutton: Stops the generator set immediately when depressed. Must be reset (pulled out) before restarting generator set.

Indicator Lamps

Detector-7 Control (Standard): The standard control panel has seven monitor system indicator lamps.

- RUN (green)
- PRE LO OIL PRES (yellow)
- PRE HI ENG TEMP (yellow)
- LO OIL PRES (red)
- HI ENG TEMP (red)
- OVERCRANK (red)
- OVERSPEED (red)

The green Run lamp comes on as soon as both primary and secondary starter circuits are opened after unit starts. The yellow pre-alarm lamps indicate that engine oil pressure is marginally low, or coolant temperature is marginal high, and should be attended to when the generator set is shut down. The red fault lamps indicate a shutdown of the generator set for low pressure, high engine temperature, overspeed, or overcrank fault condition.

Detector-12 Control (Optional): The optional control panel has a 12 lamp monitor system. The following describes each lamp function.

- RUN (green) lamp comes on when both started circuits are opened after the unit starts.
- PRE LO OIL PRES (yellow) indicates engine oil pressure is marginally low.
- PRE HI OIL TEMP (yellow) indicates engine temperature is marginally high.
- LO OIL PRES (red) indicates engine has shut down because of critically low oil pressure.
- HI ENG TEMP (red) indicates engine has shut down because of critically high temperature.
- OVERSPEED (red) indicates the engine has shut down because of excessive speed.
- OVERCRANK (red) indicates the starter has been locked out because of excessive cranking time.
- FAULT 1 (red) an undedicated fault. May be programmed as a timed or non-timed shutdown or fault light only (normally factory set for timed shutdown).
- FAULT 2 (red) same features as Fault 1 (normally factory set for non-timed shutdown).
- LOW ENG TEMP (yellow) engine temperature is marginally low for starting. Indicates possible inoperative coolant heater. Lamp lights when engine water jacket temperature is 70° F (21° C) or lower. The lamp may stay on during initial generator set operation, but should extinguish after the engine warms up.
- LO FUEL (yellow) indicates fuel supply is marginally low (if equipped).
- SWITCH OFF (flashing red) indicates generator set is not in automatic start operation mode.

CONTROL PANEL INTERIOR

Refer to Figure 2-2 for component locations inside control panel. Review the following component descriptions to better understand the operation of the generator set should a fault condition occur. Also refer to section 5, *Component Tests and Adjustments*, for more in-depth information about these components.

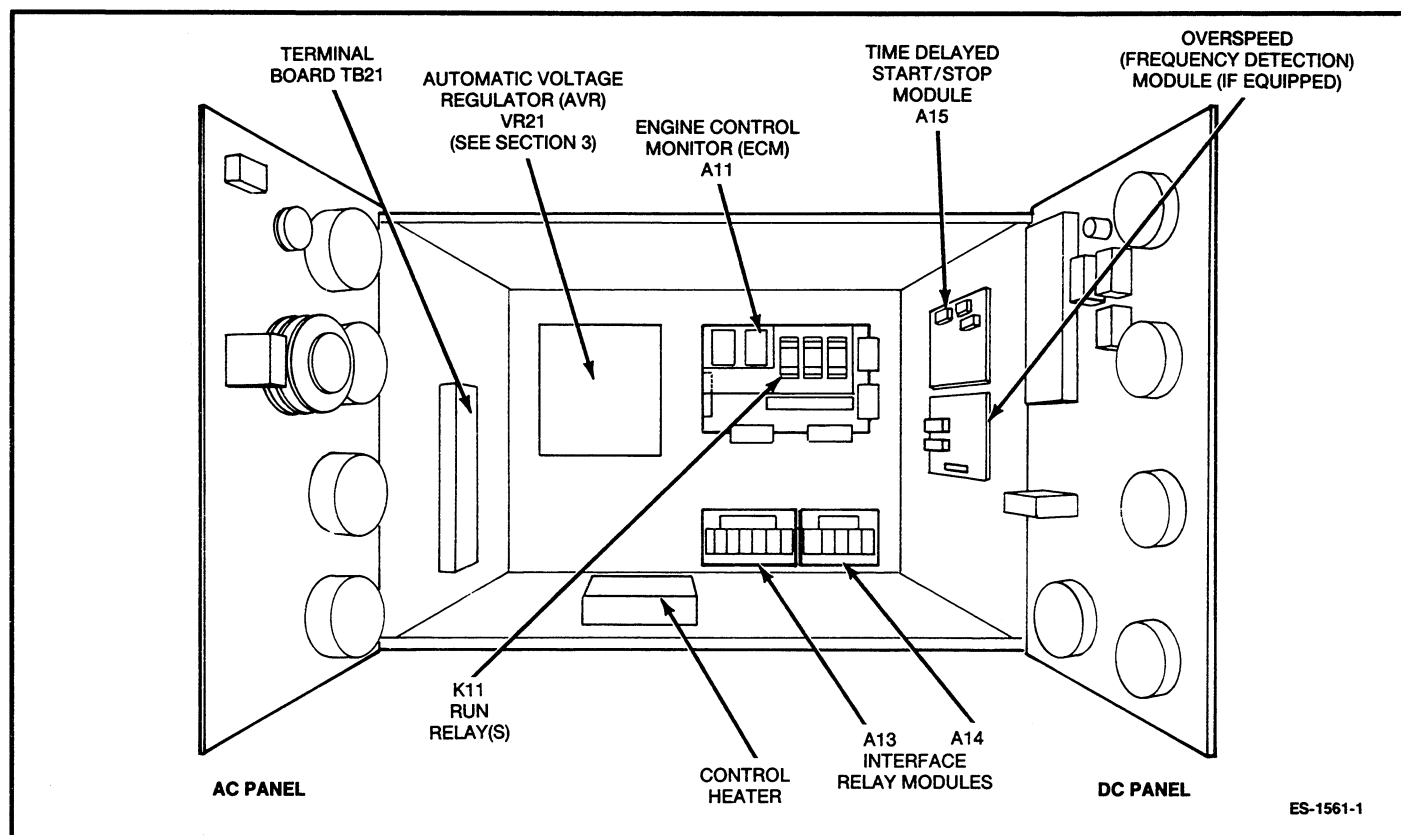


FIGURE 2-2. CONTROL PANEL INTERIOR

Engine Control Monitor

This circuit board assembly contains the basic components for normal engine start-up and shutdown, terminals for remote control interconnection, plug-in connectors for option modules and engine sensor inputs (Figure 2-3). The ECM provides the following functions of unit protection.

- Overcrank - Limits engine cranking to 75 seconds. If engine fails to start, the module lights a fault lamp and opens the cranking circuit. This cycle cranking circuit allows three 15-second cranking cycles with two 15 second rest periods.
- Overspeed - shuts down the engine immediately if overspeed occurs and lights a fault lamp. For non-PMG sets a sensor switch is mounted on the end of the generator shaft, and PMG generator sets are equipped with an overspeed (frequency detection) module inside the control panel. Either type is factory set to shut down the generator set at approximately 2100 r/min (60 Hz units), or 1850 r/min (50 Hz units). Refer to *Component Tests and Adjustments* section for further information.
- Low Oil Pressure - Shuts down the engine immediately if oil pressure drops below 14 psi (97 kPa) and lights a fault lamp. The fault is inhibited during cranking and time delayed about 10 seconds following starter disconnect. The delay allows oil pressure to rise to normal before the electronic control module monitors this system.

The pre-low oil pressure sensor and lamp provides an alarm that oil pressure is marginally low, 20 psi (138 kPa) or less. The cause should be found and corrected as soon as possible.

- High Engine Temperature - Shuts down the engine immediately if coolant temperature rises above 215° F (102° C) and lights a fault lamp. The fault is inhibited during cranking and time delayed about 10 seconds following the starter disconnect. This delay allows coolant in a hot engine time to circulate and return the water jacket to normal before the electronic control module resumes monitoring this system.

The pre-high engine temperature sensor and lamp provides an alarm that engine temperature is marginally high, 205°F (97°C) or higher. The cause should be found and corrected as soon as possible.

CAUTION

The high engine temperature shutdown system will not operate if the coolant level is too low. The high engine temperature sensor monitors coolant temperature. Loss of coolant will prevent sensor operation and allow the engine to overheat causing severe damage to the engine. Therefore, maintain adequate coolant level to ensure the operation of the high engine temperature shutdown system.

- Low Coolant Level Shutdown (Optional) - A solid-state sensor installed into the radiator provides engine shutdown if coolant level falls too low. It also lights the high engine temperature fault lamp.

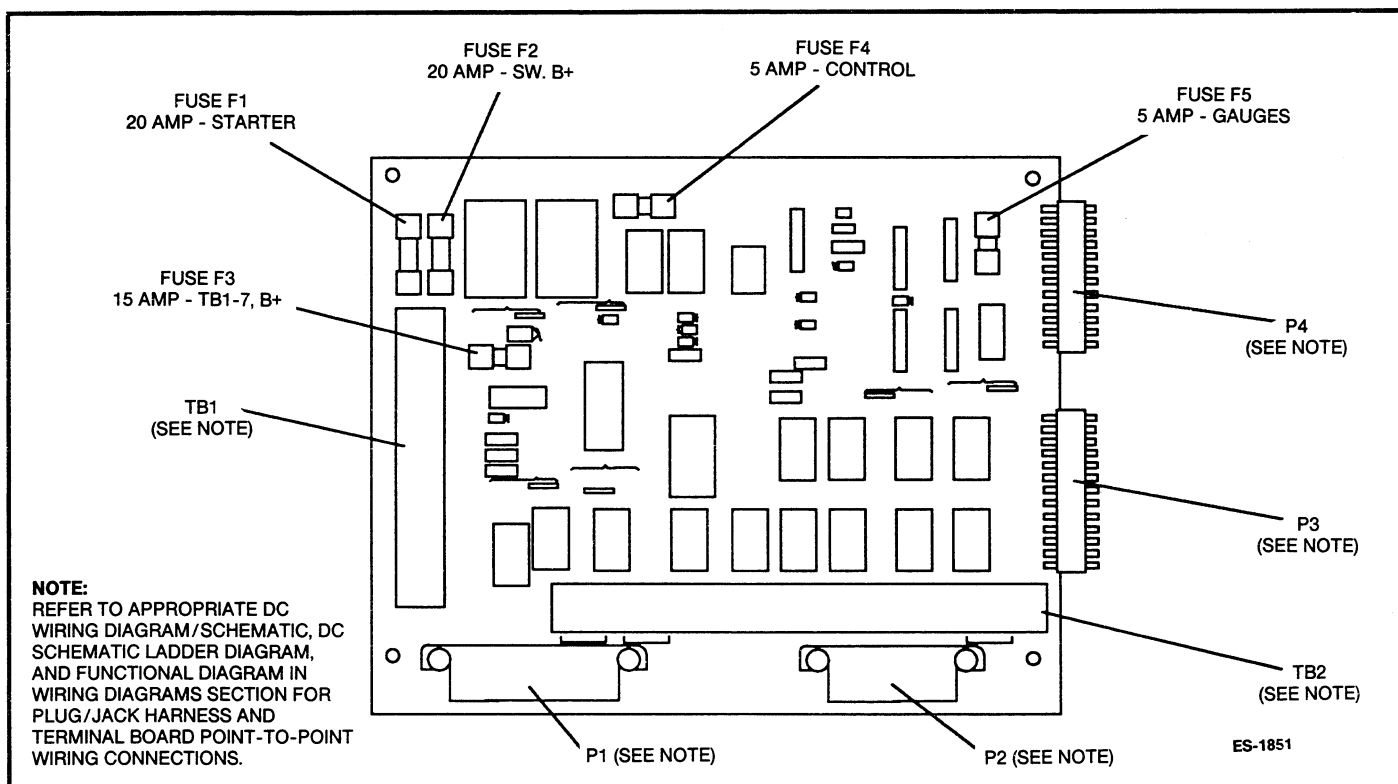


FIGURE 2-3. ENGINE CONTROL MONITOR
(Detector-12 ECM Shown)

Run Relay(s) (K11)

This relay (may be up to three) provides wiring connections for external functions of the site installation that are to be controlled by the starting and/or stopping of the generator set such as ventilation air louvers, blowers, etc. The sets of contacts in the relay base provide for either closing a circuit or opening a circuit upon energizing and de-energizing the relay (depending on the desired function wires to the base connections). The relay is energized when the generator set starts when connected to the ECM as TB1-10 (switched B+ connection).

Interface Relay Modules (A13, A14)

These relay modules are used in conjunction with the Detector ECM's to provide external monitoring of the engine-generator at customers control panel. As add-on circuit boards, they interface with the remote annunciator signals from the ECM and allow the use of either AC or DC for alarm drives. The relays are configured for low side switching by the control and supply sets of contacts for external alarm connections.

Current Transformers (Not shown)

All units equipped with AC meters have current transformers installed inside the conduit box with appropriate generator leads routed through them.

Automatic Voltage Regulator (VR21)

Refer to section 3 for more information.

Overspeed (Frequency Detection) Module

This module derives a speed (Hz) signal from the PMG (if equipped) but is powered from the generator set battery. A small time delay, typically one second, is incorporated in the overspeed function to allow for engine overshoot. The module contains two adjustable potentiometers, Overspeed and Cranking (the cranking potentiometer is not used however). Refer to section 5 for more information.

Time Delayed Start/Stop Module (A15)

This module provides time delays for starting and stopping the generator set as follows:

Delayed Starting: The time delay start function is to preclude automatic start-up of the generator set for a determined amount of time (adjustable from 1 to 15 seconds) for installations that might experience power interruptions of short duration, and therefore not want the generator set starting.

Delayed Stopping: The time delay stop function is adjustable from 1 to 15 seconds to provide for automatic cool-down running of the engine for prescribed amount of time (approximately 3-5 minutes is recommended).

Control Cabinet Heater

A control cabinet heater provides a means of humidity/temperature control of the control box interior to protect the components and ensure their effectiveness when the generator set is subjected to varying ambient conditions during extended periods of non-use. The element is controlled by an adjustable thermostat.

GENSET OPERATION

Because of varying control option combinations, the following operating descriptions will encompass a Detector-12 controller with full options. Read the information through to Emergency Shutdown to gain a full understanding of the options and how they interact with the engine control monitor (ECM).

Regardless of the controller module you have, the ECM includes the shutdown fault commands. Controllers with options provide delineation and pre-alarm of the shutdown faults, time delayed starting and stopping, and additional monitoring/control, but all engine operation commands through these options are still controlled through the ECM.

If you are reviewing this operation information for troubleshooting purposes, make sure you have eliminated all other malfunction checks external of the controls prior to troubleshooting the printed circuit board type components of the controller. Also review the *Generator* section for generator related control components and *Component Tests and Adjustments* section for more in-depth information. Refer to appropriate DC Schematic - Ladder Diagram in *Wiring Diagrams* section when reviewing the following information.

Starting Sequence

Manual: The starting sequence is initiated by placing the Run/Stop/Remote switch (S12) in the Run position.

Placing the switch S12 in the Run position energizes the ECM Run Relay (K7). By energizing K7, B+ is supplied through the electrical circuits of the ECM to energize the engine run circuits (i.e., fuel solenoid) and front panel gauges and the starter solenoid (through K3).

The engine cranking period is determined by the Overcrank Timer and Cycle Crank Driver (U1), and the Cycle Crank Relay (K12), which control energizing and de-energizing the Power Relays K2 and K3 that supply current to the on-set starter and fuel solenoids.

Automatic: With the Run/Stop/Remote switch (S12) in the Remote position, a remote start command (closure of on-site, dry contacts) to the generator set controller activates the Time Delayed Start/Stop Module (A15), which initiates its time delay start period.

Upon completion of the time delay start period, the ECM initiates engine cranking and start-up by energizing Run Relay (K7) as described in manual start-up.

When engine successfully cranks and starter disconnects, input signals from either start disconnect system of the ECM will activate the Start Disconnect Relay of module A15 (K1) which enables the module for Time Delayed Stop Mode.

During generator set operation, all safety systems function to protect and monitor set operation. At end of the generator set duty cycle, when generator output is disconnected from load and the remote run signal is discontinued, the time delayed stop function of module A15 will continue engine-generator run time for the prescribed engine cool-down period of 3-5 minutes before deactivating the run circuits of the ECM.

Starter Disconnect Parameters

This type of control uses two means of starter-disconnect in order to protect the starter in the case one means should fail. The first uses a DC relay (K14); a B+ signal taken from the battery charging alternator in most cases energizes the relay to disconnect the starter. The second method uses an AC relay (K10); voltage from the generator energizes this relay to provide a back-up to the DC relay. The control uses this method to provide uninterrupted generator set operation even if only one means of start disconnect is operational. However, the local Run lamp does not light unless both start disconnect relays operate. If the generator set is equipped with a remote Run lamp, the operator can then determine which means of start disconnect has failed for such an occurrence. If the remote Run lamp lights (and the local run lamp does not), the DC relay is not functioning.

High Engine Temperature (HET) and Low Oil Pressure (LOP) faults are time delayed about 10 seconds following starter disconnect and inhibited during cranking. This allows the coolant in a hot engine some time to circulate and return the water jacket to normal before monitoring this parameter. It also allows the oil pressure to build to normal before monitoring this system. Following this delay, these faults become immediate shutdowns for engine protection.

If conditions are correct, the engine will start and the starter will disconnect. If not, an overcrank fault occurs by U1 having cycled/timed out through drive transistor U4 to energize Fault Relay K6, which opens the start circuit of the ECM. The Reset switch (S11) must be pushed to clear the fault before attempting to restart.

Start-Disconnect Sequence

When the generator set starts, output voltage from the DC alternator energizes Start-Disconnect relay K14. Energizing K14 then closes its N.O. contacts which lights the control panel Run lamp. Also, when the generator set starts, output voltage from the generator stator energizes Start-Disconnect relay K10. Energizing K10 then closes its N.O. contacts and lights a Remote Run lamp (if equipped).

After the starter disconnects, the LOP and HET fault shutdowns will remain inhibited for another 10 seconds to allow oil pressure and engine temperature to stabilize within the operating range.

Normal Operation Parameters

After a successful engine start-up, with all conditions satisfied, the engine will gain in speed to governor controlled operation. Should the engine go into an overspeed condition, either an Over/Under Frequency Sensor, an Overspeed Module, or a mechanical overspeed switch (depending on generator type and options ordered) will ground the overspeed input circuit to the ECM to cause a shutdown and light the Overspeed fault lamp. After the problem is corrected, starting will not occur until the Reset switch is pressed.

Continuous operation of the generator set also depends on the proper oil pressure and engine temperature being maintained, and also any customer required fault conditions connected to the ECM.

Stopping Sequence

Placing the Run/Stop/Remote switch to the Stop position de-energizes Run Relay (K7) which opens the current supply through the ECM (K2) to de-energize the generator set mounted fuel solenoid (stops fuel flow which stops engine).

Emergency Shutdown

The K6 fault relay is energized when fault sensors respond to one of the following fault conditions: overcrank, low oil pressure, high engine temperature, overspeed, and over/under voltage/frequency (if equipped). Energizing K6 fault relay opens its N.C. contacts and closes its normal N.O. contacts. Opening the N.C. disconnects B+ from the Power Relays K3 and K2. This stops cranking if the engine is being cranked and shuts off the fuel flow. Closing one of the N.O. contacts of K6 activates the K8 relay which breaks power to the fault interface relays so that only the indicator associated with the fault will activate. Closing the other N.O. contacts of K6 connects B+ to the remote alarm terminal.

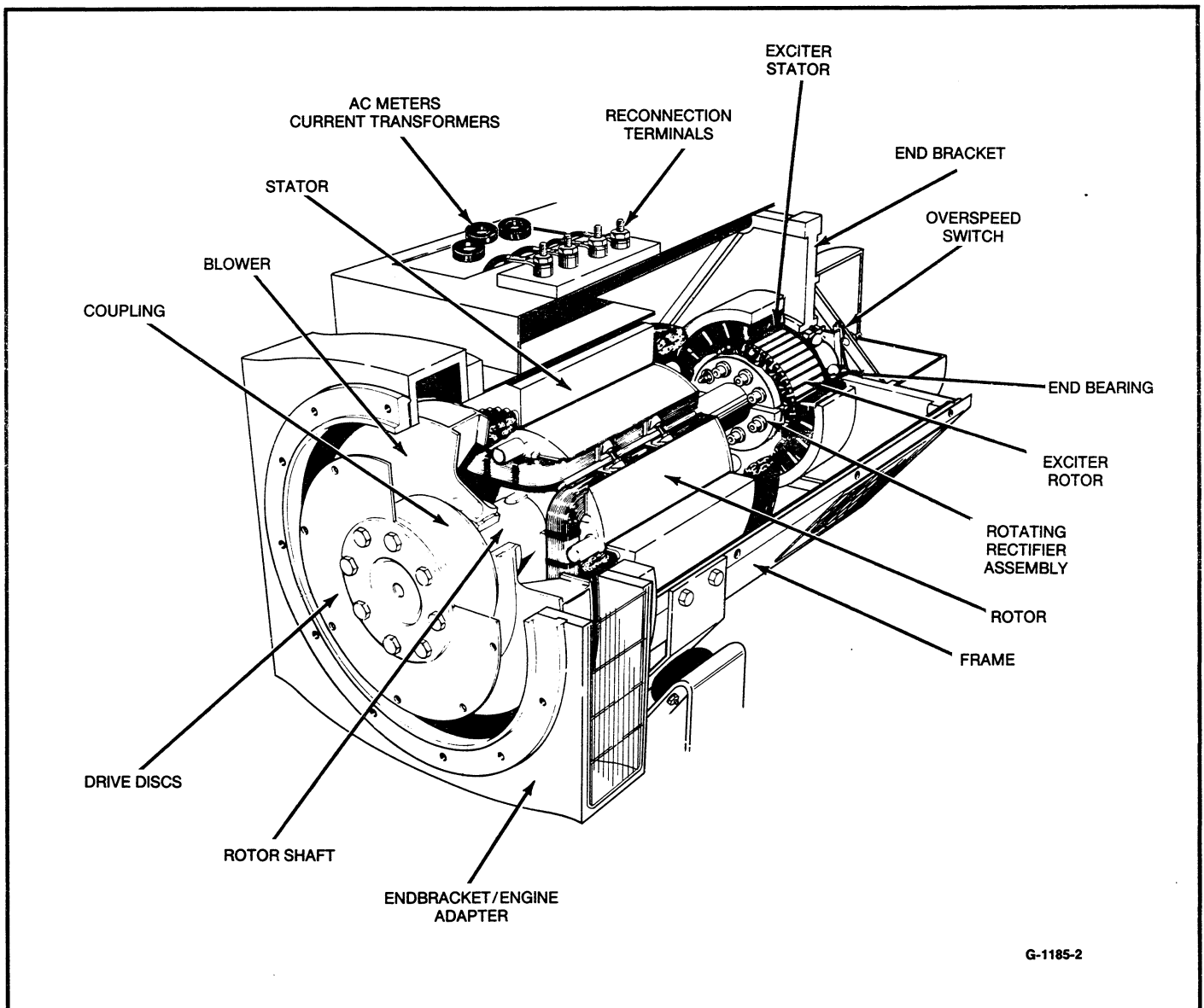
Section 3. Generator

GENERATOR DESCRIPTIONS

The AC generators are brushless, rotating field type, controlled by an automatic voltage regulator (AVR). Two types are used in these series of generator sets; self-exciter (non-PMG), and permanent magnet exciter (PMG). The non-PMG generators derive the AVR power from the output windings on the stator, and the PMG type is powered by a permanent magnet pilot exciter which provides a source of constant excitation power, independent of load changes or load current distortions.

An exciter/rotating rectifier assembly is mounted internally to the non-drive-end bearing. PMG generators have, in addition, a permanent magnet exciter overhung from the non-drive-end bearing.

Removable access covers are provided at each end of the generators and on each side of the conduit box for cleaning and inspection, and easy access to the output terminals and other ancillary equipment. See Figures 3-1 and 3-2.



G-1185-2

FIGURE 3-1. TYPICAL GENERATOR
(NON-PMG SHOWN)

GENERATOR CONTROL COMPONENTS

The following briefly describes generator related control components that effect the proper operation or shutdown of the generator set. See Figure 3-2 for component locations.

Automatic Voltage Regulator (AVR)

The AVR is mounted on the inside back wall of the control box. Refer to the Generator Operation following for further AVR operation information, and to *Component Tests and Adjustments* section for further description and adjustment procedure of the AVR.

Over/Under Voltage Sensor Module

This is an adjustable voltage-sensitive relay typically connected to the Engine Control Monitor (ECM) Fault 1 circuit to shut down the generator set when the output

voltage is over or under the normal voltage by the pre-selected amount (typically 10 percent). The module includes an adjustable time delay relay to prevent nuisance tripping (usually set at 25 percent, or approximately 2.5 seconds). The module and time delay relay are mounted on a bracket in the generator conduit box.

Over/Under Frequency Sensor Module

This is an adjustable frequency-sensitive relay typically connected to the Engine Control Monitor (ECM) Fault 2 circuit if the Over/Under Voltage module is also installed, or Fault 1 for over Hz and Fault 2 for under Hz if installed alone, to shut down the generator set when the output frequency is over or under the normal frequency by the preselected amount. (Also, Fault 2 must be converted for timed shutdown.) The Module is mounted on a bracket in the generator conduit box.

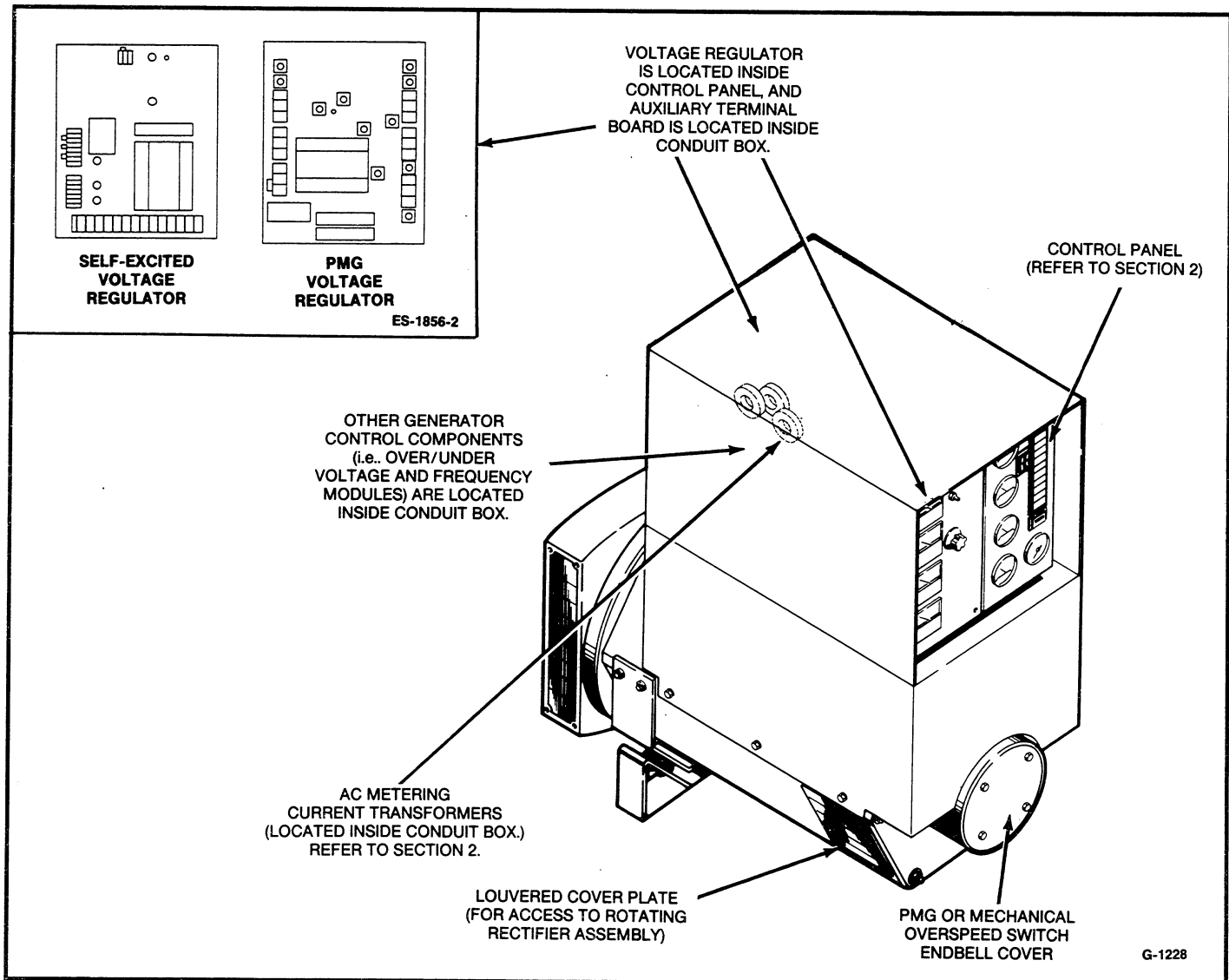


FIGURE 3-2. GENERATOR CONTROL COMPONENT LOCATIONS

GENERATOR OPERATION

Self-Excited Generator (Non-PMG)

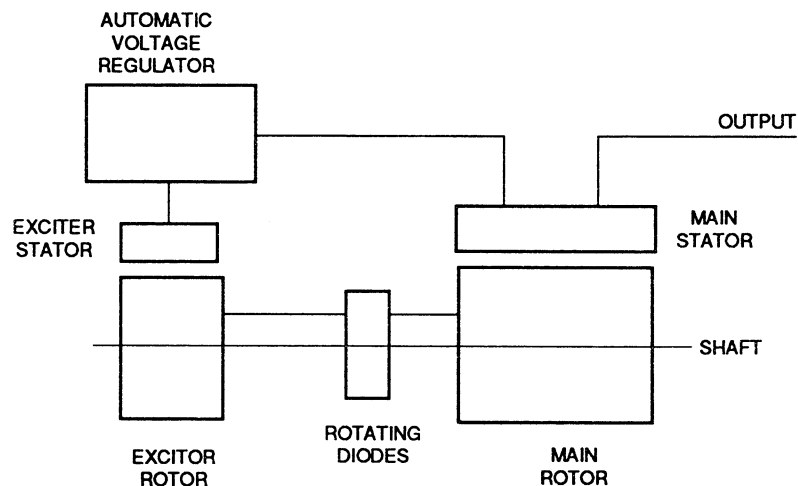
The main stator winding provides excitation power via the AVR to the exciter. The exciter stator mounts in the end bell, the exciter rotor and its rotating rectifier assemblies mount on the rotor shaft. Within the end bell, leads X (+) and XX (-), from the exciter stator winding, connect to the output terminals of the voltage regulator. A circuit within the AVR ensures positive voltage build-up, provided the residual magnetism level is sufficiently high. The AVR compares the main stator output with a reference value and feeds a controlled excitation current to the exciter stator. The AC output of the exciter rotor is converted to DC by the rectifier, comprised of 6 diodes mounted on 2 heatsinks to form positive and negative plates. The diodes are protected against harm-

ful overvoltages caused, for example, by switching circuits or out-of-phase paralleling, by a metal oxide varistor (MOV). The DC output of the rectifier provides the excitation onto the main rotor.

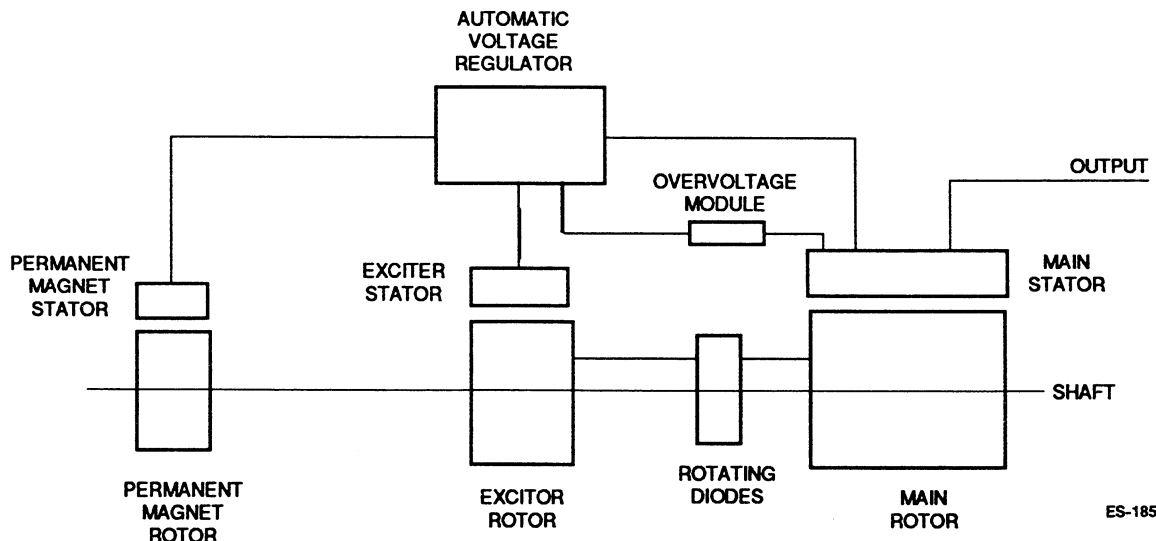
Permanent Magnet Generator (PMG)

The main excitation components (diodes, MOV, and main exciter) are identical to those of the self-generator. Output voltage is compared with a reference voltage to feed a controlled current to the main exciter stator in the same way. The fundamental difference is that the excitation power is now derived from the PMG, mounted on the main shaft, rather than from the main stator winding. Excitation power is therefore independent of output voltage, and a positive voltage build-up is ensured, without reliance on residual magnetism.

SELF-EXCITED GENERATOR (NON-PMG)



PERMANENT MAGNET GENERATOR (PMG)



ES-1852

FIGURE 3-3. GENERATOR OPERATION DIAGRAMS

OPTIONAL CIRCUIT BREAKER

Depending on site specifications and applicable code requirements, an optional circuit breaker may be mounted in the generator AC output box.

Description

All supplied breakers are thermal and magnetic trip type. Depending on customer requirements, the breaker may also include shunt trip and remote alarm connections. Review the following functions/requirements and Figure 3-4.

- Generator set output is connected to the load through the circuit breaker.
- When an overload or short circuit occurs on any one conductor, a common trip bar will disconnect all three conductors.
- The thermal trip action of the breaker is accomplished by bimetal strips. A sustained overcurrent condition will cause a thermal reaction of the bimetal and trip the breaker. Response of the bimetal is proportional to current; high current—fast response, low current—slow response. This action provides a time delay for normal inrush current and temporary overload conditions such as motor starting.
- The magnetic trip action of the breaker is caused by an electromagnet, which partially surrounds the internal bimetal strips. If a short circuit occurs, the high current through the electromagnet will attract the bimetal armature and trip the breaker. Some breaker models provide front adjustment of the magnetic trip action. These adjustments are normally set at the factory at the high position, but provide for individual conductor settings to suit customer needs.
- The shunt trip mechanism (if equipped) consists of a solenoid tripping device mounted in the breaker with external lead connections for remote signaling. A momentary signal to the solenoid will cause the breaker to trip.
- This feature is available in AC or DC voltages, and is normally installed at the factory to meet customer needs. The shunt trip mechanism is most often connected to a common fault shutdown circuit of the generator set. This quickly disconnects the set from the load on shutdown and avoids a reverse power condition.
- Auxiliary contacts (if equipped) are used for local or remote annunciation of the breaker status. They usually have one normally-open and one normally-closed contact (1 form C contacts) to comply with the annunciator equipment.
- The trip actuator (if applicable) is for periodic exercise of the breaker to clean and maintain its proper operation. Rotating this actuator mechanically simulates over-current tripping through actuation of linkages not operated by the *On/Off* handle. See section 5, *Component Tests and Adjustments*, for further information.
- Operation of the circuit breaker is determined by site-established procedures. In emergency standby installations, the breaker is often placed to the On position, and is intended for safety trip actuation in the event of a fault condition. If the breaker trips open, investigate the cause and perform remedial steps per the troubleshooting procedures. To close the breaker, the handle must be placed to the Reset position and then to On. Refer to section 4 for troubleshooting and safety procedures.

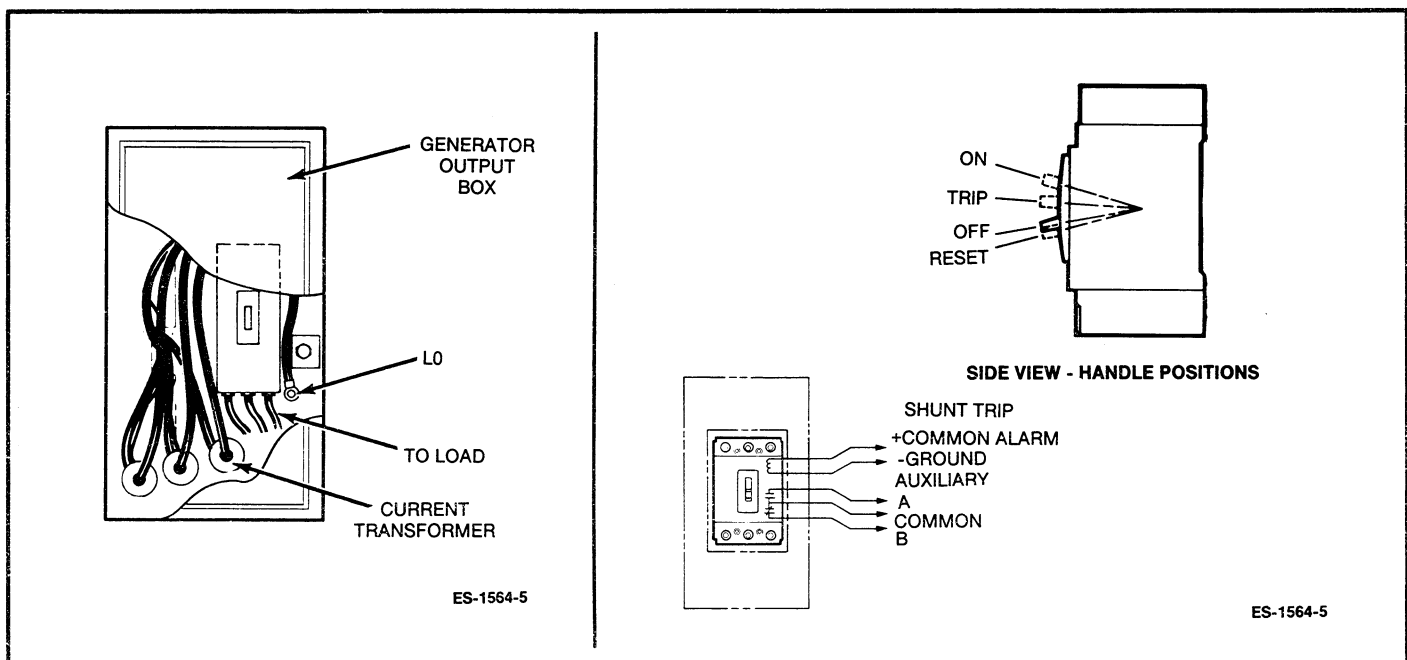


FIGURE 3-4. TYPICAL GENERATOR-MOUNTED CIRCUIT BREAKER

Section 4. Troubleshooting

GENERAL

This section contains troubleshooting information for engine-generator control systems. Be sure to review the troubleshooting information as outlined in the unit Operator's Manual before performing the procedures in this section. Refer to *Component Tests and Adjustments* section for further engine-generator component information and appropriate engine service manuals for additional information specific to the engine.

Because this section contains information about various control options, read through this section before a fault occurs to identify what is or is not applicable to your genset. This will save troubleshooting time when the actual need arises.

Before starting a troubleshooting procedure, make a few simple checks that might expose the problem. Check all modifications, repairs, or parts replacements performed since the last satisfactory operation of the generator set. A loose or otherwise incorrect wire connection, an opened switch or circuit breaker, or a loose plug-in are all potential problems that can be eliminated by a visual check.

When troubleshooting a problem, remember to keep your problem solving a methodical and most of all safe process. Hasty decisions can be costly, harmful to your health, dangerous to others, and may not solve the problem.

Regardless of the controller model a generator set has, the basics of problem analysis are fundamentally the same. Identify the fault condition then get specific about the corrective action to take. However, the Detector-7 controller does not have all the lamp indicators that the Detector-12 has; to aid in identifying other customer required fault conditions (i.e., low fuel, fault 1 and 2) that

may have caused the shutdown. Your initial problem analysis before reviewing the tables in this section should be to ask yourself the following questions:

1. Was the engine running when it shut down? If it was, shutdown is not due to overcrank.
2. Did shutdown occur within one minute after start-up? If it did, the shutdown is probably due to low oil pressure.
3. Was engine operation noticeably erratic or faster than usual? If it was, the shutdown was probably due to overspeed.
4. If the engine starts and runs, observe the oil pressure, engine temperature and frequency meter or tachometer until shutdown occurs, to determine the cause.

This section is divided into engine-related troubleshooting tables and generator-related troubleshooting flowcharts to aid you. They are:

- Table 4-1. Engine does not crank.
- Table 4-2. Engine cranks, but does not start.
- Table 4-3. Engine starts, but stops after running short time.
- Table 4-4. Engine-generator is in operation, then a fault shutdown occurs.
- Flow Chart 4-1. No AC output voltage at rated engine speed.
- Flow Chart 4-2. Unstable output voltage, engine speed stable at rated speed.
- Flow Chart 4-3. Output voltage too high or too low.
- Flow Chart 4-4. Exciter field breaker trips (if equipped.)
- Flow Chart 4-5. Unbalanced generator output voltage.
- Flow Chart 4-6. No AC output through set mounted circuit breaker.

⚠ WARNING Many troubleshooting procedures present hazards which can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review Safety Precautions, inside cover page.

TABLE 4-1. ENGINE DOES NOT CRANK

SYMPTOM	CAUSE	CORRECTIVE ACTION
1. SWITCH OFF indicator lamp flashing.	Run/Stop/Remote switch in Stop position.	Press to desired, Run or Remote position.
2. Other fault indicator lamps illuminated, but no fault exists.	Lamp Reset switch not actuated after a previous fault was remedied.	Press Lamp Reset switch to de-energize fault lamp relays of ECM, after Run/Stop/Remote switch is pressed to Stop position.
3. No indication.	<p>Fuses blown on ECM board A11.</p> <p>Starter solenoid will not energize.</p> <p>Possible defective ECM board A11.</p> <p>Broken wiring or poor connections between board A11 TB1-8 and starter solenoid.</p> <p>Faulty ECM board A11.</p>	<p>Check fuses F1 and F4. Replace if necessary with proper fuse: F1 - 20 Ampere F4 - 5 Ampere</p> <p>Inspect starter solenoid per proper test procedure.</p> <p>Check A11 board TB1-9 for B+ voltage in.</p> <p>With S12 switch in Run position, check for voltage out to starter solenoid at TB1-8 of board A11.</p> <p>Check and repair as necessary.</p> <p>If there is no voltage between TB1-8 and ground stud when the panel switch is in the Run position, the ECM is faulty. Replace.</p>
4. Time delay start is initiated, but starter solenoid does not energize after desired time delay period.	Possible defective Time Delayed Start/ Stop Module A15.	<p>Check A15 board TB1-4 for constant B+ voltage in.</p> <p>Check a15 board TB1-5 for Run Signal In voltage. Voltage at A15 board TB1-6 should be at B+ at end of start delay period.</p> <p>Check wiring and connections from A15 TB1-6 to A11 TB1-6.</p>

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TABLE 4-2. ENGINE CRANKS BUT DOES NOT START

SYMPTOM	CAUSE	CORRECTIVE ACTION
<p>1. Overcrank lamp lit.</p> <p>Low Fuel lamp also lit.</p> <p>Fuel solenoid does not energize.</p> <p>Fuel solenoid energizes, but no fuel flows.</p> <p>Engine hard to start due to cold ambient air temperature.</p>	<p>Insufficient fuel in supply tank.</p> <p>Fuse blown on ECM board A11.</p> <p>Possible defective ECM board A11.</p> <p>Broken wiring or poor connections between board A11 TB1-10 and fuel solenoid.</p> <p>Blockage of fuel supply system.</p> <p>Heater system not keeping engine warm.</p>	<p>Fill with correct fuel.</p> <p>Check fuse F2. Replace if necessary. F2 - 20 Ampere.</p> <p>Check for voltage out at TB1-10 when engine is cranking.</p> <p>Check and rectify as necessary.</p> <p>Check fuel supply system (fuel supply tank, shutoff valves, lines and connections, filters and transfer pump, etc.).</p> <p>Check heater system power supply, controls, etc., and correct as necessary.</p>
<p>2. Fault shutdown occurs, but no fault lamp indication.</p>	<p>Lamp burned out.</p>	<p>Place Run/Stop/Remote switch to Stop position, then depress Lamp Test switch to Test position to check fault lamps.</p>
<p>3. Short cranking period.</p> <p>Note: The ECM board A11 P.C. board controls are to provide cycle cranking, but generator set stops before 15 ± 3 seconds.</p>	<p>Defective ECM board A11.</p>	<p>Replace ECM (A11).</p>



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TABLE 4-3. ENGINE STARTS, BUT STOPS AFTER RUNNING SHORT TIME

SYMPTOM	CAUSE	CORRECTIVE ACTION
1. Overspeed lamp lit. Unstable engine operation.	Mechanical O.S. Switch or Overspeed Module (if equipped) initialized shutdown. Engine governor faulty or out of adjustment.	Refer to <i>Tests and Adjustments</i> section. Perform necessary adjustments of O.S. switch or module. Perform start-up and monitor engine speed to overspeed shutdown. If shutdown occurs before desired setpoint, readjust O.S. switch/module. If adjustment does not correct fault condition, replace O.S. switch/module. Refer to <i>Tests and Adjustments</i> section. Perform appropriate tests.
2. Low Oil Pressure lamp lit.	Low oil level in engine. LOP switch faulty.	Replenish as necessary. Check oil level, perform restart, and monitor oil pressure gauge. If gauge reading is within normal range, switch S1 is faulty. Replace.
3. High Engine Temperature lamp lit.	Low coolant level in engine. HET switch is faulty. Thermostat defective. Fan belt slipping.	Replenish as necessary. Check coolant level, perform restart, and monitor engine temperature gauge. If gauge reading is within normal range, switch S2 is faulty. Replace. Replace thermostat. Tighten fan belt.
4. No fault condition.	Intermittent control wiring connections.	Check condition of all control wiring to make sure connections are correct and secure.

⚠ WARNING Many troubleshooting procedures present hazards which can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review Safety Precautions, inside cover page.

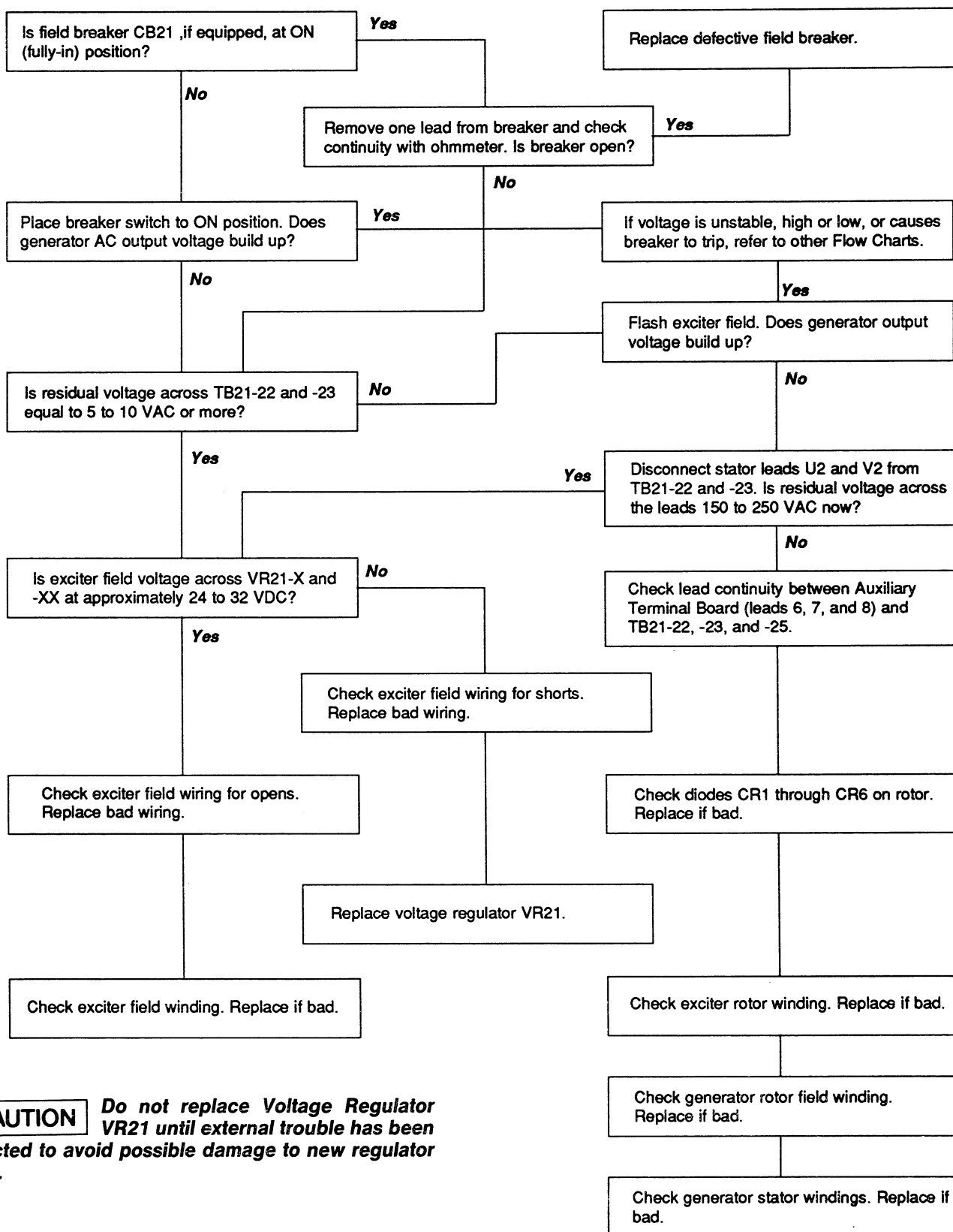
TABLE 4-4. ENGINE-GENERATOR IS IN OPERATION, THEN A FAULT SHUTDOWN OCCURS

SYMPTOM	CAUSE	CORRECTIVE ACTION
1. LOP, HET, Overspeed lamp lit.	As indicated.	Refer to Table 4-3.
2. Fault 1 or Fault 2 lamp lit.	Over/Under Voltage or Frequency, as dedicated by customer.	<p>Refer to <i>Tests and Adjustments</i> section. and perform necessary adjustments. Restart unit and monitor gauges.</p> <p>If shutdown was due to over/under voltage, the voltage regulator may require adjustment or is faulty. Refer to <i>Tests and Adjustments</i> section for adjustments, replace if faulty.</p> <p>If shutdown was due to over/under frequency, the engine governor may require adjustment or is faulty. Refer to <i>Tests and Adjustments</i> section for adjustments, replace if faulty.</p> <p>Refer also to generator-related Flow Charts that follow.</p>
3. No fault lamp lit.	<p>Possible defective ECM board A11.</p> <p>Other customer required shutdown command.</p>	<p>Check fuses F4 and F2 of ECM board A11. F4 (Main) - 5 Ampere F2 (Fuel solenoid or ignition) - 20 Ampere</p> <p>Perform restart and check for B+ voltage in at TB1-9 and voltage out at TB1-10 to fuel solenoid.</p> <p>If there is voltage out at TB1-10, check fuel supply solenoid, shutoff valves, etc.</p> <p>If there is no voltage out at TB1-10, ECM board A11 is defective. Replace.</p> <p>Refer to installation reference material, or contact your service representative for assistance.</p>



WARNING Many troubleshooting procedures present hazards which can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review Safety Precautions, inside cover page.

FLOW CHART 4-1. NO AC OUTPUT VOLTAGE AT RATED SPEED

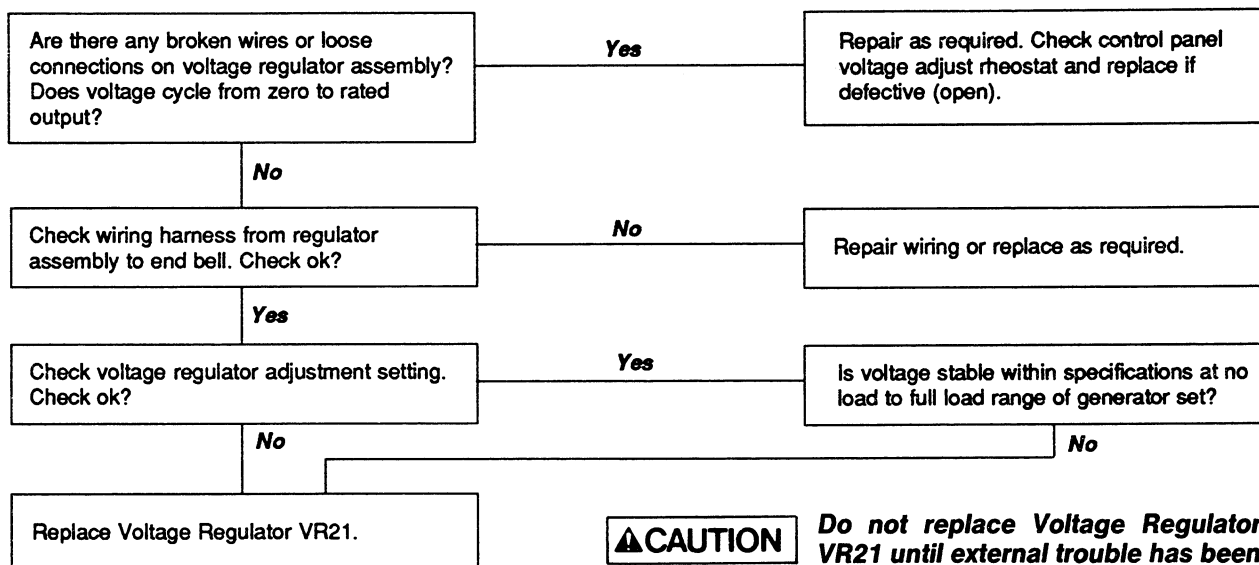


CAUTION Do not replace Voltage Regulator VR21 until external trouble has been corrected to avoid possible damage to new regulator board.

⚠ WARNING

Many troubleshooting procedures present hazards which can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review Safety Precautions, inside cover page.

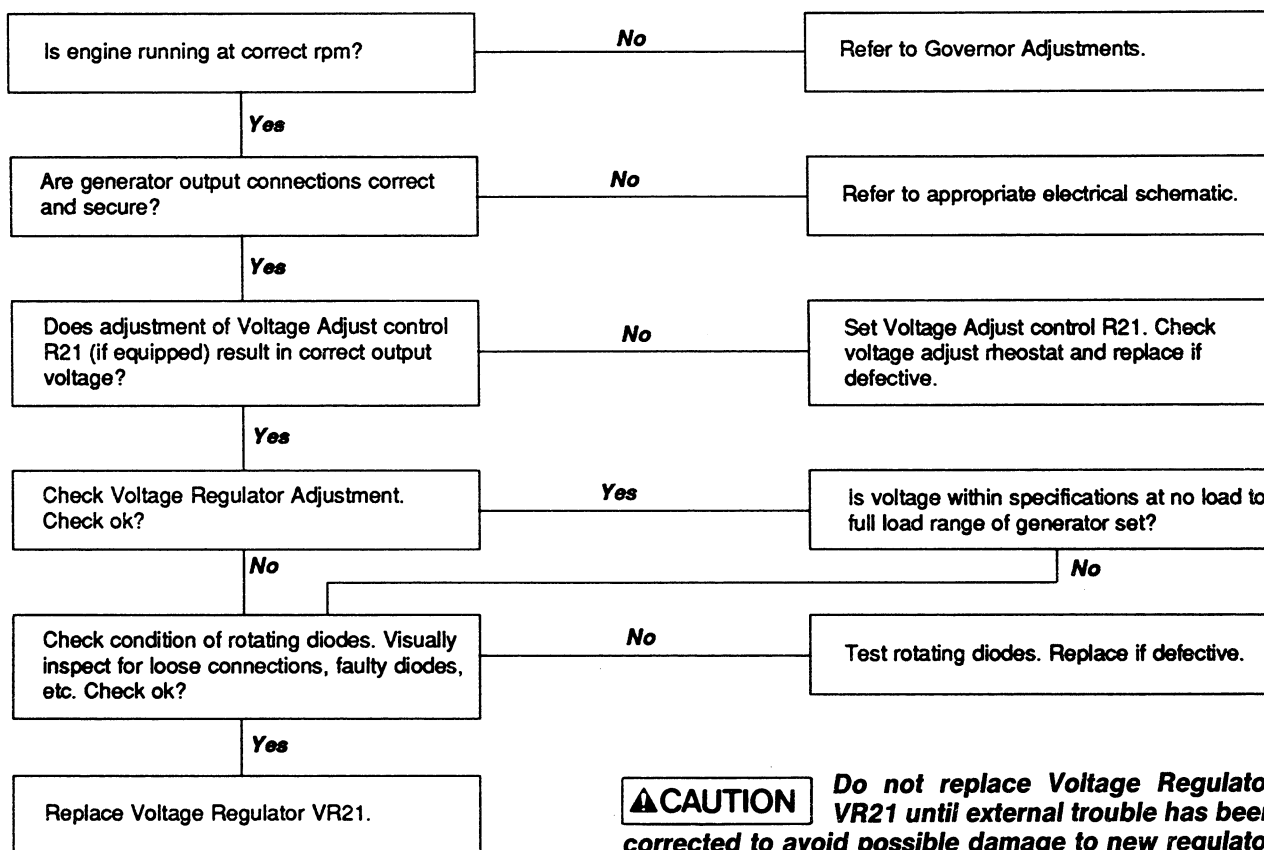
FLOW CHART 4-2. UNSTABLE VOLTAGE, ENGINE SPEED STABLE AT RATED SPEED



⚠ CAUTION

Do not replace Voltage Regulator VR21 until external trouble has been corrected to avoid possible damage to new regulator board.

FLOW CHART 4-3. OUTPUT VOLTAGE TOO HIGH OR LOW

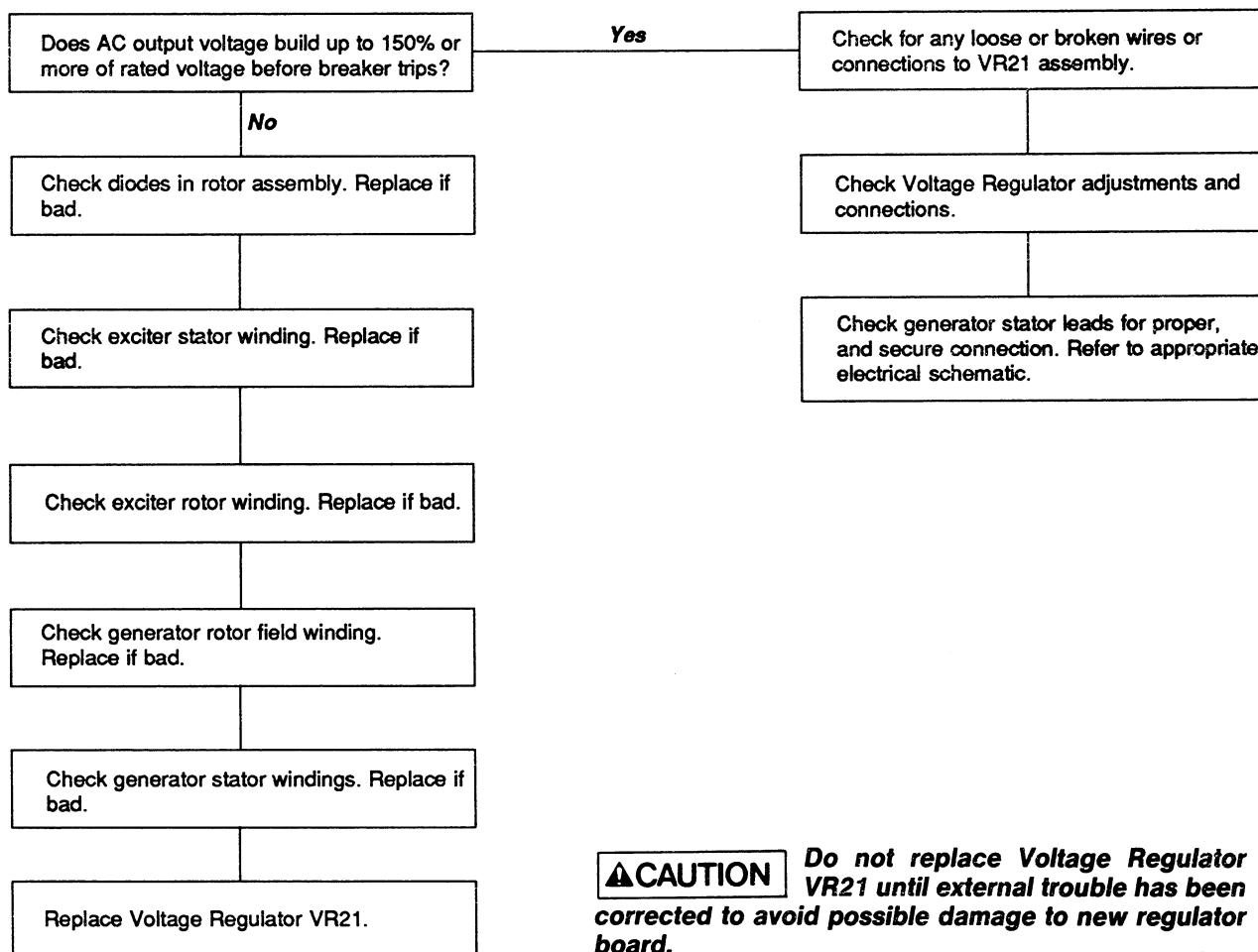


⚠ CAUTION

Do not replace Voltage Regulator VR21 until external trouble has been corrected to avoid possible damage to new regulator board.

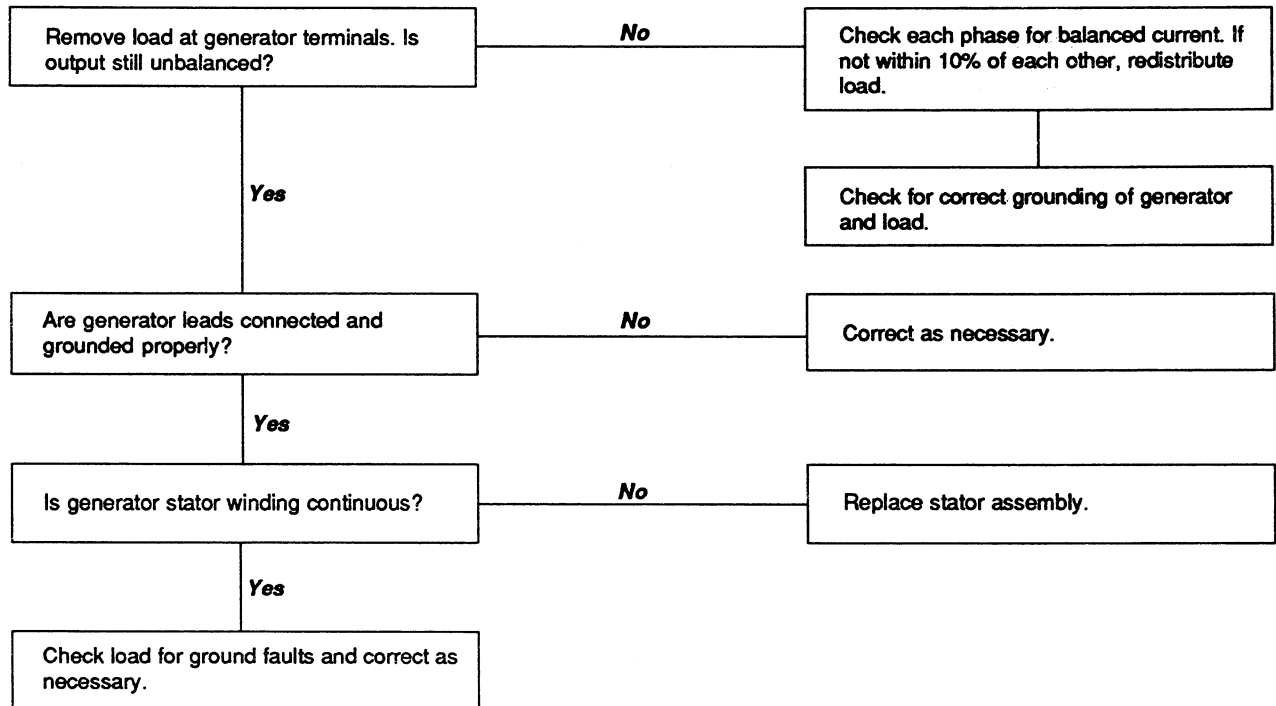
⚠ WARNING Many troubleshooting procedures present hazards which can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review Safety Precautions, inside cover page.

FLOW CHART 4-4. EXCITER FIELD BREAKER TRIPS (IF EQUIPPED)



⚠ WARNING Many troubleshooting procedures present hazards which can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review Safety Precautions, inside cover page.

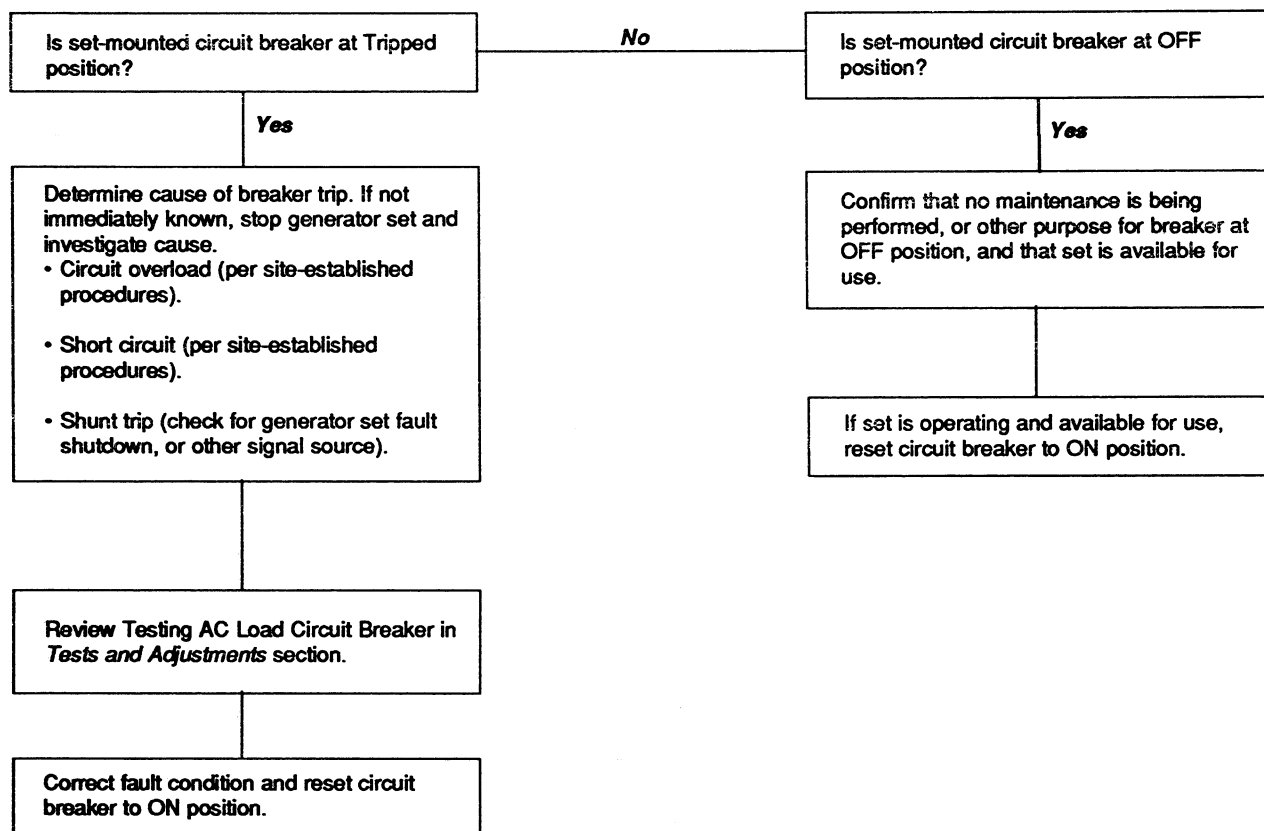
FLOW CHART 4-5. UNBALANCED GENERATOR OUTPUT VOLTAGE



⚠ WARNING

Many troubleshooting procedures present hazards which can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review Safety Precautions, inside cover page.

FLOW CHART 4-6. NO AC OUTPUT THROUGH SET MOUNTED CIRCUIT BREAKER



Section 5. Component Tests and Adjustments

GENERAL

This section contains test and adjustment information for GenSet control, generator, and engine components. Refer to the figures included with this information and also the *Wiring Diagrams* section when instructed.

⚠CAUTION

In-depth information is provided for some components such as the ECM's. Only qualified personnel with proper equipment should use this information to attempt repair of printed circuit board assemblies. Contacting your distributor for replacement parts is recommended.

ENGINE CONTROL MONITOR (ECM)

Sequence of Operation — Detector-7 ECM

Refer to schematic diagram in *Wiring Diagrams* section when reviewing this information.

Starting is initiated by applying B+ or ground to P4-7 depending on the position of links W3 and W4.

- Position A — Ground signal to run
- Position B — B+ signal to run

This energizes run relay K7, which opens its N.C. contacts (9,16) disconnecting B+ to starter relay K3, switched B+ relay K2 faults circuits, overcrank/cycle crank timer U1, and HET/LOP time delay timer U5.

K2 energizes, closing its N.O. contacts (5,3) connecting B+ to terminal TB1-10 through fuse F2 and to P4-9 through fuse F5.

K3 energizes, closing its N.O. contacts (5,3) connecting B+ to terminal TB1-8 through fuse F1. K3 is controlled by timer U1 through cycle crank relay K12. U1 can be programmed to give 3 crank periods by combining diodes across U1 pins 10, and 12; CR6 to pin 12 with CR8 to pin 10 = 3 cranks.

U1 will energize and de-energize K12 depending on the number of cranks programmed, K12 N.C. contacts (10,7) open and close to energize and de-energize K3, K3 N.O. contacts (5,3) open and close connecting and removing B+ from TB1-8.

If the set fails to start after the pre-set number of cranks, U1 pins 10,11 and 12 go high and trigger the drive transistor U4 pins 6 and 11 which grounds K6 fault relay, stopping the starting sequence by opening its N.C. contacts (9,8) de-energizing K3 and K2. U1 pins 10, 11 and 12 going high also triggers U4 pins 12 and 5 which energizes overcrank lamp drive relay K9. K9 N.O. contacts (9,13 and 4,8) close putting a ground on TB2-6 for a remote indication and also the DS18 lamp.

If the set starts, voltage builds up on the DC (K14) and AC (K10) start disconnect relays. K14 energizes at approximately 14 VDC. K10 energizes at approximately 100 VAC. Regardless of which one energizes first, either relay will break the ground path to the starter relay K3, K3 de-energizes opening its N.O. contacts (5,3) removing B+ from TB1-8. Both K10 and K14 must be energized to operate the lamp DS12. Either relay will also inhibit the overcrank timer U1 by making U1 pin 2 go high. This is achieved by removing the ground path from U1 pin 2 through U3 pins 6-11, N.C. K14 contacts (6,9) and N.C. K10 contacts (3,5). A positive is then allowed through the set. N.C. K6 contacts (3,7), N.C. K12 contacts (10,7), U3 pins 6-11 to pin 2 on U1 or via R5, U3 pins 6-11 to U1 pin 2 if K6 fault relay has operated. By making pin 2 high the timer is reset and put into a standby mode.

Either K10 or K14 will initiate U5 - LOP/LET time delay timer. This is achieved by removing the ground from U4 pin 3 and placing a positive there. This triggers U4 pins 3 and 14 to ground U5 pin 2. After a 10 second delay U5 pin 14 energizes K1 through U4 pins 1 and 16. K1 N.O. contacts (9,15) close, latching in fault circuits. K1 N.C. contacts open to latch U5 into an inactive state during run, made by removing B+ from pin 5 and grounding it through R8 and U2 pins 2 and 15.

If a fault should occur a ground is placed on the following plug points:

- P2-2, for Pre-Low Oil Pressure (PLOP)
- P2-3, for Pre-High Engine Temperature (PHET)
- P2-4, for Low Oil Pressure (LOP)
- P2-5, for High Engine Temperature (HET)
- P2-6 or terminal TB1-1, for Overspeed (OS)

Pre-LOP and pre-HET only activate a warning lamp and do not stop the set.

LOP, HET, and OS activate a lamp and also shut down the set.

Fault relay K6 is in series with the K13 (HET), K15 (LOP), K11 (OS), K4 (Fault 1) and K5 (Fault 2) fault relays. Therefore, when a ground is placed on the respective plug input it will cause both the K6 relay and the associated fault relay to energize. K6 N.C. contacts (9,8) open to de-energize K2 relay, stopping the set. K6 N.O. contacts (11,10) close to energize K8 relay. K8 opens its N.C. contacts (16,9) to remove B+ from the operational parts of the circuit. The associated fault relay will bring up an indicating lamp and also connect a ground to one of the following terminals for a remote indication:

- TB2-11, for PLOP
- TB2-10, for PHET
- TB2-9, for LOP
- TB2-8, for HET
- TB2-7, for Overspeed
- TB2-6, for Overcrank

To reset a fault the run signal must be removed from P4-7 to de-energize K7, closing its N.C. contacts (9,16) to connect B+ to the fault reset circuit. A ground is placed on P4-11 which grounds all of the latchable fault relay reset coils as follows:

- K6 - Fault Relay
- K9 - Overcrank
- K11 - Overspeed
- K13 - HET
- K15 - LOP
- K17 - PHET
- K19 - PLOP

This resets K6 fault relay and any fault relays that are latched in an active state.

To stop the set normally, the run signal is removed from P4-7 which de-energizes K7. K7 N.O. contacts (9,14) open to remove B+ from K2 relay. K2 de-energizes opening its N.O. contacts (5,3) removing B+ from TB1-10, stopping the set.

Sequence of Operation — Detector-12 ECM

Refer to schematic diagram in *Wiring Diagrams* section when reviewing this information.

Starting is initiated by applying B+ or ground to P4-7 depending on the position of links W3 and W4.

- Position A — Ground signal to run
- Position B — B+ signal to run

This energizes run relay K7, which opens its N.C. contacts (9,16) disconnecting B+ to starter relay K3, switched B+ relay K2 fault circuits, overcrank/cycle crank timer U1, and HET/LOP time delay timer U5.

K2 energizes, closing its N.O. contacts (5,3) connecting B+ to terminal TB1-10 through fuse F2 and to P4-9 through fuse F5.

K3 energizes, closing its N.O. contacts (5,3) connecting B+ to terminal TB1-8 through fuse F1. K3 is controlled by timer U1 through cycle crank relay K12. U1 can be programmed to give 2, 3, or 4 crank periods by different combinations of diodes across U1 pins 10, 11, and 12.

- CR6 to pin 12 with CR8 to pin 10 = 3 cranks
- CR6 to pin 12 with CR7 to pin 11 = 2 cranks
- CR7 to pin 11 with CR8 to pin 10 = 4 cranks

U1 will energize and de-energize K12 depending on the number of cranks programmed, K12 N.C. contacts (10,7) open and close to energize and de-energize K3, K3 N.O. contacts (5,3) open and close connecting and removing B+ from TB1-8.

If the set fails to start after the pre-set number of cranks, U1 pins 10, 11, and 12 go high and trigger the drive transistor U4 pins 6 and 11 which grounds K6 fault delay, stopping the starting sequence by opening its N.C. contacts (9,8) de-energizing K3 and K2. U1 pins 10, 11, and 12 going high also triggers U4 pins 12 and 5 which energizes overcrank lamp drive relay K9. K9 N.O. contacts (9, 13 and 4,8) close putting a ground on TB2-6 for a remote indication and also the DS18 lamp.

If the set starts, voltage builds up on the DC (K14) and AC (K10) start disconnect relays. K14 energizes at approximately 14 VDC. K10 energizes at approximately 100 VAC. Regardless of which one energizes first, either relay will break the ground path to starter relay K3, K3 de-energizes opening its N.O. contacts (5,3) removing B+ from TB1-8. Both K10 and K14 must be energized to operate the run lamp DS12. Either relay will also inhibit the overcrank timer U1 by making pin 2 go high. This is achieved by removing the ground path from U1 pin 2 through U3 pins 6-11, N.C. K14 contacts (6,9) and N.C. K10 contacts (3,5). A positive is then allowed through the K3 coil, N.C. K6 contacts (3,7), N.C. K12 contacts (10,7), U3 pins 6-11 to pin 2 on U1 or via R6, U3 pins 6-11 to U1 pin 2 if K6 fault relay has operated. By making pin 2 high the timer is reset and put into a standby mode.

Either K10 or K14 will initiate U5 - LOP/LET time delay timer. This is achieved by removing the ground from U4 pin 3 and placing a positive there. This triggers U4 pins 3 and 14 to ground U5 pin 2. After a 10 second delay U5 pin 14 energizes K1 through U4 pins 1 and 16. K1 N.O. contacts (9,15) close, latching in fault circuits. K1 N.C. contacts open to latch U5 into an inactive state during run, made by removing B+ from pin 5 and grounding it through R8 and U2 pins 2 and 15.

If a fault should occur a ground is placed on the following plug points:

- 2-1, for Low Engine Temperature (LET)
- P2-2, for Pre-Low Oil Pressure (PLOP)
- P2-3, for Pre-High Engine Temperature (PHET)
- P2-4, for Low Oil Pressure (LOP)
- P2-5, for High Engine Temperature (HET)
- P2-6 or terminal TB1-1, for Overspeed (OS)
- TB2-14, for Low Fuel
- TB2-1, for Fault 2
- TB2-2, for Fault 1
- TB2-16, for shutdown of customers requirements

Low Fuel, pre-LOP, pre-HET, and LET only activate a warning lamp and do not stop the set.

LOP, HET, OS, Fault 1, Fault 2 and Remote shutdown (TB2-16) activate a lamp and also shuts down the set.

Fault relay K6 is in series with the K13 (HET), K15 (LOP), K11 (OS), K4 (Fault 1) and K5 (Fault 2) fault relays. Therefore, when a ground is placed on the respective plug input it will cause both the K6 relay and the associated fault relay to energize. K6 N.C. contacts (9,8) open to de-energize K2 relay, stopping the set. K6 N.O. contacts (11,10) close to energize K8 relay. K8 opens its N.C. contacts (16,9) to remove B+ from the operational parts

of the circuit. The associated fault relay will bring up an indicating lamp and also connect a ground to one of the following terminals for a remote indication:

- TB2-2, for Fault 2
- TB2-4, for Fault 1
- TB2-6, for Overcrank
- TB2-7, for Overspeed
- TB2-8, for HET
- TB2-9, for LOP
- TB2-10, for PHET
- TB2-11, for PLOP

To reset a fault the run signal must be removed from P4-7 to de-energize K7, closing its N.C. contacts (9,16) to connect B+ to the fault reset circuit. A ground is placed on P4-11 which grounds all of the latchable fault relays reset coils as follows:

- K6 - Fault Relay
- K4 - Fault 2
- K5 - Fault 1
- K9 - Overcrank
- K11 - Overspeed
- K13 - HET
- K15 - LOP
- K17 - PHET
- K19 - PLOP

This resets K6 fault relay and any fault relays that are latched in an active state.

To stop the set normally, the run signal is removed from P4-7 which de-energizes K7. K7 N.O. contacts (9,14) open to remove B+ from K2 relay. K2 de-energizes opening its N.O. contacts (5,3) removing B+ from TB1-10, stopping the set.

RUN RELAY (If Equipped)

Checking Relay Coil

Connect B+ across relay coil terminals. Relay should activate if coil is okay.

Checking Relay Contacts

Connect B+ to one side of relay contacts. Connect a voltmeter to other side of relay contact. If B+ is present when relay is energized, contact is okay. The B+ reading is present in reverse order when checking normally closed (N.C.) contacts. Typical wiring diagram is shown in Figure 5-1.

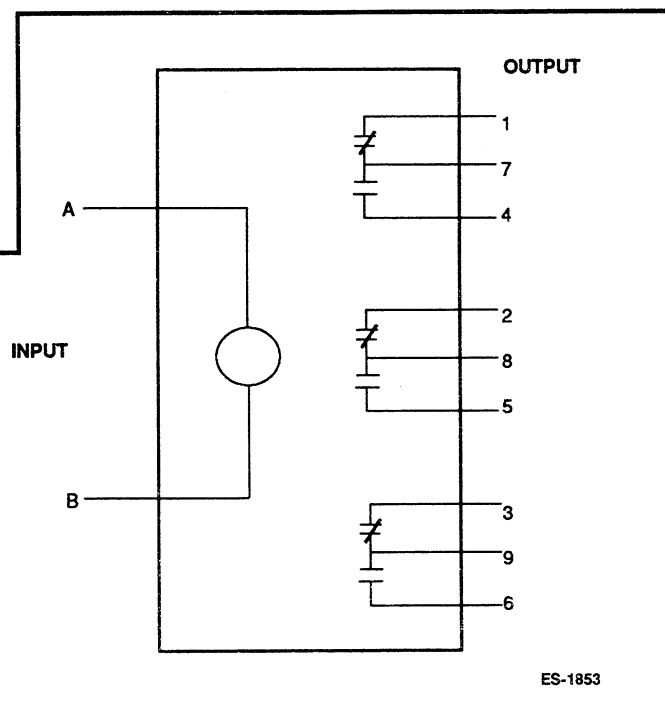
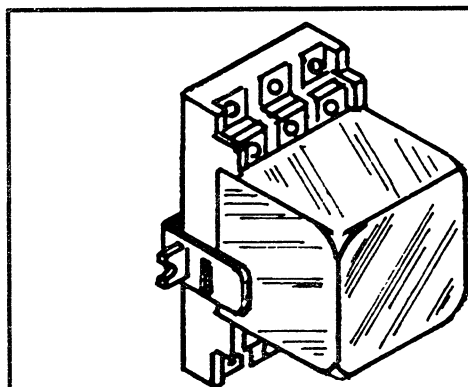


FIGURE 5-1. RUN RELAY

INTERFACE RELAY MODULES

(If Equipped)

When the customer provides a remote control panel having alarm circuits powered by a separate AC or DC source, Module A13 (7 relays) and Module A14 (5 relays) may be provided to interface with the ECM (A11) circuits. Typical wiring diagrams are shown in Figure 5-2.

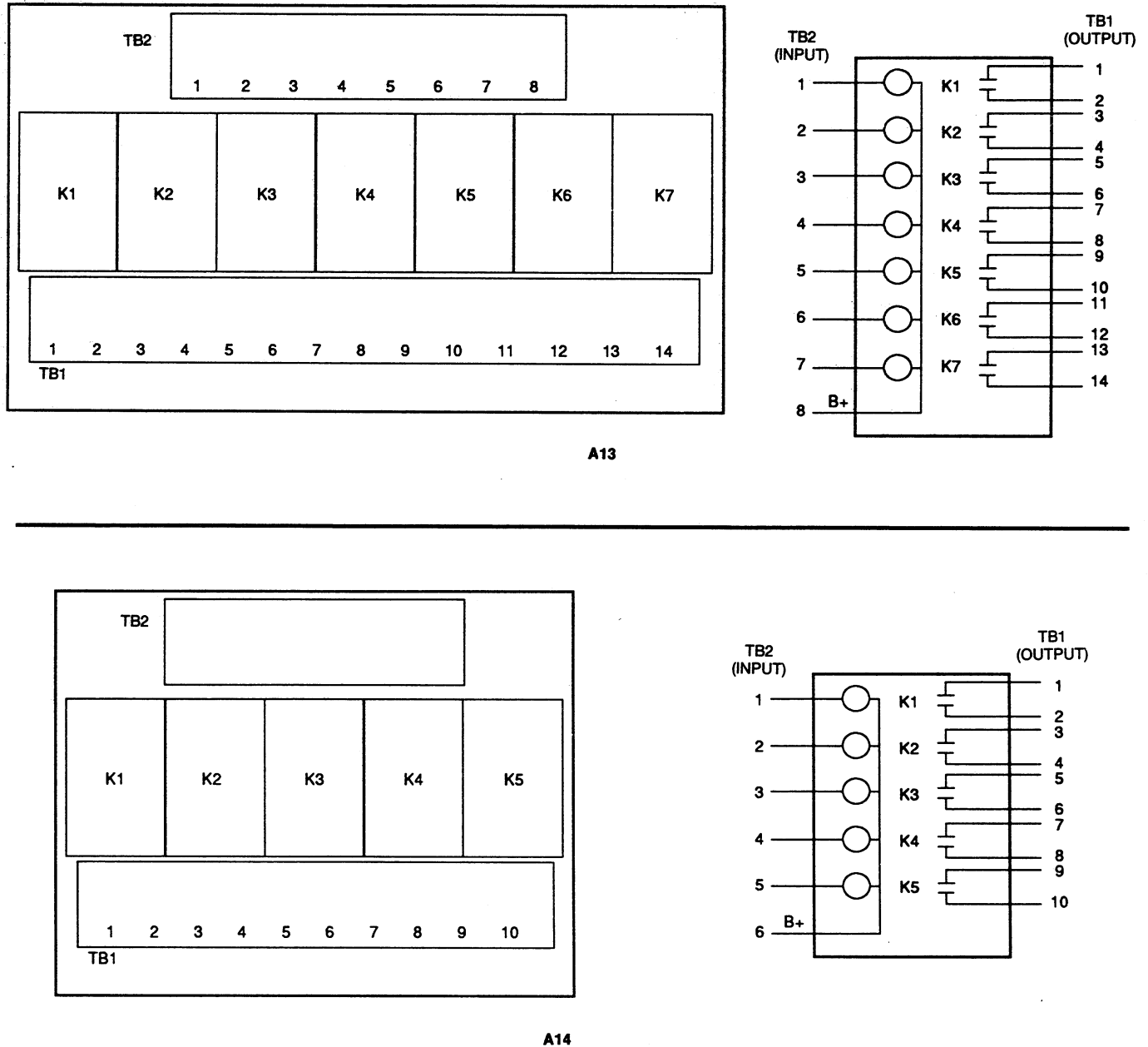


FIGURE 5-2. INTERFACE RELAY MODULES

TIME DELAYED START/STOP MODULE (If equipped)

This module contains adjustable potentiometers for time delayed start (1 to 15 seconds), and time delayed stop (1 to 15 minutes). Time delay adjustment is made by turning the appropriate potentiometer clockwise to increase or counterclockwise to decrease the time delay. Set the time delay start per site requirements, and the time delay stop for approximately 3 to 5 minutes. Typical wiring diagram is shown in Figure 5-3. Refer to *Wiring Diagrams* section for further information.

AC METERS AND CURRENT TRANSFORMERS

If a meter malfunctions, the problem might be a loose wiring connection, the meter itself, the phase selector switch, or the current transformer for that meter. If more than one meter is malfunctioning, you may have to check for proper and secure generator tap connections. Check appropriate AC wiring diagram/schematic for wire lead and terminal connections. Checking continuity of the wiring and components should identify the problem. Repair or replace any faulty wiring, replace faulty meter, current transformer, switch, etc. Refer to appropriate wiring diagram/schematic in *Wiring Diagram* section.

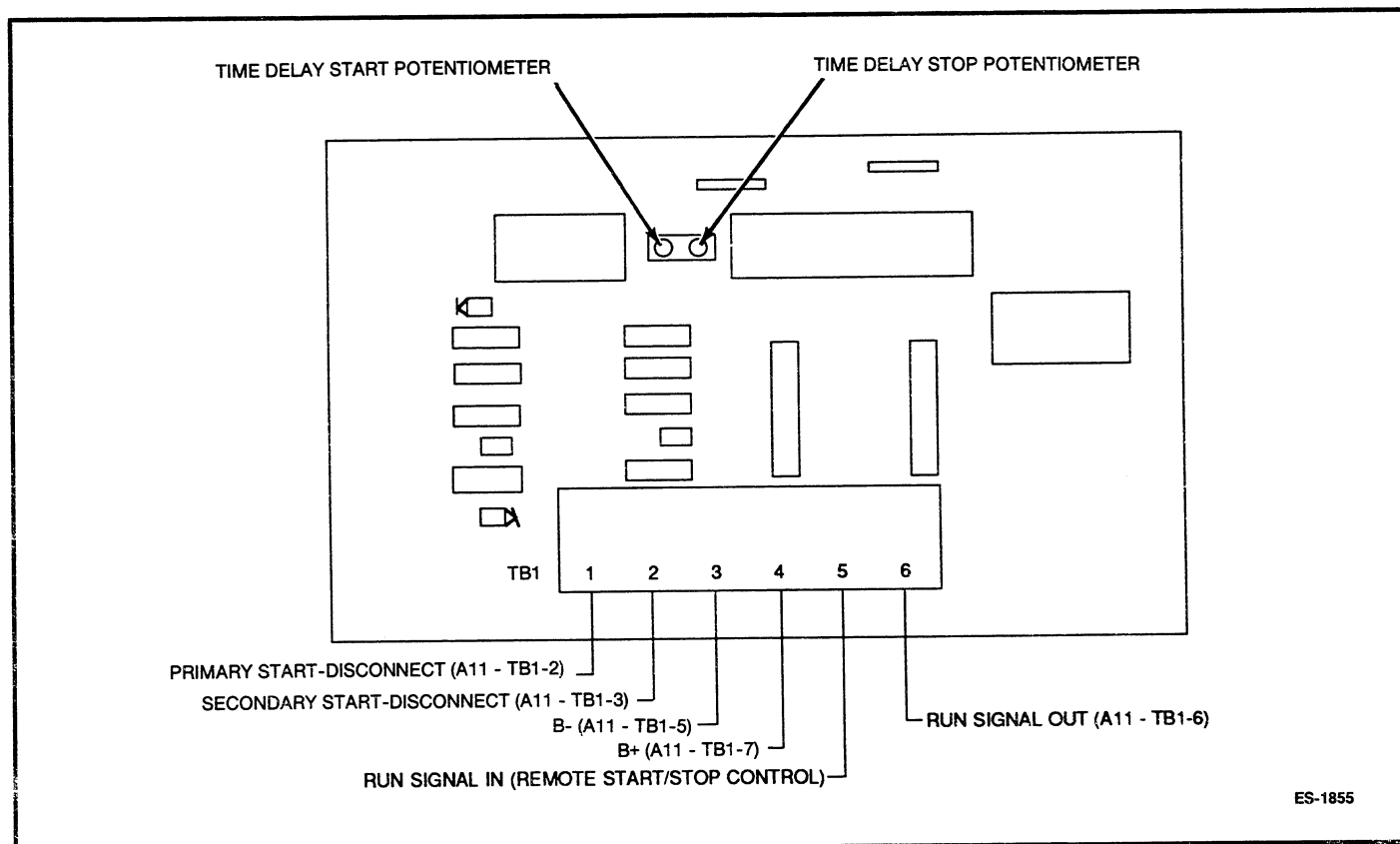


FIGURE 5-3. TIME DELAYED START/STOP MODULE

AUTOMATIC VOLTAGE REGULATOR (AVR)

Review the generator set specifications and wiring diagrams/schematics to identify the generator type (self excited, non-PMG, or, permanent magnet exciter, PMG), and AVR sensing circuit type (2-phase or 3-phase sensing). Then refer to the appropriate descriptions that follow.

NON-PMG GENERATOR SET AVR (SELF-EXCITED)

This AVR is a half wave phase controlled thyristor type and forms part of the excitation system for the generator.

In addition to regulating the generator voltage, the AVR circuitry includes underspeed and sensing loss protection to ensure safe reliable control of the generator. Excitation power is derived directly from the generator output terminals.

Positive voltage build up from residual levels is ensured by the use of efficient semiconductors in the power circuitry of the AVR.

The AVR is interlinked with the main stator windings and the exciter field windings to provide closed loop control of the output voltage with load regulation at approximately $\pm 1\%$.

In addition to being powered from the main stator, the AVR also derives a sample voltage from the output windings for voltage control purposes. In response to this sample voltage, the AVR controls the power fed to the exciter field, and the main field, in such a way as to maintain the machine output voltage within the specified limits, compensating for load speed, temperature and power factor of the generator.

A frequency measuring circuit continually monitors the generator output and provides underspeed protection of the excitation system, by reducing the output voltage proportionately with speed below a preset value. A manual adjustment is provided for factory setting of the Under Frequency Roll Off point, (UFRO). This can easily be changed to 50 or 60Hz in the field by push-on wire link selection.

Overvoltage situations caused by open circuit sensing terminals are avoided by sensing loss detection circuitry which reduces the generator terminal voltage to a safe fixed level.

Provision is made for the connection of a remote voltage trimmer (Voltage Adjust R21), allowing the user fine control of the generator's output.

Basic Operation

The internal block diagram of the AVR board is shown in Figure 5-4. The main functions of the AVR are as follows.

Input Sensing Circuit: Takes a proportion of the generator output voltage and attenuates it to a suitable lower level. This input chain of resistors includes the means by which the generator voltage is adjusted (Range + Hand Trimmer). An isolating transformer is included to allow connection to windings of different polarity and phase. An operational precision rectifier is used to convert the AC sensing voltage into DC for further processing.

Quadrature Droop Circuit: Converts the current input from a CT into a voltage, which is phase mixed with the sensing voltage. The result is a net increase in the output from the sensing network as the power factor lags, causing a reduction in excitation.

A trimmer allows control over the amount of droop signal.

Sensing Loss Detector: Is best described as an electronic changeover switch which normally connects the main comparator/amplifier to the input sensing network, and automatically changes over to the power sensing network when the normal sensing voltage is lost.

DC Mixer: Provides an interface between the AVR and accessories and allows the generator's excitation to be controlled by adding and subtracting the accessory DC output voltage to the AVR rectified sensing voltage.

Main Comparator/Amplifier: Compares the sensing voltage to the reference voltage and amplifies the difference (error) to provide a controlling signal for the power devices. The pedestal and ramp circuit and level detector and driver provide the means to infinitely control the conduction period of the output device over each half cycle (phase control), and thereby provide the exciter with the required power to maintain the generator voltage within specified limits. The stability circuit provides adjustable negative AC feedback to prevent voltage hunting and provide good steady state and transient performance of the control system.

Low Hz Detector: Measures the period of each electrical cycle and causes the reference voltage to be reduced approximately linearly with speed below a preset value. A light emitting diode (LED) gives indication of underspeed running.

Sync. Circuit: Provides a short pulse at the zero crossing of each cycle and is used to synchronize the underspeed and pedestal and ramp circuit to the generator waveform. The sync circuit is preceded by a low pass filter to prevent false zero crossing pulses due to severely distorted waveforms.

Power Devices: Are configured as half wave thyristor and freewheel diode to vary the amount of exciter field current in response to the error signal produced by the main comparator.

Suppression: Components are included to prevent subcycle voltage spikes damaging the AVR components and are also to reduce the amount of AVR thyristor noise on the main terminals of the generator.

Power Supply: Components consist of zener diodes with dropper resistor and smoothing to provide the required voltages for the integrated circuits and reference voltage.

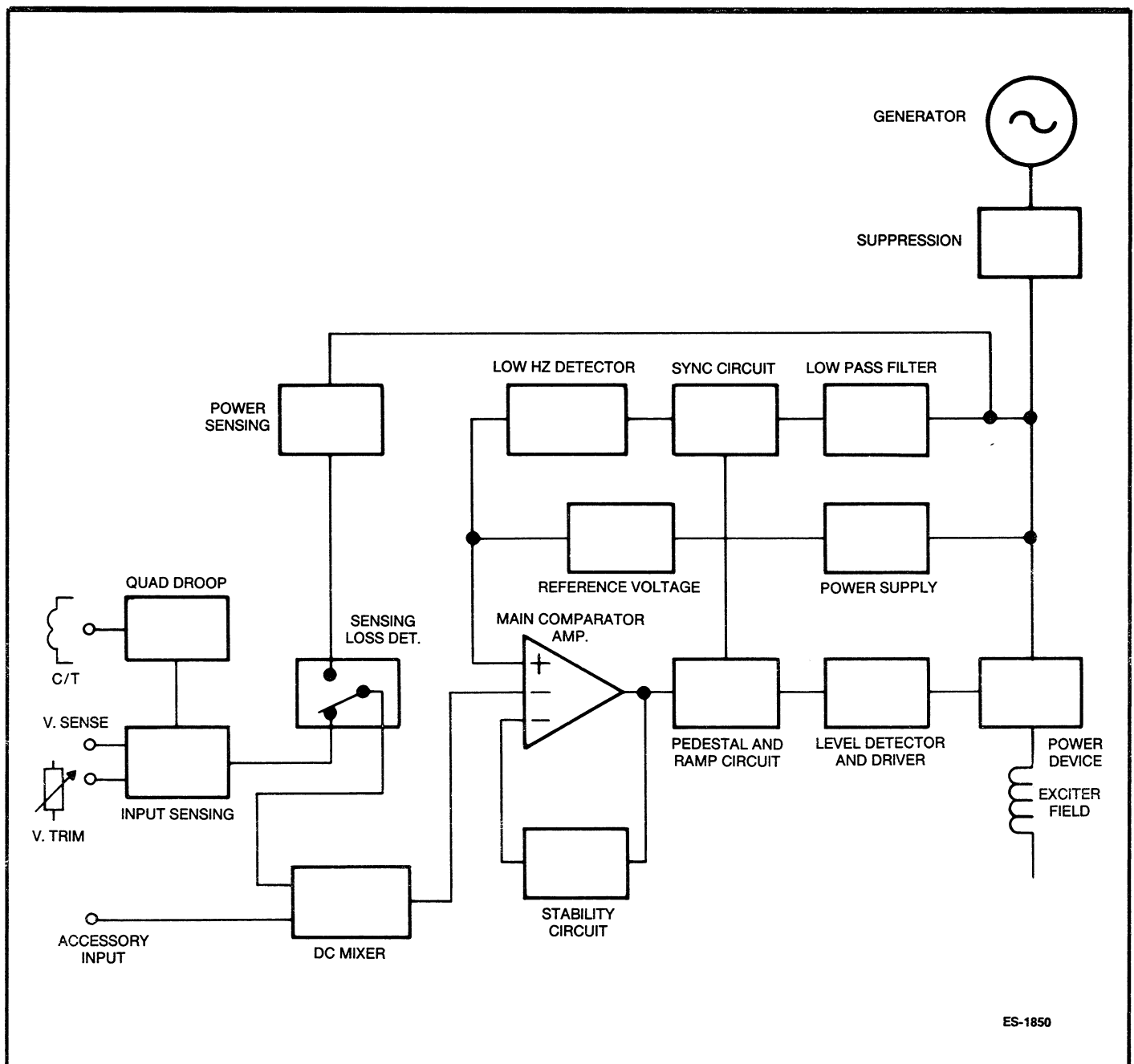


FIGURE 5-4. NON-PMG VOLTAGE REGULATOR BLOCK DIAGRAM

PMG GENERATOR SET AVR

This AVR is a three-phase full wave, power mosfet type and forms part of the excitation system for the generator.

In addition to regulating the generator voltage, the AVR circuitry includes a number of protective features which provide safe reliable control of the generator. Excitation power is derived from a permanent magnet generator (PMG), providing low Radio Frequency Interference (RFI) and immunity from thyristor type loads.

The AVR is interlinked with the main stator windings, exciter field and PMG to provide closed loop control of the output voltage with load regulation at approximately $\pm 0.5\%$ RMS.

The AVR senses the output voltage from the main stator windings and in response to this controls the power fed to the exciter field, and the main field, in such a way as to maintain the machine output voltage within the specified limits, compensating for load, speed, temperature and power factor of the generator.

Soft start circuitry is included to provide a smooth controlled build up of generator output voltage.

Sustained overvoltage situations caused by open circuit sensing terminals or short circuit power device are avoided by overvoltage detection circuitry (optional) which provides internal shutdown and circuit breaker trip signals for circuit isolation if required.

A frequency measuring circuit continually monitors the shaft speed of the generator and provides underspeed protection of the exciter system by reducing the generator output voltage proportionally with speed below a preset value. A further enhancement of this feature provides greater voltage roll off in response to rate of falling speed (dHz/dt), to improve frequency recovery time on turbocharged engines.

Current limiting circuitry (optional) provides control over the amount of short circuit current flowing during three-phase and single-phase shorts on the generator output.

Over excitation situations left uncontrolled are limited to a safe duration by internal shutdown of the AVR output device. This condition remains latched until the generator has been stopped.

Basic Operation

The internal block diagram of the AVR board is shown in Figure 5-5. The main functions of the AVR are as follows.

Sensing Resistors: Take a portion of the generator output voltage and attenuate it to a suitable lower level. This input chain of resistors includes the hand trimmer adjustment.

Quadrature Droop Circuit (Optional): Converts the current input from a CT into a voltage, which is phase mixed with the sensing voltage. The result is a net increase in the output from the sensing network as the power factor lags, causing a reduction in excitation.

RMS Converter: Is a square law precision rectifier circuit that converts the AC signals from the sensing networks into a composite DC signal representing the mean squared value of the waveform.

The output of the RMS converter includes a variable potential divider which forms the voltage range control for the AVR.

Current Converter: Is a three-phase precision rectifier and amplifier that converts the inputs from current transformers into a DC signal representing the mean value of the current waveform.

Offset Control: Provides an interface between the AVR and accessories and allows the generator's excitation to be controlled by adding and subtracting the accessory DC output voltage to the AVR rectified sensing voltage.

Power Supply: Components consist of zener diodes, dropper resistor and smoothing to provide the required voltages for the integrated circuits.

Precision Voltage Reference: Is a highly stable temperature compensated zener diode used for DC comparison.

Soft Start Circuitry: Overrides the precision voltage reference during run up to provide a linear rising voltage.

Main Comparator/Amplifier: Compares the conditioned sensing voltages with the precision reference voltage and amplifies the difference (error) to provide a controlling signal for the power device in such a way as to supply the exciter with the required amount of power to maintain the generator voltage within the specified limits.

Stability Circuit: Provides adjustable negative AC feedback to prevent voltage hunting and ensure good steady state and transient performance of the control system.

Power Control Driver: Provides the means to infinitely control the conduction period of the output device. This is achieved by pedestal and ramp control followed by a level detector and driver stage.

Power Control Devices and Rectifier: Are configured as a three phase 4 diode bridge, power mosfet and free-wheel diode to vary the amount of exciter field current in response to the error signals produced by the main comparator.

Sync: Circuit provides a short pulse near the zero point of one of the phases on the PMG and is used to synchronize the Under Frequency Roll-Off (UFRO) and power control circuits to the generator cycle period.

Under Frequency Roll-Off: Circuit measures the period of each electrical cycle and causes the reference voltage to be reduced approximately linear with speed below a presettable threshold. A light emitting diode (LED) gives indication of underspeed running.

Block Relief: Circuit measures the rate of falling speed of the generator (dHz/dt) and causes greater voltage roll off (makes the V/Hz slope steeper) to aid engine speed recovery after application of a "block" load.

Over Voltage Monitor: Continuously monitors the voltage at the generator terminals and provides signals to shut down the output device and trip an optional circuit breaker, to isolate power from the exciter and AVR in event of sustained overvoltages. A one second timer is included in the circuit to prevent operation during transient overvoltages, which are normal after load removal.

Overload Detector: Continuously monitors the level of excitation and provides signals to shut down the output device in event of sustained overloads lasting greater than ten seconds. Both the overload and overvoltage conditions are latched faults requiring the generator to be stopped for reset.

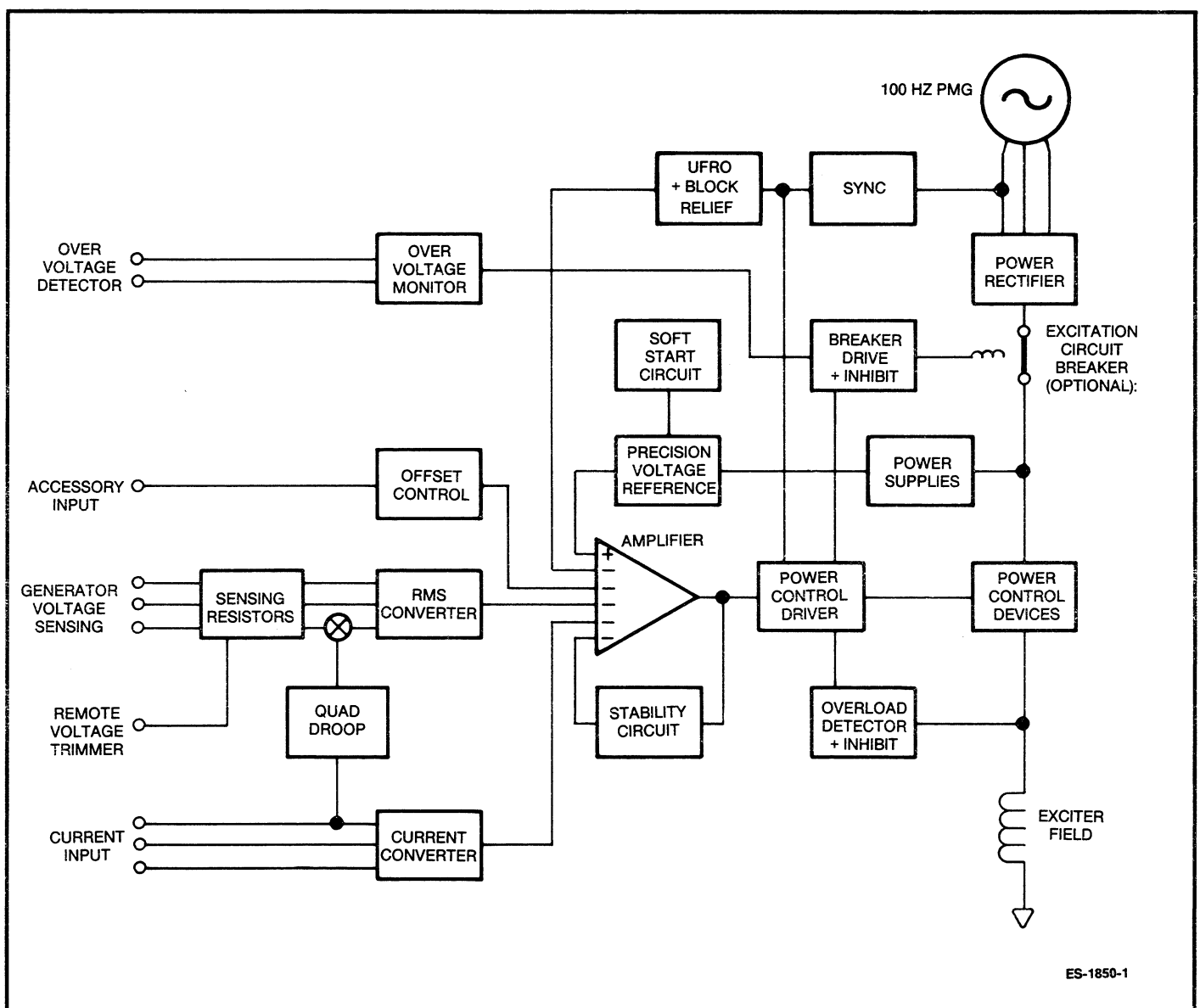


FIGURE 5-5. PMG VOLTAGE REGULATOR BLOCK DIAGRAM.

THREE PHASE SENSING UNIT FOR NON-PMG AVR (Optional)

The Three Phase Sensing Unit is an optional accessory for AVR's and forms part of the excitation system for the generator.

The unit comprises isolated line-to-line voltage sensing, precision rectification and summing to provide accurate average voltage measurement of the three phase generator voltages.

The unit is interlinked between the main stator winding and the AVR voltage sensing terminals to provide closed loop control of the output voltage with load regulation at approximately $\pm 1\%$, with the normal 4% speed droop.

In addition to measuring the generator voltages, provision is also made for the connection of a quadrature droop current transformer allowing the unit to sense power factor changes, providing the necessary sensing correction signals for parallel operation of generators.

Basic Operation

Figure 5-6 shows the internal block diagram of the Three Phase Sensing Unit. The main functions are as follows.

Input Isolator Circuit: Takes a proportion of the generator output voltage which is isolated and attenuated to a suitable lower level by transformers.

Power Supplies: For the integrated circuits are derived from separate secondary windings on the input isolating transformers.

- A *divider filter network* provides further attenuation and filtering to give slight v/Hz relief and "rounding" of subcycle voltage transients.
- A *quadrature droop* phase sensitive circuit is included to provide the necessary increase in the sensing output as generator power becomes more lagging, causing a reduction in excitation.
- *Precision rectifiers* provide the AC to DC conversion for all three phases, compensating for the forward voltage drop of the rectifier devices.
- An *analog mixer* sums the output of the three precision rectifiers providing a true average representation of the generator's three phase output voltages.

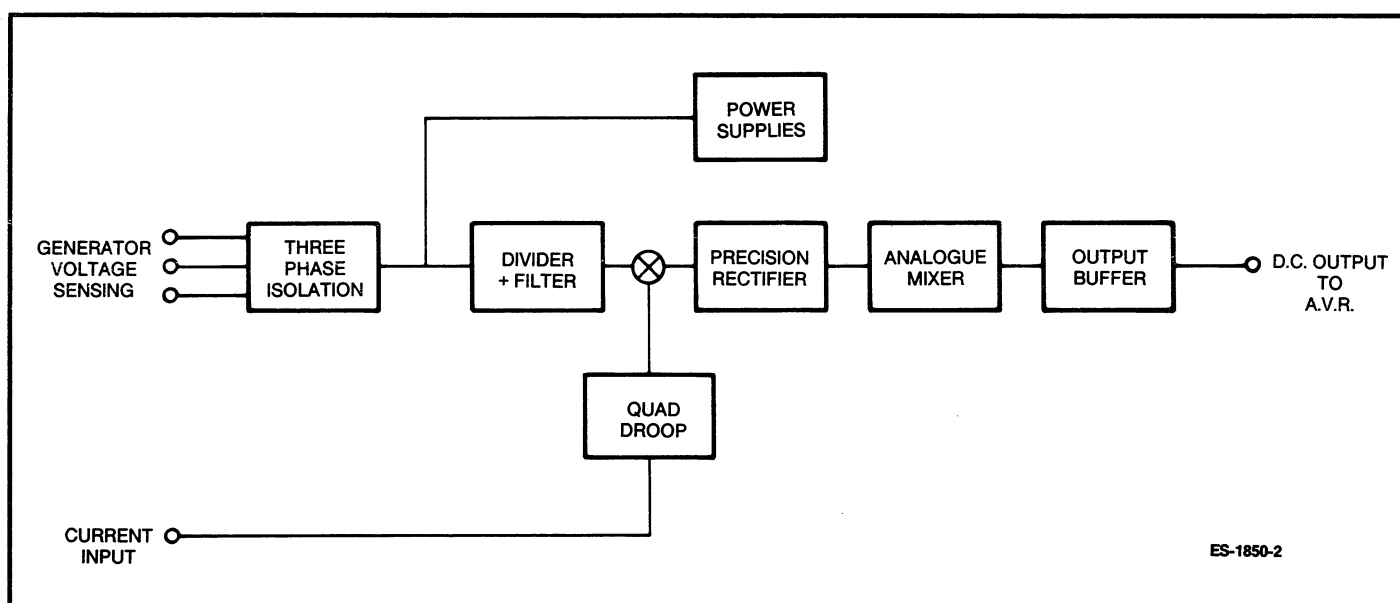


FIGURE 5-6. THREE PHASE SENSING UNIT BLOCK DIAGRAM

GENERATOR OPERATION REVIEW

Self-Excited Generator (Non-PMG)

The main stator winding provides excitation power via the AVR to the exciter. A circuit within the AVR ensures positive voltage build-up, provided the residual magnetism level is sufficiently high. The AVR compares the main stator output with a reference value and feeds a controlled excitation current to the exciter stator. The AC output of the exciter rotor is converted to DC by the rectifier, comprised of 6 diodes mounted on 2 heatsinks to form positive and negative plates. The diodes are protected against harmful overvoltages caused, for example by switching circuits or out-of-phase paralleling, by a metal oxide varistor (MOV). The DC output of the rectifier provides the excitation onto the main rotor.

Permanent Magnet Generator (PMG)

The main excitation components (diodes, MOV, and main exciter) are identical to those of the self-excited generator. Output voltage is compared with a reference voltage to feed a controlled current to the main exciter stator in the same way. The fundamental difference is that the excitation power is now derived from the permanent magnet exciter, mounted on the main shaft, rather than from the main stator winding. Excitation power is thereby independent of output voltage, and a positive voltage build-up is ensured, without reliance on residual magnetism.

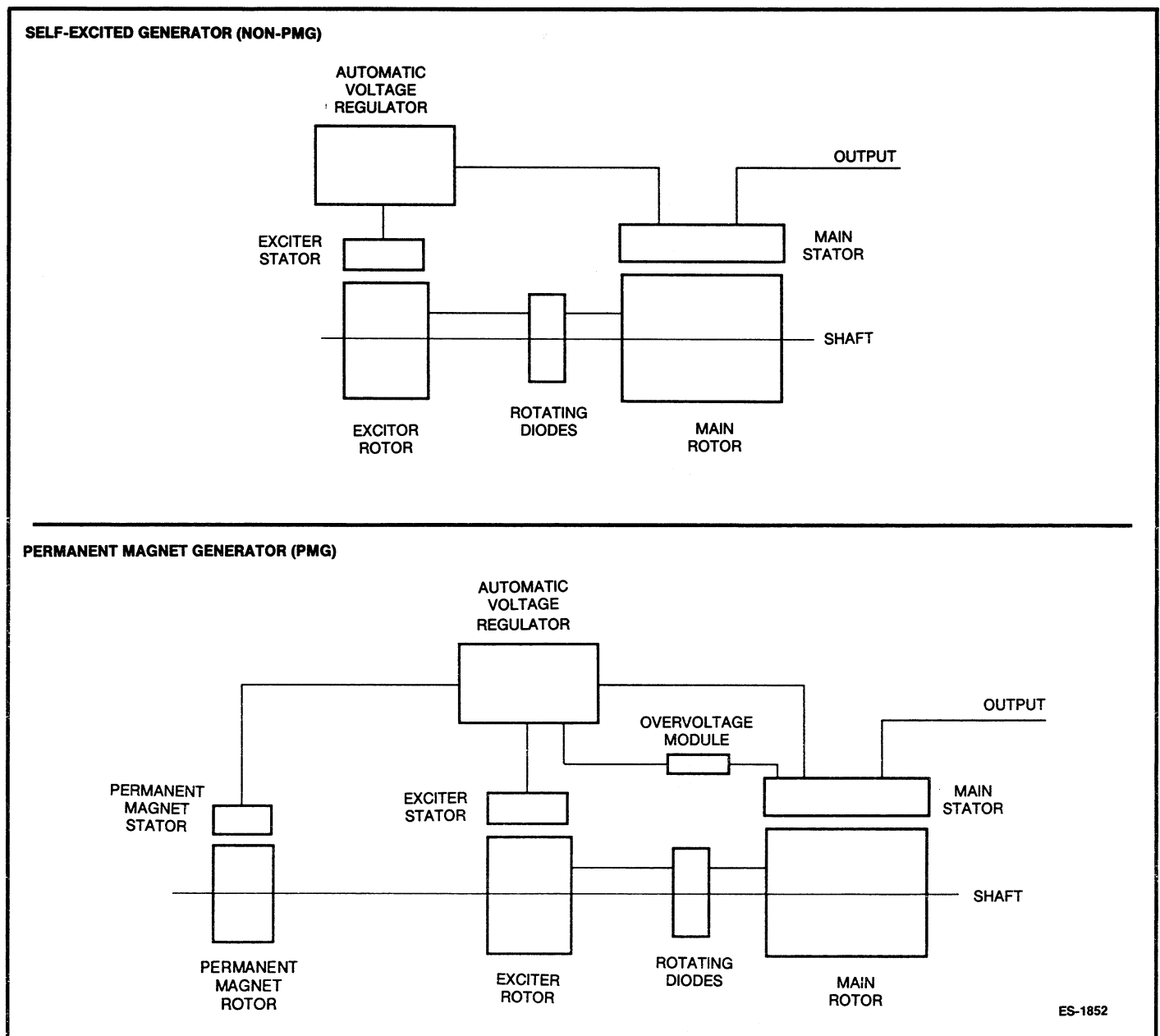


FIGURE 5-7. EXCITATION SYSTEMS (Block Diagrams)

AVR Sensing and Power Supply

2-Phase Sensing: With rated output voltage on the main terminals, the voltage across AVR leads 2 and 3 should be between 170 and 250 volts AC. This supply may be via quadrature droop burden resistor and/or drooper transformer. These should be checked for continuity.

3-Phase Sensing: The 3-Phase sensed AVR's are supplied via a separate sensing unit. With rated output voltage on the main terminals, the reference supply is to this unit and should be between 170 and 250 volts AC across 6-7, 7-8, and 8-6. This supply may be quadrature droop burden resistor and/or drooper transformer. These should be checked for continuity.

Power Supply (Non-PMG): Power supply is derived from the output windings. With rated output voltage on the main terminals the voltage across AVR leads P2 and P3 should be between 170 and 250 volts AC.

Power Supply (PMG): Power supply is derived from the permanent magnet exciter. Its output leads are connected at AVR terminals P2, P3 and P4. These must first be disconnected. With the machine at rated speed the output voltage between leads P2-P3, P3-P4, and P4-P2 should be balanced at approximately 150 volts for 50 Hz (1500 rpm) units or 180 volts for 60 Hz (1800 rpm) units.

Voltage Regulator Adjustment

Generator voltage is controlled by the optional voltage control rheostat (R21) located on the control front panel and the solid-state voltage regulator located inside control panel (see Figure 5-8).

The generator voltage may be adjusted within ± 3 percent of the rated nameplate voltage via the optional control panel mounted voltage control rheostat (R21). If the adjustment cannot be made with R21, or if R21 is not installed, adjust the voltage regulator as follows:

1. Adjust voltage control rheostat R21 (if available) to the mid position.
 - Loosen the locking nut. With a screwdriver, turn rheostat R21 fully counterclockwise, then fully clockwise, then to mid position.
2. Open the control panel doors to gain access to the voltage regulator.
3. With the generator set operating, and the voltage being monitored (either by meters on the set or with remote metering), adjust voltage regulator board Volts potentiometer to the desired generator voltage.
4. Perform fine voltage adjustment (± 3 percent) by adjusting rheostat R21, retighten locking nut.
5. Stop and restart generator set to confirm proper operation.

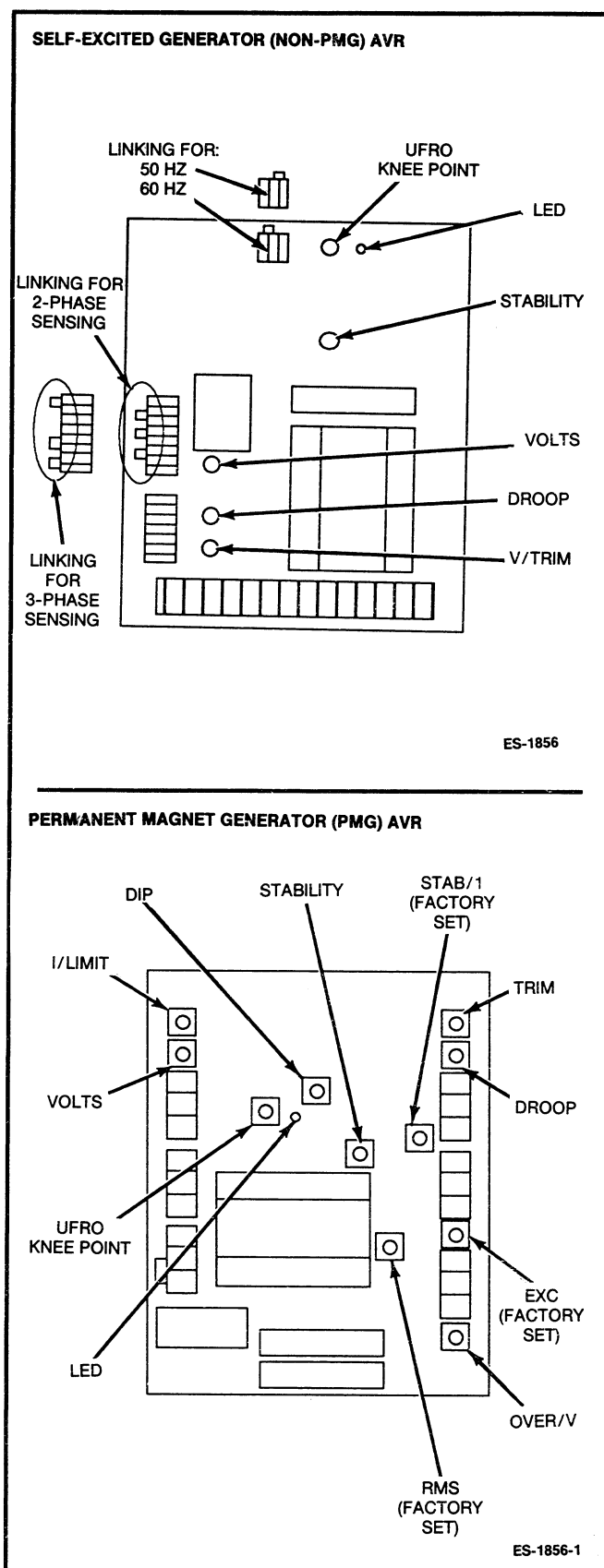


FIGURE 5-8. VOLTAGE REGULATORS

OVER/UNDER FREQUENCY SENSOR MODULE (If equipped)

Rotate the appropriate arrow indicator to adjust the module, the recommended settings are:

Nominal Hz	50	60
Under Hz Set	45	55
Reset	47	57

Over Hz Set	55	65
Reset	53	63

See typical wiring diagram in Figure 5-10.

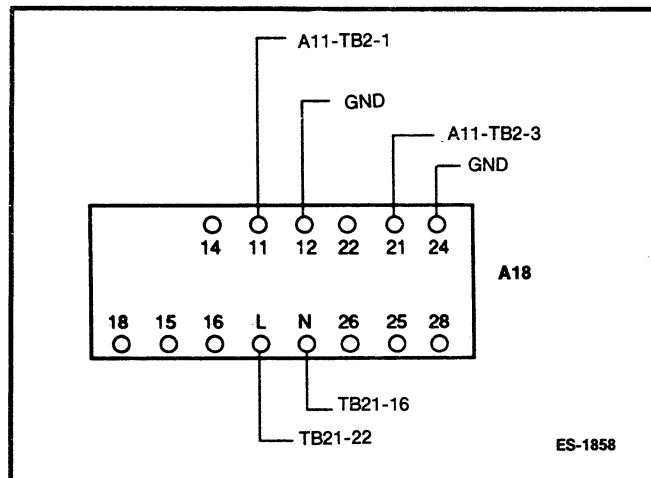


FIGURE 5-10. OVER/UNDER FREQUENCY SENSOR MODULE

OVERSPEED (FREQUENCY DETECTION) MODULE (If equipped)

This module derives a speed (Hz) signal from the PMG (if equipped) but is powered from the generator set battery. A small time delay, typically one second, is incorporated in the overspeed function to allow for engine overshoot. The module contains two adjustable potentiometers, Overspeed and Cranking (the cranking potentiometer is not used however).

The Overspeed potentiometer is adjustable from 1500 to 2500 RPM. Adjust the Overspeed potentiometer to achieve overspeed at approximately 1800 to 1900 RPM for 50 Hz units and 2100 to 2200 RPM for 60 Hz units. See typical wiring diagram in Figure 5-11.

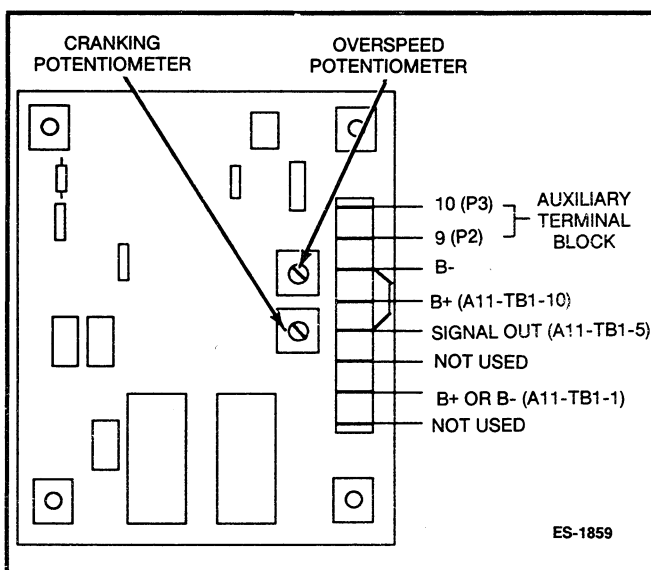


FIGURE 5-11. OVERSPEED (FREQUENCY DETECTION) MODULE

OVERSPEED SWITCH (If equipped)

Rotate the adjustment screw to achieve the proper air gap (0.005 in./0.13 mm) as shown in Figure 5-12.

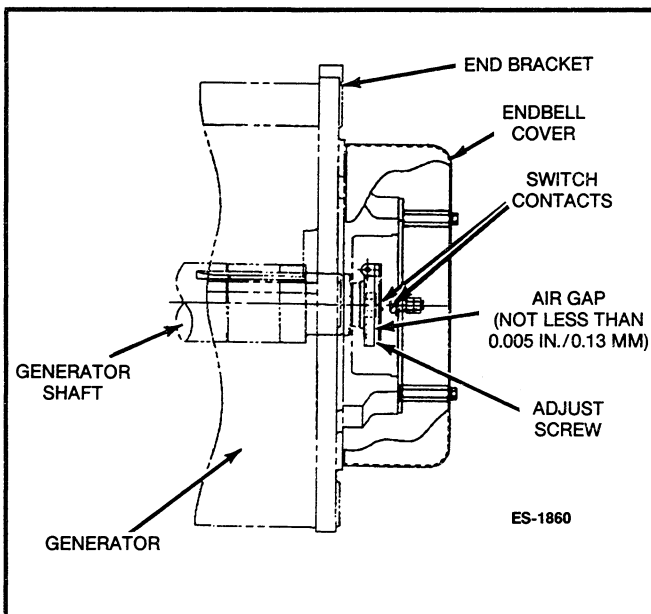


FIGURE 5-12. OVERSPEED SWITCH

ROTATING RECTIFIER ASSEMBLY

The rectifier assembly, Figure 5-13, 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 make sure that the correct polarity diodes are fitted to each respective plate.

Surge Suppressor

The surge suppressor (varistor) connected across the two rectifier plates prevents high transient reverse voltages in the field winding from damaging the diodes. This device is not polarized and will show an infinite reading in both directions with an ohmmeter. If defective, signs of burning will probably be apparent and it will give a full deflection (short-circuit) reading. Replace if defective.

Rectifier Diodes

Using an accurate ohmmeter, test each CR using negative and positive polarities. Test rectifiers (diodes) as follows.

1. Disconnect all leads from assembly to be tested.
2. Connect one meter lead to the positive (X) stud and connect other lead to CR1, CR2, and CR3 in turn; record resistance value of each rectifier.

3. Connect one meter lead to the negative (XX) stud and connect other lead to CR4, CR5, and CR6 in turn; record resistance value of each rectifier.
4. Reverse meter leads from steps 2 and 3 and record resistance value of each rectifier; positive stud(X) to CR1, CR2, and CR3; and negative Stud (XX) to CR4, CR5, and CR6.
5. All the resistance readings should be high in one test and low in the other test. If any reading is high or low in both areas, rectifier assembly is defective.
6. Replace defective rectifier assembly with new, identical part.

CAUTION Excessive dust or dirt on diodes and other components will cause over-heating and eventually failure. Keep these assemblies clean!

Use 24 in.-lbs. (2.7 N-m) torque when replacing nuts of positive (X) and negative (XX) studs, and CR1 and CR6.

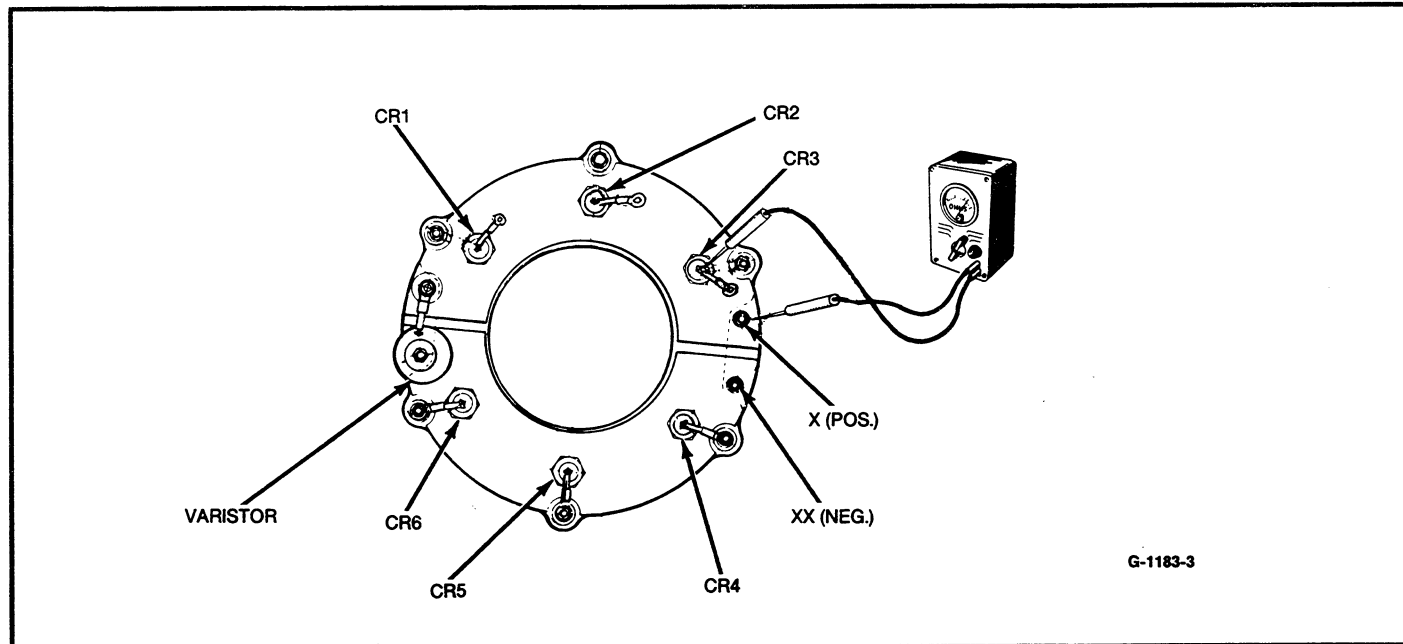


FIGURE 5-13. TESTING ROTATING RECTIFIER ASSEMBLY

Replacing Rectifiers

To replace rectifiers use the following procedure:

1. Disconnect diode lead wire from stud terminal.
2. Use proper size wrench to unscrew diode from rectifier assembly base.
3. Apply heatsink compound to underside of new diode. DO NOT apply this compound to diode stud threads.
4. Insert new diode into mounting hole. Torque diodes on rotating rectifier assembly to 36-42 in-lbs. (4-4.8 N•m)
5. Reconnect diode lead wire to stud terminal. Use 24 in-lbs. (2.7 N•m) torque when replacing nuts.

PERMANENT MAGNET EXCITER (if equipped)

The permanent magnet exciter is the main power supply for the AVR and is isolated from all other windings. For this reason the output from the exciter must be tested independently across its terminals, which are connected to auxiliary terminal board (exciter leads P2, P3, and P4). With 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 for 1500 rpm (50

Hz) or 180 volts for 1800 rpm (60 Hz) between terminals. The permanent magnet exciter will produce an output voltage completely independent from the rest of the machine, and has no effect on the separate excitation tests that follow. Refer to appropriate wiring diagram/schematic in section 7.

The permanent magnet exciter stator resistance is 4.4 ohms line-to-line.

EXCITER ROTOR

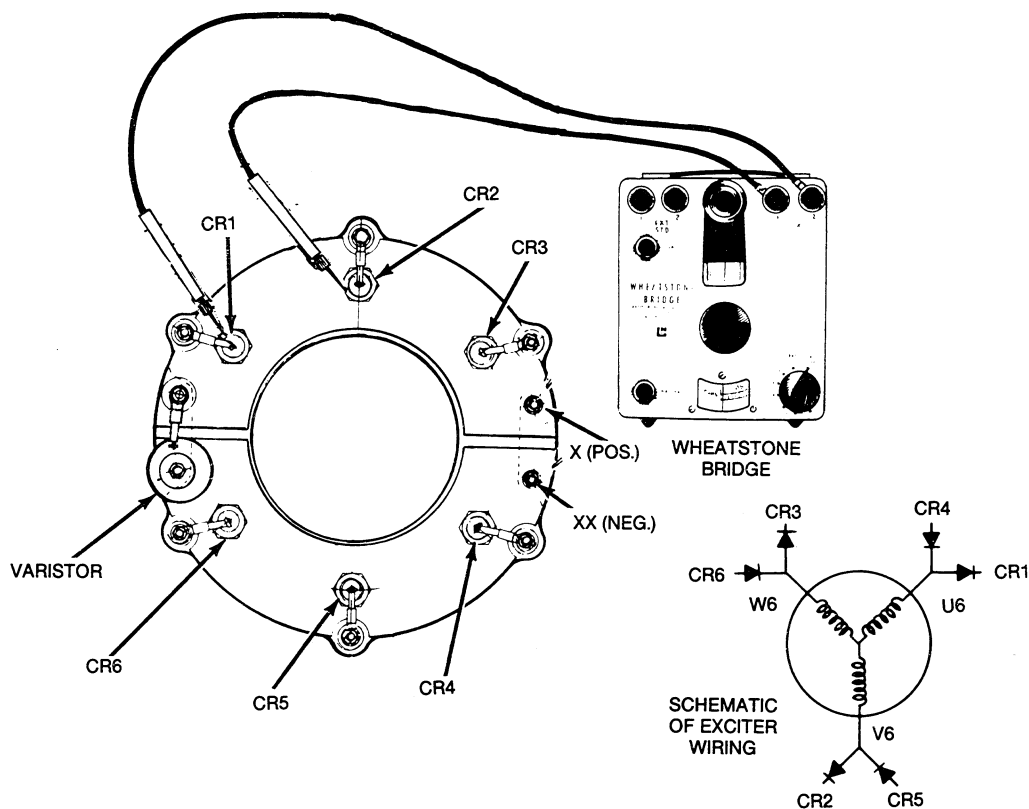
Testing for Grounds

Connect leads of ohmmeter between each CR lead and exciter rotor laminations. Use an ohmmeter set at the highest resistance range. An ohmmeter reading less than one megohm (1,000,000 ohms) indicates defective ground insulation. See Figure 5-14.

Testing for Open or Shorted Windings

Use a wheatstone Bridge for this test. Disconnect main rotor field leads which connect to rotating rectifier assemblies at the positive and negative studs. Disconnect lead wires from diodes CR1, CR2, CR3, CR4, CR5, and CR6. Test between exciter lead pairs U6-V6, V6-W6 and U6-W6. Refer to Table 5-1 for resistance values.

Be sure to identify the GenSet Model/kW rating from the generator set nameplate before reviewing Table 5-1.



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FIGURE 5-14. TESTING EXCITER ROTOR

EXCITER STATOR

Testing for Grounds

Using an ohmmeter, R x 100 scale, measure the insulation resistance between either lead X or XX and the laminations, Figure 5-15. A reading of less than infinity indicates a ground.

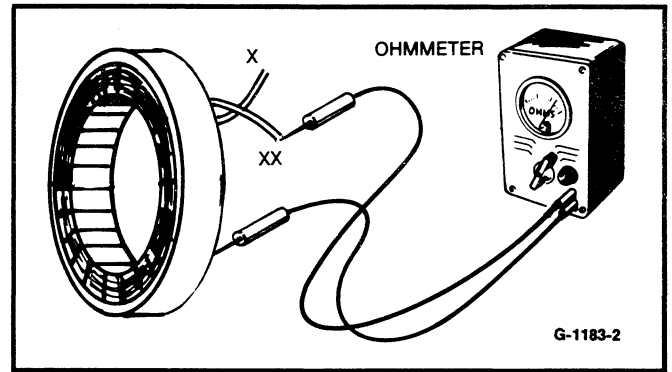


FIGURE 5-15. TESTING EXCITER STATOR FOR GROUNDS

Testing Winding Resistance

Measure coil resistance between leads X and XX with an ohmmeter, scale R x 1. See Figure 5-16. Refer to Table 5-1 for resistance values.

Be sure to identify the GenSet Model/kW rating from the generator set nameplate before reviewing Table 5-1.

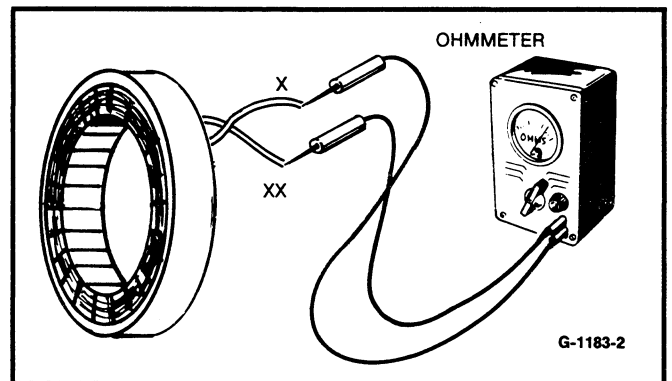


FIGURE 5-16. TESTING EXCITER STATOR FOR OPEN CIRCUIT

GENERATOR ROTOR

Testing for Grounds

Use an ohmmeter, (R x 100 scale) and measure as follows:

1. Disconnect X and XX rotor leads from the rotating diodes.
2. Measure between either lead and the rotor shaft, Figure 5-17.
3. A reading of less than infinity indicates a ground.

Testing for an Open Circuit

1. Disconnect and test between X and XX leads, Figure 5-18.
2. Replace the rotor if it is grounded or has an open or short. Refer to Table 5-1 for resistance values.

Be sure to identify the GenSet Model/kW rating from the generator set nameplate before reviewing Table 5-1.

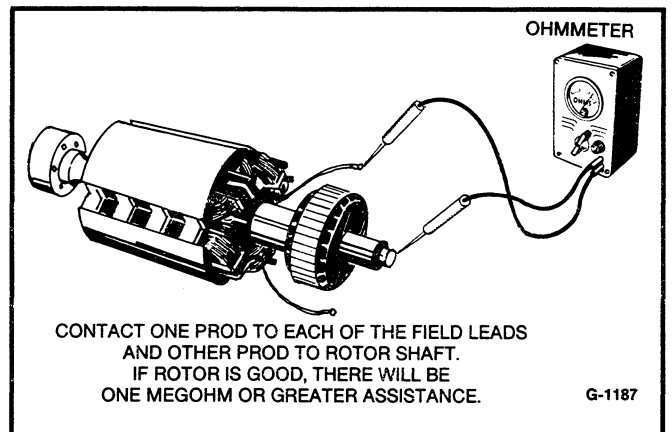


FIGURE 5-17. TESTING GENERATOR ROTOR FOR GROUNDS

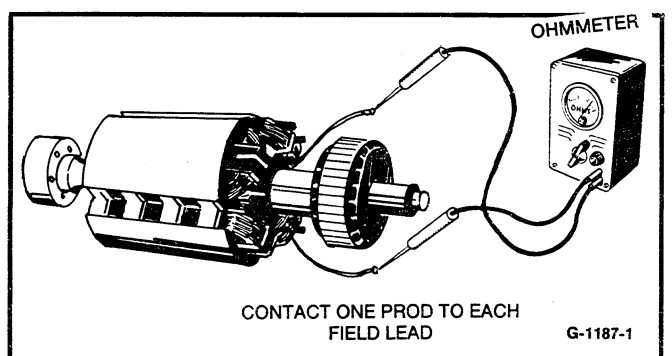


FIGURE 5-18. TESTING GENERATOR ROTOR FOR OPEN CIRCUIT

GENERATOR STATOR

Testing for Grounds

Before testing stator, disconnect control wire taps of U1, U2, U5, V2, and W2 from TB21. Isolate from ground and each other.

Connect all (U, V, and W) stator output leads together. Use an ohmmeter set on the R x 100 scale and measure the insulation resistance between these windings and the stator frame. A reading of less than infinity indicates a ground. Field circuit breaker can be either open or closed for this test.

Testing for Shorts

To check for shorts between individual windings, first refer to electrical schematic to determine individual coil lead wires (U5-U6, U1-U2, Etc.). Be sure to disconnect the instrumentation leads and stator leads U1, U2, U5, V2, and W2. Connect an ohmmeter, R x 100 scale to one lead of a stator winding (leaving the other end of the coil winding being tested open), and the other ohmmeter lead to all other stator leads connected together.

Example:

- Ohmmeter lead to: U6 coil winding lead.
- Ohmmeter lead to: U1, U2, V1, V2, V5, V6, W1, W2, W5, and W6 connected together.
- Coil winding lead open U5, open.

A reading of less than infinity indicates a short. Repeat test for all six coils.

Measure resistance of windings using a Wheatstone Bridge meter. Refer to Figure 5-19. If any windings are shorted, or grounded, first check the leads for broken wires or damaged insulation. If winding leads show no damage, and it is determined that windings are damaged internally, replace the stator assembly. Refer to Table 5-1 for resistance values.

Be sure to identify the GenSet Model/kW rating from the generator set nameplate before reviewing Table 5-1.

RECONNECTION

Figure 5-20 shows the general reconnection possibilities for the generators. When reconnecting for a different voltage, refer to AC Reconnect Wiring Diagram in section 7 and AC diagrams that came with unit.

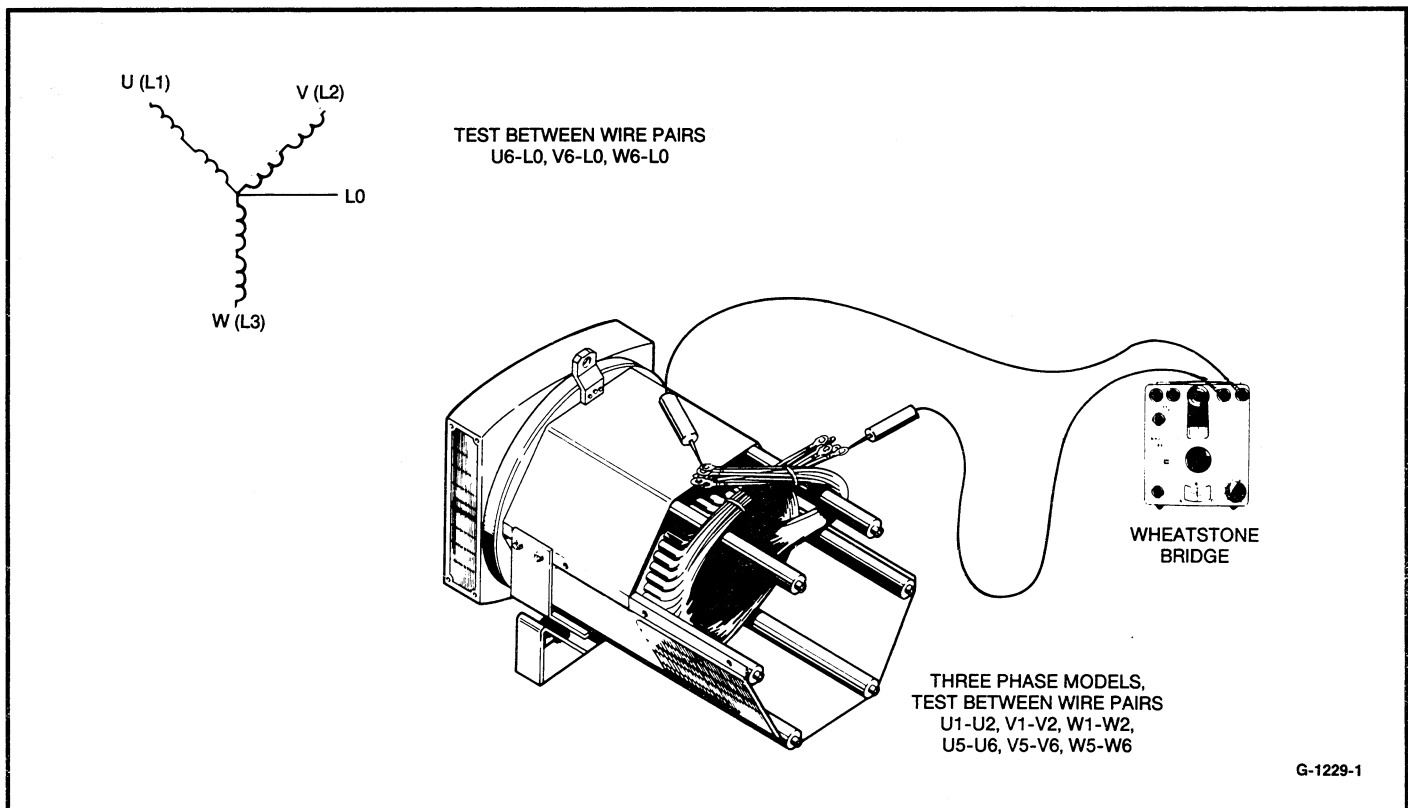
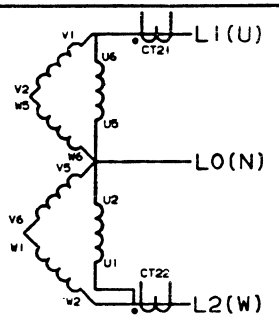
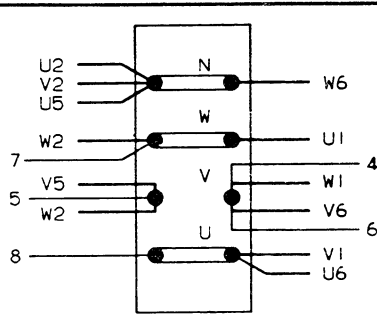
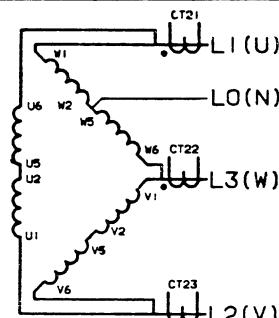
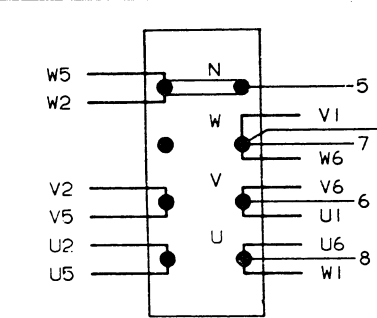
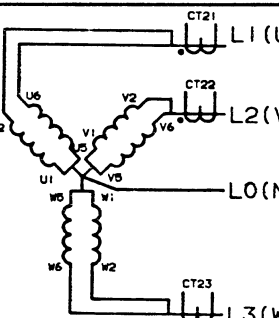
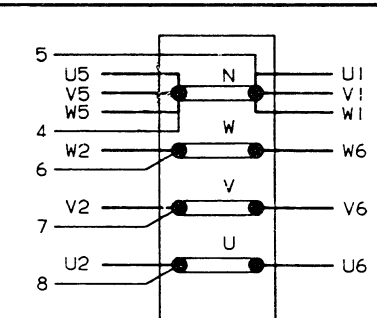
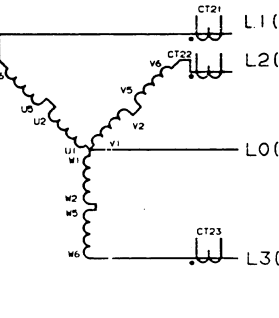
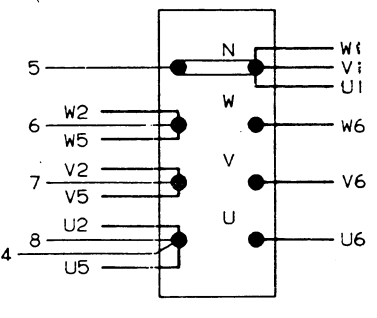


FIGURE 5-19. TESTING GENERATOR STATOR WINDINGS

TABLE 5-1 WINDING RESISTANCE VALUES*

MODEL NO.	GENSET		KW RATING		GEN STACK (MM)	EXCITER		STATOR (Per Phase: Wye or Series Wye)	ROTOR
	ID NO.		50 Hz	60 Hz		STATOR	ROTOR L—L		
4BT3.9-GC1	BT41		40	50	180	19.5	0.078	0.11	0.67
4BT3.9-GC2	BT42		50	60	240	19.5	0.091	0.071	0.8
6BT5.9-GC1	BT61		65	80	165	19.5	0.078	0.062	1.1
6BT5.9-GC2	BT62		85	100	190	19.5	0.078	0.047	1.3
6CT8.3-GS/GC1	CT61		100	125	285	19.5	0.091	0.025	1.7
6CTA8.3-GS/GC1	CTA61		135	150	335	19.5	0.091	0.022	1.9
6CTA8.3-GS/GC2	CTA62		150	175	375	19.5	0.091	0.016	2.1

*Resistance figures are approximates, at 68°F (20°C) ±10%.

VOLTAGE	PHASES	FREQUENCY (Hz)	Generator Connection	Current Transf. Conn.	GENERATOR CONNECTION SCHEMATIC DIAGRAM (Reconnectable Type Only)	GENERATOR CONNECTION WIRING DIAGRAM
120/240	1	60	DOUBLE DELTA*	1 and 3		
115/230 110/220	1	50				
240/480	3	60	HIGH (SERIES) DELTA	1 and 3		
120/240	3	60				
110/220 115/230	3	50				
120/208 127/220 139/240	3	60	LOW (PARALLEL) WYE	1 and 3		
110/190 115/220 120/208 127/220	3	50				
220/380 240/416 254/440 277/480	3	60				
220/480 230/400 240/416 254/440	3	50				
			HIGH (SERIES) WYE	1 and 2		

* - Single phase, double delta connection will reduce set rating, and may not work with 3-phase meters, etc.

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FIGURE 5-20. GENERATOR VOLTAGE CONNECTIONS

MECHANICAL GOVERNOR (Standard)

For generator sets not equipped with the electric governor, adjust the engine speed as follows:

1. Use the frequency control meter (if equipped) or an accurate tachometer.
2. Loosen the speed adjustment screw locknut. See Figure 5-21.
3. Start the generator set, allow unit to warm up to proper operating temperature, then apply full rated load.
4. Adjust the speed adjust screw in or out to reach required speed (60 Hz - 1800 r/min, or 50 Hz - 1500 r/min).
5. Hold the speed adjust screw at proper setting and retighten the locknut.
6. Remove and apply loads to check generator set response. Readjust the speed adjust screw if necessary.
7. If governor response is not satisfactory and further governor adjustments are necessary beyond this procedure, refer to the engine operation manual supplied with the unit, or, contact your service representative.

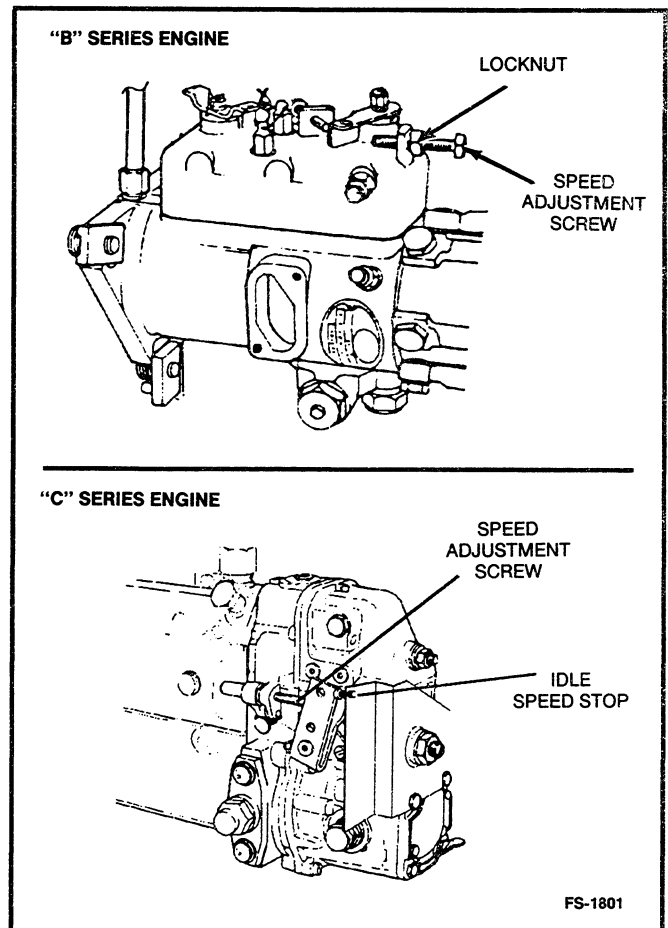


FIGURE 5-21. MECHANICAL GOVERNORS

ELECTRIC GOVERNOR (Optional)

Generator frequency is in direct ratio to engine speed which is controlled by the governor. The governor control has four potentiometers for making adjustments. See Figure 5-22. Use a frequency meter or tachometer to monitor the unit during adjustment procedure.

Gain and I: The Gain and I controls are one-turn potentiometers used to adjust the sensitivity of the governor. Adjustment of these potentiometers will shorten the response time to load changes.

Drop: The droop control is a one-turn potentiometer. It is adjustable for zero % (isochronous) to more than 5% speed droop. Fully counterclockwise rotation is 0% speed droop.

Speed: The speed control is a 20-turn potentiometer for setting the desired no-load governed speed. A clockwise rotation will increase the engine speed.

Refer to the following adjustment procedures.

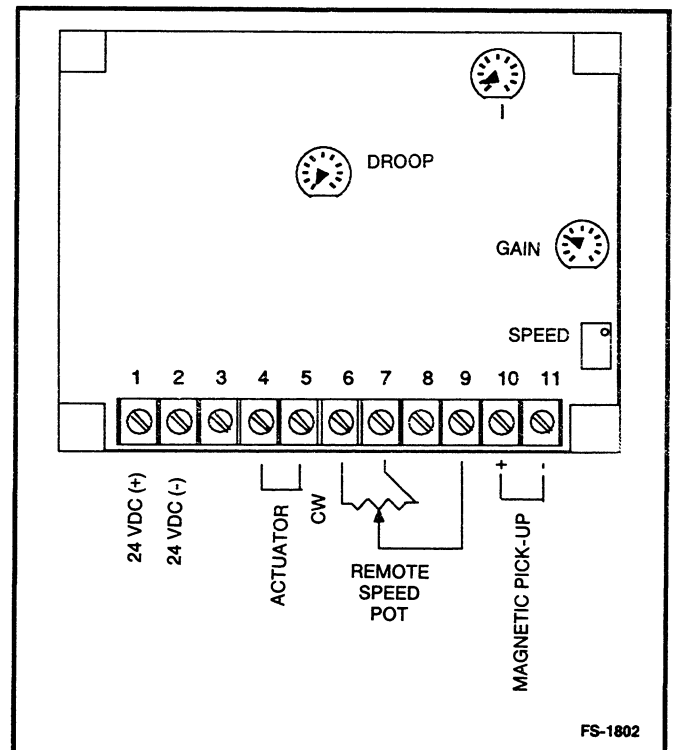


FIGURE 5-22. ELECTRIC GOVERNOR

Adjustments

Preliminary Adjustments:

1. Frequency Adjust (engine speed) potentiometer on control panel (if equipped).
 - A. Loosen the locking nut.
 - B. With a screwdriver, turn the potentiometer fully counterclockwise, then fully clockwise, then to mid position.
 - C. Hold mid position setting with screwdriver, and tighten locking nut.
2. I potentiometer.
 - A. Set the adjustment one division from zero.
3. Gain potentiometer.
 - A. Set the Gain adjustment at the third division from zero.
4. Droop potentiometer.
 - A. For isochronous operation, the droop potentiometer must be turned fully counterclockwise and will not require any further adjustment.
 - B. Turn the screw to approximately 40 for 3 per cent droop.
 - C. Turn the screw to approximately 80 for 5 per cent droop.

Calibration Checks:

1. Start the generator set.
2. For proper full-load generator set operation the engine no-load speed must first be adjusted to the desired allowable speed droop. (For example: isochronous operation set to 60.0 Hz/1800 r/min (50.0 Hz/1500 r/min), for 3% speed droop set to 61.8 Hz/1854 r/min (51.5 Hz/1545 r/min), for 5% speed droop set to 63.0 Hz/1890 r/min (52.5 Hz/1575 r/min).)

With the generator set warmed up to proper operating temperature, adjust the Speed potentiometer until the engine is operating at the desired frequency or r/min.

3. With no load connected to the generator set finalize the GAIN and I adjustments as follows:
 - A. Turn the GAIN adjustment clockwise slowly until the actuator level oscillates. Reduce the GAIN adjustment slowly counterclockwise until the level is stable. Upset the lever by hand. If the lever oscillates up to 3 diminishing oscillations and stops, the setting is correct.
 - B. Reduce the GAIN setting counterclockwise one division. Next, turn the adjustment fully clockwise while observing the actuator lever. If the lever does not become unstable, upset it by hand. When the lever slowly oscillates, turn the I adjustment counterclockwise slowly until the lever is stable. Upset the lever again, it should oscillate up to 3 times and then become stable for optimum response.
4. Apply and remove loads to check generator set response. If generator set operation is satisfactory, the governor is now calibrated. If generator set response is not satisfactory, review steps 3A and 3B. If electric governor cannot be properly calibrated, contact your service representative for assistance.

Fine Speed Adjustment: After the GAIN adjustment is made, the full load governed Speed may require a minor adjustment to equal the desired speed (i.e., 60 Hz, 1800 r/min or 50 Hz, 1500 r/min). Use the SPEED ADJUST potentiometer (when supplied) on the engine instrument panel for fine speed adjustments of less than ± 100 r/min.

BATTERIES

Check that connections are clean and tight. A light coating of non-conductive grease will help retard corrosion at terminals.

Check the charge condition of the starting batteries with a hydrometer. Keep the electrolyte at the proper level above the plates by adding distilled water. Check specific gravity and re-charge if below 1.260.

If the generator set is operated in an area where the ambient temperature is consistently above 95° F (35° C), a specific gravity of 1.225 is recommended to reduce electrolyte loss.

⚠WARNING *Ignition of explosive battery gases can cause severe personal injury. Do not smoke while servicing batteries. Wear protective apron and goggles when checking specific gravity and adding distilled water.*

If the battery loses excess water, the alternator charge may be too high. Likewise, if battery state of charge is not maintained, the charge rate may be too low. Refer to Alternator, this section. Also, if the battery will not re-charge, replace it.

BATTERY CABLES

With the starter motor operating, check the voltage drops; (1) from the battery negative post (not the cable clamp) to the grounding stud, (2) from the battery positive post to the battery terminal stud on the solenoid. Normally, each of these should be less than 0.3 volt. If extra long battery cables are used, slightly higher voltage drops may result. Thoroughly clean all connections in any part of the circuit showing excessive voltage drop.

ALTERNATOR

With the engine running, check the battery condition DC voltmeter. If the alternator is operating properly, the voltmeter reading should be between 26 and 28 volts. If the voltmeter reading is constantly more or less than this, stop the generator set and check for a loose or slipping drive belt, poor terminal connections, or broken lead wires. Repair or replace as required.

If everything checks out okay, use a voltmeter to determine the alternator output voltage and to verify accuracy of panel mounted DC voltmeter. Connect the positive (+) lead to the output terminal, and connect the negative (-) lead to ground. Start the generator set and run a few minutes to allow the voltage to stabilize. A proper operating system will have nominal output voltage of 26 to 28 volts.

If the output voltage is high (over 28 volts), check for loose or corroded voltage regulator leads. If this does correct the problem, the regulator is probably shorted and should be replaced.

If the output voltage is low (equals battery voltage), the problem could be worn or broken brushes, an open regulator, or an open field diode. Refer to appropriate engine service manual for more detailed test and service procedures.

STARTER SOLENOID

Apply B+ to the terminal marked "S". Jumper a ground wire to the solenoid mounting bracket. Solenoid should activate.

If the contacts are good, B+ should be present between terminal marked "I" and ground. The voltage drop measured across the contacts should never exceed one volt in circuit application.

FUEL SOLENOID

If there is fuel to the injection pump, but no fuel at injection nozzle, the fuel solenoid might be defective.

To check Fuel solenoid operation, remove the B+ lead connection from the solenoid, and jumper a separate B+ connection to the terminal. The injection pump should click. If no click is heard, the fuel solenoid must be replaced.

CONTROL SWITCH

Remove battery B+ cable. Place ohmmeter leads across switch. Open and close switch while observing the ohmmeter. A normally open switch should indicate infinite resistance when open and continuity when closed. A normally closed switch should indicate continuity when closed and infinite resistance when open. Replace switch if defective.

TESTING AC LOAD CIRCUIT BREAKER

General

The AC circuit breaker does not require any special maintenance other than periodic exercise and a check of conductor mounting. Circuit breaker options vary by customer requirements. Review the Optional Circuit Breaker description in section 3, and perform checks and adjustment applicable to the breaker. A typical breaker diagram is shown in Figure 5-23 for reference. When performing tests and adjustments, avoid accidental start-up by placing the Run/Stop/Remote switch in Stop position and disconnect the battery negative (-) cable.

⚠ WARNING *Accidental starting of the generator set during service procedures can result in severe personal injury or death. Place the Run/Stop/Remote switch in Stop position, and disconnect the battery negative (-) cable.*

Exerciser breaker: Actuate the breaker handle to the On and Off positions several times. If the breaker is equipped with a Trip Test button, the breaker should be tripped, reset and actuated to On several times. This will remove any dust from the mechanism and latch surfaces.

Checking Insulation Resistance: Disconnect the load and line conductors from the breaker, and place the breaker in the On position. Use an insulation resistance meter that will apply at least 500 volts to the test leads. Measure the insulation resistance between each pole, and to ground. Also test between the line and load terminals with the breaker in the Off position. A resistance reading less than 100,000 ohms indicates a ground. Investigate for possibly contamination on the breaker case surfaces, clean if necessary and retest.

Checking Contact Resistance: Extensive operation of the breaker under load may eventually cause contacts to deteriorate. Test by a Resistance Check, or by a Voltage Drop Check across the breaker poles. Except when generator set operation is required for testing, avoid accidental start-up by placing the Run/Stop/Remote switch in Stop position and disconnecting the battery negative (-) cable.

⚠ WARNING *Accidental starting of the generator set during service procedures can result in severe personal injury or death. Place the Run/Stop/Remote switch in Stop position, and disconnect the battery negative (-) cable.*

Resistance Check:

1. Disconnect the line and load wires from the circuit breaker.
2. Move the breaker handle to the On position and check the resistance across each pole (line to load).
3. Resistance should be very low (near zero) and relatively equal across all poles.

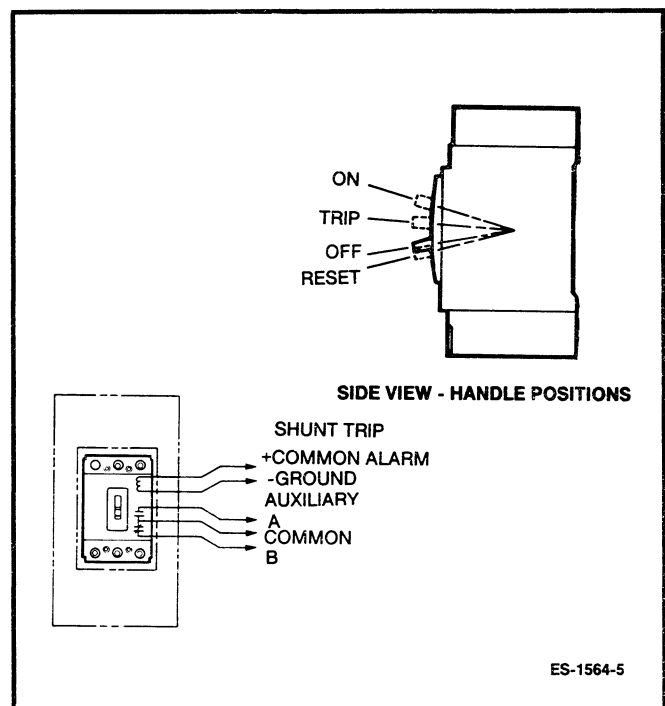


FIGURE 5-23. OPTIONAL CIRCUIT BREAKER DIAGRAM

Voltage Drop Check: This test is done with the conductors connected, generator set operating, and load applied. As a precaution against electrical shock, place an insulating mat or a dry wood platform on the floor to stand on when taking measurements.

⚠ WARNING *Contact with high voltage can cause severe personal injury or death. Do not touch any exposed wiring or components with any body part, clothing, tool or jewelry. Stand on an insulating mat or dry wood platform when taking measurements.*

1. Operate the generator set with the breaker in the On position and load applied.
2. Take voltage readings at the line connections, and then the load connections.
3. There should only be slight variation in the voltage dropped across each pole of the breaker. Unequal or excessive millivolt drops across the complete breaker, or one pole, indicates contaminated contacts or loose connections.
4. Stop the generator set by placing the Run/Stop/Remote switch in the Stop position and disconnecting the battery negative (-) cable.

⚠ WARNING *Accidental starting of the generator set during service procedures can result in severe personal injury or death. Place the Run/Stop/Remote switch in Stop position, and disconnect the battery negative (-) cable.*

Checking Shunt-Trip Operation: The shunt-trip feature is available in varying AC or DC voltages. The circuit breaker model is selected and installed at the factory to meet customer requirements. Check the shunt-trip function as follows:

1. Refer to the original equipment order, installation wiring diagrams, and unit wire routing to identify and confirm proper AC or DC signal source connections.
2. Apply the appropriate signal voltage (12-VDC; 240-, 480-VAC). The shunt-trip solenoid should energize and trip the breaker open.
3. If the breaker did not trip open, remove the signal source. Perform continuity check of interconnect wiring and shunt-trip solenoid lead wires. Replace interconnect wiring if defective.

Checking Auxiliary Contacts: If equipped, the breaker will have three leads for wiring to an internal single-pole, double throw switch. The switch allows connection of a remote annunciator (see installation wiring diagrams). Perform continuity checks of the switch with the breaker in On and Off positions to confirm operation.

Adjusting Magnet Trip Operation: If equipped with front-adjustable magnetic trip controls, the short circuit protection feature for each pole of the breaker can be adjusted equally or individually as required. Surge current above the trip settings will actuate the trip mechanism. These adjusters are set equally to the high position at the factory. Consult on-site requirements and adjust to proper position.

Section 6. Generator Disassembly/Reassembly

DISASSEMBLY

If generator testing determines that the generator needs repair, remove and disassemble as follows:

Permanent Magnet Exciter Removal (if equipped):

1. Disconnect the negative (-) battery cable to prevent accidental starting of the generator set while servicing.

⚠WARNING *Accidental starting of the generator set during this procedure presents the hazard of severe personal injury or death. Make sure to disconnect the negative (-) battery cable before beginning.*

2. Remove the endbell cover and conduit box access covers (see Figure 6-1).
3. Disconnect and withdraw leads P2, P3, and P4 from the auxiliary terminal block, inside conduit box.

4. Remove the bolts and clamps retaining the exciter stator to the endbracket.
5. Carefully guide the stator assembly from endbracket.

The highly magnetic rotor will attract the stator core, care must be taken to avoid any contact which may damage the windings.

6. Remove the through-bolt 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.

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

7. Locate the dowel pin (locating pin) on PMG rotor or main rotor shaft, remove and retain in a safe place for generator reassembly.

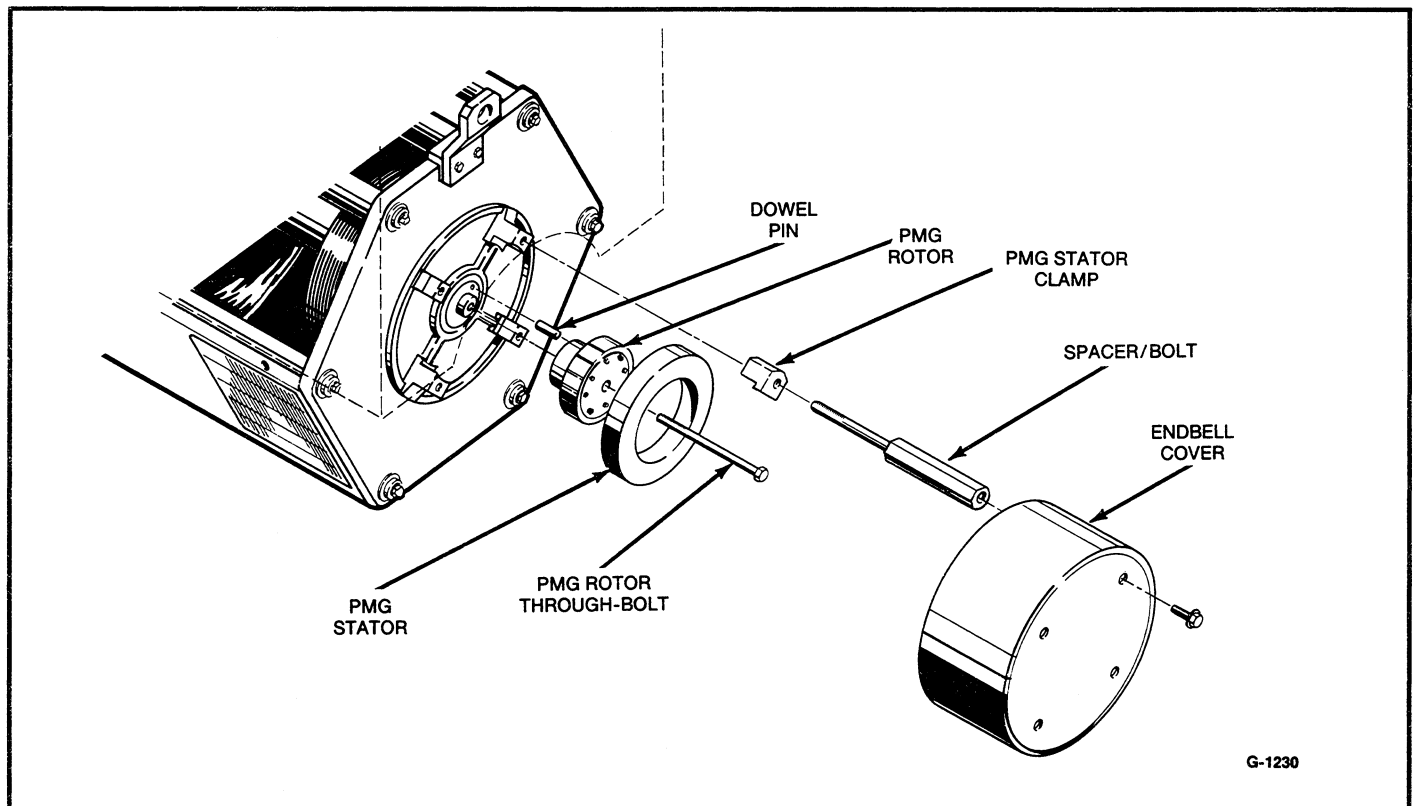


FIGURE 6-1. PERMANENT MAGNET EXCITER REMOVAL

⚠CAUTION *These instructions cover two slightly different generators. The fasteners used throughout the generator assembly and generator mounting vary in size, length, and thread type. To be sure of proper placement when reassembling, replace capscrews and washers to same threaded hole by hand a few turns after the disassembled part has been removed.*

Main Stator and Rotor Removal:

1. Disconnect the negative (-) battery cable to prevent accidental starting of the generator set while servicing.

⚠WARNING *Accidental starting of the generator set during this procedure presents the hazard of severe personal injury or death. Make sure to disconnect the negative (-) battery cable before beginning.*

2. Remove conduit box access covers. Disconnect all load wires from the terminal block assembly. If equipped with the circuit breaker option, disconnect load wires from circuit breaker. Ensure that all leads are labeled to ease reassembly.
3. Disconnect all wire leads from the auxiliary terminal block, inside conduit box, that would interfere with control housing/generator saddle removal. (Example: exciter stator leads X and XX.) Before disconnecting, check wire markings for legibility to ease reassembly.
4. Refer to proper wiring diagram/schematic in *Wiring Diagrams* section and on-site specifics for remote control/monitoring. Open control box doors, and check wire markings for legibility to ease reassembly. Disconnect all engine, generator, and on-site control wire leads from inside control box and conduit box such as:

DC Wiring

- A11/TB-8, -10, and terminals -1 through -7 and TB2 as required.
- Unplug A11/J1,J2,J3,and J4

AC Wiring

- VR21-X and -XX.
- TB21-22 to -30.

Arrange leads so they can be easily withdrawn from the control box.

5. Use a hoist or similar lifting device to support the control box housing and saddle assembly.

⚠WARNING *To prevent personal injury, use adequate lifting devices to support heavy components. Keeps hands and feet clear while lifting.*

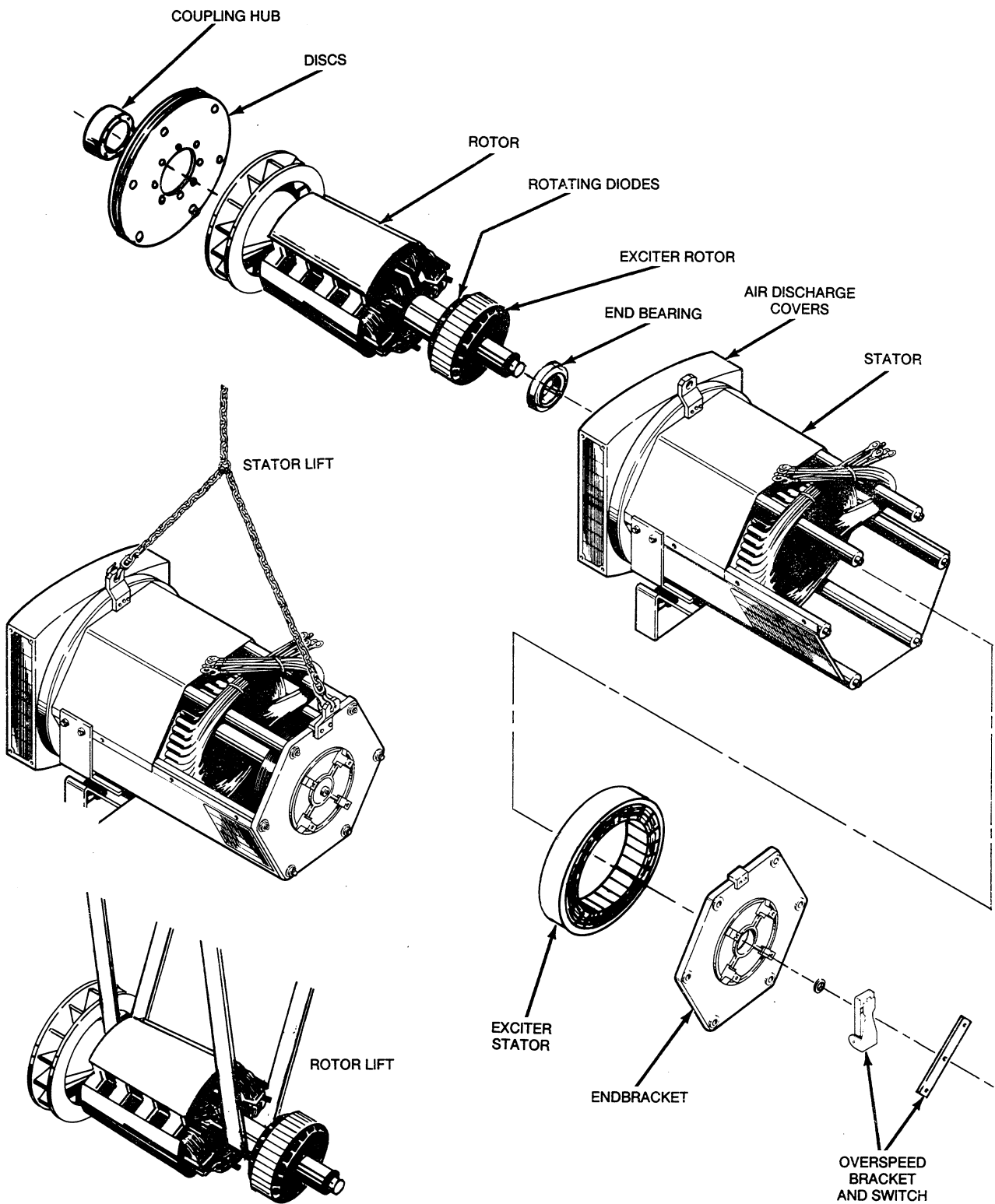
6. Loosen the fasteners that secure the saddle side panels to generator. Ensure that hoisting device is controlling weight of control box/saddle assembly.
7. Loosen saddle fasteners, and remove the control box/generator saddle as an assembly.
8. Remove as necessary, air intake components to engine that may interfere with disassembly and reassembly of generator.
9. Remove the mechanical overspeed switch assembly (if equipped).

Refer to Figure 6-2 during generator disassembly to identify and locate components.

10. Remove the generator access covers. Crank engine/generator to position the rotor such that a full pole face is at the bottom of the main stator core. Refer to Engine Service Manual for proper Cranking and Barring procedure.
11. Install lifting bars at each end of generator stator assembly.
12. Use a hoist or similar lifting device to support the generator end of the engine.

⚠WARNING *To prevent personal injury, use adequate lifting devices to support heavy components. Keeps hands and feet clear while lifting.*

13. Remove the fasteners of the vibration isolator mounts. Slightly lift the generator and adequately block the rear of the engine in place by supporting the flywheel housing. A length of steel channel and wooden blocking is required to support the rear of the engine. Place the channel and blocking under the flywheel housing. Lower the generator until most of the set weight is supported by the blocking.
14. Loosen the fasteners securing the stator adaptor ring to the engine-generator adapter.



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FIGURE 6-2. TYPICAL GENERATOR ASSEMBLY
(Non-PMG Shown)

15. Verify that the stator is adequately supported and then carefully remove the capscrews from the adapter ring.

▲WARNING *To prevent personal injury, use adequate lifting devices to support heavy components. Keep hands and feet clear while lifting.*

▲CAUTION *Improper stator assembly rigging and handling can result in damage to stator and rotor assemblies. Make sure the stator is adequately hooked/strapped to maintain level control of stator assembly while lifting and moving.*

Do not connect any lifting device to stator landing bars, doing so may damage stator assembly.

16. Carefully pry the stator assembly away from engine and rotor shaft end bearing (in stator end-bracket), being careful that hoisting device is supporting weight of stator assembly.
17. Remove the stator assembly, being careful not to drag the windings on the rotor. Place stator on wooden blocks, on its side in the horizontal position. The endbracket can now be removed from the stator for access to the exciter stator.
18. Remove fasteners from upper and lower stator covers, and generator mounting bracket. Remove stator covers.
19. Remove the endbracket assembly from the stator.
20. The exciter stator is now accessible for inspection and removal from endbracket.
21. The end bearing can now be removed, if required. Remove retaining clip, and use a gear puller to remove the end bearing from the rotor shaft. If bearing is to be used, be sure to apply puller in the inner race.

▲CAUTION *Improper removal of the end bearing will damage it. If intended for reuse, the bearing must be pulled off by the inner race.*

22. Remove the fasteners holding the engine-generator adaptor, and remove the engine.
23. Using a hoist and sling to support the rotor, carefully remove the capscrews that secure the drive disc to the engine flywheel.

▲WARNING *To prevent personal injury, use adequate lifting devices to support heavy components. Keep hands and feet clear while lifting.*

▲CAUTION

Do not allow rotor to hang on engine by drive discs alone, the discs may become bent and not suitable for reuse. To prevent damage to drive discs, support weight of rotor with adequate lifting device.

24. Remove the rotor assembly and place it in wood blocks in the horizontal position. To avoid possible distortion, do not allow the drive discs and fan to rest on anything.
25. Remove the capscrews that hold the drive disc pressure plate to the drive discs.
26. Remove pressure plate, drive discs, and disc spacer.

REASSEMBLY

Generator assembly is the reverse of the disassembly procedure, refer to Figure 6-2.

1. Reassemble exciter rotor and rotating rectifier assembly to main rotor shaft, if removed.

If you are installing a new exciter rotor, be sure to remove any balance weights from used exciter rotor and replace them into typical position of new exciter rotor. Use the keyway as a reference to locate exact weight locations. Because the balance weights vary in size/weight, remove and replace weights one at a time to make sure of proper positioning.

Reconnect main rotor wire leads to positive and negative terminals of rectifier assembly.

2. Place the rotor fan and coupling hub in position on the rotor shaft.
3. Install the drive discs spacer, drive disc, and pressure plate on the rotor shaft. Tighten fasteners to 190 ft-lbs. (257 N•m) torque.
4. Using a hoist and sling to support the rotor, align the holes in the drive disc with the corresponding holes in the flywheel.

▲WARNING

To prevent personal injury, use adequate lifting devices to support heavy components. Keep hands and feet clear while lifting.

▲CAUTION

Do not allow rotor to hang on engine by drive discs alone, the discs may become bent and not suitable for reuse. To prevent damage to drive discs, support weight of rotor with adequate lifting device.

5. Secure the rotor assembly to the flywheel (smooth rounded side of flat washer toward the drive disc). Tighten fasteners to 50 ft-lbs. (68 N•m) torque.

6. Mount the engine-generator adaptor to engine flywheel housing. Tighten fasteners to 35 ft-lbs. (47 N•m) torque.
 7. Replace end bearing on rotor shaft, if removed. Clean rotor shaft end and bearing bore before fitting. Be sure that fitting pressure is only applied to inner race.
 8. Reassemble exciter stator to stator endbracket if removed. Tighten fasteners to 7 ft-lbs (10 N•m) torque.
 9. Reassemble endbracket assembly to stator frame (using capscrews, lock washers, and endbell flat washers). Tighten fasteners to 17 ft-lbs (23 N•m) torque.
 10. Reassemble lower stator cover to stator assembly, at four mounting hole positions (two each side) toward stator endbracket. Tighten fasteners by hand at this time.
 11. Reassemble upper stator cover to stator assembly, at center two mounting hole positions (one each side). Tighten fasteners by hand at this time.
 12. Reassemble generator mounting bracket to stator assembly, at blower end mounting hole positions. Tighten fasteners by hand at this time.
 13. Confirm proper fit of stator covers, then tighten stator mounting bracket to proper torque; M12 fasteners to 65 ft-lbs. (88 N•m), M10 fasteners to 35 ft-lbs. (47 N•m).
 14. Be sure that an O-ring is mounted in groove of generator stator endbracket.
 15. Using an adequate lifting device, carefully move the stator assembly into position over the rotor assembly, being careful not to drag the windings on the rotor.
- ⚠ WARNING**

To prevent personal injury, use adequate lifting devices to support heavy components. Keeps hands and feet clear while lifting.
- ⚠ CAUTION**

Improper stator assembly rigging and handling can result in damage to stator and rotor assemblies. Make sure the stator is adequately hooked/strapped to maintain level control of stator assembly while lifting and moving.
- Do not connect any lifting device to stator landing bars, doing so may damage stator assembly.**
16. Align the holes of the stator adaptor ring with the holes in the engine generator adaptor and rotor end bearing with generator endbracket bore and install; taking care that end bearing is properly seating into O-ring of endbracket. Tighten fasteners to 35 ft-lbs. (48 N•m) torque.
 17. Using an adequate lifting device, slightly raise the generator so that the wooden blocking and steel channel can be removed from under the flywheel housing; then lower the generator so the full weight is resting on the vibration isolator mounts and generator mounting brackets. Reinstall vibration isolator fasteners and tighten securely.
 18. Install the generator access covers.
 19. Connect the grounding strap to the flywheel housing using a capscrew and EIT locking washer; and tighten securely.
 20. Refer to Figure 5-12. Mount and adjust Mechanical Overspeed Switch, if equipped.
- When installing the overspeed switch assembly (capscrew, lock washer, switch, small flat washers, large flat washer, and spacer) on the rotor shaft, tighten to 53 ft-lbs. (72 N•m) torque.

Install the overspeed switch assembly bracket and secure using two capscrews and lock washers. Tighten to 4.5 ft-lbs. (6 N•m) torque. Refer to Figure 5-12, and set to proper gap.
21. Connect overspeed switch lead wire to terminal on overspeed switch bracket.
 22. Loosen the capscrews, lock washers, and flat washers of the upper and lower generator covers (six places). Using an adequate lifting device to place and hold the control housing and saddle assembly, position the saddle mounting slots onto the generator covers mounting screws (making sure that a flat washer is on each side of saddle flanges). Tighten the capscrews to 35 ft-lbs. (47 N•m) torque.
 23. Reassemble any engine air intake components removed during generator disassembly.
 24. Connect all control wires and generator leads using the proper generator set AC and DC wiring diagram/schematic.
 25. Install generator endbell cover, or refer to Permanent Magnet Exciter Assembly/Setting Up Procedure if applicable.
 26. Verify that all connections are proper and secure and then install the conduit box access covers.
 27. Connect the negative (-) battery cable and test the generator set for operation.
 28. Refer to *Tests and Adjustments* sections for voltage regulator adjustments if necessary.

Permanent Magnet Exciter Replacement (If equipped)

Refer to Figure 6-1 when assembling permanent exciter parts to generator and PMG voltage regulator installation diagram in section 7.

1. Assemble the permanent magnet assembly to the main rotor. Place dowel pin into locating hole at end of main rotor shaft, tap dowel pin with hammer to secure fit. Assemble permanent magnet to main rotor shaft, using dowel pin as locator, and secure in place with through-bolt. Tighten to 40 to 45 ft-lbs. (54 to 61 N•m) torque.

2. Place the permanent exciter stator on endbracket assembly so that stator leads are at the 12 o'clock position. Secure stator in position using the bolts and clamps.

The highly magnetic rotor will attract the stator core; care must be taken to avoid any contact which may damage the windings.

3. Route and connect VR21 and PMG leads P2, P3 and P4 to proper terminals on auxiliary terminal block located on back wall of output box.
4. Mount the endbell cover over permanent magnet exciter assembly, and fasten in place with four M5 screws and lockwashers.
5. Refer to *Tests and Adjustments* section for voltage regulator adjustments if necessary.



Cummins Power Systems

Product Support Bulletin

Date: 7-10-89 Page 1 of 1 Bulletin No. C007

Subject: Double Delta Connection

Description Code Generator

Model Integrated B & C Gensets

Effective: Immediately

The 625-2164 reconnection diagram found in the service manual and located on the decal in the generator output box has a drawing error in the double delta configuration. The diagrams should be marked as seen in figure 1. These diagrams have been revised as of May 19, 1989.

Do not reconnect in double delta before reviewing PSB #C005 and #C006 for important information and safety warnings. Failure to follow these bulletins can have a serious effect on generator operations.

This bulletin is for informational purposes only.

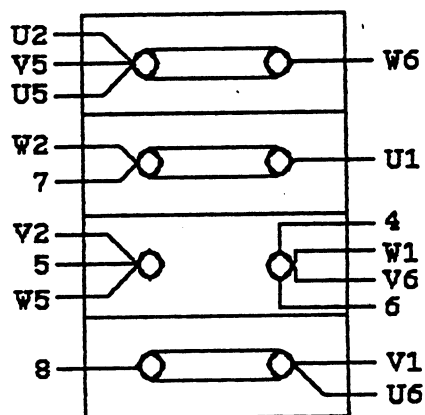


figure 1.

Charles L. Babcock
Charles L. Babcock
Manager, Field Service

*Randy.
all panels (silkscreened
have been reworked. Again
about 2 months ago.
Manuals haven't been
changed but Dick will
follow up on the
Wayne.
71*

Section 7. Wiring Diagrams

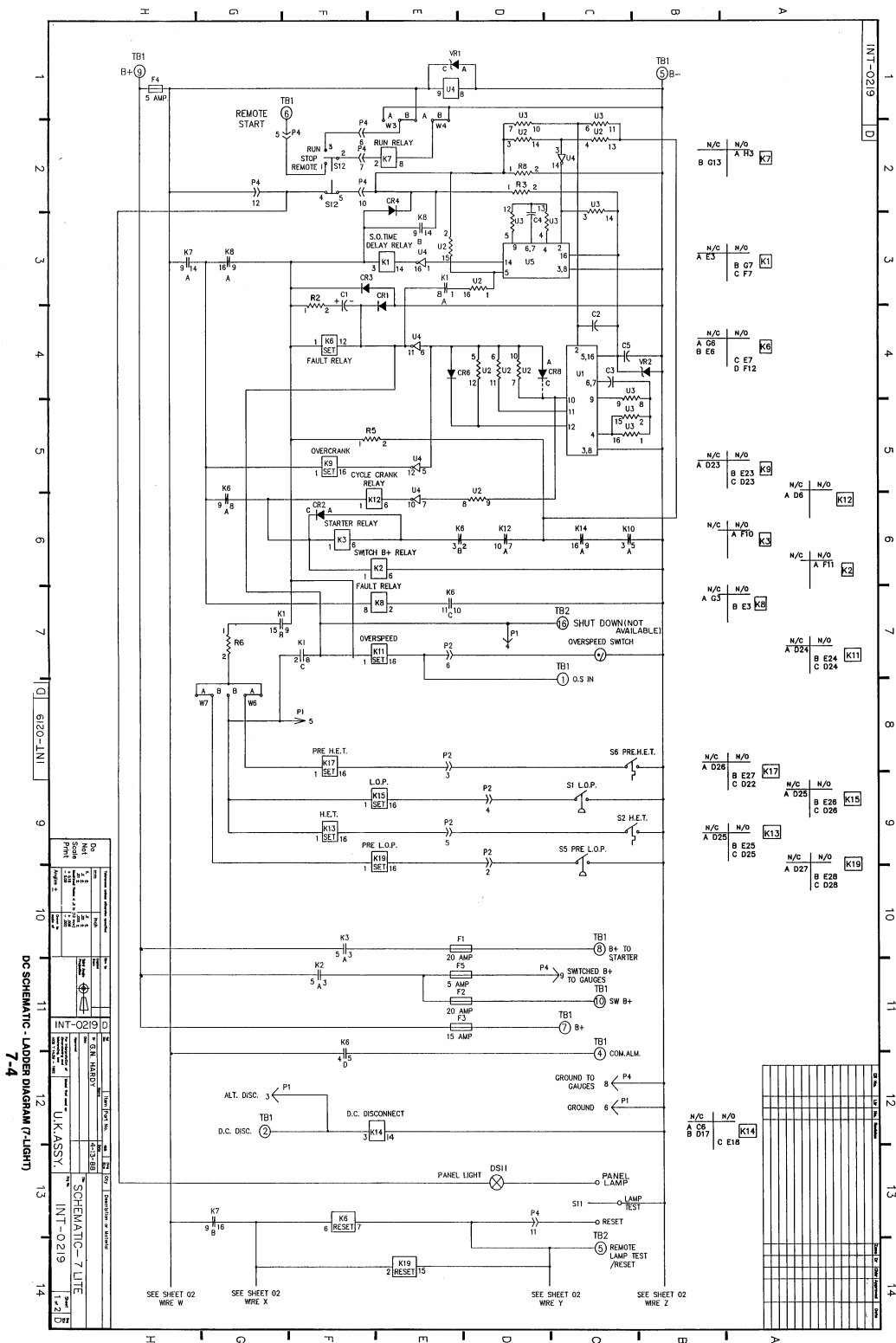
Control/Generator

This section contains the following AC and DC Wiring Diagrams/Schematics:

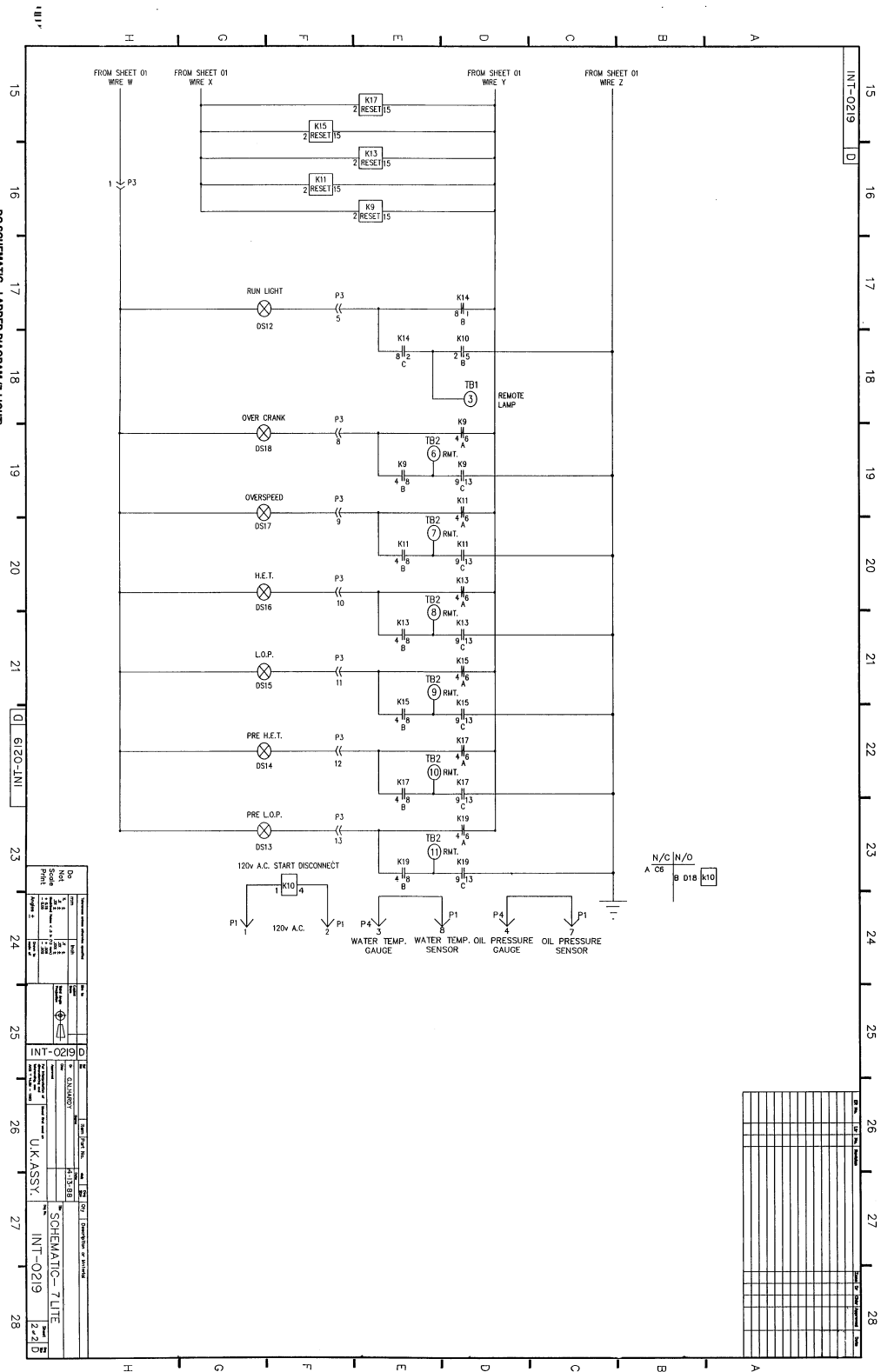
TITLE	PAGE(S)
DC Wiring Diagram/Schematic (7-Light)	7-2/3
DC Schematic - Ladder Diagram (7-Light)	7-4/5
Detector-7 ECM - PCB Assembly	7-6/7
DC Wiring Diagram/Schematic (12-Light)	7-8/9
DC Schematic - Ladder Diagram (12-Light)	7-10/11
Detector-12 ECM - PCB Assembly	7-12/13
Detector-12 ECM - Functional Diagram	7-14
AC Reconnect Wiring Diagram	7-15
AC Wiring Diagram/Schematic (W/O Meters)	7-16
AC Wiring Diagram/Schematic (With Meters)	7-17
Voltage Regulator Installation Wiring Diagram (Non-PMG)	7-18
Non-PMG Voltage Regulator Technical Data, and Three-Phase Sensing Wiring Diagram	7-19
Voltage Regulator Installation Wiring Diagram (PMG)	7-20
PMG Voltage Regulator Technical Data	7-21
Time Delayed Start/Stop Module	7-22/23
Engine Sensor Locations	7-24

⚠ CAUTION

Repair information in this manual for printed circuit board components other than fuses is not extensive; doing so requires well-trained, qualified personnel with the proper equipment. Application of meters or hot soldering irons to printed circuit boards by other than qualified personnel can cause unnecessary and expensive damage. Repair of the printed circuit boards is not recommended except by the factory.



DC SCHEMATIC - LADDER DIAGRAM (7-LIGHT)
7-5



Rev	By	App'd	Description	Date
1	INT-0219		INT-0219	
2	UK ASSY		UK ASSY	
3	SCHEMATIC - 7 LITE		SCHEMATIC - 7 LITE	
4	INT-0219		INT-0219	
5	7-5		7-5	



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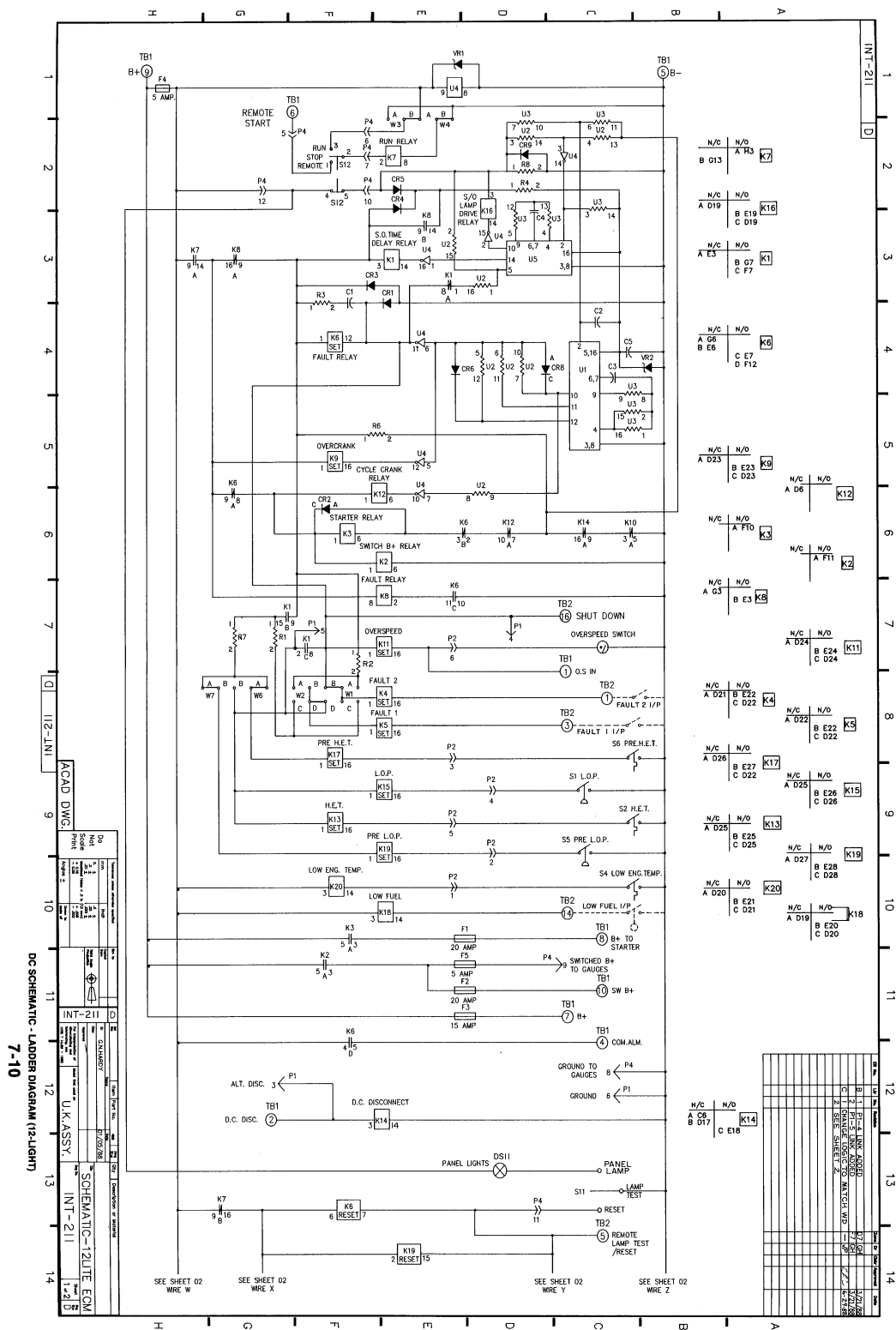
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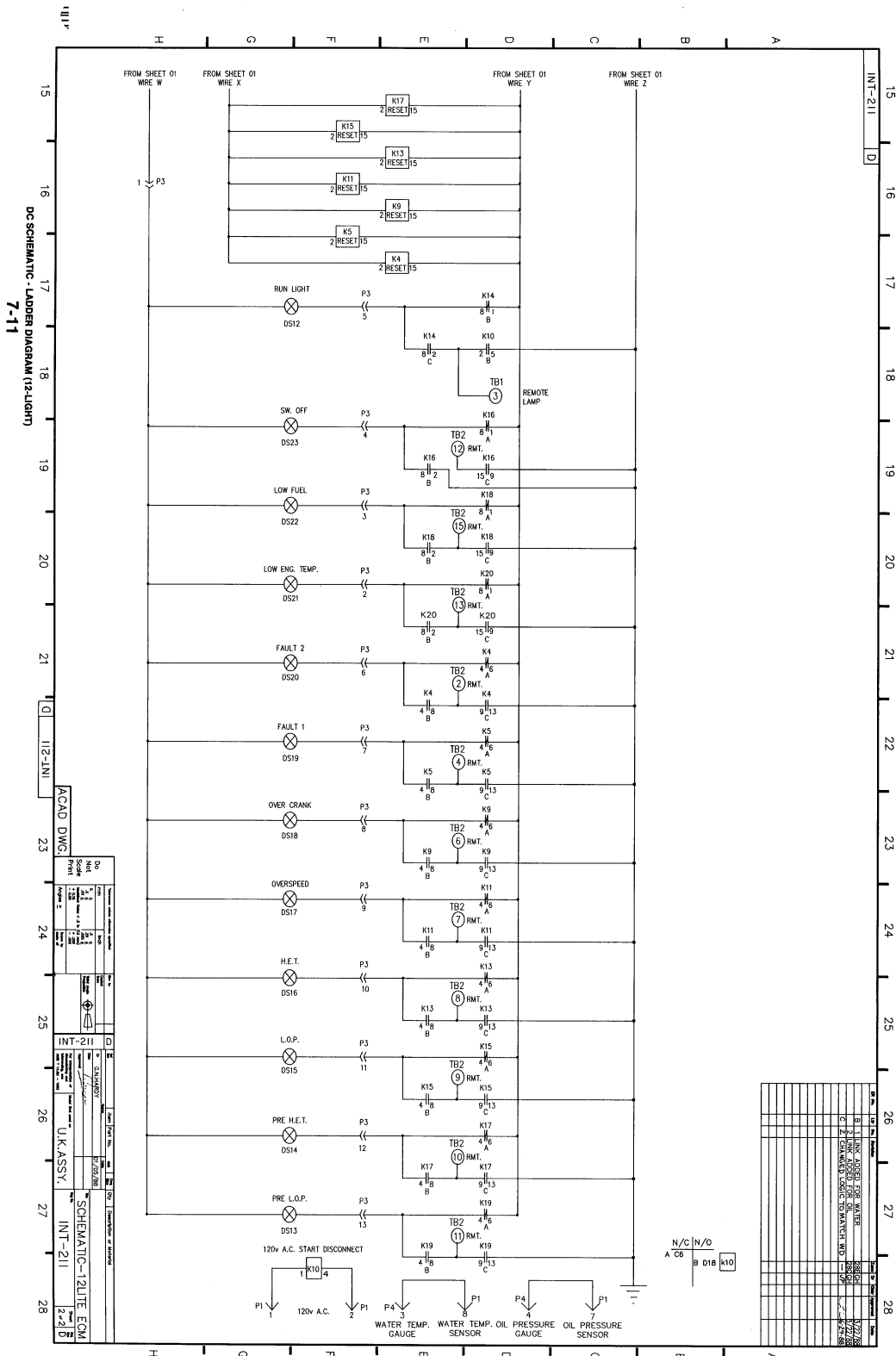
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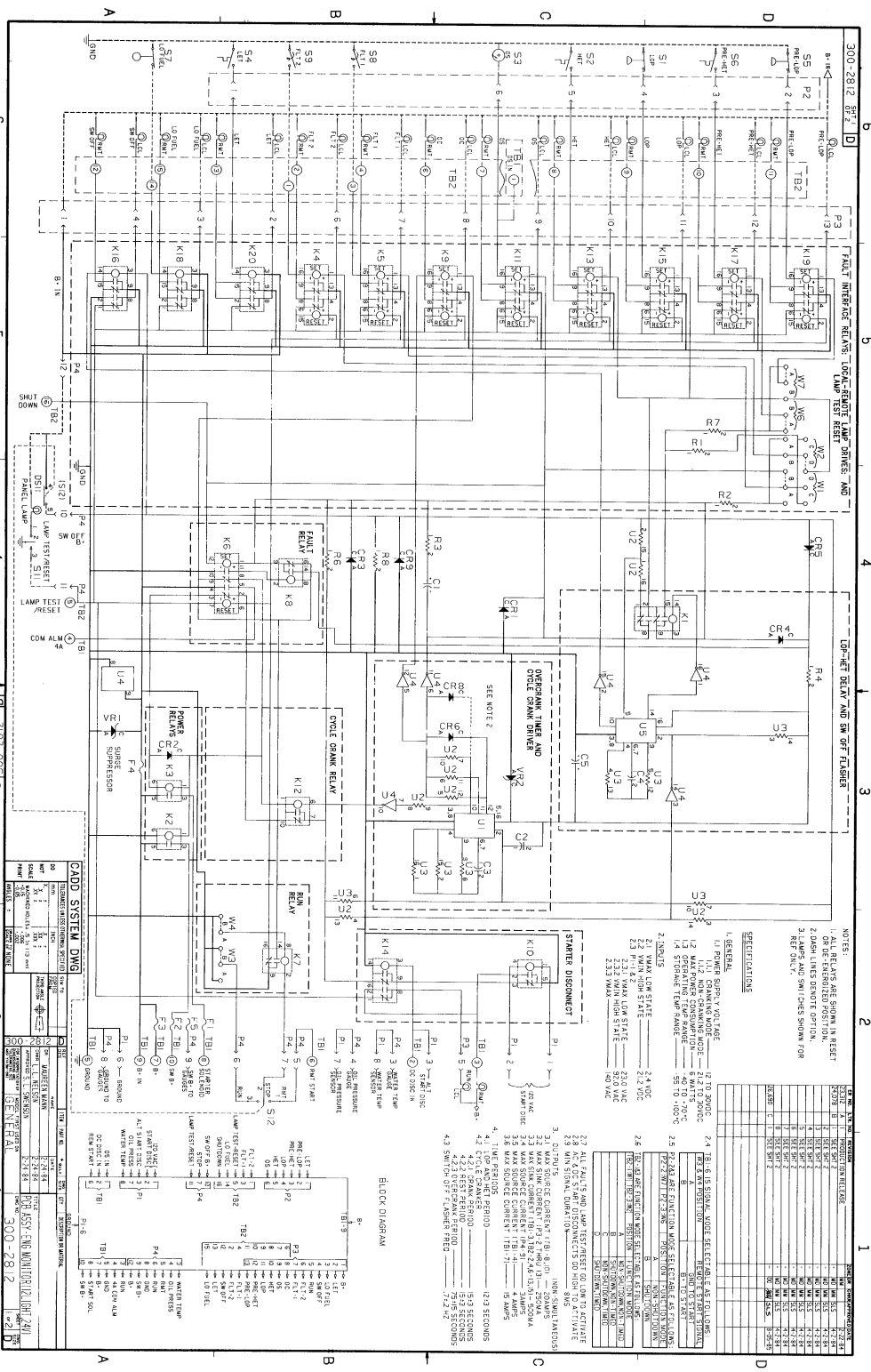
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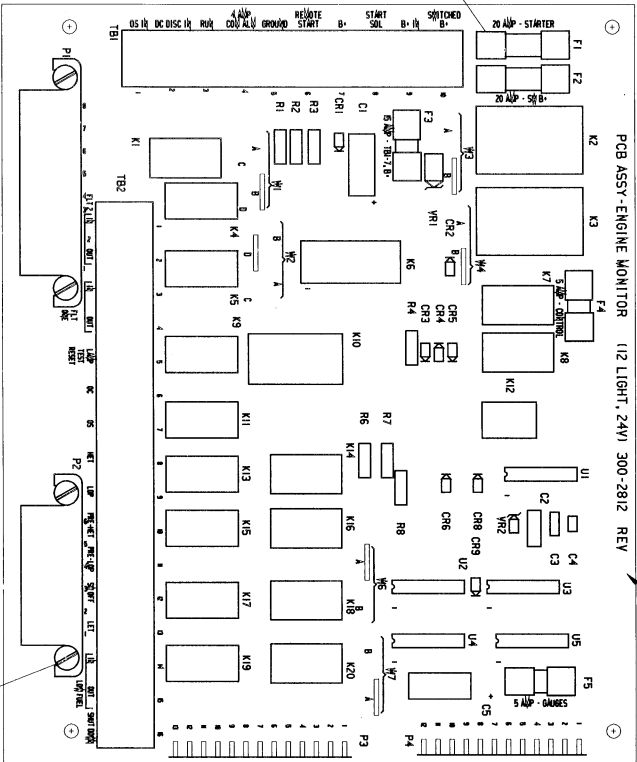
DETECTOR-12 ECM - PCB ASSEMBLY
7-12

300-2812 DET 1
MICROFILM

300-2812-003.10

FROM THIS DWG HERE. (SEE NOTE 6)

PCB ASSY-ENGINE MONITOR (12 LIGHT, 24V) 300-2812 REV



NOTES

- 1. CIRCUIT BOARD SHALL BE SOLDERED WITH ITEM #2 AT MAX SOLDER TEMP OF 500° AND MAX TIME OF 6 SECONDS.
- 2. SOLDER SHALL BE ANNOX 60/40 LEAD/TIN. SOLDER SHALL BE APPLIED TO ALL SURFACES OF BOARD.
- 3. CONFORMAL COAT BOTH SIDES OF COMPLETED BOARD WITH ITEM #4.
- 4. TEST INSPECTED CIRCUIT BOARD PER ITEM NO. 5.
- 5. FOR INSPECTION PROCEDURE SEE DWG 453-0393 (C).
- 6. STAMP REVISION LETTER PRIOR TO CONFORMAL COATING.
- 7. CONFORMAL COATING.
- 8. DESIGN OF THIS ASSY IS CONTROLLED BY ITEM #2.

ADD SYSTEM DWG			
NO.	REV.	DATE	BY
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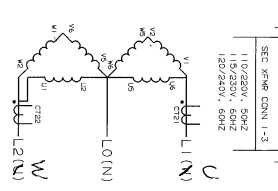
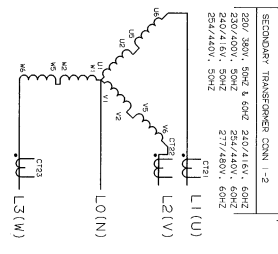
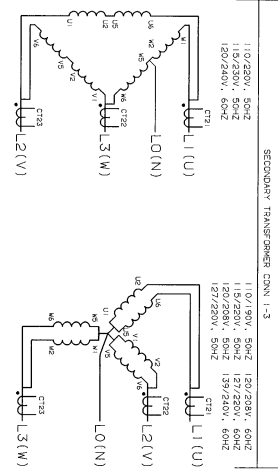
DETECTOR-12 ECM - PCB ASSEMBLY
7-13

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300-2812-003.10
MIL-HDBK-100

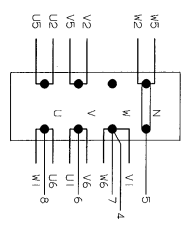
625-2164 D

UC GENERATORS

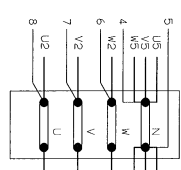
3 PHASE RECONNECTABLE, 12 LEAD



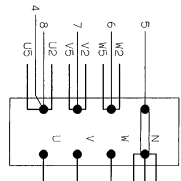
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0 PHASE, 0 WIRE
U-V-W-N-N



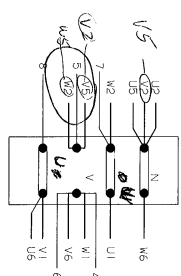
PARALLEL STAR
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0 PHASE, 0 WIRE
U-V-W-N



SERIES STAR
3 PHASE, 4 WIRE
0 PHASE, 0 WIRE
U-V-W-N



DOUBLE DELTA
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0 PHASE, 0 WIRE
U-V-N

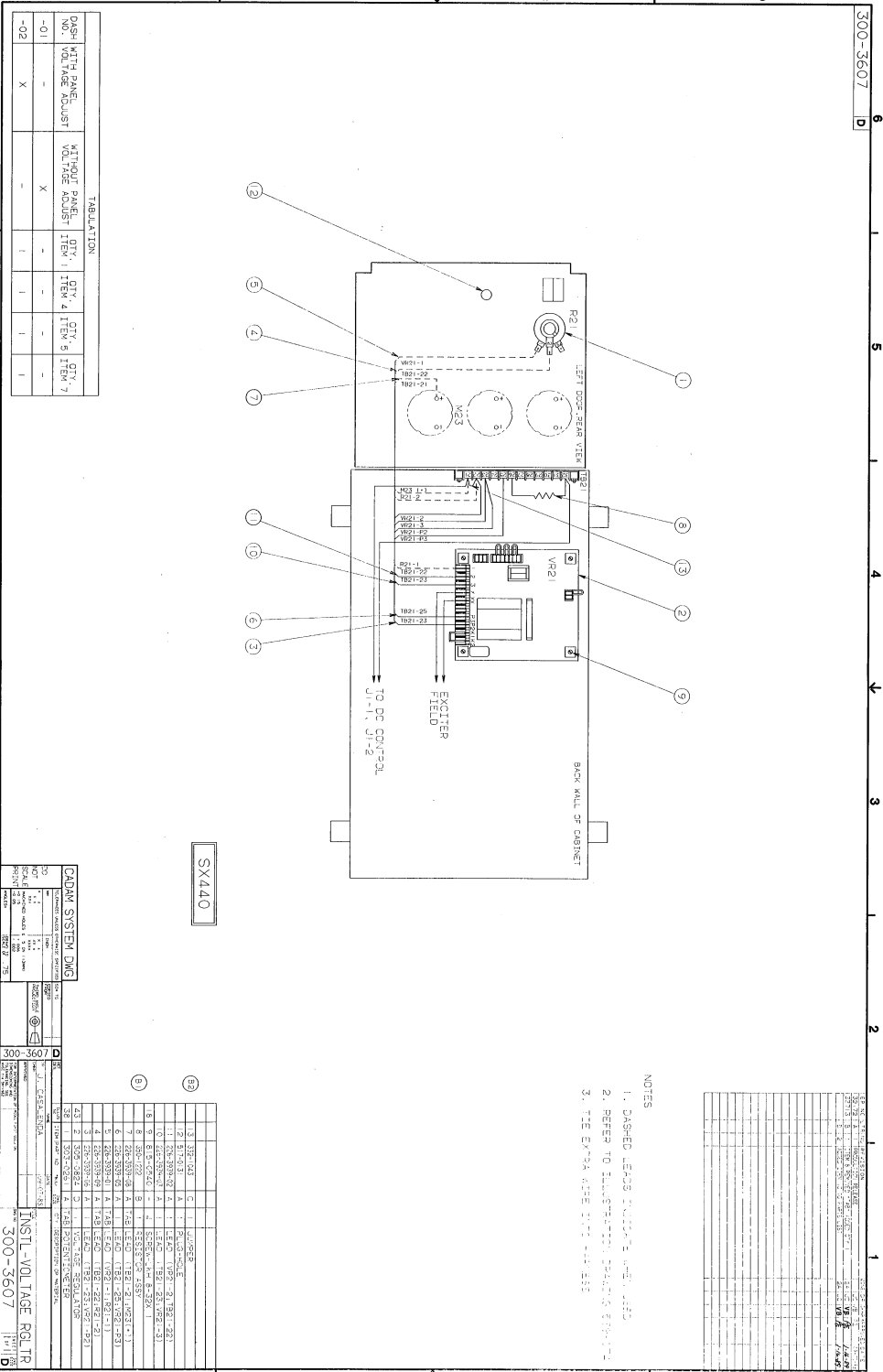


CONTROL INPUT			
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AC RECONNECT WIRING DIAGRAM
7-15

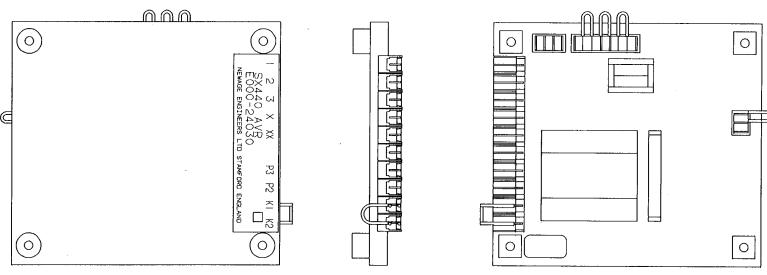
NOTE:
1. U-V-W PHASE SEQUENCE WITH C.W.
ROTATION FACING DRIVE END.



REF - 305-0824

NON-PMG VOLTAGE REGULATOR TECHNICAL DATA AND
THREE-PHASE SENSING WIRING DIAGRAM

7-19

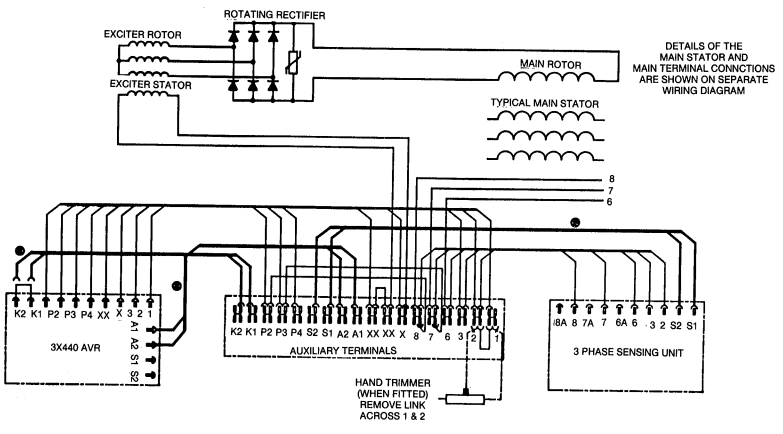


TECHNICAL DATA

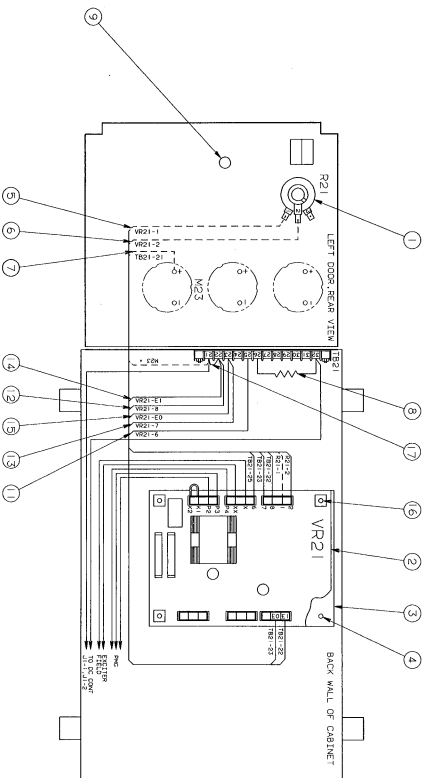
INPUT VOLTAGE	NOMINAL	170 - 250 VAC MAX.
PHASE		50 - 60 HZ
WIRE		2
OUTPUT CURRENT	MAX CONTINUOUS	90 ADC @ 207 VAC INPUT
FIELD RESISTANCE	CONTINUOUS	44C FOR 1.0 SECONDS
REGULATION	TRANSIENT	6A FOR 1.0 SECONDS
TYPICAL SYSTEM RESPONSE	REGULATION	±0.1% WITH 1% TRIMMER
EXTERNAL VOLTAGE ADJUSTMENT	(SEE NOTE 1)	±0.1% WITH 1% TRIMMER
UNSET FREQUENCY PROTECTION	(SEE NOTE 2)	±0.1% WITH 1% TRIMMER
SLOPE	(SEE NOTE 3)	170% DOWN TO 30 HZ
UNIT POWER DISSIPATION		12 WATTS
ACCESSORY INPUT	±0.1 VOLT = ±0.1% CHANGE IN OUTPUT VOLTS, 415V NOMINAL	
ENVIRONMENTAL	20-100 HZ	80MM/S
VIBRATION	100-20 HZ	5G
OPERATING TEMPERATURE	0 - 60C	95C RH
STORAGE TEMPERATURE	-55 TO +80C	

NOTES:

- (1) WITH NORMAL 4% ENGINE GOVERNING TO ±0.1% WITH 1% TRIMMER
- (2) WHEN 3 PHASE SENSING IS FITTED
- (3) FACTORY SET, SEMI-SEALED, JUMPER SELECTABLE



THREE-PHASE SENSING WIRING DIAGRAM



- NOTES
1. DASHED LEADS INDICATE WHEN USED
 2. REFER TO ILLUSTRATION DRAWING 539-074.
 3. TIE EXTRA WIRE INTO HARNESS

TABULATION							
DASH NO.	WITH PANEL VOLTAGE ADJUST	QTY.	ITEM 9	QTY.	ITEM 6	QTY.	ITEM 7
-01	-	-	-	-	-	-	-
-02	X	-	X	-	-	-	-

MX321

CADAM SYSTEM DIMS		INST-VOLTAGE ROL TO	
NO	1	300-3606	b
NO	2	300-3606	b
NO	3	300-3606	b
NO	4	300-3606	b
NO	5	300-3606	b
NO	6	300-3606	b
NO	7	300-3606	b
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NO	9	300-3606	b
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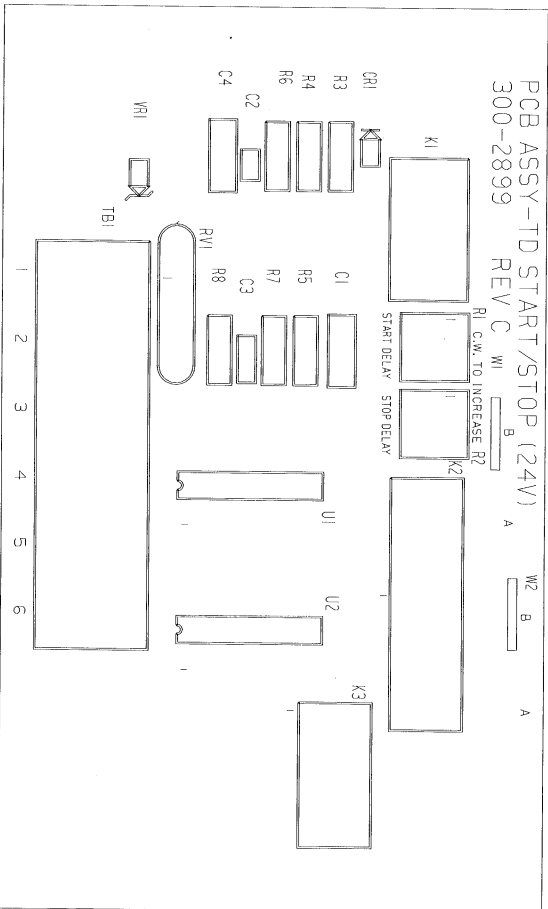


300-2899 Rev 1.0

PCB ASSY-TD START/STOP (24V)
300-2899 REV C W1 B A W2 B A

R1 C.W. TO INCREASE R2

START DELAY STOP DELAY



REV	DATE	BY	CHKD	APP'D	DESCRIPTION
1.0	10/10/88	W. J. B.	W. J. B.	W. J. B.	INITIAL RELEASE
2.0	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 2
3.0	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 3
4.0	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 4
5.0	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 5
6.0	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 6
7.0	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 7
8.0	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 8
9.0	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 9
10.0	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 10

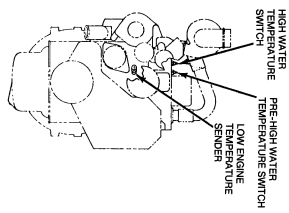
- NOTES:
1. CIRCUIT BOARD SHALL BE SOLDERED WITH ITEM 44 AT MAX SOLDER TEMP OF 500° AND MAX TIME OF 5 SECONDS.
 2. SOLDER JOINTS AND/OR COMPONENT LEADS EXCEPT POTENTIOMETER LEADS SHALL NOT PROJECT MORE THAN 1/8" BEYOND SURFACE OF BOARD.
 3. EXCEPT ITEM 44, 45 AND 46, ALL OTHER BOARD MATERIALS SHALL BE LESS THAN .002" OR GREATER THAN .01".
 4. TEST PRINTED CIRCUIT BOARD PER ITEM 46.

7. CLEAN BOARD WITH A SUITABLE SOLVENT BEFORE CONFORMAL COATING.
8. DESIGN OF THIS ASSY IS CONTROLLED BY ITEM 45.

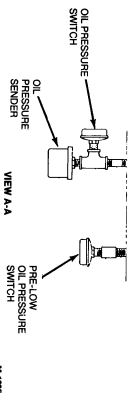
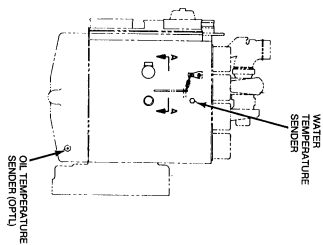
CADD SYSTEM DWG

NO	REV	DATE	BY	CHKD	APP'D	DESCRIPTION
1	1	10/10/88	W. J. B.	W. J. B.	W. J. B.	INITIAL RELEASE
2	2	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 2
3	3	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 3
4	4	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 4
5	5	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 5
6	6	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 6
7	7	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 7
8	8	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 8
9	9	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 9
10	10	10/10/88	W. J. B.	W. J. B.	W. J. B.	REVISION 10

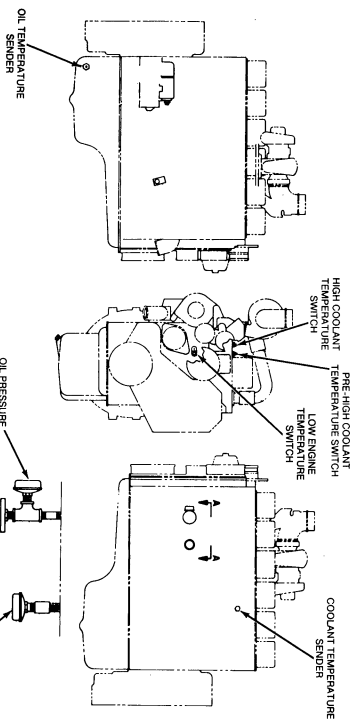
TIME DELAYED START/STOP MODULE
7-23



4B71.3

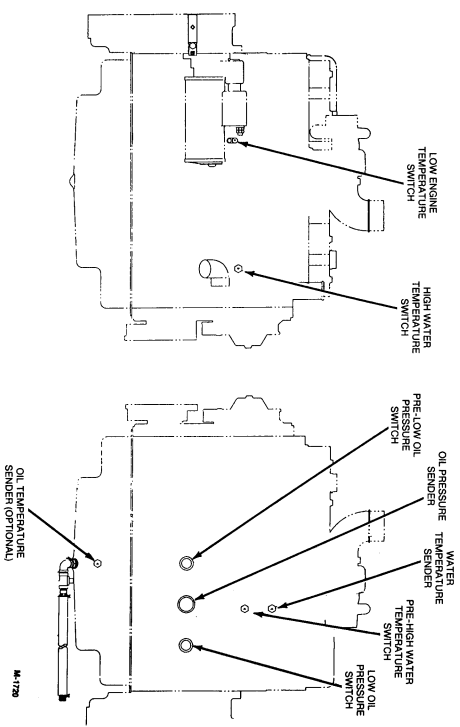


M-185



M-185-1

6CTA.3, 6CTA.3





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