

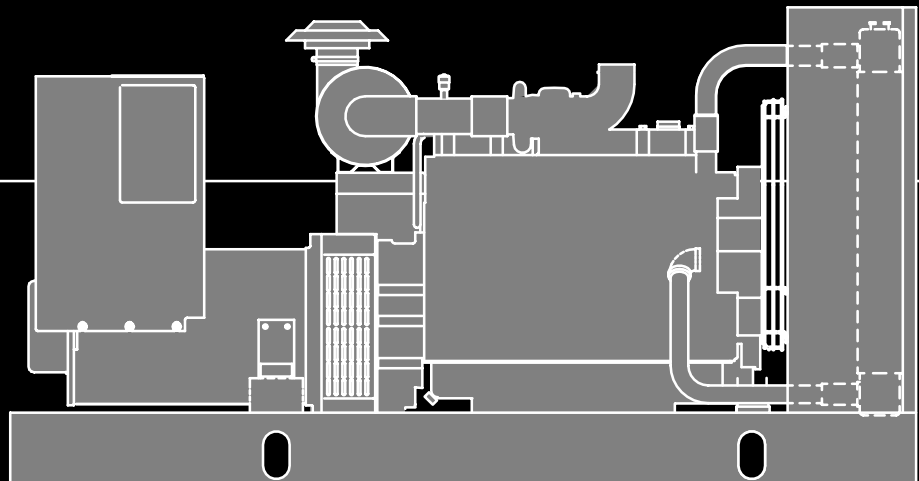


Service Manual

Detector™/Sentinel™ Controls GENERATOR SETS

Models Begin
Spec

DGBB	E
DGBC	D
DGCA	M
DGCB	M
DGCC	A
DGDA	L
DGDB	L
DGEA	K
DGFA	K
DGFB	K
DGFC	A



Supplement 960–1056

Date: 11-09-00

Insert with –

Title: Service

Numbers: See Supplement Use

PURPOSE

This supplement contains information for the revised Engine Control Monitor (ECM) board. The revised ECM board contains LED's and terminal board TB3 to aid in genset control troubleshooting. A selection jumper has also been added, which controls how the SWITCH OFF indicator operates.

Both ECM boards are identical in function and how they connect electrically. The present ECM board description in Section 3 of the Service manual has not changed, other than the additional information describing the new components and a figure showing the location of the new components.

SUPPLEMENT USE

Refer to the corresponding pages/headings of your manual and write "IMPORTANT: REFER TO SUPPLEMENT".

Please keep this supplement with the following Service manuals:

928-0502B

928-0506

960-0504A

960-0505

960-0510B

ENGINE CONTROL MONITOR (A11)

The heart of the engine control system is the engine control monitor (ECM) (Figure 3-5). It is a printed circuit board assembly mounted on the back wall of the control box. It starts and stops the engine in response to the control panel switches, engine sensors and remote control signals.

Note that there are two versions of the ECM board and that they both perform the same functions. They only differ in that one version contains additional components, which are, LED's (**DS1 – DS9**), terminal board (**TB3**) and function selection jumper **W10**. Figure 3-5 illustrates the ECM version which contains the additional components.

LED's DS1 through DS9

The ECM LED's are provided as an aid in

troubleshooting the control circuitry. The LED's indicate the following conditions:

LED	STATUS WHEN ILLUMINATED
DS1	B+ is connected to ECM and fuse F4 is good.
DS2	RUN relay is energized.
DS3	Start Command signal enabled.
DS4	Crank signal enabled.
DS5	DC Starter Disconnect signal enabled.
DS6	AC Starter Disconnect signal enabled.
DS7	LOP/HET signal active (time delay circuit has timed-out).
DS8	Reverse battery voltage.
DS9	Remote Shutdown signal active (grnd at TB2-16)

Terminals and Connectors

See Pages 9-5 through 9-9 for the appropriate connection and schematic drawings for the DC control system. See Page 9-10 for typical customer connections at terminal boards **TB1** and **TB2** on the ECM and page 9-11 if the set is also equipped with the auxiliary relay board.

TB3 provides an alternative direct connection to the ECM for the RUN/STOP/REMOTE switch for troubleshooting or if desired, customer connection.

TB3-1 = REMOTE

TB3-2 = RUN

TB3-3 = STOP

Fuses

The ECM has five replaceable fuses to protect it from overloads and ground faults. They are:

F1 Starter solenoid circuit, 20 amps.

F2 Fuel solenoid (switched B+) circuits, 20 amps.

F3 Continuous B+ out to remote circuits, 15 amps.

F4 ECM circuits, 5 amps.

F5 Engine gauge circuits, 5 amps.

Function Selection Jumpers

ECM board has six selection jumpers that can be repositioned to provide the following timed or non-timed warnings or timed or non-timed shutdowns with warnings and control of the SWITCH OFF indicator:

W1 Jumper Position (jumper **W8** must be in the **B** position):

A Non-timed warning under **FLT 2** conditions.

B Non-timed shutdown under **FLT 2** conditions.

C Timed warning under **FLT 2** conditions.

D Timed shutdown under **FLT 2** conditions.

W2 Jumper Position (jumper **W9** must be in the **B** position):

A Non-timed warning under **FLT 1** conditions.

B Non-timed shutdown under **FLT 1** conditions.

C Timed warning under **FLT 1** conditions.

D Timed shutdown under **FLT 1** conditions.

W6 Jumper Position:

A Warning under **Pre-High Engine Temperature** conditions.

B Shutdown under **Pre-High Engine Temperature** conditions.

W7 Jumper Position:

A Warning under **Pre-Low Oil Pressure** conditions.

B Shutdown under **Pre-Low Oil Pressure** conditions.

W8 Jumper Position:

A Warning while running or during standby under **FLT 2** conditions.

B Allows selection of functions with **W1** jumper.

W9 Jumper Position:

A Warning while running or during standby under **FLT 1** conditions.

B Allows selection of functions with **W2** jumper.

W10 Jumper Position (**SWITCH OFF** Indicator):

A Flashing

B Constant ON

C OFF

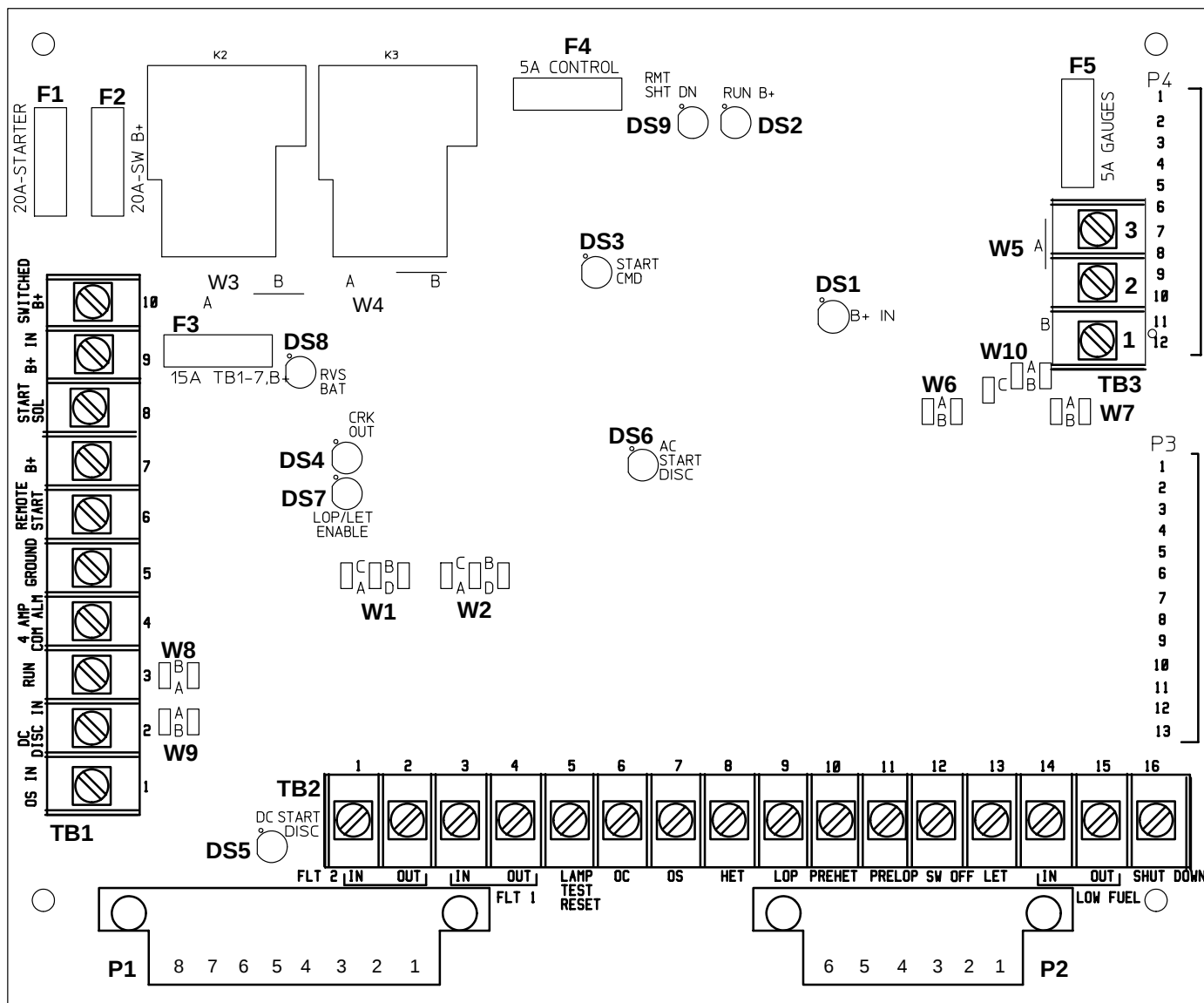


FIGURE 3-5. ENGINE CONTROL MONITOR FUSES AND FUNCTION SELECTION JUMPERS

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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, explosion, and personal injury or death 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, arcing equipment, 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.
- Be sure battery area has been well-ventilated prior to servicing near it. Lead-acid batteries emit a highly explosive hydrogen gas that can be ignited by arcing, sparking, smoking, etc.

EXHAUST GASES ARE DEADLY

- Provide an adequate exhaust system to properly expel discharged gases away from enclosed or sheltered areas and areas where individuals are likely to congregate. Visually and audibly inspect the exhaust daily for leaks per the maintenance schedule. Make sure that exhaust manifolds are secured and not warped. Do not use exhaust gases to heat a compartment.
- Be sure the unit is well ventilated.
- Engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defects, and other reproductive harm.

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 battery charger from its AC source, then 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.

DO NOT OPERATE IN FLAMMABLE AND EXPLOSIVE ENVIRONMENTS

Flammable vapor can cause a diesel engine to overspeed and become difficult to stop, resulting in possible fire, explosion, severe personal injury and death. Do not operate a diesel-powered genset where a flammable vapor environment can be created by fuel spill, leak, etc., unless the genset is equipped with an automatic safety device to block the air intake and stop the engine. The owners and operators of the genset are solely responsible for operating the genset safely. Contact your authorized Onan/Cummins dealer or distributor for more information.

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 and lock 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.

MEDIUM VOLTAGE GENERATOR SETS (601V to 15kV)

- Medium voltage acts differently than low voltage. Special equipment and training is 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. Due to the nature of medium voltage electrical equipment, induced voltage remains even after the equipment is disconnected from the power source. Plan the time for maintenance with authorized personnel so that the equipment can be de-energized and safely grounded.

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.
- Benzene and lead, found in some gasoline, have been identified by some state and federal agencies as causing cancer or reproductive toxicity. When checking, draining or adding gasoline, take care not to ingest, breathe the fumes, or contact gasoline.
- Used engine oils have been identified by some state or federal agencies as causing cancer or reproductive toxicity. When checking or changing engine oil, take care not to ingest, breathe the fumes, or contact used oil.
- 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.
- Substances in exhaust gases have been identified by some state or federal agencies as causing cancer or reproductive toxicity. Take care not to breathe or ingest or come into contact with exhaust gases.

KEEP THIS MANUAL NEAR THE GENSET FOR EASY REFERENCE

1. Introduction

ABOUT THIS MANUAL

This service manual is for generator sets with the Cummins® B and C Series diesel engines. It includes engine and generator troubleshooting guides. Engine service instructions are in the applicable engine service manual. Operating and maintenance instructions are in the applicable Operator's Manual.

This manual does not have instructions for servicing printed circuit board assemblies. Always replace a faulty printed circuit board assembly. Attempts to repair a printed circuit board can lead to costly damage to the equipment.

This manual contains basic (generic) wiring diagrams and schematics that are included to help in troubleshooting. Service personnel must use the actual wiring diagram and schematic shipped with each unit. The wiring diagrams and schematics that are maintained with the unit should be updated when modifications are made to the unit.

Read **Safety Precautions** and carefully observe all instructions and precautions in this manual.

TEST EQUIPMENT

Most of the tests in this manual can be done with an AC-DC multimeter, frequency meter, Wheatstone bridge (0.001 ohm precision is necessary for measuring stator winding resistance) and load test panel.

HOW TO OBTAIN SERVICE

Always give the complete Model, Specification and Serial number of the generator set as shown on the nameplate 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, on pages iii and iv.*

There are separate *Engine Control* and *Troubleshooting* sections for gensets using the Sentinel control or the Detector control (Figure 1-1). Refer to the *Table of Contents* for specific information relating to your genset. The remaining sections apply to both versions.

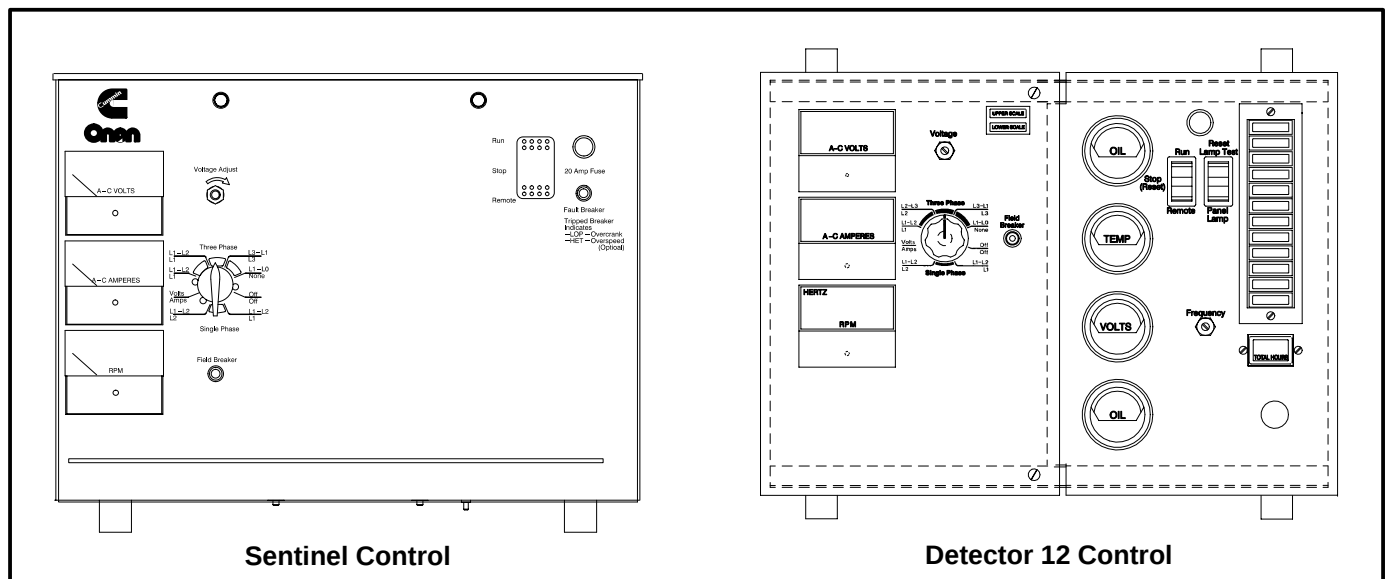


FIGURE 1-1. CONTROL PANEL CONFIGURATIONS

2. AC Control

GENERAL

The control box is mounted on top of the generator, facing the rear. Figure 2-1 (Detector Control) and Figure 2-2 (Sentinel Control) point out the components on the AC control panel. Refer to *Section 10* for the AC control wiring diagrams.

AC CONTROL PANEL COMPONENTS (DETECTOR CONTROL)

Field Circuit Breaker (CB21) The field circuit breaker protects the generator from over-excitation.

AC Voltmeter (M21) The voltmeter indicates output voltage for the phase selected.

AC Ammeter (M22) The ammeter indicates output amperage for the phase selected. Input to the am-

meter is from current transformers CT21, CT22, and CT23.

Phase Selector Switch (S21) The selector switch is used to select the phase for voltage and amperage readings.

Scale Indicator Lamps (DS21 and DS22) The scale indicator lamps indicate whether to read the upper or lower scales of the voltmeter and ammeter.

Frequency Meter (M23) The frequency meter indicates output frequency in Hertz (Hz) and engine speed in RPM.

Output Voltage Trimmer (R21) The output voltage trimmer can be used to adjust output voltage plus or minus five percent of nominal voltage.

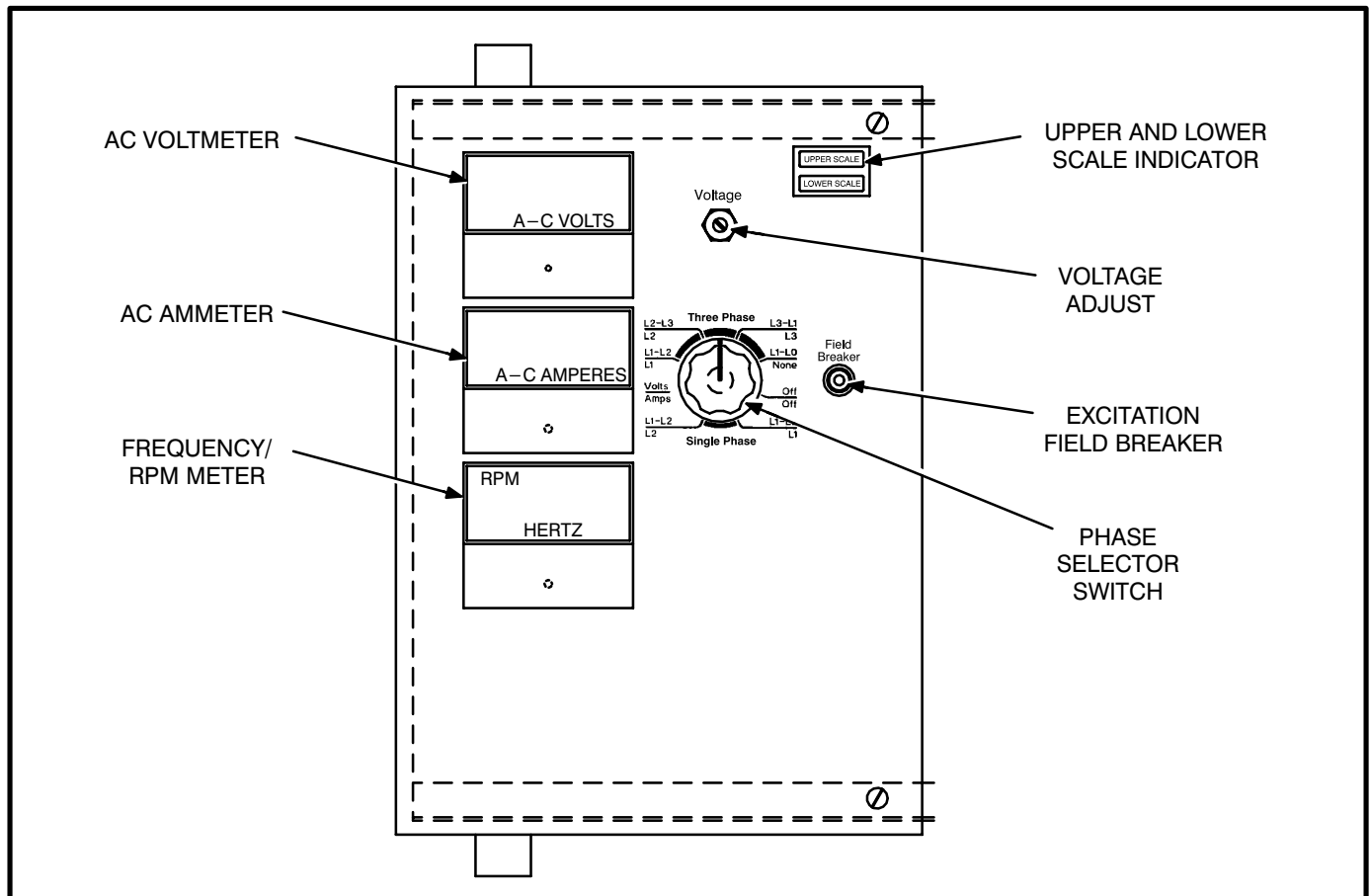


FIGURE 2-1. AC CONTROL PANEL (DETECTOR CONTROL)

AC CONTROL PANEL COMPONENTS (SENTINEL CONTROL)

AC Voltmeter (M21) The voltmeter indicates output voltage for the phase selected.

AC Ammeter (M22) The ammeter indicates output amperage for the phase selected. Input to the ammeter is from current transformers CT21, CT22, and CT23.

Frequency/RPM Meter (M23) The frequency meter indicates output frequency in Hertz (Hz) and engine speed in RPM.

Phase Selector Switch (S21) The selector switch is used to select the phase for voltage and amperage readings.

Output Voltage Trimmer (R21) The output voltage trimmer can be used to adjust output voltage plus or minus five percent of nominal voltage.

Field Circuit Breaker (CB21) The field circuit breaker protects the generator from over-excitation.

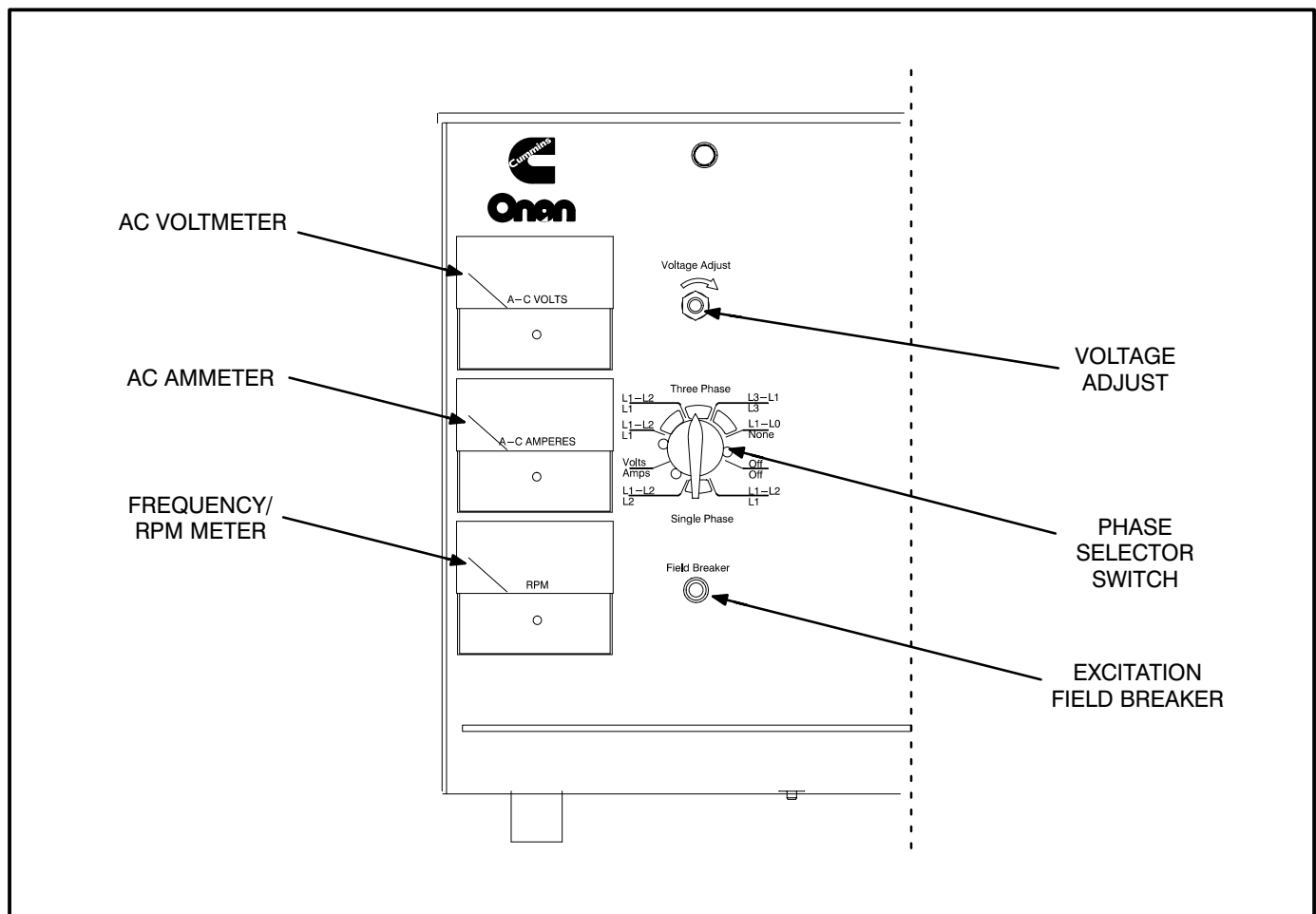


FIGURE 2-2. AC CONTROL PANEL (SENTINEL CONTROL)

AUTOMATIC VOLTAGE REGULATOR (AVR) ADJUSTMENTS

The automatic voltage regulator (AVR) is mounted inside of the control cabinet. The location of the AVR is shown in Figure 2-3 for both the Detector Control and the Sentinel Control.

Three AVR's are available – MX321, SX421 and SX460. The AVR's are adjusted by means of the potentiometers (pots) shown in Figures 2-4 and 2-5. Differences in adjustments are noted in the following control descriptions. Figures 2-6 (MX321/SX421) and 2-7 (SX460) show typical voltage regulating circuits.

These measurements and adjustments are done while the set is running and require access to uninsulated high voltage parts in the control and power output boxes.

⚠ WARNING HAZARDOUS VOLTAGE. *Touching uninsulated high voltage parts inside the control and power output boxes can result in severe personal injury or death. Measurements and adjustments must be done with care to avoid touching high voltage parts.*

For your protection, stand on a dry wooden platform or rubber insulating mat, make sure your clothing and shoes are dry, remove jewelry from your hands and use tools with insulated handles.

Jumper Reconnections (MX321 and SX421)

Jumpers provide for reconnections to adapt the AVR to the application. See Figure 2-4. With the generator set shut down, reconnect the following jumpers, if necessary, to correspond to the operating characteristics of the generator set.

- **Jumper 1-2-3 or 60-C-50:**
 - Jumper 1 – 3 or 60 – C:* Selects 60Hz
 - Jumper 2 – 3 or 50 – C:* Selects 50Hz
- **Jumper A-B-C:**
 - Jumper A – C:* Selects 90 kW or less
 - Jumper B – C:* Selects greater than 90 kW but less than 550 kW
 - Jumper A – B:* Selects greater than 550 kW

Jumper Reconnections (SX460 only)

Jumpers provide for reconnections to adapt the AVR to the application. See Figure 2-5. With the generator set shut down, reconnect the following jumpers, if necessary, to correspond to the operating characteristics of the generator set.

- **Jumper 60-C-50:**
 - Jumper 60 – C:* Selects 60Hz
 - Jumper 50 – C:* Selects 50Hz
- **Jumper 1 – 2:**
 - Jumper installed –* Without output voltage trimmer (R21)
 - Jumper removed –* With output voltage trimmer (R21)
- **Jumper 3 – 4:**
 - Jumper installed –* Selects 110/120V sensing voltage input (not used)
 - Jumper removed –* Selects 240V sensing voltage input (standard)

Voltage and Voltage Stability Adjustments (MX321, SX421 and SX460)

Use the control panel mounted voltage trimmer, if provided, for small voltage adjustments. Measure generator output voltage while the set is running without load at the nominal frequency. If the trimmer does not provide enough adjustment, lock it at its midpoint. Then turn the **VOLTS** pot fully counter-clockwise and the **STABILITY** pot to its midpoint. If the red LED (light emitting diode) on the board lights, refer to Jumper Reconnections and to UFRO Adjustments. Then turn the **VOLTS** pot clockwise until rated voltage is obtained. If voltage becomes unstable when a large load is connected, turn the **STABILITY** pot clockwise until voltage is stable. Check and readjust the **VOLTS** pot, if necessary, each time the **STABILITY** pot is readjusted.

UFRO Adjustments (MX321, SX421 and SX460)

The voltage regulator has an under-frequency protection circuit having a threshold frequency that can be preset (typically at 59 Hz for 60 Hz applications and 49 Hz for 50 Hz applications). The red LED on the board lights when frequency dips below the threshold. Determine threshold frequency by lowering generator frequency until the LED lights.

If adjustment is required, pre-set the UFRO by adjusting the generator frequency to 59 Hz for 60 Hz applications and 49 Hz for 50 Hz applications. Turn UFRO pot clockwise until the LED is lit, then counterclockwise until the LED is off. Set UFRO pot by turning the pot slowly clockwise until the LED just lights.

Note that Dip and Dwell adjustments, below, are related.

Dip Adjustments (MX321 and SX421)

The **DIP** pot adjusts the voltage vs. frequency slope of the generator for frequencies below the threshold preset by the **UFRO** pot. Turning the **DIP** pot clockwise increases the slope (for greater voltage roll off as frequency drops), making it easier for the engine to pick up a large load, but also increasing the voltage dip. The generator voltage vs. frequency slope

is the same above and below the threshold frequency when the pot is turned fully counterclockwise.

Dwell Adjustments (MX321 only)

The **DWELL** pot adjusts voltage recovery time when frequency dips below the preset threshold. Clockwise adjustment increases dwell time. Full counterclockwise adjustment eliminates dwell, in which case, voltage recovery follows engine speed recovery.

Droop Adjustments (MX321 and SX421)

The **DROOP** pot is for adjusting the input signal from the droop compensating CT in paralleling applications. **DROOP** is preset at the factory for five percent droop at full load and zero power factor.

V / Trim Adjustments (MX321 and SX421)

The **V / Trim** (MX321) or **Trim** (SX421) pot is for adjusting the input signal from a VAR / PF controller in utility paralleling applications. Full clockwise adjustment is normal, resulting in maximum sensitivity. The auxiliary controller has no effect when the pot is turned fully counterclockwise.

EXC, OVER V, I / LIMIT, STAB/1and RMS (MX321 and SX421)

These pots are factory preset and do not require adjustment.

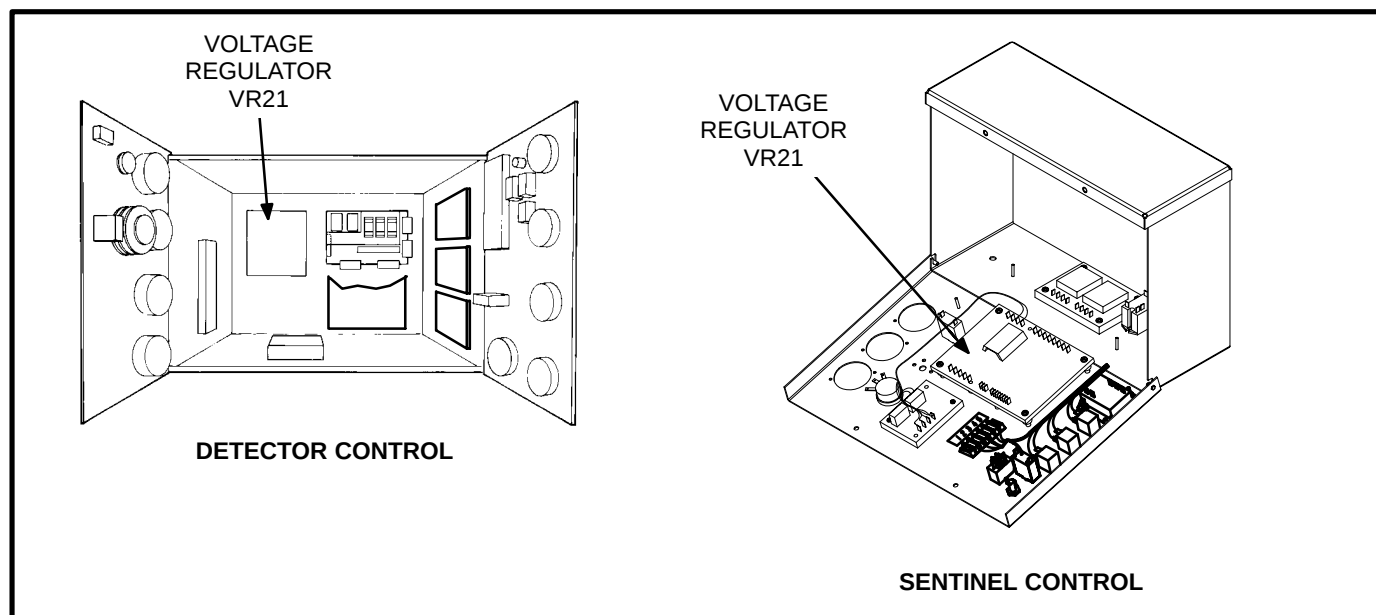
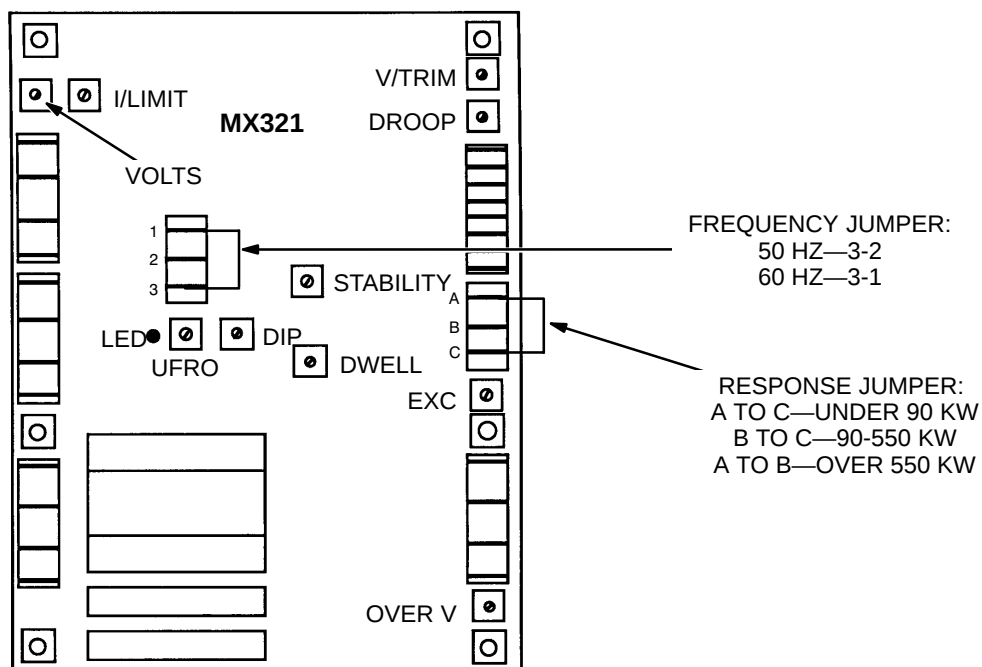


FIGURE 2-3. VOLTAGE REGULATOR LOCATION

PMG-EXCITED GENERATORS (MX321)



PMG-EXCITED GENERATORS (SX421)

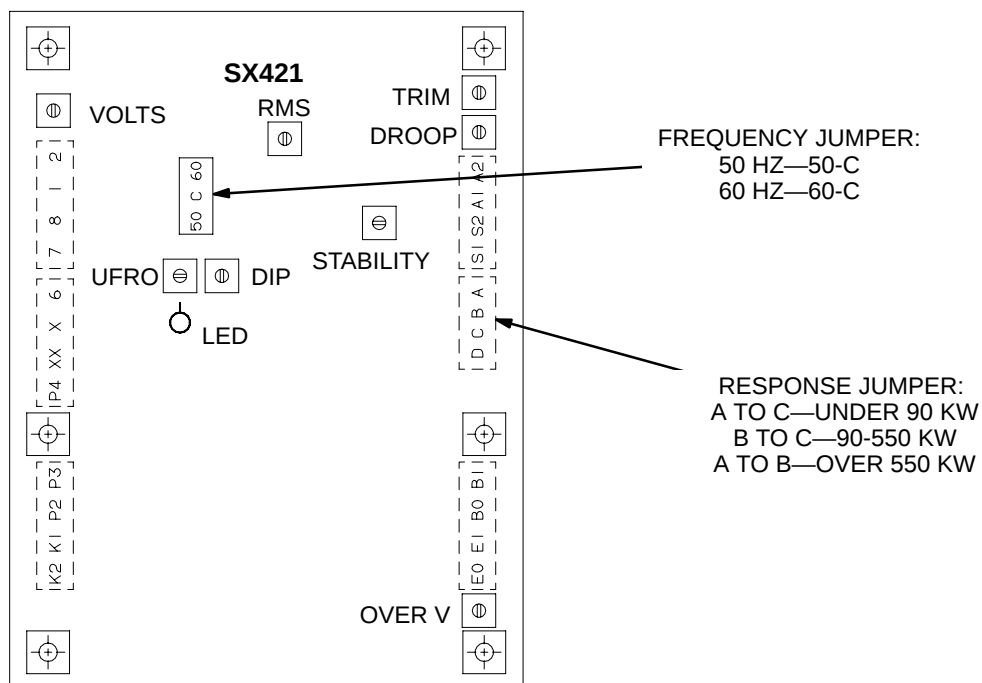


FIGURE 2-4. VOLTAGE REGULATOR ADJUSTMENT POTS AND SELECTION JUMPERS (MX321/SX421)

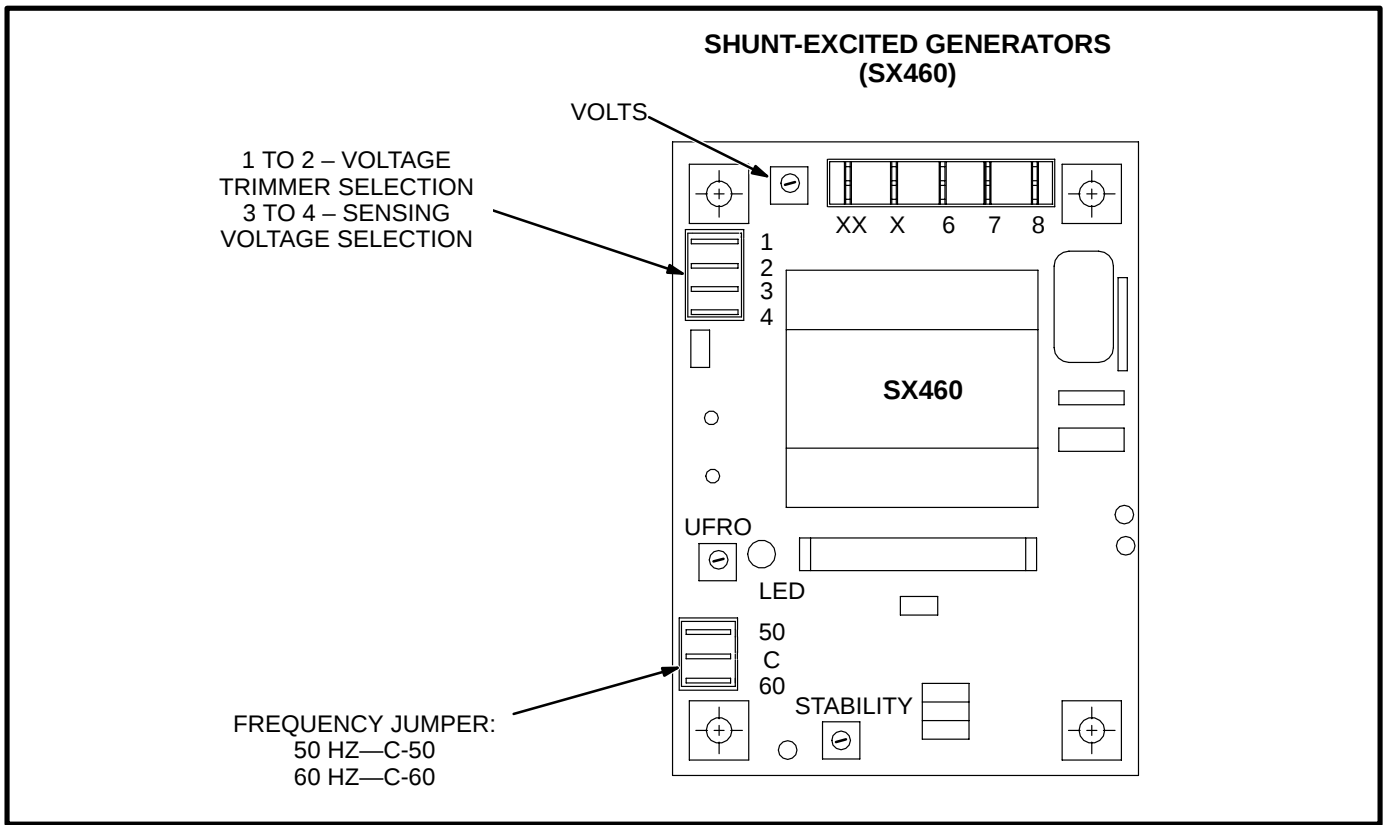


FIGURE 2-5. VOLTAGE REGULATOR ADJUSTMENT POTS AND SELECTION JUMPERS (SX460)

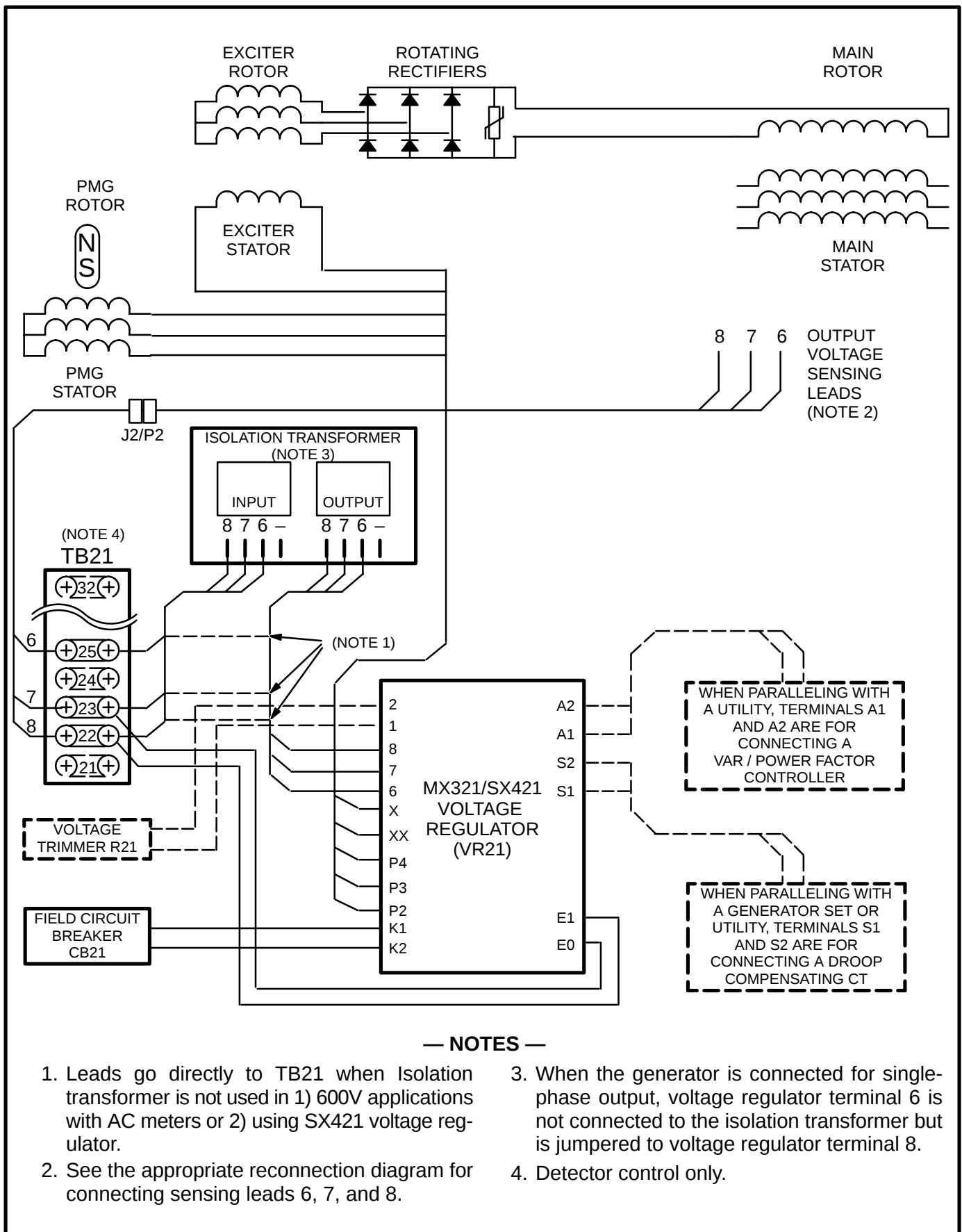
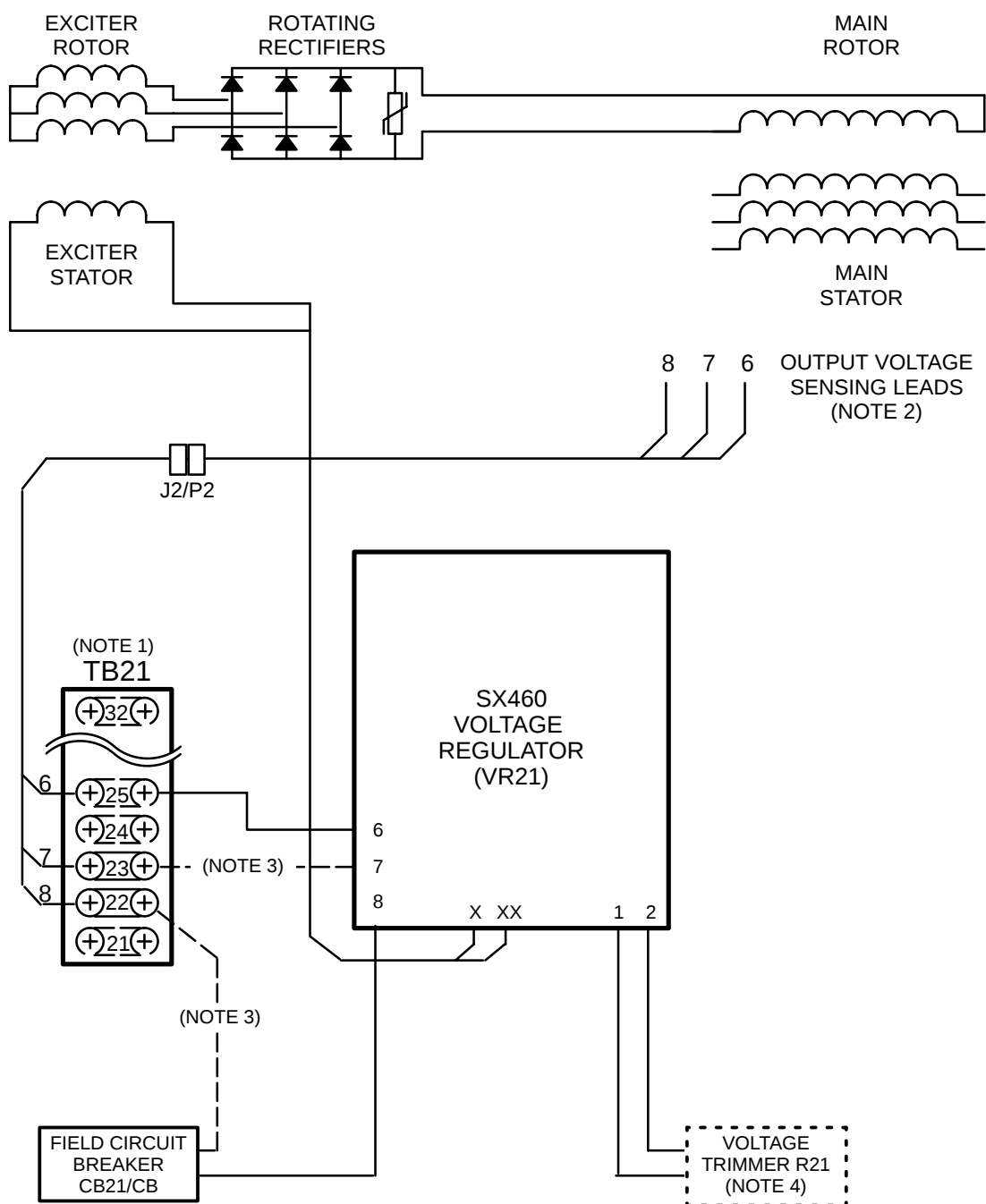


FIGURE 2-6. TYPICAL VOLTAGE REGULATING CIRCUITS FOR PMG-EXCITED GENERATORS



— NOTES —

1. Detector Control only.
2. See the appropriate reconnection diagram for connecting sensing leads 6, 7, and 8.
3. 600V Gensets: Generator tap leads 7 and 8 are used in place of these two leads.
4. There must be a jumper between voltage regulator terminals 1 and 2 when voltage trimmer R21 is not used. Voltage trimmer is standard on Detector Control, optional on Sentinel Control.

FIGURE 2-7. TYPICAL VOLTAGE REGULATING CIRCUITS FOR SHUNT-EXCITED GENERATORS

PRINCIPLE OF GENERATOR OPERATION

1. The generator field (main rotor) is rotated by the engine to induce output current (AC) in the main stator windings.
2. Generator output current is proportional to field strength, which is varied to match the load. Output voltage and frequency are held constant by the voltage regulator and engine governor, respectively.
3. Generator field strength is proportional to field current, which is supplied by the exciter.
4. The exciter field (stator) induces current in the exciter rotor windings. A full wave rectifier bridge (rotating rectifiers) mounted on the exciter rotor converts exciter output (3-phase AC) to DC. The exciter rotor is mounted on the main rotor shaft.
5. Exciter output current is proportional to exciter field current.
6. The automatic voltage regulator (AVR) regulates exciter field current by comparing generator output voltage and frequency with reference values.
7. **PMG-Excited Generators.** Exciter field current is supplied by a PMG (permanent magnet) exciter through the voltage regulator. The PMG consists of a stator and a permanent magnet rotor mounted on the end of the main rotor shaft.
8. **Shunt-Excited Generators.** Exciter field current is supplied by the generator stator through the voltage regulator. Residual field magnetism initiates “self-excitation” during startups.

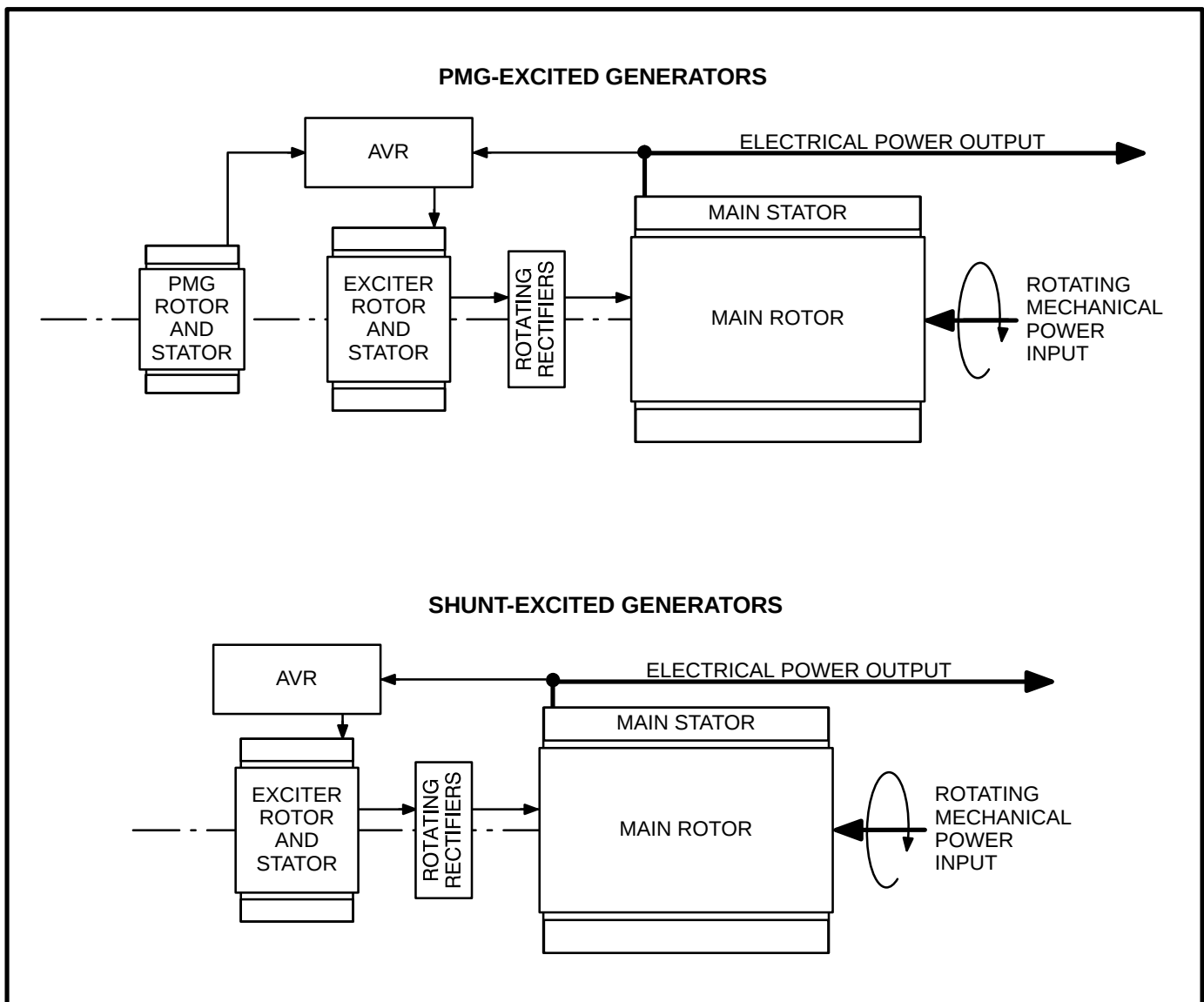


FIGURE 2-8. SCHEMATIC OF GENERATOR OPERATION

3. Engine Control (Detector Control)

GENERAL

The Detector control box is mounted on top of the generator, facing the rear. Figure 3-1 shows the components on the engine control panel.

STANDARD CONTROL PANEL COMPONENTS

Run / Stop / Remote Switch (S12) The switch is pushed to the **Run** position to start and run the generator set and the **Stop** position to stop the set. The **Remote** position allows a remote controller to automatically run the set. The switch must be in the **Stop** position when the reset switch (described next) is used to restore generator set operation following a fault shutdown.

Reset / Lamp Test / Panel Lamp Switch (S11) The switch is pushed to the **Reset** position (momentary contact) to reset the engine control to restore operation following a fault shutdown. The **Run / Stop / Remote** switch must be in the **Stop** position for reset to occur. The **Lamp Test** position (momentary contact) lights all the fault indicator lamps. Replace lamps that do not light. The **Panel Lamp** position lights the panel illumination lamp.

Oil Pressure Gauge (M11) The oil pressure gauge indicates engine oil pressure.

Coolant Temperature Gauge (M12) The coolant temperature gauge indicates engine coolant temperature.

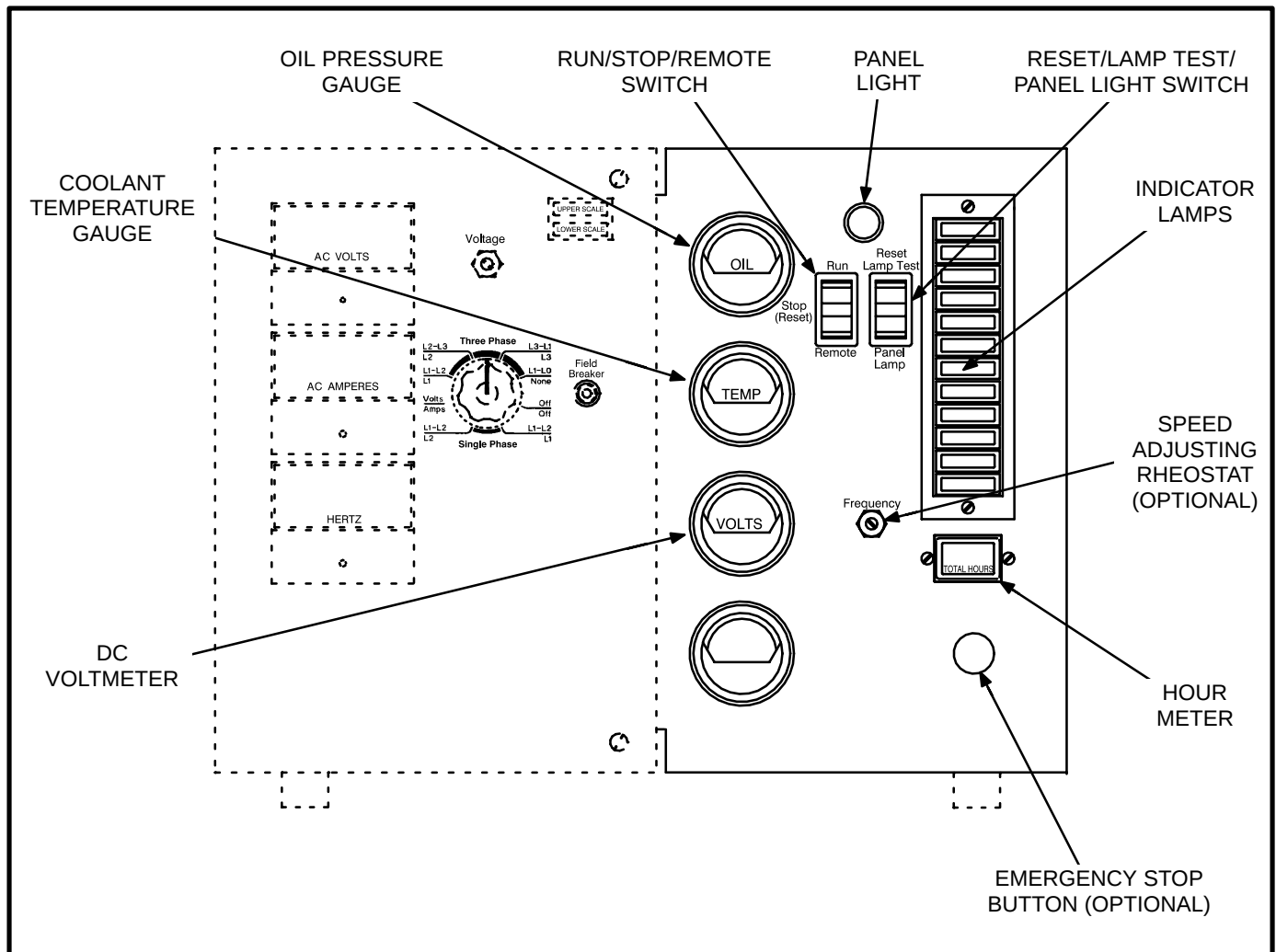


FIGURE 3-1. ENGINE CONTROL PANEL

DC Voltmeter (M13) The DC voltmeter indicates voltage across the battery terminals during operation.

Hour Meter (M14) The hour meter indicates the accumulated number of hours the set has run. It cannot be reset.

Panel Lamp (DS11) The panel lamp illuminates the control panel.

Detector-7 Fault and Status Indicator Lamps (A12)

- **Run (Green)** This lamp indicates that the generator set is running and that the starter has been disconnected.
- **Pre Low Oil Pressure (Yellow)** This lamp indicates that engine oil pressure is abnormally low (less than 20 psi [138 kPa]).
- **Low Oil Pressure (Red)** This lamp indicates that the engine shut down because of excessively low engine oil pressure (less than 14 psi [97 kPa]).
- **Pre High Engine Temperature (Yellow)** This lamp indicates that engine coolant temperature is abnormally high (greater than 220° F [104° C]).
- **High Engine Temperature (Red)** This lamp indicates that the engine shut down because of excessively high engine coolant temperature (greater than 230° F [110° C]).
- **Overcrank (Red)** This lamp indicates that the engine shut down because it did not start during the timed cranking period (approximately 75 seconds, including two rest periods).
- **Overspeed (Red)** This lamp indicates that the engine shut down because of overspeed. The overspeed shut down ranges are:
60 Hz Sets 2000 to 2200 RPM
50 Hz Sets 1800 to 2100 RPM

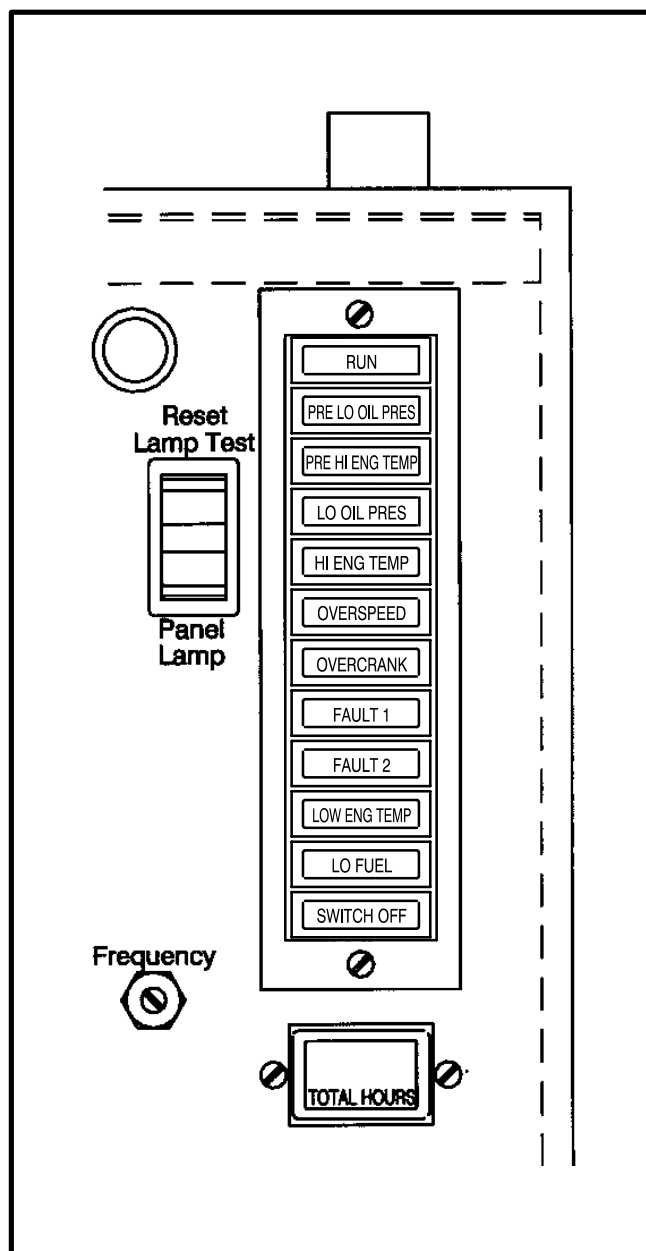


FIGURE 3-2. DETECTOR-12 INDICATOR LAMPS

OPTIONAL CONTROL PANEL COMPONENTS

Speed Adjusting Rheostat The speed adjusting rheostat is used to adjust engine speed from the control panel (an option with the optional electric governor).

Emergency Stop Button (S14) The emergency stop button is a red, push-in switch used to stop the engine. The button lights up when it is pushed in. The button has to be pulled out and the engine control reset to restore operation.

Detector-12 Fault and Status Indicator Lamps (A12) The Detector-12 control panel has the five following indicator lamps in addition to the standard seven.

- **Low Engine Temperature (Yellow)** This lamp indicates that engine temperature is less than 70° F (21° C), and the possibility that the engine might not start.
- **Low Fuel (Yellow)** This lamp indicates that the fuel supply is marginally low.

- **Switch-off (Flashing Red)** This lamp indicates that the **Run / Stop / Remote** switch is in the **Stop** position, which prevents remote, automatic operation.

- **Fault 1 (Red)** This lamp indicates that the engine shut down because of a system fault. The customer has to make connections to use this lamp. The lamp is a part of a 10 second time delay shutdown circuit. The customer can make reconnections for non-timed shutdown. See Engine Control Monitor.

OR

Basin (Yellow) This (optional) lamp indicates that the inner fuel tank is leaking and the fuel is gathering in the outer basin. This fault is normally set for a warning while the genset is running or is in the standby mode. See Engine Control Monitor.

- **Fault 2 (Red)** This lamp indicates that the engine shut down because of a system fault. The customer has to make connections to use this lamp. The lamp is part of a non-time delay shutdown circuit. The customer can make reconnections for 10 second time delay shutdown. See Engine Control Monitor.

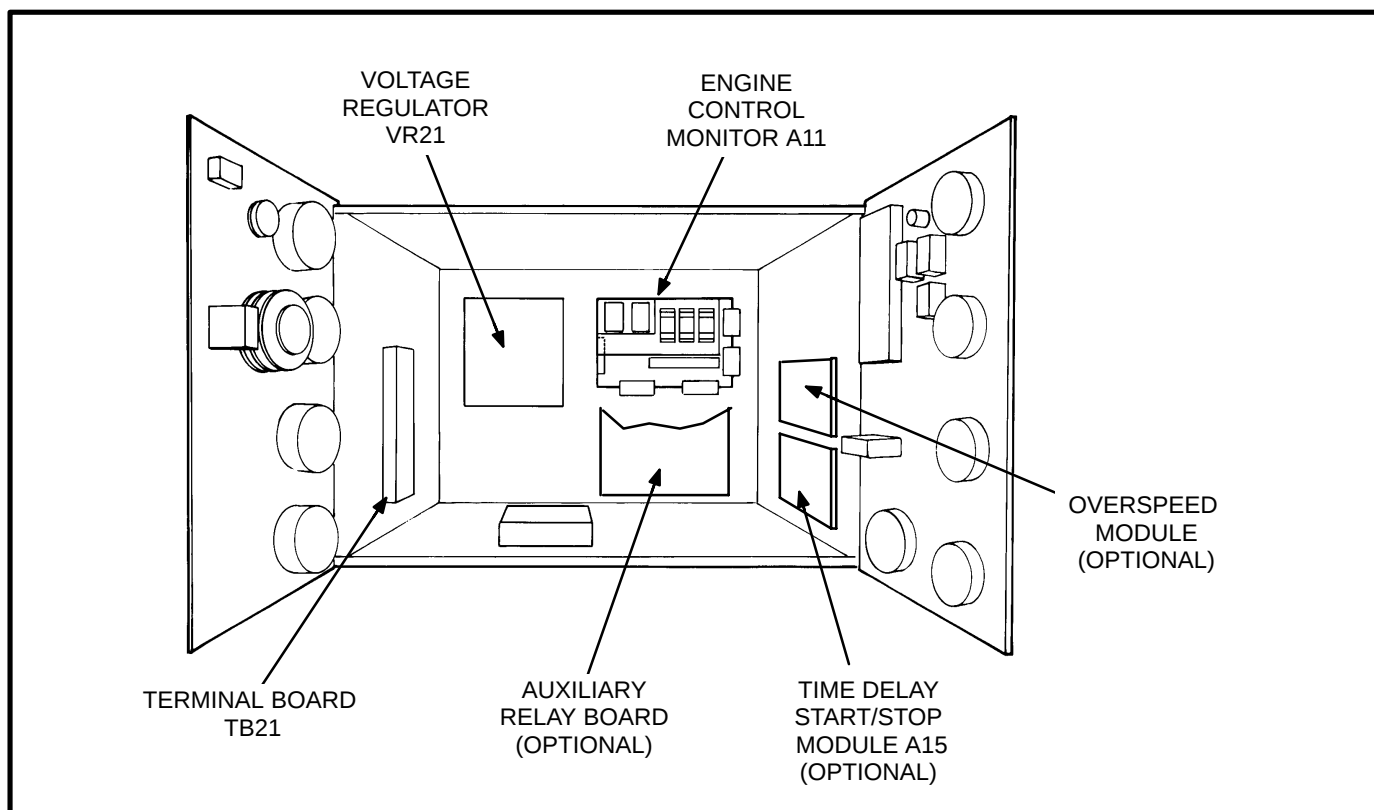


FIGURE 3-3. ARRANGEMENT OF COMPONENTS INSIDE THE CONTROL BOX

CONTROL BOX INTERIOR

Figure 3-3 shows the arrangement of components inside the control box, including the engine control monitor and some of the auxiliary components under the following headings.

ENGINE CONTROL MONITOR (A11)

The heart of the engine control system is the engine control monitor (ECM) (Figure 3-4). It is a printed circuit board assembly mounted on the back wall of the control box. It starts and stops the engine in response to the control panel switches, engine sensors and remote control signals.

Terminals and Connectors

See Pages 10-9 through 10-12 for the appropriate connection and schematic drawings for the DC control system. See Page 10-13 for typical customer connections at terminal boards **TB1** and **TB2** on the ECM and page 10-14 if the set is also equipped with the auxiliary relay board.

Fuses

The ECM has five replaceable fuses to protect it from overloads and ground faults. They are:

- F1** Starter solenoid circuit, 20 amps.
- F2** Fuel solenoid (switched B+) circuits, 20 amps.
- F3** Continuous B+ out to remote circuits, 15 amps.
- F4** ECM circuits, 5 amps.
- F5** Engine gauge circuits, 5 amps.

Function Selection Jumpers

ECM boards have six selection jumpers that can be repositioned to provide the following timed or non-timed warnings or timed or non-timed shutdowns with warnings:

- W1** (12 light only) Jumper Position (jumper **W8** must be in the **B** position):
 - A** Non-timed warning under **FLT 2** conditions.
 - B** Non-timed shutdown under **FLT 2** conditions.
 - C** Timed warning under **FLT 2** conditions.
 - D** Timed shutdown under **FLT 2** conditions.

W2 (12 light only) Jumper Position (jumper **W9** must be in the **B** position):

- A** Non-timed warning under **FLT 1** conditions.
- B** Non-timed shutdown and under **FLT 1** conditions.
- C** Timed warning under **FLT 1** conditions.
- D** Timed shutdown under **FLT 1** conditions.

W6 Jumper Position:

- A** Warning under **Pre-High Engine Temperature** conditions.
- B** Shutdown under **Pre-High Engine Temperature** conditions.

W7 Jumper Position:

- A** Warning under **Pre-Low Oil Pressure** conditions.
- B** Shutdown under **Pre-Low Oil Pressure** conditions.

W8 (12 light only) Jumper Position:

- A** Warning while running or during standby under **FLT 2** conditions.
- B** Allows selection of functions with **W1** jumper.

W9 (12 light only) Jumper Position:

- A** Warning while running or during standby under **FLT 1** conditions.
- B** Allows selection of functions with **W2** jumper.

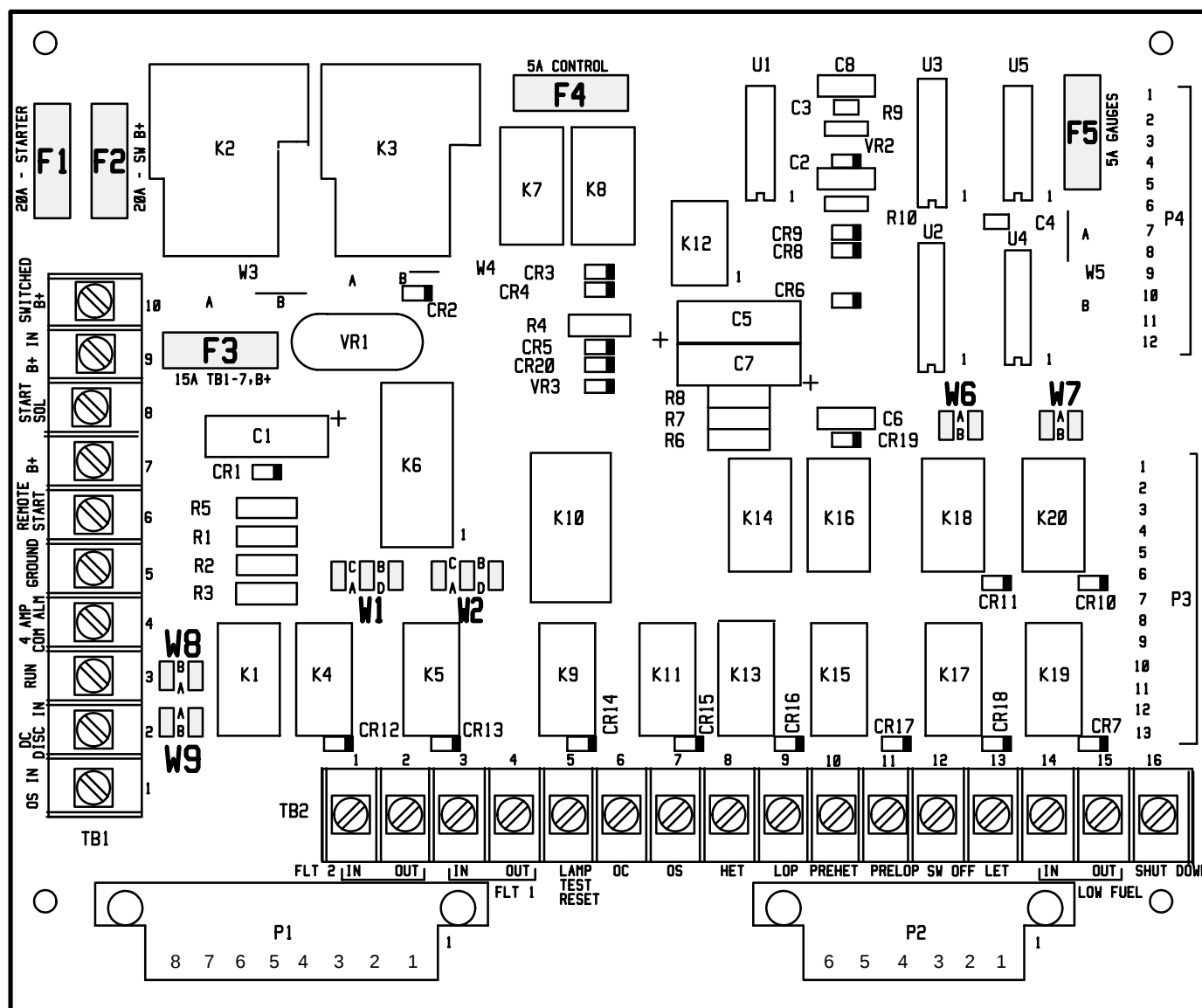


FIGURE 3-4. ENGINE CONTROL MONITOR FUSES AND FUNCTION SELECTION JUMPERS

ENGINE SENSORS

Figures 3-5 and 3-6 show the locations of the gauge senders and the coolant temperature and oil pressure sensing switches to which the ECM responds. The switches function by closing the fault or warning circuit to the engine chassis ground (battery negative [-]).

Always use pipe thread sealant on gauge senders and warning and shutdown switches.

CAUTION *Teflon tape is not recommended for switches and senders that are grounded to the engine by thread contact as it may interfere with the ground path.*

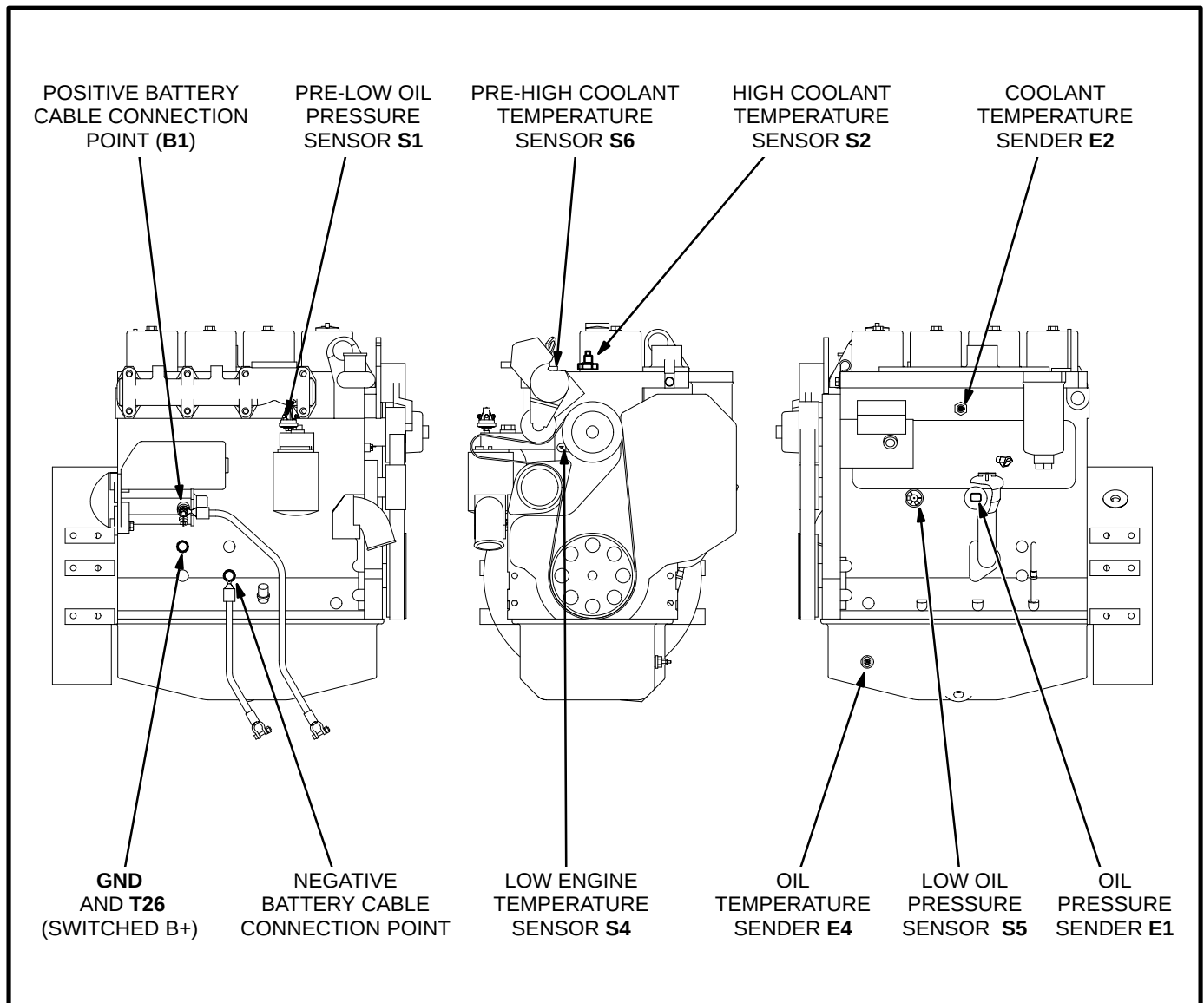


FIGURE 3-5. 4B/6B ENGINE SENSOR LOCATIONS

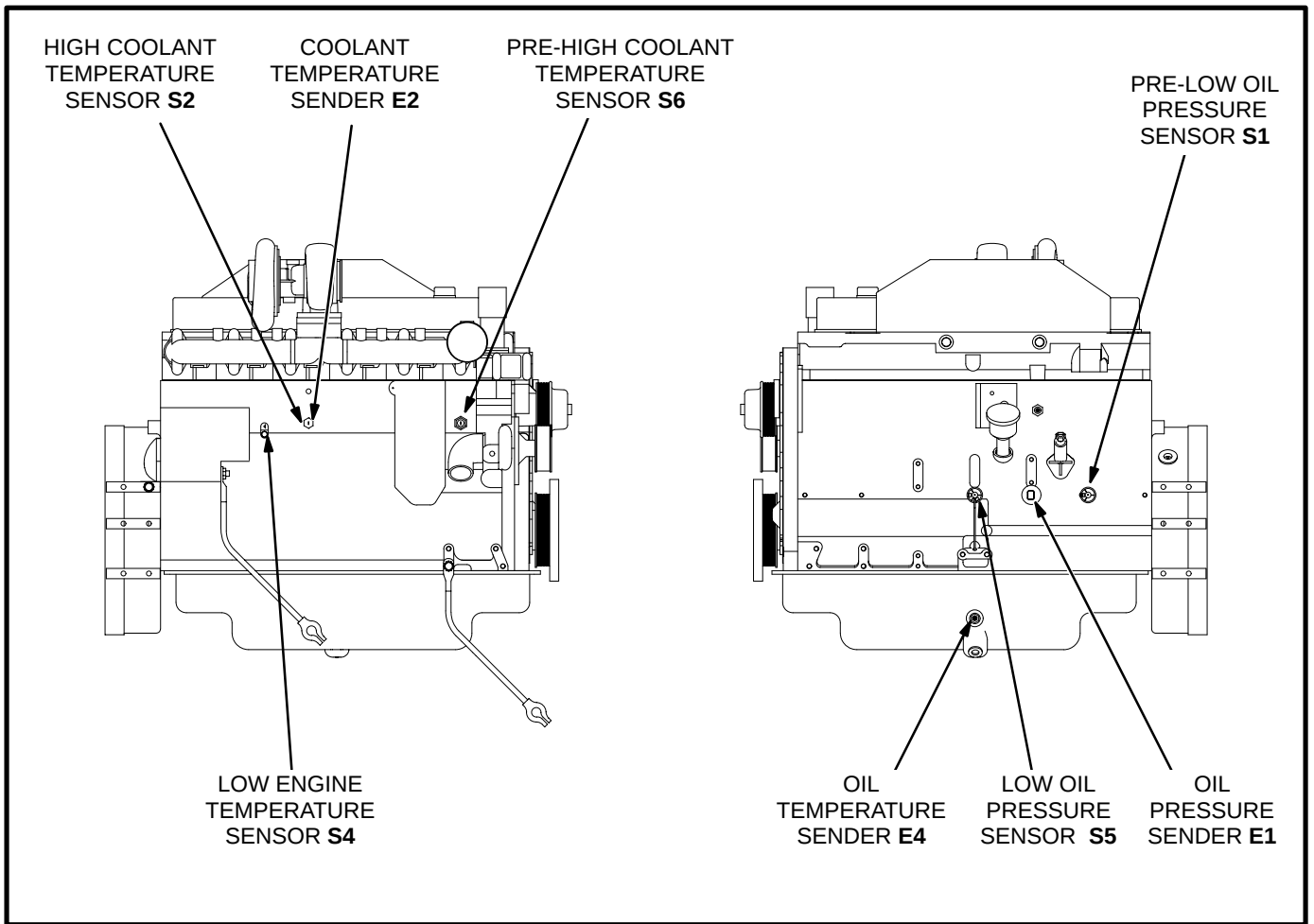


FIGURE 3-6. 6C ENGINE SENSOR LOCATIONS

Low Coolant Level Cutout Switch

When coolant level in the radiator top tank falls below the switch sensor, the switch closes the circuit to ground. This switch may be connected in parallel with the high engine temperature cutout switch to shut down the engine and light the **High Engine Temperature** lamp or in parallel with the pre-high engine temperature switch to light the **Pre High Engine Temperature** light only.

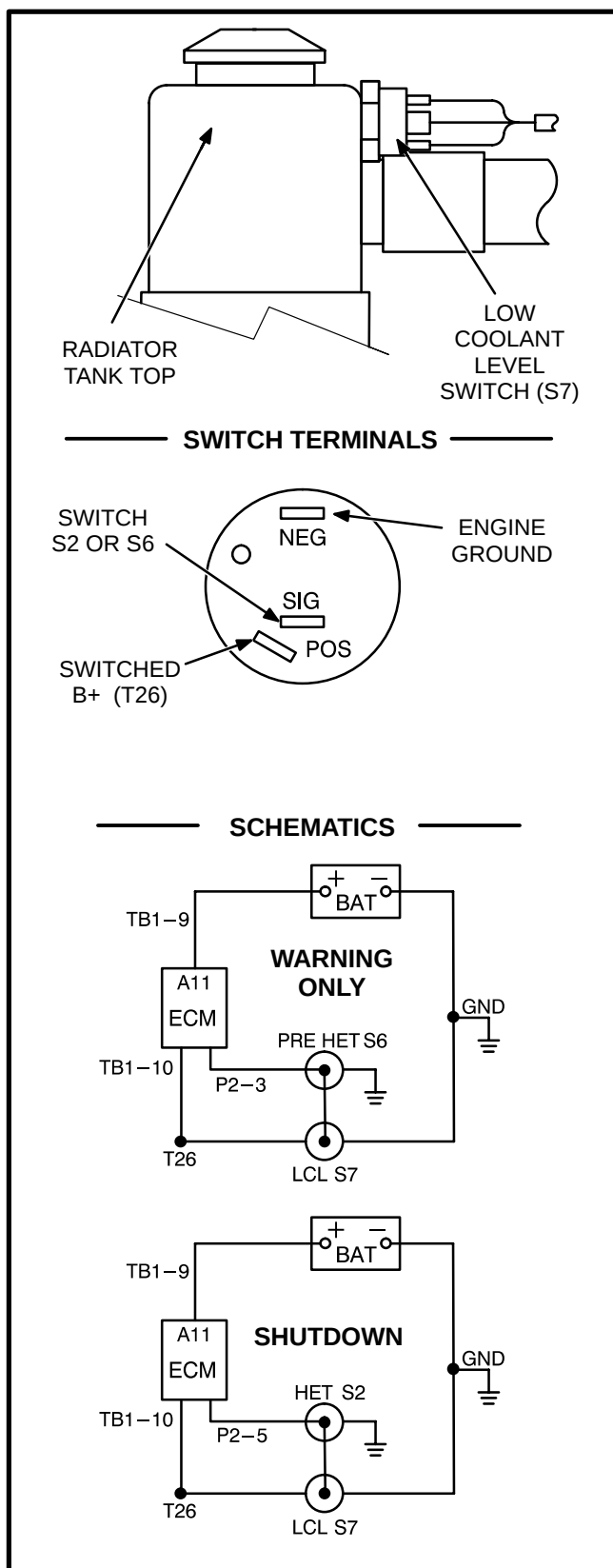


FIGURE 3-7. LOW COOLANT LEVEL SWITCH

AUXILIARY CONTROL COMPONENTS

The set might be equipped with one or more of the following components.

Mechanical Overspeed Switch (Standard)

The mechanical overspeed switch is bolted to the end of the generator rotor shaft.

1. Check overspeed cutout RPM and turn the adjustment screw, if necessary, so that shutdown occurs within the following RPM ranges:
60 Hz Sets 2000 to 2200 RPM
50 Hz Sets 1800 to 2100 RPM
2. Replace the switch if the cutout speed adjustment results in an air gap between the magnet and the fly arm of less than 0.005 inches (0.13 mm).
3. Torque the center rotor bolt to 40 ft-lbs (54 Nm) when replacing the switch.

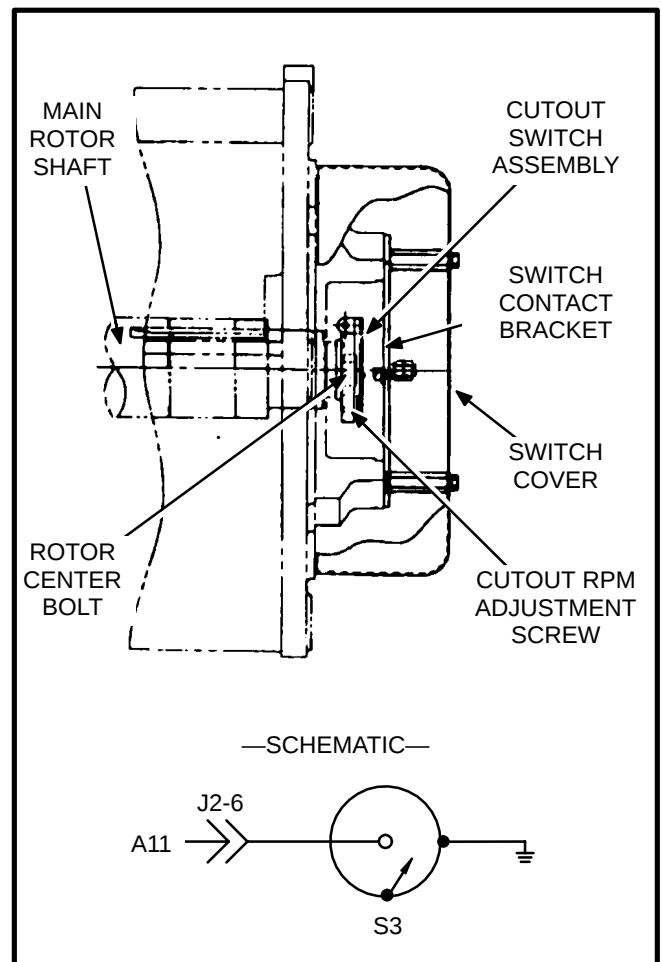


FIGURE 3-8. MECHANICAL OVERSPEED SWITCH

Electronic Overspeed Module (Optional)

PMG-excited generators are equipped with an electronic overspeed module in the control box. The

module senses PMG output frequency to determine generator speed (frequency). Adjust the overspeed pot (HIGH) to cut out at 1800 to 1900 RPM for 50 Hz sets and 2100 to 2200 RPM for 60 Hz sets.

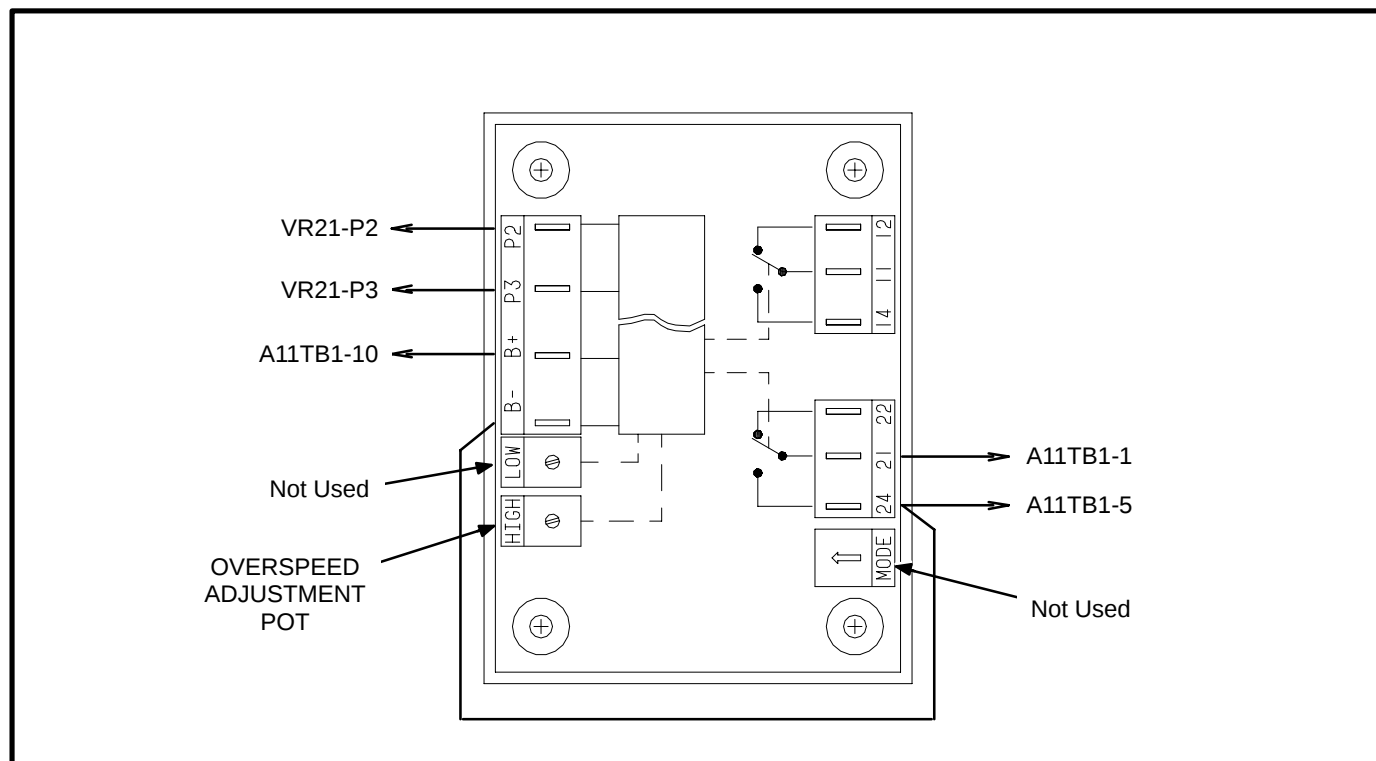


FIGURE 3-9. ELECTRONIC OVERSPEED MODULE

Auxiliary Relay Board (ARB) (Optional)

The following describes the design/functional criteria for the auxiliary relay board (ARB) (Figure 3-10) with a Detector-7 or -12 Genset control. The board is mounted directly on top of the ECM using standoffs and has access holes for the fuses located on the ECM. Page 10-14 is a detailed connection diagram for the ARB.

Terminal Blocks

TB1 – ARB TB1 and ECM TB1 are identically numbered and provide the same remote control connection points. Note that additional terminals are provided for terminals 5, 7, and 10 of ARB TB1.

TB2 through TB5 – Connection points for relays K1 through K3. TB2 provides the N/O and N/C connections (three form 'C' contacts for each relay). TB3 through TB5 provide the common connection points (TB3 for K1, TB4 for K2 and TB5 for K3).

TB6 and TB7 – Connection points for fault relays K4 through K15. Three terminals are provided for each relay, which are labeled COM, N/C, N/O.

Plug-In Relays (K1, K2, K3)

The ARB can be equipped with one to three 3-pole, double-throw relays. These relays (K1, K2, K3) are field changeable plug-in relays for easy field addition and replacement.

The relay contact ratings are:

- 10 amps at 28 VDC or 120 VAC, 80% PF
- 6 amps at 240 VAC, 80% PF
- 3 amps at 480 VAC, 80% PF

Each relay can be operated as a RUN, COMMON ALARM, or ISOLATED COIL with the changing of a jumper.

Jumper Positions for Plug-In Relays

Jumpers W1, W2, and W3 perform the same functions for their respective relays, W1 for relay K1, W2 for relay K2, and W3 for relay K3. They can be located in any of 3 positions (A, B, C) independently of each other.

Jumper Position A (Run): The relay operates as a Run relay, energizing when SW B+ is applied from the ECM.

Jumper Position B (Common Alarm): The relay operates as a Common Alarm relay. The relay energizes any time there is an engine shutdown. This signal is provided from the ECM.

Jumper Position C (Isolated): The relay operates as an Isolated relay. The relay coil is energized by a customer applied B+ signal through the terminal block; TB3-1 for relay K1, TB4-1 for relay K2, and TB5-1 for relay K3.

Jumpers W11, W12, and W13 perform the same functions for their respective relays; W11 for relay K1, W12 for relay K2, and W13 for relay K3. They can be located in two different positions (A, B) independently of one another.

Jumper Position A: The relay operates isolated from the board. The customer provides the circuit completion through terminal block; TB3 for relay K1, TB4-5 for relay K2, and TB5-5 for relay K3. The customer can operate the relay with switched ground logic or use this relay in the middle of more complex logic circuits if needed.

Jumper Position B: The relays operate with the coils connected to ground through the board connections. The coil will require a B+ signal to energize with the jumper in this position.

Fault Relays (K4 through K15)

These relay modules are used to operate a remote alarm annunciator that has an independent power source. This allows the use of either AC or DC for alarm drives. The relays are energized through the latching relays on the ECM and provided N/O and N/C contacts for each external alarm connection.

The 12 relays with form 'C' contacts are rated:

- 10 Amp, 120 VAC
- 10 Amp, 30 VDC

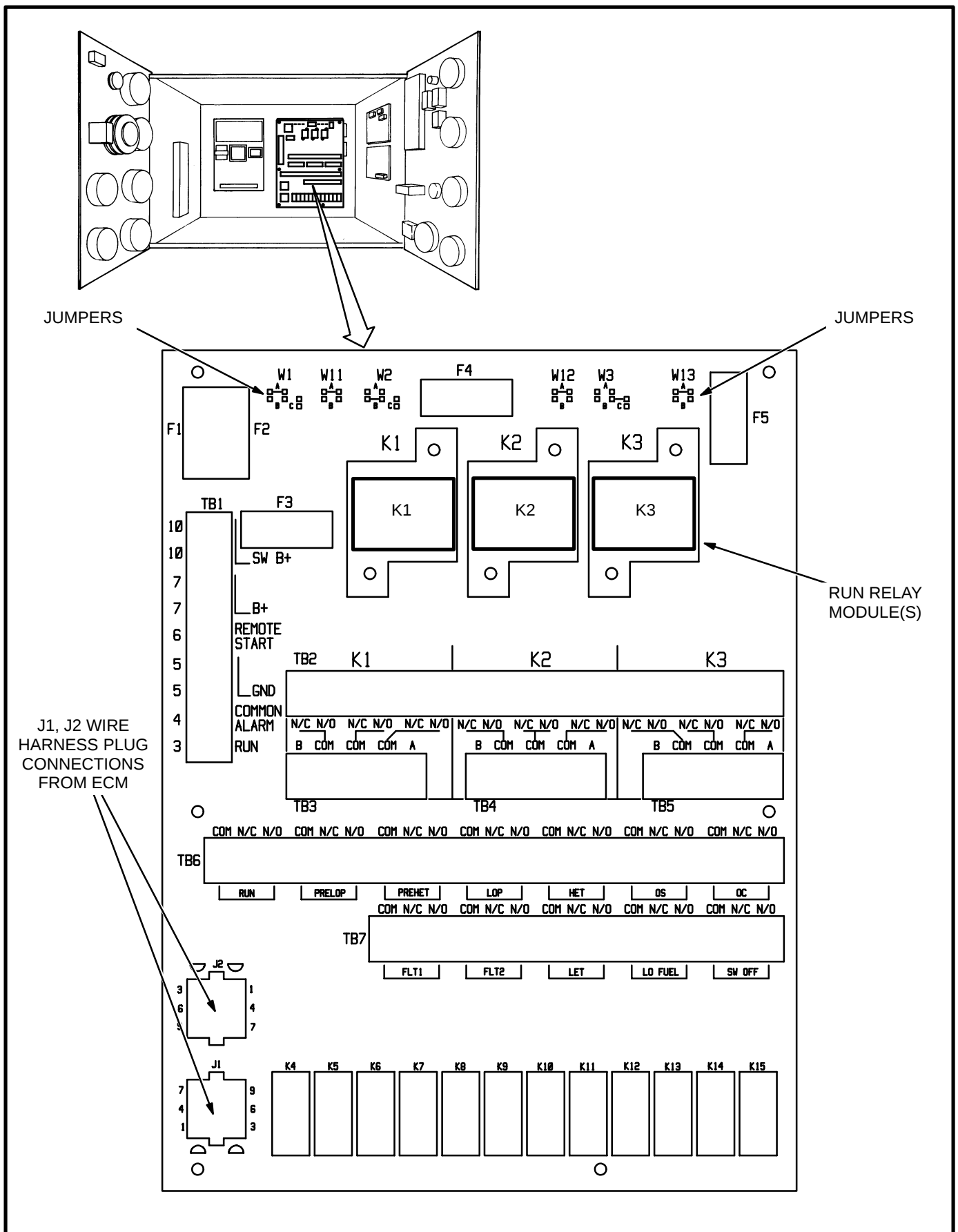


FIGURE 3-10. AUXILIARY RELAY BOARD

Time Delay Start / Stop Module (A15)

The set can be equipped with a module to delay starting and stopping when the start and stop signals are received from the remote controller. It is adjustable to delay starts from 1 to 15 seconds to

prevent nuisance starts in installations where momentary power interruptions are frequent. It is adjustable to delay stops 1 to 30 minutes to allow the prime source of power time to stabilize and the generator set to cool down.

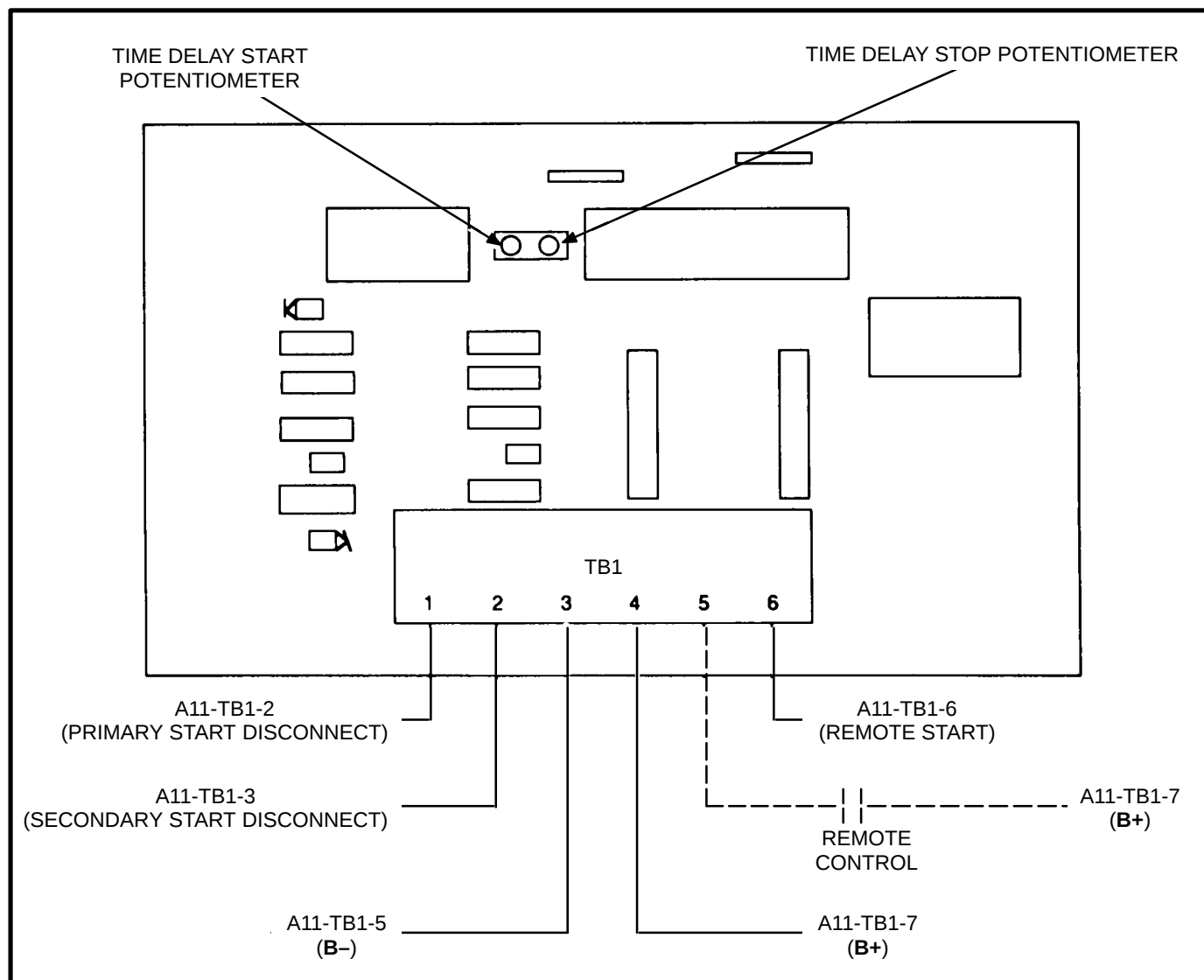


FIGURE 3-11. TIME DELAY START / STOP MODULE

SEQUENCE OF OPERATION

The sequence of operation is as follows. Refer to the schematic on Page 10-10 or 10-12, as appropriate.

1. The ECM is powered by cranking battery voltage (12 VDC). Terminal **TB1-9** is connected to battery positive (+) and connector **P1-6** to battery negative (-).
2. The starting cycle begins when relay **K7** is powered, either manually by pushing the panel **Run** switch, or automatically by a remote controller connected at terminal **TB1-6**. (The panel switch must be in the **Remote** position for remote, automatic operation.)
3. Relay **K7** powers relays **K2** and **K3**.
4. Relay **K2** powers the engine gauges and terminal **TB1-10**, to which the fuel solenoid is connected.
5. Relay **K3** powers terminal **TB1-8** to which either starter relay **K4** or B1-SW is connected. Engine cranking begins.
6. The engine starts and runs up to governed speed in a matter of seconds.
7. The starter is disconnected when engine speed gets to about 600 RPM. This is done by relay **K10** or **K14**, whichever acts first to open the circuit powering relay **K3**.
8. Relay **K10** is powered by the generator output voltage (120 VAC) through plug-in connectors **P1-1** and **P1-2**. The remote **Run** indicator lamp should light (connected through terminal **TB1-3**).
9. Relay **K14** is powered by the engine-driven battery charging alternator (12 VDC) through plug-in connector **P1-3**. The panel **Run** indicator lamp should light. Relays **K10** and **K14** are redundant.

If the starter disconnects normally but neither the panel nor the remote Run indicator lamps light, the AC (K10) starter disconnect circuit is not working.

Both the remote and the panel Run indicator lamps will light even if the DC (K14) starter

disconnect circuit is not working. Check the DC voltmeter to determine whether or not the battery charging alternator is working.

10. Relays **K2** and **K3** are deenergized (by latching relay **K6**) causing shutdown to occur if the engine does not start within 75 seconds. The **Overcrank** indicator lamp and switch S11 lamp will light and common alarm terminal **TB1-4** is powered.

The ECM has a cycle crank feature whereby the engine is cranked for three 15 second periods alternated with two 15 second rest periods.

11. Relay **K3** is de-energized (by latching relay **K6**) causing shutdown to occur during operation when a low oil pressure, high engine temperature or engine overspeed condition is sensed or the optional emergency stop button is pressed. The appropriate fault indicator lamp lights and common alarm terminal **TB1-4** is powered. (There is no fault lamp for emergency stop. The switch button will light, however, and the light in switch S11.)

The low oil pressure and high engine temperature shutdowns have 10 second time delays to allow oil pressure and engine temperature to stabilize during startup. The 10 second time delay begins after K10 or K14 is energized.

12. To restore operation after a shutdown fault has been serviced, reset latching relay **K6** by pushing the panel **Stop** switch and then the **Reset** switch. The set should run or be ready to run when the panel switch is pushed to **Run** or to **Remote**.

If the emergency stop switch has been used, the control will have to be reset to restore operation. First pull the emergency stop switch button and then push the panel Stop and Reset switches.

13. The set is stopped manually by pressing the panel **Stop** switch or automatically by a remote controller. (The panel switch must be in the **Remote** position for remote, automatic operation.)

4. Engine Control (Sentinel Control)

GENERAL

The Sentinel control box is mounted on top of the generator, facing the rear. Figure 4-1 shows the components on the engine control panel.

CONTROL PANEL COMPONENTS

Run/Stop/Remote Switch (S12) The switch is pushed to the **Run** position to start and run the generator set and the **Stop** position to stop the set. The **Remote** position allows a remote controller to automatically run the set. The switch must be in the **Stop** position when the common fault circuit breaker (described next) is used to restore generator set operation following a fault shutdown.

Common Fault Circuit Breaker The common fault circuit breaker shuts down the engine when any

fault shutdown sensor functions. Fault shutdown is indicated when the breaker reset button extends out past normal. Push the button to restore operation (after the engine has been properly serviced). The **Run/Stop/Remote** switch must be in the **Stop** position before resetting the common fault circuit breaker.

The standard fault shutdowns are low oil pressure, high engine temperature, overcrank, and overspeed. The optional fault shutdowns available with the Dry Contacts Module are low coolant level, and low fuel level.

20A Control Fuse Protects control components and wiring from current overload.

Hour Meter The hour meter indicates the accumulated number of hours the set has run. It cannot be reset.

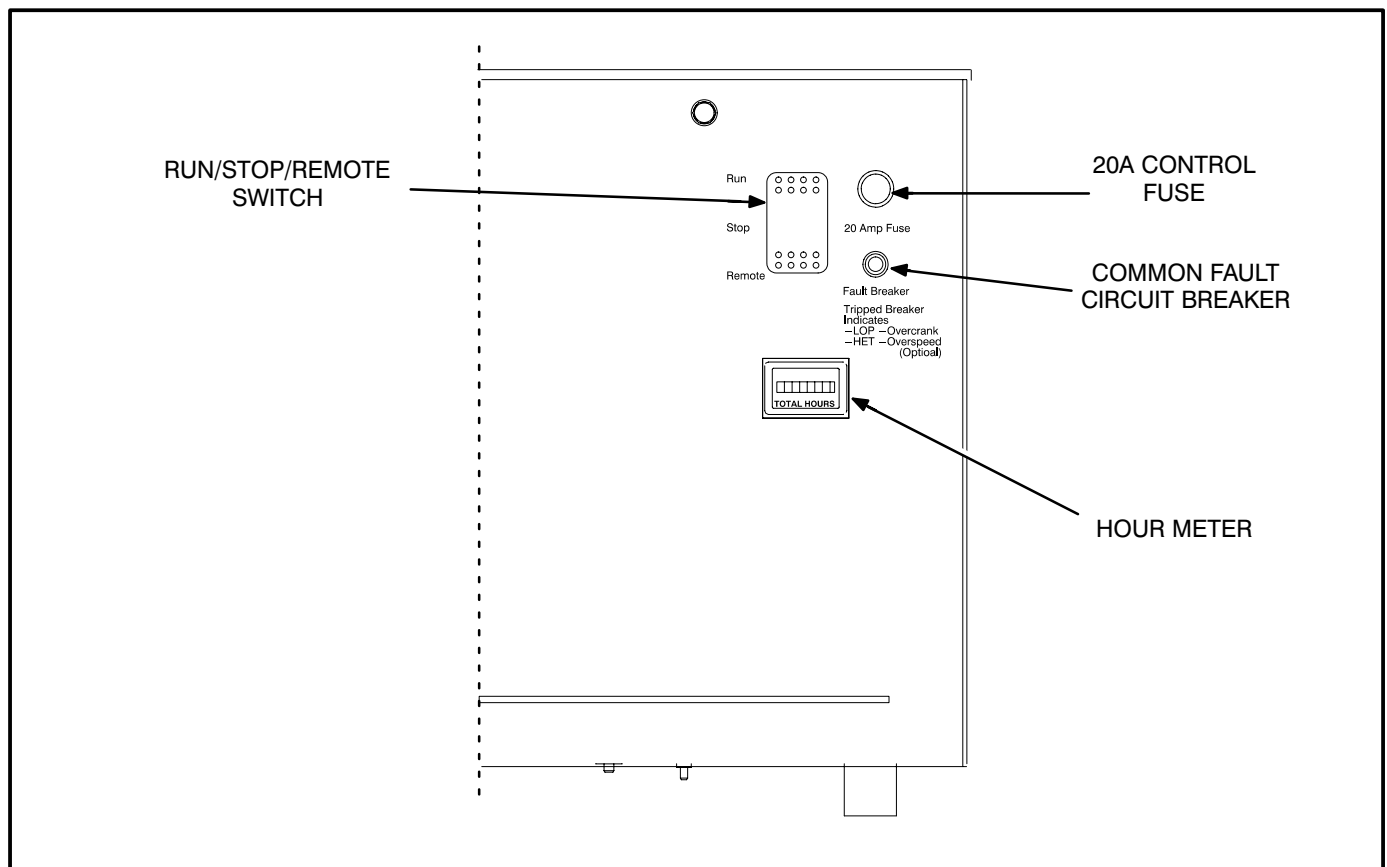


FIGURE 4-1. ENGINE CONTROL PANEL (SENTINEL)

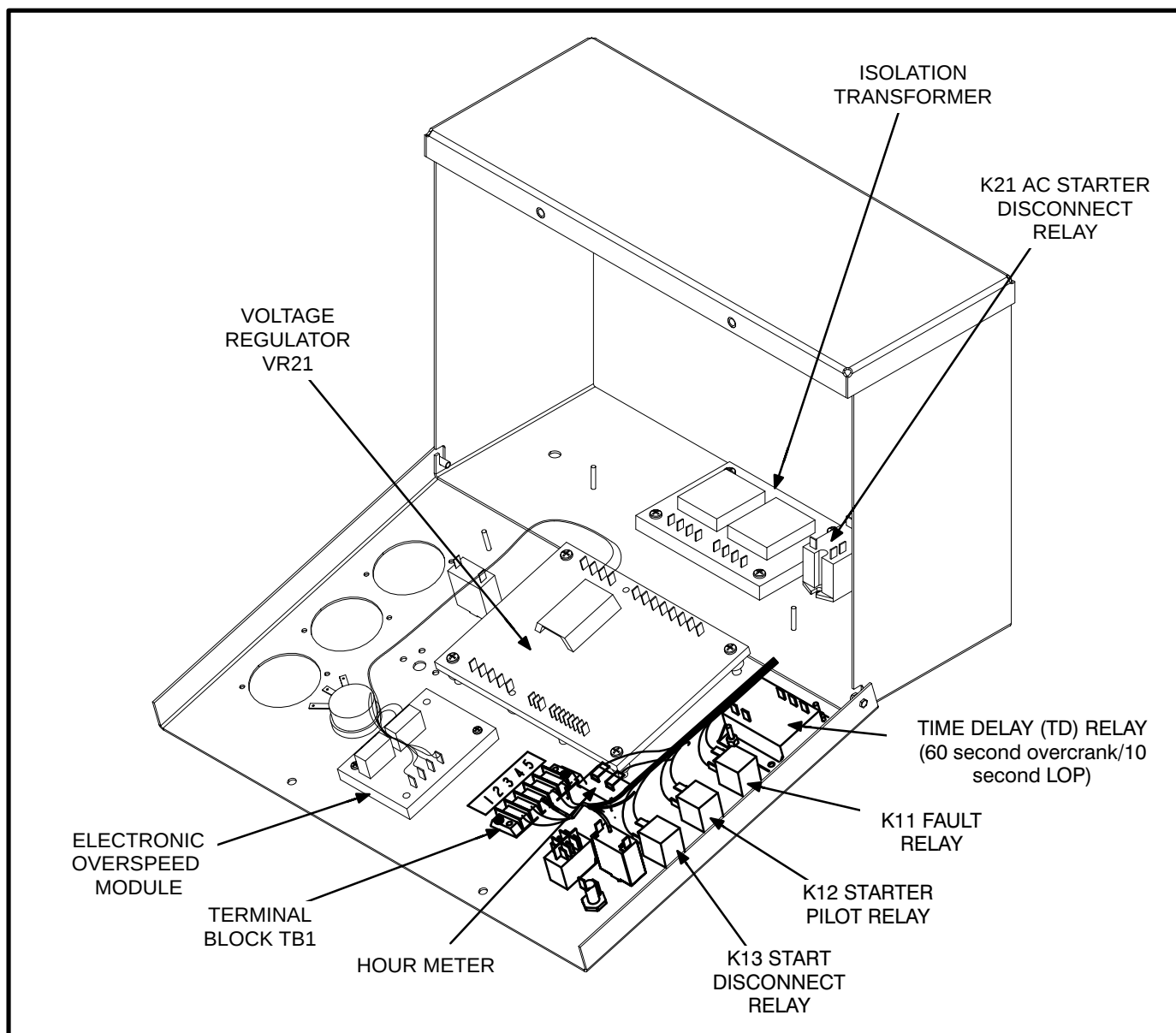


FIGURE 4-2. ARRANGEMENT OF COMPONENTS INSIDE THE CONTROL BOX

CONTROL BOX INTERIOR

Figure 4-2 shows the arrangement of components inside the control box, including the voltage regulator and some of the auxiliary components under the following headings. Refer to *Section 10* for control box *DC Wiring* diagram.

CONTROL RELAYS

A functional description of the control relays shown in Figure 4-2 is provided in the *Sequence of Operation* description at the end of this section.

TERMINAL BLOCK TB1

Terminal block TB1 provides connection points for remote starting and switched B+.

One or more remote switches can be connected to the remote terminal (TB1-4) and B+ (TB1-3).

Switched B+ auxiliary power is available when the generator set is running. When connecting customer accessories to the 12 volt B+ auxiliary terminals (TB1-1 & TB1-2), do not exceed the following current levels:

- 7 amps maximum with electronic governor.
- 12 amps maximum without electronic governor.

DRY CONTACT MODULE (Optional)

The dry contact module provides the capability of attaching a remote monitor panel. Connections are made to the terminals of relays **K8** and **K9** located on the dry contact module (Figure 4-3). A detailed connection diagram for the dry contact module is provided in Section 10.

The relay contact ratings are:

CONTACT POSITION	12V COIL VOLTAGE		24V COIL VOLTAGE	
	N.O.	N.C.	N.O.	N.C.
Max carry/break	40 A	30 A	20 A	10 A
Max make	100 A	60 A	50 A	20 A

The following faults will activate relays **K8** or **K9** as follows:

RELAY K8	RELAY K9
Over Crank Low Oil Pressure High Engine Temperature Low Coolant Level Low Fuel Level Overspeed	Low Fuel Level Rupture Basin

Note that the Low Fuel Level (LFL) will activate both relays. This enables the operator to distinguish between the following error conditions when relays **K8** and **K9** are connected to a two light remote panel.

- **K8** only: All **K8** error conditions except for LFL.
- **K9** only: Rupture Basin
- **K8** and **K9**: Low Fuel Level

* It is possible to have two coincidental faults (one engine fault and the rupture basin) and not have a low fuel condition.

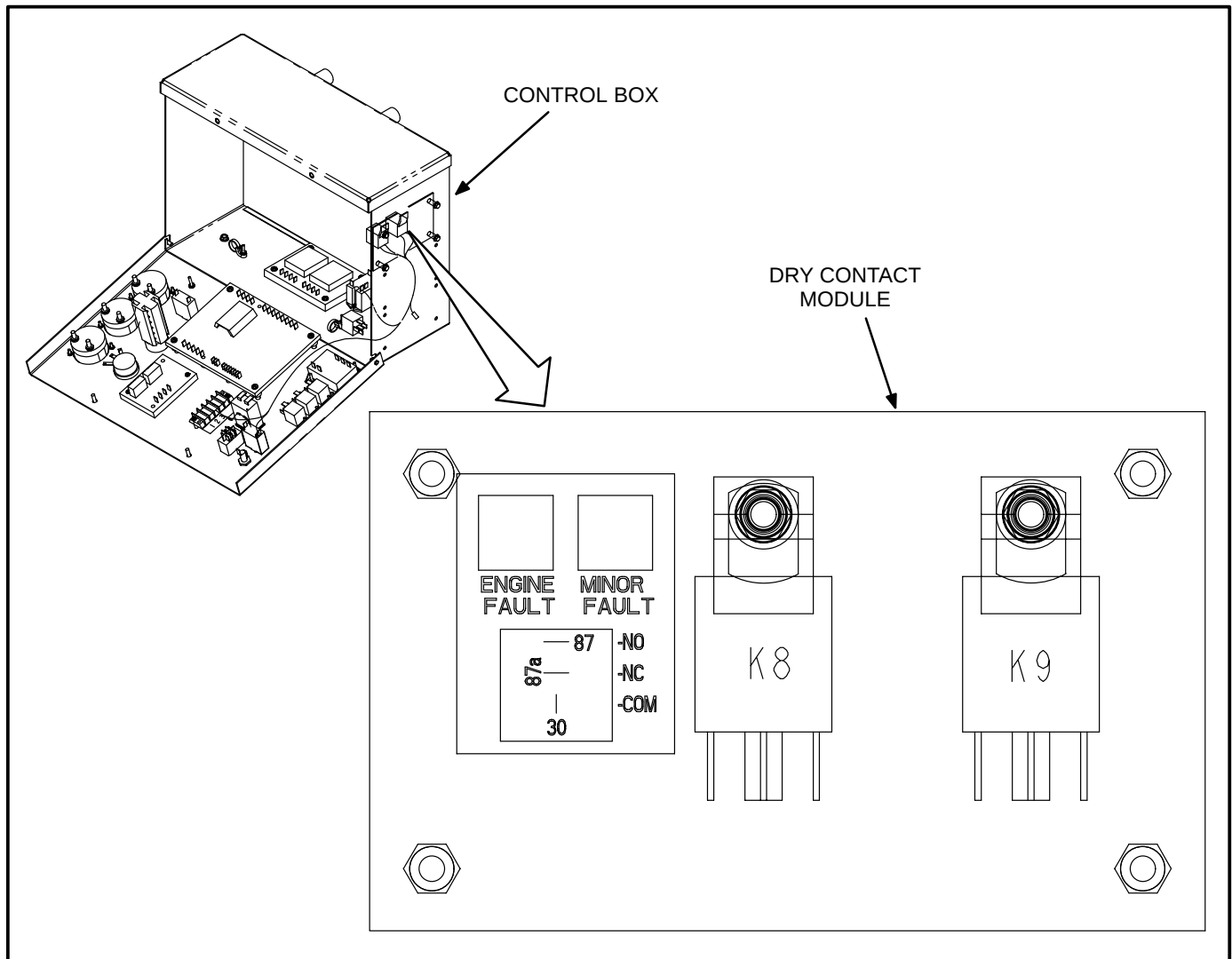


FIGURE 4-3. DRY CONTACT MODULE

ENGINE SENSORS

Figures 4-4 and 4-5 show the locations of the the coolant temperature and oil pressure sensing switches to which the Sentinel control responds. The switches function by closing the fault circuit to the engine chassis ground (battery negative [-]).

The high coolant temperature switch is activated when coolant temperature is greater than 230° F

(110° C). The low oil pressure switch is activated when oil pressure is lower than 20 psi (138kPa).

Always use pipe thread sealant on gauge senders and warning and shutdown switches.

⚠ CAUTION *Teflon tape is not recommended for switches and senders that are grounded to the engine by thread contact as it may interfere with the ground path.*

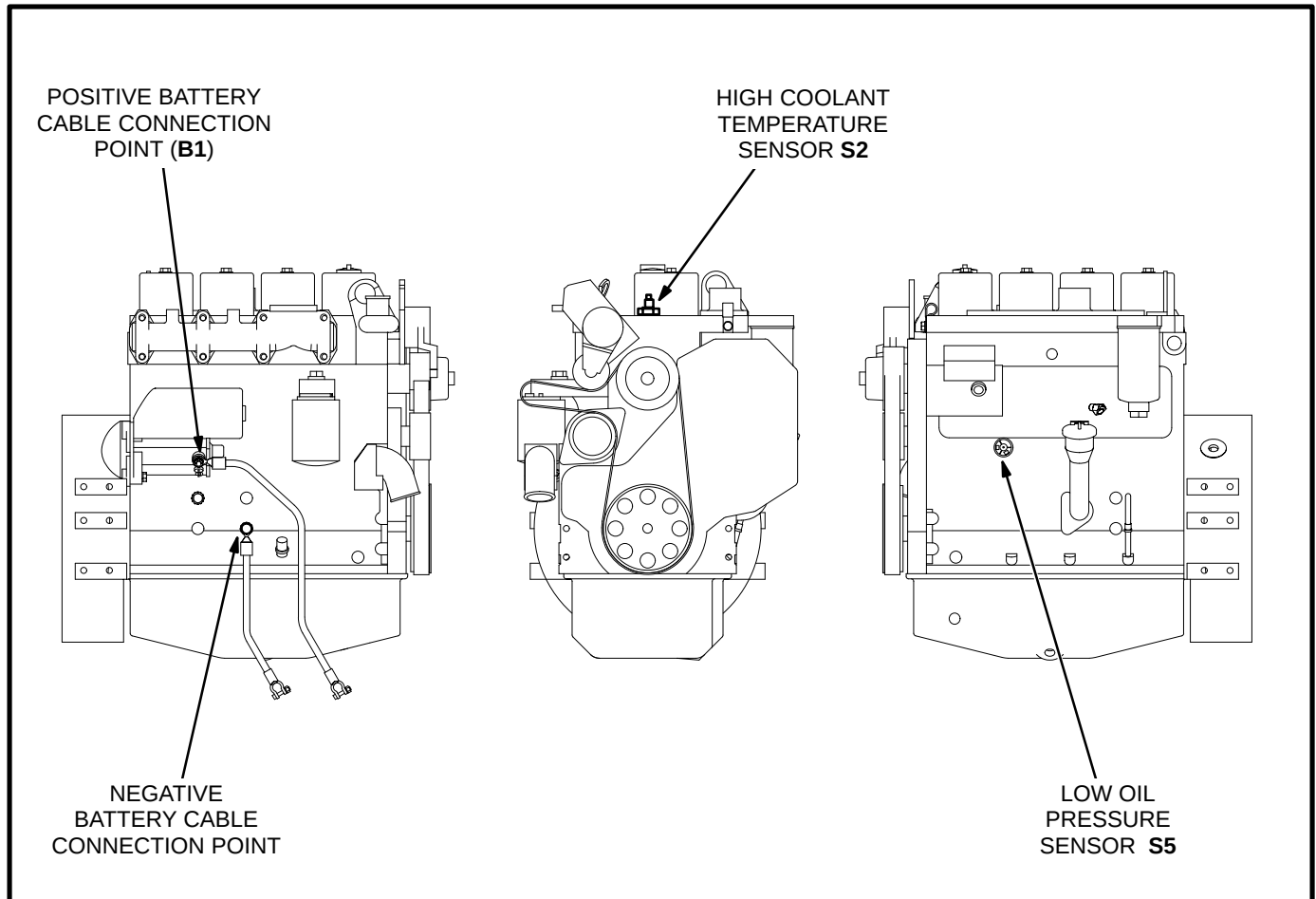


FIGURE 4-4. 4B/6B ENGINE SENSOR LOCATIONS

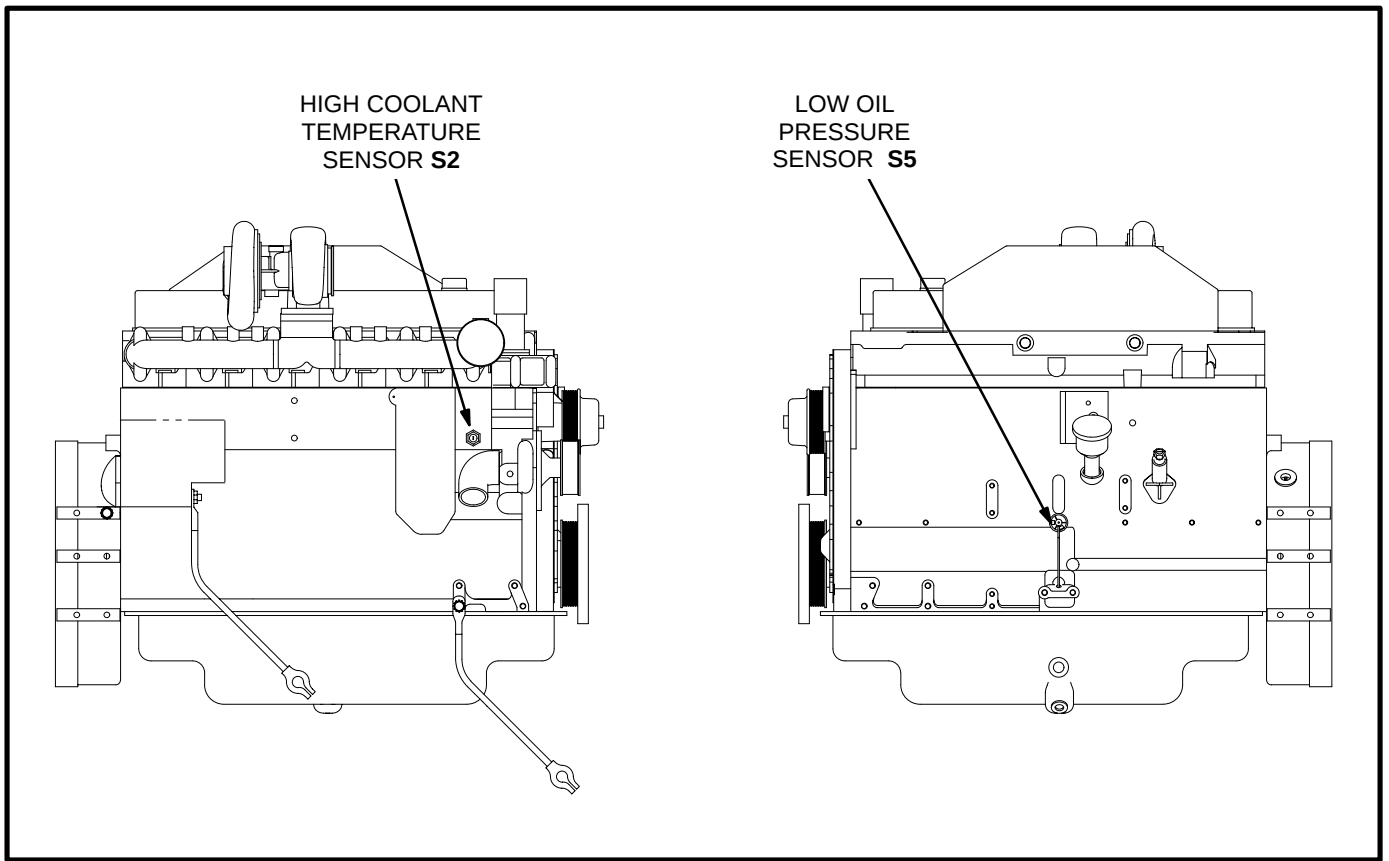


FIGURE 4-5. 6C ENGINE SENSOR LOCATIONS

AUXILIARY CONTROL COMPONENTS

The set might be equipped with one or more of the following components.

Mechanical Overspeed Switch (Standard)

The mechanical overspeed switch is bolted to the end of the generator rotor shaft.

1. Check overspeed cutout RPM and turn the adjustment screw, if necessary, so that shutdown occurs within the following RPM ranges:
60 Hz Sets 2000 to 2200 RPM
50 Hz Sets 1800 to 2100 RPM
2. Replace the switch if the cutout speed adjustment results in an air gap between the magnet and the fly arm of less than 0.005 inches (0.13 mm).
3. Torque the center rotor bolt to 40 ft-lbs (54 Nm) when replacing the switch.

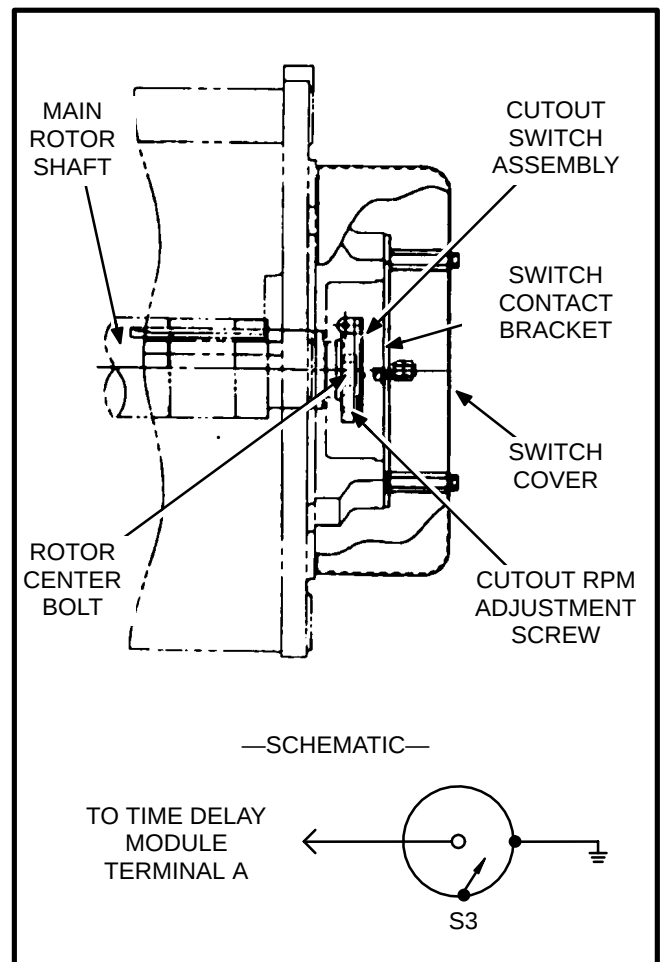


FIGURE 4-6. MECHANICAL OVERSPEED SWITCH

Electronic Overspeed Module (Optional)

PMG-excited generators are equipped with an electronic overspeed module in the control box. The

module senses PMG output frequency to determine generator speed (frequency). Adjust the overspeed pot to cut out at 1800 to 1900 RPM for 50 Hz sets and 2100 to 2200 RPM for 60 Hz sets.

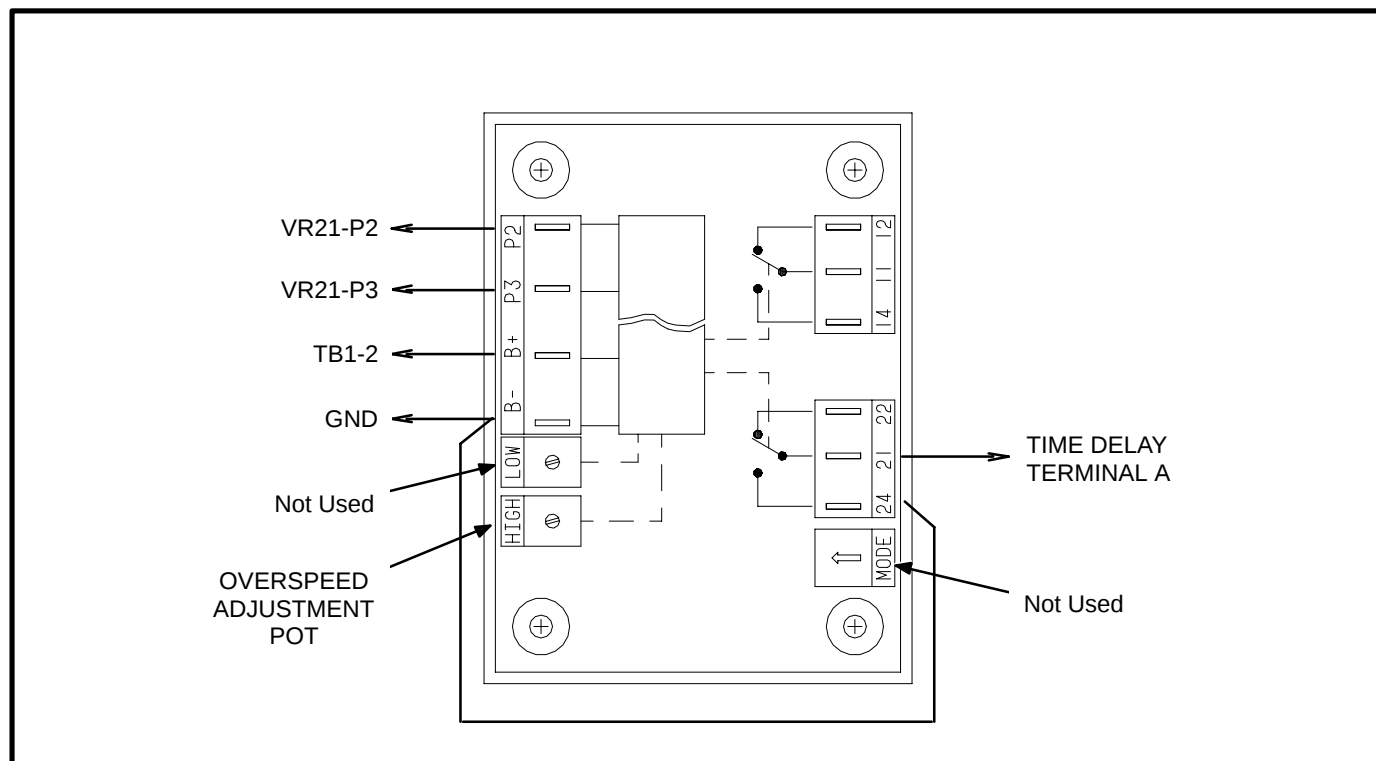


FIGURE 4-7. ELECTRONIC OVERSPEED MODULE

SEQUENCE OF OPERATION

The sequence of operation is as follows. Refer to the schematic on Page 10-15.

1. Terminal **TB1-3** is powered by cranking battery voltage (12 VDC) through a 20 amp fuse and a shunt trip circuit breaker. Terminal **TB1-5** is connected to battery negative.
2. The starting cycle begins when relay **K12**, fuel solenoid valve **K1**, overcrank timer **TD-A** and battery charging alternator field **G1 ALT-D+** are powered, either manually by pushing the panel **Run** switch, or automatically by a remote controller connected at terminal **TB1-4**. (The panel switch must be in the **Remote** position for remote, automatic operation.)
3. Relay **K12** powers the starter solenoid and engine cranking begins.
4. The engine starts and runs up to governed speed in a matter of seconds.
5. The starter is disconnected when engine speed gets to about 600 RPM. This is done by energizing relay **K13** through relay **K21** (connected to generator output) or zener diode **CR1** after the output voltage builds up on the battery charging alternator **G1**. **K13** opens the circuit powering relay **K12**, disengaging the starter.
6. Energizing **K13** de-energizes the 60 second overcrank timer and energizes the 10 second LOP delay timer. After 10 seconds, **TD-3** of the Time Delay Relay goes to ground and activates the LOP switch.
7. All engine shutdowns operate by closing to ground and energizing fault relay **K11**. When **K11** is energized, the shunt trip coil on fault breaker **CB** is energized, causing engine shutdown to occur. (**K11** also sends a signal to the optional Dry Contact Module for remote monitoring.)
8. To restore operation after a shutdown fault has been serviced, press the panel **Stop** switch and reset **CB**.
9. The set is stopped manually by pressing the panel **Stop** switch or automatically by a remote controller. (The panel switch must be in the **Remote** position for remote, automatic operation.)

5. Troubleshooting (Detector Control)

These troubleshooting charts are designed to help you diagnose generator set problems. To save time troubleshooting, read the entire manual ahead of time to understand the generator set. Go over the options and modifications and review what was

done during the last service call. Look the generator set over for any obvious problems. The problem could be as simple as an empty fuel tank, closed fuel shutoff valve, loose wire, blown fuse or tripped circuit breaker.

THE ENGINE DOES NOT CRANK IN RUN MODE

⚠ WARNING *Hazards present in troubleshooting can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the Safety Precautions page and carefully observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The Emergency Stop switch has been used. (The switch button is lit.)	Pull the Emergency Switch button. To reset the engine control, push the Run-Stop-Remote switch to Stop and the Reset switch to Reset . Then push the Run-Stop-Remote switch to Run .
2. A Fault Shutdown is being indicated by one of the red lights on the control panel.	Service the set as necessary. To reset the engine control, push the Run-Stop-Remote switch to Stop and the Reset switch to Reset . Then push the Run-Stop-Remote switch to Run .
3. A LO Shutdown is being indicated on the day tank pump control panel.	Determine the cause and service as necessary (See <i>Section 9</i>). To reset the engine control, push the Run-Stop-Remote switch to Stop and the Reset switch to Reset . Then push the Run-Stop-Remote switch to Run or Remote . Note that the engine control will shut down unless the day tank control has been reset first.
4. Cranking voltage is too low to crank the engine.	- Clean and tighten or replace the positive (+) and negative (–) battery cable connectors and cables at the battery and the set. - Recharge or replace the battery. Specific gravity for a fully charged battery is approximately 1.260 at 80° F (27° C). - If the set is in standby service, install a battery charger. - Replace the engine-driven battery charging alternator if normal battery charging voltage (12 to 14 VDC) is not obtained.

THE ENGINE DOES NOT CRANK IN RUN MODE (CONT.)

⚠ WARNING *Hazards present in troubleshooting can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the Safety Precautions page and carefully observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
5. Fuse F1 (see Figure 3-4) on ECM has blown (no voltage [B+] at ECM TB1-8).	The wire between ECM TB1-8 and starter terminal B1-SW or the wires between TB1-8 – resistor /diode assembly – battery charging alternator may be loose and shorting to ground. Repair as necessary and replace the fuse with one of the same type and amp rating (20 A). If fuse continues to blow, service or replace the starter, relay K4 , or the resistor/diode assembly.
6. The wire between ECM TB1-9 and starter terminal BAT is loose damaged or missing.	Check for battery voltage (12 VDC) between ECM TB1-9 (B+) and the grounding stud (–) on the floor of the control cabinet. Check, clean and tighten the connectors at both ends and replace the wire if it is damaged.
7. The grounding strap between the control box and the battery negative (–) terminal or the ground wire between the control and engine ground is loose, damaged or missing.	Check for continuity (zero ohms) between the grounding stud on the bottom of the control box and the battery negative (–) terminal. If there is no continuity or the grounding strap is loose or damaged, repair as necessary.
8. The Run-Stop-Remote switch (S12) or wiring is faulty.	- Disconnect pin connector J4 from the ECM and check for electrical continuity (zero ohms) between switch terminals 2 and 3 when the switch is in the Run position and between terminals 1 and 2 when it is in the Remote position. Replace the switch if either set of contacts is faulty. - If the switch works, check for electrical continuity (zero ohms) between J4-6 and J4-7 on the wire harness when the switch is in the Run position and between J4-5 and J4-7 when the switch is in the Remote position. Repair the wire harness if there is no electrical continuity in either position of the switch.
9. ECM is faulty. (Check fuses F1 and F4 and for B+ at TB1-9 again.)	Push the Run-Stop-Remote switch to Run and check for battery voltage (12 VDC) at ECM TB1-8 . Replace ECM if there is no voltage at ECM TB1-8 but 12 VDC at ECM TB1-9 .
10. The wire between ECM TB1-8 and starter solenoid terminal SW is loose, damaged or missing.	Push the Run-Stop-Remote switch to Run and check for battery voltage (12 VDC) at starter solenoid terminal SW . If there is no voltage repair the wiring as necessary.

THE ENGINE DOES NOT CRANK IN RUN MODE (CONT.)

⚠ WARNING *Hazards present in troubleshooting can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the Safety Precautions page and carefully observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
11. The starter motor or solenoid is malfunctioning.	Push the Run-Stop-Remote switch to Run and check for battery voltage (B+) at starter solenoid terminal SW . Replace the starter motor if there is voltage but the motor does not function.
12. The Time Delay Start/Stop Module (A15) is malfunctioning.	Check for constant B+ at A15 terminal TB1-4 . Check for run signal at ECM TB1-5 . Voltage at A15 TB1-6 should be at B+ at the end of the start delay period. Check wiring and connections from A15 TB1-6 to ECM TB1-6 .

THE ENGINE DOES NOT CRANK IN REMOTE MODE

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The Run-Stop-Remote switch is at Stop . (The Switch-Off light will be flashing, if provided.)	Push the Run-Stop-Remote switch to Remote .
2. The Emergency Stop switch has been used. (The switch button is lit.)	Pull the Emergency Switch button. To reset the engine control, push the Run-Stop-Remote switch to Stop and the Reset switch to Reset . Then push the Run-Stop-Remote switch to Remote .
3. A Fault Shutdown is being indicated by one of the red lights on the control panel.	Service the set as necessary. To reset the engine control, push the Run-Stop-Remote switch to Stop and the Reset switch to Reset . Then push the Run-Stop-Remote switch to Remote .
4. There is no remote circuit signal (12 VDC at auxiliary relay board A28-TB1-6) because fuse F3 on the ECM has blown.	- Replace the fuse with one of the same type and amp rating (15 A). - If fuse F3 blows again, find and repair the fault in the remote control circuit, such as a loose wire that may be shorting to ground or a shorted relay coil or other component. See <i>Section 10</i> for remote connections.
5. There is no remote circuit signal (12 VDC at auxiliary relay board A28-TB1-6) because the remote circuit is not functioning properly.	Apply 12 VDC to A28-TB1-6 . If the engine cranks, find and repair the fault in the remote control circuit. See <i>Section 10</i> for remote connections.
6. Auxiliary relay board A28 is not functioning properly.	Check for misconnections (see <i>Section 10</i>) or loose connections and replace auxiliary relay board A28 if there is 12 VDC at terminal A28-TB1-6 but not at A28-J2-6 .
7. Same as Steps 3 through 11 in the RUN mode.	See steps 3 through 11 in the preceding RUN mode.

THE ENGINE CRANKS BUT DOES NOT START

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The engine is not getting fuel.	a. Open any closed fuel shutoff valve. b. Fill the main fuel supply tank. c. Restore fuel pump prime according to the engine service manual.
2. Fuse F2 on the ECM has blown.	Replace fuse with one of the same type and amp rating. If fuse F2 blows again, the wire between ECM TB1-10 and engine block terminal T26 , or a wire between terminal T26 and an accessory may be loose or shorting to ground.
3. Fuel solenoid K1 does not energize.	a. Fuel solenoid not energized by the ECM. Check for B+ at ECM TB1-10 when cranking. If no voltage present and fuse F2 is good replace ECM. b. Connect B+ to fuel solenoid (K1) terminal BAT. Replace the fuel solenoid if does not “click” when energized. If fuel solenoid is working, check for blocked fuel line or fuel filter.
4. Low engine temperature is causing too low a cranking speed for starting.	a. Increase room temperature. b. Plug in, repair or install engine coolant heater. c. Replace the engine oil if it is not of the recommended viscosity for the ambient temperature.
5. Cranking voltage is too low to reach required cranking speed.	a. While cranking the engine, measure voltage directly across the battery terminals and then immediately across the starter motor terminal and the grounding bolt on the block. Cable, terminal or relay contact resistance is too high if the difference is more than 2 volts. Service as necessary. b. Recharge or replace the battery. Specific gravity for a fully charged battery is approximately 1.260 at 80° F (27° C). c. Replace the engine-driven battery charging alternator if normal battery charging voltage is not between 12 and 14 volts.
6. The air cleaner is blocked.	Service as necessary.
7. Ignition system, fuel system or other engine malfunction.	Service according to the engine service manual.

THE ENGINE RUNS UNTIL FAULT SHUTDOWN

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The OVERSPEED lamp comes on and the engine shuts down.	a. Reset the ECM by pushing the Run-Stop-Remote switch to Stop and the Reset switch to Reset and restart the set, monitoring engine speed. Readjust the cutout speed if it is lower than specified. Replace the overspeed module (PMG equipped sets) or the overspeed switch if it cannot be re-adjusted (see <i>Section 3</i>). b. Adjust the governor (see <i>Section 8</i>). c. Mechanical Governor: Service or replace the injection pump unit if the set still shuts down due to overspeed. a. Electronic Governor: If the governor cannot be adjusted to prevent shutdown due to overspeed, check for binding in the linkage. Repair and adjust the linkage as necessary. (A spring inside the actuator will resist movement, which is normal.) d. If the set still shuts down due to overspeed, re-install the magnetic speed pick-up unit to make sure the clearance with the flywheel gear teeth is correct. Replace the speed-pickup unit if output voltage at cranking speed is less than 2.5 VDC as measured at terminals 10 (–) and 11 (+) on the governor controller. e. Disconnect the actuator leads at governor controller terminals 4 and 5. Jumper the lead for terminal 4 to the BAT terminal on the starter solenoid and touch the lead for terminal 5 to a good ground on the block. Replace the actuator unit if it does not drive the linkage through its full travel when power is connected or return it when power is disconnected. f. Replace the governor controller if the set still shuts down due to overspeed.
2. The LO OIL PRES lamp comes on and the engine shuts down.	a. Check the engine oil level, repair any oil leaks and fill to the proper level. Then reset the ECM by pushing the Run-Stop-Remote switch to Stop and the Reset switch to Reset. b. If the set still shuts down due to low oil pressure, restart the set and observe oil pressure while cranking the engine. Service the lubricating oil system according to the engine service manual if oil pressure is less than 14 psi (97 kPa). Replace the low oil pressure cutout switch if oil pressure is greater than 14 psi (97 kPa). See <i>Section 3</i> to locate the switch.

THE ENGINE RUNS UNTIL FAULT SHUTDOWN (CONT.)

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
3. The HI ENG TEMP lamp comes on and the engine shuts down.	- Check the engine coolant level, repair any coolant leaks and refill as necessary. Then reset the ECM by pushing the Run-Stop-Remote switch to Stop and the Reset switch to Reset. - If the set still shuts down due to high engine temperature, start the engine and observe coolant temperature as the system heats up. If shutdown occurs before the coolant reaches 200° F (93° C), replace the high engine temperature cutout switch. If coolant temperature exceeds 200° F (93° C), clean and service the entire cooling system as required to restore full cooling capacity. See <i>Section 3</i> to locate the switch.
4. The FAULT 1 or FAULT 2 lamp comes on and the engine shuts down.	Service as required. (The customer has supplied the system fault indication switches. Either fault can be chosen to display the warning only. See <i>Section 3</i>.) If the shutdown was due to low frequency, the set probably ran out of fuel or the governor is out of adjustment. If the shutdown was due to over/under voltage, the voltage regulator may be out of adjustment.

THE ENGINE LACKS POWER OR IS UNSTABLE

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. Fuel delivery to the genset is inadequate.	a. Check for clogged fuel lines and filters. b. Check for air in the fuel lines and repair all air leaks. c. Measure the vertical distance between the fuel lift pump on the engine and bottom of the dip tube in the supply tank. The lift must not exceed 6 feet (1.8 meters).
2. The fuel is contaminated.	Connect the set to a supply of good quality fuel and run the set under various loads. Replace the contents of the fuel supply tank if there is a noticeable improvement in performance.
3. The engine air filter element is dirty.	Replace the air filter element.

THE ENGINE LACKS POWER OR IS UNSTABLE (CONT.)

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
4. The governor settings or linkage adjustment is incorrect.	a. Make governor settings and adjustments according to <i>Section 8, Governor</i>. b. Check the magnetic speed pick-up unit (MPU) clearance with flywheel. Replace the MPU if output voltage at cranking speed is less than 2.5 VDC measured at terminals 10 (–) and 11 (+) on the governor controller. c. Mechanical Governor: Service the fuel injection unit according to the engine service manual if it cannot be adjusted for full power or stable speed. d. Electronic Governor: If the governor cannot be adjusted for full power or stable speed, shut down the set and check for binding in the linkage. Repair and adjust the linkage as necessary. (A spring inside the actuator will resist opening the movement, which is normal.) e. Re-install the magnetic speed pick-up unit to make sure the clearance with the flywheel gear teeth is correct. Replace the speed-pickup unit if output voltage at cranking speed is less than 2.5 VDC as measured at terminals 10 (–) and 11 (+) on the governor controller. f. Disconnect the actuator leads at governor controller terminals 4 and 5. Jumper the lead for terminal 4 to the BAT terminal on the starter solenoid and touch the lead for terminal 5 to a good ground on the block. Replace the actuator unit if it does not drive the linkage through its full travel when power is connected or return it when power is disconnected. g. Replace the governor controller if it still cannot be adjusted for full power or stable speed.
5. The engine fuel system (lift pump, injection pump, injectors, timing) is faulty.	Service the fuel system according to the engine service manual.
6. The engine is worn.	Service the engine according to the engine service manual.

AN AMBER WARNING LAMP IS ON

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The PRE LO OIL PRES lamp comes on while the engine is running.	Shut down the set if possible or disconnect non-critical loads. (Oil pressure will be less than 20 psi [138 kPa] but greater than 14 psi [97 kPa.]) Service the engine lubricating system according to the engine service manual.
2. The PRE HI ENG TEMP lamp comes on while the engine is running.	Shut down the set if possible or disconnect non-critical loads. (Engine temperature will be greater than 220° F (104° C) but less than 230° F [110° C.]) Service the engine cooling system to restore full cooling capacity.
3. The LOW ENGINE TEMPERATURE lamp comes on while the set is in standby.	Plug in, repair or install engine coolant heater.
4. The LO FUEL lamp comes on.	Fill the main fuel supply tank with the appropriate grade of fuel. (The customer has supplied the fuel level switch to make use of this warning.)
5. The Basin lamp comes on.	Indicates fuel is leaking from inner tank to outer basin or the sensor may be defective. Service as required. (The customer has supplied this sensor to make use of this warning.)
6. The FAULT 1 or FAULT 2 lamp (may be a specifically labeled amber lamp) comes on.	Service as required. (The customer has supplied the system fault indicating switches. By means of selection jumpers, either fault may be chosen to shut down the engine. See <i>Section 3, Engine Control</i> .)

THE GREEN RUN LAMP STAYS OFF BUT THE SET RUNS NORMALLY

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The set mounted RUN lamp does not light, although the starter has disconnected normally and the engine is running. The remote RUN lamp does light (AC start disconnect is okay).	- Press the panel Lamp Test switch and replace the run lamp bulb if it does not light. - If the RUN lamp, wiring connections and battery charging alternator are all good and the RUN lamp does not light, replace the ECM.
2. Both the remote and set mounted RUN lamps do not light, although the starter has disconnected normally and the engine is running.	- Press the panel Lamp Test switch and replace the run lamp bulb if it does not light. Test the remote RUN lamp by suitable means and replace it if it does not light. - If both lamps are good, this indicates that the AC disconnect circuit is not working. Check the AC voltmeter to determine whether or not there is generator output voltage and service as necessary. See <i>There Is No Output Voltage in Troubleshooting</i>. - If there is generator output voltage, check for 120 VAC across pin connectors P1-1 and P1-2 on the ECM. If there is no voltage, check for loose or missing leads between the connectors and TB21-21 and TB21-32 inside the control box and service as necessary. - Replace the ECM if there is 120 VAC across pin connectors P1-1 and P1-2 but neither RUN lamp lights during normal operation.

NO OUTPUT VOLTAGE

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The line circuit breaker is OFF .	Find out why the circuit breaker was turned OFF , make sure it is safe to reconnect power, and then throw the circuit breaker ON .
2. The line circuit breaker has TRIPPED .	Shut down the set and service as necessary to clear the short circuit or ground fault that caused tripping, and then RESET the circuit breaker and start the set.
3. The line circuit breaker is faulty.	Shut down the set, make sure the power output lines from the set have been disconnected from all other sources of power, attempt to RESET the circuit breaker and throw it ON and check for electrical continuity across each line contact. Replace the circuit breaker if there is measurable resistance across any contact.
4. Field circuit breaker CB21 has TRIPPED .	RESET the circuit breaker. If it keeps tripping, troubleshoot according to the chart, <i>Field Circuit Breaker Keeps Tripping</i> .
5. Field circuit breaker CB21 is faulty.	Shut down the set, attempt to RESET the circuit breaker and disconnect either lead. Replace the circuit breaker if there is measurable resistance across the terminals.

NO OUTPUT VOLTAGE (CONT.)

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause

Corrective Action

Determine if the problem is in the voltage regulating or generator circuits as follows:

- a. Throw the line circuit breaker **OFF** and shut down the set.

⚠ CAUTION *This test involves unregulated excitation of the generator. To prevent damage to the generator due to overcurrent, make sure that all loads have been disconnected and that all faults have been cleared from the power output terminals of the generator.*

- b. Open the control panel and disconnect the field leads **X (F1)** and **XX (F2)** from the voltage regulator. See Figure 2-4. Perform the exciter stator winding resistance test (*Section 7*). The exciter stator resistance must test okay before proceeding.
- c. Prepare to measure output voltage across the generator terminals while the set is running.
- d. Bring two jumpers from a **12 volt battery** for connection to the **X (F1)** and **XX (F2)** leads inside the control box. Connect the jumper from the positive (+) post of the battery to the **F1 (X)** lead. Be prepared to connect the jumper from the negative (–) post of the battery to the **XX (F2)** lead.
- e. Check polarity again. Polarity must be correct or this test will be inconclusive because the induced and residual magnetic polarities in the exciter stator will be opposed.

⚠ DANGER *HIGH VOLTAGE. Touching uninsulated high voltage parts inside the control box can result in severe personal injury or death. Measurements and adjustments must be done with care to avoid touching high voltage parts. For your protection, stand on a dry wooden platform or rubber insulating mat, make sure your clothing and shoes are dry, remove jewelry from your hands and wear elbow length insulating gloves.*

- f. Start the set and connect the jumper wire from the battery negative (–) terminal to the **XX (F2)** lead.
- g. The generator is probably okay if rated output voltage or higher is obtained and the voltages for all phases are balanced when the exciter is powered by the 12 volt battery. Refer to the Voltage Regulator fault chart (step 6) for troubleshooting. (Normal excitation voltage ranges approximately from 10 VDC at no-load to 40 VDC at full-load.)
- h. Use the Generator fault chart. If the output voltages are not balanced, or are less than ninety percent of rated output voltage; the problem is probably in the generator. If the voltages are unbalanced, first troubleshoot the main stator—Step 11. If the voltages are uniformly low, first troubleshoot the exciter and field circuits—Steps 7, 8, 9 and 10.

6. Voltage regulating faults (**PMG-excited generators**).

- a. Follow the PMG test described in *Section 7* to determine if it is okay.
- b. Check all connections against the applicable reconnection diagram (*Section 10*) and rewire as necessary. Replace the voltage regulator if the PMG checks okay, the wiring is correct and there is no output voltage.

⚠ CAUTION *Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.*

NO OUTPUT VOLTAGE (CONT.)

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
7. Voltage regulating faults (Shunt-excited generators).	a. Flash the field as described in <i>Section 7</i>. b. Check all connections against the applicable reconnection diagram (<i>Section 10</i>) and rewire as necessary. Replace the voltage regulator if the wiring is correct and there is no output voltage. ⚠ CAUTION <i>Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.</i>
8. The exciter field winding is open.	Shut down the set and check exciter field winding resistance according to <i>Section 7</i> . Replace the exciter field assembly if winding resistance does not meet specifications.
9. The rotating rectifier assembly (diodes CR1 through CR6) is faulty.	Shut down the set and check each diode according to <i>Section 7</i> . Service as necessary.
10. The exciter rotor windings are open.	Shut down the set and check exciter winding resistances according to <i>Section 7</i> . Replace the generator rotor assembly if exciter rotor winding resistances do not meet specifications.
11. The main rotor winding is open.	Shut down the set and check main rotor winding resistance according to <i>Section 7</i> . Replace the generator rotor assembly if main rotor winding resistance does not meet specifications.
12. The stator windings are open.	Shut down the set and check stator winding resistances according to <i>Section 7</i> . Replace the generator stator assembly if stator winding resistances do not meet specifications.

OUTPUT VOLTAGE IS TOO HIGH OR TOO LOW

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. Engine speed is unstable.	Troubleshoot according to the chart, <i>The Engine Lacks Power or is Unstable</i> .
2. The voltage has been adjusted improperly.	Adjust output voltage according to <i>Section 2, AC Control</i> .
3. Improper connections have been made at the generator output terminals.	Shut down the set and reconnect according to the appropriate reconnection diagram. See <i>Section 10</i> .
4. The rotating rectifier assembly (diodes CR1 through CR6) is faulty.	Shut down the set and check each diode according to <i>Section 7, Servicing the Generator</i> . Service as necessary.
5. Voltage Regulator VR21 is faulty.	Replace the voltage regulator. ⚠ CAUTION <i>Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.</i>

OUTPUT VOLTAGE IS UNSTABLE

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The voltage has been adjusted improperly.	Adjust output voltage according to <i>Section 2, AC Control</i> .
2. The voltage adjusting rheostat on the control panel is faulty (if provided).	Unlock the voltage adjusting screw on the front of the control panel and disconnect either lead from the rheostat. Measure resistance between terminals 1 and 2 while turning the adjusting screw fully one way and then the other. Replace the rheostat if it is open at any point, or if resistance does not vary smoothly from zero to approximately 1,500 ohms for sets with the SX460 voltage regulator (shunt excited) or 5,000 ohms for sets with the MX321 voltage regulator (PMG-excited).
3. Voltage Regulator VR21 is faulty.	Replace the voltage regulator. ⚠ CAUTION <i>Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.</i>

THE FIELD CIRCUIT BREAKER KEEPS TRIPPING

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The rotating rectifier assembly (diodes CR1 through CR6) is faulty.	Shut down the set and check each diode according to <i>Section 7</i> . Service as necessary.
2. The exciter field winding is shorted.	Shut down the set and check exciter field winding resistance according to <i>Section 7</i> . Replace the exciter field assembly if winding resistance does not meet specifications.
3. The exciter rotor windings are shorted.	Shut down the set and check exciter winding resistances according to <i>Section 7</i> . Replace the generator rotor assembly if exciter rotor winding resistances do not meet specifications.
4. The main rotor winding is shorted.	Shut down the set and check main rotor winding resistance according to <i>Section 7</i> . Replace the generator rotor assembly if main rotor winding resistance does not meet specifications.
5. The stator windings are shorted.	Shut down the set and check stator winding resistances according to <i>Section 7</i> . Replace the generator stator assembly if stator winding resistances do not meet specifications.
6. Voltage Regulator VR21 is faulty.	Replace the voltage regulator. ⚠ CAUTION <i>Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.</i>

THE PHASE CURRENTS ARE UNBALANCED

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The connected loads are distributed unevenly among the phases.	Shut down the set and redistribute the loads as evenly as possible.
2. Improper connections have been made at the generator output terminals.	Shut down the set and reconnect according to the reconnection diagram. See <i>Section 10</i> .
3. The stator windings are faulty (open or shorted).	Shut down the set and check stator winding resistances according to <i>Section 7</i> . Replace the generator stator assembly if stator winding resistances do not meet specifications.
4. A load has a ground fault or short circuit.	Service the faulty equipment as necessary.

6. Troubleshooting (Sentinel Control)

These troubleshooting charts are designed to help you diagnose generator set problems. To save time troubleshooting, read the entire manual ahead of time to understand the generator set. Go over the options and modifications and review what was

done during the last service call. Look the generator set over for any obvious problems. The problem could be as simple as an empty fuel tank, closed fuel shutoff valve, loose wire, blown fuse or tripped circuit breaker.

THE ENGINE DOES NOT CRANK IN RUN MODE	
⚠ WARNING <i>Hazards present in troubleshooting can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the Safety Precautions page and carefully observe all instructions and precautions in this manual.</i>	
Possible Cause	Corrective Action
1. The common fault circuit breaker has tripped.	Service the set as necessary. To reset the engine control, push the Run-Stop-Remote switch to Stop and reset the common fault circuit breaker. Then push the Run-Stop-Remote switch to Run .
2. Cranking voltage is too low to crank the engine.	a. Clean and tighten or replace the positive (+) and negative (–) battery cable connectors and cables at the battery and the set. b. Recharge or replace the battery. Specific gravity for a fully charged battery is approximately 1.260 at 80° F (27° C). c. If the set is in standby service, install a battery charger. d. Replace the engine-driven battery charging alternator if normal battery charging voltage (12 to 14 VDC) is not obtained.
3. Fuse F1 on the front of the control panel is blown.	Check for a loose or chaffed wire shorting to ground. Make sure auxiliary loads (louvers, etc.) connected to the control circuitry do not exceed 7 amps with electronic governor or 12 amps without electronic governor.
4. The starter motor or solenoid is malfunctioning.	Push the Run-Stop-Remote switch to Run and check for battery voltage (B+) at starter solenoid terminal SW . Replace the starter motor if there is 12 volts present but the motor does not function.
5. The Run-Stop-Remote (S12) is malfunctioning.	Push the Run-Stop-Remote switch to Run and check for 12 volts at S12-2 . If voltage not present replace S12 .
6. Relay K21 is malfunctioning.	Push the Run-Stop-Remote switch to Stop and check for open circuit between K21-1 and K21-2 . If continuity, replace K12 .

THE ENGINE DOES NOT CRANK IN RUN MODE (CONT.)

⚠ WARNING *Hazards present in troubleshooting can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the Safety Precautions page and carefully observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
7. Relay K13 is malfunctioning.	Push the Run-Stop-Remote switch to Run and check for 12 volts at K13-87A . If voltage not present replace K13 .
8. Relay K12 is malfunctioning.	Push the Run-Stop-Remote switch to Run and check for 12 volts at K12-86 and K12-87 . If voltage not present replace K12 .

THE ENGINE DOES NOT CRANK IN REMOTE MODE

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The Run-Stop-Remote switch is at Stop .	Push the Run-Stop-Remote switch to Remote .
2. There is no remote circuit signal being received.	Check for 12 volts at TB1-4 and S12-2. Replace components or wiring as necessary.
3. Same as Steps 1 through 8 in the RUN mode.	See steps 1 through 8 in the preceding RUN mode.

THE ENGINE CRANKS BUT DOES NOT START

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The engine is not getting fuel.	a. Open any closed shutoff valve. b. Fill the main fuel supply tank. c. Restore fuel pump prime according to the engine service manual.
2. Fuel solenoid K1 does not energize.	Connect B+ to fuel solenoid (K1) terminal BAT . Replace the fuel solenoid if does not “click” when energized. If fuel solenoid is working, check for blocked fuel line or fuel filter.
3. Low engine temperature is causing too low a cranking speed for starting.	a. Increase room temperature. b. Plug in, repair or install engine coolant heater. c. Replace the engine oil if it is not of the recommended viscosity for the ambient temperature.
4. Cranking voltage is too low to reach required cranking speed.	a. While cranking the engine, measure voltage directly across the battery terminals and then immediately across the starter motor terminal and the grounding bolt on the block. Cable, terminal or relay contact resistance is too high if the difference is more than 2 volts. Service as necessary. b. Recharge or replace the battery. Specific gravity for a fully charged battery is approximately 1.260 at 80° F (27° C). c. Replace the engine-driven battery charging alternator if normal battery charging voltage is not between 12 and 14 volts.
5. The air cleaner is blocked.	Service as necessary.
6. Ignition system, fuel system or other engine malfunction.	Service according to the engine service manual.

THE ENGINE RUNS UNTIL FAULT SHUTDOWN

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. An OVERSPEED condition has caused the engine to shut down.	- Reset the engine control by pushing the Run-Stop-Remote switch to Stop and resetting the common fault circuit breaker. Restart the set, and monitor engine speed. Readjust the cutout speed if it is lower than specified. Replace the overspeed module (PMG equipped sets) or the overspeed switch if it cannot be readjusted (<i>see Section 4</i>). - Adjust the governor (<i>see Section 8</i>). Mechanical Governor: Service or replace the injection pump unit if the set still shuts down due to overspeed. Electronic Governor: If the governor cannot be adjusted to prevent shutdown due to overspeed, check for binding in the linkage. Repair and adjust the linkage as necessary. (A spring inside the actuator will resist movement, which is normal.) - If the set still shuts down due to overspeed, re-install the magnetic speed pick-up unit to make sure the clearance with the flywheel gear teeth is correct. Replace the speed-pickup unit if output voltage at cranking speed is less than 2.5 VDC as measured at terminals 10 (–) and 11 (+) on the governor controller. - Disconnect the actuator leads at governor controller terminals 4 and 5. Jumper the lead for terminal 4 to the BAT terminal on the starter solenoid and touch the lead for terminal 5 to a good ground on the block. Replace the actuator unit if it does not drive the linkage through its full travel when power is connected or return it when power is disconnected. - Replace the governor controller if the set still shuts down due to overspeed.
2. A LO OIL PRES has caused the engine to shut down.	- Check the engine oil level, repair any oil leaks and fill to the proper level. Then reset the engine control by pushing the Run-Stop-Remote switch to Stop and resetting the common fault circuit breaker. - If the set still shuts down due to low oil pressure, restart the set and observe oil pressure while cranking the engine. Service the lubricating oil system according to the engine service manual if oil pressure is less than 14 psi (97kPa). Replace the low oil pressure cutout switch if oil pressure is greater than 14 psi (97kPa). See <i>Section 4</i> to locate the switch.

THE ENGINE RUNS UNTIL FAULT SHUTDOWN (CONT.)

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
3. A HI ENG TEMP has caused the engine to shut down.	a. Check the engine coolant level, repair any coolant leaks and refill as necessary. Then reset the engine control by pushing the Run-Stop-Remote switch to Stop and resetting the common fault circuit breaker. b. If the set still shuts down due to high engine temperature, start the engine and observe coolant temperature as the system heats up. If shutdown occurs before the coolant reaches 200° F (93° C), replace the high engine temperature cutout switch. If coolant temperature exceeds 200° F (93° C), clean and service the entire cooling system as required to restore full cooling capacity. See <i>Section 4</i> to locate the switch.
4. A LOW FUEL (level) has caused the engine to shut down.	Indicates diesel fuel supply is running low. Check fuel supply and replenish as required. Then reset the engine control by pushing the Run-Stop-Remote switch to Stop and resetting the common fault circuit breaker.
5. A LO COOLANT (level) has caused the engine to shut down.	Check the engine coolant level, repair any coolant leaks and refill as necessary. Then reset the engine control by pushing the Run-Stop-Remote switch to Stop and resetting the common fault circuit breaker.
6. Engine shuts down due to any of the five faults but no signal is supplied to remote monitor device from Dry Contact Module (DCM).	a. Check Engine Relay (K8) function on DCM. b. Check fault breaker auxillary contacts (CB1/B) for continuity. c. Check wiring from Engine Relay (K8) to remote monitor device.

THE ENGINE LACKS POWER OR IS UNSTABLE

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. Fuel delivery to the genset is inadequate.	e. Check for clogged fuel lines and filters. f. Check for air in the fuel lines and repair all air leaks. g. Measure the vertical distance between the fuel lift pump on the engine and bottom of the dip tube in the supply tank. The lift must not exceed 6 feet (1.8 meters).
2. The fuel is contaminated.	Connect the set to a supply of good quality fuel and run the set under various loads. Replace the contents of the fuel supply tank if there is a noticeable improvement in performance.
3. The engine air filter element is dirty.	Replace the air filter element.

THE ENGINE LACKS POWER OR IS UNSTABLE (CONT.)

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
4. The governor settings or linkage adjustment is incorrect.	a. Make governor settings and adjustments according to <i>Section 8, Governor</i>. b. Check the magnetic speed pick-up unit (MPU) clearance with flywheel. Replace the MPU if output voltage at cranking speed is less than 2.5 VDC measured at terminals 10 (–) and 11 (+) on the governor controller. c. Mechanical Governor: Service the fuel injection unit according to the engine service manual if it cannot be adjusted for full power or stable speed. d. Electronic Governor: If the governor cannot be adjusted for full power or stable speed, shut down the set and check for binding in the linkage. Repair and adjust the linkage as necessary. (A spring inside the actuator will resist opening the movement, which is normal.) e. Re-install the magnetic speed pick-up unit to make sure the clearance with the flywheel gear teeth is correct. Replace the speed-pickup unit if output voltage at cranking speed is less than 2.5 VDC as measured at terminals 10 (–) and 11 (+) on the governor controller. f. Disconnect the actuator leads at governor controller terminals 4 and 5. Jumper the lead for terminal 4 to the BAT terminal on the starter solenoid and touch the lead for terminal 5 to a good ground on the block. Replace the actuator unit if it does not drive the linkage through its full travel when power is connected or return it when power is disconnected. g. Replace the governor controller if it still cannot be adjusted for full power or stable speed.
5. The engine fuel system (lift pump, injection pump, injectors, timing) is faulty.	Service the fuel system according to the engine service manual.
6. The engine is worn.	Service the engine according to the engine service manual.

NO OUTPUT VOLTAGE

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The line circuit breaker is OFF .	Find out why the circuit breaker was turned OFF , make sure it is safe to reconnect power, and then throw the circuit breaker ON .
2. The line circuit breaker has TRIPPED .	Shut down the set and service as necessary to clear the short circuit or ground fault that caused tripping, and then RESET the circuit breaker and start the set.
3. The line circuit breaker is faulty.	Shut down the set, make sure the power output lines from the set have been disconnected from all other sources of power, attempt to RESET the circuit breaker and throw it ON and check for electrical continuity across each line contact. Replace the circuit breaker if there is measurable resistance across any contact.
4. Field circuit breaker CB21 has TRIPPED .	RESET the circuit breaker. If it keeps tripping, troubleshoot according to the chart, <i>Field Circuit Breaker Keeps Tripping</i> .
5. Field circuit breaker CB21 is faulty.	Shut down the set, attempt to RESET the circuit breaker and disconnect either lead. Replace the circuit breaker if there is measurable resistance across the terminals.

NO OUTPUT VOLTAGE (CONT.)

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause

Corrective Action

Determine if the problem is in the voltage regulating or generator circuits as follows:

- a. Throw the line circuit breaker **OFF** and shut down the set.

⚠ CAUTION *This test involves unregulated excitation of the generator. To prevent damage to the generator due to overcurrent, make sure that all loads have been disconnected and that all faults have been cleared from the power output terminals of the generator.*

- b. Open the control panel and disconnect the field leads **X (F1)** and **XX (F2)** from the voltage regulator. See Figure 2-3. Perform the exciter stator winding resistance test (*Section 7*). The exciter stator resistance must test okay before proceeding.
- c. Prepare to measure output voltage across the generator terminals while the set is running.
- d. Bring two jumpers from a **12 volt battery** for connection to the **X (F1)** and **XX (F2)** leads inside the control box. Connect the jumper from the positive (+) post of the battery to the **F1 (X)** lead. Be prepared to connect the jumper from the negative (–) post of the battery to the **XX (F2)** lead.
- e. Check polarity again. Polarity must be correct or this test will be inconclusive because the induced and residual magnetic polarities in the exciter stator will be opposed.

⚠ DANGER *HIGH VOLTAGE. Touching uninsulated high voltage parts inside the control box can result in severe personal injury or death. Measurements and adjustments must be done with care to avoid touching high voltage parts. For your protection, stand on a dry wooden platform or rubber insulating mat, make sure your clothing and shoes are dry, remove jewelry from your hands and wear elbow length insulating gloves.*

- f. Start the set and connect the jumper wire from the battery negative (–) terminal to the **XX (F2)** lead.
- g. The generator is probably okay if rated output voltage or higher is obtained and the voltages for all phases are balanced when the exciter is powered by the 12 volt battery. Refer to the Voltage Regulator fault chart (step 6) for troubleshooting. (Normal excitation voltage ranges approximately from 10 VDC at no-load to 40 VDC at full-load.)
- h. Use the Generator fault chart. If the output voltages are not balanced, or are less than ninety percent of rated output voltage; the problem is probably in the generator. If the voltages are unbalanced, first troubleshoot the main stator—Step 11. If the voltages are uniformly low, first troubleshoot the exciter and field circuits—Steps 7, 8, 9 and 10.

6. Voltage regulating faults (**PMG-excited generators**).

- a. Follow the PMG test described in *Section 7* to determine if it is okay.
- b. Check all connections against the applicable reconnection diagram (*Section 10*) and rewire as necessary. Replace the voltage regulator if the PMG checks okay, the wiring is correct and there is no output voltage.

⚠ CAUTION *Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.*

NO OUTPUT VOLTAGE (CONT.)

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
7. Voltage regulating faults (Shunt-excited generators).	a. Flash the field as described in <i>Section 7</i>. b. Check all connections against the applicable reconnection diagram (<i>Section 10</i>) and rewire as necessary. Replace the voltage regulator if the wiring is correct and there is no output voltage. ⚠ CAUTION <i>Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.</i>
8. The exciter field winding is open.	Shut down the set and check exciter field winding resistance according to <i>Section 7</i> . Replace the exciter field assembly if winding resistance does not meet specifications.
9. The rotating rectifier assembly (diodes CR1 through CR6) is faulty.	Shut down the set and check each diode according to <i>Section 7</i> . Service as necessary.
10. The exciter rotor windings are open.	Shut down the set and check exciter winding resistances according to <i>Section 7</i> . Replace the generator rotor assembly if exciter rotor winding resistances do not meet specifications.
11. The main rotor winding is open.	Shut down the set and check main rotor winding resistance according to <i>Section 7</i> . Replace the generator rotor assembly if main rotor winding resistance does not meet specifications.
12. The stator windings are open.	Shut down the set and check stator winding resistances according to <i>Section 7</i> . Replace the generator stator assembly if stator winding resistances do not meet specifications.

OUTPUT VOLTAGE IS TOO HIGH OR TOO LOW

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. Engine speed is unstable.	Troubleshoot according to the chart, <i>The Engine Lacks Power or is Unstable</i> .
2. The voltage has been adjusted improperly.	Adjust output voltage according to <i>Section 2</i> .
3. Improper connections have been made at the generator output terminals.	Shut down the set and reconnect according to the appropriate reconnection diagram. See <i>Section 10</i> .
4. The rotating rectifier assembly (diodes CR1 through CR6) is faulty.	Shut down the set and check each diode according to <i>Section 7</i> . Service as necessary.
5. Voltage Regulator VR21 is faulty.	Replace the voltage regulator. ⚠ CAUTION <i>Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.</i>

OUTPUT VOLTAGE IS UNSTABLE

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The voltage has been adjusted improperly.	Adjust output voltage according to <i>Section 2, AC Control</i> .
2. The voltage adjusting rheostat on the control panel is faulty (if provided).	Unlock the voltage adjusting screw on the front of the control panel and disconnect either lead from the rheostat. Measure resistance between terminals 1 and 2 while turning the adjusting screw fully one way and then the other. Replace the rheostat if it is open at any point, or if resistance does not vary smoothly from zero to approximately 1,500 ohms for sets with the SX460 voltage regulator (shunt excited) or 5,000 ohms for sets with the MX321 voltage regulator (PMG-excited).
3. Voltage Regulator VR21 is faulty.	Replace the voltage regulator. ⚠ CAUTION <i>Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.</i>

THE FIELD CIRCUIT BREAKER KEEPS TRIPPING

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The rotating rectifier assembly (diodes CR1 through CR6) is faulty.	Shut down the set and check each diode according to <i>Section 7</i> . Service as necessary.
2. The exciter field winding is shorted.	Shut down the set and check exciter field winding resistance according to <i>Section 7</i> . Replace the exciter field assembly if winding resistance does not meet specifications.
3. The exciter rotor windings are shorted.	Shut down the set and check exciter winding resistances according to <i>Section 7</i> . Replace the generator rotor assembly if exciter rotor winding resistances do not meet specifications.
4. The main rotor winding is shorted.	Shut down the set and check main rotor winding resistance according to <i>Section 7</i> . Replace the generator rotor assembly if main rotor winding resistance does not meet specifications.
5. The stator windings are shorted.	Shut down the set and check stator winding resistances according to <i>Section 7</i> . Replace the generator stator assembly if stator winding resistances do not meet specifications.
6. Voltage Regulator VR21 is faulty.	Replace the voltage regulator. ⚠ CAUTION <i>Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.</i>

THE PHASE CURRENTS ARE UNBALANCED

⚠ WARNING *There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read the safety precautions on pages iii and iv and observe all instructions and precautions in this manual.*

Possible Cause	Corrective Action
1. The connected loads are distributed unevenly among the phases.	Shut down the set and redistribute the loads as evenly as possible.
2. Improper connections have been made at the generator output terminals.	Shut down the set and reconnect according to the appropriate reconnection diagram. See <i>Section 10</i> .
3. The stator windings are faulty (open or shorted).	Shut down the set and check stator winding resistances according to <i>Section 7</i> . Replace the generator stator assembly if stator winding resistances do not meet specifications.
4. A load has a ground fault or short circuit.	Service the faulty equipment as necessary.

7. Servicing the Generator

TESTING THE GENERATOR

These tests can be performed without removing the generator. Before starting tests, disconnect the starting battery cables (negative [-] first) to make sure the engine will not start while performing these tests.

⚠ WARNING *Accidental starting of the generator set while working on it can cause severe personal injury or death. Prevent accidental starting by disconnecting the starting battery cables (negative [-] first).*

Arcing can ignite the explosive hydrogen gas given off by batteries, causing severe personal injury. Arcing can occur if the negative (-) battery cable is connected and a tool being used to connect or disconnect the positive (+) battery cable accidentally touches the frame or other grounded metal part of the set. To prevent arcing, always remove the negative (-) cable first, and reconnect it last.

⚠ CAUTION *Always disconnect a battery charger from its AC source before disconnecting the battery cables. Otherwise, disconnecting the cables can result in voltage spikes high enough to damage the DC control circuits of the set.*

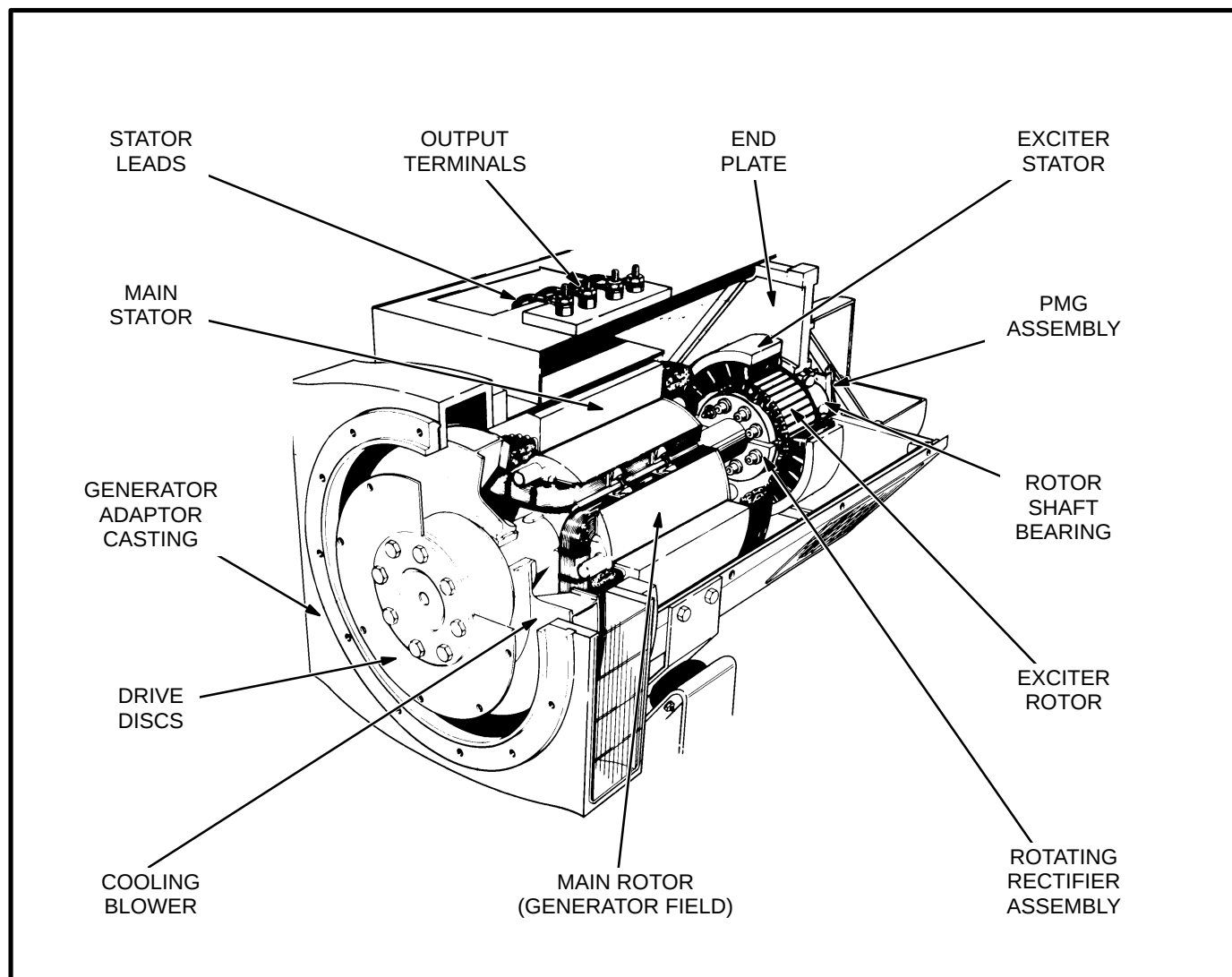


FIGURE 7-1. GENERATOR

Exciter Stator

Testing Winding Resistance: Measure winding resistance with a Wheatstone bridge or digital ohmmeter. Replace the stator if winding resistance is not as specified by Table 7-1.

Testing Winding Insulation Resistance: Disconnect the exciter stator leads from terminals **X** and **XX** on the auxiliary terminal board in the generator output box. Using an ohmmeter, measure resistance between either lead and the stator laminations. Replace the stator if insulation resistance is less than 1 megohm (1,000,000 ohms)

Flashing the Field (Self-Excited Generators Only): If necessary, flash the exciter field before or after installation. Apply 110 to 220 VAC for one to two seconds to the **X** and **XX** leads of the exciter stator. **The generator must be shut down, the AVR disconnected, a diode used to establish correct polarity and a 3 amp fuse to prevent over-excitation.** See the diagram.

Alternatively, while the set is running and disconnected from all loads, apply a 12 VDC battery for one to two seconds as shown in the diagram. **Polarity must be correct: + to X, – to XX.**

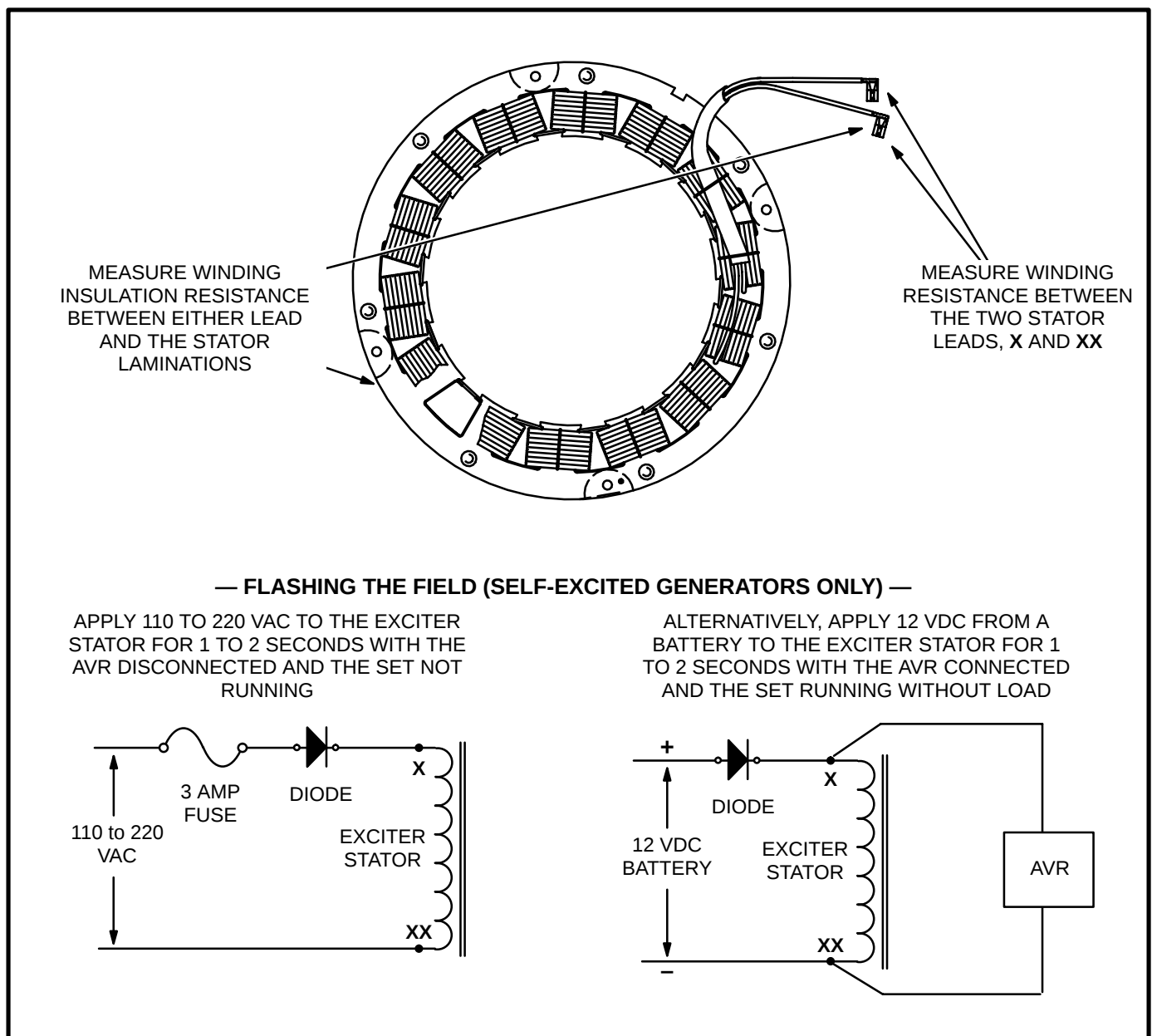


FIGURE 7-2. TESTING AND FLASHING THE EXCITER STATOR

Exciter Rectifier Bridge (Rotating Rectifier Assembly)

The exciter rectifier bridge is mounted on the exciter rotor, inboard, facing the main rotor. It consists of a positive plate and a negative plate, split diametrically. Each carries three diodes, three terminal posts for connecting exciter rotor leads to the diode pigtails and a terminal for the main rotor (generator field) lead. A surge suppresser is connected across the two plates to prevent transient voltages that could damage the diodes.

Testing Diodes: Disconnect the diode pigtails from the terminal posts. Using an ohmmeter, measure electrical resistance between each diode pigtail and the plate on which the diode is mounted. Reverse the meter test probes and repeat the tests. The electrical resistance across each diode should be high in one direction and low in the other. If the re-

sistance is high or low in both directions, replace the diode.

Replacing Diodes: Make sure the replacement diode is of the correct polarity. Disconnect the pigtail from the terminal post and unscrew the old diode. Apply heat-sink compound under the head of the diode. Make sure the compound does not get on the threads. Torque the diodes to 36 to 42 in-lbs (4 to 4.8 Nm) and the pigtail terminals to 24 in-lbs (2.7 Nm) when reassembling.

Surge Suppressor Testing and Replacement: Remove the suppresser. Replace the suppresser if it appears to have overheated or if ohmmeter readings indicate less than infinite resistance (end of scale) in both directions. Torque the terminals to 24 in-lbs (2.7 Nm) when reassembling.

CAUTION Layers of dust can cause diodes to overheat and fail. Brush dust off regularly.

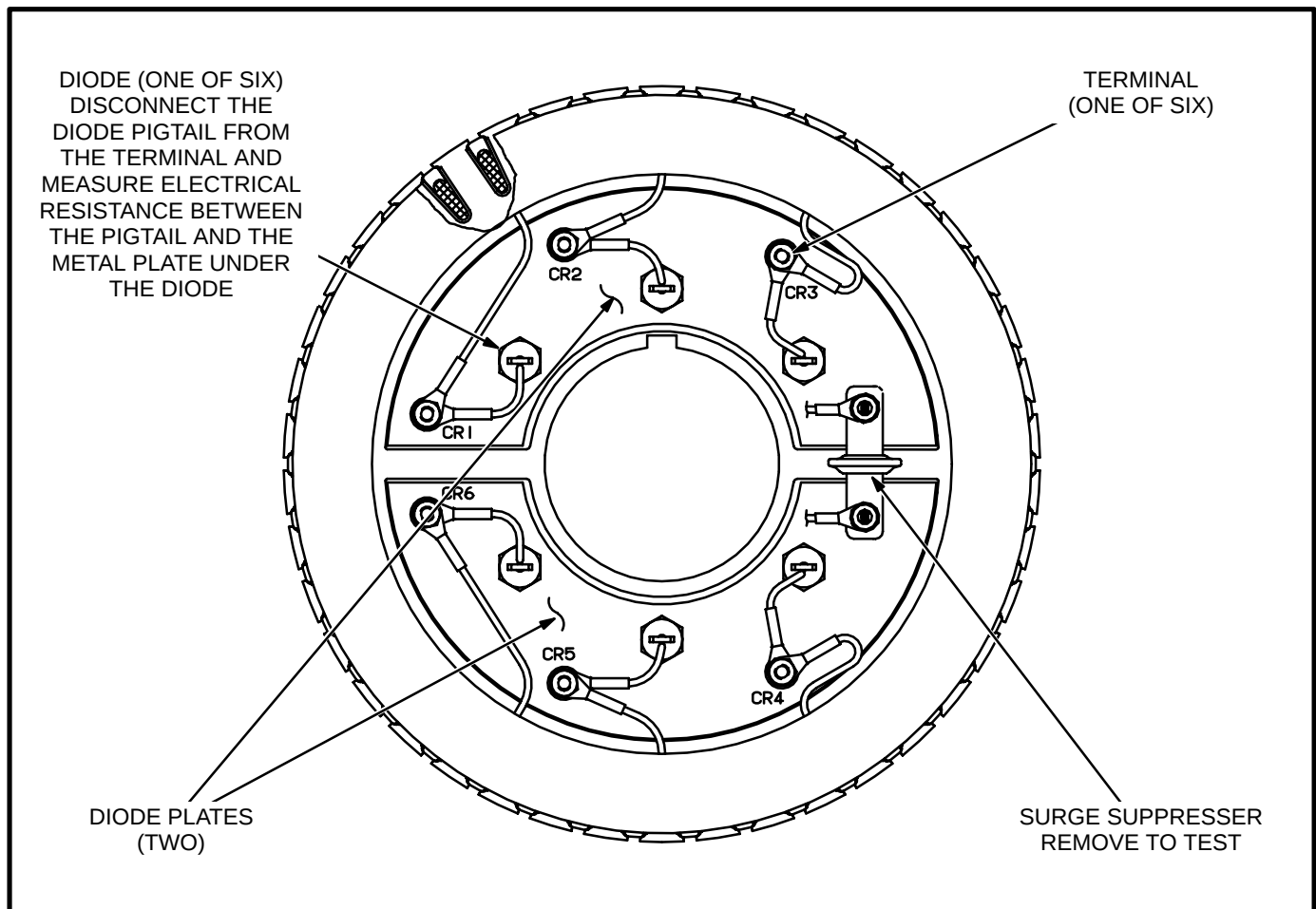


FIGURE 7-3. TESTING THE ROTATING RECTIFIER ASSEMBLY

Exciter Rotor

Testing Winding Resistance: Disconnect the six rotor winding leads from the terminal posts on the rectifier assembly. With a Wheatstone bridge, measure electrical resistance across each pair of rotor windings: **U** (CR1 or CR4) and **V** (CR2 or CR5), **V** (CR2 or CR5) and **W** (CR3 or CR6), **W** (CR3 or CR6) and **U** (CR1 or CR4). See the winding sche-

matic. Replace the whole rotor shaft assembly if the resistance of any winding is not as specified in Table 7-1.

Testing Winding Insulation Resistance: Using an ohmmeter, measure the resistance between any rotor winding lead or the terminal to which it is connected and the rotor laminations. Replace the whole rotor shaft assembly if insulation resistance is less than 1 megohm.

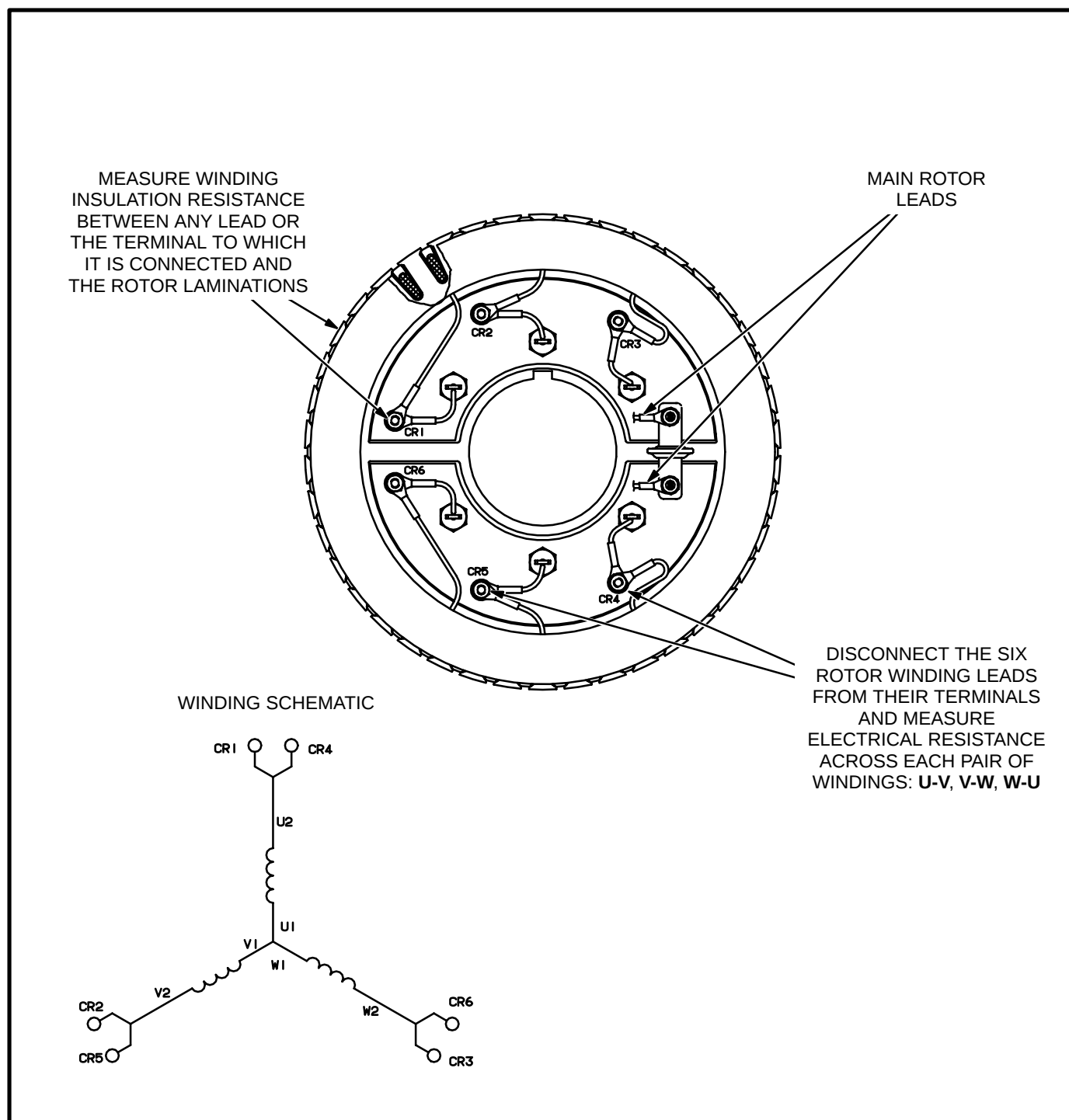


FIGURE 7-4. TESTING THE EXCITER ROTOR

Main Rotor (Generator Field)

Testing Winding Resistance: Disconnect the two leads of the main rotor from the terminals on the rotating rectifier assembly (Figure 7-4). Measure electrical resistance between the two leads with a Wheatstone bridge or digital ohmmeter. Replace the rotor if the resistance is not as specified in Table

7-1. Connect the rotor leads and torque the terminals to 24 in-lbs (2.7 Nm) when reassembling.

Testing Winding Insulation Resistance: Using an ohmmeter, measure the resistance between either lead of the main rotor windings, or the terminal to which it is connected, and the main rotor laminations. Replace the rotor if insulation resistance is less than 1 megohm.

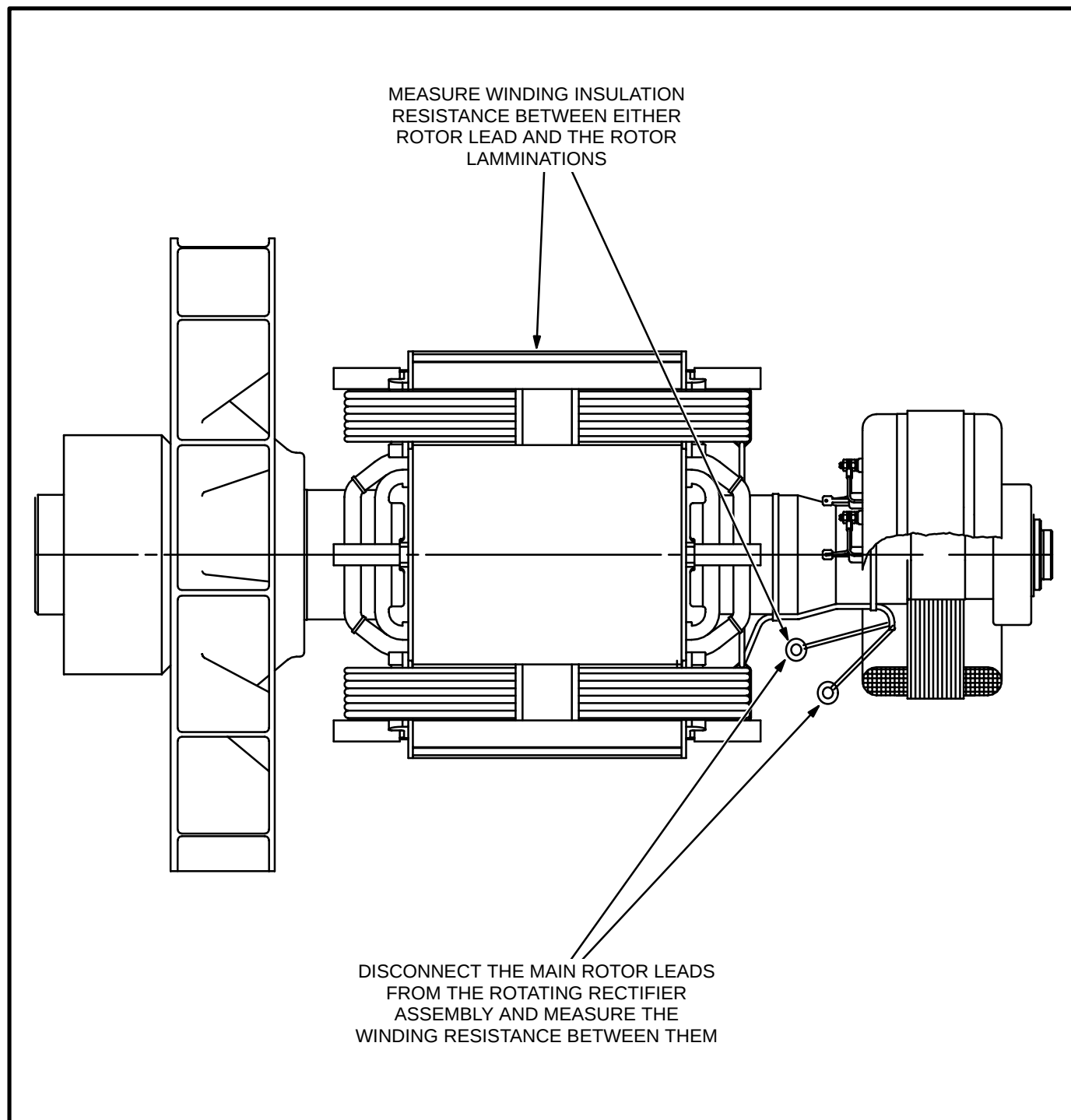


FIGURE 7-5. TESTING THE MAIN ROTOR

Main Stator

Testing Winding Resistance: Measure electrical resistance across each pair of stator leads (U1-U2, U5-U6, V1-V2, V5-V6, W1-W2 and W5-W6) with a Wheatstone bridge or ohmmeter having at least 0.001 ohm precision. Replace the stator if the resistance of any winding is not as specified in Table 7-1.

Alternatively, winding resistance can be measured line-to-line at the generator terminals (U-V, V-W, W-U) on "star" connected generators. On a 600 volt generator, line-to-line resistance should be twice the table value (two winding elements in series). On a "series star" connected generator, line-to-line re-

sistance should be four times the table value (four winding elements in series). On a "parallel star" connected generator, line-to-line resistance should be the same as the table value (two sets of two winding elements in series). Single phase only windings can be measured at W-V and should be twice the table value.

Testing Winding Insulation Resistance: Disconnect all stator leads and winding taps from their respective terminals and make sure the ends do not touch the generator frame. Using an ohmmeter, measure electrical resistance between any stator lead and the stator laminations. Replace the stator if insulation resistance is less than 1 megohm.

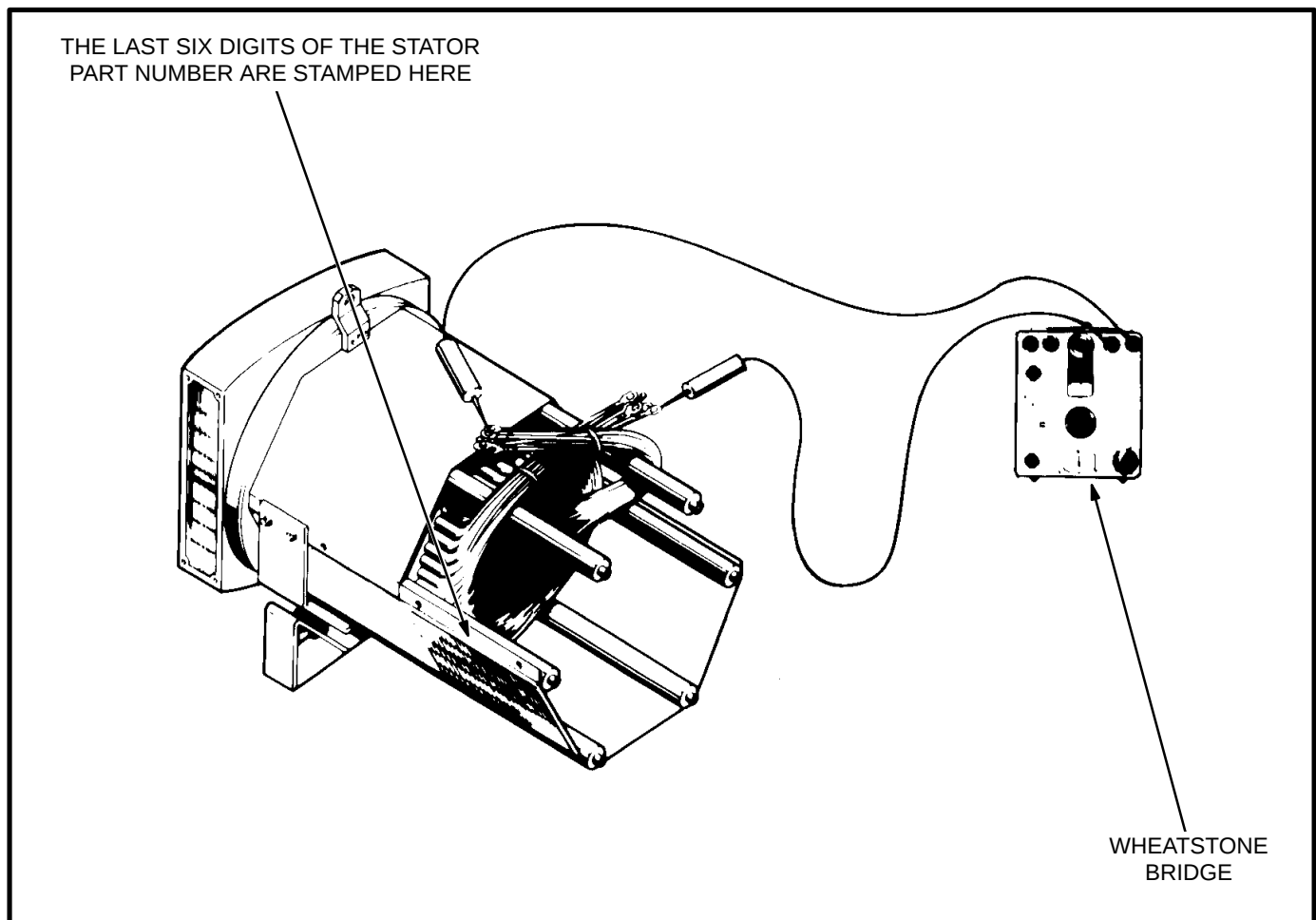


FIGURE 7-6. TESTING THE GENERATOR STATOR

TABLE 7-1. GENERATOR WINDING RESISTANCES

MAIN STATOR PART NUMBER***	MAIN STATOR (OHMS*)	MAIN ROTOR (OHMS**)	EXCITER STATOR (OHMS**)	EXCITER ROTOR (OHMS*)
220-4447-06	0.0561–0.0620	0.57	20.3	0.167
220-4447-07	0.0466–0.0515	0.64	20.3	0.167
220-4447-08	0.0371–0.0410	0.67	19.5	0.180
220-4447-09	0.0228–0.0252	0.80	19.5	0.180
220-4447-10	0.0181–0.0200	0.93	19.5	0.180
220-4447-11	0.0860–0.0950	0.57	20.3	0.167
220-4447-12	0.0613–0.0677	0.64	20.3	0.167
220-4447-13	0.0480–0.0530	0.67	19.5	0.180
220-4447-14	0.0309–0.0341	0.80	19.5	0.180
220-4447-15	0.0261–0.0289	0.93	19.5	0.180
220-4447-16	0.0561–0.0620	0.57	20.3	0.167
220-4447-17	0.0428–0.0473	0.64	20.3	0.167
220-4447-18	0.0333–0.0368	0.67	19.5	0.180
220-4447-19	0.0228–0.0252	0.80	19.5	0.180
220-4447-20	0.0171–0.0189	0.93	19.5	0.180
220-4447-26	0.1354–0.1496	0.57	20.3	0.167
220-4447-27	0.0960–0.1050	0.64	20.3	0.167
220-4447-28	0.0713–0.0788	0.67	19.5	0.180
220-4447-29	0.0485–0.0536	0.80	19.5	0.180
220-4447-30	0.0404–0.0446	0.93	19.5	0.180
220-4448-07	0.0209–0.0231	1.11	19.5	0.180
220-4448-08	0.0162–0.0179	1.20	19.5	0.180
220-4448-09	0.0143–0.0158	1.31	19.5	0.210
220-4448-10	0.0095–0.0105	1.50	19.5	0.210
220-4448-11	0.0076–0.0084	1.66	19.5	0.210
220-4448-12	0.0066–0.0072	1.80	19.5	0.210
220-4448-13	0.0260–0.0310	1.11	19.5	0.180
220-4448-14	0.0214–0.0236	1.20	19.5	0.180
220-4448-15	0.0147–0.0163	1.31	19.5	0.210
220-4448-16	0.0114–0.0126	1.50	19.5	0.210
220-4448-17	0.0100–0.0110	1.66	19.5	0.210
220-4448-18	0.0071–0.0079	1.80	19.5	0.210
220-4448-19	0.0204–0.0226	1.11	19.5	0.180
220-4448-20	0.0152–0.0168	1.20	19.5	0.180
220-4448-21	0.0105–0.0116	1.31	19.5	0.210
220-4448-22	0.0090–0.0100	1.50	19.5	0.210
220-4448-23	0.0076–0.0084	1.66	19.5	0.210
220-4448-24	0.0062–0.0068	1.80	19.5	0.210
(CONT.)				

* - These values are approximate, plus or minus 10 percent at 68° F (20° C).

** - These values are approximate, plus or minus 10 percent at 77° F (25° C).

*** - See Figure 7-6 for the location of the stator part number.

TABLE 7-1. GENERATOR WINDING RESISTANCES (CONT.)

MAIN STATOR PART NUMBER***	MAIN STATOR (OHMS*)	MAIN ROTOR (OHMS**)	EXCITER STATOR (OHMS**)	EXCITER ROTOR (OHMS*)
220-4448-31	0.0413–0.0457	1.11	19.5	0.180
220-4448-32	0.0229–0.0331	1.20	19.5	0.180
220-4448-33	0.0238–0.0263	1.31	19.5	0.210
220-4448-34	0.0181–0.0200	1.50	19.5	0.210
220-4448-35	0.0124–0.0137	1.66	19.5	0.210
220-4448-36	0.0133–0.0147	1.80	19.5	0.210
220-4448-37	0.0085–0.0095	2.05	19.5	0.210
220-4448-38	0.0095–0.0105	2.05	19.5	0.210
220-4448-39	0.0074–0.0082	2.05	19.5	0.210
220-4448-40	0.0066–0.0074	2.05	19.5	0.210
220-4448-41	0.0065–0.0073	2.05	19.5	0.210
220-4448-42	0.0131–0.0145	2.05	19.5	0.210

* - These values are approximate, plus or minus 10 percent at 68° F (20° C).

** - These values are approximate, plus or minus 10 percent at 77° F (25° C).

*** - See Figure 7-6 for the location of the stator part number.

REMOVING AND DISASSEMBLING THE GENERATOR

The generator is heavy. You will need an assistant and a hoist of sufficient capacity to remove and service the generator.

⚠ WARNING *Accidentally dropping the generator can damage it and cause severe personal injury and death. The hoist, straps and chains must have sufficient capacity and be attached properly so that the load cannot shift.*

Before starting, disconnect the starting battery cables (negative (-) first) to make sure the set will not start while working on it.

⚠ WARNING *Accidental starting of the generator set while working on it can cause severe injury or death. Prevent accidental starting by disconnecting the starting battery cables (negative (-) first).*

Always remove the negative (-) cable first, and reconnect it last, to prevent arcing if a tool accidentally touches the frame or other grounded metal part while removing the positive (+) battery cable. Arcing can ignite the explosive hydrogen gas given off by the batteries, causing severe injury.

Removing The Generator Output Box

4. Disconnect the line cables and conduit. For reconnections later, make sure each cable is clearly marked to indicate the correct terminal.
5. Disconnect the remote control wiring and conduit. For reconnections later, make sure each wire is clearly marked to indicate the correct terminal.
6. Disconnect all engine wiring harness connections in the generator control and output boxes. For reconnections later, make sure each wire is clearly marked to indicate the correct terminal.
7. Disconnect all generator control leads (winding taps) from connections in the output box. For reconnections later, make sure each wire is clearly marked to indicate the correct terminal.

8. If the set has a mounted line circuit breaker, disconnect the cables to the circuit breaker. For reconnections later, make sure each cable is clearly marked to indicate the correct terminal.
9. Attach a hoist to the generator output box, loosen the mounting bolts on the sides of the generator and remove the box.

Withdrawing The Generator From The Set

⚠ CAUTION *Do not use fan blade to bar over engine. That can damage blades and cause property damage and personal injury.*

1. The rotor will be carried inside the stator when the generator is withdrawn from the engine. Bar the engine until one of the four poles of the rotor points straight down so that the rotor will rest on the face of the pole when the generator is withdrawn.

⚠ CAUTION *The rotor can be damaged if it rests on the edges of the winding slot between two poles.*

2. Attach lifting eyes and a hoist of sufficient capacity (Figure 7-7).
3. Take up hoist slack and remove the two through bolts securing the generator to the rubber isolation mounts.
4. Raise the generator end approximately one inch (12 mm) and securely block the engine under the flywheel housing. Lower the generator slightly so that the blocks carry most of the weight.
5. Remove the bolts securing the generator drive discs to the flywheel.
6. Loosen all the bolts securing the generator adapter casting to the flywheel housing. Adjust the hoist to carry the full weight of the generator, remove the bolts and pull the generator away.

⚠ CAUTION *Never withdraw the generator leaving the rotor to hang by the drive discs. The weight of the rotor will damage the drive discs.*

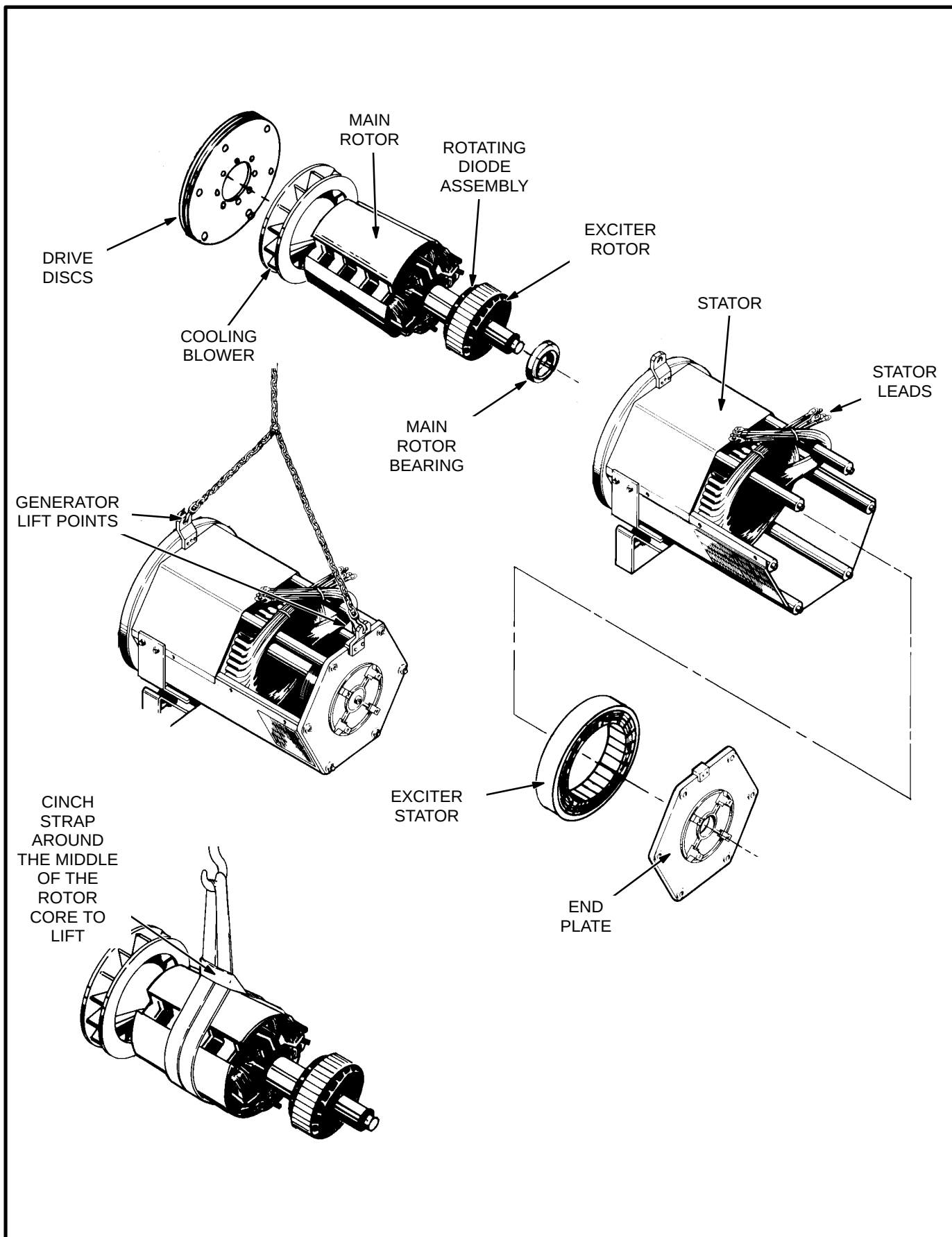


FIGURE 7-7. GENERATOR ASSEMBLY

Withdrawing the Rotor From the Generator

1. Remove the generator adaptor casting on the drive disc end and the end plate on the bearing end.
2. Using a hoist of sufficient capacity, cinch a lifting strap on the drive end of the rotor. Lift the bearing end of the rotor by hand and push it towards the drive end of the generator until half the width of the rotor core protrudes from the stator. Release the weight of the rotor and re-cinch the lifting strap around the middle of the rotor core. Withdraw the rotor until it is free of the stator, guiding it by hand on both ends to prevent contact with the stator windings
3. Rest the rotor in a cradle, solidly supporting it on two pole faces—not on the drive discs, blower or exciter.
4. Remove the retaining clip if the rotor shaft bearing is to be removed.

REASSEMBLING THE GENERATOR

Reassembling is the reverse of disassembling. Note the following.

1. Apply force to the inner race of the rotor bearing when pressing it onto the shaft, otherwise, it will be damaged. Be sure to secure the retaining clip.
2. The drive disc-to-rotor bolts should be torqued to 190 ft-lbs (257 Nm).
3. The drive disc-to-flywheel bolts should be torqued to 50 ft-lbs (67 Nm).
4. The exciter stator mounting screws should be torqued to 7 ft-lbs (10 Nm).
5. The generator end plate mounting bolts should be torqued to 25 ft-lbs (34 Nm).
6. Make sure the rubber O-ring is in place in the bearing bore in the generator endplate.
7. The generator mounting bracket bolts should be torqued to 65 ft-lbs (88 Nm) if M12 or 35 ft-lbs (47 Nm) if M10.
8. The generator-to-adaptor bolts should be torqued to 40 ft-lbs (55 Nm).
9. The adaptor-to-engine bolts should be torqued to 35 ft-lbs (48 Nm).
10. Reconnect the generator as required. See Page 10-3 or 10-4.

SERVICING THE PMG

The following is applicable if the generator is equipped with a PMG (permanent magnet) exciter.

Testing

1. Disconnect leads **P2**, **P3** and **P4** from the voltage regulator.
2. Start the engine at the set and let the speed stabilize.

⚠WARNING **HAZARDOUS VOLTAGE.**
Touching uninsulated high voltage parts inside the control and power output boxes can result in severe personal injury or death. Measurements and adjustments must be done with care to avoid touching high voltage parts.

For your protection, stand on a dry wooden platform or rubber insulating mat, make sure your clothing and shoes are dry, remove jewelry and use tools with insulated handles.

3. Measure voltage across lead pairs **P2-P3**, **P3-P4** and **P4-P2**. Voltage should be at least 150 VAC for 50 Hz sets and at least 180 VAC for 60 Hz sets, and should be approximately the same for each set of leads. If the voltages are low or uneven, check all the leads and connections between the voltage regulator and the PMG and repair as necessary before disassembling the PMG. Note the connections at the auxiliary terminal board in the power output box. See Figure 2-3.
4. Stop the set and measure electrical resistance across lead pairs **P2-P3**, **P3-P4** and **P4-P2** with a Wheatstone bridge or digital ohmmeter. Each winding should have a resistance of approximately 4.4 ohms.

Disassembling the PMG

1. Disconnect the starting battery cables (negative (-) first) to make sure the set will not start while working on it.

⚠ WARNING *Accidental starting of the generator set while working on it can cause severe injury or death. Prevent accidental starting by disconnecting the starting battery cables (negative (-) first).*

Always remove the negative (-) cable first, and reconnect it last, to prevent arcing if a tool accidentally touches the frame or other grounded metal part while removing the positive (+) battery cable. Arcing can ignite the explosive hydrogen gas given off by the batteries, causing severe injury.

⚠ CAUTION *Always disconnect a battery charger from its AC source before disconnecting the battery cables. Otherwise, disconnecting the cables can result in voltage spikes high enough to damage the DC control circuits of the set.*

2. Remove the PMG cover and disconnect the leads at the connector.
3. Remove the bolts and clamps that secure the PMG stator to the generator frame and carefully pull away the stator.

The rotor is magnetic and will attract the stator. Hold the stator firmly so that the windings are not damaged by striking the stator support lugs.

4. Remove the rotor center bolt and pull away the rotor. The rotor is magnetic and will attract iron filings. Put it in a clean plastic bag until it is re-mounted. Do not take it apart or it will lose its magnetism. Also, if the dowel pin in the end of the shaft is loose, stow it in a safe place until it is time to reassemble the PMG.

Reassembling the PMG

Reassembling is the reverse of disassembling. Torque the rotor center bolt to 40 ft-lbs (54 Nm). The stator leads must be at 12 o'clock.

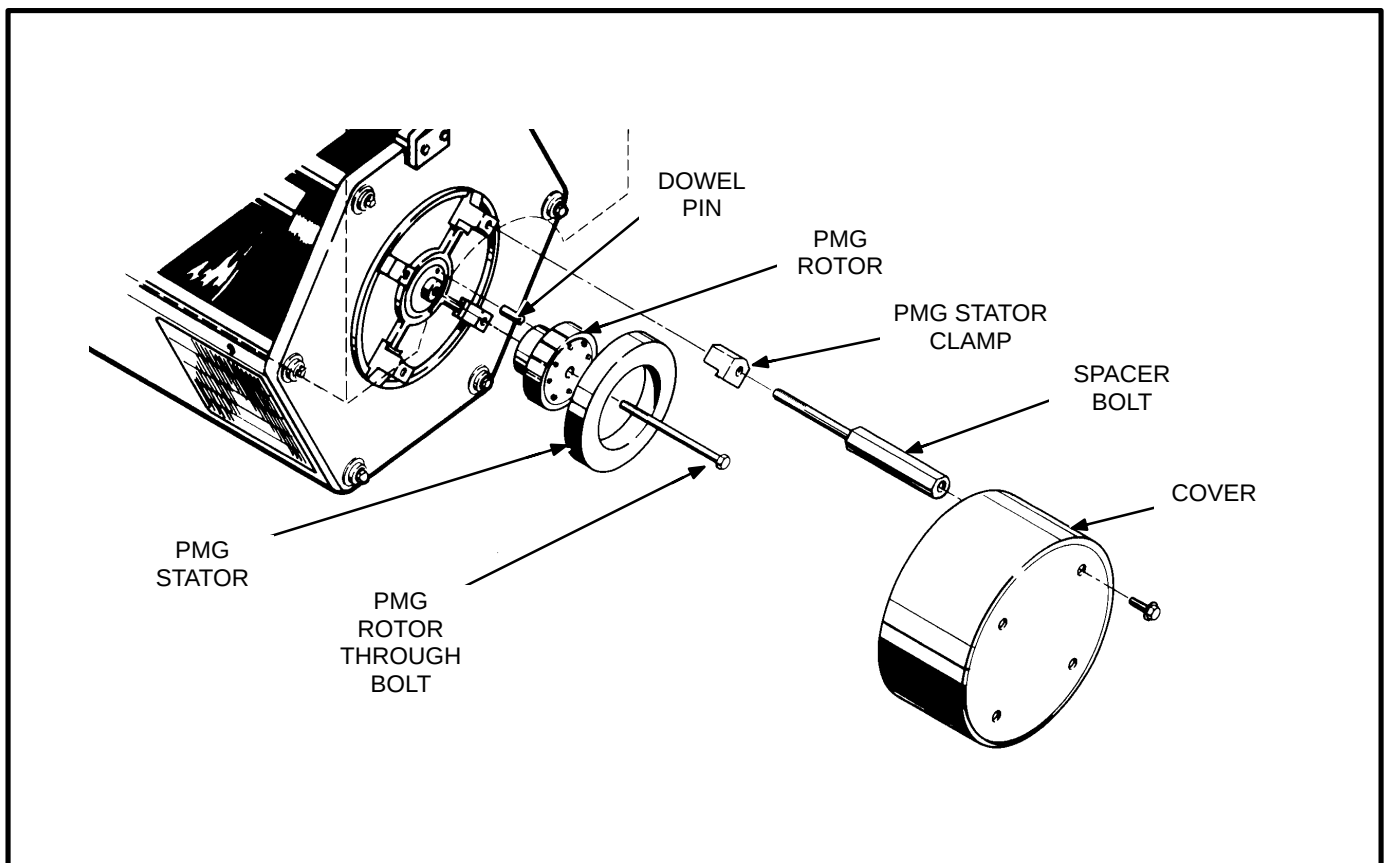


FIGURE 7-8. PMG ASSEMBLY

8. Governors

MECHANICAL GOVERNOR

Governor Adjustments

Output frequency (50Hz or 60Hz) can be adjusted by turning the governor "idle" and "speed" adjusting screws while the engine is running at its normal op-

erating temperature under full load. Adjust droop to within five percent of nominal frequency (3 Hertz for 60 Hertz sets and 2.5 Hertz for 50 Hertz sets). Check operation under various loads and increase droop if the governor hunts. Readjust full-load frequency if droop is adjusted.

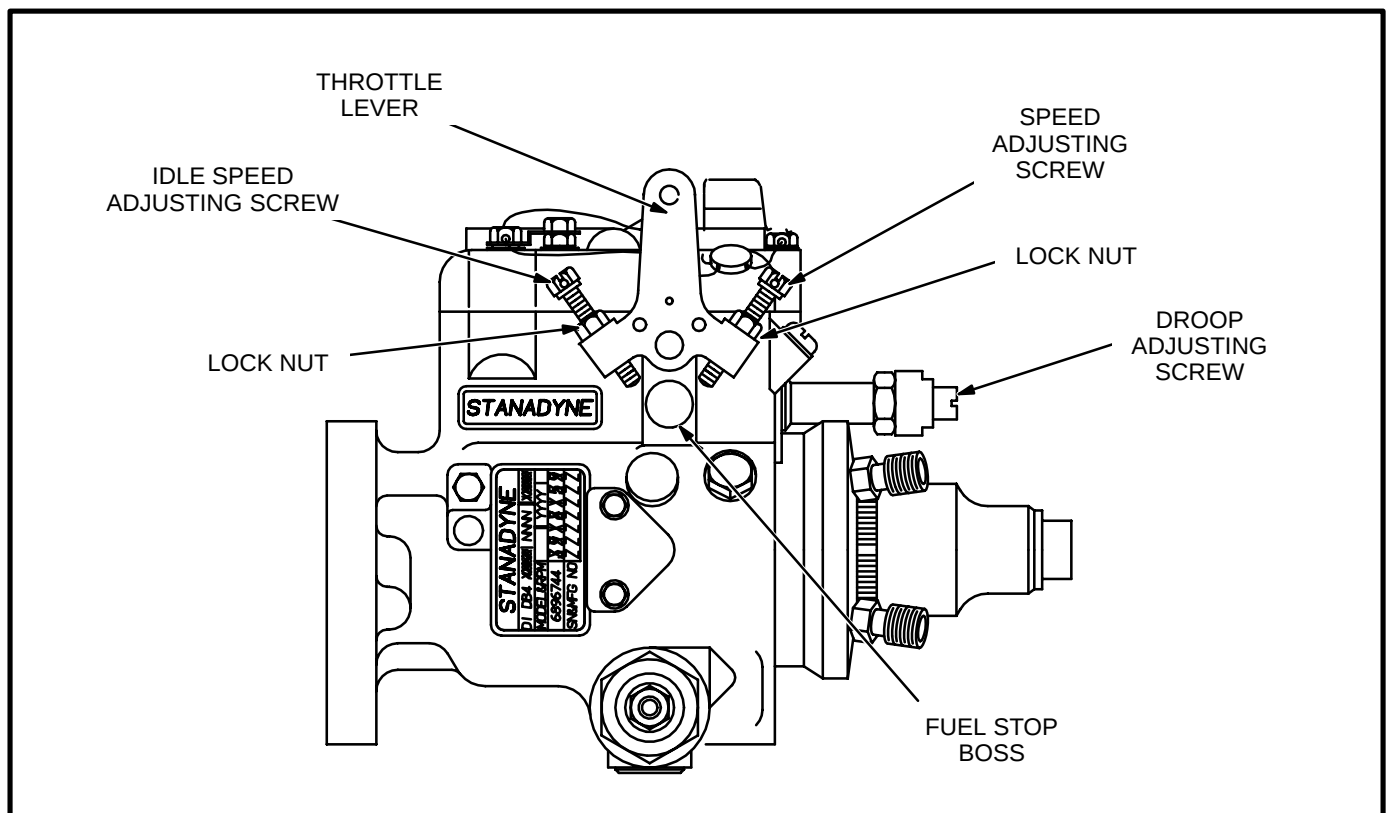


FIGURE 8-1. ENGINE GOVERNOR

ELECTRIC GOVERNOR

There are three types of governor controllers available. *Type A* is used with the external actuator/linkage to the fuel pump and *Types B and C* are used with the governor actuator that is integrated with the fuel pump.

Governor Adjustments (Type A)

If necessary, wire the controller according to Figure 8-2 and install the magnetic speed pickup unit as noted in the following subsection. Then adjust the governor controller as follows:

1. Set selector switch **S1**, on the controller to the **OFF** position.
2. Set selector switch **S2**, on the controller to the appropriate position (see Figure 8-2).
3. Note that the pots (potentiometers) on the controller are adjustable from zero to 100 percent and are marked off in divisions of ten percent. The speed pot has a 20-turn adjustment range. Set the pots initially as follows:

Gain 20%

I 20%

D 30%

Droop 0%

4. If a remote speed pot is used, set it at its mid-point.
5. Start the set and adjust the **Speed** pot to obtain the required output frequency: 60 Hertz (1800 RPM) or 50 Hertz (1500 RPM). Warm up the set under load until it is up to normal operating temperature.
6. Disconnect the load and turn the **GAIN** pot to 100 percent or until operation becomes unstable. Then turn the pot counterclockwise until operation again becomes stable.
7. Adjust **D** as in Step 5.
8. Adjust **I** as in Step 5.
9. Readjust **Speed** if necessary.
10. Manually push the throttle to the minimum speed position and hold it there until the engine reaches minimum speed. Release the throttle and observe speed overshoot. Two to five Hertz overshoot may be acceptable. If overshoot is unacceptable, turn the **I** pot clockwise (slightly) to reduce overshoot. If the set hunts during steady state operation, turn the **I** pot counterclockwise (slightly) until the set is stable.

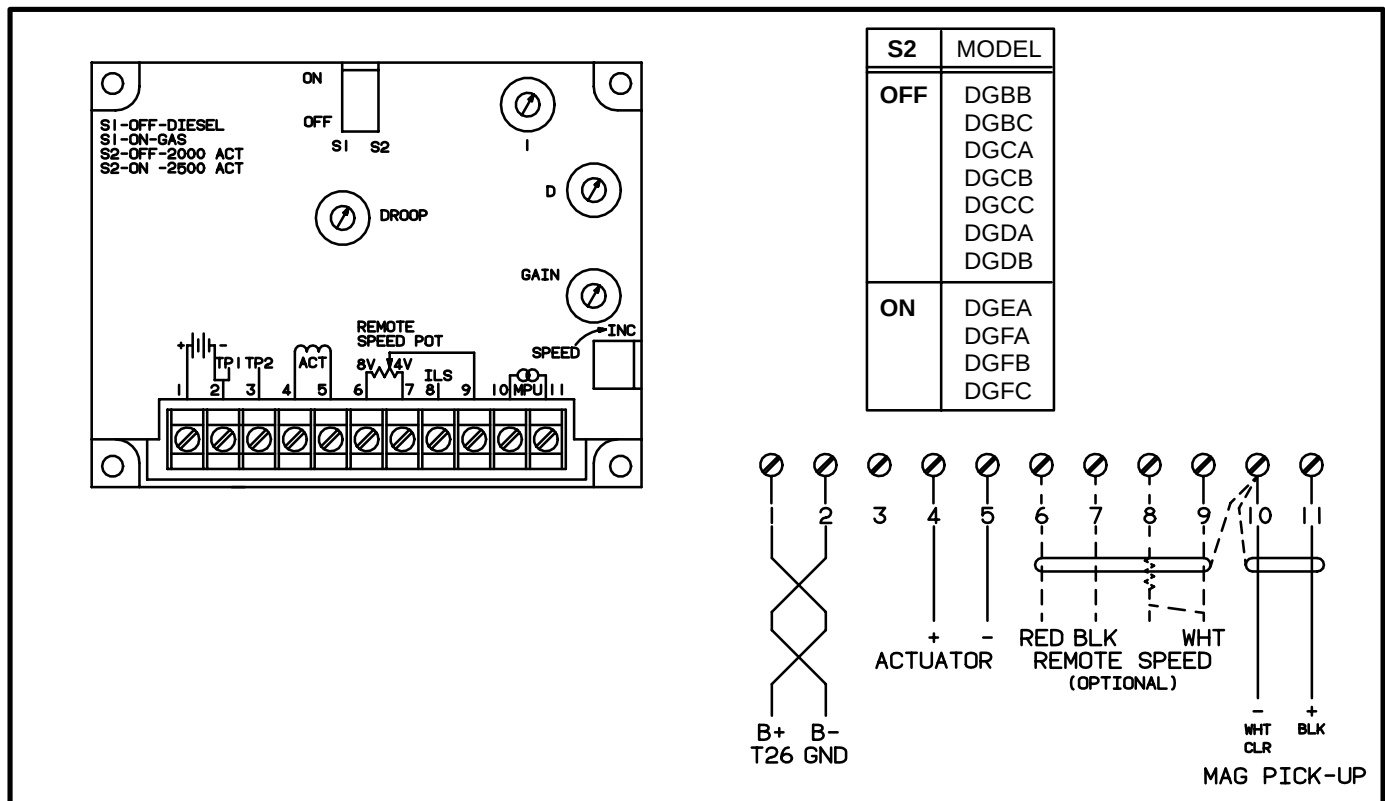


FIGURE 8-2. GOVERNOR CONTROLLER (TYPE A)

Governor Adjustments (Type B)

If necessary, wire the controller according to Figure 8-3 and install the magnetic speed pickup unit as noted in the following subsection. Then adjust the governor controller as follows:

1. Start the set and adjust the **Speed** pot to obtain the required output frequency: 60 Hertz (1800 RPM) or 50 Hertz (1500 RPM). Warm up the set under load until it is up to normal operating temperature.
2. Disconnect the load and turn the **Gain** pot to 100 percent or until operation becomes unstable. Then turn the pot counterclockwise until operation again becomes stable.
3. Interrupt the governor by momentarily removing power from the governor. The engine should recover in 3 to 5 diminishing speed oscillations.
4. If engine continues to hunt, slightly reduce the **Gain** setting (turn pot counterclockwise). Repeat Step 3.

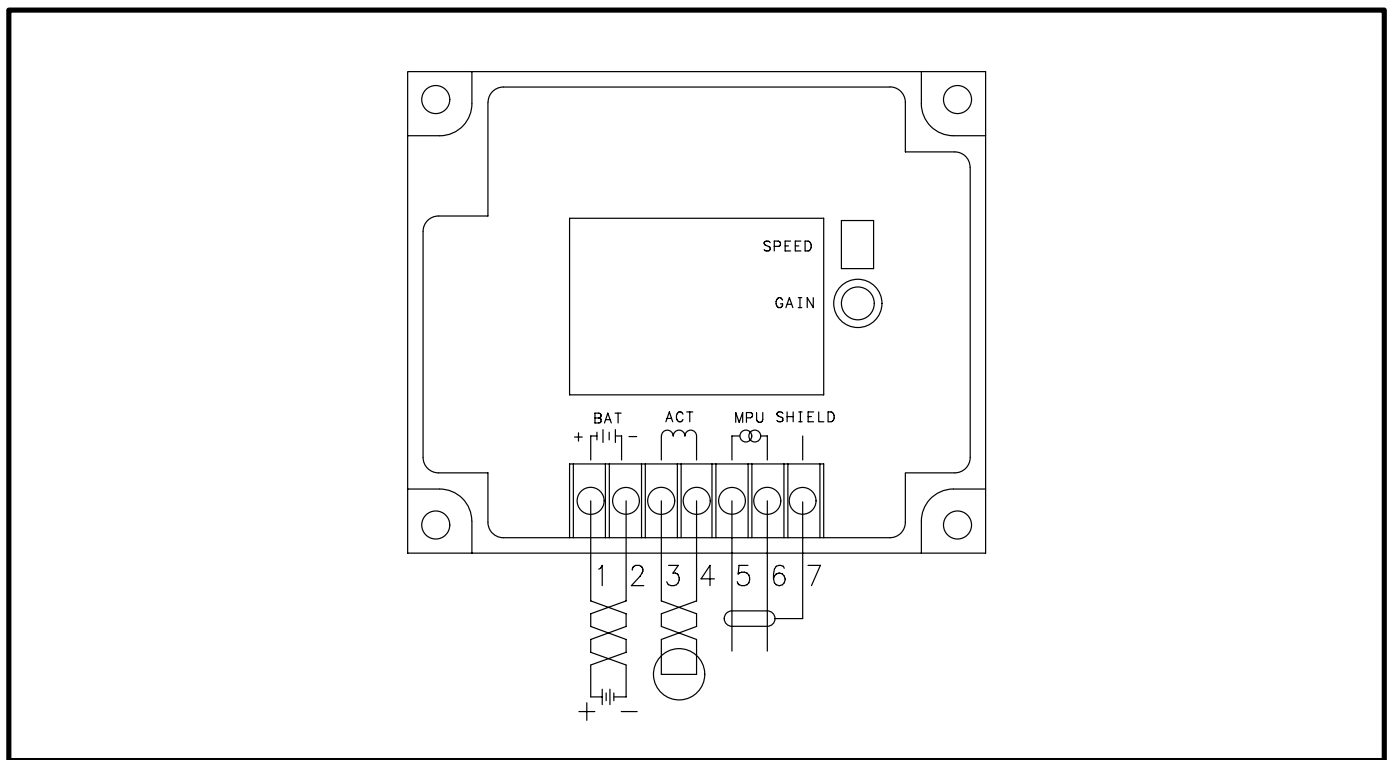


FIGURE 8-3. GOVERNOR CONTROLLER (TYPE B)

Governor Adjustments (Type C)

If necessary, wire the controller according to Figure 8-4 and install the magnetic speed pickup unit as noted in the following subsection. Then adjust the governor controller as follows:

1. Note that the pots (potentiometers) on the controller are adjustable from zero to 100 percent and are marked off in divisions of ten percent. The speed pot has a 20-turn adjustment range. Set the pots initially as follows:

Gain 30%

Integral Upper Limit 0% (fully CCW)

Droop 0% (fully CCW)

2. If a remote speed pot is used, set it at its midpoint.
3. Start the set and adjust the **Run Speed** pot to obtain the required output frequency: 60 Hertz (1800 RPM) or 50 Hertz (1500 RPM). Warm up the set under load until it is up to normal operating temperature.

4. Disconnect the load and turn the **Gain** pot to 100 percent or until operation becomes unstable. Then turn the pot counterclockwise until operation again becomes stable.
5. Interrupt the governor by momentarily removing power from the governor. The engine should recover in 3 to 5 diminishing speed oscillations.
6. If engine continues to hunt, slightly reduce **Gain** setting (turn pot counterclockwise). Repeat Step 5.
7. After the **Run Speed** and **Gain** are adjusted, apply 100% rated load to generator.
 - A. While observing Frequency or RPM meter, turn **Integral Upper Limit** pot slowly clockwise until frequency or RPM starts to decrease.
 - B. Turn **Integral Upper Limit** pot slowly counterclockwise until the frequency or RPM returns to the original set speed.
8. Readjust **Run Speed** if necessary.

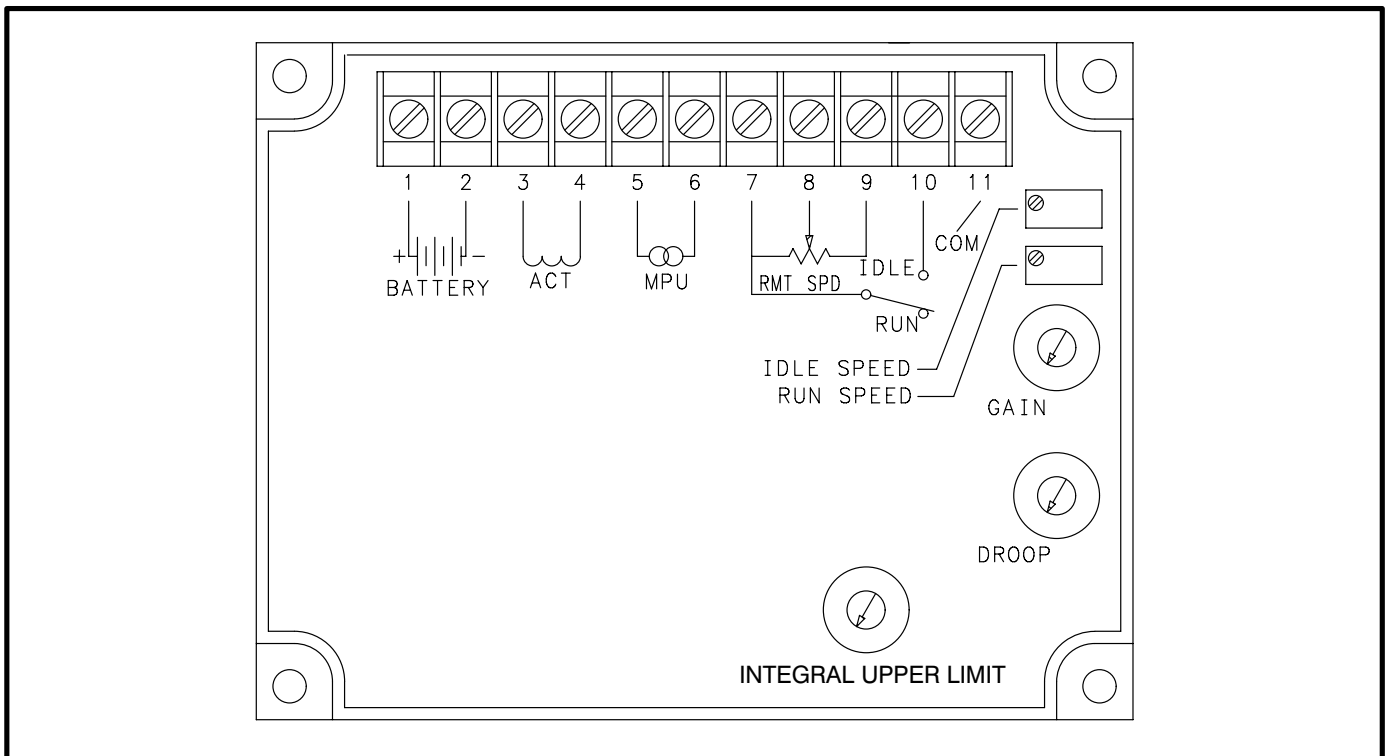


FIGURE 8-4. GOVERNOR CONTROLLER (TYPE C)

ELECTRIC GOVERNOR (TYPE A) THROTTLE LEVER/LINKAGE ADJUSTMENT

Figure 8-5 illustrates the arrangement of electric governor components on the engine.

If the injection pump has been replaced, it will be necessary to adjust the position of the throttle lever before connecting the actuator linkage. The throttle lever is on the side of the pump away from the engine. See Figure 8-5.

Throttle Lever Adjustments

1. Operate the set and disconnect all loads after the engine has warmed up to normal operating temperature.
2. Loosen the locknut on the throttle lever "idle" and "speed" adjusting screws and turn the screws to increase engine speed to 1980 RPM (66 Hertz) for 60 Hertz sets or to 1650 RPM (55 Hertz) for 50 Hertz sets.
3. Set the locknuts.

Linkage Assembly and Adjustments (DGBB through DGDB)

1. Thread the locknut onto the male swivel-end link. Then thread the female link five turns onto the male link and set the lock nut.

2. Secure the male end of the link to the injection pump lever on the engine side of the pump. Make sure to tighten two nuts on the screw before connecting the swivel end of the link to the injection pump lever.
3. Loosely thread the locknut and clevis onto the actuator shaft.
4. Disconnect leads to actuator to deactivate.
5. Start engine and with no load applied to the generator, slowly rotate the fuel pump stop lever toward the front of the engine (away from generator set control) until the engine stops. Hold the stop lever in this position. Turn the clevis on the actuator shaft until the hole in the link swivel registers with the holes in the clevis and connect the clevis and link with the screw, nut and lock washer as shown.
6. Tighten the clevis locknut on the actuator shaft.
7. Reconnect leads to actuator. Start and stop the generator set several times to make sure engine stops.

If engine does not stop, block inlet of air cleaner to kill the engine. Repeat linkage adjustment procedure to correct engine non-stop problem.

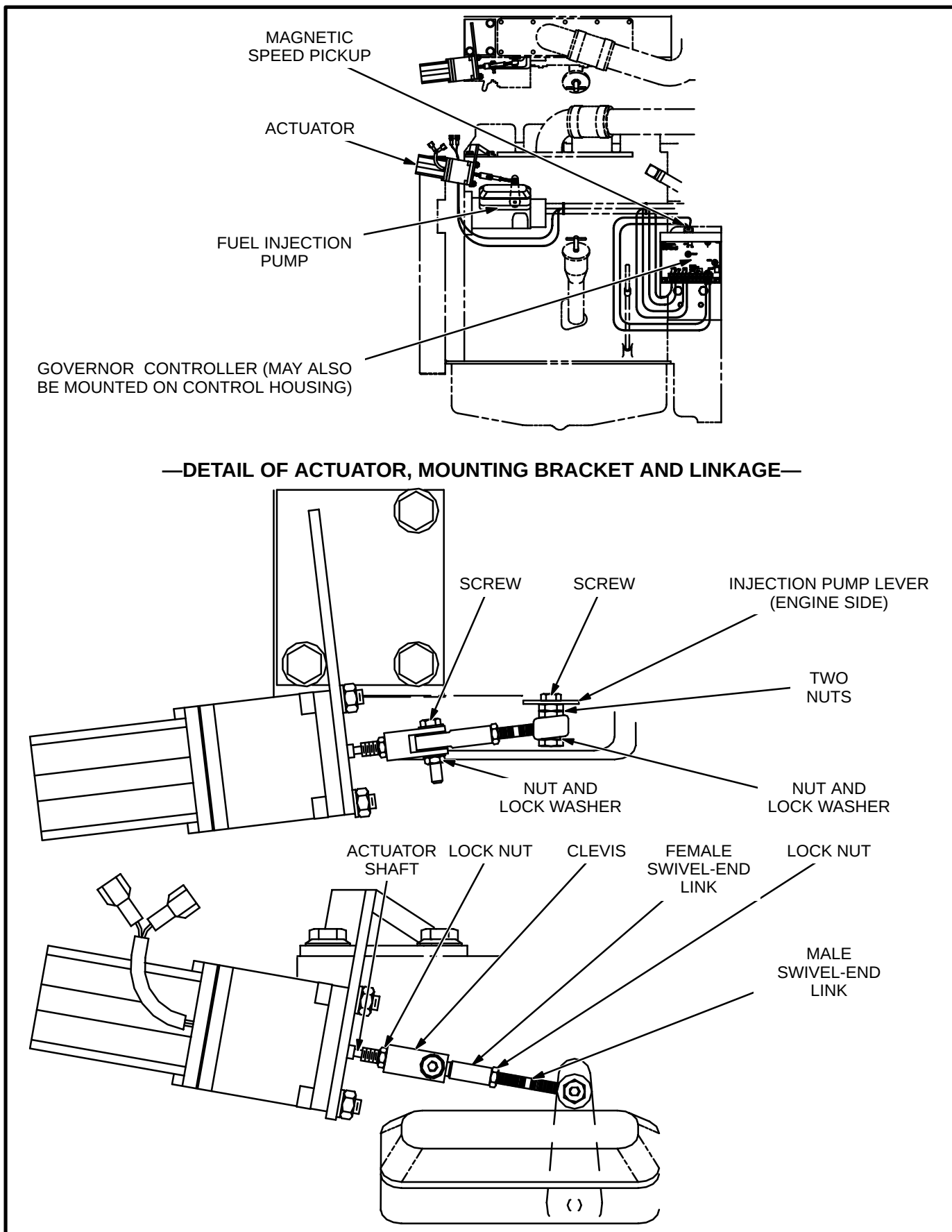


FIGURE 8-5. ELECTRIC GOVERNOR LINKAGE (DGBB THROUGH DGDB)

Linkage Assembly and Adjustment (DGEA through DGFC)

1. Thread two 1/4-28 nuts (6) and rod-ends (4) onto the stud (5). Thread rod-ends in five turns. Refer to Figure 8-6.
2. Loosely thread jam-nut and clevis (3) onto the actuator shaft.
3. Disconnect leads to actuator to deactivate.
4. Connect the genset battery cables; positive (+) cable first, then the negative (–) cable.

⚠WARNING *When engine is running, moving parts can cause severe personal injury. Do not allow hair, clothing, jewelry, or body to touch moving parts.*

5. Start engine and with no load applied to the generator, slowly rotate the fuel pump stop lever toward the rear of the engine (toward generator set control) until the engine stops. Hold the stop lever in this position and adjust gover-

nor linkage until hole in rod-end aligns with the hole in stop lever (8). Connect the clevis using 1/4-20 X 1.0 screw (9), two flat-washers (7), lock-washer (10), and nut (11).

6. Tighten the clevis jam-nut on the actuator shaft.
7. Reconnect leads to actuator. Start and stop the generator set several times to make sure engine stops.

If engine does not stop, block inlet of air cleaner to kill the engine. Repeat linkage adjustment procedure to correct engine non-stop problem.

MAGNETIC SPEED PICKUP UNIT INSTALLATION

To install the magnetic speed sensor, bar the engine until a gear tooth on the flywheel lines up in the center of the mounting hole. Thread the sensor in gently by hand until it just touches the gear tooth. Back it out one quarter turn and set the locknut.

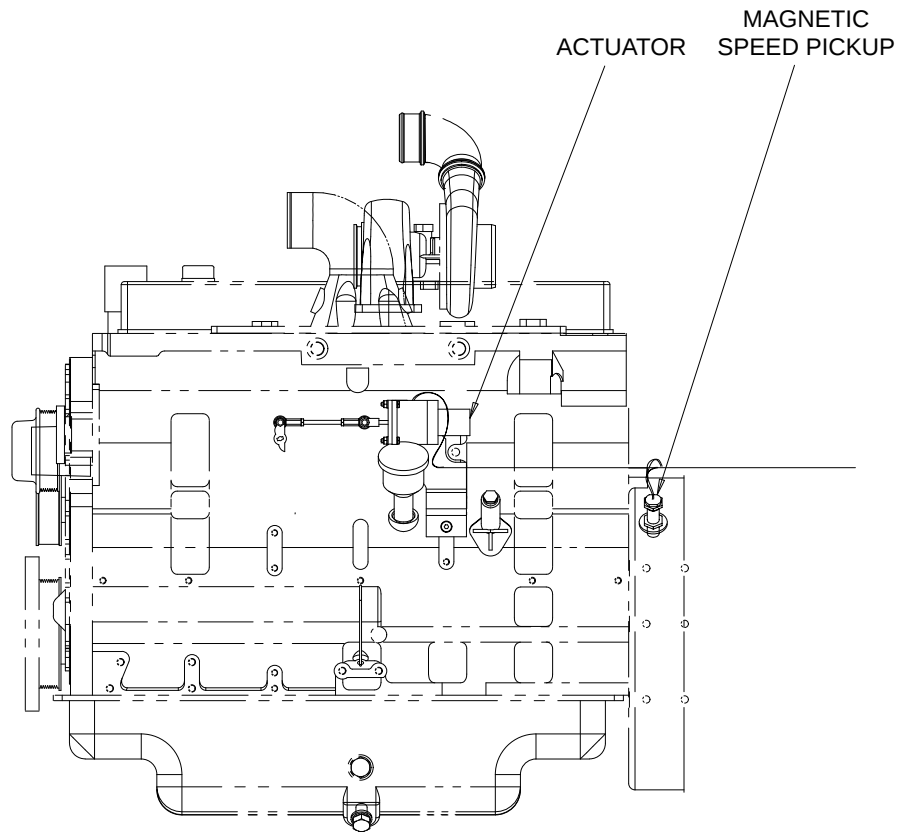
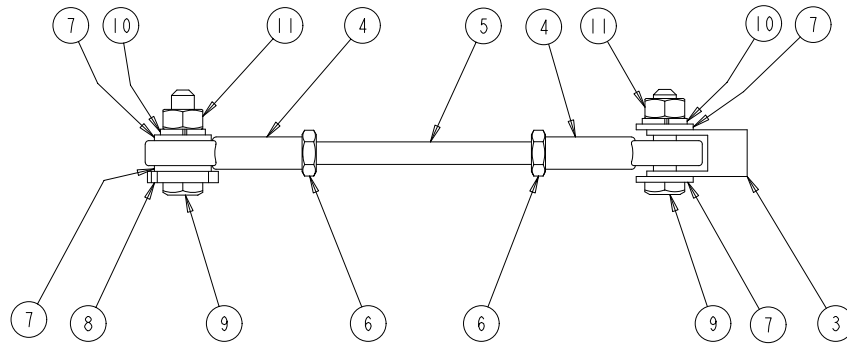


FIGURE 8-6. GOVERNOR ACTUATOR INSTALLATION (DGEA THROUGH DGFC)

9. Fuel Transfer Pump and Control

GENERAL

A fuel transfer pump and control are available when a sub-base or in-skid day tank are provided. The automatic control operates the fuel pump to maintain a reservoir of fuel in the sub-base or in-skid day tank. Figure 9-1 illustrates a typical sub-base installation.

⚠ WARNING Diesel fuel is highly combustible. Improper installation of this kit can lead to spillage of large quantities of fuel and loss of life and property if the fuel is accidentally ignited. Installation and service must be performed by qualified persons in accordance with the applicable codes.

Do not smoke near fuel and keep flames, pilot lights, sparks, arcing switches or equipment and other sources of ignition well away.

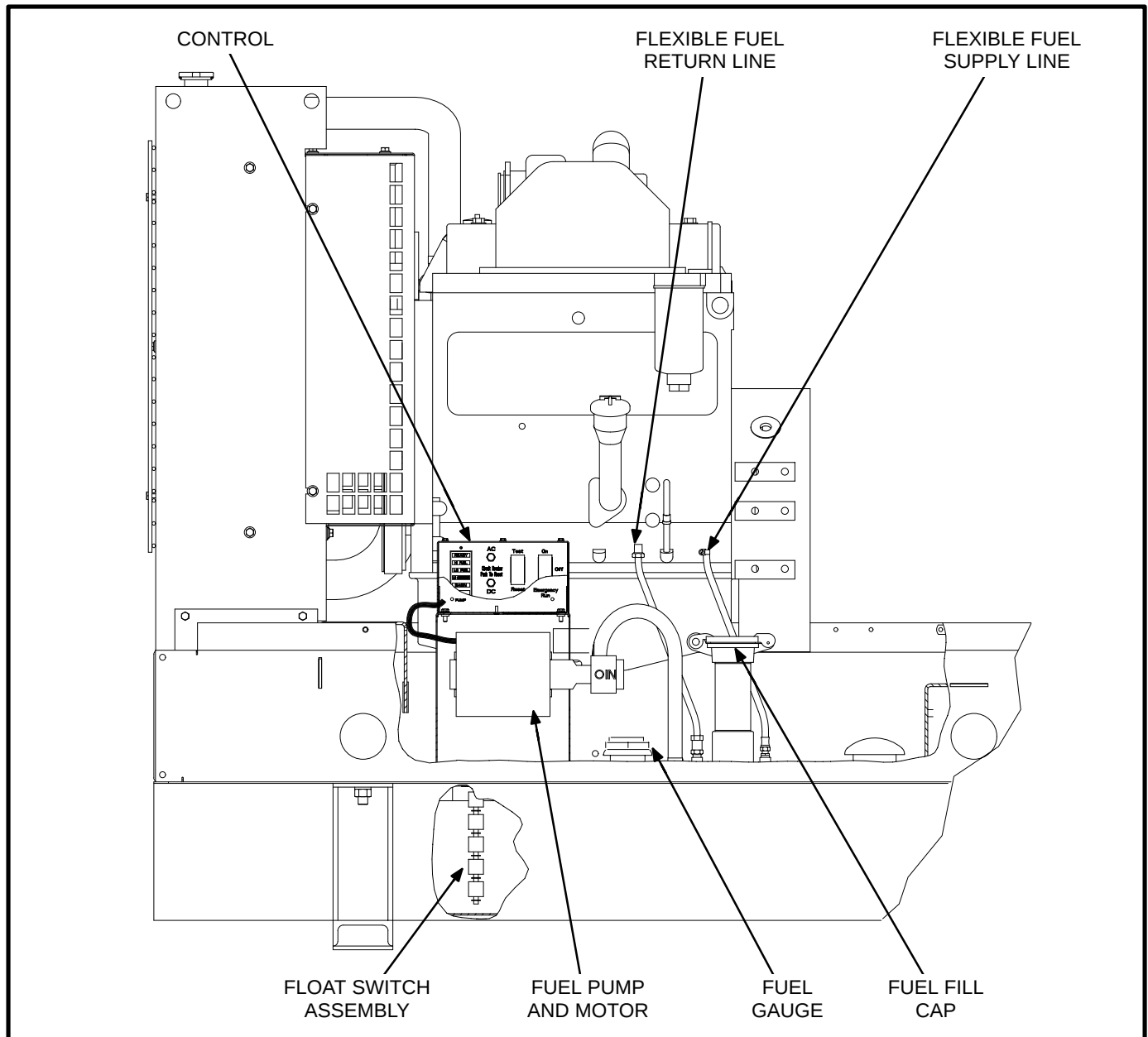


FIGURE 9-1. TYPICAL SUB-BASE INSTALLATION

OPERATION

8. Push the control switch to the **ON** position for automatic operation. The green **SYSTEM READY** light will come on and the pump will fill the tank if AC power is available for pumping and DC power is available for the internal logic circuits. The level of fuel in the tank will be automatically kept between a set of pump-on and pump-off float switches.

When filling an empty tank, the red **LO SHUT-DOWN** and **LO FUEL** lights will come on when the control switch is pushed to the **ON** position. This is normal. Push the panel **RESET** switch to turn off the red lights after the tank has been filled.

If the **SYSTEM READY** light does not come on, check for correct AC and DC power connections. See **Wiring Connections and Fuel Pump Motor Connections** below.

9. The green **PUMP ON** light indicates when the pump is running. It will come on and go off as fuel is pumped to maintain the proper level in the tank.
10. Push the control switch to the **EMERGENCY RUN** position (momentary contact) to pump fuel into the tank if the control fails to operate

the pump automatically. (The pump may continue to run after enabling the Emergency Run switch to complete the filling cycle of the tank.)

The green **PUMP ON** light does not come on when the switch is in the **EMERGENCY RUN** position.

11. The red lights indicate fault conditions and the need for service. The control panel includes the following lights:

- A. **HI FUEL:** The fuel in the tank has reached an abnormally high level, indicating possible failure of the pump-off float switch. The high-fuel float switch takes over as the automatic pump-off switch. The **HI FUEL** light stays on. The light can be **RESET** with the panel switch when the fuel level drops to normal, but will come back on again during the next pumping cycle if the fault remains.

⚠ WARNING *Continued operation with a **HI FUEL** fault present can lead to spillage of large quantities of fuel if the high-fuel float switch fails. Spilled fuel can cause loss of life and property if it is accidentally ignited or environmental damage.*

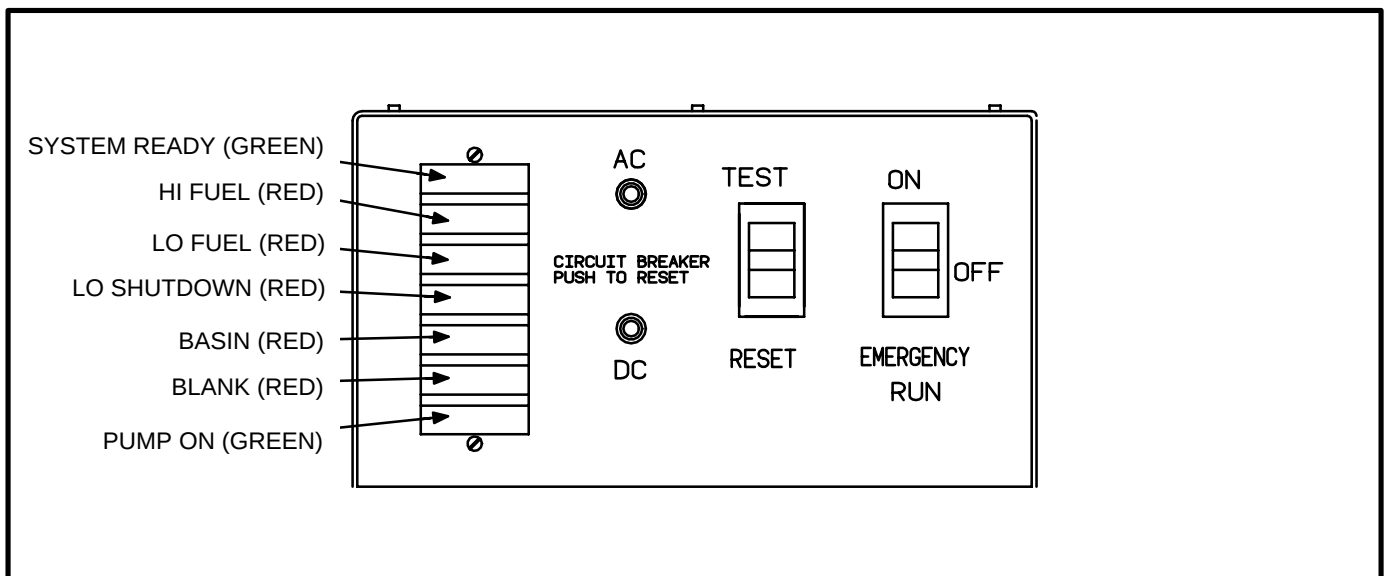


FIGURE 9-2. FUEL PUMP CONTROL PANEL

- B. **LO FUEL:** The fuel in the tank has dropped to an abnormally low level, indicating possible failure of the pump-on float switch. The lo-fuel float switch takes over as the automatic pump-on switch. The **LO FUEL** light stays on. The light can be **RESET** with the panel switch when the fuel level rises to normal, but will come back on again during the next pumping cycle if the fault remains.

⚠ CAUTION *Continued operation with a **LO FUEL** fault present can lead to low-fuel shutdown if the low-fuel float switch fails.*

- C. **LO SHUTDOWN:** The fuel has dropped to a level near the bottom of the tank, indicating an empty main fuel tank, pump failure or possible failure of both the pump-on and low-fuel level float switches. Further operation will allow air to enter the engine fuel unit, causing shutdown and the necessity to bleed the fuel unit to start up the engine again. If the light comes on, check the fuel level in the main fuel tank and fill it if necessary. As the day tank is refilling, **RESET** the light with the panel switch.

Note that connections should have been made to activate an engine fault shutdown under this condition to avoid running the engine pump out of fuel.

To restore engine operation following this fault, both the pump control and the engine control have to be RESET.

- D. **BASIN:** Fuel has overflowed into the rupture basin (if provided), indicating possible failure of both the pump-off and hi-fuel level float switches, or a leak in the day tank. **RESET** the control after the fuel in the basin has been safely disposed of and the cause of the overflow corrected.

- E. **BLANK:** For customer use.

The control fault circuits will trip and latch, requiring RESET, even if AC power is lost.

12. Press the **TEST** switch to test the indicator lights and pump operating circuits. Replace any light that does not come on. The pump will stop automatically after it has filled the tank to the normal pump-off fuel level.
13. Press the reset button of the **AC** or **DC** circuit breaker if either has tripped.

WIRING CONNECTIONS

See Day Tank Pump Control Wiring, *Section 8*, when making connections at the control box terminal board. The following should be noted.

1. The control can be powered by 120 VAC or 240 VAC. The control is set up at the factory for connection to 240 VAC.

To convert the day tank controller from 240 VAC to 120 VAC, perform the following steps.

- A. Remove the two jumpers between terminals **TB1-6** and **TB1-7** in the control box and connect one between terminals **TB1-5** and **TB1-6** and the other between terminals **TB1-7** and **TB1-8**.
- B. Move selector switch **S103** on the control PCB to the up position for 120V.
- C. On the control transformer, remove the two jumpers between terminals **H2** and **H3** and connect one between **H1** and **H3** and the other between **H2** and **H4**.

To convert the day tank controller from 120 VAC to 240 VAC, perform the following steps.

- A. Remove the jumpers between terminals **TB1-5** and **TB1-6**, and **TB1-7** and **TB1-8** in the control box and connect the two

jumpers between terminals **TB1-6** and **TB1-7**.

- B. Move selector switch **S103** on the control PCB to the down position for 240 VAC.
 - C. On the control transformer, remove the jumpers between terminals **H1** and **H3**, and **H2** and **H4** and connect the two jumpers between **H2** and **H3**.
2. Attach a tag to the control box indicating the supply voltage.
 3. To immediately shut down the engine when the **LO SHUTDOWN** light comes on, connect terminal **TB1-14** to a good grounding point on the engine block and terminal **TB1-15** to **A11 TB2-1** or **A11 TB2-3** (Customer Fault inputs) of the Detector control ECM.
 4. Terminals **TB1-10** through **TB1-17** and **TB2-23** through **TB2-27** are available for connections to remote annunciators or to either of the two customer fault inputs of the Detector control.
 5. Terminal **TB2-22** is available for connection of a grounding signal to activate the blank red light.
 6. Terminals **TB1-8** and **TB1-5** are available for connection of a 120 or 240 VAC electric fuel shutoff valve rated not more than 0.5 amps. The voltage rating of the valve must correspond with the voltage utilized for the pump. See Item 2 above.

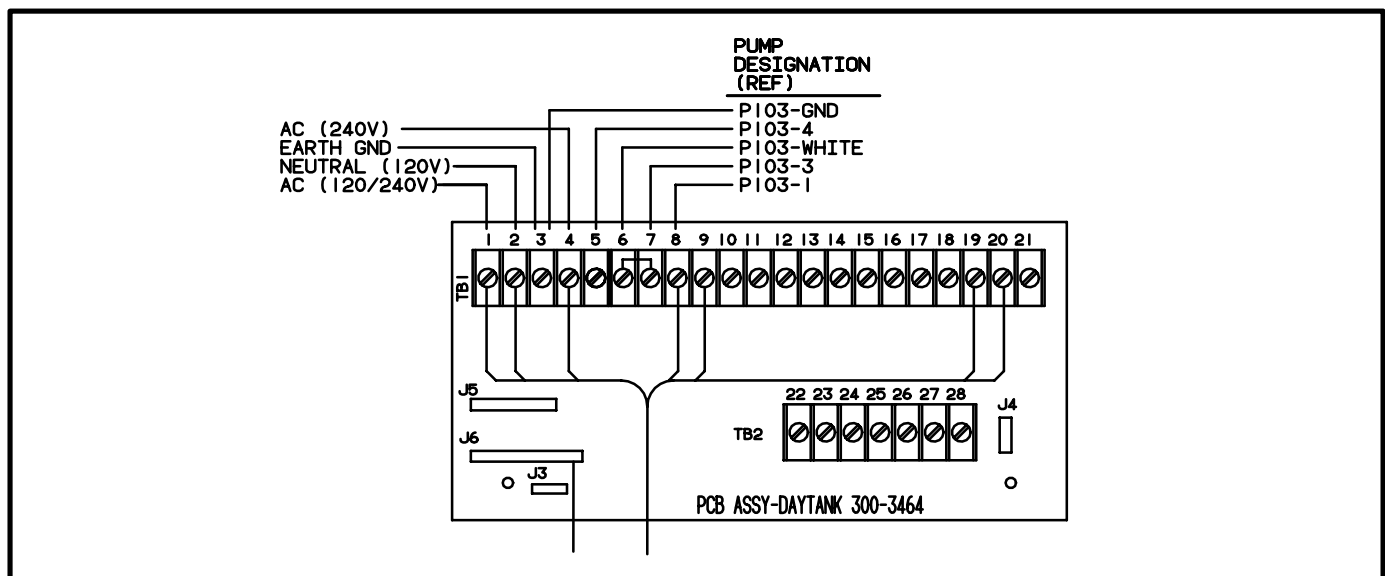


FIGURE 9-3. FUEL PUMP CONTROL TERMINAL BOARD

FUEL TRANSFER PUMP MOTOR CONNECTIONS

Connect a replacement fuel transfer pump motor as follows.

1. Remove the end bell cover for access to the motor wiring terminals.
2. Disconnect the brown lead from motor terminal **P103-3** and connect it to terminal **P103-6**. (Terminal **P103-6** is an insulated receptacle for securing the end of the lead so that it cannot move and touch the motor frame or a live terminal and cause a short circuit.)
3. Disconnect the red lead from motor terminal **P103-2**. It will be connected to the piggy-back
- terminal on the lead connected at motor terminal **P103-3**.
4. Cut the white lead from its ring connector at motor terminal **P103-4**. Strip 1/2 inch (12 mm) of insulation from the end of the white motor lead for splicing to the wire harness lead marked **P103-WHITE**.
5. Connect each lead of the five-lead wiring harness to the motor terminal or lead marked on it.
6. Connect the red motor lead to the piggy-back terminal at motor terminal **P103-3**.
7. Secure the end bell cover.

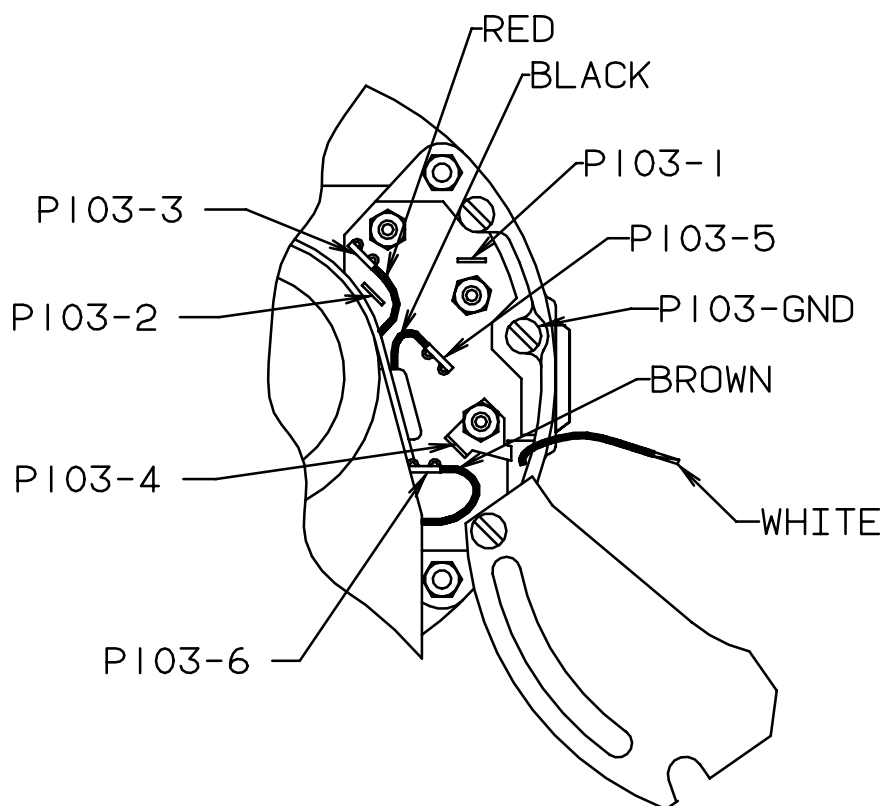


FIGURE 9-4. FUEL TRANSFER PUMP MOTOR CONNECTIONS

TESTING THE FLOAT SWITCH ASSEMBLY

The float switch assembly consists of 5 switches. Each switch has a pair of color coded leads connected to a common jack.

To test the float switches, remove the fuel pump control cover, disconnect the wiring jack and unscrew the assembly from the top of the day tank. Test as follows:

1. With an ohmmeter, test for electrical continuity (switch closed) between each pair of colored leads, while holding the assembly vertical. Replace the assembly if any switch is open (all the readings should be zero).
2. Lift each float, in turn, to 1/8 inch (3 mm) below the C-clip stop above it (use a feeler gauge) and test for electrical continuity. Replace the assembly if any switch does not open (all the readings should be infinity).
3. Use pipe thread sealant when replacing the assembly.

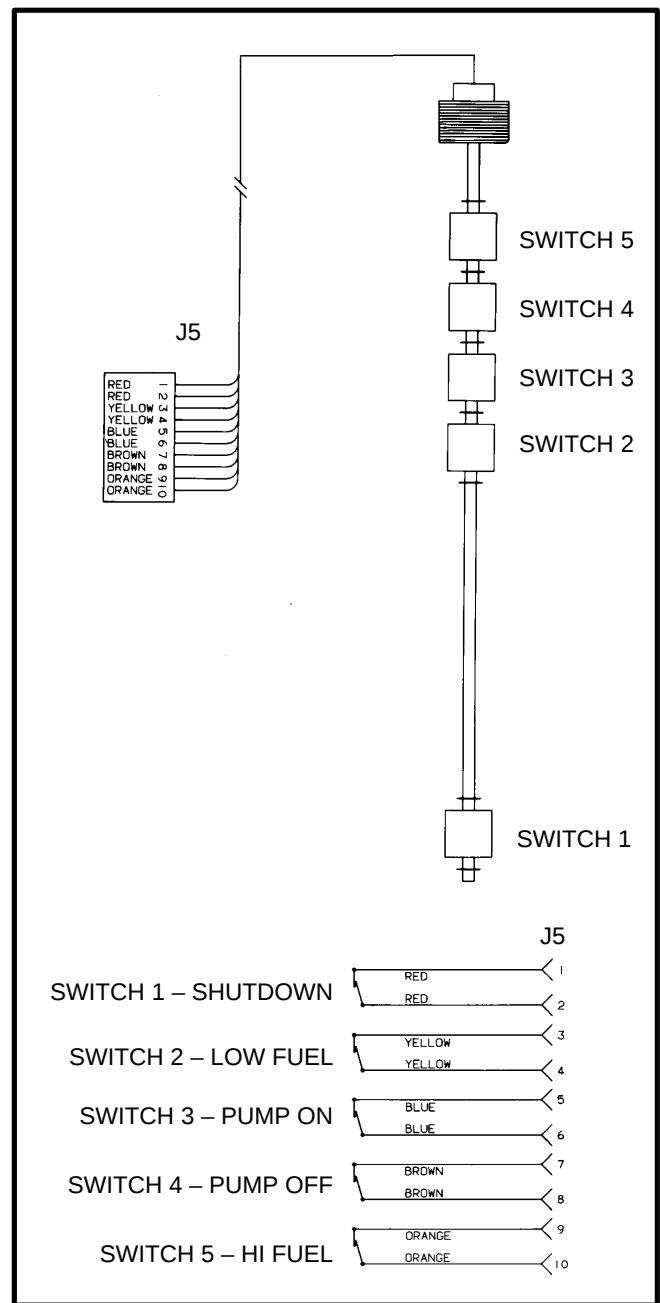


FIGURE 9-5. FLOAT SWITCH ASSEMBLY

10. Wiring Diagrams

This section consists of the schematic and connection wiring diagrams referenced in the text. The following drawings are included:

GENERAL

- Page 10-2, Generator Reconnection Diagrams, Sheet 1
- Page 10-3, Generator Reconnection Diagrams, Sheet 2
- Page 10-4, Day Tank Pump Control Wiring

DETECTOR CONTROL

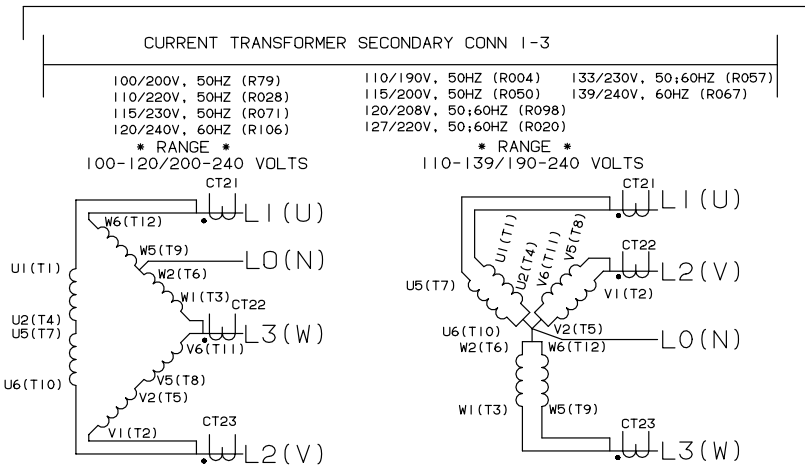
- Page 10-5, AC Control Wiring Diagram
- Page 10-6, Voltage Regulator Installation (PMG-Excited Generators)
- Page 10-7, Voltage Regulator Installation (Shunt-Excited Generators)
- Page 10-8, 7-light DC Wiring, Sheet 1
- Page 10-9, 7-light DC Wiring, Sheet 2
- Page 10-10, 12-light DC Wiring, Sheet 1
- Page 10-11, 12-light DC Wiring, Sheet 2
- Page 10-12, Typical Customer Connections At The Engine Control Monitor (ECM)
- Page 10-13, Auxiliary Relay Board (ARB)

SENTINEL CONTROL

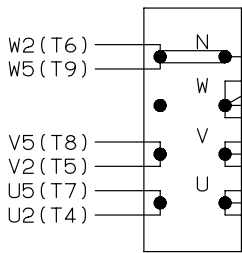
- Page 10-14, AC Control Wiring Diagram
- Page 10-15, DC Wiring
- Page 10-16, Voltage Regulator Installation (Shunt-Excited Generators)
- Page 10-17, Voltage Regulator Installation (PMG-Excited Generators)

UC GENERATORS

3 PHASE RECONNECTABLE, 12 LEAD

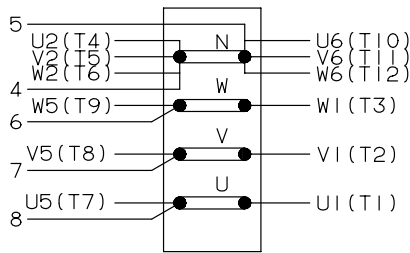


SERIES DELTA
3 PHASE 4 WIRE
OUTPUT TERMINALS
U.V.W.N.



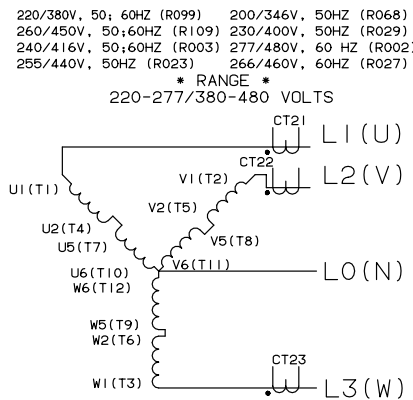
-01

PARALLEL STAR
3 PHASE 4 WIRE
OUTPUT TERMINALS
U.V.W.N.

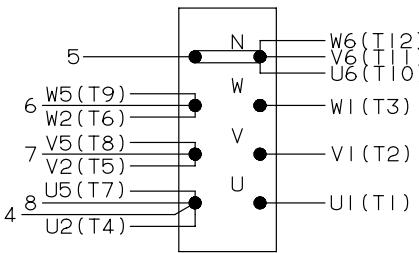


-02

CURRENT TRANSFORMER SECONDARY CONN 1-2

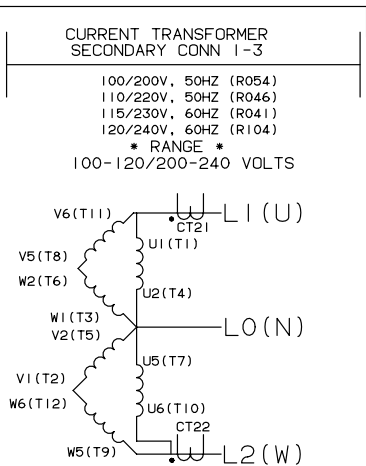


SERIES STAR
3 PHASE 4 WIRE
OUTPUT TERMINALS
U.V.W.N.

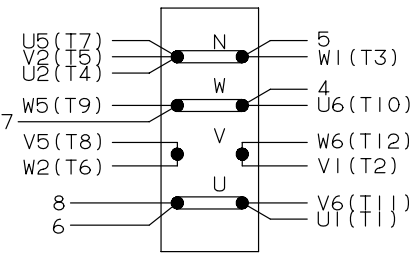


-03

1 PHASE RECONNECTABLE, 12 LEAD

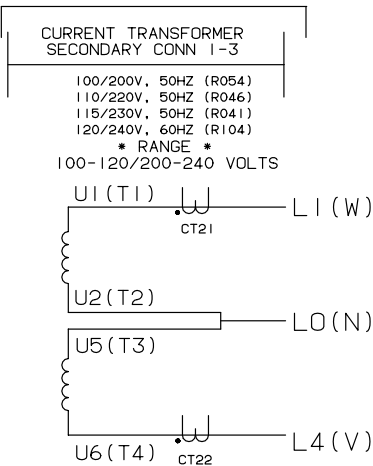


DOUBLE DELTA
1 PHASE 3 WIRE
OUTPUT TERMINALS
U.W. CENTER TAP N.

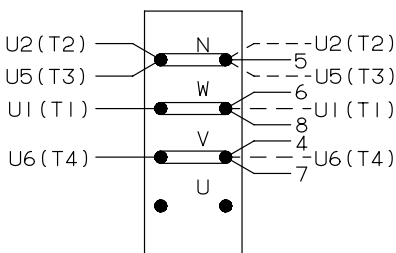


-04

1 PHASE NON-RECONNECTABLE, 4 LEAD



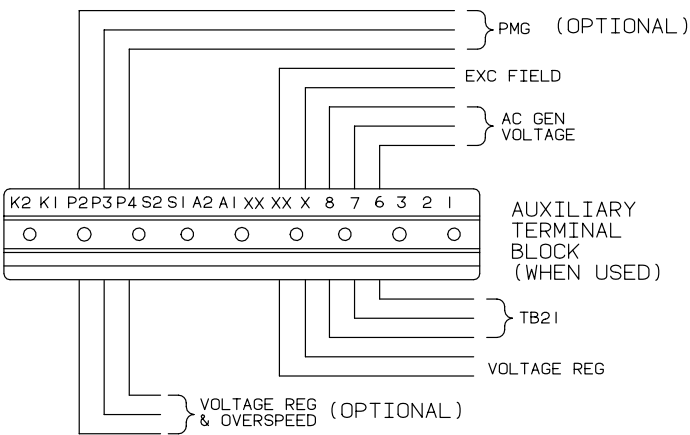
1 PHASE 3 WIRE
OUTPUT TERMINALS
W, V, CENTER TAP N



-05

NOTES:

1. UVW PHASE SEQUENCE WITH C.W. ROTATION FACING DRIVE END.
2. 347/600 VOLTS - IF VOLTAGE REGULATOR SX440 ONAN P/N 300-3607 IS SPECIFIED, CONNECT GENERATOR TAP STATOR LEADS 7 & 8 TO VR21-P2 & VR21-P3 RESPECTIVELY. INSULATE AND TIE #6 LEAD BACK.
3. 347/600 VOLTS - IF VOLTAGE REGULATOR ONAN P/N 300-3606 INSULATE AND TIE BACK GENERATOR TAP STATOR LEADS 6,7 & 8.
4. 240/480 VOLTS - IF VOLTAGE REGULATOR SX440 ONAN P/N 300-3607 IS SPECIFIED, CONNECT LEAD FROM W6 (U) AND W5 (N) TO VR21-P2 AND VR21-P3 RESPECTIVELY.
5. 1 PHASE NON-RECONNECTABLE: LARGER KW GENSETS HAVE 8 OUTPUT TERMINALS SMALLER KW HAVE 4.
6. WHEN RECONNECTING GENERATOR LEADS, BOLTS SHOULD BE TORQUED AT 22 ±2 FT-LBS.
7. 347/600 VOLTS - IF VOLTAGE REGULATOR SX460 ONAN PART #300-4830 IS SPECIFIED, CONNECT STATOR TAP LEAD 8 TO CB21-1 ON CONTROL PANEL. CONNECT TAP LEADS 6 & 7 TO AVR-6 & 7.
8. WHEN NON-DETECTOR CONTROLS ARE USED AT 600V
 - 8.1 SX460 AVR
CONNECT STATOR TAP LEAD 8 TO CB21-1 ON CONTROL PANEL. CONNECT TAPS 6 & 7 TO AVR
 - 8.2 MX321 AVR WITHOUT AC METERS:
CONNECT STATOR TAP LEADS 6, 7, & 8 TO ISOLATION XFMR BOARD T30-INPUT-6, 7, & 8.
 - 8.3 MX321 WITH AC METERS:
INSULATE AND TIE BACK STATOR TAP LEADS 6, 7, & 8.

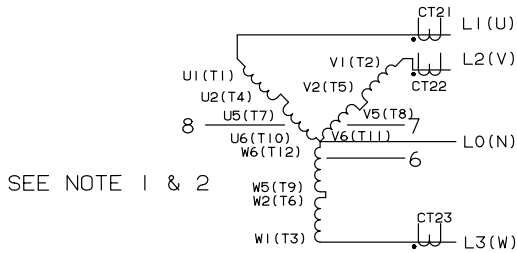


CONTROL INPUT "DETECTOR"				
CONTROL INPUT TB21	SERIES DELTA	PARALLEL STAR	SERIES STAR	DOUBLE DELTA
22	8	8	8	8
23	7	7	7	7
24	4	4	4	4
25	6	6	6	6
26	5	5	5	5
JUMPER	—	—	—	—

3 PHASE RECONNECTABLE

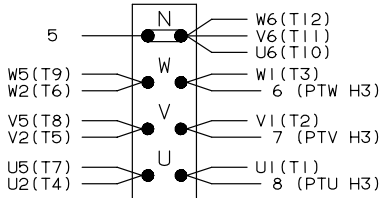
CURRENT TRANSFORMER
SECONDARY CONN 1 - 2

347/600V, 60HZ (R114)

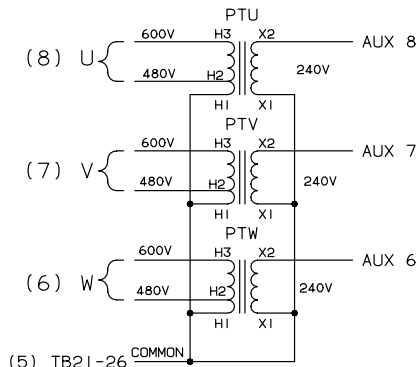


SEE NOTE 1 & 2

SERIES STAR
3 PHASE 4 WIRE
OUTPUT TERMINALS
U.V.W.N.



TRANSFORMER



REFERENCE ONLY
P/N 319-1246

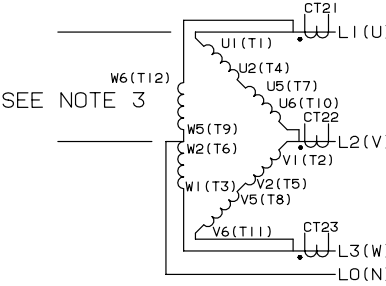
NOTE: JUMPER TB21-21 TO TB21-24
IN THE CONTROL

-06

3 PHASE NON-RECONNECTABLE

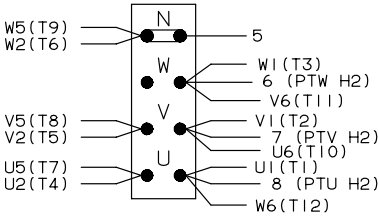
CURRENT TRANSFORMER SECONDARY CONN 1 - 2

220/440V, 50 HZ (R019)
240/480V, 60 HZ (R119)

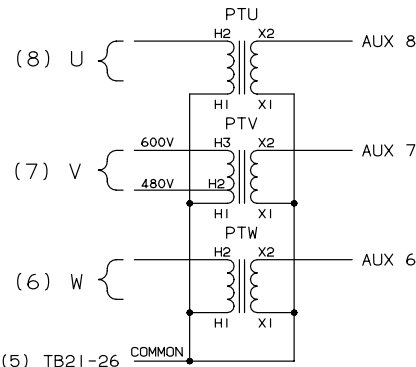


SEE NOTE 3

SERIES DELTA
3 PHASE 4 WIRE
OUTPUT TERMINALS
U.V.W.N.



TRANSFORMER



REFERENCE ONLY
P/N 319-1246

NOTE: JUMPER TB21-21 TO TB21-24
IN THE CONTROL

-07

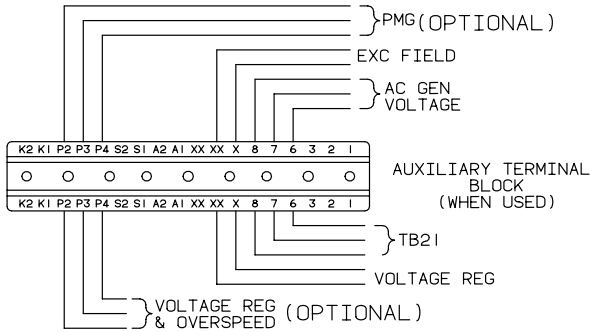
NOTES:

- 347/600 VOLTS - IF VOLTAGE REGULATOR SX440 ONAN P/N 300-3607 IS SPECIFIED, CONNECT GENERATOR TAP STATOR LEADS 7 & 8 TO VR21-P2 & VR21-P3 REPECTIVELY. INSULATE AND TIE #6 LEAD BACK.
- 347/600 VOLTS - IF VOLTAGE REGULATOR ONAN P/N 300-3606 INSULATE AND TIE BACK GENERATOR TAP STATOR LEADS 6,7 & 8.
- 240/480 VOLTS - IF VOLTAGE REGULATOR SX440 ONAN P/N 300-3607 IS SPECIFIED, CONNECT LEAD FROM W6 (U) AND W5 (N) TO VR21-P2 AND VR21-P3 RESPECTIVELY.

D2 4. WHEN RECONNECTING GENERATOR LEADS, BOLTS SHOULD BE TORQUED AT 22 ±2 FT-LBS.

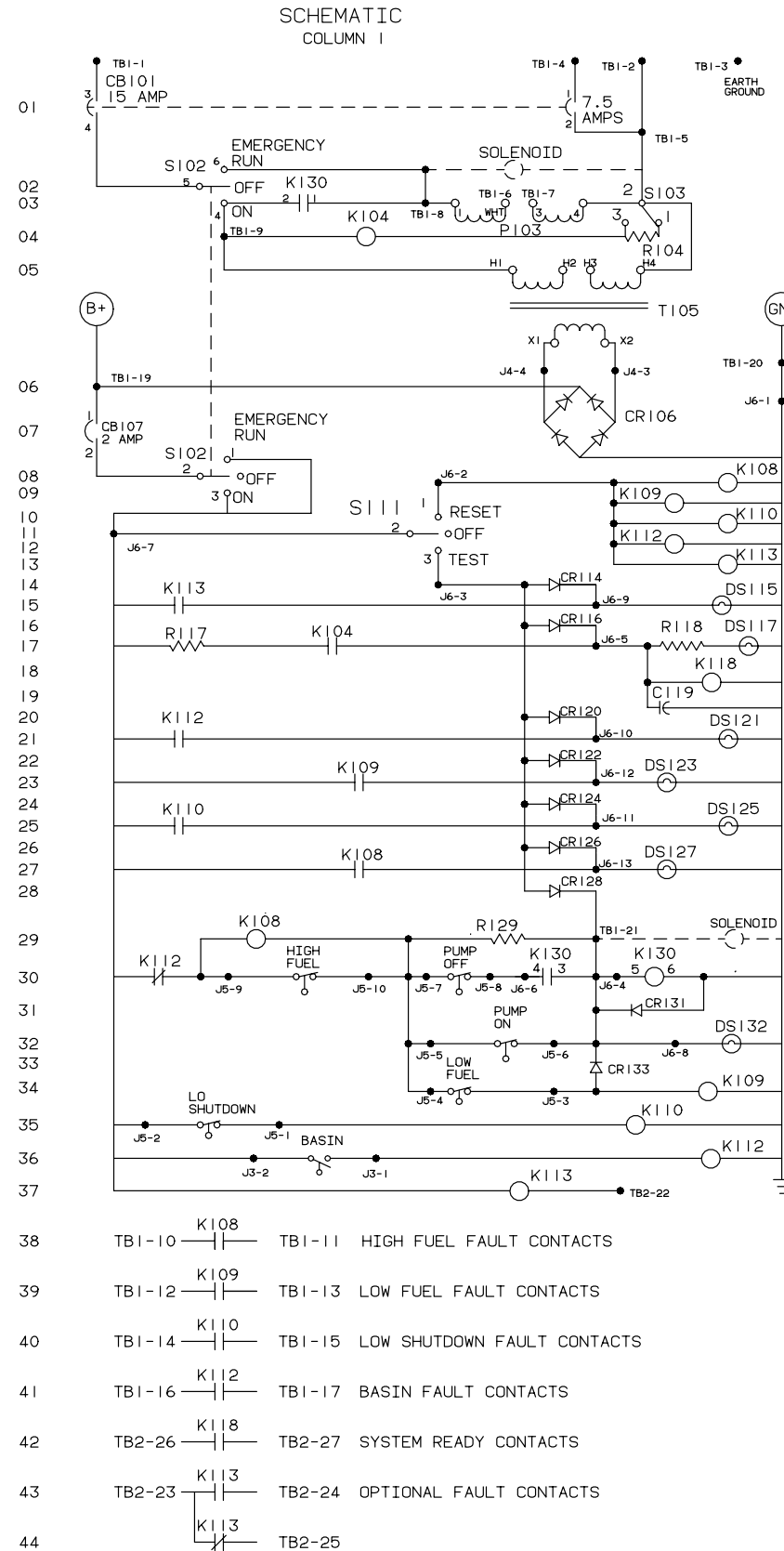
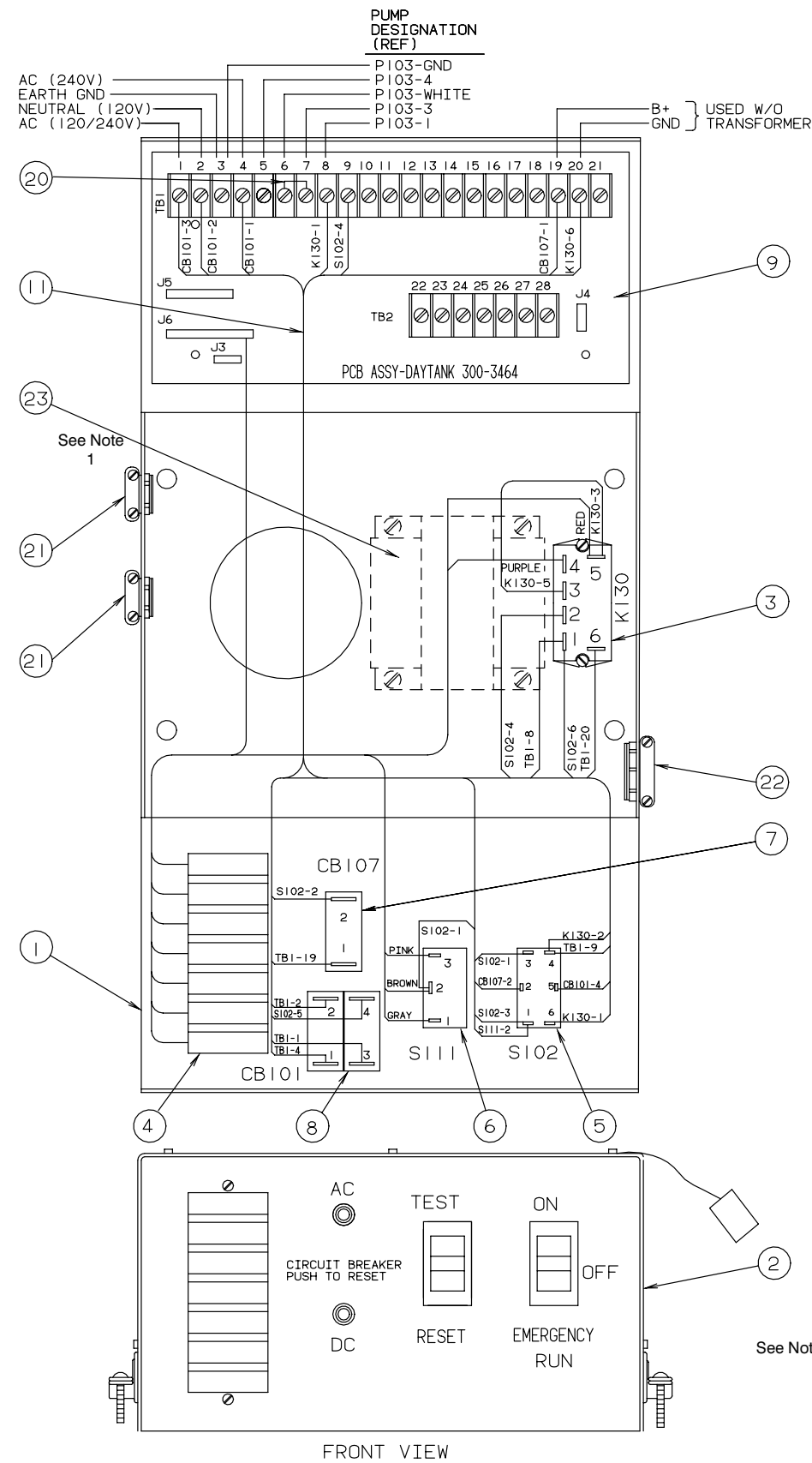
F2 5. 347/600 VOLTS - IF VOLTAGE REGULATOR SX460 ONAN PART #300-4830 IS SPECIFIED, CONNECT STATOR TAP LEAD 8 TO CB21-1 ON CONTROL PANEL. CONNECT TAP LEADS 6 & 7 TO AVR-6 & 7.

- WHEN NON-DETECTOR CONTROLS ARE USED AT 600V
 - SX460 AVR
CONNECT STATOR TAP LEAD 8 TO CB21-1 ON CONTROL PANEL. CONNECT TAPS 6 & 7 TO AVR
 - MX321 AVR WITHOUT AC METERS:
CONNECT STATOR TAP LEADS 6, 7, & 8 TO ISOLATION XFMR BOARD T30-INPUT-6, 7, & 8.
 - MX321 WITH AC METERS:
INSULATE AND TIE BACK STATOR TAP LEADS 6, 7, & 8.



CONTROL INPUT "DETECTOR"			
6 OR 12 LEAD			
CONTROL INPUT TB21	AUX TERM CON	SERIES STAR 347/600V	SERIES DELTA 240/480V
22	8	8	8
23	7	7	7
24	-	-	-
25	6	6	6
26	-	5	5
JUMPER	-	21 - 24	21 - 24

No. 625-3061 sh 2 of 2
Rev. F Sys: CADAM
Modified 5/1/96



CB101-2 POLE AC CIRCUIT BREAKER, 15 AMP, 7.5 AMP

S102-2 POLE SWITCH
P103 - 120/240V PUMP MOTOR

K104 - SYSTEM READY INTERLOCK 17

T105 - 120/240V TRANSFORMER

CR106- RECTIFIER BRIDGE

CB107 - 2 AMP CIRCUIT BREAKER

K108-HIGH FUEL RESET 27, 29, 38
K109-LOW FUEL RESET 23, 34, 39
K110-LO SHUTDOWN RESET 25, 35, 40
S111-SINGLE POLE SWITCH
K112-BASIN FAULT RESET 21, 36, 41, 30
K113-OPTIONAL FAULT RESET 15, 37, 43, 44

DS115-OPTIONAL FAULT LAMP

DS117-SYSTEM READY LAMP

K118-SYSTEM READY RELAY 42

DS121-BASIN FAULT LAMP

DS123-LOW FUEL FAULT LAMP

DS125-LO SHUTDOWN FAULT LAMP

DS127-HIGH FUEL FAULT LAMP

K108-HIGH FUEL SET 08, 27, 38

K130-PUMP RELAY 03, 30

DS132-PUMP RUN LAMP

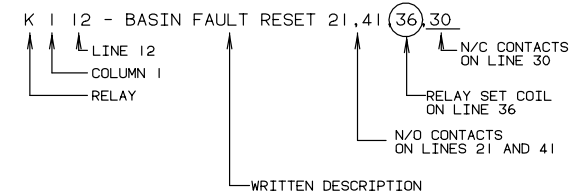
K109-LOW FUEL SET 09, 23, 39

K110-LO SHUTDOWN SET 10, 25, 40

K112-BASIN FAULT SET 12, 21, 41, 30

K113-OPTIONAL FAULT SET 13, 15, 43, 44

SCHEMATIC KEY:
EACH COMPONENT IS LOCATED BY PART NUMBER. ON THE RIGHT HAND SIDE, A DESCRIPTION IS GIVEN OF THE PART AND ITS FUNCTIONAL LOCATIONS.

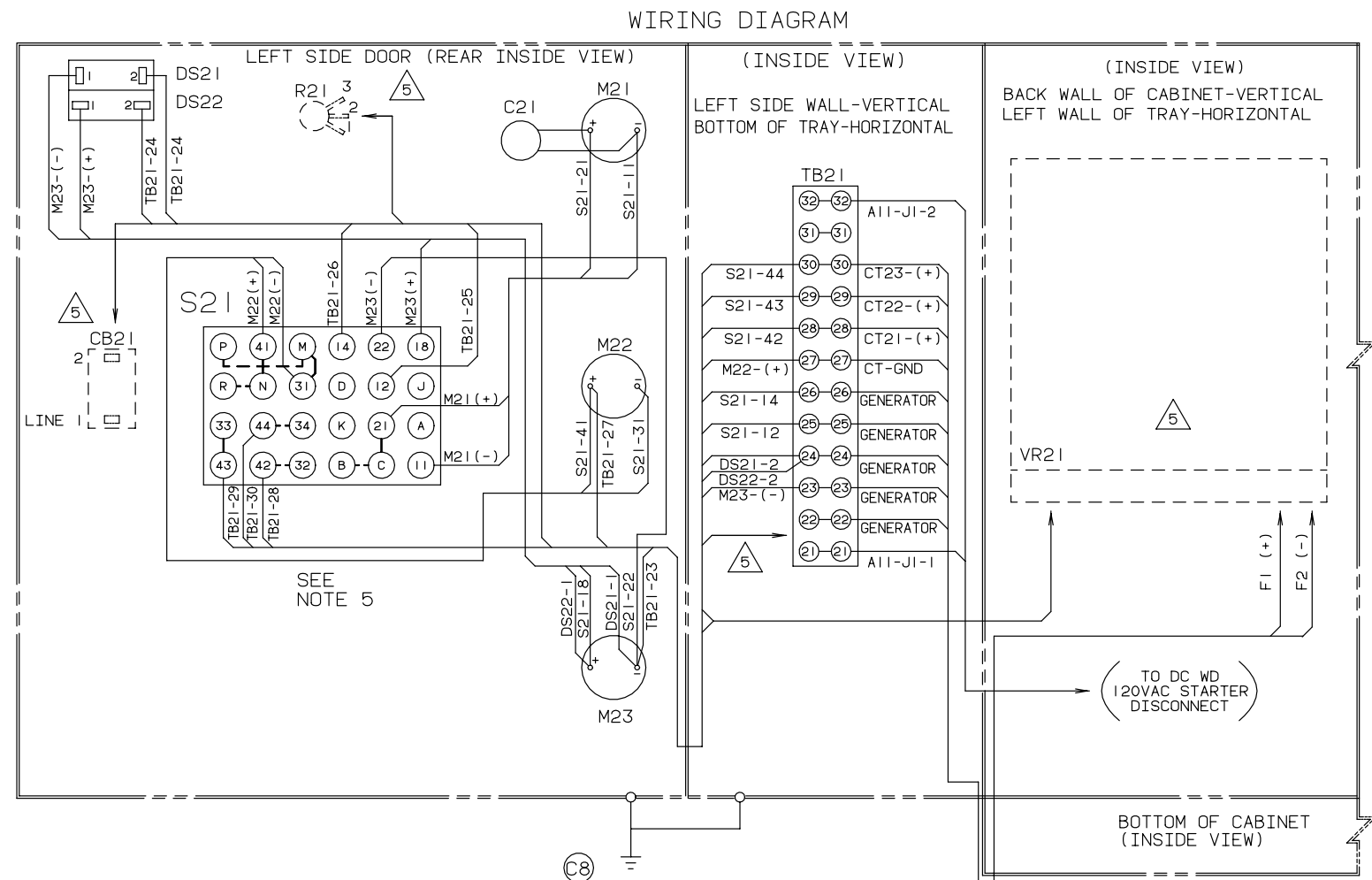
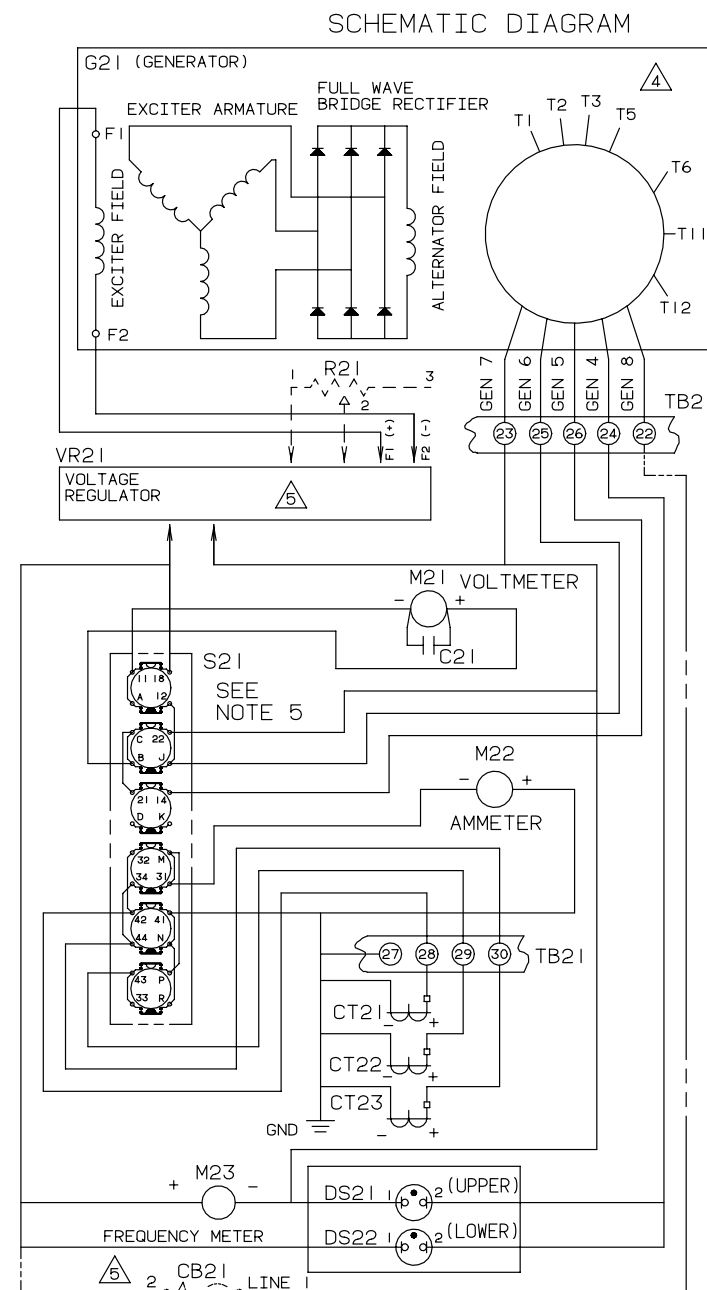


23	TRANSFORMER
22	CONNECTOR-KNOCKOUT
21	CONNECTOR-ROMEX
20	JUMPER-TERMINAL
19	
18	
17	
16	
15	
14	
13	
12	
11	HARNESS-CONTROL
10	
9	CIRCUIT BOARD ASSY.
8	CIRCUIT BREAKER 2 POLE
7	CIRCUIT BREAKER 1 POLE
6	SWITCH-ROCKER
5	SWITCH-ROCKER
4	LAMP ASSY.-7 LITE
3	RELAY-2PST
2	COVER-CONTROL
1	CONTROL BOX
ITEM	DESCRIPTION OR MATERIAL

NOTES:

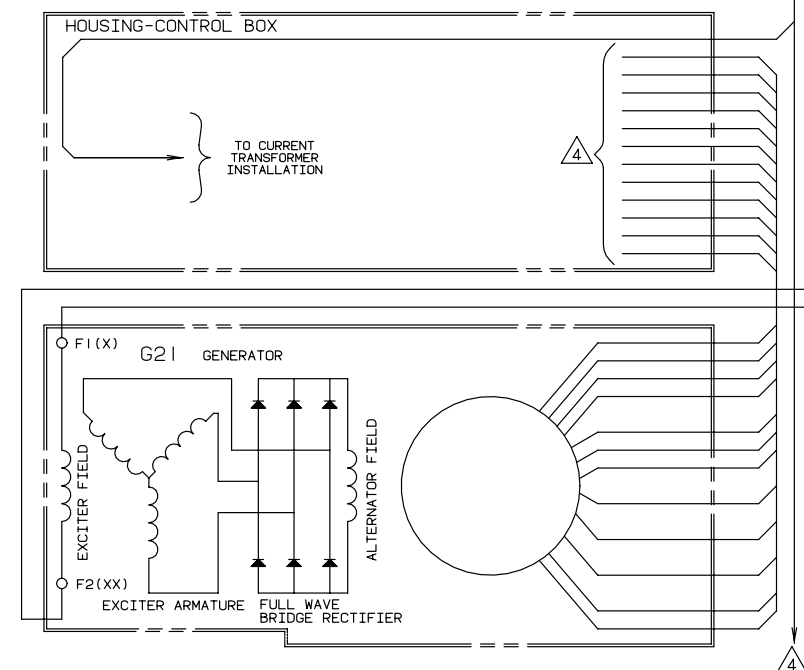
- Item 23, transformer, is not included for kits where battery connections will be made at TB1-19 and TB1-20.
- Tag the control box to indicate supply voltage.

No. 625-2141 sh 1 of
Rev. H Sys:
Modified



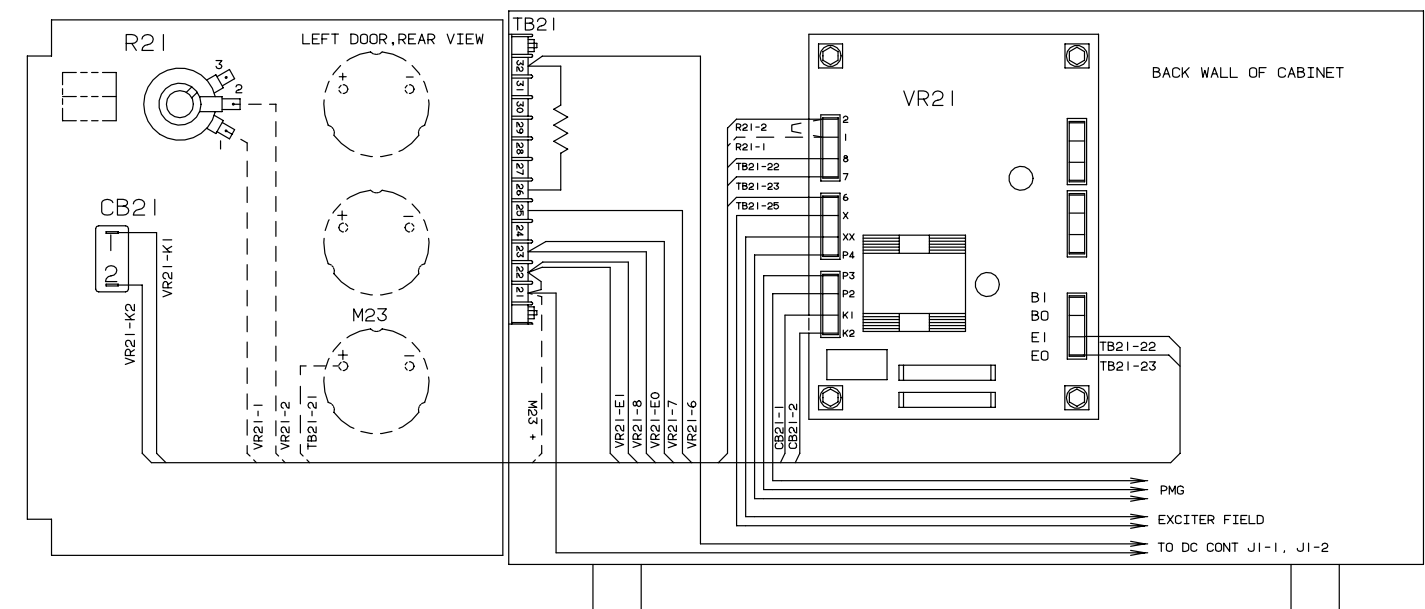
POSITION	CONTACTS CLOSED				
L1-L2 30	11-18	C-22	32-M	44-N	33-R
L2-L3 30	A-12	C-22	44-N	42-41	43-P
L3-L1 30	11-18	B-J	34-31	42-41	33-R
L1-L0 30	11-18	21-14	44-N	42-41	33-R
OFF	—	—	44-N	42-41	33-R
L1-L2 10	11-18	C-22	32-M	44-N	33-R
L1-L2 10	11-18	C-22	44-N	42-41	43-P

TABULATION	
DESIGNATION	WIRE COLOR
CT21-I	PNK/BLK
CT22-I	PRP/BLK
CT23-I	ORN/BLK
CT COMMON	GRY/BLK
GEN 4	LT GRN/BLK
GEN 5	TAN/BLK
GEN 6	RED/BLK
GEN 7	YEL/BLK
GEN 8	DK BLU/BLK



AC CONTROL WIRING DIAGRAM

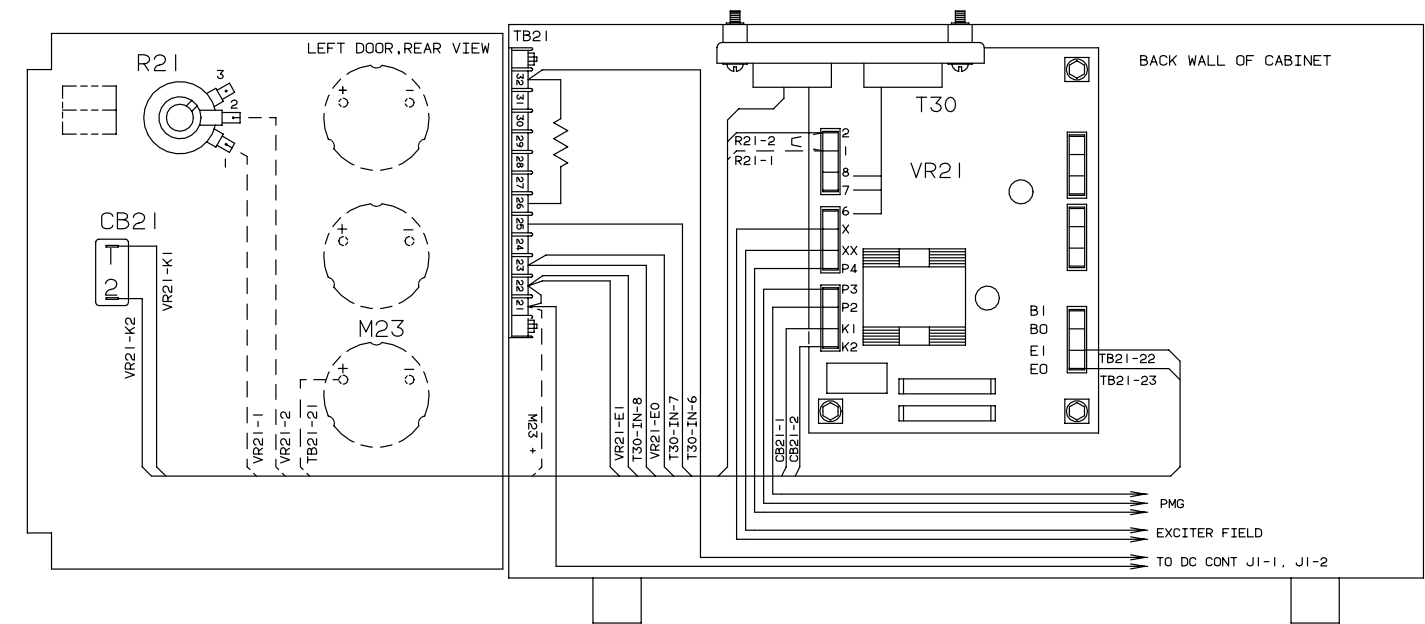
**(-05 & -06 ALL VOLTAGES)
(-03 & -04, 600 V)**



NOTES

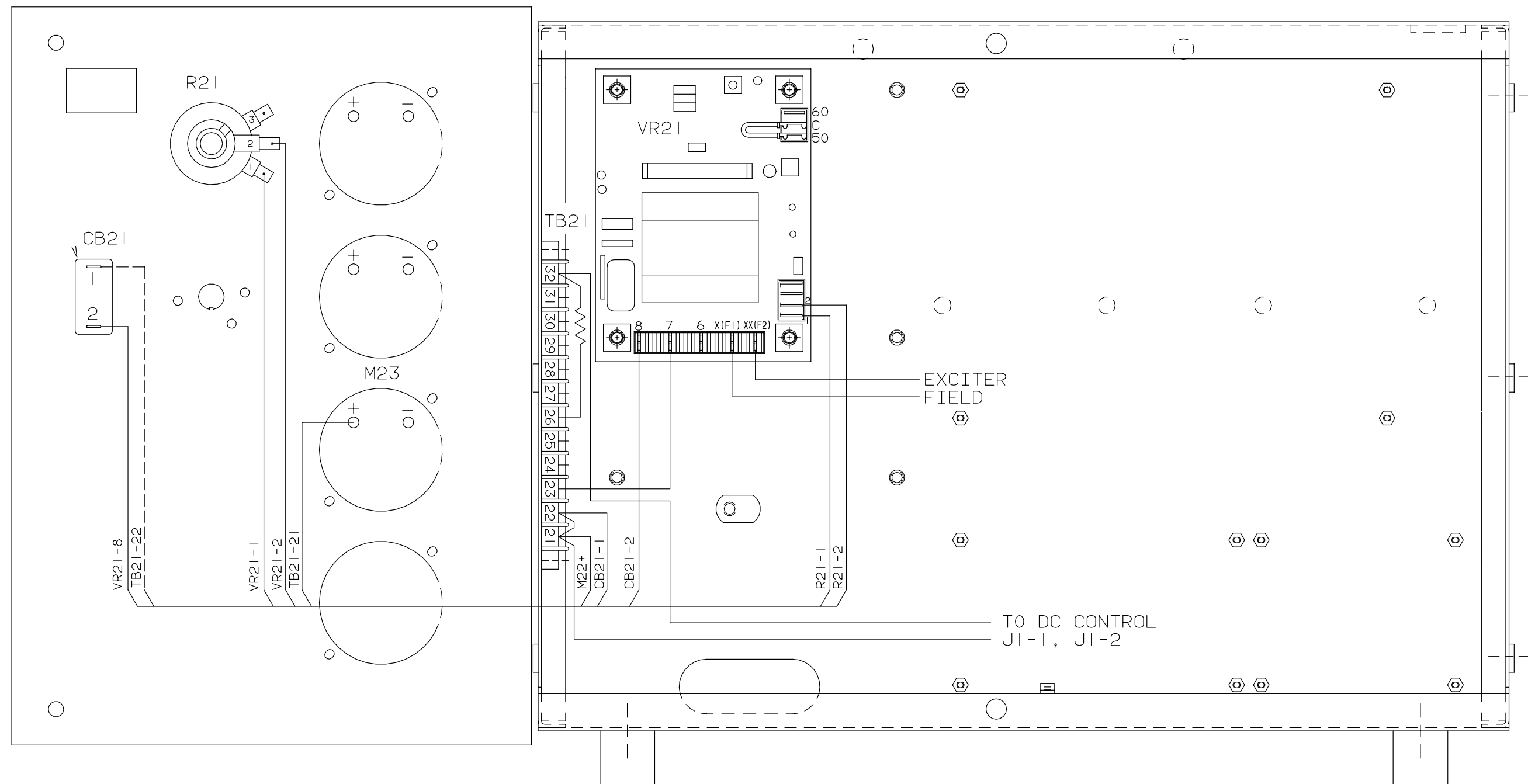
1. DASHED LEADS INDICATE WHEN USED
2. FOR 1Ø GENERATOR OPERATION:
DISCONNECT LEAD FROM TB21-25
TO T30-IN-6 AND DISCARD.
MOVE LEAD END ON T30-OUT-6 TO VR21-8.
3. -01, -03 & -05: NO AC METERS.
-02, -04 & -06: WITH AC METERS.
4. PMG NOT USED WITH AVR SX421: -05 & -06.

(-01 & -02, <600 V)



MX321
SX421

No. 300-4890 sh 1 of 1
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Modified 10/24/96

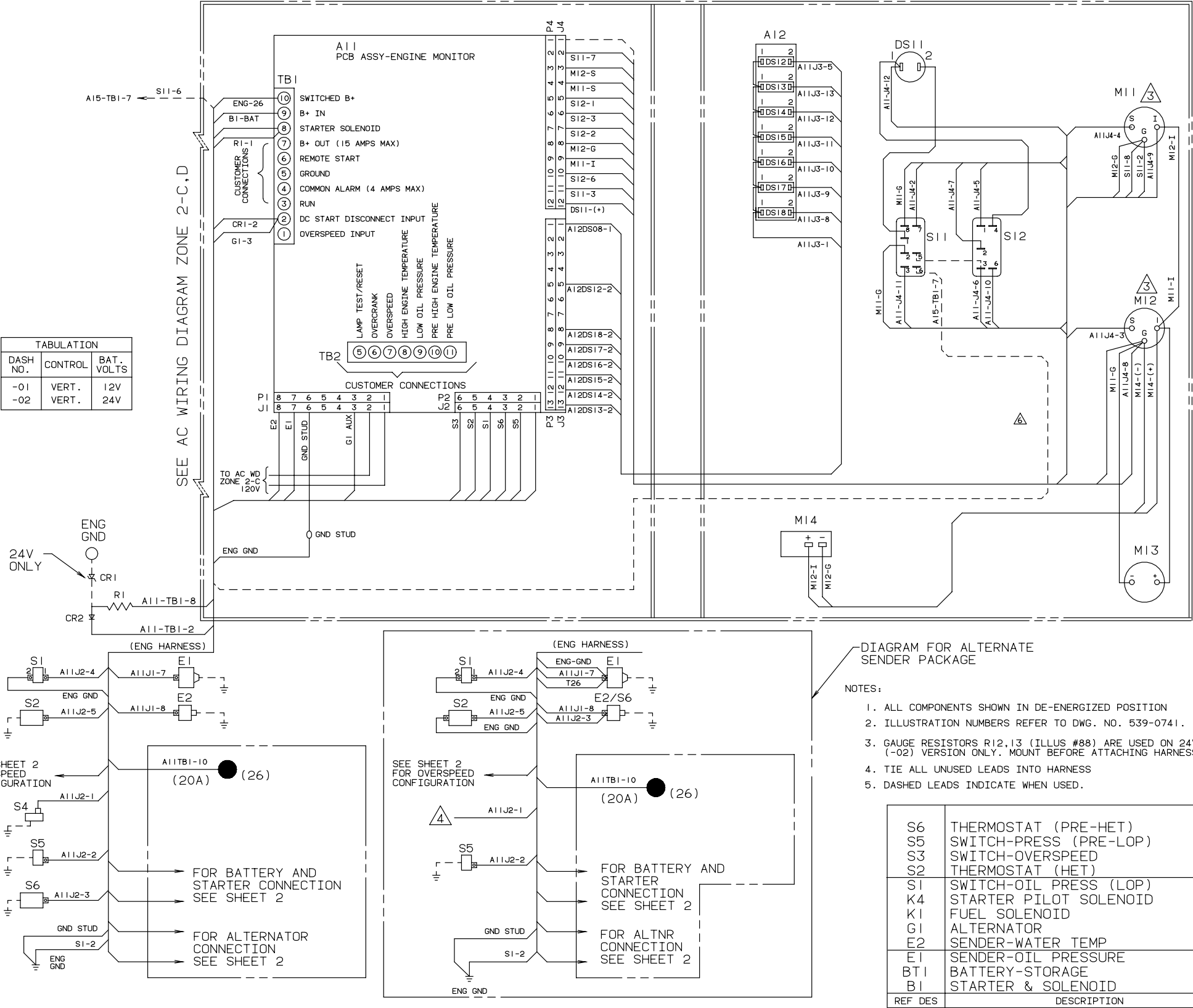


No. 300-4830 sh 1 of 1
Rev. E Sys: CADAM
Modified 10/24/96

VOLTAGE REGULATOR INSTALLATION (SHUNT-EXCITED GENERATORS)

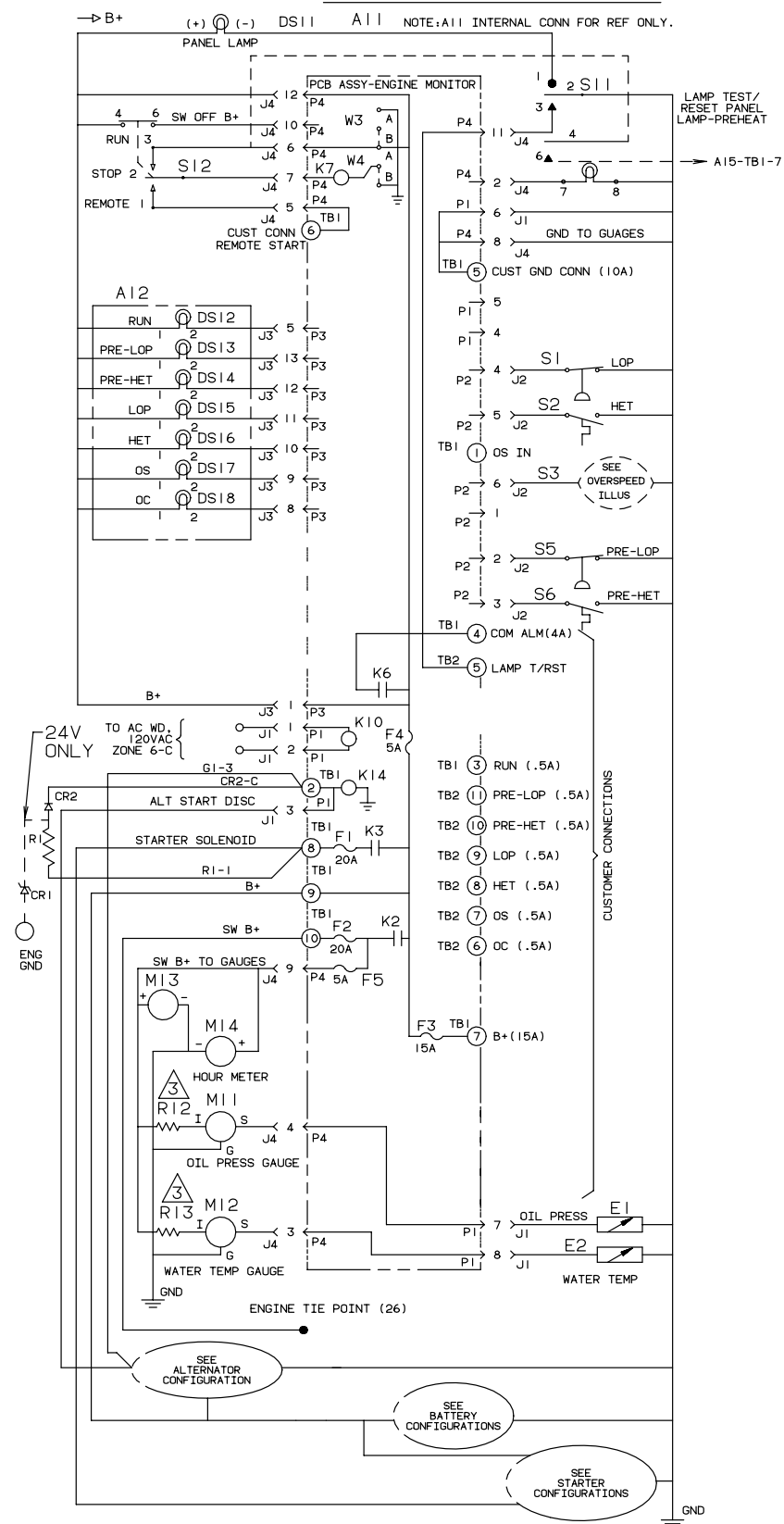
BACK CABINET-VERTICAL
SIDE WALL-HORIZONTAL

RIGHT SIDE DOOR
(INSIDE VIEW)

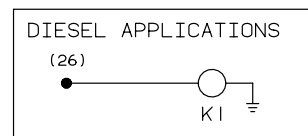


No. 612-6691 sh 2 of 2
Rev. B Sys: CADAM
Modified 4/30/96

SCHEMATIC DIAGRAM



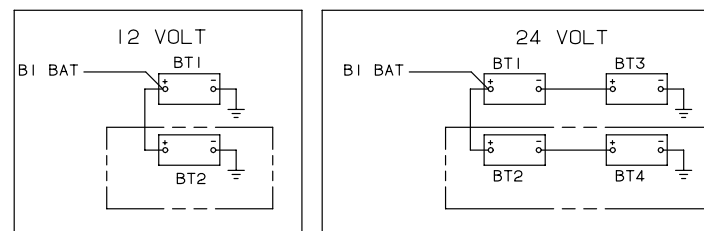
IGNITION SYSTEMS



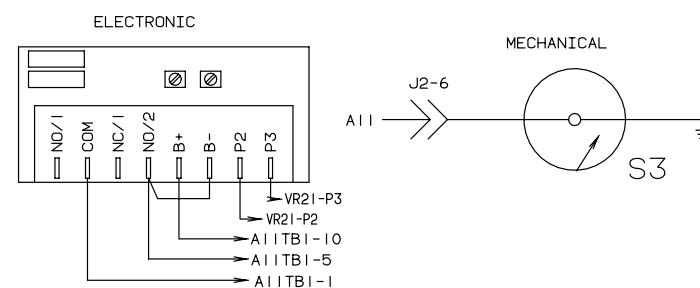
STARTER CONFIGURATIONS



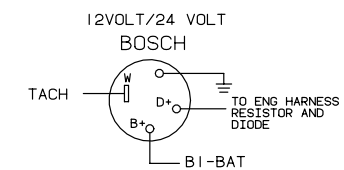
BATTERY CONFIGURATIONS



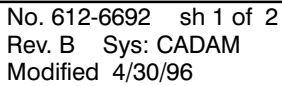
OVERSPEED CONFIGURATION



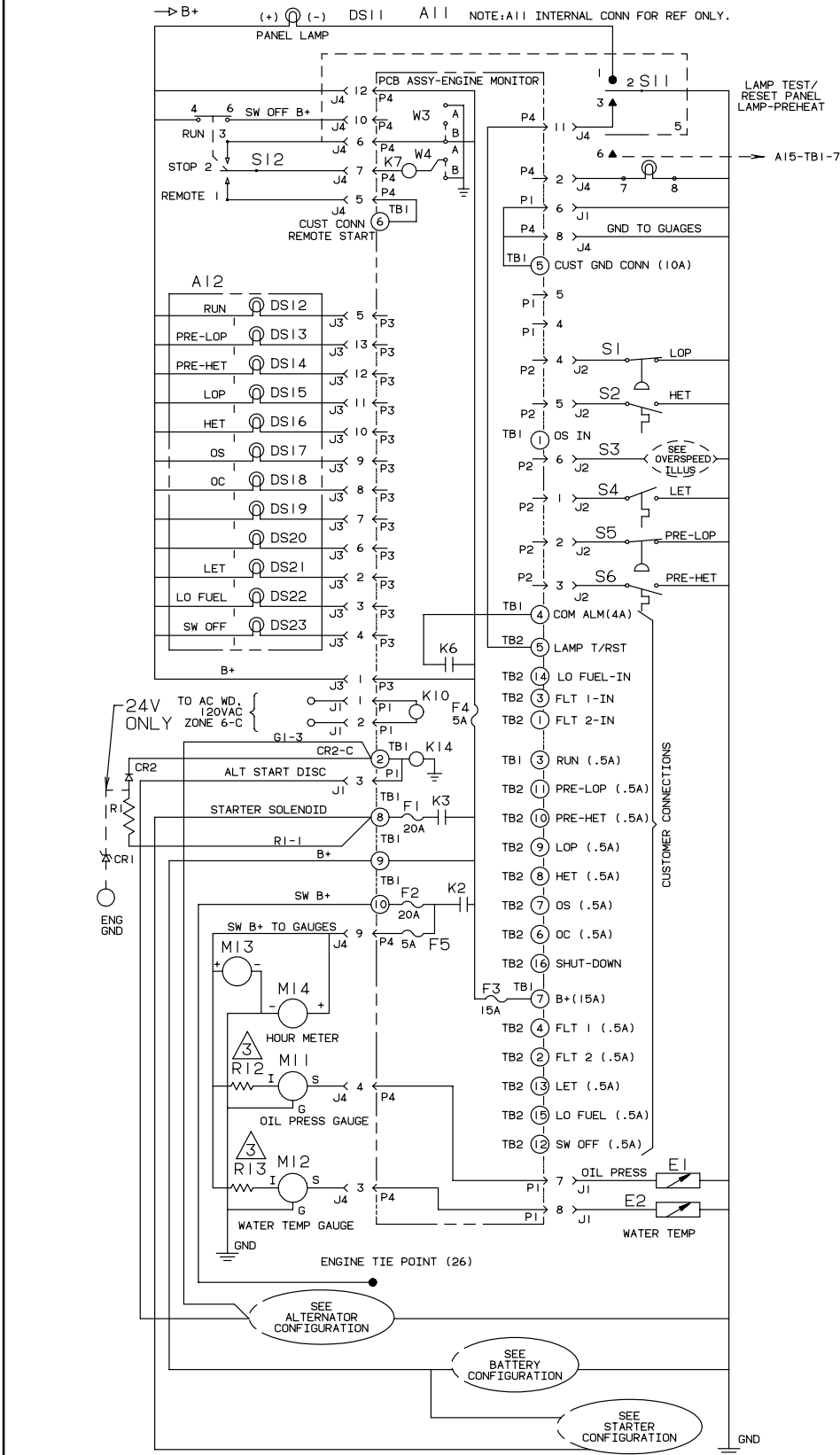
ALTERNATOR CONFIGURATIONS



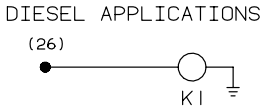
No. 612-6691 sh 2 of 2
Rev. B Sys: CADAM
Modified 4/30/96



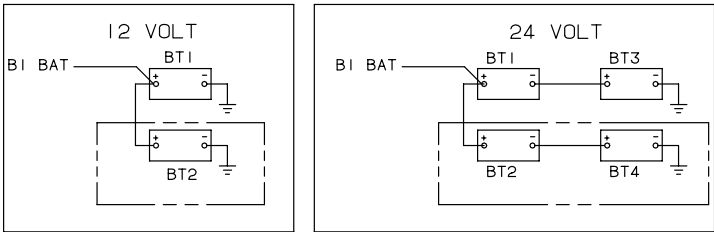
SCHEMATIC DIAGRAM



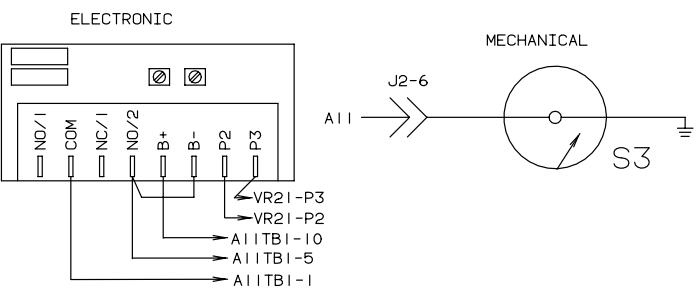
IGNITION SYSTEMS



BATTERY CONFIGURATIONS

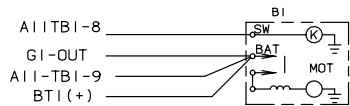


OVERSPEED CONFIGURATION

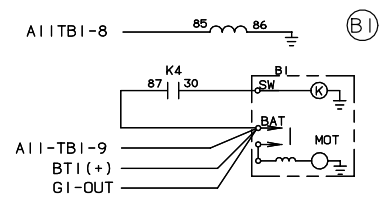


STARTER CONFIGURATIONS

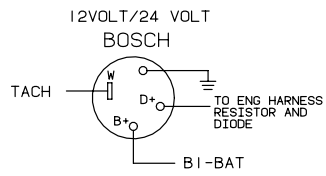
SOLENOID SHIFT "C" BLOCK
12VDC/24VDC



SOLENOID SHIFT "B" BLOCK
12VDC/24VDC



ALTERNATOR CONFIGURATIONS



TB1-10 (SWITCHED B+ OUTPUT) FUSED AT 20 AMPS, ENERGIZED WHEN THE START SIGNAL IS APPLIED AND DE-ENERGIZED AT SHUTDOWN (NORMAL AND FAULT)

TB1-9 (B + INPUT) BATTERY POSITIVE (+) CONNECTION

TB1-8 (START SOLENOID) FUSED AT 20 AMPS

TB1-7 (B+ OUTPUT) OUTPUT TO TIME DELAY START/STOP MODULE A15 (WHEN USED), FUSED AT 15 AMPS, AVAILABLE WHEN THE STARTING BATTERIES ARE CONNECTED

TB1-6 (REMOTE START) CONNECTED TO TIME DELAY START/STOP MODULE A15 (WHEN USED), CONNECT REMOTE START CONTACT OF THE AUTOMATIC TRANSFER SWITCH TO TERMINAL TB1-5 OF MODULE A15 (WHEN USED) OR TB1-6 OF EMB

TB1-5 (GROUND)

TB1-4 (COMMON ALARM B+ OUTPUT) 4 AMP RATED DEVICE MAXIMUM

TB1-3 (RUN) CONNECTED TO TIME DELAY START/STOP MODULE A15 (WHEN USED)

TB1-2 (DC DISCONNECT) CONNECTED TO TIME DELAY START/STOP MODULE A15 (WHEN USED)

TB2-1 (FAULT 2) GROUND INPUT FROM SENDER

TB2-2 (FAULT 2) GROUND OUTPUT TO LIGHT/RELAY*

TB2-3 (FAULT 1) GROUND INPUT FROM SENDER

TB2-4 (FAULT 1) GROUND OUTPUT TO LIGHT/RELAY*

TB2-5 (REMOTE RESET) MOMENTARY CONTACT TO GROUND

TB2-6 (OVERCRANK FAULT) GROUND OUTPUT TO LIGHT/RELAY*

TB2-7 (OVERSPEED FAULT) GROUND OUTPUT TO LIGHT/RELAY*

TB2-8 (HIGH ENGINE TEMPERATURE FAULT) GROUND OUTPUT TO LIGHT/RELAY*

TB2-9 (LOW OIL PRESSURE FAULT) GROUND OUTPUT TO LIGHT/RELAY*

TB2-10 (PRE-HIGH ENGINE TEMPERATURE WARNING) GROUND OUTPUT TO LIGHT/RELAY*

TB2-11 (PRE-LOW OIL PRESSURE WARNING) GROUND OUTPUT TO LIGHT/RELAY*

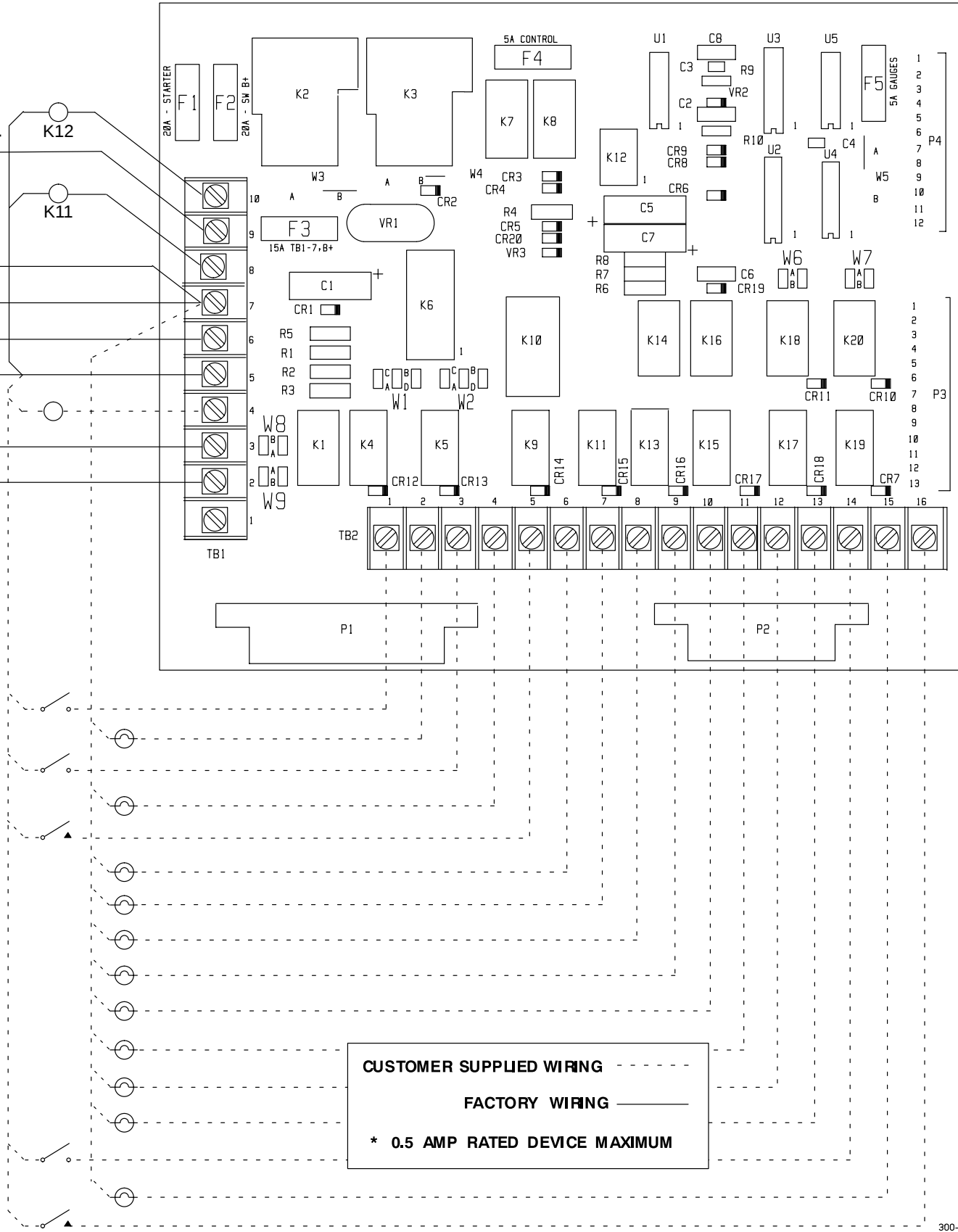
TB2-12 (SWITCH OFF WARNING) GROUND OUTPUT TO LIGHT/RELAY*

TB2-13 (LOW ENGINE TEMPERATURE WARNING) GROUND OUTPUT TO LIGHT/RELAY*

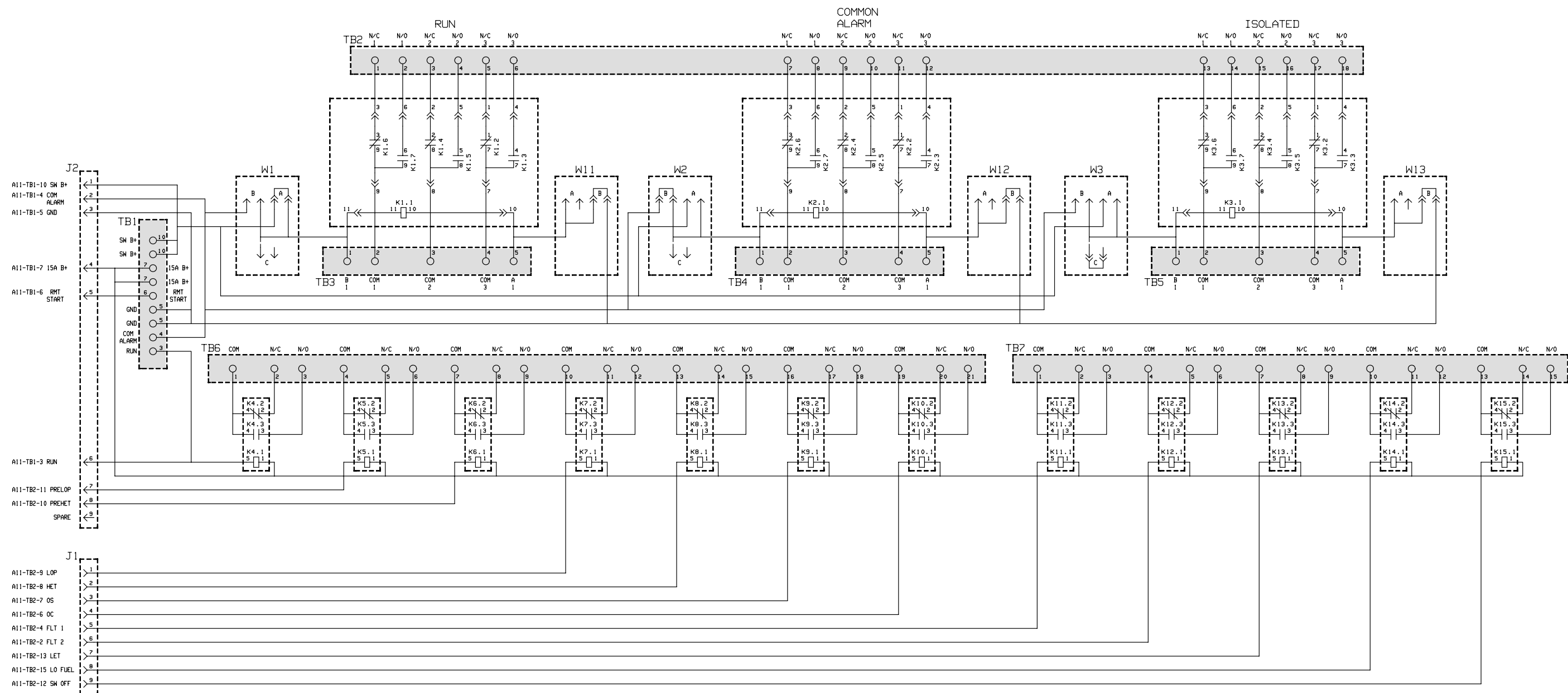
TB2-14 (LOW FUEL WARNING) GROUND INPUT FROM SENDER

TB2-15 (LOW FUEL WARNING) GROUND OUTPUT TO LIGHT/RELAY*

TB2-16 (EMERGENCY SHUT DOWN) MOMENTARY CONTACT TO GROUND

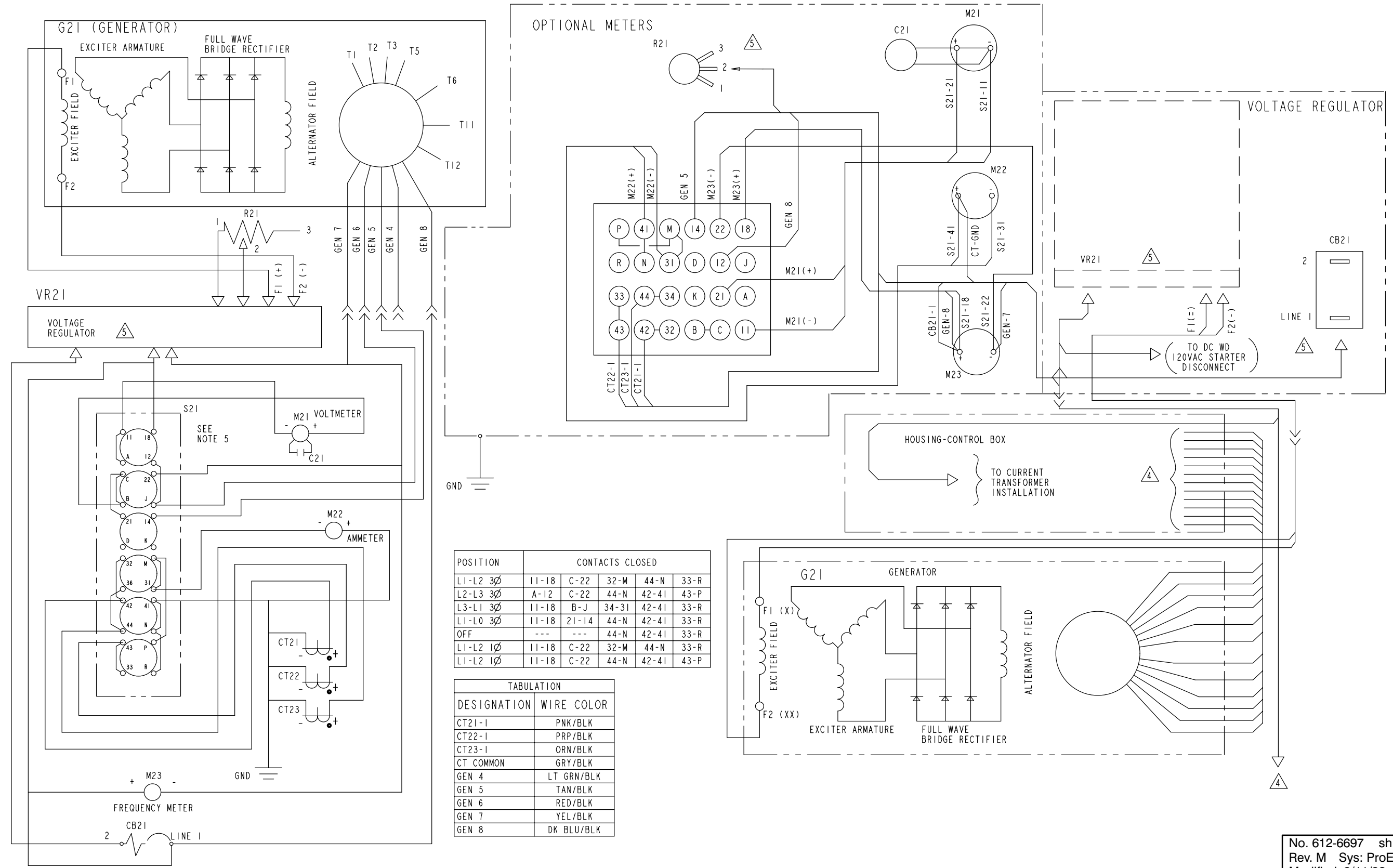


TYPICAL CUSTOMER CONNECTIONS AT THE ENGINE CONTROL MONITOR (ECM)



THE TERMINALS IN THE SHADED BOXES ARE FOR CUSTOMER CONNECTIONS

AUXILIARY RELAY BOARD (ARB)

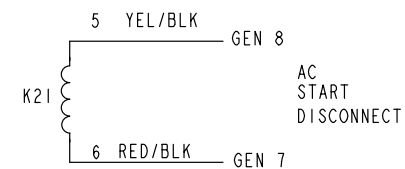
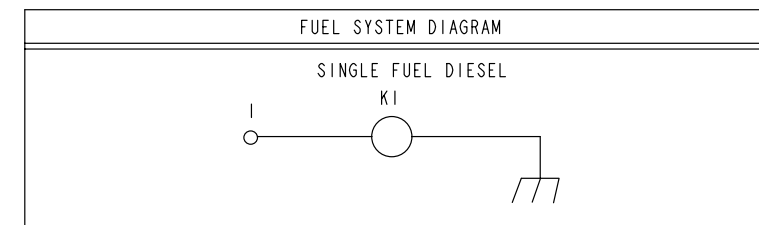
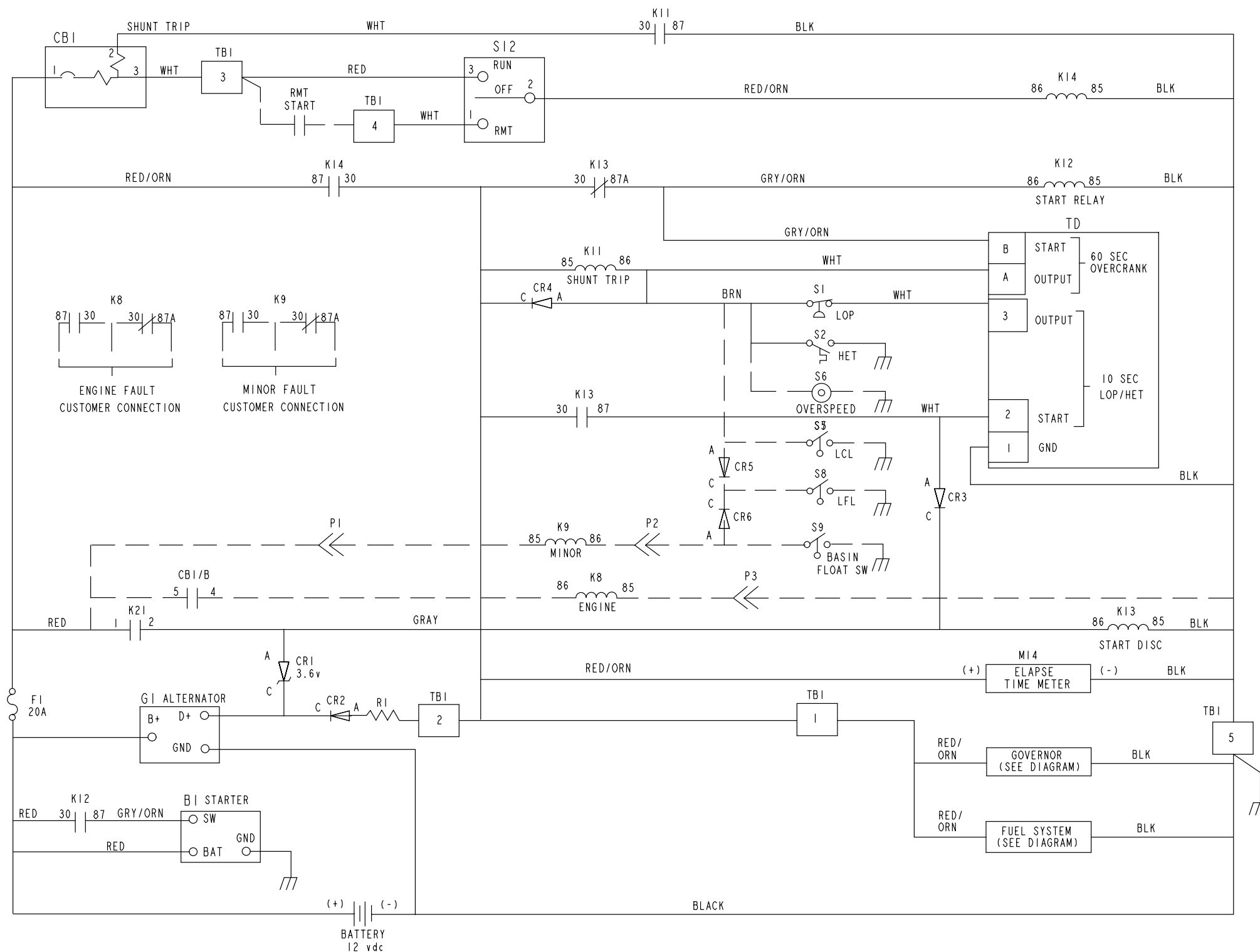


POSITION	CONTACTS CLOSED					
L1-L2 3Ø	11-18	C-22	32-M	44-N	33-R	
L2-L3 3Ø	A-12	C-22	44-N	42-41	43-P	
L3-L1 3Ø	11-18	B-J	34-31	42-41	33-R	
L1-L0 3Ø	11-18	21-14	44-N	42-41	33-R	
OFF	---	---	44-N	42-41	33-R	
L1-L2 1Ø	11-18	C-22	32-M	44-N	33-R	
L1-L2 1Ø	11-18	C-22	44-N	42-41	43-P	

TABULATION	
DESIGNATION	WIRE COLOR
CT21-1	PNK/BLK
CT22-1	PRP/BLK
CT23-1	ORN/BLK
CT COMMON	GRY/BLK
GEN 4	LT GRN/BLK
GEN 5	TAN/BLK
GEN 6	RED/BLK
GEN 7	YEL/BLK
GEN 8	DK BLU/BLK

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AC CONTROL WIRING DIAGRAM

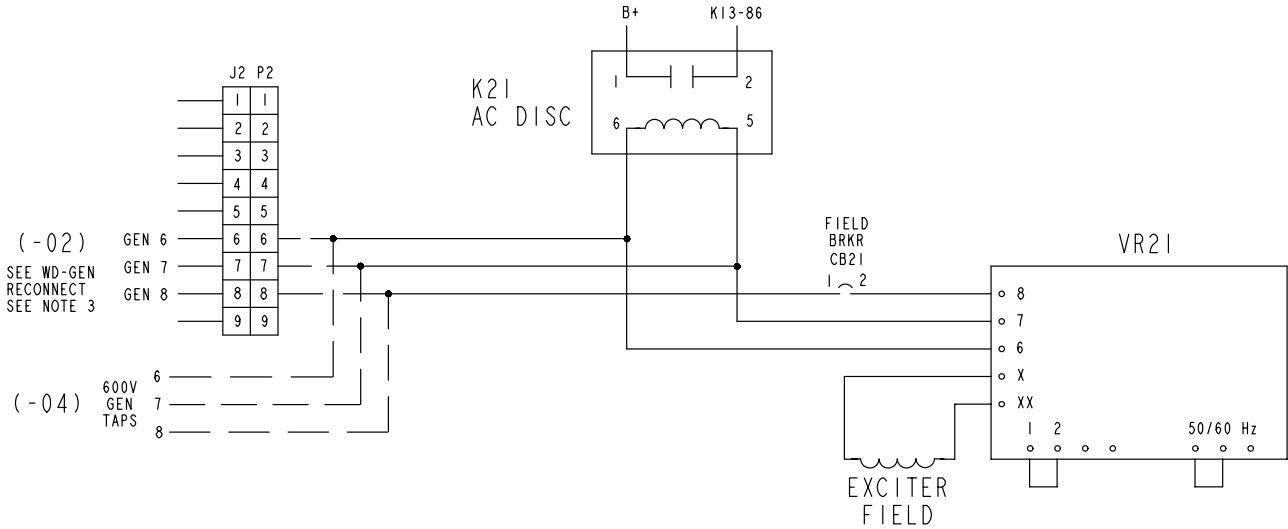


ALL COMPONENTS SHOWN IN
DE-ENERGIZED POSITION.
DASHED LINES INDICATE
OPTIONAL FEATURES

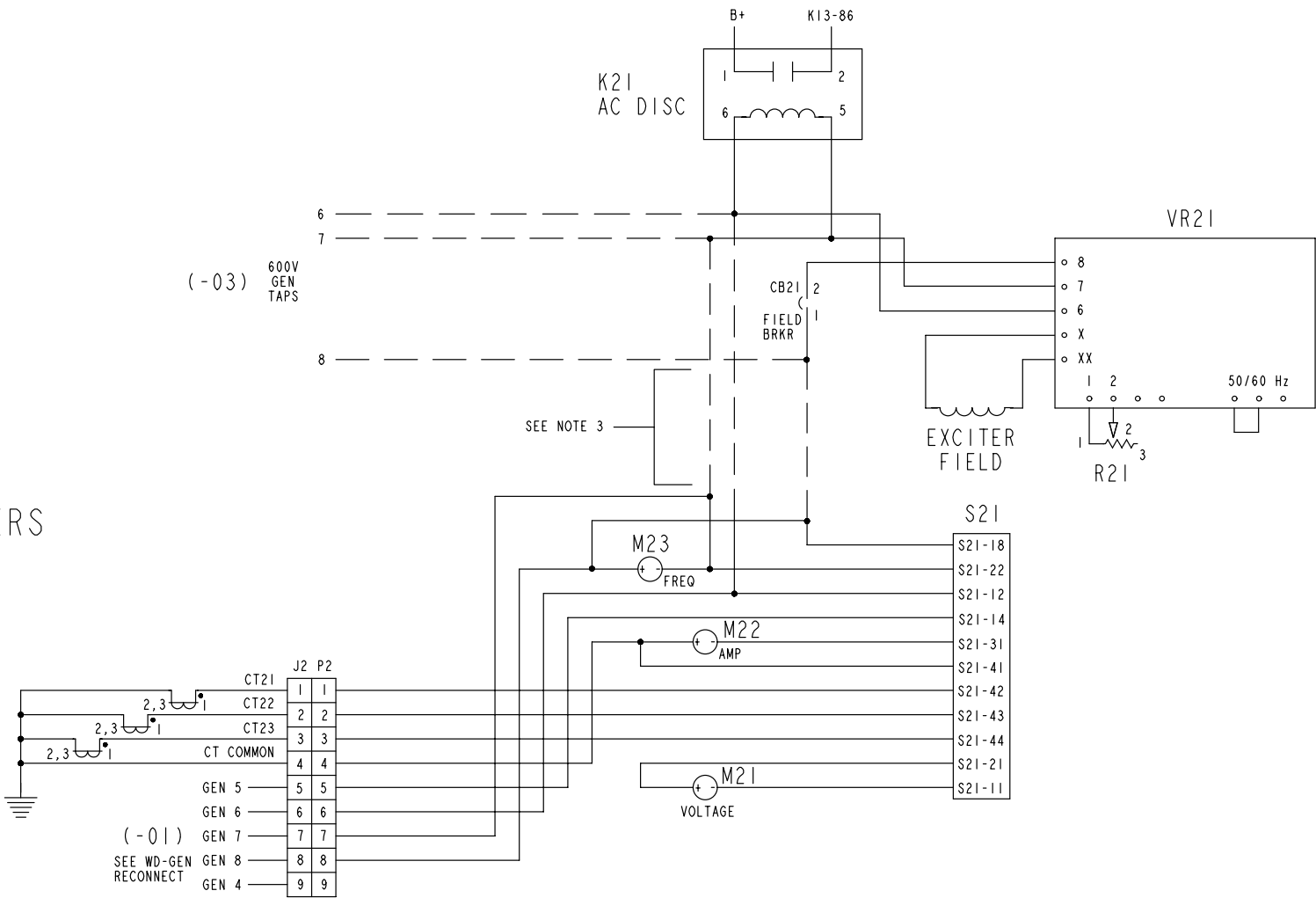
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DC WIRING

NO METERS



METERS



SCHEMATIC-SX460 REGULATOR

S21 JUMPERS

EXTERNAL	INTERNAL
M-P	N-41
34-44	M-31
C-21	A-11
32-42	B-C
I2-J	33-43
N-R	

S21 SWITCH LOGIC											
	18-11	22-C	14-21	M-32	41-42	P-43	12-A	J-B	31-34	N-44	R-33
L1-L2 3Ø	X	X		X						X	X
L2-L3 3Ø		X			X	X	X			X	
L3-L1 3Ø	X				X			X	X		X
L1-L0 3Ø	X		X		X					X	X
OFF					X					X	X
L1-L2 1ØA	X	X		X						X	X
L1-L2 1ØB	X	X			X	X				X	

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Rev. D Sys: ProE
Modified 10/24/96



S21 JUMPERS

S21 JUMPERS		S21 SWITCH LOGIC										
		18-11	22-C	14-21	M-32	41-42	P-43	12-A	J-B	31-34	N-44	R-33
		X	X		X						X	X
			X			X	X				X	
		X				X		X				X
		X		X		X			X	X		
						X					X	X
						X					X	X
						X					X	X
		X	X		X						X	X
		X	X			X	X				X	

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