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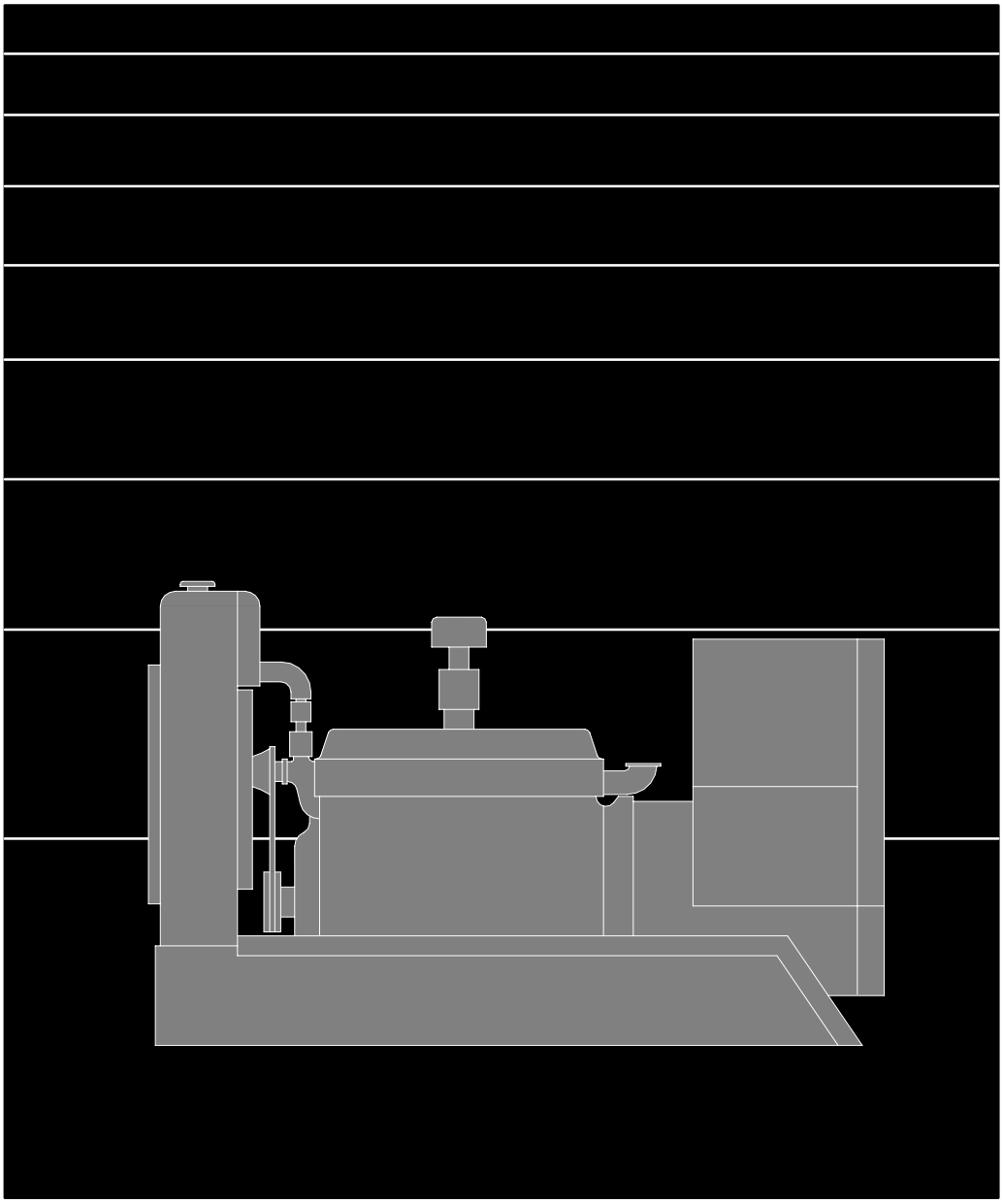
Power Generation

# Onan Service Manual

## EK-EM
## GENERATOR SET



EK - Begin Spec D, EM - Begin Spec W

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Power Generation

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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.

## 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.

## HIGH VOLTAGE GENERATOR SETS (1.9kV to 15kV)

- High voltage acts differently than low voltage. Special equipment and training is required to work on or around high 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 high 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 breath or ingest or come into contact with exhaust gases.

# 1. Introduction

## ABOUT THIS MANUAL

This service manual is for the EK (begin Spec D) and EM (begin Spec W) series gasoline and gaseous-fuel generator sets. 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 ii and iii.***

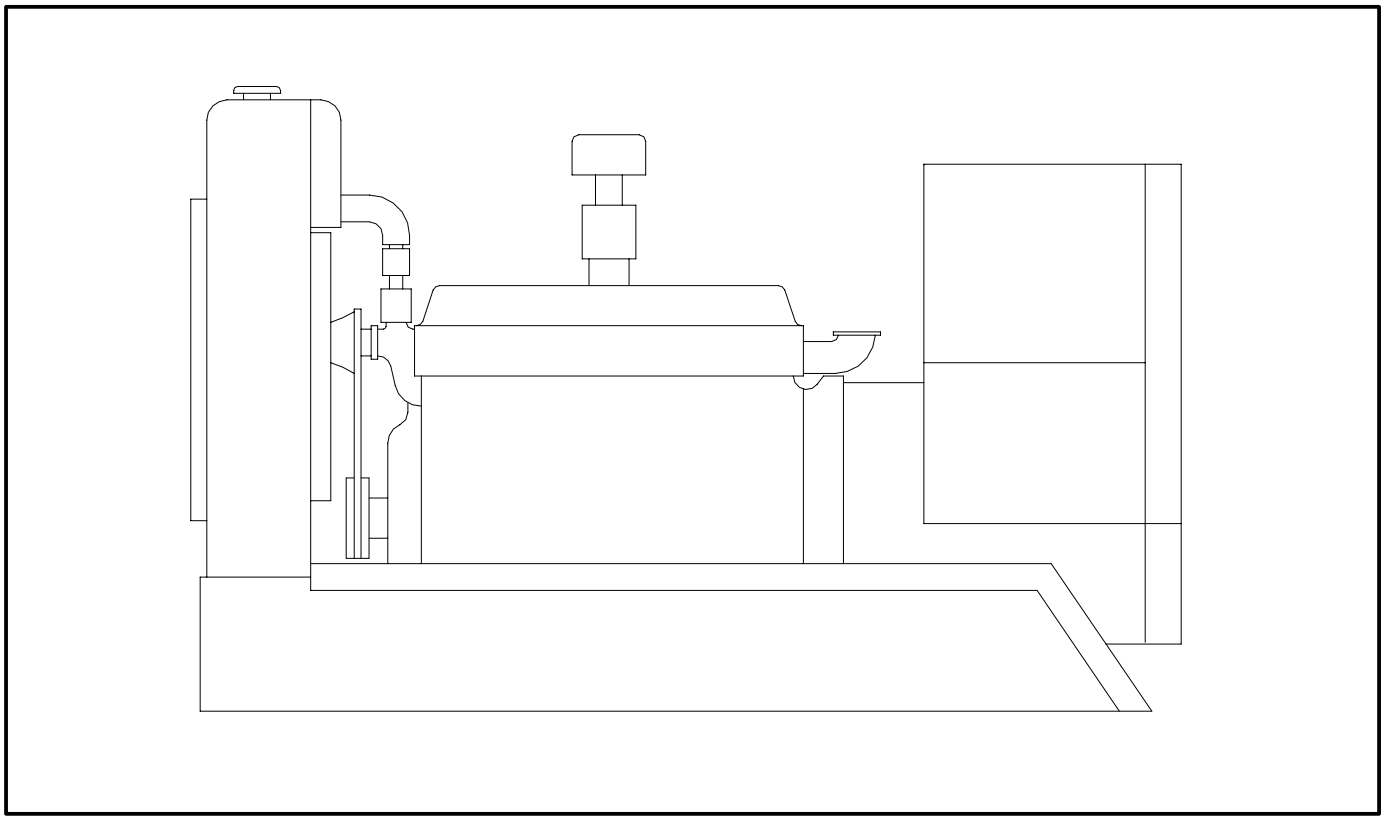


**FIGURE 1-1. TYPICAL GENERATOR SET**

# 2. AC Control

## GENERAL

The control box is mounted on top of the generator, facing the rear. Figure 2-1 points out the components on the AC control panel. Refer to *Section 7* for wiring connections.

## STANDARD CONTROL PANEL COMPONENTS

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

## OPTIONAL CONTROL PANEL COMPONENTS

**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.

**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.

**Wattmeter (M24)** The wattmeter indicates output power in kilowatts (kW).

**Powerfactor Meter (M25)** The powerfactor meter indicates output powerfactor as a percentage of unity powerfactor.

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

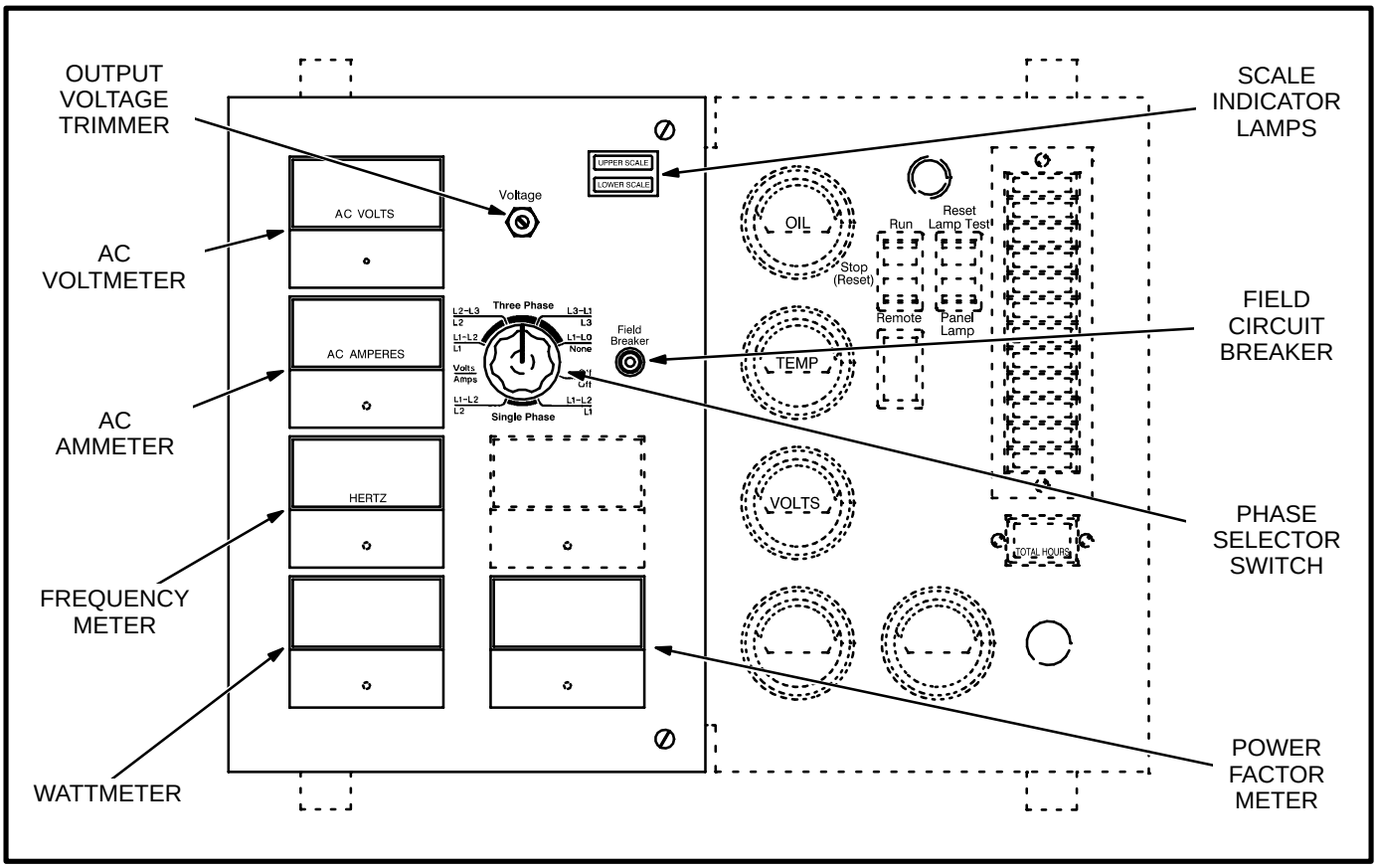



**FIGURE 2-1. AC CONTROL PANEL**

## VOLTAGE REGULATOR DESCRIPTION

The design of the Torque Match-2 Voltage Regulator (VRAS-2) provides switch selections that alter its sensing and command signals in order to achieve maximum operating performance in a variety of generator sizes and applications. Review the following, then refer to *Voltage Regulator Adjustments* for switch locations and settings specific to your generator set model.

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** ***HIGH 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 wear elbow length insulating gloves.***

### Operating Modes

***Torque-Matching (Grequency Sensing):*** In most applications, in order for the generator set to accept the application of a large momentary overload, such as motor starting, matching the torque characteristics of the engine and generator is required.

Because of the differences in engine characteristics, different torque matching may be used for various engine/generator combinations. The switch-selectable design of the VRAS-2 provides Onan the flexibility to test and set the torque-matching function to best suit each engine/generator configuration.

When set to the proper torque-matching switch settings, the VRAS-2 voltage regulator is able to maintain output voltage, within reasonable limits, by reducing the voltage just enough to take full advantage of the engine's full available power under transient conditions and prevent an unstable response.

***Non-Torque-Matching (Voltage Sensing):*** Even though the voltage regulator can also be switch-selected to a non-torque-matching constant voltage mode, independent of engine speed, this mode will not prevent the generator set from stalling during momentary overload conditions, and is not recommended for use. Consult an Onan service representative before selecting this voltage regulation mode to make sure that load demands specific to your installation would not cause an unstable operation of the generator set.

### Operating Stability

Because of the differences in exciter and main field time constants, different gain compensation is required for the various generator sizes and application. The VRAS-2 voltage regulator is switch-selectable to a kW range of operation that best suits the generator set application.

## VOLTAGE REGULATOR ADJUSTMENTS

The VRAS-2 is shown in Figure 2-2. There are three switch modules and two potentiometers on VRAS-2.

- Switch S1 – Selects the overall range of operation for the regulator. Refer to Table 2-1.
- Switches S2 and S3 – Determine the mode of regulation (Torque-Matched, or Non-Torque-Matched). Refer to Table 2-1.
- Potentiometer R32 – Provides adjustability to increase or decrease generator voltage to achieve proper setting.
- Potentiometer R34 – Used to set the frequency breakpoint. The potentiometer is adjusted at the factoryand does not require further adjustment.

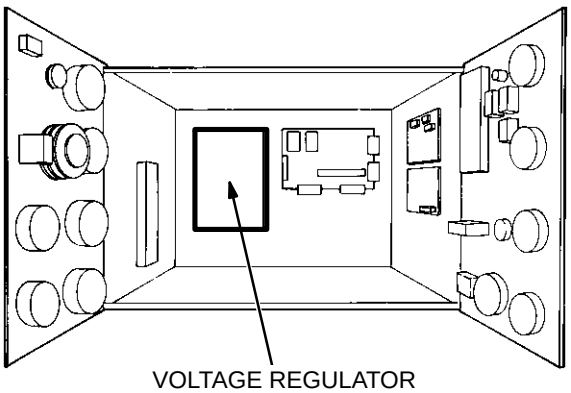
### Adjusting Voltage

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. (See *Section 6. Governor* for instructions on how to adjust the frequency.) If the trimmer does not provide enough adjustment, lock it at its midpoint. Then turn voltage adjusting pot R32 on the regulator board until rated voltage is obtained.

**TABLE 2-1. VRAS-2 SWITCH SETTINGS**

| GENSET kW RATING | STABILITY RANGE | |
|---|---|---|
| | S1-1/4 | S1-2/3 |
| 20-35 | OFF | OFF |
| 40-50 | OFF | ON |

| TORQUE MATCHING MODE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLTAGE SENSING | | | | | | FREQUENCY SENSING | | | | | |
| TMB VOLTS / HZ 60HZ | | | TMB VOLTS / HZ 50HZ | | | TMC NON-FREQ | | | TMA SEMI-FREQ | | |
| S2 | S3-1/4 | S3-2/3 | S2 | S3-1/4 | S3-2/3 | S2 | S3-1/4 | S3-2/3 | S2 | S3-1/4 | S3-2/3 |
| POS 2 | OFF | ON | POS 2 | ON | ON | POS 2 | OFF | OFF | POS 1 | OFF | OFF |



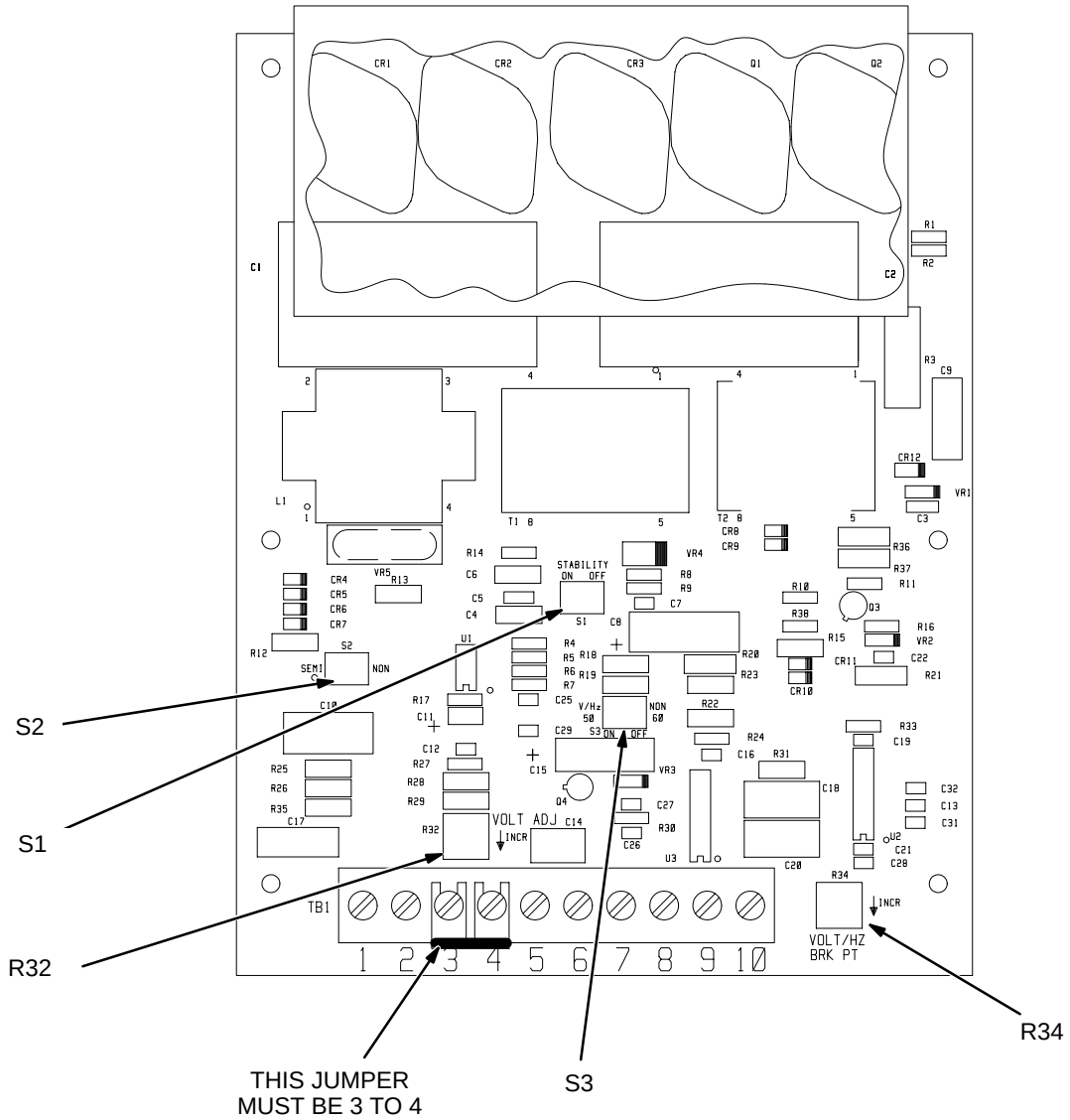




**FIGURE 2-2. VOLTAGE REGULATOR ADJUSTMENT POTS AND SELECTION JUMPERS**

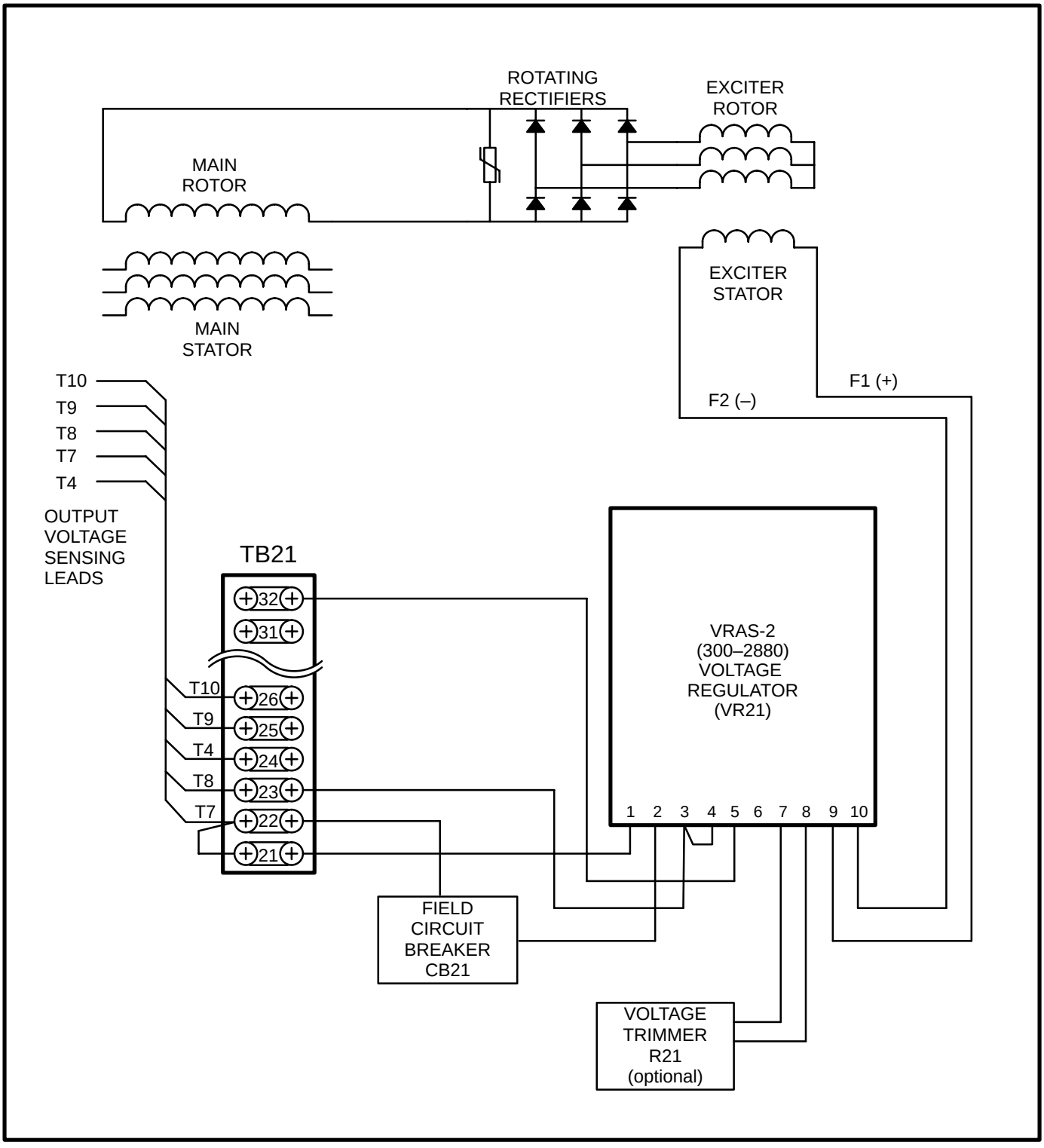



**FIGURE 2-3. TYPICAL VOLTAGE REGULATING CIRCUIT**

## 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 (VRAS-2) regulates exciter field current by comparing generator output voltage and frequency with reference values.
7. Exciter field current is supplied by the generator stator through the voltage regulator. Residual field magnetism initiates “self-excitation” during startups.

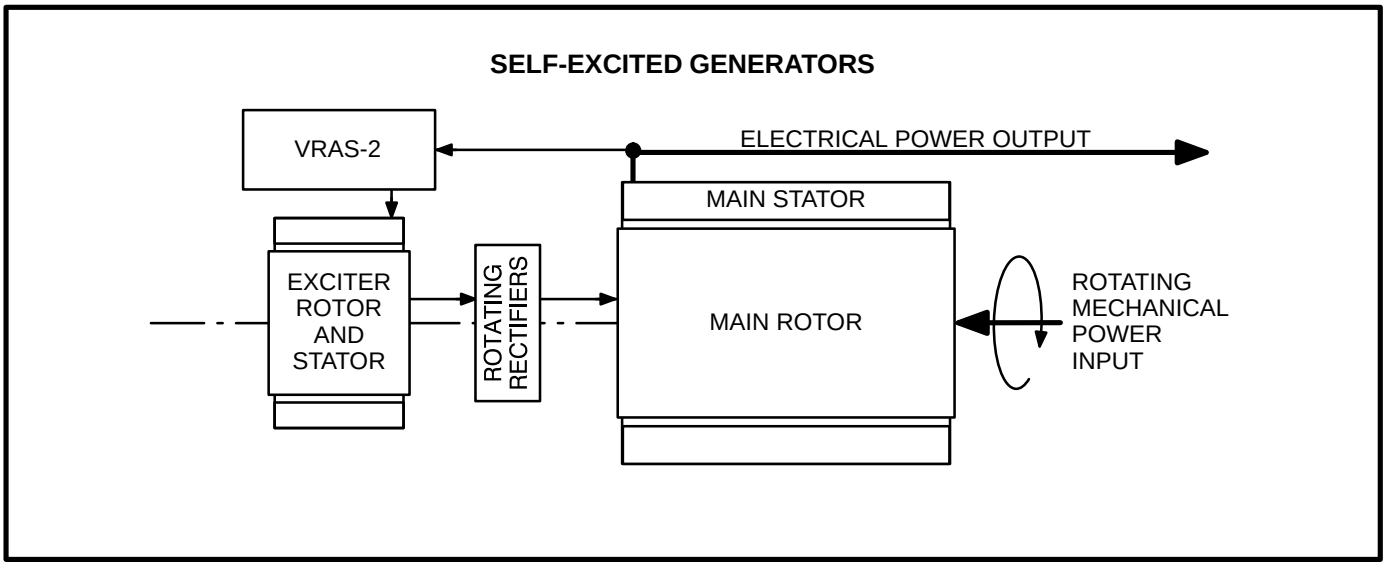



**FIGURE 2-4. SCHEMATIC OF GENERATOR OPERATION**

# 3. Engine Control

## CONTROL PANEL

The 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 to 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. Also, this switch has a light which lights following a fault or emergency shutdown. The light remains lit until the engine control has been reset. The **Panel Lamp** position lights the panel illumination lamp.

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

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

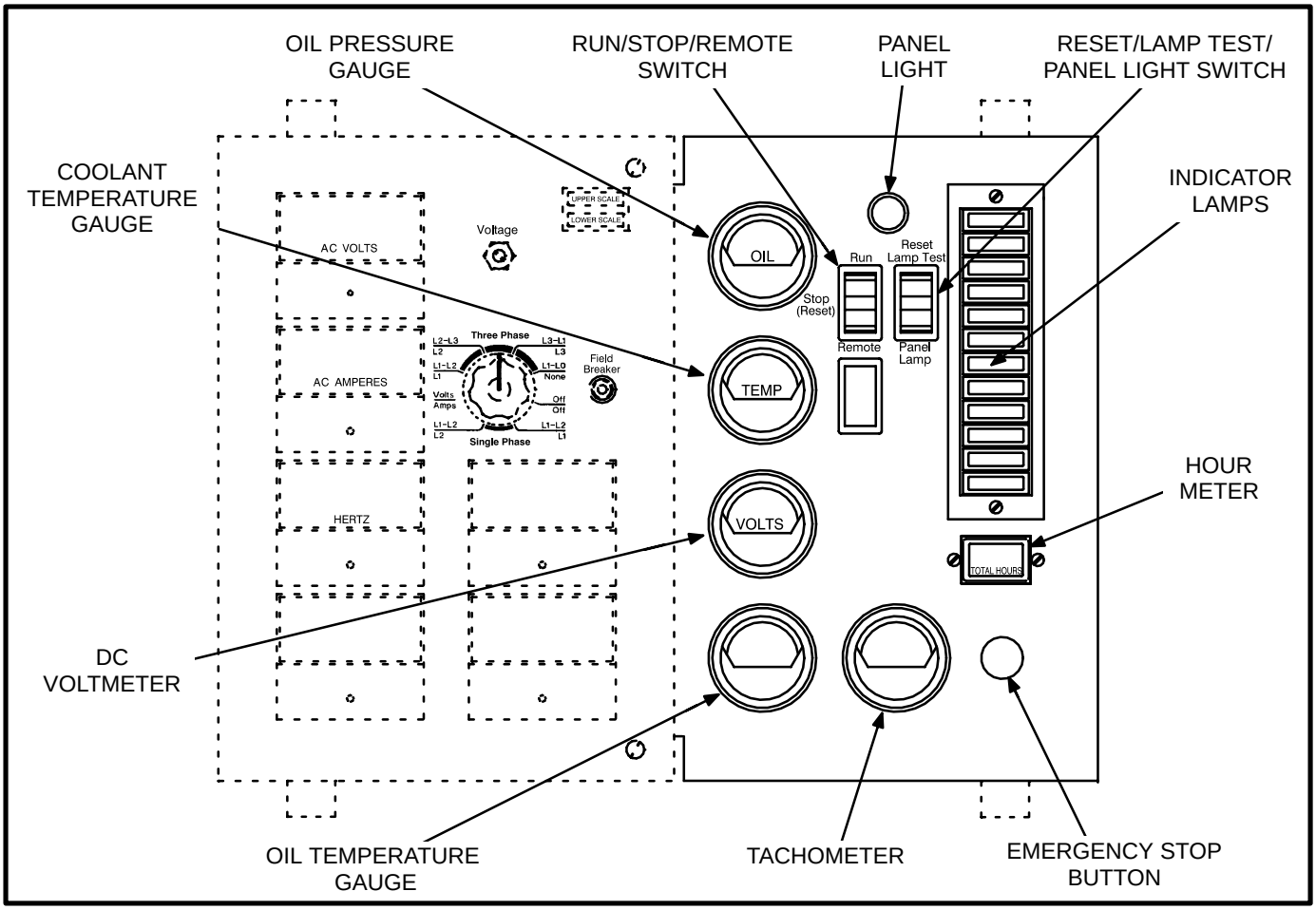



**FIGURE 3-1. ENGINE CONTROL PANEL**

**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]). Normal operating range is 35 to 60 psi (241 to 414 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.

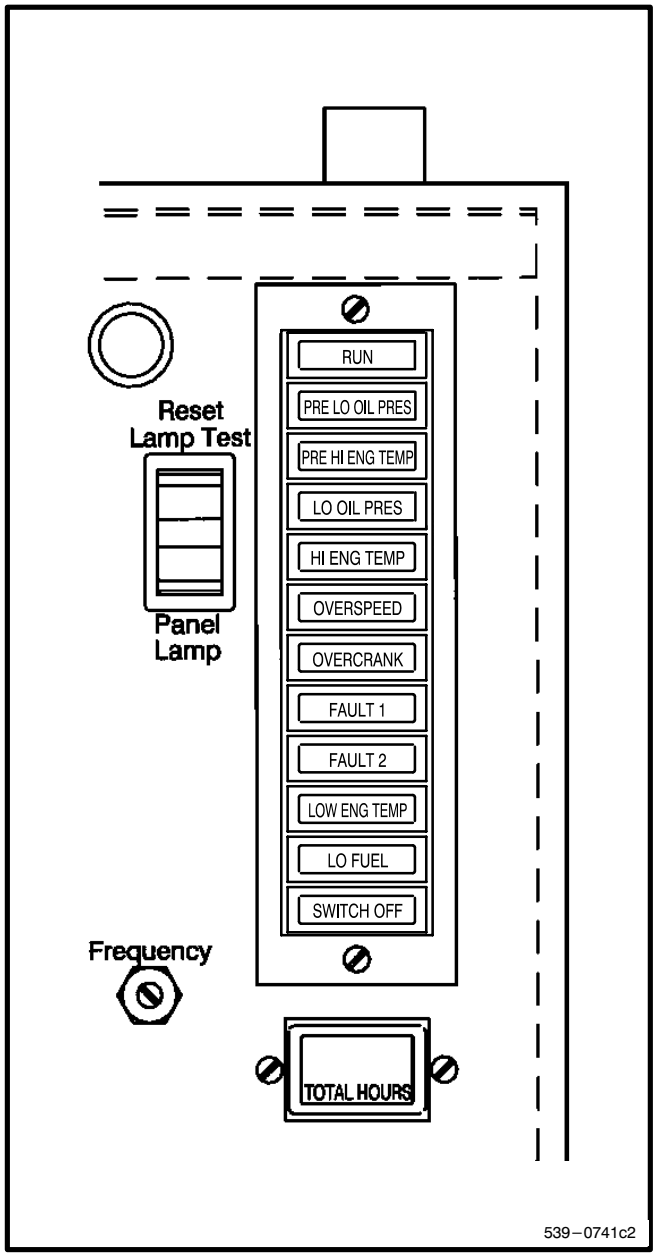



**FIGURE 3-2. DETECTOR-12 INDICATOR LAMPS**

## OPTIONAL CONTROL PANEL COMPONENTS

**Oil Temperature Gauge (M15)** The oil temperature gauge indicates engine oil temperature.

**Tachometer (M16)** The tachometer indicates engine speed in RPM.

**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, and the possibility that the engine might not start.
- **Low Fuel (Yellow)** This lamp indicates that the fuel level in the supply tank has dropped to less than the reserve necessary to run the set at full load for the prescribed number of hours. The customer has to make connections to use this lamp.
- **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 (ECM).
- **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 (ECM).
- **Switch-off (Flashing Red)** This lamp indicates that the **Run / Stop / Remote** switch is in the **Stop** position, which prevents remote, automatic operation.

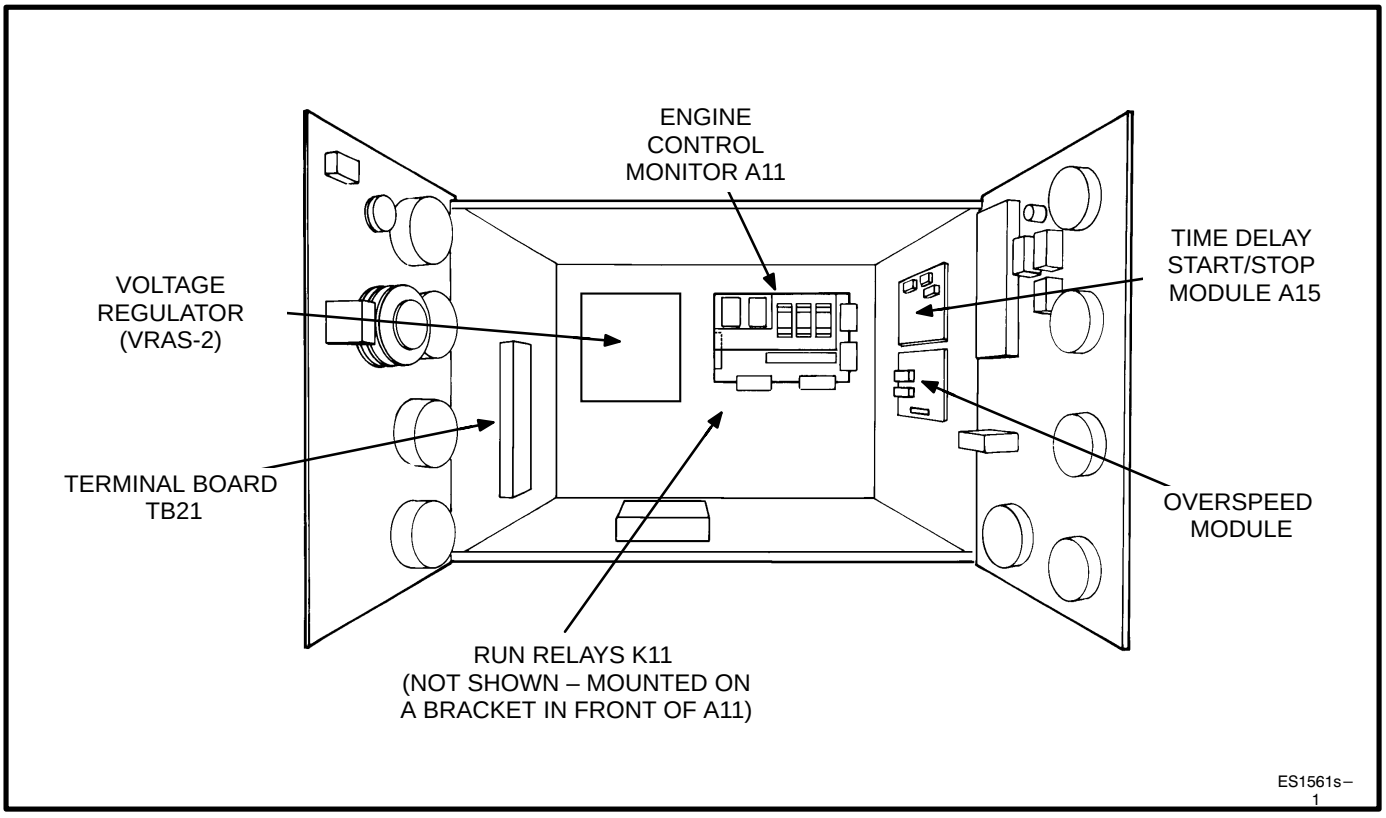



**FIGURE 3-3. ARRANGEMENT OF COMPONENTS INSIDE THE CONTROL BOX**

## 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 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 7-5 through 7-8 for the appropriate connection and schematic drawings for the DC control system. See Page 7-10 for typical customer connections at terminal boards **TB1** and **TB2** on the ECM and page 7-11 if the set is also equipped with the auxiliary relay board.

### Fuses

The ECM has five replaceable fuses to protect it from overloads and groundfaults. 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

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

- **A** Non-timed warning under **FLT 2** conditions.
- **B** Non-timed shutdown and warning under **FLT 2** conditions.
- **C** Timed warning under **FLT 2** conditions.
- **D** Timed shutdown and warning 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 and warning under **FLT 1** conditions.
- **C** Timed warning under **FLT 1** conditions.
- **D** Timed shutdown and warning under **FLT 1** conditions.

**W6** Jumper Position:

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

**W7** Jumper Position:

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

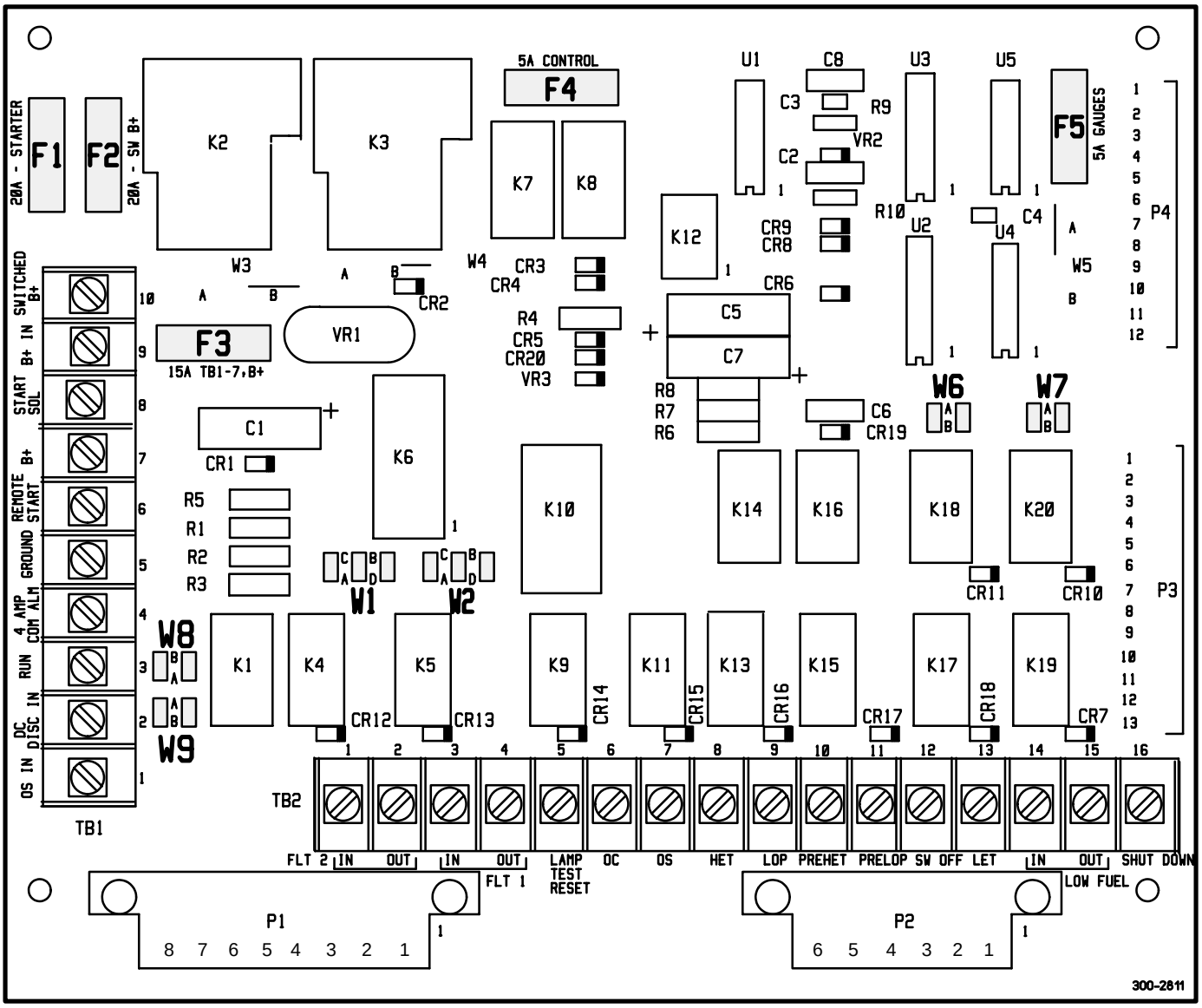



**FIGURE 3-4. ENGINE CONTROL MONITOR FUSES AND FUNCTION SELECTION JUMPERS**

## ENGINE GAUGE SENDERS AND SHUTDOWN SWITCHES

Figure 3-5 shows 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.***

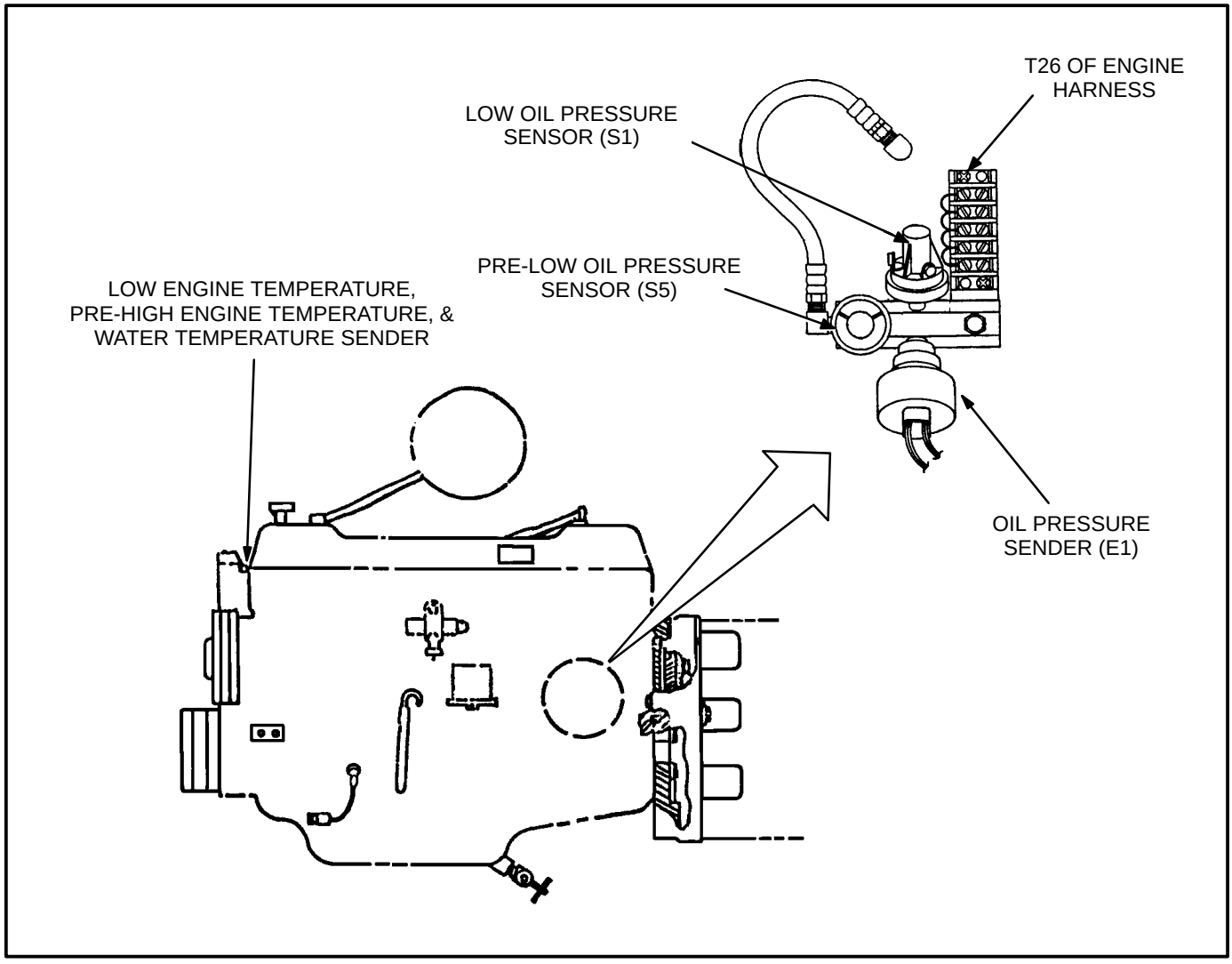



**FIGURE 3-5. ENGINE SENSOR LOCATIONS**

## 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. See Figure 3-6.

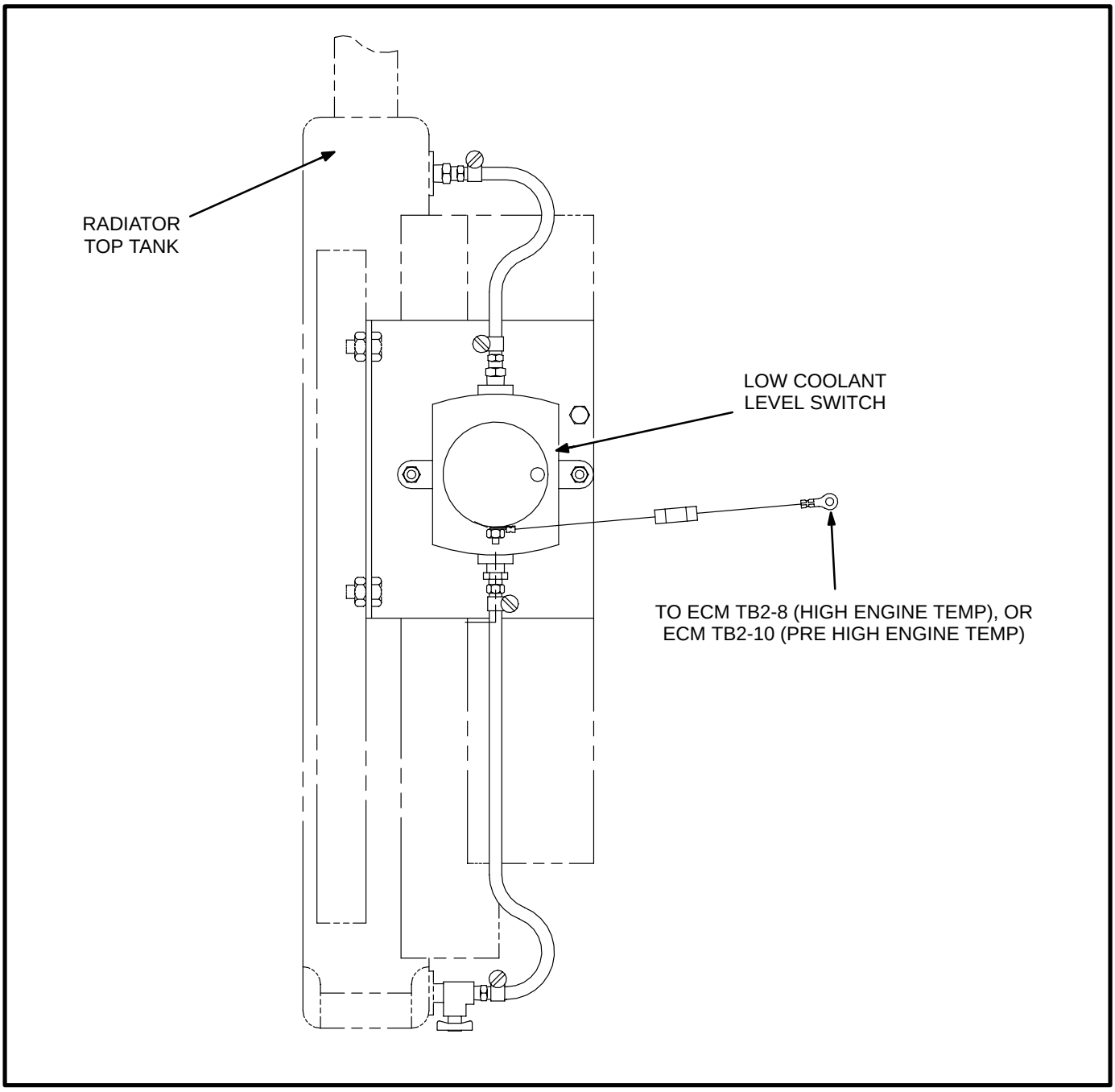
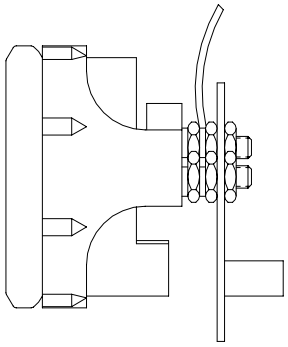



**FIGURE 3-6. LOW COOLANT LEVEL SWITCH**

## Coolant Temperature Gauge and Warning Light Circuits

An electronic PCB assembly is mounted on the back of the coolant temperature gauge (M12) with three terminal nuts. The PCB assembly carries two relays that provide signals for the low coolant and pre-high temperature warning lamps on the basis of the gauge sender output. See Figure 3-7.

**PCB MOUNTING ON BACK OF GAUGE**



**GAUGE AND PCB CONNECTIONS**

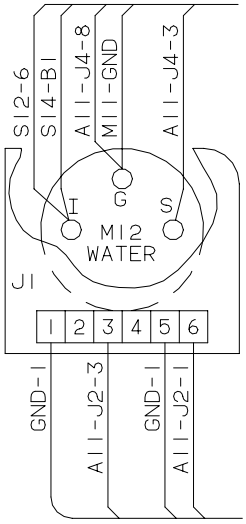



**FIGURE 3-7. COOLANT TEMPERATURE GAUGE**

## 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 2100 to 2300 RPM (50 or 60 Hz sets).

   Turn adjustment screw clockwise to increase trip speed.
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 N•m) when replacing the switch.

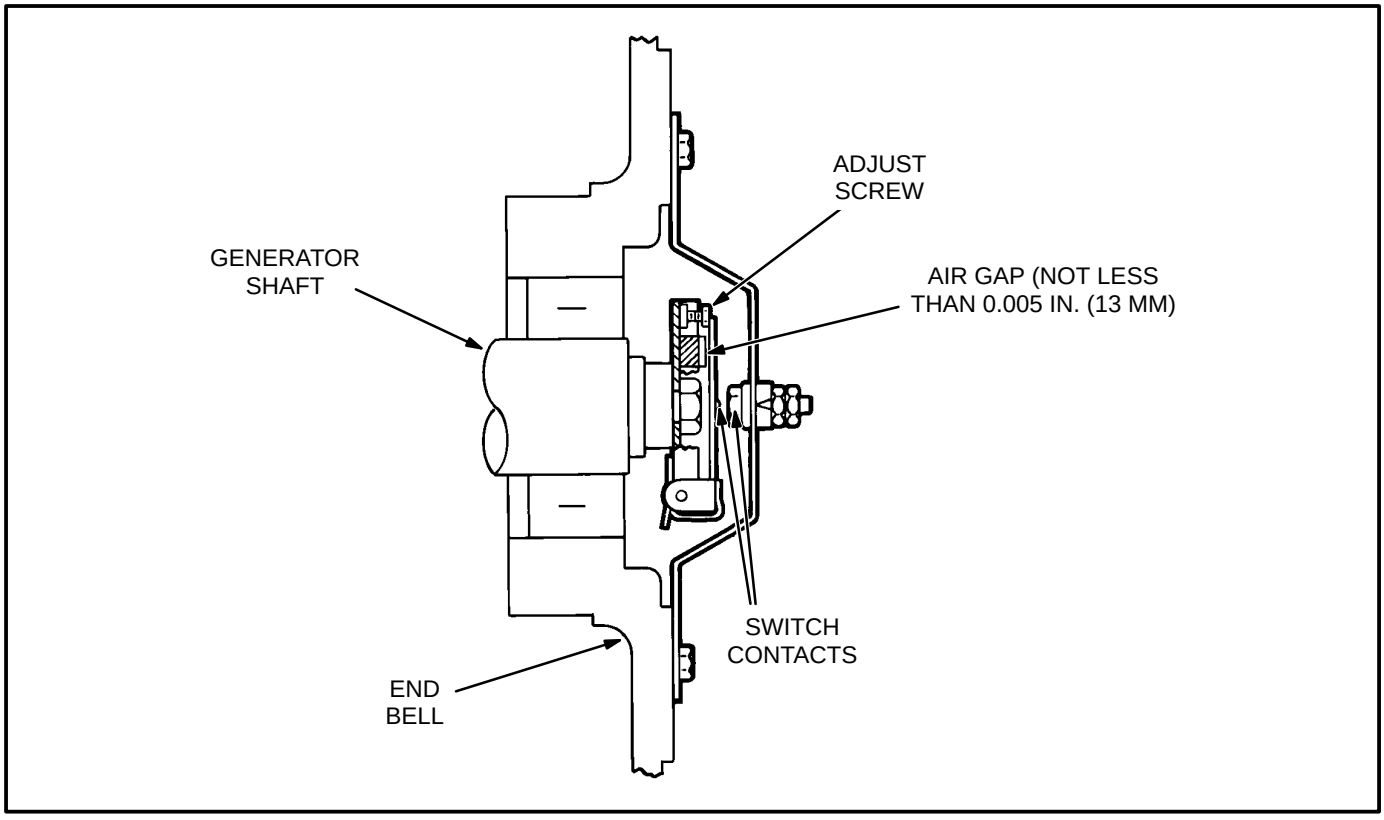



**FIGURE 3-8. OVERSPEED SWITCH ASSEMBLY**

## Auxiliary Relay Board (ARB)

The following describes the design/functional criteria for the ARB 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. There are two versions of the ARB; with and without the set of 12 Fault relays (Figure 3-9). Page 7-11 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, and 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 Switched 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 relay operates with the coil 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 optional 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 amps at 120 VAC
- 10 amps at 30 VDC

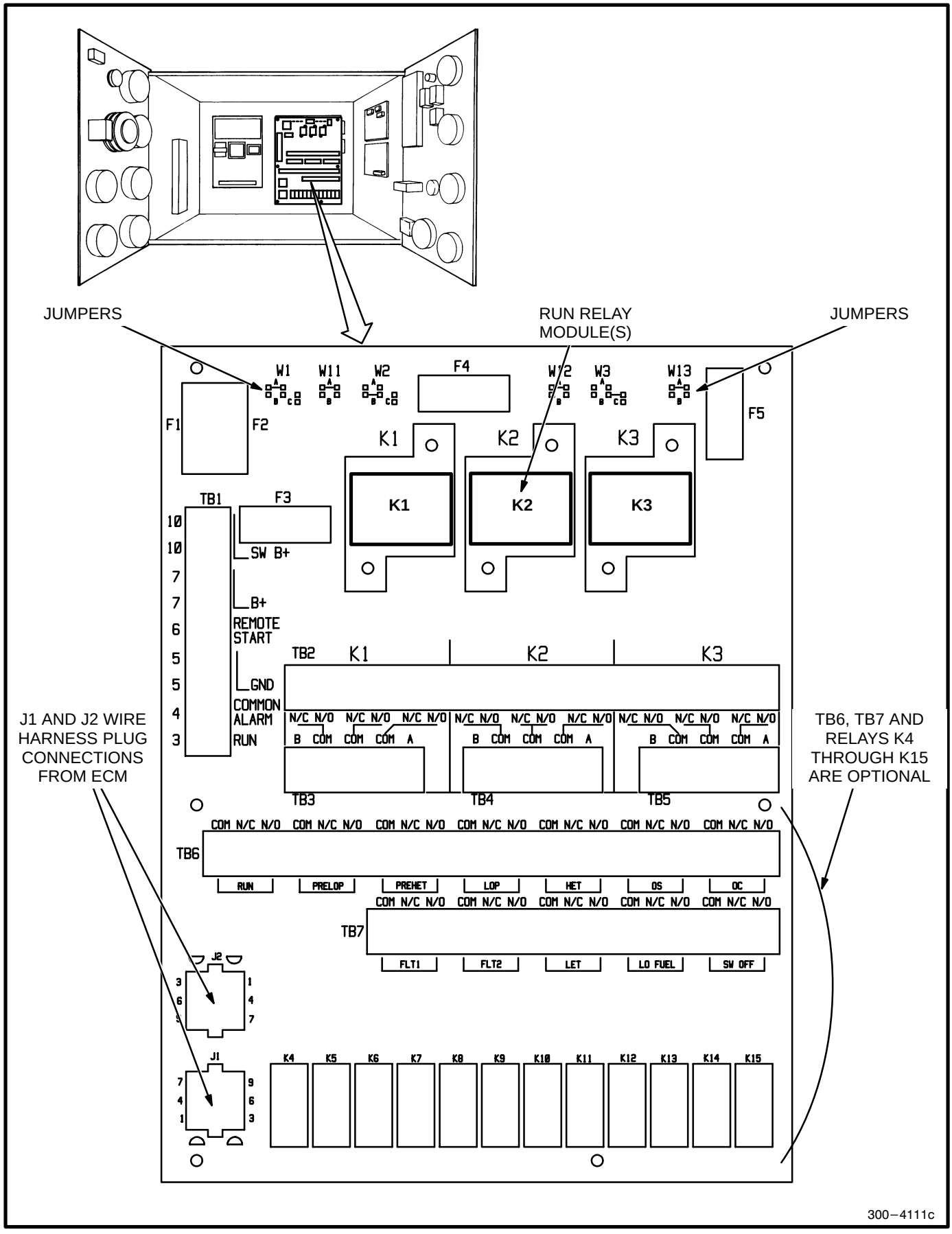



**FIGURE 3-9. AUXILIARY RELAY BOARD (ARB)**

## Over/Under Voltage Module (A17)

The set can be equipped with an adjustable voltage-sensitive relay usually connected into the **Fault 1** circuit (Detector-12 controls only) to shut down the set when the output voltage is over or under nominal voltage by the preselected percentage (typically 10 percent over and under).

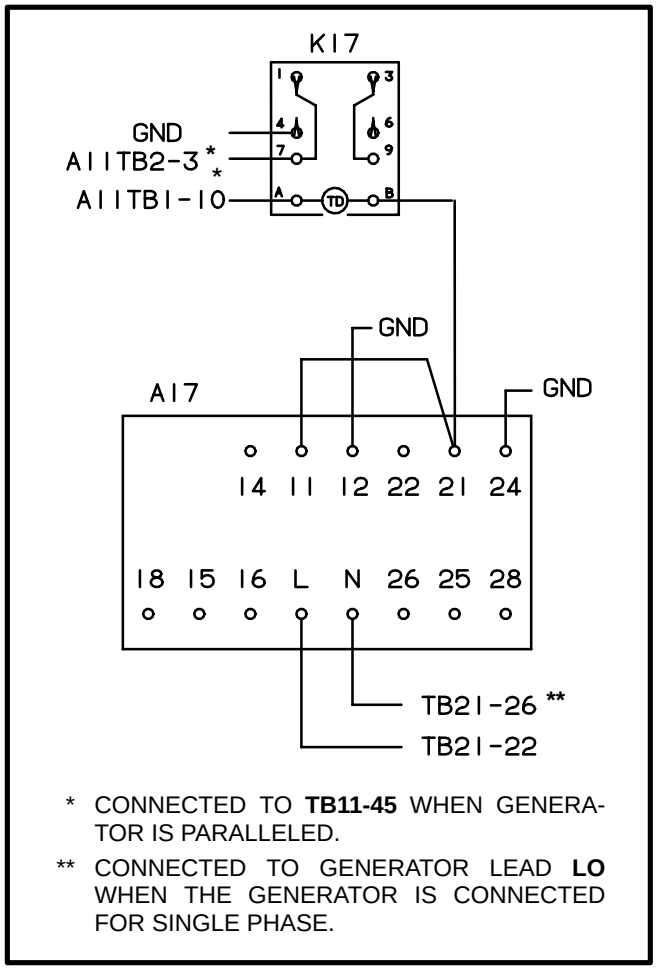
This module has an adjustable time delay relay (**K17**) to prevent nuisance tripping. An adjustment of 25 percent is equivalent to about 2.5 seconds delay.

Recalibrate the module as follows before installing it on 139/240 VAC or 277/480 VAC sets.

**⚠WARNING** ***HAZARDOUS VOLTAGE. Touching uninsulated high voltage parts inside the control panel 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 and wear elbow length insulating gloves intended for hazardous voltages.***

1. Remove the two screws that secure the top to the case of the module and withdraw the top assembly.
2. Adjust the **SET** pot for the **UNDER** setpoint on the face of the top assembly to 75 percent.
3. Apply single-phase, 60 Hertz, 104.25 VAC across terminals **L** and **N**.
4. Adjust pot **R25** on the PC board until the relay trips (de-energizes).
5. Adjust the **SET** pot for the **OVER** setpoint on the face of the top assembly to 125 percent.
6. Apply single-phase, 60 Hertz, 173.75 VAC across terminals **L** and **N**.
7. Adjust pot **R26** on the PC board until the relay trips (energizes).
8. Repeat the above steps until no adjustments are necessary.
9. Reassemble the module.
10. On the module nameplate mark out the factory calibration value for monitored voltage (120 V) and write in **139 V**.




* CONNECTED TO **TB11-45** WHEN GENERATOR IS PARALLELED.

** CONNECTED TO GENERATOR LEAD **LO** WHEN THE GENERATOR IS CONNECTED FOR SINGLE PHASE.

**FIGURE 3-10. OVER/UNDER VOLTAGE MODULE**

## Over/Under Frequency Module (A19)

The set can be equipped with an adjustable frequency-sensitive relay to shut down the set when the output frequency (Hz) is over or under nominal frequency by the preselected amount. It is usually connected into the **Fault 2** circuit (Detector-12 controls only) if the over/under voltage module is also provided. Set points are typically 5 Hertz over and under nominal frequency (50 or 60 Hertz) and reset points 3 Hertz over and under.

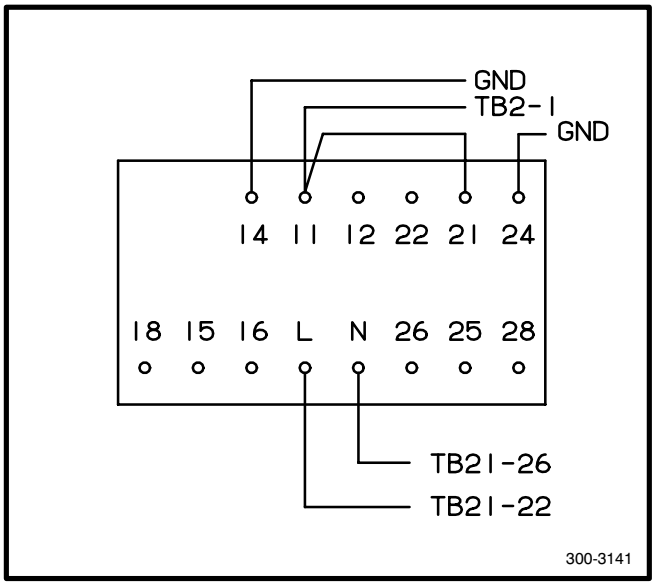



**FIGURE 3-11. OVER/UNDER FREQUENCY MODULE**

## 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.

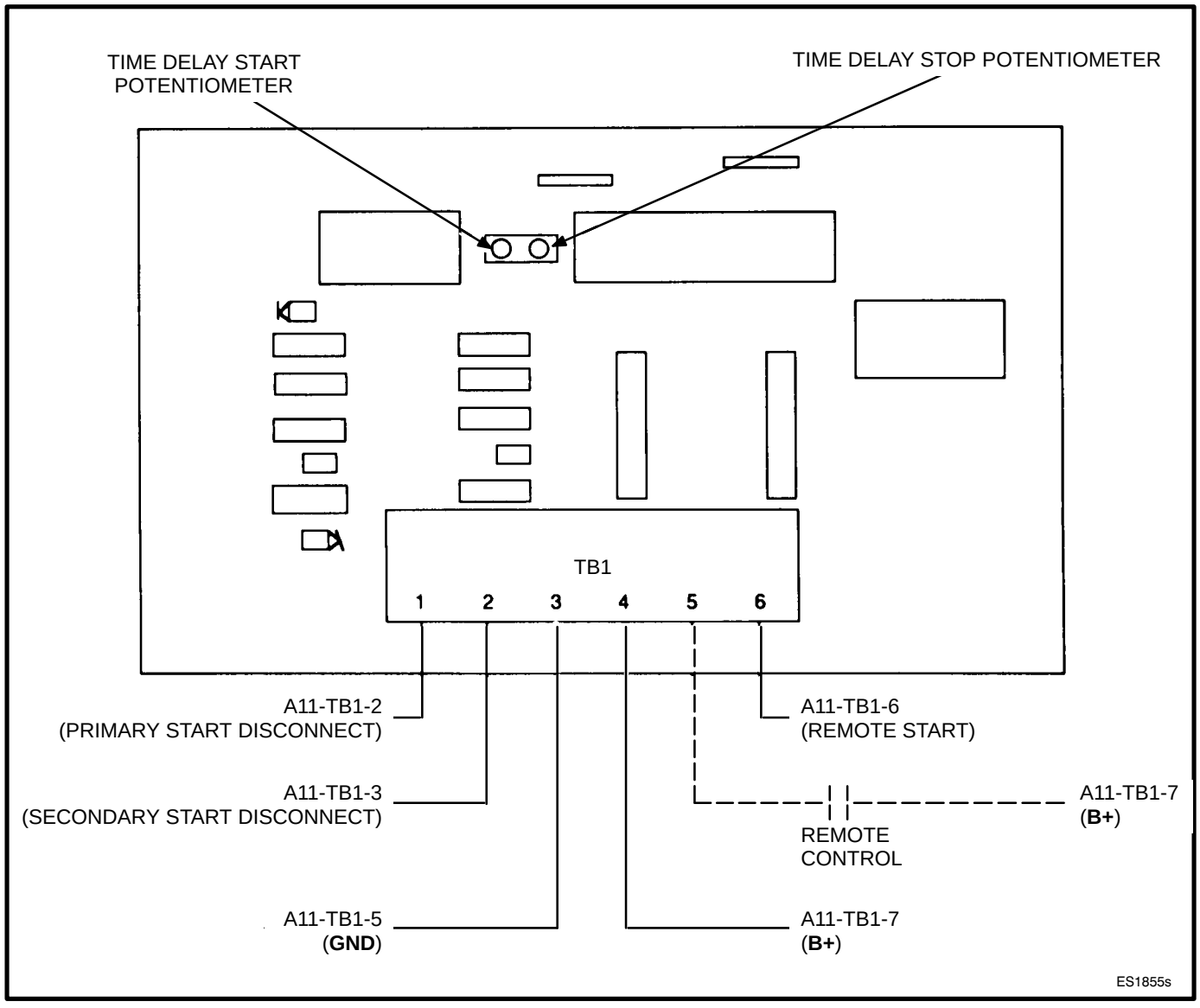



**FIGURE 3-12. TIME DELAY START/STOP MODULE**

## SEQUENCE OF OPERATION

The sequence of operation is as follows. Refer to the schematic on Page 7-6 or 7-8.

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 and ignition module are connected.
5. Relay **K3** powers terminal **TB1-8** to which starter relay **K4** 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 500 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.*
10. Relays **K2** and **K3** are de-energized (by latching relay **K6**) causing shutdown to occur if the engine does not start within 75 seconds. The **Overcrank** indicator lamp lights and common alarm terminal **TB1-4** is powered.

    **The ECM has a cycle crank feature where 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.**

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.)

* On older ECM boards (those having cartridge-type fuses):
- If the starter disconnects normally but the panel Run indicator lamp does not light, the DC (K14) starter disconnect circuit is not working.
- 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.

* On newer ECM boards (those having automotive-type fuses):
- 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.

# 4. Troubleshooting

These troubleshooting charts are designed to help you think through generator set problems. To save time troubleshooting, read the entire manual ahead of time to understand the generator set. Try to think through problems. Go over what was done during the last service call. The problem could be as simple as an empty fuel tank, closed fuel shutoff valve, loose wire, blown fuse or tripped circuit breaker.

**⚠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.***

**THE ENGINE DOES NOT CRANK**

| | |
|---|---|
| The **Run-Stop-Remote** switch is at **Stop. (**The **Switch-Off** light will be flashing, if provided.) | Push the **Run-Stop-Remote** switch to **Run** or **Remote.** |
| The **Emergency Stop** switch has been used. (The switch button and switch S11 will light.) | 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** or **Remote.** |
| The remote control circuit is faulty. | Push the **Run-Stop-Remote** switch to **Run**. If the engine cranks, find and repair the fault in the remote control circuit. |
| 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** or **Remote.** |
| A **Lo Shutdown** is being indicated on the day tank pump control panel (if provided). | Determine the cause and service 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** or **Remote.** Note that the engine control will shut down unless the day tank control has been reset first. |
| Continued on next page. | |

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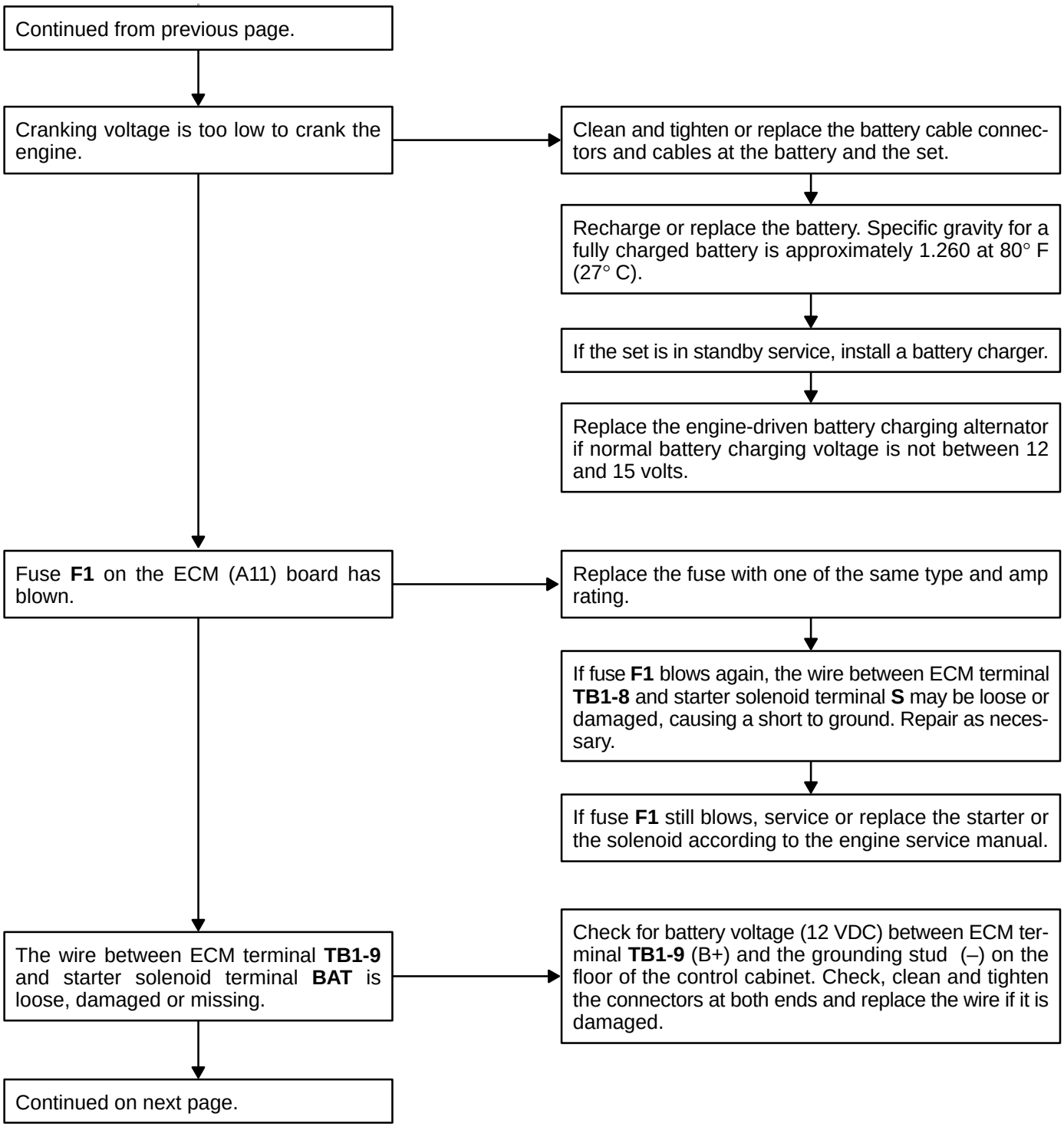
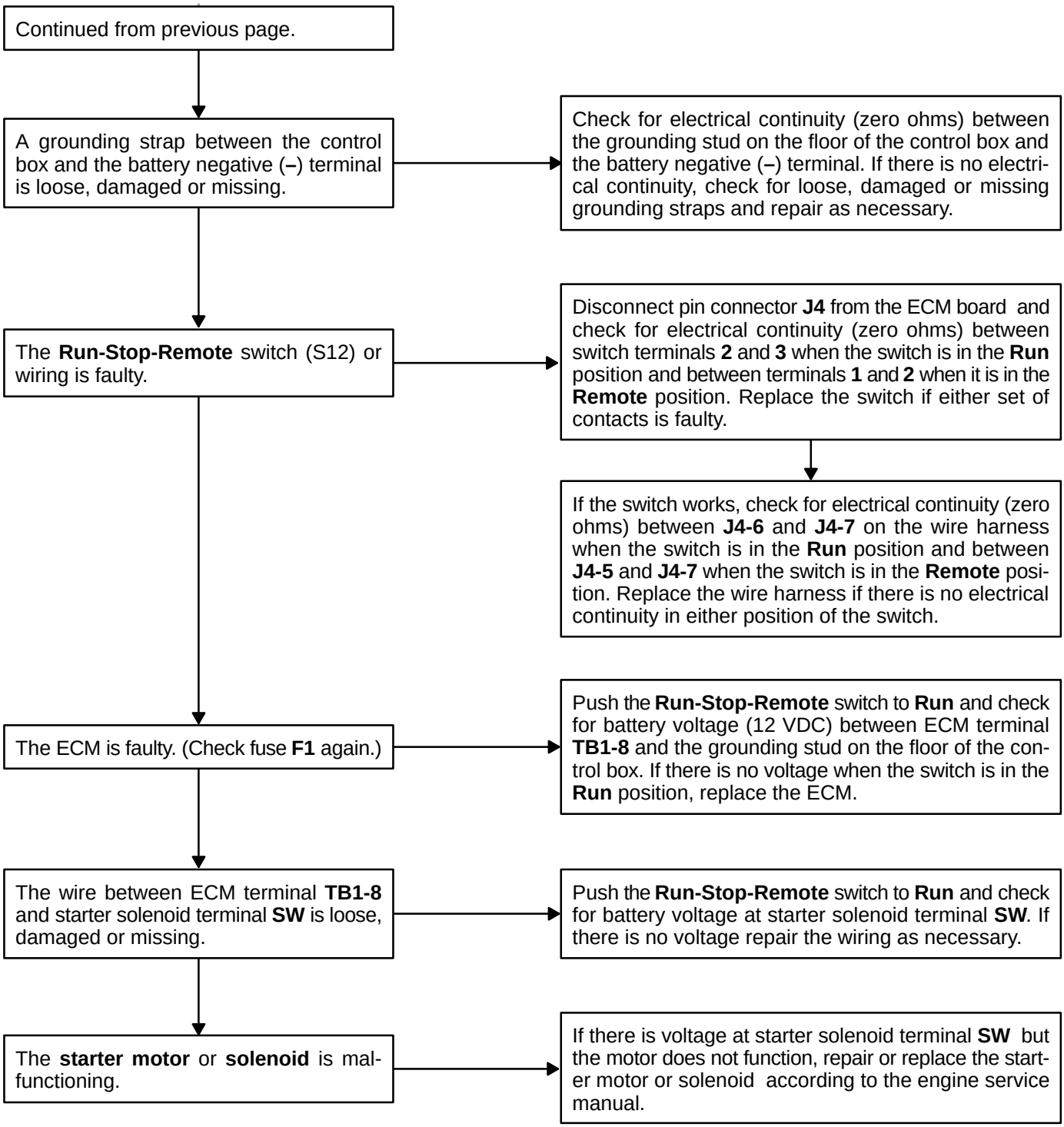
## THE ENGINE DOES NOT CRANK (CONT.)



**⚠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.***

## THE ENGINE DOES NOT CRANK (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.***

## THE ENGINE CRANKS BUT DOES NOT START

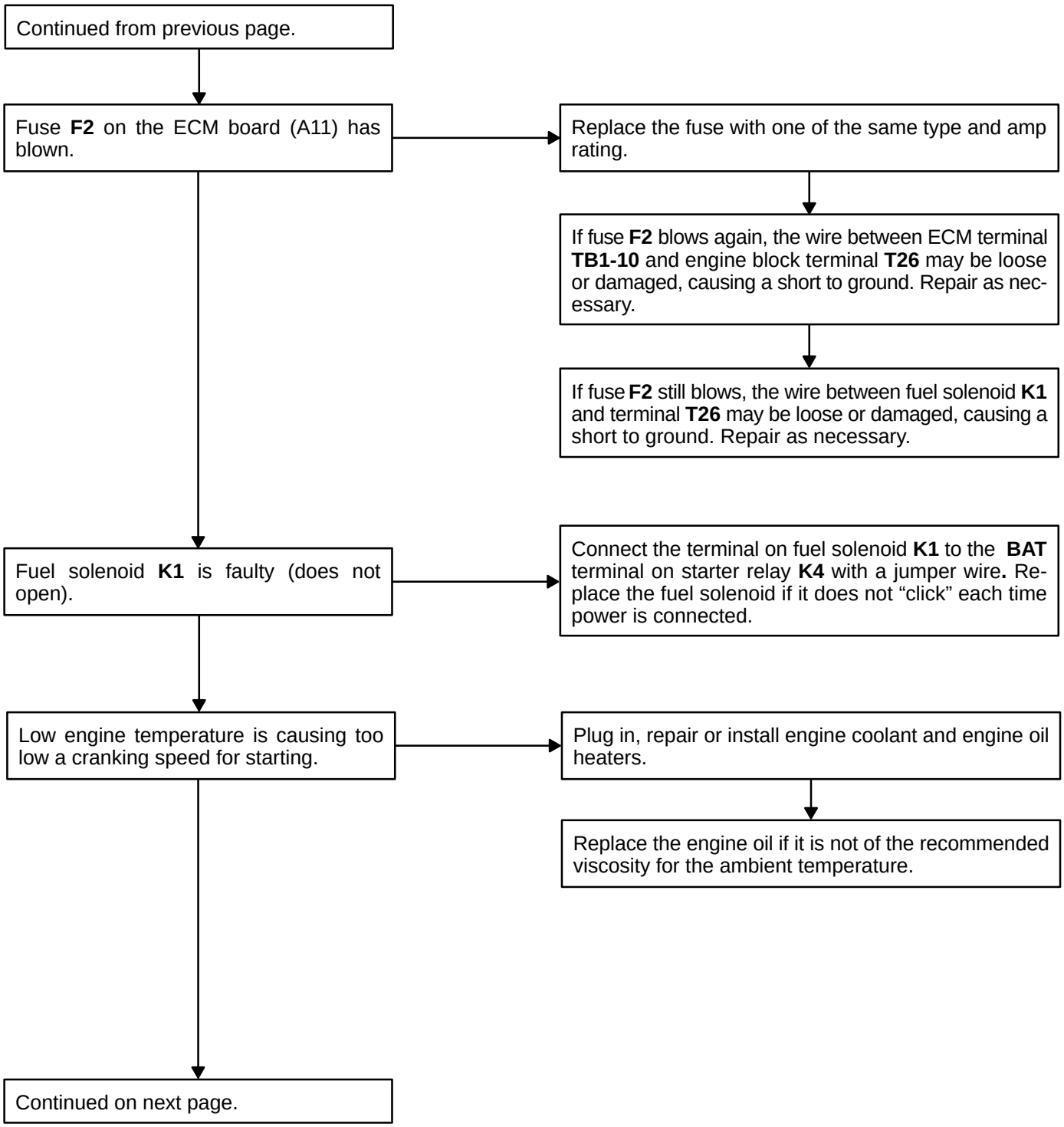
When the **Run-Stop-Remote** switch is in the **Run** position**,** the control will attempt to crank the engine for approximately 75 seconds (including two rest periods) and then the red **OVERCRANK** lamp will light if the engine does not start. If the **OVERCRANK** lamp comes on, reset the control by pushing the **Run-Stop-Remote** switch to **Stop** and the **Reset** switch to **Reset**. Then push the **Run-Stop-Remote** switch to **Run** or **Remote.**

- The engine is not getting fuel.
  - Open any closed shutoff valve in the fuel line supplying the engine.
  - Check fuel solenoid and related wiring. Repair or replace as needed.
  - Fill the main fuel supply tank if the set is gasoline or propane fueled. For natural gas fueled sets, check with the gas utility.
- The air cleaner is blocked.
  - Service as necessary.
- The engine ignition system is malfunctioning (ignition coil, distributor, spark plugs, high tension spark plug and coil cables and timing.
  - Service as necessary. Refer to wiring diagrams in *Section 7*.
- The carburetor fuel passages are clogged or the choke needs adjustment.
  - Clean and rebuild gasoline carburetors with the appropriate carburetor kit according to the kit instructions. Adjust fuel mixture and choke (refer to *Section 6*).

Continued on next page.

**⚠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.***

## THE ENGINE CRANKS BUT DOES NOT START (CONT.)



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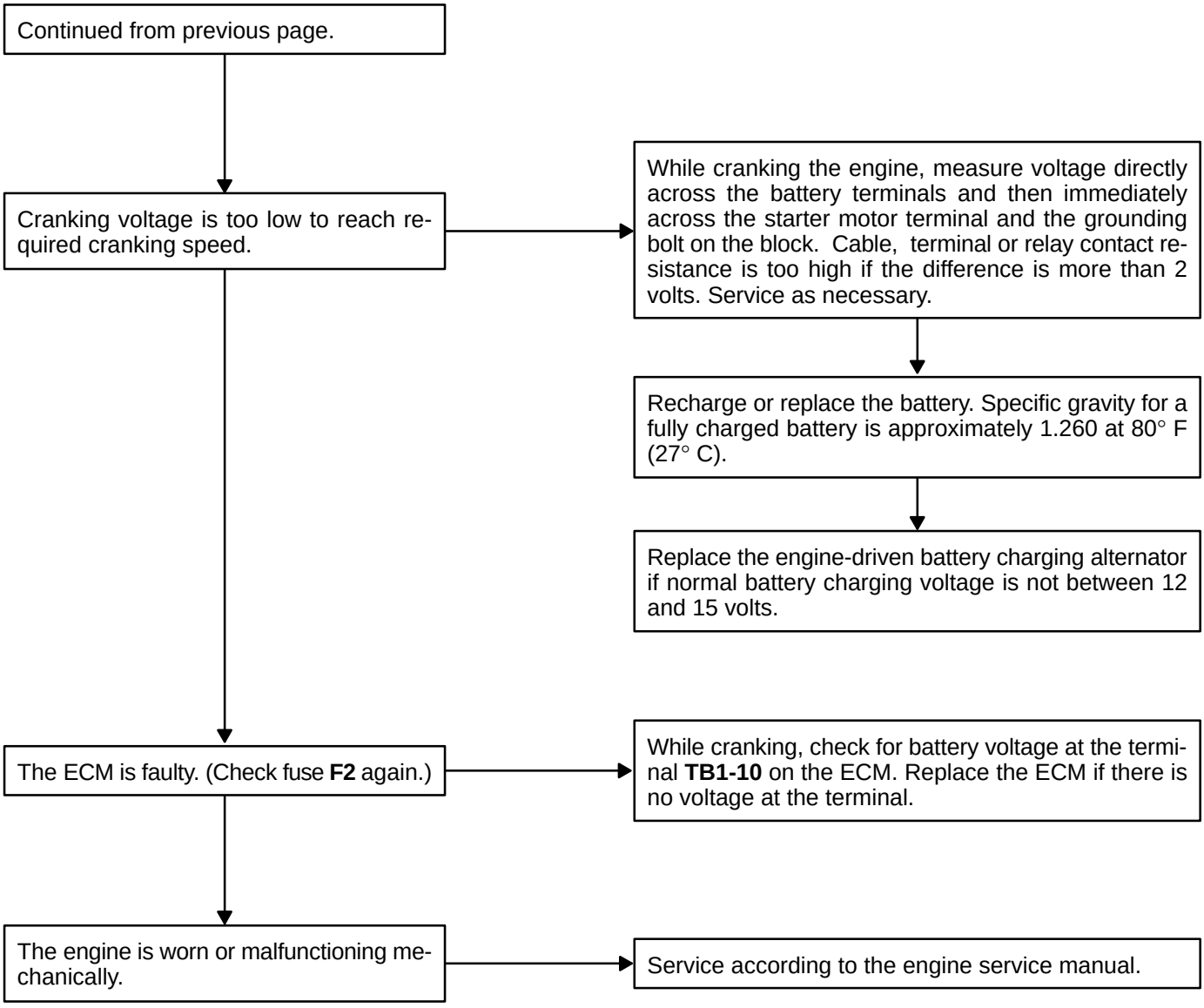
## THE ENGINE CRANKS BUT DOES NOT START (CONT.)



**⚠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.***

## THE ENGINE RUNS UNTIL FAULT SHUTDOWN (RED SHUTDOWN LAMP ON)

The **OVERSPEED** lamp comes on when the engine shuts down.

Reset the ECM by pushing the **Run-Stop-Remote** switch to **Stop** and the **Reset** switch to **Reset** and re-start the set, monitoring engine speed. Readjust the cutout speed if it is lower than specified. See Section 3, *Engine Control*.

Adjust the governor according to Section 6, *Governors.*

**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 lead connected at governor controller terminal **5** and connect it to the negative (–) terminal of the cranking battery. Then disconnect the lead connected at terminal **4** and touch it to the battery positive (+) terminal. 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.

Continued on next page.

**⚠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.***

## THE ENGINE RUNS UNTIL FAULT SHUTDOWN (CONT)

Continued from previous page.

The **LOW OIL PRESSURE** lamp comes on when the engine shuts down.

Reset the ECM by pushing the **Run-Stop-Remote** switch to **Stop** and the **Reset** switch to **Reset** and fill up with as much engine oil as necessary and repair all oil leaks.

If the set still shuts down due to low oil pressure, disconnect the wire to fuel solenoid **K1** (to keep the engine from starting) 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 10 psi. Replace the low oil pressure cutout switch if oil pressure is greater than 10 psi. See Figure 3-5, *Engine Control* to locate the switch.

The **HIGH ENGINE TEMPERATURE** lamp comes on when the engine shuts down.

Reset the ECM by pushing the **Run-Stop-Remote** switch to **Stop** and the **Reset** switch to **Reset** and fill up with as much engine coolant as necessary and repair all leaks.

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 230° F (110° C), replace the high engine temperature cutout switch. If coolant temperature exceeds 230° F (110° C), clean and service the entire cooling system as required to restore full cooling capacity. See Figure 3-5 in Section 3, *Engine Control,* to locate the switch.

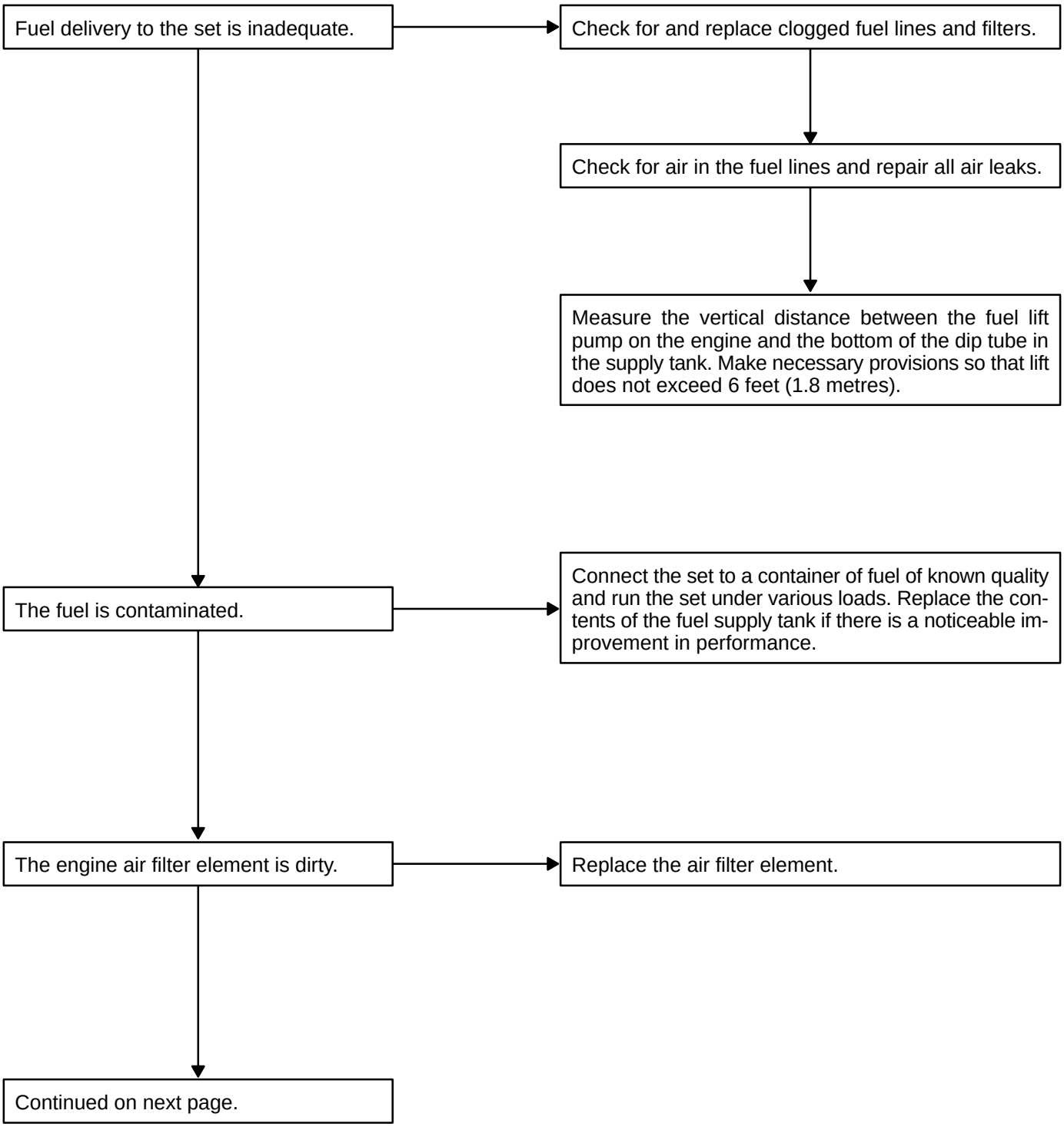
The **FAULT 1** or **FAULT 2** lamp comes on when the engine shuts down.

Service as required. (The customer has supplied the system fault indicating switches. By means of selection jumpers, either fault may be chosen to display the warning only. See Section 3, *Engine Control*.)

If the set is equipped with the optional low frequency shutdown feature and the red **FAULT 1** or **FAULT 2** lamp is on, the set probably ran out of fuel. Service as required.

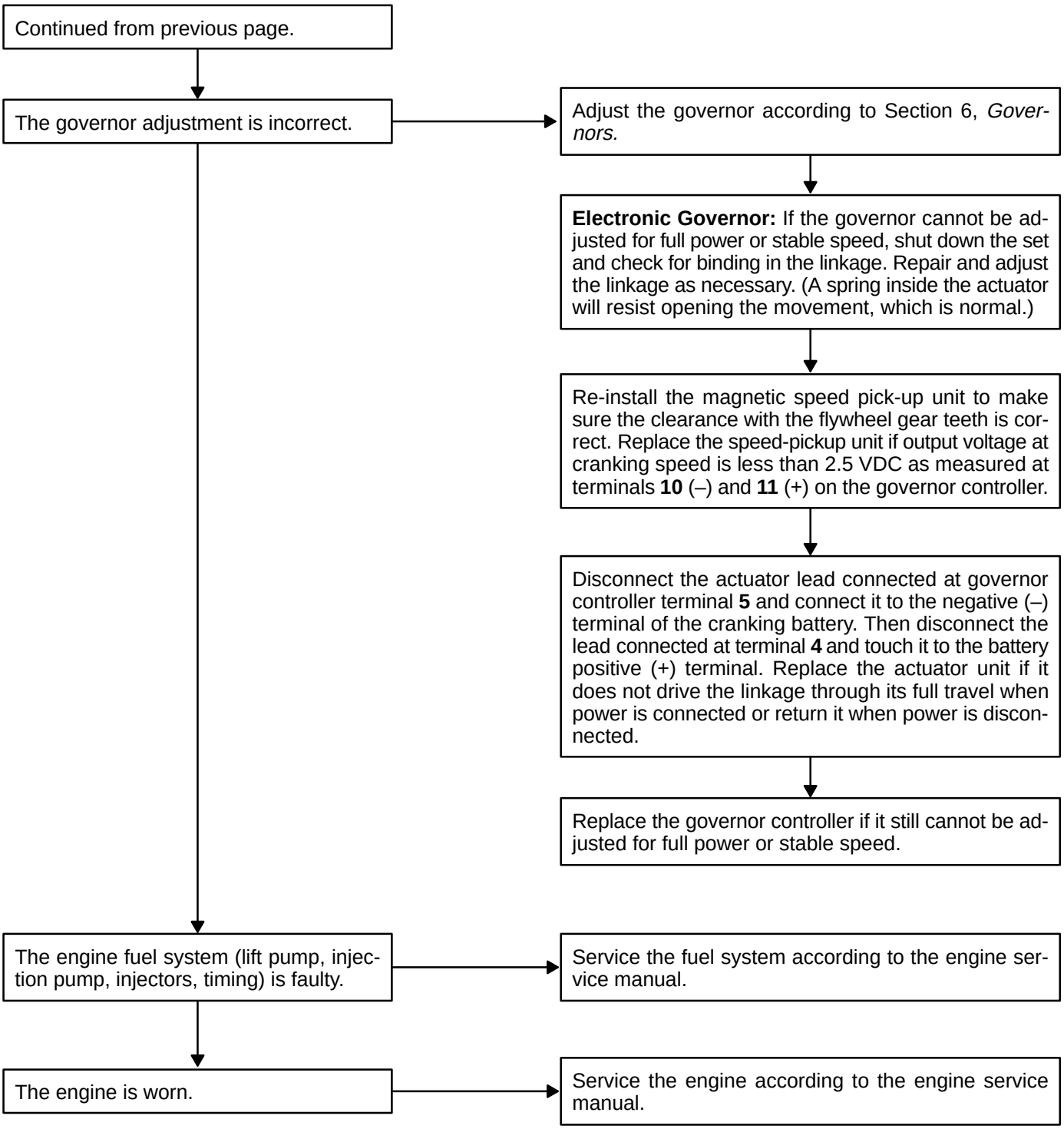
**⚠WARNING** ***Hazards present in troubleshooting can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the Safety Precautions page and carefully observe all instructions and precautions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

## THE ENGINE LACKS POWER OR STABLE SPEED



**⚠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.***

## THE ENGINE LACKS POWER OR STABLE SPEED (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.***

**AMBER WARNING LAMP ON**

| | |
|---|---|
| The **PRE-LOW OIL PRESSURE** 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 [138kPa] but greater than 14 psi [97 kPa].) Service the engine lubricating system according to the engine service manual. Normal operating range is 35 to 60 psi (241 to 414 kPa). |
| The **PRE-HIGH ENGINE TEMPERATURE** 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. |
| The **LOW ENGINE TEMPERATURE** lamp comes on while the set is in standby. | Plug in, repair or install engine coolant and engine oil heaters. |
| The **LOW 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.) |
| **FAULT 1** or **FAULT 2 (RED)** | 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 See Section 3, *Engine Control*. |

**⚠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.***

## THE GREEN RUN LAMPS STAY OFF BUT THE SET RUNS NORMALLY

The set mounted **RUN** lamp does 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.

↓ If the lamp is good, this indicates that the DC disconnect circuit (K14 relay circuit on the ECM) is not working. Check the DC voltmeter and if there is not at least 12 volts, check for loose or missing wiring between the battery charging alternator and terminal **TB1-2** and pin connector **P1-3** on the ECM. See Page **7-6** or **7-8** regarding the applicable alternator configuration. If the connections are good, replace the battery charging alternator.

↓ If the **RUN** lamp, wiring connections and battery charging alternator are all good and the **RUN** lamp does not light during normal operation, replace the ECM.

Neither the remote nor the set mounted **RUN** lamp 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 (K10 relay circuit on the ECM) is not working. Check the AC voltmeter to determine whether or not there is generator output voltage and service as necessary. See There Is No Output Voltage.

↓ 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.

**⚠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.***

## THERE IS NO OUTPUT VOLTAGE (ENGINE SPEED IS STABLE)

| | |
|---|---|
| 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**. |
| 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. |
| 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. |
| Field circuit breaker **CB21** has **TRIPPED**. | **RESET** the circuit breaker. If it keeps tripping, troubleshoot according to the chart, *Field Circuit Breaker Keeps Tripping*. |
| 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. |

Continued on next page.

**⚠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.***

## THERE IS NO OUTPUT VOLTAGE (CONT. )

Continued from previous page.

Determine, as follows, whether the fault is in the **VOLTAGE REGULATING** or **GENERATOR** circuits:

1. 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.***

2. Open the control panel and disconnect the **F1 (+)** and the **F2 (–)** leads from the voltage regulator. See Figure 2-2.

   **⚠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.***

3. Start the set and check for output voltage at the main stator terminals.
   a. Is there 5–20 VAC residual voltage at the output of the main stator windings when the exciter leads are disconnected?
   - YES: The main stator windings are good, continue with step 4.
   - NO: Use the **GENERATOR FAULT** chart to troubleshoot generator.

4. If the residual voltage is good, stop the set and reconnect the exciter leads to the exciter stator. Start the set. Has the output voltage increased?
   - YES: Adjust the Coarse Voltage Adjust pot on VRAS-2.
   - NO: Check if CB21 is closed. If CB21 is OK, flash the field using the procedure in Section 5.

5. When field is flashed, does the output voltage from the main stator increase?
   - YES: The generator assembly is OK.
   - NO: Use the **GENERATOR FAULT** chart to troubleshoot generator.

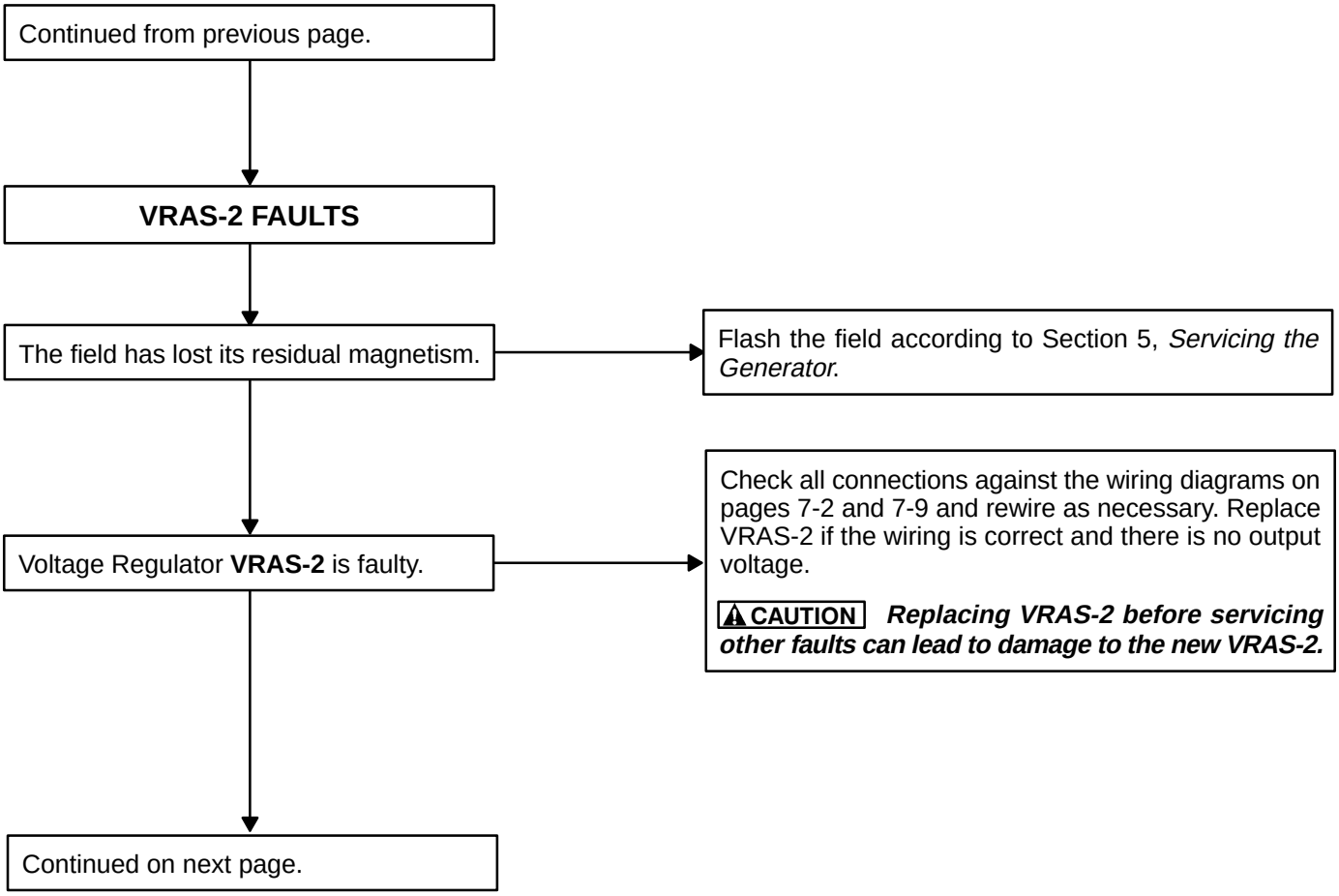
6. If the output voltage increased when the field was flashed, does the output voltage remain after the flash circuit is removed?
   - YES: The generator assembly and VRAS-2 are OK.
   - NO: VRAS-2 is defective. Use the **VOLTAGE REGULATING FAULTS** chart to troubleshoot VRAS-2.

7. Put a full load on the generator set. Does the generator set output stay up after the generator set has responded to the load?
   - YES: The generator assembly and VRAS-2 are OK.
   - NO: Check each diode according to Section 5, *Servicing the Generator.*

Continued on next page.

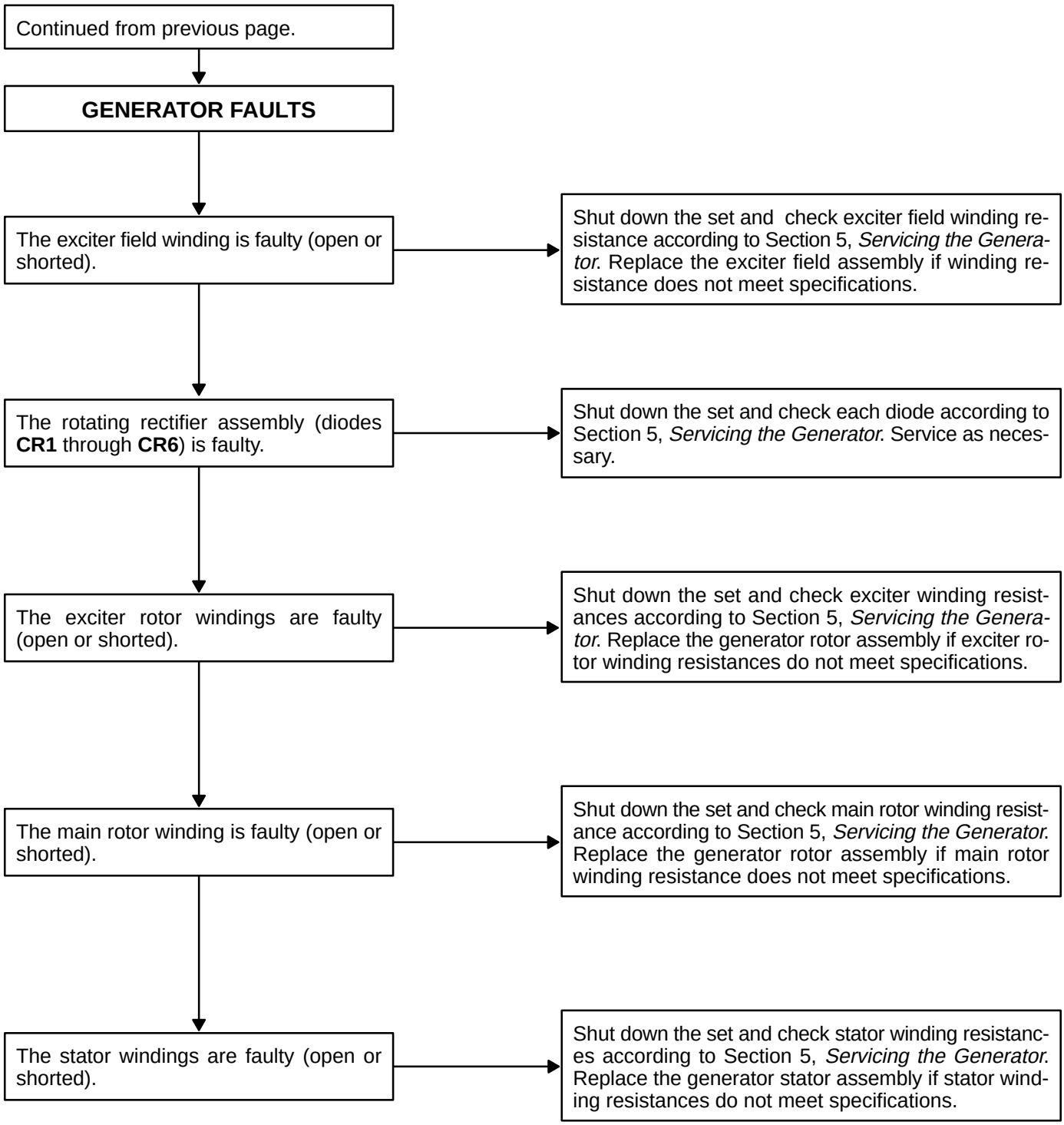
**⚠WARNING** ***Hazards present in troubleshooting can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the Safety Precautions page and carefully observe all instructions and precautions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

**THERE IS NO OUTPUT VOLTAGE (CONT. )**



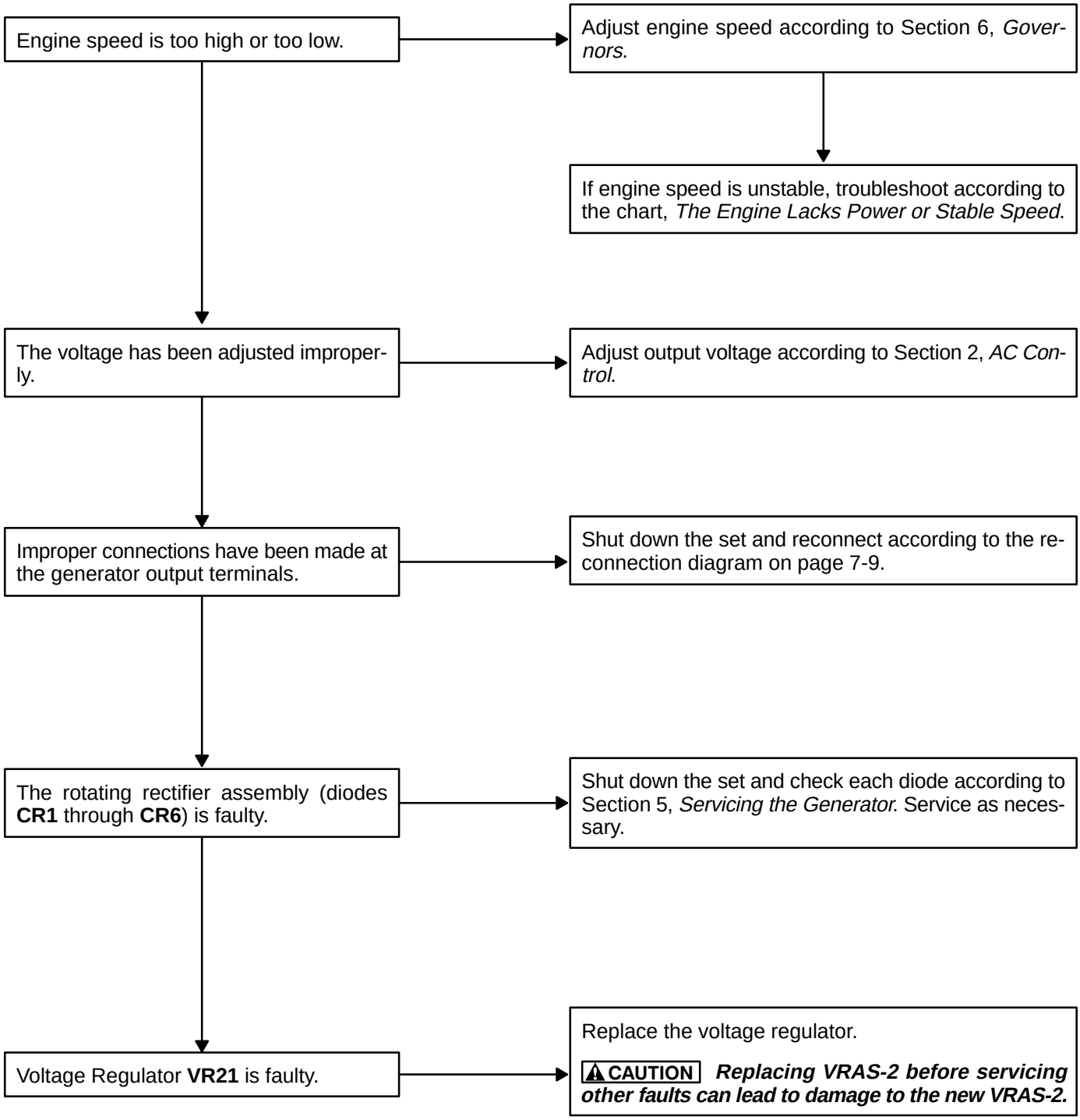
**⚠WARNING** ***Hazards present in troubleshooting can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the Safety Precautions page and carefully observe all instructions and precautions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

**THERE IS NO OUTPUT VOLTAGE (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.***

## OUTPUT VOLTAGE IS TOO HIGH OR TOO LOW



**⚠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.***

## OUTPUT VOLTAGE IS UNSTABLE

| | |
|---|---|
| The voltage has been adjusted improperly. | Adjust output voltage according to Section 2, *AC Control*. |
| 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. |
| Voltage Regulator **VR21** is faulty. | Replace the voltage regulator.<br>**⚠CAUTION** ***Replacing VRAS-2 before servicing other faults can lead to damage to the new VRAS-2.*** |

**⚠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.***

## THE FIELD CIRCUIT BREAKER KEEPS TRIPPING

| | |
|---|---|
| The rotating rectifier assembly (diodes **CR1** through **CR6**) is faulty. | Shut down the set and check each diode according to Section 5, *Servicing the Generator*. Service as necessary. |
| The exciter field winding is shorted. | Shut down the set and check exciter field winding resistance according to Section 5, *Servicing the Generator*. Replace the exciter field assembly if winding resistance does not meet specifications. |
| The exciter rotor windings are shorted. | Shut down the set and check exciter winding resistances according to Section 5, *Servicing the Generator*. Replace the generator rotor assembly if exciter rotor winding resistances do not meet specifications. |
| The main rotor winding is shorted. | Shut down the set and check main rotor winding resistance according to Section 5, *Servicing the Generator*. Replace the generator rotor assembly if main rotor winding resistance does not meet specifications. |
| The stator windings are shorted. | Shut down the set and check stator winding resistances according to Section 5, *Servicing the Generator*. Replace the generator stator assembly if stator winding resistances do not meet specifications. |
| Voltage Regulator **VR21** is faulty. | Replace the voltage regulator.<br>**⚠CAUTION** ***Replacing VRAS-2 before servicing other faults can lead to damage to the new VRAS-2.*** |

**⚠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.***

## THE PHASE CURRENTS ARE UNBALANCED

| | |
|---|---|
| The connected loads are distributed unevenly among the phases. | Shut down the set and redistribute the loads so that there is a difference of less than 10 percent between phases. |
| Improper connections have been made at the generator output terminals. | Shut down the set and reconnect according to the reconnection diagram on page 7-9. |
| The stator windings are faulty (open or shorted). | Shut down the set and check stator winding resistances according to Section 5, *Servicing the Generator*. Replace the generator stator assembly if stator winding resistances do not meet specifications. |
| A load has a ground fault or short circuit. | Service the faulty equipment as necessary. |

# 5. Servicing the Generator

## TESTING THE GENERATOR

These tests can be performed without removing the generator. Before starting tests, turn off or remove AC power from the battery charger and then disconnect the starting battery cables (negative [-] first) to make sure the engine will not start while performing these tests.

**⚠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.***

**⚠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).***

***Make certain battery area has been well-ventilated before servicing battery. Arcing can ignite explosive hydrogen gas given off by batteries, causing severe personal injury. Arcing can occur when cable is removed or re-attached, or when negative (–) battery cable is connected and a tool used to connect or disconnect positive (+) battery cable touches frame or other grounded metal part of the set. Always remove negative (–) cable first, and reconnect it last. Make certain hydrogen from battery, engine fuel, and other explosive fumes are fully dissipated. This is especially important if battery has been connected to battery charger.***

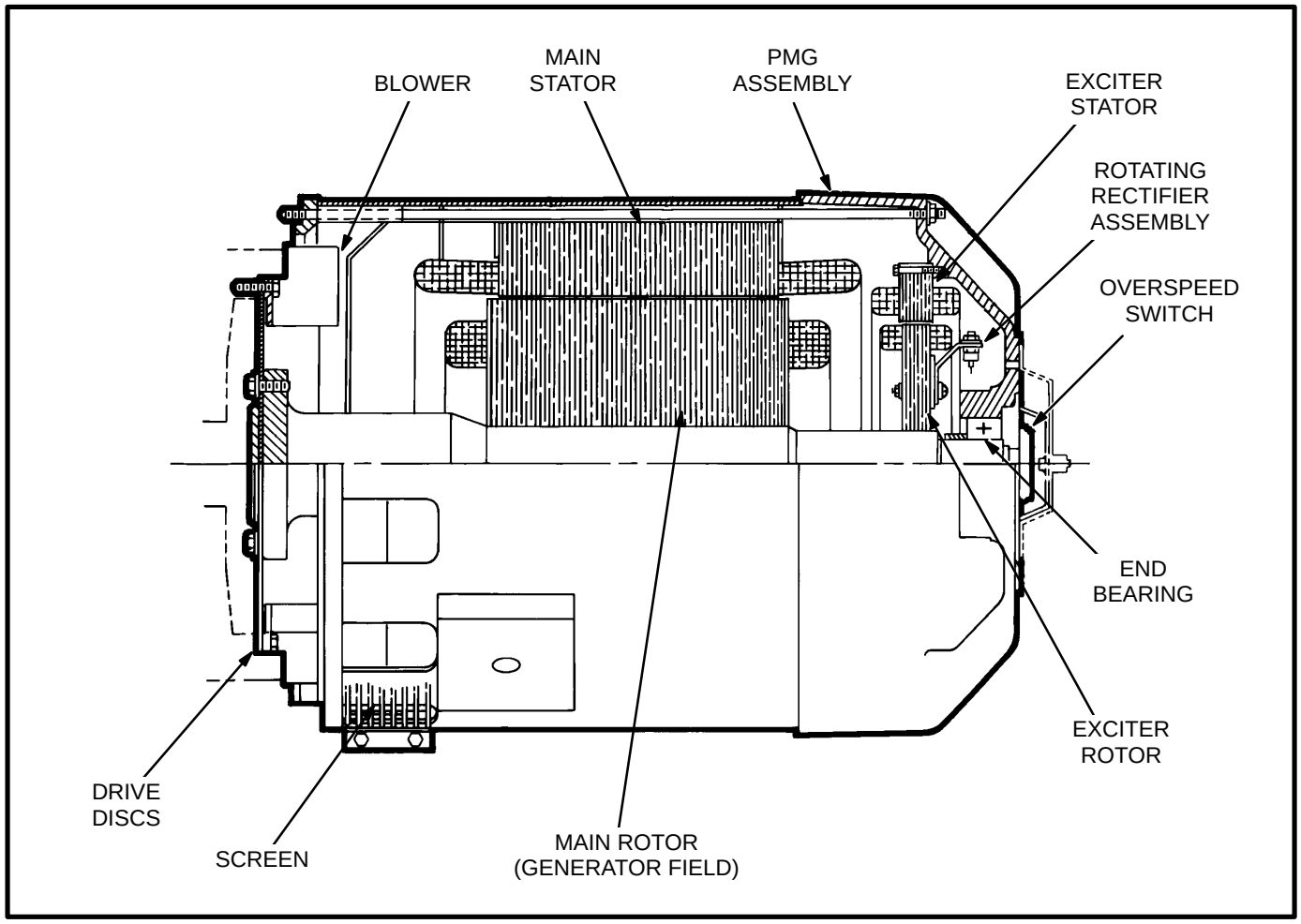



**FIGURE 5-1. GENERATOR**

## INSULATION RESISTANCE (MEGGER) & POLARIZATION INDEX (PI) TESTING

These tests are used for insulation testing and to verify that the windings are dry before the generator set is operated and develop a base line for future test comparison.

### Megger Testing

A 500 VDC megger is recommended for insulation testing. A test consists of applying the voltage between the winding and ground for one minute.

Resistance value of at least 5 megohms should be obtained for a new generator with dry windings. For a set that has been in service, the resistance reading should not be less than 1 megohm.

### PI Testing

The PI test consists of applying a voltage between the winding and ground for ten minutes and recording resistance values at one minute and at ten minutes. The PI is the ratio of a ten minute reading in megohms divided by a one minute reading in megohms. A ratio of two or greater is considered good for new and in service sets.

If low readings are obtained, the cause should be investigated and corrected before the generator set is returned to service.

If moisture is determined to be the cause of low test readings, a winding drying process will be required.

## DRYING THE WINDINGS

If low readings are obtained and moisture is determined to be the problem, the windings should be dried out and the test repeated. Use the generator heaters or blow warm air through the generator with a fan. A more effective way is to use a bolted 2 / 3-phase short across the generator terminals. This procedure must be done as described or equipment damage can result. To do this:

1. Bolt the two or the three phases of the generator together at the terminals. See the reconnection diagram in *Section 7*.
2. Disconnect the F1 and F2 leads (Figure 5-2) at the voltage regulator and connect them to a variable 12 VDC source. Positive lead to F1, negative lead to F2.
3. Attach a clamp-on ammeter to the generator leads to measure generator current, adjust the 12 VDC source for zero volts, start the set and slowly increase the excitation voltage. Obtain the highest current possible without exceeding generator rating.
4. Run the set for approximately one hour and repeat the insulation resistance tests. If further drying time is indicated, continue the drying process.

## EXCITER STATOR

### Testing Winding Resistance

Measure winding resistance with a Wheatstone bridge or digital ohmmeter. Resistance should be approximately 20 ohms at 68° F (20° C).

**Before performing the following insulation resistance test, refer to the *Insulation Resistance and Polarization Index Test* procedure at the beginning of this section.**

### Testing Winding Insulation Resistance

Disconnect the F1 and F2 exciter stator leads at the voltage regulator and isolate them from ground.

Connect the megger between one of the leads and ground and conduct the test. Replace the stator if insulation resistance is less than 1 megohm (1,000,000 ohms).

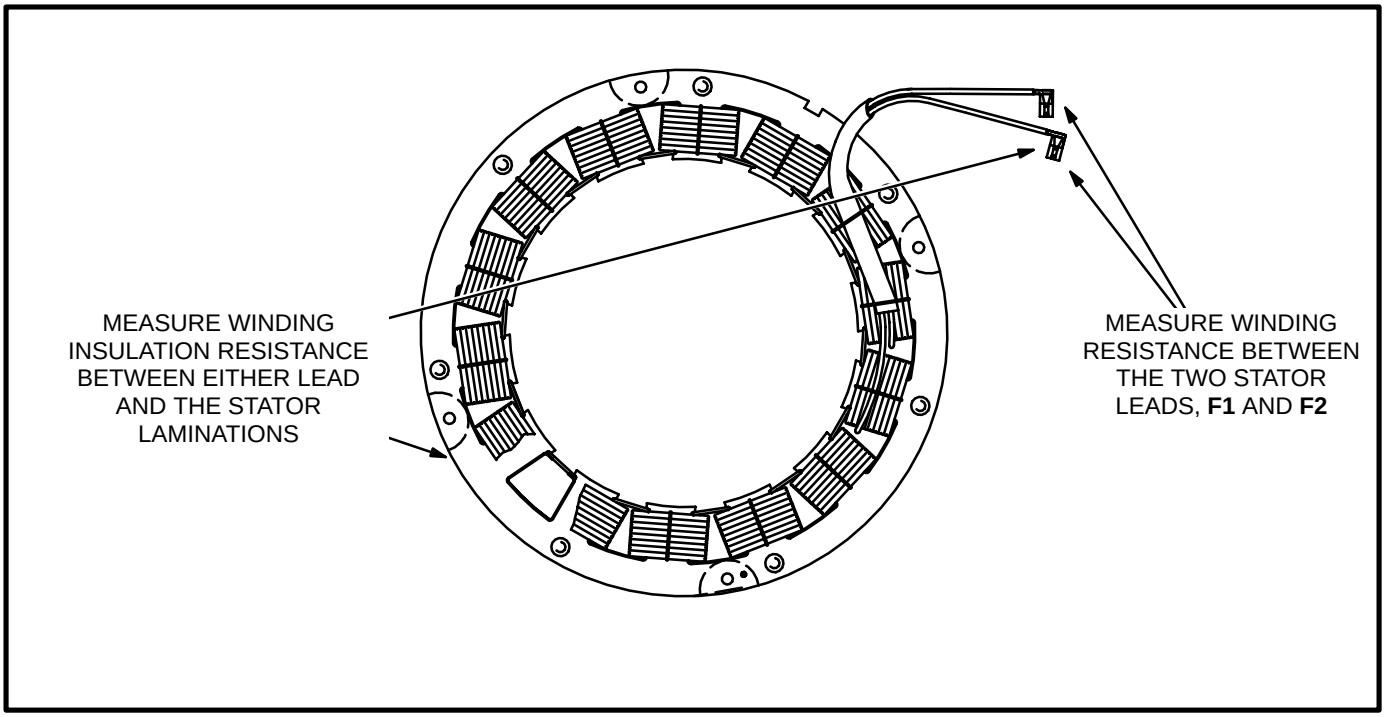



**FIGURE 5-2. TESTING AND FLASHING THE EXCITER STATOR**

## Flashing the Field

If output voltage does not build up, it may be necessary to restore residual magnetism by flashing the field. This requires a 12-volt battery, a 12-ampere 300-volt diode, and a 12-volt light bulb or a 2-watt 20-ohm resistor wired as shown in Figure 5-3.

Flashing the field can be accomplished with generator set operating or not. Either of the following procedures should be sufficient to restore residual magnetism.

**⚠ CAUTION** ***Incorrect field flashing procedures can damage regulator or exciter stator windings. Do not maintain field flash connection to exciter circuit longer than 5 seconds.***

***Make sure a diode is used in the field flash apparatus to prevent the regulator from overcharging the battery. Batteries can explode when overcharged.***

***With Generator Set in Operation:***

**⚠ 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.***

1. Start the generator set.
2. Touch the positive battery lead to TB1-9 and the negative lead to TB1-10 of VRAS-2. Hold the leads in place just long enough for the voltage to build up to the normal operating level, then remove the leads.
3. Check generator voltage, and shut down generator set. Restart generator set and run at no load. Unit must build up voltage without field flashing. If not, shut down generator set and perform continuity check of all related wiring.

***With Generator Set Shut Down:***

1. Touch the positive battery lead to TB1-9 and the negative lead to TB1-10 of VRAS-2.
2. Hold the leads in place for no longer than 5 seconds.
3. Start generator and run at no load. Unit must build up voltage without field flashing. If it does not, shut down generator set and perform continuity check of all related wiring.

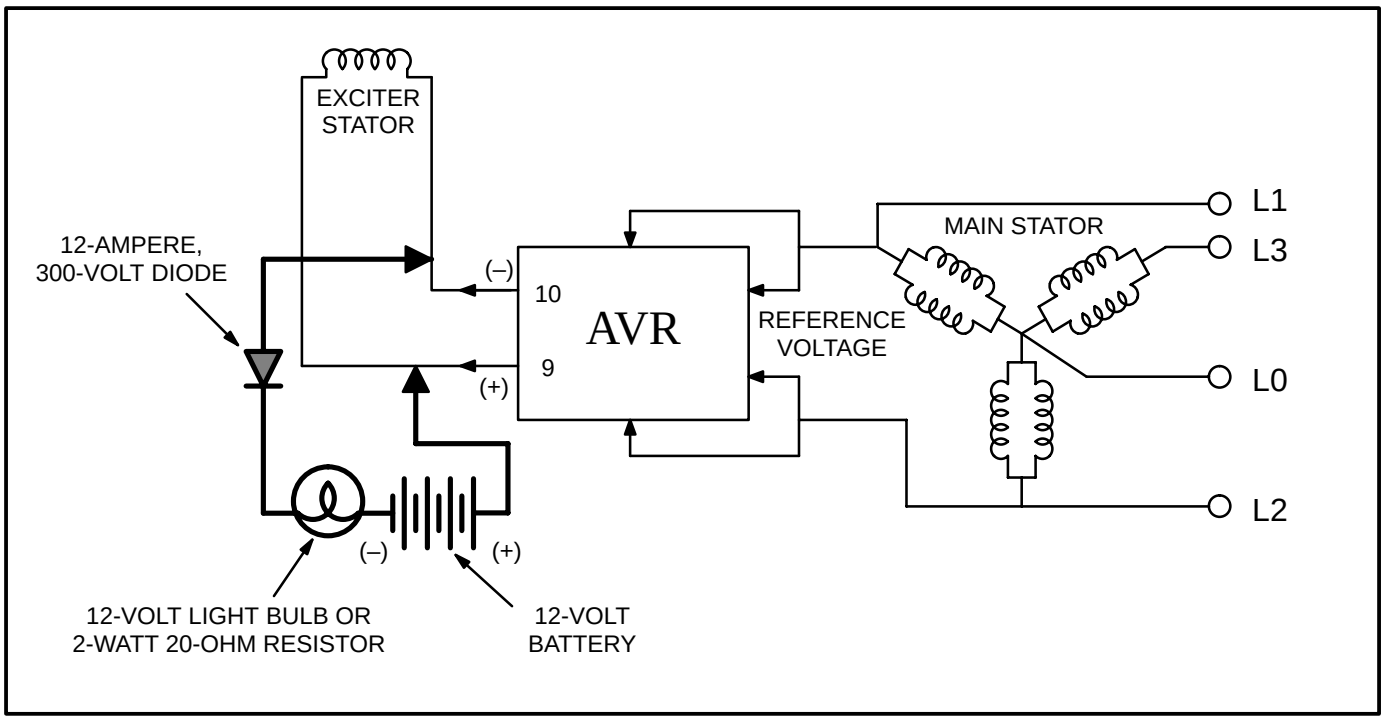



**FIGURE 5-3. FIELD FLASHING CIRCUIT**

## EXCITER RECTIFIER BRIDGE (ROTATING RECTIFIER ASSEMBLY)

The exciter rectifier bridge is mounted on the exciter rotor, outboard, facing the rear. It consists of a positive plate and a negative plate, each carrying three diodes.

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

1. Disconnect one diode at a time by removing diode from heatsink.
   A. Use proper size wrenches to hold the diode body while removing the nut.
   B. Push the diode free of the heatsink mounting hole.
2. Test that diode before proceeding to the next one.
   A. Using an ohmmeter, measure electrical resistance between the flag and the stud of the diode.
   B. 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 resistance is high or low in both directions, replace the diode.
3. To replace diodes, use the following procedure.
   A. Unsolder lead wires of defective diodes from flag terminals.
   B. Insert new diode into heatsink mounting hole. Using nut and washer provided, secure diode to heatsink.
   C. Use proper size wrenches to hold the diode body while tightening the nut. Torque diodes on rotating exciter assembly to 24 in-lbs (2.7 N•m).
   D. Solder lead wires to new diode flag terminals.

**⚠ CAUTION** ***Excessive heat on these diodes will destroy them. Use a 40 watt soldering iron. Hold a needlenose pliers between diode and soldering point to prevent destructive heating.***

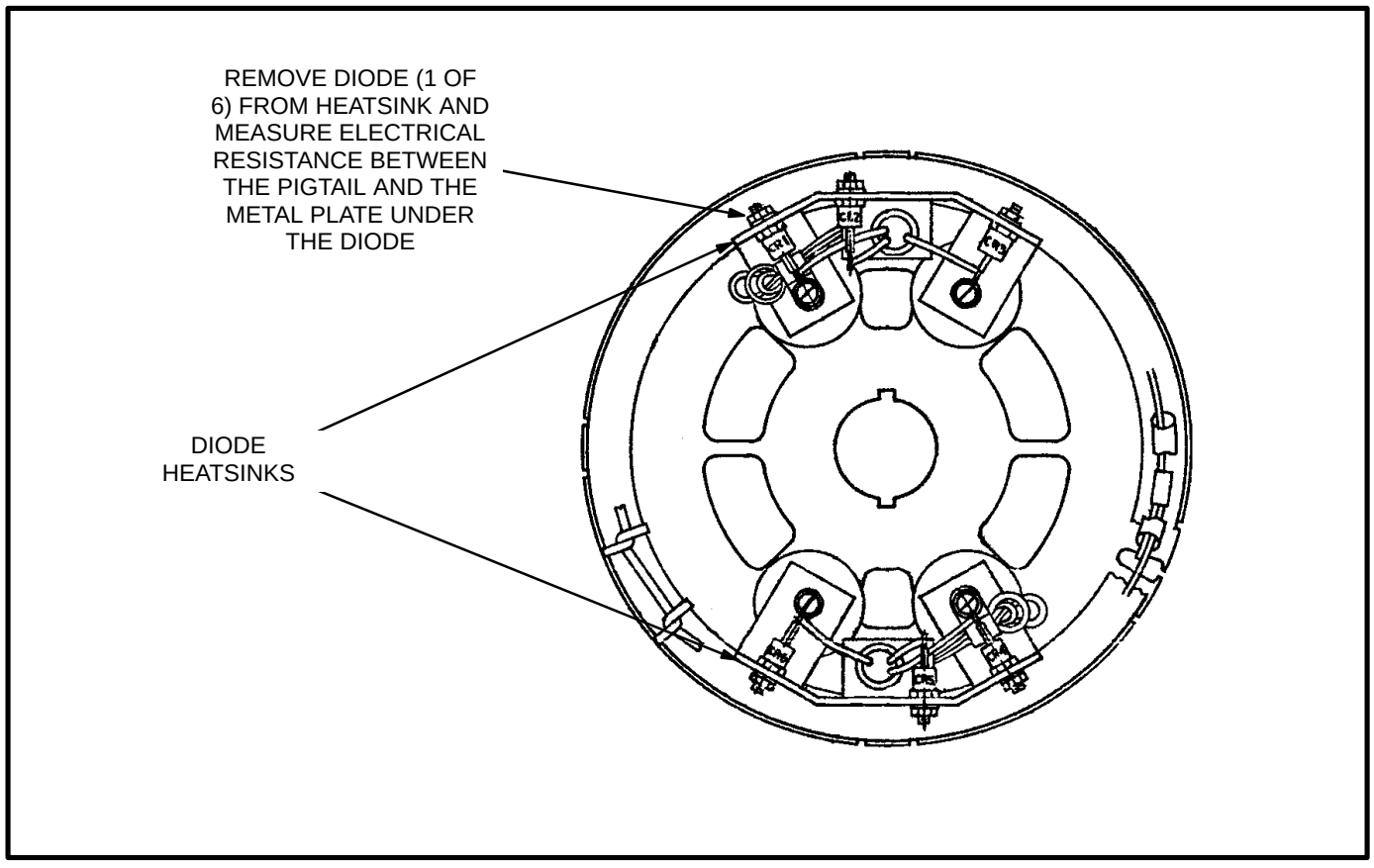



**FIGURE 5-4. TESTING THE ROTATING RECTIFIER ASSEMBLY**

## EXCITER ROTOR

### Testing Winding Resistance:

Remove diodes CR1 through CR6 from diode heat sink assemblies. With a Wheatstone bridge, measure electrical resistance across each pair of rotor windings: **T1** (CR1 or CR4) and **T2** (CR2 or CR5), **T2** (CR2 or CR5) and **T3** (CR3 or CR6), **T3** (CR3 or CR6) and **T1** (CR1 or CR4). See the winding schematic. Resistance should be 0.464 to 0.567 ohms at 68° F (20° C).

### Testing Winding Insulation Resistance:

Remove diodes CR1 through CR6 from diode heat sink assemblies. Using a megger (voltage set at 500 VDC), measure the resistance between any rotor winding lead or the terminal to which it is connected and the rotor laminations. Replace the exciter rotor if insulation resistance is less than 1 megohm.

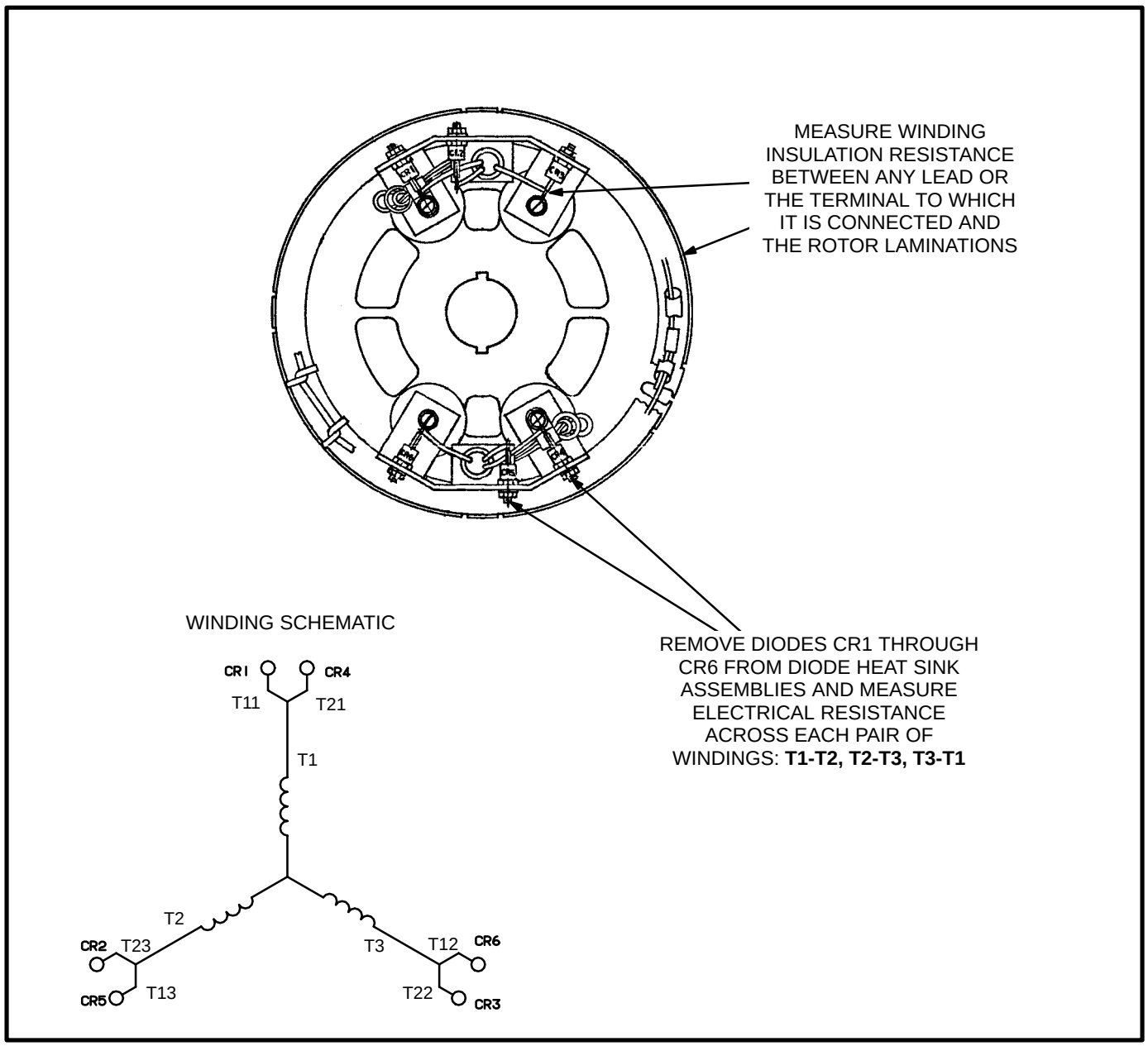



**FIGURE 5-5. TESTING THE EXCITER ROTOR**

## MAIN ROTOR (GENERATOR FIELD)

### Testing Winding Resistance

Disconnect the two leads of the main rotor from the terminals on the rotating rectifier assembly. See Figure 5-6. Measure electrical resistance between the two leads with a Wheatstone bridge or digital ohmmeter. Replace the rotor if the resistance is not as shown in the following list. Connect the rotor leads and torque the terminals to 24 in-lbs (2.7 N•m) when reassembling.

- **EK –** 3.32 to 4.06 ohms at 68° F (20° C)
- **EM –** 2.49 to 3.05 ohms at 68° F (20° C)

**Before performing the following insulation resistance test, refer to the *Insulation Resistance and Polarization Index Test* procedure at the beginning of this section.**

### Insulation Resistance and PI Test

Disconnect the two leads of the main rotor from the terminals on the rotating rectifier assembly. Using a megger (voltage set at 500 VDC), 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.

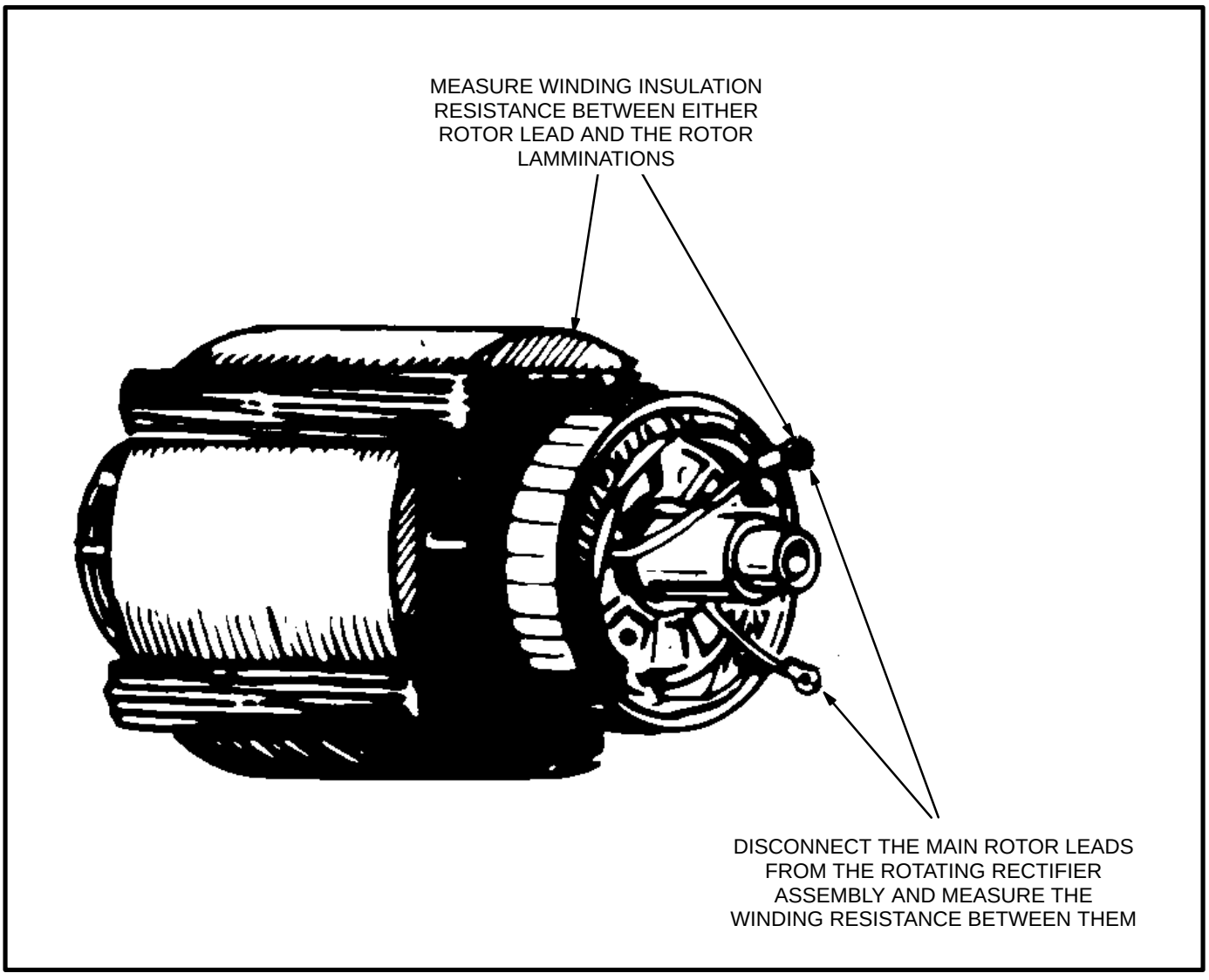



**FIGURE 5-6. TESTING THE MAIN ROTOR**

## MAIN STATOR

### Testing Winding Resistance

Disconnect all stator leads from the terminals to which they are connected. Using a Wheatstone bridge or ohmmeter having at least 0.001 ohm precision, measure electrical resistance across each pair of stator leads (T1-T4, T7-T10, T2-T5, T8-T11, T3-T6, T9-T12). Replace the stator if the resistance of any winding is not as specified in Table 5-1.

**TABLE 5-1. STATOR RESISTANCE VALUES***

| MODEL | VOLTAGE CODE | | |
|---|---|---|---|
| | L, R, 15, & 32 | H & 9X | E & 6D |
| EK | 0.116-0.141 | 0.425-0.520 | 0.432-0.528 |
| EM | 0.047-0.058 | 0.193-0.236 | 0.202-0.248 |

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

Alternatively, winding resistance can be measured line-to-line at the generator terminals (L1-L2, L2-L3, L3-L1) 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 resistance 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).

**Before performing the following insulation resistance test, refer to the *Insulation Resistance and Polarization Index Test* procedure at the beginning of this section.**

### Insulation Resistance and PI Test

Disconnect all stator leads and winding taps from their respective terminals and make sure the ends do not touch the generator frame.

*Testing For Grounds:* Using a megger (voltage set at 500 VDC), measure electrical resistance between any stator lead and the stator laminations. Replace the stator if insulation resistance is less than 1 megohm.

*Testing for Shorts:* Using a megger (voltage set at 500 VDC) measure electrical resistance between each winding, for example T1/T4 to T7/T10, T1/T4 to T2/T5, etc. Replace the stator if insulation resistance is less than 1 megohm.

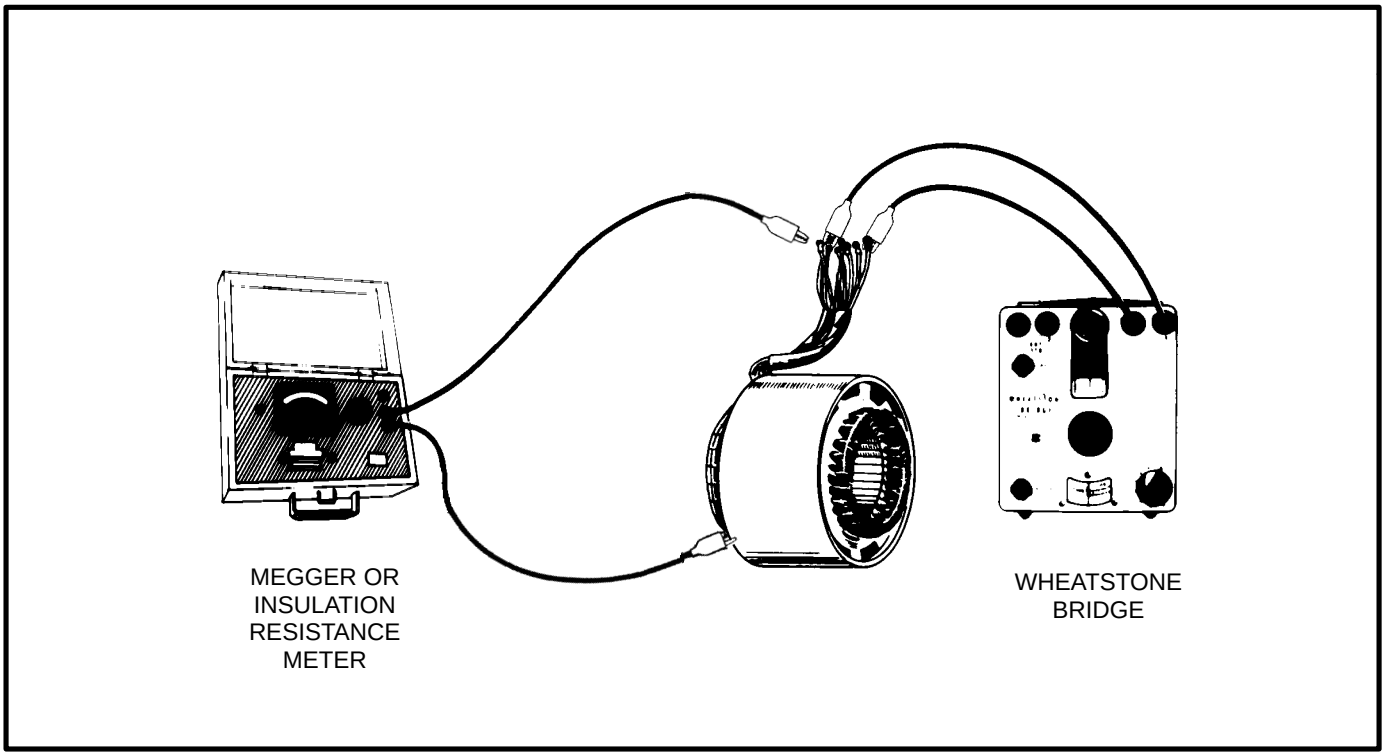



**FIGURE 5-7. TESTING THE GENERATOR STATOR**

## 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.***

8. Disconnect the line cables and conduit. For reconnections later, make sure each cable is clearly marked to indicate the correct terminal.
9. Disconnect the remote control wiring and conduit. For reconnections later, make sure each wire is clearly marked to indicate the correct terminal.
10. 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.
11. 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.
12. 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.
13. Remove the sheet metal from around the generator.
14. Remove the overspeed switch and bracket from the end bell and rotor shaft. See Figure 5-8.

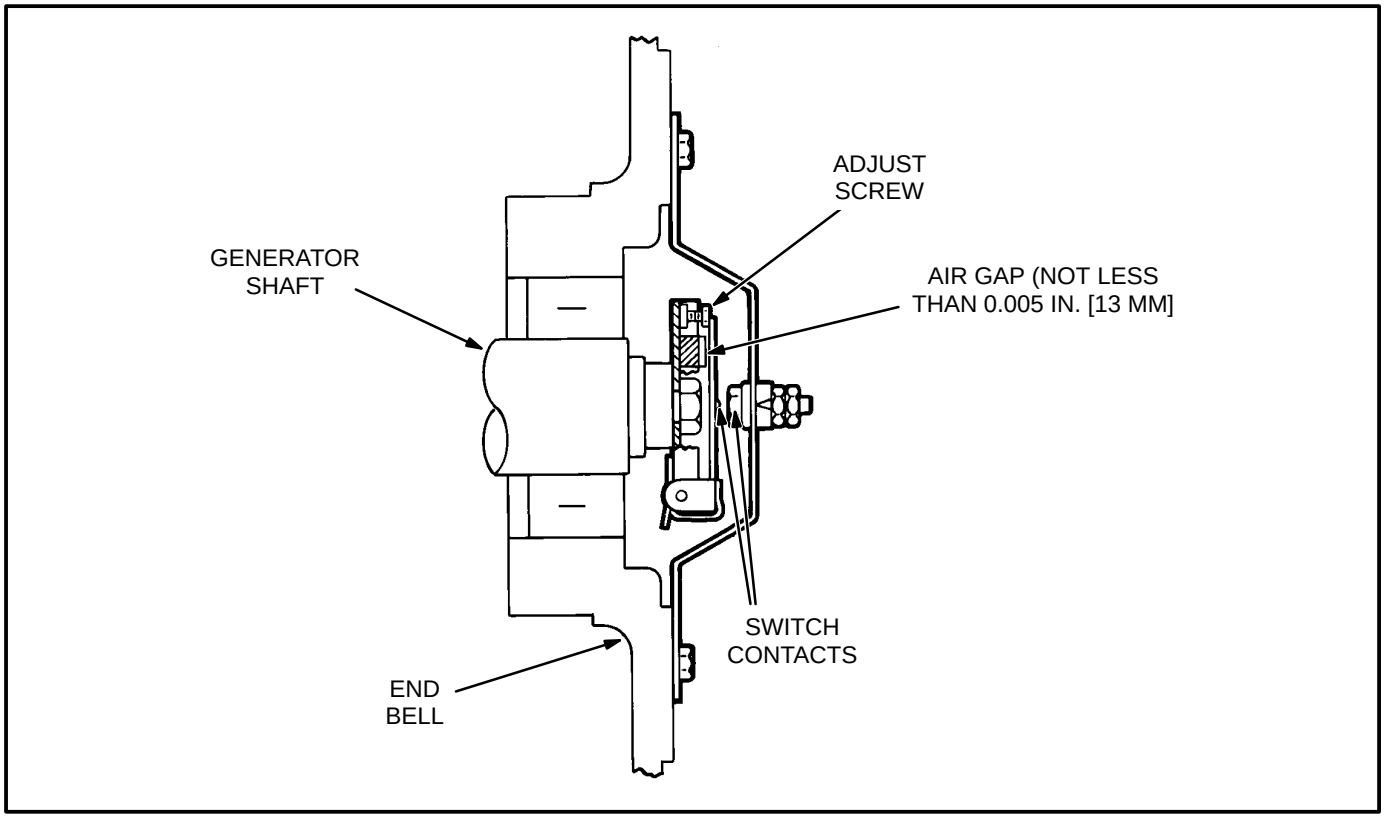



**FIGURE 5-8. OVERSPEED SWITCH ASSEMBLY**

15. Block the rear of the engine in place by supporting the flywheel housing.
16. Remove the four nuts and washers from the studs that secure the end bell.
17. Remove end bell with oil seal from stator assembly. It might be necessary to tap around end bell joint to separate end bell from stator.
18. Remove the four 1/4-inch bolts and lock washers securing the exciter stator to the end bell.
19. Remove the narrow generator air screen.
20. Remove the large capscrews securing the generator to the skid base.
21. Remove the bolts securing the stator to engine flywheel housing.
22. Using an overhead hoist and sling, slide the stator assembly off the long through-studs (note position of hose pieces on the studs, and proper orientation of the stator) being careful not to touch or drag on the rotor.

    The studs can be removed if you want to do so.

    **⚠ CAUTION** ***Do not allow the rotor to hang unsupported for any extended period. Otherwise, drive disk damage can occur.***
23. Attach the hoist and sling to the rotor assembly and apply a slight lift to support the rotor. Remove the bolts securing the drive disk to the engine flywheel and remove the rotor from the engine. Set on wood blocks so fan is not supporting any of the rotor weight.
24. Remove bearing bolt, flat washer, and lock washer. Then remove bearing. If required, remove fan from the rotor.
25. Disconnect rotor field leads from heat sinks F1 and F2 on the exciter rotor. Remove exciter rotor.

## REASSEMBLING THE GENERATOR

1. If any diodes are replaced in the exciter rotor, secure the new diode using a lock washer and nut, and torque to 12 to 15 in-lbs (1.4 to 1.7 N•m).
2. Slide exciter rotor, sleeve spacer, and press ball bearing over the generator shaft. Install the modified hex head bolt, lock washer, and flat washer and torque to 60 to 70 ft-lbs (81 to 95 N•m).
3. Place the generator fan in position on the rotor shaft.
4. Install the drive disk on the end of the rotor shaft with the chamfer on the flywheel side. Torque the placement bolts to 200 to 240 ft-lbs (271 to 325 N•m).
5. Using a hoist and sling to support the rotor, align the holes in the drive disk and fan with the corresponding holes in the flywheel.
6. Install the bolts that hold the drive disk to the engine flywheel and torque to 55 to 60 ft-lbs (75 to 81 N•m).

   **⚠ CAUTION** ***Do not allow the rotor to hang unsupported for any extended period. Otherwise, drive disk damage can occur.***
7. Using a hoist and safe lifting device, carefully move the stator into position over the rotor assembly. The stator leads should be at the 12 o'clock position when viewed from the end bell position. Make sure the short hose pieces are in place next to the flywheel housing before installing stator.
8. Align the holes of the stator with the engine flywheel housing and install the bolts. Torque to 35 ft-lbs (47 N•m).
9. Install the exciter stator in the end bell using the 1/4-inch bolts and lock washers. Torque to 7 ft-lb (9 N•m).
10. Apply a thin film of Molykote grease or equivalent to the mating surfaces of the end bearing and end bell bearing hole.
11. Install the end bell assembly, lock washers, and nuts on the studs. Torque nuts to 35 ft-lbs (47 N•m).
12. Using a lead hammer, tap the end bell at the horizontal and vertical plane to relieve stress. Retorque end bell stud nuts.
13. Install the generator air screen.
14. Refer to Figure 5-8. Mount and adjust Mechanical Overspeed Switch.

    When installing the overspeed switch assembly (capscrew, lock washer, switch, small flat washers, large flat washer, and spacer) on the rotor shaft, torque to 53 ft-lbs (72 N•m).

    Install the overspeed switch assembly bracket and secure using two capscrews and lock washers. Torque to 4.5 ft-lb (6 N•m). Refer to Figure 5-9, and set to proper gap

    Connect overspeed switch lead wire to terminal on overspeed switch bracket.
15. Install the control sheet metal back on the generator.
16. Reconnect the generator as required.

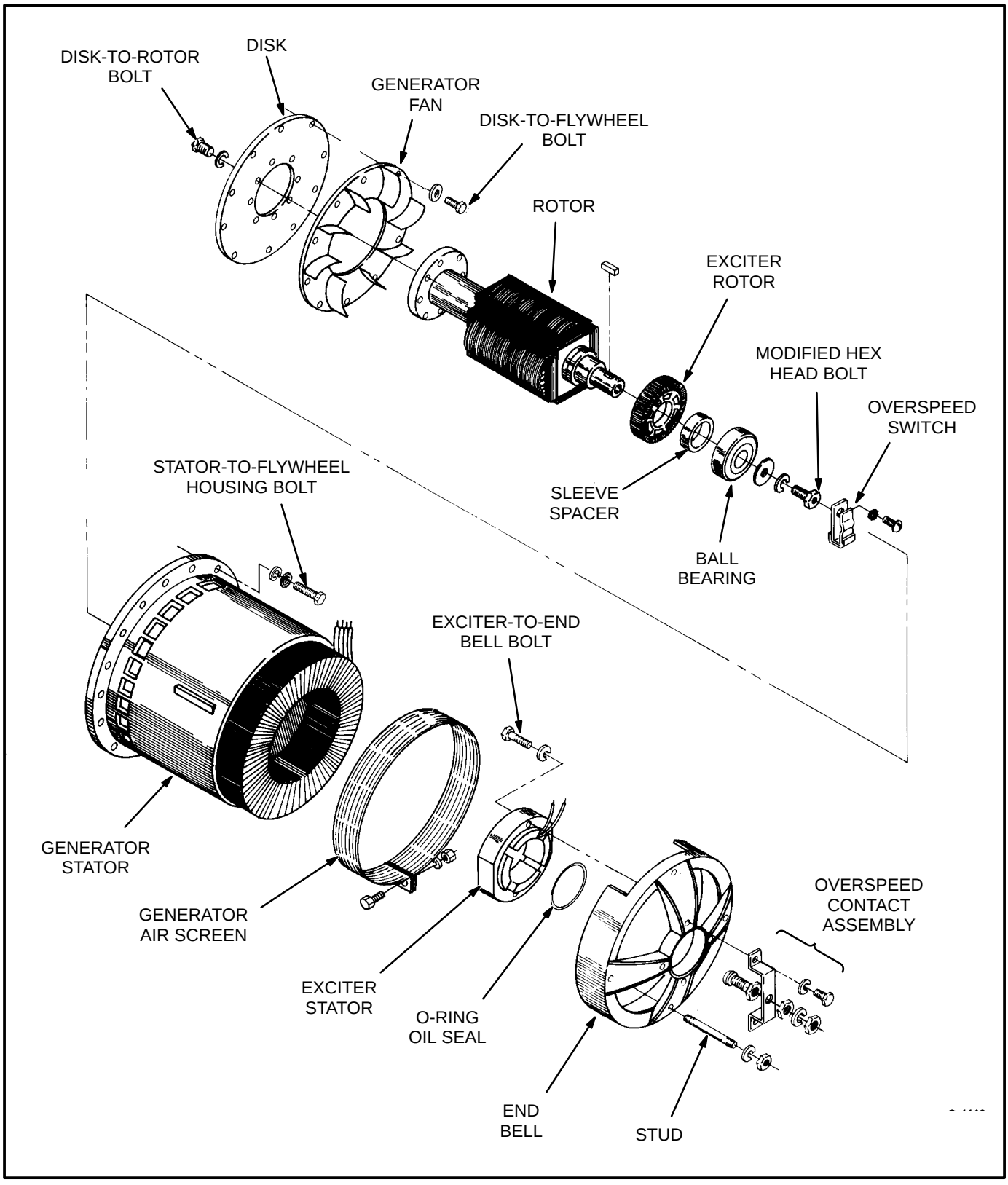



**FIGURE 5-9. GENERATOR ASSEMBLY**

# 6. Governors and Carburetors

## ELECTRIC GOVERNOR ADJUSTMENT

If necessary, adjust the gas mixture, the governor linkage and the magnetic speed pickup unit as instructed in this section before adjusting the governor controller. Make sure that the governor assembly is securely mounted. Also make sure that the governor linkage does not bind or have excessive play in it.

1. Check the dip switch settings (Figure 6-1) to make sure they are set properly, as follows:

**IGNITION TRIGGER (GOV MOD A378)**

| | SW1 (8CYL) | SW2 (6CYL) | SW3 (4CYL) | SW4 (50/60HZ) |
|---|---|---|---|---|
| **50 Hz** | OFF | ON | OFF | OFF |
| **60 Hz** | OFF | ON | OFF | ON |

**MPU TRIGGER (GOV MOD A377)**

| | SW1 | SW2 | SW3 | SW4 |
|---|---|---|---|---|
| **50 Hz** | ON | OFF | OFF | OFF |
| **60 Hz** | ON | OFF | OFF | ON |

2. Start the set, let the engine warm up under a partial load (at least 1/4 rated load) and then disconnect all loads. (If the governor has been replaced, adjust the Gain 1 and Stability 1 pots to their center settings.)

3. Adjust the Gain 1 pot until the engine is stable and responsive to governor control. (Adjust the Gain 1 pot counterclockwise to eliminate hunting.) Bump the throttle lever a couple of times to check for hunting. The unit should respond quickly but should not hunt.

4. Apply full load to the genset and adjust the Stability 1 pot to minimize overshoot. (Adjust the Stability 1 pot clockwise to increase stability.) Check stability under a range of loads; from no-load to full-load.

5. Attach a tachometer or frequency meter to the generator output leads if control panel does not come equipped with one of these meters. Adjust the Speed Trim pot until the desired speed is obtained.

6. Shut down and restart the genset to check for overspeed shutdown on startup.

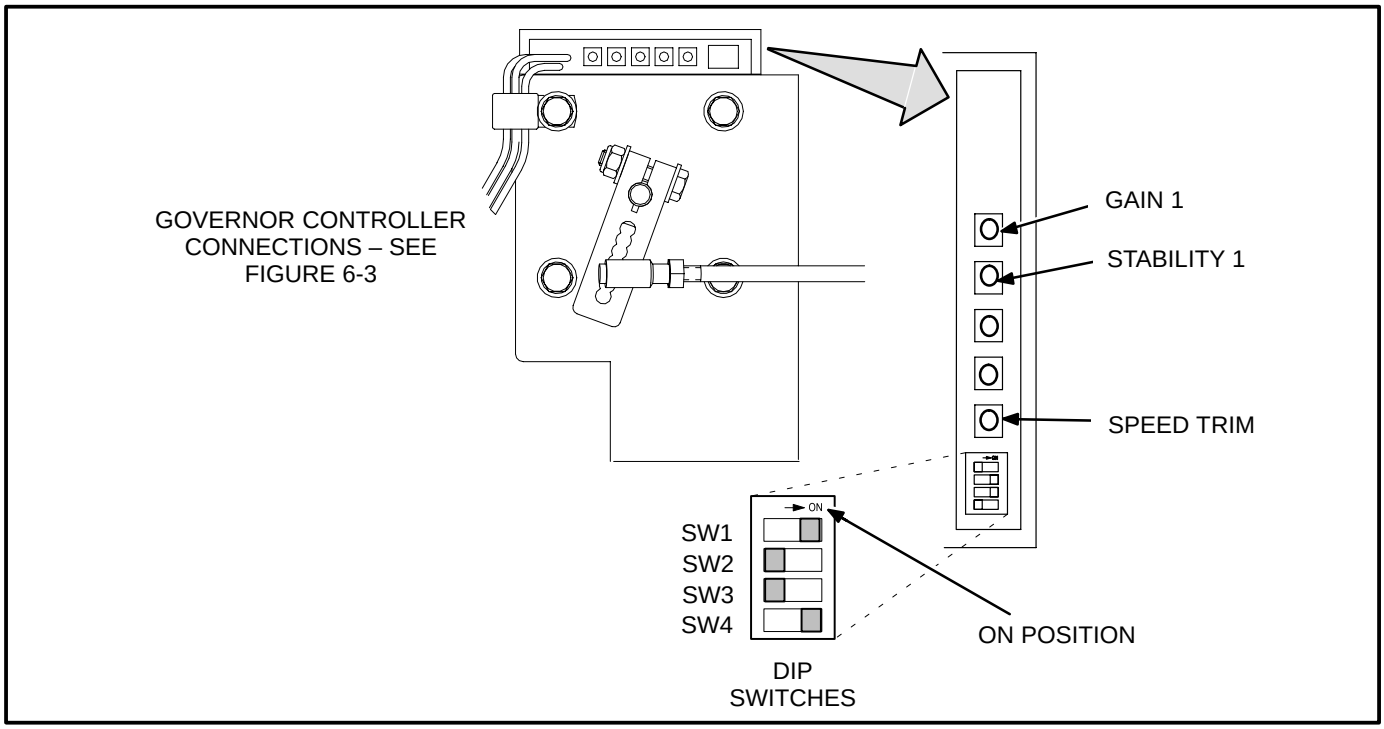



**FIGURE 6-1. GOVERNOR CONTROLLER**

## LINKAGE ADJUSTMENT

Figure 6-2 illustrates the governor linkage. Make sure that the governor controller is securely mounted to the engine bracket. To adjust the linkage:

1. With the genset stopped, check the angle of the throttle lever and governor actuator. Adjust governor lever if required. (Throttle is shown in the closed position.)
2. Verify that the ball joint screw is mounted in the third hole from the outside end of the governor arm.
3. The governor actuator shaft has 60 degrees of rotation from stop to stop. Check mounting of governor arm and linkage to assure the 60 degree actuator shaft rotation operates the throttle from closed to fully open positions.

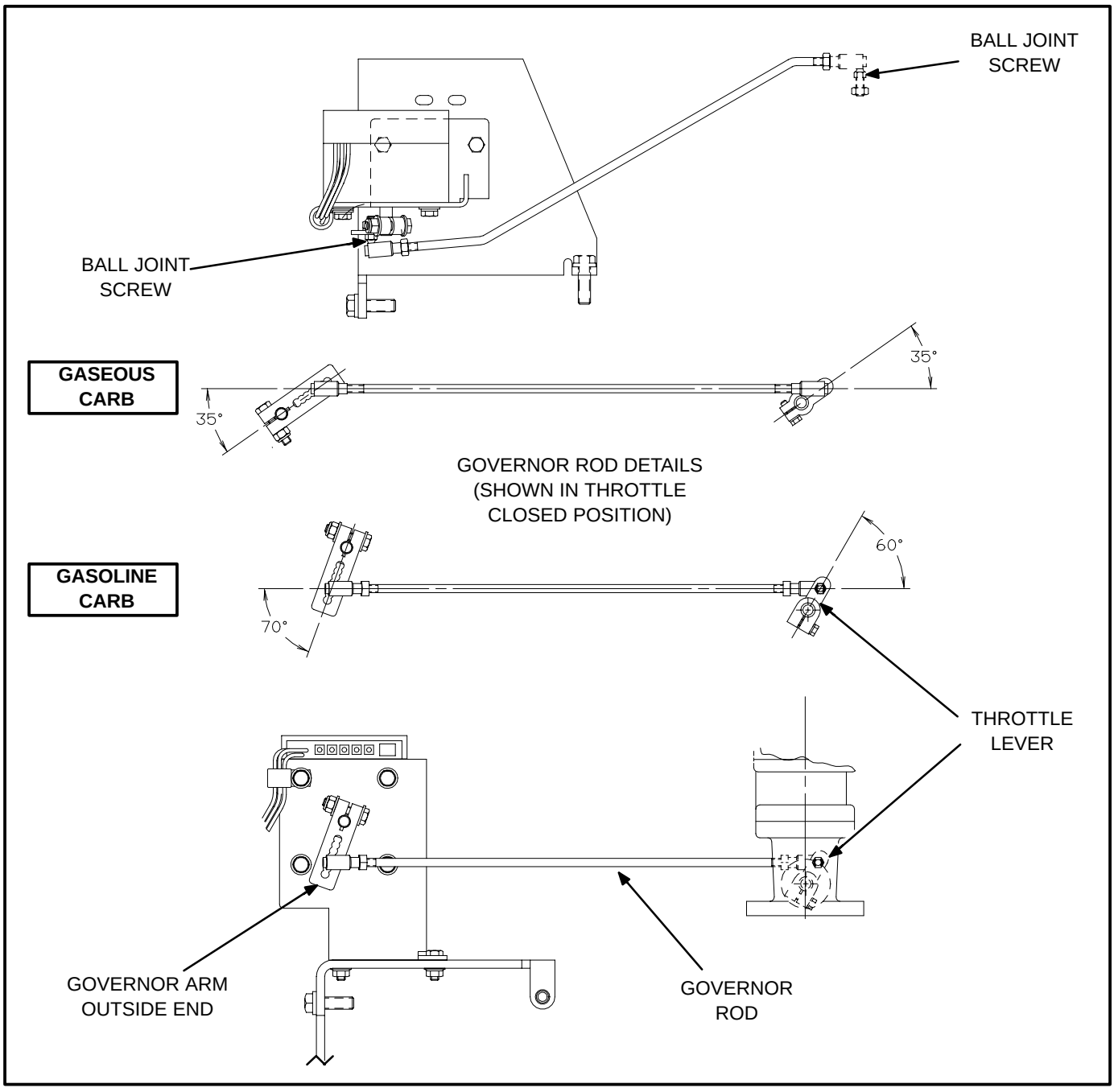



**FIGURE 6-2. GOVERNOR LINKAGE**

## MAGNETIC SPEED PICKUP UNIT ADJUSTMENT

With the magnetic speed pickup removed from the genset, manually rotate the ring gear until a tooth lines up in the center of the mounting hole. Thread the pickup in gently by hand until it just touches the ring gear tooth. Back it out 5/8 turn and set the locknut.

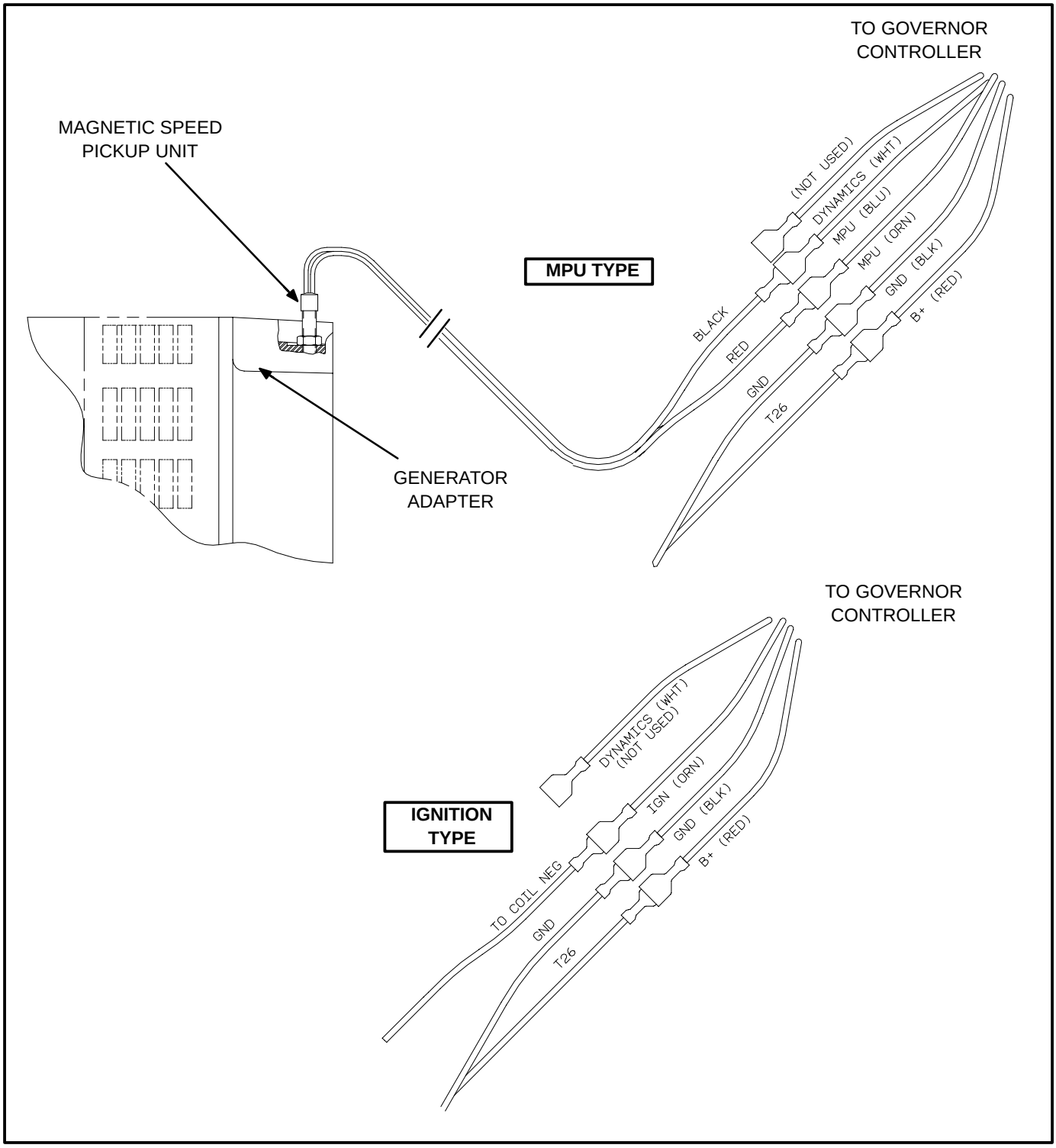



**FIGURE 6-3. MAGNETIC SPEED PICKUP UNIT / GOVERNOR CONTROLLER CONNECTIONS**

## CARBURETORS

The engine is equipped with a carburetor to run on regular gasoline and/or a gas mixer to run on natural gas or propane or both.

**⚠WARNING** ***Fuel is highly flammable and may cause severe personal injury and property damage. Do not allow cigarettes, flame, pilot lights, arcing switches or equipment in area or areas sharing ventilation.***

### Gasoline Fuel System

A gasoline carburetor (Figure 6-4) is provided for gasoline fuel systems. The main and idle mixture, and choke are adjustable on the gasoline carburetor. The main adjusting needle, at the bottom of the carburetor, affects operation at heavier load conditions. the idle adjusting needle, at the side of the carburetor, affects operation at light and no load conditions.

Under normal circumstances, factory carburetor adjustments should not be disturbed. If adjustments have been changed, an approximate setting of 1-1/2 turn open for idle needle and one turn open for main needle will permit starting. Adjust temporarily for smoothest running. Allow engine to thoroughly warm up before making final adjustment.

***Idle Mixture Adjustment:*** If the adjustment has been disturbed or the engine performs poorly under light load, make the following adjustments.

1. Shut off the engine and turn the idle adjustment screw in gently until it bottoms, and then turn it out 1-1/2 turns so that the engine will run.

**⚠CAUTION** ***The adjustment screw and seat are easily damaged. Do not force the adjustment screw.***

2. Start the engine and let the set warm up under a partial load (at least 1/4 rated load) and then disconnect all loads.
3. Turn the idle adjustment screw out (counterclockwise) approximately one half turn and jounce the throttle. If the engine begins to hunt, turn the adjustment screw in slowly until engine speed becomes stable. If one half turn does not cause instability, turn the adjustment screw out one half turn more and repeat the procedure.

***Main Mixture Adjustment:*** If the adjustment has been disturbed or the engine performs poorly under heavy load, make the following adjustments.

1. Shut off the engine and turn the main adjustment screw in gently until it bottoms, and then turn it out 1 turn so that the engine will run.
2. Start the engine and let the set warm up under a partial load (at least 1/4 rated load) and then apply a full load.
3. Slowly turn needle out until speed no longer rises. Try various electrical loads. If engine speed fluctuates at any load, turn main adjusting needle out slightly. Do not turn out more than 1/2 turn beyond original full load setting.
4. If stable speed cannot be obtained by adjusting main adjusting needle, a change in governor sensitivity adjustment will probably be necessary.

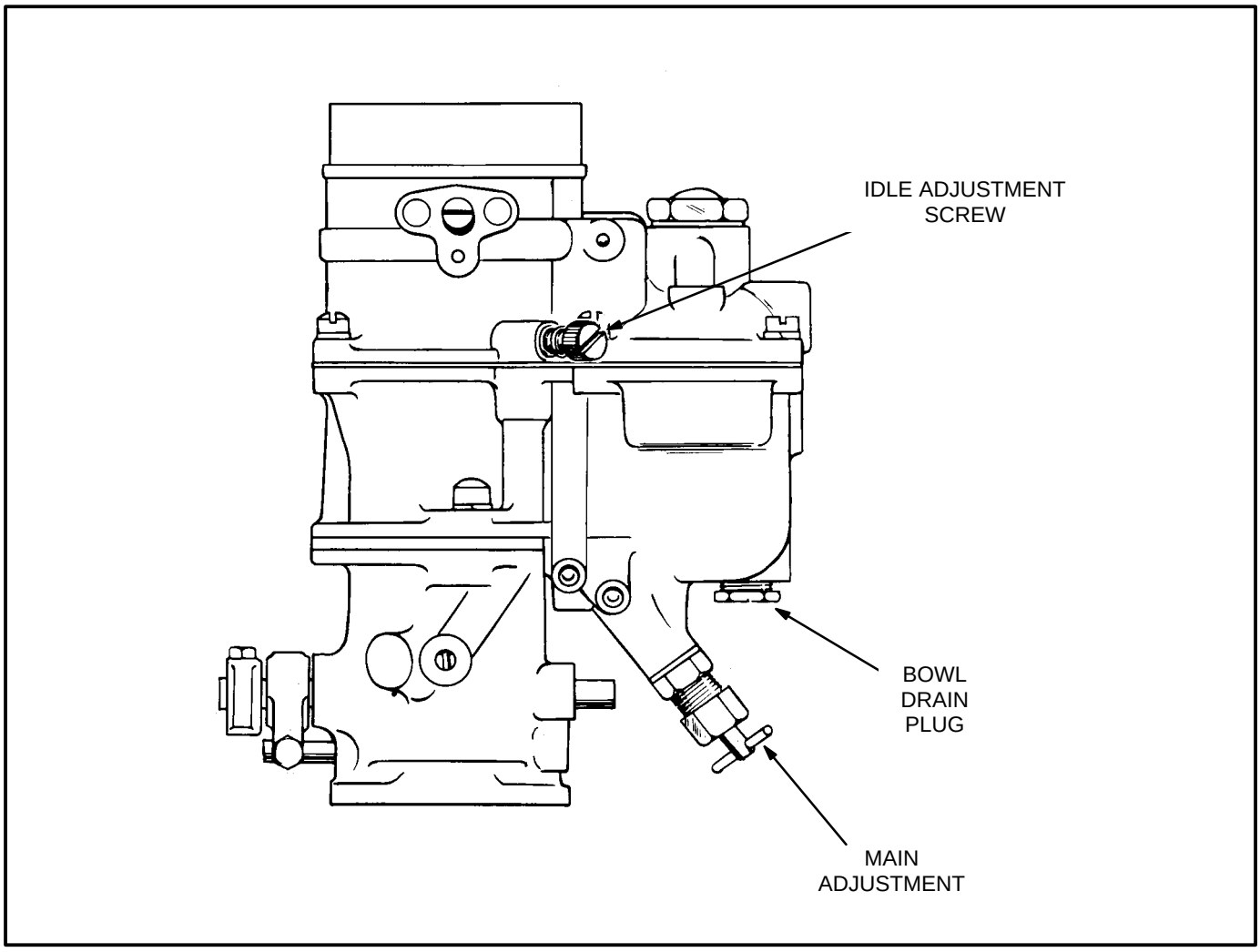



**FIGURE 6-4. GASOLINE CARBURETOR**

***Choke Adjustment for Gasoline carburetor:*** The gasoline carburetor is equipped with an automatic choke for easier cold weather starting. The choke has a bi-metal coil that progressively closes the choke plate as ambient temperature drops, in preparation for the next start. It also has an electric heating element that heats the bi-metal coil to fully open the choke soon after the engine starts.

The choke housing cover can be rotated to adjust the choke. The perimeter of the cover is graduated with evenly spaced lines cast in it. One of the lines has an asterisk (*). For normal adjustments, the asterisk (*) should line up with the line cast in the edge of the housing.

1. For better starting in cold weather, loosen the three cover screws (Figure 6-5) and rotate the cover clockwise (richer) so that the asterisk (*) is one or two lines past the line on the housing and re-tighten the cover screws.
2. For better starting in warm weather, loosen the three cover screws and rotate the cover counterclockwise (leaner) so that the asterisk (*) is one or two lines past the line on the housing and re-tighten the cover screws.

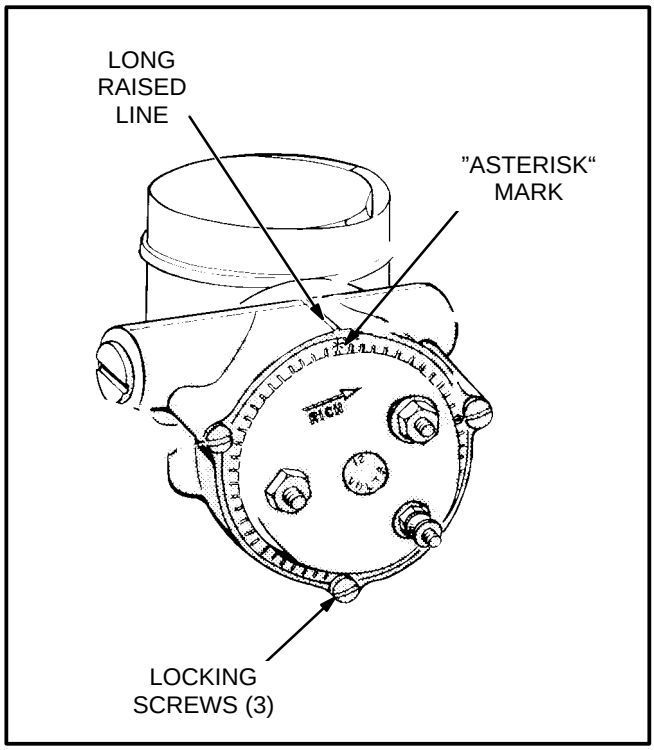



**FIGURE 6-5. ELECTRIC CHOKE**

## Gaseous and Combination Fuel Systems

An engine equipped for gasoline and natural gas or propane has a regular gasoline carburetor with a gas mixer mounted on the horn of the carburetor. The carburetor throttle serves both fuels. Each fuel has a separate shutoff solenoid valve. The position of the fuel selector switch (mounted at the base of the carburetor) determines which solenoid valve will open for operation.

An engine equipped for natural gas and propane has a gas mixer that serves both fuels. Each fuel has a separate shutoff solenoid valve and either a manual fuel selector switch or a fuel pressure switch for automatic fuel changeover. (While the engine is running, the gas pressure switch causes the natural gas solenoid valve to close and the propane solenoid valve to open when natural gas pressure is lost, without stopping the engine. When natural gas pressure is restored, the natural gas solenoid valve opens and the propane solenoid valve closes.)

***Gas Pressure:*** The fuel regulators in each line provide constant gas pressure at the gas mixer under varying load conditions (approximately 5 inches WC for natural gas and –1.5 inches WC for LPG). There is a pressure test port on the supply side if the gas mixer for measuring fuel inlet pressure.

**The maximum permissible fuel supply pressure is 20 inches WC and the minimum is 7 inches WC.** This applies to LPG as well as to natural gas. The minimum pressure refers to supply pressure under rated load (maximum gas flow). There is a pressure test port on the supply side of each fuel regulator for measuring fuel supply pressure.

***Choke Adjustment for Combination Carburetor:*** If the engine is equipped with a combination carburetor, see that the gasoline shut-off valve is closed. The electric choke (Figure 6-5) must be adjusted so the adjustable cover is turned 10 to 12 notches counterclockwise from the asterisk (*) mark. When properly adjusted, the electric choke will be completely open even at very low temperatures.

Gas fuel main adjustment should be made only when a full electrical load is applied to the genset.

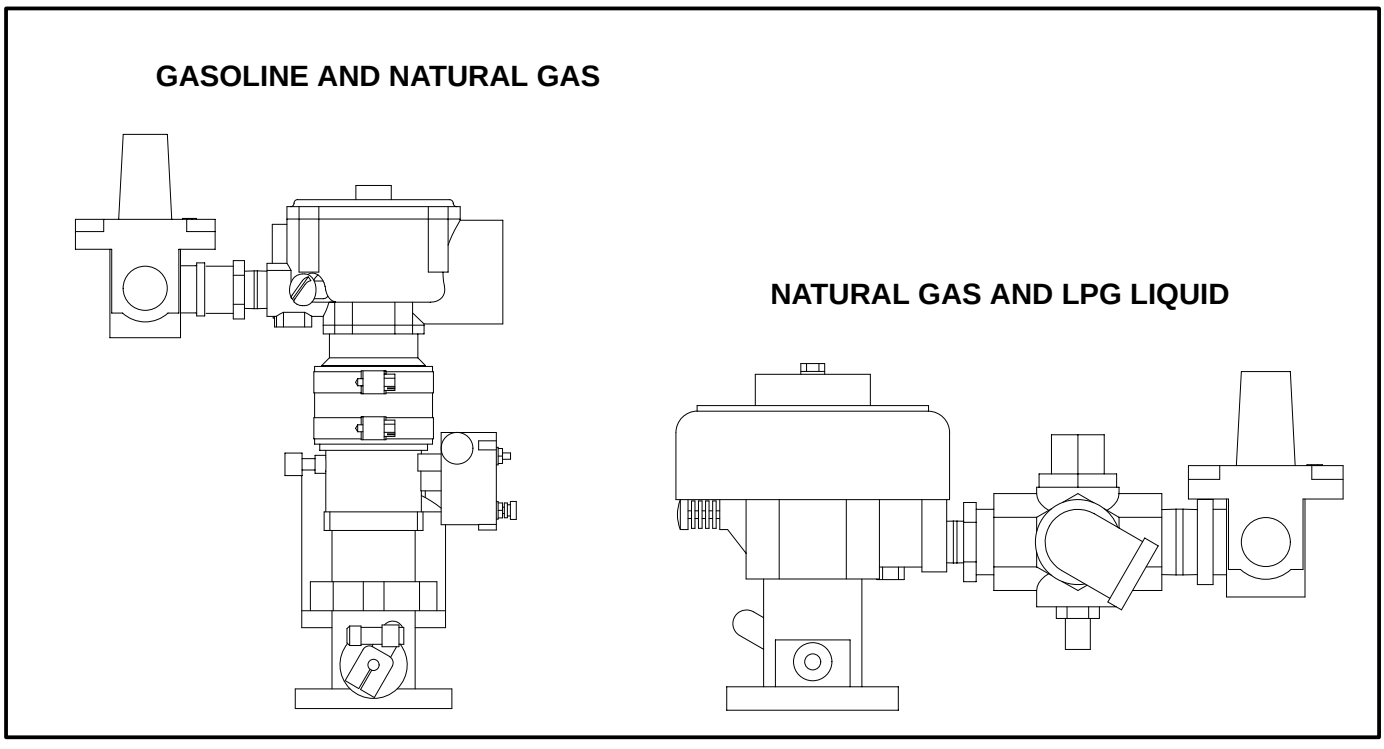



**FIGURE 6-6. COMBINATION FUEL SYSTEMS**

***Gaseous Fuel Adjustments:*** Gas mixers have power and idle adjustment screws. Engines equipped for natural gas and propane also have a propane flow adjustment valve. If necessary, make the following adjustments.

1. Start the engine and let the set warm up under a partial load (at least 1/4 rated load). If the engine is equipped for natural gas and propane, start with natural gas.
2. Disconnect all loads, shut down the set, connect a tachometer and disconnect the governor linkage at the carburetor. Start the engine and close the throttle by hand so that the engine does not overspeed. While holding the throttle closed, adjust the throttle idle position screw (the one next to the throttle lever) to obtain an engine speed of 900 RPM. Then turn the idle adjusting screw counterclockwise until engine speed becomes unstable. Turn the screw clockwise just enough to regain stability and reconnect the governor linkage.
3. Next, connect full rated load and turn the power adjusting screw clockwise until the engine begins to lose speed and then slowly back out the screw (counterclockwise) until the engine carries the full load smoothly.
4. If the set is equipped for natural gas and propane, switch to propane by means of the control panel switch (if provided) or by closing the manual shutoff valve in the natural gas supply line.
5. Reconnect full rated load and turn the propane flow adjustment valve clockwise until the engine begins to lose speed and then slowly turn it back counterclockwise until the engine carries full load smoothly.

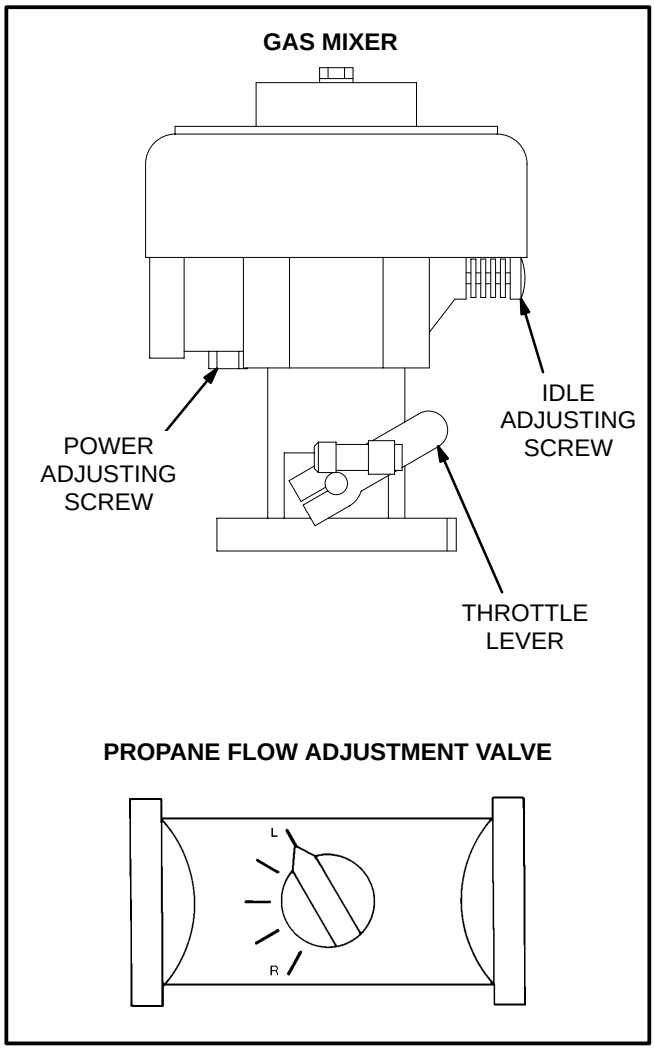


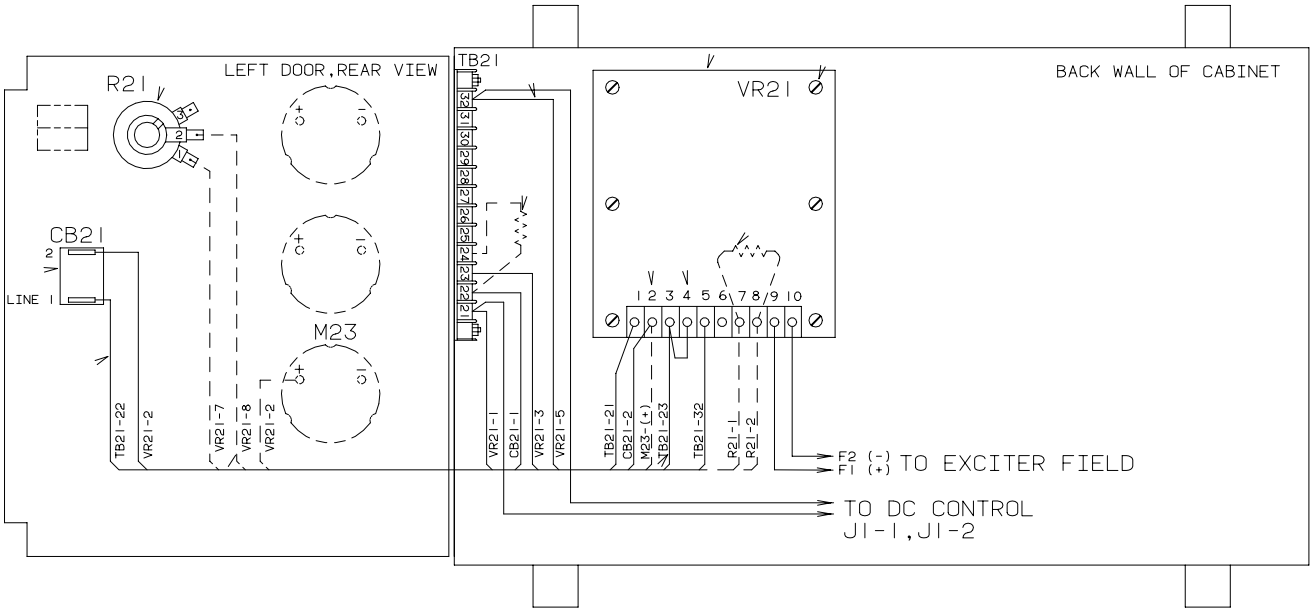

**FIGURE 6-7. GASEOUS FUEL ADJUSTMENTS**

# 7. Wiring Diagrams

This section consists of the schematic and connection wiring diagrams referenced in the text.

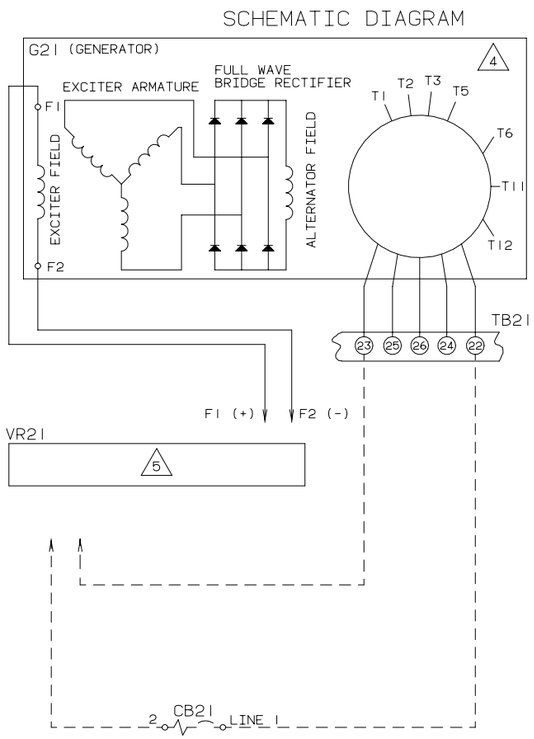
**The following diagrams are typical. Your genset may differ. Wiring and component specifications are subject to change. Contact your Distributor if you do not have the wiring diagrams applicable to your equipment.**

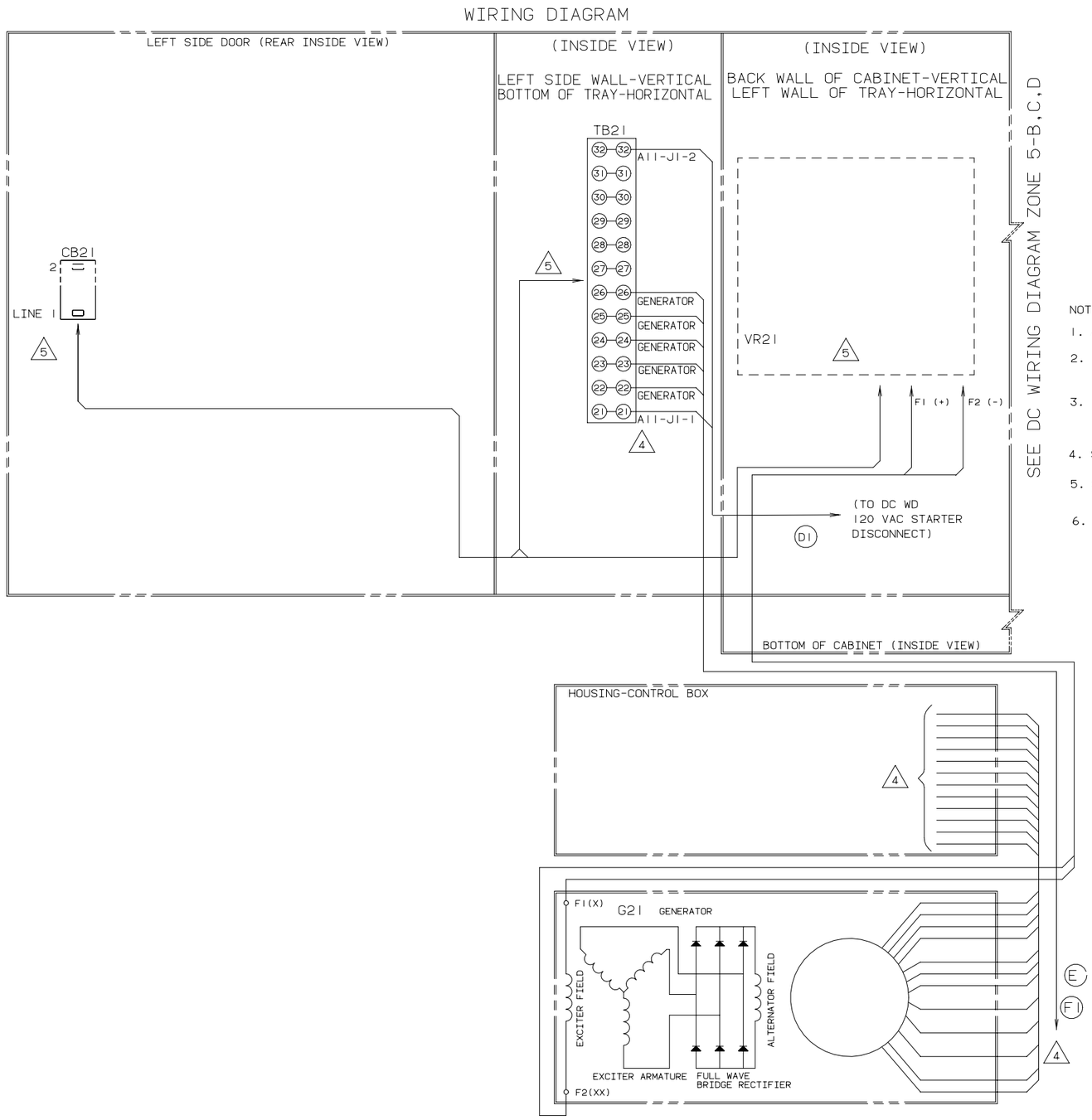
The following drawings are included:




**VOLTAGE REGULATOR (VRAS-2) INSTALLATION**

**THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.**




NOTES:

1. ALL COMPONENTS SHOWN IN DE-ENERGIZED POSITION.
2.
3.
4. SEE GENERATOR CONNECTION DIAGRAM FOR INPUT CONNECTIONS
5. SEE VOLTAGE REGULATOR INSTALLATION FOR CONNECTIONS TO VR21,CB21 AND TB21.
6.

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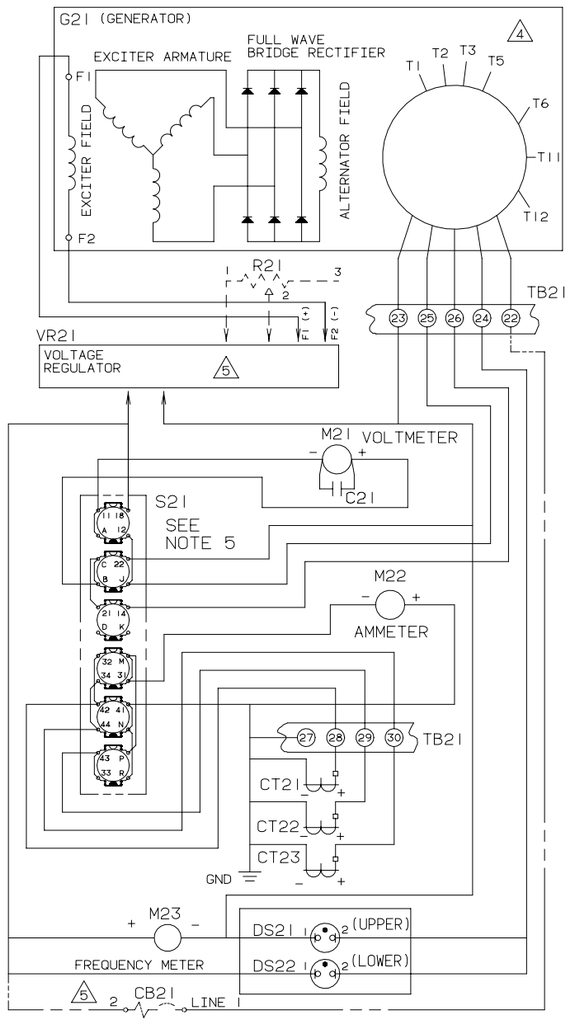
**THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.**

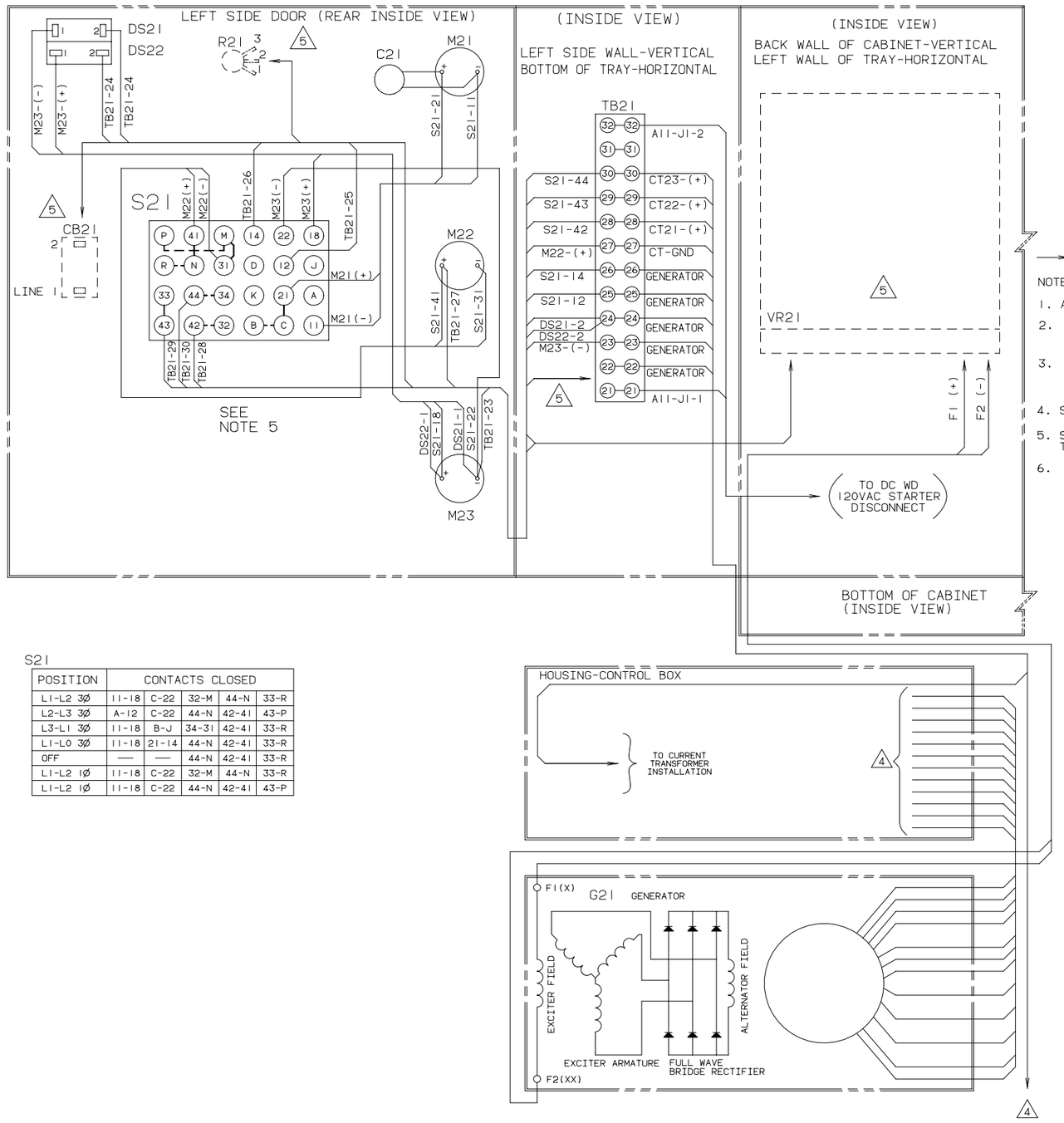
## SCHEMATIC DIAGRAM




S21

| 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 |

## WIRING DIAGRAM




→ SEE DC WIRING DIAGRAM ZONE 5-B,C,D

NOTES:

1. ALL COMPONENTS SHOWN IN DE-ENERGIZED POSITION.
2. 
3. 
4. SEE GENERATOR CONNECTION DIAGRAM FOR INPUT CONNECTIONS.
5. SEE VOLTAGE REGULATOR INSTALLATION FOR CONNECTIONS TO VR21,CB21,R21 AND TB21.
6. 

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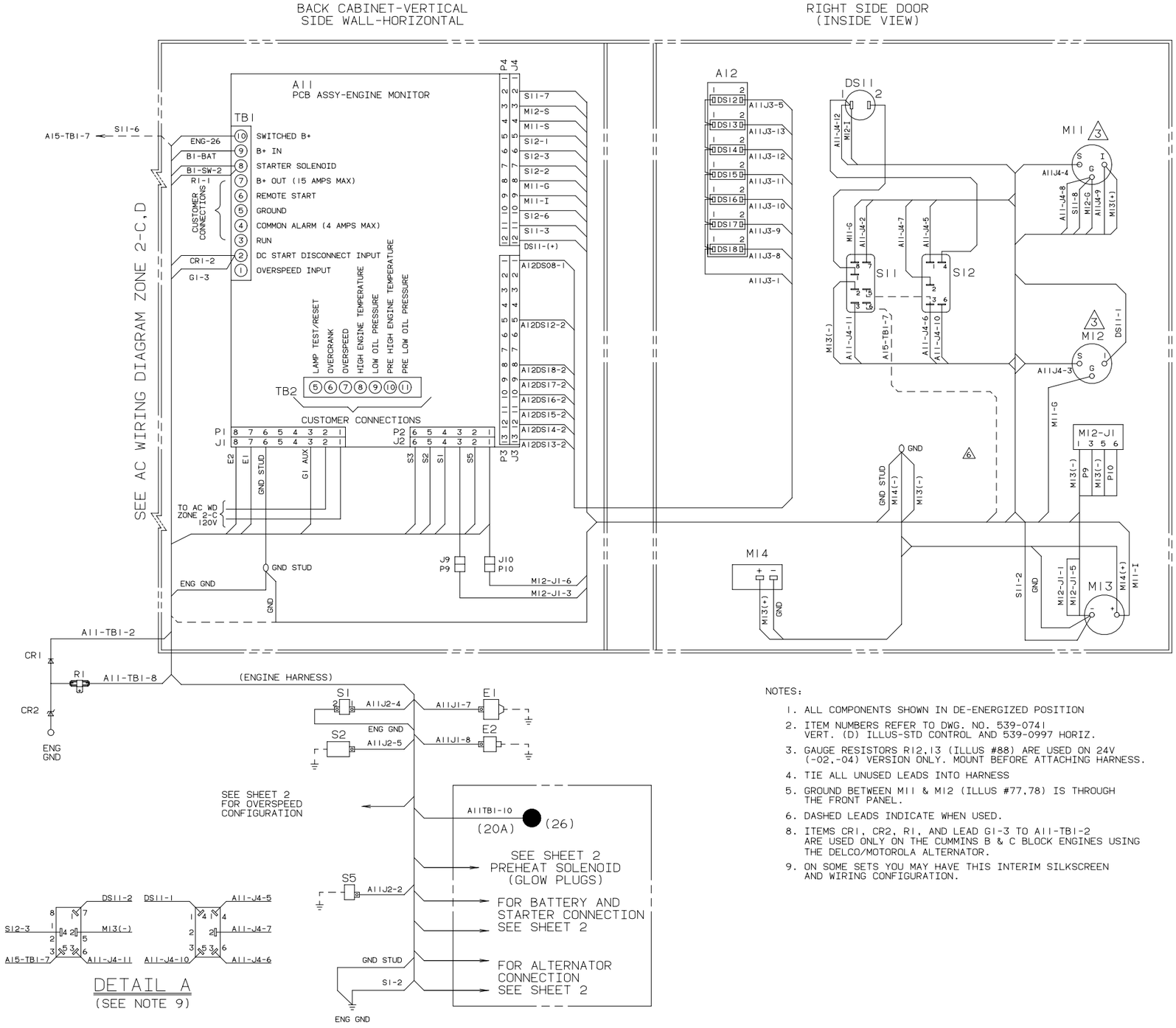
Modified 10/3/95

**AC WIRING (WITH METERS)**

**THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.**




NOTES:

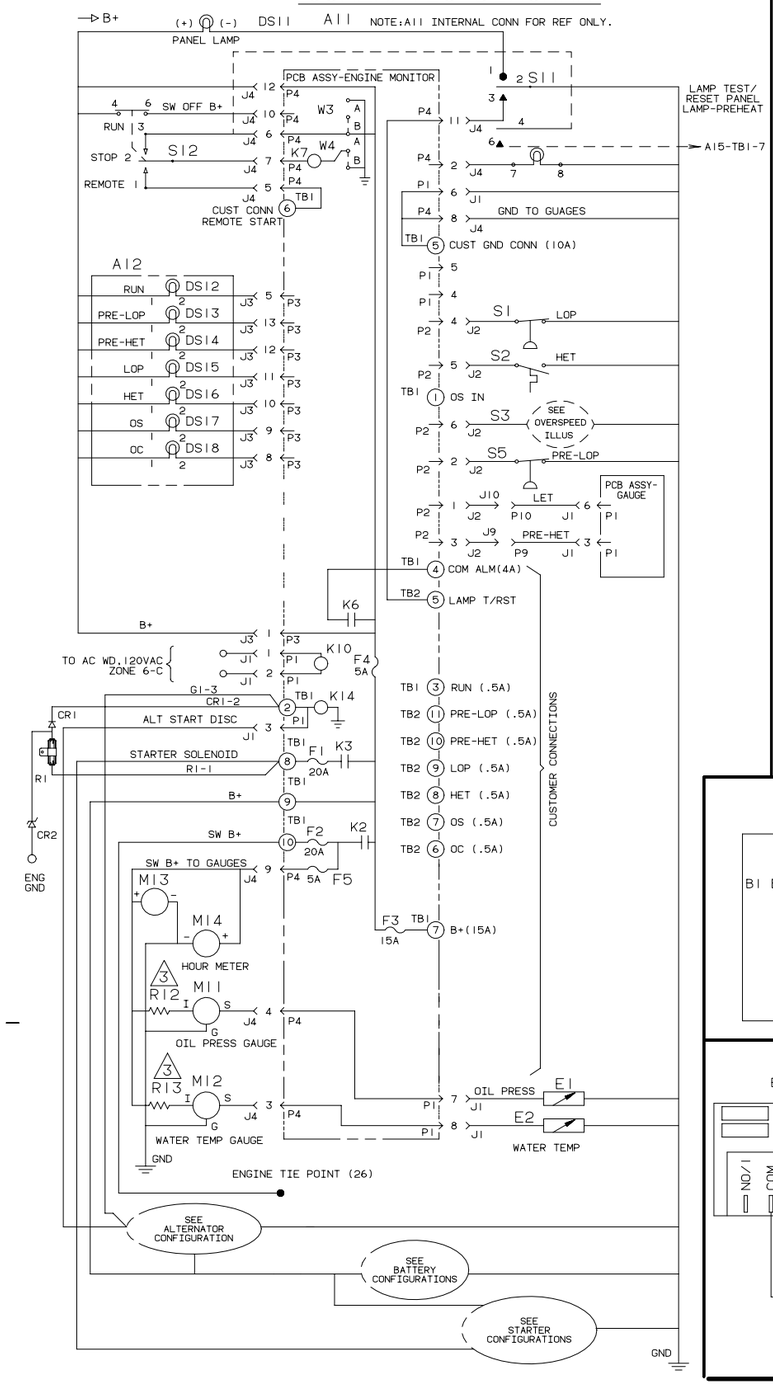
1. ALL COMPONENTS SHOWN IN DE-ENERGIZED POSITION
2. ITEM NUMBERS REFER TO DWG. NO. 539-0741 VERT. (D) ILLUS-STD CONTROL AND 539-0997 HORIZ.
3. GAUGE RESISTORS R12,13 (ILLUS #88) ARE USED ON 24V (-02,-04) VERSION ONLY. MOUNT BEFORE ATTACHING HARNESS.
4. TIE ALL UNUSED LEADS INTO HARNESS
5. GROUND BETWEEN M11 & M12 (ILLUS #77,78) IS THROUGH THE FRONT PANEL.
6. DASHED LEADS INDICATE WHEN USED.
8. ITEMS CR1, CR2, R1, AND LEAD G1-3 TO A11-TB1-2 ARE USED ONLY ON THE CUMMINS B & C BLOCK ENGINES USING THE DELCO/MOTOROLA ALTERNATOR.
9. ON SOME SETS YOU MAY HAVE THIS INTERIM SILKSCREEN AND WIRING CONFIGURATION.

No. 612-6684 sh 1 of 2
Rev. A Sys: CADAM
Modified 9-26-95

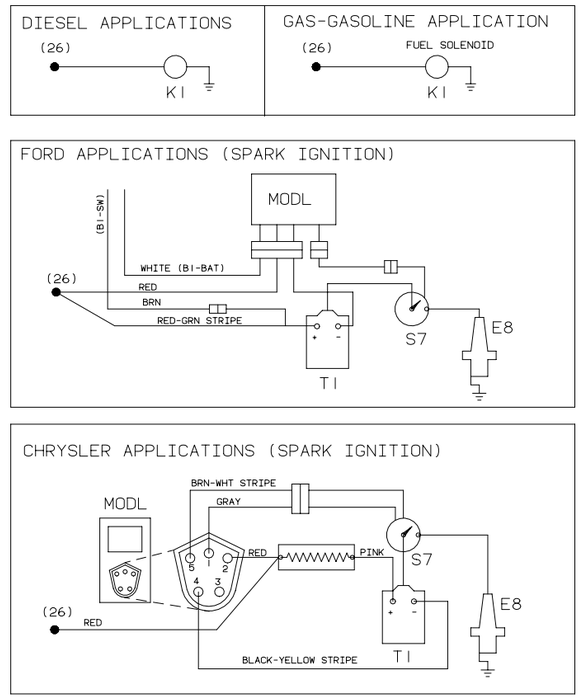
**7-LIGHT DC WIRING (SHEET 1 OF 2)**

**THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.**

# SCHEMATIC DIAGRAM




## IGNITION SYSTEMS

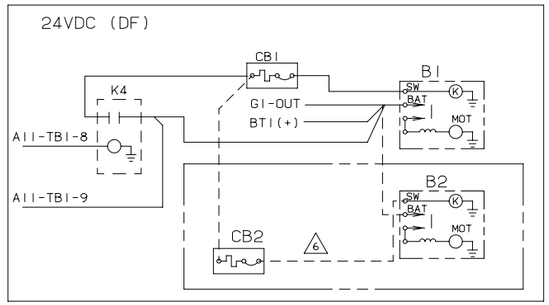


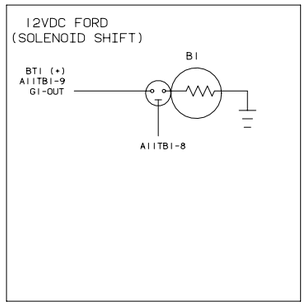


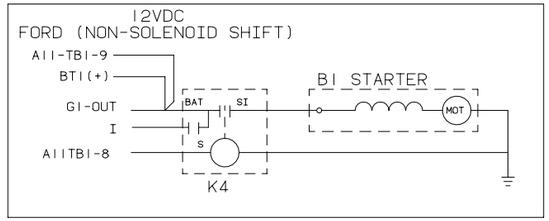


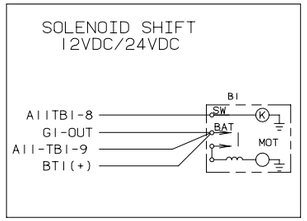



## STARTER CONFIGURATIONS

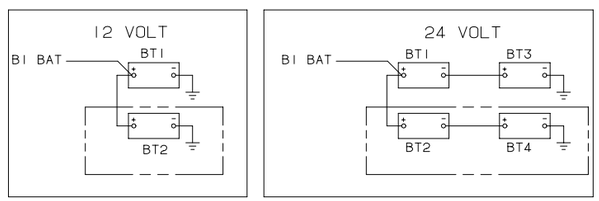


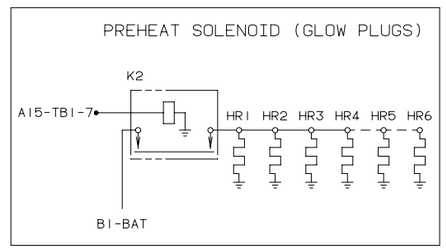



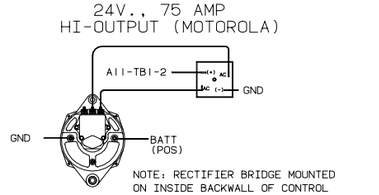



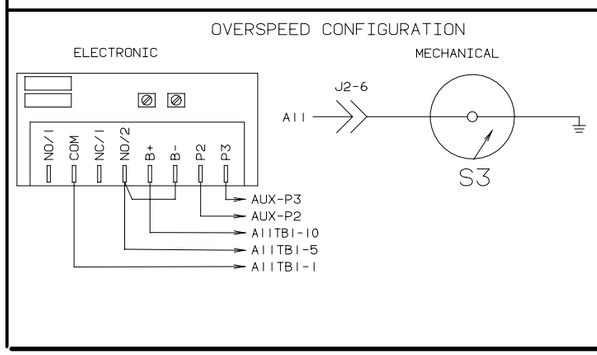




## BATTERY CONFIGURATIONS

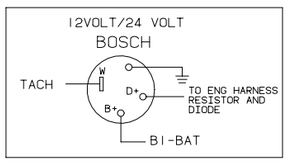


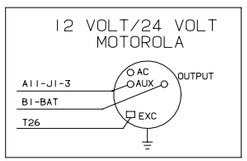



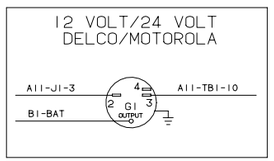




## ALTERNATOR CONFIGURATIONS




No. 612−6684 sh 2 of 2
Rev. A Sys: CADAM
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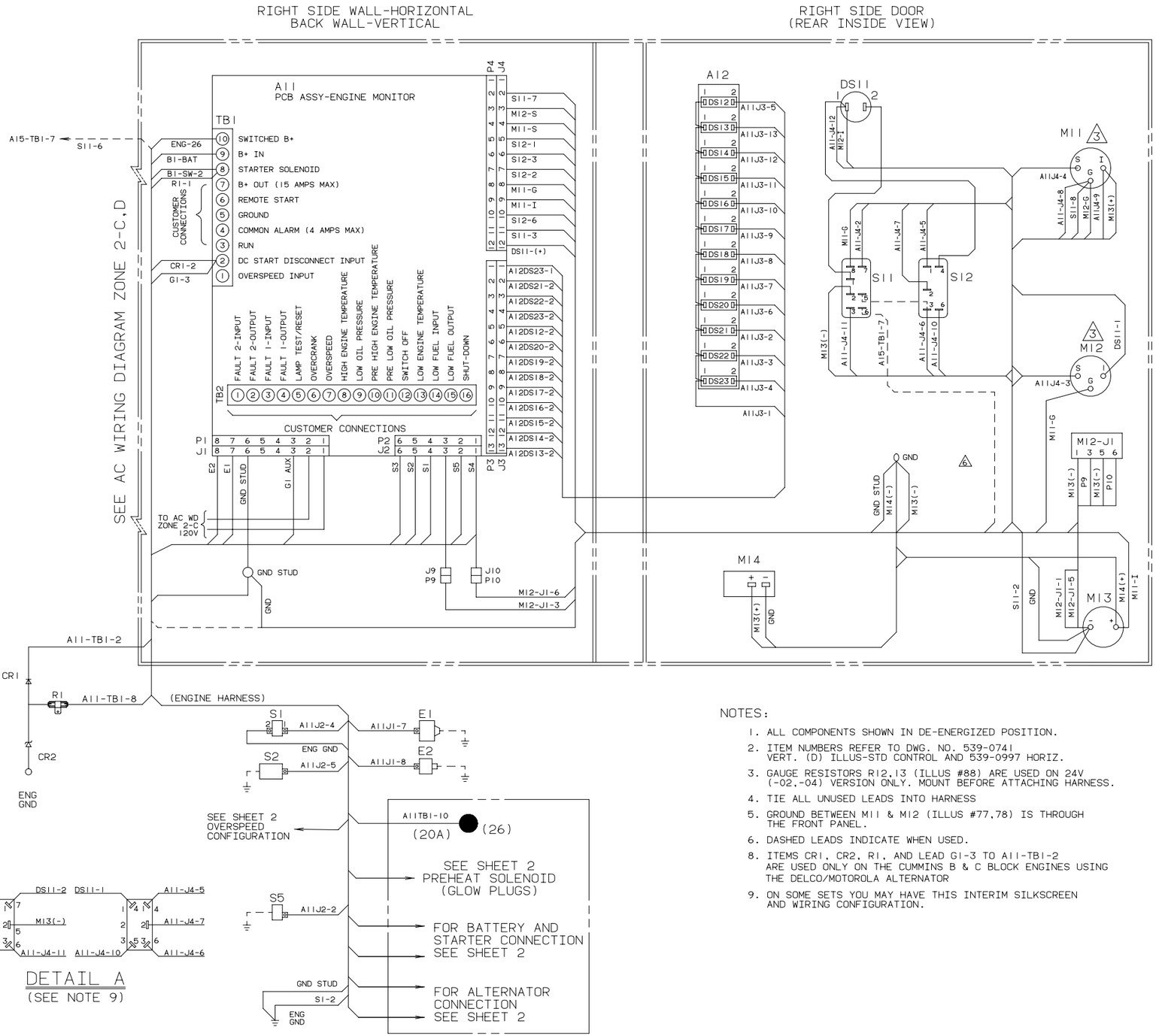
**THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.**




NOTES:

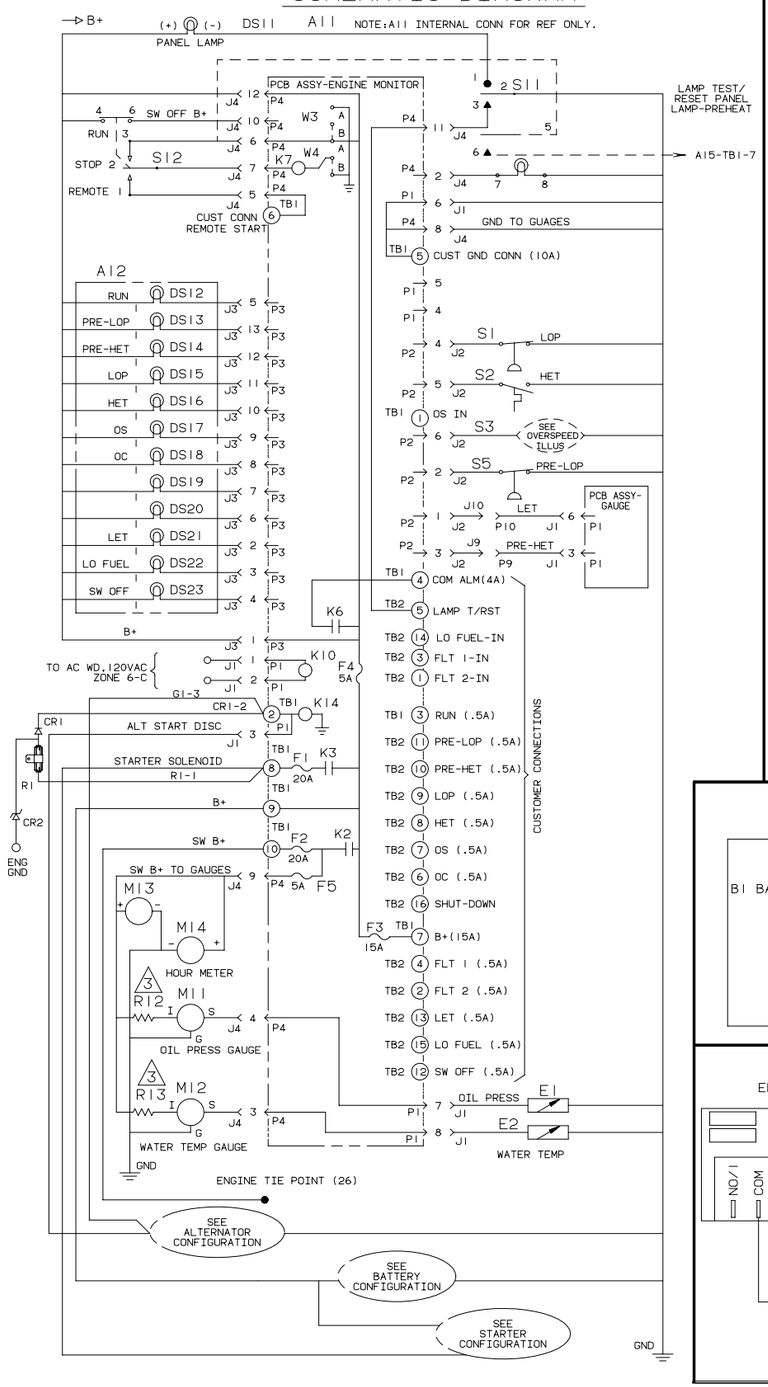
1. ALL COMPONENTS SHOWN IN DE-ENERGIZED POSITION.
2. ITEM NUMBERS REFER TO DWG. NO. 539-0741 VERT. (D) ILLUS-STD CONTROL AND 539-0997 HORIZ.
3. GAUGE RESISTORS R12,13 (ILLUS #88) ARE USED ON 24V (-02,-04) VERSION ONLY. MOUNT BEFORE ATTACHING HARNESS.
4. TIE ALL UNUSED LEADS INTO HARNESS
5. GROUND BETWEEN MI1 & MI2 (ILLUS #77,78) IS THROUGH THE FRONT PANEL.
6. DASHED LEADS INDICATE WHEN USED.
8. ITEMS CR1, CR2, R1, AND LEAD G1-3 TO A11-TB1-2 ARE USED ONLY ON THE CUMMINS B & C BLOCK ENGINES USING THE DELCO/MOTOROLA ALTERNATOR
9. ON SOME SETS YOU MAY HAVE THIS INTERIM SILKSCREEN AND WIRING CONFIGURATION.

No. 612-6685 sh 1 of 2
Rev. A Sys: CADAM
Modified 9-27-95

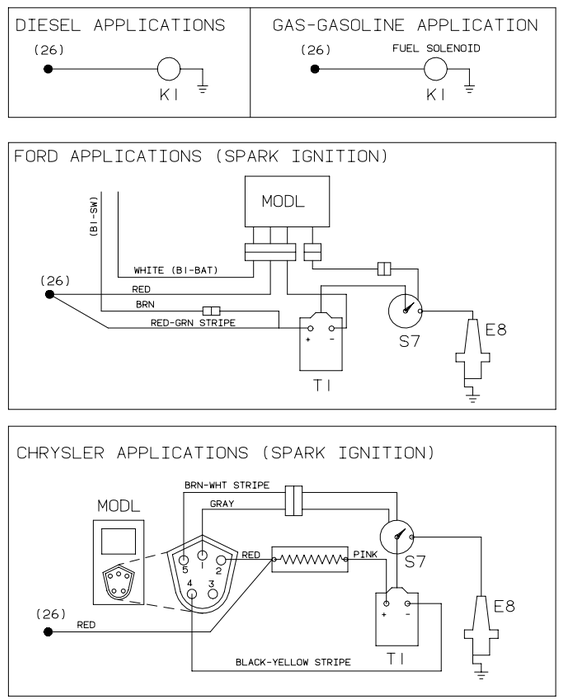
**12-LIGHT DC WIRING (SHEET 1 OF 2)**

**THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.**

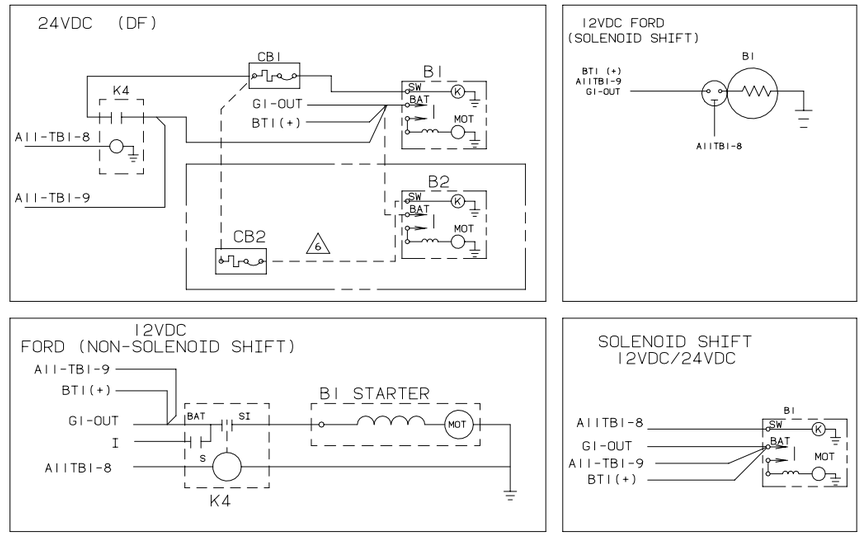
# SCHEMATIC DIAGRAM



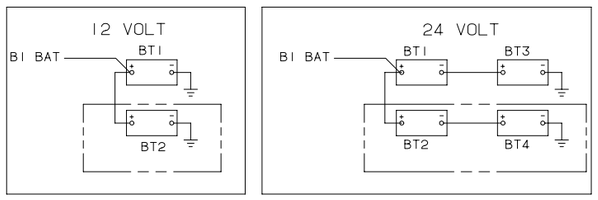

# IGNITION SYSTEMS



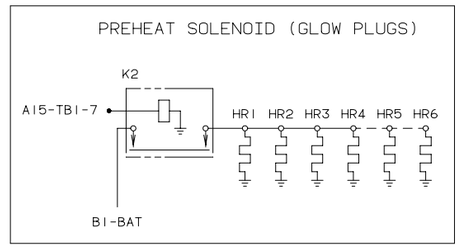

# STARTER CONFIGURATIONS



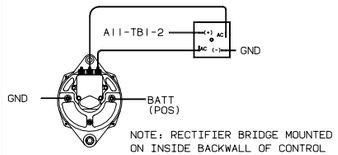

# BATTERY CONFIGURATIONS




# PREHEAT SOLENOID (GLOW PLUGS)

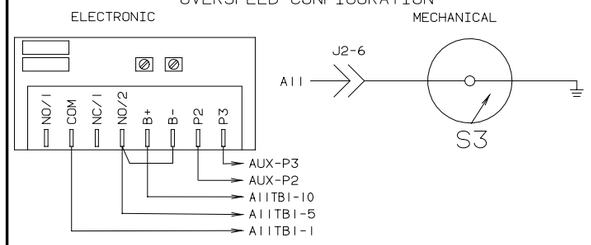



# 24V., 75 AMP HI-OUTPUT (MOTOROLA)

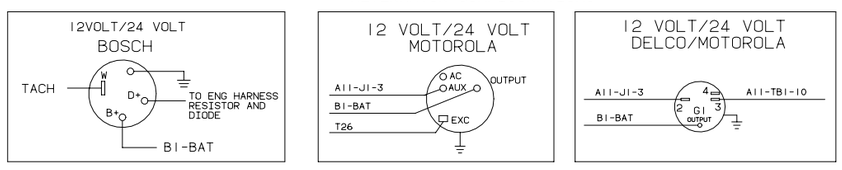



NOTE: RECTIFIER BRIDGE MOUNTED ON INSIDE BACKWALL OF CONTROL BOX BELOW AC VOLTAGE REGULATOR

# OVERSPEED CONFIGURATION




# ALTERNATOR CONFIGURATIONS



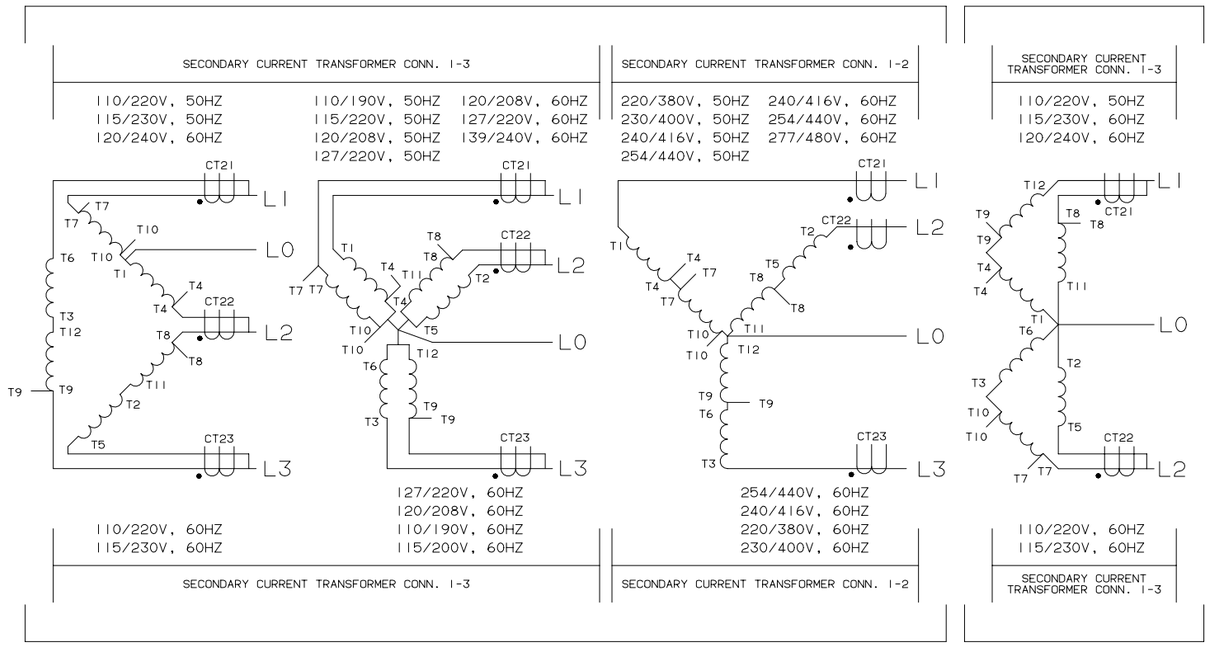

No. 612-6685 sh 2 of 2
Rev. A Sys: CADAM
Modified 9-27-95

**12-LIGHT DC WIRING (SHEET 2 OF 2)**

# UR GENERATORS

**THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.**

## 15 515 L Z — 3 PHASE RECONNECTABLE



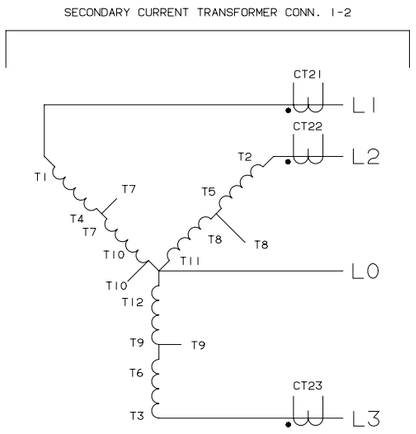

## 15 515 L Z — 1 PHASE RECONNECTABLE



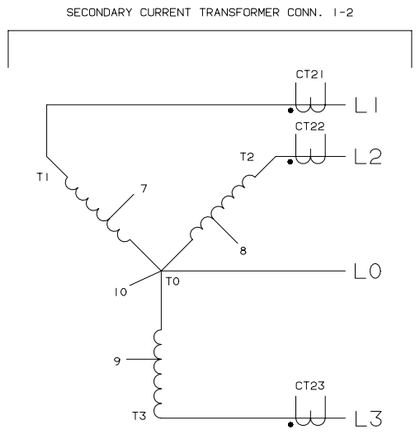

## 32 R — 3 PHASE RECONNECTABLE

## 32 R — 1 PHASE RECONNECTABLE

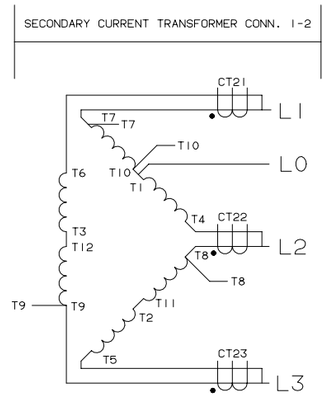
## 7 F : 220/380V 60HZ



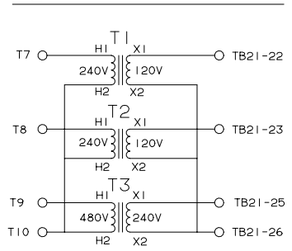

## (B1) 9X H : 347/600V 60HZ




## 6D E : 240/480V 60HZ

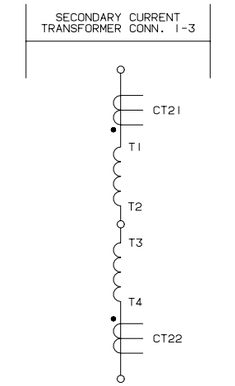



## 6D E : TRANSFORMER ASSY




## 3R B : 120/240V 60HZ

1 PHASE




| VOLTAGE CODE | | | | | | |
|---|---|---|---|---|---|---|
| CONT INPUT TB21 | 15 515 L Z | 6D E | 7 F | 3R B | 32 F | 9X H |
| 22 | T7 | T1-X1 | T7 | T1 | T7 | 7 |
| 23 | T8 | T2-X1 | T8 | T2 | T8 | 8 |
| 24 | T4 | - | - | - | T4 | - |
| 25 | T9 | T3-X1 | T9 | - | T9 | 9 |
| 26 | T10 | T1,2,3-X2 | T10 | - | T10 | 10 |
| JUMPER | - | 22-24 | - | 23-24 | | 22-24 |

NOTES:

1. CURRENT TRANSFORMER SECONDARY MUST BE MANUALLY SELECTED. HIGH VOLTAGE (ABOVE 300 VOLTS) TERMINALS 1&2,LOW VOLTAGE BELOW 300 VOLTS USE TERMINALS 1&3. TERMINAL #1 IS COMMON
2. GENERATORS 6D/E, 7/F AND 9X/H ARE NOT RECONNECTABLE AND ARE WOUND FOR A SPECIFIC VOLTAGE.

**RECONNECTION DIAGRAM**

**7-9**


No. 625-2068 sh 1of 1
Rev. B Sys: CADAM
Modified 10/2/95


Power Generation

**TB1-10 (SWITCHED B+ OUTPUT)** OUTPUT TO RELAY K12, 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)** OUTPUT TO RELAY K11, FUSED AT 20 AMPS

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

**TB1-6 (REMOTE START)** CONNECTED TO TIME DELAY START/STOP MODULE A15. CONNECT REMOTE START CONTACT OF THE AUTOMATIC TRANSFER SWITCH TO TERMINAL TB1-5 OF MODULE A15.

**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

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

**THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.**

**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*

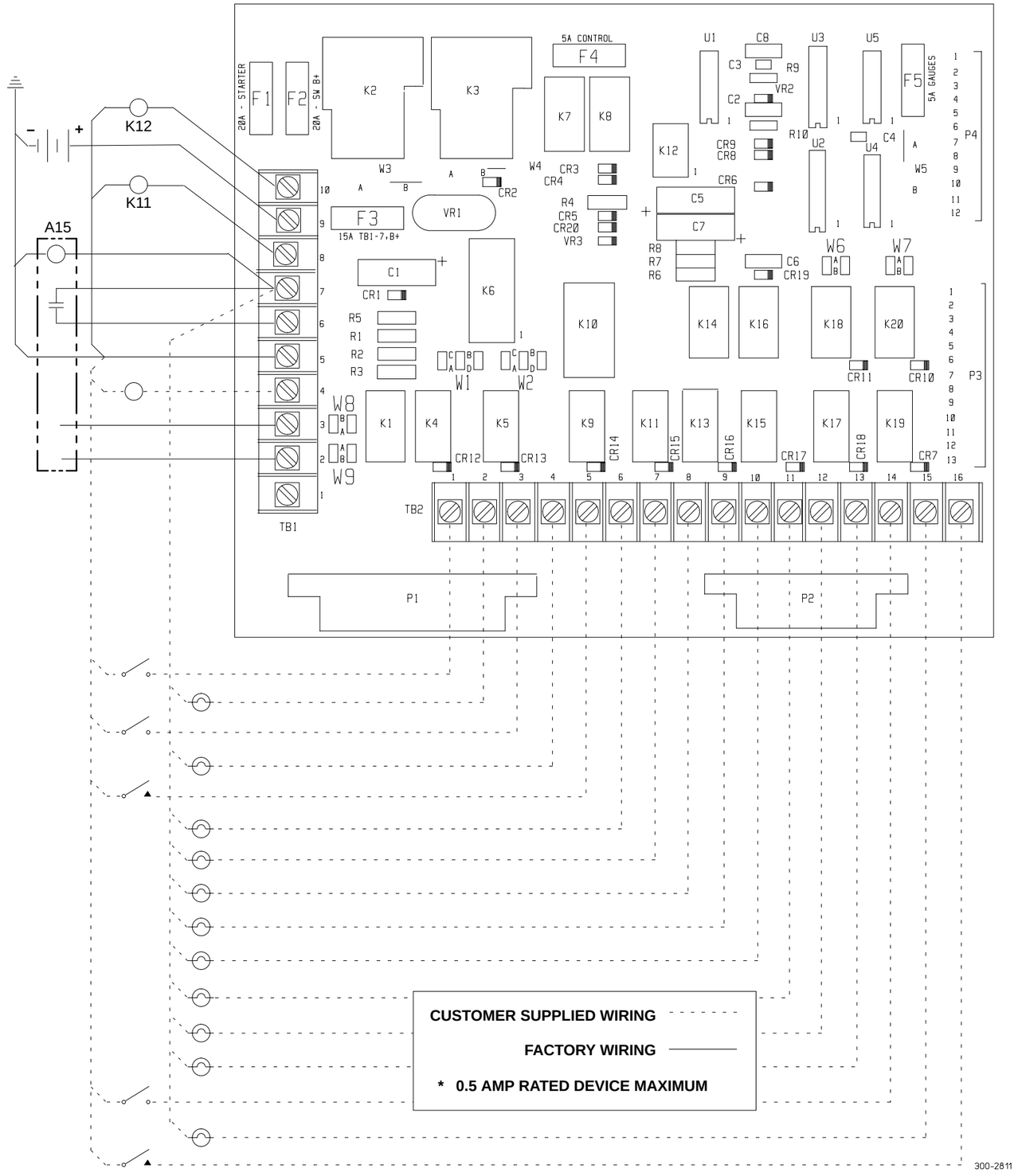
**TB2-12 (SWITCH OFF WARNING)** GROUND OUTPUT TO LIGHT/RELAY*

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

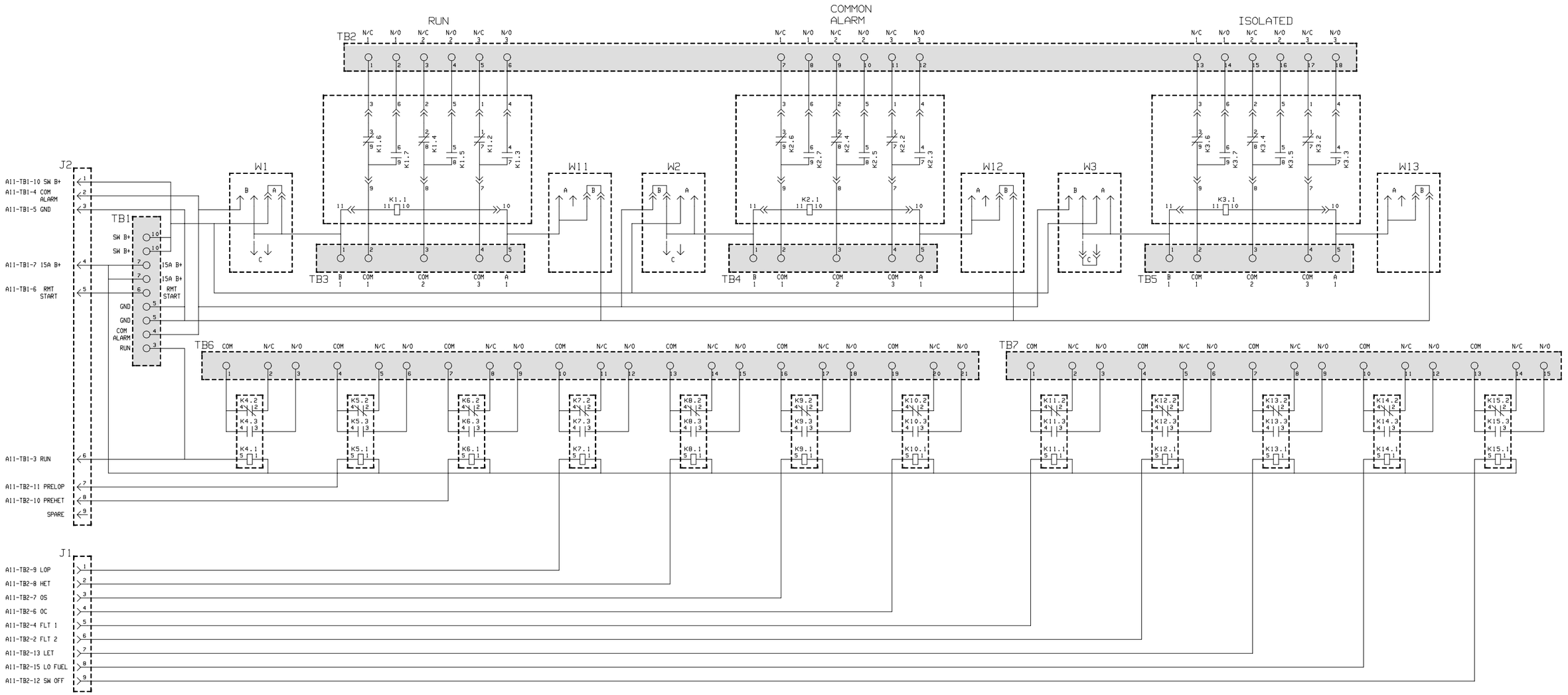
**TB2-14 (LOW FUEL WARNING)** GROUND INPUT FROM SENDER

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

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




**FACTORY AND CUSTOMER CONNECTIONS AT THE ENGINE MONITOR BOARD TERMINALS**

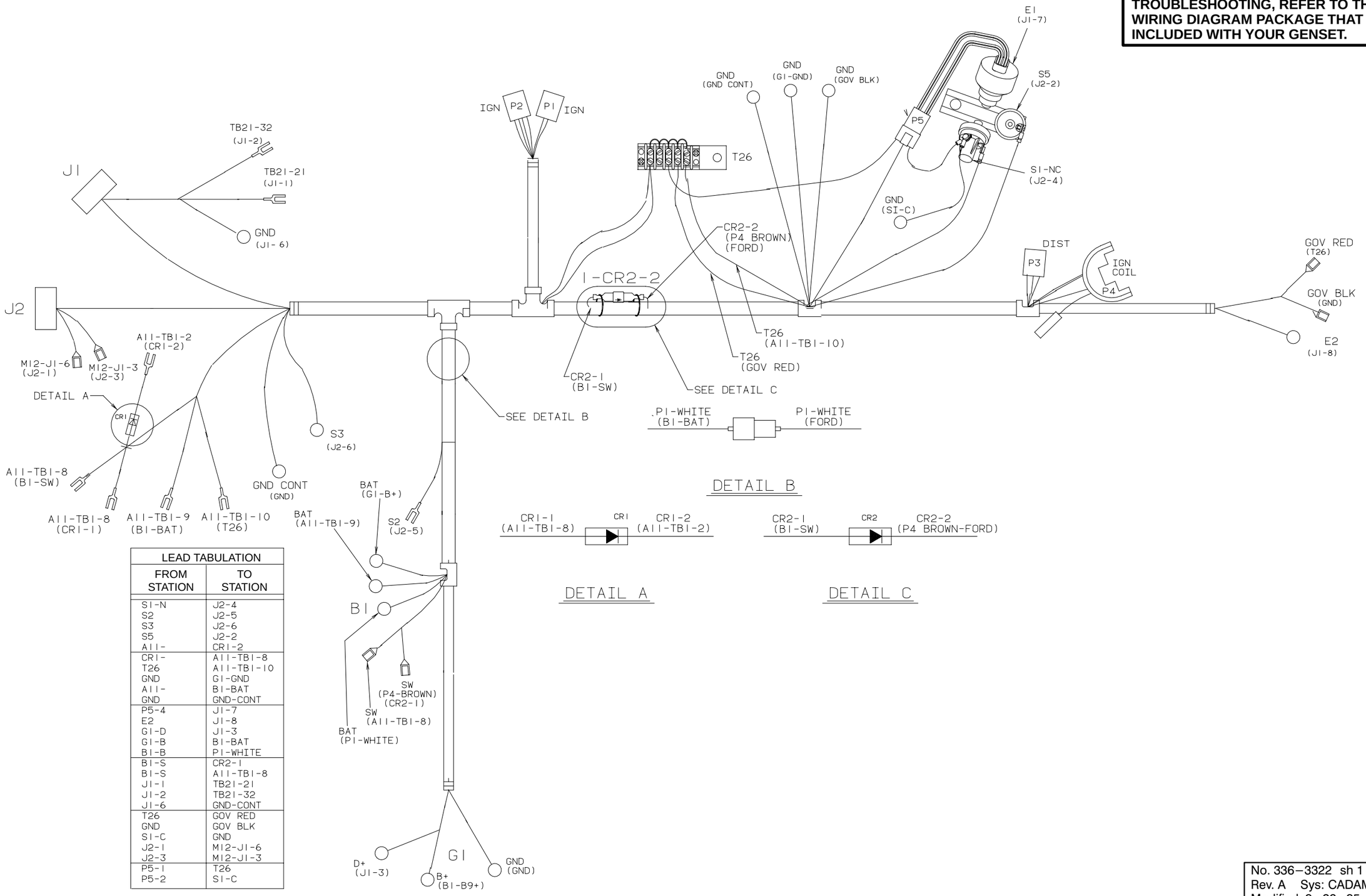



THE TERMINALS IN THE SHADED BOXES ARE FOR CUSTOMER CONNECTIONS

**THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.**

**CUSTOMER CONNECTIONS AT THE AUXILIARY RELAY BOARD**

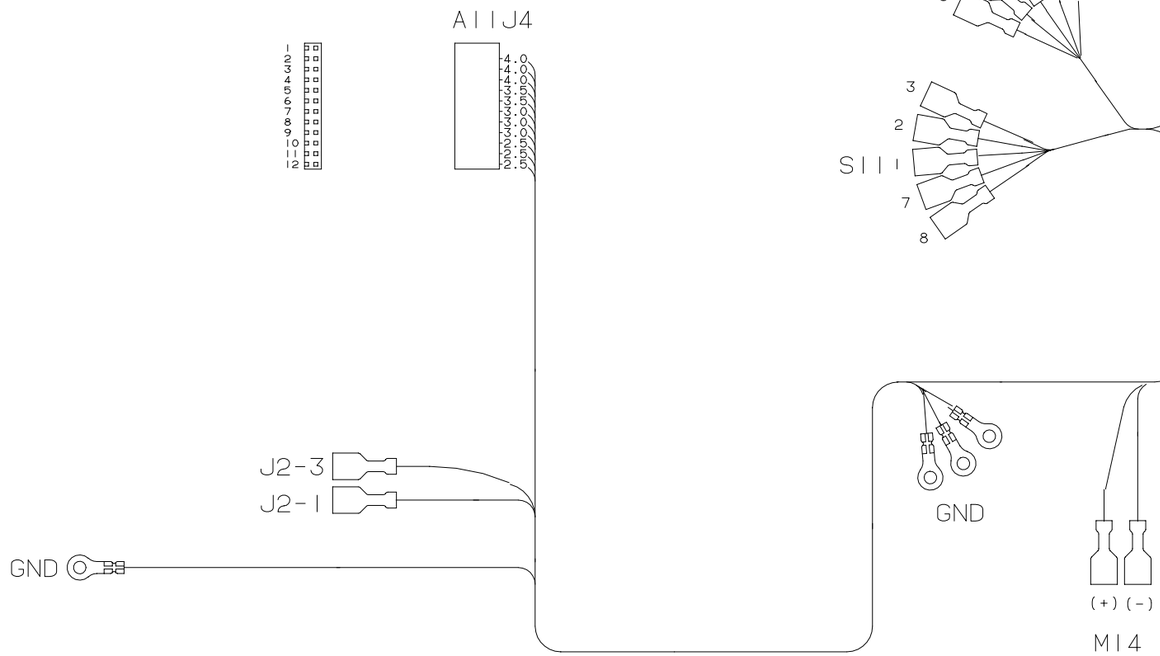
**THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.**




| LEAD TABULATION | |
|---|---|
| FROM STATION | TO STATION |
| S1-N | J2-4 |
| S2 | J2-5 |
| S3 | J2-6 |
| S5 | J2-2 |
| A11- | CR1-2 |
| CR1- | A11-TB1-8 |
| T26 | A11-TB1-10 |
| GND | G1-GND |
| A11- | B1-BAT |
| GND | GND-CONT |
| P5-4 | J1-7 |
| E2 | J1-8 |
| G1-D | J1-3 |
| G1-B | B1-BAT |
| B1-B | P1-WHITE |
| B1-S | CR2-1 |
| B1-S | A11-TB1-8 |
| J1-1 | TB21-21 |
| J1-2 | TB21-32 |
| J1-6 | GND-CONT |
| T26 | GOV RED |
| GND | GOV BLK |
| S1-C | GND |
| J2-1 | M12-J1-6 |
| J2-3 | M12-J1-3 |
| P5-1 | T26 |
| P5-2 | S1-C |

No. 336−3322 sh 1 of 1
Rev. A Sys: CADAM
Modified 9−26−95

**THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.**




| LEAD TABULATION | |
|---|---|
| FROM STATION | TO STATION |
| M12-J1-3 | J2-3 |
| M12-J1-6 | J2-1 |
| A1J4-3 | M12-S |
| A1J4-4 | M11-S |
| A1J4-5 | S12-1 |
| A1J4-6 | S12-3 |
| A1J4-7 | S12-2 |
| A1J4-8 | M11-G |
| A1J4-9 | M11-I |
| A1J4-10 | S12-6 |
| A1J4-11 | S11-3 |
| A1J4-12 | DS11-1 |
| M12-I | M13-(-) |
| S11-2 | DS11-2 |
| S11-1 | |
| M14-(-) | GND |
| M14-(+) | M13-(+) |
| DS11-1 | S12-4 |
| M11-I | M13-(+) |
| GND | M13-(-) |
| M11-G | M12-G |
| S11-7 | A1-J4-2 |
| S11-8 | M11-G |
| GND | GND |
| M12-J1-1 | M13-(-) |
| M12-J1-5 | M13-(-) |

**DC HARNESS**

**7-13**

No. 338–3326 sh 1 of 1
Rev. A Sys: CADAM
Modified 9–27–95

Power Generation

**Cummins Power Generation**
**1400 73rd Avenue N.E.**
**Minneapolis, MN 55432**
**1-800-888-6626**
**763-574-5000 International Use**
**Fax: 763-528-7229**



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