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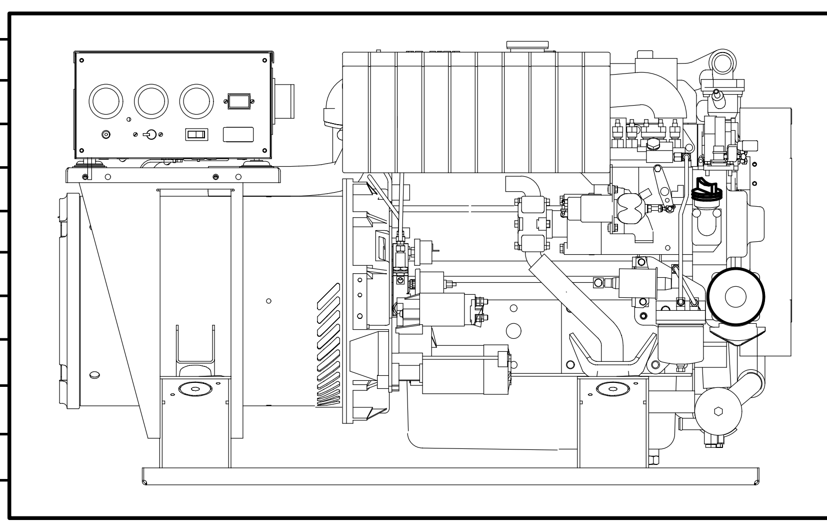
Power Generation

Onan

MARINE

Service Manual

MDKAD, MDKAE, MDKAF



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Cummins Power Generation

California

Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

Table of Contents

Safety Precautions

Thoroughly read the OPERATOR'S MANUAL before operating the genset. Safe operation and top performance can be obtained only by proper operation and maintenance.

The following symbols in this Manual alert you to potential hazards to the operator, service personnel and equipment.

⚠DANGER ***alerts you to an immediate hazard which will result in severe personal injury or death.***

⚠WARNING ***alerts you to a hazard or unsafe practice which can result in severe personal injury or death.***

⚠CAUTION ***alerts you to a hazard or unsafe practice which can result in personal injury or equipment damage.***

Electricity, fuel, exhaust, moving parts and batteries present hazards which can result in severe personal injury or death.

GENERAL PRECAUTIONS

- Keep ABC fire extinguishers handy.
- Make sure all fasteners are secure and torqued properly.
- Keep the genset and its compartment clean. Excess oil and oily rags can catch fire. Dirt and gear stowed in the compartment can restrict cooling air.
- Let the engine cool down before removing the coolant pressure cap or opening the coolant drain. Hot coolant under pressure can spray out and cause severe burns.
- Before working on the genset, disconnect the negative (-) battery cable at the battery to prevent starting.
- Use caution when making adjustments while the genset is running—hot, moving or electrically live parts can cause severe personal injury or death.
- Used engine oil has been identified by some state and federal agencies as causing cancer or reproductive toxicity. Do not ingest, inhale, or contact used oil or its vapors.
- Do not work on the genset when mentally or physically fatigued or after consuming alcohol or drugs.
- Carefully follow all applicable local, state and federal codes.
- Do not step on the genset, as when entering or leaving the engine room. The stress can break genset parts leading to possible fuel or exhaust leaks or electricution.

GENERATOR VOLTAGE IS DEADLY!

- Generator output connections must be made by a qualified electrician in accordance with applicable codes.
- The genset must not be connected to the public utility or any other source of electrical power. Connection could lead to electrocution of utility workers, damage to equipment and fire. An approved switching device must be used to prevent interconnections.
- Use caution when working on live electrical equipment. Remove jewelry, make sure clothing and shoes are dry and stand on a dry wooden platform on the ground or floor.

FUEL IS FLAMMABLE AND EXPLOSIVE

- Keep flames, cigarettes, sparks, pilot lights, electrical arc-producing equipment and switches and all other sources of ignition well away from areas where fuel fumes are present and areas sharing ventilation.
- Fuel lines must be secured, free of leaks and separated or shielded from electrical wiring.
- Use approved non-conductive flexible fuel hose for fuel connections at the genset.

ENGINE EXHAUST IS DEADLY!

- Learn the symptoms of carbon monoxide poisoning in this manual.
- Never sleep in the vessel with the genset running unless the vessel is equipped with a working carbon monoxide detector.
- The exhaust system must be installed in accordance with the genset Installation Manual and be free of leaks.
- Make sure the bilge is adequately ventilated with a power exhauster.

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not wear loose clothing or jewelry near moving parts such as PTO shafts, fans, belts and pulleys.
- Keep hands away from moving parts.
- Keep guards in place over fans, belts, pulleys, etc.

BATTERY GAS IS EXPLOSIVE

- Wear safety glasses and do not smoke while servicing batteries.
- When disconnecting or reconnecting battery cables, always disconnect the negative (**-**) battery cable first and reconnect it last to reduce arcing.

DO NOT OPERATE IN FLAMMABLE AND EXPLOSIVE ENVIRONMENTS

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

POST THESE SUGGESTIONS IN POTENTIAL HAZARD AREAS OF THE VESSEL

m-9

Section 1. Introduction

ABOUT THIS MANUAL

This manual contains troubleshooting and repair data for these components of the MDKAD, MDKAE and MDKAF generator sets:

- Engine controls
- Generator
- Exhaust system
- Cooling system

All engine service information is found in the Engine Service Manual.

Study this manual carefully. Heed all warnings and cautions. Proper use and maintenance can result in longer set life, better performance and safer operation.

This manual contains basic wiring diagrams and schematics for troubleshooting. Update these diagrams and schematics when the set is modified.

Electronic control module information is limited; in the field, it is more efficient to replace the boards than to attempt repair.

ASSISTANCE

When contacting an Onan® distributor, supply the complete model number and serial number shown on the Onan nameplate on the side of the generator control box.

TEST EQUIPMENT

- Multimeter/digital VOM
- AC voltmeter
- DC voltmeter
- Frequency meter
- Jumper leads
- Load test panel
- Megger or insulation resistance meter
- Wheatstone bridge or digital ohmmeter

⚠WARNING ***Incorrect service or replacement of parts can result in severe personal injury, death, and/or equipment damage. Service personnel must be qualified to perform electrical and mechanical service.***

SAFETY CONSIDERATIONS

Generator sets present safety hazards that the technician must know about. Read the precautions on the inside cover of this manual. Familiarize yourself with the hazards shown in Table 1-1. When the hazards are known, approach the job with a safety-conscious attitude. Being safety-conscious is the best way to avoid injury. **Reduce the chance of an accident with the following safeguards.**

Safeguards To Avoid Hazards

- **Use Protective Clothing.** Protect your body by wearing protective clothing such as:

    - Safety shoes
    - Gloves
    - Safety glasses
    - Hard hats

  Leave rings and jewelry off. Do not wear loose clothing that might get caught on equipment.

- **Reduce Workshop Hazards.**

    - Keep guards and shields in place on machinery
    - Maintain equipment in good working order
    - Store flammable liquids in approved containers away from open flame, spark, pilot light, cigarette, or other ignition source
    - Keep the workshop clean and well-lighted
    - Provide adequate ventilation
    - Keep a fire extinguisher and safety equipment nearby
    - Be prepared to respond to an emergency

- **Develop Safe Work Habits.**

  Unsafe actions are the source of most accidents with tools and machines. Be familiar with the equipment and know how to use it safely. Use the right tool for the job, and check its condition before starting. Observe the warnings and cautions in this manual and take special precautions when working around electrical equipment. Do not work alone if possible and do not take unnecessary risks.

- **Be prepared if an accident occurs.**

Agencies such as the Red Cross and local police and fire departments offer courses in first aid, CPR, and fire control. Take advantage of this information to be ready to respond to an accident. Learn to be safety conscious and make safe practices a part of your work routine. Do not work when tired or after consuming any alcohol or drug that makes the operation of equipment unsafe.

TABLE 1-1
HAZARDS AND THEIR SOURCES

- **Fire and explosions**
  - Leaking fuel
  - Hydrogen gas from charging battery
  - Oily rags improperly stored
  - Flammable liquids improperly stored
  - Any fire, flame, spark, pilot light, arc-producing equipment or other ignition sources
- **Burns**
  - Hot exhaust pipes
  - Hot engine and generator surfaces
  - Hot engine oil
  - Electrical short in DC wiring system
  - Hot engine coolant
- **Poisonous gases**
  - Carbon monoxide from faulty exhaust pipes, joints or hangers
  - Operating generator set where exhaust gases can accumulate
- **Electrical shock (AC)**
  - Improper genset load connections
  - Faulty boat wiring
  - Faulty electrical appliance
  - Faulty genset wiring
  - Working in damp conditions
  - Jewelry touching electrical components
- **Rotating Machinery**
  - Jewelry or loose clothing catching in moving parts
  - Engine coolant pump/alternator belt guard not in place
- **Slippery Surfaces**
  - Leaking or spilled oil
- **Heavy Objects**
  - Removing generator set from vessel
  - Removing heavy components

SET REMOVAL

Some service procedures require removing the generator set from the vessel. Because of the wide variety of installations, it is not possible to specify exact removal procedures for each genset. If a satisfactory method for removing a particular set cannot be determined, contact the boat manufacturer or the set installer for their recommendations.

⚠WARNING ***Generator sets are heavy and they can cause severe personal injury or death if dropped during removal. Use adequate lifting devices to provide sufficient support for the set. Keep hands and feet clear while lifting the generator set.***

Disconnecting Generator Set Systems

Some installations require partial removal of the set to gain access to the battery cable, fuel line, and other connections. Read this entire section before starting set removal. The following steps are a general guideline.

⚠WARNING ***Leakage of fuel in or around the generator set compartment presents the hazard of fire or explosion that can cause severe personal injury or death. Do not disconnect or connect battery cables if fuel vapors are present. Ventilate the compartment thoroughly before beginning work.***

1. Disconnect the generator set negative (-) battery cable at the battery terminal.
2. Disconnect the generator set positive (+) battery cable from the wire harness.
3. Disconnect the remote control plug wire from the generator set (if applicable).
4. Disconnect the generator load wires. Tag for identification when reconnecting.
5. Shut all valves leading to the outside of the vessel that might admit flotation water.
6. Disconnect the exhaust system and support brackets or hangers, to allow set removal.
7. Disconnect the sea water cooling system and its supports.
8. Disconnect the fuel lines at the genset housing. Securely plug the end of the fuel lines to prevent fuel leakage.
9. Verify that the set is adequately supported before loosening any mounting bolts or support members.

⚠WARNING ***Leakage of fuel presents the hazard of fire or explosion that can cause severe personal injury or death. Make certain all fuel line openings are plugged. Before disconnecting the fuel lines, be certain there are no ignition sources such as flame, spark, pilot light, arcing equipment or switches, cigarette, etc., in the generator set compartment or any area with shared ventilation. Keep an ABC type fire extinguisher nearby.***

When reinstalling the set, be sure all mounting hardware and electrical, exhaust, and fuel system components are connected exactly as they were before removal. Replace gaskets as necessary. See the Installation Manual during reinstallation for important safety precautions.

Check for oil and fuel leaks. Check the exhaust system audibly and visually with the generator set running. Repair leaks immediately. Replace worn, damaged, or corroded exhaust and fuel line components before leaks occur.

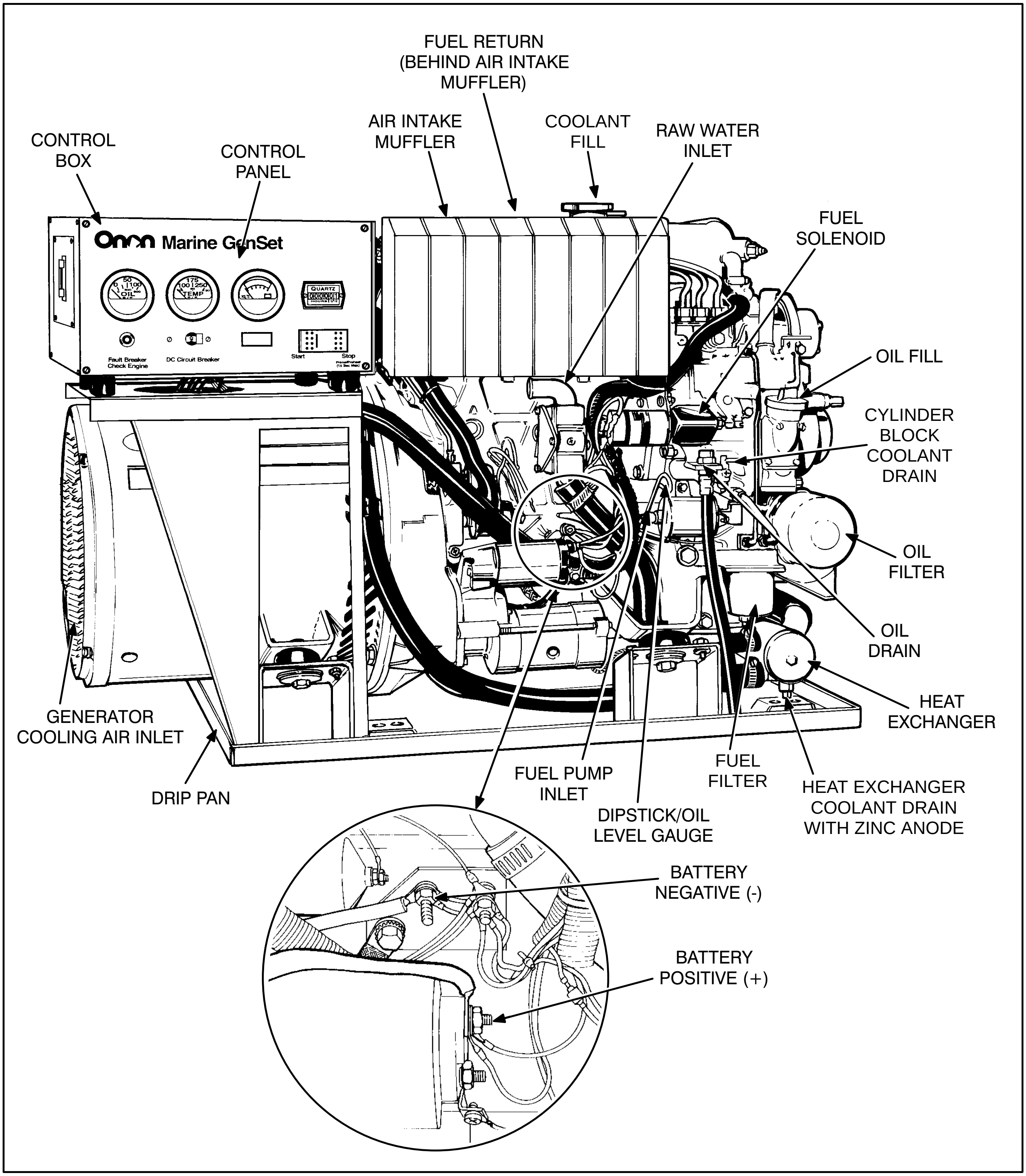


FIGURE 1-1. SERVICE SIDE—SPEC A MDKAD AND MDKAE

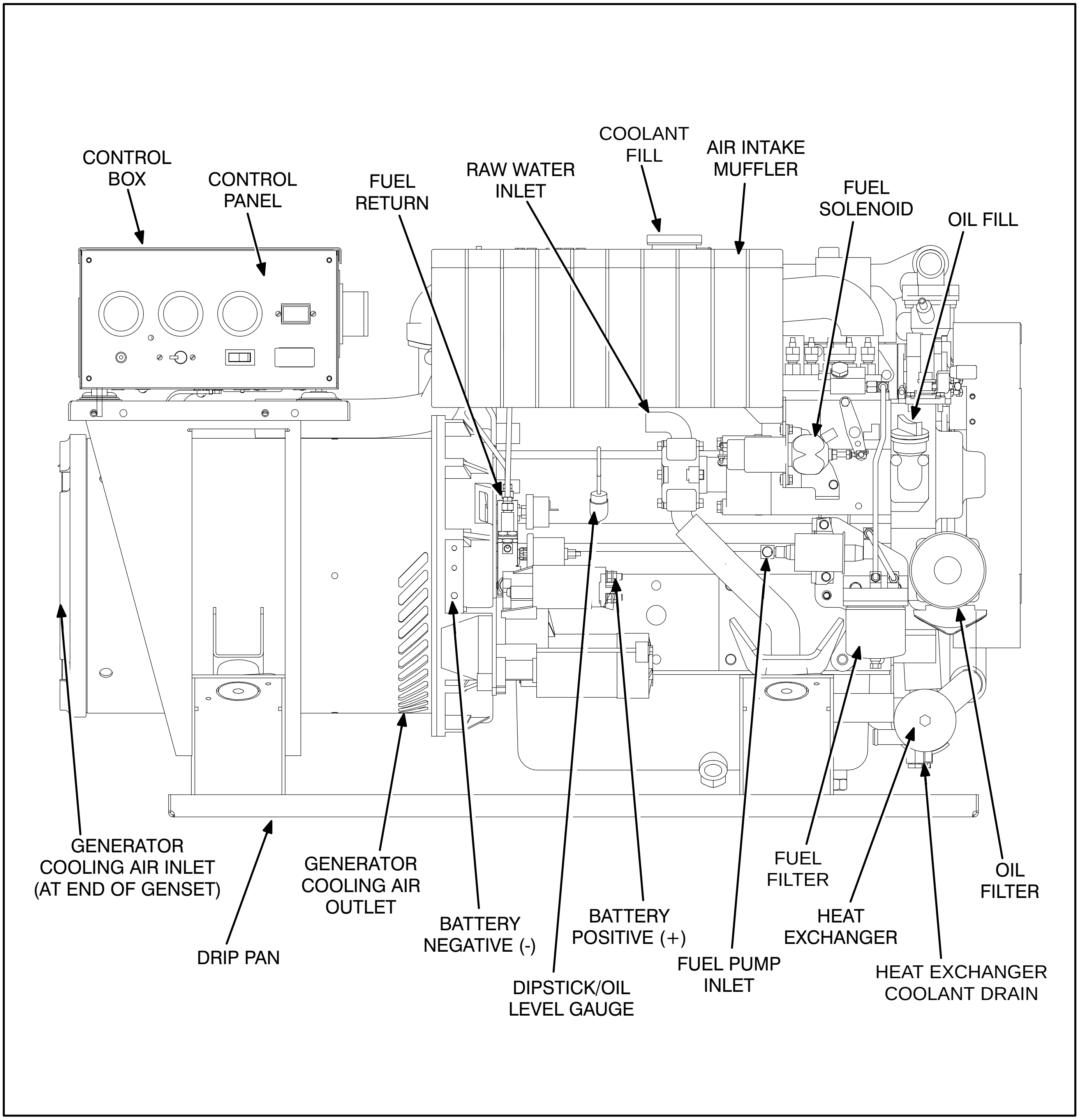


FIGURE 1-2. SERVICE SIDE—ALL MDKAF, BEGINNING SPEC B MDKAD AND MDKAE (MDKAF SHOWN)

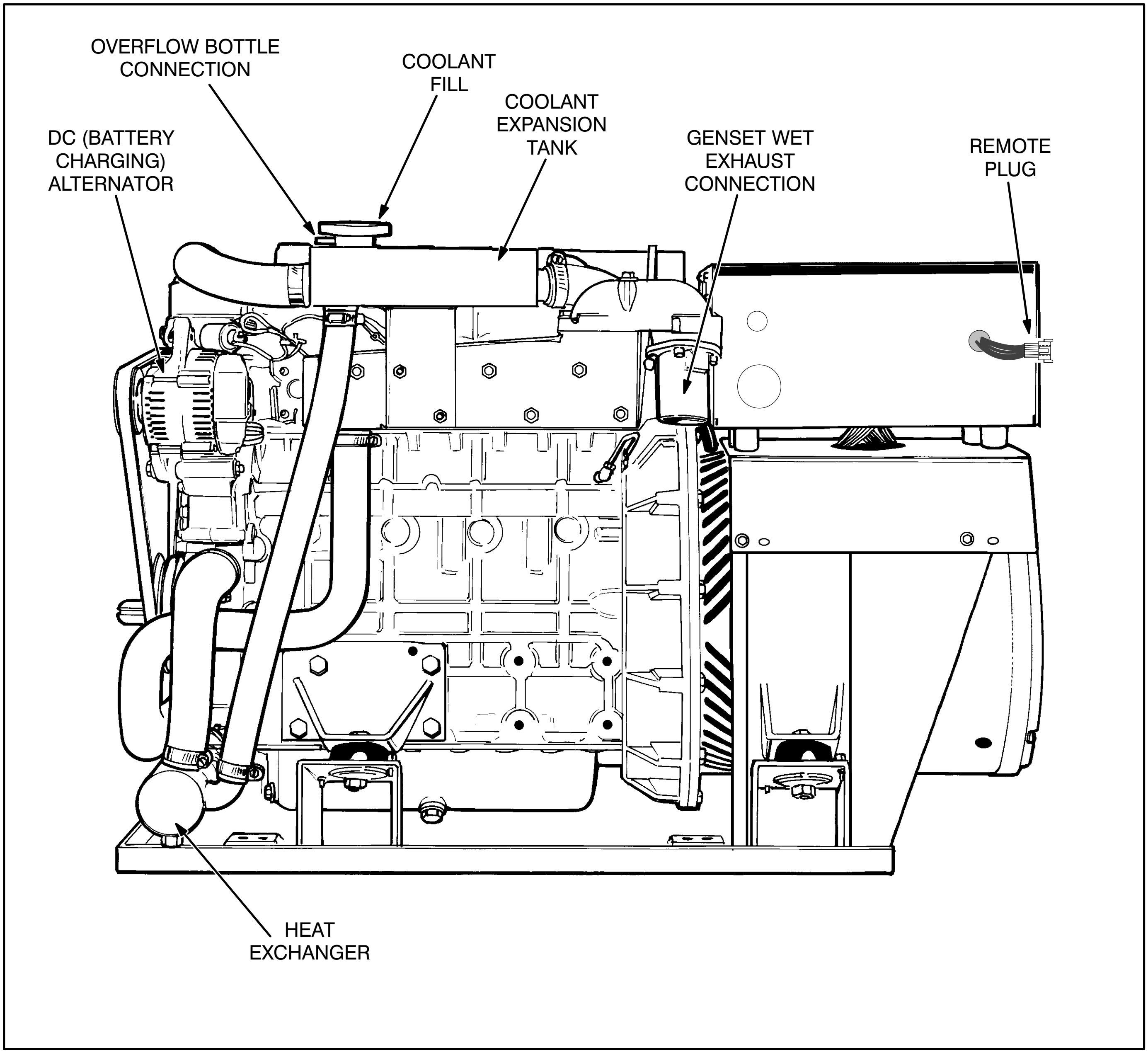


FIGURE 1-3. NON-SERVICE SIDE (MDKAD SHOWN)

Section 2. Engine Controls

INTRODUCTION

This section describes the generator set preheat/start/run control system. Component references are found on wiring/schematic diagrams in Section 9 of this manual.

CONTROL DESCRIPTIONS

Voltage Regulator

AVR1 Voltage Regulator: The Onan SR voltage regulator monitors the AC output voltage and adjusts it according to load.

Fuel Pump

E5 Fuel Pump: Fuel pump E5 is wired in parallel with fuel shutoff relay K8. It pumps fuel from the tank to the low-pressure fuel system.

Battery

BT1 Battery: Battery BT1 provides voltage to glow plugs HR1 - 4, the genset starter motor, and the DC control circuit.

Alternator

G1 Alternator: Alternator G1 is driven by a belt from the engine. It provides B+ voltage to continuously recharge battery BT1 while the genset is running.

Switches

S1 Start-Stop/Preheat Switch: Starts and stops the genset. Cylinder glow plugs are energized when S1 is held in the Stop position and the fuel pump runs to prime the set.

S11 Remote Start-Stop/Preheat Switch (optional): Starts and stops the genset from another location. Cylinder glow plugs are energized when S11 is held in the Stop position and the fuel pump runs to prime the set. This switch is functionally identical to S1.

Circuit Breakers

CB1 DC Control Breaker: A 50 ampere DC breaker protects the glow plug circuit from short circuits or overload.

CB2 "Check Engine" Fault Breaker: A DC circuit breaker that opens when overspeed, over voltage, oil, exhaust, and coolant sensors signal that there are fault conditions in the genset.

CB3 Charging Circuit Breaker: A circuit breaker that protects G1 battery charge alternator from shorts and overcurrent conditions.

CB4 DC/Emergency Stop Circuit Breaker: A 20 amp DC breaker that protects the control box wiring and remote wiring from short circuits or overload, CB4 may be used as an emergency stop switch. CB4 will trip if K7 stop solenoid is misadjusted and its pull-in coil remains energized.

CB5 "Check Generator" Fault Breaker: Shuts down the genset when high generator quadrature winding current causes it to trip. *Push the reset button to reset.* Some earlier models do not have this feature.

Relays

K1 Start Solenoid Relay: Energized when switch S1 is pushed to START. K1 contacts close to apply B+ voltage to the starter and its start solenoid (part of start solenoid assembly). NOTE: K7 fuel shutoff solenoid must be energized before K1 can be energized.

K2 Start Relay: Energized when switch S1 is pressed to START. K2 contacts close to supply B+ voltage to K3 Run relay.

K3 Run Relay: When energized by B+ through K2 contacts, K3 contacts close to supply B+ voltage to M1, M2, M3, M4 meters, K6 low coolant switch relay, K8 fuel shutoff solenoid relay, E5 fuel pump and G1 alternator.

K4 Start Disconnect Relay: When grounded by the start disconnect signal from AVR1, K4 contacts open to remove B+ from K1 start relay, and a set of K4 contacts close to provide B+ to K3 run relay. Another set of K4 contacts close, connecting CB2 fault breaker to the low oil pressure switch, high engine temperature switch and high exhaust temperature switches.

K5 Glow Plug Switch Relay: Energized when switch S1 is held in the STOP position. K5 contacts close to apply B+ voltage to the glow plug heaters HR1, HR2, HR3 and HR4.

K6 Low Coolant Switch Relay: K6 is energized when optional low coolant switch S3 closes due to low coolant level in the system. K6 contacts close to trip CB2 fault breaker.

K7 Fuel Shutoff Solenoid: K7 (mounted on the engine) is energized when the set is running, and opens a valve to allow fuel from the fuel pump into the engine. When the set stops, K7 is deenergized, and fuel flow stops.

K8 Fuel Shutoff Solenoid Relay: Energized when the set is started, K8 contacts close to activate K7 fuel shutoff solenoid. When the set is stopped, K8 contacts open to remove power from K7 fuel shutoff solenoid.

K9 Grounding Relay (optional): On gensets with the option of an ungrounded DC control system, K9 is energized when S1 is held in the Stop position, to provide a ground path for K5 glow plug switch relay, and also in the start position to provide a ground path for the starter.

Meters

M1 Run Time Meter: M1 is activated when the set is running. It registers the duration of set operation.

M2 Oil Pressure Meter (optional): M2 registers oil pressure sensed by E1 oil pressure meter (optional).

M3 Water Temperature Meter (optional): M3 registers water temperature sensed by E2 water temperature meter (optional).

M4 DC Voltage Meter (optional): M4 displays DC (B+) voltage when the set is running.

Pressure and Temperature Senders

E1 Oil Pressure Sender (optional): E1 monitors oil pressure, producing a voltage which is sensed at M2 oil pressure meter (optional).

E2 Coolant Temperature Sender (optional): E2 monitors coolant temperature, producing a voltage which is sensed at M3 coolant temperature meter (optional).

Engine Monitors

S2 High Engine Temperature Switch: S2 closes when the engine temperature gets too high. This puts a ground on the shunt of CB2 fault breaker, and CB2 opens and stops B+ to the control.

S3 Low Coolant Level Switch: S3 (optional) closes when the level of coolant in the top tank gets too low. This puts a ground on the shunt of CB2 fault breaker, and CB2 opens and stops B+ to the control.

S4 Low Oil Pressure Switch: S4 closes when the engine oil pressure drops too low. This puts a ground on the shunt of CB2 fault breaker, and CB2 opens and stops B+ to the control.

S5 High Exhaust Temperature Sensing Switch: S5 closes when the exhaust temperature gets too high. This puts a ground on the shunt of CB2 fault breaker, and CB2 opens and stops B+ to the control.

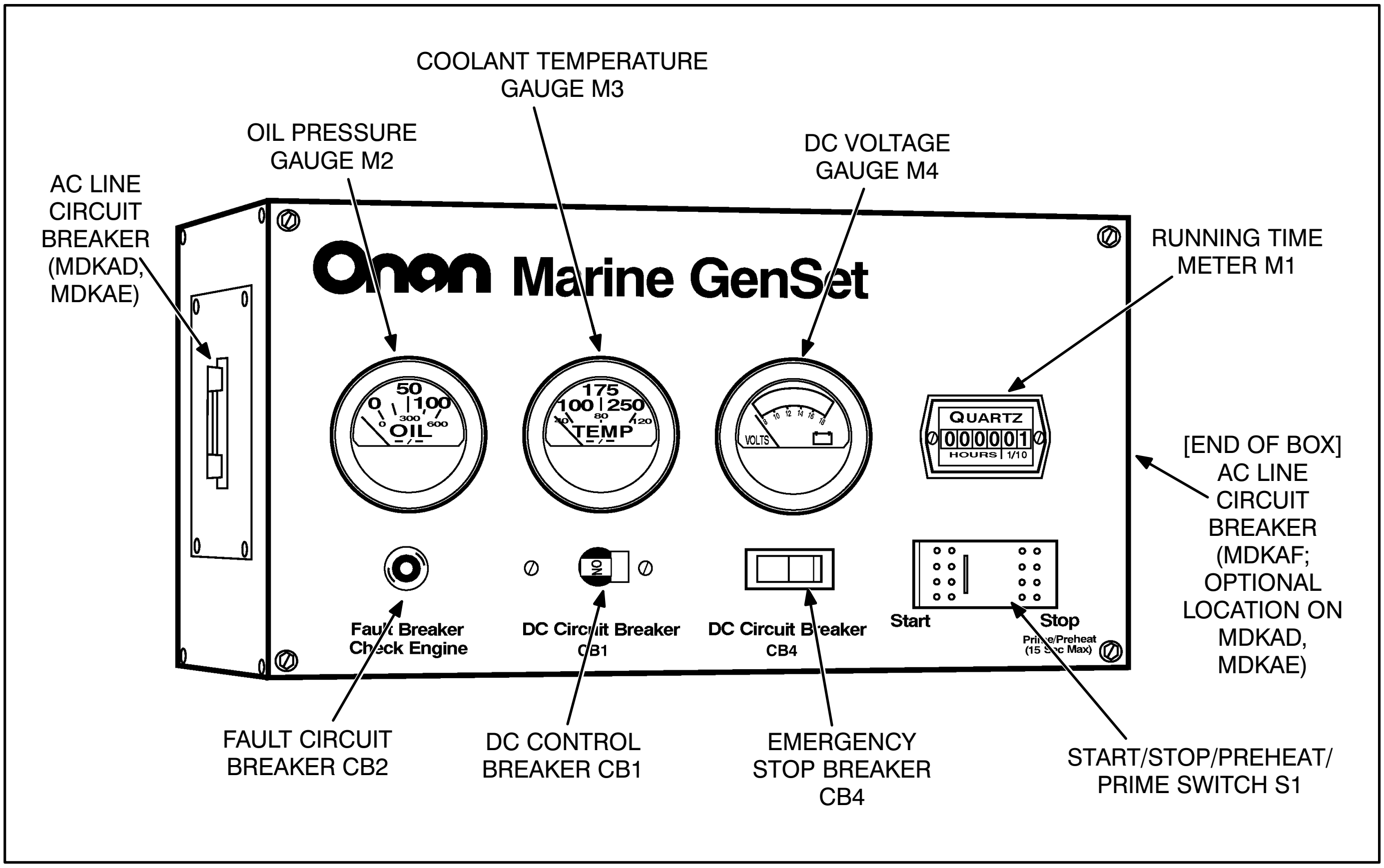


FIGURE 2-1. CONTROL PANEL

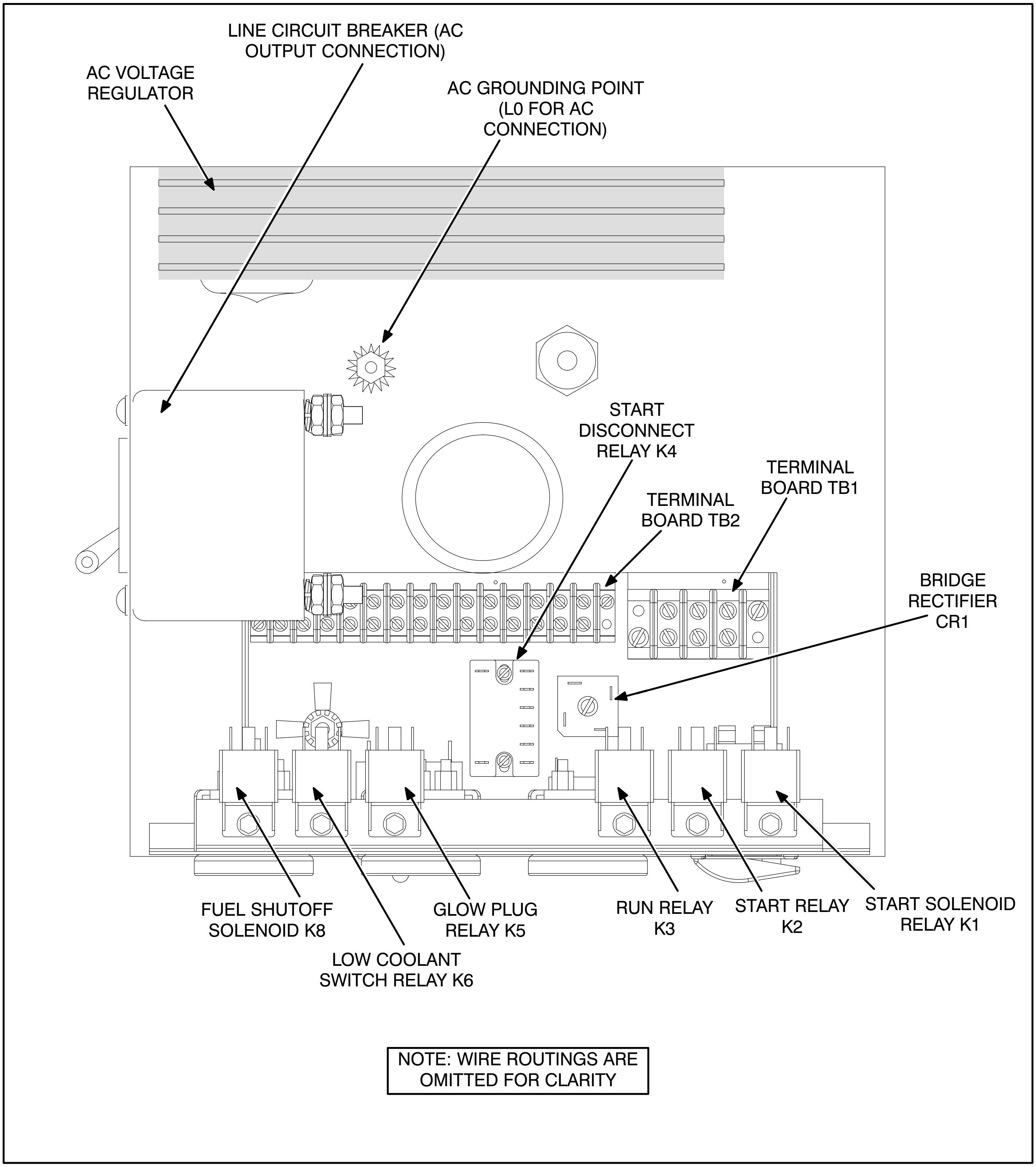


FIGURE 2-2. COMPONENTS INSIDE MDKAD/MDKAE CONTROL BOX

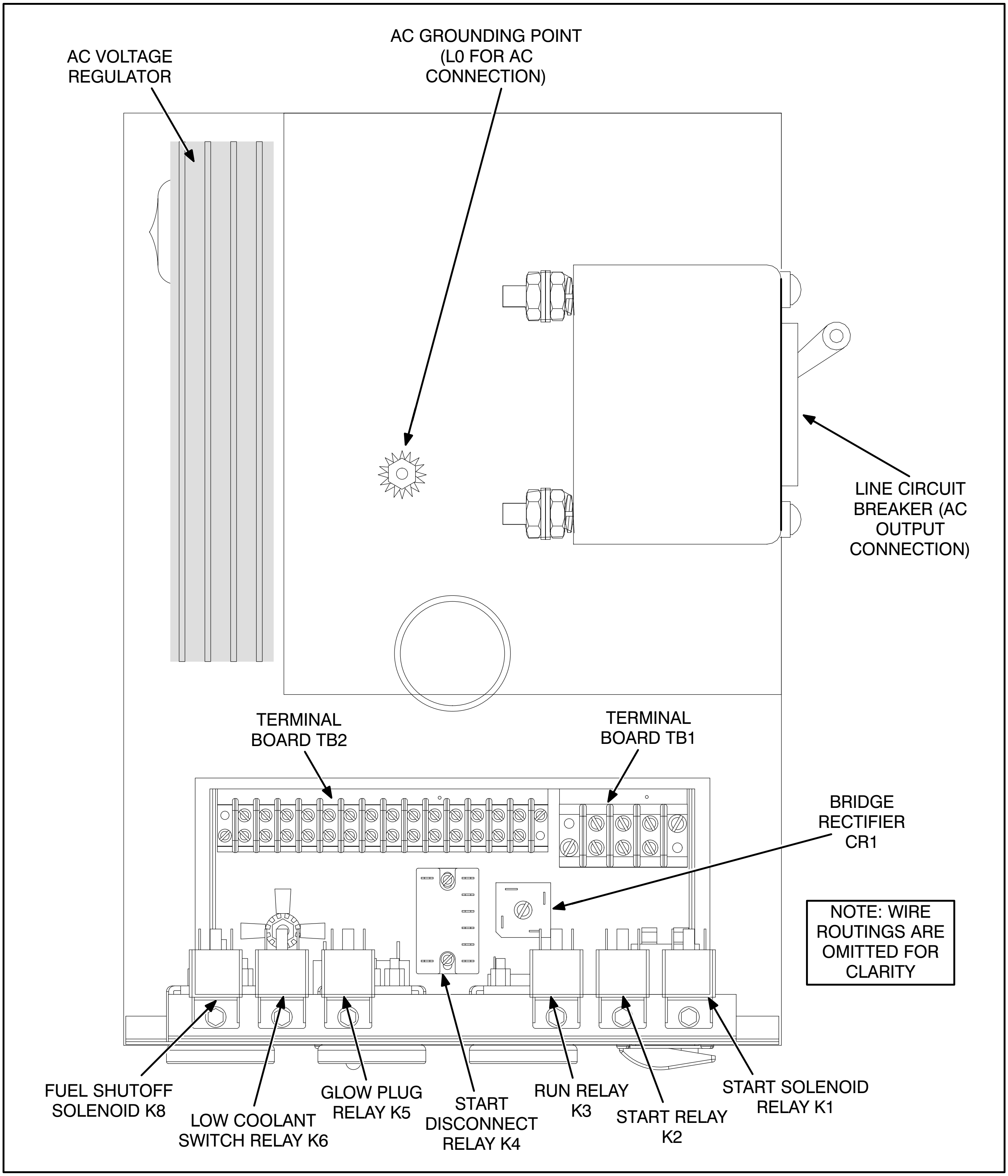


FIGURE 2-3. COMPONENTS INSIDE MDKAF CONTROL BOX

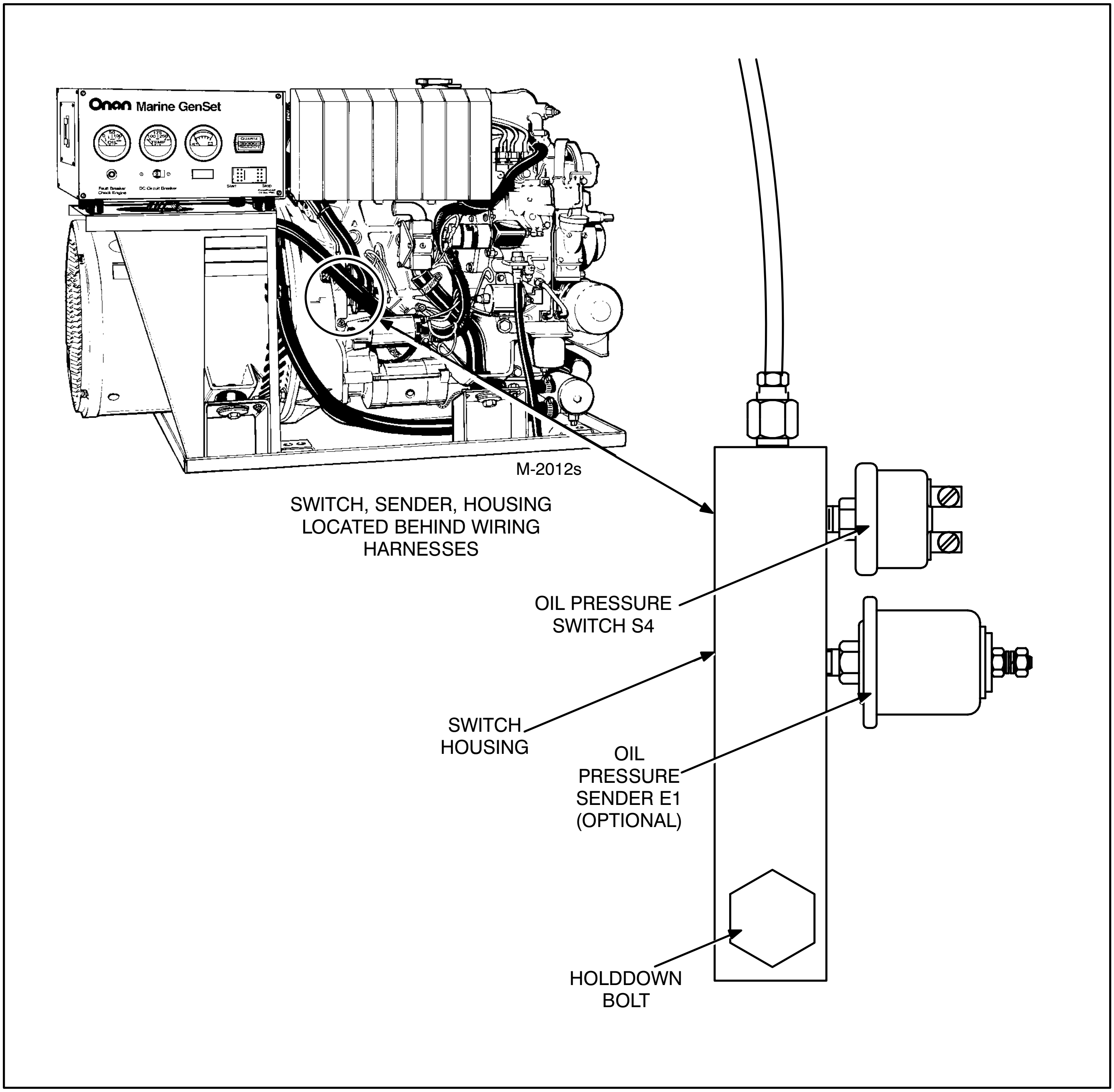


FIGURE 2-4. OIL PRESSURE SENDER, LOW OIL PRESSURE SWITCH (MDKAD SHOWN)

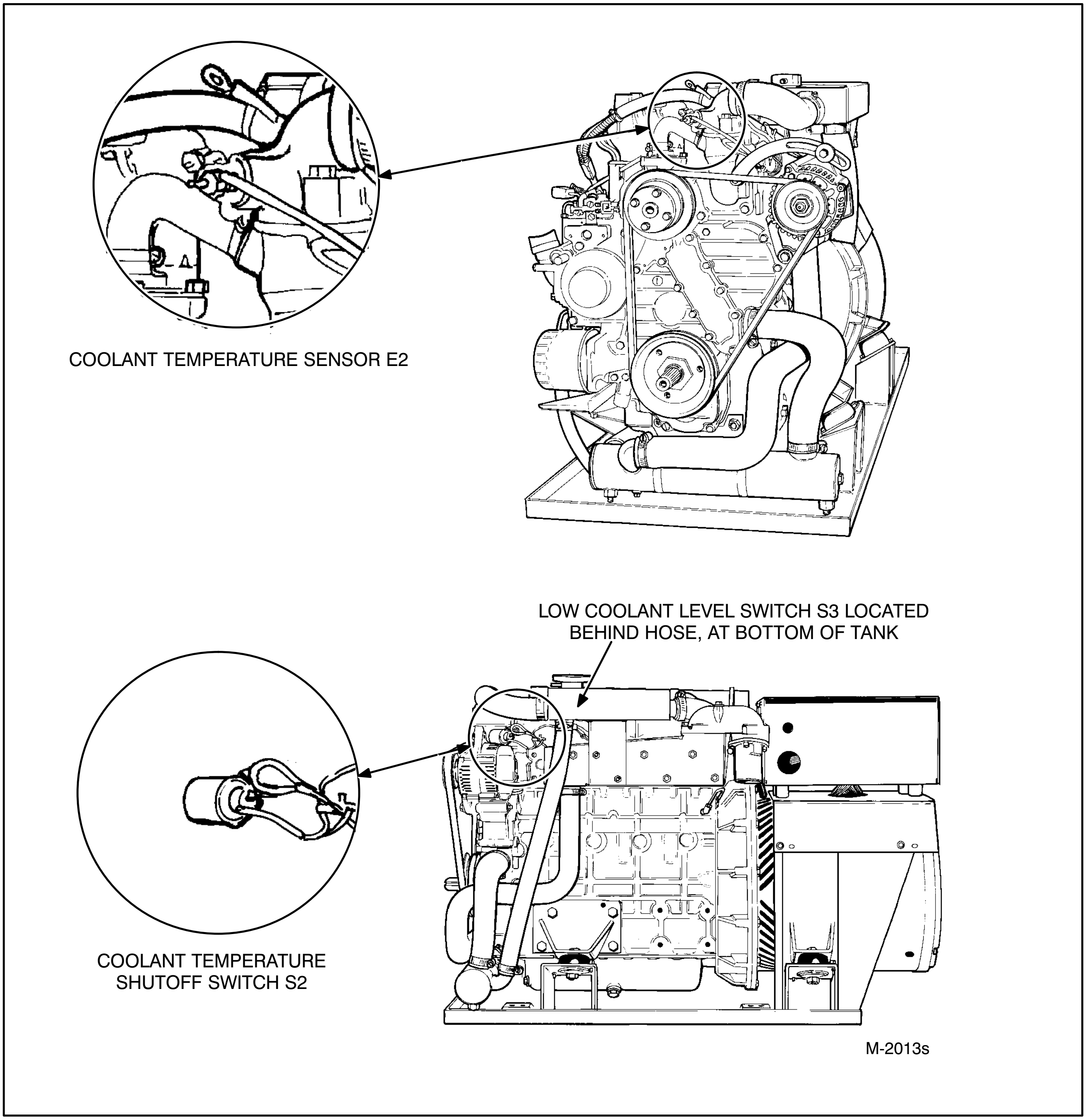


FIGURE 2-5. COOLANT TEMPERATURE SENSOR AND SWITCH, LOW COOLANT LEVEL SWITCH (MDKAD SHOWN)

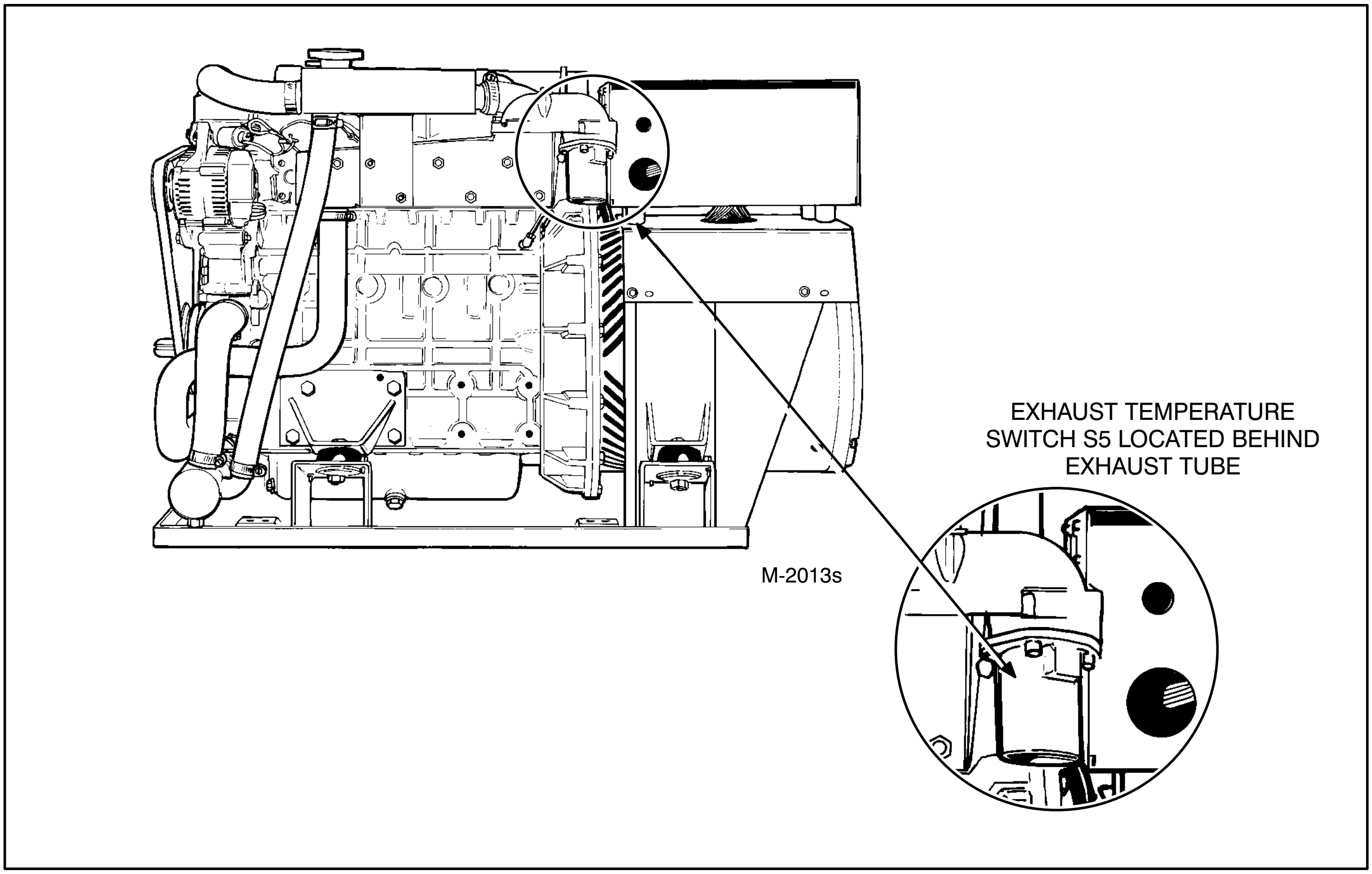


FIGURE 2-6. EXHAUST TEMPERATURE SWITCH S5 (MDKAD SHOWN)

CONTROL OPERATION

To understand control operation, refer to the following text and the schematic diagram found in Section 9 of this manual.

Starting Sequence

When start/stop switch **S1** is held in the *Stop/Preheat* position, battery B+ voltage is applied to the coil of glow plug relay **K5**. energizing it. **K5** relay contacts close and connect B+ to glow plugs **HR1 - HR4**. Current also flows through rectifier **CR4** to energize and run fuel pump **E5**, priming the fuel system.

After 5 to 15 seconds heating the glow plugs, **S1** is held in the *Start* position. This connects B+ to the coil of **K2** start relay, whose contacts close to supply B+ to **K3** run relay. **K3** contacts close to supply B+ to the **E5** fuel pump and the **K8** fuel solenoid relay, whose contacts close to supply B+ to **K7** fuel shutoff solenoid. **K7** energizes to supply a ground to energize the **K1** start solenoid relay, which cranks the engine.

With the **K1** start solenoid relay contacts closed, B+ will continue to keep the **K5** glow plug relay energized, closing its contacts to keep the glow plugs heating.

Start-Disconnect Sequence

As the generator gains speed and output voltage, **K4** start disconnect relay is energized at about 70 VAC by a DC signal from **AVR1**. (If the generator fails to develop voltage, the engine will attempt to start, but will stop as soon as the Start switch is released.) **K4** NC contacts open, disconnecting power from K1 start solenoid relay. **K4** NO contacts close to connect the shutdown switches to CB2**.** Other **K4** NO contacts close to continue to supply B+ to keep **K3** run relay energized after **K2** start relay is deenergized.

Battery Charge Circuit

Alternator **G1**, powered by a belt from the engine, supplies B+ voltage to recharge the generator set starting battery.

Stopping Sequence

Moving **S1** to the Stop position applies B+ to the ground side of the coil of run relay **K3**, deenergizing it. **K3** contacts open to remove B+ voltage from meters **M1**, **M2**, **M3** and **M4**, from fuel pump **E5**, and from fuel shutoff solenoid relay **K8**.

Fault Shutdown

S2 high engine temperature switch, **S3** low coolant level switch, **S4** low oil pressure switch, and **S5** high exhaust temperature sensing switch can all stop the generator set. **S2**, **S4** and **S5** stop the set by grounding the shunt of circuit breaker **CB2**. **S3** stops the set by energizing low coolant switch relay **K6** which closes contacts to ground **CB2**.

Remote Meter Panel (Optional)

An optional remote meter panel may be connected to the genset control by means of terminal block **TB2** or an optional connector. This panel enables the operator to monitor genset B+ voltage, coolant temperature, and oil pressure. Refer to the DC schematic diagram in Section 9 of this manual.

CONTROL TROUBLESHOOTING

Four possible engine control fault conditions are described in this section. These are:

- Engine does not crank
- Engine cranks but does not start
- Engine starts but stops after running several seconds
- Engine starts but stays running only if Start switch is held

Before starting a troubleshooting procedure, make a few simple checks that may expose the problem and cut down on troubleshooting time.

Check all modifications, repairs, and replacements performed since last satisfactory operation of set. A loose wire connection overlooked when installing a replacement part could cause problems. An incorrect connection, an opened switch or circuit breaker, or a loose plug-in are all potential problems that can be eliminated by a visual check.

Refer to Figures 2-1 through 2-6 for locating control components, leads, terminals and other check points.

Fault Circuits

"Check Generator" Fault: If the "Check Generator" fault breaker trips, as indicated by the extended reset button, the genset may have been overloaded. *Push the reset button.*

"Check Engine" Fault: The "Check Engine" faults are: low engine oil pressure, high coolant temperature, low coolant level (optional), high exhaust temperature, over/underspeed and over/undervoltage. The "Check Engine" fault breaker will trip, as indicated by the extended reset button. *Push the reset button.*

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

Trouble	Possible Cause	Corrective Action
Engine does not crank	Open circuit breaker CB1, CB2 or CB4	Check to see if breaker is accidentally tripped Check and correct fault conditions that might trip breakers: CB1: check shorts to ground on/near glow plug circuits CB2: check and correct fault conditions sensed by engine fault sensors: S2: high engine temperature S3: low coolant level S4: low oil pressure S5: high exhaust temperature CB2: check possible shorted fault sensors S1, S2, S3, S4 CB4: check K7 stop solenoid for adjustment
	No B+ voltage to starter	Check B+ and ground connections at battery and grounding point on engine Check battery cables per Checkout B (Section 3 of manual) Check B+ voltage while cranking at SW terminal on starter (TB2-11): is there voltage while pressing Start switch? Yes: problem is in starter or solenoid No: problem is in control circuit
	Start relay K1 is not functional	Check relay per Checkout D (Section 3), replace if bad Check K7 stop solenoid for adjustment
	Battery is not functional	Check battery per Checkout A (Section 3 of manual) and recharge or replace Check battery charger operation per Checkout C (Section 3)
	Starter is not functional	Remove starter from genset, check and replace if necessary

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

Trouble	Possible Cause	Corrective Action
Engine cranks but does not start	Fuel is not getting to the engine	Check fuel pump per Checkout H (Section 3) Place meter on fuel pump terminal and press Start switch: is voltage reaching fuel pump? Test fuel tank level, shutoff valves, fuel lines and connections, fuel filters, injection pump Air in fuel lines: prime fuel system
	Glow plugs not operating correctly	Check/replace individual glow plugs per instructions in Engine Manual Place meter on glow plug terminal and press Preheat switch: is voltage reaching glow plug? Test K5 glow plug relay per Checkout E (Section 3) Test continuity of K5 circuit Test Start/Stop-Preheat switch per Checkout G (Section 3)
	Fuel shutoff solenoid not operating correctly	Place meter on fuel solenoid terminal and press Start switch: is voltage reaching fuel solenoid? Test fuel solenoid circuit for continuity through B+. Disconnect fuel solenoid from circuit, test per Checkout F (Section 3). Adjust/replace as necessary.

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

Trouble	Possible Cause	Corrective Action
Engine starts but stops after several seconds	Fault conditions cause fault breaker CB2 to open	CB2: check and correct fault conditions sensed by engine fault sensors: S2: high engine temperature: check water pump operation S3: low coolant level S4: low oil pressure S5: high exhaust temperature Check possible overspeed conditions Engine speed set too high: reset to 1500 or 1800 rpm according to instructions in Section 4 of manual Voltage regulator board 50/60 Hz switch is set at 50 Hz while governor lever is set at 60 Hz: both settings must be the same Check all B+ wiring for shorts to ground
	Fuel pump is stopped or intermittent	Check fuel pump per Checkout H in next section of manual: replace if necessary Check fuel pump circuit for continuity
	Air in fuel line	Prime fuel system (press S1 to the STOP position)

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

Trouble	Possible Cause	Corrective Action
Engine starts and runs but remains running only while start switch is held	If there is AC output from the set: K4 relay may not be changing state	Remove K4, check per Checkout E (Section 3): replace if necessary Check K4 wiring for continuity
	If there is no AC output from the set: generator/voltage regulator may be at fault (not control system)	Check generator/voltage regulator per procedures in Sections 5 and 6 of manual

Section 3. Engine Control Service

GENERAL

The following checks are referred to in the Control Troubleshooting troubleshooting charts. They isolate circuit problems caused by faulty engine control components. Disconnect leads before testing components.

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

[A]

BATTERY CHECK

Check the battery charge condition with a hydrometer. Electrolyte specific gravity should be about 1.260 for a fully charged battery at 80°F (27°C). If not, add distilled water to keep electrolyte at proper level, then recharge the battery. If the battery will not recharge, replace it.

If the battery loses excess water, the charge rate may be too high. If the battery charge is not maintained, the charge rate may be too low. See procedure [C].

WARNING ***Ignition of explosive battery gases can cause severe personal injury. Do not permit any flame, spark, cigarette, or other ignition source near the battery.***

[B]

BATTERY CABLE CHECK

With the starter motor running, check these voltage drops:

1. From the battery negative post (not the cable clamp) to the cylinder block
2. From the battery positive post to the battery terminal stud on the solenoid

Normally these should be less than 0.3 volts. If extra long battery cables are used, slightly higher voltage drops may result. Thoroughly clean all connections in any part of the circuit showing excessive voltage drop.

[C]

BATTERY CHARGING CHECK

With the engine running, check the DC voltmeter (control option). The 12-volt system should read 13.5 to 15 volts.

The power source is a belt-driven alternator. The charge rate/voltage is determined by the voltage regulator in the alternator.

Improper output may be caused by a loose drive belt, poor terminal connections, broken wires, or defective alternator.

[D]

START SOLENOID CHECK

1. Apply battery positive (B+) to the terminal marked S.
2. Connect a ground wire to the solenoid terminal marked I. The solenoid should activate.
3. If the contacts are good, battery voltage should be present between terminal 1 and ground. The voltage drop measured across the contacts should never exceed one volt in circuit application.

[E]

RELAY CHECK

1. Connect B+ voltage across the relay coil terminals. The relay should activate if coil is functional.
2. Connect a voltage source to one side of relay contacts.
3. Connect a voltmeter to other side of relay contact and to the other end of the voltage source. Note the presence or absence of voltage and then energize the relay. Normally open (NO) contacts: If voltage appears when relay energizes, the contact is good. Normally closed (NC) contacts: If voltage reading goes to 0 when relay energizes, the contact is good.

[F]

FUEL SOLENOID CHECK

If there is fuel to the injection pump, but no fuel at the injection nozzle, fuel shutoff solenoid K7 may be defective.

To check solenoid operation, watch for solenoid actuation when B+ is applied (start switch in start or run position). Measure voltage at the solenoid to confirm that the start circuit is working. If there is no actuation when B+ is applied, the fuel solenoid must be adjusted or replaced. When B+ is removed, the solenoid must de-activate.

[G]

SWITCH CHECK

1. Remove battery B+ cable at the battery.
2. Place ohmmeter leads across switch.
3. Open and close switch while observing the ohmmeter. Normally open (NO) contacts should indicate infinite resistance when open and continuity when closed. Normally closed (NC) contacts should indicate continuity when closed and infinite resistance when open.

[H]

FUEL PUMP TEST

1. Disconnect the fuel line at the outlet of the fuel pump and connect a pressure gauge at the pump outlet. A gauge calibrated for 0 to 15 psi (0 to 100 kPa) is recommended. Do not tee into the fuel line. This is a static pressure test.
2. Push the Start/Stop switch to START and hold it there for several seconds until the fuel pressure stabilizes. Fuel pressure should stabilize between 3.5 and 6 psi (24 and 41 kPa).
3. If the fuel pressure is less than 3.5 psi (24 kPa), check for fuel restrictions in the system. Note that the amount of lift will affect the output pressure. For three feet (0.9 meters) lift, the output pressure will be reduced by 1.0 psi (to 2.5 psi minimum).

   The pump will have to be relocated closer to the fuel tank if it is located more than 3 feet (0.9 meters) above the end of the fuel pickup tube in the fuel tank. If the pump is defective, replace it with the correct (same part number) Onan pump. The fuel pump is not serviceable in the field.

Section 4. Generator/Voltage Regulator

GENERAL DESCRIPTION

The YD generator (Figure 4-1) is a four-pole, revolving field, brushless exciter design with drip-proof construction.

The generator rotor is directly coupled to the engine flywheel with a rigid drive disc. Engine speed determines generator output frequency. A centrifugal blower on the drive disc circulates generator cooling air which is drawn in through the end bell and discharged through vents in the blower end.

A ball bearing in the end bell supports the outer end of the rotor shaft. The end bell is attached with four bolts that thread into the end bell retainer. The brushless exciter stator mounts in the end bell while the exciter rotor and its rotating diode assemblies mount on the generator rotor shaft. Leads F1 (+) and F2 (-) from the exciter stator winding are connected to the output terminals of the voltage regulator.

Figure 4-2 shows the generator output and control/meter leads. A complete schematic diagram appears in Section 9, Wiring Diagrams.

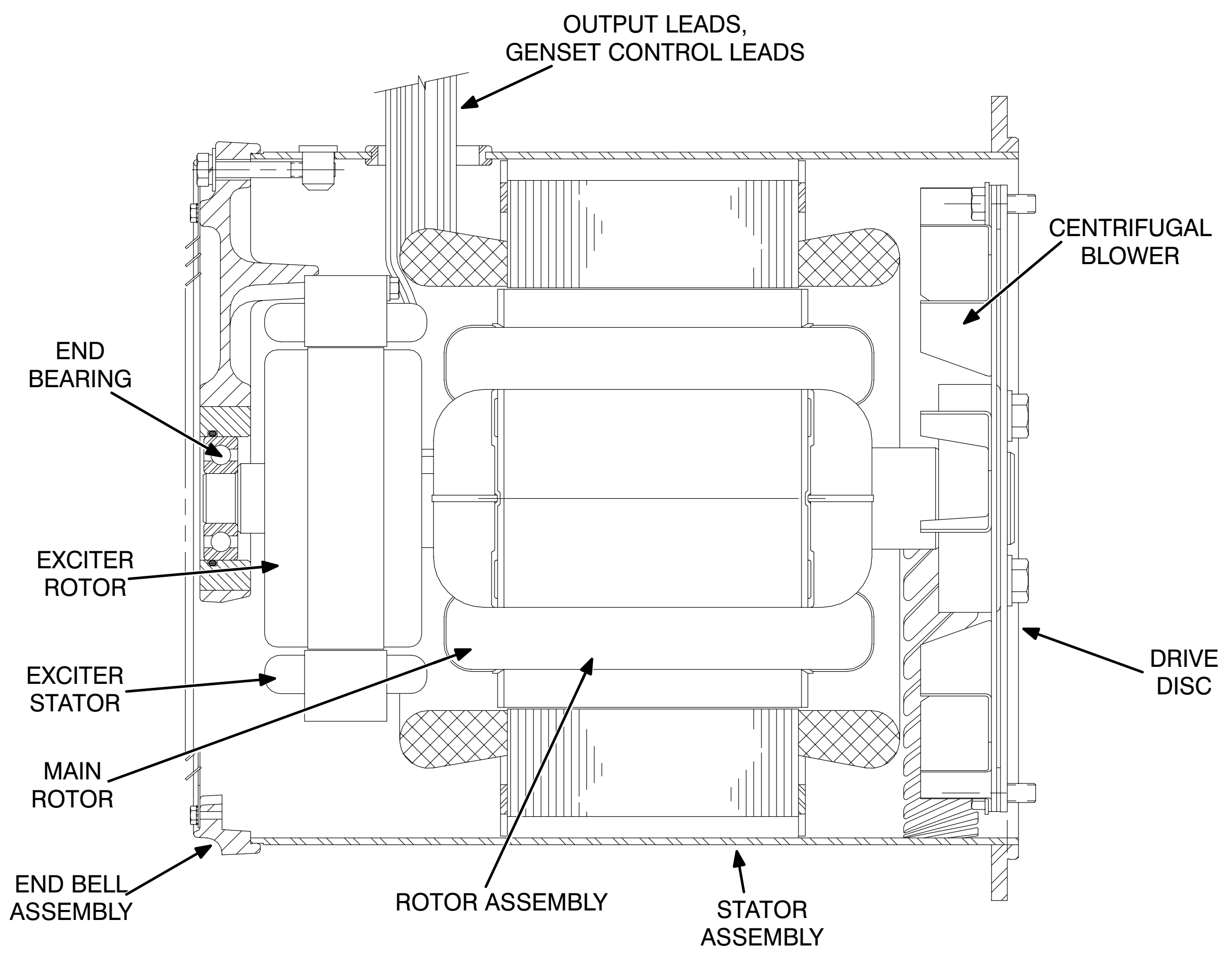


FIGURE 4-1. YD GENERATOR FOR MDKAD/MDKAE/MDKAF GENERATOR SETS

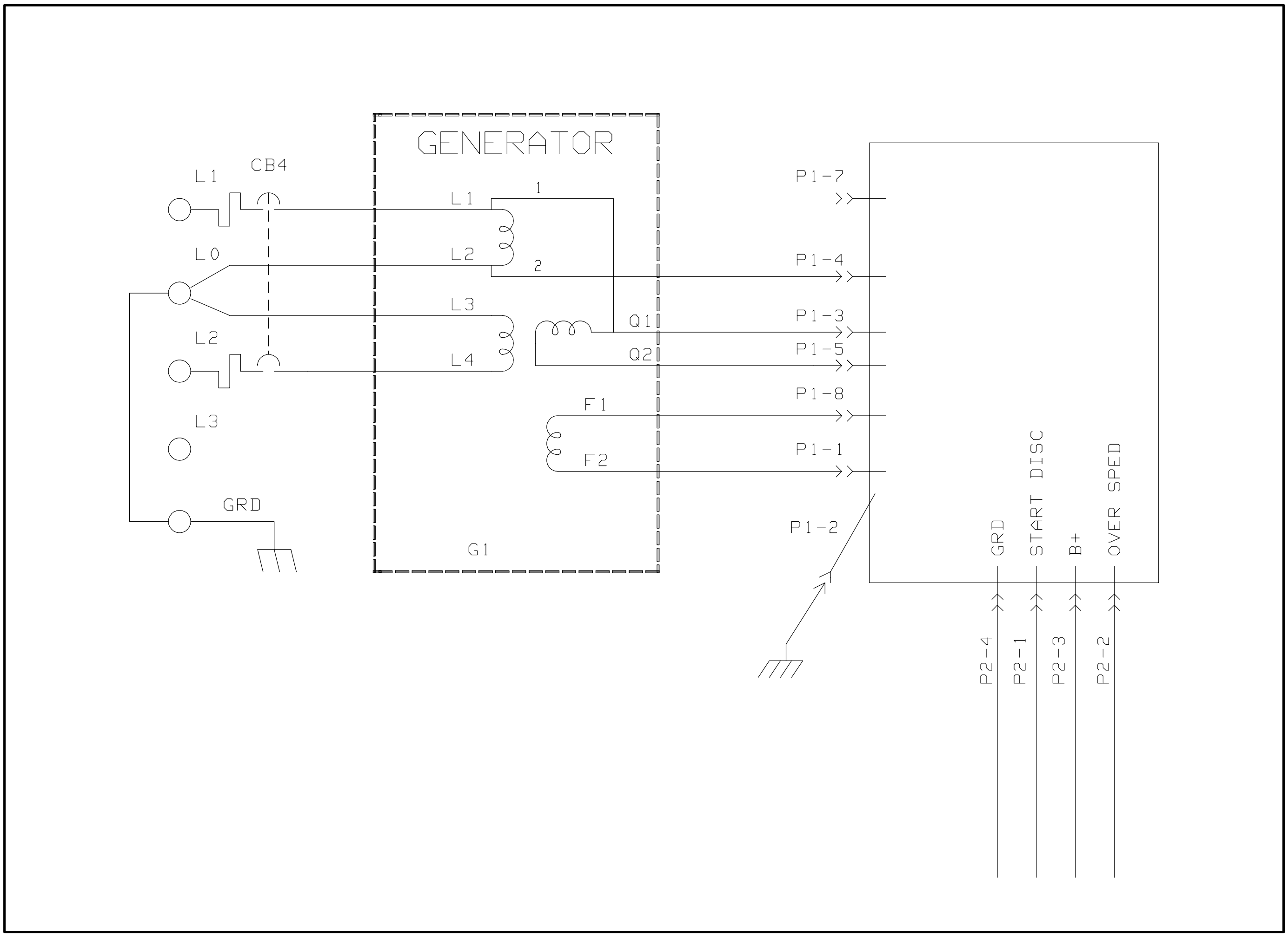


FIGURE 4-2. GENERATOR SCHEMATIC (FROM 612-6665)

GENERATOR OPERATION

Power generation involves the components shown in Figure 4-3. These components are italicized in the following text. A *permanent magnet* embedded in an *exciter stator* field pole begins the voltage build-up process as the generator set starts. Single-phase AC voltage, taken from a *main stator* winding, is connected to the *voltage regulator* as a reference for regulating the generator output voltage. The regulator DC output is coupled to the *exciter stator*.

The *exciter rotor* produces three-phase AC voltage that is converted to DC by the full wave *rotating rectifier assemblies*. The DC voltage excites the *rotor main field* winding to produce *main stator* AC for the load.

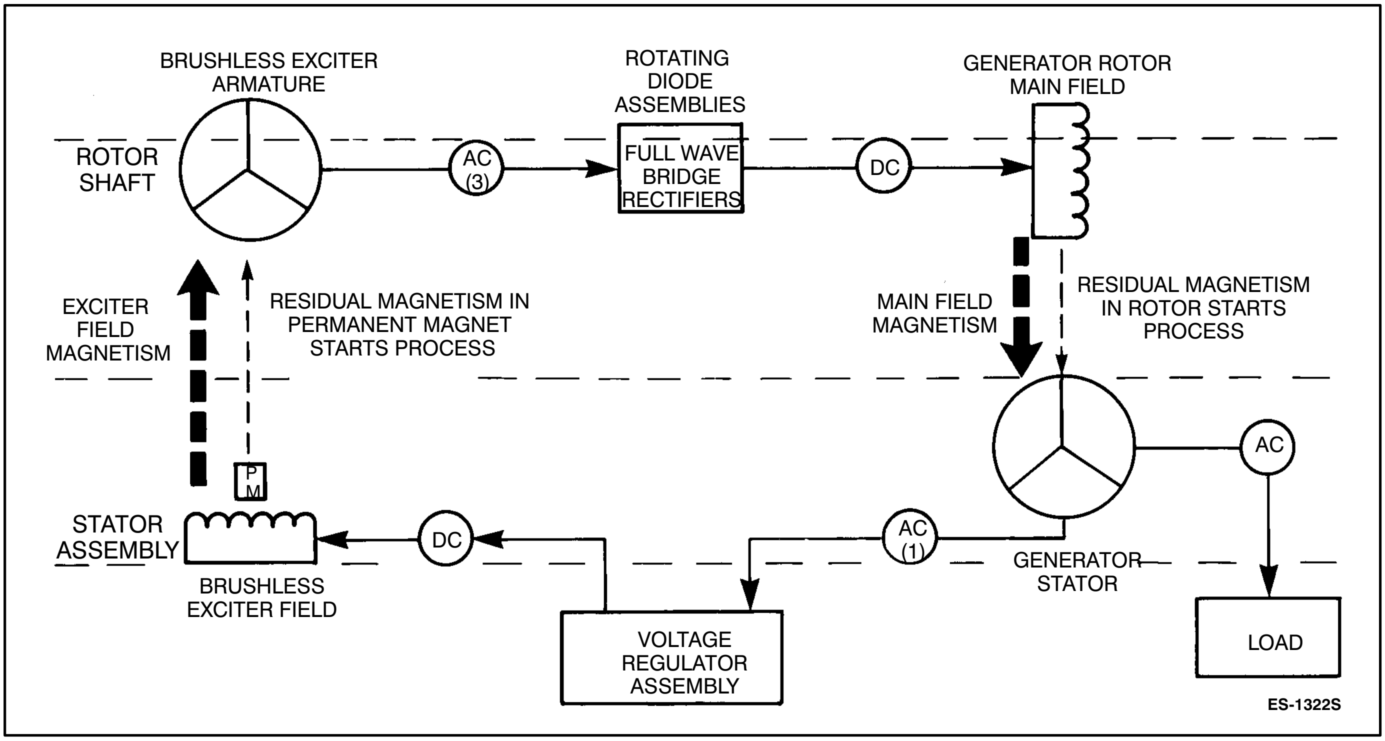


FIGURE 4-3. EXCITATION BLOCK DIAGRAM

ELECTRONIC VOLTAGE REGULATOR

The voltage regulator controls the output of the generator so that a constant voltage is maintained under varying load conditions.

Only the basic functions of the regulator are described (Figure 4-3). Voltage from one of the generator stator windings is supplied to the voltage regulator. The voltage regulator in turn supplies an excitation voltage (F1/F2) that is directly proportionate to the output voltage (L1/L0) it senses. Any changes in the generator output voltage produce a corresponding change in the excitation voltage provided by the regulator. Voltage from quadrature windings Q1/Q2 supply power to the voltage regulator itself.

The voltage regulator assembly contains no user-serviceable parts. If the assembly fails, it must be replaced.

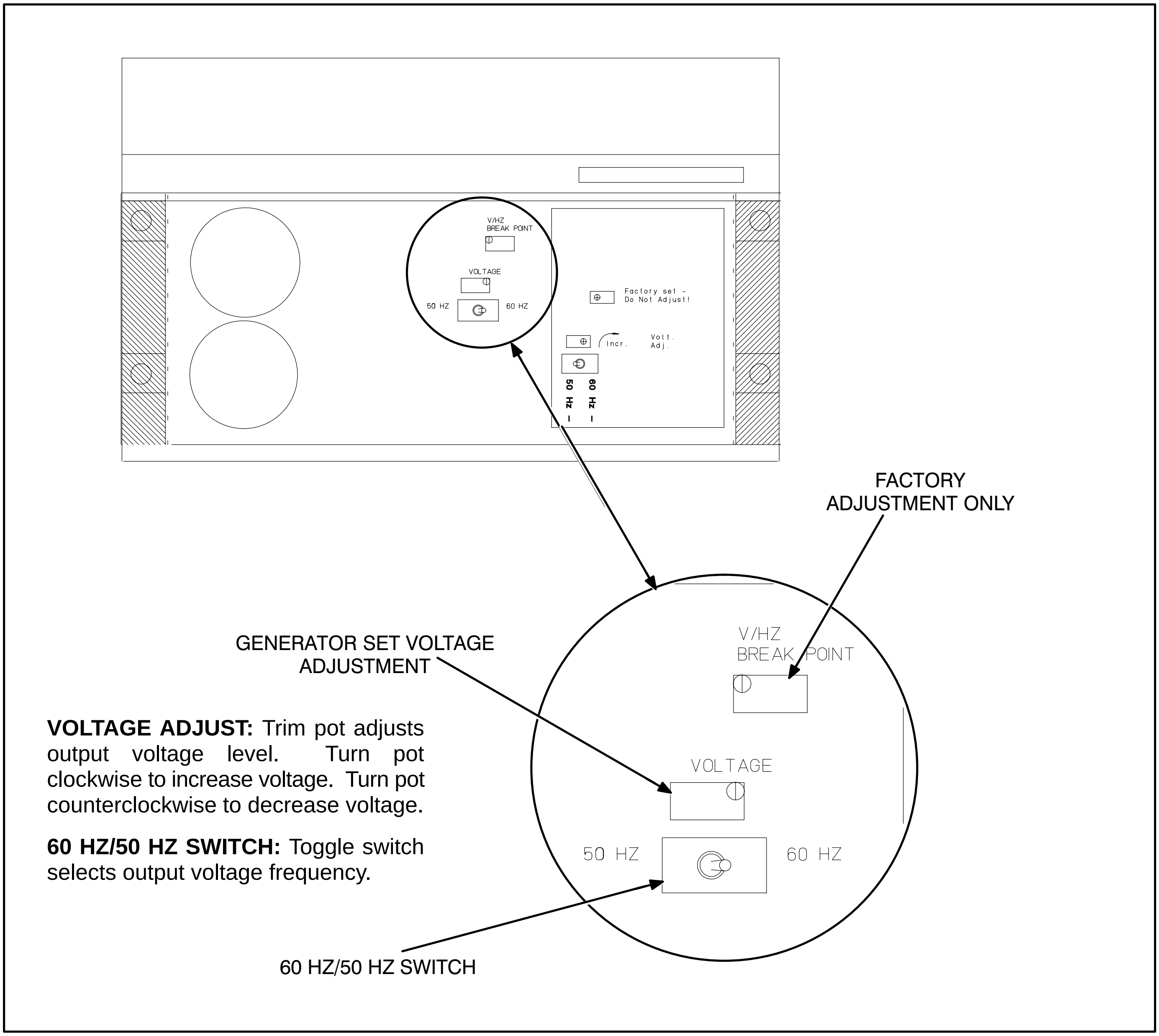


FIGURE 4-4. FRONT VIEW OF SR VOLTAGE REGULATOR (AT REAR OF CONTROL BOX)

CHANGING GENSET FREQUENCY

Changing the generator set's output voltage frequency from 50 Hz to 60 Hz, or from 60 Hz to 50 Hz, requires:

- Identifying the frequency and voltage to which the set will be changed
- Replacing the original AC output circuit breaker with a new one that is sized for the new load (if necessary)
- Switching the frequency on the generator set regulator board
- Readjusting the genset engine speed for the new frequency (50 Hz: 1500 RPM; 60 Hz: 1800

RPM), under both no-load and full-load conditions

These steps are covered below.

WARNING ***Incorrect electrical connections/ adjustments can cause equipment damage, severe injury or death. Make certain that the generator set is turned off before beginning these adjustments. Disconnect the genset starting battery, positive (+) terminal first, to disable the genset and prevent it from being started.***

Identifying New Frequency and Voltage

Determine the new frequency and voltage to which the generator set will be converted, before beginning the procedure of converting the output voltage frequency. Consider the following factors:

- Where (in what country) will the set be operated?
- What equipment will it be powering?
- How large will the genset load be?

For other genset load considerations, consult the Installation Manual, Onan publication #981-0608.

Replacing the Output Circuit Breaker

The generator AC output (line) circuit breaker may need to be replaced by one that is the correct size for the generator output voltage and amperage. Consult your Onan distributor for the correct rating and type of output circuit breaker that Onan supplies.

Note: Perform all mechanical adjustments on the generator set while it is warm: run the set for roughly 15 minutes at 50 - 75% load before beginning to adjust the levers illustrated in Figure 4-5.

Switching the Frequency at the Regulator Board

1. Turn the generator set off.
2. Open the generator set control box and locate the voltage regulator board (Figure 4-4).
3. Move the 60 Hz/50 Hz switch to the desired value.

Readjusting Engine Speed

Once the electrical adjustments have been made, the genset engine speed must be readjusted to the correct RPM for the selected frequency. At full load, this figure is:

- 50 Hz gensets: **1500 RPM**
- 60 Hz gensets: **1800 RPM**

Have the following instruments ready:

- Digital volt-ohmmeter
- Frequency meter

Figure 4-5 illustrates the genset governor control lever that must be adjusted to change the genset frequency.

1. Move the frequency adjustment lever to the desired setting: either 50 Hz (left) or 60 Hz (right).
2. Place the frequency meter across the set AC output.
3. Start the generator set.
4. Apply maximum rated load to the generator set output.
5. Observe the frequency meter. While watching the meter, adjust the frequency fine adjust screw until the meter reads the desired frequency: either 50 Hz or 60 Hz.
6. Remove all load from the generator set. Check the no-load frequency: is it within 3Hz of the load frequency set in the preceding step?
   a. If the frequency is within 3 Hz of the full-load frequency, then tighten the lock nut down: the set is adjusted correctly.
   b. If the frequency is not within 3 Hz of the full-load frequency, then turn the frequency fine adjustment screw to adjust the no-load frequency to the top of the acceptable range (53 or 63 Hz). Tighten the lock nut down.

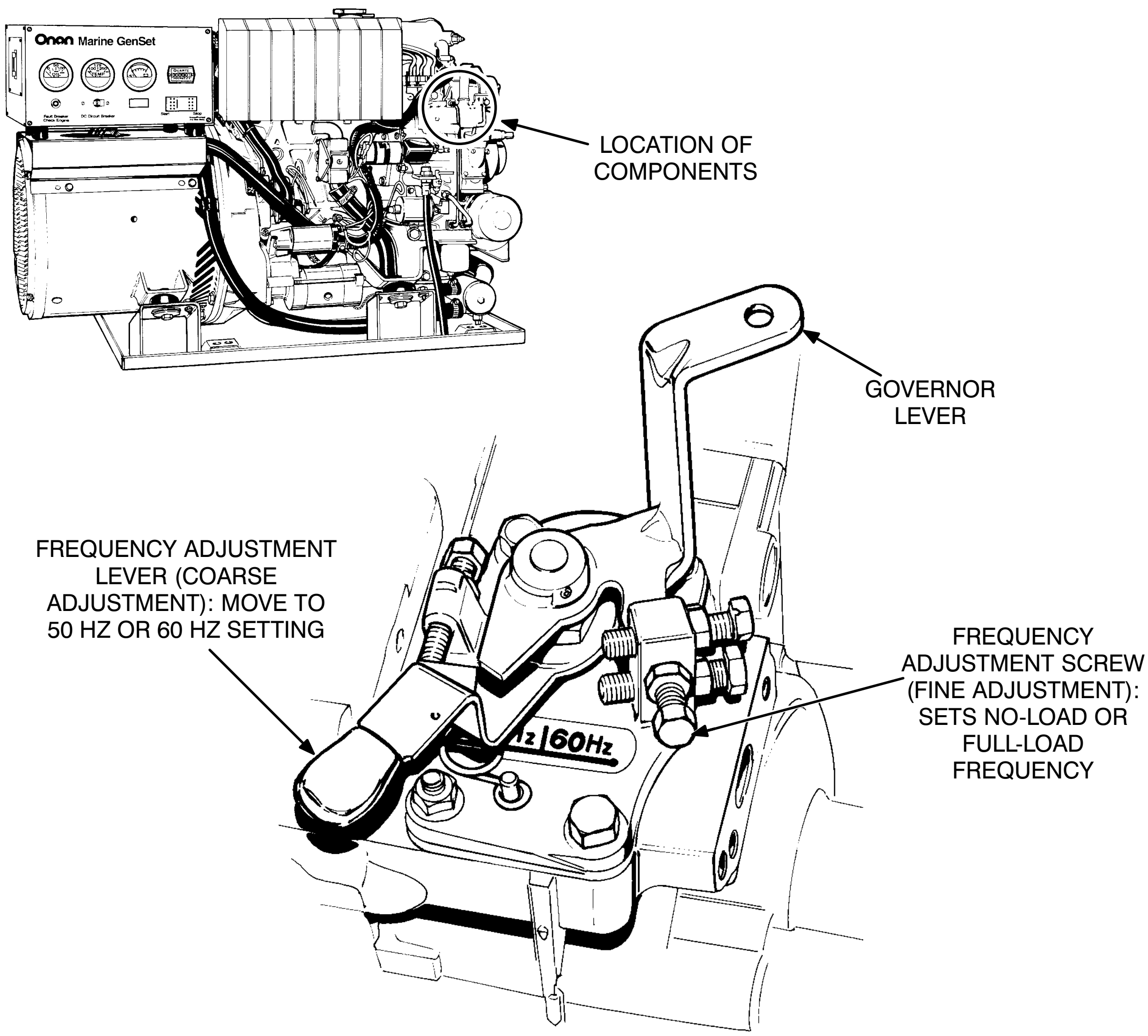


FIGURE 4-5. ENGINE FREQUENCY/SPEED CONTROL LEVERS

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

For your protection, stand on a dry wooden platform or rubber insulating mat, make sure your clothing and shoes are dry, remove jewelry and wear elbow length insulating gloves.

Readjusting Set Voltage Output

1. Adjust the voltage adjustment screw on the regulator board (Figure 4-4) to the rated output voltage at full load.
2. Recheck the output voltage.

GENERATOR SERVICE

WARNING ***Generator components are heavy and can cause severe personal injury if dropped during service. Be careful, use appropriate lifting techniques, keep hands and feet clear during service, and use the recommended service procedures.***

Generator Bearing

Inspect the bearing for evidence of outer case rotation every 1000 hours of use. (Mark the bearing and end bell positions, to show rotation at the next service interval.) The bearing should be replaced every five years, because the bearing grease gradually deteriorates due to oxidation.

Replace the O-ring if it shows evidence of wear or deterioration. Renew grease if necessary (use moly only).

Generator Disassembly

NOTE: The following steps are intended as guidelines rather than rules. Generator disassembly and assembly steps can vary depending on technician preference.

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

   WARNING ***Accidental starting of the set can cause severe personal injury or death. Disconnect the battery cables, negative (-) lead first, when repairs are made to the engine, controls or generator.***

2. Remove the generator set from the boat and place it on a sturdy work bench. Refer to Section 1 of this manual for removal guidelines.

3. Remove the cover from the control box. Disconnect the following:
   - All stator leads
   - Control box ground leads to the voltage regulator connector plug
   - Voltage regulator connector plug (to wiring harness)
   - Load circuit breaker leads: disconnect leads at breaker (if present)

   If lead markings do not clearly identify reconnection, mark the leads with tape.

4. Remove the end bell cover.

5. Remove the screws securing the control box mounting brackets. The control box and brackets are removed as an assembly.

6. Lift the control box and bracket free of the stator. The leads will be pulled out of the stator opening as the box is lifted off the stator. Do not disconnect any engine DC control wires in the control box. Set the control box and bracket on top of the engine.

7. Brace the stator in position, then remove the end bell bolts and slide off the end bell and exciter stator. It may be necessary to pry or jar the assembly loose from the main stator assembly.

8. Remove the bolts going through the generator vibration isolators (mounting feet). Lift the set using the genset lifting bracket. The generator end should rise, but the engine end should not. Brace the set with wood under the adapter, so that when it is lowered the weight will be on the wood and front mounts. Carefully lower the set.

9. Place a lifting strap around the stator and lift until it just begins to tighten. Loosen the bolts around the edge of the stator wrapper, then remove the stator assembly, being careful not to touch or drag it on the rotor. Place the stator on its side in the horizontal position.

10. Using a hoist and sling to support the rotor, carefully remove the bolts that attach the drive disc to the engine flywheel (Figure 4-6). Support the fan while removing these bolts, so that it does not fall and damage the rotor windings.

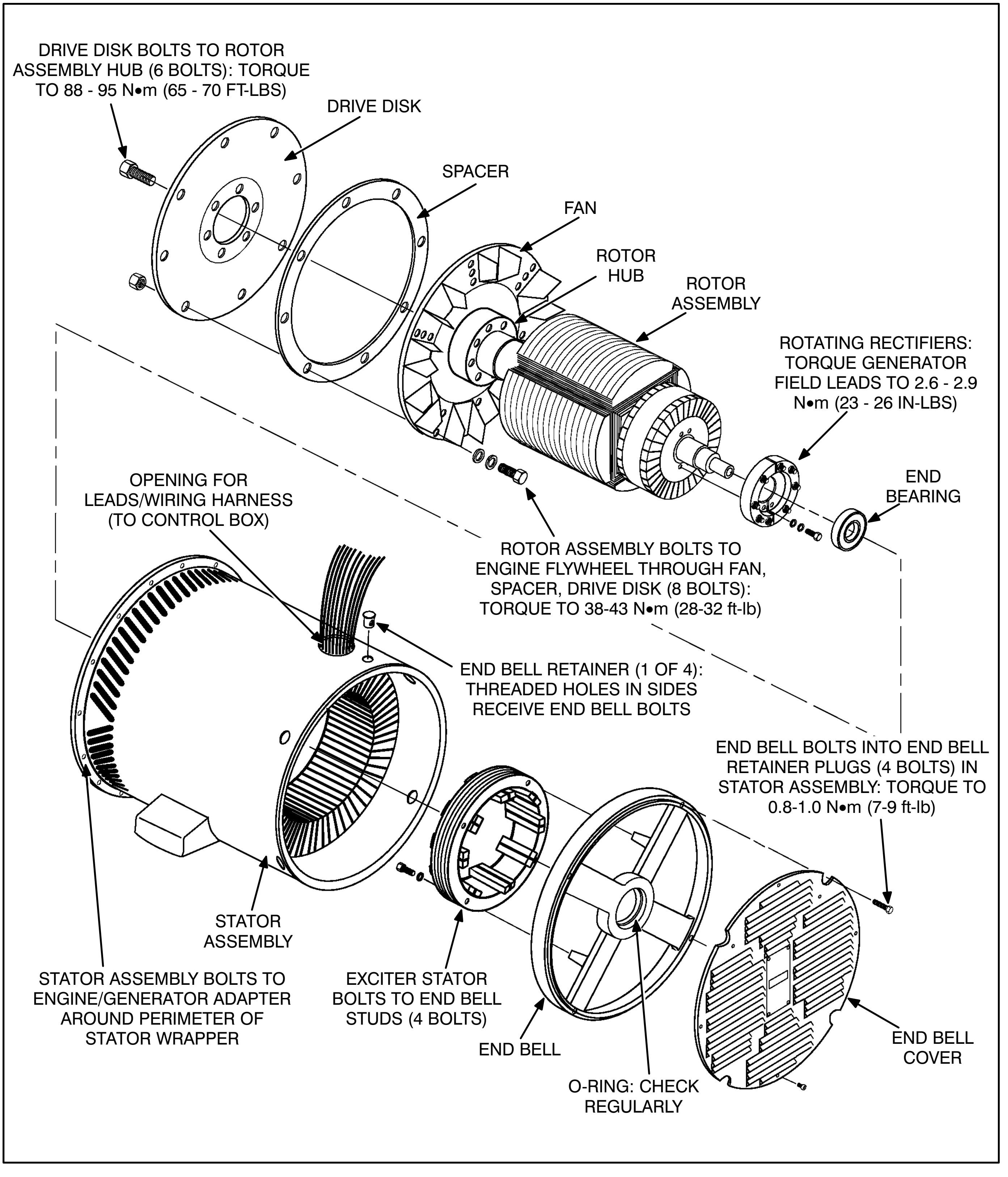


FIGURE 4-6. GENERATOR ASSEMBLY

11. Remove the rotor assembly and place it on a wood block in the horizontal position. **The drive disc and fan should not be resting on anything, or distortion may occur. Do not damage the windings.**

12. Remove the bolts that hold the drive disc to the rotor shaft.

13. Use a gear puller to remove the end bearing from the rotor shaft (Figure 4-7).

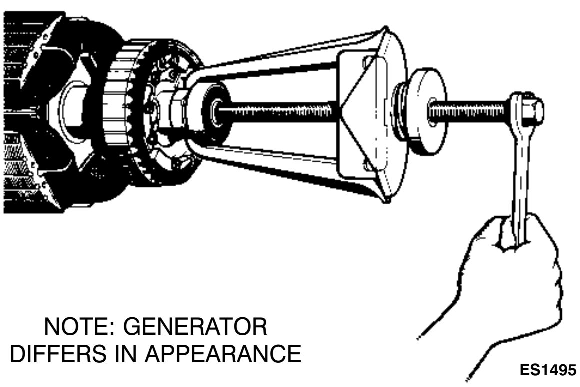


FIGURE 4-7. END BEARING REMOVAL

CAUTION ***The end bearing will be damaged if pulled on the outer race. If the bearing must be removed, replace it; this bearing should not be reused.***

14. Clamp the rotor in a fixed position.

15. Remove the generator field leads from the exciter rotor and use the end bearing puller to pull the exciter rotor off the rotor shaft.

Reassembly

1. Connect the generator field leads to F1+ and F2- terminals on the exciter assembly. Torque them to the values shown in Figure 4-8.

2. Press the new end bearing onto the rotor shaft.

3. Place the fan and spacer in position next to the rotor hub. Hold them in place using a tie wrap or string. Attach the rotor hub to the drive disk using the original hardware. Torque to 88 - 95 N•m (65 - 70 ft-lb).

3. Attach the rotor assembly to the engine flywheel. Use a hoist and sling to support the rotor. Pass the connection bolts through the fan and spacer to attach the rotor drive disk to the flywheel. Be sure the drive disk is assembled with the chamfer on the flywheel side. Torque to 38-43 N•m (28-32 ft-lb).

4. Using a hoist and safe lifting device, carefully move the stator assembly into position over the rotor. The leads should be in the top position. Bolt the stator to the engine adapter.

5. Install end bell assembly on the stator. Feed the leads from the end bell upwards through the stator opening.

6. Using a lead hammer, tap the end bell at the horizontal and vertical to relieve stress. Install the end bell retainer plugs in the end bell wrapper.

7. Install the end bell bolts and torque them to 0.8-1.0 N•m (7-9 ft-lb).

8. Feed the stator and exciter leads up through the opening in the wrapper through the opening in the control box and saddle. Secure the saddle to the generator.

9. Connect the stator wires to the load wires inside the control box.

10. Connect all applicable control leads (F1, F2, battery charging, etc.) and verify that all connections are secure.

11. Reconnect the AC voltage regulator plug inside the control box.

12. Install the end bell cover.

13. Connect the negative (-) battery cable and test generator operation.

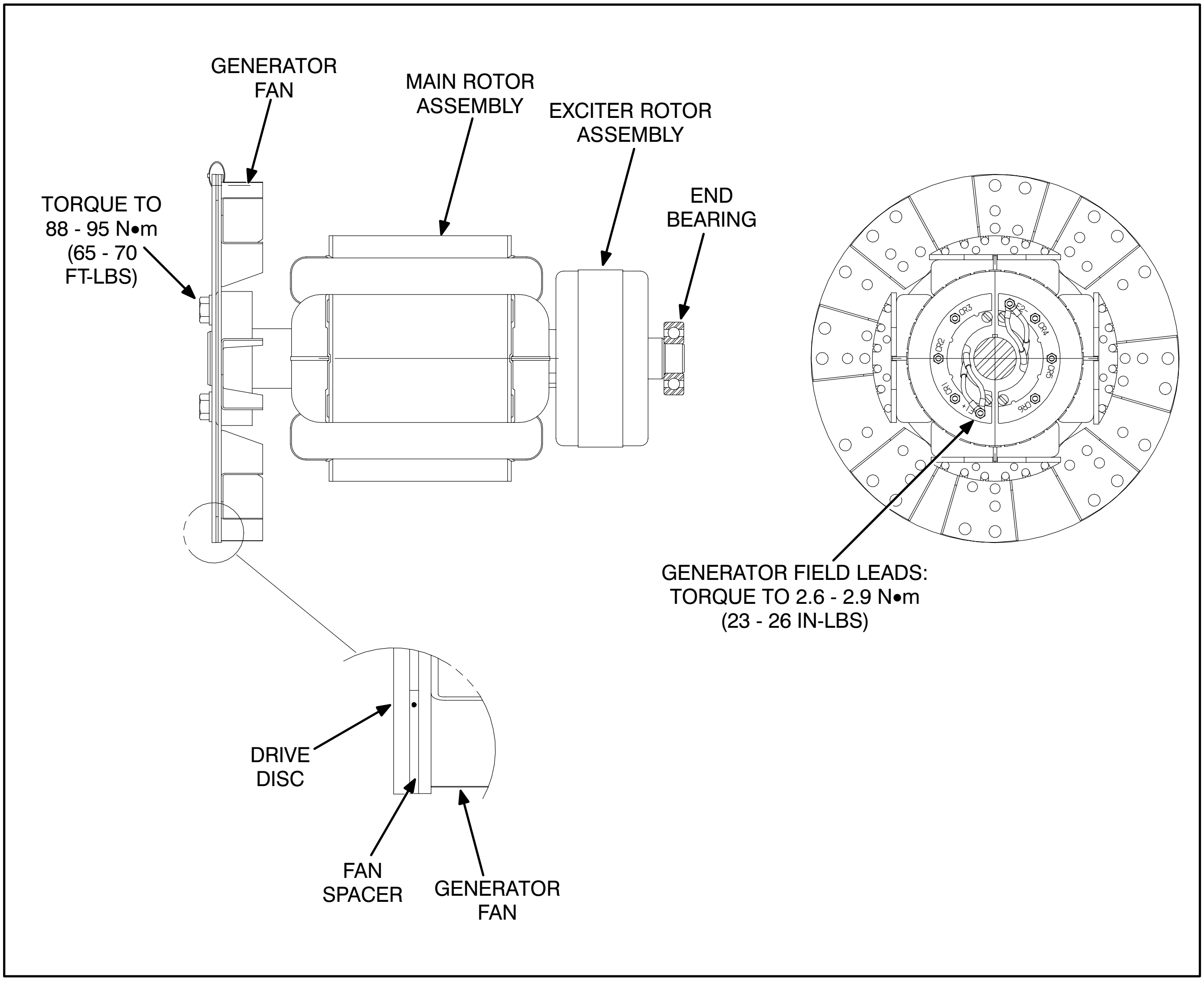


FIGURE 4-8. ROTOR ASSEMBLY AND TORQUE VALUES

5. Generator/Regulator Troubleshooting

GENERAL

This section contains troubleshooting information for the MDKAD/MDKAE/MDKAF generator and voltage regulator. Make the following visual checks before starting:

- Check for an open circuit breaker. If the breaker is open, check for an overloaded circuit and correct load problems before resetting the breaker.
- Check any modification or repair that was done since the last satisfactory operation of the set. Verify that it was done properly.
- Check to see that generator leads are connected correctly. Also check the circuit board connectors. A loose, contaminated, or misplaced wire connection can be detected by close inspection.
- If the "**Check Generator**" fault breaker trips, as indicated by the extended reset button, the genset may have been overloaded. *Push the reset button.*

TROUBLESHOOTING PROCEDURES

Determine the type of problem, then refer to the corresponding flow chart (A, B, C, or D) for troubleshooting procedures.

A. NO AC OUTPUT VOLTAGE AT RATED ENGINE RPM

B. UNSTABLE OUTPUT VOLTAGE, ENGINE SPEED STABLE

C. OUTPUT VOLTAGE TOO HIGH OR TOO LOW

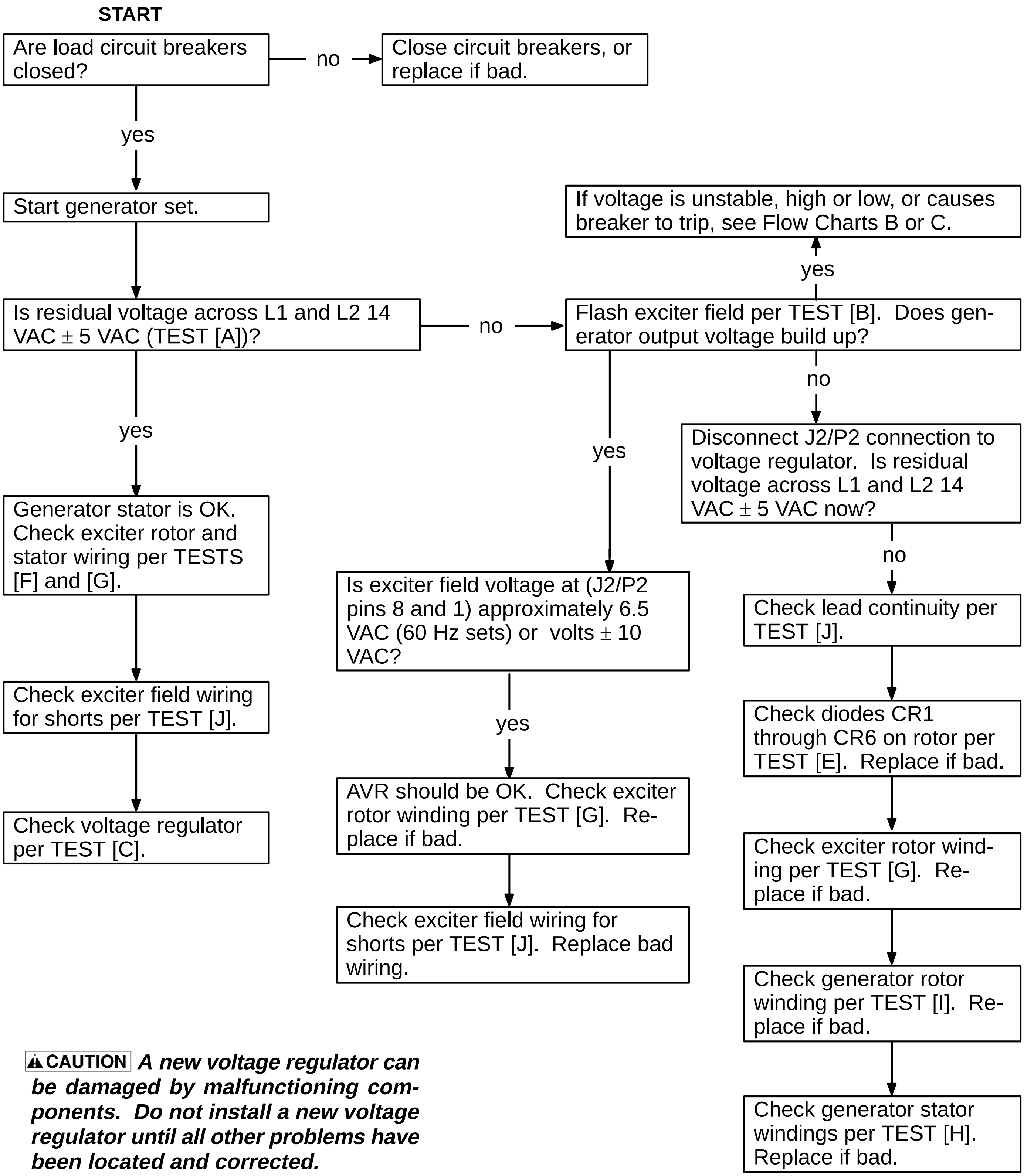
D. UNBALANCED OUTPUT VOLTAGE

To troubleshoot a problem, start at the upper left corner of the chart that corresponds to the problem, and answer all questions either YES or NO. Follow the chart until the problem is found. Perform the referenced test or adjustment procedures in the Generator/Regulator Tests section.

Components referenced in the flow charts, tests and adjustment procedures are found in the schematics and wiring diagrams in Section 7 of this manual.

FLOW CHART A. NO AC OUTPUT VOLTAGE AT RATED ENGINE RPM

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



CAUTION ***A new voltage regulator can be damaged by malfunctioning components. Do not install a new voltage regulator until all other problems have been located and corrected.***

FLOW CHART B. UNSTABLE VOLTAGE, ENGINE SPEED STABLE

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

START

Are there any broken wires or loose connections on voltage regulator assembly? — yes → Repair as required.

↓ no

Check wiring harness from regulator assembly to end bell per TEST [J]. Check OK? — no → Repair wiring or replace as required.

↓ yes

Replace the voltage regulator per procedure (D).

CAUTION ***A new AVR can be damaged by malfunctioning components within the control. Do not install a new AVR until all other problems have been located and corrected.***

FLOW CHART C. OUTPUT VOLTAGE TOO HIGH OR TOO LOW

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

START

Is engine running at correct RPM? — no → Set RPM per instructions in appropriate engine manual.

↓ yes

Does adjustment of Voltage Adjust control on the regulator board result in correct output voltage? — yes → Set control per Voltage Adjustment [K].

↓ no

Are voltage regulator connections secure? — yes → Are generator output leads properly connected? See TEST [L].

- ↓ yes → Replace the voltage regulator per procedure [D].

↓ no

Check/retighten/replace voltage regulator connections.

CAUTION ***A new AVR can be damaged by malfunctioning components within the control. Do not install a new AVR until all other problems have been located and corrected.***

FLOW CHART D. UNBALANCED GENERATOR OUTPUT VOLTAGE

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

START

Remove load at generator terminals. Is output still unbalanced?

- no → Check for correct grounding of generator and load.
- yes ↓

Are generator leads connected and grounded properly? See Test [L].

- no → Correct as necessary.
- yes ↓

Is generator stator winding continuous per TEST [H]?

- no → Replace stator assembly.
- yes ↓

Check load for ground faults and correct as necessary.

Section 6. Generator/Regulator Tests

GENERAL

The following tests and adjustments should be used for testing the generator components and the regulator in conjunction with the Troubleshooting Flow Charts in the Generator/Regulator Troubleshooting section.

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

[A]

TESTING AC RESIDUAL VOLTAGE

Test for residual AC voltage if there is no AC power output from the generator. Check between generator leads L1 and L2. Residual voltage should be14 VAC $\pm$ 5 volts (60 Hz sets) or 12 VAC $\pm$ 5 volts (50 Hz sets).

[B]

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 storage battery, 10-amp fuse, momentary-on switch, and diode assembled as shown in Figure 6-1. The procedure can be performed with the generator set turned off.

CAUTION ***Incorrect flashing procedure can damage the voltage regulator. Do not keep excitation circuitry connected longer than 5 seconds.***

1. Disconnect (unplug) the AVR before beginning this procedure.
2. Connect the positive lead to the F1 (+) exciter stator lead, and the negative lead to the F2 (-) exciter lead. F1 and F2 are accessible at the connector plug for the AVR.
3. Close the momentary-on switch for three seconds.
4. Reconnect the AVR, start the generator set and operate at no load. Output voltage must build up without field flashing. If not, shut down the generator set and perform continuity check of all related wiring.

Note that the generator set will shut down (trip the fault breaker) if AC voltage does not build up.

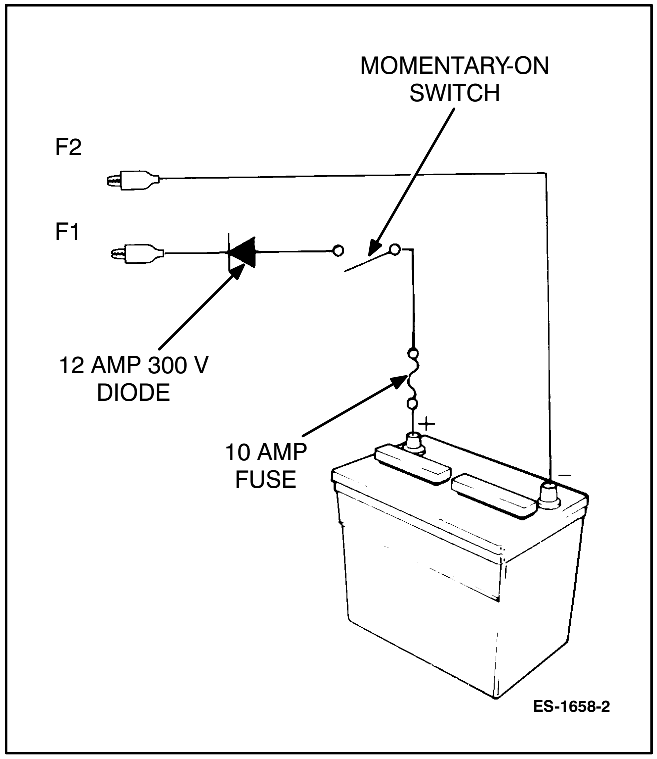


FIGURE 6-1. FIELD FLASHING CIRCUIT

[C] VOLTAGE REGULATOR TEST

The following procedure determines if the problem is in the voltage regulator or the generator. Voltage from a 6-volt lantern battery applied to the F!/F2 exciter stator should produce approximately 120 volts generator output voltage with no load.

WARNING ***Electrical shock can cause severe personal injury or death. Do not touch electrical wiring or components during testing. Disconnect electrical power by removing starting battery negative (-) cable before handling electrical wiring or components.***

NOTE: The Onan SR voltage regulator as configured for the MDKAD/MDKAE/MDKAF generator set has no external terminal block. For this reason, use a sharp voltage probe and touch it carefully to the voltage regulator pins when making these tests.

1. Stop the generator set.
2. Unplug the voltage regulator from the wiring harness.
3. Using jumpers and a spare plug or other connector, connect a 6-volt lantern battery to the F1-F2 terminals (pins 1 and 8) as illustrated in Figure 6-2.
4. Start the generator set. Use a voltmeter to measure the output at S2-Q1 (pins 4 and 3) and the output at Q1-Q2 (pins 3 and 5). S2-Q1 output should be 120 VAC ± 20 VAC. Q1-Q2 output should be 140 VAC ± 10 VAC. If these voltages are measured, then the generator is operating correctly and the problem is elsewhere.

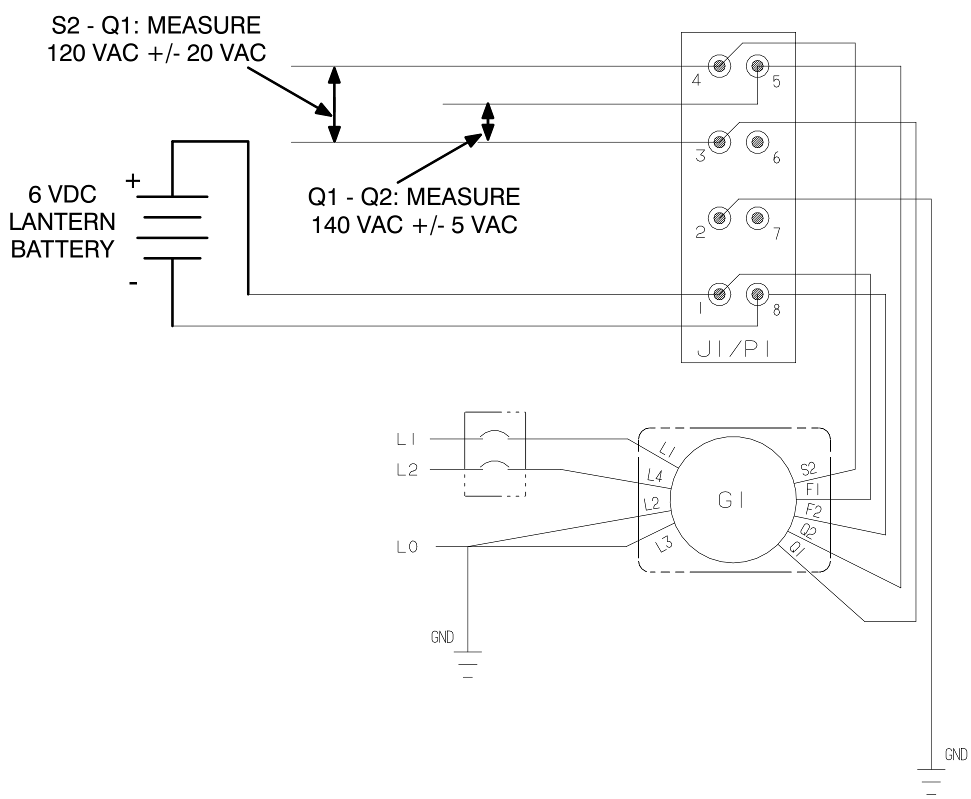


FIGURE 6-2. SR VOLTAGE REGULATOR CHECK

[D] VOLTAGE REGULATOR REPLACEMENT

Use the following procedure for replacing the AC voltage regulator assembly.

1. Stop the generator set and disconnect the starting battery leads, negative (-) lead first.
2. Unscrew the voltage regulator from the AC control box.
3. Unplug the regulator from the wiring harness.
4. Install the new regulator using the old mounting hardware.
5. Reconnect the plug connection to the wiring harness.
6. Set voltage as outlined in test [K] Voltage Adjustment.

[E]

TESTING ROTATING RECTIFIERS

Two different rectifier assemblies make up the rotating rectifier bridge assembly (Figure 6-3). Using an ohmmeter, test each CR rectifier using negative (-) and positive (+) polarities. Use the following procedure.

1. Disconnect all leads from assembly to be tested.
2. Connect one ohmmeter test lead to F1+ stud and connect the other lead to CR1, CR2 and CR3 in turn; record resistance value of each rectifier.
3. Connect one lead to F2- stud and connect other lead to CR4, CR5, and CR6 in turn; record resistance value of each rectifier.
4. Reverse ohmmeter leads from steps 2 and 3 and record resistance value of each rectifier F1+ to CR1, CR2 and CR3 and F2- to CR4, CR5 and CR6.
5. All the resistance readings should be high in one test and low in the other test. If any reading is high or low in both tests, rectifier assembly is defective.
6. Replace defective rectifier assembly.

Use 23 to 26 inch lbs (2.6 to 2.9 N•m) torque when replacing nuts of F1+ and F2-, CR1, CR2, CR3, CR4, CR5 and CR6.

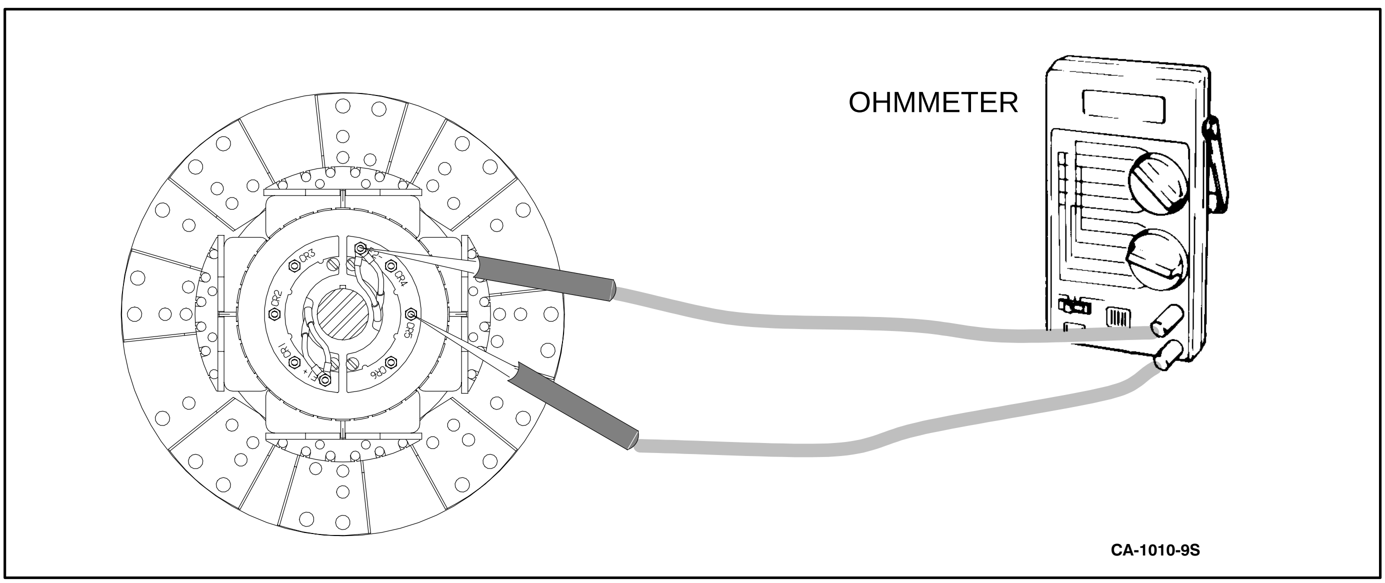


FIGURE 6-3. TESTING ROTATING RECTIFIERS

[F]
TESTING EXCITER STATOR

Testing the exciter stator (Figure 6-4) for open or shorted windings and grounds as follows:

Testing for Open or Shorted Windings

Use a Wheatstone bridge or digital ohmmeter for this test. Disconnect F1+ and F2- exciter field leads from P1 plug. The resistance between field leads should be 14.5 ohms ± 10% at 77°F (25°C).

Testing for Grounds

Connect a megger or insulation resistance meter that applies 500 VDC or more between either field lead and the exciter stator lamination. Be sure both exciter leads are disconnected from the terminal block. Reading should be 100,000 ohms or greater. If not, the exciter stator is questionable and may require removal for oven drying and retest. A shorted stator must be replaced.

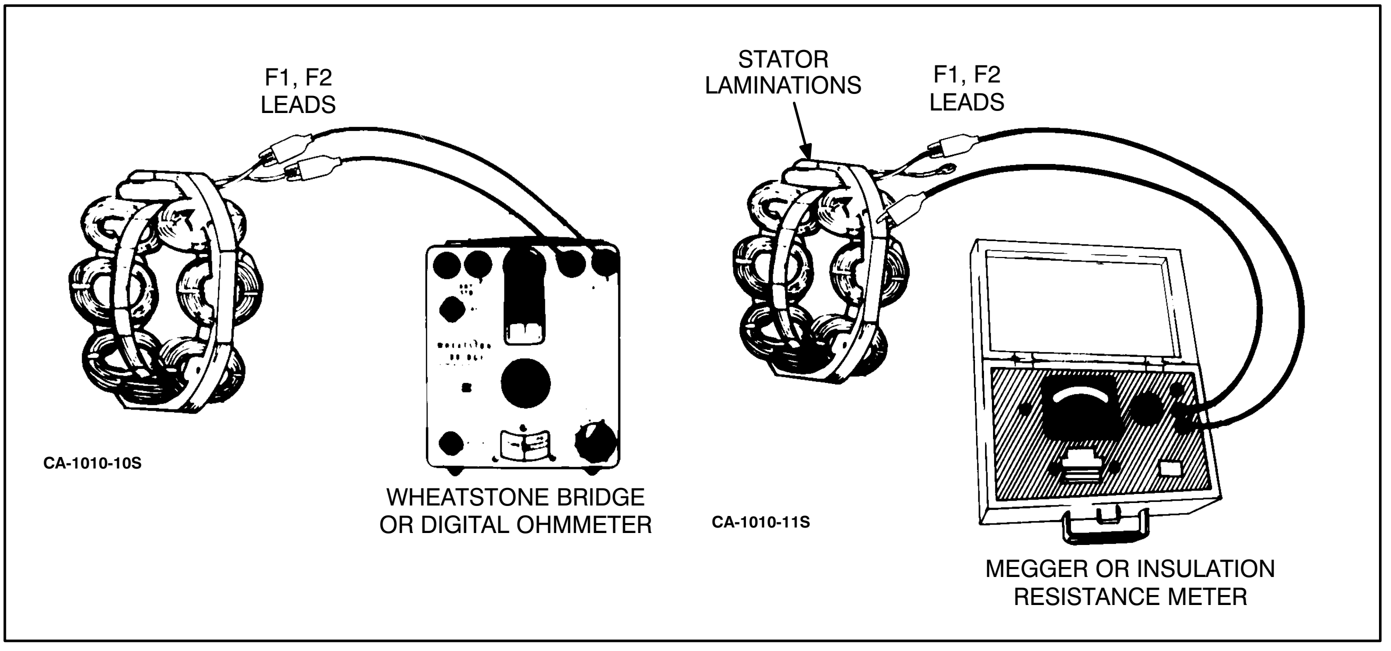


FIGURE 6-4. TESTING EXCITER STATOR

[G]

TESTING EXCITER ROTOR

Test the exciter rotor (Figure 6-5) for open or shorted windings or grounds as follows:

Testing for Open or Shorted Windings

Use a Wheatstone bridge or digital ohmmeter for this test. Disconnect main rotor field leads that connect to rotating rectifier assemblies at F1+ and F2-. Disconnect lead wires from diodes CR1, CR2, CR3, CR4, CR5, and CR6. Test between exciter lead pairs T1-T2, T2-T3 and T1-T3. Resistance at 77°F (25°C) should be 645 milliohms ± 10%.

Testing for Grounds

Test with an insulation resistance meter or Megger that applies not more than 500 volts to the test leads. With all generator leads disconnected from rotating rectifiers CR1 through CR6, apply test leads between any CR lead and the rotor laminations. Reading should be 100,000 ohms or higher. If not, the exciter rotor is questionable and may require removal for oven drying and retest. A shorted rotor must be replaced.

Use 23 to 26 inch pounds (2.6 to 2.9 N•m) torque when replacing nuts of F1+ and F2- leads, CR1, CR2, CR3, CR4, CR5, and CR6.

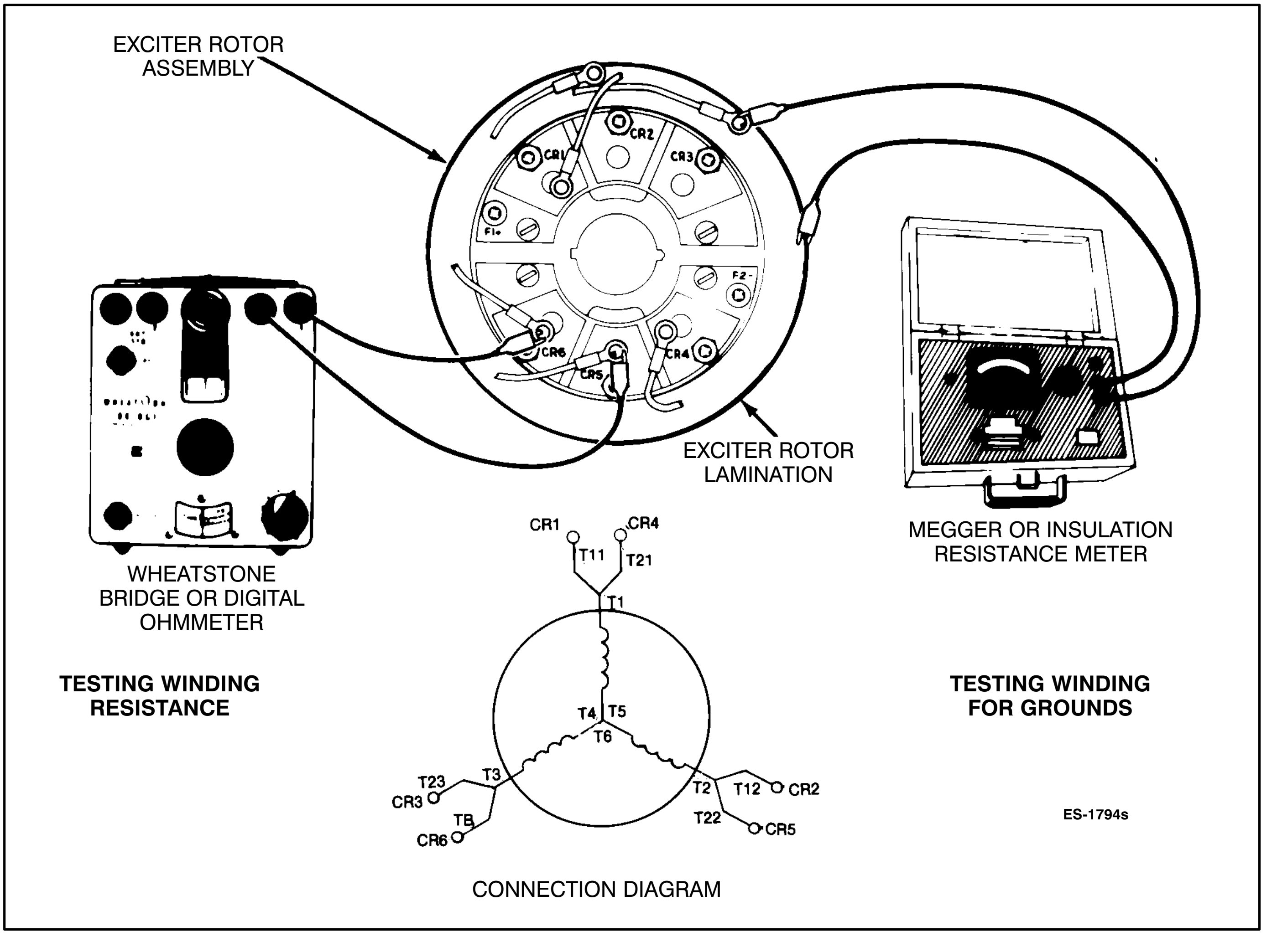


FIGURE 6-5. TESTING EXCITER ROTOR

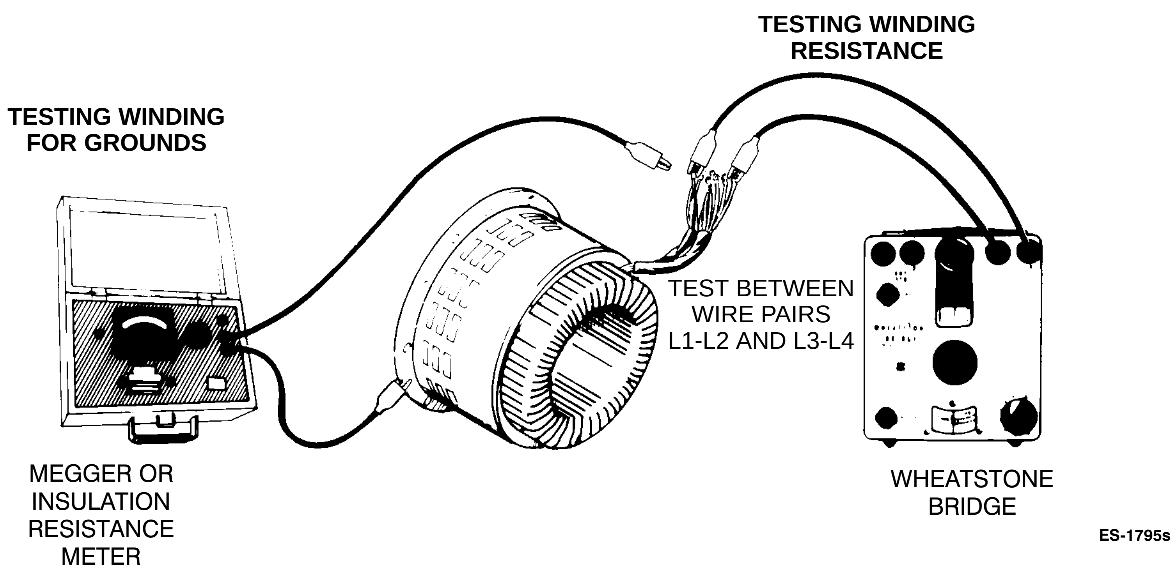


FIGURE 6-6. TESTING STATOR WINDINGS

[H]

TESTING GENERATOR STATOR

Using proper test equipment, check the stator for grounds, opens, and shorts in the windings.

Testing for Grounds

Some generators have ground connections to the frame. Check wiring diagram. All stator leads must be isolated for testing.

Use a megger or insulation resistance meter which applies not more than 500 VDC to the test leads (Figure 6-6). Test each stator winding for short to laminations. A reading less than 100,000 ohms indicates a questionable stator. Oven dry the stator and retest.

Testing for Open or Shorted Windings

Test for continuity between coil leads shown in Figure 6-6; all pairs should have equal resistance. Use an accurate instrument for this test such as a Wheatstone Bridge. For the 12/15 kW genset, the resistance at 77°F (25°C) is 0.079 ohms ± 10%. For the 16/20 kW genset, the resistance at 77°F (25°C) is 0.056 ohms ± 10%.

If a winding is shorted, open or grounded, replace the stator assembly. Before replacing the assembly, check the leads for broken wires or insulation.

[I]

TESTING GENERATOR ROTOR

For these tests, use a megger or insulation resistance meter which applies 500 VDC or more to the test leads.

Testing for Grounds

Check for grounds between each rotor lead and the rotor shaft, Figure 6-7. Use a Megger or insulation resistance meter which applies 500 VDC or more at the test leads. Perform test as follows:

1. Remove rotor leads F1+ and F2- from the rotating rectifier assemblies.
2. Connect test leads between F1+ and rotor shaft, then between F2- and rotor shaft. Meter should register 100,000 ohms or greater.

3. If less than 100,000 ohms, rotor is questionable. Oven dry the rotor and retest.

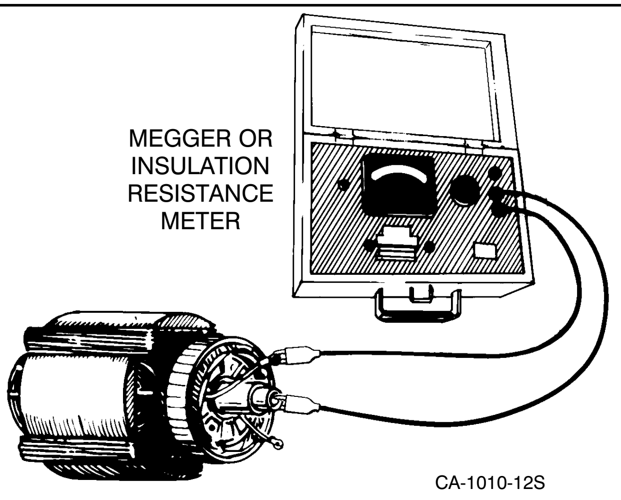
4. Replace a grounded rotor with a new identical part.

Testing for Open or Shorted Windings

Perform this test with an accurate meter such as a digital ohmmeter.

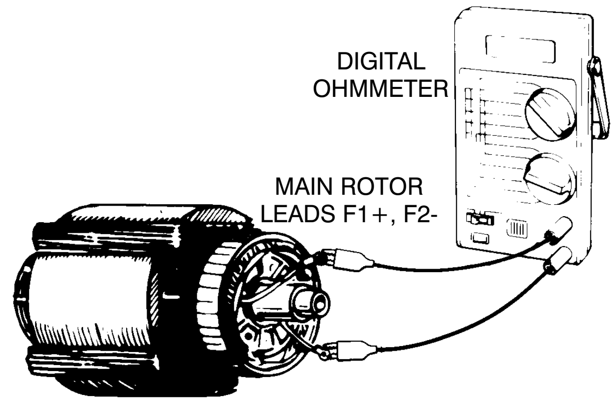
1. Remove rotor leads F1+ and F2- from rotating rectifier assemblies.

2. Using ohmmeter, check resistance between F1 and F2 leads, Figure 6-8. For the 12/15 kW genset, the resistance at 77°F (25°C) is 2.35 ohms ± 10%. For the 16/20 kW genset, the resistance at 77°F (25°C) is 2.55 ohms ± 10%. If not, replace defective rotor with a new, identical part.



TESTING WINDING FOR GROUNDS

FIGURE 6-7. TESTING ROTOR FOR GROUNDS



TESTING WINDING RESISTANCE

FIGURE 6-8. TESTING ROTOR FOR AN OPEN CIRCUIT

[J]

WIRING HARNESS CHECK

Carefully check the wiring harness as follows:

1. Inspect all wires for breaks, loose connections, and reversed connections. Refer to applicable wiring diagram.

2. Remove wires from terminals at each end and with an ohmmeter, check each wire end to end for continuity or opens.

3. Using an ohmmeter, check each wire to other wires and to ground for possible shorts or insulation breaks under areas covered by wrapping material.

4. Reconnect or replace wires/harness according to applicable wiring diagram.

[K]

VOLTAGE ADJUSTMENT

This section describes adjustment of the output voltage regulator. When checking output voltage, be sure the generator set has stabilized and is running at the correct speed (frequency). The regulator is adjusted with the set running.

⚠WARNING ***Accidental starting of the set can cause severe personal injury or death. Disconnect both battery cables, negative (-) cable first, when repairs are made to the engine, controls, or generator.***

⚠WARNING ***Contact with high voltage can cause severe personal injury or death. Do not touch any exposed wiring or components with any part of the body, clothing, tool or jewelry. Do not use non-insulated tools inside the control. Stand on an insulating mat or dry wood platform when the control doors are open.***

The output voltage adjustment potentiometer is found inside the set DC control box. See Figure 6-9.

1. Attach a voltmeter securely to the L1 and L2 leads.
2. Start the generator set and place a typical load on its output.
3. Use a small flat-blade screwdriver to set the voltage adjust potentiometer for correct voltage. For most applications, the ideal setting is 117 VAC at 60-61 hz, measured at L1-L0 terminals.

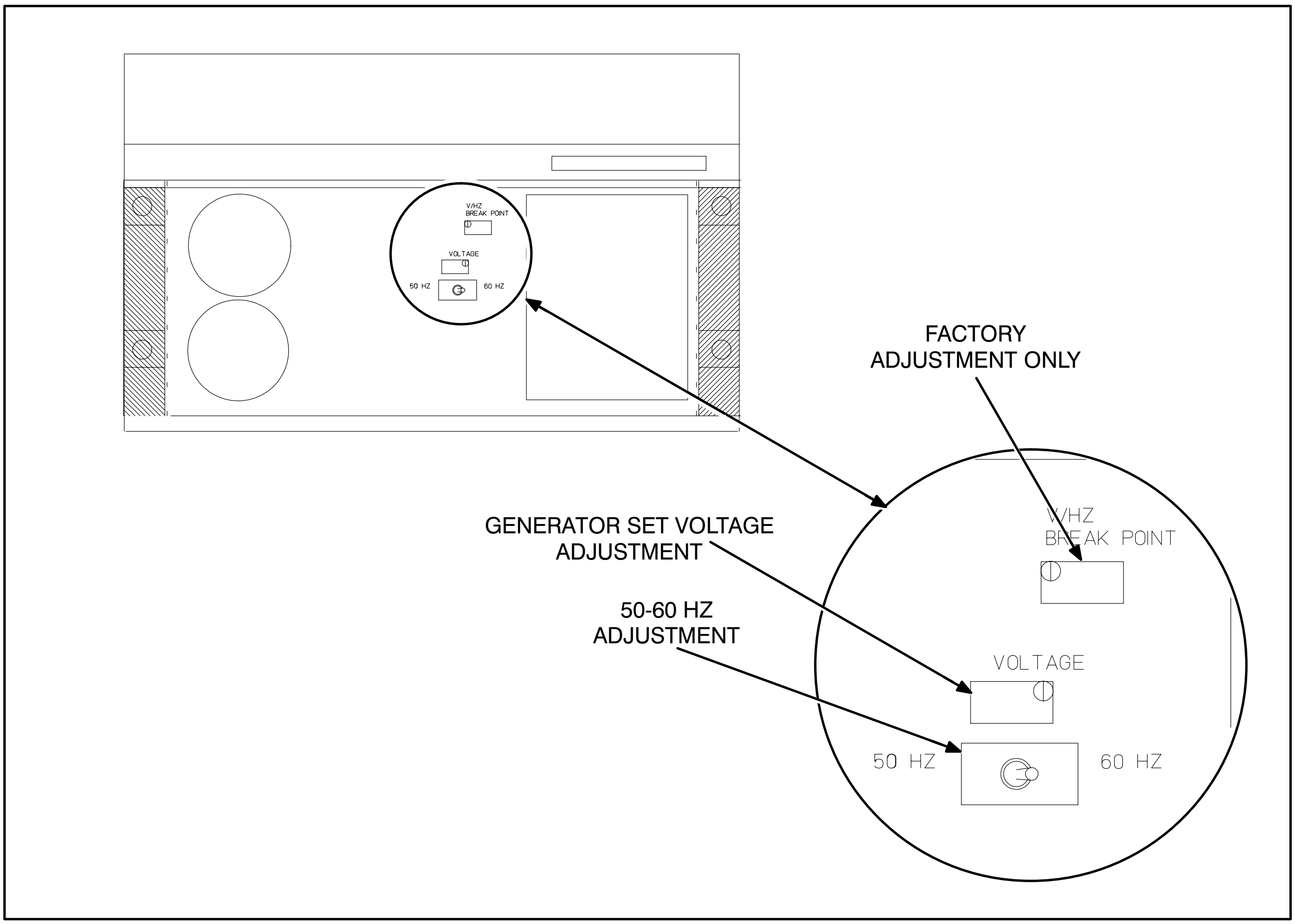


FIGURE 6-9. FRONT VIEW OF SR VOLTAGE REGULATOR (AT REAR OF CONTROL BOX)

[L]

RECONNECTION

Generator reconnection is dependent upon the generator set specification. Diagram 612-6666 (single phase) and Diagram 612-6673 (three-phase), reproduced in Section 9 of this manual, shows reconnection possibilities.

Section 7. Exhaust System

GENERAL

The MDKAD/MDKAE/MDKAF generator sets are designed for installation with a hydrodynamic muffler. The exhaust manifold is water-jacketed, and the full flow of raw water (from the outside of the vessel) for engine cooling is discharged into the exhaust gas stream through ports at the exhaust outlet of the engine. Exhaust pressure is used to expel the water out the through-the-hull exhaust fitting. Figures 7-1 and 7-2 illustrate typical exhaust/cooling installations. Refer to the Installation Manual (#981-0608) for important installation requirements.

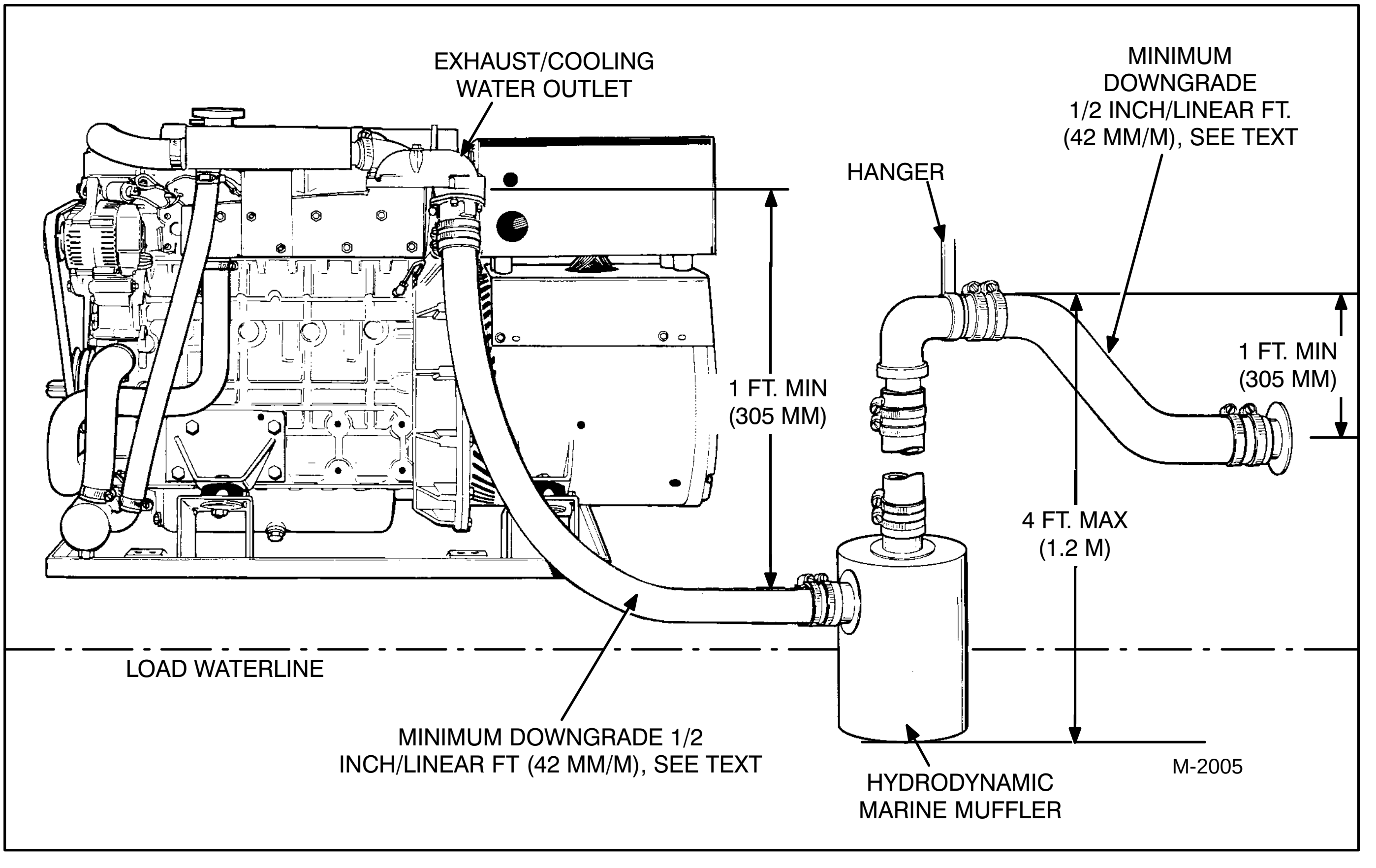


FIGURE 7-1. ABOVE LOAD-WATERLINE INSTALLATION

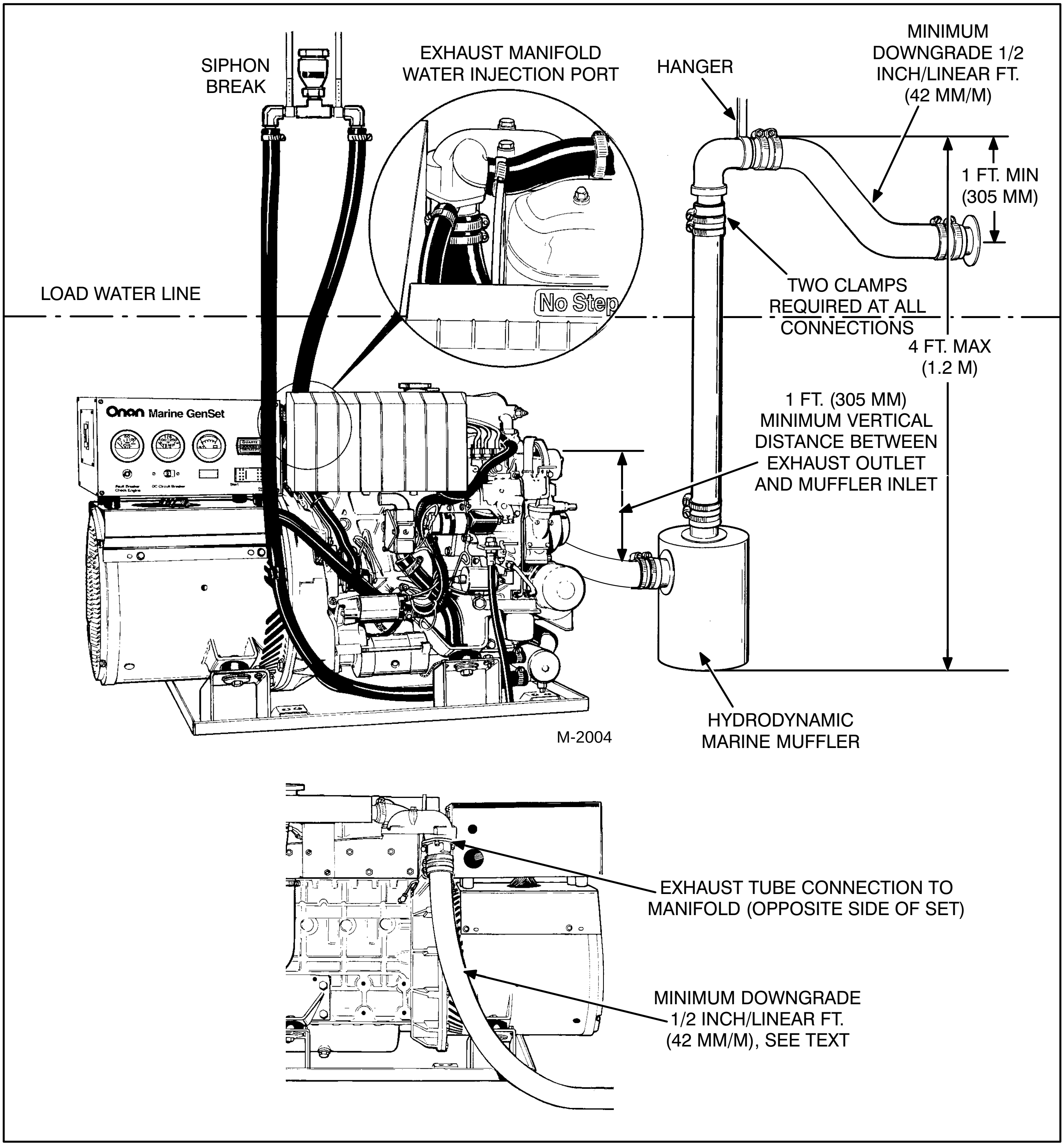


FIGURE 7-2. BELOW LOAD-WATERLINE INSTALLATION

⚠WARNING ***Improper installation, careless connection of hoses or failure to check for water and exhaust leaks can lead to flooding of the engine and boat or to severe sickness or death from exhaust gas (carbon monoxide).***

DESCRIPTION AND FAILURE MODES

The full flow of engine cooling water is necessary to keep the exhaust gases cool enough for the exhaust system to handle. The high exhaust temperature switch closes at 222° F (105.5° C), shutting down the engine to protect the exhaust system from high exhaust temperatures if the flow of cooling water fails. Failure could be the result of the following circumstances:

- Closed sea water cock
- Clogged water filter
- Defective or failed water pump
- Broken hoses or clogged heat exchanger passages
- Broken or clogged siphon valve

SERVICE

Service involves checking the exhaust and cooling systems for water and exhaust leaks, tightening clamps and replacing defective fittings or hose sections. Replace rusty components before they leak. The siphon break (if part of the system) should be checked for free movement of the valve by removing the screw-on cap, and replacing it if the valve is sticky.

If the high exhaust temperature switch has shut down the engine at any time, examine the exhaust hose and fittings and replace any sections that have been damaged by heat.

See the Installation Manual (#981-0608) for more information and diagrams of the exhaust system.

Section 8. Cooling System

DESCRIPTION

This marine generator set uses flotation water for heat exchanger and exhaust cooling. The term "raw water" is used in this manual to describe flotation water that is drawn into the boat for cooling purposes.

Figure 8-1 illustrates the heat exchanger cooling system.

A pump circulates coolant between the engine and the coolant/raw water heat exchanger. A thermostat regulates the engine operating temperature by controlling the flow of coolant. As the engine warms and cools, the coolant expands and contracts, pressurizing and depressurizing the system. The pressure cap limits coolant pressure by releasing coolant to the recovery tank. As the coolant volume contracts, the pressure cap allows the coolant in the recovery tank to siphon back into the engine. The coolant system is thereby kept full of coolant and free of air.

Raw water is pushed through the heat exchanger and water injection ports at the engine exhaust outlet by a direct-drive pump with a neoprene impeller. To prevent flooding of the engine and the hull with sea water, a siphon break must be provided upstream of the water injection ports if they are below the load water line.

When filling an empty cooling system, all coolant placed in the coolant tank flows down to the heat exchanger. Then the level of coolant rises in the engine and in the water-cooled manifold until the system is filled to the bottom of the pressure cap fill neck. Air bleeds out of the engine and water-cooled manifold internally, through the vented thermostat and the bleed hole in the coolant tank through tube. No external venting of the coolant system is required during fill.

NOTE: Always check the coolant level after initial fill by running until the engine thermostat opens. Then shut down, allow the engine to cool and top off the cooling system.

The boat installation must include a sea cock to allow service of the cooling system and a water filter to prevent abrasion of the pump and clogging of passages with dirt.

CAUTION ***The neoprene sea water pump impeller suffers permanent damage in only a few seconds if the pump is run dry. Do not run the set in dry dock or shop without connecting the pump to an ample reservoir of water at a level that will keep the pump flooded.***

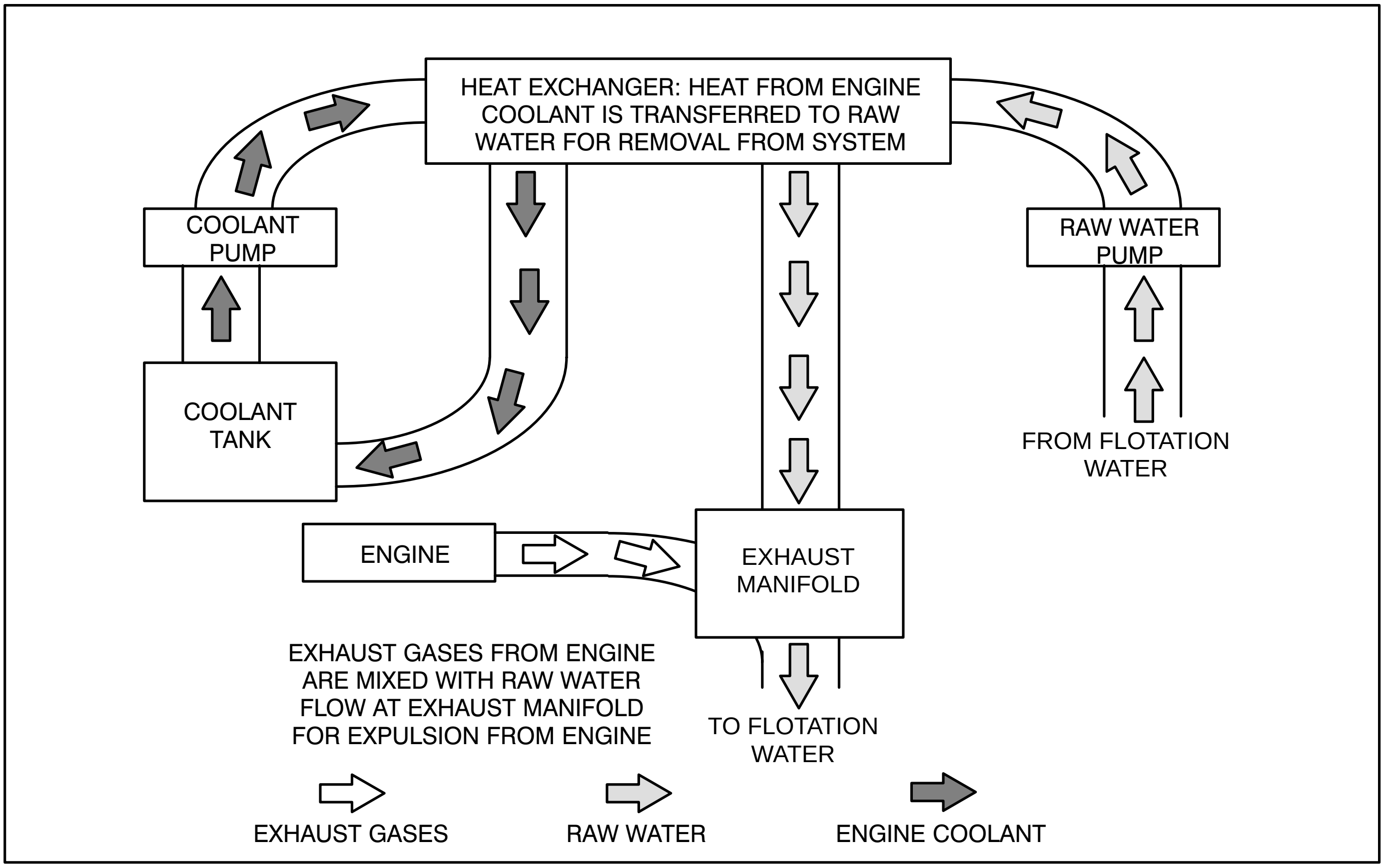


FIGURE 8-1. COOLANT FLOW, HEAT EXCHANGER COOLING SYSTEM

COOLANT

Fill the engine coolant system with a 50/50 solution of ethylene glycol or propylene glycol antifreeze and clean water. The antifreeze should include a rust inhibitor but not a stop-leak. A greater portion of antifreeze only degrades the heat transfer properties of the coolant and raises the freezing point.

Fill the recovery tank half way between the hot and cold marks. The coolant level in the tank will rise and fall as the engine runs.

Change coolant every year. To drain the coolant, let the engine cool, remove the pressure cap, disconnect the hoses to the coolant pump outlet and heat exchanger and remove the coolant plug in the heat exchanger.

WARNING ***Antifreeze is toxic and can pollute the environment. Do not allow antifreeze to escape or drain to the ground or water. Dispose according to local regulations for hazardous substances.***

Remove the thermostat and back flush the system with clean water. If there is scale and rust, use a cleaning compound according to its manufacturer's instructions. Refill with new coolant. Repair any coolant leaks before placing the set in service.

WARNING ***Hot coolant is under pressure and can cause burns if allowed to escape. Let the engine cool before removing the pressure cap.***

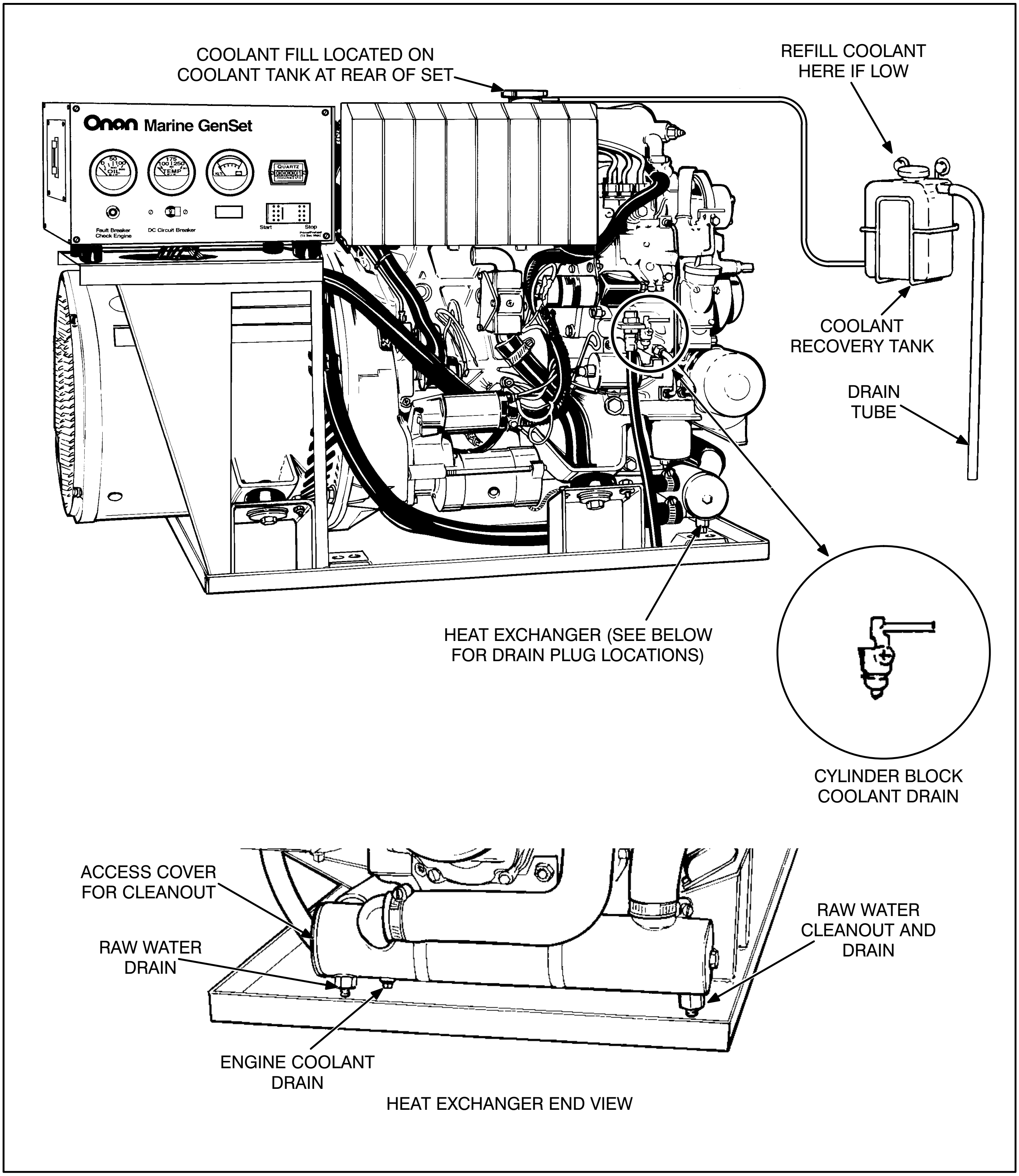


FIGURE 8-2. GENSET COOLING SYSTEM (MDKAD SHOWN)

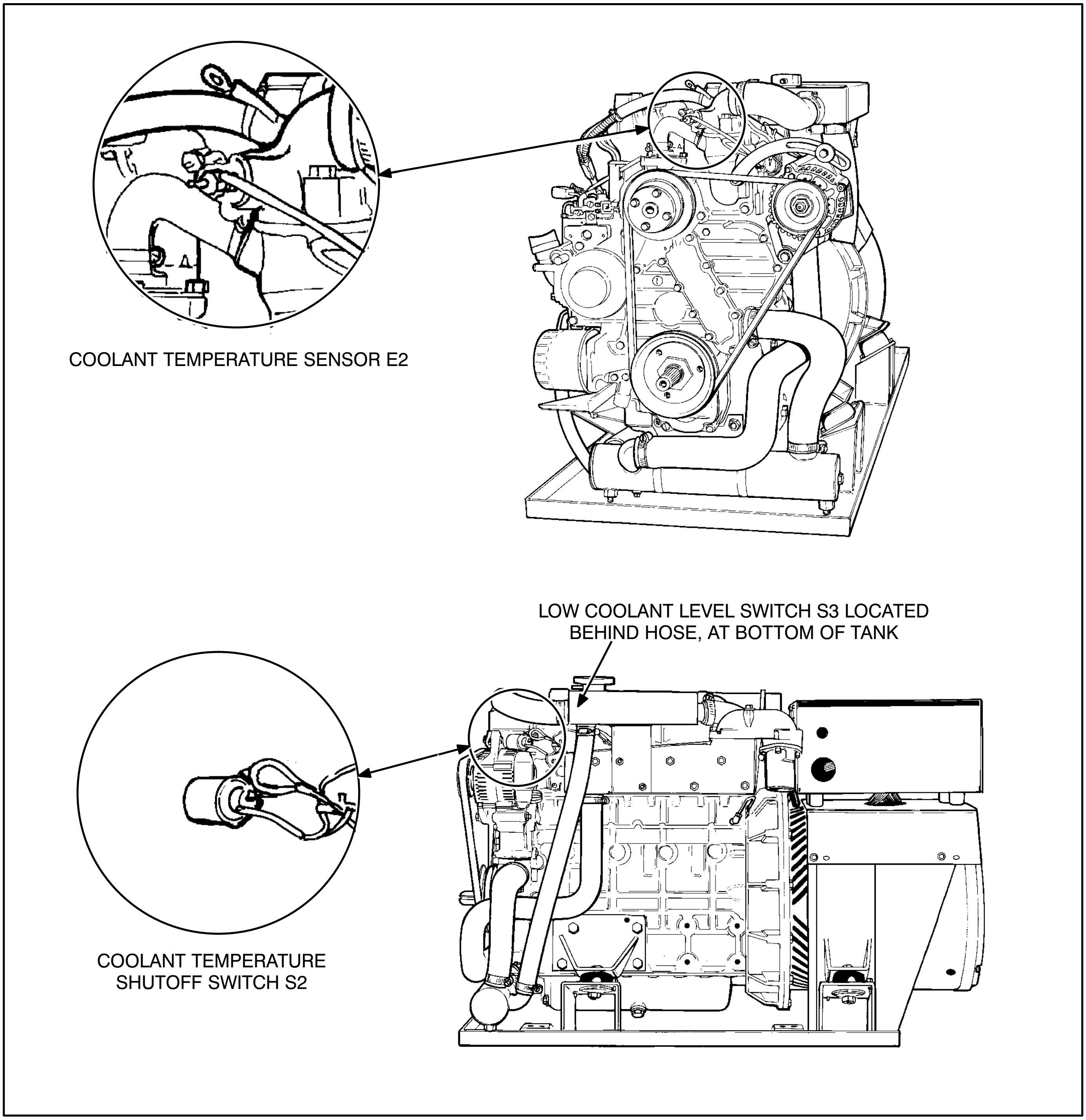


FIGURE 8-3. COOLANT TEMPERATURE SENSOR AND SWITCH, LOW COOLANT LEVEL SWITCH (MDKAD SHOWN)

COMPONENTS

Pressure Cap

Closed cooling systems make use of a pressurized cap to increase the boiling point of the coolant and allow higher operating temperatures. The cap is rated at 13 psi (88 kPa). Replace the pressure cap every two years for optimum performance.

Thermostat

The thermostat maintains the coolant at the correct temperature. At temperatures lower than 160° F (71° C), coolant circulates in the engine without flowing through the heat exchanger. At temperatures higher than 160° F (71° C), coolant is sent to the heat exchanger. Further information on the engine thermostat may be found in the Engine Manual, Onan part # 981-0521.

High Engine Temperature Sensor

The high engine temperature sensor senses coolant temperature and shuts down the engine when coolant temperature reaches the calibrated setting of the sensor, 222° F (106° C).

Coolant Temperature Gauge Sender

The optional coolant temperature sender senses coolant temperature and is connected to indicate the coolant temperature on the remote control panel gauge.

Coolant Pump

The coolant pump circulates the coolant between the engine and the coolant/sea water heat exchanger. Coolant pump information is found in the Engine Manual, Onan part # 981-0521.

Raw Water Pump

The raw water pump circulates sea (raw) water through the heat exchanger for genset cooling. Because short impeller life is usually caused by abrasion from dirt in the raw water, there should always be a water filter ahead of the pump. The raw water pump is powered by the power takeoff at the fuel injector pump. Raw water pump maintenance is described later in this manual section.

Heat Exchanger

The heat exchanger cools the engine coolant with raw water while keeping coolant and raw water apart. Coolant flows inside the shell, around the tubes. Sea water flows through one pass of tubes and returns by the other.

Remove the end cap and drain plug to clean the heat exchanger. Also remove the end cap to check for impeller debris if the raw water pump has failed when being accidentally run dry.

Coolant Tank

The coolant tank provides expansion space for engine coolant as it warms up during operation. It provides a reserve of coolant in case of minor loss. Air is vented from the cooling system through the tank, to keep the cooling system working efficiently.

Coolant Recovery Tank

The coolant recovery tank is an external reservoir that allows easy coolant level checks. It provides additional expansion space and coolant reserve.

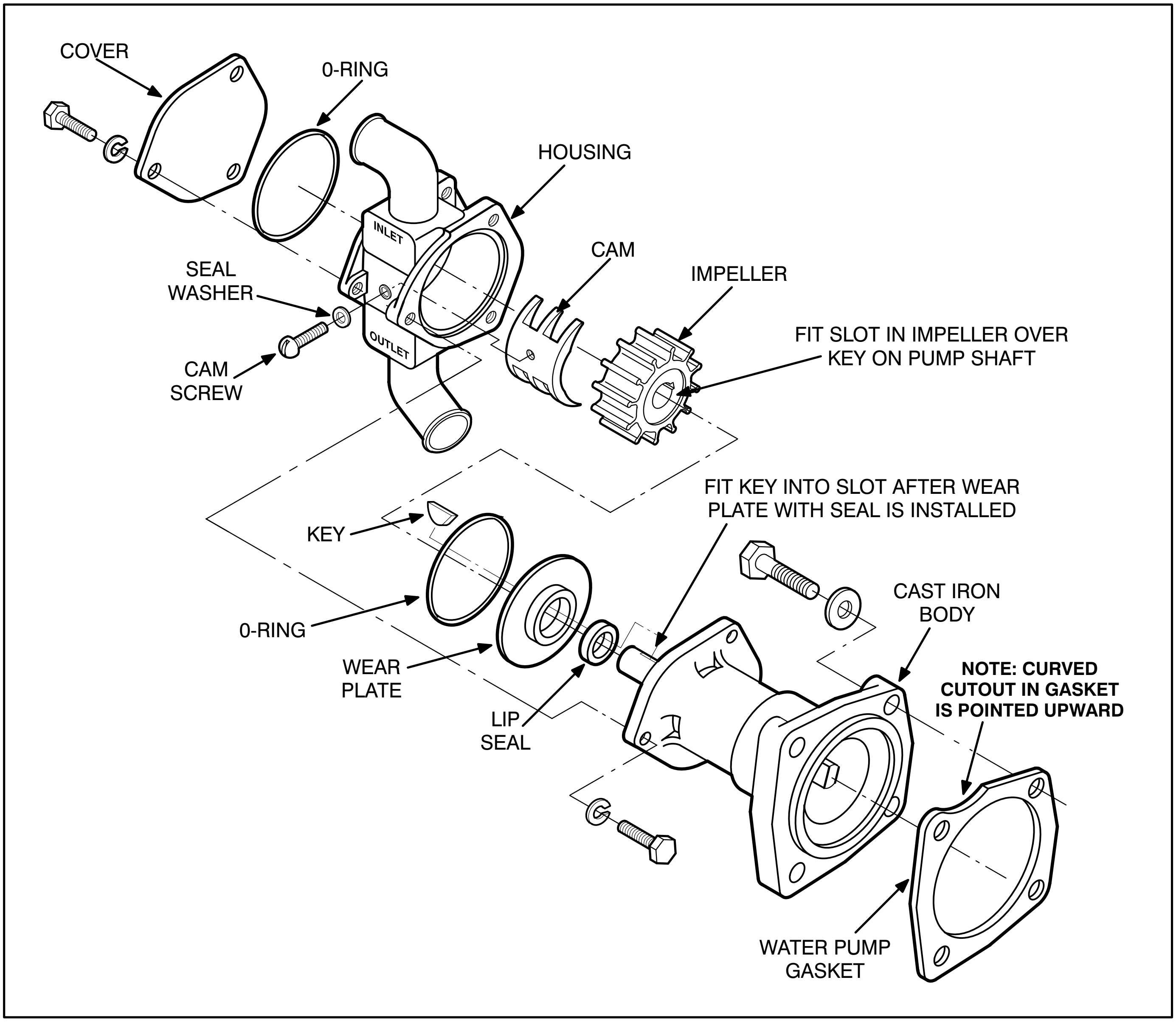


FIGURE 8-4. RAW WATER PUMP

RAW WATER PUMP MAINTENANCE

General

For maximum pump life, do the following:

- At genset startup, check to see that water is coming out of the pump. If there is no water in the first sixty seconds, shut down the engine.
- If the genset will be out of service for more than three months, remove the impeller from the pump and store it separately. This ensures that the rubber will not be deformed by the vanes being compressed for a long time.

Troubleshooting

If the pump will not prime and/or the engine runs hot:

1. Check that all correct sea cocks are open.
2. Check for blockages in system and hoses.
3. Check for any loose hoses or hose clamps.

4. Check water seal leakage at drain hole on brass housing of pump.
5. Remove pump cover plate and inspect for damaged/torn impeller.
6. Check to insure woodruff key is in place (after rebuild).

Minor Service Kit #132-0344: Removing the Rubber Impeller

The minor service kit includes the rubber impeller and one O-ring gasket. To change the impeller:

1. Cover all electrical components on the engine that lie beneath the pump, to protect against water that will drain when the cover plate is removed.
2. Remove the three capscrews that hold the cover, the O-ring seal and the rubber impeller. Use two pairs of pliers to grip two opposite vanes to remove the impeller. Note the direction in which the vanes are bent within the housing. Install the replacement impeller with the same directional bend.
3. Bend the impeller vanes to the proper position by slightly twisting the impeller when squeezing it into the pump housing. Align the impeller keyway to the key and push the impeller in until flush against the end of the housing, before reassembling the O-ring, cover and capscrews.

   Be sure that the woodruff key fits within the key slot of the impeller. Use water, silicone lubricant or soapy water to lubricate the impeller for installation.

   CAUTION ***Petroleum-based greases will chemically attack the neoprene impeller, causing it to deteriorate and/or fail. Do not use petroleum-based greases to lubricate the impeller for installation.***

Major Service Kit 132-0345

The major service kit includes the impeller, two O-rings, wear plate, cover, water lip seal, cam, seal washer, cam screw and key. To install the kit:

1. Remove the four screws holding the water pump on the engine.
2. Remove the impeller as described in the Minor Service KIt description.
3. Remove the housing from the cast iron body by removing the three hex head bolts from the back side of the pump housing. The housing will detach as well as the second O-rings.
4. Use a pliers or other gripping implement to remove the key from the pump shaft. See Figure 8-4.
5. Pry the wear plate off the cast iron body. The plate may not readily come out, and a flat tip screwdriver may be required to pry the plate out a little at a time by alternately prying on one side and the other.
6. Press the water lip seal out from the wear plate. REMEMBER the directional position of the seal so the new seal is not reassembled backward.
7. Inspect the shaft for excess grooving and wear. Some shaft wear will be apparent, but grooving which exceeds a depth of .015 in the shaft will require a complete pump replacement.
8. Remove the cam by unscrewing the cam screw and seal washer.

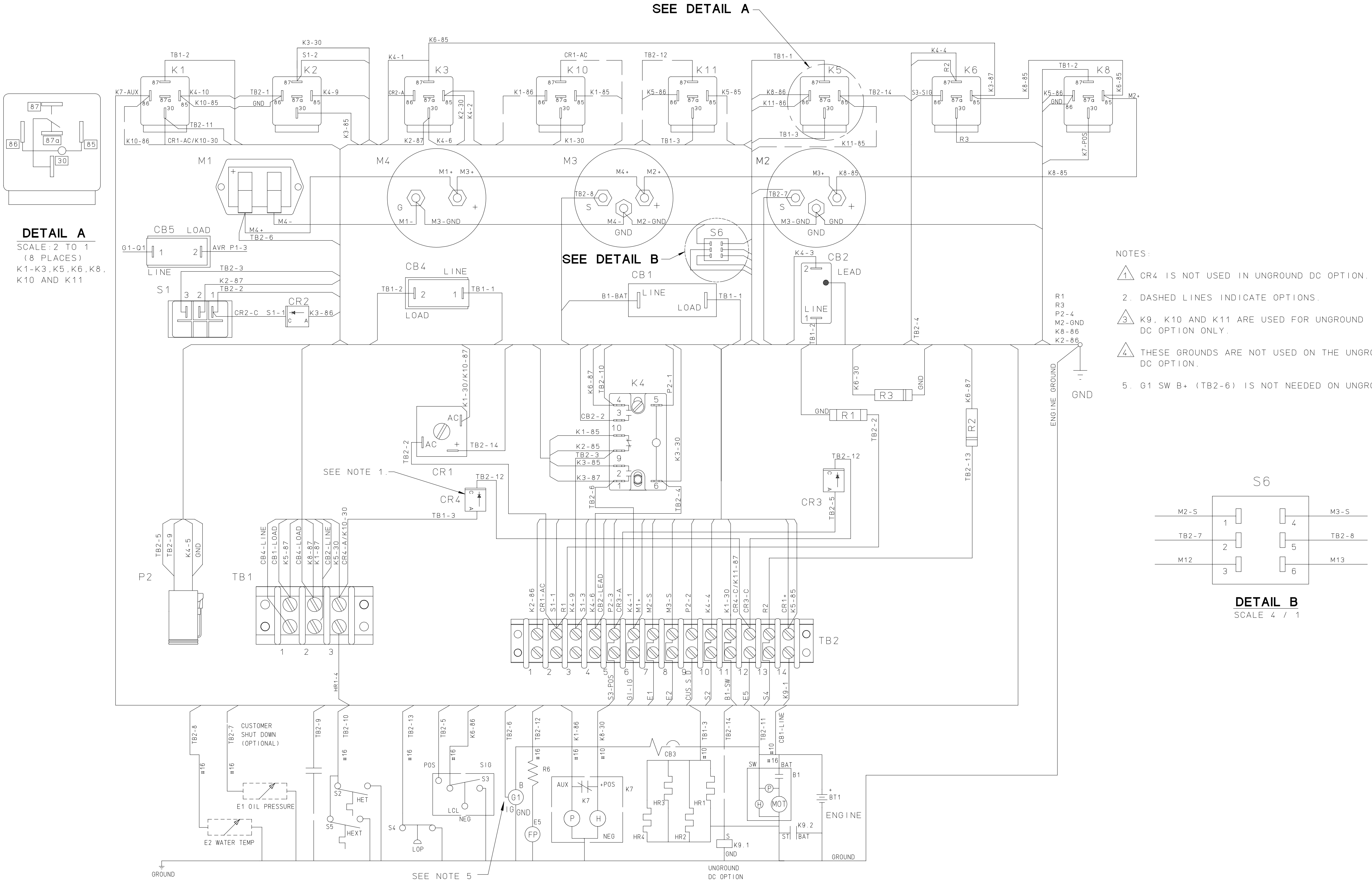
Begin reassembly by replacing the cam, seal washer and cam screw. Reassemble all parts in reverse order of assembly (see steps listed above).

When replacing the lip seal, apply a small amount of Permatex or equivalent gasket-forming sealant to the outer diameter of the seal case, to insure a tight seal. Press the new water lip seal into the new wear plate and orient the lip seal in the same direction as the old seal.

CAUTION ***Do not insert the seal backward into the new wear plate, or leakage will occur.***

Clean any dirt or corrosion buildup from the cast iron body and shaft. Push the wear plate and seal over the shaft and into the cast iron body. Then replace the key with the new one from this kit. **NOTE: Install the wear plate before replacing the key: pushing the plate over the key will destroy the new seal.**

Position the new O-ring seal gasket and attach the pump housing using the three longer bolts (#7). Reassemble the impeller as described in the Minor Service Kit section.

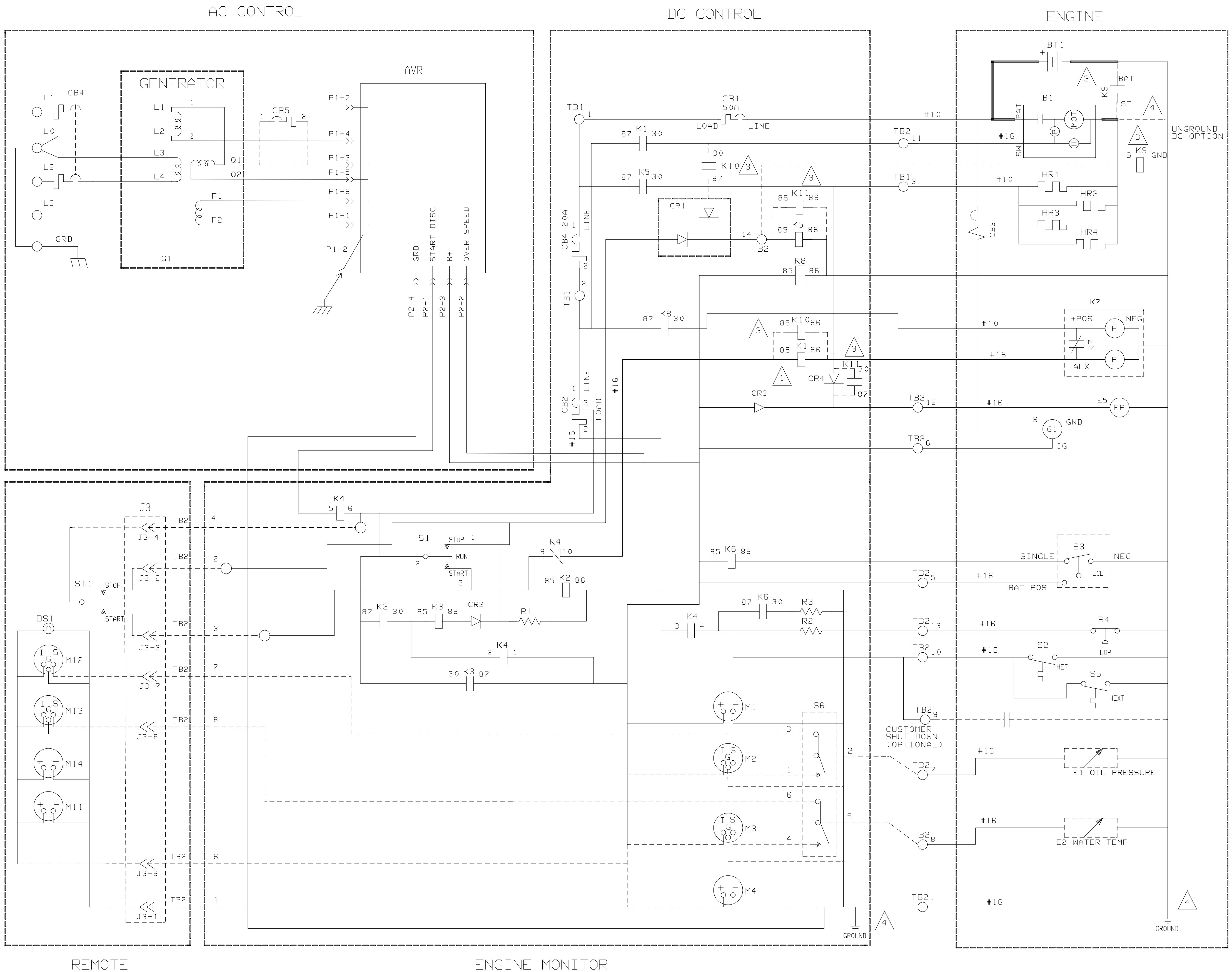


NOTES:

1. CR4 IS NOT USED IN UNGROUND DC OPTION.
2. DASHED LINES INDICATE OPTIONS.
3. K9, K10 AND K11 ARE USED FOR UNGROUND DC OPTION ONLY.
4. THESE GROUNDS ARE NOT USED ON THE UNGROUND DC OPTION.
5. G1 SW B+ (TB2-6) IS NOT NEEDED ON UNGROUNDED SET.

12 VDC CONTROL WIRING DIAGRAM

612-6665-1

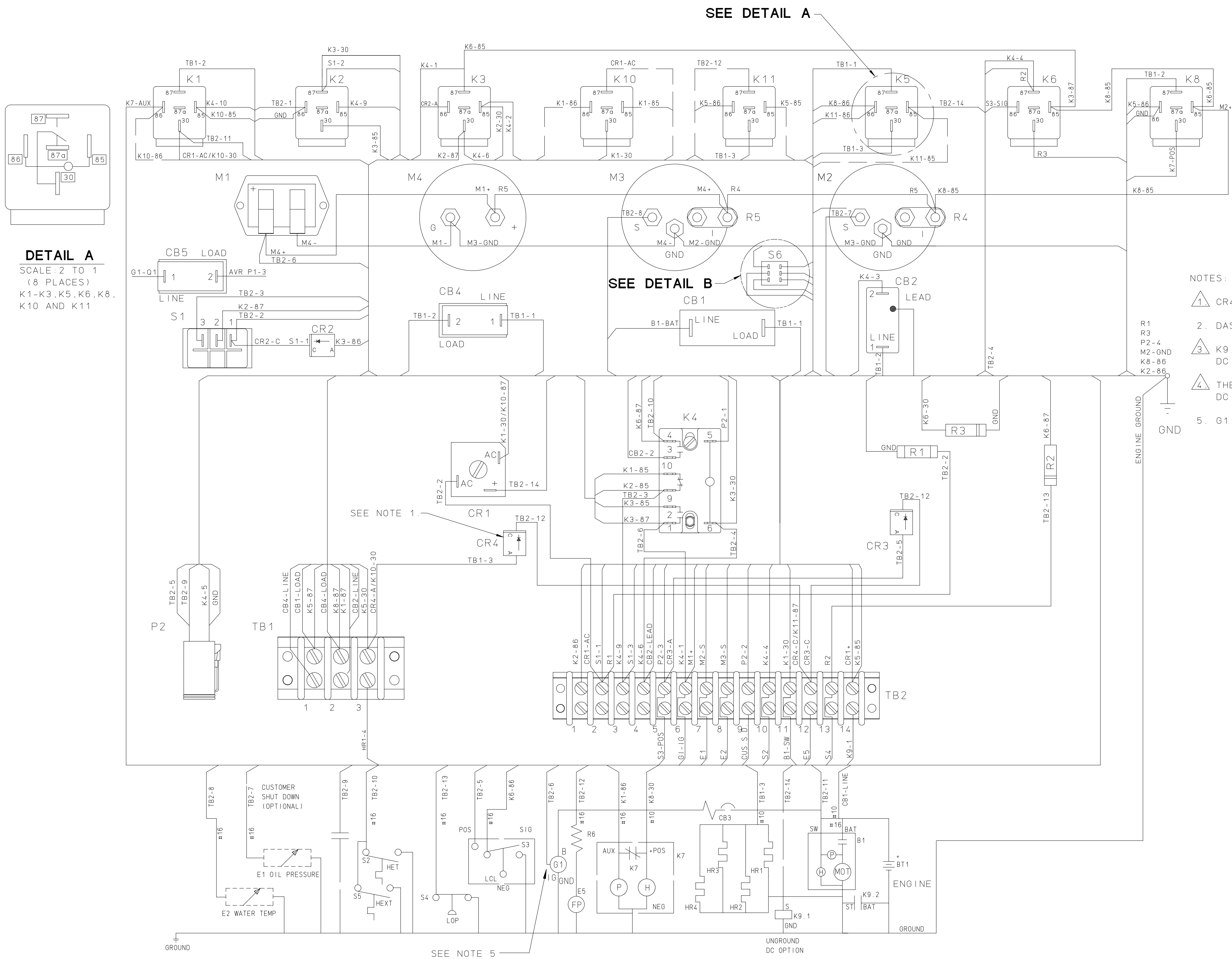


BILL OF MATERIALS

Qty		ONAN PN	Description	Ref
1	1		RELAY, 12V (STARTER)	K1
1	2		RELAY, 12V (GLOW PLUG)	K5
1	3		RELAY, 12V (FUEL SHUT OFF)	K8
1	4		BRIDGE RECTIFIER, 1/2 WAVE	CR1
1	5		CIRCUIT BREAKER,50 AMPS DC	CB1
1	6		LAMP-RUN LIGHT	L1
1	7		ACR, SRA-1900 MODIFIED	AVR1
1	8		TERMINAL STRIP 3PL	TB1
1	9		TERMINAL STRIP 14 PL	TB2
1	10		SWITCH, STOP/START,PREHEAT	S1
1	11		RELAY, START	K2
1	12		RELAY, RUN	K3
1	13		RELAY, START DISCONNECT	K4
1	14		RELAY, LOW COOLANT SWITCH	K6
1	15		RESISTOR 10 OHMS 10 W	R1
1	16		CIRCUIT BREAKER, FAULT	CB2
1	17		METER, RUN TIME	M1
1	18		METER, OIL PRESSURE	M2
1	19		METER, WATER TEMPERATURE	M3
1	20		METER, DC VOLTAGE	M4
1	21		FUEL SHUT OFF SOLENIOD	K7
1	22		FUEL PUMP (FP)	E5
1	23		LOW COOLANT LEVEL (LCL)	S3
1	24		LOW OIL PRESSURE (LOP)	S4
1	25		HIGH ENGINE TEMPERATURE (HET)	S2
1	26		HIGH EXHAUST TEMP	S5
1	27		OIL PRESSURE SENDER	E1
1	28		WATER TEMP SENDER	E2
1	29		RECTIFIER	CR2, 3, 4
1	30		RESISTOR 10 OHMS 5W	R2
1	31		RESISTOR 8.5 OHMS 5W	R3
1	32		ALTERNATOR	G1
1	33		CIRCUIT BREAKER (CHARGING)	CB3
1	34		CIRCUIT BREAKER DC/EMER STOP	CB4
1	35		BATTERY 12V	BT1
3	36		RELAYS FOR UNGROUND DC	K9,K10,K11
1	37		SWITCH-2 POLE DOUBLE THROW	S6
1	38		CIRCUIT BREAKER (FIELD)	CB5

12 VDC CONTROL WIRING SCHEMATIC

612-6665-2



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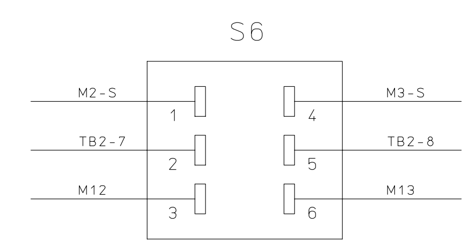
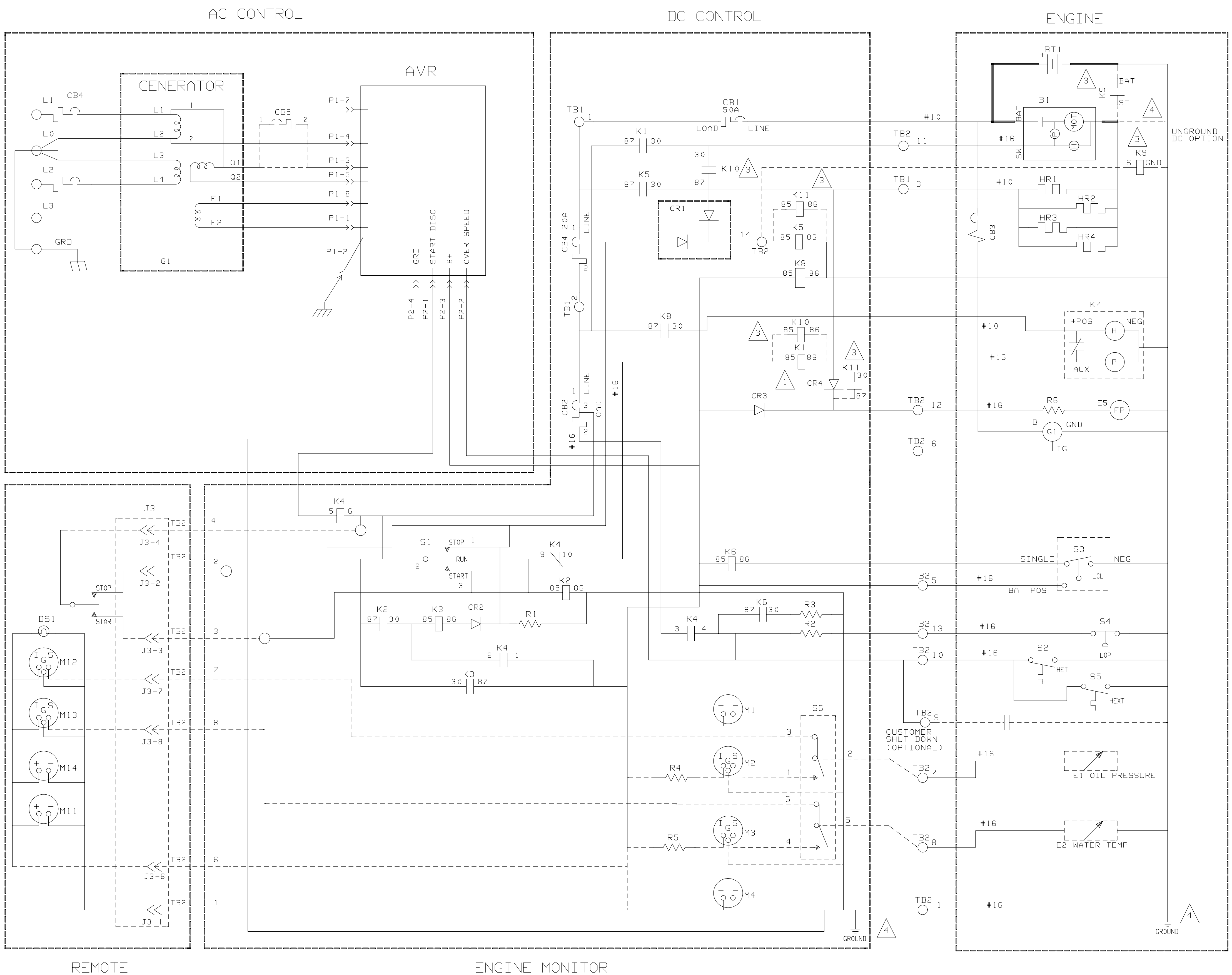
3. K9, K10 AND K11 ARE USED FOR UNGROUND DC OPTION ONLY.
4. THESE GROUNDS ARE NOT USED ON THE UNGROUND DC OPTION.
5. G1 SW B+ (TB2-6) IS NOT NEEDED ON UNGROUNDED SETS.



DETAIL B
SCALE 4 / 1

24 VDC CONTROL WIRING DIAGRAM

612-6667-1

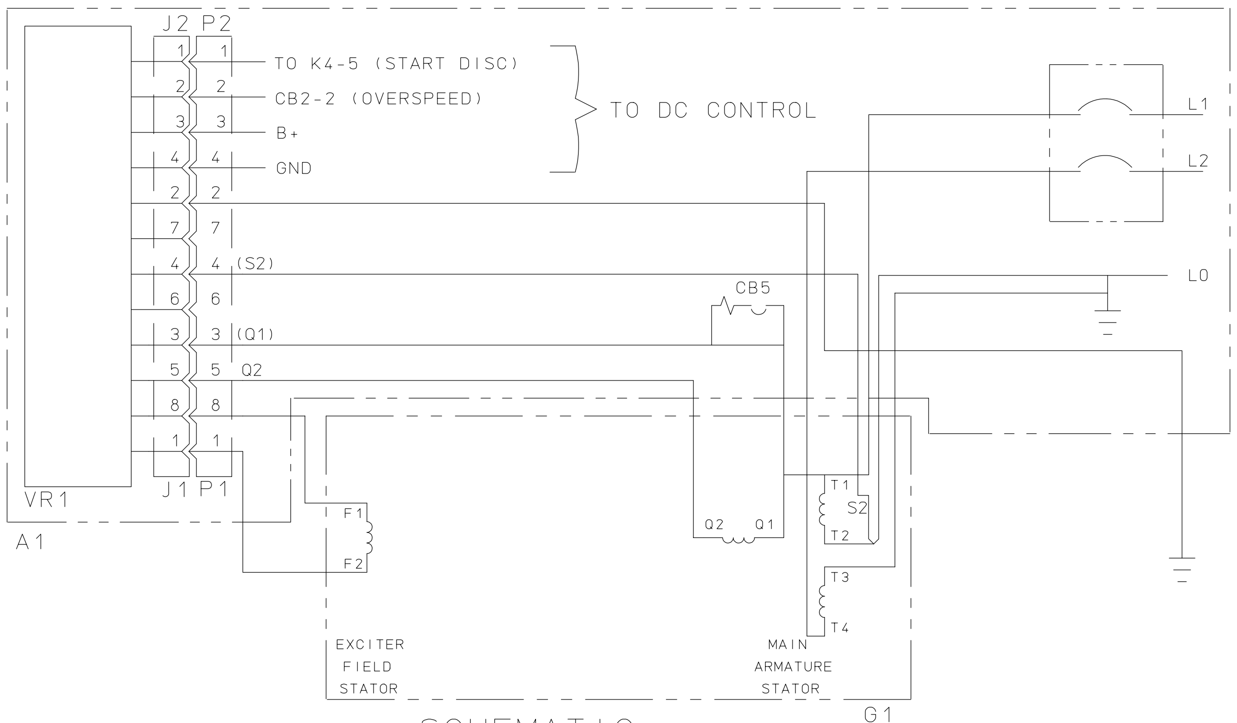


BILL OF MATERIALS

Qty		ONAN PN	Description	Ref
1	1		RELAY, (STARTER)	K1
1	2		RELAY, (GLOW PLUG)	K5
1	3		RELAY, (FUEL SHUT OFF)	K8
1	4		BRIDGE RECTIFIER, 1/2 WAVE	CR1
1	5		CIRCUIT BREAKER,50 AMPS DC	CB1
1	6		LAMP-RUN LIGHT	DS1
1	7		ACR, SRA-1900 MODIFIED	AVR1
1	8		TERMINAL STRIP 3PL	TB1
1	9		TERMINAL STRIP 14 PL	TB2
1	10		SWITCH, STOP/START,PREHEAT	S1
1	11		RELAY, START	K2
1	12		RELAY, RUN	K3
1	13		RELAY, START DISCONNECT	K4
1	14		RELAY, LOW COOLANT SWITCH	K6
1	15		RESISTOR 36 OHMS 15W	R1
1	16		CIRCUIT BREAKER, FAULT	CB2
1	17		METER, RUN TIME	M1,M11
1	18		METER, OIL PRESSURE	M2,M12
1	19		METER, WATER TEMPERATURE	M3,M13
1	20		METER, DC VOLTAGE	M4,M14
1	21		FUEL SHUT OFF SOLENIOD	K7
1	22		FUEL PUMP (FP)	E5
1	23		LOW COOLANT LEVEL (LCL)	S3
1	24		LOW OIL PRESSURE (LOP)	S4
1	25		HIGH ENGINE TEMPERATURE (HET)	S2
1	26		HIGH EXAUST TEMP	S5
1	27		OIL PRESSURE SENDER	E1
1	28		WATER TEMP SENDER	E2
1	29		RECTIFIER	CR2, 3, 4
1	30		RESISTOR 24 OHMS 10W	R2
1	31		RESISTOR 18 OHMS 10W	R3
1	32		ALTERNATOR	G1
3	33		RELAYS FOR UNGROUND DC	K9,K10,K11
1	34		CIRCUIT BREAKER (CHARGING)	CB3
1	35		CIRCUIT BREAKER DC/EMER STOP	CB4
1	36		BATTERY	BT1
1	37		RESISTOR	R4
1	38		RESISTOR	R5
1	39		RESISTOR	R6
1	40		SWITCH-2 POLE DOUBLE THROW	S6
1	41		CIRCUIT BREAKER (FIELD)	CB5

24 VDC CONTROL WIRING SCHEMATIC

612-6667-2



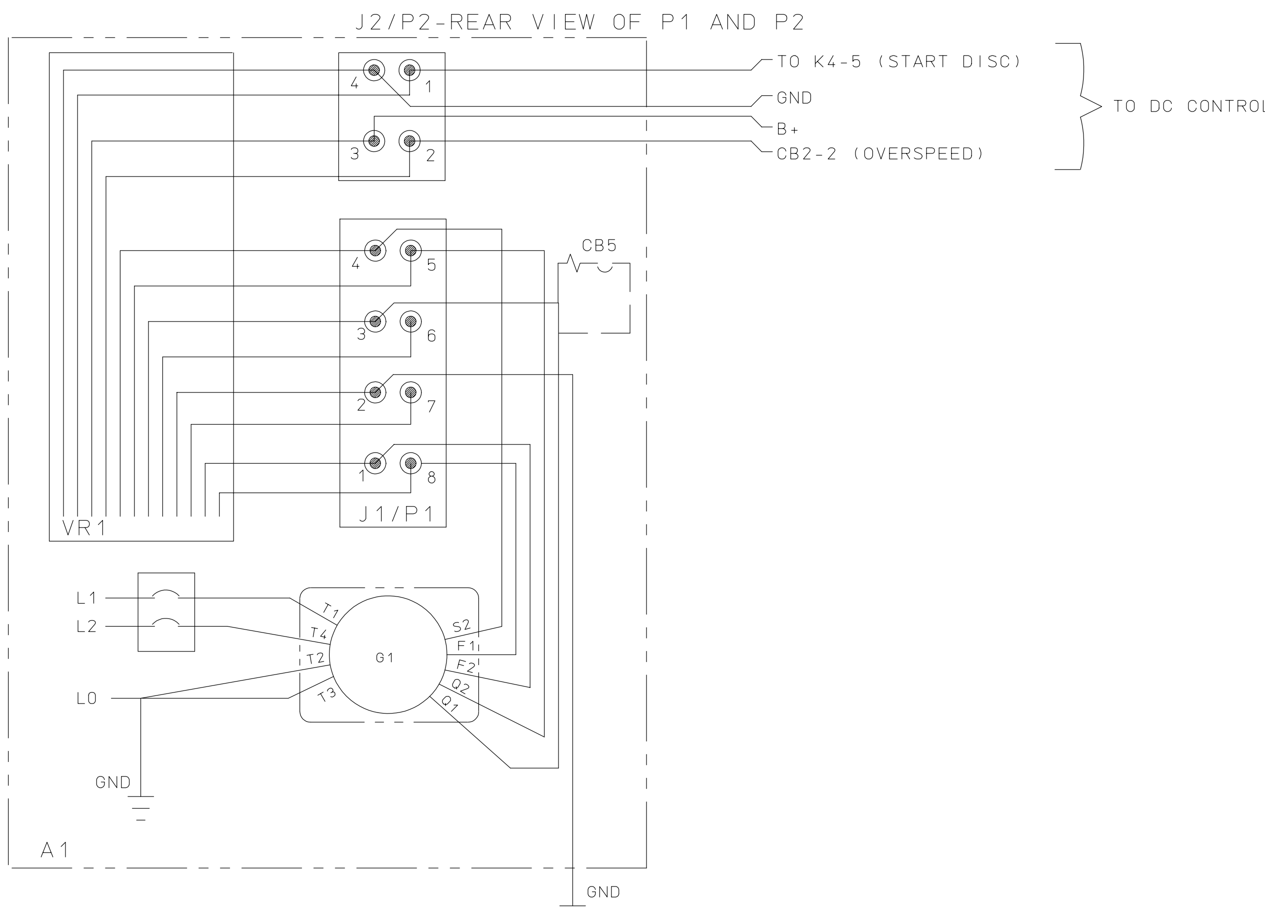
SCHEMATIC

110/220V, 115/230V & 120/240V AS SHOWN
SEE RECONNECTION CHART FOR OTHER VOLTAGES

REF DES	PART NO	DWG SIZE	QTY	DESCRIPTION
---	---	--	--	---
---	---	--	--	---
---	---	--	--	---
G1	---	--	1	GENERATOR
VR1	---	--	1	VOLTAGE REG-CAP AVR
CB5	---	--	1	CIRCUIT BREAKER (FIELD)
---	---	--	--	---
---	---	--	--	---
---	---	--	--	---
---	---	--	--	---

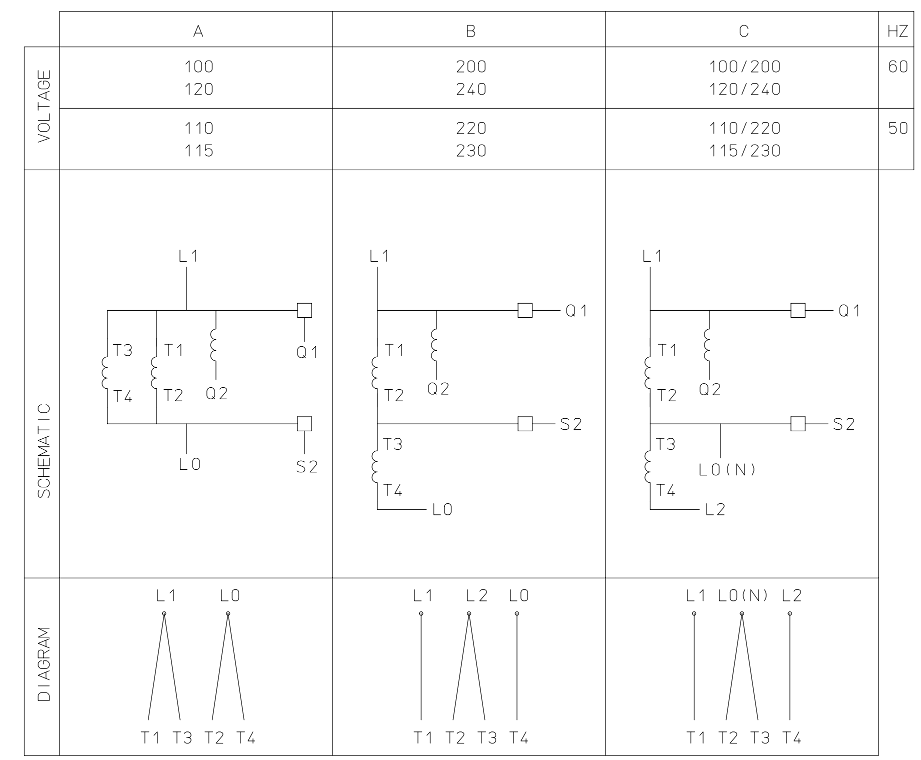
NOTES:

1. FROM J1-J7 FOR FIELD FLASHING.
2. AVR REFERENCE VOLTAGE. (S2-Q1)



WIRING DIAGRAM

110/220V, 115/230V & 120/240V AS SHOWN
SEE RECONNECTION CHART FOR OTHER VOLTAGES

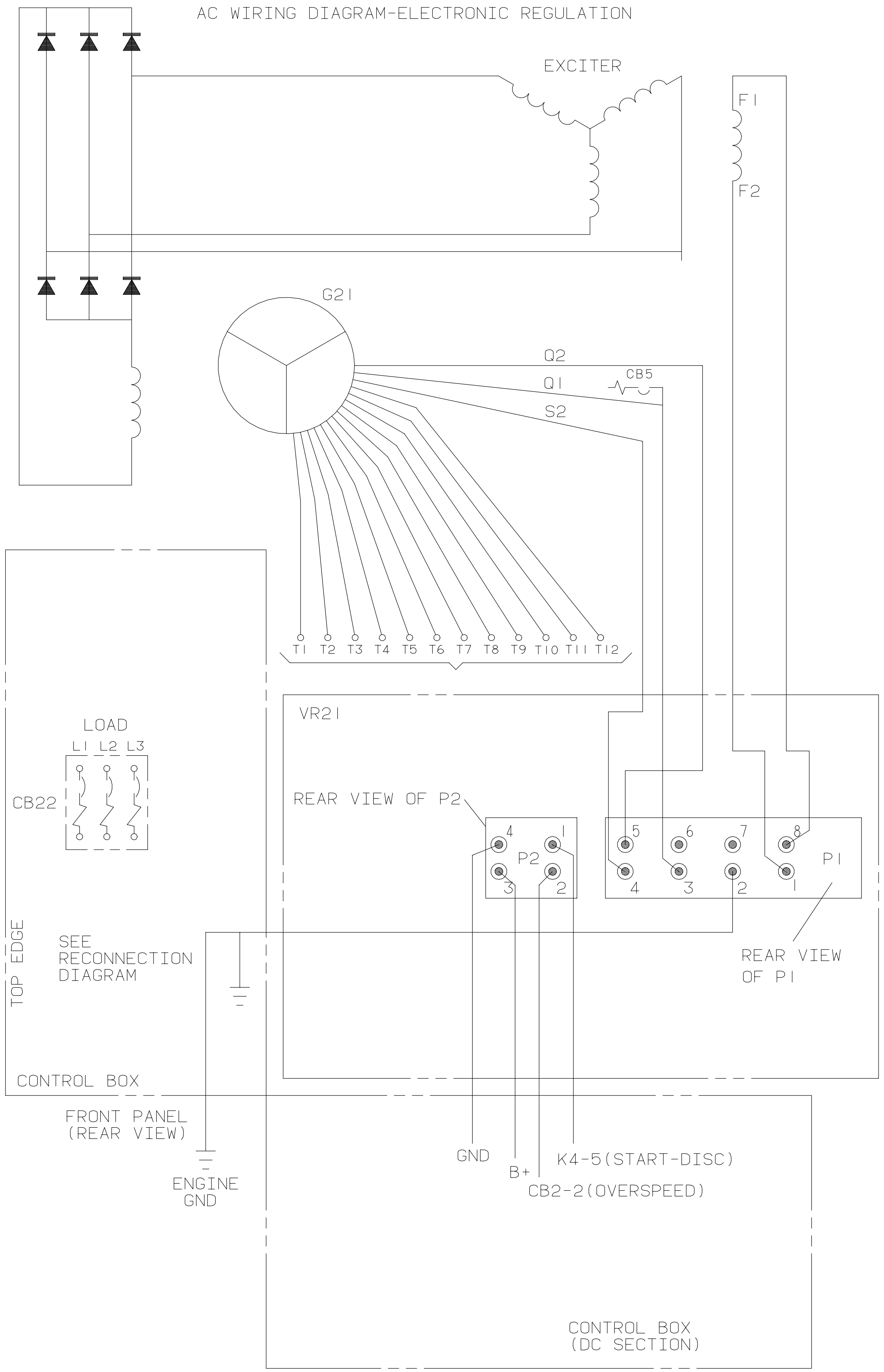


GENERATOR
RECONNECTION CHART

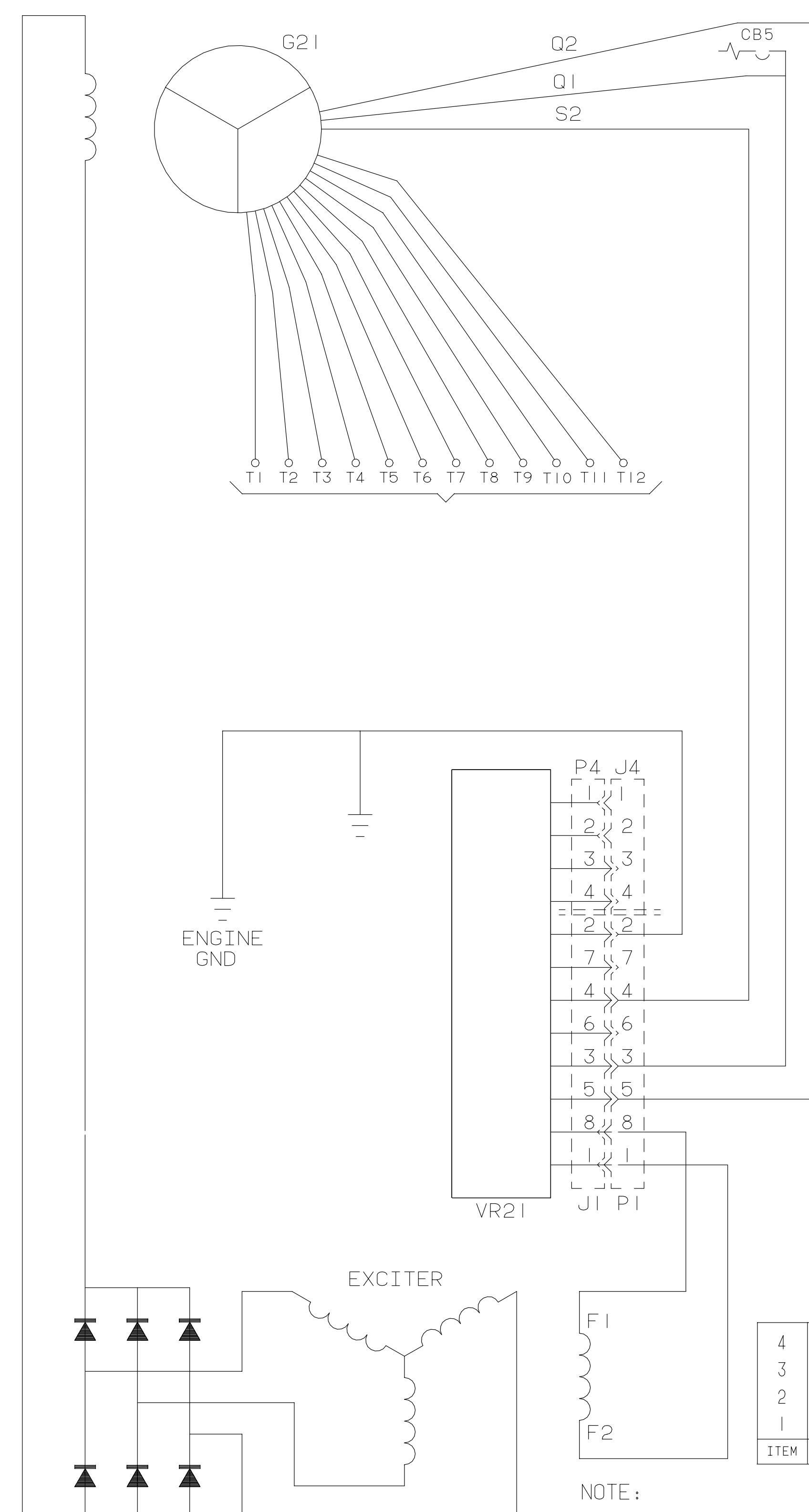
SINGLE-PHASE AC WIRING DIAGRAMS

612-6721

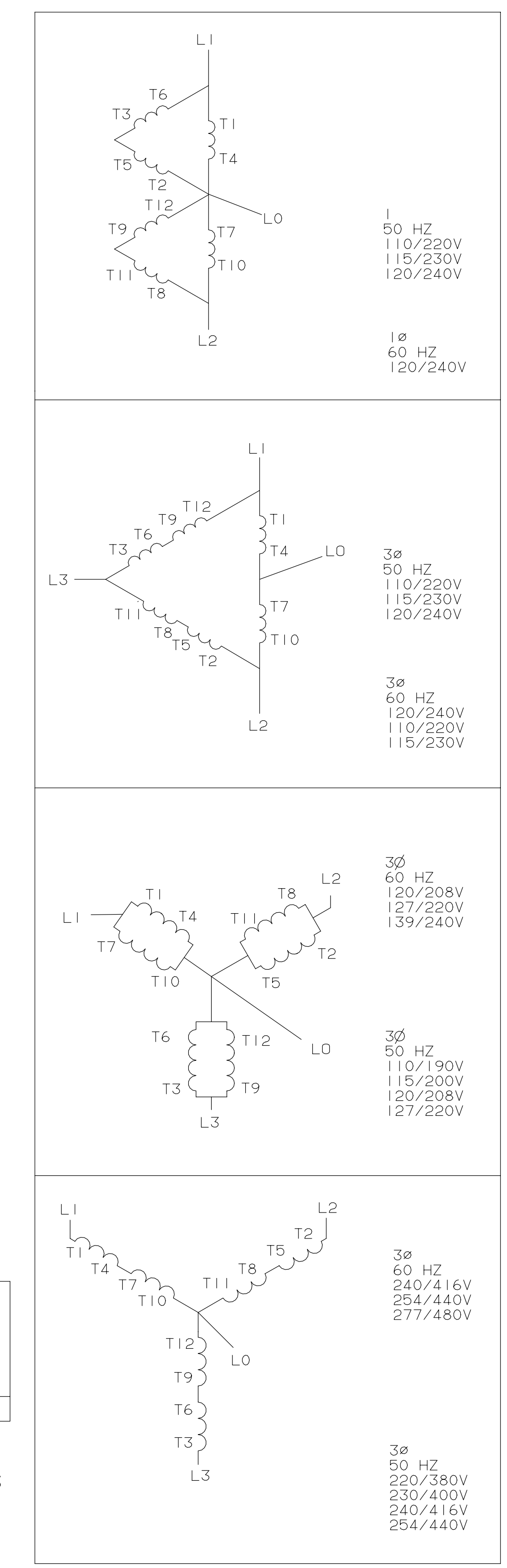
AC WIRING DIAGRAM-ELECTRONIC REGULATION



AC SCHEMATIC-ELECTRONIC REG



RECONNECTION CHART



4	CONTROL ASSY (AC)	
3	REGULATOR ASSY-VOLTAGE	VR21
2	GENERATOR-AC	G21
1	CIRCUIT BREAKER-LOAD	CB22
ITEM	DESCRIPTION OR MATERIAL	REF DES

NOTE:
1. UNLESS OTHERWISE NOTED, ALL COMPONENTS ARE SHOWN IN DE-ENERGIZED POSITION.
2. DASHED LINES INDICATE CONNECTIONS WHEN USED.

THREE-PHASE AC WIRING DIAGRAMS

612-6673

Onan

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