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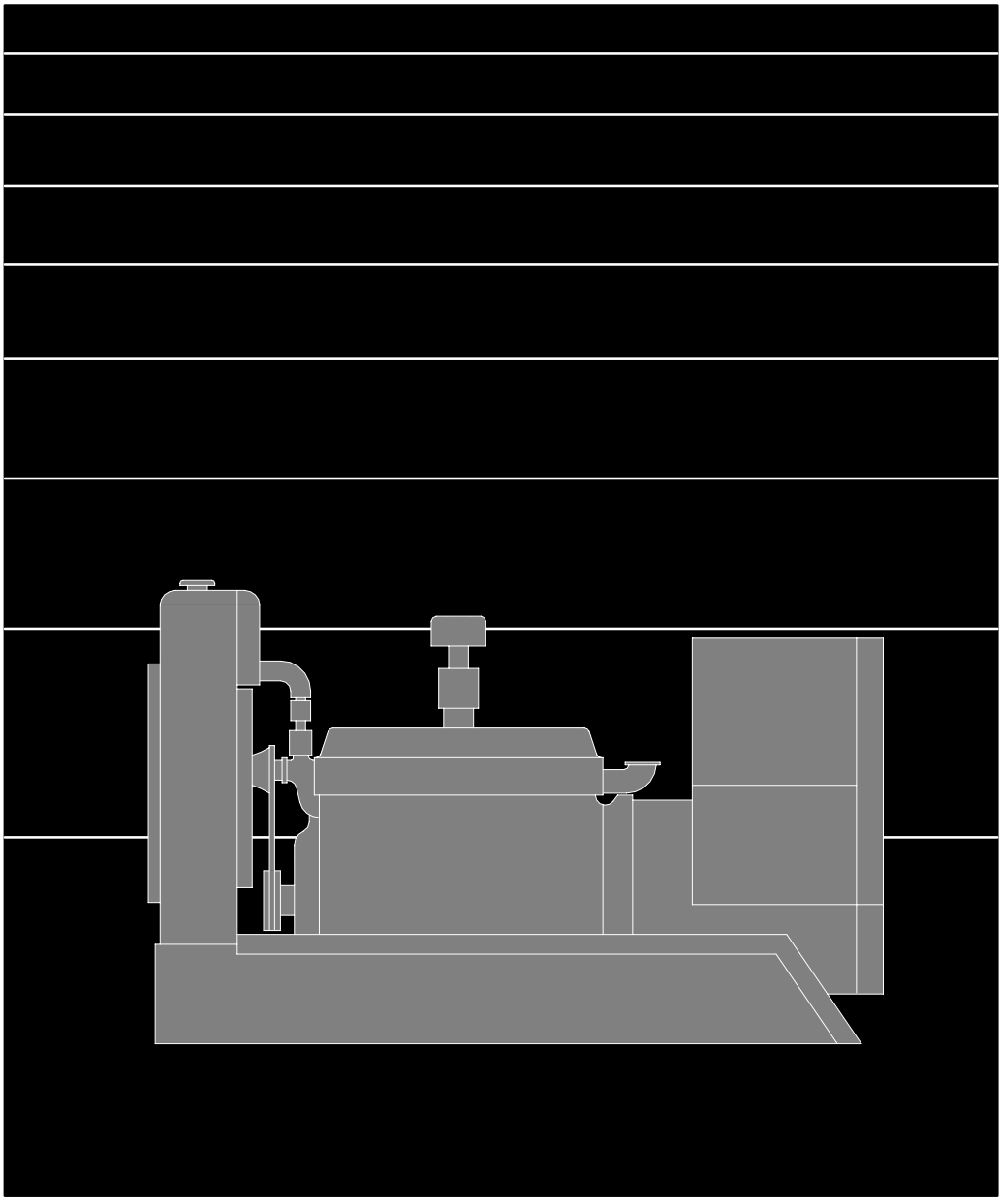
Cummins Onan

Service Manual

20 ES
(Begin Spec G)

GENERATOR SET



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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. Ensure 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.

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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.

KEEP THIS MANUAL NEAR THE GENSET FOR EASY REFERENCE

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Table of Contents

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Introduction

SERVICE MANUAL

This section contains troubleshooting and repair information for the ES series generator sets. The generator set is divided into three basic parts, the generator, the controls and the engine. Use the engine information in the applicable engine manual for service.

The manual is divided into sections for the generator and AC controls, DC controls, governor adjustments, and wiring diagrams. This manual contains basic (generic) wiring diagrams and schematics that are included to help in troubleshooting. Service personnel should 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.

This manual does not have instructions for servicing printed circuit board assemblies. After determining that a printed circuit board assembly is faulty, replace it. Do not repair it. Attempts to repair a printed circuit board can lead to costly damage to the equipment.

TEST EQUIPMENT

Most of the test procedures in this manual can be performed with a multimeter like the Simpson Model 260 VOM, or a digital VOM. Other instruments that should be available are:

AC Voltmeter
DC Voltmeter
Frequency Meter
Jumper Leads
Load Test Panel
Variac
Tachometer or Strobotach
Megger or Insulation Resistance Meter
Wheatstone Bridge or Digital Ohmmeter

GENERATOR DESCRIPTION

The YD generator (Figure 1) is a four-pole, revolving field, brushless exciter, reconnectible model of drip-proof construction. Design includes both single and three-phase, 60 hertz type generators. The generator rotor connects to the engine flywheel via a flex disc; therefore engine speed determines generator output and frequency.

A centrifugal blower, on the front end of the rotor shaft, circulates the generator cooling air which is drawn in through the end bell cover and discharged through an outlet at the blower end.

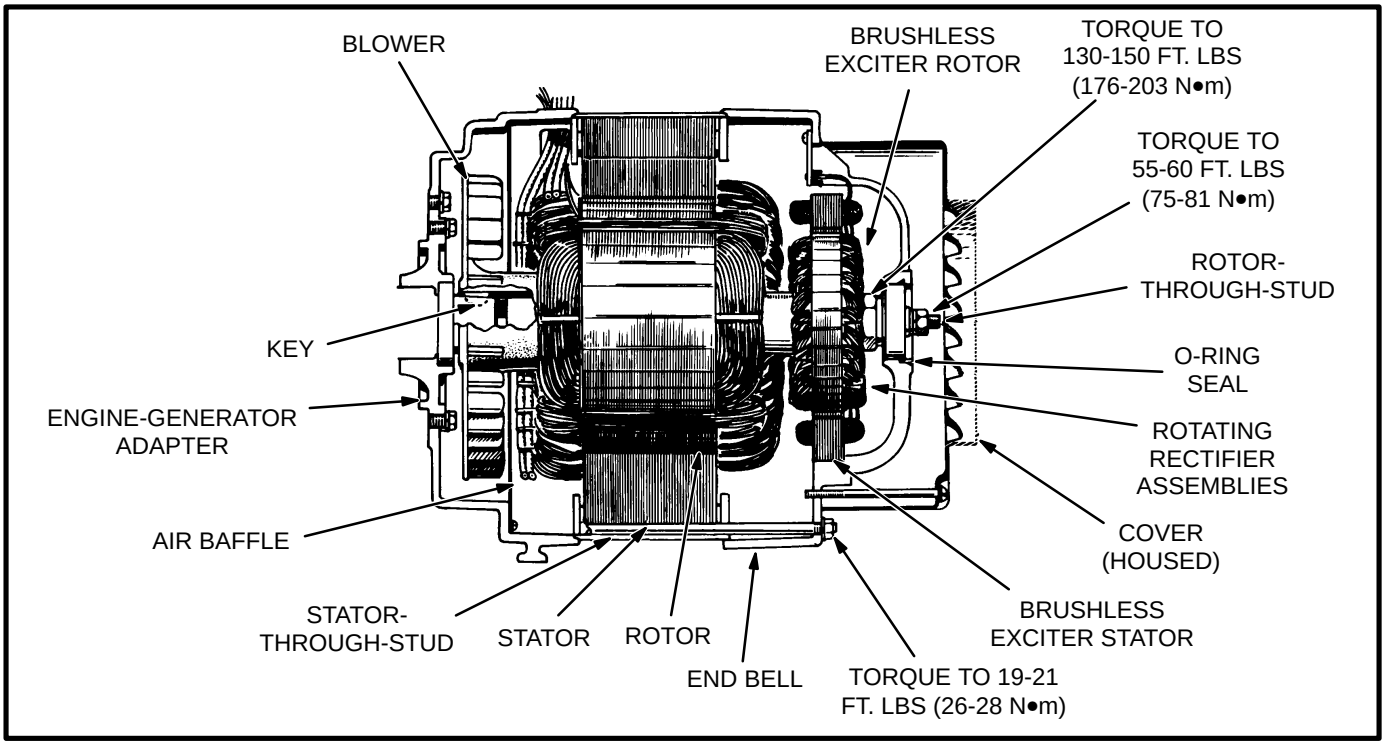

FIGURE 1. GENERATOR

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A ball bearing in the end bell supports the outer end of the rotor shaft. The end bell and generator stator housing are attached by four through-studs which pass through the stator assembly to the engine generator adapter. The brushless exciter stator mounts in the end bell while the exciter rotor and its rotating rectifier assemblies mount on the generator rotor shaft.

All generators have four wires extending from the stator housing in addition to the AC output leads. Figure 2. Lead F1 and F2 are from the exciter field winding and are connected to the output terminals of the voltage regulator. Leads 1 and 2 are connected to the stator windings and provide reference voltage and input power to the voltage regulator. These four leads are connected at the factory.

Figure 2 is a composite illustration showing four output leads for single phase units, 12 output leads for 3 phase broad range units, and four output leads for code 9X, 3 phase 347/600 volt generators.

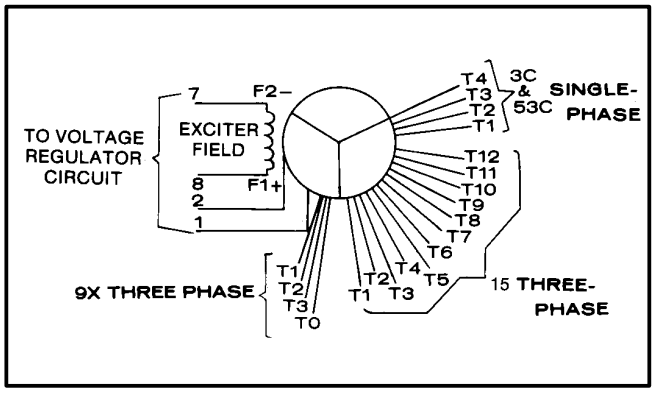

FIGURE 2. SINGLE AND THREE PHASE GENERATOR SCHEMATIC (COMPOSITE)

GENERATOR OPERATION

Operation of the generator involves the stator, voltage regulator, exciter field and armature, a full wave bridge rectifier, and the generator rotor (Figure 3). Residual magnetism in the generator rotor and a permanent magnet embedded in one exciter field pole begin the voltage build-up process as the generator set starts. Single-phase AC voltage, taken from one of the stator windings, is fed to the voltage regulator as a reference for maintaining the generator output voltage. AC voltage is converted to DC by a silicon controlled rectifier bridge on the voltage regulator printed circuit board and fed into the exciter field windings. The exciter armature produces three-phase AC voltage that is converted to DC by the rotating rectifier assembly. The resultant DC voltage excites the generator rotor winding to produce the stator output voltage for the AC load.

Generator sets without a control panel or switchboard containing AC instruments such as voltmeters, ammeters, running time meter, frequency meters, and line circuit breakers are shipped from the factory with the AC output leads separated in the output box. On generator sets with switchboards containing AC instruments, the AC output leads are wired as specified on the customer's purchase order to deliver only the voltage specified.

VOLTAGE RECONNECTION WITH OPTIONAL INSTRUMENTS

The optional AC instruments on the control panel (such as voltmeters, ammeters, transformers, and running time meters) are intended for use with specific nameplate voltages. Control components may have to be changed to match new current ratings when field reconnection for other voltage codes or voltages are made.

⚠ CAUTION ***To prevent instrument damage, contact the Onan factory for required instrument changes, new wiring diagrams, new nameplate with proper specification number and voltage before attempting to reconnect a generator with instruments on the control panel.***

Do not connect the generator in any other manner than shown in the applicable wiring and reconnection diagrams.

Severe damage will result if leads are incorrectly connected or improperly insulated. Use extreme care in checking leads to assure proper connections.

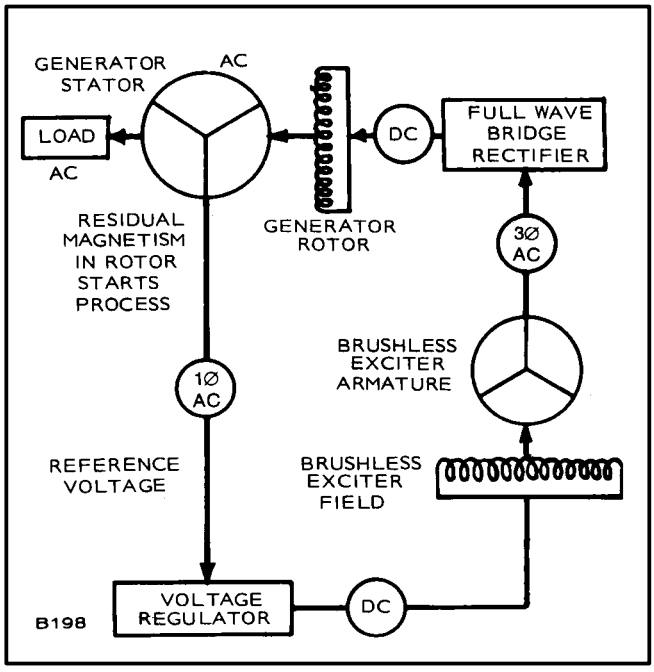

FIGURE 3. EXCITATION BLOCK DIAGRAM

PREPARATION

A few simple checks and a proper troubleshooting procedure can locate the probable source of trouble and cut down service time.

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- Check all modifications, repairs and replacements performed since last satisfactory operation of set to make sure that connection of generator leads are correct. A loose wire connection overlooked when installing a replacement part could cause problems. An incorrect connection, an opened circuit breaker, or a loose connection on printed circuit board are all potential malfunction areas to be eliminated by a visual check.
- Unless absolutely sure that panel instruments are accurate, use portable test meters for troubleshooting.
- Visually inspect components on VR21. Look for dirt, dust, or moisture and cracks in the printed solder conductors. Burned resistors, arcing tracks are all identifiable. Do not mark on printed circuit boards with a pencil. Graphite lines are conductive and can cause leakage or short circuits between components.

⚠WARNING ***Troubleshooting procedures presents hazards of electrocution, asphyxiation, burns, cuts, and other personal injury or death. Review Safety Precautions. Service personnel must be trained and experienced.***

TROUBLESHOOTING PROCEDURES
(STANDARD YD GENERATOR AND REGULATOR)

The information in this section is divided into Flow Charts A, B, C, D, and E as follows:

A. NO AC OUTPUT VOLTAGE AT RATED ENGINE RPM.
B. UNSTABLE OUTPUT VOLTAGE. ENGINE SPEED STABLE 1800 RPM.
C. OUTPUT VOLTAGE TOO HIGH OR LOW.
D. EXCITER FIELD BREAKER TRIPS.
E. UNBALANCED GENERATOR OUTPUT VOLTAGE.

To troubleshoot a problem, start at upper-left corner of the chart related to problem, and answer all questions either YES or NO. Follow the chart until the problem is found, performing referenced Adjustment and Test procedures following the Flow Charts.

⚠ CAUTION ***Do not replace the printed circuit board until the trouble not on the PC board has been located and corrected to avoid damage to new PC board.***

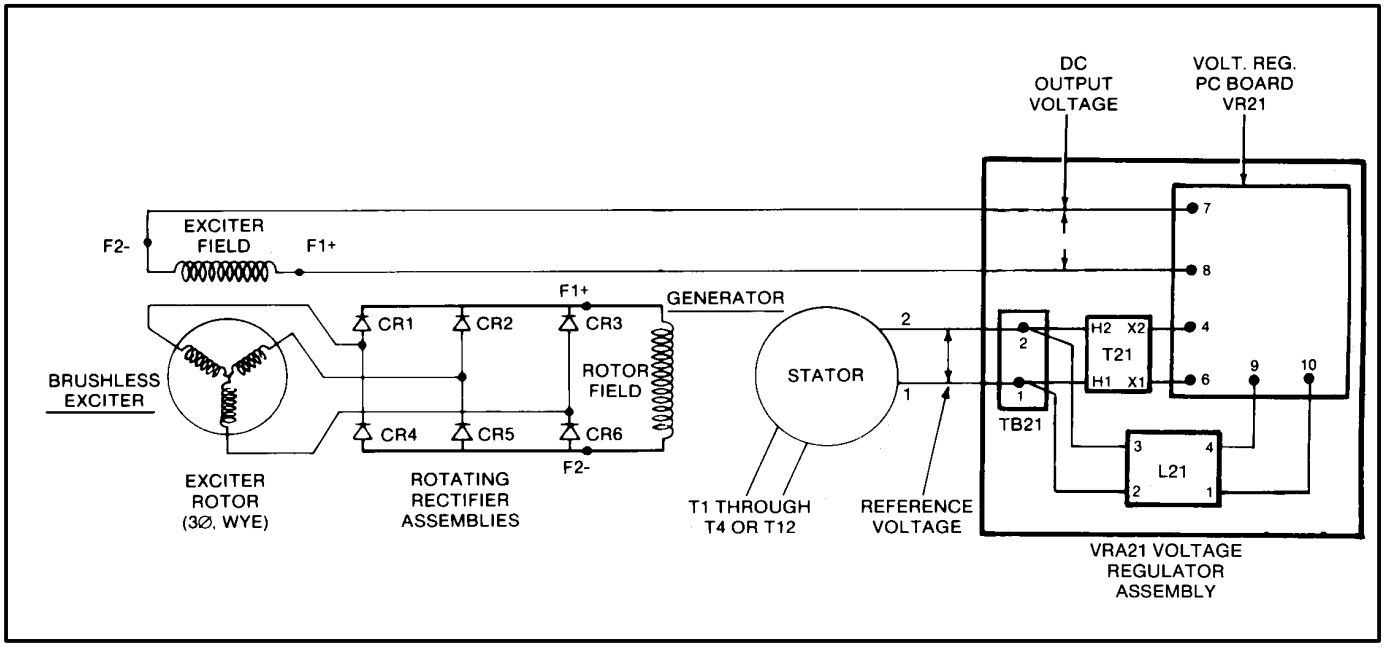

FIGURE 4. ELECTRICAL SCHEMATIC, STANDARD YD GENERATOR AND REGULATOR

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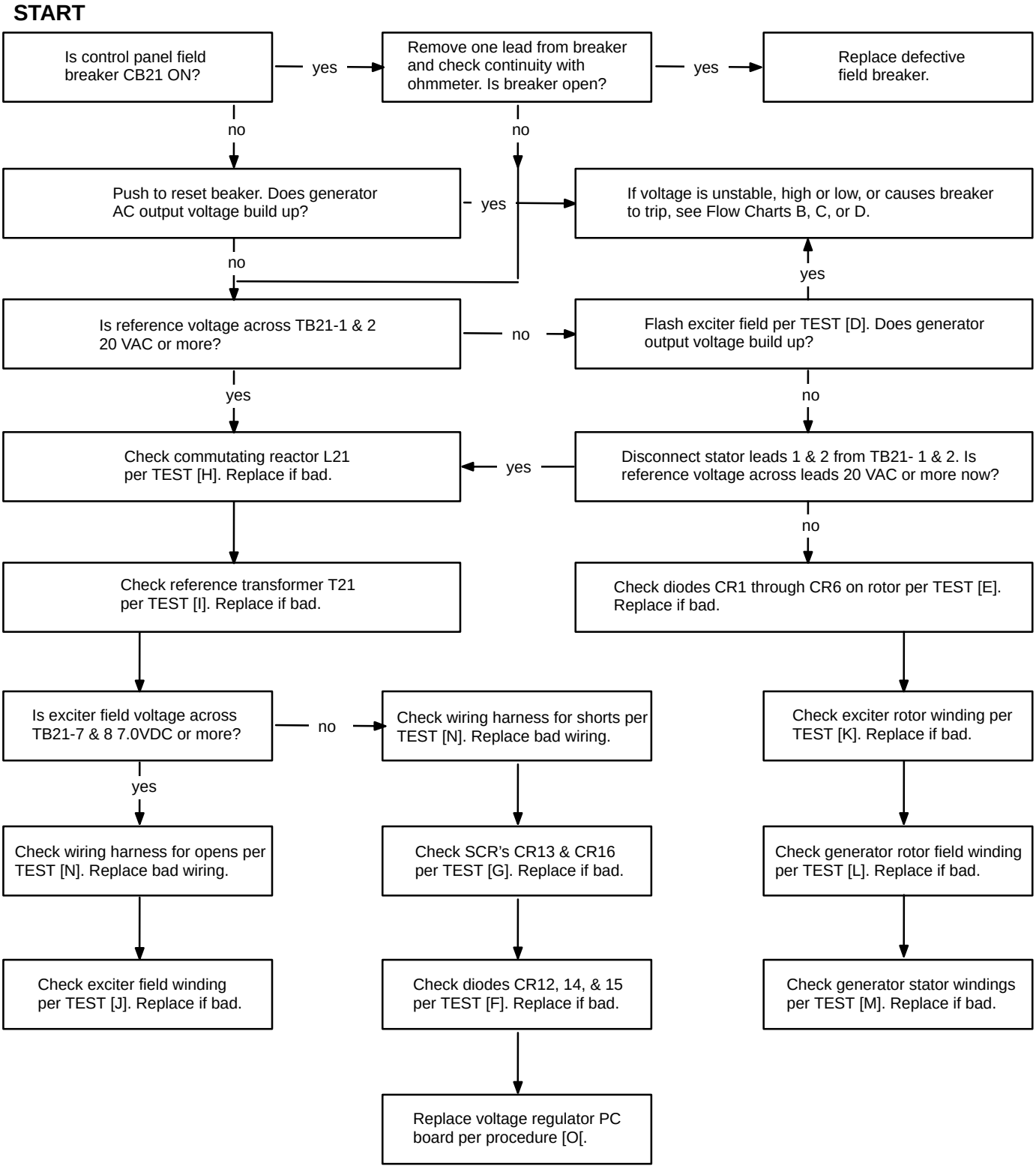
⚠WARNING ***Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review Safety Precautions on pages i and ii.***

FLOW CHART A. NO BUILD UP OF AC OUTPUT VOLTAGE



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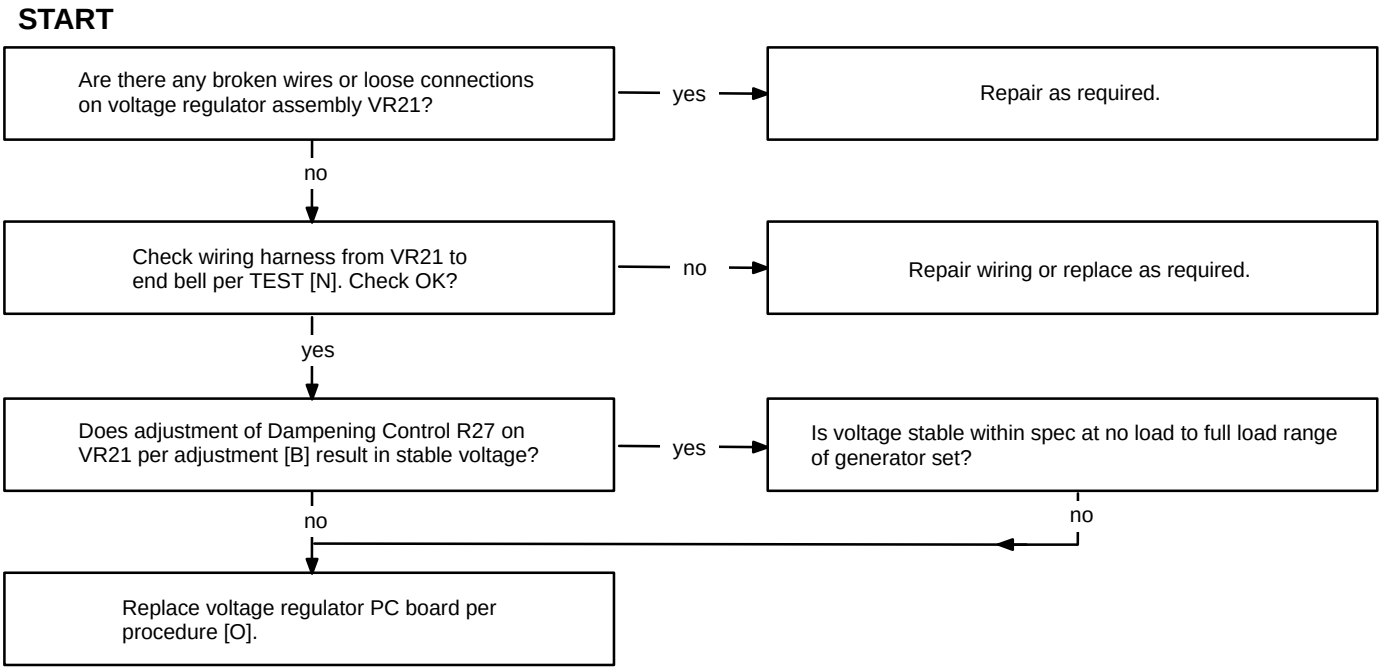
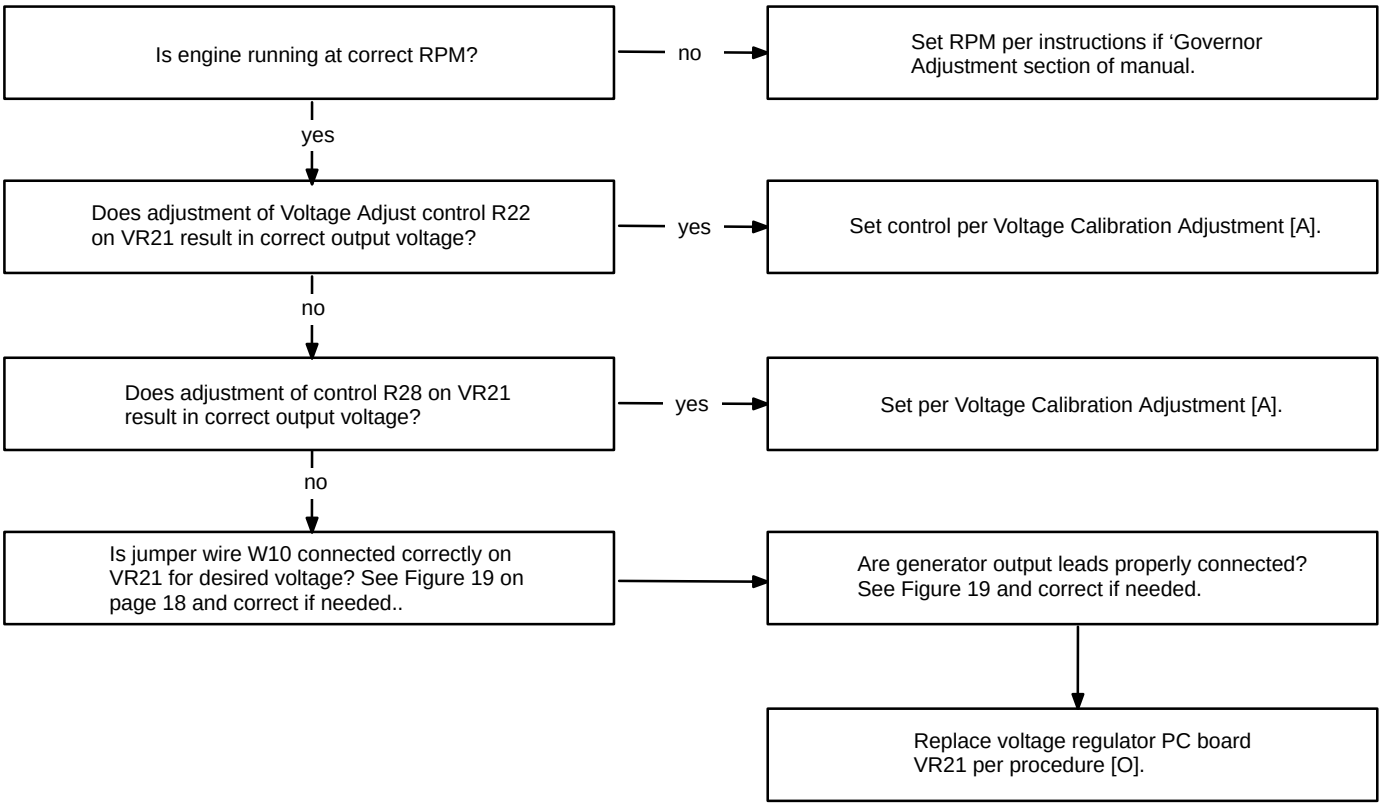
FLOW CHART B. AC OUTPUT VOLTAGE BUILDS UP, BUT IS UNSTABLE



FLOW CHART C. AC OUTPUT VOLTAGE BUILDS UP, BUT IS HIGH OR LOW



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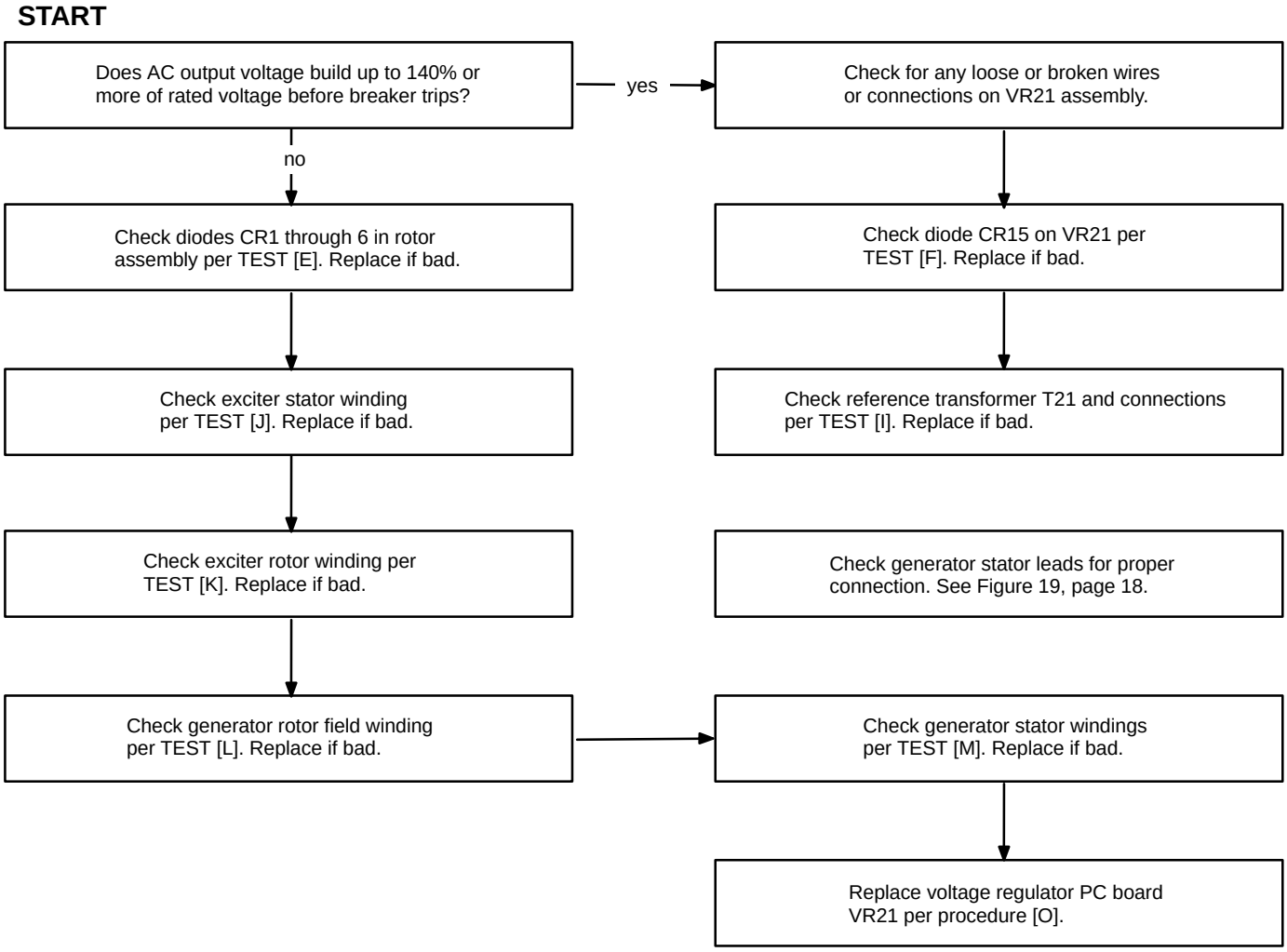
FLOW CHART D. AC OUTPUT VOLTAGE BUILDS UP, BUT FIELD BREAKER TRIPS



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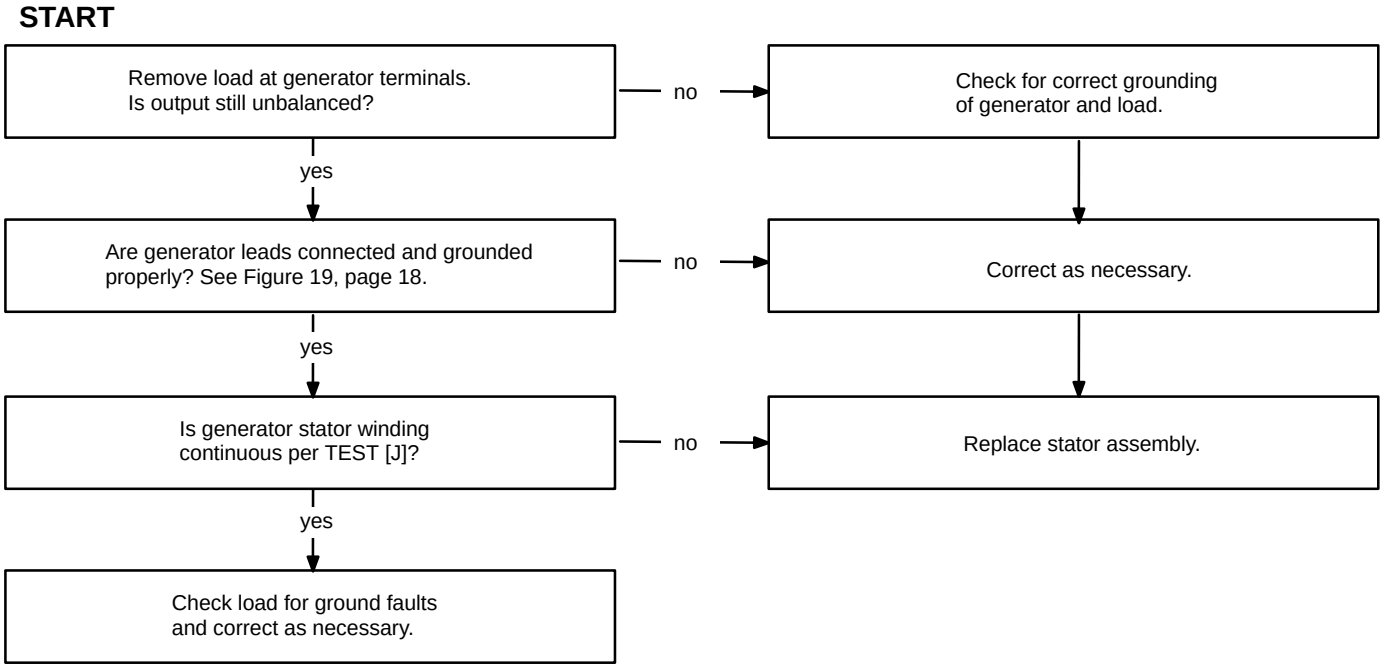
FLOW CHART E. UNBALANCED GENERATOR OUTPUT VOLTAGE



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Adjustments and Tests

GENERAL

All of the following Adjustments and Tests can be performed without disassembly of the generator. They should be used for testing generator and regulator components in conjunction with the troubleshooting flow charts.

⚠WARNING ***Troubleshooting procedures presents hazards of electrocution, asphyxiation, burns, cuts, and other personal injury or death. Review Safety Precautions. Service personnel must be trained and experienced.***

[A]

VOLTAGE CALIBRATION ADJUSTMENT

The calibration adjustment is made using an accurate AC voltmeter to observe generator output voltage and to set the correct no load voltage. If voltage regulator VR21 printed circuit board has been replaced, it may be necessary to make a calibration adjustment. To obtain the correct output voltage, proceed as follows:

1. If set has a voltage adjust potentiometer (R22) on the meter panel, set pointer halfway between minimum and maximum positions.
2. With unit running at no load, turn generator voltage potentiometer R26 on VR21 (Figure 5) clockwise to increase output voltage; turn R26 counterclockwise to decrease output voltage.

[B]

VOLTAGE STABILITY ADJUSTMENT

Voltage stability is set at the factory, but if printed circuit board VR21 has been replaced or if damping potentiometer R27 has been unnecessarily adjusted, it may be necessary to reset stability. Set stability as follows:

1. With generator set running at no load, turn potentiometer R27 (Figure 5) to a position where voltage tends to be unstable or hunt.
2. Turn R27 clockwise slowly until voltage first stabilizes. this setting will result in stable voltage under all conditions in maximum voltage regulator response time.

[C]

VOLTAGE REGULATOR CHECKOUT

The solid state voltage regulators (VR21) can be checked out on the bench for proper operation or location of faulty components. The following test equipment (one-each) is required for a proper checkout.

REF. DESIGNATION — TEST EQUIPMENT

S . . . . . Switch
L21 . . . . . Reactor
F . . . . . Fuse, 5 Amps
T1 . . . . . Transformer, Variable 2 Amp 0-150V
V2 . . . . . Voltmeter, DC ± 2% of Full Scale 3, Scale 0-50 and 0-150V and 0-10V
V1 . . . . . Voltmeter, AC ± 2% @ 10VAC, 1% @ 150V
R1 . . . . . Resistor, 100-Ohm 400W
T21 . . . . . Transformer, Input 315-0386

Transformer T21 and reactor L21 are a part of the voltage regulator assembly (VRA21); these are the only parts obtainable with an Onan part number. the big 100 ohm 400 watt resistor (R1) serves as the field during checkout.

Bench Check:

1. Remove voltage regulator from unit according to procedure given for voltage regulator replacement.
2. Referring to Figure 5 and Table 1, connect test equipment to the printed circuit board VR21 terminals as follows:

CONNECT	FROM	TO
Jumper	VR21-V1	VR21-V4
Jumper	VR21-1	VR21-2
Lead	L21-1	VR21-10
Lead	L21-4	VR21-9
Lead	T21-X1	VR21-6
Lead	T21-X2	VR21-4
AC Voltmeter	Across	T21-H1 & H2
DC Voltmeter	Across	VR21-7 & 8
VARIAC	Across	T21-H1 (fused) and H2
R1	Across	VR21-7 & 8

3. Open switch in 120 VAC supply to VARIAC.
4. Plug VARIAC into 120 VAC source.
5. Proceed with checkout according to steps in Table 1.

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TABLE 1. VOLTAGE REGULATOR CHECKOUT

V_1 AC INPUT VOLTAGE
(< = LESS THAN) V_2 DC OUTPUT VOLTAGE (> = MORE THAN)

STEP NO.	TEST NAME	PROCEDURE	REQUIREMENTS
1	Build Up	Set V_1 to 25 VAC	V_2 Shall Be > 12 VDC
2	Calibration	Set V_1 to 120 VAC	Set POT R26 to Hold V_2 Between 50-70 VDC
3	Range	A. Set V_1 to 123 VAC B. Set V_1 to 125 VAC	V_2 Shall be < 30 VDC V_2 Shall be < 10 VDC
4	Range	A. Set V_1 to 115 VAC B. Set V_1 to 117 VAC	V_2 Shall be > 85 VDC V_2 Shall be > 80 VDC
5	Max Voltage	Set V_1 to 150 V	V_2 < 10 Volts
6	Damping	Set V_1 to 120 VAC. Decrease R27 until Instability in V_1 and V_2 Occurs. Increase R27 to Stability in V_1 and V_2.	V_1 and V_2 Shall Remain Stable after Application and Removal of Generator Load.

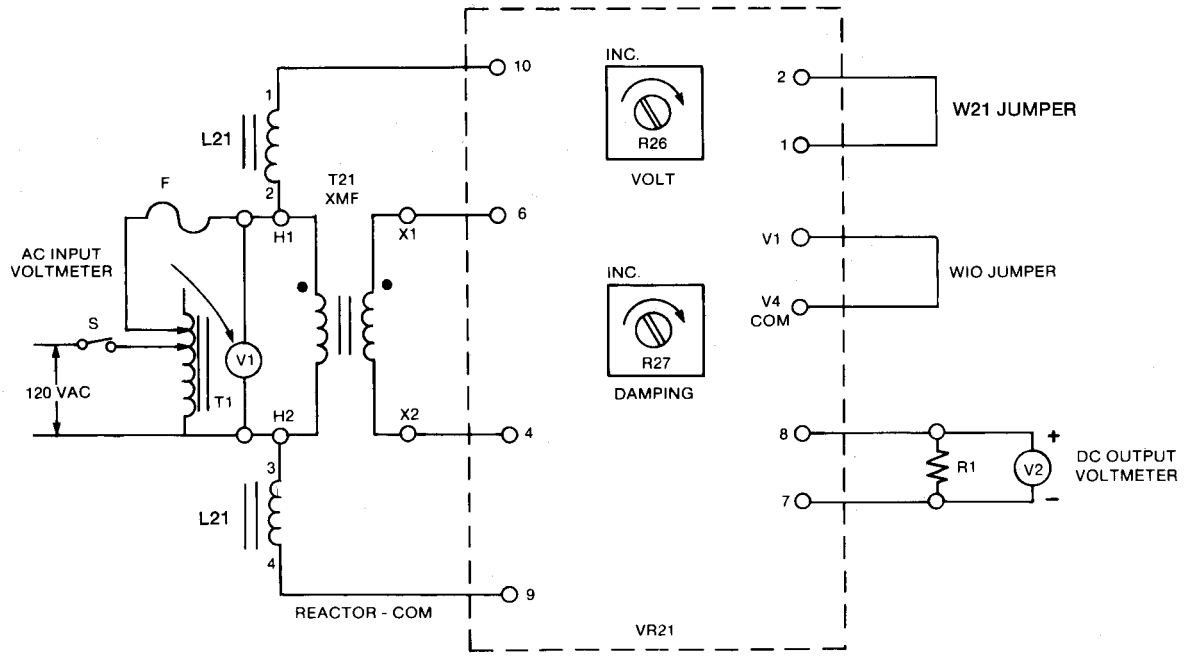

FIGURE 5. VOLTAGE REGULATOR CHECKOUT TEST EQUIPMENT CONNECTIONS

[D]

FLASHING THE FIELD

The following procedure is used for momentarily flashing the exciter field with a low voltage which restores the residual magnetism in the alternator rotor. Flashing the field is usually necessary when installing a new brushless exciter stator wound assembly, but seldom is necessary under other circumstances. Always check generator residual voltage at terminals 1 and 2 to be certain whether or not flashing the field is necessary. Generator residual voltage should be at least 20 VAC at rated speed. If residual is too low and the output voltage will not build up, flash the field as follows:

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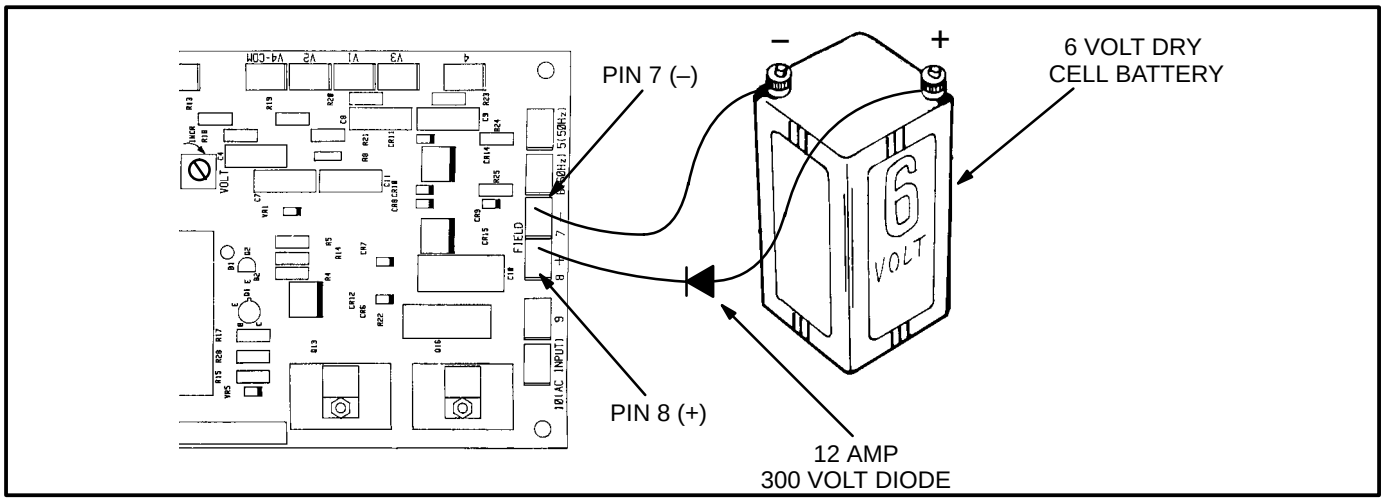

FIGURE 6. FLASHING THE FIELD

1. Locate terminals 7 (–) and 8 (+) on voltage regulator printed circuit board (VR21).
2. Use a six volt dry cell battery with two clip leads and a 12 amp, 300 volt diode as shown in Figure 6. If a six volt battery is not available, a 12 volt automotive battery can be used by adding a 20-ohm resistor in series; or a 24 volt automotive battery can be used by increasing the resistance to 40-ohms.
3. After starting engine, touch positive (+) battery lead to the +8, and negative (–) lead to –7 terminals just long enough until voltage starts to build up or damage may occur to exciter-regulator system.

⚠WARNING ***HAZARDOUS 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.

TEST PROCEDURES

All of the following tests can be performed without disassembly of the generator. Use the following test procedures for testing generator components in conjunction with the troubleshooting charts.

[E]

TESTING ROTATING RECTIFIERS

Two different rectifier assemblies make up the rotating rectifier bridge assembly, Figure 7. Using an accurate ohmmeter, test each CR using negative and positive polarities. Test rectifiers as follows:

1. Disconnect all leads from assembly to be tested.
2. Connect one test lead to F1+ stud and connect 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 with new, identical part.

Use 24 lbs-in. (2.7 Nm) torque when tightening nuts on F1+ and F2–, and CR1 through CR6.

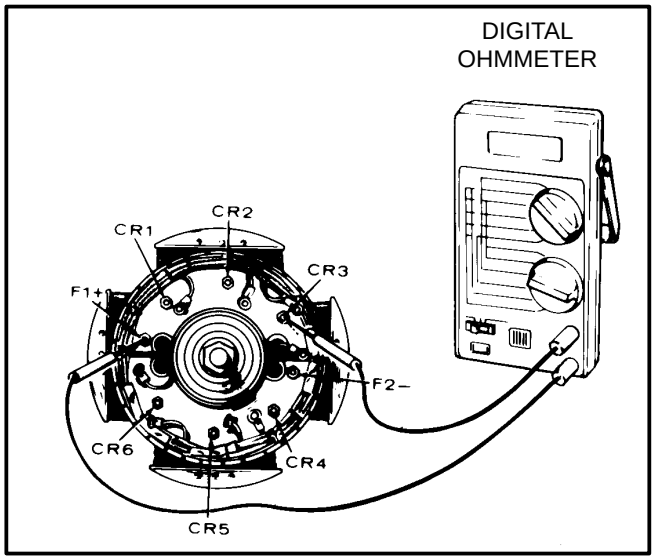

FIGURE 7. TESTING ROTATING RECTIFIERS

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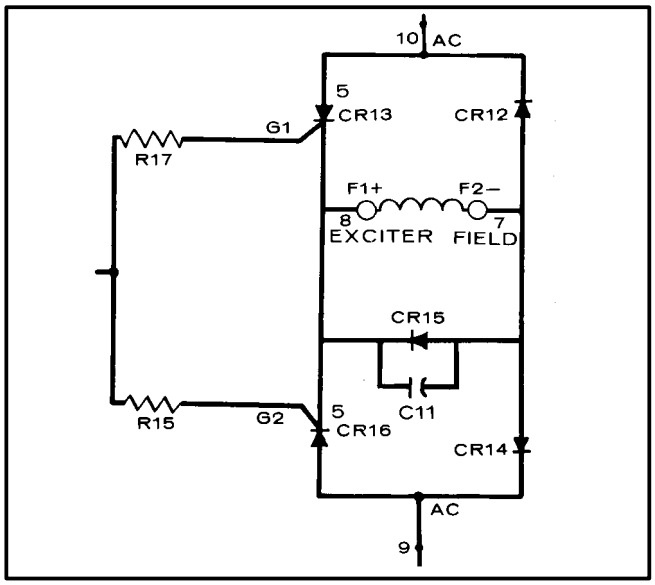

FIGURE 8. SILICON CONTROLLED RECTIFIER BRIDGE

[F]

TESTING OUTPUT BRIDGE DIODES

The output bridge rectifier diodes (Figure 8), CR12, CR14, and CR15, are located on the voltage regulator printed circuit board. Using an accurate ohmmeter, test diodes CR12, CR14, and CR15 as follows:

1. Connect one ohmmeter lead to each end of diode and observe resistance reading, Figure 9.
2. Reverse ohmmeter leads and again observe resistance readings.

   A good diode has a higher reading in one direction than the other. If both readings are high, or low, diode is defective.

3. Replace defective diodes with new, identical parts.

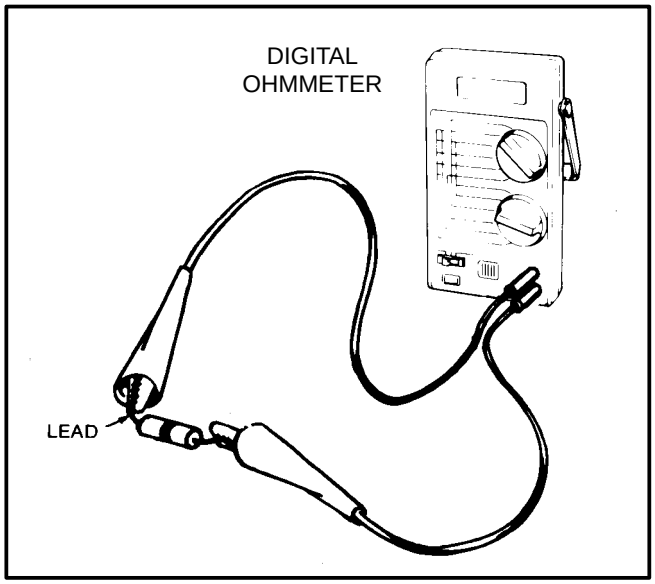

FIGURE 9, TESTING DIODES

[G]

TESTING SCR'S

Two identical silicon controlled rectifiers (SCR's), CR13 and CR16, control the DC output voltage to the exciter field. These SCR's are mounted in heat sinks on the voltage regulator and are tested as follows:

1. Using high scale on ohmmeter, connect ohmmeter leads to anode and cathode of the SCR as shown in Figure 10. The resistance reading should be one megohm or greater. Reverse ohmmeter leads to anode and cathode; resistance should again be one megohm or greater.

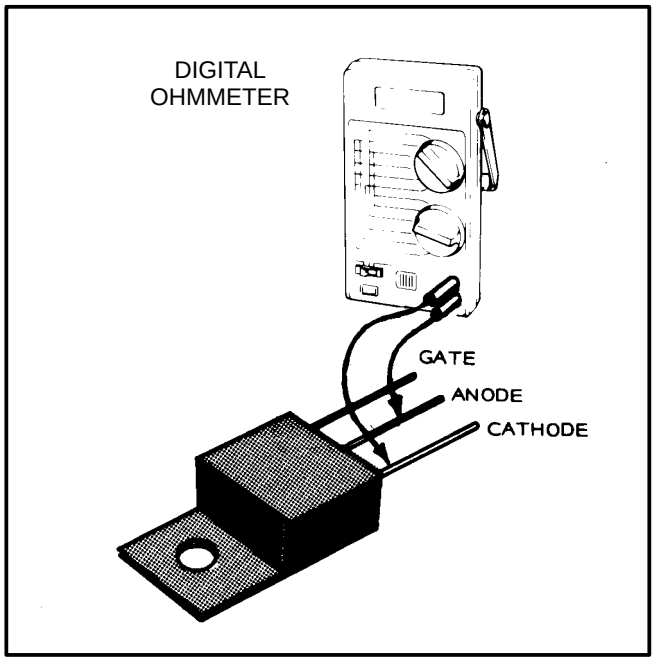

FIGURE 10. SCR RESISTANCE TEST

2. Using a 6 volt dry cell battery and a 200 ohm series resistor, observe correct polarity and connect battery leads to anode and cathode as shown in Figure 11. Observe polarity and connect a DC voltmeter across the 200 ohm resistor. The voltmeter should now read zero. Jumper anode to gate; voltmeter should now read 6 volts. Remove jumper; voltmeter should still read 6 volts because the SCR remains turned on until voltage is removed from anode to cathode.
3. If the SCR does not pass either test, it is defective. Replace defective SCR with a new, identical part.

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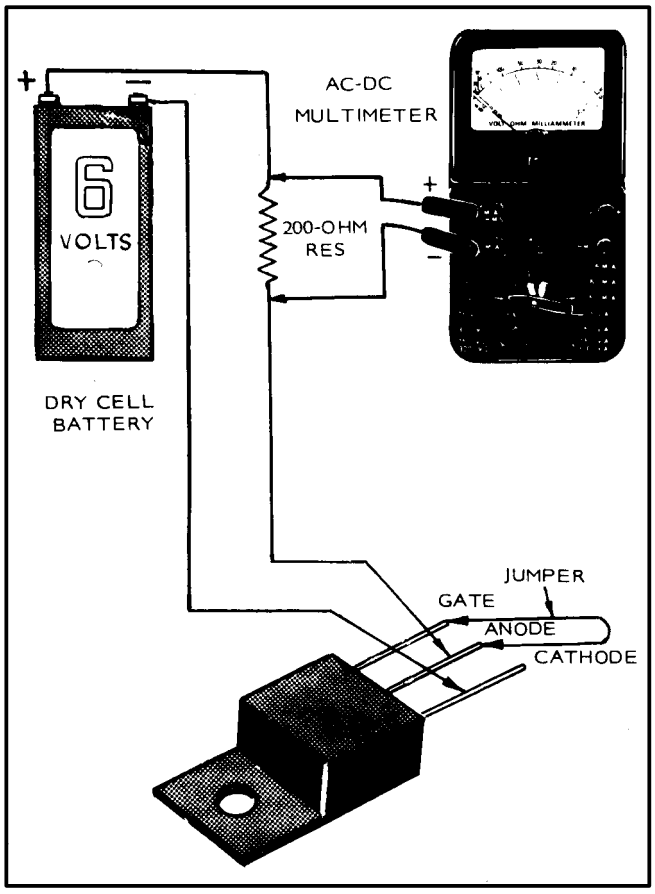
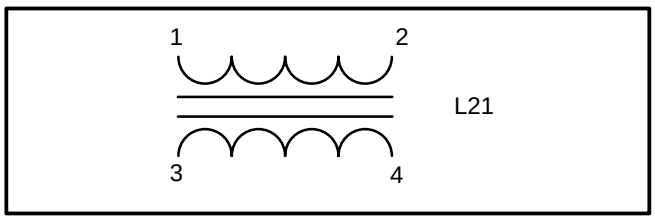


FIGURE 11. SCR VOLTAGE TEST

[H]

TESTING REACTOR

The reactor assembly L21 leads are marked 1, 2, 3 and 4. Wires 1-2 and 3-4 are wound on the same iron core.

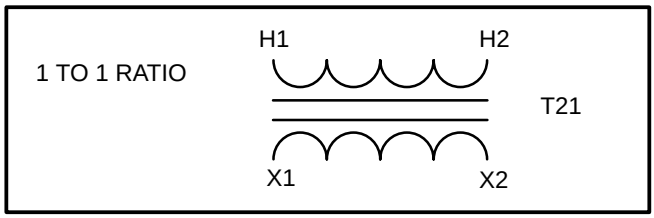


Resistance between 1-2 and 3-4 should be 0.33 to 0.39 ohms and 0.38 to 0.46 ohms respectively at 77° F (25° C). Resistance between coils (e.g. 1-3) and from any terminal to reactor frame should be infinity.

[I]

TESTING REFERENCE TRANSFORMER

The transformer T21 has four leads marked H1, H2, X1, and X2. H1-H2 are the primary leads. X1-X2 are the secondary leads.



Resistance between H1-H2 should be 113 to 139 ohms, between X1-X2 133 to 163 ohms at 77° F (25° C). Resistance between coils and from any terminal to transformer frame should be infinity.

[J]

TESTING BRUSHLESS EXCITER STATOR

Like the generator, the brushless exciter stator (Figure 12) can be tested for open or shorted windings and grounds.

Testing for Open or Shorted Windings:

Disconnect F1+ and F2– exciter field leads from terminal block in generator end bell. The resistance between field leads should be 10.98 to 13.42 ohms at 68° F (20° C).

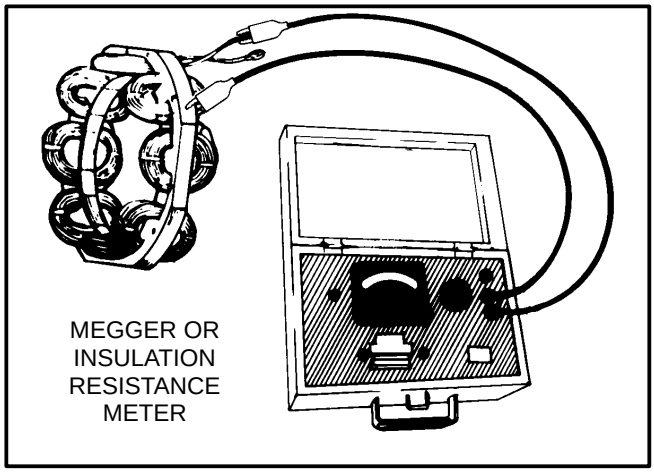


FIGURE 12. TESTING EXCITER FIELD FOR OPEN OR SHORTED WINDINGS

Testing for Grounds:

Connect Megger or insulation resistance meter between either laminations. Reading should be 1 megohm or greater. In not, the exciter stator is questionable and might require removal for oven drying and retest.

[K]

TESTING BRUSHLESS EXCITOR ROTOR (ARMATURE)

The brushless exciter rotor (Figure 13), can be tested for open or shorted windings, or grounds.

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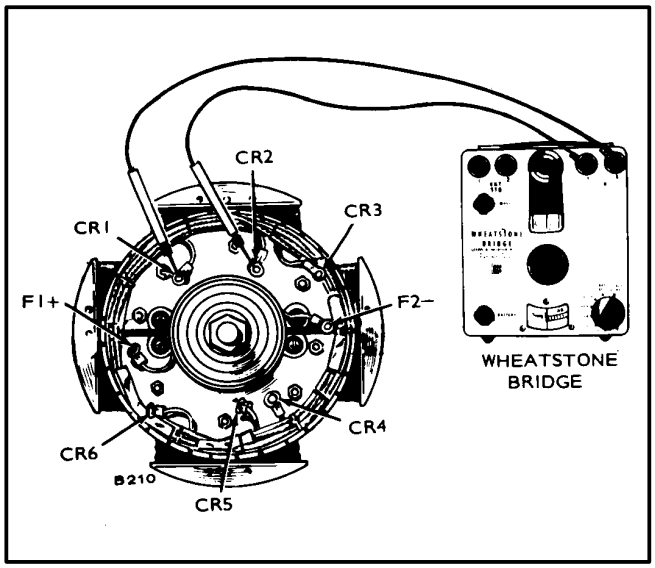

FIGURE 13. TESTING EXCITER ARMATURE

Testing for Open or Shorted Windings:

Use a Wheatstone Bridge for this test. Disconnect main rotor field leads which connect to rotating rectifier assemblies at F1+ and F2–. Disconnect lead wires from diodes CR1 through CR6. Test between exciter lead pairs T1-T2, T2-T3 and T1-T3. Resistance should be 0.5 to 0.6 at 68° F (20° C).

Testing for Grounds:

Use a Megger or insulation resistance meter that applies 500 VDC or more for this test.

With all generator leads disconnected from rotating rectifiers CR1 through CR6, apply test leads between any CR lead and the rotor lamination. Reading should be 1 megohm (1,000,000 ohms) or greater. If not, the exciter rotor is questionable and might require removal for oven drying and retest. A shorted rotor must be replaced.

[L]

TESTING GENERATOR ROTOR

For these tests, use an ohmmeter on R x 100 scale.

Testing for Grounds:

On brushless type generators, check for grounds between each rotor lead and the rotor shaft, Figure 14. Perform tests as follows:

1. Remove rotor leads F1+ and F2– from rotating rectifier assemblies.
2. Connect ohmmeter leads between F1+ and rotor shaft and between F2– and rotor shaft. Meter should not register.
3. If meter registers, rotor is grounded.
4. Replace grounded rotor with new, identical part.

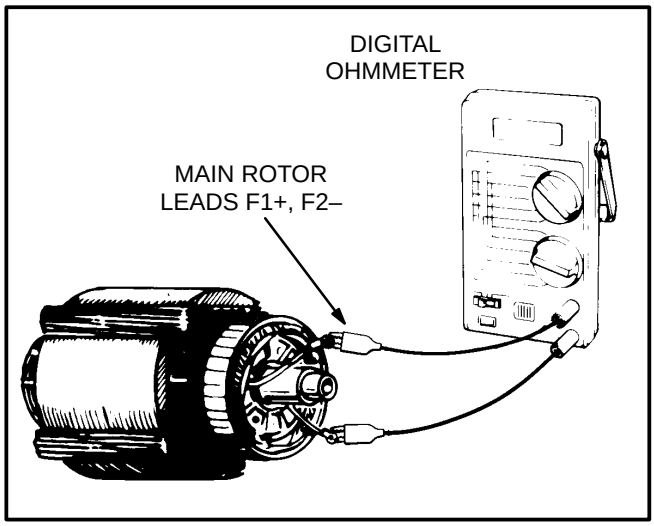

FIGURE 14. TESTING ROTOR FOR GROUNDS

Testing for Open or Shorted Winding:

All resistance values should be within ±10% of values specified in Table 2 at 77° F (25° C). Perform tests as follows:

1. Remove rotor leads F1+ and F2–0 from rotating rectifier assemblies.
2. Using ohmmeter, check resistance between F1 and F2 leads, Figure 15.
3. Replace defective rotor with new, identical part if resistance readings are not within limits shown in Table 2.

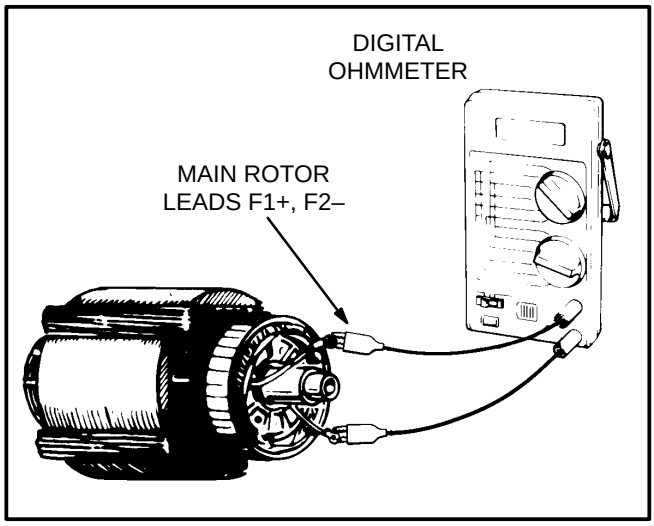

FIGURE 15. TESTING ROTOR FOR AN OPEN CIRCUIT

TABLE 2. RESISTANCE VALUES FOR ROTORS

ROTOR	ROTOR STACK LENGTH	RESISTANCE OHMS @77° F (25° C)
201-2984	5.8765	2.75
201-2985	7.125	1.80

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[M]

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.

Using an ohmmeter set at R x 100, test each stator winding for shorts to laminations. A reading less than one megohm indicates a ground.

Testing for Open or Shorted Windings:

Test for continuity between coil leads shown in Figure 16; all parts should have equal resistance. Use an accurate instrument for this test such as a Kelvin Bridge. The proper resistance values for the ES generator set are given in Table 3. All resistances should be ±10% of value shown.

If any windings are shorted, open or grounded, replace the stator assembly. Before replacing the assembly, check the leads for broken wires or insulation.

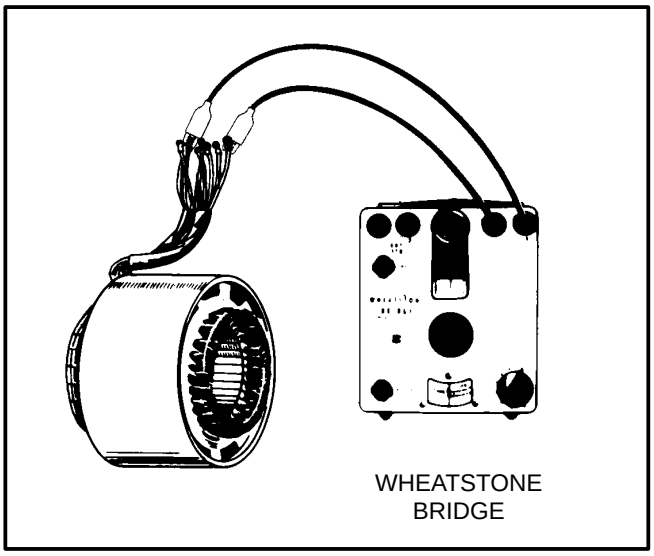

FIGURE 16. TESTING STATOR WINDINGS

[N]

WIRING HARNESS CHECK

Carefully check wiring harnesses 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 using an ohmmeter, check each wire end to end for continuity or opens.
3. Using an ohmmeter, check each wire against each of the other wires for possible shorts or insulation breaks under areas covered by wrapping material.
4. Reconnect or replace wires according to applicable wiring diagram.

[O]

VR21 REPLACEMENT

Use the following procedure for replacing the voltage regulator PC board.

1. Stop engine.
2. Disconnect and if necessary, label the following wires: 3, 4, 5 or 6, 7, 8, 9, and 10.
3. Remove four screws at corners.
4. Remove used PC board.
5. Install new PC board; secure with four screws.
6. Reconnect wires removed in step 2 at the proper terminals.
7. Place jumper W10 at proper terminals for your particular voltage code and voltage connection. See Figures 17 and 19.
8. Perform Voltage Calibration and Stability Adjustment procedures [A] and [B] to obtain the correct generator output voltage and stability with new PC board in set.

TABLE 3. RESISTANCE VALUES FOR STATORS

STATOR	PHASE	STATOR STACK LENGTH IN INCHES (mm)	RESISTANCE OHMS @68° F (20° C)
220-3691	1	5.75 (146)	.0686 ±10%
220-3685	3	5.75 (146)	.127 ±10%
220-3686	3	7.00 (178)	.104 ±10%

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VOLTAGE REGULATOR

The line-voltage regulator assembly VRA21 for the ES generator set is a solid state device. Basic components are:

- Printed circuit board VR21
- Voltage reference transformer T21
- Commutating reactor L21
- Field circuit breaker CB21
- Voltage adjust rheostat R22 (Optional)

Figure 17 shows the above components for typical control boxes. The electrical schematic and printed circuit board are shown in Figure 18.

The voltage adjust control R22 is optional on the VRA21 voltage regulator. When R22 is used, it is connected between VR21-1 and VR21-3 (Figure 17) and the jumper between VR21-1 and VR21-2 is removed.

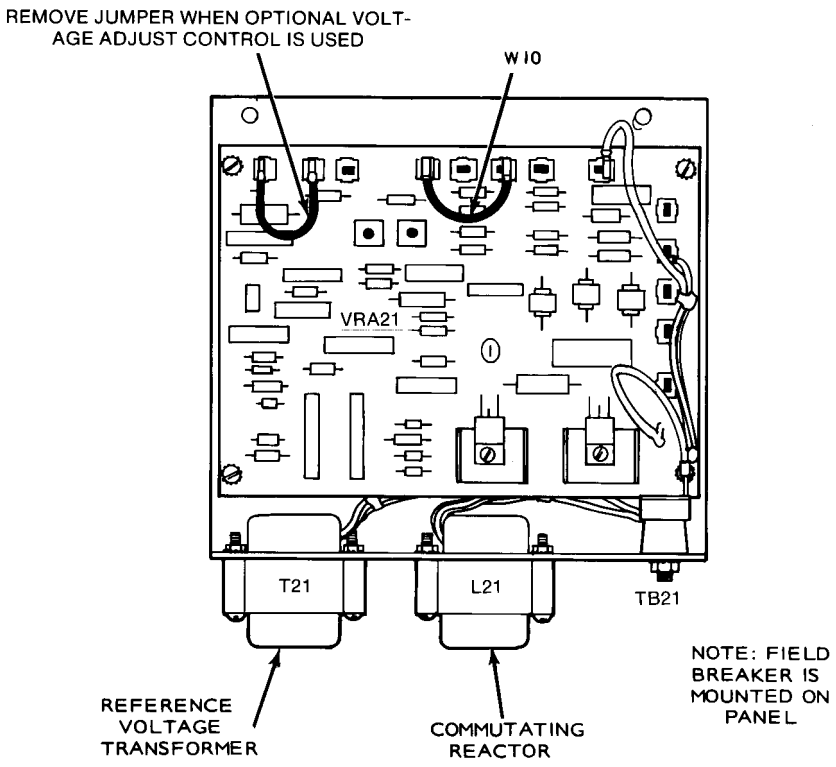

FIGURE 17. STANDARD YD VOLTAGE REGULATOR ASSEMBLY

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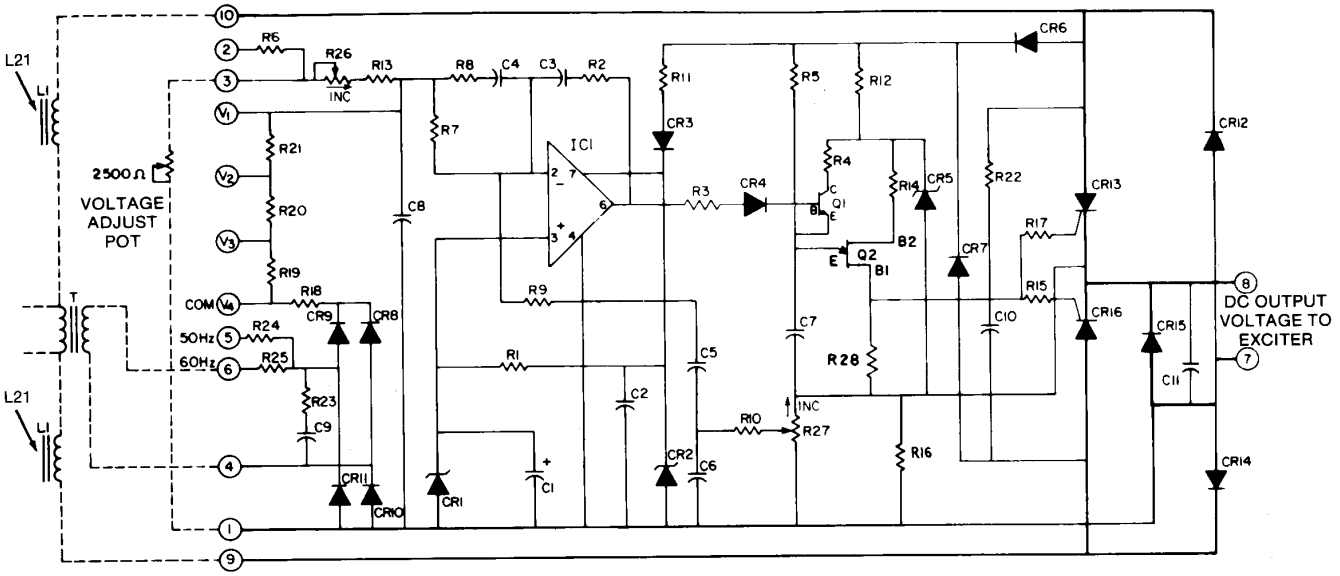
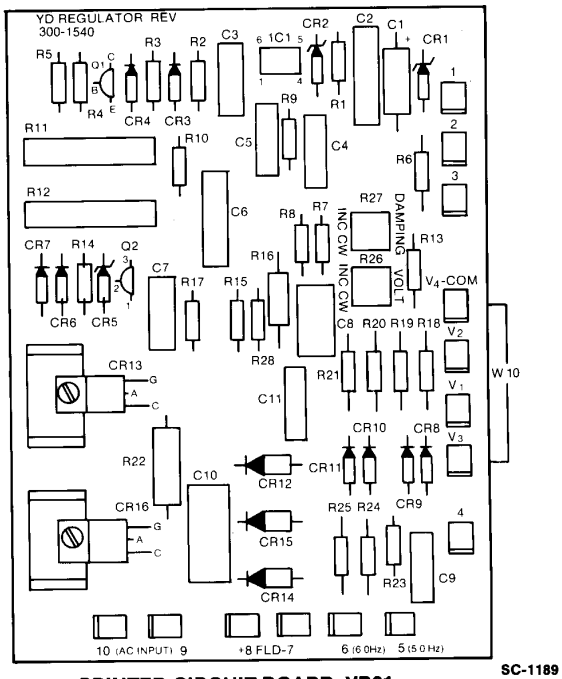


REGULATOR SCHEMATIC

REF. DES.	DESCRIPTION
T21	Transformer, Ref Voltage
L21	Commutating Reactor
IC1	INTEGRATED CIRCUIT
Q1	TRANSISTOR-NPN
R28	RESISTOR 47Ω 1/2W
R27	POTENTIOMETER 100KΩ
R26	" " 5.0KΩ
R25	RESISTOR-FILM 42.2KΩ, 1/4W
R24	" " 48.4KΩ, 1/4W
R23	RESISTOR 100, 1/2W
R22	RESISTOR 270Ω, 2W
R21	RESISTOR-FILM 2.67K 1/4W
R20	" " 1.53K 1/4W
R19	RESISTOR-FILM 3.00K, 1/4W
R18	RESISTOR FILM 28.0K, 1/4W
R16	RESISTOR 18KΩ 1W
R15, 17	" 33Ω, 1/2W
R14	RESISTOR 100Ω, 1/2W
R13	RESISTOR-FILM 11.0KΩ, 1/4W
R11, 12	RESISTOR-WIRE WOUND 4KΩ, 9W
R9	RESISTOR 1 MEGΩ, 1/2W
R8, 10	RESISTOR 100KΩ, 1/4W
R7	" 270KΩ, 1/2W
R6	RESISTOR-FILM 1.24KΩ, 1/4W
R5	RESISTOR 2 MEGΩ, 1/2W
R4	RESISTOR 3KΩ, 1/2W
R3	" 330KΩ, 1/2W
R2	" 220KΩ, 1/2W
R1	" 33KΩ, 1/2W
Q2	TRANSISTOR-UNIJUNCTION
CR13, 16	RECTIFIER-GATE CONT
CR12,14,15	RECTIFIER-DIODE
CR5	DIODE-ZENER 18V
CR3,4,6-11	RECTIFIER-DIODE 1A 400V
CR2	DIODE-ZENER 20V
CR1	" 5.6V
C10	CAPACITOR .47MFD 400V
C9	CAPACITOR .39MFD 250VDC
C8	" 1MFD 250VDC
C4, C5 C11	" .1MFD 250 VDC
C3, C7	" .22MFD 250 VDC
C2, C6	CAPACITOR .47 MFD 250VDC
C1	CAPACITOR-ELECTROLYTIC 100 MFD 10V



SC-1189

PRINTED CIRCUIT BOARD, VR21

NOTE: The 2500 ohm external voltage adjust potentiometer connects between pin 1 and pin 3. See regulator schematic. If your set does not have an external voltage adjust potentiometer, pin 1 is jumpered to pin 2.

FIGURE 18. STANDARD YD REGULATOR PC BOARD 300-1540

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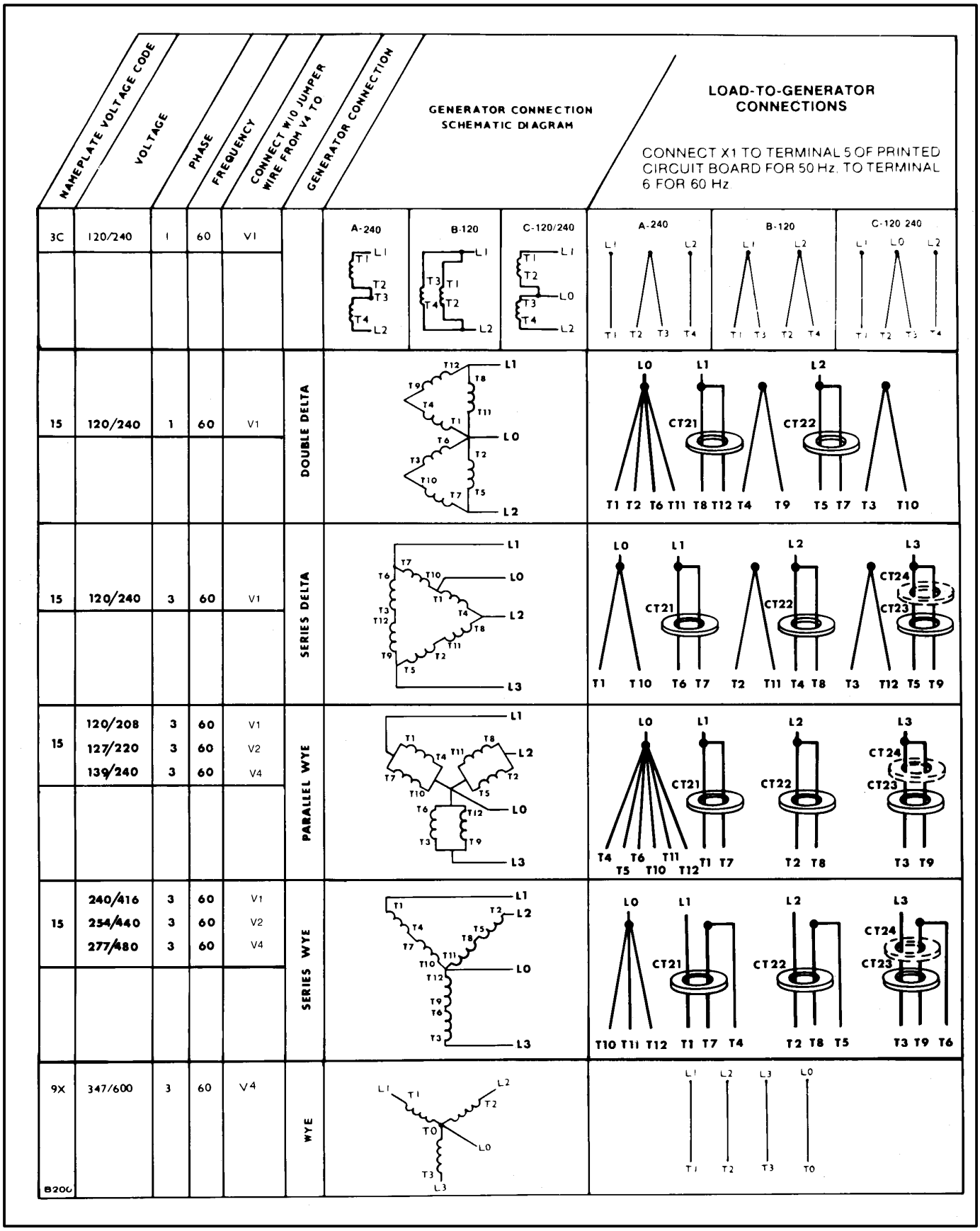

FIGURE 19. GENERATOR WIRING AND CONNECTION DIAGRAMS

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DC Control

GENERAL

The control box is mounted on vibration isolators on top of the generator output box. It can be mounted to face either side or the rear. Figure 20 illustrates a control panel that includes all the optional components.

The following components are standard on the control panel.

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

Reset / Lamp Test Switch. The switch is pushed to the **Reset** position (momentary contact) to reset the engine control to restore operation following a fault shutdown. The **Start / 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.

Oil Pressure Gauge. The oil pressure gauge indicates engine oil pressure.

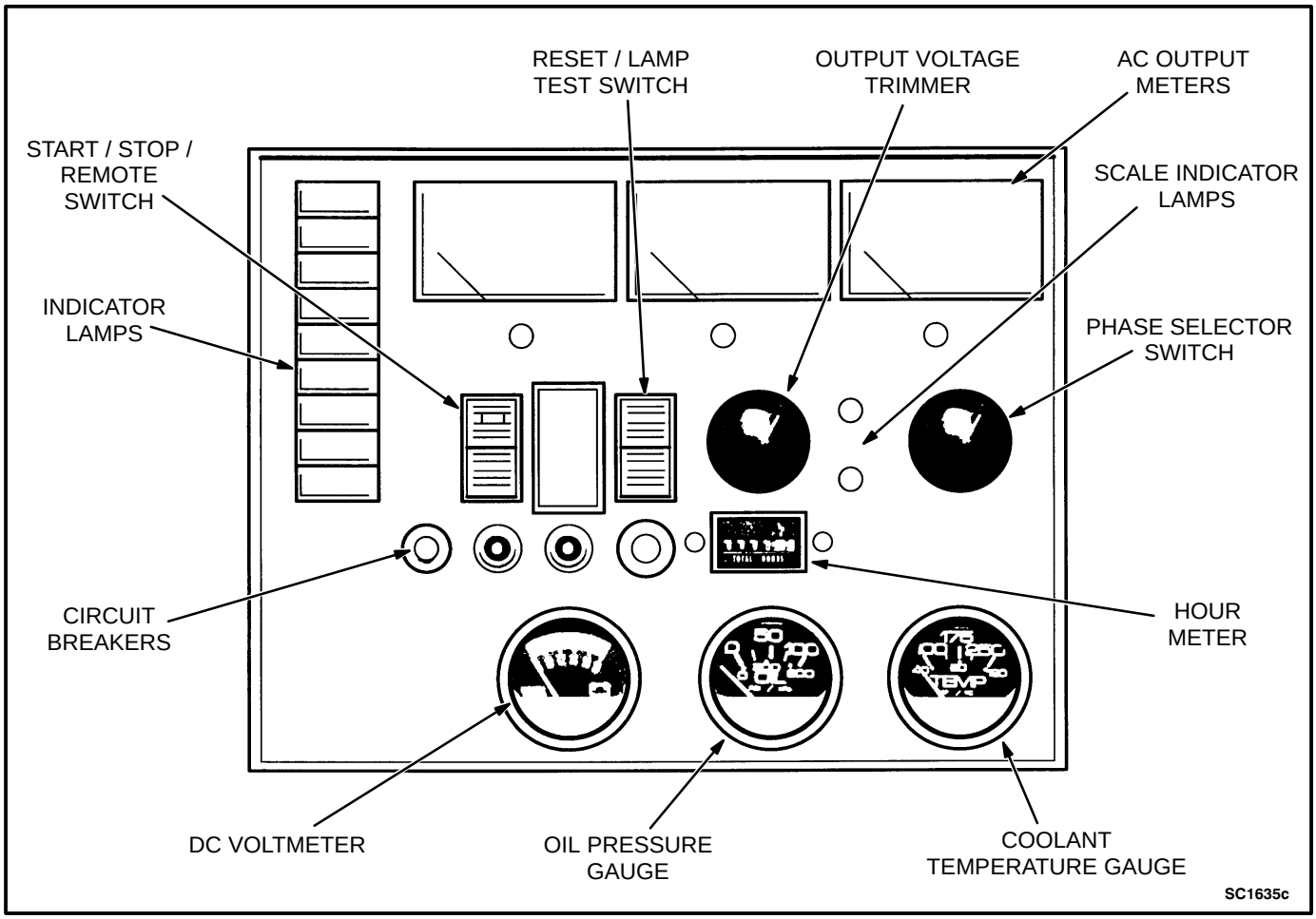

FIGURE 20. CONTROL PANEL

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Coolant Temperature Gauge. The coolant temperature gauge indicates engine coolant temperature.

DC Voltmeter. The DC voltmeter indicates battery charging voltage during operation.

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

Field Circuit Breaker. This circuit breaker protects the generator from over excitation.

Control Circuit Breaker. This circuit breaker protects the generator control circuits.

Remote Circuit Breaker. This circuit breaker protects the remote control circuits.

Auxiliary Circuit Breaker. This circuit breaker protects the governor and fuel solenoid circuits.

Two Indicator Lamps.

- **Run (Green).** This lamp indicates that the generator set is running and that the starter has been disconnected.
- **Fault Shutdown (Red).** This lamp indicates that the engine shut down because of one of the following faults.
  - **Low Oil Pressure.** Engine oil pressure dropped to less than 14 psi (97 kPA).
  - **High Engine Temperature.** Engine coolant temperature exceeded 222° F (106° C).
  - **Overcrank.** The engine shut down because it did not start during the timed cranking period.
  - **Overspeed.** The engine shut down because of overspeed.

OPTIONAL CONTROL PANEL COMPONENTS

The following components are optional on the control panel.

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

AC Ammeter. The ammeter indicates output amperage for the phase selected.

Frequency Meter. The frequency meter indicates output frequency in Hertz (Hz). Note that engine RPM is 30 times hertz.

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

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

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

Nine Indicator Lamps:

- **Run (Green).** This lamp indicates that the generator set is running and that the starter has been disconnected.
- **Pre-Low Oil Pressure Warning (Amber).** This lamp indicates that engine oil pressure is abnormally low (less than 20 psi [137 kPA]).
- **Low Oil Pressure Shutdown (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 Warning (Amber).** This lamp indicates that engine coolant temperature is abnormally high (greater than 215° F [102° C]).
- **High Engine Temperature Shutdown (Red).** This lamp indicates that the engine shut down because of excessively high engine coolant temperature (greater than 222° F [106° C]).
- **Overcrank Shutdown (Red).** This lamp indicates that the engine shut down because it did not start during the timed cranking period.
- **Overspeed Shutdown (Red).** This lamp indicates that the engine shut down because of overspeed. It is factory adjusted to shut down 60 hertz units at 2100 ±90 r/min, 50 hertz units at 1850 ±50 r/min.
- **Low Engine Temperature Warning (Amber).** This lamp indicates that engine temperature is less than 70° F (21° C) and the possibility that the engine might not start.
- **Switch-off Warning (Flashing Red).** This lamp indicates that the **Start/Stop/Remote** switch is in the **Stop** position, which prevents remote, automatic operation.

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Starter Solenoid Relay when energized (during cranking), provides full battery voltage to the starter.

Start Disconnect Relay disconnects the cranking circuit when the engine starts. The relay, energized by output voltage from the field flash terminal of the belt driven alternator, also turns the green Run indicator lamp on.

Fault Relay, when energized, turns the engine off and prevents a restart until the fault condition is corrected and the Reset switch pressed. The relay can also operate a remote DC alarm (5 ampere maximum) connected to the Fault terminal of the Engine Monitor Circuit Board (Figure 21).

Overcranking Circuit, a solid state circuit on the engine Monitor Circuit Board, limits engine cranking time from 45 to 75 seconds. If the engine fails start within this time span, the fault Relay energizes to stop cranking. The red overcrank indicator lamp (optional) and common fault alarm are turned on.

Voltage Regulator Assembly (Generator AC) controls AC generator output voltage at a predetermined level within load limits. Regulation is plus or minus1 percent from no load to full load with isochronous governing.

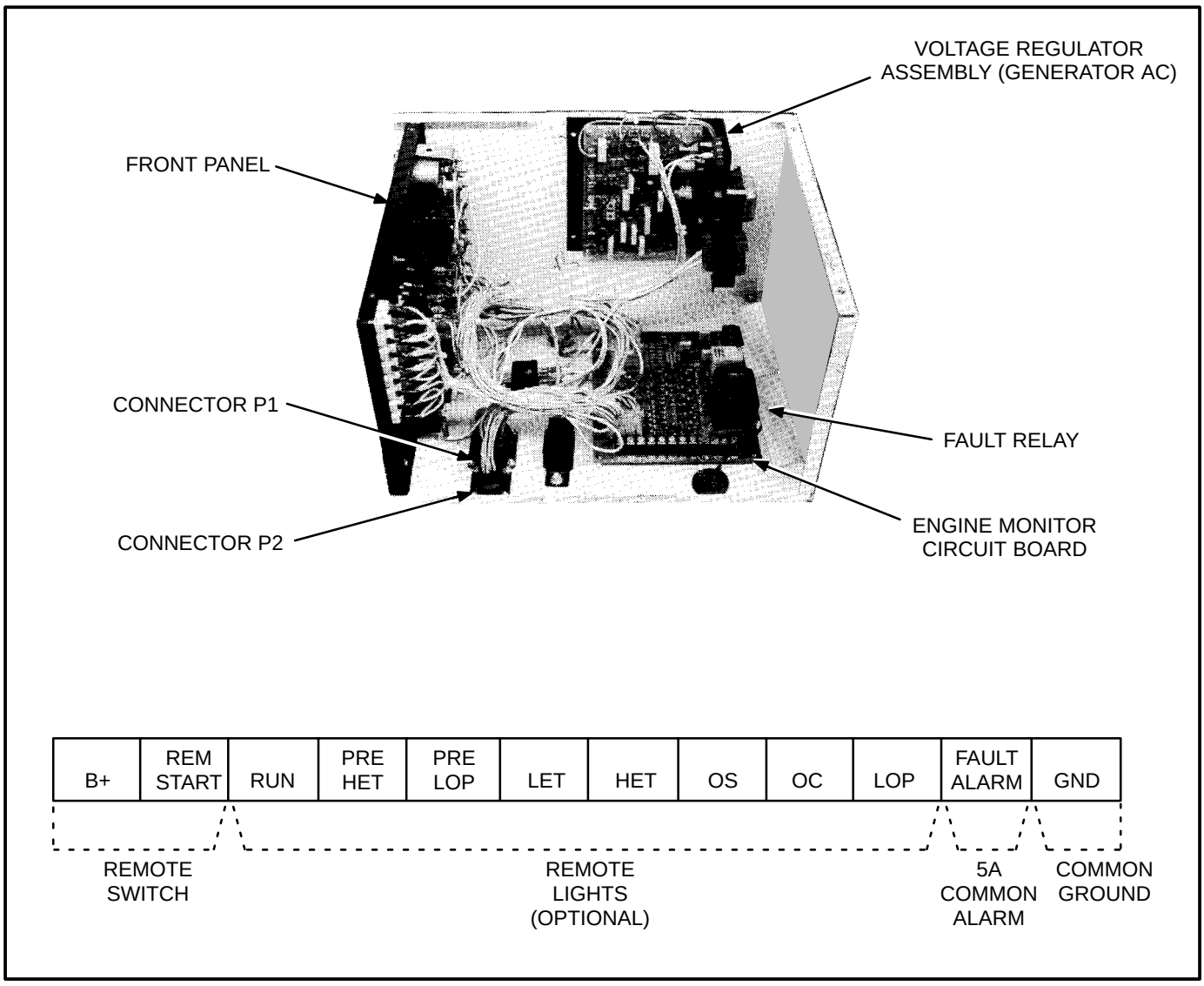

FIGURE 21. CONTROL PANEL INTERIOR COMPONENTS AND REMOTE CONNECTIONS

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ENGINE ACCESSORIES AND SENSORS

The following briefly describes the engine mounted sensors and switches (Figure 22), and how they protect the engine from unfavorable operating conditions.

All cut-off switches close and energize the Fault Relay to stop the engine if abnormal operating conditions exist. The respective control panel red lamp (optional) lights to indicate cause of the shutdown. The red Switch Off Lamp (optional) flashes ON and OFF if the Start Switch is left in the stop position (preventing automatic starting of set).

The optional remote fault alarm can be connected to the terminal shown in Figure 21. Current limitations for optional equipment not suppled by ONAN are 100 milli-amperes for each indicator lamp and 5 amperes for the fault alarm.

⚠ CAUTION ***Control components can be damaged if these current limits are exceeded for the optional equipment.***

Resistance units and switches in the monitoring and shutdown systems are sealed units and not repairable. When replacing a sensor, do not use a substitute item, since resistance units are matched to the gauge they supply. Cutoff switches are close tolerance actuation parts made for a specific application.

Oil Pressure Monitors

The oil pressure sender resistance changes with oil pressure and results in a reading on the oil pressure meter. The meter range is 0 to 100 psi (0 to 700 kPa). The low oil pressure switch closes if pressure drops to 14 psi (97 kPa), stopping the engine and activating the optional low oil pressure fault lamp.

The optional pre-low oil pressure switch closes at 20 psi (138 kPa) and turns on the amber Pre Lo Oil Pres lamp. The engine does not shut down, but the warning lamp remains on until the Reset switch is pressed (verify condition is corrected).

Engine Temperature Monitors

The resistance of the temperature sender unit changes with the engine coolant temperature and causes a reading on the Water Temp meter. The meter range is 100° to 250° F (40° to 121° C). If coolant temperature rises to 222° F (106° C, the high engine temperature cut-off switch closes, stops the engine, and lights the (optional) red High Engine Temperature Light.

⚠ CAUTION ***The High Engine Temperature Cutoff will shut down the engine only if coolant level is sufficiently high to physically contact shutdown switch. Loss of coolant will allow engine to overheat without protection of shutdown devices, causing severe damage to the engine. Make sure to maintain adequate engine coolant levels to provide proper operation of the cooling system and engine coolant overheat shutdown protection.***

The optional pre-high engine temperature switch closes at a nominal 215° F (102° C) and turns on the amber Pre/ Hi Eng Temp lamp. The engine does not shut down, but the warning lamp remains on until the Reset switch is pressed (verify condition is corrected).

The optional low engine temperature switch closes if coolant temperature drops below 70° F (21° C) to turn on the red Lo Eng Temp light. In locations where ambient temperatures drop below 70° F (21° C), the lamp indicates malfunction of the optional coolant heater.

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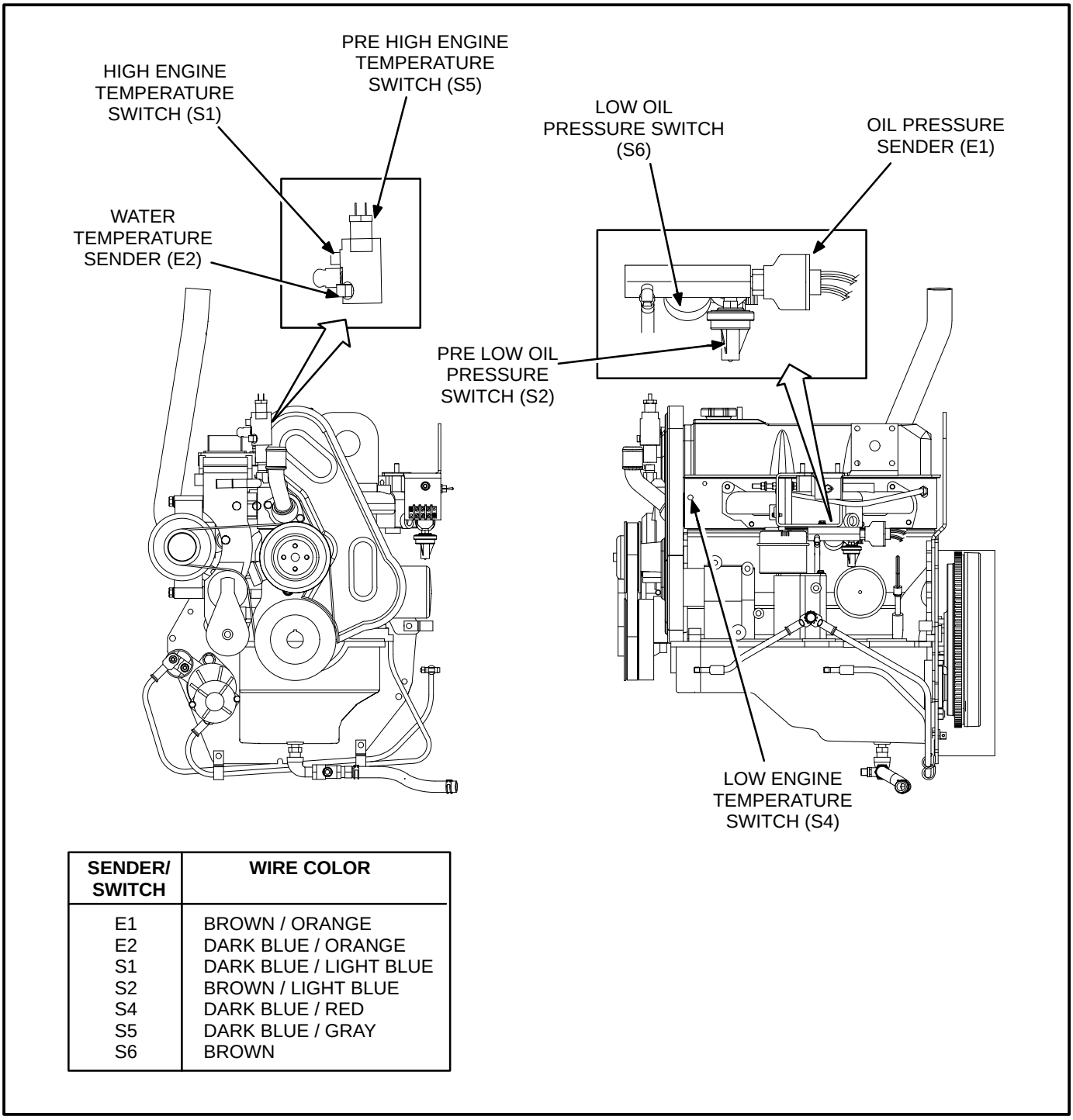

SENDER/ SWITCH	WIRE COLOR
E1	BROWN / ORANGE
E2	DARK BLUE / ORANGE
S1	DARK BLUE / LIGHT BLUE
S2	BROWN / LIGHT BLUE
S4	DARK BLUE / RED
S5	DARK BLUE / GRAY
S6	BROWN

FIGURE 22. ENGINE ACCESSORIES AND SENSORS

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Overspeed Switch

The overspeed switch (Figure 23) is a mechanical switch which grounds the overspeed circuit on the Engine Monitor Circuit Board, causing an engine shutdown and activating the optional overspeed fault lamp if an overspeed condition exists. After the problem is corrected, starting will not occur until the Reset switch is pressed.

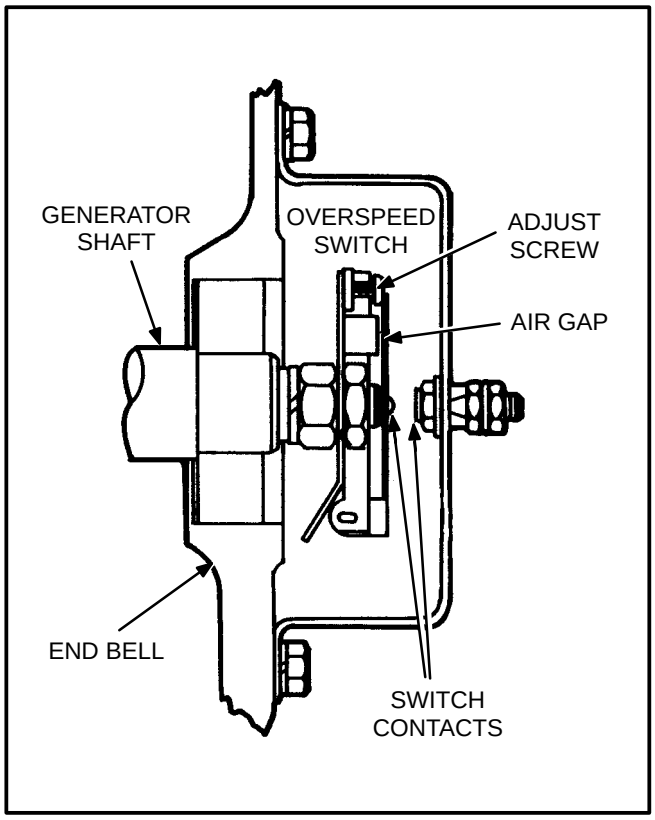

FIGURE 23. OVERSPEED SWITCH

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Engine Control System Operation

GENERAL

Dependable, trouble-free operation of the control system should be a major goal of generator set service personnel. Service personnel must thoroughly understand how the controls operate, know how to check for troubles, and know how to make the proper adjustments, replacements, or repairs in a reasonable amount of time.

The circuitry, control components, and operating cycles for the ES generator set are described below.

Prior to starting the generator set, review pre-start checklist in the Operator's manual, including checking for exhaust and fuel leaks, check the fuel supply, engine oil level, and all battery connections for loose or broken wires. If an automatic demand control is in use, check for correct connections.

The DC start and run circuits are supplied by the 12 volt battery and charging alternator. The control circuits are completed by returning to ground (negative post of battery).

The wiring diagram on Pages 41 or 42 shows the wiring diagram for the ES generator set described in the following Starting, Start-Disconnect and Stopping sequences. Relay contact references normally open (NO) and normally closed (NC) refer to position of contacts with the unit at rest (not energized).

STARTING SEQUENCE

Press the Start-Stop switch to the Start position. The engine will start and run. Release the Start-Stop switch when engine starts.

⚠ CAUTION ***Do not hold switch longer than 30 seconds during any attempt to start. Longer periods may damage the starter motor and discharge battery needlessly.***

1. The start circuit is completed by Start-Stop switch S10 at the Start position. This action energizes relay K2 of the engine monitor board (EMB), which supplies B+ to relay K5 (starter solenoid pilot relay) and EMB relay K2 which supplies B+ to relay K4 (switch B+ relay).
2. Energizing K5, energizes the starter solenoid.
3. Energizing K4 supplies B+to the governor and also energizes the fuel solenoid.

START-DISCONNECT SEQUENCE

When the engine starts, B+ from the field flash terminal of the alternator energizes the EMB Start Disconnect Relay K5. Energizing EMB relay K5 removes the B+ from EMB Start Relay K3. Also, AC disconnect through K11, breaks B+ to the start solenoid relay K5.

STOPPING SEQUENCE

Pressing S10 to Stop position de-energizes EMB relays K2 and K4 which opens B+ circuit to the ignition system, fuel solenoid and governor control.

EMERGENCY SHUTDOWN

EMB Fault Relay K6 is directly energized by one of the following fault sensors; S6 low oil pressure switch, S1 high engine temperature switch, S3 overspeed switch, OC (overcrank) Limiter.

When jEMB relay K6 is energized a NC set of contacts open B+ to the EMB Power Relay K2 and another set closes to connect B+ to an optional fault alarm. The engine sensor causing the fault, triggers a solid state circuit that lights up the appropriate fault lamp on the control panel. The engine cannot be started until fault condition is corrected and the Reset Switch S12 pressed.

The Low Oil Pressure Delay circuit is not actuated until the Start-Disconnect Relay is energized. The circuit allows a delay of 7.5 to 12.5 seconds before LOP shutdown and pre-alarm are functional. Following this initial delay, both the LOP shutdown and pre-alarm functions are immediate.

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Engine Control Troubleshooting

GENERAL

The data in this section is divided into three flow charts, and information on troubleshooting the ES solid-state engine control (page 28). The flow charts consists of:

A. Engine does not crank.

B. Engine cranks but does not start.

C. Engine starts but stops when start switch is released.

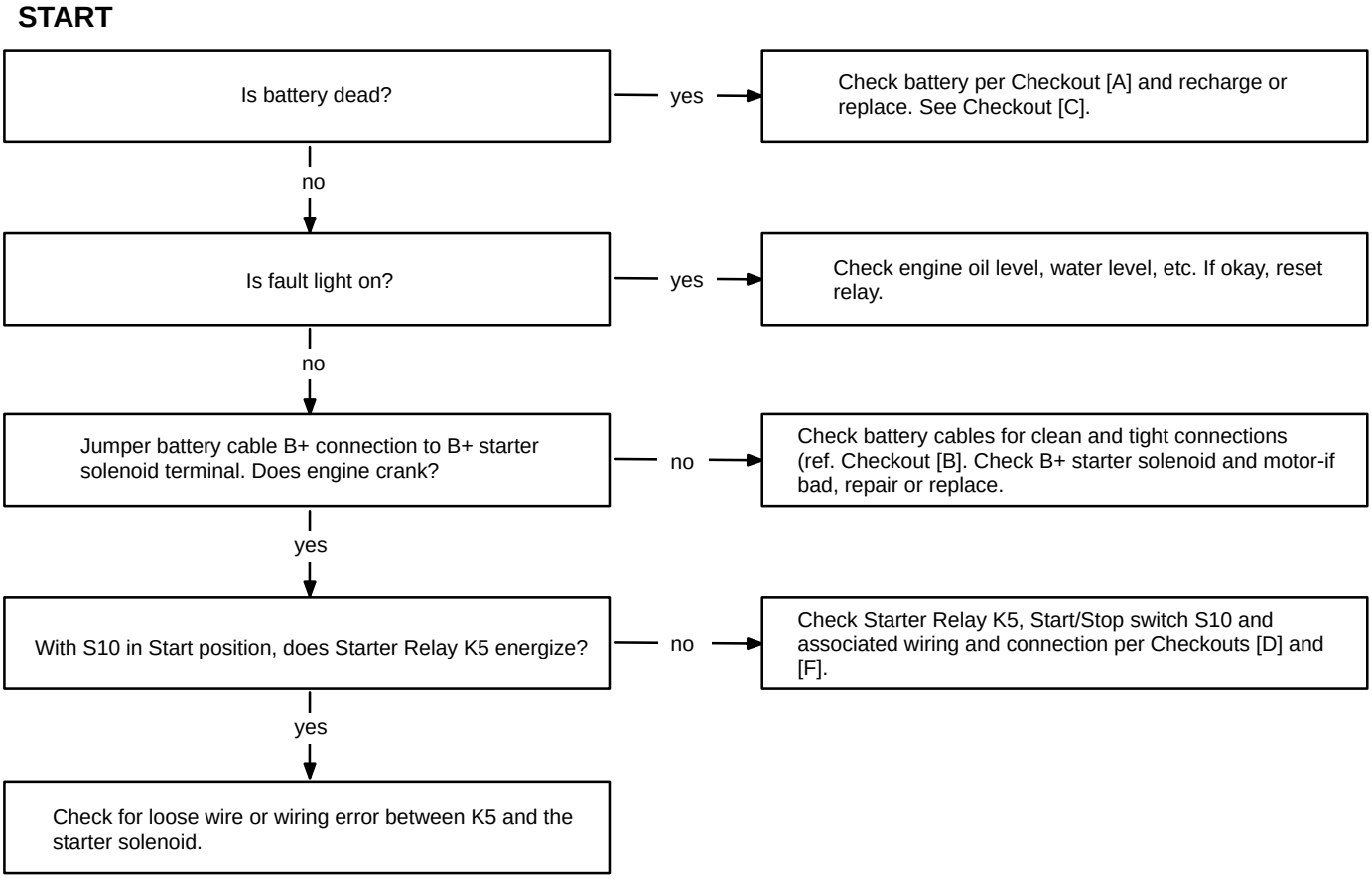
Before starting a troubleshooting procedure, make a few simple checks that may expose the problem and cut down on troubleshooting time.

- Check all modifications, repairs, 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.
- Unless absolutely sure that panel instruments are accurate, use portable test meters for troubleshooting.

To troubleshoot a problem, start at the upper-left corner of chart and answer all questions either YES or NO. Follow the chart until the problem is found, performing referenced Control Component Checkout procedures on page 29. Refer to wiring diagrams in last section in manual for locating control component leads, terminals and other check points.

⚠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 pages i and ii.***

FLOW CHART A. ENGINE DOES NOT CRANK



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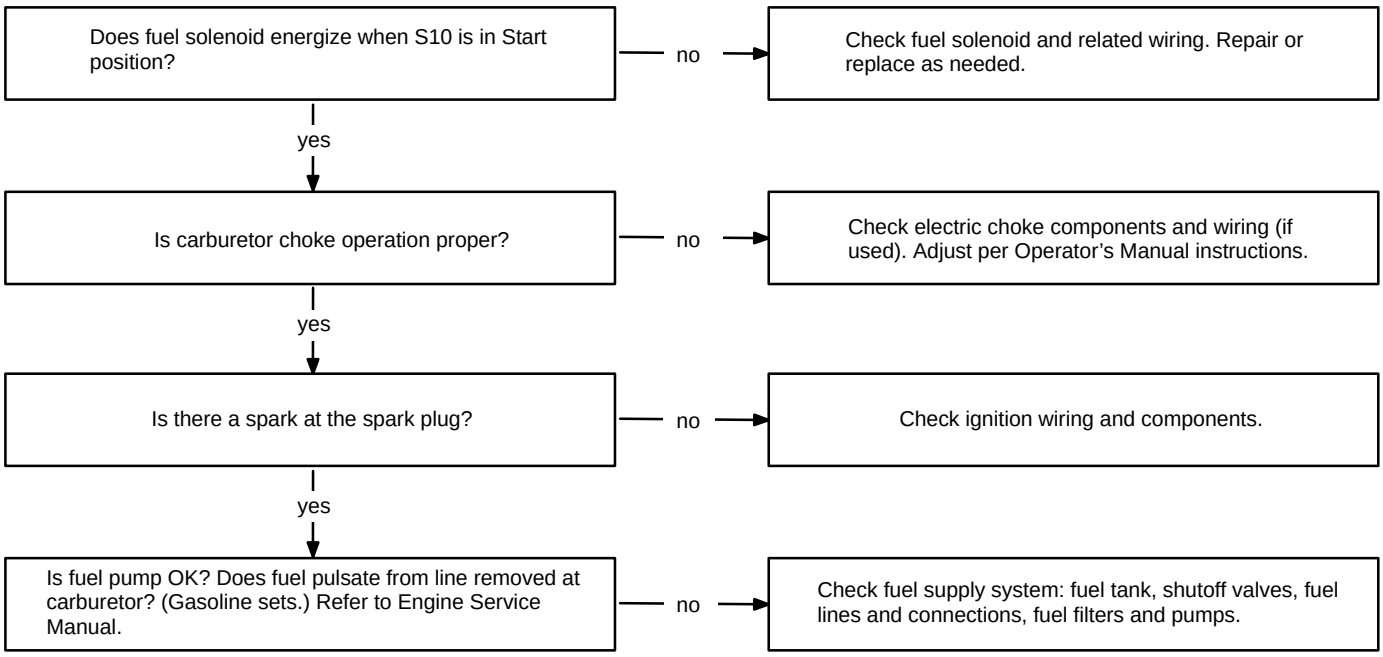
⚠WARNING ***Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review Safety Precautions on pages i and ii.***

FLOW CHART B. ENGINE CRANKS BUT DOES NOT START

START



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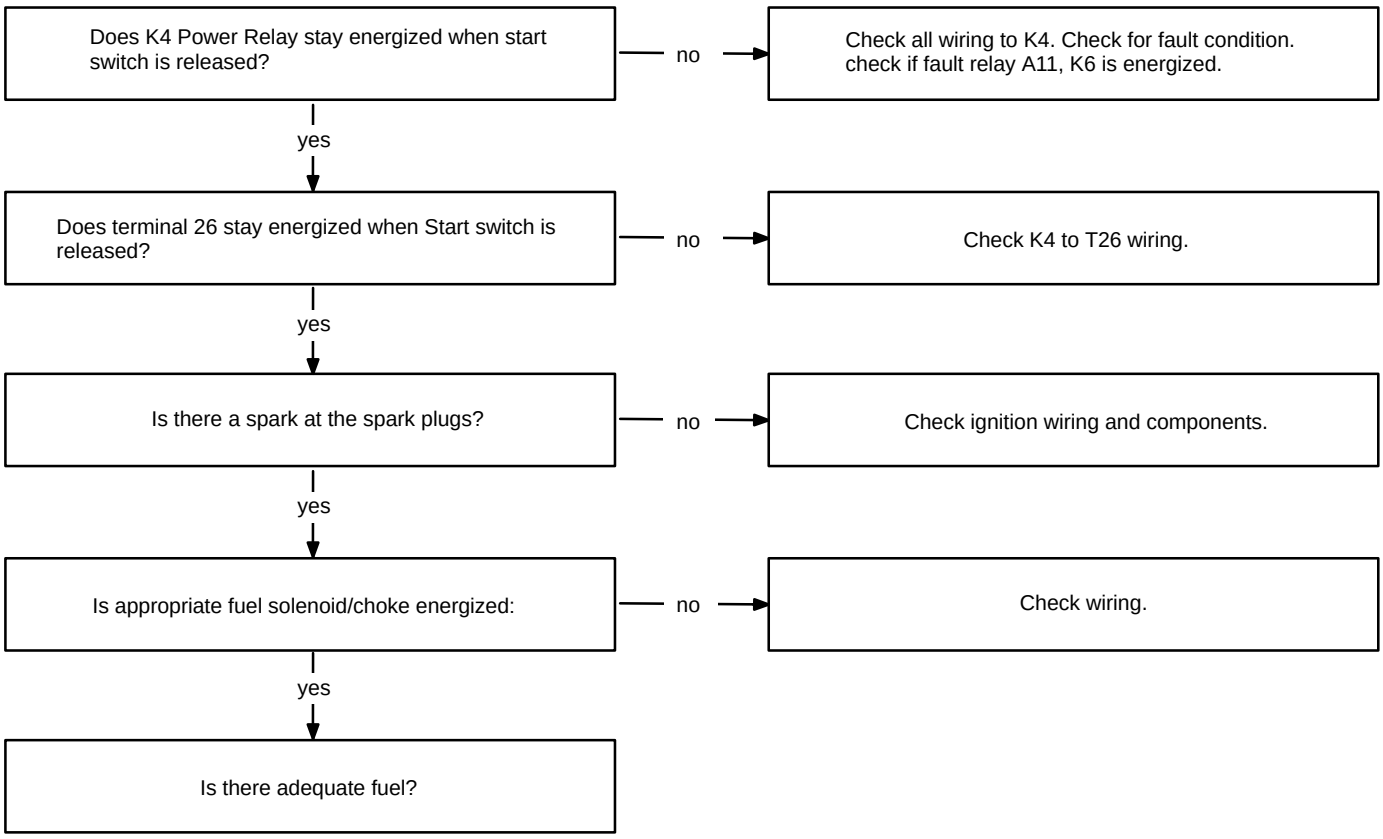
⚠WARNING ***Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review Safety Precautions on pages i and ii.***

FLOW CHART C. ENGINE STARTS BUT STOPS WHEN START SWITCH IS RELEASED

START



TROUBLESHOOTING ENGINE CONTROL

Refer to Engine Control System Operation and the schematics on pages 40 and 41 when troubleshooting this control. Repair information is not extensive since the solid-state printed circuit board lends itself more to replacement than repair. External components such as leads, switches, indicator lights, relays gauge senders, circuit breakers, DC voltage regulator, etc,. plug into the board.

If an external component is suspected of causing a problem, disconnect its associated jack (J1, J2 or J3) from the board (Figures 30 and 31) and check continuity of wiring and the component. Note some switches are NC and some NO with unit at rest. Individual components can be checked out as referenced in “Control Component Checkout” on page 29.

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Control Component Checkout

The following component checkouts are referenced in the Control Troubleshooting flow charts, pages 26 to 29. They are an aid to isolating circuit problems caused by faulty engine control components.

⚠WARNING ***Troubleshooting procedures presents hazards of electrocution, asphyxiation, burns, cuts, and other personal injury or death. Review Safety Precautions. Service personnel must be trained and experienced.***

[A]

BATTERY CHECKOUT

Check charge condition of the battery with a hydrometer. The 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 and recharge the battery. If battery will not recharge, replace it.

If the battery loses excess water, the generator charge rate may be too high. Likewise, if battery state of charge is not maintained, the charge rate may be too low. Refer to CHARGING CIRCUIT CHECKOUT [C].

⚠WARNING ***Ignition of explosive gases can cause severe personal injury. Do not smoke while servicing the batteries.***

[B]

BATTERY CABLE CHECKOUT

With the starter motor operating, check the 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, each of these should be less than 0.3 volt. If extra long battery cables are used, slightly higher voltage drops may result. Thoroughly clean all connections in any part of the circuit showing excessive voltage drop.

[C]

CHARGING CIRCUIT CHECKOUT

With the engine running at rated speed, check alternator output at battery positive (+). Voltage should indicate between 13.9 and 14.7 volts depending on regulator ambient temperature. A voltage higher than 15 volts may indicate a bad ground or defective voltage regulator.

[D]

RELAY CHECKOUT

1. Connect 12 volts across relay coil terminals. Relay should activate if coil is okay.
2. Connect 12 volts to one side of relay contacts.
3. Connect a voltmeter to other side of relay contact and 12 volt source. If 12 volts appear when relay is energized, contact is okay. The 12 volt reading appears in reverse order when checking normally closed (NC) contacts.

[E]

RESISTOR CHECKOUT

1. Remove battery B+ cable.
2. Disconnect one side of resistor and using an ohmmeter measure across resistor for an accurate reading.

[F]

SWITCH CHECKOUT

1. Remove battery B+cable.
2. Place ohmmeter leads across switch.
3. Activate switch. If meter reads continuity, switch is good.

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Fuel System / Governor

FUEL SYSTEM

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

These units can be equipped to operate on gasoline only, LPG (propane), gasoline/natural gas, gasoline/LPG and LPG/natural gas combinations. Figures 24 and 25 illustrate the fuel system components for various generator set configurations. A fuel selector switch may be provided for fuel changeover. (The position of the switch determines which fuel valve, gasoline, natural gas or LPG, will open when the set is operated).

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 located on the governor control mounting bracket, 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. If the generator set is equipped with a fuel selector switch, the position of the switch determines which solenoid valve will open for operation. If not equipped with a fuel selector switch, fuel changeover occurs automatically. (While the engine is running, a 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.)

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). The throttle assembly is controlled by an electronic governor.

The maximum permissible fuel supply pressure is 20 inches WC (water column) and the minimum is 10 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.

The recommendations in Onan publication T030, the *Application Manual for Liquid-Cooled Generator Sets*, should be followed in regard to fuel supply system pipe sizes, manual shutoff valves, fuel filters and gas pressure regulators.

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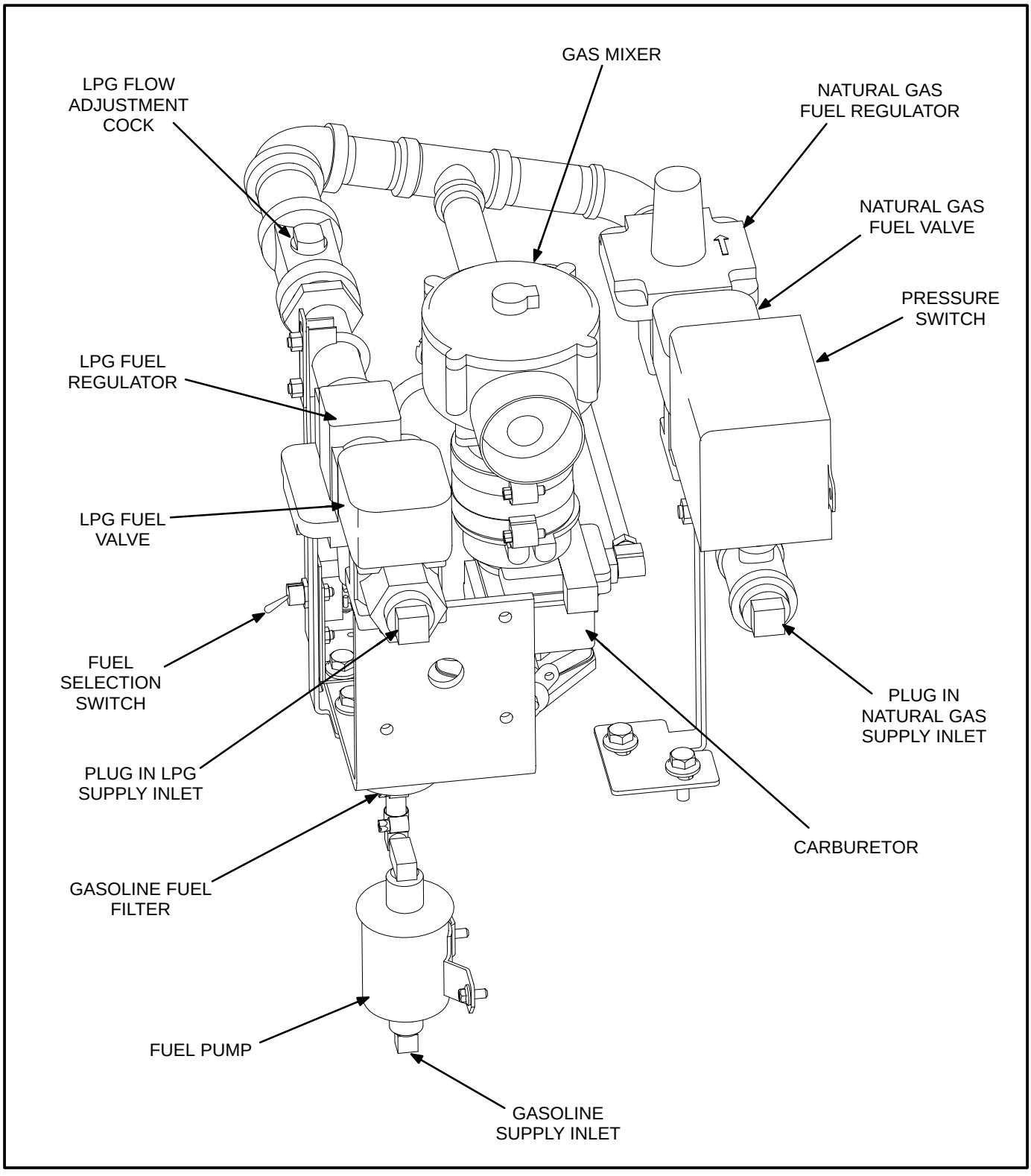

FIGURE 24. GASOLINE/NATURAL GAS/LPG VAPOR FUEL SYSTEM

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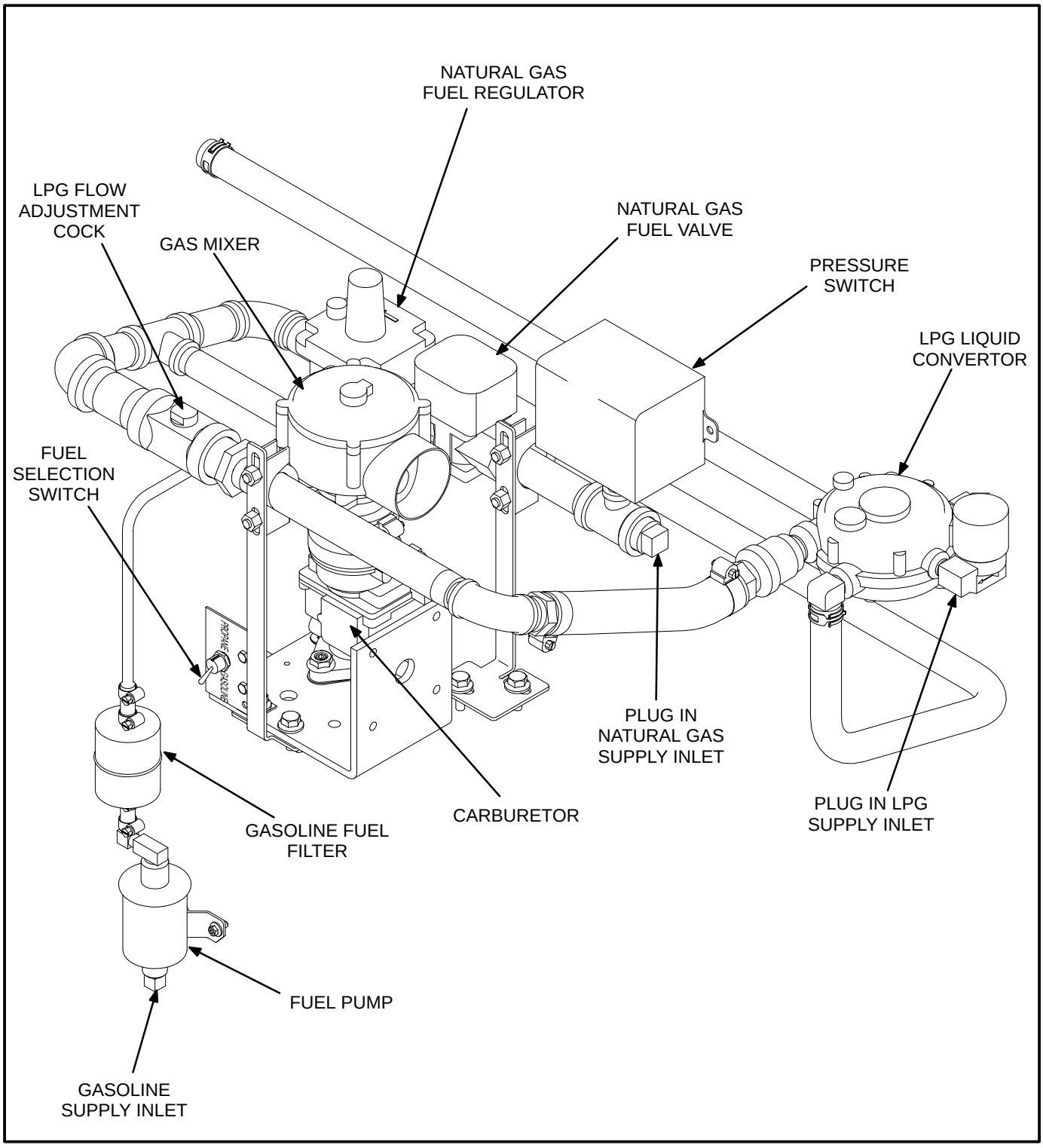

FIGURE 25. GASOLINE/NATURAL GAS/LPG LIQUID FUEL SYSTEM

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GASOLINE CARBURETOR ADJUSTMENT

A gasoline carburetor is provided for gasoline fuel systems. The idle mixture and choke are adjustable on the gasoline carburetor.

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 2-1/2 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.

Choke Adjustment: 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 and rotate the cover clockwise 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 so that the asterisk (*) is one or two lines past the line on the housing and re-tighten the cover screws.

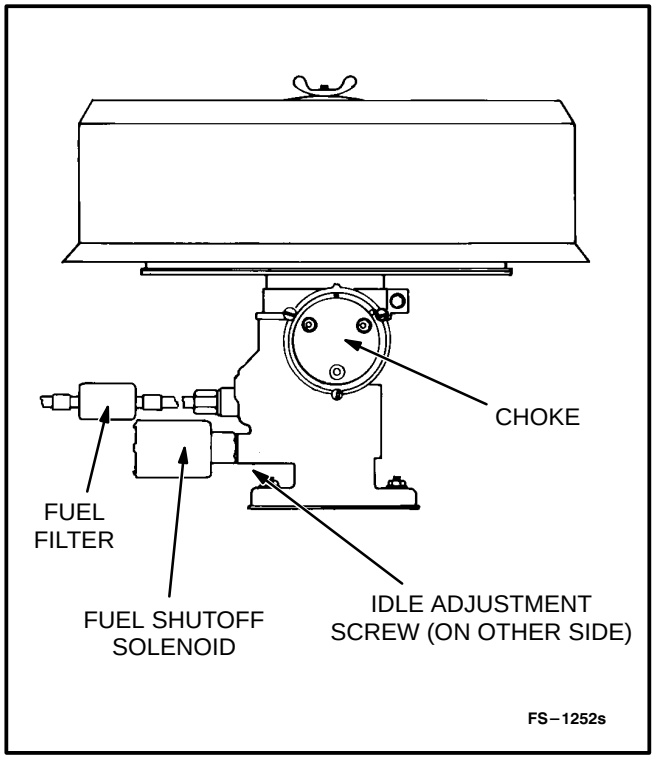

FIGURE 26. GASOLINE CARBURETOR

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GAS MIXTURE AND IDLE SPEED STOP ADJUSTMENTS

The gas mixer has power and idle mixture adjustments, the throttle assembly an idle speed stop screw, the natural gas fuel regulator a pressure adjusting screw and the LPG line a flow cock. See Figure 27.

Before starting adjustments, it is recommended that natural gas and LPG supply pressures be checked by removing the 1/8 NPT plugs in the pressure test ports at the fuel regulator inlets and connecting a water manometer. It is recommended that the service pressure regulators be adjusted to the maximum supply pressure of 20 inches WC under no-flow conditions (set not operating).

⚠ CAUTION ***During the course of these tests wide excursions in voltage and frequency can be expected. Make sure all voltage and frequency sensitive equipment have been disconnected prior to conducting these tests to protect from damage. Consequential damage to equipment as a result of failing to observe this precaution is not covered under the Onan warranty policy.***

⚠ WARNING ***Natural gas and LPG are explosive. Do not allow any cigarettes, flames, pilot lights, sparks, arcing equipment or switches or other sources of ignition around the generator set or in areas with common ventilation when performing maintenance or adjustments.***

Idle Speed Stop and Mixture Adjustments

1. Connect a tachometer if the set does not have a Hertz/RPM meter, **start the set up on natural gas** and let the engine warm up under approximately 1/4 rated load.
2. Disconnect the set from all loads, carefully disconnect the governor linkage by unsnapping the ball and socket joint at the throttle lever and close the throttle by hand. (The set will shut down if the engine is allowed to overspeed, and then the engine control will have to be reset.) While holding the throttle closed, adjust the idle speed stop screw to obtain an engine speed of 900 RPM. Reconnect the governor linkage.
3. While the engine is still running, turn the idle mixture screw clockwise (richer) until the engine begins to miss and then counterclockwise (leaner) until it again begins to miss. Then turn the screw to a position midway between the two extreme positions.

Main Mixture Adjustment

1. Connect the manometer to the outlet pressure test port of the natural gas fuel regulator, **start the set up on natural gas** and let the engine warm up under approximately 1/4 rated load.
2. While the engine is warming up, check the manometer, and if necessary, adjust the pressure to 5 inches WC by turning the regulator pressure adjusting screw located under the screw-on cap. Be sure to replace the cap.
3. Connect rated load and turn the power mixture cock counterclockwise (richer) until the engine begins to miss and then clockwise (leaner) until it again begins to miss. Then turn the cock to a position midway between the two extreme positions.
4. Switch to LPG (which may be done under load) and turn the LPG flow cock counter clockwise (richer) until the engine begins to miss and then clockwise (leaner) until it again begins to miss. Then turn the cock to a position midway between the two extreme positions.

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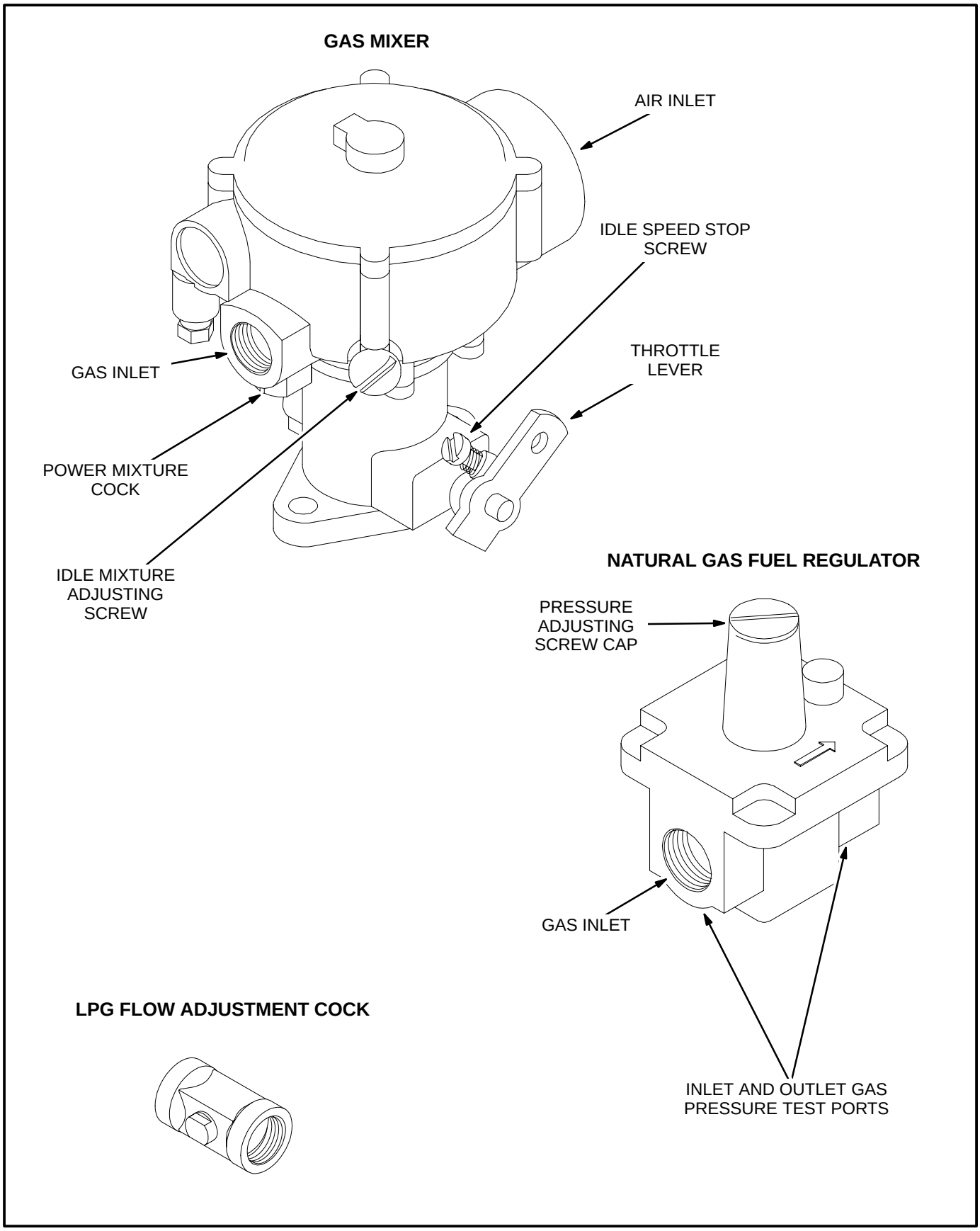

FIGURE 27. GAS MIXER AND IDLE SPEED STOP ADJUSTMENTS

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ELECTRONIC GOVERNOR

If necessary, adjust the gas mixture and governor linkage 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 28) to make sure they are set properly, as follows:

	SW1	SW2	SW3	SW4
50/60 Hz	OFF	ON	ON	OFF
60 Hz	OFF	ON	ON	ON

60 Hz gensets only: **If the governor has been replaced, begin the following adjustment with the 50/60 Hz switch settings. If 60 Hz (1800 RPM) cannot be obtained after completing the following steps, set switch settings to the 60 Hz position and repeat the following steps.**

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.

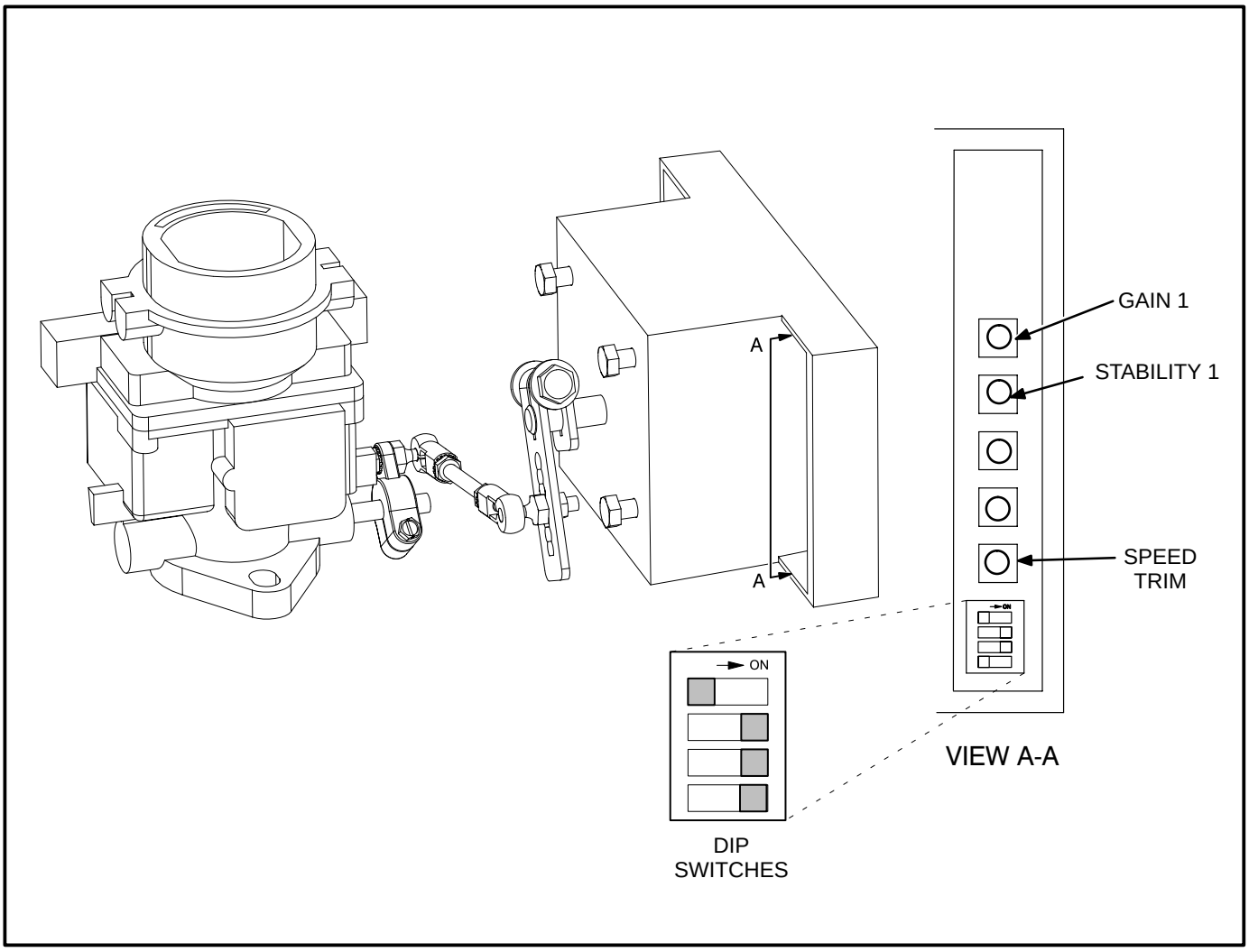

FIGURE 28. GOVERNOR CONTROLLER

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GOVERNOR LINKAGE

Figure 29 illustrates the governor linkage. Make sure that the governor controller is securely mounted to the engine bracket. To adjust the linkage:

1. Remove the governor ball joint from the ball stud of the governor lever.
2. While holding the throttle lever against the idle speed stop, verify that the throttle lever is at a 60 degree angle as shown in Figure 29. Loosen the throttle lever screw, if necessary, to adjust throttle lever.
3. Adjust the length of the governor linkage to the approximate length indicated in Figure 29.
4. Snap the ball joint back onto the governor lever. Check mounting nuts to make sure that they are secure.

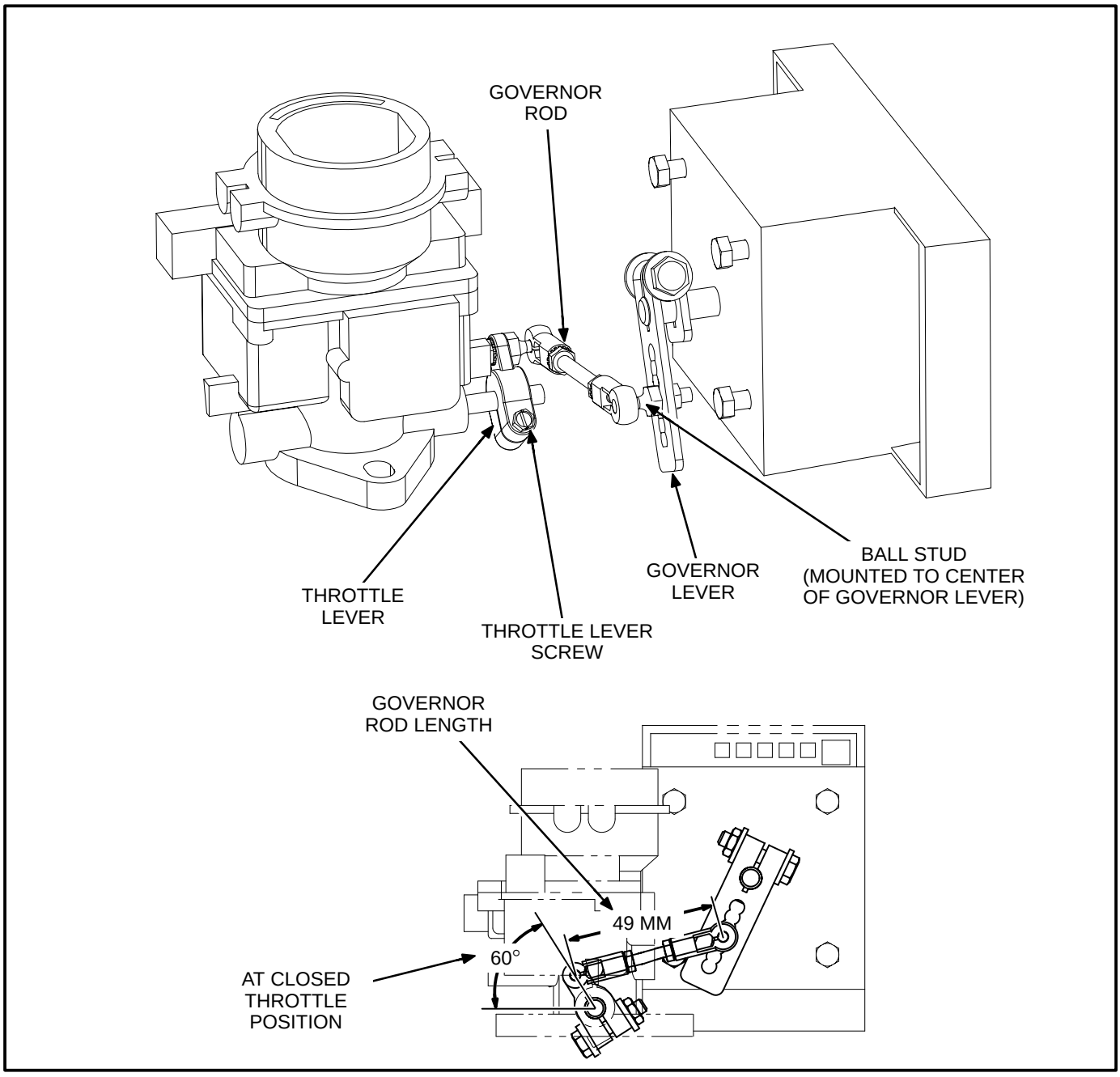

FIGURE 29. GOVERNOR LINKAGE

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Wiring Diagrams

The electrical schematics and wiring diagrams listed below are applicable to the ES Series Engine and Generator Controls

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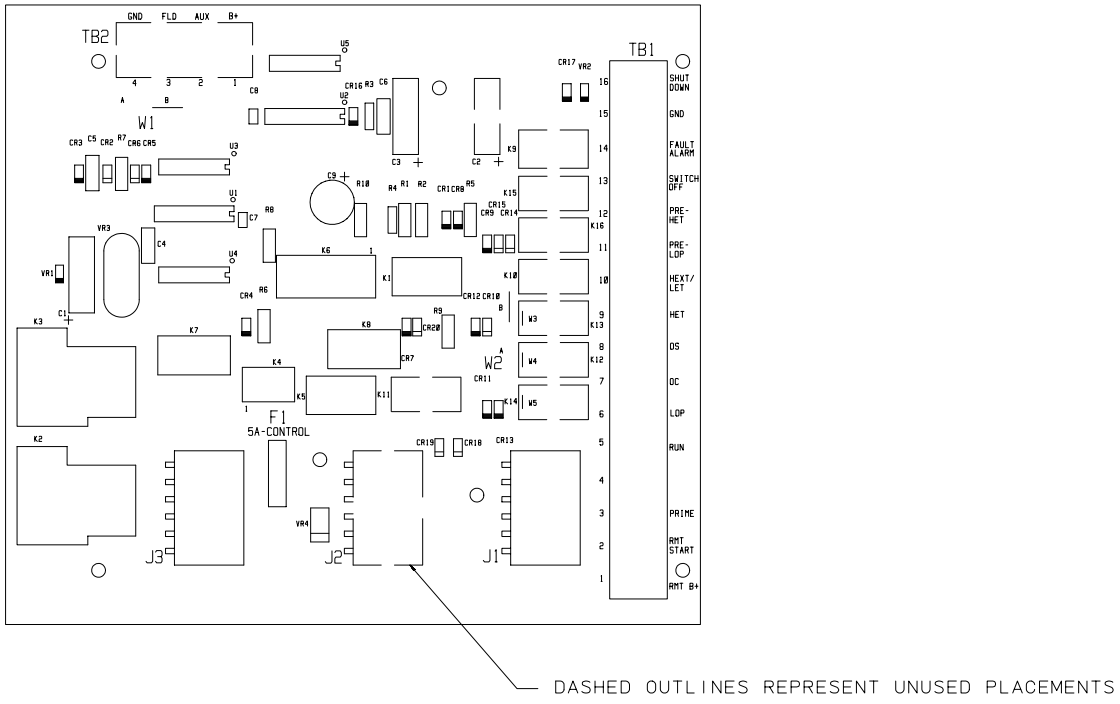
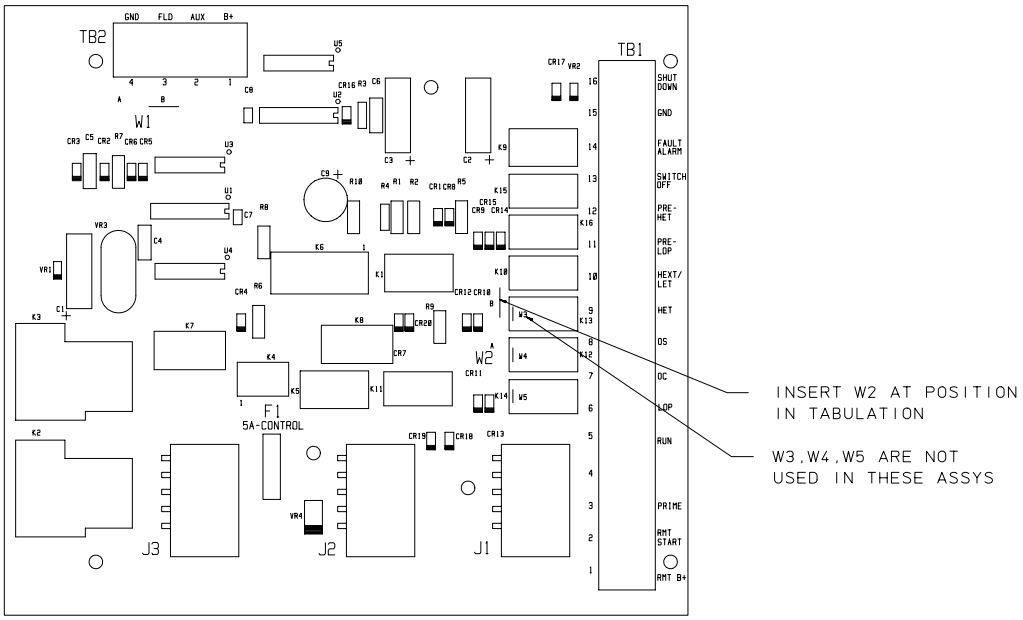


FIGURE 30. ENGINE MONITOR (2 LIGHT)



TABULATION			
ASSY P/N	MODEL	VOLTAGE	W2 POSITION
300-2453-01	MDTA	12V	A
300-2453-02	MDTA	32V	A
300-2453-03	DTA	12V	B
300-2453-04	ES 9 LITE	12V	B

FIGURE 31. ENGINE MONITOR (9 LIGHT)

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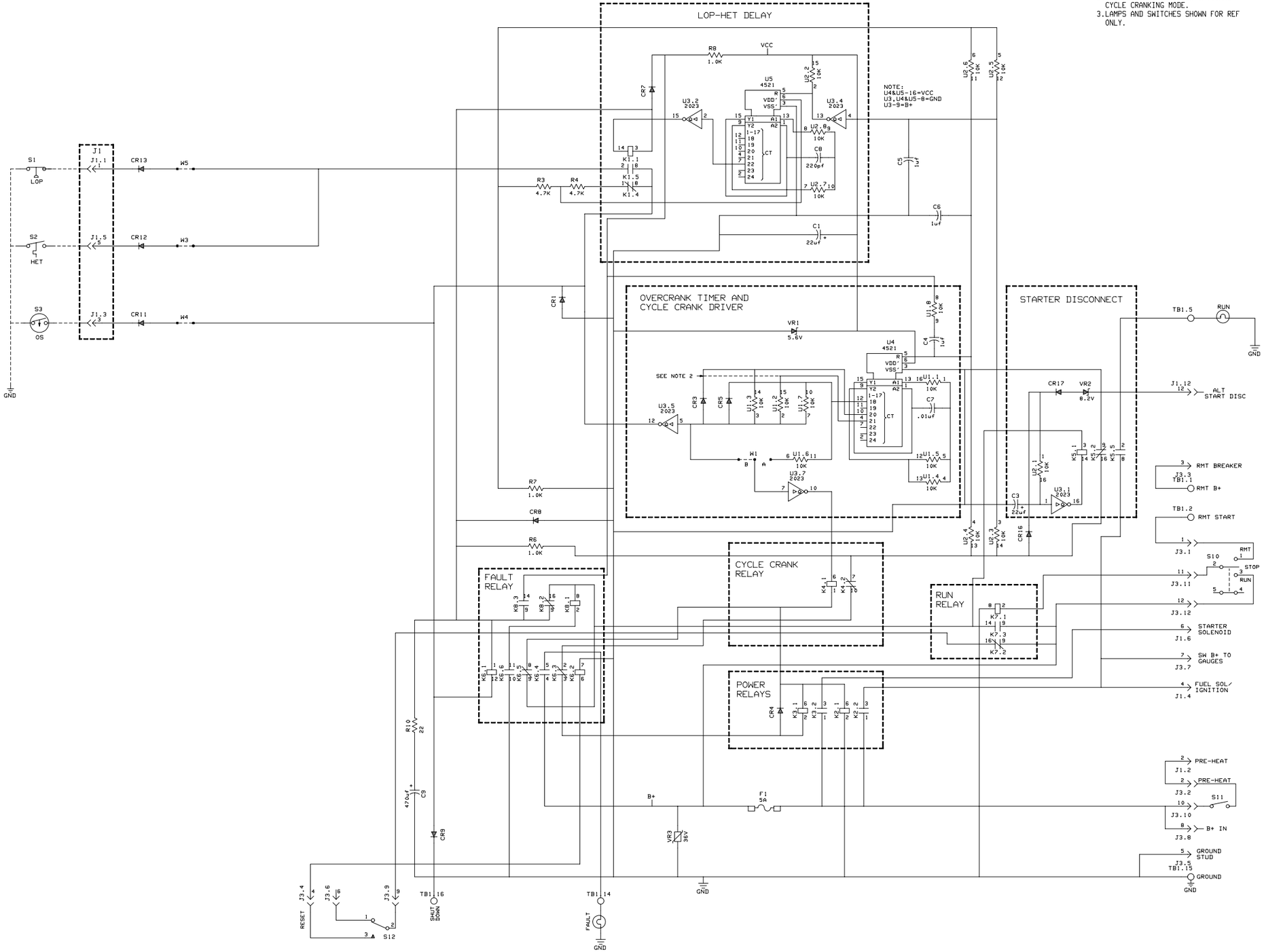
THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.

NOTES:

1. ALL RELAYS ARE SHOWN IN RESET OR DE-ENERGIZED POSITION.
2. CONNECTION OF CR3 FOR OPTIONAL CYCLE CRANKING MODE.
3. LAMPS AND SWITCHES SHOWN FOR REF ONLY.



SPECIFICATIONS

1. GENERAL
   - 1.1 POWER SUPPLY VOLTAGE
     - 1.1.1 CRANKING MODE--------6 TO 15VDC
     - 1.1.2 NON-CRANKING MODE----10.6 TO 15VDC
   - 1.2 MAX POWER CONSUMPTION------6 WATTS
   - 1.3 OPERATING TEMP RANGE------- -40 TO +70°C
   - 1.4 STORAGE TEMP RANGE--------- -55 TO +100°C

2. INPUTS
   - 2.1 VMAX LOW STATE-------------1.2VDC
   - 2.2 VMIN HIGH STATE------------10.6VDC
   - 2.3 CRANKING FUNCTION MODE SELECTABLE AS FOLLOWS:

W1 POSITION	FUNCTION MODE
A	CYCLE CRANK
B	NON-CYCLE CRANK

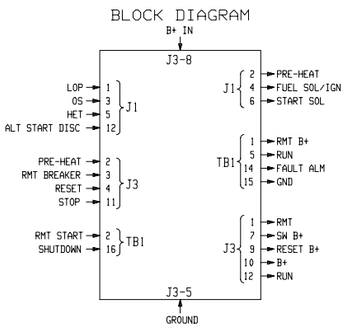
   - 2.4 ALL FAULTS GO LOW TO ACTIVATE
   - 2.5 LAMP TEST/RESET GOES HIGH TO ACTIVATE
   - 2.6 DC START DISCONNECT GOES HIGH TO ACTIVATE
   - 2.7 MIN SIGNAL DURATION--------------------8 MS
   - 2.8 FAULTS ARE FUNCTION MODE AS FOLLOWS:

INPUT	FAULT	FUNCTION MODE
J1-1	LOP	SHUTDOWN,TIMED
J1-3	OS	SHUTDOWN,NON-TIMED
J1-5	HET	SHUTDOWN,TIMED

3. OUTPUTS (NON-SIMULTANEOUS)
   - 3.1 MAX SOURCE CURRENT(J1-6)----------------10A
   - 3.2 MAX SOURCE CURRENT(J3-7)----------------3A
   - 3.3 MAX SOURCE CURRENT(TB1-14)--------------4A
   - 3.4 MAX SOURCE CURRENT(J3-10)---------------10A

4. TIME PERIODS
   - 4.1 LOP AND HET PERIOD---------12+/-3 SECONDS
   - 4.2 CYCLE CRANKER(NORMAL)
     - 4.2.1 CRANK PERIOD----------15+/-3 SECONDS
     - 4.2.2 REST PERIOD----------15+/-3 SECONDS
     - 4.2.3 OVERCRANK PERIOD-----75+/-15 SECONDS
   - 4.3 CYCLE CRANKER(OPTIONAL)
     - 4.3.1 CRANK PERIOD----------15+/-3 SECONDS
     - 4.3.2 REST PERIOD----------15+/-3 SECONDS
     - 4.3.3 OVERCRANK PERIOD-----135+/-15 SECONDS
   - 4.4 NON-CYCLE CRANK
     - 4.4.1 CRANK PERIOD---------75+/-15 SECONDS
     - 4.4.2 OVERCRANK PERIOD-----75+/-15 SECONDS

BLOCK DIAGRAM



No. 300-2510 sh 1of 2
Rev. H Sys: HP
Modified 4/28/95

FIGURE 32. ENGINE MONITOR (2 LIGHT) SCHEMATIC DIAGRAM

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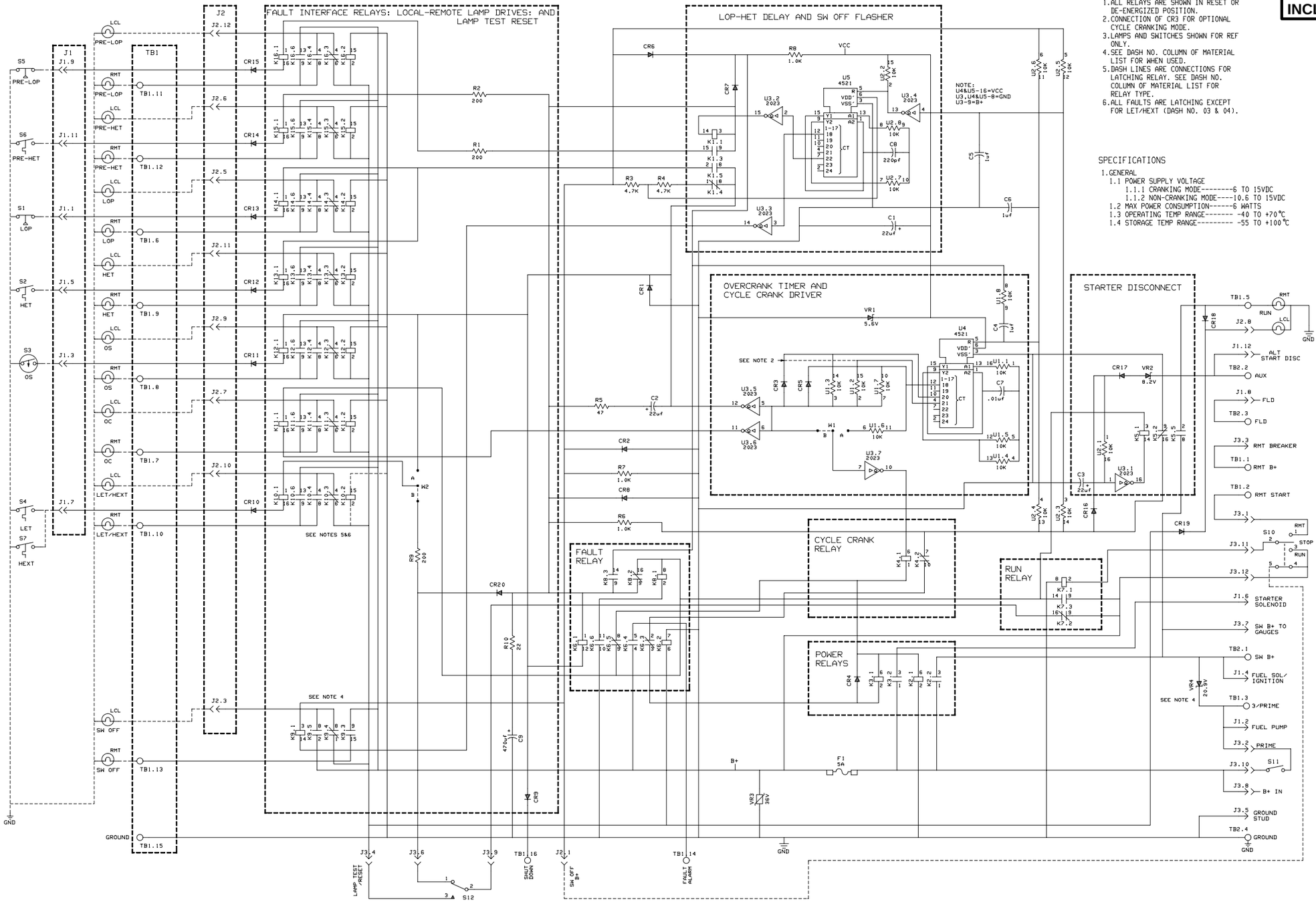

NOTES:

1. ALL RELAYS ARE SHOWN IN RESET OR DE-ENERGIZED POSITION.
2. CONNECTION OF CR3 FOR OPTIONAL CYCLE CRANKING MODE.
3. LAMPS AND SWITCHES SHOWN FOR REF ONLY.
4. SEE DASH NO. COLUMN OF MATERIAL LIST FOR WHEN USED.
5. DASH LINES ARE CONNECTIONS FOR LATCHING RELAY. SEE DASH NO. COLUMN OF MATERIAL LIST FOR RELAY TYPE.
6. ALL FAULTS ARE LATCHING EXCEPT FOR LET/HEXT (DASH NO. 03 & 04).

SPECIFICATIONS

1. GENERAL
   - 1.1 POWER SUPPLY VOLTAGE
     - 1.1.1 CRANKING MODE--------6 TO 15VDC
     - 1.1.2 NON-CRANKING MODE----10.6 TO 15VDC
   - 1.2 MAX POWER CONSUMPTION------6 WATTS
   - 1.3 OPERATING TEMP RANGE------- -40 TO +70°C
   - 1.4 STORAGE TEMP RANGE--------- -55 TO +100°C

2. INPUTS
   - 2.1 VMAX LOW STATE-------------1.2VDC
   - 2.2 VMIN HIGH STATE------------10.6VDC
   - 2.3 CRANKING FUNCTION MODE SELECTABLE AS FOLLOWS:

W1 POSITION	FUNCTION MODE
A	CYCLE CRANK
B	NON-CYCLE CRANK

   - 2.4 ALL FAULTS GO LOW TO ACTIVATE
   - 2.5 LAMP TEST/RESET GOES HIGH TO ACTIVATE
   - 2.6 DC START DISCONNECT GOES HIGH TO ACTIVATE
   - 2.7 MIN SIGNAL DURATION--------------------8 MS
   - 2.8 FAULTS ARE FUNCTION MODE AS FOLLOWS:

INPUT	FAULT	FUNCTION MODE
J1-1	LOP	SHUTDOWN,TIMED
J1-3	OS	SHUTDOWN,NON-TIMED
J1-5	HET	SHUTDOWN,TIMED
J1-9	PRE-LOP	NON-SHUTDOWN,TIMED
J1-11	PRE-HET	NON-SHUTDOWN,NON-TIMED

   - 2.9 J1-7 LET/HEXT FUNCTION MODE SELECTABLE AS FOLLOWS:

J1-7:W2	*POSITION	FUNCTION MODE
LET/HEXT	A	SHUTDOWN,NON-TIMED
	B	NON-SHUTDOWN,NON-TIMED,NON-LATCHING

   *SEE PAGE 2 FOR DEFAULT SETTINGS.

3. OUTPUTS (NON-SIMULTANEOUS)
   - 3.1 MAX SOURCE CURRENT(TB2-1,J1-6)----------10A
   - 3.2 MAX SOURCE CURRENT(J2-3,5-7,9-12)-------250mA
   - 3.3 MAX SOURCE CURRENT(TB1-6 THRU 13)-------500mA
   - 3.4 MAX SOURCE CURRENT(J3-7)----------------3A
   - 3.5 MAX SOURCE CURRENT(TB1-14)--------------4A
   - 3.6 MAX SOURCE CURRENT(J3-10)---------------10A

4. TIME PERIODS
   - 4.1 LOP AND HET PERIOD---------12+/-3 SECONDS
   - 4.2 CYCLE CRANKER(NORMAL)
     - 4.2.1 CRANK PERIOD---------15+/-3 SECONDS
     - 4.2.2 REST PERIOD----------15+/-3 SECONDS
     - 4.2.3 OVERCRANK PERIOD-----75+/-15 SECONDS
   - 4.3 CYCLE CRANKER(OPTIONAL)
     - 4.3.1 CRANK PERIOD---------15+/-3 SECONDS
     - 4.3.2 REST PERIOD----------15+/-3 SECONDS
     - 4.3.3 OVERCRANK PERIOD-----135+/-15 SECONDS
   - 4.4 NON-CYCLE CRANK
     - 4.4.1 CRANK PERIOD---------75+/-15 SECONDS
     - 4.4.2 OVERCRANK PERIOD-----75+/-15 SECONDS
   - 4.5 SWITCH OFF FLASHER FREQ----.7+/-.2 HZ

BLOCK DIAGRAM

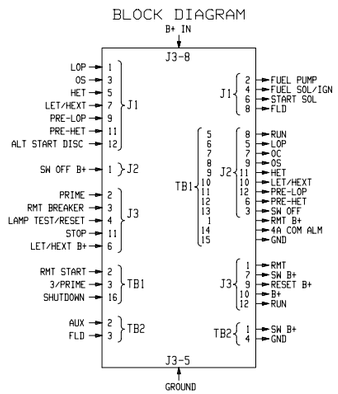

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FIGURE 33. ENGINE MONITOR (9 LIGHT) SCHEMATIC DIAGRAM

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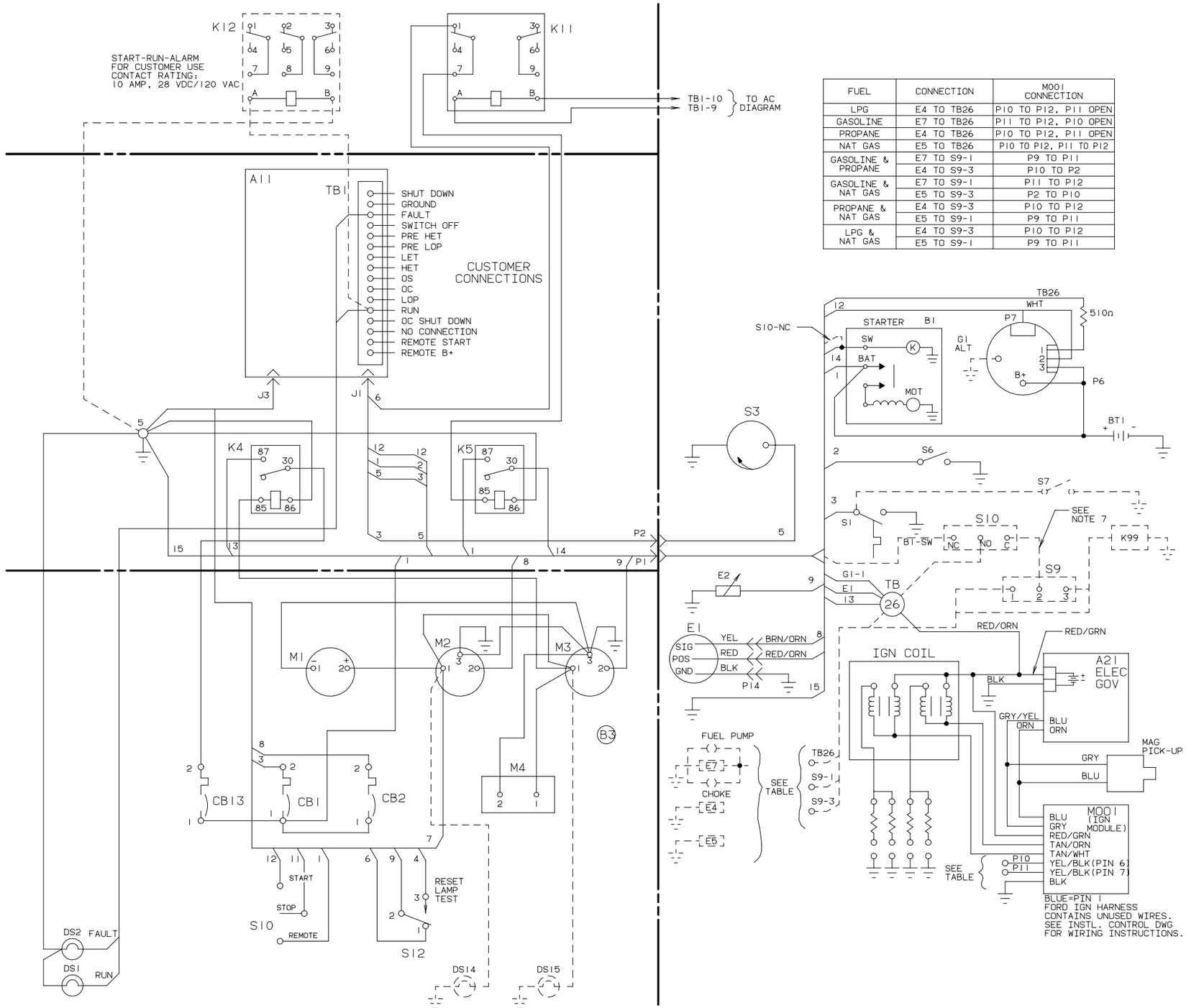

FUEL	CONNECTION	MOD1 CONNECTION
LPG	E4 TO TB26	P10 TO P12, P11 OPEN
GASOLINE	E7 TO TB26	P11 TO P12, P10 OPEN
PROPANE	E4 TO TB26	P10 TO P12, P11 OPEN
NAT GAS	E5 TO TB26	P10 TO P12, P11 TO P12
GASOLINE & PROPANE	E7 TO S9-1	P9 TO P11
	E4 TO S9-3	P10 TO P2
GASOLINE & NAT GAS	E7 TO S9-1	P11 TO P12
	E5 TO S9-3	P2 TO P10
PROPANE & NAT GAS	E4 TO S9-3	P10 TO P12
	E5 TO S9-1	P9 TO P11
LPG & NAT GAS	E4 TO S9-3	P10 TO P12
	E5 TO S9-1	P9 TO P11

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FIGURE 34. DC CONTROL (2 LIGHT) SHEET 1

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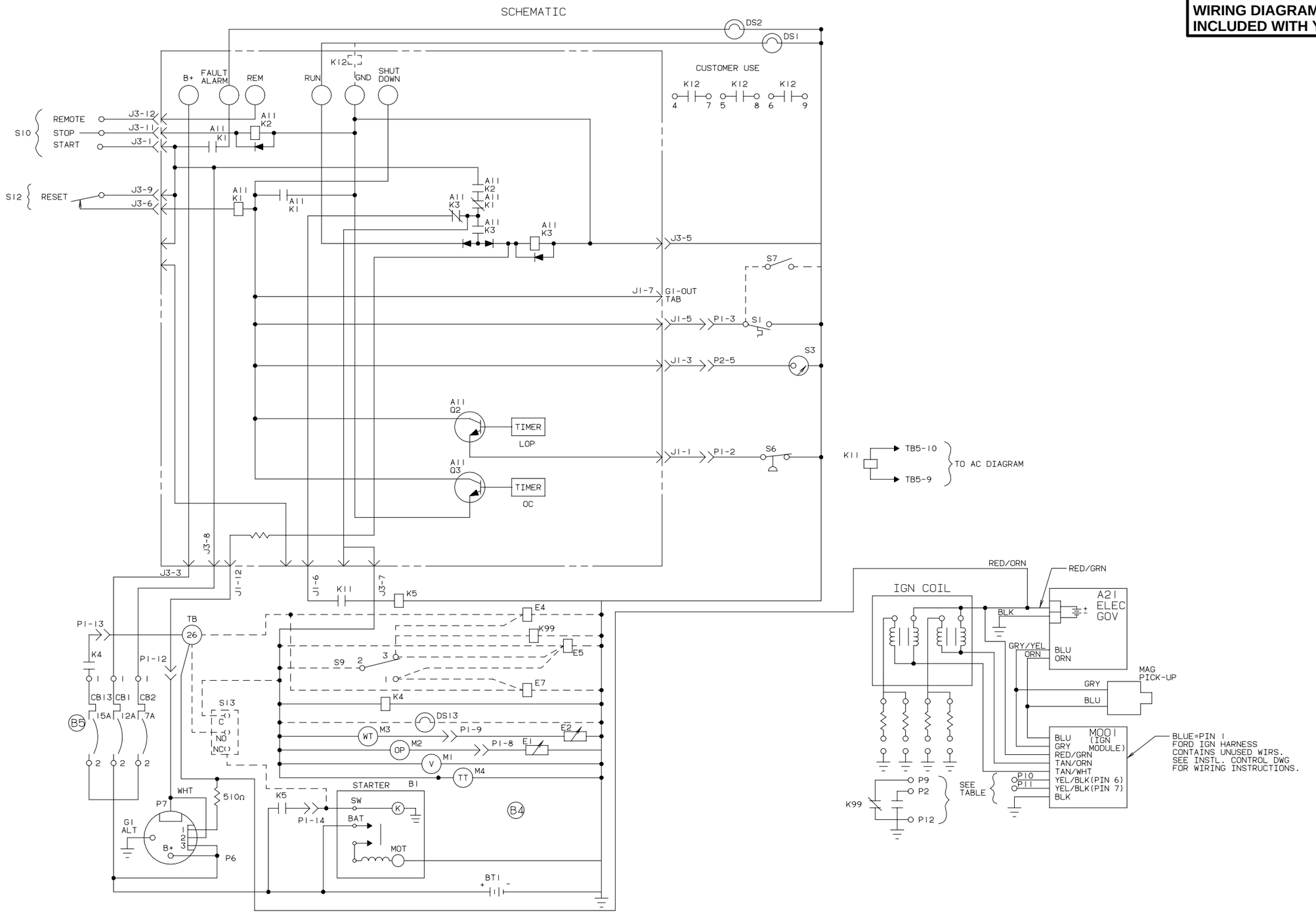

FIGURE 35. DC CONTROL (2 LIGHT) SHEET 2

No. 612−6682 sh 2 of 2
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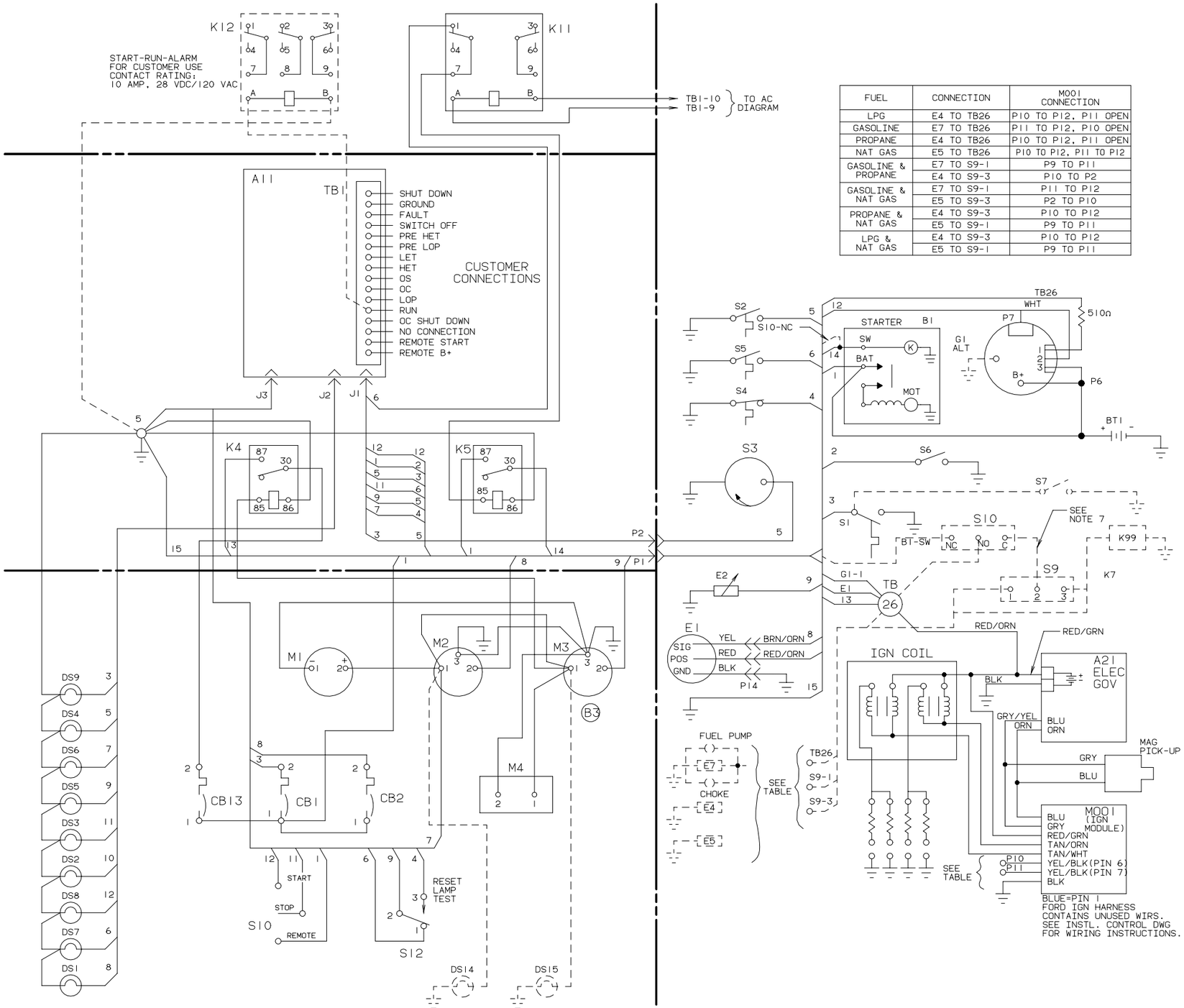

FUEL	CONNECTION	MOD1 CONNECTION
LPG	E4 TO TB26	P10 TO P12, P11 OPEN
GASOLINE	E7 TO TB26	P11 TO P12, P10 OPEN
PROPANE	E4 TO TB26	P10 TO P12, P11 OPEN
NAT GAS	E5 TO TB26	P10 TO P12, P11 TO P12
GASOLINE & PROPANE	E7 TO S9-1	P9 TO P11
	E4 TO S9-3	P10 TO P2
GASOLINE & NAT GAS	E7 TO S9-1	P11 TO P12
	E5 TO S9-3	P2 TO P10
PROPANE & NAT GAS	E4 TO S9-3	P10 TO P12
	E5 TO S9-1	P9 TO P11
LPG & NAT GAS	E4 TO S9-3	P10 TO P12
	E5 TO S9-1	P9 TO P11

No. 612−6681 sh 1 of 2
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FIGURE 36. DC CONTROL (9 LIGHT) SHEET 1

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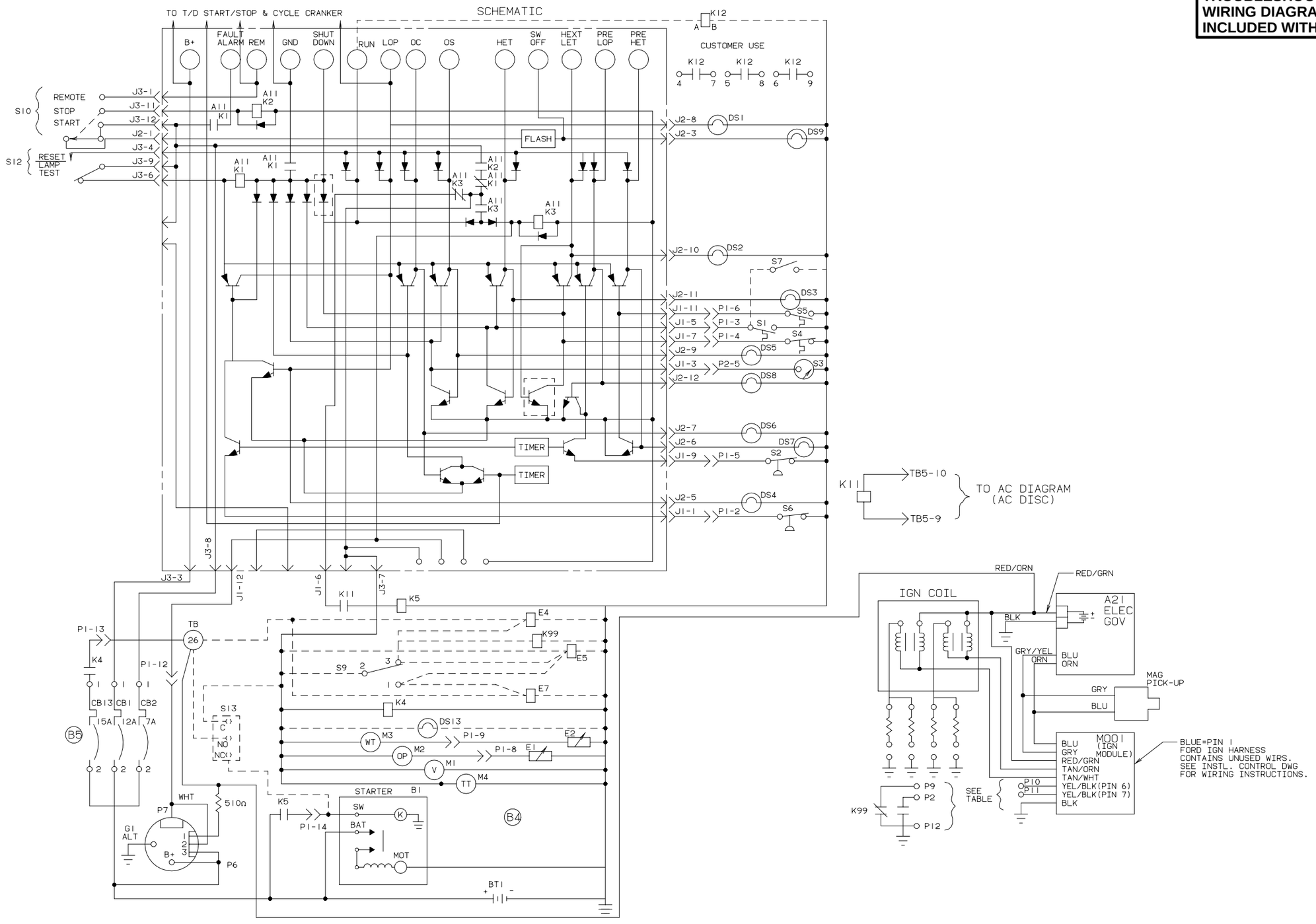

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FIGURE 37. DC CONTROL (9 LIGHT) SHEET 2

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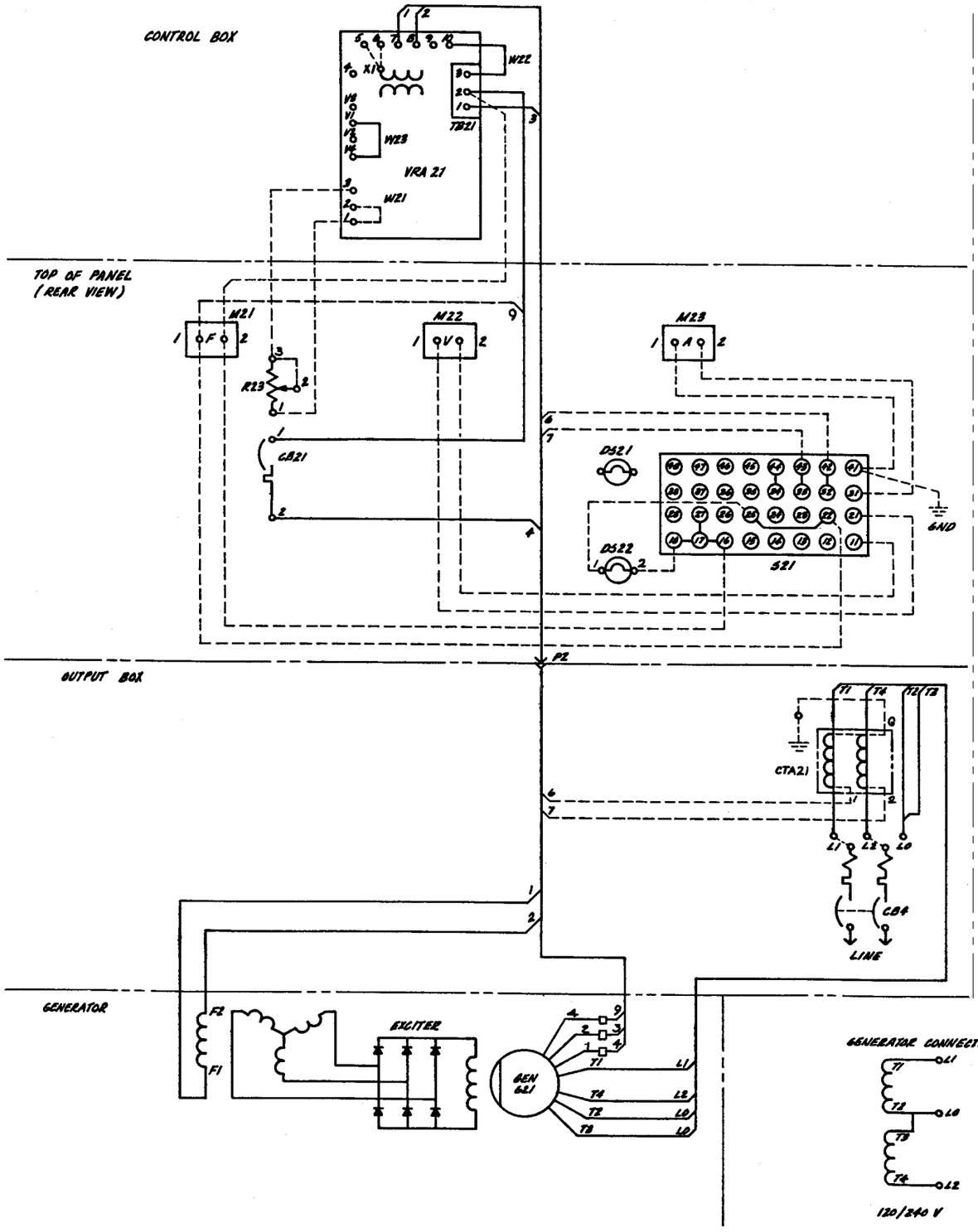
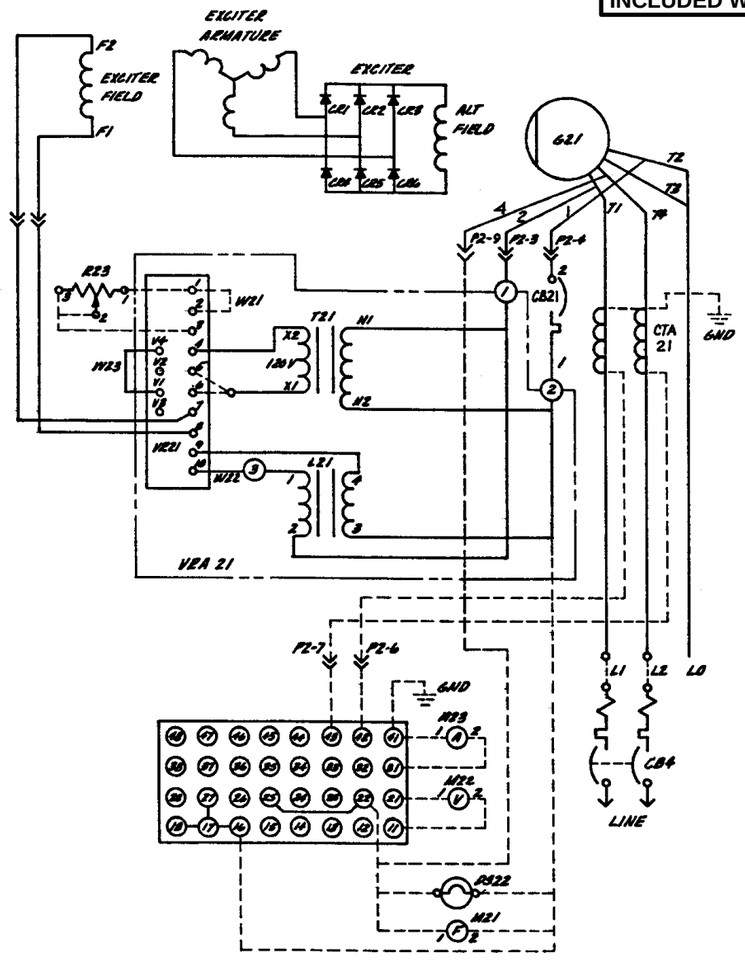
WIRING DIAGRAM



SINGLE PHASE SCHEMATIC - AC



S21

POSITION #	CONTACTS CLOSED			
L1-L2 0	11-18	21-25	31-32	41-43-44
L2-L3 3	11-12	21-25	31-33	41-42-44
L3-L1 3	11-12	21-27	31-34	41-42-43
L1-L0 3	11-14	21-27	31-35	41-42-43-44
OFF	11-14	21-28	31-34	41-42-43-44
L1-L2 1	11-16	21-32	31-32	41-43-44
L1-L2 1	11-16	21-28	31-33	41-42-44

MODEL	STANDARD			W/METER PACKAGE		
	60 HZ	50 HZ	PENN	60 HZ	50 HZ	PENN
20.0 ES	-01			-02	-03	

NOTES
1. UNLESS OTHERWISE SPECIFIED, ALL COMPONENTS SHOWN IN DE-ENERGIZED POSITION
2. CONNECT X1 TO 5 FOR 50 HZ
   CONNECT X1 TO 6 FOR 60 HZ

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Rev. C Sys: board
Modified 5/10/95

FIGURE 38. SINGLE PHASE GENERATOR CONTROL

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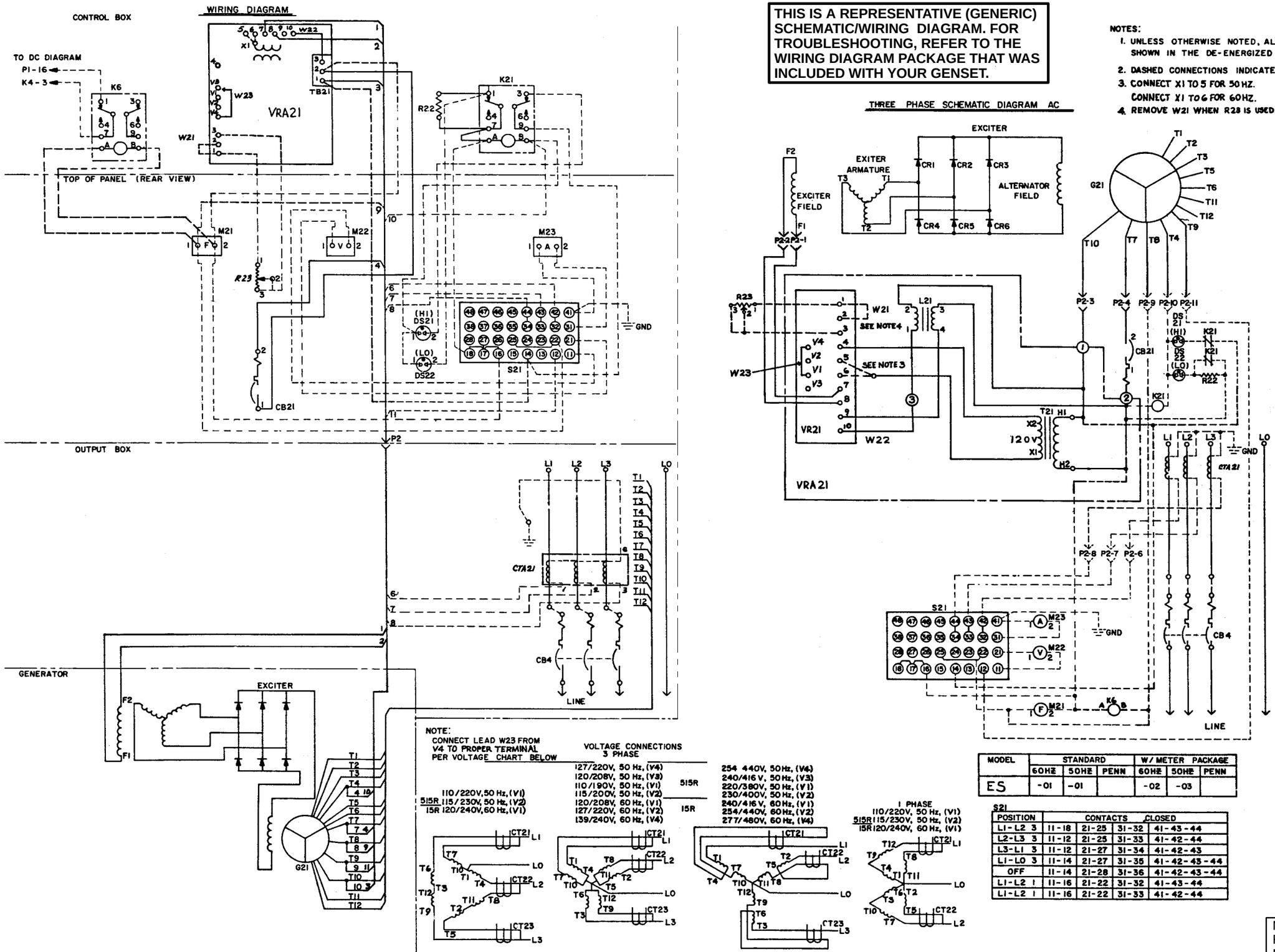
NOTES:
1. UNLESS OTHERWISE NOTED, ALL COMPONENTS SHOWN IN THE DE-ENERGIZED POSITION.
2. DASHED CONNECTIONS INDICATE WHEN USED.
3. CONNECT X1 TO 5 FOR 50 HZ. CONNECT X1 TO 6 FOR 60 HZ.
4. REMOVE W21 WHEN R23 IS USED.



MODEL	STANDARD			W/ METER PACKAGE		
	60HZ	50HZ	PENN	60HZ	50HZ	PENN
ES	-01	-01		-02	-03	

S21

POSITION	CONTACTS CLOSED			
L1-L2 3	11-18	21-25	31-32	41-43-44
L2-L3 3	11-12	21-25	31-33	41-42-44
L3-L1 3	11-12	21-27	31-34	41-42-43
L1-L0 3	11-14	21-27	31-35	41-42-43-44
OFF	11-14	21-28	31-36	41-42-43-44
L1-L2 1	11-16	21-22	31-32	41-43-44
L1-L2 1	11-16	21-22	31-33	41-42-44

No. 612-5959 sh 1 of 1
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FIGURE 39. THREE PHASE GENERATOR CONTROL

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LEAD TABULATION	
FROM STATION	TO STATION
S6-NC	P1-2
P1-4	S4
P1-6	S5
S6-C	GND
T26	P1-13
G1-B+	B1-BAT
GND	ENG GND
B1-BAT	P1-1
GND	P1-15
P14-1	T26
P14-2	S6-C
GND	A21
T26	P8-1
P14-4	P1-8
G1-B+	P6-3
S2	P1-5
B1-SW	P1-14
GND	P8-3
S1-1	P1-3
P1-9	E2-1
RESISTOR-	P6-1
P6-2	P1-12
	P7
IGN	A21
RESISTOR-2	T26
T26	A21
IGN	A21

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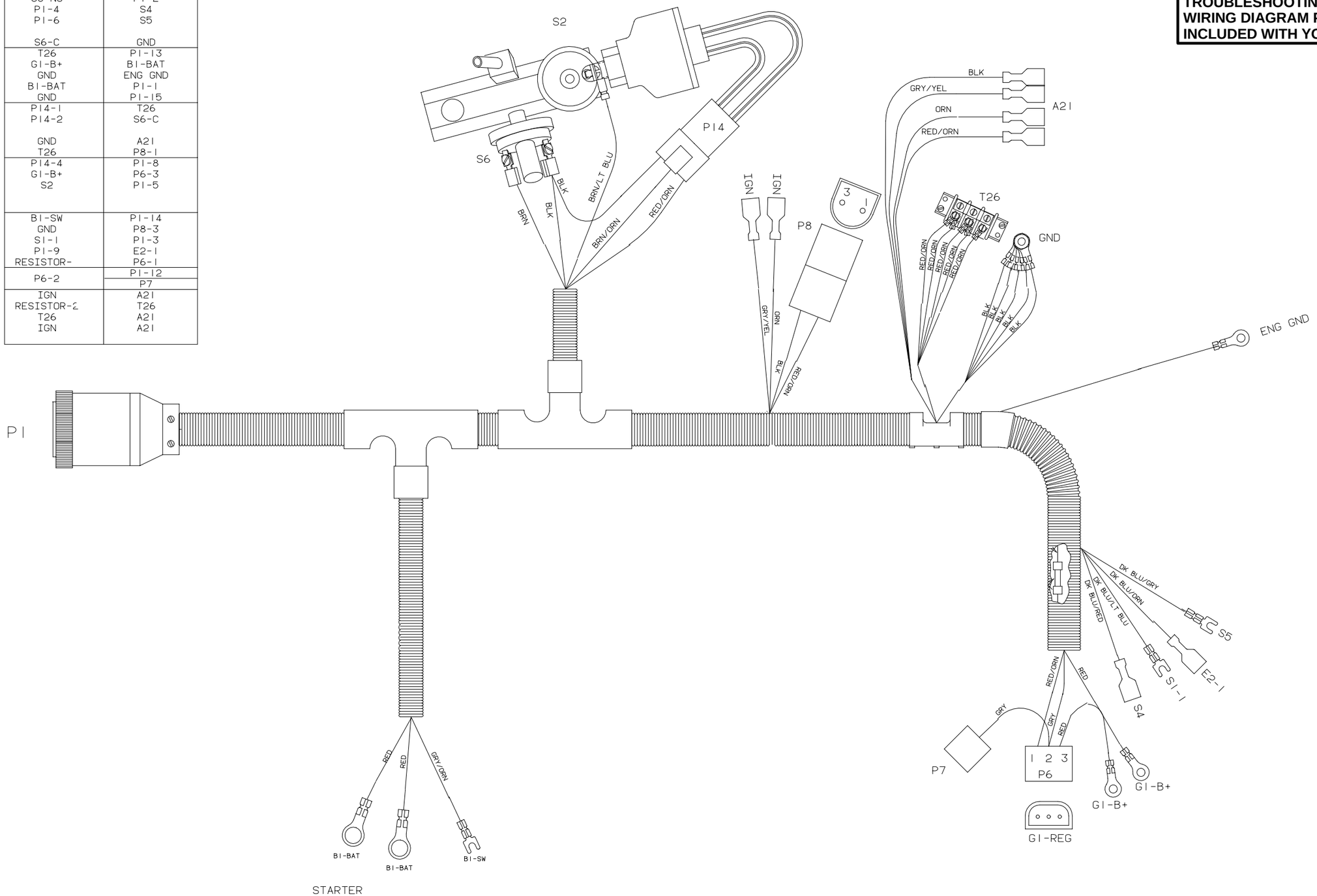

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FIGURE 40. ENGINE HARNESS

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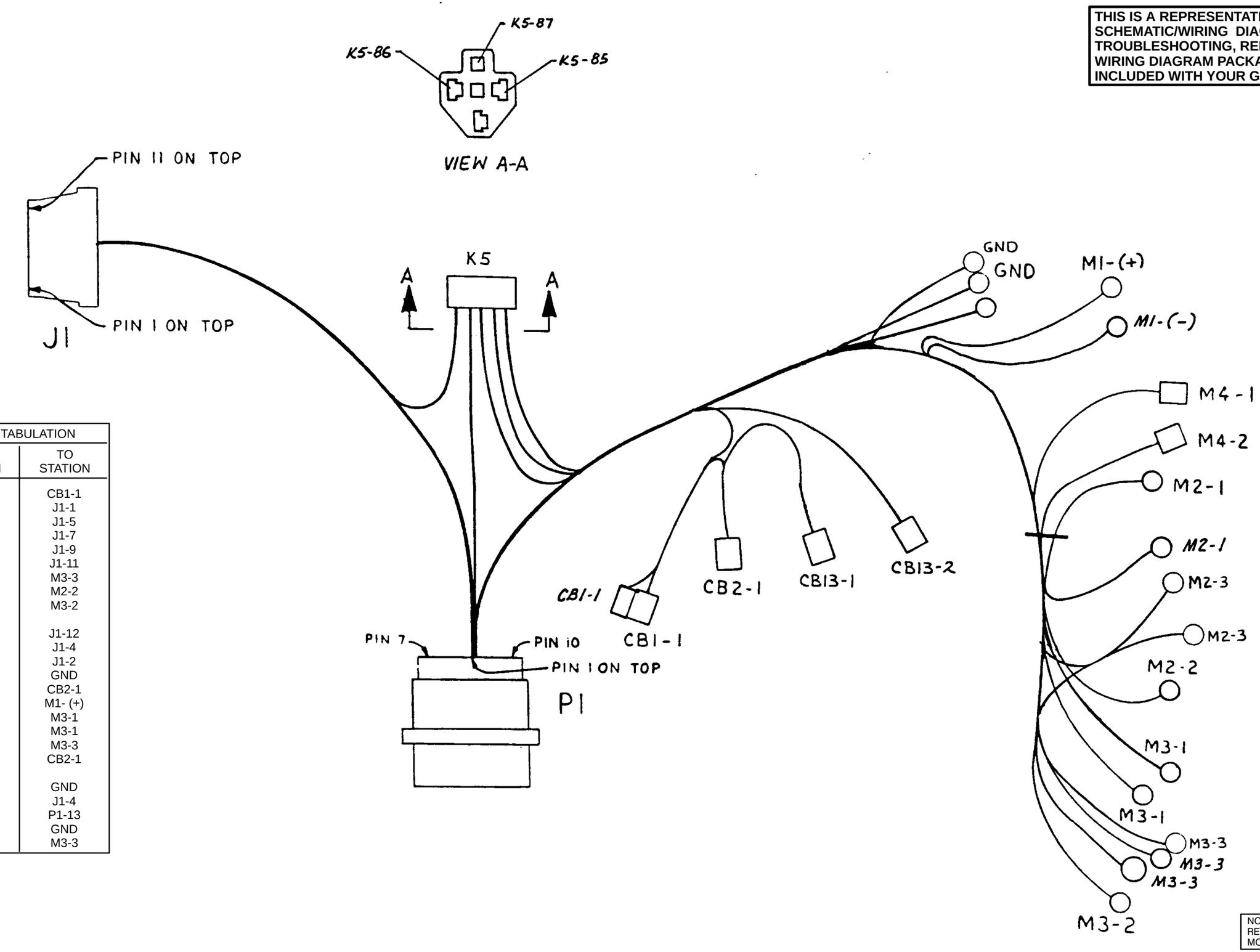

LEAD TABULATION	
FROM STATION	TO STATION
P1-1	CB1-1
P1-2	J1-1
P1-3	J1-5
P1-4	J1-7
P1-5	J1-9
P1-6	J1-11
M2-3	M3-3
P1-8	M2-2
P1-9	M3-2
P1-12	J1-12
P1-13	J1-4
P1-14	J1-2
P1-15	GND
CB1-1	CB2-1
M2-1	M1- (+)
M2-1	M3-1
M4-1	M3-1
M4-2	M3-3
CB13-1	CB2-1
K5-86	GND
K5-85	J1-4
K5-87	P1-13
M2-3	GND
M1- (–)	M3-3

NO. 338–2777 sh1
REV. C Sys. (board dwg)
MODIFIED 4/5/95

FIGURE 41. CD HARNESS

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