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Onan

Service Manual

DL4

DL6

DL6T

Generator and Controls

Safety Precautions

The following symbols in this manual highlight conditions potentially dangerous to service personnel, or equipment. Read this manual carefully. Know when these conditions can exist. Then take necessary steps to protect personnel as well as equipment.

WARNING *This symbol is used throughout the manual to warn of possible serious personal injury.*

CAUTION *This symbol refers to possible equipment damage.*

PROTECT AGAINST MOVING PARTS

Avoid moving parts of the unit. Avoid use of loose jackets, shirts or sleeves due to danger of becoming caught in moving parts.

Make sure all nuts and bolts are secure. Keep power shields and guards in position.

If you must make adjustments while the unit is running, use extreme caution around hot manifolds,

moving parts, etc.

Do not work on this equipment when mentally or physically fatigued.

GUARD AGAINST ELECTRIC SHOCK

Disconnect 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 surfaces to be damp when handling electrical equipment.

Disconnect batteries to prevent accidental engine start. Jewelry is a good conductor of electricity and should be removed before working on electrical equipment.

Use extreme caution when working on electrical components. High voltages cause injury or death.

Follow all state and local codes. To avoid possible personal injury or equipment damage, a qualified electrician or an authorized service representative must perform installation and all service.

WARNING

EXHAUST GAS IS DEADLY!

Exhaust gases contain carbon monoxide, a poisonous gas that might cause unconsciousness and death. It is an odorless and colorless gas formed during combustion of hydrocarbon fuels. Symptoms of carbon monoxide poisoning are:

- *Dizziness*
- *Headache*
- *Weakness and Sleepiness*
- *Vomiting*
- *Muscular Twitching*
- *Throbbing in Temples*

If you experience any of these symptoms, get out into fresh air immediately, shut down the unit and do not use until it has been inspected.

The best protection against carbon monoxide inhalation is proper installation and regular, frequent inspections of the complete exhaust system. If you notice a change in the sound or appearance of exhaust system, shut the unit down immediately and have it inspected and repaired at once by a competent mechanic.

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Introduction

ABOUT THIS MANUAL

For servicing purposes, the generator set can be divided into three basic parts: the engine, the generator, and the controls. This manual covers troubleshooting and repair information for the generator and the controls. Refer to the L Engine Service Manual (934-0750) when servicing the engine.

This manual has separate sections for the generator and voltage regulator, engine control, and associated wiring diagrams. While the wiring diagrams at the end of the manual are included to help trace or isolate problems, it is suggested that service personnel use the wiring diagrams shipped with the unit for troubleshooting.

Repair information for printed circuit boards is not extensive because the solid state printed circuit boards lend themselves more to replacement than repair. Application of meters or hot soldering irons to printed circuit boards by other than qualified personnel can cause unnecessary and expensive damage. Repair of the printed circuit boards is not recommended except by the factory. A return and exchange service has been initiated whereby faulty printed circuit boards can be returned to the Distributor and

exchanged for good units. For more information, contact your Onan Distributor.

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

TEST EQUIPMENT

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

- Onan Multitester
- Wheatstone Bridge
- Kelvin Bridge
- Jumper Leads
- Onan Load Test Panel
- Variac
- AC Voltmeter
- DC Voltmeter

See Tool Catalog 900-0019.

WARNING

INCORRECT SERVICE OR REPLACEMENT OF PARTS MIGHT RESULT IN SEVERE PERSONAL INJURY AND/OR EQUIPMENT DAMAGE. SERVICE PERSONNEL MUST BE QUALIFIED TO PERFORM ELECTRICAL AND/OR MECHANICAL SERVICE.

Generator and Voltage Regulator

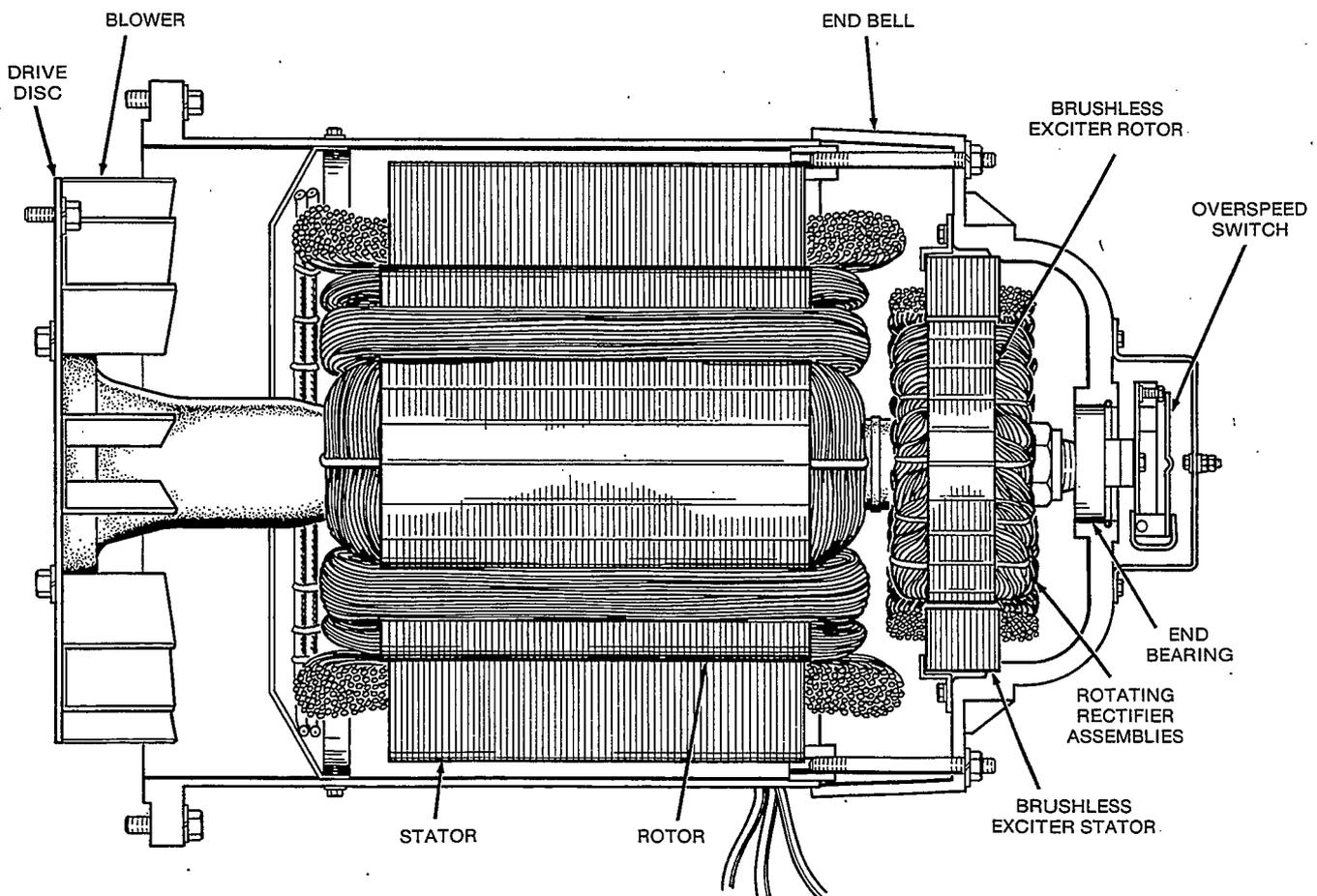
GENERATOR DESCRIPTION

The YD generator (see Figure 1) is a four pole, revolving field, brushless exciter design with drip-proof construction. Several single and three phase models are available in both 50 and 60 hertz. The generator rotor is directly coupled to the engine flywheel with a flexible drive disc. Engine speed determines generator output voltage and frequency. A centrifugal blower (on the drive disc) circulates generator cooling air which is drawn in through the end bell and discharged through an outlet 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 studs that thread into the stator (DL4 and DL6) or generator adapter casting (DL6T).

The brushless exciter stator mounts in the end bell while the exciter rotor and its rotating rectifier assemblies mount on the generator rotor shaft. Within the end bell, leads F1+ and F2- from the exciter stator winding are connected to the output terminals of the voltage regulator.

In addition to the AC output leads, single phase generators have three control wires and three phase generators have five control wires that extend from the stator housing (see Figure 2). On single phase sets, leads 1 and 4 (lead 2 is not used) are used for control input and metering. On three phase sets, leads 4, 7, 8, 9, and 10 are used for control input and metering.



XG-1141

FIGURE 1. TYPICAL YD SERIES GENERATOR (DL4 and DL6)

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 7 and 9X 3-phase generators.

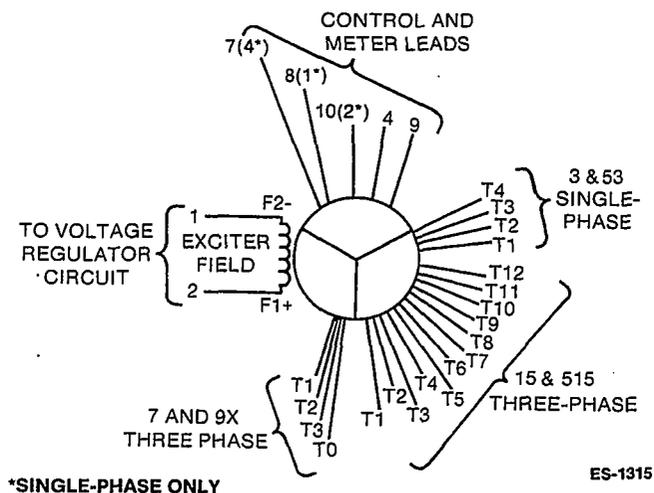


FIGURE 2. SINGLE AND THREE PHASE GENERATOR SCHEMATIC (COMPOSITE)

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 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.

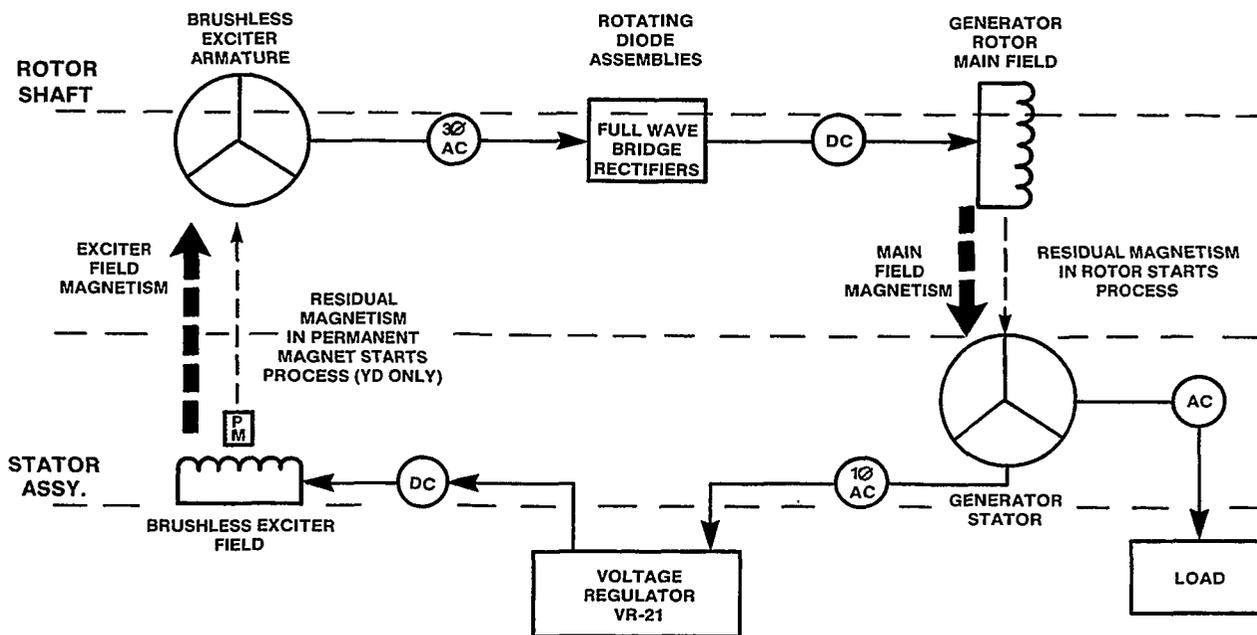


FIGURE 3. EXCITATION BLOCK DIAGRAM

STANDARD VOLTAGE REGULATOR

The voltage regulator shown in Figure 4 is standard on DL series generator sets with the YD generator. This regulator can be connected for frequency sensitive, non-frequency sensitive, or semi-frequency sensitive regulation. Unless requested, all sets are connected at the factory for frequency sensitive regulation.

Voltage Regulator Description

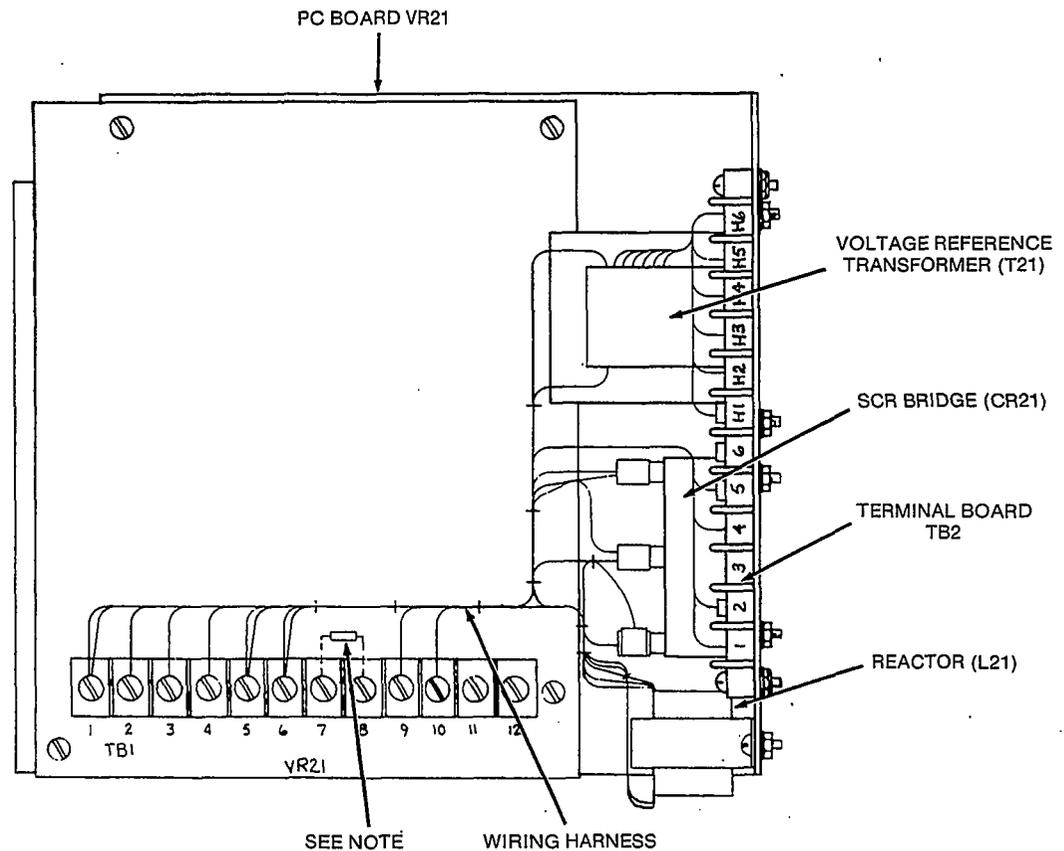
The voltage regulator controls the output voltage of the generator so that a constant voltage is maintained under varying load conditions. Basic components of the regulator are:

- Printed circuit board VR21
- Voltage reference transformer T21
- Commutating reactor L21
- SCR bridge rectifier CR21

All components are located within the generator control box. The voltage regulator printed circuit board (VR21) schematic diagram is shown in Figure 5.

Voltage Regulation Operation

The regulator assembly functions as follows: Current from one of the generator stator windings is supplied to the primary side of the voltage reference transformer (T21). This produces 240 volts AC in the transformer secondary windings which is supplied as a reference voltage to the regulator circuit board (VR21). A rise or fall in the generator stator output voltage will produce a corresponding change in the output voltage from the reference transformer secondary windings.



ES-1318

A fixed resistor (R21) is used on generator sets WITHOUT optional meters. A panel mounted potentiometer (R23) is used on generator sets WITH optional meters.

FIGURE 4. VOLTAGE REGULATOR ASSEMBLY (305-0693)

REF. NO.	PART DESCRIPTION
	Board Assembly, Printed - Complete
C1,14	Capacitor - .47 Mfd, 250 Volt
C2, C7	Capacitor - .22 Mfd, 250 Volt
C3	Capacitor - .47 Mfd, 400 Volt
C4, C12	Capacitor - .47 Mfd, 250 Volt
C5, C8	Capacitor - 1 Mfd, 100 Volt
C6	Capacitor - .33 Mfd, 250 Volt
C11	Capacitor - .1 Mfd, 400 Volt
C13	Capacitor - Electrolytic 100 Mfd, 10 Volt
CR3 Thru 11	Rectifier - Silicon
CR12	Diode - Zener 5.6 Volt
CR13	Diode - Zener 20 Volt
CR14	Diode - Zener 18 Volt
F2, F3	Fuse 1/4 Amp
1C1	Integrated Circuit
Q2	Transistor - Silicon NPN
Q3	Transistor - Unijunction
R1	Resistor - 1/2 Watt, 47-Ohm
R2, R3	Resistor - 1/2 Watt, 33-Ohm
R4	Resistor - 2 Watt, 4.7 Meg-Ohm
R5	Resistor - Fixed 10 Watt, 270-Ohm
R6	Resistor - Fixed 15 Watt, 5,000-Ohm
R7	Resistor - 1/2 Watt, 3,000-Ohm
R8, R16	Resistor - 1/2 Watt, 330,000-Ohm
R10	Resistor - 1/2 Watt, 51,100-Ohm
R11 R9	Resistor - Fixed 5 Watt, 15,000-Ohm
R12	Resistor - 1/2 Watt, 90,900-Ohm
R13	Resistor - 1/2 Watt, 10,000-Ohm
R14	Resistor - 1/2 Watt, 220,000-Ohm
R15, R27	Resistor - 1/2 Watt, 100,000-Ohm
R17	Resistor, Metal Film - 1/4 Watt, 11,000-Ohm
R18	Potentiometer - 5,000-Ohm, 1/2 Watt
R20, 22 29 & 30	Resistor - 1/4 Watt, 28,000-Ohm
R21	Resistor - Metal Film - 1/4 Watt, 5,110-Ohm
R24	Resistor - Metal Film - 1/4 Watt, 8,870-Ohm
R25, R31	Resistor - 2 Watt, 10,000-Ohm
R26	Potentiometer - 1/2 Watt, 100,000-Ohm
R28	Resistor - 1/2 Watt .47 Meg-Ohm
TB1	Terminal Block
CR15	Diode - Zener - 24 Volt
K1	Clip - Fuse
K1	Relay, Magnetic Reed
R19	Resistor - 2 Watt, 6,800-Ohm

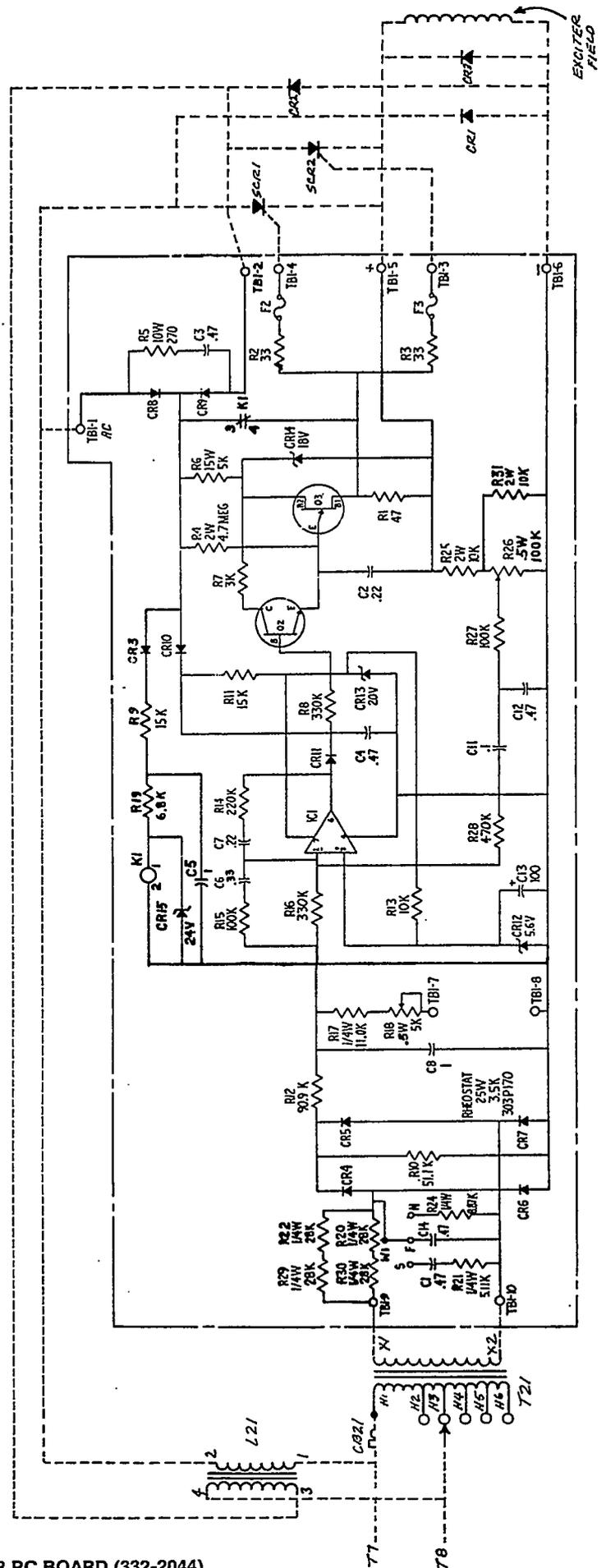


FIGURE 5. REGULATOR PC BOARD (332-2044)

Generator stator current is also supplied to the commutating reactor (L21). Reactor L21 is a choke that is used to produce a uniform AC wave. The output terminals of the reactor supply AC current to the AC input terminals on the rectifier bridge assembly (CR21).

Rectifier bridge assembly CR21 is made up of two silicon controlled rectifiers (SCR's) and three rectifier diodes. The generator exciter field is connected to the DC output terminals (+ and -) on CR21. The regulator circuit board (VR21) is connected to the SCR gate terminals (G1 and G2). When a voltage impulse from the regulator circuit board is applied to SCR gate terminals G1 and G2, input AC current from L21 is rectified to DC current which is then supplied to the exciter field.

Rectification of AC current to DC current proceeds until the input AC voltage wave falls to zero. At this point, rectification of AC to DC stops. As the AC voltage wave begins to build again, a voltage impulse is again applied to the SCR gate terminals G1 and G2 by the regulator circuit board. This initiates a new rectification cycle.

The voltage of the DC current produced at the output terminals of CR21 (+ and -) is dependent on when the rectification process begins. If a voltage impulse is applied to the SCR gate terminals early in the AC wave cycle, the DC voltage is higher. If the voltage impulse is applied later in the AC wave cycle, the DC voltage is lower.

During operation, the regulator circuit board responds to changes in the reference voltage supplied by the voltage transformer. If the reference voltage is low, the circuit board supplies a voltage impulse to the SCR gate terminals early in the AC wave cycle. This raises the voltage of the DC current produced for field excitation which results in an increase in the generator output voltage. If the reference voltage supplied to the regulator circuit board is high, the circuit board supplies a voltage impulse to the SCR gate terminals later in the AC wave cycle. This lowers the voltage of the DC current produced for field excitation which results in a decrease in the generator output voltage. The process of continuously sensing changes in the generator output voltage and adjusting the voltage supplied to the exciter field is how regulation is achieved.

SWITCHING VOLTAGE REGULATOR (Optional)

The switching voltage regulator is available as an option on DL series generator sets. This regulator can provide frequency sensitive, non-frequency sensitive, or semi-frequency sensitive regulation. All sets are connected at the factory for frequency sensitive regulation. A separate printed circuit board assembly is used for each method of regulation.

The switching voltage regulator is recommended when the generator set must power non-linear SCR loads (usually associated with solid-state equipment). The voltage sensing circuitry in the standard regulator tends to overreact to the switching transients created by SCR loads. This can result in erratic voltage regulation. The switching regulator is designed to overcome this limitation.

Voltage Regulator Description

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

- Printed circuit board VR21
- Voltage reference transformer T21
- Commutating reactors L21 and L22
- Capacitors C1 (single phase only)

All components except the C1 capacitors are located within the control box. When used, the C1 capacitors are mounted within the generator output box. The switching voltage regulator assembly is shown in Figure 6. The voltage regulator printed circuit board (VR21) schematic diagram is shown in Figure 7.

Voltage Regulator Operation

The regulator assembly functions as follows:

Current from one of the generator stator windings is supplied to the primary side of the voltage reference transformer (T21). This produces 240 volts AC in the transformer secondary windings which is supplied as a reference voltage to the regulator circuit board (VR21). A rise or fall in the generator stator output will produce a corresponding change in the output voltage from the reference transformer secondary windings.

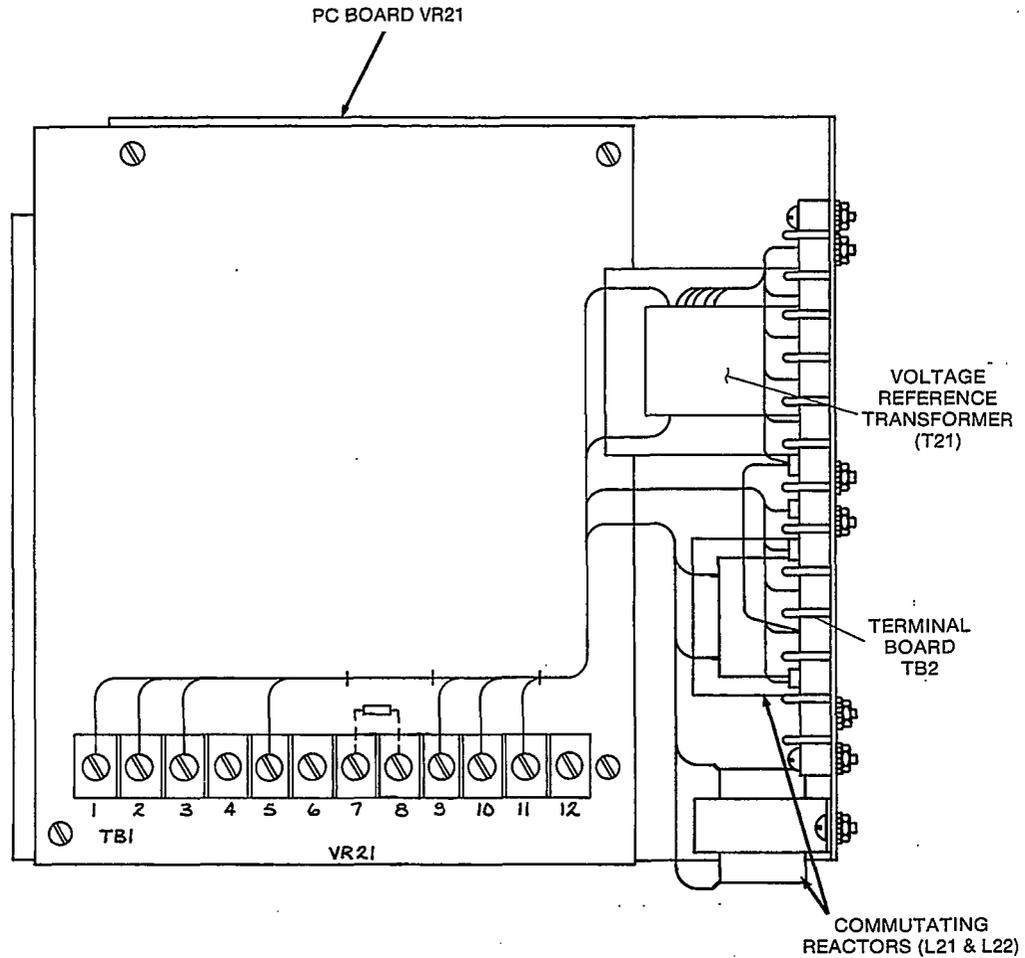


FIGURE 6. VOLTAGE REGULATOR ASSEMBLY (305-0695-02)

Generator stator current is also supplied to the commutating reactors L21 and L22 (three phase only). These reactors are used to produce a uniform AC wave. The output terminals of the reactors supply AC current to the power circuit on the regulator circuit board (VR21).

The power circuit primarily consists of a power transistor (Q4), pulse transformer (T1), and rectifying diodes. When the power transistor is turned on, AC current from the commutating reactors is rectified to DC and supplied to the exciter field. The current flow stops when the power transistor is turned off. The voltage of the DC output is directly proportional to the on-off switching frequency of the power transis-

tor. An increase or decrease in the switching frequency causes a corresponding increase or decrease in the DC voltage produced. The nominal switching frequency is approximately 125 Hz.

The pulse transformer T1 is used to trigger the firing of the power transistor. Triggering is accomplished by reverse saturating the transformer and then releasing it. This initiates conduction in the power transistor which remains on until the transformer saturates in the forward direction. Using the pulse transformer to trigger the power transistor helps isolate the power circuit from the voltage regulating circuit.

- W1 Wire Jumper, 1"
- VR2 Diode - Zener
- VR1 Diode - Zener (5W)
- U3 IC ± 12 Volt Regulator
- U2 Integrated Circuit
- U1 1C - Timer
- TB1 Terminal Block
- T2 Transformer (115/230 V, 50/60 Hz)
- T1 Transformer - Pulse
- R36 Potentiometer (10 K, 1/2W)
- R34, 35 Resistor (61.9 K, 1/2W, 1%)
- R33 Resistor (28 K, 1/4W, 1%)
- R32 Resistor (51.1K, 1/4W, 1%)
- R30 Resistor (2.2M, 1/2W, 5%)
- R29 Resistor (15K, 5W, 5%)
- R28 Resistor (5.1K, 2W, 5%)
- R24 Resistor (220K, 1/2W, 5%)
- R22 Resistor (330K, 1/2W, 5%)
- R20 Resistor (100Ω 1/2W, 5%)
- R19 Resistor (10K, 5W, 5%)
- R18 Resistor (1M, 1/2W, 5%)
- R17 Resistor (4.7K, 1/2W, 5%)
- R15 Resistor (220K, 1/2W, 5%)
- R14, 21 Resistor (100 K, 1/2W, 5%)
- R13 Resistor (5.1 K, 1/2W, 5%)
- R12 Resistor (1.2 K, 1/2W, 5%)
- R11 Resistor (2.7K, 1/2W, 5%)
- R10 Resistor (62K, 1/2W, 5%)
- R9 Resistor (27K, 1/2W, 5%)
- R8 Resistor (68K, 1/2W, 5%)
- R7, R16 Resistor (47K, 1/2W, 5%)
- R6 Resistor (150 Ω, 2W, 5%)
- R5 Potentiometer (100K, 1/2W)
- R3, 4 Resistor (10K, 1/2W, 5%)
- R2 Resistor (2.2 K, 1/2W, 5%)
- R1 Resistor (270 Ω, 10W, 5%)
- Q4 Power Transistor - Silicon (NPN)
- Q3 Transistor - Silicon (NPN High Volt)
- Q1, 2 Transistor - Silicon (PNP)
- K1 Relay
- CR28 Rectifier - Fast Recover
- CR9, 15, 22-27 Rectifier - Silicon (6A, 800V)
- CR3, 5 Diode - Fast Switching
- 14, 16-21 & 29 Rectifier - Silicon (1A, 800V)
- CR1,2,4,6,7,8 Capacitor (4000 MFD, 30V)
- C15 Capacitor - Metalized (.33 MFD, 400 V)
- C13 Capacitor - Metalized (.001 MFD, 1000V)
- C11 Capacitor - Metalized (.47 MGD .250V)
- C10 Capacitor - Metalized (1 MFD, 100V)
- C9 Capacitor - Metalized (.1 MFD, 100V)
- C7,12 Capacitor - Metalized (.22 MFD, 630 V)
- C6,8 Capacitor - Metalized (.1 MFD 250 V)
- C5 Capacitor - Metalized (1 MFD, 400V)
- C4 Capacitor - Metalized (.47 MFD, 400V)
- C3 Capacitor (10 MFD, 20V)
- C2 Capacitor - Monolytic (.22 MFD, 50V)
- C1 Capacitor - Metalized (.047 MFD, 250 V)

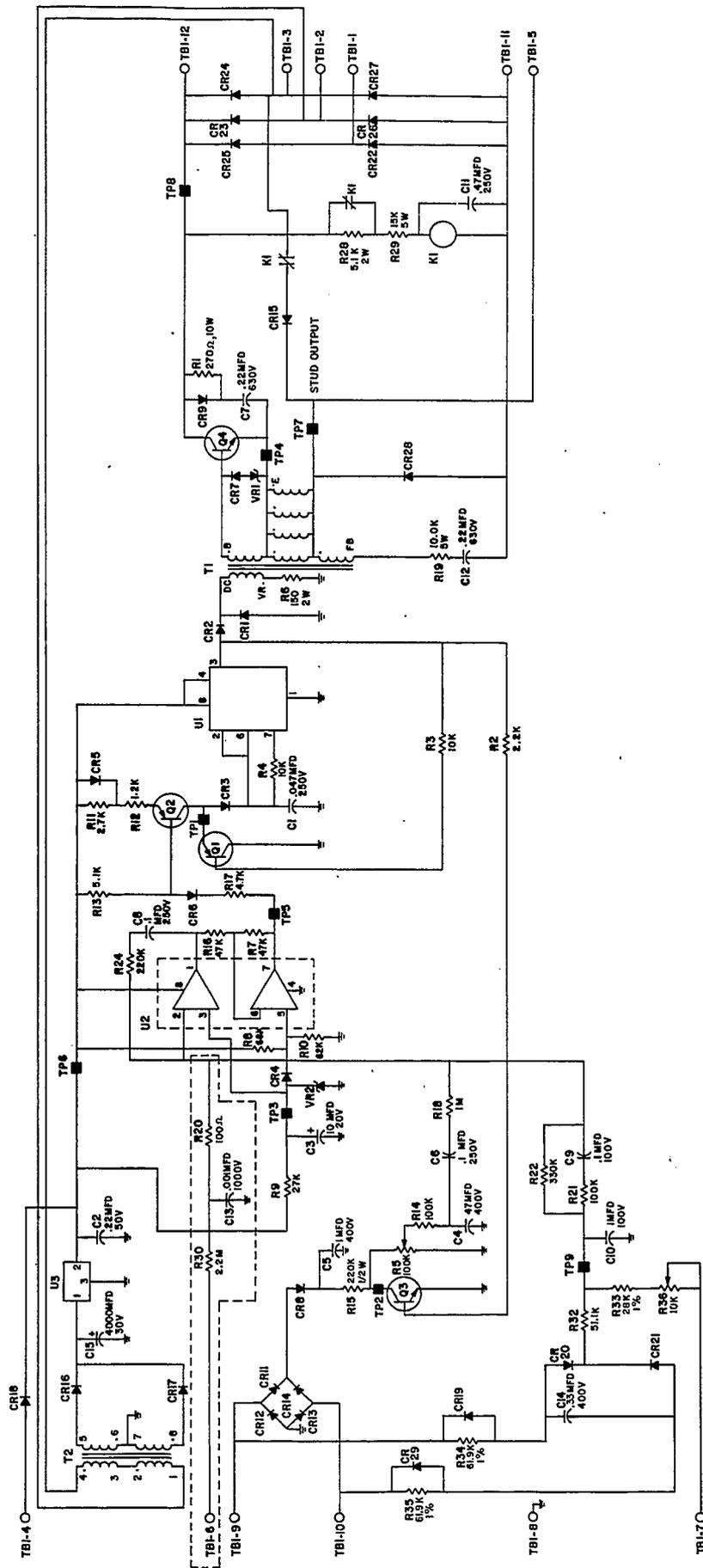


FIGURE 7. REGULATOR PC BOARD (300-2409)

The basic regulating circuit performs several functions. A voltage sensing circuit samples the generator terminal voltage by sensing changes in the output voltage from the reference transformer T21. The AC output from T21 is rectified to DC and fed to the sensing side of the error detector circuit (U2). The error detector compares the sensed voltage with a constant DC zener diode regulated voltage. The difference is amplified and fed to the control section of a voltage controlled variable frequency oscillator (U1). The oscillator responds to changes in the voltage fed to its control section by increasing or decreasing the oscillation frequency. The current pulses produced by the oscillator are fed to the pulse transformer which triggers firing of the power transistor.

By modifying the rate of current pulses fed to the pulse transformer, the DC field voltage can be controlled. This allows the generator terminal voltage to be maintained within specified limits.

Several additional circuits are used to improve the operation and efficiency of the regulating circuit. However, the basic regulating functions are performed as described.

2. Remove the generator output box cover (see Figure 8) and disconnect the stator lead wires from the load wires.
3. Unplug the control wiring harness from the underside of the control box.
4. Remove the overspeed switch bracket and switch assembly from the end bell.
5. Remove the upper and lower brackets that secure the output box to the end bell.
6. Remove the end bell stud nuts and slide off the end bell and exciter stator assembly (see Figure 9). It may be necessary to tap around the joint to separate the end bell from the stator assembly.
7. Loosen the screws that fasten the output box to the generator and remove the output box and control box as an assembly.
8. Use a hoist and safe lifting device (stator handling tongs or chain and lift hooks) to support the stator assembly as shown in Figure 9. On DL4 and DL6 sets, carefully remove the capscrews from the stator attachment ring.

GENERATOR SERVICE

The following sections describe the disassembly and reassembly procedures for the generator.

WARNING *Accidental starting of the set might cause severe personal injury or death. Disconnect the negative battery cable when repairs are made to the engine, controls, or generator.*

Disassembly

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

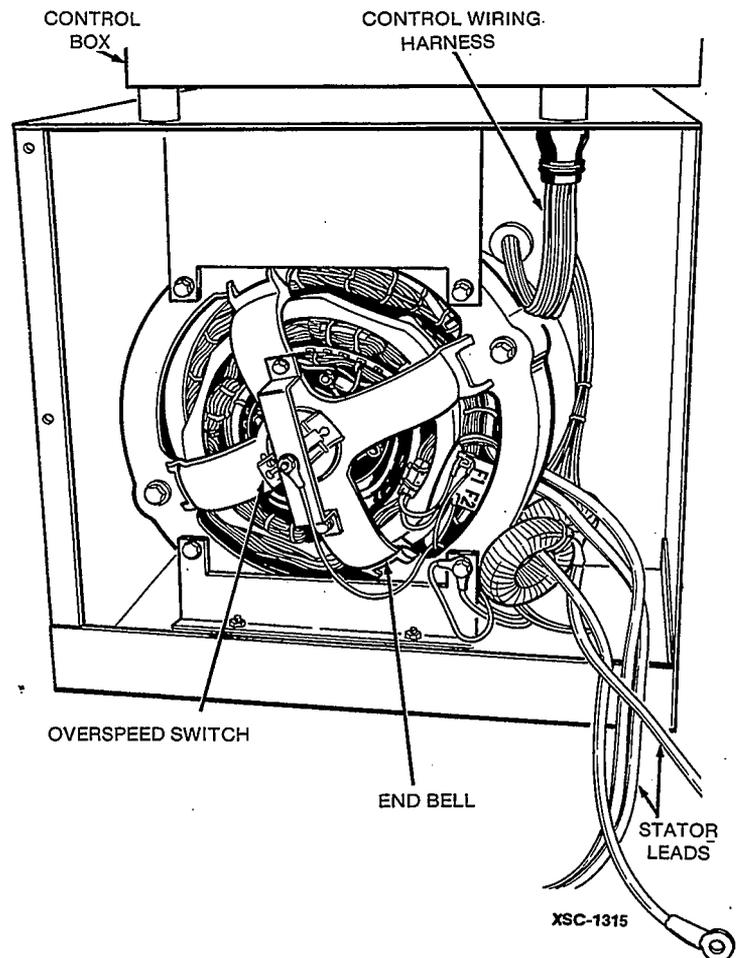


FIGURE 8. OUTPUT BOX AND CONTROL

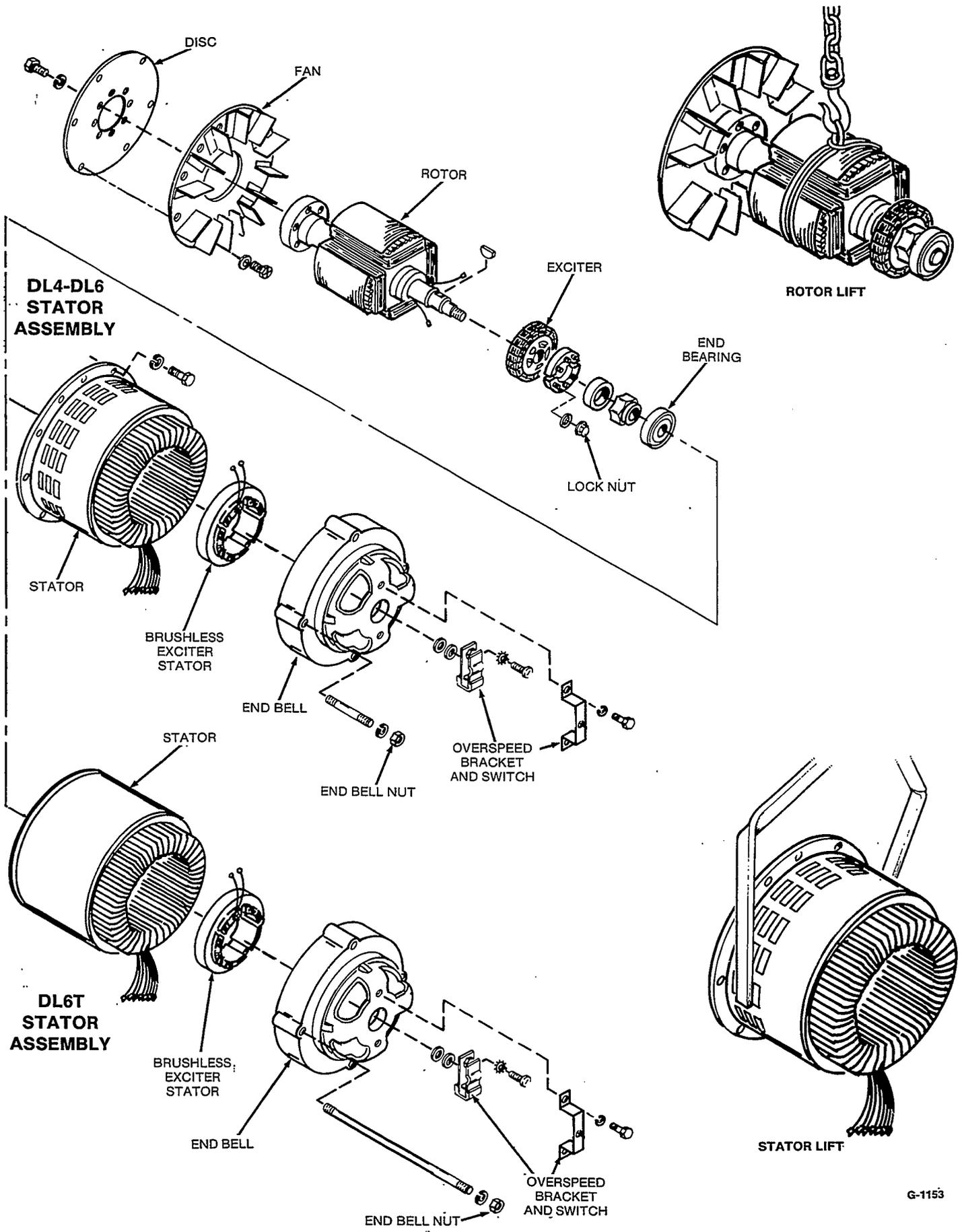


FIGURE 9. GENERATOR ASSEMBLY

9. Remove the stator assembly being careful not to touch or drag on the rotor. Place stator on its side in the horizontal position. On DL6T sets, remove the four end bell studs from the generator adapter.
10. Using a hoist and sling to support the rotor, carefully remove the capscrews that attach the drive disc to the engine flywheel (Figure 9).
11. Remove the rotor assembly and place it on wood blocks in the horizontal position. The drive disc and fan should not be resting on anything to avoid possible distortion.
12. Remove the bolts that hold the drive disc to the rotor shaft and remove the drive disc and rotor fan.
13. Use a gear puller to remove the end bearing from the rotor shaft (Figure 10).
14. Clamp the rotor in a fixed position and remove the exciter rotor lock nut.
15. Remove the generator field leads from the exciter rotor and slide the exciter off the rotor shaft.

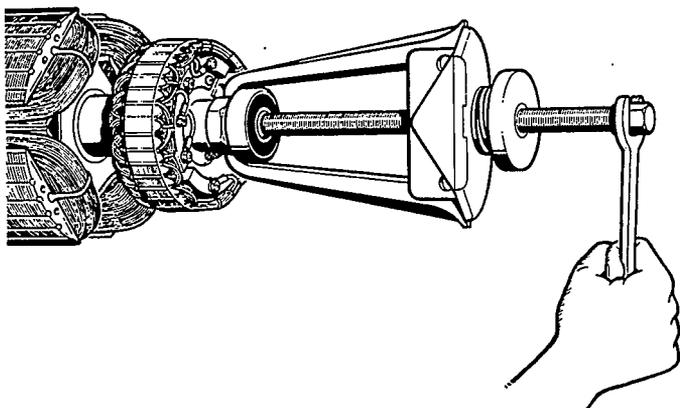


FIGURE 10. END BEARING REMOVAL

7. Install the 8 capscrews that hold the drive disc to the engine flywheel and torque to 39 ft. lbs. (52 N•m).
8. Using a hoist and safe lifting device, carefully move the stator into position over the rotor assembly. The stator leads should be at the 4 o'clock position when viewed from the end bell position.
9. On DL4 and DL6 sets, align the holes in the stator attachment ring with the holes in the flywheel housing and install the 12 capscrews. Torque to 39 ft. lbs. (52 N•m). On DL6T sets, install the end bell studs in the generator adapter.
10. Install the control box assembly.
11. Apply a thin film of Molykote grease or equivalent to the mating surfaces of the end bearing and the end bell bearing hole.
12. Install end bell assembly on the stator with the opening for the generator leads in the 4 o'clock position. Torque end bell stud nuts to 20 ft. lbs. (27 N•m).
13. Using a lead hammer, tap the end bell at the horizontal and vertical plane to relieve stress. Retorque end bell stud nuts.
14. Install the upper and lower output box brackets.
15. Plug in the control wiring harness and connect the stator lead wires to the load wires. Refer to Figure 26 for the generator voltage connections.
16. Install the overspeed switch assembly and switch bracket.
17. Verify that all connections are secure and then install the output box cover.
18. Connect the negative (-) battery cable and test generator for operation.

Reassembly

1. Slide the exciter rotor over the generator shaft and install the exciter lock nut. Torque to 130 to 150 ft. lbs. (176 to 203 N•m).
2. Connect generator field leads to F1+ and F2-terminals on exciter assembly. Torque to 23 to 26 inch lbs. (2.6 to 2.9 N•m).
3. Press the end bearing onto the rotor shaft.
4. Place the generator fan in position on the rotor shaft.
5. Install the drive disc on the end of the rotor shaft with the chamfer on the flywheel side. Torque the 8 placement bolts to 70 to 80 ft. lbs. (95 to 108 N•m).
6. Using a hoist and sling to support the rotor, align the holes in the drive disc and fan with the corresponding holes in the flywheel.

Generator/Regulator Troubleshooting

PREPARATION

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

- Check all modifications, repairs, replacements performed since last satisfactory operation of set to ensure 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.

CAUTION *Do not mark on printed circuit boards with a pencil. Graphite lines are conductive and can cause leakage or short circuit between components.*

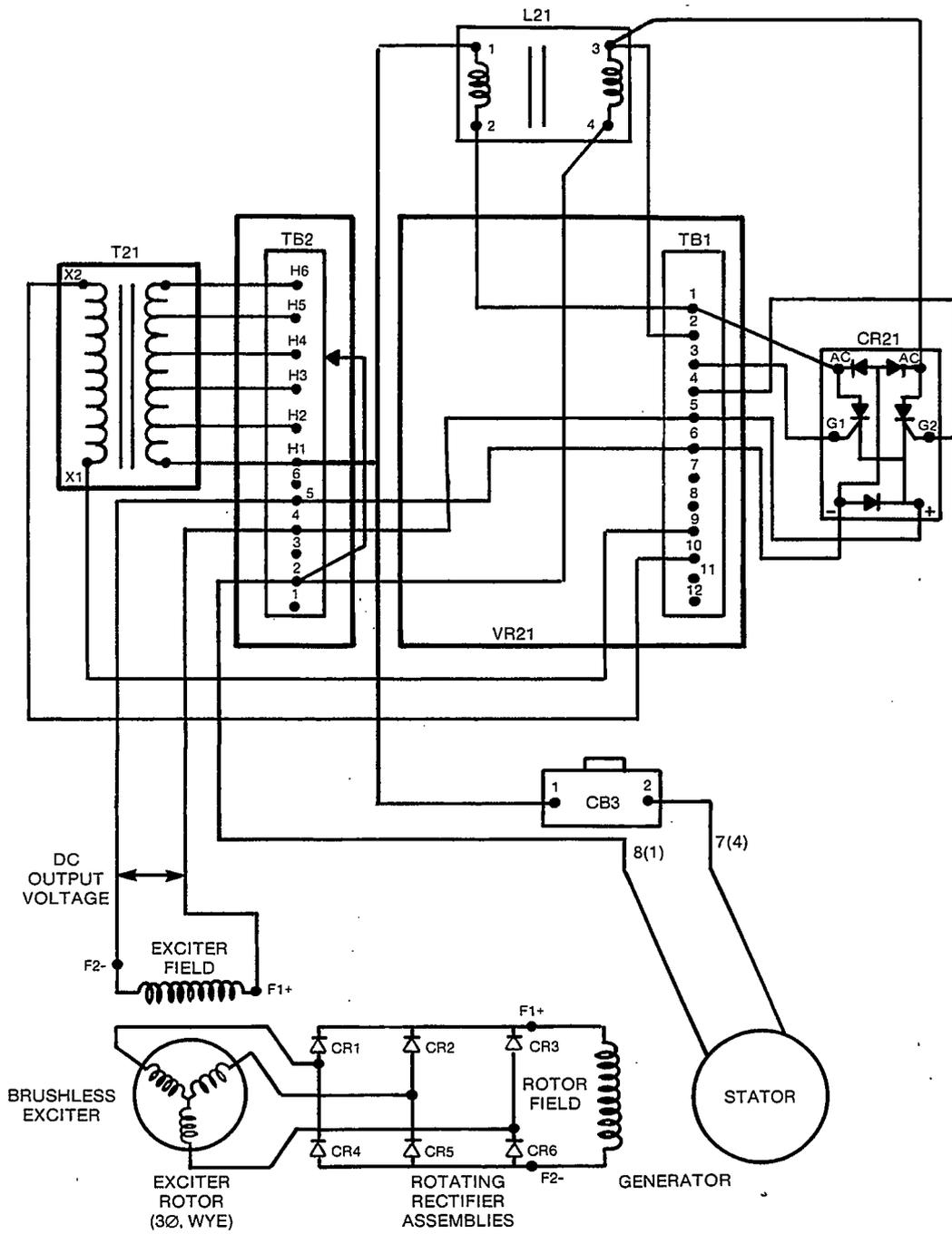
TROUBLESHOOTING PROCEDURES

The information in this section is for both single and three phase YD generators using the standard UR type voltage regulator or the optional switching voltage regulator. Determine the problem and then refer to the appropriate Flow Chart (A, B, C, D, or E) for the troubleshooting procedures.

- 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.

Referenced components in the Flow Charts and Adjustment and Test procedures can be found on the electrical schematics (Figure 11 and 12) and on assembly drawings and wiring diagrams.



ES-1317-1

FIGURE 11. YD GENERATOR AND STANDARD VOLTAGE REGULATOR

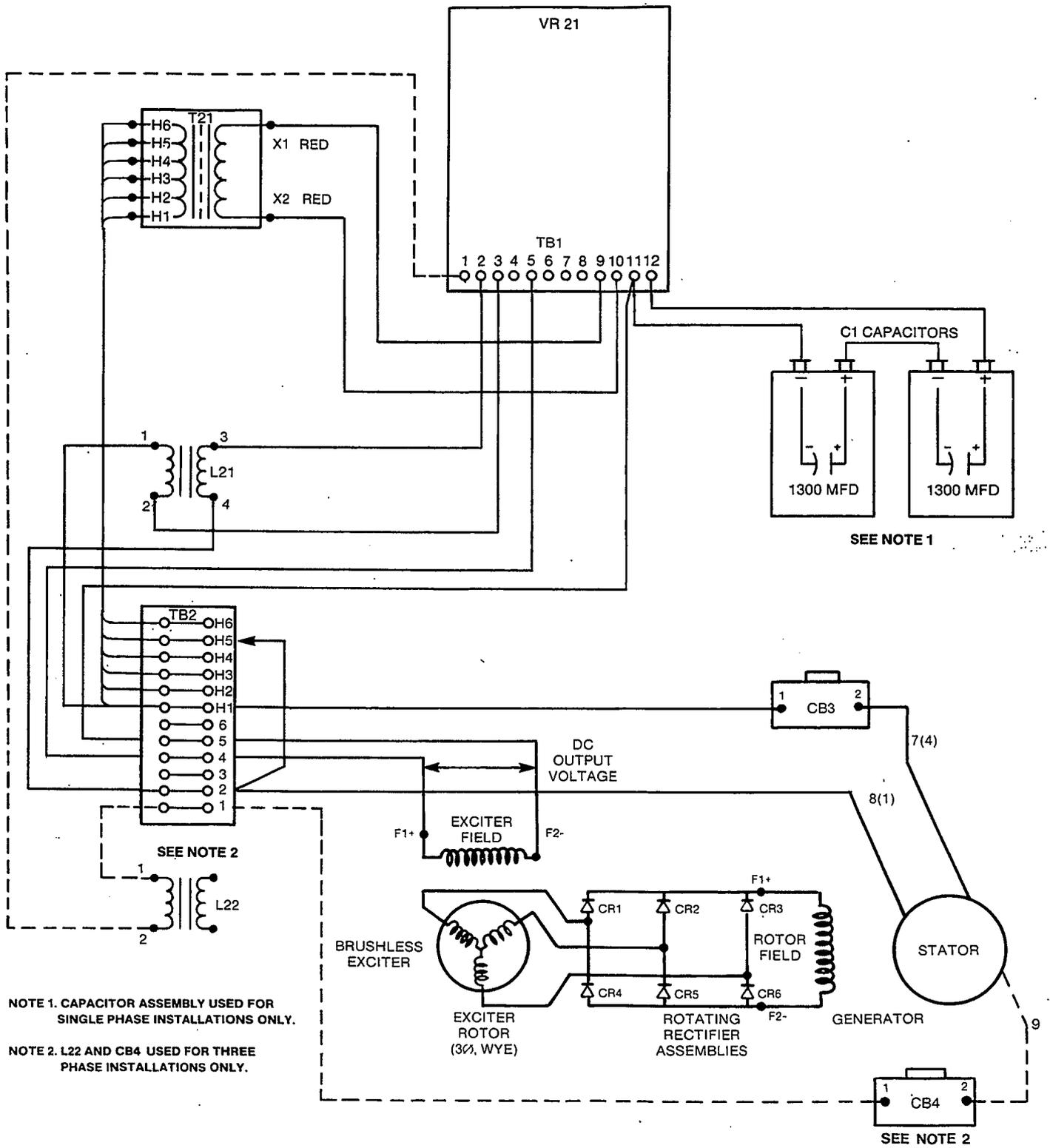
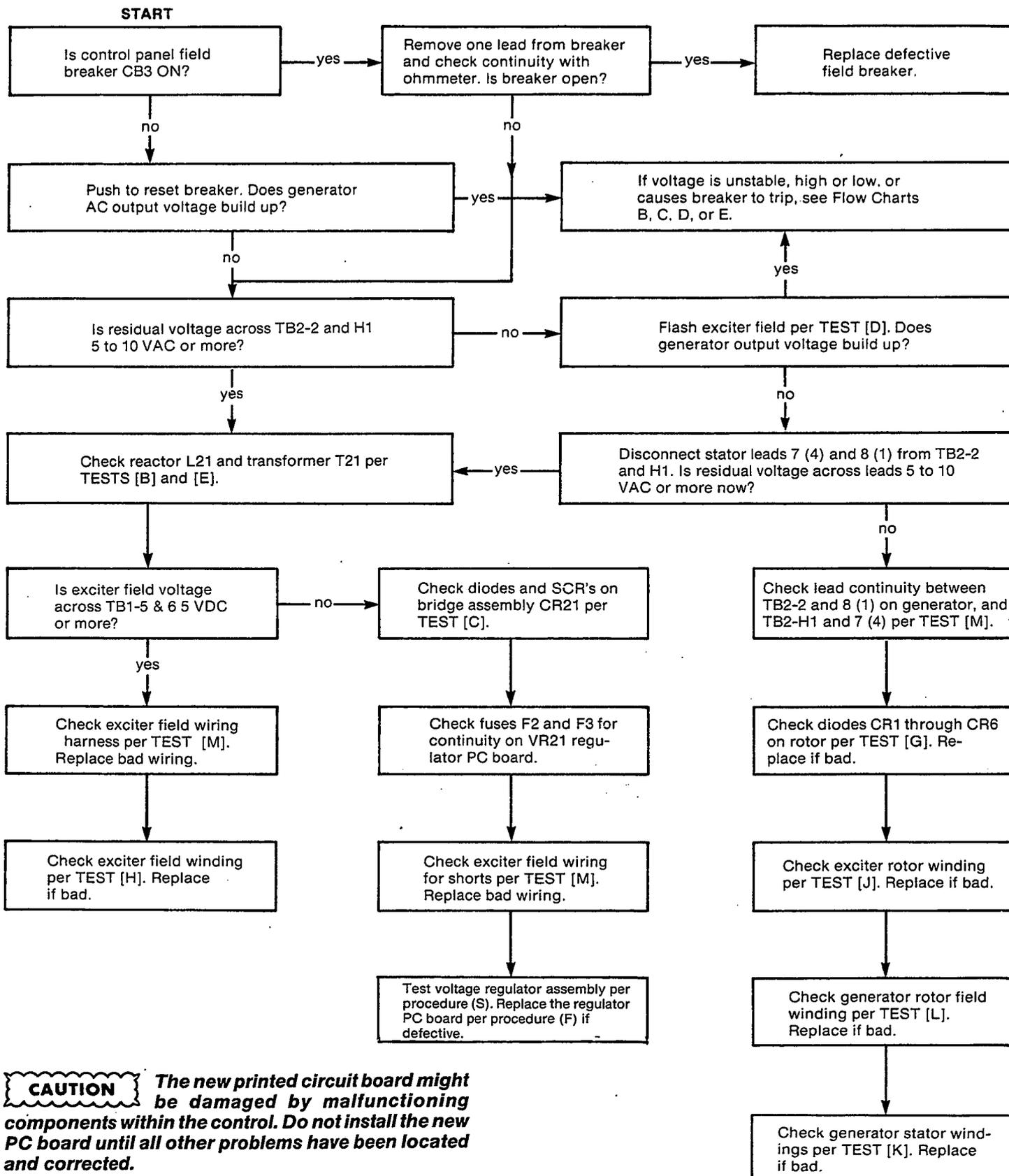
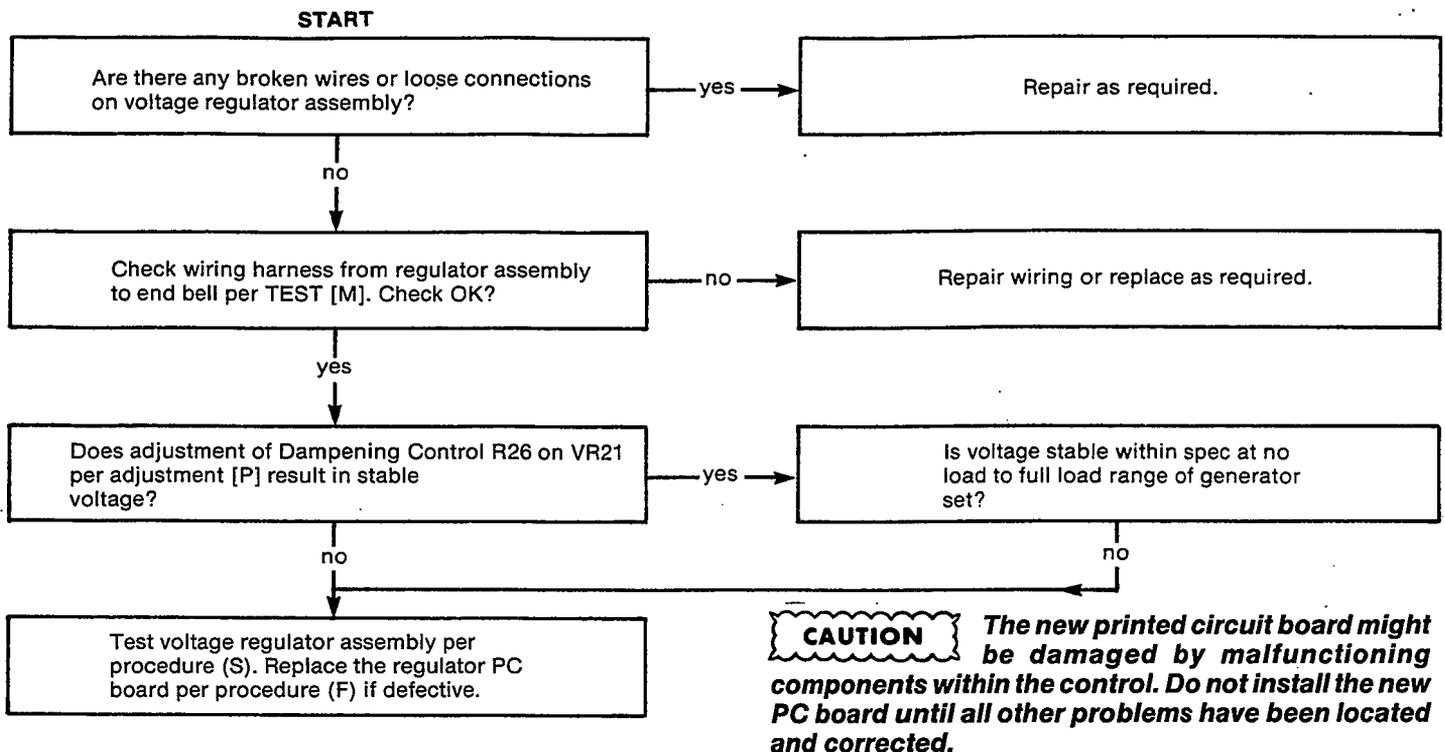


FIGURE 12. YD GENERATOR AND SWITCHING VOLTAGE REGULATOR

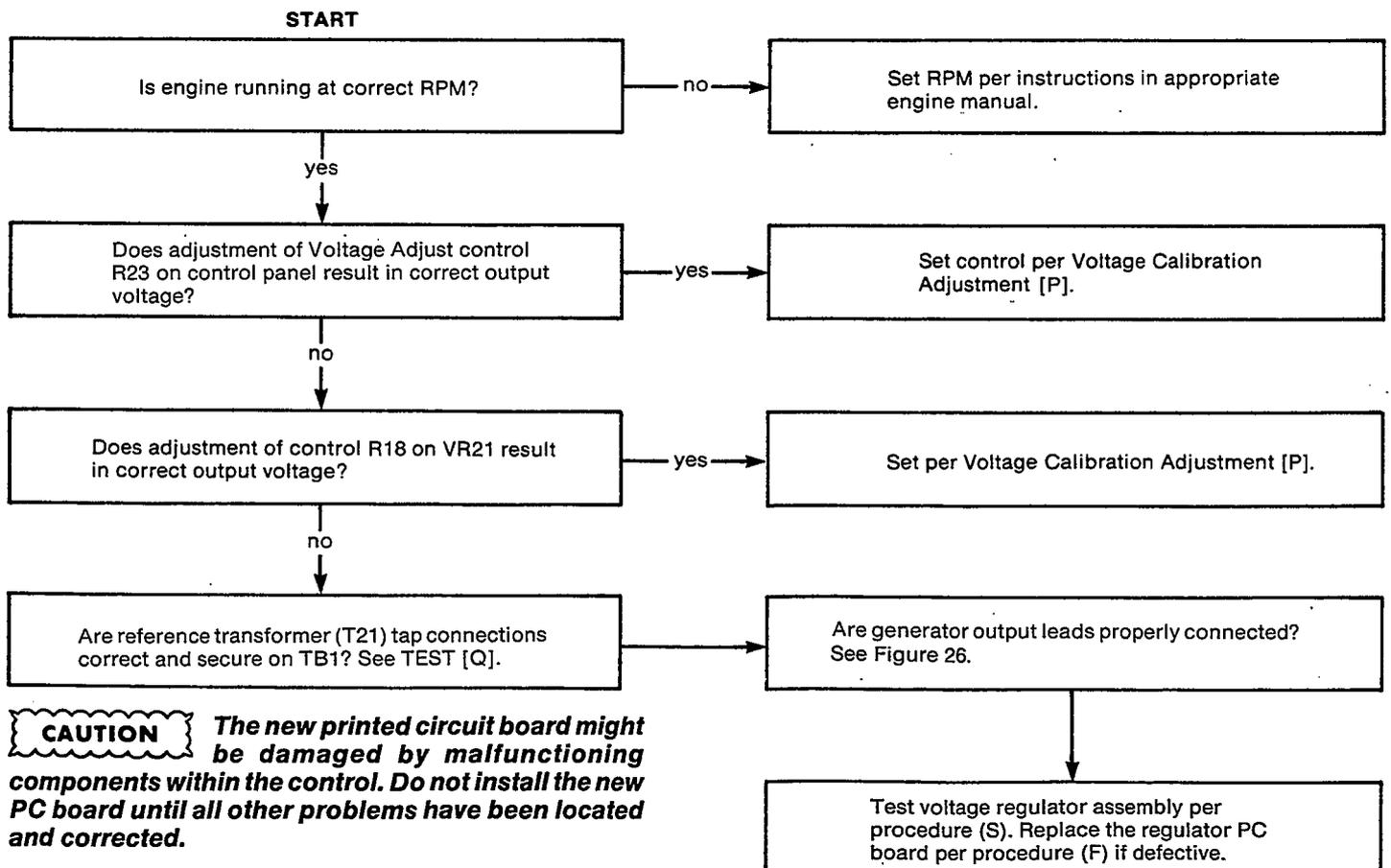
FLOW CHART A. NO AC OUTPUT VOLTAGE AT RATED ENGINE RPM STANDARD VOLTAGE REGULATOR



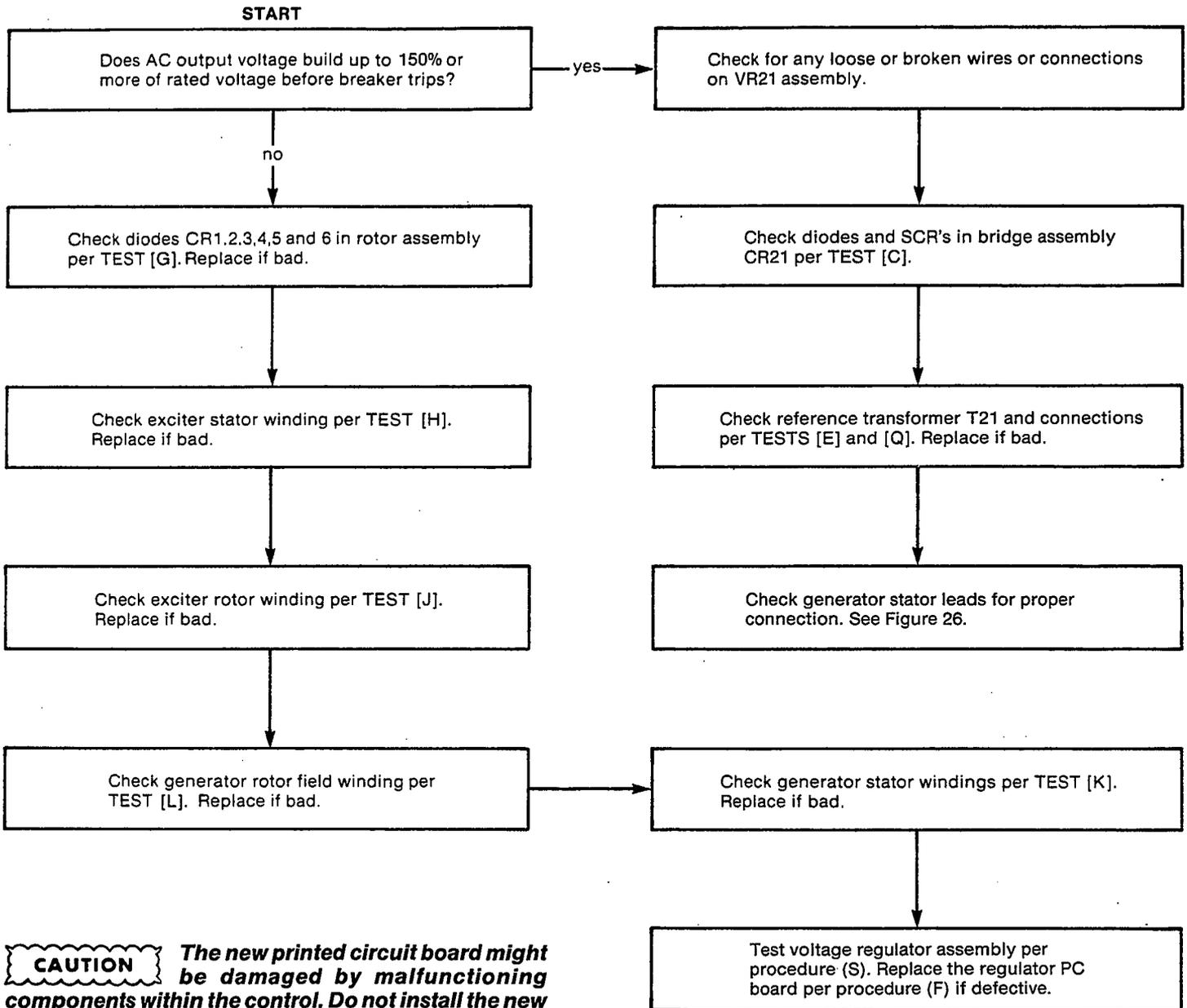
FLOW CHART B. UNSTABLE VOLTAGE, ENGINE SPEED STABLE 1800 RPM STANDARD VOLTAGE REGULATOR



FLOW CHART C. OUTPUT VOLTAGE TOO HIGH OR LOW STANDARD VOLTAGE REGULATOR

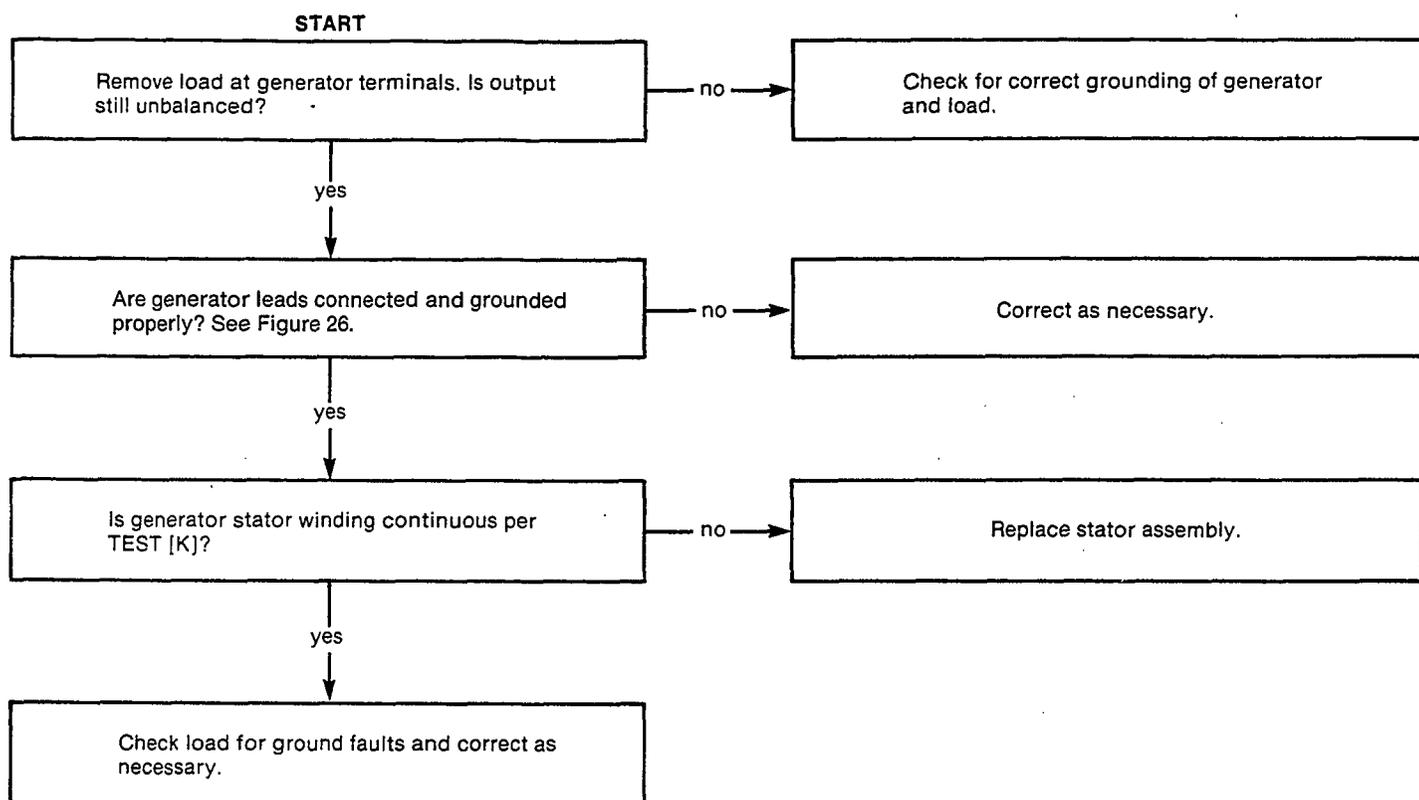


FLOW CHART D. EXCITER FIELD BREAKER TRIPS STANDARD VOLTAGE REGULATOR

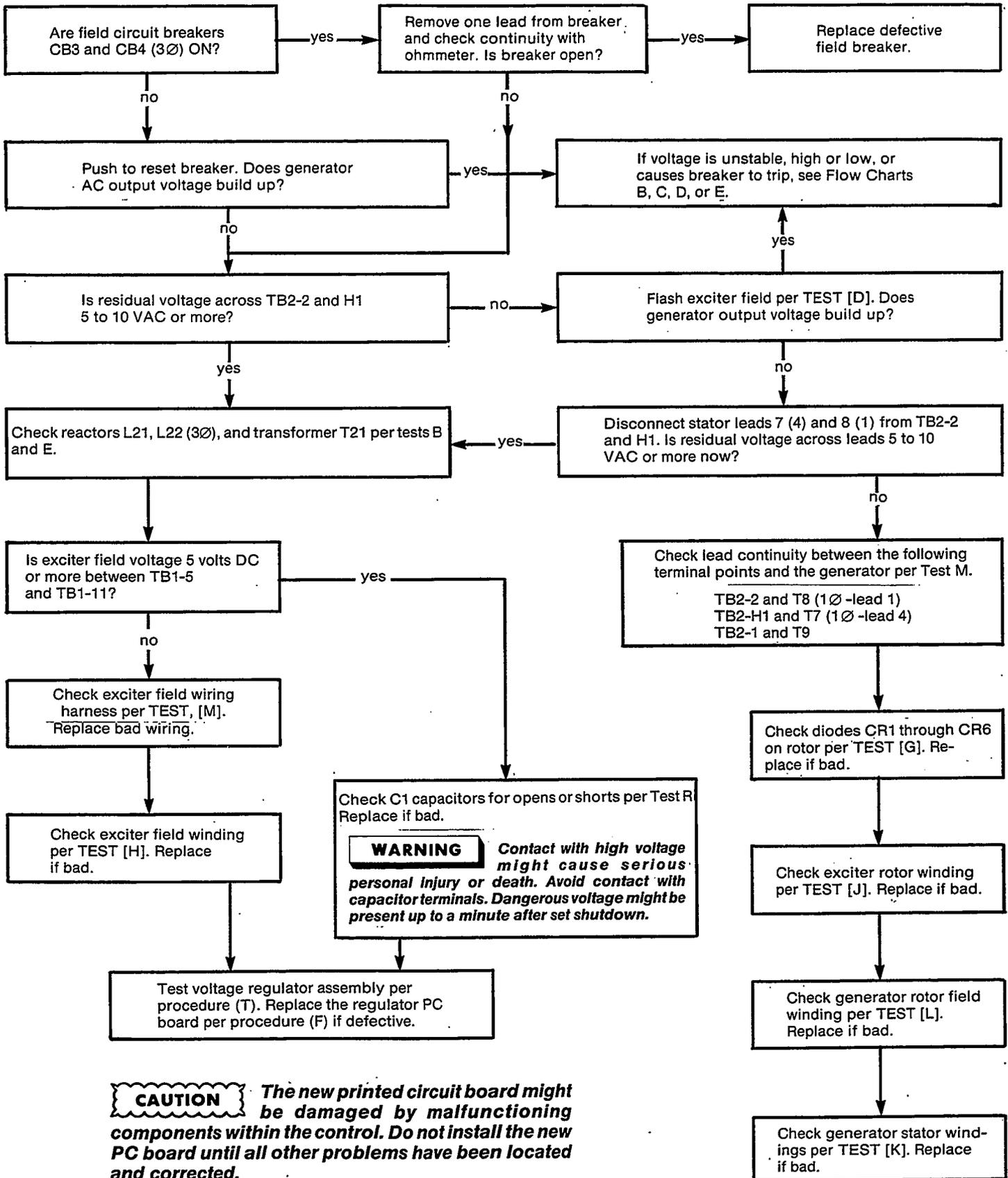


CAUTION *The new printed circuit board might be damaged by malfunctioning components within the control. Do not install the new PC board until all other problems have been located and corrected.*

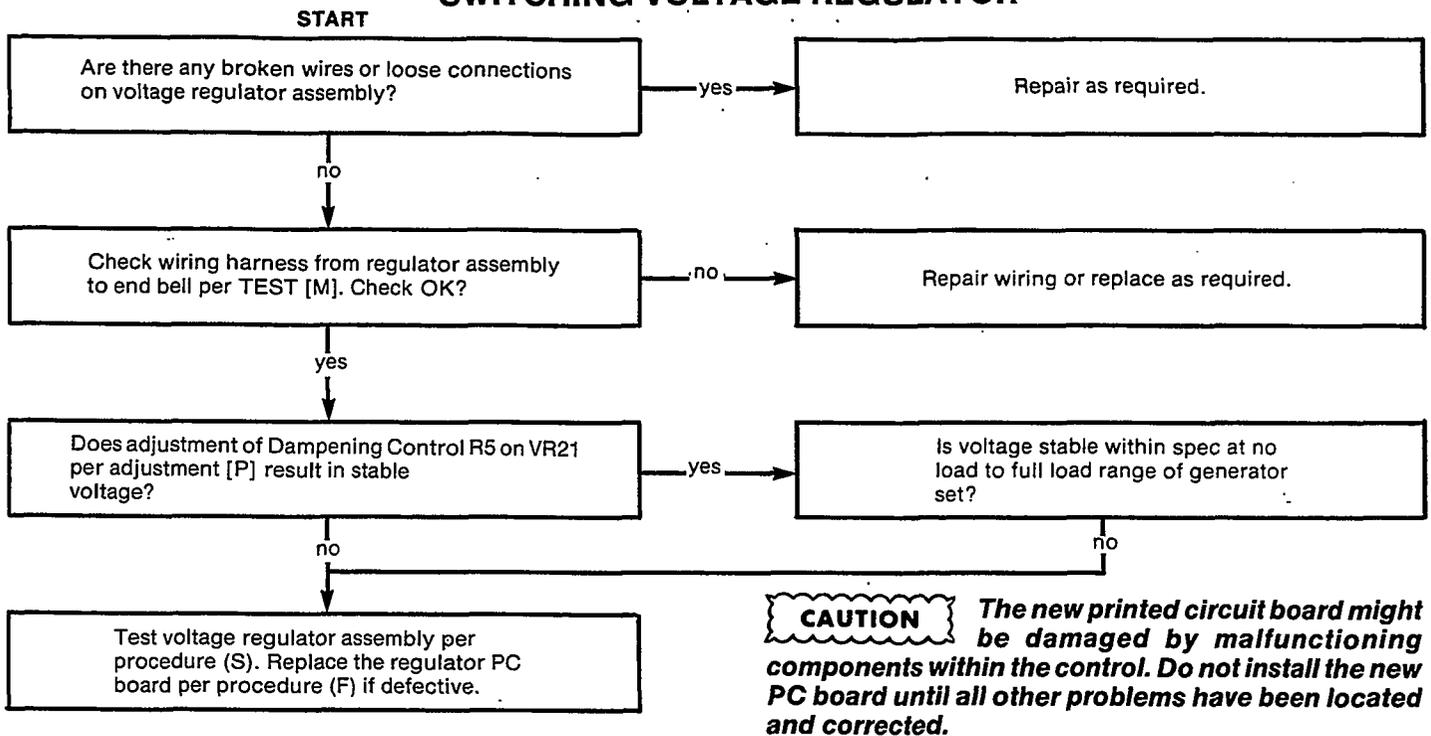
FLOW CHART E. UNBALANCED GENERATOR OUTPUT VOLTAGE STANDARD AND SWITCHING VOLTAGE REGULATOR



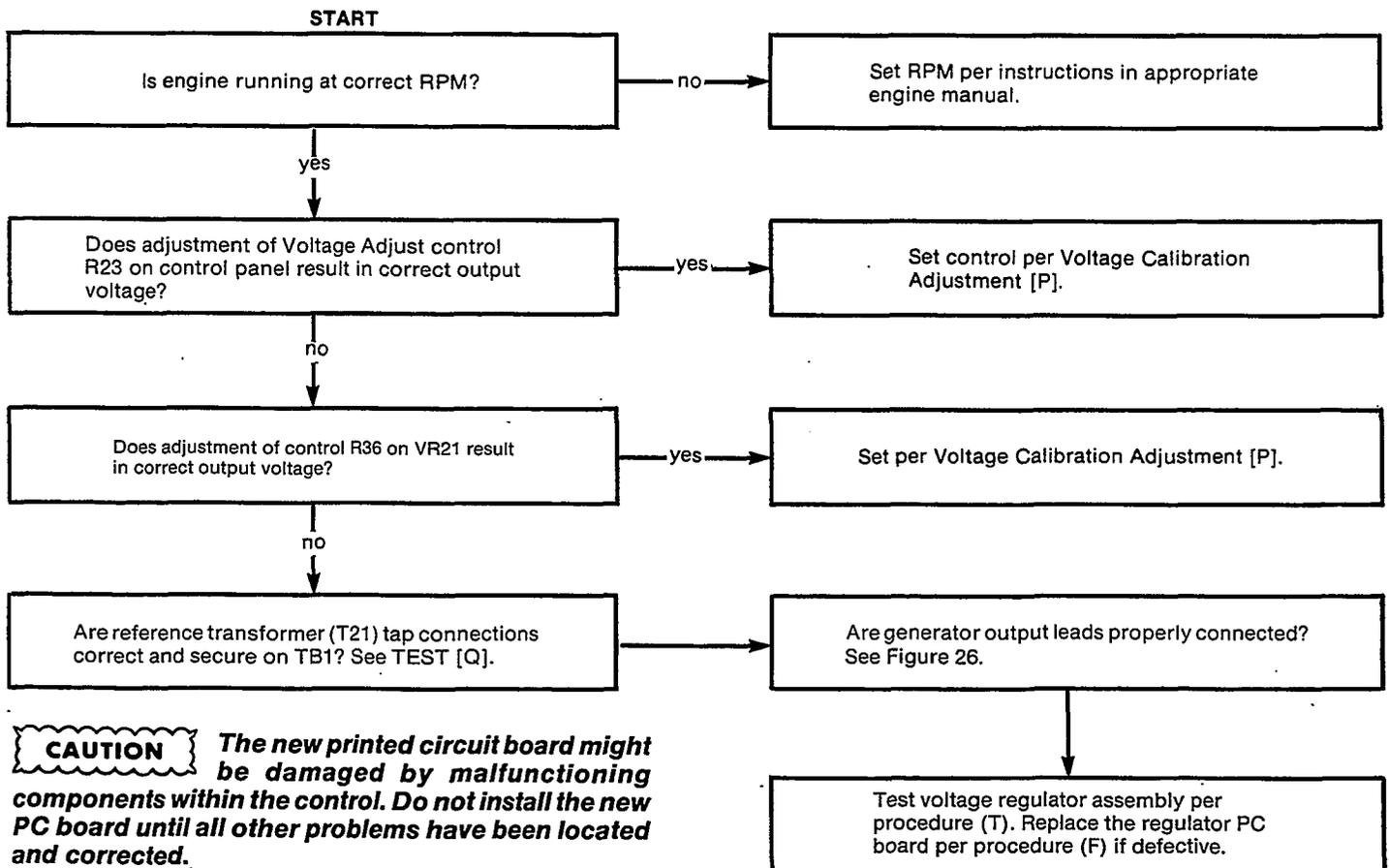
FLOW CHART A. NO AC OUTPUT VOLTAGE AT RATED ENGINE RPM SWITCHING VOLTAGE REGULATOR



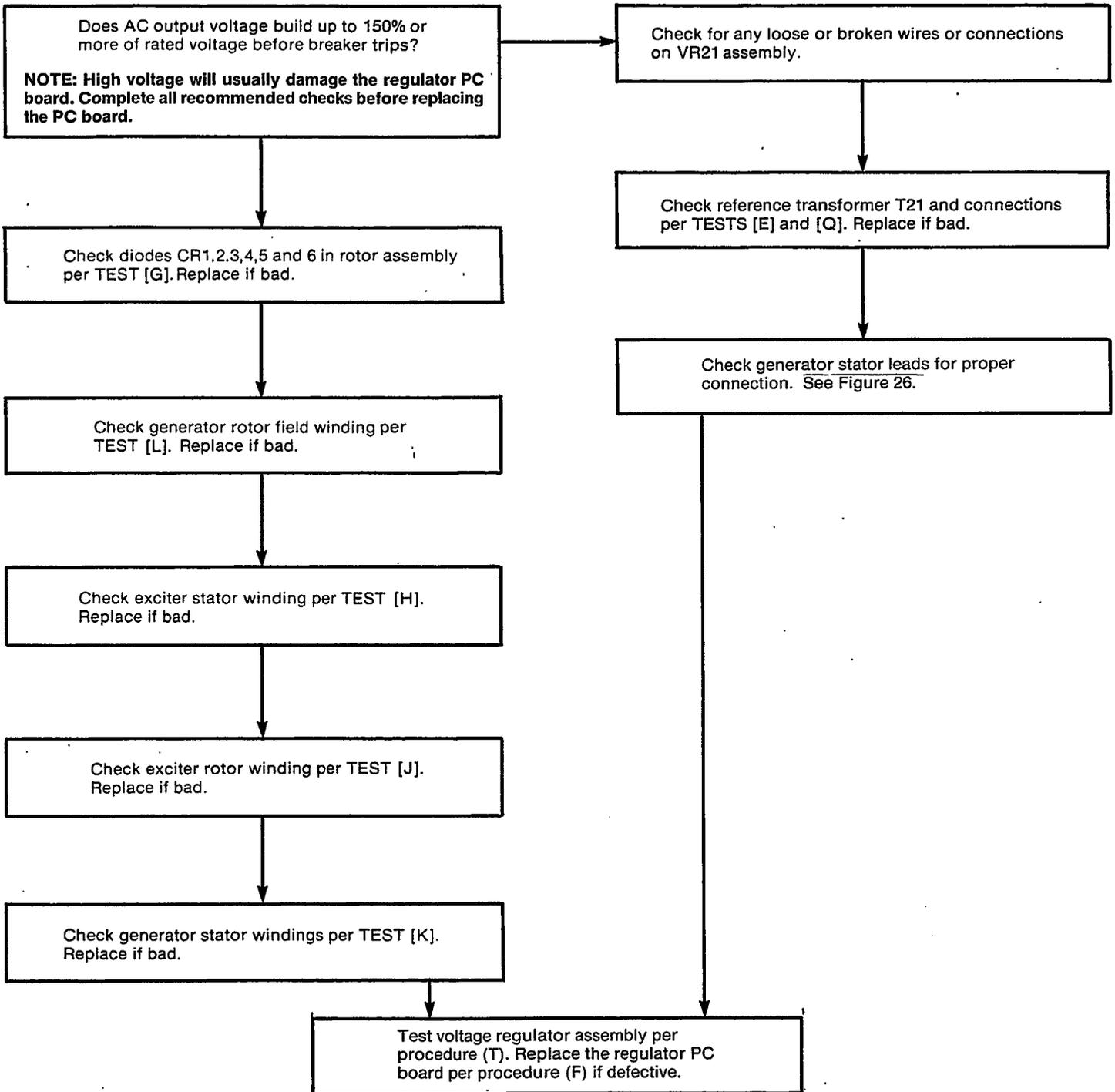
FLOW CHART B. UNSTABLE VOLTAGE, ENGINE SPEED STABLE 1800 RPM SWITCHING VOLTAGE REGULATOR



FLOW CHART C. OUTPUT VOLTAGE TOO HIGH OR LOW SWITCHING VOLTAGE REGULATOR



FLOW CHART D. EXCITER FIELD BREAKER TRIPS SWITCHING VOLTAGE REGULATOR



CAUTION *The new printed circuit board might be damaged by malfunctioning components within the control. Do not install the new PC board until all other problems have been located and corrected.*

Generator/Regulator Tests

GENERAL

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

[A]

TESTING AC RESIDUAL VOLTAGE

Test for residual AC voltage if there is no AC power output from the generator. Check between terminals 2 and H1 on TB2 (Figures 11 and 12). Residual voltage should be 5 to 10 VAC. If none, flash the field per Test (D).

If residual voltage is present at TB2, proceed to PC board VR1. On sets with the standard regulator, check between terminals 1 and 2 on TB1 (Figure 11). On sets with the switching regulator, check between terminals 2 and 3 on TB1 (Figure 12). If no voltage is present, check continuity between these points with the generator shut down. If voltage is low, check reactor (Test B) and T21 transformer (Test E).

[B]

TESTING COMMUTATING REACTORS

The L21 and L22 commutating reactors (Figure 13) mount inside the control box. Remove reactor leads from terminal board for testing.

The coils 1-2 and 3-4 are wound on the same core. Resistance between 1-2 and 3-4 should be .031 to 0.37 and .037 to 0.46 ohms respectively at 77°F (25°C). Resistance between coils and from any terminal to frame of the reactor should be infinity.

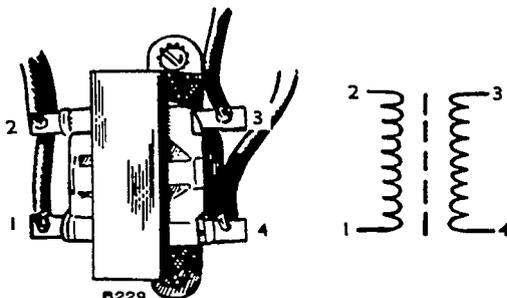


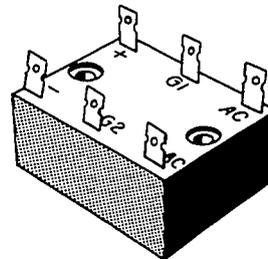
FIGURE 13. COMMUTATING REACTORS

[C]

TESTING RECTIFIER BRIDGE ASSEMBLY (CR21)

The rectifier bridge located within the control cabinet, contains 3 diodes, CR1, CR2 and CR3, and two silicon controlled rectifiers, SCR1 and SCR2. The components are encapsulated within a hermetically sealed block, therefore failure of any diode or SCR means the entire unit has to be replaced. See Figure 14.

Disconnect wires from rectifier unit prior to testing. Test unit in order shown in Table 1. Refer to Figure 15 for SCR1 and SCR2 test circuit. When test is complete and satisfactory, reconnect unit observing correct wiring hook-up.



AC TERMINALS ARE GIVEN NUMERIC DESIGNATIONS FOR TEXT REFERENCE ONLY. DOES NOT APPEAR ON UNIT.

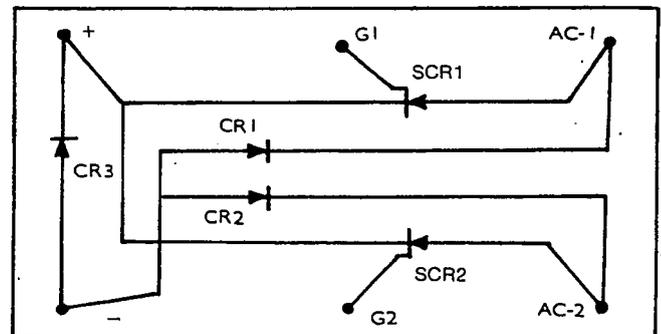


FIGURE 14. RECTIFIER BRIDGE ASSEMBLY

[D]

FLASHING THE FIELD

If output voltage does not build up it may be necessary to restore residual magnetism by flashing the field. Assemble a 6-volt battery, 10-ohm resistor, and diode as shown in Figure 16.

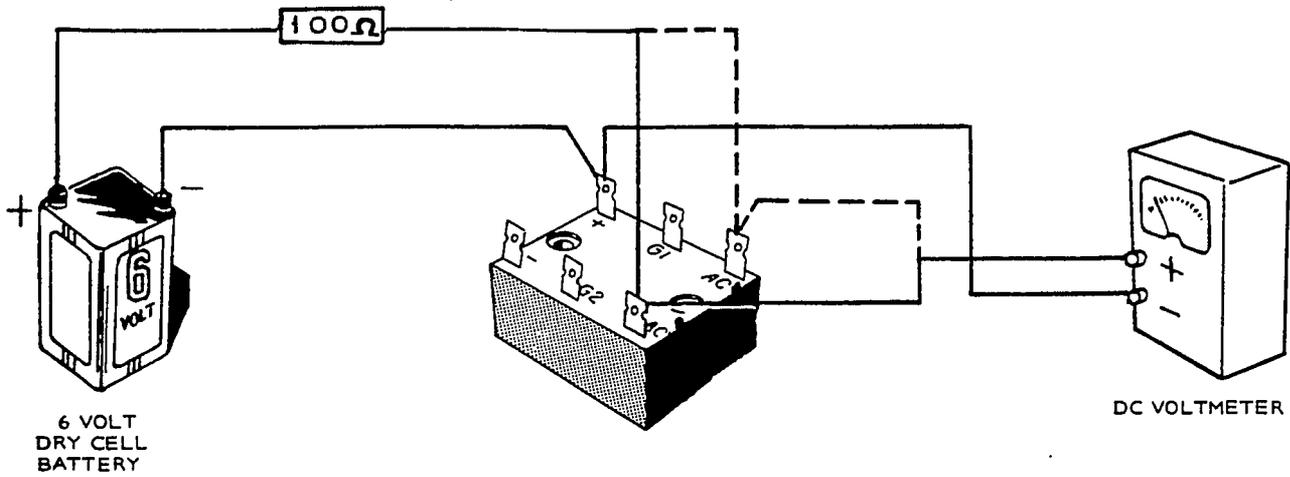
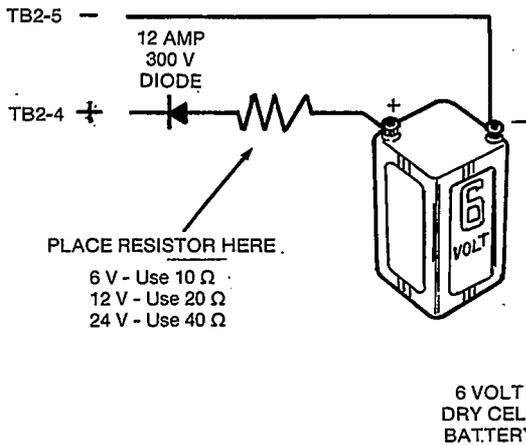


FIGURE 15. TESTING CR21

If a 6-volt lantern battery is not available, a 12-volt or 24-volt generator set battery can be used. However, a 20-ohm or a 40-ohm, 2 watt resistor must be used in series respectively with the 12 amp 300 V diode. Start the generator set and operate at normal rpm. Touch the positive (+) lead to terminal TB2-4 and the negative (-) lead to terminal TB2-5. Hold leads on terminals just long enough for voltage to build up.

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

[E]



ES-1420

FIGURE 16. FIELD FLASHING CIRCUIT

TESTING REFERENCE TRANSFORMER T21

Transformer T21 has eight leads; six are primary leads marked H1 through H6, two are secondary leads marked X1 and X2.

TABLE 1. TESTING RECTIFIER BRIDGE ASSEMBLY CR21

TEST	OHMMETER LEAD		RECTIFIER TERMINALS	TESTING		REMARKS	METER SCALE	
	+	-		CR	SCR			
1	x	x	+	CR3		Infinity	Rx10K	
2	x	x	-	CR3		6- to 50-Ohms	Rx1	
3	x	x	+		SCR1	Infinity	Rx10K	
4	x	x	AC1			Infinity	Rx10K	
5	x	x	-	CR1		6- to 50-Ohms	Rx1	
6	x	x	+		SCR2	Infinity	Rx10K	
7	x	x	AC2			Infinity	Rx10K	
8	x	x	-	CR2		6- to 50-Ohms	Rx1	
	6 V Battery with Resistor					DC Voltmeter Lead	DC Voltmeter Reading less than	
9*	AC1	+			SCR1	AC1	+	3 Volts
10**	AC2	+			SCR2	AC2	+	3 Volts

* - Apply temporary jumper from AC1 to G1 to test SCR1. Remove jumper and read voltmeter. See Figure 15.
** - Apply temporary jumper from AC2 to G2 to test SCR2. Remove jumper and read voltmeter. See Figure 15.

The winding schematic (Figure 17) shows the resistance values for the individual coils in ohms. Resistance between any primary and secondary leads and from any lead to transformer frame should be infinity.

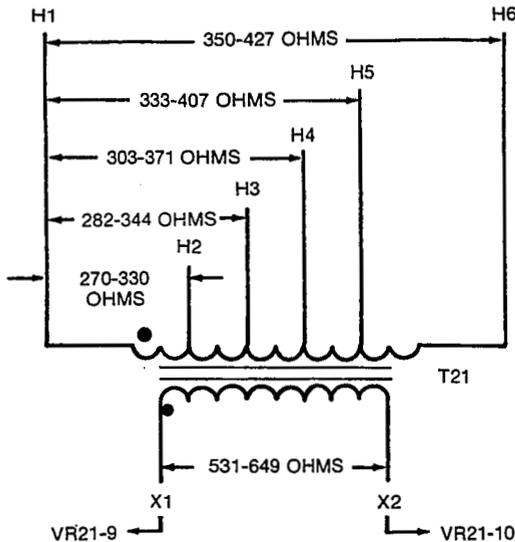


FIGURE 17. T21 WINDING SCHEMATIC

[F]

VR21 REPLACEMENT

Use the following procedure for replacing the voltage regulator PC board or VR chassis.

1. Stop engine.
2. Disconnect and if necessary, label wires. Refer to AC control wiring diagram.
3. Remove four screws at corners.
4. Remove old PC board.
5. Install new PC board; secure with four screws.
6. Reconnect wires removed in step 2 at proper terminals.
7. Place jumper W12 at proper terminals for your particular voltage code and voltage connection. See Test Procedure [Q].
8. Adjust the voltage and stability potentiometers as indicated:
Standard Regulator - Turn R18 fully counter-clockwise and R26 fully clockwise.
Switching Regulator - Turn R5 and R36 fully clockwise.
9. Perform voltage calibration and stability adjustment procedures to obtain the correct generator output voltage and stability with new PC board in set. Refer to test (P).

[G]

TESTING ROTATING RECTIFIERS

Two different rectifier assemblies make up the rotating rectifier bridge assembly, Figure 18. 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 N•m) torque when replacing nuts of F1+ and F2-, CR1, CR2, CR3, CR4, CR5, and CR6.

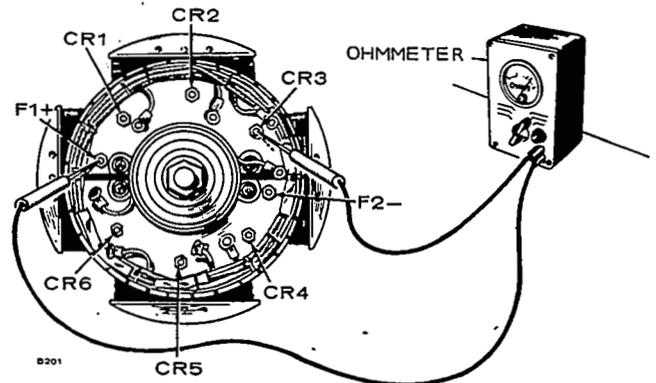


FIGURE 18. TESTING ROTATING RECTIFIERS

[H]

TESTING EXCITER STATOR

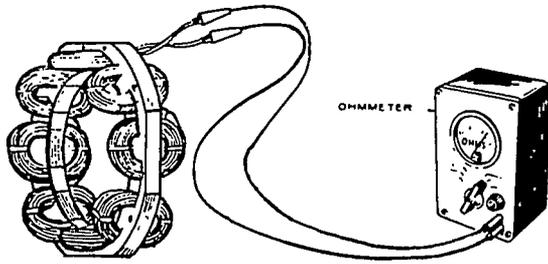
Testing the exciter stator (Figure 19) for open or shorted windings and grounds as follows:

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 13.05 to 15.95 ohms at 77° F (25° C).

Testing for Grounds

Connect ohmmeter between either field lead and exciter stator laminations. Use ohmmeter set at the highest resistance range. Resistance must be one megohm (1,000,000 ohms) or greater.



OHMMETER RESISTANCE BETWEEN F1 AND F2 SHOULD BE 13.05 TO 15.95 OHMS AT 77° F (25° C)

FIGURE 19. TESTING EXCITER FIELD FOR OPENS OR SHORTED WINDINGS

[J]

TESTING EXCITER ROTOR

Test the exciter rotor (Figure 20) for open or shorted windings or grounds as follows:

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, CR2, CR3, CR4, CR5 and CR6. Test between exciter lead pairs T1-T2, T2-T3 and T1-T3. Resistance should be 0.6 to 0.7 ohms at 68° F (20° C).

Testing for Grounds

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

[K]

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 an ohmmeter set at the highest resistance range to test each stator for shorts to laminations. A reading less than one megohm (1,000,000 ohms) indicates a ground.

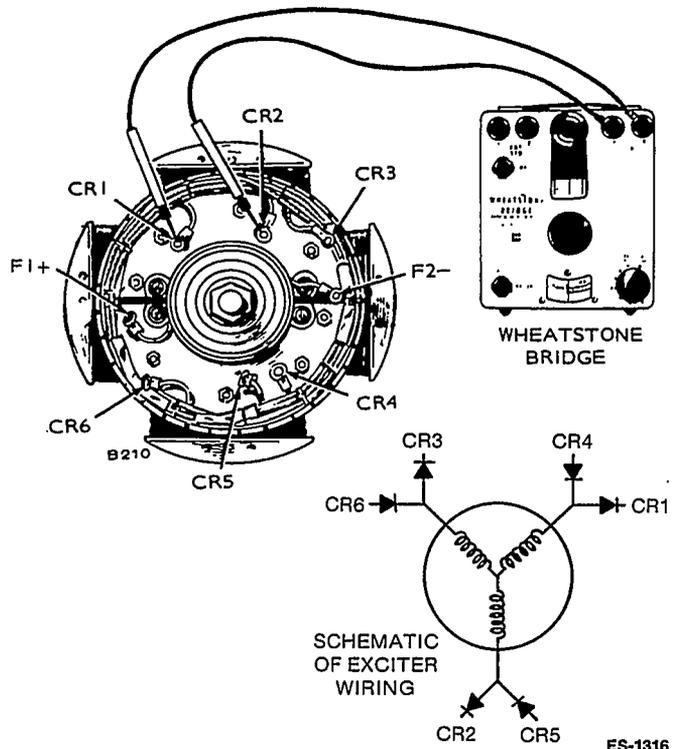


FIGURE 20. TESTING EXCITER ROTOR

Testing for Open or Shorted Windings

Test for continuity between coil leads shown in Figure 21; all pairs should have equal resistance. Use an accurate instrument for this test such as a Kelvin Bridge. Resistance values at 77° F (25° C) are given in Table 2.

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

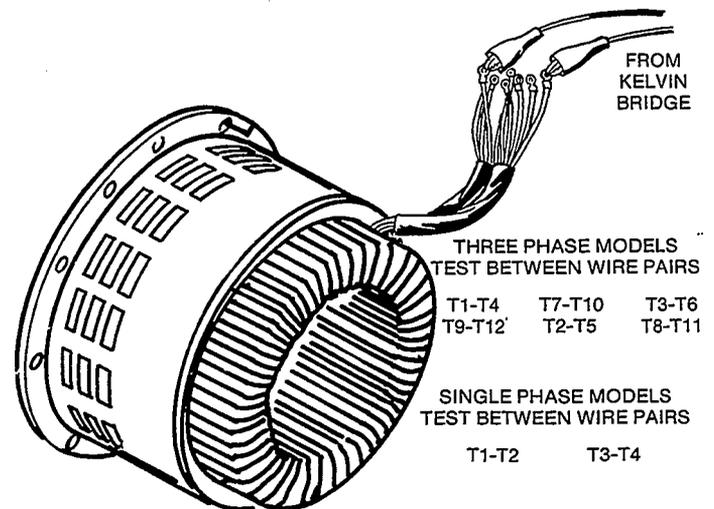


FIGURE 21. TESTING STATOR WINDINGS

TABLE 2. RESISTANCE VALUES FOR STATORS

Models (60 Hertz)	Ohms Resistance	
	Code 3R	Code 15R
20.0 DL4	0.049	0.127
25.0 DL6	0.039	0.100
30.0 DL6	0.029	0.072
40.0 DL6T	—	0.045

Models (50 Hertz)	Ohms Resistance	
	Code 53R	Code 515R
16.0 DL4	0.071	0.186
20.0 DL6	—	—
25.0 DL6	0.036	0.084
32.0 DL6T	—	0.059

[L]

TESTING GENERATOR ROTOR

For these tests, use an ohmmeter on the highest resistance range (R x 10 k Ω).

Testing for Grounds

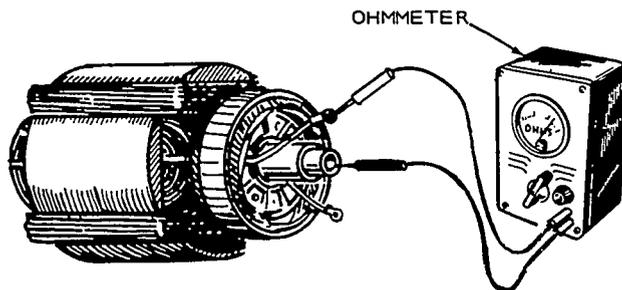
On brushless type generators, check for grounds between each rotor lead and the rotor shaft, Figure 19. Perform tests as follows:

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 register one megohm or greater.
3. If less than one megohm, rotor is grounded.
4. Replace grounded rotor with new, identical part.

Testing for Open or Shorted Windings

Perform tests as follows:

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



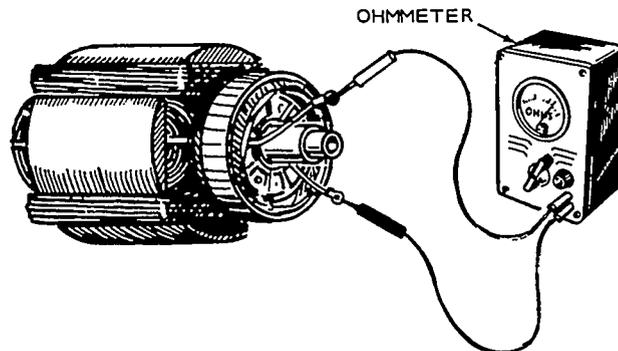
B215

CONTACT ONE PROD TO EACH OF THE FIELD LEADS AND OTHER PROD TO ROTOR SHAFT. IF ROTOR IS GOOD, THERE WILL BE ONE MEGOHM OR GREATER RESISTANCE.

FIGURE 22. TESTING ROTOR FOR GROUNDS

2. Using ohmmeter, check resistance between F1 and F2 leads, Figure 23.

The resistance values at 77°F (25°C) should be as shown in Table 3. If not, replace defective rotor with new, identical part.



CONTACT ONE PROD TO EACH FIELD LEAD

B213

FIGURE 23. TESTING ROTOR FOR AN OPEN CIRCUIT

TABLE 3. RESISTANCE VALUES FOR ROTORS

Model		Ohms Resistance	
50 Hertz	60 Hertz	Code 3R & 53R	Code 15R & 515R
16.0 DL4	20.0 DL4	1.80	2.75
20.0 DL6	25.0 DL6	2.04	1.80
25.0 DL6	30.0 DL6	2.32	2.04
32.0 DL6T	40.0 DL6T	—	2.70

[M]

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.

[N]

[P]

SENSITIVITY REFERENCE CIRCUIT (Standard Voltage Regulator)

Three types of frequency sensitivity reference voltage are possible with voltage regulator VR21.

1. *Frequency sensitive*—voltage output reduces in proportion to the engine speed.
Unless otherwise requested by the purchaser, the factory equips the set with frequency sensitive regulation.
2. *Non-frequency sensitive*—voltage output does not decrease when engine speed decreases.
A temporary overload with a non-frequency sensitive reference could cause the engine to reduce speed, and then require a 50- to 60-percent load reduction before it could return to rated speed.
3. *Semi-frequency sensitive*—voltage output decreases as engine speed decreases, but not as severely as in the “frequency sensitive” mode.

Changing Sensitivity Reference

The sensitivity reference can be changed if necessary, by unsoldering W1 on VR21 at hole “F” (frequency sensitive) and resoldering it to hole “S” (for semi-frequency sensitive) or to hole “N” (for non-frequency sensitive) voltage regulation. See Figure 24.

VOLTAGE ADJUSTMENT

After replacement of the regulator printed circuit board (VR21), the regulator must be adjusted for stability and voltage. Center the panel mounted voltage adjustment knob (if equipped) so the pointer is in a vertical position. Start the set and allow it to stabilize at the correct frequency and speed. Adjust as specified in the following sections.

Standard Voltage Regulator

Adjust the voltage by turning R18 potentiometer on printed circuit board VR21 counterclockwise to decrease the voltage or clockwise to increase the voltage. Observe the voltmeter on control panel while making the adjustment. Set voltage with no load connected. (Example: For a 120/240 volt connection, set no load voltage for 246 volts).

Adjust the stability (dampening) by turning R26 potentiometer on printed circuit board VR21 counterclockwise until the voltage becomes unstable or tends to hunt. Then turn R26 clockwise until the voltage stabilizes.

Switching Voltage Regulator

Adjust the voltage by turning R36 potentiometer on printed circuit board VR21 counterclockwise to increase the voltage or clockwise to decrease the voltage. Observe the voltmeter on control panel while making the adjustment. Set voltage with no load connected. (Example: For a 120/240 volt connection, set no load voltage for 246 volts).

Adjust the stability (dampening) by turning R5 potentiometer on printed circuit board VR21 counterclockwise until the voltage becomes unstable or tends to hunt. Then turn R5 clockwise until the voltage stabilizes.

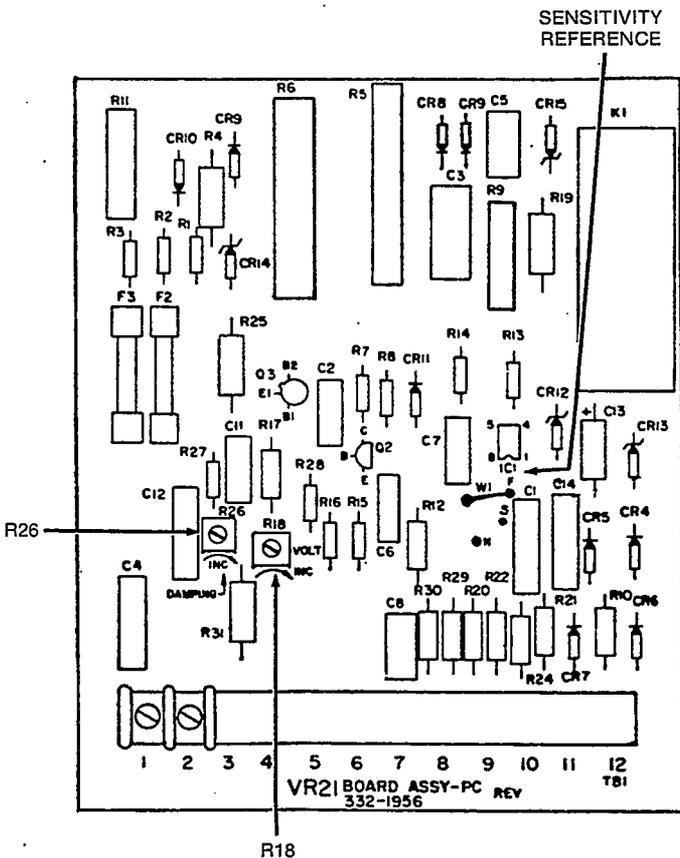


FIGURE 24. PC BOARD ASSEMBLY (332-2044)

[Q]

RECONNECTION

Figure 26 shows reconnection possibilities for the generator. When reconnecting for a different voltage, be sure to also reconnect lead W12 (inside control box) to the proper H terminal as shown in Figure 25.

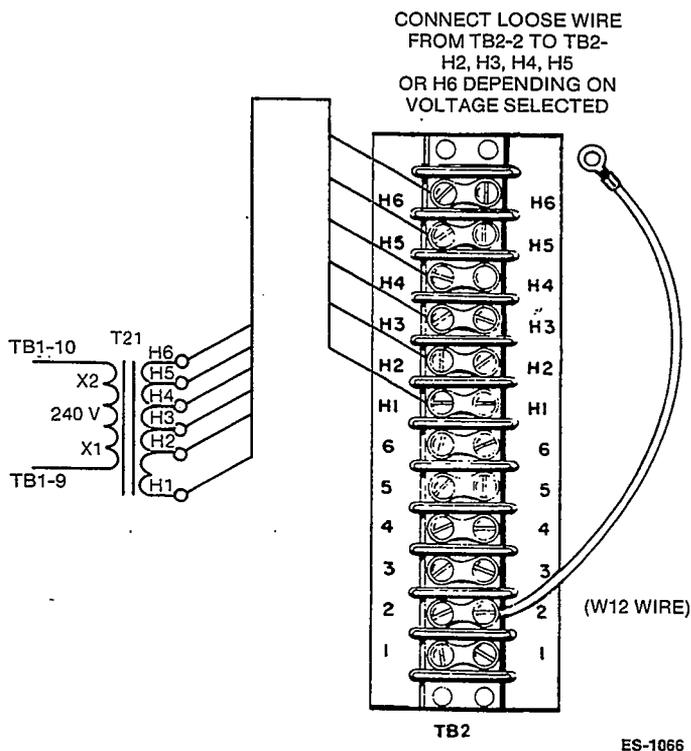


FIGURE 25. RECONNECTION LEAD W12

[R]

TESTING Q1 CAPACITORS

Single phase generator sets with the switching regulator have two capacitors (Q1) mounted in the generator output box. If the generator set does not build up an AC output voltage, the Q1 capacitors should be tested with an ohmmeter for an open condition or a short. Make sure the capacitors are discharged before testing.

WARNING Contact with high voltage might cause serious personal injury or death. Avoid contact with capacitor terminals. Dangerous voltage might be present up to a minute after set shutdown.

Place the ohmmeter on the R x 1 scale and touch the test prods to the capacitor terminals. The meter pointer should rise and then quickly drop back as the capacitor becomes charged. If the pointer does not move, the capacitor is open. If the pointer rises but does not drop back, the capacitor is shorted. Replace the capacitor if either condition exists.

[S]

TESTING VOLTAGE REGULATOR

The voltage regulator assembly can be removed from the control and tested for proper operation if necessary. The following test equipment is required.

EQUIPMENT	SCHEMATIC REFERENCE
Switch	S
5 Amp Fuse	F
Variable Transformer (4 Amp, 0-280 VAC)	T1
AC Voltmeter (+ or - 2% 10 VAC, 1% 250 VAC)	V1
3 Scale DC Voltmeter, 0-10, 0-50, and 0-300 (+ or - 2% of full scale)	V2
Resistor - 1.65K + or - 150 Ohm	R1
Resistor - 50 ohm, 1200 W	R2

NAMEPLATE VOLTAGE CODE		VOLTAGE		PHASES		HERTZ		CONNECT LEAD FROM TERMINAL TB-2 TO:		GENERATOR CONNECTION SCHEMATIC DIAGRAM
3	120/240	1	60	H5						
53	110/220	1	50	H6						
	115/230	1	50	H6						
	120/240	1	50	H5						

NAMEPLATE VOLTAGE CODE		VOLTAGE		PHASES		HERTZ		CONNECT LEAD FROM TERMINAL TB-2 TO:		GENERATOR CONNECTION SCHEMATIC DIAGRAM
7	220/380	3	60	H3						
9X	347/600	3	60	H5						

THIS DIAGRAM APPLIES TO 12 LEAD GENERATORS ONLY

NAMEPLATE VOLTAGE CODE		VOLTAGE		PHASES		HERTZ		CONNECT LEAD FROM TERMINAL TB-2 TO:		GENERATOR CONNECTION		GENERATOR CONNECTION SCHEMATIC DIAGRAM	GENERATOR CONNECTION WIRING DIAGRAM (WITH CURRENT TRANSFORMERS WHEN USED)				
15	120/240	1	60	H5		DOUBLE DELTA											
												515	115/230	1	50	H6	
												515	110/220	1	50	H6	
15	120/240	3	60	H5		SERIES DELTA											
												515	115/230	3	50	H6	
												515	110/220	3	50	H6	
15	120/208	3	60	H3		PARALLEL WYE											
												127/220	3	60	H4		
												139/240	3	60	H5		
												515	110/190	3	50	H3	
												515	115/200	3	50	H4	
15	240/416	3	60	H3		SERIES WYE											
												254/440	3	60	H4		
												277/480	3	60	H5		
												515	220/380	3	50	H3	
												515	230/400	3	50	H4	
515	240/416	3	50	H4													
515	254/440	3	50	H5													

FIGURE 26. GENERATOR VOLTAGE CONNECTIONS

98C2193

Standard Voltage Regulator Test

The regulator must be tested as a complete assembly with all components connected including the voltage reference transformer (T21), PC board (VR21), commutating reactor (L21), and SCR bridge rectifier (CR21). The 50 ohm resistor (R2) serves as the exciter field during testing. Use the following procedure to check.

1. Connect the test equipment to the regulator as shown in Figure 27.
2. Open switch S and then connect the variable transformer (T1) to the power supply.
3. Test regulator according to the steps in Table 4.

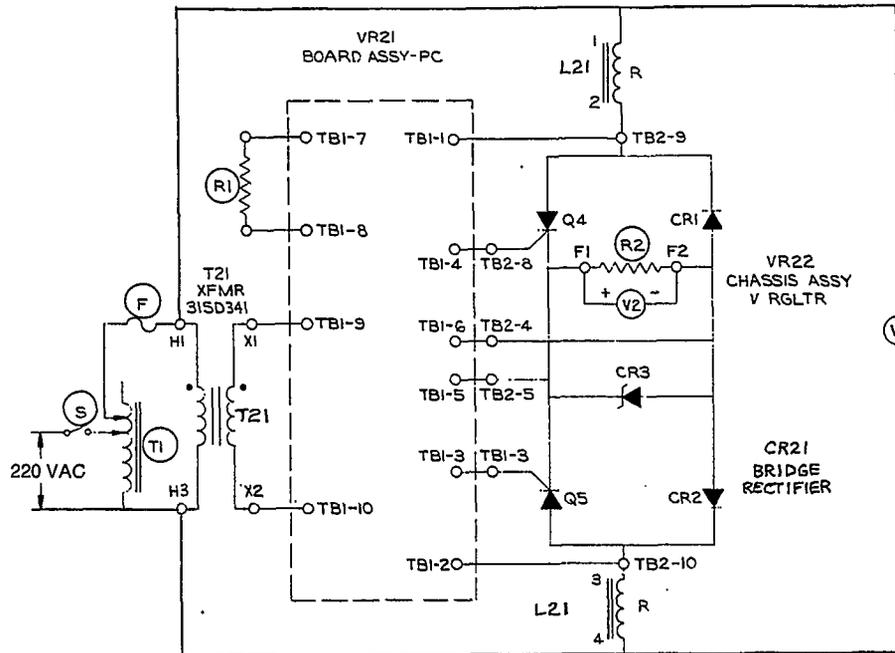


FIGURE 27. STANDARD VOLTAGE REGULATOR TEST SCHEMATIC

TABLE 4
STANDARD REGULATOR TEST AND CALIBRATION

V1 = AC INPUT VOLTAGE V2 = DC OUTPUT VOLTAGE			
Step No.	Test	Procedure	Requirements
1	Calibration	Set V1 to 208 VAC	Set Pot R18 to hold V2 Between 90-110 VDC
2	Range	A. Set V1 to 211 VAC B. Set V1 to 213 VAC	V2 shall be < 60 VDC V2 shall be < 10 VDC
3	Range	A. Set V1 to 203 VAC B. Set V1 to 205 VAC	V2 shall be > 180 VDC V2 shall be > 140 VDC

[T]

TESTING SWITCHING REGULATOR

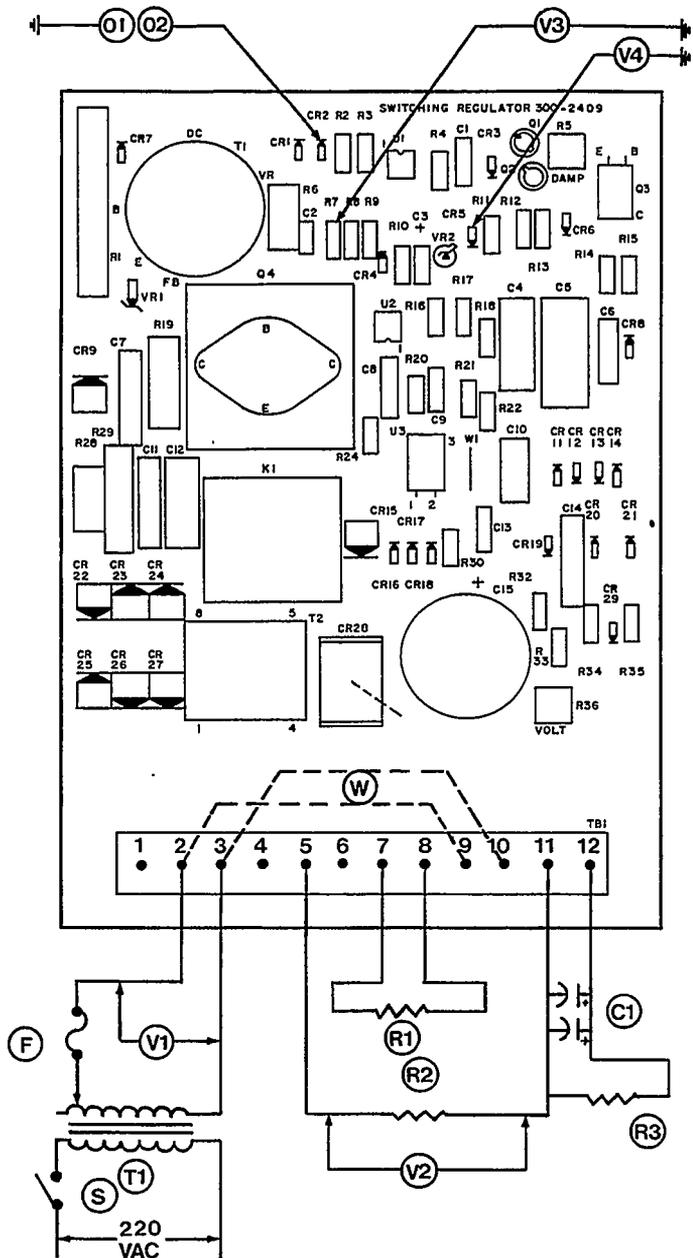
The voltage regulator assembly can be removed from the control and tested for proper operation if necessary. The following test equipment is required.

EQUIPMENT

Switch
 5 Amp Fuse
 Variable Transformer
 (4 Amp, 0-280 VAC)
 AC Voltmeter
 (+ or - 2% 10 VAC, 1% 250 VAC)
 3 Scale DC Voltmeter, 0-10, 0-50,
 and 0-300 (+ or - 2% of full scale)
 Capacitors (2) - 400 MFD
 Resistor - 1.5 K + or - 150 ohm
 Resistor - 50-80 ohm, 1200 W
 Resistor - 4700K ohm, 2 W
 Oscilloscope - 10 MHZ Bandwidth
 Jumper Wires

SCHEMATIC REFERENCE

S
 F
 T1
 V1
 V2-V4
 C1
 R1
 R2
 R3
 01, 02
 W

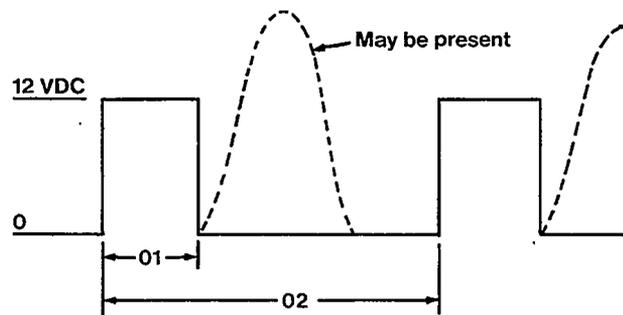


Switching Voltage Regulator Test

The regulator must be tested separately with all component connections removed from terminal board TB1. The 50-80 ohm resistor (R2) serves as the exciter field during testing. Use the following procedure to check.

1. Connect the test equipment (except jumper wires W) to the regulator as shown in Figure 28.
2. Open switch S and then connect the variable transformer (T1) to the power supply.
3. Test regulator according to the steps in Table 5. Terminal 8 may be used as the chassis ground connection.

OSCILLOSCOPE TEST PATTERN



ES-1422

FIGURE 28. SWITCHING VOLTAGE REGULATOR TEST SCHEMATIC

**TABLE 5
SWITCHING REGULATOR TEST**

V1 = AC Input Voltage V2, V3, and V4 = DC Output Voltages O1 and O2 = Oscillation Bandwidth		
Step	Procedure	Requirements
1	Set R5 at midpoint and turn R36 fully CCW Set V1 to 208 VAC	V2 shall be 105 - 125 VDC V3 shall be < 2.5 VDC O1 shall be 30 - 60 microseconds O2 shall be 330 - 390 microseconds
2	Connect jumper wires W as shown in Figure 28 Adjust R36 fully CCW Adjust R36 fully CW Adjust R36 until V2 falls to 10VDC Max. Wait 5 seconds, then proceed to step 3.	V3 shall be 4.4 - 4.8 VDC V3 shall be 7.0 - 7.8 VDC
3	Adjust V1 to 200 VAC, wait 5 seconds Adjust V1 to 210 VAC, wait 5 seconds	V2 shall be 105 - 125 VDC
4	Set V1 to 208 VAC	V2 shall be < 10 VDC V4 shall be 11.5 - 12.5 VDC (Must be steady with no drift)

Engine Control

GENERAL

The engine control system includes all functions that relate to the operation of the engine. This includes starting and stopping, instrumentation, monitoring for fault conditions, and battery charging. This section covers how the engine control operates and where the various components are located.

CONTROL PANEL

The following is a brief description of the two and nine light control panels with the optional AC meters. Although the AC meters are not part of the engine control, they are mentioned here in order to provide a complete description of the control panel exterior. Refer to Figure 29 for the location of each component.

Gauges/Meters and Switches

Oil Pressure Gauge: Indicates engine lubricating oil pressure. The gauge has a range of 0 to 100 psi (0 to 700 kPa).

Water Temperature Gauge: Indicates engine coolant temperature. The gauge is wired to a sensor unit on the engine and has a range of 100° to 250°F (40° to 121°C).

Battery Charge Rate DC Ammeter: Indicates battery charging current. Meter range is ± 30 amperes.

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

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

AC Voltmeter (Optional): Dual range instrument indicating AC generator voltage.

AC Ammeter (Optional): Dual range instrument indicating AC generator line current.

Tachometer (Optional): Indicates engine speed in r/min. The gauge has a range of 0 to 3500 r/min.

Oil Temperature Gauge (Optional): Indicates engine oil temperature. The gauge has a range of 150° to 300°F (66° to 149°C).

Start-Stop-Remote Switch: Starts and stops the unit locally, or from a remote location wired to the control panel.

Pre-Heater Switch: Provides control for glow plugs for cold diesel engine starting.

Reset Switch: Resets engine monitor circuits after an emergency shutdown. On the optional control panel the switch is also utilized to verify that the nine lamps are functioning properly.

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

Voltage Adjustment (Optional): Provides approximately plus or minus 5 percent adjustment of the rated voltage.

Circuit Breakers

Field Breaker: A 5 ampere breaker provides generator protection in case of a malfunction.

Control Breaker: A 7 ampere breaker provides protection to the control box wiring from a short circuit or overload.

Remote Breaker: A 7 ampere breaker protects accessory remote controls and wiring from a short circuit or overload.

Indicator Lights

The standard control panel has two monitor system indicator lights.

- Run (green)
- Fault (red)

The green Run light comes on as soon as the starter circuit is opened after unit starting. The red light indicates an emergency shutdown of the generator set.

The optional control panel has nine monitor system indicator lights.

- Run (green)
- Pre Hi Eng Temp (amber)
- Pre Low Oil Pres (amber)
- Lo Eng Temp (red)
- Hi Eng Temp (red)
- Overcrank (red)
- Overspeed (red)
- Lo Oil Pres (red)
- Switch Off (flashing red)

High and Low Indicator Lights indicate which scale to use on the AC voltmeter and ammeter.

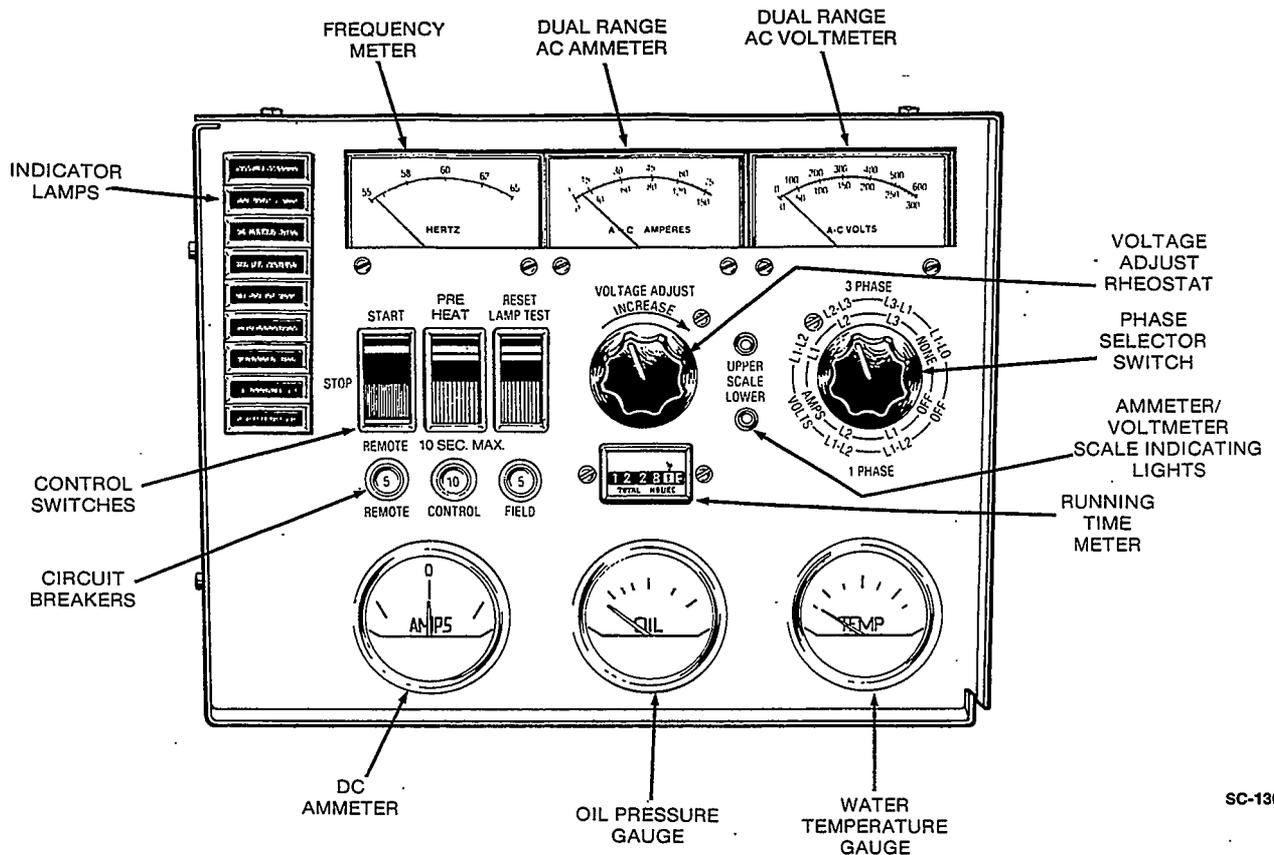


FIGURE 29. NINE LIGHT CONTROL PANEL WITH OPTIONAL AC METERS

CONTROL COMPONENTS

The following describes the basic engine control components and how they function.

Engine Monitor Circuit Board: A solid state printed circuit board that monitors all engine control system functions. This includes starting, stopping, and fault system operation. A terminal board is included for making remote connections. See Figure 30.

Overcranking Timer: A solid state circuit on the engine monitor circuit board that limits cranking time from 45 to 75 seconds. If the engine does not start, cranking will stop and an overcrank fault will be indicated.

K1 Fault Relay: Located on the engine monitor circuit. Energized when a fault condition occurs. Turns off the engine and prevents restarting until the fault condition is corrected and the Reset switch is pressed. This relay can also be used to operate a remote DC alarm (5 amp maximum) connected to the fault terminal of the engine monitor circuit board. See Figure 30.

K2 On/Off Relay: Located on the engine monitor board. Connects battery positive (B+) to the electrical circuits on the engine monitor circuit board when the

Start/Stop/Remote switch is placed in the Start position. See Figure 30.

K3 Start Disconnect Relay: Located on the engine monitor circuit board. Energized by voltage output from the battery charging alternator. Disconnects the cranking circuit and turns on the green Run indicator lamp when the engine starts. See Figure 30.

K1 Start Solenoid: Located on the generator set skid base. Connects battery positive (B+) to the starter solenoid and K2 heater solenoid when the Start/Stop/Remote switch is placed in the Start position. See Figure 31.

K2 Heater Solenoid: Located on the generator set skid base. Connects battery positive (B+) to the glow plugs when the Pre-heat switch is placed in the On position. See Figure 31.

K3 Fuel Solenoid: An integral part of the fuel injection pump. Opens the fuel control valve when the Start/Stop/Remote switch is placed in the Start position.

K11 Start Disconnect Relay: Located inside the control box. Energized by a voltage output from the generator. Disconnects the cranking circuit when the engine starts. See Figure 30.

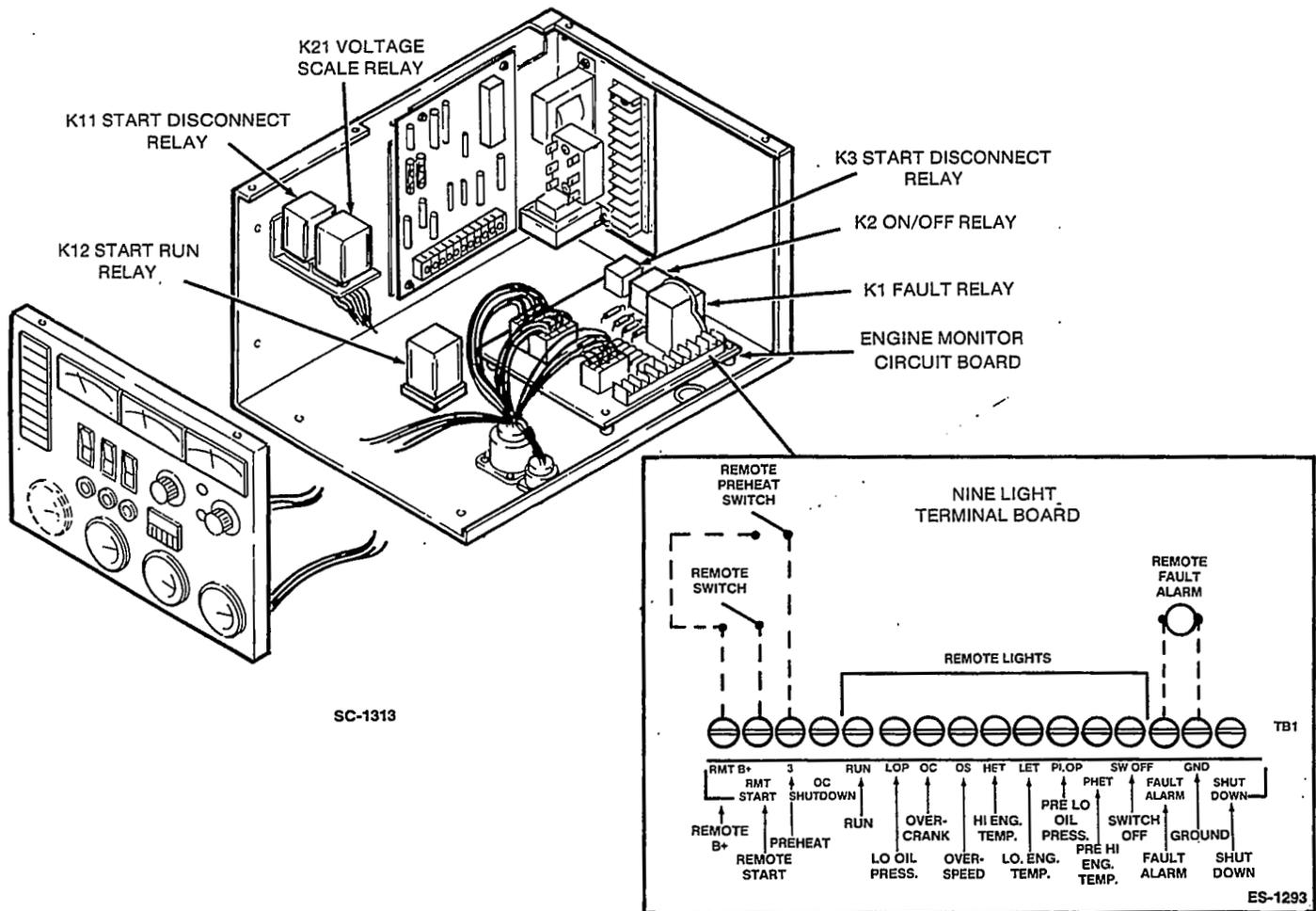


FIGURE 30. CONTROL BOX INTERIOR

K12 Run Relay (Optional): Located inside the control box. Used with warning alarm to indicate when the generator set starts. Energized when the K3 start disconnect relay connects battery positive (B+) to the green Run indicator lamp.

K21 Voltage Scale Relay: Located inside the control box. Used to operate the scale indicator lights.

ENGINE SENSORS

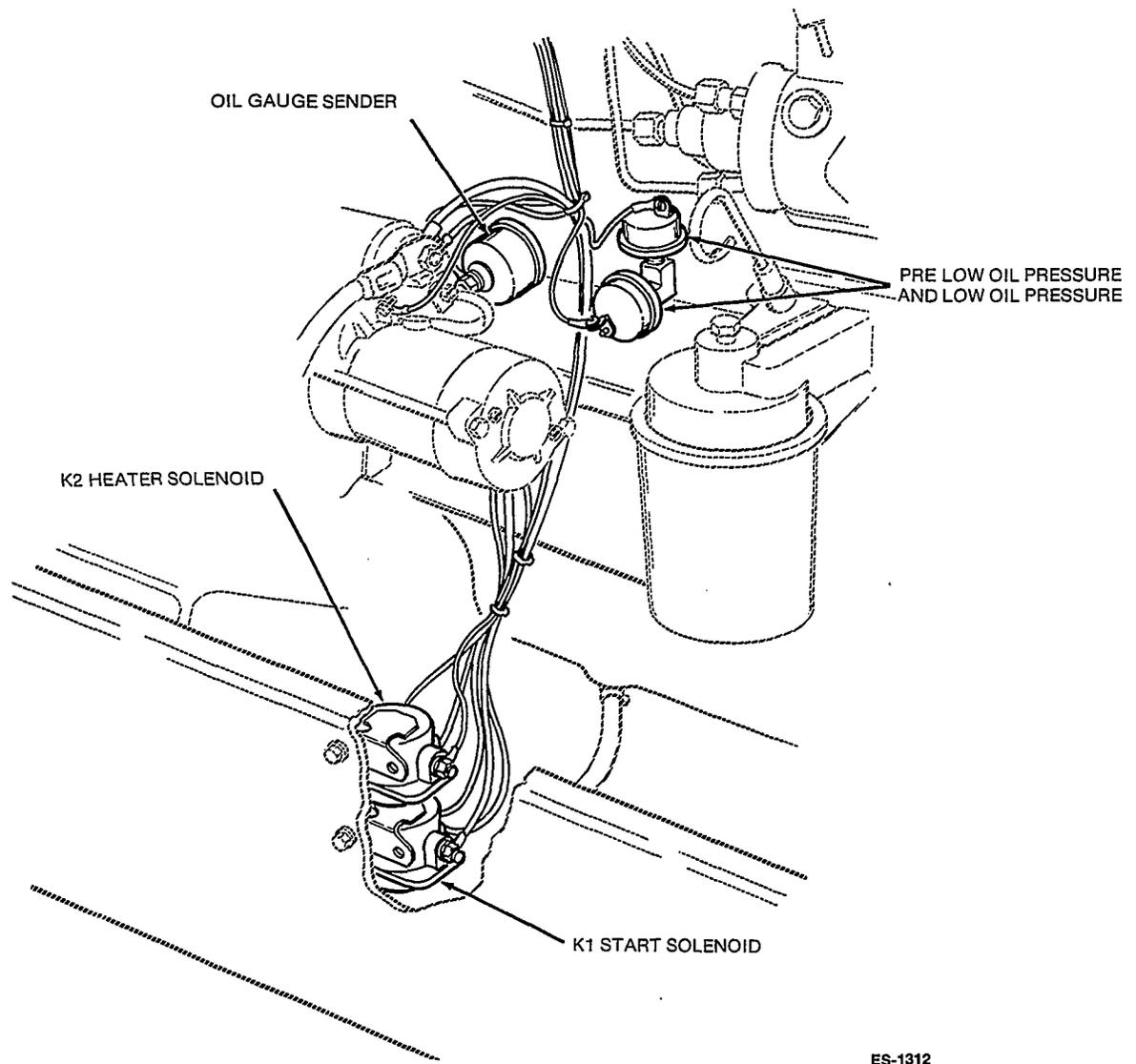
The following briefly describes the engine mounted sensors and switches, and how they protect the engine from unfavorable operating conditions.

All cut-off switches close to ground if abnormal operating conditions exist and energize the Fault Relay to stop the engine. The respective control panel lamps (optional) light to indicate cause of the shutdown. An optional remote fault alarm can be connected to the

terminal shown in Figure 30. Current limitations for optional equipment not supplied 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 parts made for a specific application.



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FIGURE 31. ENGINE CONTROL RELAYS AND SENSORS

Oil Pressure Monitors

Refer to Figure 31 for the location of the oil pressure sensors.

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.

Engine Temperature Monitors

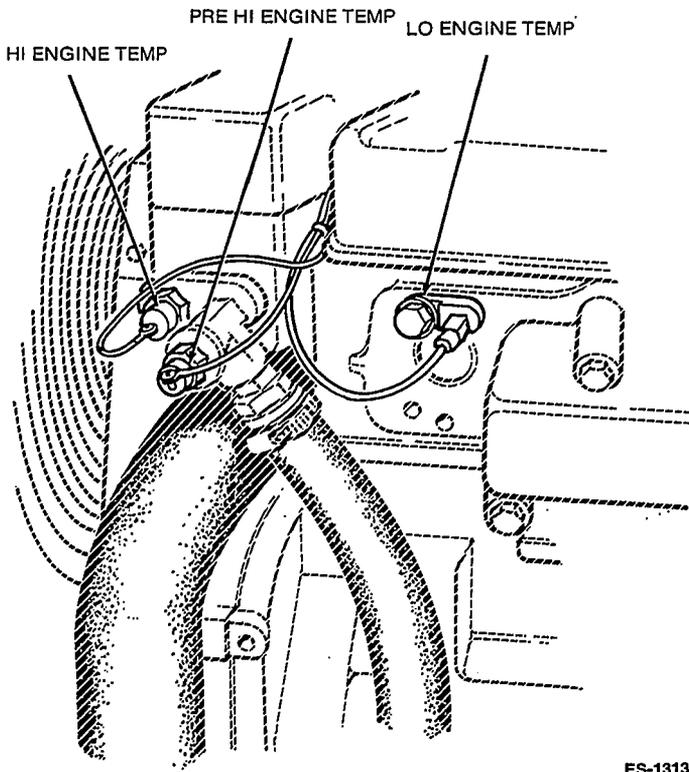
Refer to Figure 32 for the location of the engine temperature sensors.

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).

The high engine temperature switch closes if the coolant temperature rises to 222°F (106°C), stopping the engine and activating the red Hi Eng Temp light.

The optional pre-high engine temperature switch closes at a nominal 216°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.

The optional low engine temperature switches closes if coolant temperature drops below 70°F (21°C) to turn on the red Lo Eng Temp light.

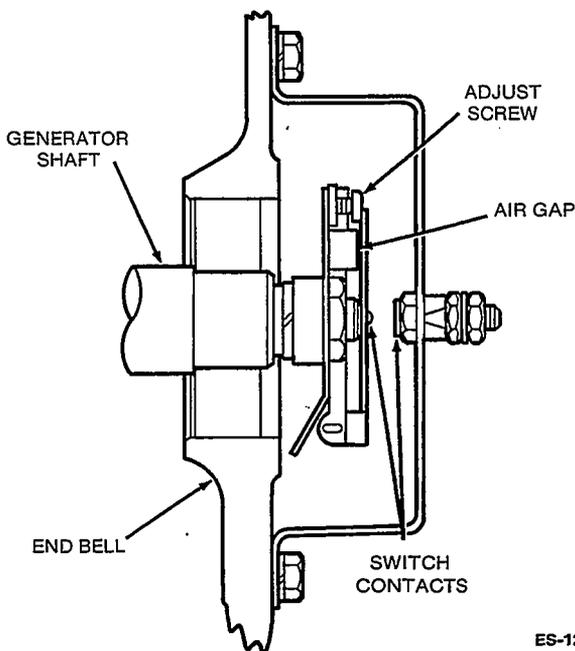


ES-1313

FIGURE 32. ENGINE TEMPERATURE SENSORS

Overspeed Switch

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



ES-1298-1

FIGURE 33. OVERSPEED SWITCH

The overspeed switch is set so contacts close at 2200 to 2250 rpm. If necessary, the speed range can be corrected by turning the adjusting screw, thereby changing the magnetic air gap (see Figure 33). The air gap must not be less than 0.005 inch (0.13 mm).

OPERATION

Dependable, trouble-free operation of the control system should be the major concern 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.

Prior to starting the generator set, 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.

Figure 34 shows a typical wiring diagram for the circuits 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

For cold engine starting, the Preheat switch (S11) is held in the preheat position for 10 seconds. This energizes the K2 heater solenoid which closes a set of NO contacts that connect B+ to the glow plugs. At the end of the preheat period, the starting sequence is initiated by placing the Start/Stop/Remote switch (S10) in the Start position.

Placing switch S10 in the Start position energizes the K2 On/Off relay which closes a set of NO contacts. Closing K2 contacts connects B+ to the electrical circuits on the engine monitor board, the K1 start solenoid, and the K3 fuel solenoid.

Energizing the K1 start solenoid closes two sets of NO contacts that connect B+ to the starter solenoid and K2 heater solenoid. Energizing the starter solenoid initiates cranking. Energizing the K2 heater solenoid continues (initiates) operation of the glow plugs.

The K3 fuel solenoid opens the fuel control when energized. This solenoid is an integral part of the fuel injection pump.

Start-Disconnect Sequence

When the generator set starts, output voltage from the auxiliary terminal of the DC alternator energizes the K3 start-disconnect relay. Energizing K3 start-disconnect relay closes one set of NO contacts and opens another set of NC contacts. Closing the NO set of K3 contacts connects B+ to the run lamp. Opening

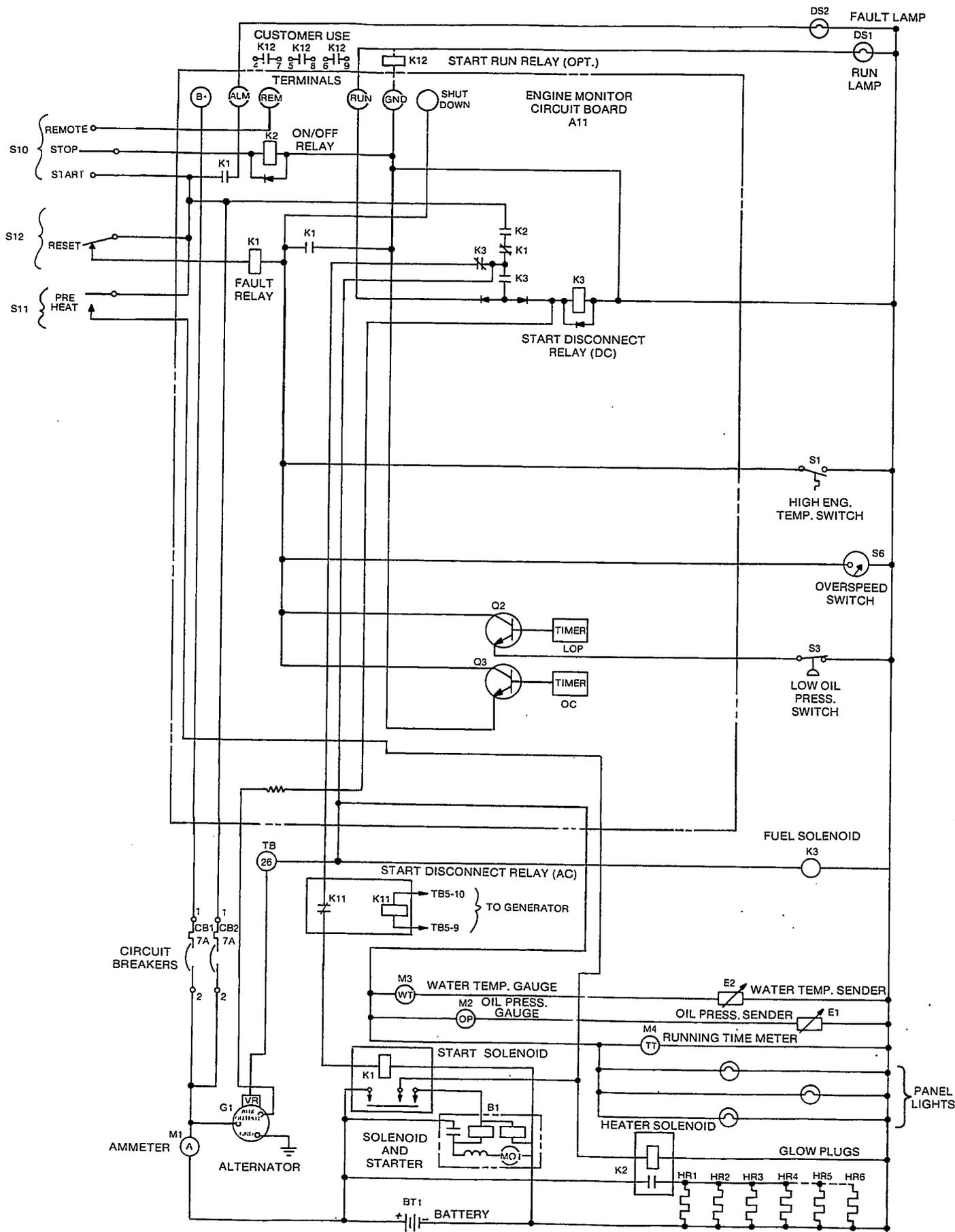


FIGURE 34. TYPICAL WIRING DIAGRAM :

the NC set of K3 contacts disconnects B+ from the K1 start solenoid. De-energizing the K1 start solenoid disconnects B+ from the starter solenoid to stop cranking and also disconnects B+ from the K2 heater solenoid to stop preheating.

A back-up start disconnect relay is used to stop cranking. When the generator set starts, output voltage from the generator stator energizes the K11 start disconnect relay. Energizing the K11 start disconnect relay opens a set of NC contacts. Opening the NC set of K11 contacts disconnects B+ from the K1 start solenoid. De-energizing the K1 start solenoid disconnects B+ from the starter solenoid to stop cranking and also disconnects B+ from the K2 heater solenoid to stop preheating.

Stopping Sequence

Placing the S10 Start/Stop/Remote switch in the Stop position disconnects B+ from the K2 on/off relay. De-energizing K2 on/off relay disconnects B+ from the K3 fuel solenoid and the electrical circuits on the engine monitor board. De-energizing the K3 fuel solenoid shuts off the fuel flow which stops the engine.

Emergency Shutdown

The K1 fault relay is energized when fault sensors respond to one of the following fault conditions: overcrank, low oil pressure, high engine temperature, and overspeed.

Energizing the K1 fault relay opens one set of NC contacts and closes two sets of NO contacts. Opening the NC set of K1 contacts disconnects B+ from the K1 start solenoid and the K3 fuel solenoid. This stops cranking if the engine is being cranked and shuts off the fuel flow. Closing one of the NO sets of K1 contacts grounds the K1 fault relay so that the K1 relay cannot be de-energized until the S12 reset switch is momentarily opened. Closing the other NO set of K1 contacts connects B+ to the remote alarm terminal.

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.

Engine Control Troubleshooting

GENERAL

The information in this section is divided into three flow charts. Determine the problem and then refer to the appropriate flow chart (A, B, or C) for the troubleshooting procedures.

- A. Engine does not crank.
- B. Engine cranks but does not start.
- C. Engine starts but stops after running several seconds.

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

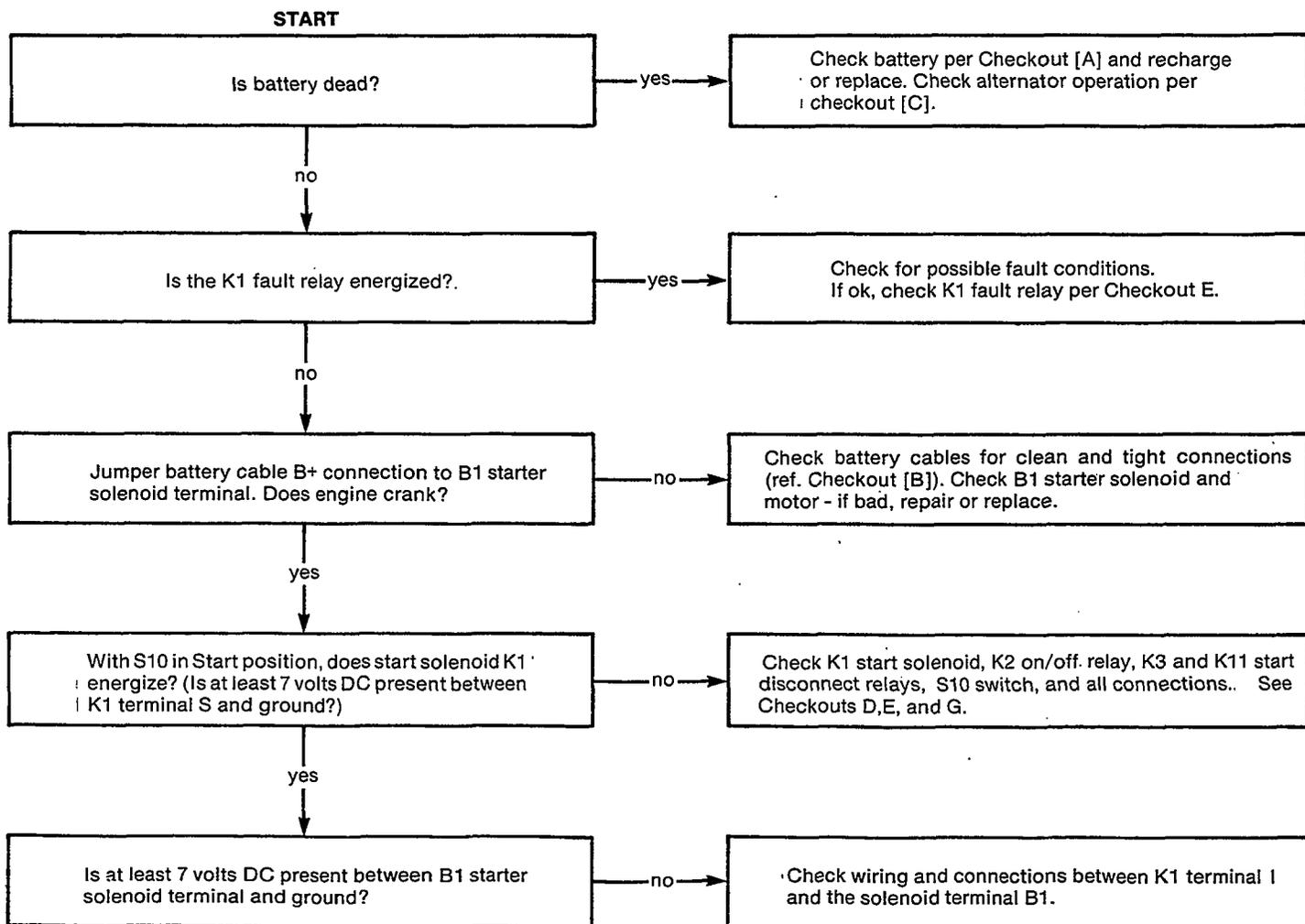
- Check all modifications, repairs, replacements

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.

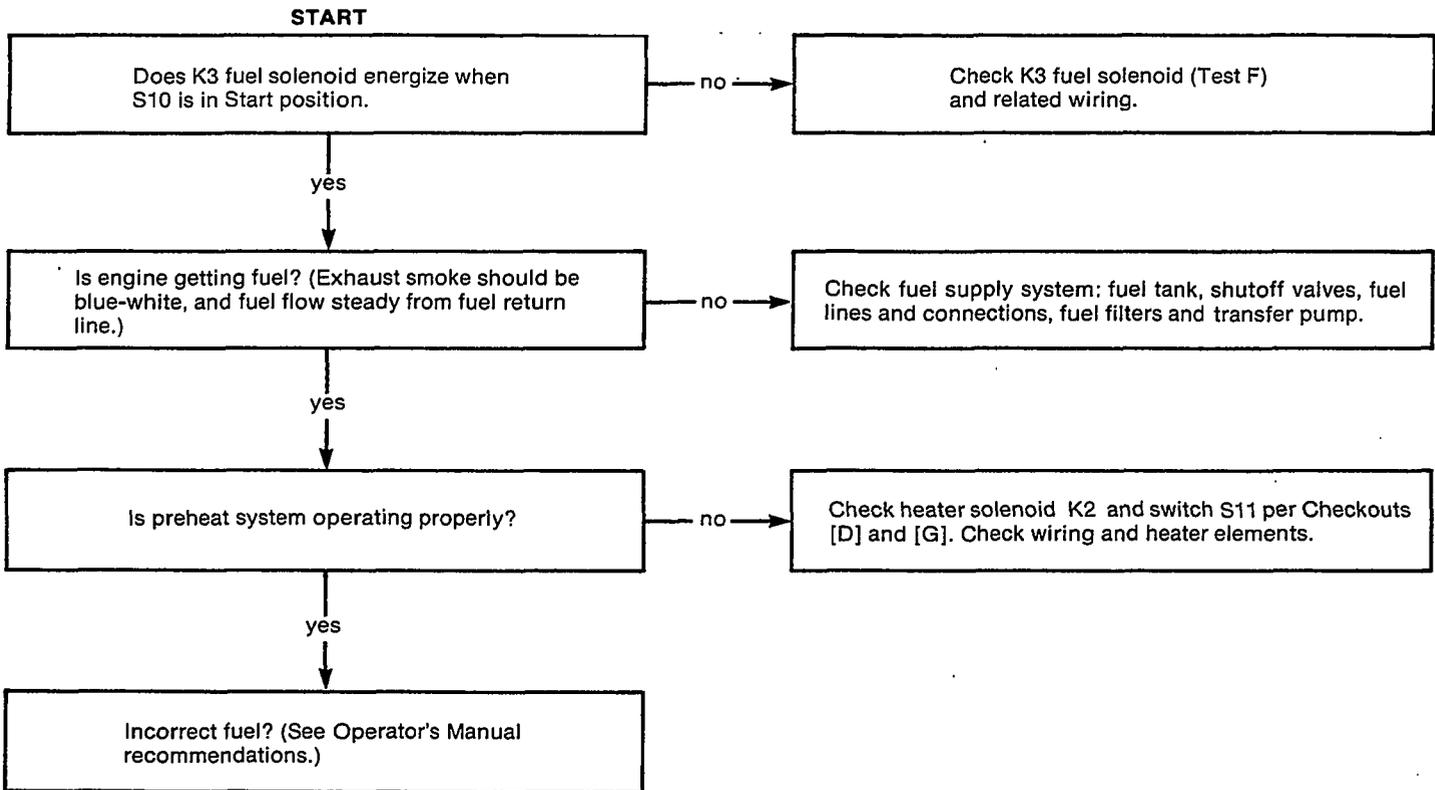
- Unless absolutely sure that panel instruments are accurate, use portable test meters for troubleshooting.

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 adjustment or test procedures. Refer to typical wiring diagram in Figure 29 for locating control component leads, terminals and other check points.

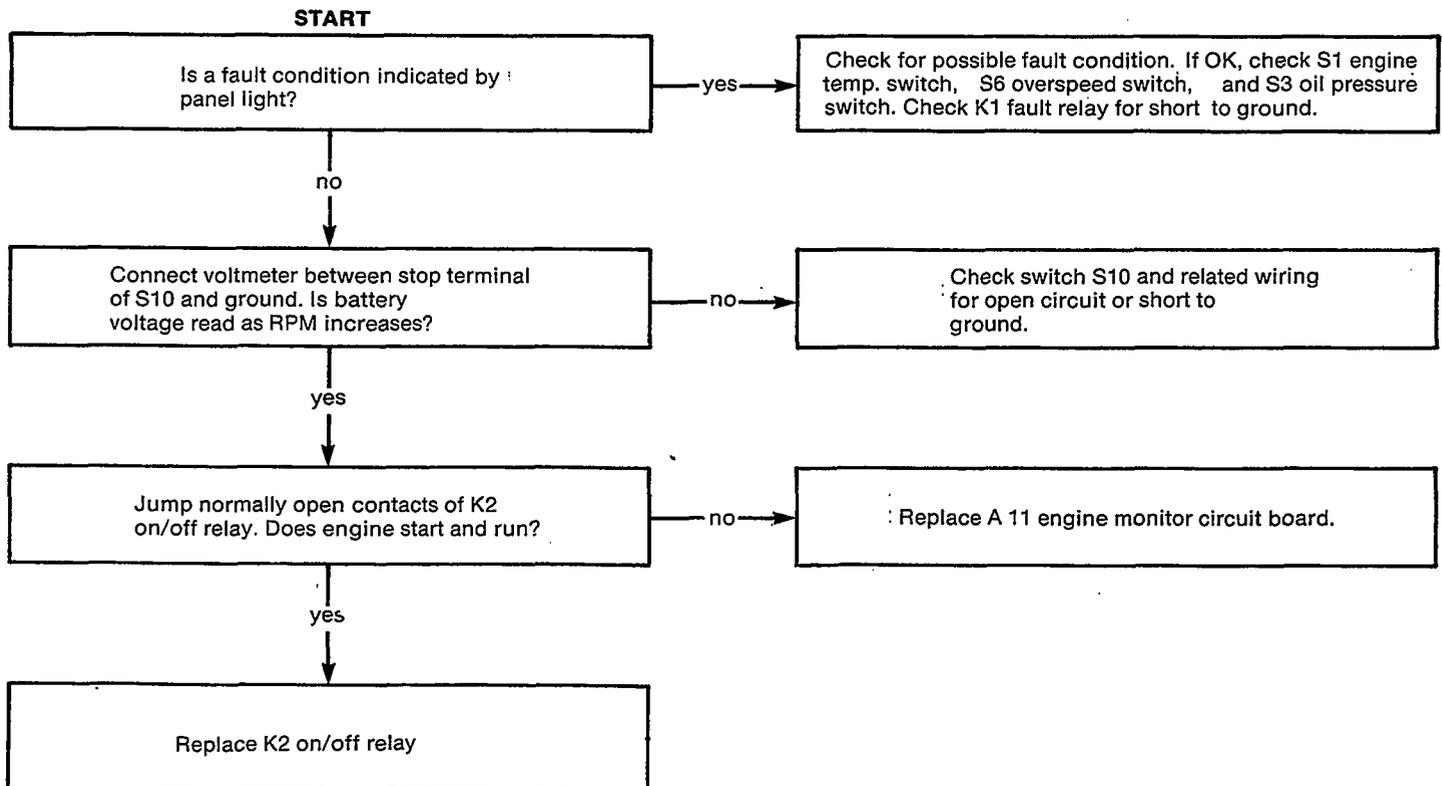
FLOW CHART A. ENGINE DOES NOT CRANK



FLOW CHART B. ENGINE CRANKS BUT DOES NOT START



FLOW CHART C. ENGINE STARTS BUT STOPS AFTER RUNNING SEVERAL SECONDS



Engine Control Adjustments/Tests

GENERAL

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

All external engine control components such as leads, switches, relays, indicator lights, senders, and gauges plug into the engine monitor board. When testing external components, disconnect the corresponding jack (J1, J2, or J3) from the board. Refer to the appropriate wiring diagram to determine the jack number.

[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 approved 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 alternator charge rate may be too high. Likewise, if battery state of charge is not maintained, the charge rate may be too low. Refer to ALTERNATOR CHECKOUT [C].

[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]

ALTERNATOR CHECKOUT

With the engine running, check the battery charge rate DC ammeter. If the alternator is operating properly, the ammeter should show a slight charge, gradually tapering to zero as the battery becomes fully charged.

If the ammeter shows a constant discharge or a constant high rate of charge, stop the generator set and check for a loose or slipping drive belt, poor terminal connections, or broken lead wires. Repair or replace as required.

If everything checks out, use a voltmeter to determine the alternator output voltage. Connect the positive (+) lead to the output terminal (see Figure 35) and connect the negative (-) lead to ground. Start the generator set and run for a few minutes to allow the voltage to stabilize. A properly operating system will have a nominal output voltage of between 13.8 and 14.8 volts.

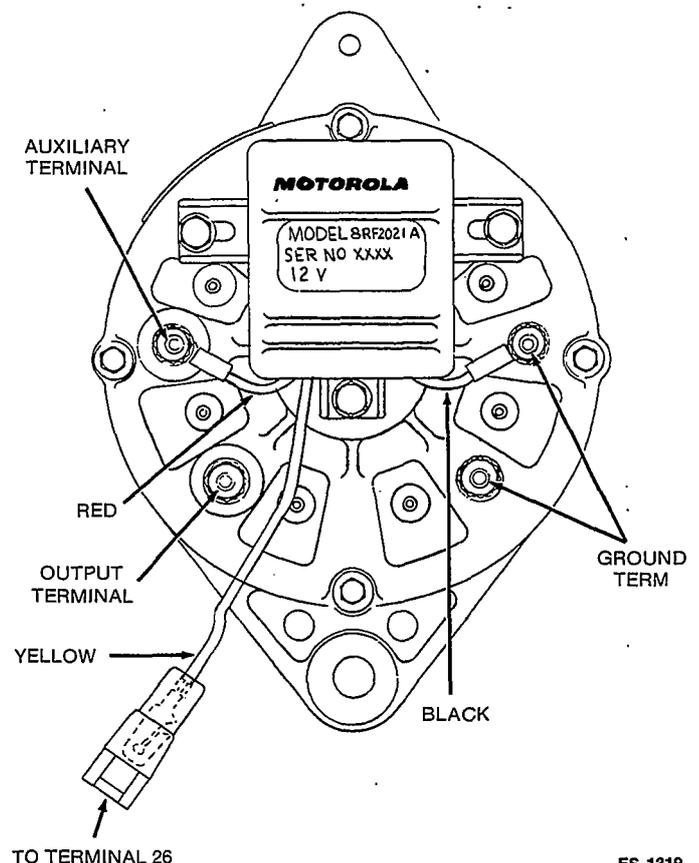


FIGURE 35. ALTERNATOR

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If the output voltage is high (over 15 volts), check for loose or corroded voltage regulator leads. If this does not correct the problem, the regulator is probably shorted and should be replaced.

If the output voltage is low (equals battery voltage), the problem could be worn or broken brushes, an open regulator, or an open field diode. Refer to Motorola Service Manual 25-183 for more detailed test and service procedures.

[D]

SOLENOID CHECKOUT

1. Apply battery positive (B+) to the terminal marked S.
2. Jumper a ground wire to the solenoid mounting bracket. Solenoid should activate.
3. If the contacts are good, 12 volts should be read between terminal I and ground. The voltage drop measured across the contacts should never exceed one volt in circuit application.

[E]

RELAY CHECKOUT

1. Connect 12 volts across relay coil terminals. Relay should activate if coil is okay.
2. Connect a 12-volt source 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 energized, contact is okay. The 12-volt reading appears in reverse order when checking normally closed (NC) contacts.

[F]

FUEL SOLENOID CHECKOUT

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

To check energized-to-run fuel solenoid operation, listen for a click in injection pump when start switch is placed in the run position. If no click is heard and there is power to solenoid with the start switch in the run position, the fuel solenoid must be replaced. To check energized-to-stop fuel solenoid operation, listen for a click in injection pump when start switch is placed in the stop position. If no click is heard and there is no power to solenoid with the start switch in the stop position, the fuel solenoid must be replaced.

Refer to the L Engine Service Manual (934-0750) for fuel solenoid replacement procedures.

[G]

SWITCH CHECKOUT

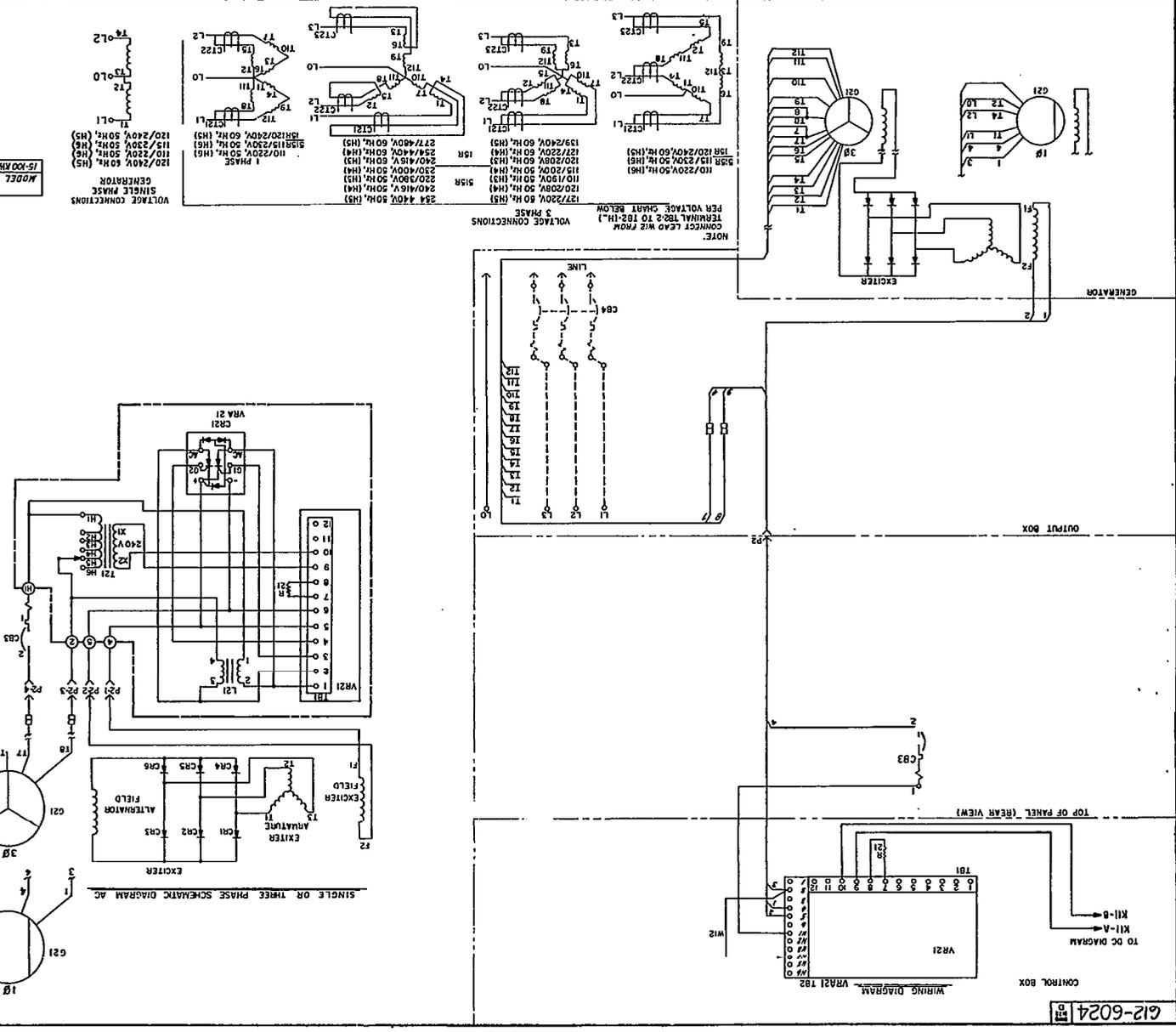
1. Remove battery B+ cable.
2. Place ohmmeter leads across switch.
3. Open and close switch while observing the ohmmeter. A normally open (NO) switch should indicate infinite resistance when open and continuity when closed. A normally closed (NC) switch should indicate continuity when closed and infinite resistance when open.
4. Replace switch if defective.

Wiring Diagrams

The electrical schematics and wiring diagrams that apply to the DL series generator sets are listed below.

- FIGURE 36.** Single Phase AC Control with Optional Meters (612-6022).
- FIGURE 37.** Three Phase AC Control with Optional Meters (612-6023).
- FIGURE 38.** Single and Three Phase AC Control (612-6024).
- FIGURE 39.** Single Phase AC Control with Switching Regulator and Optional Meters (612-6075).
- FIGURE 40.** Three Phase AC Control with Switching Regulator and Optional (612-6076).
- FIGURE 41.** Single and Three Phase AC Control with Switching Regulator (612-6077).
- FIGURE 42.** Standard Voltage Regulator Assembly (305-0693).
- FIGURE 43.** Switching Voltage Regulator Assembly (305-0695).
- FIGURE 44.** Two Light DC Control Wiring Diagram (612-6020).
- FIGURE 45.** Two Light DC Control Schematic (612-6020).
- FIGURE 46.** Nine Light DC Control Wiring Diagram (612-6021).
- FIGURE 47.** Nine Light DC Control Schematic (300-2510).
- FIGURE 48.** Two Light Engine Monitor Board Schematic (300-2510).
- FIGURE 49.** Two Light Engine Monitor Board.
- FIGURE 50.** Nine Light Engine Monitor Board Schematic (300-2453).
- FIGURE 51.** Nine Light Engine Monitor Board.

REF. DES. SYM.	DESCRIPTION	QTY	UNIT
G21	GENERATOR	1	
G22	LINE BREAKER (DOUBLE POLE)	1	
G23	LINE BREAKER (SINGLE POLE)	1	
VRA21	REGULATOR ASSY - POTVAR	1	
CR21	RECTIFIER BRIDGE	1	
TR21	TRANSFORMER - VOLT	1	
VR21	PC BOARD - VOLTAGE MGMT	1	
L21	REACTOR ASSY - COMM	1	
CR3	DIODE	1	
CR4	DIODE	1	
CR5	DIODE	1	
CR6	DIODE	1	
CR7	DIODE	1	
CR8	DIODE	1	
CR9	DIODE	1	
CR10	DIODE	1	
CR11	DIODE	1	
CR12	DIODE	1	
CR13	DIODE	1	
CR14	DIODE	1	
CR15	DIODE	1	
CR16	DIODE	1	
CR17	DIODE	1	
CR18	DIODE	1	
CR19	DIODE	1	
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CR22	DIODE	1	
CR23	DIODE	1	
CR24	DIODE	1	
CR25	DIODE	1	
CR26	DIODE	1	
CR27	DIODE	1	
CR28	DIODE	1	
CR29	DIODE	1	
CR30	DIODE	1	
CR31	DIODE	1	
CR32	DIODE	1	
CR33	DIODE	1	
CR34	DIODE	1	
CR35	DIODE	1	
CR36	DIODE	1	
CR37	DIODE	1	
CR38	DIODE	1	
CR39	DIODE	1	
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CR41	DIODE	1	
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CR43	DIODE	1	
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CR81	DIODE	1	
CR82	DIODE	1	
CR83	DIODE	1	
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CR88	DIODE	1	
CR89	DIODE	1	
CR90	DIODE	1	
CR91	DIODE	1	
CR92	DIODE	1	
CR93	DIODE	1	
CR94	DIODE	1	
CR95	DIODE	1	
CR96	DIODE	1	
CR97	DIODE	1	
CR98	DIODE	1	
CR99	DIODE	1	
CR100	DIODE	1	



MODEL	STO DC	STO AC
15-100KW	-01	-02

1. UNLESS OTHERWISE NOTED, ALL COMPONENTS SHOWN IN THE DE-ENERGIZED POSITION.
 2. OPTIONS ARE SHOWN CONNECTED IN DASHED LINES.
 3. OPTIONAL DC GAGE CAN BE FITTED INSTRICTLY.
 4. TEMPERATURE GAGE OR ANALYTIC THERMISTOR

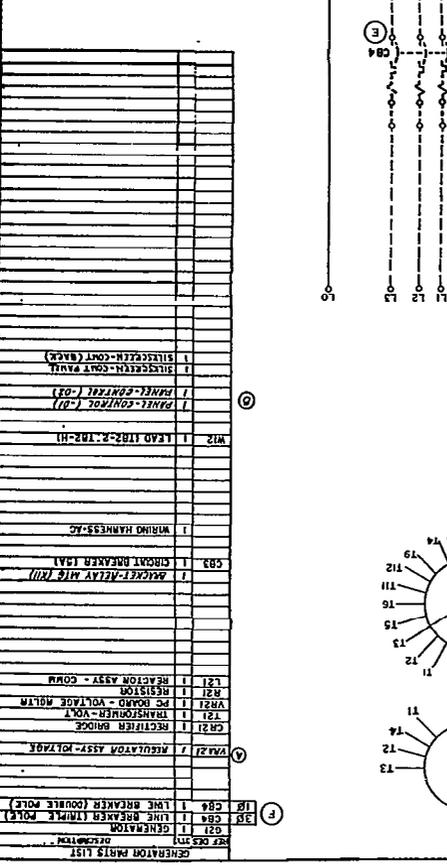
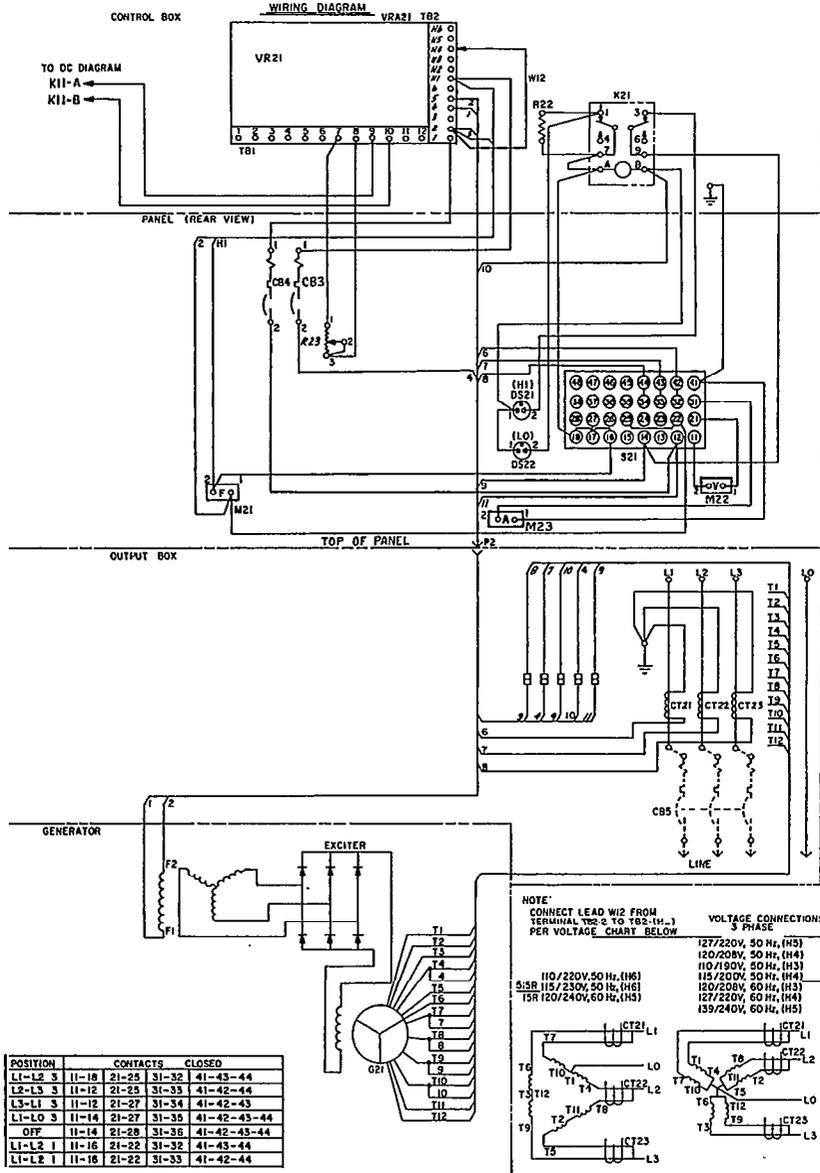


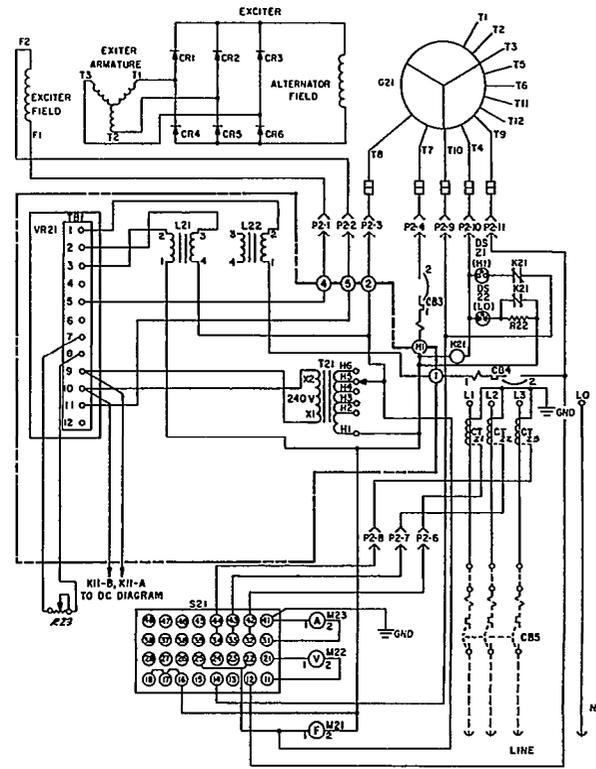
FIGURE 38. SINGLE AND THREE-PHASE AC CONTROL WITHOUT OPTIONAL METERS

612-6076

FIGURE 40. THREE PHASE AC CONTROL WITH SWITCHING REGULATOR AND OPTIONAL METERS



THREE PHASE SCHEMATIC DIAGRAM AC



PARTS LIST

REF	QTY	DESCRIPTION
G21	1	GENERATOR
CB3,4	1	LINE BREAKER (TRIPLE POLE)
CB3,4	1	CIRCUIT BREAKER (2A)
CT1,2,3	3	TRANSFORMER-CURRENT (15-30 kw)
CT1,2,3	3	TRANSFORMER-CURRENT (25-50 kw)
CT1,2,3	3	TRANSFORMER ASSY (40-50 kw)
CT1,2,3	3	TRANSFORMER ASSY (60-70 kw)
CT1,2,3	3	TRANSFORMER ASSY (71-100 kw)
CR21	1	RECTIFIER BRIDGE
T21	1	TRANSFORMER-VOLT
VR21	1	PC BOARD-VOLTAGE REGULTN
L11, L12	2	REACTOR ASSY - COMM
VR21, 2	2	RELAYISE ASSY - METER
DS1, 2	2	LAMP-AC METER SW 125V
S21	1	SWITCH-VOLT B. AMMETER
M21	1	METER-FREQ 50Hz (60-05, 05, 07)
M21	1	METER-FREQ 50Hz (60-05, 05, 07)
M22	1	METER-VOLT AC 100V (0-100)
M22	1	METER-VOLT AC 100V (0-100)
M19	1	AMM-AC (0-50-0-100) (1E-34 kw)
M19	1	AMM-AC (0-75-0-150) (1E-39 kw)
M19	1	AMM-AC (0-100-0-200) (40-50 kw)
M19	1	AMM-AC (0-160-0-320) (1E-10 kw)
M19	1	AMM-AC (0-250-0-500) (1E-22 kw)
M19	1	WIRING HARNESS-AC (METER)
K21	1	RELAY-VOLTAGE SELECTION
K21	1	BRACKET-RELAY MTG (K1, K11)
K21	1	SPRING-RELAY HOLODOWN
R22	1	RESISTOR 47K
W12	1	LEAD (T8-2, T8-1)
W12	1	LEAD (S21-12, CB4-2)
W12	1	LEAD (CB4-1, T82-1)
DS1, 2	2	LAMP
DS1, 2	2	LAMPHOLDER
	1	PANEL-CONTROL (STANDARD)
	1	PANEL-CONTROL (OPTIONAL)
	1	SILKSCREEN-CONT PANEL
	1	SILKSCREEN-CONT (BLACK)
R23	1	POTENTIOMETER-VOLT
R23	2	KNOB-RHEOSTAT

- NOTES:**
- UNLESS OTHERWISE NOTED, ALL COMPONENTS SHOWN IN THE DE-ENERGIZED POSITION.
 - OPTIONAL DC GAUGE CAN BE EITHER AN ELECTRIC OIL TEMP GAUGE OR AN ELECTRIC TACHOMETER.
 - OPTIONS ARE SHOWN CONNECTED IN DASHED LINES.

MODEL STD DC GAUGES/OPT DC GAUGES

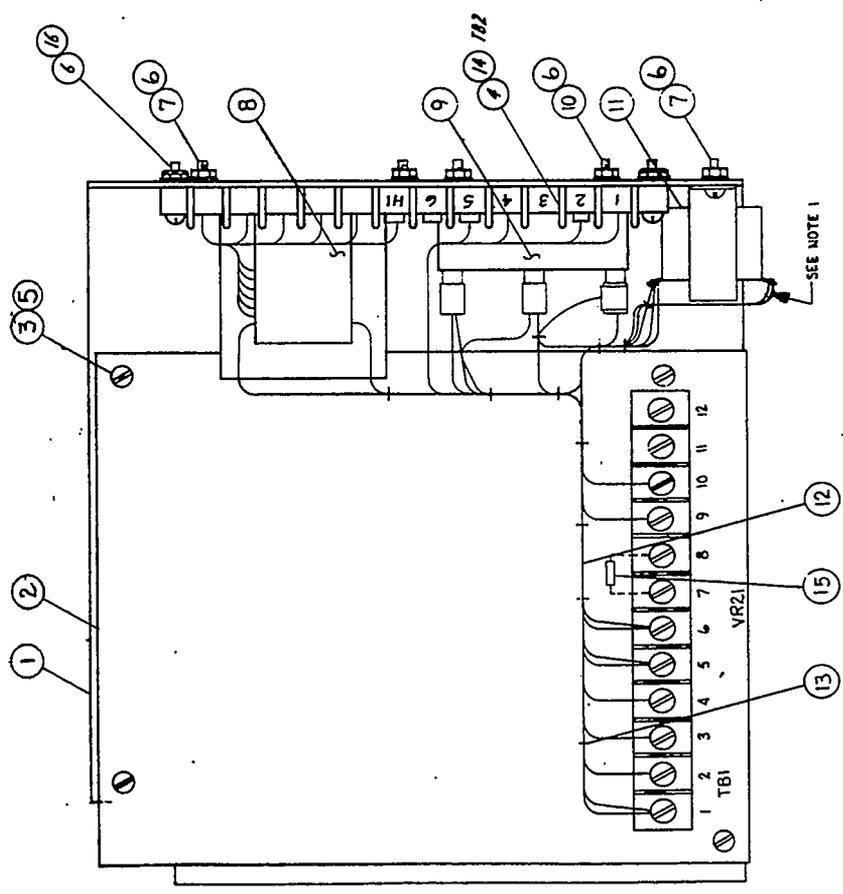
MODEL	STD DC GAUGES	OPT DC GAUGES
15-24 kw	-03 -04 -07 -08	50 Hz
25-39 kw	-01 -02 -05 -06	50 Hz
40-50 kw	-09 -10 -11 -12	50 Hz
51-70 kw	-13 -14 -15 -16	50 Hz
71-100 kw	-17 -18 -19 -20	50 Hz

21650	D	REVISED PER EA	1/21/64
20724	A	SEC ER	5/1/62
10751	A	PROD RLSE	1/1/62
EA	107		

GE DIVISION OF GMX CORPORATION
 7-14-64 JPR
 CONTROL GEN SET AC
 WIRING DIAGRAM I
 15-100 KW 3Ø
 612-6076

305-0693 C

- NOTES.
1. IMPORTANT TO TIE CLOSE TO ITEM 11 TO PREVENT INTERFERENCE FROM OTHER PARTS.
 2. TRANSFORMER CONNECTION (111)
 A 1₁ TO VR21-9
 B 1₂ TO VR21-10



17	TERMINAL-TAB
16	SCREW - RHM (6-32 X 1/8)
15	RESISTOR ASSY (-01)
14	ARMATURE STRIP
13	TIE - CABLE
12	HARNES - WIRING
11	REACTION ASSY - CORE
10	SCREW - RHM (1/4" x 6-32)
9	BRIDGE - SCR
8	TRANSFORMER - VOLT
7	SCREW - RHM (3/8 x 6-32)
6	NUT - H W/EI (6-32)
5	WASHER-ET LK (#2)
4	TERMINAL BLOCK
3	SCREW - RHM (1/4 x 6-32)
2	BOARD ASSY - PC
1	PANEL - VOLT REGULATOR

QTY	1
DESCRIPTION OR MATERIAL	REGULATOR ASSY-VOLTAGE
A DIVISION OF ORIN CORPORATION Muncie, Indiana	

305-0693

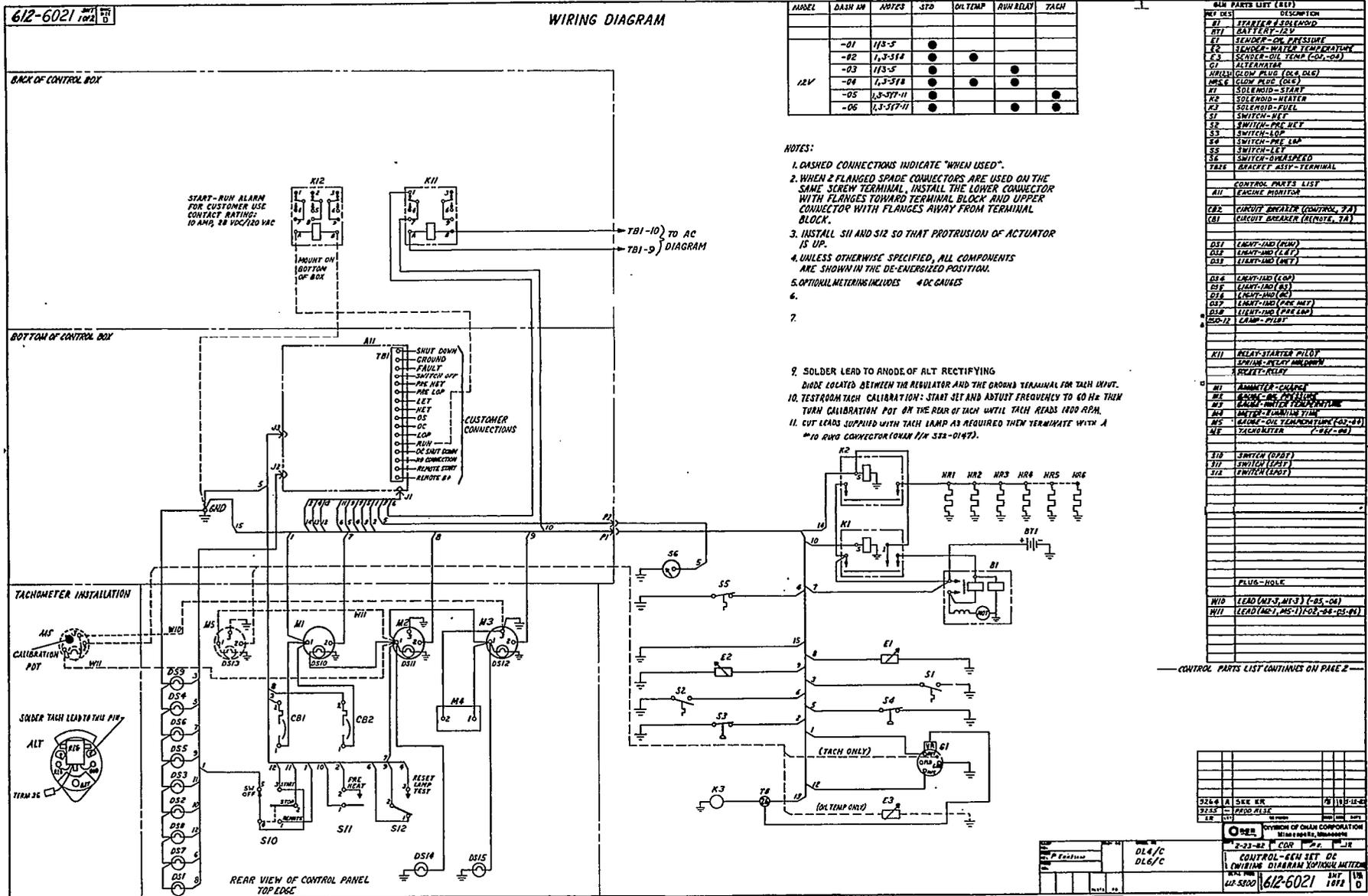
L/c

305-0693

305-0693	REV 001	DATE 6-2-62	BY J.R.	CHK P.E.
305-0693	REV 001	DATE 6-2-62	BY J.R.	CHK P.E.
305-0693	REV 001	DATE 6-2-62	BY J.R.	CHK P.E.
305-0693	REV 001	DATE 6-2-62	BY J.R.	CHK P.E.
305-0693	REV 001	DATE 6-2-62	BY J.R.	CHK P.E.
305-0693	REV 001	DATE 6-2-62	BY J.R.	CHK P.E.
305-0693	REV 001	DATE 6-2-62	BY J.R.	CHK P.E.
305-0693	REV 001	DATE 6-2-62	BY J.R.	CHK P.E.
305-0693	REV 001	DATE 6-2-62	BY J.R.	CHK P.E.
305-0693	REV 001	DATE 6-2-62	BY J.R.	CHK P.E.

FIGURE 42. VOLTAGE REGULATOR ASSEMBLY

FIGURE 46. NINE LIGHT DC CONTROL WIRING DIAGRAM



612 PARTS LIST (REV)

REF DES	DESCRIPTION
K1	STARTER & SOLENOID
BT1	BATTERY-12V
E1	SENDER-OIL PRESSURE
E2	SENDER-WATER TEMP/TEMPATURE
E3	SENDER-OIL TEMP (COP-04)
G1	ALTERNATOR
M12	GLOW PLUG (DC & GLE)
M13	GLOW PLUG (DC)
ST	SOLENOID-START
ST2	SOLENOID-HEATER
F3	SOLENOID-FUEL
S1	SWITCH-REF
S2	SWITCH-PRE KEY
S3	SWITCH-LOP
S4	SWITCH-PRE LAMP
S5	SWITCH-LET
S6	SWITCH-OVER SPEED
TB16	BRACKET ASST-TERMINAL
CONTROL PARTS LIST	
M1	ENGINE MONITOR
CB2	CIRCUIT BREAKER (CONTROL, 2A)
CB1	CIRCUIT BREAKER (ENGINE, 2A)
DS1	EMPT-IND (MOM)
DL2	EMPT-IND (L.P)
DS3	EMPT-IND (NET)
DS4	EMPT-IND (COP)
DS5	EMPT-IND (B)
DS6	EMPT-IND (G)
DS7	EMPT-IND (PRE NET)
DS8	EMPT-IND (PRE LAMP)
DS9-12	LAMP-PIST
K11	RELAY-STARTER PILOP
	SPRING-RELAY ANCHOR
	RELAY-RELAY
M1	AMMETER-CHARGE
M2	GAGE-OIL PRESSURE
M3	GAGE-WATER TEMPATURE
M4	GAGE-OIL TEMPATURE
M5	GLG-OIL TEMPATURE (COP-04)
M6	TACHOMETER (REF-04)
S10	SWITCH (OFF)
S11	SWITCH (UP)
S12	SWITCH (DOWN)
PLUS-HOLE	
W10	LEAD (M1-S, M1-3) (-05-04)
W11	LEAD (M2, M5-1) (-05-04-05-04)

CONTROL PARTS LIST CONTINUES ON PAGE 2

REV	DATE	BY	CHKD
01	2-23-82	DL4/C	DL6/C
02			
03			
04			
05			
06			
07			
08			
09			
10			

612-6021 10

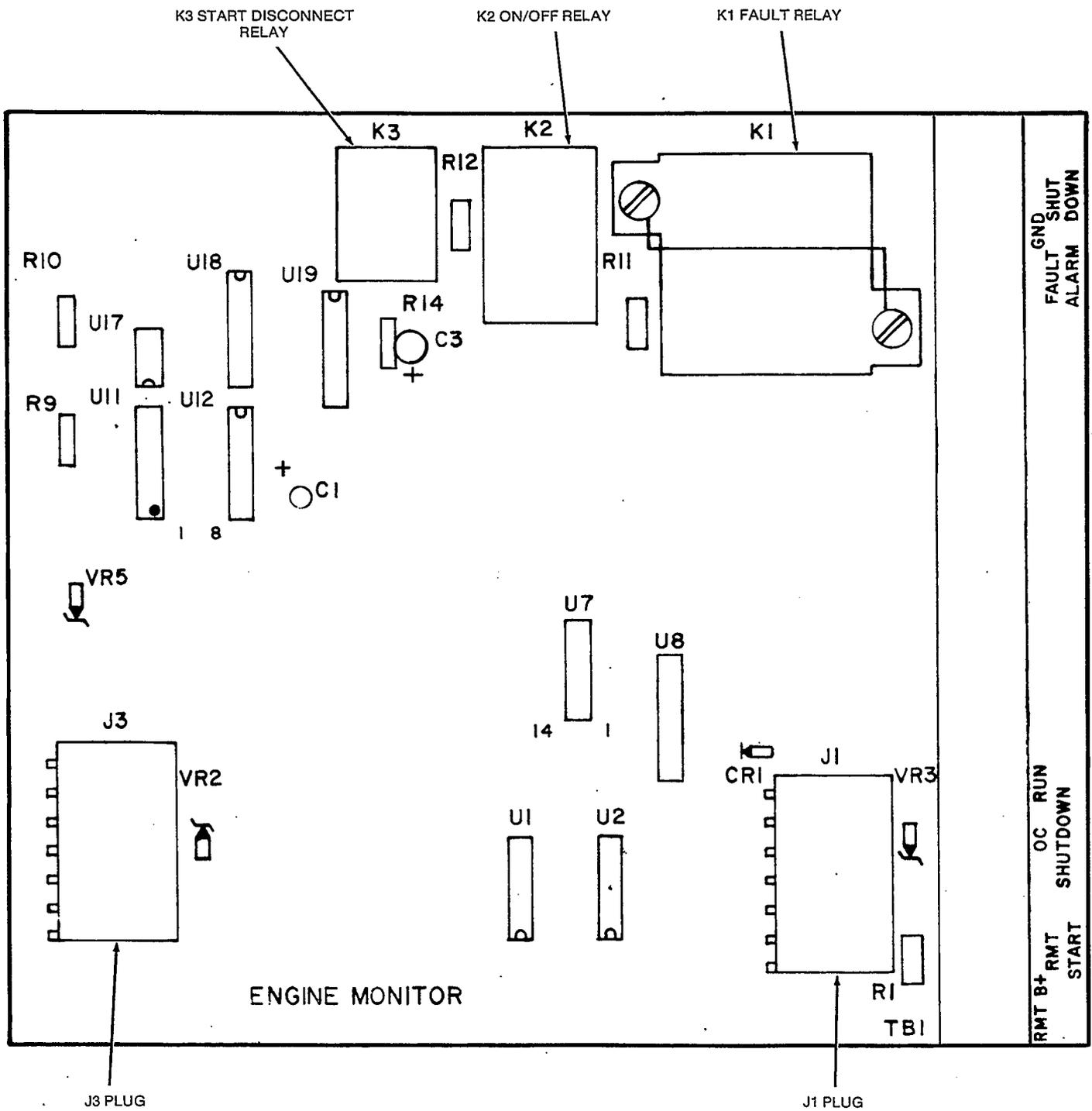


FIGURE 49. TWO LIGHT ENGINE MONITOR BOARD

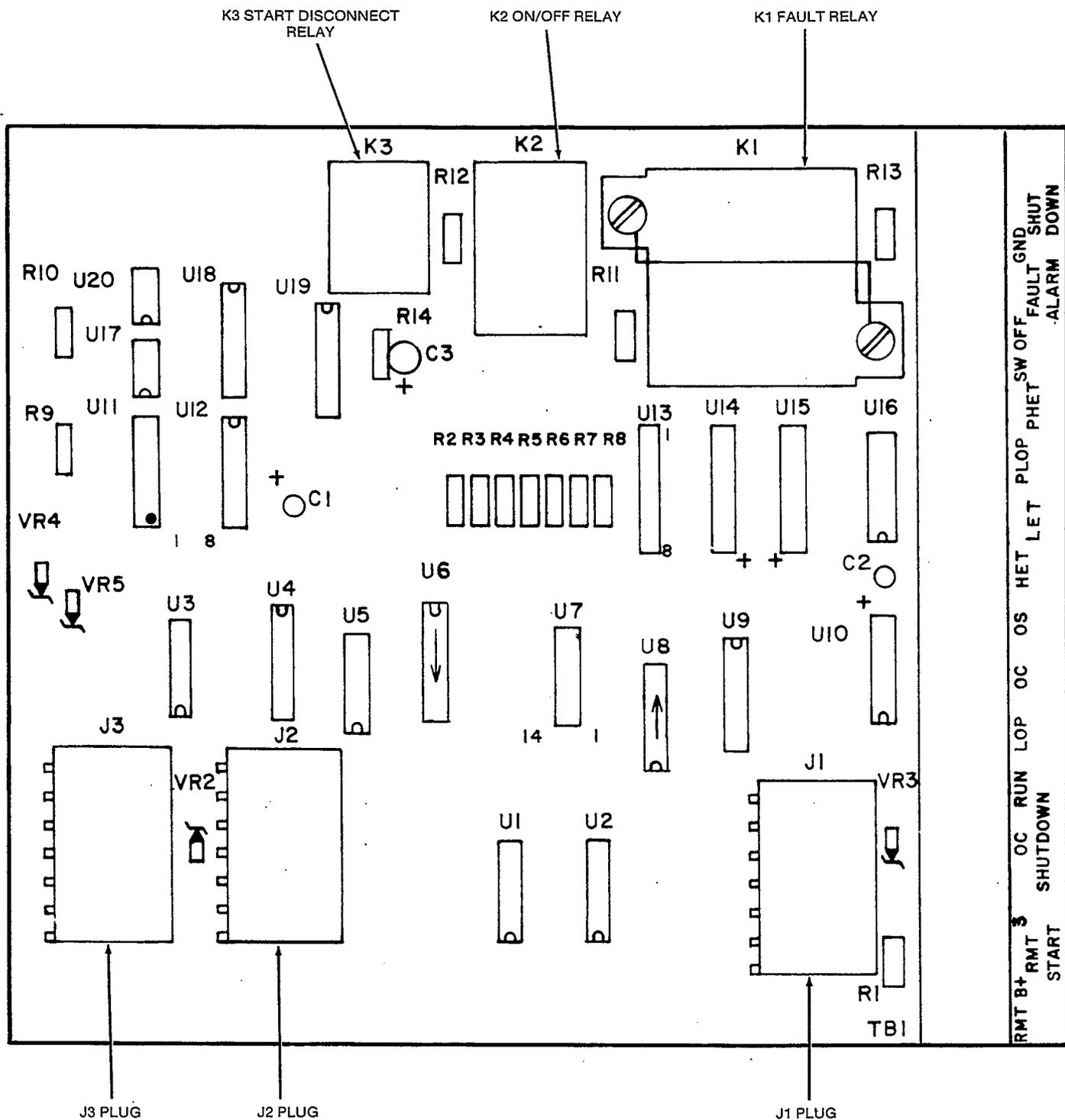
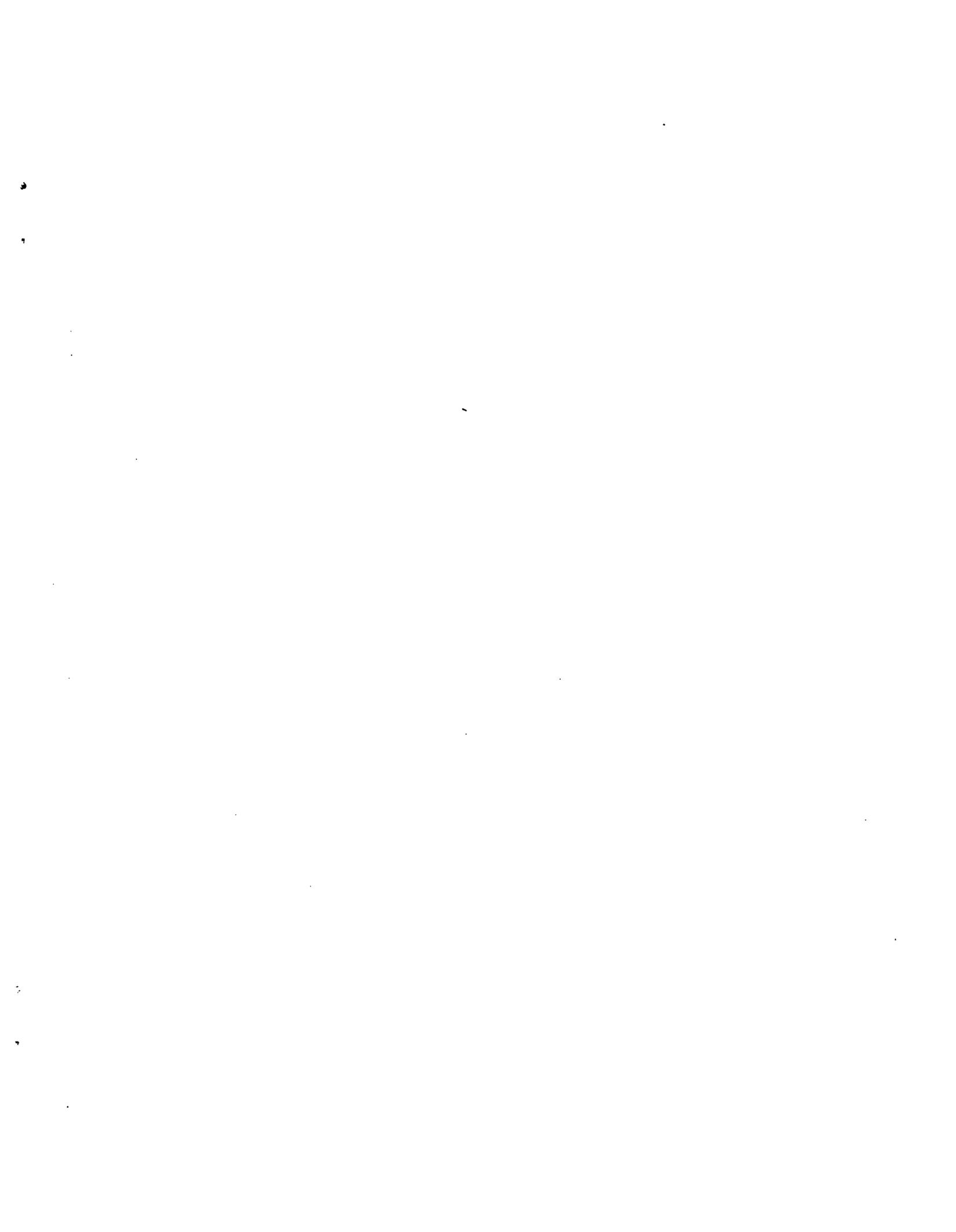


FIGURE 51, NINE LIGHT ENGINE MONITOR BOARD







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