ELECTRO-MOTIVE DIVISION • GENERAL MOTORS CORPORATION
SERVICE DEPARTMENT
MAINTENANCE INSTRUCTION

EMD STATIC VOLTAGE REGULATOR

INTRODUCTION

The purpose of this publication is to provide instructions for bench test and repair of the EMD Static Voltage Regulator, and instructions for setting the repaired device to obtain the desired regulation on a locomotive. Defects are categorized and drawings, wiring diagrams, and instructions provided for checking and repairing each category of defect.

GENERAL DESCRIPTION

The EMD static voltage regulator is a solid-state electronic assembly which regulates at 74 volts the power used for charging batteries and operating devices in the locomotive control circuitry. Some regulators also provide a stable 72 volt source which is used as a reference for the static excitation system.

The regulator maintains control voltage by varying the average value of auxiliary generator field current. In the regulator the field current is controlled by a silicon controlled rectifier SCR1. This device behaves as a switch which can be turned on by a gate signal from the detector circuit. The SCR cannot be turned off unless the gate signal is removed and anode to cathode current is reduced to lower than a small holding value. The oscillator turns SCR1 off approximately 250 times a second if SCR1 is provided a gate signal by the detector circuit. The detector provides a gate signal when the auxiliary generator voltage decreases below the desired value. When the gate signal to SCR1 is removed, SCR1 shuts off and stays off until the gate signal is returned. Thus, SCR1 feeds current to the field in pulses only when the auxiliary generator voltage is low. The current that flows in the field itself is "smoothed" by a free-wheeling diode which allows the field current to continue to flow when the SCR is turned off. In addition to the portion of the regulator devoted to maintaining a constant voltage, there is a starting circuit which allows the auxiliary generator voltage to build up from zero each time the engine is started, Fig. 1.

Physically the regulator is arranged in two parts: the case and the circuit board, Figs. 2 and 3. Large power carrying components are mounted on the case. Small solid state devices (zeners and blocking diodes) which handle relatively small amounts of power are mounted on the circuit board.

INSPECTION AND MAINTENANCE

If the auxiliary generator fuse blows frequently, check the voltage between the auxiliary generator fuse (top) and the right side of the battery switch (neg.). Voltage should be 74 volts $\pm$ 1 volt in all throttle positions. If the regulator is suspected of being faulty, replace it with a new or rebuilt regulator.

There are four major categories into which defective regulators may be classified. When a regulator is defective it

*NOTE: Information contained herein is applicable to equipment being produced as of the date of publication.

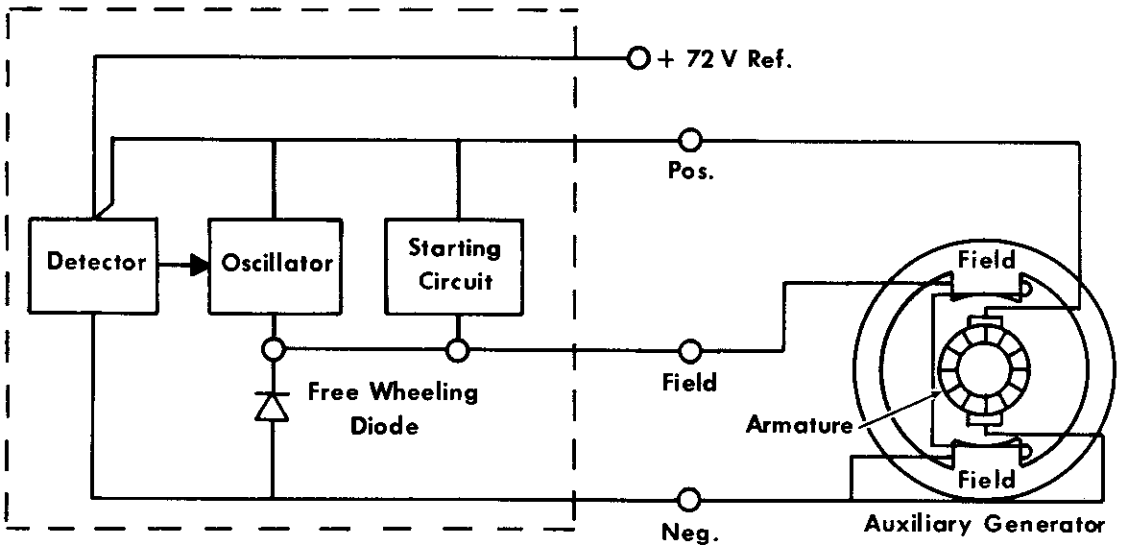


Fig. 1 — Block Diagram Representation Of Regulator

should be checked according to the categories listed below.

I. Regulator does not turn on.
II. Regulator does not turn off.
III. Voltage regulated too high.
IV. Voltage regulated too low.

The following tests in Steps 1 and 2 will determine in which category the defective regulator should be checked. Step 3 will determine if the regulator is oscillating.

Test Procedures

1. Connect the regulator to the test circuit as shown in Fig. 4 for minimum voltage test.

CAUTION: If positive and negative leads are reversed, CR1 and D3 will be damaged beyond use.

a. Three Terminal Regulators

Set the voltage adjusting rheostat RH1 on the regulator to minimum position (fully counterclockwise).

b. Four Terminal Regulators

Set the rheostat to minimum, and jumper across the adjustable wirewound resistor R1 at the bottom of the regulator, Fig. 2.

Apply power supply voltage V1. Observe the test light as voltage V1 is increased. The light should become brighter as voltage is increased to 62-70 volts, at which time it should go off. If the light does not come on at all or if it goes off at 30 to 48 volts when the starting relay picks up, the regulator is in Category I. If the light goes off before 62-70 volts, but stays on after the starting relay picks up, the regulator is in Category IV. If the light goes off at higher than 62-70 volts, but less than 100 volts, the regulator is in Category III. If the light does not go off at all, the regulator is in Category II.

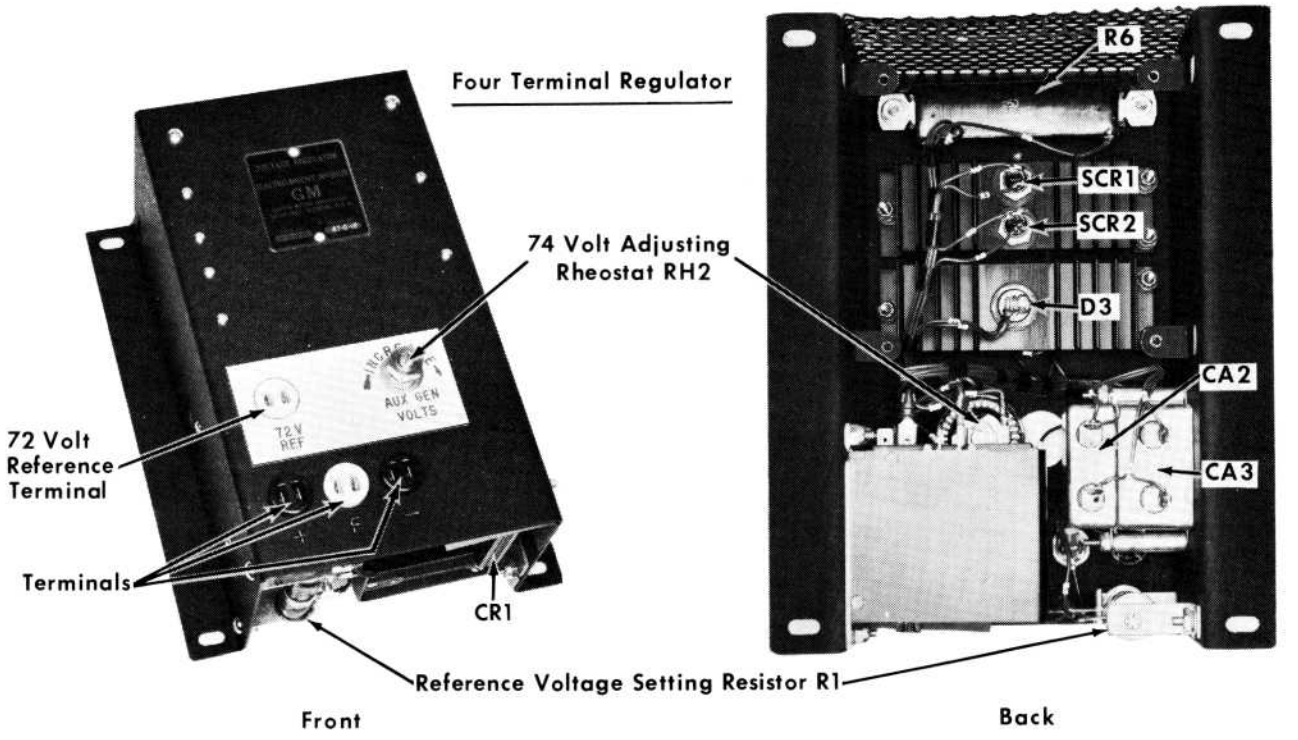
2. Connect the regulator to the test circuit as shown in Fig. 4 for maximum voltage test.

a. Three Terminal Regulators

Set voltage adjusting rheostat RH1 on the regulator to the maximum position (fully clockwise).

b. Four Terminal Regulators

Remove the jumper applied across R1 in Step 1b above, and set R1



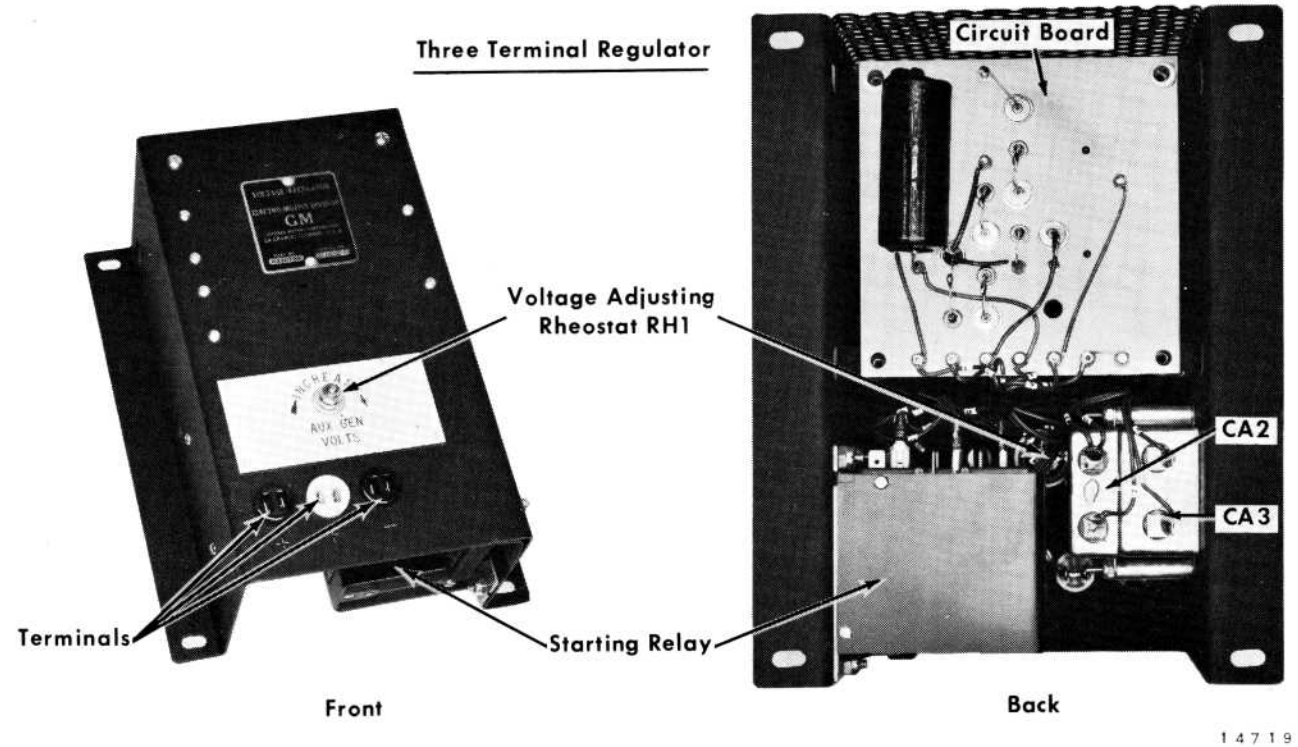


Fig. 2 — Physical Appearance And Location Of Components

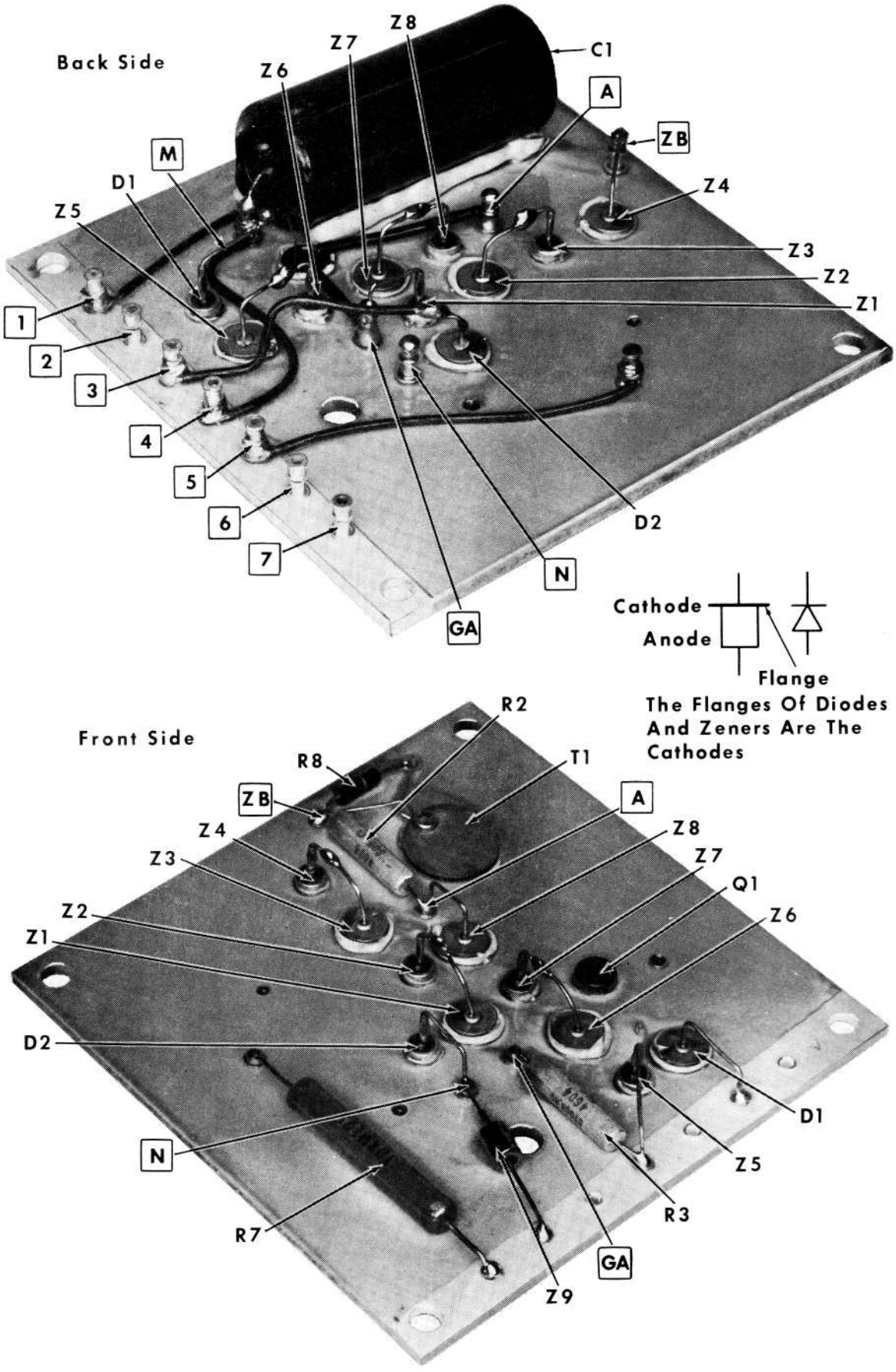
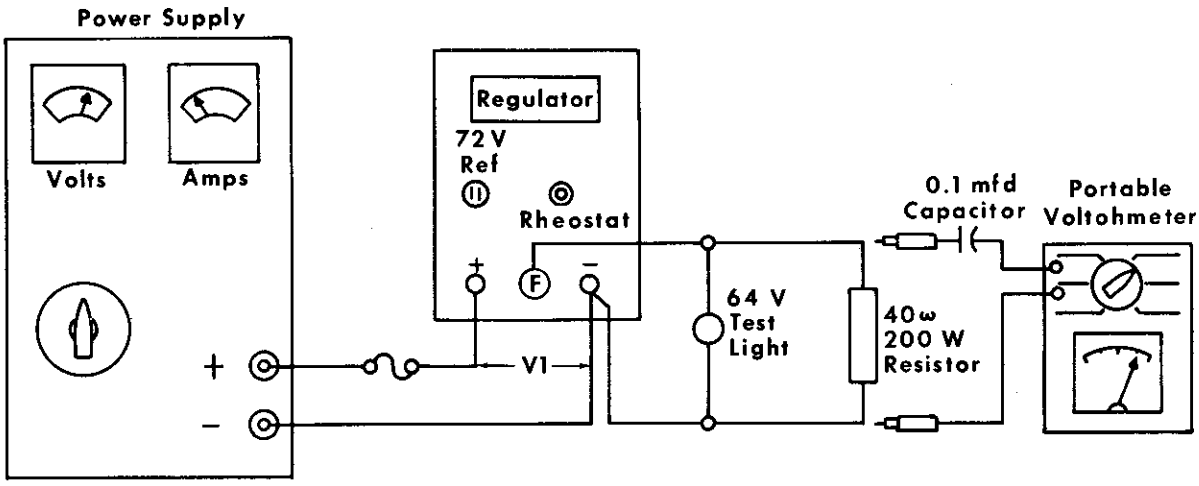


Fig. 3 — Circuit Board Of Regulator



CAUTION: Observe Proper Polarity. Polarity Reversal Will Result In Overloading Diode D3 And CR1.

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Fig. 4 — Regulator Test Circuit

resistance to maximum by insulating the slider from the resistance element.

Again apply power supply voltage V1. The test light should become brighter as voltage is increased to 76-87 volts, at which time it should go off. If the light does not come on at all or if it goes off at 30-48 volts when the starting relay picks up, the regulator is in Category I. If the light goes off before 80-76 volts, but stays on after the starting relay picks up, the regulator is in Category IV. If the light goes off at higher than 80-76 volts, but less than 100 volts, the regulator is in Category III. If the light does not go off at all, the regulator is in Category II.

c. Four Terminal Regulator Only

Connect a 50 ohm 200 watt resistor between the reference terminal and negative. Turn the rheostat RH2 at front of regulator fully clockwise. The light should go off about 3 volts higher than it did in the preceding test. If the light goes off when the starting relay picks up, and power supply current at 75 volts is less than one ampere, the rheostat is probably open. Test for continuity with an ohmmeter. Resistance should be approximately 2 ohms.

3. Oscillation Test

Restore the test circuit to its condition in Step 1 a or b. Connect the portable voltmeter to the F and negative terminals of the regulator. Use the output and common terminals of the meter and set the selector switch(es) to 50 volts AC. If the meter is not provided with an output terminal, use the positive and negative terminals of the meter and insert a .1 microfarad capacitor in series with one of the leads to filter out the DC component of the field output. Observe both the power supply ammeter and the portable voltmeter. DC currents should be roughly as shown in Fig. 5 with nothing connected to the 72 volt reference terminal, and the AC voltage should be as shown in Fig. 6.

The AC voltage jump from zero at approximately 50 volts DC in Fig. 6

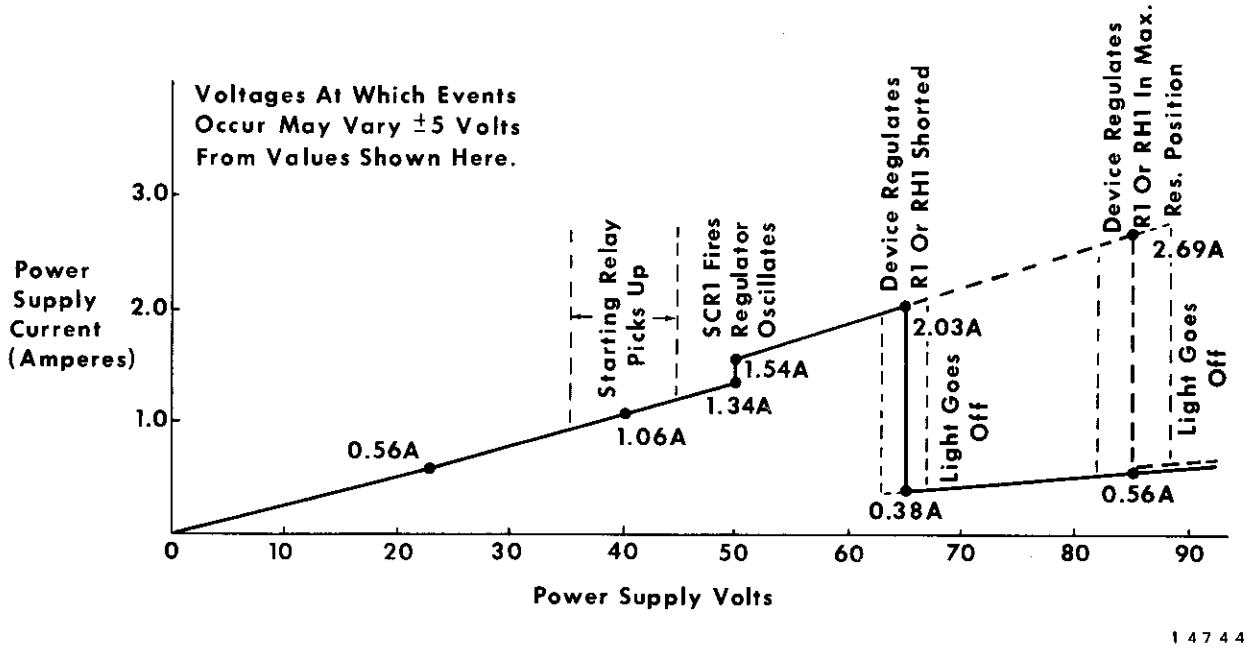


Fig. 5 — Voltage Regulator Characteristics When Connected As In Fig. 4, Steps 1 And 2

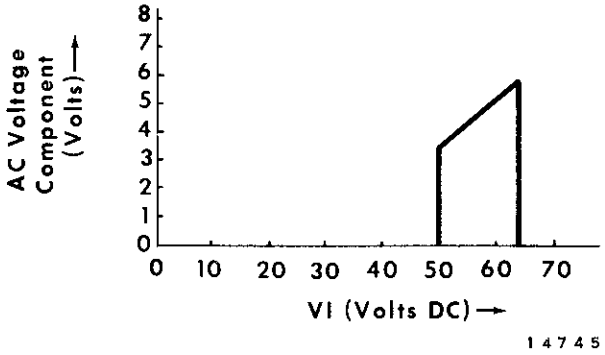


Fig. 6 — AC Component Of Field Voltage Versus Power Supply Voltage (VI)

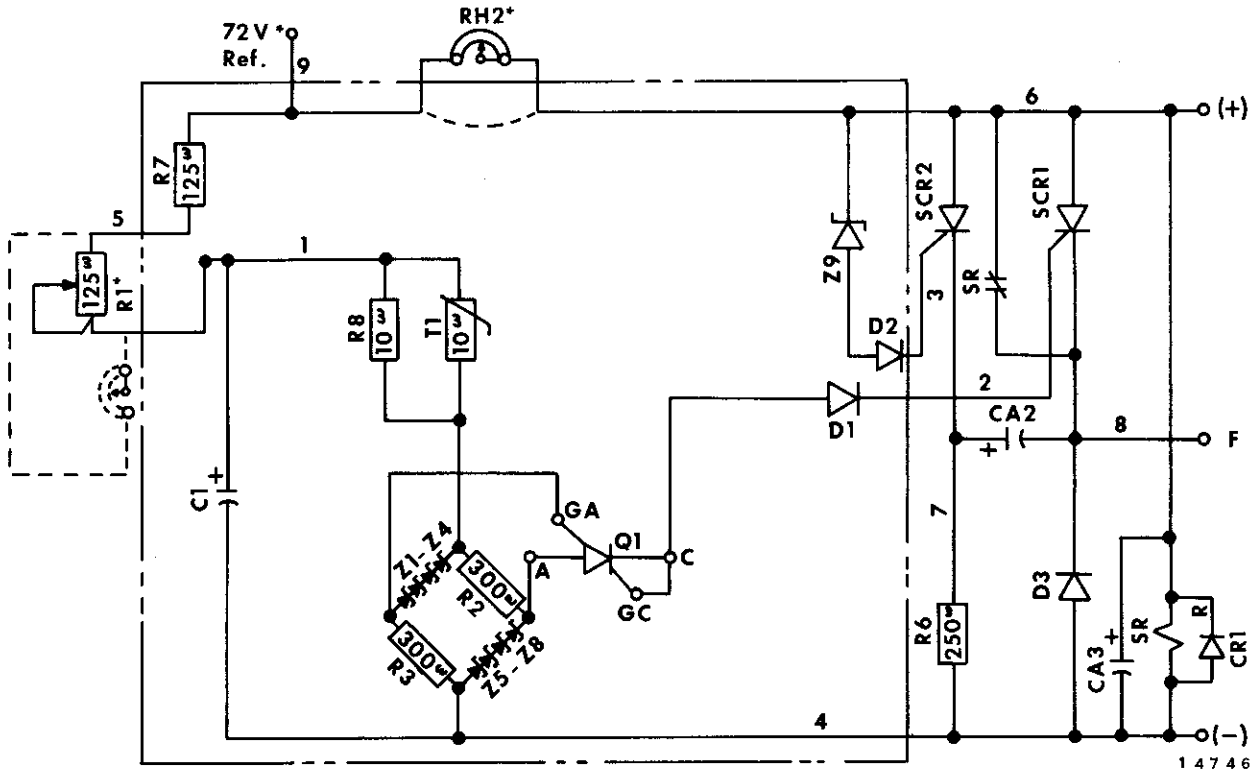
indicates that the regulator is oscillating. The regulator may start to oscillate below 50 volts DC but definitely should oscillate before 60 volts DC. Often a faint buzzing sound can be heard while the regulator is oscillating. The AC voltage is given only as a guide and varies widely depending on the meter used to measure it. Now increase the voltage until the light turns off. The AC voltage should drop off also. If the AC voltage drops off but the light stays on, the starting relay could be wired normally open instead of normally closed. Check the wires on the relay against the schematic, Fig. 7, and the pictorial schematic, Fig. 8.

If the regulator performs satisfactorily in Steps 1 through 3, then it is in operating condition and should be put in a locomotive and set to regulate at the proper voltage as described under "Setting The Regulator To Regulate At The Proper Voltage."

If the regulator did not perform properly under Test Procedures, the following should be observed to locate the trouble. Instructions for replacing diodes and SCR's are provided at the end of this Maintenance Instruction. Read them before applying heat to any soldered terminals.

Category I - Regulator does not turn on.

If the light went out as soon as the starting relay picked up in Step 1, and Step 3 indicates that the regulator does not oscillate, make the following check to determine whether the SCR's are functioning properly. Remove the cover by



NOTE: Components shown dotted are present only on three-terminal regulators. *R1, RH2, and 72 Volt reference terminal are present only on four terminal regulators.

Fig. 7 — Schematic

loosening the four side screws. Then unscrew the circuit board to gain access to the SCR's.

1. SCR Test

To perform the following test, a 3 volt battery light such as shown in Fig. 9 is required. It can easily be made from a penlite, two test probes and some wire or it can be ordered from the tool catalog (see Maintenance Data). Refer to Figs. 7 and 8 when performing these tests.

a. Remove all number (6), (6C) and (6D) wires from the NC contacts of the starting relay.

b. Remove wires from the power supply and load resistor. Connect the positive test probe and a jumper to the number (6F) wire of CA3. This will apply a positive potential to the anode of SCR1. Connect the negative test probe from the test light to the cathode (larger lug) of SCR1. Touch the loose end of the jumper to the gate of SCR1 (smaller lug). The light should come on when the jumper touches and stay on when the jumper is removed from the gate. If the light does not come on at all, check to be sure the correct polarity is observed. Also check for continuity between (6F) and the SCR anode. If the light comes on without the gate signal or goes out when the gate signal is removed, the SCR is defective and should be replaced. Test SCR2 in the same manner.

c. If SCR1 is defective, check diode D1 for a short by placing the positive test lead at terminal [2] of the circuit board and the negative lead at terminal [M], see Fig. 8. The light should be off. Reverse the leads. The light should come on. If it comes on in both directions, remove

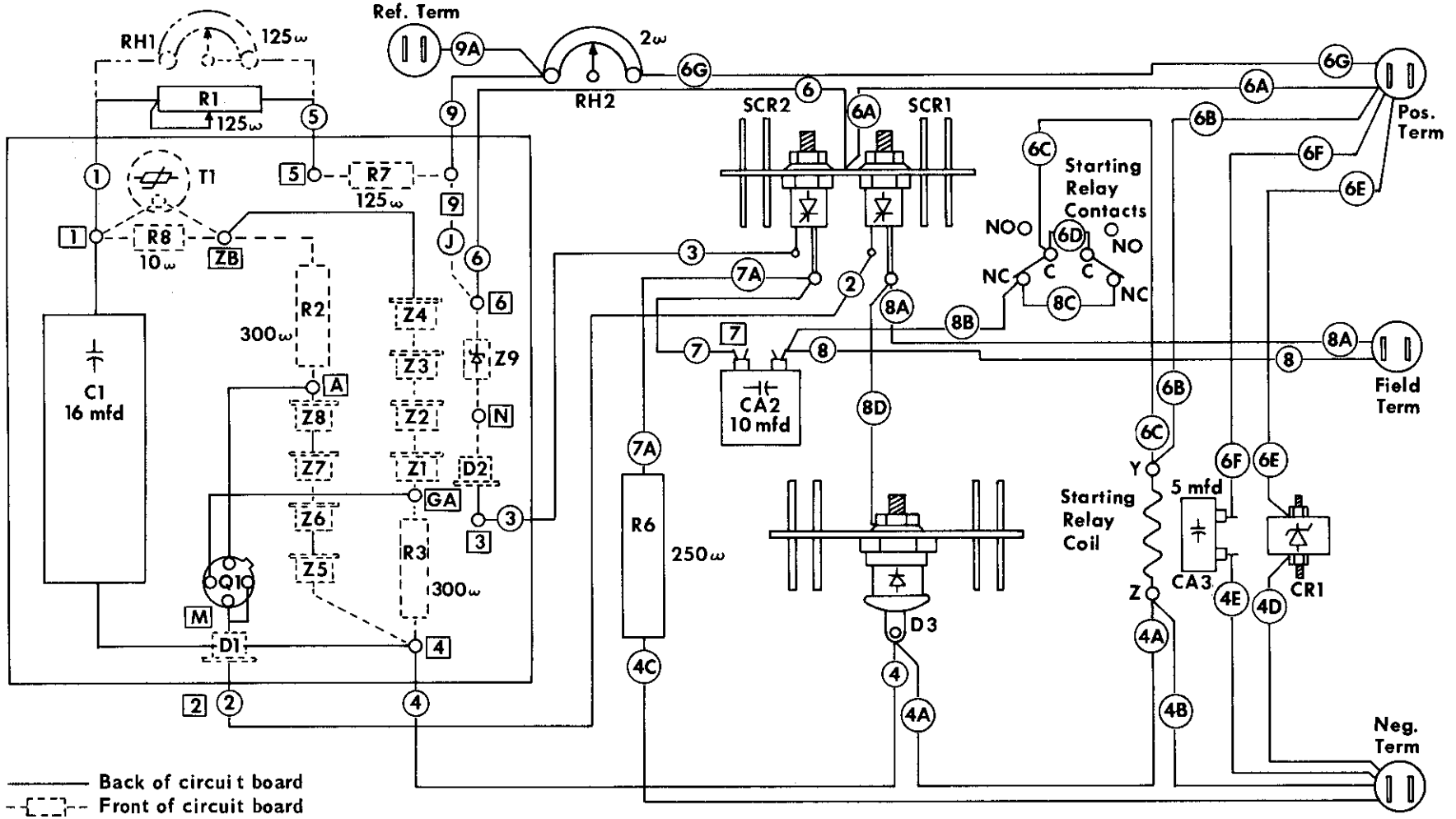


Fig. 8 — Pictorial Schematic

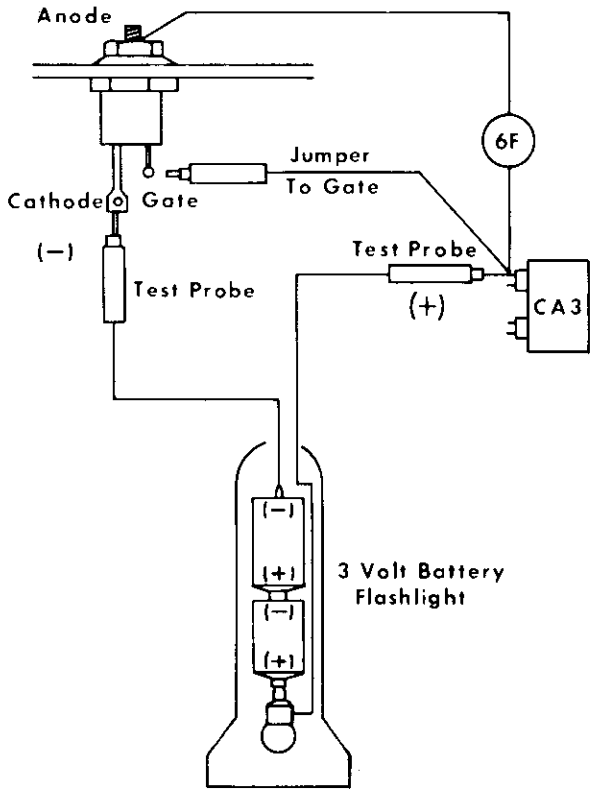


Fig. 9 — Circuit For Testing SCR's Using 3 Volt Battery Test Light

the number (2) wire from the post on the circuit board and test again.

CAUTION: Do not unsolder any wires until heat sinks are properly applied. See "Instruction For Replacing Components" at end of this Maintenance Instruction.

If diode D1 is found to be shorted, it is advisable to test the other components (Q1, Z5 to Z8) for shorts because it is likely that failure of D1 caused their failures, and replacement of one component without replacement of other faulty components will result in subsequent failure immediately after replacement. Make a similar check of the silicon controlled switch (Q1) by placing the test probes between points [M] and [A] and [M] and [GA] in both directions. The light should be off all four times. If it is shorted, connect the regulator as in Step 1 of Test Procedures, leave wire (2) disconnected, and raise V1 to 60 volts. The voltage of terminal [A] of the circuit board should be 22.4 volts positive with respect to negative. If it is zero, all four zeners Z5 through Z8 are shorted and need replacement. If the voltage is between zero and 22.4 volts, check the voltage across each zener individually, Fig. 10 (be sure that a good connection is made between the component leads and the meter probes; if necessary scrape away varnish and dirt). If any of the zeners shows a 5-6 volt drop across it, the zener is serviceable and need not be replaced.

While replacing SCR1 check diode D3 with the 3 volt battery light when the (8D) and (8A) wires are disconnected from the SCR1 cathode. If it indicates shorted or open, replace it.

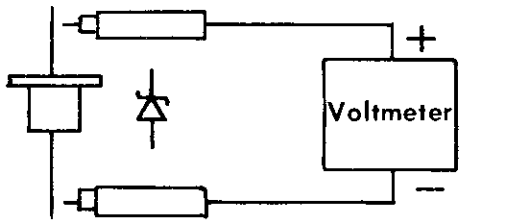


Fig. 10 — Checking Voltage Across Zener Diode

2. SCR1 Gate Circuit Test

If the regulator remains full off (light does not stay on when relay picks up in Step 1 of Test Procedures) and does not oscillate (Step 3 of Test Procedures), with SCR1 and SCR2 operational (SCR Test), the gate circuit to SCR1 is probably defective.

a. Connect the regulator as in Step 1 of Test Procedures. Set V1, Fig. 4, to 60 volts. Connect the negative test probe of the voltmeter to negative.

b. Measure positive voltage at test point [M], Fig. 8. If the voltage is approximately 23 volts, diode D1 is probably open. Disconnect the power supply and check with the 3 volt battery light.

c. If voltage at point [M] is zero, check voltages at points [A] and [GA]. [A] should be 22.4 volts positive and [GA] should be approximately 20 volts positive. If [A] is at 22.4 volts positive and is higher than [GA], but point [M] is at zero volts, then switch Q1 is probably defective. If D1 was found either shorted or open in Step b above, cut the anode lead of D1 close to the body (the anode lead is connected to point [M]). Check D1 again while it is isolated from the circuit. If it is shorted, check Q1 for a short as in Step c of SCR Test. If D1 is shorted and Q1 does not appear shorted after D1 is disconnected, jumper a new diode between point [2] and the Q1 cathode-gate cathode pair just removed from the shorted D1.

CAUTION: If D1 is shorted and not disconnected from Q1 before proceeding to Step d, it is possible to destroy SCR1, Q1, and zeners Z5 to Z8.

d. Jumper from [A] to [M] or from [A] to the anode of the new D1 if the old D1 is shorted. The regulator should oscillate, and the 74 volt test light should come on. Replace defective components as determined by Steps b through d.

e. If Step c revealed voltage at points [A] and [GA] to be zero, check voltage at [ZB]. If [ZB] is at 60 volts, both R2 and one of the zeners Z1 to Z4 are open. If voltage at [ZB] is zero, check voltages at terminals [1], then [5], then [9], all with respect to negative. When 60 volts is found at one of these terminals, the defective component is between that terminal and the last one checked.

f. If the voltage at [A] is zero or less than 22.4 volts but voltage at [ZB] is not zero, determine if resistor R2 is hot. If it is, zeners Z5 to Z8 are shorted; if it is at room temperature, resistor is open.

After faulty components have been located, replace them according to "Instructions For Replacing Components" as outlined at the end of this Maintenance Instruction. Then test the regulator as outlined in Steps 1 and 2 of Test Procedures.

Category II - Regulator does not turn off

If the 74 volt light did not go off before 100 volts in Steps 1 and 2 of Test Procedures but the regulator did oscillate in Step 3, it is likely that the gate circuit of SCR1 is at fault.

1. SCR1 Gate Test

a. Connect the regulator as in Step 1 of Test Procedures. Set V1, Fig. 4, to 70 volts. Be sure R1 or RH1 is jumpered out. Voltage at [ZB] should be at least 45 volts. If it is not, the resistance of R7, R1, or RH1, or the parallel combination of R8 and T1 is too high. Check the resistance of each against the values shown in Figs. 7 and 8.

b. Set the portable voltmeter to DC. Connect the positive test probe to

point [A]. Connect the negative lead to point [GA]. Increase V1 from zero to 70 volts. Voltage [A] to [GA] should be as shown in Fig. 11. The value at which this voltage reverses polarity is the voltage at which the regulator should turn off. It may vary between 62 to 70 volts. If the voltage of [A] with respect to [GA] does not reverse when V1 is as high as 100 volts, check the voltage across each of the zeners Z1 through Z8 individually (V1 at 70 volts). If the voltage across a zener looks suspiciously high, leave the voltmeter connected across it and vary V1 from 50 to 70 volts. If the zener voltage varies widely (more than a volt) the zener is defective.

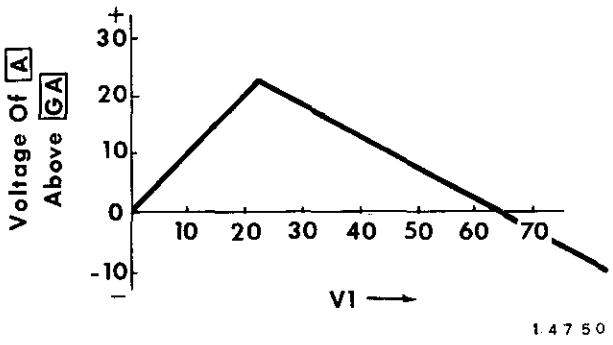


Fig. 11 — Voltage Of [A] With Respect To [GA] When Regulator Is Connected As In Step 1

c. If the zener bridge operated satisfactorily in Step b, connect the voltmeter between point [M] and negative. Voltage of point [M] should be as shown in Fig. 12. If voltage at [M] does not drop off at the same voltage that voltage reversal was observed in Step b, then Q1 is shorted between [A] and [M].

d. If Steps a through c indicate that the SCR1 gate circuit is operating properly, it is possible that the starting relay contacts are welded closed. Symptoms of this are the same as described in Step 3 of Test Procedures. Remove the (6) wires (6C) and (6D) from the relay and repeat Step 1 of Test Procedures to see if the light goes out at 62-70 volts.

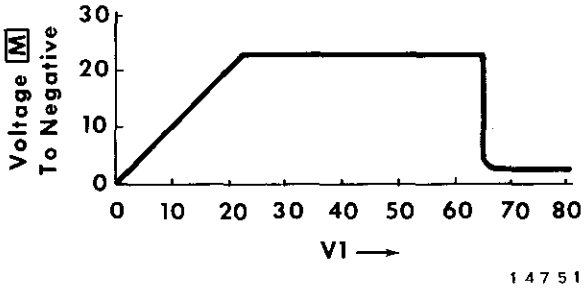


Fig. 12 — Voltage Of [M] With Regulator Connected As In Step 1

2. SCR2 Gate Test

If the light did not turn off before 100 volts in Steps 1 and 2 of Test Procedures and the regulator did not oscillate in Step 3 of Test Procedures, make the following tests to isolate the inoperative circuit and locate the defective component(s).

a. Perform the SCR test as outlined previously.

b. If both SCR's are serviceable, test the SCR2 gate circuit according to the following instructions. Connect the power supply to the positive and negative regulator terminals, but leave the 40 ohm resistor disconnected. Connect the portable voltmeter positive lead to wire (7) at CA2 and the negative lead to negative. Increase V1. The portable voltmeter should read zero until V1 is approximately 40 volts at which time it should jump to 40 volts. If the voltage jumps to 40, decrease V1 below 40. Now the voltage between [7] and negative should be the same as V1. If the voltage at [7]

remained at zero when V1 was raised well above 40 volts, Z9 or D2 is probably open.

c. Remove the power supply connections. Connect the positive lead of the 3 volt test light to [3] and negative to [N]. The light should not come on. Reverse the connections, the light should come on. If the light does not come on, D2 is open and should be replaced. Check Z9 the same way with the light between [6] and [N]. The light should come on with [N] positive and [6] negative and should not come on with polarity reversed.

d. If SCR2 appears to be shorted from [6] to the cathode in Step a, unsolder wire number (3) from the post on the circuit board.

CAUTION: Whenever applying heat to a terminal to which semiconductor devices are attached, be sure to apply a heat sink to the leads of all the devices between the terminal post and the bodies of the devices. See "Instructions For Replacing Components" at the end of this Maintenance Instruction.

Test D2 and Z9 as in Step c. If the light comes on in both directions, the device is shorted and should be replaced. Test SCR2 with the wire disconnected from point [3] as outlined under SCR Test. If it still does not operate properly, replace it.

e. If the SCR Test indicates that both SCR1 and SCR2 are serviceable and Step b indicates that the SCR2 gate circuit is functioning properly, connect the regulator as in Step 1 of the Test Procedures and connect a 10 microfarad (150 V) capacitor across the terminals of CA2. Connect the portable voltmeter to the F and negative terminals of the regulator as in Step 3 of the Test Procedures. Increase voltage from zero to 60 volts. Regulator should now oscillate.

f. If the regulator does not oscillate in Step e, disconnect the power supply and load resistor. Measure resistance from (7) to (4C). The resistance should be approximately 250 ohms. If the resistance is zero, disconnect the number (7A) wires from R6 and measure resistance directly across the resistor. If it is 250 ohms, check between the disconnected (7) wire and negative. If the resistance is zero, check the resistance between (7) and (8B) on the terminals of CA2. The resistance should be infinite with (7A) disconnected from R6. If the resistance is finite, remove CA2 and check it while it is removed from the circuit. If CA2 does have an infinite resistance when removed from the circuit, check the resistance between (8B) and (7) wires. The trouble may be wires shorted in the cable form.

Category III - Voltage regulates too high

1. If the light did not go off at 62 to 70 volts but did go off before 100 volts in Step 1 of Test Procedures, there is a problem in the detector bridge circuit. Connect the regulator as in Step 1 of Test Procedures and set V1 at 60 volts. Check the voltage across each zener leg in the detector bridge. Point [A] should be 22.4 volts positive with respect to [4], and [ZB] should be 22.4 volts positive with respect to [GA]. If either one is more than a volt

high check the voltage across each zener individually as in Fig. 10. When a zener is found that does not have the proper voltage drop, leave the voltmeter connected across it and vary V1. If the voltage across the zener varies more than a volt, the zener is defective and needs replacement.

2. If both zener strings in the bridge maintain a 22.4 volt drop, disconnect the power supply leads and check the resistance of R8 between point [ZB] and point [1] and R7 between terminal [5] and [9] on the circuit board. R8 should be 10 ohms and R7 should be 125 ohms.

   a. Three Terminal Regulators

      Set RH1 to its maximum resistance and measure the resistance. The value should be 125 ohms.

   b. Four Terminal Regulators

      Remove the jumper from R1 and insulate the slider. Leave RH2 in its maximum resistance position. The resistance of R1 should be 125 ohms; RH2 should be 2 ohms. If any of the resistance is high, it will cause the regulator to regulate high.

Category IV - Voltage regulates too low

1. If in Step 1 of the Test Procedures the light goes off with V1 less than 62 to 70 volts, make the same zener test as described in Step 1 of Category III. When either zener string maintains greater than 22.4 volts, the regulator will regulate high. When either zener string maintains less than 22.4 volts, the regulator will regulate low.

2. If both zener strings drop a constant 22.4 volts, check resistors R7, R8, and either RH1 or R1 (whichever is present) as in Step 2 of Category III. If any of these are high, the regulator will regulate high, if any are low, the regulator will regulate low.

Summary

The above mentioned checks should be sufficient to find most problems normally encountered with inoperative regulators. Components which can be identified as defective by visual inspection should of course be replaced. In some cases, such as Step c of the SCR Test, it is advisable to find what other component failures are present in order that any newly replaced components may not be ruined by the not yet replaced faulty components.

If wires become burned and create short circuits, they will have to be found by testing continuity and removing wires. It is advisable to first troubleshoot the regulator according to the above mentioned checks. Remove wires only as a last resort, or if there is a solid short between the positive to negative terminals of the regulator.

Troubleshooting flow charts have been provided as a visual guide in the Maintenance Data.

After a faulty component has been found, it should be replaced according to the "Instructions For Replacing Components" which is outlined at the end of this Maintenance Instruction and then retested as in Steps 1 through 3 of the Testing Procedures. If the regulator successfully passes these tests, it should be connected to a locomotive for proper voltage settings as given in the instructions which follow.

SETTING THE REGULATOR TO REGULATE AT THE PROPER VOLTAGE

If the regulator has been repaired and operates satisfactorily in Steps 1 through

3 of Test Procedures, it is ready to be installed in a locomotive and have its regulating voltage set. To do this turn the voltage adjusting rheostat to minimum and if the regulator has four terminals adjust the resistor R1 at the bottom to minimum resistance. With the engine shut down and the battery switch open, make the proper electrical connections to the regulator. If the regulator has four terminals, do not secure it in the high voltage cabinet; allow access to R1.

CAUTION: Do not connect or disconnect the regulator from the locomotive wiring with the engine running. The large value of auxiliary generator machine inductance can cause severe arcing and burns.

1. Three Terminal Regulators

Connect a voltmeter between the auxiliary generator fuse (positive) and the negative side of the battery switch. Start the engine. Auxiliary generator voltage should be the value observed in Step 1 of Test Procedures (62-70 volts). Put the throttle in Run 8 and set the regulator to maintain 74 volts by turning RH1. Allow components to warm and adjust voltage as needed. When the engine has operated long enough for voltage to remain constant at 74 volts without adjustment, lock the rheostat at that position by tightening the nut on the front of the rheostat. The regulator is now set and can be secured in the locomotive on which it was set.

2. Four Terminal Regulators

Connect a voltmeter between EZ and BN wires or to terminals 72 volt reference and negative on the regulator. Start the engine and put the throttle in Run 8. Adjust the slider on R1 until the voltmeter reads 72 volts $\pm$ 1/2 volt. As the auxiliary generator and regulator resistors warm up the voltage will have a tendency to increase slightly. Allow the engine to remain in Run 8 until the voltage stabilizes. Reset the voltage to 72 $\pm$ 1/2 volts and tighten the slider in place. Connect the positive lead of the voltmeter to the positive terminal of the regulator and turn the rheostat clockwise until the voltmeter reads 74 volts. Lock the rheostat by tightening its nut. Seal the nut with red lacquer.

NOTE: Regulation at other than 74 volts may be desired for battery charging purposes, but this should be set only upon instructions from the maintenance supervisor. Battery charging voltage does not affect the 72 volt reference voltage on four terminal regulators, and it does not significantly affect the generator excitation system on locomotives using three terminal regulators.

INSTRUCTIONS FOR REPLACING COMPONENTS

When removing a defective device (such as a diode) which has had its leads soldered directly to another component, cut its leads close to the body in order that there will be enough lead left for the replacement component.

To remove a device which is mounted in a hole in the circuit board, first cut its leads, then push down on the button side of it with a pair of long nose pliers until it breaks free from the board, Fig. 13. Scrape the old silastic RTV from the inside of the hole with a sharp knife. Obtain a new component and apply a layer of silastic RTV (see Maintenance Data for number) to surfaces of the component

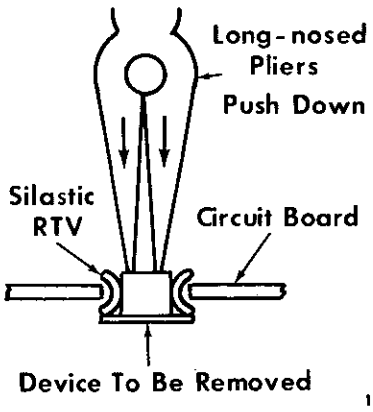


Fig. 13 — Method For Removing Defective Device

that will rest on the circuit board. Insert the new component in the hole. The silastic RTV takes a few hours to set completely; however, the leads can be connected before this time.

If the silicon controlled switch Q1 is being replaced, apply pieces of flexible insulating tubing to the diode and anode and gate leads [A] and [GA].

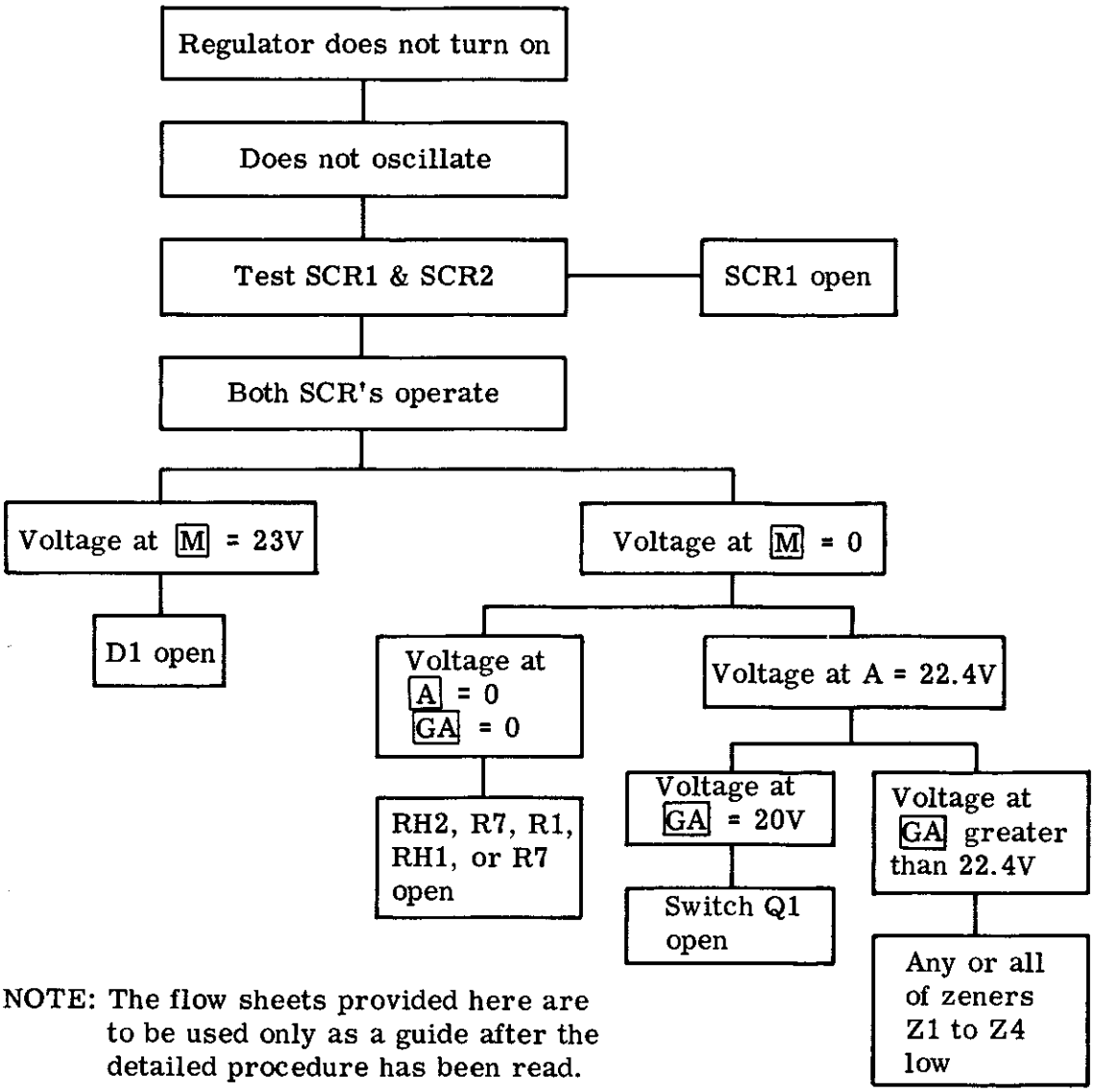
Bend and connect the leads with long nose pliers. Then apply the heat sinks. If more than one semiconductor lead is to be soldered to a terminal, apply heat sinks to all leads. Long nose pliers or alligator clips will suffice as heat sinks.

CAUTION: If heat sinks are neglected, the devices being soldered will be destroyed by the heat. Use only rosin core solder. Acid core solder causes poor connections and must not be used.

Components which require heat sinks are all zener diodes, all blocking diodes, and both SCR's. When soldering to any of the plastic terminal buttons, keep applied heat to a minimum to avoid melting the plastic. After all components have been added to the circuit board and soldered, the board should be coated with an insulating varnish (see Maintenance Data for part number). The newly replaced parts can be painted alone, or the whole board can be dipped. If the latter alternative is chosen, the board will have to set for a few hours while the varnish dries. Let the board hang by its leads from the regulator so varnish does not drip inside on other components.

If it is necessary to replace any wiring, use 16 gauge stranded wire.

REGULATOR DOES NOT TURN ON AND DOES NOT OSCILLATE



NOTE: The flow sheets provided here are to be used only as a guide after the detailed procedure has been read.

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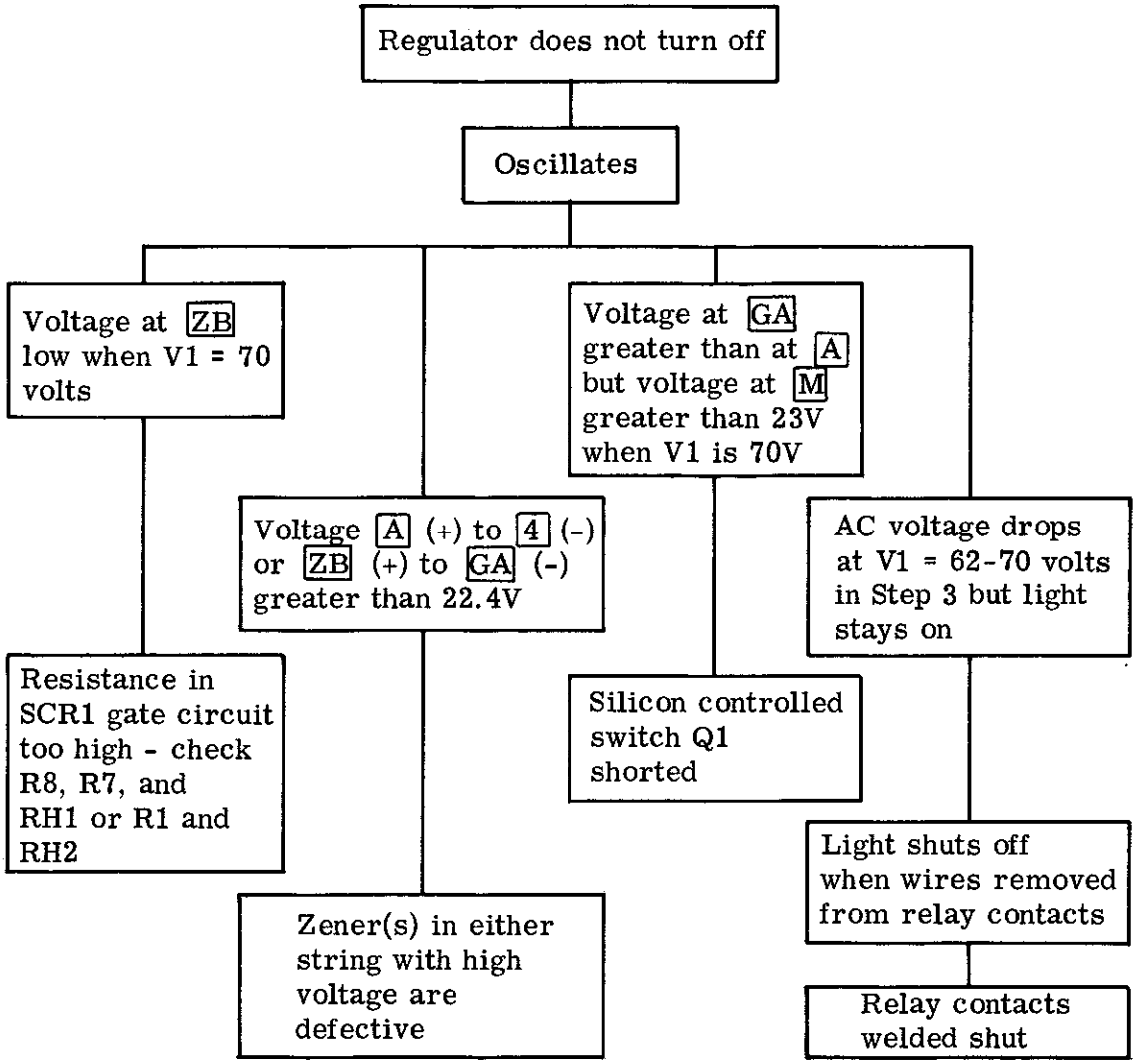
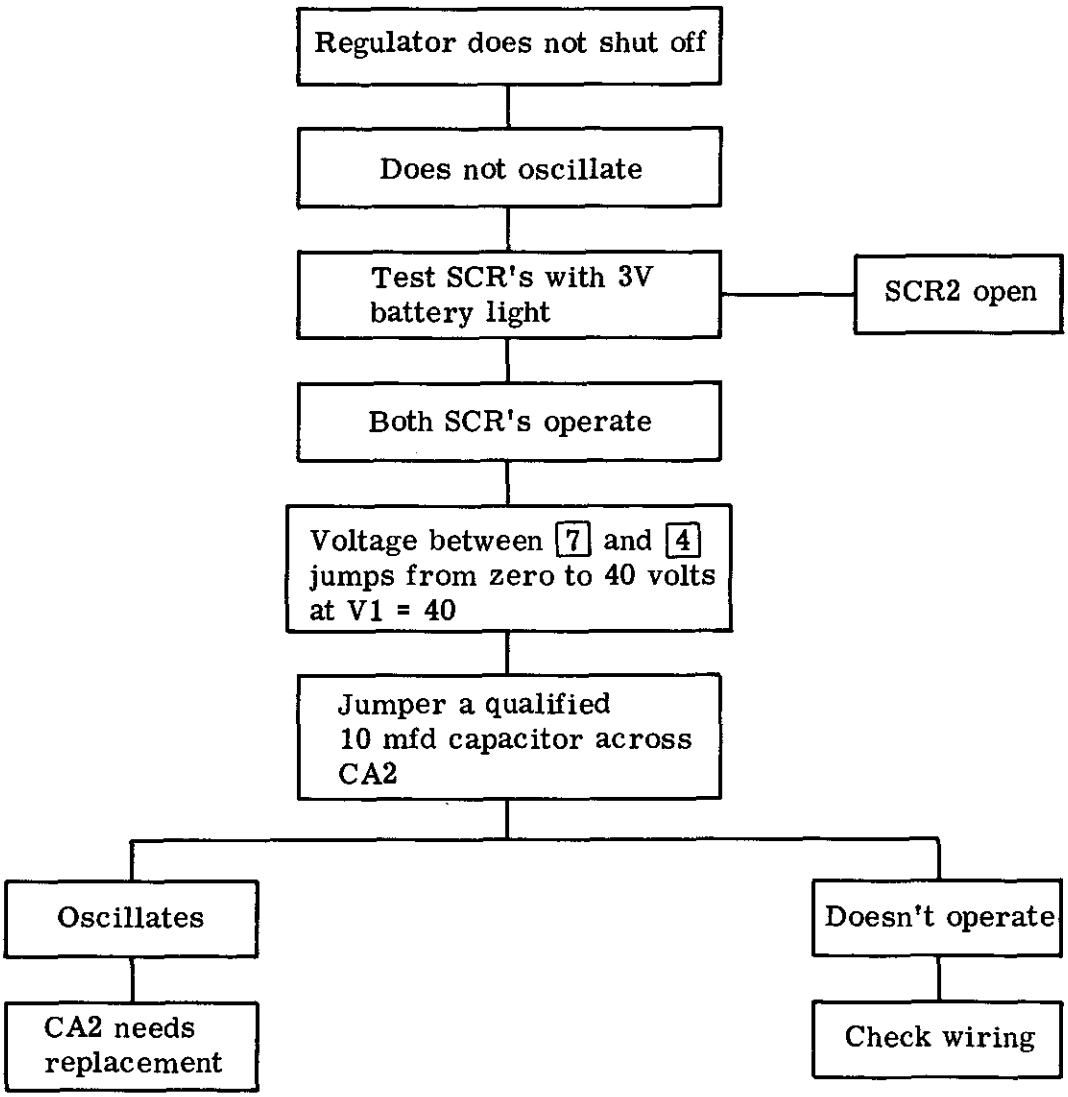
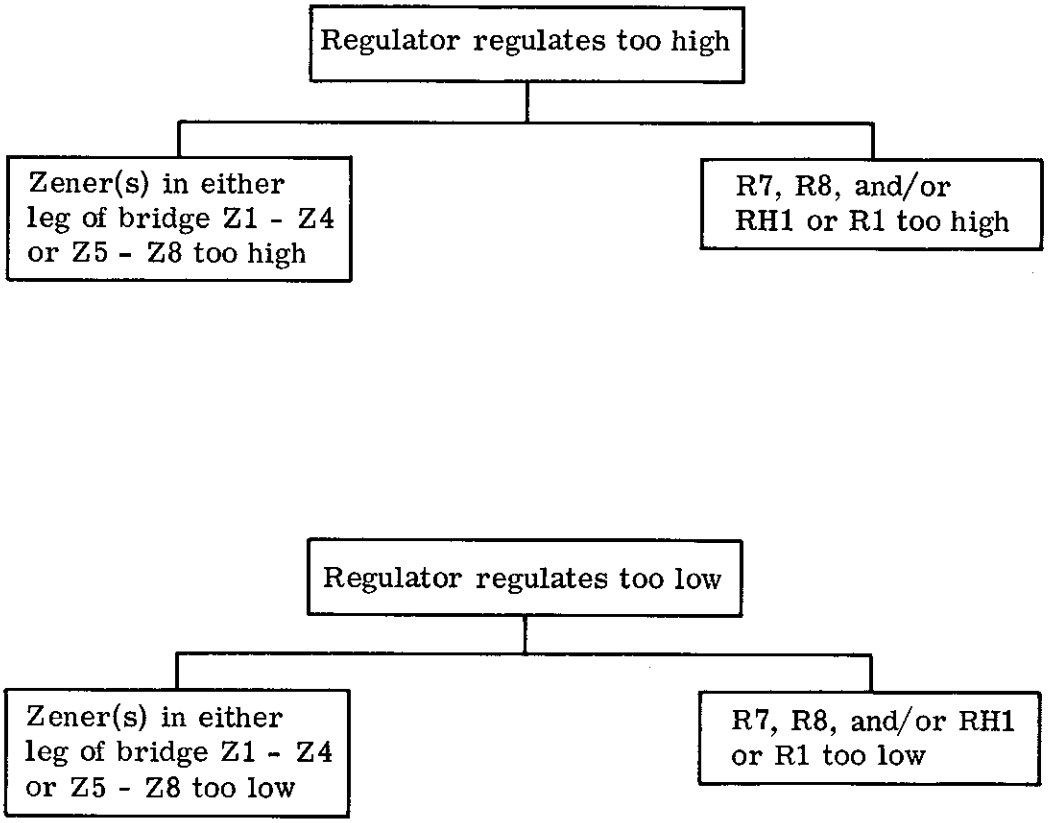
REGULATOR DOES NOT TURN OFF BUT OSCILLATES



REGULATOR DOES NOT SHUT OFF AND DOES NOT OSCILLATE



REGULATOR REGULATES EITHER HIGH OR LOW



Litho in U.S.A.

EMM
SERVICE DEPARTMENT

MAINTENANCE DATA

Power Supply

Output - 0 to 100 VDC adjustable
Minimum 4 ampere capacity
Fused for four amperes
Equipped with both ammeter
and voltmeter

Portable Volt-Amp-Ohm-Meter

EMD 8276478 Hickock Meter
Battery Complement: 1 size D dry cell
1 30 volt dry cell
Eveready #413 or
equivalent
Capacitor for Hickock - 0.1 mfd 10 VAC
Substitute for Hickock - Simpson Model 260
Capacitor not needed

64 Volt Test Light 8279561

Battery Light (3V) 8293011

Silastic RTV (2 oz. tube) 8305837

Clear Varnish (1 gal. can) 8069882

Solder-Rosincore
60/40 - .062" dia. - 5 lb. spool 8339154

Fastons 8250906

REGULATOR COMPONENTS:

Resistors

Symbol	Resistance	Wattage
+ R1	125 ohms ± 10% adj	10W
* RH1	125 ohms ± 10% pot	12-1/2W
+ RH2	2 ohms ± 10% pot	25W
R2, R3	300 ohms ± 5%	5W
R6	250 ohms ± 5%	55W
R7	125 ohms ± 5%	10W
R8	10 ohms ± 10%	1/2W

+used only on four terminal regulators

*used only on three terminal regulators

October, 1967

SERVICE DEPARTMENT

MAINTENANCE DATA (CONT'D)

Capacitors

Symbol	Capacitance	Voltage
C1	16 mfd	150VDC
CA2	10 mfd	150VDC
CA3	5 mfd	400VDC

AC NON-POLARIZED CAPACITORS

Diodes And Zener Diodes

Symbol	Type	Rating	Number
D1, D2	Blocking diode	1/2 watt	IN539
D3	Freewheeling diode	20A, 200 V	IN250A
Z1 - Z8	5.6 volt zener	1.0 watt	IN1520A
Z9	40 volt zener	1.0 watt	IN3034B

Silicon Controlled Devices

SCR1, SCR2	Silicon controlled rectifiers	25A, 200 V	2N685
Q1	Silicon controlled switch		3N59
T1	Thermistor	10 ohms 6.9:1 0°-50°C	NB11J1
Starting Relay			8378279
Suppression Rectifier (CR1)			8366053