KS-20490 RECTIFIERS
48 VOLTS, 400 AMPERES
TROUBLE-LOCATING

CONTENTS PAGE

Figures

1. GENERAL

1.01 The KS-20490 rectifiers provide an isolated, filtered, and regulated dc voltage for automatically floating and charging battery plants. The rectifiers are initially intended for use in the 100- and 300-type power plants but may be used whenever their characteristics and design apply. See Fig. 1 and 2.

1.02 This section is reissued to correct switch designations and corrections throughout. Revision arrows are used to emphasize the more significant changes. The Equipment Test List is not affected.

▶Danger: ◀ The voltages in this unit exceed 150 ac volts to ground. To avoid personal injury, avoid all contact with terminals. Do not allow a test pick to touch two metal parts at the same time or destructive and dangerous short circuits may occur. Disconnect ac supply before working on rectifier except when necessary to make tests.

1.03 This section is based on drawing SD-81996-01, Issue ▶5B.◀ If this section is to be used with equipment or apparatus that is associated with a later issue of the drawing, reference should be made to the SD and CD to determine the extent of the changes and the manner in which the section may be affected.

1.04 For a more detailed description of the operation of the KS-20490 rectifiers, refer to Section 169-742-301. Procedures for maintaining the output switch of the KS-20490 rectifier are covered in Section 169-742-701.

2. APPARATUS

2.01 ***List of Test Apparatus:*** The following test apparatus is used in this section.

TEST APPARATUS	DESCRIPTION
▶KS-20538◀	Volt-Ohm-Milliammeter (VOM)
▶545B◀	Tektronix Oscilloscope (or equivalent)
—	100-ohm resistor
▶AT-7825, C3	Screwdriver, 3/16 × 3 inch

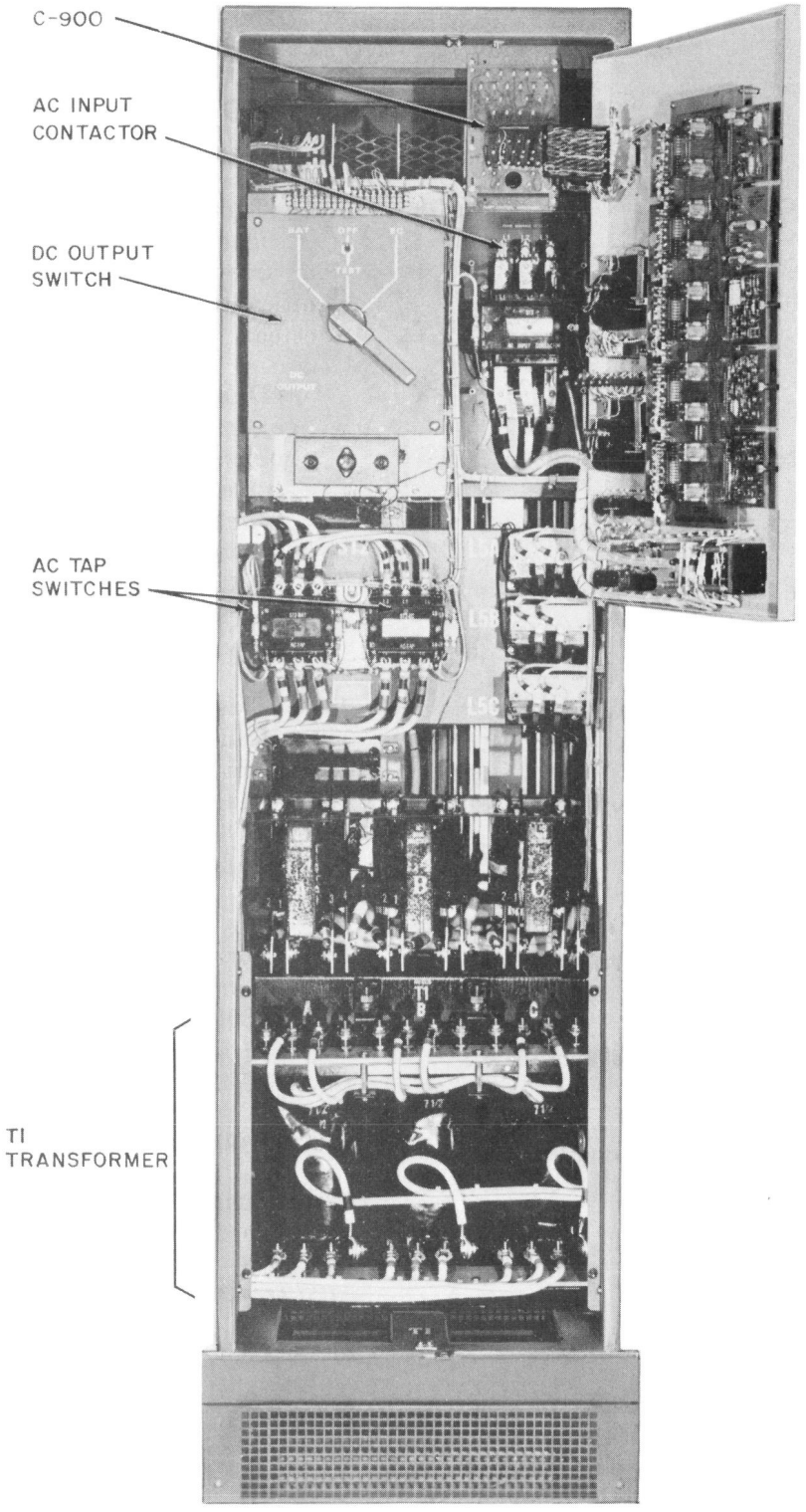

Fig. 1—KS-20490 Rectifier—Front View With Control Panel Open

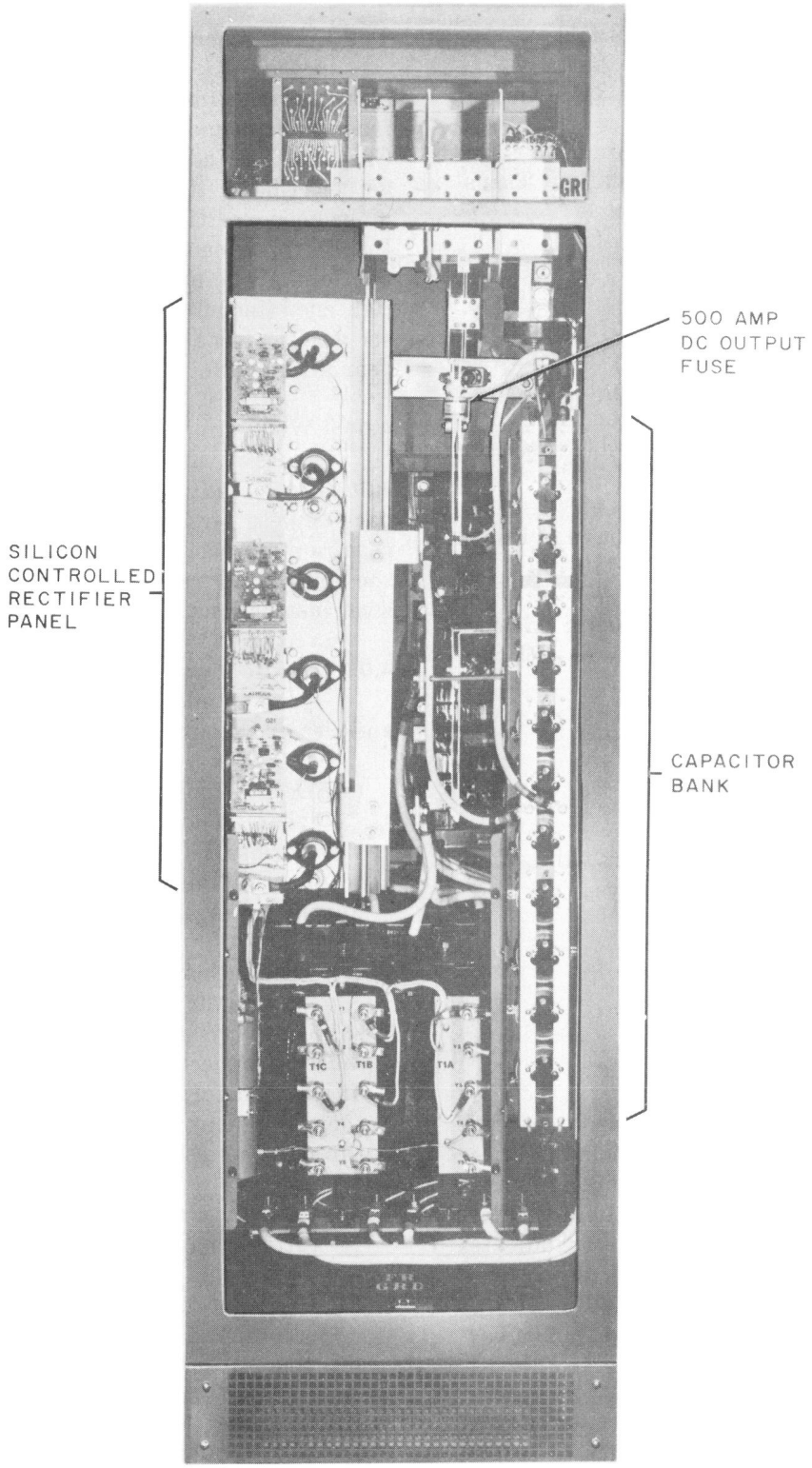

Fig. 2—KS-20490 Rectifier—Rear View With Doors Removed

TEST APPARATUS	DESCRIPTION
AT-7825, D3	Screwdriver, 1/4 × 4 inch
R-1542	Adjustable Wrench, 3/4 inch
S1-1000	Sterling Transformer, Inc., 1000 watt, 120 Vac Isolation Transformer (or equivalent)◀

3. OPERATION

3.01 Normal operation of the KS-20490 rectifiers shall be in accordance with Section 169-742-301. In the event of a trouble condition, the rectifier shall be removed from service and after the trouble condition is eliminated shall be returned to service in accordance with Section 169-742-301.

3.02 Electrolytic capacitors should be maintained in accordance with Section 032-110-701.

3.03 Circuit packs and semiconductor devices should be maintained in accordance with Section 032-173-301.

4. TROUBLE-LOCATING PROCEDURES

GENERAL

4.01 Failure of the KS-20490 rectifiers will usually be displayed in one of three ways:

(a) Meter indications

(b) Lamp indications

(c) Plant signals.

The trouble flowchart in Fig. 3 is designed to analyze troubles in rectifiers from the standpoint of these three indications. For example, if a rectifier is shut down and locked out due to a trouble, the first indication is that the OUTPUT CURRENT meter indicates zero amperes. The next noticeable indication would be the lamps on the control panel (Fig. 4). From this point, the section of the chart which applies to a particular trouble should be consulted.

4.02 When the rectifier fails, try to locate the trouble before subjecting the rectifier to restart attempts. Repeated attempts to restart the rectifier before correcting the trouble condition may damage other rectifier components.

4.03 As a general trouble-locating procedure; check for faulty connections and broken, burned, or shorted wires. Inspect the harness wiring and leads from all components for possible breaks and shorts. Check that no adjacent terminals or lugs touch together. Check that all solder and pressure points make good electrical contact using a volt-ohmmeter. Inspect for evidence of poor connection at switch and bus joints. The main load carrying bolts should be tightened (including squeeze connecting lugs) within six weeks after installation cutover and once each year after that.

4.04 When trouble is traced to a circuit pack, replace it with the proper new or repaired circuit pack. ***Do not attempt*** to repair defective circuit packs unless personnel are equipped and trained to repair circuit packs. Return defective circuit packs to the authorized repair facility in accordance with local instructions.

4.05 The following precautions should be observed prior to and during the interval of detecting and clearing troubles in the rectifier.

(a) Do not apply ac power to the rectifier except when checking voltages, currents, or waveforms. To completely isolate the rectifier from the ac line, the ac switch at the bus plug-in unit or power service must be operated to OFF.

(b) ▶The positive side of battery is grounded to provide the −48 volts dc. The use of an oscilloscope or any other ac powered test equipment must be connected to the ac power through an isolation transformer. This will prevent damage to the equipment by preventing shorts to ground through the test equipment.◀

(c) Under no circumstances should fuses of higher ratings than those specified be used.

(d) Use caution when working with wrenches, screwdrivers, and test leads to prevent shorting the dc circuit. Always disconnect the rectifier from battery and ac service before performing repairs.

4.06 Waveforms encountered in trouble-locating procedures are not contained in this section but can be found on the appropriate sheets of SD-

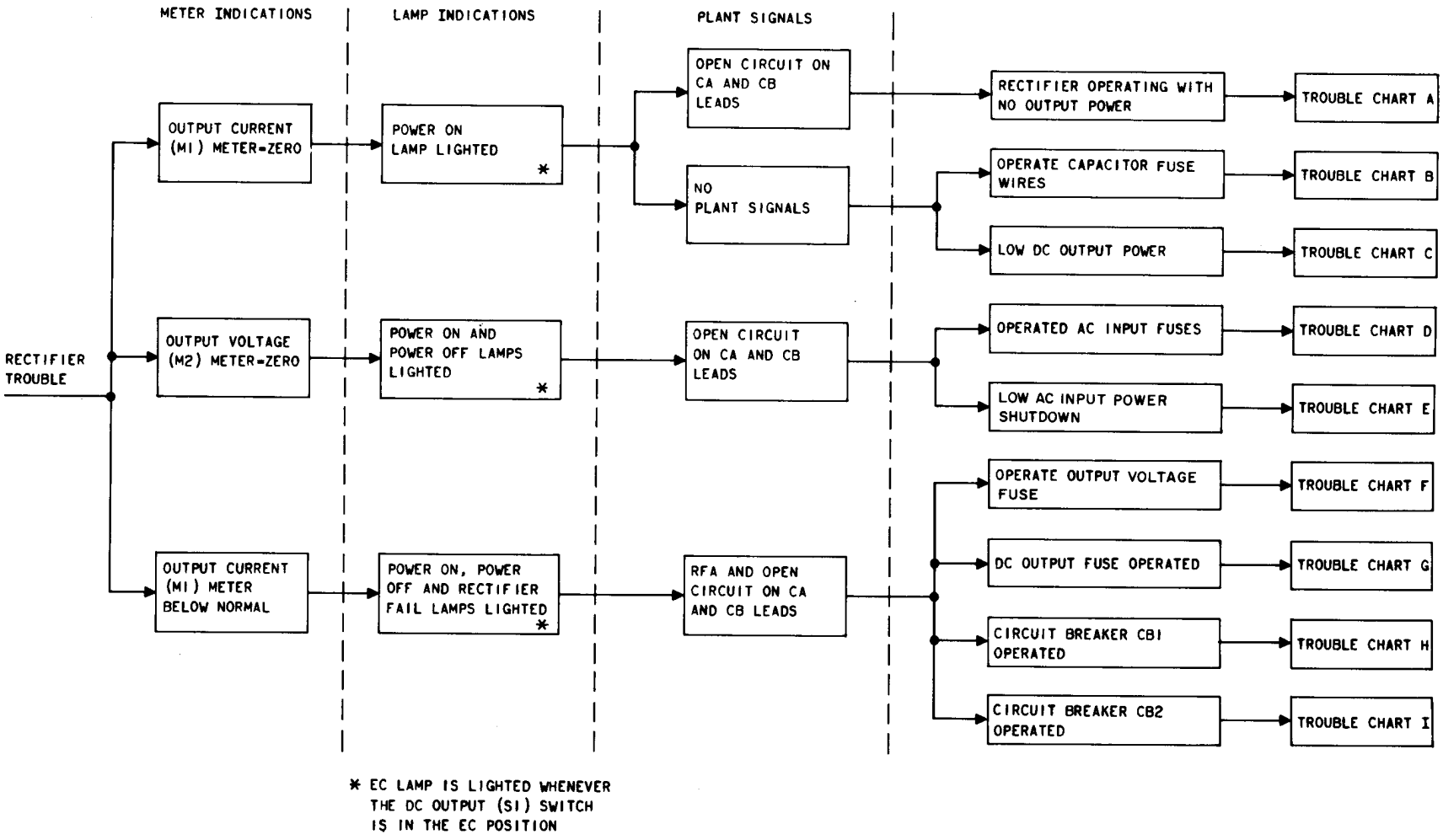

Fig. 3—Trouble Flow Chart

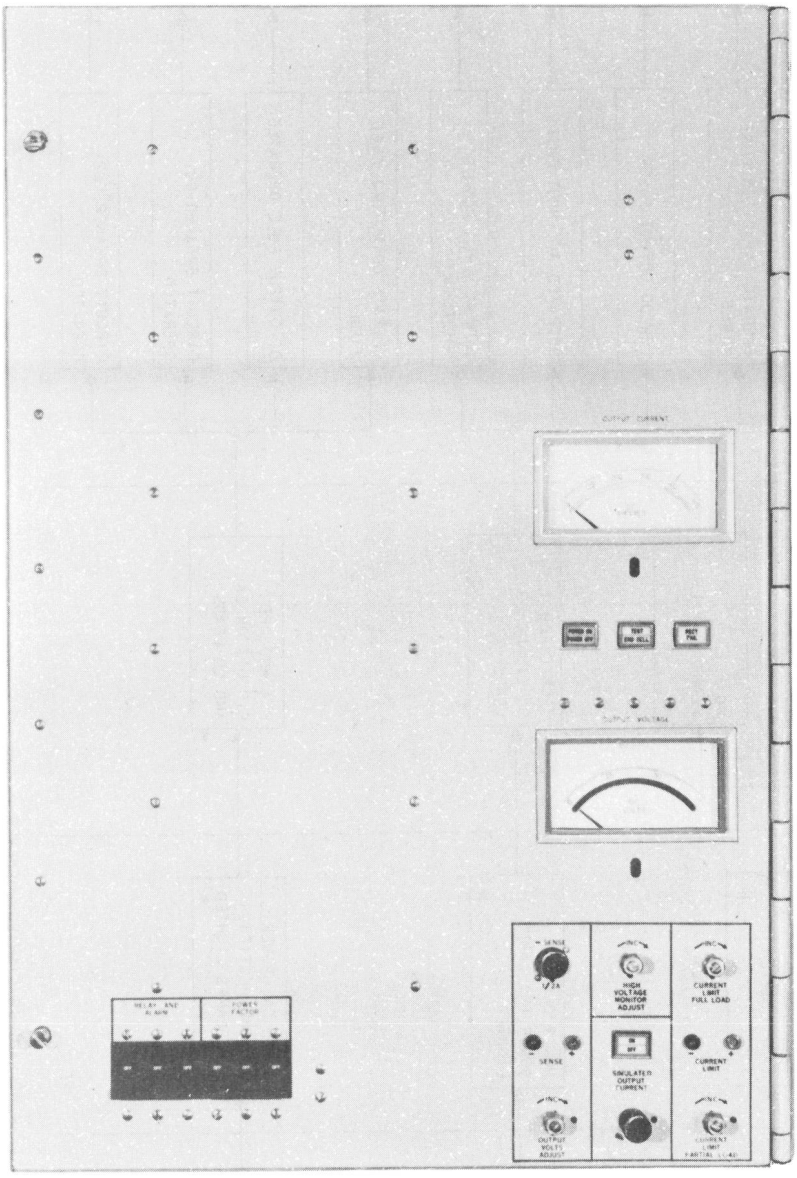

Fig. 4—KS-20490 Rectifier Control Panel Front View

81996-01, Issue ◗5B◖. When taking measurements with an oscilloscope, reference should be made to these waveforms as a guideline in locating specific troubles in the rectifier.

TROUBLE CHARTS AND TESTS

4.07 The trouble-locating procedures given in Trouble Charts A through I are to be used in conjunction with Test Charts 1 through 8. Whenever a test procedure requires testing a circuit pack, and components or test points are not accessible, circuit pack board extenders should be used.

4.08 ***Caution: The POWER ON/POWER OFF (S2) switch must be operated (depressed and released) to shut down the rectifier before the DC OUTPUT (S1) switch is operated from one position to another to prevent equipment damage and service interruption.***

4.09 ***Caution: With the rectifier shut down and disconnected from the battery [DC OUTPUT (S1) switch in the OFF position], the filter capacitors in the rectifier will discharge in approximately 1 minute. The output capacitors must be charged prior to operation of the DC OUTPUT switch to the BAT or EC position to prevent equipment damage and service interruption.***

4.10 ***Caution: Plug-in circuit packs must not be removed while the rectifier is in operation to prevent equipment damage and service interruption.***

4.11 ***Danger: Lethal voltages are present inside the commerical ac power service cabinet. Voltages are over 200 volts ac to ground. Use extreme care in removing and replacing fuses to prevent personal injury and equipment damage.***

4.12 ***Danger: Lethal voltages are present of over 200 volts ac inside the commercial ac power service cabinet. Use extreme care to prevent personal injury.***

4.13 ***Danger: The use of an oscilloscope or any other ac powered test equipment must be connected to the ac power through an isolation transformer. This will prevent personal injury and damage to the equipment caused by shorts to ground through the test equipment.***

TROUBLE CHART A

NO DC OUTPUT POWER — RECTIFIER OPERATING

POSSIBLE CAUSE	CORRECTIVE ACTION
A. OUTPUT VOLTS ADJUST (R7) rheostat improperly adjusted	(1) ▶Operate POWER ON/POWER OFF (S2) switch to POWER OFF position. The POWER OFF lamp lights and POWER ON lamp is extinguished.◀. (2) Operate the DC OUTPUT (S1) switch to OFF position. See ***Caution,*** paragraph 4.08. (3) Operate OFF/TEST (S4) switch to TEST position. (4) Operate the POWER ON/POWER OFF (S2) switch to the POWER ON position. ***Requirement:*** The OUTPUT VOLTAGE (M2) voltmeter should indicate 49.91 volts for the L11 and L12 rectifiers or 52.08 volts for the L21 and L22 rectifiers. (5) If the requirement is met, proceed to (16). If the requirement is not met, continue with (6). (6) Rotate the SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw. (7) ▶Using the KS-20538 VOM set to 100-volt dc scale, connect negative meter probe to –SENSE (J2) pin jack and the positive meter probe to +SENSE (J1) pin jack located on front of rectifier control panel.◀ (8) Loosen the locking device on the OUTPUT VOLTS ADJUST (R7) rheostat and rotate slowly cw until OUTPUT VOLTAGE (M2) meter and the ▶KS-20538◀ meter meet the requirement in (4). (9) Operate SIMULATED OUTPUT CURRENT (S3) switch to ON position. ***Requirement:*** The SIMULATED CURRENT ON lamp lights and the SIMULATED CURRENT OFF lamp is extinguished. (10) Slowly rotate SIMULATED OUTPUT CURRENT (R10) rheostat cw until OUTPUT CURRENT (M1) ammeter indicates 400 amperes. ***Requirement:*** The OUTPUT VOLTAGE (M2) voltmeter and the ▶KS-20538◀ VOM should still indicate 49.91 volts or 52.08 volts. A minor readjustment of the OUTPUT VOLTS ADJUST (R7) rheostat is permissible to retain the 49.91 volts or 52.08 volts indication.

TROUBLE CHART A (Contd)

NO DC OUTPUT POWER — RECTIFIER OPERATING

POSSIBLE CAUSE	CORRECTIVE ACTION
	(11) Tighten the locking device on OUTPUT VOLTS ADJUST (R7) rheostat.
	(12) Rotate SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw.
	(13) Operate SIMULATED OUTPUT CURRENT (S3) switch to OFF position.
	(14) Operate POWER ON/POWER OFF (S2) switch to POWER OFF position. ***Requirement:*** The POWER OFF lamp lights and the POWER ON lamp extinguishes.
	(15) Disconnect the ▶KS-20538◀ meter.
	(16) Charge the output filter capacitors in accordance with Section 169-742-301. See ***Caution,*** paragraph 4.09
	(17) Verify that the DC OUTPUT switch (S1) is in BAT or EC position.
	(18) Verify that the OFF/TEST (S4) switch is in OFF position.
	(19) Operate POWER ON/POWER OFF (S2) switch to POWER ON position.
Note: Possible causes B, C, and D will cause the TEST lamp to light. If the TEST lamp is not lit, proceed to E. If the trouble is not found after all other tests are completed, then perform B, C, and D under the assumption that the TEST lamp is defective.	
B. Fuse in place RB lead operated	Check fuse in RB lead of plant control circuit; replace if operated.
C. Loose connection at CP-P900	Locate CP-P900 in upper right corner of rectifier, behind rectifier control panel. Check to see that it is firmly seated in its connector.
D. Defective SNS relay on CP-600	(1) Operate POWER ON/POWER OFF (S2) switch to POWER OFF. (2) Operate DC OUTPUT (S1) switch to OFF position. See ***Caution,*** paragraph 4.08.

TROUBLE CHART A (Contd)

NO DC OUTPUT POWER — RECTIFIER OPERATING

POSSIBLE CAUSE	CORRECTIVE ACTION
	(3) Remove OUTPUT VOLTAGE (F3) fuse. See ***Caution,*** paragraph 4.10.
	(4) Disconnect and remove CP-100.
	(5) Disconnect and remove CP-200.
	(6) Connect a jumper from (+TEST) GRD bus bar to terminal 4 of J200 on CP-600.
	(7) Connect a jumper from (–TEST) BAT bus bar to terminal 9 of J100 on CP-600. ***Requirement:*** The SNS relay operates. The TEST lamp extinguishes.
	(8) If requirement is met, proceed to (10). If requirement is not met, continue with (9).
	(9) Replace SNS relay.
	(10) Diconnect jumpers.
	(11) Reinsert CP-200 into J200 connector.
	(12) Reinsert CP-100 into J100 connector.
	(13) Reinsert OUTPUT VOLTAGE (F3) fuse into fuse holder.
	(14) Charge the OUTPUT FILTER capacitors in accordance with Section 169-742-301. See ***Caution,*** paragraph 4.09.
	(15) Verify that DC OUTPUT (S1) switch is in BAT or EC position.
	(16) Operate POWER ON/POWER OFF (S2) switch to ON position.
E. Defective gradual output (walk-in) portion of CP-200	Test CP-200 in accordance with Test Chart 2 or if test facilities are not available, replace CP-200.

TROUBLE CHART B

OPERATED CAPACITOR FUSE WIRES

POSSIBLE CAUSE	CORRECTIVE ACTION
Defective filter capacitors C2 through C12	(1) Operate POWER ON/POWER OFF (S2) switch to OFF position. (2) Operate DC OUTPUT (S1) switch to OFF position. See ***Caution,*** paragraph 4.08. (3) ◗With the KS-20538 VOM set on 100-volt dc scale, measure the voltage across (+TEST) GRD bus bar and (–TEST) BAT bus bar.◖ ***Requirement:*** The ◗KS-20538◖ meter should indicate zero volts. (4) If requirement is met, continue to (5). If requirement is not met, shunt C2 through C12 with a 100-ohm resistor momentarily to discharge capacitors; then continue with (5). (5) ◗Disconnect KS-20538 meter. (6) Locate defective capacitor(s) with the operated fuse wire(s). Remove and replace defective capacitor(s) observing correct polarity. (7) After all OUTPUT FILTER capacitors C2 through C12 have been checked and defective capacitor(s) have been replaced, connect the capacitor fuse wires to the capacitor bus bars observing correct polarity.◖ (8) Charge OUTPUT FILTER capacitors in accordance with Section 169-742-301. See ***Caution,*** paragraph 4.09. (9) Verify that DC OUTPUT (S1) switch is in BAT or EC position. (10) Operate POWER ON/POWER OFF (S2) switch to ON position.

TROUBLE CHART C

LOW DC OUTPUT

	POSSIBLE CAUSE	CORRECTIVE ACTION
A.	Low ac input service voltage	◗Read the ac input voltage at the commercial ac power service cabinet. Verify that this voltage is within limits outlined in SD-81996-01-D4, Note 322. See ***Danger,*** paragraph 4.11.◖
B.	Defective CP-100	Test CP-100 in accordance with Test Chart 1 or if test facilities are not available, replace CP-100.

TROUBLE CHART D

OPERATED AC INPUT FUSE

	POSSIBLE CAUSE	CORRECTIVE ACTION
A.	Shorted or defective T1 transformer	(1) Operate POWER ON/POWER OFF (S2) switch to OFF position. (2) Operate DC OUTPUT (S1) switch to OFF position. See ***Caution,*** paragraph 4.08. (3) Remove fuses in the ac power service cabinet. (4) Use the ◗KS-20538◖ set on the R × 1 scale, to measure the resistance of T1 primary and to check for shorts between T1 primary and ground. ◗***Requirement:*** The primary resistance of the T1 transformer should be greater than zero ohms and less than infinity (∞) with no shorts to ground existing.◖ (5) If requirement is met, proceed to B. If requirement is not met, ◗replace T1 transformer.◖
B.	Wiring between power service cabinet and T1 transformer shorted to ground	Check wiring between power service cabinet and T1 transformer for shorts to ground. ***Requirement:*** Remove any shorts to ground.
C.	Defective ac input voltage monitor transformer CP-700	(1) Test ac input voltage monitor circuit CP-700 in accordance with Test Chart 6 or if test facilities are not available, replace CP-700. (2) Reinsert fuses or operate circuit breakers to ON in the ac power service cabinet. (3) Charge the output filter capacitors in accordance with Section 169-742-301. See ***Caution,*** paragraph 4.09. (4) Verify that DC OUTPUT (S1) switch is in BAT or EC position. (5) Operate POWER ON/POWER OFF (S2) switch to ON position.

TROUBLE CHART E

LOW AC INPUT POWER SHUTDOWN

	POSSIBLE CAUSE	CORRECTIVE ACTION
A.	Low ac input service voltage	◗Read the ac input voltage at the commercial power service cabinet. Verify that this voltage is within limits outlined in SD-81996-01-D4, Note 322. See ***Danger,*** paragraph 4.12.◖
B.	Defective ac input voltage monitor circuit (CP-700)	Test the ac input voltage monitor circuit (CP-700) in accordance with Test Chart 6 or if test facilities are not available, replace CP-700.

TROUBLE CHART F

OPERATED OUTPUT VOLTAGE (F3) FUSE

POSSIBLE CAUSE	CORRECTIVE ACTION
A. Shorted voltmeter lead	(1) Operate POWER ON/POWER OFF (S2) switch to OFF position. (2) Operate DC OUTPUT (S1) switch to OFF position. See ***Caution,*** paragraph 4.08. (3) Remove OUTPUT VOLTAGE (F3) fuse. (4) Set the ◗KS-20538◖ VOM for the R × 1 scale. (5) Connect the red lead of the ◗KS-20538◖ VOM to GRD bus bar. (6) Place the black lead on the (–) terminal of OUTPUT VOLTAGE (M2) meter. See Fig. 5. ***Requirement:*** If the meter indicates zero ohms, check for shorted connection. If no shorts are found, replace M2 meter. (7) Disconnect the ◗KS-20538◖ VOM. (8) Insert OUTPUT VOLTAGE (F3) fuse. (9) Operate RELAY AND ALARM circuit breaker (CB2) to ON position. (10) Charge the output filter capacitors in accordance with Section 169-742-301. See ***Caution,*** paragraph 4.09. (11) Verify that DC OUTPUT (S1) switch is in BAT or EC position. (12) Operate POWER ON/POWER OFF (S2) switch to ON position.
B. Defective voltage regulator and simulated output current (CP-100)	Test CP-100 in accordance with Test Chart 1 or if test facilities are not available, replace CP-100.

TROUBLE CHART G

OPERATED 500 AMP DC OUTPUT (F1) FUSE

POSSIBLE CAUSE	CORRECTIVE ACTION
A. Shorted SCR(s) Q1A, Q1B or Q1C or Q2A, Q2B, or A2C	(1) Operate POWER ON/POWER OFF (S2) switch to ON position. (2) Operate DC OUTPUT (S1) switch to OFF position. See ***Caution,*** paragraph 4.08. (3) Disconnect the cathode lead (red) and gate lead (white) of each SCR. (4) Use the ▶KS-20538◀ VOM set on R × 1 scale, to check anode (heat sink) to cathode resistance. ***Requirement:*** The meter should indicate a resistance greater than 1000 ohms. (5) Electrically reverse the meter leads by depressing the DC-Ω meter switch. ***Requirement:*** The meter should indicate a resistance greater than 1000 ohms. (6) Depress DC+Ω meter switch. (7) An SCR with an anode to cathode resistance of less than 1000 ohms in either direction should be replaced. (8) If requirements in (4) and (5) are met, proceed to troubleshoot in accordance with B. If requirements are not met and defective SCRs are replaced, proceed to D(2).
B. Shorted wiring between SCRs and ground	(1) Check wiring between SCR cathode (red lead) and the main transformer T1 for shorts to ground. ***Requirement:*** Remove any shorts in wiring or replace T1 if windings are shorted to ground. (2) If shorts are removed from circuit, proceed to D(2). If no short circuits are found, continue troubleshooting in accordance with C.
C. Defective circuit packs CP-800, CP-100, or CP-200	(1) Operate OFF/TEST (S4) switch to TEST position. (2) Verify that RELAY AND ALARM circuit breaker (CB2) is in ON position. (3) Replace DC OUTPUT (F1) fuse. (4) Replace DC OUTPUT ALARM (F2) fuse.

TROUBLE CHART G (Contd)

OPERATED 500 AMP DC OUTPUT (F1) FUSE

POSSIBLE CAUSE	CORRECTIVE ACTION
	(5) Operate POWER ON/POWER OFF (S2) switch to ON position. ***Requirement:*** Output voltage should be normal. (6) Operate SIMULATED OUTPUT CURRENT (S3) switch to ON position. (7) Turn the SIMULATED OUTPUT CURRENT (R10) rheostat slowly cw until OUTPUT CURRENT (M1) meter indicates 400 amperes. ***Requirement:*** The voltage should decrease slightly and current should remain at 400 amperes. (8) If requirement is not met, test circuit packs 800, 200, and 100 in accordance with TEST CHARTS 7, 2, and 1 respectively, or replace circuit packs if test facilities are not available. If the requirements are met or circuit packs are replaced proceed to D(2). If the requirements are not met, continue with C(9). (9) Turn SIMULATED OUTPUT CURRENT (R10) rheostat fully cw. (10) Operate SIMULATED OUTPUT CURRENT (S3) switch to OFF position. (11) Operate OFF/TEST (S4) switch to OFF position.
D. Defective DC output (S1) switch	(1) Inspect and clean DC output (S1) switch in accordance with Section 169-742-701. ▶***Note:*** The DC OUTPUT switch center arm rotary contact is equipped with sacrifical contacts. These contacts prevent damage to the main contacts by accepting the inrush of current when the switch is operated to the BAT or EC position. These sacrificial contacts are replaceable. The remainder of the DC OUTPUT switch must be replaced as a unit.◀

TROUBLE CHART G (Contd)

OPERATED 500 AMP DC OUTPUT (F1) FUSE

POSSIBLE CAUSE	CORRECTIVE ACTION
	(2) When all troubles are cleared, verify the following: (a) DC OUPUT (F1) fuse has been replaced with a good fuse. (b) DC OUTPUT ALARM (F2) fuse has been replaced with a good fuse. (c) OFF/TEST (S4) switch is in TEST position. (d) RELAY AND ALARM circuit breaker (CB2) is in ON position. (e) SIMULATED OUTPUT CURRENT (S3) switch is in OFF position. (3) Charge the output filter capacitors in accordance with Section 169-742-301. See ***Caution,*** paragraph 4.09. (4) Verify that DC OUTPUT (S1) switch is in BAT or EC position. (5) Operation POWER ON/POWER OFF (S2) switch to ON position.

TROUBLE CHART H

POWER FACTOR CIRCUIT BREAKER (CB1) OPERATED

	POSSIBLE CAUSE	CORRECTIVE ACTION
A.	Main transformer (T1) shorted	(1) Operate POWER ON/POWER OFF (S2) switch to OFF position. (2) Operate DC OUTPUT (S1) switch to OFF. See ***Caution,*** paragraph 4.08. (3) Remove the associated fuses or operate circuit breakers to OFF in the commercial ac power service cabinet. See ***Danger,*** paragraph 4.11. (4) Use the ▶KS-20538◀ VOM set on R × 1 scale to check T1A, T1B, and T1C windings for shorts to ground. (5) Clear shorts or replace T1 if windings are defective and proceed to C(2). (6) If no shorts or opens are found, continue with B.
B.	POWER FACTOR INDUCTOR (L5) shorted	(1) Use the ▶KS-20538◀ VOM set on R × 1 ohms scale to check POWER FACTOR INDUCTORS L5A, L5B, and L5C for shorted or opened windings and shorts to ground. (2) Clear shorts or replace L5 if defective; then proceed to C(2). (3) If no shorts or opens are found, continue with C(4).
C.	POWER FACTOR CAPACITORS C1A, C1B, and C1C shorted	(1) Use the ▶KS-20538◀ VOM set on R × 1 scale to check POWER FACTOR CAPACITORS C1A, C1B, and C1C for shorts. ***Requirement:*** If the ▶KS-20538◀ VOM indicates zero ohms, the capacitor is shorted and should be replaced. (2) Charge the output filter capacitors in accordance with Section 169-742-301. See ***Caution,*** paragraph 4.09. (3) Verify that DC OUTPUT (S1) switch is in BAT or EC position. (4) Operate POWER ON/POWER OFF (S2) switch to ON position. ▶(5) Verify that the OFF/TEST (S4) switch is in OFF position.◀

TROUBLE CHART I

RELAY AND ALARM CIRCUIT BREAKER (CB2) OPERATED

	POSSIBLE CAUSE	CORRECTIVE ACTION
A.	DC OUTPUT (F2) fuse operated	Test in accordance with TROUBLE CHART G.
B.	OUTPUT VOLTAGE (F3) fuse operated	Test in accordance with TROUBLE CHART F.
C.	±125V fuse operated	(1) Operate POWER ON/POWER OFF (S2) switch to OFF position. (2) Operate DC OUTPUT (S1) switch to OFF. See ***Caution,*** paragraph 4.08. (3) Remove ±125V (F4) fuse and check it with ◗KS-20538◖ VOM set on R × 1 scale. ***Requirement:*** Zero ohms meter indication indicates the fuse is good. Infinite (∞) ohms meter indication indicates the fuse is blown. (4) If the fuse is good, reinsert ±125V (F4) fuse and proceed to D. If the fuse is blown, insert a new fuse and continue with (5). (5) Test DCCT circuit CP-250 in accordance with TEST CHART 8 or if test facilities are not available, replace CP-250 ***Note:*** If trouble is corrected, proceed to F(2). If trouble is not corrected, continue with (6). (6) Test stablizer circuit CP-400 in accordance with TEST CHART 4 or if test facilities are not available, replace CP-400. ***Note:*** If trouble is corrected, proceed to F(2). If trouble is not corrected, continue troubleshooting in accordance with D.
D.	Plant grounded HV lead	(1) Operate OFF/TEST (S4) switch to TEST position. (2) Operate POWER ON/POWER OF (S2) switch to ON position. (3) Observe OUTPUT VOLTAGE (M2) voltmeter indication. ***Requirement:*** The OUTPUT VOLTAGE (M2) voltmeter should indicate 49.91 volts dc for L11 and L12 rectifiers or 52.08 volts dc for L21 and L22 rectifiers.

TROUBLE CHART I (Contd)

RELAY AND ALARM CIRCUIT BREAKER (CB2) OPERATED

POSSIBLE CAUSE	CORRECTIVE ACTION
	(4) If the requirement is met, proceed to F(2). If the requirement is not met, continue with (5).
	(5) Rotate SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw.
	(6) Set the ▶KS-20538◀ VOM for 100-volt dc scale. Connect negative lead to –SENSE (J2) pin jack and positive lead to +SENSE (J1) pin jack on front of rectifier control panel.
	(7) Loosen the locking device on OUTPUT VOLTS ADJUST (R7) rheostat.
	(8) Rotate OUTPUT VOLTS ADJUST (R7) rheostat 1/2 turn ccw. ***Requirement:*** The OUTPUT VOLTAGE (M2) voltmeter should indicate a decrease in voltage.
	(9) If the requirement is not met, rotate OUTPUT VOLTS ADJUST (R7) rheostat 1/2 turn cw, tighten the locking device, and proceed to (e). If requirement is met, continue with (10).
	(10) Operate SIMULATED OUTPUT CURRENT (S3) switch to ON position.
	(11) Rotate OUTPUT VOLTS ADJUST (R7) rheostat ccw until the requirement in (8) is met.
	(12) Rotate SIMULATED OUTPUT CURRENT (R10) rheostat cw until OUTPUT CURRENT (M1) ammeter indicates 400 amperes.
	(13) Readjust OUTPUT VOLTS ADJUST (R7) rheostat to maintain the 49.91 volts for L11 and L12 or 52.08 for L21 and L22.
	(14) Rotate SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw.
	(15) Diconnect the ▶KS-20538◀ VOM and proceed to F(2).
E. Defective or maladjusted high voltage monitor CP-300	(1) Check the high voltage monitor adjustment in accordance with Section 169-742-301. Adjust if necessary.
	(2) If the high voltage monitor circuit still malfunctions after adjustment, perform the tests in TEST CHART 3. Repair or replace CP-300 and continue with F(2).

TROUBLE CHART I (Contd)

RELAY AND ALARM CIRCUIT BREAKER (CB2) OPERATED

POSSIBLE CAUSE	CORRECTIVE ACTION
F. Defective 120-Hz monitor CP-500	(1) Test CP-500 in accordance with TEST CHART 5. Repair or replace CP-500 and continue with (2). (2) Verify that: • SIMULATED OUTPUT CURRENT (R10) rheostat is fully ccw. • SIMULATED OUTPUT CURRENT (S3) switch is in OFF position. • The locking device on OUTPUT VOLTS ADJUST (R7) rheostat is secured. • POWER ON/POWER OFF switch is in OFF position. (3) Charge the output filter capacitors in accordance with Section 169-742-301. See ***Caution,*** paragraph 4.09. (4) Verify that the DC OUTPUT (S1) switch is in BAT or EC position. (5) Operate POWER ON/POWER OFF (S2) switch to ON position. (6) Verify that the OFF/TEST (S4) switch is in OFF position.

TEST CHART 1

CP-100 — VOLTAGE REGULATOR AND SIMULATED OUTPUT CURRENT CIRCUIT

TEST PROCEDURE

(1) Operate POWER ON/POWER OFF (S2) switch to OFF position.

(2) Operate DC OUTPUT (S1) switch to OFF. See ***Caution***, paragraph 4.08.

(3) Remove CP-100 circuit pack from its connector (see Fig. 5). See ***Caution***, paragraph 4.10.

(4) With the ◗KS-20538◖ VOM, set for Rx1 ohms scale, check the following per Table A.

◗TABLE A◖

METER CONNECTIONS		APPROXIMATE METER INDICATION IN OHMS	METER INDICATION NOTING PROBABLE TROUBLE	
NEGATIVE PROBE	POSITIVE PROBE		∞ OHMS	ZERO OHMS
Pin 11	Pin 9	5	Open CR114	
Pin 9	Pin 11	∞		Shorted CR114
Pin 8	Pin 6	∞		Defective CR104
Pin 15	Anode of CR105	5	Open CR105	Shorted CR105
Pin 15	Anode of CR106	5	Open CR106	Shorted CR105
Pin 15	Anode of CR107	5	Open CR107	Shorted CR105
Cathode of CR109	Pin 4	5	Open CR109	Shorted CR109
Cathode of CR110	Pin 4	5	Open CR110	Shorted CR110
Cathode of CR111	Pin 4	5	Open CR111	Shorted CR111
Cathode of CR112	Anode of CR112	5	Open CR112	Shorted CR112
Cathode of CR113	Anode of CR113	5	Open CR113	Shorted CR113
Anode of CR103	Cathode of CR103	∞		Shorted CR103
Anode of CR115	Cathode of CR115	∞		Shorted CR115
Cathode of CR101	Anode of CR101	5	Open CR101	Shorted CR101

TEST CHART 1 (Contd)

CP-100 — VOLTAGE REGULATOR AND SIMULATED OUTPUT CURRENT CIRCUIT

TEST PROCEDURE

(5) With the KS-20538 VOM set on Rx10K ohm scale, check the following per Table B.

TABLE B

METER CONNECTIONS		APPROXIMATE METER INDICATION IN OHMS	METER INDICATION NOTING PROBABLE TROUBLE
NEGATIVE PROBE	POSITIVE PROBE		ZERO OHMS
Pin 7	Pin 8	7K	Shorted Q104
Pin 15	Cathode of CR100	10M	Shorted CR100
Pin 15	Cathode of CR101	∞	Shorted CR101

(6) Place the CP-100 circuit board in a circuit board extender.

(7) Operate OFF/TEST (S4) switch to TEST position.

(8) Connect an oscilloscope across (+) and (–) terminals of OUTPUT CURRENT (M1) ammeter. See ***Danger***, paragraph 4.13.

(9) Operate POWER ON/POWER OFF (S2) switch to ON position and compare waveforms with SD-81966-01.

(10) Operate POWER ON/POWER OFF (S2) switch to OFF position. See ***Caution***, paragraph 4.08.

(11) Remove CP-100 circuit board from the circuit board extender. Remove the circuit board extender and replace the CP-100 circuit board in its connector.

(12) Charge OUTPUT FILTER capacitors in accordance with Section 169-742-301. See ***Caution***, paragraph 4.09 .

(13) Verify that DC OUTPUT (S1) switch is in BAT or EC position.

(14) Verify that OFF/TEST (S4) switch is in OFF position.

(15) Operate POWER ON/POWER OFF (S2) switch to ON position.

TEST CHART 2

CP-200 — CURRENT LIMIT, LO — CURRENT, GRADUAL OUTPUT CIRCUIT

TEST PROCEDURE

(1) Operate POWER ON/POWER OFF (S2) switch to OFF position. See ***Caution,*** paragraph 4.08.

(2) Operate DC OUTPUT (S1) switch to OFF position.

(3) Operate OFF/TEST (S4) switch to TEST position.

(4) Operate SIMULATED OUTPUT CURRENT (S3) switch to ON position.

(5) Rotate SIMULATED OUTPUT CURRENT (R10) rheostat cw until OUTPUT CURRENT (M1) ammeter indicates 400 amperes.

(6) Operate POWER ON/POWER OFF (S2) switch to ON position.

(7) Take the following measurement on CP-200 ▶(Fig. 5) with the KS-20538 VOM set for 10 volts dc. Connect the negative meter probe the J200, pin 6 and the positive meter probe to J200, pin 1.

(8) Verify that the meter indicates 5.5 to 5.7 volts dc. If the voltage indication is not within tolerance, refer to TEST CHART 8.

Note: Do not disturb the meter connections.◀

(9) Rotate SIMULATED OUTPUT CURRENT (R10) rheostat ccw until OUTPUT CURRENT (M1) ammeter indicates 200 amperes.

▶(10) Verify that the meter indicates 3.4 to 3.6 volts dc. If the voltage indication is not within tolerance, refer to TEST CHART 8.

(11) With the KS-20538 VOM set for 10 volts dc, connect the negative meter probe to the junction of R219 and R221 and the positive meter probe to the J200, pin 1.

(12) Verify that the meter indicates 2.8 to 4.2 volts dc. If the voltage indication is not within tolerance, integrated circuit A200, A201, or A202 is defective.

(13) Rotate SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw.

(14) With the KS-20538 VOM set for 100 volts dc, connect the negative meter probe to J200, pin 3, and the positive meter probe to J200, pin 1.

(15) Verify that the meter indicates 44.5 to 49.5 volts dc. If the voltage indication is not within tolerance, component A200, Q200, or Q201 is defective.

Note: Do not disturb the meter connections.◀

(16) Rotate SIMULATED OUTPUT CURRENT (R10) rheostat cw until OUTPUT CURRENT (M1) ammeter indicates 50 amperes.

TEST CHART 2 (Contd)

CP-200 — CURRENT LIMIT, LO — CURRENT, GRADUAL OUTPUT CIRCUIT

TEST PROCEDURE

(17) With the KS-20538 meter set for 1-volt dc, verify that the meter indicates 0.7 to 0.9 volt dc. If the voltage indication is not within tolerance, component A200, Q200, or Q201 is defective.

(18) Disconnect the KS-20538 meter.

(19) If the trouble is not located, proceed to TEST CHART 8. If the trouble is located, correct it and continue with (20).

(20) Operate POWER ON/POWER OFF (S2) switch to OFF position.

(21) Rotate SIMULATED OUTPUT CURRENT (R10) rheostat fully cw.

(22) Operate SIMULATED OUTPUT CURRENT (S3) switch to OFF position.

(23) Charge OUTPUT FILTER capacitors in accordance with Section 169-742-301. See ***Caution***, paragraph 4.09.

(24) Verify that OFF/TEST (S4) switch is in OFF position.

(25) Verify that DC OUTPUT (S1) switch is in BAT or EC position.

(26) Operate POWER ON/POWER OFF (S2) switch to ON position.

TEST CHART 3

CP-300 — HIGH VOLTAGE MONITOR CIRCUIT

TEST PROCEDURE

(1) Operate POWER ON/POWER OFF (S2) switch to OFF position.

(2) Operate DC OUTPUT (S1) switch to OFF position. See ***Caution,*** paragraph 4.08.

(3) Remove CP-300 circuit pack from its connector (Fig. 5). See ***Caution,*** paragraph 4.10.

(4) With the KS-20538 VOM set for Rx1 ohms scale, check the following per Table C.

TABLE C

METER CONNECTIONS		APPROXIMATE METER INDICATION IN OHMS	METER INDICATION NOTING PROBABLE TROUBLE
NEGATIVE PROBE	POSITIVE PROBE		ZERO OHMS
Pin 7	Anode of CR320	4 to 6	Shorted CR320
Pin 7	Cathode of CR304	∞	Shorted CR304
Pin 7	Cathode of CR305	∞	Shorted CR305 or CR301
Pin 11	Anode of CR306	4 to 6	Shorted CR306
Cathode of CR307	Pin 15	4 to 6	Shorted CR307
Pin 5	Anode of CR300	4 to 6	Shorted CR300
Pin 5	Anode of CR301	4 to 6	Shorted CR301
Cathode of CR303	Anode of CR303	4 to 6	Shorted CR303

(5) If above tests do not indicate trouble, suspect a defective A300 or A301 and replace the circuit pack.

(6) Verify that the CP-300 circuit pack is firmly seated in its connector.

(7) Charge the output filter capacitors in accordance with Section 169-742-301. See ***Caution,*** paragraph 4.09.

(8) Verify that the DC OUTPUT (S1) switch is in the BAT or EC position.

(9) Operate POWER ON/POWER OFF (S2) switch to the ON position.

TEST CHART 4

CP-400 — STABILIZER CIRCUIT

TEST PROCEDURE

(1) Operate POWER ON/POWER OFF (S2) switch to OFF position.

(2) Operate DC OUTPUT (S1) switch to OFF position. See ***Caution,*** paragraph 4.08.

(3) Remove the CP-400 circuit pack from its connector (Fig. 5). See ***Caution,*** paragraph 4.10.

(4) With the KS-20538 meter set for Rx1 ohms scale, check the following per Table D.

TABLE D

METER CONNECTIONS		APPROXIMATE METER INDICATION IN OHMS	METER INDICATION NOTING PROBABLE TROUBLE
NEGATIVE PROBE	POSITIVE PROBE		ZERO OHMS
Pin 4	Anode of CR400	4 to 6	Shorted CR400
Pin 1	Pin 8	Initially low, steadily increasing to ∞	Shorted C402
C401A and R401 Junction	Pin 15	Initially low, steadily increasing to ∞	Shorted C401A or C401B
C401A and R404 Junction	Pin 15	Initially low, steadily increasing to ∞	Shorted C404A or C404B

(5) If trouble is found, replace CP-400 circuit pack. If trouble is not found, reinsert the old CP-400 and continue with (6).

(6) Charge the output filter capacitors in accordance with Section 169-742-301. See ***Caution,*** paragraph 4.09.

(7) Verify that DC OUTPUT (S1) switch is in BAT or EC position.

(8) Operate POWER ON/POWER OFF (S2) switch to ON position.

TEST CHART 5

CP-500 — 120 Hz MONITOR CIRCUIT

TEST PROCEDURE

(1) Operate POWER ON/POWER OFF (S2) switch to OFF position.

(2) Operate DC OUTPUT (S1) switch to OFF position. See ***Caution***, paragraph 4.08.

(3) Remove the CP-500 circuit pack from its connector (Fig. 5). See ***Caution***, paragraph 4.10

(4) With the KS-20538 VOM set for Rx1 ohms scale, check the following per Table E.

TABLE E

METER CONNECTIONS		APPROXIMATE METER INDICATION IN OHMS	METER INDICATION NOTING PROBABLE TROUBLE
NEGATIVE PROBE	POSITIVE PROBE		ZERO OHMS
Cathode of CR502	Pin 15	4 to 6	Shorted CR502
Pin 14	Anode of CR503	4 to 6	Shorted CR503
Cathode of CR504	Anode of CR504	4 to 6	Shorted CR504
Anode of CR501	Pin 15	∞	Shorted CR501
Anode of CR500	Cathode of CR500	∞	Shorted CR500
C501 and L500 Junction	C501 and R500 Junction	Initially low, steadily increasing to ∞	Shorted C501 and/or C502
Terminal 2 of L500	Terminal 1 of L500	Low	Shorted L500, C503, and/or C504
Anode of CR504	Pin 15	Initially low, steadily increasing to ∞	Shorted C500

TEST CHART 5 (Contd)

CP-500 — 120 Hz MONITOR CIRCUIT

TEST PROCEDURE
(5) If all tests pass, suspect A500 and replace CP-500 circuit pack.
(6) Charge the output filter capacitors in accordance with Section 169-742-301. See ***Caution***, paragraph 4.09.
(7) Verify that DC OUTPUT (S1) switch is in BAT or EC position.
(8) Operate POWER ON/POWER OFF (S2) switch to ON position.

TEST CHART 6

CP-700 — AC INPUT VOLTAGE MONITOR CIRCUIT

TEST PROCEDURE

(1) Operate POWER ON/POWER OFF (S2) switch to OFF position.

(2) Operate DC OUTPUT (S1) switch to OFF position. See ***Caution***, paragraph 4.08.

(3) Remove fuses from the power service cabinet. See ***Danger***, paragraph 4.11.

(4) Remove protective covering from the terminals of CP-700 circuit pack. (See Fig. 6.)

(5) With the KS-20538 VOM set for Rx1 ohms scale, check the following per Table F on CP-700 circuit board (Fig. 6).

TABLE F

METER CONNECTIONS		APPROXIMATE METER INDICATION IN OHMS	METER INDICATION NOTING PROBABLE TROUBLE
NEGATIVE PROBE	POSITIVE PROBE		ZERO OHMS
Cathode of CR703	Pin 1	4 to 6	Shorted CR703
Pin 4	Pin 5	4 to 6	Shorted CR704
Cathode of CR705	Anode of CR705	4 to 6	Shorted CR705
Cathode of CR706	Anode of CR706	4 to 6	Shorted CR706
Cathode of CR707	Anode of CR707	4 to 6	Shorted CR707
Anode of CR700	Cathode of CR700	∞	Shorted CR700
Anode of CR701	Cathode of CR700	∞	Shorted CR701
Anode of CR700	Cathode of CR705	Initially low, but steadily increasing to ∞	Shorted C702
Cathode of CR705	Cathode of CR706	Initially low, but steadily increasing to ∞	Shorted C701
Cathode of CR706	Cathode of CR707	Initially low, but steadily increasing to ∞	Shorted C700

TEST CHART 6 (Contd)

CP-700 — AC INPUT VOLTAGE MONITOR CIRCUIT

TEST PROCEDURE

(6) If all tests are positive, check the following per Table G with the KS-20538 meter set for Rx1K ohms scale.

TABLE G

METER CONNECTIONS		APPROXIMATE METER INDICATION IN OHMS	METER INDICATION NOTING PROBABLE TROUBLE	
NEGATIVE PROBE	POSITIVE PROBE		ZERO OHMS	
Lead 2 of Winding A	Terminal 6	1200	Shorted Winding	Open Winding
Lead 2 of Winding B	Terminal 7	1200	Shorted Winding	Open Winding
Lead 2 of Winding C	Terminal 8	1200	Shorted Winding	Open Winding

(7) If all tests are positive, A700 is defective. Replace the CP-700 circuit pack.

(8) Charge the output filter capacitors in accordance with Section 169-742-301. See ***Caution***, paragraph 4.09.

(9) Verify that DC OUTPUT (S1) switch is in BAT or EC position.

(10) Verify that the OFF/TEST switch is in the OFF position.

(11) Reinsert the fuses in the power service cabinet. See ***Danger***, paragraph 4.11.

(12) Operate POWER ON/POWER OFF (S2) switch to ON position.

TEST CHART 7

CP-800 — PULSE CIRCUIT

TEST PROCEDURE

(1) Operate POWER ON/POWER OFF (S2) switch to OFF position.

(2) Operate DC OUTPUT (S1) switch to the OFF position. See ***Caution***, paragraph 4.08.

(3) Locate CP-800 circuit boards at rear of rectifier.

(4) Remove the CP-800A, B, or C circuit packs from their connectors. See ***Caution***, paragraph 4.10.

(5) With the KS-20538 meter set for Rx1 ohms scale, check the following per Table H.

TABLE H

METER CONNECTIONS		APPROXIMATE METER INDICATION IN OHMS	METER INDICATION NOTING PROBABLE TROUBLE
NEGATIVE PROBE	POSITIVE PROBE		ZERO OHMS
Pin 8	Pin 7	4 to 6	Shorted CR802
Cathode of CR803	Pin 7	4 to 6	Shorted CR803
Pin 7	Anode of CR806	4 to 6	Shorted CR806
Cathode of CR804	Pin 6	4 to 6	Shorted CR804
Pin 6	Anode of CR807	4 to 6	Shorted CR807
Pin 8	Pin 6	4 to 6	Shorted CR805
Cathode of CR801	Anode of CR801	4 to 6	Shorted CR801
Cathode of CR817	Anode of CR817	4 to 6	Shorted CR817
Cathode of CR816	Anode of CR816	4 to 6	Shorted CR816
Cathode of CR815	Anode of CR815	4 to 6	Shorted CR815
Pin 6 of A800	Pin 2 of A801	4 to 6	Shorted CR814
Pin 2 of A801	Anode of CR800	4 to 6	Shorted CR800

TEST CHART 7 (Contd)

CP-800 — PULSE CIRCUIT

TEST PROCEDURE

▶TABLE H (Contd)◀

METER CONNECTIONS		APPROXIMATE METER INDICATION IN OHMS	METER INDICATION NOTING PROBABLE TROUBLE
NEGATIVE PROBE	POSITIVE PROBE		ZERO OHMS
Cathode of CR808	Anode of CR808	4 to 6	Shorted CR808
Cathode of CR809	Anode of CR809	4 to 6	Shorted CR809
Cathode of CR819	Anode of CR819	4 to 6	Shorted CR819
Cathode of CR810	Anode of CR810	4 to 6	Shorted CR810
Pin 5	Anode of CR811	4 to 6	Shorted CR811
Cathode of CR818	Anode of CR818	4 to 6	Shorted CR818
Pin 15	Anode of CR813	4 to 6	Shorted CR813
Pin 1	Anode of CR812	4 to 6	Shorted CR812

(6) Operate OFF/TEST (S4) switch to TEST position.

(7) Place the CP-800 circuit pack in circuit board extender, if necessary.

(8) Operate POWER ON/POWER OFF (S2) switch to ON position and take the following measurement.

▶(9) With the KS-20538 meter set for 10 volts dc, connect the negative meter probe to pin 5 and the positive meter probe to the cathode of CR814. Verify the meter indicates 5.4 volts dc.

Note: A meter indication above 5.4 volts dc indicates a defective A800.◀

(10) With an oscilloscope, measure the gate (+) to cathode (–) gating pulses and compare with SD-81996-01 sheet B2. See ***Danger***, paragraph 4.13.

(11) Operate POWER ON/POWER OFF (S2) switch to OFF position.

▶(12) If the requirements are not met, replace defective circuit pack(s) CP-800A, B or C.◀

(13) Operate OFF/TEST (S4) switch to OFF position.

(14) Charge the output filter capacitors in accordance with Section 169-742-301. See ***Caution***, paragraph 4.09.

(15) Verify that DC OUTPUT (S1) switch is in BAT or EC position.

(16) Operate POWER ON/POWER OFF (S2) switch to ON position.

TEST CHART 8

CP-250 — DCCT CIRCUIT

TEST PROCEDURE

(1) Operate POWER ON/POWER OFF (S2) switch to OFF position.

(2) Operate DC OUTPUT (S1) switch to OFF position. See ***Caution***, paragraph 4.08.

(3) Remove the protective plastic shield from the CP-250 circuit pack. See Fig. 7.

(4) With the KS-20538 meter set for Rx1 ohms scale, check the following per Table I.

TABLE I

METER CONNECTIONS		APPROXIMATE METER INDICATION IN OHMS	METER INDICATION NOTING PROBABLE TROUBLE
NEGATIVE PROBE	POSITIVE PROBE		ZERO OHMS
Pin 6	Pin 4	4 to 6	Shorted CR252
Pin 3	Pin 6	4 to 6	Shorted CR250
Pin 5	Pin 4	4 to 6	Shorted CR253
Pin 3	Pin 5	4 to 6	Shorted CR251
R250 and C251 Junction	Pin 3	Initially low, steadily increasing to ∞	Shorted C251
R250 and C250 Junction	Pin 3	Initially low, steadily increasing to ∞	Shorted C250

(5) Operate OFF/TEST (S4) switch to TEST position.

(6) Adjust SIMULATED OUTPUT CURRENT (R10) rheostat fully cw.

(7) Operate SIMULATED OUTPUT CURRENT (S3) switch to ON position.

(8) Rotate SIMULATED OUTPUT CURRENT (R10) rheostat ccw until OUTPUT CURRENT M1 meter indicates 200 amperes.

TEST CHART 8 (Contd)

CP-250 — DCCT CIRCUIT

TEST PROCEDURE
♦(9) Connect an oscilloscope between pins 2 and 8 on CP-250 circuit board and compare oscillogram on SD-81996-01, sheet B6 with oscilloscope indication. See ***Danger***, paragraph 4.13.
(10) If tests are positive, proceed to (11). If tests are negative, replace CP-250 circuit board, then proceed to (11).♦
(11) Rotate SIMULATED OUTPUT CURRENT (R10) rheostat fully cw.
(12) Operate SIMULATED OUTPUT CURRENT (S3) switch to OFF position.
(13) Charge the output filter capacitors in accordance with Section 169-742-301. See ***Caution***, paragraph 4.09.
(14) Verify that DC OUTPUT (S1) switch is in BAT or EC position.
♦(15) Verify that OFF/TEST switch is in OFF position.♦
(16) Reinstall the protective cover over CP-250 circuit board.
(17) Operate POWER ON/POWER OFF (S2) switch to ON position.

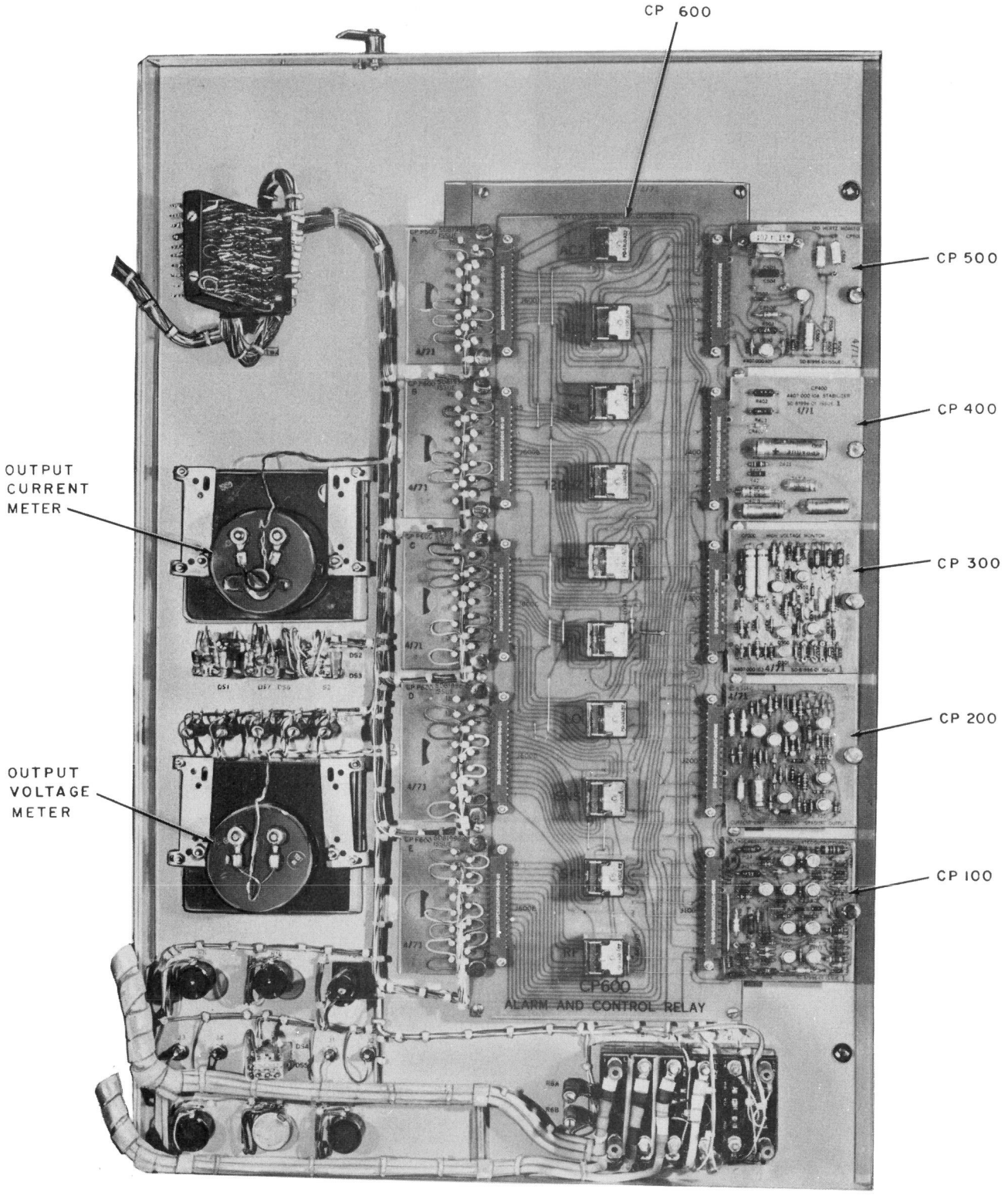

Fig. 5—KS-20490 Rectifier Control Panel Rear View

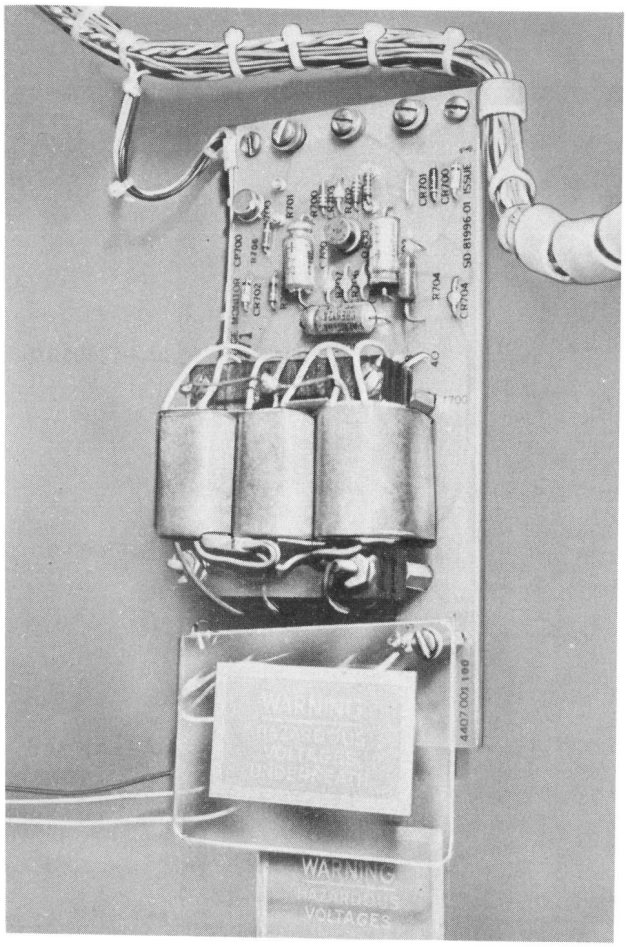

Fig. 6—Circuit Pack 700-AC Input Voltage Monitor

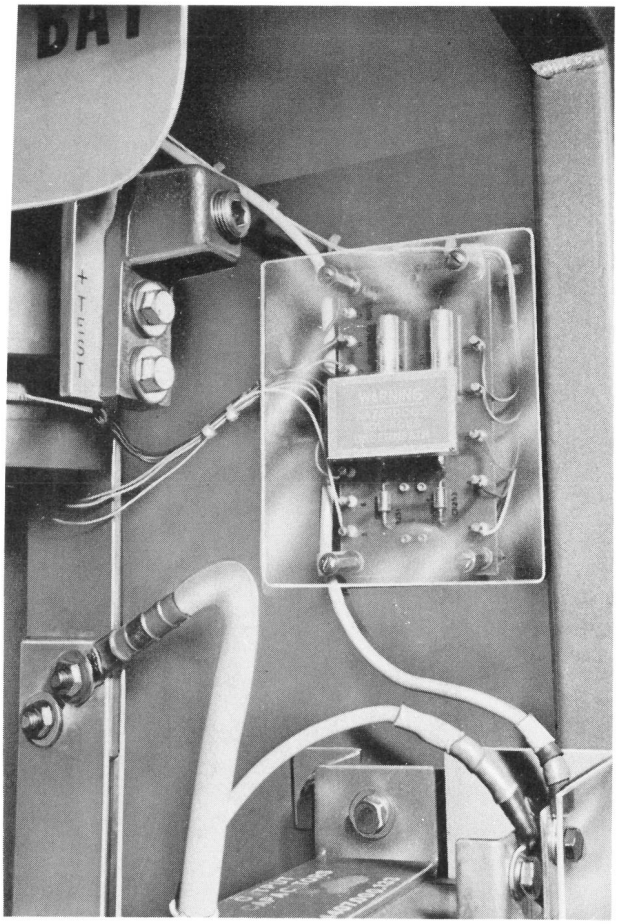

Fig. 7—Circuit Pack 250-DCCT Circuit