

**KS-20491, L21, L22, L23, AND L24, RECTIFIERS**  
**24 VOLTS, 100 AMPERES**  
**ITT-NORTH ELECTRIC COMPANY**  
**TROUBLE-LOCATING INFORMATION**

	PAGE		PAGE
1. GENERAL . . . . .	1	D. Critical Point Operating Voltages . . . . .	13
2. APPARATUS . . . . .	6	E. T1-T2 Transformer—Normal Operating Voltages . . . . .	13
3. OPERATION . . . . .	6		
4. TROUBLE-LOCATING PROCEDURES . . . . .	7	1. GENERAL	
THYRISTORS . . . . .	9	1.01 The KS-20491 rectifier (Fig. 1, 2, 3, and 4) provides regulated dc power from a single-phase ac source normally for use in charging and floating a 12-cell battery plant.	
5. CONNECTING CIRCUITS . . . . .	13	1.02 This section is reissued to include two variations of the KS-20491 rectifier. The first variation will be referred to as rectifier -01, and the second as rectifier -02, with reference to the schematic diagrams SD-82462-01 and SD-82462-02. Significant differences will be pointed out and correlated to the rectifiers. Revision arrows are used to emphasize the significant changes. This issue does affect the Equipment Test List.	
<b>Figures</b>		1.03 This rectifier is arranged for single-phase, 60 ±3 Hz, ac input and is suitable for use with battery power plants where 3-phase service is not available. The output voltage regulation for combined line and load variation is ±1 percent steady state when the rectifier is operating in an ambient temperature range of 10 to 50°C.	
1. KS-20491 Rectifier (SD-82462-01)—Front View . . . . .	2	1.04 This rectifier uses three printed circuit boards. Their functions are covered in Table A.	
2. KS-20491 Rectifier (SD-82462-01)—Front Cover Removed . . . . .	3	1.05 To facilitate testing of the printed circuit boards, a printed circuit extender board (CP4) is furnished with each rectifier. If a circuit board	
3. KS-20491 Rectifier (SD-82462-02) . . . . .	4		
4. KS-20491 Rectifier (SD-82462-02)—Front Panel Removed . . . . .	5		
5. Trouble-Locating Flowchart . . . . .	8		
6. Silicon Controlled Rectifier-Thyristor . . . . .	13		
7. Triac . . . . .	13		
<b>Tables</b>			
A. Circuit Boards . . . . .	6		
B. Indicator Lamps . . . . .	9		
C. Rectifier Troubles . . . . .	10		

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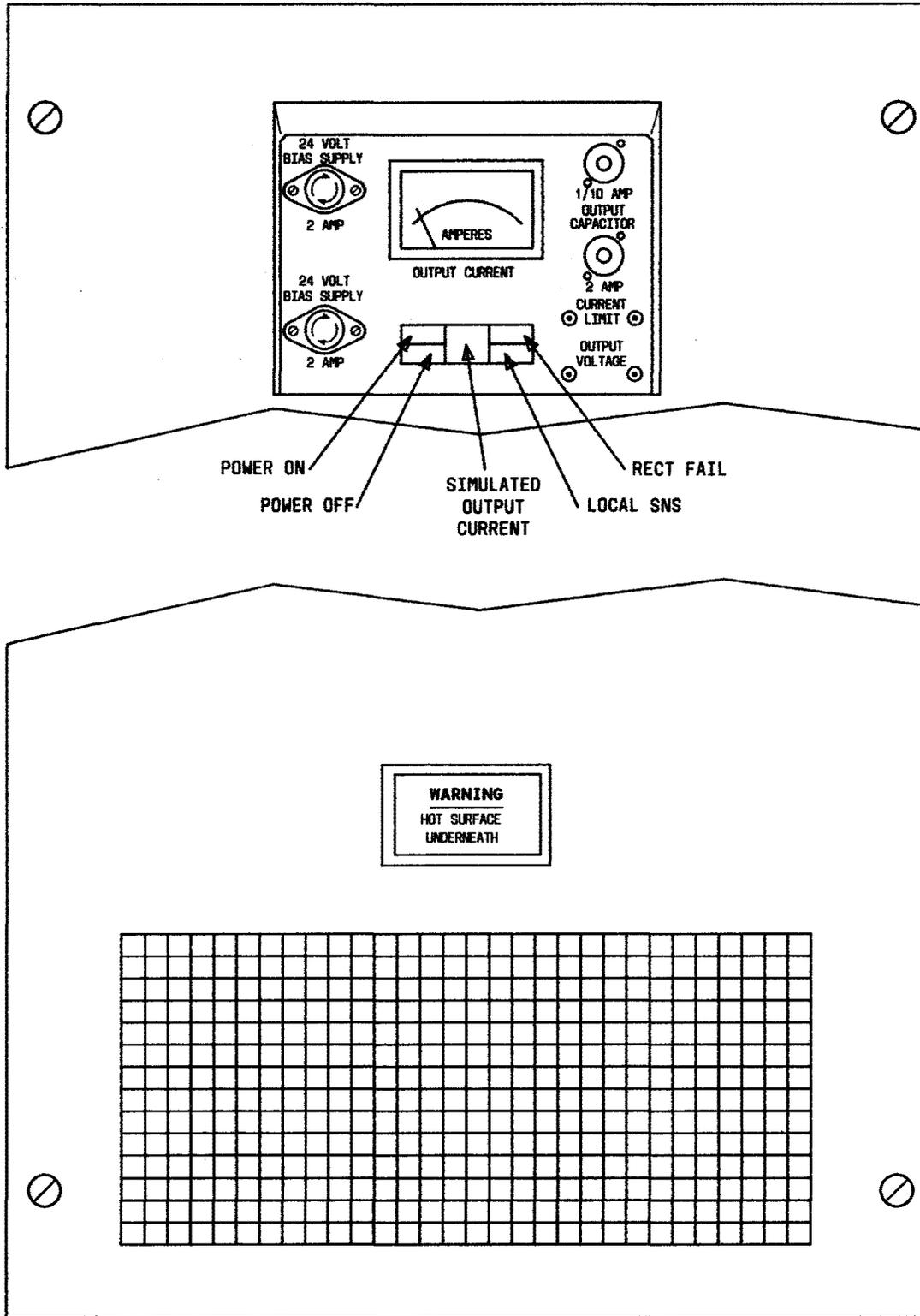


Fig. 1—KS-20491 Rectifier (SD-82462-01)—Front View

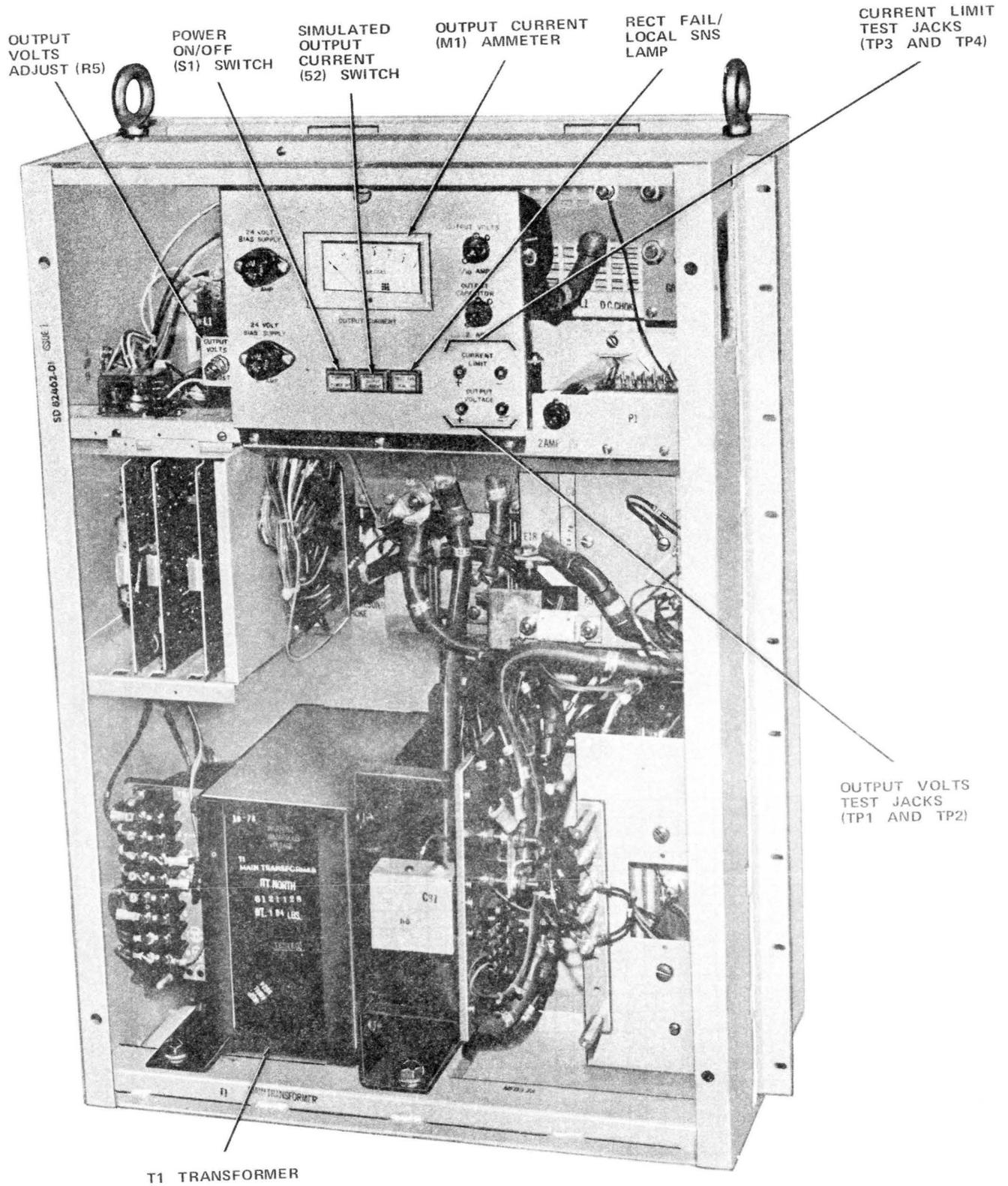


Fig. 2—KS-20491 Rectifier (SD-82462-01)—Front Cover Removed

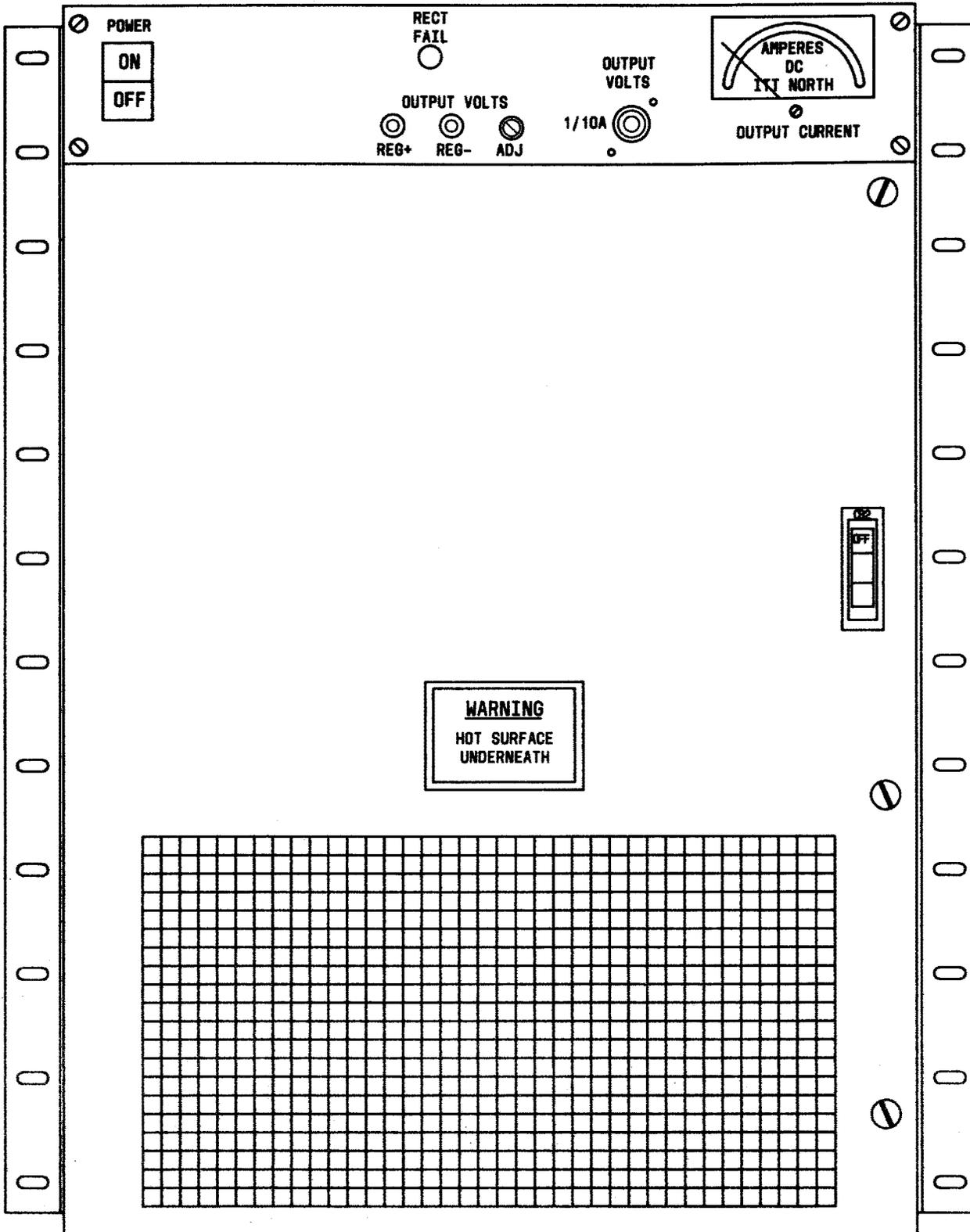


Fig. 3—KS-20491 Rectifier (SD-82462-02)◆

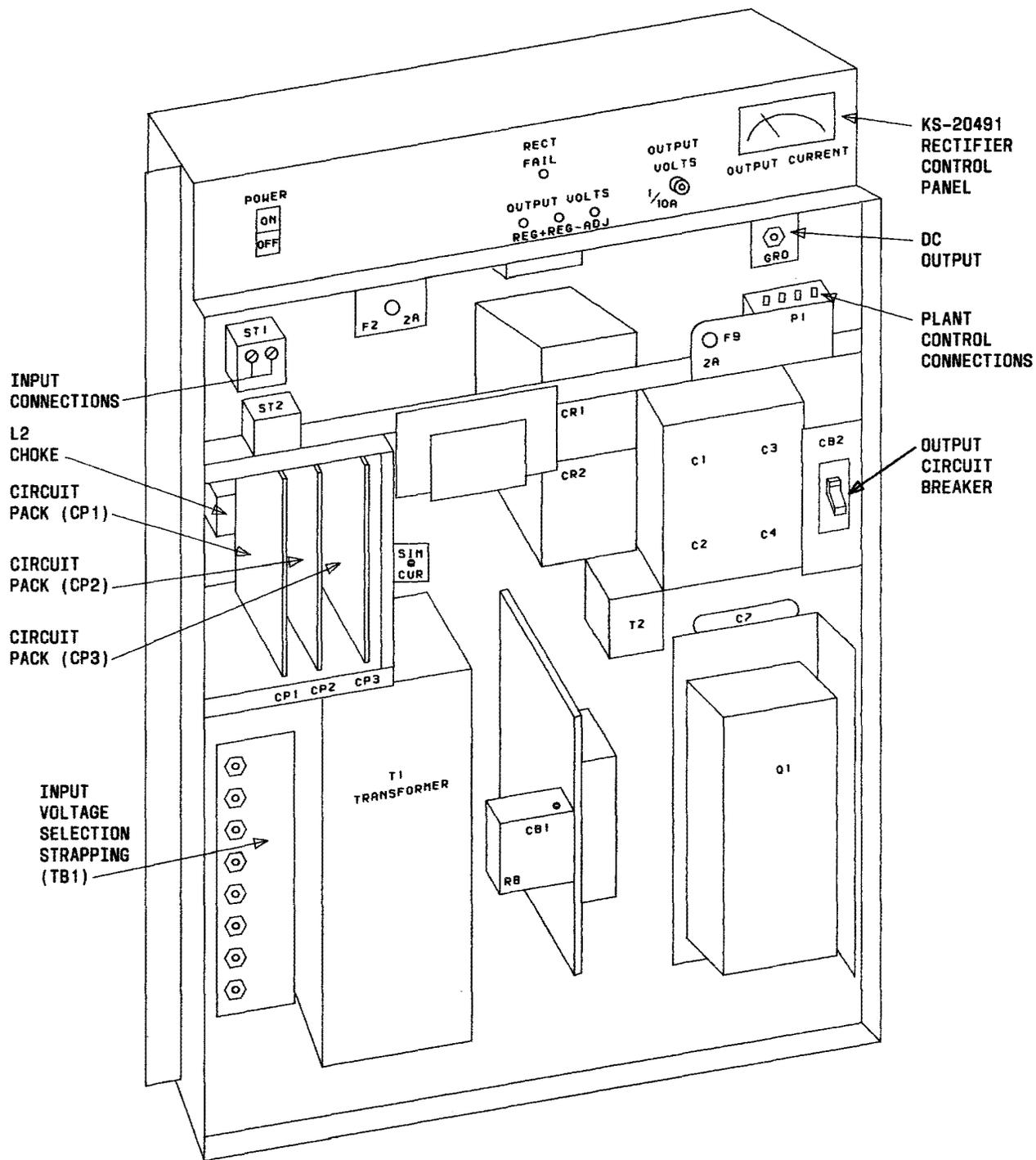


Fig. 4—KS-20491 Rectifier (SD-82462-02)—Front Panel Removed

**TABLE A**  
**CIRCUIT BOARDS**

CIRCUIT PACK	LIST NUMBER	KS-20491 RECTIFIER
CP1 — DC Auxiliary Power Supplies, AC Monitor and Simulated Output Current	L201	L21, 22, 23, & 24
CP2 — Voltage and Current Regulation and Current Limit	L202 L204	L21, 22, 23, & 24
CP3 — Alarm Circuits	L203 L205	L21, 22, 23, & 24
CP4 — Extender Board		
CP5 — Connector Card Mounting for CP1-CP3		

(CP1-CP3) is properly mated with the extender board (CP4) and the combination inserted into the appropriate connector on the rectifier, the circuit board will be exposed for testing.

**1.06** This issue of the section is based on the following drawings:

- SD-82462-01, Issue 2B
- ♦SD-82462-02, Issue 3AC.♦

For a detailed description of the operation, see the corresponding circuit description. If this section is to be used with equipment or apparatus that is associated with earlier or later issues of the drawings, reference should be made to the SDs and CDs to determine the extent of the changes and the manner in which the section may be affected.

**1.07** Refer to Table B for information on testing and locating troubles in the printed circuit boards.

**1.08** Refer to Section 032-173-301 for additional information for testing, replacing, and handling of circuit packs and semiconductor devices.

## 2. APPARATUS

**2.01** *List of Tools and Test Apparatus:* The following tools and test apparatus are used in this section.

TOOLS	DESCRIPTION
—	3-Inch C Screwdriver
—	12-Inch Test Clip Cord

### TEST APPARATUS

♦KS-20599, L4      Digital Multimeter (DMM)♦

## 3. OPERATION

**3.01** ♦Three separate operating phases constitute the normal operation of the rectifier as follows:

- (1) The rectifier is started and allowed (through electronic circuitry) to stabilize at a desired output value.
- (2) The rectifier provides power to a load.

- (3) The rectifier is shut down manually or automatically (due to a trouble condition).

**3.02** To provide power for control purposes, an auxiliary power supply circuit derives its input from the ac line voltage in parallel with the input to the primary of the power transformer. In this configuration, the auxiliary power supply monitors the ac input to the rectifier, and causes the rectifier to shut down if the commercial line voltage is too low. The shutdown is effected by control relays which depend upon the auxiliary power supply for their operating voltages.

**3.03 Normal Shutdown of Rectifier -01:** By depressing the POWER ON-POWER OFF switch to the OFF position, the rectifier may be shut down without sending an alarm.

**3.04 Normal Shutdown of Rectifier -02:** By depressing the POWER switch to OFF, the rectifier may be shut down without sending an alarm.

**3.05 Trouble Shutdown of Rectifier -01 and -02:** The rectifier will automatically shut down if the line voltage is too low for proper operation of the rectifier, or if a high-voltage condition exists at the rectifier output. In either case, the RECT FAIL light emitting diode (LED) is lighted on the control panel of both the plant and rectifier, and a minor alarm is sent.

**3.06 Remote Shutdown of Rectifier -01 and -02:** The rectifier may be remotely shut down by applying ground to the TR lead of the plant control circuit.⚡

#### 4. TROUBLE-LOCATING PROCEDURES

**4.01** Troubles in the KS-20491 rectifier can be listed in two categories:

- Loss of output
- Undesired output, either voltage or current, or both.

**4.02** When trouble occurs, as evidenced by visual and/or audible alarms, the status of the visual indicators should be checked. The visual indicators consist of the power switch (OFF and ON positions), the RECT FAIL LED, and the output circuit breaker

(ON and OFF positions). The deflection of the OUTPUT CURRENT meter may also indicate a problem if the indicated current level is other than expected.

**4.03** The trouble flowchart in Fig. 5 is designed to locate troubles from this viewpoint. The output of the rectifier should be checked and the appropriate category of the flowchart should be consulted to isolate the trouble.

**4.04 ⚡DANGER: AC input power and battery should be disconnected from the rectifier before attempting maintenance in the power sections of the rectifier. Use extreme care when touching any component, such as transformers, which may have heated during operation. This admonition pertains to paragraphs 4.07 through 4.16.**

**4.05 DANGER: When using test equipment which is isolated from equipment ground, use extreme care due to the possible presence of hazardous voltages on the test equipment chassis. Triac circuit voltages are in excess of 300 volts. This admonition pertains to paragraphs 4.07 through 4.16.**

**4.06 DANGER: When using test equipment powered from AC line which has one probe (lead) connected to chassis, that probe (lead) must always be connected to equipment ground. If waveshape requires connection of probe (lead) to a point other than equipment ground, the equipment must be isolated from ground through a suitable adaptor plug when troubleshooting the rectifier. This admonition pertains to paragraphs 4.07 through 4.16.⚡**

**4.07** Trouble-locating should begin with a visual inspection. Check for faulty connections, broken, burned, or shorted wires. Inspect the wiring harness and leads from all components for possible breaks and shorts. Check that all solder joints make good electrical contact.

**4.08** Troubleshooting of the main frame should not be attempted until printed circuit boards, CP1 through CP3, have been found to be good.

**4.09** When the trouble is traced to a circuit pack, replace it with a new or properly repaired circuit pack. Do not attempt to repair defective circuit

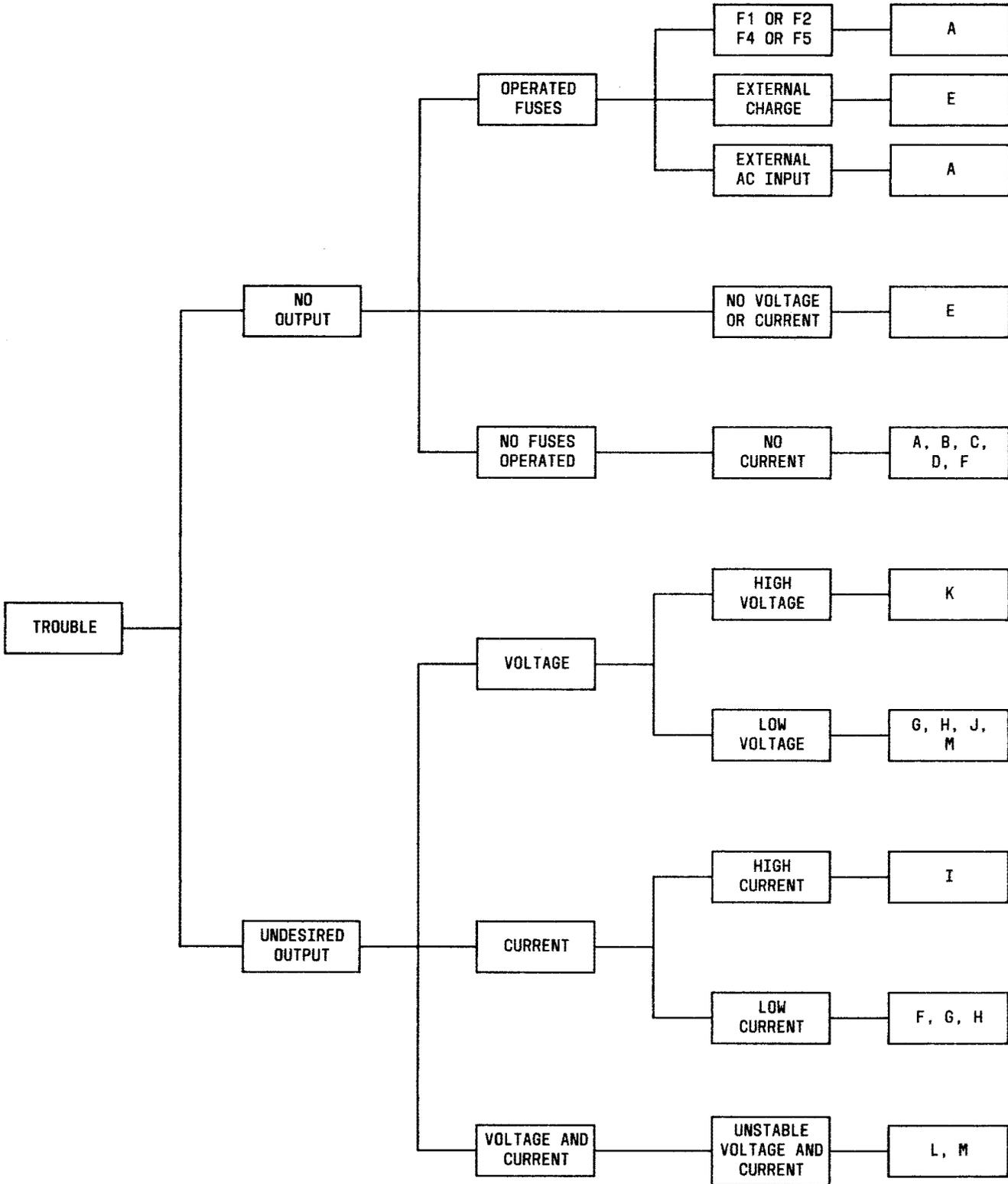


Fig. 5—Trouble-Locating Flowchart

packs unless personnel are equipped and trained to repair circuit packs. Handle the defective circuit pack in accordance with local instructions.

**4.10** When trouble is encountered, the source of trouble may be determined by the visual indicators or indicator lamps. This rectifier is equipped with lamps as shown in ♦Table B.♦

**4.11** Refer to ♦Table C♦ for troubles occurring in the rectifier.

**4.12** Table D provides a set of normal operating voltages at critical points of the circuit. Test jacks of different colors are provided on the accessible edges of the CP boards.

**Note:** All measurements are to be made with a DMM with the meter (+) terminal connected to the test point in the table and the (-) terminal connected to the green test jack on CP1.

**4.13** Table E provides a set of normal voltages for the T1 and T2 transformers.

#### THYRISTORS

**4.14 Silicon Controlled Rectifier—Thyristor (SCR):** The SCR can be tested in the following manner:

(1) With the DMM set to the 10MΩ scale, connect the positive (+) lead to the cathode and the negative (-) lead to the anode. The value of resistance shall be 1 megohm minimum. Reverse the meter leads; the value of resistance shall be 1 megohm minimum. (Refer to Fig. 6.)

(2) With the meter still connected negative (-) to cathode, positive (+) to anode, using the 12-inch test clip cord, short the gate to the anode. The value of resistance should decrease to less than 1K ohm.

**4.15** The triac is a bidirectional thyristor which can be tested in the following manner:

(1) With the DMM set to the 10MΩ scale, connect the positive (+) lead to MT1 and the negative (-) lead to MT2 of the triac. (Refer to Fig. 7.) The value of resistance shall be 1 megohm minimum. Reverse the meter leads; the resistance shall be 1 megohm minimum.

(2) With the meter leads still connected to the MT1 and MT2, using the 12-inch test clip cord,

♦TABLE B♦

#### INDICATOR LAMPS

LAMPS	CAUSE OF OPERATION
RECT FAIL	Lighted when rectifier shuts down as a result of one or more of the following conditions: <ol style="list-style-type: none"> <li>(1) Fuse(s) operated               <ol style="list-style-type: none"> <li>(a) External charge fuse</li> <li>(b) CHG fuse</li> <li>(c) CONTR fuse</li> <li>(d) F1 or F2 fuse(s)</li> </ol> </li> <li>(2) Internal output circuit breaker tripped</li> <li>(3) Circuit packs CP1, CP2, or CP3 not inserted properly into connector</li> <li>(4) Low input voltage.</li> </ol>
SIMULATED OUTPUT CURRENT*	Lighted whenever the SIMULATED OUTPUT CURRENT (S2) switch is depressed.
POWER ON*	Lighted when POWER ON — POWER OFF (S1) switch is in the ON position.
POWER OFF	Lighted when POWER ON — POWER OFF (S1) switch is in the OFF position.
LOCAL SNS*	Lighted when RG or RB lead is broken. (SNS relay released).

\*-01 Rectifier Only

short the gate to MT2. The value of resistance should be between 10 to 500 ohms. Reverse the meter leads on MT1 and MT2 and again short the gate to MT2. The value of resistance should be between 10 to 500 ohms.

♦TABLE C♦

## RECTIFIER TROUBLES

TROUBLE CONDITION	PROBABLE CAUSE	REMEDY
A. Rectifier shutdown. POWER OFF, RECT FAIL lamps lighted (if equipped)	(1) AC service failure  (2) Operated fuses F1 or F2, F4 and F5  (3) Operated fuses F6 or F7	Check AC voltage between L1 and L2 for low line voltage, as outlined in paragraph 4.16.  Replace fuses. If fuse does not hold, check for defective T2 transformer or defective C1-C5 capacitors.  Replace fuses. If fuse does not hold, check for defective C6 or C7 capacitors.
B. Rectifier shutdown. POWER ON — POWER OFF lamps lighted (if equipped)	False ground signal on TR lead from plant	Check wiring of TR lead per applicable plant schematic diagram.
C. Rectifier shutdown. Interlock released. RECT FAIL, POWER ON lamps lighted (if equipped)	Circuit packs not making reliable contact with connectors	Check carefully that circuit packs CP1-CP3 are firmly inserted in connectors.
D. Rectifier shutdown. RECT FAIL, POWER ON lamps lighted (if equipped)	(1) Defective ALARM CIRCUITS circuit pack  (2) Defective relay ST1  (3) Defective contactor ST2  (4) Defective POWER ON — POWER OFF (S1) switch	Replace circuit pack CP3.  Replace relay ST1.  Replace contactor ST2.  Replace (S1) switch.
E. Rectifier shutdown. EXTERNAL CHARGE FUSE or circuit breaker operated or internal circuit breaker operated. POWER ON lamp lighted. RECT FAIL lighted (if equipped)	Defective diode in Power Circuit Secondary	Disconnect AC input and operate POWER ON — POWER OFF (S1) switch once or operate power switch to ON. Use a KS-20599 digital multimeter and check for defective diodes CR1 or CR2.

♦TABLE C♦ (Contd)

## RECTIFIER TROUBLES

TROUBLE CONDITION	PROBABLE CAUSE	REMEDY
F. Rectifier operating. No DC output current. POWER ON lamp lighted	(1) OUTPUT VOLTS ADJUST (R5) rheostat not properly adjusted  (2) VOLTAGE REGULATOR and CURRENT LIMIT CIRCUITS circuit pack defective	Check output volts adjustment as outlined in Section 169-703-302.  Replace circuit pack CP2.
G. Rectifier operating. Low output voltage or current. POWER ON lamp lighted (if equipped)	(1) OUTPUT VOLTS ADJUST (R5) rheostat not properly adjusted  (2) CURRENT LIMIT ADJUST (R222) rheostat not properly adjusted  (3) Excessive charge lead drop  (4) Low AC input voltage	Check output volts adjustment as outlined in Section 169-743-302.  Check current limit adjustment as outlined in Section 169-743-302.  Check rectifier output lugs for tightness and good connection.  Check AC input voltage as outlined in paragraph 4.16.
H. Rectifier operating. Low output voltage or current. POWER ON, LOC SNS lamps lighted (if equipped)	Loss of sensing. (Open RB or RG leads). Operated sense lead fuse. SNS relay released	Check plant sensing circuit for an open. Replace sense lead fuse if necessary.
I. Rectifier operating. High DC output current (output voltage near normal). POWER ON lamp lighted (if equipped)	(1) CURRENT LIMIT ADJUST (R222) rheostat not properly adjusted  (2) Defective current limit circuit	Check current limit adjustment as outlined in Section 169-743-302.  Replace CP2.
J. Rectifier operating. Low output voltage. POWER ON lamp lighted (if equipped)	(1) Defective SRS relay or C107 capacitor on CP1.  (2) Shorted Q201, defective walk-in circuit or defective A205 on CP2  (3) Shorted Q1 Triac	Replace CP1.  Replace CP2.  Check Q1 for short and replace as required.

▶TABLE C◀ (Contd)

RECTIFIER TROUBLES

TROUBLE CONDITION	PROBABLE CAUSE	REMEDY
K. Rectifier operating. High output voltage. POWER ON lamp lighted (if equipped)	(1) OUTPUT VOLTS ADJUST not properly adjusted	Check output volts adjustment as outlined in Section 169-743-302.
	(2) Defective Q1 Triac	Check Q1 for open as outlined in paragraph 4.15. Replace if required.
	(3) Defective CP2	Replace CP2.
L. Rectifier operating. Unstable output. POWER ON lamp lighted (if equipped)	VOLTAGE REGULATOR and CURRENT LIMIT CIRCUITS circuit pack defective	Replace circuit pack CP2.
M. Rectifier operating. Poor regulation at battery. POWER ON lamp lighted (if equipped)	(1) Excessive charge lead drop	Check rectifier output lugs for tightness and good connection.
	(2) VOLTAGE REGULATOR and CURRENT LIMIT CIRCUITS circuit pack CP2 defective	Replace circuit pack CP2.

4.16 ▶AC Input Voltage Check: To check ac input voltage, proceed as follows:

- (1) Check that the external ac input fuses are installed and the switch is in the ON position, or the external circuit breaker in the bus duct or in the power service cabinet is in the ON position.
- (2) Depress the power switch to the off position. The POWER OFF lamp lights (if equipped).▶
- (3) Remove the F1 and F2 fuses.

(4) Using the KS-20599, L4, digital multimeter, set to ACV and 1K, measure the ac input at terminals L1 and L2 of the ST2 contactor. The meter should indicate the following:

NOMINAL VALUE	OPTION	ABSOLUTE LIMITS
208 Volts	Z, T	186 — 221 Volts
240 Volts	Z, V	216 — 253 Volts
480 Volts	Y	430 — 506 Volts

**TABLE D**  
**CRITICAL POINT OPERATING VOLTAGES**

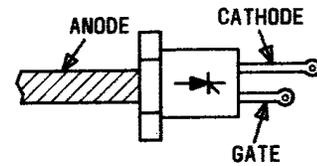
TEST POINT +LEAD OF METER		VOLTAGE READING VDC
Red	CP1	-22.0
Brown		-08.0
Black		-12.0
Yellow		+10.8
Orange		+00.6
Blue		-10.0
Slate		-10.4
Black	CP2	-22.47
Red		-01.20
Brown		+00.00
Orange		+00.00
Brown	CP3	-21.00

**TABLE E**

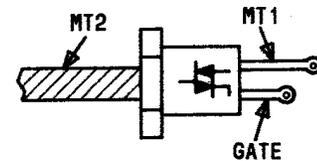
**T1 AND T2 TRANSFORMERS**  
**NORMAL OPERATING VOLTAGES**

TRANSFORMER	WINDING	READING AT NO LOAD
T1	5 - 6A	20.6 Vac
	6B - 7A	20.6 Vac
	7B - 8	210.0 Vac
	8 - 9	183.0 Vac
	12 - 13	29.0 Vac
	10 - 11	34.0 Vac
T2	6 - 7	20.0 Vac
	7 - 8	20.0 Vac
	9 - 10	19.5 Vac*

\*-02 Rectifier Only.



**Fig. 6—Silicon Controlled Rectifier-Thyristor**



**Fig. 7—Triac**

- (5) Remove the multimeter.
- (6) Replace the F1 and F2 fuses.

**5. CONNECTING CIRCUITS**

**5.01** This circuit will function with the following circuits:

- SD-81612-01, Charge and Discharge Circuit, 111A Power Plant
- SD-82299-01, Charge Bay Circuit.