

**RECTIFIERS**  
**KS-20491, L21, L22, L23, L24**  
**24 VOLTS, 100 AMPERES**  
**LORAIN PRODUCTS CORPORATION**  
**TROUBLE-LOCATING INFORMATION**

CONTENTS	PAGE
1. GENERAL . . . . .	1
2. LIST OF TOOLS AND TEST APPARATUS . . . . .	4
3. OPERATION . . . . .	4
4. TROUBLE-LOCATING PROCEDURES . . . . .	6

**Figures**

1. KS-20491 Rectifier—Front View . . . . .	2
2. KS-20491 Rectifier—Front Cover Removed . . . . .	3
3. Trouble-Locating Flowchart . . . . .	7
4. Waveforms—Checking Voltages at T1 and T2 Transformers . . . . .	13

**1. GENERAL**

**1.01** The KS-20491 rectifier (Fig. 1 and 2) provides regulated dc power from a single-phase ac source normally for use in charging and floating a 12-cell battery plant.

**1.02** This section is reissued to:

- (a) Provide information on options ZK, ZL, ZN, and ZP

(b) Update admonishments in accordance with the latest standards and trouble charts in accordance with the new options.

Revision arrows are used to emphasize the more significant changes. This reissue does not affect the Equipment Test List.

**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 ±0.5 percent steady state when the rectifier is operating in an ambient temperature range of 20 to 25°C and ±1 percent in an ambient temperature range of 10 to 50°C.

**1.04** The rectifier is not a complete operating unit. It can be used only in power plants containing the necessary auxiliary equipment. The rectifier uses a KS-20618 regulator as a control circuit. The primary function of the KS-20618 is to regulate the output voltage of the rectifier. In addition, it provides current limitation, alarms, and accepts control signals from the plant.

**1.05** The KS-20618 regulator has four printed circuit boards. Two of the four printed circuit boards perform the functions for voltage and current control. One board contains the alarm and plant control functions, and the fourth board furnishes power for the other three boards.

**1.06** To facilitate testing of the four printed circuit KS-20618 regulator boards, a printed circuit extender board (CP5) is furnished with each rectifier. If a KS-20618 regulator circuit board (CP1-CP4) is

**NOTICE**

Not for use or disclosure outside the  
Bell System except under written agreement

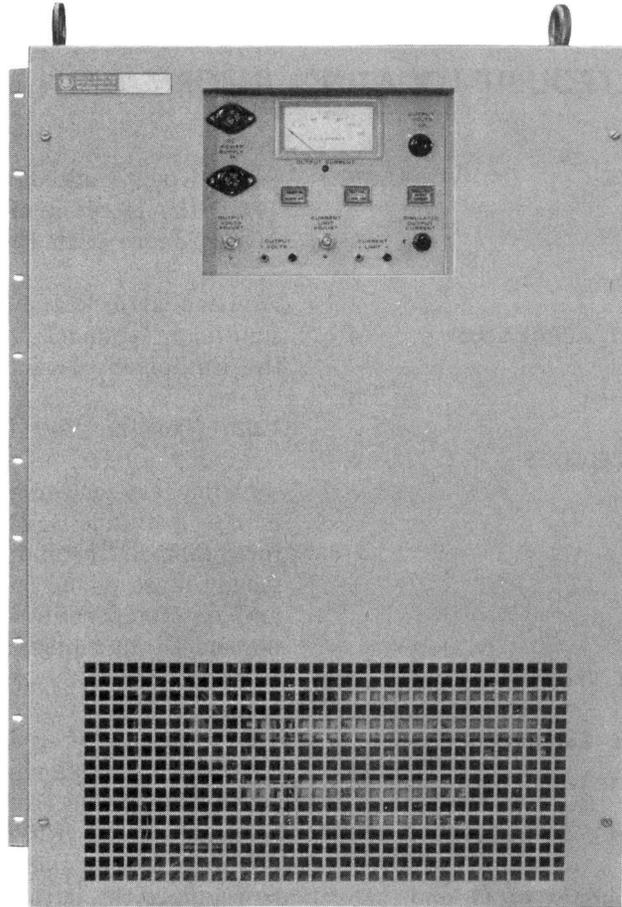


Fig. 1—KS-20491 Rectifier—Front View

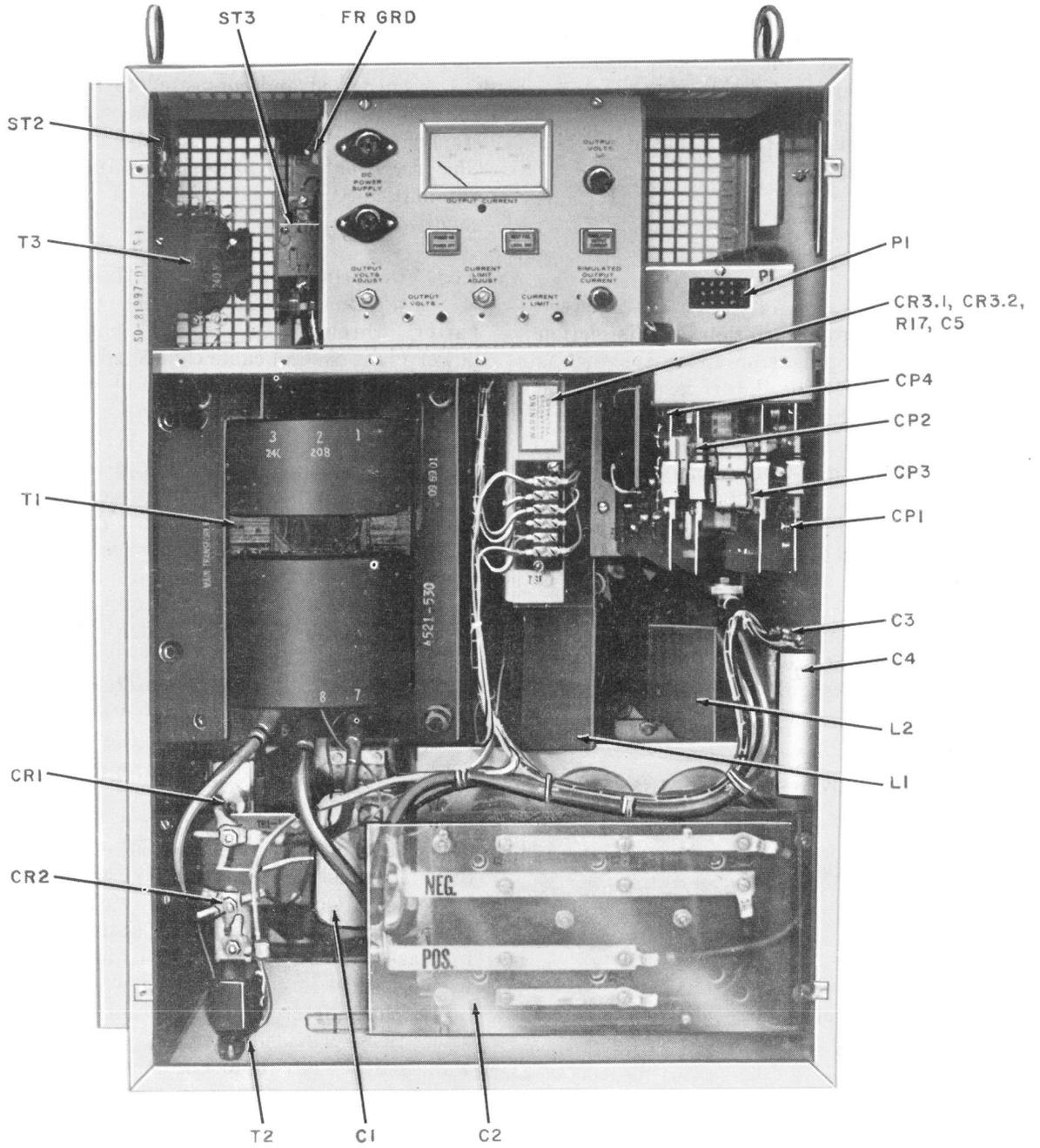


Fig. 2—KS-20491 Rectifier—Front Cover Removed

properly mated with the extender board (CP5) and the combination inserted into the appropriate connector on the rectifier, the KS-20618 regulator circuit board will be exposed for testing.

1.07 This issue of the section is based on the following drawings:

- SD-81997-01, Issue ♦7B♦
- SD-82030-01, Issue ♦5B♦

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.

1.08 Refer to Section 024-490-301 for information on testing and locating troubles in the KS-20618 regulator.

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

2. LIST OF TOOLS AND TEST APPARATUS

CODE OR SPEC NO.	DESCRIPTION
<b>TOOLS</b>	
—	3-Inch C Screwdriver
<b>TEST APPARATUS</b>	
KS-8039	Volt-Milliammeter (or equivalent)
KS-20538	Volt-Ohm-Milliammeter (or equivalent)
—	Digital Multimeter, John Fluke Mfg. Co. Model 8100A AC and DC Volts (or equivalent)
—	Oscilloscope, Tektronix Model 545 with Type W Differential Input Preamplifier (or equivalent)

3. OPERATION

3.01 Normally the KS-20491 rectifier will remain energized and connected to the battery. In addition to manual turn-off, the rectifier may be stopped and started by signals from the plant. The rectifier will shut down and/or lock out automatically upon occurrence of certain trouble conditions.

3.02 In normal operation with the rectifier output terminals BAT and GRD connected to the battery through the external charge fuse, the power plant control cable connected to the rectifier, the circuit breaker or switch and fuse unit in the bus duct or in the power service cabinet in the ON position, and the rectifier POWER ON—POWER OFF (S1) switch in the OFF position, the ac line voltage is supplied to the dc power supply circuit through fuses in the rectifier. The DC POWER SUPPLY CIRCUIT (CP4) furnishes internal control power to the various control circuits. The voltage regulator circuit (CP2) is connected to the “RG” and “RB” remote sensing leads.

3.03 *To start the rectifier*, depress the rectifier POWER ON—POWER OFF (S1) switch to the ON position. If the voltage monitor circuit on (CP4) senses that sufficient internal regulator voltage is available, the ac input contactor operates to connect ac input power to the rectifier power circuit and the POWER ON lamp lights. Simultaneously, the regulator walk-in (Gradual Increase in Output Current) circuit is activated so the rectifier output current starts out low and increases linearly toward full load. After the walk-in cycle is complete, the walk-in circuit has no further effect on the current limiting circuit. ♦Rectifiers provided with ZK option have a fast walk-in reset circuit to minimize transient voltage overshoot when the ac service restores after a service outage.♦

3.04 *To shut down the rectifier*, the POWER ON—POWER OFF (S1) switch is depressed and released, and the POWER OFF lamp is lighted. In power plant operation, the power plant may shut down the rectifier by a ground signal on the plant “TR” lead, the ST1 relay is released, releasing the ac input contactor. The rectifier then restarts when the ground is removed from the plant “TR” lead.

**3.05 Battery Voltage Shutdown:** If the battery voltage should exceed a maximum limit, the power plant will apply ground to the "HV" lead. If, at that time, the rectifier is carrying 5 amperes or more of current, the rectifier is shut down and locked out. The RECT FAIL lamp lights and a ground signal is sent to the power plant circuit over the "RFA" lead.

**3.06 Rectifier Overvoltage Shutdown:** Rectifiers provided with ZL option have an overvoltage shutdown circuit that will shut down and lock out the rectifier and activate its failure alarms when the output terminal voltage exceeds a preset level. This level to be set at  $29.75 \pm 0.2$  volts.

**3.07 Rectifier Automatic Restart:** Rectifiers provided with ZN option have an automatic restart circuit which will restart the rectifier upon receiving a loop closure signal from the plant if the rectifier has been shut down and locked out by a temporary fault such as transient high voltage.

**3.08 Blown External Charge Fuse:** If a rectifier fault should occur to short the rectifier output terminals, the external charge fuse will operate, blowing its associated charge alarm fuse. When the external charge alarm fuse operates, battery voltage is placed on the plant "CFA" lead (through a resistor) which shuts down and locks out the rectifier, and a ground signal is sent to the power plant circuit over the "RFA" lead.

**Note 1:** On rectifiers equipped with "S" option, the rectifier remains shut down and locked out as long as the plant "CFA" signal (derived from an operated external charge fuse) is present maintaining the RF relay (on CP3) energized.

**Danger:** If the external charge and charge alarm fuses associated with a rectifier equipped with "S" option, operate, depress the POWER ON—POWER OFF (S1) switch to the OFF position before removing the external charge and charge alarm fuses. If this admonishment is not followed, the rectifier will automatically restart once the plant "CFA" is removed.

**Note 2:** On rectifiers equipped with "R" option, once the plant "CFA" signal energizes the RF relay and the rectifier shuts down and is locked out, the -28 volt supply will maintain the RF relay energized through its own "lock-up" transfer contact. The rectifier will remain locked out until the operated external charge and charge alarm fuses are removed and the POWER ON—POWER OFF (S1) switch is depressed to the OFF position.

**Note 3:** On rectifiers equipped with ZB wiring, the RECT FAIL lamp does not light if the external charge fuse operates because the rectifier has shut down and no "BAT" voltage is available. On rectifiers equipped with ZC option wiring, if the external charge fuse operates, the RECT FAIL lamp lights. With ZC option, power to operate the RECT FAIL lamp circuit and the HV relay circuit is continuously provided by the plant CBS signal via terminal 15 on the PLANT CONTROL DISCONNECT, J1 connector.

**3.09 Rectifier Failure Alarm:** Rectifiers provided with ZP option include a modified failure alarm circuit to prevent an RFA alarm and lamp indication when the rectifier is manually turned off.

**3.10 Voltage Monitor Shutdown (CP4):** If for any reason the +15 and/or -15 volt supplies in the DC POWER SUPPLY CIRCUIT (CP4) fall below a preset value, the ST1 relay is released. This releases the ac input contactor to shut down the rectifier but does not lock it out. When the voltage is restored, the rectifier will restart automatically.

**Note:** Removal of either CP1, CP2, CP3, or CP4 circuit pack from its socket inhibits the start or shuts down the rectifier. Reinserting the circuit packs in their proper sockets restores normal operation.

**3.11 Rectifier Testing:** In order to perform tests and adjustments on the rectifier independently of battery load, proceed as follows.

- (a) Disconnect the PLANT CONTROL DISCONNECT (J1) connector.
- (b) Remove the external charge and charge alarm fuses.

## SECTION 169-743-311

This prevents alarms from being sent to the plant while testing. The "RG" and "RB" leads are opened and the SNS relay is released, transferring the sensing for CP2 to the rectifier BAT and GRD output terminals. The rectifier local SNS lamp lights. The output voltage may be set and current functions may be adjusted and tested independently from battery load.

### 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.

The trouble flowchart in Fig. 3 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.

**4.02** 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.

**4.03** Trouble-shooting of the main frame should not be attempted until all printed circuit boards (CP1 through CP4) making up the KS-20618 regulator have been found to be good. Refer to Section 024-490-301 for procedures to test the KS-20618 regulator.

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

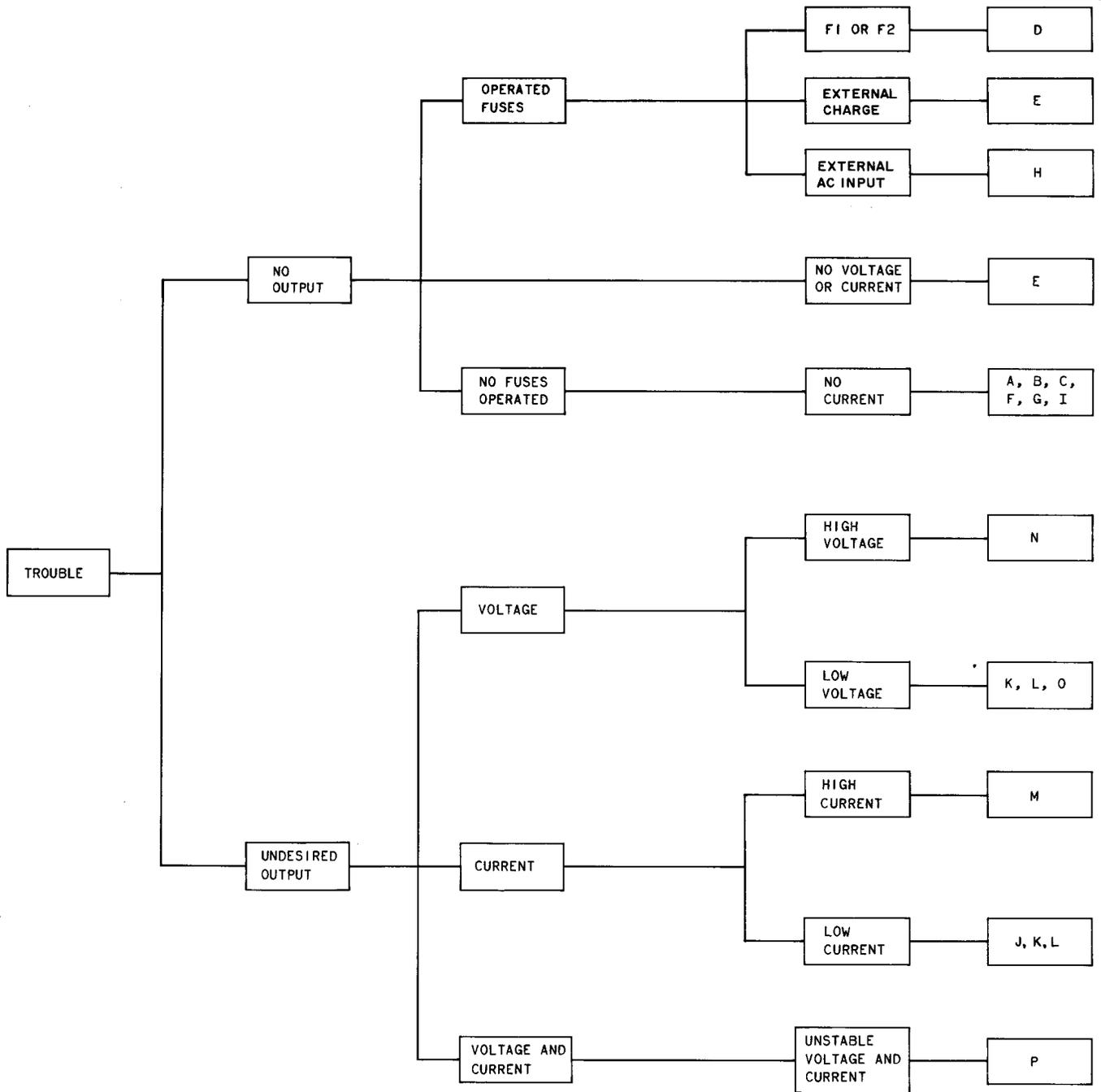


Fig. 3—Trouble-Locating Flowchart

4.05 When trouble is encountered, the source of trouble may be determined by the visual

indicators or indicator lamps. This rectifier is equipped with the following lamps.

SECTION 169-743-311

<u>LAMPS</u>	<u>CAUSE OF OPERATION</u>
RECT FAIL	Lighted whenever the rectifier is manually turned off and ZP option is not provided or whenever the RF relay operates to shut down and lock out the rectifier, or when the ST1 relay releases providing there is no signal on the TR lead. The lamp will not light when the external charge fuse operates. An exception to this is when ZL option is provided.
SIMULATED OUTPUT CURRENT	Lighted whenever the SIMULATED OUTPUT CURRENT (S1) switch is depressed.
POWER ON	Lighted when POWER ON — POWER OFF (S1) switch is in the ON position.

<u>LAMPS</u>	<u>CAUSE OF OPERATION</u>
POWER OFF	Lighted when POWER ON — POWER OFF (S1) switch is in the OFF position. The lamp will light when S1 switch is in the ON position if the rectifier is shut down by plant HV, TR, or CFA signals, a low-voltage condition sensed by the voltage detector circuit on CP4, or loss of line voltage.
LOCAL SNS	Lighted when RG or RB lead is broken or the plant control cable is disconnected.

**TROUBLE CHART**

- 4.06 Check the following trouble chart for troubles occurring in the rectifier.

<u>Item</u>	<u>Trouble Condition</u>	<u>Probable Cause</u>	<u>Remedy</u>
(a)	Rectifier shutdown. Interlock release. RECT FAIL, POWER ON-POWER OFF lamps lighted.	Circuit packs not making reliable contact with connectors.	Check carefully that circuit packs CP1-CP4 are firmly inserted in connectors.
(b)	Rectifier shutdown. Signal from plant. POWER ON — POWER OFF lamps lighted.	False ground signal on TR lead from plant.	Check wiring of TR lead to plant for false ground.
(c)	Rectifier shutdown. Defective starting circuitry. RECT FAIL, POWER ON-POWER OFF lamps lighted.	Defective ALARM CIRCUITS circuit pack.	*Substitute circuit pack CP3.
		(+) or (—) 15 volts not present on POWER SUPPLY CIRCUIT circuit pack CP4.	*Substitute circuit pack CP4.
		Defective relay ST2.	Replace relay ST2.
		Defective contactors ST3.	Replace contactor ST3.
(d)	Rectifier shutdown. DC POWER SUPPLY fuse (F1, F2) operated. POWER OFF, RECT FAIL lamps lighted.	Defective POWER ON-POWER OFF (S1) switch.	Replace (S1) switch.
		Defective diode CR1-CR4 in DC POWER SUPPLY CIRCUIT circuit pack CP4.	*Substitute circuit pack CP4.
		Defective capacitor C3 and/or C4.	Replace capacitor C3 and/or C4.
(e)	Rectifier shutdown. EXTERNAL CHARGE FUSE and CHARGE ALARM FUSES operated. POWER ON lamp lighted. ♦ RECT FAIL lighted when ZC option is provided. ♦	Defective DC POWER SUPPLY TRANSFORMER T3.	Replace T3.
		Defective diode in POWER CIRCUIT SECONDARY.	Disconnect AC input and operate POWER ON — POWER OFF (S1) switch once. Use a KS-20538 volt-ohm-milliammeter and check for defective diodes CR3.1 and CR3.2.
		Defective OUTPUT CAPACITOR C2.1-C2.5.	Disconnect AC input and operate POWER ON — POWER OFF switch once. Check capacitors C2.1-C2.5 for defects.

SECTION 169-743-311

<u>Item</u>	<u>Trouble Condition</u>	<u>Probable Cause</u>	<u>Remedy</u>
(f)	Rectifier shutdown. Signal from plant. POWER ON — POWER OFF, RECT FAIL lamps lighted.	False ground on HV lead from plant when rectifier is carrying 5% or more of rated current.	Insert probes of KS-8039 volt-milliammeter into OUTPUT VOLT test jacks. Operate POWER ON — POWER OFF (S1) switch twice and observe output voltage. If output voltage does not exceed the plant high voltage limit, a false ground is present on the HV lead.
(g)	Rectifier shutdown due to high output voltage. POWER ON-POWER OFF, RECT FAIL lamps lighted.	OUTPUT VOLTS ADJUST not properly adjusted.	Check output volts adjustment as outlined in Section 169-743-301.
		VOLTAGE REGULATOR and CURRENT LIMIT CIRCUITS circuit pack CP2 defective.	*Substitute circuit pack CP2.
		PULSE CIRCUITS circuit pack CP3 defective.	*Substitute circuit pack CP3.
(h)	Rectifier shutdown. AC line fuse operated. POWER OFF, RECT FAIL lamps lighted.	PULSE CIRCUIT TRANSFORMER T2 defective.	Replace transformer T2.
		MAIN TRANSFORMER T1 defective.	Operate POWER ON — POWER OFF (S1) switch once. Replace AC fuse. Reoperate POWER ON — POWER OFF (S1) switch. If fuse operates immediately, T1 is defective and must be replaced.
(i)	Rectifier shutdown. POWER OFF, RECT FAIL lamps lighted.	AC service failure.	Check AC voltage between L1 and L2 for low average line voltage, as outlined in 4.07.
(j)	Rectifier operating. No DC output current. POWER ON lamp lighted.	OUTPUT VOLTS ADJUST (R8) rheostat not properly adjusted.	Check output volts adjustment as outlined in Section 169-743-301.
		VOLTAGE REGULATOR and CURRENT LIMIT CIRCUITS circuit pack defective.	*Substitute circuit pack CP2.
		Defective thyristors Q1.1 and Q1.2.	Remove AC input power. Check for a defective thyristor Q1.1 and Q1.2.

<u>Item</u>	<u>Trouble Condition</u>	<u>Probable Cause</u>	<u>Remedy</u>
		PULSE CIRCUITS circuit pack CP1 defective.	*Substitute circuit pack CP1.
		Defective capacitor C1.	Replace capacitor C1.
(k)	Rectifier operating. Low output voltage or current. POWER ON lamp lighted.	OUTPUT VOLTS ADJUST (R8) rheostat not properly adjusted.	Check output volts adjustment as outlined in Section 169-743-301.
		CURRENT LIMIT ADJUST (R10) rheostat not properly adjusted.	Check current limit adjustment as outlined in Section 169-743-301.
		Excessive charge lead drop.	Check rectifier output lugs for tightness and good connection.
		Low AC input voltage.	Check AC input voltage between L1 and L2 as outlined in 4.07. Check transformer T1 as outlined in 4.08.
(l)	Rectifier operating. Low output voltage or current. POWER ON, LOC SNS lamps lighted.	Loss of sensing. (Open RB or RG leads).	Check plant sensing circuit for an open. Check that the SNS relay on the ALARM CIRCUIT circuit pack CP3 is pulled in.
(m)	Rectifier operating. High DC output current (output voltage near normal). POWER ON lamp lighted.	CURRENT LIMIT ADJUST (R10) rheostat not properly adjusted.	Check current limit adjustment as outlined in Section 169-743-301.
(n)	Rectifier operating. High output voltage. POWER ON lamp lighted.	OUTPUT VOLTS ADJUST (R8) rheostat not properly adjusted.	Check output volts adjustment as outlined in Section 169-743-301.
		VOLTAGE REGULATOR and CURRENT LIMIT CIRCUITS circuit pack CP2 defective.	*Substitute circuit pack CP2.
(o)	Rectifier operating. Poor regulation at battery. POWER ON lamp lighted.	Excessive charge lead drop.	Check rectifier output lugs for tightness and good connection.
		VOLTAGE REGULATOR and CURRENT LIMIT CIRCUITS circuit pack CP2 defective.	*Substitute circuit pack CP2.

<u>Item</u>	<u>Trouble Condition</u>	<u>Probable Cause</u>	<u>Remedy</u>
(p)	Rectifier operating. Unstable output. POWER ON lamp lighted.	VOLTAGE REGULATOR and CURRENT LIMIT CIRCUITS circuit pack defective.	*Substitute circuit pack CP2.
		PULSE CIRCUITS circuit pack CP1 defective.	*Substitute circuit pack CP1.
		Defective thyristors Q1.1 and Q1.2.	Replace thyristors Q1.1 and Q1.2.
		PULSE CIRCUIT TRANSFORMER T2 defective.	Replace transformer T2.

\* Substitution of circuit packs may be performed without putting rectifier in test mode of operation.

**4.07 AC Input Check:**

- (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 ON—POWER OFF (S1) switch to the OFF position. The POWER OFF lamp lights.
- (3) Remove the F1 and F2 fuses.
- (4) Using the Fluke, Model 8100A, Digital Multimeter, set to the 1000-volts ac range, measure the ac input at terminals L1 and L2 of the ST3 contactor. The meter should indicate the following:

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

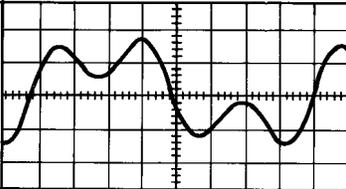
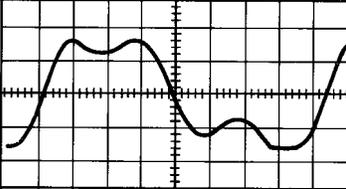
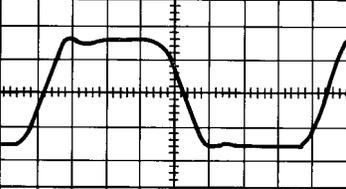
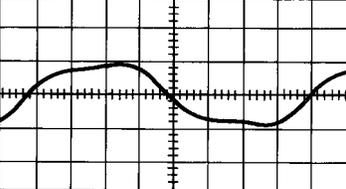
- (5) Remove the Fluke multimeter.
- (6) Replace the F1 and F2 fuses.

**4.08 Transformer Check:**

**Note 1:** Do not perform the following tests on the transformers until the ac input has been checked as in 4.07.

**Note 2:** Select a properly grounded oscilloscope. Connect only the probes to test points within the rectifier. Do not connect the ground probe(s) or lead(s) of the oscilloscope to any part of the rectifier.

- (1) Put the rectifier in the test mode of operation as in 3.08.
- (2) Using the Tektronix Model 545 oscilloscope, and KS-20538 volt-ohm-milliammeter, check the voltage at the terminals given in Fig. 4. The charts show typical ac voltages and waveforms at varying loads.
- (3) If the transformer checks are within reasonable limits, the trouble is probably within the KS-20618 regulator. See Section 024-490-301 for test procedures for the regulator.

LOAD (RESISTIVE)	T1		T2				WAVEFORM
	TERMINALS						
	5-4	5-6	1-2	4-3	4-5	6-7	
0 AMPS	20V	20V	40V	16V	16V	4V	
10 AMPS	24V	24V	48V	19V	19V	5V	
25-100 AMPS	29V	29V	58V	23V	23V	6V	
0 AMPS Q1.1 AND/OR Q1.2 SHORTED (DEFECTIVE THYRISTORS) SEE NOTE.	13V	13V	26V	11V	11V	3V	

NOTE:  
 IN THE TEST MODE OF OPERATION, IF RECTIFIER  
 OUTPUT VOLTAGE IS ABNORMALLY HIGH AND  
 OUTPUT VOLTAGE WILL NOT RESPOND TO OUTPUT  
 VOLTS ADJUST (R8) POTENTIOMETER, TURN RECTIFIER  
 OFF. OUTPUT VOLTAGE MUST BE REDUCED TO  
 CONTINUE TESTING BY TEMPORARILY CONNECTING A  
 14 GA JUMPER FROM TSI TERMINAL 1, TO  
 TSI TERMINAL 6. RECTIFIER OUTPUT VOLTAGE  
 UNDER THIS CONDITION WILL BE TYPICALLY  
 17 VOLTS.

Fig. 4—Waveforms—Checking Voltages at T1 and T2 Transformers