

RECTIFIERS
KS-20493, L21 AND L22
-48 VOLTS, 100 AMPERES
LORAIN PRODUCTS CORPORATION
TROUBLE-LOCATING INFORMATION

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1. GENERAL

1.01 The KS-20493 rectifier (Fig. 1 and 2) provides regulated dc power from a single-phase ac source normally for use in charging and floating a 24-cell battery plant.

Note: From 48.00 Vdc to 56.20 Vdc, the rated output current is 100 amperes. Beyond 57.20 Vdc, up to 61.40 Vdc, the rated output current is 80 amperes.

1.02 This section is reissued to:

- (a) Provide information on options ZK, ZL, ZN, and ZP
- (b) Incorporate an addendum
- (c) Update admonishments and trouble charts in accordance with new options.

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

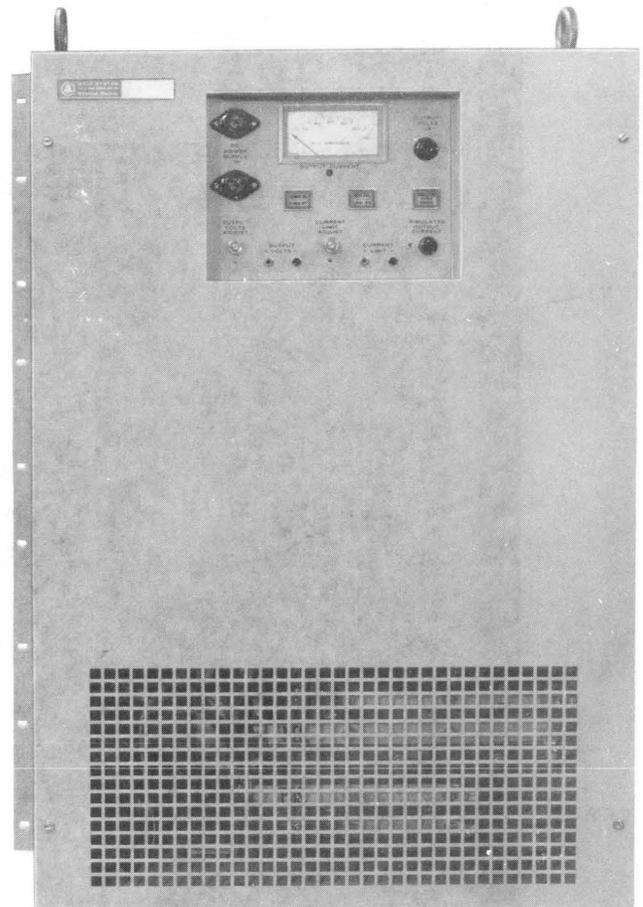


Fig. 1—KS-20493 Rectifier—Front View

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

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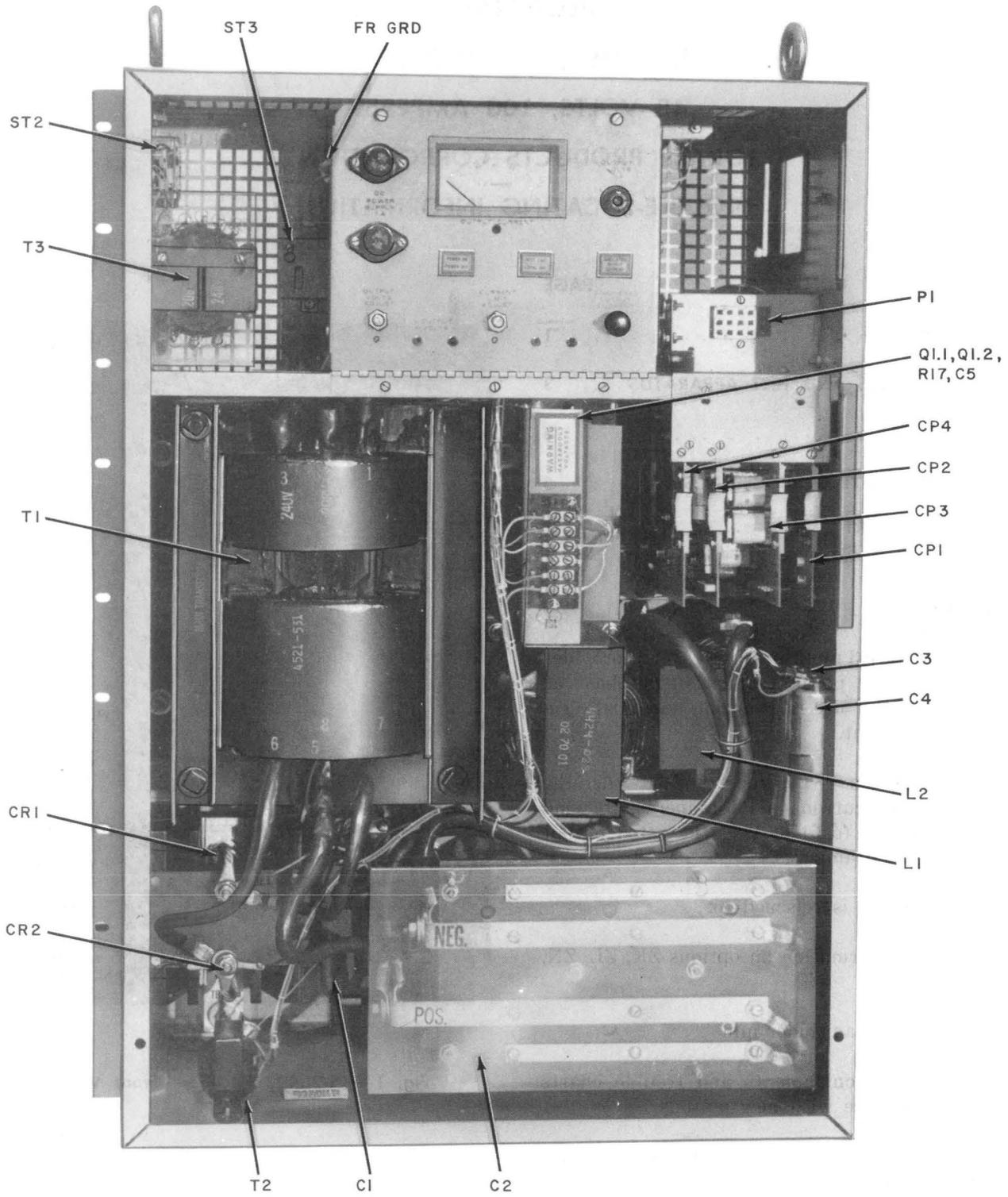


Fig. 2—KS-20493 Rectifier—Front Cover Removed

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 properly mated with the extender circuit (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-81999-01, Issue **7B**

SD-82030-01, Issue **6D**

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
TOOLS	
—	3-Inch C Screwdriver
TEST APPARATUS	
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-20493 rectifier will remain energized and connected to the battery. In addition to manual turnoff, 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 POWER ON—POWER OFF (S1) switch is 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*, operate 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

will operate to connect ac input power to the rectifier power circuit and the POWER ON lamp will light. 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.♦

Note: The CP2 circuit has been modified to improve possible unstable operation when rectifiers are operated in parallel. CP2 per KS-20618, L2 (A option) is replaced by CP2 per KS-20618, L7 (ZA option).

3.04 To shut down the rectifier, depress the POWER ON-POWER OFF (S1) switch to the OFF position. The POWER OFF lamp lights. In power plant operation, the power plant may shut down the rectifier by a ground signal on the plant "TR" lead. This releases the ST1 relay which releases 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 57.5 volts with an operate tolerance of ± 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 Overload Protection: If a rectifier fault should occur to short the rectifier output terminals, the external charge fuse operates, blowing the associated charge alarm fuse (or the external charge circuit breaker operates and auxiliary alarm switch closes). The rectifier shuts down and locks out. When the external charge alarm fuse operates (or auxiliary alarm switch closes), 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 or closed auxiliary alarm switch) 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" signals 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 protection devices operate 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 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 restarts 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 power.

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. 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 of battery load.

4. TROUBLE-LOCATING PROCEDURES

4.01 Troubles in the KS-20493 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 Locating troubles in 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.

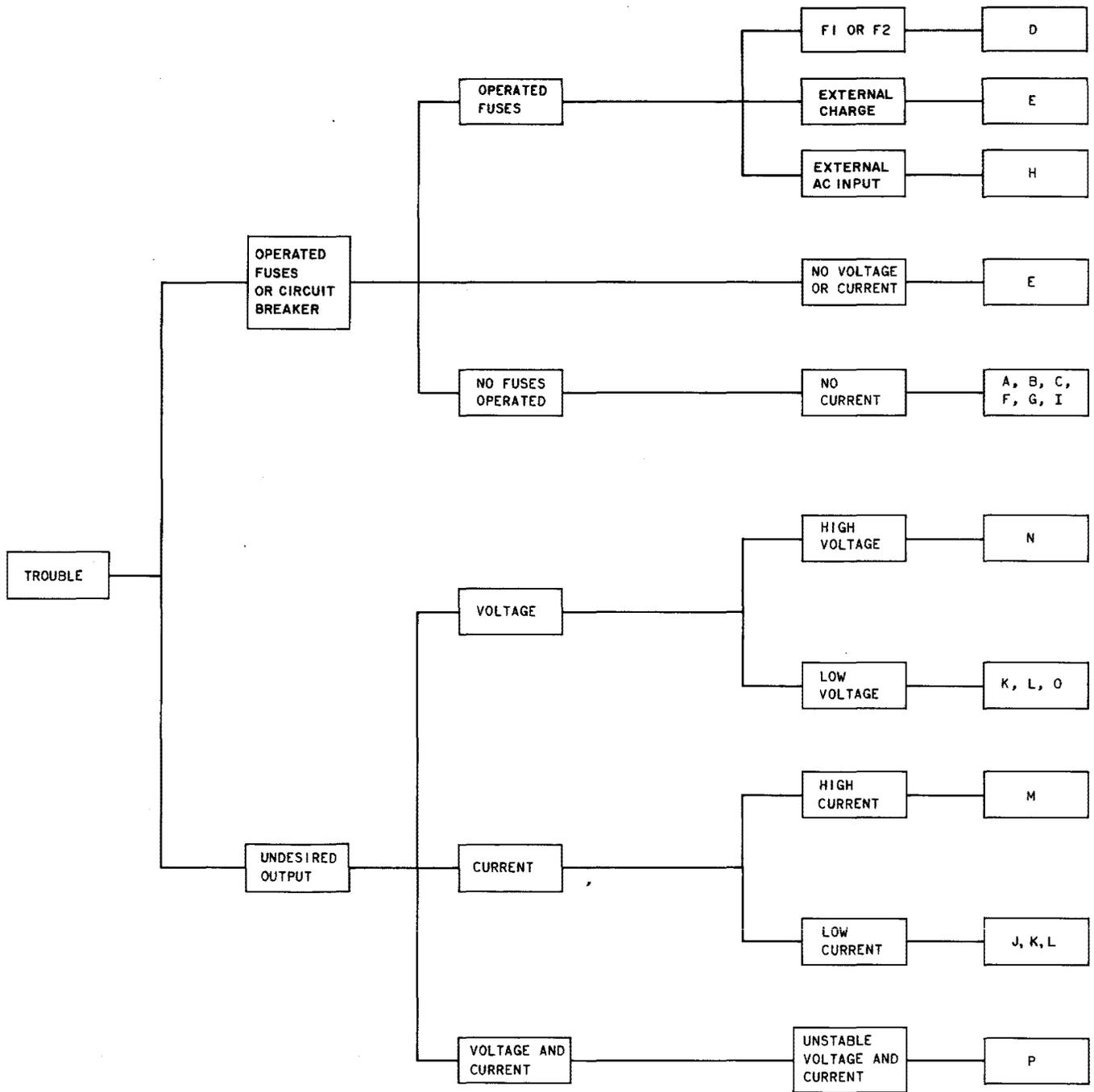


Fig. 3—Trouble-Locating Flowchart

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.

<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.
POWER ON	Lighted when POWER ON - POWER OFF (S1) switch is in the ON position.
LOCAL SNS	Lighted when RG or RB lead is broken or the plant control cable disconnected.

<u>LAMPS</u>	<u>CAUSE OF OPERATION</u>
RECT FAIL	→ Lighted whenever the rectifier CS 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 ZC option is provided.←
SIMULATED OUTPUT CURRENT	Lighted whenever the SIMULATED OUTPUT CURRENT (S2) switch is depressed.

TROUBLE CHART

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

SECTION 169-745-311

<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 contactor ST3.	Replace contactor ST3.
		Defective POWER ON-POWER OFF (S1) switch.	Replace (S1) switch.
(d)	Rectifier shutdown. DC POWER SUPPLY fuse (F1, F2) operated. POWER OFF, RECT FAIL lamps lighted.	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.
		Defective DC POWER SUPPLY TRANSFORMER T3.	Replace T3.
(e)	Rectifier shutdown. EXTERNAL CHARGE and CHARGE ALARM FUSE operated. POWER ON lamp lighted. →RECT FAIL lighted when ZC option is provided.←	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- → C2.6 ←	Disconnect AC input and operate POWER ON-POWER OFF (S1) switch once. Check capacitors C2.1- → C2.6 ←

<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 percent 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 pot. not properly adjusted.	Check output volts adjustment as outlined in Section 169-745-301.
		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. Re-operate 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 169-745-301.
		VOLTAGE REGULATOR and CURRENT LIMIT CIRCUITS circuit pack defective.	*Substitute circuit pack CP2.

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<u>ITEM</u>	<u>TROUBLE CONDITION</u>	<u>PROBABLE CAUSE</u>	<u>RÉMEDY</u>
		Defective thyristors Q1.1 and Q1.2.	Remove AC input power. Check for a defective thyristor Q1.1 and Q1.2.
		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 169-745-301.
		CURRENT LIMIT ADJUST (R10) rheostat not properly adjusted.	Check current limit adjustment as outlined in Section 169-745-301.
		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.
		MAIN TRANSFORMER (TI) defective.	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 169-745-301.
(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 169-745-301.
		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>
(o)	Rectifier operating. Poor regulation at battery. POWER ON lamp lighted.	Excessive charge lead drop. VOLTAGE REGULATOR and CURRENT LIMIT CIRCUITS circuit pack CP2 defective.	Check rectifier output lugs for tightness and good connection. *Substitute circuit pack CP2.
(p)	Rectifier operating. Unstable output. POWER ON lamp lighted.	VOLTAGE REGULATOR and CURRENT LIMIT CIRCUITS circuit pack CP2 defective. PULSE CIRCUITS circuit pack CP1 defective. Defective thyristors Q1.1 and Q1.2. PULSE CIRCUIT TRANSFORMER T2 defective.	*Substitute circuit pack CP2. *Substitute circuit pack CP1. Replace thyristors Q1.1 and Q1.2. Replace transformer T2.

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

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

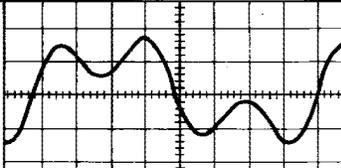
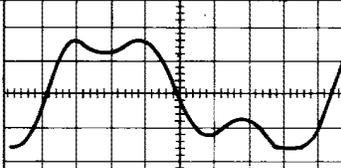
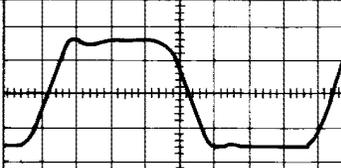
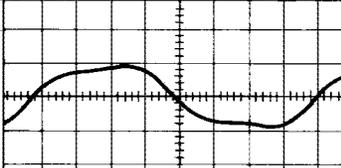
- (5) Remove the digital multimeter.
- (6) Replace the F1 and F2 fuses.

4.08 Transformer Check

Note 1: Do not perform the following tests on the transformer 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.

LOAD (RESISTIVE)	T1		T2				WAVEFORM
	TERMINALS						
	5-4	5-6	1-2	4-3	4-5	6-7	
0 AMPS	37V	37V	37V	15V	15V	4V	
10 AMPS	47V	47V	47V	19V	19V	5V	
25-100 AMPS	60V	60V	60V	23V	23V	6V	
0 AMPS Q1.1 AND/OR Q1.2 SHORTED (DEFECTIVE THYRISTORS) SEE NOTE.	32V	32V	32V	13V	13V	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

- (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.