KS-19212, L1 AND L2, RECTIFIERS
24 VOLTS, 1600 AMPERES
TROUBLE LOCATING

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Figures

1. GENERAL

1.01 The KS-19212, L1 and L2, semiconductor type rectifiers provide 24-volt, 1600-ampere dc power for floating and charging storage batteries primarily in 300-type power plants.

1.02 Whenever this section is reissued, the reason for reissue will be given in this paragraph. This issue does not affect the Equipment Test List.

Danger 1: The voltages inside these units exceed 150 volts to ground. Avoid all contact with terminals. Do not allow a test pick to touch two metal parts at the same time, as destructive or dangerous short circuits may occur.

Danger 2: Inductors and transformers of these rectifiers have class H insulation and the temperatures of the inner windings may be around 170° C (338° F). The outside temperatures will be proportionately high. Heat sinks and studs of semiconductor power devices may be around 90° C (194° F). Avoid all contact with these components to prevent burns.

Warning 1: Do not operate the TEST-MAN-AUTO switch to the MAN position unless the associated battery load or a 400-ampere minimum resistive load is connected to the output of the rectifier. The MAN position of the TEST-MAN-AUTO switch is used primarily for locating rectifier troubles and should not be left unattended in this position. When the TEST-MAN-AUTO switch is in the MAN position, the rectifier cannot maintain a constant output if the input line voltage should vary.

Warning 2: Verify that the OFF-NOR switch is in the OFF position before operating the SW1 and SW2 switches from one position to another.

1.03 This issue of the section is based on drawing SD-81629-01, Issue 4B. For a detailed description of the operation, see the corresponding circuit description (CD). If this section is to be used with an earlier or later issue of the schematic drawing (SD), 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.

1.04 For more detailed information on the operation of the KS-19212, L1 and L2, rectifiers, refer to Section 169-712-301. Procedures for maintaining the SW1 and SW2 switches of the KS-19212 rectifiers are contained in Section 169-712-701.

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

1.06 Semiconductor devices and printed circuit assemblies should be maintained in accordance with Section 032-173-301.

1.07 See Fig. 1, 2, and 3 for the locations of the major rectifier controls and components.

2. LIST OF TOOLS AND TEST APPARATUS

CODE OR SPEC NO.	DESCRIPTION
TOOLS	
—	3-inch C Screwdriver
TEST APPARATUS	
KS-14510	Volt-Ohm-Milliammeter
KS-20599, L4	Digital Multimeter (or equivalent) (see Danger)
—	Ground Fault Circuit Interrupter, Hubbell No. GFP 115, or equivalent
—	Isolation Plug, Hubbell No. BL-12-767, or equivalent
—	Oscilloscope-Tektronix 545B, or equivalent, equipped with current probe amplifier 134

Danger: In order to avoid the danger inherent in using isolated ac operated instruments, use the following procedure.

(1) ***Connect the ground fault circuit interrupter, Hubbell No. GFP 115, or equivalent, to a 115-volt source.***

(2) ***Insert the isolation plug, Hubbell No. BL-12-767, or equivalent, into the ground fault circuit interrupter.***

(3) ***Connect the ac operated instrument to the isolation plug.***

3. OPERATION

3.01 Normal operation of the KS-19212, L1 and L2, rectifiers shall be in accordance with Sections 169-712-301. In the event of a trouble condition, the rectifier should be removed from service and restored to service in accordance with Section 169-712-301. Before restoring the rectifier to service, it should be checked in accordance with paragraph 3.02.

3.02 ***Restoring The Rectifier To Service After a Trouble Condition:*** Under all trouble conditions, before placing the rectifier back in service, proceed as follows:

(1) Operate the OFF-NOR (S1) switch to the OFF position.

(2) Position the following rectifier controls as indicated:

POSITION	CONTROL
F	SW1 Switch
BAT	SW2 Switch
NOR	TEST-NOR (S4) Switch
TEST	TEST-MAN-AUTO (43) Switch
Midposition	RAISE-LOWER (84CS) Switch
Fully ccw	MAN Potentiometer

(3) Set the high contact of the AR1 ammeter relay to 2000 amperes.

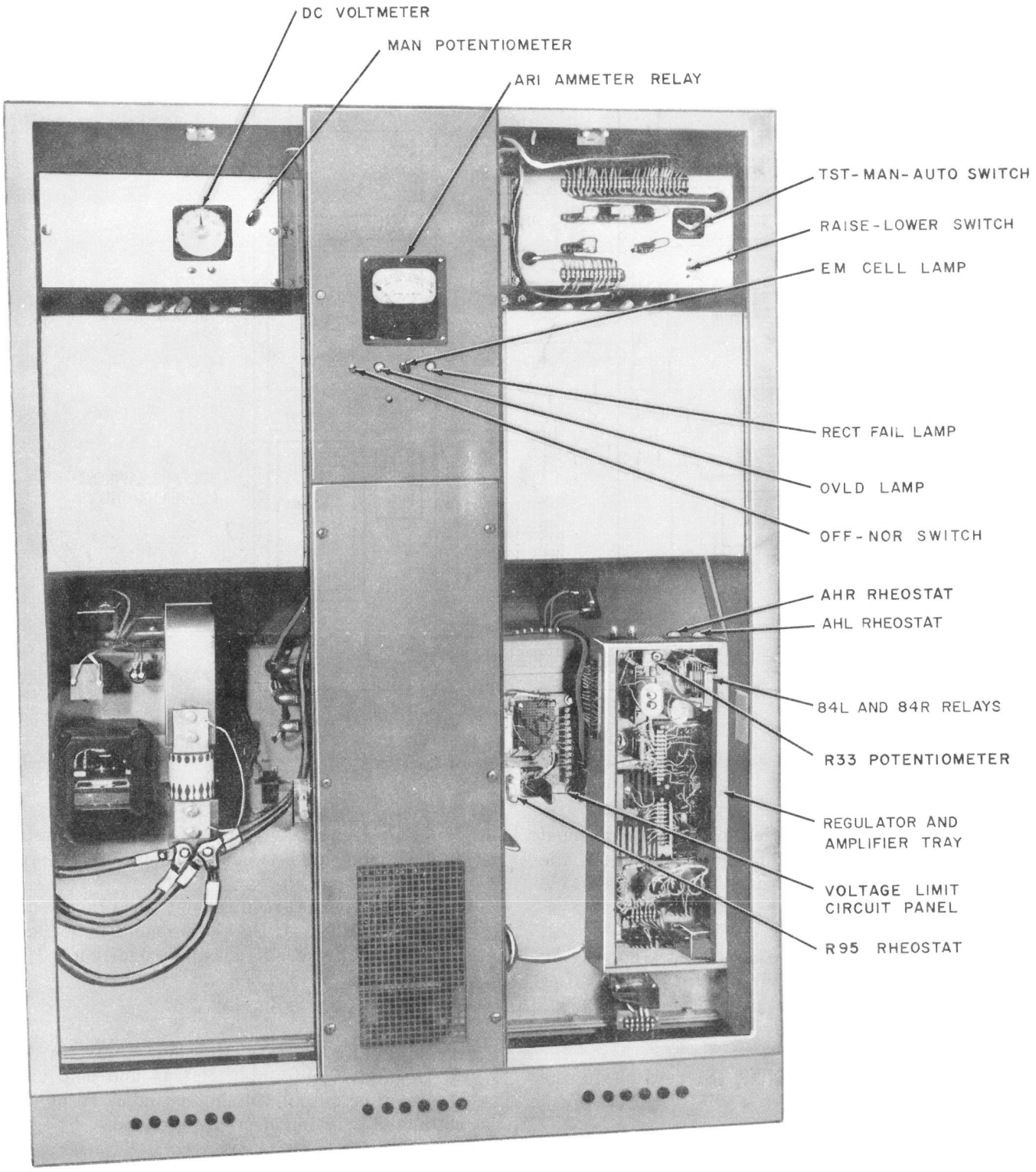

Fig. 1—KS-19212, L1 and L2, Rectifiers—Front View With Door Open

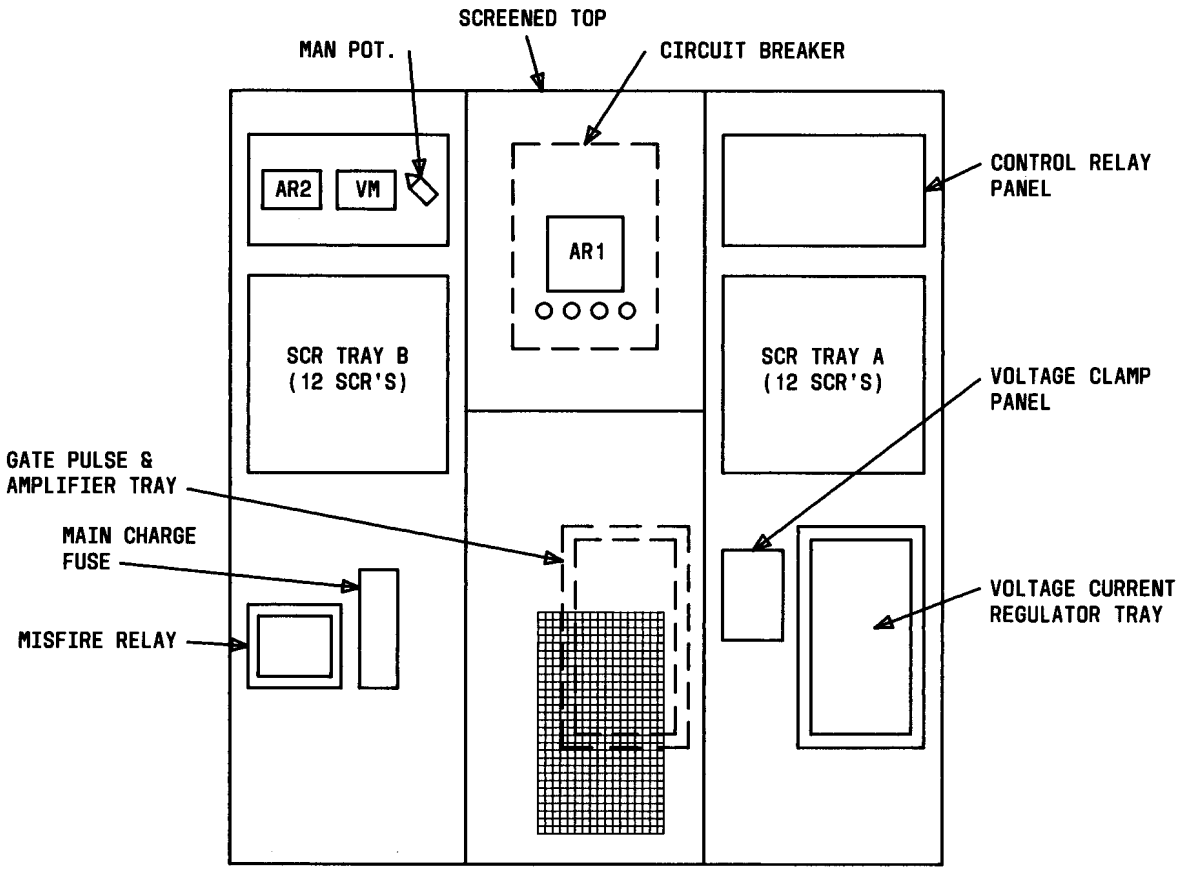

Fig. 2—Main Component Locations

(4) Verify that the rectifier load that is connected to the F and G terminals will allow the output current to increase to at least 1750 amperes.

(5) Block operated the associated ST relay in the plant control circuit for the rectifier being checked. Refer to Section 069-020-801 for information on relay blocking.

(6) Operate the OFF-NOR (S1) switch to the NOR position.

(7) Manually operate the 84R relay in the regulator and amplifier tray and hold.

Warning: Do not allow the rectifier output current to exceed 1740 amperes as damage to the rectifier may result.

Requirement: The AR1 ammeter relay should indicate between 1660 and 1740 amperes.

Note: If the requirement in (7) is met, proceed to (8). If the requirement is not met, refer to the specific trouble condition.

(8) Release the 84R relay.

(9) Manually operate the 84L relay in the regulator and amplifier tray and hold until the rectifier output voltage, as indicated on VM voltmeter, will not decrease any more.

(10) Release the 84L relay.

(11) Operate the OFF-NOR (S1) switch to the OFF position.

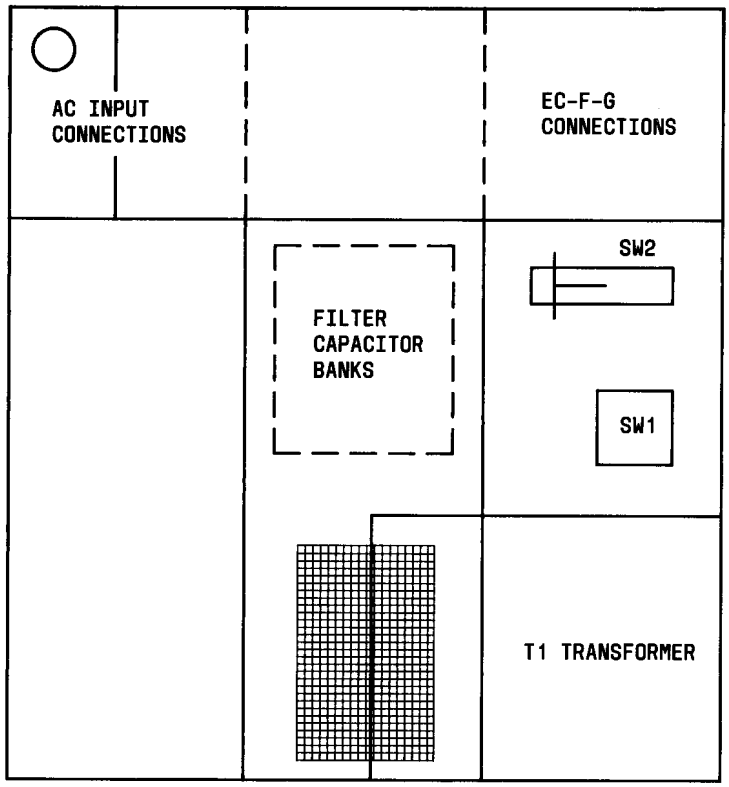

Fig. 3—Rear View—Doors Open

(12) Unblock the associated ST relay in the plant control circuit.

(13) Set the high contact of the AR1 ammeter relay at 1540 amperes, unless the associated power plant Bell System Practice specifies a different value.

4. TROUBLESHOOTING PROCEDURES

4.01 Failure of the KS-19212 rectifier will usually be characterized by one of the following four conditions.

- Operated fuses and consequent loss of output
- Operated circuit breakers and consequent loss of output
- Loss of output without operation of fuses and circuit breakers
- Erratic output, either voltage or current or both.

The trouble flowchart in Fig. 4 is designed to analyze troubles in rectifiers from the standpoint of these four symptoms. For example, if initial inspection of a faulty rectifier indicates a fuse is operated, the section of the trouble flowchart which applies to that particular fuse 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 troubleshooting procedure, check for faulty connections, 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. Check that all solder and pressure points

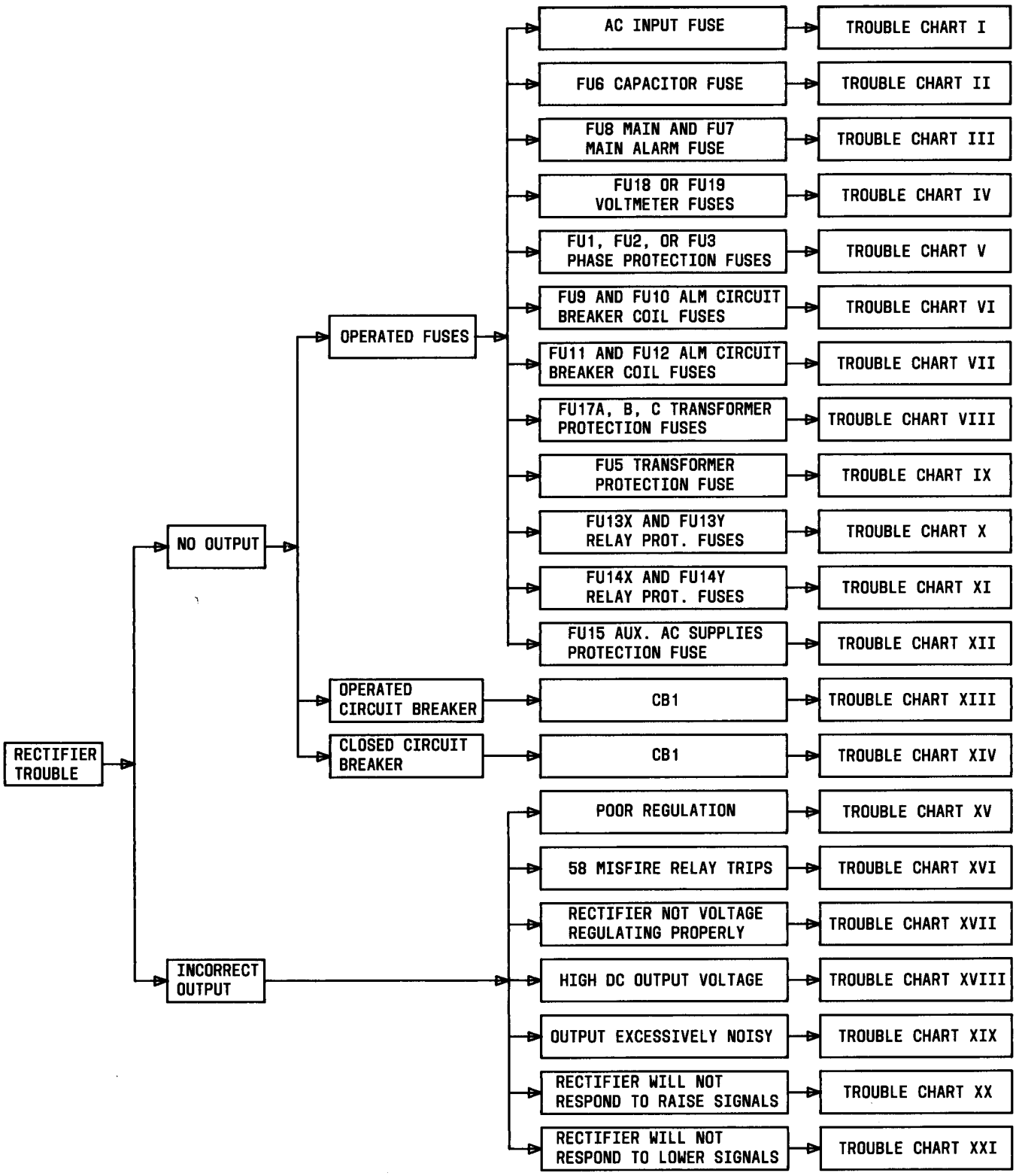

Fig. 4—Trouble Flowchart

make good electrical contact using a volt-ohmmeter. Inspect for evidence of poor connections at switch and bus joints.

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

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

Warning 1: 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.

Warning 2: Plus side of battery is grounded. When using an oscilloscope or any other test equipment powered from the AC line which has one probe connected to the chassis, that probe must always be connected to frame ground when troubleshooting the rectifier.

Warning 3: Under no circumstances should fuses of higher ratings than those specified be used.

Warning 4: Use caution when working with wrenches and test leads to prevent shorting the DC circuit.

4.06 Dynamic tests of certain components, such as diodes, transformers, and transistors used in KS-19212 rectifiers, are provided in Part 5. These tests are referenced in the Trouble Charts.

4.07 The following danger and warnings should be observed while operating or performing maintenance on the rectifier.

Danger 1: Voltages inside the rectifier are over 150 volts to ground. Avoid all contact with terminals.

Danger 2: Always disconnect the rectifier from battery and the ac service before performing repairs.

Warning 1: Do not remove any printed circuit assembly while the rectifier is in operation.

Warning 2: Verify that the OFF-NOR switch is in the OFF position before operating the S2 switch from one position to another.

Warning 3: With the rectifier shut down and disconnected from the battery [DC OUTPUT (S2) switch in the OFF position], the filter capacitors in the rectifier will discharge in approximately 1 minute. The output capacitors should be charged in accordance with Section 169-712-301 prior to operation of the DC OUTPUT (S2) switch to the BAT or EC position.

Warning 4: Operation of the rectifier while a trouble exists may cause additional failures of some components. It is essential, while testing, to be alert to the need of quickly shutting down the rectifier until the trouble is localized and corrected. Remove power from the circuit before removing and replacing printed circuit assemblies.

5. COMPONENT CHECKING PROCEDURES

5.01 The test procedures in paragraphs 5.02 through 5.06 are given to aid in determining a defective component not mounted on a circuit card. In general, the components most likely to become defective with use are semiconductor devices and capacitors. These tests should be made with the rectifier disconnected from ac input power and battery potential.

Warning 1: When using an ohmmeter for checking semiconductors, use mid-range ohm scale (scales below RX10,000 and above RX10). The high scale ohmmeter voltage may damage the semiconductor device. A scale too low can force excessive current through some semiconductors. Refer to Section 032-173-301.

Warning 2: Before soldering or unsoldering leads of semiconductors, refer to Section 032-173-301. Always use a heat sink when soldering leads on semiconductor devices.

Warning 3: Before checking circuits which contain electrolytic capacitors, reference should be made to Section 032-110-501.

5.02 ***Capacitors:*** When checking capacitors, determine if the capacitor can be checked safely in the circuit without disconnecting one lead from the capacitor. If either ac or dc voltage sources cannot be isolated from the capacitor under test, disconnect one lead from the capacitor terminal. Initially, the capacitor should be discharged by temporarily connecting a 100-ohm, 10-watt resistor across the capacitor terminals. When checking electrolytic capacitors, proper polarity of the test meter to the capacitor terminals must be observed. When using the KS-14510 meter, the black lead of the test meter must be connected to the (+) positive terminals of the capacitor and the red lead of the test meter is connected to the (-) negative capacitor terminal. When testing paper or mica capacitors, polarity of meter leads is not significant. To check a capacitor, proceed as follows:

(1) Set the KS-14510 meter on OHMS X 10,000 scale. (The ohmmeter battery voltage on the OHMS X 10,000 scale is 30 volts dc.)

(2) Connect the meter leads across the capacitor terminals (observing proper polarity for electrolytic capacitors).

Requirement: The ohmmeter indicates low resistance initially and then indicates an increase in resistance as the capacitor charges. Normal resistance readings are as follows:

(a) Paper or mica capacitor of less than 1 microfarad should read 100 megohms or more.

(b) Paper capacitors of more than 1 microfarad should read less than 100 megohms.

(c) Electrolytic capacitors should read greater than 100,000 ohms.

Note: For replacement and maintenance of aluminum type electrolytic capacitors, refer to Section 032-110-701.

5.03 ***Diodes:*** To check a diode, proceed as follows:

(1) Set the KS-14510 meter on the OHMS X 1000 scale. (The OHMS X 1000 scale provides minimum current drain—0.075 milliamperes).

(2) Connect the meter leads across the diode leads. Then reverse the meter connection across the diode.

Note 1: The meter indicates high resistance in one direction and low resistance in the opposite direction.

Note 2: Low resistance or high resistance in both directions indicates a possibly defective diode. If the check indicates a defective diode, disconnect one lead from the diode and repeat the resistance check.

Note 3: For additional information on diode test, refer to Section 032-173-301.

5.04 ***Transistors:*** To check a transistor, proceed as follows:

(1) Set the KS-14510 meter on the OHMS X 10 scale (digital meter on 1000 OHMS).

(2) Connect the meter leads as follows:

(a) Connect meter between emitter and collector leads of the transistor. Then reverse the meter connections to the emitter and collector.

Requirement: The meter indicates high resistance in both directions.

Note: Low or zero resistance in either direction indicates a defective transistor. If the check indicates a defective transistor, disconnect the emitter or collector lead and repeat the resistance check.

(b) Connect the meter between the emitter and base leads of the transistor. Then reverse the meter connections to the emitter and base.

Requirement: The meter indicates low resistance in one direction and high resistance in the opposite direction.

Note: Zero resistance indicates a shorted junction, infinite (∞) resistance indicates an open junction. If a short or open is indicated, disconnect the emitter lead and repeat the resistance check.

(c) Connect the meter between the collector and base leads of the transistor. Then reverse the meter connections to the collector and base.

Requirement: The meter indicates low resistance in one direction and high resistance in the opposite direction.

Note: Zero resistance indicates a shorted junction, infinite (∞) resistance indicates an open junction. If a short or open is indicated, disconnect the collector lead and repeat the resistance check.

5.05 ***Transformers:*** If a trouble condition still exists after checking the possibility of defective circuit cards, semiconductor devices, and capacitors, check for a possible defective transformer as follows:

(1) Set the KS-14510 meter on OHMS X 1000 scale.

(2) Connect the meter leads across each winding of the transformer.

Requirement: The meter indicates continuity—low resistance.

Note: High or infinite (∞) resistance indicates a defective winding.

(3) Connect the meter leads between the case and one winding terminal of the transformer.

Requirement: The meter indicates an open—infinite (∞) resistance.

Note: Low or zero resistance indicates a defective transformer.

5.06 ***Thyristors (Silicon-Controlled Rectifiers):*** Malfunctioning thyristors or their associated circuitry may exhibit the following symptoms:

- Thyristor reactor(s) very hot, possibly to the point of giving off smoke
- 58 relay (misfire circuit) functioning, causing the 52 (CB-1) circuit breaker to trip (open)
- Thyristor heat sink cold after a period of loading.

The following method may be used to check for possibly defective thyristor circuitry.

Note: Before proceeding, visually inspect the SCR for cracks, burns, or scorched spots on the porcelain which may indicate an open SCR.

(1) Locate the 12 input cables at the top of the thyristor power trays.

(2) Connect the P6021 current probe to the 545B oscilloscope.

(3) Place the rectifier in the MAN mode of operation of Section 169-712-301.

Warning 1: Do not operate the unit above 1/4 rated load until the trouble is cleared.

Warning 2: Under no circumstances should any adjustments of the six rheostats located at the top of the gate pulse generator tray be made.

(4) Connect the current probe to each of the 12 input cables and record the current readings.

Requirement: Current balance is considered satisfactory if no pair of cells indicates a difference exceeding 10 percent of the average.

(5) Remove the rectifier from service in accordance with the following procedures:

(a) Remove the rectifier from plant operation in conformance with the associated power plant Bell System Practice.

(b) Operate the NOR-OFF switch to the OFF position.

(c) Operate the rectifier circuit breakers to the OFF position.

(d) Operate the associated switch and fuse unit in the bus duct or power service cabinet to OFF position.

(e) Operate the SW2 switch to the OPEN position.

(6) Disconnect the questionable thyristor gate lead at the T-13 transformer secondary terminals.

(7) Prepare the test set-up shown in Fig. 5 and perform (8) through (12).

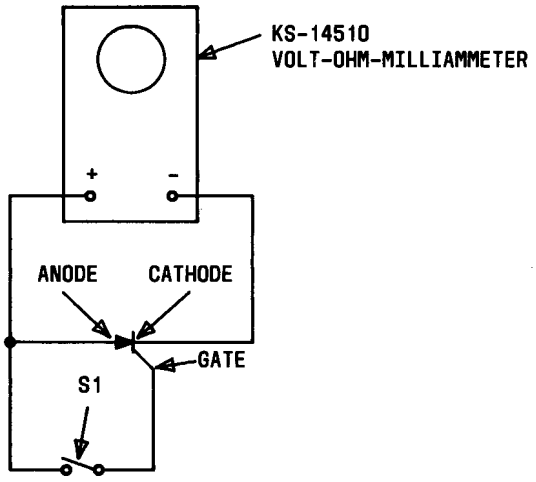

Fig. 5—SCR Test Set-Up

(8) Connect an ohmmeter as shown in Fig. 5:

(a) Cathode to the negative voltage

(b) Anode to the positive voltage

(c) Switch S1 in OFF position between gate and anode.

(9) With the ohmmeter in the RX1 scale, operate switch S1 to the ON position.

Requirement: The ohmmeter indicates a resistance of from 20 to 50 ohms.

(10) Operate switch S1 to the OFF position.

Requirement: The resistance reading of (9) remains unchanged.

(11) Momentarily disconnect one end of the lead from the cathode of the SCR to the negative voltage at the meter.

Requirement: The resistance reading is infinite.

(12) Reconnect the lead end that was removed in (11).

Requirement: The resistance reading is infinite until S1 is again closed.

Note: Failure to achieve any of the above requirements indicates a faulty silicon controlled rectifier.

5.07 *AR1 General Electric Type 195 Ammeter Relay—List 1 and 2 Rectifiers:*

(a) ***General:*** The low- and high-set signals are given by the AR1 ammeter relay when the light-activated SCR (LASCR) is cut off by the meter pointer blocking the light source (lamp) within the instrument. When the LASCR is cut off, the associated low-set and high-set relays within the ammeter relay housing release. In the event the lamp burns out, both the low-set and high-set relays are released. With the lamp burned out, the logic of the plant circuit is such that the rectifier will accept lower signals but will not accept raise signals because ground signal is maintained on the OC lead.

(b) ***Lamp Check:*** With the rectifier operating and provided the high-set pointer of the AR1 ammeter relay is not positioned over the high-set point, the high-set relay is energized and the normally open contacts 8 and 12, and 9 and 13 of the high set are closed. If it is suspected that the lamp is burned out, connect the KS-14510 volt-ohm-milliammeter, set on the X100 OHMS scale, between contacts 8 and 12, or 9 and 13 of the ammeter relay. An open circuit indication will indicate that the high-set relay is released (contacts 8 and 12, or 9 and

13 open) and the lamp is burned out. This check is valid only if the high-set relay is not defective.

5.08 ***AR1 and AR2 General Electric Type 195 Ammeter Relays—List 3 and 4 Rectifiers:***

(a) ***General:*** The low- and high-set signals are given by the ammeter relay when the light activated SCR (LASCR) is cut off by the meter pointer blocking the light source (lamp) within the instrument. When the LASCR is cut off, the associated low-set and high-set relay within the ammeter relay housing releases. In the event the lamp burns out, both the low-set and high-set relays are released. With the AR1 lamp burned out, the logic of the plant circuit is such that the rectifier will accept lower signals but not raise signals because ground signal is maintained on the SP lead. If the lamp in the AR2 relay is burned out, the plant logic is such that on increasing plant load the next rectifier in the chain will never begin operation because a ground signal is maintained on the CL lead.

(b) ***Lamp Check:*** With the rectifier operating, and provided the high-set pointer of the ammeter relay is not set on the high-set point, the high-set relay is energized and the normally open contacts 8 and 12, and 9 and 13 of the high-set relay are closed. If it is suspected that the lamp is burned out, connect the KS-14510 volt-ohm-milliammeter, set to the RX100 range, between contacts 8 and 12, and 9 and 13 of the ammeter relay. An open circuit indication will indicate that the high-set relay is released (contacts 8 and 12, and 9 and 13 open) and the lamp is burned out. This check is valid only if the high-set relay is not defective.

5.09 ***AR1 General Electric Type 195 Ammeter Relay—List 11 and 12 Rectifiers:***

(a) ***General:*** The low-set signal is given by the ammeter relay when the light activated SCR (LASCR) is cut off by the meter pointer blocking the light source (lamp) within the instrument. When the LASCR is cut off, the low-set relay within the AR1 ammeter relay housing releases.

(b) ***Lamp Check:*** If it is suspected that the lamp in the AR1 ammeter relay is burned out, connect the KS-14510 volt-ohm-milliammeter, set to the RX1000 range, between the CA and CB leads. An open circuit indication will indicate that the lamp is burned out, providing the rectifier output exceeds 160 amperes.

5.10 ***General Electric Type 195 Ammeter Relay—All List Numbers—Lamp Replacement:*** The General Electric type 195 (AR1) ammeter relay consists of two separate units, an indicator set-point unit and a control unit. The lamp is contained in the indicator set-point unit which is piggy-back mounted on the control unit. In the event of a lamp failure, the lamp may be removed by removing the control unit from the set-point unit and then loosening the two screws on the rear of the indicator set-point unit in order to rotate the lamp cover. The lamp may then be pulled out of the lamp holder and replaced.

TROUBLE CHART 1

OPERATED AC INPUT FUSES

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
RECT FAIL	OUTPUT VOLTAGE 0 AR1 CURRENT 0	Ground on LP Lead.
PROBABLE CAUSE	**TEST PROCEDURE**	**CORRECTIVE ACTION**
Shorted thyristor SCR1A, 1B through SCR6A, 6B (24 thyristors total)	Check thyristors per paragraph 5.06	Replace defective thyristors.

TROUBLE CHART 2

OPERATED FU6 CAPACITOR FUSES

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
RECT FAIL	OUTPUT VOLTAGE 0 AR1 CURRENT 0	Ground on LP Lead.
PROBABLE CAUSE	**TEST PROCEDURE**	**CORRECTIVE ACTION**
Shorted capacitor in C18 filter capacitor bank	Check capacitors per paragraph 5.02	Replace capacitor as required.

TROUBLE CHART 3

OPERATED FU8 MAIN FUSE AND FU7 MAIN ALM FUSE

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
OVLD	OUTPUT VOLTAGE 0 AR1 CURRENT 0	GROUND ON LP LEAD.
PROBABLE CAUSE	**TEST PROCEDURE**	**CORRECTIVE ACTION**
A. Overload permitted by incorrect setting of AR1 ammeter relay high contact	Check setting in accordance with Section 169-712-301	Reset ARI high contact in accordance with Section 169-712-301.
B. Overload permitted by faulty or blocked 84R relay	Manually operate relay to determine that relay will operate mechanically	Repair or replace as required.

TROUBLE CHART 4

OPERATED VOLTMETER FUSES FU18 (Y) OR FU19 (X)

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
	OUTPUT VOLTAGE 0 AR1 CURRENT — NORMAL	
PROBABLE CAUSE	**TEST PROCEDURE**	**CORRECTIVE ACTION**
Defective or shorted VM voltmeter	Using the KS-14510 volt-ohm-milliammeter; check for shorted voltmeter	Repair or replace as required.

TROUBLE CHART 5

OPERATED FU1, FU2, OR FU3 PHASE PROTECTION FUSES

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
RECT FAIL	OUTPUT VOLTAGE 0 AR1 CURRENT 0	GROUND ON LP LEAD.

	PROBABLE CAUSE	TEST PROCEDURE	CORRECTIVE ACTION
A.	Short circuit condition on one or more Gate Pulse Boards	Remove power from the rectifier and substitute a new or repaired board for one that shows signs of excessive heating	Replace Gate Pulse Boards as necessary.
B.	Shorted winding on transformers T7, T8, or T13	Check transformers per paragraph 5.05	Replace as necessary.
C.	Defective amplifier circuit board	Remove power from rectifier and substitute a new or repaired amplifier board	Replace as necessary.
D.	Shorted capacitor C2 on primary side of T7	Check capacitor per paragraph 5.02	Replace as necessary.

TROUBLE CHART 6

OPERATED FU9 AND FU10 ALARM CIRCUIT BREAKER COIL FUSES

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
RECT FAIL	OUTPUT VOLTAGE 0 AR1 CURRENT 0	GROUND ON LP LEAD.
PROBABLE CAUSE	**TEST PROCEDURES**	**CORRECTIVE ACTION**
Shorted 52X closing control relay coil	With power removed from the rectifier and using a KS-14510 volt-ohm-milliammeter check the coil of 52X for a short circuit condition	Repair or replace as required.

TROUBLE CHART 7

OPERATED FU11 AND FU12 ALARM CIRCUIT BREAKER COIL FUSES

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
RECT FAIL	OUTPUT VOLTAGE 0 AR1 CURRENT 0	GROUND ON LP LEAD.
PROBABLE CAUSE	**TEST PROCEDURE**	**CORRECTIVE ACTION**
Shorted 52UV under voltage relay coil	With power removed from the rectifier and using a KS-14510 volt-ohm-milliammeter check the coil of 52UV for a short circuit condition	Repair or replace as required.

TROUBLE CHART 8

OPERATED FU17A, FU17B, AND FU17C TRANSFORMER PROTECTION FUSES (Y AND Z OPTIONS)

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
RECT FAIL	OUTPUT VOLTAGE 0 AR1 CURRENT 0	GROUND ON LP LEAD.

	PROBABLE CAUSE	TEST PROCEDURE	CORRECTIVE ACTION
A.	Short circuit condition in manual supply	Check C23A capacitor and DZ8A diode for short circuit per paragraphs 5.02 and 5.03	Replace as necessary.
B.	Short circuit condition in error detector circuit	Check C23B capacitor for short circuit per paragraph 5.02	Replace as necessary.
C.	Short circuit condition in current reference circuit	Check C23C capacitor for short circuit per paragraph 5.02	Replace as necessary.

TROUBLE CHART 9

OPERATED FU5 TRANSFORMER PROTECTION FUSE

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
RECT FAIL	OUTPUT VOLTAGE 0 AR1 CURRENT 0	GROUND ON LP LEAD.

PROBABLE CAUSE	TEST PROCEDURE	CORRECTIVE ACTION
Short circuit condition in controlled current regulator circuit (x option)	Check C16 capacitor per paragraph 5.02	Replace as necessary.

TROUBLE CHART 10

OPERATED FU13X (X OPTION) AND FU13Y (Y OPTION) RELAY PROTECTION FUSES (LIST 2)

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
RECT FAIL	OUTPUT VOLTAGE 0 AR1 CURRENT 0	GROUND ON LP LEAD.

	PROBABLE CAUSE	TEST PROCEDURE	CORRECTIVE ACTION
A.	Faulty closing coil 52CLC	With power removed from the rectifier and using a KS-14510 volt-ohm-milliammeter, check the 52CLC coil for short circuit condition	Replace as necessary.
B.	Faulty 3 relay (ZS option)	With power removed from the rectifier and using a KS-14510 volt-ohm-milliammeter, check the 3-relay coil for short circuit condition	Replace as necessary.

TROUBLE CHART 11

OPERATED FU14X (X OPTION) AND FU14Y (Y OPTION) RELAY PROTECTION FUSES (LIST 1)

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
RECT FAIL	OUTPUT VOLTAGE 0 AR1 CURRENT 0	GROUND ON LP LEAD.

	PROBABLE CAUSE	TEST PROCEDURE	CORRECTIVE ACTION
A.	Faulty closing coil 52CLC	With power removed from the rectifier and using a KS-14510 volt-ohm-milliammeter, check the 52CLC coil for short circuit condition	Replace as necessary.
B.	Faulty 3 relay (ZS option)	With power removed from the rectifier and using a KS-14510 volt-ohm-milliammeter, check the 3-relay coil for short circuit condition	Replace as necessary.

TROUBLE CHART 12

OPERATED FU15 AUXILIARY AC SUPPLIES PROTECTION FUSE

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
RECT FAIL	OUTPUT VOLTAGE 0 AR1 CURRENT 0	GROUND ON LP LEAD.
PROBABLE CAUSE	**TEST PROCEDURE**	**CORRECTIVE ACTION**
A. Faulty DCCT current transformer coil windings 3 and 4, 5 and 6 on T3 transformer.	With power removed from the rectifier and using a KS-14510 volt-ohm-milliammeter, check coil windings for short circuit	Replace as required.
B. Shorted R45A or R45B varistor	With power removed from the rectifier and using a KS-14510 volt-ohm-milliammeter, check varistors for short circuit condition	Replace as required.

TROUBLE CHART 13

RECTIFIER WILL NOT START (CB1 WILL NOT CLOSE)

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
RECT FAIL	OUTPUT VOLTAGE 0 AR1 CURRENT 0	GROUND ON LP LEAD.
PROBABLE CAUSE	**TEST PROCEDURE**	**CORRECTIVE ACTION**
A. No control power (undervoltage relay on CS-1 not energized)	Check for presence of battery control voltage at WEB terminal strip. Check fuses	Trace connecting circuit for open. Replace fuses as required.
B. No ac input voltage at input to unit	Check input for ac power	Notify power company if other than a temporary condition.
C. 58 misfire relay set at 0		Reset 58 misfire relay to 1.5.

TROUBLE CHART 14

RECTIFIER WILL NOT START (CB1 CLOSES)

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
RECT FAIL	OUTPUT VOLTAGE 0 AR1 CURRENT 0	GROUND ON LP LEAD.

	PROBABLE CAUSE	TEST PROCEDURE	CORRECTIVE ACTION
A.	DC OUTPUT switch (SW2) in open position	Inspect setting	Close DC OUTPUT switch to desired position.
B.	Open control lead at TB1-17	Check continuity of control circuit	Repair or replace as necessary.
C.	Q7 transistor not firmly engaged in socket	Check that Q7 is tight in socket	Reposition as necessary.
D.	Math 2000-ampere dc output fuse opened	Check fuse for continuity	Replace as necessary.

TROUBLE CHART 15

POOR REGULATION

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
	OUTPUT VOLTAGE — ERRATIC AR1 CURRENT — ERRATIC	

	PROBABLE CAUSE	TEST PROCEDURE	CORRECTIVE ACTION
A.	Improper transformer T1 primary tap connections for the nominal plant voltage		Check and change, if necessary, the transformer T1 tap connections per the nominal plant voltage vs. the transformer tap voltages as depicted by SD-81629-01.
B.	Faulty Q7 transistor in regulator tray	Substitute new transistor	Replace as necessary.
C.	Faulty regulator tray	Operate the 43 switch to TEST and perform the normal test position checks thus determining if the regulator tray is performing its intended functions	Readjust as necessary.

TROUBLE CHART 16

58 MISFIRE RELAY TRIPS (CB1 DE-ENERGIZED)

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
RECT FAIL	OUTPUT VOLTAGE 0 AR1 CURRENT 0	GROUND ON LP LEAD.

PROBABLE CAUSE	TEST PROCEDURE	CORRECTIVE ACTION
A. Major input line unbalance or improper tap connections on transformer T1	Check input line for balance under load conditions and check T1 tap connections	Notify power company if any phase-to-phase reading is more than 5 percent different from the average of all readings. Adjust tap switch as required.
B. Open fuse in gate pulse generator tray	Check fuses for continuity	Replace as necessary.
C. Faulty SCR	Check per paragraph 5.06	Replace as necessary.
D. Faulty T13 transformer	Check per paragraph 5.05	Replace as necessary.
E. Faulty gate pulse generator tray	Operate the 43 switch to TEST and perform the normal test position checks thus determining if the regulator is performing its intended function	Repair or readjust as necessary.

TROUBLE CHART 17

RECTIFIER NOT VOLTAGE REGULATING PROPERLY (LIST 3 AND 4)

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
PROBABLE CAUSE	**TEST PROCEDURE**	**CORRECTIVE ACTION**
A. CR relay energized via plant CC signal lead, TS-1	If the rectifier is the master and is intended for voltage regulation, then the CR relay should not be energized. The same is true for the CRL relay.	Connections to plant must be changed.
B. Transformer T-1 is connected on wrong taps according to the nominal plant voltage	Check and change, if necessary, the transformer T1 tap connections per the nominal plant voltage with respect to the transformer tap voltages as depicted by SD-81629-01	Readjust as required.
C. Sensing lead is open to battery	Check sensing lead for continuity.	Repair or replace as necessary.
D. Faulty regulator tray	Operate the 43 switch to the TEST position. Determine if the regulator tray is performing its regulation function as it should by adjusting the voltage control rheostat on the regulator tray and observing the rectifier bus voltage. The bus voltage should follow the adjustment of R76. (Voltage regulation is ±1.0 percent). If the regulator tray checks out satisfactorily, the interconnecting harness between the rectifier bus and the regulator tray should be carefully checked.	If it is determined that the regulator tray is not functioning properly, it is recommended that the tray be replaced rather than troubleshooting the individual circuits.

TROUBLE CHART 18

HIGH DC OUTPUT VOLTAGE

LAMP INDICATION	METER INDICATION	PLANT SIGNALS

	PROBABLE CAUSE	TEST PROCEDURE	CORRECTIVE ACTION
A.	DC OUTPUT Switch (SW-2) in EMC position	Check position of SW-2 for proper position with respect to SW-3	Reposition SW-2 as required.
B.	Output volts adjust potentiometer not adjusted properly	Check adjustment of output voltage in accordance with the following sections: L1, L2 169-712-301 L3, L4 169-713-301 L11, L12 169-713-312	Readjust as necessary.
C.	MAX VOLT LIMIT (R95) potentiometer not adjusted properly (List 1 and 2 only)	Check adjustment of potentiometer in accordance with Section 169-712-301	Readjust as necessary.
D.	Voltage clamp circuit not operating properly	Check voltage at input to voltage clamp panel and for correct operation of relay 59 (located on clamp panel). Check for proper setting of rheostat on voltage clamp panel	Readjust as necessary.
E.	Gate pulse generator tray not operating properly	Check voltage at input of gate pulse generator tray at RE1, A and B. Voltage should not exceed 22V dc.	Troubleshoot input circuits.

TROUBLE CHART 19

OUTPUT EXCESSIVELY NOISY

LAMP INDICATION	METER INDICATION	PLANT SIGNALS

	PROBABLE CAUSE	TEST PROCEDURE	CORRECTIVE ACTION
A.	Defective filter capacitor in C18 filter capacitor bank	Check capacitors in accordance with paragraph 5.02	Replace capacitor as required.
B.	Unbalanced ac line voltage	Check ac input voltage. The phase-to-phase voltage should not vary more than 5 percent of the average	Notify power company if other than a temporary condition.

TROUBLE CHART 20

RECTIFIER WILL NOT RESPOND TO RAISE SIGNALS (LIST 1 AND 2)

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
	OUTPUT VOLTAGE — LOW AR1 CURRENT— NORMAL	

	PROBABLE CAUSE	TEST PROCEDURE	CORRECTIVE ACTION
A.	Raise rate potentiometer (AHR) incorrectly adjusted	Check adjustment in accordance with section 169-712-301	Readjust as required.
B.	Defective 84R relay	Test operate the 84R relay	Replace as required.
C.	Open circuit condition on plant RR lead preventing battery signal from reaching rectifier	Check for presence of battery voltage on RR lead. If absent, check for bad connections, blown plant control fuses and broken wires.	Repair and replace as necessary.
D.	Defective AR1 ammeter relay	Check per paragraph 5.07	Replace as required.

TROUBLE CHART 21

RECTIFIER WILL NOT RESPOND TO LOWER SIGNALS (LIST 1 AND 2)

LAMP INDICATION	METER INDICATION	PLANT SIGNALS
	OUTPUT VOLTAGE — HIGH AR1 CURRENT— NORMAL	
PROBABLE CAUSE	**TEST PROCEDURE**	**CORRECTIVE ACTION**
A. Lower rate potentiometer (AHL) incorrectly adjusted	Check adjustment of potentiometer in accordance with Section 169-712-301	Readjust as required.
B. Defective 84L relay	Test operate 84L relay	Replace as required
C. Open circuit condition on plant RL lead preventing battery signal from reaching rectifier	Check for presence of battery voltage on RL lead. If absent, check for bad connections, blown plant control fuses, and broken wires	Repair and replace as required.