KS-21113 RECTIFIER
WARREN COMMUNICATIONS COMPANY
140 VOLTS, 200 AMPERES
OPERATING METHODS

CONTENTS PAGE

1. GENERAL

1.01 The KS-21113 L1 and L2 rectifiers provide an isolated, filtered, and regulated DC output voltage for automatically floating and charging 70-cell, lead acid, battery plants. These rectifiers are initially intended for use in 415 type power plants but may be used wherever their characteristics and design apply. The rectifiers operate on a 3-phase, 57- to 63-Hz alternating current. The L1 and L2 rectifiers are rated at +154 volts DC, 200 amperes; however, they will produce up to 163 volts DC for initial charging of 70 cells.

1.02 Whenever this section is reissued, the reason for reissue will be listed in this paragraph. This section does affect the Equipment Test List.

Warning 1: The voltages in this unit 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 and dangerous short circuits may occur. Disconnect the ac input power to the rectifier before working on the unit except when necessary to make tests.

Warning 2: This rectifier includes automatically controlled equipment. Extreme care must be exercised to prevent automatic starting of those parts of the rectifier on which maintenance work is to be done. Before starting work, prevent automatic starting of equipment by removing fuses, blocking relays, opening switches, etc, as necessary. When maintenance work has been completed, make sure that the circuit has been restored to normal.

Caution: No output fusing is provided in the rectifier; under no circumstances should rectifier be operated on battery without a KS-21114 control and dc distribution bay or other approved means of fusing.

1.03 The instructions given in this practice are based on circuit schematic drawing SD-82241-01, Issue 1. For a detailed description of operation, see the corresponding circuit description.

2. LIST OF TOOLS AND TEST APPARATUS

CODE OR SPEC NO.	DESCRIPTION
TOOLS	
—	3-Inch C Screwdriver
KS-21113 L221	Extender Board
TEST APPARATUS	
KS-20599 L4	Digital Multimeter or approved equivalent (4 1/2 digits minimum)

3. OPERATION

3.01 ***Preparing to Start:*** When preparing to initially place the rectifier in service:

(a) Ascertain that ac power is off.

(b) Check that input AC connections are secure.

(c) On L1 rectifiers, check that T1 transformers are connected for correct input voltage (208/240).

(d) Check that output DC connections are secure.

(e) Check that plant connections are properly made.

(f) Check that all fuses and lamps are installed in their respective holders (except CHG fuse in the KS-21114 DC bay).

(g) Check that all circuit packs are correctly installed (Fig. 1).

(h) Disconnect the plant connector P900 (Fig. 2).

(i) The associated CHG fuse and its alarm fuse in the KS-21114 DC bay should be out and the DC voltage at the rectifier terminals must be zero.

(j) Replace all front panels and close the control panel (Fig. 1).

3.02 ***Starting:*** To start the rectifier, proceed as follows.

(1) Operate the associated circuit breaker or switch and fuse unit in the ac power cabinet to the ON position.

Requirement: The POWER OFF lamp is lighted.

Note 1: If the RECT FAIL lamp lights in addition to POWER OFF, the POWER ON/POWER OFF pushbutton is in the ON position. Depress the pushbutton one time only. The RECT FAIL lamp should extinguish.

Note 2: If the RECT FAIL lamp will not extinguish or if other lamp indications are noted, refer to Part 5.

(2) Depress the POWER ON/POWER OFF pushbutton one time.

Requirement: The rectifier and fans start. The POWER OFF lamp is extinguished; the POWER ON lamp lights.

(3) Connect the KS-20599 multimeter at the test jacks on the rectifier labeled + REG and − REG.

Requirement: Voltage indicated on the KS-20599 multimeter is 151.9 volts ±0.76.

Note: Output voltage may be adjusted if necessary by rotating the potentiometer adjustment that is accessible through the small hole in the control panel (see Fig. 3).

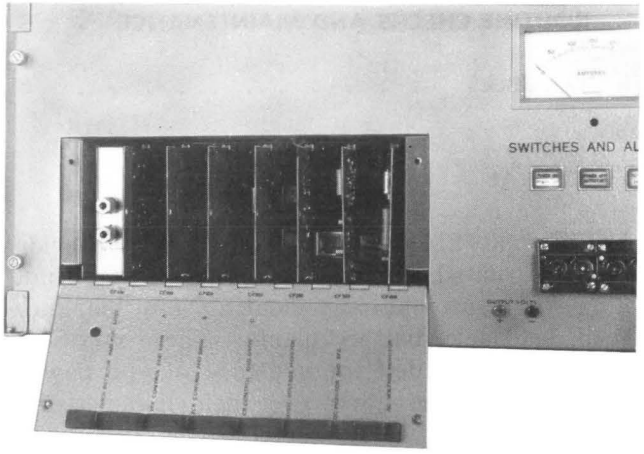

Fig. 1—KS-21113 L1 Rectifier-Circuit Packs

(4) Disconnect the KS-20599 multimeter.

(5) Check that voltmeter on KS-21114 dc bay indicates correct battery voltage.

Requirement: Indicated battery voltage is 151.9 volts. If the battery voltage is less than 151.9 volts ±0.76, refer to Part 5.

(6) Replace CHG fuse in the KS-21114 dc bay. This connects the rectifier to battery with the filter capacitor fully charged.

(7) Replace the associated alarm fuse in the KS-21114 dc bay.

(8) Turn rectifier off by depressing the POWER ON/POWER OFF pushbutton.

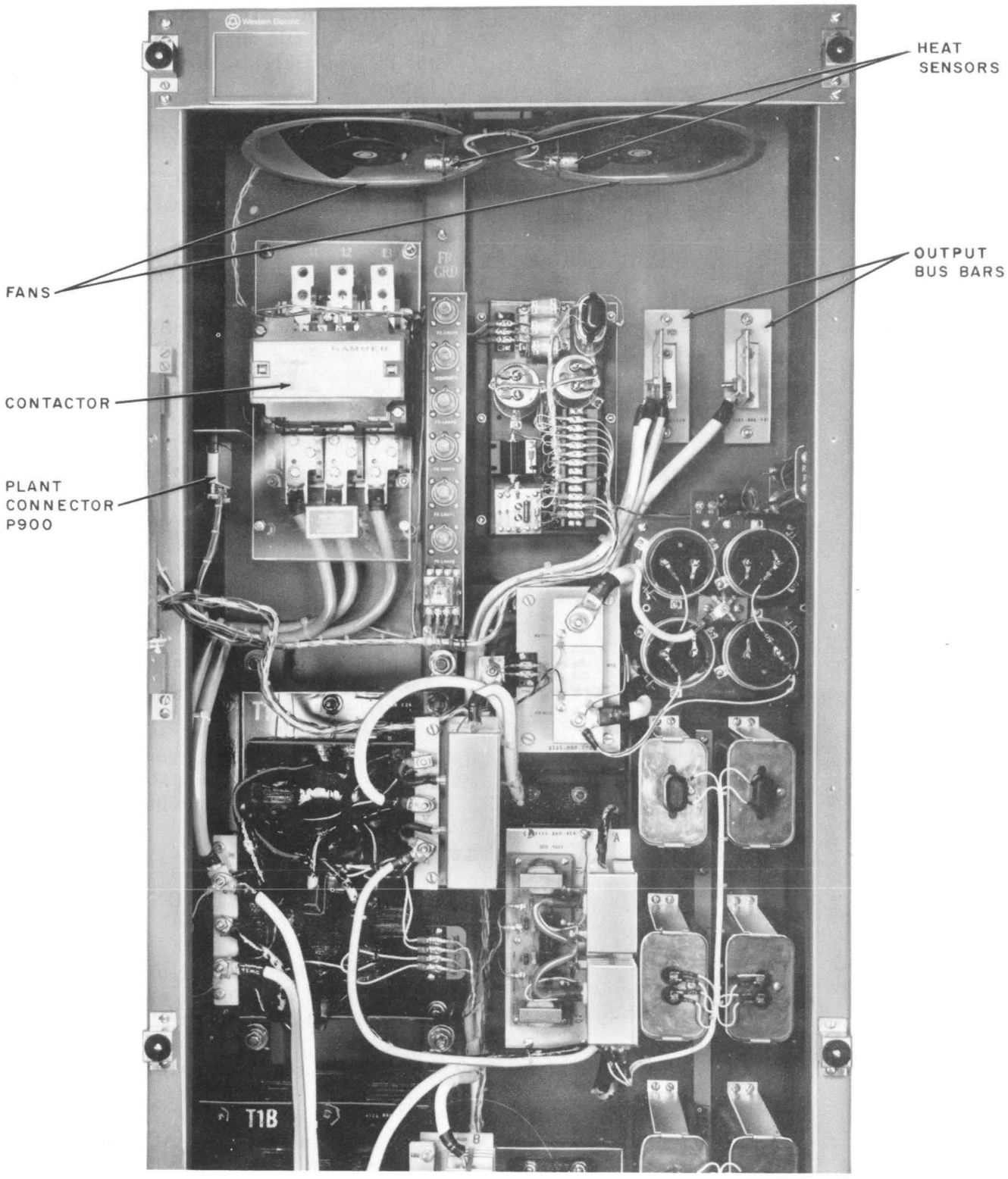

Fig. 2—KS-21113 L1 Rectifier—415A Power Plant—Top Partial View With Cover Removed

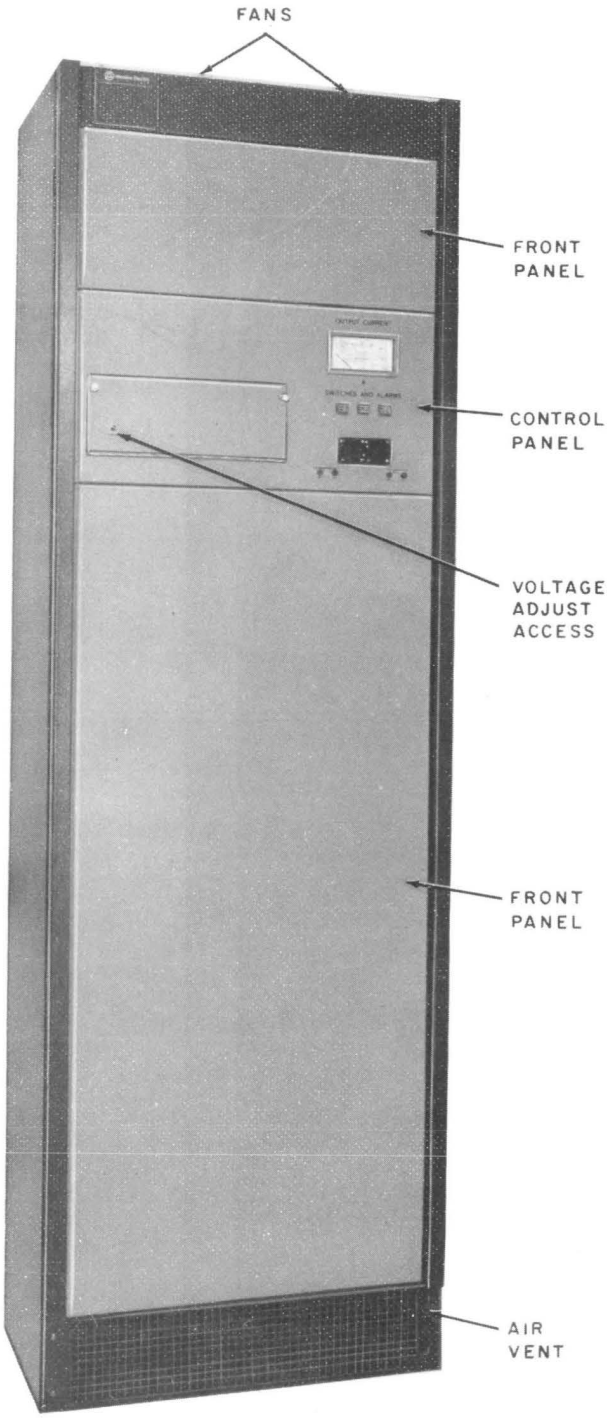

Fig. 3—KS-21113 L1 Rectifier-Covers in Place

Requirement: The rectifier shuts down, the POWER ON lamp is extinguished and the POWER OFF and RECT FAIL lamps are lighted.

(9) Reconnect plant connector P900.

Requirement: The RECT FAIL lamp is extinguished; the POWER OFF lamp remains lighted.

(10) The unit is now ready for operation.

Note 1: If the rectifier is turned off before connecting the unit to battery and replacing the plant connector, the RECT FAIL lamp will light and remain on until the output capacitors discharge. This requires approximately 40 seconds and the rectifier cannot be restarted until the RECT FAIL lamp extinguishes.

Note 2: If the rectifier is operated without front panels in place and the control panel closed, uniform airflow through the unit will be disrupted and a FAN FAIL indication may be observed.

Note 3: If other rectifiers are connected to the same battery, the unit under test may deliver more or less current than the others because its voltage is set slightly different. After replacing the plant connector to provide remote sensing, the voltage should be adjusted to share the load at float voltage.

3.03 *Normal Shutdown*

(1) Depress the POWER ON/POWER OFF pushbutton.

Requirement: The rectifier shuts down, the POWER ON lamp is extinguished; the POWER OFF lamp is lighted.

Note: For service access remove power as follows.

(2) Operate the associated AC circuit breaker or switch and fuse unit to the OFF position.

(3) Remove alarm fuse from associated CHG fuse in KS-21114 DC bay; remove CHG fuse.

(4) Disconnect plant connector P900.

3.04 ***Plant Shutdown*** will occur under the following conditions.

(a) The rectifiers will shutdown without lockout when the plant places a ground signal on the TR lead; the POWER ON lamp extinguishes and the POWER OFF and red AUTO START lamps light. The unit will restart when the ground signal is removed.

(b) The rectifier will shut down if the rectifier is delivering current when the plant places a ground signal on the HV lead. The POWER ON lamp extinguishes, the POWER OFF, AUTO START, and RECT FAIL lamps light. The unit can be restarted by a remote closure on the RS RSR leads or by cycling the POWER OFF/POWER ON pushbutton to OFF then ON.

(c) If the AC service voltage to the plant goes below limits, the rectifier will shutdown without lockout. The POWER ON lamp extinguishes, the POWER OFF and AUTO START lamps light. The rectifier will restart when normal AC voltage is restored.

Warning: Do not attempt to service the rectifier when the red AUTO START lamp is lighted. The unit is not locked out and can restart from remote action without notice.

3.05 ***Trouble Shutdown:*** In the event of a serious malfunction, the rectifier will shut down and lock out for self-protection. The RF relay releases and it is necessary to operate the POWER ON/POWER OFF switch to OFF to re-energize the relay before the rectifier will start again. The following malfunctions will cause the rectifier to shut down and lock out:

(a) Operation of any DC fuse

Note: Fuses F1 through F6 protect the AC monitor, power supply and fan circuits. Operation of F1, F2 or F3 will be detected as an AC loss and the rectifier will shutdown and light the AUTO START lamp. Operation of F4 or F5 will cause FAN 1 or FAN 2 to stop, lighting the FAN FAIL lamp and forcing the rectifier to half load. Operation of F6 will cause both fans to stop, shutting down the rectifier and lighting the RECT FAIL and FAN FAIL lamps.

(b) Failure of both fans or insufficient air flow due to blocked filter or intake

(c) Printed wiring board removed or plant connector removed or inserted while unit is running

(d) Severe unbalanced operation due to failure in one or more phases

(e) Loss of critical control voltage.

3.06 ***Test Mode***

(a) To place the rectifier in the test mode, depress the POWER ON/POWER OFF pushbutton to POWER OFF.

Requirement: The rectifier shuts down, the POWER ON lamp extinguishes, the POWER OFF lamp lights.

(b) Remove the alarm fuse from the associated CHG fuse in the KS-21114 DC bay; remove CHG fuse, in that order.

(c) Disconnect plant connector P900.

(d) When turned off in this mode, the RECT FAIL lamp will light while the DC capacitors discharge. It will not be possible to restart the rectifier until the RECT FAIL lamp extinguishes. This requires approximately 40 seconds with no load connected.

(e) Depress the POWER ON/POWER OFF pushbutton to restart the rectifier.

Requirement: The POWER OFF lamp is extinguished, the POWER ON lamp is lighted, and the rectifier starts.

(f) The rectifier will start and run in the test mode without battery only if plant connector P900 is disconnected and no voltage is present at the output terminals prior to turn on.

4. ROUTINE CHECKS AND MAINTENANCE

4.01 ***General:*** Except for cleaning the filter, the rectifier should be removed from service before performing maintenance checks.

4.02 ***Filter:*** To insure proper air flow through the unit, the filter must be cleaned periodically by flushing with warm water and drying thoroughly. The period of maintenance will depend upon the cleanliness of the area. To remove the filter, remove the four screws holding the perforated kickplate and remove the plate. Reach under the rectifier and rotate the clips on left and right sides of the filter to clear the filter. Pull the filter down at the front and remove. To replace, first locate the filter in the recess under the cabinet, then slide to the rear and over the lip at the back of the enclosure. Push the filter up in front and rotate the clips to lock it in place.

4.03 ***Output Voltage:*** To check the rectifier output voltage, proceed as follows.

(1) Connect the KS-20599 digital voltmeter, set on the 1000 volt dc scale, to the + REG and − REG jacks.

Requirement: The KS-20599 voltmeter indicates 151.9 volts ±0.76. If the requirement is met, proceed to (3). If the requirement is not met, continue with (2).

(2) Adjust the VOLTS ADJUST potentiometer until the KS-20599 voltmeter indicates 151.9 volts ±0.76. This potentiometer is located on the CP100 circuit board (Fig. 1). The adjustment range of this potentiometer is approximately 150 to 163 volts dc. CW rotation of the potentiometer will cause the rectifier output to increase and ccw rotation will cause the rectifier output to decrease.

(3) Disconnect the KS-20599 voltmeter from the + REG and − REG test jacks of the rectifier and connect it to the VM jacks located on the front panel of the associated KS-21114 bay. Verify that the plant voltmeter reading agrees with the reading indicated on the digital multimeter. If the readings are different, adjust the zero setscrew on the plant voltmeter until the plant voltmeter agrees with the digital multimeter. Record calibration date in accordance with local office procedures.

4.04 ***Current Limit:*** To check the current limiting circuit of the rectifier, proceed as follows.

(1) Operate the POWER ON/POWER OFF pushbutton to the POWER OFF position.

Note: In order to perform this test, the plant should have over 200 amperes of load. If the load is less than 200 amperes, consult the 415A Power Plant BSP.

(2) Connect the KS-20599 digital multimeter, set on the 1000 volt dc scale, to the + REG and − REG jacks.

(3) Operate the POWER ON/POWER OFF pushbutton to the POWER ON position.

Requirement: The rectifier starts; the POWER OFF lamp is extinguished; the POWER ON lamp is lighted.

(4) Rotate the VOLTS ADJUST potentiometer in a cw direction. The rectifier output voltage will increase slightly but not exceed the regulation limits of the plant.

(5) The rectifier output current will increase as the potentiometer is rotated in the cw direction.

(6) When the rectifier output current reaches 200 amperes, the droop circuit should take control. Further increase in the potentiometer rotation will not cause the rectifier output current to go above 200 amperes.

(7) If a further increase in the rotation of the potentiometer causes the rectifier output current to exceed 200 amperes, then it is necessary to readjust the CURRENT LIMIT ADJUST potentiometer (R118) located on the CP100 board.

(8) With the rectifier still operating at above 200 amperes, rotate the CURRENT LIMIT ADJUST potentiometer in the ccw direction until the output current is set at 200 amperes. Further rotation of the CURRENT LIMIT ADJUST potentiometer in the ccw direction will cause the rectifier to go into current droop below 200 amperes.

(9) The VOLTS ADJUST potentiometer can now be turned in a ccw direction until the rectifier output current is sharing the load with the other plant rectifiers.

(10) The KS-20599 digital multimeter should indicate approximately 151.9 volts $\pm$0.76.

(11) Disconnect the KS-20599 digital multimeter from the REG jacks of the rectifier.

Note: Do not rotate any potentiometer on any circuit board other than OUTPUT VOLTAGE ADJUST and the CURRENT LIMIT ADJUST controls, both located on the panel on the CP100 circuit board. These controls are of the 16-turn type.

(12) Operate the POWER ON/POWER OFF pushbutton to the POWER OFF position.

Requirement: The rectifier shuts down; the POWER ON lamp is extinguished; the POWER OFF lamp is lighted.

SHUTDOWN AND ALARM FEATURE CHECKS

4.05 ***PWB Interlock Check:*** With the rectifier operating in the test mode, depress the POWER ON/POWER OFF pushbutton to turn the unit off. Wait until the RECT FAIL lamp extinguishes, then carefully remove any circuit board but CP300 from the card file. The rectifier RECT FAIL lamp should light. Depress the POWER ON/POWER OFF pushbutton one time; the rectifier should not start. Replace the board; the rectifier should not start. Cycle the POWER ON/POWER OFF pushbutton to OFF then ON, the rectifier should start. Repeat with another board if desired.

Note: If the CP300 PWB is removed, the rectifier will shut down but the RECT FAIL lamp will not light because the RF relay which energizes the lamp is located on the CP300.

4.06 ***AC Monitor Check:*** With the rectifier operating in the test mode and with no load, operate the associated AC circuit breaker or switch and fuse unit to the OFF position. The POWER ON lamp should extinguish, the POWER OFF and red AUTO START lamps should light. The lamps will remain lit momentarily while the DC capacitors discharge. Before the lamps extinguish and the RF relay releases, move the circuit breaker or switch to the ON position, the rectifier should restart and run after a short delay.

4.07 ***Fuse Alarm Check:*** With the rectifier operating in the test mode, depress the POWER ON/POWER OFF pushbutton to turn the unit off. Wait until the RECT FAIL lamp extinguishes then replace F7, F601, F602 or F603 with a blown fuse; the RECT FAIL lamp should light. Depress the POWER ON/POWER OFF pushbutton once; the rectifier should not start. Replace the blown fuse; the rectifier should not start. Cycle the POWER ON/POWER OFF pushbutton to OFF then ON, the rectifier should start. Repeat with another fuse if desired.

Note: If F604 is replaced with a blown fuse while in the test mode, the rectifier will not start but the RECT FAIL lamp will not light. This is because power for the lamp comes from F604. With battery present, the RECT FAIL lamp will light under the above condition receiving power from F7.

4.08 ***Internal High Voltage Monitor Check:*** With the rectifier operating in the test mode, depress the POWER ON/POWER OFF pushbutton to turn the unit OFF. Remove F603 leaving the holder empty. Depress the POWER ON/POWER OFF pushbutton one time, the rectifier should start but shutdown after a slight delay. The POWER OFF, AUTO START and RECT FAIL lamp should be lit, indicating the shutdown was from high voltage. Replace F603 and cycle the POWER ON/POWER OFF pushbutton to OFF then ON to cancel the alarm and restart the rectifier.

4.09 ***Fan Fail Check:*** With the rectifier operating in the test mode, depress the POWER ON/POWER OFF pushbutton to turn the unit OFF. Remove F4 leaving the holder empty. Depress the POWER ON/POWER OFF pushbutton. The unit should start but fan 1 should not run. After a short delay (20 seconds), the FAN FAIL lamp should light. If dummy load is available, begin applying load to the rectifier. Current limit should take effect at approximately 100 amperes. Remove load and depress the POWER ON/POWER OFF pushbutton to turn the rectifier off. The FAN FAIL lamp should extinguish. Replace F4 and repeat the above test with F5 removed to stop fan 2; next remove both F4 and F5. Depress the POWER ON/POWER OFF pushbutton to start the rectifier, both fan 1 and fan 2 will not run. After a short delay, the rectifier will shut down. The POWER OFF, RECT FAIL and FAN FAIL lamps will be lighted. Replace F4 and F5 and depress

the POWER ON/POWER OFF pushbutton twice. The POWER OFF, RECT FAIL and FAN FAIL lamps should be extinguished, the POWER ON lamp should be lit and the rectifier should start.

5. TROUBLES

5.01 Failure of the KS-21113 rectifier will usually be characterized by one of these conditions:

- Shutdowns
- Poor Performance
- Circuit Board Tests.

The trouble flowchart in Fig. 4 is designed to analyze troubles in the rectifier from the standpoint of these three symptoms. For example, if initial inspection of a faulty rectifier indicates poor performance, the section of the trouble flow chart which applies to that particular problem should be consulted.

5.02 In the event of trouble, the rectifier should be examined for obvious signs of damage. If the problem appears to be in circuitry, the easiest method of repair is to replace plug-in circuit boards rather than attempting to isolate faulty components. Following is a list of boards and the functions they control:

CP100 Regulation and Current Limit (L215)

CP200 High Voltage Monitor (L216)

CP300 Failure Relay Circuit & DC Monitor (L217)

CP400 AC Monitor and TR Relay (L218)

CP500 Relays (L219)

CP800 SCR Synchronization and Control (L220)

SHUTDOWNS

5.03 A failure in the rectifier is usually accompanied by a shutdown and alarm indication. Before attempting to restart the rectifier, the failure should be analyzed for possible causes and corrective action taken. The lamps on the control panel plus the plant signal leads should provide sufficient information to determine the reason for shutdown. Table A gives all possible lamp indications after shutdown and possible causes. No other combinations of lamps should exist after a shutdown unless there is a malfunction in the alarm circuits. Also, if the POWER ON lamp is lighted, the unit must be running as this indicates the main contactor is closed. The only lamps that can be lighted along with POWER ON are the FAN FAIL lamp indicating one fan has failed or marginal air flow or the RECT FAIL lamp indicating open remote sensing. If repeated high voltage or DC monitor shutdowns occur, it is probable that output voltage control circuits have malfunctioned. Replace CP100 or CP800A, B or C, and check operation of CP850 Pulse Transformer Boards.

POOR PERFORMANCE

5.04 Poor performance may not lead to a shutdown but will be noticed in the way the rectifier works with the battery. Refer to Table B for several performance problems which may occur and their possible causes.

CIRCUIT BOARD TESTS

5.05 It is difficult to repair circuit boards by operation in a unit because the unit will probably shutdown before tests can be made on the defective board.

> ***Note:*** The trimmer potentiometers on the circuit boards are factory adjusted in test fixtures to compensate for the tolerance of components. It is unlikely a board can be repaired by turning one of these potentiometers. Readjustment should be necessary only in the event critical components on the circuit board are changed.

Several test points are available on the printed circuit boards, and when the KS-21113 L221 extender board is used, readings may be taken at any terminal of the edge connector. Table C summarizes the voltages which may be used and the effect of adjustments for each circuit board.

STARTING RECTIFIER INTO LOW BATTERY

5.06 If a rectifier has to be connected to a discharged battery, the following steps should be taken.

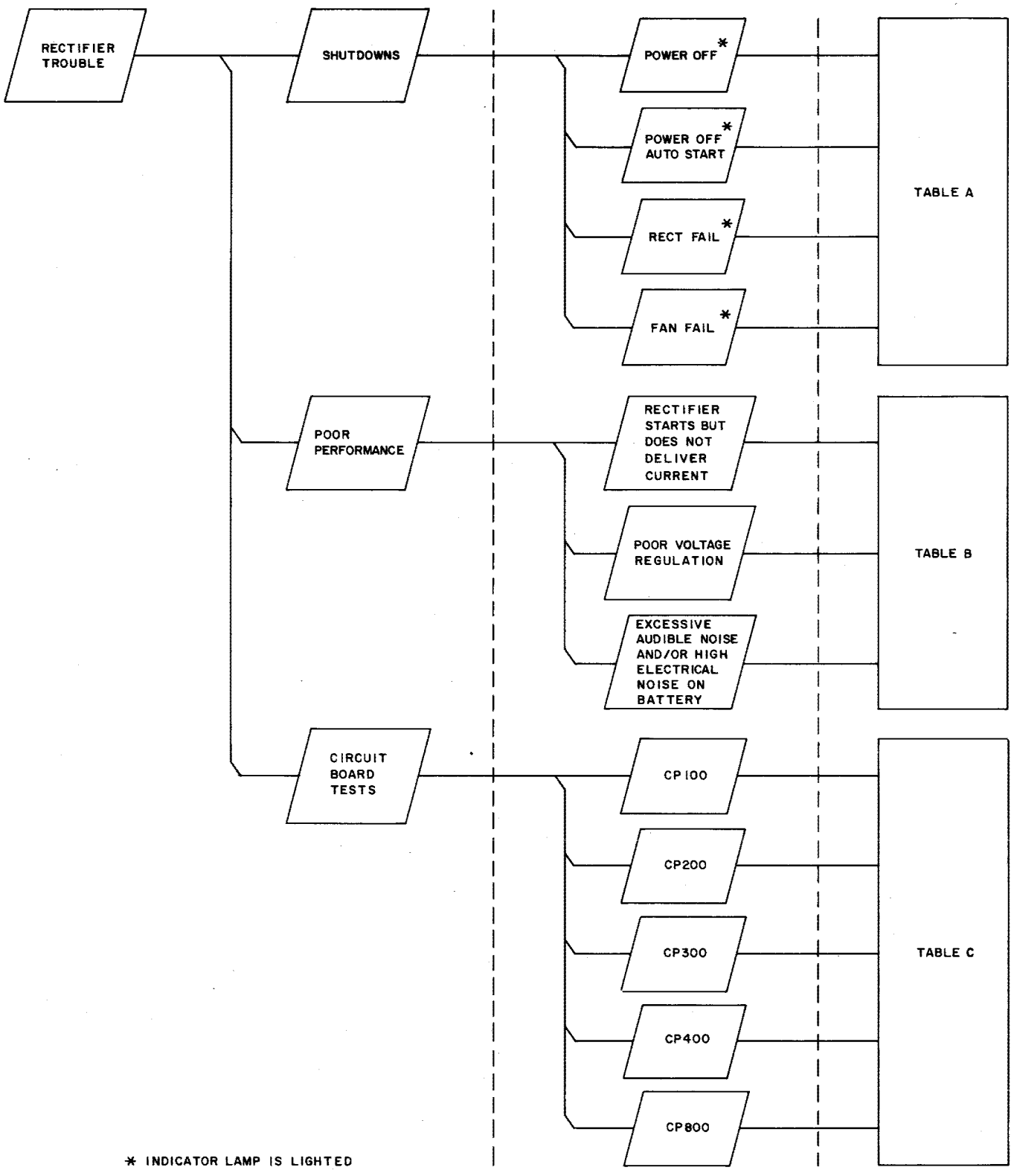

Fig. 4—Trouble Flow Chart

TABLE A

SHUTDOWNS (REFER TO 5.03)

LAMPS LIT	REASON	ACTION
[POWER OFF]	(a) Pushbutton OFF. (b) CP300 out of place.	Check SI (A) and SI (E) for indication. Replace CP300 or depress pushbutton to start unit.
[POWER OFF] [POWER OFF] [AUTO START]	(a) Loss of AC. (b) Low AC. (c) Ground on TR. (d) Blown F1, F2 or F3.	Check SI (B) and SI (C) to determine whether AC or TR shutdown. If AC, check AC circuit breaker and F1, F2 and F3. If TR, check plant.
[POWER OFF] [POWER OFF] [AUTO START] [RECT FAIL]	(a) High voltage shutdown.	Check SI (D) for indication then cycle POWER ON/POWER OFF pushbutton to OFF then to ON to restart.
[POWER OFF] [RECT FAIL]	(a) Blown DC fuse. (b) Printed board or plant connector out of place. (c) Unbalanced DC operation (DC Monitor).	Check SI (E) and SI (F) to determine if FA or PW shutdown. If FA replace blown fuse, if PW replace circuit board or plant connector in socket. If neither, unbalanced operation is probable.
[POWER OFF] [RECT FAIL] [FAN FAIL]	(a) Both fans failed. (b) Insufficient air flow due to blocked filter or intake. (c) Blown F6 or both F4 & F5.	Check SI (G) for indication, then replace or clean filter, replace fuses or fans.

TABLE B

POOR PERFORMANCE (REFER TO 5.04)

PROBLEM	CAUSES
Rectifier starts but does not deliver current.	(a) Voltage set too low. (b) Defective CP100.
Poor voltage regulation.	(a) Current limit improperly set. (b) Defective CP100. (c) Sensing incorrectly connected.
Excessive audible noise and/or high electrical noise on battery.	(a) Bad magnetic component. (b) One SCR of the pair associated with one phase not firing.

TABLE C

CIRCUIT BOARD TESTS (REFER TO 5.05)

BOARD	CONNECT	READ	
CP100	Pin 8 to Pin 17	23 to 27 VDC	
	Pin 8 to Pin 4	-3.7 to -4.1 VDC	
	Pin 20 to TP101	10.0 to 10.3 VDC	Adjustable by R110
	Pin 8 to Pin 7	-.01 to +.01 VDC at zero output current	Adjustable by R124
CP200	Pin 7 to Pin 1	23 to 27 VDC	
	Pin 7 to Pin 21	23 to 27 VDC	
	Pin 7 to TP201	4.8 to 5.0 VDC	Adjustable by R213
	Pin 7 to Pin 22	-.01 to +.01 VDC at zero output current	
	Pin 5 to Pin 6	Closure at 2 to 5% load	Adjustable by R221
CP300	Pin 7 to Pin 1	23 to 27 VDC	
	Pin 7 to Pin 21	23 to 27 VDC	
	Pin 7 to TP302	11 to 13 VDC	
CP400	Pin 7 to Pin 1	23 to 27 VDC	
	Pin 7 to TP401	4.4 to 5.1 VDC	Adjustable by R415
CP800	Pin 8 to Pin 17	23 to 27 VDC	
	Pin 8 to Pin 4	-3.7 to 4.1 VDC	

(1) Using the KS-20599 multimeter, measure the battery voltage at the VM jacks of the KS-21114 bay.

(2) Operating the rectifier in the test mode, adjust the rectifier output voltage so that it equals the battery voltage. If the battery voltage is below the lowest set level of the rectifier, then adjust the OUTPUT VOLTAGE ADJUST potentiometer to the extreme ccw position.

(3) Replace the CHG fuse. It should be noted that the greater the voltage differential between the rectifier and the battery, the greater the amount of connecting current.