KS-20490, L11, L12, L21, AND L22, RECTIFIERS
48 VOLTS, 400 AMPERES
OPERATING METHODS

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1. GENERAL

1.01 ▶The KS-20490, L11, L12, L21, and L22 rectifiers provide an isolated, filtered, and regulated dc voltage for automatically floating and charging battery plants. The KS-20490, L11 and L12, rectifiers were initially intended for use with the 301C, 302A, or 302B power plants. The KS-20490, L21 and L22, rectifiers were initially intended for use with the 111A, 303A, or 326-type power plants. The KS-20490, L11 and L12, rectifiers are used to automatically float and charge 23-cell battery plants with manual switching of end-cells for either 25- or 27-cell operation. The KS-20490, L21 and L22, rectifiers are for use with 24-cell battery plants without end cells. The rectifiers are designed for continuous operation, and during normal operation are energized and connected to the load.◀

1.02 This section is reissued to update paragraphs 1.01, 3.05, and 3.07 through 3.09, and specify KS-20538 volt-ohm-milliammeter and other minor changes throughout. Revision arrows are used to emphasize the more significant changes. The Equipment Test List is not affected.

1.03 The KS-20490, L11 and L21, rectifiers operate on an ac input voltage of 186 to 253 volts, 3-phase, 3-wire, 57- to 63-Hz alternating current, with input transformer taps to match different ac line voltages. The KS-20490, L12 and L22, rectifiers operate on an ac input voltage of 430 to 506 volts, 3-phase, 3-wire, 57- to 63-Hz alternating current, and have sufficient regulating range without changing input transformer taps over the input line variations from 430 to 506 volts. The output of these rectifiers is rated at nominal 48 volts, 400 amperes and is automatically controlled to limit output current at preset values. Phase multiplication is obtained by the use of phase shifting taps which provide effective multiphase operation when two or more rectifiers are operated in parallel. Power factor correction is provided for a minimum of 80 percent lagging at nominal voltage and full load. Line voltage monitoring with protective shutdown without lockout is provided at approximately 80 percent of nominal input voltage.

1.04 The T1 main transformer of the rectifiers is equipped with winding taps to permit shifting of the phase relationship between the input current to the rectifier and the ac service voltage to obtain leading or lagging phase shift angles of 7-1/2 or 22-1/2 degrees. The phase shifting is used to minimize the ac input line distortion when more than one rectifier is installed.

> ***Note:*** The rectifiers are shipped with the T1 main transformer connected for +22-1/2 degree phase shift operation unless otherwise specified on the purchase order.

1.05 If more than four rectifiers are used, repeat the pattern. Refer to SD-81996-01. When rectifiers are operated in parallel, the following phase shift arrangement is recommended:

First rectifier: +22.5 degrees

Second rectifier: −7.5 degrees

Third rectifier: +7.5 degrees

Fourth rectifier: −22.5 degrees

Caution 1: Before removing or installing circuit packs in the rectifier, operate the ♦POWER ON/POWER OFF♦ switch to the POWER OFF position and then operate the DC OUTPUT (S1) switch to the OFF position to prevent equipment damage and service interruption.

Caution 2: Verify that the ♦POWER ON/POWER OFF♦ switch is in the POWER OFF position before operating the DC OUTPUT (S1) switch from one position to another to prevent damage to the DC OUTPUT switch and service interruption.

Caution 3: The output filter capacitors in the rectifiers must be charged to the approximate battery or battery plus end-cell voltage before operating the DC OUTPUT (S1) switch to the BAT (all rectifiers) or EC (L11 and 12 rectifiers only) position to prevent damage to the DC OUTPUT switch and service interruption. To charge the filter capacitors, follow the procedures in paragraph 3.05.

Warning: 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 power to the rectifier before working on the unit except when necessary to make tests.

1.06 Rectification is accomplished by a 6-phase double-wye circuit arrangement with interphase inductors and silicon controlled rectifiers (SCRs) as the switching and rectifying elements. Regulation is obtained by controlling the firing pulses which fire the SCRs. Early pulses in each half cycle give greater rectified output; later pulses give less output. The rectified output is filtered, metered, and connected through the output fuse F1 to the main poles of the DC OUTPUT (S1) switch where the mode of operation is selected. On L11 and L12 rectifiers, this switch selects operation on 23-cells in the BAT position and on 25- or 27-cells in the EC position. On L21 and L22 rectifiers not having end cells, this switch selects operation on 24-cells in the BAT position. The switch has an OFF position, disconnecting the rectifier from the battery for maintenance and test purposes.

Note: If the DC OUTPUT (S1) switch is operated from one position to another while the ♦POWER ON/POWER OFF♦ (S2) switch is in the POWER ON position, the rectifier will shut down and lock out. To restart the rectifier after a lockout occurs, operate the ♦POWER ON/POWER OFF♦ (S2) switch to the POWER OFF position to reset the relay logic, and then operate the switch back to the POWER ON position to restart the rectifier.

1.07 The control circuits are physically divided and arranged into functional groups consisting of 13 printed circuit boards. Nine of the printed boards are of the plug-in type: CP100, CP200, CP300, CP400, CP500, CP800A, CP800B, CP800C, and CP900.

(a) CP100, VOLTAGE REGULATOR and SIMULATED CURRENT: The VOLTAGE REGULATOR portion in conjunction with the pulse circuit maintains the dc output at the desired voltage level by varying the conduction angle of the power thyristors. The SIMULATED OUTPUT CURRENT portion provides a continuously adjustable simulated load current up to at least 125 percent of the output current rating of the rectifier. The SIMULATED OUTPUT CURRENT circuit is used to set and test the current dependent features, such as the full load current limit when the rectifier is operated in the TEST mode.

(b) CP200, CURRENT LIMIT, LO-CURRENT, GRADUAL OUTPUT: The CURRENT LIMIT portion overrides the signals impressed on the voltage regulator by the sense leads and assumes control of the voltage regulator, switching the rectifier from voltage regulating to current regulation control. All rectifiers are equipped with the CURRENT LIMIT, FULL LOAD adjuster, and L11 and L12 rectifiers are equipped with a CURRENT LIMIT, PARTIAL LOAD adjustor which sets the point(s) at which switch-over occurs. The state of the LO-CURRENT portion of the circuit is part of the logic of the high-voltage shutdown and lockout features of the rectifier and plant circuits. The GRADUAL OUTPUT ("walk-in") portion of the circuit assumes control of the voltage regulator each time the rectifier is restarted and causes the rectifier to assume the load at a preset rate.

Note: The rectifier will not operate continuously into a short-circuited output. A short-

circuited output results in the loss of the −48 volt control voltage which releases the RF relay. Release of the RF relay shuts down and locks out the rectifier.

(c) CR250 DCCT (nonplug-in): This circuit stabilizes the operation of the DIRECT- CURRENT CURRENT-TRANSFORMER assembly.

(d) CP300 HIGH-VOLTAGE MONITOR: This circuit shuts down and locks out the rectifier on a selective basis if the battery voltage exceeds a predetermined level for a specific period of time. The operating adjustment is made with the rectifier in the TEST mode.

(e) CP400 STABILIZER: This circuit ensures proper operation of the rectifier whether in the BAT, EC, or TEST mode.

(f) CP500 120 HERTZ MONITOR: This circuit shuts down and locks out the rectifier if any type of internal fault occurs which essentially causes "single phasing" operation of the rectifier.

(g) CP600 ALARM AND CONTROL RELAY: This circuit transmits and receives remote alarm and control signals to and from the power plant control circuit. Unless in the TEST mode of operation, the rectifier is controlled by the power plant except for shutdown and lockout due to an internal failure. Various shutdown and alarm features are provided.

(h) CP700 AC INPUT VOLTAGE MONITOR: This circuit automatically shuts the rectifier off when the ac input voltage drops below a predetermined value and automatically restarts the rectifier when the voltage restores to an acceptable level.

(i) CP800 PULSE: Three pulse circuits are required, one each for the two power thyristors associated with each phase. The circuits generate the pulses required to turn on the power thyristors.

(j) CP900 PLANT CONTROL: This circuit contains the wiring terminals for all the power plant control leads.

(k) CP P900 PLANT CONTROL DISCONNECT: This circuit provides a quick-disconnect feature for the control leads wired from the power plant.

1.08 Each rectifier is equipped with an output voltmeter, output ammeter, current limit test jacks, and sense voltage test jacks.

1.09 ▶Routine checks are intended to detect trouble conditions prior to equipment failure and service interruption. Routine checks and adjustments should be made during periods which will cause the least service interruption.◀

1.10 This issue of the section is based on drawing SD-81996-01, Issue ▶5B.◀ If this section is to be used with equipment or apparatus reflecting later issue(s) of the drawing(s), 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.

1.11 For more detailed information on the operation and maintenance of individual equipment or apparatus, refer to the appropriate Bell System Practice.

Warning: The following points of the rectifier will always have battery voltage on them if the rectifier is connected to the office battery.

- ***BAT and EC output bus bars***
- ***Common terminal (ALL) of the S1J switch***
- ***The RECT FAIL lamp circuit.***

2. APPARATUS

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

TOOLS	DESCRIPTION
—	3-Inch C Screwdriver
—	Light Bulb Capacitor Charging Tool (ITE-4175)
KS-6320	Tool

TEST APPARATUS

KS-20538 Volt-Ohm-Milliammeter

Note: Equivalents may be substituted.

3. OPERATION

3.01 ***Normal Operation:*** Initially, the rectifier must be started manually. During normal operation, the rectifier remains energized and connected to the load. In addition to manual turnoff, the rectifier may be stopped, but not turned off, and restarted by signals from the associated power plant. Under certain trouble conditions, the rectifier will automatically shut down and lock out. The rectifier will not operate unless the DC OUTPUT (S1) switch is fully seated in the OFF-TEST, BAT, or EC position (EC position provided on L11 and L12 rectifiers only).

Note: For proper operation of the DC OUTPUT (S1) switch, depress the PUSH TO OPERATE lever on the handle and rotate the handle about 1/4 inch in the direction of the new position. Then, release the lever and rotate smartly into the desired position (lever will automatically lock when the switch is aligned).

Caution 1: Whenever the DC OUTPUT (S1) switch is in the OFF position and the OFF-TEST (S4) switch is in the OFF position, the OUTPUT CAPACITORS C2 through C12 are discharged by resistors R1, R1A, and R1B in approximately 1 minute. Failure to precharge the OUTPUT CAPACITORS will damage the switch contacts and result in service interruption when the DC OUTPUT (S1) switch is operated to either the BAT or EC position. See paragraph 3.05.

Caution 2: The signals generated by the actual load current and the load current drawn by an external resistive load connected to the +TEST and −TEST lugs are additive. Also, when the DC OUTPUT (S1) switch is in the OFF position, the OFF-TEST (S4) switch in the TEST position and the SIMULATED OUTPUT CURRENT (S3) switch in the ON position, then the signals generated by the simulated output current circuit and the load current drawn by an external resistive load connected to the +TEST and −TEST lugs are additive. In loading the rectifier while performing checks or adjustments, do not exceed the current capacity of the rectifier or equipment damage and service interruption will result.

Caution 3: The SIMULATED OUTPUT CURRENT (R10) rheostat must always be returned to the fully ccw position when not in use to prevent equipment damage and service interruption.

Caution 4: The SIMULATED OUTPUT CURRENT (S3) switch must be in the OFF position if load current is supplied to a resistive load connected to the +TEST or −TEST lugs (see Caution 2), or equipment damage and service interruption will result.

3.02 ***Preparing to Start:*** When preparing to start the rectifier, check the following:

(1) The controls are positioned as indicated.

- DC OUTPUT (S1) switch to OFF
- POWER ON/POWER OFF (S2) switch to POWER OFF
- SIMULATED OUTPUT CURRENT (S3) switch to OFF
- OFF-TEST (S4) switch to OFF
- Associated ac switch and fuse unit in bus duct or in power service cabinet to OFF
- SIMULATED OUTPUT CURRENT (R10) rheostat to fully ccw
- Circuit Breakers CB1 and CB2 to ON.

(2) The batteries are connected to the OUTPUT terminals of the rectifier.

(3) All external connections are made in accordance with the schematic drawing covering the associated circuit of which the unit is a part.

(4) All associated fuses are installed in their respective fuse holders.

(5) The nominal ac voltage at the input of the rectifier is within allowable tolerances.

Note: Measure the input voltage using the KS-20538 volt-ohm-milliammeter conditioned for 300-votls ac for the L11 and L21 rectifiers or the 1000-volt ac range for the L12 and L22 rectifiers.

(6) Verify that all circuit packs are properly installed in the rectifier.

Note: If any circuit pack is not properly installed in the rectifier, the interlock path in the rectifier will be opened, and the unit will not start.

3.03 ***Starting Rectifier Used in a Power Plant:*** To start the rectifier when the rectifier is used in a power plant, proceed as follows:

(1) Perform the procedures in paragraph 3.02.

(2) Operate the associated ac switch and fuse unit in the bus duct or in the power service cabinet to the ON position.

(3) Operate the OFF-TEST (S4) switch to the TEST position.

(4) Connect the KS-20538 volt-ohm-milliameter, conditioned for 100 volts dc, to the rectifier +SENSE (J1) and −SENSE (J2) test jacks.

(5) Operate the POWER ON/POWER OFF (S2) switch to the POWER ON position. The POWER ON lamp lights and the POWER OFF lamp extinguishes.

(6) Loosen the locking device on the OUTPUT VOLTS ADJUST (R7) rheostat.

(7) Adjust the OUTPUT VOLTS ADJUST (R7) rheostat until the KS-20538 meter indicates 46 volts for the L11 and L12 rectifiers or 48 volts for the L21 and L22 rectifiers.

Note: The KS-20538 meter that is connected to the rectifier will not indicate the same voltage that is actually available to the batteries.

(8) Operate the POWER ON/POWER OFF (S2) switch to the POWER OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

(9) Operate the OFF-TEST (S4) switch to the OFF position.

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

(11) Perform the capacitor charging procedure given in paragraph 3.05.

(12) After performing the capacitor charging procedures, restore the rectifier to normal plant operation (set the rectifier output voltage) in accordance with the associated power plant Bell System Practice.

Note: The associated power plant output voltmeter indicates the actual voltage that is available to the batteries. The nominal float voltage for the batteries in a standard plant is usually 2.17 volts per cell. For additional information on the required voltages for different types of batteries, refer to Section 157-601-301.

(13) If the rectifier is not supplying the required output voltage to the batteries, adjust the OUTPUT VOLTS ADJUST (R7) rheostat cw to increase the output voltage or ccw to decrease the output voltage. After the voltage is adjusted, tighten the locking device on the OUTPUT VOLTS ADJUST (R7) rheostat, being careful not to disturb the setting.

Note: The OUTPUT VOLTAGE (M2) voltmeter indicates the output voltage of the rectifier, not the battery voltage, regardless of the position of the DC OUTPUT (S1) switch. When the DC OUTPUT (S1) switch is in the BAT or EC position, the battery voltage deviates from this reading by the charge lead closed loop voltage drop which varies directly with the output current.

3.04 ***Starting Rectifier Not Used in a Power Plant:*** To start the rectifier not used in a power plant, proceed as follows:

(1) Perform the procedures in paragraph 3.02.

(2) Operate the associated ac switch and fuse unit in the bus duct or in the power service cabinet to the ON position.

(3) Operate the OFF-TEST (S4) switch to the TEST position.

(4) ▶Connect the KS-20538 volt-ohm-milliammeter conditioned for 100 volts dc, to the rectifier +SENSE (J1) and −SENSE (J2) test jacks.◀

(5) Operate the ▶POWER ON/POWER OFF◀ (S2) switch to the POWER ON position. The POWER ON lamp lights and the POWER OFF lamp extinguishes.

(6) Loosen the locking device on the OUTPUT VOLTS ADJUST (R7) rheostat.

(7) Adjust the OUTPUT VOLTS ADJUST (R7) rheostat until the ▶KS-20538◀ meter indicates 46 volts for the L11 and L12 rectifiers or 48 volts for the L21 and L22 rectifiers.

(8) Disconnect the ▶KS-20538◀ meter from the rectifier.

(9) Operate the POWER ON/POWER OFF (S2) switch to the OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

(10) Operate the OFF-TEST (S4) switch to the OFF position.

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

(12) Perform the capacitor charging procedures given in paragraph 3.05.

3.05 ***Charging Filter Capacitors:*** In order to prevent damage to the switch contacts when the DC OUTPUT (S1) switch is operated to the BAT or EC position, capacitors ▶C2 through C12 must be◀ charged by the following method. Verify that the procedures in paragraph 3.02 have been followed and continue as follows:

(1) ▶Verify that the OFF-TEST (S4) switch is in the TEST position.

Danger: Always connect the light bulb capacitor charging tool to the COMMON terminal (E3) first, then to terminal E1 or E2. This will prevent dangerous shorts to ground and personal injury.

(2) Using alligator clips, connect the light bulb capacitor charging tool between terminal E1 and terminal E3 for the BAT position or between terminal E1 and terminal E2 for the EC position (L11 and L12 rectifiers only).

(3) With the light bulb capacitor charging tool connected, screw in the light bulb. When the light bulb is at maximum brilliance, verify that the rectifiers OUTPUT VOLTAGE (M2) voltmeter indicates 48 to 52 volts dc.◀

Note 1: The voltage indicated on the OUTPUT VOLTAGE (M2) voltmeter before the DC OUTPUT (S1) switch is operated to the desired BAT or EC position will be slightly lower than the nominal battery or battery plus end-cell voltage.

Note 2: The END CELL lamp lights when the DC OUTPUT (S1) switch is in the EC position.

Caution: Verify that the ▶POWER ON/POWER OFF◀ (S2) switch is in the POWER OFF position before operating the DC OUTPUT (S1) switch from one position to another to prevent equipment damage and service interruption.

(4) When the OUTPUT VOLTAGE (M2) voltmeter indicates ▶48 to 52 volts dc◀ battery voltage or battery plus end-cell voltage, immediately operate the DC OUTPUT (S1) switch to the desired BAT or EC position.

(5) ▶Operate the OFF/TEST switch (S2) to the OFF position.

Danger: When disconnecting the light bulb capacitor charging tool from the rectifier terminals, always disconnect both ends at the same time to prevent shorts and personal injury.

(6) Disconnect the light bulb capacitor charging tool from the rectifier terminals.◀

(7) Operate the associated ac switch and fuse unit in the bus duct or in the power service cabinet to the ON position. The POWER OFF lamp lights.

3.06 ***Stopping:*** To stop (turn-off) the rectifier, depress the ▶POWER ON/POWER OFF◀ (S2) switch to the POWER OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

3.07 ***Taking Rectifier Out of Service:*** To remove the rectifier from service, proceed as follows:

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

(2) Operate the ▶POWER ON/POWER OFF◀ (S2) switch to the POWER OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

(3) Operate the DC OUTPUT (S1) switch to the OFF position. (The RECT FAIL alarm to the plant is cut off.)

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

Note: When the rectifier is shut down, the output filter capacitor should fully discharge through resistors in approximately 1 minute.

(5) Operate the RELAY AND ALARM POWER (CB2) circuit breaker to OFF.

(6) Disconnect the CP-P900 PLANT CONTROL DISCONNECT from its connector.

▶Danger: Hazardous currents are present from both the battery bus and the rectifier battery bus connections to ground. Use extreme care to prevent personal injury in removing the battery bus connections from the rectifier. Use only insulated approved Bell System tools or equivalent to accomplish this task.

(7) Disconnect the battery bus cable from the rectifier at the rectifier battery bus terminals.

Note: If the rectifier is to be left out of service for an extended period of time, remove all associated fuses from their respective fuse holders.

Caution: The electrolytic capacitors, OUTPUT CAPACITORS shall be connected to a source of direct current of suitable voltage and polarity in accordance with Section 032-110-701.

(8) Insulate the battery bus cable ends with Bell System approved tape.◀

3.08 ***Restarting Rectifier Which Was Taken Out of Service:*** To restore the rectifier to service, proceed as follows:

▶Warning: When the rectifier has been out of service for an extended period of time, the electrolytic capacitors (OUTPUT CAPACITORS C2 through C12), shall be connected to a source of direct current of suitable voltage and polarity in accordance with Section 032-110-701.◀

(1) Reconnect the CP-P900 PLANT CONTROL DISCONNECT in its connector.

(2) Operate the associated ac switch and fuse unit in the bus duct or power service cabinet to the ON position.

(3) Operate the RELAY AND ALARM POWER (CB2) circuit breaker to ON.

(4) Place the rectifier in operation as outlined in paragraph 3.03 or 3.04.

3.09 ***Start-up Procedure:*** If the battery terminal voltage is 1.75 volts per cell or less, the relays and contactors may not pull up when the ac service voltage restores after a prolonged power service failure. If the rectifier does not restore, it may lock out and enable the rectifier failure alarm. Disregard the rectifier failure alarm and proceed as follows:

▶Danger: When the office has experienced an extended period of commercial power failure and the battery voltage is less than or equal to 1.75 volts dc per cell,

each battery should be checked for possible cell reversal prior to manually starting the rectifiers in the battery plant. Failure to do so could result in an explosion and personal injury if cells have reversed.

(a) Preparation of controls:

(1) Perform the capacitor charging procedure in paragraph 3.05 and operate the DC OUTPUT (S1) switch to the BAT position.

(2) Verify the OFF-TEST (S4) switch is in the OFF position.

(3) Verify the POWER FACTOR CB1 circuit breaker is on.

(4) Verify the RELAY AND ALARM CB2 circuit breaker is on.

(5) Operate the associated ac switch and fuse unit in the bus duct or in the power service cabinet to the ON position.

(6) Verify the line-to-line voltages of the ac power service are within the following ranges:

RECTIFIER OPTION	VOLTAGE TAP USED ON T1	ALLOWABLE AC VOLTAGE RANGE
L12, L22	480V	430-506
L11, L21	208V	186-221
	240V	216-253

(b) Perform the following:

(1) On L11 and L12 rectifiers, manually maintain the AC TAP (ST2) contactor operated in the BAT position using the plunger furnished. On L21 and L22 rectifiers, manually maintain the ST2 relay operated by using a wooden stick such as the KS-6320 tool.

(2) Depress and maintain depressed the pushbutton furnished on the AC INPUT CONTACTOR (ST3). The rectifier starts and will operate in the current limit mode.

(c) When the OUTPUT VOLTAGE (M2) voltmeter indicates at least 1.85 volts per cell:

(1) Release the AC INPUT CONTACTOR (ST3) and then release the ST2 relay. The rectifier failure alarm is enabled.

(2) Depress the POWER ON/POWER OFF switch to the POWER OFF position, then to the POWER ON position. The rectifier is operating in the BAT mode of operation. If it is desired to charge the end cells, follow the procedure in the appropriate Bell System Practice.

4. ROUTINE CHECKS

4.01 Keep the ventilating passages of the rectifier unobstructed to ensure adequate cooling during operation.

4.02 Inspect the AC TAP (ST2) and the AC INPUT CONTACTOR (ST3) in the rectifier for the condition of contacts and clean if necessary. The relays mounted on circuit packs are not adjustable and should be replaced in the event of a malfunction or poor condition of contacts.

Danger: Use all necessary precautions when working on the DC OUTPUT (S1) switch when battery power is connected to the switch or when disconnecting battery bus bars to prevent short circuits from occurring which could result in fires, equipment damage, or personal injury.

4.03 The DC OUTPUT (S1) switch should be cleaned and lubricated in accordance with Section 030-745-701. Before cleaning and lubricating the switch, the rectifier must be disconnected from the ac input power, and it is preferred that the rectifier be completely disconnected from the batteries. To perform maintenance on the DC OUTPUT (S1) switch with the rectifier completely disconnected from the plant, follow the instructions in paragraph 3.07. If a decision is made not to disconnect the rectifiers from the battery, follow the instructions in subparagraphs 3.07(1) through (4). After performing maintenance on the switch, restore the rectifier to normal operation by following the instructions in paragraph 3.03 or 3.04.

4.04 Check the accuracy of the rectifier OUTPUT VOLTAGE (M2) voltmeter in accordance with Section 100-510-701.

4.05 ***Output Voltage Check (Rectifier Used in a Power Plant):*** To check the rectifier output voltage when the rectifier is used in a power plant, proceed as follows:

(1) Observe the voltage indication on the associated power plant output voltmeter.

Note: The associated power plant voltmeter indicates the actual voltage available at the battery. The nominal float voltage for the battery in a standard plant is 2.17 volts per cell. For additional information on the required voltages on different types of batteries, refer to Section 157-601-701.

(2) Verify that the rectifier is supplying the required output voltage to the batteries. If the rectifier is not providing the required output voltage (in accordance with the associated plant requirements), proceed with (3).

(3) Loosen the locking device on the OUTPUT VOLTS ADJUST (R7) rheostat.

(4) Adjust the OUTPUT VOLTS ADJUST (R7) rheostat cw to increase or ccw to decrease the output voltage until the indication on the associated power plant voltmeter is the correct value.

4.06 ***Output Voltage Check Rectifier Not Used in a Power Plant:*** To check the rectifier output voltage when the rectifier is not used in a power plant, proceed as follows:

(1) Operate the ▶POWER ON/POWER OFF◀ (S2) switch to the POWER OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

(2) Operate the DC OUTPUT (S1) switch to the OFF position.

(3) Operate the ▶OFF-TEST◀ (S4) switch to the TEST position.

(4) Observe the OUTPUT VOLTAGES (M2) voltmeter and OUTPUT CURRENT (M1) ammeter for an indication of zero.

(5) Loosen the locking device and rotate the OUTPUT VOLTS ADJUST rheostat fully ccw.

(6) Rotate the SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw.

(7) Using the ▶KS-20538 volt-ohm-milliammeter,◀ set to the 100 VOLT DC range, connect the negative lead to the −SENSE J2 pin jack of the rectifier and the positive lead to the +SENSE (J1) pin jack.

(8) Operate the ▶POWER ON/POWER OFF◀ switch to the POWER ON position. The POWER ON lamp lights and the POWER OFF lamp extinguishes. The rectifier is disconnected from the battery and the rectifier is operating in the TEST mode.

(9) Slowly rotate the OUTPUT VOLTS ADJUST (R7) rheostat cw until the OUTPUT VOLTAGE (M2) voltmeter and the ▶KS-20538 volt-ohm-milliammeter◀ indicate 49.91 volts for the L11 and L12 rectifiers or 52.08 volts for the L21 and L22 rectifiers.

(10) Operate the SIMULATED OUTPUT CURRENT (S3) switch to the ON position. The SIMULATED CURRENT ON lamp lights and the SIMULATED CURRENT OFF lamp extinguishes.

(11) Slowly rotate the SIMULATED OUTPUT CURRENT (R10) rheostat cw until the OUTPUT CURRENT (M1) ammeter indicates 400 amperes. The OUTPUT VOLTAGE (M2) voltmeter and the ▶KS-20538 volt-ohm-milliammeter◀ should still indicate 49.91 volts or 52.08 volts. (A minor readjustment of the OUTPUT VOLTS ADJUST (R7) rheostat is permissible to retain the indication of 49.91 volts or 52.08 volts.)

(12) Tighten the locking device on the OUTPUT VOLTS ADJUST (R7) rheostat, being careful not to disturb the setting.

(13) Rotate the SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw.

(14) Operate the ▶POWER ON/POWER OFF◀ (S2) switch to the POWER OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

(15) Disconnect the ▶KS-20538 volt-ohm-milliammeter.◀

(16) Restore the rectifier to normal operation in accordance with paragraph 3.03 or 3.04.

4.07 ***Full Load Current Limit Check and/or Adjustment:*** To check the rectifier full load current limit circuit, proceed as follows:

(1) Operate the ▶POWER ON/POWER OFF◀ (S2) switch to the POWER OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

(2) Operate the DC OUTPUT (S1) switch to the OFF position.

(3) Operate the ▶OFF-TEST◀ (S4) switch to the TEST position.

(4) Verify that the SIMULATED OUTPUT CURRENT (R10) rheostat is rotated fully ccw.

(5) Operate the ▶POWER ON/POWER OFF◀ (S2) switch to the POWER ON position. The POWER ON lamp lights and the POWER OFF lamp extinguishes.

(6) Operate the SIMULATED OUTPUT CURRENT (S3) switch to the ON position. The SIMULATED CURRENT ON lamp lights and the SIMULATED CURRENT OFF lamp extinguishes.

(7) Slowly rotate the SIMULATED OUTPUT CURRENT (R10) rheostat to the fully cw position.

Requirement: The OUTPUT CURRENT (M1) ammeter shall not exceed 410 amperes.

Note: The FULL LOAD CURRENT LIMIT (R8) rheostat is factory adjusted to limit the output current to 400 amperes and does not generally require field adjustment. If the rectifier output does not meet the requirement in (7), proceed to (8). If the requirement is met, proceed to (10).

(8) Loosen the locking device on the FULL LOAD CURRENT LIMIT (R8) rheostat. Readjust the (R8) rheostat cw to increase or ccw to decrease the full load current limit value as required to obtain a reading on the OUTPUT CURRENT (M1) ammeter between 395 and 405 amperes. The preferred setting is 400 amperes. Tighten the locking device, being careful not to disturb the setting.

(9) Depress the SIMULATED OUTPUT CURRENT (S3) switch to the OFF position. The SIMULATED CURRENT OFF lamp lights and the SIMULATED CURRENT ON lamp is extinguished.

(10) Rotate the SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw.

(11) Operate the ▶POWER ON/POWER OFF◀ (S2) switch to the POWER OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

(12) Restore the rectifier to normal operation in accordance with paragraph 3.03 or 3.04.

4.08 ***Partial Load Current Limit Check and/or Adjustment (L11 and L12 Rectifiers Only):*** To check the partial load current limiting circuits in the L11 and L12 rectifiers, proceed as follows:

(1) Operate the ▶POWER ON/POWER OFF◀ (S2) switch to the POWER OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

(2) Operate the DC OUTPUT (S1) switch to the OFF position.

(3) Operate the ▶OFF-TEST◀ (S4) switch to the TEST position.

(4) Verify that the SIMULATED OUTPUT CURRENT (R10) rheostat is rotated fully ccw.

(5) Connect a temporary frame ground, using a suitable cord, to the PL terminal 4 of the CP900 control terminal strip.

(6) Operate the ▶POWER ON/POWER OFF◀ (S2) switch to the POWER ON position. The POWER ON lamp lights and the POWER OFF lamp extinguishes.

(7) Operate the SIMULATED OUTPUT CURRENT (S3) switch to the ON position. The SIMULATED CURRENT ON lamp lights and the SIMULATED CURRENT OFF lamp extinguishes.

(8) Slowly rotate the SIMULATED OUTPUT CURRENT (R10) rheostat to the full cw position. The OUTPUT CURRENT (M1) ammeter should indicate the current value specified in the associated power plant Bell System Practice. If a plant requirement is not given, rotate the (R10) rheostat fully cw. The OUTPUT CURRENT (M1) ammeter indicates 195 to 205 amperes.

Note: The CURRENT LIMIT PARTIAL LOAD (R9) rheostat is factory adjusted to limit

the output current at 195 to 205. The preferred setting is 200 amperes. (A higher value between 200 and 400 amperes may be selected as required locally.) If the requirement in (8) is met, proceed to (15). If the requirement is not met, continue with (9).

(9) Rotate the SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw.

(10) Loosen the locking device on the PARTIAL LOAD CURRENT LIMIT (R9) rheostat and rotate the (R9) rheostat fully cw.

(11) Rotate the SIMULATED OUTPUT CURRENT (R10) rheostat fully cw. The OUTPUT CURRENT (M1) ammeter should indicate 400 amperes.

(12) Rotate the PARTIAL LOAD CURRENT LIMIT (R9) rheostat ccw until the OUTPUT CURRENT (M1) ammeter indication is the current value specified in the power plant Bell Systems Practice. If a plant requirement is not given, rotate the (R9) rheostat ccw until the OUTPUT CURRENT (M1) ammeter indicates the desired partial load current limit value between 200 and 400 amperes.

(13) Tighten the locking device on the PARTIAL LOAD CURRENT LIMIT (R9) rheostat, being careful not to disturb the setting.

(14) Rotate the SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw and repeat (8).

(15) Rotate the SIMULATED OUTPUT CURRENT (R10) potentiometer fully ccw.

(16) Operate the SIMULATED OUTPUT CURRENT (S3) switch to the OFF position. The SIMULATED CURRENT OFF lamp lights and the SIMULATED CURRENT ON lamp extinguishes.

(17) Operate the ◗POWER ON/POWER OFF◖ (S2) switch to the OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

(18) ◗Remove the frame ground from terminal PL4 on the CP900 PLANT CONTROL circuit board.◖

(19) Restore the rectifier to normal operation in accordance with paragraph 3.03 or 3.04.

Note: Current limit Adjustment Using Actual load—The current limit settings in paragraphs 4.07 and 4.08 may be made using actual load current and/or load current supplied to a resistive load connected to the +TEST and −TEST lugs as follows. Load the rectifier to a value of current as indicated on the OUTPUT CURRENT (M1) ammeter to a magnitude approximately 10 amperes beyond the desired current limit setting. (It may be necessary to adjust the FULL LOAD CURRENT LIMIT (R8) rheostat cw in order to obtain this reading.) Then rotate the FULL LOAD CURRENT LIMIT (R8) rheostat ccw until the (M1) ammeter indicates the desired setting. To adjust the partial load current limit setting, apply a frame ground to terminal 4 on CP900 circuit pack. Adjust the (M1) ammeter for 10 amperes beyond the desired partial load current limit setting. (It may be necessary to adjust the PARTIAL LOAD CURRENT LIMIT (R9) rheostat cw in order to obtain this reading.) Then rotate the PARTIAL LOAD CURRENT LIMIT (R9) rheostat ccw until the (M1) ammeter indicates the desired setting. Remove the external resistive load after the adjustment is complete and remove the frame ground. ***Observe the cautions in paragraph 3.01.***

4.09 ***High-Voltage Monitor Check and/or Adjustment:*** To check the high voltage shutdown and lockout circuit, proceed as follows:

Note: If a voltmeter of sufficient accuracy is not available, the high-voltage shutdown check and/or adjustment may be made using the OUTPUT VOLTAGE (M2) voltmeter. This is a temporary adjustment and shall only be used under emergency conditions. The accuracy of the (M2) meter is ±0.75 volts; therefore, the setting must be readjusted as soon as a portable voltmeter of sufficient accuracy is available.

(1) Operate the ◗POWER ON/POWER OFF◖ (S2) switch to the POWER OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

(2) Operate the DC OUTPUT (S1) switch to the OFF position.

(3) Operate the OFF-TEST (S4) switch to the TEST position.

(4) Verify that the SIMULATED OUTPUT CURRENT (R10) rheostat is rotated fully ccw.

(5) Connect a jumper from terminal 11 to terminal 12 on CP-P900 PLANT CONTROL DISCONNECT.

(6) Disconnect CP-P900 PLANT CONTROL DISCONNECT from its connector.

(7) Connect a jumper from −TEST lug to terminal 19 on CP-P900 PLANT CONTROL DISCONNECT and one from +TEST lug to terminal 21 of CP-P900.

(8) Connect the ◗KS-20538 volt-ohm-milliammeter,◖ set to the 100 VOLTS DC range, to the +TEST and −TEST lugs.

(9) Operate the ◗POWER ON/POWER OFF◖ (S2) switch to the POWER ON position. The POWER ON lamp lights and the POWER OFF lamp extinguishes. Wait approximately 15 seconds.

(10) Operate the SIMULATED OUTPUT CURRENT (S3) switch to the ON position. The SIMULATED CURRENT ON lamp lights and the SIMULATED CURRENT OFF lamp extinguishes.

(11) Rotate the SIMULATED OUTPUT CURRENT (R10) rheostat cw until the OUTPUT CURRENT (M1) ammeter indicates approximately 100 amperes.

(12) Loosen the locking device on the OUTPUT VOLTS ADJUST (R7) rheostat and slowly rotate the (R7) rheostat cw until the pointer on OUTPUT CURRENT (M1) ammeter dips; immediately stop rotating the potentiometer. (The pointer may dip and restore several times before the rectifier shuts down and locks out.) The rectifier will shut down and lock out after a time period of 0.5 to 1.0 seconds has elapsed. All lamps extinguish and the RECT FAIL lamp lights.

(13) Rotate the SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw.

(14) Depress the ◗POWER ON/POWER OFF◖ (S2) switch twice to restart the rectifier.

Requirement: The ◗KS-20538 volt-ohm-milliammeter,◖ connected across the +TEST and −TEST test jacks, shall indicate 51.6 volts ±0.1 volts for L11 and L12 rectifiers or 53.8 volts ±0.1 volt for the L21 and L22 rectifiers.

Note: If the requirement in (14) is met, proceed with (24). If the requirement is not met, proceed with (15).

(15) Rotate the SIMULATED OUTPUT CURRENT (R10) rheostat cw until the OUTPUT CURRENT (M1) ammeter indicates approximately 100 amperes.

(16) Loosen the locking device and rotate the HIGH VOLTAGE MONITOR ADJUST (R16) rheostat fully cw.

(17) Adjust the OUTPUT VOLTAGE ADJUST (R7) rheostat for an indication on the ◗KS-20538 volt-ohm-milliammeter◖ of 51.6 volts for L11 and L12 rectifiers or 53.8 volts for L21 and L22 rectifiers.

(18) Slowly rotate the HIGH VOLTAGE MONITOR ADJUST (R16) rheostat ccw until the pointer on the OUTPUT CURRENT (M1) ammeter dips; immediately stop rotating the (R16) rheostat. The (M1) ammeter may dip and restore several times but after a time period of 0.5 to 1.0 seconds has elapsed, rectifier shuts down and locks out. All lamps extinguish and the RECT FAIL lamp lights.

(19) Tighten the locking device on the HIGH VOLTAGE MONITOR ADJUST (R16) rheostat, being careful not to disturb the setting.

(20) Rotate the SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw.

(21) Depress the ◗POWER ON/POWER OFF◖ (S2) switch twice to restart the rectifier.

(22) Repeat (11) through (14) to recheck the setting of the high-voltage monitor circuit.

(23) Rotate the SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw.

(24) Operate the SIMULATED OUTPUT CURRENT (S3) switch to the OFF position. The SIMULATED CURRENT OFF lamp lights and the SIMULATED CURRENT ON lamp extinguishes.

(25) Operate the ◗POWER ON/POWER OFF◖ (S2) switch to the OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

(26) Disconnect the ◗KS-20538 volt-ohm-milliammeter◖ from the +TEST and −TEST lugs.

(27) Disconnect the jumpers from terminals 19 and 21 on CP-P900 and the +TEST and −TEST lugs.

(28) Disconnect the jumper from terminal 11 and 12 on CP-P900.

(29) Reconnect CP-P900 PLANT CONTROL DISCONNECT in its connector.

(30) Restore the rectifier to normal operation in accordance with paragraph 3.03 or 3.04.

4.10 ***Shutdown Feature—DC OUTPUT (S1) Switch Interlock:*** The following check is made with the rectifier in the TEST mode of operation. Proceed as follows:

(1) Operate the ◗POWER ON/POWER OFF◖ (S2) switch to the POWER OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

(2) Operate the DC OUTPUT (S1) switch to the OFF position.

(3) Operate the OFF-TEST (S4) switch to the TEST position.

(4) Verify the circuit breakers (CB1) and (CB2) are in the ON position.

(5) Operate the ◗POWER ON/POWER OFF◖ (S2) switch to the POWER ON position. The POWER ON and TEST lamps light. The POWER OFF lamp extinguishes.

(6) Depress the DC OUTPUT (S1) switch ◗"Push to Operate" lever.◖

Requirement: The rectifier will shut down and lock out. The RECT FAIL lamp lights, the POWER OFF lamp lights, and the POWER ON lamp remains lighted.

(7) Release the DC OUTPUT (S1) switch ◗"Push to Operate" lever.◖

(8) Operate the POWER ON/POWER OFF (S2) switch twice to restart the rectifier. The POWER ON lamp lights and the RECT FAIL and POWER OFF lamps extinguish.

(9) Restore the rectifier to normal operation in accordance with paragraph 3.03 or 3.04.

4.11 ***Shutdown Feature—Circuit Breaker CB1:*** To check the operation of the circuit breaker CB1, the rectifier must be isolated from the battery and in the TEST mode of operation. Proceed as follows:

(1) Operate the POWER ON/POWER OFF (S2) switch to the POWER OFF position. The POWER OFF lamp lights and the POWER ON lamp extinguishes.

(2) Operate the DC OUTPUT (S1) switch to the OFF position.

(3) Operate the OFF-TEST (S4) switch to the TEST position.

(4) Verify the circuit breakers (CB1) and (CB2) are in the ON position.

(5) Operate the POWER ON/POWER OFF (S2) switch to the POWER ON position. The POWER ON and TEST lamps light. The POWER OFF lamp extinguishes.

(6) Operate the POWER FACTOR circuit breaker (CB1) to the OFF position.

Requirement: The RECT FAIL lamp lights and the rectifier shuts down.

(7) Operate the POWER FACTOR circuit breaker (CB1) to the ON position.

Requirement: The rectifier does not restart and the RECT FAIL lamp remains lighted.

(8) Operate the ◗POWER ON/POWER OFF◖ (S2) switch to the POWER OFF position and then to the POWER ON position.

Requirement: The rectifier restarts and the RECT FAIL lamp extinguishes.

(9) Restore the rectifier to normal operation as outlined in paragraph 3.03 or 3.04.

4.12 ***Shutdown Feature—Circuit Breaker (CB2):*** To check the operation of the circuit breaker (CB2), the rectifier must be isolated from the battery and in the TEST mode of operation. Proceed as follows:

(1) Repeat subparagraphs 4.11(1) through (5).

(2) Operate the RELAY AND ALARM circuit breaker (CB2) to the OFF position.

Requirement: The rectifier shuts down and the RECT FAIL lamp lights.

(3) Operate the RELAY AND ALARM circuit breaker (CB2) to the ON position.

Requirement: The rectifier does not restart and the RECT FAIL lamp remains lighted.

(4) Operate the ◗POWER ON/POWER OFF◖ (S2) switch to the POWER OFF position and then to the POWER ON position.

Requirement: The rectifier restarts and the RECT FAIL lamp extinguishes.

(5) Restore the rectifier to normal operation as outlined in paragraph 3.03 or 3.04.

4.13 ***Shutdown Feature—DC OUTPUT ALARM (F2) Fuse and OUTPUT VOLTAGE (F3) Fuse:*** To check the fuse failure shut down feature, the rectifier must be isolated from the battery and in the TEST mode of operation. Proceed as follows:

(1) Repeat subparagraphs 4.11(1) through (5).

(2) Remove the DC OUTPUT ALARM (F2) fuse and install a blown fuse in its place.

Requirement: The circuit breaker (CB2) trips, the rectifier shuts down, and the RECT FAIL lamp lights.

(3) Remove the blown fuse and install the original DC OUTPUT ALARM (F2) fuse.

Requirement: The rectifier will not restart and the RECT FAIL lamp remains lighted.

(4) Operate the circuit breaker (CB2) to the ON position.

(5) Operate the POWER ON/POWER OFF (S2) switch to the POWER OFF position and then to the POWER ON position.

Requirement: The rectifier restarts. The RECT FAIL lamp extinguishes.

(6) Repeat (1) through (5) substituting the blown fuse into the OUTPUT VOLTAGE (F3) fuse block.

(7) Replace the blown fuse with a good one and restore the rectifier to normal operation as outlined in paragraph 3.03 or 3.04.

4.14 ***Shutdown Feature, Plant HV Lead:*** To check the high-voltage plant shutdown feature, the rectifier must be isolated from the battery and in the TEST mode of operation. Proceed as follows:

(1) Repeat subparagraphs 4.11(1) through (5).

Caution: Do not touch the HV terminal 6 on CP900 as this will shut down all other paralleled rectifiers in the battery plant resulting in service interruption.

(2) Connect a temporary frame ground, using a suitable cord, to the HV TEST terminal on CP900 circuit pack.

(3) Operate the SIMULATED OUTPUT CURRENT (S3) switch to the ON position.

(4) Slowly rotate the SIMULATED OUTPUT CURRENT (R10) rheostat cw until the OUTPUT CURRENT (M1) ammeter indicates approximately 40 amperes.

Requirement: The rectifier shuts down and the RECT FAIL lamp lights.

(5) Rotate the SIMULATED OUTPUT CURRENT (R10) rheostat fully ccw.

(6) Operate the SIMULATED OUTPUT CURRENT (S3) switch to the OFF position.

(7) Operate the POWER ON/POWER OFF (S2) switch to the POWER OFF position and then to the POWER ON position.

Requirement: The rectifier restarts and the RECT FAIL lamp extinguishes.

(8) Disconnect the frame ground from the HV TEST terminal on CP900.

(9) Restore the rectifier to normal operation as outlined in paragraph 3.03 or 3.04.

4.15 ***Shutdown Feature—Plant TR Lead:*** To check the operation of the plant TR shutdown

feature, the check is made with the rectifier in the TEST mode of operation. Proceed as follows:

(1) Repeat subparagraphs 4.11(1) through (5).

(2) ◗Connect a temporary frame ground, using a suitable cord to terminal TR7 on CP900 PLANT CONTROL circuit board.◖

Requirement: The rectifier will shut down. The POWER OFF lamp lights and the POWER ON lamp remains lighted.

(3) Disconnect the temporary frame ground from CP900 circuit pack.

Requirement: The POWER OFF lamp extinguishes. The rectifier restarts automatically.

(4) Restore the rectifier to normal operation in accordance with paragraph 3.03 or 3.04.

4.16 ***Inspect Output Filter Capacitor Fuses:*** Each output filter capacitor is fused by two ◗24-gauge fusible wire lengths◖ to protect the capacitor from excessive ripple current. One fuse is connected to the positive terminal and the other to the negative terminal. In the event of a shorted capacitor, the fuse disconnects the capacitor from the rectifier output. ***No alarm is given. Therefore, the fuses should be periodically inspected.***

5. TROUBLES

5.01 Refer to Section 169-742-311 for trouble locating information for the KS-20490 rectifier.