

**J86296 RECTIFIER**  
**48 VOLTS, 400 AMPERES**  
**VOLTAGE-REGULATED OUTPUT CONTROL**  
**FOR 23-, 25-, OR 27-CELL PLANT (REGULAR AND EMERGENCY CELLS)**  
**OPERATING METHODS**

**1. GENERAL**

**1.01** The J86296 semiconductor-type, self-regulating rectifier, using saturable reactor control, is used to float, charge, and overcharge storage batteries of the 301C and 302A power plants. The output range for automatic or manual operation is 46 to 62 volts, 5 to 400 amperes. The input power requirement is 3-phase, 3-wire, 60-Hz  $\pm 2$  percent, 196 to 245 volts or 410 to 480 volts  $\pm 7$  percent. With the rotary switch (S1) set to BAT, GR1, or GR2 position, the rectifier may be connected to charge a 23-, 25-, or 27-cell battery, respectively. The RECT OFF-NOR switch must be set to OFF before setting the S1 switch from one position to another.

**Warning:** Voltages inside the rectifier case are over 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. Battery voltage will be present on the terminals of the S1 rotary switch.

**1.02** This section is being reissued to make the following changes:

- (a) To revise the adjustment procedures for the Automatic Control Circuit, the Current Limit Circuit, and the Overload (OL) relay.
- (b) To add routine checks for the rectifier Ventilating Passages, Magnetic Amplifier Range Adjustment, and AR1 and AR2 Ammeter Relay High and Low Settings.

This reissue does affect the Equipment Test List.

**1.03** This issue of the section is based on the following drawings:

SD-81398-01, Issue 9—Rectifier Circuit (Fig. 1 and 2)

SD-81411-01, Issue 3—VR-824 Network

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.

**1.04** For more detailed information on operation and maintenance of related equipment or apparatus, refer to appropriate Bell System Practices.

**1.05** Battery voltage indications, called for in the section, may be made with the plant voltmeter or a KS-8039 volt-milliammeter, provided the instrument is connected at the battery and has been calibrated for accuracy at float voltage. The accuracy of the plant meter when compared with a standard shall be within  $\pm 0.2$  volt. These limits apply at any point in the float voltage range.

**Note:** The mechanical contacts of the AR1 and AR2 ammeter relays may be replaced with the solid state contacts of the KS-20522, L13 Controller. The controller contains no moving parts or heated filaments, which provides more reliable service with less maintenance than the mechanical contacts. The KS-20522, L13 Controller is available as part of a modification kit which includes mounting hardware, wire, installation and wiring information, and, where required, some minor external components. The modification kit for this rectifier is coded as J86741A, List 4

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for AR1 and J86741A, List 5 for AR2. For additional information, refer to the following:

SD-82023-01—KS-20522 Solid State Controller Circuit

Section 024-360-201—KS-20522 Solid State Controller Operation and Adjustments

**2. TOOLS AND TEST APPARATUS**

CODE OR SPEC NO.	DESCRIPTION
<b>TOOLS</b>	
418A	5/16 and 7/32-Inch Open Double-End Flat Wrench
—	3-Inch C Screwdriver
—	Blocking and insulating tools, as required. (Use tools and apply as covered in Section 069-020-801.)
<b>TEST APPARATUS</b>	
—	*Ballantine Laboratories, Inc, Model 300U/3 Electronic Voltmeter or
—	*Hewlett-Packard Co, Model 400D Electronic Voltmeter
—	*A. B. DuMont Lab Inc, Type 304 Oscilloscope
KS-3008	Stopwatch
KS-8039	DC Volt-Milliammeter
KS-14510	Volt-Ohm-Milliammeter

\*This equipment is not required for normal maintenance (see 5.06).

**3. OPERATION**

**Note:** All controls are accessible when the front doors are opened with the exception of the COMM SUPPR and BAL 1 through

BAL 6 potentiometers. These controls are accessible when the hinged control panel (J86295B) is swung out. The ADJ VOLTS COARSE and FINE, CON CUR-H and L, GAIN ADJ, and ANTI-HUNT controls are located on the VR network (CPS 1).

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

(a) The rectifier controls are positioned as follows:

RECT (S2) switch to OFF

\*S1 dc output switch to BAT OFF

NOR-TEST R key to TEST R

AUTO-MAN key to AUTO

AMPL (S4) switch to NOR

REG (S6) switch to NOR

CON CUR TST (R33) potentiometer fully counterclockwise (ccw)

REG TST (R54) potentiometer fully ccw

MAN (R32) potentiometer fully ccw

CONT (CB1) circuit breaker to ON

48V CONT1 (CB2) circuit breaker to ON

48V CONT2 (CB3) circuit breaker to ON

Associated ac switch and fuse unit located in bus duct or power service cabinet to ON.

**\*Note:** Before operating the S1 switch from one position to another, shut down the rectifier. In an operating plant, shift the load from the rectifier before shutting it down.

(b) The GAIN ADJ, CON CUR-H and L, and ANTI-HUNT potentiometers are adjusted in accordance with Part 4.

**Note:** Do not reposition any other control at this time.

- (c) Correct primary taps on the T1 transformer and the taps on TS2 terminal strip for the T2 transformer are selected, as shown on the SD drawing, for the ac service available.
- (d) The connection at contact 7 of the BO relay is disconnected and insulated when the rectifier is used with the 301C plant to prevent rectifier shutdown during ac power failure. (See SD-81398-01, Fig. 2).
- (e) All rectifier control fuses and associated load distribution fuses of the proper size are installed.◆

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

- (1) ◆Verify that the rectifier controls are positioned as listed in 3.01.
- (2) Connect the KS-8039 dc volt milliammeter (or equivalent digital dc voltmeter) across the REG (+) and REG (-) test jacks.
- (3) Operate the RECT (S2) switch to the NOR position.
- (4) Adjust, as required, the ADJ VOLTS COARSE and FINE potentiometers until the KS-8039 meter indicates 49.0 volts (for 23 cells).

**Note:** The rectifier output voltage is set low initially to prevent a high voltage shutdown when the rectifier is switched into the plant circuit.

- (5) Operate the RECT (S2) switch to the OFF position.◆
- (6) Operate the S1 dc output switch to the BAT position.
- (7) Operate the NOR TEST R key to the NOR position.
- (8) Operate the RECT (S2) switch to the NOR position.

**Requirement:** ◆The connecting plant circuit applies battery over the CT lead to start the rectifier.

- (9) Observe the indication on the plant voltmeter and the KS-8039 meter.
- (10) Adjust, as necessary, the ADJ VOLTS COARSE and FINE potentiometers until the KS-8039 meter and the plant voltmeter indicate the float voltage as specified in the appropriate power plant Bell System Practice. (Typical float voltage requirement is 49.9 volts dc for 23 cells.)



**The plant output voltmeter indicates the voltage that is available at the battery. The plant voltmeter and the KS-8039 meter may not indicate the same voltage due to loop voltage drop of the charge leads. The rectifier output voltage must be adjusted until the voltage requirement is met at the plant voltmeter.**

**Note:** The nominal float voltage for the battery in a standard plant is usually 2.17 volts per cell. For additional information on the required float voltage, refer to Section 157-601-301.◆

- (11) On the power plant control panel, operate the FLOAT-CHG key to the CHG position.

**Requirement:** ◆The rectifier output voltage should increase approximately 1 volt.◆

- (12) Adjust, as necessary, the CHG (R61) potentiometer until the KS-8039 meter and the plant voltmeter indicate the charge voltage as specified in the appropriate power plant Bell System Practice. (Typical charge voltage requirement is 50.6 volts dc for 23 cells.)

**Note 1:** ◆The nominal charge voltage for the battery in a standard plant is 2.20 volts per cell.◆

**Note 2:** When the rectifier is used in the 301C plant, the CHG potentiometer is shorted out and the charge voltage is adjusted with the CHARGE potentiometer in the plant.

- (13) In the connecting plant, operate the FLOAT-CHG key to the FLOAT position. ◆Observe that the rectifier output voltage returns to the float value.

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- (14) Block the CR relay operated to remove the short from the CUR REG (R60) potentiometer. (Refer to 069-020-801 for procedure to block relays.)
- (15) Adjust, as required, the CUR REG (R60) potentiometer until the KS-8039 meter and the plant voltmeter indicate 50.9 volts dc (23 cells).
- (16) Remove the block from the CR relay. Observe that the rectifier output voltage returns to the float value.
- (17) If the OLA relay was blocked, remove the block.
- (18) Lock the setting of the ADJ VOLTS COARSE and ADJ VOLTS FINE potentiometers.
- (19) Disconnect the KS-8039 meter.◆

**3.03 Stopping:** To remove the rectifier from operation, proceed as follows.

- (1) ◆Remove the rectifier from plant service in accordance with the appropriate power plant Bell System Practice.◆
- (2) Operate the RECT (S2) switch to the OFF position.
- (3) ◆If the rectifier is to be out of service for an extended period of time, proceed as follows:
  - (a) Operate the S1 dc output switch to the BAT OFF position.
  - (b) Operate the control circuit breakers CB1, CB2, and CB3 to the OFF position.
  - (c) Operate the associated ac switch and fuse unit located in bus duct or power service cabinet to the OFF position.
  - (d) **Caution: Connect the electrolytic capacitors of the output filter to a source of direct current of suitable voltage and polarity in accordance with 032-110-701.◆**

**3.04 Manual Operation:** To operate the rectifier manually, proceed as follows.

- (1) ◆Operate the RECT (S2) switch to the OFF position.
- (2) Operate the S1 dc output switch to the required BAT, GR1, or GR1 and GR2 positions.
- (3) Operate the NOR-TEST R key to the TEST R position.◆
- (4) Operate the AUTO-MAN key to the MAN position.
- (5) ◆Check that the MAN (R32) potentiometer is fully ccw.
- (6) Operate the RECT (S2) switch to the NOR position.◆
- (7) Rotate the MAN (R32) potentiometer clockwise (cw) to increase the output to the desired value.

**Note:** Continuity of service is provided by this manual control. The MAN (R32) potentiometer should always be restored to its maximum ccw position at the completion of a check or when returning to automatic regulation.

**3.05 Summary of Nominal Settings:** The following adjustments should prevail for 23-cell battery unless plant requirements differ.

- (a) The ADJ VOLTS COARSE and FINE potentiometers adjusted until the rectifier voltage output is equal to the battery float voltage requirement (49.9 volts).
- (b) The CHG potentiometer adjusted to 2.20 volts per cell (50.6 volts).
- (c) The CUR REG potentiometer adjusted to 50.9 volts.
- (d) AR1 ammeter relay
  - (1) Set the low contact at 20 amperes.
  - (2) Set the high contact at 380 amperes.
- (e) AR2 ammeter relay

- (1) Set the low contact at 100 amperes (25 percent of full load).
- (2) Set the high contact at 300 amperes (75 percent of full load).
- (f) The CON CUR-H potentiometer adjusted at 412 amperes.
- (g) The CON CUR-L potentiometer adjusted at 300 amperes (for No. 5 X-BAR, 200 to 300 amperes).
- (h) The OL relay operates at 450 amperes in less than 5 seconds.⚡

#### 4. ROUTINE CHECKS

**4.01** ⚡It is suggested that the following routine checks be made in accordance with the Equipment Test List, or after the rectifier has been out of service for an extended period of time and is to be returned to service or if maintenance is performed which may affect the settings of the rectifier controls.

**Caution:** *The MAN (R32) potentiometer should always be turned completely ccw before operating a test switch to avoid excessive voltage and current.*

**Note:** When adjusting the ADJ VOLTS COARSE, GAIN, ANTI-HUNT, CON CUR-L, and CON CUR-H potentiometers, use the 418A tool to unlock the locking nut of the potentiometer. When the required setting is obtained, use the tool to lock the potentiometer.

**4.02 Ventilating Passages:** Keep the ventilating passages of the rectifier unobstructed to ensure adequate cooling during operation. The interior of the rectifier should be cleaned periodically while the rectifier is shut down. Remove dust from all accessible components inside the rectifier cabinet with a long handle, blade type brush. Using a suitable vacuum cleaner, vacuum the floor area inside the rectifier cabinet to remove all dust and dirt. The period between cleanings should be determined by local conditions.⚡

**4.03 Contactor and Relays:** The contactor and relays should be inspected for adjustment and condition of contacts to make sure that they

are in accordance with the circuit requirements table and Bell System Practices which apply.

**4.04 Automatic Control Circuit:** To check the operation of the automatic control circuit, proceed as follows.

**Note:** An increase in current on the SAT CURRENT 1 milliammeter increases the rectifier output voltage. An increase in current on the SAT CURRENT 2 milliammeter decreases the rectifier output voltage.

(1) Operate the RECT (S2) switch to the OFF position.

(2) Operate the following controls:

S1 dc output switch to BAT

NOR-TEST R key to TEST R

AUTO-MAN key to AUTO

AMPL (S4) switch to TST

REG (S6) switch to NOR

CON CUR TST (R33) potentiometer fully ccw

MAN (R32) potentiometer fully ccw

ADJ VOLTS COARSE potentiometer fully ccw

Associated ac switch and fuse unit located in bus duct or power service cabinet to ON.⚡

(3) Operate the RECT (S2) switch to the NOR position.

**Requirement:** ⚡The SAT CURRENT 2 milliammeter indicates some value.

(4) Rotate the ADJ VOLTS COARSE potentiometer cw to reduce SAT CURRENT 2 indication to zero.

**Requirement:** The SAT CURRENT 1 milliammeter indication increases to more than 100 milliamperes.

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- (5) Rotate the ADJ VOLTS COARSE potentiometer fully ccw.⚡
- (6) Operate the REG (S6) switch to the TST position.

**Requirement:** The SAT CURRENT 2 milliammeter indicates some value.

- (7) Rotate the REG TST (R54) potentiometer cw to obtain 1 to 2 milliamperes on the SAT CURRENT 2 milliammeter.
- (8) Operate and hold the REG TST (S5) switch to the TST position. (The REG TST switch is a momentary contact switch and must be held operated in the TST position.)

**Requirement:** The SAT CURRENT 1 milliammeter indication decreases to zero. The SAT CURRENT 2 indication increases to more than 100 milliamperes.

**Note:** If the requirement is not met, the CPS1 VR control circuit is possibly defective.

- (9) Release the REG TST (S5) switch.
- (10) Rotate the REG TST (R54) potentiometer fully ccw.
- (11) Operate the REG (S6) switch to the NOR position.
- (12) Operate the RECT (S2) switch to the OFF position.

**4.05 Current Limit Circuit:** To check the current limiting circuit, proceed as follows.

- (1) ⚡Operate the RECT (S2) switch to the OFF
- (2) Operate the following controls:

S1 dc output switch to BAT OFF

NOR-TEST R key to TEST R

AUTO-MAN key to AUTO

AMPL (S4) switch to NOR

CON CUR TST (R33) potentiometer fully ccw

MAN (R32) potentiometer fully ccw

ADJ VOLTS COARSE potentiometer fully ccw

CON CUR-H potentiometer fully ccw

CON CUR-L potentiometer fully ccw

Associated ac switch and fuse unit located in bus duct or power service cabinet to ON.

- (3) Connect the KS-8039 dc volt-milliammeter (or equivalent digital dc voltmeter), across the REG (+) and REG (-) test jack on the control panel.

**Caution:** When one terminal of the voltmeter is grounded, connect that terminal to the REG (+) test jack.⚡

- (4) Set the high contact on the OUTPUT CURRENT (AR1) ammeter relay to 500 amperes. If the AR1 ammeter relay is equipped with the KS-20522 Controller, rotate the H CONT potentiometer, located on the controller, fully cw.
- (5) Operate the RECT (S2) switch to the NOR position.
- (6) Adjust, as necessary, the ADJ VOLTS COARSE potentiometer until the dc voltmeter indicates float voltage. (Typical 49.9 volts dc for 23 cells.)⚡
- (7) Operate and hold the CON CUR TST (S3) switch to the TST position. (The CON CUR TST switch is a momentary contact switch and must be held operated in the TST position.)

**Requirement:** The AR1 ammeter relay indicates approximately 200 amperes.

- (8) Slowly rotate the CON CUR TST (R33) potentiometer cw until the AR1 ammeter relay indicates 412 amperes.

- (9) Observing the dc voltmeter connected at REG (+) and REG (-) test jacks, rotate the CON CUR-H potentiometer ccw until the voltage indication decreases 1 volt.

(10) Release the CON CUR TST (S3) switch and rotate the CON CUR TST (R33) potentiometer fully ccw. Lock the setting of the CON CUR-H potentiometer.

(11) Check the constant current high setting by holding the CON CUR TST (S3) switch operated and rotating the CON CUR TST (R33) potentiometer slowly cw until the voltage indication on the dc voltmeter drops 1 volt.

**Requirement:** The AR1 ammeter relay indicates 412 amperes.

(12) When the requirement is met, release the CON CUR TST (S3) switch and rotate the CON CUR TST (R33) potentiometer fully ccw.

**Note:** Where the rectifier is used as a G1 unit in a 301-C plant or as a G2 unit in a 302A plant, (13) through (20) are not required.

(13) Block the CRL relay operated. (Refer to Section 069-020-801 for procedure to block relays.)

(14) Operate and hold the CON CUR TST (S3) switch to the TST position.

(15) Slowly rotate the CON CUR TST (R33) potentiometer cw until the AR1 ammeter relay indicates 300 amperes (or 200 amperes for No. 5 Crossbar load).

(16) Observing the dc voltmeter connected at REG (+) and REG (-) test jacks, rotate the CON CUR-L potentiometer ccw until the voltage indication decreases 1 volt.

(17) Release the CON CUR TST (S3) switch and rotate the CON CUR TST (R33) potentiometer fully ccw. Lock the setting of the CON CUR-L potentiometer.

(18) Check the constant current low setting by holding the CON CUR TST (S3) switch operated and rotating the CON CUR TST (R33) potentiometer slowly cw until the voltage indication on the dc voltmeter drops 1 volt.

**Requirement:** The AR1 ammeter relay indicates 300 amperes (or 200 amperes for No. 5 Crossbar load).

(19) When the requirement is met, release the CON CUR TST (S3) switch and rotate the CON CUR TST (R33) potentiometer fully ccw.

(20) Remove the block from the CRL relay.

(21) Operate the RECT (S2) switch to the OFF position.

(22) Insulate the 8B contact of the CRL relay. (Refer to Section 069-020-801 for procedure to insulate contacts.)

(23) Operate the RECT (S2) switch to the NOR position.

(24) Operate and hold the CON CUR TST (S3) switch to the TST position and slowly rotate the CON CUR TST (R18) potentiometer cw until the AR1 ammeter relay indicates 412 amperes. Wait 2 minutes, then rotate CON CUR TST (S3) potentiometer until the AR1 ammeter relay indicates 420-425 amperes. Wait 4 minutes to make sure the OL relay does not operate. Now, **very slowly**, rotate the CON CUR TST (R33) potentiometer cw until the AR1 ammeter relay indicates 450 amperes.

**Requirement:** The OL relay operates within 5 seconds to operate the OLA relay and shuts down the rectifier. The OVERLOAD lamp lights and the RF relay operates to provide an alarm in the connecting plant.

**Note:** When the rectifier does not shut down within the specified time, operate the OLA relay manually to determine whether the failure circuit path is operative. If the rectifier shuts down when the OLA relay is operated manually, the failure path is satisfactory but the OL relay circuit or OL relay may not be properly adjusted. See 4.08.

(25) Release the CON CUR TST (S3) switch.

(26) Operate the RECT (S2) switch to the OFF position. The OVERLOAD lamp extinguishes.

(27) Rotate the CON CUR TST (R33) potentiometer fully ccw.

(28) Remove the insulation from contact 8B of the CRL relay.

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- (29) ◆ Disconnect the dc voltmeter from the REG (+) and REG (-) test jacks.
- (30) Readjust the high contact of the AR1 ammeter relay to 400 amperes in accordance with 4.10.

**4.06 Magnetic Amplifier Range Adjustment:**

To adjust the magnetic amplifier range of control, proceed as follows.

- (1) Operate the RECT (S2) switch to the OFF position.
- (2) Operate the following controls:
  - S1 dc output control to BAT
  - NOR-TEST R key to TEST R
  - AUTO-MAN key to MAN
  - AMPL (S4) switch to NOR
  - REG (S6) switch to NOR
  - CON CUR TST (R33) potentiometer fully ccw
  - MAN (R32) potentiometer fully ccw
  - ADJ VOLTS COARSE-FINE potentiometers set for float voltage
  - Associated ac switch and fuse unit located in bus duct or power service cabinet to ON.
- (3) Connect the KS-8039 dc volt-milliammeter (or equivalent digital dc voltmeter) across the REG (+) and REG (-) test jacks on the control panel.

**Caution:** *When one terminal of the voltmeter is grounded, connect that terminal to the REG (+) test jack.*

- (4) Operate the RECT (S2) switch to the NOR position.
- (5) Rotate the MAN (R32) potentiometer cw to increase the charging current until the indication on the dc voltmeter is at float value (typical 49.9 volts dc for 23 cells) for currents below the full rated output of the rectifier.

Maintain float value, as applicable, as the charging current decreases.

- (6) When the current indicated on the OUTPUT CURRENT (AR1) ammeter relay is less than 50 amperes, operate the AUTO-MAN key to the AUTO position.
- (7) Rotate the MAN (R32) potentiometer fully ccw.
- (8) Adjust the ADJ VOLTS FINE potentiometer, as required, to obtain an output of 49.9 volts dc for 23 cells.
- (9) Add sufficient load to obtain a rectifier output of 200 amperes.
- (10) Observe the SAT CURRENT 1 and SAT CURRENT 2 milliammeters.

**Requirement:** The current indication on SAT CURRENT 1 milliammeter should equal the current indication on SAT CURRENT 2.

- (11) Adjust as required, the BIAS (R26) potentiometer until the indications on the SAT CURRENT 1 and SAT CURRENT 2 milliammeters are approximately equal.
- (12) Operate the RECT (S2) switch to the OFF position.
- (13) Disconnect the dc voltmeter from REG (+) and REG (-) test jacks.

**4.07 Float and Charge Voltage Adjustment:**

Adjust the float and charge voltage in accordance with 3.04.

**4.08 Overload (OL) Relay Adjustment:** Adjust the OL relay *only* if the requirement is not met in the overload shutdown test in 4.05.

- (1) Operate the RECT (S2) switch to the OFF position.
- (2) Operate the following controls:
  - S1 dc output switch to BAT OFF
  - NOR-TEST R key to TEST R
  - AUTO-MAN key to AUTO

AMPL (S4) switch to NOR

REG (S6) switch to NOR

CON CUR TST (R33) potentiometer fully  
ccw

MAN (R32) potentiometer fully ccw

ADJ VOLTS COARSE-FINE potentiometer  
set for float voltage

CON CUR-H and CON CUR-L potentiometers  
set in accordance with 4.05

Associated ac switch and fuse unit located  
in bus duct or power service cabinet to ON.

- (3) Set the high contact on the OUTPUT CURRENT (AR1) ammeter relay to 500 amperes. If the AR1 ammeter relay is equipped with the KS-20522 Controller, rotate the H CONT potentiometer located on the controller fully cw.
- (4) Insulate the 8B contact of the CRL relay. (Refer to Section 069-020-801 for procedure to insulate contacts.)
- (5) Rotate the OL ADJ (R112) potentiometer fully cw.
- (6) Operate the RECT (S2) switch to the NOR position.
- (7) Operate and hold the CON CUR TST (S3) switch to the TST position.
- (8) Rotate the CON CUR TST (R33) potentiometer cw until the AR1 ammeter relay indicates 412 amperes.
- (9) Wait for 5 minutes with the CON CUR TST (S3) switch in the TST position to stabilize the heater of OL relay, then continue with (10).
- (10) Slowly readjust the CON CUR TST (R33) potentiometer cw until the AR1 ammeter relay indicates 450 amperes.

**Note:** It is important that the 450-ampere setting be made exactly, as the OL relay is very sensitive to small current variations.

Do not overshoot the 450-ampere division on the AR1 ammeter relay.

- (11) While holding the CON CUR TST (S3) switch in the TST position, rotate the OL ADJ (R112) potentiometer slowly *ccw*, **in steps**, until the OL relay operates and the rectifier shuts down within 5 seconds after the adjustment is made.
- (12) Release the CON CUR TST (S3) switch; rotate the CON CUR TST (R32) potentiometer fully *ccw*; and then operate the RECT (S2) switch to the OFF position.
- (13) Operate the RECT (S2) switch to the NOR position and repeat (7) through (10) to check the setting.

**Requirement:** The OL relay operates within 5 seconds at the 450-ampere level to operate the OLA relay and shut down the rectifier.

**Note:** *If the requirement is met, proceed to (28).* If the adjustment range of the OL ADJ (R112) potentiometer is not sufficient to meet the requirement, continue with (14).

- (14) Release the CON CUR TST (S3) switch, rotate the CON CUR TST (R33) potentiometer fully *ccw*, and then operate the RECT (S2) switch to the OFF position.
- (15) **Warning:** *Verify that the RECT (S2) switch is in the OFF position. Rotate the OL ADJ (R112) potentiometer fully *ccw*.*
- (16) Turn the small adjusting screw, accessible through a hole in the top cover of the OL relay, out about 2 turns and then press the adjusting screw firmly downward.
- (17) Operate the RECT (S2) switch to the NOR position.
- (18) Operate and hold the CON CUR TST (S3) switch to the TST position.
- (19) Rotate the CON CUR TST (R33) potentiometer cw until the AR1 ammeter relay indicates 412 amperes.
- (20) Wait for 5 minutes with the CON CUR TST (S3) switch in the TST position to

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stabilize the heater of the OL relay, then continue with (21).

(21) Slowly readjust the CON CUR TST (R33) potentiometer cw until the AR1 ammeter relay indicates 450 amperes.

(22) While holding the CON CUR TST (S3) switch in the TST position, immediately start turning the adjustment screw of the OL relay in, **very slowly**, until the relay operates and shuts down the rectifier.

(23) Release the CON CUR TST (S3) switch, rotate the CON CUR TST (R33) potentiometer fully ccw, and then operate the RECT (S2) switch to the OFF position.

(24) Operate the RECT (S2) switch to the NOR position, and repeat (18) through (21) to check the OL relay setting.

**Requirement:** The OL relay operates within 5 seconds at the 450-ampere level.

**Note:** If the requirement is met, continue with (25). If the requirement is not met, repeat (23) to turn the rectifier off and then repeat (16) through (24) until the OL relay does operate within 5 seconds.

(25) Release the CON CUR TST (S3) switch, rotate the CON CUR TST (R33) potentiometer fully ccw, and then operate the RECT (S2) switch to the OFF position.

(26) Rotate the OL ADJ (R112) potentiometer fully cw and repeat (6) through (13) to adjust the overload shutdown circuit.

(27) Release the CON CUR TST (S3) switch, rotate the CON CUR TST (R33) potentiometer fully ccw, and then operate the RECT (S2) switch to the OFF position.

(28) Remove the insulation from the 8B contact of the CRL relay.

(29) Readjust the high contact of AR1 ammeter relay in accordance with 4.10.4

**Note:** This procedure should eliminate cyclic hunting of the rectifier output voltage.

(1) Operate the RECT (S2) switch to the OFF position.

(2) Operate the following controls:

S1 dc output switch to BAT OFF

NOR-TEST R key to TEST R

AUTO-MAN key to AUTO

AMPL (S4) switch to NOR

REG (S6) switch to NOR

CON CUR TST (R33) potentiometer fully ccw

MAN (R32) potentiometer fully ccw

Associated ac switch and fuse unit located in bus duct or power service cabinet to ON.4

(3) Connect an ac vacuum tube voltmeter (or equivalent digital voltmeter set on ac millivolt scale) across REG (+) and REG (-) test jacks.

**Caution:** *When one terminal of the voltmeter is grounded, connect that terminal to the REG (+) test jack.*

(4) Operate the RECT (S2) switch to the NOR position.

(5) Adjust, as required, the ADJ VOLT COARSE and FINE potentiometers until the VM output voltmeter indicates 49.9 volts dc for 23 cells.4

**Requirement:** The ac voltmeter indicates a ripple voltage of less than 150 millivolts. The indication should be nearly steady, indicating minimum cyclic hunting.

**Note:** If the requirement is met, proceed to (7). If the requirement is **not** met, continue with (6).

(6) Slowly rotate the ANTI-HUNT potentiometer ccw until the requirement is met.

### 4.09 Gain and Anti-Hunt Adjustment

**Note:** When the requirement cannot be obtained with the best possible adjustment of the ANTI-HUNT potentiometer, rotate the GAIN ADJ potentiometer ccw until the requirement is met.

- (7) ♦ When cyclic hunting is eliminated, lock the GAIN ADJ and ANTI-HUNT potentiometers.♦
- (8) Operate the RECT (S2) switch to the OFF position.
- (9) Disconnect the ac voltmeter.

**4.10 ♦ High and Low Settings of AR1 and AR2 Ammeter Relays:** To check the settings of the AR1 and AR2 ammeter relays, proceed as follows.

**Note 1:** The mechanical contacts of the AR1 and AR2 ammeter relays may be replaced with the solid state contacts of the KS-20522, L13 Controller. The high and low settings are adjusted by the L CONT (low) and H CONT (high) potentiometer on the controller. Clockwise adjustment of the L CONT or H CONT potentiometer increases the setting. Refer to Section 024-360-201 for additional information on the KS-20522 Controller.

**Note 2:** This adjustment procedure applies to the setting of the mechanical contacts or the adjustment of the KS-20522 Controller.

**AR1 and AR2 Low Contact Setting**

- (1) Operate the RECT (S2) switch to the OFF position.
- (2) Operate the following controls:
  - S1 dc output switch to BAT
  - NOR TEST R key to TEST R
  - AUTO-MAN key to MAN
  - AMPL (S4) switch to NOR
  - REG (S6) switch to NOR
  - CON CUR TST (R33) potentiometers fully ccw

MAN (R32) potentiometer fully ccw

ADJ VOLT COARSE-FINE potentiometers set for float voltage

Associated ac switch and fuse unit located in bus duct or power service cabinet to ON.

- (3) Connect the KS-14510 volt-ohm-milliammeter, set on 60 DC VOLTS scale, between terminal 7 of TS6 and ground.
- (4) Observe the KS-14510 meter for the low setting of AR1, and the CL relay for the low setting of AR2.
- (5) Operate the RECT (S2) switch to the NOR position.

**Requirement:** The KS-14510 meter indicates zero volts and the CL relay is released.

- (6) Slowly rotate the MAN (R32) potentiometer cw until the KS-14510 meter indicates voltage.

**Requirement:** The AR1 ammeter relay indicates  $20 \pm 0.2$  amperes.

- (7) Continue rotating the MAN (R32) potentiometer cw until the CL relay operates.

**Requirement:** The AR2 ammeter relay indicates  $100 \pm 1$  amperes (25% of full load).

**Note:** If the requirements are met in (6) and (7), proceed to (9). If either requirement is *not* met, continue with (8).

- (8) Rotate the MAN (R32) potentiometer fully ccw and adjust the AR1 *or* AR2 low setting upscale. Adjust the MAN (R32) potentiometer cw to the appropriate level, and then adjust the AR1 *or* AR2 low setting downscale until the requirements in (6) and (7) are met.

**AR1 and AR2 High Contact Setting**

- (9) Position the rectifier controls as follows:
  - MAN (R32) potentiometer fully ccw
  - RECT (S2) switch to OFF
  - S1 dc output switch to BAT OFF

AUTO-MAN key to AUTO

NOR-TEST R key to TEST R

- (10) Block nonoperated the overcurrent (OC) relay in the *plant*. (Refer to Section 069-020-801 for procedure to block relays.)
- (11) Disconnect the KS-14510 meter from terminal 7 of TS6 and reconnect the meter between terminal 8 of TS6 and ground.
- (12) Observe the CH relay for the high setting of AR2 and the KS-14510 meter for the high setting of the AR1.
- (13) Operate the RECT (S2) switch to the NOR position.

**Requirement:** The KS-14510 meter indicates voltage and the CH relay is released.

- (14) Operate the hold the CON CUR TST (S3) switch to the TST position. (The CON CUR TST switch is a momentary contact switch and must be held operated in the TST position.)

**Requirement:** The AR2 ammeter relay indicates approximately 200 amperes.

- (15) Slowly rotate the CON CUR TST (R33) potentiometer cw until the CH relay operates.

**Requirement:** The AR2 ammeter relay indicates  $300 \pm 3$  amperes (75% of full load).

- (16) Continue rotating the CON CUR TST (R18) potentiometer cw until the KS-14510 meter indication drops to zero. **Do not exceed 410 amperes on the AR1 ammeter relay before readjusting the high setting of AR1.**

**Requirement:** The AR1 ammeter relay indicates  $400 \pm 4$  amperes.

**Note:** If the requirements are met in (15) and (16), proceed to (18). If either requirement is not met, continue with (17).

- (17) Release the CON CUR TST (S3) switch, rotate the CON CUR TST (R33) potentiometer fully ccw, and then adjust the AR1 *or* AR2 high setting upscale. Operate and hold the CON CUR TST (S3) switch to the TST position and

adjust the CON CUR TST (R33) potentiometer cw to the appropriate level. Adjust the AR1 *or* AR2 high setting downscale until the requirements in (15) and (16) are met.

- (18) Release the CON CUR TST (S3) switch, rotate the CON CUR TST (R33) potentiometer fully ccw, and then operate the RECT (S2) switch to the OFF position.
- (19) Disconnect the KS-14510 meter.
- (20) Remove the block from the OC relay in the *plant*.

## 5. TROUBLES

### General

**5.01** This rectifier consists of a main power circuit controlled through a semiconductor regulating circuit whose input is battery voltage through the regulating leads of the main unit. In addition, a signal from the current sensing circuit is introduced into the regulating circuit for the purpose of current limitation. The output of the regulating circuit is introduced into saturable reactors in the main power circuit in order to make the desired corrections in the power output. In the maintenance of intricate equipment, trouble must be localized in an orderly way. This is difficult in the case of a circuit having this feedback loop arrangement because trouble anywhere in the loop will give faulty operation of other parts of the loop which may be trouble free. In this rectifier, provision has been made for opening the loop by means of switches which permit checking the performance of each major subdivision of the equipment until the trouble is located.

**Caution:** Before operating a test switch, the MAN potentiometer should always be rotated completely ccw to avoid excessive voltage and current.

**5.02** Although it may vary widely with extreme conditions, the saturating current when observed in connection with daily routine and compared with operating experience, can serve as a guide to the causes of unusual operation or trouble conditions. The purpose of the saturating current milliammeters is to give a continuous indication of the output of the semiconductor regulating circuit which controls the output of the

main power rectifying circuit. The saturating current supply circuit and main power circuit are generally performing satisfactorily if increasing the amount of saturating current, SAT CURRENT 1, increases the rectifier output and increasing the saturating current, SAT CURRENT 2, decreases the rectifier output. Provision is made to manually control this saturating current, in which case most of the features of the more complex regulating circuit are temporarily disabled.

**5.03** When any kind of trouble is encountered, it is necessary to decide whether to locate the trouble with the equipment operating or de-energized. This rectifier has been designed to make some parts accessible for testing with the power connected. The jacks are mounted on the face of the panel and are accessible when the front door is open. All parts over 150 volts to ground have been covered. Trouble is easier to find if the equipment can be fully energized, but if it is of a nature that causes excessive output from the equipment, perform the initial steps with the system de-energized, and energize it for short periods only while electrical measurements are made. Also, operation for more than a few minutes at a time while trouble exists, even though the output may not be excessive, may result in overheating of some components. It is essential, when testing, to be alert for the need of quickly shutting down the rectifier at any time until the trouble is localized and cleared.

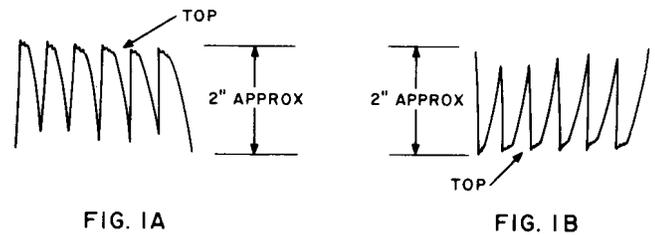
**5.04** The control potentiometers and switches should be replaced if they become defective in any respect.

**5.05** To avoid unbalance, only the complete rectifying element (stack) should be replaced. In no case should any attempt be made to replace part of the rectifier cells in the stack assembly which is part of the rectifying element.

**5.06** To check for a defective saturable reactor, proceed as follows.

- (1) Connect the DuMont type 304 oscilloscope to the SCOPE Y and SCOPE G or SCOPE X and SCOPE G jacks.
- (2) Adjust the sweep frequency so as to have six partial sine waves present on the oscilloscope as indicated in Fig. 1. The trace may appear as either one of the two figures

shown. The height of the trace shall be approximately 2 inches. If all waves are adjusted to approximately equal height, the cores of the L1 through L6 saturable reactors are balanced and the trouble is elsewhere (check filter). If they are not of equal height, it is an indication of a defective saturable reactor or an open BAL 1 through BAL 12 balancing potentiometer. Badly distorted waves may indicate a defective power diode.



**Fig. 1—Core Characteristics of Saturable Reactors**

- (3) Check potentiometers for open circuit with the KS-14510 volt-ohm-milliammeter.
- (4) Replace any potentiometer having an open circuit.
- (5) Readjust all potentiometers using the same method as specified in (6) for use after a saturable reactor is replaced.
- (6) In checking for a defective saturable reactor, the adjustment of any of the BAL potentiometers affects the lower position (opposite TOP Fig. 1) of two partial sine waves. If the height of any wave cannot be adjusted, it is an indication of a defective associated saturable reactor. Replace it and adjust the core characteristics of *all* of the saturable reactors as follows: Use SCOPE Y and SCOPE G jacks for BAL 1 through BAL 6, SCOPE X and SCOPE G jacks for BAL 7 through BAL 12 potentiometers.
  - (a) BAL 1 through BAL 12 balancing potentiometers of the saturable reactors shall be turned maximum ccw. Increase the load of the rectifier to 200 amperes.
  - (b) Determine which balancing potentiometer affects the height of the longest half wave viewed on the oscilloscope (longest is

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defined as the longest line from TOP as designated in Fig. 1).

- (c) Adjust this potentiometer until the two affected sine waves are of equal height.
- (b) Adjust all remaining potentiometers to equal this one.
- (e) With the electronic voltmeter (see Caution) connected across the REG+ and REG- jacks and using it as an indicator, all balancing potentiometers may be slightly readjusted to obtain minimum reading without regard to the possible slight unbalance on the oscilloscope. The balancing will vary with the load.

**Caution:** *If one side of the oscilloscope is grounded, connect the grounded side to SCOPE G jack which is ground bus. If one side of the electronic voltmeter is grounded, plug this side in the REG + jack.*

### Point-To-Point Voltages

**5.07** As long as the rectifier unit operates satisfactorily, point-to-point voltage values are not needed and are not operating requirements to be checked in routine. In case the rectifier output cannot be obtained, they may be useful in locating defective conditions.

**5.08** High voltages to ground are present within the rectifier and every precaution should be observed to avoid any contact with exposed metal parts or terminals when the rectifier is in operation, or when not in operation but connected to either line or battery.

**Caution:** *When using any portable instrument, the leads should be carefully examined to make sure the insulation is undamaged. The leads should be connected to the instrument before making contact with the circuit to be tested. If the leads are to be changed from one jack or terminal to another at the meter, the ac power should first be removed from the rectifier being tested, or if test picks are being used, they should be removed from the rectifier under test.*

**5.09** The readings given in Table A represent typical values at 206 and 435 volts ac line voltage measured at the rectifier input and with the output voltage and current adjusted as indicated in Table A. These readings are made with the KS-14510 meter.

**5.10** Access for making measurements depends on the location of the equipment.

**Caution:** *The indications shown in Table A are for a typical rectifier in good working condition. A defective rectifier with the power connected may have quite different voltages than those shown. Therefore, it may be desirable to use a higher voltage scale on the meter until the indications determine the proper scale to use for the defective conditions.*

- (a) For equipment located on the front of the **control panel**, open the doors on the front of the cabinet. This will expose the panel, and will not affect the operation of the rectifier.
- (b) For equipment located on the **rear of the control panel**, with the doors open, unfasten and swing the panel out. This will not shut down the rectifier.
- (c) For equipment located in the **rear of the cabinet**, open the rear doors. This will not shut down the rectifier.
- (d) When making measurements of the voltages of equipment located on the rear of the control panel or in the rear of the cabinet, test clip leads will be required.

**5.11 Trouble Chart:** Should any of the following troubles develop, it is suggested that the possible cause be checked in the order given. If the trouble is not found, look for loose or open connections or short circuits due to foreign matter lying across wiring terminals. If a check of the possible causes listed below, or the use of the point-to-point voltages (see Table A) does not lead to the location of the trouble, it is advisable to make resistance measurements with the circuit completely de-energized, comparing the measured values with the values shown on the circuit drawing.

TROUBLE	POSSIBLE CAUSE	TROUBLE	POSSIBLE CAUSE
(a) No dc output current (no saturating current)	Blown ac supply or control fuse. CB3 circuit breaker in OFF position. Bias supply failure. BO relay failure. AC contactor not operated.	(g) High dc output voltage (output current less than full load)	Rectifier in MAN position. CHG fuse blown. REG fuse blown.
(b) No dc output current (high SAT CURRENT 1)	CHG fuse blown. Bias adjustment incorrect — excessive BIAS current.	(h) Output excessively noisy	Defective filter capacitors. Unbalanced ac line voltage (more than 5 percent). Defective rectifier stacks. BAL 1 (R1) through BAL 12 (R12) potentiometers misadjusted.
(c) Low dc output current (low SAT CURRENT 1)	ADJ VOLTS FINE or ADJ VOLTS COARSE potentiometer misadjusted. CON CUR H potentiometer misadjusted. Low line voltage or T1 transformer taps incorrect. Faulty transistor amplifier.		
(d) Low dc output current (high SAT CURRENT 1)	Excessive charging lead drop. Rectifier operating single phase. Excessive BIAS current.	(i) Unstable output (hunting)	ANTI-HUNT potentiometer misadjusted. GAIN ADJ potentiometer misadjusted. Defective 824A network. Insufficient load. OL relay misadjusted.
(e) High dc output current (output voltage normal or nearly so)	CON CUR H potentiometer misadjusted. Defective 824A network.	(j) Rectifier shuts off after short interval of operation	
(f) Output current high (output voltage high)	Defective 824A network or adjustment. High line voltage or incorrect T1 transformer taps. Insufficient BIAS current.	(k) Poor regulation at battery	CON CUR H potentiometer misadjusted. Excessive charging lead drop. NOR-TST R switch in TST R position. Line voltage out of limits. GAIN ADJ potentiometer too far ccw.

**Note:** GAIN ADJ and ANTI-HUNT potentiometers should be kept as near full cw position as possible.

**Caution:** *Hunting should be corrected as soon as possible to prevent damage to rectifier.*

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<b>TROUBLE</b>	<b>POSSIBLE CAUSE</b>
(l) Ripple indication greater than 200 millivolts	Defective L1, L2, L3, L4, L5, or L6 saturable reactor (see 5.06).  Open balancing BAL 1 through BAL 12 potentiometers.  Blown Amp-Trap F1 through F12 fuses.  Defective filter.

TABLE A						
Output Volts: 50 Volts						
Output Current: As Required To Cause Sat Current 1 = Sat Current 2						
APPARATUS	METER CONNECTIONS		INPUT: 206 VOLTS		INPUT: 435 VOLTS	
	FROM TERM	TO TERM.	METER SCALE VOLTS	INDICATION VOLTS	METER SCALE VOLTS	INDICATION VOLTS
AC Contactor	T1	T2	300 ac	206	600 ac	435
	T1	T3	300 ac	206	600 ac	435
	T2	T3	300 ac	206	600 ac	435
T2 Transformer ("T" Option)	1	2	300 ac	206		
	7	8	300 ac	150		
	9	10	300 ac	150		
	11	12	300 ac	150		
	13	14	60 ac	28		
T2 Transformer ("S" Option)	1	3			600 ac	435
	6	7			300 ac	150
	8	9			300 ac	150
	10	11			300 ac	150
	12	13			60 ac	28
Jacks	J1	GRD	60 dc	12*	60 dc	12*
	J2	GRD	60 dc	12*	60 dc	12*
	J3	GRD	60 dc	26*	60 dc	26*
	J4	GRD	60 dc	26*	60 dc	26*
	J5	GRD	60 dc	12.5*	60 dc	12.5*
	J6	GRD	60 dc	12.5*	60 dc	12.5*
	J7	GRD	60 dc	26*	60 dc	26*
	J8	GRD	60 dc	26*	60 dc	26*
	J9	GRD	60 dc	26*	60 dc	26*
	J10	GRD	60 dc	12.5*	60 dc	12.5*
	J11	GRD	60 dc	26*	60 dc	26*
	J12	GRD	60 dc	12.5*	60 dc	12.5*

\*The dc voltages shown are negative with respect to ground.