J86249A, B, AND C RECTIFIERS
AND
J86249E L1 ELECTRONIC CONTROL
OPERATING METHODS

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1. GENERAL

1.01 The J86249 regulated metallic-type rectifier, in conjunction with the J86249E L1 electronic control, provides regulated dc power for 300-type plants. See Fig. 1 and 2. It is designed to provide regulated dc power from an ac power service. The rectifier is available in ratings of 44 to 65 volts, 100 amperes dc, 22 to 33 volts, 100 amperes dc, and 22 to 33 volts, 200 amperes dc, and is suitable for floating and charging storage batteries. The input power requirement is 210 volts ±8 percent, 3-phase, 3-wire, 60-Hz ±2 percent alternating current, but, with transformers, it may be connected to nominal 230- or 250-volt power service. It is self-regulating within ±0.5 percent and is suitable for use in room temperatures from 50 to 104°F (10 to 40°C).

1.02 This section is reissued to:

(a) Omit the information under the headings "How the Rectifier Works" and "Manual Control."

(b) Add point-to-point voltages for the J86249B rectifier.

(c) Revise the routine checks.

(d) Bring the section generally up to date.

Since this is a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 The abbreviations cw and ccw refer to clockwise and counterclockwise, respectively.

1.04 Keeping the ventilating passages and rectifier cells clean is especially important to prevent excessive heating. Care should be taken when soldering above stacks to prevent solder splashes from shorting cells in a rectifier stack.

1.05 Routine checks are intended to detect defects, and insofar as possible to guard against circuit failures liable to interfere with service. Checks and adjustments, other than those required by trouble conditions, should be made during a period when they will cause the least unfavorable reaction to service.

Caution: 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. The door switches, when open, disconnect the 3-phase power from the transformers, but leave the incoming terminals of the AC contactor connected. They also disconnect battery from the main rectifier elements, but leave the CHARGE fuse and certain other equipment connected. Battery voltage will be present on the terminals of the OUTPUT (S3) rotary switch and elsewhere in the

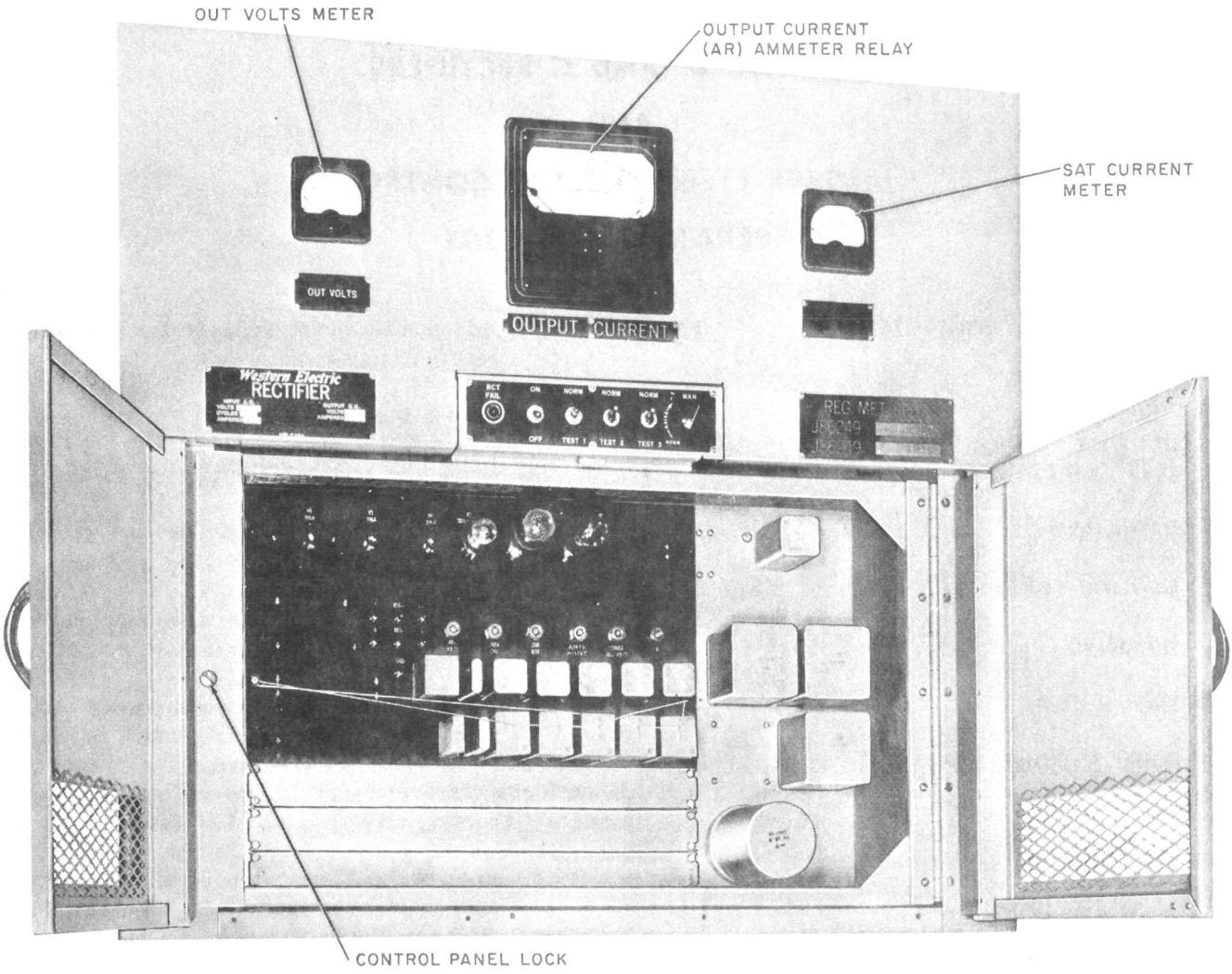


Fig. 1—J86249E L1 Electronic Control Panel and Rectifier Output Meters

rectifier when the CHARGE fuse is removed. The door switches are provided for the protection of personnel and should not be made inoperative. The dc windings (3-4) of saturable reactors L1, L2, L3, and L6 may have ac voltages of over 1000 volts under trouble conditions.

1.06 The instructions are based on drawing SD-81129-01, Fig. 1 and 2. For detailed description of the operation, see the corresponding circuit description.

1.07 More detailed information on the operation and maintenance of individual pieces of apparatus, such as instruments and switches, is given in other sections and the attendant should be familiar with them. All apparatus should be adjusted in accordance with these sections and with the circuit requirements table or the circuit description associated with the circuit drawing.

1.08 Battery voltage indications may be made with the plant voltmeter or a KS-8039 volt-milliammeter, provided that the instrument is connected at the battery and has been calibrated for accuracy at float voltage.

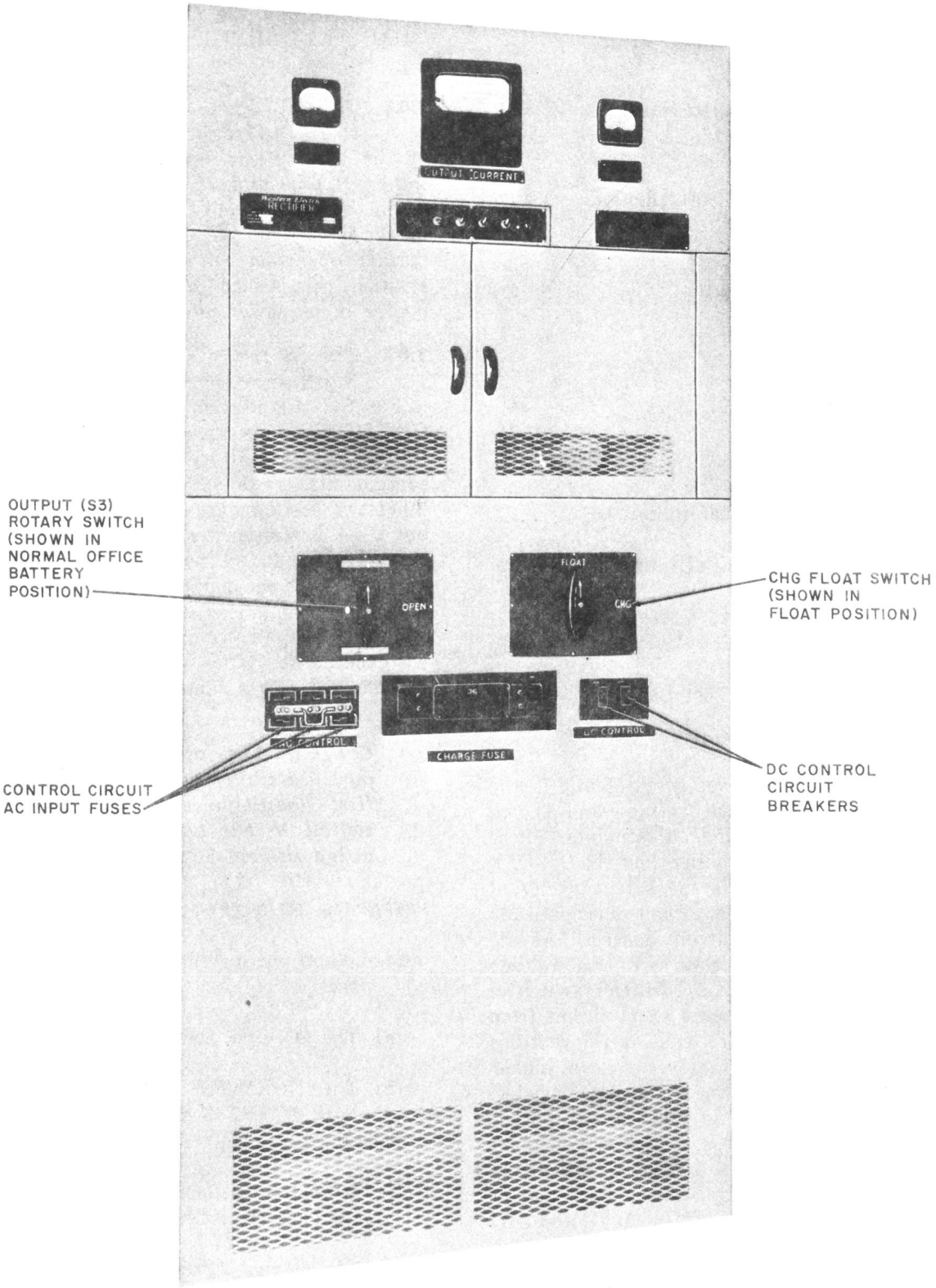


Fig. 2—J86249A, B, or C Rectifier With J86249E L1 Electronic Control

2. LIST OF TOOLS, GAUGES, MATERIALS, AND TEST APPARATUS

CODE OR SPEC NO.	DESCRIPTION
TOOLS	
—	3-Inch C Screwdriver
GAUGES	
R-1032, Detail 1	Thermometer
MATERIALS	
—	Felt Pad
TEST APPARATUS	
KS-8039	Volt-Milliammeter
KS-14510	Volt-Ohm-Milliammeter
—	Voltmeter, Weston Model 904 300/150 Volt
—	35-Type Test Set

3. OPERATION

3.01 The rectifier is completely automatic in the regulation of the float voltage and should require no day-to-day routine adjustments. It is started and stopped by the operation of the ON-OFF switch. If the load exceeds the safe capacity of the rectifier, the regulating circuit automatically switches over to constant current control. As the load diminishes, the rectifier returns to float voltage regulation. Operation of a CHG-FLOAT switch in the connecting circuit removes a short circuit from the OVER CHG potentiometer, causing the rectifier to operate under voltage regulation at a higher value as determined by the setting of the potentiometer. The rectifier should start and build up its output in less than one minute unless the associated plant causes a greater delay. The voltage at which the rectifier will regulate is adjustable by means of two potentiometers, COARSE ADJ VOLTS and ADJ VOLTS. Higher voltages for charging the battery may be obtained, without disturbing the float voltage adjustment, by externally removing a short circuit from the OVER CHG potentiometer. The amount of current in the regulating coils of the reactors is indicated on ammeter SAT CURRENT. The output voltage and current of the rectifier will be indicated on the OUT VOLTS voltmeter and OUTPUT CURRENT (AR) ammeter relay (see Fig. 1).

3.02 The CHG-FLOAT switch will normally be in the FLOAT position. Usually a boost charge of the battery can be made with the switch in the FLOAT position. The CHG position is required when the battery and emergency cells are charged in series. While regulation can be secured for normal operation with the switch in the CHG position, this is inadvisable as it results in a much poorer input power factor.

3.03 The S3 rotary switch, marked OPEN (see Fig. 2) and designated OUTPUT rotary switch in Fig. 3, is a 3-position switch. The center position OPEN disconnects the negative charging lead from the associated battery to remove battery from components while servicing the rectifier. The other two positions are not marked on the rectifier, but the top position connects the rectifier negative charging lead to the normal office batteries. The bottom position usually connects the rectifier negative charging lead to the normal office batteries and the emergency end cells, which are in series with the normal office batteries, for charging after a prolonged power failure.

Caution: Do not turn the rectifier to ON position under automatic control without first operating the OUTPUT (S3) rotary switch to the battery position (except as noted in 5.06 and 6.04).

PREPARING TO START

3.04 When putting the rectifier in service, check that:

(a) The ON-OFF switch is in the OFF position.

(b) The NORM-TEST 1, NORM-TEST 2, and NORM-TEST 3 switches are in the NORM position.

(c) If input transformers are provided, the taps used are correct for the power supply voltage.

(d) The correct tubes are in the sockets.

(e) The correct CHARGE and VM fuses are in place.

(f) The correct AC CONTROL fuses and supply fuses are in place.

(g) The potentiometers COARSE ADJ VOLTS, OVER CHG, and MAN are in full ccw positions. The ADJ VOLTS potentiometer is in its approximate midposition.

Caution: The MAN potentiometer should always be rotated fully ccw to avoid excessive voltage and current when a NORM-TEST switch is operated.

(h) The CHG-FLOAT switch is operated to the FLOAT position.

(i) The OUTPUT (S3) rotary switch is operated to the desired position (see 3.03).

Caution: Except as indicated in 5.06 and 6.04, do not start the rectifier with the OUTPUT (S3) rotary switch in the OPEN position.

(j) Covers and doors are tightly closed so that the door switches S1 and S8 are operated.

(k) Circuit breakers CONT and CHG ALM are closed.

(l) Sufficient office load or a variable load of adequate capacity is available to fully load the rectifier.

(m) The rectifier terminals are strapped in accordance with the application drawing for the particular office.

(n) The CHG-FLOAT switch in the associated plant is operated to the FLOAT position or OVER CHG potentiometer is otherwise shorted out.

(o) The high and low contacts of the AR ammeter relay are set to 90 percent and 5 percent, respectively.

Note: If the office load is less than 5 percent of rated rectifier load, set the low contact of the AR ammeter relay lower (minimum of 2 percent) to prevent a false rectifier failure alarm.

STARTING

3.05 ***Float Voltage:*** To put the rectifier in service, observe the directions in 3.03 and proceed as follows:

(1) Operate CHG-FLOAT switch to FLOAT.

(2) Set OUTPUT (S3) rotary switch to the desired position (see 3.03).

(3) Operate ON-OFF switch to ON.

(4) Allow approximately one minute for the tubes to heat.

(5) Rotate COARSE ADJ VOLTS potentiometer cw until, with the battery at float voltage, the rectifier is carrying its share of the load or, if there are no rectifiers operating in parallel with it, until it is carrying the entire load. The rectifier output current should be between 25 and 75 percent of full rated output.

(6) Rotate the ADJ VOLTS potentiometer until the desired float voltage is obtained.

Note: This adjustment should be made with the battery fully charged or nearly so, and with the rectifier carrying approximately its normal load, if known, otherwise with a load of one-fourth to three-fourths of full rated output. If at any time it is necessary to reset the COARSE ADJ VOLTS potentiometer, the ADJ VOLTS potentiometer should first be restored to its midposition.

3.06 ***Overcharge Voltage:*** The OVER CHG potentiometer may be externally short circuited by the connecting circuit and is ineffective in that event. After adjusting the float voltage, temporarily remove the short circuit and adjust the OVER CHG potentiometer for the desired battery voltage. Record this voltage for reference. This setting should be rechecked when the rectifier output current is less than three-fourths rated load.

STOPPING

3.07 To remove the rectifier from service, proceed as follows:

(1) Operate NORM-TEST 1 switch to TEST 1.

(2) Using the MAN potentiometer, adjust the rectifier output to zero.

Note: Allow time for the other rectifiers operating in parallel to accept the load.

(3) Operate ON-OFF switch to OFF.

(4) If the rectifier is to be left out of service, remove the ac power fuses and CHARGE fuse.

(5) Rotate MAN potentiometer to NORM.

(6) Operate NORM-TEST 1 switch to NORM.

3.08 Measure the input voltage of each phase to the rectifier stacks when the stacks are new and the rectifier is operating at rated current, voltage, and normal-line input. Use the Weston Model 904 voltmeter, or an equivalent 0.5 percent accurate meter. Record these readings and place them on the rectifier for future reference.

4. ROUTINE CHECKS

4.01 As often as local experience demands, the relays should be inspected for adjustment and condition of contacts, making sure that they are in accordance with the circuit requirement tables and Bell System Practices which apply.

4.02 Periodically check the regulation of the rectifier as follows:

(1) Increase the load to the rectifier to full load.

Requirement: The rectifier shall be self-regulating within ±0.5 percent.

(2) Decrease the load to the rectifier to one-fourth of full load.

Requirement: The rectifier shall be self-regulating within ±0.5 percent.

(3) Restore the load to normal float operation.

4.03 ***Test Operation:*** Periodically operate the NORM-TEST switches to check the rectifier operation as follows.

Caution: The MAN potentiometer must be in its NORM (full ccw) position before switching the NORM-TEST switches from NORM to TEST.

(1) Operate the NORM-TEST 1 switch to TEST 1.

(2) Rotate the MAN potentiometer cw.

Requirement: The saturating current and voltage output shall increase.

(3) Rotate the MAN potentiometer to NORM.

(4) Operate the NORM-TEST 1 switch to NORM.

(5) Operate and hold the NORM-TEST 2 switch to TEST 2.

(6) Rotate the MAN potentiometer cw.

Requirement: The saturating current and voltage output shall increase.

(7) Rotate the MAN potentiometer to NORM.

(8) Operate the NORM-TEST 2 switch to NORM.

(9) Operate and hold the NORM-TEST 3 switch to TEST 3.

(10) Rotate the COARSE ADJ VOLTS potentiometer to three-fourths full cw position.

(11) Rotate the MAN potentiometer cw.

Requirement: The saturating current shall increase. A point shall be reached where further rotation of the MAN potentiometer has no effect.

Note: This point is where the regulating circuit switches from constant voltage to constant current regulation.

(12) Rotate the COARSE ADJ VOLTS potentiometer fully ccw.

(13) Rotate the MAN potentiometer to NORM.

(14) Operate the NORM-TEST 3 switch to NORM.

(15) Operate the ADJ VOLTS potentiometer to midrange.

(16) Rotate the COARSE ADJ VOLTS potentiometer cw until, with the battery at float voltage or if there are no rectifiers operating in parallel with it, it is carrying the full load.

(17) Rotate the ADJ VOLTS potentiometer to obtain the desired float voltage.

4.04 ***Rectifier Circuit Checks:*** Periodically perform the checks as follows:

Overload Limit OL Relay

(1) Rotate CUR MAX potentiometer fully cw.

(2) Operate the NORM-TEST 1 switch to TEST 1.

(3) Using the MAN potentiometer, adjust the rectifier output to zero.

Note: Decrease the load to the battery or increase the output of the other rectifiers or charge generators supplying it, as required, to avoid service reaction.

(4) Operate the ON-OFF switch to OFF.

(5) Connect the BAT and GRD terminals of the 35-type test set to terminals 3 and 2 of the AR ammeter relay shunt, respectively.

(6) Adjust the sliders of the 35-type test set for 25 ohms and connect terminals T and R together.

Note: It is important to keep the slider adjusted for a resistance of 25 ohms or more to prevent errors in shunt voltage readings.

(7) Position the high contact of the AR ammeter relay to the extreme right position.

(8) Operate the ON-OFF switch to ON.

(9) Using the MAN potentiometer, adjust the rectifier output current to 90 percent of rated rectifier output, as indicated by the OUTPUT CURRENT (AR) ammeter relay.

(10) Adjust the slider to give an indication of 9 milliamperes on the 15-milliampere scale. Leave the sliders undisturbed; 100 percent of full load will give an indication of 10 milliamperes; 110 percent of full load will give an indication of 11 milliamperes.

(11) Adjust the rectifier output, using the MAN potentiometer, to 110 percent of full load current.

Requirement: The OL relay shall operate and a plant alarm is given.

(12) If the requirement in (11) is not met, adjust the A potentiometer until the OL relay operates.

Maximum Current Limit

(13) Using the MAN potentiometer, adjust the rectifier output to 25 percent of full load, as indicated on the 35-type test set.

(14) Allow the battery to discharge to 90 percent of float voltage, or lower, by manually reducing the output of the other rectifiers or charging generators supplying it, or increasing the load.

(15) Operate the NORM-TEST 1 switch to NORM.

(16) Rotate the CUR MAX potentiometer slowly ccw until the rectifier output current stabilizes at approximately 105 percent of full load when the battery voltage is between 94 and 96 percent of float voltage.

Note: An output of 105 percent of full load is indicated by 10.5 milliamperes on the 35-type test set. As an alternate check, the KS-8039 volt-milliammeter, set to the 1.5 VOLTS DC range, connected to terminals 2 and 3 of the AR ammeter shunt, will indicate 0.263 volt for 105 percent of full load. Disconnect the KS-8039 volt-milliammeter.

(17) Operate the NORM-TEST 1 switch to TEST 1.

(18) Using the MAN potentiometer, adjust the rectifier output to zero and rotate the MAN potentiometer to NORM.

Note: Reduce the load to the battery or increase the output of the other rectifiers or charging generator supplying it, as required, to prevent service reaction.

(19) Operate the ON-OFF switch to OFF.

(20) Disconnect the 35-type test set from terminals 2 and 3 of the AR ammeter relay shunt.

(21) Operate the NORM-TEST 1 switch to NORM.

(22) Operate the ON-OFF switch to ON and restore the rectifier to normal float operation.

Anti-Hunt

(23) If a cyclic increase and decrease of the rectifier output current is observed while

completing the routine check and adjustments, adjust the ANTI-HUNT potentiometer slowly until the hunting decreases to a minimum.

Note: In general, after the checks and adjustments are completed, the ANTI-HUNT potentiometer will operate most satisfactorily when left in the midrange position for a calcium battery load and in the three-fourths full cw position for a lead-antimony battery. If the ANTI-HUNT potentiometer is incapable of eliminating cyclic hunting of the rectifier output, use option A shown in SD-81129-01, if provided.

Overcharge Voltage

(24) Disconnect the external short circuit, located in the connecting circuit, across the OVER CHG potentiometer.

Requirement: The rectifier output voltage shall increase to the value obtained in 3.06.

(25) Connect the external short circuit, located in the connecting circuit, across the OVER CHG potentiometer.

4.05 ***OUTPUT CURRENT (AR) Ammeter Relay:*** Periodically check the setting of the high and low contacts of the AR ammeter relay as given in 3.04. To check the calibration of the OUTPUT CURRENT (AR) ammeter, proceed as follows:

(1) Operate the NORM-TEST 1 switch to TEST 1.

(2) Using the MAN potentiometer, adjust the rectifier output to zero.

Note: Decrease the load to the battery or increase the output of the other rectifiers or charging generators supplying it, as required, to prevent service reaction.

(3) Rotate the MAN potentiometer to NORM.

(4) Operate the ON-OFF switch to OFF.

(5) Operate the NORM-TEST 1 switch to NORM.

(6) Connect the KS-8039 volt-milliammeter, using the 1.5 VOLTS range, to terminals 2 and 3 of the AR ammeter shunt or to the SH+ and SH- jacks, if provided.

(7) Operate the NORM-TEST 1 switch to TEST 1.

(8) Operate the ON-OFF switch to ON.

(9) Rotate the MAN potentiometer slowly cw until the KS-8039 volt-milliammeter indicates 225 millivolts (0.225 volts).

Note: Increase the load to the battery or decrease the output of the other rectifiers supplying it, as required, to prevent service reaction.

Requirement: The OUTPUT CURRENT (AR) ammeter relay shall indicate 90 ±3 amperes for the 100-ampere rectifiers or 180 ±6 amperes for the 200-ampere rectifiers.

(10) Rotate the MAN potentiometer to NORM.

Note: Decrease the load to the battery or increase the output of the other rectifiers or charging generators supplying it, as required, to prevent service reaction.

(11) Operate the NORM-TEST 1 switch to NORM.

(12) Adjust the rectifier to assume the normal office load.

5. TROUBLES

5.01 This rectifier consists of a main power circuit controlled through an electronic regulating circuit whose input is the output voltage of the main unit. In addition, the drop in voltage across the output ammeter relay shunt is introduced into the regulating circuit for the purpose of current limitation. The output of the regulating circuit is introduced into the main power circuit to effect 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 or 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 (see 4.03).

Caution: The MAN potentiometer should always be rotated completely ccw before operating a test switch to avoid excessive voltage and current.

5.02 Aging taps are provided on transformers T1 through T3 for use when the main rectifier element has aged, usually after a long period of use. The connections should not be changed from taps 3 to taps 2 until the rated output cannot be obtained from the rectifier and until a thorough check has been made to be sure that there are no troubles. If rated output can be obtained with manual control, it will indicate that the transformer taps do not need to be changed.

5.03 If the rectifier stacks seem hot, check the temperature with a thermometer. Hold the bulb of the thermometer against the stack, covering that part of the bulb which is not in contact with the stack with a piece of felt or equivalent. If the temperature exceeds 90°C, the stacks are probably nearing the end of their useful life and the supervisor should be notified so that replacement of stacks may be considered.

5.04 An alternate method for determining if the rectifier stacks are approaching the end of their useful life is to measure the ac input voltage (across each phase) to the rectifier stacks when the rectifier is operating under the same conditions as outlined in 3.08, with a Weston Model 904 voltmeter or an equivalent 0.5 percent meter. Compare these values with those obtained in 3.08. When the voltage difference between the two sets of readings exceeds 2 volts, refer the matter to the supervisor as the rectifier stacks may have to be replaced. Since some of the rectifier stacks are arranged to form a bridge circuit, these should all be aged equally. If replacement is necessary due to aging, replace all stacks. If, however, a single stack opens or shorts when the others are comparatively new, the single stack may be replaced with one of the same code. Do not combine stacks from different manufacturers.

5.05 There is no provision for aging taps for varistor SR13 in the magnetic amplifier. To determine if the varistor needs to be replaced, proceed as follows:

(1) Operate the NORM-TEST 1 switch to TEST 1.

(2) Rotate the MAN potentiometer to the maximum cw position ***momentarily.***

Requirement: The SAT CURRENT meter indicates three-fourths of full scale.

Caution: Do not keep MAN potentiometer in the maximum cw position longer than is necessary to determine the SAT CURRENT meter indication because the output voltage increases rapidly.

Note: If the SAT CURRENT ammeter does not indicate three-fourths of full scale, check the electron tubes V1 and V2. If the tubes are found to be satisfactory, then the trouble is in the SR13 varistor and should be replaced.

(3) Rotate the MAN potentiometer to NORM.

(4) Operate the NORM-TEST 1 switch to NORM.

5.06 The taps on transformer T14 should be factory-adjusted for a minimum rectifier output voltage not greater than 45 volts for J86249A rectifiers or not greater than 22 volts for J86249B and J86249C rectifiers. If any of the following parts, C17, C18, T14, L6, or SR13 are replaced during maintenance, the T14 transformer taps may have to be reselected to meet the minimum voltage requirement. A change (shown on SD-81129-01) in the normal connections of transformer T14 was made to increase the adjustment range. To check the rectifier minimum voltage, proceed as follows:

(1) Decrease the load to the rectifier to no load.

(2) Operate the OUTPUT switch to OPEN.

(3) Operate the ON-OFF switch to OFF.

(4) Disable the regulating circuit (remove tube V1).

(5) Short circuit terminals 20 and 28 (see 6.04).

(6) Select an adjustable tap on transformer T14.

(7) Operate the ON-OFF switch to ON.

(8) Operate the NORM-TEST 1 switch to TEST 1.

(9) Record the output voltage.

(10) Repeat (3), (6), (7), and (9). As the adjustable tap lead is moved over the tap range, the rectifier output voltage should decrease to a minimum and then rise. Connect to the tap causing minimum voltage. If the voltage decreases as numerically lower taps are used but

does not meet the minimum voltage requirement when tap 6 is reached, try the following tap arrangement.

(a) Remove the strap between T14 transformer terminals 10 and 11 and connect a strap between terminals 6 and 13.

(b) Connect the adjustable tap to terminal 11 or 12 as required to meet the minimum voltage limit.

Caution: When changing taps, disconnect the rectifier from the power supply before touching the terminals.

(11) Shutdown the rectifier and repeat 3.05 and 3.06 to return the rectifier to normal float conditions.

5.07 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 milliammeter is to give a continual indication of the output of the magnetic amplifier, which output also controls the input to the main saturable reactors. The saturating current supply circuit and main power circuit are generally performing satisfactorily if increasing the amount of saturating current increases the rectifier output and decreasing the saturating current 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. Three test switches provide for the application of a manually adjustable potential to the grid-to-cathode circuits of certain tubes as follows:

NORM-TEST 1 Switch—Tube V2

NORM-TEST 2 Switch—Tube V4 (6-7-8 half)

NORM-TEST 3 Switch—Tube V6 (6-7-8 half)

By their separate operation to their TEST positions (in each instance the other two switches remaining on NORM) the series tube, the final amplifier, and the second current control amplifier may be tested (see 4.03).

5.08 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 in the face of the panel, which is accessible when the front doors are 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, it will be necessary to take the initial steps with the system de-energized, energizing it in subdivisions 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 component. 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.

5.09 In general, the only items likely to become defective with use are the electron tubes which are subject to aging but should have long useful life. Check the tubes in any available electron tube test set, in accordance with its associated instructions, one at a time or mark the tubes, as interchanging tubes may affect adjustments. Tubes which test low may still be satisfactory. Certain typical defects, such as grid emission or cathode-to-grid shorts may not be detected on the test set as they might occur only after the tube has heated for some time. Tube substitution should be the final criterion for replacement.

5.10 The control potentiometers, the KS-5716 switches, and the KS-5649 door switches should be replaced if they become defective in any respect.

Trouble Chart

5.11 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 or the use of the point-to-point voltage table 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
No dc output current (no saturating current in automatic control)	Blown ac supply or control fuse.
	CONT circuit breaker operated.
	Door switch open.
	COARSE ADJ VOLTS or CUR MAX potentiometer out of adjustment.
	V1, V2, V3, V4, or V6 tube failure.
	AC contactor failure.
No dc output current (high saturating current in automatic control)	CHARGE fuse blown.
Low dc output current (high saturating current when in automatic or manual control)	V1, V2, V4, or V6 tube weak.
	Aged main rectifier stacks.
	Aged SR13 stacks.
	Low-line voltage.
	Excessive charging lead drop.
High dc output current (high saturating current in automatic control)	High-line voltage.
	Failure or low emission voltage in V5.
	Excessive grid current in V2.
	REG leads open or fuse blown.
	COARSE ADJ VOLTS potentiometer out of adjustment.
	Rectifier in manual with MAN potentiometer not fully ccw.
Output excessively noisy	Filter capacitor defective.
	Faulty connection to filter capacitors.
	Unbalanced ac line voltage (more than 5 percent).
	Defective stack in main rectifier assembly.
Unstable output	AH potentiometer (when furnished) misadjusted.
	Faulty C7, C9, R38, or R39.
High output current in manual or automatic condition	"A" option required.
	RV1 failure.
Rated output current not obtainable with saturating current maximum under MAN control	Excessive drop in dc connection to load.
	Shorted C31 — C35.
	Main rectifier stacks high resistance due to aging.
	SR13 aged.
Rectifier shuts off after a short interval of operation	OL relay not adjusted properly.
Poor regulation at battery	Aged main or MAG AMPL stacks.
	Aged tubes.
	Excessive charging lead drop.

6. POINT-TO-POINT VOLTAGES

6.01 Point-to-point voltages are intended for use when unsatisfactory operation is encountered in which case they may prove useful in locating the cause. They are not operating requirements to be checked in routine and are not needed while the rectifier is operating satisfactorily. As given in the tables, they are approximate and typical of a rectifier connected to normal power supply, adjusted to the float voltage of the battery, and carrying load as indicated.

6.02 High voltages 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.

Caution: When using any portable instrument, the leads should be carefully examined to make sure the insulation is undamaged. The leads should be connected at the instrument before making contact with the circuit to be tested. If connections are to be changed from one instrument range to another, the alternating current should first be disconnected from the equipment being tested or if test picks are being used, they should be removed from the equipment under test.

6.03 Readings should be made with a KS-14510 voltmeter. The output of the rectifier will not be appreciably affected by connecting the voltmeter leads to the circuit elements. In general, door switches are not intended for use in disconnecting power, but for convenience, they may be so used during the infrequent taking of point-to-point voltages.

6.04 Viewed from the rear, the socket terminals, starting from the keyway or blank position, are numbered cw. Before taking the voltage readings, perform the following operations:

(1) Shut down the rectifier by operating the ON-OFF switch to the OFF position.

(2) Remove the regulating fuse (part of power plant).

(3) Short-circuit terminals 20 and 28.

Note: Care should be exercised when short-circuiting these terminals on the terminal block so as not to short them to the adjacent terminals or the VM fuse will blow.

(4) Operate the OUTPUT (S3) rotary switch to the OPEN position.

(5) Check that circuit breakers CONT and CHG ALM are on.

(6) Operate the ON-OFF switch to the ON position.

TABLE A — POINT-TO-POINT VOLTAGES

J86249A PANEL METER READINGS:	SAT CURRENT = 0.070 AMPERE OUTPUT VOLTS = 49.5 VOLTS
J86249B PANEL METER READINGS:	SAT CURRENT = 0.090 AMPERE OUTPUT VOLTS = 26.0 VOLTS
J86249C PANEL METER READINGS:	SAT CURRENT = 0.070 AMPERE OUTPUT VOLTS = 25.75 VOLTS

METER CONNECTIONS		METER SCALE (VOLTS)	READING (VOLTS)		
TEST POINT	TEST POINT		J86249A	J86249B	J86249C
Contactor AC					
T1	T2	300AC	205	208	208
T2	T3	300AC	205	208	206
T1	T3	300AC	205	208	207
L1	L2	300AC	205	208	208
L2	L3	300AC	205	208	207
L1	L3	300AC	205	208	208
Control Circuit Fuses (Both Sides)					
F1	F2	300AC	202	207	208
F2	F3	300AC	202	207	208
F1	F3	300AC	202	207	208

TABLE A — (Cont)

METER CONNECTIONS		METER SCALE (VOLTS)	READING (VOLTS)		
TEST POINT	TEST POINT		J86249A	J86249B	J86249C
Rectifier Stack AC Supply					
Between Each Phase		60AC	37	20	21
		60AC	37	20	21
		60AC	37	20	21
Pin Jacks					
REG+	REG−	60DC	48.5	26	25.5
SH+	SH−	0.3DC	0	0	0
S+	S−	12DC	6.5*	5*	4.0*
P	GND	300DC	143**	152**	148**
B	GND	300DC	255***	252***	258***
P	B	300DC	113	113	117
Transformers					
T1 — Term. 1	Term. 2	300AC	165	178	170
Term. 2	Term. 3	12AC	9.5	10	10.2
Term. 1	Term. 3	300AC	172	187	182
T2 — Term. 1	Term. 2	300AC	162	177	175
Term. 2	Term. 3	12AC	9.4	10	10.4
Term. 1	Term. 3	300AC	170	186	183
T3 — Term. 1	Term. 2	300AC	163	182	175
Term. 2	Term. 3	12AC	9.7	10.2	10.2
Term. 1	Term. 3	300AC	175	187	181
T4 — Term. 1	Term. 2	300AC	70	60	73
Term. 2	Term. 3	60AC	34	30	37
Term. 1	Term. 3	300AC	108	90	113
T5 — Term. 1	Term. 2	300AC	75	58	70
Term. 2	Term. 3	60AC	36.5	30	34
Term. 1	Term. 3	300AC	113	92	110
T6 — Term. 1	Term. 2	300AC	68	50	75
Term. 2	Term. 3	60AC	33	26	38
Term. 1	Term. 3	300AC	100	80	112
T10 — Term. 1	Term. 2	300AC	203	207	208
Term. 3	Term. 4	600AC	370	387	385
Term. 4	Term. 5	600AC	370	380	385
Term. 6	Term. 7	12AC	5	4.5	5.2
T11 — Term. 1	Term. 2	300AC	205	208	208
Term. 3	Term. 4	300AC	105	109	110
Term. 5	Term. 6	12AC	6	6.2	6.2
Term. 7	Term. 8	12AC	6	6.2	6.2
T12 — Term. 1	Term. 2	300AC	205	210	208
Term. 3	Term. 4	60AC	36	37	37
Term. 4	Term. 5	600AC	420	425	425
T13 — Term. 1	Term. 6	300AC	105	130	108
Term. 8	Term. 12	12AC	6.3	6.2	6.3
Term. 7	Term. 12	12AC	6.9	7.4	6.9

TABLE A — (Cont)

METER CONNECTIONS		METER SCALE (VOLTS)	READING (VOLTS)		
TEST POINT	TEST POINT		J86249A	J86249B	J86249C
T14 — Term. 1	Term. 2	300AC	100	105	100
Term. 3	Term. 4	300AC	100	105	100
Term. 5	Term. 10	300AC	248	250	248
Term. 11	Term. 13	12AC	11.3	11	11.3
Term. 5	Term. 6	300AC	232	230	230
Inductors					
L1 — Term. 1	Term. 2	300AC	265	255	262
Term. 3	Term. 4	3DC	2†	2.75†	2.2†
L2 — Term. 1	Term. 2	300AC	272	256	257
Term. 3	Term. 4	3DC	2†	2.75†	2.2†
L3 — Term. 1	Term. 2	300AC	268	250	260
Term. 3	Term. 4	3DC	2†	2.75†	2.2†
L6 — Term. 1	Term. 2	300AC	102	95	107
Term. 5	Term. 6	300AC	102	93	108
Term. 3	Term. 4	12DC	6.2†	5†	4.2†
Rectifying Elements					
RV1 — Term. 1	Term. 2	300DC	113	113	117
RV2 — Term. 2	Term. 2	300AC	138	150	141
Term. 1	Term. 3	300DC	143	151	145
SR13 — Term. AC	Term. AC	60AC	15	10.3	17
Term. (39)+	Term. (40)—	12DC	6	4.2	6.7
Potentiometer and Rheostats					
A — Term. 1	Term. 2	3DC	0	0	0
COARSE ADJ VOLTS (P1) Term. 1	Term. 2	60DC	23.5	24	25
MAN(P3) — Term. 1	Term. 2	300DC	245	240	250
Term. 1	Term. 3	3DC	0	0	0
CHG(P5) — Term. 1	Term. 3	3DC	0	0	0
Resistors					
R1	Each	60DC	26	31	28
R2	side of	3DC	0	0	0
R3	resistor	3DC	0	0	0
R4		300DC	38.3	49	78
R5		300DC	70	60	75
R6		300DC	133	150	155
R7		300DC	61	85	63
R8		3DC	0	0	0
R9		3DC	1.35	0.50	0.4
R11		12DC	7.5	7.6	7.4
R12		60DC	30.5	34	33

TABLE A — (Cont)

METER CONNECTIONS		METER SCALE (VOLTS)	READING (VOLTS)		
TEST POINT	TEST POINT		J86249A	J86249B	J86249C
R13		60DC	16.5	18	19
R15		300DC	80	108	105
R16		60DC	46***	53***	45***
R17		12DC	7.2	9.3	8.7
R18		60DC	21	29	25
R19		3DC	0	0	0
R20		300DC	95***	92***	100***
R21		300DC	116††	92††	115††
R22		300DC	83††	50††	75††
R25		12DC	1.45	0	6
R26		600DC	322	340	315
R28		60DC	22	0	0
R29		300DC	105	—	160
R30		3DC	0	—	0
R32		12DC	6.5*	—	4.4*
R33		60DC	15	—	0
R34		12DC	9.7	0	0
R35		300DC	78	0	0
R36		60DC	27.2	0	0
R38		3DC	0	0	0
R39		3DC	0	0	0
R40		12DC	2.5	4.8	0
Capacitors					
C2		300DC	113	—	117
C3		3DC	0.65	0.2	0.03
C4		3DC	0.03	0.2	1
C6		3DC	1.4	6.2	0.7
C7	R38 to R39 side	60DC	35*	37*	40*
C7	ANTI-HUNT Pot. to R39 side	60DC	40*	36*	38*
C8		300DC	143***	150***	145***
C9		60DC	40*	49*	47*
C10		60DC	23	35	30
C11		12DC	4.6	2.4	16
C12		60DC	35	48	34††
C13		12DC	2.9	5	2
C14		60DC	48.3	22	0.6
C15 & C16		60DC	48.2	22	24
C17 & C18		300AC	255	266	255
Tubes					
V1 — Term. 2	Term. 8	12AC	4.9	5	5.1
Term. 2	Term. 4	600DC	332	350	365
Term. 2	Term. 6	600DC	332	350	365
V2 — Term. 2	Term. 7	12AC	5.9	6.1	6.15
Term. 8	Term. 3	600DC	327	340	362
Term. 8	Term. 4	600DC	327	340	362
Term. 8	Term. 5	60DC	35	48	41*
V3 — Term. 2	Term. 5	300DC	143**	150**	145**

TABLE A — (Cont)

METER CONNECTIONS		METER SCALE (VOLTS)	READING (VOLTS)		
TEST POINT	TEST POINT		J86249A	J86249B	J86249C
V4 — Term. 1	Term. 9	12AC	6	6.2	6.2
Term. 8	Term. 7	12DC	1.4	6.3	8
Term. 2	Term. 3	12DC	2.9	5	3.5
Term. 2	Term. 4	300DC	115	147	130
V5 — Term. 1	Term. 9	12AC	6	6.1	6.2
Term. 8	Term. 6	300DC	115	95	125
Term. 8	Term. 7	12DC	4.6	2.4	5
Term. 2	Term. 3	60DC	23	35	31
Term. 2	Term. 4	300DC	115	95	125
V6 — Term. 1	Term. 9	12AC	5.7	—	5.7
Term. 8	Term. 6	60DC	18.3	—	18.3
Term. 8	Term. 7	0.3DC	0.03	—	0.03
Term. 2	Term. 3	3DC	0.67	0.05	0.67
Term. 2	Term. 4	300DC	68	35.3	68
RV3 — Term. 1	Term. 2	300DC	67	67	75
Term. 2	Term. 3	300DC	77	77	65
Term. 1	Term. 3	300DC	147	147	138

* Output voltage may increase when taking this reading.

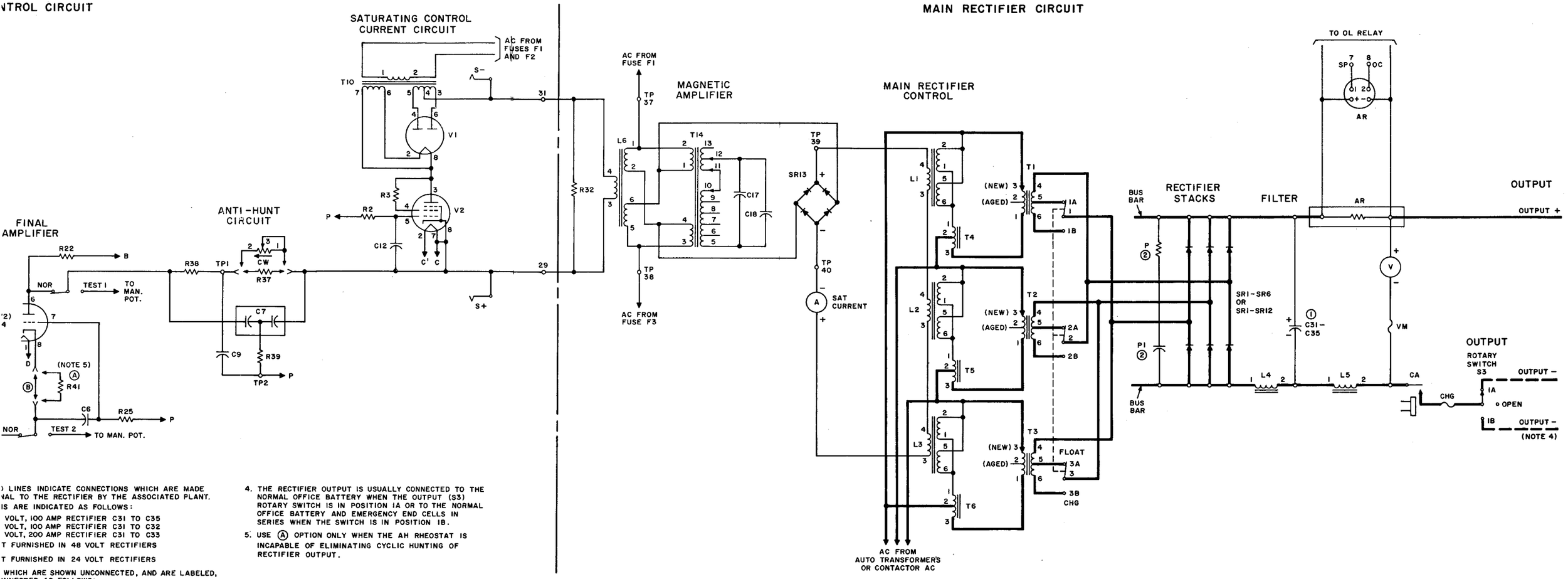
** This voltage may vary from 142 to 165 volts plus meter errors.

*** This voltage will vary with the P to GND voltage.

† ***Caution: The dc windings (3-4) of saturable reactors L1, L2, L3, and L6 may have ac voltages of 100 to 200 volts normally and over 1000 volts under trouble conditions.***

†† These voltages may vary considerably from those given.

— This part is not in the circuit.



) LINES INDICATE CONNECTIONS WHICH ARE MADE
NAL TO THE RECTIFIER BY THE ASSOCIATED PLANT.
IS ARE INDICATED AS FOLLOWS:

VOLT, 100 AMP RECTIFIER C31 TO C35
VOLT, 100 AMP RECTIFIER C31 TO C32
VOLT, 200 AMP RECTIFIER C31 TO C33
T FURNISHED IN 48 VOLT RECTIFIERS
T FURNISHED IN 24 VOLT RECTIFIERS

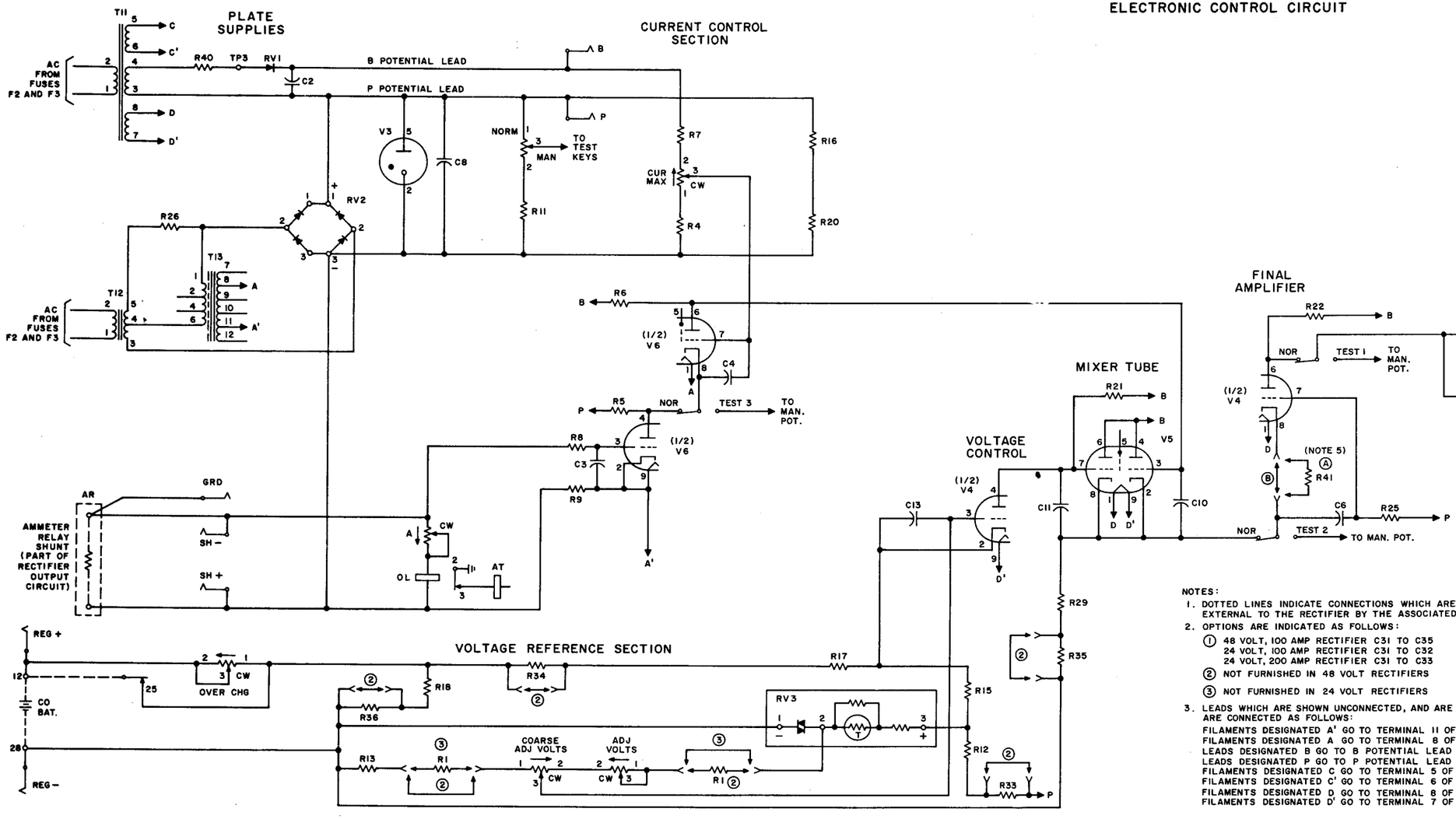
WHICH ARE SHOWN UNCONNECTED, AND ARE LABELED,
ONNECTED AS FOLLOWS:

ENTS DESIGNATED A' GO TO TERMINAL 11 OF T13
ENTS DESIGNATED A GO TO TERMINAL 8 OF T13
DESIGNATED B GO TO B POTENTIAL LEAD
DESIGNATED P GO TO P POTENTIAL LEAD
ENTS DESIGNATED C GO TO TERMINAL 5 OF T11
ENTS DESIGNATED C' GO TO TERMINAL 6 OF T11
ENTS DESIGNATED D GO TO TERMINAL 8 OF T11
ENTS DESIGNATED D' GO TO TERMINAL 7 OF T11

4. THE RECTIFIER OUTPUT IS USUALLY CONNECTED TO THE NORMAL OFFICE BATTERY WHEN THE OUTPUT (S3) ROTARY SWITCH IS IN POSITION 1A OR TO THE NORMAL OFFICE BATTERY AND EMERGENCY END CELLS IN SERIES WHEN THE SWITCH IS IN POSITION 1B.
5. USE (A) OPTION ONLY WHEN THE AH RHEOSTAT IS INCAPABLE OF ELIMINATING CYCLIC HUNTING OF RECTIFIER OUTPUT.

Fig. 3—Simplified Schematic of J86249 Rectifier With J86249E L1 Electronic Control

ELECTRONIC CONTROL CIRCUIT



NOTES:

1. DOTTED LINES INDICATE CONNECTIONS WHICH ARE MADE EXTERNAL TO THE RECTIFIER BY THE ASSOCIATED PLANT.
2. OPTIONS ARE INDICATED AS FOLLOWS:
   - (1) 48 VOLT, 100 AMP RECTIFIER C31 TO C35
     24 VOLT, 100 AMP RECTIFIER C31 TO C32
     24 VOLT, 200 AMP RECTIFIER C31 TO C33
   - (2) NOT FURNISHED IN 48 VOLT RECTIFIERS
   - (3) NOT FURNISHED IN 24 VOLT RECTIFIERS
3. LEADS WHICH ARE SHOWN UNCONNECTED, AND ARE LABELED, ARE CONNECTED AS FOLLOWS:
   FILAMENTS DESIGNATED A' GO TO TERMINAL 11 OF T13
   FILAMENTS DESIGNATED A GO TO TERMINAL 8 OF T13
   LEADS DESIGNATED B GO TO B POTENTIAL LEAD
   LEADS DESIGNATED P GO TO P POTENTIAL LEAD
   FILAMENTS DESIGNATED C GO TO TERMINAL 5 OF T11
   FILAMENTS DESIGNATED C' GO TO TERMINAL 6 OF T11
   FILAMENTS DESIGNATED D GO TO TERMINAL 8 OF T11
   FILAMENTS DESIGNATED D' GO TO TERMINAL 7 OF T11
4. THE RECTIFIER OUTPUT IS USUALL NORMAL OFFICE BATTERY WHEN ROTARY SWITCH IS IN POSITION OFFICE BATTERY AND EMERGENC SERIES WHEN THE SWITCH IS IN
5. USE (A) OPTION ONLY WHEN THE INCAPABLE OF ELIMINATING CYC RECTIFIER OUTPUT.