KS-15689 RECTIFIER
RELAY-TYPE OUTPUT CONTROL
OPERATING METHODS

1. GENERAL

1.01 This section covers the operation of a regulated metallic-type rectifier using a saturable reactor control. It provides regulated dc power from ac power service for use in charging storage batteries in 301- and 302-type power plant. The rectifier is rated at 44- to 65-volt, 200-ampere direct current. The input power requirement is 210-, 230-, or 250-volt, ± 8 percent, 3-phase, 3-wire, 60-Hz ± 2 percent, alternating current. The output is automatically adjusted by the operation of relays in response to signals from the connecting circuit. This rectifier is suitable for use in room temperatures from 50°F to 104°F (10°C to 40°C).

1.02 This section is reissued to add a reference to the KS-20522 controller and to generally update the section. This reissue affects the Equipment Test List.

Warning 1: 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 or destructive and dangerous short circuits may occur. When practical, disconnect the ac supply before working on the rectifier except when necessary to make tests.

Warning 2: The door switches, when open, disconnect the 3-phase power from the transformers, but leave the incoming terminals of the contactor connected to the ac service. They also disconnect battery from the main rectifier elements, but leave the CHG fuse and certain other equipment connected. Battery voltage will be present on the terminals of the OUTPUT (S3) rotary switch and elsewhere in the rectifier when fuse CHG is removed. The door switches are provided for the protection of personnel and should not be made inoperative.

Warning 3: The dc windings (3-4) of saturable reactors L1, L2, L3, and L6 may have ac voltage of over 1000 volts upon failure or removal of resistors R50, R51, and R52.

Caution: The taps on transformer T14 are factory adjusted for a minimum rectifier output voltage not greater than 45 volts. If any of the following parts, C18, T14, L6, or SR13, are replaced during maintenance, the T14 transformer may have to be reselected to meet the minimum voltage requirements.

1.03 This issue of the section is based on SD-81242-011, Issue 7D. 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 More detailed information on the operation and maintenance of individual pieces of apparatus, such as instruments and switches is given in the corresponding Bell System Practices. All apparatus should be adjusted in accordance with these practices and with the circuit requirements table or the circuit description associated with the circuit drawing.

2. LIST OF TOOLS AND TEST APPARATUS

Code or Spec No.	Description
TOOLS	
—	3-Inch C Screwdriver
R-1032	Thermometer, Detail 1
TEST APPARATUS	

—	Test Set, 35 Type
KS-14510	Volt-Ohm-Milliammeter (or equivalent)
KS-8039	DC Volt-Milliammeter (or equivalent)

MATERIALS

—	Pad, Felt

3. OPERATION

A. Preparing To Start

3.01 When putting the rectifier into service initially, check that:

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

(b) The TEST key is in the normal position.

(c) The input transformer taps match the power supply voltage (210, 230, or 250 volts).

(d) Connect tubes are in the sockets.

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

(f) The correct AC CONTROL fuses are in place in the rectifier, and the supply fuses are in the supply panel.

(g) Potentiometers MAN and AHR are each in their extreme counterclockwise (ccw) positions, and potentiometer AHL is set at a point 1/4 of its travel away from its ccw position.

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

(i) The OUTPUT (S3) rotary switch is operated to the vertical down position (see 3.09).

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

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

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

(m) Voltmeter VM has been calibrated in accordance with 4.05.

(n) A 35-type test set or a 300-millivolt meter is available.

B. Initial Adjustments

▲***Note:*** The KS-20522 Controller has been developed to provide in a solid-state unit, the same functions as contacts in the ammeter relays. The controller contains no moving parts or heated filaments; therefore it should provide more reliable service with far less maintenance than the mechanical contacts. The KS-20522 Controller is available as part of the modification kit which includes mounting hardware, wire, installation and wiring information, and, where required, some minor external components. There will be a modification kit available for several different applications. For additional information, see Section 024-360-201 and SD-82023-01 and the associated circuit description.◀

3.02 ***Output Voltage Adjustment:*** Observing the directions in 3.01, check the output voltage adjustment as follows.

(1) Operate the MAN-TEST key to MAN.

(2) Operate the ON-OFF key to ON.

(3) Rotate the shaft of the MAN potentiometer slowly clockwise (cw), observing the SAT CURRENT milliammeter, the OUTPUT VOLTS voltmeter, and the OUTPUT CURRENT ammeter relay (see Fig. 1).

(4) Add load to the battery or reduce the output of other rectifiers or generators supplying it, as required, to avoid service reactions.

(5) Bring the output up to its full rated value by turning the MAN potentiometer cw.

(6) Reverse the operation, finally bringing the MAN potentiometer to its normal ccw position.

(7) Operate the MAN TEST key to TEST.

(8) Bring the rectifier up to its rating by operating the RAISE-LOWER key to RAISE

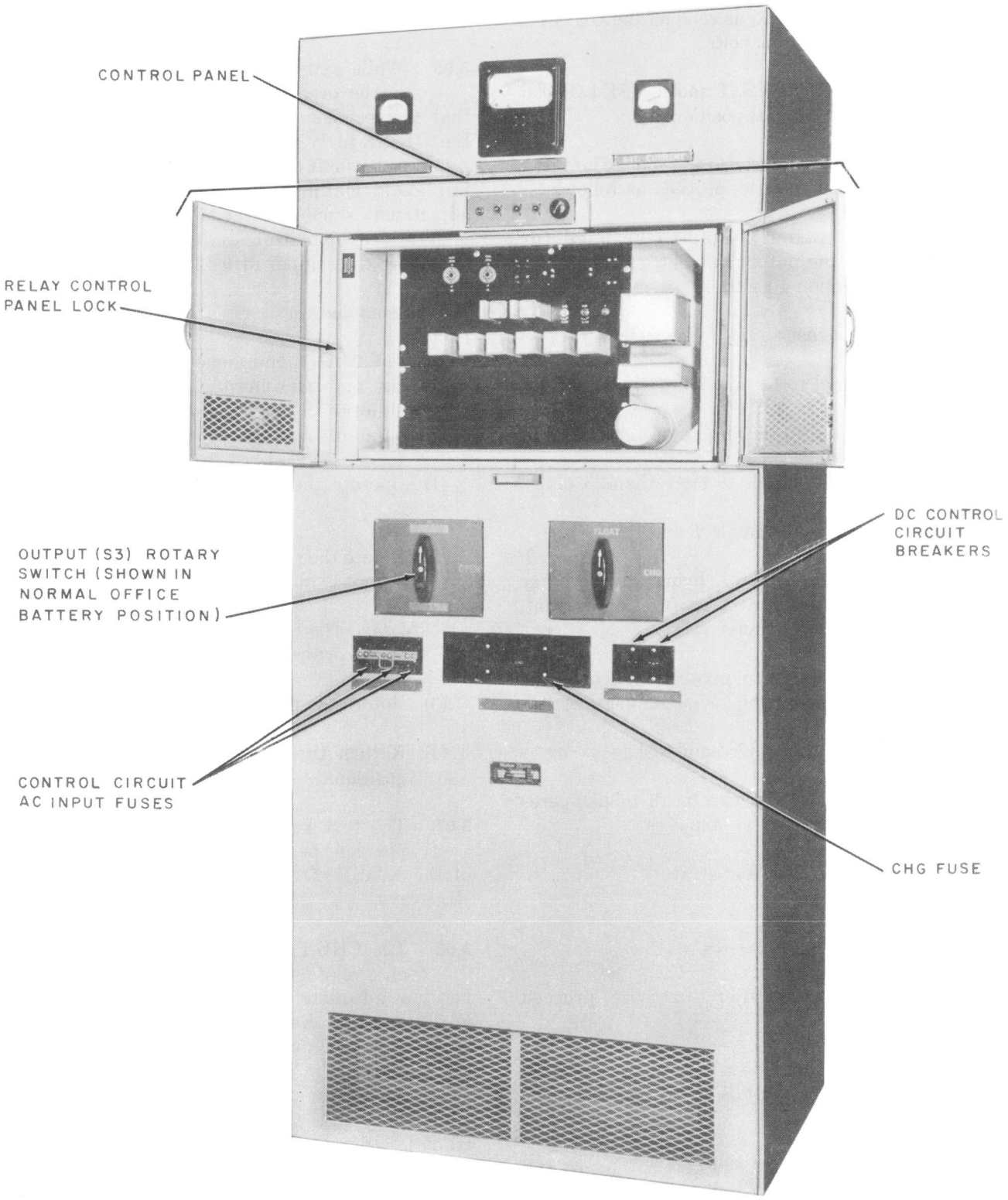

Fig. 1—KS-15689 Rectifier With Relay Control Panel

until the rectifier output, as read on the OUTPUT VOLTS voltmeter, is 45 volts.

(9) Restore the MAN-TEST and RAISE-LOWER keys to their normal positions.

3.03 ***Overload Limit Adjust:*** To adjust the overload limit feature, proceed as follows.

(1) For the external meter to be used for measuring the output current, use a 35-type test set (see Section 100-101-101).

(2) Connect the test set as follows:

BAT terminal to terminal 3 of shunt AR.

GRD terminal to terminal 2 of shunt AR.

(3) Set one of the sliders to more than 25 ohms.

(4) Strap together terminals T and R.

(5) Under manual control, bring the rectifier output of 90 percent of its full-load current, as indicated by the ammeter relay.

(6) Adjust the slider to give an indication of 9 milliamperes on the 15 milliampere scale.

Note: Leave the slider undisturbed.

(7) Full load will be indicated by 10 milliamperes and 110 percent by 11 amperes.

(8) Disconnect test set and strap.

C. Restoring Rectifier To Service

3.04 To restore the rectifier to service, proceed as follows.

(1) Bring the output down to zero by operating the RAISE-LOWER key to the LOWER position.

(2) Reduce the load previously added to the battery, or increase the output of other rectifiers or generators in order to maintain normal service.

(3) Shut down rectifier and restore the RAISE-LOWER key to its normal position.

D. Correcting Response of Rectifier

3.05 While carrying out the adjustments covered in the preceding paragraphs, it may appear that the response of the rectifier under control of the RAISE-LOWER key is too slow. Correct by rotating the shaft of the AHL or AHR potentiometer, but avoid making the response too fast. This adjustment should be reviewed when the rectifier is put into operation under automatic control supplying the regular office load. (See 4.06.)

E. Manual Control

3.06 The MAN potentiometer is used to control the rectifier manually. With the MAN potentiometer in the NORM position, check its operation as follows.

(1) Operate the MAN-TEST key to MAN.

(2) Rotate the potentiometer cw until the desired output is obtained.

Note: The output will remain at this setting, without drift, but is sensitive to line variations.

(3) Rotate the potentiometer back to NORM.

(4) Return the MAN-TEST key to its normal position.

3.07 The test key, when operated to the TEST position, permits manual control by the use of the RAISE-LOWER key to operate the RR and RL relays.

3.08 The CHG-FLOAT switch (S2) changes taps on transformers T1 to T3. In the FLOAT position, adequate voltage is available for floating and charging the battery. The CHG position provides the additional voltage necessary for charging the main battery plus the emergency cells. This switch should be operated to the desired position while the rectifier is shut down for changing the OUTPUT (S3) rotary switch (see 3.09) to the desired battery connection.

3.09 The rotary switch (S3), designated OPEN on the lower left-hand side of the rectifier (see Fig. 1), is a 3-position switch. In the OPEN position (horizontal position to the right), the switch disconnects the rectifier from the batteries. In

the vertical up position, the OUTPUT (S3) rotary switch connects the rectifier output to the normal office batteries, and in the vertical down position it usually connects the rectifier to the normal office batteries and emergency end cells, which are in series with each other.

F. Rectifier Stacks (Voltage Measurement)

3.10 When the rectifier stacks are new and the rectifier is operating at rated current, voltage, and normal line input, measure the input voltage across each phase of the stacks with the KS-8039 DC volt-milliammeter or equivalent 0.5 percent accuracy meter. Record these readings for future reference. (See 5.07.)

4. ROUTINE CHECKS

A. General

4.01 Routine checks are intended to detect defects, particularly in infrequently operated parts of the equipment, and insofar as possible to guard against circuit failures which may 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 1: For normal operation, under control of the connecting circuit, the MAN-TEST key should be in its normal (center) position and the ON-OFF key in the ON position.

Caution 2: Operation of the MAN-TEST key to either MAN or TEST position removes the rectifier from the control of the connecting circuit. The output is then under manual control and the rectifer may be connected to supply and load by the ON-OFF key.

Caution 3: The CHG-FLOAT switch (S2) should be operated only while the rectifier is shut down. Never, in normal operation, turn the rectifier to the ON position before battery or load is connected (OUTPUT rotary switch in vertical position), unless the rectifier is in the test position and the MAN potentiometer in its extreme ccw position. Otherwise, the metallic rectifying cells may be punctured and fail.

Note: The current indicated on the SAT CURRENT milliammeter is in the order of 100 milliamperes for half load and will range between extremes of 20 and 250 milliamperes.

B. Check Electron Tubes

4.02 Routine checks of the electron tubes should be made periodically with the electron tube tester available in the office in accordance with the standard information on that tester.

C. Check Relays

4.03 The relays should be inspected periodically for adjustment and condition of contacts making sure that they are in accordance with the circuit description requirements, circuit requirements table, and sections which apply.

D. Clean Ventilating Passages

4.04 Keep the ventilating passages and rectifier cells clean to prevent excessive heating.

E. Checking VM Voltmeter

4.05 At installation and periodically thereafter, the pointer of voltmeter VM should be set at a point in the floating range by means of the zero adjuster, so that its indication agrees exactly with that of a voltmeter connected in parallel with it. The zero adjuster screw should then be sealed with wax or adhesive tape over the screwdriver slot to discourage unauthorized changes.

F. Adjust AHL and AHR Potentiometers

4.06 Adjustments of AHL and AHR potentiometers are made with the purpose of minimizing fluctuations in the battery voltage. Care is required to insure that the change in output is large enough for the purpose, but not so great as to produce hunting. In general, lowering should be slightly faster than raising. The change in the charge voltage of C12 is dependent not only on the adjustment of the potentiometer, either AHL or AHR, but also on the duration of the signal from the regulating device in the associated plant, the condition of the battery, and the fluctuations in the load. Readjustments may be made necessary by changes in the character of the office load. Turning the shaft of the potentiometer in a cw direction will increase the speed of the correction.

G. Change Transformer Taps

4.07 Aging taps are provided on transformers T1 to 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 other troubles. If rated output can be obtained with manual control, it will indicate that the transformer taps do not need to be changed providing an abnormal amount of saturating current is not required. (Approximately 250 ma is maximum saturating current.)

4.08 The taps on transformer T14 are factory adjusted for a minimum rectifier output voltage not greater than 45 volts. If any of the following parts, C18, T14, L6, or SR13 are replaced during maintenance, the T14 transformer may have to be reselected to meet the minimum voltage requirements. This can be done as follows.

(1) Check the rectifier minimum voltage with the rectifier operating at no load (OUTPUT rotary switch operated to OPEN).

(2) Operate the MAN-TEST switch to the MAN position.

(3) Rotate the MAN potentiometer to the maximum ccw position.

(4) Remove tube V1 to disable the regulating circuit.

(5) Move the adjustable tap lead over the tap range.

Note: As the adjustable tap lead is moved over the tap range, the rectifier output voltage should decrease to a minimum and then rise.

(6) Connect to the tap causing minimum voltage.

(7) If the voltage decreases as numerically higher taps are used but does not meet the minimum voltage requirement when tap 13 is reached, perform the following tap arrangement.

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

(a) Remove the strap between transformer T14 from its present position and connect a strap between terminals 11 and 10.

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

H. Checking Varistor SR13

4.09 There is no similar provision for aging taps for varistor SR13 in the magnetic amplifier. To determine if the varistor needs to be replaced, proceed as follows with the rectifier connected to the battery.

(1) Operate the MAN-TEST key to MAN position.

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

(2) Rotate the MAN potentiometer to the maximum cw position momentarily and note that the SAT CURRENT ammeter reads 3/4 of full-scale reading.

(3) If the SAT CURRENT ammeter does not read 3/4 of full scale, check electron tubes V1 and V2 (see 4.02).

(4) If the tubes are found to be satisfactory, then the trouble is in the varistor SR13 and the varistor should be replaced.

(5) Operate the MAN-TEST key to its normal position.

I. Slow Rectifier Response

4.10 While carrying out adjustments on the rectifer, it may appear that the response under control of the RAISE-LOWER key is too slow. Correct by rotating the shaft of the AHL or AHR potentiometer, but avoid making the response too fast. This adjustment should be reviewed when the rectifier is put into operation under automatic control supplying the regular office load. (See 4.06.)

5. TROUBLES

GENERAL

5.01 In general, the only items likely to become defective with use are tubes V1 and V2, which are subject to aging but should have long life.

Note: If drifting occurs with the rectifier at full load, try another V2 tube.

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

5.03 Jacks mounted on the front panel provide connections for a portable voltmeter for use in checking the voltage in various parts of the circuit when locating troubles.

5.04 Although it may vary widely in extreme conditions, the saturating current, when observed in daily routine can serve as a guide to the causes of unusual operation of trouble conditions.

5.05 Varistors or rectifier stacks will age with use, and after a period of years may require changing the connection from the NEW to the AGED tap where this arrangement is available. In other cases varistor RV5 or SR13 must be replaced (see 4.09). Since the receiver 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 others are comparatively new, the single stack may be replaced with one of the same code. Do not combine stacks from different manufacturers.

5.06 If the rectifier stacks seem hot, check the temperature with a thermometer as follows.

(1) 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.

(2) If the temperature exceeds 90°C, the stacks are probably nearing the end of their usefulness and the supervisor should be notified so that replacement of the stack may be considered.

5.07 An alternate method for determining if the rectifier stacks are approaching the end of their usefulness is as follows.

(1) Measure the ac input voltage to each phase of the rectifier stacks when the rectifier is operating under the same conditions as outlined in 3.10 with the KS-8039 DC volt-milliammeter or an equivalent 0.5 percent voltmeter.

(2) Compare these values with those obtained in 3.10.

(3) If the stack voltages increase 2 volts above the values obtained when the stacks were new, refer the matter to the supervisor as the stacks may have to be replaced.

POINT-TO-POINT VOLTAGES

5.08 Point-to-point voltages are intended for use when unsatisfactory operation is encountered; in which case they may prove useful in locating the cause. These voltages are not operating requirements to be checked in routine and are not needed while the rectifier is operating satisfactorily. As given in the tables in SD-81242, voltages are approximate and typical of the rectifier connected to normal power supply, adjusted to the float voltage of the battery and at no load as indicated.

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 ac 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.

5.09 Readings should be made with the KS-14510 volt-ohm-milliammeter or equivalent. 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, may be so used during the infrequent taking of point-to-point voltages.

5.10 Typical values of voltages between jacks or between terminals of apparatus are shown on SD-81242.

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 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.

Troubles	Possible Causes
No dc output current (No saturating current)	Blown ac supply or control fuse
	Weak tubes
	CONT circuit breaker operated
	Door switch operated
	Contactor AC not operated
No dc output current (High saturating current)	CHG fuse blown
	OUTPUT (S3) rotary switch in OPEN position
	Aged rectifier stacks
	Low line voltage
Low dc output current (low saturating current)	Weak tubes
	Aged rectifier SR13 stacks
	Relay RL break contact failing
	Relay RR make contact failing
Low dc output current (high saturating current)	Aged main rectifier stacks
	Excessive charging lead drop
	Low line voltage

Troubles	Possible Causes
High dc output current (high saturating current)	Plant voltage regulation out of adjustment
	Relay RR operated continuously
	Relay RL make contact failing
	Relay LC make contact failing
	Grid emission in tube V2
	Near zero grid voltage in tube V2 caused by failure of a component of the relay control circuit
	Rectifier in MAN with MAN potentiometer not fully CCW
Output excessively noisy	Filter capacitor aged or defective
	Faulty connection to filter capacitors
	Unbalanced ac line voltage (more than 5 per cent)
	Defective stack in main rectifier assembly
Rated output current not obtainable with saturating current maximum, under MAN control	Excessive drop in dc connection to load Defective C31-C35

Troubles	Possible Causes
	Main rectifier cells high resistance due to aging
	CHG fuse or OUTPUT (S3) rotary switch open
Cannot reduce dc output to zero with saturating current minimum under MAN control	CHG-FLOAT switch on CHG instead of FLOAT
	High line voltage
	T14 misadjusted
Output voltage varying	Potentiometer AHR or AHL not correctly adjusted
Poor regulation at battery	Aged main or MAG AMP stacks
	Excessive charging lead drop