RECTIFIERS
KS-5651 AND KS-5651-01
RELAY TYPE OUTPUT CONTROL
OPERATING METHODS

1. GENERAL

1.01 This section covers the operation of a metallic-type rectifier using a saturable reactor control. It provides a regulated voltage for floating and charging central office 24- or 48-volt batteries in 301C power plants. The rectifier is available in three sizes; 24 volts, 100 and 200 amperes and 48 volts, 100 amperes dc. The power required is 210-, 230-, or 250-volt, 3-phase alternating current. The rectifier is not complete and self-regulating but requires periodic raise or lower signals from some voltage-sensitive device to control the output. The rectifier is suitable for use in room temperatures from 50° to 104°F (10° to 40°C).

Warning 1: Voltages inside the rectifier case are higher than those usually encountered in telephone power plants.

Warning 2: Avoid all contact with terminals as high voltages are present. Do not allow a test pick to touch two metal parts at the same time as destructive and dangerous short circuits may occur.

Warning 3: The door switch behind the hinged control panel, when open, disconnects the 3-phase power from the transformers but leaves a number of terminals, contacts, and fuses at the service voltage and usually at voltage to ground. The door switch behind the hinged control panel is provided for the protection of personnel and should not be made inoperative.

Warning 4: Disconnect ac supply before opening covers or doors to work inside of rectifier. Even with the OFF or OPEN rotary switch in the neutral or OFF position, the studs of the switch are connected by unfused leads to the battery. With the ON-OFF key OFF and the OFF or OPEN rotary switch in the 24V1 or 48V1 or EM CELL position, there are additional connections protected from the battery only by the large charge fuse.

Caution: Do not use OFF or OPEN rotary switch to stop the rectifier.

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

1.03 A metallic rectifier cell is an elementary rectifier having one positive electrode, one negative electrode, and one rectifying junction. A rectifying element is a circuit element which has the property of conducting current effectively in one direction only and may consist of a group of metallic rectifier cells connected in parallel or series arrangement, or both. The term rectifier stack or varistor used in apparatus coding includes one or more rectifier cells. Rectifying elements may be made up of one or more rectifier stacks or varistors. A rectifier is an assembly consisting of a rectifying element and associated auxiliaries such as transformers, filters, and switches. To avoid unbalance, a complete set of rectifier stacks or varistors in a configuration should be replaced even though only one rectifier stack may be defective.

1.04 This issue of the section is based on SD-80969-01, Issue 1, Figs. 1, 2 or 6, 4, A, and 8 and SD-81087-01, Issue 5, Figs. 1, 3, A, and 5. 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.

1.05 Additional information on the operation and maintenance of individual pieces of apparatus, such as instruments, keys, relays, and switches,

etc, is given in the corresponding Bell System Practices. All apparatus should be adjusted in accordance with these sections and the circuit reqirements tables of the circuit drawings.

2. LIST OF TOOLS AND TEST APPARATUS

2.01 The test apparatus required is the KS-14510 volt-ohm-milliammeter and the 35-type test set.

3. OPERATION

A. Preparing to Start

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

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

(b) Correct transformer and reactor taps have been used for the power service voltage.

(c) Correct tubes are in the sockets.

(d) Hinged control panel is closed tightly so door switch is operated.

(e) Proper fuses are in place and the circuit breakers CONT, CBA, and CHG ALM are closed when provided.

(f) A, AH (or AHR, when present), and MAN rheostats and potentiometers are completely counterclockwise (ccw). AHL rheostat, when present, is set at a point 1/4 of its travel away from its full ccw position. The D potentiometer, when present, is set at its midpoint.

(g) Turn the CHG-FLOAT switch to the FLOAT position.

(h) Close OFF or OPEN rotary switch to the 24-volt, 48-volt, or EM CELL position.

B. Initial Adjustments

3.02 Before placing the rectifier into service, make the following adjustments:

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

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

Note: Allow one minute for heating of control tubes.

(3) Slowly operate MAN potentiometer clockwise (cw) and observe that saturating current is indicated on the SC ammeter and that the output, once started, increases as the potentiometer is turned and that rated output current can be obtained.

(4) Operate the potentiometer completely ccw.

(5) Operate the RAISE and LOWER keys in turn and observe that the control relays RR and RL respond and that the output increases and decreases.

Note 1: If a raise signal is received from the regulator when the manual LOWER key is operated, the LOWER key prevails.

Note 2: If a lower signal from the regulator is received when the manual RAISE key is operated, the lower signal prevails.

C. Manual Control

3.03 Relay PH connects power to transformer T4 and is provided for use in automatic plants to preheat the control tubes in anticipation of starting. This avoids delay in securing output when additional current is required to maintain the plant battery.

3.04 The CHG-FLOAT switch changes the top connections on T1 to T3 transformers. In the FLOAT position, adequate voltage is available for all normal operation. The CHG position provides additional voltage such as that for charging the main battery plus emergency cells. The CHG-FLOAT switch should be operated to the proper position when the rectifier is stopped to change the OFF or OPEN rotary switch from the main battery to the emergency cell connection or the reverse.

3.05 CA contactor automatically makes the connection to the battery as the output voltage builds up on starting and normally closes when the voltage is about 20 or 44 volts for the 24- or 48-volt rectifier respectively.

3.06 Where the AH rheostat is provided, it serves to adjust the rate at which capacitor C12 is

charged or discharged. Where AHL and AHR rheostats are provided, ajustment can be made separately of the rate of charging and of the rate of discharging this capacitor. The charge voltage on C12 indirectly controls the output of the rectifier. The change in charge voltage is dependent not only on the adjustment of rheostat AH, or of AHL and AHR, but on the duration of the raise or lower signal from the voltage regulating device in the plant control circuit. The type of voltage regulating device, the condition of the battery, the fluctuations in the load, and the setting of potentiometer D (when furnished) are also elements indirectly affecting the required adjustment of these rheostats. To obtain the minimum fluctuations in the battery voltage under the local conditions requires the use of personal judgement.

3.07 In general, lowering the output should occur at a somewhat faster rate than raising it. If the battery voltage indicates that the output is not keeping up with load changes or is making the changes too great for the load variations, a readjustment of rheostat AH should be made to try to improve the operation. Once a suitable adjustment is obtained, changes in the rheostats settings should seldom be required and, ordinarily, only when the general character of the daily-load has changed. Operating either of these rheostats cw increases the change in charge or discharge on capacitor C12 for each raise or lower signal.

3.08 Potentiometer D should be adjusted by observation to minimize the change in output which, if the potentiometer were not furnished, would occur in the intervals between the appearance of raise or lower signals from the plant control circuit. The effect of this adjustment should be considered when adjusting AHL or AHR. Operating the shaft ccw will reduce the increase in output and can be carried far enough to bring about a decrease.

3.09 The MAN potentiometer controls the output by applying continuously an adjustable voltage bias directly to the cathodes and grids of tubes V2 and V3 when the MAN-TEST key is operated to the MAN position. As the MAN potentiometer is operated cw, the output is increased.

D. Changing Transformer Taps

3.10 Transformers T1 to T3 have aging taps 2 and 3, the connection, when new, being at tap 1. This tap should not be changed to the next tap 2 or 3 until the output can no longer be obtained and until a thorough check has been made to be sure that there are no other troubles. If output can be secured with manual control, it will indicate that the transformer tap does not need to be changed.

E. Ammeter Relay Operation

3.11 Ammeter relay AR ordinarily should have the low contact set at 5 percent and the high contact at 100 percent as shown on the relay scale by the position of their respective indicating pointers.

3.12 Ammeter relay AR is internally connected in such a way that the current which flows through the high contacts to operate some control relay increases the current through the operating coil of the AR relay and prevents chattering of the contacts. This increase in current also affects the value at which the contacts open. The current through the contacts should not exceed 30 milliamperes. The higher the current the greater the separation between operate and release values (closing and opening of contacts). The lower the current the greater the possibility of chatter.

◗*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 a 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 associated circuit description.◖

F. Placing Rectifier in Test Mode

3.13 In order to place the rectifier in the test mode of operation proceed as follows.

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

Note: This connection is provided to permit maintenance work on the rectifier without interference from the regulator.

(2) To return the rectifier to normal operation, operate the MAN-TEST key to neutral or center position for automatic control by the plant regulator.

4. ROUTINE CHECKS AND ADJUSTMENTS

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 liable to interfere with service. Tests and adjustments, other than those required by trouble conditions, should be made during a period when they will cause the least unfavorable reaction.

A. Routine Adjustments

4.02 ***Setting Change in Output Voltage:*** To set the rate change in adjusting output voltage, proceed as follows.

Note 1: All keys must be in the normal position, and the external connecting circuit must be in full operation under control of its voltage monitoring element.

Note 2: Load conditions must be manipulated by external means so that output current indicated is about quarter load.

(1) Operate rheostat AH cw, when present, with a screwdriver until instability is apparent by large periodical swings in the indicated output current and then ccw 1/4 turn. This adjusts the amount of change in output for each raise or lower signal given by the associated plant-control circuit.

Note: This setting will be determined by local conditions and should be the one which holds the battery voltage most constant.

(2) With the rectifier floating the available load, use the manual RAISE and LOWER key to change the output enough so that the automatic control will make a correction and its operation can be observed.

(3) Where rheostats AHR and AHL, and potentiometer D are furnished, adjust AHR to control the raise, and AHL to control the lower corrections.

Caution: The lower correction is somewhat faster than the raise.

Note: These adjustments are preliminary and require rechecking and readjustment when the rectifier is supplying the normal office load.

(4) Observe the drift in the output, which occurs when no raise or lower signals are being received, and adjust potentiometer D as required to reduce the number of corrections called for by the plant control circuit.

4.03 ***Adjusting Overload Relay:*** To adjust overload relay OL in addition to the usual current flow test, proceed as follows.

Note: All rheostats should be in the extreme ccw position.

(1) Operate MAN-TEST key to TEST.

(2) Operate rheostat A maximum cw.

(3) Block relay in control equipment of next rectifier or generator, if provided, to prevent its starting.

(4) Operate ON-OFF key to on position.

(5) Using a 35C, 35D, or 35F test set:

(a) Move No. 1 red and block sliders to the right.

(b) Open all short-circuiting switches.

(c) Operate BATT and GRD CO key.

(d) Open G switch.

(e) Connect terminals T and R across ammeter relay shunt AR without disturbing present wiring.

(f) Close No. 1 short-circuiting switch.

(g) Operate key to 15 MIL AMPS position for the 35C test set or operate keys to 3 MA and 15 MIL AMPS positions for the 35D or 35F test set.

(h) Move No. 1 red slider to maximum left with block slider to right.

(i) Operate REV key, if meter reads reverse.

Note: The test set across the shunt is used to determine when 110 or 220 amperes are flowing through the shunt, since the ammeter relay only reads to 100 or 200 amperes.

(6) Adjust the test set with No. 1 block slider to read 40 mils on outer scale when 80 or 160 amperes are flowing as indicated by the ammeter relay.

Note: Cover and cap must be on relay OL.

(7) Using RAISE key, increase output current until the test set reads 55 mils.

(8) Hold this adjustment as closely as possible and operate rheostat A ccw until relay OL operates.

Note: Operation of OL causes relay RL to operate, reducing the output, and to remain operated until relay OL releases. This should be at about full-load current.

(9) Check the setting of rheostat A several times using the RAISE key.

(10) Make a final check in which the output gradually increases as the charge on capacitor C12 decreases.

Note 1: This may require 5 through 30 minutes.

Note 2: The battery voltage may be any convenient value and need not be held constant for this test.

(11) Restore MAN-TEST key to neutral position, disconnect test set, and remove any blocking tools.

4.04 ***Adjusting Ammeter Relay:*** Ammeter relay AR ordinarily should have the low contact set at 5 percent and the high contact at 100 percent as shown on the relay scale by the position of their respective indicating pointers.

4.05 ***Overcharge Voltage Adjustment:*** The OVER CHG rheostat provides means for the connecting circuit to periodically select an overcharge voltage to which the rectifier will regulate without disturbing the FLOAT ADJ. This can be done as follows.

(1) In making the initial adjustment, open the connection in the external circuit between terminal 7 and 12.

(2) Gradually rotate rheostate OVER CHG cw until the desired regulated overcharge value is attained.

(3) Final adjustment should be made with less than half rated current.

4.06 ***Regulated Current Adjustments:*** To make regulated current adjustments, proceed as follows.

(1) Operate FLOAT CHG switch to CHARGE.

(2) Operate CCH relay by holding CCH key operated.

(3) Adjust CCH potentiometer to give 103 ± 1 percent of rated full load current.

Note: This condition should be held for a few minutes to be sure the setting will not drift.

(4) Adjust CCL potentiometer with CCL key operated to give within 4 percent of half-rated rectifier output current.

Note: These settings should be made with the VM key operated and with the VM voltmeter reading within 5 percent of the regulated voltage value.

B. Routine Checks

4.07 ***Check Output Voltage and Current:*** To check the output voltage and current, proceed as follows.

(1) Operate the CHG-FLOAT switch to the desired position.

(2) Operate the OFF or OPEN rotary switch connecting to the battery and load.

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

Caution: Never turn the rectifier ON before the battery or load is connected, or the metallic rectifying cells may be punctured and fail.

The output should start and build up under control of associated equipment. The amount of current in the regulating coils of the reactors is indicated on ammeter SC. A typical value under normal operating conditions is in the order of 50 milliamperes. Under manual operations, the extremes are about 10 to 250 milliamperes. The output voltage and current will be indicated on voltmeter VM and ammeter relay AR.

4.08 ***Check Vacuum Tubes:*** In general, the only items likely to become defective with use are tubes V1, V2, and V3. These are subject to aging but should have long life. Periodically check the condition of the vacuum tubes as follows.

(a) Where facilities for the manual control of the input voltage, such as the emergency alternator, are available, reduce the input voltage to the minimum for the particular installation, in accordance with Table A.

TABLE A

NOMINAL	MINIMUM
210	193
230	212
250	230

(1) Allow voltage to remain at minimum for about 3 minutes, meanwhile observing the output.

(2) If the rectifier is operating in parallel with other charging equipment, see that it continues to carry its share of the load.

(3) If the rectifier is carrying the entire load on the battery, see that the battery voltage remains within the limits specified in local job information.

(4) Check in accordance with (b), all vacuum tubes in rectifiers which do not regulate within limits.

(b) When necessary after a check per (a), or where facilities for such a check are not available, check the vacuum tubes with whatever vacuum-tube tester is available, in accordance with the section for that tester.

4.09 ***Check Relays:*** The relays should be inspected occasionally for adjustment and condition of contacts, making sure that they are in accordance with the circuit requirements and sections which apply.

4.10 ***Clean Ventilating Passages:*** Keep the ventilating passages and rectifying discs clean to prevent excessive heating.

4.11 ***Replacing Potentiometers and Rheostats:*** Control potentiometers and rheostats are totally enclosed and should be replaced if they become defective in any respect.

4.12 ***Replacing Rotary Switch:*** The KS-15119 rotary switch is totally enclosed and should be replaced if it becomes defective in any respect.

5. TROUBLES

5.01 The saturating current, although it may vary widely with extreme conditions, 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.

Table B—Point-to-Point Voltages

5.02 The values in Table B of point-to-point voltages are given as typical under normal conditions. Under extreme conditions, the ranges are necessarily quite wide but may be helpful in locating trouble. Use a KS-14510 voltmeter.

Trouble Chart

5.03 Should any of the troubles develop covered in the Trouble Chart, it is suggested that the possible cause be checked in the order given. If the trouble is not readily found, look for loose connections or short circuits due to foreign matter lying across wiring terminals.

TABLE B

Quantity Measured	Connect to Pin Jacks	Typical Volts	Typical Range Volts
Tube V1 output	S-, SP	600	500-650
V2 or V3, plate to cathode	SP, S+	550	250-650
Saturating voltage	S-, S+	50	10-250
Voltage C13	S+, Term.* 3B of relay ST	125	120-130

*Accessible on front of panel.

Trouble	Possible Cause
No dc output current	Power failure.
	Blown ac supply fuse or CHG fuse.
	Door switch behind hinged control panel open.
	Failure of tube V1 or V2 and V3
	Shorted capacitor C31 to C60
	Plant voltage regulator out of adjustment.
	Relay RL operated continuously.
	Relay PH or ST not operated.
	Contactor AC or CA not operated
Low dc output current. Low saturating current.	Plant voltage regulator out of adjustment.
	Low line voltage.
	Tube V2 or V3 failure.
	Tube V1, V2, or V3 low emission, aged.
	Relay RL back contact failing.
	Relay RR make contact failing.
	Rheostat AH, if present, not set correctly to keep up with load changes.
	Rheostats AHR and AHL, and potentiometer D, if present, not set correctly to keep up with load changes.
Rated output current not obtainable with saturating current maximum under MAN control.	One of three line leads open or high resistance at some contact in line circuit.
	CHG-FLOAT switch on FLOAT when charging, especially emergency cells.
	Rectifier cells high resistance due to aging.
	OL relay or A rheostat out of adjustment.
High dc output current. High saturating current	Plant voltage regulator out of adjustment.
	High line voltage.
	Relay RR operated continuously.
	Relay RL make contact failing.
	Rheostat AH, if present, not set correctly to keep up with load changes.
	Rheostats AHR and AHL, and potentiometer D, if present, not set correctly to keep up with load changes.
Low dc output. High saturating current.	Unbalance in ac line voltages.
	Similar taps not used on all reactors and transformers.

Trouble	Possible Cause
	AC voltages applied to rectifying element (terminals AC1 to AC2, AC2 to AC3, AC3 to AC1) differ by more than 5 per cent.
	Switch CHG-FLOAT on FLOAT when charging, especially emergency cells.
	Rectifier cells high resistance due to aging.
Output excessively noisy	Three ac voltages applied to rectifying element (terminals AC1 to AC2, AC2 to AC3, AC3 to AC1) differ by more than 5 per cent.
	Filter capacitors aged or defective.
	Filter capacitor connections loose or open.
High dc output current with saturating current minimum under MAN control.	CHG-FLOAT switch on CHG (not FLOAT).
	High line voltage.
Output voltage varying.	Rheostat AH, if present, set to cause two large changes in output.
	Rheostat AHR and AHL and potentiometer D, if present, set to cause two large changes in output.