

KS-15689 L1 RECTIFIER
AND
KS-15689 L3 ELECTRONIC CONTROL
OPERATING METHODS

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when open, disconnect the 3-phase power from the transformers, but leave the incoming terminals of contactor AC connected. 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 rotary switch and elsewhere in the rectifier when CHG 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 L1, L2, L3, and L6 saturable reactors may have ac voltages of over 1000 volts due to failure or removal of R32, R50, R51, and R52 resistors.

1. GENERAL

1.01 The KS-15689 L1 rectifier is designed to provide regulated dc power from an ac power source for use in charging storage batteries in 302A power plants. Some 301C plants may be modified to use this rectifier. It is rated at 48-volt, 200-ampere direct current. The input power requirement is 210-, 230-, or 250-volt ± 8 percent, 3-phase, 3-wire, 60-cycle ± 2 percent alternating current. 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 revise Part 4, ROUTINE CHECKS, and to add a procedure to check the OUT VOLTS meter. Since this reissue covers a general revision, arrows ordinarily used to indicate changes have been omitted. This reissue does affect the Equipment Test List.

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 or destructive or dangerous short circuits may occur. The door switches,*

1.03 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. 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.

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

1.05 This issue of the section is based on the following drawing:

SD-81242, Fig. 1 and Fig. 2.

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.

1.06 For more detailed information on the operation and maintenance of individual equipment or

apparatus, refer to the appropriate Bell System Practice.

1.07 Battery voltage readings called for herein 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.

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

2. LIST OF TOOLS, TEST APPARATUS, AND MATERIALS

CODE OR SPEC NO.	DESCRIPTION
TOOLS	
—	3-Inch C Screwdriver (or the replaced 3-inch cabinet screwdriver)
TEST APPARATUS	
35 Type	Test Set
KS-8039	DC Volt-Milliammeter
KS-14510	Volt-Ohm-Milliammeter
—	Voltmeter, AC Weston Model 904, Scale 150 (or the replaced Model 155)
R-1032, Detail 1	Thermometer
MATERIAL	
—	Felt Pad

3. OPERATION

3.01 The rectifier is completely automatic in the regulation of float voltage and should require no routine adjustments. It is started and stopped by the operation of the NOR-OFF switch and the CONT key. If the load exceeds the safe capacity of the rectifier, the regulating circuit switches over to constant current regulation. As the load diminishes, the rectifier brings the voltage to the float value and returns to voltage regulation. Operation of a CHG-FLOAT switch in the connecting

circuit removes a short circuit from the CHG potentiometer, causing the rectifier to operate under voltage regulation at a higher value, determined by the setting of the potentiometer. See 3.06.

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.

Caution: *Never operate the OUTPUT (S3) rotary switch to OPEN while the rectifier is carrying a load.*

If this caution is not observed, the rectifying cells may be punctured and fail. The rectifier should start and build up its output in less than 1 minute unless the associated plant causes a greater delay. The amount of current in the regulating coils of the reactors is indicated on SAT CURRENT ammeter.

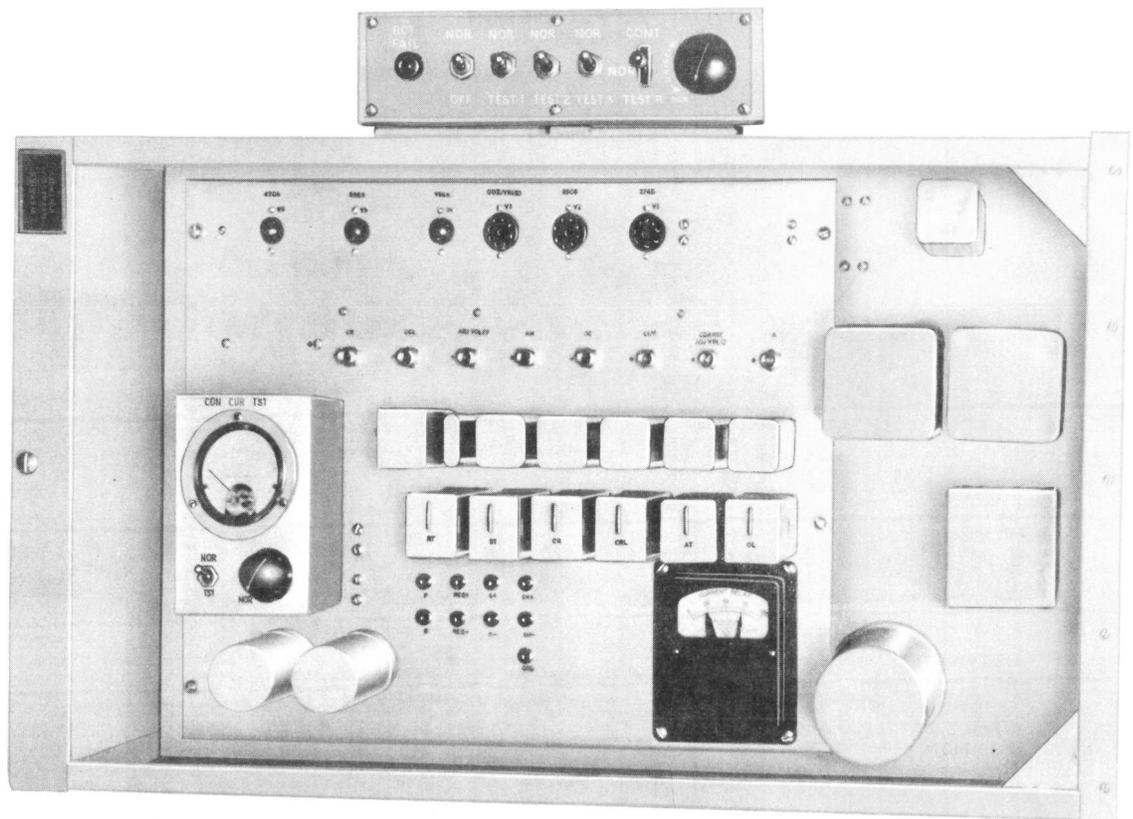
3.03 The OUTPUT (S3) rotary switch is a three-position switch. In the OPEN position (horizontal position to the right), the switch disconnects the rectifier from the batteries. In the vertical up position, the OUTPUT switch connects the rectifier output to the normal office batteries, and in the vertical down position, it usually connects the rectifier to the normal office batteries and emergency end cells which are in series with each other.

Caution: *Never operate the OUTPUT (S3) rotary switch to OPEN while the rectifier is carrying load. If this caution is not observed, the rectifying cells may be punctured and fail.*

Preparing to Start

3.04 When putting the rectifier into service, check that:

- (a) The NOR-OFF key is in the OFF position (see Fig. 1 or 2).
- (b) NOR TEST 1, NOR TEST 2 and NOR TEST 3 switches are in their NOR positions.
- (c) The CONT key and CC TEST switch is in the NOR position.



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Fig. 1—KS-15689 Electronic Control Panel

- (d) The input transformer taps match the power supply voltage (210, 230, or 250 volts).
- (e) Correct tubes are in the sockets.
- (f) The correct CHARGE and VM fuses are in place.
- (g) The correct AC CONTROL fuses are in place in the rectifier and the supply fuses are in the supply panel.
- (h) The CHG-FLOAT switch is operated to the desired position (see 3.02).
- (i) The OUTPUT (S3) rotary switch is operated to the battery position, vertical up position, see Fig. 2. (See 3.03).
- (j) Covers and doors are tightly closed so that the S1 and S8 door switches are operated.
- (k) CONT and CHG ALM circuit breakers are closed.
- (l) There is sufficient office load to fully load the rectifier, or a variable load of adequate capacity available.
- (m) The rectifier terminals are strapped in accordance with the application drawing for the particular office.
- (n) The CHG-FLOAT key in the associated plant is operated to the FLOAT position or CHG potentiometer is otherwise shorted out.
- (o) The high and low contacts of the OUTPUT CURRENT (AR) ammeter relay are set as follows:
 - (1) The high contact is set at 180 amperes.
 - (2) The low contact is set at 10 amperes.

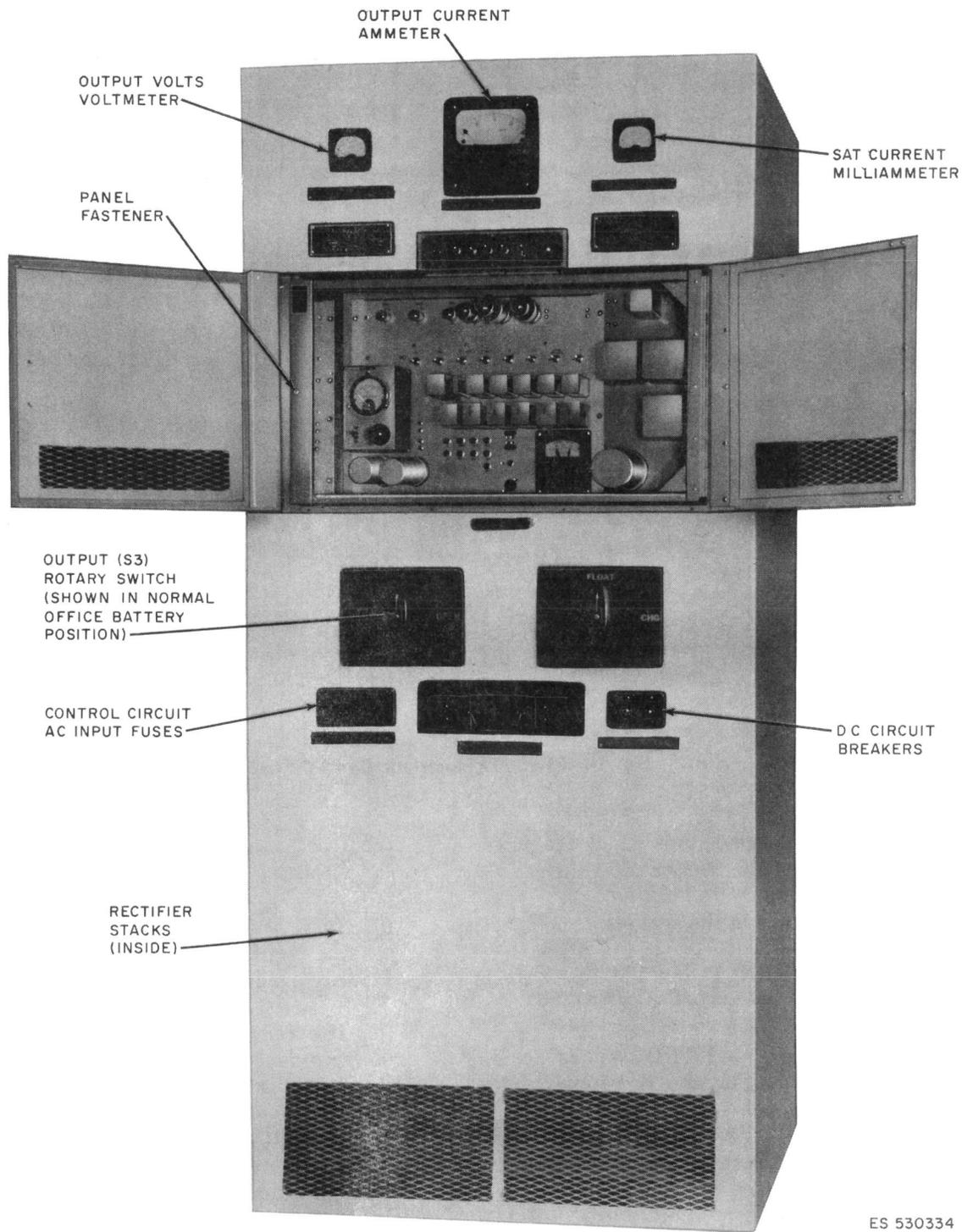


Fig. 2—KS-15689 L1 Rectifier with KS-15689 L3 Electronic Control Panel

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

(p) The high and low contacts of the AR2 ammeter relay are set as follows:

- (1) The high contact is set at 75 percent of rated load.
- (2) The low contact is set at 25 percent of rated load.

Note: If the settings in (o) and (p) differ from plant requirements, the plant requirements take precedence.

Starting—Rectifier Carrying Load

3.05 Float Voltage: To adjust for float voltage, observe the directions in 3.04 and proceed as follows (see 3.02).

- (1) Operate the CHG-FLOAT switch to FLOAT.
- (2) Operate the NOR-TEST 1 switch to TEST 1.
- (3) Operate the NOR-OFF switch to NOR.

Note: The RECT FAIL lamp is lighted.

- (4) Operate the CONT key to TEST R.
- (5) Allow approximately one minute for the tubes to heat.
- (6) Rotate the MAN potentiometer slowly cw until the RECT FAIL lamp is extinguished.
- (7) Quickly rotate the MAN potentiometer to the NOR position (maximum ccw).
- (8) Operate NOR-TEST 1 switch to NOR.
- (9) Rotate the COARSE ADJ VOLTS potentiometer cw, with the battery at float voltage, until the rectifier is carrying its share of the load or, if there are no other rectifiers operating in parallel with it, until it is carrying the entire load on the battery.

Note: Observe the OUT VOLTS voltmeter and the SAT CURRENT ammeter. The rectifier output current should be between 25 and 75 percent of rated full load.

(10) Connect the KS-8039 volt-milliammeter, set to the 75 VOLTS range, to the REG+ and REG- pin jacks.

(11) Adjust the load to the rectifier for approximately 50 percent of rated full load.

(12) Rotate the ADJ VOLTS potentiometer until the rectifier voltage, as indicated on the KS-8039 volt-milliammeter, is 49.9 volts for 23 cells.

Note: This value is based on a float value of 2.17 volts per cell.

(13) Disconnect the KS-8039 volt-milliammeter.

(14) Adjust the load to the rectifier for the normal office load.

3.06 Charge Voltage: To adjust for charge voltage, observe the directions in 3.04 (see 3.02) and proceed as follows:

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

Note: Remove the short across the CHG potentiometer. (Operate the CHG-FLOAT switch in the connecting circuit to CHG.)

(2) Connect the KS-8039 volt-milliammeter, set to the 75 or 30 VOLTS range, to the REG+ and REG- pin jacks.

(3) Operate the NOR-OFF switch to NOR.

(4) Adjust the CHG potentiometer until the battery voltage as indicated on the KS-8039 volt-milliammeter, increases to 50.6 volts for 23 cells.

Note: This value is based on a charge value of 2.2 volts per cell. If plant requirements differ, the plant requirements take precedence.

(5) After this adjustment has been completed, reduce the rectifier output to zero.

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

- (6) Operate the NOR-OFF switch to OFF.
- (7) Disconnect the KS-8039 volt-milliammeter.

Note: Restore the short across the CHG potentiometer. (Operate the CHG-FLOAT switch in the connecting circuit to FLOAT.)

- (8) Operate the CHG-FLOAT switch to FLOAT.
- (9) Restore the rectifier to normal operation, as covered in 3.05.

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

3.07 When the rectifier is to be placed in service initially or if the rectifier has been out of service for an extended period of time, it is recommended that the routine checks in 4.03 and 4.04 be performed.

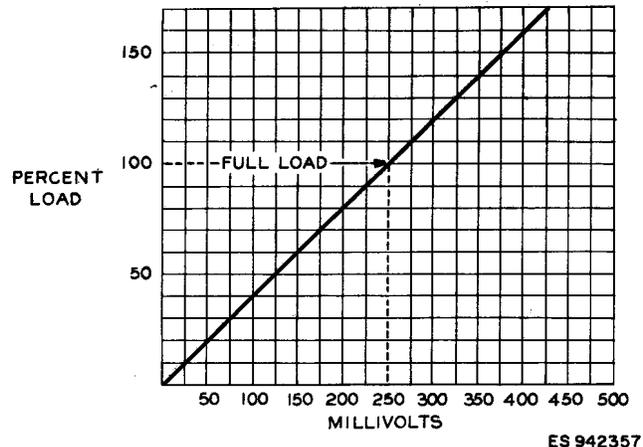
3.08 Measure the input voltage, with a Weston Model 904 voltmeter or equivalent, across each phase of the rectifier stacks when the rectifier stacks are new and when the rectifier is operating at rated current, voltage, and normal line input. Record these readings and place them on the rectifier for future reference. See 5.10.

CCH, CCL, and OL Relay Adjustments—Rectifier at No Load and Disconnect From the Battery

3.09 To facilitate the adjustment of the OL relay and the constant current controls CCH and CCL, a constant current test circuit is furnished as part of the rectifier control section. Before using the CC TST circuit or doing any repair work on the rectifier, disconnect the charging unit without disturbing plant operation. See associated plant sections.

3.10 To determine the percent load a rectifier is carrying, see Fig. 3 for corresponding voltage drop across the CC TEST millivoltmeter. Then increase or decrease the CC TST potentiometer until the CC TST millivoltmeter indicates the voltage

obtained from the graph. For example, when the CC TST millivoltmeter indicates 250 millivolts, the rectifier is carrying 100 percent load.



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Fig. 3—Rectifier Load, in Percent, Versus CC TST Millivoltmeter Reading

3.11 Verify the accuracy of the CC TST millivoltmeter and the AR ammeter relay at any load by using the following equation:

$$[\text{CC TST millivolts}] = 5/4 \times \text{load}$$

The load is the reading obtained from the AR ammeter in amperes. Compare the calculated CC TST millivolts with the actual reading on the CC TST millivoltmeter. They should agree within ± 10 millivolts. If the observed and calculated voltages are not within these limits, the meters should be tested in accordance with 4.05

3.12 To check the operation of the CC TST circuit, connect the KS-8039 voltmeter, set to the 75 VOLTS DC scale, to the REG+ and REG- jacks. Operate the CC TST switch to TST and note the KS-8039 voltmeter reading. Rotate the CC TST potentiometer until the voltage decreases two volts below the previously indicated voltage. This indicates satisfactory performance of the CC TST circuit, which may be used for adjusting the OL relay and the CCH and CCL constant current controls.

Caution: Do not shut the rectifier down in the process of making the above test.

If the rectifier is shut down, it has to be run for 10 minutes before tube V6 (420A) stabilizes and the test can be repeated.

Note: The 275-millivolt setting on the CC TST millivoltmeter, with rectifier disconnected from the battery, is equivalent to 262 millivolts (or 105 percent load) when CCH is adjusted using load.

3.13 Adjust the load to obtain full scale reading on the ammeter relay and adjust the zero setting of the CC TST millivoltmeter to obtain a reading of 250 millivolts.

Caution: *The CC TST millivoltmeter may not be on zero with no voltage across it.*

This condition is normal as a result of the foregoing adjustment at full load. Do not change the zero setting.

3.14 CCH and CCL Potentiometer Adjustment:

Adjust the CCH potentiometer after the rectifier has been operating continuously for at least 1/2 hour and after having been disconnected from the plant in accordance with associated plant section.

- (1) Ensure that the OUTPUT (S3) rotary switch is in the OPEN position.
- (2) Operate the CONT key to the TEST R position.
- (3) Verify that the CC TST rheostat is rotated fully ccw and the CC TST switch is in the NOR position.
- (4) Note that the rectifier output voltage as indicated on the VM voltmeter is float voltage ± 4 volts.
- (5) Rotate CCH potentiometer maximum cw.
- (6) Operate the CC TST switch to TST and rotate CC TST rheostat cw until CC TEST meter indicates 275 ± 2 millivolts (or 105 percent load).
- (7) Rotate CCH potentiometer ccw until the rectifier output voltage on VM voltmeter decreases 2 volts.

Note: Some adjustment of both the CCH and CCL rheostat may be necessary because of interaction.

- (8) Rotate the CC TST rheostat fully ccw.
- (9) Operate the CC TST switch to NOR position.
- (10) Block the CRL relay operated.
- (11) Rotate the CCL potentiometer maximum cw.
- (12) Operate the CC TST switch to TST and rotate CC TST rheostat cw until CC TEST meter indicates 200 ± 2 millivolts.
- (13) Rotate CCL potentiometer ccw until rectifier output voltage on VM voltmeter decreases 2 volts.

Note: Some adjustment of both the CCH and CCL rheostats may be necessary because of interaction.

- (14) Rotate the CC TST rheostat fully ccw and operate the CC TST switch to NOR.
- (15) Restore the rectifiers to normal operation in accordance with the appropriate plant practice.

3.15 OL Relay Adjustment: To adjust the OL relay, disconnect the rectifier without disturbing plant operation in accordance with the associated plant section. Proceed as follows.

- (1) Ensure that the OUTPUT (S3) rotary switch is in the OPEN position.
- (2) Operate the CONT key to the TEST R position.
- (3) Operate the NOR-TEST 1 switch to the TEST 1 position.
- (4) Verify that the rectifier output voltage, as indicated on the VM voltmeter, is at float value ± 4 volts.
- (5) Rotate A rheostat maximum cw
- (6) Operate CC TST switch to TST position and **hold only while making adjustments.**

(7) Rotate CC TST rheostat slowly cw until the OL relay operates. Check that the OL relay has operated by connecting the ohmmeter section of a KS-14510 volt-ohm-milliammeter or equivalent across terminal 1 of OL relay and frame GRD jack.

(8) The OL relay should operate with 350 millivolts applied. If the OL relay does not operate with 350 millivolts applied, as indicated on the CC TST meter, rotate the A rheostat ccw until the OL relay operates. Readjust the CC TST rheostat as the A rheostat is varied.

(9) Reduce the CC TST voltage until the OL relay releases. If the release point exceeds 300 millivolts rotate the A potentiometer ccw.

(10) Increase the CC TST voltage to operate the OL relay, then reduce the voltage and check release value. Readjust the A potentiometer if the release point is not 300 millivolts.

(11) Repeat (10) until the OL relay releases at 300 millivolts (120 percent of rectifier rating).

(12) Rotate the CC TST rheostat fully ccw.

(13) Restore the NOR-TEST 1 switch to the NOR position.

(14) Restore the rectifier to normal operation in accordance with the appropriate plant practice.

3.16 ANTI-HUNT Potentiometer Adjustment:

If a periodic increase and decrease of the indication of the OUTPUT CURRENT ammeter is observed while performing the routine checks or in normal operation, adjust the ANTI-HUNT potentiometer slowly until the swings decrease to a minimum. If the AH rheostat is incapable of eliminating cyclic hunting of rectifier output, use option W shown on drawing SD-81242-01, Fig. 2, if provided.

Note: In general, it will be found that the ANTI-HUNT potentiometer will work most satisfactorily when left in the midrange position for lead-calcium battery loads and in the 3/4-full cw position for the lead-antimony battery loads.

4. ROUTINE CHECKS

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

4.02 Periodically operate the CONT key to the TEST R position and note that the rectifier begins or continues to operate. Return the CONT key to the NOR position.

4.03 Periodically, operate the NOR-TEST switches to check the rectifier operation as follows.

Note: Do not shut the rectifier down in the process of this test. If the rectifier is shut down during this test, the RH relay must be reoperated before continuing tests.

(1) Verify that the MAN potentiometer is rotated fully ccw.

(2) Operate the NOR-TEST 1 switch to TEST 1. Check that the RH relay operates and locks up.

(3) Rotate the MAN potentiometer cw.

Requirement: The saturating current and rectifier output voltage shall increase as the potentiometer is rotated cw.

(4) Rotate the MAN potentiometer ccw to NOR.

(5) Operate the NOR-TEST 1 switch to NOR.

(6) Operate and hold the NOR-TEST 2 switch to TEST 2.

(7) Rotate the MAN potentiometer cw.

Requirement: The saturating current and rectifier output voltage shall increase as the potentiometer is rotated cw.

(8) Rotate the MAN potentiometer ccw to NOR.

(9) Operate the NOR-TEST 2 switch to NOR.

(10) Operate and hold the NOR-TEST 3 to TEST 3.

- (11) Rotate the COARSE ADJ VOLTS potentiometer three-fourths cw.
- (12) Rotate the MAN potentiometer cw.

Requirement: The saturating current and rectifier output voltage will increase. A point will be reached where further rotation of the MAN potentiometer has no effect. This point is where the regulating circuit switches over from constant voltage to constant current regulation as selected by the setting of the CON CUR H or CON CUR L potentiometer (see 4.04).

4.04 CCH and CCL Potentiometer Adjustments:

Check the adjustment of the **CCH potentiometer** after disconnecting the rectifier without disturbing plant operation (for method of disconnecting rectifier, see associated plant section). Rotate CC TST rheostat until rectifier output volts, as read on the VM voltmeter, decreases 2 volts. If CC TST meter reading is less than 240 millivolts, readjust CCH potentiometer until droop occurs at 275 millivolts. Reconnect the rectifier.

Note: It is only necessary to check the CCH potentiometer adjustment. Since the CCH and CCL potentiometers are in the same circuit, the CCL potentiometer will be out of adjustment each time the CCH potentiometer is out of adjustment and must then be adjusted.

4.05 AR Ammeter Relay and CC TST Meter

Check: Check the AR ammeter relay and CC TST meter against a KS-8039 volt-milliammeter as follows.

- (1) Connect the KS-8039 volt-milliammeter, set to the 1.5 VOLT DC scale, to terminals 2 and 3 of the AR shunt.
- (2) Load the rectifier until the KS-8039 volt-milliammeter indicates 225 millivolts (0.225 volts).

Requirement: The AR ammeter relay indicates 180 ± 6 amperes. The CC TST meter indicates 225 ± 6 millivolts (0.225 ± 0.006).

Note: If the above requirements are not met, the ammeter and/or voltmeter are/is out of calibration and should be calibrated before

performing checks or adjustments using those meters.

4.06 VM Voltmeter Check: Adjust the load to the batteries or adjust the load supplying it, as required, to avoid service reaction. Proceed as follows.

- (1) Operate the ON-OFF key to OFF.
- (2) Connect the KS-8039 volt-milliammeter, set to the 75 VOLTS DC range, in parallel with the VM voltmeter.

Caution: Avoid all contact with exposed electrical surfaces.

- (3) Operate the NOR-TEST 1 key to TEST 1.
- (4) Operate the ON-OFF key to NOR.
- (5) Operate the CONT key to TEST R.
- (6) Allow approximately one minute for the tubes to heat.
- (7) Rotate the MAN potentiometer slowly cw until the KS-8039 volt-milliammeter indicates float voltage.
- (8) Adjust the zero adjust screw on the VM voltmeter until it agrees exactly with the KS-8039 volt-milliammeter.
- (9) Rotate the MAN potentiometer fully ccw to NOR.
- (10) Operate the NOR-TEST 1 key to NOR.
- (11) Operate the NOR-OFF key to OFF.
- (12) Disconnect the KS-8039 volt-milliammeter.
- (13) Restore the rectifier to normal operation in accordance with the appropriate plant practice.

4.07 Following the installation of a new V6 (420A) electron tube, option V shown on drawing SD-81242-01, Fig. 2 may be necessary in order to obtain full range of the constant current adjustments. The constant current adjustments should be made daily for several days. Subsequent readjustments

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should be made approximately every 2 weeks for several months, or as required.

4.08 Electrolytic capacitors should be maintained in accordance with Section 032-110-701.

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 turned completely ccw before operating a test switch 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 milliammeter is to give a continual indication of the output of the regulating circuit, which output also controls the input to the main power rectifying circuit. If increasing the amount of saturating current increases the rectifier output and decreasing the saturating current decreases the rectifier output, the saturating current supply circuit and main power circuit are generally performing satisfactorily. 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 from

MAN potentiometer in the grid-to-cathode circuits of certain tubes as follows:

NOR-TEST 1 switch—V1 and V2 tube

NOR-TEST 2 switch—V4 tube (6-7-8 half) and TEST 1 circuit

NOR-TEST 3 switch—V6 tube (6-7-8 half) and TEST 1 and TEST 2 circuits

By their separate operation to their TEST positions (in each instance, the other two switches remaining on NOR), the series tube, the final amplifier, and the second current control amplifier may be tested.

Note: If the output is low when the rectifier is under automatic control, connect a KS-14510 meter across S+ and S- jacks and check that the RH relay operates at 50 volts or less in less than 5 seconds. If the RH relay does not operate, the trouble is in the RH-SC circuit.

5.03 When any kind of trouble is encountered, it is necessary first 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. However, 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.

5.04 Electron tubes may become defective with use. Check the tubes in any available tube tester in accordance with the information for the tester, one at a time, or mark the tubes since interchanging tubes may spoil 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 tester as they might occur only after the tube has heated for some time.

Note: Where routine replacement of all tubes is practiced as a preventative maintenance measure, do not include the V6 (420A) electron tube, since this is a long life tube and should be replaced only if defective.

If the performance of the V6 (420A) electron tube is in doubt and a check by substitution is made, restore the 420A tube to its original position if no improvement is noticed. (See 5.05.)

5.05 Following the installation of a new V6 (420A) electron tube, option V shown on drawing SD-81242-01, Fig. 2 may be necessary in order to obtain full range of the constant current adjustments. The constant current adjustments should be made daily for several days. Subsequent readjustments should be made approximately every 2 weeks for several months, or as required.

5.06 Rectifier stacks will age with use so that, after a period of years, it may be necessary to change the connection from the NEW to the AGED tap. See 5.07. When replacement is required due to aging, replace the stacks covered in 5.08.

5.07 Aging taps are provided on T1 to T3 transformers for use when the main rectifier element has aged. 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.

5.08 To determine if the SR13 rectifier stack needs to be replaced, proceed as follows, with the rectifier connected to the battery. Operate the NOR-TEST 1-NOR switch to the TEST 1 position. Rotate the MAN potentiometer to the maximum cw position momentarily and note that the SAT CURRENT ammeter reads 3/4 of full scale reading.

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.

If the SAT CURRENT ammeter does not read 3/4 of full scale, check V1 and V2 electron tubes. See 5.04. If the tubes are found to be satisfactory, then the trouble is in the SR13 rectifier stack and the rectifier stack should be replaced. See 5.09. Operate the TEST 1-NOR switch to NOR position.

5.09 Selenium rectifier cells may fail due to aging which is an increase in the resistance of the cells. The replacements of only the defective stack in the rectifying element that consists of more than one stack may result in an unbalanced condition in the rectifying element. To avoid unbalance, replace stacks as follows.

- (a) When replacing a defective stack or stacks in a multiple stack element, replace all other stacks in the element that have been in service 2 years or longer.
- (b) Do not combine stacks of different list numbers or different manufacturers.
- (c) Do not attempt to replace part of the rectifier cells in a stack or bolt assembly. Always replace the entire stack.

5.10 If the rectifier stacks seem hot, check the temperature with a thermometer as follows. Hold the bulb of the R-1032 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.

5.11 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 covered in 3.08. 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.

5.12 The taps on T14 transformer 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

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maintenance, the T14 transformer taps may have to be reselected to meet the minimum voltage requirements. Check the rectifier minimum voltage with the rectifier operating at no load [OUTPUT (S3) rotary switch operated to OPEN], the NOR-TEST 1 switch in the TEST 1 position, the MAN potentiometer maximum ccw and with the regulating circuit disabled (remove the V1 tube). 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.

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

Trouble Chart

5.13 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 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 drawings.

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 operated
	SC and RH relay failure
	COARSE ADJUST VOLTS potentiometer out of adjustment
	CCH potentiometer out of adjustment
	V1, V2, V3, V4, and V6 tube failure
	TD1 relay failure
	AC contactor not operated

TROUBLE	POSSIBLE CAUSE
No dc output current (high saturating current in automatic control)	CHG fuse blown
	OUTPUT (S3) rotary switch in OPEN position and CONT key in NOR
	Aged rectifier stacks
Low dc output (low saturating current in automatic control)	Low line voltage
	COARSE ADJUST VOLTS out of adjustment
	CCH potentiometer out of adjustment
Low dc output current (high saturating current in automatic control or manual control)	Weak V1, V2, V3, V4, or V6 tube
	Aged SR13 rectifier stacks
	Aged main rectifier stacks
High dc output current and high saturating current in automatic control	Excessive charging lead drop
	Low line voltage
	CHG or CUR REG potentiometers not shorted out
Output excessively noisy	Failure to low emission in V5
	Excessive grid current in V2
	REG leads open or fuse blown
Filter capacitors defective	COARSE ADJ VOLTS potentiometer out of adjustment
	Rectifier in manual with MAN potentiometer not fully ccw
	Faulty connection to filter capacitors

TROUBLE	POSSIBLE CAUSE
Unstable output (hunting)	Unbalanced ac line voltage (more than 5 per cent)
	Defective stack in main rectifier assembly
Output voltage surge during starts	AH potentiometer misadjusted
	Faulty C7, C9, R38, or R39
Rated output current not obtainable with saturating current maximum under MAN control	TD1 relay locked up
	Excessive drop in dc connection to load
	Shorted C31-35
	Main rectifier cells high resistance due to aging
Cannot reduce dc output current to zero with saturating current minimum under MAN control	CHG fuse or OUTPUT (S3) rotary switch open
	R40 or RV1 failure
Rectifier shuts off after short interval of operation	T14 misadjusted
	OL relay not adjusted
Poor regulation at battery	RT relay not operating
	CCH potentiometer not adjusted properly
	Aged main or MAG AMP stacks
	Excessive charging lead drop
	RH relay not operated
	Weak V1, V2, V3, V4, and V6 tubes

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 meter. 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.

Table A—Point-to-Point Voltages

6.04 Viewed from the rear, the socket terminals, starting from the key way or blank positions, are numbered clockwise. Before taking the voltage readings, be sure the CCH potentiometer has been adjusted in accordance with 3.14 and perform the following operations.

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- (a) Shut the rectifier down and remove the regulating fuse (part of power plant).
- (b) Strap terminals 20 and 28.

not to short them to the adjacent terminals or the VM fuse will blow.

Note: Care should be exercised when short circuiting these terminals on the terminal strip

- (c) Turn the rectifier on and, after the rectifier has been operating for 10 minutes, operate the CONT key to the TEST R position.

TABLE A — POINT-TO-POINT VOLTAGES

Panel Meter Readings:				
Sat Current = 0.018 Amperes Output Volts = 49.5 Volts				
METER CONNECTIONS		METER SCALE (volts)	METER SETTING (ac or dc)	READING (volts)
TEST POINT	TEST POINT			
Contactor AC				
L1	L2	300	AC	228
Rectifier Stack AC Supply				
AC1	AC2	60	AC	39
Pin Jacks				
REG+	REG-	60	DC	49.2
SH+	SH-	3	DC	0
S+	S-	12	DC	5*
P	GND	300	DC	143.5
B	GND	300	DC	248
P	B	300	DC	103
Transformers				
T1, T2, T3 — Term 1	Term 2	300	AC	170
Term 2	Term 3	60	AC	11
Term 1	Term 3	300	AC	180
Term 4	Term 5	60	AC	39
Term 4	Term 6	60	AC	46.5
T4, T5, T6 — Term 1	Term 2	300	AC	83
Term 2	Term 3	60	AC	39
Term 1	Term 3	300	AC	119
T10 — Term 1	Term 2	300	AC	208
Term 3	Term 4	600	AC	385
Term 4	Term 5	600	AC	385
Term 6	Term 7	12	AC	5

* Output voltages may increase when taking this reading.

TABLE A — POINT-TO-POINT VOLTAGES (Cont)

METER CONNECTIONS		METER SCALE (volts)	METER SETTING (ac or dc)	READING (volts)
TEST POINT	TEST POINT			
<i>Transformers (cont)</i>				
T11 — Term 1	Term 2	300	AC	208
Term 3	Term 5	300	AC	109
Term 6	Term 7	12	AC	6.05
Term 8	Term 9	12	AC	6.05
T12 — Term 1	Term 2	300	AC	209
Term 3	Term 4	60	AC	37
Term 4	Term 5	600	AC	432
T13 — Term 1	Term 6	300	AC	115
Term 8	Term 12	12	AC	6.75*
T14 — Term 1	Term 2	300	AC	104
Term 3	Term 4	300	AC	104
Term 5	Term 10	300	AC	250
Term 11	Term 13	60	AC	11.9
T15 — Term 1	Term 2	60	AC	18
<i>Inductors</i>				
L1, L2, L3 — Term 1	Term 2	300	AC	292
Term 3	Term 4	12	DC	8**
L6 — Term 1	Term 2	300	AC	107
Term 5	Term 6	300	AC	107.5
Term 3	Term 4	12	DC	5**
<i>Rectifying Elements</i>				
RV1 — Term 1	Term 2	300	DC	103
SR13 — Term AC	Term AC	60	AC	56
Term +	Term —	60	DC	25
SR1-SR12 — Term AC	Term AC	60	AC	39
Term +	Term—	60	DC	49
*6.3 volts on rms-type meter.				
**Caution: The dc windings 3-4 of L1, L2, L3, and L6 inductors may have ac voltages of 100 to 200 volts normally and over 1000 volts due to failure or removal of R32, R50, R51, and R52 resistors				
Note: This table will be more detailed as soon as more point-to-point data is available.				

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- (d) Operate the NOR-TEST 1-NOR switch to the TEST 1 position.
- (e) Operate the OUTPUT (S3) rotary switch to OPEN.
- (f) Restore the NOR-TEST 1-NOR switch to NOR position.

Note: The voltage read on the output voltmeter at this time is slightly higher than

the float voltage since the voltmeter reads float voltage and CUR REG potentiometer voltage. This condition is satisfactory since the point-to-point voltages are approximate.

Caution: *Point-to-point voltages should be taken only after the rectifier has been operating for at least 10 minutes and the tube V6 has stabilized.*

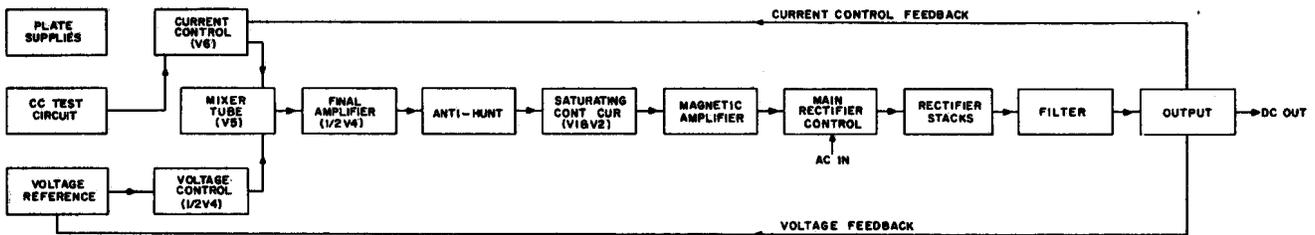


Fig. 4—Block Diagram of KS-15689 L1 Rectifier with KS-15689 L3 Electronic Controls