110A POWER PLANT

1. GENERAL

1.01 This section describes the operation of the 110A power plant having a capacity of 10 to 120 amperes at 22 to 26 volts or 10 to 240 amperes at 44 to 50 volts. The plant consists of 24- and 48-volt, regulated 30-ampere rectifiers, batteries, control, and distribution equipment all mounted on frameworks. The plant is designed for a 210- to 250-volt, 60-cycle, single-phase power service. The plant is suitable for operation in room temperatures 0°F to 104F (-18C to 40C).

Caution: Voltages inside of the rectifier case are over 150 volts to ground and between terminals. The precautions outlined in the operating section on the rectifiers should be observed.

1.02 This section is reissued to add references to J86263 metallic-type rectifiers, substitution of resistors for counter cells, and new instructions for maintenance of counter cells. Changes are marked with arrows.

1.03 Instructions are based on the following drawings. For detailed description of the operation of the individual circuits, see the corresponding circuit descriptions.

SD-80714-01 - Tube Rectifier Circuit 30 Amperes, 48 Volts
SD-80720-01 (Mfr. Disc.) - Discharge Circuit 44 to 50 Volts
SD-80720-02 - Discharge Circuit 44 to 50 Volts
SD-80722-01 (A&M Only) - Charge Circuit 44 to 50 Volts
SD-80722-02 - Charge Circuit 44 to 50 Volts
SD-80753-01 - Discharge Circuit 22 to 26 Volts
SD-80755-01 - Charge Circuit 22 to 26 Volts
SD-80757-01 - Tube Rectifier Circuit 30 Amperes, 24 Volts
SD-81180-01 - Metallic Rectifier Circuit 30 Amperes, 48 Volts ↰
SD-81181-01 - Metallic Rectifier Circuit 30 Amperes, 24 Volts
SD-81210-01 - Resistors to Replace Counter Cells ↲

1.04 Additional information on the operation and maintenance of individual pieces of apparatus such as instruments, keys, relays, etc. is given in other sections and the attendant should be familiar with them. All relays, etc. are assumed to have been adjusted in accordance with these sections and the circuit requirements tables on the circuit drawings. Refer also to such sections as:

A301.005 - Storage Batteries - Continuous Float Operation
A301.307 - Regulated Tube Rectifier - Booster Control
A301.341 - Regulated Metallic Rectifier ←
A401.001 - Storage Batteries
A401.004 - Counter Cells
A401.507 - Contactors, etc.
A438.961 - Electrolytic Capacitors
A462.005 - 260-type Relays
A462.014 - Time Relays
A804.001 - 35-type Test Sets ←

1.05 Routine checks should be made during a period when they will cause the least unfavorable reactions.

1.06 The abbreviations CW and CCW, used herein, refer to clockwise and counterclockwise rotation respectively.

1.07 The grid battery in the regulator has an initial peak voltage which decreases to a lower value in a few days or weeks. The voltage then remains almost constant, dropping off gradually during most of the life. The end of grid battery life can usually be recognized by irregular operation of the rectifier. The grid battery should be replaced when the control rheostat is full CCW. ← ←

1.08 Unless otherwise specified, all voltage and current readings called for in this section may be taken with the voltmeters provided in the plant.

1.09 Information in this section is arranged under the following headings.

1.10 List of Tools, Gauges, and Materials

Screwdriver, cabinet, 3"
Voltmeter, Weston, Model No. 280, d-c

2. OPERATION

Description

2.01 Each plant, 24 or 48 volts, makes use of 30-ampere rectifiers of the corres-

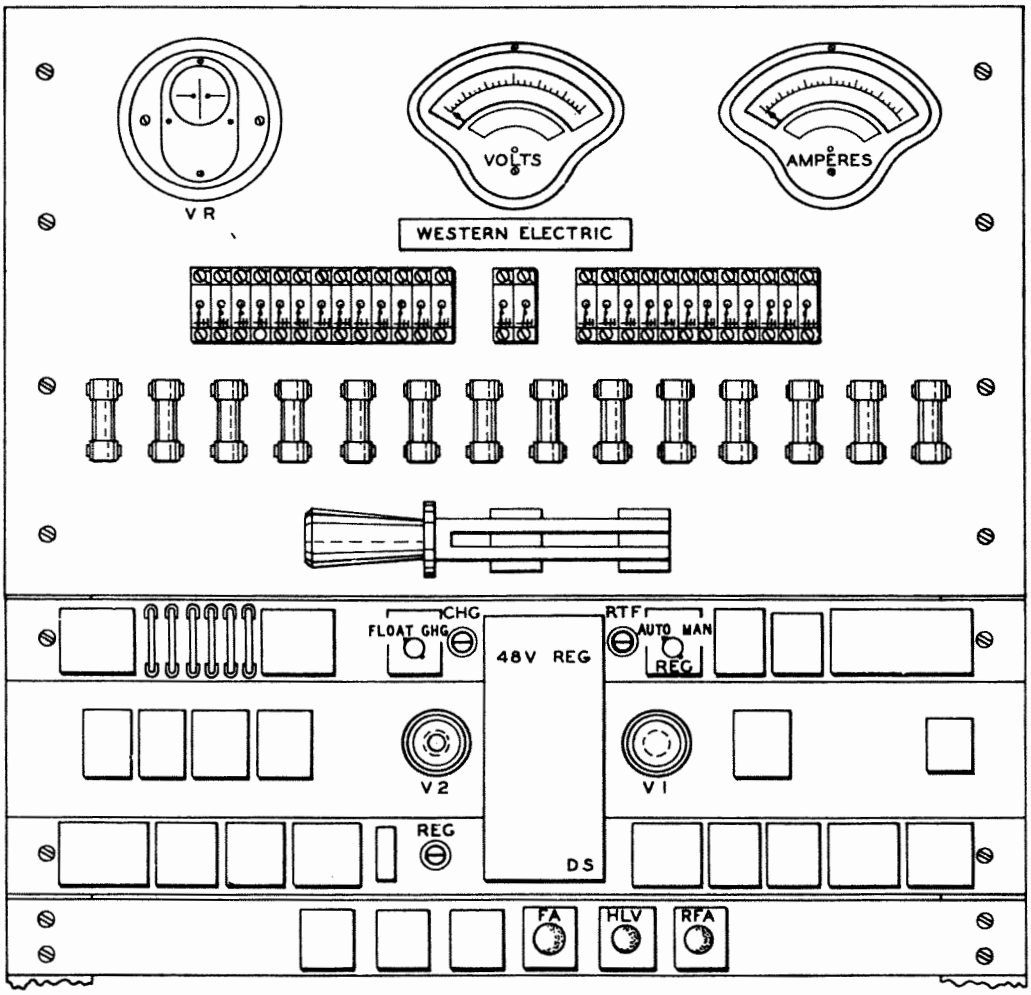

Fig. 1 - 48-volt Plant Controls

ponding voltage to float the load and charge the batteries. Several types of rectifiers may be used in these plants. The J86263A or B rectifiers employ metallic rectifier stacks. The J86207P or S rectifiers use vacuum tubes except where they have been modified to use metallic rectifier stacks. Where vacuum tube rectifiers are used, a time delay circuit is included to allow the tube filaments to warm up before plate voltage is applied. Regulation is secured by "booster control" which involves equipment for changing the plate voltage of the rectifier tubes or voltage to the rectifier stacks. This equipment consists of a motor-driven, continuously tapped autotransformer and an insulating booster transformer. Operation of the motor-driven transformer, in response to manual or automatic signals, raises or lowers voltage and controls the output of the rectifier. A voltage control unit or regulator consisting of an amplifier and a bridge circuit is used to furnish raise and lower signals for automatic control to maintain the battery within the floating limits. Only one regulator is required for a 24- or 48-volt plant. The 48-volt plant is designed to use from one to eight rectifiers and the 24-volt plant one to seven rectifiers. On constant load plants, rectifiers in excess of those required to float the load should be available to charge the battery. Where the plant load is variable, charging can be done during light-load periods. The plant control automatically connects or disconnects rectifiers as the load conditions require. When a rectifier carrying load is shut OFF for any reason, another rectifier automatically starts and takes the load. The battery equipment of the 48-volt plant consists of 24 cells in series together with three counter cells, the first counter cell being cut in or out of circuit automatically and the other two being switched in a single step by manual control. The battery equipment of the 24-volt plant consists of twelve cells in series together with two

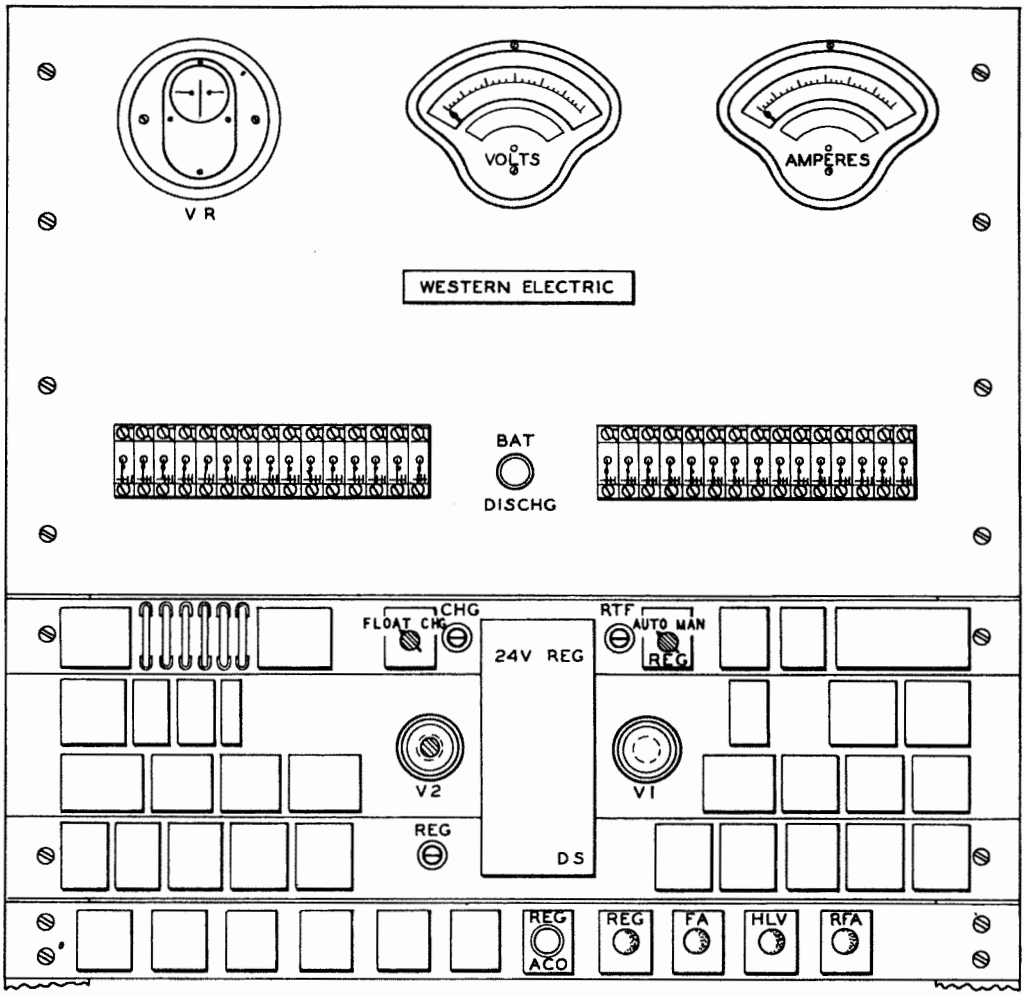

Fig. 2 - 24-volt Plant Controls

counter cells each being cut in or out of circuit separately and automatically. In some 24-volt plants where the load will not vary more than 10 per cent of the total, load resistors may be used instead of counter cells to perform the same function. Provision is made to automatically hold the voltage at the charging value as long as the FLOAT-CHG key is in the CHG position.

2.02 Major alarms are provided to indicate high or low discharge voltage and failure of any d-c fuse other than those mounted on the rectifiers. Minor alarms are provided to indicate failure of a rectifier tube, stack, or fuse. A regulator failure alarm is provided for 24-volt plants.

Preparing to Start

2.03 The rectifiers are assumed to be ready for plant operation having been checked in accordance with operating Section A301.307 for J86207 rectifiers or A301.341 for J86263 rectifiers.

2.04 When putting a regulator (Fig. 4 of SD-80722-02, Fig. 5 of SD-80722-01, or Fig. 5 of SD-80755-01) into service, see that:

(a) A-c fuses are removed.

(b) Proper transformer taps have been connected for the power service voltage.

(c) Correct tubes are in the sockets.

(d) Proper number of grid battery cells are in circuit.

(e) REG and CHG rheostats are in the extreme CCW position and RTF rheostat is in the extreme CW position.

(f) REG switch is in MAN position.

(g) FLOAT-CHG switch is in FLOAT position.

(h) Associated charge and discharge circuits are properly fused.

(i) CEMF GR2 switch is closed.

(j) VR switch is closed.

(k) Rectifier keys are in the OFF and NORM positions.

(l) Correct a-c fuses are put in place.

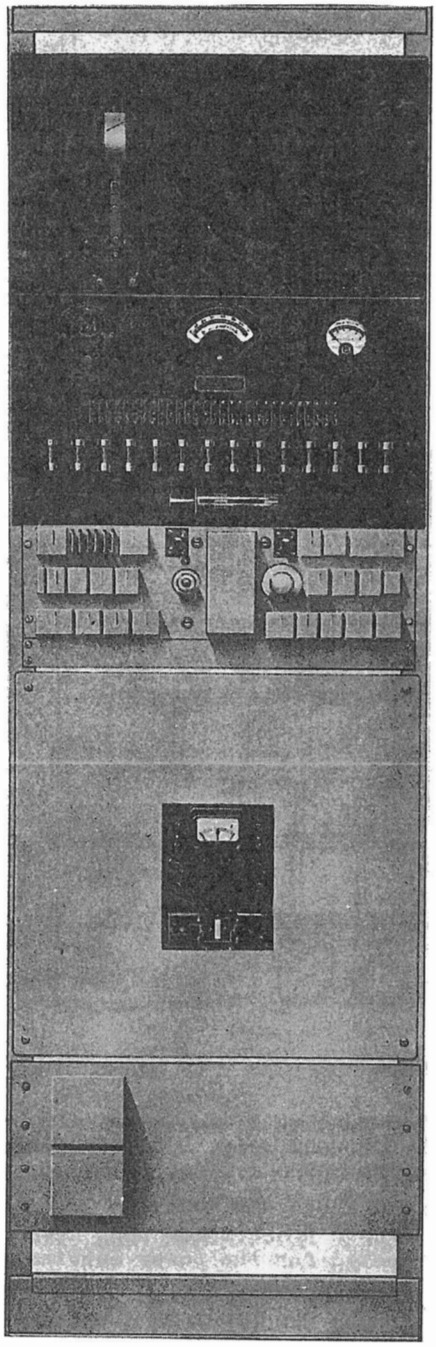

Fig. 3 - Typical Charge Bay For 48-volt Plants

Initial Adjustments (See Figs. 1 and 2)

2.05 For the first rectifier, move TR brush a short distance by operation of the RAISE key and then operate the ON-OFF key to the ON position. Note that contactor C1 does not operate until TR brush has completed its travel back to the minimum voltage position and that with tube-type rectifiers there is a time delay of from 3 to 5 minutes after operation of the C1 contactor before the operation of the ST1 relay. The tubes will show a slight glow but there will be no output from the rectifier. Where metallic-type rectifiers are used no time delay is required and the rectifiers will start immediately. Operate the ON-OFF key to the OFF position.

2.06 For succeeding rectifiers, block the CI and CI2 relays operated. Repeat the operations of 2.05 for each rectifier in order. Remove the blocking in CI and CI2 relays.

2.07 For preliminary charge of battery, have regulator keys in FLOAT and MAN positions and rectifier keys in the ON and TEST positions.

(a) Allow 3 to 5 minutes for tubes to heat only where tube-type rectifiers are used.

(b) Adjust output of each rectifier to desired value (not in excess of full-load rating) by operation of RAISE and LOWER keys.

(c) Charge until voltage is at float value.

2.08 For adjustment of regulator for float at time of installation, have regulator keys in FLOAT and MAN positions and rectifier keys in the ON and TEST positions.

(a) With voltage at float value, 51.6 volts for the 24-cell plant or 25.8 volts for the 12-cell plant, (voltmeter key operated) and maintained at that value by operation of rectifier RAISE or LOWER keys, move REG rheostat in a CW direction until both the L and R relays are released.

(b) Restore REG key to the AUTO position.

(c) Restore rectifier TEST-NORM keys to NORM position.

Note: All rectifiers but the first will probably release at this point and all will go back to the minimum voltage position of the TR autotransformer brush, after which rectifiers will restart, as required, to carry the load.

(d) Check that regulator now maintains the float voltage, readjusting, if necessary, in accordance with 2.09.

2.09 For readjustment of regulator for float during maintenance when a small setting change is all that is necessary, have regulator keys in the FLOAT and AUTO positions and the rectifier keys in the ON and NORM positions.

(a) Rotate the REG rheostat slowly CW to raise voltage or CCW to lower voltage, allowing time for battery voltage to respond until both R and L relays are released when battery voltage is at float value (voltmeter key operated 51.6 volts for the 24-cell plant or 25.8 volts for the 12-cell plant). The operation of the R and L relays will be indicated by the sound of the operation of the RR and RL relays of the last operating rectifier providing its output is between 5 and 25 amperes.

(b) Check that regulator now maintains floating voltage.

2.10 For adjustment of regulator for charge, first adjust for float and then have regulator keys in the CHG and AUTO positions and the rectifier keys in the ON and NORM positions.

(a) Rotate CHG rheostat slowly CW allowing time for battery voltage to respond until both R and L relays are released when battery voltage is at the charge value 56 or 28 volts (voltmeter key operated). The operation of the R and L relays will be indicated by the sound of the operation of the RR or RL relays of the last operating rectifier provided its output is between 5 and 25 amperes.

(b) Check that regulator now maintains charging voltage. Readjust, if required.

2.11 To test for transfer, there must be at least one operating and one idle rectifier. Have regulator keys in the FLOAT and AUTO position and rectifier keys in the ON and NORM positions.

(a) Operate TEST-NORM key of rectifier No. 1 to TEST position.

(b) Reduce output of rectifier No. 1 slowly to zero with the LOWER key allowing time for the other rectifiers to assume the load. Note that the next idle rectifier starts and carries the load after its 3- to 5-minute starting time delay only where tube-type rectifiers are used.

(c) Restore TEST-NORM key of rectifier No. 1 to NORM. It should reclaim the load from the rectifier that started when No. 1 was shut down.

(d) Repeat with all successive rectifiers except the last one.

2.12 To test that rectifiers stop when regulator amplifier tube fails, have regulator keys in the FLOAT and AUTO positions and the rectifier keys in the ON and NORM positions.

(a) Remove regulator tube V2. When discharge circuit voltage reaches trip value, all rectifiers should shut down. Unless otherwise specified on the circuit, trip value shall be approximately 26.5 volts for a 24-volt battery and 52.75 volts for a 48-volt battery as read at the discharge bus bar (voltmeter key released).

(b) When the voltage reaches trip value, turn RTF rheostat CCW until RTF1 relay operates, causing all rectifiers to shut down.

(c) Operate REG key to the MAN position.

(d) Reinsert regulator tube V2.

(e) Restore REG key to AUTO. Regulator and rectifiers should function and connect to the load in the normal manner.

(f) Repeat above to check the voltage at which RTF1 relay operates and adjust RTF rheostat if necessary.

2.13 To test rectifier action at time of a-c failure, have regulator keys in the FLOAT and AUTO positions and all rectifier keys in the ON and NORM positions.

(a) Remove regulator a-c fuses. All rectifiers should stop and the TR autotransformer brushes should move to the minimum voltage position. The C1 contactor in the No. 1 rectifier will reoperate when the autotransformer brush reaches the minimum voltage position, but there will be no output. In a real power failure, the autotransformer brushes will not move to the minimum position until the power is restored.

(b) Replace the regulator a-c fuses. Regulator and rectifiers should now function and connect to the load in the normal manner.

Routine Adjustments

Normal Operation

2.14 Put regulator REG key in the AUTO position. Operation to the MAN position discontinues the control of the regulator over all rectifiers.

2.15 Put regulator CHG-FLOAT key in the FLOAT or CHG position, depending on whether float voltage or charge voltage is desired at the time. See 2.21.

2.16 Put rectifier ON-OFF keys in the ON position. Operation to the OFF position immediately shuts off a rectifier output.

2.17 Put rectifier TEST-NORM keys in the NORM position. Operation to the TEST position disconnects the automatic raise and

lower controls, but leaves a rectifier operating and subject to control with the RAISE and LOWER keys.

2.18 When functioning properly the rectifiers will assume load in sequence as the load increases. That is, the second will take load when the first reaches full load and so on. As the load decreases, the last rectifier in operation will reduce its output and stop and so on in the reverse order from assuming the load.

Stopping a Rectifier

2.19 Operate TEST-NORM key to the TEST position. Reduce load on the rectifier with the LOWER key slowly to zero allowing time for other rectifiers, if any, to assume the load. Operate the ON-OFF key to the OFF position. If rectifier is to be left out of service, remove a-c fuses and the d-c CHG fuse.

Starting a Rectifier After A Shutdown

2.20 See that all fuses are in place. See that TEST-NORM key is in the NORM position. Restore the ON-OFF key to the ON position.

Equalizing or Boost Charges

2.21 To obtain equalizing or boost charge voltage, operate the CHG-FLOAT key to the CHG position and then make discharge circuit changes, if necessary. An example of a necessary discharge circuit change would be the opening of a counter cell switch during charge. For adjustment of regulator for charging voltage, see 2.10. After charge, restore CHG-FLOAT key to the FLOAT position and then restore discharge circuit to normal. If all rectifiers shut down at this point due to voltage above trip value (see 2.12), momentarily operate the REG key to the MAN position and then back to the AUTO position.

3. ROUTINE CHECKS

3.01 Float Voltage and Electrolyte Level: The float voltage of the battery should be checked whenever an attendant visits the office for other reasons. Ordinarily an observation of the voltage by pressing the voltmeter key is sufficient if the voltage is within the floating limits. At least every five to seven weeks the electrolyte level in the battery and counter cells should be checked. Battery readings should be made and recorded in accordance with Section A301.005. If the floating voltage is not within the established floating voltage range, the regulator should be readjusted. The voltage range can be observed by operating the RAISE key momentarily a number of times until the automatic control gives a LOWER signal operating the RL relay. The battery voltage when the RL relay operates should be observed. Repeat using the LOWER key and observing when the RR relay operates. These voltages give the range in which the regulator is trying to hold the battery voltage. Adjust REG rheostat, if necessary, until the average is at the float value. (See 2.09.) The frequency of checking may be changed as experience indicates.

3.02 Time delay relay DS where used, should be checked occasionally to be sure that a minimum of 3 minutes delay is obtained.

3.03 Transfer of load occurs in the regular operation of the plant, additional rectifiers being started as the load increases. To be sure that all rectifiers will function properly, particularly where they are not all used in the daily load cycle, on each routine visit, stop as many rectifiers beginning with the first as is necessary to start the last rectifier. (See 2.19.) Restore the rectifiers to service one at a time.

3.04 Power failure operation should be checked particularly where power service is seldom interrupted. (See 2.13.)

3.05 Regulator tube failure should be tested to be sure the plant shuts down when the amplifier tube V2 fails. A tube failure can be made by removing the tube from its socket. This will cause a RAISE signal and the plant voltage will increase until RTF1 relay operates, shutting down all rectifiers until the tube is replaced and the REG key is operated to the MAN position and then restored to the AUTO position. The rectifiers should then start automatically in a normal manner.

3.06 Routine checks of the vacuum tubes in the regulator can be made with any available vacuum tube tester to indicate when a tube is poor and needs to be replaced.

3.07 Alarms: Periodically check that the following alarms will function, using the procedures below:

(a) To cause a REG alarm (24-volt plants only), block the A relay on the regulator panel operated. Remove blocking.

(b) To cause an FA alarm, connect a W1AF test cord between the alarm and battery bus bars on the charge bay fuse panel. Remove cord.

(c) To cause an RFA alarm, connect a W1AF test cord between the alarm and battery posts for 35-type fuses on J86207 rectifiers or use a 265C tool to cause the alarm for J86263 rectifiers equipped with 70-type fuses.

Note: Check fuse alarms where 70-type fuses are used by inserting a 266C tool (wire burnisher) held in a 265C tool (contact burnisher holder) through the aperture in the front of

the fuse holder through which the colored fuse bead protrudes. Insert the tool far enough to short the brass collar in the fuse holder cap to the fuse body thus causing an alarm. Withdraw the tool.

Caution: When shorting fuse parts to cause an alarm, the exposed metal parts of the 265C burnishing tool holder are at voltage to ground. Avoid shock by firmly attaching the cap to the tool holder barrel and holding the cap only.

(d) To check the HLV relay and alarm, open the VR knife switch in series with the VR relay and connect a 35D test set across the switch terminals. Use the B/G/V test set arrangement with auxiliary battery. (See A804.001.) By means of the variable test set resistors raise and lower the voltage applied to the VR relay and observe that its high or low contacts are made at the voltage specified in the circuit requirements table and that an alarm is caused.

4. TROUBLES

4.01 If rectifier is not regulating at proper voltage and whenever new grid battery or regulator tube is installed, reset regulator as outlined in 2.09.

4.02 After new fuse or tube has been installed, a rectifier is again placed in service by momentarily operating the ON-OFF key to OFF and then to ON again.

4.03 If current of any rectifier is in excess of 32 amperes, check adjustment of OL and RB relays and associated A and B rheostats.

4.04 KS-5563 rheostat is totally enclosed. If it becomes defective in any respect, it should be replaced.

4.05 Locate rectifier in trouble. Its output will be zero and its associated G relay will be operated. Check d-c fuses, CHG and RC. Replace if blown. If fuses are not blown and alarm still operates, replace both rectifier tubes (V1 and V2 on rectifier) where so equipped. If this corrects trouble, put back the old tubes one at a time, until the defective tube is located.

4.06 If all rectifiers show capacity output, either the V2 regulator tube has failed, or the load is in excess of combined rectifier output.

4.07 If any rectifier does not seem to be carrying the load it should be carrying, operate its TEST key and attempt to change output with RAISE and LOWER keys. Failure to respond could indicate a-c power failure, blown a-c fuse, poorly adjusted relays, possibly RR or RL, or faulty motor capacitor (E on rectifier). See 2.18 for order in which rectifiers should assume load. Incorrect position of keys would, of course, prevent a rectifier from assuming its load.

4.08 If all rectifiers show no load, proceed as follows:

(a) If L relay is operated, replace regulator tube V1.

(b) If R relay is operated, replace regulator tube V2.

Note: As a matter of information, the bridge unbalance current required to operate the A relay is approximately twice that required to operate the L or R relays.

4.09 When working on or changing solution in counter cells, precautions should be taken to short-circuit the normally in-circuit counter cells to avoid opening the total battery. During this period, the normally shorted counter cells should be unshorted to keep the total battery voltage within limits. These operations may be performed as follows:

(a) 24-volt Plants (see SD-80753-01)

(1) In these plants, normally in-circuit counter cell GR1 may be short-circuited by blocking open the bottom 1-2 contacts of relay G1. This will release contactor G1 thus applying the short. Normally shorted counter cell GR2 may be put in circuit by blocking closed the bottom 1-2 contacts of relay G2. This will operate contactor G2 thus removing the short. When finished, restore the plant to normal by removing the relay blocking.

(2) When working on the normally shorted counter cells, block open the bottom 1-2 contacts of relay G2 to prevent automatic operation of this relay and contactor G2 which would remove the short. Remove blocking when finished.

(b) 48-volt Plants (see SD-80720-02)

(1) In these plants normally in-circuit counter cell GR1 may be short-circuited by blocking open bottom contacts 3-4 of relay H3. This will release contactor GR1 thus applying the short. Normally shorted counter cells GR2 may be put in circuit by manually opening the associated knife switch. Remove blocking when finished.

(2) Counter cells normally shorted by a knife switch may be worked on without further precautions.

Trouble Chart

4.10 If any other troubles are found, it is suggested that the possible causes be checked in the order listed.

Trouble	Possible Cause
No current	A-c supply interrupted (no voltage or a-c fuse blown). Ammeter relay operated (on low contact). Failure of rectifier tube (V1 or V2 on rectifier).
A-c input fuse blown	Defective rectifier tube (V1 or V2 on rectifier).
Low or high voltage	Failure of one rectifier tube (V1 or V2 on rectifier).
Low d-c voltage	Rectifier overloaded. Grid battery aged. Failure of a vacuum tube (V1 or V2 on regulator).
	Failure of any relay in starting chain such as AR, OC, ST, VRC, DS1.
Limit switch operated	A-c line voltage too high or too low. Charge fuse blown. Load too high. Failure of a vacuum tube (V1 or V2 on regulator).
Discharge circuits noisy	Failure of C1 and/or C2 capacitor.

Note: Failure of a rheostat to perform its function or erratic control by the rheostat may be due to dirt on rheostat contacts. Clean, as feasible, including rear contact, if any. Defective rheostats whose construction does not allow cleaning should be replaced.