REGULATED TUBE RECTIFIERS

PHASE SHIFT CONTROL

J86207C AND F

1. GENERAL

1.01 This section covers the operation of phase shift controlled, regulated tube rectifiers J86207C and F. They are designed for battery charging. The C rectifier is rated at 8 amperes, 132 to 152 or 130 volts d-c and is arranged to transfer to regulated current when its capacity at regulated voltage is reached. The F rectifier is rated at 2 amperes, 142 volts d-c, and has a ballast lamp to protect it against overload.

1.02 This section is reissued to make a number of minor changes, include information on cleaning tube, socket, and clip contacts, and to give a revised method of checking the grid battery condition. All changes are marked by arrows.

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

1.03 Before doing any work inside the rectifier case, disconnect both, the a-c by disconnecting the a-c plug, and the d-c by removing the charge fuse. For C rectifier, the fuse in the regulating lead should also be removed. Where switches are available in the a-c circuit, it is satisfactory to operate them instead of disconnecting or connecting the a-c plug as called for herein.

1.04 All models of the F rectifier have door switches which open the a-c supply when the front cover is removed. Earlier models of the C rectifier had no door switches, since the a-c plug had to be removed to remove the cover. Later models have door switches which open the a-c contactor control circuit and thereby open the a-c supply. The rectifier output should be reduced to zero and the a-c input disconnected before opening the doors or removing the cover.

1.05 Regulated tube rectifiers for floating storage batteries operate at 2.15 ±0.01 or 2.17 ±0.01 volts per cell as specified for the particular installation, the voltage adjustment being set at the top of the voltage range, namely 2.16 or 2.18 volts, to allow for the slow downward drift with aging of the grid battery.

1.06 Grid batteries used with these rectifiers have 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 almost all of the life. To adjust for aging on the grid battery associated with the amplifying tube V4, the arm of the float regulating rheostat (FLOAT REG on C rectifier and REG on F rectifier) is arranged to turn through 300 degrees. If, as is desirable, the battery has been installed within three months of the manufacture date stamped on it, the first 50 to 100 degrees are usually used up quickly as the battery initial peak voltage decreases. Adjustments then become small and infrequent and remain so for almost the entire life of the grid battery. The end of grid battery life can usually be recognized by irregular operation of the rectifier, and the battery should be replaced if the voltage, as read with an ordinary voltmeter, is less than 85 per cent of the nominal value. It is recommended that the other grid battery, if there is one, be checked whenever the one associated with the V4 tube is checked. Latest models of these rectifiers have only one grid battery.

1.07 Grid emission sometimes occurs, due to cathode material which has been carried over to the grid. The effect of this is negligible until the temperature of the tube becomes high enough to cause this active material on the grid to give off electrons which causes the grid to lose control. This effect disappears as the tube cools, so that satisfactory operation may be possible at light loads when it is not possible at full load.

1.08 Voltmeter RV is used to indicate the internal voltage relationships inside the rectifier and readings on it are neither input or output voltages. When on manual control, at approximately float voltage, voltmeter RV should read between 10 and 25 if the automatic equipment is ready to take over control. The combined rheostat and switch should be snapped from

manual to automatic only when voltmeter RV reads between 10 and 25. After switching to automatic control, voltmeter RV should read between 5 and 50 if circuit is functioning properly depending on output.

1.09 Early models of the C rectifier were not equipped with TIF filter units to prevent radiation of noise on the a-c power lines. This type of filter was added only in those cases where trouble was experienced. Later models have the filter provided as part of the rectifier equipment and mounted within the casing.

2. OPERATION

Preparing to Start

2.01 When putting a rectifier into service initially, check against the circuits to see that:

(a) Tubes are in the correct sockets.

(b) Relays are properly adjusted.

(c) Correct transformer taps are connected.

(d) Proper grid battery is in circuit.

(e) On C rectifier, the resistance in series with the overcharge rheostat is correctly connected or strapped.

2.02 The following procedure should be observed when first starting a rectifier, or when it is not known that regulating and control circuits are in satisfactory adjustment.

(a) Turn OVER CHG rheostat and float regulating rheostat to their maximum counterclockwise positions.

(b) Turn the combined rheostat and switch to maximum counterclockwise position and then in a clockwise direction until a click indicates that it is just over on manual control. Maximum resistance of rheostat R is now in and rectifier output will be minimum.

(c) Plug in a-c cord or turn AC switch to ON and check that relay GR operates in desired time (45 ±10 seconds.)

(d) If the battery is not at float value, charge it.

(e) To charge a battery with an F rectifier not yet in adjustment, snap combined rheostat and switch to manual position. Turn rheostat R in clockwise direction until either its maximum clockwise position is reached or the nominal charging rate of the battery is reached. Charge until battery voltage is at float value or slightly over.

(f) To charge a battery with a C rectifier not yet in adjustment, adjust as outlined in paragraphs 2.05 and 2.06 and charge until battery voltage is at float value or slightly higher.

(g) Adjust for regulated voltage operation per paragraphs 2.03 and 2.04.

Adjustment for Regulated Voltage

2.03 With battery charged to approximately float value and held there under manual control of rheostat R, and with OVER CHG rheostat in maximum counterclockwise position, adjust voltage with the float regulating rheostat until voltage as read on voltmeter RV is from 10 to 25. Failure to obtain such voltage may indicate a trouble condition or may merely indicate a depleted grid battery.

2.04 With voltage on voltmeter RV reading from 10 to 25, snap the combined rheostat and switch to automatic position and adjust for float voltage by slight changes in the position of the float regulating rheostat. Voltmeter RV should now read from 5 to 20 under load and from 10 to 50 at no load. Check the output voltage at the end of ten minutes and reset, if necessary. Final adjustment should be made with the rectifier hot.

Adjustment of C Rectifier for Current Regulation

2.05 Start adjustment of C rectifier for current regulation with

Rheostats A and B in maximum counterclockwise position or with slides to extreme left.

Rheostat N, if any, in maximum clockwise position.

Rheostat CR, if any, in maximum counterclockwise position.

2.06 Adjust as follows:

(a) Bring up current under manual control of rheostat R and adjust with rheostat A, if necessary, so that relays OL and TR operate at desired value, (9 amperes, unless otherwise specified). Operation of relays OL and TR should be indicated by lighting of lamp RC on more recent rectifiers. If rheostat R does not have sufficient control to provide the necessary current, disconnect the rectifier for a few minutes and allow

the battery to discharge slightly. If an artificial load is necessary to provide sufficient current, the approximate resistance in ohms required will be the d-c voltage divided by current in amperes desired to supplement the regular load.

(b) Adjust output current with rheostat R to approximately 8 amperes. ←

(c) If voltmeter RV reads less than 10 with relays OL and TR operated, ← bring it up to 10 by operation of the rheostat B and snap to automatic position.

(d) Turn rheostat N, if any, slowly in the counterclockwise direction until it begins to affect voltmeter RV reading. Then turn rheostat N clockwise approximately one-eighth turn.

(e) Adjust for desired regulated current value (8 amperes unless otherwise specified) using rheostat B. Final adjustment for regulated current should be made with the battery voltage as close to float value as feasible.

Note: On the few rectifiers having a rheostat CR, the adjustments specified herein for rheostat B shall be made with rheostat CR, and rheostat B should remain in its extreme left-hand position.

Battery Charge

2.07 When the regulating equipment is in satisfactory adjustment, charging may be left to the automatic equipment. To go from float on regulated voltage to equalizing or boost voltage, turn the OVER CHG rheostat in a clockwise direction until the output current is near but less than the current required to operate relay OL of C rectifiers or until the current is 1.8 amperes for F rectifiers. The current falls off between settings, and one or two adjustments of this rheostat may be necessary to get the voltage up to the charging value specified for the office. To avoid exceeding discharge voltage limits, the charge-discharge portion of the F rectifier circuit adjusts itself automatically for charging as the overcharge rheostat is manipulated. With charge-discharge circuits of C rectifiers, it may be necessary to make this adjustment manually, in which case, such charge-discharge circuit should be restored to normal after the overcharge. For example, on charge-discharge circuit SD-80653-01, the change from normal to charging is made with the switch associated with the voltage relay. On SD-80650-01, the change is made with the counter emf cell switch.

2.08 If the current is raised too fast on F rectifiers, the action of the ballast lamp may keep the OVER CHG rheostat changes from being quickly reflected in voltmeter readings which would be misleading. In the case of the C rectifier, relay OL might operate if voltage were raised too fast. The OVER CHG rheostat would then have no further control until the voltage relay in the charge-discharge circuit unlocked the transfer relay. If this occurs, care should be taken that the OVER CHG rheostat is not left in a position representing voltages above float value.

2.09 To return to the floating operation, turn the OVER CHG rheostat back to its maximum counterclockwise position. The output current will fall to near zero but will increase automatically to the desired value for floating when the voltage decreases to the floating value.

Routine Checks and Adjustments

2.10 Voltmeter RV on automatic voltage regulation should read from 5 to 20 under load and from 10 to 50 at no load. ←

2.11 Grid emission of rectifying tubes (see paragraph 1.06) can be checked when the rectifier has been operating at or near full load. Turn combined rheostat and switch to manual control. If current cannot be reduced to 10 per cent of rectifier rating, rectifier tube probably has grid emission and should be replaced.

2.12 Routine checks of regulated voltage and adjustment, if required, should be made periodically and after new tubes or grid batteries have been installed. The OVER CHG rheostat should be in the maximum counterclockwise position. Adjustments are made by small changes in the setting of the float regulating rheostat (FLOAT REG on C and REG on F). Voltage adjustments should be made at less than 8 amperes for the C rectifier and less than 1-1/2 amperes for the F rectifier.

Caution: Settings of voltage regulating rheostats should not be changed while rectifier is on current regulation, and setting on current-regulating rheostats should not be changed while rectifier is on voltage regulation

2.13 Regulated current value of C rectifiers should be checked and reset, if necessary, as outlined in paragraph 2.06.

(a) When rectifier is placed in service.

(b) When it is thought the setting might be incorrect.

(c) When amplifier tube V4 has been replaced.

(d) When grid battery has been changed.

(e) When other than small routine changes have been made in regulated voltage setting.

2.14 Current at which OL relays of C rectifiers operate causing transfer to regulated current need be checked only when rectifier is placed in service and when it is thought the setting might be incorrect.

2.15 After adjusting, routine starting and stopping is a matter of connecting or disconnecting the a-c plug, of operating the a-c switch where such switch has been provided in the a-c supply circuit, or of operating the AC ON/OFF key in the later C rectifiers.

3. GENERAL TROUBLES

3.01 Short life of rectifying tubes may be due in part to low filament emission, short time delay for heating of filament, and dirty corroded surface with insufficient spring tension in anode clip. The low filament emission may be due to dirty contacts in the tube socket. This can be corrected by burnishing the prongs on the tube base and the sprigs in the socket. For the latter, use abrasive cloth over a match or tooth pick to brighten the spring contact surfaces within the socket. The time delay TD relay operating time, between the application of power and the operation of relay GR should be at least 35 seconds for each rectifier. The anode lead at the top of the tube is soldered to the cap and may become unsoldered due to heating caused by dirty contact surfaces between the cap and the clip. Every three months and whenever tubes are replaced, the anode clip should be cleaned on the contact surface with abrasive cloth and the clip adjusted by bending so that there is appreciable contact pressure and fit with the cap. If the clip cannot be so adjusted, it has lost its spring tension due to heating and should be replaced. The tube caps should similarly be cleaned. Caps which become unsoldered can usually be resoldered if the lead and cap surfaces can be cleaned. Only a very short amount of anode lead sticks through the depression in the cap and careful work will be required.

3.02 If any regulator trouble is being experienced, throw the combined rheostat and switch from automatic to manual control, and if the charging current can be controlled, the trouble is in the regulating circuit. This may be confirmed by operation of the float regulating rheostat with combined rheostat and switch still in the manual control position. If battery is at approximately float voltage, failure to affect voltmeter RV reading indicates trouble in the regulating circuit.

3.03 In case of low voltage, it is suggested that steps in determining cause be taken in the following order.

(A) Look at Filaments of Tubes

(1) If all are lighted, the a-c power is satisfactory.

(2) If all tubes are out, see that rectifier a-c plug is in, that a-c fuses are satisfactory, and that the AC key, where provided, is ON.

(3) If some tubes are lighted and some in the same rectifier are out, replace tube whose filament is out.

(B) Look at Ammeter

(1) If rectifier is charging, as indicated by current of more than 0.5 amperes for the C or 0.2 amperes for the F, the rectifier would seem to be in satisfactory operating condition. The low voltage might have been due to a temporary overload or short power failure, or readjustment for voltage regulation or current regulation on the C may be in order.

(2) If rectifier is not charging, snap combined rheostat and switch to manual position and increase charging current as much as possible but not to exceed rectifier rating.

(a) If charging current is now available, charge to floating voltage.

(b) If charging current is not available, replace both rectifier tubes and repeat (A) and (B). When the trouble has been cleared, reinstall the old tubes one at a time to determine which are defective.

(C) Look at Voltmeter RV

Operating with the combined rheostat and switch in the manual position, this check should be made when the battery voltage is at float value or slightly higher and, in the case of the C rectifier, with relay TR in the non-operated position. With a majority of C rectifier applications, the most

convenient method of being sure relay TR is released, is to momentarily operate the high alarm (usually H) relay in the associated charge-discharge circuit. Later C rectifiers are equipped with an amber colored indicator lamp RC which is lighted when the rectifier is on current regulation and is out when operating on voltage regulation.

(1) If voltmeter RV reads from 10 to 25, snap the combined rheostat and switch to the automatic position.

(a) If the rectifier output goes to zero, replace the phase shift tube V3.

(b) If the rectifier seems to be carrying all or an appreciable part of the load, adjust for regulated voltage with the float regulating rheostat.

(2) If voltmeter RV reads less than 10, swing the float regulating rheostat from one end to the other.

(a) If voltmeter RV responds only slightly, make gain test per paragraph 3.06.

(b) If voltmeter RV makes no response, read grid battery voltage with any available voltmeter. Discard grid battery if it reads less than 85 per cent of its nominal value. If grid battery is satisfactory and RV still makes no response, replace amplifier tube V4.

(D) Check current regulation of C rectifier as follows:

(1) Raise current under manual control of rheostat R and observe, on the rectifier ammeter, the current at which transfer occurs. (See paragraph 2.06 if sufficient current can not be obtained.)

(2) Reset transfer point, if required, to desired value (usually 9 amperes) using rheostat A.

(3) With rectifier transferred to current regulation relays (OL and TR operated) but still under manual control of rheostat R, set current to desired regulated value (usually 8 amperes).

(4) If voltmeter RV now reads less than 10, bring it up to 10 by changes in the rheostat B setting.

(5) When voltmeter RV reads between 10 and 25, snap to automatic and make final adjustment of regulated current using rheostat B.

Note: If there is a rheostat CR, it should be used instead of rheostat B for all adjustments specified herein for the B_1 and the B should remain at all times in its extreme left-hand position.

3.04 An output high-voltage alarm that clears itself may be disregarded. When high output voltage persists, the trouble is probably in the control relays. With the C rectifier, the relay TR and associated high-alarm relay (usually H) would be suspected. With the F rectifier, trouble might be with the relays controlling the counter emf cells or with other relays. Failure of the amplifier tube V4 would also give this trouble. Check per paragraph 3.06.

3.05 It is suggested that checks for troubles, other than high or low voltage, be made in the following order. Starting shall be on manual control instead of automatic when there is the least suspicion of trouble on the circuit. After bringing up to a positive reading of between 10 and 25 volts on voltmeter RV, it is satisfactory to switch to automatic control without checking other adjustments.

Trouble	Possible Cause
No current	A-c supply interrupted (no voltage, blown a-c fuse, disconnected plug, or a-c key OFF).
	Failure of rectifier (thyratron) tube V1 or V2
	Charge fuse blown.
	Failure of relay GR to operate.
	Failure of phase shift tube V3.
A-c input fuse blown	Failure of rectifier (thyratron) tube V1 or V2.
Charge fuse blown	Failure of amplifier tube V4.
	On C rectifier failure of overload relay OL to operate.
	Grid emission from rectifier tube V1 or V2.
Low Current	Failure of one rectifying tube V1 or V2, no mercury glow.

Trouble	Possible Cause
Low current on regulated current satisfactory on regulated voltage	Grid emission in amplifier tube V4. Check per paragraph 3.06.
Failure of relay GR to operate	Varistor failed or shorted.
	Failure of time delay relay TD to operate. Relay GR under control of the TD relay is expected to operate in 45 ±10 seconds unless otherwise specified.
Erratic operation of time delay relay	Loose bimetallic strip assembly, making tightening of machine screw necessary.
Poor current regulation	Grid emission from amplifier tube. Make gain test of paragraph 3.06.
	On C rectifiers having slide wire rheostat B, rheostat B more than 60 per cent from left indicates new amplifier tube V4 is needed.
High current	If current with manual control cannot be reduced to 10 per cent of rectifier rating, rectifier tube probably has grid emission and should be replaced.

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. Dirty rheostats, whose construction does not allow cleaning, should be replaced.

3.06 To make gain test of amplifier tube, raise current manually until float voltage is reached. Adjust with regulating rheostat until voltmeter RV reads 5 or 6 volts. Increase rectifier output with the manual rheostat R until battery or rectifier voltage is 2 volts above float voltage. Voltmeter RV should then read 20 volts or more if amplifier tube is satisfactory. Restore circuit to normal working conditions if tube tests are satisfactory, otherwise replace tube and repeat test.

3.07 Irregular output or "kicks" on the ammeter needle may be caused by a defective grid battery whose voltage is being sustained by the small grid current. Check the voltage of the battery with any available voltmeter, and replace the battery with a new one if the voltmeter indicates less than 85 per cent of rated voltage.