704C (J86590) POWER PLANT
48 VOLTS
OPERATING METHODS

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1. GENERAL

1.01 The 704C power plant (J86590A, B, and C) is for use with any system requiring 44- to 50-volt positive and negative supply up to 400 amperes. This plant uses 8-, 30-, or 100-ampere regulated rectifiers as the charging medium. The 8- and 30-ampere rectifiers operate from a single phase, 210- to 250-volt, 60-Hertz, commercial ac power service. The 100-ampere rectifiers operate from a 3-phase, 60-Hertz, 210-volt ac power service, and with an additional autotransformer provided, also operate from 230-, 250-, or 460-volt ac service.

1.02 This section is reissued to add information on the KS-20493 rectifier. The Equipment Test List is not affected.

Warning: Voltages inside the rectifier cases are over 150 volts to ground and between terminals. The precautions outlined in the operating sections on the rectifiers should be observed.

1.03 The J86590A plant is used to furnish a negative supply of 48 volts within the range of 8 to 120 amperes. The J86590B plant is used to furnish a positive supply of 48 volts within the range of 8 to 120 amperes. Whenever the negative capacity exceeds 8 amperes, both negative and positive supplies are provided. These two plants may use various types of rectifiers, each equipped with wiring options for charging either a positive or negative grounded battery. The J86207S, 30-ampere rectifiers employ the use of electron tubes, except where they have been modified for metallic rectifier stacks. The J86263A, 30-ampere rectifiers are furnished with metallic rectifier stacks. The type of regulation used for these rectifiers is termed booster control, which involves equipment for changing the plate voltage of the rectifier tubes or the voltage applied to the rectifying element. This equipment consists of a motor-driven, continuously tapped autotransformer and an insulating booster transformer. Operation of the motor-driven autotransformer, by manual or automatic control, raises or lowers the plate voltage or rectifying element voltage and controls the output of the rectifier. ▶The KS-20493 L21 and L22 ferroresonant type rectifier has been added to the 704C power plant. The rectifier utilizes back-to-back thyristors and a KS-20618 regulator to electronically control a ferroresonant transformer for control of the output voltage. The output voltage is protected by the external charge fuse (external to the rectifier), and by the current limit feature.◀

1.04 The semiconductor-type rectifiers also used in the J86590A and J86590B plants consist essentially of transformers (with taps for line compensation) connected to a single-phase, full-wave bridge for the J87233A, 30-ampere rectifier or connected to a 3-phase, full-wave bridge for the J87223C and J87223D, 100-ampere rectifiers. The rectified voltage is blocked by PNPN semiconductor devices in either the positive or negative output load, providing a positive or negative supply. The PNPN devices are fired by a blocking oscillator, which in turn is controlled by a transistor error

detector. The error detector senses voltage differences and provides automatic regulation of the voltage and current. The current is filtered by inductors and then supplied to the load.

1.05 The J86590C plant is used to furnish a positive supply of 48 volts within the range of 0 to 8 amperes. It is unique in that it does not use a charge control circuit, and no provision is made to charge the batteries. A J86207J regulated tube rectifier is used to float the batteries. Countercells are used to maintain the discharge bus voltage within limits. If a negative supply of 48 volts within the range of 0 to 8 amperes is required, the J86583 (704B) plant is used.

1.06 The J86590A and J86590B plants are designed to use from one to four rectifiers. Rectifier capacity, in excess of that required to supply the load, should be available to charge the battery. The plant control automatically connects or disconnects rectifiers as the load conditions require. When the first rectifier is shut off for any reason, the second rectifier, unless already in use, automatically starts and takes the load up to its capacity. Rectifiers 3 and 4 will act in a similar manner. The battery equipment for each plant consists of 24 cells in series together with one countercell. This countercell is cut into or out of the circuit automatically. Some plants have two additional countercells switched in a single step by manual operation of the GR2 switch. Provision is made to hold the voltage automatically at the charging value as long as the CHG-FLOAT key is in the CHG position.

1.07 Some of these power plants are arranged to furnish 44- to 52-volt as well as 44- to 50-volt supply (52 volts instead of 50 volts at the discharge bus bar). In these plants, resistance has been added in series with the voltage relay coil and a 50-52 VOLT key provided to cut in or short-out the resistance. A lamp is provided which lights when the switch is in the 50-VOLT position for testing or other purposes. With the key in the 52-VOLT position, the voltage relay permits the discharge voltage to increase to 52 volts. If the plant is set for regular operation at 50 volts, the lamp is removed from its socket. Operation of the CHG-FLOAT key is not affected by the position of the 50-52 VOLT key.

1.08 Major alarms are provided to indicate discharge fuse failure, high or low discharge voltage, and voltage unbalance. Minor alarms are provided to indicate rectifier failures and regulator failure. Each audible alarm is accompanied by a visual alarm lamp. Also, a key is provided to silence the audible alarm when the alarm is due to regulator failure.

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

SD-80606-02, Issue 12, J86207J Regulated Tube Rectifier

SD-80714-01, Issue 21, J86207S Regulated Tube Rectifier

SD-80722-01, Issue 23, 100- and 700-Type Plants Charging Circuits

SD-80722-02, Issue 22, Charge Circuit

SD-80774-01, Issue 11, Discharge Circuit

SD-80775-01, Issue 3, Alarm Circuit

SD-81180-01, Issue 14, J86263A Metallic-Type Rectifier

SD-81543-01, Issue 7, Regulated Rectifier Control Circuit

SD-81597-01, Issue 8, Rectifier Circuit, Semiconductor Type, 30 Amperes, 48 Volts

SD-81756-01, Issue 15, Rectifier Circuit, Semiconductor Type, 100 Amperes, 48 Volts

SD-81760-01, Issue 6, Regulator Circuit

SD-81999-01, Issue 3, Rectifier Circuit, Ferroresonant Type, 100 Amperes, 48 Volts

SD-82030-01, Issue 3, Regulator Circuit

If this section is to be used with equipment or apparatus reflecting later or earlier issue(s) of drawings reference should be made to the SDs and CDs to determine the extent of the changes and the manner in which this section may be affected.

1.10 More detailed 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.

1.11 The KS-19481 L1 grid battery eliminator replaces the KS-7105 grid battery. The output of the KS-19481 L1 is rated at 22.5 volts direct current when the input leads (white) are connected to a 5-volt ac source. The output leads (red and black) are connected with the red lead (+) to (C+) and the black lead (−) to (C−).

1.12 The KS-19481 L2 grid battery eliminator replaces the KS-7889 grid battery in the J86207J rectifier. The output of the KS-19481 L2 is rated at 46.5 volts direct current when the input leads (white) are connected to a 5-volt ac source. The output leads (red and black) are connected with the red lead (+) to (C+) and the black lead (−) to (C−).

1.13 The REG potentiometer should be adjusted for the correct float voltage after placing the KS-19481 grid battery eliminator in service in the power plant.

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

2. LIST OF TOOLS AND TEST APPARATUS

CODE OR SPEC NO.	DESCRIPTION
TOOLS	
—	3-Inch C Screwdriver
TEST APPARATUS	
*KS-14510	Volt-Ohm-Milliammeter
—	Voltmeter, Weston Model 931, Ranges 300/150/75/30
—	Clip, No. 365 Tool (two required per cord for testing)
W1AF	Cord (8-1/2 feet long equipped with two No. 360A Tools)
W1U	Cord (1 foot 8 inches long equipped with one No. 2 test clip and one KS-6280 connecting clip with one No. 108 cord tip)

*A digital multimeter such as the Hickok Model 3420 is a preferable substitute for this meter.

3. OPERATION

3.01 *Starting the J86207S and J86263A Rectifiers*

(1) Operate the regulator REG key to AUTO and the FLOAT-CHG key to the FLOAT position.

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

(3) Operate the rectifier NOR-TST key to the NOR position.

3.02 *Stopping the J86207S and J86263A Rectifiers*

(1) Operate the rectifier NOR-TST key to the TST position.

(2) Slowly reduce the load on the rectifier to zero by operating the rectifier LOWER key, allowing time for other rectifiers to assume the load.

(3) Operate the ON-OFF key to the OFF position. If the rectifier is to be left out of service, remove the ac fuses and the dc charge fuse.

Note: The RAISE and LOWER keys are self-restoring and have effect only while held in position manually. They should only be used when the NOR-TST key is in the TST position.

3.03 *Starting the J87223C and J87223D Rectifiers*

(1) Operate the regulator REG key to the AUTO position and the FLOAT-CHG key to the FLOAT position.

(2) Operate the POWER ON-OFF (S1) switch to the ON position.

(3) If the output voltage of the rectifier is not equal to the battery float requirements, rotate the VOLTS ADJ (R14) potentiometer as required to acquire the nominal operating voltage.

3.04 ***Stopping the J87223C and J87223D Rectifiers:*** Operate the POWER ON-OFF (S1) switch to the OFF position. If the rectifier is to be left out of service, remove the ac fuses and the dc charge fuse.

3.05 ***Starting the J87233A Rectifier***

(1) Operate the regulator REG key to the AUTO position and the FLOAT-CHG key to the FLOAT position.

(2) Operate the OUTPUT (CB1) circuit breaker to the ON position.

(3) If the voltage output of the rectifier is not equal to the battery float requirements, rotate the ADJ VOLTS (R11) potentiometer as required to acquire the normal operating voltage.

3.06 ***Stopping the J87233A Rectifier:*** Operate the OUTPUT (CB1) circuit breaker to the OFF position. If the rectifier is to be left out of service, remove the ac fuses.

3.07 ***Starting the KS-20493 Rectifier***

(1) Depress the POWER ON-POWER OFF (S1) switch.

Requirement: The POWER ON lamp lights.

(2) Loosen the locking device and rotate the OUTPUT VOLTS ADJUST (R8) rheostat cw to increase or ccw to decrease the output voltage of the rectifier until the voltage at the battery (as indicated on the plant voltmeter) is the required value. Tighten the locking device for the OUTPUT VOLTS ADJUST (R8) rheostat being careful not to disturb the setting.

Requirement: The voltage at the battery should meet the voltage values specified for the power plant.

(3) Observe the OUTPUT CURRENT (M1) ammeter to make sure the rectifier accepts its portion of the load.

3.08 ***Stopping the KS-20493 Rectifier***

(1) Depress the POWER ON-POWER OFF (S1) switch.

Requirement: The POWER OFF lamp lights.

(2) If the rectifier is to be left out of service for an extended period of time, remove the ac service fuses, external charge and charge alarm fuses and disconnect the plant control cable.

Warning: All power should be disconnected before attempting maintenance in the power sections of the rectifier. The battery should be disconnected when the rectifier is shut down for extended periods or for maintenance. Be careful not to short circuit the battery or sensing terminals.

3.09 ***Starting a Rectifier After Shutdown***

(1) Replace all ac fuses and the dc charge fuse.

(2) Start the rectifier as outlined in 3.01, 3.03, 3.05, or 3.07.

3.10 ***Equalizing or Boost Charges:*** Periodically, the battery should be given a boost charge. See Section 157-601-701. To obtain boost charge voltage, operate the FLOAT-CHG key to the CHG position and open the countercell switch CEMF GR2, during charge. For adjustment of the regulator for charging voltage, refer to 4.04. After charge, restore the FLOAT-CHG key to the FLOAT position and then restore the discharge circuit to normal by closing the countercell switch, CEMF GR2. If all rectifiers shut down at this point due to voltage above trip value (see 4.06), momentarily operate the REG key to the MAN position and then back to the AUTO position.

3.11 ***Charging Batteries After a Drop Discharge:*** If, during an extended interval with emergency ac power, the emergency reserve engine does not have the capacity to operate sufficient charging units to maintain the battery at float voltage, the battery reserve may become insufficient for starting the plant after a deep discharge to below emergency volt limits. If this is the case, the following procedure should be employed.

(1) After it has been affirmed that the central office equipment is inoperative due to a low battery reserve, ***notify the supervisor and at his direction remove the discharge fuses.*** The removal of the office load generally allows the battery voltage to recover enough to start at least one charging unit.

(2) Using a portable voltmeter, check all of the batteries for a reversal of polarity in accordance with ▶157-601-701.◀ (See note.)

(3) Replace discharge fuses when the plant appears to function normally and all charging units are available.

Note: If one or more cells in a series becomes fully discharged while the remainder of the cells are still discharging, there will be a reversal, that is, a change of polarity on the discharged cells with adverse affects on the plates.

4. ROUTINE CHECKS AND ADJUSTMENTS

4.01 The purpose of routine checks on the plant is to determine whether or not all the features, indications, and alarms are in proper operating condition. Basically, the objective of these checks is to cause all equipment to operate at periodic intervals without intentionally causing drastic or harmful situations. These checks should be made as often as previous experience indicates the need. Routine checks should be made during a period when they will cause the least unfavorable reactions.

ADJUSTMENTS OF VOLTAGE CONTROL EQUIPMENT

4.02 ***Panel Voltmeter Accuracy Check***

(1) Using the 75-volt scale, connect the Weston model 931 voltmeter across the terminals of the panel voltmeter.

(2) Operate the rectifier NOR-TST key to the TST position.

(3) Verify the panel voltmeter for −48 volts battery. Depress the +48V BAT key to verify the +48 volts battery.

(4) Manually adjust the first rectifier output by operating the RAISE or LOWER key until the battery voltage is maintained at 2.17 volts per cell (52 volts).

Note: If necessary, manually adjust additional rectifiers until float voltage is acquired.

(5) If the panel voltmeter is within ±2 percent of its deflection as compared to the Weston model 931 voltmeter, adjust the panel voltmeter by turning the adjusting screw. Place a mask bearing the legend ***zero-correct at 52 volts*** and the date over the adjusting screw.

4.03 ***Float Voltage Adjustment***

(1) Operate the regulator REG key to the MAN position and the FLOAT-CHG key to the FLOAT position.

(2) Operate the rectifier NOR-TST key to the TST position and the ON-OFF key to the ON position.

(3) With the voltage at float voltage (52 volts) as read on the panel voltmeter and maintained at that value by operation of the rectifier RAISE or LOWER keys, rotate the REG rheostat clockwise until the L and R relays on the control panel are released.

(4) Verify that the regulator now maintains float voltage.

(5) If float voltage is not maintained, slowly rotate the REG rheostat clockwise to raise voltage, or counterclockwise to lower voltage. Allow time for the battery voltage to respond until both the L and R relays are released and the battery is at float value. The operation of the L and R relays is indicated by the sound of the operation of the RL and RR relays of the last operating rectifier, providing its output is between 5 and 25 amperes.

(6) Verify that the regulator now maintains float voltage.

(7) Operate the rectifier NOR-TST key to the NOR position.

(8) Operate the regulator REG key to the AUTO position.

Note: If the rectifier is not regulating at proper voltage, check the grid battery or the grid battery eliminator (see 1.11, 1.12, and 1.13).

4.04 ***Charge Voltage Adjustment***

(1) First adjust for float voltage as outlined in 4.03.

(2) Operate the regulator FLOAT-CHG key to the CHG position, then verify that the REG key is in the AUTO position.

(3) Verify that the rectifier NOR-TST key is in the NOR position and that the ON-OFF key is in the ON position.

(4) Rotate the CHG rheostat slowly clockwise. Allow time for the battery voltage to respond until it is at charge voltage (2.2 volts per cell).

(5) Verify that the regulator now maintains charge voltage. Readjust, if required.

(2) Operate the regulator FLOAT-CHG key to the FLOAT position.

REGULATION CONTROL CIRCUIT CHECK

4.05 ***Rectifier Transfer Check:*** There must be at least one operating and one idle rectifier.

(1) Verify that the regulator FLOAT-CHG key is in the FLOAT position and the REG key is in the AUTO position.

(2) Operate the rectifier NOR-TST key to the TST position and the ON-OFF key of the first rectifier is in the ON position.

(3) Using the LOWER key, reduce the output of the first rectifier slowly to zero, allowing time for the next rectifier to assume the load. Where electron tube-type rectifiers are used, there is a 3- to 5-minute delay in starting.

(4) Restore the NOR-TST key to the NOR position. The first rectifier will reclaim the load from the rectifier that started when the first rectifier was shut down.

(5) Repeat (1) through (4) on all successive rectifiers, except the last one.

4.06 ***Regulation Tube Failure Check***

(1) Verify that the regulator FLOAT-CHG key is in the FLOAT position and the REG key is in the AUTO position.

(2) Verify that the rectifier NOR-TST key is in the NOR position and the ON-OFF key is in the ON position.

(3) Adjust the RTF rheostat so that the RTF1 and RTF2 relays operate at trip value in accordance with the circuit requirements tables.

(4) Remove the ***regulator*** electron tube V2. When the discharge circuit voltage reaches trip value, all rectifiers will shut down. The trip value, as read on plant voltmeter, shall be 54 volts as read on the discharge bus bar (−48V DISCHG or +48V DISCHG key operated).

(5) Operate the REG key to the MAN position.

(6) Reinsert the regulator electron tube V2.

(7) Operate the REG key to the AUTO position. The regulator and rectifiers should function and connect to the load in the normal manner.

4.07 ***Power Failure Check***

(1) With the rectifier operating normally, remove the regulator ac fuses. All rectifiers will stop and the TR autotransformer brushes should move to the minimum voltage position. The C1 contactor in the first rectifier will reoperate but there will be no output.

(2) Replace the regulator ac fuses. The regulator and rectifiers should function and connect to the load in the normal manner.

4.08 ***Rectifier Electron Tube Failure***

(1) With the rectifier operating normally, insulate the bottom contacts 6-7 of the G relay.

(2) Manually operate the TF relay. The TF relay will lock operated, operate the G relay, and the rectifier will shut down.

(3) Operate the rectifier ON-OFF key to the OFF position, then to the ON position. The TF relay will release and the rectifier will start

and assume the load after a delay of 3 to 5 minutes.

(4) Remove the insulation from the contacts of the G relay.

ALARMS

4.09 ***Regulator Failure Alarm:*** To check the regulator failure alarm, block relay VA2 in the alarm circuit operated. This should cause a minor alarm to sound and the REG FAIL lamp to light. Operation of the REG FAIL ACO key should silence the audible alarm but the REG FAIL lamp will remain lighted. Remove block from relay VA2 when test is completed.

4.10 ***Discharge Fuse Failure Alarm:*** The positive and negative discharge fuse failure alarms can be tested by applying test battery (48 volts) with a W1AF test cord to the alarm bars of the positive and negative discharge fuses, respectively. The PDF and NDF relays, respectively, will operate and cause a major alarm to sound. The FA lamp will also light. Remove test battery after test.

> ***Note:*** When testing a positive DISCHG fuse alarm, use positive test potential of the same value as the plant. For instance, when testing the alarm for a +48 volt DISCHG fuse, connect one end of the W1AF test cord to +48 volts and touch the other end of the test cord to the alarm stud. The procedure on negative plants would be similar, that is, a negative test potential would be used to test alarms on negative plants.

4.11 ***Rectifier Failure Alarm:*** The rectifier failure alarm can be tested by applying test voltage (48 volts) to terminal 4 of each J86207S or J86263A rectifier terminal strip with a test clip, leaving time between the test on each rectifier for the unit to return to its operating position in the sequence. Applying the test voltage to terminal 4 of a rectifier will operate the corresponding G relay, turn off the rectifier under test and operate relay ±RFA, which will cause the RFA lamp to light and cause the office alarms to sound. See note in 4.10 for explanation of test voltage.

4.12 ***High-Low Voltage Alarm:*** To test the positive and negative high-voltage alarms use a W1U test cord to strap the center (C) terminal of voltage relay ±VR to either its high (H) or low (L) terminal. The countercell control circuit will function to add or remove countercells in a manner to correct the simulated fault. Also the HLV relay in the alarm circuit will function to bring in a major alarm and light the HLV lamp. Perform the test on both the +VR and −VR voltage relays. Remove strap from relay when test is complete.

4.13 ***Voltage Unbalance Alarm:*** Plants, using a J86207J rectifier for the positive supply, are provided with a voltage unbalance alarm. To test this alarm, use a W1U test cord to strap the center terminal (C) of UVR relay to either its high (H) or low (L) terminal. The A2 relay in the alarm circuit will operate, causing a major alarm to sound and the UNBAL VA lamp to light. Remove strap when test is complete.

5. TROUBLES

> ***Caution: If the charge circuit is opened for maintenance, connection of an energized lead to the rectifier charge fuse should not be attempted. The charge circuit should have its final connection made at the 233C retardation coil.***

5.01 If the rectifier is not regulating at proper voltage and whenever new grid battery or regulator tube is installed, reset the regulator as outlined in 4.03.

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

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

5.04 KS-5563 rheostats are totally enclosed. If they become defective in any respect, they should be replaced.

5.05 When a rectifier alarm is given, locate the rectifier in trouble. Its output will be zero and its associated G relay will be operated. Check the ac, CHG, and control fuses. On the J86207S rectifier, also check RG fuse. Replace if blown. If fuses are not blown and the alarm still operates, check the rectifier in accordance with its operating section.

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

5.07 If any rectifier does not seem to be carrying the load it should, operate its TEST key to the TEST position and attempt to change the output with RAISE and LOWER keys. Failure to respond could indicate that one or both rectifier tubes are defective, or that there is a rectifier element failure, ac power failure, blown ac fuse, blown rectifier charge fuse, poorly adjusted relays, possibly RR or RL, or faulty motor capacitor (E on rectifier). Incorrect position of keys would prevent a rectifier from assuming its load.

5.08 If all rectifiers show no load, proceed as follows.

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

(b) If the 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.

5.09 Checks of the vacuum tubes in the regulator can be made with any available tube tester.

TROUBLE CHART

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

TROUBLE	POSSIBLE CAUSE
(a) No voltage or current	AC supply interrupted (no voltage or ac fuse blown).
	Failure of rectifier tube (V1 or V2 on rectifier).
	Failure of rectifier stack RV1, RV2, RV3, or RV4.
(b) AC input fuse blown	Defective rectifier tube (V1 or V2 on rectifier).
	Defective rectifier stack RV1, RV2, RV3, or RV4.
(c) Low dc voltage	Failure of one rectifier tube (V1 or V2 on rectifier).
	Failure of one rectifier stack RV1, RV2, RV3, or RV4.
	Rectifier overloaded.
	Grid battery aged or KS-19481 grid battery eliminator defective.
	Failure of any relay in starting chain such as AR, OC, ST, VRC, DS.
(d) Limit switch operated	AC line voltage too high or too low.
	Charge fuse blown.
	Load too high.
	Failure of a vacuum tube (V1 or V2 in regulator).

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