410A AUTOMATIC POWER PLANT
OPERATING METHODS

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1. GENERAL

1.01 This section covers the operation of the 410A automatic power plant (J86584) which provides a 130-volt supply for loads from 1 to 25 amperes for plate supply and grounded telegraph applications with provision for increasing the capacity of some plants to 40 amperes. Regulated tube rectifiers (J86240A and J86207C), constant-current metallic rectifiers (J86266), regulated rectifier-inverters (J86425A), 10-ampere SCR rectifiers (J87228), 30-ampere SCR rectifiers (J87229), or a combination of these are used for charging batteries from a 190- to 265-volt ac power source. The plant maintains fuse panel voltage limits of 125 to 135 volts.

Caution 1: Voltages inside the rectifier or rectifier-inverter cases are over 150 volts to ground and between terminals; precautions outlined in the operating sections on the respective equipments should be observed.

Caution 2: When checking any circuits in this plant which contain electrolytic capacitors, refer to Section 032-110-501.

1.02 This section is reissued to add references to the 10-ampere rectifier (J87228) and the 30-ampere rectifier (J87229), and to bring the section up to date. This reissue does affect the Equipment Test List.

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-80942-01	410A Discharge Circuit
SD-80943-01	410A Charge Circuit
SD-80948-01	Type L Carrier Power Control Circuit
SD-80949-01	Rectifier-Inverter Circuit
SD-80620-01	Rectifier J86207C
SD-80620-02	Rectifier J86207C
SD-80620-03	Rectifier J86207C
SD-81076-01	Rectifier J86240A
SD-81302-01	Rectifier J86266
SD-81576-01	Rectifier J87228
SD-81584-01	Rectifier J87229

1.04 The 410A plant provides a 130-volt dc supply for loads from 1 to 25 amperes normally or may be equipped with additional rectifiers to supply up to 40 amperes. Regulated tube-type rectifiers, metallic-type constant-current rectifiers, rectifier-inverters, and 10- and 30-ampere SCR rectifiers are used to float the load and charge a 66- or 70-cell battery. Tube-type rectifiers and rectifier-inverters are automatically started and stopped, as required by the load, maintaining the battery at float voltage during normal operation. The SCR rectifiers are started and stopped manually.

They are adjusted for float voltage and will decrease output before any of the regular rectifiers which have been locked on constant current. Metallic-type rectifiers, which are placed in operation manually, provide constant current for 66-cell battery plants and are shut down if the plant goes to high voltage. The discharge voltage is maintained at 125 to 135 volts by means of automatically controlled countercell or resistor groups. A voltmeter with a key provides means for observing either the battery or the fuse panel load voltage.

1.05 ***Rectifier charging equipment (J86207C and J86240A rectifiers),*** together with the control equipment, is arranged so that as the load increases, each rectifier in turn regulates the voltage until its output reaches about 9 amperes. It then transfers to current regulation and its output is held at 8 amperes, voltage control being passed to the next succeeding rectifier. As the load decreases, the rectifiers ultimately raise the battery voltage and cause the high contacts of VR2 voltage relay to close. If all rectifiers are on current control, this will cause the last rectifier to transfer back to voltage control, or if the last rectifier was on voltage control, will cause the last rectifier to stop and the last preceding rectifier to transfer from current to voltage control. This will continue each time the high-voltage contacts close until only enough rectifiers are in operation to float the load. If any rectifier is turned off, the control functions as though the rectifier were not in the chain. If a rectifier on voltage control fails, it cannot start the next rectifier in the usual way. When the battery voltage reaches the lower limit, all available rectifiers will be started and an alarm given. When the rectifier which failed is again put into service, it may be necessary to force it to current regulation by turning the succeeding rectifiers off manually, and then restoring them to service in sequence to ensure that only the last one required is on voltage regulation. Failure of the last rectifier will be indicated only by a low-voltage alarm.

1.06 ***The 10- and 30-ampere J87228 and J87229 rectifiers*** may be used in place of the regulated tube rectifiers to increase plant load capacity. These rectifiers are connected directly to the battery bus. Controlling operations are provided by apparatus in the rectifiers with turnon and turnoff being done manually. Provisions are provided for parallel operations of the 10- and 30-ampere rectifiers. Since they are adjusted for float voltage, they will decrease output before any of the regular rectifiers which have locked on constant current. They shut down automatically on a high rectifier current fuse failure and on an external signal of high battery voltage with some rectifier current. The rectifiers are automatically limited to about 10 and 30 amperes, respectively. Although equal load sharing is not a requirement, the ideal voltage adjustment is obtained by some degree of load sharing between the new rectifiers and the voltage regulating old rectifier at float voltage.

1.07 ***Rectifier-inverters*** are used as the first charging units when the 410A plant supplies power for some Type L Carrier Telephone Systems and are all kept in operation during normal conditions. ***When one rectifier-inverter*** is used alone or with rectifiers, it operates exactly the same as a rectifier would for the first charging unit, holding the voltage closely regulated until its output becomes about 9 amperes; it then transfers to current control at about 8 amperes output and causes the starting of a rectifier, if provided. Additional rectifiers, if provided, are started and stopped when rectifiers only are used. The rectifier-inverter also transfers back to voltage control, when the battery voltage reaches the upper limit of VR2 relay and all rectifiers, if provided, have shut down. During power failure, the rectifier-inverters supply ac power to the Type L Carrier System.

1.08 ***When two rectifier-inverters*** are used with rectifiers, they are the first and second units, the first being a voltage regulating unit as in the case of one rectifier-inverter, and the second being a current regulating unit adjusted to have a high enough output to prevent a high-voltage alarm under normal battery float conditions. This may require the use of dummy load resistors, D1, D2, etc, across the battery charging leads in the inverters. If the first rectifier-inverter transfers to current regulation, it starts a rectifier, and so on as load increases. If the rectifiers are not able to keep the battery voltage above the low limit of VR2 voltage relay, the second rectifier-inverter will be changed from its normal current adjustment to maximum current. When the high limit of VR2 is reached with decreasing load, it transfers the second rectifier-inverter back to low or normal current regulation and then cuts off the rectifiers in order as before. If the first rectifier-inverter is turned off temporarily, the second rectifier-inverter

becomes the voltage regulating unit in place of the first.

1.09 ***When more than two rectifier-inverters*** are used with rectifiers, the third and fourth units are connected and adjusted for low-current regulation, but are changed to high-current regulation in succession as the load causes the battery voltage to drop to the low limit of VR2 relay after all rectifiers are operating. As the load decreases and the battery voltage reaches the high limit of VR2, the rectifier-inverters are returned to their normal condition of low-current regulation, one at a time beginning with the last unit; then the rectifiers are stopped in turn. If any rectifier-inverter is turned off, the control bypasses that unit as though it were not in the chain.

1.10 ***Metallic-type constant-current rectifiers*** (J86266) can be used with tube-type and SCR rectifiers and rectifier-inverters to float the load and charge the plant battery. These rectifiers are brought into operation manually. When in operation, they provide a selected constant current between 16 and 24 amperes. The regular 410A control circuit will not vary the output of this rectifier. Load variations must be taken up by operating the J86207C, J86240, J87228, or J87229 rectifier. It is recommended that only one J86266 rectifier be used and that the busy hour load not exceed 40 amperes.

1.11 ***Countercell or resistor groups*** are used to oppose the battery voltage and maintain the discharge voltage between 125 and 135 volts. The countercells or resistors are automatically controlled and are arranged in two or three groups, one or more groups being normally in the circuit. During power failure and battery discharge, the groups are successively short-circuited as the battery voltage decreases and, during charging, are successively put into the discharge circuit as the battery voltage increases. Equipment additions which increase the load raise the voltage drop across a resistor group, thereby making a readjustment of the resistor strapping necessary. Adjustments in resistor strapping may be made for fixed loads or for partially variable loads with the variable load less than 10 percent of the fixed load within different ampere ranges up to full capacity. See 3.06.

1.12 ***To charge the battery,*** the CHG-NOR key is operated to the CHG position. This changes the voltage regulation adjustment of all rectifiers to the charge voltage and the voltage range of VR2 voltage relay to the higher or charging range. This will usually cause all rectifiers to go in succession to current control until the battery is raised to the charging voltage. When this occurs, the last rectifier will be returned to voltage control at the charging voltage limits which should prevent alarms. When charging is completed, the key is returned to the NOR position to restore the charging voltage to the float value. Operation of the key to either position, with the resulting voltage limit changes, may cause a momentary alarm.

1.13 ***Alarms*** have been provided to indicate power failure, high or low battery voltage during normal operation or charging, failure of a rectifier or rectifier-inverter, high or low fuse panel voltage, blown fuses, and, in plants for both positive and negative battery, an unbalance when the difference between the two battery voltages is more than 5 volts.

1.14 ***Load distribution*** provides for division of the load over at least two discharge fuses. A filter permits a common plate and positive telegraph supply.

1.15 Additional information on the operation and maintenance of individual pieces of apparatus, such as instruments, keys, relays, and switches, is given in other sections and the attendant should be familiar with them. All relays, etc, should be adjusted in accordance with these sections and the circuit requirement tables on the circuit drawings.

2. LIST OF TEST APPARATUS

CODE OR SPEC NO.	DESCRIPTION
TEST APPARATUS	
716A	Receiver
2W17A	Cord
—	35-Type Test Set

3. OPERATION

Preparing to Start

3.01 When preparing to put the plant in service, check that:

(a) All fuses are the proper size and type and are in place.

(b) The CHG-NOR key is in the NOR position.

(c) All voltage relay links are closed.

(d) Rectifier adjustments have been made in accordance with the appropriate Bell System Practices.

Starting and Stopping

3.02 Start and stop all rectifier-inverters and power control equipment as outlined in the operating section on rectifier-inverters.

3.03 Start and stop the rectifiers in accordance with the operating section on the rectifiers.

Note: The plant as a whole, once started, remains in operation continuously. Starting and stopping of individual rectifiers or rectifier-inverters for correction of troubles or routine maintenance is done manually. These operations are given in the operating sections of the respective units.

Adjustments

3.04 With the CHG-NOR key in the NOR position, adjust the float voltage in accordance with Section 157-601-301. The charging voltage should be adjusted to 150 volts for 66-cell battery plants where three groups of resistors or countercells are furnished; to 145 volts for 66-cell battery plants where two groups of resistors or countercells are furnished, and to 154 volts for 70-cell battery plants.

3.05 All rectifier-inverters required to provide the alternating current for the office under power failure conditions must be kept operating as rectifiers during normal conditons. If only one rectifier-inverter is provided, other charging units should be adjusted so that the rectifier-inverter gives a minimum of 2 amperes on voltage control with minimum office load. When there is more than one rectifier-inverter on a battery, the sum of low-current adjustments of all rectifier-inverters, except the first, should equal the minimum load minus 2 amperes, the first rectifier-inverter giving the 2 amperes on voltage control. For example, with three rectifier-inverters and a minimum load of 12 amperes, 130VG2 and 130VG3 should be adjusted to carry 5 amperes each on low-current control, leaving 2 amperes for 130VG1 on voltage control. Under some conditions, the minimum output of all rectifier-inverters which will not bring in a failure alarm may exceed the minimum office load, so that it will be necessary to connect the dummy load furnished with each rectifier-inverter to keep all rectifier-inverters operating without excessive battery charging.

3.06 Where resistor groups are provided, adjust for loads within different ranges up to full capacity by strapping the resistors in accordance with the table in SD-80942-01 appropriate to the particular option furnished.

4. ROUTINE CHECKS

4.01 Check the float voltage of the battery and readjust if necessary.

4.02 Observe electrolyte level in battery cells and countercells to make sure it has not dropped to the low level line.

4.03 Turn off one or more of the first charging units, if necessary, to make sure the condition of all the control equipment and rectifiers is satisfactory, and that the rectifiers can be expected to start and operate correctly, if required. If the SCR rectifiers (J87228 and J87229) are used, the load may be shifted to them by momentarily turning off the old rectifiers from the high numbered end of the sequence. Be sure to turn on again any units taken out of service temporarily for this test.

4.04 Change the rectifier operating on voltage control to manual control and purposely reduce the output as though the rectifier had failed in service. If the SCR rectifiers are used in the G0 position, it may be necessary to turn them off. When the battery voltage drops to the low limit (see circuit requirement table for VR2 relay adjustment) a low-voltage alarm should come in and the remaining rectifiers should start to correct the low-voltage condition of the battery. If the

load on the regulating rectifier was low, it may be necessary to change the last rectifier on current control to manual to let the battery voltage drop to the low limit. Be sure to turn on again any units taken out of service and restore them to automatic control.

4.05 Put the CHG-NOR key in the CHG position. This will usually cause all the rectifiers to go to current control until the battery voltage reaches the upper limit of the charging range of VR2 (see circuit requirement table). Observe that the operation of the countercell or resistor control keeps the discharge voltage within the normal limits (125 to 135 volts) as the battery voltage rises.

4.06 In offices where power failures are infrequent, the operation of the automatic control for the countercell or resistor groups should be checked occasionally under simulated power failure conditions. Reduce the output of enough rectifiers or rectifier-inverters under manual control to allow the battery voltage to decrease to 135 volts. As the discharge voltage drops, the automatic control will short-out one group of countercells or resistors (see circuit requirement table for VR1 relay adjustment). With 135 volts at the battery, one group will still be in the circuit. To make sure that this group would be shorted under extended power failure, open the VR1 voltage relay switch. After the test, the switch should be closed and the charging units returned to normal operation. Observe that the countercell or resistor groups are cut in the circuit again to maintain the discharge voltage within the 125- to 135-volt limit. During the above checks, also check that the discharge voltage does not change more than 8 volts when a countercell or resistor group is added or removed. High-voltage drop across a resistor group indicates improper strapping. High-voltage drop across a countercell group indicates that the electrolyte needs renewing.

> ***Note:*** In offices provided with an emergency source of ac power, these checks could be coordinated, if convenient, with a routine test of the emergency alternator at a time when the office load is being transferred from the regular to the emergency supply.

Fuse Alarm

4.07 Check the FA fuse failure alarm periodically. To check this alarm, connect battery through a receiver to the alarm bus bar associated with the PABS bus bar. The FA lamps should light, and be extinguished when the battery is removed.

Rectifier and Rectifier-Inverter Failure Alarms

4.08 Check the rectifier and rectifier-inverter failure alarms (RECT FAIL or R-I FAIL) periodically. Check the rectifier failure alarm when rectifiers 1 and 2 are operating. To check the RECT FAIL alarm, manually release the RA relay in the first rectifier. The RECT FAIL lamp should light while the relay is held released, and be extinguished when the relay is operated. To check the R-I FAIL alarm, manually release the AL2 relay in the rectifier-inverter. The R-I FAIL lamp should light while the relay is held released, and should be extinguished when the relay is operated.

Voltage Control Alarms

4.09 To check each voltage alarm circuit proceed as follows. Using the No. 2W17A cord, connect the T and R terminals of the 35-type test set across the link switch associated with the voltage relay in the alarm circuit being tested, connecting the R terminal to the positive side of the link switch. When testing for a high-voltage condition, connect dry cells to terminals BAT and GRD of the test set, as required, connecting the positive terminal of the dry cells to the GRD terminal of the test set. Locking levers of keys No. 1 through 4 of the test set should be open, and all the resistance sliders should be in their extreme right positions. Connect an external voltmeter across the terminals of the voltmeter relay under test to check the accuracy of the voltmeter relay.

4.10 Close the locking lever of the No. 3 key and move the No. 3 resistor sliders to their extreme left position. Set the other test keys as follows:

KEY	POSITION
BAT & GRD CO	Operated
REV	Normal

SWITCH	POSITION
G	Open

Close all knife switches in the test set to cut out all fixed resistance. Under this condition the test set has its least resistance and the dry cell battery is out of the circuit.

4.11 Cut the test set into the alarm circuit by opening the switch associated with the voltage relay. Care should be taken not to open the circuit through the voltage relay or to change the current flow in such a way as to cause any violent operation of the relay as this might prevent a case of contact trouble being detected.

4.12 Gradually move the No. 3 sliders to the right, thus introducing resistance and lowering the voltage across the voltage relay. Check that at the approximate point where the low-voltage alarm should come in (see circuit requirement table), the audible and visual signals operate. (If the low contact has not closed when both No. 3 sliders have reached their extreme right position, slide them fully back to the left. Then by means of the No. 3 knife switches, cut in 25,000 ohms and again gradually move the sliders to the right.)

4.13 Move the No. 3 sliders to their extreme right positions. From the reading of the external voltmeter, determine whether the voltage has been reduced sufficiently to permit the introduction of the test battery without causing the high contact to make. Estimate the test battery voltage on the basis of 1-1/2 volts per cell. (If the voltage has not been reduced sufficiently by means of the No. 3 switches, cut in additional resistance as required to obtain the necessary reduction in voltage.) Then restore the BAT & GRD CO key and raise the voltage gradually by moving the No. 3 sliders toward the left to remove resistance from the circuit. Check that at the approximate point where the high-voltage alarm should come in (see circuit requirement table), the audible and visual signals operate.

Float Voltage Alarm

4.14 Check the low and high contacts of the VR2 relay by following the procedures covered in 4.09 through 4.13. When either the high or low contacts are operated, the FLOAT ALM lamp should light and the minor alarm should sound. The FLOAT ALM lamp can be extinguished by operation of the VOLT ACO key.

High-Low Voltage Alarm

4.15 Check the low and high contacts of the VR1 relay by following the procedures covered in 4.09 through 4.13. When either the high or low contacts are closed, the H-L VOLT ALM lamp should light and the major alarm should sound. The H-L VOLT ALM lamp will be extinguished when the high- or low-voltage condition is removed.

Unbalanced Voltage Alarm

4.16 In plants with both positive and negative batteries, check that the UBV relay operates when the difference between the two discharge voltages exceeds 5 volts. Decrease the voltage of one battery supply by introducing resistance as described in 4.12. When the UBV relay operates, the UNBAL VOLT lamp should light and the major alarm should sound. The UNBAL VOLT lamp can be extinguished by operation of the VOLT ACO key. Operation of this key causes the UNBAL GD lamp to light. The UNBAL GD lamp will be extinguished when the unbalanced voltage condition is removed.

4.17 When the tests described above have been completed, in each case close the switch associated with the voltage relay in the circuit under test before disconnecting the 35-type test set.

5. TROUBLES AND ALARMS

5.01 Plant troubles listed are those in connection with the control which automatically connects or disconnects units of charging equipment and the control which automatically cuts countercell or resistor groups in or out of the discharge circuit. Troubles in rectifiers or rectifier-inverters are covered in their respective operating sections.

5.02 The following table shows the alarm lamps in alphabetical order and their function.

LAMP	FUNCTION
FA	Indicates blown fuse.
FLOAT ALM	Indicates high or low battery voltage.
H-L VOLT ALM	Indicates high or low discharge voltage.
R-I FAIL	Indicates rectifier-inverter failure.
RC	Indicates that rectifier is operating under current control when lighted, and under voltage control when unlighted.
RECT FAIL	Indicates rectifier failure.
RECT GD	Indicates that the RECT FAIL lamp has been extinguished by means of the RECT ACO key.
UNBAL GD	Indicates that the UNBAL VOLT lamp has been extinguished by means of the VOLT ACO key.
UNBAL VOLT	Indicates that the difference between battery voltages in plants with both positive and negative battery is greater than 5 volts.

5.03 The following table lists troubles and possible causes.

TROUBLE	POSSIBLE CAUSE
Battery voltage low	Power failure.
	Voltage-regulating charger out of adjustment.
	Failure of voltage-regulating charger and VR2 out of adjustment or failing to close low contact.
Battery voltage high	CHG-NOR key in CHG position.
	Regulating charger out of adjustment.
	VR2 out of adjustment or failing to close high contact.
Discharge fuse panel voltage low	VR1 out of adjustment or failing to close low contacts.
	Failure of automatic control for countercells or resistor groups.
	Where resistor groups are provided, resistor incorrectly strapped.
	Low battery voltage.
Discharge fuse panel voltage high	VR1 out of adjustment or failing to close high contacts.
Fuse panel voltage high	Failure of automatic control for countercells or resistor groups.
	Where resistor groups are provided, resistors incorrectly strapped.
Unbalanced voltages of positive and negative telegraph batteries	Positive VR1 or negative VR1 not correctly adjusted.
	Positive or negative regulating charger out of adjustment.
Plate supply noisy	One or more capacitors or their fuses open.
	Capacitors aged.