

**702C POWER PLANT
ARRANGED FOR AUTOMATIC START CONTROL
OPERATING METHODS**

	PAGE		PAGE
1. GENERAL	1	VOLTAGE REGULATED AND G-ZERO RECTIFIER ALARMS	23
2. LIST OF TOOLS AND TEST APPARATUS	5	ALARM MULTIPLE	23
3. OPERATION	6	5. TROUBLES	23
AUTOMATIC OPERATION	6		
REMOVING CHARGING UNIT FROM OR RESTORING TO SERVICE	6	1. GENERAL	
MANUAL OPERATION	8	1.01 The 702C power plant provides 130-volt power for toll and telegraph systems requiring from 25 to 1000 amperes for the positive polarity load and 5 to 1000 amperes for the negative polarity load. The plant includes charging equipment and its control, batteries and emergency cells with their control, distribution equipment, and alarms. The charging equipment in older plants usually consists of motor-generator sets ranging in capacity from 25 to 300 amperes and/or current-regulated rectifiers of 100- and 300-ampere capacity, the exception being the use of rectifiers of 8-ampere capacity where the negative load is less than 25 amperes, as covered in 1.05. In some modernized plants, G-zero voltage-regulated rectifiers are used in conjunction with motor-generator sets and or current-regulated rectifiers as the source of charging power. In standard plants, all charging power is supplied by continuously operating voltage-regulated rectifiers. The control equipment provides for automatic starting and regulation of the sets or rectifiers, automatic control of the emergency cells, and, if provided, the counter cells. Some of the older plants require manual switching of the emergency and counter cells.	
BOOST CHARGING BATTERIES	9	1.02 This section is reissued to add reference to an alarm cut-off option for the emergency switch off-normal alarm; to add reference to the KS-20019, 12 solid-state silicon CEMF cells; to add reference to two new rectifiers that yield a gradual increase in output current when the rectifiers are turned on; to add notes stating that the plant must be under manual control when testing the	
RECHARGING AFTER POWER FAILURE	10		
OPERATION OF EMERGENCY CELL SWITCHES DURING POWER FAILURE	13		
DISCHARGE FUSE REPLACEMENT	14		
4. ROUTINE TESTS	14		
GENERAL	14		
GENERATORS	14		
GENERATORS AND RECTIFIERS	17		
VOLTAGE ADJUSTMENTS	18		
FUSES AND ALARMS	18		
CHARGING UNIT FAILURE ALARM	21		
VOLTAGE CONTROL ALARMS	21		
VOLTAGE CONTROLLER (FLOAT ALARM)	22		
130V HL OR EM CELL SW LAMP	23		
COUNTERCELL VOLTAGE CONTROL ALARMS	23		

CB, CC, and OL relays; to add reference to the OLS relay in the OL relay tests; to add reference to the KS-20522 Controller; and to change the CHG(Gen) 1/4 A fuse alarm indication in Table B. The Equipment Test List is not affected.

Warning: *This power plant includes automatically controlled equipment; care must be exercised to prevent accidental starting of parts of the plant on which maintenance is to be done. Before starting work, prevent automatic starting of equipment by removing fuses, blocking relays, opening switches, etc, as necessary. When maintenance has been completed, make sure that the circuit has been restored to normal.*

1.03 Types of 702C Power Plants

(a) In older plants, one motor-generator or rectifier for each positive or negative battery operates continuously and others are started and stopped automatically, as required, to maintain the battery voltage and carry the discharge circuit load. A voltage controller is used to furnish raise and lower signals to the charging units to carry the office load and to float the storage batteries. Additional charging units are automatically started and connected in service when the load increases to the point where the unit(s) in service are fully loaded. As the load decreases, the charging units no longer required are automatically disconnected from service.

(b) In modified plants using 100-ampere G-zero voltage-regulated rectifiers in addition to regular charging units, the first added rectifier is used to initiate the raise and lower signals required for control of the existing regular charging units. Should this rectifier fail, the plant automatically reverts back to the existing voltage controller for raise and lower signals. A control panel is required with the first regulated rectifier and is located in the first bay. The second added rectifier, in addition to normally supplying a share of office load, may be used to provide a voltage-regulated charge-by-load feature when recharge of emergency cells is required.

(c) In an all-voltage-regulated rectifier plant, the continuously operating charging units are

adjusted individually to maintain the storage batteries at float voltage. A rectifier control panel and equalizing or load sharing features are not required. Normally, two to twelve 100-ampere voltage-regulated rectifiers are furnished. Boost charging may be accomplished manually by turning the FLOAT-CHG key to the CHG position, which causes all rectifiers to regulate the main battery at approximately 2.2 volts per cell. Each rectifier has an associated battery switch with F and EC positions to switch the output of the rectifier from the main battery (F) to the main battery in series with series or parallel groups of emergency cells (EC) for high rate charge by load, or to unload emergency cells during overload. The first regulated rectifier is equipped to provide a regulated charge-by-load feature for lower rate recharge of emergency cells.

1.04 The battery for each polarity, except as covered in 1.05, consists of a string of 61 main cells with two 4-cell groups of emergency cells and, if provided, one 3-cell group of counter cells. When the battery size requires it, two or more additional strings of cells may be permanently connected in parallel. The emergency cells and counter cells are switched into or out of the discharge circuit, by manual or automatic means, to maintain the discharge voltage within proper limits during emergency and overcharge periods. The emergency cells are continuously floated in older plants by a manually controlled rectifier. A regulated rectifier is used on newer plants and may be added to older plants.

1.05 In older plants where the ultimate negative load is less than 25 amperes, 8-ampere rectifiers are used for charging and floating a 66- or 70-cell battery. The rectifiers are automatically regulated and connected to or disconnected from the battery as the load varies. Three groups of three counter cells are cut into or out of the discharge circuit under automatic control to maintain the voltage within the 125- to 135-volt limits during normal operation and power failure conditions.

1.06 The main control board (J86326A or B) mounts the various voltage, control, and alarm relays required for the operation of the plant. A simplified J86326C main control board is required for plants using only voltage-regulated rectifiers as charging units and for trickle charging of emergency cells. This requires use of related options in the associated J86325 battery control board.

1.07 Alarms are provided to indicate abnormal float voltage, high or low voltage, voltage unbalance between positive and negative plants, failure of a charging unit, and fuse failure. Since the main control board will be located in the power room away from other office equipment provisions are made for interconnecting the alarms to either the power audible alarm circuit or the office alarm system. Therefore, when a power alarm operates, an audible and visual alarm is indicated in other locations in the building.

1.08 In addition to the rectifier modifications, the following features have been incorporated in the equipment.

(a) A shutdown feature has been added for raise-lower charge units. In the event of a REG fuse failure in the battery control circuit, all motor-generator sets and/or raise-lower rectifiers are automatically shut down and a major alarm sounds.

(b) An emergency switch OFF-NOR alarm circuit has been added in the dc power alarm circuit to light a lamp indicating emergency cell usage. When the switch is in the OFF position, a minor alarm sounds.

Note: ♦An alarm cut-off option has been added for the emergency switch off-normal alarm.♦

(c) When the EMC switch is in the NOR position, a high discharge voltage provides a ground signal to the control and regulation circuit, which selectively shuts down the voltage-regulated rectifier or rectifiers which may have failed causing the high voltage in the control and regulation circuit. When a regulated rectifier is shut down, a minor alarm is sounded and the AM lamp in the charge bay assembly and RFA lamp on the rectifier are lighted.

(d) Fuses have been provided for the potentials (130V) required in the HV shutdown and LV alarm circuits in the control and regulation circuit for plants furnished with all voltage-regulated rectifiers.

1.09 The following abbreviations are used to facilitate reading:

cw—Clockwise

ccw—Counterclockwise

G1-G5—Generator or current-controlled rectifier designated +130VG1-G5 or -130VG1-G5

G1-G12—Voltage-regulated rectifier designated +130VG1-G12 or -130VG1-G12

G01-G06—G-zero voltage-regulated rectifier

CU—Charging Unit

CU1—Charging Unit No. 1

NOR—Any key position marked NOR, NORM, or NORMAL

1.10 The instructions are based on the following drawings. For detailed descriptions of the operation of individual circuits, see the corresponding circuit descriptions. The particular circuits associated with a particular installation are covered in the job wiring list.

Motor Starter Circuit

SD-81036-01, Iss 26—Motor Starter Circuit for Manual and Automatic Starters (A&M Only)

SD-81393-01, Iss 5—Motor Starter Circuit

Generator Start Control Circuit

SD-81009-01, Iss 3—Generator Start Control and Regulation Circuit—Automatic Start Control (A&M Only—Replaced by SD-81333-01)

SD-81333-01, Iss 18—Generator Start Control and Regulation Circuit—Automatic Start Control (A&M Only—Replacing SD-81009-01, Partially Replaced by SD-81696-01)

SD-80997-01, Iss 11—Charging Generator Circuit—Manual and Automatic Regulation (A&M Only—Partially Replaced by SD-81335-01)

SECTION 167-705-301

SD-81032-01, Iss 12—Charging Generator Circuit—Manual and Automatic Regulation—Reserve Generator (A&M Only—Partially Replaced by SD-81336-01)

SD-81335-01, Iss 12—Charging Generator Circuit—Automatic Regulation and Start—Regular Generators (Replacing SD-80997-01)

SD-81336-01, Iss 12—Charging Generator Circuit—Automatic Regulation and Auto Start—Reserve Generators (Replacing SD-81032-01)

SD-80620-03, Iss. 18—Regulated Tube Rectifier Circuit—Phase Shift Control—230 Volts, 50 to 60 Hertz AC, 130 Volts, 8 Amperes DC—J86207C

SD-80620-03, Iss. 18—KS-15661 Voltage Regulated Rectifier KS-15661 L27—13 Volts, 3 Amperes—Power Data Section 4.44, Sheet 4

SD-81065-01, Iss 7—Rectifier Circuit—Metallic Type—Manual Regulation—20 Volts, 4 Amperes DC—J86230B

SD-81463-01, Iss. 10—Rectifier Circuit—Metallic Type—Raise-Lower Control—130 Volts, 100 Amperes—KS-15885 L1, L2, and L3

SD-81477-01, Iss. 4—Application Schematic—100-Ampere, 160-Volt Metallic Rectifier

SD-81593-01, Iss. 13—Regulated Rectifier Circuit—130 Volts, 100 Amperes DC—Semiconductor Type—J87224

SD-81633-01, Iss. 4—Rectifier Circuit—Metallic Type—Raise-Lower Control—130 Volts, 300 Amperes—KS-19216 L1 or L2

SD-81031-01, Iss. 4—Charge Control Circuit—5 to 25 Amperes, Negative 130 Volts (A&M Only)

Battery Control Circuit

SD-81000-01, Iss. 7—Battery Control Circuit—Manual Switching of Emergency Cells—Positive 125 to 135 Volts, 25 to 1000 Amperes (A&M Only)

SD-81021-01, Iss. 5—Battery Control Circuit—Manual Switching of Emergency Cells—Positive and Negative 125 to 135 Volts, 25 to 1000 Amperes (A&M Only)

SD-81022-01, Iss. 11—Battery Control Circuit—Automatic Switching of Emergency Cells—Positive 125 to 135 Volts, 25 to 1000 Amperes (A&M Only—Replaced by SD-81022-02)

SD-81022-02, Iss. 12—Battery Control Circuit—Automatic Switching of Emergency Cells—Positive 125 to 135 Volts, 50 to 1000 Amperes (Replacing SD-81022-01)

SD-81023-01, Iss. 12—Battery Control Circuit—Automatic Switching of Emergency Cells—Positive and Negative 125 to 135 Volts, 25 to 1000 Amperes (A&M Only—Replaced by SD-81023-02)

SD-81023-02, Iss. 12—Battery Control Circuit—Automatic Switching of Emergency Cells—Positive and Negative 125 to 135 Volts, 50 to 1000 Amperes (Replacing SD-81023-01)

SD-81024-01, Iss. 9—Battery Control Circuit—Automatic Switching of Emergency Cells—Positive 125 to 135 Volts, 25 to 1000 Amperes, Negative 125 to 135 Volts, 5 to 25 Amperes (A&M Only)

SD-81025-01, Iss. 4—Battery Control Circuit—Manual Switching of Emergency Cells—Positive 125 to 135 Volts, 25 to 1000 Amperes, Negative 125 to 135 Volts, 5 to 25 Amperes (A&M Only)

Discharge Circuit

SD-81015-01, Iss. 5—Discharge Circuit—125 to 135 Volts (A&M Only—Replaced by SD-81015-02)

SD-81015-02, Iss. 4—Discharge Circuit—125 to 135 Volts (Replacing SD-81015-01)

Charge and Discharge Circuit

SD-81696-01, Iss. 8—700 Type Plants—Charge and Discharge Circuit—Positive or Negative 125 to 135 Volts, 0 to 1000 Amperes—708A Power Plant

Power Alarm Circuit

SD-80995-01, Iss. 13—Power Alarm Circuit (A&M Only—Replaced by SD-80995-02)

SD-80995-02, Iss. 7—Power Alarm Circuit (Replacing SD-80995-01)

SD-81061-01, Iss. 17—Power Audible Alarm Circuit

1.11 For more detailed information on the operation and maintenance of individual equipment and apparatus, refer to the appropriate Bell System Practices. The voltage controller, relays, etc, shall be adjusted in accordance with the applicable sections and the circuit requirements tables on the circuit drawings.

1.12 The countercells originally used with the discharge control circuit are wet alkaline CEMF cells. The wet alkaline cells generate explosive gases which present a potential fire hazard. The wet alkaline CEMF cells are replaced by KS-20019 L1 solid-state silicon CEMF cells. The silicon countercells eliminate the fire hazard presented by wet cells, since the silicon countercells do not generate explosive gases. Should the silicon

countercell fail, due to abnormal operating conditions, the cell will short-circuit to prevent the possibility of an open battery string. A hot surface warning label (P-840224018) should be applied to the battery stand shelves for the silicon countercells.

Note: The KS-20019, L1 solid-state silicon CEMF cells have been replaced by KS-20019, L2 solid-state silicon CEMF cells.

1.13 The J87224A, L7 and J87224B, L6 rectifiers are equipped with a new circuit feature that yields a gradual increase in output current when the rectifiers are turned on and prevents a momentary output current surge.

2. LIST OF TOOLS AND TEST APPARATUS

CODE OR SPEC NO.	DESCRIPTION
TOOLS	
265C	Contact Burnisher Holder
266C	Wire Burnisher
361B	Relay Winding Connector
365	Clip
(2 reqd)	
720A	Battery Pick-up Tool
141	Cord Tip
W1AY	Cord (Equipped with a 360A Tool on each end)
411C	Test Pick
(2 reqd)	
—	3-Inch C Screwdriver
—	Fuse Puller, 7-1/2 Inches, Ideal Industries Cat. No. 34-002
—	Blocking and Insulating Tools as required. Use and apply as covered in Section 060-020-801.

SECTION 167-705-301

CODE OR SPEC NO.	DESCRIPTION
TEST APPARATUS	
KS-14510	Volt-Ohm-Milliammeter
W1AF	Cord
W1AY	Cord
2W17A	Cord (W2W cord equipped with one No. 310 plug and two No. 360 tools)
411B	Tool
35-Type	Test Set

Note: Equivalents may be substituted.

3. OPERATION

AUTOMATIC OPERATION

3.01 Plants of 25- to 1000-Ampere Capacity:

For normal operation, with the keys in the following position, there should be enough generators or rectifiers in operation to float the battery. However, if an equalizing or boost charge is to be given using automatic regulation, the float charge key on the main control board should be operated to the CHG position. (See 3.09.)

(a) On Main Control Board—

- (1) The CHG-FLOAT key should be in the FLOAT position.
- (2) The MAN-AUTO key should be in the AUTO position.

(b) On Battery Control Board—

- (1) Manual controlled emergency cell switches should be closed to the top position.
- (2) The MAN-AUTO key should be in AUTO position.

(c) On Generator Control Bays—

- (1) The handwheel and knife switch should be in the BAT position.
- (2) The keys should be in the NOR position.

(d) On Rectifier Bays—

- (1) The rotary BAT switch should be in the F position.
- (2) The keys should be in the NOR position.
- (3) The MAN-AUTO key should be in the AUTO position.
- (4) CB1 should be in the ON position.

(e) On Rectifier Charge Bay Assemblies (4-100A Rectifiers)—

- (1) The BAT SW switch should be in the F position.
- (2) The AC ON-OFF key on the rectifier control panels should be in the ON position.

3.02 Plants of Less Than 25-Ampere Capacity:

For normal operation, with the keys in the positions specified as follows, enough 8-ampere rectifiers should be in operation to float the battery.

- (1) **On Main Control Board—**The NOR-CHG key should be in the NOR position.
- (2) **On Rectifier Control Panels—**The AC ON-OFF key should be in the ON position.

REMOVING CHARGING UNIT FROM OR RESTORING TO SERVICE

3.03 Generators:

(a) Removing Generator From Service—

Note: If the generator is not carrying load or not operating, it is only necessary to operate the STOP-NOR key to the STOP position to remove it from service.

- (1) Operate the TEST-NOR key of the generator to the TEST position.
- (2) Operate the LOWER key of the generator to reduce output slowly, allowing time for the voltage control circuit to function and start the succeeding CU if required to carry the load.

- (3) As output of the succeeding CU builds up, operate the LOWER key of the generator until the RL relay remains released.
- (4) Operate the STOP-NOR key to the STOP position.
- (5) Operate the TEST-NOR key to the NOR position.
- (6) If the generator is to be disconnected from the battery, operate the generator knife switch to the open (horizontal) position.

(b) Restoring Generator to Service—

- (1) Check the position of the generator handwheel and knife switch.
- (2) Operate the TEST-NOR key of the generator to the NOR position. If the RL relay operates, wait until it releases.
- (3) Operate the STOP-NOR key of the generator to the NOR position.
- (4) If succeeding CUs are connected, wait until the run contactor of the generator starter operates and then operate the LOWER key of the last connected CU and reduce its output approximately 10 percent.
- (5) When the generator connects to load as indicated by operation of CA contactor, operate the LOWER key of the last connected CU until the generator reaches either its maximum output or the output necessary to disconnect succeeding CUs.

3.04 Rectifiers (Plants of 25- to 1000-Ampere Capacity):

(a) Removing Current-Regulated Rectifier From Service—

Note: If the rectifier is not carrying load or not operating, it is only necessary to operate the STOP-NOR key to the STOP position to remove it from service.

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

- (2) Operate the LOWER key of the rectifier to reduce output slowly, allowing time for the voltage control circuit to function and start the succeeding CU if required to carry the load.

- (3) As output of the succeeding CU builds up, operate the LOWER key of the rectifier until the RL relay does not operate.

- (4) Operate the STOP-NOR key to the STOP position.

- (5) Operate the TEST-NOR key to the NOR position.

- (6) If the rectifier is to be disconnected from the battery, operate the rotary switch to the OFF position.

(b) Restoring Current-Regulated Rectifier to Service—

- (1) Check the position of the rotary switch.
- (2) Operate the TST-NOR key of the rectifier to the NOR position. If the RL relay operates, wait until it releases.
- (3) Operate the STOP-NOR key of the rectifier to the NOR position.
- (4) If succeeding CUs are connected, operate the LOWER key of the last connected CU and reduce its output approximately 10 percent.
- (5) As the output of the rectifier builds up, operate the LOWER key of last connected CU until the rectifier reaches full-ampere output or the output necessary to disconnect succeeding CU.

(c) Removing Voltage-Regulated Rectifier From Service—

Removing one or more rectifiers will not affect normal operation of the plant. To remove a rectifier from service, operate the AC ON-OFF switch to the OFF position. Since at least one spare rectifier is furnished, the load dropped by the rectifier will be assumed by the connected idling spare. If a rectifier is to be disconnected from the battery, operate the BAT switch to the OFF position.

SECTION 167-705-301

(d) **Restoring Voltage-Regulated Rectifier to Service**—If the rectifier was out of service and is to be returned to service, operate the BAT SW switch to the F position and the AC ON-OFF key to the ON position. If the rectifier assumes full load, no load, or if in assuming partial load it raises the plant float voltage, recheck rectifier adjustment. (See 4.17.)

(e) **Removing G01 (G-Zero) Rectifier From Service**—

- (1) Rotate the VOLTS ADJ potentiometer on the rectifier ccw until the output reaches 131.0 volts.
- (2) Operate the MAN-AUTO key on the main control board to the MAN position.
- (3) Operate the RAISE key on the main control board (a generator or rectifier may start). Release the RAISE key when the output of G01 nears zero and the VRA relay releases.
- (4) Restore the MAN-AUTO key on the main control board to the AUTO position when G01 reaches zero and the float voltage increases to normal (132.4 volts).
- (5) Operate the AC ON-OFF key and the BAT SW switch on the rectifier to the OFF position.

(f) **Restoring G01 (G-Zero) Rectifier to Service**—

- (1) At the rectifier, operate the AC ON-OFF key to the ON position and the BAT SW switch to the F position.
- (2) Operate the MAN-AUTO key on the main control board to the MAN position.
- (3) Momentarily operate the LOWER key on the main control board. When G01 picks up the load at 131.0 volts, return the MAN-AUTO key to the AUTO position and adjust the VOLTS ADJ potentiometer on the rectifier to float voltage (132.4 for 61 cells).

(g) **Removing G02 Through G06 (G-Zero) Rectifiers From Service**—

- (1) Rotate the VOLTS ADJ potentiometer on the rectifier slowly ccw and observe the sudden drop to partial load.

(2) Wait for G01 to pick up to full load and the other G-type CUs to assume the remainder of the load.

(3) If the rectifier does not drop to zero, rotate the VOLTS ADJ potentiometer further ccw. With the rectifier at zero, operate the BAT SW switch to OFF.

(h) **Restoring G02 Through G06 (G-Zero) Rectifier to Service**—

- (1) At the rectifier, operate the AC ON-OFF key to the ON position and the BAT SW switch to the F position.
- (2) Operate the MAN-AUTO key on the main control board to the MAN position and rotate the VOLTS ADJ potentiometer on the rectifier cw to assume the load from G01. Then rotate the VOLTS ADJ potentiometer to set the output voltage to 133.4 volts.
- (3) Restore the MAN-AUTO key to the AUTO position and observe that the plant float voltage returns to 132.4 volts.

3.05 *Rectifier (Plants of Less Than 25-Ampere Capacity):*

(a) **Removing Current-Regulated Rectifier From Service**—Operate the AC ON-OFF key on the rectifier to the OFF position.

(b) **Restoring Current-Regulated Rectifier to Service**—Operate the AC ON-OFF key on the rectifier to the ON position.

MANUAL OPERATION

3.06 *Plants of 25- to 1000-Ampere Capacity:*

If the regulation of the plant is to be done manually, operate the MAN-AUTO key on the main control board to the MAN position. The voltage may then be raised or lowered by operating the RAISE or LOWER keys on the main control board.

3.07 *Generators*

(a) Remove the generator from service as covered in 3.03(a).

(b) Operate the TEST-NOT key to the TEST position.

- (c) Operate the STOP-NOR key to the NOR position.
- (d) Motor starter should go to the run position after brief delay as indicated by sound of run contactor operating.

Note 1: If the CU is operated across the battery, changes in output should be slow enough to allow the voltage control circuit to make the necessary adjustments in other operating CUs.

Note 2: The reserve CU, when started manually, will not connect to battery unless the +130V-NOR key is operated to the +130V position or the -130V-NOR key is operated to the -130V position. Before operating those keys, operate LOWER key until the RL relay remains released.

Caution: *If motor starter fails to go to the run position, application of load to generator will cause autotransformer in starter to burn out.*

- (e) Operate the RAISE key until the generator connects to battery as indicated by the CA contactor operating. Then operate the RAISE key and slowly increase output until the generator assumes the desired load.
- (f) When manual operation is completed—
 - (1) Operate the LOWER key until the generator disconnects.
 - (2) In the case of the reserve generator, operate the LOWER key until the RL relay releases and then restore the operated +130V-NOR key or -130V-NOR key to the NOR position.
 - (3) Operate the TEST-NOR key to the NOR position.

3.08 Rectifier (Plants of 25- to 1000-Ampere Capacity)—

- (a) Remove the rectifier from service as covered in 3.04(a).
- (b) Operate the TST-NOR key to the TST position.

- (c) Operate the STOP-NOR key to the NOR position. See 3.07, Note 1 and 2.
- (d) Operate the RAISE key until the rectifier assumes the desired load.
- (e) When manual operation is completed—
 - (1) Operate the LOWER key until the RL relay releases.
 - (2) In the case of the reserve rectifier, restore the operated +130V-NOR key or -130V-NOR key to the NOR position.
 - (3) Operate the TST-NOR key to the NOR position.

BOOST CHARGING BATTERIES

3.09 Main Battery

- (a) Operate the CHG-FLOAT or NOR-CHG key on main control board to the CHG position.
- (b) In 25- to 1000-ampere capacity plants, if countercells are provided and are manually controlled, operate the FLOAT-CHG switch on the battery control board to the CHG position when the 130V FLOAT alarm sounds.
- (c) When the charge is completed, operate the CHG-FLOAT or NOR-CHG key on the main control board to the FLOAT or NOR position.
- (d) In 25- to 1000-ampere capacity plants, if countercells are provided and manually controlled, operate the FLOAT-CHG switch on the battery control board to the FLOAT position when the 130V FLOAT alarm sounds.
- (e) In plants using 100-ampere regulated rectifiers, all rectifiers are adjusted to float in parallel across the main battery. Boost charging may be accomplished manually by operating the FLOAT-CHG key to the CHG position. This causes all rectifiers to regulate the battery at approximately 2.2 volts per cell.

Note: If countercells are provided and are automatically controlled, the circuit voltage will be maintained within proper limits. However, if the countercells are manually controlled, the high-voltage alarm will sound

SECTION 167-705-301

when the battery voltage rises and countercells must then be switched into the circuit.

- 3.10 *Emergency Cells:*** Adjust trickle charger to boost charge value. (See Section 157-601-701.)

RECHARGING AFTER POWER FAILURE

3.11 *General:* The 702C plant is arranged for recharging emergency cells by the method known as "charge by load." In the case of an emergency which has discharged a considerable part of the battery capacity, a high starting rate may be used; but under no conditions should the cells be charged at more than 150 percent of the 8-hour discharge rate at the start of the charge, or at more than the finish rate at the end of the charge. If the electrolyte temperature reaches 110°F (43°C) before the charge is completed, reduce the charge rate by 50 percent. When charging emergency cells, any trickle charger in use may be left connected. If countercells are used, see Section 157-601-701 for precautions regarding temperature and other factors. A simplified circuit showing the basic switching arrangements for charging the main battery and the EM cells is shown in Fig. 1.

3.12 If the power failure was of short duration and the emergency cells were not switched into the battery circuit, the main battery will automatically recharge to float voltage.

3.13 *Plants Arranged for Connection of Emergency Cell Groups in Series but Not in Parallel*

(a) Power failure during which the first (G1) group of emergency cells was switched into the main battery—

(1) Permit CUs to restore main battery to float voltage.

● ***Automatically Switched Emergency Cells:*** NOR-EM switch returns to the NOR position.

● ***Manually Switched Emergency Cells:*** When the high-voltage alarm operates, operate the NOR-EM switch on the battery control board to the NOR position.

(2) The EM G1—G1 and G2 or CHG G1—G1 and G2 manually operated knife switch

on the battery control board should be closed to the EM G1 or CHG G1 position.

(3) Connect sufficient CUs across the main battery and emergency cells as covered in 3.16 to provide the allowable charging current through the emergency cells.

(4) At the main control board, read the voltmeter at the top of the panel. If the voltmeter is provided with a plus-minus toggle switch, operate the switch to the desired polarity. Then depress the 130V BAT and EM CELL voltmeter key of the same polarity. The observed change in voltage is the voltage across the G1 group of emergency cells. This voltage will be referred to as the G1 voltage.

(5) When the G1 voltage rises to 10 volts, reduce the CU output until the G1 voltage is 8.8 volts.

(6) As the emergency cells approach full charge, the G1 voltage will increase more rapidly and the charging current will decrease. When the charging current is approximately zero, the G1 group is fully charged.

(7) Reconnect the CUs across the main battery as covered in 3.18.

(b) Power failure during which both (G1 and G2) groups of emergency cells were switched into the main battery—

(1) Permit CUs to restore main battery to float voltage.

● ***Automatically Switched Emergency Cells:*** NOR-EM switch returns to the NOR position.

● ***Manually Switched Emergency Cells:*** When the high-voltage alarm operates, operate the EM G1—G1 and G2 switch on the battery control board to the EM G1 position. When the high-voltage alarm again operates, operate the NOR-EM switch to the NOR position.

(2) The G2 group is charged first as covered in (a), except that in (a)(2) the EM G1—G1 and G2 or CHG G1—G1 and G2 switch on the battery control board should be closed to the G1 and G2 position, instead of to the G1 position. Use a portable voltmeter connected

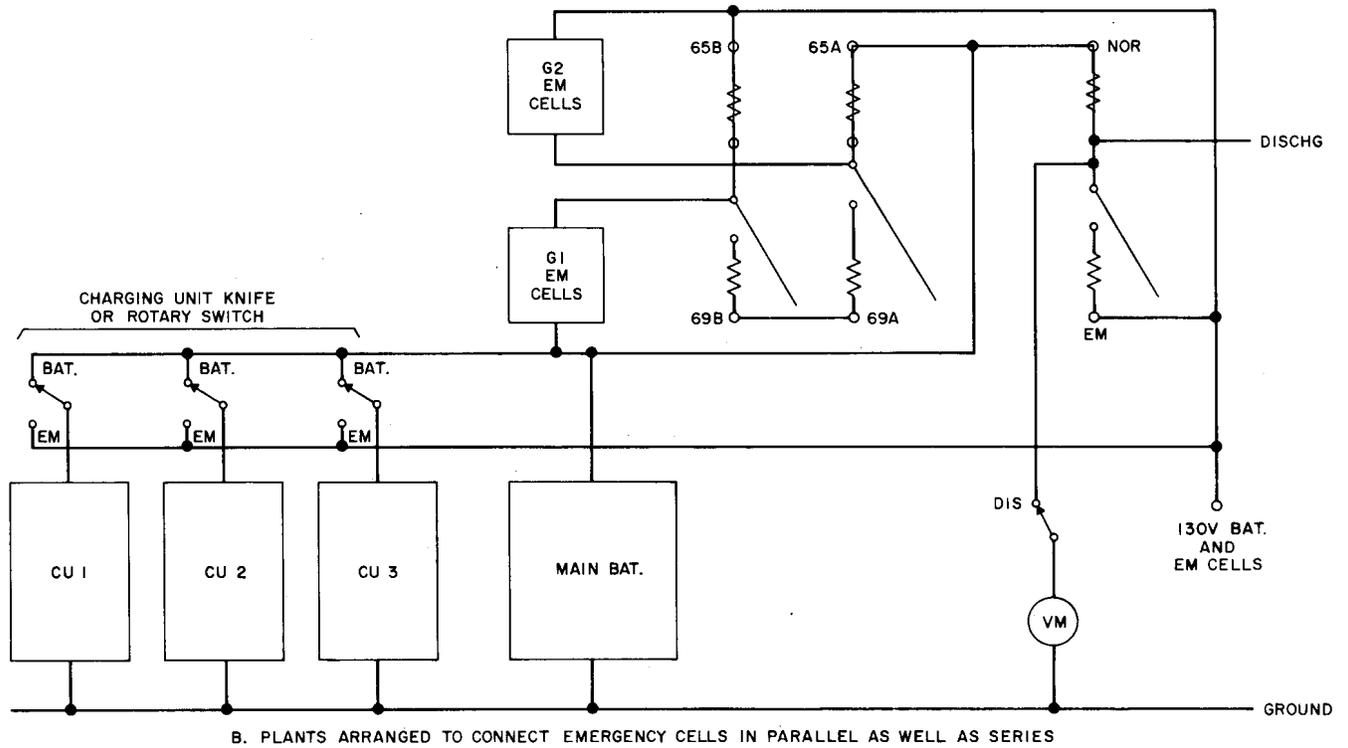
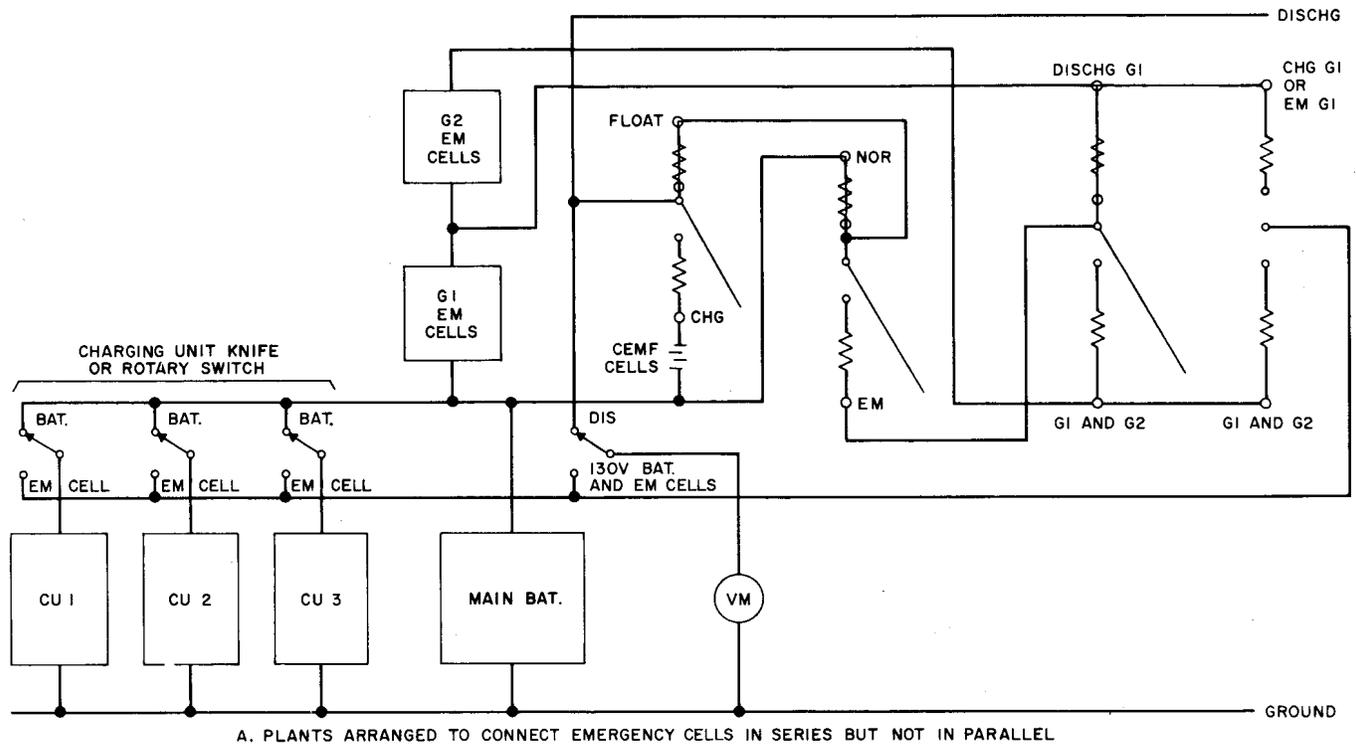


Fig. 1—Simplified Charge and Discharge Circuit

SECTION 167-705-301

directly across G2 group, instead of the panel voltmeter, to obtain the G1 voltage referred to in (a).

(3) When charging of G2 group is completed, charge G1 group as covered in (a).

(c) Where G02 is furnished, the recharge procedure covered in (a) is simplified by the provision of an additional sensing lead to permit G02 to decrease its output automatically to permit excessive voltage across the GR1 cells. When G02 is used as the CU in (a)(3), steps (a)(4), (5), and (6) become automatic.

Caution: *The F-EC switch should not be left permanently in the EC position because overcharging of the emergency cells could occur if the plant load exceeded the capacity of the remaining rectifiers.*

3.14 *Plants Arranged for Connection of Emergency Cells in Parallel as Well as in Series:*

The emergency cells are recharged, connected in parallel, as covered in 3.13(a) or (c), except that (a)(2) is omitted. In this case the voltage across G1 and G2 groups connected in parallel is the equivalent of the G1 voltage. To determine the charging current through one cell group, divide the overall charging current by the number of strings in parallel. Parallel-series plants may be furnished with voltage-regulated rectifiers. In that case, the regulated recharge described in 3.13(c) is provided by G01 instead of G02.

3.15 *Charging Batteries After a Deep 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.** (See 3.21.) 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 become 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.

3.16 *Prevention of Emergency Cell Polarity Reversal:*

If, during an extended interval with emergency ac power, the emergency engine does not have capacity to operate sufficient CUs to maintain the main battery at float voltage (see note), the emergency cells may be damaged by reversal of polarity. To prevent this, connect the CUs across the main battery and the EM cells as covered in 3.17. In plants in which the emergency cells connect in series only, operate the EM G1—G1 and G2 or CHG G1—G1 and G2 knife switch on the battery control board to the position which matches the position of the discharge switch before switching the CUs. When commercial power is restored, return the plant to normal operation as covered in 3.18 and then recharge the EM cells as covered in 3.13 or 3.14.

Note: The alarm circuits of some unattended emergency engines include a relay and several 3-position keys. The keys provide connection to the control circuits of certain CUs which can receive emergency power from the engine. In the STOP BY AUTO ENG position, each key stops the associated CU automatically while the engine is carrying the load. In the MAN STOP position, the key stops the CU manually independently of the engine and lights a MAN GD lamp adjacent to the key. The OPEN position of the key permits normal operation of the CU.

3.17 *Switching Charging Units From Connection Across the Main Battery to Connection Across the Main Battery and Emergency Cells*

Note: In plants in which the emergency cell groups connect in series only, the manually

operated EM G1—G1 and G2 or CHG G1—G1 and G2 knife switch on the battery control board should be closed to the desired position before switching the CUs.

- (a) Remove the last CU from service as covered in 3.03(a) or 3.04(a), (c), or (e).
- (b) If the CU is a generator, operate the handwheel and knife switch to the EM CELLS position. If the CU is a rectifier, operate the rotary switch to the EC position.
- (c) Restore the CU to service as covered in 3.03(b) or 3.04(b), (d), or (f).
- (d) If more than the full-ampere output of the last CU is required, switch the preceding CUs as necessary, in a similar manner.
- (e) If less than full-ampere output of any CU is required, operate the TEST-NOR key to the TEST position and adjust the output using the RAISE and LOWER keys.
- (f) In plants using voltage-regulated or G-zero rectifiers, switching is accomplished by operating the associated BAT SW switch from the F to the EC position.

3.18 *Switching Charging Units From Connection Across the Main Battery and Emergency Cells to Connection Across the Main Battery*

- (a) Remove the highest numbered CU to be switched from service as covered in 3.03(a) or 3.04(a), (c), or (e).
- (b) If the CU is a generator, operate the handwheel and knife switch to the BAT position. If the CU is a rectifier, operate the rotary switch to the F position.
- (c) Restore the CU to service as covered in 3.03(b) or 3.04(b), (d), or (f).
- (d) If not required for charging emergency cells, switch succeeding CUs in a similar manner.
- (e) If the manually operated EM G1—G1 and G2 or CHG G1—G1 and G2 switch, referred to in note of 3.17, is to be operated to the EM G1 or CHG G1 position and CUs are charging the emergency cells, operate the TEST-NOR

keys of these CUs to the TEST position and operate LOWER keys to reduce output 50 percent. Close the charge switch to the new position and then adjust the CUs to the desired output.

- (f) In plants using voltage-regulated or G-zero rectifiers, switching is accomplished by operating the associated BAT SW switch from the EC to the F position.

OPERATION OF EMERGENCY CELL SWITCHES DURING POWER FAILURE

3.19 *Manually Controlled Emergency Cell*

Switches: In the event of a power failure, or other conditions which prevent maintaining the battery voltage by means of CUs, the emergency cells shall be switched into the discharge circuit when the low-voltage alarm sounds.

- (a) Operate the NOR-EM switch on the battery control board to the EM position.
- (b) When the low-voltage alarm sounds, operate the EM G1—G1 and G2 switch to the G1 and G2 position.
- (c) When CUs have been restarted and connected to battery carrying office load, and the voltage alarm sounds due to high voltage, operate EM G1—G1 and G2 switch to EM G1 position.
- (d) When the voltage alarm again sounds due to high voltage, operate the NOR-EM switch to the NOR position.

3.20 *Automatically Controlled Emergency Cell*

Switches: The emergency cell groups are automatically switched into or out of the discharge circuit under voltage control by the motor-driven emergency cell switches. If these cells are to be switched by manual control, the MAN-AUTO key on the battery control board should be operated to the MAN position. The EM cells may then be switched in or out by operating the RAISE or LOWER keys, respectively, of the emergency cell switch circuit. These keys should be held operated momentarily, repeating the operation of the keys for each group of cells to be switched in or out.

Caution: *When operating EM cell switches manually, the operator should not hold the RAISE or LOWER key down after the EMC switch runs under its own control.*

SECTION 167-705-301

If the emergency cell switch fails to function, remove the EM CELL A and B CONT fuses on the 24- or 48-volt battery control board. Operate the knife-type motor-driven switch manually as follows. Remove the cotter pin holding the top of the insulated link. Disconnect the link and operate the switch manually. If the switch has a cover, the cover must be removed in order to disconnect the link. The switch is then operated by inserting the adjust handle mounted on the right side of the switch panel in the socket on the switch.

DISCHARGE FUSE REPLACEMENT

3.21 When replacing fuses on discharge panels equipped with KS-5047 fuse and switch units (single-pole, double-throw), always have the fuse shunted by the knife blade before removing or inserting fuses. When a discharge fuse blows, operate the switch to the other position, which inserts the good fuse in the circuit. If this discharge fuse does not blow, then replace the alarm fuse. If the second discharge fuse blows, check for trouble.

4. ROUTINE TESTS

GENERAL

4.01 The purpose of making routine checks on this 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 periodically without intentionally causing drastic or harmful situations, such as complete power failure. The checking time and testing intervals should be based on local conditions and past experience.

4.02 When the weekly engine routines are performed, the power plant should be permitted to go through its automatic functions so that charging units will be shut down, emergency cells will come into operation if required, and, on restoration of power, the charging units will connect in the required manner.

Note: The automatic operation of the emergency cells can be checked by stopping enough charging equipment to cause one group of emergency cells to be cut into the discharge circuit. Observe voltages just before switching takes place. Readjust voltage relay if required.

4.03 *BAT Voltmeter Accuracy Check*

- (a) Connect the KS-8039 volt-milliammeter across the terminals of the BAT voltmeter.
- (b) Compare the indications of the BAT and KS-8039 meters. If the meters do not agree, adjust the zero adjusting screw on the BAT voltmeter as required.
- (c) Place masking tape over the adjusting screw and note the date the adjustment was made.
- (d) Disconnect the KS-8039 volt-milliammeter.

GENERATORS

4.04 *CB Reverse Current and CC Relay Check*

Note: Plant must be under manual control for this test.

(a) **CB (Reverse Current) Relay Check—**

- (1) Operate the emergency cell MAN-AUTO key at the main control board to the MAN position.
- (2) Operate the VM key at the generator control bay to the GEN position.
- (3) Rotate the generator manual control handwheel fully cw. The CA contactor releases.
- (4) Open the generator knife switch to the open (horizontal) position.
- (5) Block operated the CC relay on the generator control bay under test.
- (6) Slowly rotate the generator manual control handwheel ccw.

Requirement: The CB relay operates before 119 volts are reached. The CA contactor also operates.

- (7) Rotate the generator manual control handwheel cw until the CA contactor and CB relay release.
- (8) Remove the block from the CC relay.

(b) **CC Relay Check—**

Note: Plant must be under manual control for this test.

(1) After the CA contactor has released, close the generator knife switch to the BAT position. In the case of the reserve generator, also operate the +130V-NOR key to the +130V position or the -130V-NOR key to the -130V position.

Warning: *Never close or open the generator knife switch while the CA contactor is operated, as personal injury and commutator damage may result.*

(2) Connect the KS-14510 volt-ohm-milliammeter, using the 12-volt dc scale, across the main contacts of the CA contactor. Connect the negative lead of the volt-ohm-milliammeter to the armature contact and the positive lead to the stationary contact of the contactor for +130 volt plants. For -130 volt plants, reverse the connection of the volt-ohm-milliammeter leads to the contactor.

(3) Rotate the generator manual control handwheel slowly ccw until the volt-ohm-milliammeter reads 1 volt.

(4) Reverse the external volt-ohm-milliammeter leads at the contactor (volt-ohm-milliammeter reads minus 1 volt).

(5) Rotate the generator manual control handwheel slowly ccw. The CA contactor should operate when the external volt-ohm-milliammeter indicates 1 volt, that is, before generator voltage is 1 volt higher than battery voltage.

(6) Disconnect the volt-ohm-milliammeter.

(7) Move the low-contact pointer of the ammeter relay to the extreme left of scale (see 4.07).

(8) Rotate the handwheel slowly cw while observing the ammeter relay. The CB relay and CA contactor should release when the reverse current (below the zero reading) is between 3 and 8 percent of generator full-ampere output.

Caution: *Do not permit the reverse current to exceed the 8-percent value, as excessive reverse current may affect future operation of the CB reverse current relay.*

Note: On some generators it may be necessary to use the RAISE or LOWER key, in addition to rotating the generator manual control handwheel, when increasing or decreasing the generator voltage.

(9) Rotate the generator manual control handwheel fully cw. The CA contactor releases.

(10) Operate the generator knife switch to the open (horizontal) position.

(11) Adjust the ammeter relay as outlined in 4.07(a).

4.05 Overload Relay Associated With Generators:

The OL relay should operate when the generator output rises to 115 percent of full-ampere output and should release when generator output reduces to 85 percent of full-ampere output. In the following procedure, raise and lower the output of the generator, as required, by means of the generator manual control handwheel.

Note: Plant must be under manual control for this test.

(a) Operate the emergency cell MAN-AUTO key at the main control board to the MAN position.

(b) Rotate the generator manual control handwheel fully cw. The CA contactor releases.

Note: The cover must be on the OL relay when adjusting the OLA and OLR potentiometers. Observe the OL1 or OLS relay to determine when the OL relay operates.

(c) Move the high contact of the ammeter relay so that it does not make contact when the generator is delivering 105 percent of full-ampere output.

(d) Using the 0.3-volt scale, connect the KS-14510 volt-ohm-milliammeter across the ammeter relay shunt at the same points as the connection for the winding of the OL relay. The volt-ohm-milliammeter will read percentage output in millivolts in accordance with Table A.

TABLE A

LOAD IN PERCENT	MILLIVOLTS
85	213
100	250
105	262
110	275
115	288

(e) Rotate the generator manual control handwheel ccw to raise the output to the full-ampere rating of the generator.

(f) Read the drop across the ammeter relay shunt as indicated on the millivoltmeter, then increase output until the voltage drop is 115 percent of that obtained when the generator is delivering full-ampere output (see Table A). Slowly rotate the OLA rheostat ccw until the OL relay operates as indicated by operation of the OL1 or OLS relay.

(g) Decrease the output to 105 percent of full-ampere output and check that the OL relay does not release.

(h) Continue to decrease the output of the generator until 85 percent of generator full-ampere output is reached or the OL relay releases. If the OL relay does not release at 85 percent of generator full-ampere output, check the circuit requirements of the relay. If these are met, cut the strap between OLA and OLR rheostats. Then, with generator carrying 85 percent of its full-ampere output, slowly rotate the OLR potentiometer cw until OL relay releases.

Note: The OL relay normally releases within limits, in which case, removal of the strap is not necessary. Removal of the strap is required only in exceptional cases.

(i) Check the operation of the OL relay as follows. Observe the OL1 or OLS relay to determine when the OL relay operates.

(1) Raise the generator output to 105 percent of full-ampere output and check that the OL relay does not operate.

(2) Raise the generator output to 115 percent of full-ampere output and check that the OL relay operates.

(3) Decrease the generator output to 105 percent of full-ampere output and check that the OL relay remains operated.

(4) Continue to decrease the generator output to 85 percent of full-ampere output and check that the OL relay is released.

(j) Reset ammeter relay high contacts.

(k) Disconnect the volt-ohm-milliammeter.

(l) Operate the emergency cell MAN-AUTO key at the main control board to the AUTO position.

(m) Restore the CU to normal service as outlined in 3.03(b).

4.06 Adjustment of Motor-Driven Rheostat

(a) Operate the STOP-NOR key to the STOP position.

(b) Rotate the handwheel to the BAT position.

(c) Block the FR relay operated.

(d) Operate the LOWER key until the RL relay releases (all resistance in position).

(e) Operate the STOP-NOR key to the NOR position.

(f) Operate the RAISE key and slowly increase voltage to 112 volts. Mark this point temporarily on the motor-driven rheostat.

(g) Operate the RAISE key until the CA contactor operates and then slowly continue to increase the output until the generator is operating at full-ampere output at 135 volts for plants without countercells or at 142 volts for plants with countercells. If the countercells are manually controlled, operate the FLOAT-CHG switch on the battery control board to the CHG position when the high-voltage alarm sounds. Read voltage by operating the VM key on generator control panel to the BAT position.

- (h) Slowly decrease the generator output by operating the LOWER key, allowing the battery voltage to decrease until the ammeter indicates no output (do not go to reverse current) with battery voltage of 128 volts. If the FLOAT-CHG switch was manually operated in (g), operate the switch to the FLOAT position when the low-voltage alarm sounds.
- (i) Operate the STOP-NOR key to the STOP position.
- (j) Operate the generator knife switch to the open (horizontal) position.
- (k) Remove the block from the FR relay.
- (l) The position of the motor-driven rheostat in (h) or the setting previously marked, depending on which results in the most resistance in the motor-driven rheostat, shall be the all resistance in position. With the rheostat arm in this position, set the B limit switch operating lever against the limit switch so that the contacts just open and clamp the lever in place.

GENERATORS AND RECTIFIERS

4.07 Ammeter Relays

(a) Ammeter Relay Associated With Generators—

- (1) The low contacts shall be adjusted to make with a reverse current sufficient to deflect the moving pointer 1 to 2 percent of the generator full-ampere output below zero (see Note 1).
- (2) The high contacts shall be adjusted to make with a current equal to the generator full-ampere output (see Note 2).
- (3) Restore the emergency cell MAN-AUTO key to the AUTO position.

(b) Ammeter Relay Associated With Current-Regulated Rectifiers—

- (1) The low contacts shall be adjusted to make with a current equal to 5 percent of the rectifier full-ampere output (see Note 1).

- (2) The high contacts shall be adjusted to make with a current equal to the rectifier full-ampere output (see Note 2).

Note 1: Adjustment of the low contact necessitates removal of the relay cover. The position of the low contact pointer may then be changed by grasping the projecting insulated lower end and moving it as required.

Note 2: In some instances, the load may fluctuate at a value which will cause frequent starting and stopping of the succeeding CU. This condition can be improved by readjusting the high contact for a reduced output of the CU.

(c) Ammeter Relay Associated With G-Zero Rectifiers—

The spread between the low and high contacts of the ammeter relay shall be at least 30 amperes to prevent excessive operation of the raise and lower controls. The spread will depend on the magnitude of load changes and, in plants with raise-lower rectifiers, may also be affected by line voltage changes. The contacts may be set between 10 and 90 percent of the range of the rectifier to give the desired loading on the last operating raise-lower set. For example, settings of 60 percent and 90 percent may permit shutdown of one raise-lower set. Settings of 10 percent and 40 percent may be used to increase the load on a motor-generator set to prevent light load commutator troubles.

Note: The KS-20522 Controller has been developed to provide, in a solid-state unit, the same functions as contacts in the ammeter relays. The controller contains no moving parts or heated filaments; therefore it should provide more reliable service with far less maintenance than the mechanical contacts. The KS-20522 Controller is available as part of a modification kit which includes mounting hardware, wire, installation and wiring information, and, where required, some minor external components. There will be a modification kit available for several different applications: The J86741A, List 8 kit (KS-20522, L2 Controller) is used for field modification of ammeter used in J86284K or J86284L, 100 to 200 amperes, 130-volt rectifier charging unit per SD-81333-01, Fig. 18, X and ZH options,

SECTION 167-705-301

for 24-volt control. The J86741A, List 9 kit (KS-20522, L3 Controller) is used for field modification of ammeter relay used in J86284K or J86284L, 100 to 200 amperes, 130 volt rectifier charging unit per SD-81333-01, Fig. 18, Y and ZH options, for 48-volt control. For additional information, see Section 024-360-201 and SD-82023-01 and the associated circuit description.♦

VOLTAGE ADJUSTMENTS

4.08 Emergency Cell Float Adjustments: A metallic disc-type rectifier, either of the unregulated or regulated type, is permanently connected to float the emergency cells. The unregulated rectifier is provided with a continuously tapped autotransformer for changing the rectifier voltage and thereby its output current (see Section 169-215-301). The voltage adjustment is secured by trial and should be made when the cells have been fully charged and the supply voltage is normal. The adjustment should hold the voltage as close as practical to 2.17 volts per cell. The regulated rectifier voltage is set to the required float value by making connections to the proper secondary taps on the saturable reactor-type transformer of the rectifier (see Section 169-262-301). The voltage adjustment should be checked periodically as the battery and rectifier age. It is not necessary to disconnect the rectifier during a recharge period. Two regulated rectifiers (one across each group) may be furnished to substitute for the unregulated rectifier in older plants.

4.09 Plant of 25-Ampere Capacity or Less: The rectifiers should be adjusted to regulate on voltage control at approximately 2.17 volts per cell (see Section 169-603-303). Connect the rectifiers one at a time to the battery by operating the NOR-CHG key to the CHG position. Slowly adjust the OVER CHG rheostat until approximately 2.3 volts per cell is secured, being careful to avoid overload for the rectifier to prevent transfer from voltage to current control. Return the NOR-CHG key to the NOR position.

4.10 Plants Using G-Zero Voltage-Regulated Rectifiers: The G01 rectifier shall be accurately adjusted to maintain float voltage. Additional G-zero rectifiers shall be adjusted for a voltage slightly higher than that of the G01 rectifier. This keeps the G-zero rectifiers at full load but permits them to back off to protect against a plant

high-voltage condition. Normally, G01 maintains float voltage. If the VR voltage controller closes its high contact when G01 is operating, ground from an operated G01 relay over the HV1 lead will shut down G01 if it is contributing to the high-voltage condition. With G01 shut down, the VR voltage controller takes over to provide the necessary signals.

4.11 Plants Using All Voltage-Regulated Rectifiers: All voltage-regulated rectifiers are adjusted to float in parallel across the main battery and to regulate the battery at approximately 2.17 volts per cell.

Note: The ideal adjustment would be to have each of the rectifiers share the load equally but, because of the extreme accuracy of the voltage-regulating circuits, equal load sharing is not a practical requirement.

FUSES AND ALARMS

4.12 Test all fuse-failure alarms and indicators periodically as covered in Table B. The operator should analyze the test indication shown in Table B prior to applying the test voltage or ground to ascertain whether the test would shut down essential equipment. It may be necessary to postpone these tests to a lighter load period.

4.13 35-Type Fuse: Test 35-type fuse alarms and indicator lamps using a W1AF cord equipped with one 411C test pick and one 365 connecting clip. The test can be made by connecting the test battery or ground to the alarm bar or stud under the alarm fuse. Note that the alarm operates when the connection is made.

4.14 70-Type Fuse: To test the 70-type fuse alarms, proceed as follows.

Note: The later design of fuse caps for 70-type fuses contain an aperture or slot adjacent to the hole for the colored bead, providing access to the alarm test point (see Fig. 2). The new P-344900 fuse cap assembly is for use on non-modular fuse blocks (18A, 19A, and 21A) and the P-11F667 fuse cap assembly is for use on modular fuse blocks (22- through 27-type). This style cap should be used when testing fuse alarms.

TABLE B

FUSE LOCATION (SEE NOTE 1)	FUSE DESIGNATION	TEST PROCEDURE	INDICATION
Main Control Board (MCB)	ALM 130V REG & CONT 1/2 AMP ALM 6.25 AMP FN	Connect 24 or 48 Volts on Alarm Stud Connect 24 or 48 Volts on Alarm Stud Connect 24 or 48 Volts on Alarm Stud None, blown fuse indicated by	Note 2 Note 2 Note 2 Note 2
Battery Control Board (BCB)	BAT 1/4A BAT — AMP EM CELL 1-1/3A EM CELL — AMP EM CELL G1 1/4A EM CELL G1 3 AMP EM CELL VM 1-1/3A EM CELL VR 1-1/3A REG 1/4A REG 15 AMP FBD 1/4A VRP 1-1/3A	Connect 130 Volts on Alarm Stud None, blown fuse indicated by Connect 130 Volts on Alarm Stud None, blown fuse indicated by Connect 130 Volts on Alarm Stud None, blown fuse indicated by Press 130V BAT & EM CELL key on MCB None, blown fuse indicated by Connect 130 Volts on Alarm Stud None, blown fuse indicated by Connect 130 Volts on Alarm Stud Connect 130 Volts on Alarm Stud	Note 3 Note 3 & 7 Note 3 Note 3 & 7 Note 3 Note 3 Note 3 Voltmeter on MCB indicates BAT & EM CELL voltage Note 4 Note 5 Note 5 & 6, Voltmeter on BCB reads zero Note 5 Note 2
Charging Unit Panel (CUP)	C 1-1/3A CHG (Gen) 1/4A CHG (Rect) 1/2A CONT (Rect) 1/4A VM (Rect) 1-1/3A VM (Gen) 1-1/3A VM & VR 1-1/3A CBA (Gen) 1-1/3A	Connect 130 Volts on Alarm Stud Connect 130 Volts on Alarm Stud Connect 130 Volts on Alarm Stud Connect 130 Volts on Alarm Stud None, blown fuse indicated by Operate voltmeter key on CUP to BAT Connect 130 Volts on Alarm Stud Connect 130 Volts on Alarm Stud	Note 7 Note 9 Note 7 Note 7 Voltmeter on CUP indicates zero voltage Voltmeter on CUP indicates BAT voltage Note 7 Note 7

NOTES

- Fuses listed do not appear in all plants.
- CBS lamp lights on MCB; PWR lamp lights in emergency engine room; major alarm bell rings.
- CHG & MISC lamp lights on MCB; PWR lamp lights in emergency engine room; minor alarm bell rings.
- 130V EM CELL SW lamp lights on MCB; PWR lamp lights in emergency room; major alarm bell rings (Note 8).
- DISCHG lamp lights on MCB; PWR lamp lights in emergency engine room; major alarm bell rings, if provided DFL lamp lights on BCD.
- Operation of the REG fuse will shut down the motor-generator or rectifier.
- GEN PAN lamp lights on MCB; minor alarm bell rings; GEN FAIL or RECT FAIL lamp (RFA lamp on regulated rectifiers) lights on CUP, associated CU stops and succeeding CU starts (Note 8).
- In some plants alarm operation is delayed 3 minutes by thermal relay.
- GEN PAN lamp lights on MCB; minor alarm bell rings, associated CU stops and succeeding CU starts (Note 8).

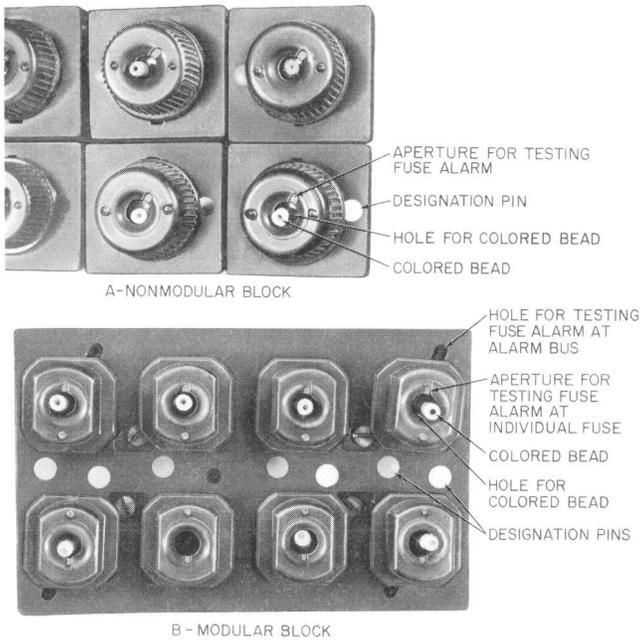


Fig. 2—Typical 70-Type Fuse Arrangement

Caution: Due to possible fuse and/or equipment damage, the former procedure of testing fuse alarms by inserting a 411C tool or a 266C tool (wire burnisher) held in a 265C tool (contact burnisher holder) beside the colored bead on older fuse caps without the slot or aperture, should be discontinued.

- (1) Prepare the alarm test cord by connecting one end of the W1AY testing cord to the

141 cord tip and 720A voltage pickup tool. (The KS-6278 connecting clip may be used to replace the 720A voltage pickup tool.) On the opposite end of the W1AY testing cord, connect the 411C test pick (see Fig. 3).

- (2) Install the 720A voltage pickup tool in a spare 70-type fuse position. (If the 720A tool is not available, obtain the same polarity voltage supply by connecting a KS-6278 connecting clip with the W1AY testing cord to the positive or negative bus bar.)

Caution: Test only the fuses associated with the same polarity voltage supply.

- (3) With the tip of the 411C tool (attached to the battery connected W1AF cord) touch the exposed alarm test point on the fuse cap for one fuse.

Requirement: The FA relay operates, the FUSE ALARM (FA) lamp lights, and a major alarm is activated.

Note: Tests made at the individual fuse cap check the contact between the fuse cap and the alarm bus bar. On modular type fuse blocks, there is also an aperture in the corner of the fuse block to test directly to the alarm bus bar (see Fig. 2).

- (4) Remove the 411C tool from the fuse cap.

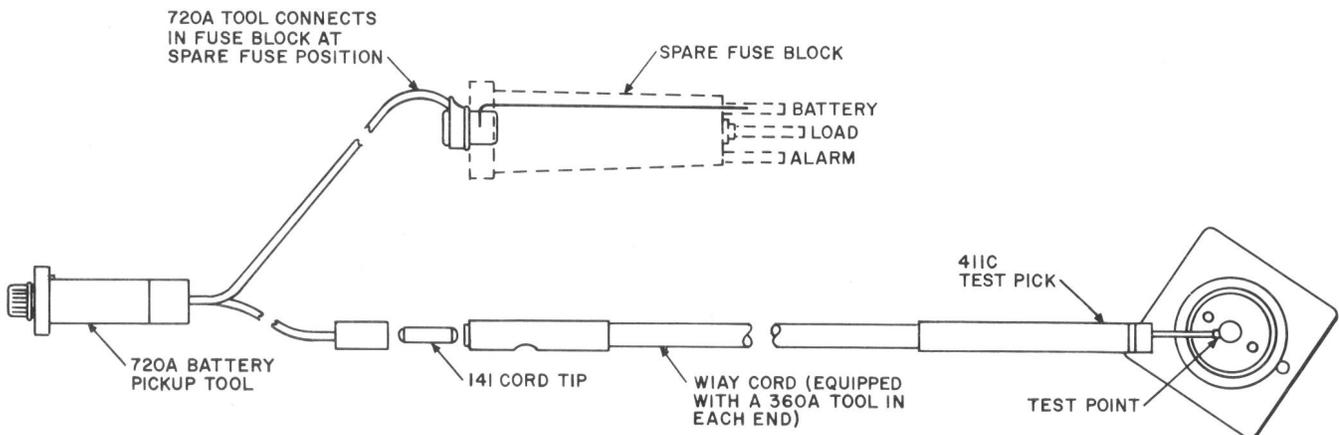


Fig. 3—Fuse Alarm Testing Cord-Tool Connection

Requirement: The FA relay releases, the FUSE ALARM (FA) lamp extinguishes, and the major alarm is deactivated.

- (5) Repeat (3) for each fuse.
- (6) Remove the 720A tool from the spare fuse position. (If the KS-6278 connecting clip is used, disconnect the clip from the bus bar.)

4.15 Fuse Alarms—Alarm-Type Fuse Shunting a Larger Fuse: Remove the alarm-type fuse associated with a large fuse and replace it with a blown fuse of the same type. The alarm operates when the blown fuse is inserted. Remove the blown fuse and replace the alarm-type fuse.

4.16 Fuse Alarms—Circuits Supplied Through an Alarm-Type Fuse: Connect one test pick of the W1AF cord to the terminal at the side of any fuse which is covered by the alarm under test. Momentarily connect the other test pick of the cord to the associated alarm stud or alarm bar. Note that the alarm operates while the cord is connected.

CHARGING UNIT FAILURE ALARM

Note: Do not perform this check for the J87224 rectifier unless it is equipped with the gradual increase in output circuit (see 1.13).

4.17 Each charging unit should be checked periodically for the associated failure alarms. If the charging unit is not idle, remove it from service as described in 3.03(a) or 3.04(a). Operate the associated switch or circuit breaker supplying ac power to the unit to its OFF position or carefully remove the fuses. Operate all keys to the NOR position. The GEN FAIL or RECT FAIL lamp on the unit under test should light. The GEN FAIL lamp should light on the main control board after a delay of about 1 to 3 minutes and the minor alarm sounds. The GEN FAIL and PWR lamps and the audible alarm can be cut off by operating the GEN FAIL ACO key on the main control board. When this key is operated, the GEN FAIL GD lamp lights on the main control board. Operate the STOP-NOR key to the STOP position and close circuit breaker or replace fuses. Restore the CU to service as covered in 3.03(b) or 3.04(b).

VOLTAGE CONTROL ALARMS

4.18 The voltage alarm circuits should be tested periodically using a 35-type test set.

4.19 Test Set Connections to High- and Low-Voltage Alarms: Using a 2W17A cord, connect the T & R jack of the 35-type test set across the test link of the voltage relay associated with the alarm under test. For the positive plant, connect the T terminal to the battery side of the test link. For the negative plant, connect the R terminal to the battery side of the test link. Set the test set keys as follows.

KEYS	POSITION
BAT & GRD CO	Operated
REV	Normal
SWITCH	POSITION
G	Open

Connect dry cells in series to the BAT and GRD terminals of the test set (estimate 1-1/2 volts per cell) to operate the voltage relay to its high contact. In the positive plant, connect the GRD terminal of the test set to the negative terminal of the dry cells; in the negative plant, connect the GRD terminal of the test set to the positive terminals of the dry cells. Connect an external voltmeter with an accuracy of at least 1/2 percent across the voltage relay. Locking levers of No. 1 to 4 keys should be open and all the resistance sliders should be in their extreme right position.

4.20 Close the locking lever of No. 3 key and move the No. 3 resistor sliders to their extreme left position. Operate all knife switches in the test set to remove all fixed resistance. Under this condition, the test set has its least resistance and the dry-cell battery is out of the circuit.

4.21 Place the test set into the circuit by carefully removing the test link associated with the voltage relay under test. Care should be taken not to open the circuit through the voltage relay or to change the current flowing in the circuit to cause any violent operation of the relay, as this may prevent a case of contact trouble from being detected in this test.

4.22 High- and Low-Voltage Alarms: Test the low-voltage and high-voltage contacts of the 130V EM CELL, VR, HL, or HLV relays in the following manner.

SECTION 167-705-301

(a) **Low-Voltage Test:** Gradually move the No. 3 sliders to the right, lowering the voltage across the voltage relay. Note the point where the major alarm sounds and the 130V HL or EM CELL SW lamp lights (see circuit requirements table). If the voltage has not been lowered beyond the allowable range when both No. 3 sliders have reached their extreme right position, slide them fully back to the left. Then operate the No. 3 knife switches to add 25,000 ohms and again gradually move the sliders to the right.

(b) **High-Voltage Test:** Move the No. 3 sliders to their extreme right position. From the reading of the voltmeter, determine whether the voltage has been reduced sufficiently to add the test battery without causing the high contact to make (see circuit requirements table). Estimate the test battery voltage on the basis of 1-1/2 volts per cell. (If the voltage has not been reduced sufficiently, add additional resistance by opening one or more No. 3 knife switches.) Then restore the BAT & GRD CO key and raise the voltage gradually by moving the No. 3 sliders toward the left. Note the point when the high-voltage major alarm sounds and the 130V HL, EM CELLS, or CEMF CELL SW lamps light.

- (c) Operate the BAT & GRD CO key.
- (d) Remount the test link before removing the test equipment.

4.23 *Voltage Unbalance Alarm in Plants With Both Positive and Negative Batteries*

- (1) Operate the MAN-AUTO key on the battery control board for each polarity to the MAN position.
- (2) With the battery voltage of each polarity at float value, observe that the armature of the UB voltage relay in the battery control circuit is approximately centered between contacts.
- (3) Operate the MAN-AUTO key for each polarity on the main control board to the MAN position.
- (4) For each polarity, one at a time, raise and lower the discharge voltage indicated on the panel voltmeter by means of the associated

RAISE and LOWER keys. Observe that when the two discharge voltages differ by 5 ± 0.5 volts, the UB lamp lights, a minor alarm sounds, and the associated lamp lights.

- (5) Momentarily depress the UB ACO key. Observe that the UB GD lamp lights; the UB lamp is extinguished; the minor alarm is silenced; and the associated lamp is extinguished.
- (6) Operate the MAN-AUTO keys on the main and battery control boards to the AUTO position.

VOLTAGE CONTROLLER (FLOAT ALARM)

4.24 Test the low- and high-float voltage contacts of the voltage controller as follows, noting the approximate point when the audible and visual signals operate. (See circuit requirements table. Check voltage by observing battery control board panel meter.)

- (a) On the main control board, operate the MAN-AUTO key to the MAN position and the CHG-FLOAT key to the FLOAT position.
- (b) Operate the LOWER key on the main control board until the R relay remains operated.
- (c) After approximately 3 minutes, the 130V FLOAT lamp should light and a minor alarm should sound.
- (d) Restore the MAN-AUTO key to the AUTO position.
- (e) After the battery has stabilized and the alarm is silenced, operate the MAN-AUTO key to the MAN position.
- (f) Operate the RAISE key on the main control board until the L relay remains operated.
- (g) After approximately 3 minutes, the 130V FLOAT lamp should light and a minor alarm sound.
- (h) Operate the 130V FLOAT ACO key on the main control board. The 130V FLOAT lamp will be extinguished; the minor alarm will be silenced; and the 130V FLOAT GD lamp will light on the main control board.

- (i) Operate the MAN-AUTO key to the AUTO position to restore the circuit to normal.
- (j) Block the PF relay nonoperated.

Caution: *All charging units will shut down with the PF relay in the nonoperated position.*

- (k) Wait about 3 minutes until the indications in (g) are observed.
- (l) Remove the block from the PF relay which should silence the alarms.

130V HL OR EM CELL SW LAMPS

4.25 Check that the 130V HL or EM CELL SW lamp operates when emergency cells are brought into the circuit. The EM CELL SW lamp will not light until approximately 235 seconds after failure of the EMC switch to operate.

COUNTERCELL VOLTAGE CONTROL ALARMS

4.26 Countercells are cut in when the voltage is high and are cut out when the voltage is low.

VOLTAGE REGULATED AND G-ZERO RECTIFIER ALARMS

4.27 When a rectifier fails or is shut down due to high plant voltage, the RFA lamp in the rectifier and the AM lamp in the charge bay assembly light and ground is extended to the A, F, and AT leads to office alarms. Should the BAT SW switch be operated to the EC position, the AM lamp will light.

4.28 *High-Voltage Shutdown and Low-Voltage Alarms on Plants With All Voltage-Regulated*

Rectifiers: If a high plant voltage exists, with the EMC switch in the normal position, any regulated rectifiers furnishing approximately 30 percent or more of their full-load current rating are selectively shut down. To restore the rectifier to normal, operate the ON-OFF key to the OFF position and then to the ON position. In the event of a discharge voltage lower than 130 ± 0.7 volts, as determined by the LV relay, the LVA lamp will light after a short delay and ground will be sent over the A, FT, and AT leads to office alarms.

4.29 *High-Voltage Shutdown on G-Zero*

Rectifiers: If a high plant voltage exists, operation of the L and C01 relays sends ground over the HV lead to selectively shut down any G-zero rectifier furnishing 30 percent or more of its full-load current rating.

ALARM CHECK

4.30 *Plants of Less Than 25-Ampere Capacity:*

Insulate the top contacts 1 and 2 of the H1 relay and the bottom contacts 1 and 2 of the L1 relay in the countercell switching circuit.

- (1) Block the H1 relay operated.
- (2) Keep the relay blocked operated for about 3 minutes. After this time has elapsed, the CEMF CELL SW lamp should light and the major alarm sounds.
- (3) Remove the block from the H1 relay and block the L1 relay operated.
- (4) Wait for about 3 minutes until the indications described in (2) are observed.
- (5) Remove the block from the L1 relay and remove the insulation from the L1 and H1 relay contacts.

ALARM MULTIPLE

4.31 The alarm multiple should be checked to be sure that major and minor power alarms in other locations in the building will sound in conjunction with corresponding audible alarms in the power room.

5. TROUBLES

5.01 Plant troubles listed are only those in connection with the charge control circuit, which automatically connects or disconnects units of charging equipment, and the control, which automatically switches countercells or emergency cells into or out of the discharge circuit. Troubles in units of equipment, such as motor-generator sets, rectifiers, and regulators, are covered in the respective Bell System Practices.

5.02 The generator field rheostats are adjusted at the time of installation and should not require adjustment unless disturbed for some reason,

SECTION 167-705-301

such as the replacement of a rheostat or parts of a rheostat. In the event that trouble is encountered (due to inability to obtain the proper generator output and voltage), do not change the rheostat settings as the trouble is undoubtedly due to other conditions.

Caution: Before replacing a battery charge or emergency cell charge fuse, operate all CU STOP-NOR keys to the STOP position. These precautions will prevent the generators or rectifiers from starting when the blown alarm fuse is removed. After replacing the charge fuse and alarm fuse, restore the keys to their NOR position, starting with the lowest-numbered charging unit.

5.03 The following list shows all alarm lamps in alphabetical order, together with functions. Action to be taken is also given in some cases.

LAMP	INDICATES
CBS	Control battery supply fuse alarm and voltage control fuse blown. (See Note 1.)
CEMF CELL SW	Countercell switching circuit may be in trouble. Check discharge voltage.
CHG & MISC	Charge or miscellaneous fuse blown. (See Note 1.)
DISCHG	Discharge fuse blown. (See Note 1.)
DFL (at battery control board)	Discharge fuse blown (See Notes 1 and 2.)
FLOAT +130V FLOAT -130V	Float voltage alarm. Trouble in CU voltage control circuit. Operate ACO key to silence alarm.
FLOAT +130V GD FLOAT -130V GD	130V FLOAT alarm has been silenced by operation of ACO key.
GEN or RECT FAIL (at main control board)	Charging unit failure. Operate ACO key to silence alarm.
GEN or RECT FAIL GD	GEN FAIL alarm has been silenced by operation of ACO key.

LAMP	INDICATES
GEN or RECT FAIL (at the CU)	Control fuse blown or charging unit failure.
GEN PAN	CU panel fuse blown. Look for blown fuse on CU panels. (See Note 1.)
OFF-NOR (-130V)	EMC switch in OFF-NOR position.
RFA and AM	Regulated rectifier shut down. Look for blown CHG fuse in rectifier, blown REG fuse in battery control circuit, or high battery voltage.
+130V EM CELL SW -130V EM CELL SW	Failure of EMC switch to operate.
UB	Voltage unbalance between positive and negative batteries. Operate ACO key to silence alarm.
UB GD	130V UNBALANCE alarm has been silenced by operation of ACO key.

Note 1: Where alarm fuses are in parallel with supply fuses, replace blown supply fuse first and then the alarm fuse.

Note 2: Some plants have a DFL lamp at the top of each battery discharge fuse panel which gives a visual signal of any fuse failure in that bay.

5.04 Trouble Chart: The troubles and possible causes listed are not necessarily all-inclusive but are merely indicative of some of the difficulties that may be encountered when the 702C power plant is not operating normally. The operator can tell the trouble location by the designation of the lamp lighted on the generator bay, rectifier bay, or main control board. In the case of fuse alarms, Table B will assist the operator in locating the difficulty.

TROUBLE	POSSIBLE CAUSE
Battery voltage high or low	VR voltage controller out of adjustment, if voltage can be corrected by use of manual control keys.

TROUBLE	POSSIBLE CAUSE	TROUBLE	POSSIBLE CAUSE
Battery voltage high	<p>Voltage controller MAN-AUTO key in MAN position.</p> <p>Failure of motor-driven rheostat in generator or autotransformer in rectifier.</p> <p>Generator or rectifier TEST-NORMAL key in TEST position.</p> <p>Rectifier CB2 circuit breaker operated.</p> <p>Failure of tube in rectifier of negative plant of less than 25-ampere capacity.</p> <p>Regulated rectifier failure.</p> <p>Voltage controller CHG-FLOAT key in CHG position.</p>	Fuse panel voltage high	<p>Battery trouble.</p> <p>Control failed to switch countercells in circuit during charging.</p> <p>Control failed to switch emergency cells out of circuit after power was restored.</p> <p>130V EM CELL control out of adjustment.</p>
Battery voltage low	<p>Motor-generator or rectifier fails to start. Power failure or blown ac fuse.</p> <p>Load exceeds connected CU capacity. (See 3.15 Note.)</p> <p>CU STOP-NOR keys in STOP position.</p> <p>CU stopped. C, CHG, or VM & VR fuse blown.</p> <p>Rectifier CB1 circuit breaker operated.</p> <p>CU fails to start after replacing blown C, CHG, or VM & VR fuse. CU will not restart until STOP-NOR key has been put in STOP and then NOR position.</p>	Fuse panel voltage low	<p>Control failed to short circuit countercells or to switch emergency cells into circuit.</p> <p>130V EM CELL control out of adjustment.</p> <p>FR relay operates at too low a voltage or does not make good contact.</p>
		Set takes too long to connect to load	Delay relay in alarm circuit out of adjustment.
		Set operates properly but alarm comes in too quickly	Check the appropriate rectifier section.
		Rectifier line contactor operates but rectifier does not give output	Defective emergency cell switch control circuit.
		Emergency cell switch alarm operates with battery voltage within proper limits	Emergency cell MAN-AUTO switch is in MANUAL position. Trouble with EM CELL switching relay.
		Battery voltage low and emergency cell switch does not operate	

SECTION 167-705-301

TROUBLE	POSSIBLE CAUSE
Charge and miscellaneous discharge fuse alarm operates	Fuse blown, either battery or emergency cell charge, rectifier charge fuse, or miscellaneous discharge fuse. (See Caution after 5.02)
Generator panel fuse alarm operates	Fuse blown on generator panel. After replacing fuse, the set will not restart until STOP key has been operated to STOP position and then returned to NOR position.
CU failure alarm operates and all sets and rectifiers are stopped	Service failure or blown fuse in main supply to power service distributing cabinet.
Generator failure alarm operates with one set stopped when it should be running	Blown service fuse or defective motor-starter or start control circuit. If the start control circuit is defective, the set should start when the TEST key is operated to the TEST position with STOP key in NOR position. Shutdown due to overload.
Set starts but does not build up sufficient voltage to connect to load	No field or defective regulation circuit.
Rectifier not operating when it should be operating	Blown service fuse or CB1 circuit breaker operated. AC contactor not operated.

TROUBLE	POSSIBLE CAUSE
Regulated rectifier not operating	Blown service fuse or ground lead of C1 contactor open (CHG, A, or B fuse in rectifier or REG fuse in battery control circuit blown). High battery voltage.
Unbalanced voltages of positive and negative batteries	Positive or negative VR voltage controller out of adjustment. Rectifier out of adjustment. 130V HL relay out of adjustment.
Plate supply noisy.	One or more discharge filter capacitors or their fuses open. Capacitors aged. Generator brushes arcing.

5.05 Timers: Maintenance is not required on KS-8560 motor-driven timers or to thermal KS-16615 time delay relays. They should be replaced if they stick in the operated position or if the operating time is less than 1-1/2 minutes or more than 4 minutes.

5.06 OLA and OLR Rheostats: These rheostats should be replaced if they become defective in any respect.