702C POWER PLANT
MANUAL START CONTROL OF GENERATOR EQUIPMENT
OPERATING METHODS

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1. GENERAL

1.01 The 702C power plant provides positive or positive and negative 130-volt power for toll and telegraph systems requiring from 25 to 1000 amperes of current. The plant includes charging equipment and associated controls, batteries and emergency cells with controls, distribution equipment, and alarms.

1.02 This section is reissued to include procedures for connecting charging units across emergency cells and to update information. Since this is a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 Motor-generator sets are the normal charging equipment ranging in size from 25 to 300 amperes, the exception being the use of rectifiers where the negative load is less than 25 amperes. The control equipment provides for manual starting of the sets with options as to automatic or manual control of regulation, emergency cells, and countercells. One motor-generator for each positive or negative battery is operated continuously, and others are started and stopped manually as required to maintain the battery voltage and carry the discharge circuit load. A reserve set is normally furnished with these plants for use when one of the sets is disconnected from service for maintenance purposes.

1.04 The battery for each polarity normally consists of a string of 61 cells with two 4-cell groups of emergency cells and one 3-cell group of countercells. Two or more strings of cells may be permanently connected in parallel to meet current requirements. The emergency cells or countercells are connected or disconnected from the discharge circuit by manual or automatic means to maintain the discharge voltage within the required limits during emergency and overcharge periods. The emergency cells are continuously floated by unregulated rectifiers.

1.05 Where the negative load is less than 25 amperes, rectifiers are used to charge and float a 66-cell battery. The rectifiers are automatically regulated and connected to or disconnected from the battery as load variations require. Three groups of three countercells are connected to or disconnected from the discharge circuit under automatic control to maintain the voltage within the 125- to 135-volt limit during normal operation and power failure conditions. Under some conditions, the plant may be arranged for the use of an automatically started and regulated motor-generator set to secure rapid recharging of battery after

power failure and for routine charging. The generator is restarted after power is restored if the battery voltage is low for 6 minutes. The generator output is automatically increased until full-load current is reached or until the low contacts of voltage relay (VR) open. When the high contacts of voltage relay (VR) close, the generator output is reduced as governed by voltage relay (VR) until reverse current stops the generator set.

1.06 Alarms are provided to indicate the failure of a charge or discharge fuse or control fuse, that voltages are outside the proper limits, the failure of a motor-generator set, and the operation of the emergency switch.

Caution 1: This power plant includes automatically controlled equipment; care must be exercised to prevent accidental starting of parts of the plant on which maintenance work is to be done. Before starting work, prevent automatic starting of equipment by removing fuses, blocking relays, opening switches, etc, as necessary. When maintenance is completed, make sure that the circuit has been restored to normal.

Caution 2: Voltages inside the power plant are over 150 volts to ground and between terminals. Avoid all contact with terminals. Do not allow a test pick to touch two metal parts at the same time as dangerous and destructive short circuits may occur. Disconnect the ac supply before working on the power plant, except as necessary to make tests.

1.07 The following abbreviations are used in this practice.

cw—clockwise

ccw—counterclockwise

G1—Generator No. 1

CU—Charging Unit

NOR—any switch position marked NOR, NORM, or NORMAL.

1.08 Routine checks should be made during a period when they will not interfere with service.

1.09 A test load is required to make certain adjustments of motor-generator sets and rectifiers. The test load should be sufficient to absorb at least 125 percent of the output of the largest charging unit.

1.10 The instructions are based on the following schematic drawings. For detailed description of the operation of individual circuits, see the corresponding circuit descriptions.

MOTOR STARTER CIRCUIT

SD-81036-01	Motor Starter Circuit for Manual and Automatic Starters (A&M Only)
SD-81393-01	Motor Starter Circuit

GENERATOR START CONTROL CIRCUIT

SD-80996-01	Generator Regulation Circuit—Manual Start Control (A&M Only)

CHARGING GENERATOR CIRCUIT

SD-80997-01	Charging Generator Circuit—Manual and Automatic Regulation (A&M Only)
SD-81032-01	Charging Generator Circuit—Manual and Automatic Regulation—Reserve Generator (A&M Only-partially replaced by SD-81336-01)

RECTIFIER CIRCUIT

SD-81065-01	Rectifier Circuit—Metallic Type—Manual Regulation—20 Volts, 4 Amperes—J86230B
SD-81447-01	Application Schematic—For 100 Amperes, 160 Volts—Rectifiers
SD-81463-01	Rectifier Circuit—100 Amperes, 160 Volts—KS-15885 Rectifier
SD-81633-01	Rectifier Circuit—300 Amperes, 160 Volts—KS-19216 Rectifier

CHARGE CONTROL CIRCUIT

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

BATTERY CONTROL CIRCUIT

SD-81001-01	Battery Control Circuit—Manual Switching of Emergency Cells—Positive 125 to 135 Volts, 25 to 1000 Amperes (A&M Only)
SD-81021-01	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	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	Battery Control Circuit—Automatic Switching of Emergency Cells—Positive 125 to 135 Volts, 25 to 1000 Amperes
SD-81023-01	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	Battery Control Circuit—Automatic Switching of Emergency Cells—Positive and Negative 125 to 135 Volts, 50 to 1000 Amperes
SD-81024-01	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	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)

DISCHARGE CIRCUIT

SD-81015-01	Discharge Circuit—125 to 135 Volts (A&M Only)

POWER ALARM CIRCUIT

SD-80995-01	Power Alarm Circuit (A&M Only—Replaced by SD-80995-02)
SD-80995-02	Power 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 regulator, relays, etc, should be adjusted in accordance with the applicable sections and the circuit requirement tables on the circuit drawings.

2. LIST OF TOOLS AND TEST APPARATUS

CODE OR SPEC NO.	DESCRIPTION
TOOLS	
365	Connecting Clip
411B	Test Pick
—	Blocking and insulating tools as required. (Use tools and apply in accordance with Section 069-020-801.)
TEST APPARATUS	
KS-14510	Volt-Ohm-Milliammeter
W1AF	Cord (8-1/2 feet long equipped with one 360A tool at each end)
W1AY	Cord (8-1/2 feet long equipped with one 360A tool at each end)

Note: Equivalents may be substituted where desired.

3. OPERATION

PREPARING TO START

3.01 When preparing to put the plant in service, check the following.

(a) Motors and motor-generators are clear of any obstructions and are free to run.

(b) The NOR-STOP keys are in the STOP position.

(c) The correct size fuses are in place.

(d) The rectifiers are prepared to start in accordance with the appropriate Bell System Practices.

(e) The emergency cell switches are closed in the FLOAT or NOR positions.

OPERATION OF PLANT

3.02 To place the plant in service, proceed as follows.

(a) ***In Plants With Manual Regulation and Manual Emergency Cell Control—***

(1) Operate the battery control switches on the main control board to the FLOAT, NOR, and EM G1 positions.

(2) On the generator control board, rotate the generator field rheostat fully in the LOWER direction.

(3) Place the motor-generators in service as described in 3.03 and 3.05.

(b) ***In Plants With Automatic Regulation and Automatic or Manual Emergency Cell Control—***

(1) Operate the MANUAL-AUTO switch to AUTO.

(2) Operate the generator control rheostat to the BAT position.

(3) Place the motor-generator in service as described in 3.07 and 3.09.

A. Starting and Stopping Motor-Generator Sets

3.03 ***Starting and Connecting a Motor-Generator Set With Manual Regulation:***

(1) Determine that the generator field rheostat is rotated completely in the LOWER direction.

(2) Operate the BAT-EM CELL switch to the BAT or EM CELL position, as required.

(3) Start the set by operating the pushbutton at the starter or by operating the handle of the starting compensator to the START position until the set comes up to speed (no further rise in the tone or pitch of the set) and then operate the handle to the RUN position.

(4) Slowly rotate the field rheostat in the RAISE direction until the circuit breaker automatically closes. Continue to rotate the field rheostat in the RAISE direction until the output current is at the desired value.

3.04 ***Stopping a Motor-Generator Set With Manual Regulation:***

(1) Rotate the field rheostat in the LOWER direction until the output of the set is reduced to zero, transferring the load, if possible, to one or more other sets.

(2) Operate the release or OFF button at the motor starter.

Note: Reverse current will automatically open the circuit breaker.

(3) Operate the BAT-EM CELL switch to the open (horizontal) position.

3.05 ***Starting a Reserve Generator With Manual Regulation:***

(1) Operate the +130—-130 GEN REG switch to the +130 or -130 position, depending on whether the battery plant is positive or negative.

(2) Rotate the generator field rheostat in its maximum LOWER direction.

(3) Set BAT-EM CELL switch to BAT.

(4) Set STOP-NOR switch to NOR or set the handle of the starting compensator to START until the set reaches the proper speed (no further rise in the tone or pitch of the set) and then operate the handle to the RUN position.

(5) Slowly rotate the field rheostat in the RAISE direction until the circuit breaker automatically closes. Continue to rotate the field rheostat in

the RAISE direction until the output current is at the desired value.

3.06 ***Stopping a Reserve Generator With Manual Regulation:***

(1) Rotate the generator field rheostat in the LOWER direction until the output of the set is reduced to zero, transferring the load, if possible, to one or more other sets.

(2) Operate the STOP-NOR switch to STOP or depress the release button at the motor starter.

(3) Operate either the +130—NOR or–130—NOR switch to NOR, depending upon whether the plant is a positive or negative plant.

(4) Operate the BAT-EM CELL switch to the open (horizontal) position.

3.07 ***Starting and Connecting a Motor-Generator With Automatic Regulation:***

(1) Operate the LOWER key on the generator control panel to determine that the motor-generator is in the "all resistance in" position. Determine that the RL relay does not operate.

(2) If the generator is to be connected across battery only, determine that the manually operated generator control rheostat is positioned to the line on the control panel designated BAT.

Note: If the generator is to be connected across both the battery and emergency cell, the rheostat should be positioned to the line designated EM CELL or BAT & EM CELL.

(3) Operate the BAT-EM CELL switch to BAT or EM CELL position, as required.

(4) If the set is equipped with an automatic starter, operate the STOP-NOR key to the NOR position. If the set is equipped with a manual starter, operate the handle of the start compensator to the START position until the set comes up to speed (no further rise in the tone or pitch of the set) and then operate the handle to the RUN position.

(5) Operate the RAISE key on the generator panel to operate the motor-driven rheostat until the CA and CB contactors operate. Continue to operate the RAISE key until the output of the set is at the desired value.

(6) If the generator set is to be used for regulating the battery voltage, operate the CHG-FLOAT key on the voltage regulator to FLOAT and operate the VR key from the OFF position to select the generator to be regulated.

3.08 ***Stopping a Motor-Generator Provided With Automatic Regulation:***

Note: If the generator set being removed from service is being used for regulating the battery voltage, start the associated generator set (which is arranged for automatic voltage regulation) as described in 3.07 before disconnecting the generator set being removed from service.

(1) Operate the VR key to select another automatically regulated generator.

(2) Operate the LOWER key on the generator control panel to reduce the output of the generator until the motor-driven rheostat is in the "all resistance in" position.

(3) Release and operate the LOWER key to determine that the RL relay does not operate, thereby indicating that the rheostat is in the "all resistance in" position.

(4) If the generator set is provided with an automatic starter, operate the STOP-NOR switch to STOP. If the generator set is provided with a manually operated motor starter, depress the release button on the front of the starter.

Note: Reverse current will automatically open the circuit breaker.

(5) Operate the BAT-EM CELL switch to the open (horizontal) position.

3.09 ***Starting a Reserve Generator With Automatic Regulation:***

(1) Operate either the +130—NOR or -130—NOR switch to the +130 or -130 position, depending

upon whether the plant is a positive or negative plant.

(2) Operate the LOWER key on the generator control panel to determine that the motor-driven rheostat is in the "all resistance in" position. Determine that the RL relay does not operate.

(3) If the generator is to be connected across the battery only, determine that the manually operated rheostat is positioned to the line on the control panel designated BAT.

Note: If the generator is to be connected across both the battery and emergency cell, the rheostat should be positioned to the line designated EM CELL or BAT & EM CELL.

(4) Operate the BAT-EM CELL switch to BAT or EM CELL position, as required.

(5) If the generator set is provided with an automatic starter, operate the STOP-NOR switch to the NOR position. If the generator is provided with a manual starter, operate the starter switch to the START position until the set comes up to speed (no further rise in tone or pitch of the set) and then operate the starter switch to the RUN position.

(6) Operate the RAISE key on the generator panel until CA and CB contactors operate. Continue to operate the RAISE key until the output of the set is at the desired value.

(7) If the generator set is to be used for regulating the battery voltage, operate the CHG-FLOAT key on the voltage regulator to FLOAT and operate the VR key from the OFF position to select the generator to be regulated.

3.10 ***Stopping a Reserve Generator With Automatic Regulation:***

Note: If the generator set being removed from service is being used for regulating the battery voltage, start the associated reserve generator set which is arranged for automatic voltage regulation as described in 3.09 before disconnecting the generator set being removed from service.

(1) Operate the VR key to select another automatically regulated generator.

(2) Operate the LOWER key on the generator control panel to reduce the output of the generator until the motor-driven rheostat is in the "all resistance in" position.

(3) Release and operate the LOWER key to determine that the RL relay does not operate, thereby indicating that the rheostat is in the "all resistance in" position.

(4) If the generator is provided with an automatic motor starter, operate the STOP-NOR switch to STOP. If the generator set is provided with a manually operated motor starter, depress the release button on the front of the starter.

Note: Reverse current will automatically open the circuit breaker.

(5) Operate the BAT-EM CELL switch to the open (horizontal) position.

B. Boost Charging

3.11 ***Boost Charging Main Battery:***

(a) If battery checks indicate that the battery is to be charged, operate the FLOAT-CHG key in the regulating circuit to CHG.

Note: With the FLOAT-CHG key in the CHG position, the automatic regulation circuit will make the necessary adjustments to increase the battery voltage to the charge value.

(b) The manually operated motor-generator sets must be adjusted for charge voltage using the hand operated rheostat. Adjust for a charge voltage of 2.2 volts per cell.

(c) If CEMF cells are automatically controlled, the circuit voltage will be automatically maintained within the proper limits. If, however, these cells are manually controlled, the voltage alarm will sound when the battery voltage rises sufficiently. The CEMF cells must then be cut into the discharge circuit.

(d) When the regular cells of the battery are being charged and the voltage rises to cause a high-voltage alarm, operate the center EM switch to NOR and the left-hand EM switch to CHG.

(e) When the battery is being charged during the heavy load period of the day, observe the temperature of the CEMF cells.

Caution: If the temperature rises to 130 degrees Fahrenheit, operate the FLOAT-CHG key to FLOAT. Add water to CEMF cells, if necessary, and after the battery temperature returns to 90 degrees Fahrenheit or approximately room temperature, operate the FLOAT-CHG key to CHG.

(f) When the charge is completed, reduce the output of each manually regulated generator approximately 50 percent. After the battery voltage decreases to the float value, operate the FLOAT-CHG key to FLOAT. Readjust the output of the manually controlled generators to the necessary values to carry the load.

C. Emergency Cells

3.12 *Charging Emergency Cells:*

(a) ***General:*** Any trickle charger in use may be left connected. The emergency cells will be charged in series with the regular battery. The charging rate through the emergency cells will vary with load conditions; therefore, the generator capacity to be connected across the battery and emergency cells will depend upon the office load. Generator capacity, not exceeding the normal rate of the emergency cells, should be used for this purpose except in the case of an emergency which has discharged a considerable part of the battery capacity. Under this condition, additional generators may be used if load conditions permit, but under no conditions should the cells be charged at more than twice normal rate.

(b) ***Cell Temperature:*** If the electrolyte temperature reaches 110 degrees Fahrenheit before the charge is completed, the charging rate should be reduced 50 percent by transferring generators from the emergency cell charging bus to the battery bus. If both the battery and emergency cells are being charged at the same time, the Caution in 3.11 regarding CEMF cell temperature should be observed.

(c) ***Boost Charging Main Battery With Emergency Cells:*** If both the battery and emergency cells are to be charged at the same time, follow the procedures in (1) through (4) to charge the emergency cells in series with the battery.

(1) From left to right, set the EM switch to CHG, EM, and G1 & G2.

(2) Set BAT-EM CELL switch on generator control panel to EM CELL.

(3) Set STOP-NOR switch on generator panel to NOR.

(4) Hold RAISE key operated until the charge voltage level is reached.

(d) ***Transfer of Generator From Main Battery to Emergency Cell:*** To transfer a generator from battery to emergency cell charging position, proceed as follows.

(1) Reduce the generator output to zero as outlined in 3.04, 3.06, 3.08, or 3.10.

Note: It is not necessary to stop the set, by means of the motor starter, in (1).

(2) Set the right-hand EM switch to the position for the emergency cell group or groups to be charged.

(3) Set BAT-EM CELL switch to EM CELL.

(4) Connect generator set to the load in accordance with 3.03, 3,05, 3.07, or 3.09.

(5) If both battery and emergency cells are to be charged, operate the FLOAT-CHG key of the regulation circuit to CHG.

Note: When the emergency cells are to be charged, if more than one generator is in use, the generator to be automatically regulated should be connected across only the battery in order to obtain close voltage regulation on the discharge bus bars.

(6) If battery conditions require changing the position of the right-hand EM switch from G1 & G2 to G1 when using a manually regulated generator, first reduce the output of the generator being used to 50 percent of normal output.

(7) Operate the right-hand EM switch to G1 and adjust the manual field rheostat for the desired output. If the battery control panel is provided with motor-driven rheostats, operate the RAISE or LOWER key until the desired output is obtained.

3.13 ***Manually Controlled Emergency Cell Switches:***

(a) ***Power Failure or Emergency Condition:*** In the event of a power failure or other conditions which prevent maintaining the battery voltage by means of generators, the emergency cells shall be cut into the discharge circuit as follows when the low-voltage alarm operates.

(1) Operate the outside EM switches to FLOAT and G1 and the center switch to EM.

(2) When the low-voltage alarm operates again, set the right-hand EM switch to G1 & G2.

(3) If the high-low voltage alarm sounds due to high voltage, operate the right-hand EM switch to G1.

(4) If the high-low voltage alarm sounds a second time due to high voltage, operate the center EM switch to NOR.

(b) ***Regular Battery Cell Charge:*** If the regular cells of the battery are being charged, the high voltage alarm sounds due to high voltage and the center EM switch is set to NOR, operate the left-hand EM switch to CHG, which connects the CEMF cells into the discharge circuit.

(c) ***Boost Charge of Main Battery With Emergency Cells:*** If it is necessary to charge emergency cells in series with the regular cells of the battery, operate the center EM switch to NOR and the right-hand EM switch to G1 & G2.

3.14 ***Automatically Controlled Emergency Cell Switches:***

Note: The emergency and CEMF cells are automatically cut into or out of the discharge circuit under voltage control.

(a) Do not operate manual RAISE or LOWER keys unless alarms are received indicating existence of high- or low-voltage condition.

(b) If it is necessary to switch emergency and CEMF cells by manual control, proceed as follows.

(1) Operate the MAN-AUTO key to MAN.

(2) Momentarily operate the RAISE or LOWER keys.

(3) Repeat the operation of the keys for each group of cells to be cut in or out.

(c) To charge the emergency cells, set the right-hand EM switch to G1 or G1 & G2, as required.

D. Prevention of Emergency Cell Polarity Reversal

3.15 ***General:*** If, during an extended interval with emergency ac power, the emergency engine does not have the capacity to operate sufficient charging units to maintain the battery at float voltage, the emergency cells may be damaged by reversal of polarity. To prevent this, connect the charging units across the main battery and emergency cells as described in 3.17 and 3.18.

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

3.16 ***Switching Charging Units From Main Battery to Connection Across the Main Battery and Emergency Cell:***

Note: In plants where all groups of the emergency cells connect in series only, the manually operated right-hand EM switch on the control panel should be closed to the

desired position before switching the charging units.

(1) Remove the last charging unit from service in accordance with 3.06, 3.08, and 3.10.

(2) If the charging unit is a generator, set the generator field rheostat and BAT-EM CELL switch to EM CELL.

(3) If the charging unit is a rectifier, set the rotary switch to EC.

(4) Restore the charging unit to service in accordance with 3.05, 3.07, and 3.09.

(5) If more than full load of the last charging unit is required, switch the preceding charging units.

(6) If less than full load of any charging unit is required, operate the TEST-NOR key to TEST and adjust the output using the RAISE and LOWER keys or the generator field rheostat.

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

(1) Remove the highest numbered charging unit from service in accordance with 3.06, 3.08, and 3.10.

(2) If the charging unit is a generator, operate the generator field rheostat and BAT-EM CELL switch to BAT.

(3) If the charging unit is a rectifier, operate the rotary switch to F.

(4) Restore the charging unit to service in accordance with 3.05, 3.07, and 3.09.

(5) If succeeding charging units are not required for charging emergency cells, change connections as given in (1) through (3).

(6) If the manually operated right-hand EM switch is to be operated to the G1 position and the charging units are charging the emergency cells, operate the TEST-NOR keys of these charging units to TEST and operate the LOWER keys or adjust the generator field rheostat to reduce output approximately 50 percent.

(7) Operate the right-hand EM switch to the G1 position.

(8) In plants using voltage regulated rectifiers, switching is accomplished by setting the associated BAT switch from EC to F.

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

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

(2) Using a portable voltmeter, check all of the batteries for a reversal of polarity in accordance with 157-601-301. (See note.)

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

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

E. Negative Battery Plants of 25-Ampere Capacity or Less

3.19 ***Normal Operation:*** Operate all rectifier ON-OFF keys to the ON position. All of the rectifiers will start if the battery voltage is low and will automatically disconnect if not required to float the load at 142 volts. In normal operation, the rectifiers will connect and disconnect automatically as required by the load.

(a) ***Charging:*** Operate the NOR-CHG key to CHG. This changes the regulated voltage of the rectifiers and the voltage range of the

voltage relay (VR). If the low contact of the voltage relay (VR) remains closed for 6 minutes and a motor-generator set is provided for use with the negative battery plant, the set will automatically start and stop if the control keys on the generator panel are in the NOR position. The motor-generator set operates in a similar manner after power failure.

(b) ***To Discontinue Charging:*** Operate the NOR-CHG switch to the NOR position.

(c) ***To Stop Rectifiers:*** Operate the AC ON-OFF key to the OFF position. If maintenance work is to be done, remove the CHG G- fuse in the rectifier and the RC fuse for the control. When maintenance work is completed, replace the fuses and operate the AC ON-OFF key to ON.

Caution: Voltage of approximately 150 volts to ground is present on terminals of the rectifier when the ON-OFF key is operated to OFF and the fuses are removed. An unfused battery lead provides starting of another rectifier on standby if an increasing load requires it. All idle rectifiers will be started if the low contacts of the voltage relay (VR) close; however, only the rectifiers necessary to float the battery and load will remain connected.

4. ROUTINE CHECKS

4.01 As often as local experience demands, the relays should be inspected for condition of contacts, making sure that they are in accordance with the circuit requirements and Bell System Practices which apply.

4.02 Electrolytic capacitors should be maintained in accordance with Section 032-110-701.

4.03 In negative battery plants of 25 amperes or less, periodically remove from service as many of the rectifiers usually in service as necessary to cause starting of all infrequently used rectifiers and the motor-generator set, if provided. This procedure should be completed to determine that the infrequently used equipment and associated controls are in good working condition.

4.04 Where automatic voltage regulation is used, observation of the float voltage and float voltage limits should be made in accordance with schedules in Section 157-601-301, Storage Batteries—Continuous Float Operation, and readjustments made, if required.

4.05 Where automatic control of emergency cells and countercells is used, check the operation of this equipment by charging the main battery long enough to cause the countercells to be connected to the circuit. Remove as many of the charging units from service as necessary to cause one group of emergency cells to be connected to the circuit. Observe the voltages prior to switching and make readjustments in the control, if required.

4.06 The dc output should be checked periodically to determine that it is correct.

CIRCUIT CHECKS

4.07 ***Adjustment of Motor-Driven Field Rheostat:***

(1) Shut down the motor-generator set as described in 3.04, 3.06, 3.08, or 3.10.

(2) Block the FR relay operated.

(3) Operate the LOWER key and determine that the motor-driven rheostat is in the "all resistance in" position.

Note: If the RL relay does not operate, the rheostat should be in the correct position.

(4) Start the motor-generator set by the pushbutton at the starter, by hand operation of the starter, or by operating the NOR-STOP (OFF) key to NOR.

(5) Adjust the motor-driven rheostat so that when the set starts, the generator voltage will build up to 110 to 115 volts. Mark this point on the motor-driven rheostat for a temporary reference.

(6) Set the BAT-EM CELL switch to BAT, or in case of the reserve motor-generator, set the BAT-EM CELL switch to BAT and the +130V—-130V switch to the desired position.

(7) Operate the RAISE key until the CA circuit breaker and reverse current CB relay close.

(8) Continue to operate the RAISE key until the motor-driven rheostat is adjusted to full-load current with a battery voltage of approximately 142 volts.

(9) When the generator reaches full load, operate the LOWER key to decrease generator output, allowing time for the battery voltage to decrease.

(10) Determine that the generator goes to no load with the generator cold and with a battery voltage of 128 volts.

Requirement: The motor-driven rheostat "all resistance in" position will be the point located in (2) through (5) or (8) and (9) depending on which results in the most resistance in the rheostat.

(11) Determine that the "all resistance in" limit switch is adjusted to open at the point of greatest resistance on the rheostat given in the requirement in (10).

(12) Operate the NOR-STOP switch to STOP.

(13) Remove blocking tool from the FR relay.

(14) Restore the generators to service as covered in 3.03, 3.05, 3.07, or 3.09.

4.08 ***Adjustment of Manually Operated Rheostat in Plants With Automatic Regulation and Automatic or Manual Emergency Cell Control:***

(a) Determine that the manually operated rheostat arm is set in the position which will make the effective resistance equal to that shown on the nameplate of the associated generator. This position should be marked BAT.

(b) If this resistance value is not given, determine the rheostat arm position by increasing the load to obtain rated, full-load amperes from the generator at 142 volts with the machine hot (run at full load for at least an hour), and with the motor-driven rheostat resistance all cut out.

Note: For a generator used with a 66-cell battery on which the load is normally less than 25 amperes, the manual rheostat should be set to secure 148 volts at full load with the generator hot and the motor-driven rheostat all cut out. This position should be marked with a line on the front of the panel. The motor-driven rheostat will have the "all resistance in" limit switch adjusted as in 4.07, but at 138 volts instead of 128 volts.

4.09 ***Adjustment of Manual Field Rheostat for Charging Emergency Cells:***

(1) Shut down the motor-generator sets as described in 3.04, 3.06, 3.08, or 3.10.

(2) Emergency cell control—

(a) Manual—operate the manual emergency cell switches to the CHG, EM, and EM G1 & G2 position.

(b) Automatic—operate the manual EM CHG switch to the G1 & G2 position.

(3) Operate the BAT-EM CELL switch on the generator control panel to the EM CELL position.

(4) Operate the NOR-STOP switch on the generator control panel to NOR.

(5) Operate the RAISE key with the generator connected to battery and to both groups of emergency cells.

(6) Hold the RAISE key operated until the motor-driven rheostat is in the "all resistance out" position.

(7) Adjust the manually operated field rheostat until the generator is delivering rated, full-load current at 160 volts.

(8) Operate the LOWER key and decrease the generator output to no load.

(9) Emergency cell control—

(a) Manual—operate the manual emergency cell switch to the EM G1 position, removing a single group of emergency cells.

(b) Automatic—operate the manual EM CHG switch to the G1 position, removing a single group of emergency cells.

(10) Adjust the generator output by the motor-driven rheostat for a no-load condition at 141 volts, or until the "all resistance in" position is reached. If necessary, adjust the manual field rheostat to secure a no-load condition at 141 volts.

Requirement: This position of the manual field rheostat should be marked EM CELLS on the front of the panel. On some generators the setting of the manually operated rheostat marked BAT will also meet the requirements for emergency cell charging, in which case the position should be BAT & EM CELL.

(11) Operate the NOR-STOP key to STOP.

(12) Operate the BAT-EM CELL switch on the generator panel to BAT.

(13) Operate the battery control switches to the FLOAT, NOR, and EM G1 positions.

(14) Restore the generators to service as described in 3.03, 3.05, 3.07, or 3.09.

4.10 ***Overload (OL) Relay Adjustment:*** With the OL and OL1 relays adjusted to meet the current flow values given in the circuit requirements table, check the adjustment of the OLA and OLR rheostats as follows.

Note: The OL relay is provided to prevent excessive overload on a generator when used with automatic regulation. The relay should operate when the output current of the generator rises to between 110 and 115 percent of the generator current rating and release when the current has been reduced to between 85 and 100 percent of the rating. Operation of the OL relay causes the OL1 relay to operate, which in turn causes the generator rheostat to reduce the generator output.

(1) Shut down the motor-generator set as described in 3.04, 3.06, 3.08, or 3.10.

(2) Move the high contact of the AR ammeter relay to the extreme right position.

(3) Operate the BAT-EM CELL switch to the open (mid) position.

(4) Connect the test load through a fuse (125 percent of generator current rating) between the hinge clip of the BAT-EM CELL switch and ground (leaving the switch open).

(5) Connect the KS-14510 volt-ohm-milliammeter, set to the 0.3 VOLT DC range, across the AR ammeter relay connections on the shunt.

(6) Operate the NOR-TEST switch to TEST.

(7) Operate the NOR-STOP switch to NOR.

(8) Increase the output current of the generator by rotating the manual rheostat in the RAISE direction and adjusting the test load until the KS-14510 volt-ohm-milliammeter indicates 275 to 287.5 millivolts (110 to 115 percent of generator rating).

Requirement: The OL relay operates (indicated by operation of OL1 or OLS relay).

(9) If the requirement in (8) is not met, rotate the OLA rheostat cw to increase the level at which the OL relay operates or ccw to decrease the level.

(10) Slowly reduce the generator output using the manual rheostat until the KS-14510 volt-ohm-milliammeter indicates 250.0 millivolts (100 percent of generator current rating).

Requirement: The OL relay remains operated.

(11) Slowly reduce the generator output until the KS-14510 volt-ohm-milliammeter indicates 212.5 millivolts (85 percent of generator current rating).

Requirement: The OL relay releases before the KS-14510 volt-ohm-milliammeter indicates 212.5 millivolts.

Note: If the output of the generator is less than 85 percent when the OL relay releases, cut strap "F" between the OLA and OLR rheostats, and then with the generator carrying 85 percent of generator rating, slowly rotate OLR potentiometer cw until the OL relay releases. The OL relay normally releases within limits. Removal of the strap is required only in exceptional cases.

(12) If the OL relay circuit requires adjustment, repeat (8) through (11) to check the operation of the OL relay.

(13) Reduce the generator output to zero.

(14) Operate the NOR-STOP key to STOP.

(15) Disconnect the artificial load connected in (4).

(16) Disconnect the KS-14510 volt-ohm-milliammeter.

(17) Reset the AR ammeter high contact to original position.

(18) Restore the generator to service as covered in 3.03, 3.05, 3.07, or 3.09.

4.11 ***AR Ammeter Relay Contact Check:***

(a) The AR ammeter relay high contacts shall be set to close on a current equal to the full-load ampere rating of the generator.

(b) The low contact requires no adjustment except for an automatically started and controlled generator in a small negative plant where it should be set for a reverse current of 1 to 2 percent of the generator full-load current.

4.12 ***Fuse and Alarm Checks:***

(1) Test all fuse-failure alarms and indications as given in Table A.

Note: Analyze the test indication shown in Table A prior to applying the test voltage or test ground to determine whether the test would shut down essential equipment. If the

TABLE A

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

NOTES:

1. Fuses listed do not appear in all plants.
2. CBS lamp lights on MCB; PWR lamp lights in emergency engine room; major alarm bell rings.
3. CHG & MISC lamp lights on MCB; PWR lamp lights in emergency engine room; minor alarm bell rings.
4. 130V EM CELL SW lamp lights on MCB; PWR lamp lights in emergency room; major alarm bell rings (Note 8).
5. DISCHG lamp lights on MCB; PWR lamp lights in emergency engine room; major alarm bell rings, if provided DFL lamp lights on BCB.
6. 130V FLOAT lamp lights on MCB; PWR lamp lights in emergency engine room; minor alarm bell rings (Note 8).
7. 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).
8. In some plants alarm operation is delayed 3 minutes by thermal relay.

equipment would be shut down, postpone these tests to a lighter load period.

Caution: Avoid shock by firmly attaching the cap to the tool-holder barrel and holding the cap only.

(2) Fuse (35-Type): Using a W1AF cord equipped with two 360 tools and a 365 clip or a 411B test pick in each end, connect the test battery or ground to the alarm bay or stud immediately under the fuse associated with the alarm being tested.

(3) Fuse (70-Type): Using the KS-14510 volt-ohm-milliammeter, test for no voltage or dead ground on the alarm lead of all 70-type fuses except the CHG fuse.

Requirement: The KS-14510 volt-ohm-milliammeter indicates at least 200 ohms.

Note: During a fuse alarm check, false grounding of the alarm circuit can cause severe arcing. Do not insert the test prod past the metal collar just inside the fuse holder cap because this may cross the battery connection on the top of the fuse with the alarm circuit.

(4) Using a W1AY cord equipped with a 360 tool and a 411B test pick in each end, test the alarm circuit of 70-type fuses that are mounted in individual fuse blocks by inserting the tip of the 411B tool into the aperture provided in the fuse block cover, for the alarm to be tested, and touch the alarm bar.

(5) Using a W1AY cord equipped with a 360 tool and a 411B test pick in each end, test the alarm circuit of the 70-type fuses mounted in a modular fuse block (such as the 22- or 23-type block) by inserting the tip of the 411B tool into the aperture provided in the fuse block cover, for the alarm to be tested, and touch the alarm bar.

(6) Fuse Alarms (Alarm-Type Fuse Shunting a Larger Fuse): Remove the alarm-type fuse associated with a larger fuse.

(7) Using a W1AF cord equipped with two 360 tools and a 365 clip or a 411B test pick in each end, connect first one and then the other alarm fuse terminal to the fuse alarm stud or bar.

Requirement: The alarm operates while the cord is connected.

(8) Replace the alarm-type fuse.

(9) Fuse Alarm (Circuits Supplied Through an Alarm-Type Fuse): Using the cord described in (7), connect one test pick on the cord to the terminal at the side of any fuse which is covered by the alarm under test and momentarily connect the other test pick on the cord to the associated alarm stud or alarm box.

Requirement: The alarm operates while the cord is connected.

(10) Charging Unit Failure Alarm: If the charging unit is not idle, remove it from service as described in 3.04, 3.06, 3.08, or 3.10.

(11) Operate the associated switch or circuit breaker supplying ac power to the unit to OFF or carefully remove power input fuses.

(12) Operate all keys to normal position.

Requirement: The GEN FAIL or RECT FAIL lamp on the unit under test lights and the GEN FAIL lamp on the main control board lights after a delay of 1 to 3 minutes. The PWR lamp in the emergency engine room lights and the minor alarm bell sounds.

(13) Operate the GEN FAIL ACO key on the main control panel.

Requirement: On the main control panel, the GEN FAIL GD lamp lights and the GEN FAIL lamp extinguishes. The PWR lamp in the emergency engine room extinguishes and the minor alarm bell is silent.

(14) Operate the STOP-NOR key and set circuit breakers to ON or replace fuses.

(15) Restore charging unit to service as described in 3.03, 3.05, 3.07, or 3.09.

4.13 ***Emergency Cell Float Voltage Check:*** A disc-type unregulated rectifier is provided to float the emergency cells and is permanently

connected to them. The adjustment is secured by trial and should be made when the cells have been fully charged and when the supply voltage is normal. A continuously tapped autotransformer in the rectifier provides means for changing the rectifier voltage and thereby, its output current. The adjustment selected should be the one which will hold the voltage nearest to 2.17 volts per cell favoring a slightly higher rather than a lower voltage. This adjustment should be checked from time to time as the battery and rectifier age. It is not necessary to disconnect the rectifier after a power failure during which the cells have been discharged or during a recharging period.

5. TROUBLES

5.01 Plant troubles listed are only those in connection with 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, regulators, etc, are covered in the respective Bell System Practices.

5.02 ***Trouble Chart:*** Should any of the following troubles occur, check the possible causes listed.

> ***Caution: Before replacing a battery or an emergency cell charge fuse, shut down all operating generators and rectifiers associated with the particular battery. After replacing the fuse, restart the generators and rectifiers in the usual manner.***

TROUBLE	POSSIBLE CAUSE
Battery voltage high or low	Voltage controller VR out of adjustment if voltage can be corrected by use of manual control keys.
	Voltage controller key in OFF position.
	Failure of motor-driven rheostat.
	Rectifier out of adjustment.
	Failure of tube or solid state component in rectifier.
Battery voltage high	Voltage controller CHG-FLOAT key in CHG position.
	Unregulated generator output exceeds load.
Battery voltage low	Load exceeds connected generator capacity or unregulated generator output should be increased.
	Power failure or blown ac fuse.
	CHG fuse blown.
	Generator stopped. CHG or VM and VR fuse blown.
Generator fails to start after replacing blown CHG or VM and VR fuse	Set will not restart until NORMAL-STOP key has been put in STOP position.
Fuse panel voltage high	Control failed to put countercells in circuit during charging.
	Control failed to switch emergency cells out of circuit after power was restored.
	130V EM CELL controller out of adjustment.
Fuse panel voltage low	Control failed to short-circuit countercells or to put emergency cells into circuit.
	130V EM CELL controller out of adjustment.
Unbalanced voltages of positive and negative batteries	Positive or negative voltage controller VR 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.

5.03 If trouble is not found, look for open connections.

5.04 ***Motor-Driven Timers TD1 and TD2:*** In the absence of instructions to the contrary, no maintenance need be given to motor-driven timers as indicated by KS-8560. 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.

5.05 ***OLA and OLR Rheostats:*** These rheostats are totally enclosed and should be replaced if they become defective in any respect.