

167-621-301

302A POWER PLANT

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Manual Operation of Plant	17	1.01 This section describes the operation of 302A power plants (J86434) arranged for voltage regulation, automatic start control of motor-generator sets and/or rectifiers, and auto- matic control of emergency cell switching. The usual operating routines are covered, and appa- ratus adjustments are described that apply par- ticularly to this plant which are not covered in other sections. For day-to-day maintenance, ex- cept battery equipment, it should not be neces- sary to refer to other sections unless defective apparatus or apparatus out of adjustment or needing other maintenance attention, such as lubrication or cleaning, is involved. Refer to the battery sections for specific information on bat- teries.	
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Caution: This plant includes automatically controlled equipment, and 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 work has been completed, make sure that the circuit has been restored to normal.

SECTION A301.817

1.02 This section is reissued to add information on the J86273 rectifier. Since this reissue covers a general revision, the arrows ordinarily used to indicate changes, have been omitted.

1.03 Routine checks should be made during a period when they will cause the least service reaction.

1.04 Certain abbreviations have been used in this section to make the reading as easy as possible. They are listed below.

- cw — clockwise rotation
- ccw — counterclockwise rotation
- G1 — generator No. 1
- G2 — generator No. 2
- G- — generator No. 1 or No. 2
- G3-G7 — generators No. 3 to No. 7
- G-X — any one of generators No. 3 to No. 7
- G-H — the highest numbered charging unit of the plant when it is a generator
- R1 — rectifier No. 1
- R2 — rectifier No. 2
- R3-R7 — rectifiers No. 3 to No. 7
- R-X — any one of rectifiers No. 3 to No. 7
- R-H — the highest numbered charging unit of the plant when it is a rectifier
- CU — charging unit
- CU1 — charging unit No. 1
- CU2 — charging unit No. 2
- CU3 — charging unit No. 3
- CU-X — any one of charging units No. 3 to No. 7
- CU-H — the highest numbered charging unit of the plant
- NOR — any key position marked as NOR, NORM, or NORMAL

1.05 The instructions are based on the drawings listed below. For detailed descriptions of the operation of individual circuits, see the corresponding circuit descriptions. Also, refer to Fig. 6.

- SD-80836-01 — Battery Control Circuit—24 and 28 Volts
- SD-80838-01 — Battery Control Circuit — 24 Volts

SD-80965-01 — Calculation of Equipment and Lead Sizes

SD-80966-01 — Discharge Circuit — 24 and 48 Volts

SD-81060-01 — DC Power Alarm Circuit

SD-81061-01 — Power Audible Alarm Circuit

SD-81064-01 — Rectifier Circuit — J86220B

SD-81109-01 — 24-volt CEMF Cell Control Circuit

SD-81121-01 — Battery Control Circuit — 48 Volts

SD-81129-01 — Rectifier Circuit — J86249

SD-81147-01 — Voltage Regulator and Exciter — J86250

SD-81148-01 — Charge Control Circuit — 48 Volts

SD-81155-01 — Charging Generator Circuit — With Motor-driven Rheostat

SD-81160-01 — Charging Generator Circuit — With Automatic Voltage Regulation

SD-81175-01 — Charge Control Circuit — 24 Volts

SD-81178-01 — Motor-starter Circuit (Replaced by SD-81393-01)

SD-81184-01 — Rectifier Application Schematic — J86249 Rectifier

SD-81185-01 — Power Service Circuit

SD-81234-01 — Battery Control Circuit — 10,000 Amperes

SD-81242-01 — KS-15689 Rectifier

SD-81317-01 — Rectifier Circuit — J86273

SD-81393-01 — Motor-starter Circuit (Replaces SD-81178-01)

1.06 More detailed information on the operation and maintenance of individual pieces of apparatus, such as instruments, keys, and relays, is described in other sections and the attendant should be familiar with them. All relays, etc, should be adjusted in accordance with these sections and the circuit requirement tables on the circuit drawings. Related sections are:

A301.005 — Storage Batteries — Continuous Float Operation of Lead Acid Type

- A301.304 — Rectifiers — Metallic Type — Unregulated and Manually Regulated
- A301.321 — J86249 Rectifier Unit — Relay-type Output Control
- A301.331 — J86249E, List 3 Rectifier — Electronic Control
- A301.347 — KS-15689 Rectifier — Electronic Control
- A301.348 — KS-15689 Rectifier — Relay-type Output Control
- A301.362 — J86273 Rectifier — 48 Volts, 200 Amperes — Voltage Regulated Output Control
- A301.363 — J86273 Rectifier — Current Regulated Output Control
- A301.536 — J86250 Voltage Regulator and Exciter
- A301.601 — Power Failure Routine
- A401.001 — Storage Batteries — Lead Acid Types
- A401.004 — Countercells — Alkaline
- A401.101 — Charging Generators — Commercial Type
- A401.507 — Automatic Starting Compensators, Circuit Breakers, Contactors, Field Control Panels, Magnetic Switches, and Starters
- A401.508 — Contactors, Emergency Cell Switches, Relays, and Starters
- A401.519 — Contactors — KS-5323, KS-5323-01, KS-5694, and KS-15572
- A401.520 — Cutler-Hammer Automatic Reverse Current Relays — KS-5323-01 and KS-15572
- A401.521 — Control Relays—KS-5350, KS-5451, KS-5728, KS-15503, KS-15598, KS-15806, and Transfer Switches — KS-5264
- A401.522 — Ammeter Relay
- A401.531 — KS-15610 and KS-15624 Switch Panels — Single Motor-driven Type
- A401.539 — Rheostats and Switch Rheostats — Manually Operated—Miscellaneous Types
- A401.541 — Rheostats — Manually Operated
- A401.542 — Motor-driven Rheostats

- A401.556 — KS-5453 Voltage Relays — Direct Current — Solenoid Type
- A401.905 — Commutators, Collector Rings, Interrupters, and Brushes
- A438.961 — Capacitors, Electrolytic — Aluminum Type
- A801.002 — Lead Acid Type Storage Batteries — Theory and Definitions
- A801.817 — No. 302A Power Plant — 24- and 48-volt Supplies With Automatic Voltage Regulation
- A801.910 — Test Loads for Power Equipment

1.07 Adjustment of the stationary low contact pointer of AR, AR1, and AR2 ammeter relays necessitates removal of the relay cover. The position of the low contact pointer may be changed by grasping it at the insulated lower end and moving it as required.

1.08 A test load is required to make certain adjustments of motor-generator sets and rectifiers. Without generator cutoff, the test load should be sufficient to absorb the combined outputs of CU1 and the largest succeeding unit. With generator cutoff, the load should be sufficient to absorb the combined outputs of CU2 and the largest succeeding unit plus approximately 10 per cent of the rated load of the largest of these two units.

1.09 *List of Tools and Test Apparatus* (Equivalents may be substituted)

CODE OR SPEC NO.	DESCRIPTION
TOOLS	
265C	Contact Burnisher Holder
266C	Wire Burnisher
361B (2 reqd)	Relay Winding Connector
365 (4 reqd)	Clip
411A (2 reqd)	Test Pick
508A	Armature Blocking Tool
KS-6320	Orange Stick
—	3-inch Cabinet Screwdriver
—	Fuse Puller, 7-1/2 inches, Ideal Industries

SECTION A301.817

CODE OR SPEC NO.	DESCRIPTION
TEST APPARATUS	
716A	Receiver
931	Voltmeter, dc, scale 0-3 volts
KS-8039	Voltmeter
KS-14510	Volt-ohm-milliammeter
W1AF (2 reqd)	Cord
W2W or W3M	Cord
—	29 Connector
—	35-type Test Set

2. OPERATION

DESCRIPTION

2.01 A brief description of the operation of the 302A power plant is covered in the following paragraphs. For a detailed description of the plant and its operation, refer to Section A801.817.

2.02 The main battery cells are continuously floated under control of the voltage regulation equipment. The emergency cells are automatically cut in or out of the discharge circuit to maintain the discharge voltage within proper limits during the emergency period. The emergency cells are continuously trickle charged by J86220 unregulated rectifiers. In plants where 24 volts is obtained from the 48-volt plant through countercells, the 24V discharge circuit voltage is automatically kept within limits by switching additional countercells in or out of the discharge circuit.

2.03 The control circuit is arranged to prevent loading a generator until after the motor starting device is in its running position. In an office involving several power plants with motor-generator sets, sequence starting is provided in the control circuits in order to prevent several motors starting at the same time which might blow the main fuses after a power failure. Under this method of operation, the first set of the 48-volt plant starts first, then the first set of the 24-volt plant, and finally the 130-volt plant.

2.04 The first two charging units are arranged for voltage regulation and the succeeding units for current regulation. Voltage regulation of the plant is maintained by the first

charging unit, if it is operating alone. If the second charging unit comes into operation, it maintains the voltage regulation of the plant. The plant may or may not be arranged for generator cutoff of the first charging unit when the second comes into operation. The succeeding current regulated charging units are brought into operation as required to supply additional load. Conversely, as the load decreases, charging units are successively disconnected from the load as they are no longer required.

2.05 A generator cutoff feature may be provided in 48-volt variable load plants where the first charging unit is of smaller capacity than the second charging unit. With this arrangement, when the load increases to a value where CU1 can no longer satisfy the load requirements, CU2 will start, take over the load, and cause CU1 to disconnect. Conversely, when the load decreases to 80 per cent of the full-load rating of CU1, CU1 restarts and takes over the load allowing CU2 to disconnect. If the load increases to a value where CU2 and all succeeding current regulated charging units are operating and additional capacity is required, CU1 will start under current control, and assist the other charging units in carrying the load.

2.06 When the generator cutoff feature is not provided, CU1 will always be operating unless it is removed from service manually. With this arrangement, if CU1 operating under voltage control goes to full load, CU2 will come into operation under voltage regulation and CU1 will operate under constant current control at a reduced load. If CU2 goes to full load, CU1, operating under constant current control will go to full load and CU2 will decrease its output correspondingly. If CU2 goes to full load a second time, CU3 will come into operation under current regulation and assume enough of the load so that CU2 remains below 3/4 of its full-load rating. Successive current-regulated charging units are brought into operation as necessary so that CU2 remains below 3/4 load. Likewise, if the output of CU2 drops to 1/4 load, the current-regulated units will reduce their output and will shut down as necessary to keep the CU2 output above 1/4 load. If current-regulated charging units CU3-CU-H shut down and the output of CU2 falls to no load, CU1 which is operating under current control will continue operating at a reduced load. (See note.) If the

output of CU2 again falls to no load, CU2 will be disconnected and CU1 will be returned to voltage regulation after a time delay.

Note: The reduced output at which CU1 operates under current regulation is adjustable between 50 and 75 per cent of the full-load rating of CU1. The value to which it is adjusted, in any case, depends on the variable component of the office load. See SD-81148-01.

2.07 Alarms are provided to indicate such conditions as abnormal battery voltage, generator failure, fuse failure, power failure, and operation of emergency cell switch.

PREPARING TO START INITIALLY

2.08 Before putting the plant into service check that:

(a) All motor-generator sets are clear of any obstructions and are free to run. Where possible, as a check, it is desirable to turn by hand all parts that normally rotate.

Caution: Care must be exercised when doing this to prevent electric shock or physical injury.

(b) The procedures for preparing to start in the rectifier BSP sections have been observed.

(c) The procedures for preparing to start in the voltage regulator and exciter BSP section have been observed.

(d) STOP-NOR key is in the STOP position and CONT and REG keys are in the NOR positions. (See Fig. 2.)

(e) STOP-NOR key is in STOP position and TEST NOR key is in NOR position. (See Fig. 4.)

(f) Correct size fuses are in place.

(g) In charging machines No. 3 to No. 7, each generator control OLA potentiometer is turned completely cw and each OLR potentiometer is turned completely ccw. (See Fig. 4.)

(h) EM CELL SW MAN-AUTO keys are in the MAN position. (See Fig. 1.)

(i) Generator knife switches are in the OPEN (horizontal) position. The switch is shown in the closed position in Fig. 5. In the open position the movable switch blade should not touch any stationary switch contacts.

(j) GEN REG MAN-AUTO key is in MAN position. (See Fig. 1.)

(k) GEN REG CHG-FLOAT key is in FLOAT position. (See Fig. 1.)

INITIAL ADJUSTMENTS

Generators No. 1 and 2

2.09 Check each generator as follows:

(a) Generator Rotation

(1) Rotate the generator manual control handwheel maximum cw.

(2) Operate the CONT key to TEST.

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

(4) In the motor-starter the start contactor should operate, the motor-generator set should start rotating cw, as viewed from the generator end. After a short delay, the run contactor and SR relay should operate. The start contactor will then release.

(b) Generator Voltage

(1) Rotate the VM key to position GEN.

(2) Rotate the generator manual control handwheel ccw so that the generator voltage is about 30 volts for 65-volt generators or 15 volts for 33-volt generators.

(c) Reverse Current Relay

(1) Block CC relay operated.

(2) Slowly rotate the generator manual control handwheel ccw and check that reverse current CB relay operates before 45 volts are reached on 65-volt generators or before 25 volts are reached on 33-volt generators. CA contactor should also operate.

(3) Remove the block from CC relay.

(4) Rotate the handwheel cw until CA contact or CB relays release.

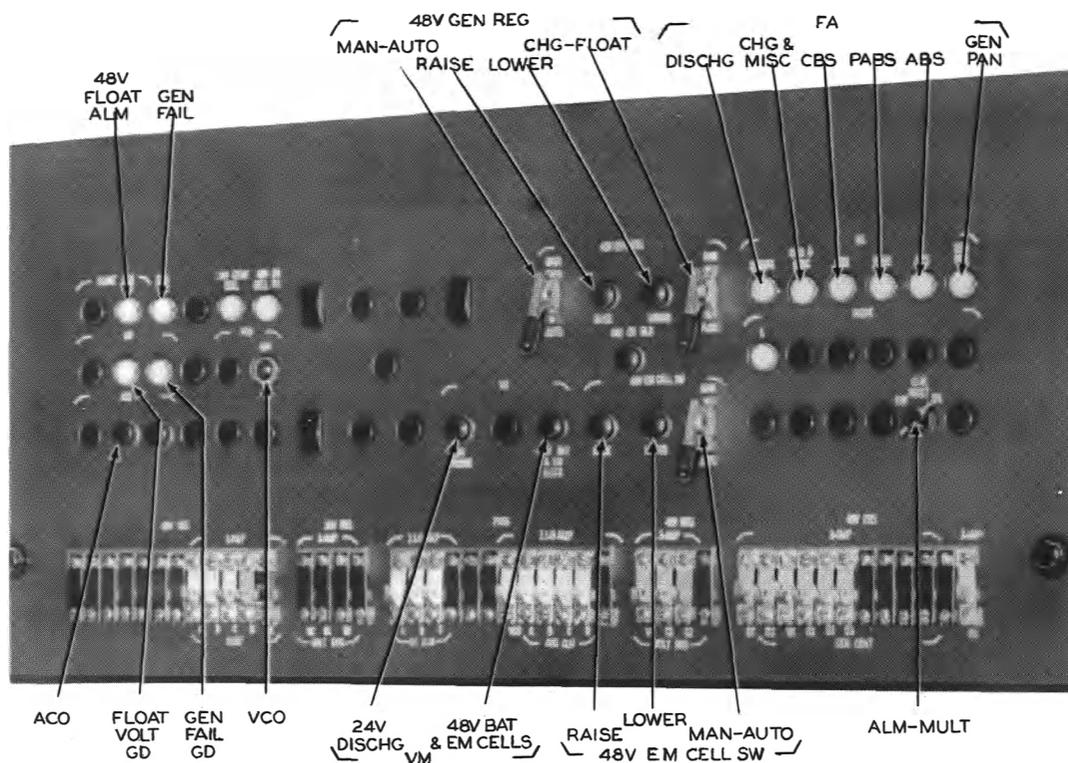


Fig. 1 - Main Control Board

- (5) Close the generator knife switch to the 24- or 48-volt position.

Caution: Never close the generator knife switch while CA contactor is operated as personal injury and commutator damage may result.

- (6) Connect an external voltmeter (KS-14510) across main contacts of CA contactor. Use the 3-volt scale and connect the positive lead to the armature contact.
- (7) Rotate handwheel slowly ccw until voltmeter reads 1 volt.
- (8) Reverse the voltmeter leads (voltmeter reads -1 volt).
- (9) Rotate handwheel slowly ccw. CA contactor should operate before voltmeter reads 1 volt. (That is before generator voltage is 1 volt higher than battery voltage.)

- (10) Remove the voltmeter.

- (11) Move the low contact pointer of AR1 ammeter relay to extreme left of scale. (See 1.07.)

- (12) Rotate handwheel slowly cw while observing AR1 ammeter relay. CA contactor and CB relay should release before the reverse current (below the zero reading) reaches 11 per cent of the generator rated ampere output, if SD-81155-01 is provided, or when the reverse current is between 3 and 8 per cent of the generator rated ampere output in the case of all other generator circuits.

Caution: Do not permit reverse current to exceed the 11 per cent value if SD-81155-01 is provided or the 8 per cent value if another generator circuit is provided, as excessive reverse current may affect future operation of the reverse current CB relay.

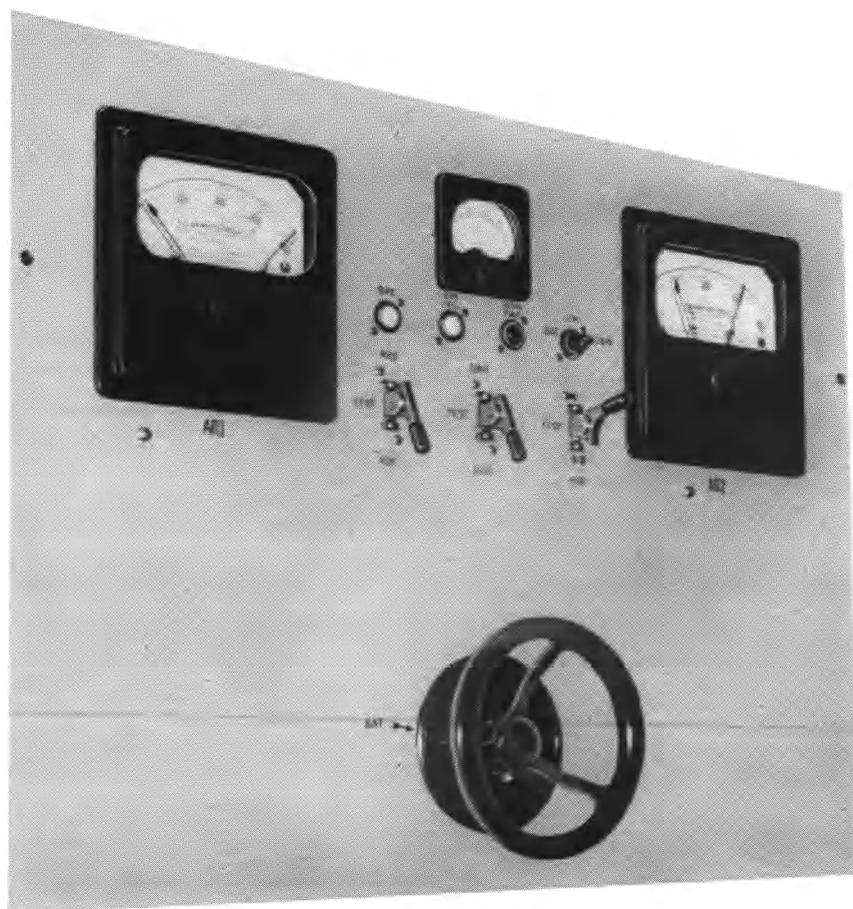


Fig. 2 – Voltage-regulated Generator Controls

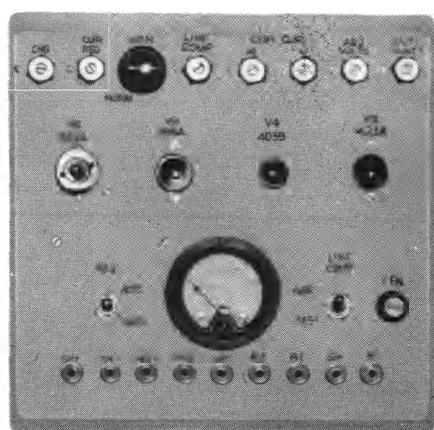


Fig. 3 – Voltage Regulator Controls

(d) *Voltage Regulator*

- (1) Open the generator knife switch (horizontal position). Operate the controls on the voltage regulator (Fig. 3) as follows.
- (2) The MAN, ANTI-HUNT 1, CUR REG, CHG, and ADJ VOLTS potentiometers maximum ccw (the AH2 potentiometer, inside the voltage regulator, is factory-set and should not be changed at this time).
- (3) The LINE COMP, CON CUR H, and CON CUR L potentiometers maximum cw.
- (4) The REG switch (on regulator panel) to MAN and the LINE COMP switch to NOR.
- (5) The REG key (on top of the generator control bay) to TEST, noting that the generator voltage increases slightly.

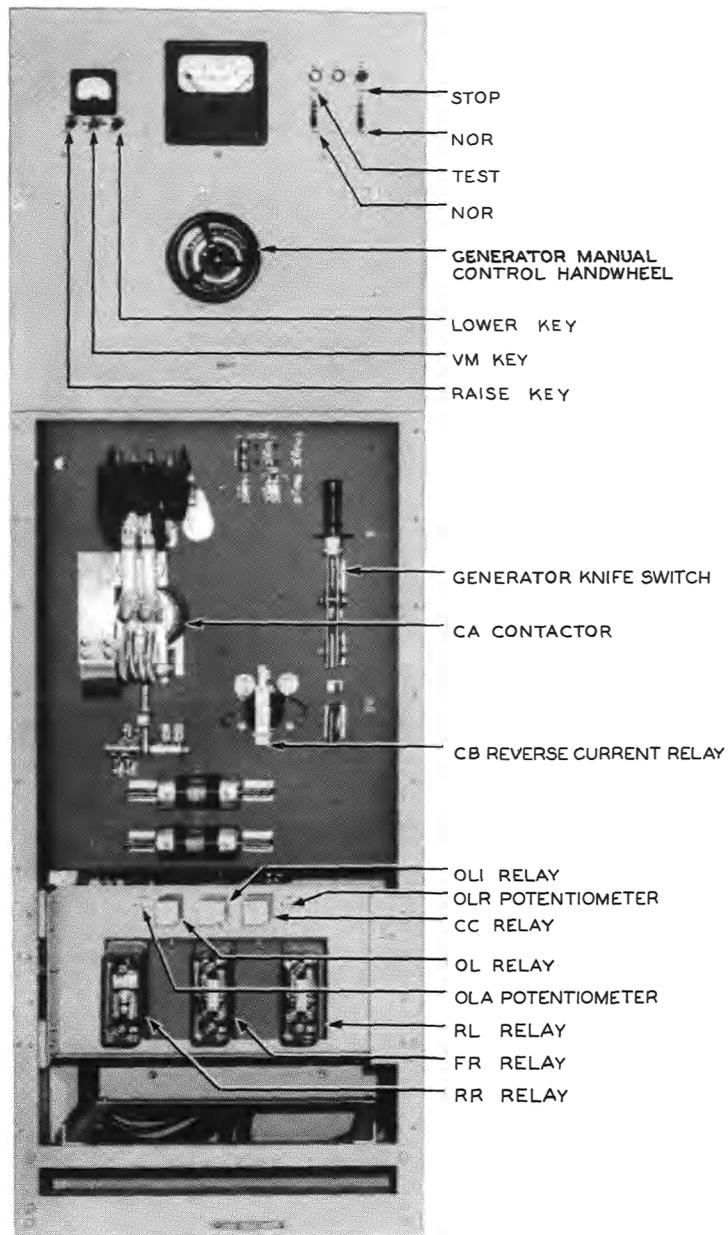


Fig. 4 – Current-regulated Generator Control Bay

(e) Generator Manual Control Handwheel

(1) Rotate the handwheel ccw to increase the generator voltage approximately to the rated value of 65 or 33 volts. Rotate the handwheel slowly cw to decrease the generator voltage to the following value:

11-cell battery	23 volts
12-cell battery	25 volts
23-cell battery	48 volts

Stop when this value is reached. If this value is passed, start over again and approach more slowly. When the proper setting has been obtained, the position of the pointer of the handwheel should be marked with a line and stenciled BAT.

2.10 Ammeter Relays on Generator and Rectifier Control Bays

(a) The high contacts of AR1 ammeter relay shall be adjusted to close on a current equal to the full-ampere rating of the associated generator. The low contacts shall be adjusted to close with a reverse current sufficient to deflect the pointer 1 to 2 per cent of the generator rated ampere output below the zero. (See 1.07.)

Note: The initial adjustment procedure requires that CU1 and CU2 carry 110 per cent load for a short period. It will not be necessary to move the high contact of AR1 or insulate it while making this adjustment. However, if the high contact of AR1 is moved during any subsequent tests, care must be exercised to prevent it from touching the case.

(b) Adjust the low contacts of AR2 relay to make contact at 25 per cent of full-load reading on descending load. The high contacts should close on approximately 75 per cent of the ampere rating of the charging unit with increasing load. (See 1.07.)

(c) In order to determine when the generator or rectifier has 110 per cent load on it, observe the CC TST millivoltmeter in accordance with the following paragraphs on the CC TEST circuit except in the case of the J86273 rectifier. If the J86273 rectifier is provided, observe the AR1 ammeter and follow the procedure covered in Section A301.362.

(1) The CC TEST circuit furnished with voltage regulators for generator or with voltage-regulated rectifiers consists of a millivoltmeter (0 to 500 millivolts), a CC TST key, and a potentiometer.

(2) With the CC TST key operated to TST, this circuit is used to simulate load to the voltage regulator. For instance, to simulate 105 per cent load, operate the CC TST key to TST, and then rotate the CC TST potentiometer so that the CC TST millivoltmeter reads 246 for 750-ampere generators or 262 for all other generators and 275 (see note) for all rectifiers, except the J86273. This condition will affect the regulating circuit in the same way as an actual 105 per cent load.

Note: The 275 reading includes an additional correction for rectifiers. See rectifier BSP section for details.

(3) With the CC TST key operated to NOR, the millivoltmeter is bridged across the ammeter relay shunt and may be used as an indication of the output current. In this case, the millivoltmeter should read 235 for full load on the voltage regulator for 750-ampere generators or 250 for full load on the voltage regulator for all other generators and for all rectifiers. The following table shows load percentages and corresponding millivoltmeter readings.

LOAD IN PER CENT	CC TEST MILLIVOLTMETER READING	
	FOR 750-AMPERE GENERATORS	FOR ALL OTHER GENERATORS AND RECTIFIERS EXCEPT J86273
75	176	188
77	181	193
79	186	198
85	200	213
100	235	250
105	246	262
110	258	275
115	271	288
120	282	300
125	293	310
150	352	375

(4) **External Millivoltmeter:** Where the voltage regulator for a generator or for a voltage-regulated rectifier is not equipped with the CC TEST circuit, an external milli-

voltmeter with the proper scale such as a 35-type test set can be connected to read load currents in excess of 100 per cent. See 2.10(c)(3), table. Connect the dc millivoltmeter to the SH+ and SH- test jacks on the voltage regulator or voltage-regulated rectifier. If a KS-14510, List 1 volt-ohm-milliammeter is used on the 0.3-volt scale, full scale would be equivalent to 120 per cent load.

Note: Where a 35-type test set is used, select a low scale so that the current drawn by the test set does not exceed 20 milliamperes and thus cause calibration error due to wiring resistance.

2.11 Generator Cutoff Relay, G2 Only, Where Generator Cutoff Is Provided: Adjust GC relay to release on 80 per cent of the ampere rating of the first charging unit as described in 2.12. This relay is connected across the ammeter relay shunt of the second charging unit.

Note: When the full load rating of G1 is less than 1/3 of the full load rating of G2, the GC adjustment is not required. In this case, the low contact adjustment of AR2 in G2 shall be at 80 per cent of full-load rating of G1 rather than 25 per cent of full-load rating of G2 as indicated in 2.10(b).

2.12 Generator Cutoff Potentiometer, G2 Only, Where Generator Cutoff Is Provided

- (a) Rotate GCR rheostat to its extreme ccw position.
- (b) Close the generator knife switch to the 48V(24V) position.
- (c) Start the second charging unit as follows:
 - (1) Operate the REG key to NOR.
 - (2) Operate the CONT key to TEST.
 - (3) Operate the STOP key to NOR.
 - (4) Raise the voltage with the generator manual control handwheel to 1 volt above the battery voltage. (The voltage regulator has not yet been adjusted.) After the CA contactor operates, raise the output of the generator to full output. Adjust load as required so as not to raise battery voltage above 2.3 volts per cell. Then reduce the output to a value equal to 80 per cent of the rating of CU1.

- (d) Slowly rotate GCR rheostat until GC relay releases.

- (e) With GCR rheostat set as above, increase the output of charging generator No. 2 to full load and then slowly decrease the output and check that GC relay releases at 80 per cent of the rating of CU1.

2.13 Voltage Regulation Apparatus and J86250 Voltage Regulator G1 and G2

- (a) Connect a KS-8039 voltmeter or approved equivalent to the voltage regulator by means of the REG+ and REG- pin jacks. (Use No. 29 cord tip with voltmeter leads.)

- (b) Check that the manual control handwheel is in BAT position and that the voltage regulator controls are positioned as in 2.09(d) except that REG switch is on AUTO.

- (c) Slowly rotate ADJ VOLTS potentiometer cw until the voltage read on the external voltmeter (REG- and REG+ jacks) increases to the following value.

49.9 volts for 23 cells

26.0 volts for 12 cells

23.9 volts for 11 cells

Note: The values shown in the table above are based on a float value of 2.17 volts per cell. However, the value of float voltage which is shown in Section A301.005 will always be used as the accepted value. The values shown above are for the convenience of the maintenance forces.

- (d) Operate the REG switch on the voltage regulator to the MAN position.

- (1) Operate the generator knife switch to the 24V or 48V BAT position.

- (2) Slowly rotate the MAN potentiometer (voltage regulator panel) cw until CA contactor operates. Charge the battery until the generator output is less than 25 per cent of generator rating at float voltage.

- (3) Rotate the MAN potentiometer to its ccw position. CA contactor will release.

- (4) Restore the REG switch (voltage regulator panel) to AUTO.

- (5) Operate the CONT and REG keys (generator panel) to NOR. The machine should now connect to the load automatically. (CA contactor operates.) If it does not, rotate the CUR REG potentiometer (voltage regulator panel) slowly cw until CA contactor operates.
- (e) Readjust the ADJ VOLTS potentiometer to float value given in (c) and allow at least 5 minutes to permit battery voltage to stabilize.
- (f) Insulate 4T and 5T contacts of RT relay. Slowly rotate CUR REG potentiometer cw until the voltage read on the external voltmeter (REG- and REG+ jacks) increases to 1 volt above battery float voltage, again waiting to permit battery voltage to stabilize. Remove insulation from RT relay. Battery will restore to float voltage.
- (g) Operate the FLOAT-CHG key on the main control board to the CHG position. Rotate the CHG potentiometer on the voltage regulator cw until the battery voltage increases to:
- 50.6 volts for 23 cells
 - 26.4 volts for 12 cells
 - 24.2 volts for 11 cells
- Allow time for the battery voltage to stabilize. When this adjustment has been completed, restore the FLOAT-CHG key to the FLOAT position. Battery will restore to float voltage.
- (h) If the generator control bay is equipped with the CC TEST circuit described in 2.10(c), disregard (i) to (o), inclusive, and proceed as covered in (p). If the generator control bay is not equipped with CC TEST circuit, follow the instructions in (i) to (o), inclusive.

Not Equipped with CC TEST Circuit

- (i) Insulate 4T and 5T contacts of RT relay. Battery voltage will increase approximately 1 volt. Increase the load to 95 to 100 per cent of the generator rating. Adjust the CON CUR H potentiometer ccw until the battery voltage is maintained at the float voltage. If periodic swings of the output current meter are observed, rotate the ANTI-HUNT 1 potentiometer slowly cw until the swings decrease

to a minimum. If necessary, rotate the ANTI-HUNT 2 potentiometer (inside voltage regulator) slightly cw to stop hunting.

Note: The ANTI-HUNT 2 potentiometer should never be adjusted to less than 200,000 ohms.

- (j) Operate the LINE COMP switch and observe the value to which the output current returns after the initial change. If the output does not recover, release the LINE COMP switch and rotate the LINE COMP potentiometer slightly ccw. Readjust the CON CUR H potentiometer to maintain float voltage. Repeat operations of the LINE COMP switch and adjustment of the LINE COMP and CON CUR H potentiometers until operation of the LINE COMP switch causes approximately +2 per cent change in output. Remove the insulation from contacts of RT relay. Rotate CON CUR H fully cw.

- (k) Recheck the float, current regulation, and charge voltage values in accordance with (e), (f), and (g). Increase the load slowly until the generator output reaches 110 per cent of its rated output. Then rotate the CON CUR H potentiometer ccw until the output drops to 105 per cent of its rating. Since part of the load is now being supplied from the battery, its voltage should decrease. Maintain the generator output at 105 per cent by adjusting the CON CUR H potentiometer while the voltage is decreasing to:

- 48.9 volts for 23 cells
- 25.25 volts for 12 cells
- 23.15 volts for 11 cells

Leave the CON CUR H potentiometer at the setting which gives 105 per cent output at the above voltage.

- (l) **G1 Only:** Remove the load so as to reduce the generator output to zero. Then block CR and CRL relays operated. This raises the generator voltage 1 volt above the float value. Add load slowly up to 80 per cent of the generator rated output. Rotate the CON CUR L potentiometer ccw until the generator output drops to 75 per cent of its rated output. Since part of the load is now being supplied by the battery, its voltage should decrease. Watch the battery voltage as it drops and,

when it reaches the float voltage, quickly adjust the CON CUR L potentiometer further ccw so that the generator is delivering 75 per cent of its rated output at float voltage. Remove the block from CR and CRL relays.

Note: The setting of the CON CUR L potentiometer should be as close as possible to 75 per cent of the full-load rating of the machine without permitting variable load to cause false starting of the second machine. Make this adjustment when load variation is at a minimum. See SD-81147-01 and its associated circuit description.

(m) Decrease the load to 50 per cent of the generator rating and readjust the ADJ VOLTS potentiometer to the float voltage, if necessary. Increase the load slowly to 100 per cent of the generator rating and observe that the high contact of AR1 ammeter relay makes before the voltage drops below:

49.0 volts for 23 cells

25.5 volts for 12 cells

23.4 volts for 11 cells

(n) Increase the load to 120 per cent of the generator rating and observe that the generator output does not exceed 115 per cent of the rating when the battery has decreased to 2.0 volts per cell. [See (o).]

(o) If periodic swings of the generator output occur as the voltage is decreasing to 2.0 volts per cell, rotate the ANTI-HUNT 2 potentiometer (inside voltage regulator) slowly cw until the hunting almost stops [see note under (i)]. Then adjust the ANTI-HUNT 1 potentiometer until the hunting stops. With G1 and G2 operated in parallel, it may be necessary to make further adjustments of the ANTI-HUNT 1 or ANTI-HUNT 2 potentiometer.

Equipped With CC TEST Circuit

(p) Adjust the circuit operation of the OL relay as follows. (Cover must be on relay. Observe the OL1 relay to tell when OL relay is operated.)

- (1) Operate STOP-NOR key to STOP (generator will stop).
- (2) After CA contactor has released, open the generator knife switch.

(3) Operate CONT key to TEST and STOP-NOR key to NOR. (Generator will start).

(4) Rotate CC TST and OLR potentiometers fully cw.

(5) Operate CC TST key to TST and hold operated.

(6) If the OL relay is not operated, rotate the OLR potentiometer slowly ccw until the relay operates.

(7) Rotate CC TST potentiometer ccw until OL relay releases. Release value of OL relay should be between 120 and 125 per cent of generator full-load rating. [See table in 2.10(c) (3) for millivoltmeter readings.]

(8) Rotate OLR potentiometer ccw if release value of OL relay exceeds 125 per cent of generator rating and cw if it is less than 120 per cent of the rated output. With CC TST potentiometer reoperate and release OL relay, adjusting OLR potentiometer until release value of OL relay is within limits.

(9) Recheck release adjustment of OL relay after permitting the OL relay to cool for 5 minutes. (The release value of the OL relay should be 120 per cent of rated generator output when relay is cold, simulating condition of restart after power failure.)

(10) Release the CC TST key. Rotate CC TST potentiometer full ccw. Operate CC TST key to TST and hold operated. Rotate CC TST potentiometer cw and check that OL relay operates before 150 per cent of rated load is reached. [See table in 2.10(c) (3).] Release the CC TST key.

Note: Allow the OL relay to cool for 5 minutes before readjustment.

(q) With the generator operating at no load as in (p), adjust the droop (regulation cutoff) point as follows:

- (1) Rotate the CC TEST and LINE COMP potentiometers maximum ccw.
- (2) Rotate the CON CUR H potentiometer maximum cw.
- (3) Operate the CC TST switch to TEST.

(4) Rotate the CC TST potentiometer cw so that the CC TST millivoltmeter reads 254 for 750-ampere generators or 270 for all other generators.

(5) Rotate the CON CUR H potentiometer ccw until the generator output voltage decreases 2 volts for 48-volt plants or 1 volt for 24-volt plants.

(6) Rotate the CC TST potentiometer as required to obtain 250 millivolts on the CC TST millivoltmeter for 750-ampere generators or 265 for all other generators.

Note: The CON CUR H and CC TST adjustments are interdependent and several attempts at each adjustment of steps (5) and (6) may be necessary to obtain the required voltage decrease with the CC TEST millivoltmeter reading 250 or 265 millivolts.

(r) Operate the LINE COMP switch to the TEST position and hold it in that position for a few seconds while watching the CC TST millivoltmeter. If the reading is not approximately 254 millivolts for 750-ampere generators or 270 millivolts for all other generators, restore the LINE COMP switch to NOR and rotate the LINE COMP potentiometer slightly cw. Restore the reading of the CC TST millivoltmeter to 250 or 265 millivolts with the CON CUR H potentiometer. Repeat the CON CUR H and LINE COMP adjustments, as necessary, until the reading on the CC TST millivoltmeter changes from 265 millivolts to 270 millivolts or from 250 to 254 millivolts when the LINE COMP switch is operated for a few seconds. Restore the LINE COMP switch to NOR and release CC TST switch.

(s) The CON CUR L adjustment as outlined in (1) to (6), inclusive, is required for the first generator when used without generator cutoff. This is not required with generator cutoff.

- (1) Block the CRL relay operated.
- (2) Block the CR relay operated, if not previously blocked.
- (3) Operate and hold the CC TST switch.
- (4) Rotate the CC TST potentiometer slowly cw until the CC TST millivoltmeter indicates a load equivalent of 79 per

cent for 48V generators or 77 per cent for 24V generators. See 2.10(c) (3) and note under 2.13(I).

(5) Rotate CON CUR L potentiometer ccw until the generator output drops to 75 per cent of its rated output. Verify that the generator output voltage drops 1 volt at this value.

(6) Remove the blocks from CR and CRL relays.

Note: The CON CUR L potentiometer adjustment and the CC TST potentiometer adjustment are interdependent. Some re-adjustment of both may be required to obtain 75 per cent load with a drop of 1 volt. [See note, 2.13(I).]

(t) Rotate the CC TST potentiometer slowly cw until the generator output voltage decreases to:

CELLS	VOLTS
11	22
12	24
23	46

If the generator voltage cannot be decreased to this value, turn the MAN rheostat in the generator control board slightly cw until the desired voltage is obtained. During this time, the generator output indicated in the CC TST millivoltmeter should not exceed 271 for 750-ampere generators and 288 for all others.

(u) If the generator output voltage hunts during these adjustments, rotate the ANTI-HUNT 1 potentiometer as required to stop the hunting. The ANTI-HUNT 2 potentiometer may also be used if the range of ANTI-HUNT 1 is insufficient. Do not adjust the ANTI-HUNT 2 potentiometer under a minimum resistance of 200,000 ohms. (Use ohmmeter across terminals 2 and 3. Operate STOP key to STOP before connecting meter.)

Generators No. 3 Through 7

2.14 Check each generator as follows:

(a) Generator Rotation

- (1) Rotate generator manual control hand-wheel maximum cw.
- (2) Generator knife switch shall be in the open (horizontal) position.

- (3) Operate the TEST-NOR key to TEST.
 - (4) Operate and hold LOWER key until motor driven rheostat is in its "all resistance" position as indicated by release of RL relay.
 - (5) Operate STOP-NOR key to NOR.
 - (6) Motor generator set should start rotating cw as viewed from generator end.
- (b) **Generator Voltage:** Check as covered in 2.09(b).
- (c) **Generator Reverse Current Relay:** Check as covered in 2.09(c).

Note: On current regulated machine 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.

2.15 Ammeter Relays

- (a) The high contacts of the ammeter relay shall be adjusted to close on a current equal to the full-ampere rating of the associated generator. The low contacts shall be adjusted to make with a reverse current sufficient to deflect the pointer 1 to 2 per cent of the generator rated ampere output below zero.
- (b) The initial adjustment procedure requires that G3-G7 carry 110 per cent load for a short period. [See 2.10(c) (4).] It will not be necessary to move the high contact of AR ammeter relay or insulate it while making this adjustment. However, if the high contact of AR is moved during any subsequent tests, care must be exercised to prevent it from touching the case.

2.16 Generator Manual Control Handwheel

(a) BAT Setting of Handwheel Pointer

- (1) Operate NOR-STOP key to STOP.
- (2) Operate generator knife switch to the OPEN (horizontal) position.
- (3) Disconnect battery from generator and apply artificial load.
- (4) Manually operate FR relay using the KS-6320 orange stick.
- (5) Operate NOR-STOP key to NOR.

- (6) Operate RAISE key continuously until RR relay releases. (All resistance out position.)
- (7) Turn handwheel ccw until generator is operating at rated ampere output at the voltages shown in the following table with the machine hot (run at full output for at least 1 hour).

CELLS IN BATTERY	VOLTAGE
11	28
12	30
23	56

- (8) Mark with a line and designate BAT on the front of the panel, the position of the handwheel pointer at which the generator delivers full-ampere output at the required voltage.
- (9) Turn handwheel cw and run generator at no load for 1 hour allowing it to cool.
- (10) Operate NOR-STOP key to STOP.
- (11) Remove artificial load and reconnect battery.

(b) Adjustment of Motor-driven Rheostat

- (1) Close the generator knife switch to the 24V or 48V position.
- (2) Operate NOR-STOP key to NOR.
- (3) Operate LOWER key continuously until RL relay releases. (All resistance in position.)
- (4) Operate RAISE key until generator is operating at rated ampere output at the voltage shown in the following table. (Read voltage by operating VM key on generator control panel to BAT.)

CELLS IN BATTERY	VOLTAGE
11	25.9
12	28.2
23	54.1

- (5) When generator reaches full output, operate the LOWER key slowly decreasing the output, (allow time for the battery voltage to decrease). Continue operating LOWER key until the ammeter relay

just closes its lower contact with the battery voltage shown in the following table.

CELLS IN BATTERY	VOLTAGE
11	23.1
12	25.2
23	48.3

- (6) Operate NOR-STOP key to STOP.
- (7) Operate generator knife switch to the OPEN (horizontal) position.
- (8) With the rheostat arm in the position in step (5), set the B limit switch operating lever against the limit switch so that the contacts just open and then clamp the lever in place. This position of the motor-driven rheostat shall be considered the "all resistance in" position.

(c) **EM CELLS Position of Handwheel**

- (1) Rotate the handwheel fully cw.
- (2) Close the generator knife switch to EM CELL position.
- (3) Close the EM CELL CHG knife switch to GR1 and GR2 positions.
- (4) Operate NOR-STOP key to NOR. (Generator will start.)
- (5) Operate RAISE key continuously until RR relay releases. (All resistance out position.)
- (6) Rotate handwheel ccw until CA contactor operates and the generator delivers rated ampere output at the voltages in the following table.

CELLS	VOLTAGE
11 cells & 2 EM CELLS	30.3
12 cells & 2 EM CELLS	32.5
23 cells & 4 EM CELLS	62.8

- (7) The position of the handwheel pointer in step (5) shall be marked with a line and designated EM CELLS on the front of the panel.

Note: On some generators it will be found that the first setting of the generator manual control handwheel described in (a) will also meet the requirements for the second or EM CELL setting in which case the position should be marked and designated BAT & EM CELLS.

- (8) Operate LOWER key until CA contactor releases.
- (9) Open generator knife switch (horizontal position).
- (10) Operate EM CELLS CHG knife switch to G1 position.
- (11) Close the generator knife switch to the EM CELLS position.
- (12) Operate RAISE key until CA contactor operates. Raise voltage to voltage indicated in table in step (13) allowing time for the battery to stabilize.
- (13) Operate LOWER key to decrease output and verify that ammeter relay low contacts make at the voltages in the following table.

CELLS	VOLTAGE
11 cells & 1 EM CELL	26.4
12 cells & 1 EM CELL	28.5
23 cells & 2 EM CELLS	54.9

- (14) Operate NOR-STOP key to STOP.
- (15) Rotate handwheel to BAT position if two positions have been designated.
- (16) Operate generator knife switch to the OPEN (horizontal) position.

2.17 Overload Relay: OL relay should operate when the generator output rises to 115 per cent of rated current and should release when generator output reduces to 85 per cent of the generator rated current. In the following paragraphs, raise and lower the output of the generator by means of the generator manual control handwheel.

- (a) Rotate OLA potentiometer to its maximum cw position and OLR potentiometer to its maximum ccw position.

Note: The cover must be on the OL relay when adjusting the OLA and OLR potentiometers.

- (b) Move ammeter relay high contact beyond the full-load scale marking or operate STOP keys of all nonrunning sets to the STOP position. [See 2.15(b).]

(c) Connect a millivoltmeter across the ammeter relay shunt at the same points as the connections for the winding of OL relay. An external millivoltmeter with the proper scale such as a 35-type test set can be connected to indicate load currents in excess of 100 per cent. [See 2.10(c) (4).]

(d) Operate the generator knife switch to the 48V (24V) position. Operate the TEST key to TEST and the STOP key to NOR. Raise the generator output to its full-ampere rating.

(e) Read the drop across the ammeter relay shunt as indicated on the millivolt meter, then increase the output until the voltage drop across the shunt is 110 per cent of that obtained when the generator is delivering full-rated output. [See 2.10(c) (3).] Slowly rotate OLA potentiometer ccw until OL relay operates.

(f) Decrease the generator output to 105 per cent full-load rating and check that OL relay does not release.

(g) Continue to decrease the output of the generator until 85 per cent of generator rated output is reached or OL relay releases. If OL relay does not release at 85 per cent of generator rated output, cut the strap between OLA and OLR rheostats. Then with generator carrying 85 per cent of its full-rated output, slowly rotate OLR potentiometer in a cw direction 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.

(h) Check operation of OL relay as follows. Raise generator output to 105 per cent full load and check that OL relay does not operate. Raise generator output to 115 per cent of full load and check that OL relay operates. Decrease generator output to 105 per cent of full load and check that OL relay remains operated. Continue to decrease generator output to check that OL relay releases at 85 per cent load or higher.

(i) Reset ammeter relay high contacts or return STOP keys to NOR position.

Rectifiers (J86249, KS-15689, or J86273)—Electronically Controlled—Charging Units No. 1 and 2 (See Appropriate BSP Section for Adjustments Other Than Ammeter Relay)

2.18 If J86249 or KS-15689 rectifier is provided, adjust AR1 ammeter to close its low contacts at 5 per cent and its high contacts at 90 per cent of the rated rectifier output. If J86273 rectifier is provided, adjust AR1 ammeter to close its low contacts at 2 per cent and its high contacts at 100 per cent of the rated output of the rectifier.

2.19 Adjust AR2 ammeter relay to close its low contacts at 25 per cent and its high contacts at 75 per cent of the rated output of the rectifier.

Rectifiers (J86249, KS-15689, or J86273)—Relay Controlled — Charging Units No. 3 Through 7 (See Appropriate BSP Section for Adjustments Other Than Ammeter Relay)

2.20 Adjust the AR ammeter relay to close its low contacts at 2 per cent and its high contacts at 100 per cent of the rated rectifier output.

OPERATION OF PLANT

Automatic Operation of Plant

2.21 For normal operation, with the keys in the positions specified below, enough generators or rectifiers should be in operation to float the load. However, if an equalizing or boost charge is required using automatic regulation, the float charge key on the main control board should be operated to the CHG position.

(a) On the main control board

(1) FLOAT-CHG key should be in FLOAT position.

(2) GEN-REG and EM CELL SW MAN-AUTO keys should be in AUTO position.

(b) The keys on generator control bays should be in the NOR positions.

(c) On rectifier bays

(1) ON-OFF or RECT keys should be in ON position.

- (2) All other rectifier keys should be in NOR position.

Note: During an extended heavy-load period with normal or emergency ac power, the charging units may not have sufficient capacity to maintain the main battery at float voltage and the emergency cells may cut in. If the heavy load continues through the emergency cells, they may reverse polarity and become damaged. To prevent damage, operate the charging unit switches to the EM CELLS position as instructed in 2.44(c) thus reducing the discharge on the emergency cells as well as the main battery.

Manual Operation of Plant

2.22 To regulate machines No. 3 to 7 manually, operate the GEN REG MAN-AUTO key on the main control board MAN. The output of the highest numbered relay-controlled charging units may then be controlled by means of the RAISE and LOWER keys on the main control board, but charging units No. 1 and/or 2 will still maintain voltage regulation if their ampere capacities are not exceeded by the removal of relay-controlled charging unit capacity. See 2.38 and 2.39 for the manual operation of individual charging units.

Rectifiers

2.23 In general, rectifiers can be used in conjunction with motor-generator sets in this plant. The control circuit is designed to cause the rectifier units to connect and disconnect in the same manner as motor-generator sets.

Caution: *The rectifier MAN potentiometer should always be kept in the maximum ccw position except when the rectifier is both connected to the battery and is being used under MAN control (MAN-TEST or NOR-TEST 1 key in MAN or TEST 1 position). If the rectifier should be operating under MAN control without battery or load and the MAN potentiometer is turned cw enough, the rectifying element may be damaged. Never turn the rectifier ON under automatic control before the battery or load is connected or the rectifying element may also be damaged. Use the OFF or OPEN rotary switch to remove rectifier*

from service only after the rectifier has been shut down by operation of the ON-OFF or NOR-OFF key to the OFF position.

2.24 In the following paragraphs, when keys on J86249, KS-15689, or J86273 rectifier are referred to, uniform designations will be used for comparable keys as shown below.

(a) *Electronically Controlled Rectifiers*

- (1) Keys designated RECT or NOR-OFF will be referred to as RECT and their positions as NOR and OFF.
- (2) Keys designated CONT or NOR-TEST R will be referred to as NOR-TEST R and their positions as NOR and TEST R.
- (3) Keys designated AUTO-MAN and NOR-TEST 1 will both be referred to as AUTO-MAN and their positions AUTO and MAN, and NOR and TEST 1, respectively, will be referred to as AUTO and MAN.

(b) *Relay Controlled Rectifiers*

- (1) Keys designated MAN-TEST or MAN-NOR-TST will both be referred to as MAN-TEST; their positions, MAN, TEST and NOR (center) and MAN, TST and NOR, will be referred to as MAN, TEST and NOR.
- (2) Keys designated ON-OFF or RECT will be both referred to as ON-OFF and their positions, ON and OFF, and NOR and OFF, respectively, will be referred to as ON and OFF.

Removing From Service and Restoring to Service — Charging Units No. 1 and 2

General

2.25 The procedure for removing a charging unit from service depends on the reasons for doing so as well as the position of the unit in the sequence. Since CU1 and CU2 are the only charging units arranged for automatic voltage regulation at least one of these units must be in service at all times. The following paragraphs outline the operating procedures for removing and restoring a charging generator or rectifier.

2.26 The procedure in this paragraph should be used only in an emergency or when a slight drop in voltage will not affect the operation of connected equipment or cause service reaction. Normally, the procedures given in 2.27 through 2.33 should be followed.

(a) *Generator No. 1 or 2*

- (1) To remove from service, operate the NOR-STOP key to STOP.
- (2) To restore to service, operate the NOR-STOP key to NOR.

(b) *Rectifier No. 1 or 2*

- (1) To remove from service, operate the NOR-OFF key to OFF.
- (2) To restore to service, operate the NOR-OFF key to NOR.

Plant Arranged for Generator Cutoff

2.27 Removing and Restoring Generator No. 1: The various conditions under which G1 may be removed from and restored to service are covered below.

- (a) If G1 is not operating, operate the STOP key to its STOP position.
- (b) If G1 is operating
 - (1) Operate REG key of G1 to TEST.
 - (2) Operate CONT key of G1 to TEST.
 - (3) G2 will start if its keys are all in the NOR positions.
 - (4) When GEN FAIL lamp of G2 goes out, operate STOP key of G1 to STOP and return REG and CONT keys of G1 to NOR.
- (c) To restore G1 to service, restore STOP key to NOR.

Note: If G2 is the only charging unit operating and the load is of a value that can be carried by G1, the generator cutoff feature will time out and cause G1 to restart in 3 minutes. If more than one charging unit is operating, G1 will fail to start automatically unless the load decreases to a value which can be carried by G1 without the aid of any other charging unit or if the total load on the plant requires all charging units, at which time the control circuit will function and restart G1 after a 3-minute delay.

2.28 Removing and Restoring Generator No. 2: The various conditions under which G2 may be removed from and restored to service are covered below.

- (a) If G2 is not operating, operate the STOP key to STOP.
- (b) If G2 is operating
 - (1) Operate REG key of G2 to TEST.
 - (2) Operate CONT key of G2 to TEST.
 - (3) CU1 will start if its keys are in NOR position.
 - (4) When the GEN FAIL lamp of CU1 goes out, CU1 may go to full load and cause CU3 to start. After CU3 connects, its output will rise until the output of CU1 is below 75 per cent load.
 - (5) When the output of G2 drops to zero, operate the STOP key of G2 to STOP and return the REG and CONT keys of G2 to NOR.
- (c) To restore G2 to service, operate the STOP key of G2 to NOR. When CU3 is running, G2 will restart if CU1 load is over 25 per cent and will cut in and stop CU1. If the total load is less than 80 per cent of CU1's rating, CU1 will be restarted in 3 minutes and G2 will then be disconnected.

2.29 Removing and Restoring No. 1 Rectifier: The various conditions under which R1 may be removed from and restored to service are covered below.

Note: Plants presently being furnished do not use rectifiers as the second charging unit.

- (a) If R1 is not operating, operate the RECT key to OFF.
- (b) If R1 is operated
 - (1) Operate the NOR-TEST R key of R1 to TEST R. (This may cause battery voltage to fluctuate temporarily until G2 connects.)
 - (2) G2 will start at this time if its keys are all in their NOR positions.
 - (3) When the GEN FAIL lamp on G2 goes out, operate the RECT key of R1 to OFF and return the NOR TEST R key to NOR.

(c) To restore R1 to service

- (1) Restore the RECT key to NOR.
- (2) If G2 is the only charging unit operating and the load is of a value that can be carried by R1, the generator cutoff feature will time out and cause R1 to restart in 3 minutes.
- (3) If more than one charging unit is operating, R1 will not restart automatically until the load decreases to a value which can be carried by R1 without the aid of any other charging unit, or until the total load on the plant requires all charging units, at which time the control circuit will function and restart R1 after a 3-minute delay. (See 2.23.)

Plant Not Arranged for Generator Cutoff**2.30 Removing and Restoring Generator No. 1:**

When it is desired to remove G1 from service, on plants not arranged for generator cutoff, it will be necessary to check if CU2 is operating and if it can carry the additional load which will be dropped by G1, when removed. The various conditions are described below.

CU2 Not Operating

- (a) Operate REG key of G1 to TEST.
- (b) Operate CONT key of G1 to TEST.
- (c) CU2 should start.
- (d) After GEN FAIL or RECT FAIL lamp of CU2 goes out, operate NOR-STOP key of G1 to STOP.
- (e) Restore CONT and REG keys of G1 to NOR.
- (f) To restore G1 to service, operate NOR-STOP key of G1 to NOR.

CU2 Operating

- (a) If CU2 can carry additional load caused by removing G1
 - (1) Operate STOP key of G1 to STOP.
 - (2) To restore G1 to service, operate STOP key of G1 to NOR.
- (b) If CU2 cannot carry the additional load caused by removing G1 and no other sets are operating

- (1) Operate REG key of CU1 to TEST.
- (2) Operate CONT key of CU1 to TEST.
- (3) CU2 should go to full load and cause CU3 to start and connect.
- (4) When CU1 goes to zero output, operate STOP key of G1 to STOP.
- (5) To restore G1 to service, operate in the following order, the CONT, REG, and STOP keys of G1 to NOR.

(c) If CU2 and succeeding sets are operating

- (1) Operate REG key of G1 to TEST.
- (2) Operate CONT key of G1 to TEST.
- (3) CU2 will cause CU3-CU7 to raise the output as required.
- (4) When G1 goes to zero output, operate STOP key of G1 to STOP.
- (5) To restore G1 to service, operate in the following order, the CONT, REG, and STOP keys of G1 to NOR.

2.31 Removing and Restoring Generator No. 2

- (a) Operate REG key of G2 to TEST.
- (b) Operate CONT key of G2 to TEST.
- (c) The battery voltage output may drop slightly. CU1 will return to voltage regulation control at full load and cause additional charging units to be added as required.
- (d) When CU2 goes to zero output, operate STOP key of G2 to STOP.
- (e) To restore G2 to service, operate in the following order the CONT, REG, and STOP keys of G2 to NOR.

2.32 Removing and Restoring Rectifier No. 1:

To remove R1 from service, check if CU2 is operating and can carry the additional load which will be dropped by R1 when R1 is removed. The various conditions are covered below.

CU2 Not Operating

- (a) Operate the NOR-TEST R key of R1 to the TEST R position. (This may cause the voltage to fluctuate until CU2 connects.)

- (b) When the GEN FAIL lamp of CU2 goes out, operate the RECT key of R1 to OFF.
- (c) Restore the NOR-TEST R key of R1 to NOR.
- (d) Restore R1 to service by operating the RECT key of R1 to NOR.

CU2 Operating

- (a) If CU2 can carry the additional load caused by removing R1
 - (1) Operate the RECT key of R1 to OFF.
 - (2) To restore R1 to service, operate the RECT key of R1 to NOR.
- (b) If CU2 cannot carry the additional load caused by removing R1, and if no other sets are operating:
 - (1) Operate the MAN-TEST key of CU3 to TEST.
 - (2) Hold the RAISE key of CU3 operated until CU2 lowers its output sufficiently to carry the additional load of R1.
 - (3) After CU3 takes on load, release its RAISE key and operate the RECT key of R1 to OFF.
 - (4) Operate RECT key of CU3 to NOR (all other keys should be in NOR position).
 - (5) To restore R1 to service, operate RECT key of R1 to NOR (all other keys should be in NOR position).
- (c) If CU2 is operating and succeeding sets are also operating
 - (1) Operate the MAN-TEST key, of the CU which succeeds the last operating CU, to TEST. (This CU will hereafter be referred to as the oncoming CU.)
 - (2) Hold the RAISE key of the oncoming CU operated until CU2 lowers its output sufficiently to carry the additional load of R1.
 - (3) After the oncoming CU takes on load, release its RAISE key and operate RECT key of R1 to OFF.
 - (4) Return MAN-TEST key of oncoming CU to NOR.

- (5) To restore R1 to service, operate RECT key of R1 to NOR (all other keys should be in NOR positions).

2.33 Removing and Restoring Rectifier No. 2:

The various conditions under which R2 may be removed from or restored to service are covered below.

(a) If Only CU1 and R2 Are Operating

- (1) Operate MAN-TEST key of CU3 to TEST.
- (2) Operate RAISE key of CU3 and hold operated until R2 drops to almost no output.
- (3) Release RAISE key of CU3 and operate RECT key of R2 to OFF.
- (4) Return MAN-TEST on CU3 to NOR.
- (5) To restore R2 to service, operate RECT key of R2 to NOR (all other keys of R2 should be in NOR position).

(b) If CU1, R2, and Succeeding CUs Are Operating

- (1) Operate the MAN-TEST key of the CU which succeeds the last operating CU, to TEST. (This CU will hereafter be referred to as the oncoming CU.)
- (2) Operate the RAISE key of the oncoming CU and hold operated until R2 drops to almost no output.
- (3) Release the RAISE key of the oncoming CU and operate RECT key of R2 to OFF.
- (4) Return MAN-TEST key of oncoming CU to NOR.
- (5) To restore R2 to service, operate RECT key of R2 to NOR (all other keys of R2 should be in NOR positions).

Removing From Service and Restoring to Service Charging Units No. 3 Through 7 — Plants With or Without Generator Cutoff

2.34 Removing and Restoring Generators No. 3 Through 7

(a) To Remove G-X From Service

- (1) Operate TEST key of G-X to TEST.

(2) Operate LOWER key of G-X and hold operated until generator output falls to a low value and a succeeding set assumes the load.

(3) Release LOWER key of G-X.

(4) When output of CU2 drops to 75 per cent or below, operate LOWER key of G-X until its output is reduced to zero.

(5) Operate STOP key of G-X to STOP.

(6) Return TEST key of G-X to NOR.

(b) To Restore G-X to Service

(1) Operate STOP key of G-X to NOR (all other keys should be in NOR positions).

(2) If succeeding CUs are connected, operate LOWER key on last connected CU until G2 goes to full load and starts G-X.

2.35 Removing and Restoring Rectifier No. 3 to 7

(a) To Remove R-X From Service

(1) Operate MAN TEST key of R-X to TEST.

(2) Operate LOWER key of R-X and hold operated until R-X output falls to a low value and a succeeding set assumes the load.

(3) Release LOWER key of R-X.

(4) When output of CU2 drops to 75 per cent or below, operate LOWER key of R-X until its output is zero.

(5) Operate RECT key of R-X to OFF.

(6) Operate MAN TEST key of R-X to NOR.

(b) To Restore R-X to Service

(1) Operate RECT key to ON.

(2) If succeeding CUs are connected, operate LOWER key on last connected CU until CU2 goes to full load and connects R-X.

Manual Operation of Charging Units

2.36 Manual Operation of Generator No. 1 or 2

Caution: Observe that plant voltage remains within limits when operating the generator manually as covered below.

Caution: If starter fails to go to run position as covered below, application of load will cause starter autotransformer to burn out.

To Place G1 or G2 Into Operation Manually

(a) Operate CONT key to TEST.

(b) Operate NOR-STOP key to NOR.

(c) Starter must operate to run position as indicated by sound of run contactor operating.

(d) Rotate generator manual control handwheel ccw until CA contactor operates which indicates the set is connected to battery.

(e) Raise or lower output as required by use of handwheel.

(f) After manual operation is completed, return handwheel to BAT position and CONT key to NOR.

An Alternate Method of Manual Operation Is Covered Below

(a) Operate MAN potentiometer on voltage regulator to NOR position.

(b) Operate REG switch on voltage regulator to MAN.

(c) Operate CONT key to TEST.

(d) Operate REG key to TEST.

(e) Operate NOR-STOP key to NOR.

(f) Starter must operate to run position as indicated by sound of CA contactor operating.

(g) Rotate MAN potentiometer on voltage regulator slowly until CA contactor operates. Connection of set to battery is indicated by sound of CA contactor operating.

(h) Control output as required using MAN potentiometer.

- (i) When manual operation is completed
 - (1) Operate REG and CONT key to NOR.
 - (2) Operate REG switch on voltage regulator to AUTO.
 - (3) Operate MAN potentiometer on voltage regulator to NOR.

2.37 Manual Operation of Rectifier No. 1 or 2

To Place R1 or R2 Into Operation Manually

- (a) Check that MAN potentiometer and OFF key are at NOR positions.
- (b) Operate CONT key to TEST R position.
- (c) Operate TEST 1 switch to TEST 1 and wait about 1 minute for electron tube warm up.
- (d) Turn MAN potentiometer slowly cw until CA contactor operates. Connection of set to battery is indicated by the sound of the CA contactor operating.
- (e) When manual operation is completed
 - (1) Operate MAN potentiometer to NOR.
 - (2) Operate TEST 1 key to NOR.
 - (3) Operate CONT key to NOR.

Caution: *Observe plant voltage when operating the rectifier manually.*

2.38 Manual Operation of Generator No. 3 to 7

- (a) Check that STOP key is in NOR position.
- (b) Operate TEST key to TEST.
- (c) Starter must operate to run position as indicated by sound of CA contactor operating.

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

- (d) When set connects to battery as indicated by sound of CA contactor operating, operate RAISE key until set assumes the desired load.

- (e) When manual operation is completed
 - (1) Operate LOWER key until set disconnects.
 - (2) Operate TEST key to NOR.

Caution: *Observe that plant voltage remains within limits when operating the generator manually.*

2.39 Manual Operation of Rectifier No. 3 to 7

- (a) Check that ON-OFF key is in ON position.
- (b) Operate MAN-TEST key to TEST.
- (c) Wait about 1 minute for electron tube warm up.
- (d) When set connects to battery as indicated by sound of CA contactor operating, operate RAISE key until set assumes desired load.

- (e) When manual operation is completed
 - (1) Operate LOWER key until set disconnects.
 - (2) Operate MAN-TEST key to NOR position.

Caution: *Observe that plant voltage remains within limits when operating the rectifier manually.*

Boost Charging Main Battery

2.40 To boost charge the battery, operate the FLOAT-CHG key on the main control board to the CHG position. With the key in this position, the circuit will make the necessary adjustments in operation automatically, and cause the starting of additional charging units, if required. When the charge has been completed, restore the FLOAT-CHG key on the main control board to the FLOAT position.

Boost Charging Emergency Cells

2.41 Adjust trickle charger to boost charge value.

Recharging After Power Failure

2.42 General: The 302A plant is arranged for recharging emergency cells by the method known as "charge by load." Under this method, the voltage regulating CU (CU1 or CU2) is left

connected to maintain float voltage on the main battery while the current regulating units (CU3-CU7) are connected to the EM CELL BUS. (Refer to Fig. 5.) Output current from the current regulating CUs passes through the emergency cell group to be charged and thence to load. If charging by load is attempted during a light-load period, any increase in output of CU3-CU7 will cause a corresponding decrease in the output of the voltage regulating unit (CU1 or CU2). In order to regulate voltage, the voltage regulating CUs must deliver some current. Therefore, the charging rate through the emergency cells will vary with load conditions. Where the load is high, the maximum amount of charging current through the emergency cells is determined by the finishing rate and temperature of the battery as follows. The emergency cells shall be charged at a rate not exceeding the finishing rate (nominal charging rate) of the emergency cells. However, 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 condition should the cells be charged at more than 150 per cent of the 8-hour rate at the start of the charge or at more than the finishing rate at the end of the charge. (See Section A401.001.1.) If the electrolyte temperature reaches 110°F (43°C) before the charge is completed, the charge rate shall be reduced 50 per cent by transferring CUs from the emergency cell bus to the battery bus. When charging emergency cells, any trickle charger in use may be left connected. Regardless of the number of CUs that are required to charge the emergency cells, CU1 or CU2 must be maintained in control of the main battery. Usually, CUs No. 3 to 7, under manual control, will be used to charge the emergency cells. The position in which to place the EM CELL CHG knife switch is determined by the position of the motor-driven EM CELL switch except in the case where the load is less than the total capacity of the power plant. [See 2.44(c).] The load is indicated by the DISCH ammeters on the emergency cell switch bay.

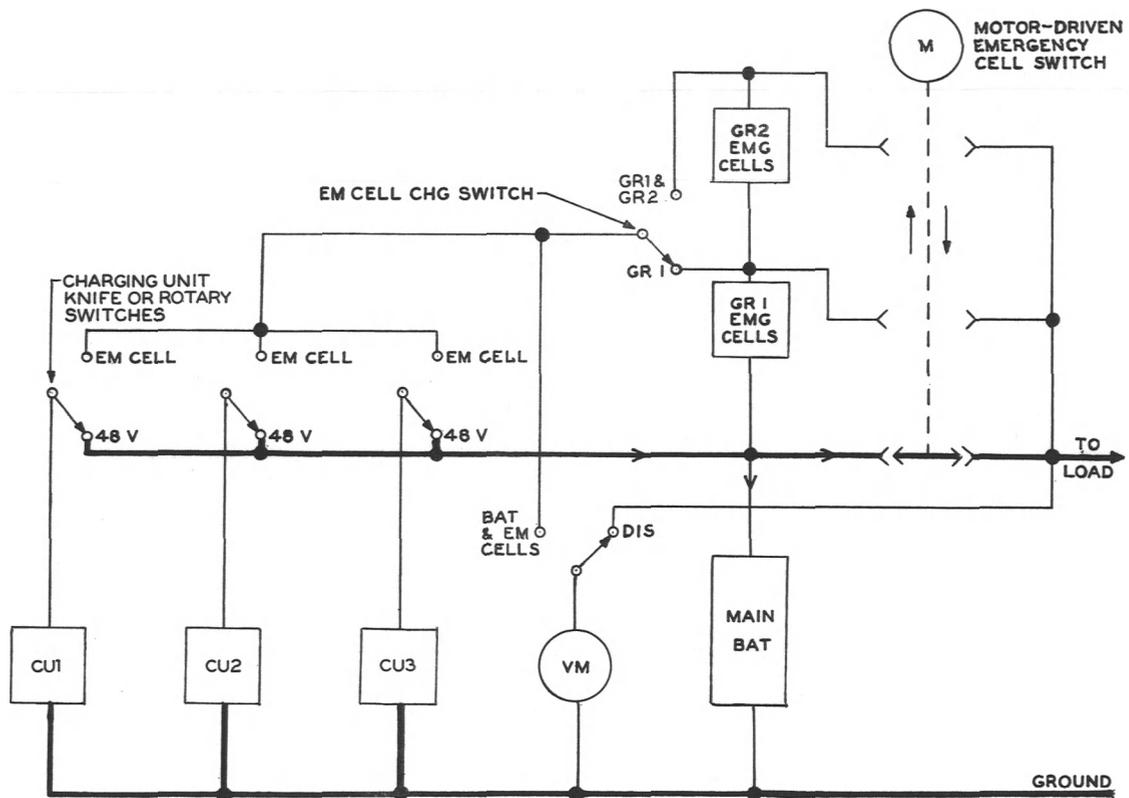


Fig. 5 - Simplified Boost Charge Circuit

2.43 If the power failure was short during a light-load period, and the EM cells alarm lamp is not lighted, the emergency cells were not cut in and the main battery will automatically recharge to float voltage.

2.44 If the power failure was long enough to cut in the emergency cells, the EM cells alarm lamp will remain lighted even though the main battery has recharged enough to cause the emergency cell switch to return to the normal position. In this case, check the individual cell voltage of the GR1 and GR2 emergency cells with a portable voltmeter, such as the Model 931 voltmeter, to see if they require recharging using the CUs or whether the trickle charge would be sufficient. Depending on the duration of the power failure and load conditions, several procedures for recharging the batteries are suggested in (a) to (c) below. A simplified circuit showing the basic switching arrangement is shown in Fig. 5.

Note: These instructions apply to 48-volt plants but may also be used for 24-volt plants, except that the specified emergency cell group voltages shall be halved. For information on manual operation of CUs see 2.36 to 2.39.

(a) If the power failure was of short duration during a light-load period and only the first group of emergency cells was cut in, first permit the charging units to restore the main battery to float voltage and thus cause the motor-driven emergency cell switch to return automatically to normal. As the main battery recharges, the output current of the voltage regulating CU (CU1 or CU2) and the last CU will decrease. When the voltage regulating CU is down to about 1/4 of its rated output and the last CU is about 1/2 of its rated output, reduce the output of the last CU by operating its LOWER key until it disconnects, providing the voltage regulating unit can carry the additional load caused by removing the last CU. Do not shut down the last CU until the voltage regulating unit can carry the last CUs load. When the last CU disconnects, if it is a generator, turn its manual control handwheel to the EM CELLS position and operate its knife switch to the EM CELLS position. If the last CU is a rectifier, operate its rotary switch to the EM CELL GR1 posi-

tion. Then, operate the associated EM CELL CHG knife switch on the emergency cell switch panel to the GR1 position. Place the last CU under manual control as covered in 2.36 to 2.39. At the main control board, read the voltmeter at the top of the panel. Then depress the 48V & EM CELLS voltmeter key while watching this voltmeter. The observed change in voltage on this voltmeter is the voltage across the GR1 emergency cells. This voltage is hereafter referred to as GR1 voltage. When the GR1 voltage rises to 5 volts, reduce the last CU output until the GR1 voltage is 4.4 volts. As the batteries approach a full charge, the GR1 voltage will increase more rapidly and the CU output current will decrease. When the output of the CU is approximately zero, GR1 is fully charged. Operate the NOR-STOP key to STOP. Restore the CU handwheel to the BAT position, if it is a generator, and restore its knife switch to the 48V or 24V position. If the CU is a rectifier, restore its rotary switch to the 48V or 24V position. Restore the CU to normal operation as covered in 2.36 to 2.39.

(b) If both groups of GR1 and GR2 emergency cells were cut in during the power failure, and sufficient charging capacity is available, first permit the charging units to bring up the voltage of the main battery enough to cause the emergency cell switch to cut back to the normal position. When the last CU decreases to about half its rated output and the voltage regulating CU decreases to about one quarter of its rated output, reduce the output of the last CU using the LOWER key until this CU disconnects, providing the voltage regulating CU can carry the additional load caused by removing the last CU. Do not shut down the last CU until the voltage regulating unit can carry the last CUs load. When the last CU disconnects, turn its manual control handwheel to the EM CELL position, if it is a generator, and operate its knife switch to the EM CELLS position. If the CU is a rectifier, operate its knife switch to the EM CELL GR1 & GR2 position. Then, operate the associated EM CELL CHG knife switch on the emergency cell switch panel to the GR1 & GR2 position. Place the last CU under manual control as covered in 2.36 to 2.39. Charge the GR2 cells as in (a), except that the GR2 voltage should be measured di-

rectly with a portable voltmeter, and not with the panel voltmeter. When the GR2 cells are fully charged, lower the last CUs output until it disconnects and RL relay releases. Operate the EM CELLS CHG switch to the GR1 position and charge the GR1 cells as in (a).

(c) If power is restored during a heavy-load period and the motor-driven EM CELL switch is in the GR2 position, the charging units must be connected to the GR2 position if the charging capacity of the CUs is less than the load demand. However, if the charging capacity of the CUs is in excess of the load demand, switching the CUs to the GR2 position will cause the motor-driven EM CELL switch to quickly return to the GR1 position, thus requiring immediate switching of the CUs to the GR1 position. Therefore, if the charging capacity of the CUs is in excess of the load demand, the CUs should be connected initially to the GR1 position which would avoid repeating the switching operation of the CUs. The procedures for connecting the CUs to the GR1 position are covered below. Procedures for connecting the CUs to the GR2 position, which should rarely be required, are similar except that the EM CELL CHG switch is operated to the GR2 instead of the GR1 position.

- (1) Starting with the highest numbered CU, (CU3-CU7) reduce its output by operating the LOWER key until it disconnects.
- (2) Operate NOR-STOP key to STOP if CU is a generator or ON-OFF key to OFF, if a rectifier.
- (3) If the CU is a generator, turn the manual control handwheel to the EM CELLS position.
- (4) Operate the EM CELL CHG knife switch on the emergency cell switch panel to the GR1 position.
- (5) Operate the CU knife or rotary switch to the EM CELLS or EM CELLS GR1 position.
- (6) Return the CU to normal operation by operating the NOR-STOP key to NOR or ON-OFF key to ON.
- (7) Repeat steps 1 to 6 for each succeeding current regulating CU from the last CU downward. (CU3-CU7).

(8) Shut down CU1 and CU2 by operating the NOR-STOP key to STOP in the case of generators or the ON-OFF key to OFF in the case of rectifier.

(9) Repeat steps 5 and 6. (In plants with generator cutoff return G2 to service first and then CU1.)

If ac power is being supplied from emergency engine do not turn on more than capacity will supply. When the battery voltage increases enough to cause the emergency cell switch to return to the normal position, check the GR1 voltage as in (a). When the GR1 voltage rises to 5 volts, manually shut down CU1 by operating its NOR-STOP key to STOP or ON-OFF key to OFF. Then, operate its knife or rotary switch to the 48V position and handwheel, if a generator, to the BAT position. Restore it to normal operation by operating the NOR-STOP key to NOR or ON-OFF key to ON. As charging continues, check the GR1 voltage. When it rises to 5 volts again, shut down CU2 by operating its NOR-STOP key to STOP or ON-OFF key to OFF. Then, operate its knife or rotary switch to the 48V position, and its handwheel to the BAT position, if it is a generator. Restore CU2 to normal operation by operating the NOR-STOP key to NOR or ON-OFF key to ON. On each current-regulated CU except the last, manually lower the output using the LOWER key until the CU disconnects. Then, operate the knife or rotary switch to the 48V position and handwheel, if it is a generator, to the BAT position. Restore to normal operation by operating the NOR-STOP key to NOR or ON-OFF key to ON. Continue charging the GR1 and GR2 emergency cells as in (a) or (b), as required.

Motor-driven Emergency Cell Switch

2.45 The emergency cell groups are automatically cut into or out of the discharge circuit under voltage control by the motor-driven emergency cell switch. If these cells are to be switched by manual control, the MAN-AUTO key, located with the emergency cell controls on the main control board, should be operated to the MAN position. The EM cells may then be cut in or out by operating the RAISE or LOWER keys, respectively, of the emergency cell circuit. These

keys should be held operated momentarily, repeating the operation of the key for each group of cells to be cut in or out. If the emergency cell switch stops between positions, clear the trouble promptly. Remove the EM CELL CONT fuse on the battery control board. The switch can now be operated safely by means of the hand crank. To do this, insert the hand crank into the aperture (front top of switch) and crank rapidly cw to remove emergency cells or ccw to add cells. Do not stop cranking until contacts are fully engaged, as stopping between positions will damage the current-limiting resistors. The contact position of the switch can be viewed through the window on the front cover. The charging of the emergency cells is covered in 2.41 to 2.44.

Caution: *Do not operate the switch more often than once every 5 minutes, otherwise the current-limiting resistors may overheat and burn out.*

Emergency Cell Float

2.46 A metallic-type unregulated rectifier is permanently connected to float the emergency cells. Adjustment of the rectifier should be made when the cells have been fully charged and when the line voltage is normal. An adjustable continuously tapped autotransformer in the rectifier provides means for changing the rectifier voltage and thereby its output current. The rectifier should be adjusted to hold the voltage nearest to 2.17 volts per cell. 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 when the main battery CUs are used.

24-volt Countercell Control Circuit

2.47 Where the 302A power plant is a combined 24- and 48-volt plant, with a 24-volt demand of less than 100 amperes, the plant may be arranged to supply the 24-volt load through countercells which connect to the 48-volt plant. These cells are automatically cut into or out of the 24-volt supply circuit to maintain the voltage within limits under all conditions of load.

Discharge Fuse Replacements

2.48 When replacing fuses on discharge panels equipped with KS-5047 fuse and switch units (single pole, double throw), always have the fuse terminals 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, replace the alarm fuse. If this second discharge fuse blows, check for trouble.

3. ROUTINE CHECKS

General

3.01 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 at periodic intervals 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.

3.02 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 operate, and on restoration of power, the charging units will connect in the required manner.

3.03 The operations described under Operation of Plant should be periodically checked for each charging unit of the plant. In performing these operations, raise or lower the voltage just enough to start the necessary follow-up operation. Fully automatic functions of the plant can be assumed to be in good operating condition if all the manual and test conditions shown under Operation of Plant are fulfilled during the periodic check.

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 during switching of the emergency cells. Readjust voltage relay if required.

Fuses and Alarms

3.04 Check all fuse-failure alarms and indicators periodically as covered in Table A. Check the alarms and indicator lamps with a low-resistance test receiver. Grasshopper fuse operation may be checked with either a No. 361B or No. 411A tool. The check can usually be made by connecting the test voltage on the alarm bar or stud immediately under the fuse being checked. The operator should analyze the test indication shown in Table A prior to applying the test voltage or test ground, to ascertain whether the test would shut down essential equipment. If such is the case, it may be desirable to postpone these tests.

3.05 Check fuse alarms on 70-type fuses, by inserting a No. 266C tool held in a No. 265C holder through the aperture in the front of the fuse holder through which the colored fuse bead protrudes. Insert the tool far enough to short the brass collar in the fuse holder cap to the fuse body thus causing an alarm.

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

3.06 In tests requiring the use of the test receiver, connect it in the circuit momentarily only in order to avoid overheating the receiver windings. In fuse alarm circuit tests generally the test receiver should be connected to the equipment side of the fuse. The receiver should be kept away from the ear when testing to avoid the effect of clicks.

3.07 Fuse Alarms — Alarm-type Fuse Shunting a Larger Fuse: Remove the alarm-type fuse associated with a large fuse. With a test receiver, connect first one and then the other alarm fuse terminal to the fuse alarm stud or bar. Note each time that the alarm operates while the receiver is connected. Replace the alarm-type fuse.

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

Charging Unit Failure Alarm

3.09 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 2.25 to 2.35. Carefully remove the fuses supplying the unit or operate associated switch or circuit breaker to its OFF position. Operate all keys to NOR.

CU1 — With generator cutoff, block RS2 relay operated. Without generator cutoff it is not necessary to block any relay.

CU2 to CU7 — Block the corresponding ST-relay operated.

The GEN FAIL or RECT FAIL lamp on the unit under test should light. After a delay of about 3 minutes, the GEN FAIL lamp should light on the main control board. Also, after the 3-minute delay, the PWR lamp in the emergency engine room should light and the minor alarm bell ring. The GEN FAIL and PWR lamps, and the audible alarm can be cut off by operating the ACO key on the main control board. When this key is operated, the GEN FAIL GD lamp lights on the main control board. Remove block from RS2 or ST relay. Replace fuses or restore circuit breaker.

3.10 Shut down of G1 and G2 due to overload on generator provided with CC TEST circuit should be checked as follows:

- (a) Operate CC TST key to TST.
- (b) Rotate CC TST potentiometer cw until OL relay operates and causes generator to shut down.

Note: If generator reaches 150 per cent of its rated output without the OL relay operating, stop CU and check OL relay.

- (c) GEN FAIL lamp of CU under test should light.
- (d) After a delay of about 3 minutes, GEN FAIL lamp on main control board should light.
- (e) Operate ACO key, GEN FAIL lamp will go out and GD lamp will light on main control board.

Voltage Control Alarms

3.11 Periodically the voltage alarm circuits should be tested. The paragraphs below are common to both the 24- and 48-volt plants and should be applied to both plants when the checks are made.

3.12 High-, Low-, and Float-voltage Alarms:

Using a W2W or W3M cord, connect the T & R terminals of 35-type test set across the test link of the voltage relay being tested, connecting the R terminal to the positive (G) side of the test link. When testing for a high-voltage condition, connect dry cells to BAT and GRD terminals of the test set as required (estimate 1-1/2 volts per cell), connecting the positive terminal of the dry cell or cells to the GRD terminal of the test set. If checking accuracy of a voltmeter relay, an external voltmeter with an accuracy of at least 1/2 per cent must be connected across the terminals of the voltmeter relay under test. Locking levers of No. 1 to No. 4 keys should be open and all the resistance slides should be in their extreme right positions.

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

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

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

3.14 Cut 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 such a way as to cause any violent operation of the relay as this may prevent a case of contact trouble from being detected in this test.

3.15 High-low-voltage Relay: Test the low-voltage and high-voltage contacts of the HLW relay in the following manner.

(a) **Low-voltage Test:** Gradually move the No. 3 slides to the right, thus introducing resistance and lowering the voltage across the voltage relay. Note that at the approximate point where the low-voltage alarm should come in, the audible and visual signals operate (EM CELL SW lamp and major alarm). If the voltage has not been lowered beyond the allowable range when both No. 3 slides have reached their extreme right position, slide them fully back to the left. Then by means of the No. 3 knife switches, cut in 25,000 ohms and again gradually move the slide to the right.

(b) **High-voltage Test:** Move the No. 3 slides to their extreme right positions. From the reading of the voltmeter determine whether the voltage has been reduced sufficiently to permit the introduction of the test battery without causing the high contact to make. Estimate the test battery voltage on the basis of 1-1/2 volts per cell. (If the voltage has not been reduced sufficiently, cut in additional resistance by opening one or more No. 3 knife switches as required to get the necessary reduction in voltage.) Then restore the BAT & GRD CO key and raise the voltage gradually by moving the No. 3 slider toward the left to remove resistance from the circuit. Note that at the approximate point when the high-voltage alarm should come in, the audible and visual signals operate (EM CELLS SW lamp and major alarm).

(c) When the tests described in 3.15(a) and (b) have been completed, reconnect the test link before removing the test equipment.

3.16 Float-voltage Relay: Using the method described in 3.15(a), check the low-voltage alarm contact of FV float relay. When low-voltage contact closes, HV timing motor, if provided, should start, PWR lamp in the emergency engine room should light, and a minor alarm should sound. If HV timer is provided, these signals will operate after a 3-minute delay. To check the dc timed float alarm if provided, repeat the low-contact closure of FV voltage relay with HV1 relay blocked nonoperated. In about 3 minutes the -V FLOAT ALM lamp should light. Remove the HV1 relay block. Using the method described in 3.15(b), check the high-

voltage alarm contact of FV float relay. Operation of alarms for high-contact closure of FV float relay is the same as that for low-contact closure, described above. Reclose test link after operation of the alarm circuit has been checked.

3.17 High-voltage Relay: Check the low- and high-voltage contacts of HV relay as follows:

- (a) To check the low-voltage contacts, use the method covered in 3.15(a). This will simulate a failure of VC fuse and cause shutdown of CU1 and CU2 or of all charging units, according to the option furnished in the plant. Do not make this test when temporary loss of the first two charging units will cause service reaction.
- (b) To check the high-voltage contacts, use the method covered in 3.15(b).
 - (1) VCO lamp (24) or (48) should light on main control board. If HV timing motor is provided, lamp will light after a 3-minute delay.
 - (2) CU1 and CU2 or all charging units will shut down according to option furnished in the plant.
 - (3) The PWR lamp should light in the emergency engine room and the major alarm bell should ring.
 - (4) Reconnect the test link and remove the test set.
 - (5) Operate the (24) or (48) VCO RLS key to return the circuit to normal.

Emergency Cell Lamp

3.18 Check that the -EM CELL SW lamp operates when GR1 or GR1 and GR2 emergency cells are brought into circuit. See note under 3.03 for instructions on bringing emergency cells into circuit.

Countercell Voltage Control Alarms

3.19 Contrary to the operation of the emergency cells, countercells are cut in when the voltage is high and are cut out when the voltage is low. In the 302A power plant, the countercells are used to provide 24 volts from a 48-volt plant when the current requirement for 24-volt supply does not exceed 100 amperes. Periodically the operation of the countercell switching circuit should be checked as described below.

3.20 Voltage Check

- (a) Read 24V DISCHG voltage on the plant voltmeter.
- (b) Block operated H relay just long enough to check that one countercell has been added to the circuit (G1 contactor operates) and the voltage has fallen accordingly. Remove block. The circuit will automatically return to normal.

3.21 Alarm Check

- (a) Insulate the top contacts 4 and 5 of L relay and the top contacts 1 and 2 of H relay in the countercell switching circuit.
- (b) Block operated H relay.
- (c) Keep the relay blocked operated for about 3 minutes. After this time has elapsed, the CEMF CELL lamp should light and the major alarm bell ring. Also, the PWR lamp in the emergency engine room should light.
- (d) Remove the block from H relay and block operated L relay.
- (e) Wait for about 3 minutes until the indications described in (c) are observed.
- (f) Remove the block from L relay and remove the insulation from the L and H relay contacts.

Alarm Multiple

3.22 The alarm multiple should be checked to be sure that major and minor alarms from other parts of the building will give corresponding audible alarms in the power room when the ALM MULT key, located on the main control board, is in the ON position.

Emergency Cell Switch

3.23 Check the voltage drop requirement covered in Section A401.531, quarterly.

4. TROUBLES

4.01 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 cuts countercells or emergency cells into or out of the discharge circuit. Troubles in units of equipment, such as motor-

generators sets, rectifiers, and regulators, are covered in the respective BSP sections. (See 1.06.)

4.02 The generator rheostats are adjusted at the time of installation and should not require readjustment unless disturbed for some reason, such as the replacement of a rheostat or parts of a rheostat. In the case of trouble, where the proper generator output and voltage cannot be obtained, do not change the rheostat settings as the trouble is undoubtedly due to other conditions.

4.03 Motor-driven TD1 and TD2 Timers: If no instructions are given, no maintenance of KS-8560 motor-driven timers is required. The timers 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.

4.04 Caution: Before replacing a battery charge or emergency cell charge fuse, operate all generator STOP keys to STOP; rectifier ON-OFF keys to OFF; and rectifier OFF keys to OFF. 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 or ON position, starting with the lowest numbered charging unit.

4.05 The following table lists all alarm lamps in alphabetical order together with functions. Action to be taken is also indicated in some cases.

LAMP	FUNCTION AND ACTION
ABS FA	Alarm battery supply fuse alarm. (See note.)
CBS FA	Control battery supply fuse alarm and voltage control fuse failure. (See note.)
CEMF CELL	Countercell switching circuit trouble. [See 3.21(c).]
CHG & MISC FA	Charge and miscellaneous fuse alarm. (See note.)
DISCHG FA	Discharge fuse alarm. (See note.)
EM CELL	Indicates emergency cell switch has operated.

LAMP	FUNCTION AND ACTION
EM CELL SW	Emergency cell switch alarm.
FLOAT	Float-voltage alarm. Operate ACO key.
FLOAT VOLT GD	FLOAT VOLT alarm has been cut off by operation of ACO key.
GEN FAIL (at the generator)	Control fuse or charging unit failure.
GEN FAIL (at main control board)	Charging unit failure. Operate ACO key. (See 3.08.)
GEN FAIL GD	GEN FAIL alarm has been cut off by operation of ACO key. (See 3.09.)
GEN PAN FA	Generator panel fuse alarm. Look for blown fuse on generator panels. If no GEN FAIL lamp is lighted, check panel of first nonoperating machine. (See note.)
PABS FA	Power alarm battery supply fuse alarm. (See note.)
PWR	Trouble in power room.
RCT FAIL	Rectifier failure. (See 3.09.)
VCO	High central office voltage. Operate VCO RLS key to cancel alarm. If alarm comes in again, check for cause. (See 3.17.)

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

4.06 Trouble Chart: The troubles and possible causes listed below are not necessarily all-inclusive but are merely indicative of some of the difficulties that may be encountered when the 302A power plant is not operating normally. In the case of visual alarms, the operator can tell the trouble location by the designation of the lamp which is lighted on the generator bay, rectifier bay, or main control board. In the case of fuse alarms, Table A will assist the

operator in locating the difficulty. If the trouble is not found with the assistance of the indicators and trouble chart, reference must be made to the schematic diagrams and circuit descriptions listed in 1.05.

TROUBLE	POSSIBLE CAUSE	TROUBLE	POSSIBLE CAUSE
Battery floating voltage high or low	J86250 voltage regulator out of adjustment.	24-volt discharge bus voltage high or low when obtained from a 48-volt plant through counter-cells	Control circuit failed to cut counter-cells in or out.
	Charge control AUTO-MAN key in MAN position.		Rectifier line contactor operates but rectifier has no output
	Failure of motor-driven rheostat.	Emergency cell switch alarm operates with battery voltage within proper limits	Defective emergency cell switch control circuit.
	Rectifier out of adjustment.		Battery voltage low and emergency cell switch does not operate
Battery floating voltage high	Failure of J86250 voltage regulator and exciter tubes.	Discharge fuse alarm operates	Emergency cell MAN-AUTO switch is in MAN position. Trouble with EM CELL relay.
	Battery trouble.		24- or 48-volt discharge fuse blown.
Battery floating voltage low	FLOAT-CHG key in CHG position.	Charge and miscellaneous discharge fuse alarm operates	Fuse blown, either battery or emergency cell charge, rectifier charge fuse, or miscellaneous discharge fuse. (See caution 4.04.)
	Motor-generator or rectifier fails to start.		Alarm battery supply fuse alarm or control battery alarm operates
	Load exceeds connected generator capacity.	Generator panel fuse alarm operates	
	Generator STOP keys in STOP position.		Generator stopped. C, CHG, or VM & VR fuse blown.
Discharge voltage high	Generator fails to start after replacing blown C, CHG, or VM & VR fuse. Set will not restart until STOP key has been operated to STOP position and returned to NOR.	Control failed to switch emergency cells out of circuit.	Control failed to switch emergency cells into circuit.
	Power failure or blown ac fuse.		
Discharge voltage low			

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TROUBLE	POSSIBLE CAUSE
<p>Generator failure alarm operates with one set stopped when it should be running</p>	<p>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 on current-controlled sets or the CONT key on voltage-controlled sets is operated to the TEST position with STOP key in NOR position. Shut down due to overload.</p>
<p>Set starts but does not build up sufficient voltage to connect to load</p>	<p>No field (see Section A301.101) or defective regulation circuit.</p>

TROUBLE	POSSIBLE CAUSE
<p>Set takes too long to connect to load</p>	<p>FR relay on current-controlled set operates at too low voltage or does not make proper contact to short-circuit field rheostat.</p>
<p>Set operates properly but alarm comes in too quickly</p>	<p>Faulty delay relay in alarm circuit.</p>
<p>Rectifier not operating when it should be operating</p>	<p>Blown service fuse or AC line contactor not operated. If charge control circuit is defective, the rectifier can be operated manually as described in 2.37 or 2.39.</p>

TABLE A

FUSE LOCATION	FUSE DESIGNATION	TEST PROCEDURE	INDICATION
Charging Generators No. 1 and 2 — 24-volt Circuit Breaker Panel	GEN CONT CHG FA C CBA1 CBA2 VM & VR	Place 24 volts on alarm stud. Place GND on alarm stud. Place 24 volts on alarm stud. Place 24 volts on EM CELL auxiliary contact. Place 24 volts on BAT auxiliary contact. Place 24 volts on alarm stud.	Note 1 Note 1* Note 1* EM CELL lamp lights BAT lamp lights Note 1*
Charging Generators No. 1 and 2 — 48-volt Circuit Breaker Panel	GEN CONT CHG FA C CBA1 CBA2 VM & VR	Place 48 volts on alarm stud. Place GND on alarm stud. Place 48 volts on alarm stud. Place 48 volts on EM CELL auxiliary contact. Place 48 volts on BAT auxiliary contact. Place 48 volts on alarm stud.	Note 1 Note 1* Note 1* EM CELL lamp lights BAT lamp lights Note 1*
Charging Generators No. 3 to 7 — 24 Volts	GEN CONT 6.25A GEN CONT 1/2A CHG FA C CBA1 CBA2 VM	No test required. Place 24 volts on alarm stud. Place GND on alarm stud. Examine visually. Place 24 volts on EM CELL auxiliary contact. Place 24 volts on BAT auxiliary contact. Place 24 volts on alarm stud.	None Note 1 Note 1 None EM CELL lamp lights BAT lamp lights Note 1
Charging Generators No. 3 to 7 — 48 Volts	GEN CONT 6.25A GEN CONT 1/2A CHG FA C CBA1 CBA2 VM	No test required. Place 48 volts on alarm stud. Place GND on alarm stud. Examine visually. Place 48 volts on EM CELL auxiliary contact. Place 48 volts on BAT auxiliary contact. Place 48 volts on alarm stud.	None Note 1 Note 1 None EM CELL lamp lights BAT lamp lights Note 1
Main Control Board	24V CBS Strip 48V CBS Strip PABS Strip (s) 24V REG VC 24V REG G1 24V REG G2 48V REG VC 48V REG G1 48V REG G2	Place 24 volts on alarm bar. Place 48 volts on alarm bar. Place test voltage on alarm bar. Use 24 volts on 24-volt plant. Use 48 volts on 48-volt and combined plants. Place 24 volts on alarm stud. Place 24 volts on alarm stud. Place 24 volts on alarm stud. Place 48 volts on alarm stud. Place 48 volts on alarm stud. Place 48 volts on alarm stud.	Note 2 Note 2 Note 3 Note 2 Note 2 — Transfer to Charging Unit No. 2 Note 2 — Transfer to Charging Unit No. 1 Note 2 Note 2 — Transfer to Charging Unit No. 2 Note 2 — Transfer to Charging Unit No. 1

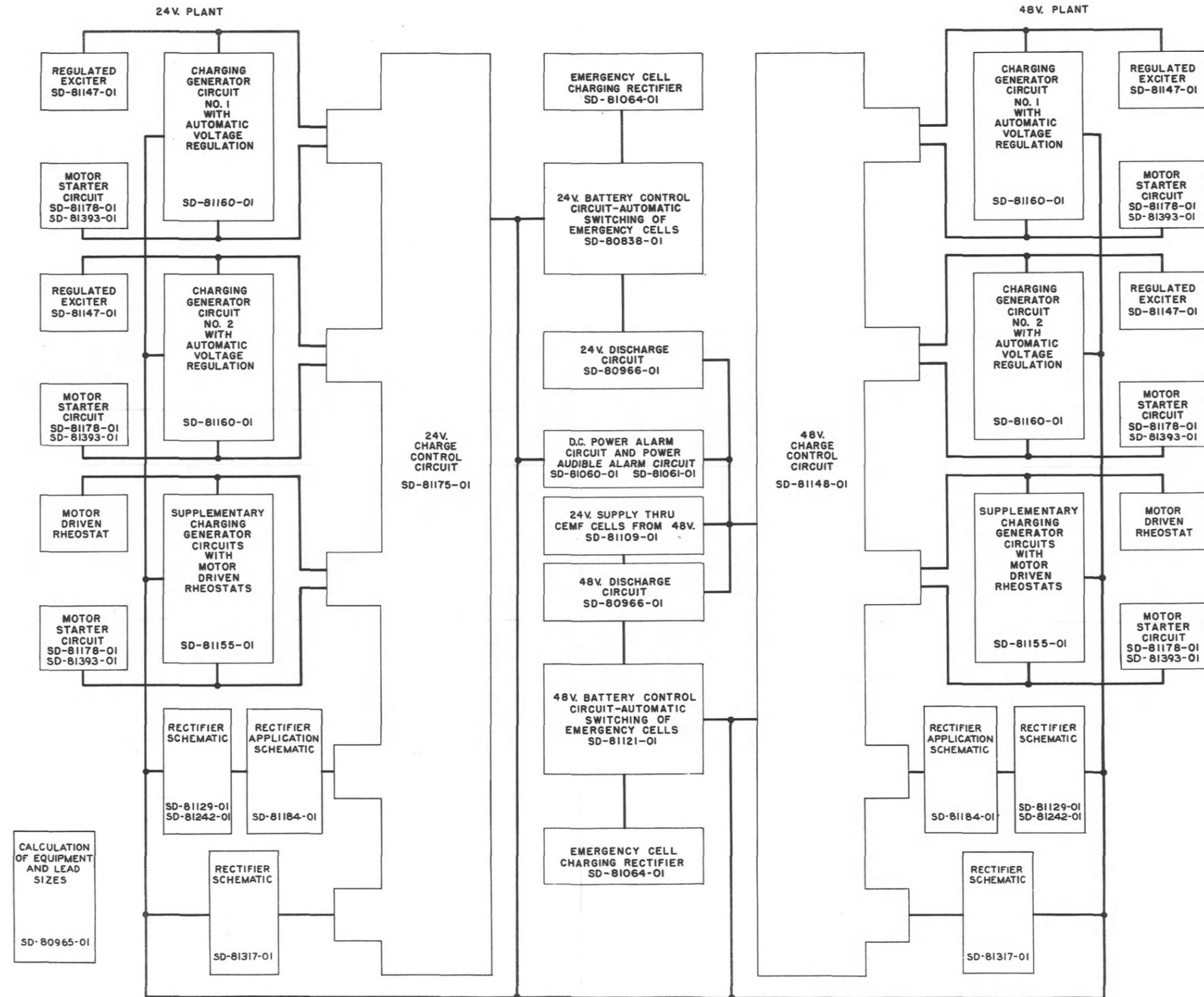
*Set will not restart until STOP NOR key has been operated to STOP and returned to NOR.

TABLE A — (Contd)

FUSE LOCATION	FUSE DESIGNATION	TEST PROCEDURE	INDICATION
Battery Control Board and Emergency Cell Control Panel (See note 4.)	BAT CHG XA EM CELL CHG XA EMC G1 15A EMC G2 15A EMC G1 15A EMC G2 15A REG — 15A EM CELL SW CONT A and B EMC VM 3A VM 3A	No test required.	None A reading indicates fuse is not blown.
	BAT CHG 1/2A EM CELL CHG 1/2A EMC G1 1/2A EMC G2 1/2A EMC G1 1/2A EMC G2 1/2A REG 1/2A EM CELL SW CONT A and B 1/2A	On 24-volt plant, place 24 volts on alarm stud. On 48-volt plant, place 48 volts on alarm stud.	Note 5 Note 5 Note 6 Note 6 Note 6 Note 6 Note 7 Note 7
	24-volt Fuses CO FIRE DRILL 24VR RING PWR BD 24V CBS EMG ALM PWR ALM ALM BAT SUP	Place 24 volts on alarm stud. Place 24 volts on alarm stud.	Note 7 Note 7 Note 7 Note 7 Note 7 Note 8 Note 8
	48-volt Fuses EMG ALM 24V CEMF RING PWR BD 48V CBS PABS ABS	Place 48 volts on alarm stud. Place 48 volts on alarm stud.	Note 7 Note 7 Note 7 Note 7 Note 8 Note 8

Notes

1. GEN PAN FA lamp lights on main control board; PWR lamp in emergency engine room lights; minor alarm bell rings; associated generator stops and transfers control to next set.
2. CBS lamp lights on main control board; PWR lamp in emergency engine room lights; major alarm bell rings.
3. PABS FA lamp lights on main control board; rings alarm battery supply signal bell.
4. All fuses shown do not appear on all plants. Check those which apply to the plant being checked.
5. GR relay operates to stop generators No. 1 and 2.
6. CHG & MISC lamp lights on main control board; PWR lamp lights in emergency engine room; minor alarm bell rings.
7. DISCH lamp lights on main control board; PWR lamp lights in emergency engine room; major alarm bell rings.
8. ABS FA lamp lights on main control board; rings alarm battery supply signal bell.



Note: Rectifiers can be used as charging units No. 1 to No. 2 or as charging units No. 3 to No. 7.

Fig. 6 - 302A Power Plants — Automatic Start Control, Automatic Charge Control, and Automatic Emergency Cell Switching of 24- and 48-volt Charging Units