RECTIFIER
KS-19210 L2 AND L7
24 VOLTS, 400 AMPERES
OPERATING METHODS

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1. GENERAL

1.01 These rectifiers provide regulated dc power from an ac power source for use in charging storage batteries in the 301C and 302A-type power plants. The rectifiers are rated at 24 volts, 400 amperes direct current; however, they will provide a maximum of 30.8 volts at full load for a 14-cell plant or 33.4 volts if rectifier is operating in the manual mode to charge emergency cells. The input power requirement is 3-phase, 3-wire, 60-cycle ± 2 percent alternating current. Taps are provided to operate the rectifier from an ac power source between 190 and 250 volts for the KS-19210 L7 rectifier and between 400 and 500 volts for the KS-19210 L2 rectifier with an allowable line variation of -10 percent to $+5$ percent for either rectifier.

Warning: Voltages inside the rectifier cabinet are over 150 volts to ground. Avoid all contact with terminals. Do not allow a test pick to touch two metal parts at the same time, as destructive or dangerous short circuits may occur.

1.02 This section is reissued for the following reasons:

(a) To add a new output filter capacitor charging procedure.

(b) To reference a switch cleaning, testing, and adjusting procedure.

(c) To update the section in general.

This issue of the section does affect the Equipment Test List.

1.03 The S1 output selector switch is provided to switch the rectifier output from the F bus to EC bus. With S1 set in BAT, GR1, or GR1 and GR2 position, the rectifier may be connected to charge 11, 12, or 13 cells for an 11-cell plant or 12, 13, or 14 cells for a 12-cell plant.

Caution: ◗Do not operate the S1 output selector switch from the OFF to the F or EC position when the rectifier OFF-NOR (S4) switch is in the NOR position.

1.04 This issue of the section is based on the following drawing: SD-81627-02, Issue 3. For a detailed description of the operation, see the corresponding circuit description. If this section is to be used with equipment or apparatus that is associated with an earlier or later issue of the schematic drawing, reference should be made to the SDs and CDs to determine the extent of the changes and the manner in which the section may be affected.◖

1.05 For more detailed information on operation and maintenance of associated equipment or apparatus, refer to the appropriate Bell System Practice.

1.06 The abbreviations cw and ccw, used herein, refer to clockwise and counterclockwise respectively.

2. LIST OF TOOLS AND TEST APPARATUS

CODE OR SPEC NO.	DESCRIPTION
▶TOOLS	
—	Resistor (10 ohm, 50 watt)
—	Fuse (6 ampere, 125 volt dc)
—	Switch (15 ampere, 125 volt dc)◀
TEST APPARATUS	
—	A.B. Dumont Lab Inc Type 304 Oscilloscope. This oscilloscope is not required for normal routine maintenance. See 5.05.
KS-8039	DC Volt-Milliammeter
KS-14510 L1	Volt-Ohm-Milliammeter

3. OPERATION

3.01 ▶***Preparing to Start:*** When preparing to put the rectifier in service, proceed as follows.

(1) Position the controls as follows:

CONTROL	POSITION
NOR-TST (S5) Key	TST
AUTO-MAN (S2) Key	MAN
OFF-NOR (S4) Switch	OFF
S1 Switch (dc output selector)	OFF
CONT (CB1) Circuit Breaker	OFF
LOWER-NOR (S7) Switch	NOR
RAISE-NOR (S6) Switch	NOR
Associated switch and fuse unit in bus duct or power service cabinet	OFF
CC TST (S3) or RUN-SET Simulated Output Current Switch	OFF or RUN
CC TST (R36) Potentiometer	Fully ccw
MAN ADJ (R17) Potentiometer	Fully ccw

(2) The ac input taps on the T1 transformer are connected for the available ac voltage.

(3) The T2 and T5 transformers are connected in accordance with the SD and rectifier output requirements.

(4) All external connections are made in accordance with the schematic drawing covering the associated circuit of which the rectifier is a part.

(5) All associated fuses are installed in their respective fuse holders.

(6) All appropriate circuit packs, fuses, and lamps are installed in the rectifier.

3.02 ***Charging Output Filter Capacitors:*** This procedure charges the output filter capacitors, preventing arcing when closing the S1 output selector switch to the BAT F or EC position from the OFF position. To charge the output filter capacitors, proceed as follows.

(1) The rectifier controls are positioned as listed in 3.01.

Note: The jumper used in this procedure is a series connection of a resistor (10 ohm, 50 watt), a fuse (6 ampere, 125 volt), and an ***on-off*** switch (15 ampere, 125 volt). Suitable clip leads are utilized to connect the series combination in the rectifier circuit.

(2) ***Warning: To prevent inadvertent shorting of a voltage connected jumper with other parts of the rectifier, always make the battery (F or EC) connection last.***

Connect the jumper (jumper switch in ***off*** position) from the switch side of the CHG (F5) fuse holder to a convenient point on the battery connected F (BAT) or EC (GR1 or GR1 & GR2) terminal plate of the S1 output selector switch.

(3) Operate the jumper switch to the ***on*** position.

(4) When the rectifier voltmeter indicates approximately battery or battery plus end-cell voltage, operate the S1 output selector switch to the required F or EC position.

(5) Operate the jumper switch to the ***off*** position.

(6) ***Caution: To prevent shorting with other parts of the rectifier, remove both clip leads simultaneously.***

Disconnect the jumper from the rectifier circuit.

3.03 ***Starting—Automatic Operation***

Note: With the controls in position for automatic operation, the rectifier will start, operate, and stop by signals from the plant.

(1) Perform the capacitor charging procedure as outlined in 3.02.

(2) Operate the associated switch and fuse unit in the bus duct or in the power service cabinet to the ON position.◀

(3) Operate the CONT (CB1) circuit breaker to the ON position.

(4) Operate the AUTO-MAN (S2) key to the AUTO position.

(5) Operate the NOR-TST (S5) key to the NOR position.

(6) Operate the OFF-NOR (S4) switch to NOR position. ▶The rectifier is now connected to the plant control circuit and is placed into service in accordance with the appropriate power plant Bell System Practice.

Note: If operational conditions require manual operation, place the rectifier in the manual mode of operation in accordance with the appropriate power plant Bell System Practice.◀

3.04 ***Starting—Manual Operation***

(1) ▶Perform the capacitor charging procedure as outlined in 3.02.

(2) Operate the associated switch and fuse unit in the bus duct or in the power service cabinet to the ON position.◀

(3) Operate the CONT (CB1) circuit breaker to the ON position.

(4) Operate the NOR-TST (S5) key to the TST position.

Note: ▶When the NOR-TST (S5) key is operated to the TST position, the control of the rectifier is transferred from the plant to the switches on the rectifier. With the S5 key in the TST position, the rectifier may be operated in either regulated or unregulated mode depending upon the position of AUTO-MAN (S2) key.◀

(5) Operate the AUTO-MAN (S2) key to the MAN position.

Note: ▶With the AUTO-MAN (S2) key in the MAN position, the transistor amplifier is disconnected from the rectifier circuit and regulation must be controlled by the manual adjustment of the MAN ADJ (R17) potentiometer.◀

(6) Operate the OFF-NOR (S4) switch to NOR position. The rectifier is in the manual mode of operation and is controlled by the switches on the rectifier.

(7) ▶Rotate the MAN ADJ (R17) potentiometer cw to increase the current on the rectifier to the desired value. Adjust the MAN ADJ (R17) potentiometer ccw or cw to maintain the output current.◀

Note: Before shifting from manual to automatic mode of operation, refer to the appropriate power plant Bell System Practice.

3.05 ***Removing from Service***

(1) Remove rectifier from service in accordance with appropriate power plant Bell System Practice.

(2) ▶Verify that the OFF-NOR (S4) switch is in the OFF position.

(3) Operate the CONT (CB1) circuit breaker to the OFF position.

(4) Operate the S1 output selector switch to the OFF position.

(5) Operate the associated switch and fuse unit in the bus duct or power service cabinet to the OFF position.◀

3.06 ***Restoring to Service:*** To restore a rectifier to service after being disconnected, proceed as follows.

Note 1: If the rectifier has been out of service for an extended period of time, perform the routine checks in Part 4 before restoring the rectifier to service.

Note 2: If the rectifier shuts down automatically due to a blown fuse, set OFF-NOR (S4) switch to OFF to release the relays before restoring to service.

(1) ▶Verify that the controls are positioned as outlined in 3.01.

(2) Perform 3.03 or 3.04 to start the rectifier.◀

Note: Restore rectifier to service in accordance with appropriate power plant Bell System Practice.

4. ROUTINE CHECKS

4.01 ▶Perform the routine checks at intervals in accordance with the Equipment Test List.◀ It is suggested that the routine checks be made if maintenance is performed which may affect the settings of the rectifier controls or if the rectifier has been out of service for an extended period of time and is to be returned to service.

Note: ▶The setting of the MAX VOLT LIMIT (R128), MIN LD SIG (R56), and MAX LD SIG (R58) potentiometers, may be set as required by the associated plant.◀

4.02 ***Contactor and Relays:*** As often as local experience demands, the contactor and relays should be inspected for adjustment and condition of contacts, making sure that they are in accordance with the circuit requirements table and the Bell System Practices which apply.

4.03 ▶***S1 Output Selector Switch:*** Clean, test, and adjust the S1 output selector switch in accordance with the procedures outlined in Section 169-704-701.◀

4.04 ***Voltage Limiting Circuit Checks***

(1) ▶Remove the rectifier from service in accordance with 3.05◀

(2) Remove CONTROL (F12) fuse.

(3) Connect a temporary jumper between terminals 8 and 9 on TS3.

(4) Connect the KS-8039 meter between the J1(+) and J2(−) pin jacks.

Note: Determine that the CC TST (R36) potentiometer is rotated fully ccw.

(5) ▶Operate the associated switch and fuse unit in the bus duct or power service cabinet to the ON position.◀

(6) Operate the CONT (CB1) circuit breaker to the ON position.

(7) Operate the AUTO-MAN (S2) key to the AUTO position.

(8) Verify that the NOR-TST (S5) key is in the TST position.

(9) Operate the OFF-NOR (S4) switch to NOR position.

(10) Set RAISE-NOR (S6) switch to RAISE and hold operated until the output voltage no longer increases.

Requirement: The KS-8039 meter should indicate between 26.5 and 27.2 volts for an 11-cell connection and between 28.7 and 29.4 volts for a 12-cell connection.

Note: If the KS-8039 meter indicates the requirement given in (10), proceed to (12). If the KS-8039 meter does not indicate the requirement given in (10), proceed with (11).

(11) If the indication observed in (10) is below 26.5 volts or above 27.2 volts for an 11-cell connection or below 28.7 volts or above 29.4 volts for a 12-cell connection, rotate the MAX VOLT LIM (R128) potentiometer cw to raise the limiting point or ccw to lower the limiting point. ▶Operate the LOWER-NOR (S7) switch to LOWER until the voltage is at a minimum. Repeat (10) to check the setting.◀

(12) When the correct voltage indication is obtained on the KS-8039 meter, set the LOWER-NOR (S7) switch to LOWER and hold operated until the voltage cannot be reduced further.

(13) Operate OFF-NOR (S4) switch to OFF position.

(14) Disconnect the KS-8039 meter.

(15) Remove the jumper from terminals 8 and 9 on TS3.

Note: If no further tests are to be made, replace CONTROL (F12) fuse and restore rectifier to service in accordance with 3.06.

4.05 ***Current Limiting Circuit Check***

(1) ▶Remove the rectifier from service in accordance with 3.05.◀

(2) Remove CONTROL (F12) fuse.

(3) Connect a temporary jumper between ▶teminals 8 and 9 on TS3.

(4) Connect the KS-8039 meter between the J1 (+) and J2(−) pin jacks.◀

(5) Rotate MAX CUR LIM (R86) potentiometer fully cw.

(6) ▶Operate the associated switch and fuse unit in bus duct or power service cabinet to the ON position.◀

(7) Operate CONT (CB1) circuit breaker to ON position.

(8) Operate the AUTO-MAN (S2) key to AUTO position.

(9) Verify that the NOR-TST (S5) key is in the TST position.

(10) Operate the OFF-NOR (S4) switch to NOR position.

(11) Operate RAISE-NOR (S6) switch to RAISE and hold operated until the ▶output voltage no longer increases. [The KS-8039 meter indication should meet the voltage limit requirement in 4.04 (10).]◀

(12) Operate CC TST (S3) switch to ON and hold; or, if provided, set RUN-SET switch to SET and hold.

(13) Rotate CC TST (R36) potentiometer cw until the OUTPUT ammeter indicates 420 amperes.

(14) Rotate MAX CUR LIM (R86) potentiometer slowly ccw until CONTROL ammeter indicator deflects to the left.

(15) Rotate CC TST (R36) potentiometer ccw until the CONTROL ammeter indicator deflects to the right.

Requirement: The OUTPUT ammeter should indicate between 410 and 430 amperes.

Note: If the requirement is met in (15), proceed to (18). If the requirement is not met, proceed with (16).

(16) Operate RAISE-NOR (S6) switch to RAISE and hold for approximately 5 seconds.

Note: ▶The voltage may have dropped below the voltage limit if the current limit setting has taken considerable time.

(17) Repeat (13), (14), and (15).

(18) Rotate CC TST (R36) potentiometer fully ccw.◀

(19) Release CC TST (S3) switch or RUN-SET switch, if provided.

(20) Operate LOWER-NOR (S7) switch to LOWER and hold operated until the output voltage is reduced to a minimum.

(21) Operate OFF-NOR (S4) switch to OFF position.

(22) ▶Operate CONT (CB1) circuit breaker to OFF position.

(23) Disconnect the KS-8039 meter.◀

(24) Remove jumper from terminals 8 and 9 on TS3.

(25) Restore CONTROL (F12) fuse.

Note: ▶If no further tests are to be made, restore rectifier to service in accordance with 3.06.◀

4.06 ***Minimum Load Signal Check***

(1) ▶Remove the rectifier from service in accordance with 3.05.

(2) Operate the associated switch and fuse unit in bus duct or power service cabinet to the ON position.◀

(3) Operate CONT (CB1) circuit breaker to ON position.

(4) Operate the AUTO-MAN (S2) key to AUTO position.

(5) Verify that the NOR-TST (S5) key is in the TST position.

(6) Operate the OFF-NOR (S4) switch to NOR position.

(7) Operate CC TST (S3) switch to ON and hold; or, if provided, operate RUN-SET switch to SET and hold.

(8) Rotate CC TST (R36) potentiometer slowly cw until relay K13 releases.

Requirement: The OUTPUT ammeter should indicate between 20 and 40 amperes.

Note: If the OUTPUT ammeter indicates the requirement given in (8), proceed to (14). If the OUTPUT ammeter does not indicate the requirement given in (8), proceed with (9).

(9) Rotate MIN LD SIG (R56) potentiometer fully cw.

Requirement: The K13 relay should release.

(10) Adjust CC TST (R36) potentiometer until the OUTPUT ammeter indicates 30 amperes.

(11) Slowly rotate MIN LD SIG (R56) potentiometer ccw until K13 relay operates.

(12) Rotate CC TST (R36) potentiometer ▶cw◀ until the K13 relay releases.

(13) Rotate CC TST (R36) potentiometer ccw until the K13 relay operates.

Requirement: The K13 relay should operate or release between 20 and 40 amperes.

Note: If the required indication is not obtained, repeat (9) through (13).

(14) ▶Rotate CC TST (R36) potentiometer fully ccw.◀

(15) Release CC TST (S3) or RUN-SET switch if provided.

Note: ▶If no further tests are to be made, restore rectifier to service in accordance with 3.06.◀

4.07 ***Maximum Load Signal Check***

(1) ▶Remove the rectifier from service in accordance with 3.05.

(2) Operate the associated switch and fuse unit in bus duct or power service cabinet to the ON position.◀

(3) Operate CONT (CB1) circuit breaker to ON position.

(4) Operate the AUTO-MAN (S2) key to AUTO position.

(5) Verify that the NOR-TST (S5) key is in the TST position.

(6) Operate the OFF-NOR (S4) switch to NOR position.

(7) Operate the CC TST (S3) switch to ON and hold; or, if provided, operate RUN-SET switch to SET and hold.

(8) Rotate CC TST (R36) potentiometer cw until the OUTPUT ammeter indicates 375 amperes.

Requirement: The K10 relay should operate.

(9) Rotate CC TST (R36) potentiometer cw until K10 relay releases.

Requirement: The OUTPUT ammeter should indicate between 395 and 405 amperes.

Note: If the OUTPUT ammeter indicates the requirement given in (9), proceed to (14). If the OUTPUT ammeter does not indicate the requirement given in (9), proceed with (10).

(10) ▶Rotate CC TST (R36) potentiometer ccw or cw◀ until the OUTPUT ammeter indicates 400 amperes.

(11) Slowly rotate MAX LD SIG (R58) potentiometer ▶cw◀ until K10 relay releases.

(12) Rotate CC TST (R36) potentiometer ccw until K10 relay operates.

(13) Rotate CC TST (R36) potentiometer cw until K10 relay releases.

Requirement: The K10 relay should operate or release between 395 and 405 amperes.

Note: If the required indication is not obtained, repeat (10) through (13).

(14) ▶Rotate CC TST (R36) potentiometer fully ccw.◀

(15) Release CC TST (S3) switch or RUN-SET switch, if provided.

(16) Operate OFF-NOR (S4) switch to OFF position.

(17) Restore the rectifier to service in accordance with 3.06.

5. TROUBLES

5.01 The rectifiers consist of a main power circuit controlled through an electronic regulating circuit. In addition, the output of the current sensing circuit is introduced into the regulating circuit for the purpose of current signaling and limitation. The output of the regulating circuit is introduced into the main power circuit to effect the desired corrections in the power output. In the maintenance of intricate equipment, trouble must be localized in an orderly way. This is difficult in the case of a circuit having this feedback or loop arrangement because trouble anywhere in the loop will give faulty operation of other parts of the loop which may be trouble free. In these rectifiers, provision has been made for opening the loop by means of the AUTO-MAN (S2) key which, when operated to the MAN position, permits isolating the trouble to the regulating circuit only.

Caution: The MAN ADJ (R17) potentiometer should always be rotated fully ccw before operating the AUTO-MAN (S2) key to MAN to avoid excessive voltage and current.

5.02 Although it may vary widely with extreme conditions, the control current when observed in connection with daily routine and compared with operating experience, can serve as a guide to the causes of unusual operation or trouble conditions. The purpose of the CONTROL ammeter is to give a continuous indication of the output of the regulating circuit. This output also controls the output of the rectifier. The control current supply circuit and main power circuit are generally performing satisfactorily if increasing the amount of control current increases the rectifier output and decreasing the control current decreases the rectifier output. When the AUTO-MAN (S2) key is in the MAN position, the MAN ADJ (R17) potentiometer is provided to manually control the control current, in which case some of the features of the more complex regulating circuits are temporarily disabled.

5.03 When any kind of trouble is encountered, it is necessary first to decide whether to locate the trouble with the equipment operating or de-energized. These rectifiers have been designed to make some parts accessible for testing with the power connected. The jacks are mounted on the face of the panel, which is accessible when the front doors are open. Trouble is easier to find if the equipment can be fully energized. However, if the trouble is of a nature that causes excessive output from the equipment, perform the initial steps with the system de-energized, and energize it for short periods only while electrical measurements are made. Also, operation for more than a few minutes at a time while trouble exists, even though the output may not be excessive, may result in overheating of some components. It is essential, when testing, to be alert to the need for quickly shutting down the rectifier at any time until the trouble is localized and cleared.

5.04 ***Trouble Chart:*** Should any of the following troubles develop it is suggested that the possible cause be checked in the order given. If the trouble is not found, look for loose or open connections or short circuits due to foreign matter lying across wiring terminals.

TROUBLE	POSSIBLE CAUSE
(a) No dc output current (no control current indicated on *CONTROL* ammeter)	Blown ac supply or control fuse
	CONT circuit breaker in *OFF* position
	K2, K4 relay failure
	AC (K1 contactor not operated)
(b) No dc output current (high control current indicated on *CONTROL* ammeter)	F5 CHG fuse blown
(c) Low dc output voltage (low positive control current indicated on *CONTROL* ammeter)	*RAISE ADJ* (R106) potentiometer out of adjustment
	Current limiting circuits out of adjustment (see 4.05)
	Faulty current sensing circuit
	Faulty regulator circuit
(d) Low dc output (high control current indicated on *CONTROL* ammeter)	*RAISE ADJ* (R106) potentiometer out of adjustment
	Low line voltage or T1 transformer taps incorrect
	Rectifier operating single phase
	Defective saturable reactor (see 5.05)
(e) High dc output voltage (low control current indicated on *CONTROL* ammeter)	*RAISE ADJ* (R106) potentiometer out of adjustment
	High line voltage or T1 transformer taps incorrect
	Defective saturable reactor (see 5.05)
(f) High dc output voltage (high control current indicated on *CONTROL* ammeter)	*RAISE ADJ* (R106) potentiometer out of adjustment
	Faulty current sensing circuit
	Faulty regulator circuit
(g) Output excessively noisy	Defective filter capacitors
	Unbalanced ac line voltage (more than 5 percent)
	Defective rectifier stacks
(h) Unstable output (hunting)	See 5.06
	Caution: Hunting should be corrected as soon as possible to prevent damage to the rectifier.
(i) Poor regulation at battery	R139 potentiometer out of adjustment
	MAX CUR LIM (R86) potentiometer out of adjustment
	NOR-TST key in *TST* position
(j) Ripple indication greater than 200 millivolts at battery	Defective L4, L5, or L6 saturable reactor (see 5.05)
	Defective filter
	Open phase

5.05 To check for a defective saturable reactor, proceed as follows:

(a) Connect the oscilloscope between ground and the anode of CR7 diode.

5.05 To check for a defective saturable reactor, proceed as follows:

(a) Connect the oscilloscope between ground and the anode of CR7 diode.

(b) Adjust the sweep frequency so as to have six complete cycles present on the oscilloscope. If all waves are approximately of equal height, the cores of the L4, L5, and L6 saturable reactors are balanced and the trouble is elsewhere (check filter). If they are not of equal height, it is an indication of a defective saturable reactor, a shorted CR1 to CR6 diode, or a defective R4 to R6 resistor.

(c) Check the diodes for short circuit and the resistors for open circuit with the KS-14510 L1 meter in accordance with Section 032-173-301.

(d) Replace any defective components.

5.06 To stop hunting, slowly rotate the ANTI HUNT COARSE (R21) potentiometer ccw until hunting ceases. If the rectifier still hunts after rotating the ANTI HUNT COARSE (R21) potentiometer fully ccw, proceed as follows:

(a) Rotate the ANTI HUNT COARSE (R21) potentiometer fully cw. Rotate the ANTI HUNT FINE (R93) potentiometer one-eighth of a turn ccw. Again rotate the ANTI HUNT COARSE (R21) potentiometer ccw until hunting ceases.

(b) If the rectifier still hunts after rotating the ANTI HUNT COARSE (R21) potentiometer fully ccw, repeat (a) as required until hunting ceases.