

RECTIFIERS
KS-19210 L4 AND L9
24 VOLTS, 400 AMPERES
OPERATING METHODS

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for an 11-cell plant or 12, 13, or 14 cells for a 12-cell plant.

Warning: *Voltages inside the rectifier cabinet exceed 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.*

Caution: *Do not operate the S1 switch to the BAT, GR1, or GR1 and GR2 positions without first charging the output filter capacitors.*

1. GENERAL

1.01 These rectifiers provide regulated dc power from an ac power source for use in floating and charging storage batteries in the 302A and 301C 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 14-cell plant or 33.4 volts if the rectifier is operating in the manual mode to charge emergency cells. The input power requirement is 3-phase, 3-wire, 60-Hz ± 2 percent ac. Taps are provided on the input transformer to match the nominal ac line voltage. The KS-19210 L4 rectifier operates within the absolute limits of 400 and 500 volts ac, and the KS-19210 L9 rectifier operates within the absolute limits of 190 and 250 volts ac. Either rectifier will operate with a permissible change from the nominal input voltage of -10 percent to $+5$ percent.

1.02 This section is reissued to revise the general information, the automatic operation procedure, the manual operation procedure, the routine checks; and to add a capacitor charging procedure, and a reference to the switch testing, cleaning, lubricating and adjusting procedure. This reissue does affect the Equipment Test List.

1.03 With the rotary switch (S1) set in BAT, GR1, or GR1 and GR2 positions, the rectifier may be connected to charge 11, 12, or 13 cells

1.04 If the rectifier automatically shuts down due to a blown fuse, set OFF-NOR switch to OFF to release the relays before restoring the rectifier to service.

1.05 The abbreviations cw and ccw refer to clockwise and counterclockwise, respectively.

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

1.07 The instructions given in this practice are based on circuit schematic drawing SD-81627-02, Issue 3B. For a detailed description of 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(s) of the schematic drawing, reference should be made to the SD(s) and CD(s) to determine the extent of the changes and the manner in which the section may be affected.

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

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2. LIST OF TOOLS AND TEST APPARATUS

CODE OR SPEC. NO.	DESCRIPTION
TOOLS	
—	→ 10 ohm, 50 watt Minimum Resistor
—	6 ampere, 125-volt DC Rated Fuse
—	15- ampere, 125-volt DC Rated Switch ←
—	3-Inch C Screwdriver
—	Blocking and insulating tools (Use tools and apply as covered in Section 069-020-801.)

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	Volt-Ohm-Milliammeter
* →	A digital type voltmeter is a suitable substitute for this meter. ←

3. OPERATION

3.01 Preparing to Start: When preparing to put the rectifier in service, check that:

- (a) The controls listed (see note) are positioned as follows:

CONTROLS	POSITION
OFF-NOR switch	OFF
S1 switch	OFF
AUTO-MAN key	AUTO
NOR-TST key	NOR
CC TST (RUN-SET) switch	Released (RUN)
CONT (CB1) circuit breaker	OFF

Caution: Where a CC TST (RUN-SET) switch is provided, it should never be operated to ON (SET) position except when necessary to make tests. The CC TST potentiometer should be rotated fully ccw.

Note: Do not disturb the setting of any of the other controls at this time.

- (b) The T1 input transformer taps have been selected to match the ac input voltage.
- (c) The MAN ADJ potentiometer is rotated fully ccw.
- (d) The associated fuses are in place.

3.02 Capacitor Charging: To charge the output filter capacitors, verify that the procedure in 3.01 has been followed and proceed as follows.

- (1) Connect a 10-ohm, 50-watt minimum resistor, a 6-ampere, 125-volt DC rated fuse, and a 15-ampere, 125-volt DC rated switch (operated to the OFF position) in series.
- (2) **Caution:** When connecting the resistor, fuse, and switch combination to the rectifier, always connect the combination to the charge and discharge side of the F or EC bus bar last to prevent short circuits from occurring.

Connect the resistor, fuse, and switch combination between the switch side of the CHG (F5) fuse and the charge and discharge side of the F (if S1 is to be operated to the BAT position) or the EC (if S1 is to be operated to the GR1, or GR1 and GR2 position) bus bar.

- (3) Operate the switch of the resistor, fuse, and switch combination to the ON position.
- (4) When the rectifier output VM meter indicates the approximate battery or battery plus end cell voltage, operate the S1 switch to the BAT position.
- (5) Operate the switch of the resistor, fuse, and switch combination to the OFF position.
- (6) **Caution:** When disconnecting the resistor, fuse, and switch combination from the rectifier, always disconnect both ends of

the combination from the rectifier at the same time to prevent short circuits with other parts of the rectifier.

Disconnect the resistor, fuse, and switch combination from the rectifier.

3.03 Automatic Operation: To place the rectifier in automatic operation, observe the directions in 3.01 and 3.02 and proceed as follows.

Note: ♦The rectifier output voltage, set when the rectifier is not connected to the battery, may increase as much as a volt when the rectifier is connected to the plant (BAT, GR1, or GR1 and GR2 switch position) because of the plant sense control circuit. The rectifier float voltage may be set high enough to cause shutdown or lockout when the rectifier is connected to the plant. The VOLT ADJ (R26) potentiometer should be adjusted substantially ccw (even to stop if desired) just before connecting to the plant. After the rectifier is connected to the plant, the float voltage should be adjusted upward to the proper value as in (6).♦

- (1) Rotate VOLT ADJ potentiometer fully ccw.
- (2) ♦Verify that the S1 switch is in the BAT position.♦
- (3) Operate CONT (CB1) circuit breaker to ON.
- (4) Operate OFF-NOR switch to NOR.
- (5) Rotate VOLT ADJ potentiometer slowly cw until the rectifier picks up load.
- (6) ♦Continue to rotate VOLT ADJ potentiometer slowly cw until the rectifier is carrying full load or its share of the load if operating in parallel with other voltage-regulated rectifiers, in the manner outlined in the associated power plant Bell System Practice. When the rectifier is used in the plant the plant voltmeter reading supercedes the rectifier voltmeter reading.

Note 1: The voltage reading at the rectifier is not always the same as the voltage reading at the power plant meter. Any difference will be due to line drop or meter error, or it may be due to another rectifier determining the voltage on the plant meter.

Note 2: The nominal float voltage for the batteries in a standard plant is usually 2.17 volts per cell. For additional information on the required voltages for different types of batteries, refer to Section 157-601-301 and 157-601-701.♦

(7) Mark the setting of the VOLT ADJ potentiometer. The rectifier is completely automatic in the regulation of float voltage and should require no day-to-day routine adjustment. The rectifier signals the values of loads to the plant to indicate rectifier load condition. The rectifier receives signals from the plant which will turn the rectifier on or off as needed.

3.04 Manual Operation: With the rectifier adjusted and operating as covered in 3.03, the rectifier is placed in manual operation as follows.

Caution: *An operator must be on duty continuously when the rectifier is operating in the manual mode. Manual operation is intended for trouble-locating procedures or to maintain the rectifier in service if trouble exists in the control circuit. The MAN ADJ potentiometer should be rotated fully ccw before operating the AUTO-MAN key from one position to another.*

- (1) Operate the AUTO-MAN key to MAN.
- (2) Rotate the MAN ADJ potentiometer cw until the rectifier is carrying the ♦desired load as specified in the associated power plant Bell System Practice.

Note 1: The nominal float voltage for the batteries in a standard plant is usually 2.17 volts per cell. For additional information on the required voltages for different types of batteries, refer to Section 157-601-301 and 157-601-701.♦

Note 2: Rotate MAN ADJ potentiometer fully ccw, before operating the AUTO-MAN key to AUTO.

3.06 Stopping: ♦To stop the rectifier, proceed as follows.♦

- (1) Rotate VOLT ADJ potentiometer fully ccw.

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- (2) Operate OFF-NOR switch to OFF.
- (3) If the rectifier is to be left out of service for a long period of time, set S1 switch to OFF and operate the CONT (CB1) circuit breaker to OFF.

3.05 ♦ Removing from and Restoring to Service:
Remove the rectifier from service and restore it to service in accordance with the appropriate power plant Bell System Practice.♦

4. ROUTINE CHECK

4.01 This rectifier is designed for continuous operation. It is suggested that the routine checks in Part 4 be performed periodically, and after any trouble conditions have been corrected, or if the rectifier has been out of service for a long period of time.

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 they are in accordance with the circuit requirements table and Bell System Practices which apply.

4.03 Normal Setting of Controls for Routine Checks: The controls are positioned as follows:

Caution: ♦Do not operate the S1 switch to the BAT, GR1, or GR1 and GR2 position without first charging the output filter capacitors.♦

CONTROLS	POSITION
OFF-NOR switch	OFF
S1 switch	OFF
AUTO-MAN key	AUTO
NOR-TST key	TST
CC TST (RUN-SET) switch	Released (RUN)
CONT (CB1) circuit breaker	ON
CC TST potentiometer	Fully ccw
MAN ADJ potentiometer	Fully ccw
VOLT ADJ potentiometer	Adjusted for float voltage

4.04 ♦ Current Limit Checks: ♦ Verify that the controls listed in 4.03 are in the given positions and proceed as follows.

Maximum Current Limit Check—

- (1) Remove rectifier from service in accordance with the appropriate Bell System Practice.
- (2) Block K9 relay unoperated in accordance with Section 069-020-801.
- (3) Operate OFF-NOR switch to NOR.
- (4) Operate CC TST switch to ON and hold; or if RUN-SET switch is provided, operate it to SET.
- (5) Rotate CC TST potentiometer cw until the AM1 ammeter indication stops increasing.

Requirement: The AM1 ammeter indicates between 410 and 320 amperes.

Note: If the requirement is met in (5), proceed to (8). If the requirement is not met, proceed with (6).

- (6) Adjust MAX CUR LIM potentiometer until AM1 ammeter indicates between 410 and 420 amperes.
- (7) Rotate CC TST potentiometer fully ccw and then cw until the current indication on the AM1 ammeter stops increasing.

Requirement: Same as (5).

- (8) Rotate CC TST potentiometer fully ccw.
- (9) Release CC TST switch; or if RUN-SET switch is provided, operate it to RUN.
- (10) Operate OFF-NOR switch to OFF.
- (11) Remove blocking tool from K9 relay.

High Current Limit Check—

Note: This check is not required for G2 unit in a 302A plant nor for G1 unit in a 301C plant.

- (12) Block K9 relay operated.

- (13) Block K8 relay unoperated.
- (14) Operate OFF-NOR switch to NOR.
- (15) Operate CC TST switch to ON and hold; or if RUN-SET switch is provided, operate it to SET.
- (16) Rotate CC TST potentiometer cw until the AM1 ammeter indication stops increasing.

Requirement: AM1 ammeter should indicate between 390 and 410 amperes.

Note: If the requirement is met in (16) proceed to (19). If the requirement is not met, proceed with (17).

- (17) Adjust HI CUR LIM potentiometer until the AM1 ammeter indicates between 390 and 410 amperes.
- (18) Rotate CC TST potentiometer fully ccw, and then cw until AM1 ammeter indication stops increasing.

Requirement: Same as (16).

- (19) Release CC TST switch; or if RUN-SET switch is provided, operate it to RUN.
- (20) Operate OFF-NOR switch to OFF.
- (21) Rotate CC TST potentiometer fully ccw.
- (22) Remove blocking tools from K8.

Low Current Limit Check—

Note: This check is not required for G2 unit in a 302A plant nor for G1 unit in a 301C plant.

- (23) Block K8 relay operated.
- (24) Operate OFF-NOR switch to NOR.
- (25) Operate CC TST switch to ON and hold; or if RUN-SET switch is provided, operate it to SET.
- (26) Rotate CC TST potentiometer cw until the AM1 ammeter indication stops increasing.

Requirement: The AM1 ammeter indicates between 190 and 210 amperes (or 290 and 310 amperes if current swings in the load are greater than 100 amperes).

Note: If the requirement is met in (26), proceed to (29). If the requirement is not met, proceed with (27).

- (27) Adjust LO CUR LIM potentiometer until AM1 ammeter indicates between 190 and 210 (290 and 310) amperes.

- (28) Rotate CC TST potentiometer fully ccw and then cw until the current indication on the AM1 ammeter stops increasing.

Requirement: Same as (26).

- (29) Rotate CC TST potentiometer fully ccw.
- (30) Release CC TST switch; or if RUN-SET switch is provided, operate it to RUN.
- (31) Operate OFF-NOR switch to OFF.
- (32) Remove blocking tools from K8 and K9 relays.

4.05 ♦ Plant Load Signal Checks: ♦ Verify that the controls listed in 4.03 are positioned as indicated and proceed as follows.

Plant Minimum Load Signal Check—

- (1) Operate OFF-NOR switch to NOR.
- (2) Operate CC TST switch to ON and hold; or if RUN-SET switch is provided, operate it to SET.
- (3) Rotate CC TST potentiometer slowly cw until K13 relay releases and then slowly ccw until K13 relay operates.

Requirement: The AM1 ammeter indicates within ± 10 amperes of the SP signal requirement specified in the appropriate Bell System Practice. In absence of the plant requirement, the AM1 ammeter indicates between 20 and 40 amperes.

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Note: If the requirement is not met in (3) adjust the CC TST potentiometer, as required, to obtain an indication on the AM1 ammeter equal to the value given in the plant requirement. In the absence of a plant requirement, obtain an indication of 30 amperes on the AM1 ammeter. If K13 relay is operated, rotate MIN LD SIG potentiometer cw until K13 relay releases. If K13 relay is released, rotate MIN LD SIG potentiometer ccw until K13 relay operates. Then rotate CC TST potentiometer fully ccw and repeat (3).

(4) Rotate CC TST potentiometer fully ccw.

Plant Low Load Signal Check—

(5) Rotate CC TST potentiometer slowly cw until the K11 relay releases, then, slowly ccw until K11 relay operates.

Requirement: The AM1 ammeter should indicate within ± 10 amperes of the CL signal requirement specified in the appropriate Bell System Practice. In the absence of a plant requirement, the AM1 ammeter should indicate between 90 and 110 amperes.

Note: If the requirement is not met in (5), adjust CC TST potentiometer, as required, to obtain an indication on the AM1 ammeter equal to the value given in the plant requirement. In the absence of a plant requirement, obtain an indication of 100 amperes on the AM1 ammeter. If K11 key is operated, rotate LOW LD SIG potentiometer cw until K11 relay is released. If K11 relay is released, rotate LOW LD SIG potentiometer ccw until K11 relay is operated. Then rotate CC TST potentiometer ccw and repeat (5).

Plant High Load Signal Check—

(6) Rotate CC TST potentiometer cw until K12 relay releases, then, slowly ccw until K12 relay operates.

Requirement: AM1 ammeter indicates within ± 10 amperes of the plant requirement specified in the appropriate Bell System Practice for CH signal. In the absence of a plant requirement, the AM1 ammeter indicates 290 and 310 amperes.

Note: If the requirement in (6) is not met, adjust CC TST potentiometer, as required, to obtain an indication on the AM1 ammeter equal to the value given in the plant requirement. In the absence of a plant requirement, rotate CC TST potentiometer, as required, to obtain an indication of 300 amperes on AM1 ammeter. If K12 relay is operated, rotate HIGH LD SIG potentiometer cw until K12 relay releases. If K12 relay is released, rotate HIGH LD SIG potentiometer ccw until K12 relay operates. Then rotate CC TST potentiometer ccw and repeat (6).

Plant Maximum Load Signal Check—

(7) Rotate CC TST potentiometer slowly cw until K10 relay releases, then, slowly ccw until K10 relay operates.

Requirement: AM1 ammeter indicates within ± 5 amperes of the OC signal requirement specified in the appropriate Bell System Practice. In the absence of a plant requirement, AM1 ammeter indicates between 390 and 400 amperes.

Note: If the requirement in (7) is not met, adjust CC TST potentiometer as required to obtain an indication on the AM1 ammeter equal to the value given in the plant requirement. In the absence of a plant requirement, obtain an indication of 395 amperes on AM1 ammeter. If K10 relay is operated, rotate MAX LD SIG potentiometer cw until K10 relay is released. If K10 relay is released rotate MAX LD SIG potentiometer ccw until K10 relay is operated. Then rotate CC TST potentiometer ccw and repeat (7).

(8) Rotate CC TST potentiometer fully ccw.

(9) Release CC TST switch, or if RUN-SET switch is provided, operate it to RUN.

(10) Operate OFF-NOR switch to OFF.

4.06 Alarm and Indicating Lamps: Verify that the controls listed in 4.03 are in the given positions and proceed as follows.

(1) Remove the 70-type fuse from the CHG ALM fuse holder.

- (2) Install a blown 70-type fuse in the CHG ALM fuse holder.
- (3) Operate OFF-NOR switch to NOR.

Requirement: Battery is applied to the FA lead.

- (4) Operate the associated AR relay in the plant.

Requirement: The RECT FAIL and OVER LOAD lamps light.

- (5) Operate OFF-NOR switch to OFF.
- (6) Remove the blown 70-type fuse from the CHG ALM fuse holder and install the original 70-type fuse.
- (7) Repeat (1) through (6) for the CONTACTOR ALM, RELAY ALM, CONT, and CAP ALM fuses and observe that the RECT FAIL lamp lights.

Note: The OVER LOAD lamp remains extinguished.

- (8) Operate OFF-NOR switch to NOR.
- (9) Momentarily depress DS1, DS2, and DS3 pushbuttons.

Requirement: Each lamp lights, indicating the input power factor correction fuse is not blown.

- (10) Operate OFF-NOR switch to OFF.
- (11) Operate NOR-TST key to NOR.
- (12) Restore rectifier to service in accordance with the appropriate Bell System Practice.

4.07 *Switch Testing, Cleaning, and Adjustment:*

The S1 switch should be tested, cleaned, lubricated, and adjusted in accordance with Section 169-704-701.4

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 in 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 key which, when operated to the MAN position, permits isolating the trouble to the regulator.

Caution: *The MAN ADJ potentiometer should always be rotated fully ccw before operating the AUTO-MAN 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. A MAN ADJ potentiometer is provided to manually control the control current with the AUTO-MAN key in the MAN position, in which case some of the features (including the maximum current limit) of the more complex regulating circuits are temporarily disabled.

5.03 When any kind of trouble is encountered, it is necessary 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 and are 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, take 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

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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	Blown ac supply or control fuse. CONT circuit breaker in OFF position. K2, K4 relay failure. AC (K1) contactor not operated. F5 CHG fuse blown.
(b) Low dc output voltage	VOLT ADJ potentiometer out of adjustment. Current limiting circuits out of adjustment (see 4.04). Faulty current sensing circuit. Faulty regulator circuit. VOLT ADJ potentiometer out of adjustment. Low line voltage or T1 transformer taps incorrect. Rectifier operating single phase. Defective saturable reactor.
(c) High dc output voltage	VOLT ADJ potentiometer out of adjustment. High line voltage or T1 transformer taps incorrect. Defective saturable reactor.

VOLT ADJ potentiometer out of adjustment.

Faulty current sensing circuit.

Faulty regulator circuit.

- (d) Output excessively noisy
 - Defective filter capacitors.
 - Unbalanced ac line voltage (more than 5 percent).
 - Defective rectifier stacks.
- (e) Unstable output (hunting)
 - See 5.06.
 - Improper phasing of ac input leads.

Caution: *Hunting should be corrected as soon as possible to prevent damage to the rectifier.*

- (f) Poor regulation at battery
 - MAX CUR LIM (MAX CUR ADJ) potentiometer out of adjustment.
 - Charging lead drop in excess of 2 volts.
 - NOR-TST key in TST position.
- (g) Ripple indication greater than 200 millivolts at battery
 - Defective L4, L5, or L6 saturable reactor (see 5.05).
 - Defective filter.
 - Open phase.
 - ANTI-HUNT potentiometer out of adjustment.

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 a short circuit and the resistors for an open circuit with the KS-14510 meter in accordance with Section 032-173-301.

(d) Replace any defective components.

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

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

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

Note: Violent hunting will occur if two rectifiers are paralleled on an artificial load without the plant battery connected.

5.07 If a transistorized control board is defective, remove the control board, install a new control board, and return the defective control board to the Western Electric Company for repair and/or reconditioning.