RECTIFIER
KS-19210, L1
24 VOLTS, 400 AMPERES
OPERATING METHODS

CONTENTS PAGE

1. GENERAL

1.01 The KS-19210, L1 rectifier provides current regulated dc power from an ac power source for floating and charging central office 24-volt storage batteries. This rectifier is intended for continuous operation with or without end-cells. This rectifier is used primarily in the 302A and ▶301C power plants and may also be used wherever the characteristics and design apply.◀

1.02 This section is reissued to add an output filter capacitor charging procedure, a reference to a switch cleaning Bell System Practice, to add additional routine checks in Part 4, and to update the section in general. This reissue does affect the Equipment Test List.

1.03 ▶The KS-19210 L1 rectifier is rated MD and is replaced by KS-19210 L7 rectifier.◀

1.04 The KS-19210 L1 rectifier is rated at −24 volts dc with a full load capacity of 400 amperes. ▶However, the rectifier will produce −33.4 volts dc at full load for a 14-cell operation.◀ The input power requirement is a 3-phase, 3-wire, 60 Hz (±2 percent) alternating current at a nominal voltage of 208- to 230-volts ac. ▶The allowable line voltage variation of −10 to +5 percent must be within the absolute limits of 190- to 250-volts ac. Taps are provided on the T1 input transformer to match the nominal input voltage. Taps are provided on the T5 transformer to permit operation with either 11-cell or 12-cell batteries. The S3 output selector switch arranges the circuit to charge the battery (BAT), the battery plus one end cell (GR1) or the battery plus two end cells (GR1 & GR2).◀

Warning: The voltages in this unit 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 or destructive and dangerous short circuits may occur. Disconnect ac supply before working on rectifier except when necessary to make tests.

Caution: ▶Do not operate the S3 output selector switch to either the BAT or EC position without first charging the output filter capacitors as outlined in 3.02. Failure to do so may ultimately lead to degradation of the S3 output selector switch contacts due to high current.

1.05 This issue of the section is based on the following drawing: SD-81627-01, Issue 2B. 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.◀

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

1.07 The abbreviations cw and ccw used in this section 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)←
—	3-inch Screwdriver
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 start the rectifier, proceed as follows.

(1) Position the controls as follows:

CONTROL	POSITION
OFF-NOR (S1) Switch	OFF
AUTO-MAN (S2) Key	MAN
S3 Switch (dc output selector)	BAT OFF
NOR-TST (S4) Key	TST
CB1 Circuit Breaker	OFF
LOWER-NOR (S5) Switch	NOR
RAISE-NOR (S6) Switch	NOR
Associated switch and fuse unit in bus duct or power service cabinet	OFF
MAN ADJ (R32) Potentiometer	Fully ccw

(2) The AR1 ammeter relay contacts are set as follows unless plant requirements differ.

AMMETER RELAY	LOW CONTACT	HIGH CONTACT
AR1	20 Amperes	400 Amperes

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

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

(5) All 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 S3 output selector switch to the F or EC position from the BAT OFF position. To charge the output filter capacitors, proceed as follows.

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

Note 1: 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 jumper in the rectifier circuit.

(2) ***Caution: 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 F10 output fuse holder to a convenient point on the battery connected F (BAT) or EC (GR1 or GR1 & GR2) terminal plate of the S3 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 S3 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 and operate the S3 output selector switch 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 CB1 circuit breaker to the ON position.

(4) Operate the NOR-TST (S4) key to the NOR position.

(5) Operate the OFF-NOR (S1) 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***

Caution: An operator must be on duty continuously when the rectifier is operating in the manual mode.

(1) ▶Perform the capacitor charging procedure and operate the S3 output selector switch 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 CB1 circuit breaker to the ON position.

(4) Operate the NOR-TST (S4) key to the TST position.

Note: ▶When the NOR-TST (S4) 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 S4 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 (R32) potentiometer.◀

(6) Operate the OFF-NOR (S1) 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 (R32) potentiometer cw until the rectifier voltmeter indicates ▶the voltage specified in the appropriate power plant Bell System Practice.

Note: The nominal float voltage for the battery in a standard plant is usually 2.17 volts per cell. For additional information on the required float voltage, refer to Section 157-601-301.◀

(8) Load the rectifier in accordance with the appropriate power plant Bell System Practice.

(9) Adjust the MAN ADJ (R32) potentiometer to increase or decrease the load on the rectifier to the desired level.

Note: ▶Before shifting from manual to automatic mode of operation, rotate MAN ADJ (R32) potentiometer fully ccw and 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 (S1) switch is in the OFF position.

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

(4) Operate the S3 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.

Note: If the rectifier is to be disconnected for an extended period of time, connect the electrolitic capacitors to a source of direct current of suitable voltage and polarity as covered in Section 032-110-701.

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, operate OFF-NOR (S1) 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.

3.07 ▶***Boost-Charging of the Battery:*** To boost-charge the battery, refer to the appropriate power plant Bell System Practice. For additional information on boost charging, refer to Section 157-601-701.◀

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.◀

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 ▶***S3 Output Selector Switch:*** Clean, test, and adjust the S3 output selector switch in accordance with the procedures outlined in Section 169-704-701.

4.04 Keep the ventilating passages of the rectifier unobstructed to ensure adequate cooling during operation. The interior of the rectifier should be cleaned periodically while the rectifier is shut down. The cleaning interval should be determined by local conditions.

4.05 ***Voltage Limiting Circuit Check***

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

(2) Operate the OFF-NOR (S1) switch to the OFF position.

(3) Operate the S3 output selector switch to the BAT-OFF position.

(4) Operate the NOR-TST (S4) key to the TST position.

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

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

(7) Operate the OFF-NOR (S1) switch to the NOR position.

(8) Operate the RAISE-NOR (S6) switch to the RAISE position until the voltage indicated on the KS-8039 meter no longer increases. Release the RAISE-NOR (S6) switch.

Requirement: The maximum voltage limit may be set as required by the associated power plant Bell System Practice. In the absence of a plant requirement, the voltage should limit at 26.8 $\pm$0.3 volts for a 11-cell connection or 29.0 $\pm$0.3 volts for a 12-cell connection.

Note: If the requirement is met in (8), proceed to (14). If the voltage limits before the bottom of the range given in (8), proceed with (9). If the voltage does not stop at the top of the range given in (8), proceed to (12).

(9) Rotate the MAX VOLT LIM (R77) potentiometer slightly cw.

(10) Operate the RAISE-NOR (S6) switch to the RAISE position until the voltage increases to the center of the voltage limit range given in (8). Release the RAISE-NOR (S6) switch.

(11) Rotate the MAX VOLT LIM (R77) potentiometer ccw until the voltage just begins to decrease. Leave the R77 potentiometer at this setting and proceed to (14).

(12) Operate the LOWER-NOR (S5) switch to the LOWER position until the voltage decreases to the center of voltage limit range given in (8). Release the LOWER-NOR (S5) switch.

(13) Rotate the MAX VOLT LIM (R77) potentiometer ccw until the voltage just begins to decrease. Leave the R77 potentiometer at this setting and proceed with (14).

(14) Operate LOWER-NOR (S5) switch to the LOWER position until voltage is reduced to a minimum. Release the LOWER-NOR (S5) switch.

(15) Operate the OFF-NOR (S1) switch to the OFF position.

(16) Disconnect the KS-8039 meter from J1 and J2 test jacks.

(17) To start the rectifier perform 3.03 or 3.04.

4.06 ▶*Maximum Current Limit Check*

Note: Perform this check with the rectifier connected to the plant load. Load the rectifier in accordance with the appropriate power plant Bell System Practice.

(1) Verify that the rectifier is in plant service operating in the automatic mode.

(2) Set the high contact of AR1 ammeter relay to 500 amperes.

(3) Operate the NOR-TST (S4) key to the TST position.

(4) Operate the RAISE-NOR (S6) switch to the RAISE position until the load indicated on the AR1 ammeter relay no longer increases.

Requirement: The indication on the AR1 ammeter relay should be 420 $\pm$10 amperes.

Note: If the requirement is met in (4), proceed to (10). If the current limits before the bottom of the range given in (4), proceed with (5). If the current does not limit at the top of the range given in (4), proceed to (7).

(5) Rotate the CLAMP ADJ (R80) potentiometer slightly cw to raise the current limit setting.

(6) Repeat Step (4). When the requirement in (4) is met, proceed to (10).

(7) Operate the LOWER-NOR (S5) switch to the LOWER position until the AR1 ammeter relay indicates 400 amperes. Release the LOWER-NOR (S5) switch.

(8) Rotate the CLAMP ADJ (R80) potentiometer slightly ccw to lower the current limit setting.

(9) Repeat Step (4). When the requirement in (4) is met, proceed with (10).

(10) Operate the LOWER-NOR (S5) switch to the LOWER position until the AR1 ammeter

relay indicates 400 amperes. Release the LOWER-NOR (S5) switch.

(11) Position the high contact of the AR1 ammeter relay in accordance with plant requirements, or in the absence of a plant requirement, set the high contact of AR1 to 400 amperes.

(12) Return the rectifier to normal service in accordance with the appropriate power plant Bell System Practice.

4.07 ***Fuse Alarm Check:*** This check is made with the rectifier connected to the battery. The following procedure must comply with the appropriate power plant Bell System Practice. The rectifier lamps may not light in the 301C power plant.

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

(2) Operate the OFF-NOR (S1) switch to the OFF position.

(3) ***Caution: Do not operate the S3 output selector switch to the F or EC position without first charging the output filter capacitors as outlined in 3.02.***

Verify that the S3 output selector switch is in the BAT position.

(4) Operate the NOR-TST (S4) key to the TST position.

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

Output Fuse

(6) Remove the OUTPUT FUSE ALM (F11) fuse and replace it with an operated fuse.

(7) Operate the OFF-NOR (S1) switch to the NOR position.

Requirement: The K10 relay operates, the K13 relay releases to provide a lock-up path, battery appears on the FA lead to the plant, and both the RECT-FAIL (DS2) and the OVLD (DS3) lamps may light.

(8) Operate the OFF-NOR (S1) switch to the OFF position.

(9) Replace the non-operated F11 fuse in the F11 fuse holder.

(10) Operate the OFF-NOR (S1) switch to the NOR position.

Requirement: The locked-up relays reset, battery is removed from the FA lead, and the lamps extinguish.

(11) Operate the OFF-NOR (S1) switch to the OFF position.

Relay and Capacitor Fuse

(12) Remove the RELAY FUSE ALM (F12) fuse and replace with an operated fuse.

(13) Operate the OFF-NOR (S1) switch to the NOR position.

Requirement: The K6 relay operates, the K13 relay releases to provide a lock-up path, battery appears on the FA lead to the plant, and the RECT-FAIL (DS2) lamp may light.

(14) Operate the OFF-NOR (S1) switch to the OFF position.

(15) Replace the non-operated F12 fuse in the F12 fuse holder.

(16) Operate the OFF-NOR (S1) switch to the NOR position.

Requirement: The locked-up relays reset, battery is removed from the FA lead, and the lamps extinguish.

(17) Operate the OFF-NOR (S1) switch to the OFF position.

(18) Repeat (12) through (17) for the CAP FUSE ALM (F17) fuse.

F1, F2, and F3 Fuses

(19) Operate the OFF-NOR (S1) switch to the NOR position.

(20) Momentarily depress DS4, DS5, and DS6 pushbuttons.

Requirement: Each lamp lights as it is depressed, indicating that the input power factor correction capacitor fuse (F1, F2, or F3) is not blown and that all three phases are energized.

(21) Operate the OFF-NOR (S1) switch to the OFF position.

(22) Return the rectifier to service in accordance with the appropriate power plant Bell System Practice.◀

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 checking the performance of each major subdivision of equipment until the trouble is isolated. A MAN ADJ (R32) potentiometer is provided for use in conjunction with the AUTO-MAN (S2) key to manually control the control current when some of the more complex regulating circuits are temporarily disabled by operation of the AUTO-MAN (S2) key to the MAN position.

Caution: The MAN ADJ (R32) potentiometer should always be turned fully ccw before operation of 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 (AM) 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.

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. Trouble is easier to find if the equipment can be fully energized. However, if it is of a nature that causes excessive output from the equipment, it will be necessary to perform the initial steps with the system de-energized and energize it for short periods only while electrical measurements are made. 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. Therefore, it is essential when testing to be alert for the need to quickly shut down the rectifier.

5.04 Should any of the following troubles develop, it is suggested that the possible causes 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 saturating current).	Blown ac supply fuse. CB1 circuit breaker in off position. K8, K9, or K13 relay failure. AC contactor not operated.
(b) Low dc output current (low control current).	Check RAISE circuit. Low line voltage or T1 transformer taps incorrect. Faulty transistor amplifier.
(c) Low dc output current (high saturating current).	Rectifier operating single phase.
(d) High dc output current (output voltage normal).	Defective transistor amplifier.
(e) Output current high (output voltage high).	RAISE circuit adjustment. Defective transistor amplifier. High line voltage or T1 transformer taps incorrect.
(f) High dc output voltage (output current less than full load).	Rectifier in MAN position.
(g) Output excessively noisy.	Defective filter capacitors. Unbalanced ac input voltage. Defective rectifier stacks. R4-R6 potentiometers require adjustment.
(h) Hunting	ANTI-HUNT (R26 and R61) potentiometers require adjustment (see 5.06).

TROUBLE	POSSIBLE CAUSE
Caution: Hunting should be corrected as soon as possible to prevent damage to the rectifier.	
(i) High ripple indication	Defective L4-L6 saturable reactors (see 5.05). Incorrect adjustment of R4-R6 balancing potentiometers. Defective filter.

5.05 ***Saturable Reactor Check:*** To check for a defective saturable reactor proceed as follows.

(a) Connect the oscilloscope between terminal 1 of L8 and terminal 2 of L7.

(b) Adjust the sweep frequency so as to have six complete cycles present on the oscilloscope. If all waves are approximately equal in height, the cores of L4, L5, and L6 saturable reactors are balanced and the trouble is elsewhere. 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 R1 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 032-173-701.

(d) Replace any defective components.

5.06 ***Anti-Hunt Adjustment:*** If there is cyclic hunting, adjust R26 and R61 potentiometers. Rotate both potentiometers fully clockwise and proceed as follows.

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

(b) Rotate R26 slowly ccw until hunting is eliminated.

(c) If the rectifier continues or increases hunting, rotate R26 to maximum cw position, then rotate R61 ccw 1/4-turn. Rotate R26 ccw until hunting is eliminated.

(d) Repeat (c) if hunting continues. Advance R61 by 1/4-turn each time.

(e) Disconnect the KS-8039 meter from the J1 and J2 test jacks.