RECTIFIERS
KS-19210, L3
24 VOLTS, 400 AMPERES
OPERATING METHODS

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1. GENERAL

1.01 The KS-19210, L3 rectifier provides regulated dc power from an ac power source for floating and charging central office 24-volt storage batteries. This rectifier is used as a G1 or G2 unit in a 302A-type power plant and is rated at 24 volts, 400 amperes direct current. The input power requirement is 3-phase, 3-wire, 60-Hz ± 1.2 Hz alternating current applied to the input transformer through an input contactor. Taps are provided on the input transformer to match the ***nominal*** ac line voltage. The KS-19210, L3 rectifier operates within the absolute limits of 190 and 250 volts with an allowable variation of input voltage from -10 to $+5$ percent about the tap value.

1.02 This section is reissued to revise the general information, preparing to start, starting, and routine checks; and to add a capacitor charging procedure and a reference to the switch testing, cleaning, and adjustment procedure. This reissue does affect the Equipment Test List.

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

Caution 1: Operate the OFF-NOR switch to the OFF position before moving the S3 switch from one position to another.

Caution 2: Do not operate the S3 switch to the BAT, GR1, or GR1 and GR2 position without first charging the output filter capacitors.

1.03 The rectifier is completely automatic in the regulation of float voltage. It is started and stopped by the plant control circuit and by the operation of the OFF-NOR switch.

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

1.05 The rectifier may be connected to charge an 11-, 12-, or 13-cell battery for an 11-cell plant or a 12-, 13-, or 14-cell battery for a 12-cell plant with the rotary switch (S3) set in BAT, GR1, or GR1 and GR2 positions, respectively.

1.06 The abbreviations cw and ccw, used throughout the practice refer to clockwise and counterclockwise, respectively.

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

1.08 The instructions given in this practice are based on circuit schematic drawing SD-81627-01, Issue 2B. 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 a later or earlier issue of the schematic drawing, reference should be made to the CD(s) and SD(s) to determine the extent of the changes and the manner in which the section may be affected.

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

1.10 ▶The KS-19210, L3 rectifier has been rated "Manufacture Discontinued" and is replaced by the KS-19210, L9 rectifier.◀

2. LIST OF TEST APPARATUS

CODE OR SPEC. NO.	DESCRIPTION
TOOLS	
—	3-inch Screwdriver
—	Blocking and insulating tools as required. (Use tools and apply as covered in Section 069-020-801.)
TEST APPARATUS	
—	A. B. DuMont Lab Inc. Type 304 Oscilloscope. This scope is not required for normal maintenance (see 5.05).
* KS-8039	DC Volt-Milliammeter
* KS-14510	Volt-Ohm-Milliammeter

* →Equivalents may be substituted. ←

3. OPERATION

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

(a) Verify that the controls listed are positioned as follows:

CONTROL	POSITION
OFF-NOR switch	OFF
AUTO-MAN key	AUTO
NOR-TST key	NOR
S3 switch	BAT-OFF
CB1 circuit breaker	OFF
MAN ADJ potentiometer	Fully ccw

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

(b) Check that the input transformer taps have been selected to match the AC input voltage.

(c) Verify that the associated fuses are in place.

3.02 ***Charging Output Filter Capacitors:*** To charge the output filter capacitors, verify that the procedures in 3.01 have 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 charge and discharge side of the F bus bar (if the S3 switch is to be operated to the BAT position) or the EC bus bar (if the S3 switch is to be operated to the GR1 or GR1 and GR2); and the switch side of the F10 fuse.

(3) Operate the switch of the resistor, fuse, and switch combination to the ON position.

(4) When the rectifier VM voltmeter indicates the approximate battery or battery plus end-cell voltage, operate the S3 switch to the desired BAT, GR1, or GR1 and GR2 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 from occurring.***

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

3.03 ***Starting for Automatic Operation:*** To start the rectifier for automatic operation, verify that the procedures in 3.01 have been followed and proceed as follows.

Caution 1: Verify that the OFF-NOR switch is in the OFF position before operating the S3 switch from one position to another.

Caution 2: Do not operate the S3 switch to the BAT, GR1, or GR1 and GR2 position without first charging the output filter capacitors. (See 3.02).

(1) Charge the output filter capacitors in accordance with 3.02.

Note: The rectifier output voltage, set when the rectifier is not connected to the plant, may increase as much as a volt when the rectifier is connected to the plant (BAT, GR1, or GR1 and GR2 position) due to the plant sense control circuit. If there is reason to believe that the rectifier float voltage may be set high enough to cause shutdown or lockout when the rectifier is started, the NOR VOLT ADJ (R37) potentiometer should be adjusted substantially ccw (even to potentiometer stop if desired) just before starting. After the rectifier is started, the float voltage should be adjusted upward to the proper value specified in (5).

(2) Rotate the NOR VOLTS ADJ potentiometer almost fully ccw.

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

(4) Operate the OFF-NOR switch to the NOR position.

(5) Slowly rotate the NOR VOLTS ADJ potentiometer cw until the power plant voltmeter indicates the correct float voltage as specified in the appropriate power plant Bell System Practice.

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. When the rectifier is connected to the plant, the plant voltmeter reading is considered to be correct, not the rectifier voltmeter reading.

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.

3.04 ***Starting for Manual Operation:*** If the rectifier must be operated in the manual mode, refer to the appropriate power plant Bell System Practice and proceed as follows.

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

(1) Charge the output filter capacitors in accordance with 3.02.

(2) Operate the NOR-TST key to TST.

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

(4) Operate the CB1 circuit breaker to ON.

(5) Operate the OFF-NOR switch to NOR.

(6) Rotate the MAN ADJ (32) potentiometer slowly cw until the rectifier output VM voltmeter indicates the correct voltage specified in the appropriate power plant Bell System Practice and the rectifier is carrying the proper load.

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 Sections 157-601-301 and 157-601-701.

Note 2: Rotate the MAN ADJ potentiometer fully ccw and operate the OFF-NOR switch to OFF before returning to the automatic mode of operation.

3.05 ***Stopping:*** To stop the rectifier, proceed as follows.

(1) Rotate the NOR VOLTS ADJ potentiometer fully ccw.

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

(3) If the rectifier is to be left out of service for a long period of time, operate the S3 switch to the BAT-OFF position and operate the CB1 circuit breaker to the OFF position.◀

3.06 ***Removing From Service:*** Remove rectifier from service in accordance with Bell System Practice 167-621-301. ▶If the rectifier is to left out of service for an extended period of time, remove the associated fuses and refer to Section 032-110-701 for information on maintaining electrolytic capacitors when they are not in service.◀

3.07 ***Restoring to Service:*** Restore rectifier to service in accordance with Section 167-621-301.

4. ROUTINE CHECKS

4.01 ▶This rectifier is designed for continuous operation. It is suggested that the routine check in Part 4 be performed periodically, 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 that they are in accordance with the circuit requirements table and the Bell System Practices which apply.

4.03 ***Maximum Current Limit Check:*** ▶With the rectifier operating normally, verify that the controls listed are positioned as indicated and proceed as follows.

Caution 1: Verify that the OFF-NOR switch is in the OFF position before operating the S3 switch from one position to another.

Caution 2: Do not operate the S3 switch to the BAT, GR1, or GR1 and GR2 position without first charging the output filter capacitors. (See 3.02.)

CONTROL	POSITION
OFF-NOR switch	OFF
AUTO-MAN key	AUTO
NOR-TST key	TST
S3 switch	BAT
CB1 circuit breaker	ON

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

(1) Connect the KS-8039 voltmeter to output voltage jacks J1(−) and J2(+).

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

(3) Load the rectifier by transferring the load from other units in the plant in accordance with the power plant Bell System Practice.

(4) Increase the load on the rectifier until the voltage reading on the KS-8039 meter drops.

Requirement: The voltage reading should drop 0.5 volt between 390 and 410 amperes indicated on the AM (ammeter relay).

Note: If the requirement is met in (4), proceed to (7). If the requirement is not met proceed to (5).

(5) If the voltage drops before 390 amperes, rotate the DROOP ADJ potentiometer cw; if the voltage does not drop before 410 amperes, rotate the DROOP ADJ potentiometer ccw.

(6) Adjust the load as necessary to meet the requirement in (4).

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

(8) Disconnect the KS-8039 meter.

(9) Mark the setting of the DROOP ADJ potentiometer.◀

4.04 ***Constant Current High and Low Settings:*** ▶Verify that the controls listed in 4.03 are positioned as indicated and proceed as follows.

(1) Block the K12 and K7 relays operated.

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

(3) Increase the load on the rectifier in accordance with the appropriate power plant Bell System Practice until the current stops increasing.

Requirement: The current should limit between 390 and 410 amperes.

Note: If the requirement is met in (3), proceed to (5). If the requirement is not met in (3), proceed to (4).

(4) If the current limits before 390 amperes, rotate the HI CUR ADJ potentiometer cw to increase the limit. If the current does not limit at 410 amperes, rotate the HI CUR ADJ potentiometer ccw to decrease the limit.

(5) Reduce the load on the rectifier in accordance with the appropriate power plant Bell System Practice until the AR1 ammeter relay indication is slightly less than 200 amperes.

(6) Block K7 relay unoperated.

(7) Increase the load on the rectifier in accordance with the appropriate power plant Bell System Practice until the current stops increasing.

Requirement: The current should limit between 190 and 210 amperes, or between 290 and 310 amperes if the current swings in load are greater than 100 amperes.

Note: If the requirement is met in (7) proceed to (9). If the requirement is not met in (7), proceed to (8).

(8) If the current limits before the required value, rotate the LO CUR ADJ cw to increase the limit. If the current does not limit at the required value, rotate the LO CUR ADJ ccw to decrease the limit until it meets requirements in (7).

(9) Reduce the load on the rectifier to a minimum in accordance with the appropriate power plant Bell System Practice.

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

(11) Remove the blocking tools from the K12 and K7 relays.

(12) Mark the settings of the HI CUR ADJ and the LO CUR ADJ potentiometers.

4.05 ***Alarm and Indicating Lamps Check:*** Verify that the controls listed in 4.03 are in the positions indicated and proceed as follows.

(1) Place a blown 70-type fuse in the OUTPUT ALM fuse holder.

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

Requirement: Battery is applied to the FA lead and the RECT-FAIL and the OVLD lamps light.

(3) Operate the OFF-NOR switch to OFF.

(4) Remove the blown fuse from the OUTPUT ALM fuse holder and install the original 70-type fuse.

(5) Repeat (1) through (4) for the RELAY ALM, TST-CONT, and CAP. ALM fuses.

Requirement: The RECT-FAIL lamp lights but the OVLD lamp remains extinguished.

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

(7) Momentarily depress the DS4, DS5, and DS6 pushbuttons.

Requirement: Each lamp lights indicating that the power factor correction fuses are not blown.

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

(9) Restore the rectifier to service in accordance with the appropriate power plant Bell System Practice.

4.06 ***Switch Testing, Cleaning, and Adjustment:*** The S3 switch should be tested, cleaned, lubricated, and adjusted in accordance with Section 169-704-701.

Note: The inside of the rectifier should be dusted periodically.◀

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 key which, when operated to the MAN position, permits isolating the trouble to the regulating circuit only. A MAN ADJ (R32) potentiometer is provided for use in conjunction with the AUTO-MAN key to manually control the control current when some of the more complex regulating circuits are temporarily disabled by operation of the AUTO-MAN key to the MAN position.

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

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, 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.

TROUBLE CHART

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 fuses CB1 circuit breaker in OFF position K8, K9, or K13 relay failure AC contactor not operated
(b) Low dc output current (low control current)	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)	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 GAIN (R29) potentiometers require adjustment (See 5.06)

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

TROUBLE	POSSIBLE CAUSE
(i) High ripple indication	Defective L4-L6 saturable reactors Defective R4-R6 balancing potentiometers Defective filter (See 5.05)

5.05 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 032-173-301.

(d) Replace any defective components.

5.06 If there is cyclic hunting, adjust R26 and R29 potentiometers. Start with both potentiometers rotated fully clockwise and proceed as follows.

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

(b) If the rectifier continues or increases hunting, rotate R26 to maximum cw position, then rotate R29 ccw 1/4-turn and again rotate R26 ccw until hunting is eliminated.

(c) Repeat (b) if hunting continues. Advance R29 by 1/4-turn each time.