

**Lucent Technologies**  
Bell Labs Innovations



*Lineage<sup>®</sup> 2000*  
*100-Ampere, 60-Hertz*  
*Ferroresonant Rectifier*  
*J85503A-1*

Product Manual  
Select Code 169-790-119  
Comcode 107021818  
Issue 6  
October 1998  
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***Product Manual***  
***J85503A-1***

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***October 1998***

***Lucent Technologies***  
***Lineage<sup>®</sup> 2000***  
***100-Ampere, 60-Hertz***  
***Ferroresonant Rectifier***

**Notice:**

Every effort was made to ensure that the information in this document was complete and accurate at the time of printing. However, information is subject to change.



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# ***1 Introduction***

## ***General Information***

This product manual (Select Code 169-790-119) describes the J85503A-1 100-ampere ferroresonant rectifier. This rectifier converts commercial 208V, 240V, or 480V ac input power at 60 hertz into  $\pm 24$  or -48-volt dc output for telecommunications loads.

Since central offices usually obtain their electrical power from potentially noisy commercial ac lines (and emergency generators during commercial power failures), and since high quality dc power is required in order for the equipment to operate correctly, the J85503A-1 rectifier is an excellent choice for any telecommunications battery plant.

The J85503A-1 rectifier can be used with a Lineage<sup>®</sup> 2000 battery plant, older vintage Lucent Technologies battery plants, or any commercial battery plant. With certain options, it can also operate off battery.

## ***Customer Training***

Lucent Technologies offers customer training on many Power Systems products. For information call 1-972-284-2163. This number is answered from 8:00 a.m. until 4:30 p.m., Central Time Zone (Zone 6), Monday through Friday.

## ***Customer Service***

For customers in the United States, Canada, Puerto Rico, and the US Virgin Islands, call 1-800-THE-1PWR (1-800-843-1797). Services provided through this contact include initiating the spare parts procurement process for out of service emergencies, ordering Lucent Technologies documents, and providing other product and service information.

For other customers worldwide, call 001-972-840-0382. This number is answered from 8:00 a.m. until 4:30 p.m., Central Time Zone (Zone 6), Monday through Friday.

## ***Technical Support***

Technical support for Lucent Technologies customers is available around the world during the normal product warranty period and also while specific contractual agreements extend this service.

For customers in the United States, Canada, Puerto Rico, and the US Virgin Islands, call 1-800-CAL-RTAC (1-800-225-7822) to contact a product specialist to answer your technical questions and assist in troubleshooting problems.

For other customers worldwide, contact your local field support center or your sales representative to discuss your specific needs.

## ***Product Repair and Return***

Repair and return service is provided for Lucent Technologies customers around the world. For customers in the United States, Canada, Puerto Rico, and the US Virgin Islands, call 1-800-255-1402 for information on returning of products for repair.

For other customers worldwide, contact your sales representative to discuss your particular circumstances.

## ***Warranty Service***

For warranty service worldwide, contact your Warranty Service Manager (WSM). The WSM serves specific customer-groups, who have taken ownership of the product. For product conformance issues prior to customer ownership, contact your local customer service.

## 2 *Product Description*

### *Overview*

In most telecommunications applications, the output of the rectifier system is electrically connected in parallel with the batteries. The rectifiers provide both the power to the telephone equipment through the plant distribution and the charging and float current to the batteries. In the event of commercial power failure, the batteries supply the required dc power to the telephone equipment. This transition needs no switching because of the parallel connection of the rectifiers and batteries.

### *Ferroresonant Technology*

The J85503A-1 rectifier is a member of the Lucent Technologies family of Lineage<sup>®</sup> 2000 rectifiers. Like all the rectifiers in the family, it represents a significant advancement in efficiency, space savings, and serviceability. The rectifier uses the electronically controlled, closed-loop, ferroresonant technology developed by Lucent Technologies. This technology provides excellent output regulation in spite of variations in the incoming commercial line voltage and frequency, and the outgoing current or “load.”

Highlights of ferroresonant technology include:

- Eliminates internal switching transients typically associated with other technologies.
- Reduces noise and transients from commercial lines. As the interface between commercial power and telephone equipment, the ferroresonant rectifier significantly attenuates noise and lightning surges from commercial lines.

- Introduces far less noise into closely coupled telephone lines than other technologies due to lower harmonic components in the input current waveshape.
- Provides highly efficient power conversion.
- Ferroresonant technology and the rectifier's physical design features combine to provide reliable service, easy maintenance, and greater cost-effectiveness on a dollars-per-output-ampere basis.
- All components in the rectifier meet Lucent Technologies's strict specifications and reliability standards. The rectifier uses an extremely efficient free-convection cooling system that keeps components operating at temperatures well below the recommended maximum, resulting in high reliability.
- All circuits for power control, alarms, voltage regulation, current limiting, restart, plant interface, and remote monitoring/control are mounted on replaceable circuit modules. Front access to the circuit modules simplifies replacement or adjustment, if required. Standardized modules simplify parts inventory, resulting in lower costs and better equipment availability.
- The rectifier is contemporary in appearance with a blue cabinet, white front door, and flat-black control panel.
- The rectifier can be used in a plant with or without batteries and with or without a controller. One of three input voltages and two output voltages may be ordered. Optional noise filtering can be added. Each option requires different equipment, which Lucent Technologies has organized into numbered lists to simplify ordering. (See “Options.”)

## ***Standard Features***

The J85503A-1, 100-ampere rectifier has the following standard features.

- **Output current “walk-in”:** This circuit controls the time required for the rectifier to reach its rated output voltage after it is turned on. Initially, the output voltage is about 80 percent of normal, and gradually increases to the required value in approximately 10 seconds. As the output voltage “walks in,” so does output current. This feature minimizes

the starting surge on the customer's power source and is especially important with a more limited power source, such as an emergency generator set.

- **External selective high voltage shutdown:** If the battery voltage goes too high, the controller signals all of the connected rectifiers. This signal causes the rectifier(s) that are delivering at least 10 percent of rated output current to shut down. The remaining rectifiers continue to operate.
- **Backup high voltage shutdown:** This circuit prevents damage to the rectifier in the event of a high battery voltage condition. Each rectifier senses its own output voltage and shuts down when this voltage exceeds a preset value. This circuit operates if the external selective high voltage shutdown (SHVSD) fails to operate. This backup high voltage shutdown (BUHVSD) operates from an independent voltage source in accordance with Bellcore standards.
- **Output current limit:** The rectifier provides a constant output voltage up to its rated output current, at which point it provides constant current. When the output current tends to increase above the rated output, the current limit circuit overrides the voltage regulating signal and limits the output current of the rectifier.
- **Back-up current limit:** In addition to the output current limit, the ferroresonant transformers self-limit current output between 125-175 percent of full load, or 125-175 amperes.
- **Isolated output current indication:** When used with a Microprocessor Controlled System (MCS) controller, the rectifier provides an isolated 2- to 10-volt signal, corresponding to a range of no-load to 125 percent of rated output load, which is used to indicate the rectifier drain on the controller.
- **Safety interlocks:** A series-loop circuit electrically interconnects the control circuit modules and prevents rectifier operation if an open circuit is detected.
- **Output capacitor fusing:** A combination of a main fuse and alarm fuse protects each output filter capacitor.

- **Fuse alarm circuit:** The low-power control functions shut down the rectifier if a fuse alarm (**FA**) occurs. One fuse alarm protects each of the regulation leads. When any fuse alarm occurs, a Rectifier Failure Alarm (**RFA**) LED lights on the front panel and an RFA signal is generated.
- **Unbalance alarm:** An alarm occurs and the rectifier shuts down if severe unbalance develops between the ferroresonant transformers. The rectifier-fail circuit delivers this alarm after a 3-second delay to allow transient disturbances to subside, such as those occurring during initial turn-on.
- **Man alarm:** This alarm indicates that either the rectifier has been turned off manually or has lost commercial input power.
- **Restart circuit:** The rectifier has an automatic restart feature that is compatible with most controllers. If a rectifier shuts down due to the external selective high voltage shutdown, most controllers try at least once to restart it automatically.
- **Remote sense leads:** These leads permit remote regulation of the rectifier.
- **TR:** This signal (Transfer Rectifier) remotely shuts down the rectifier.

## ***Additional Features***

### **Dynamic Response**

For any step load change of 10 to 90 percent, or 90 to 10 percent, or a step change of 10 percent of the input voltage, the sense point voltage remains within 5 percent of its setting, and returns and remains in the 1/2 percent band within 300 milliseconds. For batteryless operation, for any step load change of 50 to 90 percent, or 90 to 50 percent, or a step change of 10 percent of the input voltage, the sense point voltage remains within 10 percent of its setting, and returns and remains in the 2 percent band within 500 milliseconds.

### **Electromagnetic Compatibility (EMC)**

The J85503A-1 rectifier complies with FCC Docket 20780, Part 15, Subpart J, as required for Class A applications. In addition,

the rectifier meets all specified operating characteristics when subjected to electric fields up to 10 volts per meter over a frequency range of 20 to 1000 MHz.

## ***Circuit Modules***

The rectifier's signal processing and control circuitry are located on replaceable circuit modules or packs. Circuit modules are plug-in boards that can be ordered. All of the circuit modules are accessible by opening the rectifier's front panel door. Figure 2-1 shows the location of the circuit modules and other features of the rectifier. Figures 2-2, 2-3, and 2-4 show the **CM1**, **CM2**, and **CM3** board layouts, respectively. A description of each module follows.

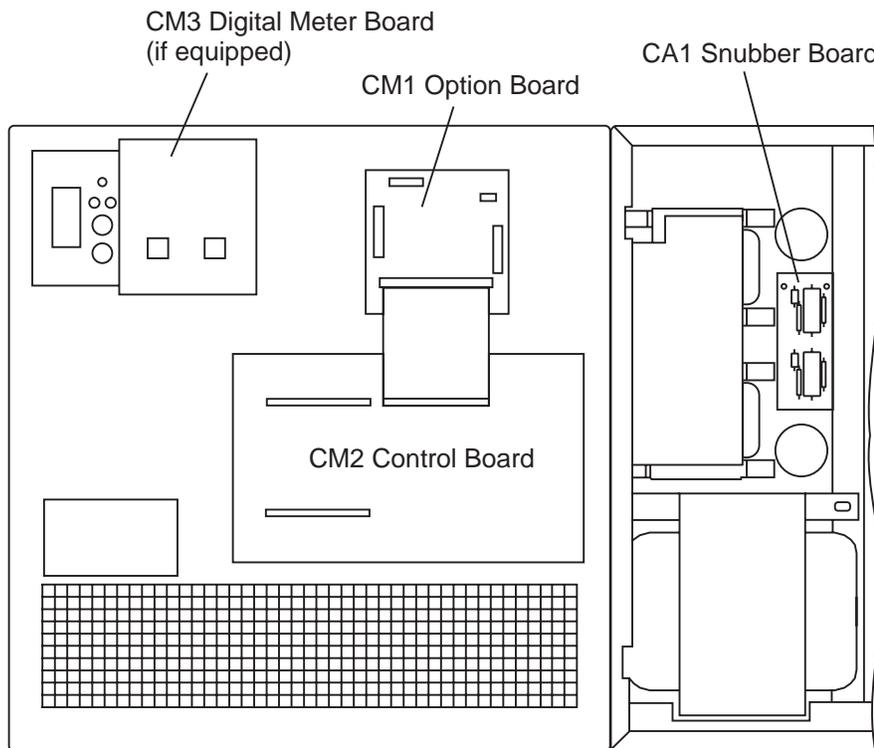
- The **CM1** circuit module (ED-83159-30 Group 1, A) contains circuitry common to several rectifiers in the Lineage® 2000 rectifier family. The factory provides the options required for each application by removing certain wire straps and resistors from the **CM1** board. The factory modification of **CM1** is complete when the board is installed in the rectifier. However, ordered spare or replacement **CM1** boards have not been modified. The customer must make this modification. See Section 8 for information on parts to be removed and retained.
- The **CM2** control circuit module (208A) contains the following circuits:
  - Local power supplies
  - Feedback regulator
  - Walk-in feature
  - Backup high voltage shutdown
  - Rectifier portion of external selective high voltage shutdown
  - Remote shutdown
  - Manual on/off relay
  - Phase monitor
  - Restart feature
  - Unbalance shutdown
  - Fuse alarm
  - Electronic current limit
  - Output current isolation circuit
- The **CM3** circuit module (207A) controls the digital **Output** meter on the rectifier control panel. The meter displays the rectifier's output current, voltage, or the plant

battery voltage depending on the three-position selector switch (see “Front Panel Controls and Indicators”).

- The CA1 circuit module (ED83162-30 Group 1) contains a triac/thyristor snubber network. Refer to schematic drawing SD-82605-01 for further information.

### Caution

Circuit modules must not be connected or disconnected with voltages present or equipment damage may occur. See “Replacing Circuit Modules” in Section 8, *Spare Parts and Replacement Procedures*, for how to replace circuit modules.



**Figure 2-1: Location of Circuit Modules**



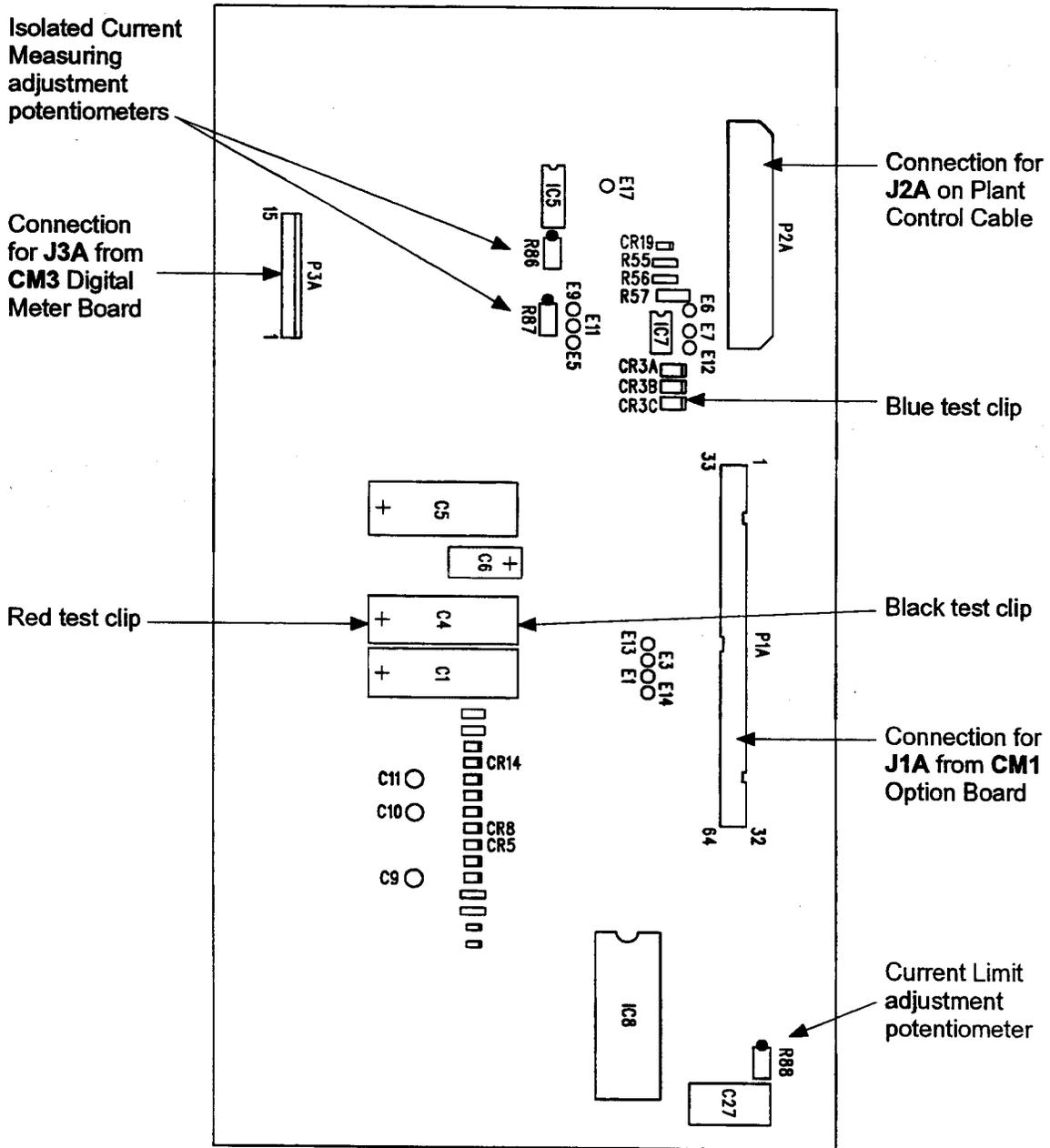


Figure 2-3: CM2 Control Board Showing Test Clip Connections and Other Component Details

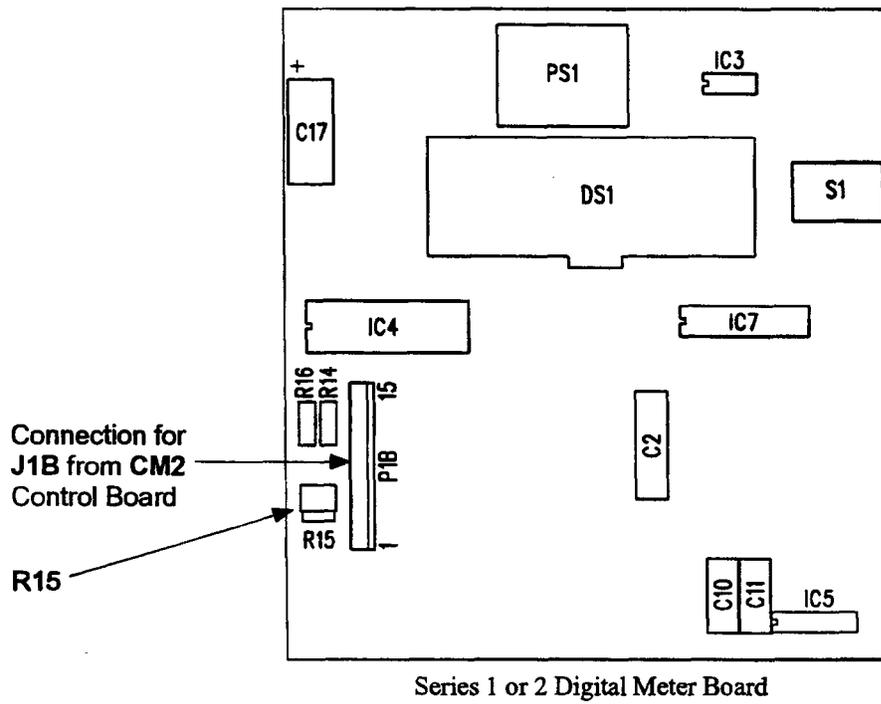
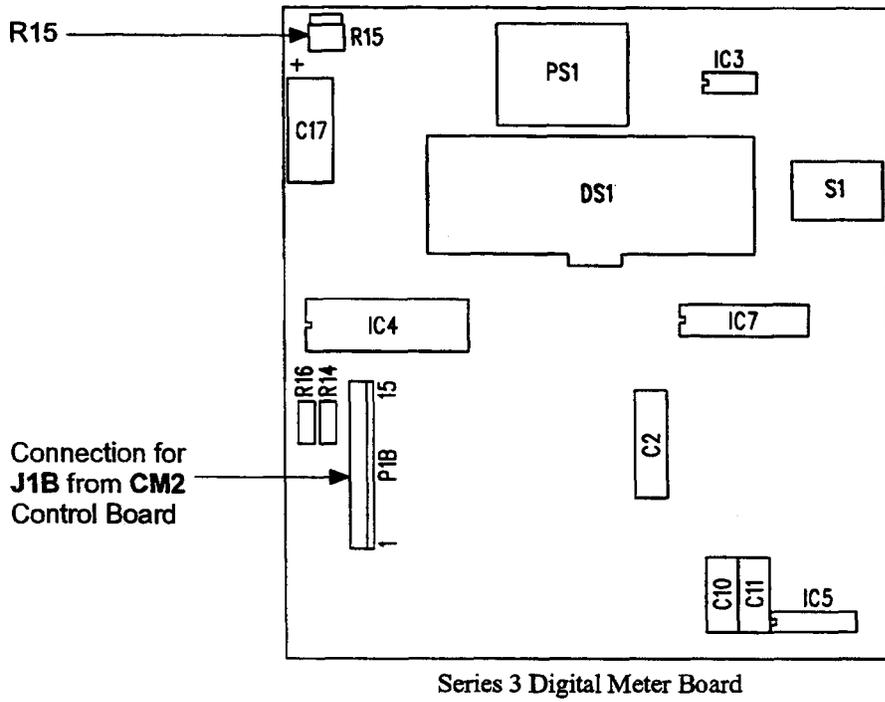
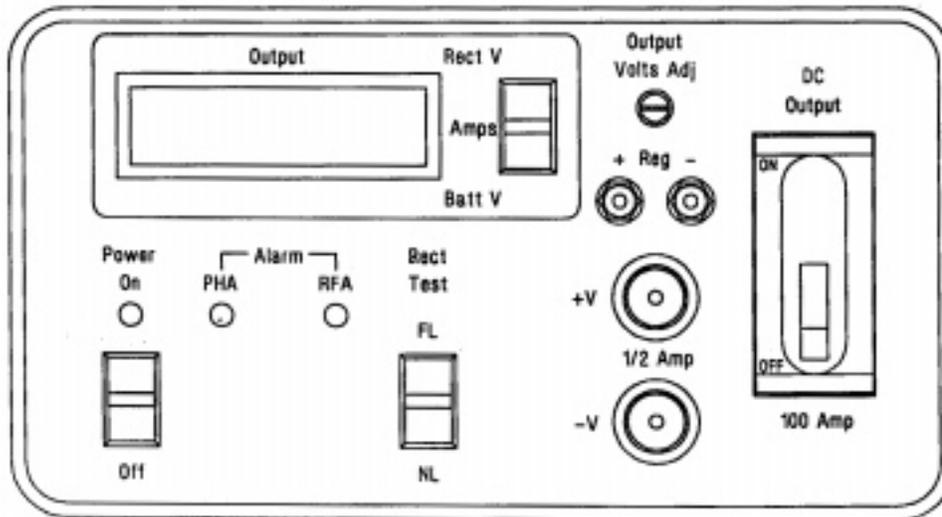


Figure 2-4: Partial Sketch of CM3 Digital Meter Board

## Front Panel Controls and Indicators

Figure 2-5 shows the front control panel of the J85503A-1, 100-ampere rectifier.



*Figure 2-5: Control Panel on the J85503A-1 Rectifier*

The following list describes the controls and indicators on the rectifier control panel. These features should be observed and manually operated during normal rectifier performance. Bold letters indicate labels that appear on the control panel or inside the rectifier.

- The digital **Output** meter displays (1) the rectifier output current when the selector switch is in the **Amps** position, (2) the rectifier output voltage when the selector switch is in the **Rect V** position, and (3) the plant battery voltage when the selector switch is in the **Batt V** position. The default display is rectifier output current. Table 2-A gives the accuracy of this meter in the various positions. The output voltage (**Rect V**) accuracy depends on the vintage of the digital meter board, or circuit module **CM3**, in the rectifier.

**Table 2-A: Digital Meter Accuracy**

<b>Meter Position</b>	<b>Accuracy</b>
Rect V	±0.5 volt for Series 1 or 2 <b>CM3</b> digital meter boards
	±0.02 volt for Series 3 <b>CM3</b> digital meter boards*
Batt V	±0.02 volt for any <b>CM3</b> digital meter board
Amps	±2.5 percent of rectifier rating
* Series 3 <b>CM3</b> boards can be identified by the designation “AM3” which is stamped on the wiring (noncomponent) side of the board. A partial sketch of the <b>CM3</b> boards is provided in	

- The **Power** (Control) switch turns the rectifier on and off. When the switch is in the **Off** position, the rectifier cannot be turned on by the plant controller. When in the **On** position, an MCS controller can remotely turn the rectifier on or off to satisfy the plant load current requirements. The **Power On** LED emits a green light to indicate that the rectifier is on.
- The Phase Alarm (**PHA**) LED emits a red light when any one or more of the three ac input phase voltages decreases approximately 35 percent from the nominal value. If the voltage on any phase is completely missing, a phase alarm issues and the rectifier shuts down. If the load is light, the rectifier may stay on.
- The Rectifier Failure Alarm (**RFA**) LED lights and a signal is sent to the plant controller if the rectifier fails because of external or internal high voltages, a blown fuse, or an internal unbalance.
- The **Rect Test** switch provides a manual test of the rectifier regulation by simulating a full load (**FL**) or no load (**NL**) condition. Operating the switch raises or lowers the output voltage setting of the rectifier by 0.25 volt when on battery. When the switch is in the center position, the rectifier is in the normal operating state.
- The **Output Volts Adj** potentiometer provides for manual adjustment of the output float voltage.

- The **Reg** test jacks allow for measuring the plant output voltage at the points where the remote sense leads are connected. This measurement is accurate only when the remote sense leads are connected.
- The **1/2 Amp +V** and **-V** alarm fuses protect the voltage sense leads to the rectifier control and regulation circuits.
- The **DC Output** circuit breaker protects the plant from rectifier malfunction and excessive current, and may be used to disconnect the rectifier from the battery. An **Output** circuit breaker alarm issues and the **RFA** LED lights when the circuit breaker trips.

## ***Alarm and Control Flow***

The J85503A-1, 100-ampere rectifier is typically installed in a battery plant that is monitored and controlled by a Lucent Technologies Lineage<sup>®</sup> 2000 controller. The rectifier generates various monitoring and alarm signals and, in this type of installation, sends them to the controller for processing and subsequent action. The action may be local or remote alarm indications or control signals fed back to the rectifier. Refer to the various Lineage<sup>®</sup> 2000 controller product manuals for a description of rectifier signal processing and resultant action.

Figure 2-6 shows the typical signal flow between a rectifier and a Lucent Technologies controller. The control signals and alarms enter and leave the rectifier via the control circuit module **CM2**. The Lineage<sup>®</sup> 2000 family of plant controllers also uses replaceable circuit modules which give flexibility to battery plant design.

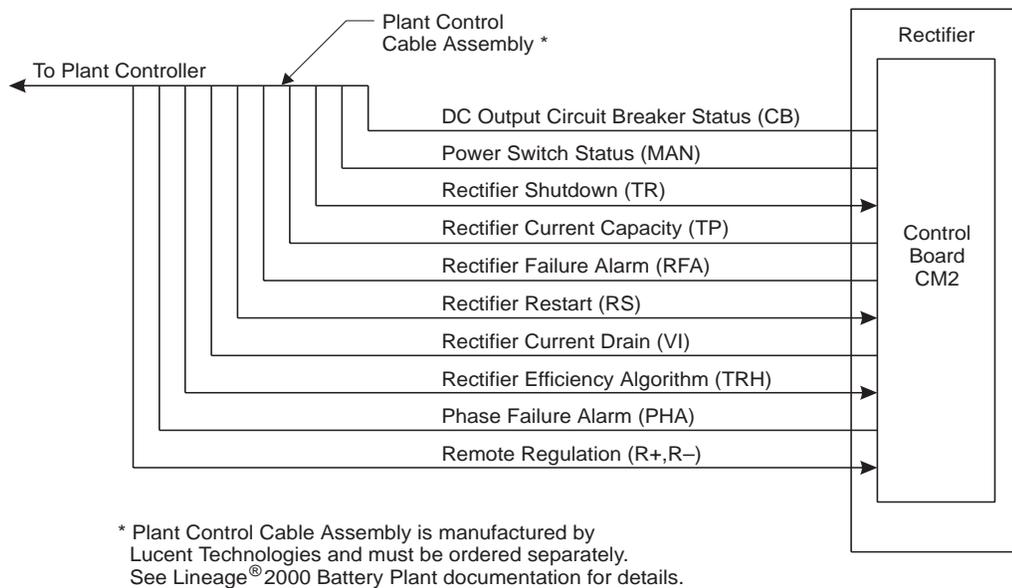


Figure 2-6: Signal Flow between Rectifier and Lucent Technologies Controller

**Physical,  
Thermal, and  
Electrical  
Specifications**

Table 2-B, Table 2-C, and Table 2-D give the physical, thermal, and electrical specifications for the Lineage® 2000 J85503A-1, 100-ampere rectifier. Regulation on battery is 0.5% for the line, load, frequency, and temperature specifications. Regulation off battery is 2% for these specifications.

**Table 2-B: Physical and Thermal Specifications of the J85503A-1 Rectifier**

	Output DC ±24V	Output DC -48V
Dimensions (inches)	23.25 wide x 24 tall x 12 deep	
Weight (lbs)	300	350
Heat Dissipation* BTU/hr at full load	1300	2050
Humidity Rating	10 to 95% (non-condensing)	
Operating Altitude	Sea level to 10,000 feet (3048 meters)	
Operating Temperature	35 - 122°F 1.5 - 48.8°C	
* Measured at 28 Vdc for 24-volt rectifiers and at 54 Vdc for 48-volt rectifiers.		

**Table 2-B: Physical and Thermal Specifications of the J85503A-1 Rectifier**

	<b>Output DC ±24V</b>	<b>Output DC -48V</b>
Audible Noise at 5 ft. above floor and 2 ft. in front of rectifier	Less than 65 dBA	
Earthquake Rating	Meets Zone 4 per Bellcore TR-EOP-000063 (Issue 3)	
* Measured at 28 Vdc for 24-volt rectifiers and at 54 Vdc for 48-volt rectifiers.		

**Table 2-C: Input Specifications for the J85503A-1 Rectifier**

<b>3-Phase Input AC (volts)</b>		<b>Nominal Line Current (amps)</b>		<b>Frequency (Hz)</b>
<b>Nominal</b>	<b>Range</b>	<b>±24V</b>	<b>-48V</b>	
208	184-220	9.1	19.2	60 ±3
240	212-254	8.3	16.7	
480	424-508	4.2	8.5	
Data recorded at full load, 28 Vdc for 24-volt rectifiers and 54 Vdc for 48-volt rectifiers.				

**Table 2-D: Output Specifications for the J85503A-1 Rectifier**

<b>Nominal Rectifier (amps/volts)</b>	<b>Output Range (amperes)</b>	<b>Output Range (dc volts)</b>	<b>Minimum Efficiency* at Full Load (percent)</b>	<b>Minimum Power Factor at Full Load</b>	<b>AC Ripple† (mV peak to peak) Standard Filter/Optional Filter</b>	<b>Maximum Noise at Battery† (dBmC) Standard Filter/Optional Filter</b>
100 / 24	0 - 100	21.5 - 28.0	88	0.95	300	45 / 32
100 / 48	0 - 100	43.0 - 56.0	90	0.88	300	42
* Efficiency measured at nominal line, 28 Vdc or 54 Vdc.						
† Measured at 400amp/hr battery (4 times rectifier capacity), with a 2-volt lead drop for standard and 0.5-volt drop for optional filter.						

## 3 *Ordering Information*

### *Options*

Table 3-A gives the equipment lists that are available for the Lineage<sup>®</sup> 2000 J85503A-1, 100-ampere rectifier. Lists 1-6 are always required depending on the choice of input ac and output dc voltages. Lists 10 and 15 or 16 are also always required to provide a digital meter and additional output filtering.

Emergency or end cells, List 17, are additional cells which are either manually or automatically connected in series with the battery in the event of low-battery voltage such as occurs during an ac power failure. The use of emergency cells maintains prescribed voltage limits during battery discharge. The emergency or end cell switch is an electromechanical device which switches emergency cells in or out of the discharge circuit.

**Table 3-A: Equipment Lists for the J85503A-1 Rectifier**

<b>List Number</b>	<b>Input AC (volts)</b>	<b>Output DC (volts)</b>
1	208	+24
2	208	-48
3	240	+24
4	240	-48
5	480	+24
6	480	-48
<b>Always Required List Number</b>	<b>Provides</b>	
10	Digital meter	
15	Additional output filtering on 24V rectifiers	
16	Additional output filtering on 48V rectifiers	
<b>Optional List Number</b>	<b>Provides</b>	
17	Emergency (EM) cell charging capability	
18	Chassis assembly for mounting rectifier in J86658A, 3820 power conditioning cabinet	
B	Circuit breaker in positive output lead (Negative Ground System), 24V rectifier only	

# 4 *Safety*

Please read this section carefully before installing, maintaining, or repairing the J85503A-1 rectifier.

## *Admonishments*

Always take precautions to protect personal safety as well as the equipment when working on power systems. Throughout this manual, admonishments relating to personal safety are labeled **DANGER** or **Warning**. Those relating to equipment damage are labeled **Caution**. Please read all admonishments carefully and follow safety instructions and warnings.

## *Safety Statements*

- For use only in restricted access areas (dedicated equipment rooms, equipment closets, or the like) in accordance with articles 110-16, 110-17, and 110-18 of the U.S. National Electric Code (NEC), ANSI/NFPA No. 70, and pursuant to applicable local codes.
- This equipment must not be installed over combustible surfaces.
- This equipment is to be used in controlled environments (an area where the humidity is maintained at levels that can not cause condensation on the equipment, the contaminating dust is controlled, and the steady-state ambient temperature is within the range specified).
- This equipment has been evaluated for use in a continuous ambient temperature of up to 35 degrees Celsius.
- AC branch circuits to this equipment must be protected with either fuses or circuit breakers sized as required by the National Electric Code (NEC)

- and/or local codes. The size of the overcurrent protector used must not exceed 50A. Refer to the equipment ratings to assure rating of equipment will not exceed 80% of the value of the protector chosen.
- An accessible ac disconnect/protection device to remove ac power from the equipment in the event of an emergency must be provided.
  - For installations in the United States, UL-listed compression connectors should be used to terminate UL-listed field-wired conductors where required. For all installations, the appropriate connector should be applied only to the correct size conductor as specified by the connector manufacturer using only the connector manufacturer's recommended tooling or tooling approved for that connector.
  - If the proper connector for the country of installation is not provided, obtain appropriate connectors and follow manufacturer's and all local requirements for proper connections. All national and local rules and regulations are to be followed when making field connections.
  - Torque electrical connections to the values specified on labels or in the product documentation.

## ***Precautions***

When working on or using this type of equipment, follow these precautions:

- This unit must be installed, serviced, and operated only by skilled and qualified personnel who have the necessary knowledge and practical experience with electrical equipment and who understand the hazards that can arise when working on this type of equipment.
- Because of the hazardous voltages supplied to and within the equipment, make sure the equipment, all associated framework, and the cable rack are properly grounded per local job instructions before turning on any power to the rectifier.
- For equipment connected to batteries, disconnecting the AC alone will not necessarily remove power to the equipment. Make sure the equipment is not also powered by the batteries or the batteries are not connected to the output of the equipment.
- AC voltage may be present in the unit even when the Power switch is in the Off position.

- Hazardous DC energy (from batteries and rectifier output) and voltages up to 600 volts are present in the unit. Use a voltmeter to insure no voltage, or the expected voltage, is present before contacting any uninsulated conductor surface. Follow the procedures in the order given to minimize dangerous encounters with these voltages. Exercise extreme caution when working near the battery busbars.
- When servicing the rectifier, disconnect the ac service and the dc battery buses. Use extreme caution when handling the battery bus cables since these cables still contain hazardous currents from the batteries. The disconnected charge battery and charge ground connectors (cables) must be taped adequately to prevent them from contacting each other or any other metal surface. Alternatively, the dc battery cables from the rectifier can be disconnected at the plant charge battery and charge ground buses.
- DC capacitors may be charged even with power disconnected from the rectifier. If filter capacitor fuses have blown, capacitors will be charged. Always check all of the dc capacitor terminals (observe polarity) with a voltmeter before performing this procedure, and discharge capacitors safely, if necessary.



**Wait at least 5 minutes after shutting down ac and circuit breaker before working on capacitors or associated buswork.**

- Batteries may be connected in parallel with the output of the rectifiers. Turning off the rectifiers will not necessarily remove power from the bus. Battery voltage may still be present on one side of the output DC circuit breaker even with the circuit breaker off. Make sure the battery power is also disconnected and/or follow safety procedures while working on any equipment that contains hazardous energy/voltage.
- Use only properly insulated tools.
- Remove all metallic objects (key chains, glasses, rings, watches, or any other jewelry).
- Wear safety glasses.
- Test circuits before touching.
- Lock out and tag any circuit breakers/fuses when

- possible to prevent accidental turn on.
- Be aware of potential hazards in the area you are working before entering the equipment.
  - Identify exposed hazardous electrical potentials on connectors, wiring, etc. (note the condition of these circuits, especially any wiring).
  - Use care when removing or replacing any covers - avoid contacting any circuits.
  - Use gloves when handling thermally hot components inside the rectifier. Transformers are very hot after sustained operation.

### ***Warning Statements and Safety Symbols***



This symbol identifies the need to refer to the equipment instructions for important information.



This symbol (or equivalent) is used to identify the presence of hazardous ac mains voltage.



This symbol (or equivalent) is used to identify the presence of hazardous ac mains voltage.



This symbol is used to identify the presence of hazardous ac or dc voltages. It may also be used to warn of hazardous energy levels.



One of the above two symbols (or equivalent) may be used to identify the presence of rectifier and battery voltages. The symbol may sometimes be accompanied by some type of statement - for example: "Battery voltage present. Risk of injury due to high current. Avoid contacting conductors with uninsulated metal objects. Follow safety precautions."



This symbol is used to identify the need for safety glasses and may sometimes be accompanied by some type of statement, for example: "Fuses can cause arcing and sparks. Risk of eye injury. Always wear safety glasses."



This symbol is used to identify the presence of a hot surface. It may also be accompanied by a statement explaining the hazard. A symbol like this with a lightning bolt through the hand also means that the part is or could be at hazardous voltage levels.



These symbols are used to identify the safety earth ground or bonding point for the equipment.



## **5**                      ***Installation***

### ***Introduction***

This section provides information to consider before installing the J85503A-1 rectifier in a Lineage® 2000 Battery Plant. The section also describes the input and output wiring required and the recommended procedure for installing the rectifier from uncrating through startup. Lucent Technologies offers “turn-key” engineering and installation services for the products described in this product manual. Consult your Lucent Technologies representative for details.

### ***Safety***

Please read Section 4, *Safety*, thoroughly before installing the J85503A-1 rectifier, and carefully read and follow the admonishments as they are presented throughout this documentation.

### ***Preparing for Installation***

Location of the J85503A-1 rectifier and associated equipment must conform to the specific plans of each Lineage® 2000 plant installation. Physical, thermal, and electrical specifications are given in Section 2. These specifications must be considered in the plans for any installation that includes this rectifier.

### ***Handling Equipment***

Each J85503A-1 rectifier weighs at least 300 pounds. Therefore, the customer must make prior arrangements for appropriate material handling facilities and equipment to unload, uncrate, and set up the rectifier. Proper handling is necessary to assure personnel safety and protect the equipment. Each rectifier is shipped in a tri-walled corrugated cardboard container secured to a wooden shipping skid. The container should be moved by a forklift.

### ***Bay Mounting***

J85503A-1 rectifiers that are shipped as part of a battery plant are installed in the battery plant racks before shipment. Rectifiers ordered as individual units are shipped in individual containers.

The rectifiers mount in Lucent Technologies 26-inch wide bays, with 24-5/16 inch mounting centers. The bays have drilled holes on 1-inch centers, in the vertical plane, to accommodate #12-24 threads per inch self-tapping screws. Any restrictions on the location in the bays is specified in documentation for the specific power plant.

Size 3/8-16 eyebolts are provided for lifting the rectifier into position in the plant bay. They should be removed before the rectifier is permanently mounted in the bay. A supplementary bay that contains ONLY rectifiers, should be located so that the backs of the rectifiers are at least three inches from any wall behind them.

### ***Heat Dissipation***

Heat dissipated to the environment is another factor in selecting a location for the J85503A-1. The maximum heat exhausted by each 24 and 48-volt rectifier is approximately 1300 BTU/hr and 2050 BTU/hr respectively. The rectifiers use free convective cooling, where cooler air enters the cabinet through perforations in the front door and is exhausted through perforations in the top cover. A minimum of 23 inches in front and 2 inches above the rectifier must be free of obstructions to allow the door to swing free and provide for adequate ventilation. In a side-by-side alignment of rectifiers, the cabinet door opens 90° and projects approximately 23 inches (59 cm) into the front aisle causing no interference with adjacent rectifiers.

#### **Caution**

Do not block rectifier ventilation openings or damage may result due to overheating.
--

### ***AC Input Power***

The customer is responsible for providing ac power to the rectifier. Table 5-A gives requirements for the ac power installation. Separate branch circuits must be provided to each rectifier to assure reliability of the system. The wiring method should meet national and local codes. If the codes governing the installation allow it, Armored Cable (AC), also known as BX, makes routing the ac wiring within the bay easier.

**Table 5-A: AC Input Requirements**

List	Volts	Amps	Line Fuse Type, Rating	Input Circuit Breaker Size (amps)	Number of Input Wires, Gauge*	Armored Cable Trade Size (inches) for Wire Size Shown	Max. Input Wire Gauge	Conduit Knockout, & Conduit Trade Size† (inches)	Terminal Supplied on Rectifier
L1	208	9.1	FRN-R, 15	15	4, #14 AWG	1/2	10 AWG	1-1/8, 3/4	Screw Type
L3	240	8.3	FRN-R, 15	15					
L5	480	4.2	FRN-R, 10	10					
L2	208	19.2	FRN-R, 25	25	4, #10 AWG				
L4	240	16.7	FRN-R, 25	25					
L6	480	8.5	FRN-R, 15	15	4, #14 AWG				

\* Input wire count includes “green wire” ground. Use KS-24194 L3 or 75°C commercial wire.  
 † Where the trade size of the conduit used is smaller than the trade size for which the conduit knockout was sized, use appropriate knockout reducing washers.

Figure 5-1 shows the ac input conduit hole and alternate hole and termination points for the ac input wires and the “green wire” ground. This wire is the ac equipment ground (AC EG), also known as frame ground (**FRAME GRD**).

Table 5-A shows the recommended customer-supplied fuse size and type for the branch circuit protection in the ac service panel supplying input to the rectifier. The types shown are BUSSMANN<sup>1</sup> fuses. Equivalent UL listed fuses or circuit breakers can be used in lieu of those shown. If circuit breakers are used, they should have trip elements of an equivalent rating to the recommended fuse.

The AC EG or frame ground is normally connected using the mechanical connection provided. Discard this connection if you prefer the T&B<sup>2</sup> crimp connection also provided. See note 61 on J-drawing, J85503A-1.

1. BUSSMANN is a trademark of the BUSSMANN Company.  
 2. T&B is a trademark of the Thomas & Betts Company.

**DC Output Power**

The majority of dc power plants for telecommunication applications are designed to use single conductor cables (in parallel for current capacity or to limit voltage drop) supported on ladder racks. Experience has shown that the use of flexible cables (welding type cables) makes installation of this type wiring much simpler. Therefore, the terminals are sized to fit KS-24194 L2 wire, which is very flexible.

Figure 5-1 shows the dc output conduit hole and alternate hole. Figure 5-2 shows the dc output wire termination points. Table 5-B specifies the dc output cable size, T&B connectors, and crimp die. Also see note 57 on J-drawing, J85503A-1.

**Table 5-B: DC Output Requirements**

<b>Amps</b>	<b>Output Wire Size*</b>	<b>Output Conduit Trade Size (inches)</b>	<b>Connectors Required</b>	<b>T&amp;B Crimp Die</b>
100	#2 AWG	1-1/4	2 studs (5/16" dia., 7/8" apart) T&B 54858BE (2-hole crimp lug)	Green
* Use KS-24194 L2 wire. It is a flexible, stranded copper wire, rated 600 volts; stranding meets American Society for Testing and Materials (ASTM) B 172 Class I. This non-halogen, insulated wire is rated 90°C. The insulation has a combustibility rating of 28% minimum as determined by ASTM D2863. Wire sizes were chosen to limit the voltage drop to 2 volts where the cable loop is approximately 200 feet.				

**Installation Tools**

The following tools are required for installing rectifiers:

- Material handling equipment to unload rectifiers at site, remove them from shipping containers, and place them in final positions
- Common electrician's hand tools, including jeweler's screwdriver, electrical tape, wire cutters and strippers, 14 AWG to 2 AWG wire
- Proper crimping tools and dies for connectors used in the installation.

- Common mechanic's hand tools, including flat blade screwdriver (0.30 inch blade width), socket and torque wrench for 3/8 inch bolts, channel lock pliers for ac conduit tightening, hammer, and crowbar for uncrating
- Size 3/8-16 lifting eyebolts
- Digital Multimeter (DMM) Fluke® 8060A or equivalent with  $\pm 0.02$  percent accuracy on dc scale

### ***Unpacking***

Move the crated rectifier to a convenient area for uncrating and follow the steps listed below.

1. Remove any shipping bands.
2. Check “tilt” or “shock” indicators. If tripped, contact shipping company and process claims form.
3. Pry off top, then sides of crate.
4. Inspect exposed exterior of rectifier for shipping damage.
5. With rectifier lying on its back, open the front door and visually inspect for shipping damage.
6. If material is damaged, contact shipping company and process claims form.
7. Verify that the main ac voltage at the distribution panel agrees with the List options specified on the label inside the front door of the rectifier. If it does not agree, two possible conditions on the rectifier may be corrected by the customer.
  - Incorrect ac input voltage (see Table 3-A)
  - Incorrect system polarity (circuit breaker in the wrong dc output bus). Positive ground systems have the breaker in the negative output bus, and negative ground systems have the breaker in the positive output bus.

The customer may decide to correct either type of condition instead of returning the rectifier. The procedure for rewiring the ac input connections to match the customer's ac supply (208 or 240 volts) is

provided in “Converting AC Voltage” in Section 5. The procedure for placing the **DC Output** circuit breaker (**CBA1**) in the opposite output bus is described in “Converting DC Output Polarity”.

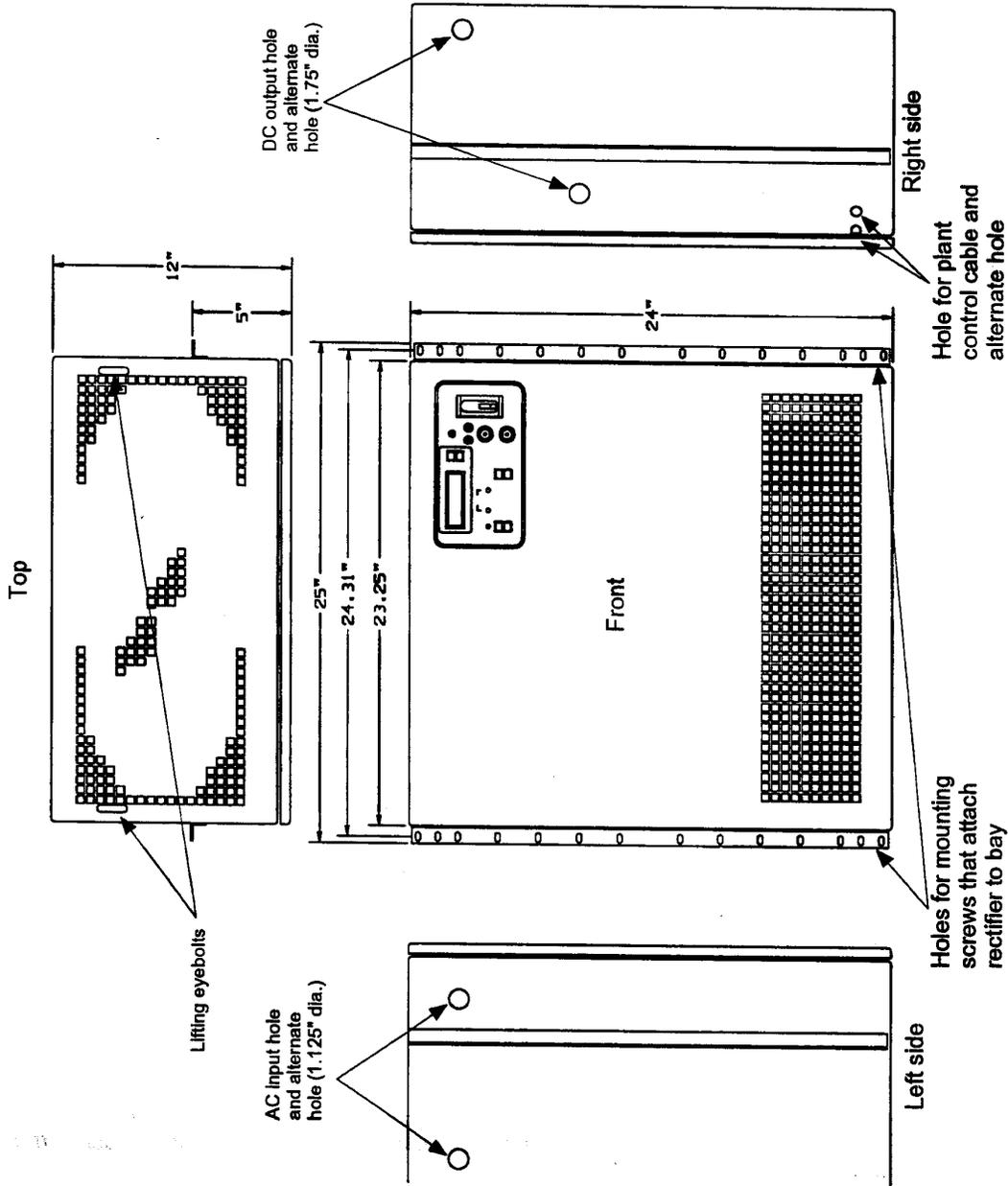


Figure 5-1: Four Views of the J85503A-1 Rectifier

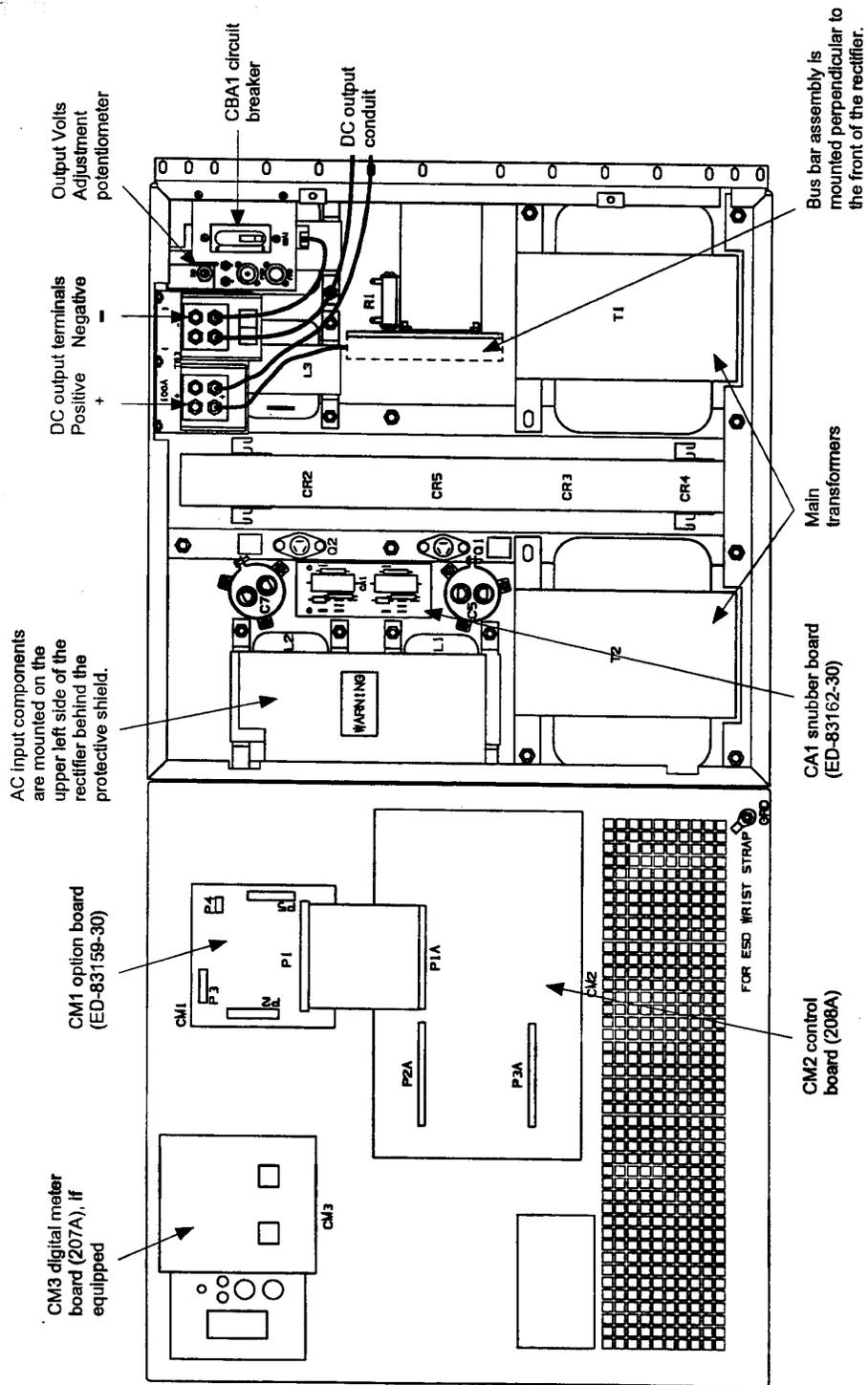
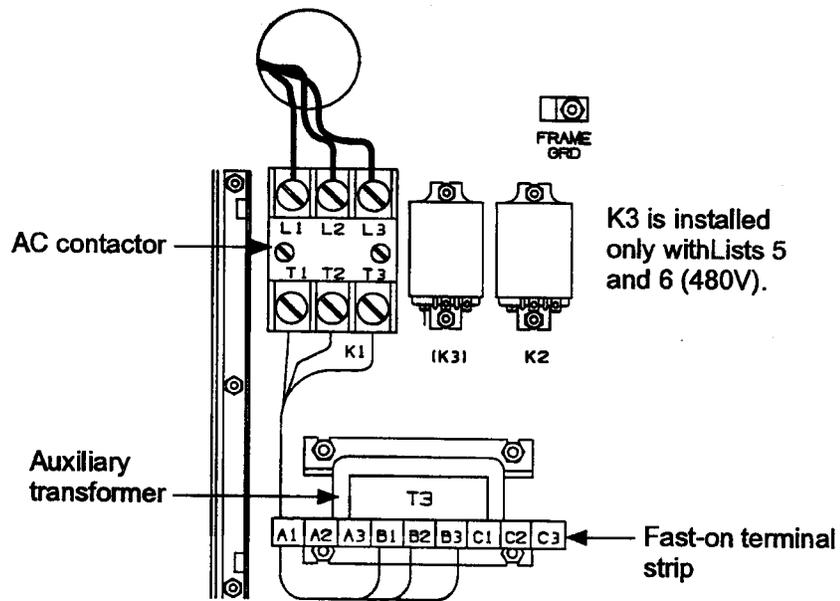


Figure 5-2: Front View of J85503A-1 Rectifier with Door Open



**Figure 5-3: AC Input Components Mounted on the Upper Left Side of the J85503A-1 Rectifier Behind the Protective Shield**

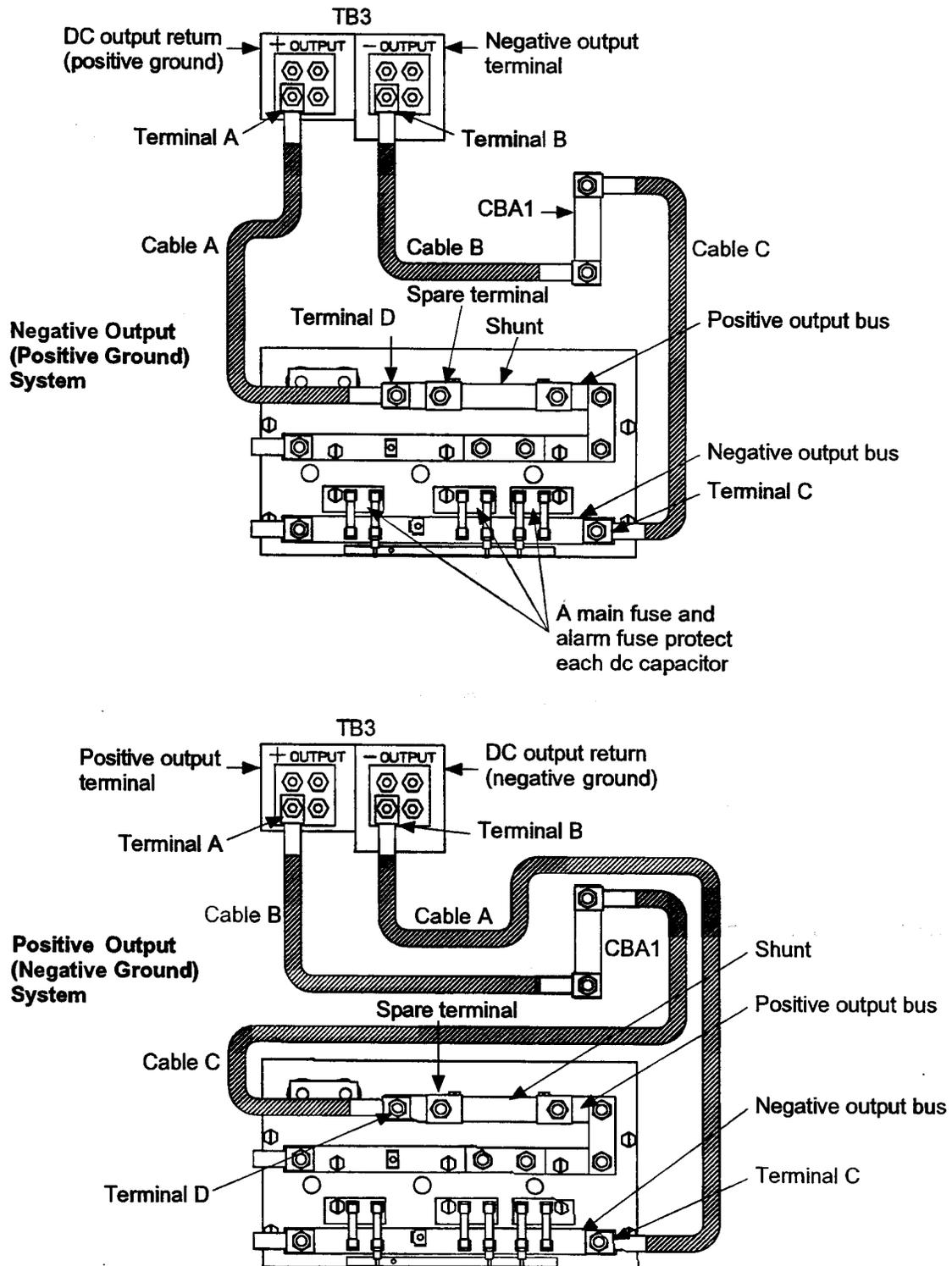


Figure 5-4: Output Polarity Conversion and Component Detail on Bus Bar Assembly

## ***Installing or Adding a Rectifier***

Before beginning this procedure, read the section above on “Preparing for Installation” in its entirety. This procedure is appropriate for installing a rectifier in a new plant or adding a rectifier to an existing plant to increase capacity. The assumption is made, however, that the rectifier is being added to an operating plant.

Observe the safety precautions in the Safety section and those given with each procedure whenever working on or near electrically live equipment.

Only persons trained and experienced in the installation of power equipment should install this rectifier.

### **DANGER**

- Follow procedures in the order given to minimize exposure to voltages up to 530 volts ac and 60 volts dc.
- Remove all jewelry and use insulated tools when working on or near electrically live parts.
- Use a voltmeter to insure no voltage, or the expected voltage, is present before contacting any uninsulated conductor surface.
- Use gloves when handling thermally hot components inside the rectifier.
- AC voltage is present even when the **Power** switch is in the **Off** position.
- Be sure that the associated framework and cable rack are properly grounded, per local job instructions, before turning on any rectifier.
- Battery voltage is still present on one side of the **DC Output** circuit breaker when both the ac power and dc circuit breaker are turned off.

### ***Install AC Power Cables***

Use Figures 5-1, 5-2, and 5-3 as references for this section.

1. Using site drawing information, locate the exact position specified for the rectifier.

2. Disconnect ac power from ac distribution service panel that supplies power to the rectifier.
3. Install fuse holders or circuit breaker for the rectifier in the ac distribution service panel. Leave circuit breaker in **off** position or remove fuses.
4. Install three phase leads and frame ground at service panel and route conductors to rectifier.
5. Install the connector you prefer onto the frame ground lead (see “AC Input Power” in Section 5). Use the proper crimping tool and die for the connector to prevent damage to equipment. Strip the ends of the three phase leads that will be installed in the rectifier.
6. Secure phase leads and **FRAME GRD** lead in rectifier as shown in Figure 5-3. Install ground lead first. Torque all frame ground connections and phase connections for Lists 5 and 6 to 20 in-lbs. Torque phase connections to 35 in-lbs for Lists 1 - 4.
7. Verify that the branch circuit breaker to the rectifier in the ac service panel is **off** or fuses are removed. Reenergize ac service panel. Tag branch circuit breaker or fuse holders to inform others not to close (turn on) the breaker or insert fuses. If the branch circuit, (all phase leads plus the frame ground), is protected by fuses, physically remove the fuses from the area of the ac service panel.

***Install DC Power  
Cables***

Plant bus bars may carry 52 volts dc. Observe safety warnings and precautions in Section 4.

Use Figures 5-1 and 5-2 as references for this section.

1. Turn **DC Output** circuit breaker on rectifier off (down).
2. Measure the lengths of cable required to run the dc output from the rectifier to its termination point on the charge bus, and to run the dc return from the rectifier to its termination point on the charge ground bus.
3. Cut cables to length and install crimp connectors. Use the proper crimping tool and die for the connector to prevent damage to equipment. See Table 5-B.

4. Tape or otherwise insulate the connectors on the end of each cable that does not terminate in the rectifier.
5. Place dc return cable in cable rack.
6. Thread end of cable through right side of rectifier and terminate connector at the appropriate ground bus bar in the rectifier. The ground bus bar is positive for negative output voltage plants, and negative for positive output voltage plants. Torque connection to 120 in-lbs. See Figure 5-2.
7. Remove tape or insulation from connector at other end of cable and terminate on plant charge ground bus bar.
8. Place dc output cable in cable rack.
9. Thread end of output cable through right side of rectifier and terminate connector on dc output bus bar in rectifier. Torque to 120 in-lbs. See Figure 5-2.

### **Warning**

Avoid arc or sparks. Before making contact between connectors and the output bus bar in the next step, use a DMM to verify a true open circuit between connector and known battery plant ground.

10. Remove tape or insulation from connector at other end of output cable, and terminate connector on (hot) charge bus bar.

### ***Install Plant Control Cable Assembly for a Lucent Technologies Controller***

The Plant Control Cable Assembly has a 24-pin or 16-pin connector on one end and a 40-pin connector on the other end. The 24-pin or 16-pin end terminates on the battery plant controller and the 40-pin end terminates on connector **P2A** of the **CM2** control board located in the rectifier (see Figure 5-2).

1. Route the plant control cable from the controller chassis via the cable racks to the rectifier, then through the opening provided for this cable (see Figure 5-1).
2. Terminate the 40-pin connector on **P2A** of **CM2** and dress cable (using strain relief bushings and cable ties provided) inside rectifier allowing for the door to be opened and

closed without putting stress on the cable. After securing the cable, disconnect the cable from **P2A**.

3. Determine the number to be assigned the rectifier in the rectifier lineup, that is, 1, 2, 3, etc.
4. If the controller is an MCS, cut leads TP3, TP1, and TP0 (pin numbers 18, 20, and 21) in the controller end of the control cable (see your controller manual). This signals to an MCS that the rectifier is a 100A.
5. For Microprocessor Controlled System (MCS) plants or Conventional Controlled System (CCS) plants, remove the plastic covers on the back of the bay housing the controller. The back of the controller has sixteen 24-pin connectors labeled **Rect 1** through **Rect 16**.

For a Galaxy controller, locate the J85501F-1 L-31 MCS-compatible RIM (Rectifier Interface Module) mounted on the rear of the controller backplane. Each RIM (position A, B, or C) has 8 rectifier ports.

For Expandable Controlled System (XCS) plants, open the front panel and thread the control cable through the hole in the wall of the controller. There are six 16-pin connectors labeled **Rect 1** through **Rect 6**.

For Evolutionary Control System - 6U (ECS) plants, open the front panel and thread the control cable through the slot inside the controller. On the backplane of the lower panel on the controller there are six 40-pin connectors labeled **Rect 1** through **Rect 6**.

#### **Caution**

Remove the REG fuse associated with the rectifier from the controller.

6. Plug the cable into the connector assigned to the rectifier number determined in Step 3 above. This action will cause a minor alarm in an MCS or Galaxy controller.
7. Dress and tie down the cable to provide stress relief at the connector.

The rectifier is now installed. The last three sections in this chapter are optional procedures that may be needed at installation. If not, proceed to Section 6, *Testing*.

## Converting AC Voltage

Converting the ac input voltage to a rectifier is necessary only if the ac wiring is incorrect in the unit or if rectifiers are moved and the input ac voltage is different. Refer to Figure 5-3 during this procedure. Also see note 18 on J-drawing, J85503A-1.

### DANGER

This procedure **MUST** be performed **ONLY** on a rectifier completely disconnected from the battery and plant bus, **AND** with ac power disconnected at the ac service panel.

Table 5-C is used for both 208 to 240-volt ac and 240 to 208-volt ac conversions. Use the half of the table (top or bottom) that starts with the desired input line voltage.

**Table 5-C: AC Voltage Conversion**

Input Line Voltage	Main Transformer/K1 Contactor Connections Needed	Main Transformer Leads to be Removed from K1 and Insulated	Auxiliary Transformer (T3) Connections Needed via Fast-On Terminal Strip (on T3)
To 208 Vac	T2-2 to K1-T1 T1-4 to K1-T2 T1-2 to K1-T3	T2-3 T1-5 T1-1	A1 to B2 B1 to C2 C1 to A2
To 240 Vac	T2-3 to K1-T1 T1-5 to K1-T2 T1-1 to K1-T3	T2-2 T1-4 T1-2	A1 to B3 B1 to C3 C1 to A3

Note: The wires in the second column are from main transformers T1 and T2 and are all bundled together between T1 and T2. Three wires (the ones for the current input line voltage) pass behind the relay shield and go up to the K1 contactor. The other three are taped and remain in the bundle. The numbers following the T1 and T2 designations in the second column are the numbers marked on the bundled wires. Do not be confused by the T1, T2, and T3 designations following K1; these refer to the K1 contactor terminals, not the transformers.

This procedure is accomplished in two parts. The first is to install on the **K1** contactor the alternate set of three ac leads (from the six bundled wires) for the new ac input voltage (208 or

240). The second is to rewire the auxiliary transformer (**T3**) input by reconnecting jumpers on the fast-on terminal strip mounted on **T3**.

#### **Connecting the Three Alternate AC Leads:**

1. Remove the relay shield to expose the **K1** contactor and the **T3** terminal strip. Remove the three wires from the **K1** contactor and note that they are marked according to the ac voltage to be converted from, (3, 5, and 1 to convert from 240 Vac, or 2, 4, and 2 to convert from 208 Vac). See the third column of the table.
2. Insulate the ends of the wires removed from **K1** with either UL and CSA approved tape or tubing.
3. Remove the three alternate voltage wires from the bundle and verify that the wires are marked according to the ac voltage to be converted to, (2, 4, and 2 for 208 Vac, or 3, 5, and 1 for 240 Vac). Pull these wires up to **K1**.
4. Push the wires removed from **K1** in Step 1 down to where the alternate voltage wires were and bundle them.
5. Install the three alternate voltage wires to the **K1** contactor as specified in the second column of the table.

#### **Jumper Connections on Fast-On Terminal Strip:**

6. Note that permanent connections to the terminal strip are on contacts **A1**, **B1**, and **C1**. The yellow jumper wires connected to these same terminals go to the **C2**, **A2**, and **B2** terminals for a 208 Vac input, and to the **C3**, **A3**, and **B3** terminals for a 240 Vac input. Therefore, a conversion involves moving each of the three jumpers one terminal in either direction.
7. Make the terminal strip jumper connections for the desired input line voltage per the fourth column in the table.
8. Replace the relay shield removed in Step 1.

### ***Converting DC Output Polarity***

This section gives conversion procedures for the dc output polarity of the Lineage<sup>®</sup> 2000 J85503A-1  $\pm 24$ -volt rectifier. Use the section “Negative Output (Positive Ground) to Positive

Output (Negative Ground)” to convert to a positive output (negative ground) system, and use the section “Positive Output (Negative Ground) to Negative Output (Positive Ground)” to convert to a negative output (positive ground) system.

***Negative Output  
(Positive  
Ground) to  
Positive Output  
(Negative  
Ground)***

**DANGER**

This procedure MUST be performed ONLY on a rectifier completely disconnected from the battery and plant bus, AND with ac power disconnected at the ac service panel.

In Figure 5-4, rectifier wiring appears as in the upper drawing before the work is started, and appears as in the lower drawing upon completion of the work. Save the washers and nuts that are removed for later use.

1. Remove both ends of Cable A from terminal A and terminal D. Save the cable.
2. Remove the end of Cable B from terminal B. Reconnect this end to terminal A.
3. Remove the end of Cable C from terminal C. Reconnect this end to terminal D.
4. Install Cable A, removed in Step 1, between terminal B and terminal C. Cable A may have to be positioned other than the way shown in order to reach between B and terminal C.
5. The wiring should now appear as in the lower drawing of Figure 5-4. Indicate, by stamping on the inside of the rectifier front panel, that the rectifier is now a positive output (negative ground) system (List B).

***Positive Output  
(Negative  
Ground) to  
Negative Output  
(Positive Ground)***

**DANGER**

This procedure MUST be performed ONLY on a rectifier completely disconnected from the battery and plant bus, AND with ac power disconnected at the ac service panel.

In Figure 5-4 rectifier wiring appears as in the lower drawing before the work is started, and appears as in the upper drawing upon completion of the work. Save the washers and nuts that are removed for later use.

1. Remove both ends of Cable A from terminal B and terminal C.
2. Remove the end of Cable C from terminal D. Reconnect this end to terminal C.
3. Remove the end of Cable B from terminal A. Reconnect this end to terminal B.
4. Install Cable A, removed in Step 1, between terminal A and terminal D.
5. The wiring should now appear as in the upper drawing of Figure 5-4. Indicate that the rectifier is now a negative output (positive ground) system by removing the "List B" stamping.

### ***Initial Battery Charging (Optional)***

Initial battery charging should be planned as part of the plant installation. If initial battery charging is desired with the current rectifier installation, **the rectifier should be tested before following this procedure (see Section 6, Testing).**

The J85503A-1 rectifier is capable of supplying a new battery string with its initial charge. Since the voltage levels recommended by battery manufacturers for initial battery charging are considerably above the normal plant voltage, neither the battery nor the rectifier used to supply its initial charge should be connected to the rest of the plant during this procedure. One rectifier should be sufficient to supply the charge. However, the high voltage shutdown levels must be raised to accomplish the initial charge. The following procedure describes how to raise the high voltage shutdown levels.

1. Set the rectifier controls as shown in Table 5-D.

**Table 5-D: Rectifier Control Settings  
for Initial Battery Charge**

<b>Controls</b>	<b>Position/Status</b>
Rectifier <b>Power</b> Switch	<b>Off</b> (down)
Rectifier <b>DC Output</b> circuit breaker	<b>Off</b> (down)
<b>Output Volts Adj</b> potentiometer	Fully counterclockwise
Plant control connector <b>J2A</b> on <b>CM2</b> control board mounted on inside of door	Disconnected from <b>P2A</b> on <b>CM2</b>

2. Remove straps provided for options “K” and “M,” not “K,M” on **CM1** option board and retain for replacement after initial charge (see Figure 2-2).
3. At the ac service panel supplying power to the rectifier, insert the input fuses assigned to the rectifier or turn the circuit breaker On.
4. Close the rectifier door and turn the **Power** switch **On**. The green **Power** LED must light. (If not, do not attempt to turn on the circuit breaker. Troubleshoot the problem per Section 7, *Troubleshooting and Adjustments*.) Wait 10 seconds after turning on the **Power** switch.

**Note**

**If the rectifier continues to operate, proceed to Step 5.** If the rectifier shuts down due to initial high voltage, monitor the **Rect V** voltage. When this reading reaches 26 volts for 24-volt plants, or 52 volts for 48-volt plants, turn on the **DC Output** circuit breaker on the rectifier. If the rectifier shuts down for any other reason, such as component failure, see Section 7, *Troubleshooting and Adjustments*.

5. Holding the meter selector switch in the **Rect V** position, use a small screwdriver to turn the **Output Volts Adj** potentiometer clockwise until the digital meter reads approximately battery voltage, typically 26 volts for 24-volt plants, or 52 volts for 48-volt plants.

6. Turn the **DC Output** circuit breaker on (up).

**Caution**

<p>In the following step, DO NOT set the rectifier output voltage to exceed 62 volts (48-volt rectifier) or 31 volts (24-volt rectifier) or damage to the unit may result.</p>
--

7. Adjust the **Output Volts Adj** potentiometer to obtain the desired initial charge voltage within the limits specified in the preceding caution.
8. After completing the initial charge, turn the rectifier **Power** switch **Off** and the **DC Output** circuit breaker off (down).
9. Replace option straps K and M on the **CM1** option board.
10. Turn the **Output Volts Adj** potentiometer fully counterclockwise.
11. To restore the rectifier to service, follow the procedure in Section 7, *Troubleshooting and Adjustments*.



# 6 *Testing*

## *Introduction*

This section gives test procedures for newly installed and/or operating rectifiers. If the plant in which a rectifier is being installed has never been operational, the plant and controller tests must be performed before the rectifier tests. Consult the plant and controller product manuals for their installation test procedures.

Rectifiers can be tested on or off line. “On line” means a battery string and/or office load is connected to the rectifier. A dummy test load and a Battery Plant Simulator Test Set are required for testing off line. See “Tools and Test Equipment” later in this section for a description of these items. For troubleshooting and diagnostic procedures, refer to Section 7, *Troubleshooting and Adjustments*. Those unfamiliar with the function of rectifier controls and indicators should read Section 2, *Product Description*.

## *Precautions*

When working on power systems, observe safety precautions in Section 4 and those within each procedure.

- The ac input voltage powers certain control relays, the Rectifier Failure Alarm (**RFA**), and the ac contactor. Voltage is available to these circuits whenever the ac service is available to the rectifier.
- Remote sensing of rectifier output occurs via the plant control cable connected to **P2A** on control board **CM2**. This cable must be disconnected when internal sensing is desired, as when testing off line, using a test load.

### Warning

Do not turn the <b>DC Output</b> circuit breaker ON, close an external charge circuit breaker, or install an external charge fuse until told to do so.
--

## ***Tools and Test Equipment***

The following items are needed for testing the rectifier.

- DMM (Digital Multimeter) Fluke 8060A or equivalent meter having 0.02 percent accuracy on dc scale
- Battery Plant Simulator Test Set, customer constructed, or equivalent (see Figure 6-1)
- DC dummy test load, 26-volt (24-volt rectifier) or 52-volt (48-volt rectifier) with adjustment to provide a load of 120 amperes, 120 percent of the rectifier's rating
- Jeweler's screwdriver for adjusting potentiometers
- Straightened paper clip inserted in eraser of wooden pencil

### ***Battery Plant Simulator Test Set***

The Battery Plant Simulator Test Set is a convenient tool used to isolate communication troubles between the plant controller and the rectifier. It simulates the plant controller relative to receiving signals from, and sending signals to, the rectifier. If there is a problem and the rectifier works properly with the test set, the problem is either at the controller or in the interface wiring (plant cable). Figure 6-1 shows how to construct a test set and cable.

### ***Test Load Connection***

The following procedures are used to connect a test load when called for in a test or other procedure. Refer to the rectifier control panel in Figure 2-5. Test load connections are made on the internal bus of the rectifier. Therefore, to isolate the rectifier from the batteries and plant bus, the rectifier **DC Output** circuit breaker must be left open (off) while the test load is connected.

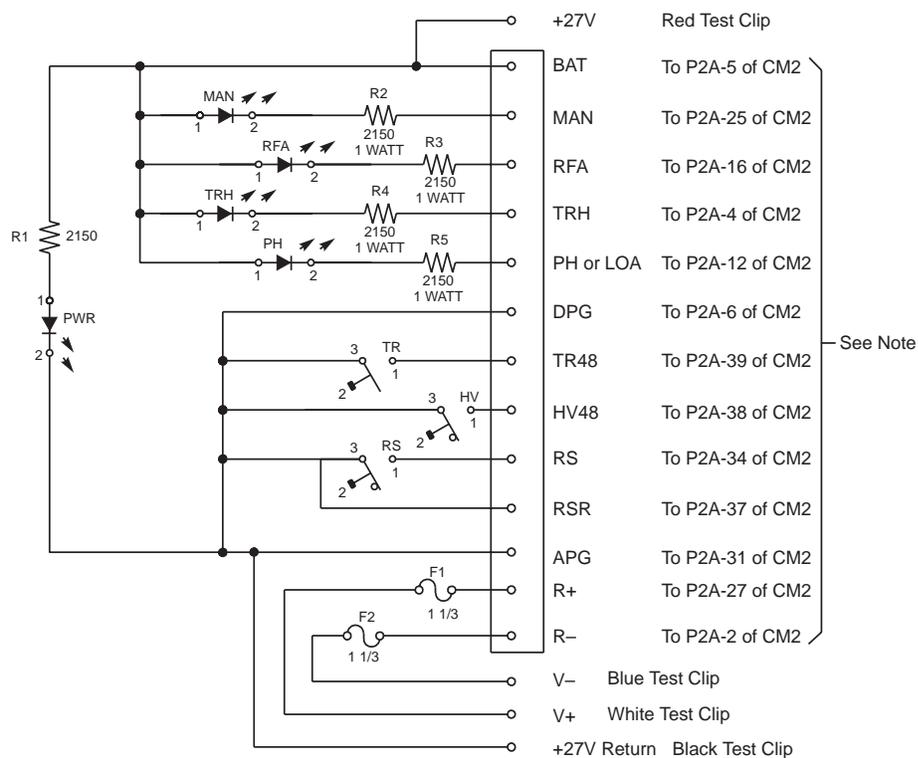
1. At the ac service panel, remove ac power to the rectifier.
2. Turn off (down) the rectifier **DC Output** circuit breaker.
3. Disconnect **J2A** from **CM2** by unlatching first, then pulling the cable connector.

### Caution

Support the **CM2** control board when disconnecting the cable leads or damage to the control board may result.

Do **NOT** disconnect plant control cable connector **J2A** from control board **CM2** by pulling the cable.

4. Refer to Figure 5-4 and connect the test load between the spare terminal on the positive output bus and terminal C on the negative output bus.



**Note:**

Use 24 AWG multiconducting wire and 40-pin female connector from Amp, Inc., Harrisburg, PA. Cable will then plug into **P2A** connector on **CM2** board. For example, the wire coming from PH, shown above, must be terminated on pin 12 of the new connector, and RS on pin 34, etc. The suggested Amp hardware part numbers are:

- 1-102398-8 (housing)
- 1-102537-8 (cover)
- 1-102536-8 (cover)

For the remaining 4 extension wires outside the brace, terminate in miniature alligator clips color coded as shown.

**Figure 6-1: Battery Plant Simulator Test Set**

**Initial  
Conditions for  
Testing Off  
Line**

The following steps establish initial conditions for the equipment before testing.

1. Verify that the ac supply and rectifier controls are as shown in Table 6-A.

**Table 6-A: Rectifier Control Settings for Testing Off Line**

<b>Controls</b>	<b>Position/Status</b>
Associated ac circuit breaker or fuses at the ac service panel	Off or fuses removed and holders tagged "Out of Service"
Rectifier <b>Power</b> switch	<b>Off</b> (down)
Rectifier <b>DC Output</b> circuit breaker	<b>Off</b> (down)
Output Volts Adj potentiometer	Fully counterclockwise (20 turns to stop)
Connector <b>J2A</b> on plant control cable	Disconnected from P2A on <b>CM2</b>

2. Use the documentation for the particular battery plant to perform all the preliminary checks on the plant prior to the rectifier tests. If the rectifier is in a microprocessor controlled plant with an efficiency algorithm feature, disable this feature. (See the controller manual for instructions.)
3. Using the digital multimeter (DMM) on the dc volts scale, make the following checks:
  - Before the REG fuse is installed in the plant controller, verify that battery voltage is **not** present between the rectifier output charge terminal and dc output return (see Figure 5-4).
  - Install the regulation (REG) fuse associated with the rectifier in the plant controller.
  - Check for battery voltage between pins 27 and 2 of control cable connector **J2A**. The **J2A** connector is at the rectifier end of the plant control cable. Pin 27 should be positive with respect to pin 2.

### Note

On **J2A**, pins 1, 5, 10, 15, and 20 are marked on the connector. Pin 21 is in the row across from pin 1. Pin 40 is across from pin 20.

- As an extra precaution, check for battery voltage between ground and pin 2 (negative plant) or pin 27 (positive plant). If no voltage exists, there is a wiring problem associated with the control cable or controller. The problem must be found and repaired before proceeding with testing.
  - With the BAT fuse installed in the plant controller, check for battery voltage between pin 5 of **J2A** and ground.
  - If the plant is equipped with an MCS controller, again on **J2A**, check for 15-20 volts dc between pins 35 and 31. Pin 35 should be positive with respect to pin 31.
4. Place the Battery Plant Simulator Test Set (Figure 6-1) at a convenient location near the rectifier. Connect **J2A**, on the other end of the cable from the test set, to connector **P2A** on the **CM2** control board mounted on the inside of the front door. Connect the red, black, blue, and white test clips from the test set to the **CM1** and **CM2** boards in the rectifier as detailed in Table 6-B. Refer to Figures 2-2 and 2-3.

**Table 6-B: Test Set Connections**

Test Clip	Connection	Figure No.	Voltage
Red	Positive side of capacitor <b>C4</b> on <b>CM2</b> (208A or B) board	2-3	+27
Black	Negative side of capacitor <b>C4</b> on <b>CM2</b> (208A or B) board	2-3	GRD
Blue	Top lead of diode <b>CR3C</b> (cathode) on <b>CM2</b> (208A or B) board	2-3	-V
White	Upper lead of resistor <b>R11</b> on <b>CM1</b> (ED-83159-30) board	2-2	+V

## ***Testing Off Line***

The following tests involve use of the test load and a Battery Plant Simulator Test Set. Refer to “Test Load Connection” earlier in this section for the procedure to connect a test load, and to “Battery Plant Simulator Test Set” and “Initial Conditions for Testing Off Line”, both earlier in this section, for a Battery Plant Simulator Test Set.

**If the rectifier fails any of the following off line tests, replace the CM2 control board as described in “Replace CM2 Control Board” in Section 8, *Spare Parts and Replacement Procedures*, and begin testing again.**

### ***Startup***

1. Turn on the ac supply to the rectifier. The PWR lamp on the test set should light brightly. If it does not light properly, check the connection of the two small red and black clip leads. They may be reversed or otherwise incorrectly connected. These leads provide the operating voltages in the test set, and the red lead should be approximately 27 volts dc with respect to the black lead.
2. The PWR lamp should remain lit during the remaining tests as long as the ac supply is turned on.
3. Set the test meter to the 100 volts range, and connect it to the **Reg** jacks on the bracket of **CBA1**. These jacks are the

same as on the rectifier control panel when the door is closed (see Figure 2-5).

4. Adjust the test load so that when the rectifier is turned on, it will deliver 5-20A, 5 to 20 percent of full load.
5. Turn the **Power** switch **On**. The rectifier should start. The test meter should indicate 20-25 volts (24-volt rectifier) or 40-50 volts (48-volt rectifier). The MAN lamp on the test set should light and remain lit as long as the rectifier is turned on.

**Regulation  
(NL/FL) Test (Off  
Line)**

1. Hold the meter selector switch in the **Rect V** position. Watch the test meter and move the **Rect Test** switch to **NL**. In the **NL** position, the voltage should drop between 0.3 and 0.6 volt.
2. Repeat Step 1 with the **Rect Test** switch in the **FL** position. The voltage should increase between 0.1 and 0.4 volt.

**Rectifier Failure  
Alarm/Fuse  
Alarm Test (Off  
Line)**

1. Insert a piece of bare wire or the end of a paper clip into a pencil eraser. Holding the pencil, insert the wire next to the alarm indicator of the +V fuse on the control panel. Note that the rectifier shuts down and the **RFA** lamp on the control panel lights.
2. Turn the **Power** switch **Off**, then back **On**. The **RFA** light should go off.
3. Repeat Steps 1 and 2 at the -V fuse.

**Current Limit  
Test (Off Line)**

**Note**

Adjust the current limit only after verifying that a current limit problem exists.

1. Connect the test meter to the rectifier side of **CBA1** and dc output return.

### Note

$V_{out}$  is the voltage reading between the rectifier output terminal and return, see Figure 5-4.

2. Strap a short across capacitor **C27** on **CM2**, see Figure 2-3.

At  $I_{load} = 100-102A$ , 100 to 101 percent of rated output current, use the **Output Volts Adj** potentiometer to adjust  $V_{out}$  to:

52.08 volts (48-volt rectifier)

26.04 volts (24-volt rectifier)

3. Remove strap from capacitor **C27** on **CM2**. Observe that  $V_{out}$  is:

51.98 - 52.03 volts (48-volt rectifier)

25.99 - 26.01 volts (24-volt rectifier)

If not, see “Adjust Current Limit” in Section 7, *Troubleshooting and Adjustments*.

4. Increase the load to 109-111A,  $110 \pm 1$  percent.  $V_{out}$  should be below:

51.58 volts (48-volt rectifier)

25.79 volts (24-volt rectifier)

If not, see “Adjust Current Limit” in Section 7, *Troubleshooting and Adjustments*.

5. Decrease the load to 96-98A, 96 to 98 percent of the rectifier rating. Observe that  $V_{out}$  is greater than:

52.03 volts (48-volt rectifier)

26.01 volts (24-volt rectifier)

### *Phase Failure Test (Off Line)*

1. Set the load to 50-60A, 50 to 60 percent of the rectifier's rated amperage.
2. With the **Power** switch still **On**, turn off the ac service and note that the rectifier shuts down and that both the PWR and MAN lamps on the test set go off.

3. Verify that no ac voltage is present on the input leads of the ac contactor **K1** (see Figure 5-3).
4. Disconnect one input lead, **L1**, **L2**, or **L3** on **K1**, or at the ac service panel, whichever is more convenient. Insulate the lead.
5. Turn on the ac at the service panel. The rectifier should not restart, and the PWR, MAN, and PH lamps on the test set should light. The **PHA** lamp on the rectifier should also light.
6. Turn off the ac at the service panel and reconnect the input lead.
7. Turn on the ac at the service panel. The rectifier should restart. On the test set, only the PWR and MAN lamps should light.

***Backup High  
Voltage  
Shutdown  
(HVSD) Test  
(Off Line)***

1. If the **DC Output** circuit breaker is On, turn it Off (down).
2. Slowly turn the **Output Volts Adj** potentiometer clockwise until the rectifier shuts down. This should occur between 29 and 31.25 volts (24-volt rectifier) or between 58 and 62.5 volts (48-volt rectifier). The **RFA** on the rectifier and the RFA on the test set should light.
3. Turn the **Output Volts Adj** potentiometer counterclockwise.
4. Restart the rectifier using the RS switch on the test set.
5. Adjust the voltage to approximately 26.0 volts (24-volt rectifier) or 52.0 volts (48-volt rectifier). The **RFA** lamps on the rectifier and the test set should go out.

***Control (TR) Test***

1. Press and hold the transfer rectifier (TR) switch on the test set for 5 seconds. The rectifier should turn off simulating a remote shutdown from the controller. The **Power On** light should go off. The digital meter on the rectifier should go off, and the TRH lamp on the test set should light.
2. Release the switch. The rectifier should restart and the TRH lamp should go out.

3. Reduce the test load to zero.
4. Press the HV switch on the test set. The rectifier should continue to operate.

***Selective High  
Voltage  
Shutdown  
(SHVSD) and  
Restart***

1. Adjust the test load so that the rectifier delivers 10-15A, 10 to 15 percent of its rated amperage.
2. Momentarily press the HV switch on the test set. The rectifier should shut down and the **RFA** lamps on the rectifier and the test set should light.
3. Momentarily press the RS switch on the test set. The rectifier should restart and both **RFA** lamps should go off.

***Meter  
Calibration Test  
(Off Line)***

1. Adjust the load so that the rectifier delivers approximately 50 amperes, 50% of its rated current capacity.
2. Connect a DMM, set on the dc millivolt scale, across the rectifier's 125A/50mV shunt.
3. Observe the DMM and record the rectifier's shunt voltage. The shunt is rated  $125A/50mV = 2.5A/mV$ , which means that each millivolt of voltage drop across the shunt indicates 2.5A of output current.
4. Convert the DMM shunt voltage reading to amperes. For example, if the DMM reads 20mV, then  $20\text{ mV} \times 2.5A/mV = 50A$  of output current.
5. Compare the amperes calculated in Step 4 with the digital display of the meter while the switch is in the AMPS position.
6. If the digital display reading is between  $\pm 2\%$  of the amperes calculated in Step 4, this procedure is completed.
7. If the rectifier drain indication is not as indicated in Step 6, calibrate the CM3 card via its R15 potentiometer as specified in Section 7.

***Off-Line Test  
Completion***

1. Reduce load so the rectifier delivers 20-30A, 20-30% of its rated current.

2. Adjust the **Output Volts Adj** potentiometer to between 52.02 and 52.13 (or 26.01 and 26.06) volts read on the **Output** meter, or to float voltage as determined by “Adjust Rectifiers to Float Voltage” later in this section.
3. Turn the **Power** switch **Off**.
4. Reduce the load to zero.
5. Turn off the ac power at the ac service panel.
6. Disconnect and remove the Battery Plant Simulator Test Set, the DMM (Digital Multimeter), and the test load.
7. If the reason for performing the rectifier tests was to affirm the operation of the rectifier, and was not part of total plant testing, restore the rectifier to service by following the procedures described under “Restore Rectifier to Service” in Section 7, *Troubleshooting and Adjustments*. If this is part of total plant testing, leave the plant control cable disconnected at this time, until directed to reconnect it as part of another plant procedure.

### ***Bringing Rectifier On Line***

The following steps bring the rectifier into service in preparation for testing on line. The term “on line” means a battery string and/or office load is connected to the rectifier.

Perform all the preliminary checks on the plant before testing the rectifiers. The same precautions for personal safety and equipment protection should be taken as when testing off line (see “Precautions” at the beginning of this section).

1. Verify the ac supply and rectifier controls are as shown in Table 6-C.

**Table 6-C: Rectifier Control Settings Prior to Testing On Line**

<b>Controls</b>	<b>Position/Status</b>
Associated ac circuit breaker or fuses at the ac service distribution panel	Off or fuses removed and holders tagged “Out of Service”
Rectifier <b>Power</b> switch	Off (down)
Rectifier <b>DC Output</b> circuit breaker	Off (down)
Output Volts Adj potentiometer	Fully counterclockwise
Associated REG fuse in plant controller	Removed

2. If the rectifier is in a microprocessor-controlled plant with an efficiency algorithm feature, disable this feature. (See the controller manual for instructions.)
3. At the ac service panel supplying power to the rectifier, insert the input fuses assigned to the rectifier or turn the circuit breaker On.

**Warning**

DO NOT turn on the **DC Output** circuit breaker without first turning the rectifier **On**, then **Off**.

4. To bring the rectifier into service,
  - a. Turn the rectifier **Power** switch **On**. The green **Power** LED must light. Wait 10 seconds.

**Note**

**If the rectifier continues to operate, proceed to Step b.** If the rectifier shuts down due to initial high voltage, monitor the **Rect V** voltage. When this reading reaches 26 volts for 24-volt plants, or 52 volts for 48-volt plants, turn on the circuit breaker. If the rectifier shuts down for any other reason, such as component failure, see Section 7, *Troubleshooting and Adjustments*.

- b. Hold the meter selector switch in the **Rect V** position, and use a small screwdriver to turn the **Output Volts Adj** potentiometer clockwise until the digital meter reads approximately battery voltage, typically 26 volts for 24-volt plants or 52 volts for 48-volt plants.
  - c. Turn the **DC Output** circuit breaker on (up).
  - d. Turn the **Power** switch **Off**.
5. For testing with a controller, connect plant control cable **J2A** to **P2A** on **CM2**, then replace REG fuse in the controller. For a controllerless application, leave **J2A** disconnected, and replace REG fuse in the remote bay.
  6. Turn rectifier **Power** switch **On**.

## ***Testing On Line***

On and off-line testing require different procedures, although most tests can be performed in either situation. The Control (TR) and Selective HVSD Tests are omitted from this section because these signals originate in the plant controller or a remote location, and the test procedure depends on that device. (See your plant controller product manual.)

If you have just tested the rectifier off line, it is not necessary to repeat the tests on line.

**If the rectifier fails any of the following on line tests, replace the CM2 control board as described in “Replace CM2 Control Board” in Section 8, *Spare Parts and Replacement Procedures*, and begin testing again.**

### ***Regulation (NL/FL) Test (On Line)***

#### **Note**

At least two rectifiers must be operating when this test is done, and the load requirement must be greater than 10A, 10% of the rated output for the rectifier under test.
--

1. If the rectifier is delivering less than 10A, turn the **Output Volts Adj** potentiometer clockwise until it delivers 10A.

2. Observe the amperes reading on the **Output** meter. Hold the **Rect Test** switch in the **NL** position. The output amperes should decrease.
3. Repeat from Step 1 and in Step 2 hold the **Rect Test** switch in the **FL** position. The output current should increase.

**Rectifier Failure  
Alarm/Fuse  
Alarm Test (On  
Line)**

**Notes**

This procedure causes the rectifier to fail. When the procedure is performed on line, sufficient rectifiers must be operating to assume the load of the rectifier being tested.

This test causes the rectifier to issue alarms to the plant controller

1. Insert a piece of bare wire or the end of a paper clip into a pencil eraser. Holding the pencil, insert the wire next to the alarm indicator of the +**V** fuse on the control panel. Note that the rectifier shuts down and the **RFA** lamp on the control panel lights.
2. Turn the **Power** switch **Off**, then back **On**. The **RFA** light should go off.
3. Repeat Steps 1 and 2 at the -**V** fuse.

***Current Limit  
Test (On Line)***

**Notes**

Adjust the current limit only after verifying that a current limit circuit problem exists.

There must be two or more rectifiers with a plant load of at least 25 percent higher than the capacity of the largest rectifier.

This method applies to a working plant. If the conditions in the following note cannot be met, the unit must be tested off line.

In a working plant, the current limit set point can be found by adjusting the **Output Volts Adj** potentiometer on the rectifier under test to obtain approximately 3/4 load and a battery float voltage set to specification for type of battery being used.

1. Connect a DMM to the **Reg** test jacks to verify the battery voltage.
2. Hold the **Rect Test** switch in the full load (**FL**) position to raise the rectifier output current to current limit. The output current should indicate 100-102A, 100 to 101 percent of the rated output current.
3. If the output current is not within 100-102A, the current limit needs adjustment. See "Adjust Current Limit" in Section 7, *Troubleshooting and Adjustments*.

**Note**

At the rated output current of the rectifier, the shunt voltage is 40 millivolts.

***Isolated Current  
Measuring (VI)  
Test (MCS or  
Galaxy  
Controller)***

This procedure checks the isolated current measuring circuit (voltage proportional to current adjustment) on the rectifier's **CM2** control board. The procedure is required only when **CM2** is installed as part of a Lineage® 2000 MCS (Microprocessor Controlled System) or Galaxy system and when the output current reading on the rectifier does not agree to within 2.5 percent of the MCS or Galaxy controller reading. This procedure

must be performed while connected to an MCS or Galaxy controller and a battery.

Refer to Figure 2-3 for components on the **CM2** control board. Plant control cable connector **J2A** MUST be connected to **P2A** on **CM2** for this procedure.

1. Connect a DMM across the rectifier shunt (see Figure 5-4).
2. Increase the load so the rectifier delivers approximately 50A, 50 percent of its rated current capacity.
3. Observe the DMM and record the rectifier's shunt voltage.  
The shunt is rated  $\frac{125A}{50mV} = \frac{2.5A}{mV}$ , which means that each millivolt of voltage drop across the shunt indicates 2.5A of output current.
4. Convert the DMM's shunt voltage reading to amperes. For example, if the DMM reads 40mV, then  $40mV \times \frac{2.5A}{mV} = 100A$  of output current. As this calculation indicates, the rectifier is operating at full load, and the rectifier shunt voltage is 40mV at full load.
5. Compare the amperes calculated in Step 4 with the rectifier drain indication on the MCS or Galaxy controller.
6. If the rectifier drain indication is between 0 and 2% **higher** than the amperes calculated in Step 4, this procedure is completed.
7. If the rectifier drain indication is between 0 and 2% **lower** than the amperes calculated in Step 4, adjust potentiometer **R86** on **CM2** control board to obtain a rectifier drain reading that is between 0 and 2% higher than the amperes calculated in Step 4.
8. If the rectifier drain indication was not within the limits specified in Step 6 or 7, the isolated current measuring circuit needs adjustment. See "Adjust Isolated Current Measuring Circuit (VI)" in Section 7, *Troubleshooting and Adjustments*.

**Phase Failure  
Test (On Line)**

1. Turn the **DC Output** circuit breaker off (down).
2. With the **Power** switch still **On**, turn off the ac service and note that the rectifier shuts down.
3. Verify that no ac voltage is present on the input leads of the ac contactor **K1** (see Figure 5-3).
4. Disconnect one input lead, **L1**, **L2**, or **L3** on **K1**, or at the ac service panel, whichever is more convenient. Insulate the lead.
5. Turn on the ac at the service panel. The rectifier should not restart. The **PHA** lamp on the rectifier should light.
6. Turn off the ac at the service panel and reconnect the input lead.
7. Turn on the ac at the service panel. The rectifier should restart.

**Backup High  
Voltage  
Shutdown  
(HVSD) Test (On  
Line)**

If the **DC Output** circuit breaker is on, turn it off (down).

1. Connect the DMM to the rectifier output terminals (see Figure 5-2).
2. Slowly turn the **Output Volts Adj** potentiometer clockwise until the rectifier shuts down. This should occur between 29 and 31.25 volts (24-volt rectifier) or between 58 and 62.5 volts (48-volt rectifier). The **RFA** lamp on the rectifier should light.
3. Turn the **Output Volts Adj** potentiometer counterclockwise.
4. Restart the rectifier by turning the **Power** switch **Off** then back **On**.
5. Adjust the voltage to approximately 26.0 volts (24-volt rectifier) or 52.0 volts (48-volt rectifier). The **RFA** lamp on the rectifier should go out.

**Meter  
Calibration Test  
(On Line)**

Check calibration of the digital meter annually as preventive maintenance.

1. Adjust the load so that the rectifier delivers approximately 50 amperes, 50% of its rated current capacity.
2. Connect a DMM, set on the dc millivolt scale, across the rectifier's 125A/50mV shunt.
3. Observe the DMM and record the rectifier's shunt voltage. The shunt is rated  $125\text{A}/50\text{mV} = 2.5\text{A}/\text{mV}$ , which means that each millivolt of voltage drop across the shunt indicates 2.5A of output current.
4. Convert the DMM shunt voltage reading to amperes. For example, if the DMM reads 20mV, then  $20\text{ mV} \times 2.5\text{A}/\text{mV} = 50\text{A}$  of output current.
5. Compare the amperes calculated in Step 4 with the digital display of the meter while the switch is in the AMPS position.
6. If the digital display is between  $\pm 2\%$   $\pm 2\text{A}$  than the amperes calculated in Step 4, this procedure is completed.
7. If the rectifier drain indication is not as indicated in Step 6, calibrate the CM3 card via its R15 potentiometer as specified in Section 7.

**Note**

Series 3 **CM3** boards can be identified by the designation "AM3" (or greater than 3) which is stamped on the wiring (noncomponent) side of the board. A partial sketch of the **CM3** boards is provided in Figure 2-4.

8. If the rectifier meter cannot be calibrated, replace the rectifier **CM3** digital meter board as described in "Replace CM3 Digital Meter Board" in Section 8, *Spare Parts and Replacement Procedures*, and repeat this procedure from Step 1.
9. Disconnect the DMM from the rectifier.

## ***Adjust Rectifiers to Float Voltage***

Float voltage is the optimum voltage level at which a battery string gives maximum life and full capacity. This voltage depends on the type and number of batteries in a plant:

Float voltage per cell x number of cells = battery string float voltage

Traditionally, 2.17 volts per cell is the float voltage for flooded lead-acid batteries such as the Round Cell. For a 24-cell configuration of Round Cells, string voltage is:

$$2.17 \times 24 = 52.08 \text{ volts}$$

Traditionally, 2.27 volts per cell is the float voltage for starved electrolyte batteries such as VR cells. For a 12-cell configuration of VR cells, string voltage is:

$$2.27 \times 12 = 27.24 \text{ volts}$$

To adjust rectifiers to the pre-determined float voltage, the rectifiers must be on line with plant cables connected and REG fuses installed in the plant controller or a remote bay.

### ***Adjust Rectifiers Individually***

The fastest way to adjust a group of rectifiers to float voltage is to adjust them individually, turning each one off after adjustment, and turning them all on after the last adjustment. In order to use this method, however, the load requirement at the time of the adjustments must be **less than** the capacity of the smallest rectifier.

1. Measure the battery voltage by holding the meter selector switch in the **Batt V** position.
2. If the battery voltage is not the pre-determined float voltage or the desired battery float voltage, perform the following:
  - a. If the voltage is too high, turn the **Output Volts Adj** potentiometer counterclockwise.
  - b. If the voltage is too low, turn the **Output Volts Adj** potentiometer clockwise.
  - c. Check the battery voltage and repeat Steps a and b above until the battery voltage is within the required tolerance of the desired float voltage.

3. Turn the rectifier off and repeat this procedure for each rectifier in the group.
4. Turn all rectifiers on after the last rectifier is adjusted.

### ***Adjust Rectifiers as a Group***

If the load requirement is always **greater than** the capacity of the smallest rectifier, adjust the rectifiers to float voltage using the following procedure. Rectifiers must be on line with plant cables connected and REG fuses installed in the plant controller or a remote bay.

1. Measure the battery voltage by holding the meter selector switch in the **Batt V** position.
2. If the battery voltage is not the pre-determined float voltage or the desired battery float voltage, perform the following:
  - a. If the voltage is too high, turn the **Output Volts Adj** potentiometer counterclockwise on the rectifier with the highest output current.
  - b. If the voltage is too low, turn the **Output Volts Adj** potentiometer clockwise on the rectifier with the lowest output current.
  - c. Check the battery voltage and repeat Steps a and b above until the battery voltage is within the required tolerance of the desired float voltage.
3. If all rectifiers are not carrying some load current (between 5 percent and 95 percent of rated load):

#### **Note**

Rectifiers are not required to share load current equally.
--

- a. Turn off all spare rectifiers, but leave enough rectifiers on to handle the load current.
- b. Turn up (clockwise) the **Output Volts Adj** potentiometer on rectifiers carrying less than 5 percent rated load till they carry more than 5 percent rated load.
- c. Turn down (counterclockwise) the **Output Volts Adj** potentiometer on rectifiers carrying more than 95

percent rated load until they carry less than 95 percent rated load.

- d. Repeat from Step 2 (battery voltage check and adjustment) until all rectifiers are carrying between 5 and 95 percent rated load and the battery voltage is within the required tolerance of the desired float voltage.
- e. Turn on one of the spare rectifiers, and turn off one of the previously loaded rectifiers (same number of rectifiers on).
- f. Repeat Steps b through d for each rectifier that has not be adjusted.
- g. Upon completion, turn all rectifiers on.



# 7 *Troubleshooting and Adjustments*

## *Introduction*

This section provides troubleshooting information and adjustment procedures for the Lineage® 2000 J85503A-1 rectifier. Whenever working on or near electrically live equipment, observe all safety precautions given in Section 4 and within each procedure.

For tools and test equipment required for certain adjustments, refer to “Tools and Test Equipment” in Section 6, *Testing*. For technical assistance at any time, call Lucent Technologies at 1-800-CAL-RTAC (1-800-225-7822).

## *Remove Rectifier from Service*

In general, adjustments should be made to a rectifier while it is removed from service. If a problem is suspected with a rectifier, find the problem in Table 7-A. Then follow this procedure for removing the rectifier from service before making the adjustments.

1. Observe and record the rectifier output voltage.
2. Turn the rectifier **Power** switch **Off**.
3. Turn the rectifier **DC Output** circuit breaker off (down).
4. At the ac service panel supplying power to the rectifier, remove the input fuses assigned to the rectifier or turn the circuit breaker Off.
5. At the plant controller, remove the REG fuse associated with the rectifier.

6. At the rectifier, loosen the locking screws and open the door.
7. Locate the **CM2** control board.

### **Caution**

The REG fuse associated with the rectifier in the plant controller must be removed before cable connector **J2A** is disconnected or damage to rectifier circuit pack may result.

Support the **CM2** control board with your hands when disconnecting the cable leads or damage to control board may result.

Do NOT disconnect plant control cable connector **J2A** from control board **CM2** by pulling the cable.

8. Disconnect **J2A** from **CM2** by unlatching first, then pulling the cable connector.
9. If the rectifier voltage was NOT at the desired float voltage before it was turned off, rotate the rectifier **Output Volts Adj** potentiometer fully counterclockwise.
10. At the ac service panel supplying power to the rectifier, insert the input fuses assigned to the rectifier or turn the circuit breaker On.
11. Turn the rectifier **Power** switch **On**, and wait approximately 30 seconds for the voltage to stabilize. The rectifier is now ready to be tested off line.

## ***Diagnosics and Troubleshooting***

Table 7-A lists possible problems, causes, and solutions that may occur with the rectifier subsystems. Schematic Drawing, SD-82605-01, referred to in the table, is shipped with the J85503A-1 rectifier.

**Table 7-A: Troubleshooting (Sheet 1 of 3)**

Problem	Probable Cause	Probable Corrective Action
<p>1. Rectifier will not start. (<b>J2A</b> should be disconnected. If not, the controller could be shutting the rectifier down.)</p>	<p>1. No ac input to rectifier. 2. <b>CM2</b> board is defective</p>	<p>1. Check for ac input voltage to rectifier. 2. Check for ac voltage on secondary of <b>T3</b>. See SD. 3. Check for +27 Vdc (<math>\pm 5V</math>) across <b>C4</b> on <b>CM2</b>. If not present, but ac is present on all secondaries of <b>T3</b>, check the connection <b>P1/J1</b> on <b>CM1</b>. If the connection is okay, replace the <b>CM2</b> board as described in “Replace CM2 Control Board” in Section 8. 4. Check wiring associated with coil of <b>K1</b>, and contacts <b>4-7</b> of <b>K2</b>.</p>
<p>2. Rectifier starts or attempts to start but <b>RFA</b> lights.</p>	<p>1. Fuses F1- F3, FA1-FA3, and/or +V, -V blown. 2. <b>CM2</b> board is defective.</p>	<p>1. Check fuses as described in “Clear Rectifier Failure Alarm (RFA)” in Section 7. 2. Measure output voltage while rectifier is powering up. If the output voltage exceeds 29 or 58 volts, the rectifier is shutting down due to high output voltage. See Probable Causes associated with Problem 4.</p>
<p>3. Rectifier <b>PHA</b> lights.</p>	<p>1. One of the phase voltages is too low under a load condition. 2. One of the phase voltages coming into the <b>CM2</b> board is too low. 3. <b>CM2</b> board is defective.</p>	<p>1. Check connections and voltage at contactor. 2. Verify that the voltages across <b>C9</b>, <b>C10</b>, and <b>C11</b> on <b>CM2</b> are equal <math>\pm 2V</math>. 3. Replace <b>CM2</b> board as described under “Replace CM2 Control Board” in Section 8.</p>

**Table 7-A: Troubleshooting (Sheet 2 of 3)**

<b>Problem</b>	<b>Probable Cause</b>	<b>Probable Corrective Action</b>
4. Rectifier goes to high voltage at turn-on.	<ol style="list-style-type: none"> <li>1. <b>Output Volts Adj</b> potentiometer is set too high.</li> <li>2. <b>CM2</b> board is defective.</li> <li>3. Open triac.</li> </ol>	<ol style="list-style-type: none"> <li>1. Turn potentiometer counterclockwise.</li> <li>2. Replace <b>CM2</b> as described under “Replace <b>CM2</b> Control Board” in Section 8.</li> <li>3. Replace triac as described under “Thyristors (Q1 or Q2)” in Section 8.</li> </ol>
5. Rectifier <b>RFA</b> lights at certain loads.	<ol style="list-style-type: none"> <li>1. Unbalance circuit is working.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace <b>CM2</b> as described under “Replace <b>CM2</b> Control Board” in Section 8.</li> </ol>
6. Control panel digital meter does not light.	<ol style="list-style-type: none"> <li>1. Defective wiring to <b>CM3</b> digital meter board.</li> <li>2. <b>CM3</b> board is defective.</li> <li>3. <b>CM2</b> board is defective.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check wiring to <b>CM3</b> board. Check connectors <b>J1B</b> on <b>CM3</b> and <b>J3A</b> on <b>CM2</b> for proper insertion.</li> <li>2. Replace <b>CM3</b> as described under “Replace <b>CM3</b> Digital Meter Board” in Section 8 and then calibrate as described under “Calibrate <b>CM3</b> Digital Meter” in this section.</li> <li>3. Replace <b>CM2</b> as described under “Replace <b>CM2</b> Control Board” in Section 8.</li> </ol>
7. <b>Power</b> LED is on; ac is good; rectifier output voltage is zero.	<ol style="list-style-type: none"> <li>1. Open ac contactor coil or contactor not making contact.</li> </ol>	<ol style="list-style-type: none"> <li>1. Turn off power at ac service panel and measure contactor coil resistance. If it is open, replace contactor/coil.</li> </ol>

**Table 7-A: Troubleshooting (Sheet 3 of 3)**

<b>Problem</b>	<b>Probable Cause</b>	<b>Probable Corrective Action</b>
8. Rectifier output voltage is low, not adjustable, and power is on.	<ol style="list-style-type: none"> <li>1. Defective <b>CM2</b>.</li> <li>2. Shorted triac.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace <b>CM2</b> as described under “Replace <b>CM2</b> Control Board” in Section 8. Verify that output voltage is adjustable. If not, replace triac as described under “Thyristors (Q1 or Q2)” in Section 8.</li> </ol>

## ***Adjustments***

This section includes procedures to check fuses (Clear RFA), calibrate the digital meter, adjust the isolated current measuring circuit, and adjust the current limit.

### ***Clear Rectifier Failure Alarm (RFA)***

1. Observe and record the status of the fuses in the plant controller.
2. Turn the rectifier **Power** switch **Off**.
3. If any of the following fuses are blown, replace them with one of the same type and capacity: **+V**, **-V**, **F1**, **F2**, **F3**, **FA1**, **FA2**, or **FA3**.
4. Turn the rectifier **Power** switch **On**.
5. If the rectifier started, minor alarm on controller cleared, and the rectifier **RFA** LED extinguished, then the RFA problem has been cleared. Otherwise, continue with the following procedures.
6. Observe and record the rectifier output voltage.
7. If the rectifier output voltage is **greater than** the plant float voltage, then use the following procedure:
  - a. Turn the **Output Volts Adj** potentiometer counterclockwise to lower the output voltage to the correct value.

- b. If the rectifier **Output Volts Adj** potentiometer can adjust the voltage to the correct level, then the RFA problem has been cleared. Otherwise, continue this procedure.
8. If the rectifier output voltage is **less than** the plant voltage and/or all rectifiers shut down, then use the following procedures.
    - a. If the **CM2** control board has not been replaced, then replace it at this time as described under “Replace CM2 Control Board” in Section 8, *Spare Parts and Replacement Procedures*.
    - b. If the rectifier started, minor alarm on the controller cleared, and the rectifier **RFA LED** went out, then the RFA problem has been cleared. Otherwise, continue the procedure.
    - c. If replacing the **CM2** control board does not clear the problem, then the outputs from **T1** and **T2** are probably unbalanced. Try the following:
      - Check the wiring to the thyristors. (See Figure 5-2.)
      - Check for defective thyristors. Replace, if defective, as described under “Thyristors (Q1 or Q2)” in Section 8, *Spare Parts and Replacement Procedures*.

**Calibrate CM3  
Digital Meter**

Refer to Figures 5-2 and 2-4.

**Note**

Calibration is not feasible unless the DMM test meter has an accuracy of $\pm 0.02$ percent or better.
--

1. Loosen the locking screws and open the front door of the rectifier.
2. Locate the **CM3** digital meter board on the inside of the front door.

### Caution

For Series 1 or 2 **CM3** boards, use extreme care when removing the board from the support standoffs (see notes below).

### Note

A Series 3 **CM3** board can be calibrated without removing the board from the support standoffs. A Series 1 or 2 **CM3** board must be removed from the support standoffs to calibrate the meter.

### Note

Series 3 **CM3** boards can be identified by the designation “AM3” which is stamped on the wiring (non-component) side of the board. A partial sketch of the **CM3** boards is provided in Figure 2-4.

3. If a Series 3 **CM3** board is provided, skip to Step 5.
4. For Series 1 or 2 **CM3** boards, remove the board from the two support standoffs and the switch bezel by using a small flat-bladed screwdriver to unlatch the bezel clips from the switch and push in the latches on each standoff. Do not disconnect any connector(s) leading to the control board. Pull the **CM3** board a short distance away from the door so that the board may be turned over with the component side facing you.
5. Locate the **R15** potentiometer on the meter board (see Figure 2-4). For Series 3 **CM3** boards, **R15** is easily accessible on the component side of the board. For Series 1 or 2 **CM3** boards, **R15** is located under the wires of the cable connected to **P1B**. The wires will probably have to be pulled aside carefully or separated a small amount in order to access the screwdriver adjustment on **R15**.
6. Adjust the load so that the rectifier delivers approximately 50 amperes, 50% of its rated current capacity.
7. Connect a DMM, set on the dc millivolt scale, across the rectifier's 125A/50mV shunt.

8. Observe the DMM and record the rectifier's shunt voltage. The shunt is rated  $125\text{A}/50\text{mV} = 2.5\text{A}/\text{mV}$ , which means that each millivolt of voltage drop across the shunt indicates 2.5A of output current.
9. Convert the DMM shunt voltage reading to amperes. For example, if the DMM reads 20mV, then  $20\text{mV} \times 2.5\text{A}/\text{mV} = 50\text{A}$  of output current.
10. Compare the amperes calculated in Step 9 with the digital display of the meter while the switch is in the AMPS position. If the digital display is not between  $\pm 2\% \pm 2$  amperes of the amperes calculated in Step 9, calibrate the CM3 card via its R15 potentiometer.
11. If the rectifier meter will not adjust via R15 to the calculated load, replace the CM3 meter board as described under "Replace CM3 Digital Meter Board" in Section 8. Repeat this procedure from Step 1.
12. If the rectifier load display can be calibrated to the proper load and the CM3 board is a Series 1 or 2 board, reposition the board over the support standoffs. Verify that the latches and switch bezel clips snap to lock the board in place. A Series 3 board will not require this step.
13. Close the door of the rectifier and secure it with the locking screws.

***Adjust Isolated  
Current  
Measuring  
Circuit (VI)***

This procedure adjusts the isolated current measuring circuit (voltage proportional to current adjustment) on the rectifier's **CM2** control board. Use the test in "Isolated Current Measuring (VI) Test (MCS or Galaxy Controller)" in Section 6, *Testing*, to verify that the circuit needs adjustment before following this procedure. The procedure must be performed with the rectifier connected to an MCS or Galaxy controller and to a battery.

Figure 2-3 shows test points and components on the **CM2** control board. Other "E" test points are always positive with respect to either **E14** or **E17** for all voltage measurements. The plant control cable connector **J2A** **MUST** be connected to **P2A** on **CM2** for this procedure.

1. Hold the meter switch on the control panel in the **Amps** position. With the rectifier turned on and delivering

current, adjust the **Output Volts Adj** potentiometer counterclockwise until the meter reads zero amperes.

2. Connect a DMM (set on the dc millivolt scale) across the rectifier's shunt. The digital meter should read zero millivolts. If not turn the **Output Volts Adj** potentiometer further counterclockwise until it does.
3. Set the digital meter on the 20-volt dc scale and measure the voltage between test points **E5** and **E14** on the **CM2** control board. This voltage should be less than 0.5 volt.
4. Measure and record the voltage between points **E6** and **E17** on the **CM2** control board. The voltage should be between 5.59 and 6.41 volts. This voltage is called V6.
5. Measure the voltage between **E11** and **E14**. This voltage should be equal to one less than V6 times 1.1667. That is:

$$E11 = 1.1667 \times V6 - 1$$

If the measured value at point **E11** (with respect to point **E14**) is not equal to the calculated value, adjust the **R87** potentiometer on the **CM2** control board to obtain the calculated value at **E11**.

6. Connect the DMM between point **E7** and **E17** (or the anode of **CR19**) on the **CM2** control board. Adjust potentiometer **R86** to obtain a DMM indication of 2.0 volts.
7. Connect the DMM across the rectifier shunt and adjust the **Output Volts Adj** potentiometer to obtain a shunt voltage indication of 10.0 mV.
8. The meter should indicate the 25.0A when the meter selector switch is in the **Amps** position.
9. Measure the voltage between **E7** and **E17**. The anode of diode **CR19** may be used as test point **E17**. This voltage should be  $3.6 \pm 1$  percent volts.
10. Observe the rectifier drain reading as reported by the MCS or Galaxy controller. If the controller's reading is not within 0-2% higher than the rectifier load, readjust potentiometer R86 of the CM2 until it is.

**Adjust Current  
Limit**

**Off Line Adjustment:** Use the “Current Limit Test (Off Line)” in Section 6, *Testing*, to verify that the current limit circuit needs adjustment, before continuing with this procedure.

In Steps 4 and 5 of the “Current Limit Test (Off Line)” in Section 6, *Testing*, if  $V_{out}$  is not within the required range, adjust **R88** on **CM2** (see Figure 2-3) until a correct voltage reading is obtained.

**On Line Adjustment:** Use the “Current Limit Test (On Line)” in Section 6, *Testing*, to verify that the current limit circuit needs adjustment before continuing with this procedure.

1. Hold the **Rect Test** switch in the full load (**FL**) position and observe the output current.
2. If the output current is not within 100-102A, hold the **Rect Test** switch in the full load (**FL**) position and adjust the current limit potentiometer **R88** on **CM2**, (see Figure 2-3) until the rectifier delivers 100-102A.

**Restore  
Rectifier to  
Service**

1. Set the ac supply and rectifier controls as shown in Table 7-B.

**Table 7-B: Control Settings Prior to Restoring Rectifier to Service**

Controls	Position/Status
Associated ac circuit breaker or fuses at the ac service distribution panel	Off or fuses removed and holders tagged “Out of Service”
Rectifier <b>Power</b> switch	Off (down)
Rectifier <b>DC Output</b> circuit breaker	Off (down)
Rectifier REG fuse in the plant controller	Removed

2. If the rectifier voltage was NOT at the desired float voltage before it was turned off, rotate the **Output Volts Adj** potentiometer fully counterclockwise.
3. At the ac service panel, install the ac fuses or turn the ac input circuit breaker ON.

4. To bring the rectifier into service:
  - a. Turn the rectifier **Power** switch **On**. The green **Power** LED must light. Wait 10 seconds.

**Note**

**If the rectifier continues to operate, proceed to Step b.** If the rectifier shuts down due to initial high voltage, monitor the **Rect V** voltage. When this reading reaches 26 volts for 24-volt plants, or 52 volts for 48-volt plants, turn on the circuit breaker. If the rectifier shuts down for any other reason, such as component failure, see “Diagnostics and Troubleshooting” earlier in this section.

- b. Hold the meter selector switch in the **Rect V** position, and use a small screwdriver to turn the **Output Volts Adj** potentiometer clockwise until the digital meter reads approximately battery voltage, typically 26 volts for 24-volt plants or 52 volts for 48-volt plants.
    - c. Turn the **DC Output** circuit breaker on (up).
    - d. Turn the **Power** switch **Off**.
5. At the rectifier, connect the control cable connector **J2A**.
6. At the plant controller, install the REG fuse associated with the rectifier that is being restored to service.
7. Turn the rectifier **Power** switch **On**.
8. Close the rectifier front door and secure the locking screws.
9. Adjust the rectifier to float voltage as described in “Adjust Rectifiers to Float Voltage” in Section 6, *Testing*.
10. If the rectifier is installed in a microprocessor-controlled plant that has an efficiency algorithm feature, enable this feature. (See the controller manual for instructions).



## 8 *Spare Parts and Replacement Procedures*

### *Ordering Circuit Modules*

Lucent Technologies combines into spare parts kits **CM1**, **CM2**, **CM3**, and **CA1** circuit boards, described in Section 2, *Product Description*. Kit number H569-358 L8 contains these replaceable boards for the J85503A-1 rectifier. Table 8-A shows the contents of this kit along with the part numbers.

**Table 8-A: Spare Circuit Module Kit Number H569-358 L8**

<b>Lucent Comcode</b>	<b>Part Number</b>	<b>Description</b>
601176381	CM1 (ED-83159-30 G1,A)	Option Board
104032701	CM2 (208A)	Control Board
104032693	CM3 (207A)	Digital Meter Board
601081243	CA1 (ED-83162-30 G1)	Snubber Network

### *Handling Circuit Modules*

The following guidelines describe how to prevent electrostatic discharge (ESD) and properly handle and protect circuit packs (modules) in a central office or outside plant environment. These guidelines satisfy the minimum requirements for all three ESD-sensitive classifications (I, II, III) and, therefore, all circuit packs in these classes are handled in the same manner, regardless of sensitivity. Factory packaging provides shielding in the rare instances when it is necessary.

## ***Electrostatic Discharge***

### **Caution**

Grounded antistatic wrist straps must be worn for all circuit pack handling. The alligator clip connector of the wrist strap must be connected to a bare metal frame ground. The wrist strap must contact the skin and is not to be worn over clothing. At least once every week of use, verify that the resistance between the wrist strap and its connector plug is  $1M\Omega \pm 10$  percent. If a static-sensitive pack has already been found faulty, do not ignore requirements for handling static-sensitive packs. Continued mishandling may create other, more serious, problems with the pack.

- Assume all circuit packs containing electronic (solid-state) components can be damaged by ESD.
- When handling circuit packs (storing, inserting, removing, etc.) or when working on the backplane, always use the appropriate grounding procedure: either a wrist strap connected to ground or, when standing, a heelstrap with a grounded dissipative floormat.
- A grounded person must never hand an unprotected circuit pack to an ungrounded person. A static discharge from the ungrounded person through the circuit pack to the grounded person could cause an electrostatic discharge failure. All persons and equipment at a work location must be at the same common ground potential to be static safe.
- Handle all circuit packs by the faceplate or latch and by the top and bottom outermost edges. Never touch the components, conductors, or connector pins.
- Do not rub or wipe circuit packs to clean them unless you and the circuit pack are at the same ground potential.
- Observe warning labels on bags and cartons. Whenever possible, do not remove circuit packs from antistatic bags or cartons until ready to insert into the rectifier. Otherwise, open all circuit packs at a static-safe work position with wrist straps and dissipative table mats.
- Upon removal from the rectifier, immediately put circuit packs into antistatic packages. Always store and transport

circuit packs in antistatic packaging. Shielding is not required unless specified.

- Keep all static-generating materials away from circuit packs. These materials include common plastics such as food wrappers, clear plastic bags, styrofoam containers, packing material, drinking cups, notebooks, and nonconducting plastic solder suckers. The insulation on small hand tools does not represent a static hazard.
- Keep adhesive tape (Scotch, masking, etc.) away from static-sensitive devices.
- When soldering static-sensitive semiconductor devices, the soldering iron must be grounded to the work table which must also be earth grounded.
- Do not wax the equipment aisles in central offices.
- Whenever possible, maintain relative humidity above the 20-percent level.

### ***Modifying the CM1 Option Board***

As described in schematic drawings SD-82605-01, replacement **CM1** option boards are supplied with all wire straps and resistors in place. The same wire straps and resistors that were removed from the original board must be removed from replacement boards in order for the rectifier to operate properly.

Table 8-B and Figure 2-2 show the straps and resistors to keep and to remove from the **CM1** board for each option on the J85503A-1 rectifier. The plug-in type wire straps are removed completely from a 2-hole jack. The other wire straps shown are soldered in and are never replaced once they are removed.

**Table 8-B: Modifications for the CM1 Board**

<b>List/Option</b>	<b>Keep Straps or Resistors Marked with</b>	<b>Remove Straps or Resistors Marked with</b>	<b>Stamping to be Added on ED-83159-30</b>
1, 3, or 5	N, V, K, M	F, R, W	Mod AA
1, 3, or 5 and 17	N, V	F, R, W, K, M	Mod AB
2, 4, or 6	N, W, K, M	F, R, V	Mod AC
2, 4, or 6 and 17	N, W	F, R, V, K, M	Mod AD

## Spare Fuses

Table 8-C provides spare fuse information for the J85503A-1 rectifier. A commercial equivalent fuse and the appropriate SD sheets are referenced.

**Table 8-C: Spare Fuse Information**

Fuse Designation in SD Drawing	Lucent Part Code	Rating (Amperes)	Commercial* Equivalent	Shown on SD Sheets
F1	KS-19780, L6	30	SOC‡ Type SKM4	B1, C4
F2				
F3				
FA1	70G	1/2	BUSSMAN† 70G	B1, C1
FA2				
FA3				
FA5 (-V)	70G	1/2	BUSSMAN† 70G	B1, C1
FA6 (+V)				
* Or other suitable commercial equivalent.				
† BUSSMAN is a trademark of the BUSSMAN Company.				
‡ SOC is a trademark of SAN-O Industrial Corporation.				

## Replacing Circuit Modules

This section gives step-by-step instructions for replacing circuit modules **CM1**, **CM2**, and **CM3**.

### Caution

Follow instructions above under “Handling Circuit Modules” to minimize electrostatic discharge when handling circuit modules.

Do not connect or disconnect circuit modules with voltages present or equipment damage may occur.

### Replace CM1 Option Board

1. Turn the rectifier **Power** switch **Off**.
2. Turn the rectifier **DC Output** circuit breaker off (down).
3. At the ac service panel supplying power to the rectifier, remove the input fuse assigned to the rectifier, or turn the circuit breaker **Off**.

4. At the plant controller, remove the REG fuse associated with the rectifier. Disconnect control cable connector **J2A** from the control board **CM2**.
5. At the rectifier, loosen the locking screws and open the rectifier door.
6. Locate the **CM1** option board.
7. Using a drawing of the option board like that in Figure 2-2, record where each cable connects to the board.

### **Caution**

Support the **CM1** option board with your hands when connecting and disconnecting the cables, or damage to the board may result.

Do NOT disconnect cables by pulling the cable.

8. Remove all cables from **CM1** by unlatching first, then pulling the cable connector.
9. Remove **CM1** from its four support standoffs by using a small flat-bladed screwdriver to push in the latches on each standoff.
10. Verify that the new option board has the correct straps and resistors in place. If not, modify the board as described under “Modifying the CM1 Option Board” earlier in this section.
11. Position the new **CM1** board over the four support standoffs. Verify that each latch snaps and locks in place.
12. Reconnect all cables that were disconnected in Step 8.
13. If the rectifier is to be restored to service, refer to “Restore Rectifier to Service” in Section 7, *Troubleshooting and Adjustments*.

### ***Replace CM2 Control Board***

Follow instructions under “Handling Circuit Modules” earlier in this section to minimize electrostatic discharge when handling circuit modules.

1. Turn the rectifier **Power** switch **Off**.
2. Turn the rectifier **DC Output** circuit breaker off (down).
3. At the ac service panel supplying power to the rectifier, remove the input fuse assigned to the rectifier, or turn the circuit breaker Off.
4. At the plant controller, remove the REG fuse associated with the rectifier.
5. At the rectifier, loosen the locking screws and open the rectifier door.
6. Locate the **CM2** control board.

### **Caution**

Support the **CM2** control board with your hands when connecting and disconnecting the cables, or damage to the board may result.

Do NOT disconnect cables by pulling the cable.

7. Disconnect **J2A** from **CM2** by unlatching first, then pulling the cable connector.
8. Disconnect the **J1A** connector on the cable from the **CM1** option board.
9. Disconnect the **J3A** connector on the cable from the **CM3** digital meter board.
10. Remove the **CM2** control board from the six support standoffs by using a small flat-bladed screwdriver to push in the latches on each standoff.
11. Position the new **CM2** control board over the six standoffs. Verify that each latch snaps and locks in place.
12. Connect **J3A** to **P3A** on the new **CM2** control board.
13. Connect **J1A** to **P1A** on the new **CM2** board.

14. If the rectifier is to be restored to service, refer to “Restore Rectifier to Service” in Section 7, *Troubleshooting and Adjustments*.

**Replace CM3  
Digital Meter  
Board**

Follow instructions under “Handling Circuit Modules” earlier in this section to minimize electrostatic discharge when handling circuit modules.

1. Turn the rectifier **Power** switch **Off**.
2. Turn the rectifier **DC Output** circuit breaker off (down).
3. At the ac service panel supplying power to the rectifier, remove the input fuse assigned to the rectifier or turn the circuit breaker Off.
4. At the plant controller, remove the REG fuse associated with the rectifier. Disconnect control cable connector **J2A** from the control board **CM2**.
5. At the rectifier, loosen the locking screws and open the door.
6. Locate the **CM3** digital meter board.

**Caution**

Support the **CM3** digital meter board with your hands when connecting and disconnecting the cables or damage to the board may result.

Do NOT disconnect cables by pulling the cable.

7. Remove the **CM3** meter board from the two support standoffs and **S3** switch bezel by using a small flat-bladed screwdriver to unlatch the bezel clips from the switch and push in the latches on each standoff.
8. Disconnect **J1B** from **CM3** by unlatching first, then pulling the cable connector.
9. Position the new digital meter board over the two support standoffs. Verify that the latches on each standoff and **S3** switch bezel clips snap to lock the meter board into place.

10. Plug in the cable connector that leads to the control board.
11. Check calibration of rectifier meter as described in “Meter Calibration Test (Off Line)” in Section 6, *Testing*.
12. If the rectifier is to be restored to service, refer to “Restore Rectifier to Service” in Section 7, *Troubleshooting and Adjustments*.

## ***General Considerations for Replacing Components***

Only disassembly procedures are given in this section. Reinstallation procedures are usually the exact reverse of removal procedures (i.e., follow the removal procedures in reverse to reinstall the component). Specific instructions are given when this does not apply exactly, or where special considerations or precautions must be taken during reinstallation. Applicable portions of Section 5, *Installation*, may be helpful. Portions of Section 6, *Testing*, can be used after reinstallation to verify proper operation of the rectifier. Some points are common to all rectifier disassembly work. Please read this section before using the rectifier disassembly procedures.

- Take precautions against accidental personal injury or damage to equipment. Observe warnings given in Section 2, *Product Description*, in addition to the following admonishment, while undertaking any disassembly or reinstallation procedure on a rectifier.

### **DANGER**

<p>The following disassembly or reinstallation procedures <b>MUST</b> be performed only on a rectifier completely disconnected from the plant battery buses, <b>AND</b> with no input from the ac service panel connected to the rectifier. The plant control cable <b>J2A</b> should also be disconnected from the <b>CM2</b> board.</p>
---

The ac service and dc battery buses can be safely disconnected from the rectifier by following the first eight steps of “Disconnecting a Rectifier” later in this section, but all work must be done carefully because you are working with live cables at battery bus potentials and current capabilities. The disconnected charge battery and charge ground connectors must be taped adequately to

prevent them from contacting each other or any other metal surface. Alternatively, the dc battery cables from the rectifier can be disconnected at the plant charge battery and charge ground buses.

- Always make note of the lead connection points (termination points) before unsoldering or disconnecting them to insure trouble-free reinstallation. This includes potentiometer leads, or the solderless, quick-disconnect type connections used on circuit boards, relays, inductors, transformers, and wire bundles.
- Always disconnect quick-disconnect connections by pulling straight apart with pliers to avoid bending or breaking the tabs. Do not pull on wire. Always remember to save hardware, thermal pads, and other items necessary for reassembly in a convenient place.
- Heat-generating semiconductor components, such as diodes and thyristors (triacs), employ heat-conductive devices for heat sinking such as thermal grease or thermal pads. The thermal grease used should be KS-21343, **L1**, or an equivalent. Diode thermal pads used in new rectifiers are type DP125, comcode 405229154. Triacs **Q1** and **Q2** use DP102, comcode 403208242.
- DC capacitors can be examined to see if they have “blown” (i.e., vented) due to voltage breakdown failure. A small hole in the capacitor top, called a “blowhole,” is plugged in a new or good capacitor, but is empty (blown out) in a failed unit. Some capacitor blowholes cannot be viewed directly until removed, or almost removed, from the rectifier. A dental-type mirror aids in viewing these capacitors' blowholes before disassembly. Lucent Technologies recommends that all dc capacitors in a rectifier be replaced whenever any one of them blows.
- Procedures for testing and replacing individual rectifier diodes are provided under “Rectifier Diode Test and/or Replacement” later in this section. Also provided under “Heat Shrink Removal” later in this section is the procedure for taking apart bolted and insulated connections, such as those used on large transformer leads.

- All removal and replacement procedures are easier to perform on bay-mounted rectifiers that have been removed from the bay.
- Most component removals are straightforward and obvious. Therefore, these procedures can be used as a guide by qualified service personnel, rather than as step-by-step procedures. For example, you may prefer to remove a part not called for in order to make more room for access to a component being replaced.

Table 8-D and Table 8-E provide the reassembly torquing requirements for the electrical and mechanical connections in the rectifier. Use these values unless otherwise directed in the procedures.

**Table 8-D: Torque and Minimum Yield Strength for Mechanical Connections (Using Hex Head Cap Screws)**

Cap Screw Diameter (inches)	Min. Yield Strength (PSI)	Torque (Ft-Lb) UNC
1/4	57,000	6
5/16	57,000	12
3/8	57,000	22
7/16	57,000	35
1/2	57,000	54
9/16	57,000	77
5/8	57,000	107
3/4	57,000	190
7/8	36,000	193
1	36,000	290
1-1/8	36,000	410
1-1/4	36,000	580
1-3/8	36,000	760
1-1/2	36,000	1010

**Table 8-E: Minimum Torque for all Electrical Connections**

Screw Size	Torques in In-Lb or (Ft-Lb)					
	Wire Connections		Hand Tightened		Nut Tightened	
	Slotted Machine	Hex or Socket Cap	Slotted Machine	Hex or Socket Cap	Slotted Machine or Hex Cap	Socket Cap
8-32	15	15	19	19	19	23
10-24	21	21	27	27	27	33
1/4-20	50	50	65	65	65	80
5/16-18	—	100	—	135	135	165
3/8-16	—	180	—	240	240	290
7/16-14	—	280	—	385	385	465
1/2-13	—	500	—	585	585	710
5/8-11	—	(71)	—	(97)	(97)	(118)
3/4-10	—	(125)	—	(172)	(172)	(209)

Notes:

1. Slotted machine screws should be the pan-head type.
2. Slotted machine and hex cap screws should be SAE Grade 2 steel or equivalent.
3. Socket cap screws should have 100,000 PSI minimum tensile strength.
4. Steel flat washers should be furnished under heads of socket cap screws.
5. Ferrous screws and washers should have a corrosion protective finish.
6. Locking means is only required for connections subject to vibration. Belleville type washers or jam nuts are the preferred means.
7. For less than 1/4 inch thick tapped copper bars, use slotted No.8, No.10, or 1/4-inch machine screws to minimize applicable torque. When larger screws are required, provide captive-type steel nuts or reduce torques.
8. Torque recommendations are also suitable for all non-ferrous fasteners, except aluminum.
9. Where application permits, hex cap screws should be used.

## ***Replacing Components***

### **DANGER**

The following disassembly or reinstallation procedures **MUST** be performed only on a rectifier completely disconnected from the plant battery buses, **AND** with no input from the ac service panel connected to the rectifier. The plant control cable **J2A** should also be disconnected from the **CM2** board.

Disconnect the rectifier as described under “Disconnecting a Rectifier” later in this section. Refer to Figure 2-1, Figure 5-2, and Figure 5-3 for component locations.

#### ***Output Volts Adjustment Potentiometer***

1. Noting their positions, unsolder the leads from **R6**.
2. To remove **R6**, remove the nut holding **R6** to bracket.

#### ***DC Output Circuit Breaker, CBA1 and CBA1 Bracket***

Refer to Figure 5-3 to positively identify Cables B and C when they are referenced. Note that these cables are the same, as far as **CBA1** is concerned, in both the negative and positive versions of the rectifier.

1. Disconnect Cable B from output terminal block **TB3** by unbolting the connection.
2. Remove the two screws holding **CBA1** to the rectifier frame (**CBA1** bracket screws).
3. On the back of **CBA1**:
  - a. Remove the two quick-disconnect connectors.
  - b. Remove Cable C (the other dc lead) from **CBA1**.
4. In front, remove the two mounting screws that hold **CBA1** to the **CBA1** bracket.

#### ***Protective Shield***

1. If wires are tied to the shield, cut the wire ties to free the shield for removal.

2. Remove the three nuts that secure the shield to the side of the rectifier frame, and remove shield.
3. The following components should be exposed: **T3**, **L1**, **L2**, **K1**, **K2**, **K3**, and **T2**.

**Transformer (T3)**

1. Remove the quick-disconnect connectors from **T3**.
2. On left side of rectifier frame, loosen the bottom two mounting nuts of **T3**, then remove the top two nuts.
3. While supporting the weight of **T3**, slide it up and out.

**K1 Contactor  
Relay**

1. If you are moving **K1** out of the way as part of the process of getting to **L1**, then it is only necessary to carefully (the terminal tabs are fragile) remove the terminal screws and wires (with terminals) from the top of **K1**. The bottom leads of **K1** can remain attached. Skip to Step 3.
2. If you are removing **K1** in order to replace it, then perform Step 1 and then remove the bottom leads from **K1** by removing their screws. Observe the same caution as in Step 1.
3. Remove the bottom two nuts and loosen the top nut in order to remove **K1**.

**K2 or K3 Relay  
(Contactors)**

Relay **K3** is found in 480 VAC input rectifiers only.

1. Remove quick-disconnect connectors from relay.
2. To remove the relay, remove the top nut and loosen the bottom nut.

**AC Inductors (L1  
or L2)**

The **L1** inductor is located behind **T3**, and the **L2** inductor is located behind **K1** and **K2**.

1. The transformer (**T3**) must be moved in order to access **L1** or **L2**, but it is not necessary to remove all of the **T3** leads. Remove the top four (non-yellow) quick-disconnect connector leads from **T3** (the remaining leads to **T3** are long enough to allow **T3** to rest on the floor of the

rectifier). Remove **T3** from the frame of the rectifier per Steps 2 and 3 of Procedure D in this part.

2. For **L2** removal, it is necessary to remove all three relays; **K1**, **K2**, and **K3** (for 480 VAC input units only). Perform procedures described above in “K1 Contactor Relay” on the previous page and “K2 or K3 Relay (Contactors)” on this page to remove the relays.
3. For either **L1** or **L2** removal, cut the cable ties from the inductor leads. Then, disconnect the quick-disconnect connector leads (coming from **L1** or **L2**) from the corresponding capacitor and thyristor (**C7** and **Q2** for **L2**, or **C5** and **Q1** for **L1**).
4. To remove inductor **L1** or **L2**, remove all four of the nuts that mount it to the rear wall (make sure the weight is supported adequately).

**CA1 Board  
(Snubber  
Network)**

1. Remove quick-disconnect connectors from **CA1**.
2. Remove the board from each of the six spring-tab support standoffs (one at a time) by depressing the spring tab with a screwdriver blade while pulling out on that portion of the board.
3. During reassembly, the **CA1** board can be replaced by pushing all six of the holes down over the support standoffs simultaneously. Verify that all of the tabs lock in place.

**Thyristors (Q1 or  
Q2)**

1. Remove quick-disconnect connectors from the thyristor to be removed.
2. Remove the nut that holds the thyristor to the bracket. Retain the thermal pad for reinstallation.

**AC Capacitors  
(C5 or C7)**

1. Remove quick-disconnect connectors from the capacitor.
2. Remove the three nuts that hold the capacitor and the capacitor clamp to the rectifier frame.
3. Remove the clamp from the capacitor.

4. During reinstallation, before attaching the clamp to the frame, make sure that the bottom of the clamp is flush with the bottom of the capacitor.

### ***Diode Heat Sink Assembly***

It is possible to remove individual rectifier diodes from the heat sink while the heat sink assembly is still mounted in the rectifier. Any diode can be reached with a standard offset ratchet wrench in this manner. However, the diode heat sink assembly can be removed, if desired. It is easily dismantled from the rear of the rectifier by loosening the bolts in the slotted brackets and then lifting up and out. However, difficulty may be encountered in getting the heat sink past some of the wires and cables that block it from coming straight out, if the wires and cables are not disconnected. The transformer leads should not be moved or bent at their breakout points.

For diode testing or removal information, see “Rectifier Diode Test and/or Replacement” later in this section.

### ***DC Inductors (L3 or L4)***

Inductor **L4**, if equipped, is mounted just to the right of inductor **L3**.

#### **To Remove Inductor L3:**

1. To access **L3**, remove the cable from the positive side (left) of **TB3**. As shown in Figure 5-3, this is either Cable A (in a negative output system) or Cable B (in a positive output system).
2. Disconnect the lead from the inner tab of **L3**.
3. Remove the other (outer tab) lead (coming from **L3**) from its connection point at the junction of leads 7 of **T1** and **T2** (near the bottom of the rectifier in the middle). This requires removing the tape and unbolting the connection terminals of the 1/0 gauge leads.
4. While supporting the weight of **L3**, remove all four of the mounting nuts that secure it to the rear wall. Remove **L3**.

#### **To Remove Inductor L4:**

1. Remove the **CBA1** bracket assembly as described in “DC Output Circuit Breaker, CBA1 and CBA1 Bracket” earlier

in this section. Move the assembly out of the way to the left.

2. Disconnect the lead from the inner tab of **L4**.
3. Remove the other (outer tab) lead (coming from **L4**) from its connection point on the bus bar assembly.
4. While supporting the weight of **L4**, remove all four of the mounting nuts that secure it to the rear wall. Remove **L4**.

**DC Capacitors  
(C1, C2, or  
C3/C4)**

**DANGER**

DC capacitors may be charged even with power disconnected from the rectifier. This would be true if the main bus bar fuses are open. Always check all of the dc capacitor terminals (observe polarity) with a voltmeter before performing this procedure, and discharge capacitors in a safe manner, if necessary.
--

1. Remove Cables A and C from the bus bar assembly (refer to Figure 5-3).
2. Remove the cable from the inner tab of **L3**.
3. Remove the heat sink common cable from the top of the heat sink.
4. For the dc capacitor and bus bar assemblies, remove both of the nuts from the rear wall studs and the nuts from the studs on the right side wall of the frame. Remove the unit to access the individual capacitors.
5. To remove any individual capacitor, remove the two terminal screws that hold the capacitor to the dc capacitor and bus bar assembly. Note that **C1** is the rear-most capacitor, **C2** is the middle capacitor, and **C3/C4** is the front-most capacitor (before assembly is dismounted).

**Main  
Transformers  
(T1 or T2)**

This procedure assumes that the rectifier has been removed from the bay.

1. Disconnect the transformer primary leads from the **K1** contactor relay (two for **T1** or one for **T2**).
2. Remove the associated rectifier diodes from the heat sink that connect to transformer leads 6 and 8.
3. Near the bottom of the rectifier, disconnect the leads that connect **T1** to **T2**, and to the cable that runs up to the outer tab of **L3**. This involves untaping the connectors and unbolting the terminals that connect the cables.
4. Disconnect leads 9 and 10 of the transformer at the ac capacitor (quick-disconnect leads).
5. Disconnect the quick-disconnect connector sense leads 11 through 14 where they connect in the front of the rectifier at the chassis bottom.
6. Remove the long angle bracket along the chassis bottom by unbolting the eight nuts that secure it to the rectifier frame bottom and to the transformers **T1** and **T2**.
7. Place something, such as a wooden block, under the transformer to be removed.
8. Unbolt the three remaining nuts at the transformer legs. Remove the bracket that holds the upper transformer leg to the side of the chassis.
9. While supporting the weight of the transformer with appropriate lifting equipment (at least 500 lbs.), slide the transformer out of the rectifier.

**Rectifier Diode  
Test and/or  
Replacement**

If not already done, perform the diode heat sink assembly procedure.

1. Remove the nut from the stud that secures the diode to the heat sink. The stud can be anode or cathode of diode, see the rectifier SD to determine. Lift the diode body from the heat sink by the “pigtail” side, opposite of stud side, and save the removed thermal pad for reinstallation.

2. The diode is now electrically isolated for test purposes.
3. If this procedure is being performed to test a diode, skip to Step 8. To replace a diode that is known to be defective, continue with Step 4.
4. Refer to the next section to remove any heat shrink tubing and tape on the pigtail connection.
5. With the actual connection exposed, remove the nut and bolt that holds the connection together. Save the hardware for reinstallation. Discard the defective diode.
6. Connect the pigtail lead of the replacement diode by reversing the work done in the previous two steps, Step 5 first and then Step 4. Use the hardware saved in Step 5. When reversing Step 4, use heavy duty (thick wall) heat shrink tubing rated at 300 volts minimum at 105 degrees Celsius. See the next section for a recommended type of heat shrink tubing. If electrical tape is used, it should be identically rated.
7. Install the stud of the replacement diode through the mounting hole in the heat sink. Use the thermal pad, DP125, comcode 405229154 that was saved in Step 2. Install the new stud nut and torque to 100-125 in-lbs. This completes the rectifier diode replacement procedure. If maintenance is completed, reinstall the diode heat sink assembly as described above under “Diode Heat Sink Assembly”.
8. **Testing a Rectifier Diode:** Use a meter with a diode test function, or measure the forward and backward resistances of the diode, to determine if the diode is good. A good diode should measure at least 50 ohms in both directions, and one direction should measure at least 50 times the other. The larger resistance is, of course, the back resistance, and the smaller is the forward resistance.

Most diodes that fail do so by shorting (i.e. they measure shorted or almost shorted in both directions). The pigtail side of the diode can be electrically accessed, with a clip lead or probe, by pushing the insulating tubing and/or tape approximately 1/4 to 1/2-inch away from the point where the pigtail lead enters the diode body.

9. If the diode checked bad, proceed to Step 4 of this procedure to remove and replace it. If the diode checked good, proceed to Step 7 of this procedure to reinstall.

### ***Heat Shrink Removal***

This information is applicable to both rectifier diode “pigtail” lead insulation and some main transformer lead insulation in J85503A-1 rectifiers.

Remove heavy duty (thick wall) heat shrink insulation by carefully cutting it away with a sharp knife. Any electrical tape used to reinforce the connection must be removed. The heavy duty heat shrink tubing recommended is rated at 300 volts minimum at 105 degrees Celsius. A recommended heat shrink tubing is T&B HS4-30L, comcode 402696306.

### ***Disconnecting a Rectifier***

This section gives the procedure for disconnecting a rectifier from an operating plant. Before performing the procedure, personnel should be familiar with “Installing or Adding a Rectifier” in Section 5, *Installation*.

1. At the rectifier control panel, turn the **Power** switch **Off**, and the **DC Output** circuit breaker off (down).
2. At the ac distribution service panel, remove the fuses or open the circuit breaker supplying the rectifier with ac power. Tag fuse holders or circuit breaker to instruct all personnel to leave circuit deenergized.
3. Remove associated REG fuse from plant controller.
4. Disconnect the plant control cable from the rectifier **CM2** control board, at connector **P2A**. Remove the cable from the cable tie anchors to permit its withdrawal through the conductor opening in the cabinet. The cable tie anchors, while providing a secure physical support of the cable assembly, protect the cable assembly from undesirable abrasion and bending.
5. The rectifiers' output filter capacitor must be completely discharged. Verify by connecting a DMM directly to the capacitor bus bars inside the rectifier. It will take several minutes to completely discharge the capacitors, after the **DC Output** circuit breaker is turned off in Step 1.

6. One at a time, disconnect the battery plant end of the dc output and output return conductors from the battery plant charge and charge ground bus bars. Insulate the connector ends and label the conductors for easy identification when reconnecting.
7. One at a time, disconnect the dc output conductors from the rectifier “hot” and return bus bars. Insulate the connector ends and label the conductors for easy identification when reconnecting.
8. One at a time, disconnect the ac input conductors from their terminations and the ac equipment ground (green) conductor from the cabinet. Insulate the connector ends and label the conductors for easy identification when reconnecting.
9. Unfasten the ac conduit that is structurally attached to the rectifier. Displace the disconnected conduit to the side, and, if necessary, tie the conduit to an adjacent structure to prevent interference with the rectifier removal.
10. Withdraw all disconnected conductors from the rectifier cabinet and place them aside so as not to interfere with the rectifier removal or cause a personnel hazard.
11. Baffles between rectifiers in bays may have to be removed.
12. Size 3/8-16 lifting eyebolts may be fastened into the threaded holes in the top of the rectifier for removal by a forklift, or the rectifier may be attached to the lifting device of your choice before the mounting screws on each side of the unit are removed. **Remember that the unit weighs at least 300 pounds.**
13. When the rectifier is supported by the lifting device of your choice, remove the mounting screws that attach the unit to the bay.
14. The rectifier is now both electrically and physically disconnected and may be safely lifted from the bay.

## 9 *Product Warranty*

A. Seller warrants to Customer only, that:

1. As of the date title to Products passes, Seller will have the right to sell, transfer, and assign such Products and the title conveyed by Seller shall be good;
2. Upon shipment, Seller's Manufactured Products will be free from defects in material and workmanship, and will conform to Seller's specifications or any other agreed-upon specification referenced in the order for such Product;
3. With respect to Vendor items, Seller, to the extent permitted, does hereby assign to Customer the warranties given to Seller by its Vendor of such Vendor Items, such assignment to be effective upon Customer's acceptance of such Vendor Items. With respect to Vendor items recommended by Seller in its specifications for which the Vendor's warranty cannot be assigned to Customer, or if assigned, less than Sixty (60) days remain of the Vendor's warranty or warranty period when the Vendor's items are shipped to Customer or when Seller submits its notice of completion of installation if installed by Seller, Seller warrants that such Vendor's items will be free from defects in material and workmanship on the date of shipment to Customer. In such an event, the applicable Warranty Period will be sixty (60) days.

B. The Warranty Period listed below is applicable to Seller's Manufactured Products furnished pursuant to this Agreement, unless otherwise stated:

### Warranty Period

Product Type	New Product	Repaired Product or Part*
Central Office Power Equipment	24 Months	6 Months
* The Warranty Period for a repaired Product or part thereof is as listed or, in the case of Products under Warranty, is the period listed or the unexpired term of the new Product Warranty Period, whichever is longer.		
** The Warranty Period for Products ordered for Use in Systems or equipment Manufactured by and furnished by Seller is that of the initial Systems or equipment.		

- C. If, under normal and proper use during the applicable Warranty Period, a defect or nonconformity is identified in a Product and Customer notifies Seller in writing of such defect or nonconformity promptly after Customer discovers such defect or nonconformity, and follows Seller's instructions regarding return of defective or nonconforming Products, Seller shall, at its option attempt first to repair or replace such Product without charge at its facility or, if not feasible, provide a refund or credit based on the original purchase price and installation charges if installed by Seller. Where Seller has elected to repair a Seller's Manufactured Product (other than Cable and Wire Products) which has been installed by Seller and Seller ascertains that the Product is not readily returnable for repair, Seller will repair the Product at Customer's site.

With respect to Cable and Wire Products manufactured by Seller which Seller elects to repair but which are not readily returnable for repair, whether or not installed by Seller, Seller at its option, may repair the cable and Wire Products at Customer's site.

- D. If Seller has elected to repair or replace a defective Product, Customer shall have the option of removing and reinstalling or having Seller remove and reinstall the defective or nonconforming Product. The cost of the removal and the reinstallation shall be borne by Customer. With respect to Cable and Wire Products, Customer has the further responsibility, at its expense, to make the Cable and Wire Products accessible for repair or replacement and to restore the site. Products returned for repair or replacement will be accepted by Seller only in accordance with its instructions

and procedures for such returns. The transportation expense associated with returning such Product to Seller shall be borne by Customer. Seller shall pay the cost of transportation of the repair or replacing Product to the destination designated by Customer within the Territory.

- E. The defective or nonconforming Products or parts which are replaced shall become Seller's property.
- F. If Seller determines that a Product for which warranty service is claimed is not defective or nonconforming, Customer shall pay Seller all costs of handling, inspecting, testing, and transportation and, if applicable, traveling and related expenses.
- G. Seller makes no warranty with respect to defective conditions or nonconformities resulting from actions of anyone other than Seller or its subcontractors, caused by any of the following: modifications, misuse, neglect, accident, or abuse; improper wiring, repairing, splicing, alteration, installation, storage, or maintenance; use in a manner not in accordance with Seller's or Vendor's specifications or operating instructions, or failure of Customer to apply previously applicable Seller modifications and corrections. In addition, Seller makes no warranty with respect to Products which have had their serial numbers or month and year of manufacture removed, altered, or with respect to expendable items, including, without limitation, fuses, light bulbs, motor brushes, and the like.

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