RECTIFIER TROUBLESHOOTING

By
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General Safety Practices

As Cathodic Protection rectifiers are connected to the AC utility power, **electrical shock hazards** are present within the rectifier units. It is recommended that only qualified electronic or electrical personnel operate and maintain these units and that those personnel familiarize themselves with the areas of possible hazard within the unit. Following these practices can enhance the safety of personnel.

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General Safety Practices (CONTINUED)

Prior to site maintenance or inspection, **familiarize yourself with the rectifier and conditions at the site.**

Prior to doing any maintenance or troubleshooting on a rectifier unit, be **familiar with any possible hazard points** within the unit. Review the electrical schematic and the physical layout of the rectifier should be done in advance.

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General Safety Practices (CONTINUED)

Prior to opening the rectifier enclosure door, **check for hazardous voltages** being present on the enclosure with an AC voltage detector, if hazardous voltages are detected set the fused **AC disconnect to the "OFF"** position. Recheck AC presence, if AC is still present, there is a problem with the fused AC disconnect and contact an electrician for assistance.

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General Safety Practices (CONTINUED)

Whenever possible, set the AC disconnect from the power utility to the **"OFF"** position prior to starting any work on the rectifier unit. Even with the rectifier AC input circuit breaker in the "OFF" position, hazardous voltages are still present at any terminals connected to the rectifier AC input terminals. Always tag and lock out the disconnect to ensure others do not energize it while you are completing the rectifier work.

When taking readings across the rectifier AC/DC terminals, it is recommended to use only **one hand**, if possible.

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TROUBLESHOOTING - PRELIMINARY

Component Description:

- **To troubleshoot, one must first have a working knowledge of the individual parts and their relation to one another.**
- **To gain such knowledge, one needs to follow the order in which they appear, starting at the AC input of the rectifier.**

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TROUBLESHOOTING - PRELIMINARY

Lightning Arresters

- Wide variety of sizes, shapes, and forms.
- Most are a set of gapped points.
- Failure itself is unlikely to directly cause failure to other components following it.
- May be tested, but the equipment needed is seldom available in the field.
- Visual inspection is adequate.

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TROUBLESHOOTING - PRELIMINARY

Circuit Breakers

- A mechanical switch with either a magnetic or thermal trip element.
- Excessive current through trip element will open the mechanical contacts.
- Voltage or continuity checks can be made.

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TROUBLESHOOTING - PRELIMINARY

Transformer

- Two coils of wire wound around a laminated iron core.
- One winding, called the "primary", has the input voltage applied to it.
- Primary induces voltage onto the other winding, called the "secondary", through a magnetic coupling in the core.
- Taps placed on the secondary allow different voltages to be selected for the output.
- Very rugged and is not prone to failure; lightning or inadequate insulation can cause failure.

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TROUBLESHOOTING - PRELIMINARY

Transformer Cont.

- Open in primary - no voltage induced onto the secondary to be applied to rectifier stack.
- Open in secondary - between the two taps being used for the stack supply voltage, no voltage will exist across those taps or any taps that span the open. If beyond the tap setting being used, the transformer may be used within the range excluding the open.
- Short in either winding - will result in excessive currents in the windings, which will eventually cause failure.

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TROUBLESHOOTING - PRELIMINARY

Rectifier Stack

- **Changes the AC to DC by inverting alternate halves of the AC waveform, making all portions electrically unidirectional.**
- **Selenium or silicon semiconductors accomplish this.**
- **Semiconductors may fail in an open or shorted condition.**

- Open - output will either be half its previous output or zero, depending on whether half or the entire stack fails.
- Short - causes excessive currents which will burn up wiring or the transformer if the breaker does not trip in time.
- Aging - another mode of failure of selenium; a gradual failure that decreases the output of the stack with same amount of AC applied to it.

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TROUBLESHOOTING - PRELIMINARY

Fuses

- **Protects the more expensive components.**
- **Consists of a low melting point metal element, which carries a specific current.**
- **Current exceeding the rating creates heat which melts the element, opening the circuit it is protecting.**

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TROUBLESHOOTING - PRELIMINARY

Meters

- Indicates the amount of DC voltage and current present in the output.
- Coil of fine wire, permanent magnet, and a pointer (form of DC motor).
- Switches are usually recommended to remove the meters from the circuit.
- To verify readings, use portable meters of known accuracy and compare readings.

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TROUBLESHOOTING - BASIC

- ✓ An adequate inspection and maintenance program will reduce the possibility of rectifier failure.

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TROUBLESHOOTING - BASIC

- ✓ Rectifier failures do occur however, and the field technician must know how to find and repair troubles quickly to reduce rectifier down time.

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TROUBLESHOOTING - BASIC

Equipment:

Need not be elaborate, but must be adequate to do the job.

1. Digital or analog multimeter for reading AC and DC voltages and DC current up to 10 amperes, resistance, millivolts.
2. Necessary small tools.
3. Heavy duty shorting cable and several jumper cables with alligator clips.

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Proper Tools Required To Work On Rectifiers

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TROUBLESHOOTING - BASIC

Precautions:

The following precautions should be observed when troubleshooting rectifiers;

1. TURN THE RECTIFIER OFF when handling components within the rectifier. Open the disconnect switch ahead of the rectifier as well as the internal circuit breakers.

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TROUBLESHOOTING - BASIC

2. Be careful when testing a rectifier that is in operation. Most rectifiers are located in isolated areas and an injured technician may be far from help. Some companies insist their technicians stand on a rubber mat and wear rubber gloves when working on electrical equipment.

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TROUBLESHOOTING - BASIC

2. Be careful when testing a rectifier that is in operation. Most rectifiers are located in isolated areas and an injured technician may be far from help. Some companies insist their technicians stand on a rubber mat and wear rubber gloves when working on electrical equipment.

3. Consult the rectifier wiring diagram before starting to troubleshoot. It is the road map that guides you through the internal workings of the rectifier and tells you how the rectifier works. Before attempting to make adjustments or correct faults in a circuit, it is helpful to know the following:

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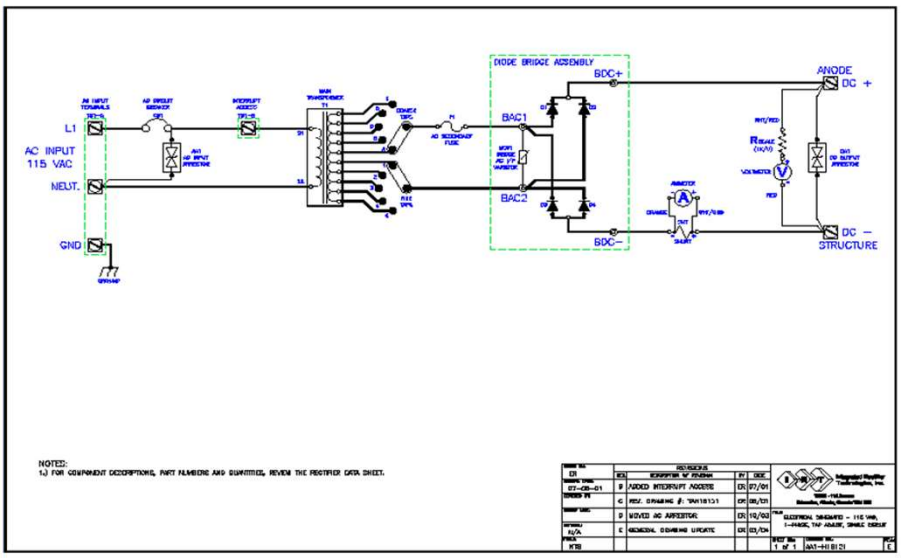

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TROUBLESHOOTING - BASIC

A. What the circuit is supposed to do in normal operation and how to operate it.

B. What each part or piece of equipment in the circuit contributes, and how each functions.

C. The location of parts and routing of conductors.

D. The most likely cause of any given malfunction.

E. The best places to “get into” the circuit for making tests.

This information is available in the rectifier maintenance manual.

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TROUBLESHOOTING - BASIC

4. Make certain that the meters used in troubleshooting are properly connected. The voltmeter should be connected across the points where voltage is to be measured, while the ammeter should be placed in series with the circuit being tested. A millivoltmeter should be connected across the terminals on the rectifier shunt. Correct polarity must be observed when using DC instruments. Turn the rectifier off before using an ohmmeter to avoid harming the instrument.

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TROUBLESHOOTING - PROCEDURES

Most rectifier troubles are simple and do not require extensive detailed troubleshooting procedures. Most common problems are: blown fuses, faulty meters, loose terminals, open ground bed leads and lightning damage. These troubles are usually found by a simple visual examination of the rectifier.

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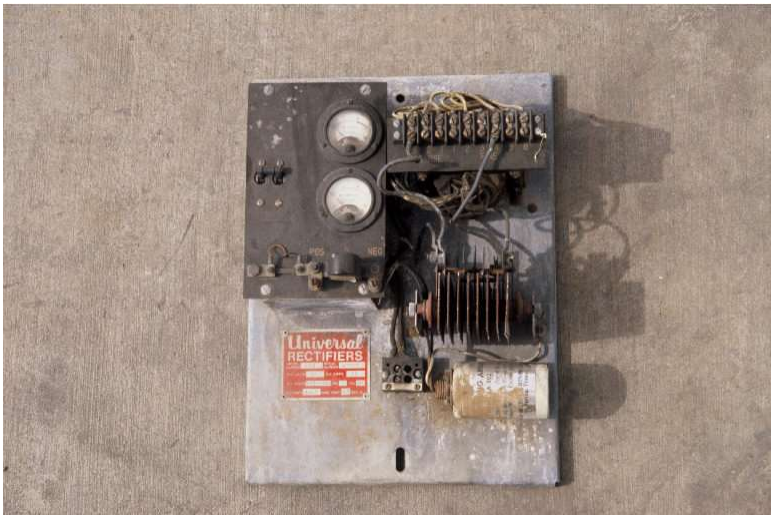

Catastrophic Failure By Lightning

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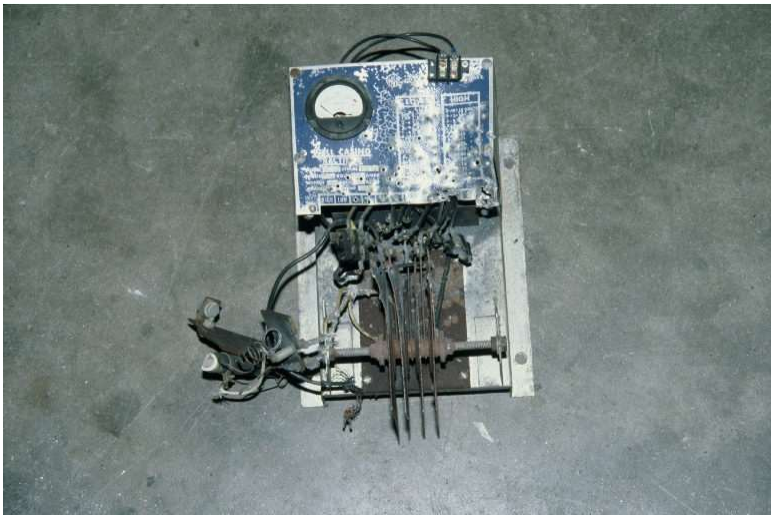

Vandalism – Shot With Shotgun

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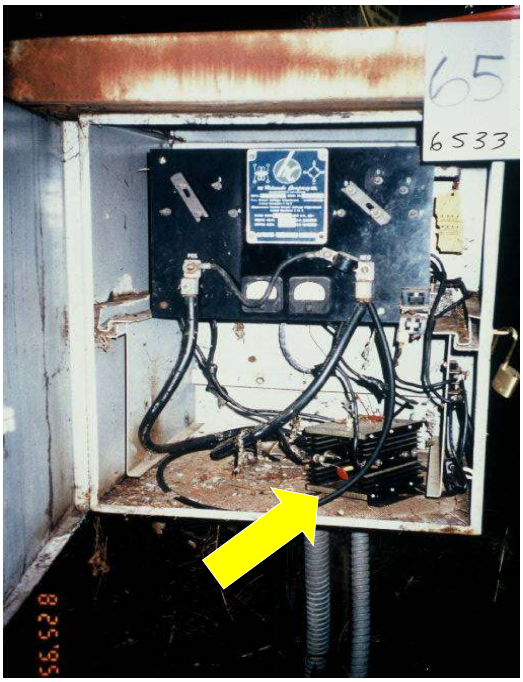
Poor Repairs –

Stack allowed to short to case screens



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CASH for CLUNKERS

- Rectifier Style -

*Replace your old C.P. rectifier & receive up to $250**

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TROUBLESHOOTING - PROCEDURES

For more difficult trouble, however, it is usually better to systematically isolate the rectifier components until the defective part is found. This amounts to trading a difficult problem for several simpler ones. This may be done as follows:

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TROUBLESHOOTING - PROCEDURES

Rectifier AC Input Circuit Breaker Does Not Trip and There Is No DC Output

WARNING! Be aware of hazardous voltages and risk of electrical shock. Ensure to follow all safety precautions and use only approved testing devices.

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TROUBLESHOOTING - PROCEDURES

Step 1:

With the AC input circuit breaker in the ON position, check the AC voltage level on the line side terminals of the AC input circuit breaker and ensure it matches what's indicated on the rectifier rating label

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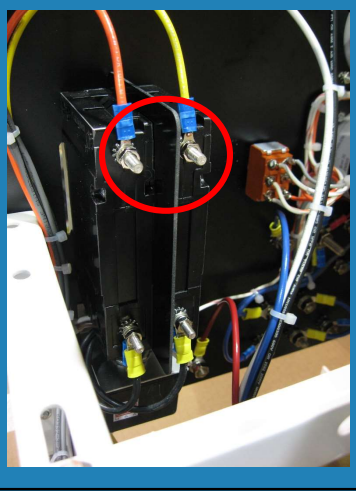
TROUBLESHOOTING - PROCEDURES



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TROUBLESHOOTING - PROCEDURES

Step 2:

With the AC input circuit breaker in the ON position, check for a proper AC voltage level on the load side of the breaker (it should be the same as the line side)

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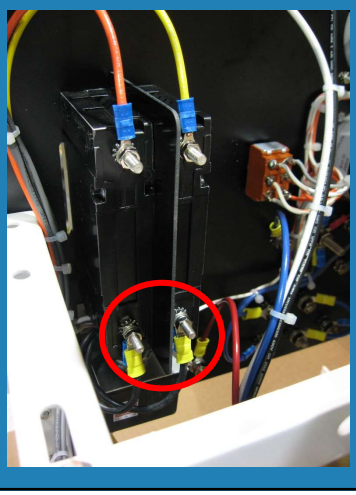
TROUBLESHOOTING - PROCEDURES



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TROUBLESHOOTING - PROCEDURES

Step 3:

If troubleshooting a dual input Rectifier, check the AC input voltage configuration terminals to ensure:

a) The input configuration settings are correct
b) The connections are secure / tight

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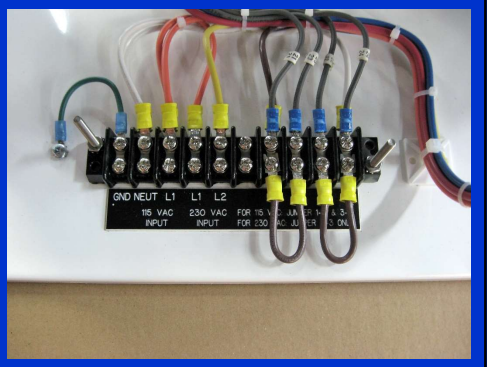

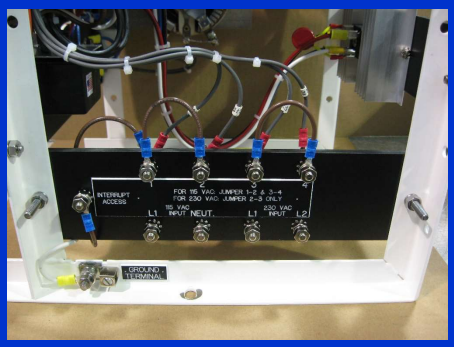

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TROUBLESHOOTING - PROCEDURES

Step 4:

Check the transformer secondary winding:

a) Place the digital volt meter (DVM) leads across the Coarse and Fine transformer tap link bars to determine if an AC voltage is present; voltage may be measured between any of the secondary taps.

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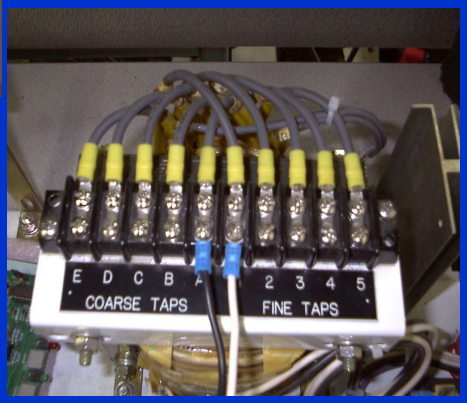

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TROUBLESHOOTING - PROCEDURES

Step 4:

b) Equal AC voltage should exist between any two adjacent Coarse tap terminals

c) An equal, though lower, AC voltage should be measured between any two adjacent Fine tap terminals

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TROUBLESHOOTING - PROCEDURES

Step 5:

Measure the AC voltage going into the diode bridge/stack (this voltage should be the same as what was measured across the Coarse and Fine transformer tap link bars

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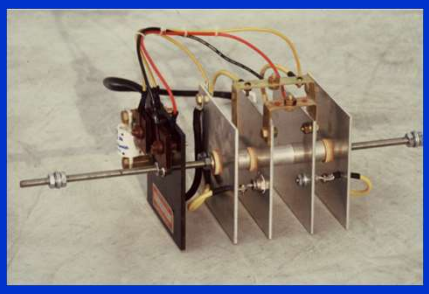
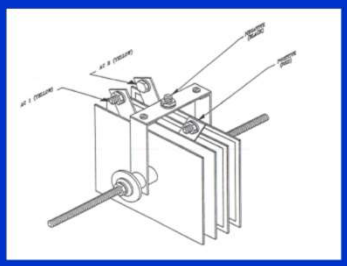
TROUBLESHOOTING - PROCEDURES





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TROUBLESHOOTING - PROCEDURES

Step 6:

If AC voltage is present at diode bridge/stack AC input terminals:

a) Check the DC output voltage of the bridge/stack
b) If voltage is present, but is less than what it should be, perform the Bridge/Stack Testing Procedure to determine if the bridge/stack are not functioning properly (i.e. half-waving)

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TROUBLESHOOTING - PROCEDURES

Step 7:

If the expected DC voltage is present at the output terminals of the bridge/stack, but not at the Rectifier DC output terminals, check for loose connections or open leads between these two sets of terminals (if so equipped, this may include checking continuity across the leads of a filter inductor/choke)

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TROUBLESHOOTING - PROCEDURES

Step 8:

If the expected DC voltage is present at the Rectifier DC output terminals but the rectifier meter indicates no current:

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TROUBLESHOOTING - PROCEDURES

Step 8:

a) Verify proper voltage (in millivolts) across the calibrated terminals on the metering shunt and across the input terminals of the ammeter:

i. If there is proper voltage at the shunt but not at the ammeter, check for loose connections, open leads or possibly a faulty metering switch between the shunt and the ammeter

ii. If there is proper voltage at the ammeter, the ammeter is faulty

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TROUBLESHOOTING - PROCEDURES

Step 8:

b) If there is no voltage at the shunt, there is likely an open circuit in the external DC Leads (anode or structure)

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TROUBLESHOOTING - PROCEDURES

The meter switches may be checked with an ohmmeter or, after consulting the wiring diagram, jumper wires may be placed across the switch terminals. (Care must be taken not to short across both switch terminals at the same time on units equipped with combination volt-ammeters.

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TROUBLESHOOTING - PROCEDURES

Rectifier AC Input Circuit Breaker Trips
(likely indicating a short circuit condition)

WARNING! Be aware of hazardous voltages and risk of electrical shock. Ensure to follow all safety precautions and use only approved testing devices.

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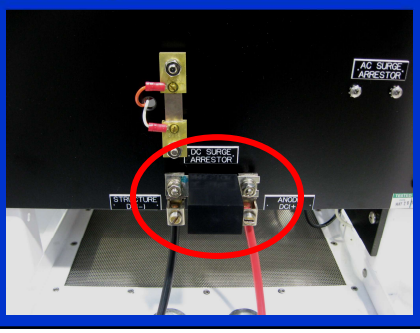
TROUBLESHOOTING - PROCEDURES

Step 1:

If a DC Surge/Lightning Arrestor is present:

a) **Disconnect the DC surge arrestor from the circuit**



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TROUBLESHOOTING - PROCEDURES

Step 1:

If a DC Surge/Lightning Arrestor is present:

b) Set the AC input circuit breaker to the “ON” position

c) If the breaker does not trip, the short is likely within the arrestor and it should be replaced

d) If the breaker trips again, proceed to Step 2

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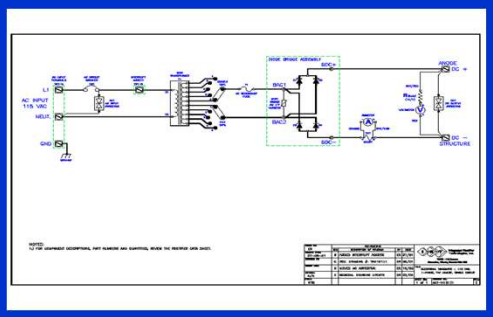
TROUBLESHOOTING - PROCEDURES

Step 2:

If an AC Surge/Lightning Arrestor is present (and is wired into the load side of the AC Input Circuit Breaker):



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TROUBLESHOOTING - PROCEDURES

Step 2:

If an AC Surge/Lightning Arrestor is present (and is wired into the load side of the AC Input Circuit Breaker):

a) Disconnect the AC arrestor from the circuit
b) Set the AC input circuit breaker to the "ON" position
c) If the breaker does not trip, the short is likely within the arrestor and it should be replaced
d) If the breaker trips again, proceed to Step 3

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TROUBLESHOOTING - PROCEDURES

Step 3:

Isolate the Transformer from the DC circuit:

a) Remove the transformer link bars from the transformer tap studs

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TROUBLESHOOTING - PROCEDURES

Step 3:

Isolate the Transformer from the DC circuit:

b) Set the AC input circuit breaker to the "ON" position

c) If the breaker continues to trip, inspect the transformer coil and leads for visible signs of a shorted condition (discoloration, burnt wire insulation, etc.).

d) If the breaker does not trip, this indicates that the AC section of the rectifier is not an issue and the DC section should be investigated further, replace link bars and proceed to Step 4

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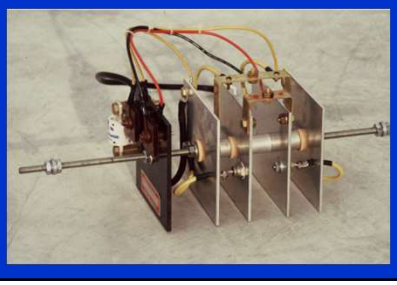
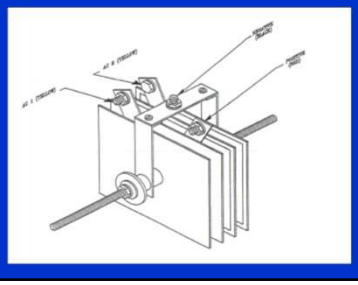
TROUBLESHOOTING - PROCEDURES

Step 4:

Isolate the Diode Bridge/Stack from the rest of the DC Output Circuit:

a) Remove one of the DC leads from the diode bridge/stack





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TROUBLESHOOTING - PROCEDURES

Step 4:

Isolate the Diode Bridge/Stack from the rest of the DC Output Circuit:

b) Set the AC input circuit breaker to the “ON” position

c) If the breaker continues to trip, the bridge/stack is likely defective and should be replaced

d) If the breaker does not trip, the short is likely between the external anode ground bed or structure leads

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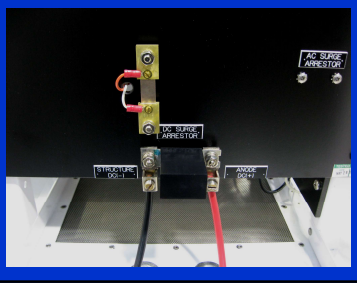
TROUBLESHOOTING - PROCEDURES

Step 5:

Isolate the External DC Load from the Rectifier:

a) Remove one of the external DC leads (anode or structure)



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TROUBLESHOOTING - PROCEDURES

Step 5:

Isolate the External DC Load from the Rectifier:

b) Set the AC input circuit breaker to the "ON" position

c) If the breaker continues to trip, the circuit breaker itself is likely defective and should be replaced

d) If the breaker does not trip, the short is likely located in the external DC output load circuit (someplace between the anode and structure leads)

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TROUBLESHOOTING - TIPS

Many rectifier problems are relatively obvious to the experienced technicians upon physical examination. The obvious should never be overlooked! Loose connections, signs of arcing, strange odors, etc., indicate troubles that do not require elaborate test procedure to uncover. Some helpful tips to follow:

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TROUBLESHOOTING - TIPS

1. If no output voltage or current is present, the trouble and remedy may be:

A. Breaker Tripped (or fuse blown)

(1) If apparently due to steady overload, reduce the output slightly.

(2) If the breaker trips repeatedly even with the output reduced, the cause may be a short circuit in some component. Isolate the component as described and repair or replace.

(3) If the breaker trips occasionally for no obvious reason, the cause may be:

(a) Temporary overload due to soil moisture changes.

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TROUBLESHOOTING - TIPS

(b) Line voltage surges, or wrong line voltage connections. Adjust the rectifier for operation at the proper line voltage for the location.

(c) Intermitted short circuits. Isolate the component as described before. Check for loose brackets or connections. Check with ohmmeter while moving leads etc. (Make certain power is turned off when using the ohmmeter).

(d) Thermal breaker may be affected by sun heat, install a shield or shade.

B. No AC line voltage. Check with the light or AC voltmeter. Do not overlook the possibility that service to the rectifier may have been interrupted.

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TROUBLESHOOTING - TIPS

C. Open circuit in some component or connection

(1) Check all connections, especially the AC voltage selector (dual input units only), fine and course transformer tap adjustments and stack connections.

(2) Rectifier stacks, use an AC voltmeter to see if voltage is applied to the stacks. If so, it may be open-circuited and should be checked with an ohmmeter and possibly replaced. (Note - an ohmmeter check is not a valid test for determining whether selenium stacks are aged). If multiple stack arrangements are used, check leads between stacks for opens. On silicon stacks, disconnect each silicon diode and check individually with an ohmmeter for forward and reverse resistance. A bad diode is either shorted or open.

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TROUBLESHOOTING - TIPS

D. Defective meters or meter switches. Follow the procedure discussed earlier in the Troubleshooting Procedures Section, paragraph 11.

E. Defective Transformer. If AC line voltage is applied to the primary, but none is present in the secondary, check to see whether there is an audible hum coming from the transformer.

(1) If so, the primary is operating, but the secondary is probably open.

(2) Check the above conclusions by isolating the transformer and checking the resistance of the windings with an ohmmeter.

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TROUBLESHOOTING - TIPS

(a) Secondary should have generally less than 1 ohm resistance.

(b) Primary should have perhaps 1 -10 ohms resistance.

(c) If either is quite high, that winding is effectively an open circuit and the transformer will have to be replaced. (It is difficult to make internal repairs on a transformer). Make certain that the high resistance is in the winding and not in some connecting lug.

F. Circuit breaker (or thermal overload protector). If the contacts do not close,they should be repaired or the breaker replaced.

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TROUBLESHOOTING - TIPS

2. If maximum DC output voltage at rated DC current is only about half what it should be, the trouble may be:

A. Rectifier may be set for higher input voltage than that being used.

B. Half the stacks or plates open-circuited, making the unit operate as a half wave, rather than full wave rectifier.

C. Badly aged stacks.

D. Low line voltage.

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TROUBLESHOOTING - TIPS

E. In a three phase unit, in addition to the above, one phase may:

(1) Be open circuited, in which case the current in one AC line will be considerably less than that in the other two.

(2) Have stacks that are more aged than the other two.

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TROUBLESHOOTING - TIPS

VARIABLE TRANSFORMER CONTROL

Some rectifiers may be equipped with a variable transformer in lieu of the standard tap and link bar arrangement for output adjustment. The variable transformer will provide stepless, infinite control of the output of the rectifier.

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TROUBLESHOOTING - TIPS

Troubleshooting the variable transformer will be the same as the procedure for the main transformer. AC input voltage should be checked across terminal 1 and 4.

Output AC voltage can be checked across terminals 1 and 3. Control knob should be at maximum rotation. Output voltage of the variable transformer should be the same as the input voltage. If no AC voltage is present on the output terminals of the variable transformer, check for open winding or damaged, dirty or worn wiper brush.

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