15th Annual KGA Expo

Rectifier Maintenance, and Troubleshooting

By
Don Olson

PH. (918) 805-7587
e-mail: dolson@mobiltex.com

About Me

2015 – 2022 *IRT Integrated Rectifier Technologies, Inc.*
Afton, Oklahoma

2008 – 2015 *Honeywell / Mercury Instruments*
Claremore, Oklahoma

2006 – 2008 *Corrpro Companies, Inc.*
Tulsa, Oklahoma

1996 – 2006 *MESA Products, Inc.*
Tulsa, Oklahoma

1991 – 1996 *Cathodic Protection Services*
Sand Springs, Oklahoma

1982 – 1991 *Good-All Electric*
Ogallala, Nebraska / Fort Collins, Colorado

SAFETY FIRST

- Safety is number 1
- Electricity can kill !!!!!!
- Have a healthy respect for it
- Use safety precautions

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 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.

General Safety Practices *(CONTINUED)*

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

2. 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.

General Safety Practices *(CONTINUED)*

3. 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.


DANGER
DO NOT TOUCH
THIS WILL KILL YOU
AND HURT THE ENTIRE
TIME YOU ARE DYING!
DANGER


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DANGER

General Safety Practices (CONTINUED)

4. 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.

5. When taking readings within the rectifier, it is recommended to use only one hand, if possible.

Where Cathodic Protection Is Used

- Here are some of the industries that commonly use Cathodic Protection to minimize the effect of corrosion:

- Pipeline (Transmission / Distribution)
- Oil and Gas Production
- Water / Wastewater
- Refinery Industry
- Gas Distribution / Utility
- Offshore / Marine
- Infrastructure (Bridge decks; parking decks)

Installation

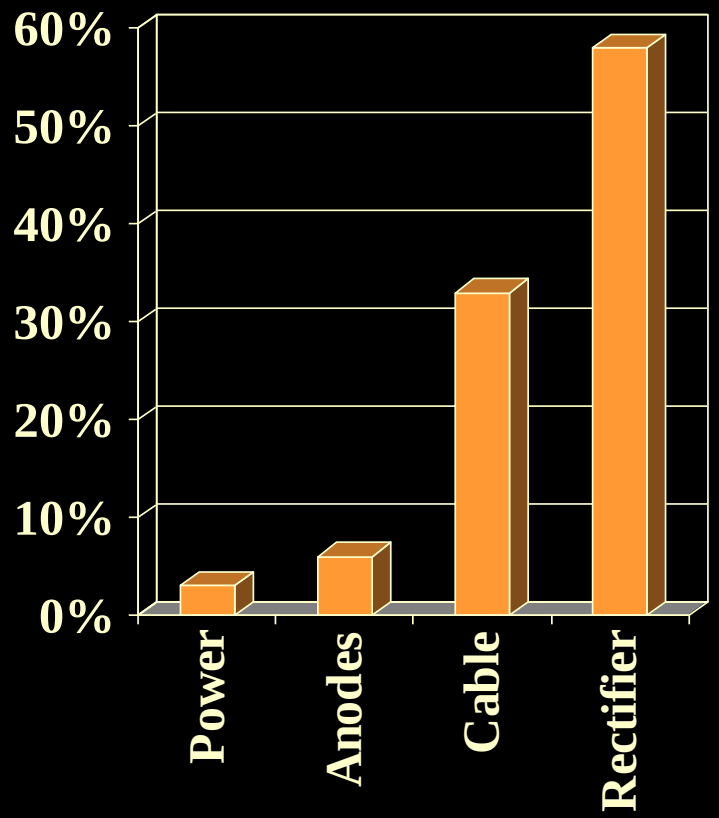
Corrosion is a continuous process and a corrosion control system must provide continuous protection.

A good cathodic protection design includes proper selection of equipment and correct installation procedures.

To High For Servicing


RENT-A-FENCE

Causes of Cathodic Protection System Failures



Of the failures to the rectifier ---

85% is to the stack or related parts.
Remainder makes up the transformer & misc.

Rectifier Construction

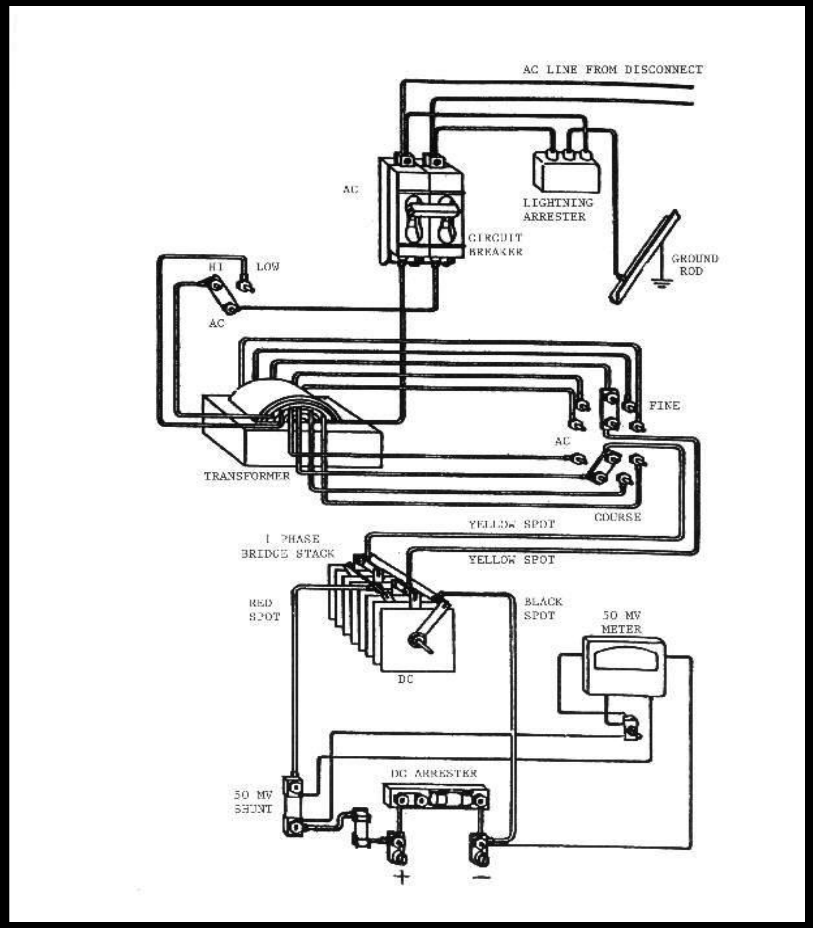
- The major components Rectifier construction are:
  - AC Input Breaker
  - Transformer & Choke
  - Secondary Fusing
  - Diode Bridge (stack)
  - Shunt
  - Metering
  - AC/DC Surge Protection
  - Enclosure

Troubleshooting Preliminary

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.

Troubleshooting Preliminary - Component Description

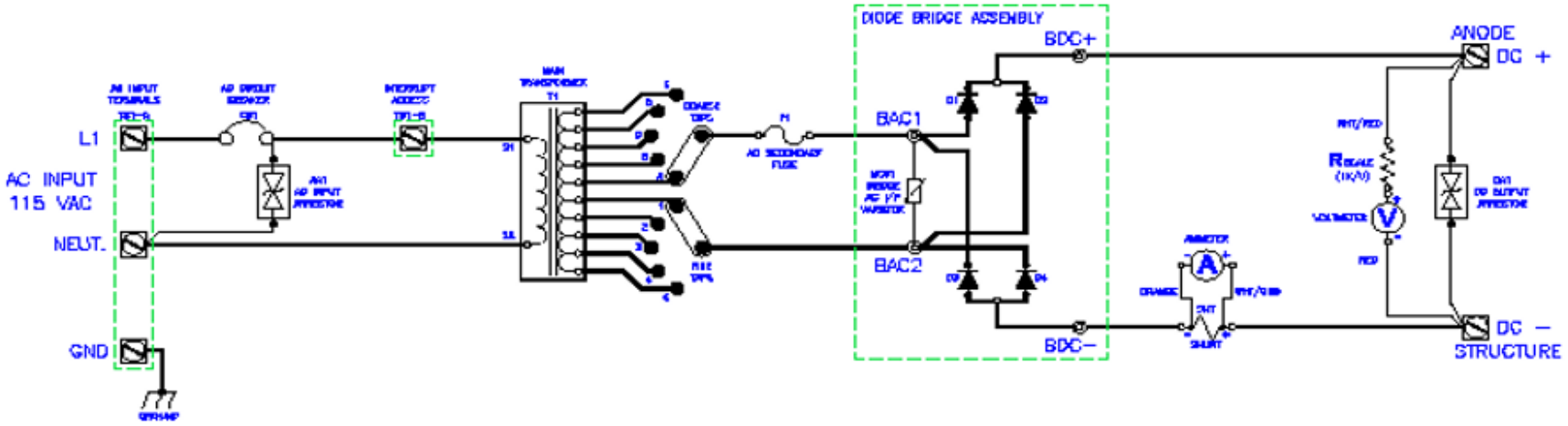


Power Train consist of a transformer and a stack.

Other components perform useful functions -

1. **Lightning arresters** on input and output - protects from voltage surges.
2. **Circuit breakers** on AC - on/off switch, provides overload protection.
3. **Transformer** - steps up or down line voltages to useable levels, allows for adjustment of the output, isolates the DC circuit from its source.
4. **Stack** - converts AC to DC
5. **Meter, Shunt, and Switch** - means of monitoring the output.
6. **Fuses** - provide overload protection.

Basic cathodic rectifier is a simple device.



NOTES:
1.) FOR COMPONENT DESCRIPTIONS, PART NUMBERS AND QUANTITIES, REVIEW THE RECTIFIER DATA SHEET.

ER	REVISIONS				
	BOL	DESCRIPTION OF REVISION	BY	DOC
07-05-01	B	ADDED INTERRUPT ACCESS	ER	07/01
	C	REV. DRAWING #: TAH18131	ER	08/131
	D	MOVED AC ARRESTOR	ER	10/03
N/A	E	GENERAL DRAWING UPDATE	ER	03/134
MTS				

Integrated Rectifier Technologies, Inc.

TITLE: ELECTRICAL SCHEMATIC – 115 VAC, 1-PHASE, TAP ADJUST, SINGLE OUTPUT

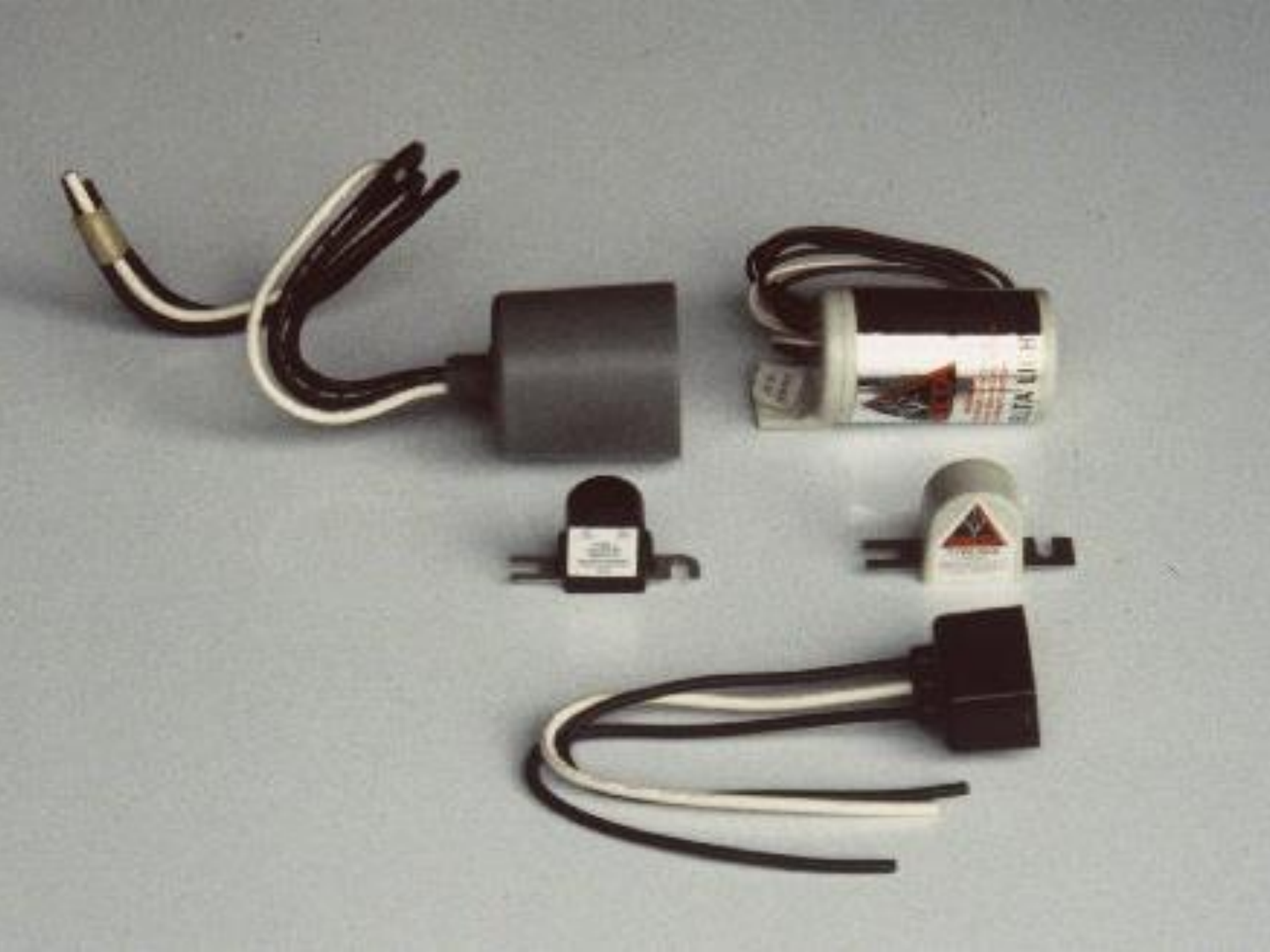
SHEET No. 1 of 1 | DRAWING NO. AA1-H18121 | REV. E

Lightning Arresters

- There are various types of arresters designed for many applications:

  Expulsion, Valve, Rare Gas and Silicon

- Failure of the arrester itself is unlikely to directly cause failure of other components but leaves rest of the rectifier vulnerable.
- May be tested, but the equipment need is seldom available in the field.

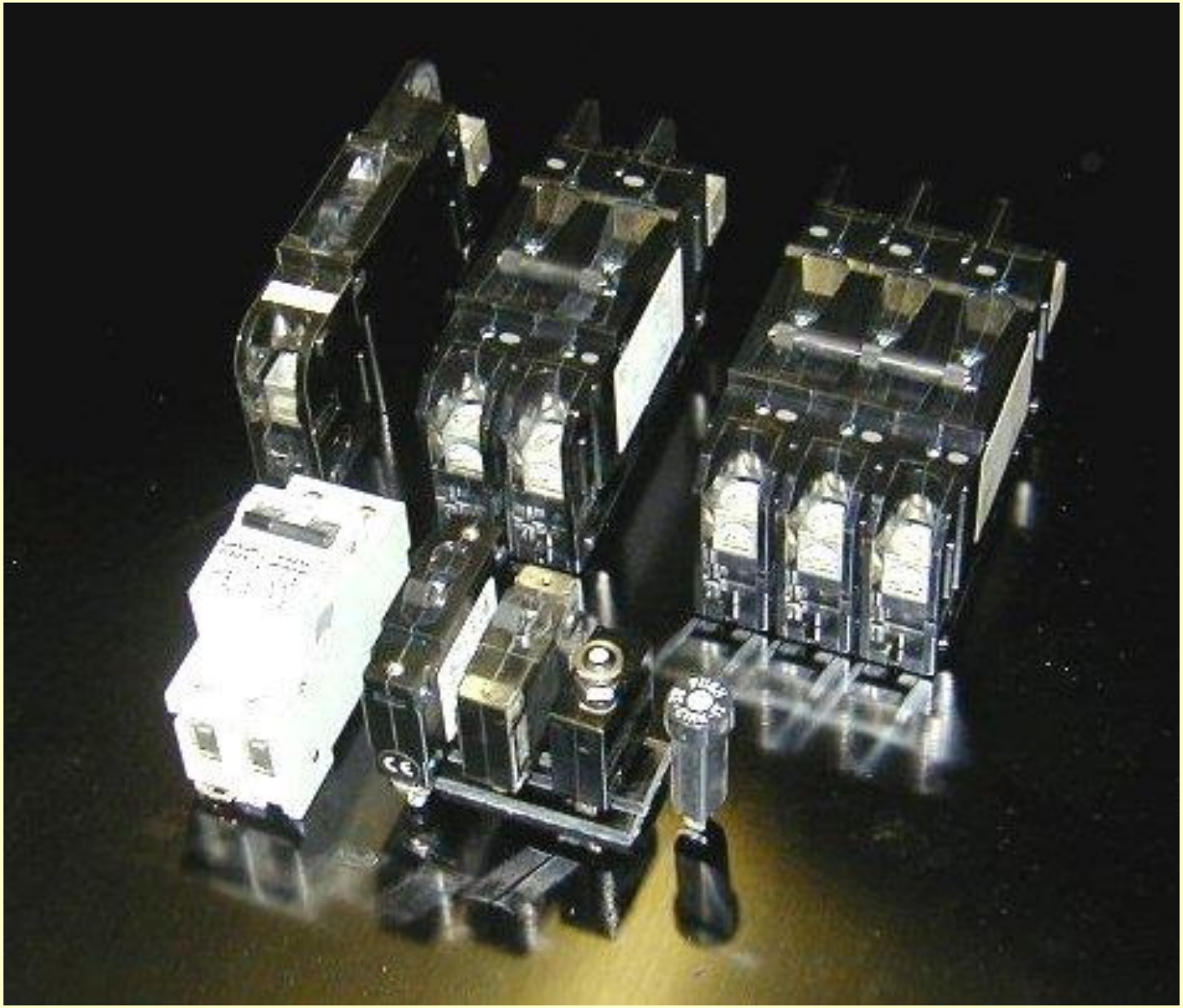


Circuit Breakers

- Primary function is to provide overload protection to the circuit and to serve as an ON - OFF switch.

- Three basic types used in cathodic protection rectifiers:

1. Fully Thermal
2. Thermal-Magnetic
3. Fully Magnetic

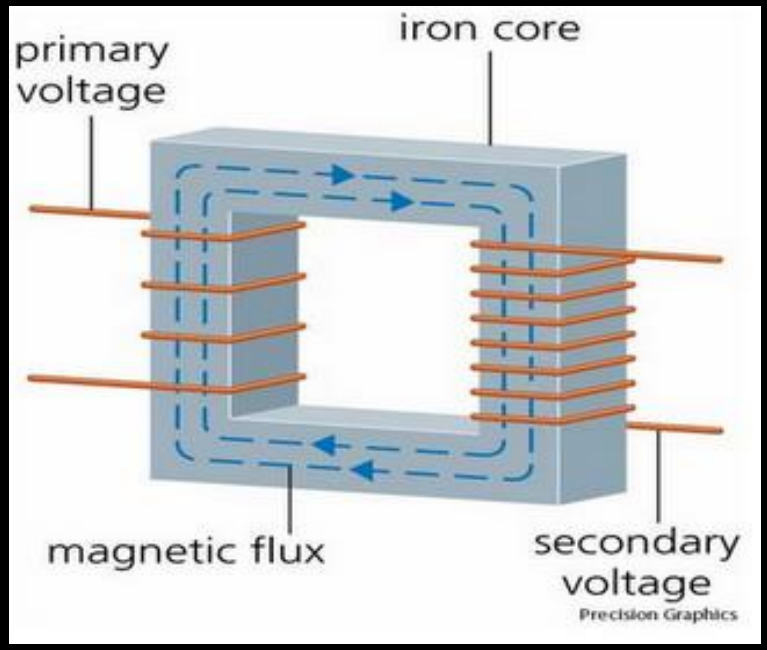


Circuit Breakers

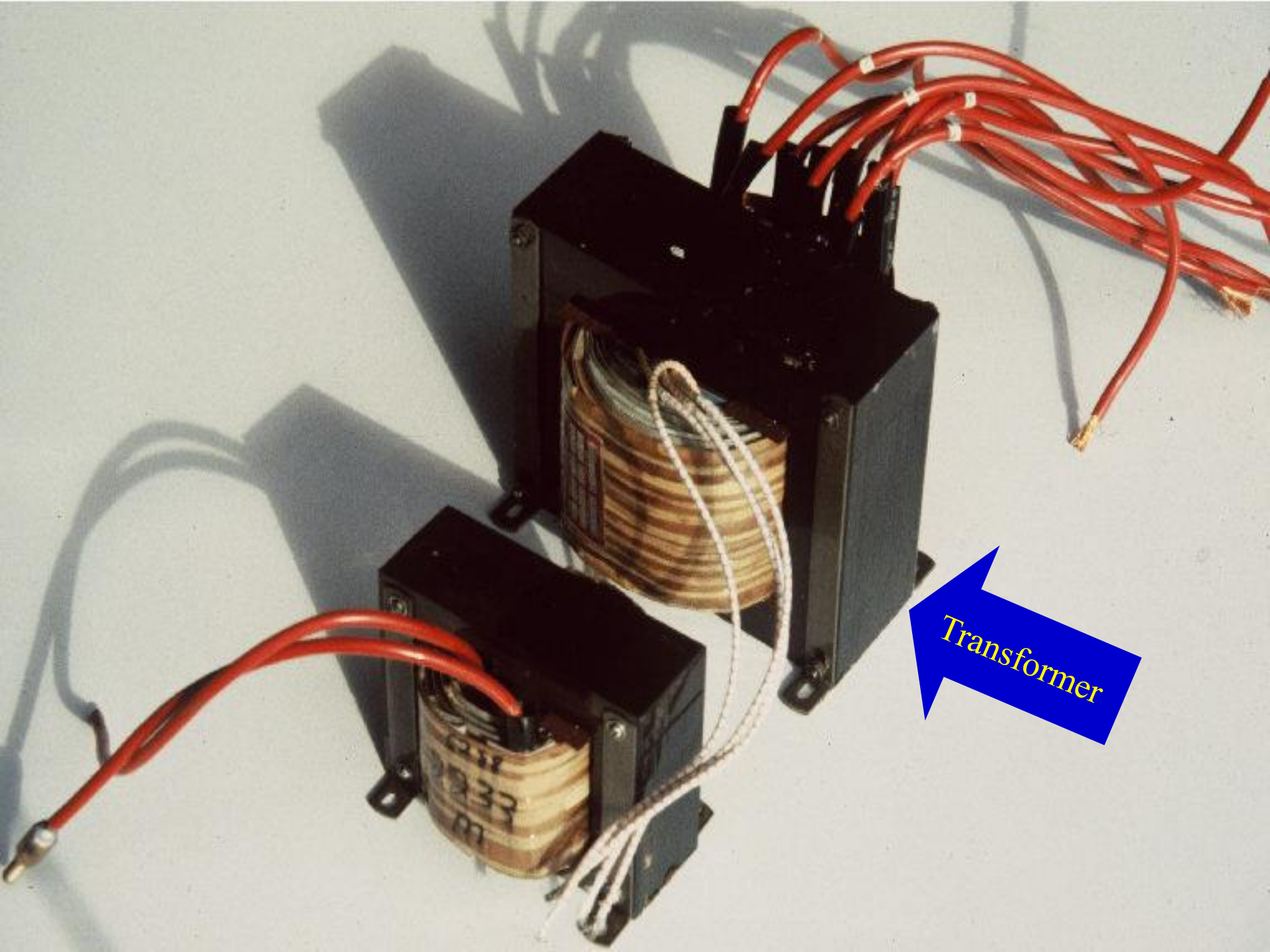
- Should be placed in each **“HOT”** AC supply line.
- Breaker handles must always be ganged so that all input lines open at the same time, removing all power from the unit (companion trip).

Transformer

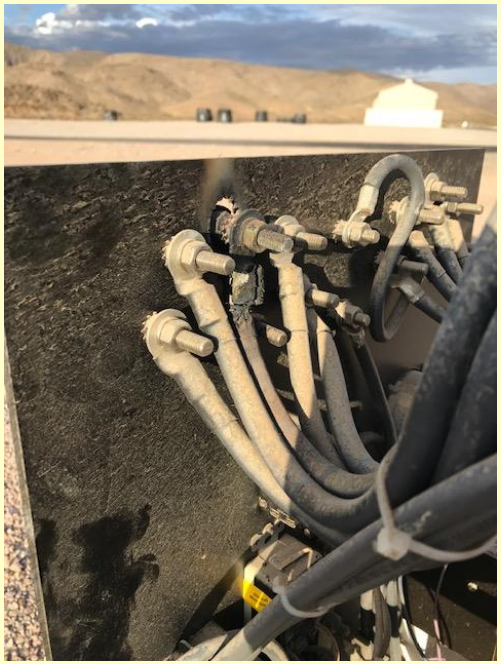
- Two coils of wire wound around a laminated iron core.
- Steps a voltage up or down to a useable level.
- Isolates the primary from the secondary.
- Secondary taps allows for adjustment of the output.
- **Primary** winding has the input voltage applied to it.
- **Secondary** winding receives voltage through a magnetic coupling in the core.



- Very rugged and is not failure prone, but lightning or inadequate insulation can cause failure.


Transformer


COARSE TAPS
100 AMPERE
AC SEC. FUSE
FINE TAPS
YARD RECTIFIER
SHUNT FACTOR 2.0
RECTIFIER # 23
GFI BREAKER
INTEGRATED RECTIFIER
TECHNOLOGIES, INC.
TOTAL AMPS
SHUNT
GFI OUTLET
ON
POWER
OFF
AC SURGE
ARRESTOR
DC SURGE
ARRESTOR

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IFIER

Transformer Cont.

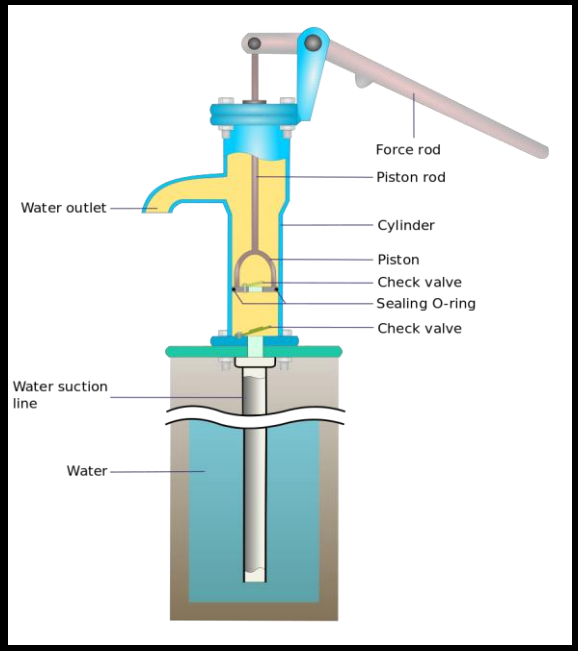
- Open in primary - no voltage induced onto the secondary to be applied to rectifier stack.
- Open in secondary - between the two taps being used for the stack supply voltage, no voltage will exist across those taps or any that span the open. If beyond the tap setting being used, the transformer may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

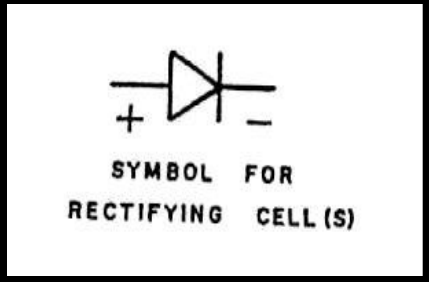
Rectifier Construction *(CONTINUED)*

Rectifying Devices

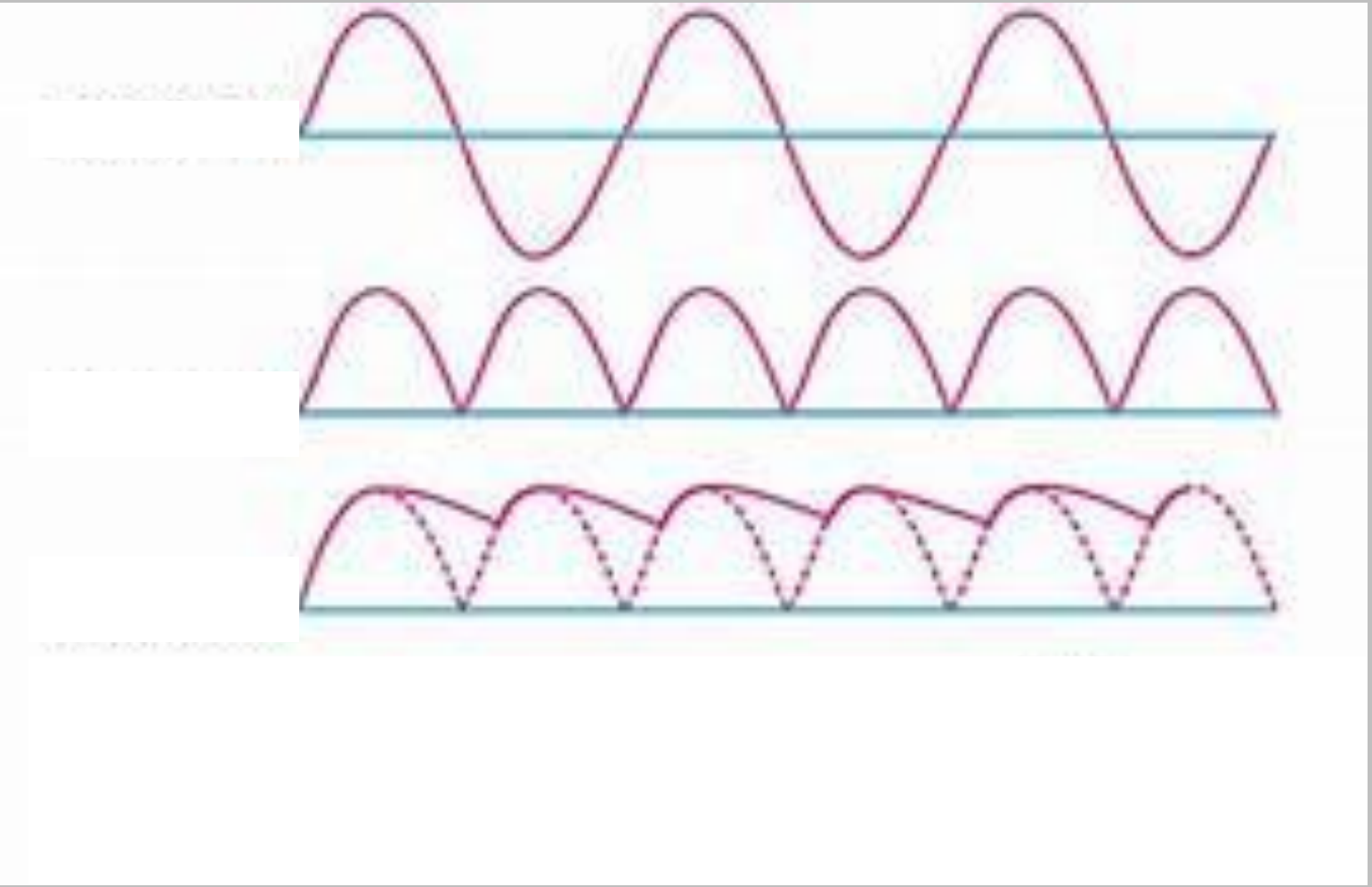
- Function of the device is to pass current in one direction and to block it in the opposite direction.
- Changes the AC to DC by inverting alternate halves of the AC waveform, making all portions of the waveform electrically unidirectional.

- Silicon or Selenium (outdated technology)





Rectifying Elements



Rectifying Cells Cont.

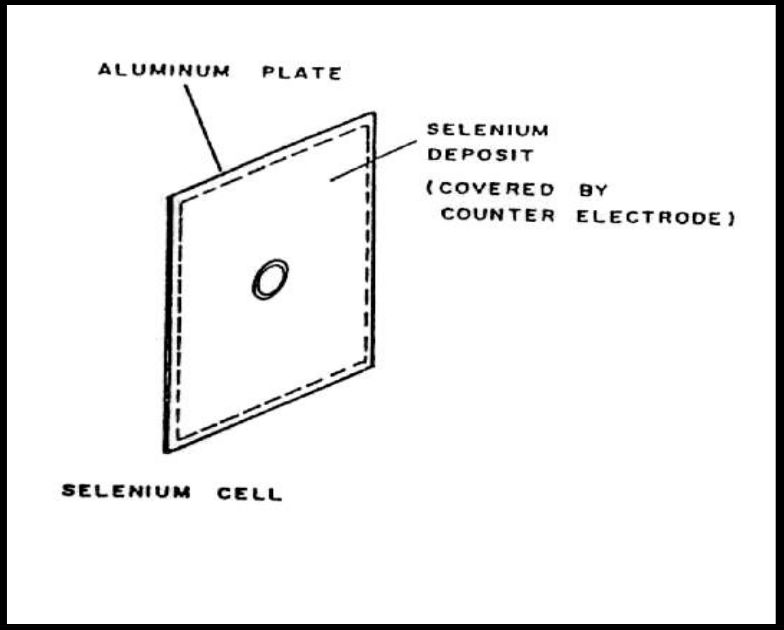
- Fail in “open” or “shorted” condition:

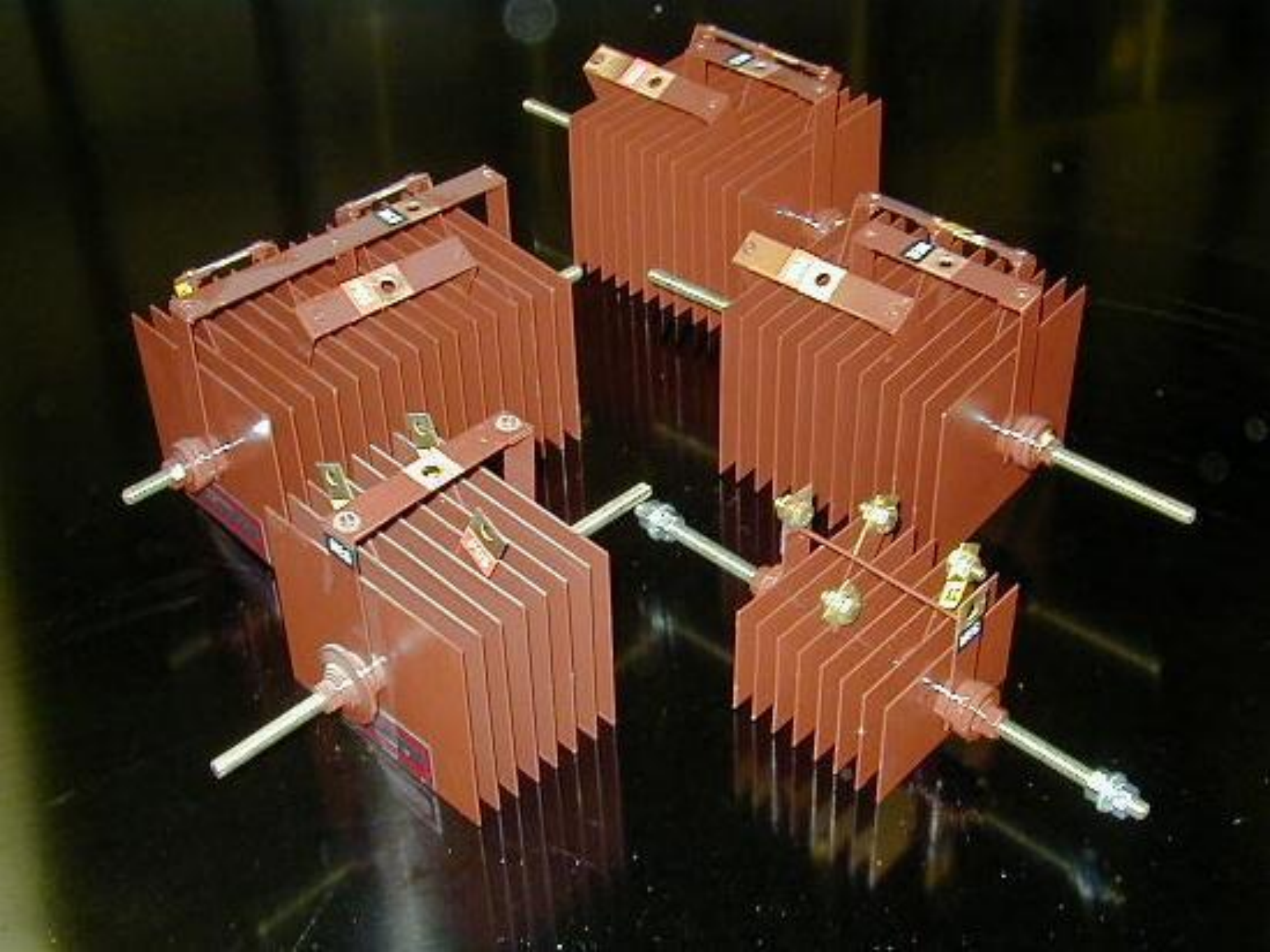
  Open - output will either be half its previous output or zero depending on whether half or the entire stack fails.

  Shorted - causes excessive currents, burn up wiring or the transformer if breaker does not trip in time.

Selenium Cells

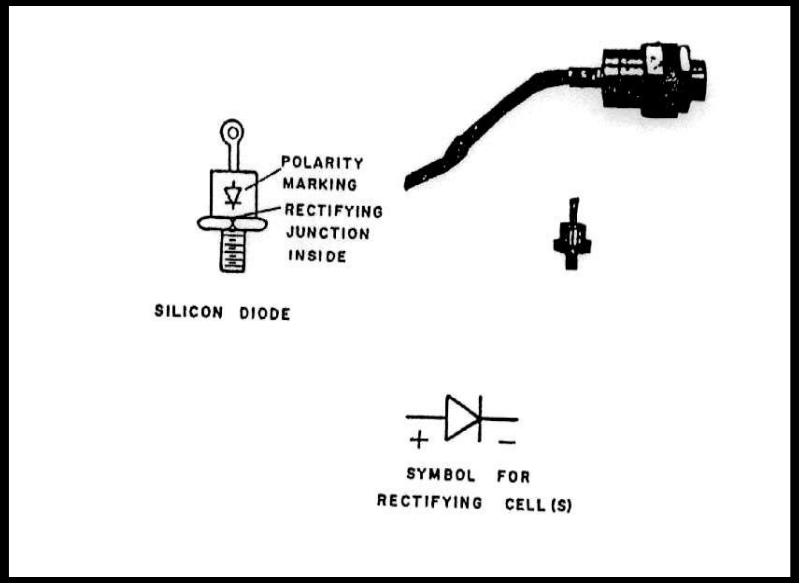
- Most economical in lower voltage circuit where current requirement not great.
- Aluminum plate with deposit of selenium crystals.
- Cells may be arranged on a stack in series or parallel or both to produce the desired voltage and current rating.
- **"Aging"** - gradual failure that decreases the output of the stack with same amount of AC.





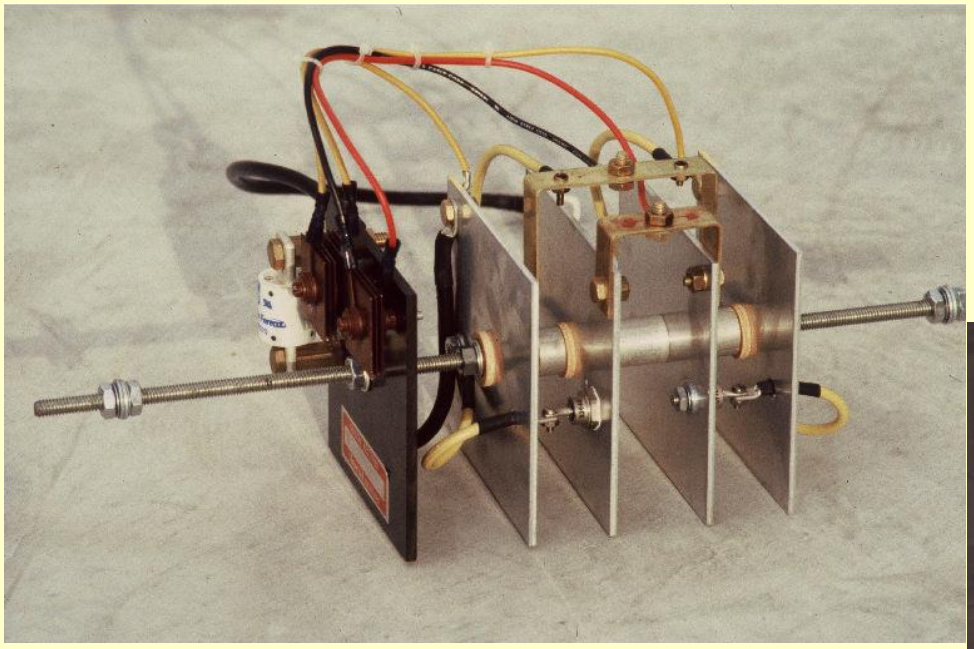
Silicon Diodes

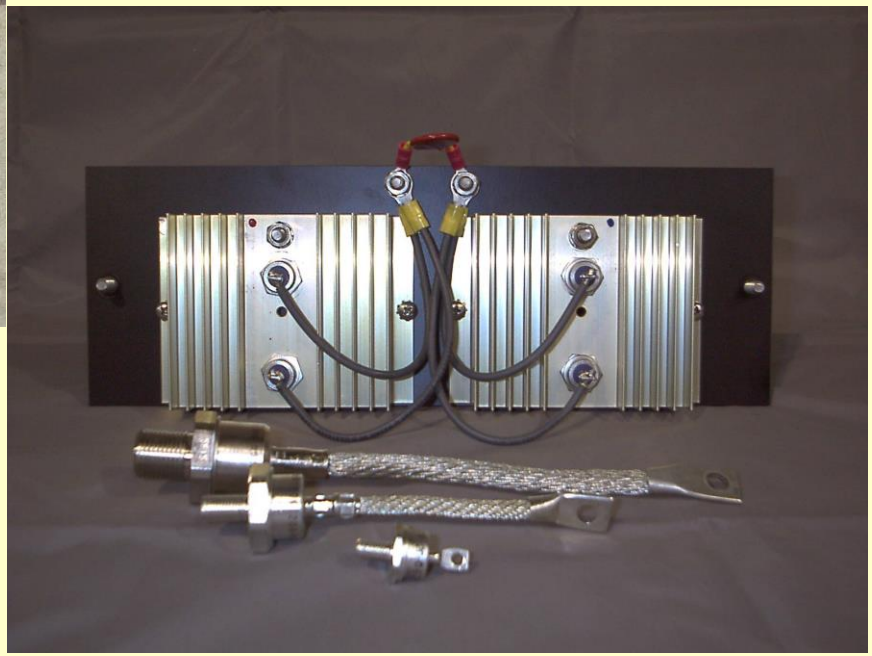
- Most economical in higher voltage and current circuits.
- Single crystalline. Single wafer sliced from a pure crystal of silicon.
- Hermetically sealed within a metal case and does not age.
- Mounted on a metal plate (heat sink) which draws heat away from the junction area.
- Power module stacks
- Single Phase: 4 diodes
- Three Phase: 6 diodes



< Typical Diodes

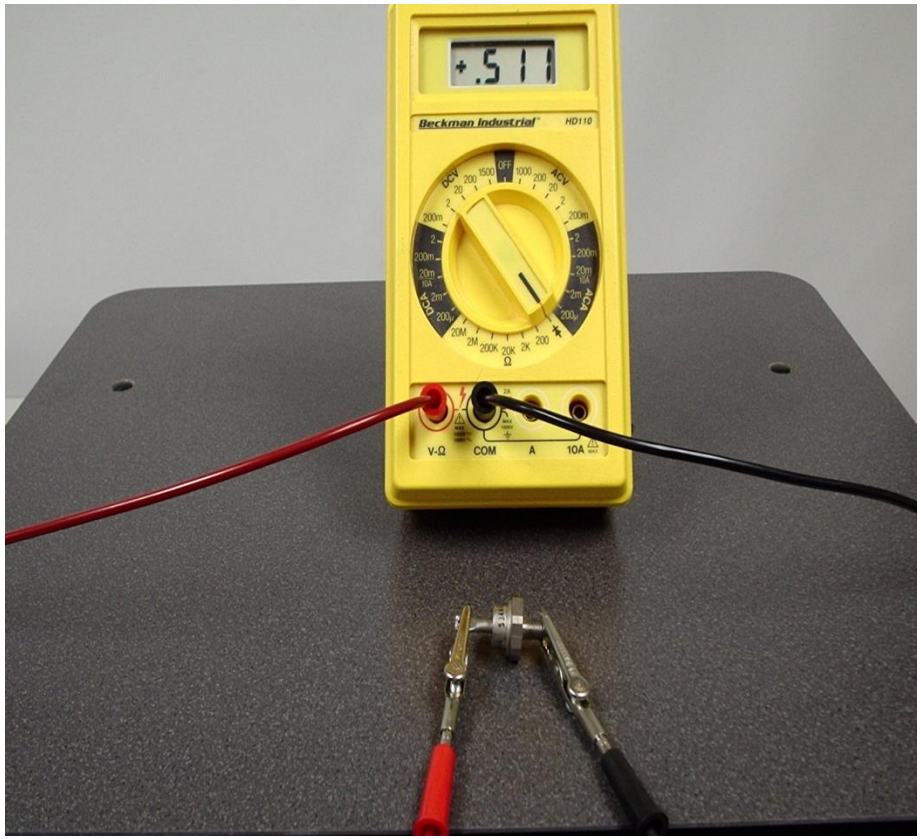
Modular Stacks >





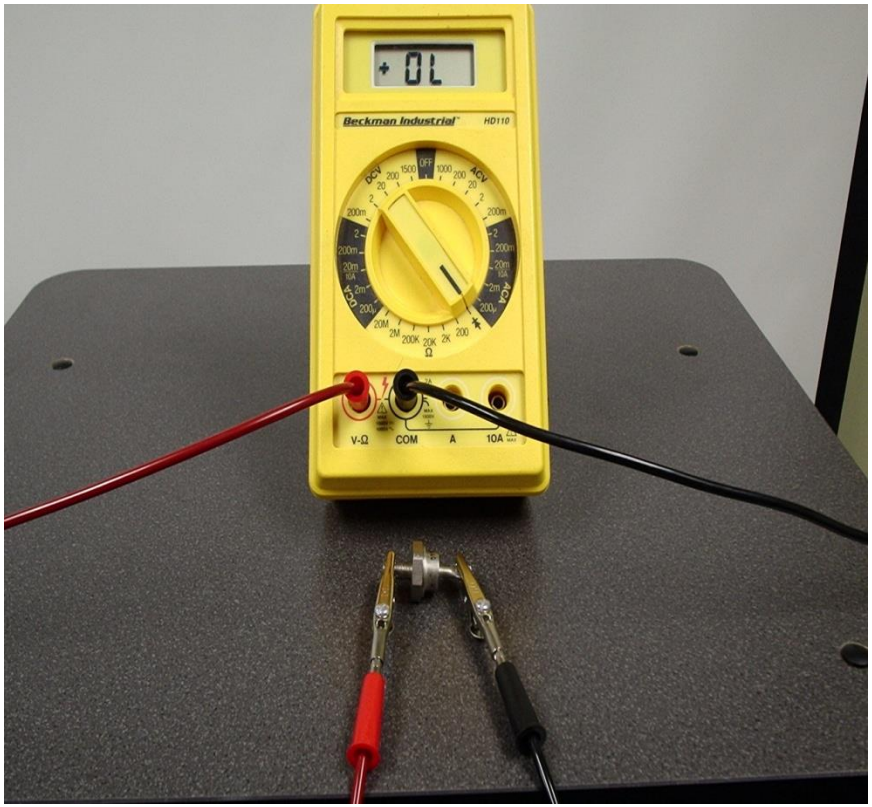
Silicon Diode Bridge Assembly

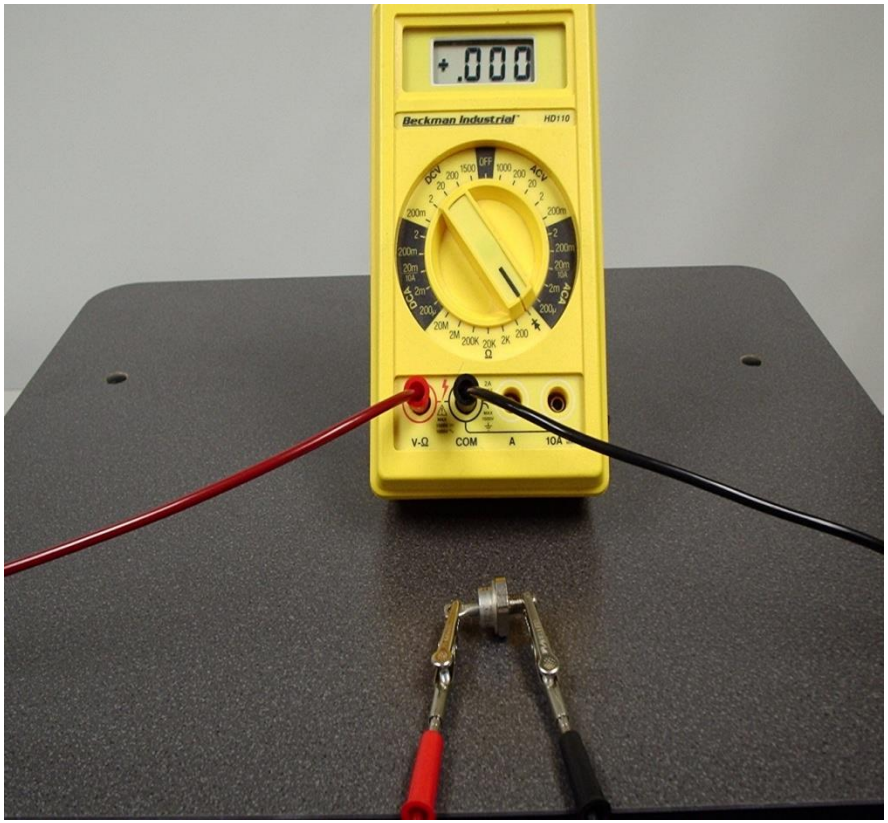
Checking Diodes



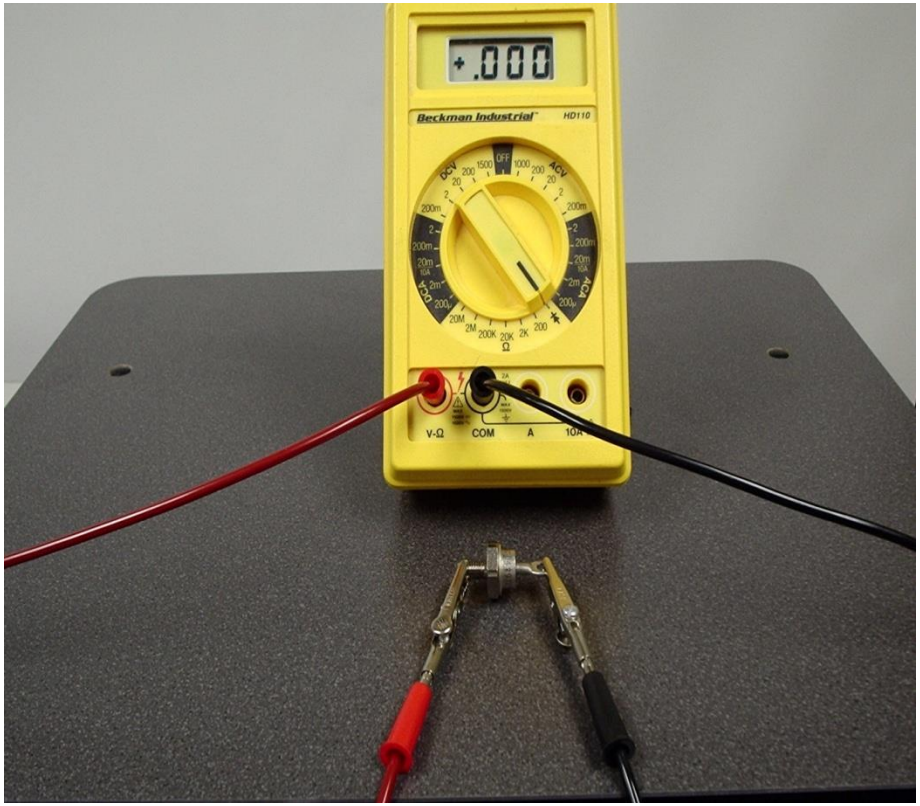
A good forward-biased diode displays a voltage drop ranging from 0.5 to 0.8 volts for the most commonly used silicon diodes. A forward-biased diode acts as a closed switch, permitting current to flow.

OL is displayed when a good diode is reversed biased. The OL indicates the diode is functioning as an open switch.

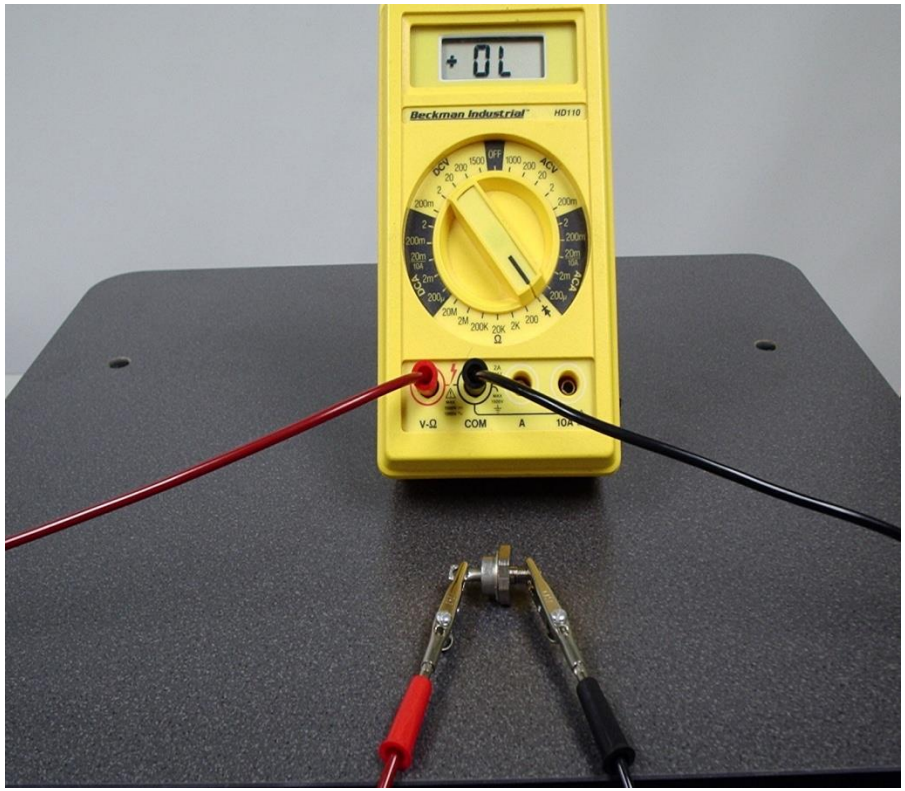




Checking Diodes

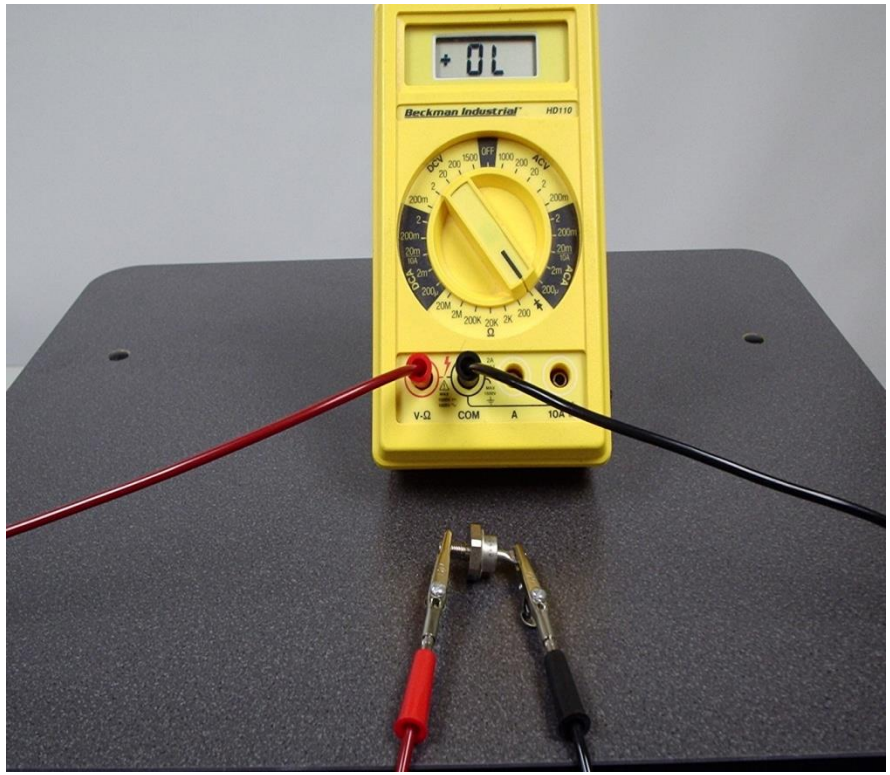


A shorted diode has the same voltage drop reading in both directions



Checking Diodes

A bad (opened) diode does not allow current flow in either direction. OL will be displayed in both directions.

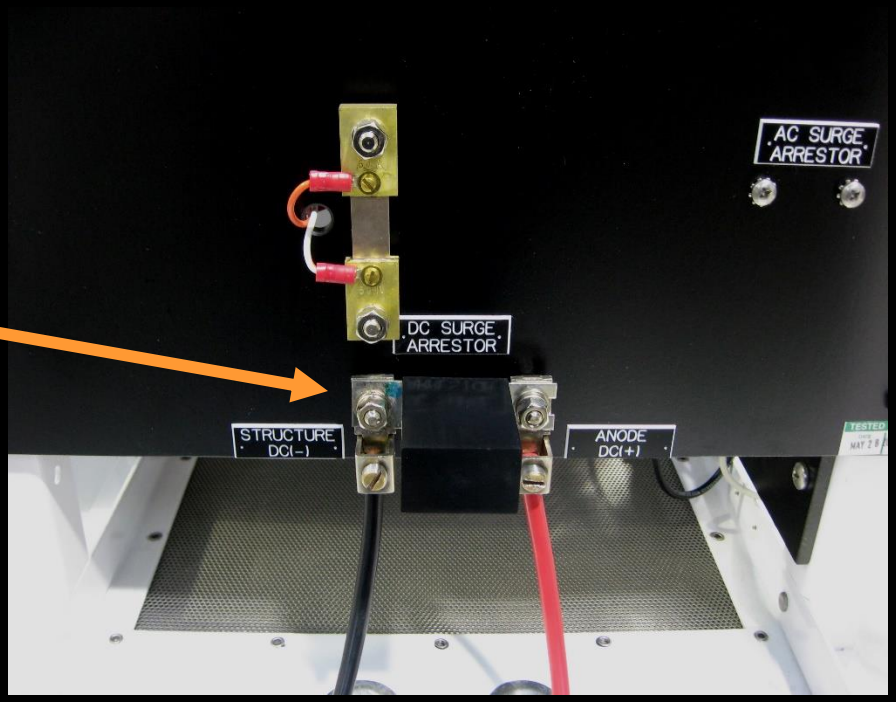


Turn Circuit Breaker Off

Remove Link Bars

Make sure secondary fuse is good or breaker is on

Remove Positive & Negative Leads

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FLUKE
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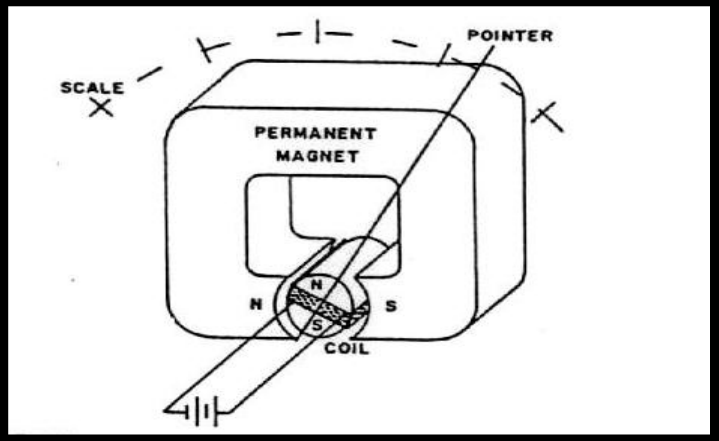
TESTED

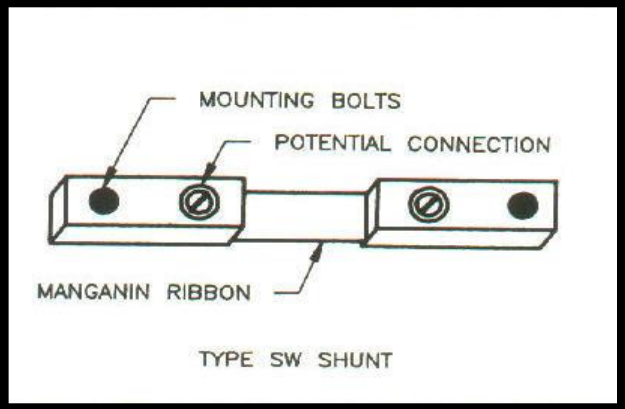
Meters



- Used to indicate the amount of DC voltage and current in the output.
- Coil of fine wire, permanent magnet, and pointer (form of DC motor).

- 50 MV full scale movement.
- Voltmeter - calibration resistors
- Ammeter - shunt installed
- Need to be temperature compensated.
- Meter switches good investment, usually push-to-read type.
- Use portable meter to verify readings.

Shunts



- A precisely calibrated resistor designed to drop 50 MV when the rated current flows through it.

- There are usually two quick methods of determining the current rating of a shunt in a rectifier:
  1) Check the ammeter for the FULL scale ampere rating, not the red line rating.
  2) Check the shunt itself. It will usually have its rating in amperes and millivolts stamped on it. Most rectifier shunts are calibrated for 50 millivolts.

Shunt Multiplier Table (50 MV Shunts)

Shunt Ampere Rating	Ampere Per Millivolt
10	.20
12	.24
15	.30
20	.40
25	.50
30	.60
40	.80
50	1.00
60	1.20
75	1.50
80	1.60

Fuses

- Consist of a low melting point metal element, which carries a specific amount of current.
- Quick blow rectifier fuses for silicon rectifiers:
  - Protects the diodes; will “open” very quickly.
  - Usually placed in the secondary of the transformer.
- Slower blowing fuses for selenium rectifiers:
  - Can withstand an overload for longer period of time.

Troubleshooting Basic

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

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


WARNING
IF YOU DON'T SCHEDULE TIME FOR MAINTENANCE, YOUR EQUIPMENT WILL SCHEDULE IT FOR YOU

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.

Troubleshooting Basic -
Precautions

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 breaker.

Troubleshooting Basic -
Precautions

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.

Troubleshooting Basic -
Precautions

3. Consult the rectifier wiring diagram before starting to troubleshoot. Will guide you through the internal working of the rectifier.

It is helpful to know the following:

a) what the circuit is supposed to do in normal operation.

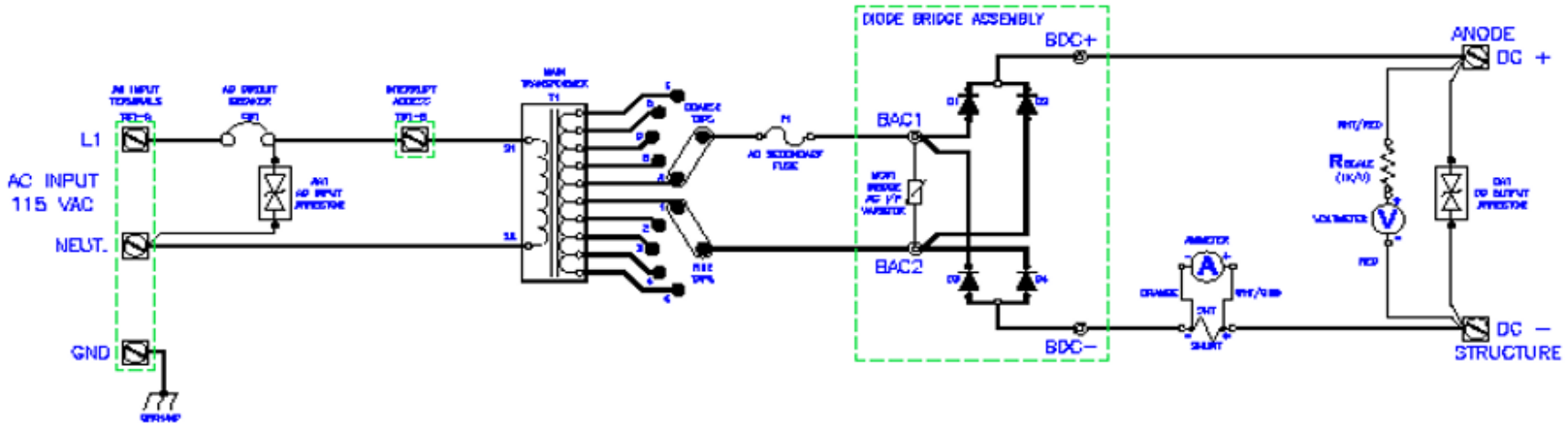
b) what each part or piece of equipment in the circuit contributes.

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 test.

This information is available in the rectifier manual.



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	SYM	DESCRIPTION OF REVISION	BY	DATE
07-08-01	B	ADDED INTERRUPT ACCESS	ER	07/01
	C	REV. DRAWING #: "AA1B1131	ER	05/131
	D	MOVED AC ARRESTOR	ER	10/03
N/A	E	GENERAL DRAWING UPDATE	ER	03/134
MTS				

Integrated Rectifier Technologies, Inc.

TITLE: ELECTRICAL SCHEMATIC – 115 VAC, 1-PHASE, TAP ADJUST, SINGLE RESALE

SHEET No. 1 of 1 | DRAWING NO. AA1-H1B131 | REV. E

Troubleshooting Basic -
Precautions

4. Make certain that the meters used in troubleshooting are properly connected.

a) Voltmeter - connected across the points where voltage is to be measured.
b) Ammeter - placed in series with the circuit being tested.
c) Millivoltmeter - connected across the terminals on the rectifier shunt.
d) Correct polarity must be observed when using DC instruments.
e) Turn the rectifier off before using an ohmmeter.

Troubleshooting Procedures

Most rectifier troubles are simple and do not require extensive detailed troubleshooting procedures.

Most common problems are:

a) blown fuses
b) faulty meters
c) loose terminals
d) open leads (ground bed, structure)
e) lightning damage

These troubles are usually found by a simple visual examination of the rectifier.

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:

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.

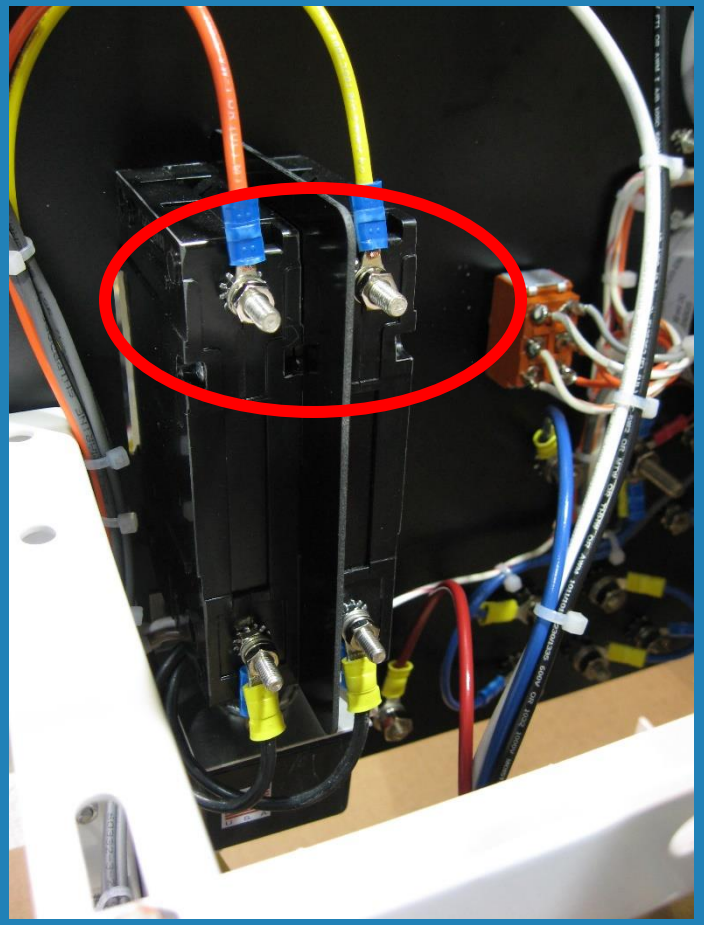
MOBILTEX

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


COARSE
FINE

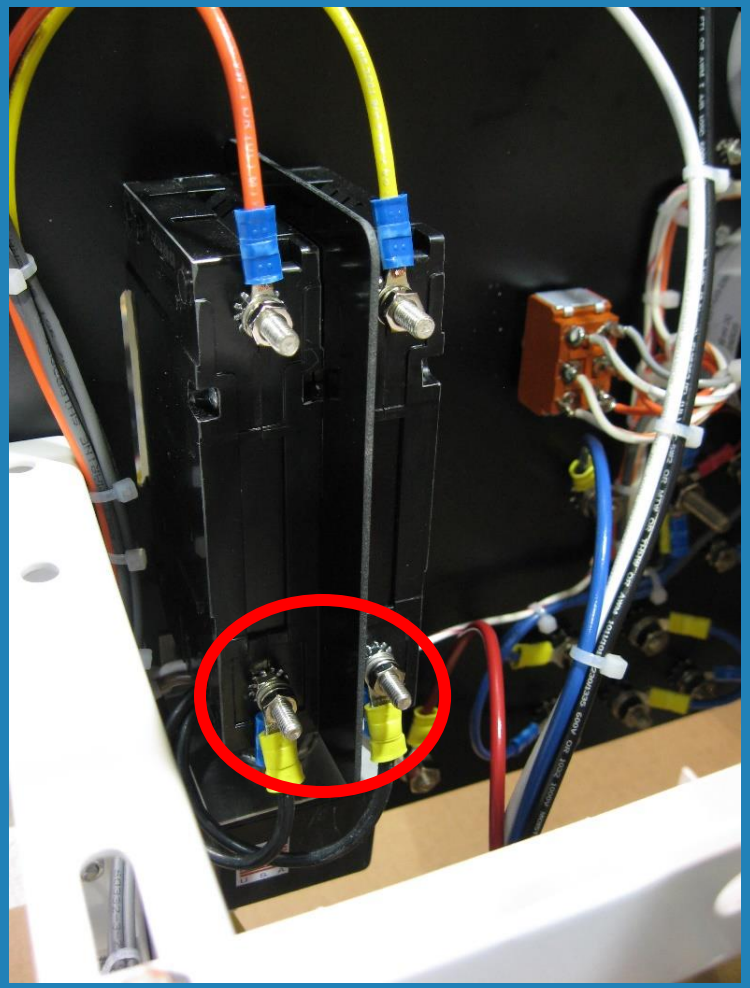


TROUBLESHOOTING - PROCEDURES

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)


COARSE
FINE

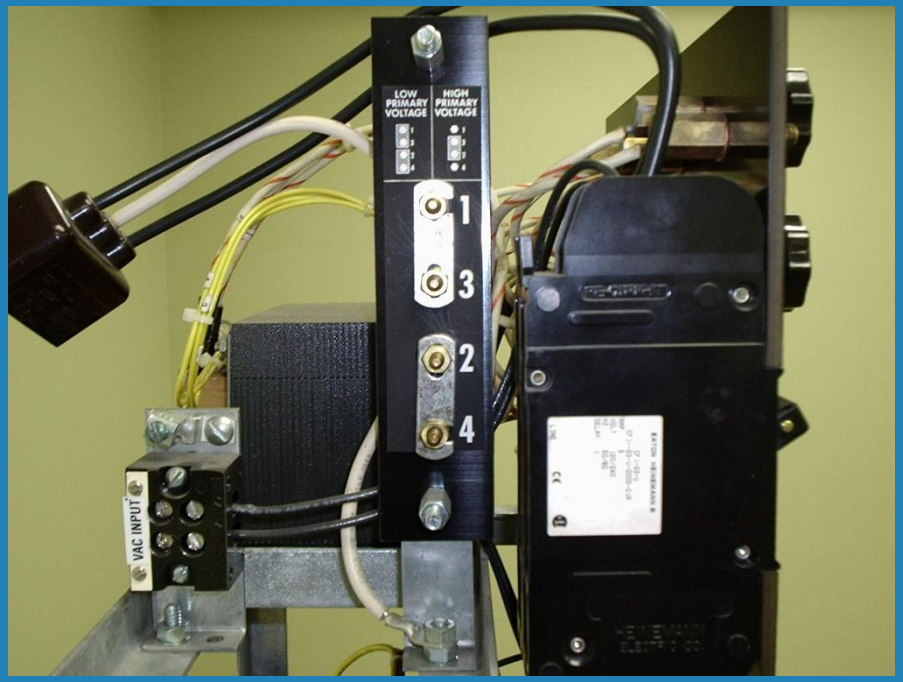


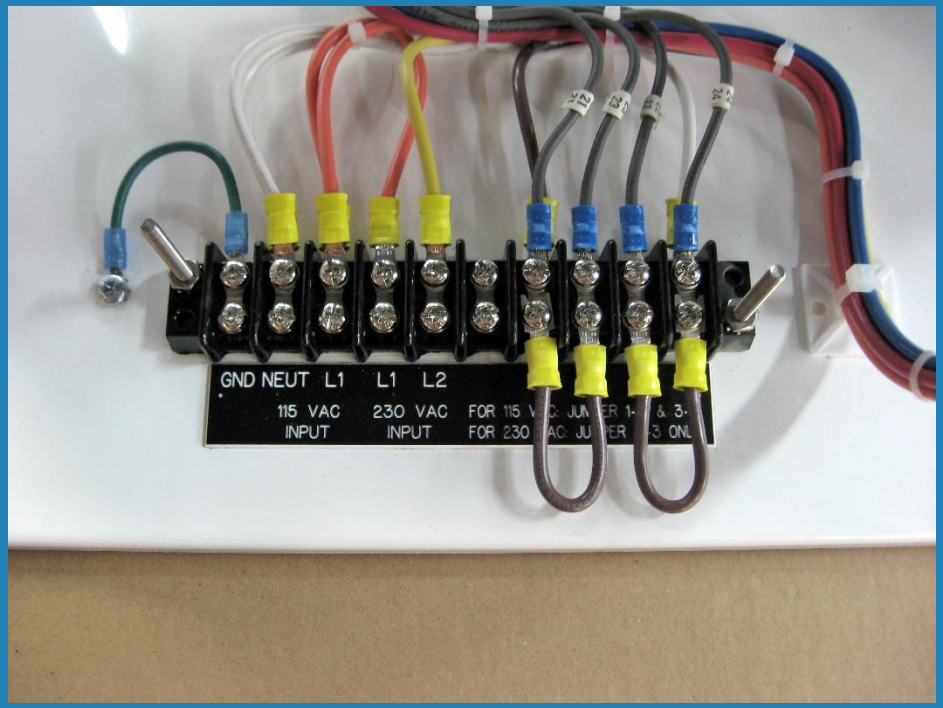
TROUBLESHOOTING - PROCEDURES

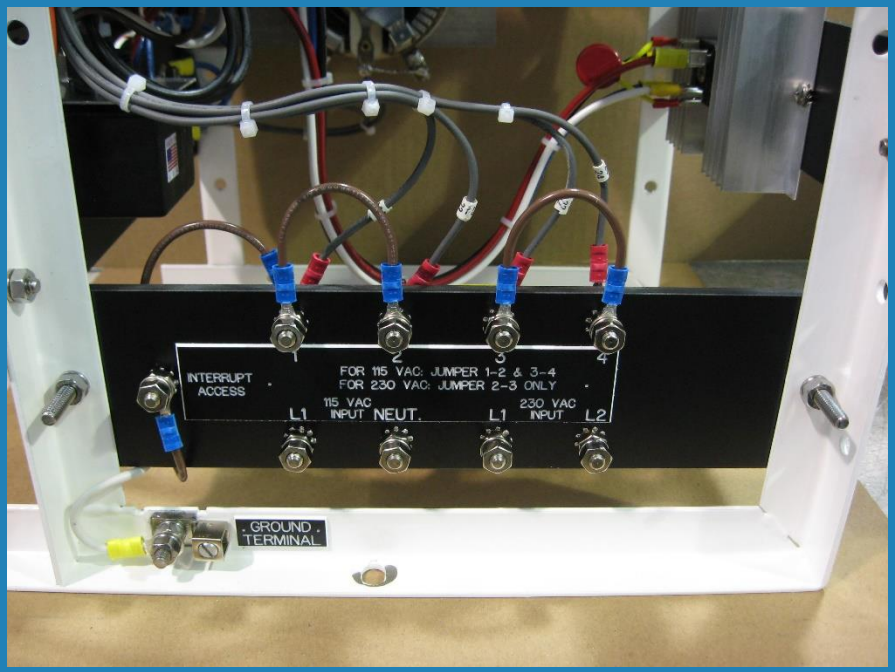
Step 3:

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


LOW PRIMARY VOLTAGE
HIGH PRIMARY VOLTAGE
1
3
2
4
VAC INPUT


GND NEUT L1 L1 L2
115 VAC INPUT
230 VAC INPUT


INTERRUPT ACCESS
FOR 115 VAC: JUMPER 1-2 & 3-4
FOR 230 VAC: JUMPER 2-3 ONLY
115 VAC INPUT NEUT.
L1
230 VAC INPUT
L2
GROUND TERMINAL

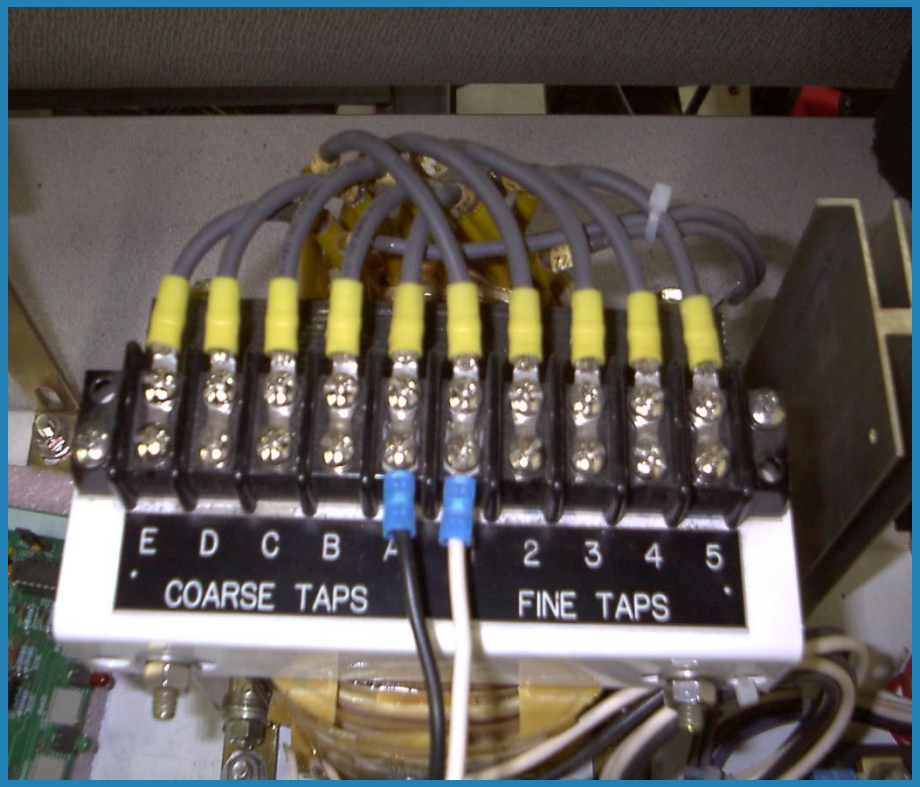
TROUBLESHOOTING - PROCEDURES

Step 4:

Check the transformer secondary winding:

a) Place the digital voltmeter (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.


C
B
D
A
E
TAPS
3
2
4
1
5
10 AMPERE
AC SEC. FUSE
VOLTMETER
ON
OFF
DC VOLTS
INTEGRATED RECTIFIER
TECHNOLOGIES, INC.
AMMETER


E D C B A
COARSE TAPS
2 3 4 5
FINE TAPS

TROUBLESHOOTING - PROCEDURES

Step 4:

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

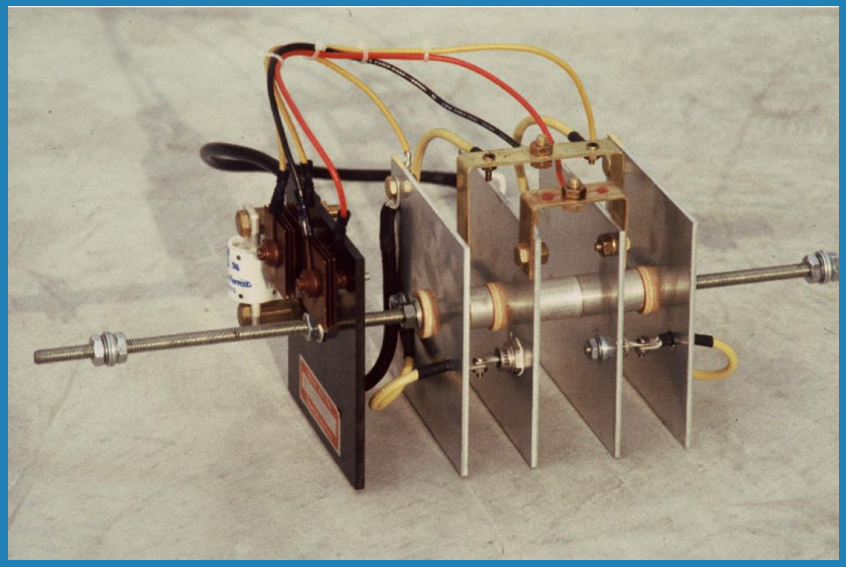
c) An equal, though lower, AC voltage should be measured between any two adjacent Fine tap terminals

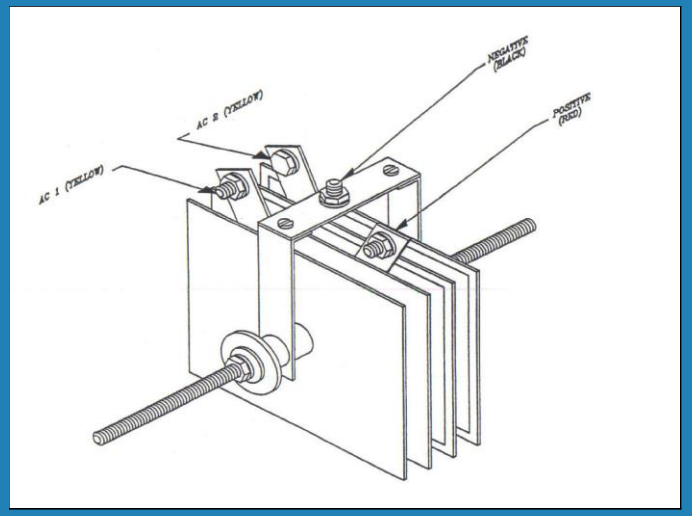
TROUBLESHOOTING - PROCEDURES

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

TROUBLESHOOTING - PROCEDURES





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)

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)

TROUBLESHOOTING - PROCEDURES

Step 8:

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

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

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)

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.

TROUBLESHOOTING - PROCEDURES

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

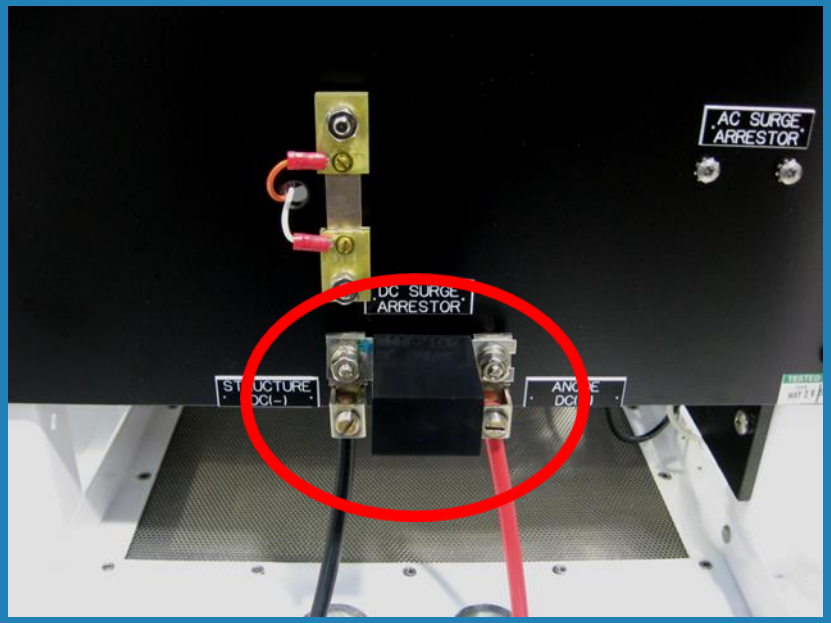
WARNING! Be aware of hazardous voltages and risk of electrical shock. Ensure to follow all safety precautions and use only approved testing devices.

MOBILTEX

TROUBLESHOOTING - PROCEDURES

Step 1:

If a DC Surge/Lightning Arrestor is present:



TROUBLESHOOTING - PROCEDURES

Step 1:

If a DC Surge/Lightning Arrestor is present:

a) Disconnect the DC surge arrestor from the circuit

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

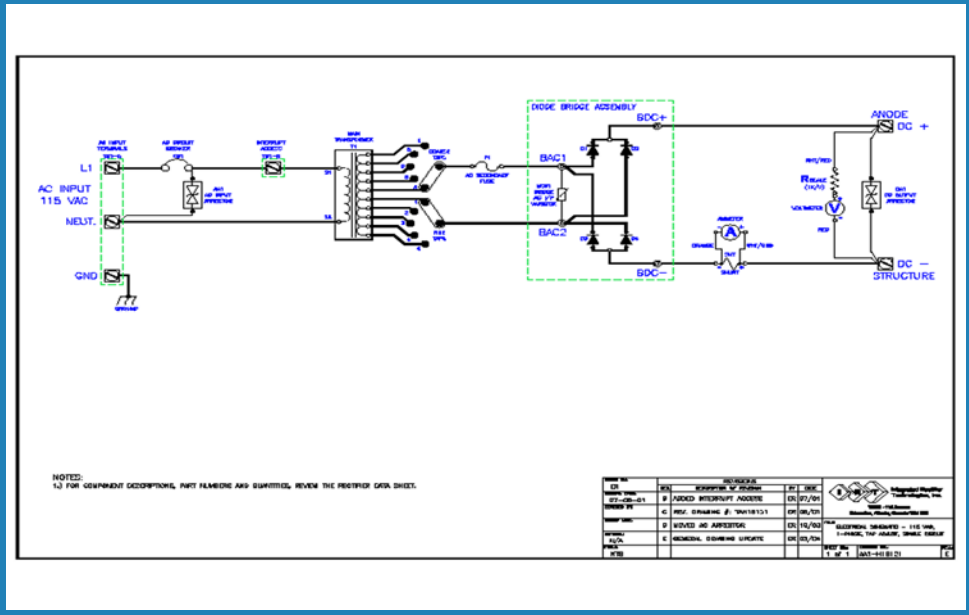
c) If the breaker does not trip, the short is likely within the arrestor and it should be replaced

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

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):



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

TROUBLESHOOTING - PROCEDURES

Step 3:

Isolate the Transformer from the DC circuit:

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

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.).

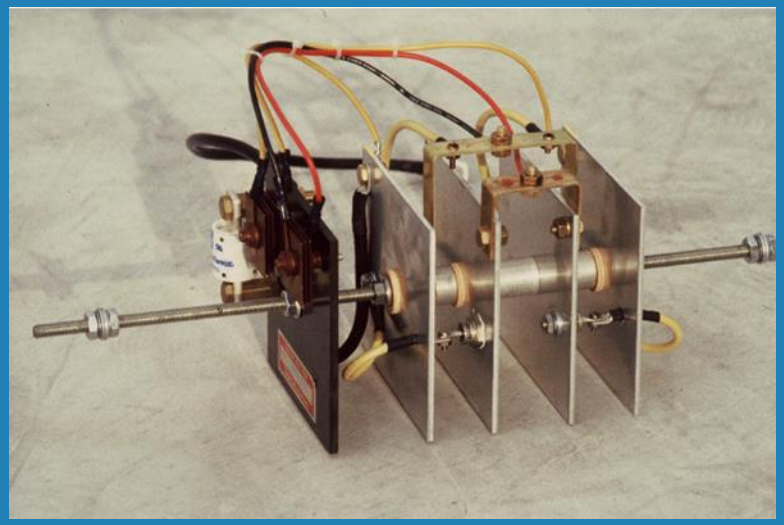
d) If the breaker does not trip, this indicates that the AC section of the rectifier is not an issue and the DC section should be investigated further, replace link bars and proceed to Step 4

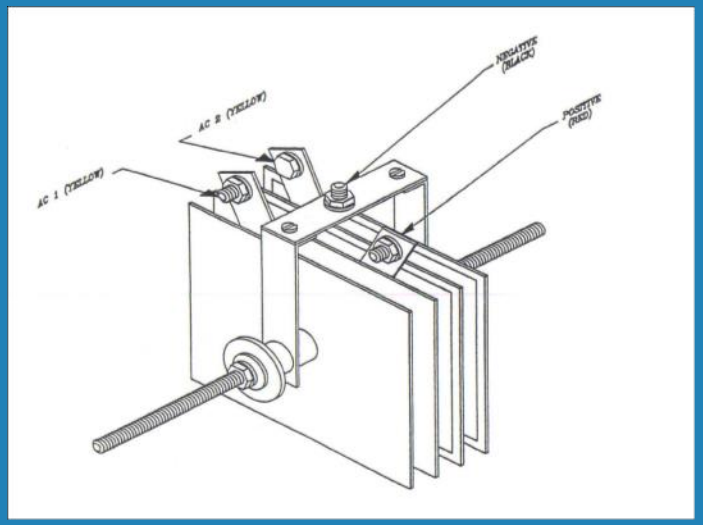
TROUBLESHOOTING - PROCEDURES

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





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

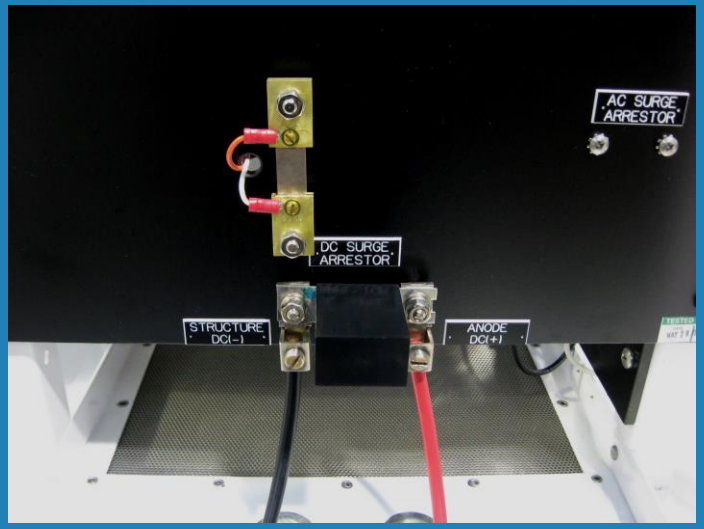
d) If the breaker does not trip, the short is likely between the external anode ground bed or structure leads

TROUBLESHOOTING - PROCEDURES

Step 5:

Isolate the External DC Load from the Rectifier:

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



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)

TROUBLESHOOTING - PROCEDURES

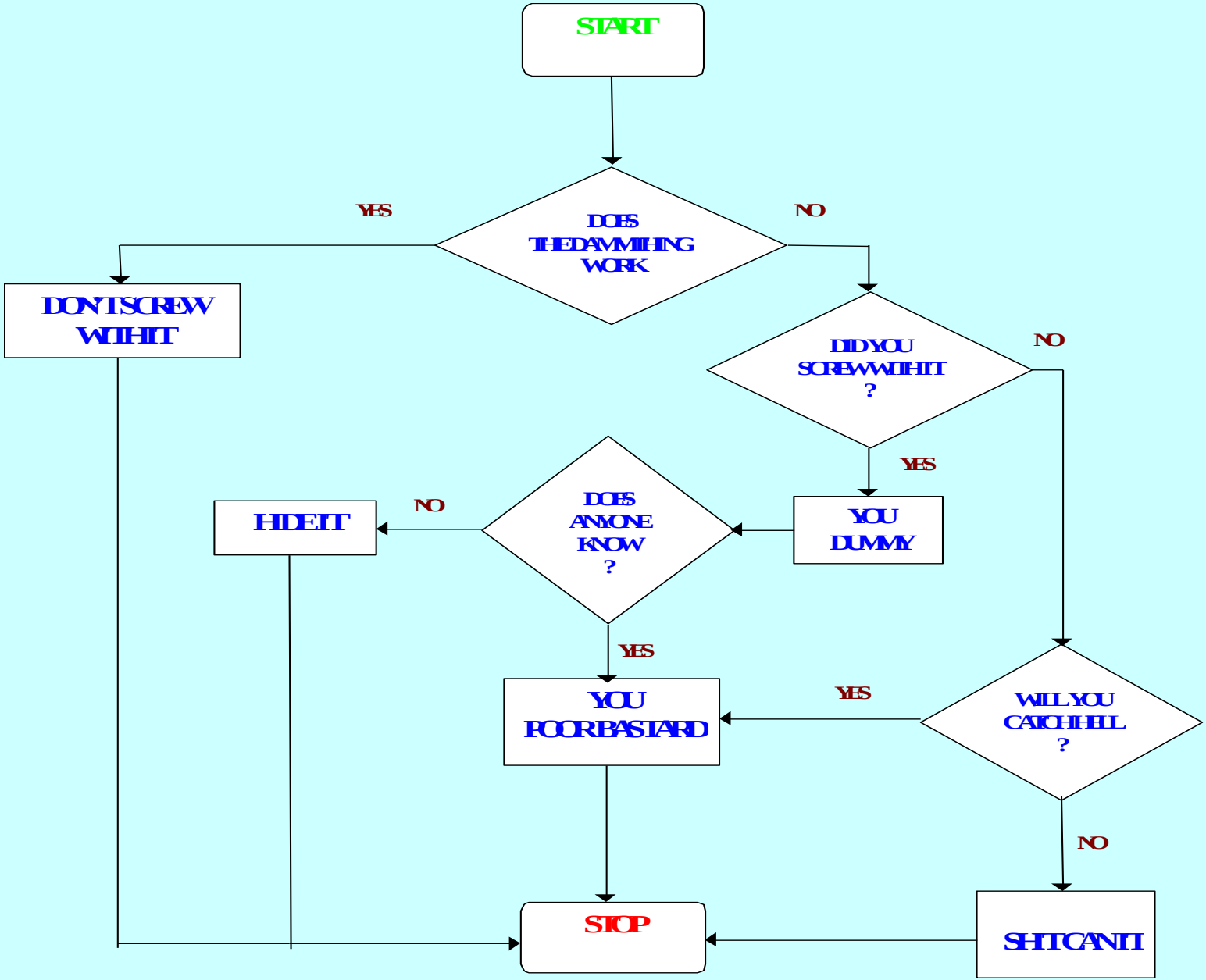
Step 5:

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)


START
DOES THE DAMMIHNG WORK
YES
NO
DON'T SCREW WITH IT
DID YOU SCREW WITH IT ?
NO
YES
DOES ANYONE KNOW ?
NO
HIDE IT
YOU DUMMY
YES
YOU POOR BASTARD
YES
WILL YOU CATCH HELL ?
NO
STOP
SHIT CAN IT