Basic Cathodic Protection Rectifier Training

By
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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

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Basic Cathodic Protection Rectifier Training

- ***General Safety Practices***
- ***Rectifiers and Their Applications*** – discuss styles, type and features.
- ***Basic Rectifier Theory*** – discuss rectifier component design and operation.
- ***Installation and Routine Maintenance*** – discuss proper selection of equipment and correct installation procedures.
- ***Troubleshooting Standard Units*** – discuss equipment needed along with step by step procedure for troubleshooting, what signs to look for and where to take readings.
- ***Hands-On Troubleshooting Standard Units*** – students analyze various problems on actual working rectifiers.

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Introduction

- This course depicts the basic principles of cathodic protection, the areas of use, and the electrical circuitry of the rectifier. Knowledge of all the above in necessary to allow the course to focus on the simple technical trouble-shooting procedures used to further assist the field service technicians.

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SAFETY FIRST

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

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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 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)*

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.

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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.

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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 with in the rectifier, it is recommended to use only one hand, if possible.

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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)

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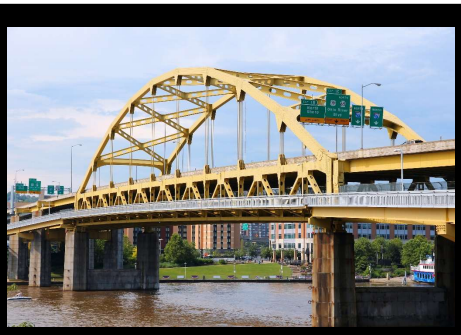

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Types Of Rectifiers

- The work horse of the cathodic protection industry is the standard tap-adjusted rectifier. However, this simple unit is not suited for every application.
- Cathodic protection rectifiers are available with specialized features and in various configurations.

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Air-Cooled Rectifier

- Unit and components enclosed in a steel enclosure.
- 1-3 doors which provide access to the unit for testing and repairs.
- Top and bottom have screening to allow the circulation of air.
- Can be wall, pole, or pedestal mounted depending on size and weight of unit.

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Air-Cooled Rectifier

- Typical Pipeline Rectifier
- Galvanized, Painted, Polyester Powder Coated Enclosure
- Slide-Out Racks
- 20 year Life Expectancy, Min

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Air-Cooled Rectifier

- Old style – components bolted to case
- Not easy to work on or repair

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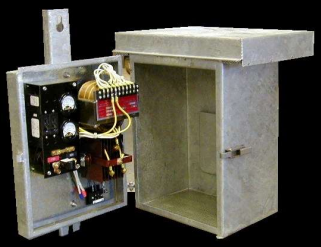
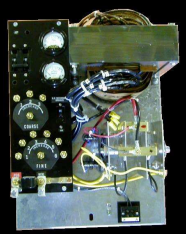
Air-Cooled Rectifier





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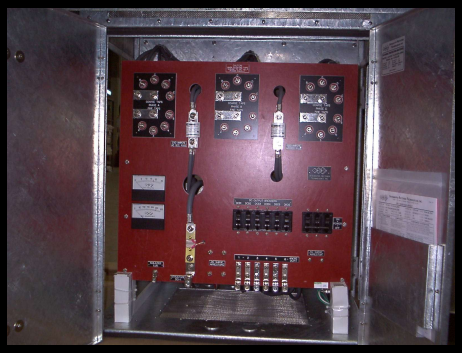
Air-Cooled Rectifier

- Three phase unit for high power requirements
- More efficient
- Base mounted



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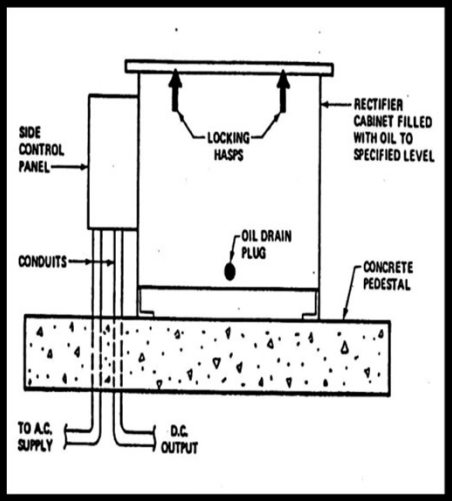
Oil-Cooled Rectifier

- Used in areas where dust, salt air, corrosive fumes, hazardous locations or excessive moisture are present.
- Rectifier and its components are installed in a steel enclosure and completely immersed in oil isolating it from extreme environments.
- Are normally pedestal mounted due to weight.



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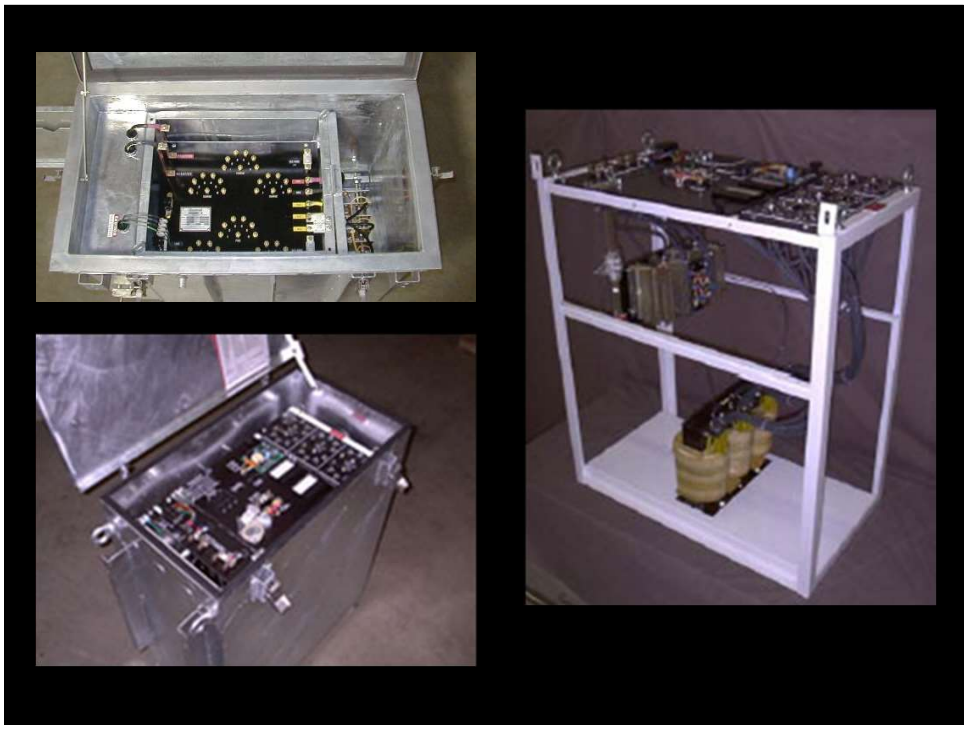

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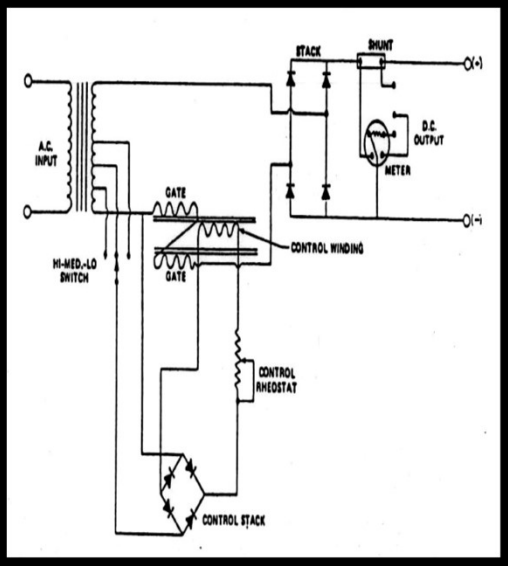
Constant Current Rectifiers

- Has a special circuit which enables the rectifier to provide a nearly constant current output regardless of load resistance.
- Used in applications where load resistance changes drastically and the output current would be exceeded with a normal rectifier.



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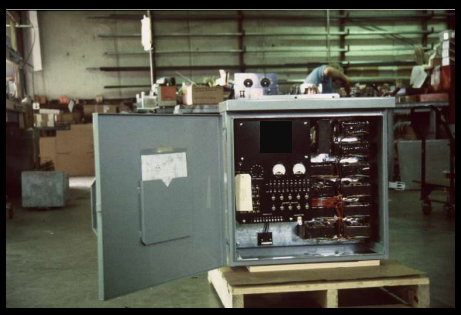

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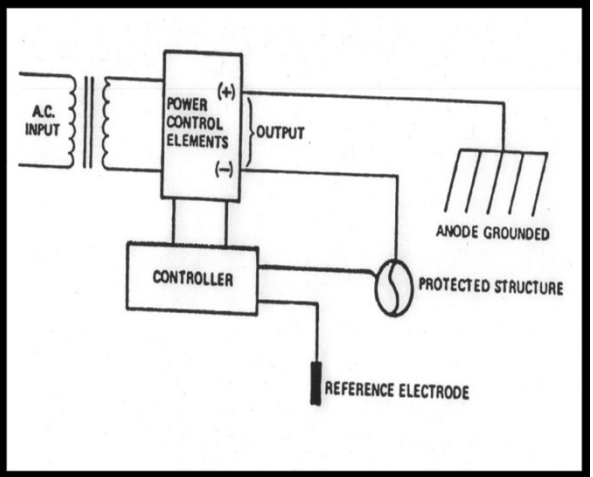
Automatic Potential Controlled

- Monitors the structure-to-electrolyte potential and maintains it at a desired level.
- Requires the use of a permanently installed reference electrode and an additional test lead wire connection to the structure. Both are connected to a microprocessor control board.
- The controller automatically adjusts the output voltage to keep the reference cell potential at a preset level.
- Very useful on water storage tanks, harbor structures, structures subject to stray currents.



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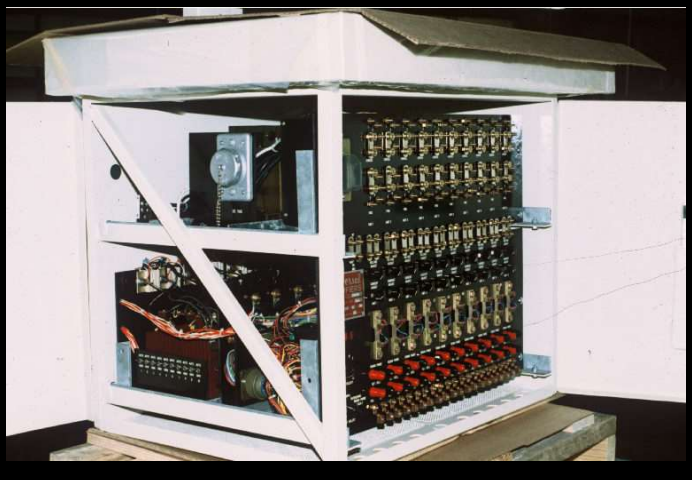
Bridge Deck Rectifier

(Rebar Cathodic Protection)



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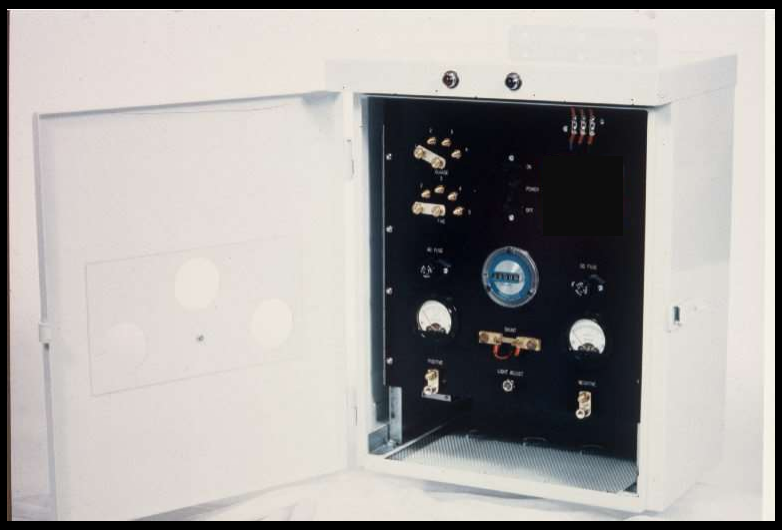
Service Station Rectifier



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Portable Test Rectifier

- Designed to provide an adjustable direct current source for determining the current requirements of cathodic protection systems.
- Housed in a box similar to a tool box and weighs about 76 pounds.
- Adjustable time interrupter

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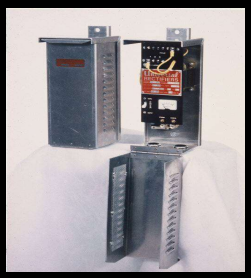
Small Utility Type

- Versatile, compact, and lightweight for any low power requirement.
- Air or oil-cooled cabinets.
- Manual or automatic potential control.



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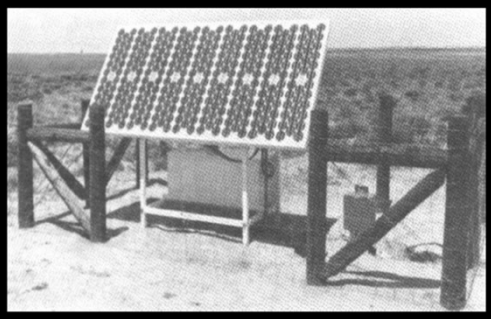
Solar Power Supplies

- Used in areas where conventional energy sources are not readily available.
- Solar array - converts light energy to DC power.
- Battery bank and controller regulator.



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Thermal-Powered Generators

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Thermal-Powered Generators

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Basic Rectifier Theory

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Cathodic Protection System Power Supplies

1. **Rectifiers** - most commonly used DC source for a cathodic protection system application. Converts AC power (taken from a distribution system) to DC power.
2. **Solar Cells** - units are used in areas where sunlight is available for a large percentage of the time. Solar cells convert sunlight to DC power.
3. **Wind Powered Generators** - these units are used in areas where a fairly constant breeze/wind is blowing. Wind drives a turbine assembly which in turn drives a generator assembly providing the input to a rectifier unit.
4. **Thermal Electric Generators** - produce power by direct conversion of heat into electricity utilizing fuel from tanks or from wellhead or pipelines.

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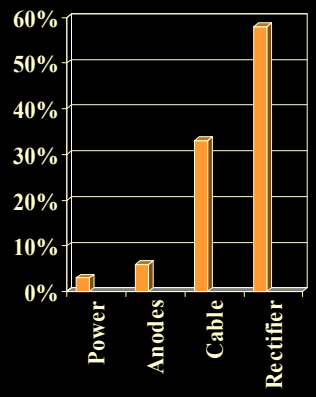
Causes of Cathodic Protection System Failures



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

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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

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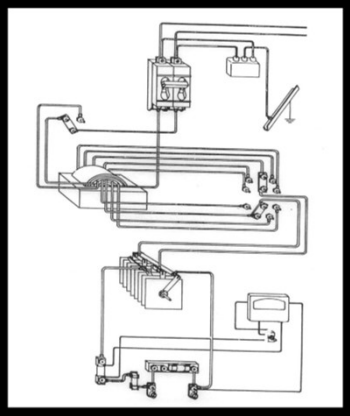
Typical Rectifier Components



Basic cathodic rectifier is a simple device.

Power Train consists 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 short circuit 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 and short circuit protection.

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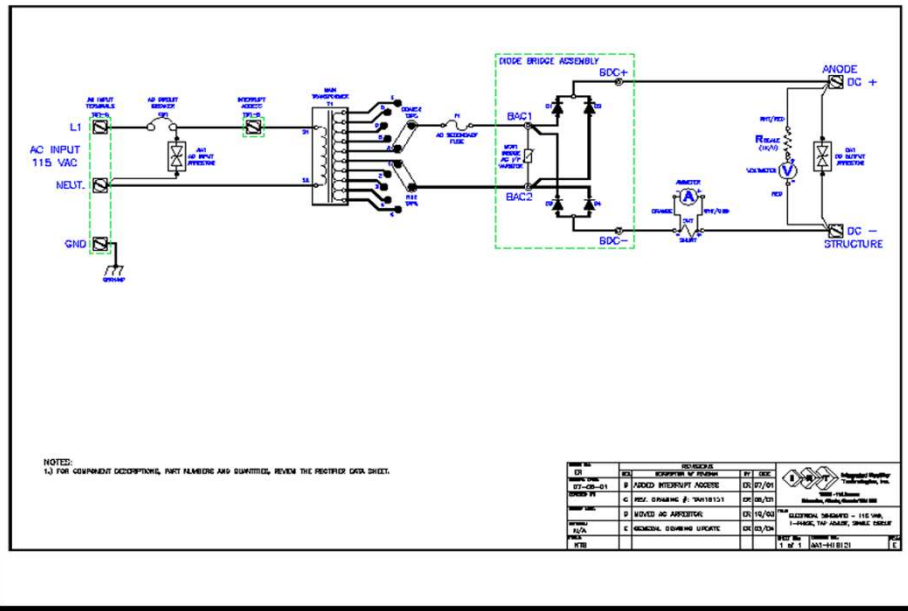

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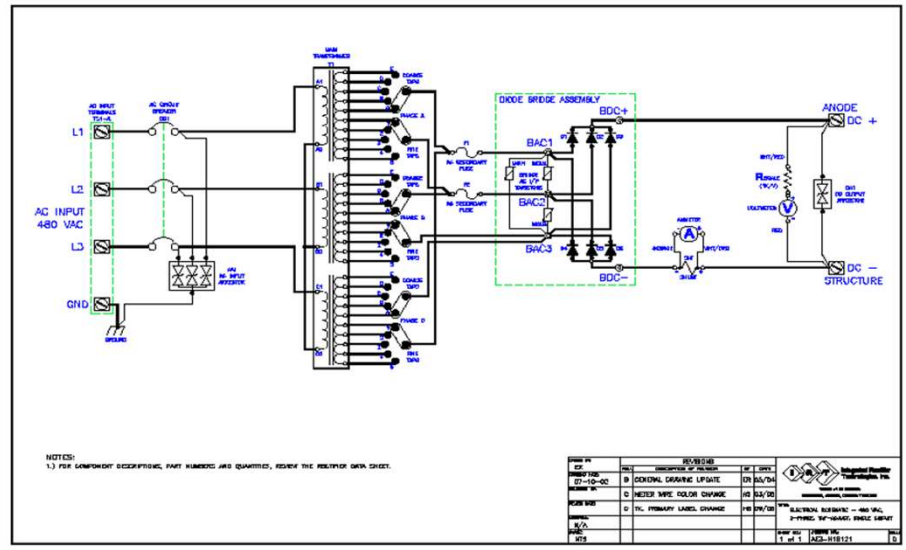

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Lightning Arresters

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

  Expulsion, Valve, and Silicon

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

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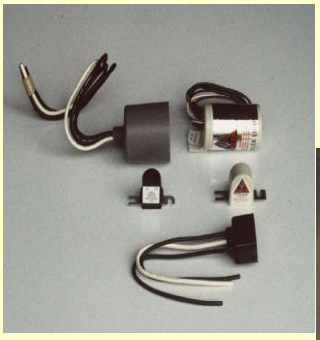

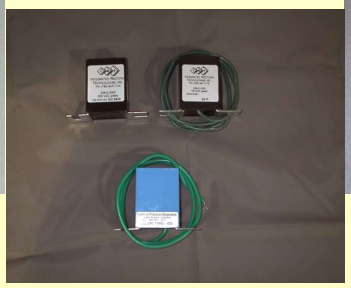

Typical Lightning Arrestors
(Cheap insurance, regardless of choice)

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Lightning Arresters Cont.

- The simplest form is the arc-gap:
  - A. High voltage surge ionizes air between two electrodes causing current to arc across a gap.
  - B. Condition continues until the voltage drops below the ionization level.

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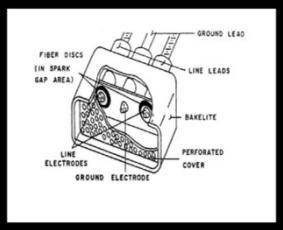
Expulsion Type Lightning Arresters



- Pair of line electrodes separated from a ground electrode by fiber discs.
- Discs break down arc into multitude of smaller ones, causing arcs to extinguish more quickly limiting or preventing damage to the arrester.

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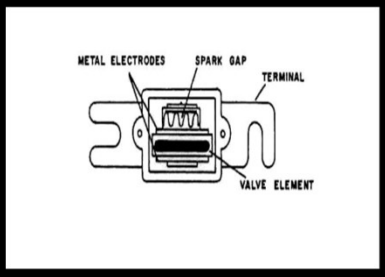
Valve Type Lightning Arresters



- Utilizes a resistive element (valve element) held between two metal electrodes, separated from a set of metal fingers by an arc gap.
- Arc jumps from fingers to nearest electrode.
- Valve element conducts current from one electrode to the other.
- Low impedance to extremely high voltages, high resistance to normal line voltages, prevents normal line voltage from arcing.

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Silicon Type Lightning Arresters

- Two or more electrodes surrounded by silicon oxide.
- Voltage surge across electrodes causes the silicon oxide to ionize and change from a compound to silicon. Large amounts of current flows.
- Converts back to silicon oxide and no longer conducts when voltage drops.

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Metal Oxide Varistors

- Used to protect silicon diodes, SCR's and other sensitive electronic components.
- Voltage sensitive resistors.
- React quickly to voltage surges and can conduct large amounts of current for short periods of time.
- Placed across the AC input and DC output of the stack.

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Circuit Breakers

- Primary function is to provide OFF-ON control, short circuit protection and input overload protection.
- Three basic types used in cathodic protection rectifiers:
  1. Fully Thermal
  2. Thermal-Magnetic
  3. Fully Magnetic

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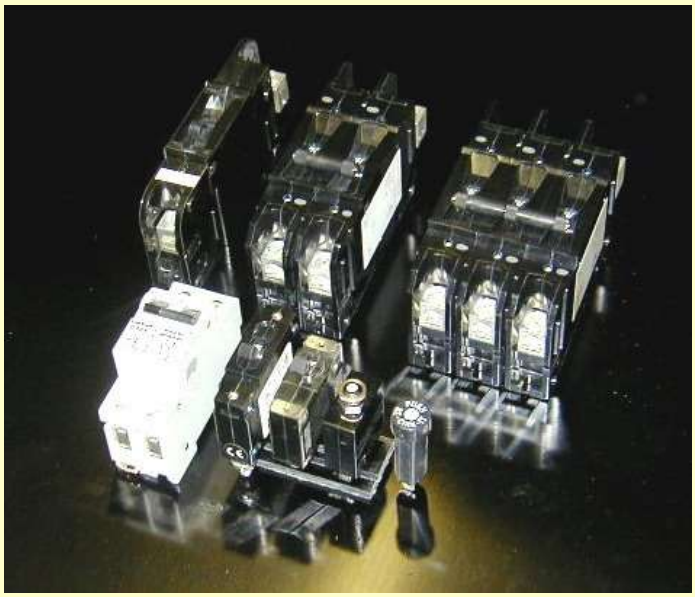

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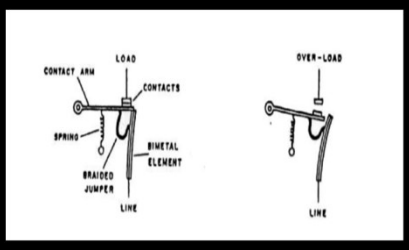
Fully Thermal Circuit Breakers



- Bi-metallic elements which carry current when the breaker is on.
- Rating exceeded, heat from the current causes metals to expand.
- Responds to heat, very sensitive to ambient temperatures.
- Opens more quickly on warm days than on cold days.
- Must cool before resetting.

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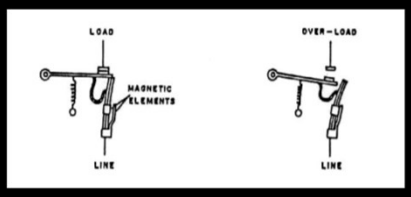
Thermal-Magnetic Circuit Breaker



- Operation nearly the same as the thermal breaker.
- Magnetic plate attached to the elements to speed the opening of the contacts during overloads.
- May be used on rectifiers equipped with interrupters. Slower reaction time.

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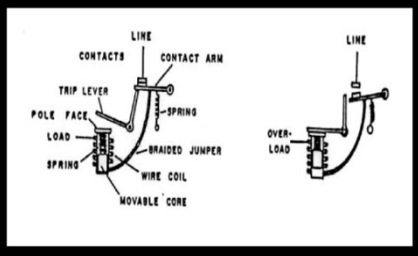
Magnetic Circuit Breakers



- More suitable for cathodic protection.
- Responds only to current overloads.
- Number of turns and wire size of a magnetic coil around a sealed tube determines current rating.
- Iron core retained by compression spring.
- During overload, magnetic action causes core to be drawn toward pole face.
- Independent of temperature.

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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).

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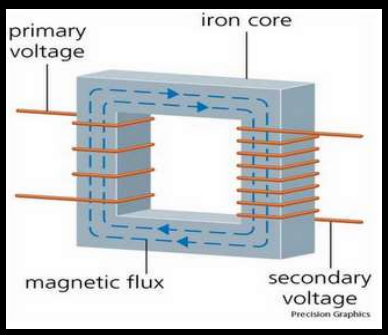
Transformer

- 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.

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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 and breakers tripping or fuses blowing.

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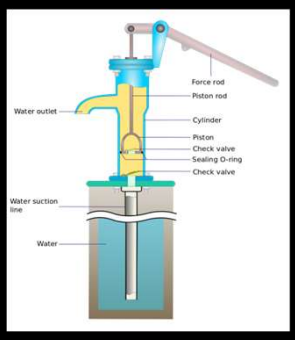
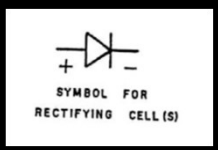
Rectifier Construction (CONTINUED)

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)





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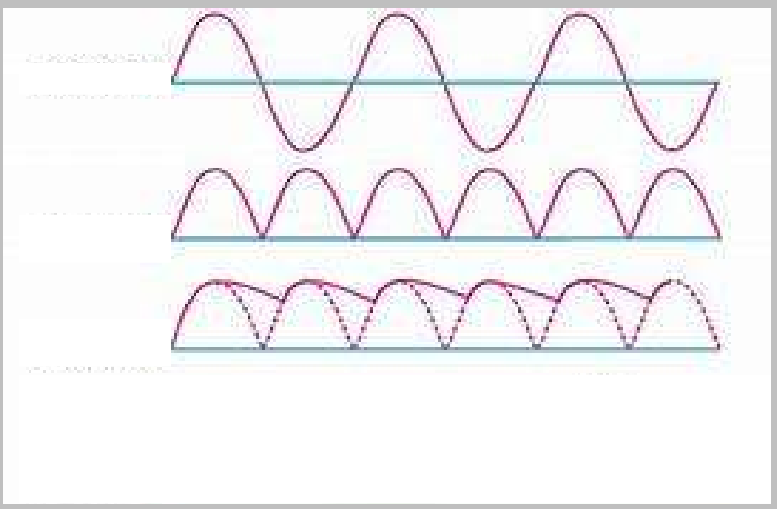
Rectifying Elements



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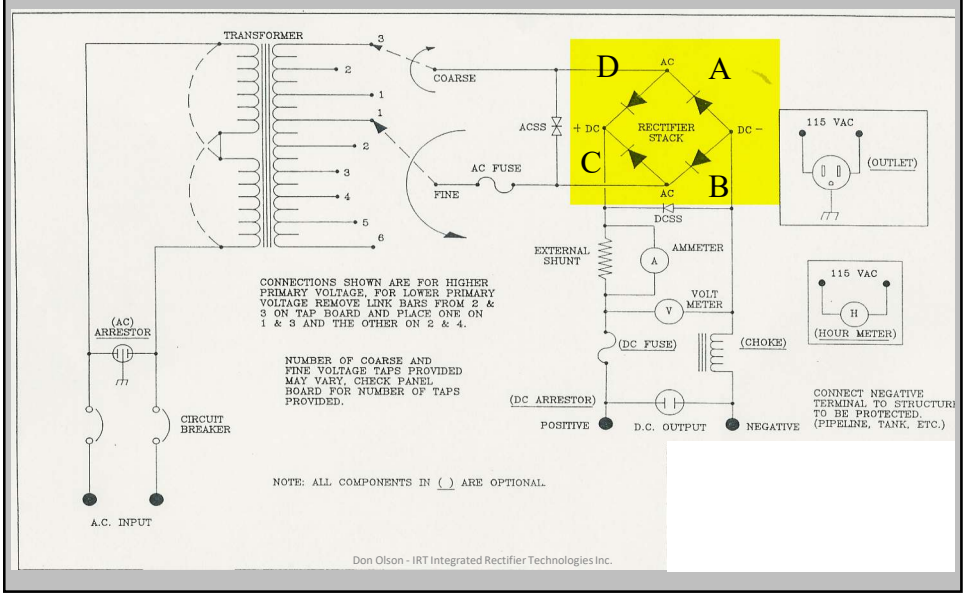
Rectified diode bridge



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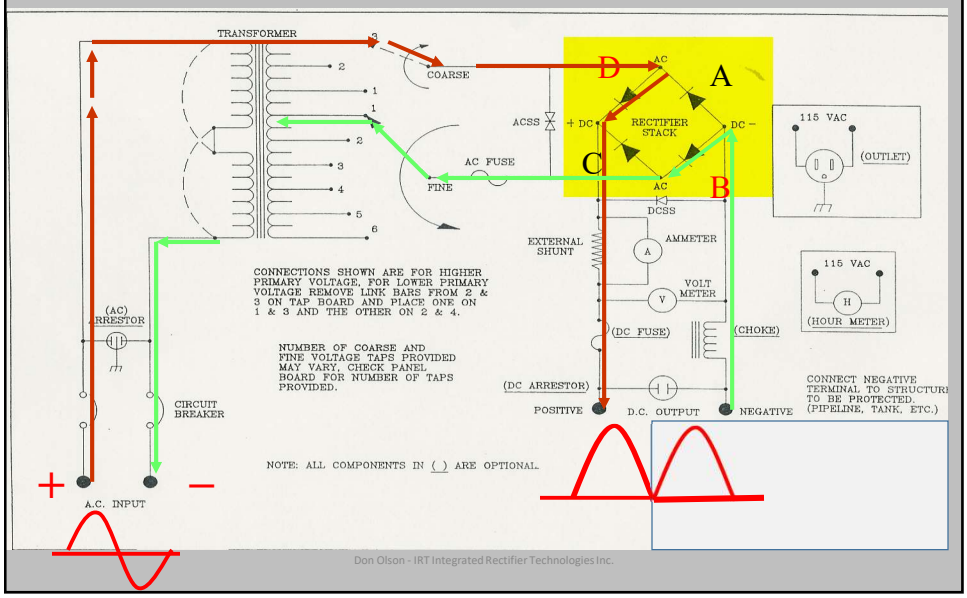
Rectified diode bridge



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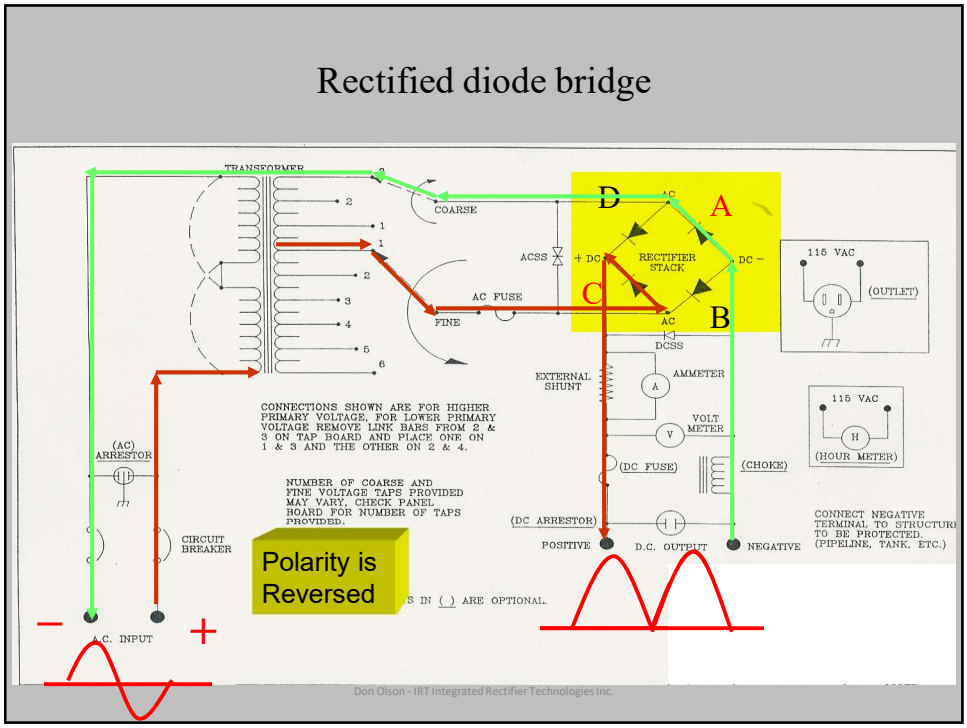
Rectified diode bridge



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Rectifying Devices 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.

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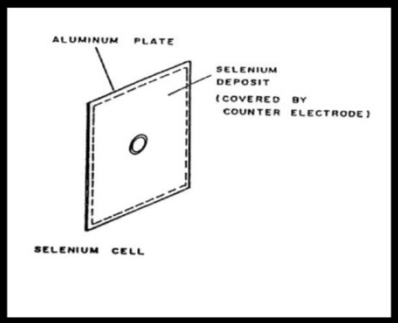
Selenium Cells

- 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.



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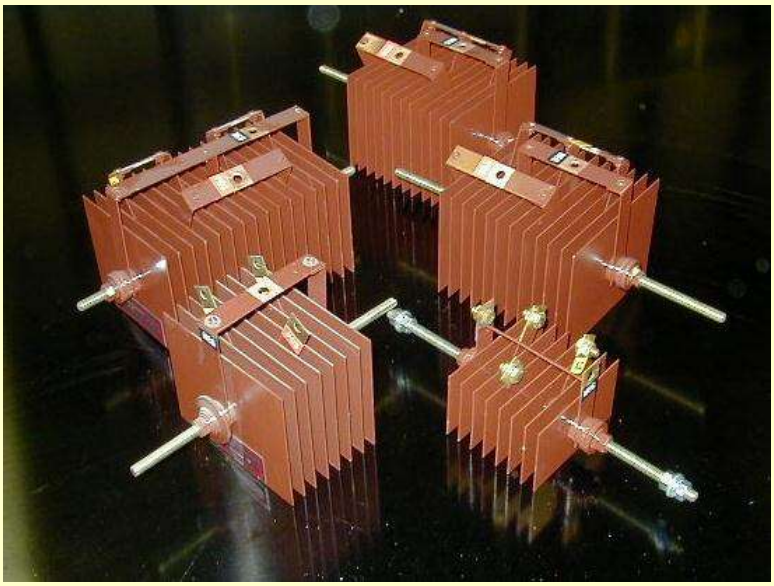

Selenium Stacks

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Tri-Amp STACK CODING SYSTEM

PREFIX LETTER SEE NOTE 1	C100	S	1	B	3	S	1	G

CELL SIZE	CELL SPACING		STACK CONNECTION	ELEMENTS (ARMS) PER RECTIFIER		TYPE OF MOUNTING NOTE 4	TYPE OF FINISH	REVERSE VOLTAGE PER CELL (RMS)
C6: 1" sq. C11: 1.3" sq. C16: 1.6" sq. C25: 2" sq. C44: 2.6" sq. C60: 2.3" x 4" C100: 4" sq. C133: 4" x 5.3" C200: 4" x 8" C266: 8" x 5.3" C401: 4" x 16" C402: 8" x 8" C600: 8" x 12" C800: 8" x 16"	F: Fan 800&1100 LFM or oil Immersion S: Standard or Fan 500 LFM	NUMBER OF SERIES CELLS PER ELEMENT (ARM)	H: Half Wave B: Bridge C: Center Tap (+) J: Center Tap (–) D: Doubler HA: 3 Phase Wye (Half Wave +) HB: 3 Phase Wye (Half Wave –) BA: 3 Phase Bridge CA: 3 Phase Center Tap (6 Phase star) SEE NOTE 3	1 4 2 2 2 3 3 6 6	NUMBER OF PARALLEL CELLS PER ELEMENT (ARM)	E: Eyelet G*: Bracket (One end) H*: Bracket (Both ends) S: Stud *NEMA standard	1. Standard 2. Extra 3. Marine 4. #2 plus Fungicide 5. #3 plus Fungicide 6. #1 plus Fungicide	A: 18 Volts G: 26 Volts H: 30 Volts K: 33 Volts L: 36 Volts P: 45 Volts

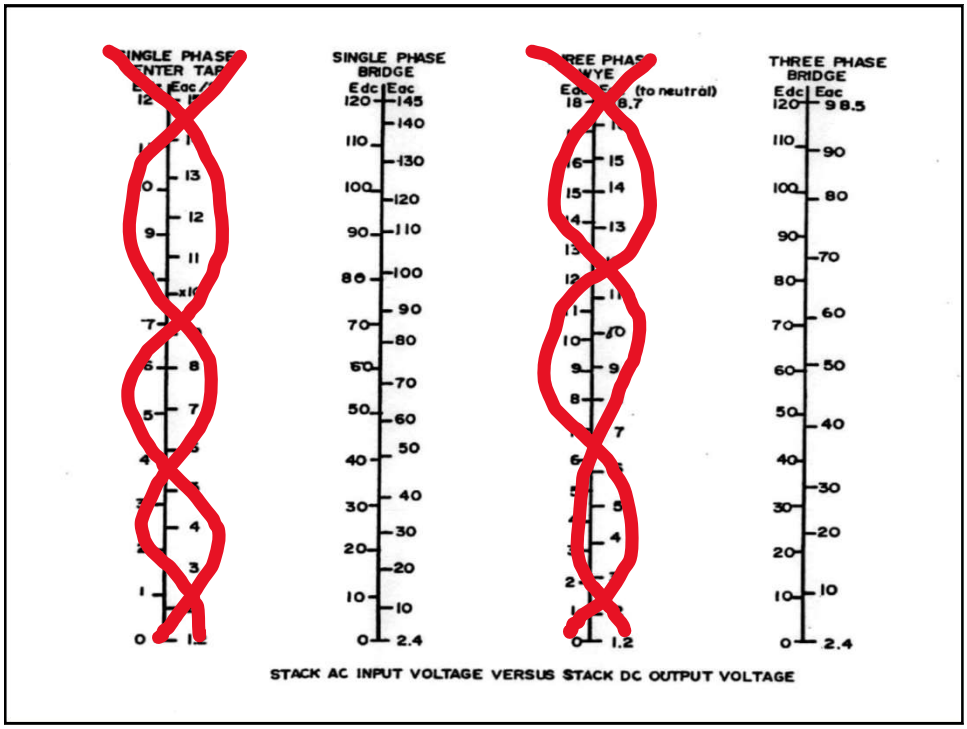
NOTE 1: Prefix "C" indicates Tri-Amp 26V, 30V and 33V cells
Prefix "GT" indicates Tri-Amp 36V, 40V and 45V cells
No prefix indicates older double density types

NOTE 2: Standard NEMA Date Code Symbol:
Numeral indicates year of manufacture: 0 = 1970, 1 = 1971, etc.
Letter indicates month of manufacture: A = Jan., B = Feb., C = Mar., D = April, E = May, F = June, G = July, H = Aug., J = Sept., K = Oct., L = Nov., M = Dec. For example: 0A is Jan, 1970, 1J is Sept., 1971. (Letter "I" is not used.)

NOTE 3: TOTAL NUMBER OF CELLS PER STACK = NUMBER OF ELEMENTS (ARMS) x CELLS IN SERIES x CELLS IN PARALLEL
Example: C100S1B3S1G 1 x 4 x 3 = 12

NOTE 4: Standard terminals supplied for C6 thru C44 are solder type. For screw type terminals, in coding, insert the numeral "1" after designation for Type of Mounting, and before numeral designation Type of Finish.
Example: C6S1B1S11G underlined numeral "1" is inserted to indicate screw type terminals.

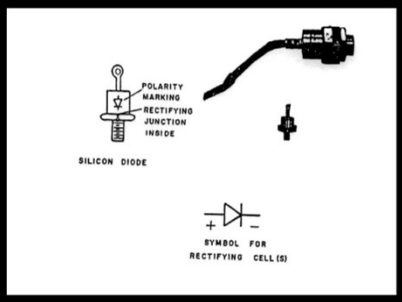
70



71

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.
- Diode Bridge Modules
- Single Phase: 4 diodes
- Three Phase: 6 diodes

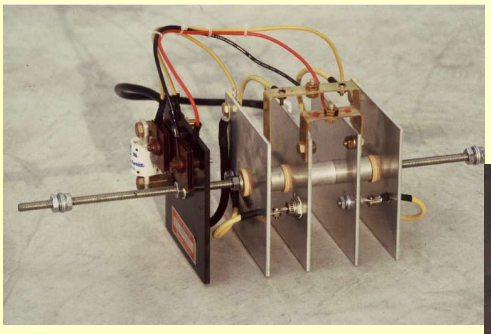


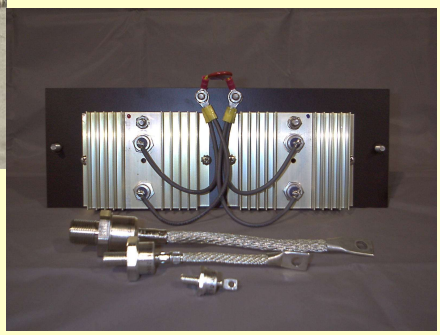
72

< Typical Diodes

Diode Bridge Modules >

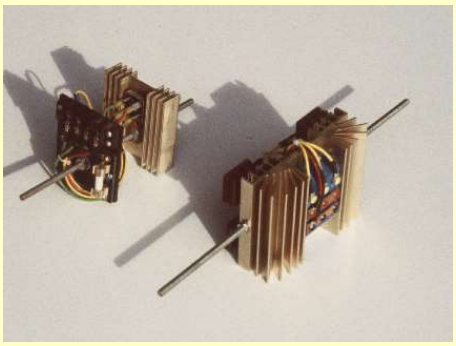
73





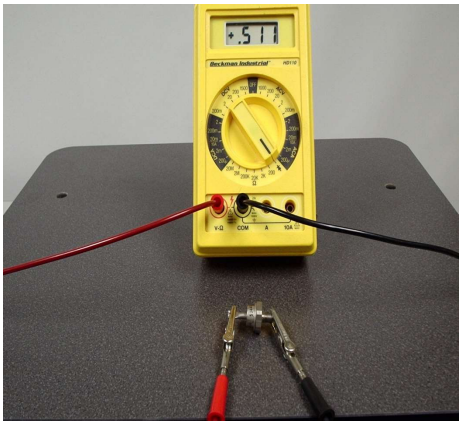
Silicon Diode Bridge Assembly

74

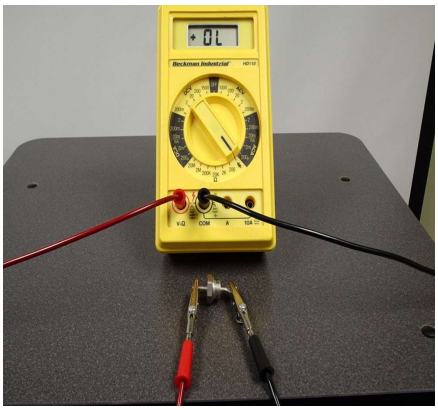


Diode Modular Bridge Assemblies

75



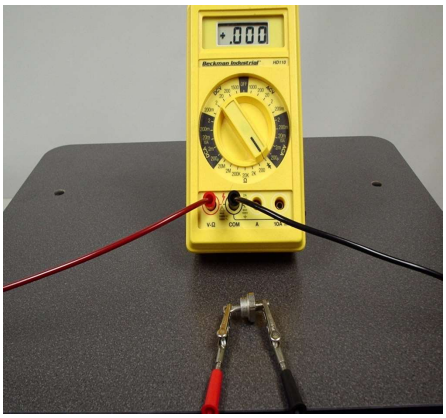
Checking Diodes



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.

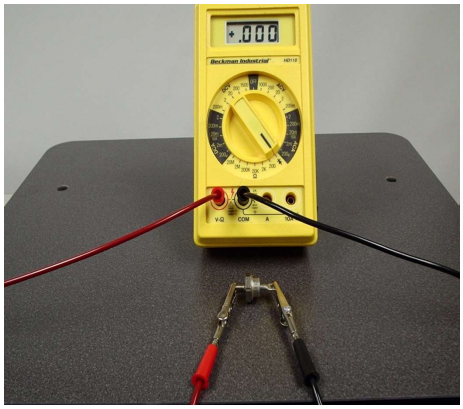
OL is displayed when a good diode is reversed biased. The OL indicates the diode is functioning as an open switch.

76

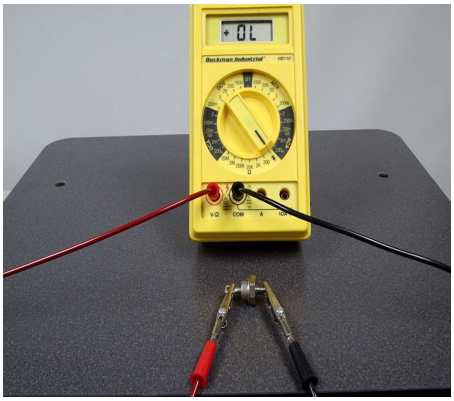


Checking Diodes

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

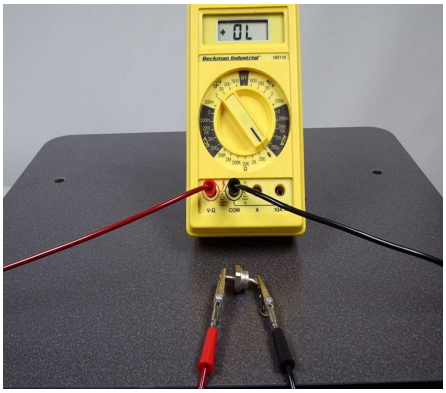


77



Checking Diodes

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



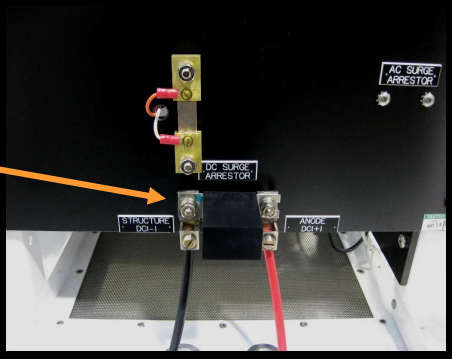
78

Turn Circuit Breaker Off

Remove Link Bars

Make sure secondary fuse is good or breaker is on

Remove Positive & Negative Leads



79

80


COARSE TAPS
FINE TAPS
INTEGRATED RECTIFIER TECHNOLOGIES, INC.
ON
POWER
OFF
AC SURGE ARRESTOR
DC SURGE ARRESTOR

81


COARSE TAPS
FINE TAPS
INTEGRATED RECTIFIER TECHNOLOGIES, INC.
ON
POWER
OFF
AC SURGE ARRESTOR

82


COARSE TAPS
FINE TAPS
INTEGRATED RECTIFIER TECHNOLOGIES, INC.
ON
POWER
OFF
AC SURGE ARRESTOR

83


COARSE TAPS
FINE TAPS
INTEGRATED RECTIFIER TECHNOLOGIES, INC.
ON
POWER
OFF
AC SURGE ARRESTOR

84


COARSE TAPS
FINE TAPS
60 AMPERE
250 VAC
AC SEC. FUSE
INTEGRATED RECTIFIER
TECHNOLOGIES, INC.
ON
POWER
OFF
AC SURGE
ARRESTOR
DC SURGE
ARRESTOR
ANODE
DCI+1

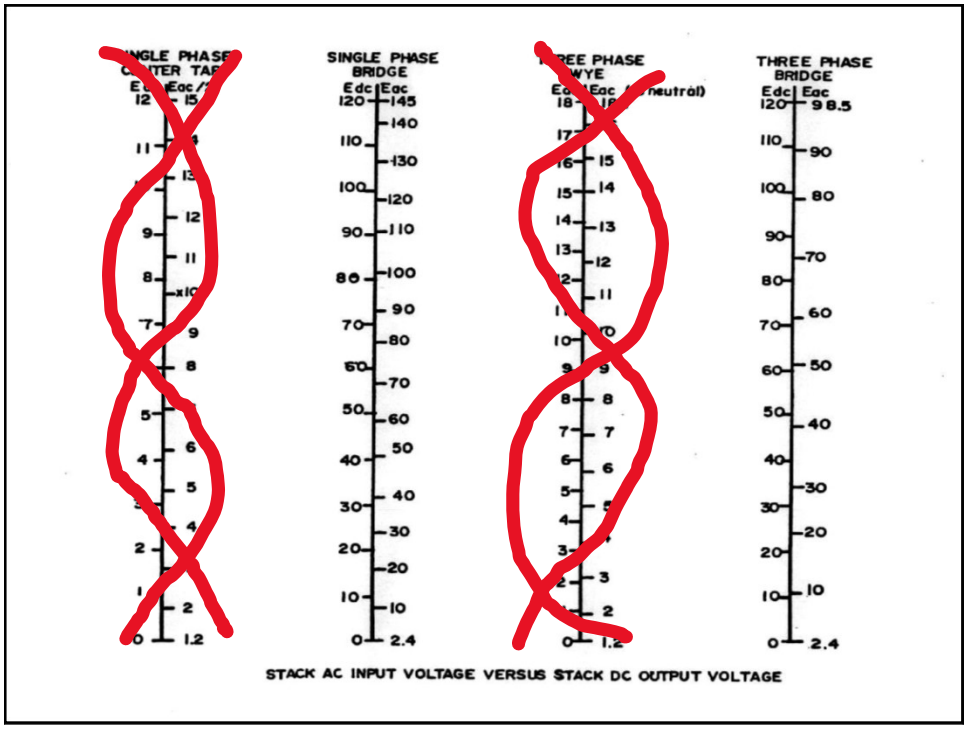
85


COARSE TAPS
FINE TAPS
60 AMPERE
250 VAC
AC SEC. FUSE
INTEGRATED RECTIFIER
TECHNOLOGIES, INC.
ON
POWER
OFF
AC SURGE
ARRESTOR
DC SURGE
ARRESTOR
ANODE
DCI+1

86


COARSE TAPS
FINE TAPS
60 AMPER
250 VAC
AC SEC. FUS
INTEGRATED RECTIFIER
TECHNOLOGIES, INC.
ON
POWER
OFF
AC SURGE
ARRESTOR
DC+ SURGE
ARRESTOR

87


SINGLE PHASE
BRIDGE
Edc Eac
120 145
110 140
100 130
90 120
80 110
70 100
60 90
50 80
40 70
30 60
20 50
10 40
0 30
20
10
2.4
THREE PHASE
BRIDGE
Edc Eac
120 98.5
110 90
100 80
90 70
80 60
70 50
60 40
50 30
40 20
30 10
20
10
0
2.4
STACK AC INPUT VOLTAGE VERSUS STACK DC OUTPUT VOLTAGE

88

Advantages/Disadvantages of Selenium

Advantages:

1. Withstand surges due to lightning much better w/o additional protecting devices.
2. Cost effective in lower voltage and current ratings.
3. Can withstand short term overloads.

Disadvantages:

1. Expensive in high voltage and current ratings.
2. Cannot be practically replaced.
3. Replacement stacks can be expensive to stock.

89

Advantages/Disadvantages of Silicon

Advantages:

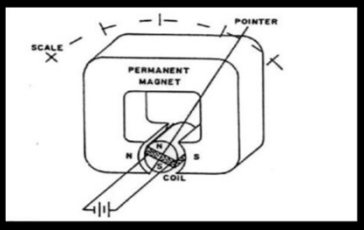
1. Cost effective in high current ratings.
2. More efficient in higher voltage ratings.
3. Replacement cells are easily stocked.
4. Longer life.

Disadvantages:

1. Must be surge protected.
2. Sometimes more expensive initially.

90

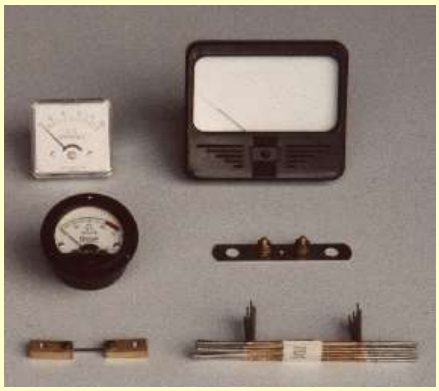
Meters



- 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).

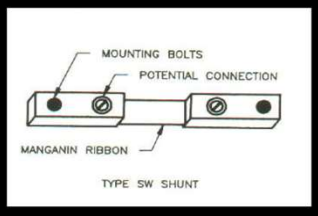
- 50 mV full scale movement.
- Voltmeter - calibration resistors
- Ammeter - shunt installed
- Need to be temperature compensated.
- Meter switches good investment, usually push-to-read type.
- Use portable meter to verify readings.

91



92

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.

93

94

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

95

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 in case of an overload; it will "open" very quickly.
  - Usually placed in the secondary of the transformer to provide maximum overload protection, and also protection from surges originating on the AC line.
- Slower blowing fuses for selenium rectifiers:
  - Can withstand an overload for longer period of time.

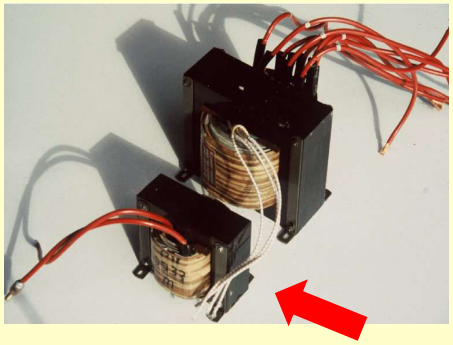
96

97

Efficiency Filters (Chokes)

- Filtering is the process of reducing the AC component "ripple" of the output waveform in order to improve conversion efficiency.
- Can also reduce electrical interference with communication equipment.
- May increase the cost of the rectifier, but in most cases will pay for themselves the first year of operation.
- Conversion efficiency usually increased by 10 to 15 percent with their use.

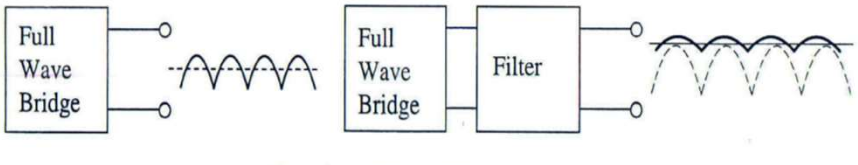
98



Chokes

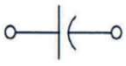
99

Efficiency Filters (cont.)



Passive Filter Elements

Choke - Iron core inductor (a magnetic energy storage device)



Capacitor - Electrolytic (a charge storage device)

Both store energy when waveform is rising and release energy when waveform is falling

100

Efficiency Filter (cont.)

Choke -

a) is an inductor formed by placing a coil of wire around a laminated iron core.

b) usually placed in series with one of the DC output legs.

c) has an inductance which opposes any change in current in the rectifier output.

101

Efficiency Filters (cont.)

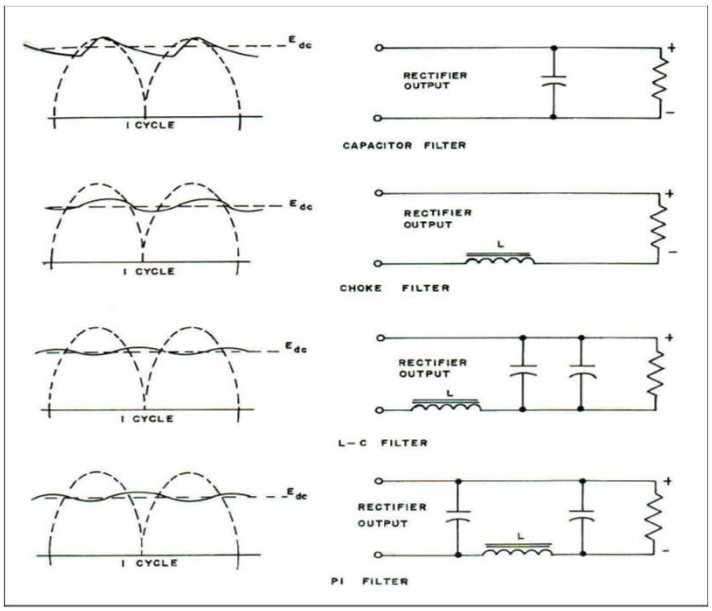
Capacitors -

a) consists of two electrodes separated by a dielectric or insulator.

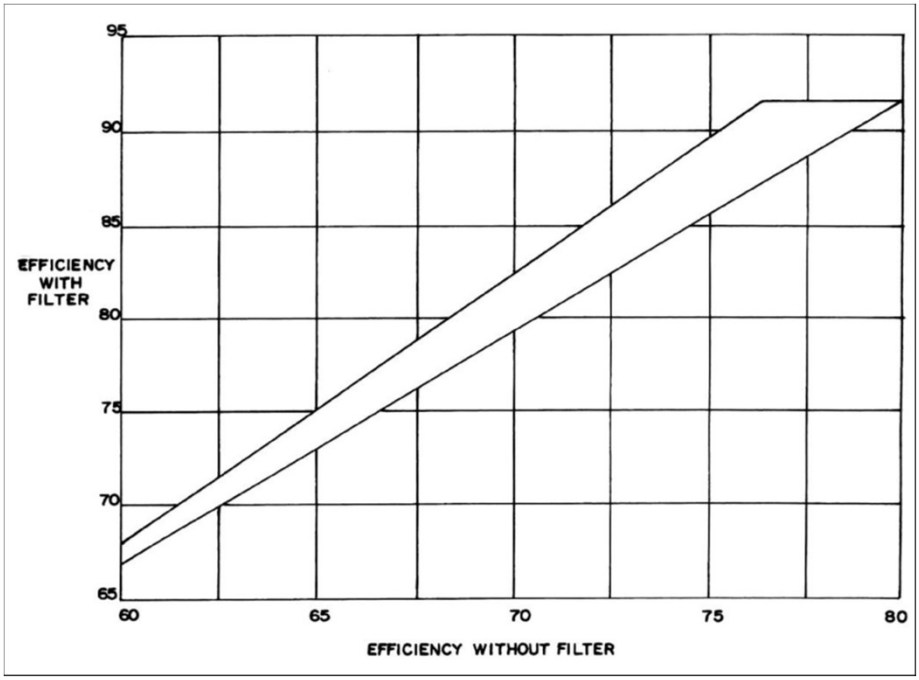
b) current cannot flow but possesses ability to store a charge.

c) opposes any change of voltage across a circuit.

102

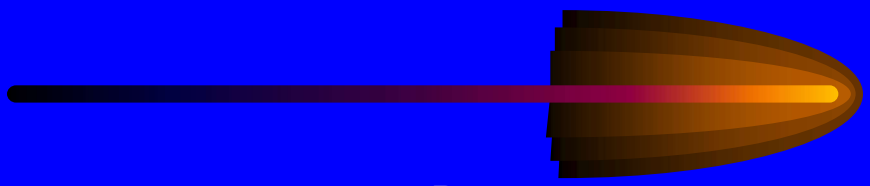

E dc
1 CYCLE
RECTIFIER OUTPUT
+
-
CAPACITOR FILTER
E dc
1 CYCLE
RECTIFIER OUTPUT
L
+
-
CHOKE FILTER
E dc
1 CYCLE
RECTIFIER OUTPUT
L
+
L-C FILTER
E dc
1 CYCLE
RECTIFIER OUTPUT
L
+
-
PI FILTER

103


95
90
85
80
75
70
65
EFFICIENCY WITH FILTER
60
65
70
75
80
EFFICIENCY WITHOUT FILTER

104

Installation and Routine Maintenance



By
Don Olson

MOBILTEX

Mobiltex Data, Inc.
dolson@mobiltex.com
(918) 805-7587

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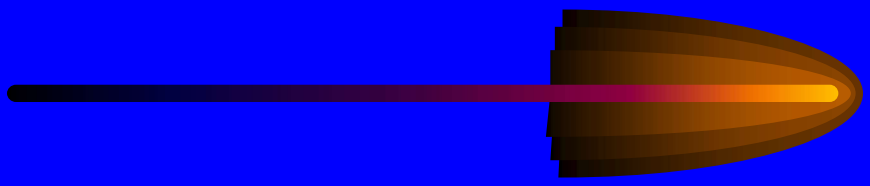
Installation and Routine Maintenance



Corrosion is a continuous process, and a corrosion control system must provide continuous protection. Good cathodic protection design includes proper selection of equipment and correct installation procedures.

106

Installation and Routine Maintenance

- **Purchase The Correct Rectifier**

a) Designed for rugged unattended service
b) Cabinet design - material and finish
c) Right output - future requirements in mind
d) Type of output control

107

Painted / Powder Coated enclosure

Similar cost as galvanize

Not as durable

108

Marine Grade Aluminum

More expensive than paint and galvanize

Very light weight

109

Anodized aluminum

Very costly

110

Paint over galvanize

111

Installation and Routine Maintenance

- **Check Your New Rectifier**
- **Rectifier Installation**
  a) Easily accessible
  b) Away from heat producing equipment
  c) Oil immersed rectifiers radiate heat through sides of the cabinet.

112

113

To High For Servicing

114

115

To High For Servicing

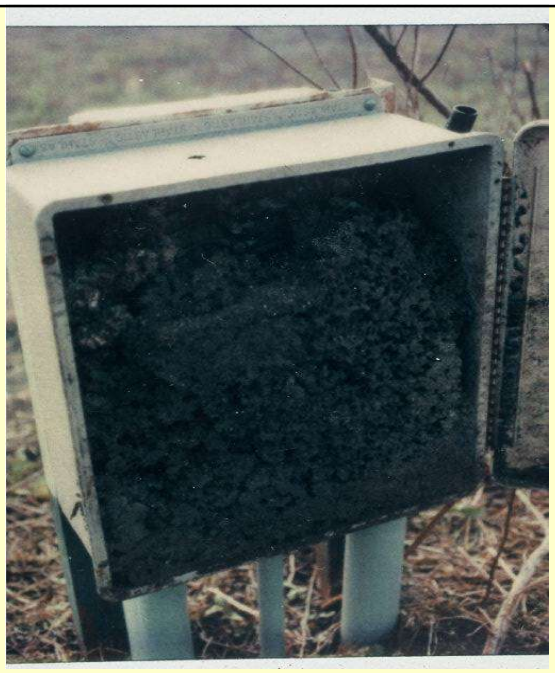
116

117

Too low in weeds. Probably infested with wasps, snakes, rats etc.

118

Junction box destroyed by ants



119

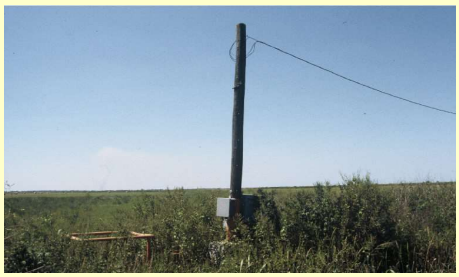
Poor cooling, no air circulation, in sun

120

Pole about to fall over.
Should correct before failure

121

122



RMU

More information available on rectifier, but rectifiers tend to suffer from neglect

123

Installation and Routine Maintenance

- **Rectifier Protection**
  - a) Circuit breakers, fused disconnect switch
  - b) Lightning Arresters
  - c) Secondary or DC fuses / breakers
- **Personnel Safety**
  - a) All enclosures, air or oil, should be properly grounded to a ground rod near the installation.

124

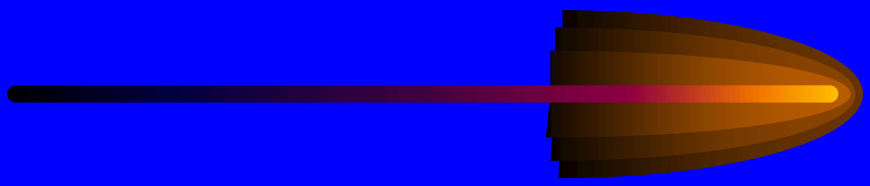
125

Installation and Routine Maintenance

- **Proper Input Voltage**
- **Correct Polarity**
  a) Negative - structure
  b) Positive - anode
  c) Verify that the structure potential shifts negatively

126

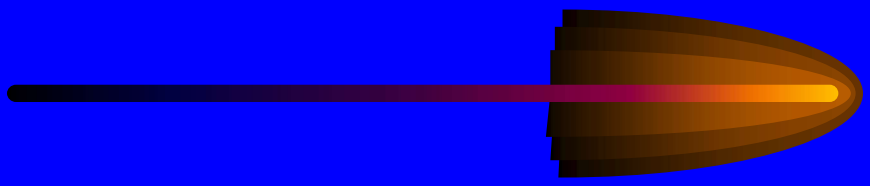
Installation and Routine Maintenance



- **Anode Bed Changes**
- **Adjusting Three Phase Rectifiers**
- **Rectifier Warranty**

127

Installation and Routine Maintenance



- A good maintenance program will greatly reduce the need for troubleshooting.
- Caution on the part of the technician is extremely important. It is recommended that the cabinet be initially brushed with the back of the hand before opening the door or use of a non-contact AC detection pen.

128

Installation and Routine Maintenance

- **Physical Inspection** **(Look, Listen, Smell, Feel)**
  a) Paint touch up
  b) Lubricate hinges and catches
  c) Nicks and dents
  d) Proper cooling - keep screens clean, check oil periodically for contamination, dielectric strength and moisture on the bottom.

129

130

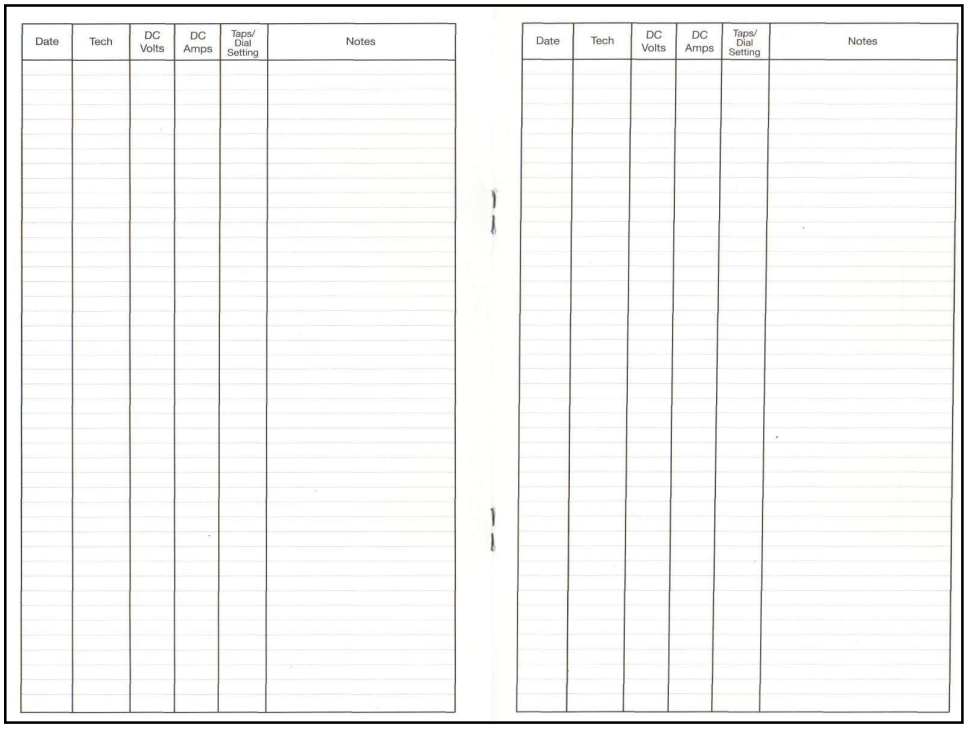
Installation and Routine Maintenance

- **Electrical Inspection**

a) Record keeping - tells how the rectifier is presently performing, many times may predict a failure.

1) AC input voltage
2) Bridge / Stack AC input voltage
3) DC output voltage and current
4) Transformer tap settings
5) Rectifier Conversion Efficiency

131



Date	Tech	DC Volts	DC Amps	Taps/ Dial Setting	Notes

Date	Tech	DC Volts	DC Amps	Taps/ Dial Setting	Notes

132