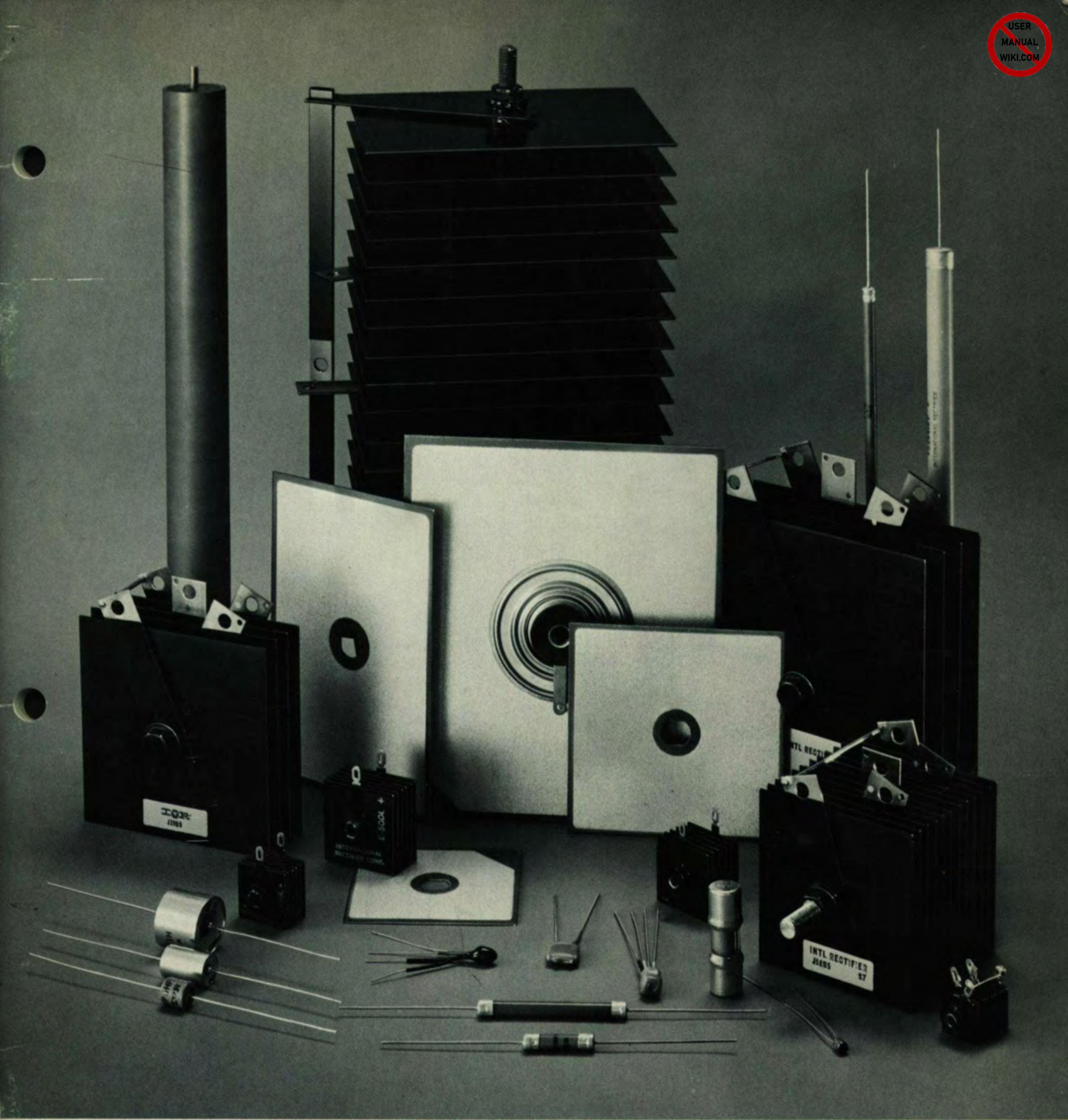


selenium rectifiers and transient suppressors

ENGINEERING BROCHURE B-108 INTERNATIONAL RECTIFIER IOR

This Brochure lists all the necessary specifications, characteristics, parameters, and ratings to select and apply International Rectifier's complete line of Selenium Rectifiers, Klip-Sel Transient Voltage Suppressors, and Contact Protectors.

A discussion on **How To Use This Brochure** is presented on Page 2.

Note that the black tabs on the Headings of the Table of Contents show the page number on which the individual sections start. Each page of the section will have its tab alined with the Table of Contents tab. In addition, each page carries a simplified title defining the data on the page.

For delivery and price quotations, and for any further technical information, check the following list:

Or contact IR's El Segundo Offices.

HOW TO USE THIS BROCHURE

Selenium and its construction and use as a rectifier is described below and on the following page.

Selenium and its use as a voltage transient suppressor is discussed starting on page 4.

IF YOU KNOW THE TYPE OF SELENIUM RECTIFIER YOU WANT, refer to the Table of Contents.

IF YOU DO NOT KNOW THE TYPE OF SELENIUM RECTIFIER YOU WANT, read the description below and the detailed data starting on page 18.

IF YOU KNOW THE TYPE OF TRANSIENT SUPPRESSOR YOU WANT, refer to the Table of Contents.

IF YOU DO NOT KNOW THE TYPE OF SUPPRESSOR YOU WANT, refer to the discussion on transient voltage suppressors starting on page 4 or to the discussion of contact protectors on page 16.

IF YOU HAVE AN INDUSTRIAL PART NUMBER, see the cross reference on page 38.

INTRODUCTION

The Selenium Rectifier, which is introduced below, starts with IR's line of transient voltage suppressors, the Klip-Sel series. The brochure continues with selenium rectifiers in the general order of size from the stack assemblies thru the cartridges and diodes.

This does not necessarily catalog all the possible assemblies or configurations currently available but does cover the coding and characteristics for all popular and typical series.

Selenium Rectifiers

A rectifier is an electronic device which offers very low resistance to current flowing in one direction and very high resistance to current flowing in the opposite direction. This property permits the rectification of alternating currents and the control of various signals and controlling currents in electronic equipment.

A selenium rectifier is usually an assembly of one or more selenium cells in a stack, cartridge, or diode. For higher ratings than those permitted by single cells, the cells are connected in series for higher applied voltage ratings and in parallel for higher current ratings.

Applications

Although newer types of semiconductors have been receiving a great deal of attention, selenium still offers versatile, inexpensive rectification with a famous record of extremely long-term reliability. Individual devices still provide almost 90% of their original ratings after over twenty years of continuous service.

Currently, selenium rectifiers are being used in a wide variety of industrial, commercial, and entertainment applications including: Industrial power conversion systems; Battery chargers; Voltage regulation; Electroplating; Electrolysis; Electrostatic coating and painting; All types of communications systems: including Color television; Computers; Airborne communications systems; Remote control systems; Magnetic circuits; All types of entertainment systems; Power supplies for relays, solenoids, and electric counters; and many, many more.

Special applications include Klip-Sels, for transient voltage suppression, and contact protectors for switch protection from arc damage.

Selenium also offers high surge handling capability and high reliability factors. These allow it to be used in most rectification applications without the use of additional surge protection devices.

Selenium Cell Construction

A selenium rectifier cell consists essentially of a baseplate, a selenium layer, and a counter-electrode layer. The baseplate and the counter-electrode layer serve as electrodes for the rectifier, both being good electrical conductors. The ideal selenium rectifier permits forward current to flow from the baseplate to the counter-electrode layer and blocks all current in the opposite direction.

The production of selenium rectifiers is a complex procedure involving numerous processes. Some of the important processes are outlined below.

The Baseplate

The aluminum baseplate used in IR selenium cells supports the various materials required to produce the rectifier. To improve the conduction between the baseplate and the selenium layer, the baseplate is roughened by acid etching and then a thin layer of nickel is deposited by electroplating.

The Selenium Layer

The thin selenium layer is deposited on the treated baseplate by the evaporation process. The selenium is first treated with a halogen additive to improve the electrical characteristics of the selenium. The selenium is then heated, vaporized, and allowed to condense on the baseplate in a layer from 0.002 to 0.006 inch thick, depending on the intended use of the cell.

The Barrier Layer

The selenium-coated baseplate is now heat-treated to start the formation of the barrier layer, the region in which rectification actually takes place. After the heat treating process, barrier layers of material are applied to the plate, either by evaporation or by spraying. These barrier layers increase the blocking characteristics of the selenium layer of the cell.

The Counter-Electrode Layer

A metal alloy layer is sprayed on the barrier layer to form the counter-electrode; that is, the electrical contact opposite the baseplate. During this process, the selenium and barrier layers are masked so that the counter-electrode layer is deposited so that it can not short out across the baseplate.

Forming

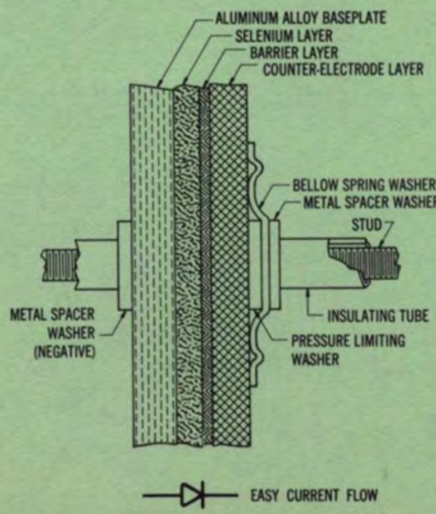
The selenium cell is now complete but the processing is not. To develop the reverse characteristics of the cell, the barrier is electro-formed by passing an increasing dc voltage through the cell in the reverse direction of the cell. This process takes from one to twenty-four hours or more, depending on the size of cell and its intended use.

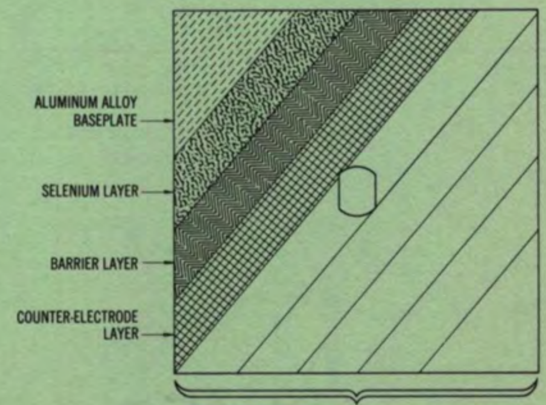
Assembly

The cell must now be mounted in some form of assembly. This may include only a spring contact and terminal against the counter-electrode and a terminal for the baseplate, all held together by an insulated eyelet. Or the assembly may be multiple cells mounted in a complex stack assembly. Or a miniature selection of plates mounted in a moisture-proof tubing, shrink-fit tubing or phenolic case.

IR Selenium Products

The IR Selenium Rectifier is now ready for long-term service in one of the applications discussed above and described in detail on the following pages.





KLIP-SEL TRANSIENT VOLTAGE SUPPRESSORS

All electrical systems and equipment are subject to transients of widely varying magnitudes, causes, and repetition rates. Since many of these transient disturbances can result in voltage spikes of sufficient energy content to degrade or destroy semiconductor devices (such as Silicon Rectifier Diodes, Silicon Controlled Rectifiers, Silicon or Germanium Transistors, etc.) it is often necessary to apply transient suppression circuit accessories to protect a system or equipment and to improve reliability.

Another semiconductor device — the selenium rectifier — has been modified to provide excellent protection for other semiconductor devices. This device is the Klip-Sel, International Rectifier's Selenium Transient Voltage Suppressor.

The following discussion includes the steps used in selecting the proper Klip-Sel, a simplified application guide, an explanation of the part number code, the dimensional characteristics of the Klip-Sels, and a listing of standard Klip-Sels. A cross reference guide is included in the back of this catalog.

Voltage Transients

There are many sources of voltage transients. In the following paragraphs the use of Klip-Sels to clamp various types of transient voltage and the appropriate circuitry for this clamping will be illustrated and described.

Transients Caused By Energizing A Transformer Primary

Voltage transients of magnitudes severe enough to cause damage to semiconductor devices may result from energizing the transformer primary in either of the circuits illustrated in Figure 1. In Figure 1(A), transients up to two times the peak value of the supply voltage are possible. In Figure 1(B), the full primary peak voltage may be impressed, by interwinding capacitive coupling, across the secondary. (For example: a 440 Volt rms primary voltage may impress as much as 620 Volts on a low voltage — say 20 Volts — secondary and rectifier.)

Either a non-polarized Klip-Sel or a polarized Klip-Sel connected as shown in the figures is effective in clamping transients of these types to safe values.

Transients Caused By De-Energizing Inductive Circuits

The transients resulting from any of the four circuits of Figure 2 can be some of the most destructive. Peak transient voltages up to 10 times the peak supply voltage have been

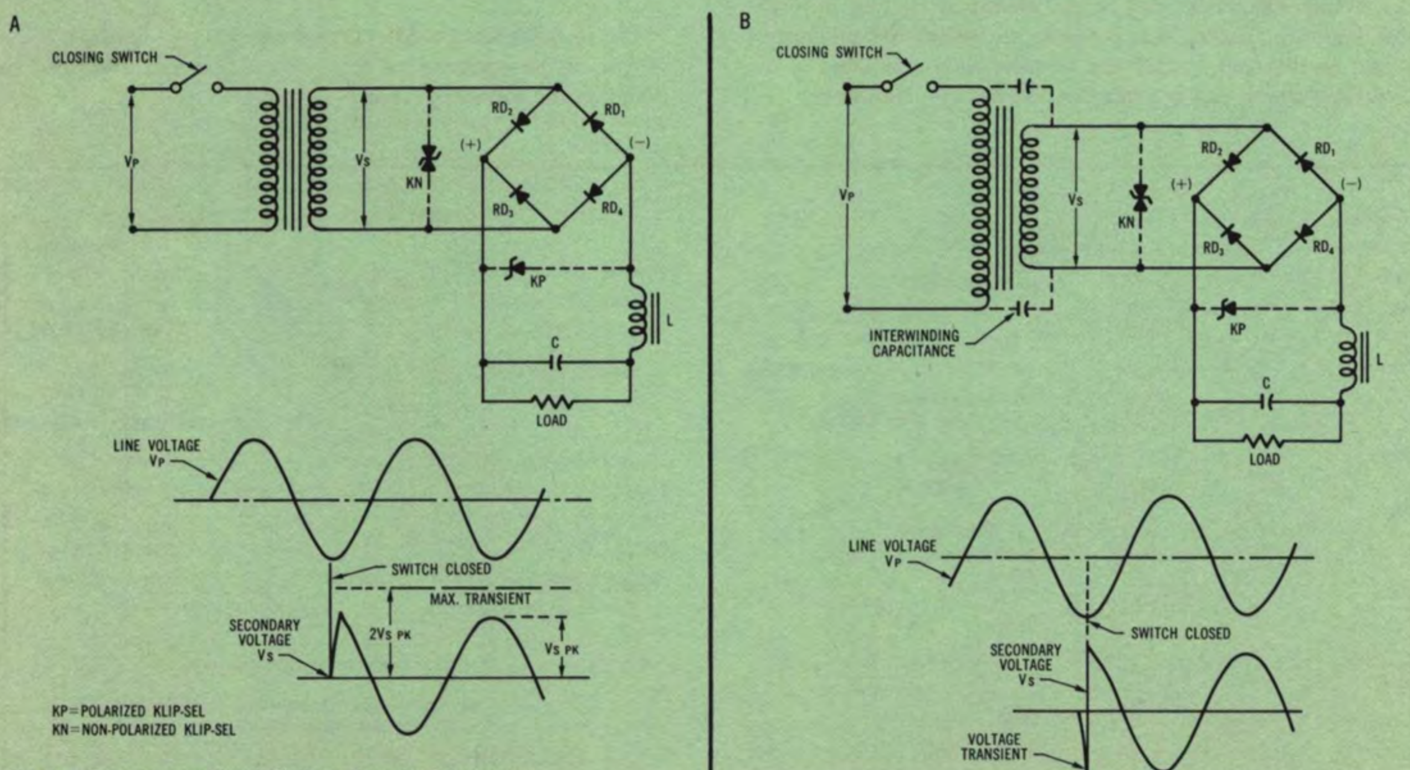


Fig. 1 — Transformer Circuit Voltage Transient Sources

observed for Figures 2(A) and 2(B). In Figure 2(C), the peak transient voltage can equal:

$$V_t = I_{Load} \times \sqrt{\frac{L}{C}}$$

Where:

V_t = Transient Voltage

I_{Load} = Current through the load

L = Load inductance

C = Load capacitance

From this equation it is evident that when L is large compared to C the transient can be very severe. In fact, when the only capacitance in the circuit is leakage capacitance to ground, the transient condition may be the worst possible.

In the circuits of Figure 2(A), (B), or (C) either a non-polarized or polarized Klip-Sel will usually provide adequate protection. However, for Figure 2(D), the only effective location for the Klip-Sel is across the rectifier dc terminals. Usually a polarized Klip-Sel is selected for this use (however, if a non-polarized Klip-Sel is the only one available, it will also provide protection in this location).

Symbols

V_{rms} = Max. RMS working voltage. High Line system voltage.

i_t = Transient discharge current

I_{sec} = Transformer secondary operating current RMS.

I_m = Transformer Magnetizing current (may be expressed in per cent, i.e., $\%I_m$).

F_V = Operating voltage factor

V_P = Primary Voltage

V_S = Secondary Voltage

(symbol) = Non-Polarized Klip-Sel (KN)

(symbol) = Polarized Klip-Sel (KP)

V_T = Transient Voltage

I_{AC} = Alternating Current

V_{AC} = AC Voltage

F_C = Clamping Voltage Factor

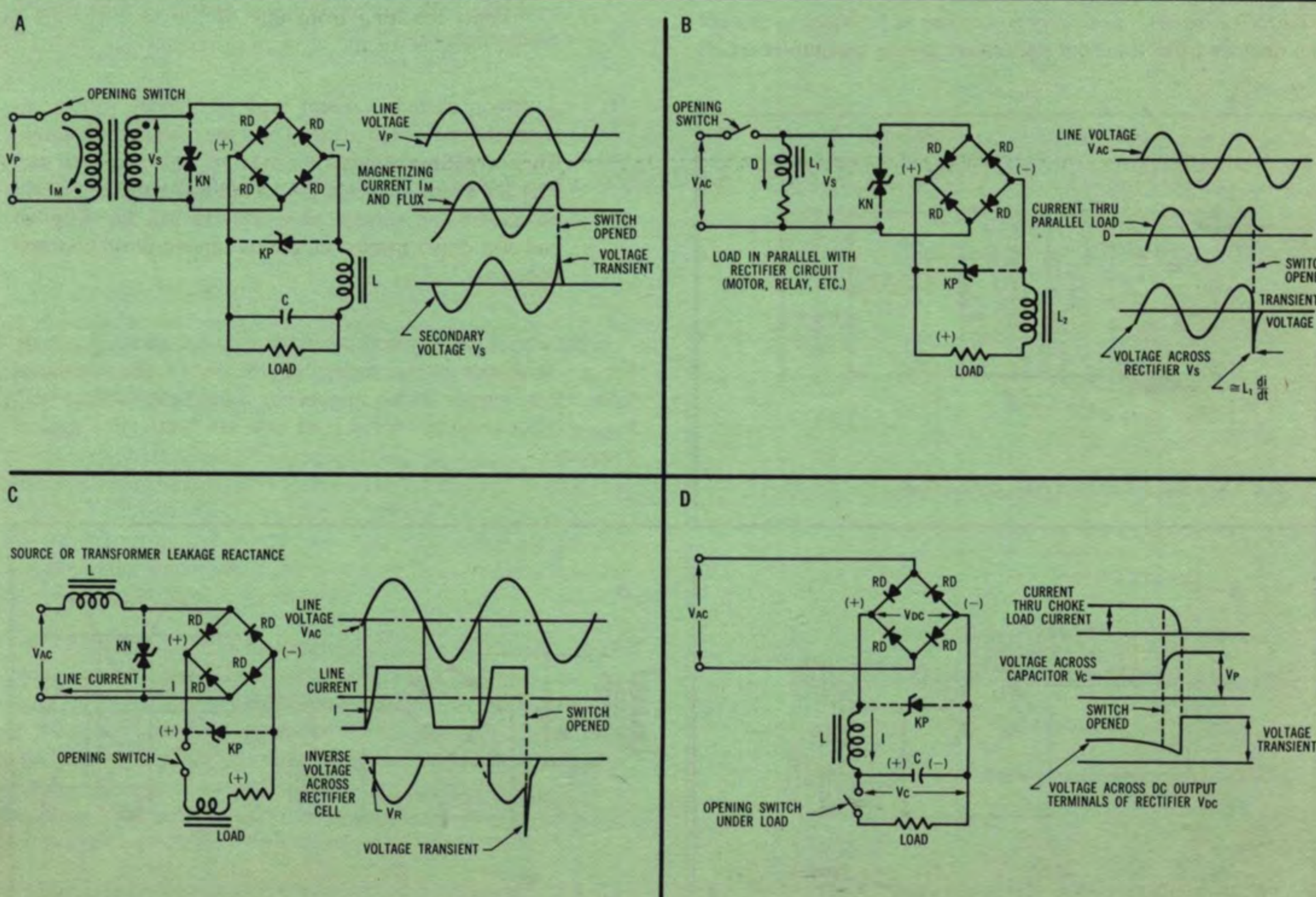


Fig. 2—Inductive Circuit Voltage Transient Sources

Miscellaneous Causes of Voltage Transients

There are many other causes of transient voltages. Figure 3 illustrates how a shorted rectifier diode in a circuit where several are connected in parallel can cause a transient voltage at the time the isolating fuse clears the circuit fault. A non-polarized Klip-Sel is recommended for protecting the rectifier diode here (although a polarized Klip-Sel across the dc terminal will help also). A large capacity Klip-Sel may be required. In a relatively high power rectifier unit having several diodes in parallel, the energy content of the transient may be very substantial.

Figure 4 illustrates how the firing of magnetic amplifiers or of silicon controlled rectifiers (SCRs) may generate transients. These transient voltages are similar to those generated by commutation and hole storage effects except that they may be much more severe since they often occur later in the cycle when reverse voltages are higher and where the rate of change of voltage, current, and flux (in transformer or mag-amp circuits) is more rapid.

In the magnetic amplifier circuit (Figure 4(A)), the Klip-Sel should be a polarized device across the dc terminals. In this way the small leakage current of the Klip-Sel will not reduce the magnetic amplifier gain.

In the silicon controlled rectifier circuit (Figure 4(B)), a non-polarized Klip-Sel is necessary across the ac terminal to protect the devices from transient generated during commutation. If the load is highly inductive, a polarized Klip-Sel should also be connected across the dc terminals to protect against load generated transients (particularly when the SCRs are phase controlled to small conduction angles).

Figure 5 illustrates a different type of a transient voltage caused by a dc motor with either an overhauling load, or with a high inertia load, where the motor field is suddenly strengthened to reduce motor speed.

This type of transient differs from the previous ones in that it may be either a sharp spike of high voltage, or may be a sustained higher voltage (V_{cemf}). If the field is strengthened only momentarily (causing the sharp spike), a polarized Klip-Sel will provide adequate protection. However, when the transient results from a sustained overhauling load, the Klip-Sel may not have adequate thermal capacity to absorb the sustained energy. In this case the transient can probably best be handled in one of the following ways:

(A) A polarized Klip-Sel to absorb the initial voltage spike, plus an over-voltage relay which will apply a shunt load (a resistor) across the motor armature to absorb the sustained energy and reduce the peak voltage.

(B) A silicon controlled rectifier with associated circuitry to act as the over-voltage relay and apply the shunt load (the SCR has much faster operating time than a mechanical relay).

(C) A silicon carbide varistor type of bleeder resistor to shunt the motor armature. This type of varistor is a non-linear voltage device similar in operation to the Klip-Sel but while it has larger thermal capacity, it will not clamp the voltage as sharply as will the Klip-Sel and also draws more continuous current during normal operation.

In the above cases, a non-polarized Klip-Sel across the rectifier ac terminals is recommended to absorb any transients from the ac supply which may occur during the time of high V_{cemf} when devices on the load side are ineffective against transients.

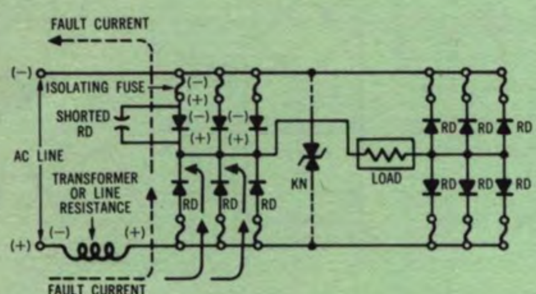


Fig. 3 — Voltage Transient from Circuit Fault

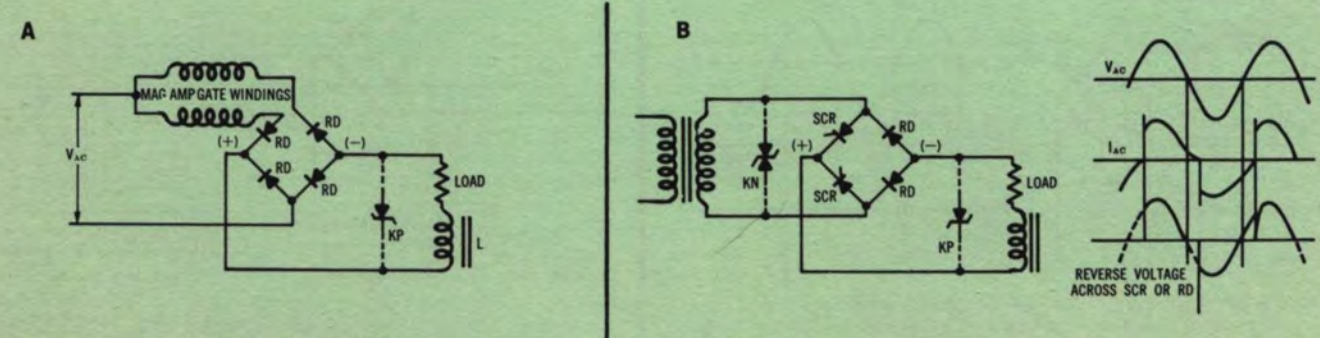


Fig. 4 — Voltage Transient from Circuit Firing

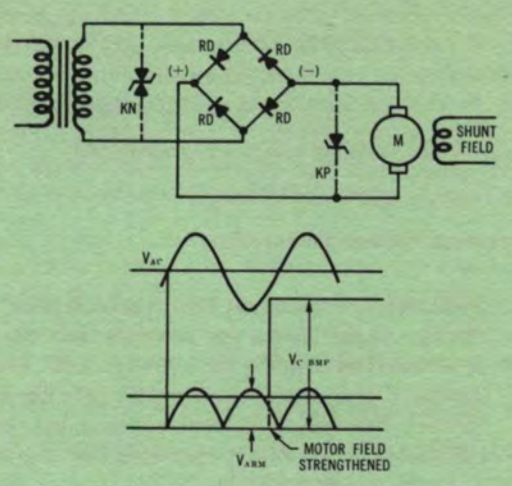


Fig. 5 — Voltage Transient from Field Strengthening

Figure 6 illustrates transients caused by the starting of a synchronous motor at speeds below synchronism (as the motor is started), the stator acts as the primary of a transformer and the rotor field winding acts as the secondary. Under this condition and until the motor reaches synchronous speed, large voltages will be induced in the rotor field winding. The voltages are of both polarities so that on one half of the cycle the rectifiers will have to block the generated voltage, and on the other half cycle carry large forward currents.

The surge rating of the rectifiers must be based on this current surge which starts at a high value and then decays to zero as the motor approaches synchronous speed.

A polarized Klip-Sel, connected as shown in Figure 6, will be effective in clamping this type of transient. The size of the Klip-Sel must be based on the energy content of the transient waveform which can typically have a current rating of twelve times the full load dc output current of the field supply.

The actual transient voltages and currents depend on individual machine constants and on the ac impedance of the rotating field winding. They also vary from a maximum at the instant of starting (when slip frequency equals line frequency) to a minimum when it is equal to the dc field resistance as the motor pulls into synchronous speed.

Many transients may be received through the supply lines. These may be caused by a wide variety of conditions, including dropping of large loads, lightning and faults (short circuits) on the power system. It may be difficult to protect against such transients as they are often of unknown magnitude and power content. The non-polarized Klip-Sels are usually the best choice for these "unknown" transients; connections should be made across the rectifier ac terminals.

Most of these examples have discussed single phase circuits. However, the same basic Klip-Sel location may also apply to poly-phase circuits. In addition, in single-way, poly-phase circuits, polarized Klip-Sets are generally specified. They are connected in parallel with the rectifier in each phase.

Advantages Of Klip-Sels

Several advantages usually result from designing Klip-Sels as protective elements for silicon rectifier equipment: the addition of Klip-Sel protection is designed to prevent rectifier failures; where the Klip-Sels are correctly applied, it is often possible to reduce the Peak Reverse Voltage rating (PRV) of the rectifier or silicon controlled rectifier, increase the system reliability by minimizing features, and reduce rectifier costs.

Klip-Sel transient protection devices are usually superior in action and results to other modes of transient suppression for the following reasons:

(A) **Resistance-Capacitance Networks.** RC networks can (1) draw high charging currents (if the capacitance must be large), (2) cause damped oscillations unless accurately designed to avoid resonating with supply transformer, magnetic amplifier, or load inductances.

(B) **Thyrite voltage sensitive varistors.** The rate of change of resistance with increasing voltage in these devices is substantially less than that of Klip-Sels, thus requiring higher rectifier Reverse Voltage ratings to achieve equal protection, and, conversely, they consume more power at normal operating voltages than do Klip-Sels.

(C) **Silicon Breakdown (Zener) Diodes.** Zener voltage regulators have lower transient energy absorbing capacity than Klip-Sels. Also, Klip-Sels inherently have substantial shunt capacitance and accordingly often provide faster response to transients with steep voltage wave fronts than do Zener diodes.

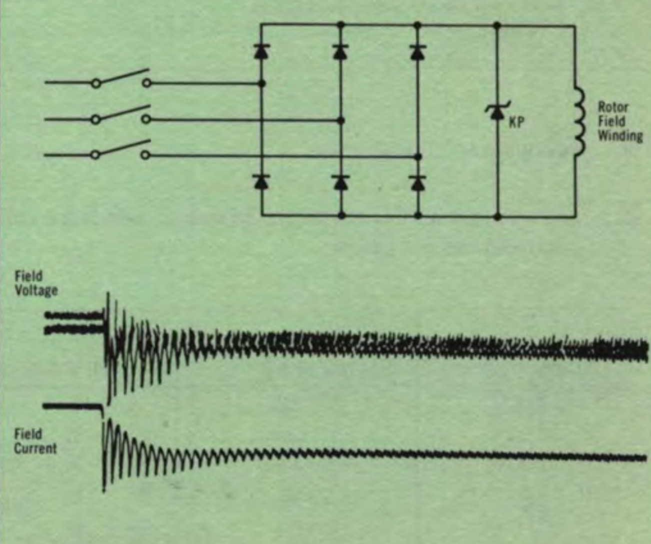


Fig. 6 — Voltage Transients from Synchronous Motor

SELECTING KLIP-SELS

1. Transient Surge Current (i_t)

The transient surge currents generated by transformers are generally the most severe transients that will be encountered. It is this current that will determine the cell size to be used. The following steps give a simple means of calculating the required i_t rating, and therefore the required cell size.

(A) Determine (from manufacturer specifications or by measurements) the transformer KVA rating, and estimate whether it has a high, medium, or low reactance. (If the transformer is constructed so that the secondary windings are tightly coupled, electrically, to the primary windings, it will probably have a low reactance.)

(B) Refer to Figure 7 and, using KVA rating and estimated reactance, choose the best estimate of % magnetizing current ($\%I_m$).

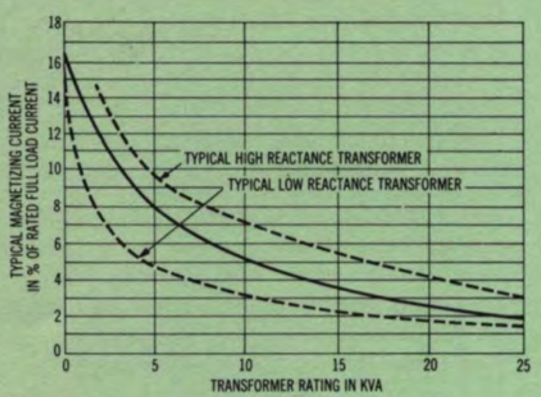


Fig. 7 — Typical Magnetizing Current Vs. Transformer KVA Rating

(C) Calculate $i_t = \%I_m \times Isec \times 0.75$

(D) From the value of i_t calculated in step C, select the cell size from the list below:

Cell i_t Rating (Amps)	Cell Size (Inches)	Cell Code
0.25 Max.	.375 Dia.	Y
1.0 Max.	.50 Dia.	Z
3.0 Max.	1.0 Sq.	A
15.0 Max.	2.0 Sq.	L
35.0 Max.	3.0 Sq.	D
65.0 Max.	4.0 Sq.	P
135.0 Max.	5.0 x 6.0	F

For example, assuming 5KVA high reactance transformer with secondary current of 20 Amps rms.

$i_t = \frac{10}{100} \times 20 \times 0.75 = 1.5$ Amps. Use cell code "A" which has a rating of 3.0 Amps and cell size of 1.0"Sq.

2. Operating Voltage Factor (F_V)

(A) **Operating voltage factor (F_V) non-polarized.** The operating voltage factor for non-polarized operation is determined by dividing the high-line RMS system voltage by 26 and rounding off to the next highest whole number. For example: assume a high-line voltage of 125 VRMS. $\frac{125V}{26} = 4.8$, therefore, use $F_V = 5$. The Klip-Sel assembly rating then is: $F_V \times 26 = 5 \times 26 = 130V$.

(B) **Operating Voltage Factor (F_V) polarized.** The operating voltage factor for polarized operation is determined by dividing the high-line voltage by 22 and rounding off to the next highest whole number. For example: assume a high-line voltage of 100V. $\frac{100V}{22} = 4.55$, therefore, use $F_V = 5$. The Klip-Sel assembly rating then is: $F_V \times 22 = 5 \times 22 = 110V$.

3. Clamping Voltage Factor (F_C)

The clamping voltage factor equals the maximum clamping voltage divided by the Klip-Sel assembly voltage rating (at rated clamping current).

(A) **Clamping Voltage Factor (F_C) non-polarized.** For non-polarized applications, there are three maximum clamping factors available: 2.3, 2.5, and 2.7. The peak reverse voltage rating (PRV) or the transient voltage rating (whichever it is found desirable to use) of the solid state device to be protected will determine which clamping factor to use. The clamping factor designations are D, E, and F, respectively. If the ratio of the PRV of the silicon diode to Klip-Sel assembly rating is low, then naturally the lower factors must be used.

For example: assume a single phase bridge circuit with silicon diodes rated at 300 Volts PRV and a Klip-Sel assembly rated at 130V across the secondary of the transformer. A clamping voltage factor of 2.7 would mean the maximum clamping voltage would be 350V (130 x 2.7) which is too high. A clamping factor of 2.3 would have to be used 130 x 2.3 = 300 V. If the above silicon diode has a transient rating of 400V, the Klip-Sel assembly with a clamping factor of 2.7 could be used. 130 x 2.7 = 350V. The idea is to keep the clamping voltage below the rating to be protected.

(B) **Clamping Voltage Factor (F_C) polarized.** For polarized applications, there are also three clamping factors available, also designated D, E, and F (2.6, 2.8, and 3.0 respectively). In most cases, the clamping factor is generally not of great importance in application since the polarized Klip-Sel is used on the dc side of single phase and three phase bridges. This is because the polarized Klip-Sel is essentially across two diodes in series.

For example: assume a single phase bridge using 200V PRV silicon diodes and with an output of 100V. For 100V, a polarized Klip-Sel assembly with an operating voltage factor of 5 would be required ($\frac{100}{22} = 4.55$; use 5). The maximum clamping voltage of this assembly would be (110 x 3.0 = 330V or 5Fv x 22 x F_C). Since the PRV of the diodes to be protected is 2 x 200 = 400V, the factor of 3.0 is adequate.

4. Using the cell size derived by the procedure as outlined in (1), the operating voltage factor outlined in (2), and the clamping voltage factor outlined in (3), refer to Table 1 and construct the proper Klip-Sel code number.

5. Where transients occur on a repetitive basis, refer to Figures 8 and 9 (page 10) for non-polarized and polarized applications respectively. This curve gives the relationship between pulse duration energy, and repetition rate for each 26VRMS of Klip-Sel rating.

For example: a polarized Klip-Sel, KSDP1DAF (3″ cell), is capable of absorbing one Watt-Second of energy per pulse with one second between pulses.

6. Maximum allowable surge current versus pulse width for non-repetitive pulses is given in Figure 10 (page 11). For the shorter times it is possible that the maximum rated clamping voltage will be exceeded. For maximum safety for components that are being protected it is recommended that the rated current not be exceeded.

TABLE 1—PART NUMBER CODE SYSTEM

KSA 5 D A E

Cell Size & Polarity	Fv Operating Voltage Factor	Type of Finish	Type of Mounting	Fc Max. Clamping Factor
26 VOLT CELLS				
Non-Polarized KY—0.375″ dia. KZ—0.5″ dia. KSA—1.0″ sq. KSL—2.0″ sq. KSD—3.0″ sq. KSP—4.0″ sq. KSF—5.0″ x 6.0″	Number 1 to 20 **Non-Polarized** (Multiply by 26 to obtain maximum continuous RMS rating.)	D—Commercial T—Moisture & fungus resistant	A—Bolt① B—Stud C—1 Bracket D—2 Brackets P—Pigtail (cartridges only)	**Non-Polarized** D = 2.3 E = 2.5 F = 2.7 (Multiply RMS rating by clamping factor to obtain typical peak voltage after clamping.)
Polarized KYP—0.375″ dia. KZP—0.5″ dia. KSAP—1.0″ sq. KSLP—2.0″ sq. KSDP—3.0″ sq. KSPP—4.0″ sq. KSFP—5.0″ x 6.0″	**Polarized** (Multiply by 22 to obtain maximum continuous dc rating.)			**Polarized** D = 2.6 E = 2.8 F = 3.0 (Multiply dc rating by clamping factor to obtain typical peak voltage after clamping.)
30 VOLT CELLS				
Same as above	**Non-Polarized** (Multiply by 30 to obtain maximum continuous RMS rating.) **Polarized** (Multiply by 25 to obtain maximum continuous dc rating.)	Same as above	Same as above	**Non-Polarized** L = 2.2 M = 2.4 **Polarized** L = 2.5 M = 2.7

① Not available all lengths.

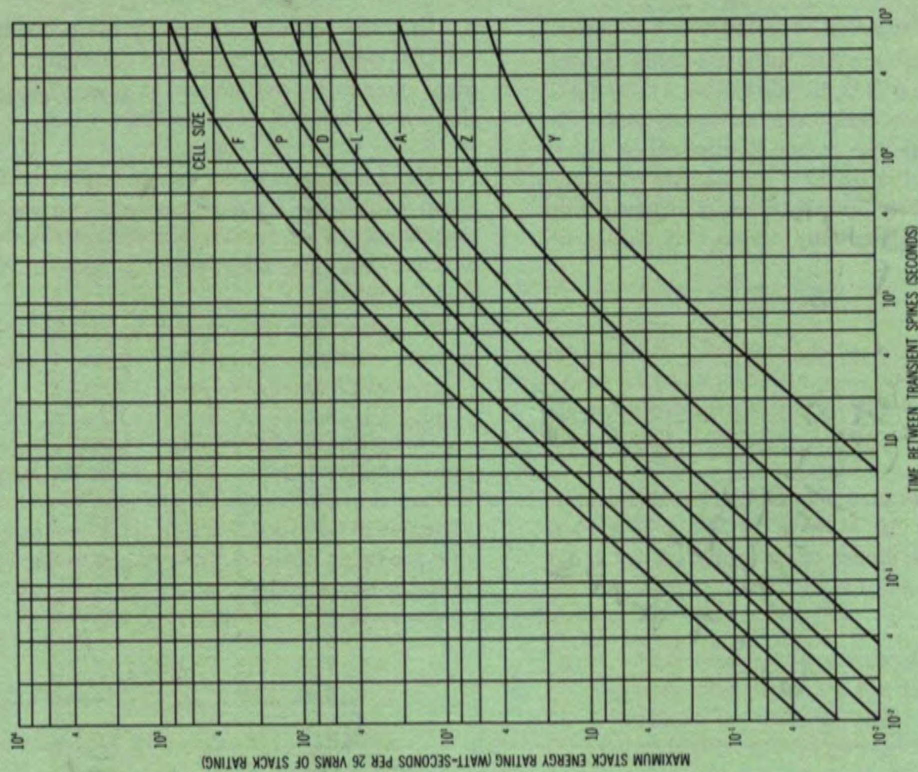


Fig. 8 — Stack Energy Rating Vs. Time Between Pulses — Non-Polarized Types

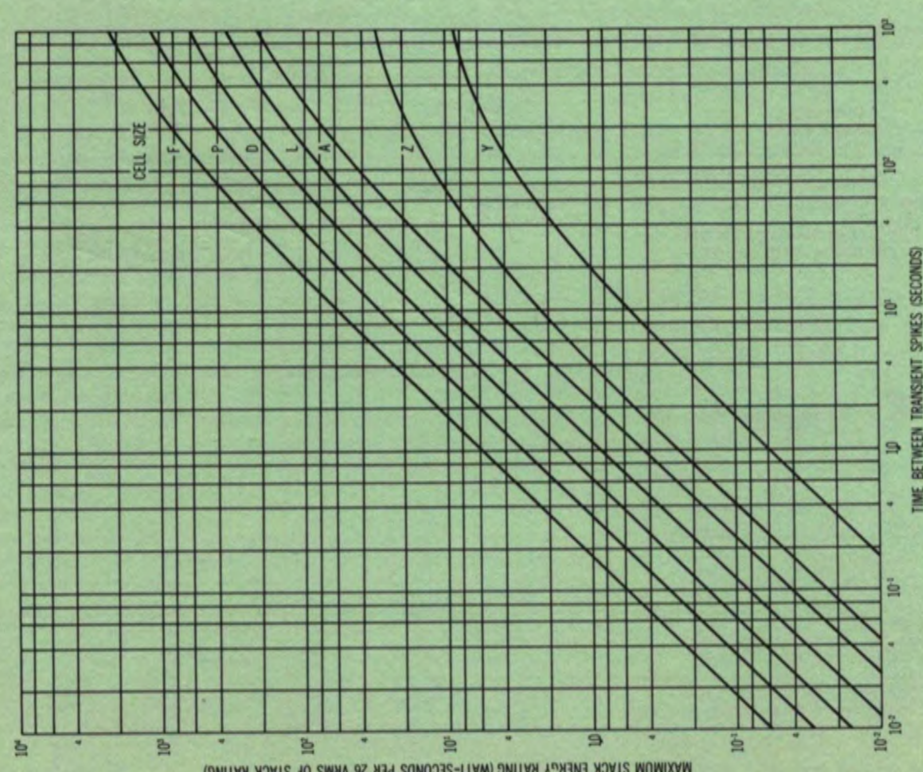


Fig. 9 — Stack Energy Rating Vs. Time Between Pulses — Polarized Types

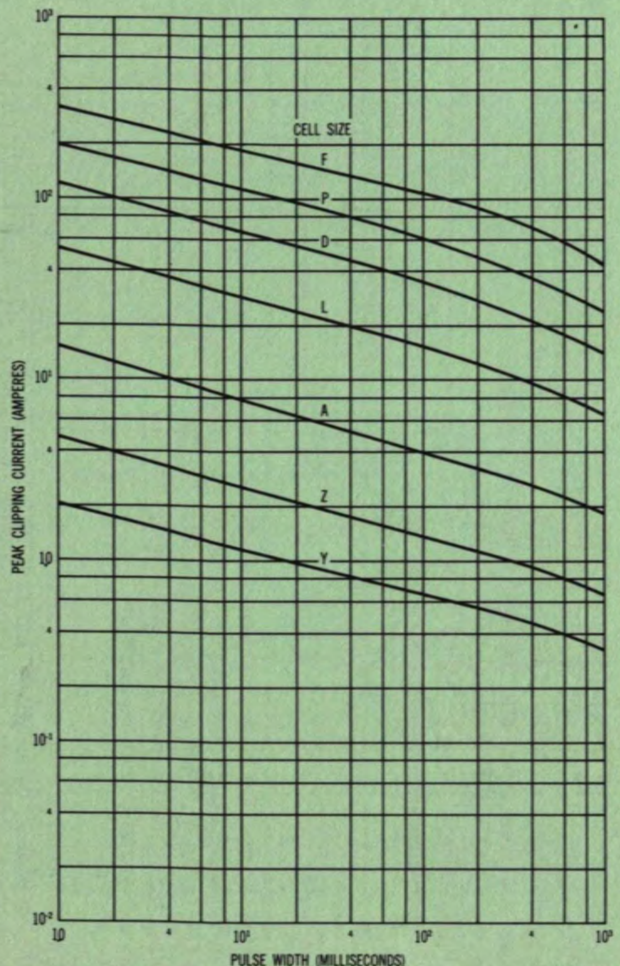


Fig. 10 — Surge Current Vs. Pulse Width

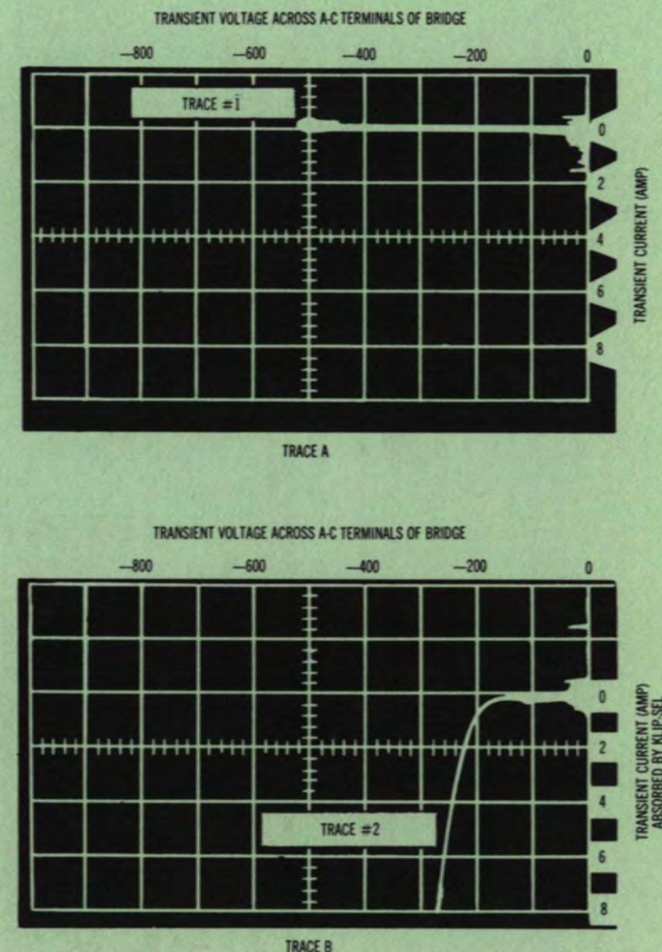


Fig. 11 — Clamping Traces

These are maximum values, and if the stack is operated at a slightly reduced voltage (to accommodate line variation conditions and normally introduced safety factors), the actual wattage consumed per cell will be substantially less.

To illustrate how effective Klip-Sels can be in protecting a single phase bridge silicon rectifier stack, Figure 11 (page 11) shows two traces, each one representing the voltage impressed directly across the ac input terminals of the rectifier bridge. Trace No. 1 was made with a capacitive discharge transient voltage of slightly over 500V peak, and without a Klip-Sel connected to the bridge. From this trace it can be seen that essentially zero current was drawn by the bridge and apparently no clipping action took place.

Trace No. 2 was taken after a Klip-Sel had been connected directly across the ac terminals of the rectifier bridge, and the same 500V transient voltage pulse was again impressed across the ac terminals of the bridge. From this trace it can be seen that the Klip-Sel actually drew 8 Amperes peak current, but limited the peak value of the voltage to approximately 270V. Accordingly, it can be seen that the addition of this Klip-Sel device would satisfactorily protect a rectifier bridge, which is operating on a 117V ac line, from a 500 Volt transient, when using rectifier diodes of only 300V PRV rating; whereas, without the Klip-Sel, rectifier diodes in excess of 500V PRV would be necessary to avoid being damaged or destroyed by a 500 Volt transient.

Simplified Application Guide

A simplified guide for the use of Klip-Sel transient voltage suppressors is given in Table 2. This guide is designed to aid in the selection of Klip-Sels for most common applications where the peak reverse voltage rating transient reverse voltage rating applied RMS voltage and type of circuit are known.

The types of Klip-Sels listed are designed to utilize the transient rating of the rectifier to be protected. For example: the Klip-Sel KY2DPF has a maximum clamping voltage of 52V x 2.7 = 140V. This means that the transient rating of the rectifier must be at least 140V, preferrably it would be 150V or higher.

If the transient rating of the rectifier is unknown, or it has no transient rating, then a Klip-Sel must be designed around the PRV rating of rectifier. Table 2 could not be used as a guide in this case.

Standard Device Types

In many cases the Klip-Sel must be selected using the earlier selection calculations for peak current, clamping voltage, and operating voltage. Standard Klip-Sels are listed in Table 3.

These tables list all part numbers of standard Klip-Sels with the appropriate ratings and notations. Dimensions for Klip-Sels may be calculated from Table 4 (page 14).

Additional Notes

The actual power drawn by the Klip-Sel during normal operating conditions is very low. As an example, at the maximum continuous rating, the table below lists the actual power loss per cell.

Cell Code	Cell Size (Inches)	Maximum Power Loss (mW)
Y	.375 Dia.	50
Z	.50 Dia.	100
A	1.0 Sq.	300
L	2.0 Sq.	1500
D	3.0 Sq.	3500
P	4.0 Sq.	6500
F	5x6	13200

TABLE 2 — SIMPLIFIED KLIP-SEL APPLICATION GUIDE

Device Voltage Rating (V)	Max. Rated RMS Operating Voltage (V)	Transient Voltage Rating (V)	For Individual ① Rectifier Rated Thru 3 Amp	For Individual ① Rectifier Rated Thru 16 Amp	For Individual ① Rectifier Rated Thru 60 Amp	For Individual ① Rectifier Rated Thru 250 Amp
100	52 Volts	150	KY2DPF	KZ2DPF	KSA2DAF	KSL2DAF
150	78 Volts	250	KY3DPF	KZ3DPF	KSA3DAF	KSL3DAF
200	104 Volts	300	KY4DPF	KZ4DPF	KSA4DAF	KSL4DAF
300	156 Volts	425	KY6DPF	KZ6DPF	KSA6DBF	KSL6DBF
500	234 Volts	650	KY9DPF	KZ9DPF	KSA9DBF	KSL9DBF
600	286 Volts	800	KY11DPF	KZ11DPF	KSA11DBF	KSL11DBF
700	312 Volts	850	KY12DPF	KZ12DPF	KSA12DBF	KSL12DBF
800	364 Volts	1000	KY14DPF	KZ14DPF	KSA14DBF	KSL14DBF
900	416 Volts	1150	KY16DPF	KZ16DPF	KSA16DBF	KSL16DBF
1000	442 Volts	1200	KY17DPF	KZ17DPF	KSA17DBF	KSL17DBF

Note: The types listed above are non-polarized. For polarized types add "P" to cell size; thus, KY = KYP.
① Based on average industrial ratings. For currents not listed refer to text.

TABLE 3 — STANDARD, KLIP-SEL TYPES

STANDARD NON-POLARIZED TYPES

Max. RMS Operating Volts	Max. Clamping Volts @ Peak Current	Peak Current 0.25A	1.0A	3.0A	15A	35A	65A	135A
26	70	KY1DPF	KZ1DPF	KSA1DAF	KSL1DAF	KSD1DAF	KSP1DAF	KSF1DAF
52	140	KY2DPF	KZ2DPF	KSA2DAF	KSL2DAF	KSD2DAF	KSP2DAF	KSF2DAF
78	210	KY3DPF	KZ3DPF	KSA3DAF	KSL3DAF	KSD3DAF	KSP3DAF	KSF3DAF
104	280	KY4DPF	KZ4DPF	KSA4DAF	KSL4DAF	KSD4DAF	KSP4DAF	KSF4DAF
130	350	KY5DPF	KZ5DPF	KSA5DAF	KSL5DAF	KSD5DAF	KSF5DAF	KSP5DAF
156	420	KY6DPF	KZ6DPF	KSA6DBF	KSL6DBF	KSD6DBF	KSP6DBF	KSF6DBF
182	490	KY7DPF	KZ7DPF	KSA7DBF	KSL7DBF	KSD7DBF	KSP7DBF	KSF7DBF
208	560	KY8DPF	KZ8DPF	KSA8DBF	KSL8DBF	KSD8DBF	KSP8DBF	KSF8DBF
234	630	KY9DPF	KZ9DPF	KSA9DBF	KSL9DBF	KSD9DBF	KSP9DBF	KSF9DBF
260	700	KY10DPF	KZ10DPF	KSA10DBF	KSL10DBF	KSD10DBF	KSP10DBF	KSF10DBF
286	770	KY11DPF	KZ11DPF	KSA11DBF	KSL11DBF	KSD11DBF	KSP11DBF	KSF11DBF
312	840	KY12DPF	KZ12DPF	KSA12DBF	KSL12DBF	KSD12DBF	KSP12DBF	KSF12DBF
338	910	KY13DPF	KZ13DPF	KSA13DBF	KSL13DBF	KSD13DBF	KSP13DBF	KSF13DBF
364	980	KY14DPF	KZ14DPF	KSA14DBF	KSL14DBF	KSD14DBF	KSP14DBF	KSF14DBF
390	1050	KY15DPF	KZ15DPF	KSA15DBF	KSL15DBF	KSD15DBF	KSP15DBF	KSF15DBF
416	1120	KY16DPF	KZ16DPF	KSA16DBF	KSL16DBF	KSD16DBF	KSP16DBF	KSF16DBF
442	1190	KY17DPF	KZ17DPF	KSA17DBF	KSL17DBF	KSD17DBF	KSP17DBF	KSF17DBF
468	1260	KY18DPF	KZ18DPF	KSA18DBF	KSL18DBF	KSD18DBF	KSP18DBF	KSF18DBF
494	1330	KY19DPF	KZ19DPF	KSA19DBF	KSL19DBF	KSD19DBF	KSP19DBF	KSF19DBF
520	1400	KY20DPF	KZ20DPF	KSA20DBF	KSL20DBF	KSD20DBF	KSP20DBF	KSF20DBF

STANDARD POLARIZED TYPES

Max. RMS Operating Volts	Max. Clamping Volts @ Peak Current	Peak Current 0.25A	1.0A	3.0A	15A	35A	65A	135A
22	66	KYP1DPF	KZP1DPF	KSAP1DAF	KSLP1DAF	KSDP1DAF	KSPP1DAF	KSFP1DAF
44	132	KYP2DPF	KZP2DPF	KSAP2DAF	KSLP2DAF	KSDP2DAF	KSPP2DAF	KSFP2DAF
66	198	KYP3DPF	KZP3DPF	KSAP3DAF	KSLP3DAF	KSDP3DAF	KSPP3DAF	KSFP3DAF
88	264	KYP4DPF	KZP4DPF	KSAP4DAF	KSLP4DAF	KSDP4DAF	KSPP4DAF	KSFP4DAF
110	330	KYP5DPF	KZP5DPF	KSAP5DAF	KSLP5DAF	KSDP5DAF	KSPP5DAF	KSFP5DAF
132	396	KYP6DPF	KZP6DPF	KSAP6DBF	KSLP6DBF	KSDP6DBF	KSPP6DBF	KSFP6DBF
154	462	KYP7DPF	KZP7DPF	KSAP7DBF	KSLP7DBF	KSDP7DBF	KSPP7DBF	KSFP7DBF
171	528	KYP8DPF	KZP8DPF	KSAP8DBF	KSLP8DBF	KSDP8DBF	KSPP8DBF	KSFP8DBF
198	594	KYP9DPF	KZP9DPF	KSAP9DBF	KSLP9DBF	KSDP9DBF	KSPP9DBF	KSFP9DBF
220	660	KYP10DPF	KZP10DPF	KSAP10DBF	KSLP10DBF	KSDP10DBF	KSPP10DBF	KSFP10DBF
242	726	KYP11DPF	KZP11DPF	KSAP11DBF	KSLP11DBF	KSDP11DBF	KSPP11DBF	KSFP11DBF
264	792	KYP12DPF	KZP12DPF	KSAP12DBF	KSLP12DBF	KSDP12DBF	KSPP12DBF	KSFP12DBF
286	858	KYP13DPF	KZP13DPF	KSAP13DBF	KSLP13DBF	KSDP13DBF	KSPP13DBF	KSFP13DBF
308	924	KYP14DPF	KZP14DPF	KSAP14DBF	KSLP14DBF	KSDP14DBF	KSPP14DBF	KSFP14DBF
330	990	KYP15DPF	KZP15DPF	KSAP15DBF	KSLP15DBF	KSDP15DBF	KSPP15DBF	KSFP15DBF
352	1056	KYP16DPF	KZP16DPF	KSAP16DBF	KSLP16DBF	KSDP16DBF	KSPP16DBF	KSFP16DBF
374	1122	KYP17DPF	KZP17DPF	KSAP17DBF	KSLP17DBF	KSDP17DBF	KSPP17DBF	KSFP17DBF
396	1188	KYP18DPF	KZP18DPF	KSAP18DBF	KSLP18DBF	KSDP18DBF	KSPP18DBF	KSFP18DBF
418	1254	KYP19DPF	KZP19DPF	KSAP19DBF	KSLP19DBF	KSDP19DBF	KSPP19DBF	KSFP19DBF
440	1320	KYP20DPF	KZP20DPF	KSAP20DBF	KSLP20DBF	KSDP20DBF	KSPP20DBF	KSFP20DBF

TABLE 4 — KLIP-SEL DIMENSION CALCULATOR (See Fig. 12)

Variable + Constant = Mounting Dimension

Cell Size ①	Variable ①	+ Constant
STACK TYPES		
KSL	2Nx0.075″	1.46″
KSLP	Nx0.075″	1.33″
KSA	2Nx0.060″	1.26″
KSAP	Nx0.060″	1.15″
CARTRIDGE TYPES		
KZ (Dia. = 0.70″ Max.)		
N = 1 to N = 5	—	0.63″
N = 6 to N = 11	—	0.88″
N = 12 to N = 22	—	1.63″

Cell Size ①	Variable ①	+ Constant
KZP (Dia. = 0.70″ Max.)		
N = 1 to N = 10	—	0.63″
N = 11 to N = 22	—	0.88″
N = 23 to N = 40	—	1.63″
KY (Dia. = 0.57″ Max.)		
N = 1 to N = 5	—	0.63″
N = 6 to N = 11	—	0.88″
N = 12 to N = 22	—	1.63″
KYP (Dia. = 0.57″ Max.)		
N = 1 to N = 10	—	0.63″
N = 11 to N = 22	—	0.88″
N = 23 to N = 40	—	1.63″

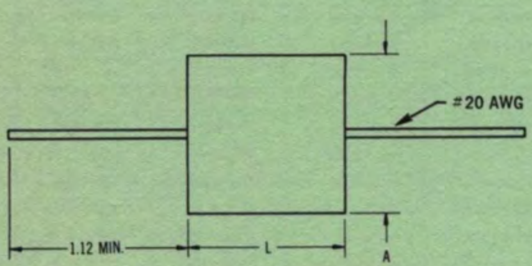
① N = Number of cells of given polarity = Fv Operating Voltage Factor from Table 1 (page 9).

For cells 3″ square and larger refer to the selenium stack assemblies mounting dimension chart (page 24). Use the narrow spacing mounting under column headed D, P cells for polarized Klip-Sels. For non-polarized Klip-Sels add 0.120″ for each increment in operating voltage factor.

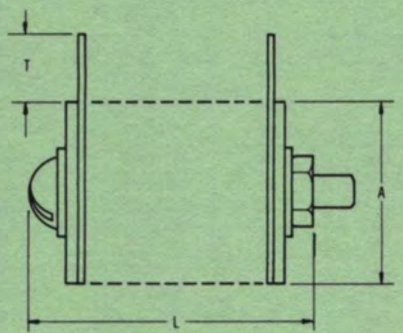
For example: the mounting dimension for KSF5DAF would be 2.62 + (5x 0.120) = 3.22″.

For other dimensions of Klip-Sel stacks refer to the "standard dimensions of selenium rectifier stacks" chart.

Fig. 12 — Dimensional Diagrams



TYPICAL CARTRIDGE TYPES



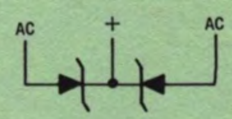
STACK TYPES

Special Klip-Sels

For unusual transient energy problems, special Klip-Sel assemblies can be furnished in the following classifications.

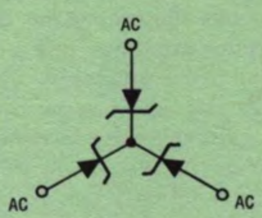
1. Types with more cells in series than are listed in the tables in both open stack construction and cartridge types.
2. Multi-element types for use in doublers, center-taps, three-phase bridges, etc.
3. Parallel arrangement of cells for unusual power handling capabilities. When your transient energy problems are special consult your IR Field Office or IR's El Segundo Offices. Some of the special multi-element types available are shown here.

SINGLE PHASE

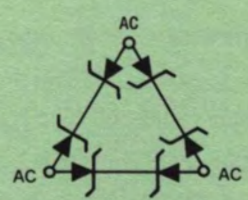


Center tap when used in center tap rectifier circuits, provides protection from source transients.

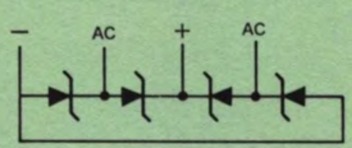
THREE PHASE



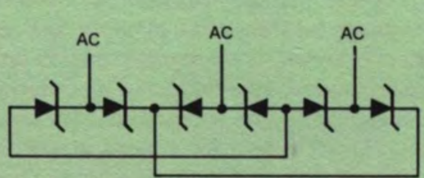
When used in any three phase circuit, protection from source transients.



Same as above except has better energy handling capability.



Used with single phase bridge rectifier. One element across each leg of rectifier. Protection from any source transients.



Used with three phase bridge rectifier. One element across each leg of rectifier, protection from any source transients.

THE NEED FOR CONTACT PROTECTION

Arcing, while producing serious deterioration of contacts which can result in circuit failures, also introduces other undesirable features. For example, the high voltage transients which are generated may cause insulation puncture or otherwise effect circuit operation. The transients created are of radio frequency which can supply interference effects to other adjacent circuits.

In any electric circuit, where contacts interrupt the flow of current, there will usually be arcing across the contacts regardless of the nature of the load. The effect is particularly magnified if the load is inductive and also if the supply is dc rather than ac. A typical illustration of an inductive circuit is shown

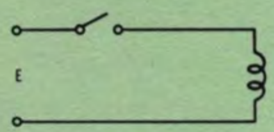


Fig. 1 — Inductive Circuit

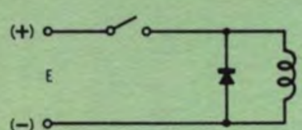


Fig. 2 — Polarized Protection

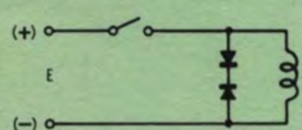


Fig. 3 — Non-polarized Protection

in Fig. 1. When the switch is open, a high voltage will be generated due to the collapse of the magnetic field in the coil. The value of this voltage is equal to $-L\frac{di}{dt}$ where L equals the core inductance and $\frac{di}{dt}$ equals rate of change of current with time. This generated voltage is of reverse polarity as indicated by the above equation. After the contacts are opened the flow of current in the circuit is suddenly stopped, and the voltage induced in the coil could, theoretically, rise to infinity. However, due to the circuit parameters involved, the induced voltage will rise to limits such as 1000 Volts in an average 24 Volt coil circuit. At voltages of these magnitudes, arcing will occur between the opening contacts, and will be maintained until extinguished by increased separation of the contacts.

Arcing can occur across the contacts in free air whenever the voltage exceeds 300 Volts. Several methods are in use to reduce the generated voltage below a value at which arcing will not occur. These have used components such as fixed resistors, semiconductors, capacitors, permanent magnets, and arc blowout coils. Semiconductor devices have proved to be the most effective, and have the additional advantages of small size, long life, low cost, and ease of mounting. Of the other methods, the capacitor-resistor combination is costly and bulky. While providing arc reduction, it can sometimes draw excessive charging currents, and also increase the drop-out time.

Blowout coils or magnets may tend to increase the generated voltage and, although reducing the arcing, the increased voltage may be detrimental to the circuit insulation.

Typical Circuits Using Contact Protectors

Typical circuits illustrating the use of semiconductors in contact protection are shown in Fig. 2 and Fig. 3. The choice of which circuit to use will depend upon three factors: (1) supply voltage; (2) maximum permissible induced voltage; and (3) maximum allowable time delay in de-energizing the coil.

In a circuit such as Fig. 1, the voltage induced in the coil after the contacts are open may be expressed by

$$V = IR\ \epsilon^{\left(-\frac{tR}{L}\right)}$$

This reduces to $V = E\left(1 + \frac{R_S}{R_L}\right)$ when $t = 0$

Where V = decay voltage (at time t, after contacts open)

I = steady state coil current

R = total circuit resistance = $R_L + R_S$

E = supply voltage

R_L = coil resistance = $\frac{E}{I}$

L = coil inductance (in millihenrys)

R_S = suppressor resistance

t = decay time

ϵ = base of naperian log

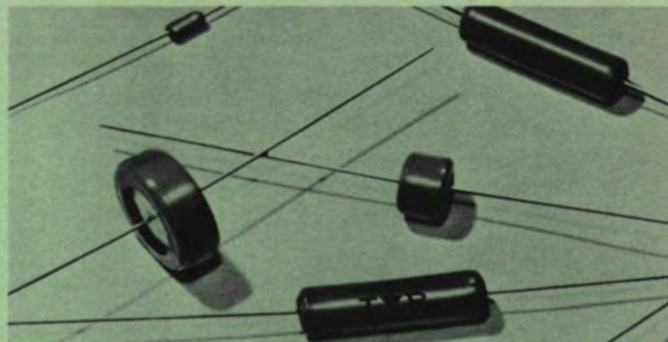
It is thus seen that the peak voltage is dependent only on the supply voltage and the ratio of suppressor resistance to coil resistance. However, if R_S is made small in order to reduce the peak generated voltage, the delay time becomes longer. The circuit of Fig. 2 has a low forward resistance, and the circulating current will tend to flow for a much longer time than it takes for the current to decay in an unprotected circuit. If decay time is important, then the circuit of Fig. 3 should be used. If the supply is ac, then Fig. 3 is absolutely necessary, since the suppressor must block voltages of both polarities equally.

CONTACT PROTECTORS

The contact protectors listed in Table 1 are available in several configurations; including diode types and cartridges. Hermetically sealed units, available on special order, are of particular importance when severe environmental conditions are encountered.

All units listed are assembled with selenium cells in a back-to-back configuration. This affords the best protection to the contacts, with the least effect on the operation of the circuit. In specifying contact protectors it is important that the maximum voltage rating of the protector exceeds the maximum value of the supply voltage.

Current ratings given are for intermittent operation with a maximum of 30 to 40 operations per second. If the frequency of operation exceeds 40 operations per second, a cell with a larger rating should be used and more information may be required in order to analyze the heating effect produced in the protector.



The ratings are based upon maximum ambient temperature of 35 °C. When higher ambient temperatures are encountered, some derating will be necessary.

TABLE 1 — CONTACT PROTECTOR TYPES AND SPECIFICATIONS (@ 35°C AMBIENT TEMPERATURE)

AC TYPES (Electrical Characteristics; Diode Type: A MAX. DIA., B MAX., ②; Cartridge Type: 2½ TYP., B MAX., A MAX.)

Working Volts ac Max.	Max. Coil Current (Amp)	Diode Type Code No.	Diode Dimension A (Max.)	Diode Dimension B (Max.)	Cartridge Type Code No.	Cartridge Dimension A (Max.)	Cartridge Dimension B Max.
26	.20	S1V1D	.47	.55	S1V1P	.380	.620
52	.20	S2V2D	.47	.55	S2V2P	.380	.620
78	.20				S3V3P	.380	.620
104	.20				S4V4P	.380	.620
130	.20				S5V5P	.380	.620
156	.20				S6V6P	.380	.990
26	.40	S1Y1D	.47	.55	S1Y1P	.500	.620
52	.40				S2Y2P	.500	.620
78	.40				S3Y3P	.500	.620
104	.40				S4Y4P	.500	.620
130	.40				S5Y5P	.500	.620
156	.40				S6Y6P	.500	.990
26	.60				S1Z1P	.640	.754
52	.60				S2Z2P	.640	.754
78	.60				S3Z3P	.640	.754
104	.60				S4Z4P	.640	.754
130	.60				S5Z5P	.640	.754
156	.60				S6Z6P	.640	.990
26	.90				S1X1P	1.060	.620
52	.90				S2X2P	1.060	.620
78	.90				S3X3P	1.060	.620
104	.90				S4X4P	1.060	.620
130	.90				S5X5P	1.060	.620
156	.90				S6X6P	1.060	.990
26	1.2				S1W1P	1.380	.620
52	1.2				S2W2P	1.380	.620
78	1.2				S3W3P	1.380	.620
104	1.2				S4W4P	1.380	.620
130	1.2				S5W5P	1.380	.620
156	1.2				S6W6P	1.380	.990

DC TYPES (Electrical Characteristics ①; Diode Type: A MAX. DIA., B MAX., ②; Cartridge Type: 2½ TYP., B MAX., A MAX.)

Working Volts dc Min.	Working Volts dc Max.	Max. Coil Current (Amp)	Diode Type Code No.	Diode Dimension A (Max.)	Diode Dimension B Max.	Cartridge Type Code No.	Cartridge Dimension A (Max.)	Cartridge Dimension B (Max.)
15	22	.25	S1V1D	.310	.470	S1V1P	.380	.620
23	44	.25	S2V1D	.350	.470	S2V1P	.380	.620
45	66	.25	S3V1D	.400	.470	S3V2P	.380	.620
67	88	.25				S4V2P	.380	.620
89	110	.25				S5V2P	.380	.620
111	132	.25				S6V2P	.380	.620
133	154	.25				S7V2P	.380	.620
15	22	.60	S1Y1D	.470	.550	S1Y1P	.500	.620
23	44	.60	S2Y1D	.470	.550	S2Y1P	.500	.620
45	66	.60				S3Y2P	.500	.620
67	88	.60				S4Y2P	.500	.620
89	110	.60				S5Y2P	.500	.620
111	132	.60				S6Y2P	.500	.620
133	154	.60				S7Y2P	.500	.620
15	22	.90				S1Z1P	.640	.754
23	44	.90				S2Z1P	.640	.754
45	66	.90				S3Z2P	.640	.754
67	88	.90				S4Z2P	.640	.754
89	110	.90				S5Z2P	.640	.754
111	132	.90				S6Z2P	.640	.754
133	154	.90				S7Z2P	.640	.754
15	22	1.4				S1X1P	1.060	.620
23	44	1.4				S2X1P	1.060	.620
45	66	1.4				S3X2P	1.060	.620
67	88	1.4				S4X2P	1.060	.620
89	110	1.4				S5X2P	1.060	.620
111	132	1.4				S6X2P	1.060	.620
133	154	1.4				S7X2P	1.060	.620
15	22	2.0				S1W1P	1.380	.620
23	44	2.0				S2W1P	1.380	.620
45	66	2.0				S3W2P	1.380	.620
67	88	2.0				S4W2P	1.380	.620
89	110	2.0				S5W2P	1.380	.620
111	132	2.0				S6W2P	1.380	.620
133	154	2.0				S7W2P	1.380	.620

① When connecting dc contact protectors, the terminal marked in red, or at the end with polarity marking, should be connected to the positive side of the circuit.

② Meniscus formed at lead on top of diode .187 max.

SELENIUM STACK ASSEMBLIES

As the world's largest supplier of industrial metallic rectifiers, International Rectifier has the broadest line to meet any and all requirements.

Many units in the field are still in use today after 20 years. Internal quality assurance life tests on some units have continued for 18 years during which time over 30,000 KWH have been converted. Evaluations show these units still have approximately 90% of their original output voltage.

"Plate Lok" Keyed Construction

IR's exclusive "Plate Lok" construction prevents rotation of the plates in the stack, eliminating contact damage.

Bellows Spring Contact

Bellows Spring Contact assures high efficiency for the collection of current from the cells counter electrode by contacting a large area and applying a precise and constant pressure for a long and dependable life.

Selenium Stacks

IR presents this line of selenium stack assemblies in four sections. The first section provides information, graphs, and coding applicable to all selenium stack assemblies; the next section (page 26) lists the selenium stack assemblies currently available for off-the-shelf delivery, including all of the configurations that have been and still are so popular and a listing of multi-circuit stacks (page 27) which the customer may convert into more than 5 basic circuits plus interconnect individual units; and the third section (page 28) lists the broad line of loose plate kits that are available for those who would rather do it themselves; and, finally, the fourth section (page 30) covers the popular miniature stacks offering the same quality and reliability as their bigger brothers at ratings applicable to magnetic and entertainment systems.

Each section includes mounting dimensions for the various configurations available.

Stack Coding

Table 1 (page 20) describes the general coding used for Selenium Stack Assemblies.

To determine the number of cells in any stack, multiply the number of cells in series by the number of arms in the stack circuit (see Table 2, page 20) by the number of cells in parallel; for example:

H2B2SDBGX
2 x 4 x 2 = 16

Voltage Rating

The number of cells in series times the individual cell voltage rating determines the stack rating. In the example given there are two cells in series each of which has a rating of 26VRMS. Therefore the stack is rated at 52VRMS. The next to last letter in the code designates the individual cell rating and may be changed to take advantage of higher voltage cells available.

Any number of cells may be used in series up to the limit shown in Table 5 (page 24). When more cells are necessary than are allowed by Table 5 to achieve the desired voltage rating, more than one stack may be connected in series. In addition, individual half-wave stacks may be connected to form other circuits such as a single phase bridge or three phase bridge.

The smaller stack, produced by IR this year, has a higher rating than the larger stack — which was a standard of the industry less than 10 years ago.

A common method of achieving the desired configuration is to connect multiples of "Doubler" stacks together. Table 1, page 27, tabulates a line of standard doubler stacks, called multi-circuit stacks, available from stock. As shown in the examples below the table, these doublers can be connected to form other circuits or connected in series and parallel to increase the voltage or current rating.

Current Rating

Also in the example shown above, there are two cells in parallel per arm. This has the effect of doubling the current rating of the stack. Referring to Table 4, page 22, the current rating for a single phase bridge constructed using "H" (6″ x 7.25″) cells is 13.0 Amperes. The current rating with two cells in parallel is 26.0 Amperes. The current rating of the stack could also be increased by changing the last letter in the code of the example "H2B2SDBGX," the letter "X" means single or standard density cells, which conforms to the NEMA standard of 160 mA per square inch of active area. There are four classifications of cell densities listed in Table 4, page 22. Double density is twice the rating of the standard and so on. If twice the current rating of the example were required, the letter "D" would be put in place of the letter "X" in the code.

It should be noted that the higher cell voltages are not possible coincident with higher current densities. It can be seen in Table 4, under the column headings, that 45 Volt cells are available in standard density and double density current rating while up to 30V cells are available in quadruple density cells and up to 40V cells in triple density.

The mounting dimensions for any configuration is determined from Table 5, page 24. Using the above example, we have determined that there are sixteen cells in the stack and that the code letter "S" denotes standard spacing. Referring to Table 5 under the column "standard" under F.H.J cells, we see that the mounting dimension for 16 cells is 10.25 inches. This is the dimension from end nut to end nut and does not include the stud extensions which are used for mounting purposes. Other stack dimensions are given in Table 6 (page 25) such as stud extensions and terminal extensions.

If brackets were required for the above example, the mounting dimension or the hole-to-hole dimension would be found by adding the dimension "D" in Table 6 to the mounting dimension (nut to nut) previously determined. The "D" dimension for "H" cells is .81". 10.25 plus .81 equal 11.06 the mounting dimension as shown in the illustration "stud and 2 bracket mounting style D" in Figure 7, page 25.

Circuits

The third figure in the code designates the circuit configuration and, as shown in Table 2, page 20, also determines the number of arms in the stack circuit. This number times the number of cells in series times the number of cells in parallel equals the number of cells in the stack. The circuits mentioned in Table 2 are shown in Figure 1, page 21. Each of the arrows in rectifier circuit diagrams represents an arm of the circuit. Each arm may consist of a number of cells in series and or in parallel.

The formulas in Table 3, page 20, are for some of the most commonly used circuits. Other factors are given in the general information section on circuits. To determine the output voltage of the example stack we would use the formula as shown for the single phase bridge. We assume the stack is operating at 44 VRMS. These values allow 10% for line variations and 5% for transformer regulation. We also assume the stack is operating at 13.0 Amperes in an ambient of 35°C. The only information missing is the forward voltage drop. Since this is a standard density stack with current density of 160 mA per square inch, we can refer to the curve of Figure 5, page 23, for forward voltage drop versus output current density. Going to 160 mA per square inch on the horizontal axis up to the standard density wave and then left to the vertical axis we see that the forward voltage drop per cell is approximately one Volt. Applying all of the known values to the formula.

$$E_{AC} = 1.15\,\text{Edc} + 2nD$$

$$44 = 1.15\,\text{Edc} + 2 \times 2 \times 1.0$$

$$\frac{44\text{-}4}{1.15} = \text{Edc}$$

$$\text{Edc} = \frac{40}{1.15} = 34.8\text{VDC}$$

Standard single phase bridges and center-tap rectifiers as shown on pages 26 and 27 are also available from stock as are the doublers previously mentioned. The single phase bridge stacks cover the output current range from 0.5 to 20 Amperes convection cooled and from 36 to 180 VRMS.

PERFORMANCE CHARACTERISTICS AND RECTIFIER DESIGN DATA

Current Characteristics

Current ratings given in Table 4, page 22, are for ambient temperatures up to 35°C.

For higher temperatures, derate the current output as shown in Figure 2, page 23, for all types of cells.

Figure 3, page 23, shows cell current re-rating as affected by cooling air velocity. Note especially that the double, triple, and quadruple density re-rating curve only applies on applications such as battery charging and electroplating, where there are no short time overloads whatsoever. For applications where short time overloads are encountered, refer to Figure 4, page 23, for re-rating values.

Narrow cell spacing is normally recommended only for forced cooled applications. On free convection cooled applications where narrow spacing is used, the current should be derated to at least 75% of the normal cell rating in the Output Current Ratings Table 4, page 22, and the rectifier stack must be mounted so that the cells are in a vertical plane to allow proper natural cooling through the fins.

The current ratings in the Output Current Ratings Table 4 are for resistive and inductive loads in single phase operation and for all loads in three phase operation. For single phase battery, capacitive, and motor loads, multiply current ratings by the following factors to insure long life:

CIRCUIT	CIRCUIT CODE (See Fig. 1, Pg. 21)	MULTIPLIER
1 Phase Half Wave	H	0.6
1 Phase FWCT	C, J	0.8
1 Phase FWB	D	0.8

Similarly, a current de-rating to 80% is recommended for cathodic protection applications.

For altitudes above 3,000 feet, derate current by 2.5% per 1,000 feet.

Overload Characteristics

The ability of IR's Selenium cells to withstand high current overloads during intermittent duty is shown in Figure 4, page 23. For pulse load applications, such as solenoid operation, contact your local IR Field Office (listed in the back of the catalog) or IR's El Segundo offices.

Voltage Considerations

In designing the voltage rating of a rectifier stack, the normal line variations (±10%) and transformer regulation (3% to 5%) must be considered. The stated voltage ratings of the cells are the maximum allowable continuous voltages that can be impressed on the cells. Therefore, the voltage rating of the selenium stack must be 10% to 15% above the nominal input voltage.

For dc blocking applications, the maximum dc voltage is 80% of the RMS ratings.

For single-phase half wave rectifiers with capacitive or battery loads, the maximum allowable applied voltage is one-half the RMS rating of the cells.

The derating of the cell voltage with ambient temperature is shown in Figure 2, page 23, for all cell types.

Figure 5, page 23, shows the RMS forward voltage drop per cell as a function of rectifier output current density for single phase (180° conduction) operation of standard, double, triple, and quadruple density cells. The maximum recommended current density for various cells operating under free convection or forced air cooling is shown in the table in the figure.

TABLE 1—POWER RECTIFIER STACK CODING

TYPICAL STACK CODE → H 2 B 2 S D B G X

Cell Type (and Size) ①	Number of Cells in Series per Arm	Type of Circuit ②	Number of Cells in Parallel per Arm	Type of Spacing ③	Type of Finish	Type of Mounting	Reverse Voltage Rating ⑦	Type of Cell ⑦
A (1″ sq) B (1.2″ sq) C (1.5″ sq) L (2″ sq) D (3″ sq) P (4″ sq) J (4″ x 6″) F (5″ x 6″) H (6″ x 7¼″)	Determined by RMS Voltage applied and Inverse Voltage Rating of Cells	Single Phase H—Half Wave B—Bridge C—Center Tap + J—Center Tap − D—Doubler M—MAG Amp. Bridge Three Phase S—Half Wave + L—Half Wave − T—Bridge U—Center Tap Z—Mag Amp Bridge ④ Y—Mag Amp Bridge ⑤	Determined by DC Current required and Cell Current Capacity	N—Narrow S—Standard W—Wide	D—Commercial Finish Standard Coating T—Military Finish Multiple Coating with Fungicide T2, T3, T4 } Special Military Finish ⑥	A—Bolt, no Mtg. Bracket B—Stud, no Mtg. Bracket C—Bolt with One Mtg. Bracket D—Stud, Two Mtg. Brackets E—Eyelet	G— 26 Volt H— 30 Volt K— 33 Volt L— 36 Volt M— 40 Volt P— 45 Volt	X—Standard and High Voltage D—Double Density T—Triple Density Q—Quadruple Density

① See Table 4, page 22. ② See Figure 1, page 21. ③ See Table 5, page 24. ④ 6 AC Terminals, 2 DC Terminals. ⑤ 3 AC Terminals, 6 DC Terminals.
⑥ Available for severe environmental requirements. ⑦ See Table 4, page 22.

TABLE 2—ARMS PER CIRCUIT

Type	Arms	Type	Arms
Single Phase		**Three Phase**	
H—Half Wave	1	S—Half Wave +	3
B—Bridge	4	L—Half Wave −	3
C—Center Tap +	2	T—Bridge	6
J—Center Tap −	2	U—Center Tap	6
D—Doubler	2	Z—MAG Amp. Bridge	6
M—MAG Amp. Bridge	4	Y—MAG Amp. Bridge	6

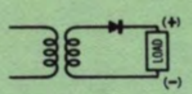
TABLE 3—SELENIUM STACK CIRCUITS

CIRCUIT		EQUATION	AC/DC CURRENT RATIO
DESIGNATION	FIGURE		
SINGLE-PHASE			
Half Wave	H	$E_{ac} = 2.3\ E_{dc} + nD$	1.8
Center Tap	C	$E_{ac} = 2.3\ E_{dc} + 2nD$	0.8
Bridge	B	$E_{ac} = 1.15\ E_{dc} + 2nD$	1.15
THREE PHASE			
Half Wave	S	$E_{ac} = 1.49\ E_{dc} + 1.73nD$	0.65
Center Tap	U	$E_{ac} = 1.48\ E_{dc} + 2nD$	0.46
Bridge	T	$E_{ac} = 0.74\ E_{dc} + 2nD$	0.85

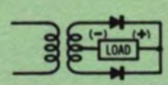
E_{ac} = Transformer secondary line to line voltage — Voltage rms
E_{dc} = Average DC output voltage — Volts
n = Number of cells in series per arm
D = Forward voltage drop per cell — Volts rms

Fig. 1 — Selenium Stack Circuits

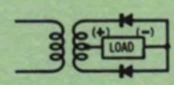
RECTIFIER CIRCUITS—SINGLE PHASE



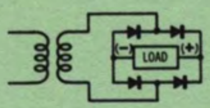
H — SINGLE PHASE HALFWAVE



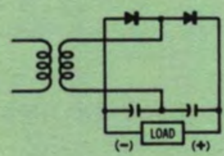
C — SINGLE PHASE CENTER TAP (COMMON POSITIVE)



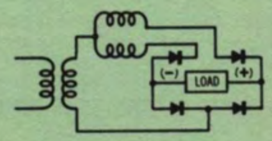
J — SINGLE PHASE CENTER TAP (COMMON NEGATIVE)



B — SINGLE PHASE BRIDGE

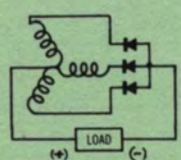


D — VOLTAGE DOUBLER

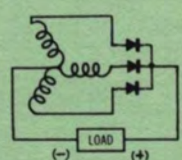


M — SINGLE PHASE MAG. AMP. BRIDGE

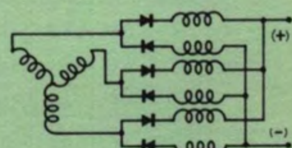
RECTIFIER CIRCUITS—MULTI-PHASE



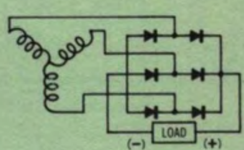
L — 3 PHASE WYE (HALF WAVE) (COMMON NEGATIVE)



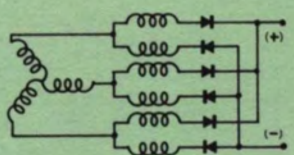
S — 3 PHASE WYE (HALF WAVE) (COMMON POSITIVE)



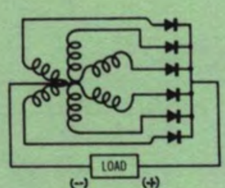
Y — 3 PHASE MAG. AMP. BRIDGE



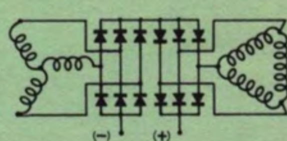
T — 3 PHASE BRIDGE



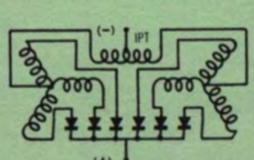
Z — 3 PHASE MAG. AMP. BRIDGE



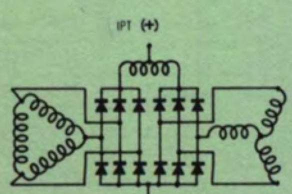
U — 6 PHASE STAR (3 PHASE CENTER TAP)



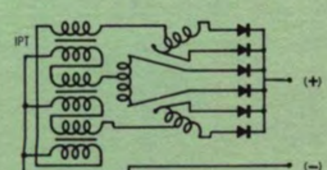
K — 6 PHASE SERIES BRIDGE (2 T-3 PHASE BRIDGES)



F — 3 PHASE DOUBLE WYE U — CENTER TAP



I — 6 PHASE PARALLEL BRIDGE (WITH OR WITHOUT IPT) (2 T-3 PHASE BRIDGES)



E — 3 PHASE TRIPLE DIAMETRIC (U — CENTER TAP)

TABLE 4 — OUTPUT CURRENT RATINGS @ 35°C AMBIENT TEMPERATURE (AMPERES)

		See Fig. 1, Page 21	Ripple %	STANDARD DENSITY CELLS 26 to 45 Volts RMS Reverse									DOUBLE DENSITY CELLS 26 to 45 Volts RMS Reverse								
	Cell Type			A	B	C	L	D	P	J	F	H	A	B	C	L	D	P	J	F	H
Single Phase	D.C. Blocking	—	—	.19	.3	.47	.9	1.8	3.2	5.4	6.4	10.0	.38	.6	.96	1.8	3.36	6.3	10.8	12.7	19.5
Single Phase	Half Wave	H	121.0	.13	.2	.32	.6	1.2	2.1	3.6	4.2	6.6	.25	.4	.64	1.2	2.24	4.2	7.2	8.5	13.0
Single Phase	Full Wave Centertap & Bridge	B, C, J, M	48.0	.26	.4	.64	1.2	2.4	4.2	7.25	8.5	13.0	.50	.8	1.28	2.4	4.49	8.4	14.4	17.0	26.0
Three Phase	Triple Diametric	E	4.2	1.0	1.55	2.5	4.65	8.0	14.0	24.0	28.0	44.0	2.00	3.1	5.0	7.8	15.0	28.0	48.0	56.7	88.0
Three Phase	Wye & Bridge	L, S / T, Y, Z	18.0 / 4.2	.39	.6	.96	1.8	3.6	6.3	11.0	13.0	20.0	.78	1.2	1.92	3.4	6.1	11.4	19.6	23.0	40.0
Three Phase	Double Wye	F	4.2	.71	1.1	1.75	3.3	6.5	11.5	19.8	22.8	36.0	1.42	2.2	3.5	6.6	12.4	22.8	39.3	46.2	72.0
Six Phase	Star	U	4.2	.5	.76	1.2	2.3	4.6	8.1	13.5	15.7	24.8	1.00	1.52	2.4	4.2	8.6	16.3	27.6	32.8	50.0
Six Phase	Parallel Bridge without IPT	I ①	1.2	.5	.76	1.2	2.3	4.6	8.1	13.5	15.7	24.8	1.00	1.52	2.4	4.2	8.6	16.3	27.6	32.8	50.0
Six Phase	Parallel Bridge with IPT	I ①	1.2	.71	1.1	1.75	3.3	6.5	11.5	19.8	22.8	36.0	1.42	2.2	3.5	6.6	12.4	22.8	39.3	46.2	72.0
Six Phase	Series Bridge	K ①	1.2	.39	.6	.96	1.8	3.6	6.3	11.0	13.0	20.0	.78	1.2	1.92	3.6	6.1	11.4	19.6	23.0	40.0

		See Fig. 1, Page 21	Ripple %	TRIPLE DENSITY CELLS 26 to 40 Volts RMS Reverse									QUADRUPLE DENSITY CELLS 26 to 36 Volts RMS Reverse								
	Cell Type			A	B	C	L	D	P	J	F	H	A	B	C	L	D	P	J	F	H
Single Phase	D.C. Blocking	—	—	.57	.9	1.44	2.7	5.2	9.7	16.8	19.8	30.4	.75	1.2	1.92	3.6	6.7	12.6	21.6	25.4	40
Single Phase	Half Wave	H	121.0	.38	.6	.96	1.8	3.5	6.55	11.2	13.2	20.5	.5	.8	1.3	2.4	4.5	8.4	14.4	17.0	27
Single Phase	Full Wave Centertap & Bridge	B, C, J, M	48.0	.78	1.2	1.92	3.6	7.0	13.2	22.5	26.5	39.0	1.0	1.6	2.56	4.8	9.0	16.8	28.8	34.0	52
Three Phase	Triple Diametric	E	4.2	3.0	4.6	7.5	13.8	23.3	43.5	74.0	87.3	132.0	4.0	6.2	10.0	15.6	30.0	56.0	96.0	113.4	176
Three Phase	Wye & Bridge	L, S / T, Y, Z	18.0 / 4.2	1.16	1.8	2.88	5.4	9.5	17.8	30.2	35.6	60.0	1.56	2.4	3.84	6.8	12.2	22.8	40.0	46.0	80
Three Phase	Double Wye	F	4.2	2.1	3.3	5.25	9.9	19.0	35.6	60.4	71.3	108.0	2.84	4.4	7.0	13.2	24.8	45.6	78.6	92.4	144
Six Phase	Star	U	4.2	1.5	2.28	3.6	6.9	13.5	25.2	42.7	50.6	75.0	2.0	3.0	4.8	8.4	17.2	32.6	55.2	65.6	100
Six Phase	Parallel Bridge without IPT	I ①	1.2	1.5	2.28	3.6	6.9	13.5	25.2	42.7	50.6	75.0	2.0	3.0	4.8	8.4	17.2	32.6	55.2	65.6	100
Six Phase	Parallel Bridge with IPT	I ①	1.2	2.1	3.3	5.25	9.9	19.0	35.6	60.4	71.3	108.0	2.84	4.4	7.0	13.2	24.8	45.6	78.6	92.4	144
Six Phase	Series Bridge	K ①	1.2	1.16	1.8	2.88	5.4	9.5	17.8	30.2	35.6	60.0	1.56	2.4	3.84	7.2	12.2	22.8	39.2	46.0	80

① Ordered under special part numbers. Contact local IR Field Office or El Segundo for information.

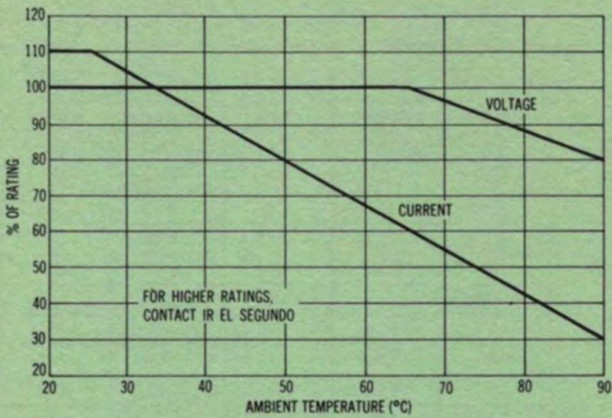


Fig. 2 — Voltage and Current Derating vs. Ambient Temperature

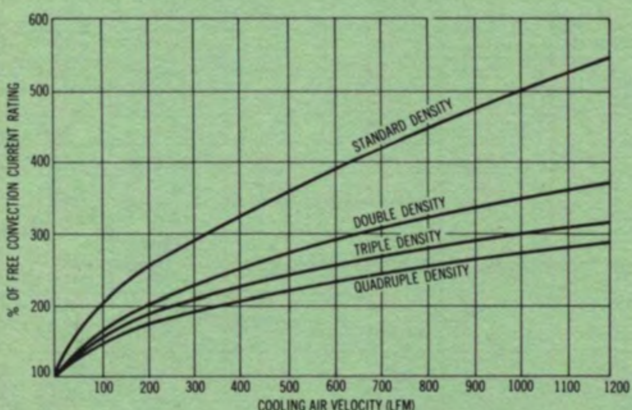


Fig. 3 — Current Re-Rating vs. Cooling Air Velocity

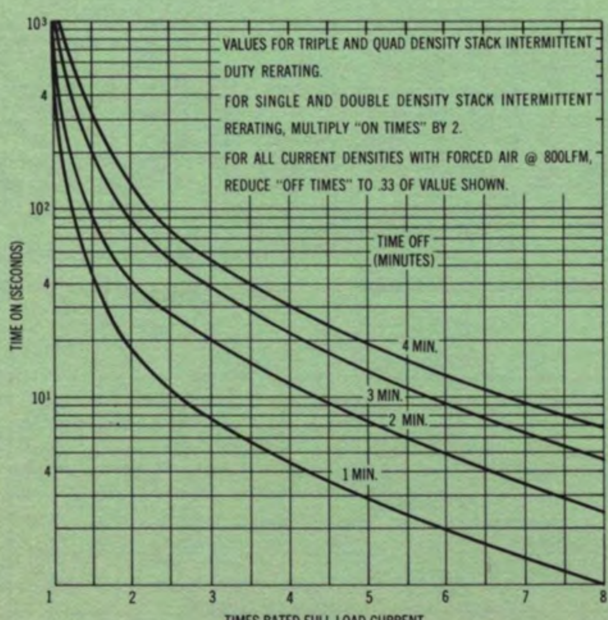
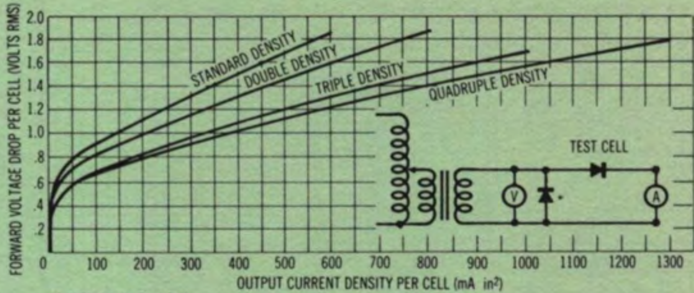


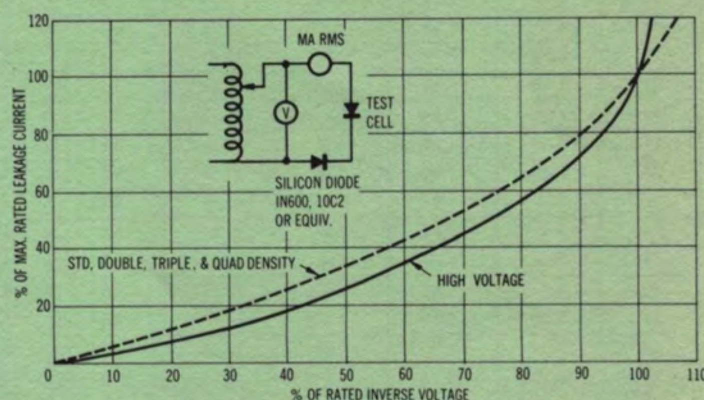
Fig. 4 — Intermittent Duty Re-Rating



*Cell Similar to Test Cell

The curves shown apply to single phase ½ wave, centertap, bridge resistive or inductive load and three phase ½ wave circuits. For three phase bridge and six phase star circuits, the forward voltage drop will be approximately 88% of that shown.

Fig. 5 — Typical Forward Voltage Drop vs. Current Density



NOTE: LOW LEAKAGE CELLS ARE AVAILABLE UPON REQUEST.

Rated Voltage (Volts RMS)	Max. Rated Leakage Current (mA RMS/Inches² active area)
22	11.2
26	9.5
30	8.25
33	7.5
36	6.6
45 ①	5.5

① High Voltage Type

Fig. 6 — Typical Leakage Current vs. Reverse Voltage

TABLE 5 — STACK MOUNTING DIMENSIONS (MTG)

Dimensions for Mounting Styles A, B, C, and D ① (See Fig. 7)

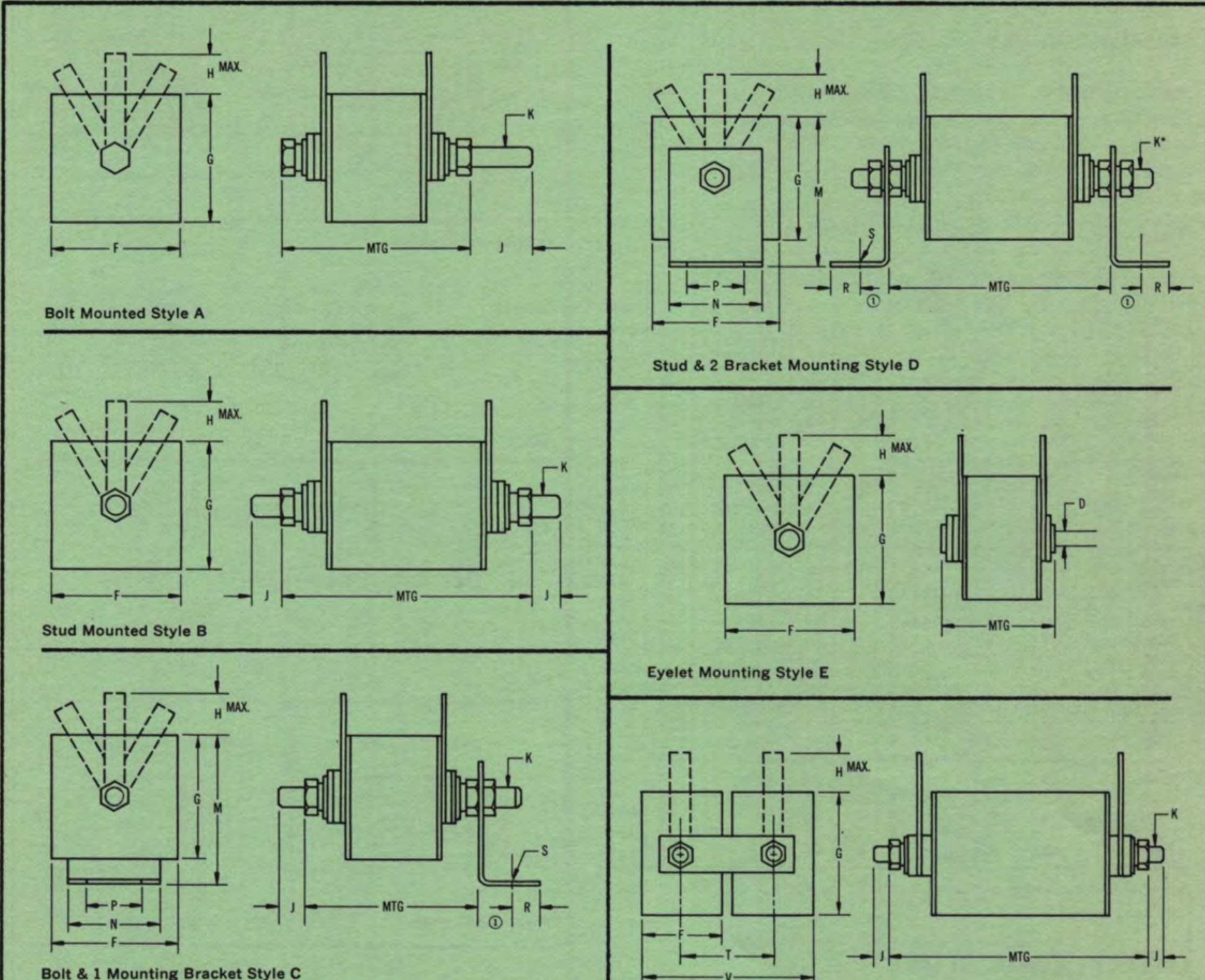
	A, B, C Cells			L Cells			D, P Cells			F, H, J Cells		
Cells	Wide	Standard	Narrow	Wide	Standard	Narrow	Wide	Standard	Narrow	Wide	Standard	Narrow
1	1.0	1.0	0.88	1.06	1.06	1.06	1.5	1.5	1.5	1.5	1.5	1.5
2	1.19	1.12	1.0	1.38	1.38	1.25	2.0	1.88	1.75	2.25	2.12	1.81
3	1.44	1.31	1.19	1.75	1.63	1.5	2.56	2.25	2.06	2.94	2.69	2.12
4	1.63	1.5	1.38	2.06	1.88	1.69	3.12	2.63	2.31	3.56	3.25	2.44
5	1.88	1.69	1.5	2.38	2.12	1.88	3.75	3.0	2.62	4.31	3.81	2.69
6	2.12	1.88	1.63	2.75	2.44	2.12	4.31	3.38	2.88	5.0	4.44	3.0
7	2.38	2.12	1.75	3.06	2.75	2.38	4.88	3.75	3.19	5.75	5.0	3.31
8	2.56	2.25	1.94	3.38	3.0	2.5	5.5	4.19	3.5	6.44	5.63	3.63
9	2.81	2.5	2.12	3.75	3.25	2.75	6.0	4.5	3.75	7.12	6.19	3.94
10	3.0	2.63	2.25	4.06	3.5	3.0	6.63	4.88	4.06	7.88	6.75	4.25
11	3.12	2.88	2.38	4.38	3.81	3.12	7.19	5.31	4.38	8.56	7.38	4.56
12	3.5	3.06	2.56	4.75	4.06	3.38	7.75	5.69	4.63	9.25	7.94	4.81
13	3.75	3.25	2.69	5.06	4.31	3.63	8.31	6.06	4.94	10.0	8.5	5.12
14	4.0	3.44	2.88	5.38	4.63	3.75	8.88	6.56	5.19	10.69	9.06	5.44
15	4.19	3.63	3.0	5.75	4.88	4.0	9.44	6.81	5.5	11.38	9.69	5.75
16	4.44	3.81	3.12	6.06	5.12	4.19	10.0	7.19	5.81	12.12	10.25	6.0
17	4.63	4.0	3.31	6.38	5.44	4.38	10.56	7.56	6.06	12.81	10.81	6.31
18	4.88	4.19	3.44	6.75	5.69	4.63	11.12	7.94	6.38	13.5	11.38	6.63
19	5.12	4.38	3.63	7.06	6.0	4.81	11.69	8.31	6.63	14.19	12.0	6.94
20	5.38	4.56	3.75	7.38	6.25	5.0	12.25	8.69	6.94	14.88	12.56	7.25
21	5.56	4.75	3.88	7.75	6.5	5.25	12.88	9.06	7.19	15.63	13.12	7.5
22	5.81	5.0	4.06	8.06	6.75	5.5	13.44	9.44	7.5	16.31	13.75	7.81
23	6.0	5.19	4.19	8.38	7.06	5.69	14.0	9.81	7.75	17.0	14.31	8.12
24	6.25	5.38	4.38	8.75	7.31	5.88	14.5	10.25	8.06	17.69	14.88	8.44
25	6.5	5.5	4.5	9.06	7.63	6.12	15.12	10.31	8.38	18.38	15.5	8.75
26	6.75	5.75	4.63	9.38	7.88	6.31	15.69	11.0	8.63	19.06	16.06	9.0
27	6.94	5.88	4.75	9.75	8.12	6.5	16.25	11.38	8.94	19.75	16.63	9.31
28	7.12	6.12	4.94	10.06	8.38	6.75	16.81	11.75	9.25	20.56	17.25	9.63
29	7.38	6.25	5.12	10.38	8.69	6.94	17.38	12.12	9.5	21.25	17.81	9.94
30	7.63	6.5	5.25	10.75	9.0	7.12	18.0	12.5	9.81	21.94	18.38	10.25
31	7.88	6.69	5.38	11.06	9.25	7.38	18.56	12.88	10.06	22.63	18.94	10.5
32	8.06	6.88	5.5	11.38	9.5	7.56	19.12	13.25	10.31	23.31	19.5	10.81
33	8.25	7.0	5.69	11.75	9.75	7.75	19.69	13.63	10.63	24.0	20.19	11.12
34	8.5	7.25	5.88	12.06	10.0	8.0	20.31	14.0	10.88	—	20.75	11.44
35	8.75	7.44	6.0	12.38	10.31	8.19	20.88	14.38	11.19	—	21.31	11.75
36	9.0	7.63	6.12	12.75	10.63	8.38	21.44	14.75	11.5	—	21.88	12.06
37	9.25	7.75	6.25	13.06	10.88	8.63	22.0	15.12	11.75	—	22.44	12.31
38	9.44	8.0	6.44	13.38	11.12	8.81	22.5	15.5	12.06	—	23.0	12.63
39	9.69	8.12	6.63	13.75	11.38	9.0	23.06	15.88	12.38	—	23.56	12.94
40	9.88	8.38	6.75	14.06	11.69	9.25	23.69	16.31	12.63	—	24.12	13.25

①Standard spacing systems. To obtain other mounting dimensions, spacers are added to end assemblies to attain correct measurement.

Dimensions for Mounting Style E (See Fig. 7)

Cells	A, B, C Cells	L Cells	D, P, F, J, H Cells
1	0.38	0.63	0.44
2	0.44	0.63	—
3	0.69	1.0	—
4	0.69	1.0	—
5	0.94	1.0	—
6	0.94	—	—
7	1.0	—	—
8	1.0	—	—
Eyelet Clearance for: (Dim. D—Max.)	8-32 Bolt		5/16 Bolt

Fig. 7 — Standard Dimensions of Selenium Rectifier Stacks



Bolt can be used up to Listed Max. Dim. Stud used above Max. Dim.	Plate Size	Max. Dim.	Plate Size	Max. Dim.
	A, B, C	2.81	D, P	5.0
	L	3.12	J, F, G, H	4.25

TABLE 6— STACK DIMENSIONS

Plate Code	Active Area (sq. in.)	Dimensions (inches)														
		Plate Size		H Max. Terminal Ext.	J Thread Ext.	K Stud Size	M Height	N Bracket Width	P Mntg. Width	R Bracket Ext.	S Slot Size		T	V Overall Width	Style ①	
		Width F	Height G								Length	Width			C	D
A	0.62	1.0	1.0	0.44	0.38	8-32	1.56	1.0	0.59	0.22	0.25	0.16	—	—	0.25	0.5
B	1.0	1.2	1.2	0.44	0.38	8-32	1.88	1.5	0.75	0.22	0.31	0.16	—	—	0.25	0.5
C	1.63	1.5	1.5	0.44	0.38	8-32	2.0	1.5	0.75	0.22	0.31	0.16	—	—	0.25	0.5
L	3.0	2.0	2.0	0.63	0.38	¼-20	2.38	1.5	0.75	0.31	0.36	0.17	—	—	0.31	0.62
D	7.0	3.0	3.0	0.63	0.75	⅜-16	3.94	3.0	1.5	0.31	0.5	0.22	—	—	0.41	0.81
P	13.2	4.0	4.0	0.81	0.75	⅜-16	4.75	3.0	1.5	0.34	0.5	0.22	—	—	0.41	0.81
J	22.5	4.0	6.0	1.19	0.75	⅜-16	6.63	4.0	2.0	0.34	0.5	0.22	4.06	8.06	0.41	0.81
F	26.5	5.0	6.0	1.19	0.75	⅜-16	6.63	4.0	2.0	0.34	0.5	0.22	5.06	10.06	0.41	0.81
H	41.0	6.0	7.25	1.13	0.75	⅜-16	7.88	4.0	2.0	0.34	0.5	0.22	6.06	12.06	0.41	0.81

① To obtain bracket mounting dimensions, add the dimension listed under applicable style to mtg. dimension from Table 5.

STANDARD STACKS

These standard stacks are listed for easy, off-the-shelf ordering. They have been expressly designed to meet the widest possible variety of industrial requirements in addition to assisting in standardization and reducing inventories.

TABLE 1 — STACK RATINGS AND DIMENSIONS

Type	Output		Max. Input AC Volts	Circuit & Connecting Diag. Fig.	Dimensions (Inches)						
	DC Volts	DC Amp			Fig.	A	B	MD	X	Y	Stud
J14C04	0	0.5	36	1	3	1.0	1.0	1.12	.38	.44	8-32
J14C1		1.5	36	1	3	1.5	1.5	1.12	.38	.44	8-32
J14C5	to	5.0	36	1	3	3.0	3.0	1.12	.75	.63	3/8-16
J14C8		10.0	36	1	3	4.0	4.0	1.88	.75	1.12	3/8-16
J14C17	14	20.0	36	1	3	6.0	5.0	2.12	.75	1.25	3/8-16
J29B04	0	0.5	36	2	4	1.0	1.0	1.5	.38	.44	8-32
J29B1		1.5	36	2	4	1.5	1.5	1.5	.38	.44	8-32
J29B5	to	5.0	36	2	4	3.0	3.0	2.63	.75	.63	3/8-16
J29B8		10.0	36	2	4	4.0	4.0	2.63	.75	1.12	3/8-16
J29B17	29	20.0	36	2	4	6.0	5.0	3.25	.75	1.25	3/8-16
J58B04	0	0.5	72	2	4	1.0	1.0	2.25	.38	.44	8-32
J58B1		1.5	72	2	4	1.5	1.5	2.25	.38	.44	8-32
J58B5	to	5.0	72	2	4	3.0	3.0	4.19	.75	.63	3/8-16
J58B8		10.0	72	2	4	4.0	4.0	4.19	.75	1.12	3/8-16
J58B17	58	20.0	72	2	4	6.0	5.0	5.63	.75	1.25	3/8-16
J116B04	0	0.5	144	2	4	1.0	1.0	3.81	.38	.44	8-32
J116B1		1.5	144	2	4	1.5	1.5	3.81	.38	.44	8-32
J116B5	to	5.0	144	2	4	3.0	3.0	7.19	.75	.63	3/8-16
J116B8		10.0	144	2	4	4.0	4.0	7.19	.75	1.12	3/8-16
J116B17	116	20.0	144	2	4	6.0	5.0	10.25	.75	1.25	3/8-16
J135B04	0	0.5	180	2	4	1.0	1.0	4.56	.38	.44	8-32
J135B1		1.5	180	2	4	1.5	1.5	4.56	.38	.44	8-32
J135B5	to	5.0	180	2	4	3.0	3.0	8.69	.75	.63	3/8-16
J135B8		10.0	180	2	4	4.0	4.0	8.69	.75	1.12	3/8-16
J135B17	135	20.0	180	2	4	6.0	5.0	12.56	.75	1.25	3/8-16

For forced cooling rerating, see Double Density Curve, Figure 3, page 23.

BATTERY CHARGER STACKS

Truly universal and economical selenium rectifiers for "Fast Chargers." Fully rated at 100 and 60 Amps, with fan cooling, these rectifiers offer instant replacement or instant design solution for battery chargers. Both forward and reverse configurations are listed.

TABLE 2 — BATTERY CHARGER STACK RATINGS

Type	Output		Max. Input AC Volts ②	Circuit Diagram Fig.	Dimension Diagram Fig.
	DC Volts	DC Amps ①			
BCR100	6-12	50-100	33	5	7
BCR60	6-12	30-60	33	5	7
BCF100	6-12	50-100	33	6	7
BCF60	6-12	30-60	33	6	7

① Forced convection cooled.
② Line-to-line voltage (see Figures 5 & 6).

Circuit and Connecting Diagrams

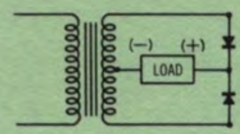


Fig. 1 — Center Tap

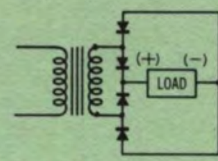


Fig. 2 — Single Phase Bridge

Diagrams of Dimensions

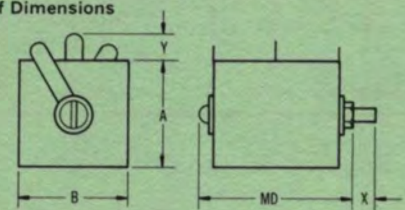


Fig. 3

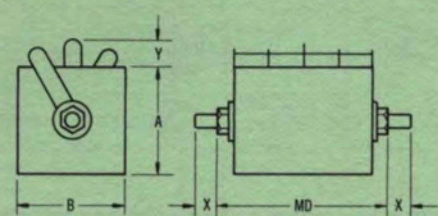


Fig. 4

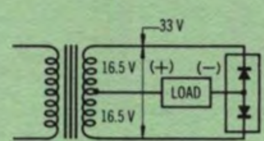


Fig. 5 — BCR Circuit

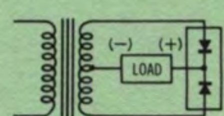
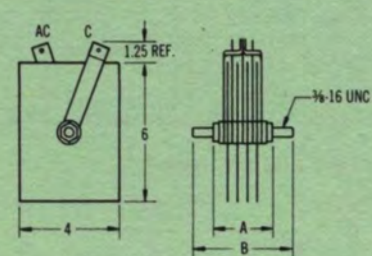


Fig. 6 — BCF Circuit



Stack	Dimensions (in.)		
	A	B	C
BCR100	3.88	5.64	Neg (—)
BCR60	2.44	3.94	Neg (—)
BCF100	3.88	5.64	Pos (+)
BCF60	2.44	3.94	Pos (+)

Fig. 7 — Battery Charger Stack Dimensions.

MULTI-CIRCUIT STACKS

Each J-D Selenium Stack is a dual doubler with the hardware supplied to connect the circuits shown in Figures 2 thru 6.

Multiple circuit applications, and broad current and voltage ranges are possible by connecting and interconnecting individual and multiple units.

External hardware supplied by user is required to interconnect individual units as shown in Figures 7 and 8. Instruction sheets are included with each unit.

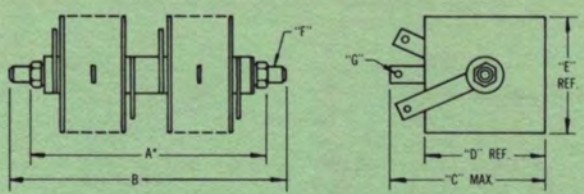


Fig. 1

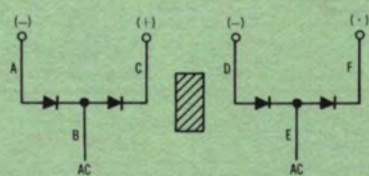


Fig. 2 — 2 Doubler Stacks

NOTE: Supplied configuration — Buss as shown for indicated circuits.

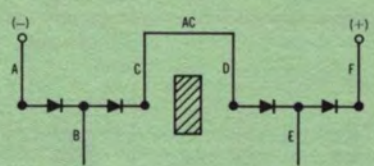


Fig. 3 Half Wave or Doubler Type With Center Link

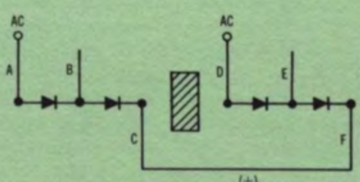


Fig. 4 — Center Tap, Common Positive

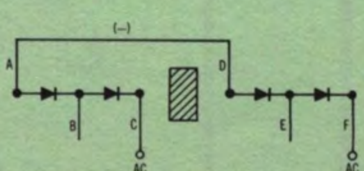


Fig. 5 — Center Tap, Common Negative

TABLE 1 — STACK RATINGS AND DIMENSIONS

(connected as 1Ø bridge)

	IR Number	Output DC Volt	Output DC Amp	Input AC V RMS	A	B	C	D	E	F Stud Size	G Hole Size
①	J29D2	29	2.0	36	1.50	2.25	2.00	1.50	1.50	8-32	0.062x0.156 slot
	J58D2	58	2.0	72	2.25	3.00	2.00	1.50	1.50	8-32	
	J135D2	135	2.0	180	4.56	5.31	2.00	1.50	1.50	8-32	
②	J29D7	29	7.0	36	2.62	4.12	4.38	3.00	3.00	3/8-16	.265
	J58D7	58	7.0	72	4.19	5.69	4.38	3.00	3.00	3/8-16	.265
	J135D7	135	7.0	180	8.69	10.19	4.38	3.00	3.00	3/8-16	.265
②	J29D13	29	13.0	36	2.62	4.12	5.19	4.00	4.00	3/8-16	.265
	J58D13	58	13.0	72	4.19	5.69	5.19	4.00	4.00	3/8-16	.265
	J135D13	135	13.0	180	8.69	10.19	5.19	4.00	4.00	3/8-16	.265
②	J29D25	29	25.0	36	3.25	4.75	7.25	6.00	5.00	3/8-16	.265
	J58D25	58	25.0	72	5.62	7.12	7.25	6.00	5.00	3/8-16	.265
	J135D25	135	25.0	180	12.56	14.04	7.25	6.00	5.00	3/8-16	.265

① Supplied with #20 copper wire for bussing.
② Supplied with hardware as needed for bussing.

For forced cooling rerating, see Triple Density curve, Figure 3, page 23.

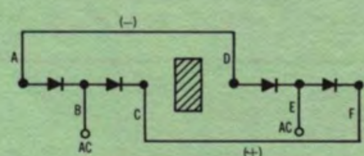


Fig. 6 — Single Phase Bridge

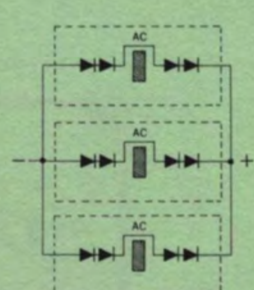


Fig. 7 3-J135D25'S for 360 VRMS Max. Input, up to 450 VDC at 35 Amps DC Output.

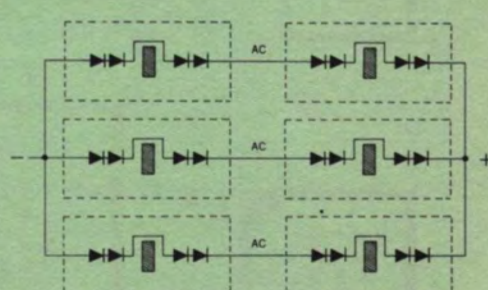


Fig. 8 6-J135D25'S for 720 VRMS Max. Input, up to 900 VDC at 35 Amps DC Output.

LOOSE CELL KITS

Special Application Cells

International Rectifier offers three series of special cells to meet specific requirements. These cells are available with or without hardware or assembled as mentioned below.

Exclusive Center-Tap Cells

IR's exclusive split counter-electrode cells are designed for single cell rectifiers; such as home battery chargers. The center tap cells are available under the part numbers in Table 1 as assembled units, or as loose cells. Figure 1 shows the center-tap cell assembly, the application schematic, and the plate dimensions. Figure 2 shows the configuration of the loose center-tap cell.

Commercial Series

Five series of commercial cells with the popular dead-center, dead-border configuration are available from IR. Instead of being masked as the industrial cells, these cells are coated with epoxy to form the dead areas, as shown in Figure 3. This cell construction allows assembly of stacks with metal washers in place of bellows springs and is available in both single and double density current ratings.

Industrial Cells

Figure 4 gives the outline and dimensions for industrial cells available with or without the hardware listed in Table 2. For specific applications, the contents of the kits may be varied as required. The quantities shown are the suggested items for 100 cells.

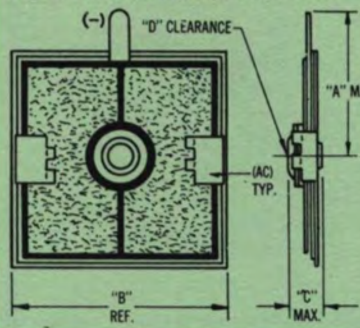
Application Data

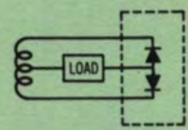
Figure 5 shows a typical selenium stack assembly, and identifies the parts and terminals available. For further information, or to discuss your specific application, feel free to contact your local IR Field Office or IR's El Segundo Offices.

TABLE 1 — CENTER-TAP CELLS

Part Number	Cell Size	Input Vrms	Output A dc
62-0324	C	33	1.5
62-0325	L	33	2
62-0326	D	33	4
62-0327	D	33	6
62-0328	P	33	10

Fig. 1 — Center-Tap Cell Assemblies

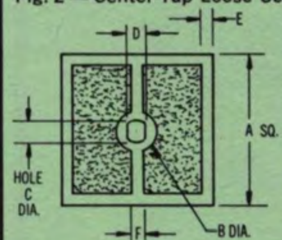




DIMENSIONS

CELL	A	B	C	D Clearance for:
C	1.22	1.75	.33	#8
L	1.69	2.25	.33	#8
D	2.25	3.25	.44	5/16
P	2.69	4.25	.44	5/16

Fig. 2 — Center-Tap Loose Cells

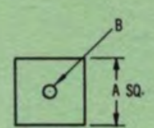


DIMENSIONS

CELL	A	B	C	D	E	F
B	1.200	.468	.257①	—	.062	.100
C	1.500	.468	.257①	—	.062	.130
L	2.000	.640	.402	.330	.062	.145
D	3.000	.88	.541	.453	.093	.195
P	4.000	.88	.541	.453	.093	.195

① Round hole only. Also available with .125 hole on special order.

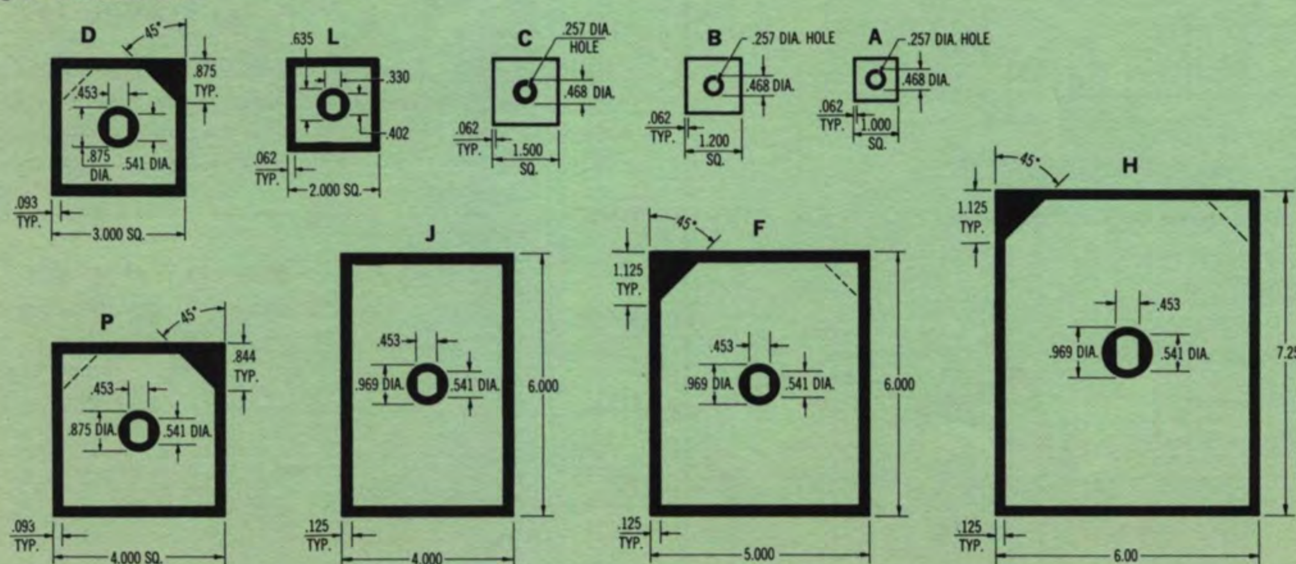
Fig. 3 — Commercial Cells



DIMENSIONS

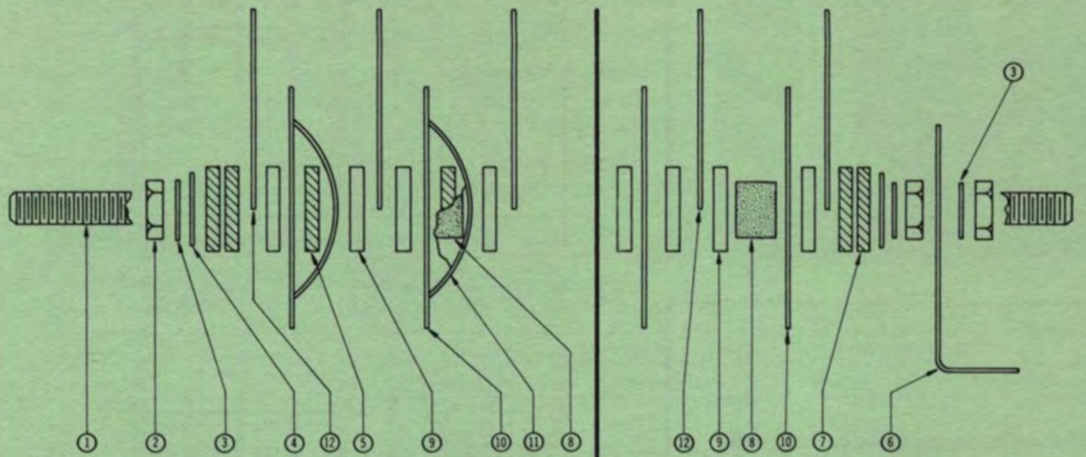
CELL	A	B
Q	.666	.257
A	1.000	.257
B	1.200	.257
C	1.500	.257
M	2.000	.257

Fig. 4 — Industrial Cells



Loose Cell Kits

Fig. 5 — Typical selenium stack assembly and parts description



Bellows Springs Construction
available in A, B, C, L, D, P, J, F and H cells

Dead Center Construction
available in Q, A, B, C and M cells

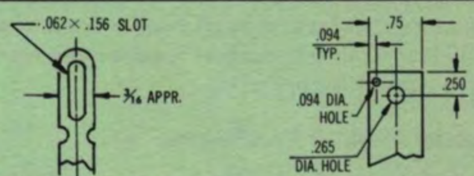
Special Faston terminal
for A cells and larger

Special Top Bus Bar

Special Side Bus Bar

1 Center stud
2 Nut
3 Lock Washer
4 Metal end washer
5 Pressure limiting washer
6 Bracket
7 Insulating washer
8 Insulating Tube
9 Metal spacer washer
10 Cell
11 Bellow spring contact
12 Terminal lug

Items 3 and 6 are supplied only in special order kits.



Standard terminal
for cells A thru L

Standard terminal
for D cells and larger

TABLE 2 — PLATE KIT LIST

Cell (10)	Center Stud (1)	Nut (2)	Metal end washer (4)	Pressure limiting washer (5)	Insulating washer (7)	Insulating tube (8)	Metal spacer washer (9)	Bellow spring contact (11)	Terminal lug (12)
A (100)	8-32 (5 ft)	8-32 (50)	AN960-8L (50)	SP-183-1 (100)	SP-183-23 (75)	SP-190-9 (4 ft)	SP-180-27 (200)	SP-171-1 (100)	SP-151-102 (100)
B (100)	8-32 (5 ft)	8-32 (50)	AN960-8L (50)	SP-183-1 (100)	SP-183-23 (75)	SP-190-9 (4 ft)	SP-180-27 (200)	SP-171-1 (100)	SP-151-103 (100)
C (100)	8-32 (5 ft)	8-32 (50)	AN960-8L (50)	SP-183-1 (100)	SP-183-23 (75)	SP-190-9 (4 ft)	SP-180-27 (200)	SP-171-1 (100)	SP-151-104 (100)
L (100)	1/4-20 (5 ft)	1/4-20 (50)	AN960-416L (50)	SP-183-8 (100)	SP-183-65 (75)	SP-195-1 (4 ft)	SP-180-126 (200)	41-1924 (100)	41-0073 (100)
D (100)	3/8-16 (5 ft)	3/8-16 (50)	3/8 (50)	SP-183-10 (100)	SP-183-10 (75)	SP-195-2 (4 ft)	SP-180-53 (120) SP-180-54 (80)	41-1849 (100)	SP-150-2.1A (100)
P (100)	3/8-16 (5 ft)	3/8-16 (50)	3/8 (50)	SP-183-10 (100)	SP-183-10 (75)	SP-195-2 (4 ft)	SP-180-53 (120) SP-180-54 (80)	41-1849 (100)	SP-150-2.8A (100)
J (100)	3/8-16 (5 ft)	3/8-16 (50)	3/8 (50)	SP-183-10 (100)	SP-183-10 (75)	SP-195-2 (4 ft)	SP-180-53 (120) SP-180-54 (80)	SP-170-2 (100)	SP-150-4.2A (100)
F (100)	3/8-16 (5 ft)	3/8-16 (50)	3/8 (50)	SP-183-10 (100)	SP-183-10 (75)	SP-195-2 (4 ft)	SP-180-53 (120) SP-180-54 (80)	SP-170-2 (100)	SP-150-4.2A (100)
H (100)	3/8-16 (5 ft)	3/8-16 (50)	3/8 (50)	SP-183-10 (100)	SP-183-10 (75)	SP-195-2 (4 ft)	SP-180-53 (120) SP-180-54 (80)	SP-170-2 (100)	SP-150-4.8A (100)

NOTE: Numbers under headings refer to item numbers in Figure 5
Numbers under Part Numbers refer to quantities in each standard kit of 100 cells. Non-standard kits are available.

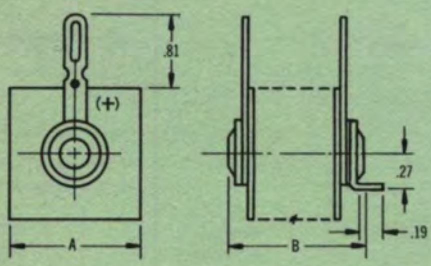


Fig. 1 — Half wave stacks.

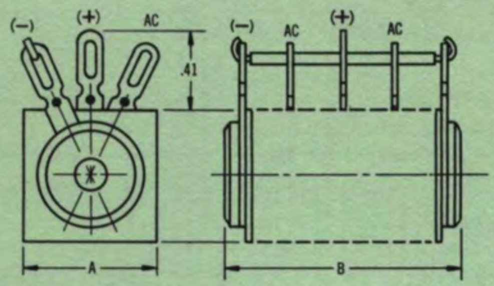


Fig. 2A — Fullwave Stacks

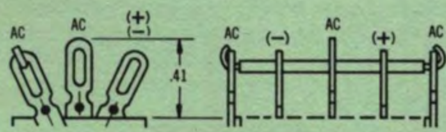


Fig. 2B — Magnetic Amplifier Stacks

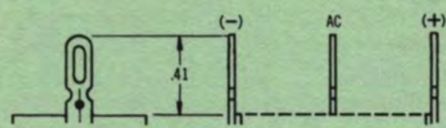


Fig. 2C — Doubler Stack

MINIATURE STACKS

This listing is a selection of miniature stack assemblies designed for application in various magnetic circuits and entertainment systems. The small size and high ratings inherent in these devices gives them broad utilization in many areas requiring miniaturized rectification at off-the-shelf prices.

Some of the devices listed can be connected directly to a 117 Volt ac input, while others require input networks or power supply systems for operation.

Magnetic Amplifier Rectification

Bridges Q4M and Q8M can be modified to magnetic-amplifier bridges by removing the ac busbar. This three ac terminal configuration makes it a convenient medium voltage magnetic amplifier system rectifier.

TABLE 1 — STACK RATINGS AND DIMENSIONS

IR Number	Max. AC Input (Volts RMS)	Max. DC Output (mA)	Peak Reverse Voltage (V)	Min. Series Resistance (Ω)	Fig.	Dimensions (in.)	
						A Sq.	B
HALF WAVE RECTIFIERS							
Q1H	36	65	—	47	1	0.67	0.44
A1H	36	100	—	22	1	1.0	0.44
B1H	36	150	—	15	1	1.2	0.44
C1H	36	250	—	5	1	1.5	0.44
M1H	36	500	—	5	1	2.0	0.44
FULL WAVE RECTIFIER BRIDGES							
Q1B	36	100	—	—	2A	0.67	0.81
Q4B	130	100	—	—	2A	0.67	1.25
Q8B	260	100	—	—	2A	0.67	1.75
A1B	36	180	—	—	2A	1.0	0.81
A4B	130	180	—	—	2A	1.0	1.25
B1B	36	300	—	—	2A	1.2	0.81
C1B	36	600	—	—	2A	1.5	0.81
M1B	36	1200	—	—	2A	2.0	0.81

IR Number	Max. AC Input (Volts RMS)	Max. DC Output (mA)	Peak Reverse Voltage (V)	Min. Series Resistance (Ω)	Fig.	Dimensions (in.)	
						A Sq.	B
ENTERTAINMENT SYSTEM RECTIFIERS ①							
E075L	130	75	380	—	1	0.66	0.75
E150L	130	150	380	—	1	1.0	1.0
E300L	130	300	380	—	1	1.2	1.25
E500L	130	500	380	—	1	1.5	1.25
E650L	130	650	380	—	1	2.0	1.25
MAGNETIC-AMPLIFIER BRIDGE, SINGLE PHASE							
Q4M	130	100	—	—	2B	0.67	1.25
Q8M	260	100	—	—	2B	0.67	1.75
VOLTAGE DOUBLER, SINGLE PHASE ②							
Q8D	260	100	—	—	2C	0.67	1.25

① E000L specifies lug mounting shown in Fig. 2 and dimensions listed.
E000S specifies stud mounting.
E000B specifies bracket mounting.

② Ratings for 2 units connected as single phase bridge.

CARTRIDGE ASSEMBLIES

Offering both cartridge and diode configurations for halfwave circuits, and single phase bridge types, these rectifier assemblies extend and expand the capability of the miniature stacks (page 30) as well as the cartridge types (pages 32 and 33) and the diode type (page 36) to meet the lower power selenium rectifier requirements.

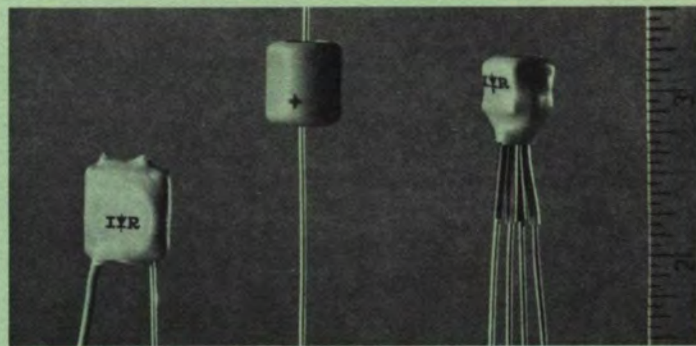
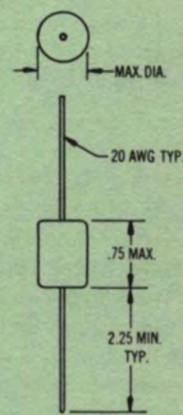


TABLE 1 — DEVICE RATINGS AND DIMENSIONS
HALF-WAVE CARTRIDGE TYPES (Ratings @ 35°C)

Part No.	Max. Peak Reverse Voltage (V)	Max. RMS Input Voltage (V)		Output Current (mAdc)	
		Resistive	Capacitive	Resistive	Capacitive
3UT1	190	135	66	3.0	1.8
6UT1	390	270	132	2.6	1.6
12UT1	760	540	264	2.2	1.3
15UT1	950	675	330	2.2	1.3
17UT1 ①	1060	765	380	2.2	1.3
20UT1	1270	900	440	2.0	1.2
3VT1	190	135	66	7.0	4.2
6VT1	380	270	132	6.0	3.6
12VT1	760	540	264	5.5	3.3
15VT1	950	675	330	5.0	3.0
20VT1	1270	900	440	5.0	3.0
3YT1	190	135	66	13	7.8
6YT1	380	270	132	12	7.2
12YT1	760	540	264	11	6.6
15YT1	950	675	330	11	6.6
20YT1	1270	900	440	10	6.0

①Type used for boosted B+ for television

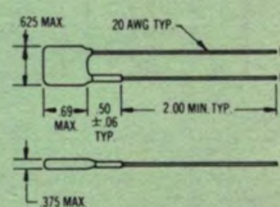


Positive lead color coded red

Type	Max. Dia.	Cell Dia.
UT	.20″	.125″
VT	.325″	.250″
YT	.45″	.375″

HALF-WAVE DIODE TYPES (Ratings @ 35°C)

Part No.	Max. Peak Reverse Voltage (V)	Max. RMS Input Voltage (V)		Output Current (mAdc)
		Resistive	Capacitive	Capacitive
R1HT	50	36	25	75
R2HT	100	72	50	75
R3HT	150	108	75	75
R6HT	300	216	130	75
R9HT	450	324	175	75

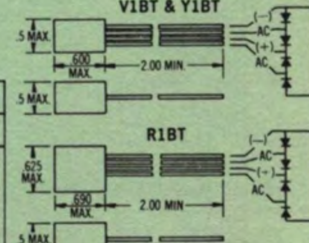


Positive lead color coded red

SINGLE PHASE BRIDGE TYPES (Ratings @ 35°C)

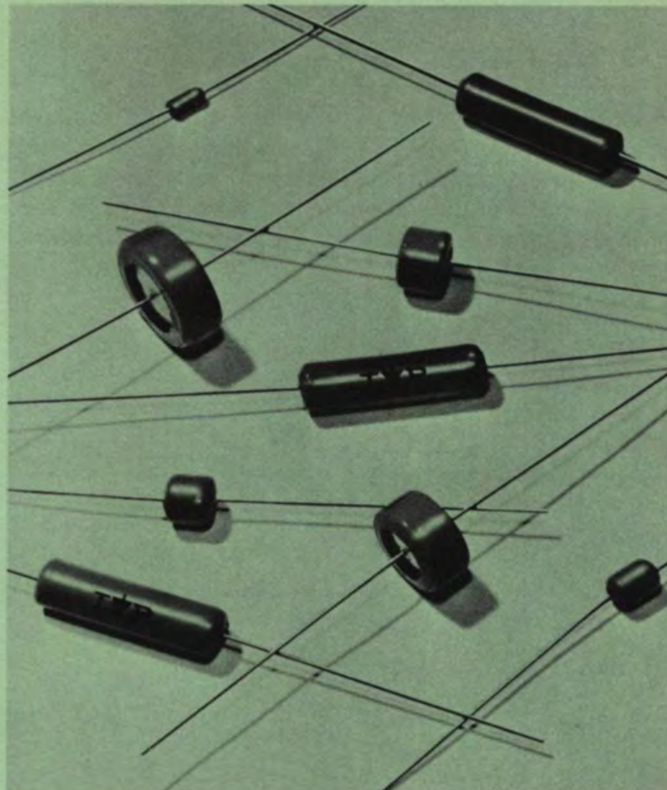
Part No.	Max. Peak Reverse Voltage (V)	Max. RMS Input Voltage (V)		Output Current (mAdc)	
		Resistive	Capacitive	Resistive	Capacitive
V1BT	50	36	36	80	64
Y1BT	50	36	36	200	160
R1BT	50	36	36	300	240

Note: Doublers and Center-Tap Circuits are also available. Contact Local IR Field Office or IR's El Segundo Office.



Leads color coded:
− = Black, + = Red, AC = Yellow.

Cartridge Assemblies



PLASTIC CARTRIDGE RECTIFIERS

Selenium plastic cartridge rectifiers are enclosed in IR's special plastic tubing. These cartridge rectifiers furnish Peak Reverse Voltage ratings from 63.5 to 1250 Volts with current range from 7 to 40 mA.

IR's special thin selenium cells combine minimum space requirements with maximum voltage and current characteristics. In addition, these special cells provide a reduced forward power loss which contributes to a low internal temperature rise.

These cartridges are capable of heavy duty operation with no risk of catastrophic failure.

The VP series differs from the VS series on page 33 only in the type of case and the limitations on cell size imposed by this special case. In addition, plastic tubing offers easy installation with no chance of shorting by electrically active exposed metal ferrules.

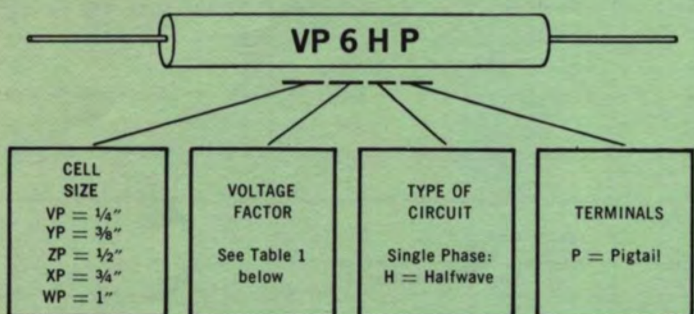
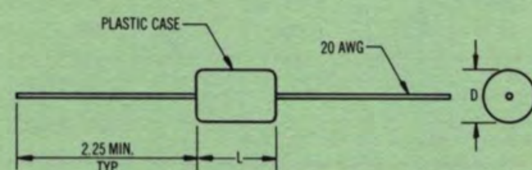


TABLE 1

Voltage Factor	Peak Reverse Voltage (Volts)	Max. AC Input Voltage (Volts RMS)		Nominal DC Output Voltage (Volts)		PLASTIC TYPES				
		Res. Load	Cap. Load ①	Res. Load	Cap. Load ②	VP Cell	YP Cell	ZP Cell	XP Cell	WP Cell
1	63.5	45	22	17	22	VP1HP	YP1HP	ZP1HP	XP1HP	WP1HP
2	125	88	45	34	45	VP2HP	YP2HP	ZP2HP	XP2HP	WP2HP
4	250	177	90	68	90	VP4HP	YP4HP	ZP4HP	XP4HP	WP4HP
6	380	269	135	106	135	VP6HP	YP6HP	ZP6HP	XP6HP	WP6HP
8	500	353	180	135	180	VP8HP	YP8HP	ZP8HP	XP8HP	WP8HP
12	750	540	270	215	270	VP12HP	YP12HP	ZP12HP	XP12HP	WP12HP
16	1000	707	360	271	360	VP16HP	YP16HP	ZP16HP	XP16HP	WP16HP
20	1250	885	450	340	450	VP20HP	YP20HP	ZP20HP	XP20HP	WP20HP



Cell Type	Max. DC Output Current (mA)		Nominal Cell Dia. (in.)	— L — Max. Length (in.)		— D — Max. Dia. (in.)
	Res. Load	Cap. Load		Voltage Factor 1-10	Voltage Factor 11-20	
VP	7	4.2	1/4	.562	.765	.320
YP	12	8.4	3/8	.562	.781	.450
ZP	20	14	1/2	.754	.974	.597
XP	30	21	3/4	.600	.820	.862
WP	40	28	1	.600	.820	1.142

① The RMS input voltages listed are maximum permissible when the rectifier-filter may be disconnected from the load while energized, or when an energy storage capacitor is the load. For other loads, a higher value of applied RMS voltage may be permissible as long as the Peak Reverse Voltage rating is not exceeded.

② The dc output voltages listed are guidance values only. The actual dc voltage may be either higher or lower depending on the size of filter capacitor, and the relative time constants of the filter capacitor—source impedance, and of the filter capacitor—load impedance.

FERRULE CARTRIDGE RECTIFIERS

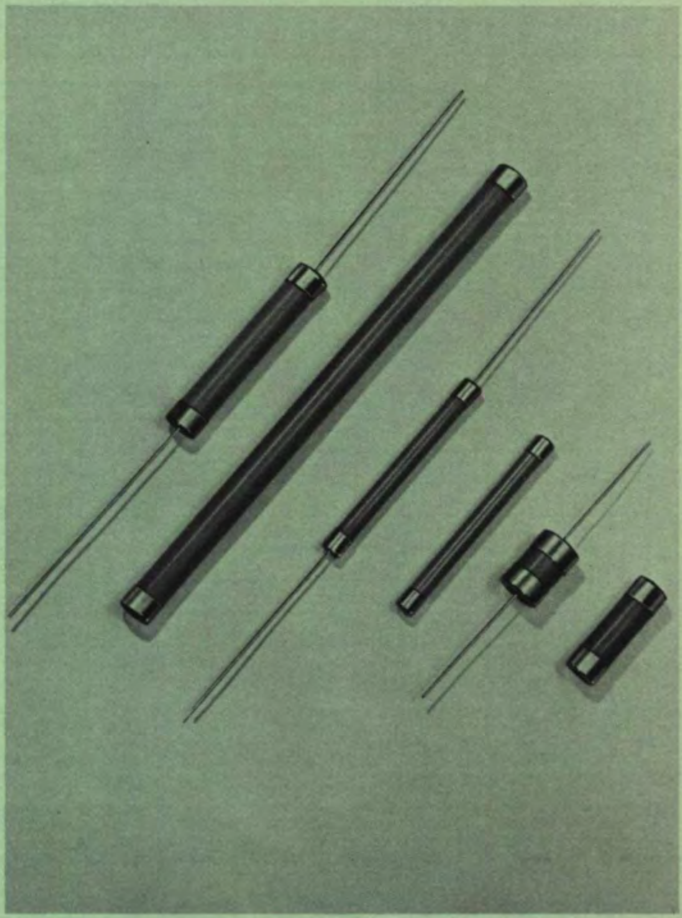
These selenium cartridges are mounted in ferrule-tipped cases as compared with the plastic-cased cartridges listed on page 32. For flexibility in mounting, these cartridges are supplied either with or without leads.

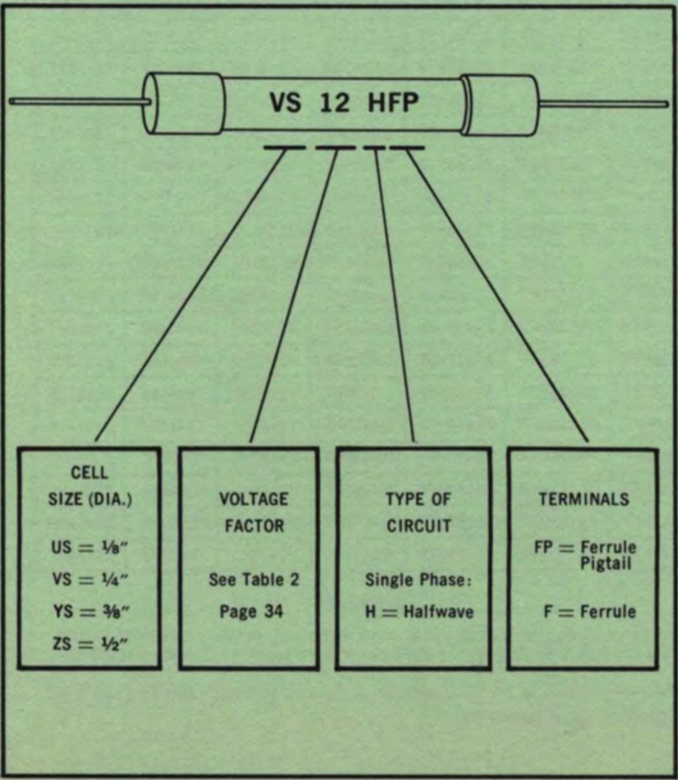
These series of selenium cartridges provide a Peak Reverse Voltage range of from 63.5 to 30,000 Volts.

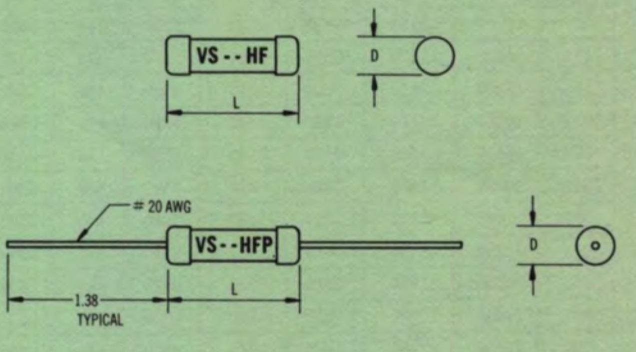
Four of the most popular cell sizes are available in this type of cartridge. As listed in the table and the dimensional diagrams, the length and width of the cartridges varies with the cell size and the Voltage Factor. As compared with IR's special series plastic cartridges, these devices offer much higher voltages due to the longer case lengths available.

The thin selenium cells used in these cartridges are developed especially by IR for this application. They offer maximum voltage and current characteristics with minimum space requirements.

These cartridges remove the risk of catastrophic failure when used in the heavy duty operations for which they are designed.







DIMENSIONS IN INCHES

CELL TYPE	NOMINAL DIAMETER CELL	CELL DIA.	CELL ACTIVE AREA	D — MAX. FERRULE DIAMETER
US	1/8	.125	.012	.280
VS	1/4	.250	.049	.450
YS	3/8	.375	.110	.562
ZS	1/2	.500	.196	.750

See Table 2, page 34, for L dimensions

TABLE 2

Voltage Factor	Peak Reverse Voltage	Max. AC Input Voltage (Volts RMS)		Nominal DC Output Voltage (Volts)		—L— Length (Inch) ③	FERRULE — PIGTAIL TYPES				FERRULE TYPES			
		Res. Load	Cap. Load ①	Res. Load	Cap. Load ②		US Cell	VS Cell	YS Cell	ZS Cell	US Cell	VS Cell	YS Cell	ZS Cell
1	63.5	45	22	17	22	1	US1HFP④	VS1HFP	YS1HFP	ZS1HFP	US1HF④	VS1HF	YS1HF	ZS1HF
2	125	88	45	34	45	1	US2HFP④	VS2HFP	YS2HFP	ZS2HFP	US2HF④	VS2HF	YS2HF	ZS2HF
4	250	177	90	68	90	1	US4HFP④	VS4HFP	YS4HFP	ZS4HFP	US4HF④	VS4HF	YS4HF	ZS4HF
6	380	269	135	106	135	1	US6HFP④	VS6HFP	YS6HFP	ZS6HFP	US6HF④	VS6HF	YS6HF	ZS6HF
8	500	353	180	135	180	1	US8HFP④	VS8HFP	YS8HFP	ZS8HFP	US8HF④	VS8HF	YS8HF	ZS8HF
12	750	540	270	215	270	1	US12HFP④	VS12HFP	YS12HFP	ZS12HFP	US12HF④	VS12HF	YS12HF	ZS12HF
16	1000	707	360	271	360	1	US16HFP④	VS16HFP	YS16HFP	ZS16HFP	US16HF④	VS16HF	YS16HF	ZS16HF
20	1250	885	450	340	450	1	US20HFP④	VS20HFP	YS20HFP	ZS20HFP	US20HF④	VS20HF	YS20HF	ZS20HF
24	1500	1060	540	407	540	1	US24HFP④	VS24HFP	YS24HFP	ZS24HFP	US24HF④	VS24HF	YS24HF	ZS24HF
28	1750	1240	630	474	630	1	US28HFP④	VS28HFP	VS28HFP	ZS28HFP	US28HF④	VS28HF	YS28HF	ZS28HF
32	2000	1414	720	542	720	1	US32HFP④	VS32HFP	YS32HFP	ZS32HFP	US32HF④	VS32HF	YS32HF	ZS32HF
40	2500	1770	900	678	900	1	US40HFP	VS40HFP	YS40HFP	ZS40HFP	US40HF	VS40HF	YS40HF	ZS40HF
48	3000	2120	1080	813	1080	1	US48HFP	VS48HFP	YS48HFP	ZS48HFP	US48HF	VS48HF	YS48HF	ZS48HF
56	3500	2475	1260	950	1260	1⅛	US56HFP	VS56HFP	YS56HFP	ZS58HFP	US56HF	VS56HF	YS56HF	ZS56HF
63	4000	2830	1417	1084	1417	1¼	US63HFP	VS63HFP	YS63HFP	ZS63HFP	US63HF	VS63HF	YS63HF	ZS63HF
71	4500	3185	1595	1220	1595	1⅜	US71HFP	VS71HFP	YS71HFP	ZS71HFP	US71HF	VS71HF	YS71HF	ZS71HF
79	5000	3540	1775	1355	1775	1½	US79HFP	VS79HFP	YS79HFP	ZS79HFP	US79HF	VS79HF	YS79HF	ZS79HF
95	6000	4250	2135	1627	2135	1¾	US95HFP	VS95HFP	YS95HFP	ZS95HFP	US95HF	VS95HF	YS95HF	ZS95HF
111	7000	4950	2500	1900	2500	2	US111HFP	VS111HFP	YS111HFP	ZS111HFP	US111HF	VS111HF	YS111HF	ZS111HF
126	8000	5560	2835	2165	2835	2¼	US126HFP	VS126HFP	YS126HFP	ZS126HFP	US126HF	VS126HF	YS126HF	ZS126HF
142	9000	6370	3195	2440	3195	2½	US142HFP	VS142HFP	YS142HFP	ZS142HFP	US142HF	VS142HF	YS142HF	ZS142HF
158	10000	7070	3555	2710	3555	2¾	US158HFP	VS158HFP	YS158HFP	ZS158HFP	US158HF	VS158HF	YS158HF	ZS158HF
174	11000	7780	3920	2980	3920	3⅛	US174HFP	VS174HFP	YS174HFP	ZS174HFP	US174HF	VS174HF	YS174HF	ZS174HF
189	12000	8490	4250	3250	4250	3⅜	US189HFP	VS189HFP	YS189HFP	ZS189HFP	US189HF	VS189HF	YS189HF	ZS189HF
205	13000	9200	4620	3520	4620	3⅝	US205HFP	VS205HFP	YS205HFP	ZS205HFP	US205HF	VS205HF	YS205HF	ZS205HF
221	14000	9910	4970	3790	4970	3⅞	US221HFP	VS221HFP	YS221HFP	ZS221HFP	US221HF	VS221HF	YS221HF	ZS221HF
237	15000	10610	5330	4070	5330	4⅛	US237HFP	VS237HFP	YS237HFP	ZS237HFP	US237HF	VS237HF	YS237HF	ZS237HF
252	16000	11320	5670	4340	5670	4⅜	US252HFP	VS252HFP	YS252HFP	ZS252HFP	US252HF	VS252HF	YS252HF	ZS252HF
268	17000	12030	6030	4610	6030	4⅝	US268HFP	VS268HFP	YS268HFP	ZS268HFP	US268HF	VS268HF	YS268HF	ZS268HF
284	18000	12740	6390	4880	6390	4⅞	US284HFP	VS284HFP	YS284HFP	ZS284HFP	US284HF	VS284HF	YS284HF	ZS284HF
300	19000	13460	6750	5150	6750	5⅛	US300HFP	VS300HFP	YS300HFP	ZS300HFP	US300HF	VS300HF	YS300HF	ZS300HF
315	20000	14140	7090	5420	7090	5⅜	US315HFP	VS315HFP	YS315HFP	ZS315HFP	US315HF	VS315HF	YS315HF	ZS315HF
331	21000	14860	7450	5690	7450	5⅝	US331HFP	VS331HFP	YS331HFP	ZS331HFP	US331HF	VS331HF	YS331HF	ZS331HF
347	22000	15580	7810	5960	7810	5⅞	US347HFP	VS347HFP	YS347HFP	ZS347HFP	US347HF	VS347HF	YS347HF	ZS347HF
363	23000	16290	8170	6230	8170	6⅛	US363HFP	VS363HFP	YS363HFP	ZS363HFP	US363HF	VS363HF	YS363HF	ZS363HF
378	24000	17000	8510	6510	8510	6⅜	US378HFP	VS378HFP	YS378HFP	ZS378HFP	US378HF	VS378HF	YS378HF	ZS378HF
394	25000	17700	8870	6780	8870	6⅝	US394HFP	VS394HFP	YS394HFP	ZS394HFP	US394HF	VS394HF	YS394HF	ZS394HF
410	26000	18400	9230	7050	9230	6⅞	US410HFP	VS410HFP	YS410HFP	ZS410HFP	US410HF	VS410HF	YS410HF	ZS410HF
426	27000	19100	9590	7320	9590	7⅛	US426HFP	VS426HFP	YS426HFP	ZS426HFP	US426HF	VS426HF	YS426HF	ZS426HF
441	28000	19800	9920	7600	9920	7⅜	US441HFP	VS441HFP	YS441HFP	ZS441HFP	US441HF	VS441HF	YS441HF	ZS441HF
457	29000	20500	10300	7860	10300	7⅝	US457HFP	VS457HFP	YS457HFP	ZS457HFP	US457HF	VS457HF	YS457HF	ZS457HF
473	30000	21200	10630	8140	10630	7⅞	US473HFP	VS473HFP	YS473HFP	ZS473HFP	US473HF	VS473HF	YS473HF	ZS473HF

① The RMS input voltages listed are maximum permissible when the rectifier-filter may be disconnected from the load while energized, or when an energy storage capacitor is the load. For other loads, a higher value of applied RMS voltage may be permissible as long as the Peak Reverse Voltage rating is not exceeded.

② The dc output voltages listed are guidance values only. The actual dc voltage may be either higher or lower depending on the size of filter capacitor, and the relative time constants of the filter capacitor—source impedance, and of the filter capacitor—load impedance.

③ See page 33 for dimensional diagram.

④ US cell cartridges are .69 in. long.

FOR OTHER CIRCUITS	MULTIPLY CURVE VALUES BY
1 PHASE HALF WAVE CAP.	0.6
1 PHASE BRIDGE OR C.T. RES.	2.0
1 PHASE BRIDGE OR C.T. CAP.	1.6
3 PHASE HALF WAVE (Y)	2.6
3 PHASE BRIDGE	3.0
3 PHASE STAR	3.6

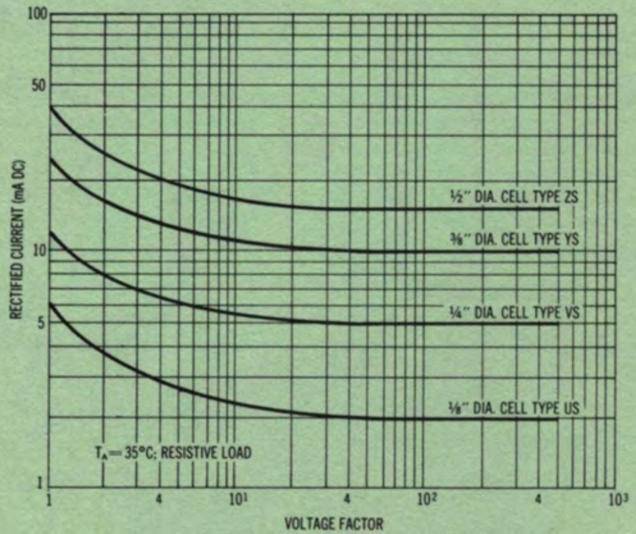
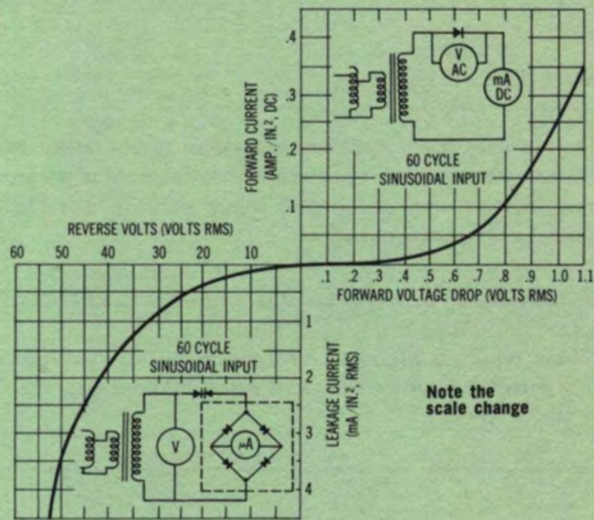


Fig. 1 — Maximum DC Output Current vs. Voltage Factor



Note the scale change

DC microammeter average readings converted to RMS readings by multiplying by the 1.11 form factor.

Fig. 3 — Typical Dynamic Characteristics

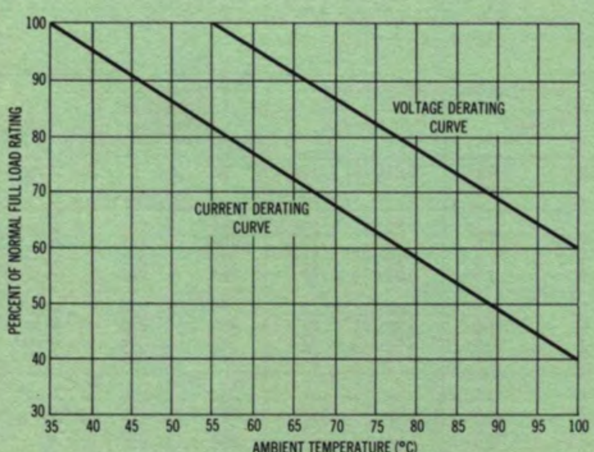
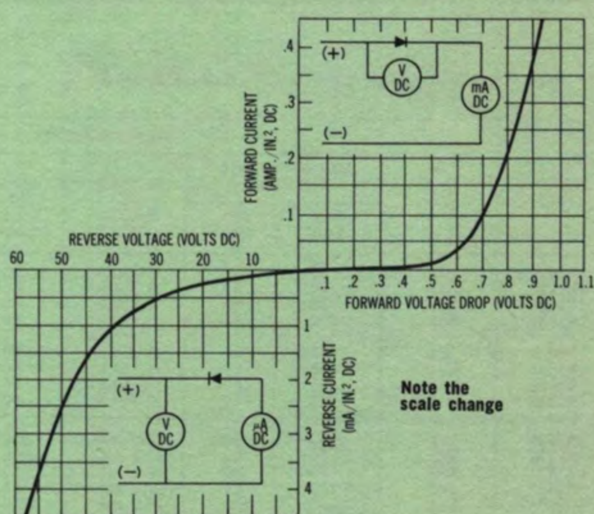


Fig. 2 — Derating Curves for Cartridges Operating at Elevated Temperatures



Note the scale change

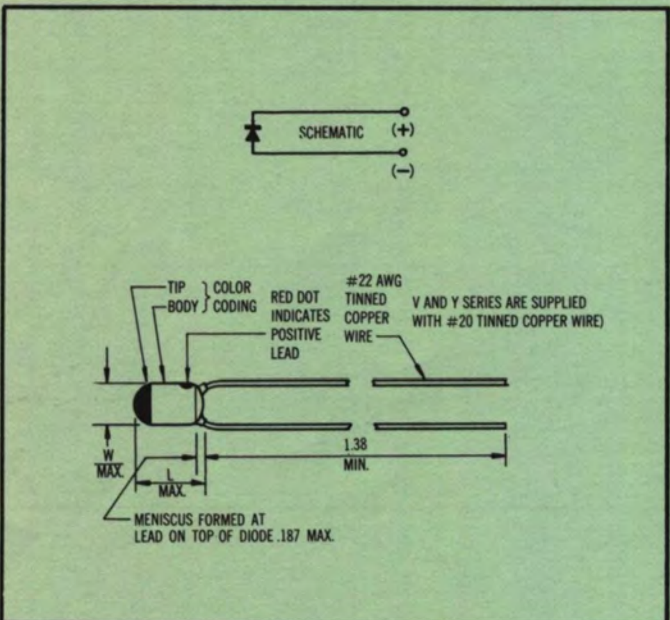
Fig. 4 — Typical Static Characteristics

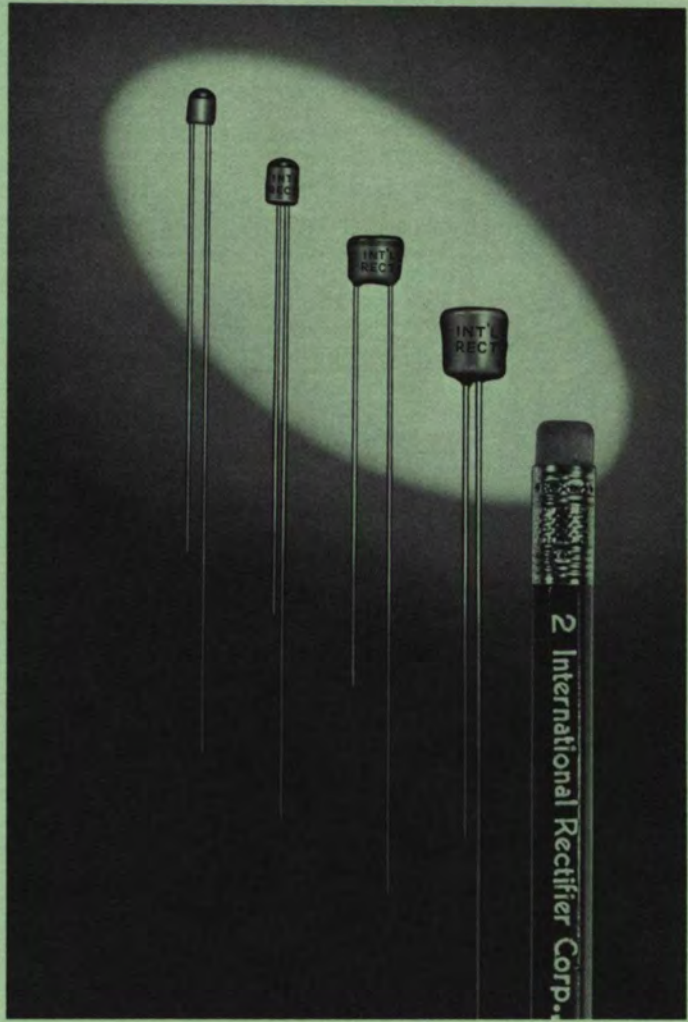
DIODE RECTIFIERS

Selenium diodes for applications where temperature may be high and where space and weight are important parameters. The miniature size and pigtail leads simplify installation in compact, congested chassis.

All the listed devices are designed for operation in the temperature range from −50° to 100°C.

These rectifiers are ideal for applications in computers, airborne systems, hearing aids, and entertainment systems.





TYPICAL RATINGS, AND CHARACTERISTICS @ 25°C

JEDEC TYPE	IR TYPE	Maximum Ratings: AC Input Voltage (Volts RMS) Res. Load	Maximum Ratings: AC Input Voltage (Volts RMS) Cap. Load	Rectified DC Output ①	Surge @ 1 Sec. (mA)	Peak Reverse Voltage (Volts)	Freq. (KC)	Electrical Characteristics (DC) Forward (Volts)	Forward I Max. (mA)	Reverse (Volts)	Reverse I Max. μA	Maximum Dimensions (Inches) W	Maximum Dimensions (Inches) L	Color Coding Tip
1N1627	1U1	33	20	3.75mA	80	48	100	1	1.5	26	27	.190	.265	Brown
1N1628	2U1	66	40	3.75mA	80	96	100	2	1.5	52	27	.190	.265	Red
1N1629	3U1	99	60	3.75mA	80	144	100	3	1.5	78	27	.210	.265	Orange
1N1630	4U1	132	80	3.75mA	80	192	100	4	1.5	104	27	.265	.265	Yellow
1N1631	5U1	165	100	3.75mA	80	240	100	5	1.5	130	27	.285	.265	Green
1N1632	6U1	198	120	3.75mA	80	288	100	6	1.5	156	27	.345	.265	Blue
1N1633	7U1	231	140	3.75mA	80	336	100	7	1.5	182	27	.345	.265	Violet
1N1634	8U1	264	160	3.75mA	80	384	100	8	1.5	208	27	.345	.265	Gray
1N1635	1V1	33	20	12.5 mA	250	48	25	1	5.0	26	108	.320	.395	②
1N1636	2V1	66	40	12.5 mA	250	96	25	2	5.0	52	108	.320	.395	②
1N1637	3V1	99	60	12.5 mA	250	144	25	3	5.0	78	108	.360	.425	②
1N1638	4V1	132	80	12.5 mA	250	192	25	4	5.0	104	108	.395	.425	②
1N1639	5V1	165	100	12.5 mA	250	240	25	5	5.0	130	108	.395	.425	②
1N1640	1Y1	33	20	28.0 mA	550	48	10	1	11.0	26	240	.465	.525	②
1N1641	2Y1	66	40	28.0 mA	550	96	10	2	11.0	52	240	.465	.525	②
1N1642	3Y1	99	60	28.0 mA	550	144	10	3	11.0	78	240	.465	.525	②

① For capacitive load use 80% of listed DC output current values.
② IR Part Number is stamped on body.

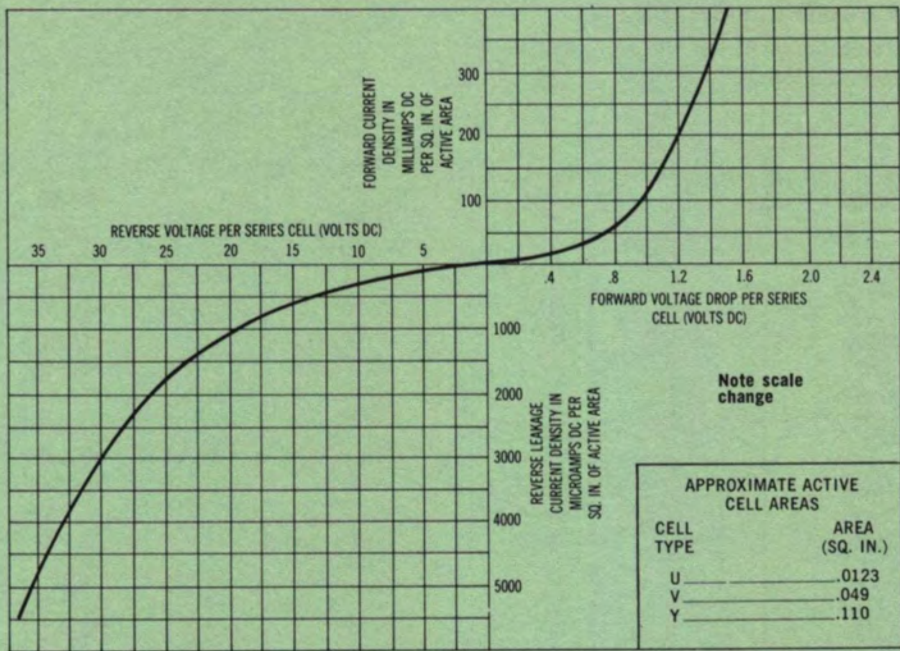


Fig. 1 — Static DC Characteristics

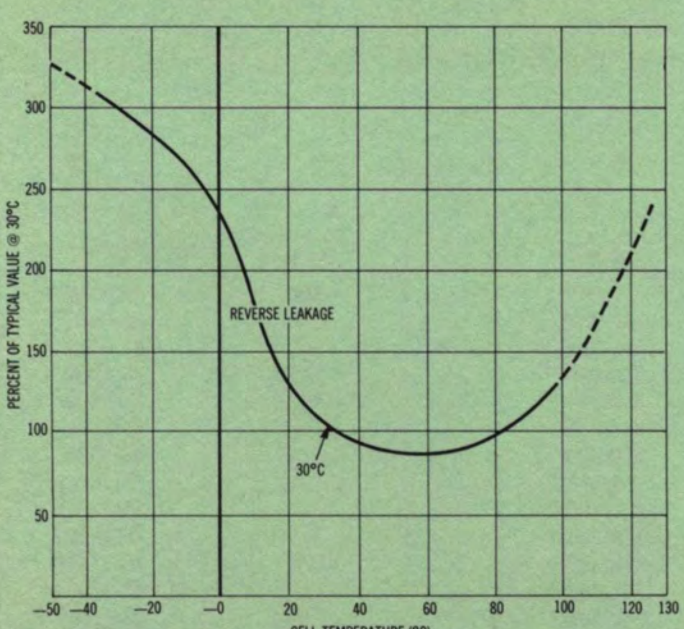


Fig. 2 — Reverse Leakage vs. Cell Temperature

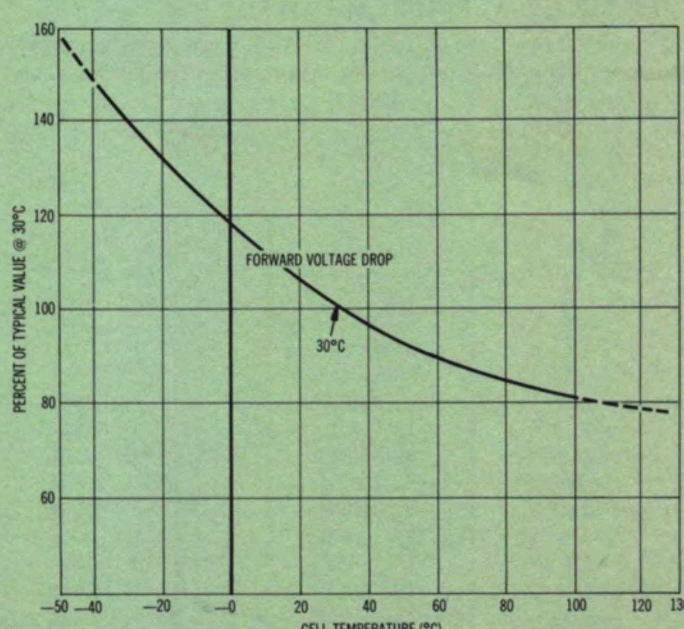


Fig. 3 — Forward Voltage Drop vs. Cell Temperature

CONTACT PROTECTOR CROSS REFERENCE LIST

Listed IR parts are electrical substitutes for competitive devices. See page 17 for specifications.

Bradley Part No.	IR No.
SP7M2R1	S1V1P
SP7M3R2	S2V1P
SP7M5R3	S3V2P
SP7M6R4	S4V2P
SP7M7R5	S5V2P
SP7M8R6	S6V2P
SP7M9R7	S7V2P
SP7M4R2	S2V2P
SP7M6R3	S3V3P
SP7M8R4	S4V4P
SP7M10R5	S5V5P
SP7M12R6	S6V6P
SP7P2R1	S1Z1P
SP7P3R2	S2Z1P
SP7P5R3	S3Z2P
SP7P6R4	S4Z2P
SP7P7R5	S5Z2P
SP7P8R6	S6Z2P
SP7P9R7	S7Z2P
SP7P4R2	S2Z2P
SP7P6R3	S3Z3P
SP7P8R4	S4Z4P
SP7P10R5	S5Z5P
SP7P12R6	S6Z6P

Sarkes Tarzian Part No.	IR No.
S-235	S1V1P
S-237	S2V1P
S-239	S3V2P
S-241	S4V2P
S-243	S5V2P
S-245	S6V2P
S-247	S7V2P
S-249	S2V2P
S-251	S3V3P
S-253	S4V4P
S-255	S5V5P
	S6V6P
S-236	S1Z1P
S-238	S2Z1P
S-240	S3Z2P
S-242	S4Z2P
S-244	S5Z2P
S-246	S6Z2P
S-248	S7Z2P

ITT Federal Part No.	IR No.
8A1PS1	S1V1P
8A2PS1	S2V1P
8A3PS2	S3V2P
8A4PS2	S4V2P
8A5PS2	S5V2P
8A6PS2	S6V2P
8A7PS2	S7V2P
8A2PS2	S2V2P
8A3PS3	S3V3P
8A4PS4	S4V4P
8A5PS5	S5V5P
8A6PS6	S6V6P
15A1PS1	S1Z1P
15A2PS1	S2Z1P
15A3PS2	S3Z2P
15A4PS2	S4Z2P
15A5PS2	S5Z2P
15A6PS2	S6Z2P
15A7PS2	S7Z2P
15A2PS2	S2Z2P
15A3PS3	S3Z3P
15A4PS4	S4Z4P
15A5PS5	S5Z5P
15A6PS6	S6Z6P

KLIP-SEL CROSS REFERENCE LIST

A cross reference list of IR Klip-Sels which are electrical substitutes for the types listed. Similar information for other circuits and devices not listed is available upon request. See page 9 for Klip-Sel part number codes; page 13 for Standard part numbers.

West. No. SD1AA-	IR No.
-3AA	KSA2DAM
-6AA	KSA3DAM
-9AA	KSA4DAM
-12AA	KSA5DAM
-15AA	KSA6DBM
-18AA	KSA7DBM
-21AA	KSA8DBM
-24AA	KSA10DBM
-27AA	KSA11DBM
-30AA	KSA12DBM
-33AA	KSA13DBM
-36AA	KSA14DBM
-39AA	KSA15DBM
-42AA	KSA16DBM
-45AA	KSA18DBM
-48AA	KSA19DBM

West. No. S03AA-	IR No.
-3AA	KSL2DAM
-6AA	KSL3DAM
-9AA	KSL4DAM
-12AA	KSL5DAM
-15AA	KSL6DBM
-18AA	KSL7DBM
-21AA	KSL8DBM
-24AA	KSL10DBM
-27AA	KSL11DBM
-30AA	KSL12DBM
-33AA	KSL13DBM
-36AA	KSL14DBM
-39AA	KSL15DBM
-42AA	KSL16DBM
-45AA	KSL18DBM
-48AA	KSL19DBM

West. No. S04AA-	IR No.
-3AA	KSL2DAM
-6AA	KSL3DAM
-9AA	KSL4DAM
-12AA	KSL5DAM
-15AA	KSL6DBM
-18AA	KSL7DBM
-21AA	KSL8DBM
-24AA	KSL10DBM
-27AA	KSL11DBM
-30AA	KSL12DBM
-33AA	KSL13DBM
-36AA	KSL14DBM
-39AA	KSL15DBM
-42AA	KSL16DBM
-45AA	KSL18DBM
-48AA	KSL19DBM

KLIP-SEL CROSS REFERENCE LIST

G.E. No. 6RS5SP-	IR No.
-1B1	KY1DPM
-2B2	KY2DPM
-3B3	KY3DPM
-4B4	KY4DPM
-5B5	KY5DPM
-6B6	KY6DPM
-7B7	KY7DPM
-8B8	KY8DPM
-9B9	KY9DPM
-10B10	KY10DPM
-11B11	KY11DPM
-12B12	KY12DPM
-13B13	KY13DPM
-14B14	KY14DPM
-15B15	KY15DPM
-16B16	KY16DPM
-17B17	KY17DPM
-18B18	KY18DPM
-19B19	KY19DPM
-20B20	KY20DPM

G.E. No. 6RS20SP-	IR No.
-1B1	KZ1DPM
-2B2	KZ2DPM
-3B3	KZ3DPM
-4B4	KZ4DPM
-5B5	KZ5DPM
-6B6	KZ6DPM
-7B7	KZ7DPM
-8B8	KZ8DPM
-9B9	KZ9DPM
-10B10	KZ10DPM
-11B11	KZ11DPM
-12B12	KZ12DPM
-13B13	KZ13DPM
-14B14	KZ14DPM
-15B15	KZ15DPM
-16B16	KZ16DPM
-17B17	KZ17DPM
-18B18	KZ18DPM
-19B19	KZ19DPM
-20B20	KZ20DPM

G.E. No. 6RS21SA-	IR No.
-1D1	KSA1DAF
-2D2	KSA2DAF
-3D3	KSA3DAF
-4D4	KSA4DAF
-5D5	KSA5DAF
-6D6	KSA6DBF

G.E. No. 6RS21SA-	IR No.
-7D7	KSA7DBF
-8D8	KSA8DBF
-9D9	KSA9DBF
-10D10	KSA10DBF
-11D11	KSA11DBF
-12D12	KSA12DBF
-13D13	KSA13DBF
-14D14	KSA14DBF
-15D15	KSA15DBF
-16D16	KSA16DBF
-17D17	KSA17DBF
-18D18	KSA18DBF
-19D19	KSA19DBF
-20D20	KSA20DBF

G.E. No. 6RS25SA-	IR No.
-1D1	KSL1DAF
-2D2	KSL2DAF
-3D3	KSL3DAF
-4D4	KSL4DAF
-5D5	KSL5DAF
-6D6	KSL6DBF
-7D7	KSL7DBF
-8D8	KSL8DBF
-9D9	KSL9DBF
-10D10	KSL10DBF
-11D11	KSL11DBF
-12D12	KSL12DBF
-13D13	KSL13DBF
-14D14	KSL14DBF
-15D15	KSL15DBF
-16D16	KSL16DBF
-17D17	KSL17DBF
-18D18	KSL18DBF
-19D19	KSL19DBF
-20D20	KSL20DBF

Sarkes No.	IR No.
S487	KSA2DAF
S488	KSA3DAF
S489	KSA4DAF
S490	KSA6DBF
S490B	KSL6DBF
S491	KSA7DBF
S492	KSA8DBF
S493	KSA11DBF
S493C	KSL11DBF
S494	KSA14DBF
S494C	KSL14DBF
S495	KSA16DBF

I.T.T. No. 102G-	IR No.
-1BX1	KSA1DAF
-2BX2	KSA2DAF
-3BX3	KSA3DAF
-4BX4	KSA4DAF
-5BX5	KSA5DAF
-6BX6	KSA6DBF
-7BX7	KSA7DBF
-8BX8	KSA8DBF
-9BX9	KSA9DBF
-10BX10	KSA10DBF
-11BX11	KSA11DBF
-12BX12	KSA12DBF
-13BX13	KSA13DBF
-14BX14	KSA14DBF
-15BX15	KSA15DBF
-16BX16	KSA16DBF
-17BX17	KSA17DBF
-18BX18	KSA18DBF
-19BX19	KSA19DBF
-20BX20	KSA20DBF

Vickers No.	IR No.
SP102	KSA1DAF
SP105	KSA2DAF
SP107	KSA3DAF
SP110	KSA3DAF
SP115	KSA4DAF
SP117	KSA5DAF
SP120	KSA6DBF
SP125	KSA7DBF
SP130	KSA9DBF
SP135	KSA10DBF
SP140	KSA11DBF
SP150	KSA14DBF
SP160	KSA17DBF
SP173	KSA19DBF

Syntron No.	IR No.
SD00	KSA1DAF
SD01	KSA2DAF
SD03	KSA4DAF
SD02	KSA3DAF
SD04	KSA5DAF
SD05	KSA6DBF
SD06	KSA9DBF
SD07	KSA11DBF
SD08	KSA12DBF
SD09	KSA15DBF
SD10	KSA17DBF
SD11	KSA19DBF

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Telex: 9-1268

New York City—
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Cable: FRIGDEL

Warburton Franki Industries
(Melbourne) Pty. Ltd.
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Cable: IGNITION

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Telex: 21257

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