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INTERNATIONAL RECTIFIER CORPORATION

IOR

SYMBOL OF QUALITY IN SEMICONDUCTORS

RECTIFIER NEWS

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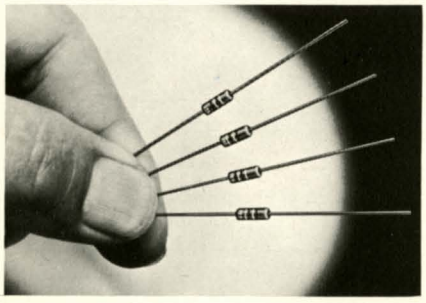
IR SOLAR CELLS POWER TIROS II

In a magnetic field similar to that which surrounds the earth in space, photo floods of intensive brilliance were used to test the 9,260 solar cells supplied to RCA Astro-Electronics Division by International Rectifier Corporation for TIROS II, the second weather-eye satellite successfully orbited.

PHOTO COURTESY OF RCA

18 New Developments In Review

Whatever your design objectives . . . miniaturization, improved performance, economy, or sheer dependability . . . you'll find semiconductor devices worthy of your serious consideration in this round-up of recent and significant additions to the industry's widest, most diversified semiconductor line.



SUBMINIATURE DIFFUSED JUNCTION SILICON GLASS DIODES GENERAL PURPOSE AND HIGH CONDUCTANCE SERIES

35 new glass diode types incorporating advanced silicon diffused junction techniques provide exceptional forward and reverse characteristics.

JEDEC Types 1N456-464 and 1N456A-464A, general purpose diodes designed to meet rigid military standards, will provide from 30 to 200 ma output current @ 25°C, with maximum reverse current of from 0.025 to 0.5 microamperes at max. operating voltage at 25°C. JEDEC Types 1N482-488, 1N482A-488A and 1N482B-486B are high conductance types designed to meet military specifications, and will furnish from 100 to 200ma output current @ 25°C, with max. reverse current of from 0.100 to 0.250 microamperes at specified test voltage at 25°C. All units have an operating temperature range from —55°C to +200°C, and feature glass-to-metal hermetic sealing for ruggedness and optimum reliability.

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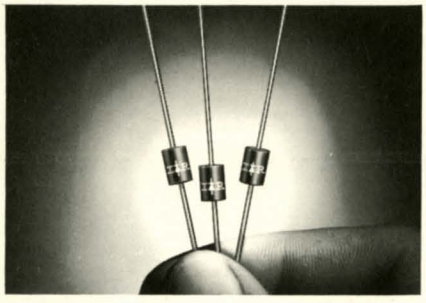

MINIATURE DIFFUSED JUNCTION SILICON RECTIFIERS RATED AT ¾ AMPS, WITHSTAND 50 AMP/8 MILLISECOND SURGE

Completely new diffusion techniques have resulted in this first of a series of miniaturized 750 ma rated (@ 25°C) diffused junction silicon diodes featuring low reverse current (200 μa) at rated PRV, a much higher than average surge current rating (50 amps peak, 1 cycle) and an exceptionally low forward voltage drop (0.92 volts) at rated current. They are primarily designed for industrial and TV applications where miniaturization and high power handling capabilities are required. The complete series, designated types X5A2, X5A4, X5A5 and X5A6, provides peak reverse voltage ratings of 200, 400, 500 and 600 volts, and an operating temperature range from —65°C to +130°C.

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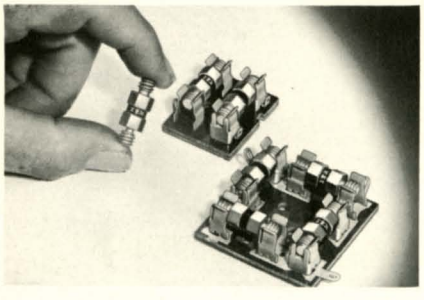

PLUG-IN SILICON DIFFUSED JUNCTION RECTIFIERS FEATURE HIGH SURGE CURRENT CAPACITY

Ruggedized, 500 ma rated silicon 'plug-in' rectifiers utilize completely new diffusion techniques resulting in very low reverse current (200 μa) at rated PRV, a much higher than average surge current rating (50 amps peak, 1 cycle) an exceptionally low forward voltage drop (0.92 volt) . . . and may be rapidly snapped into radio-TV, motor control, audio-amplifier, industrial power supply and other circuits utilizing clip-type rectifier holders.

These new devices provide peak reverse voltage ratings from 200 to 600 volts, and are equipped with heavy-duty threaded stud terminals assuring positive contact in standard clip-type holders. Circuit assemblies that may be rapidly and easily assembled include ½ wave, full wave center tap, single phase bridge, ½ wave and full wave voltage doublers and numerous polyphase circuits.

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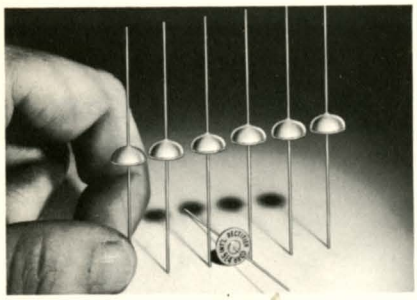

ECONOMY "TRI-SEALED" SILICON DIODES FOR COMMERCIAL EQUIPMENT — TO 600 PRV AT 500 MA

Low cost, high temperature, 200 to 500 ma-rated silicon diodes are now available with PRV ratings from 400 to 600 volts. Specifically designed for television, radio and commercial equipment applications where high temperature is called for, these units are operable to 70°C ambient temperature (100°C case temp.). The 2E4 diode is rated at 200 ma at 400 PRV. The 5E4, 5E5 and 5E6 diodes are rated at 350 ma at 400 PRV, 500 PRV and 600 PRV, respectively.

All units are multi-sealed with successive layers of humidity-resistant, insulating resins and sealants, assuring optimum protection against environmental extremes, shock and vibration.

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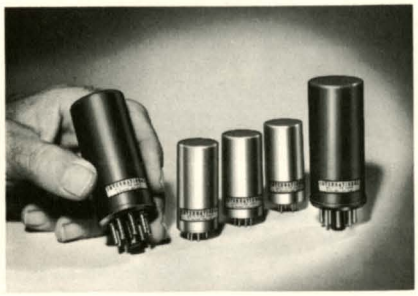

PLUG-IN SILICON EQUIVALENTS TO 14 POPULAR VACUUM TUBE TYPES

Instant operation, the ability to function at high temperatures; rugged, shatterproof housings and the long life characteristics of silicon are advantages offered by a new series of plug-in silicon rectifiers designed to match the electrical ratings of many standard vacuum tube rectifiers.

Seven types cover the current range from 85 to 600 ma, with PRV ratings from 1500 to 2800 volts.

Within this series are exact electrical and base connection equivalents for such tube types as the 6X4, 12X4, 5AW, 5U4, 5R4, 6AX5, 6X5, OZ4, 5X4, 5Z3, 80, 82, 83, 84/6Z4, as well as many other standard tubes.

All types are hermetically sealed, and exhibit maximum stability in all mounting positions.

Circle No. 5 on Card

MINIATURE SILICON REPLACEMENTS FOR OZ4, 6X5, 6X4, 12X4 TUBES EXHIBIT HIGH SURGE CAPACITY — LOW NOISE

Two new high voltage silicon plug-in rectifiers are equipped with tube bases to allow direct replacement of electronic tube types 6X4, 12X4, OZ4, and 6X5.

Rated at 1250 volts peak reverse voltage at 80 ma dc output, the ST-8 rectifier is designed to replace vacuum tube types OZ4 and 6X5, while providing better surge current capabilities, less noise characteristics and high temperature operation on vibrator-type power supply applications such as auto radios, military and commercial portable radios, and other communication systems.

The miniature 1N570, rated at 1500 PRV at 75 ma dc output, is designed to replace MIL types 6X4 and 12X4 vacuum tubes in a wide range of power supply applications, including radio and television, test equipment, computers and related data processing equipment. Both units have an operating temperature range from —65°C to +75°C.

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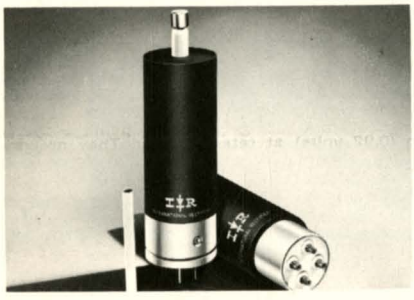
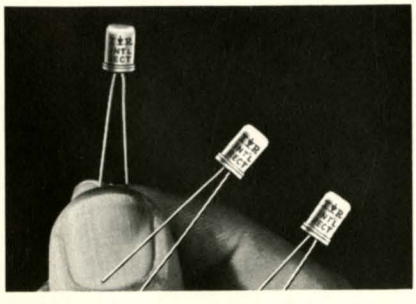


SILICON PLUG-IN REPLACEMENTS FOR 8008 AND 872A MERCURY VAPOR TUBES

High voltage silicon plug-in rectifiers directly replace Types 8008 and 872A mercury vapor rectifier tubes. By eliminating the filament transformer and time-delay relay necessary to tube operation, they occupy ½ the space and weigh less than ½ of equivalent tube circuitry.

Rated at 10,000 volts peak reverse voltage and 1250 ma dc output (at 75°C), the ST-9 and ST-10 are equipped with tube bases to allow direct insertion into existing tube sockets. They have an operating temperature range from —65°C to +75°C, and are designed to provide the superior advantages of silicon rectifier operation (no warm-up time, long life, high temperature operation, compact, rugged package) on a wide range of broadcast, TV, short-wave transmitter, radar, airline, industrial RF induction heating and other power communication and industrial applications.

Circle No. 7 on Card



MINIATURE 1N429 ZENER REFERENCE ELEMENT PROVIDES ±1% STABILITY FROM —55°C TO +100°C

Hermetically sealed 1N429 silicon zener reference elements for military and civilian land, sea and airborne power supplies will provide voltage stability of ±1% or better over the temperature range from —55° to +100°C. The 1N429 has a low 6.2 volt operating voltage (in contrast to the high starting level of gas tube regulators), making it highly suitable for precision instrumentation, computer and other data processing equipment where precise low voltage regulation is required. In addition, any number of 1N429 diodes may be used in series to obtain higher voltage reference levels.

Rated at 200 mw power dissipation at 25°C, the 1N429 has a maximum dynamic impedance of 20 ohms at 7.5 ma, and a power derating factor of 1 milliwatt/°C. Units measure 0.330 inches X 0.230 inches (dia.) maximum, and feature an hermetically sealed, all welded case for optimum resistance to humidity, corrosion and temperature extremes.

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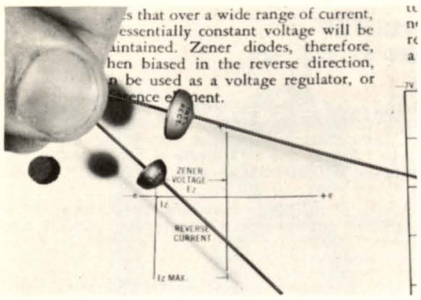


ECONOMY LINE SILICON ZENER DIODES, 500 MW, 1 WATT AND 10 WATT TYPES

An economy line of silicon zener diodes substantially lower in cost than standard units are designed specifically for commercial equipment applications. These diodes demonstrate low zener impedance values and very sharp zener "knees." They are available in 500 milliwatt, 1 watt and 10 watt rated series, and standard RETMA 10% voltage steps from 5.6 to 27 volts.

All types embody a new technical advancement in the sealing of zener diode junctions, termed "Tri-Sealed" — a three-layer seal assuring high resistance to humidity, shock, vibration, temperature extremes and other adverse environmental conditions.

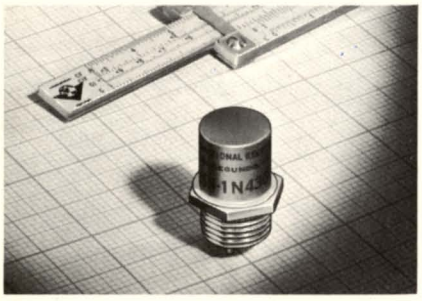
Circle No. 9 on Card

HIGH TEMPERATURE 6 AND 12 AMP DIFFUSED JUNCTION SILICON RECTIFIERS OPERATE TO 190°C.

Two series of 6 and 12 amp rated silicon diffused junction rectifiers, designed specifically to meet rigid military specifications, are capable of operating to base temperatures of 190°C. The 6 amp series is designated JEDEC Types 1N1341 through 1N1347, and the 12 amp series Types 1N1199 through 1N1205. Both series have peak reverse voltage ranges from 50 to 500 volts.

All units are manufactured by precision-controlled diffusion processes, assuring extremely low forward voltage drop, low leakage, and high uniformity of characteristics over the entire operating temperature range. Each diode is nickel-plated, to provide minimum contact resistance and prevent corrosion. A flattened-pierced end on the top (anode) lead assures fast, easy wiring into production assemblies.

Circle No. 10 on Card



USN 1N430 SILICON REFERENCE ELEMENT CONFORMS TO MIL-E-1/1060 (NAVY) SPECS

USN-1N430 silicon zener voltage reference elements conforming to MIL-E-1/1060 (Navy) will provide a reference voltage of 8.4 volts (average) at 10 ma bias current and a dynamic resistance of 11 ohms (average).

Units feature an extremely rugged assembly which can withstand the severe shock and vibration requirements of military semiconductor device specifications. They will provide a stability of ±16 millivolts or better over a temperature range from —55°C to +100°C, with temperature coefficients of ±0.002%/°C.

Also available, but not covered by individual military specifications are the 1N430A and 1N430B reference elements, selected to tighter temperature coefficient tolerances and higher operating temperature ranges than the USN-1N430.

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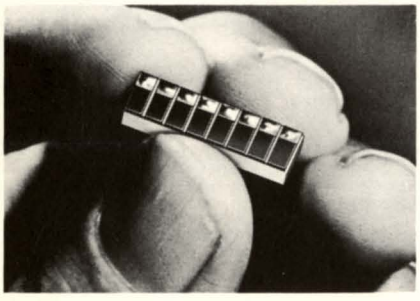


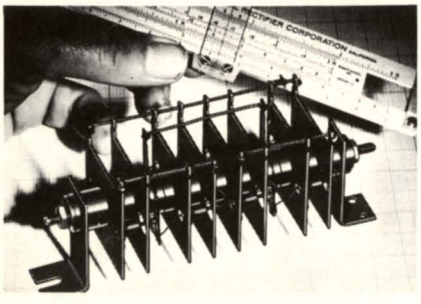
READOUT PHOTOCELLS FOR DATA HANDLING SYSTEMS

Designed specifically for computer and data processing equipment where rapid detection of light passing through punched cards or tape is required, these silicon photovoltaic readout matrices feature extremely fast response time in the order of 10 microseconds. The self-generating devices convert light energy directly into electricity, with no need for external power supplies.

Each matrix is made up of a multiple array of individually segmented silicon cells. Light energy striking a particular segment will cause power to flow from that segment only. Typical current generated is 300 microamperes for 0.01 square inch of active cell area at 1,000 footcandles illumination.

Extreme flexibility of design enables these units to be supplied in single cell or multiple-cell assemblies, as required. They are characterized by negligible temperature dependence, long operating life, uniform response from cell to cell in one matrix, and rugged construction.

Circle No. 12 on Card

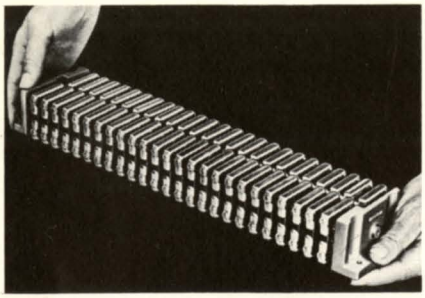


MEDIUM POWER SILICON RECTIFIER STACKS IN MORE THAN 125 JEDEC TYPES

A broad series of over 125 JEDEC type silicon medium power rectifier stack assemblies offers ready-to-install packaged power engineered by specialists to provide maximum power output through ideal heat transfer design. Units span a current range from 1.5 to 14.4 amperes d.c. output, with d.c. output voltages from 31 to 1500 volts.

Designated JEDEC types 1N2638 through 1N2764, stacks consist of glass-to-metal hermetically sealed silicon diodes mounted on 1.56 inch copper cooling fins. Mounting dimensions are from 3.48 inches to 7.53 inches. Circuit configurations are single phase ½ wave, center tap, bridge and mag. amp. bridge; 3-phase ½ wave and bridge, and 6-phase star.

Circle No. 13 on Card



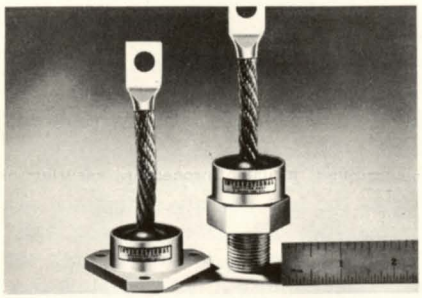
SUPERPOWER RECTIFIER HIGH VOLTAGE COLUMNS DELIVER UP TO 1000 WATTS PER CUBIC INCH OF VOLUME

These new rectifier columns incorporate the modular design concept to provide more power per cubic inch of rectifier area than other existing rectifier stack configurations . . . along with extremely compact size, physical ruggedness and predictable reliability of the highest order. In addition, modular rectifier design insures maximum design flexibility, shortens development time and simplifies procurement cycles.

Superpower rectifier columns are available for voltages ranging from 10,000 to 120,000 volts, with current capacity ranges from 1 to 50 amperes.

Applications requiring superpower supplies of this magnitude include long-range radar, television and broadcast transmitters, high voltage dc resistance welders, particle accelerators, induction heaters, pulse modulators and pulse-forming circuitry for plasma research.

Circle No. 14 on Card



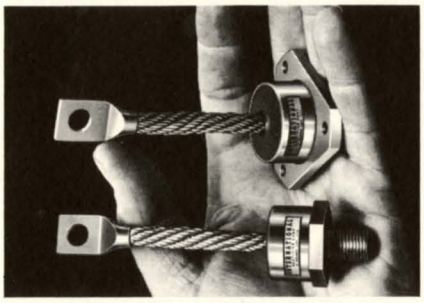
45 TO 150 AMP RATED "QUAD-SEALED" SILICON POWER RECTIFIERS FOR ECONOMY IN INDUSTRIAL POWER USES

These silicon rectifiers are capable of withstanding surge currents up to 20 times their nominal current rating (1000 amperes peak at rated full load).

Twin series of stud mounted and triangular base "Quad-Sealed" rectifiers are especially recommended for industrial power and battery charging applications where low cost and high surge current capabilities are called for. Each rectifier junction is "Quad-Sealed" by a four-barrier sealant and class H varnish process, thus completely enclosing the assembly in a ruggedized case totally resistant to moisture and contaminants . . . while permitting expansion and contraction of the assembly under wide temperature excursions.

The two new series provide dc output ratings from 45 to 150 amperes; peak reverse voltage ratings from 50 to 600 volts over an operating temperature range from —20°C to +130°C.

Circle No. 15 on Card



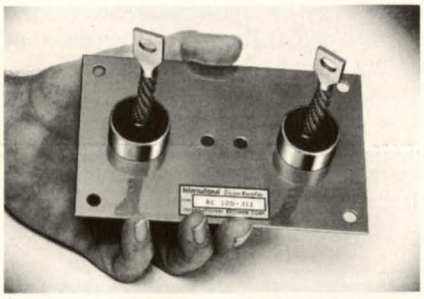
70 TO 250 AMP "QUAD-SEALED" SILICON RECTIFIERS FOR HEAVY DUTY INDUSTRIAL POWER CONVERSION

Designed specifically for battery charging and industrial power applications at an economical price range, these twin stud mounted and triangular base series provide output ratings from 70 to 250 amperes dc, peak reverse voltage ratings from 50 to 600 volts, and an operating temperature range from —20°C to +130°C base temperature.

Triangular base units are specifically engineered for limited space applications. Since both stud mounted and flat base devices provide excellent thermal transfer from diode junction to base to cooling fin, they are especially recommended for medium to high current applications calling for high surge current capabilities.

Reverse polarity types are available in both stud mounted and triangular base series.

Circle No. 16 on Card



LOW COST 100 AMP RATED SILICON RECTIFIER FOR BATTERY CHARGING APPLICATIONS

A low cost, 100 ampere rated silicon rectifier, complete with heat sink, is designed for rapid, easy installation on a wide variety of battery charging applications. The center-tap rectifier features single unit, compact construction, consisting of two silicon junctions mounted on a 4" x 6" nickel-plated copper cooling fin. Mounting holes are spaced to facilitate mounting to practically any battery charger.

All junctions incorporate the exclusive International Rectifier "Quad-Seal" process, including successive layers of humidity resistant, insulating resins and sealants assuring optimum operation over a temperature range from —20 to +130°C.

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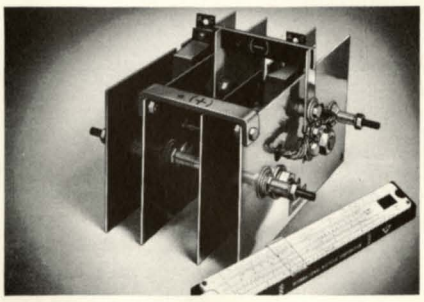


HIGH CURRENT SILICON RECTIFIER POWER STACKS FEATURE BUILT-IN PARALLELING REACTORS TO INCREASE EFFICIENCY

These pre-engineered high power silicon rectifier stacks incorporate built-in paralleling reactors to insure equal current distribution through parallel circuit branches. The units feature ratings up to 750 amperes, with from 50 to 600 volts peak reverse voltage ratings.

A standard "building block" is a 2-1-2-D "doubler" module with integral paralleling reactor, and four 70 amp rated silicon junction rectifiers mounted on copper cooling fins. Two of these modules may be mounted to form a single phase bridge (as shown in photo) rated up to 550 amperes rectified d.c. output (when operating within recommended temperature and cooling limits).

Three of these basic modules will form a 3-phase bridge rated to 750 amperes. Other configurations include "Scott 4-phase bridges", and 6-phase bridges in both series and parallel connections and proportional ratings.

Circle No. 18 on Card

Protection of Circuit Components with Zener Diodes

The Ruggedness of The Zener Diode Permits It To Absorb Overloads And Protect Delicate Circuitry

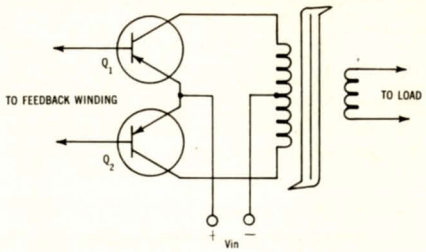


Fig. 1. The switching circuitry for a typical transistor power converter.

The zener diode has the ability to pass current when a specified breakdown voltage is exceeded, and therefore may be used to protect transistors, meters, or any device which may be damaged by excessive voltage.

Particularly critical in this regard are transistors. Like a diode, they too have an avalanche breakdown voltage which is somewhat higher than the specification V_{CE}. Unlike the zener diode they cannot be cycled in and out of the avalanche region. Exceeding V_{CE} often results in the destruction of the transistor due to a total breakdown of the junction known as "punch-through."

Power Converters

The transistorized power converter provides an excellent illustration. These devices are quite popular in airborne electronic units for d.c. to a.c. and d.c. to d.c. conversion.

The aircraft electrical system is a notorious source of transients that may exceed V_{CE}. If these high voltage pulses are allowed to reach the power converter, they will appear on the transistors, for the low inductance of the transformer primary is not sufficient to provide a significant amount of attenuation. Even if the transient is less than V_{CE} it may occur simultaneously with a negative half-cycle, thereby creating a total collector potential which is destructive.

Fig. 1 shows a typical transistor power converter. When transistor Q1 is conducting, the other transistor will be cut-off. However, due to auto-transformer action the collector-emitter potential of Q2 will be two-times V_{in}. Thus for a 12 volt system, the collector to emitter potential would be 24 volts, neglecting internally generated transients on the leading edge of the switching cycle.

If transistors with a 30 volt V_{CE} were used in this example, a transient in the electrical system which exceeded six volts could conceivably damage one or both transistors.

One solution is to employ transistors with 80 or even 100 volt V_{CE} ratings. It is also possible to series connect transistors across each half of the switching winding. However, either solution is more expensive than the use of two zener protection diodes, as shown in Fig. 2. These diodes are selected to have a V_Z which is slightly higher than two-times maximum V_{in} and well below the maximum V_{CE} ratings for the transistors. Any transient, whether of internal or external origin, which exceeds the diode avalanche voltage will initiate conduction. This effectively clips or limits the transient well below the point where it could damage the equipment.

Audio Amplifiers

Class B servo and audio amplifiers are particularly susceptible to transient destruction. Should a pulse appear on the supply line (Fig. 3), it will pass unhindered to the transistor collectors due to the low primary inductance of transformer T2. The transient will cause an increase in the collector to base leakage since it flows through the base-emitter junction. Thus, the pulse is amplified by the transistor Beta and creates a sudden increase in collector current, almost simultaneously with the arrival of the transient. All design limits for the output stage are exceeded and transistor "punch-through" is usually the result.

The transient energy appearing at the base can destroy the base-emitter junction. Shunt resistors R1 and R2, in Fig. 3, will minimize this possibility in addition to reducing the amplitude of the pulse transformed to the collector circuit of Q1, through T1.

Complete transient protection may be obtained by incorporating zener diodes between each collector and the common emitter circuit. As before, these diodes are selected with a V_Z which is somewhat greater than two-times the supply voltage. Connected in this manner, the diodes limit destructive transients before they can damage the components.

The driver transistor is protected due

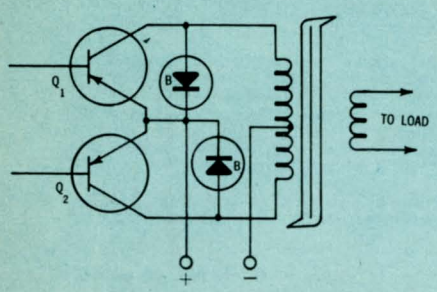


Fig. 2. A power converter modified for transient protection, with zener diodes.

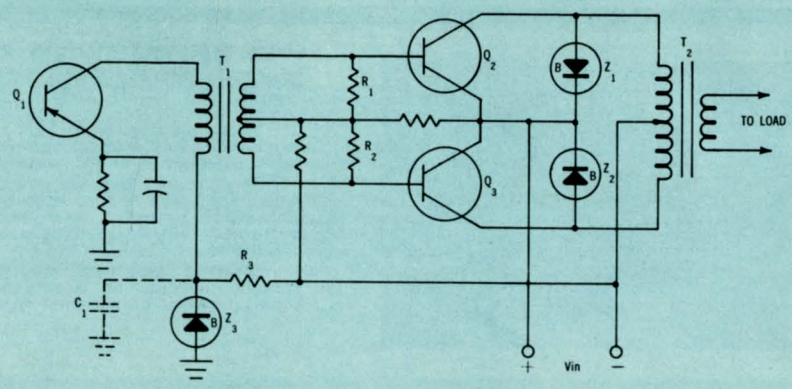


Fig. 3. A Class B audio or servo amplifier protected by zener diodes. Even high voltage transients will not damage this amplifier.

to the resistance of R3, the primary of T1, and the low reactance of C1. Substituting a zener diode (Z3) in the position normally occupied by the electrolytic capacitor will provide absolute protection in addition to greater decoupling (and improved low frequency response) due to the constant low impedance of Z3. The higher stabilized collector voltage for Q1 will allow less degeneration and consequently higher stage gain.

It has been shown[1] that this system affords complete protection even when the transistors are pulsed with 300 volt transients, having a duration of one microsecond.

RF Amplifiers

The self biased Class C r.f. amplifier tube may be damaged if the r.f. drive energy should fail. For protection it is customary to connect a small pentode between screen grid and ground as shown in Fig. 4, with bias for this tube supplied from the potential which appears across the grid leak resistor. Should the drive fail, there is no bias for the "clamp" tube and it conducts heavily. This, of course, reduces the screen potential and plate current of the stage, insuring that its dissipation is not exceeded.

A less complicated, and in many cases less expensive, system is shown in Fig. 5. A zener diode in the cathode circuit establishes the minimum bias consistent with maximum dissipation in the stage. In operation the grid bias is the sum of V_Z and the potential across R due to grid current flow. If the drive should cease, sufficient bias to protect the amplifier tube is provided by the zener diode. Since the protection device has no filament to burn out, reliability is greatly increased.

The correct diode for the application may be determined by consulting the tube characteristics to determine the maximum current which will not exceed the dissipation at a given plate potential:

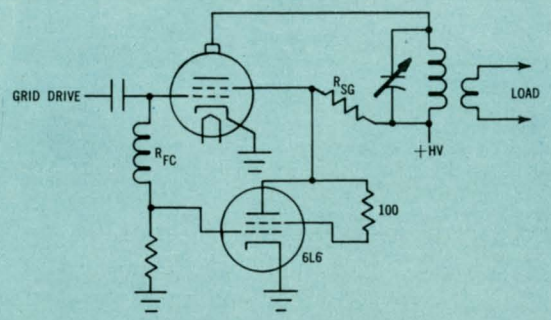
$$I_p = \frac{P_d}{E_p}$$

where; I_p = maximum plate current
P_d = plate dissipation
E_p = plate voltage

When I_p is known, the correct bias for this current may be determined from the characteristic curves. The diode would be selected as near this value as possible. The diode wattage may be easily determined when voltage and current in the diode circuit are known. The next largest size should be selected.

1. B. B. Daien, "Protect Transistors Against Destructive Transients," Electronic Design, Nov. 1959,

Fig. 4. Class C r.f. power amplifier protected by a "clamp" tube.



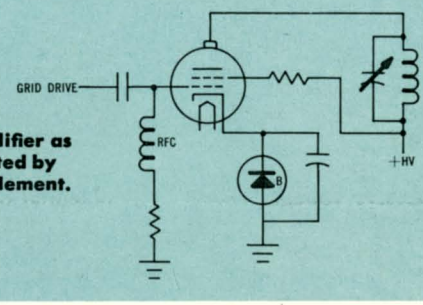


Fig. 5. The same amplifier as in Fig. 4, but protected by a zener diode bias element.

Meter Protection

D'Arsonval meter movements, due to their delicate construction, are easily damaged with even moderate overloads. Although the moving coil may not open, the sudden application of excessive current can cause the pointer to strike the end-stop violently. If the applied force is sufficient, the needle will be permanently bent.

The zener diode, with its ability to limit at a specific voltage, may be used to provide complete protection against physical damage due to overload.

A suitable circuit is shown in Fig. 6. The diode must be connected to a point on the voltage divider (or multiplier resistor) which is near V_Z.

For the purposes of illustration, assume a protected 10 volt d.c. meter is desired. To minimize circuit loading a basic 100 microampere movement with a 1,000 ohm coil is to be used. A zener diode rated in excess of 7 volts and below 10 volts should be used, for they exhibit a sharper "knee" and therefore do not affect full scale linearity. Therefore, an 8.2 volt diode has been chosen for this application. The total resistance of the multiplier (R1 + R2) may be determined by using the formula:

$$R1 + R2 = \frac{E_{in}}{I_m} - R_m$$

where; E_{in} = maximum voltage to be measured
I_m = full-scale meter sensitivity
R_m = meter coil resistance

Thus, in the example, a 99,000 ohm multiplier resistor would be used. The ratio of R1 to R2, which determines the voltage available for the zener diode, is given by the formula:

$$R2 = \frac{R1 + R2 \times V_Z}{E_{in}}$$

Resistor R2 therefore is 83.2KΩ, and of course, resistor R1 is the difference, or 15.8KΩ.

For extreme accuracy the tiny diode leakage current must be taken into consideration. The leakage current will cause a small voltage drop across R1, and will cause a slight decrease in the meter current. This effect will be least when a diode close to V_{in} is used, making R1 a small portion of the total resistance.

If full scale linearity proves to be a problem, the diode should conduct 5% above the maximum input voltage. Thus in the formula for R2, a figure of 10.5 volts would be used for V_{in}. This will allow the pointer to deflect beyond full scale but it will not have sufficient inertia to damage it.

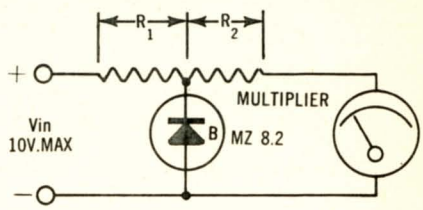
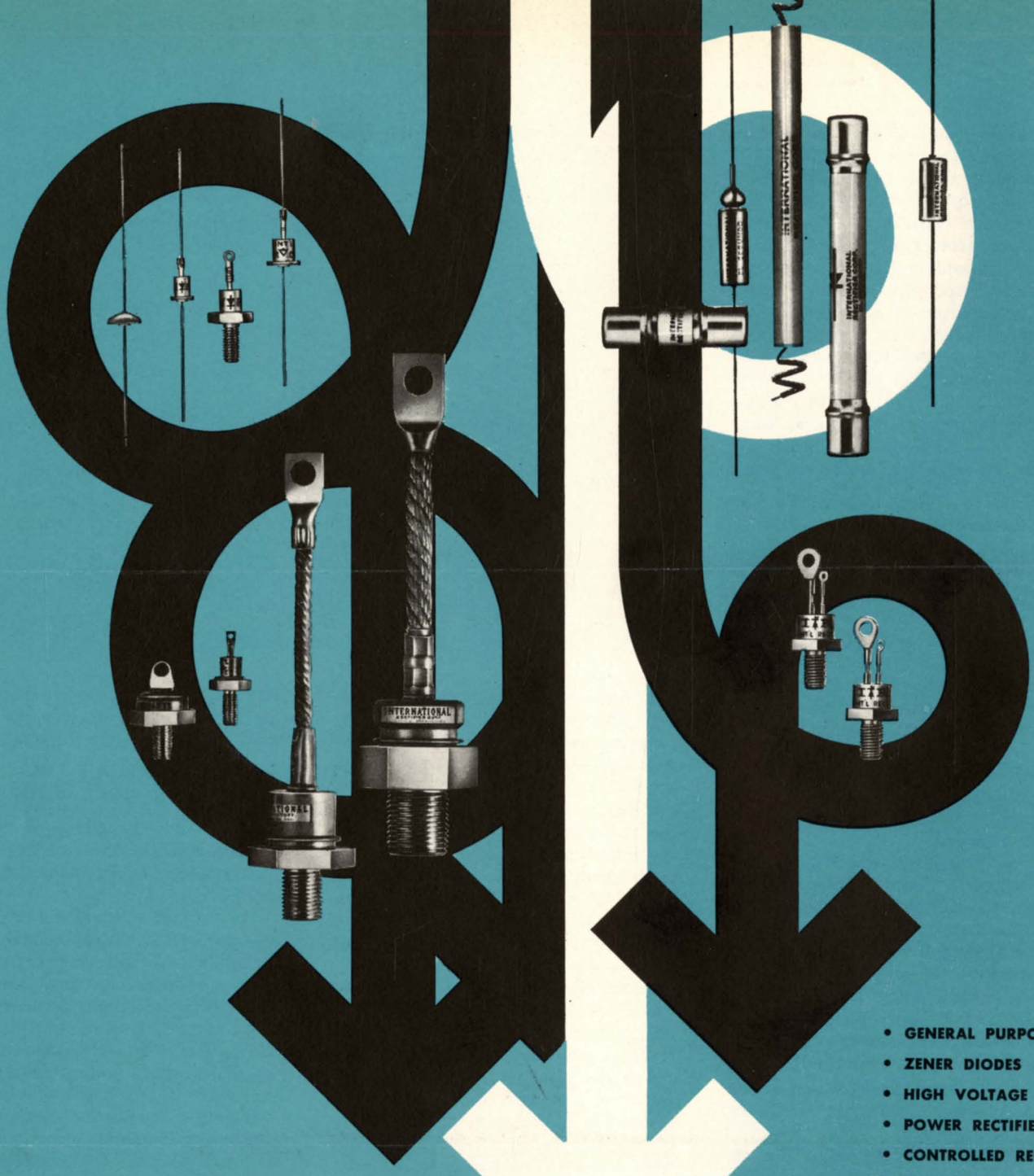


Fig. 6. A zener diode meter protection circuit.



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