JUNE / JULY / 1960

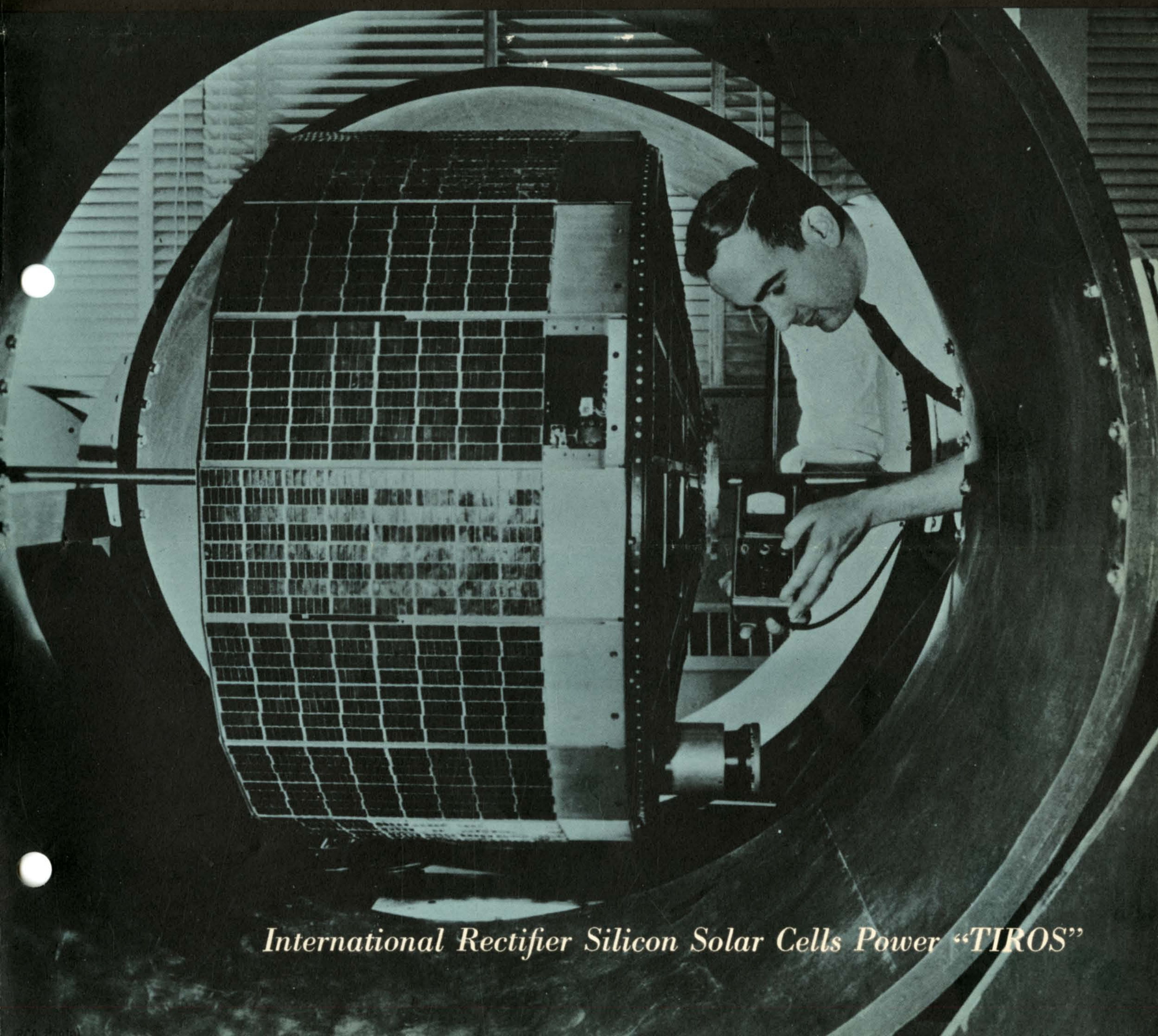
INTERNATIONAL RECTIFIER CORPORATION

A WORLD OF DIFFERENCE THROUGH RESEARCH

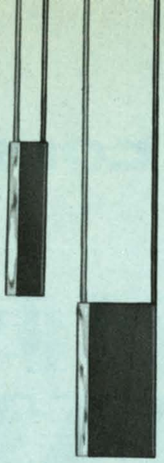
SYMBOL OF QUALITY IN·SEMICONDUCTORS

RECTIFIER NEWS

PUBLISHED BY INTERNATIONAL RECTIFIER CORPORATION • EL SEGUNDO • CALIFORNIA



International Rectifier Silicon Solar Cells Power "TIROS"



Typical configurations of standard Silicon Solar Cells manufactured by International Rectifier. For complete information request Bulletin SR-280.

Silicon Solar Cells Power The TIROS 1 Weather Satellite

History was made on April 1, 1960, when the United States launched its first picture-taking weather satellite, Tiros I, whose TV cameras, video tape recorders, transmitters and other electronic gear are powered entirely by 9260 silicon solar cells made by International Rectifier Corporation.

Tiros (Television and Infra-Red Observation Satellite) is perhaps the most elaborate electronics package yet sent into orbit about the earth and is designed to probe secrets of cloud cover and earth heat. In essence, it is a sophisticated experimental tool which will influence the pattern for advanced approaches to precise weather satellites aloft at all times.

The Astro-Power Division of International Rectifier Corporation supplied the specialized solar cells to the RCA Astro-Electronic Products Division, Princeton, N.J., who designed and built the satellite and its associated ground system equipment for the National Aeronautics and Space Administration (NASA). The United States Army Signal Research and Development Laboratory at Fort Monmouth, N.J. had technical direction of the project.

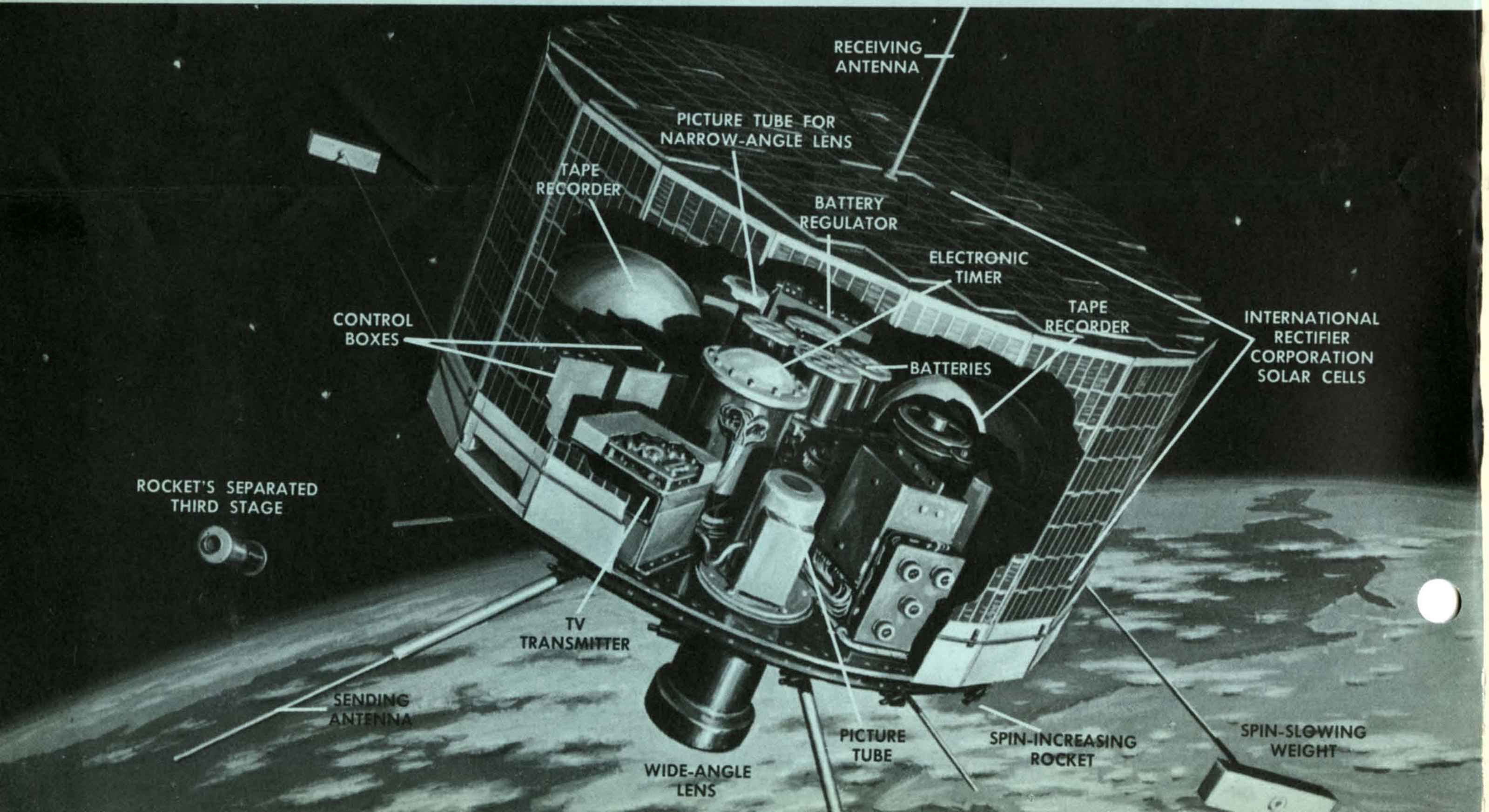
Covering the sides and top of the vehicle is the large network of silicon solar cells which form the heart of the power supply and give life to the payload. Each solar cell, measuring 1 x 2 cm of surface area, is capable of converting sunlight directly and efficiently into electricity without the need for moving parts, and without any radio-activity problems.

The solar cells supplied to AEP-RCA by International Rectifier Corporation were provided with specialized glass cover slides designed for temperature control. The output of a silicon solar cell decreases if its temperature rises and one of the most effective ways of controlling the surface temperature of the cells is to cover them with thin glass cover-slides securely bonded by a thin, transparent film of a suitable adhesive.

To reduce unwanted reflection of the active, visible light from the glass surface, a special "anti-reflection" but transparent film was also deposited on the glass slides. The net result was a reliable and efficient component, specifically designed for harnessing part of the vast amount of solar energy available in space.

The solar cell power supply of the satellite is arranged to deliver 28 v and 14 v. Although the solar cell array is capable under certain conditions of an instantaneous power output of about 58 watts, nickel-cadmium batteries are employed to provide peak power to the instrumentation package, as well as to maintain a constant power supply even when the vehicle is in the earth's shadow. At the present time the power being withdrawn from the batteries is about 25-30 watts per orbit.

This drawing shows the TIROS at the precise moment of settling into orbit over the Indian Ocean, 45 minutes after launching. Spin-slowing weights can be seen spinning out from the base on unwinding cables, slowing the spinning vehicle from 120 RPM to 10 RPM . . . to insure optimum picture-taking. Tape-recorded pictures are stored until a radio signal from the ground triggers the transmitter.



This data is part of the 100-page International Rectifier Corporation Zener Diode Handbook. Copies may be obtained from Electronic Distributors or our Product Information Department. Price: $2.00 (Check or Money Order).

For full details on the International Rectifier zener diode line request Bulletin SR-260.

SILICON ZENER DIODES AS FILAMENT VOLTAGE REGULATORS IN AC APPLICATIONS

The design engineer may be inclined to associate the zener diode, and zener diode applications, with control and regulation of d.c. power supplies. Although the majority of zener diodes are used in this type of circuitry, they are equally applicable in a.c., audio, r.f., and control systems,

When supplied with alternating current and connected as a shunt regulator (see Fig. 1), the zener diode is capable of limiting both the positive and negative parts of an a.c. cycle (Photo 1).

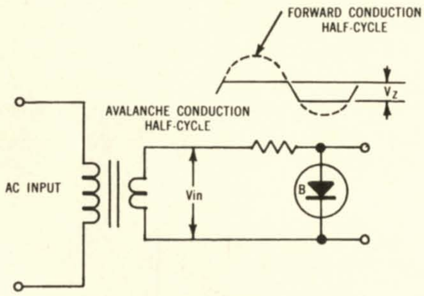


Fig. 1. Basic a.c. regulator circuit.

The diode conducts almost immediately after the signal passes through zero and into the positive segment. On the negative half cycle, the diode does not conduct until the applied voltage reaches V_z (Photo 2). The net result is a rather non-symmetrical square wave. This effect can be minimized with higher values of V_{in}, but can never be completely eliminated unless two shunt connected diodes are employed in a back-to-back configuration (Photo 3).

Filament Regulators

The fact that the zener diode can be used to limit a.c. as well as d.c. provides an interesting application as a filament voltage regulator. It is occasionally necessary to stabilize the a.c. potential applied to a tube filament. Before zener diodes were commonly available, control of filament potential was accomplished exclusively by using saturable core reactors, ballast tubes, and elaborate rectifier/regulator circuits.

Filament regulation of a variable frequency oscillator is a logical application for the versatile zener diode. Undesirable frequency shifts might occur with line voltage variations between 100 and 130 volts. These extremes would cause a filament voltage change of 5.4 to 7.0 volts.

An a.c. filament regulator, for six volt tubes, may be supplied from a 12.6 volt filament buss, as shown in Fig. 2. Although 6.3 volt zener diodes are available, the regulation is more important than the exact filament voltage. A zener diode on the low side of the nominal filament voltage might increase tube life.

The back-to-back configuration must be employed to avoid excessive current flow during the forward conduction half-cycle. Connected as shown, one diode establishes V_z, while the other diode appears as a short. During the next half-cycle this condition reverses.

When dealing with a.c., the ratio of average to peak zener current (ρ) must be taken into consideration. Although this figure varies with diodes and applied voltage, a figure of 0.6 will be suitable for most operating conditions.

In computing values for use in Fig. 2, the minimum value for I_z must be known. To insure proper regulation at minimum line voltage, select a value which is 10% of the minimum load

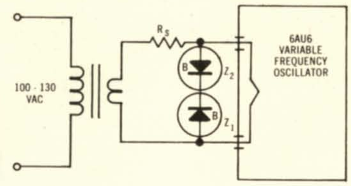


Fig. 2. An a.c. regulator application for filament temperature stabilization. The component values are worked out in the text.

current. For the purposes of illustration it may be assumed the filament current is a linear function and would vary between 260 and 330 ma. for the above conditions. Thus an I_{zmin} of 26 ma. is established. The minimum current through R_s will then be 286 ma., which is the sum of the minimum filament and zener diode current. The peak cur-

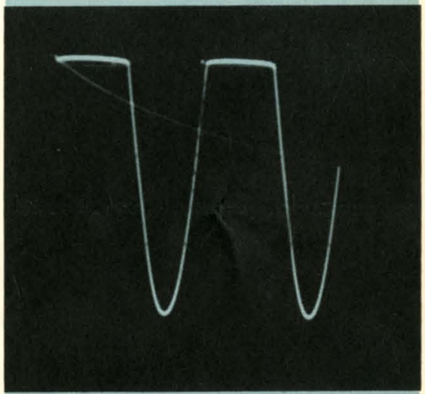


Photo 1. A.C. signal applied to the zener diode regulator in Fig. 1. In this oscillogram the negative peak of the a.c. has not reached V_Z, the avalanche breakdown voltage.

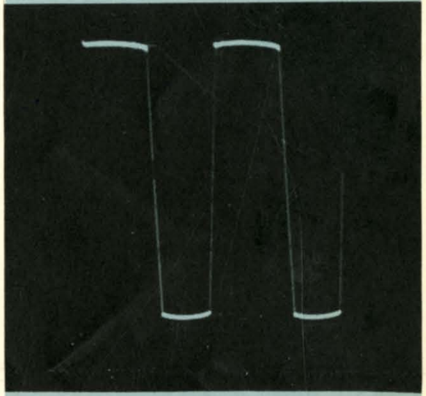


Photo 2. In this oscillogram the applied voltage has exceeded V_Z. Note the width at the zero conduction point compared with the width at V_Z.

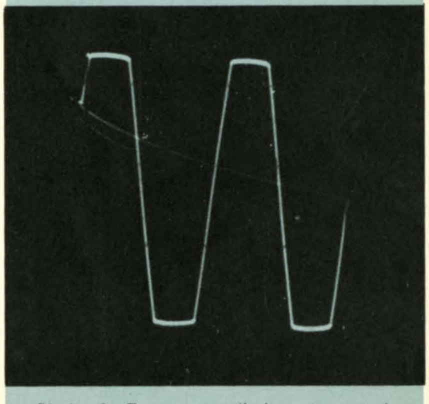


Photo 3. Two zener diodes connected "back-to-back" (anode to anode) prevent excessive current flow during the forward conduction cycle. The regulator in Fig. 2 will exhibit this waveform.

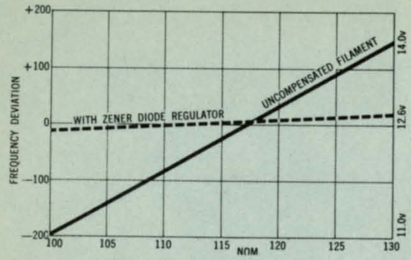


Fig. 3. Line variations plotted versus frequency shift.

rent through this resistor at minimum line voltage is:

$$I_{R_{speak}} = \frac{I_{R_s}}{\rho} \text{ or } \frac{.286}{.6} = .477 \text{ a.}$$

where; $I_{R_{speak}}$ = peak current in R_s

ρ = ratio of average to peak current (0.6)

The resistance of R_s is:

$$R_s = \frac{V_{inmin}(1.414) - V_z}{I_{R_{speak}}}$$

where; V_{inmin} = min. supply voltage (10.8)

V_z = zener voltage

$I_{R_{speak}}$ = peak current in R_s

solving;

$$R_s = \frac{10.8(1.414) - 5.6}{.447 \text{ amp.}}$$

$$R_s = 20.3 \text{ ohms}$$

The maximum zener current will occur when the line voltage is highest. Since the diode is conducting heavily ρ must once again be considered. The maximum zener current can be determined from the following equation:

$$I_{zmax} = \frac{V_{inmax}(1.414) - V_z}{R_s} (\rho)$$

where; V_{inmax} = maximum input voltage (14..0)

V_z = zener voltage (5.6)

R_s = series resistor (20.3 ohms)

ρ = ratio of average to peak current (0.6)

solving;

$$\frac{19.8 - 5.6}{20.3} 0.6$$

$$I_{zmax} = 0.42 \text{ amp.}$$

Each diode will dissipate half the heat generated in the circuit. Therefore the power dissipating ability of each diode is equal to:

$$P_z = \frac{V_z \times I_{zmax}}{2}$$

where; P_z = power dissipated by each diode

I_{zmax} = maximum zener current

solving; $P_z = \frac{2.35}{2} = 1.18$ watts

Therefore the next larger size diode, a 3.5 watt package, would be used.

The power dissipated by resistor R_s may be computed from the following:

$$P_{R_s} = R_s (I_{zmax} + I_{Lmin})^2$$
$$P_{R_s} = 20.3 \times (0.68)^2$$
$$P_{R_s} = 9.38 \text{ watts}$$

Thus in Fig. 2, two International Rectifier Corporation 3.5 watt zener diodes would be used (3Z5.6) in conjunction with a 20 ohm, 10 watt dropping resistor.

To illustrate the improvement in frequency stability, the curve of frequency versus line voltage was plotted and is reproduced in Fig. 3. It can be seen that the frequency shift is less than 50 cycles in either direction from the mean frequency.

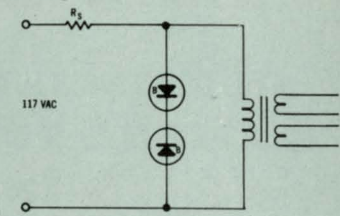


Fig. 4. A primary a.c. regulator.

The regulator could also be placed in the primary circuit as shown in Fig. 4. Connected in this manner the diode is able to regulate each of the secondary windings. This circuit, however, requires higher voltage units and relatively higher power ratings, and is therefore more costly.

The filament regulation technique which has just been described in detail can also be applied to mobile installations where the voltage variation is more extreme than is usually encountered with a.c. power lines.

Where power consumption is a prime consideration on a.c. power circuits, an inductor or capacitor can be used as a ballast device. Such a circuit is shown in Fig. 5. The capacitor is selected to have a reactance substantially the same as a calculated value for R_s at the power line frequency — 60 or 400 cycles.

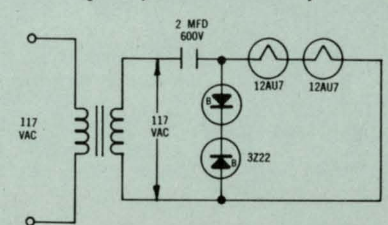


Fig. 5. An inductor or oil-filled capacitor can be used as a ballast in place of R_s.

"SOLAR KING" — the Largest Silicon Solar Cell Panel Ever Assembled Embarks on European Technical Tour.

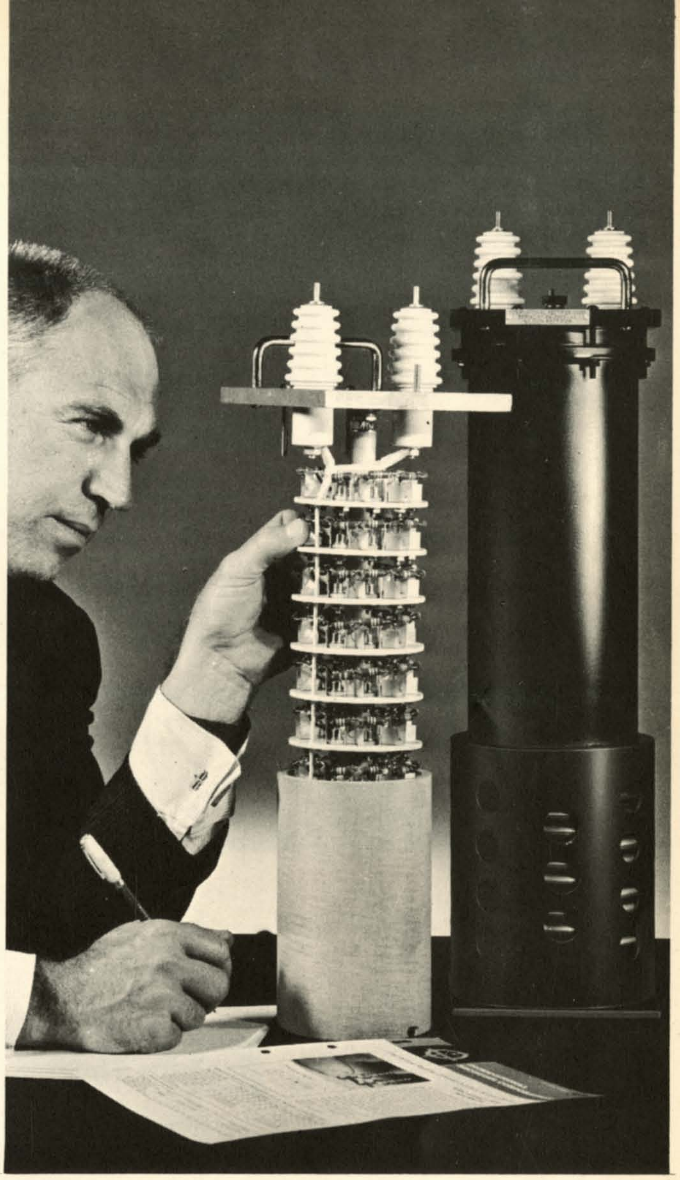
International Rectifier Corporation's demonstration of the commercial possibilities for silicon solar cells became international front page news this Spring when this solar-powered car—the world's first—was exhibited in Los Angeles, Chicago and New York City.

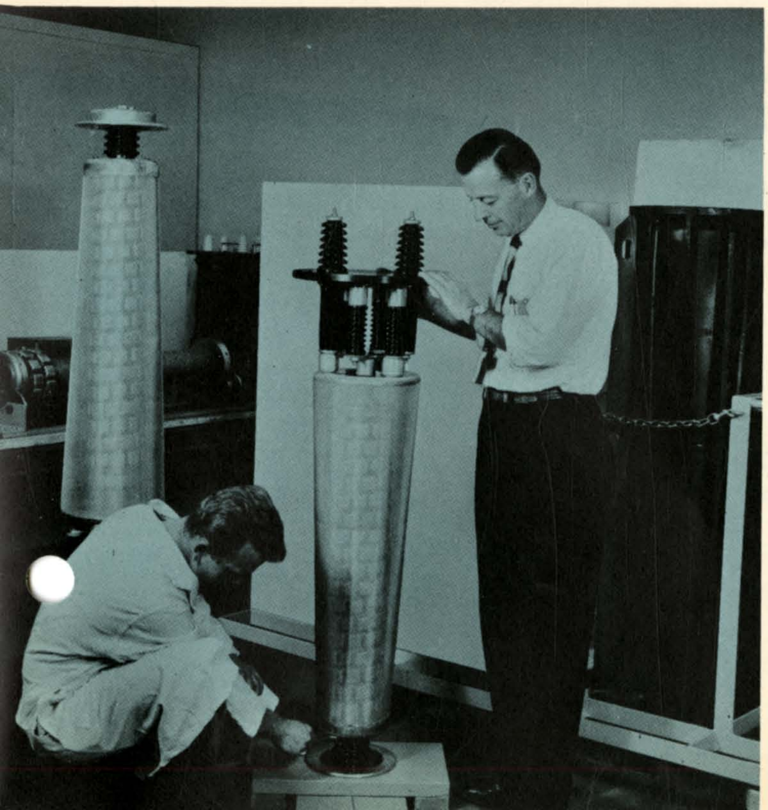
Atop this 1912 electric vehicle is the "Solar King" — the largest single silicon solar cell panel ever assembled. The 10,640 silicon solar cells directly convert sunlight into electrical energy which, through the use of intermediate storage batteries, propels the automobile.

In June 1960 this solar-powered car will begin a European tour, starting with its exhibition at the "Rassegna," International Congress of Electronics, in Rome June 15 through June 29. At that time Dr. Charles Escoffery, Technical Assistant to the President of International Rectifier, will present a technical paper on the state of the solar cell art. This showing will be followed by demonstrations and technical seminars in Paris, Amsterdam, Copenhagen and London.

INTERNATIONAL RECTIFIER
"CREATIVE SPECIALIZATION"
APPLIED TO

Custom Super-Power High Voltage Rectifier Elements





As creative specialists in the field of high voltage rectification, International Rectifier has developed and supplied more standard high voltage devices than any other manufacturer in the industry. The first to offer a complete line of selenium high voltage "cartridge type" rectifiers in hundreds of configurations, International Rectifier also was the first to introduce cartridge type silicon high voltage rectifiers to industry in 1956. The years of experience in high voltage rectifier design can be focused on your *special* high voltage rectifier elements with equal success. The units pictured and described here are two practical solutions to radar super power tube d.c. supplies. They demonstrate the outstanding capabilities in concept and design that have solved complex high voltage rectification problems for others. It can be done for you.

* * * * *

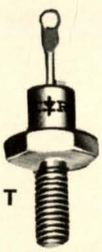
ABOVE . . . Six of these high voltage rectifiers combine to form a 3-phase full-wave bridge providing 18,000 volts at 2 amperes, and capable of handling 40,000 volts (peak reverse voltage rating) over a temperature range from —30°C to +105°C. Each stack consists of 99 six ampere rated silicon rectifiers mounted in tiers, along with the required resistors and capacitors, to provide the required rating. These tiers are mounted in oil-filled, hermetically sealed brass tanks to provide optimum power dissipation; minimize "hot spots."

AT LEFT . . . These heavy duty assemblies are designed to furnish 30,000 volts at 9 amperes d.c. in a 3-phase full-wave bridge circuit. They will withstand peak reverse voltages of 70,000 volts, and peak surge currents of 200 amperes. The "heart" of these power packs is 176 25-ampere rated silicon rectifiers connected in series. The rectifier cells are shielded by a Faraday screen and immersed in an oil-filled, hermetically sealed tank with integral cooling ribs.

A New Feature of International Rectifier General Purpose Silicon Rectifiers That Provides Maximum Solderability . . . Superior Resistance to Corrosion . . .

53 JEDEC TYPES.... 6 JAN TYPES....

NOW COMPLETELY TIN-PLATED!



T

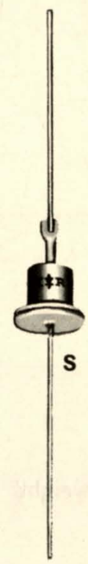
These International Rectifier Corporation hermetically sealed silicon rectifiers are now tin-plated from top to bottom to assure installation ease through 100% solderability, and to provide an even higher degree of resistance to corrosive agents than ever before attained.

The types listed are just part of the extensive line of International Rectifier Corporation rectifiers. You may also choose from several series of hermetically sealed, all-welded styles, as well as economy-type tri-sealed rectifiers with comparable ratings. Whatever your requirement, it can be met with an International Rectifier device of the highest quality.

* * * * *

JEDEC Number	Peak Reverse Voltage	DC Output MA @ 100°C Case
STUD MOUNTED SERIES CASE TYPE T		
1N607	50	800
1N608	100	800
1N609	150	800
1N610	200	800
1N611	300	800
1N612	400	800
1N613	500	800
1N614	600	800
1N607A	50	800
1N608A	100	800
1N609A	150	800
1N610A	200	800
1N611A	300	800
1N612A	400	800
1N613A	500	800
1N614A	600	800

M



S

JEDEC Number	Peak Reverse Voltage	DC Output MA @ 50°C Ambient
MINIATURE TOP HAT SERIES PIGTAIL LEADS—CASE M		
1N1701	50	300
1N1702	100	300
1N1703	200	300
1N1704	300	300
1N1705	400	300
1N1706	500	300
1N1707	50	500
1N1708	100	500
1N1709	200	500
1N1710	300	500
1N1711	400	500
1N1712	500	500
STANDARD TOP HAT SERIES PIGTAIL LEADS—CASE S		
1N440	100	300
1N441	200	300
1N442	300	300
1N443	400	300
1N444	500	300
1N1692	100	600
1N1693	200	600
1N1694	300	600
1N1695	400	600
1N440B	100	750
1N441B	200	750
1N442B	300	750
1N443B	400	750
1N444B	500	650
1N536	50	750
1N537	100	750
1N539	300	750
1N1095	500	750
1N1096	600	750
1N1487	100	750*
1N1488	200	750*
1N1489	300	750*
1N1490	400	750*
1N1491	500	750*
1N1492	600	750*

DELIVERY FROM STOCK

JAN 1N253 . . . 100 PRV
Per Mil-EI/1024A

JAN 1N254 . . . 200 PRV
Per Mil-EI/989B

JAN 1N255 . . . 400 PRV
Per Mil-EI/990B

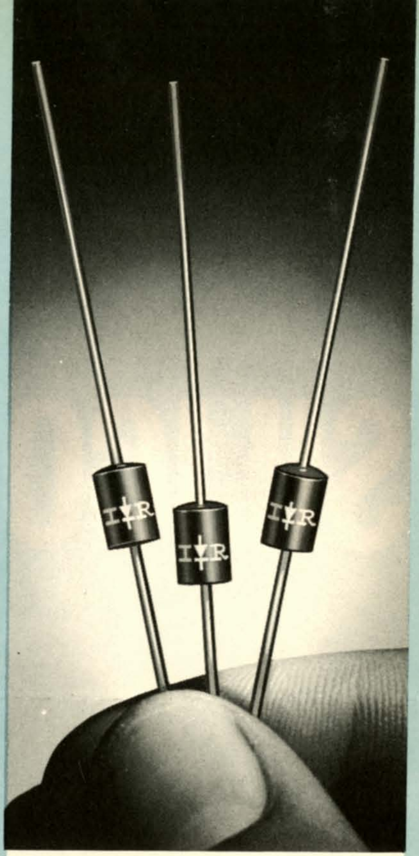
JAN 1N538 . . . 200 PRV
Per Mil-EI/1084A

JAN 1N540 . . . 400 PRV
Per Mil-EI/1085A

JAN 1N547 . . . 600 PRV
Per Mil-EI/1083A

*current rating @ 25°C.

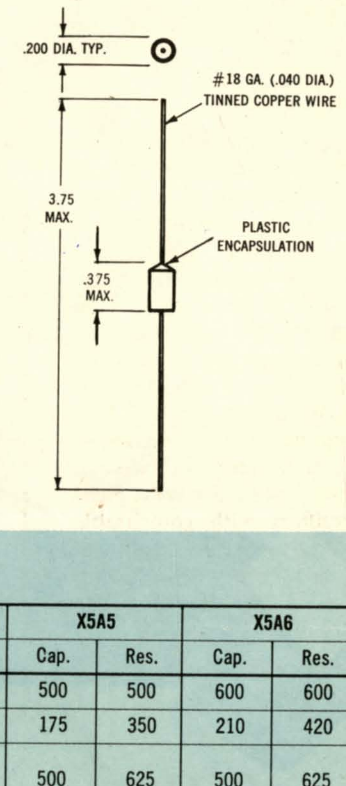
new | developments



Miniature Diffused Junction Silicon Rectifiers Rated at 500 ma Without Heat Sink . . . Withstand 50 amp/8 millisecond Surge Current

This first of a series of miniature silicon rectifiers incorporates completely new diffusion techniques to provide high current ratings and superior electrical characteristics in a ruggedized miniature encapsulated package. Primarily designed for industrial and TV applications, the new units feature a very low reverse current at rated peak reverse voltage, an exceptionally low forward voltage drop, and high current-handling capabilities.

The leads are oversize for strength and increased heat dissipation. Additional capabilities resulting from the new processing techniques are: high mechanical strength and much higher than normal surge current rating (50 amp at 8 milliseconds) for a unit of this size. The junction is encapsulated in a stable, high temperature, high strength non-metallic case. This sealing process utilizes three layers, including a resilient sealant to permit expansion and contraction under temperature loads and a high temperature sealant that completely seals the assembly with an extremely hard layer dimensionally and physically stable over the operating temperature range. This three-layer process produces an environmental seal superior to other units of similar construction. These rectifiers have an operating temperature range from —65°C +130°C and a storage temperature range from —65°C to +150°C. Net weight: approximately 1 gram.



Maximum Ratings and Characteristics

RECTIFIER TYPES	X5A2		X5A4		X5A5		X5A6	
	Cap.	Res.	Cap.	Res.	Cap.	Res.	Cap.	Res.
Peak Reverse Voltage, Volts	200	200	400	400	500	500	600	600
Max. RMS Input Voltage, Volts	70	140	140	280	175	350	210	420
Max. Rectified DC Output, ma (@ 100°C ambient temperature)	500	625	500	625	500	625	500	625
Max. Surge Current (1 cycle), amps.	50	50	50	50	50	50	50	50
Max. DC Reverse Current (μa) @ 100°C (Full cycle average over 10 sec.)	200	200	200	200	200	200	200	200
Max. DC Voltage Drop @625 ma, Volts	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Minimum Surge Resistor, Ohms	4.7	—	4.7	—	6.2	—	7.5	—
Recommended Surge Resistor, Ohms	7.5	—	7.5	—	10	—	12	—

MANUFACTURED BY THE WORLD'S LARGEST SUPPLIER OF INDUSTRIAL METALLIC RECTIFIERS

INTERNATIONAL RECTIFIER CORP. • EL SEGUNDO, CALIF. • OREGON 8-6281 • CABLE ADDRESS: RECTUSA

INTERNATIONAL RECTIFIER NEWS is published bi-monthly by International Rectifier Corporation, El Segundo, California. Entire Contents Copyrighted 1960. Reproduction or reprinting of any article in part or whole is prohibited except by written authorization which may be obtained by writing the Executive Editor: William E. Wilson. Items of interest and Technical Articles from readers are most welcome and should be submitted to the Technical Editor: Dr. C. A. Escoffery.

A PARTIAL LISTING OF INDUSTRY'S

WIDEST LINE!

25 THRU 250 AMP SILICON RECTIFIERS

Type Number	Peak Inverse Voltage, Volts	Maximum RMS Input Voltage, Volts	Rectified DC Output Current, Amperes
A 25 to 45 Amp Rated High Temperature (−65°C to +190°C) Types			
1N2128A	50	35	25 to 45 Amperes (output varies with size of heat sink & type of cooling used)
1N2129A	100	70	
1N2130A	150	105	
1N2131A	200	140	
1N2132A	250	175	
1N2133A	300	210	
1N2134A	350	245	
1N2135A	400	280	
1N2136A	450	310	
1N2137A	500	350	
B 25 to 35 Amp Rated Commercial "Quad-Sealed" (−20°C to +130°C) Types			
1N2128	50	35	25 to 35 Amperes (output varies with size of heat sink & type of cooling used)
1N2129	100	70	
1N2130	150	105	
1N2131	200	140	
1N2132	250	175	
1N2133	300	210	
1N2134	350	245	
1N2135	400	280	
1N2136	450	310	
1N2137	500	350	

Type Number	Peak Inverse Voltage, Volts	Maximum RMS Input Voltage, Volts	Rectified DC Output Current, Amperes
C 45 to 150 Amp Rated Industrial Types (−60°C to +190°C)			
45L5	50	35	45 to 150 Amperes (output varies with size of heat sink & type of cooling used)
45L10	100	70	
45L15	150	105	
45L20	200	140	
45L25	250	175	
45L30	300	210	
45L35	350	245	
45L40	400	280	
45L45	450	310	
45L50	500	350	
45L60	600	420	
D 70 to 250 Amp Rated Industrial Types (−60°C to +190°C)			
1N2054	50	35	70 to 250 Amperes (output varies with size of heat sink & type of cooling used)
1N2055	100	70	
1N2056	150	105	
1N2057	200	140	
1N2058	250	175	
1N2059	300	210	
1N2060	350	245	
1N2061	400	280	
1N2062	450	310	
1N2063	500	350	