ELECTRONIC DESIGN

JULY 23, 1958

DIODES 1958

HIGHLIGHTS OF ISSUE

ELECTRONIC DESIGN

DATA REQUEST PROCESS CARD
Use Before Sept. 3rd, 1958

Name _____ Title _____

Company _____

Company Address _____ City _____ Zone _____ State _____

For Change of Address:
Old Company Name _____ Old Company Address _____

	10	20	30	40	100	110	120	130	140	200	210	220	230	240	300	310	320	330	340	400	410	420	430	440	500	510	520	530	540
1	11	21	31	41	101	111	121	131	141	201	211	221	231	241	301	311	321	331	341	401	411	421	431	441	501	511	521	531	541
2	12	22	32	42	102	112	122	132	142	202	212	222	232	242	302	312	322	332	342	402	412	422	432	442	502	512	522	532	542
3	13	23	33	43	103	113	123	133	143	203	213	223	233	243	303	313	323	333	343	403	413	423	433	443	503	513	523	533	543
4	14	24	34	44	104	114	124	134	144	204	214	224	234	244	304	314	324	334	344	404	414	424	434	444	504	514	524	534	544
5	15	25	35	45	105	115	125	135	145	205	215	225	235	245	305	315	325	335	345	405	415	425	435	445	505	515	525	535	545
6	16	26	36	46	106	116	126	136	146	206	216	226	236	246	306	316	326	336	346	406	416	426	436	446	506	516	526	536	546
7	17	27	37	47	107	117	127	137	147	207	217	227	237	247	307	317	327	337	347	407	417	427	437	447	507	517	527	537	547
8	18	28	38	48	108	118	128	138	148	208	218	228	238	248	308	318	328	338	348	408	418	428	438	448	508	518	528	538	548
9	19	29	39	49	109	119	129	139	149	209	219	229	239	249	309	319	329	339	349	409	419	429	439	449	509	519	529	539	549
50	60	70	80	90	150	160	170	180	190	250	260	270	280	290	350	360	370	380	390	450	460	470	480	490	550	560	570	580	590
51	61	71	81	91	151	161	171	181	191	251	261	271	281	291	351	361	371	381	391	451	461	471	481	491	551	561	571	581	591
52	62	72	82	92	152	162	172	182	192	252	262	272	282	292	352	362	372	382	392	452	462	472	482	492	552	562	572	582	592
53	63	73	83	93	153	163	173	183	193	253	263	273	283	293	353	363	373	383	393	453	463	473	483	493	553	563	573	583	593
54	64	74	84	94	154	164	174	184	194	254	264	274	284	294	354	364	374	384	394	454	464	474	484	494	554	564	574	584	594
55	65	75	85	95	155	165	175	185	195	255	265	275	285	295	355	365	375	385	395	455	465	475	485	495	555	565	575	585	595
56	66	76	86	96	156	166	176	186	196	256	266	276	286	296	356	366	376	386	396	456	466	476	486	496	556	566	576	586	596
57	67	77	87	97	157	167	177	187	197	257	267	277	287	297	357	367	377	387	397	457	467	477	487	497	557	567	577	587	597
58	68	78	88	98	158	168	178	188	198	258	268	278	288	298	358	368	378	388	398	458	468	478	488	498	558	568	578	588	598
59	69	79	89	99	159	169	179	189	199	259	269	279	289	299	359	369	379	389	399	459	469	479	489	499	559	569	579	589	599

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The sound design, sturdy construction and reliable operation long associated with G-V Hermetically Sealed Thermal Relays is available in a low-cost form, fully qualified for industrial control . . . light and inexpensive enough for electronic and communications circuits.

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  A dust tight metal shell completely enclosing the relay mechanism and contacts, crimped tightly to the base, provides complete protection for the structure.
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  Time delay intervals are preset at the factory. Thus changes of delay interval in the field which might damage associated equipment are avoided.
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  Directly interchangeable with all other octal-size relays.

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ENGINEERING REVIEW

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Low-Noise Microwave Amplifier Uses Semiconductor Diodes

Using a semiconductor diode as the active element, a variable reactance amplifier now under development, may prove to be an exceptional low-noise uhf and microwave device. Although still in the experimental stage at Bell Telephone Labs, preliminary results indicate that the device can improve the performance of many types of microwave receivers. It is relatively simple to construct and operate, and shows prospects of having a long life.

Variable reactance is provided by the diode whose capacitance varies with the applied voltage. As with other varactor amplifiers, the applied voltage is derived from an hf pump signal. This signal causes the diode to function as a time-varying capacitance and supplies the energy which is necessary to produce amplification.

At 6000 mc a bandwidth of 8 mc with a noise figure of 5 to 6 db has been obtained. Gain was 18 db and the pump signal 12,000 mc. Gain can be traded for additional bandwidth if desired, and vice versa.

A traveling-wave amplifier configuration using arrays of several diodes shows promise of providing bandwidths of 25 per cent or more in the uhf region. Using four stages with the special diodes in such an array, Bell Labs demonstrated a band-

(Continued on page 6)

Equipment for studying amplifying properties of a nonlinear capacitor semiconductor diode. The right hand is holding the special diode and enclosure, and is about to insert it in the proper location in the waveguide structure. A pump frequency of 12,000 mc enters from the left. The signal, in this case 6,000 mc, comes in from the right, is amplified and reflected back inside the same waveguide. The incoming and outgoing signals may be separated by a ferrite microwave circulator.

Type of traveling wave amplifier employing a four-stage array with varactor diodes is being tested. This configuration shows promise of providing bandwidths of 25 per cent more than present devices in the vhf region.

ENGINEERING REVIEW

width of 100 mc at a 400 mc signal frequency, with a pump frequency of 900 mc and a pump power of 10 mw. This experimental amplifier has a gain of 10 db and a noise figure of only 3-1/2 db.

A single type of diode can be used to make an amplifier for any desired frequency from the high microwave region down to dc. The noise performance improves rapidly as the frequency decreases from microwaves down into the uhf region, making such an amplifier potentially useful for uhf television receivers.

It appears that these components can be assembled to provide a relatively inexpensive device. No refrigeration is required, and no magnetic fields are necessary. The low-noise characteristics are realizable at room temperatures.

Although the variable capacity effect is present in commercial diodes, Bell Laboratories' scientists have developed, under a Signal Corps contract, special diffused silicon diodes to maximize this effect. Series resistance, which could be a source of noise, is minimized in these diodes. Units fabricated at the Laboratories have an active diameter of about 0.002 in.

Inequities in Spectrum Conservation Cited

Severe inequities exist in the matter of national radio spectrum conservation, a General Electric Communications executive declared, and if land mobile radio services are to "suffer the costs, trials, and tribulations of further sharing and squeezing," they are justified in requesting a "fair share of the spectrum."

These remarks were made by Richard P. Gifford of Syracuse, N.Y., Manager of Engineering for the GE Communication Products Dept., at the annual meeting of the American Gas Association.

Gifford said the land mobile radio services have taken the lead nationally in spectrum conservation.

Computer Users Exchange Programs

The nation's utilities, electric equipment, and computer manufacturers have set up a system for exchanging digital computer programs. Ninety-two programs for electric utility engineering problems have been made available by their owners to other companies under specified conditions. Now on the list are 38 programs concerned with the design and operation of networks, feeders and transmission lines; 13 on the economics of generating, dispatching and loading; and smaller numbers concerned with mathematics, transient stability, load forecasting, and other fields. This work was sparked by committees of the AIEE.

EASY PICKUP of radiation from airborne navigational or bombing radar is possible with an improved version of a Ground Observer Corps radio receiving set. The unit, which was designed to fit atop the standard GOC helmet, will pass the pulses received through its eight transistor amplifier and feed the audible signals to the observer through an ordinary ear-plug. Only distinct pulses will be picked up by the antenna when it is aimed at the source of the radiations. All the observer has to do is turn his head from side to side until he (or she) gets a good, strong sound. Weighing 12 oz it is effective over a range of more than 100 miles. Power for the unit is provided by a special mercury-cell battery in a light-weight case measuring 2 x 4 x 1 in. The battery will give approximately 160 hours of operation before replacement is necessary. The antenna was built by Farnsworth Electronics Co., Fort Wayne, Ind.

ENGINEERING REVIEW

Data-Handler Measures 10,000 Samples Per Second

As many as 4,800,000 separate items of inf mation can be processed in eight minutes usi 10-1/2 in. reels of standard magnetic tape, wi a recently introduced recording and transcribi system. The Digital Data Recorder-Transcrib developed by Minneapolis-Honeywell Regulat Co., Philadelphia, Pa., employs multiplexing a analog-to-digital conversion and consists of 1 multiplex channels. Each data sample, which the input information received by the record from multiple transducers, is converted to a 1 bit binary so that the resolution of the system one part in 1024. Over-all accuracy is within 0 per cent.

The 10-bit binary number, together with 7-bit binary representing the channel numbe and a zero or spare bit are recorded on the fi or intermediate tape in three lines of 6 bits ea across the intermediate tape.

A total of eight tracks on half-inch tape a used. One carries a clock pulse, another a "wor pulse, and the remainder the data and chann number pulses. Each sample is represented b three characters on the tape. Thus, for a bas rate of 10,000 samples per second, it is necessar to record 30,000 characters. This is accomplishe by using a tape speed of 60 in. per second an a pulse packing of 500 per in. along the tape.

Original data to be processed by computer selected by an editing device called a "data s lector." Two time settings, one for the beginni of the desired data, another for the end, are ma by means of decimal switches. Another contr provides for setting by the computer programm of the number of words—anywhere from 50

Two-unit Digital Data Recorder-Transcriber can make 10,000 measurements of temperature, pressure, strain and other variables in one second.

10,000—to be included in one block of the computer tape.

An auxiliary unit, called the "channel monitor," serves to visually read out in decimal form any manually selected channel at the rate of one per second. This facilitates initial calibrations and subsequent monitoring procedures and is part of the basic DDRT system.

U.S., British Standards Not Quite Cricket

Effort is currently being made to settle a difference of one part in slightly over a billion in British and American measurement standards.

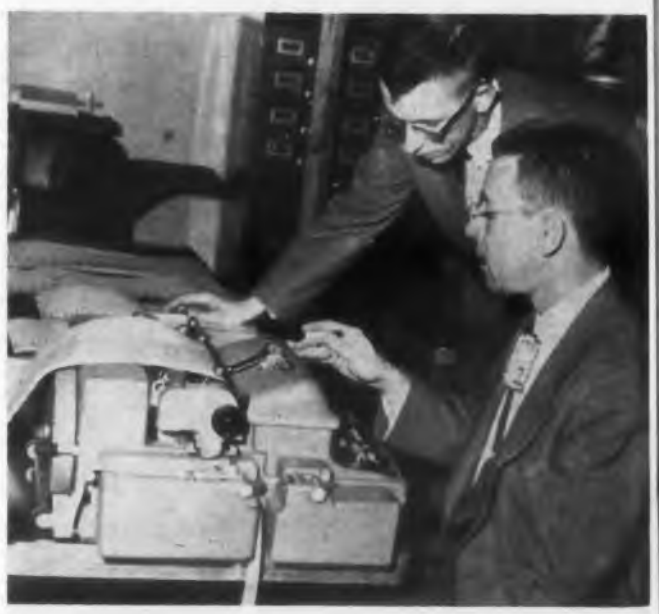
The discrepancy exists in the radio comparison between "atomic clocks" in each country which are based on the unvarying vibrations of the cesium atom and generally accepted as the most accurate standard available. In an attempt to close this gap, the U. S. Army Signal Engineering Labs. at Fort Monmouth, N.J. have shipped two cesium beam standards to Britain for comparison.

Known as the Atomichron, the atomic clock has a possible accuracy of one part in 10 billion and is used to measure frequencies and time intervals. It was discovered last summer that the frequency of radio signals controlled by the cesium standard at the National Physical Laboratory at Teddington, England, varied by nine parts in 10 billion from the frequency of similar equipment in the United States, or approximately 10 times the theoretical accuracy variation. The atomichron has an accuracy of one sec per 300 years.

Scientists of U. S. Army Signal Laboratories inspect recording from cesium beam standard which disagrees with its counterpart in England.

Doing a Slow Turn

One of the drive requirements on a new 84-ft diam radio telescope for missile and star tracking is that it turns at the rate of one revolution per day. This reduction drive, which has a maximum ratio of 1,440,000 to 1, will handle the specification. Final reduction in the drive is provided by a huge 50-in. center distance double-enveloping worm gearset. In use, the worm tracks around the gear, which is held stationary, to drive the paraboloid antenna as it searches the sky. The gearset is shown being checked for tooth contact in a hobbing machine at Cone-Drive Gears, Div. Michigan Tool Co., Detroit, Mich. where it was designed. Gear teeth had to be cut on the O.D. of a steel race for a large ball bearing, which supports the antenna.



Middlebrain

This new small computer, a Royal Precision LGP-30, product of Royal McBee Corp., Port Chester, N.Y. is filling the in-between job of working out experimental and small problems too complicated for manual solution but not pressing enough to squeeze into the crowded schedule of the big computers. The machine is in use at the Flight Simulation Laboratory at White Sands.

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Electron Tube News
—from SYLVANIA

Pioneering new concepts—Everywhere in electronics

IN BASIC TUBE DESIGN...

Double triode, type 7244, and single triode, type 7245

Stacked mount in glass bulb offers practical answers to industry's current needs

Sylvania's stacked mount structure is now available to design engineers because of a new glass envelope design that facilitates mass production of the tubes. Complete electrical, mechanical and environmental tests show that the new tube is capable of meeting the highest requirements of today's operational equipment. Its unique stacked construction offers an inherent ruggedness and reliability for superior vacuum tube performance. Actual test data comparing the stacked structure with conventional structures indicates as much as a 2 to 1 improvement in vibrational output at 6 times the G level.

The new stacked tube has already excited tremendous military interest. Eventually an entire line will be available for military and industrial applications.

Less change in electrical characteristics due to element temperatures at high dissipation levels • Better control of cutoff • Lower knee voltage—more uniform control of knee • Less chance for shorts, microphonism and noise • Better plate-to-screen current ratio • Higher screen grid dissipation • Less arcing.

Send for your free copy of Sylvania's new Framelok Grid Booklet, including a grid sample, for full information on the electrical and mechanical characteristics of the Framelok design

▲ Cutaway view of the Framelok design

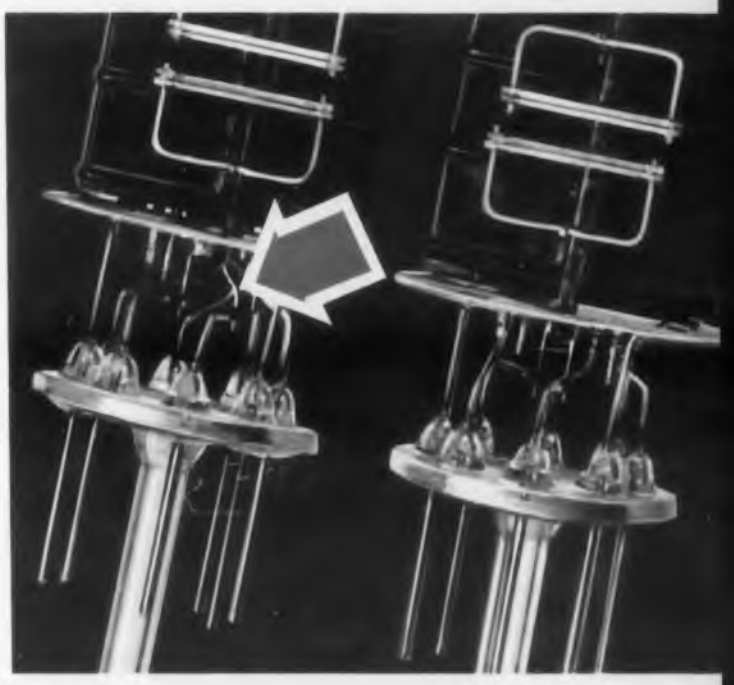
Widespread interest in Sylvania's exclusive Framelok design fosters new type development

Accelerated development of new Framelok tube types is underway at Sylvania as a result of fast-growing acceptance of the revolutionary design shown for the first time at the 1958 IRE Convention.

Design engineers are already analyzing new circuit requirements in terms of the Framelok design. New application possibilities ranging from television to audio are developing rapidly.

Behind this widespread acceptance are these basic reasons why designers prefer the Framelok design over conventional types:

• Greater uniformity of electrical characteristics in tube after tube • Greater stability of electrical characteristics during tube life •



Entertainment receiving tubes are subjected to military-type inspection procedures

These two mounts may look alike to the untrained eye . . . but trained inspection personnel can spot defects in one (left) that could cause future trouble. All Sylvania entertainment tube types must pass this visual mount inspection procedure based on that used for military types. As a result equipment manufacturers enjoy fewer line rejects, lower manufacturing costs.

SYLVANIA SETS THE Gold Brand Standard

Gold Brand Subminiatures undergo 1,000-hour life tests

Life tests on subminiatures are increased to insure maximum reliability

Sylvania increases the life assurance on its premium subminiature tube line by increasing its life test program from 500 to 1,000 hours. The increase establishes additional positive proof of the high reliability and excellent performance of the subminiature tube line.

Gold Brand types meet missile requirements

Gold Brand Premium Guided Missile types withstand severe durability tests

Every tube type in Sylvania's Gold Brand Guided Missile line meets environmental testing more severe than that required in many advanced military specs. Each type is subjected to severe vibrational fatigue tests at sweep frequencies from 30 cps to 3000 cps at 10 G's for 6 hours in several standard positions.

All Gold Brand Sylvania subminiature tubes undergo the White Noise Test. The tubes are subjected to a white noise vibrational spectrum covering the frequency band of 100 to 5000 cps., the rms G-level is 2-3 G's per octave with peak G-level of 15 G's. The tubes are tested for both rms and peak vibrational output and limits are established on each.

Type	Description
6946	Medium-Mu Triode
6947	Medium-Mu Double Triode
6948	High-Mu Double Triode
6788	Sharp cutoff audio-frequency pentode
6943	Sharp cutoff RF Pentode
6944	Semi-Remote cutoff RF Pentode
6945	Audio-Frequency Beam Pentode

Gold Brand types meet rigid new specifications

Sylvania writes new Gold Brand Specs for commercial and industrial applications

To meet your needs for reliable tubes in commercial and industrial equipment, Sylvania has written new specifications which tailor military standards to commercial, and industrial requirements. Some of the typical controls specified for Gold Brand tubes include Multiple Life Tests ranging from 500 to 1,000 hours, Impact Shock Tests of up to 500 G, Fatigue Tests, Vibration Tests, Glass Strain Tests and Variable Control Tests.

The following are the 12 Gold Brand types on which full specifications are available:

Type	Description
407A	Medium-mu double triode (9-pin miniature)
408A	Sharp-cutoff pentode (7-pin miniature)
6AU6WA	Sharp-cutoff pentode (7-pin miniature)
6X4WA	Double diode (7-pin miniature)
5654	Sharp-cutoff pentode (7-pin miniature)
5670	Medium-mu double triode (9-pin miniature)

Type	Description
5725	Dual-control pentode (7-pin miniature)
5726	Double diode (7-pin miniature)
5749	Semi-remote cutoff pentode (7-pin miniature)
5751	High-mu double triode (9-pin miniature)
5814A	Medium-mu double triode (9-pin miniature)
6005	Beam Pentode (7-pin miniature)

Gold Brand subminiature Type 6814 meets rugged requirements of airborne computers

Type 6814 for missile computers

Prime example of a Gold Brand subminiature ideally suited for airborne computer use is type 6814. Fully proven in current operational equipments the tube features controlled sharp cutoff and zero bias plate current for good switching action. It exhibits exceptional freedom from development of cathode interface throughout life.

The 100% Production DC shorts test as well as a standard AC shorts test on type 6814 minimizes the possibility of flicker shorts—assuring greater reliability in this tube's many applications, particularly in switching and triggering circuits. In addition, it withstands a minimum 1000-hour life test.

You can get the complete engineering story on Sylvania's Gold Brand Lines in the new 33-page Gold Brand booklet.

IN NEW TUBE TYPES . . .

Five new types are added to the receiving tube line

Type 12DV8—Designed for 12-volt auto radios, this 9-pin miniature double-diode, space charge grid tetrode can be used as a combined detector, AVC rectifier and transistor driver. The tetrode section has the advantage of low R_p for better transistor matching.

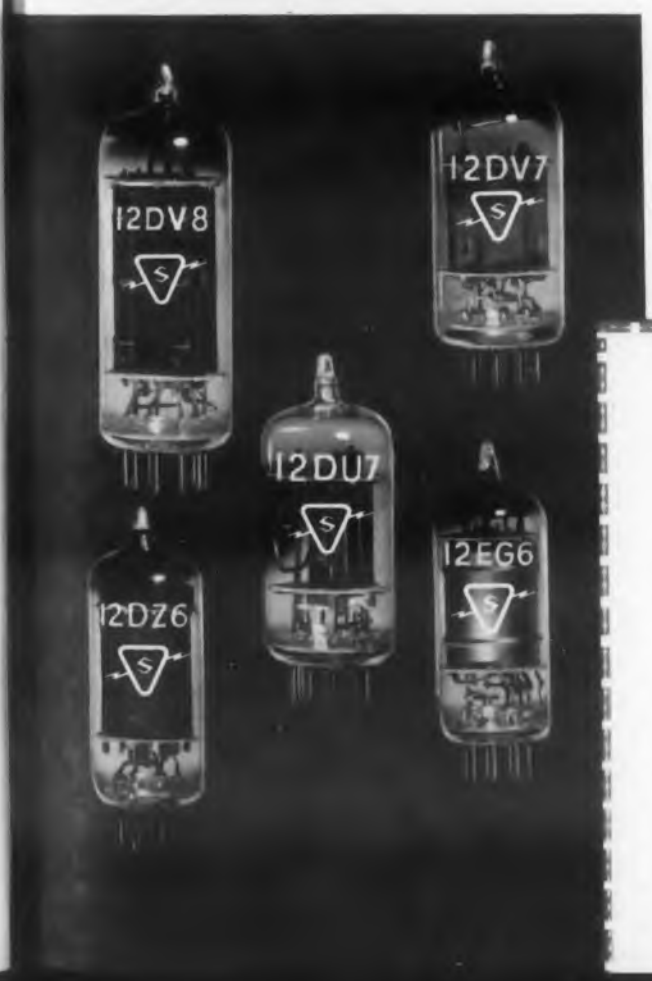
Type 12EG6—This tube is designed primarily for use in 12-volt auto radios as an RF amplifier. It is a 7-pin miniature dual control Heptode with a unipotential cathode. AVC voltage can be applied to two control grids reducing back biasing of the AVC line with large RF signals.

Type 12DZ6—This miniature pentode has a remote cutoff to give a Gm of 50 umhos at a bias of 10 to 12 volts for improved AGC characteristics in hybrid radio receivers. The plate resistance of 15,000 ohms, coupled with a Gm of 3600 umhos, insures high performance in weak signal areas.

Type 12DU7—This 9-pin miniature double diode-tetrode can be used as a transistor driver in addition to functioning as a detector and AVC rectifier in hybrid auto receivers. In this multipurpose, low-cost tube, power output distortion is controlled to a maximum of 5%.

Type 12DV7—A double diode-triode for use in 12-volt hybrid auto radios. With a 12-volt plate supply the triode features a plate current of 750 ua, a mu of 15 and a Gm of 1000 umhos. The diodes feature a separate cathode connection for maximum flexibility in detector and AVC circuits.

New receiving tube types



New five-inch experimental evaporated phosphor CRT

IN NEW TRANSPARENT PHOSPHOR TUBES . . .

Experimental five-inch evaporated phosphor CRTs offered for applications research and development

Steady progress is being made in the development of evaporated (transparent) phosphor cathode-ray tubes at Sylvania. Now 5-inch and other small tubes are being produced and are available for experimental purposes.

High industry interest in evaporated (transparent) phosphor tubes is centered around the major benefits the tubes offer over conventional CRT s. Among the more important characteristics are:

- **Higher resolution**—Transparent screens are capable of higher resolution than conventional settled screens because the phosphor crystals are smaller by many orders of magnitude. Video displays with sharper definition are possible.
- **Improved contrast** in high ambient light conditions—Transparent phosphors permit outside light to pass through the "screen" cutting reflection to a minimum. This characteristic is highly important where scopes must operate in high ambient light.
- **Minimum Screen Noise**—Because evaporated phosphor crystals are much smaller than those in conventional coatings, screen noise, the interplay of light reflections on the crystal faces, is reduced. The result is sharpest possible definition.
- **More Uniform Light Output**—The phosphor coating on evaporated screen CRTs is some 10 times as thin as standard coatings. This smooth screen coating contributes to far greater uniformity in light output.
- **Less Screen Burn**—Transparent phosphor tubes offer better resistance to screen burning because the crystals are closer to the glass faceplate. This allows better heat dissipation and cooler operation.

Since all of these advantages are not available in a single evaporated phosphor tube design, it is necessary to specify which characteristics are most important for the intended application. Send full information on your particular application when you request experimental samples. Write to Sylvania direct or call your Sylvania representative.

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1100 Main St.
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In Industrial Television . . .

Special CRT is specifically designed for industrial TV monitor use

Now, higher fidelity in industrial television is possible with new cathode-ray tube, type 8FP4. It gives added definition and resolution to industrial television performance.

Type 8FP4 is an 8″ rectangular all-glass, magnetic focusing tube with an ion trap and 90° magnetic deflection.

New test picture tube speeds receiver production line testing

A new 8″ 110° test picture tube, type 8YP4, is specifically designed for television receiver and picture tube testing. Its small size, light weight and convenient shape make it the ideal production line test tube.

The 8YP4 is equipped with a conventional base and a convenient adaptor for conversion to a rigid pin base. It has built-in automatic electrostatic self-focusing making external focus connections or adjustments unnecessary. It employs a 6.3 volt, 600 ma heater that will also operate in 450 ma series heater strings.

New ITV monitor

In Industrial and Military C-R Tubes

New CRT type 5ADP2

New high-precision scope tubes, types 5ADP, 5ABP, and 5AQP, were developed for photography, radar and specialized uses

Sylvania again expands its line of special-purpose industrial and military cathode-ray tubes with a series of high-precision types designed for specialized uses. These tubes incorporate a high-precision electron gun made to ultra-fine tolerances. Sharp clean scope presentations result for high-precision photography.

The new tubes, types 5ADP, 5ABP, and 5AQP, are available in screen phosphors ranging from P1 to P11.

In Television Picture Tubes . . .

Sylvania combines the advantages of 110° deflection and 450 ma heater in three new picture tubes

Sylvania, trend setter in electron-tube design, has developed new 110° picture tubes incorporating the 450 ma 6.3 volt heater. The new tubes, types 17CTP4, 21DHP4 and 24AQP4, combine the space savings of 110° tubes with the power and cost advantages of 450 ma heaters. The low power heater not only reduces heat with total set power savings of approximately 18 watts but permits use of a lower wattage, less expensive series resistor. The end result is a line of picture tubes that meet the needs of new portable and console TV receiver designs.

Type 24AQP4 with 450 ma heater

SYLVANIA

SYLVANIA ELECTRIC PRODUCTS INC.
1740 Broadway, New York 19, N. Y.
In Canada: Sylvania Electric (Canada) Ltd.
University Tower Bldg., Montreal

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▶ ☐ 7245	☐ 5AQP	☐ Sylvania Gold Brand Booklet
▶ ☐ 12DV8	☐ 5ADP	☐ Additional explanation, and application requirement form for Sylvania transparent phosphor CRT s
▶ ☐ 12EG6	☐ 8FP4	
▶ ☐ 12DZ6	☐ 8YP4	
☐ 12DU7	☐ 17CTP4	
☐ 12DV7	☐ 21DHP4	
	☐ 24AQP4	

Name_____

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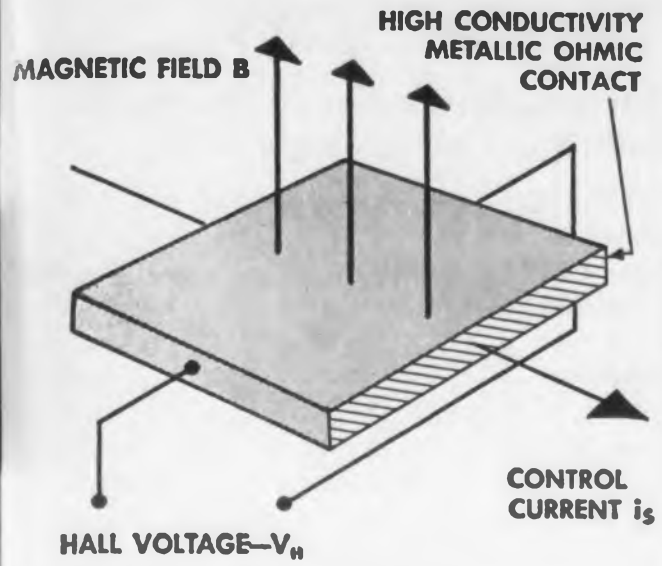
Use this handy business reply card to request additional information on these important new Sylvania developments



Hallmark in Generators

A generator operating on the Hall effect has been built for practical application. The Hall generator is essentially a solid state multiplying device that provides a voltage output proportional to the product of two electrical quantities: (a) the current passing through it; and, (b) magnetic field perpendicular to it. Output voltages of 1/2 v are easily obtained in the device using magnetic fields of 5 kilogauss and control currents of 1/2 a. In addition, the output impedance can be adjusted from 0.01 to 20 ohm and their maximum frequency response ranges from 10^7 to 10^8 cps. Two semiconductor materials, indium antimonide and indium arsenide, are used in the generator built by Westinghouse Electric Corp., Pittsburgh, Pa.

CIRCUITS WANTED

The Bureau of Ships recently awarded a contract to Transistor Applications, Inc. to prepare a "Selected Semiconductor Circuits Handbook."

The Boston firm will invite companies, government organizations and individuals to submit reliable transistor and diode circuits and their descriptions for possible inclusion in the handbook. Among the many circuits to be covered will be amplifiers, oscillators, mixers and converters, switches, and power supplies.

All circuits will be reviewed by a committee of technical authorities, and all contributors will receive full credit.

The handbook, it is hoped, will encourage better engineering practice by transistor circuit engineers, in designing circuits for military electronic equipment.

We, at ELECTRONIC DESIGN, hope this project will lead to some standardization in semiconductor circuitry. Our readers can help by sending their contributions to the Research Director at Transistor Applications, Inc., 50 Broad St., Boston, Mass.

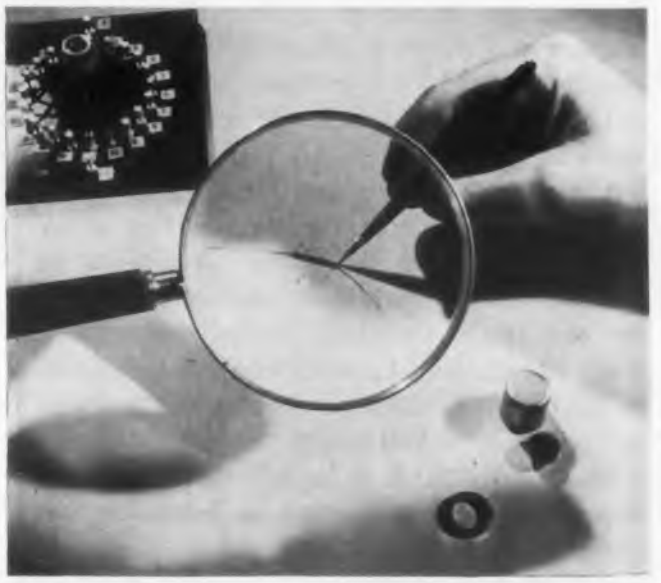
ENGINEERING REVIEW

Ultraminiature Device Integrates Entire Circuit in Single Unit

Development of an experimental shift register transistor 1/2 in. long and 0.004 in. thick may herald another significant breakthrough in ultraminiaturization of integrated electronic devices. This unit is expected to perform application functions of circuits which presently require twenty transistors, forty resistors, and twenty capacitors. Laboratory operation of the shift register transistor indicates the feasibility of integrating both active and passive elements. Ten transistor-like elements on a single strip of germanium function as separate two-way switches connected in series. Each of these elements can receive and hold a single bit of information in the form of a strong or weak current, corresponding to 0 or 1. Storage of ten-digit numbers is possible.

The bits of information are fed into the device one by one at high speed at one end, and are shifted from one element to the next, in order, by shift pulses. When these pulses are stopped, each bit of information will remain in one of the transistor-like elements. When the pulses are restarted, each bit shifts from one element to the next until the pulses are again stopped. When the bits reach the final element, they are read out in the same order in which they were fed in at the start. In this way, the information is kept intact, yet its passage is delayed as long as needed.

Development of the shift register transistor is being carried on at RCA Laboratories, Princeton, N.J.



Shift register transistor is expected, with further development, to perform functions that now require a circuit arrangement of twenty transistors, forty resistors, and twenty capacitors. Object at upper left is a testing unit for the device. At lower right are elements of capsule in which an experimental unit is enclosed for testing.

French Field Effect Device Claims 500-1000 mc Operation

French invention of a field effect type semi-conductor, reported to operate between 500 and 1000 mc at several watts, is not expected to overshadow the transistor.

Known as a "technetron," it consists of a type N germanium rod with an electrode at each end. An indium ring placed in a groove of the rod serves as the control electrode. Gain is claimed to be about 200 at 500 mc.

Significance of this development is mitigated, however, by rapid advances in US transistor art. The diffused-base transistor produced by Western Electric is noteworthy. In addition, present performance ratings being demanded for transistorized military equipment are equal to or better than the characteristics of the technetron.

GE, Bell Labs, RCA and others, moreover, have done work on field effect devices for several years and patents have been issued.

Technetron was the invention of Stanislas Teszner, working at France's National Center of Telecommunications Research.

TV Interference Reported By The FCC

The Chief Engineer's office of the Federal Communications Commission has recently completed a report, "Polarization Discrimination in Television Broadcasting." In considers the possibility of reducing TV co-channel and adjacent channel interference by having alternately spaced stations transmit with vertical and horizontal polarizations. The report, T.R.R. 4.3.10, contains a summary of available data and information relating to cross-polarization effects in TV broadcasting. Also included is an indication of the results which may be expected.

Copies of the report may be obtained from the FCC, Technical Research Division, Room 7506, New Post Office Building, Washington 25, D.C.

CIRCLE 11 ON READER-SERVICE CARD ➤

WASHINGTON REPORT

Herbert H. Rosen

EIA Concerned Over Industry's Future

The Electronic Industries Association expressed grave concern for the future of the industry during its recent national convention. The cause of this concern is the industry's heavy dependence on Government R & D contracts and the absence of consumer research in the long-range plans of many electronic manufacturers. According to EIA analysts, few companies have made plans for the day when the Defense Department will not be so richly endowed. They raise such questions as: What will the industry do then to inspire demand for more electronic merchandise? Where will the designs come from? How can we change engineers from thinking about the environment of the missile to the decor of the average living room or kitchen?

Judging from recent figures, however, the electronics industry is in the strongest position it has ever been. In spite of a mild recession in the last part of 1957, the fiscal year ending March 1958 saw a total revenue of $7.5 billion—up $1.8 billion from the previous period. If distribution, servicing, installation, and broadcasting revenues are added, the electronics industry amounts to a whopping $12.5 billion.

By the major categories EIA uses to classify the industry, the revenues were obtained from the following sources: amusement devices (radio, TV, phono), $1.5 billion; industrial and communications products, $1.15 billion; military equipment, $3.9 billion; and replacement parts, $0.95 billion.

The EIA cited foreign competition as another problem confronting the industry. While present U.S. imports from French, German, English, and Japanese electronics manufacturers are not very large, there is evidence that they will make some serious inroads into our commercial markets within a short time.

Most of this competition has come in the form of radios and components. Many engineers feel that these parts—and some instruments—are on a par with their U.S. counterparts. But even with import duties and "Buy American Act" restrictions, their prices are usually much lower than domestic products. Moreover, the overseas com-

panies are beginning to move into the large contracts field and are bidding against U.S. firms, especially on NATO business.

One area EIA has not publicly commented upon is the imports from the Russian satellite countries. Yet, recent reports have disclosed that several Hungarian electronics companies have successfully shipped a wide range of instruments to the U.S. through Austria. Although the Federal government has imposed restrictions on trading with satellite nations, the regulations are ambiguous with respect to transshipments from the so-called neutral nations of which Austria is one.

Observers assume that the Hungarians are feeling out the market. They have found out that the Austrians are quite pleased with their instruments, although they do get damaged in transit. Further, the Hungarians have no network of service people to maintain their equipment. These difficulties can be surmounted if the Hungarians find reasonable acceptance of their products in the work markets.

CAA Forms Another Airways Plan

June marked the 20th anniversary of the Civil Aeronautics Administration. April and May marked another period of disastrous air tragedies that heaped much criticism on the way the CAA controls the air space along which airliners and military aircraft must fly.

The Federal Airways Plan the CAA developed earlier has since been compressed and revised twice. The latest revision calls for the expenditure of more than $1 billion over the next five years. This money will buy new electronic communication, air traffic control, and air navigation equipment. It will equip more control centers with automatic processing machines. It will ready the personnel for better display devices. Also, the long-sought-after enroute and inroute equipment that will give virtually positive control over aircraft flying along the 95,000 miles of airways the CAA expects to be monitoring by 1963.

With the help of the Air Modernization Board, a greatly expanded research program should reap new benefits, ease the job of control, and greatly increase the safety of flying. The $175 million to be spent on equipment in FY '59 will buy large numbers of long-range and short-range radars, surface detection equipment, beacons, VOR's, VORTAC's, ILS's and some automatic data processors.

While the electronics industry can accommodate these orders now, should the program be accelerated much more, there will be a growing competition between military and civilian (CAA) orders.

MEETINGS

Aug. 6-8: Special Technical Conference on Non-Linear Magnetics and Magnetic Amplifiers

Hotel Statler, Los Angeles, Calif. Sponsored by AIEE. The four technical sessions will include: technological and theoretical aspects of non-linear magnetics and magnetic amplifiers; computer applications; special purpose devices and applications; and "new frontiers" in the field. Exhibits will be displayed by 40 manufacturers selected for their contributions to the industry. For more information about the conference, write AIEE, 33 West 39th St., New York 18, N.Y.

Aug. 13-15: 7th Annual Conference on Industrial Applications of X-Ray Analysis

Albany Hotel, Denver, Colo. Sponsored by University of Denver, Denver Research Institute, Metallurgy Div. For additional information write William M. Mueller, Metallurgy Div., Denver Research Institute, University of Denver, Denver 10, Colo.

Courses-Seminars

Aug. 4-15: Special Summer Program on Microwave Ferrites. Massachusetts Institute of Technology, Cambridge 39, Mass. Topics will include Electromagnetic Theory of Fields in the Presence of Ferrites, Measurements of Ferrite Characteristics, and Linear and Non-linear Ferrite Devices: Theory and Application. Write to *Dr. Herman A. Haus, Assistant Professor, M.I.T. Department of Electrical Engineering* for information.

Aug. 11-22: 3rd Annual Statistical Methods in Industry Course. University of California, Los Angeles, Calif. Sponsored by the UCLA College of Engineering, University Extension, and the American Society for Quality Control. In addition to the above course, there will be a 3-week course in Industrial Reliability, **Aug. 4-22.** Address requests for information on the courses to *Edward P. Coleman, Professor, College of Engineering, University of California, Los Angeles 24, Calif.*

Paper Deadlines

Aug. 1: Deadline for paper for the **7th Annual Meeting of the Standards Engineers Society.** Papers preferably should be related to the theme of the meeting, STANDARDIZATION, A MUST FOR THE SPACE AGE. This meeting will be held on Sept. 22-24 at the Benjamin Franklin Hotel, Philadelphia, Pa. Send papers of 1600-2400 words in length, typed and double-spaced in quadruplicate to *E. D. Clark, c/o Standard Pressed Steel Co., Jenkintown, Pa.*

EDITORIAL

If You're Going To Diodize, Do It Right

The transistor, ten years old last month, has certainly stolen the show from its older brother, the semiconductor diode. Its fame has spread well beyond the realm of the electronics designer. It has become a byword to the public—so much so, that the magic word "transistorized" is almost a sure salesman.

But who ever heard of an instrument being "diodized?" True, the diode has not shared in the dramatic growth of its illustrious three terminal brother, but it too has grown, these past ten years.

Diodes are available today that are head and shoulders above the diodes of a decade ago, so far as performance is concerned. They've made possible circuit applications, not possible with diodes of old.

Yet, diodes simply don't have the glamor of transistors—and probably never will. As a matter of fact, some authorities feel that diodes are on the way out—to be replaced, in most applications by transistors.

But they're here today—and there's lots to know about them. Diodes have more than their share of misapplication. The latest listing of Derivation and Tabulation Associates, Inc., (67 Lawrence Ave., West Orange, N.J.) shows an array of almost 2500 diode types confronting the circuit designer. How is he to know where to start—how to select the diode he needs? Should he ignore listings altogether and simply specify his requirements to a diode manufacturer? And what can he reasonably specify?

Diodes come in different packages, and with different junctions. Do these make any difference? By now, everybody knows that for high temperature applications, say above 85 C, germanium is ruled out, and silicon is called for. And most people know silicon units are perhaps two or three times more costly than germanium. But cost aside, where is germanium superior?

Life would be simple indeed if we had a perfect diode—a diode to pass extremely high forward currents, with infinitesimal reverse leakage; a diode which could switch either way in no time at all; a diode with practically no forward voltage drop and a very high peak inverse voltage rating; and a diode not bothered by temperature extremes and humidity.

Don't be fooled by the apparent simplicity of the diode. It's simple to use it improperly and inefficiently. In the diode report in this issue, ELECTRONIC DESIGN has assembled solid design information from leading diode authorities. It can help you get the most out of your diode dollar.

George D Rostky

350 RCA relay types

Each and every one of RCA's 350 Relay types is precision assembled, incorporate exclusive RCA features for extremely long-life and in-service reliability. RCA Relays cover the widest range of missile, airborne and industrial applications. They have been designed to meet and exceed the rigorous environmental limits imposed by MIL-R-5757A, B, C and MIL-R-25018 USAF specifications.

If your requirements run to relays—you'll want the comprehensive "RCA Sub-Miniature Relays" brochure illustrated above. Contains everything you need to know about RCA Relays—general information, specifications, type and rating, as well as header and enclosure diagrams. Write for your free copy now!

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CIRCLE 15 ON READER-SERVICE CARD

WITH ALMOST 2500 diode types available, the diode industry is still in its infancy. A dynamic one, it is true—but an infancy, nevertheless.

It seems ironic that it can be so tagged, when, in the span of just a few years, it has made such great strides. This industry has developed:

- Millimicrosecond switching diodes;
- Diodes to operate at hundreds of megacycles;
- Diodes with reverse resistances to tens of thousands of megohms;
- Diodes (rectifiers, if you like), to pass 100 amps and more;
- Diodes with peak inverse voltages of 1500 v and more;
- Diodes to act as voltage variable capacitors. These should have a profound impact on afc and variable frequency oscillator designs. Companies like Pacific Semiconductor (Varicap), and International Rectifier (Semicap) have led the way, but many other companies will follow.

Newer semiconductor devices are making their appearance regularly. General Electric recently announced its silicon controlled rectifier which can control 5 amps at 125 deg C with a gating current of about 10 ma. This device is really a semiconductor thyratron, a triode, as far as we can see, but GE likes to think of it as a diode. Other manufacturers will be making these soon.

This fall, Westinghouse will show samples of a 20 amp silicon "Dynistor," a hyperconductive negative resistance diode. This is a highly efficient solid state power switch, promising wide use in relay, controlled rectifier, and pulse generator applications.

Two Aspects of Immaturity

There are two signposts of the immaturity of this vital industry:

1. The status of diode manufacture.
2. The status of standardization.

They Don't Make Them. They Pick Them. Manufacturing diodes it not yet a science. It's more of an art. When a manufacturer sets out to make a particular computer diode, for example, he hopes that at the end of the line, perhaps 70 per cent of the diodes will fit the specifications. The rest of the diodes aren't junked. They become TV video detector diodes, or general purpose diodes. Or, if there's a customer handy, whose specs they meet, he gets them.

The diodes that fail a particular test aren't scrap. They just get a different number. And that's why we have so many types—with more coming. One man's junk is another man's spec.

What's true of diodes is even more true of transistors, though their numbers, happily, haven't even reached a thousand. At one plant, a production foreman told us each line yielded some 8 to 10 different transistor types.

DIODES 1958

Contents

Too Many Diodes?

George H. Rostky
Associate Editor
ELECTRONIC DESIGN

The customer doesn't pay for diode manufacturing alone. Only about 25 cents of his dollar goes here. His big cost is for testing. As his specs become tighter, his costs go up.

With so many diode types available, one might expect that any diode user could find the diode he needs in manufacturers' catalogs. But it's not so. Manufacturers tell us that half their production, or more, is to customer specs. The rest fill the catalogs of stock items. This is because so many customers have special requirements.

Many Standards Make None. Since testing is the heart of diode manufacture, surely we can expect a highly developed system of standard tests and measurements. All important diode types and their properties are surely defined and classified. Or are they?

Try to find agreement on how to measure reverse recovery time, or forward recovery. How is peak inverse voltage defined? Everybody knows the difference between a diode and a rectifier. But try to get a clear cut definition. We tried. Here are some responses from manufacturers:

- A rectifier passes more than 200 ma at 25 deg C;
- A rectifier passes more than 300 ma;
- It's a rectifier if it has the "top hat" construction;
- If it's used in circuits which carry information, it's a diode;
- A rectifier is a special case of a diode defined in terms of its function as a converter;
- A diode is for low current. A rectifier is for large current;
- Whole subject needs industry clarification;
- No difference.

Diode manufacturers can disagree on almost anything. When we asked how they felt about the most important errors manufacturers had made, answers like these came back:

- Not enough effort at cost reduction;
- Too much price cutting;
- Price structure chaotic;
- Mechanizing too early;
- Mechanizing too late;
- Not enough standardization;
- Improper test specifications;
- Lack of communications.

When we asked what they felt were the important errors of diode users, we were told:

- Lack of communications;
- Specifications not clearly enough related to requirements;
- Overspecifying;
- Expecting ideal diodes.

But when we asked how they felt about the pricing structure, here was uniformity at last. Only two types of answers:

- Prices are too high;
- Prices are too low.

Standards . . . Maybe Next Year

IRE, AIEE, EIA, and the military have committees at work trying to establish definitions and standards. These committees have made more progress in the past year than in any comparable earlier period. We can expect concrete results from these committees sometime next year.

Once a good set of standards has been established, many of the duplicating diode types may be eliminated. This can result in substantial savings from reduced stock problems, and better interchangeability.

Even today, the growing pains in the diode industry are beginning to subside. There is more cooperation among industry members in efforts to realize some sensible standards. But we've still a long way to go.

Most manufacturers feel there will be fewer types as a result of the increased standardization. But all agree there will be more types before there are fewer. Process improvements and new developments will cause the total number of types to expand before standardization helps reduce it.

Meanwhile, design engineers can serve their interests best by communicating with the diode manufacturer as much as possible. He can work more closely with him, even during circuit design. He should try to avoid extremely exacting specifications which jack up the price.

Where possible, he should try to stick to just a few diode types. Where diode selection is concerned, the manufacturer is still his best friend.

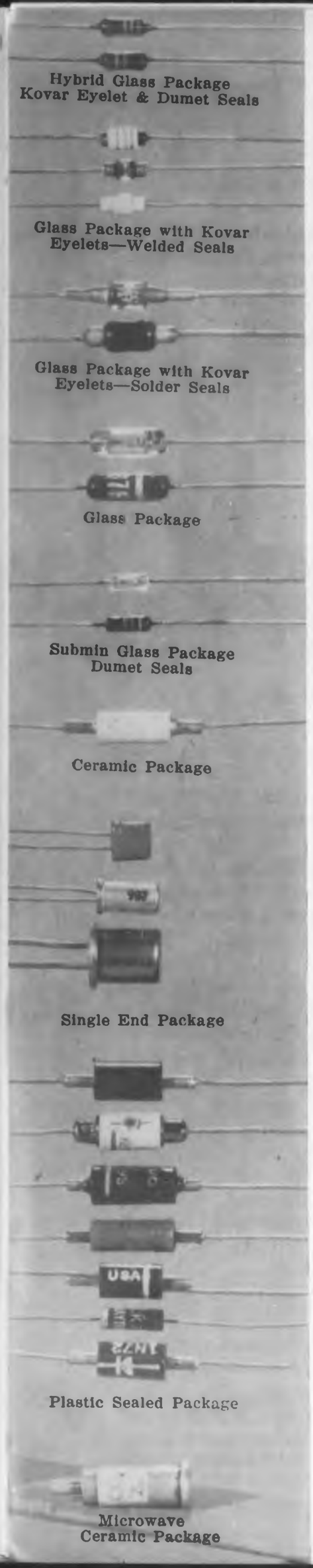
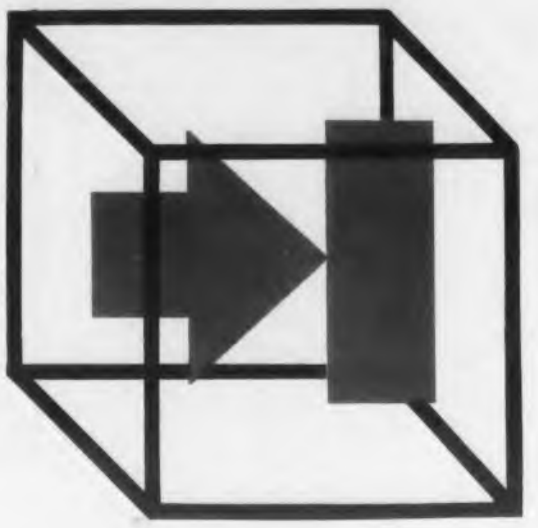


Fig. 1. Most popular signal diode packages.



Diode Packages and Junctions

J. S. Gillette and W. B. Mitchell
Raytheon Semiconductor Div.
Newton, Mass.

The man who designs diodes may not learn much here. But for the circuit designer, here, at last, is a clear-cut presentation of the "whats" and "so-whats" of diode construction.

ALMOST 2500 diode types are currently available. Their electrical characteristics, performance, and appearance vary widely. For almost all EIA (JETEC) registered diodes, there is more than one junction type and encapsulation to meet the specified limits.

This is generally the result of open-ended limits, such as "minimum forward conductance" and "maximum package diameter." It is common to purchase the same diode type from different manufacturers and to get diodes of radically different characteristics. Yet they will meet all the registered specifications for that particular type.

The circuit designer should know the characteristics of each type of diode junction as well as the characteristics of the many types of encapsulations. This discussion of the most common encapsulations, junction constructions, and some typical applications should provide a bird's-eye view of most germanium and silicon diode types available.

Diode Packages

Glass package. One of the most popular encapsultations today is the subminiature all glass package, shown in Fig. 1. This package is not only small and light, but it is truly hermetically sealed with glass to dumet wire seals.

One disadvantage is its high thermal resistance of about 1 deg C per mw. This greatly limits the maximum allowable power dissipation. Nevertheless, most signal or low power applications can be handled by diodes in this package.

A slightly larger version of this package is also shown in Fig. 1. The characteristics of this package are similar to the subminiature glass package except for the slightly lower thermal resistance of about 0.7 deg C/mw.

Other commonly used glass packages include those with Kovar eyelets sealed to a glass barrel. Final sealing is by welding or soldering pins to the eyelets. Though these packages are larger than the subminiature glass, the thermal resistance of 0.3 deg C/mw is considerably better.

The soldered package has the disadvantage that it is difficult to keep the solder flux out during sealing. Also, the maximum operating temperature may be limited by the melting point of solder.

A new hybrid package combines small size with improved thermal resistance. It has an eyelet on one end and a glass to dumet seal at the

other end. The eyelet is soldered or welded. This package has a thermal resistance of about 0.4 deg C/mw.

Ceramic package. The ceramic package with solder seals has characteristics similar to the soldered glass package. It is used much less than any of the other glass packages.

Plastic package. For applications which require a reasonably good humidity resistance, but not necessarily a true hermetic seal, plastic sealed capsules are often adequate.

Single ended package. The packages mentioned so far are the coaxial or double ended types. Sometimes, from either a manufacturing consideration, or for a circuit application, single ended packages are desirable. These are available in soldered or welded types, with different sizes and thermal resistances.

Microwave package. The ceramic body microwave package is designed for low losses at microwave frequencies.

Junction Construction

Point Contact. The oldest and most familiar type, the point contact diode, consists, essentially, of a pointed metallic whisker, in contact with a small piece of silicon or germanium. A cross section of a typical germanium point contact diode is shown in Fig. 2. This diode is available in the subminiature glass package, the soldered glass, the large glass, and the coaxial plastic packages.

Typical forward currents at one volt run 5 to 10 ma. Reverse resistances run as high as a few megs with some piv ratings as high as 225 v. Though these types can be used as low level power rectifiers, their main applications are in entertainment and computer circuits.

Their entertainment uses include video detectors, a-m second detectors, afc and avc diodes, dc restorers, and fm discriminators.

The small junction area of point contact diodes allows the diode to be operated at high frequencies. Diodes of this type often have reverse transient responses in the millimicrosecond region. This characteristic is often needed in high speed computer circuits such as gates and flip-flops.

(Cont. on p. 22)

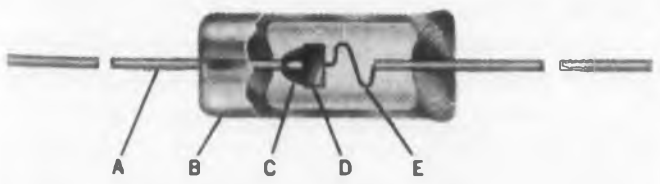


Fig. 2. Germanium point contact diode in a subminiature glass case. **A**—dumet wire lead, **B**—glass case, **C**—ohmic contact, **D**—germanium crystal, **E**—tungsten cat whisker.

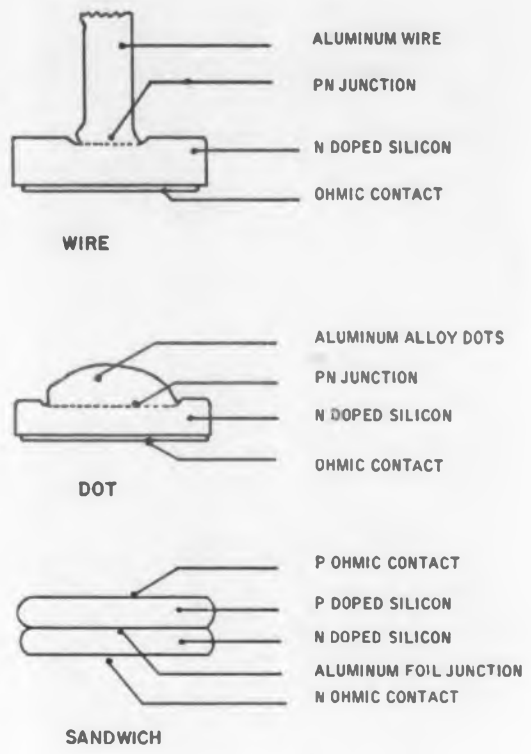


Fig. 3. (left) Silicon alloy junction types.

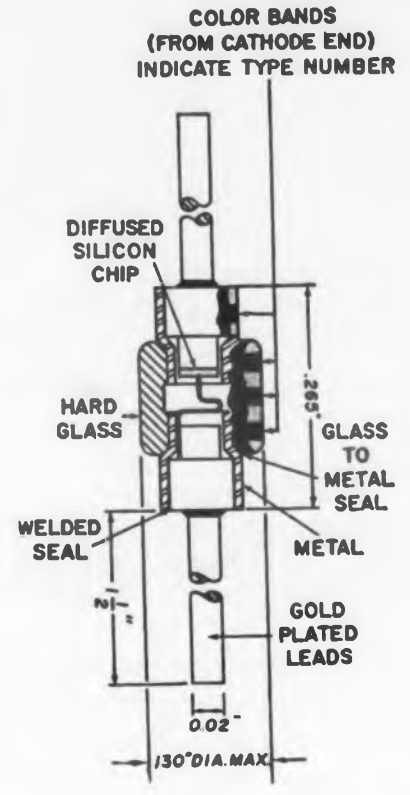


Fig. 4. (right) Diffused silicon diode in a welded glass package.

Silicon point contact diodes, available in the subminiature glass, the coaxial plastic, and microwave packages, are primarily used for high frequency mixers in the microwave region. Their forward and reverse characteristics are generally poorer than those of the germanium point contact diodes.

Plated point contact. A plated point contact diode, commonly known as a VLI (very low impedance) diode, is made by plating the tungsten whisker of a point contact germanium diode with indium, or any other *p* type doping material such as a gold gallium alloy.

This process greatly improves the forward conduction capabilities of this diode without appreciably changing the reverse characteristics. This diode provides typical forward currents of 300 ma at a volt.

The junction size depends on the plating thickness and the shape of the point. Larger junctions have greater forward conductance and poorer inverse transient response, on the order of a few tenths of a microsecond, compared with millimicroseconds for the small junction point contact diodes.

Typical applications include gates, clamps, magnetic core circuits, and diode matrices.

Bonded diodes. These are usually formed by placing a *p* doped wire, like aluminum or gold gallium on the surface of a chip of *n* type silicon or germanium, and passing current through the wire and chip. Local heating at the chip surface through-welds the wire to the chip, forming a *pn* junction.

The bonded process falls into two groups.

- Small wire diameters, pulsed with high currents for a few milliseconds,
- Larger diameters, of 10 to 20 mils, pulsed for a few seconds.

The small diameter types are not etched after bonding and are often bonded after encapsulation. The large diameter bonded diodes are generally chemically etched after bonding.

Large wire diameter gold bonded diodes are available with piv's of 180 v, and with reverse resistances exceeding 50 megs at 100 v. Typical forwards exceed 100 ma at 0.6 vdc.

The small wire diameter gold bonded diode has forward characteristics similar to the large area type, but the junctions are not etched after

bonding. Typical reverse resistances run about one meg.

Inverse pulse recovery for the gold bonded diodes varies with type and manufacturer. Typical recovery for the small diameter type is 0.3 μs. Larger diameter types recover in one to two μs. In most applications, the small diameter gold bonded diodes and VLI's are interchangeable.

The small diameter gold bonded diodes are available in the subminiature glass and coaxial plastic packages. The large diameter types are good for low reverse leakage at room temperatures.

Silicon bonded diodes. These are available with piv's to only 20 v, with back impedances to 100 megs, and forward currents up to about 5 ma at a volt. Pulse recovery is similar to that of germanium point contact types. These diodes can be used for detection at a few hundred megacycles.

Large diameter etched types have piv's up to 300 v with reverse resistances of 10^5 megs at room temperature. Forwards run to 50 ma at a volt, and their pulse recovery averages more than 2 μs.

Bonded silicon diodes are used primarily in high temperature military circuits like phase detectors, clamps, and modulators. They have very low leakage at elevated temperatures. Reverse resistance at 200 v is upwards to 100 megs at 150 C.

Alloy (fused) process. Silicon junction diodes are also made by either the alloy or diffusion processes. These involve furnace firing at 600 C and higher.

The three major alloy processes are:

- Wire alloying. An aluminum wire is alloyed into an *n* type silicon chip at just below the melting point of the aluminum wire, as shown in Fig. 3a.
- Dot alloying. An aluminum or aluminum alloy dot is fired into a small piece of silicon. This process is similar to the process by which fused transistors are made. It is shown in Fig. 3b.
- Sandwich. A thin foil of aluminum is alloyed between a piece of *n* type and *p* type silicon, as in Fig. 3c.

Diffused process. Diffused silicon diodes are probably the newest construction. A *pn* junction is usually formed by exposing a thin slice of *n* type silicon to a gaseous doping agent such as boron trichloride at temperatures in the range of 1300 C. The boron, a *p* type dope, diffuses through the silicon's crystal lattice.

Since both sides of the slice are exposed to the gaseous dope, a *pnp* structure results. One *p* layer is removed to obtain a single *pn* junction. The slice is then cut into the desired chip size and mounted in the diode package. A typical

diffused silicon diode in a welded glass package is shown in Fig. 4.

As with germanium diodes, junction size determines the electrical characteristics of silicon diodes. Dot sizes vary upwards from a 10 mil diameter with the diffused of sandwich alloy process. Maximum junction diameter is limited by the dimensions of the silicon crystals. Forward currents range from a few ma to as much as 100 amps.

One disadvantage of silicon diodes is their high "threshhold," or forward voltage at which appreciable conduction begins. For germanium the threshhold is about 0.3 v, while for silicon, it is about 0.7 v.

The main advantage of silicon is the much higher reverse resistance available, and the much higher operating temperatures. Germanium is generally limited to temperatures below 100 C, while silicon is good to over 200 C. For both types, reverse resistance is about halved for each temperature increase of 10 C.

Power Diodes

Both fused and diffused junctions are generally used for high power rectifiers These methods allow a wide range of junction area. It is impractical to have a large area point contact or bonded diode.

The small glass package with Kovar eyelets, shown in Fig. 1, allows, with a silicon unit, power dissipation of about 1/2 watt. Typical units can carry 400 ma at 25 C with piv's up to 600 v. Most of these are diffused.

A larger package, with higher ratings, is shown in Fig. 5. This package is ring welded on the base, and either pinch welded or flattened and welded at the top. These carry up to an ampere at 25 C, and have piv's to 1000 v. Units in this family are either fused or diffused.

For higher current ratings and greater power dissipation, larger diodes are made with a mounting stud. This stud allows heat to be conducted from the junction to an external heat sink. The stud also affords a means of mounting the diode, and in general, is one electrical terminal, usually the cathode.

Fig. 6 shows a widely used stud type. Recent advances in technology have improved the capabilities of this package, so that rectifiers are

Fig. 5. Diodes like this one have piv's to 1000 v.

now available with ratings of 5 amps and higher. A full wave single phase bridge with these diodes can deliver 4 kw with an efficiency better than 98 per cent. Both fused (alloyed) and diffused junctions are packaged this way.

Tomorrow's Diodes

The junctions and packages discussed here are by no means the only possible ones. But they cover the bulk of commercially available types. With future developments, there should be improvements in both junction and package design.

New materials are under development to operate at temperatures up to 500 and 600 C. Diodes are being rated at hundreds of amps. Packages have been announced—the size of a pin head. There is little doubt that the future will see many different diode types with characteristics which today would appear fantastic.

Fig. 6. Stud mounted diodes can carry more than 5 amperes.

Diode Manufacturers

Amperex Electronic Co.
230 Duffy Ave.,
Hicksville, N. Y.

Automatic Manufacturing
65 Gouverneur St.,
Newark 4, N. J.

Audio Devices Inc.,
620 East Dyer Rd.,
Santa Ana, Calif.

Bendix Aviation Corp.,
Westwood Ave.,
Long Branch, N. J.

Berkshire Labs.,
584 Bank Village
Greenville, N. H.

Bogue Electric Mfg. Co.,
100 Pennsylvania Ave.,
Paterson, N. J.

Bomac Labs, Inc.
Salem Road,
Beverly, Mass.

Bradley Labs.
168 Columbus Ave.,
New Haven 11, Conn.

CBS-Hytron
Danvers, Mass.

Clevite Transistor Prod. Inc.,
241 Crescent St.,
Waltham, Mass.

Fansteel Metallurgical Corp.,
North Chicago, Ill.

Fretco, Inc.,
406 N. Craig St.,
Pittsburgh 13, Pa.

Gahagan Inc.,
Waterman Ave.,
Esmond 17, R. I.

General Electric Co.,
1 River Road,
Schenectady 5, N. Y.

General Electric Co.,
1224 W. Genesee St.,
Syracuse, N. Y.

General Transistor Corp.,
95-18 Sutphin Blvd.,
Jamaica 35, N. Y.

Hoffman Electronics Corp.,
930 Pitner Ave.,
Evanston, Ill.

Hughes Products
International Airport Station
Los Angeles 45, Calif.

International Rectifier Corp.,
1521 E. Grand Ave.,
El Segundo, Calif.

International Resistance Co.,
Boone, N. C.

Kemtron Electron Products Inc.,
14 Prince Place,
Newburyport, Mass.

Microwave Associates Inc.,
Burlington, Mass.

Motorola Inc.,
5005 E. McDowell Rd.,
Phoenix, Ariz.

Nucleonics Products Co.,
Box 5552, Metro Station,
Los Angeles 55, Calif.

Pacific Semiconductors Inc.,
10451 West Jefferson Blvd.,
Culver City, Calif.

Philco Corp.,
Lansdale, Pa.

Radio Corporation of America,
Somerville, N. J.

Radio Receptor Co., Inc.,
240 Wythe Ave.,
Brooklyn 11, N. Y.

Raytheon Mfg. Co.,
55 Chapel St.,
Newton 58, Mass.

Sarkes Tarzian Inc.,
415 N. College Ave.,
Bloomington, Ind.

Shockley Semiconductor Div.,
Beckman Instruments Inc.,
Mountain View, Calif.

Sperry Rand Corp.,
So. Norwalk, Conn.

Sylvania Electric Products Inc.,
100 Sylvan Road,
Woburn, Mass.

Texas Instruments Inc.,
6000 Lemmon Ave.,
Dallas 9, Tex.

Thermosen Inc.,
375 Fairfield Ave.,
Stamford, Conn.

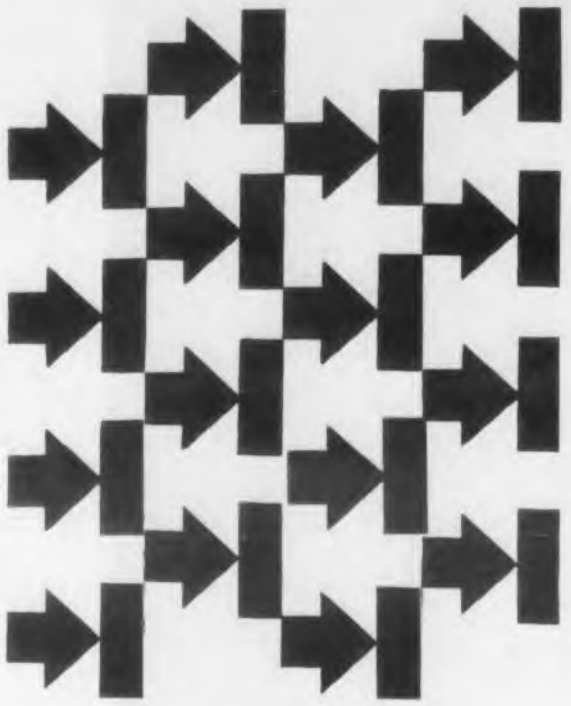
Transitron Electronics Corp.,
Melrose, Mass.

United States Dynamics Corp.,
1250 Columbus Ave.,
Boston 20, Mass.

U. S. Semiconductor Products Inc.,
3536 W. Osborn Rd.,
Phoenix, Ariz.

Western Electric Co. Inc.,
120 Broadway,
New York 5, N. Y.

Westinghouse Electric Corp.,
Youngwood, Pa.



Choosing Diodes

for Typical Pulse Systems

Frank C. Jarvis

Sylvania Electric Products Inc.
Electronic Systems Div.
Waltham, Mass.

A SERIOUS problem in designing modern electronic equipment is the proper selection from the many types of diodes for the numerous applications in a complex pulse system. At first glance, the problem seems trivial; but, when the design enginer tries to select the proper diode, a formidable array of advertising literature confronts him.

Typical advertisements describe diodes with clichés like "infinitesimally low back leakage currents," "exceptionally fast recovery," "extremely high forward conductance." Varied specifications are asserted: "forward current at one volt," "back leakage at a specified back voltage," "maximum peak inverse voltage," "zener voltage," "maximum surge current," "maximum peak recurrent current," "maximum junction dissipation," and "temperature derating factors for junction dissipation and reverse voltage."

To select the proper diode type, the engineer must weigh these claims. A thorough knowledge of the previously listed terms and diode characteristics, and a complete understanding of the environmental specifications imposed by the contracting agency are required.

This article can guide the proper selection of diode types. It discusses, also, three basic philosophies for selecting diodes for a complete system. Its primary purpose is to reemphasize the need for considering these philosophies before choosing a particular diode type.

Three Philosophies

The three methods for diode selection are:

1. One diode type for each application in a system;
2. One diode type for all applications in a system;
3. Two or three diode types for all applications in a system.

The diodes for a typical pulse circuit serve as examples for each method. This circuit is a typical portion of the systems encountered today. It includes four distinctly different diode applications. It is assumed that the temperature limits imposed on this system by the contracting agency vary from —55 C to 70 C. Since the upper temperature is 70 C, both germanium and silicon units can be used. (If the upper temperature limit exceeds 75 C, only silicon units can be used reliably in most applications.)

Method 1

The first approach calls for selecting a different diode type for each application. For the system illustrated, this method entails the use of four different diode types. First of all, since the repetition rate of the blocking oscillator using diode *A* is only 10 kc, any germanium or silicon diode with a PIV greater than the voltage drop across the primary of the pulse waveform during the tube "on" time is applicable. If cost is also a consideration, germanium should be specified for diode *A* instead of silicon.

For operation of the circuit using diode *B*, however, a diode with an extremely high front-to-back ratio and a fast reverse-recovery time is necessary. These stringent requirements, call for an aluminum-bonded, small-area-junction silicon diode type with only a mediocre forward conductance, but an extremely fast reverse-recovery time. Because of the relatively low back impedance of germanium diodes at high temperatures, their use is not feasible here.

Diode *C*, on the other hand, needs a high back impedance. Other characteristics such as reverse recovery and forward impedance are not very important here. Hence, any general-purpose silicon diode with a PIV greater than the circuit bias voltage works well.

To provide proper clamping action, diode *D* must present a low forward impedance at low signal levels. Since a germanium junction usually becomes a low impedance device at 0.2 and 0.3 v in the forward direction whereas the same type of silicon junction requires 0.6 v, the natural selection here is a germanium junction type. Since the repetition rate is still only in the order of 10 kc, diode recovery time is not a problem.

Method 1 results in the selection of four distinctly different diode types. This approach has several disadvantages. First, the four diode types

Frank Jarvis, a diode and transistor specialist, feels that in a few years transistors will replace 80 per cent of today's diode applications. But the problem of diode selection is with us today. This article shows the advantages and disadvantages of three basic philosophies.

which have been discussed represent only four diodes in a system which may conceivably have thousands of diodes. The complexity of the logistics required under such an approach is prohibitive. In addition, the down time due to equipment failure is undoubtedly increased because of the confusion inherent in identifying and replacing a diode which has failed or must be replaced because of some other component failure.

The one and only advantage of this approach is that since each diode has been selected for each application, maximum performance, but not necessarily maximum reliability, is achieved.

Method 2

The second approach, selecting one diode type for the entire system, is not easily achieved because of the different electrical properties which various diode types exhibit. In the circuit chosen for illustration, one general purpose diode type requires the following characteristics:

1. Low forward impedance at low signal levels;
2. High back impedance at low signal levels;
3. A High PIV;
4. Fast reverse recovery.

The high PIV and high back resistance at high temperatures are readily achieved with a silicon diode. But the low forward impedance can be obtained only with germanium, unless the designer is willing to compromise and accept the higher impedance silicon units.

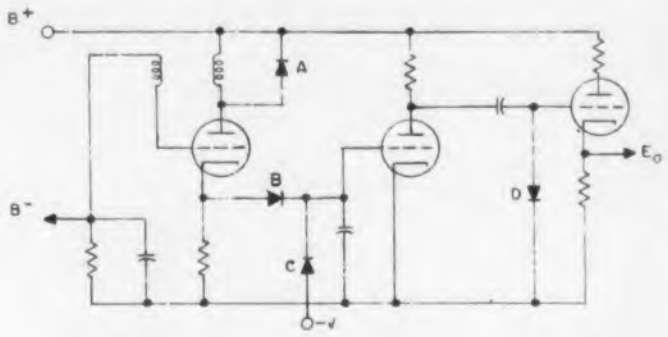
Another factor which causes trouble is that most high-conduction type diodes have slow reverse recovery and mediocre back impedance. Both characteristics hurt system performance in the case of diode *B*.

Undoubtedly, compromises can be made and one diode can be specified for the entire system. However, unless these compromises do not cause marginal circuit performance, the resulting specification still requires a diode which is beyond the state of the art of present semiconductor manufacturing. The cost and availability of such a unit do not justify its use.

Therefore, the use of one general purpose diode is not presently feasible. The only advantages of being able to specify one diode type are a reduction in the types of spares needed and a simplification which is good for maintenance.

Method 3

The third and most practical approach is to review the necessary diode requirements with the objective of specifying several diode types for all circuit requirements. For the circuit shown this method yields two main diode types. The first is a high back impedance, fast recovery, low PIV silicon unit for diodes *B* and *C;* the second is a high PIV, low forward resistance germanium diode for *A* and *D*.



Typical pulse circuit with four different diode applications.

Since the silicon unit for diodes *B* and *C* has a low PIV requirement, an aluminum-bonded, small-area-junction silicon type can be used; thus, high back impedance and fast recovery are obtained simultaneously. Conversely, the high PIV needed for diodes *A* and *D* is also easy to get, and, though the back impedance of this diode is not exceptionally large, no harm will result since only the diode front-to-back impedance ratio is important in both cases.

Since both types are easily manufactured, they are readily available and relatively inexpensive. In addition, no harmful compromises are made. If anything, a more reliable system evolves, because in many cases, the diodes used have higher PIV's, better recovery, or higher forward conductance than necessary. Thus, reasonable diode deterioration with life will not affect circuit performance.

A Few Diodes For Many Jobs

Of the three methods, the third is most practical. Method 1 causes an acute problem in servicing and logistics, though it allows each diode in the system to operate at its maximum capabilities.

Method 2 can be used only by sacrificing individual diode characteristics. Such compromises hurt in most cases and cause marginal circuit performance. In addition, requirements for a general-purpose diode of this type tax the state of the art and may result in an inferior diode type which will be extremely expensive and difficult to obtain. Since the only advantages to be gained by method 2 are a reduction in the types of necessary spare parts and a decrease in the down-time involved with maintenance it should be avoided in most cases.

Method 3 is obviously a compromise of methods 1 and 2. But this method does not require any compromise in diode characteristics and, hence, circuit performance. Diode types obtained by this method can be chosen for characteristics that are complementary to one another. This method increases overall system reliability without imposing the logistics problem and confusion that are unavoidable in method 1.

Zener diodes are very handy if you use them properly. They're the darndest things if you don't.

With Zener Diodes the Curves make all the difference

Bernard B. Daien
Chief Engineer
Transistor Devices Inc.
Kenilworth, N. J.

ZENER DIODES have little-known traits which can plague the unsuspecting circuit designer. Individual zener diodes bearing the same type number, even produced by the same manufacturer, often exhibit widely differing characteristics.

The designer may suddenly find that a circuit performs well on paper, but fails on the breadboard. The fault lies in one of the zener's lesser known characteristics.

Soft Knees and Sharp

Figs. 1A and 1B show voltage-current curves for two good zener diodes of the same type. The current scale is expanded at the low current, or "knee" end. This is essential. It permits inspecting the sharpness of break at levels which are important in many applications.

Sharp Knees. The diode in Fig. 1A has a very sharp break at 7.0 v. It is flat to 500 μa but tends to rise in voltage as the current increases further. This zener would work well in the circuit of Fig. 2, a typical shunt regulator, the zener being in the transistor's base return lead.

In this circuit, the zener draws little current, so the sharpness of break is important. Since the zener will not pass more than 500 μa, its poor regulation at higher current levels doesn't matter. The zener whose curve is shown in Fig. 1B would be bad in this circuit due to its rounded knee.

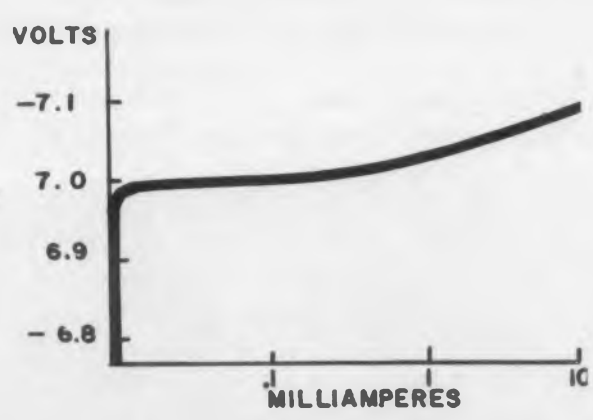
Soft Knees. The zener of Fig. 1B would work well in the simple regulator of Fig. 3, where the current might vary from 1 to 10 ma, since its curve above 1 ma is quite flat. Conversely, the zener of Fig. 1A would not perform well in this circuit because of its slope above 1 ma.

One must conclude that zeners should be specified with a working current range. They

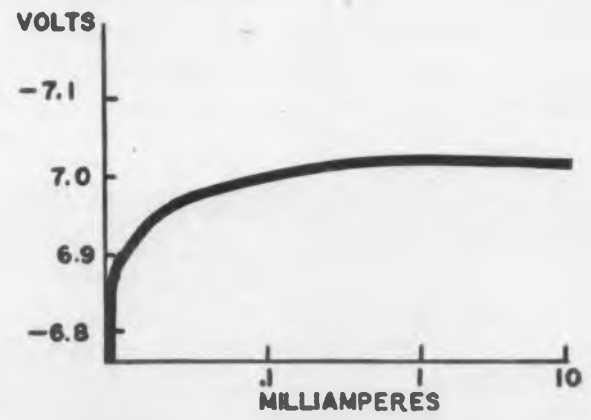
Bernard Daien has been doing design and development work for over a decade and a half.

The material he presents here will be as true tomorrow as it is today, but more will be needed at a faster and faster rate. With the semiconductor field moving so rapidly, and with applications well behind technological breakthroughs, applications must close the time gap—else new developments may be obsolete before they get into production.

Fig. 1. Typical zener diode characteristic curves.



A. The sharp knee is important in many applications.



B. The soft knee doesn't matter if the zener is to be operated above 1 ma.

should be tested, either by the manufacturer or user, to determine whether or not they meet desired curve characteristics in a given current range.

Zener Voltage Ratings

The sharpness of break and temperature coefficient of a good zener depend on the voltage rating. The lower the voltage rating, the less sharp the knee. Below five volts, the knee becomes very soft indeed. It would appear that eliminating low voltage zeners would end this problem.

Unfortunately, the temperature coefficient also varies with the working voltage, from a positive value at higher voltages, to a negative value below five volts. There is a crossover, or zero coefficient point, usually between five and six volts.

Temperature Compensation. Designers faced with widely varying temperatures often specify temperature compensated zeners. Such zeners are compensated by additional forward biased diodes in series with the zener and within the same package.

Of course, these compensating diodes have resistance. The zener's effective resistance is increased, or, putting it another way, regulation against current change is worsened. Zeners are no exception to the old saw: "We never get something for nothing."

The user may trade voltage change due to temperature for voltage change due to current. He must determine what percentage of the total voltage change is due to temperature, and what percentage is due to current variation through the zener—and then determine the optimum crossover point between the two effects. This is an area where the designer's intelligent choice

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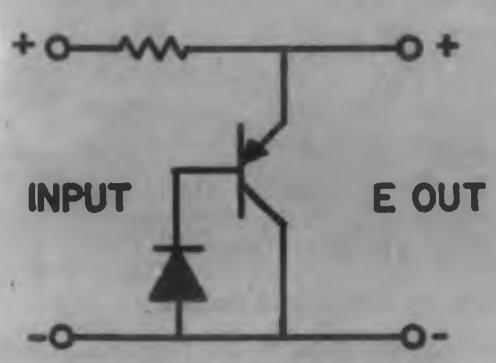


Fig. 2. In this shunt regulator, the zener should have a sharp knee.

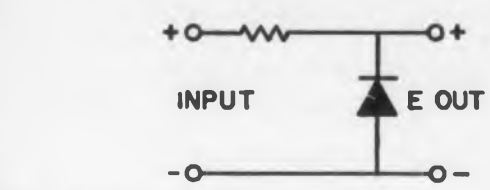


Fig. 3. This regulator would do better with a zener whose curve is flat at higher currents.

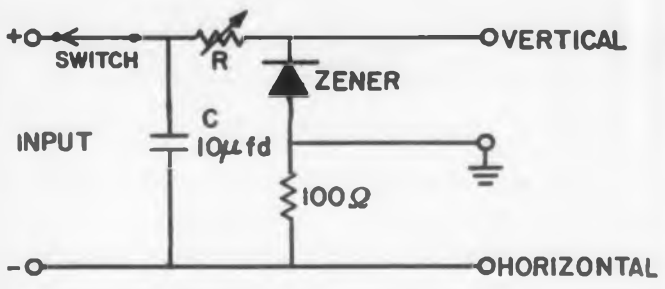


Fig. 4. A simple zener curve tracer to be used with a calibrated dc scope.

can make worthwhile improvements in overall regulation.

Zeners in Series

Zeners are often placed in series for higher voltage operation. Five and six volt zeners are often specified because of their low temperature coefficient. Again, if variation in voltage with changing current is a major problem, it might be wise to consider using fewer diodes with a higher voltage rating. This results in a positive temperature coefficient, but gives a much sharper knee, and a flatter slope due to lower series resistance.

Dynamic Impedance

When zeners are used as ac filter elements, to reduce ripple, as in Fig. 3, or as bias diodes, dynamic impedance becomes important. The dynamic impedance varies with the dc current through the diode, becoming greater at low currents.

A zener with a 10 ohm dynamic impedance at 100 ma may rise to a 200 ohm impedance at 1 ma. Where low dynamic impedance is required, one must provide some bias current for the zener if selection of individual diodes is to be minimized. Again, impedance also varies with voltage. Seven volt diodes generally have a lower impedance at any given current.

Noise and Power

At some current level below 1 ma, many zeners generate appreciable random noise. Varying the current less than 100 μa either way eliminates this effect. In applications where this noise is likely, it is wise to bypass the zener circuit heavily with capacity.

It is quite practical to use the zener as a compact random noise generator by employing this phenomenon.

Zener diodes are power rated, and suitably derated for higher ambient temperatures. When they are mounted on a chassis, local hot spots can cause excessive drift. It is good practice, therefore, to heat sink the zeners to a cool part of the chassis.

Zeners are now available in several power ratings, and can be used in series for still higher dissipation when power capabilities are to be pushed. Of course, it is never wise to run them at their maximum ratings.

Check the Curves

Unfortunately, it is not yet possible to mass produce zeners "like peas in a pod." They can be purchased to conform to a general specification, but individual variations make it advisable to "select out" for characteristics which are not tied down in the general specification. Often, one can trace out the curves of zeners in stock, and select enough to meet requirements.

Simple Curve Tracer. A simple zener curve tracer can be built to do the job. The circuit of Fig. 4 is used in conjunction with a calibrated dc oscilloscope. In this circuit, the voltage drop across the 100 ohm resistor is proportional to the zener current. Each 100 μa gives a 10 mv horizontal deflection.

The supply voltage should be about 50 per cent higher than the zener voltage but is not at all critical. R is adjusted, with the switch closed, till the desired zener current is obtained. This current is indicated by the horizontal deflection of the scope. The value of R depends on the supply voltage and zener voltage. It is estimated from

$$R \cong \frac{E_{supply} - E_{Zener}}{Desired\ Current} - 100\ ohms$$

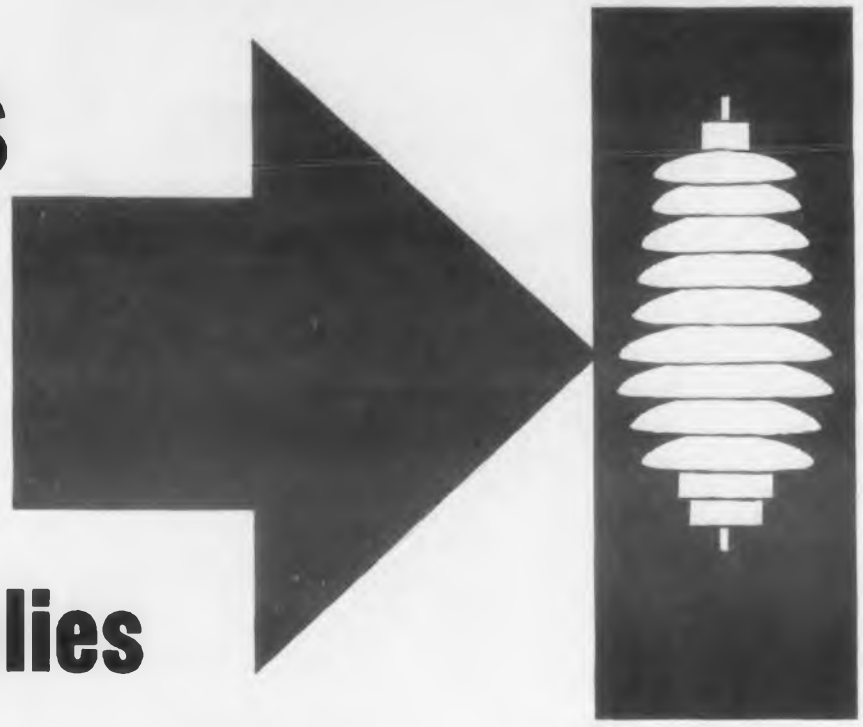
where R is in ohms, E in volts, and the current is in amperes. The 100 ohms are subtracted to make up for the current sensing resistor. Naturally, where high values of R are called for, the 100 ohms can be neglected.

Opening the switch permits the capacitor charge to decay through the zener circuit. As the current falls, the horizontal deflection sweeps out the current change while the vertical deflection indicates the change in voltage across the zener diode only. The trace may be slowed by increasing the capacity of C. The knee of the curve can be expanded as far as scope sensitivity permits. This is useful for close examination.

Acknowledgment

Credit goes to Mr. S. H. Malavasi for much of the laboratory work essential to these observations.

Rectifiers in High Voltage Power Supplies



F. W. Gutzwiller
General Electric Co.
Semiconductor Products Department
Clyde, N. Y.

The unique advantages of semiconductor rectifiers are, by now, well known. But they have their pitfalls too. This article shows how to avoid them.

WHEN THE peak inverse voltage (PIV) on rectifiers in high voltage supplies exceeds the ratings of a single available semiconductor cell, series connection of cells can meet the circuit requirements. But, the recommendations for series operation made by different manufacturers often seem to conflict.

This problem arises mainly because generalizations for both germanium and silicon cells, and for different junction areas and types of design are very difficult, if not impossible. Different rectifier types show different electrical and thermal characteristics. They call for different procedures in connecting for series operation.

Reverse Characteristics

Soft Breakdown Types. Fig. 1 shows the reverse characteristics of two unmatched cells. The shape of these reverse voltage-current characteristics is typical of germanium, and medium and high current silicon cells. In this figure, cells 1 and 2 are series connected across a reverse voltage of 600 v.

The reverse current i_r must be the same through both cells if no alternative parallel paths exist. Therefore, i_r will stabilize at a value such that the sum of the voltages indicated by the intersection of i_r with the characteristic curves is the total impressed on the circuit. For example, i_r intersects with the characteristic of cell 1 at 200 v and of cell 2 at 400 v for a total voltage of 600. This shows the significant difference in reverse voltage sharing for series cells with dissimilar reverse characteristics.

This difference is further aggravated by the exponential increase of the reverse current characteristic with increasing junction temperature. A difference in junction temperature of only a few degrees causes a grossly unequal distribution of voltage between cells though the characteristics are identical at the same temperature. Differences in junction temperature of several degrees must be expected in practical operation due to variations in forward voltage drop, internal thermal impedance, reverse heating, and external heat dissipation.

To reduce extremes in voltage sharing which might lead to dielectric breakdown or excessive reverse heating, cells with the characteristics of Fig. 1 (often referred to as "soft breakdown") should usually be factory matched in their reverse characteristics for series operation.

Sharp Breakdown Types. Fig. 2 shows the reverse voltage-current characteristic of two typical low current silicon rectifiers. Instead of the "soft breakdown" shown in Fig. 1 for germanium cells and larger area silicon, the small area silicon has a sharp breakdown at some voltage greater than rated PIV. If the reverse current in the breakdown region is not limited, intensive local heating immediately destroys the cell.

Mr. Gutzwiller (r), has years of experience in control and power equipment, and in designing and applying semiconductors. He wrote this highly informative design article to help overcome the rash of misapplication of high voltage rectifiers.

On the other hand, if the reverse current in the breakdown is limited by other series cells, as in Figs. 1 and 2, that cell can carry its full share of the inverse indefinitely with no bad effects, though the cell is operated at greater than rated PIV.

As long as the total reverse voltage across all the series cells does not exceed the sum of their respective breakdown voltages, reliable operation can result though the reverse characteristics are completely mismatched. For this reason, series matching is usually not required for the types of silicon low current rectifiers with "sharp breakdown."

Referring back to Fig. 1, if, for some reason, the reverse blocking characteristic of cell 2 should start to deteriorate, the characteristic of cell 2 would gradually shift upward with a simultaneous increase in slope. As the characteristic of cell 2 rises, i_r increases slightly, redistributing the voltage carried by each cell so cell 2 develops less voltage than initially and cell 1 develops more. Together the cells continue to share the entire 600 v supply.

Thus, a self-correcting action takes place. The cells with the lowest reverse current and the most stable reverse characteristics tend to assume a proportionally larger share of the reverse voltage than the less stable cells with the higher reverse current. Where the deterioration of the reverse characteristic of a cell operating *alone* across a voltage source eventually leads to thermal runaway and complete failure as reverse current increases, an unstable cell in *series* with stable cells has a limit on its reverse current, imposed by the stable cells.

Thermal runaway and failure cannot occur unless all the cells in series in one string run away together. The chances are reduced drastically as the number of series cells is increased. Overall circuit reliability is greatly improved by using cells in series. This assumes, of course, that cells don't open.

Transient Peak Inverse Voltage

Normal switching and the functioning of overcurrent protective devices can result in transient PIV's as high as ten times normal on the rectifier banks. Though most rectifiers can handle some additional PIV briefly, the transient voltage rating is usually not sufficient to withstand these overvoltages. It is normally cheaper to reduce voltage transients by minor circuit changes than by installing sufficient rectifier PIV capacity to handle these short term over-voltages with no attenuation.

Maximum transient PIV can generally be reduced to 150 per cent of normal, or less, by shunting the main filter choke with a resistor, and using the output capacitor to filter high frequency transients, and by connecting Thyrite resistors across the transformer secondary or the dc bus.

Crest values of voltage transients are very difficult to determine analytically for rectifier circuits. The magnitude of voltage surges depends on such things as the arc-quenching characteristics of the switching device, the induetances and capacitances distributed through the circuit, the core characteristics of the transformer, and the reverse characteristics of the rectifiers. Actual voltage measurements on prototype equipment are therefore the most positive method for determining the amplitude of voltage surges.

Several methods can be used. High speed oscilloscopes and peak recording voltmeters measure transient voltages well, if a satisfactory voltage divider is used.

(Continued on following page)

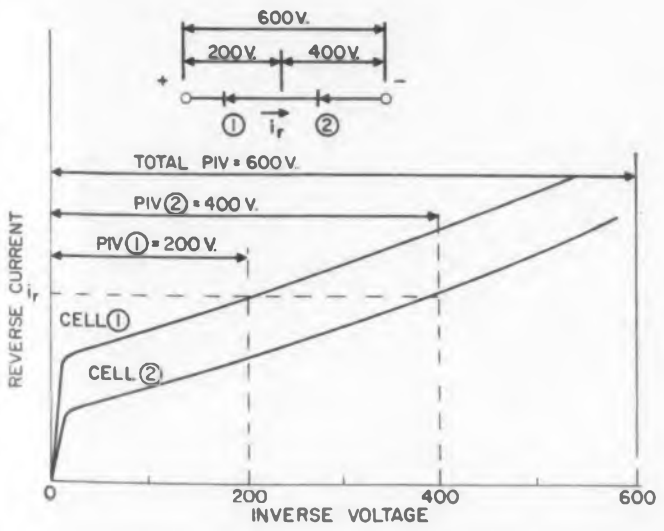


Fig. 1. Voltage sharing between unmatched series cells. (Germanium or large area silicon).

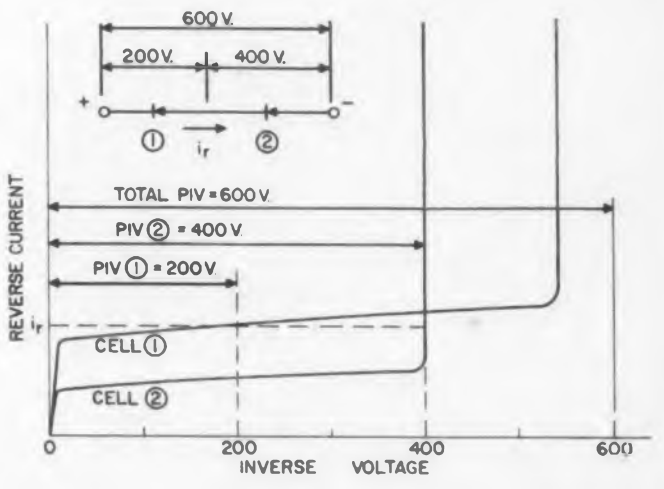
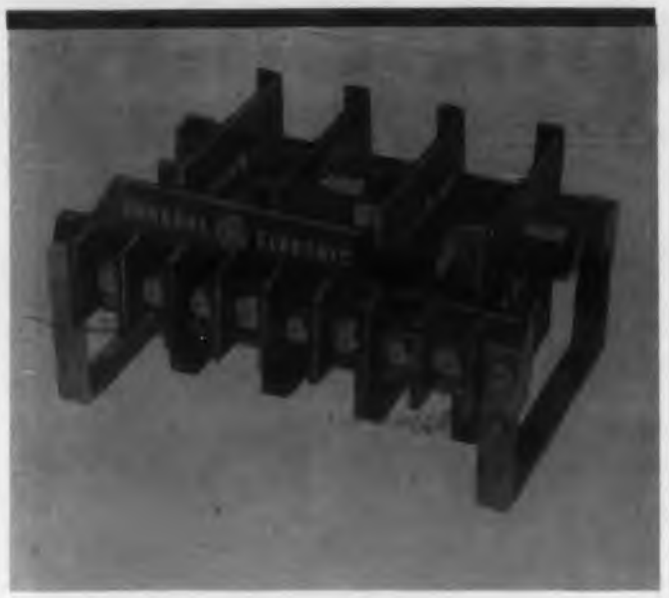


Fig. 2. Voltage sharing between series cells with sharp breakdown. (Small area silicon).



This typical rectifier stack has four GE 4JA3011 medium power germanium cells. The cells are rated at 300 PIV each, and can pass 8.5 amps in a 45 C ambient.

Spark Gaps

Calibrated sphere spark gaps from *B plus* to ground in bridge circuits or across rectifier legs of single way circuits can also be used to measure transient crest voltages. (See Ref. 3.) Current through the spark gap should be limited by a noninductive resistance (at least one ohm per volt of test voltage) in series with the gap on the ungrounded side. Suitable overcurrent protective devices should be used to interrupt the power follow-through after the voltage surge has passed.

If the worst voltage transients occur while deenergizing the circuit, as is often the case when the transformer primary is switched, a permanent sphere gap installed across the dc output of the bridge circuits and adjusted to a safe level above normal voltage should reduce transients substantially.

Effects of Steep Wavefronts

When a steep voltage wavefront strikes a long string of series rectifiers, the voltage distributes unequally across the series cells if they are perfectly matched in reverse characteristics. The rectifier cell furthest from ground electrically assumes the largest part of the voltage. The extent of the inequality depends on the number of series cells, the relative magnitude of the cell capacitance, and the capacitance from cell to ground. Fig. 3 shows a rectifier leg with equivalent shunt and series capacitance.

Assuming the cells have a very high back resistance, and that the capacitance of individual cells and the capacitance between cells and ground are uniform throughout the string, Dr. R. de Buda of Canadian General Electric Co. has shown that the peak voltage across the cell nearest the line ΔE_n can be expressed as (See Ref. 4):

$$\Delta E_n = E_n \sqrt{\frac{C_p}{C_s}} \quad \coth N \sqrt{\frac{C_p}{C_s}}$$

where E_n = peak voltage across entire rectifier leg, N = number of rectifiers in series per leg, C_p = capacitance between a single cell and ground, and C_s = series capacitance of a single rectifier.

While reverse conduction of the rectifier can reduce the extremes of transient voltage inequality, the equation is useful in analyzing the situation. In a typical example, using GE 4JA3011 germanium rectifier stacks, mounted on standoff insulators to a metal panel, one might expect C_p to be as high as 2 μμf, while C_s is about 15 μμf at high voltage levels.

If a 15 kv steep front transient is impressed across 50 cells, solution of the equation indicates 5400 v will appear across the rectifier cell furthest from ground for an instant until the capacitance network has stabilized. While the effect of voltages this large on a rectifier cell is not well understood, empirical data show it is desirable to distribute transient voltages more uniformly across the entire rectifier string.

This can be done by decreasing C_p or increasing C_s. By mounting the rectifier stacks against a dielectric instead of a metal panel, or by mounting the stacks progressively further from ground potential as their relative voltage increases, C_p can be reduced considerably and the transient voltage distribution can be improved.

On the other hand, by shunting each cell with a capacitor, relatively large compared to the cell's capacitance, C_s is increased to where C_p is negligible in comparison. If a 0.01 μfd capacitor is used across each 4JA3011 cell, the worst transient crest voltage per cell is reduced to a safe 350 v. Similar improvement results from a 0.001 μfd capacitor across each group of six cells. For greatest benefit from shunt capacitance, capacitors with small tolerances in capacitance should be used.

Cell Recovery

Another source of voltage transients across cells in series is the "hole storage" or "recovery" phenomenon. After a germanium or silicon cell conducts forward current, a brief interval (microseconds), is needed to sweep out current carriers from the base region of the semiconductor before the cell can block reverse voltage. Until the cell recovers, it behaves like a short circuit in the reverse direction. Rectifiers of a given design vary somewhat in the length of time needed for recovery.

Referring to the simple bridge of Fig. 4, assume cell 1 in leg *A* has a fast recovery and cells 2, 3, 4, and 5 have slow, but identical recovery times. The flat top of the forward current waveshape is due to the filter-inductance in the load. The load current flows in leg *A* beyond the point of supply voltage reversal due to inductance in the ac source.

At a rate determined by the source inductance, the load current commutates to leg *B* till, at some point *X*, the current through leg *A* reaches zero.

At this instant, the supply voltage has reached a large inverse value. The cell with the fastest recovery time (cell 1 in this example) absorbs

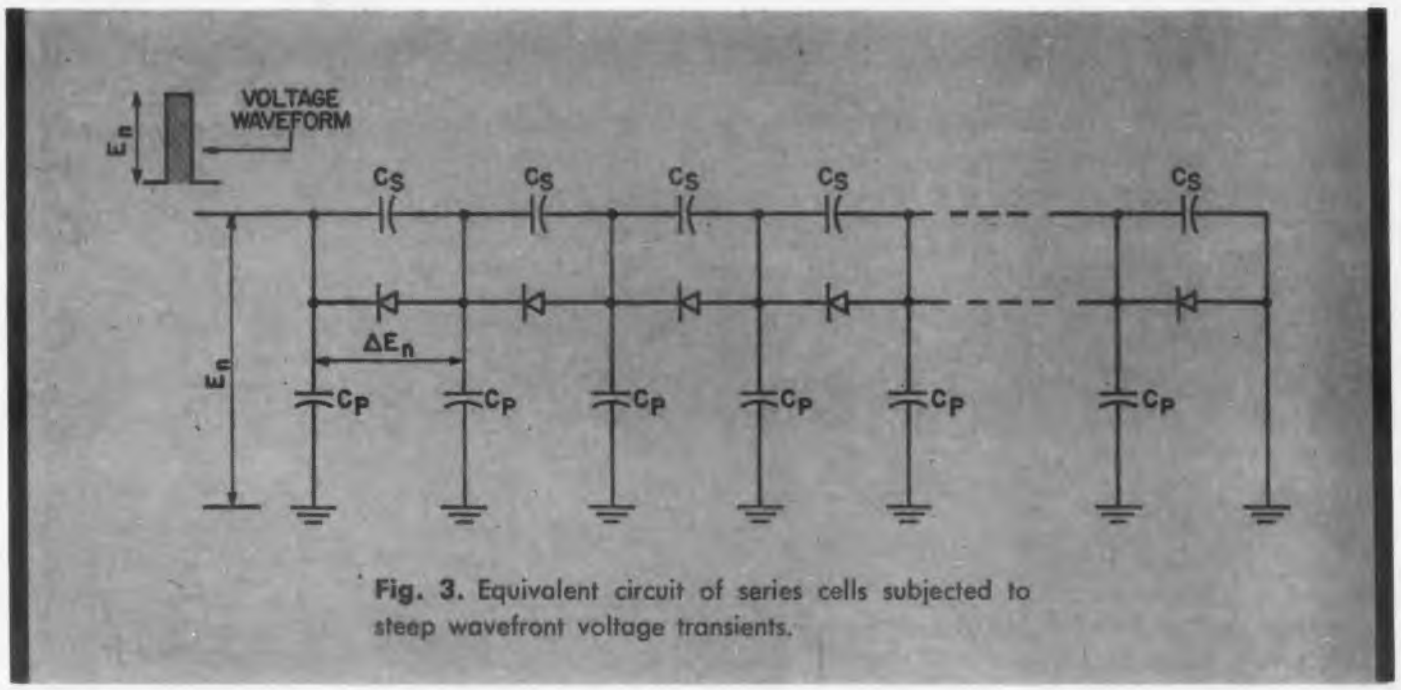


Fig. 3. Equivalent circuit of series cells subjected to steep wavefront voltage transients.

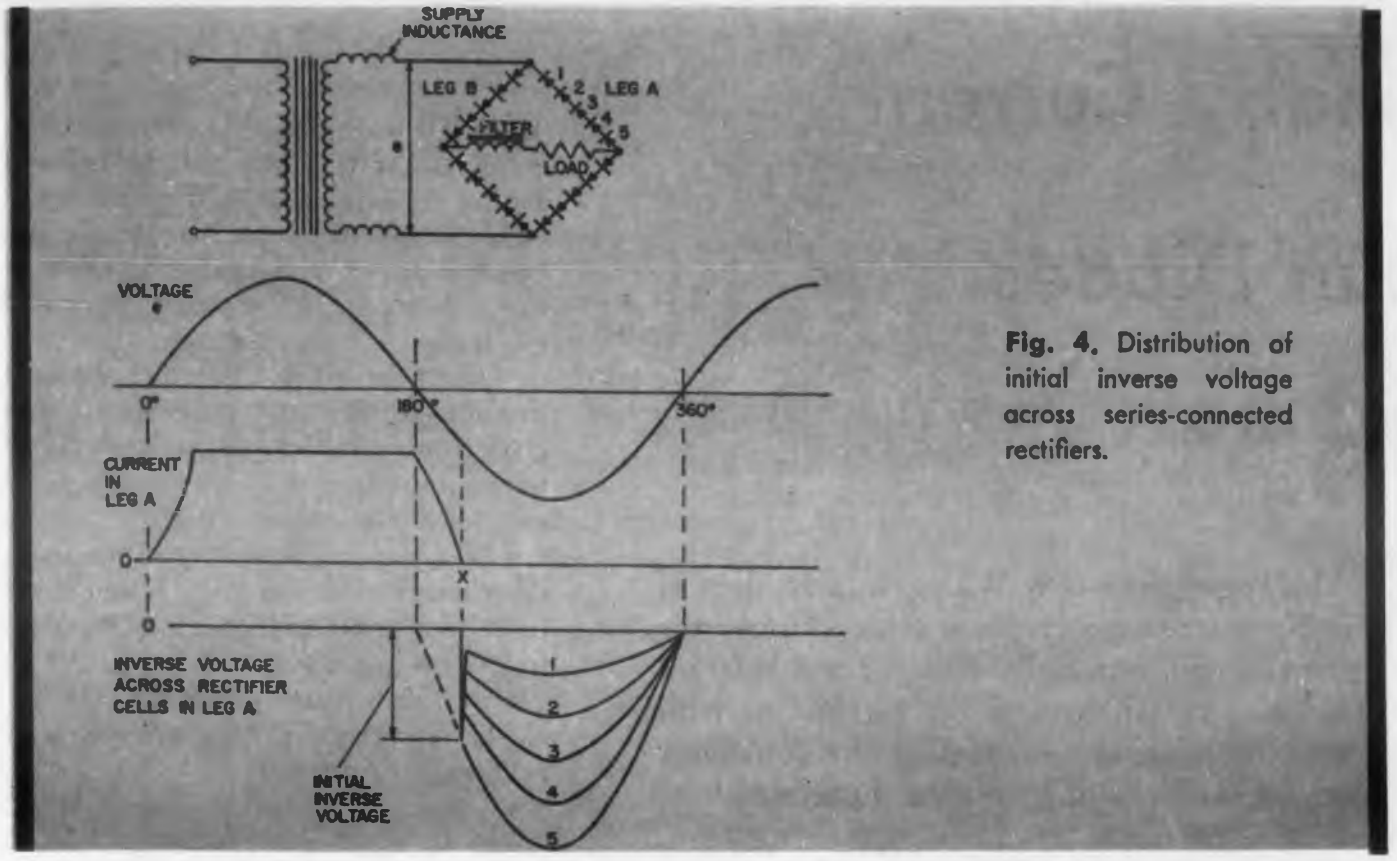


Fig. 4. Distribution of initial inverse voltage across series-connected rectifiers.

this entire voltage till the other cells in turn have recovered. This may require only a few microseconds. After all cells recover, the cells in the string share inverse voltage according to their respective reverse characteristics.

While the angle of overlap is usually quite small, when many rectifiers are in series, the initial inverse voltage across a fast-recovery cell can be many times the voltage across that cell at the peak of the supply voltage. This voltage spike should be within the continuous PIV rating of the cell.

Where the initial inverse voltage exceeds the PIV rating of a single cell, capacitors across individual cells will eliminate the voltage spike. The capacitor size depends on the difference in recovery time between cells. In any event, it need not exceed

$$C = 10\ I_f/E$$

where C = maximum capacitance to distribute recovery transient within cell PIV rating (μfd), I_f = amperes flowing through cell immediately preceding commutation, and E = maximum continuous PIV rating of the cell.

Voltage inequalities may also arise because of unequal reverse currents due to corona effects. Corona can be a serious problem when rectifiers are mounted in air, even at voltages as low as 10 to 20 kv.

Prototype Testing

When initially testing a prototype high voltage rectifier circuit, it is wise to start with a voltage source of 25 per cent of normal or less, to prevent catastrophic failure of the rectifiers from unexpected high voltage transients.

Overcurrent Protection

There are two major areas of rectifier overcurrent protection.

1. Protection against overloads and short circuits of the load, and
2. Protection of the remaining good rectifier legs if one of the rectifier strings fails.

If periodic maintenance is used to monitor individual cells, and the rectifiers are used within their ratings, the second type of fault protection should be mainly academic. This type can normally be part of load fault protection with little added effort.

The surge current curve, available from the manufacturer for a particular rectifier, defines the overload capacity of the cell for periods between one cycle and a few seconds. Beyond this time the duty can be considered continuous so far as the rectifier is concerned.

Inverse time protective elements, like fuses, circuit breakers, and overload relays are adequate for protection beyond a few cycles, if coordinated with the surge curve and continuous rating of the cell.

But, when a low resistance short circuit occurs in the load, the resulting fault currents can exceed the surge current rating of the rectifier for the few cycles necessary for conventional protective devices to function. For this type of duty, current limiting fuses that interrupt the fault current before it reaches its first peak are necessary. Commercially available current limiting fuses (like the General Electric CLF or Chase-Shawmut Amp-Trap) adequate for this duty are more likely to be found in the lower voltage types. This makes primary fusing more desirable than secondary fusing if the transformer magnetizing inrush current is not high enough to blow the fuses when there is no fault.

Another approach to fault protection uses high speed vacuum switches in the primary. These are tripped by current sensitive relays. They can interrupt faults within two cycles. To keep fault currents within rectifier ratings for two cycles, it may be necessary to introduce current limiting impedance in the form of additional transformer reactance, external resistance, or current limiting reactors.

Stack Mounting

Standard rectifier stacks have maximum voltage ratings between fins and mounting brackets of about 3 to 5 kv rms. If the voltage to ground on any stack exceeds this value, the stack should be mounted on standoff insulators or some type of insulating board. Mounting brackets of adjacent stacks should not be interconnected.

Rectifier Maintenance

After the first 500 to 1000 hours of rectifier operation, a simple ohmmeter check can locate individual shorted cells that need replacement. Thereafter, this check need not be repeated before 5000 to 10,000 hours. More critical tests can be made on individual cells by applying rated inverse voltage and displaying the cell's reverse characteristic on a scope. Circuits for this test can be furnished by manufacturers.

Unless exceptionally clean air is available for rectifier cooling, dust will deposit on rectifier cooling surfaces and reduce the heat dissipation. The fins should be cleaned regularly.

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Reducing Standby Current With Silicon Diodes

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General Electric Company
Semiconductor Products Department
Syracuse, New York

T. Peter Sylvan is well known to readers of ELECTRONIC DESIGN for his articles on transistor circuit design, especially with the uni-junction transistor. In addition to his experience with semiconductors, he's worked on atomic reactor instrumentation and hydrogen thyratrons.

In this article he discusses an application problem he's frequently called on to solve. He shows how a single diode can help stabilize basic transistor circuits without the need for an additional power supply.

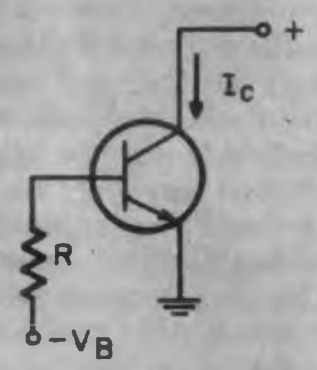

Fig. 1. A reverse bias is applied to the transistor by means of a base bias resistor and a second voltage supply $-V_B$.

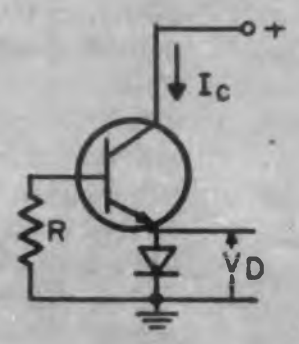

Fig. 2. Connecting the base resistor between base and emitter eliminates the need for a second power supply.

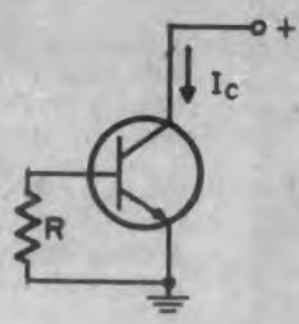

Fig. 3. The use of a diode reduces collector standby current.

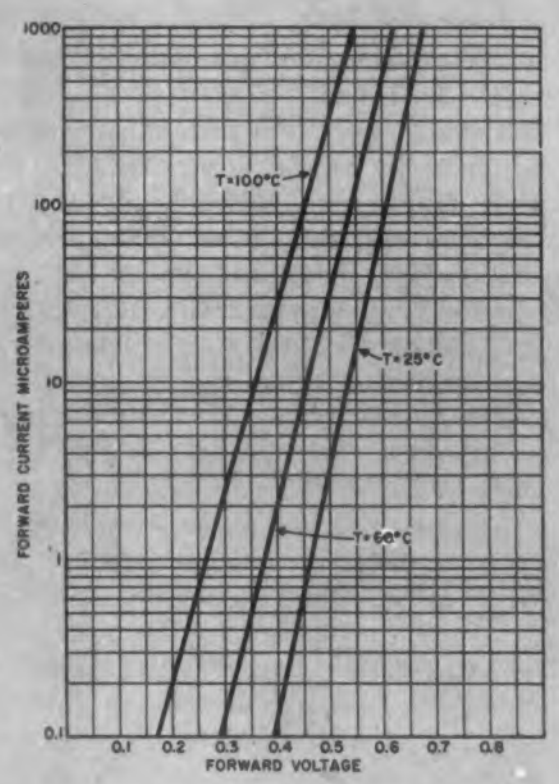

Fig. 4. Typical forward characteristics of a silicon junction diode.

SERIOUS undesirable effects when biasing a transistor can be reduced by the use of a diode in the emitter circuit. An effective back bias can be obtained without appreciable increase in the collector standby current above cut-off, I_{CBO}.

When germanium transistors are used in switching circuits, gating circuits, and class B amplifier circuits, it is necessary to minimize the collector standby current for the following reasons:

- If direct coupled stages are used, the current from one stage is amplified by the following stage and may seriously reduce the signal current.
- At higher temperatures the collector current may become excessive and lead to thermal runaway.
- Unless the collector current is reduced to a value approaching I_{CBO}, a common emitter stage will pass noise and undesirable small amplitude signals.

This article describes typical biasing techniques using a base resistor and shows the advantages of using a diode to reduce collector standby current.

Using A Base Bias Resistor

A biasing technique, frequently used to reduce collector standby current, calls for applying a reverse bias to the transistor with base bias resistor R and a second voltage supply $-V_B$ as shown in Fig. 1. This circuit permits the collector standby current to be reduced to a value, slightly less than I_{CBO}. However, it has the disadvantage of requiring an extra power supply.

If it is not possible to use a second power supply for stabilization, the base resistor, R, can be connected between the base and the emitter as shown in Fig. 2. The collector current in this case depends on the value of R and the characteristics of the transistor. This circuit has been analyzed by Ebers and Moll[1] who give an equation for calculating I_e for any value of R:

$$I_e = \frac{I_{CBO}}{1 - \alpha_N \alpha_I} \left[1 + \frac{\alpha_N (1 - \alpha_I)}{(1 - \alpha_N) + \frac{KT}{q} \frac{(1 - \alpha_N \alpha_I)}{I_{EBO} R}} \right] \quad (1)$$

In the limit as R approaches zero the

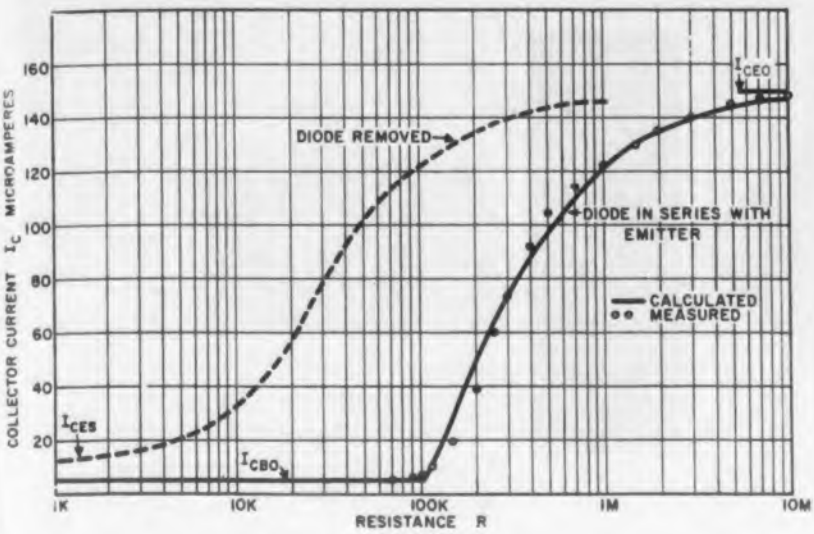

Fig. 5. Collector current of type 2N43 germanium transistor as a function of base resistance.

collector current[2] is described by:

$$I_c = \frac{I_{CBO}}{1 - \alpha_N \alpha_I} = I_{CES} \qquad (2)$$

where α_N and α_I are the normal and inverse alphas of the transistor respectively.

And in the limit as R becomes very large the collector current is described by:

$$I_c = \frac{I_{CBO}}{1 - \alpha_N} = I_{CEO} \qquad (3)$$

The inverse alpha, α_I, is generally greater than 0.7 for typical germanium alloy transistors so that I_{CES} is three or more times as large as I_{CBO}.

Using A Silicon Diode

A significant improvement in the collector standby current is obtained by using a silicon diode in the emitter circuit as shown in Fig. 3. The forward characteristics of a typical silicon diode at several temperatures are shown in Fig. 4. From this figure it is seen that even for currents which are very low compared to I_{CBO} there is an appreciable voltage drop across the diode. The diode can thereby provide a very effective back bias for the transistor without an appreciable increase in the collector above I_{CBO}.

For the circuit of Fig. 3 it is desirable to know the variation of the collector current with R and the diode characteristics. An exact analysis is quite complex. However, an approximate solution can lead to very useful results. It is only necessary to assume that the drop across the diode is constant at the value V_D measured at a forward current equal to I_{CBO}. With this assumption the following equation can be derived:

$$I_c = \frac{(1 + \Omega I_{EBO} R - \Omega \alpha_I V_D) I_{CBO}}{1 - \alpha_N \alpha_I + \Omega I_{EBO} R (1 - \alpha_N)} \qquad (4)$$

where $\frac{1}{\Omega} = \frac{KT}{q} \cong 0.026\, v \text{ at } 25\, C$

Eq (4) is identical to Ebers and Moll's eq (1) except for the term $\Omega\, \alpha_I\, V_D$ in the numerator. It will be noted that in the limit as R approaches infinity this equation reduces to eq (3) as it should. In the limit as R approaches zero, I_c in eq (4) becomes less than I_{CBO} in which case the equation is invalid. At values below this point I_c may be assumed equal to I_{CBO}.

To determine the accuracy of eq (4) the parameters of a 2N43 transistor were measured:

$I_{CBO} = 4.3\ \mu a$, $I_{EBO} = 2.8\ \mu a$, $I_{CEO} = 150\ \mu a$

and for the diode:

$$V_D = 0.47\ v\ (at\ 4.3\ \mu a)$$

The value of α_N was calculated from eq. 3 and the value of α_I was calculated from

$$\alpha_N\, I_{EBO} = \alpha_I\, I_{CBO}$$

giving $\alpha_I = 0.65$, $\alpha_N = 0.971$ (5)

Comparison of the calculated and measured values of I_c as a function of R are shown in Fig. 5. The improvement obtained over the case with the diode removed is shown by the dotted line in the same figure.

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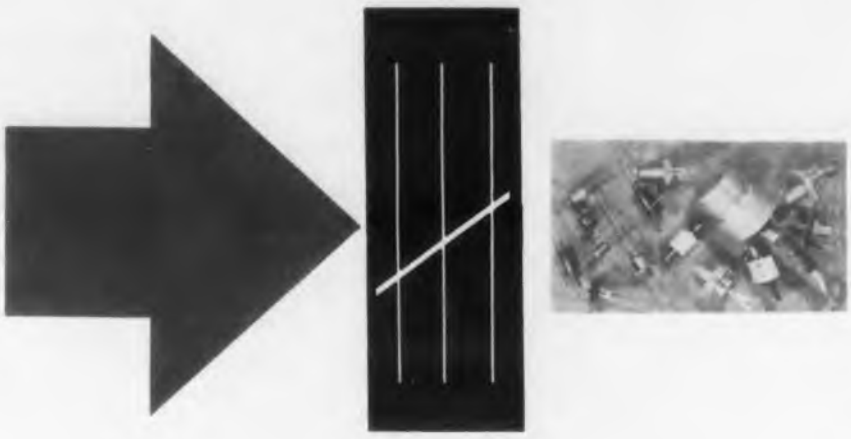

Rectifier Power Nomogram

J. S. Gillette and W. B. Mitchell

Raytheon Semiconductor Div.
Newton, Mass.

Here's a time saving nomogram. In just a few moments you can determine the power dissipated in a diode or the average rectified current to the load.

PERHAPS the most important problem in high current rectifiers, is the power dissipated in the junction—and how to calculate it. This power determines the type of heat sink necessary and the maximum allowable ambient temperature.

Calculation of the power in the junction is not always simple, as diode forward characteristics are not linear. Generally, the power dissipated in the reverse direction is very small and can be neglected. This is especially true with silicon rectifiers.

Hence, it is only necessary to calculate the power dissipated during the conducting cycle.

Forward E-I Characteristics

The forward characteristic looks like the solid line in Fig. 1. This curve, in the conducting region, can be approximated, with little error, by two straight lines, as shown by the dotted lines.

E_o is generally referred to as the "threshhold" and R_d, the dynamic resistance. Using the approximation, the power dissipated by the diode is given by

$$P = I_o E_o + (I_{rms})^2 R_d$$

where I_o is the average rectified current per diode, E_o the "threshhold" voltage, I_{rms} the rms value of the rectified current per diode, and R_d the dynamic diode resistance.

E_o can be assumed as 0.7 v for silicon diodes and 0.3 v for germanium.

Dissipation Nomogram

Fig. 2 is a nomogram relating power dissipated, average rectified current into a resistive load, and the dynamic resistance. The left hand scale is in watts per amp, the center scale in amps, and the right hand scale in ohms. Two power scales are given—one for silicon and one for germanium. The two right hand scales are for different circuit configurations—one for single phase ($k = I_{rms}/I_o = 1.57$), and the other for three phase ($k = 1.75$).

How To Use The Nomogram. Assume a three phase, full wave rectifier, with silicon diodes delivering 30 amps dc to a resistive load. Assume, also, that the diodes have 0.01 ohm dynamic resistance. The average current per rectifier leg is 30/3 = 10 amps.

Connect the 0.01 ohm point on the three phase axis with the 10 amp point on the current axis. This line, extended, intersects the power axis at 1.06 watts per amp. With 10 amps per diode, the power dissipated in each diode is 10.5 w. Total dissipation in the six diodes is 63 w.

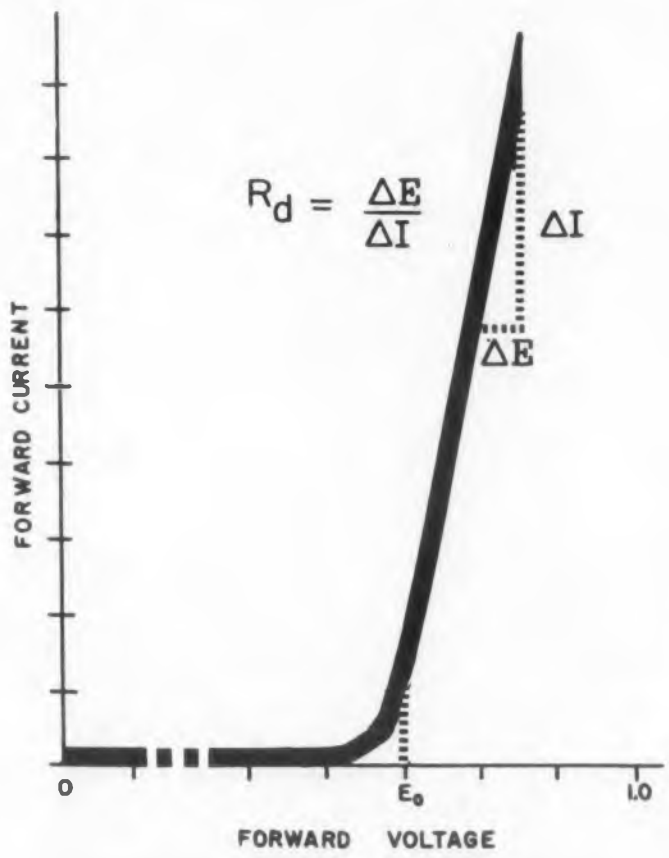

Fig. 1. Typical silicon diode forward characteristics.

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Rectifier Power Nomogram

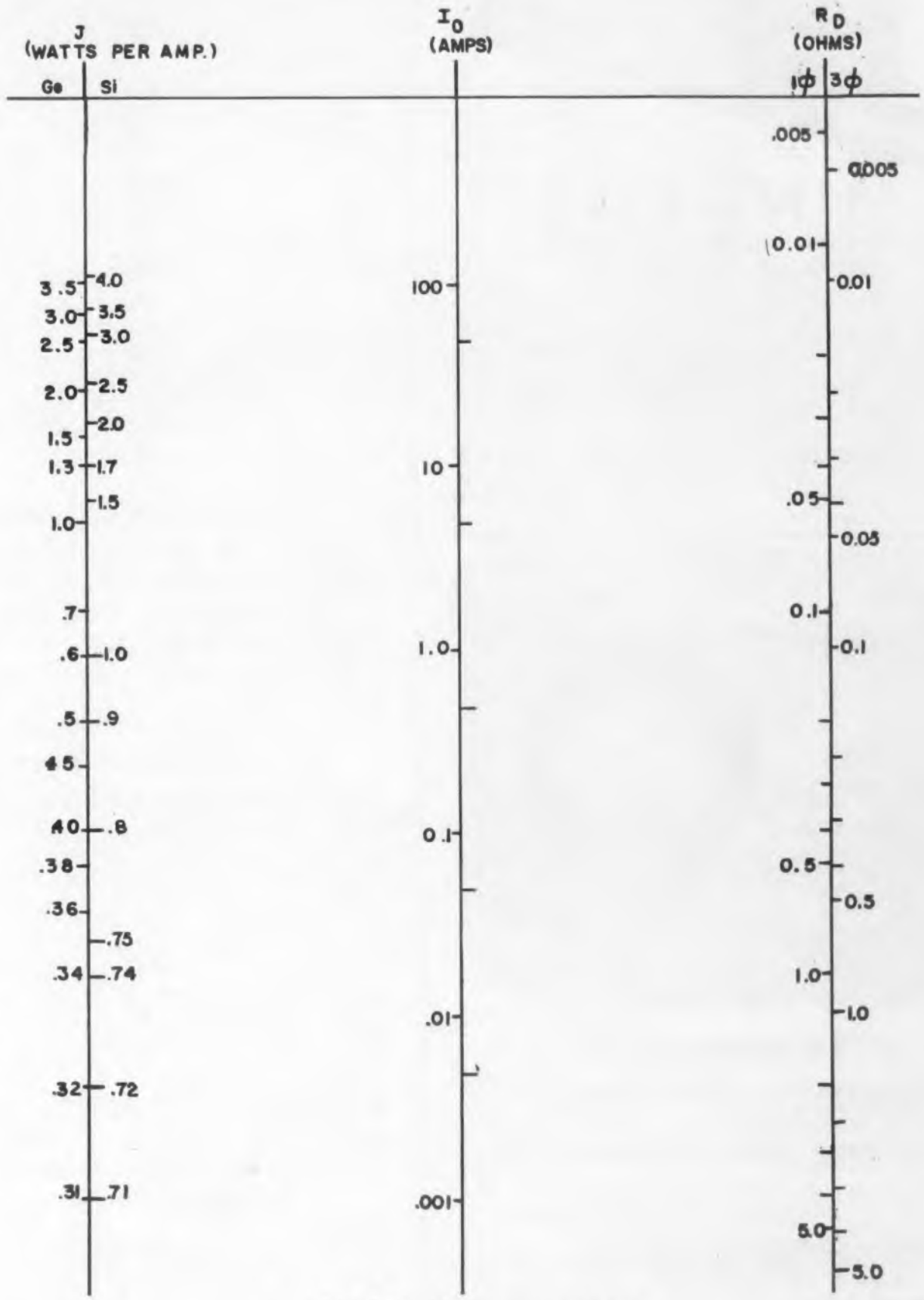

Fig. 2. Rectifier power nomogram.

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Designing with Diodes

We all know how to use diodes in detector circuits, discriminators, mixers, logical circuits, bias supplies, and many other applications. But the uses of semiconductor diodes are limited only by our ingenuity.

We asked many of our readers to send us their favorite diode circuits. Here are those we selected. Some are almost obvious applications. But others are really off the beaten track.

Filament Protection For Low Voltage Filaments

A 6v power supply shown in the figure was built for checking a receiver which used 1.4 v and 2.8 v filament tubes. The circuit worked fine except when one of the filaments burned out.

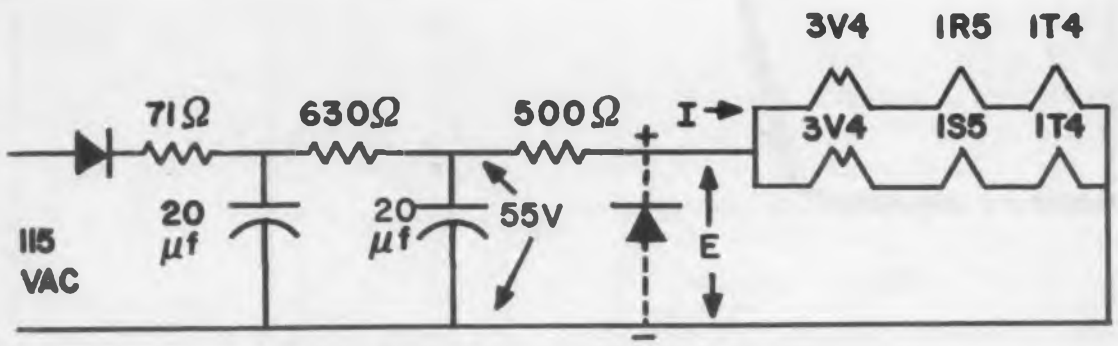
The current I is constant at about 100 ma. When both filament strings are in the circuit, 50 ma are provided through each string. But, if a filament should burn out in either string, the total current (100 ma) passes through the other string till one of the other filaments burns out. Thus, if one filament goes, another goes too.

To correct this, a silicon zener diode, SV805. was added to the circuit as shown by the dotted lines.

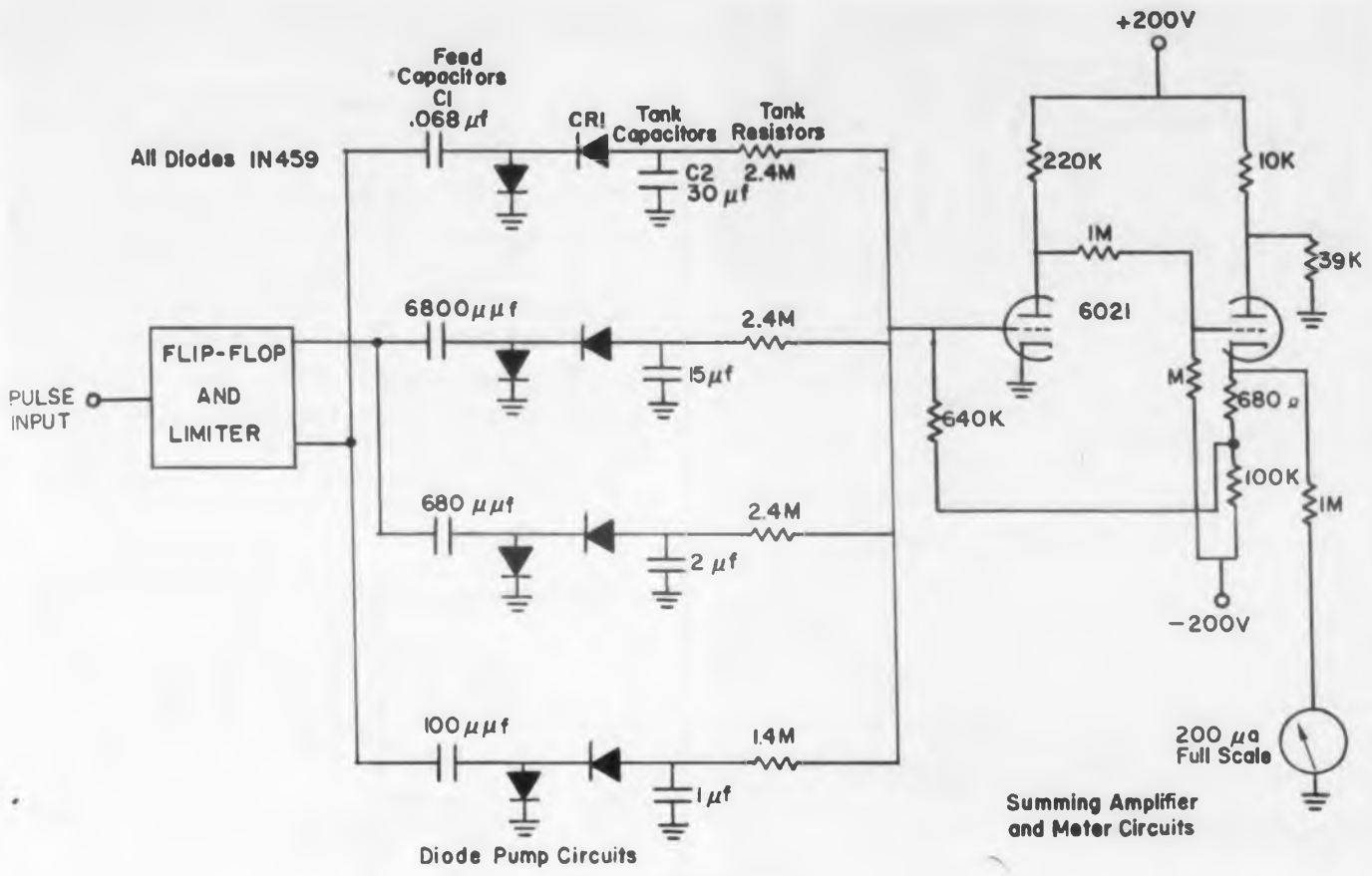
Now, with both strings conducting, $E = 5.6$ v. With one string open, $E = 6$ v and the current through the remaining tubes is still about 50 ma. With both strings open, $E = 6.5$ v.

The SV805 was chosen because it can handle 100 ma at 6 v, though it normally passes about 50. At 5.6 v, the current through it is very small.

Henry Chu, Nortronics, Div. of Northrop Aircraft, Inc., Hawthorne, Calif.



Zener diode helps prevent filament burnout.



Count rate meter.

Logarithmic Count Rate Meter

This logarithmic count rate meter reads the average rate of pulses coming in, either at a constant repetition rate or randomly spaced. The frequency of the waveform out of the limiter is half that applied at the input to the count-rate circuit. The constancy of pulse amplitudes applied from the limiter to the diode pump circuits determines the accuracy with which calibration of the didoe pump circuit as a pulse-rate counter is maintained.

Each of the four diode pump circuits in the figure, provides a current which, when added to the output of the other pump circuits, is proportional to the logarithm of the count rate over a 1000:1 range. Currents from the four diode pumps are added in the summing amplifier.

Each pump develops a voltage across its tank capacitor that is low for all count rates below a specific value, rises to a saturation value as the count rate goes through a specific range of frequencies (more than one and less than two decades), and remains at saturation for all higher count rates.

The actual range of frequencies at which any specific diode pump circuit changes its contribution to the total pump output is determined by the time constant of the feed capacitor and tank resistor for a specific diode pump circuit. Time constants for individual pump circuits are chosen so they make their major change in contribution at frequencies a decade apart from one another.

The pumps with the smallest and largest time constant receive 18 per cent more pulse voltage than the other two. The four feed capacitors are alternately charged through the shunt diodes and discharged into their respective tank capacitors through their associated series diodes. While C_1 discharges, for example, CR_1 conducts, thus charging tank capacitor C_2.

Each tank capacitor constantly discharges through its tank resistor. The negative voltage across a tank capacitor increases till the rate of loss of charge through its tank resistor equals the rate at which charge is fed to the capacitor. As the voltage across the tank capacitor increases, the charge transferred to it during each pulse decreases.

Discharge currents are added by feeding them into a virtual ground formed at the input to the summing amplifier. Hence, the voltage at the cathode of the second stage of the summing amplifier varies as the logarithm of the count rate. Negative feedback makes the summing amplifier insensitive to supply voltage changes and makes a zero set control unnecessary.

This circuit is a modification of a circuit described by Cooke-Yarborough and Pulsford in the April 1951 issue of the British *Proceedings of the Institution of Electrical Engineers, Part II.*

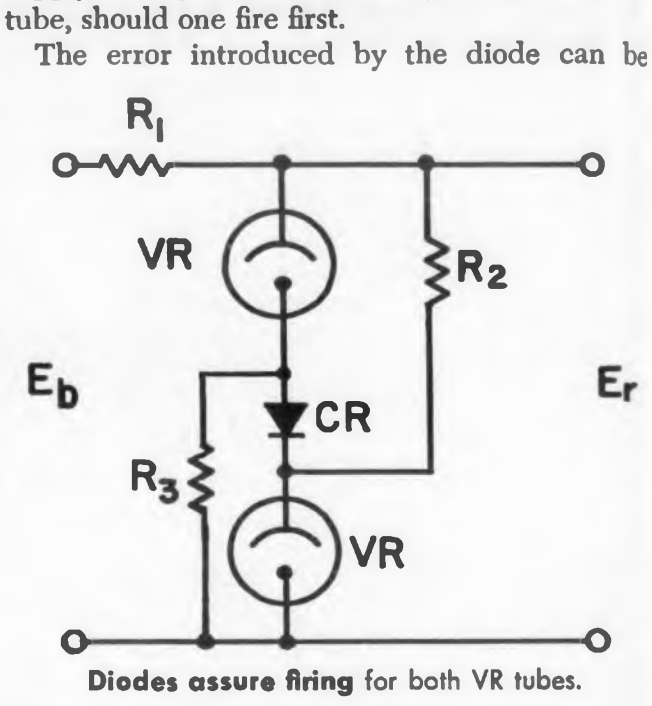
T. H. Bridgeman, Engineer, Airborne Instruments Laboratory, Mineola, N. Y.

IDEAS FOR DESIGN

Improved Firing For Series VR Tubes

This circuit will improve the firing of two voltage regulator tubes in series, when the supply voltage is slightly greater than twice the operating potential of the VR tubes. The diode guaranteed the firing of both VR tubes by applying the full supply voltage across each, and not the supply voltage minus the drop across one VR tube, should one fire first.

The error introduced by the diode can be



Diodes assure firing for both VR tubes.

neglected because of VR voltage tolerances.

In the circuit, R_1 is designed for maximum VR current at maximum E_b, while R_2 and R_3 are designed for minimum VR current at E_b. The diode must have a PIV rating greater than $E_{b\ max}$.

Gene A. Richards, Circuit Engineer, Farnsworth Electronics Co., Fort Wayne, Ind.

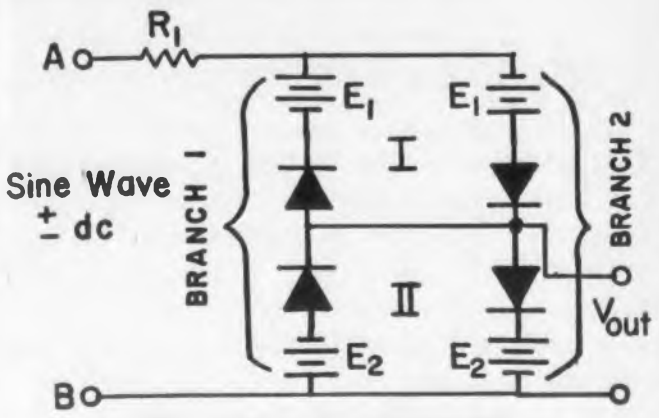
Sine Wave — DC Comparator Without Amplifiers

This circuit was used to get a pulse output when a 30 kc sine wave was instantaneously equal to a varying positive or negative dc voltage. V_{out} is a square wave with a peak to peak amplitude of $2E_2$ minus twice the drop across a 1N626 diode.

Output polarity depends on whether point A is positive or negative with respect to point B. The output swings from positive to negative when point A goes negative with respect to B, at which time branch 1 conducts.

E_1 and E_2 are adjusted so none of the diodes are biased on or off with zero input signal. The pulse required is formed by differentiating the resultant square wave. The circulating current

in loop 1 can be minimized by adding two resistors in series with loop 1 diodes.



Sine wave—dc comparator.

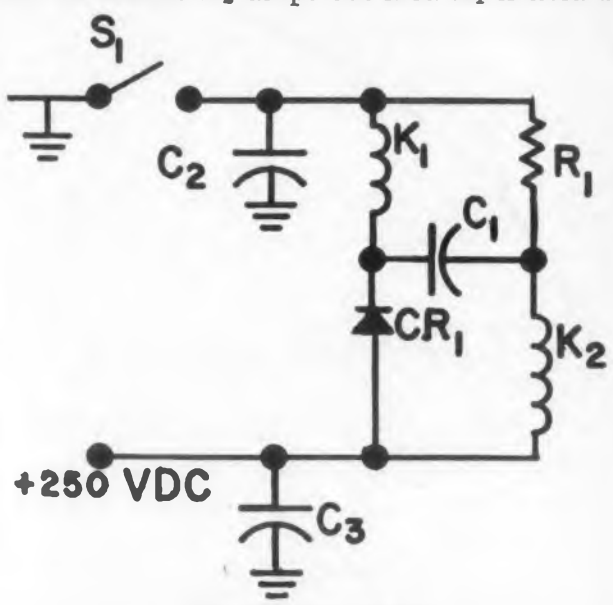
1N626 diodes were used because they have a fast response. The main advantage of the circuit is that a large output results without using amplifying devices. The circuit provides a large output without using amplifiers.

Paul Margolin, Engineer, Allen B. DuMont Labs., East Paterson, N. J.

Relay Delay Circuit

Two relays, K_1 and K_2, in parallel are to be energized from the same keying pulse. But K_1 must pull in before K_2 and, on release, K_2 must drop out before K_1.

The circuit shown does this job neatly. When the circuit is energized, K_1 pulls in first since a higher voltage is applied across its coil. K_2 is delayed on pull-in because R_1 is in series with its coil. On release K_2 drops out first. K_1 is held by



Relay delay circuit.

the discharge of C_1. The diode prevents C_1 from discharging through any path except K_1—R_1. The delay in drop-out of K_1 is determined by the time constant R_1C_1.

The diode must have a PIV rating, capable of sustaining the charge on C_1. A good choice is a 1N38A or a 1N458.

Norman D. Miller, Texas Instruments, Inc., Dallas, Texas.

IDEAS FOR DESIGN

Non Linear Function Generator

This circuit will generate a non linear amplitude response similar to that shown in Fig. 1. With the proper selection of circuit parameters, it can provide a wide range of non linear characteristics.

The diodes in the feedback network of the operational amplifier of Fig. 2, are zeners with a breakdown voltage of V_b. (A double anode unit could be used instead of the two single ended diodes.)

The circuit gain is approximately R_f/R_{in} until the output amplitude approaches the breakdown potential of the diodes. Then the gain equals the parallel sum of R_f and the diode impedance divided by R_{in}. Since the diode impedance is very small, the gain for amplitudes beyond the diode breakdown level is very small. Such a circuit is commonly used as a limiter with the characteristics shown in Fig. 3.

If a resistor is placed in series with the diodes,

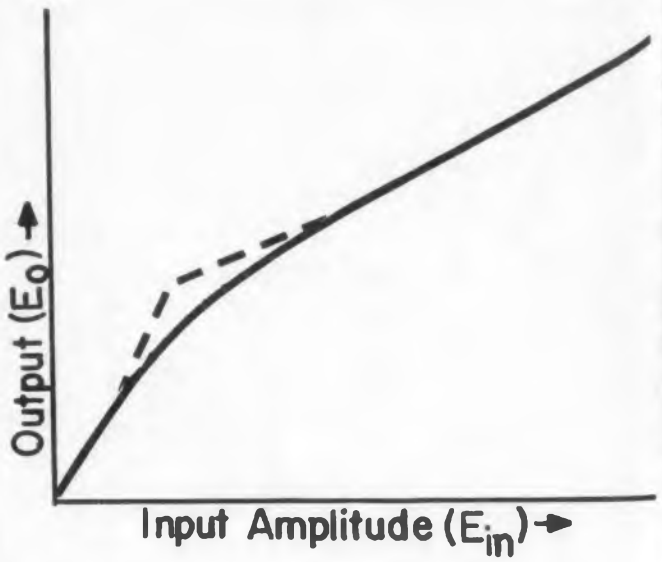


Fig. 1. This is the kind of non linear function the circuit in Fig. 4 can generate.

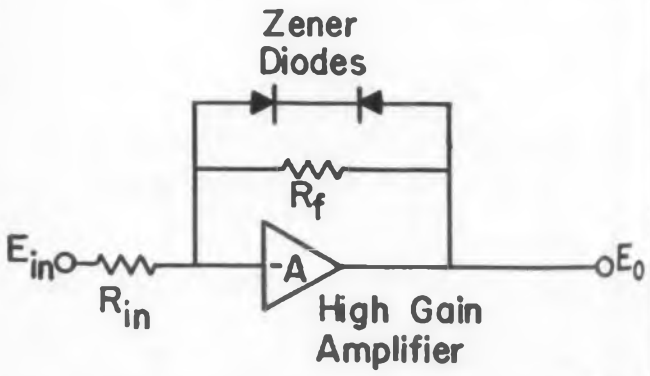


Fig. 2. This circuit uses an operational amplifier to provide limiting action as shown in Fig. 3.

as in Fig. 4, the gain above the diode breakdown level approaches a value equal to the parallel sum of R_{f1} and R_{f2} divided by R_{in}.

Theoretically, the amplitude response would be similar to the dotted curve of Fig. 1. But, in practice, the diodes break down gradually, so the response is rounded off.

Wide variations of the curve shape are obtained by adjusting the values of R_{in}, R_{f1}, R_{f2}, and the diode breakdown potential. Zener diodes are available with breakdown points ranging from a couple of volts to at least 30 v.

The ratio of R_{f1} to R_{in} determines the slope in the low level region. The ratio of the parallel combination of R_{f1} and R_{f2} to R_{in} fixes the slope at high levels. The diode breakdown point controls the point at which the curve breaks.

The use of two diodes or a double anode diode makes the circuit bidirectional, so it can handle ac as well as dc signals. However, ac signals are distorted above the diode breakdown level. In some cases, a low pass filter can eliminate the harmonics.

R. J. Ransil, Group Engineer, Lockheed Aircraft Corp., Sunnyvale, Calif.

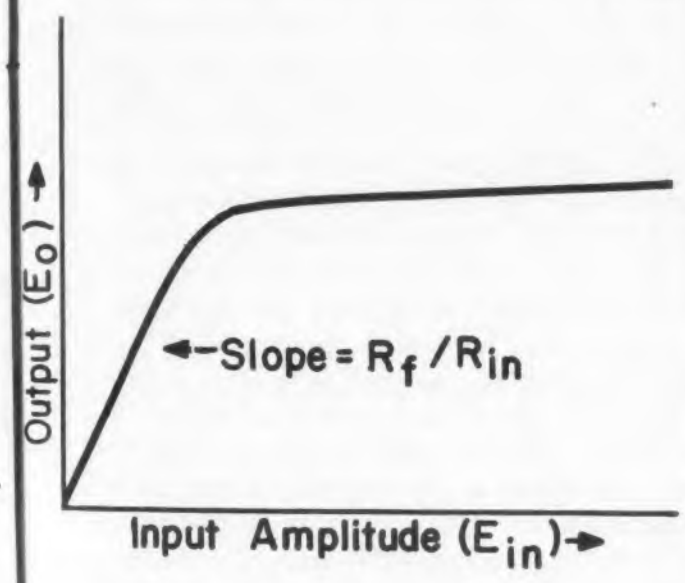


Fig. 3. Typical limiter characteristics.

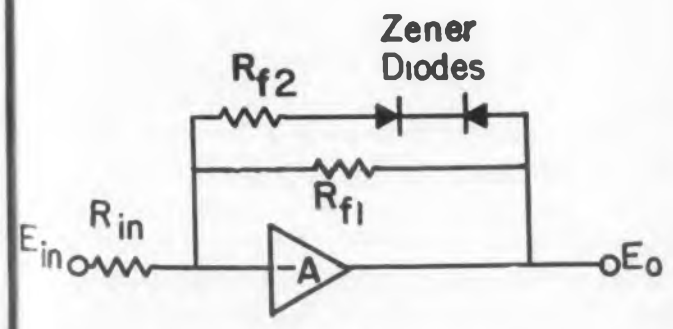


Fig. 4. This circuit can provide a wide range of non linear characteristics.

Microwave Applications of Thermistors

Part 2

Leonard I. Kent
Chief Microwave Engineer
The Narda Microwave Corp.
Mineola, N. Y.

In this concluding segment, comprehensive investigation is made of waveguide thermistor mounts. Impedance matching considerations are carefully outlined over the various frequency bands. A simple d-c self-balance bridge circuit for making accurate r-f power measurements is also discussed. Thermistor characteristics, thermistor mounts, dc characteristics, broadband mounts, and coaxial mounts were given extensive treatment in Part 1.

TO MATCH the impedance of a thermistor element to a waveguide mount over a complete waveguide operating range, several factors must be considered. These factors can be listed briefly as:

- rf characteristics of the thermistor element in its operating environment;
- impedance of the waveguide section in which the element is placed, and its variation with frequency;
- impedance variation of the required back cavity;
- transition from the waveguide section containing the thermistor to the required waveguide input.

The thermistor element to be used with the waveguide mounts for the frequency ranges 1120 to 10,000 mc (L- to XB-band) is the cartridge type that contains two beads connected in series as shown in Figs. 1 and 2. For the higher frequencies, the miniature-type cartridge containing a single bead is used. The rf characteristics of a thermistor element are determined by many constituents. One is the rf impedance of the beads themselves. This is made up of the dc bias resistance shunted by a resistance and capacity series branch which results from the finite particle size of the sintered oxides within the beads and the imperfect contact between neighboring particles of the mixture. This complete combination is in series with the inductance caused by the 0.001-in. diameter lead wires. The other constituents are the lead lengths employed, which determines this inductance value; the structure supporting the beads, which will contribute shunt capacity across the beads as well as more series inductance; and the proximity of the thermistor beads to the environment within the mount itself. Instead of analytically determining the various parameters that contribute to the rf characteristics of the thermistor element, it is more practical to empirically find an equivalent resistance and shunt reactance for the various mounts and frequency ranges required.

Thermistor beads in the cartridge elements are mounted within a gap small enough to allow minimum lead length for low inductance. The diameter of the supporting posts is large enough to give low inductance and small enough not to create excessive shunt capacitance. A thin dielectric sleeve is cemented over the beads and its supporting structure to retain the concentricity of the assembly and to protect the beads from excessive cooling by air convection currents within the waveguide mount. Without this protection, the drift problem of the bridge circuit using the element would be aggravated.

Since the resistive component of the shunt equivalent circuit of the thermistor element will be equal to 200 ohms or less, a waveguide characteristic impedance of this value should be used in obtaining the empirical data. In order to minimize the variation of the characteristic impedance with frequency, a ridged waveguide section makes the ideal transmission line. Not only does ridged waveguide allow small variation of impedance with frequency because of its reduced cut-off frequency, but its characteristic impedance can be readily adjusted to other values that may be required.[1] With a broadband open circuit across the thermistor element, it was found that a ridged waveguide of 200 ohms characteristic impedance can be used for the section containing the element with a good impedance match. This was true for the frequency ranges within 1120 to 5850 mc. From 5850 to 8200 mc, the optimum characteristic impedance was approximately 190 ohms. At higher frequencies, the required impedance for this section of waveguide became gradually less. In the design of fixed tuned mounts for each waveguide band, the impedance and length of the back cavity, which was also ridged waveguide, was first calculated, and then the back cavity was empirically adjusted to minimize the effect of the shunt reactive component of the thermistor element. This, thereby, provided a broadband open circuit. The characteristic impedance of the back cavity was greater than that of the forward section so that an impedance approximating an open circuit would always shunt the thermistor. The capacitive step discontinuity at the junction between the back cavity and the forward waveguide section was compensated by appropriately

shortening the length of the cavity.

At least two approaches could be taken to make a broadband transition from the ridged waveguide section to the conventional waveguide input. One is to use a continuous linear taper of the appropriate length, and another is the use of quarter-wave step transformer sections whose reflections follow a Tchebyscheff response.[2] Although the latter would give better performance for a shorter length, it would be more expensive to fabricate. The linear taper is easier to manufacture, and the performance of a taper that is slightly longer than a step transformer is equivalent. This would not be true if the ridged section had an impedance much less than 200 ohms. Fig. 1 shows the cross-section of a thermistor mount using this approach. Waveguide mounts from 2600 mc and higher use this type of transition, while the two mounts covering 1120 to 2600 mc use the step transformer design in order to conserve length in the larger size waveguides.

Fig. 2 shows a low-frequency thermistor mount which uses the dual-bead cartridge element; similar high frequency units use the miniature cartridge element. Because of the small sizes of the high-frequency mounts and the need for smaller lead lengths, the miniature thermistor element is made available. The vswr of all the mounts within their ranges, from L- to X-band, is less than 1.50 with the maximum value for mounts above 12,400 mc being slightly higher. The elements can be used interchangeably in any of the appropriate mounts. Power levels from 0.01 to 10 mw can be measured. The mounts from 1120 to 3950 mc also accept specified 200-ohm cartridge bolometers with a vswr of less than 1.35, and the unit lying in the range of 3950 to

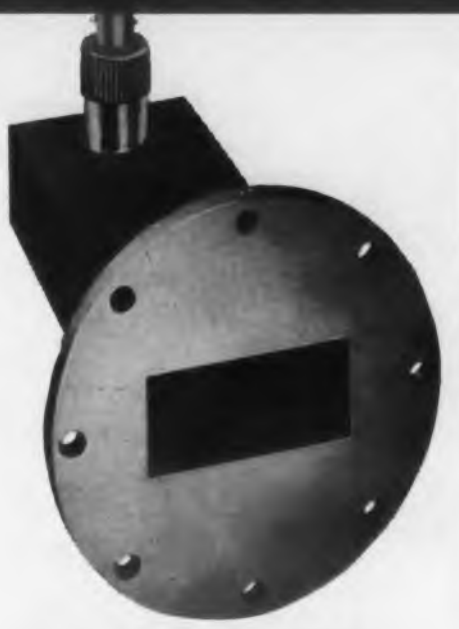


Fig. 2. Broadband waveguide thermistor mounts (top); higher frequency broadband wavemounts (bottom).

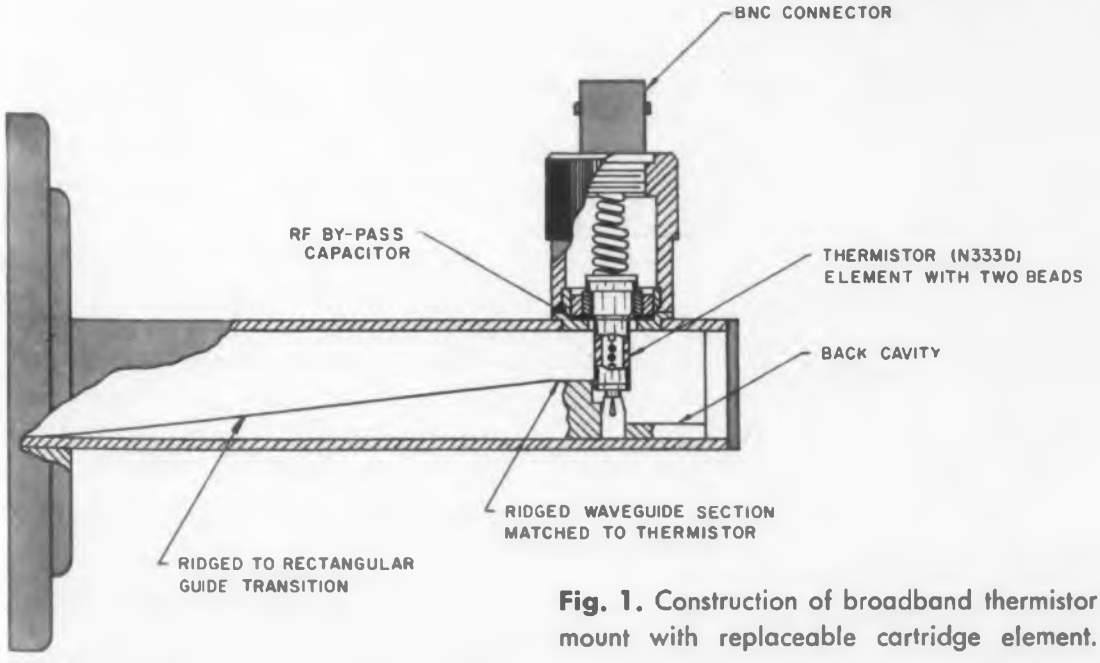


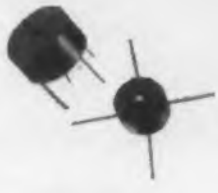
Fig. 1. Construction of broadband thermistor mount with replaceable cartridge element.

Quiggley's Breakfast Brainstorm

...or the case of the sub-miniature toroids

Major Quiggley, DC, AC, etc. banged his fist on the table and stared with fascination at the breakfast cereal before him. "Eureka! I've got it!" he bellowed with enthusiasm. "Sub-miniature toroids, just the size of these Cheerios* to solve our limited space problems!" The major beamed with satisfaction. "Great idea!" he purred. "I'll call B & W and get them to develop it!"

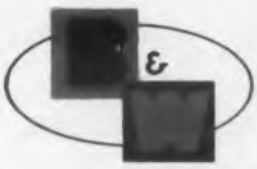
Major Quiggley rushed to the office, put through a call to Barker & Williamson, and rapidly outlined his earth-shaking idea. "It will revolutionize the industry!" he concluded with final triumph. Tactfully, the harassed sales manager explained that B & W had not only been manufacturing toroids the size of Cheerios for many years, but also have available a complete line of sub-miniature as well as larger types. He indicated that many of the toroids were so small that the center hole was only 1/16" in diameter! Quiggley sputtered, "You should let a feller know, old chap! Send one of your sales engineers right over!"



Here's What Major Quiggley Learned About Toroids from the B & W Sales Engineer:

- *Sizes*—B & W manufactures a complete range of standard and special toroid coils and related networks.
- *Tolerances*—5% for standard types and as close as 1% for specials.
- *Finishes*—plain—waxed—tape wrapped—encapsulated, or hermetically sealed to MIL-T-27A Specs where required.
- *Delivery*—To meet your requirements in time and quantity.

*Reg. Trademark—General Mills



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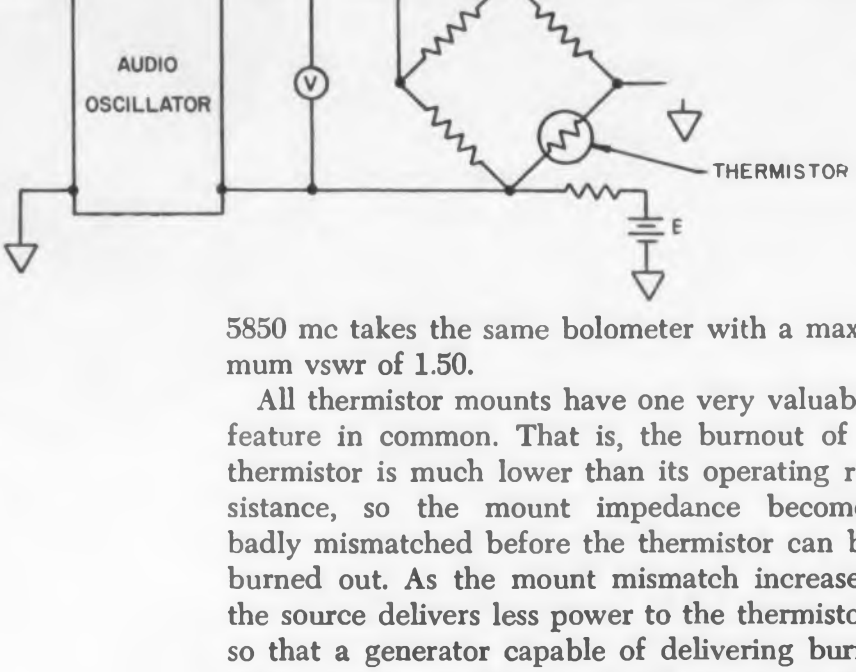

Fig. 3. Self-balancing power bridge.

5850 mc takes the same bolometer with a maximum vswr of 1.50.

All thermistor mounts have one very valuable feature in common. That is, the burnout of a thermistor is much lower than its operating resistance, so the mount impedance becomes badly mismatched before the thermistor can be burned out. As the mount mismatch increases, the source delivers less power to the thermistor, so that a generator capable of delivering burnout power to a matched load will not necessarily burn out the thermistor beads. Several hundred milliwatts are required before burnout occurs.

Power Measuring Techniques

Once the thermistor element and the matched thermistor mount is available, all that remains to make rf power measurements is the appropriate metering circuitry. Two basic types of bridge networks can be used for this purpose. One is a dc Wheatstone bridge that requires manual adjustment to obtain the information necessary to read power; the other is a self-balanced bridge circuit which is driven by an audio oscillator whose feedback depends upon the unbalance of the bridge. For the first approach, a dc Wheatstone bridge circuit similar to the one shown in Fig. 3 can be used. The thermistor forms one arm of the bridge, which is first balanced with no rf power into the mount. The value R_A is observed, and then rf power is permitted to flow into the mount. The change in R_A (ΔR_A) which is necessary to return the bridge to balance is observed. From the following relation, which is based upon the difference of dc power in the thermistor with the rf power on and off, the rf power can be determined.

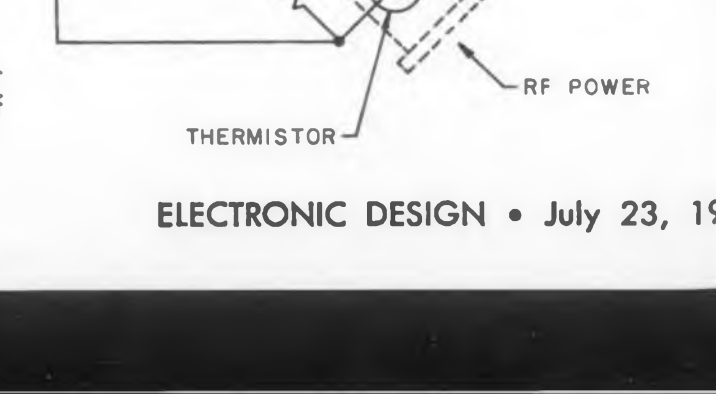

Fig. 4. D-C bridge circuit for measuring r-f power.

$$rf\ power = \frac{V^2 R \Delta R_A \left(R_A + R + \frac{\Delta R_A}{2}\right)}{2 (R_A + R)^2 (R_A + R + \Delta R_A)^2}$$

Instead of measuring resistances, changes in currents or voltages can be used to determine the power. The meters employed can even be calibrated in terms of power although the calibration may be nonlinear. In any case, this method is not as convenient as that which uses a self-balancing bridge circuit.

The components of a self-balanced bridge are essentially those shown in Fig. 4. The circuit consists of a Wheatstone bridge, high-gain audio amplifier with a voltmeter across the output, feedback circuit to provide for oscillations, and a dc bias network. The thermistor, which is placed in one arm of the bridge, has an initial resistance higher than the operating resistance of the bridge. The large feedback factor of the circuit permits large amplitude oscillations which rapidly reduce the thermistor resistance. Equilibrium occurs when the thermistor resistance is slightly larger than the operating resistance of the bridge. The oscillation frequency of most commercial bridges available is in the order of 10.5 kc. Since the bridge circuit tends to maintain the thermistor resistance at its specified operating value, an increase of rf or dc power into the element would cause an equivalent decrease of audio power. This decrease in audio power is used to determine rf power. The voltmeter circuit across the output of the oscillator measures the average bridge voltage. A dc current is supplied to the meter in the forward direction, and rectified audio is applied in the reverse direction. Therefore, for a decrease in audio signal, an up-scale deflection occurs. The voltmeter scale is calibrated in power units. For any range of measurements, dc bias current is adjusted so that the rectified audio reverse current bucks out the forward dc current in the meter. The audio power, which is then at a known level, decreases as the thermistor is exposed to rf energy. The meter deflects up-scale, thereby giving the rf power reading directly.

Situations will arise when powers greater than the thermistor power ratings are to be measured. In these cases, precision attenuators and directional couplers can be used to reduce the power by an accurately known ratio. Extremely accurate coaxial and waveguide directional couplers and waveguide attenuators are commercially available for such purposes.

References

1. Extremely Broadband Component Development, Final Report Contract No. DA 36-039-SC-42662, Signal Corps Engineering Labs, Fort Monmouth, N. J.
2. Broadband Ridged Waveguide Components Final Report Contract No. AF 30(602)-1426. RADC, Griffiss Air Force Base, Rome, N. Y., pp 24-25; 50-54

INSULATING PROBLEM?

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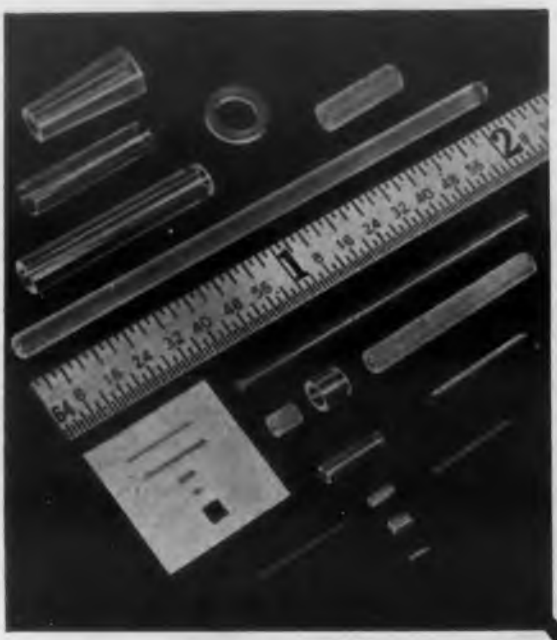

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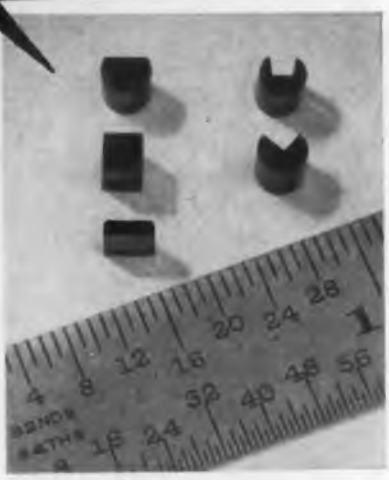

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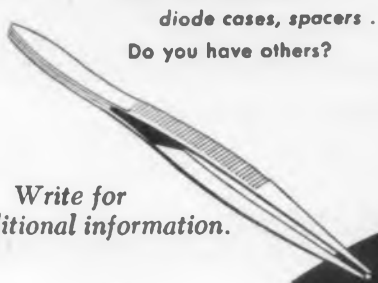

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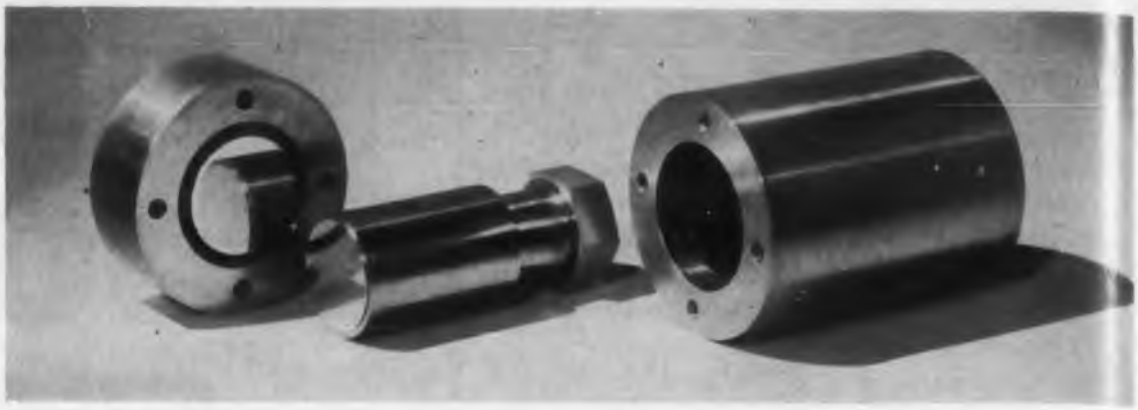


Magnetostriction-driven capacitor chops dc input at 8 kc. Result: input to amplifier has infinite impedance to dc, bandwidth of instrument runs from zero to 1 kc. Optically-flat (mirror surface) capacitor plates keep two mil average spacing.

Magnetostriction chopper makes

Infinite Z Amplifier

FREQUENCY stability and wide bandwidth in this dc amplifier are obtained by a unique high frequency chopper. A magnetostrictive element varies the spacing between two capacitive plates of classic configuration (see photo). Moving parts—but no friction.

Since the bandpass of dc amplifiers that convert the signal to ac is limited to about one fourth the chopper frequency, many manufacturers have eschewed mechanical choppers altogether and gone to solid state switching. Slow, continuous aging and heat sensitivity make transistors for this use a not-unmixed blessing: once-a-week calibration of the amplifier may be unsatisfactory.

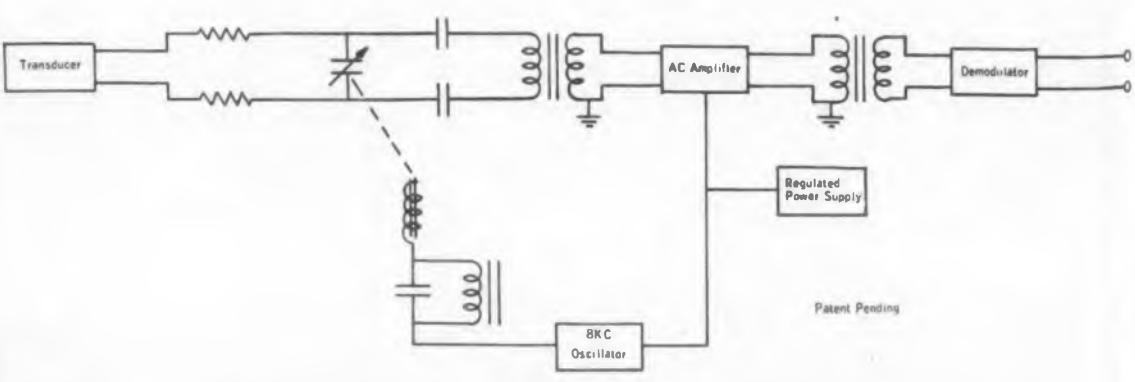


Fig. 1. Amplifier has a differential input and a floating output. Common mode rejection is 100,000 to 1.

Mechanical choppers, on the other hand, are susceptible to wear and result in limited bandpass. The frequency range is generally extended by crossover networks.

Video Instruments, 3002 Pennsylvania Ave., Santa Monica, Calif., resolved the problem by driving a magnetostrictive element with eight kc energy. Bandpass of the Model 74 is 0 to 1 kc with no crossover networks and zero drift is better than 0.1 per cent of full scale after warm-up.

Input impedance is infinite to dc.

Clearly there is no electrical continuity from one side of the magnetostrictive capacitor to the other. Fig. 2 shows the basic patent schematic. An average two mil spacing is maintained between the optically-flat plates. A hermetic seal eliminates dust and oxidation.

The Video Model 74 has a differential input, isolated from ground, with a 0 to ±50 mv capacity. The zero to ±5 v, 20 ma max output is floating—either side or no side can be grounded. Output impedance is two ohms or less. Common mode rejection of the amplifier is 100,000 to 1 for common mode signals up to 100 v.

Gain can be as high as 1,000, and dc linearity is better than 0.2 per cent. Recovery time from overloads is less than 1 msec. The instrument is designed to work in a 60 to 120 F temperature range; its power requirements are 110 v ac, 60 to 400 cps, unregulated. A 28 v dc amplifier can be obtained on special order.

Note that in contrast to most transistorized amplifiers which may have a quiescent current on the order of 0.04 μa, the Model 74 has no quiescent current flowing through the input circuit.

For further information on this wideband dc amplifier turn to the Reader-Service card and circle 268.

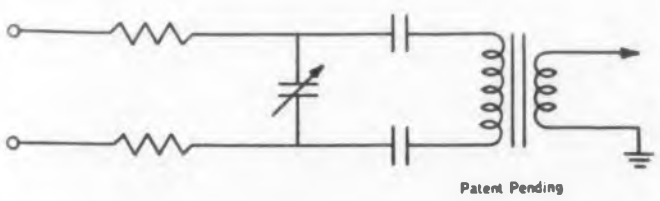


Fig. 2. Schematic shows input to Video Model 74 dc amplifier. Lack of quiescent current in input circuit is a bonus achieved by the physical separation of the capacitor plates.

Clever Mechanical

WE EXPECT at least one really good idea in each piece of equipment we analyze. But when we see something with a whole slew of good ideas—well, we write about it.

In Voldicon, a transistorized analog to digital converter, we found:

- A host of clever mechanical contrivances make the equipment more reliable, less expensive, and easier to repair.
- Interchangeable printed circuit modules make for a wide variety of special purpose conversions, or different display representations.
- A clever counting technique.

How It Counts

Designed by Adage, Inc., 292 Main St., Cambridge, Mass., Voldicon doesn't use a fixed program of successive approximations.

It counts through each decade, most significant decade first. While counting through any decade, lower order decades are set to 9. When the advancing count results in a number in the register, greater than the input, a "shift" pulse sets the succeeding decade to zero. Counting then proceeds in that decade. At balance, a "stop" pulse is generated.

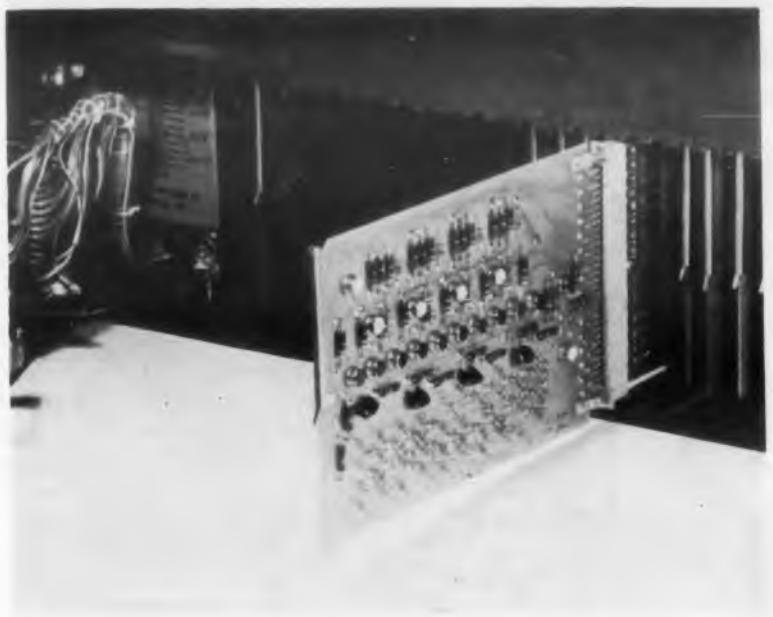
Here are the steps in balancing against an input of 0.231 v.

099
199
299
Shift
209
219
229
239
Shift
230
231
Stop

Before these steps, Voldicon first determines the polarity of the input by setting the register to 000 and examining the polarity of the error point. Next, it sets the register to 999 to make an overload test. If the input does not exceed 999, it goes through the balancing procedure.

More information is available if you turn to the Reader-Service card and circle 193.

and Electrical Design— *The Perfect Marriage*



The housing is a green sand aluminum casting instead of sheet metal. It carries half the price tag of sheet metal. It can be drilled and tapped, and is available from the foundry on a few days' notice. Grooves in the floor and ceiling guide p-c cards into position for insertion.

(Right) The universal chassis extender takes any card and pokes it out where you can work on it while the converter is operating.

An ejection lever pops cards out of their mating connectors with very little force. Without it, some 30 or 40 pounds of horizontal pull might be needed.

(Below) Foolproof coding and keying for cards and receptacles. Orientation of the coding socket on the p-c card and the sleeve over the pin on the receptacle prevents jamming a card into the wrong connector, or sticking it in upside down. It guides the right card home and prevents "over-seating." Top and bottom of cards and connectors are coded.

Wrong card.

That's not right, either.

Ah—there we go.

NEW PRODUCTS

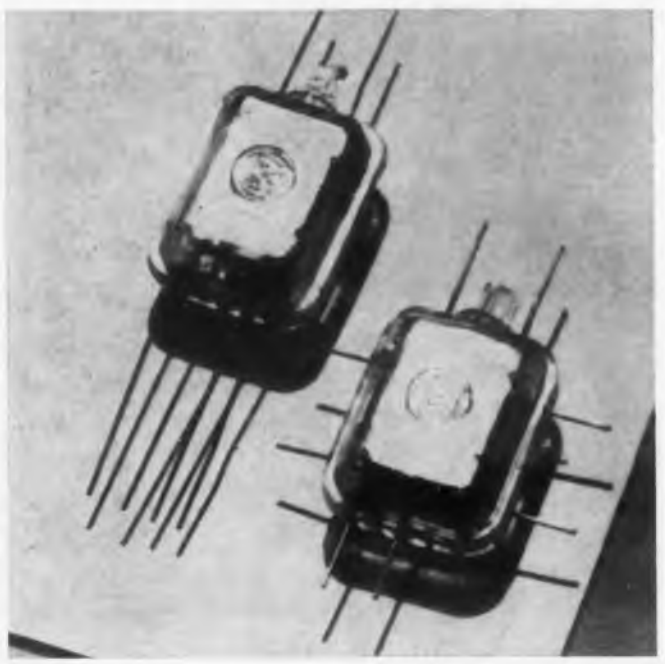
To provide a complete coverage of ALL new products generally specified when designing electronic original equipment, the New Product section has been extended. To include the largest number of items, products which are best suited to a brief description have been noted at the end of the section.

PRECISION BEARING

An electromagnetic device oscillates the outer ring of the supporting bearings in this device, reducing the starting torque to a point where it is equal to the running torque. Called the Model D-3 Dynamic bearing, the unit is used in gyro gimbals and platforms where a low-torque support is needed. The bore measures 0.1875 in. Torque rating is below 25 dynecentimeters, with no increase in torque after 1000 hours of operation.

The Barden Corp., Dept. ED, Danbury, Conn.

CIRCLE 43 ON READER-SERVICE CARD



RECEIVING TUBES

The "match box" design of these tubes provides a more reliable, miniature form of the common receiving tube. Electrode structure is conventional, but the shape of the tube permits a mounting structure integral with the envelope, reducing microphonism and improving vibration and shock resistance. The tube may be strapped onto a printed circuit board, the strap serving as an efficient heat sink. Leads are better spaced, minimizing interaction between input and output.

Westinghouse Electric Corp., Electronic Tube Div., Dept. ED, Elmira, N.Y.

CIRCLE 44 ON READER-SERVICE CARD

CURRENT BRIDGE

Supplying precisely-known dc currents, model 500 current bridge has such uses as calibrating meter movements and galvanometers, or testing relay drop-out and pull-in. The unit will supply either single-ended or differential current output up to a maximum of 100 ma. A standard cell and precision bridge circuit allow measurement to a full-scale accuracy of 0.25 per cent. The bridge setting may be read to four significant figures. Two output ranges, 0 to ±10 ma and 0 to ±100 ma, are provided.

American Measurement & Control, Inc., Dept. ED, 240 Calvary St., Waltham 54, Mass.

CIRCLE 45 ON READER-SERVICE CARD

SILICON DIODES

Used for fast switching where current and temperature requirements exceed capabilities of germanium diodes. All units in the S-130 series handle a switching current over 0.5 amp at 25 C ambient. Maximum recovery time is 0.8 μsec, in switching a 500 ma, 2 μsec pulse to −50 v. Operating temperature range is −65 to +150 C. Forward conductance is such that the units develop less than 1 v drop at 400 ma in a 25 C ambient under dc conditions.

Sperry Rand Corp., Sperry Semiconductor Div., Dept. ED, South Norwalk, Conn.

CIRCLE 46 ON READER-SERVICE CARD

NEW PRODUCTS

Transistor Logic Elements

For synthesis of digital systems

Containing all circuit types required for synthesis of digital systems, these transistor logic circuits and networks are designed for 100 kc operation and for use from −55 to +75 C. They are packaged in encapsulated plug-in modules for in line or 9-pin miniature tube socket mounting.

Epsco, Inc., Components Div., Dept. ED, 108 Cummington St., Boston, Mass.

CIRCLE 48 ON READER-SERVICE CARD

TWT Solenoid

Provides flux of 600 gauss

Type 39803 solenoid was designed to produce a flux of 600 gauss for focusing traveling wave tubes. The solenoid proper is 7-1/2 in. long and has a circular opening of 1-1/2 in. Weighing 13 lbs, it produces full flux field with an input power of 100 to 125 w. A small built-in blower keeps the temperature rise to 65 C.

New York Transformer Co., Inc., Dept. ED, Alpha, N.J.

CIRCLE 49 ON READER-SERVICE CARD

◀ CIRCLE 50 ON READER-SERVICE CARD

Filters

Cut off frequencies to 100 kc

These Chebishev type high pass and low pass electrical wave filters come with cut off frequencies up to 100 kc. Featuring high attenuation, low insertion loss, and stability over a wide temperature range, they are available in epoxy molded or hermetically sealed construction.

Polyphase Instrument Co., Dept. ED, E. 4th St., Bridgeport, Pa.

CIRCLE 51 ON READER-SERVICE CARD

Junction Transistors

Germanium alloy type

A series of germanium alloy junction transistors are available for use in military and industrial computers. The 2N578, 2N579, and 2N580 are pnp types for use in high-current switching circuits. Maximum collector current rating is —400 ma, and minimum alpha-cutoff frequencies are 3, 5, and 10 mc respectively.

For medium-speed switching circuits, pnp types 2N581 and 2N583, and npn type 2N585 are available. Maximum collector-to-base voltage rating for the pnp types is —18 v; for the npn type, 25 v.

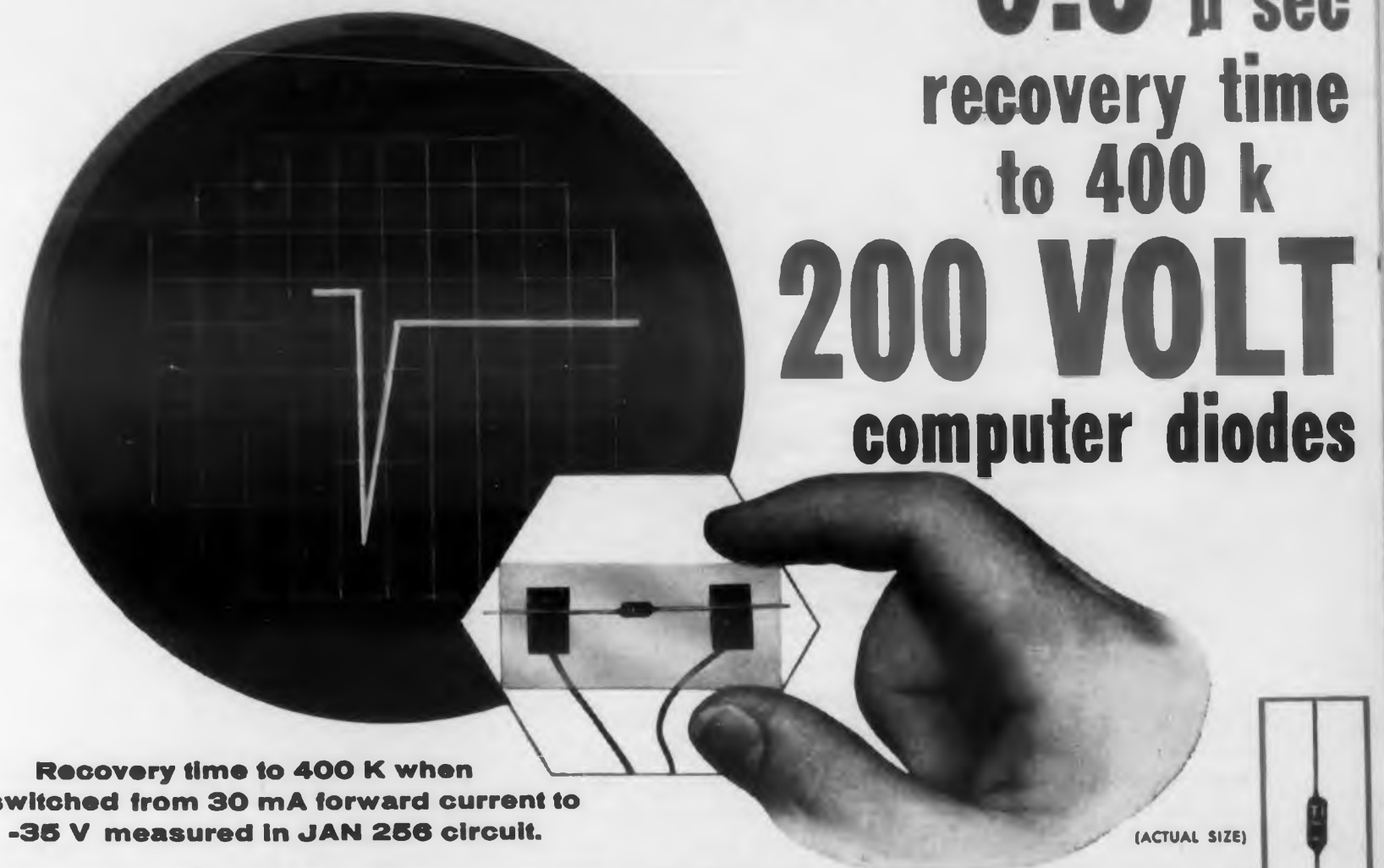
The pnp types 2N582 and 2N584 are for high-speed switching circuits. They feature a minimum alpha-cutoff frequency of 14 mc, and a minimum current transfer ratio of 40 with a collector current of —20 ma.

Radio Corporation of America, Semiconductor Div., Dept. ED, Somerville, N.J.

CIRCLE 52 ON READER-SERVICE CARD

CIRCLE 53 ON READER-SERVICE CARD

T/I diffused silicon 0.3 μ sec recovery time to 400 k 200 VOLT computer diodes



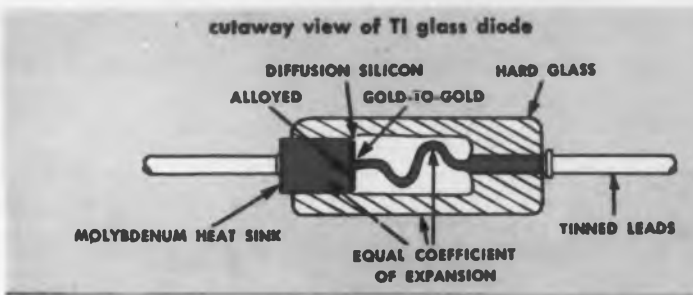
Recovery time to 400 K when switched from 30 mA forward current to -35 V measured in JAN 256 circuit.

(ACTUAL SIZE)

TI diffused silicon computer diodes give you 0.3 μ sec maximum recovery time at 400 K with PIV ratings to 200 volts.

For your computer applications, TI hard glass diodes provide 100 mA average rectified forward current at 25°C. All units are rated to meet military requirements, and provide fast recovery, higher conductance ratings, and shock-proof reliability.

Check the characteristics below and specify TI diodes for all your computer applications.



Also in this same glass package, TI general purpose diodes

max ratings	1N645	1N646	1N647	1N648	1N649	
PIV	225	300	400	500	600	V
I_O	400	400	400	400	400	mA
I_O	150	150	150	150	150	mA
i_f	1.25	1.25	1.25	1.25	1.25	amp
P	600	600	600	600	600	mW
I_{DC}	3	3	3	3	3	Amp
T_A	—65 to +150					°C
specifications						
V_Z	275	360	480	600	720	V
LI_b	0.2	0.2	0.2	0.2	0.2	μA
LI_b	15	15	20	20	25	μA
E_b	1.0	1.0	1.0	1.0	1.0	V
C	9	9	9	9	9	μμf

maximum ratings	1N659	1N660	1N661	
Peak Inverse Voltage at —65 to +150°C	50	100	200	V
Average Rectified Forward Current at +25°C	100	100	100	mA
Average Rectified Forward Current at +150°C	30	30	30	mA
Recurrent Peak Forward Current at +25°C	320	320	320	mA
Operating Temperature, Ambient	—65 to +150			°C
Altitude	100,000			ft
specifications				
Minimum Breakdown Voltage at +100°C	60	120	240	V
Maximum Reverse Current at PIV at +25°C	5	5	10	μA
Maximum Reverse Current at PIV at +100°C	25	50	100	μA
Maximum Voltage Drop at I_O = 6mA at 25°C	1	1	1	V
Maximum Reverse Recovery Time*	0.3	0.3	0.3	μsec
Typical Capacitance at —10V at 1 mc	2.7	2.7	2.7	μμfd

Recovery time to 400K when switched from 30 mA forward current to —35V. Measurement made with a Hauman ND-1 standard pulse recovery test set approved by JETEC-14 and described in JAN-256.

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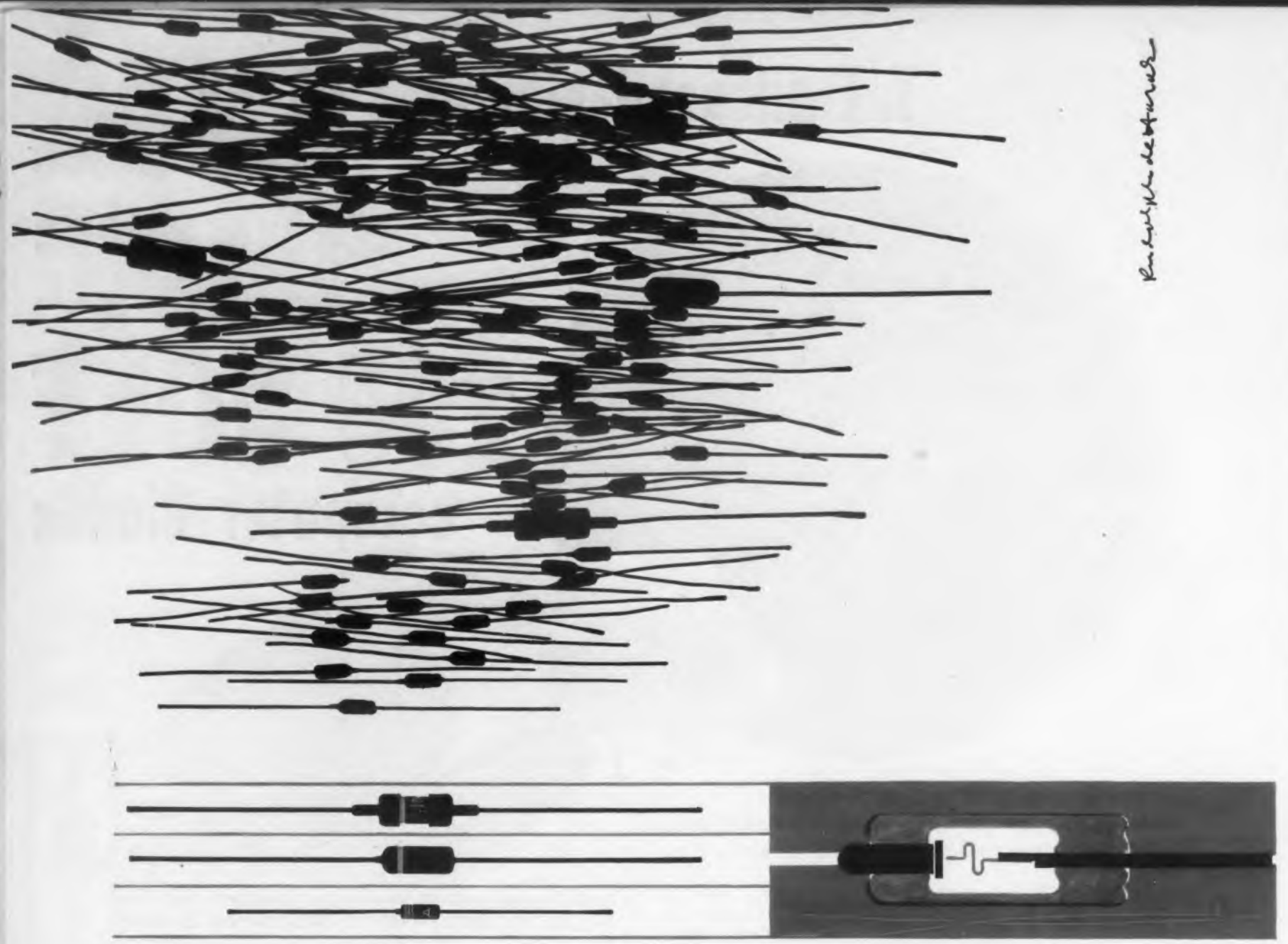

MINIATURE *all-glass technique...*

point-contact or gold-bonded

construction... available with

solder-in leads or clip-in studs.

SUBMINIATURE *all-glass technique...*

copper heat-sink...

available on standardized tape

for automatic insertion.

AVAILABLE TYPES *standard EIA or*

to your own specifications.

FOR QUALITY IN QUANTITY ASK AMPEREX

the industry's
reliable source of
germanium and silicon diodes
for computers,
radio... tv... hi-fi
and other professional or
consumer applications

Amperex® electronic corp.
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IN CANADA:
ROGERS ELECTRONIC TUBES & COMPONENTS
11-19 Brentcliffe Road, Leaside, Toronto 17, Ont.

NEW PRODUCTS

Antenna Rotator

Handles 200-lb antennas

This power-driven antenna rotator, called the VAR variable speed antenna rotator, will accommodate antennas weighing up to 200 lbs. It will simultaneously tilt the antenna up to 180 deg and rotate 720 deg at variable speeds up to 30 deg per sec for fast tracking in any direction. Acceleration is 30 deg per sec^2.

Houston Fearless Corp., Dept. ED, 11857 W. Olympic Blvd., Los Angeles 64, Calif.

CIRCLE 54 ON READER-SERVICE CARD

Pressure Transducer

Measure one cubic in.

Series 1000 pressure transducers occupy one cubic in. of space and are available with an output signal which varies linearly or non-linearly with pressures over ranges of from 0-10 to 0-50 psi. The units use a precision carbon film resistance element requiring minimum brush pressure. Resistance values range up to 10,000 ohm. Best linearity is 0.4 per cent.

Computer Instruments Corp., Dept. ED, 92 Madison Ave., Hempstead, N.Y.

CIRCLE 55 ON READER-SERVICE CARD
CIRCLE 56 ON READER-SERVICE CARD
CIRCLE 273 ON READER-SERVICE CARD

New Data!

silicon & germanium

diodes and rectifiers

These pages contain condensed specifications for the PSI ever-broadening line of semiconductor products. Continued development has led to new products, new packaging methods... recent additions include the PSI *Varicap* (voltage-variable capacitor), three MIL types of silicon fast recovery diodes, and high voltage (1–3,000v) rectifiers.

Detailed specifications and characteristic curves are available from your nearby PSI distributor or regional sales office.

Pacific Semiconductors, Inc.

HERE'S YOUR COPY!

Pull out—save for your files

PSI T.M.

Silicon **Fast Recovery** *Diodes*

(Diffusion computer diodes)

ACTUAL SIZE

PSI or EIA TYPE NUMBER	Minimum Saturation Voltage *@ 100 μa (volts)	Minimum Forward Current mA @ v	Maximum Reverse Current (μa)		Reverse Recovery Characteristics	
			25°C	100°C	Reverse Resistance (ohms)	Maximum Recovery Time (μS)
PS 720	30	3 @ 1	5 (20v)	25 (20v)	100K	0.5[1]
PS 721	60	5 @ 1	5 (45v)	50 (45v)	100K	0.3[1]
PS 722	100	5 @ 1	5 (75v)	50 (75v)	100K	0.3[1]
PS 723	200	3 @ 1	20 (175v)	100 (175v)	100K	0.3[1]
PS 724	150	4 @ 1	20 (125v)	100 (125v)	100K	0.3[1]
1N 625	30	4 @ 1.5	1 (10v) 10 (20v)	50 (20v)	400K	1 μsec[2]
1N 626	50	4 @ 1.5	20 (35v)	100 (35v)	400K	1 μsec[2]
1N 627	100	4 @ 1.5	20 (75v)	100 (75v)	400K	1 μsec[2]
1N 628	150	4 @ 1.5	20 (125v)	100 (125v)	400K	1 μsec[2]
1N 629	200	4 @ 1.5	20 (175v)	100 (175v)	400K	1 μsec[2]
MILITARY TYPES						
1N 643 Mil-T-1/ 12679 SigC	200	10 @ 1	.025 (10v) 1 (100v)	5 (10v) 15 (100v)	200K	0.3[1]
1N 662 Mil-E-1/ 1139 SigC	100	10 @ 1	1 (10v) 20 (50v)	20 (10v) 100 (50v)	100K	0.5[1]
1N 663 Mil-E-1/ 1140 SigC	100	100 @ 1	5 (75v)	50 (75v)	200K	0.5[1]

*Maximum DC working inverse voltage is 85% of minimum saturation voltage.

OTHER SPECIFICATIONS:

Peak Pulse Current—1 μsec, 1% duty cycle; 2.0 Amps. Typical Inverse Capacitance at −10v: 3 μμf. Storage and Operating Temperature Range: −65°C to 150°C.

1. After switching from 5mA forward current to 40v reverse voltage (10v reverse voltage for PS720), reverse resistance reaches stated value in stated time.

2. Measured in modified IBM "Y" recovery circuit, switching from 30mA to −35v.

Silicon **General Purpose** *Diodes*

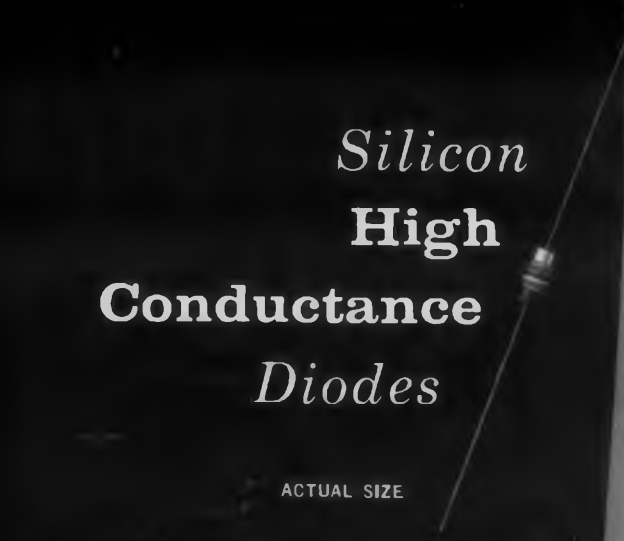
ACTUAL SIZE

EIA TYPE NUMBER	Minimum Saturation Voltage @ 100 μa @ 25°C (volts)	Minimum Forward Current @ +1.0 VDC @ 25°C (mA)	Maximum Inverse Current at Maximum DC Operating Voltage (μa @ volts)		Maximum Average Rectified Current (mA)	
			@ 25°C	@ 150°C	@ 25°C	@ 150°C
1N456	30	40	.025 @ 25	5 @ 25	90	
1N456A	30	100	.025 @ 25	5 @ 25	200	70
•1N457	70	20	.025 @ 60	5 @ 60	75	
1N457A	70	100	.025 @ 60	5 @ 60	200	70
•1N458	150	7	.025 @ 125	5 @ 125	55	
1N458A	150	100	.025 @ 125	5 @ 125	200	70
•1N459	200	3	.025 @ 175	5 @ 175	40	
1N459A	200	100	.025 @ 175	5 @ 175	200	70
1N461	30	15	.5 @ 25	30 @ 25	60	
1N461A	30	100	.5 @ 25	30 @ 25	200	70
1N462	70	5	.5 @ 60	30 @ 60	50	
1N462A	70	100	.5 @ 60	30 @ 60	200	70
1N463	200	1	.5 @ 175	30 @ 175	30	
1N463A	200	100	.5 @ 175	30 @ 175	200	70
1N464	150	3	.5 @ 125	30 @ 125	40	
1N464A	150	100	.5 @ 125	30 @ 125	200	70

•JAN Types

OTHER ABSOLUTE MAXIMUM RATINGS:
Power Dissipation 0.5 Watts @ 25°C. Power Dissipation 0.25 Watts @ 150°C. 1 Second Surge Current 1.5 Amperes 25°C. Storage and Operating Temperature Range —80 °C to 200°C.

Silicon **High Conductance** *Diodes*



ACTUAL SIZE

PSI or EIA TYPE NUMBER	Minimun Saturation Voltage @ 100 μa @ 25°C (volts)	Maximum Forward Voltage DC @ 25°C (volts)		Maximum Inverse Current at Maximum DC Operating Voltage (μa @ volts)		Maximum Average Rectified Current (mA)	
		@ 100 mA	@ 200 mA	@ 25°C	@ 150°C	@ 25°C	@ 150°C
1N482	40	1.1		.250 @ — 30v	30	125	50
1N482A	40	1.0		.025 @ — 30v	15	200	70
1N482B	40	1.0		.025 @ — 30v	5	200	70
PS603	40		1.0	.250 @ — 30v	30	200	100
PS604	40		1.0	.025 @ — 30v	15	200	100
PS605	40		1.0	.025 @ — 30v	5	200	100
1N483	80	1.1		.250 @ — 60v	30	125	50
1N483A	80	1.0		.025 @ — 60v	15	200	70
1N483B	80	1.0		.025 @ — 60v	5	200	70
PS609	80		1.0	.250 @ — 60v	30	200	100
PS610	80		1.0	.025 @ — 60v	15	200	100
PS611	80		1.0	.025 @ — 60v	5	200	100
1N484	150	1.1		.250 @ —125v	30	125	50
1N484A	150	1.0		.025 @ —125v	15	200	70
1N484B	150	1.0		.025 @ —125v	5	200	70
PS615	150		1.0	.250 @ —125v	30	200	100
PS616	150		1.0	.025 @ —125v	15	200	100
PS617	150		1.0	.025 @ —125v	5	200	100
1N485	200	1.1		.250 @ —175v	30	125	50
1N485A	200	1.0		.025 @ —175v	15	200	70
1N485B	200	1.0		.025 @ —175v	5	200	70
PS621	200		1.0	.250 @ —175v	30	200	100
PS622	200		1.0	.025 @ —175v	15	200	100
PS623	200		1.0	.025 @ —175v	5	200	100
1N486	250	1.1		.250 @ —225v	50	125	50
1N486A	250	1.0		.050 @ —225v	25	200	70
1N486B	250	1.0		.050 @ —225v	10	200	70
PS627	250		1.0	.250 @ —225v	50	200	100
PS628	250		1.0	.050 @ —225v	25	200	100
PS629	250		1.0	.050 @ —225v	10	200	100
1N487	330	1.1		.250 @ —300v	50	125	50
1N487A	330	1.0		.100 @ —300v	25	200	70
PS632	330		1.0	.250 @ —300v	50	200	100
PS633	330		1.0	.100 @ —300v	25	200	100
1N488	420	1.1		.250 @ —380v	50	125	50
1N488A	420	1.0		.100 @ —380v	25	200	70
PS636	420		1.0	.250 @ —380v	50	200	100
PS637	420		1.0	.100 @ —380v	25	200	100

OTHER ABSOLUTE MAXIMUM RATINGS:
Maximum Power Dissipation 0.5 Watts @ 25°C. Maximum Power Dissipation 0.25 Watts @ 150°C. Maximum 1 Second Surge Current 1.5 Amperes @ 25°C. Storage and Operating Temperature Range —80° to 200° C.

Varicap *Voltage Variable Capacitors*

ACTUAL SIZE

Varicap Type	Capacitance @ 4VDC μμf	Capacitance Approx. Range (μμf)	Capacitance △ C * Ratio	Quality Factor (Q) @ 50 mc. Minimum @ 4VDC	Quality Factor (Q) @ 50 mc. Typical @ 4VDC	Quality Factor (Q) @ 50 mc. Typical @ MWV	Maximum Working Voltage (MWV) Volts D.C.
MODULATION & AFC APPLICATIONS							
V-20	20	10-50	(5/1)	7.0	18.7	29.4	20
V-27	27	14-70	(5/1)	7.0	15.7	24.7	20
V-33	33	17-85	(5/1)	7.0	14.6	22.9	20
V-39	39	20-100	(5/1)	7.0	15.1	24.2	20
V-47	47	24-120	(5/1)	7.0	15.4	24.2	20
V-56	56	30-150	(4.5/1)	7.0	13.5	21.2	15
V-68	68	38-170	(4.5/1)	9.0	14.0	22.0	15
V-82	82	47-210	(4.5/1)	9.0	13.0	20.4	15
V-100	100	57-260	(4.5/1)	8.0	11.0	17.3	15
TUNING APPLICATIONS							
V-7E	7	1.5-18.0	(12/1)	3.0	4.5	22.5	100
V-10E	10	2.0-24.0	(12/1)	3.5	5.5	27.5	100
V-12E	12	2.5-30.0	(12/1)	4.0	6.5	32.5	100
V-15E	15	3.0-36.0	(12/1)	4.5	7.5	37.5	100
V-20E	20	5.0-52.5	(10.5/1)	7.0	18.7	78.5	70
V-27E	27	7.0-70.0	(10/1)	7.0	15.7	63.5	65
V-33E	33	9.0-85.0	(9.5/1)	7.0	14.6	56.5	60
V-39E	39	11.0-100.0	(9/1)	7.0	15.1	55.8	55
V-47E	47	14.0-120.0	(8.5/1)	7.0	15.4	53.8	50
V-56E	56	19.5-155.0	(8/1)	7.0	13.5	41.8	40

* △ C is the ratio of the capacitance at 0.1 VDC to the capacitance at the maximum inverse working voltage.

Silicon **Subminiature** *Rectifiers*

ACTUAL SIZE

400 MILLIAMPERE EIA TYPES					400 mA @ 25°C—150 mA @ 150°C		
EIA TYPE	Peak Recurr. Inverse Voltage @ 150°C (v)	Max. RMS Input Voltage[1] @ 150°C (v)	Maximum Avg. Rectified Current (mA)[1]		Maximum Reverse Current @ PIV (μa)		Maximum Voltage Drop[2] 25°C (v)
			@ 25°C	@ 150°C	@ 25°C	@ 100°C	
1N645	225	160	400	150	0.2	15	1.0
1N646	300	210	400	150	0.2	15	1.0
1N647	400	280	400	150	0.2	20	1.0
1N648	500	350	400	150	0.2	20	1.0
1N649	600	420	400	150	0.2	25	1.0

1. Resistive or inductive load.
2. Averaged over one cycle for full wave resistive or choke input circuit with rectifier operating at full rated current and maximum RMS input.

Storage and Operating Temperature Range —65°C to 200°C.

400 MILLIAMPERE PSI TYPES				400 mA @ 25°C—150 mA @ 150°C	
	MAXIMUM RATINGS @ 100°C			ELECTRICAL CHARACTERISTICS	
PSI TYPE NUMBER	Peak Recurr. Inverse Voltage (volts)	Maximum RMS Input Voltage[1] (volts)	Maximum Average Rectified Current[1] (mA)	DC Forward Voltage @ Specified Current @ 25°C (volts @ mA)	Maximum Average Inverse Current[2] @ 100°C (μa)
TYPE		@ 150°C		@ 25°C	@ 150°C
PS 405	50	35	150	1.5 @ 500	500
PS 410	100	70	150	1.5 @ 500	500
PS 415	150	105	150	1.5 @ 500	500
PS 420	200	140	150	1.5 @ 500	500
PS 425	250	175	150	1.5 @ 500	500
PS 430	300	210	150	1.5 @ 500	500
PS 435	350	245	150	1.5 @ 500	500
PS 440	400	280	150	1.5 @ 500	500
PS 450	500	350	125	1.5 @ 500	500
PS 460	600	420	125	1.5 @ 500	500

250 MILLIAMPERE PSI TYPES				250 mA @ 25°C—125 mA @ 100°C	
PS 005	50	35	125	1 @ 100	100
PS 010	100	70	125	1 @ 100	100
PS 015	150	105	125	1 @ 100	100
PS 020	200	140	125	1 @ 100	100
PS 025	250	175	125	1 @ 100	100
PS 030	300	210	125	1 @ 100	100
PS 035	350	245	125	1 @ 100	100
PS 040	400	280	125	1 @ 100	100
PS 050	500	350	125	1 @ 100	100
PS 060	600	420	125	1 @ 100	100

Silicon **Very High Voltage Cartridge** *Rectifiers*

¼ ACTUAL SIZE

ELECTRICAL SPECIFICATIONS		Absolute Max. Rtgs. H/W Res. Load at 75° C Ambient		Electrical Characteristics @ 25° C Ambient	
EIA TYPES	"L" Length Inches	Peak Inverse Voltage (v)	Maximum Rectified DC output Cur. (mA)	Forward DC volt drop @ Rated DC Cur. (v)	Reverse DC Cur. @ Rated PIV (mA)
1N1139	4 5/16	3600	65	27.0	.025
1N1141	4 5/16	4800	60	36.0	.025
1N1143	4 5/16	6000	50	45.0	.025
1N1144	6 1/16	7200	50	54.0	.025
1N1146	6 1/16	8000	45	60.0	.025
1N1147	6 1/16	12000	45	60.0	.025
1N1148	6 1/16	14000	50	52.0	.025
1N1149	6 1/16	16000	45	60.0	.025

Storage and Operating Temperature Range —55°C to 150°C.

Silicon **High Voltage** *Rectifiers*

ACTUAL SIZE

EIA TYPE NUMBER	Peak Inverse Voltage @ 25 & 100°C (volts)	Continuous DC Voltage @ 25 & 100°C (volts)	Average Rectified Current (Amps) @ 25°C	Average Rectified Current (Amps) @ 100°C	RMS Input Voltage @ 25 & 100°C (volts)	Max. DC Fwd. Voltage Drop @ 100mA DC 25°C
1N1730	1000	1000	200	100	700	5
1N1731	1500	1500	200	100	1050	5
1N1732	2000	2000	200	100	1400	9
1N1733	3000	3000	150	75	2100	12

Maximum DC Reverse Current @ Rated PIV—25°C: 10μA; 100°C: 100μA.
Maximum Surge Current (8msec.) @ 25 & 100°C—2.5 Amps.
Dimensions:

Length—1N1730 and 1N1731: .50", 1N1732 and 1N1733: 1.0"
Diameter—1N1730, 1N1731 and 1N1732: .375", 1N1733: .50"
Leads: .030" diam., 1¼" long on all units.

Silicon **Miniature** *Rectifiers*

ACTUAL SIZE

Germanium **Point Contact** *Diodes*

ACTUAL SIZE

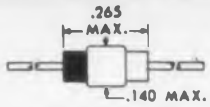
500 MILLIAMPERE TYPES			500 mA @ 25°C—200 mA @ 150°C		
	MAXIMUM RATINGS @ 150°C			ELECTRICAL CHARACTERISTICS	
PSI TYPE NUMBER	Peak Recurr. Inverse Voltage (volts)	Maximum RMS Input Voltage[1] (volts)	Maximum Average Rectified Current[1] (mA)	DC Forward Voltage @ Specified Current @ 25°C (volts @ mA)	Maximum Average Inverse Current[2] @ 150°C (μa)
PS 105	50	35	200	1.5 @ 500	500
PS 110	100	70	200	1.5 @ 500	500
PS 115	150	105	200	1.5 @ 500	500
PS 120	200	140	200	1.5 @ 500	500
PS 125	250	175	200	1.5 @ 500	500
PS 130	300	210	200	1.5 @ 500	500
PS 135	350	245	200	1.5 @ 500	500
PS 140	400	280	200	1.5 @ 500	500
PS 150	500	350	150	1.5 @ 500	500
PS 160	600	420	150	1.5 @ 500	500

		ELECTRICAL CHARACTERISTICS @ 25°C	MAXIMUM RATINGS @ 25°C	
PSI or EIA TYPE NUMBER	Minimum Forward Current @ +1V (mA)	Maximum Inverse Current @ Specified Inverse Voltage (mA @ volts)	Inverse Working Voltage (volts)	Inverse Saturation Voltage @ 1 mA (volts)
1N34A	5	0.03 @ 10 0.5 @ 50	60	75
1N38A	4	0.006 @ 3 0.5 @ 100	100	120
1N55B	5	0.500 @ 150	150	190
1N63	4	0.05 @ 50	100	125
1N67A	4	0.005 @ 5 0.05 @ 50	80	100
1N68A	3	0.625 @ 100	100	130
1N89	3.5	0.008 @ 5 0.1 @ 50	80	100
1N90	5	0.5 @ 50	60	75
1N95	10	0.5 @ 50	60	75
1N96	20	0.5 @ 50	60	75
1N97	10	0.008 @ 5 0.1 @ 50	80	100
1N98	20	0.008 @ 5 0.1 @ 50	80	100
1N99	10	0.005 @ 5 0.05 @ 50	80	100
1N100	20	0.005 @ 5 0.05 @ 50	80	100
1N116	5	0.1 @ 50	60	75
1N117	10	0.1 @ 50	60	75
1N118	20	0.1 @ 50	60	75
1N126*	5	0.05 @ 10 0.850 @ 50	60	75
1N127	3	0.025 @ 10 0.3 @ 50	100	125
1N128	3	0.01 @ 10	40	50
1N191	5	$R_b \geq$ 400K (−10v to −50v) @ 55°C. From 30mA fwd to −35v, $R_b \geq$ 50K in 0.5 μsec. 400K in 3.5 μsec. R_L = 2300 Ω.	70	
1N192	5	$R_b \geq$ 200K (−10v to −50v) @ 55°C. From 30mA fwd to −35v, $R_b \geq$ 50K in 0.5 μsec. 200K in 3.5 μsec. R_L = 2300 Ω.	70	
1N198*	4	0.01 @ 10 0.05 @ 50	80	100
	5	0.075 @ 10 @ 75°C 0.250 @ 50 @ 75°C	60 @ 75°C	
PS208	Note 1	0.02 @ 10 0.12 @ 60 After switching from 5 mA 1 μsec. forward pulse to −40V, back resistance must equal or exceed 80K in 0.3 μsec. Loop resistance = 2300 ohms	60	90
PS210	15	0.02 @ 20 0.1 @ 100	100	125
		0.15 @ 20 @ 55°C 0.3 @ 100 @ 55°C		
PS211	30	0.05 @ 50	60	75
		0.2 @ 50 @ 55°C		
PS214	5	0.01 @ 5	60	75

Note 1 — During 0.1 μsec. 50mA peak half-sine forward pulse (Maximum PRF = 100 KC.), forward voltage ≤ 3v. *JAN Type.

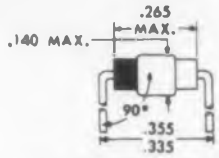
OTHER ABSOLUTE MAXIMUM RATINGS: Continuous DC Forward Current 55 mA @ 25°C. Average Rectified Current (60 cps) 40 mA @ 25°C. Peak Rectified Current 125 mA @ 25°C. 1 second Surge Current 350 mA @ 25°C. Storage and Operating Temperature Range −78°C to +90°C.

OTHER CHARACTERISTICS Shunt Capacitance @ −10 volts —Typical 0.35 μμf @ 25°C— Maximum 0.6 μμf @ 25°C.

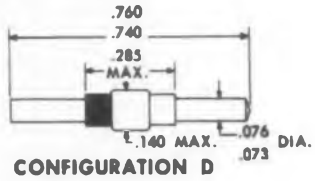


CONFIGURATION A

CONFIGURATION B



CONFIGURATION C



CONFIGURATION D

Physical Characteristics

HERMETICALLY SEALED—Glassed-to-metal fused and metal-to-metal welded seals.

TERMINALS — Tinned copper leads .020 inches diameter. Lead length 1¼ inch minimum.

MARKING—Cathode end designated by wide black band on shell (black band indicates positive bias on Varicaps). Type number designated by color bands on the body, reading from the cathode end.

ALL DIMENSIONS SHOWN IN INCHES.

Pacific Semiconductors, Inc.

10451 West Jefferson Boulevard, Culver City, California
TExas 0-6113 • TWX: Culver City Cal 7135

NEW YORK—2079 Wantagh Ave., Wantagh, Long Island, N.Y.
SUnset 1-7470 • TWX: Wantagh NY 2320

CHICAGO—6957 W. North Ave., Oak Park, Illinois
VIllage 8-9750 • TWX: OKP 1547

SEATTLE—Administration Bldg., Boeing Field, Seattle, Wash.

EXPORT—Pacific Semiconductors, Inc., 431 Fifth Avenue, New York 16, N.Y. • Cable: TELTECHNAL, NY

DISTRIBUTORS:

ALLIED RADIO, Chicago, Illinois
ALMO RADIO COMPANY, Philadelphia 7, Pennsylvania
CRAMER ELECTRONICS, INC., Boston 16, Massachusetts
DENVER ELECTRONIC SUPPLY CO., Denver, Colorado
ELECTRONIC SUPPLY CORP., Pasadena, California
ELECTRONIC INDUSTRIAL SALES, Washington 1, D. C.
PEERLESS RADIO DISTRIBUTORS, INC., Jamaica 33, New York
PENINSULA TV AND RADIO SUPPLY, San Jose, California
STANDARD SUPPLY COMPANY, Salt Lake City, Utah
TERMINAL RADIO CORPORATION, New York 7, New York
WHOLESALE ELECTRONIC SUPPLY, Dallas, Texas
WHOLESALE RADIO PARTS COMPANY, Baltimore 1, Maryland

Recording Systems

6- and 8-channel

A series of 6- and 8-channel direct writing oscillographic recording systems provide reduced size and improved performance and reliability. The 350 series have a frequency response flat to 100 cps at 10-division peak-to-peak amplitude and 3 db down at 120 cps.

Sanborn Co., Dept. ED, 175 Wyman St., Waltham 54, Mass.

CIRCLE 57 ON READER-SERVICE CARD

Pressure Switch

Snap action

An intermediate mechanical snap action in the 90000 series pressure switch insures trigger switching of the electrical switch element and prevents welding of contacts. For use with hydraulic fluids or compressed air, the unit comes in pressure settings from 5 to 4000 psi.

Hydraulic Research and Manufacturing Co., Dept. ED, 2835 N. Naomi St., Burbank, Calif.

CIRCLE 58 ON READER-SERVICE CARD

CIRCLE 59 ON READER-SERVICE CARD ➤

➤ CIRCLE 273 ON READER-SERVICE CARD

NEW PRODUCTS

Waveform Generator

For testing non-linear systems

For testing servomechanisms and automatic control systems, this function generator is designed particularly for experimental work on non-linear systems. Type LF51 low frequency waveform generator permits a comprehensive variety of electrical test signals to be generated over a wide range of frequencies. Waveforms include sine and square waves, ramp functions, triangular, sawtooth, trapezoidal and sine-squared pulses. Square waves and pulses can be generated with durations of 100 μsec up to 1000 seconds while the frequency of sine waves can be varied from 500 cps down to 0.0005 cps. Complete or one-half cycles, or continuous operation can be obtained in all of the above waveforms.

British Industries Corp., Dept. ED, 80 Shore Rd., Port Washington, N.Y.

CIRCLE 60 ON READER-SERVICE CARD

Computer Diodes

Fast recovery time

Reverse recovery times of types Q5-100, Q5-250, Q10-200, and Q10-300 computer diodes are 5 mμsec maximum to 0.4 ma, after switching from 1.6 ma forward current to −3 v reverse voltage applied through a 750 ohm loop resistance. These high speed alloy junction computer diodes have high forward conductance.

Qutronic Semi-Conductor Corp., Dept. ED, 525 Broadway, New York 12, N.Y.

CIRCLE 61 ON READER-SERVICE CARD

◀ CIRCLE 62 ON READER-SERVICE CARD

Power Supply

0 to 36 v

Model SC-36-0.5 power supply delivers 0-36 v, 0-0.5 amp. Regulation for line or load is less than 0.1 per cent or 0.003 v, whichever is greater. Ripple is less than 1 mv rms. Recovery time is less than 50 μsec.

Kepco Laboratories, Inc., Dept. ED, 131-38 Sanford Ave., Flushing 55, N.Y.

CIRCLE 63 ON READER-SERVICE CARD

Bridge Calibrator

0.25 per cent accuracy

This precision mv per volt standard for convenient calibration and maintenance of strain gage systems provides a series of bridge outputs from 0.00 mv/v to 4.80 mv/v in eight increments. Nominal outputs are guaranteed to 0.25 per cent.

Bytrex Corp., Dept. ED, 294 Centre St., Newton 58, Mass.

CIRCLE 64 ON READER-SERVICE CARD

Non-linear Potentiometer

Measures 1-3/4 in. diam

A 1-3/4 in. diam sine-cosine potentiometer is available, featuring high resolution. Conformity to the desired sine or cosine function is within ±1 per cent of peak to peak amplitude. No padding resistors are used. The unit provides 20 K per quadrant.

G. M. Giannini & Company, Inc., Dept. ED, 918 E. Green St., Pasadena 1, Calif.

CIRCLE 65 ON READER-SERVICE CARD

CIRCLE 66 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Power Amplifier-Demodulator

Transistorized unit drives hydraulic valves

Designed specifically as a drive for hydraulic valves in control systems, this unit consists of a 150 mw power amplifier coupled to a solid state, phase sensitive demodulator. Transformers and other frequency sensitive elements are eliminated, this permitting satisfactory operation over a frequency range of 0 to 10 kc. The device requires a 5 mw input signal, which can be supplied by the model 204G Transistor servo amplifier. If the 204G/208G combination is used, it will drive a hydraulic valve to full output from an input signal of 3 mv across 100 ohms.

Taber Instrument Corp. Dept. ED, North Tonawanda, N.Y.

CIRCLE 68 ON READER-SERVICE CARD

Magnetic Diode Control

Operates GE controlled rectifier

The model MDC magnetic diode control is designed to operate the GE type ZJ-39A controlled rectifier used in power control systems and servo drives. The unit develops steep-wave-front current pulses to actuate the GE gated diodes from a low energy dc control signal. MDC models range from a single phase half-wave unit to control one diode to a three phase full-wave, push-pull unit to control 6 diodes in a three phase power servo system. Both 400 and 60 cps models are available.

Fairfield Engineering Corp., Dept. ED, 934 Hope St., Springdale, Conn.

CIRCLE 69 ON READER-SERVICE CARD

Pulse Sorter

Controls random inputs

The pulse sorter 136A is connected in series with both the forward and reverse inputs to the reversible binary counter 111B and blanks both pulses, should they occur within 5 μsec of each other. The sorter will also serve as a reversible commutator when used with the reversible shift register 109A.

Navigation Computer Corp., Dept. ED, 1621 Snyder Ave., Philadelphia 45, Pa.

CIRCLE 70 ON READER-SERVICE CARD

Soldering Tool

Uses resistance principal

Designed for production soldering, this dual metal tip soldering tool incorporates the advantages of resistance soldering without requiring a grounding circuit. The tool is especially designed for soldering miniature connectors.

Wassco Electric Prod. Corp., Dept. ED, 204 S. Larkin Ave., Joliet, Ill.

CIRCLE 71 ON READER-SERVICE CARD

Headers

Glass-to-metal seal

Entering the glass-to-metal seal field, this company is producing headers and other hermetically sealed products custom fabricated of high temperature glass.

Vacuum Ceramics, Inc., Dept. ED, Cary, Ill.

CIRCLE 72 ON READER-SERVICE CARD

NEW PRODUCTS

Pulse Generator
256 discrete steps

Used for the testing and calibration of multichannel pulse height analyzers with 2^n channels, model PPG-256 precision pulse generator uses a mercury relay for the generation of positive or negative pulses, simulating the output of most radiation detectors. The output pulse amplitude may be varied over a 100 volt range in 256 discrete steps with a ratio accuracy of 0.1.

Tullamore Electronics Lab., Dept. ED, 6055 S. Ashland Ave., Chicago 36, Ill.

CIRCLE 75 ON READER-SERVICE CARD

Twin-T Filters
Null attenuation of 60 db

In these encapsulated, hermetically sealed twin-T filters, precision resistors and temperature compensating capacitors maintain attenuation over a wide temperature range. Null attenuation is 60 db or better. A range of null frequencies and impedance levels are available.

T T Electronics, Inc., Dept. ED, P.O. Box 180, Culver City, Calif.

CIRCLE 76 ON READER-SERVICE CARD

Drafting Pencil
Won't smear on Mylar

Duralar pencils have a plastic-base lead that is smearproof on Mylar matte-surface tracing film. Drawings erase completely and reproduce as sharply as India ink originals.

J. S. Staedtler, Inc., Dept. ED, Hackensack, N.J.

CIRCLE 77 ON READER-SERVICE CARD

Flight Simulators

Test assemblies weighing up to 300 lb

These simulators duplicate the forces of flight in the three axes of yaw, pitch, and roll. Speeds of up to 50 cps are possible, depending upon the variables involved. Packages weighing as much as 300 pounds have been tested. Motion speeds can be independently varied from 1/25 to 4 cps in each axis simultaneously. Variation of maximum rotational oscillation of this unit is to within ±5 deg at top speeds and to within ±45 deg at 1/4 cps.

J. W. Fecker, Inc., Dept. ED, 6592 Hamilton Ave., Pittsburgh 6, Pa.

CIRCLE 78 ON READER-SERVICE CARD

Impedance Comparator

High stability

Model 343 impedance comparator features high stability. The equipment gives accuracy of 0.05 per cent over wide range of impedances from 10 ohm to 15 meg without adjustment.

Inland Electronics Corp., Dept. ED, 500 Rathbone Ave., Aurora, Ill.

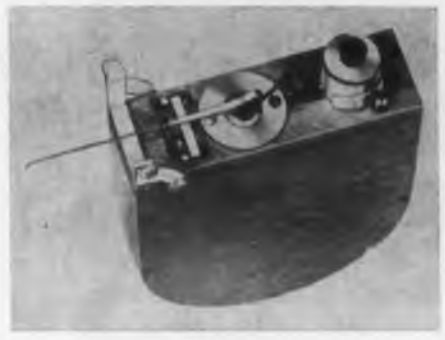
CIRCLE 79 ON READER-SERVICE CARD

CIRCLE 80 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Galvanometer

Transistor driven



For use with transistor powered amplifiers in oscillograph recording applications, this galvanometer gives flat frequency response from dc to 35 cps, and extended flat response up to 200 cps with compensated signal amplification. Total dc coil resistance is 260 ohms, center tapped. A standard 3-in. pen can be driven 1 cm by 16.5 ma, or 4.025 v across the outside coil terminals. The unit comes in cased (model 8006) and uncased (model 8016) designs.

Edin Co., Inc., Dept. ED, 207 Main St., Worcester 8, Mass.

CIRCLE 82 ON READER-SERVICE CARD

Servo Repeater System

Plug-in

The model W 1902 plug-in potentiometer servo repeater system includes a servo amplifier, servo motor, single or multi-turn potentiometer, input power step down transformer, and gear train. It positions its output shaft proportional to a 400 cps input signal voltage in the range of 0 to 10 v or 0 to 100 v full scale. Typical performance with 200:1 gear ratio is: follow up accuracy, ± 0.05 per cent of signal voltage; velocity constant, 52 sec^{-1}; maximum output torque, 20 oz-in.; maximum output speed, 90 deg/sec; acceleration, 180 deg/sec; bandwidth, 6 cps; damping ratio, 0.6 to 0.7.

Waldorf Instrument Co., Dept. ED, Huntington Station, N.Y.

CIRCLE 83 ON READER-SERVICE CARD

Proportional Amplifier

Control up to 150 w

The PA4A-1 proportional magnetic amplifier provides proportional control of up to 150 w output power with input power of a few milli-microwatts. An input signal of less than 1 μa will produce full power output. Self-contained except for the bridge elements, the unit is designed for —67 to +200 F continuous operation.

Magnetic Controls Co., Dept. ED, 6405 Cambridge St., Minneapolis 16, Minn.

CIRCLE 84 ON READER-SERVICE CARD

Flat Wiring

Film-insulated multiconductor

Called Plyo-Duct, this application of the firm's printed circuit products is available in both standard parallel line arrangements and special custom patterns. Standard Plyo-Duct is available on spools in eight and fifteen conductor sizes. The flat copper conductors are 0.0027 in. in thickness and 0.075 in. wide. Overall thickness is 0.0008 in. The 0.156 in. center to center spacing allows the harness to employ standard pin terminal printed circuit connectors. The cable offers light weight, less space consumption, high flex life, uniformity of length and spacing, and high current carrying properties for cross-sectional areas. Standard insulation is polyester film, but the cable is also available with glass reinforced silicone plastic laminations for high temperature applications.

Methode Manufacturing Corp., Dept. ED, 7447 W. Wilson Ave., Chicago 31, Ill.

CIRCLE 85 ON READER-SERVICE CARD

CIRCLE 86 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Recorders

Strip chart and X-Y

The model 80 strip chart recorder shown, features push-button selection of chart feeds in any desired combination of 12 speeds plus calibrated scale ranges in specified combinations from 1 mv to 500 v. A second instrument, the model 6 Autograf is also available. It is an x-y recorder electrically equivalent to previous models but designed for use with a roll of up to 100 complete charts which may be automatically advanced by manual or remote control in one frame (or chart) steps. Successive charts may then be torn off or stored on a take-up roll as desired.

F. L. Moseley Co., Dept. ED, 409 N. Fair Oaks Ave., Pasadena, Calif.

CIRCLE 87 ON READER-SERVICE CARD

Slide Attenuators

Operate at 4 oz maximum pressure

Series 825 and 835 slide attenuators can be operated with a maximum pressure of 4 oz. They are available in balanced and unbalanced ladders and in T-type attenuators; in any standard input and output impedance; with or without tapers; in 20 and 30 steps; and with Cue position.

The Daven Co., Dept. ED, Livingston, N.J.

CIRCLE 88 ON READER-SERVICE CARD

Project Engineer Fred M. Schumacher (R.) points out construction details in a newly-designed subminiature stacked ceramic gun used in an advanced design traveling-wave tube. Looking on are Engineers James F. Lynch (L.) and John P. Lindley.

new!

AXIAL LEAD

Silicon Zener Diode

allows automatic machine insertion and complete mounting flexibility . . .

u.s. semcor silicon

Axial Lead Zener Diode

U.S. SEMCOR now offers their high quality, low power Zener Diodes in a new sub-miniature, axial lead package!

Absolute minimum package size allows every economy of space and weight afforded by this widely accepted axial lead configuration. Since U. S. SEMCOR *silicon* Zener Diodes are not position-sensitive, in-line leads give added advantage of completely flexible mounting position.

Construction details of this new axial lead package provide an efficient heat-dissipating path from the Zener Diode junction. This assures better heat transfer . . . a conservative power rating of 200 mw max. @ 25°C . . . and a high safety factor in critical applications.

- Designed for automatic machine assembly on printed circuit boards
- Up to 200 milliwatt allowable power dissipation
- Flexible mounting position
- All welded construction
- Space and weight economy
- Minimum Zener impedance
- Low saturation current
- Superior voltage regulation
- Within physical size of standard 1-watt resistor

SEMCOR — U. S. SEMICONDUCTOR PRODUCTS, INC.

Our field Engineering Representatives welcome the opportunity to consult with you on standard or special ZENER DIODE requirements. For address of office nearest you—or for complete technical data—WRITE TODAY to Sales Engineering Dept., U. S. Semiconductor Products, Inc., 2336 West Osborn Road, Phoenix, Arizona.

CIRCLE 92 ON READER-SERVICE CARD

NEW PRODUCTS

Connectors

Solderless

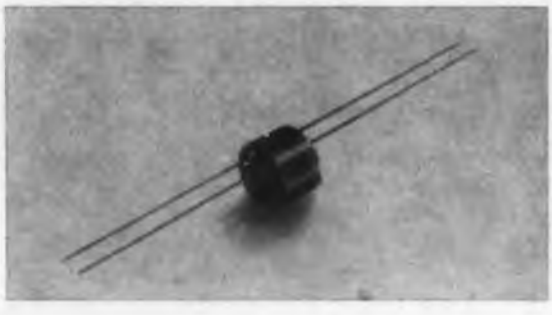
Solderless insulated and noninsulated terminals for uniform, permanent connections. Available in a wide range of styles and sizes.

Waldom Electronics Inc., Dept. ED, 4625 W. 53rd St., Chicago 32, Ill.

CIRCLE 93 ON READER-SERVICE CARD

Pulse Transformers

Compact



These units are available as blocking oscillator pulse transformers covering a range of pulse widths from 0.05 to 2.0 μsec, and as pulse coupling transformers covering a wide range of impedance ratios and pulse widths.

ESC Corp., Dept. ED, 534 Bergen Blvd., Palisades Park, N.J.

CIRCLE 94 ON READER-SERVICE CARD

Spectrum Analyzer

10 mc to 40,880 mc frequency range

Covering a frequency range of 10 mc to 40,880 mc in a single unit, the model SA-84 spectrum analyzer has stable local oscillators and built-in attenuators up through X band. A simplified band selection automatically displays an expanded slide-rule dial of the band in use. The spectrum is displayed on a cathode ray tube.

Polarad Electronics Corp., Dept. ED, 43-20 34th St., Long Island City 1, N.Y.

CIRCLE 95 ON READER-SERVICE CARD

Best Insurance for Component and Systems Reliability!

Corrosion...dust...fungus...altitude... humidity...pressures. *True* hermetic sealing completely eliminates their usually disastrous effects on electronic and mechanical apparatus.

GHS offers uniquely qualified techniques and specially developed facilities in the field of hermetic sealing. They are guaranteed to add a *permanent plus* to your product reliability.

For inert gas filling, 100% mass spectrometer leak testing of any assembly, and every phase of *true* hermetic sealing to meet military or industrial specs, GHS in-plant services are unequalled.

The GHS Megpot©

Quickly, efficiently tests your components, insulation. Features 10 million megohms, 100, 200 or 500V DC, automatic "charge" and safety controls, non-destructive (as high as 5000V AC) high-potential test set with current limiting and automatic shut-off circuit. Portable.

Write for Specific Information... and use the GHS Advisory Services without obligation.

GHS
ELECTRONICS FOR LAND SEA AND SPACE
GENERAL HERMETIC SEALING CORPORATION
Valley Stream, N. Y. • VAlley Stream 5-6363

CIRCLE 97 ON READER-SERVICE CARD

Pressure Transducer

Low vibration error at 25 g

The model 470 absolute pressure transducer has signal error of less than 0.5 per cent at 25 g up to 2000 cps. Acceleration error is less than resolution at 75 g, and error shift during rated vibration is less than resolution. Temperature error is also low.

Bourns Labs, Inc., Dept. ED, Riverside, Calif.

CIRCLE 98 ON READER-SERVICE CARD

VTVM's

Need limited panel space

These single-range vtvm's require only as much panel space as ordinary 4-1/2 in. meters. The model 320 dc line comes in seven standard ranges from 0 to 1 to 0 to 1000 v. The ten standard ranges for the model 330 ac line are from 0 to 10 mv to 0 to 300 v rms. The ac meters operate at frequencies from 20 cps to 100 kc.

Metronix, Inc., Dept. ED, Chesterland, Ohio.

CIRCLE 99 ON READER-SERVICE CARD

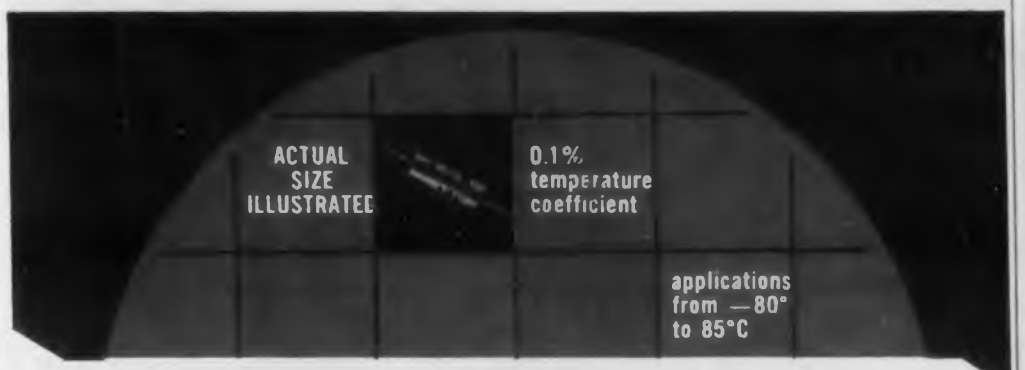
Servo-Couplings

Have zero backlash

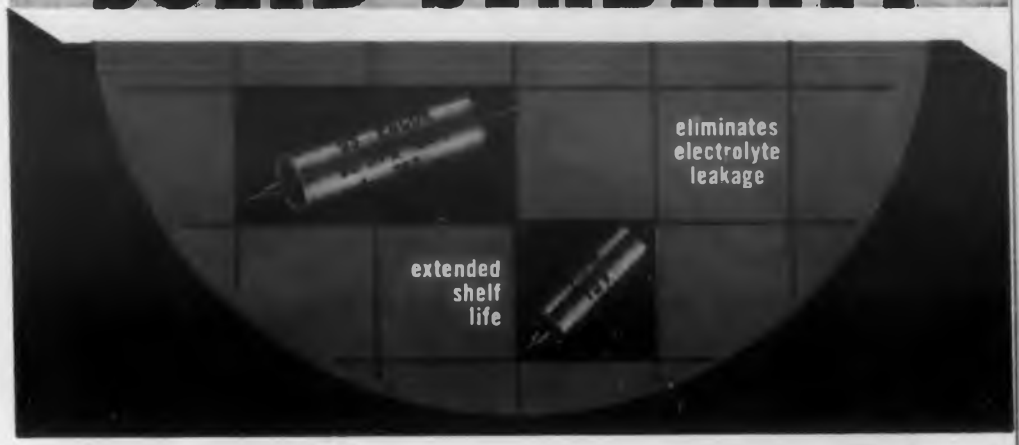
These flexible servo-couplings have zero backlash and low inertia. They are 7/16 in. long by 3/4 in. in diameter. Bore diameters are from 1/16 through 3/16.

Renbrandt, Inc., Dept. ED, 6 Parmelee St., Boston 18, Mass.

CIRCLE 100 ON READER-SERVICE CARD



SOLID STABILITY



u. s. edcor *hermetically sealed* *solid tantalum capacitors*

extreme stability at low temperatures

allows applications where other types are unsatisfactory

U. S. Edcor Solid Tantalum capacitors consist of a solid, inorganic, non-volatile electrolyte. Their superior performance and improved frequency characteristics may best be utilized in low voltage applications requiring large values of capacitance, where stability is of utmost importance. These factors make them especially suitable for transistor circuitry.

- **operating temperature:** —80°C to +85°C
- **leakage current:** 0.05 micro-amps/mfd/volt
- **no exposed welds**
- **moisture resistance:** Mil standard 202, method 106
- **capacitance:** .33 mfd to 150 mfd
- **non-corrosive electrolyte**

u s edcor

CIRCLE 101 ON READER-SERVICE CARD

IERC HEAT-DISSIPATING ELECTRON TUBE SHIELDS

— AND EQUIPMENT "DOWN TIME" LOSSES CAUSED BY HEAT, SHOCK AND VIBRATION!

Investigate the extraordinary tube-saving, cost-saving potentials of IERC Heat-dissipating Tube Shields — the only complete, commercially-available line of effective heat-dissipating electron tube shields for **miniature, subminiature and octal/power** size tubes. IERC's expanded line of heat-dissipating tube shields for the larger size power tubes offer, for the first time, **a practical method to retain these tubes** in severe shock and vibration environments!

The most complete electron tube heat-dissipation information is yours for the asking! Technical data comprised of IERC and independent laboratory test reports will be sent upon request on your company letterhead.

CROSS-LICENSED WITH NORTH AMERICAN AVIATION, INC.
PATENTED OR PATS PEND.

International

electronic research corporation
145 West Magnolia Boulevard, Burbank, California

LATEST addition to IERC's product line is the IERC HEAT DISSIPATOR for POWER TRANSISTORS. Effective reduction of temperatures, elimination of heavy, large or finned surfaces plus adaptability for use in confined spaces are prime features. Technical Bulletin PP112 is included with general IERC information sent on request.

Heat-dissipating electron tube shields for miniature, subminiature octal and power tubes

CIRCLE 102 ON READER-SERVICE CARD

NEW PRODUCTS

Data Recorder

For airborne use

A 14 channel two-speed airborne recorder, model TR-781 consists of four shock mounted major units and a portable test meter. One fm channel may be used for time base recording and voice monitoring.

Telectro Industries Corp., Dept. ED, 35-16 37th St., L.I.C. 1, N.Y.

CIRCLE 103 ON READER-SERVICE CARD

Ribbon Cable

Has Teflon insulation

Insulated with Teflon resin applied in thicknesses of 0.003 to over 0.030 in., Multi-Tet cable ribbons come in wire sizes from AWG 12 to 34. A single ribbon can have up to 100 conductors.

W. L. Gore & Associates, Dept. ED, R.D. 2, Papermill Rd., Newark, Del.

CIRCLE 104 ON READER-SERVICE CARD

Tape Recorder

Reproduces instrumentation data

The PS-200 tape recorder is available in tape speeds ranging from 60 to 1-7/8 ips and lower with wow and flutter held under 0.1 per cent rms at 30 ips. From 1 to 14 channels can be provided by using 1/4, 1/2, or 1 in. wide tape.

Precision Instrument Co., Dept. ED, 922 Terminal Way, San Carlos, Calif.

CIRCLE 105 ON READER-SERVICE CARD

Degausser

Automatic

This automatic bulk tape eraser is designed for fast, high-volume degaussing on a continuous or intermittent basis. It accommodates all types of metal and plastic reels in tape widths up to 1 in. and in diameters 7 through 14 in.

Ampex Corp., Dept. ED, 934 Charter St., Redwood City, Calif.

CIRCLE 107 ON READER-SERVICE CARD

Thermocouple

Withstands 3000 F

A metal-sheathed, ceramic-insulated thermocouple wire, Cerami-Kouple has high electrical sensitivity and withstands high temperatures (to 3000 F) and corrosive atmospheres.

E. C. Smith Mfg. Co., Dept. ED, Conshohocken, Pa.

CIRCLE 108 ON READER-SERVICE CARD

Magnetic Coils

Nearly impervious to shock, vibration

A new method of manufacture and encapsulation makes these units almost impervious to shock and vibration. The coils will also withstand temperatures up to 350 F for 100 hr and show no evidence of shorted turns in subsequent tests.

Precision, Inc., Dept. ED, 730 Lyndale Ave. N., Minneapolis, Minn.

CIRCLE 109 ON READER-SERVICE CARD

NEW PRODUCTS

Coaxial Ratio Transformers

Low phase shift

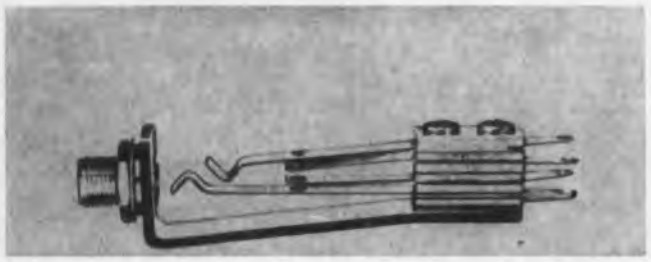
Models CRT-1, CRT-2, and CRT-3 coaxial ratio transformers have high input impedance, low output impedance, and low phase shift. The precision ac voltage dividers feature 0.001 per cent terminal linearity and 6 place continuous resolution.

Gertsch Products, Inc., Dept. ED, 3211 S. La Cienega Blvd., Los Angeles 16, Calif.

CIRCLE 113 ON READER-SERVICE CARD

Long Frame Jacks

Open and closed circuits



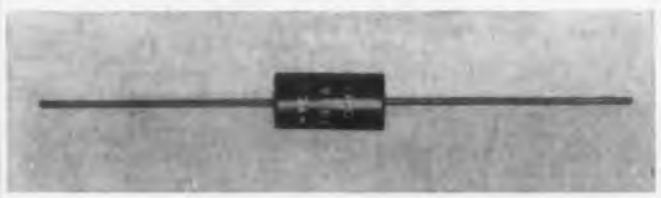
These long frame precision jacks are available in two and three conductor, open and closed circuits. With special contacts, ratings may be increased from the standard 3 amp up to 10 amp at 110 v noninductive load.

Richards Electrocraft, Inc., Dept. ED, 4432 N. Kedzie Ave., Chicago, Ill.

CIRCLE 114 ON READER-SERVICE CARD

Precision Resistor

Low range



This low cost precision wire wound resistor can be made in values as low as 0.1 ohm at ±0.05 per cent. Size and encapsulation are identical to the standard PH series.

International Resistance Co., Hycor Div., Dept. ED, 12970 Bradley Ave., Sylmar, Calif.

CIRCLE 115 ON READER-SERVICE CARD

Silicon Rectifiers

200 to 600 v peak inverse

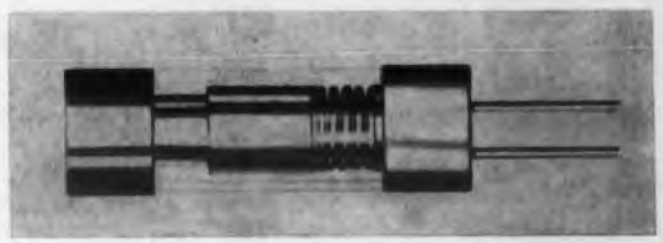
Three JAN-type silicon power rectifiers—IN538, IN540, and IN547—are made to meet MIL-E-1/1084A, MIL-E-1/1085A, and MIL-E-1083A specs. The units cover the range from 200 to 600 v peak inverse, and from 750 ma dc output at 50 C to 250 ma dc output at 150 C.

General Instrument Corp., Dept. ED, 65 Gouverneur St., Newark 4, N.J.

CIRCLE 117 ON READER-SERVICE CARD

Thermal Relay

Utilizes temperature sensitive pellet



A temperature sensitive pellet, which abruptly changes from a solid to a liquid state at a specified temperature, provides a reliable actuating force in this relay. Principal applications of the 2000 series include overload protection. Reliable performance is obtained at high altitudes. Current ratings are 2, 7.5, 10, 25, and 50 amp, and temperature sensitivities are in the 120 to 600 F range.

Networks Electronic Corp., Dept. ED, 14806 Oxnard St., Van Nuys, Calif.

CIRCLE 118 ON READER-SERVICE CARD

Oscillator-Voltmeter

Covers 18 cps to 1.1 mc range

The type 1501 oscillator-voltmeter covers the range 18 cps to 1.1 mc. In the oscillator, which delivers 10 v open circuit, distortion is under 0.2 per cent. The voltmeter has an overall accuracy of ±3 per cent.

Waveforms, Inc., Dept. ED, 331 Sixth Ave., New York 14, N.Y.

CIRCLE 119 ON READER-SERVICE CARD

NEW AMPHENOL

ACTUAL SIZE

STUB E

smallest, lightest MS "E" connector

Stub E connectors meet or surpass the environmental resistance requirements of MIL-C-5015C. Stub E connectors are the *stubbiest* MS "E" designs available– AMPHENOL took advantage of every space-saving trick in the engineer's book while at the same time meeting all dimensional requirements of MIL-C-5015C.

Stub E connectors have a fully unitized rear sealing grommet assembly in which the grommet, compression nut and ring are a single unit, making assembly and disassembly quick and easy. Solder pockets of the silver-plated contacts are pre-filled for easier, less expensive soldering.

Shell styles 3100, 3101, 3102 and 3106, sizes 8S through 36 and 51 insert arrangements are available.

AMPHENOL

NEW PRODUCTS

Oscilloscope

For systems use

The type IT1193A cathode-ray oscillograph has identical horizontal and vertical deflection systems with maximum deflection sensitivity of 0.025 v peak-to-peak per in. from dc to 150 kc. Relative phase shift of the two amplifiers is not over 2 deg below 50 kc. All power supplies are regulated.

Industrial Television Inc., Dept. ED, 369 Lexington Ave., Clifton, N.J.

CIRCLE 120 ON READER-SERVICE CARD

Sequencer

Motor driven

This motor driven switching device can be used for the proper sequencing of instrumentation or similar calibration signals and applications. All of the operations are controlled by a printed circuit disc which may be easily changed. Operates at very high altitudes and withstands 100 g.

Topp Industries, Inc., Dept. ED, Beverly Hills, Calif.

CIRCLE 121 ON READER-SERVICE CARD

Stable Tank Circuits

Shock, vibration resistant

Stable tank circuits potted in silicone rubber and hermetically sealed in MIL T-27 metal cases. A low cost substitute for crystals, they are shock and vibration resistant and adjustable over a considerable frequency.

International Resistance Co., Hycor Div., Dept. ED, 12970 Bradley Ave., Sylmar, Calif.

CIRCLE 122 ON READER-SERVICE CARD

◀ CIRCLE 123 ON READER-SERVICE CARD

Capacitors

0.1 per cent accuracy

These capacitor standards are compact and readily combined to duplicate the function of decades. The banana plug terminals are detachable. The use of a complete capacitance set and the 4-position adapter provides a highly accurate decade system. Tolerance approaches the ±0.1 per cent accuracy of the individual standard. All the capacitors through 0.1 μfd are constructed using silvered mica capacitors. Values from 0.2 μfd through 0.5 μfd are a combination of polystyrene and mica.

ARCO, Dept. ED, 64 White St., New York 13, N.Y.

CIRCLE 125 ON READER-SERVICE CARD

High Pressure Valve

Weighs 0.77 lb

Containing a captive seal, this three-way solenoid-operated valve weighs 0.77 lb. It can handle pressures of over 3000 psi and withstands more than 350 F.

Robertshaw-Fulton Controls Co., Dept. ED, Milford, Conn.

CIRCLE 126 ON READER-SERVICE CARD

CIRCLE 127 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Environmental Cabinet

0 to 180 C temperature range

In the Power-O-Matic control system, actual control point is within ±0.5 deg C. The constant-flow mechanical refrigeration system is extra large for additional electrical load dissipation capacity and rapid pull down rate. This permits rapid cycle and close temperature control.

Blue M Electric Co., Dept. ED, Blue Island, Ill.

CIRCLE 128 ON READER-SERVICE CARD

Variable Resistor

5 watt unit

A 5 w wirewound variable resistor, the model 4 Radiohm has good heat transfer characteristics and dielectric strength of 4500 v per mil at 25 C. Ambient temperature range is —65 to +200 F.

Centralab, A Div. of Globe-Union, Inc., Dept. ED, 900 E. Keefe Ave., Milwaukee 1, Wisc.

CIRCLE 129 ON READER-SERVICE CARD

Punched Card Sensor

For IBM, Remington Rand cards

Punched card sensors designed to program data punched on standard IBM or Remington Rand code cards. Model M-1 accepts IBM cards, has 960 hole positions. Model K-1 accepts Remington Rand cards and has 540 hole positions.

Taurus Corp., Dept. ED, 8 Coryell St., Lambertville, N.J.

CIRCLE 130 ON READER-SERVICE CARD

Klystron Power Supply

Offers high stability

Type 1856 klystron power unit has been designed to operate low voltage klystron oscillators with a high degree of frequency and power stability. The power unit will operate klystrons either singly or in pairs (as signal source and local oscillator). Separate controls are provided to facilitate the operation of two tubes simultaneously and completely independently of each other.

Electronic & Television Consultants, Dept. ED, P.O. Box 47, Highbridge Station, New York 52, N.Y.

CIRCLE 131 ON READER-SERVICE CARD

Signal Generator

Covers 40.7 to 400 mc range

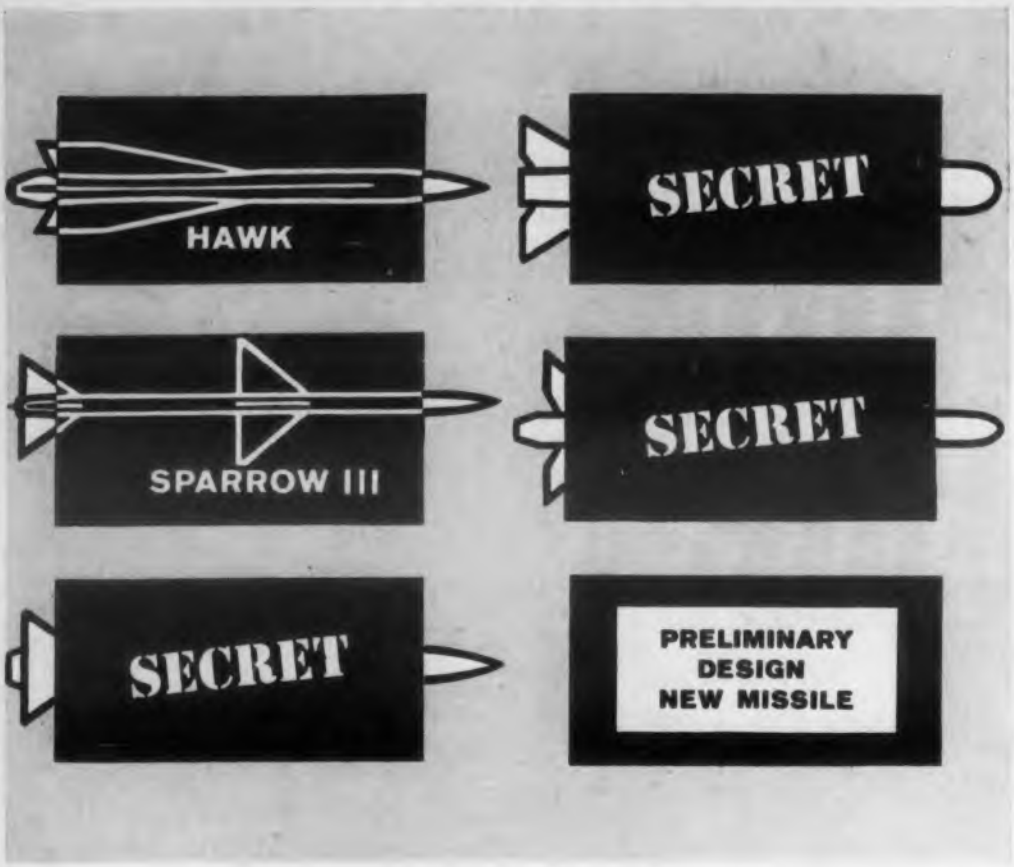
Capable of supplying stable high power signals, the model 30A standard signal generator covers the range of 40.7 to 400 mc/sec with a nominal output power of 10 v with 15 v available under maximum power conditions. The model 30B is a similar generator with 50 w of output power.

BJ Electronics, Borg-Warner Corp., Dept. ED, 3300 Newport Blvd., Santa Ana, Calif.

CIRCLE 132 ON READER-SERVICE CARD

CIRCLE 133 ON READER-SERVICE CARD ➤

ENGINEER OPPORTUNITIES AT RAYTHEON



RAYTHEON MISSILE CONTRACTS now cover complete systems responsibility for both air-to-air and surface-to-air missiles.

These advanced missile projects call for exceptional creativity

The need for engineering resourcefulness and creativity grows continually as Raytheon missile activities expand into new areas.

As an experienced engineer with a keen interest in working on advanced missile projects, you can begin building a rewarding future at Raytheon *today*.

There may well be an opportunity in one of the following areas that is right for you:

SYSTEMS	**APPLICATIONS**
PACKAGING	**CIRCUIT DESIGN**
MICROWAVE	**RELIABILITY**
RADAR	**SPECIFICATIONS**

For interview at our suburban laboratory in Bedford, Mass., write, wire or telephone collect: CRestview 4-7100. Ask for R. W. McCarthy.

RAYTHEON MANUFACTURING COMPANY
Bedford, Massachusetts

RAYTHEON

MISSILE SYSTEMS DIVISION

Excellence in Electronics

NEW PRODUCTS

Sweeping Oscillator

Center frequencies between 1 mc and 350 mc

The Rada-Sweep 300 fundamental frequency sweeping oscillator has 10 switched bands with fixed center frequencies set to order. For sweeping radar or other if's and networks between 1 mc and 350 mc center frequencies, the unit is stable, has low harmonic content, and is free from spurious signals. One switch provides sweep and markers simultaneously.

Kay Electric Co., Dept. ED, Maple Ave., Pine Brook, N.J.

CIRCLE 135 ON READER-SERVICE CARD

Digital Clock

For data logging systems

This digital clock is for use in digital data logging systems and control applications. It features a single plane in-line lamp bank assembly which can be remotely installed and individual time reset push-buttons for each decade.

Parabam, Inc., Dept. ED, 110 Lomita St., El Segundo, Calif.

CIRCLE 136 ON READER-SERVICE CARD

Coaxial Cable

Approved to MIL-C-17

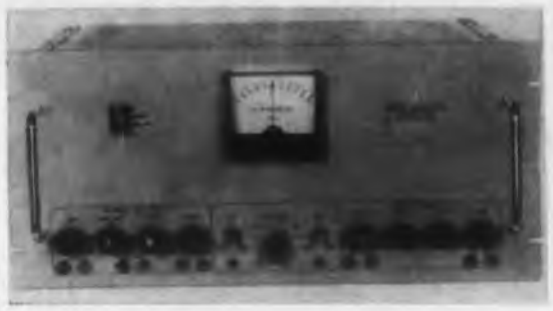
Three Kel-F jacketed Teflon miniature coaxial cables designed for rf transmission. Approved to MIL-C-17, they use a 30 AWG conductor. The primary insulation of extruded Teflon resin is shielded with a braid of 38 AWG silver plated copper.

Tensolite Insulated Wire Co., Inc., Dept. ED, W. Main St., Tarrytown, N.Y.

CIRCLE 137 ON READER-SERVICE CARD

Servoamplifier

Built-in metering circuit



The model 601 servoamplifier has a built-in metering circuit that measures output-current level and balance, differential current, B plus level, dither level, and feedback-signal quadrature level. Independent level and balance controls enable the current to run from 8 to 25 ma without interaction.

American Measurement and Control, Inc., Dept. ED, 240 Calvary St., Waltham, Mass.

CIRCLE 139 ON READER-SERVICE CARD

Panel Meters

Expanded scale

Expanded scale dc voltmeters can be supplied in the model 1135 and 1145 side indicator panel meters. The 1135 has a scale length of 2.1 in. and a panel area of 2 sq in. Scale length of the 1145 is 2.7 in., and panel area is 5.5 sq in. Voltage ranges lie between 4 and 265 v dc, and accuracy is ±2 per cent of full scale.

International Instruments Inc., Dept. ED, P.O. Box 2954, New Haven 15, Conn.

CIRCLE 140 ON READER-SERVICE CARD

Crystal Diodes

Permit improvement in radar range

Three premium microwave crystal diodes which permit nearly 20 per cent improvement in radar range with no increase in transmitter power. Over-all noise figure is 10.3 db for type 1N53B, 8.8 db for type 1N78B, and 11.3 db for type 1N26A. Units have greater uniformity of impedance.

Sylvania Electric Products Inc., Dept. ED, 1100 Main St., Buffalo, N.Y.

CIRCLE 141 ON READER-SERVICE CARD

BULOVA

FAMED FOR PRECISION SINCE 1875

CRYSTAL FILTERS

Precision engineered multiple-crystal filters are now available as packaged units from one of the world's foremost manufacturers of quality crystals.

By being able to maintain exacting control of individual crystal characteristics, during manufacture, Bulova can quickly and economically produce precision crystal filters on a custom design or production basis.

TELEMETRY: Many telemetry centers are now relying on Bulova filters to preserve the accuracy of multiplexed data during processing. Wide band and narrow band filters are available.

SINGLE SIDE BAND: For voice and other ssb applications Bulova filters provide excellent suppression of unwanted side band in both transmitting and receiving equipment.

Center frequencies from 10 KC to 20 MC, with bandwidths of .01%-8% of center frequency can be provided in either symmetrical or assymetrical filters using Bulova high precision crystals.

Send for literature on Bulova's standard and custom design filters today, or let our engineering staff study your filter problem and recommend a suitable package for your particular application.

BULOVA

watch company

Electronics Division
Woodside 77, N.Y.

Write Dept. A-848 For Full Information and Prices on Crystal Filters

CIRCLE 143 ON READER-SERVICE CARD

NEW PRODUCTS

AC Microammeter

1-ohm input impedance

Featuring high sensitivity and low input impedance, this ac microammeter permits low-level current measurements to be made without disturbing the circuit under test. Two input probes are provided. A clamp-on probe permits rapid measurement of currents in the 300 μa to 100 ma range. The probe is constructed of high permeability magnetic material, and its mating surfaces are lapped to insure minimum leakage.

The insertion probe consists of a current transformer enclosed in a Mu metal shield. Two separate primaries provide turns ratios of 1 to 1 and 1 to 100. The 1 to 1 ratio permits measurements of levels down to 3 μa full scale, with a noise level of less than 0.1 μa. The input impedance is approximately 1 ohm, with a noise level of less than 0.03 μv.

Quan-Tech Lab., Dept. ED, Morristown, N.J.

CIRCLE 144 ON READER-SERVICE CARD

Windings

Range of 50 ohms to 750 K

Electrical characteristics of these precision wire windings are: range 50 ohms to 750 K, using standard resistance wires; up to 1.6 meg using precious metal wires. Total resistance accuracy: standard wires from ±5 to ±1 per cent; specials to ±1.4 per cent.

Brys Instrument Co., Dept. ED, 7026 6th Ave., Brooklyn 9, N.Y.

CIRCLE 145 ON READER-SERVICE CARD

CIRCLE 147 ON READER-SERVICE CARD >

BUILD YOUR PRODUCT BETTER ...WITH JOHNSON COMPONENTS!

Whatever the choice — from the smallest nylon connector to the largest variable capacitor — time and again design and development engineers specify Johnson components. Outstanding in reliability, Johnson components are backed by sound and imaginative engineering. Next time you're looking for one of the following components — check Johnson first!

- VARIABLE CAPACITORS
- INSULATORS • PILOT LIGHTS
- PLUGS AND JACKS
- INDUCTORS • TUBE SOCKETS
- KNOBS AND DIALS

connectors

Designed to meet severe electrical and mechanical requirements, Johnson manufactures a complete line of nylon connectors as well as a standard group of plugs and jacks. Nylon components include: insulated solderless tip and banana plugs; tip and banana jacks; tip jack and sleeve assemblies; metal-clad tip jacks; binding posts. Tough, low-loss nylon won't chip or crack even when subjected to extreme temperature changes or abnormal mechanical stress. Designed for fast, easy mounting—available in 13 bright colors for coded applications.

tube sockets

Pick the tube socket that meets your specifications from Johnson's 3 basic grades for every socket type! Check Johnson's standardization program . . . you'll find that selection is simplified, delivery cycles are shorter—and many times you'll get superior quality sockets at lower cost due to the elimination of special set-up and tooling charges. This unique tube socket standardization program provides you with complete specifications for standard, industrial and military socket requirements. Write for your free copy of Tube Socket Standardization Booklet No. 536, today!

variable capacitors

Available in a wide range of capacities and voltage ratings, Johnson Variable Capacitors are widely used for commercial and military applications. Types range in size from the diminutive "M" series to large Type "C" Single and Dual capacitors measuring up to 17 21/32" long. This comprehensive line offers types with construction features such as: soldered plates; DC-200 impregnated steatite end frames; types with stator support rods soldered directly to ceramic end frames; units with high capacity per cubic inch and low capacity to chassis; and types with special platings and spacings in production quantities.

pilot lights

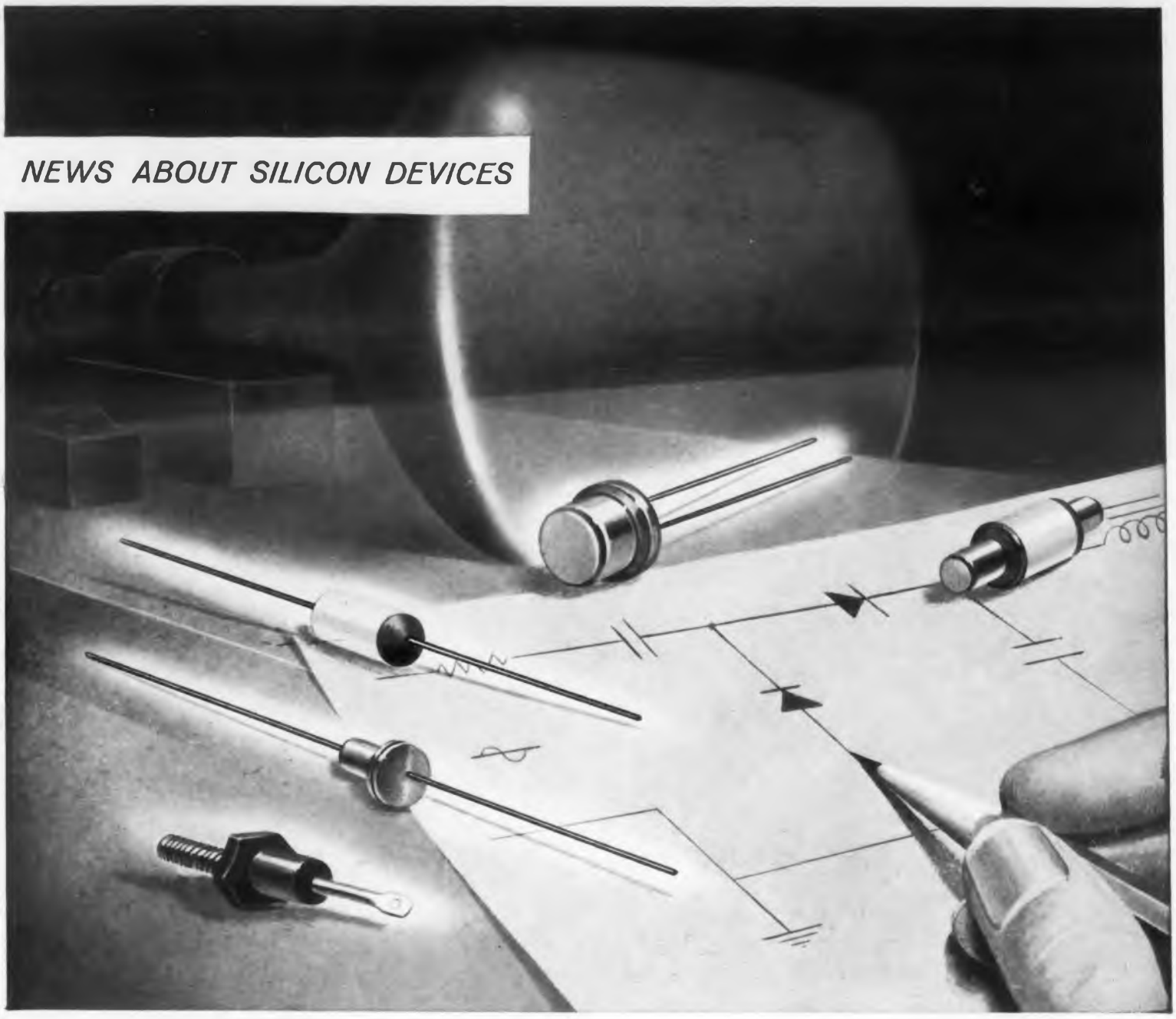
Save valuable specification time by selecting your panel indicators from Johnson's "preferred" line. Available types include: faceted jewel or wide angle lucite lens models; enclosed or open body styles; bayonet, candelabra, or miniature screw types; and a wide variety of mounting brackets and assemblies. Jewels are available in clear, red, green, amber, blue, or opal. Specials, including types to meet military specifications are also available in production quantities. All Johnson pilot lights are described in detail in Pilot Light Catalog 750—send for your free copy today!

Free Catalog

For detailed specifications on the complete line of Johnson electronic components—write for your free copy of our newest component catalog, today!

E. F. Johnson Company

1020 SECOND AVENUE SOUTHWEST • WASECA, MINNESOTA



Reverse current: 10^{-7} amp. Rectification ratio: 10,000,000:1

Now... new efficiency for TV power supplies with dependable diodes of Du Pont Hyperpure Silicon

More efficient power supplies . . . savings in space and weight . . . important reasons why TV manufacturers are replacing conventional rectifying systems with silicon diodes. Today, several types of silicon diodes and rectifiers are readily available for TV circuits. TV manufacturers have tested silicon rectifiers and report no noticeable change in output voltage under continuous load conditions over long periods of time. Silicon components can operate in ambients from –65° to 150° C. They maintain excellent electrical stability and resist aging.

Silicon components have high shock and vibration limits. They are up to 99% efficient in units operated at 60 cps. and require little maintenance. Silicon cells permit a rectification ratio as high as 10 million to 1—almost negligible reverse conductance. Silicon bridges are available with ratings from 1 to 1,000 amperes and more than 600 volts rms.

Note to device manufacturers: You can produce silicon transistors, rectifiers and diodes of the highest quality with Du Pont Hyperpure Silicon. It's now available in three grades for maximum efficiency and ease of use . . . with a purity range of 3 to 11 atoms of boron per billion. Technical information on crystal growing is available from Du Pont . . . pioneer producer of semiconductor-grade silicon.

NEW BOOKLET ON DU PONT HYPERPURE SILICON

You'll find our new, illustrated booklet about Hyperpure Silicon helpful and interesting—it describes the manufacture, properties and uses of Du Pont Hyperpure Silicon. Just drop us a card for your copy. E. I. du Pont de Nemours & Co. (Inc.), Pigments Department, Silicon Development Group, Wilmington 98, Delaware. (This offer limited to United States and Canada.)

PIGMENTS DEPARTMENT

DU PONT HYPERPURE SILICON

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

CIRCLE 219 ON READER-SERVICE CARD

Expanded Scale Frequency Meter

0.25 per cent accuracy

A self-contained, needle-indicator type unit for panel mounting, this 400 cps expanded scale frequency meter has a standard 380 to 420 cps scale readable to accuracies of 0.25 per cent over its full range. Between 380 and 420 cps the bridge used in the meter provides an output linearly proportional to input frequency.

Helipot Corp., Div. of Beckman Instruments, Inc., Dept. ED, Newport Beach, Calif.

CIRCLE 148 ON READER-SERVICE CARD

Recording Amplifier

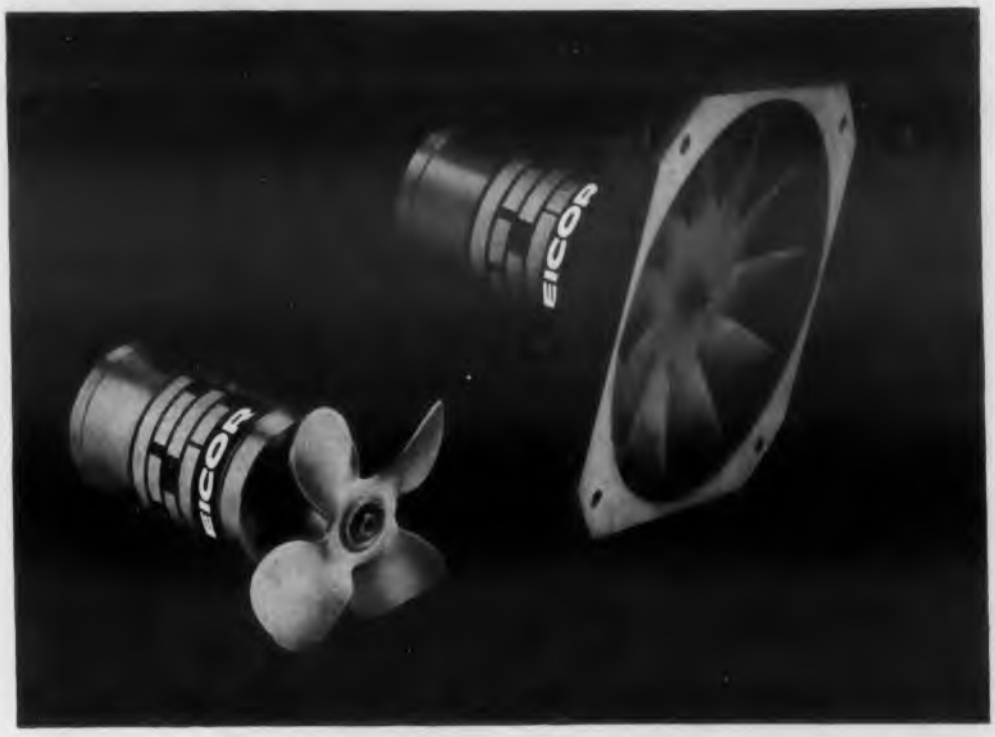
Miniature 14-channel unit

Designed for use in airborne data acquisition systems, the Minidrive provides for 14 channels of pulse data recording on magnetic tape. The unit will present the parallel output code of the company's Minidatrac to tape heads, and will also provide odd-even parity checking and gates which will allow the recording of additional information, such as block counter pulses and other auxiliary inputs.

Epsco, Inc., Dept. ED, 588 Commonwealth Ave., Boston 15, Mass.

CIRCLE 149 ON READER-SERVICE CARD

PM BLOWERS



NEW

MINIATURE, 60 VDC BLOWER UNITS

RELIABLE • EFFICIENT • RUGGED

Eicor Permanent Magnet 60 Volt blower motors provide unusual power and performance in a small unit of only 1.186 diameter and 1.890 length.

- **Class B insulating system.**
- **Suitable for operation from a rectified 115V, 60 cps or 400 cps source.**
- **Input voltage may be designed for any voltage up to 60V.**
- **Long brush life.**
- **Toroidal magnet for low external field and high mechanical strength.**
- **Cartridge brushholders for easy field maintenance.**
- **All-metal frame construction.**
- **Designed to withstand severe environmental conditions.**

EICOR

4233 WEST NORTH AVE., CHICAGO 39

Another F. L. Jacobs Division

CIRCLE 151 ON READER-SERVICE CARD

NEW CONCEPTS IN TR TUBES...

MA338 is typical of these new tubes. It is a significant advance over the conventional 6334.

Microwave Associates now offers guaranteed crystal protection for entire life of tube . . . even under full power and elevated temperatures.

Out of Microwave's Switching Devices Laboratory, directed by Dr. Lawrence Gould, comes an important advance in duplexer tubes.

NEW KEEP-ALIVE DESIGN with new ruggedized windows and new stable gas fill maintains spike and flat leakage powers within specified limits over a wide temperature range.

Duplexer loss *plus* interaction *plus* noise generation from keep alive are controlled within tight limits as specified by the system overall noise figure requirement.

RETROFIT IS EASY . . . single and dual tubes are physically interchangeable with conventional tubes, or tubes can be shortened if desired.

Each half of a dual tube is tested individually to provide guaranteed performance. Tubes for applications requiring high repetition rate and short recovery time are available.

FOR COMPLETE DATA about these new TR tubes and other advanced tubes for switching high powers with guaranteed crystal protection at any frequency, write or phone for specific information.

MICROWAVE ASSOCIATES, INC.

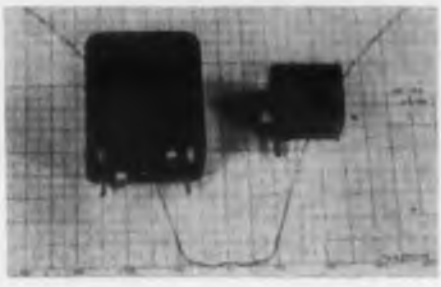
BURLINGTON, MASSACHUSETTS • Telephone: BRowning 2-3000

CIRCLE 152 ON READER-SERVICE CARD

NEW PRODUCTS

Narrow Passband Filters

Miniature



Operating in the frequency range of 175 to 300 kc, type 2E2SM6 narrow passband filters feature high selectivity, stability, and subminiature size. In bandwidths from 20 cps to over 1 kc, these filters can be made with a shape factor (60/6 db) of 3.5 to 1. Insertion loss can be as low as 1 db, while the ripple in the passband is less than 1 db. Drift is less than 10 cps over the temperature range of 0 to 75 C.

Bulova Watch Co., Electronics Div., Dept. ED, Woodside 77, N.Y.

CIRCLE 153 ON READER-SERVICE CARD

Relays

Feature 10 amp contact rating

Design and performance details of these transistorized time delay relays include: time delay periods from 0.01 to 60 sec; timing accuracy of ±10 per cent of nominal delay period; and contact arrangements and ratings of either 1-pole, double throw, 10 amp resistive or 3-pole, double throw, 10 amp resistive.

Industrial Marketing Assoc., Dept. ED, 4 N. Jerusalem Ave., Hicksville, N.Y.

CIRCLE 154 ON READER-SERVICE CARD

Servo Valve

Proportional flow control

A line of servo valves has been designed featuring fast response, low internal friction, minimum null shift, faithful reproduction of small input signals, and insensitivity to variations in temperature and load or supply pressures. The servo valve is a proportional flow control unit. It operates on a dynamic continuous flow sensing principle, made possible by the flowmeter design. Output flow of hydraulic fluid is linearly proportional to the amplitude of the electrical differential input signal. The valves are available for rated flow capacities from 1/2 gpm to 7 gpm and can be designed for use with systems pressures of 500 psi or higher.

Pesco Products Div., Borg-Warner Corp., Dept. ED, Bedford, Ohio.

CIRCLE 155 ON READER-SERVICE CARD

Hydrogen Thyratron

30 megawatts peak power

The model 1802 hydrogen thyratron is a compact unit with 30 megawatts peak power. An air-cooled ceramic envelope permits operation in ambient temperatures up to 100 C, and units have been successfully tested for shock up to 500 g and vibration at 10 g up to 2000 cps. The model 1802 falls in the power range between 5948/1754 and 1257 thyratrons. It is about 3 in. in diameter and 5 in. long.

Edgerton, Germeshausen & Grier, Inc., Dept. ED, 160 Brookline Ave., Boston, Mass.

CIRCLE 156 ON READER-SERVICE CARD

WILMAD

Precision Bore Glass Tubing

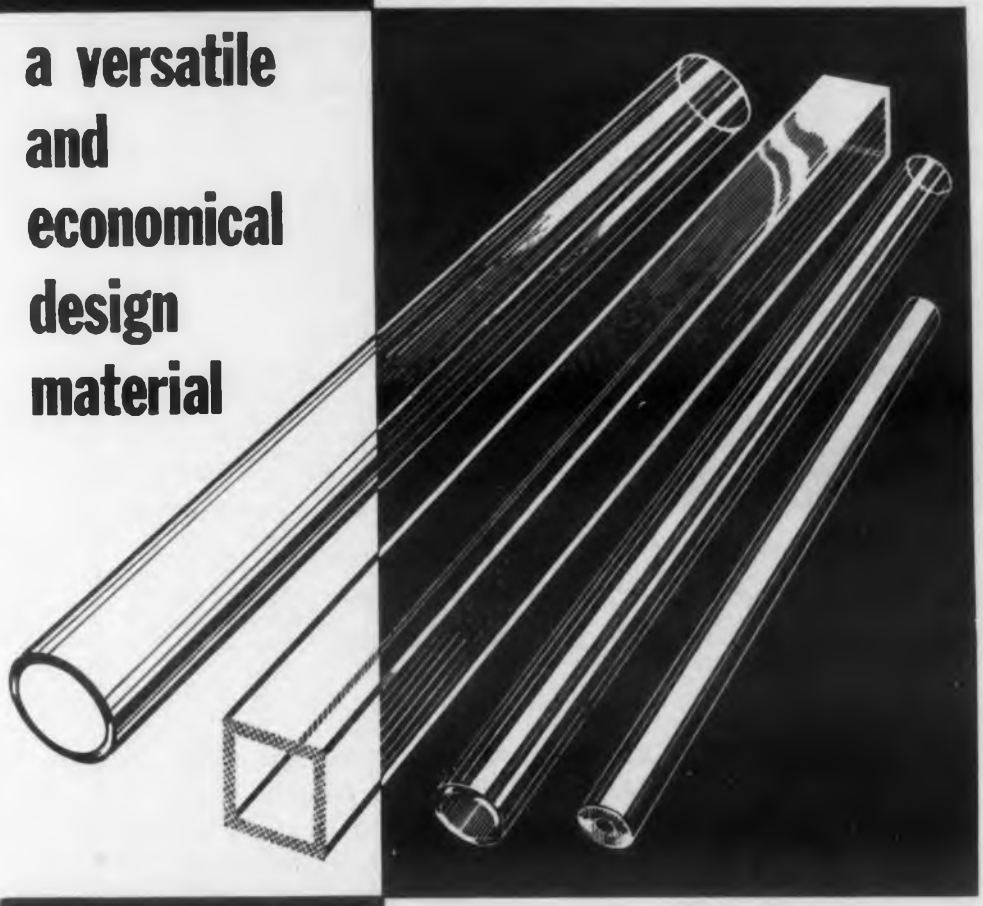
Wilmad precision bore glass tubing is continually being fashioned into newer and better components for many products which demand extreme accuracy at a reasonable cost. And for good reason!

Wilmad consistently works to tolerances of ±0.0002" in the standard sizes of stock tubing. Piece after piece is amazingly uniform, assuring the user repeatability of performance and results. The tubing exteriors may be ground concentric to the bore where necessary. Close O.D. tolerances can be maintained when the exteriors are ground or ground and polished. When requirements dictate extra straight tubing, extremely close camber tolerances can be held.

Economically, Wilmad precision glass components offer a lower initial cost than many other precision-worked materials. There is the possibility that the glass components can be designed to reduce assembly and fabrication costs, too!

If you think precision glassware may be the answer to your design problems, or want to learn more about how glass can be put to work in your product, write to us. We will welcome the opportunity to help.

a versatile and economical design material



WILMAD GLASS CO., INC.

Landisville, N. J.

CIRCLE 158 ON READER-SERVICE CARD

ACEPOT®

SUB-MINIATURE, PRECISION, WIRE-WOUND

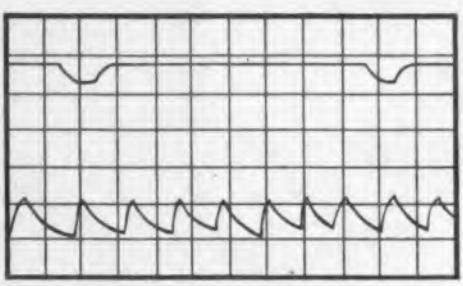
LINEAR POTENTIOMETERS

Small pot size — Big pot performance

Only ½" in diameter, the ACEPOT excels in a combination of all around top performance characteristics comparable to larger units. For example, these precision units feature ± 2% resistance tolerance and ± 0.3% independent linearity. Every potentiometer is completely sealed against sand, dust and foreign matter to avoid abrasive action between moving parts. All materials and metals are treated for maximum resistance to salt spray, corrosion, humidity and conform to shock and vibration tests. ACEPOTS are designed and assembled MIL-A-8625A, QQ-M-1512, JAN-T-152, MIL-E-5272A, MIL-R-19A, NAS-710 and MIL-R-19518 (ships).

ACEPOT LINEARITY TEST

Plot of voltage ratio error versus rotation illustrates linearity to better than ± 0.3%.



ACEPOT RESOLUTION TEST

Section of oscillograph trace of electrical resolution shows voltage change for each turn of wire.

ACE offers a wide variety of linear and nonlinear precision, wirewound potentiometers in standard, special and AIA sizes. Custom designs to meet special requirements can be made available on short lead time. Call, write or teletype Dept. G, ACE ELECTRONICS ASSOCIATES, INC., 99 Dover Street, Somerville, Mass., SOmerset 6-5130, TWX SMVL 181.

ACEPOT®
ACETRIM®
ACESET®
ACEOHM®

ACE ELECTRONICS ASSOCIATES, INC.

CIRCLE 159 ON READER-SERVICE CARD

NEW PRODUCTS

Logic Units

Contain 17 components

Type 200C9 multiple logic package consists of a ceramic-base printed circuit with integral resistors and capacitors. One unit can be used as a flip-flop, pulse generator, or gating, amplifying, clipping, shaping, or delaying circuit by external connections to the nine leads brought out from the printed circuit network. The assembly is for low-speed transistor circuits and contains 10 resistors, 5 capacitors, and 2 transistors in one single encapsulation.

Sprague Electric Co., Dept. ED, North Adams, Mass.

CIRCLE 160 ON READER-SERVICE CARD

Servo Motor

Miniature size 6

Weighing 0.9 oz, this size 6 servo motor will develop a stall torque of 0.125 oz-in., and has a free speed of 6200 rpm. The unit is available for 400 cps operation with 26, 33, or 52 v control phase windings. The control phase is center-tapped for operation directly with transistor amplifiers. Operating temperature range is from −55 to +120 C.

Daystrom Transicoil Corp., Dept. ED, Worcester, Montgomery County, Pa.

CIRCLE 161 ON READER-SERVICE CARD

Focus Coil

Does not overheat

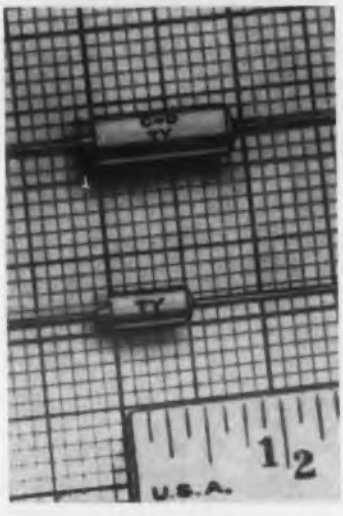
Type F20 electromagnetic focus coil is designed for photographic, flying spot, military and other special purpose tubes requiring short focal lengths at up to 25 kv accelerating potential without overheating. Minimum spot distortion is achieved by machining coil case to close dimensional tolerances. Sharp focus for high beam currents is assured by a large id to focus gap ratio.

Syntronic Instruments, Inc., Dept. ED, 100 Industrial Rd., Addison, Ill.

CIRCLE 163 ON READER-SERVICE CARD

Solid Electrolyte Capacitors

Operate from —80 to +85 C



This series of small, tantalum solid electrolyte capacitors have useful temperature characteristics with a —80 to +85 C range. They have good stability of capacitance with time and temperature and are resistant to corrosion and vibration effects.

Cornell-Dubilier Electric Corp., Dept. ED, South Plainfield, N.J.

CIRCLE 164 ON READER-SERVICE CARD

2 NEW INSTRUMENTS by TECHNITROL

THE DYNAMIC DIODE TESTER

An invaluable means for the rapid, accurate checking of semiconductor diodes for irregularities. The dynamic curve, more revealing than static testing, is quickly apparent on the screen, and is readily adapted to volume testing. And the easy portability of this 16-pound instrument makes it ideal for field work as well as for bench or rack installation.

Designed for use with the Cathode Ray Indicator, this moderate-price instrument provides for a variety of back and forward voltages, as well as independently-controlled ranges for back and forward currents.

THE CATHODE RAY INDICATOR

Send for Bulletin 1002

Provides a visual indicating device for the dynamic display of electrical signals and is intended primarily as an output indicating device for such instruments as the Dynamic Diode Tester and transistor curve tracers.

Also makes an ideal display unit for analogue computer and other applications where the repetitive cycle rate of display is consistent with screen persistences of available five-inch cathode ray tubes.

High-quality components assure a stable instrument which provides a very sharp focused beam on the face of the tube.

Designed for standard 19″ relay rack mounting or with separate mounting legs at additional cost.

DESIGNED AND BUILT BY

TECHNITROL
ENGINEERING COMPANY
1952 E. Allegheny Ave., Phila. 34, Pa.

Manufacturers of Pulse Transformers, Delay Lines and Electronic Test Equipment.

CIRCLE 166 ON READER-SERVICE CARD

on the fence about signal generators?

No need to be foiled in efforts to establish a reliable pole beacon for missile checkout equipment, rapier-witted friend Sherman claims. Our new Model 82 Signal Generator Series, with one power supply and five plug-in r-f oscillators, can parry any problem of instrumentation inflexibility with one thrust (or five), depending upon the scope of your frequency requirements.

We've been told by users that they like its extreme flexibility... resulting in but a bit of the van space previously required for attuning telemetry and guidance channels, tracking and acquisition radar and voice links.

The basic power chassis comprises both high and low power supplies, a variable amplitude (1 kc) sine wave oscillator and a square wave shaper. Individual, interchangeable, r-f assemblies contain the remainder of the generator components and provide coverage of 20-80 mc, 300-500 mc, 800-1100 mc, 1100-1600 mc, and 2700-3000 mc frequency ranges. Two types of modulator units offer the option of high or low power operation in the 500-1000 mc range.

Your request for further information will result in worthwhile, seriously inclined literature.

BJ ELECTRONICS
B-W
BORG WARNER

BJ ELECTRONICS
BORG-WARNER CORPORATION
Reliability you can count upon

3300 NEWPORT BOULEVARD, P. O. BOX 1679, SANTA ANA, CALIFORNIA
EXPORT SALES: BORG-WARNER INTERNATIONAL CORP., CHICAGO, ILLINOIS

CIRCLE 167 ON READER-SERVICE CARD

NEW PRODUCTS

Capacitance Bridge

High-speed automatic unit

This high-speed, 1 mc automatic capacitance limit bridge requires no external capacitors. Units are available with semi or fully automatic component feeding and sorting mechanisms.

Industrial Instruments, Inc., Dept. ED, 89 Commerce Rd., Essex County, N.J.

CIRCLE 168 ON READER-SERVICE CARD

Drone Command Antenna

For shipboard use

This uhf 3 bay, circularly polarized omni-directional antenna is ruggedized to make it serviceable for shipboard application. The AT-781/U has a vertically stacked array of four quadrature unipoles interposed between the 2nd and 3rd bays to improve overhead coverage.

Gabriel Electronics, Dept. ED, Needham Heights, Mass.

CIRCLE 169 ON READER-SERVICE CARD

AIR FILTER.—P-61 filter panel prevents objectionable dust particles from entering electronic cabinets and other electronic devices.

Air-Maze Corp., Dept. ED, 25000 Miles Rd., Cleveland 28, Ohio.

CIRCLE 190 ON READER-SERVICE CARD

WIRE SPARKER.—20 kv dc sparker permits nondestructive fault detection at wire speeds of 4000 fpm.

Peschel Electronics, Inc., Dept. ED, R.F.D. 1, Patterson, N.Y.

CIRCLE 171 ON READER-SERVICE CARD

RADIATION RECORDER.—Gamma intensity time recorder is portable, transistorized. It records on magnetic tape the time and intensity of gamma radiation to which it is exposed.

Land-Air, Inc., Dept. ED, 7444 W. Wilson Ave., Chicago 31, Ill.

CIRCLE 172 ON READER-SERVICE CARD

LAMPHOLDER.—Model H2005-IL lampholder is for use with 2-pin lamps in high heat applications.

Drake Mfg. Co., Dept. ED, 1711 W. Hubbard St., Chicago 22, Ill.

CIRCLE 173 ON READER-SERVICE CARD

THERMISTOR KIT.—Model G200 kit is designed for experimental work, and for familiarizing engineers with thermistors.

Fenwal Electronics, Inc., Dept. ED, Mellen St., Framingham, Mass.

CIRCLE 174 ON READER-SERVICE CARD

CRYSTAL OVEN.—JKO 13S oven provides operating temperatures from 55 to 125 C with temperature stability of ±1.0 per cent. Operates on 12 to 115 v.

James Knights Co., Dept. ED, Sandwich, Ill.

CIRCLE 175 ON READER-SERVICE CARD

CHART VIEWER.—Model 276 for oscillographic recording provides variable chart drive speeds and takes charts to 16 in. wide and 200 ft. long. Has transparent plastic cursor.

Sanborn Co., Industrial Div., Dept. ED, 175 Wyman St., Waltham 54, Mass.

CIRCLE 176 ON READER-SERVICE CARD

TUBE AND TRANSISTOR TESTER.—Model 10-60 features a beam current test, a sensitive gas test, and functional testing of voltage regulator tubes.

Precision Apparatus Co., Inc., Dept. ED, Glendale, N.Y.

CIRCLE 177 ON READER-SERVICE CARD

DIGITAL CLOCKS.—DC-100 clocks are designed for industrial applications and have seven digit outputs.

G. M. Giannini & Co., Inc., Dept. ED, 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 178 ON READER-SERVICE CARD

TUNING INDICATOR.—Type EM84/6FG6, for use in broadcast receivers and tape recorders, has a rectangular indication pattern.

Amperex Electronic Corp., Dept., ED, 230 Duffy Ave., Hicksville, N.Y.

CIRCLE 179 ON READER-SERVICE CARD

Reader preference studies show that more and more Electronic Design subscribers are becoming "one publication" readers. The reason for this is simple. Electronic Design is more complete, more timely, and of more direct interest to the electronic design engineer than any other technical publication. Electronic Design is 100% design—brings information to the engineer's attention much faster than monthly publications with diverse editorial interests. Electronic Design runs not only more new product items than any other magazine, but runs all the new products of interest to the electronic design engineer. Save valuable reading time, and keep completely up to date, by reading Electronic Design — every other Wednesday in 1958.

DESIGN

A HAYDEN Publication
830 Third Avenue
New York 22, N.Y.

NEW PRODUCTS

GEAR REDUCER.—Six station unit can produce a variety of reduction ratios. A selector knob accomplishes ratio changes smoothly.

The Haxton Gear Co., Inc., Dept. ED, 7-11 Main St., East Rockaway, N.Y.

CIRCLE 181 ON READER-SERVICE CARD

CAPTIVE FASTENERS.—Cadmium plated KM fasteners for use on equipment requiring sheet metal enclosure.

Camloc Fastener Corp., Dept. ED, 61 Spring Valley Rd., Paramus, N.J.

CIRCLE 182 ON READER-SERVICE CARD

LOW-LEVEL DC INVERTER.—Type D-100 voltmeter inverter permits use of a standard ac vtvm for microvolt dc readings and eliminates the need for buying dc vtvm's. Range is 100 μv to 100 v.

Microdyne, Dept. ED, 300 W. Washington St., Chicago 6, Ill.

CIRCLE 183 ON READER-SERVICE CARD

GROUND POWER SUPPLY.—500 amp silicon rectifier type regulated ground dc power supply has dc output voltage of 25 to 40 v at continuous load capacities up to 500 amp.

Perkin Engineering Corp., Dept. ED, 345 Kansas St., El Segundo, Calif.

CIRCLE 184 ON READER-SERVICE CARD

MOUNTINGS.—BTR mountings designed for use in aircraft and missiles requiring mounting systems having natural frequencies above 20 cps.

Lord Manufacturing Co., Dept ED, 1635 West 12th St., Erie, Pa.

CIRCLE 185 ON READER-SERVICE CARD

CIRCUIT BREAKER.—Model 4000 is rated 0.05 to 6 amp, and may be used for applications requiring quick-release protection.

E-T-A Products Co. of America, Dept. ED, 5085 N. Elston Ave., Chicago 30, Ill.

CIRCLE 186 ON READER-SERVICE CARD

SILICON RECTIFIER.—The 1N1169 is designed to replace conventional selenium rectifiers used in TV sets.

Westinghouse Electric Corp., Semiconductor Dept., Dept. ED., Youngwood, Pa.

CIRCLE 187 ON READER-SERVICE CARD

PRESSURE TRANSDUCER.—A high temperature version of model 45176 is now available for use in ambient temperatures to 149 C.

G. M. Giannini & Co., Inc. Dept. ED, Pasadena, Calif.

CIRCLE 188 ON READER-SERVICE CARD

TRANSISTORS.—Ten general purpose types, 2N563 through 2N572, feature tight parameter control.

General Transistor Corp., Dept. ED, 91-27 138th Place, Jamaica 35, N.Y.

CIRCLE 189 ON READER-SERVICE CARD

New Products Index

New products, new materials and production products announced during the first half of this year are listed here by category. Following each category are issue and page numbers. The date corresponding to the issue number is given at the bottom of the page.

Components

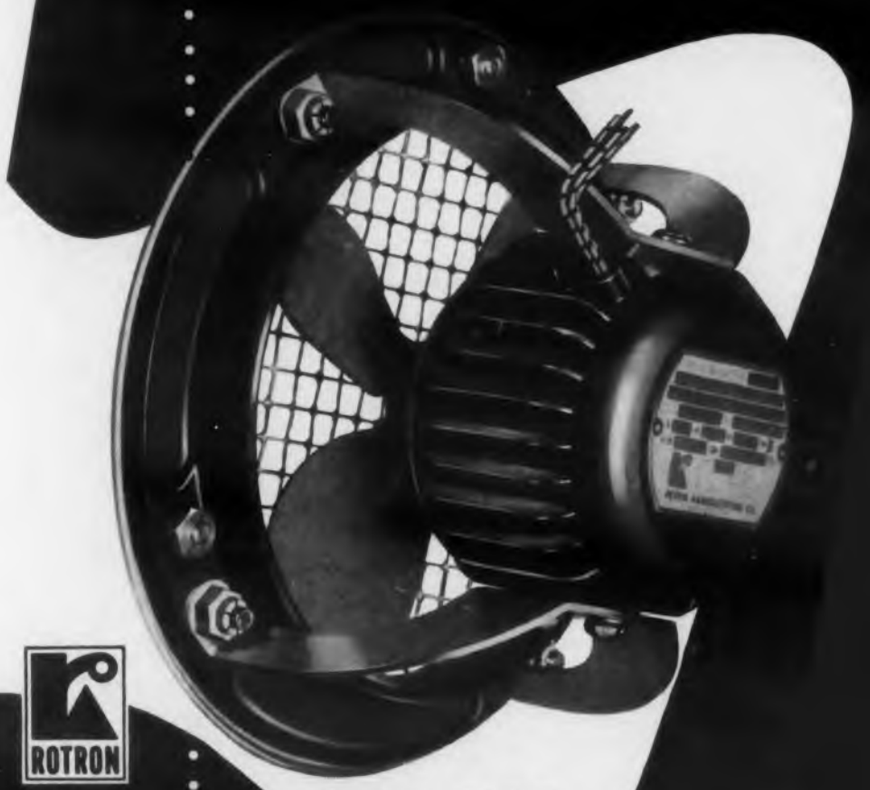
1 — Jan. 8 | 2 — Jan. 22 | 3 — Feb. 5 | 4 — Feb. 19
5 — Mar. 5 | 6 — Mar. 19 | 7 — Apr. 2 | 8 — Apr. 16
9 — Apr. 30 | 10 — May 14 | 11 — May 28 | 12 — June 11
13 — June 25

new model DFE

4 inch propeller fans with screen and venturi

Made with 22 different motor types,
1 Ø, 3 Ø, • 50-60-400 CPS,
variable frequency,
also with "ALTIVAR" high altitude motors.

Request copies of new catalog sheets
#s 50102-5, 50102-6 and 50102-7



ROTRON

ROTRON

MANUFACTURING CO., Inc.

WOODSTOCK • NEW YORK

CIRCLE 194 ON READER-SERVICE CARD

Test Equipment

Materials, Production Equipment and Systems

NEW LITERATURE

Technical Product Surveys 195

Technical surveys and what they can do for a product development program are explained in a 4-page brochure. The text outlines ways in which product data on user requirements, applications, competitive products, and market conditions are gathered and analyzed. It also describes six types of survey that can be made. Designers for Industry, 4241 Fulton Pkwy., Cleveland 9, Ohio.

Tube Clamps 196

Catalog 5-KK features heat reducing tube clamps. The 16-page booklet covers types for all miniature and subminiature tubes and many components, in both beryllium copper and heat treated silver. Methods of attaching clamps to heat sink and/or chassis are discussed. The Birtcher Corp., 4371 Valley Blvd., Los Angeles 32, Calif.

Power Supply 197

Bulletin GEC-1497, two pages, provides information concerning a 28-v, one-amp unregulated transformer-rectifier airborne power supply. A photo, graph, line drawing, and lists of electrical and mechanical characteristics illustrate primary features of the 14-oz, convection-cooled unit. General Electric Co., Schenectady 5, N.Y.

Tuning to The Satellites

"You Can Record the Satellites!" is a 12-page illustrated booklet showing how to receive and record satellite radio signals and help space research. It tells how to set up equipment, how to interpret recordings, and how to tell whether they are of value to the official satellite project. *Copies may be had for a 10¢ mailing fee from Audio Devices, Inc., Dept. ED, 444 Madison Ave., New York 22, N.Y.*

photo courtesy of Bourns Laboratories

MILLISECOND WELDING HELPS BOURNS BEAT HEAT PROBLEMS IN TRIMPOT® ASSEMBLY

Heat must be kept at a minimum in joining leads to the resistance element tabs of this sensitive TRIMPOT® potentiometer. The long pulses of most welders would transmit heat to the .001" Evanohm resistance wire, altering its characteristics and impairing performance. Low-temperature soldering might mean "cold" joints. With a Weldmatic, Bourns makes welds in 1½ milliseconds – no chance for heat transfer beyond the weld! Result: high component accuracy, low reject rate. Write for Weldmatic literature.

WELDMATIC DIVISION OF UNITEK CORPORATION
260 North Halstead Avenue • Pasadena, California

SALES ENGINEERING REPRESENTATIVES IN PRINCIPAL CITIES

CIRCLE 199 ON READER-SERVICE CARD

SANDERS MINICUBE® BLOWER

Blower and Motor in 1" Cube
Cools and ventilates miniature equipment

Designed for use in aircraft and missiles, this Sanders Minicube Blower is ruggedly packaged . . . operates over wide ranges of vibration, acceleration and temperature.

APPLICATIONS

- Maintaining uniform flow of air in restricted spaces.
- Preventing fogging of lenses and viewing glasses.
- Eliminating hot spots around Klystrons and other electronic tubes and devices.

SPECIFICATIONS

Input: 400 cps, 3 watts
Voltage: Model 1A — 6.3 volts
Model 2A — 26 volts
Speed: 22,000 rpm approx.
Size: 1" x 1" x 1"
Weight: 1 1/4 oz

For complete details about prices, delivery schedules, and conformance to military specifications, write:

SANDERS ASSOCIATES
NASHUA, NEW HAMPSHIRE

DAYTON, OHIO • INGLEWOOD, CALIFORNIA • WASHINGTON, D. C.

CIRCLE 200 ON READER-SERVICE CARD

VSWR and RF WATTMETERS

25 MCS TO 3000 MCS

These rugged, compact units accurately measure and indicate the RF power and VSWR of coaxial transmission lines. Each type combines a frequency insensitive bidirectional coupler and complete indicator circuit in one small case. Accuracy of power measurement is ± 5% of full scale.

Model No.	Frequency Range (Mcs)	Power Range (Watts)	RF Connectors
712N	25—1000	0-2.5; 5; 10 in 3 scales	N*
723N	1000—3000	0-12 in one scale	N†

** Also available with UHF, BNC and Type C connectors*
† Also available with BNC and Type C connectors

For more information please write for 68-page catalog No. 12 or see Electronics Buyers' Guide or Electronic Engineers Master.

U.S. Letters Patent No. 2,588,390

M.C. JONES ELECTRONICS CO., Inc.
BRISTOL, CONNECTICUT

CIRCLE 204 ON READER-SERVICE CARD

NEW LITERATURE

Ultrasonic Cleaning 205

A 24-page bulletin, S-200, explains practical applications and basic principles of ultrasonic cleaning methods and equipment. Design information occupies a large part of the booklet, along with information on solutions and chemicals recommended for ultrasonic cleaning. Optimum frequencies, characteristics of the cleaning liquid, efficiency, and other such factors are also discussed. Branson Ultrasonic Corp., 40 Brown House Rd., Stamford, Conn.

Coil Winding 206

This catalog page illustrates an efficient heavy duty (4 to 23 awg wire) multiple transformer and bobbin winder which form winds coils without pounding. Technical details are given on dimensions, types of coils wound, wire sizes, set-up time, tension and motor equipment, winding speeds and range. Geo. Stevens Mfg. Co., Inc., Pulaski Rd at Peterson, Chicago 46, Ill.

Programming System 207

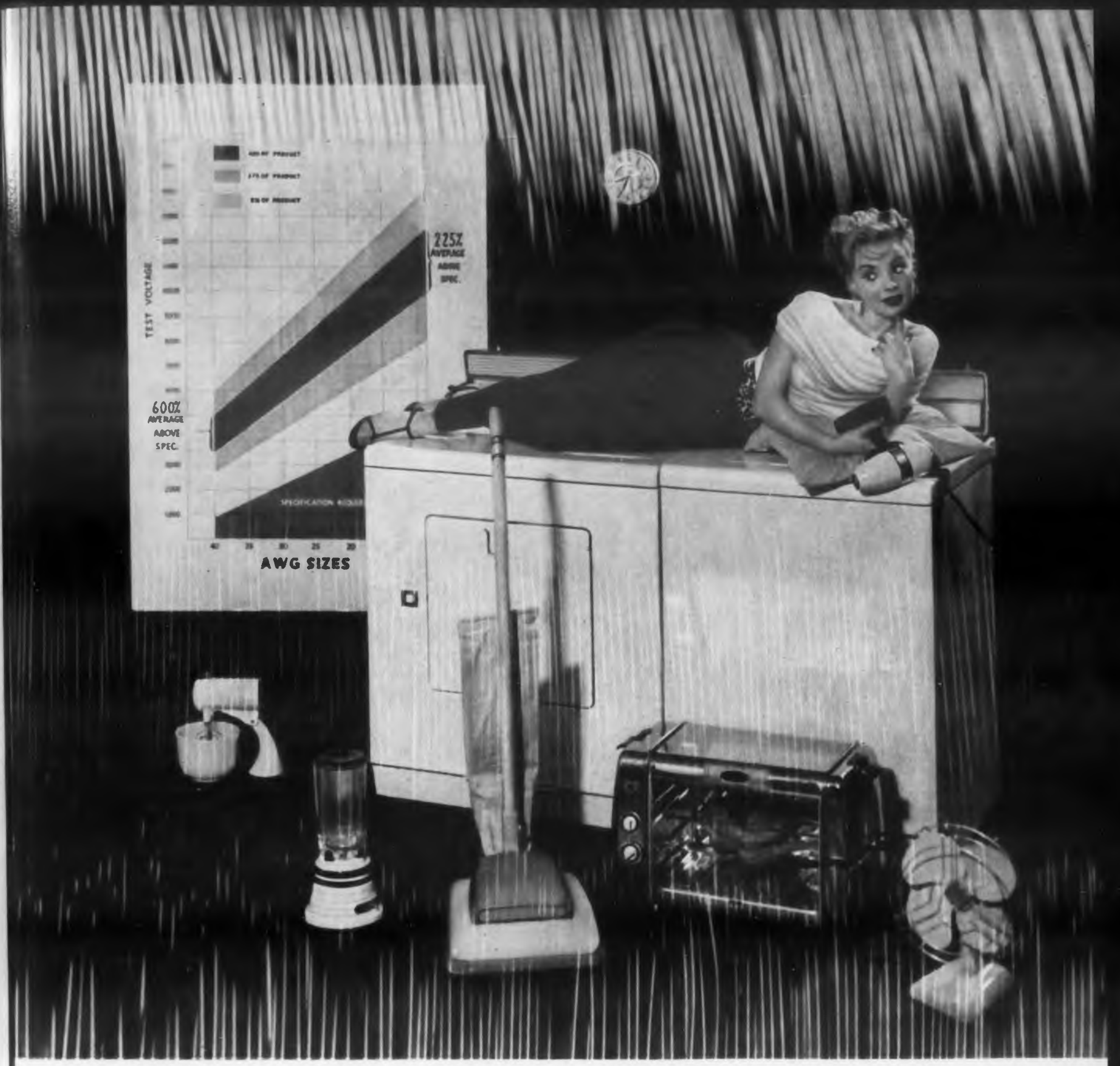
A four-page bulletin describing a programming system method is now available. The system, known as the Intercom 1000, has been designed for use with a general purpose digital computer and is a major simplification in the process of writing instructions to a computer. Bendix Computer Div., 5630 Arbor Vitae St., Los Angeles, Calif.

Mercury Switches 208

A catalog covering a recently introduced line of glass mercury switches is available. Full specifications and scale line drawings are supplied. Capacity ranges are also given. Gordos Corp., 250 Glenwood Ave., Bloomfield, N.J.

Core Inductance Limits 209

Guaranteed practical inductance limits for molybdenum permalloy powder cores have been published for distribution. Magnetics, Inc., Butler, Pa.



"A girl has to think about Magnet Wire and specifications and things...."

"...I mean, really! Maybe you think that's too deep for an average housewife like me. But let me ask you, who's got the most to lose if magnet wire doesn't have the proper dielectric strength? Yours truly, that's who! Who suffers if the temperature and abrasion resistance isn't up there? Who but us, with all our appliances?

"I just wish we *housewives* could pick the magnet wire that goes into the motors and coils of every one of these things. I mean, really! Because I'd pick *Roebling Magnet Wire.* It's *always* way higher than the NEMA Specifications. And if you think that's not important to a girl...!" Electrical Wire Division, John A. Roebling's Sons Corporation, Trenton 2, N. J.

ROEBLING

Branch Offices in Principal Cities
Subsidiary of The Colorado Fuel and Iron Corporation

Thermocouples 212

A 28-page catalog, describing a complete line of miniature thermocouples is now available. Gasket, bayonet, protected and shielded designs are described. Information is contained on uses and advantages of each type, on calibrations and temperature ranges, details of construction, adapters and mounting accessories, and thermocouples leads. Various terminals and quick-coupling connectors are also illustrated and temperature conversion tables are provided. Thermo Electric Co., Inc., Saddle Brook, N.J.

Electrolytic Capacitors 213

Subminiature electrolytic capacitors, both tubular and upright, are featured in a 4-page catalog. Part numbers are listed in tables along with dimensions and voltage and temperature ranges. Illustrated with graphs, photographs, and dimensional drawings, the catalog also gives complete specifications. Illinois Condenser Co., 1616 N. Throop St., Chicago 22, Ill.

High Vacuum Valves 214

Data Sheet 571, two pages, points out the principal features of series ST gate type high vacuum valves. Photographs and dimensional drawings illustrate the text. F. J. Stokes Corp., Vacuum Equipment Div., 5500 Tabor Rd., Philadelphia 20, Pa.

Altitude-Pressure Table 215

A table of equivalent pressures in millimeters of mercury for altitudes from sea level to 2 million feet is offered free. The table is printed on a wallet-size card. F. J. Stokes Corp., Vacuum Equipment Div., 5500 Tabor Rd., Philadelphia 20, Pa.

Specialty Motors 216

GEC-1502 is a 4-page bulletin on a full line of small ac motors for diverse applications. A selection chart shows over 200 rating combinations available in the three frame sizes. Dimensions, construction, and performance are illustrated and described. General Electric Co., Schenectady 5, N.Y.

MAXIMUM POWER · MINIMUM SIZE

TRUE DIFFUSED JUNCTION SILICON POWER DIODES

Now, you can select from a full series of high power silicon rectifiers having the superior uniformity and reliability of *true* diffused junction construction. Conservatively rated up to 30 amperes at 50 to 400 p.i.v., these high-performance diodes feature a low forward voltage drop and an ambient temperature range of —65°C. to +150°C.

Small, rugged and efficient, Silotron stud-mounted types incorporate a glass-to-metal hermetic seal and a solid copper construction for maximum electrical conductivity and heat dissipation. Lower-priced than many less-advanced types, these rectifiers are economical and reliable long-life components for new or replacement designs. For maximum design flexibility, all Silotron diodes are available with reversed polarity.

TYPE NO.	MAX. AVG. FWD. CURRENT, 40° C.* (AMPERES)	PEAK INVERSE VOLTS	RMS VOLTS MAX.	LEAKAGE MA.**
P1005	10	50	35	<5
P1010	10	100	70	<5
P1015	10	150	105	<5
P1020	10	200	141	<5
P1040	10	400	283	<5
P1505	15	50	35	<5
P1510	15	100	70	<5
P1515	15	150	105	<5
P1520	15	200	141	<5
P1540	15	400	283	<5
P2005	20	50	35	<5
P2010	20	100	70	<5
P2015	20	150	105	<5
P2020	20	200	141	<5
P2040	20	400	283	<5
P2505	25	50	35	<5
P2510	25	100	70	<5
P2515	25	150	105	<5
P2520	25	200	141	<5
P2540	25	400	283	<5
P3005	30	50	35	<5
P3010	30	100	70	<5
P3015	30	150	105	<5
P3020	30	200	141	<5
P3040	30	400	283	<5

* 6" x 6" heat sink
** at max. rated forward current and PIV

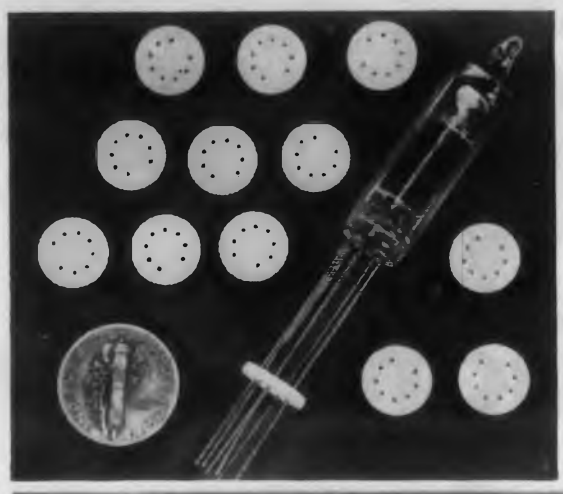
Maximum forward voltage drop:
25°C. at full rated current. 1.2 volts

Write today for complete details on our full line

THERMOSEN, INC.

375 FAIRFIELD AVENUE • STAMFORD, CONNECTICUT

CIRCLE 218 ON READER-SERVICE CARD



No. 1

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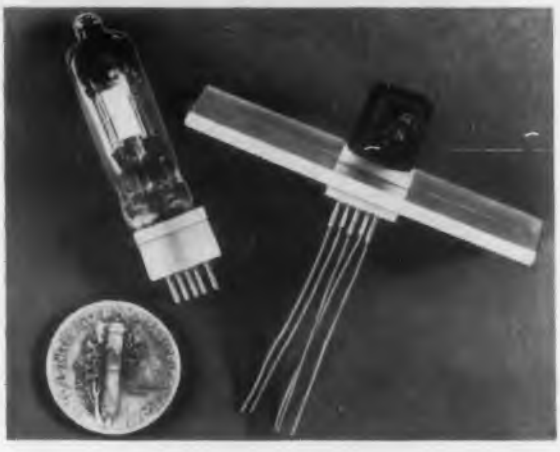

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Division of United States Gasket Co., Camden 1, New Jersey

Fluorocarbon Products Inc.

CIRCLE 220 ON READER-SERVICE CARD

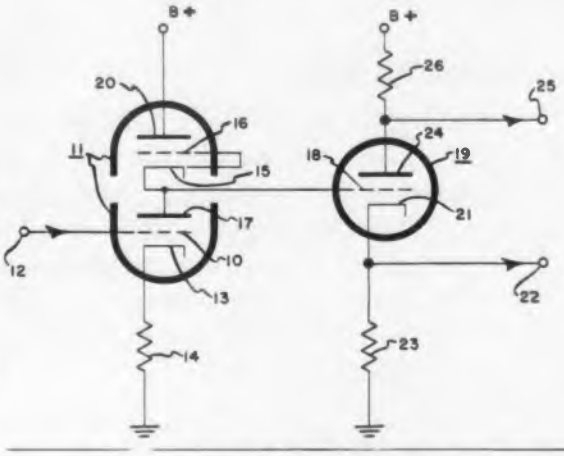
PATENTS

Phase Inverter

Patent No. 2,827,521. L. R. Jacobsen. (Assigned to Hoffman Electronics Corp.)

A phase splitter is connected to a high gain constant-current amplifier in order to obtain symmetrical output voltages free from distortion and phase shift.

A conventional phase splitter, such as triode 19 by itself, would require a source of bias for the amplifier to operate along a linear characteristic. In general, the use of a parallel resistor and condenser in the cathode circuit for requisite bias voltage results in phase shift.



Tube 11, such as a 12AU7, operates as a constant-current amplifier which is dc coupled to the grid of the phase splitter. The constant-current amplifier consists of a triode load to linearize the output characteristics and feedback due to the unbypassed cathode resistor 14. The circuit parameters are selected so that with no signal applied to terminal 12, the grid to cathode bias of tube 19 permits the phase splitter to operate along a linear characteristic. The overall gain of the combination of constant-current amplifier and phase splitter is calculated to be twice the amplification factor of the constant-current amplifier.

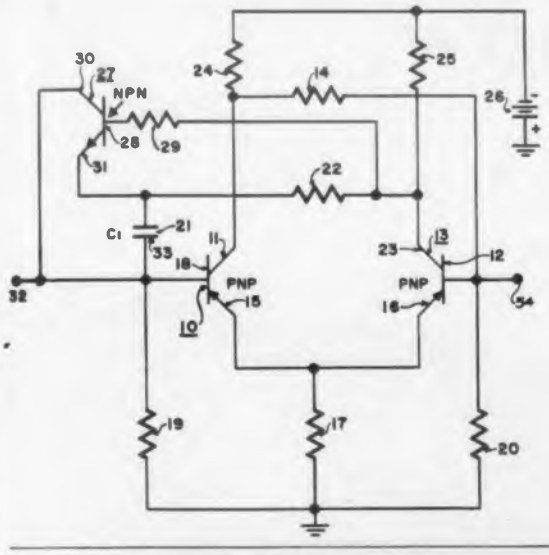
Multivibrators

Patent No. 2,827,574. Seymour Schneider. (Assigned to Hoffman Electronics Corp.)

A complementary type transistor is connected across the cross coupling condenser of a transistor multivibrator to reduce the recovery time of the multivibrator to the quiescent state. When connected as shown, transistor 27 short cir-

cuits condenser C1 as long as transistor 13 is conducting. Transistor 27 is switched to cutoff when transistor 10 conducts. The short circuit is removed and condenser C1 charges.

In the quiescent state transistor 12 is conducting and transistor 10 is at cutoff. A negative pulse applied to electrode 32 causes transistor 10 to conduct; the junction of resistors 24 and 14 becomes positive and transistor 13 cuts off since base 12 is at a positive potential. When the voltage on base 18 approaches the voltage across resistor 17, transistor 10 cuts off and transistor 13 is switched.



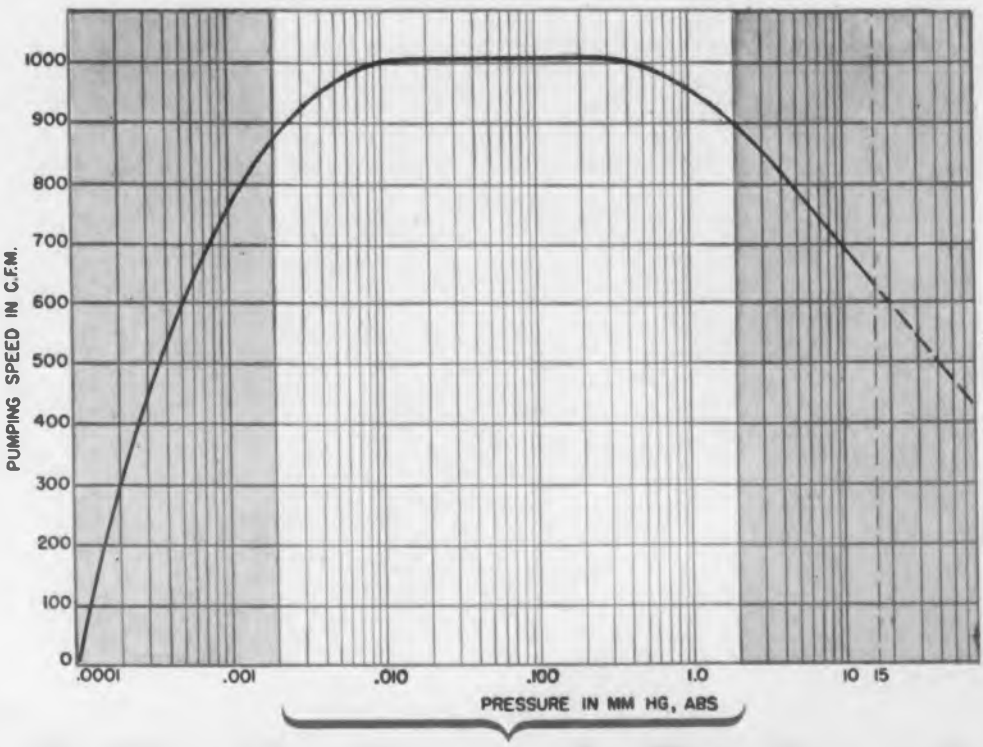
Condenser C1 would ordinarily discharge through resistors 22 and 19 at this time. However, with transistor 13 conducting, base 28 of transistor 27 is at a positive voltage with respect to emitter 31 and transistor 27 conducts, rapidly discharging condenser C1.

The circuit is thus highly sensitive to the succeeding negative pulse applied to terminal 32.

Oscillation Cut Off

Patent No. 2,815,426. Milton Rothstein. (Assigned to Radio Receptor Co., Inc.)

The device includes an hf circuit having an hf generator connected to a load. A control component controls the output of the generator. A spark gap, in circuit with the control component, normally does not conduct during the operation of the generator. A dc power source is controlled by a switch which energizes the spark gap. When the switch is closed a dc breakdown potential is impressed across the gap. This initiates conductive sparking which alters the control effect.



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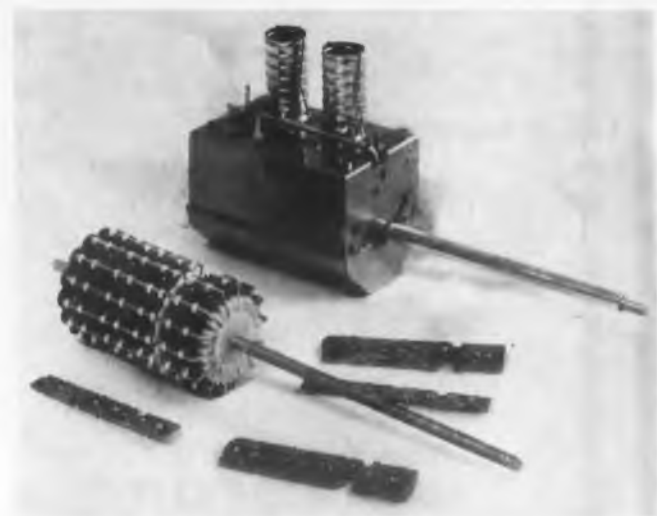
Many 'Firsts' Displayed

At British Component Show

More than 170 exhibitors were represented at the recent Radio and Electronic Component Show held in London. Though a little more restrained in appearance than our IRE Show, there was no dearth in new product announcements.

High-temperature transformer announced by Gresham Ltd. for airborne applications operates at 130 to 150 C.



Printed wiring and coils are being used for the first time by the British for frequencies as high as 220 mc in this 14-channel TV current tuner developed by Sidney S. Bird, Ltd.

MANY OF England's latest "firsts" were featured at the 15th Radio and Electronic Components Show held in London recently. More than 170 exhibitors unveiled components, materials, and processes encompassing the entire spectrum of current British effort.

As a great number of the displays were sponsored by the Government's R & D Committee, which promotes the development of components to meet military requirements, the most noticeable trends in component design were quite similar to those experienced by American component manufacturers, including:

- Extended temperature range;
- Still further miniaturization particularly in switches, connectors, relays, etc.;
- Increased environmental robustness and ability to withstand high values of 'g' up to 45 and 50;
- Extended use of grain-oriented silicon-iron material in strip or laminated form for magnetic components—particularly saturable reactors and transductors.

Present minimum requirements for guided missile components, according to the Ministry of Supply is that they must stand up to:

- Temperatures varying from minus 55 deg C to 125 deg C;
- Humidity up to 95 per cent;
- Shock of 50 bumps at 100 g;
- Vibration of 10 g sweeping 50 to 2000 cps for 10 hours;
- Endurance of 2000 hours at max ratings and upper temperature limit.

Discussions have also been held on the advisability of instituting a 0.01 per cent reliability factor for all missile components and equipment.

Printed circuit components appear to have come into their own of late. New in Britain was the use of a 14-channel TV and fm tuner of a printed circuit chassis and coils in the 40 mc to 220 mc frequency range. Improved gain and noise characteristics were reported by Sidney S. Bird, Ltd. who developed the tuners.

Painton and Co., Ltd. displayed a range of

"Flatpot" preset wirewound potentiometer developed by Painton & Co., Kingsthorpe, Northampton.

BRITISH NEW PRODUCTS

miniature flat wirewound potentiometers suitable for stacking in printed circuit applications. Each measures 1-1/2 x 5/16 x 7/32 in. in ranges from 10 ohms to 10 kilohms. Painton also announced that a miniature 20-way printed circuit plug and socket with 0.1 inch centers is nearing completion.

Increased operating temperatures of components was marked. Concentration of effort in this area resulted in the development of an experimental transformer designed to operate at 500 deg C. This model is interleaved with glass cloth on a split-metal form, with a core of grain-oriented silicon iron laminations. Normal rating is 100 volt-amperes at 1600 cps. A series of small open-C and E-core transformers designed to operate at temperatures of 130 to 155 C were exhibited by Gresham Transformers Ltd. These units are intended for airborne equipment continually operated at 100 C ambients.

Samples of boron nitride, the first material to become available in any quantity for use as a good insulator and dielectric at temperatures of 500 C, were exhibited by the Ministry of Supply. The Ministry also presented examples of solid circuit assemblies produced through the successful deposition of thin resistive, capacitive and magnetic films and their connections upon a single baseplate.

New semiconductor devices displayed by Mullard Ltd. included three silicon pnp transistors—one audio and two high frequency types—with junction temperature ratings from minus 55 to plus 150 C, as well as a subminiature silicon diode and two gold-bonded germanium diodes.

The germanium diodes exhibited an eminent suitability for use with high frequency transistors in computer circuits.

This manufacturer also featured matrix planes containing 32 x 32 or 64 x 64 loop cores wired in stacks as complete memory storage units for computers, with storage capacity of 1,024 and 4,096 words, respectively.

Among new test instruments shown was a signal generator built by Taylor Electrical Instruments Ltd. covering the frequency range from 100 kc to 220 mc, all on fundamentals, with a calibration accuracy of 1 per cent.

Immediately below, ELECTRONIC DESIGN presents some additional representative products unveiled at the show.

DC Microammeter

High torque/weight

Robust instrument, with torque/weight ratio at least twice that of conventional movements. It consists of a center core magnet surrounded by a soft iron ring where the oil rotates around the magnet. Meter offers stick-free operation, inherent magnetic shielding, and can withstand 10,000 per cent overload. Manufacturer has also announced a high sensitivity 5 μa meter.

Taylor Electrical Instruments Ltd., Dept. ED, Montrose Avenue, Slough, Bucks.

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Audio Frequency Transformer

Push-pull output

This range of push-pull output transformers is intended for use in equipment reproducing the full audio frequency range with the lowest distortion. Two models are available to give optimum performance at various power levels up to 50 w and tappings are provided for ultra linear connection. They are finished with a die-cast shrouding and can be mounted in either direction. By employing grained oriented core material, high performance figures are obtained.

Partridge Transformers Ltd., Roebuck Road, Chessington, Surrey; M. Swedgal Electronics, Dept. ED, 258 Broadway, New York 7, N. Y.

CIRCLE 245 ON READER-SERVICE CARD

Precision Potentiometer

Low-starting torque

The Type 11 potentiometer has a starting torque of 0.5 gm cm. As part of the manufacturer's range of precision potentiometers, it is designed to provide analog conversion from mechanical rotation to an electrical signal. Linear and sine/cosine laws are available and other non-linear functions can be manufactured. Potentiometer has good resolution and linearity. They are capable of reliable operation under severe shock.

Ferranti Ltd., Dept. ED, Hollinwood, Lancs.

CIRCLE 248 ON READER-SERVICE CARD

Miniature Rotary Trimmer

Solid electrode

This Air Dielectric Rotary Trimmer has the rotor and stator each milled from solid metal eliminating practically all joints and assuring high electrical and mechanical stability with close conformity to specifications.

Known as the SMT9/7.3, it measures 0.375 x 0.375 x 0.477 in. Terminal lugs, comprising strips 0.05 in. x 0.015 in., can be bent down 90 deg bringing their centers to modules of 0.10 in., for direct mounting on printed circuit boards.

A differential capacitor Type SDMT9/7.3 is also available in the same construction and with the same dimensions as the trimmer.

Principal specifications of both are: gap 0.009 in., capacity $\leqslant 1.8\mu\mu f$ to $\geqslant 7.3\mu\mu f$, test voltage 1000 v dc, insulation 5000 meg power factor 0.001, torque 2.8 oz.

Oxley Developments Ulterston, England; British Radio Electronics Ltd., Dept. ED, 1833 Jefferson Pl. N.W., Washington 6, D. C.

CIRCLE 249 ON READER-SERVICE CARD

RUSSIAN TRANSLATIONS

What the Russians Are Writing

J. George Adashko

AUTOMATIC CONTROL

Synthesis of Structure of Multiple-Loop Regulation in the Presence of Delay Elements by M. V. Meyerov. AT 12/57, pp 1098-1108, 4 figs.

Certain methods are described that permit synthesis of multiple-loop control systems with delay elements. The gains of the separate circuits are made as large as possible.

Methods for Optimum Regulation by I. S. Morosanov. AT 11/57, pp 1029-1044, 10 figs.

Discusses fundamental methods of optimizing control systems. The systems are classified in accordance with the

method used to optimize the system. The features of self-oscillating modes are illustrated with an example of optimum relay systems. Practical recommendations are made. Refers to several American articles on process control and on servomechanisms, among them an article by Shull, "An Automatic Cruise Control Computer for Long Range Aircraft" Transactions IRE, (Electronic Computers), No. 12, 1952.

Certain Features of Switching in Nonlinear Systems of Automatic Regulation with Piecewise-Smooth Characteristic of the Nonlinear Elements by M. A. Ayzerman and F. R. Gantmakher. AT 11/57, pp 1017-1028, 11 figs.

The authors discuss characteristics comprising infinite curves, those comprising sections of curves, and others. Usually the theory of relay systems deals with switching in which the dead time is short compared to the operating time, or in which switch operation is assumed instantaneous. The author discusses other types of switching, of the "sliding" type.

Dynamic Accuracy of Servo System Containing a Nonlinear Element with Polynomial Characteristic by S. Ya. Rayevskiy. AT 11/57, pp 1010-1016, 2 figs.

The author computes the rms error for assumed stochastic disturbances. He uses successive approximation on the basis of an approximate representation of the higher moments in terms of the lower ones.

MEASUREMENTS

Method for Measuring Audio Frequencies by A. I. Fyurstenberg. RE 12/57, pp 67-72, 5 figs, 2 tables.

Description of a simplified procedure, producing an accuracy of ± 0.05 per cent, and requiring no complicated or expensive equipment. Using a heterodyne frequency meter and an oscillograph one can measure frequencies approximately from 5000 cycles and above without using frequency multiplication or division. Lissajous figures with large multiplicities together with auxiliary calculations make it possible to measure frequencies from 1000 cycles up. Lower frequencies can be measured with a heterodyne frequency meter, an intermediate oscillator, and two oscillographs.

Instrument for Measuring Nonlinear Distortion by L. Ya. Kantor. CJ 12/57, pp 8-10, 4 figs.

Description of a simple instrument to measure nonlinear distortion. It uses the principle of compensation for the fundamental component of the output voltage by means of the amplifier input voltage.

New Method for Measuring the Bandwidth Radiated by a Radio-Telegraph Transmitter by M. S. Gurevich. CJ 12/57, p 27, 1 fig.

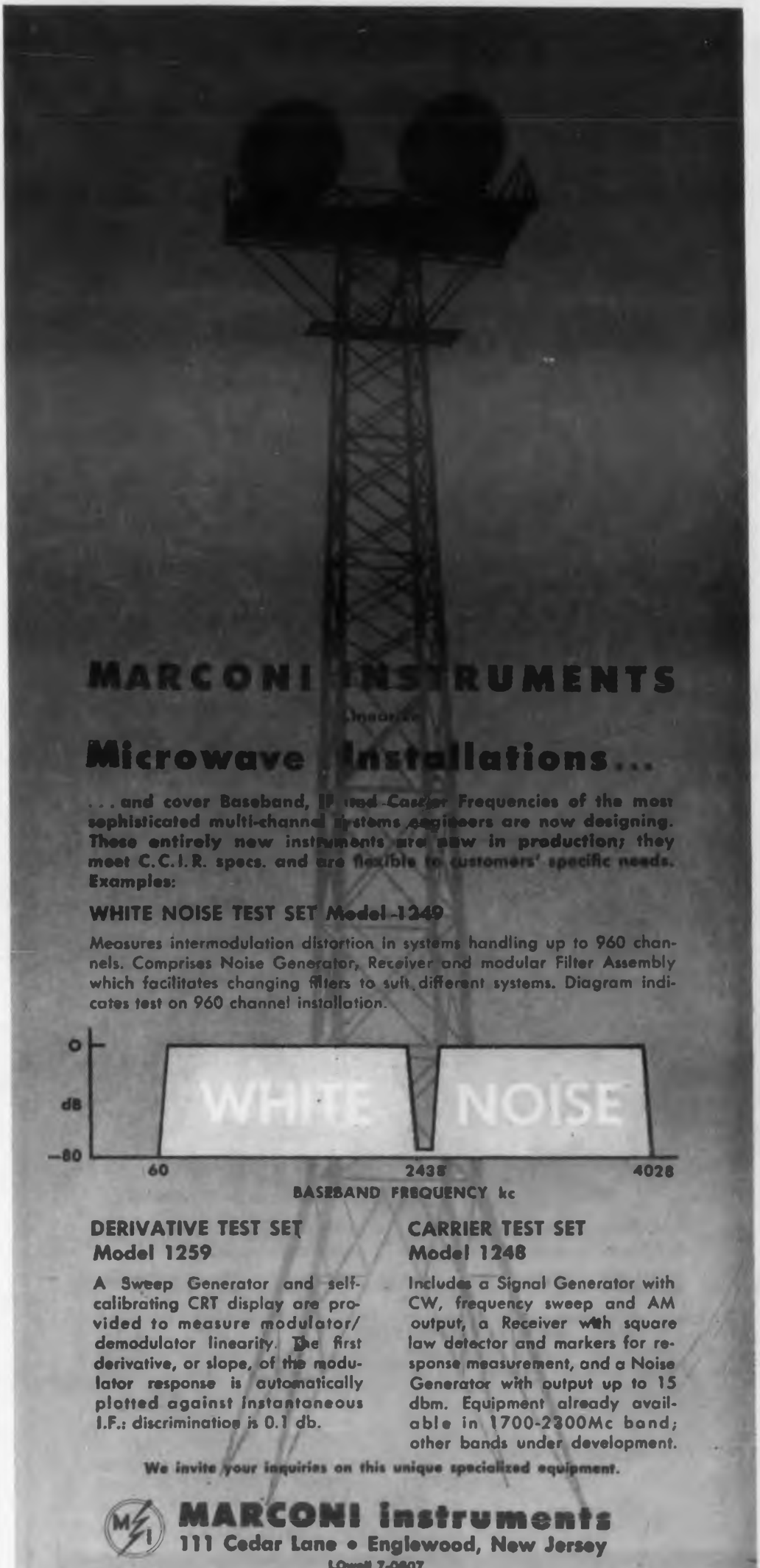
This apparatus was described by the Polish delegation at the 8th Plenary Session of the International Consultative Committee on Radio, held in Warsaw in August-September 1956. The method is based on comparing the total power of the signal (100%) with a portion of the power (1%) located outside the measured actual bandwidth. The block diagram of the apparatus is shown and its basic operation is described.

Frequency-Measuring Setup by A. Ya. Stukman. CJ 1/58, pp 13-14, 5 figs.

Description of a setup to measure the nominal carrier frequency of radio transmitters at the reception point; the accuracy is approximately 0.5×10^{-6}. In addition, one can use the apparatus to measure the frequency drift and to observe spectra of transmitter radiation of fm transmitters. The block diagram, some of the circuit elements, and the external appearance of the apparatus are illustrated.

Apparatus for Checking Level Indicators and Broad-band Vacuum Tube Voltmeters by I. Ye. Moiseyev. CJ 1/58, pp 10-11, 5 figs.

The author considers apparatus comprising a signal generator, a thermocouple meter, and a non-inductive voltage divider to verify the operation of level indicators and broad-band vacuum tube voltmeters. He also gives practical recommendation on the preparation of a thermocouple instrument used for the purpose.



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CARRIER TEST SET Model 1248

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RUSSIAN TRANSLATIONS

CIRCUITS

Broadband Amplifiers with Distributed Amplification by L. Z. Bobrovnikov. RE 12/57, pp 73-80, 14 figs, 1 table.

Here considered are several problems of practical broadband amplifiers, using distributed amplification. Such amplifiers are frequently more effective in producing a really broad band than conventional lumped amplifiers. The author gives a method for designing such amplifiers and proposes various schemes for connecting triodes in such amplifiers. Experimental results are reported.

Synthesis of Pulse Systems and Systems with Pulse Feedback by V. P. Perov. AT 12/57, pp 1081-1097, 7 figs, 4 tables.

The author determines the optimum characteristics of pulse systems. He uses, as an optimum criterion, the condition that the rms error be a minimum for a specified dynamic accuracy and a specified system time constant. A disturbance is supposed to consist of noise and a signal, the noise being a stationary random function, and the signal being a sum of a stationary random component and a regular one. Reference is made to work by Johnson ("Optimum Linear Discrete Filtering of Signals Containing a Non-Random Component" Transactions IRE, on Information Theory, June 1956).

Design of Magnetic Amplifiers for a Given Supply Voltage by N. P. Vasil'yeva and O. A. Sedykh. AT 11/57, pp 1052-1060, 5 figs, 1 table.

For specified supply voltage and for a specified load the volume of the amplifiers is proportional to the ratio of the supply voltage to the load voltage if the magnetic conditions remain unchanged. Formulas are derived and data are given with which one may choose between an optimum amplifier with a separate matching transformer and an amplifier designed for a specified supply voltage. The conclusions apply both for feedback amplifiers and for those without feedback.

Analysis of Block Diagrams of Sequential-Type Digital Electronic Computers by G. A. Mikhaylov. AT 12/57, pp 1109-1119, 5 figs.

The author establishes the relationships between the design features and the type of problem on one hand, and the operating speed and other characteristics of computers on the other. Comparison is made of single, two- and three-

address coding systems for the commands.

Simplest Passive Network for Formation of Linearly Varying Voltage by P. N. Matkhanov. RE 12/57, pp 63-66, 3 figs.

The circuit described is very good for linear cathode-ray tube sweep, particularly if high sweep velocities and large voltage deflections are required.

Analysis of Circuits for Neutralization of Internal Feedback in Junction Transistors at Low Frequencies by Kh. I. Cherne. EC 12/57, pp 9-16, 8 figs.

Since a transistor transmits power in both directions at all frequencies (unlike a vacuum tube) the authors examine the g-neutralization (i.e., the use of a parallel-series, neutralizing, linear, passive, four-terminal network) of junction transistors with common emitter and with common collector. A circuit analysis is given with experimental results. Reference is made to Houser's "A Unilateral Transistor Amplifier" (*Proceedings of the National Electronics Conference*, Vol. XI, 1955) and Stern, Aldridge, and Chow's "Internal Feedback and Neutralization of Transistor Amplifier," (*Proceedings IRE*, No. 7, 1955).

Graphic Method of Synthesis of Contact Circuits by V. N. Roginskiy. EC 11/57, pp 82-88, 7 figs.

A graphical method is proposed for the design of contacting multi-terminal networks by selecting the numbers of states of the relays, which the circuits should or can close. The proposed method gives, in some cases, more economical circuits than do analytical methods. It is mentioned that a machine for the synthesis of relay circuits is being developed in the Laboratory on the Development of Scientific Problems of Wire Communication of the Academy of Sciences, U.S.S.R.

Parasitic Radiations of Transmitters with Two Master Generators by Ya. I. Efrussi. EC 11/57, pp 59-64, 2 tables.

The author considers parasitic combination frequencies, generated by the mixer of a transmitter with two master generators, and the passage of these frequencies through subsequent stages of the transmitter.

Design of Generator in Overdriven Mode by S. I. Yevtyanov. EC 11/57, pp 52-58, 4 figs.

In the design of a generator in the overdriven mode it is necessary to use coefficients of expansion for small cutoff angles θ. The article obtains

IDEAS FOR DESIGN—*ENTRY BLANK*

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STATEMENT OF THE PROBLEM—

MY SOLUTION. AND WHY— **(Please be explicit. Include sketches or photos that will help the idea across)**

Signed_____
Title_____
Company_____
Address_____

(Place illustrations on separate sheet if necessary)

RUSSIAN TRANSLATIONS

a series for the expansion coefficients, in powers of $(1 - \cos\theta)$. These series have good convergence at small cutoff angles. They permit preparation of convenient tables for the coefficients of expansion not of θ, but of $\cos\theta$. It is also possible to carry out harmonic analysis of pulses of plate current in the overdriven mode, seldom resorting to the tables of the expansion coefficients.

Generalization of the Theory of Diode Detection of Weak Signals by L. S. Gutkin. EC 11/57, pp 47-51, 6 figs.

The author derives a single equivalent detector circuit, valid for detecting weak unmodulated, amplitude-modulated, and pulse signals, and also for small noise voltages or a sum of signal and noise. Examples of application of this circuit to the calculation of several types of signals are given.

INFORMATION THEORY

Transmission of Signals by Modulated Noise by A. A. Kharkevich. EC 11/57, pp 42-46, 2 figs.

The author discusses the possibility of using noise as a carrier by modulating it in some form or another. The statistical properties of noise as a carrier are analyzed in some detail. Reference is made to an article by S. O. Rice "Filtered Thermal Noise—Fluctuation of Energy as a Function of Interval Length" *Journal of Acoustical Society of America*, Vol. 14, No. 4, 1943.

Transient and Steady-State Processes in Pulse Systems with Variable Parameters that Change in Jumps by F. M. Kilin. AT 12/57, pp 1062-1080, 10 figs.

The author develops one method for determining the transients and steady-state processes in pulse systems with variable parameters that change abruptly. The stepped-function formalism in conjunction with continuous functions is used to describe phenomena that take place in such a system.

Integral Canonical Representation of Random Functions and Their Application to Determination of Optimum Linear Systems by V. S. Pugachev. AT 11/57, pp 971-984.

The author derives a formula for the weighting function of the optimum one-dimensional linear system for the case of infinite observation time (infinite memory of the system), when the observed random function is the result of the passage of white noise through a linear system. The

formulas of Wiener and Booton are derivable from the formula derived in this article for particular cases.

ELECTRON PHYSICS

The December 1957 issue of *Radiotekhnika i Elektronika* covers many properties and effects of different types of vacuum tube cathodes.

PROPAGATION

Radio Forecasting and Geophysical Observations by V. Ivanitskiy. R 12/57, pp 20-23.

Discusses in popular form the connection between radio wave propagation conditions and various geophysical phenomena, and shows how propagation studies can throw light on geophysical data and vice versa.

Type TE Wave in Metallic Rib by N. N. Malov, General Physics Faculty, State Pedagogical Institute. REE 10/57, pp 1289-1293, 5 figs, 2 tables.

Brief analysis of a semi-infinite trough with ideal metallic walls, operating in the TE_{10} mode.

Longitudinal Electric Waves in Rectangular Wave-guides with Periodic Diaphragms by R. M. Leont'yeva. RE 12/57, pp 36-45, 8 figs.

The author investigates the propagation of longitudinal electric waves in a space bounded by a periodic cone-like structure and a metal plane above it. (See Fig. 1.) The problem reduces to an infinite system of linear algebraic equations.

An exact characteristic equation is obtained in the form of an infinite determinant. By estimating three successive approximations the author establishes the degree of convergence of the determinant. A series of plots that illustrate the influence of the metallic plane of the finite thickness of the diaphragm, and the coefficient of the structure on the dispersion properties of the structure are given.

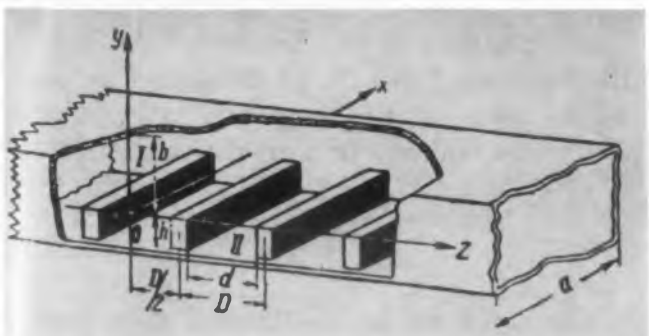

Fig. 1. Longitudinal electric waves are propagated through this periodic structure.

GERMAN ABSTRACTS

E. Brenner

Load-Independent Oscillators

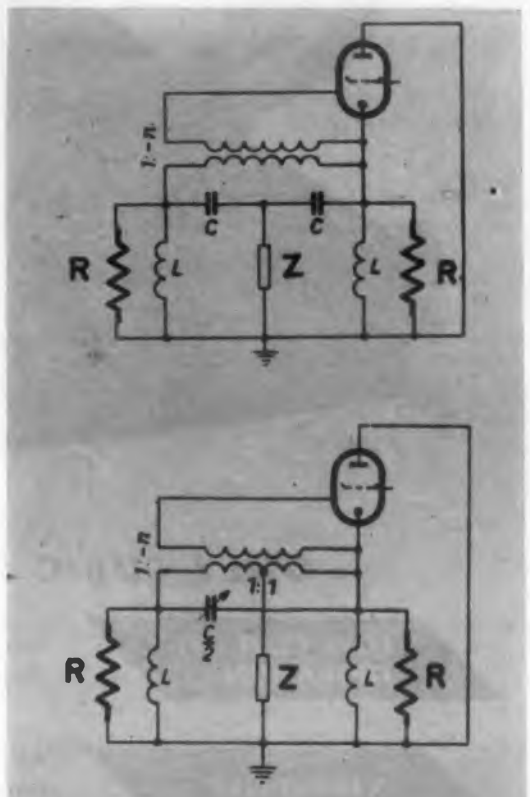

Fig. 1. Examples of load independent oscillators. In each case the frequency of the oscillations is $1/2\pi LC$; the condition of oscillations is $g_m 1/R$. Oscillator for fixed frequency operations above. This circuit is modified below for variable frequency operation.

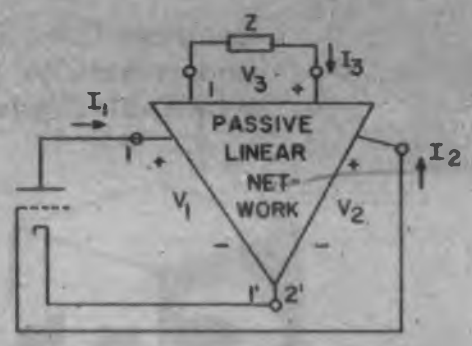

Fig. 2. Five pole, three terminal pair network used in feedback amplifier.

USE OF certain three terminal pair networks in the feedback circuit of an oscillator makes it possible to design oscillators in which the amplitude conditions for oscillations are independent of the value of the load impedance.

One realization of such an oscillator for fixed frequency operation is shown in Fig. 1a. If the circuit is modified as shown in Fig. 1b, variable frequency operation is possible. Load impedance in each case is Z.

A general design procedure for such oscillators can be deduced with the aid of the generalized circuit indicated in Fig. 2. It is assumed that all the elements in the passive network obey the reciprocity theorem so that the transfer impedance matrix is symmetrical with respect to the principal diagonal. If it is further assumed that the tube draws no grid current then the relations between the terminal voltages and currents are given by

$$V_1 = z_{11} I_1 + z_{13} I_3$$
$$V_2 = z_{12} I_1 + z_{23} I_3$$
$$0 = z_{13} I_1 + (z_{33} + Z) I_3$$

Furthermore, if the tube operates ideally then $I_1 = g_m V_2$. The condition for oscillations is therefore

$$g_m = -\frac{1}{z_{11} - z_{13} z_{23}/(z_{33} + Z)}$$

In order to make this condition independent of the load impedance, Z, set the imaginary part of z_{12} to zero (at the frequency of oscillation), choose the real part of z_{12} negative and set

$$\frac{z_{13} z_{23}}{(z_{33} + Z)} = 0$$

The condition for oscillations then becomes $g_m = -1/z_{12}$. This last condition is fulfilled if either $z_{13} = 0$ or $z_{33} = \infty$ or $z_{23} = 0$. The first two of these possibilities are not practical since for these cases the load voltage would be zero. Hence

the network is designed so that z_{23} is zero at the oscillation frequency. Under this condition the load current is related to the tube current by

$$I_3 = I_1 z_{13}/(z_{33} + Z)$$

If the internal impedance of the generator, R, equals z_{33} the load current is half of its short circuit value.

Once the basic network structure has been chosen the circuit is adjusted experimentally to obtain the required conditions. This is generally accomplished by interpreting the impedances of z_{ij} as open circuit impedance functions and measuring appropriate voltage ratios. To have z_{12} real at the same frequency at which z_{23} is zero, a variable reactance connected between terminal pair 2-2′ is helpful.

In Fig. 3 a circuit is shown which oscillates at the frequency $f = \omega_0/2\pi$. The circuit is adjusted correctly when

$$R = \frac{R_1}{4} \cdot \frac{1}{1 + (\omega_0 R_1 C/2)^2}$$

$$L = \frac{1}{2\,\omega_0^2 C} \cdot \frac{1}{1 + (\omega_0 R_1 C/2)^2}$$

Experimental investigation of the circuit showed that a 100 kc oscillator, designed according to Fig. 3 and the equation for L, had constant frequency within 100 cps for load resistances between 20 ohms and 20,000 ohms. The circuit used for the reactive loads was found to be frequency stable within 300 cps for capacitive loads and within 160 cps for inductive loads.

Abstracted from an article by E. Frisch and W. Herzog, Nachrichtentechnische Zeitschrift, *Vol. 10, No. 1, Jan. 1957, pp 35-38.*

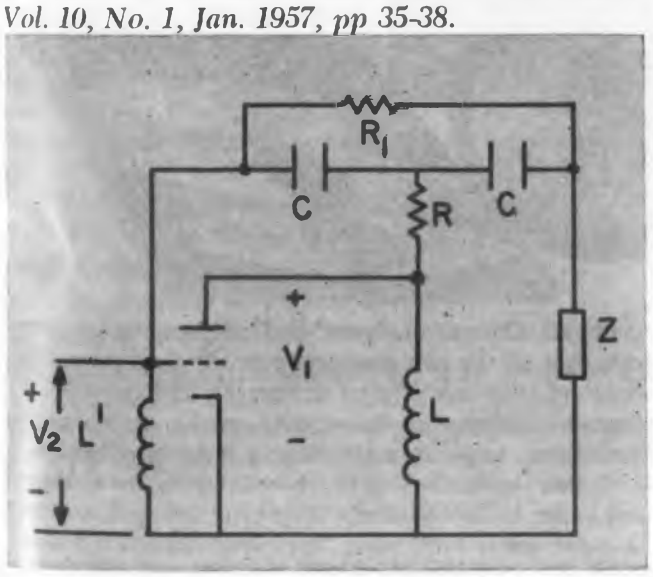

Fig. 3. Bridged Tee network used in an oscillator. Z is the load impedance. The element L' has been added to facilitate experimental adjustment to the required conditions.

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STANDARDS AND SPECS

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Electrical Conductors

Nine standards of the American Society for Testing Materials concerned with properties of electrical conductors have been approved as American Standards by the American Standards Association. These standards are:

American Standard C7.8-1957—Standard Specifications for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft (ASTM B8-56);

American Standard C7.4-1957—Tentative Specifications for Tinned Soft or Annealed Copper Wire for Electrical Purposes (ASTM B33-56T);

American Standard C7.26-1957—Standard Specification for Seamless Copper Bus Pipe and Tube (ASTM B188-56);

American Standard C7.15-1957—Tentative Specifications for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes (ASTM B189-56T);

American Standard C7.16-1957—Standard Specifications for Cored, Annular, Concentric-Lay-Stranded Copper Conductors (ASTM B226-56);

American Standard C7.18-1957—Standard Specifications for Concentric-Lay-Stranded Copper Covered Steel Conductors (ASTM B228-56);

American Standard C7.19-1957—Standard Specifications for Concentric-Lay-Stranded Copper and Copper Covered Steel Composite Conductors (ASTM B229-56);

American Standard C7.29-1957—Tentative Method for Determination of Cross-Sectional Area of Stranded Conductors (ASTM B263-56T);

American Standard C7.35-1957—Standard Specifications for Three-Quarter Hard Aluminum Wire for Electrical Purposes (ASTM B262-56).

Copies of the standards are available at 30 cents each from the American Standards Association, 70 East 45 Street, New York 17, N.Y., or from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

Insulation

IEC Publication 93, Recommended Methods Of Test For Volume And Surface Resistivities Of Electrical Insulating Material

Part I gives definitions of the quantities measured, general information on the tests, and minimum requirements for the test report. Part II gives recommendations for shapes of test speci-

mens and electrodes for solid insulating materials, test specimens and cells for liquid insulating materials, electrode materials for solid samples, calculation of volume and surface resistivities, conditioning, applied voltage, mounting specimens and general principles. The publication contains seven figures illustrating the use of various types of electrodes, and the circuits to be used for the measurements described. Copies of this publication may be obtained from the American Standards Association, 70 East 40th Street, New York 17, N.Y. for $2.40 per copy.

Electron Tubes

EIA STANDARD RS-209, NEMA PUBLICATION NO. 500, JETEC No. JO-G2-2, EIA-NEMA STANDARDS FOR ELECTRON TUBES, MARCH 1958

Section 1 gives the dimensional characteristics of electron tubes. This section is a revision of standard ET-105-C. Section 2 covers electron tube bases, caps, and terminals. It gives dimensional characteristics of electron tubes and designations for bases, caps, and terminals. It also lists the standard tube bases, caps, and terminals. This section is a revision of standard ET-103-D. Section 3 covers electron tube base gauges, miscellaneous gauges, accessory weights for base pin alignment gauges, standard base pin alignment gauges, and miscellaneous gauge details. This section is a revision of standard ET-106-C. Copies of this standard may be obtained from the Electronic Industries Association, 11 West 42nd Street, New York 36, N.Y. for $3.50 per copy.

Standards Proceedings

PROCEEDINGS OF THE STANDARDS ENGINEERS SOCIETY, 1957

How to achieve the savings that standardization makes possible is described by outstanding authorities in the Proceedings of the Standards Engineers Society's Six Annual Meeting. Seventeen papers presented at the meeting are given in full, with charts and illustrations. The meeting was held in New York on Sept. 23-25, 1957. The subjects covered include standards and management, company standards, cooperation between company departments, sources of information for preparing standards, reliability, and the relation of standards to cost reduction. Of particular interest to those working in the fields of electronic standardization is the paper entitled Relationship of Standardization and Reliability of Military Equipment presented by James Bridges, Office of Assistant Secretary of Defense, Research and Engineering. Copies of this 128-page publication can be obtained from the Standards Engineers Society, P.O. Box 281, Camden, N.J. The price is $3.75 per copy for non-members and $3.00 for members.

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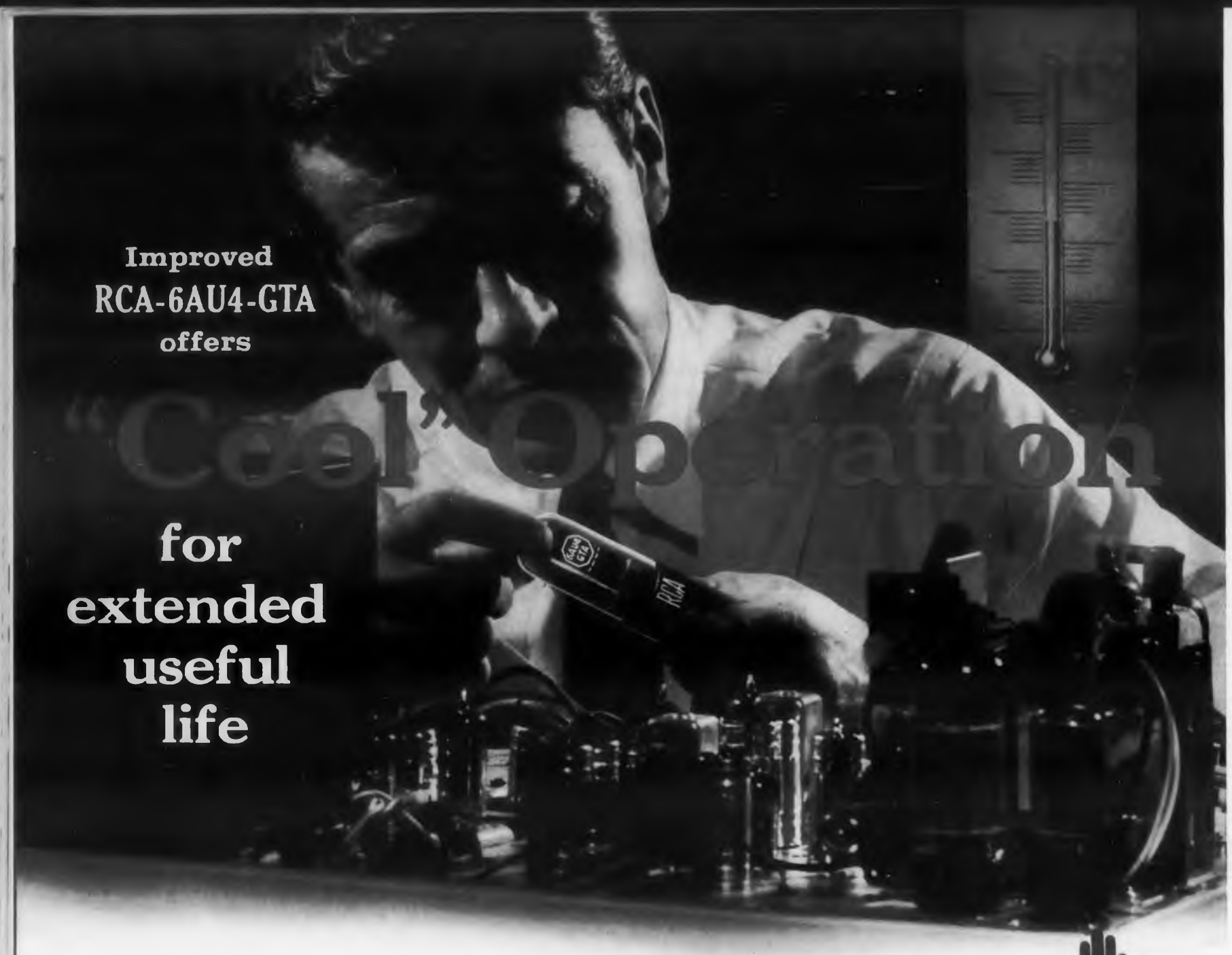

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