If potting, laminating, sealing or encapsulation are factors in your operation, you should investigate Epon resins. Because they provide a unique combination of desired electrical and physical properties, they are finding increased use in many phases of the electrical industry.

**Potting and Encapsulation** . . . Epon resins offer remarkable adhesive properties, forming strong bonds to metals and glass, and creating airtight enclosures for sensitive components and vacuum tubes.

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**Laminating** . . . Epon resin, laid up with inert fibrous fillers, produces laminates with superior dielectric properties and moisture resistance. Epon resin laminates can be dip soldered, sheared, punched and drilled, and provide excellent dimensional stability.

And, solvent-free Epon resin adhesive formulations . . . between glass, metal, or plastic . . . cure at room temperature with contact pressure alone.

Can Epon resins solve a production problem for you? For assistance and technical literature, write us now.

---

**HIGHLIGHTS OF ISSUE**

**Diodes 1958 (Cover)** . . . . 18

Here is ELECTRONIC DESIGN's special report on semiconductor diodes. In addition to valuable feature articles covering many phases of diode circuit design, we've included a handy list of all the major American diode manufacturers.

In our report "Too Many Diodes?" we've presented the low-down on what's going on in the diode manufacturing industry and on the status of standardization. To round out our report, we've taken our regular "Ideas for Design" department and devoted it exclusively to "Designing With Diodes."

**Infinite Z Amplifier** . . . . . . 50

A new magnetostriuctive chopper makes this dc amplifier unusual and noteworthy. The unit is driven by a high frequency so that the bandpass of the amplifier is greater than usual.

**Semiannual Product Index** . . . . 91

Over 1200 new products, materials and production products, announced during the first half of this year, are listed according to type. The index gives the page number and issue in which the product originally appeared.

**British Component Show** . . . . . 98

British manufacturers unveiled a host of new products at the recent British Radio and Component Show. This staff report describes some of the major developments and cites the design trends experienced by British engineers.
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### For Personal Use Only

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Statistical Tabulating Dept.
830 Third Avenue
New York 22, New York
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Dependability and long life previously available only in high-cost relays...

G-V RED/LINE

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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.

Delays of 2 seconds to 3 minutes  •  Energizing voltages - 6.3 to 230 AC or DC.

• RUGGED STAINLESS STEEL MECHANISM
  Relay mechanism is of stainless steel, differential expansion type, used in all G-V Thermal Relays. All parts are welded into a single integral structure.

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  No glass is used in mechanism, encasing shell, or base. This avoids the danger of cracking or breakage in handling and use.

• STEEL ENCASED HEATERS
  Heating elements are conservatively designed, wound with nichrome wire on mica and encased in stainless steel, insuring long heater life even when energized continuously.

• DUST TIGHT ENCLOSURE
  A dust tight metal shell completely enclosing the relay mechanism and contacts, crimped tightly to the base, provides complete protection for the structure.

• TAMPER PROOF
  Time delay intervals are preset at the factory. Thus changes of delay interval in the field which might damage associated equipment are avoided.

• DIRECTLY INTERCHANGEABLE
  Directly interchangeable with all other octal-size relays.

Available through Selected Distributors

G-V CONTROLS INC.
18 Hollywood Plaza, East Orange, New Jersey

Write for Publication 131
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All illustrations same size. Ratings at 25°C unless otherwise indicated.

1N253 through 1N256 available to MIL Specifications.
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)
ENGINEERING STRENGTH

This towering figure represents 3,300 Raytheon people at your service, helping to develop and produce magnetrons, klystrons and special purpose tubes—the most complete line in the industry.

The heart of this Raytheon division is our famous Research and Development Laboratory with 1,065 specialists, of whom 207 are professional engineers.

Put this dependable source of engineering manpower to work on your problems. Call on Raytheon's Application Engineering Service. Write for complete data booklet. There is no cost or obligation.

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.

> CIRCLE 4 ON READER-SERVICE CARD
For MISSILE Applications!

NOW...200, 300, 400 & 500 AMPERE

DC POWER SUPPLIES

with wide continuously adjustable
24 TO 32 VOLT RANGE

by PERKIN!

APPLICATIONS:
- Centralized Laboratory or Plant DC Power.
- Missile Check-Out and Launching
- Battery Charging & Standby Service
...and other heavy duty 28 volt DC Power applications.

immediate delivery!

OUTSTANDING FEATURES:
Automatic Magnetic Amplifier Regulation to ±1/2%. No Tubes. Moving Parts or Vibrating Contacts. Remote Voltage Sensing to Provide Regulation at Remote Loads. Wide 24 to 32 Volt Output Range to Compensate for Voltage Drop in Output Cable. Fast Response (0.1 to 0.2 seconds) With No Hunting or Drift. AC Line Voltage Stabilization. No Disturbing Radio Interference... Higher Efficiency, Maintenance-Free and No Warm-Up Time as Compared to M.G. Sets...MIL-Type Workmanship & Conservative Design.

There are over 15,000 Perkin units in operation in industry today.

ADDITIONAL SPECIFICATIONS:
Regulation: ±1/2% for any combination of line and load changes. AC Input: 208, 230 or 460V, ±10%, 3 phase, 60 cps. Ripple: 1 1/2% RMS. All units available with dollies for mobility.

AVAILABLE MODELS:
MR2432-200A, 200 amps • MR2432-300A, 300 amps • MR2432-400A, 400 amps
When you require a power supply, SPECIFY PERKIN,
for a wider range of standard models and immediate delivery from stock.

Wire factory collect for prices. For a prompt reply on your application, write factory on your letterhead.

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 radations. 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.
The miniature 7205, 7229 and 7230 and subminiature 7231 and 7232 ... CBS-Hytron originals ... introduce a new and growing family of fast-switching krytrons. These cold-cathode trigger tubes are efficient and accurate. They replace relays and thyratrons in simpler circuits for reliable military and industrial equipment. They control up to 500 amperes with input signals of fewer than 20 microamperes. And they are designed to operate under extreme conditions of heat, shock and vibration. You will find these new krytrons useful as electronic relays ... timers ... oscillators ... sensors ... and pulsers. Check their features and characteristics. Write for CBS-Hytron Bulletin E-287.

KRYTRON... NEW ELECTRONIC SWITCH

**FEATURES**

1. Rugged and reliable
2. Compact and light
3. Silent and cool
4. Stable inert gas fill
5. Instant-firing keep-alive
6. Sure dark/cold starts
7. Negligible jitter

**MAJOR CHARACTERISTICS**

- High hold-off voltages: 1000, 2000, 3000 volts
- High instantaneous pulse current: 500 amperes
- Low trigger voltage: 205 min. volts
- Low driving current: 20 microamperes
- Short anode delay time: 4 microseconds
- Minimum anode delay variation: 0.4 microsecond
- Wide ambient temperature range: -55 to +85°C

Reliable products through
Advanced-Engineering

CBS HYTRON, Danvers, Massachusetts
A Division of Columbia Broadcasting System, Inc.

---

# ENGINEERING REVIEW

**Data-Handler Measures 10,000 Samples Per Second**

As many as 4,800,000 separate items of information can be processed in eight minutes using 10-1/2 in. reels of standard magnetic tape, a recently introduced recording and transcribing system. The Digital Data Recorder-Transcriber developed by Minneapolis-Honeywell Regulator Co., Philadelphia, Pa., employs multiplexing and analog-to-digital conversion and consists of five multiplex channels. Each data sample, which is the input information received by the recorders from multiple transducers, is converted to a 10-bit binary so that the resolution of the system is one part in 1024. Over-all accuracy is within 0.1 per cent.

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

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

Original data to be processed by computer is selected by an editing device called a "data selector." Two time settings, one for the beginning of the desired data, another for the end, are made by means of decimal switches. Another control provides for setting the computer program of the number of words—anywhere from 50...
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 Atomicichron, 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 atomicichron has an accuracy of one sec per 300 years.

MAGNETIC LATCH RELAY

Type 9228 4 PDT, 5 amp, 3 amp, microamp

FEATURES
Available in a variety of types from 2 PDT to 6 PDT
Contact ratings from microamp to 15 amp
Hermically sealed and 100% seal-tested
Choice of stud, bracket or plug-in mountings
Solder lug, plug-in or potted lead terminals
Solid or bifurcated contacts
Coils for dc or ac applications

TYPICAL RATINGS
Normal operating voltages — ac and dc — 6-115 volts
Contact ratings: @ 28 vdc or 115 vac
single phase
Resistive — 3 amp @ 125°C
5 amp @ 30°C
Inductive — 1.5 amp
Motor load — 1.5 amp
Rated duty — continuous
Minimum operating cycles — 100,000
Weight — approx. 0.35 lb.
Shock — 50 G's
Vibration — 15 G's to 2,000 cps
Temperature range — 70°C to +125°C

Applicable specifications — MIL-R-6106C Class A, A8, B8
minimum current tests applicable — MIL-R-5767B Class A and B
Mention your special requirements such as microamp switching, high vibration, special mountings.

LEACH RELAY

A division of

CORPORATION

5915 Avalon Boulevard, Los Angeles 3

CIRCLE 7 ON READER-SERVICE CARD
Here's how General Electric solves typical DC power-supply problems for computers and special applications

**PROBLEM**

"We need to devote our engineering time to designing our electronic circuitry... not the power components."

**SOLUTION**

This is a frequent problem facing computer manufacturers. General Electric's Rectifier Department has complete engineering and manufacturing capability not only to design and apply all types of power supplies, but also to incorporate power supplies into completely integrated systems.

These systems could include load distribution, supply sequencing, protection for power supply and load, and complete power distribution. Let General Electric tackle your DC power problems such as those associated with load IR drop, "cross talk," and other nuisance-type problems plaguing your engineers.

**PROBLEM**

"It's always a problem making sure transistorized equipment is safe from its power supply."

**SOLUTION**

To alleviate this problem, General Electric has developed several methods of making transistorized equipment safer in this respect. With G-E protective circuits, shorting a plus high-voltage bus to a plus or minus low-voltage bus would not cause the low-voltage bus to exceed a small percentage of nominal rated value.

General Electric power supplies protect completely transistorized pieces of equipment from large losses due to over-voltage failures.

**PROBLEM**

"My power supply requirements fluctuate so much... big jobs, little jobs, all in between."

**SOLUTION**

G-E has built individual power supplies and complete systems ranging from less than one watt up to 35,000 kilowatts. These power supplies span the complete range of DC power—regulated and unregulated—applying all types of components. G-E experience includes completely transistorized supplies, and supplies with the new controlled rectifier, magnetic amplifiers, voltage stabilizing transformers, and motor-alternator "brute force" systems.

**PROBLEM**

"We have a real low-voltage power distribution problem with our computer."

**SOLUTION**

Low-voltage distribution problems can be handled easily through load compensation. Curve "A" is not desired no-load to full-load regulation at load point. "B" is regulation at load without remote sensing or load compensation. "C" represents IR compensation in power supply itself. "D" is amount of IR or load compensation.

If you have a computer or special power-supply problem, free your engineers of this problem and turn it over to General Electric for solution. It's more economical! G-E engineers can call on over 40 years of experience in the metallic rectifier field and put this experience to work in solving your particular problem—large or small. Contact your nearest General Electric Apparatus Sales Office or write Section B465-6, Rectifier Department, General Electric Company, Lynchburg, Virginia.

Progress Is Our Most Important Product

GENERAL ELECTRIC

CIRCLE 8 ON READER-SERVICE CARD

---

**Doing a Slow Turn**

One of the drive requirements on a new 84-ft diameter 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.

CIRCLE 272 ON READER-SERVICE CARD
Electron Tube News— from SYLVANIA

Pioneering new concepts— Everywhere in electronics

IN BASIC TUBE DESIGN . . .

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.

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
- 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.

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.

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

Cutaway view of the Framelok design
Gold Brand Standard

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 Subminiatures undergo 1,000-hour life tests

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:

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<td>Dual-control pentode (7-pin miniature)</td>
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<td>Double diode (7-pin miniature)</td>
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<td>Double diode (7-pin miniature)</td>
<td>5751</td>
<td>High-mu double triode (7-pin miniature)</td>
</tr>
<tr>
<td>5554</td>
<td>Sharp-cutoff pentode (7-pin miniature)</td>
<td>5814A</td>
<td>Medium-mu double triode (9-pin miniature)</td>
</tr>
<tr>
<td>5670</td>
<td>Medium-mu double triode (9-pin miniature)</td>
<td>6003</td>
<td>Beam Pentode (7-pin miniature)</td>
</tr>
</tbody>
</table>

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 range 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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6946</td>
<td>Medium-Mu Triode</td>
</tr>
<tr>
<td>6947</td>
<td>Medium-Mu Double Triode</td>
</tr>
<tr>
<td>6948</td>
<td>High-Mu Double Triode</td>
</tr>
<tr>
<td>6778</td>
<td>Sharp cutoff audio-frequency pentode</td>
</tr>
<tr>
<td>6942</td>
<td>Sharp cutoff RF Pentode</td>
</tr>
<tr>
<td>6944</td>
<td>Semi-Remote cutoff RF Pentode</td>
</tr>
<tr>
<td>6945</td>
<td>Audio-Frequency Beam Pentode</td>
</tr>
</tbody>
</table>

Gold Brand subminiature Type 6814 meets rugged requirements of airborne 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 $G_m$ 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 $G_m$ 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 $G_m$ of 15 and a $G_m$ of 1000 umhos. The diodes feature a separate cathode connection for maximum flexibility in detector and AVC circuits.

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 phosphor tubes is centered around the major benefits the tubes offer over conventional CRTs. 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 phosphor 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 CRT's 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.
In Industrial Television...

Special CRT is specifically designed for industrial TV 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.

In Industrial and Military C-R Tubes

New high-precision scope tubes, types 5ADP, 5ABP, and 5AQP, were developed for photography, radar and 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 24AQ4P4, 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.

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

Please send the following information on the items checked below:

ENGINEERING DATA SHEETS

Receiving Tubes

[ ] 7244
[ ] 7245
[ ] 12DV8
[ ] 12F6
[ ] 12DZ6
[ ] 12DU7
[ ] 12DV7

Cathode-Ray Tubes

[ ] 5ABP
[ ] 5AQP
[ ] 8FP4
[ ] 8Y4
[ ] 17CTP4
[ ] 21DHP4
[ ] 24AQ4P4

[ ] Sylvania Framelok Grid Booklet
[ ] Sylvania Gold Brand Booklet
[ ] Additional explanation, and application requirement form for Sylvania transparent phosphor CRT

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

Name________________________
Address______________________
Company______________________
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 range from 10¹⁰ to 10⁶ 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.

Burnell & Co., pioneers in the development of toroids, filters and related networks now offer the most complete—the most reliable line of encapsulated toroids.

Burnell encapsulated toroids include the only encapsulated adjustable toroids available anywhere—satisfy the toughest circuit demands in serviceability—light weight—miniaturization.

Burnell encapsulated toroids are particularly useful in guided missile and similar miniaturization fields where space and mounting are highly critical factors. Send for free, new Catalogue No. 104 covering scores of applications with schematics and performance curves.
Radio Receptor...

your prime source for
every type of

SILICON and
GERMANIUM

high speed
high conductance
high temperature
high voltage
high back resistance

DIODES

Code No.  Fwd. DC Cur. (MA) @ Indicated Voltage  Rev. DC Cur. (x A) @ Indicated Voltage  Max. Inv. Voltage  Reverse Recovery

SILICON DIODES (All ratings and characteristics are at 25°C)

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Fwd. DC Cur. (MA)</th>
<th>@ Indicated Voltage</th>
<th>Rev. DC Cur. (x A)</th>
<th>@ Indicated Voltage</th>
<th>Max. Inv. Voltage</th>
<th>Reverse Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1N914</td>
<td>100 @ 1.0V</td>
<td>55 @ 50V @ 150°C</td>
<td>100</td>
<td>200</td>
<td>100</td>
<td>80K to 0.2 usec*</td>
</tr>
<tr>
<td>1N915</td>
<td>100 @ 1.0V</td>
<td>55 @ 50V @ 150°C</td>
<td>100</td>
<td>200</td>
<td>100</td>
<td>80K to 0.2 usec*</td>
</tr>
<tr>
<td>1N916</td>
<td>100 @ 1.0V</td>
<td>55 @ 50V @ 150°C</td>
<td>100</td>
<td>200</td>
<td>100</td>
<td>80K to 0.2 usec*</td>
</tr>
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</table>

GERMANIUM DIODES (All ratings and characteristics are at 25°C)

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<tr>
<th>Code No.</th>
<th>Fwd. DC Cur. (MA)</th>
<th>@ Indicated Voltage</th>
<th>Rev. DC Cur. (x A)</th>
<th>@ Indicated Voltage</th>
<th>Max. Inv. Voltage</th>
<th>Reverse Recovery</th>
</tr>
</thead>
<tbody>
<tr>
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<td>100 @ 1.0V</td>
<td>55 @ 50V @ 150°C</td>
<td>100</td>
<td>200</td>
<td>100</td>
<td>80K to 0.2 usec*</td>
</tr>
<tr>
<td>1N918</td>
<td>100 @ 1.0V</td>
<td>55 @ 50V @ 150°C</td>
<td>100</td>
<td>200</td>
<td>100</td>
<td>80K to 0.2 usec*</td>
</tr>
</tbody>
</table>

*When switching from 5 mA to 40V.  †When switching from 30 mA to 85V.

The specs shown here are just a small sampling of the complete Radio Receptor diode line which covers every combination of characteristics needed for your circuitry. For full information, write today to Section ED-7.

SEMICONDUCTOR DIVISION  
RADIO RECEPTOR COMPANY, INC.  
Subsidiary of General Instrument Corporation  
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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 invention of a field effect type semiconductor, 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 Tesznor, 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." It 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.

**NOW...from Transistor the world's FASTEST DIODES for milli-microsecond switching!**

Here at last are diodes suitable for extremely high speed transistorized computer circuitry. These diodes offer you the convenience and simplicity of conventional types — but they are on the order of 50 times faster! Produced and priced for computer use, they are intended for critical applications at normal transistor bias levels.

The S570G germanium diode has optimized switching characteristics in the region below 10 milli-microseconds. Total stored charge after a 10ma forward current is less than that of a 3p (micro-microfarad) capacitor at 6 volts! Germanium type S555G obtains better D.C. characteristics at some sacrifice of speed. The S266G is a bonded silicon diode intended for use in high temperature high speed equipment. Low leakage current makes it useful also as a pulse stretcher. It is typically faster than any of the presently available silicon diodes.

These new diodes can reduce the number of transistors in circuits. They may be used to simplify coupling and logic design, reducing dependence on critical timing and synchronization. For example, difficult DCTL circuits may be made DCDTL with no loss in speed. Available now, these diodes will open many new frontiers.

---

**Specifications**

- **Type:** Transistor, Diode, Registor, Rectifier
- **Location:** Wakefield, Massachusetts
- **Contact:** Visit us at the WESCON Show — Booths 1567-68
Quality begets quality—it's an established axiom that premium products must begin with quality components. BISHOP has been producing platinum and precious metal products since 1842... precision stainless steel tubing since 1931. The BISHOP family of metal products includes a broad variety of components for the designer, engineer... just to mention a few:

- **Capillary Tubing**—standard and special sizes
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- **Glass-To-Metal Sealing Alloys**—low expansion alloys
- **Thermocouples**—noble metal and noble metal alloys
- **Tubing**—nickel, stainless, platinum, special alloys
- **Tubular Fabricated Parts**—all varieties
- **Composite Wires**—base and precious metals in various combinations
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**CATALOGS, DATA SHEETS SENT PROMPTLY ON REQUEST**

Begin your next design with **unexcelled** quality BISHOP component materials. Write, wire or phone Malvern 3100.
companies 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.

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Multi-Channel Magnetic Heads

A BASIC DESIGN FOR STANDARD REQUIREMENTS

...CUSTOM CONFIGURATIONS FOR SPECIAL APPLICATIONS

Clevite "Brush" Multi-Channel Heads offer distinct advantages for system manufacturer and user alike... providing comparative ease and speed of installation, alignment and replacement... precise dimensional uniformity... extremely rigid mounting.

Clevite's basic design, in 1 to 32 channel form, meets most standard customer requirements on commercial, industrial, scientific and military equipment. Slight modifications adapt them to many special applications. In addition, Clevite supplies custom designs; several are shown below.

As an independent magnetic head specialist, Clevite provides unmatched design experience and production economy. One of our specialists will be pleased to discuss your application by detailed correspondence or personal visit. Write: Product Manager, Magnetic Heads, Clevite Electronic Components, 3311 Perkins Ave., Cleveland 14, O.

Conventional, high resolution or flux-responsive performance is available in any standard or special multi-channel configuration.

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DIVISION OF CLEVITE

MAGNETIC HEADS
TRANSUCERS
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CERAMICS AND ELEMENTS
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 H. Roesty
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!
Type WL-7228 is the first to offer write-through plus high voltage selective erase

The new WL-7228 is a two-write gun storage display tube developed by Westinghouse for such applications as fire control radar, weather radar, data transmission and half-tone storage requiring a bright, stored, scintillation-free display.

Either write gun can be used for write-through, to display non-stored information. Also, either write gun can be used to selectively erase with very high selectivity and erase speed. Unusually high writing speeds under practical writing conditions.

Typical operating characteristics: Electrostatic focus and deflection for both write guns. Screen voltage: 10,000 volts. Resolution: 250 lines/diameter. Brightness: 2800 foot-lamberts.

Sample orders are invited or write for technical data to Westinghouse Electric Corporation, Elmira, N. Y.

YOU CAN BE SURE...IF IT'S Westinghouse

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 thyatron, 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.
Too Many Diodes?

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.
Diode Packages and Junctions

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

Fig. 1. Most popular signal diode packages.

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 encapsulations 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 dummy 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 dummy 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 megas with some pvi 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, acf 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.

**The Hughes HA7500 Series silicon pnp transistors**

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For details of the various types, please write: Hughes Products, Semiconductor Division, International Airport Station, Los Angeles 45, California.

**Hughes Products**

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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 low.

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 meg's 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 pn’s to only 20 v, with back impedances to 100 meg, 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 pn’s up to 300 v with reverse resistances of 10⁹ meg 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 meg 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 dopant, diffuses through the silicon’s crystal lattice.

Since both sides of the slice are exposed to the gaseous dopant, 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
The A-MP Component Tip provides these new advantages to manufacturers using printed circuit techniques:
- eliminates the need for eyelets or thru-plating on two-sided boards
- prevents cold solder problems by eliminating any movement of the component during dipping cycle
- permits bridging or offsetting of components—for air circulation and elimination of temperature influence
- design promotes solder-wicking and uniform solder deposit
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AMP-engineered, high-speed, automatic tipping machines provide an easy and economical method for applying A-MP Component Tips to leads of single-piece or belted components.

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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 "threshold," or forward voltage at which appreciable conduction begins. For germanium the threshold 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 now economical.

A diode is a semiconductor device that can pass electron flow in only one direction.

The A-MP Component Tip provides these new advantages to manufacturers using printed circuit techniques:
- eliminates the need for eyelets or thru-plating on two-sided boards
- prevents cold solder problems by eliminating any movement of the component during dipping cycle
- permits bridging or offsetting of components—for air circulation and elimination of temperature influence
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AMP-engineered, high-speed, automatic tipping machines provide an easy and economical method for applying A-MP Component Tips to leads of single-piece or belted components.

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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.

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**Diode Manufacturers**

- **Amperex Electronic Co.**
  250 Duffy Ave., Hicksville, N. Y.

- **Automatic Manufacturing**
  85 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.

- **Berkeley Labs.**
  584 Bank Village Greenville, N. H.

- **Bogus Electric Mfg. Co.**
  100 Pennsylvania Ave., Paterson, N. J.

- **Bomac Labs, Inc.**
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- **Bradley Labs.**
  168 Columbus Ave., New Haven 11, Conn.

- **CBS-Hytron Danvers, Mass.

- **Clevite Transistor Prod. Inc.**
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- **Fansteel Metallurgical Corp.**
  North Chicago, Ill.

- **Fretco, Inc.**
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  Waterman Ave., Lansdale, Pa.

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

- **General Electric Co.**
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- **General Transistor Corp.**
  95-18 54th Blvd., Jamaica 35, N. Y.

- **Hoffman Electronics Corp.**
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- **Hughes Products**
  International Airport Station Los Angeles 45, Calif.

- **International Rectifier Corp.**
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- **International Resistance Co.**
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- **Kemtron Electron Products Inc.**
  14 Prince Place, Newburyport, Mass.

- **Microwave Associates Inc.**
  Burlington, Mass.

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  5505 E. McDowell Rd., Phoenix, Ariz.

- **Nucleonics Products Co.**
  Box 5522, Metro Station, Los Angeles 55, Calif.

- **Pacific Semiconductors Inc.**
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- **Shockley Semiconductor Div.**
  Beckman Instruments Inc., Mountain View, Calif.

- **Spray Rand Corp.**
  So. Norwalk, Conn.

- **Sylvania Electric Products Inc.**
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- **Texas Instruments Inc.**
  6000 Lemmon Ave., Dallas 5, Tex.

- **Thermosan Inc.**
  375 Fairfield Ave., Stamford, Conn.

- **Transistor Electronics Corp.**
  Melrose, Mass.

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

- **U. S. Semiconductor Products Inc.**

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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 engineer 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
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;

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 those 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.

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.
With Zener Diodes

the

Curves make all the difference

Bernard B. Dainen
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ZENRO 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 should be used properly, and their characteristics are a matter of desire.

The semiconductor field is expanding at a faster rate than ever. 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

(Continued on following page)
BENDIX RUGGEDIZED REFLEX KLYSTRONS WITH THERMAL TUNING

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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 ma 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

\[
R = \frac{E_{\text{supply}} - E_{\text{zener}}}{\text{Desired Current}} - 100 \text{ ohms}
\]

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.
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 v. 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.
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 PIVs 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 chokes 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 inducances 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)
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 $\Delta E_n$ can be expressed as (See Ref. 4):

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

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 4J3011 germanium rectifier stacks, mounted on standoff insulators to a metal panel, one might expect $C_p$ to be as high as 2 $\mu$F, while $C_s$ is about 15 $\mu$F 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 $\mu$F capacitor is used across each 4J3011 cell, the worst transient crest voltage per cell is reduced to a safe 350 v. Similar improvement results from a 0.001 $\mu$F 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 waveform 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...
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

\[
C = 10 \frac{I_r}{E}
\]

where \(C\) = maximum capacitance to distribute recovery transient within cell PIV rating (\(\mu F\)), \(I_r\) = 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.

References

5. New 50 KW AM Transmitter Designed Around Modern Components; Dyer, Mapham, Walker; a paper presented at the NARTB convention, Chicago, Apr. 8, 1957.
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 cutoff, $I_{CBO}$.

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 who give an equation for calculating $I_e$ for any value of $R$:

$$I_e = \frac{I_{CBO}}{1 - \alpha N A T} \left[ 1 + \frac{\alpha N (1 - \alpha)}{(1 - \alpha N) + \frac{KT (1 - \alpha N)}{q I_{CBO} R}} \right]$$

(1)

In the limit as $R$ approaches zero the...
collector current is described by:

$$I_c = \frac{I_{CEO}}{1 - \alpha_N \alpha_I} = I_{CRS}$$ (2)

where $\alpha_N$ and $\alpha_I$ 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:

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

The inverse alpha, $\alpha_N$, is generally greater than 0.7 for typical germanium alloy transistors so that $I_{CRS}$ is three or more times as large as $I_{CEO}$.

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 $I_{CEO}$ 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 $I_{CEO}$.

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 $I_{CEO}$. With this assumption the following equation can be derived:

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

where $\frac{1}{\Omega} = \frac{K T}{q} \approx 0.026$ $v$ at $25^\circ C$

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 $I_{CEO}$ in which case the equation is invalid. At values below this point $I_c$ may be assumed equal to $I_{CEO}$.

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

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

and for the diode:

$V_D = 0.47 \, v$ (at $4.3 \, \mu A$)

The value of $\alpha_N$ was calculated from eq. 3 and the value of $\alpha_I$ was calculated from

$$\alpha_N I_{EBO} = \alpha_I I_{CEO}$$

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.

References

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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 "threshold" 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 \( I_\text{a} \) is the average rectified current per diode, \( E_0 \) the "threshold" voltage, \( I_{\text{rms}} \) the rms value of the rectified current per diode, and \( R_d \) the dynamic diode resistance.

\( E_0 \) 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 \( (k = I_{\text{rms}}/I_\text{a} = 1.57) \), 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 amp dc to a resistive load. Assume, also, that the diodes have 0.01 ohm dynamic resistance. The average current per rectifier leg is \( 30/3 = 10 \) amp.

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 amp per diode, the power dissipated in each diode is 10.5 w. Total dissipation in the six diodes is 63 w.
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.
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 diode 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 C₁ discharges, for example, CR₁ conducts, thus charging tank capacitor C₂.

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.
### Servo Motors For Transistorized Operations

- Meets MIL-E-5272 - 
- $-65^\circ \text{C} \to +125^\circ \text{C}$ temperature range.

#### Table: Motor Specifications

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*For 40V connection

### 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 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 $E_p$.

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 $2E_b$ 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

---

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### Electronic Design - July 23, 1958
in loop 1 can be minimized by adding two resistors in series with loop 1 diodes.

 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

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.
ALLEN-BRADLEY PRESENTS...

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\[ \frac{1}{4}, \frac{1}{2}, \text{and} \ 1\text{-WATT} \]

PRECISION RESISTORS

**Far exceed MIL Specs for film and wire-wound resistors**

Allen-Bradley's new, truly accurate, metal grid resistors are now available in 1/4, 1/2, and 1-watt ratings, producing test results that are a substantial improvement over the MIL Specifications for wire-wound and film type precision resistors. They combine remarkable stability, under load and on the shelf, with an exceptionally low temperature coefficient. The metal alloy grid is noninductive, providing excellent high frequency characteristics. They also have an exceptionally low noise level . . . comparable to that of wire-wound units. Each unit is individually calibrated and marked with nominal resistance value, tolerance (± 0.1 to 1%), and temperature coefficient. Provided with gold plated leads for flawless soldering. Considering their superior characteristics, these new resistors justly qualify under the Allen-Bradley trademark of Quality.

The construction of the 1/4, 1/2, and 1-watt resistors is identical. At the upper left is an enlarged view of the metal alloy grid, mounted on glass, which forms the resistance element. (A) Actual size of 1-watt element, (B) encapsulating epoxy resin body, (C) finished unit hermetically sealed in ceramic tube.

Type GAH
1 Watt at 100°C
± 0.1 to 1%

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.

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 \( R_f/R_\text{in} \) 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 \( R_\text{in} \). 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,
as in Fig. 4, the gain above the diode breakdown level approaches a value equal to the parallel sum of \( R_{n1} \) and \( R_{n2} \) divided by \( R_{n} \).

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 \( R_{n1} \) to \( R_{n} \) determines the slope in the low level region. The ratio of the parallel combination of \( R_{n1} \) and \( R_{n2} \) to \( R_{n} \) 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.

![Diagram of a circuit](image)

**Fig. 3.** Typical limiter characteristics.

![Diagram of a circuit](image)

**Fig. 4.** This circuit can provide a wide range of nonlinear characteristics.

---

In stock — ready for immediate delivery — the multi-purpose vacuum-tube voltmeter the whole industry has been talking about ... the Du Mont 405.

**Sensitive:** 0.1 volt full-scale measurements on either ac or dc. Can measure as low as .002 volt dc or .01 volt ac. Measures full scale to 1000 volts dc or 300 volts ac.

**Accurate:** Overall accuracy ±2% full-scale dc, ±3% ac.

**Wide Range:** Voltage measurements from 50 cps to 700 megacycles.

**Versatile:** Suitable for safely measuring dc signals up to 1000 volts off-ground through isolation of circuit from chassis ground.

**High Impedance:** 121 megohm dc input resistance to prevent circuit loading.

**Dual Input:** Second input available on front panel for accessory probe. Either input selected by front-panel switch.

**Low Drift:** Drift limited to ±5 millivolts/hour maximum.

**Probe Storage:** Front panel compartment for storage of probes and accessories.

---

**DU MONT TYPE 405 VACUUM-TUBE VOLTMETER**

For further details or demonstration, fill in and return...
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, d-c 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. 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. 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
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 \( \frac{1}{4}\) 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.

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selenium • copper oxide • silicon

See Bradley for a completely objective approach to your diode requirements.

BRADLEY LABORATORIES, INC.
174 COLUMBUS AVENUE, NEW HAVEN 11, CONN.
CIRCLE 38 ON READER-SERVICE CARD
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 $R_A$ ($\Delta R_A$) 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.

$$P = k (\Delta R_A)$$

where $k$ is a constant determined by the characteristics of the bridge network and the thermistor.

**Fig. 3. Self-balancing power bridge.**

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

Distortion Eliminating Voltage Regulator responds to transient surges and harmonics, as well as to normal variations caused by line and load changes. The Curtiss-Wright Model 104 DEVR corrects for any deviations of up to 20% from pure sine wave, regardless of their nature, in less than 125 microseconds.

It provides the answer where line fluctuations or distortion cause inaccuracies and loss of engineering and production man-hours in the design and manufacture of electronic systems for aircraft and missiles. In servos and computers, and wherever summing operations are performed, the Model 104 DEVR assures increased accuracy and stability. It is invaluable for standards laboratories and others where accuracy of instrumentation is pushed to extremes; it also increases equipment life by eliminating surges.

Write today for complete information. Price: $1875 f.o.b., Carlstadt, N. J.

The DEVR is also available in 60 cps model.
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- diode cases, spacers . . .
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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 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 band-pass. 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 ke 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.

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or a COMPLETE DIGITAL, MISSILE ELECTRICAL CHECKOUT SYSTEM

for measuring DC to 0.01%, AC to 0.1%, Ohms to 0.01%, DC ratios to 0.01% and AC ratios to 0.02%

Standard, off-the-shelf modules never become obsolete—provide maximum versatility. As needs change, simply regroup old modules or add new ones. Your system is always current at minimum cost and engineering. Internal construction is also modularized for ease of maintenance.

Fully transistorized circuits result in increased reliability, reduced power consumption, low heat dissipation, miniaturized packages, and eliminate radio noise and line transients.

Important new specifications—Wider, dynamic ranges cover all voltages from 100 microvolts to 1,000 volts; resistance from 10 milliohms to 10 megohms. Input power frequencies from 50 to 400 cycles. New balance logic speeds down ranging. Automatic AC ranging from 30 to 10,000 cycles. Use of transistors increases switch life by a factor of three.

Wide selection of input and output modules for operating printers, IBM punches, etc., can be accommodated without modifications. All contacts are accessible at rear panels with connectors. With plug-in modules, digitized data is provided in printed form, punched cards or tape without modification to basic measuring instruments.

CIRCLE 41 ON READER-SERVICE CARD
Micro-Miniature Relays by Iron Fireman

1600 Standard Models. Illustrated here are Iron Fireman's two basic microminiature relay types. Each is available in either voltage or current sensitive models in a choice of four standard header styles with any of five standard mountings. All of these 80 variations are offered in ten different standard coil resistances and in both single and double pole contact arrangements. Further, additional variations can be engineered to fit many special requirements.

Complete specifications and performance data are given in our Bulletins R-600 and R-700, which we will be happy to supply on request. Write to Iron Fireman Mfg. Co., Electronics Division, 2838 S. E. 9th Ave., Portland 2, Ore.

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 0. 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.

<table>
<thead>
<tr>
<th>099</th>
<th>199</th>
<th>299</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift</td>
<td>209</td>
<td>219</td>
</tr>
<tr>
<td>229</td>
<td>239</td>
<td>Shift</td>
</tr>
<tr>
<td>230</td>
<td>231</td>
<td>Stop</td>
</tr>
</tbody>
</table>

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.

(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.

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.
CURRENT BRIDGE
Suppling 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

HERE’S WHY KIN TEL’S DIFFERENTIAL DC AMPLIFIERS FIT IN INSTRUMENTATION SYSTEMS

160 db DC, 120 db 60 cycle common mode rejection with balanced or unbalanced input ■ Input completely isolated from output ■ Input and output differential and floating ■ 5 microvolt stability for thousands of hours ■ .05% linearity, 0.1% gain stability ■ Gain of 10 to 1000 in five steps ■ >5 megohms input, <2 ohms output impedance ■ 120 cycle bandwidth ■ Integral power supply

These are just a few of the many outstanding features of the Model 114A differential DC amplifier...features that make this amplifier really work in instrumentation systems...features that will help solve your instrumentation problems today.

Ideal for thermocouple amplification, the 114A eliminates ground loop problems; allows the use of a common transducer power supply; permits longer cable runs; drives grounded, ungrounded or balanced loads, and can be used inverting or non-inverting.

For additional information and technical literature on this exceptional instrument, write or call KIN TEL – the world’s largest manufacturer of precision, chopper-stabilized DC instruments.

KIN TEL 114A differential DC amplifiers...convenient, interchangeable plug-in mounting in either 6-amplifier 19" rack mount modules or single-amplifier cabinets.

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CIRCLE 47 ON READER-SERVICE CARD

ELECTRONIC DESIGN • July 23, 1958
NEW T/I diffused junction silicon rectifiers

3 AMP 600 VOLT silicon rectifiers

TI diffused junction silicon rectifiers give you full 3-ampere output at 50°C with PIV ratings to 600 volts.

The TI diffusion process assures you of complete uniformity of characteristics and provides either anode-to-stud or cathode-to-stud polarity. Quick easy wiring into production assemblies is additionally facilitated by the eyelet on the top lead. All welded, rugged construction with glass-to-metal seal provides high resistance to shock and vibration. Check the characteristics below and specify economically priced TI rectifiers for all your medium power applications.

Anode-to-stud units denoted by "R" suffix to type number.

<table>
<thead>
<tr>
<th>Maximum ratings</th>
<th>1N1124/1N1125</th>
<th>1N1126</th>
<th>1N1127</th>
<th>1N1128</th>
<th>1N1129</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Inverse Voltage at -65°C to +150°C</td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>500</td>
<td>600</td>
</tr>
<tr>
<td>Average Rectified Forward Current at +25°C</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Average Rectified Forward Current at +50°C</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Recurrent Peak Forward Current at +50°C</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Surge Current, 1 Cycle at 50 Cycles at +50°C</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Operating Temperature, Ambient</td>
<td>-65 to +150°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Specifications

| Max. Full Cycle Avg. Reverse Current at +150°C | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Max. Reverse Current at +25°C | 10 | 10 | 10 | 10 | 10 |
| Max. Forward Voltage Drop at | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| Ip = 1 Amp at +25°C | |

* Rectifier mounted on 2" x 2" Heat Sink, 1/16" aluminum.

NEW PRODUCTS

Transistor Logic Element

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.


CIRCLE 49 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

Contact your nearest TI sales office or distributor for detailed silicon diode and rectifier data sheets

CIRCLE 50 ON READER-SERVICE CARD
Filters

Cut off frequencies to 100 kc.

These Chebyshev 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.


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 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.

- **Maximum Ratings**
  - **Peak Inverse Voltage**: -65 to +150°C
  - **Average Rectified Forward Current**: 100 mA
  - **Recurrent Rectified Forward Current**: 30 mA
  - **Operating Temperature, Ambient**: +45 to +150°C

- **Specifications**
  - **Minimum Breakdown Voltage**: 1000 V
  - **Maximum Reverse Current at PIV at -25°C**: 50 mA
  - **Maximum Voltage Drop at I0 = 60mA at 25°C**: 0.3 mV
  - **Breakdown Voltage for 1N646**: 1000 V

Recovery time to 400 K when switched from 30 mA forward current to -35 V. Measurement made with a Hauman HD-1 standard pulse recovery test set approved by JETEC-14 and described in JAN-256.
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.
230 Duffy Avenue, Hicksville, L. I., New York
IN CANADA:
ROGERS ELECTRONIC TUBES & COMPONENTS 11-19 Bremcliff 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 sec².

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
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.

### Silicon Fast Recovery Diodes

**Diffusion computer diodes**

<table>
<thead>
<tr>
<th>PSI or EIA TYPE NUMBER</th>
<th>Minimum Saturation Voltage (volts)</th>
<th>Minimum Forward Current mA @ 300mV</th>
<th>Maximum Reverse Current (ma)</th>
<th>Reverse Recovery Characterization</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSI 720</td>
<td>30</td>
<td>3 A 1</td>
<td>5 (20v)</td>
<td>25 (20v)</td>
</tr>
<tr>
<td>PSI 721</td>
<td>60</td>
<td>5 A 1</td>
<td>5 (20v)</td>
<td>50 (45v)</td>
</tr>
<tr>
<td>PSI 722</td>
<td>100</td>
<td>5 A 1</td>
<td>5 (20v)</td>
<td>50 (75v)</td>
</tr>
<tr>
<td>PSI 723</td>
<td>200</td>
<td>3 A 1</td>
<td>10 (15v)</td>
<td>100 (15v)</td>
</tr>
<tr>
<td>PSI 724</td>
<td>400</td>
<td>4 A 1</td>
<td>20 (30v)</td>
<td>100 (30v)</td>
</tr>
<tr>
<td>IN 625</td>
<td>30</td>
<td>4 A 1</td>
<td>1 (10v)</td>
<td>50 (20v)</td>
</tr>
<tr>
<td>IN 626</td>
<td>50</td>
<td>4 A 1</td>
<td>10 (20v)</td>
<td>100 (20v)</td>
</tr>
<tr>
<td>IN 628</td>
<td>100</td>
<td>4 A 1</td>
<td>20 (15v)</td>
<td>100 (15v)</td>
</tr>
<tr>
<td>IN 629</td>
<td>200</td>
<td>4 A 1</td>
<td>20 (15v)</td>
<td>100 (15v)</td>
</tr>
</tbody>
</table>

**MILITARY TYPES**

| IN 643                | 200                               | 10 @ 1                             | 30 (10v)                    | 15 (10v)                         | 200K 0.5 |
| IN 662                | 100                               | 10 @ 1                             | 1 (10v)                     | 20 (10v)                         | 100K 0.5 |
| IN 663                | 100                               | 10 @ 1                             | 5 (75v)                     | 50 (75v)                         | 200K 0.5 |

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

**OTHER SPECIFICATIONS:**

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 40v.
<table>
<thead>
<tr>
<th>PSII or EIA TYPE</th>
<th>Minimum Saturation Voltage @ 100 mA (volts)</th>
<th>Maximum Forward Current @ 100 mA (mA)</th>
<th>Maximum Inverse Current at Maximum DC Operating Voltage @ 100 mA (mA)</th>
<th>Maximum Average Rectified Current @ 100 mA (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1N462A</td>
<td>4.0</td>
<td>1.0</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1N462B</td>
<td>4.0</td>
<td>1.0</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1N464A</td>
<td>150</td>
<td>1.0</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1N464B</td>
<td>150</td>
<td>1.0</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1N485A</td>
<td>200</td>
<td>1.0</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1N485B</td>
<td>200</td>
<td>1.0</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1N486A</td>
<td>250</td>
<td>1.0</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1N486B</td>
<td>250</td>
<td>1.0</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1N487A</td>
<td>330</td>
<td>1.1</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1N487B</td>
<td>330</td>
<td>1.1</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1N488A</td>
<td>420</td>
<td>1.1</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1N488B</td>
<td>420</td>
<td>1.1</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1N489A</td>
<td>560</td>
<td>1.1</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1N489B</td>
<td>560</td>
<td>1.1</td>
<td>0.15</td>
<td>0.25</td>
</tr>
</tbody>
</table>

**Silicon General Purpose Diodes**

**Silicon High Conductance Diodes**

**Varicap Voltage Variable Capacitors**

* *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

---

### Silicon Very High Voltage Cartridge Rectifiers

1/4 ACTUAL SIZE

---

### Silicon High Voltage Rectifiers

ACTUAL SIZE

---

### 400 MILLIAMPERE EIA TYPES

<table>
<thead>
<tr>
<th>EIA TYPE</th>
<th>Peak Recurr. Inverse Voltage @ 150°C (V)</th>
<th>Max. RMS Input Voltage @ 150°C (V)</th>
<th>Maximum Rectified Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN645</td>
<td>225</td>
<td>160</td>
<td>0.2</td>
</tr>
<tr>
<td>IN646</td>
<td>300</td>
<td>210</td>
<td>0.2</td>
</tr>
<tr>
<td>IN647</td>
<td>400</td>
<td>280</td>
<td>0.2</td>
</tr>
<tr>
<td>IN648</td>
<td>500</td>
<td>350</td>
<td>0.2</td>
</tr>
<tr>
<td>IN649</td>
<td>600</td>
<td>420</td>
<td>0.2</td>
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### 400 MILLIAMPERE PSI TYPES

<table>
<thead>
<tr>
<th>PSI TYPE NUMBER</th>
<th>Peak Recurr. Inverse Voltage (V)</th>
<th>Maximum RMS Input Voltage (V)</th>
<th>Maximum Rectified Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>405</td>
<td>50</td>
<td>100</td>
<td>0.2</td>
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<tr>
<td>410</td>
<td>100</td>
<td>70</td>
<td>0.2</td>
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<tr>
<td>415</td>
<td>150</td>
<td>105</td>
<td>0.2</td>
</tr>
<tr>
<td>420</td>
<td>200</td>
<td>140</td>
<td>0.2</td>
</tr>
<tr>
<td>425</td>
<td>250</td>
<td>175</td>
<td>0.2</td>
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<td>430</td>
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<td>210</td>
<td>0.2</td>
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<tr>
<td>435</td>
<td>350</td>
<td>245</td>
<td>0.2</td>
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<tr>
<td>440</td>
<td>400</td>
<td>280</td>
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<tr>
<td>450</td>
<td>500</td>
<td>350</td>
<td>0.2</td>
</tr>
<tr>
<td>460</td>
<td>600</td>
<td>420</td>
<td>0.2</td>
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</table>

### 250 MILLIAMPERE PSI TYPES

<table>
<thead>
<tr>
<th>PSI TYPE NUMBER</th>
<th>Peak Recurr. Inverse Voltage (V)</th>
<th>Maximum RMS Input Voltage (V)</th>
<th>Maximum Rectified Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>005</td>
<td>50</td>
<td>35</td>
<td>0.2</td>
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<tr>
<td>010</td>
<td>100</td>
<td>70</td>
<td>0.2</td>
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<tr>
<td>015</td>
<td>150</td>
<td>105</td>
<td>0.2</td>
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<tr>
<td>020</td>
<td>200</td>
<td>140</td>
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<td>025</td>
<td>250</td>
<td>175</td>
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<td>030</td>
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<td>035</td>
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<tr>
<td>040</td>
<td>400</td>
<td>280</td>
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<td>045</td>
<td>450</td>
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<td>050</td>
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<td>0.2</td>
</tr>
<tr>
<td>060</td>
<td>600</td>
<td>420</td>
<td>0.2</td>
</tr>
</tbody>
</table>

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**ELECTRICAL SPECIFICATIONS**

- **Absolute Max. Ratings:**
  - **H/W Res. @ 75°C Ambient**
  - **Electrical Characteristics:**
    - **Rated DC Cur. (mA)**
    - **Reversal Drop (%)**

<table>
<thead>
<tr>
<th>EIA NUMBER</th>
<th>&quot;L&quot; Length (cm)</th>
<th>Peak Recurr. Inverse Voltage (V)</th>
<th>Continuous DC Voltage (V) @ 25°C</th>
<th>Average Rectified Current (Amps) @ 25°C</th>
<th>Max. DC Fwd. Volts @ 100mA</th>
<th>Max. DC Rectified Current (mA) @ 25°C (V)</th>
<th>Max. DC Rectified Current (mA) @ 100°C (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1N1119</td>
<td>4.5</td>
<td>3600</td>
<td>65</td>
<td>27.7</td>
<td>.025</td>
<td>.025</td>
<td>.025</td>
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<tr>
<td>1N1141</td>
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<td>4800</td>
<td>60</td>
<td>36.0</td>
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<td>.025</td>
<td>.025</td>
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<td>1N1143</td>
<td>4.5</td>
<td>6000</td>
<td>50</td>
<td>45.0</td>
<td>.025</td>
<td>.025</td>
<td>.025</td>
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<td>1N1144</td>
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<td>7200</td>
<td>45</td>
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<td>.025</td>
<td>.025</td>
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<td>8000</td>
<td>45</td>
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<td>.025</td>
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<td>12000</td>
<td>45</td>
<td>60.0</td>
<td>.025</td>
<td>.025</td>
<td>.025</td>
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<td>1N1148</td>
<td>4.5</td>
<td>14000</td>
<td>50</td>
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<td>4.5</td>
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<td>45</td>
<td>60.0</td>
<td>.025</td>
<td>.025</td>
<td>.025</td>
</tr>
</tbody>
</table>

---

1. Resistive or inductive loads.
2. Averaged over one cycle for full wave resistive or choke input circuit with rectifier operating at full rated current and maximum RMS input.
3. Storage and Operating Temperature range: -55°C to 150°C.
Germanium Point Contact Diodes

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 Varicap). Type number designated by color bands on the body, reading from the cathode end.

**ALL DIMENSIONS SHOWN IN INCHES.**

**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.

CIRCLE 58 ON READER-SERVICE CARD

FOR ACCURATE ATTENUATION OVER A WIDE FREQUENCY RANGE...

RF Attenuators by DAVEN

These units are used in signal generators, wide-band amplifiers, pulse generators, field intensity meters, micro-wave relay systems, and repeater stations. They find application as laboratory standards, test equipment, and for checking out all types of instruments.

Daven RF Attenuators are available, in combination, with losses up to 120 Db in two Db steps; or 100 Db in one Db steps. Due to their internal circuitry and construction, they have a zero insertion loss over the frequency range from DC to 225 megacycles.

Standard impedances are 50 and 73 ohms, with special impedances available on request. Resistor accuracy is within ±2% at DC. An unbalanced circuit is used which provides constant input and output impedance. The units are supplied with either UG-58/U or UG-185/U receptacles or Coaxial lead terminations. Individual units with single-section cavities can be obtained.

Many of these types are available for delivery from stock.

Solenoid actuated RF Attenuators are also available in various decibel combinations and any number of steps up to 5.

Write for complete information

CIRCLE 59 ON READER-SERVICE CARD

CIRCLE 273 ON READER-SERVICE CARD

THE DAVEN CO.
Livingston, N. J.

WORLD'S LARGEST MANUFACTURER OF ATTENUATORS
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 μsec 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.

Qutronics Semi-Conductor Corp., Dept. ED, 525 Broadway, New York 12, N.Y.
CIRCLE 61 ON READER-SERVICE CARD

NEW PRODUCTS

Filters, the leading specialists in the development and manufacture of sub-miniature relays is proud to announce the addition of the new Powrmite micro-miniature relay to its existing line of traditionally outstanding relays.

In every field of achievement there is always one leader. In relays with highest available reliability the leader is Filters, Incorporated. All of the experience and know how gained in attaining its position of leadership have gone into making Filters new Powrmite micro-miniature relay truly reliable—again the leader in a field of many.

FILTERS, INC.
Main office and plant: Port Washington, N. Y., Port Washington 7-8220
West coast office: 13273 Ventura Blvd., Studio City, Cal., STanley 3-2770
VIBRATION 20 G'S AT 2000 CPS
50 G'S SHOCK • 2 AMP OR DRY CIRCUIT • —65ºC. TO +125ºC.

CIRCLE 62 ON READER-SERVICE CARD
Power Supply
0 to 36 v

Model SC-36-0.5 power supply delivers 0-36 v, 0.05 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 usec.

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 0.000 mv/v to 4.80 mv/v in eight increments. Nominal outputs are guaranteed to 0.25 per cent.

Bytex 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

The diodes listed are typical of the wide selection available at International Rectifier to solve your rectification problem...with excellent reliability! Your letterhead inquiry will bring the bulletin you specify and—if you include the details of your project—a recommendation stating the diode best suited to your need. The illustration at left suggests the scope of our complete line of selenium, germanium and silicon rectifiers for all dc needs from microwatts to megawatts, literally the widest range in the industry.
For top performance in circuitry...specify wire and cable insulated with TFE-fluorocarbon resins

You, too, can benefit by the use of conductors insulated with TFE resins. For example, you can save weight and space with miniaturized types of wire and cable. Reduce your inspection and replacement costs. Handle unexpected power surges. Extend the operating range of your equipment to meet the toughest environmental conditions.

TFE-fluorocarbon resins improve the performance, safety and reliability of your equipment. They simplify your soldering, potting and miniaturization problems. Their electrical and structural properties do not deteriorate with age.

Best of all, you can enjoy sales and cost advantages by using wire protected by TFE resins. Look up your local supplier in the Yellow Pages (under "Plastics—Du Pont")...or for technical information write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., Room 187, Du Pont Building, Wilmington, Delaware.

In Canada: Du Pont Company of Canada (1956) Limited, P.O. Box 660, Montreal, Canada.

çu Write for the "HOTTEST STORY IN INSULATION." It gives you the facts that can help make your design, your product, your installation a winner.

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

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.

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.

READER-SERVICE CARD
The pulse sorter 139A 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.

CIRCLE 70 ON READER-SERVICE CARD

Tung-Sol's latest 12v auto-radio tube developments—12EZ6 and 12FA6—provide a gain figure substantially above that of any other similar type. With these new tubes, the car-radio designer can simplify circuitry, thereby cutting out possible trouble spots. Bandwidth and frequency-drift problems are minimized...overall radio reliability rises.

Compare for yourself the advanced Tung-Sol types with the tubes they replace! Electrical data below!

**12EZ6**
- 7-pin, miniature, sharp cutoff pentode for use as RF or IF amplifier. Capable of 50% more gain than old Types 12AF6 and 12BL6...with but a slight drop in Rp.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>NEW 12EZ6</th>
<th>OLD 12AF6</th>
<th>OLD 12BL6</th>
</tr>
</thead>
<tbody>
<tr>
<td>heater voltage</td>
<td>12.6</td>
<td>12.6</td>
<td>12.6</td>
</tr>
<tr>
<td>plate voltage</td>
<td>12.6</td>
<td>12.6</td>
<td>12.6</td>
</tr>
<tr>
<td>grid #3 voltage</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>grid #2 voltage</td>
<td>12.6</td>
<td>12.6</td>
<td>12.6</td>
</tr>
<tr>
<td>grid #1 voltage</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>plate current</td>
<td>1.9</td>
<td>1.1</td>
<td>1.33</td>
</tr>
<tr>
<td>plate resistance</td>
<td>0.20</td>
<td>0.35</td>
<td>0.5</td>
</tr>
<tr>
<td>transconductance</td>
<td>2,500</td>
<td>1,300</td>
<td>1,350</td>
</tr>
<tr>
<td>grid #1 voltage</td>
<td>-2.8</td>
<td>-2.7</td>
<td>-6.0</td>
</tr>
</tbody>
</table>

**12FA6**
- 7-pin, miniature, pentagrid converter for use as oscillator-mixer. Capable of 20% more conversion gain than old Type 12AD6.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>NEW 12FA6</th>
<th>OLD 12AD6</th>
</tr>
</thead>
<tbody>
<tr>
<td>heater voltage</td>
<td>12.6</td>
<td>12.6</td>
</tr>
<tr>
<td>plate voltage</td>
<td>12.6</td>
<td>12.6</td>
</tr>
<tr>
<td>grids #3 &amp; #4 voltage</td>
<td>13.6</td>
<td>12.6</td>
</tr>
<tr>
<td>plate resistance (approx.)</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>conversion transconductance</td>
<td>320</td>
<td>320</td>
</tr>
<tr>
<td>grid #2 &amp; #4 current</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>grid #3 voltage for C2 = 5 μhos (approx.)</td>
<td>-3.3</td>
<td>-3.3</td>
</tr>
<tr>
<td>grid #3 voltage for C2 = 20 μhos (approx.)</td>
<td>-2.0</td>
<td>-1.8</td>
</tr>
</tbody>
</table>

**Conversion Feedback**: G2-4 to cathode value approximately 10% G2 to cathode voltage.

**Contact Potential**: Approximately 12% of G2 to cathode voltage.

**Tung-Sol helped pioneer the 12v hybrid auto radio...**

**Makes a high-performance tube for virtually every other entertainment circuit need—radio, TV, hi-fi! For full data on the new 12EZ6 and 12FA6...to fill any socket you have with a quality tube, write or phone us today! Commercial Engineering Dept., Tung-Sol Electric Inc., Newark 4, N. J.

CIRCLE 73 ON READER-SERVICE CARD
Zero cases, sealed pressure-tight by LINK-LOCK,
guard instruments against humidity, dust, atmospheric pressure changes

Delicate electronic and optical equipment is shipped long distances . . . handled again and again . . . and sometimes stored for long periods in transit cases manufactured by the Zero Manufacturing Company, Burbank, California.

The unique containers shown here are deep-drawn aluminum, seamless, with precision-fitting gasketed lids. They comply with rigid military specifications, insuring protection of contents against humidity, dust, and variations in pressure.

To effect the critically important pressure-tight seal, Zero specifies Simmons LINK-LOCK fasteners.

Here's why LINK-LOCK is ideal for use on precision-built military cases as well as on inexpensive commercial containers:
- Positive-locking without springs.
- Impact and drop resistant; not affected by arctic temperatures.
- Compact design—lies flat open or secured.
- Latch design can be varied to suit different applications.
- High preloading and high load-carrying capacity.

WRITE FOR CATALOG NO. 1257
It contains specifications, drawings, details of LINK-LOCK and other Simmons Fasteners with unlimited money-saving applications.

NEW PRODUCTS

Pulse Generator
256 discrete steps

Used for the testing and calibration of multichannel pulse height analyzers with 2º channels, model PPC-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 150, 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

SIMMONS FASTENER CORPORATION
1763 North Broadway, Albany 1, New York
QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK • DUAL-LOCK • HINGE-LOCK
See our 8 page catalog in Sweet's 1958 Product Design File
CIRCLE 74 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 on 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

Ling vibration testing proves reliability of Explorer satellites before launching

The success story of the Explorer Satellites actually began long before the countdown. Every piece and component was vibration "flown" again and again through endless testing and checkout procedures.

In fact, the fully assembled Explorer Satellites now in orbit were given a thorough vibration testing at Caltech's Jet Propulsion Laboratory in Pasadena, California.

The actual conditions of space flight were computed in a synthesized program, and, using Ling Electronic power generators and advanced techniques, space flight conditions were duplicated in the laboratory!

The ability to develop complex test equipment for new and challenging areas such as this is one of the reasons Ling is recognized as a leader in high power electronics.
How to make a Magnetic Core that's really SMALL?

use AL PERMENDUR

Write for your copy "MAGNETIC MATERIALS"

This 32-page book contains valuable data on all Allegheny Ludlum magnetic materials, silicon steels and special electrical alloys. Illustrated in full color, includes essential information on properties, characteristics, applications, etc. Your copy gladly sent free on request.

ADDRESS DEPT. ED-7

When the conditions of service make it imperative for you to hold the size and weight of magnetic cores at an absolute minimum, that's the place to use Permendur. With it you can push the flux density up to 20 kilogausses, and practically eliminate weight as a consideration.

Along with its suitability for cores wherever the premium is laid on compactness, Permendur is just the thing for sonar magnetostriction applications, too. We maintain proper annealing facilities for this alloy. Write for technical data on it, and let our engineers help you to cash in on its possibilities.

In addition to Permendur, we offer a range of high-permeability alloys, oriented silicon steels and other electrical alloys that is unmatched in its completeness. Our services also include the most modern facilities for lamination fabrication and heat treatment.

Let us supply your requirements. Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.

NEW PRODUCTS

Galvanometer

Transistor driven

For use with transistor powered amplifiers in oscillograph recording applications, this galvanometer gives flat frequency response from dc to 55 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 a 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, 150 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

ELECTRONIC DESIGN • July 23, 1958
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 0.0038 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.

CIRCLE 85 ON READER-SERVICE CARD

CIRCLE 86 ON READER-SERVICE CARD

SYLLOGISM FOR TOMORROW

PREMISE | Today's advanced Control System technologies are the result of military research and development.

PREMISE | Tomorrow's industrial Control Systems will utilize the most advanced technologies of the Control Sciences.
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.


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

ADVANCED DESIGN OF LOW-NOISE
A MAJOR EFFORT OF GENERAL ELECTRIC

Pioneering in traveling-wave tube design is one of many advanced microwave activities being conducted at the General Electric Power Tube Department's Microwave Laboratory at Palo Alto, California. In the traveling-wave tube field, particular emphasis is placed on new design concepts leading to improvements in low-noise capabilities from S through K bands, extending the sensitivity and bandwidth of advanced receivers used in radars, communications, electronic countermeasures and radio astronomy.

The Laboratory's fields of activities are applied research, advanced development, and product design in microwave tubes and microwave techniques. All development work is done with an eye to practical, economical manufacture—thus minimizing the time lapse between prototype development and quantity production—and to the realistic tube needs of future microwave equipment. Technical inquiries pertaining to advanced microwave tube development invited. Power Tube Dept., General Electric Co., Schenectady, N. Y.

Professional opportunities available for engineering and scientific personnel. Inquiries invited.
Vital development work in the following classes of tubes is a continuing activity of the G-E Microwave Laboratory's staff of scientists, engineers, and specialized technical personnel.

- Pulse klystron power amplifiers
- CW klystron amplifiers
- High-power pulsed TWT amplifiers
- Medium-power CW TWT amplifiers
- Low-noise, broadband TWT amplifiers
- Super-power klystrons
- Voltage-tunable oscillators
- High-power duplexers
- Microwave filters
- Frequency multiplier TWT amplifiers

Typical of traveling-wave tubes being developed at the G-E Microwave Laboratory is this prototype (components associated with tube not shown) with a noise figure below 10 db across the entire band of 4 to 8 KMC, and a gain of 25 db. Important design characteristics are extreme bandwidth and increased sensitivity combined with ruggedness, reliability, light weight.

The MV-37A differential-input dc millivoltmeter has a common mode rejection ratio of 1000:1 both on its sensitive direct ranges and its nonsensitive range where the input signal is being attenuated. A switching relay which inserts the same input attenuator alternately in either channel eliminates attenuator errors between the two input channels.

Millivac Instruments, Div. of Cohu Electronics, Inc., Dept. ED, P.O. Box 997, Schenectady, N.Y.

CIRCLE 89 ON READER-SERVICE CARD

These six voltage-controlled subcarrier telemetering oscillators feature small size and low power requirements. Model 0-22, little over a one-inch cube, draws a total of 25 mw one volt gives 7-1/2 per cent frequency change; input is 1/2 meg and output up to several volts on rdb channels.

Dorsett Laboratories, Inc., Dept. ED, 401 East Boyd St., Norman, Okla.

CIRCLE 90 ON READER-SERVICE CARD
AXIAL LEAD
Silicon Zener Diode

new!

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

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

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.

U.S. SEMICOR PRODUCTS, INC.
3250 West Osborn Road, Phoenix, Arizona

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. Semiconductors Products, Inc., 3250 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

EFFICIENT regulated DC power supply

Can you use a ±1% regulated dc power supply that has no filter choke drops... that has an unusually low ratio of size and weight to power output? If so, consider a Sola Regulated DC Power Supply.

This unique power supply combines: 1) a special Sola Constant Voltage Transformer, 2) a semiconductor rectifier, and 3) a high-capacitance filter without choke.

The output of this special Sola transformer (illustrated above) is virtually a square wave, form factor approx. 1.05. It not only minimizes ripple, but limits peak voltage to rectifier.

The current-limiting action of the Sola transformer permits the use of enormous capacitance for filtering, by controlling capacitor charging, thereby protecting it, and the rectifier junctions.

This dc source will give you exceptional performance on intermittent, pulse, and variable loads. The Sola-regulated dc supply is very reliable, simple, and compact. It’s moderately priced.

Write for Bulletin 31G-DC-235
Sola Electric Co., 4633 W. 18th St., Chicago 50, Ill.
CIRCLE 96 ON READER-SERVICE CARD

ELECTRONIC DESIGN • July 23, 1958
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.

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

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
- moisture resistance: Mil standard 202, method 106
- leakage current: 0.05 microamps/mfd/volt
- no exposed wires
- no corroding electrolyte

CIRCLE 101 ON READER-SERVICE CARD
IERC HEAT-DISSIPATING ELECTRON TUBE SHIELDS

PREVENT COSTLY “BIG TUBE” FAILURES

— 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.
Teletron 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.
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

Follow the Caravan!

to Ontario
in SOUTHERN CALIFORNIA

2000 ACRE INDUSTRIAL PARK

Be a part of the forward move to the planned-with-a-future 2000 acre industrial park in the very heart of ever-expanding Southern California. Ready now for occupation is plenty of zoned, low-cost industrial land with development carefully guided by an extensive plan of ample 88' and 100' roadways, railroad drill tracks to major railways, ample sewage and complete utilities services. Bounded on two sides by four-lane super state highways, the acreage is 11/2 uniform sloping land with 3000 pound bearing pressure per square inch. Centralized location puts you minutes away from Metropolitan Los Angeles and all outbound points.

established wealth ...
... a promised future

WRITE TODAY

Forde Seward, Manager
ASSOCIATION OF COMMERCE AND INDUSTRY, INC.
206 West "B" Street, Ontario, California
NAME: ____________________________________________
TITLE: ____________________________
BUSINESS: ____________________________
ADDRESS: ________________________________________

CIRCLE 106 ON READER-SERVICE CARD

ELECTRONIC DESIGN • July 23, 1958
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

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


CIRCLE 108 ON READER-SERVICE CARD

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

Cable is a Rex specialty

Complete design and cabling facilities are available to handle all cabling problems—efficiently, perfectly. The Rex reputation as the foremost specialist in designing and manufacturing cable justifies your complete confidence.

Genalex III toroidal cores feature high stability of inductance with time, high stability of inductance after subjecting the core to a dc saturating flux, high Q, low harmonic distortion, low temperature coefficient of inductance, negligible external field, and small overall size.

Color coded Genalex III cores are available for immediate delivery in five standard ranges of permeability: 14, 26, 60, 125, and 140. Seven standard sizes are stocked ranging from 0.500" O.D. to 1.350" O.D.

Genalex cores are a product of Salford Electrical Instruments, Ltd., a subsidiary of The General Electric Co. Ltd. of England.

WALLACE E.

Connolly & Company

"National headquarters for Genalex toroidal cores"

P.O. Box 295 • Manlo Park, California

CIRCLE 111 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.

CIRCLE 115 ON READER-SERVICE CARD

General Electric Semiconductor News

New controlled rectifier does all these

Maximum Allowable Ratings and Characteristics

<table>
<thead>
<tr>
<th>(Resistive or Inductive Load)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z129A</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>35</td>
</tr>
<tr>
<td>17.5</td>
</tr>
<tr>
<td>Average Forward Current (Iav) Up to 14 amperes</td>
</tr>
<tr>
<td>150 amperes</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>150 amperes</td>
</tr>
<tr>
<td>5 ma (Full Cycle Average)</td>
</tr>
<tr>
<td>25 ma</td>
</tr>
<tr>
<td>3 Volts</td>
</tr>
</tbody>
</table>

Finer performance of G-E low-current silicon rectifiers now within reach for all your requirements

The time has come to reconsider possible applications of G.E.'s outstanding low-current silicon rectifiers in the 1N536, 1N440 Series (150°C line) ... the 1N1487 Series (125°C line) ... and four recently added types in the 100°C area, the new 1N1692 Series. You'll find these devices more attractive to use than ever before—both in quality and price—with equally fine values in low-current silicon stacks. Stud-mounted units are also available.

General Electric low-current silicon rectifiers are designed for maximum forward conductance at high operating temperatures. High current loads are carried without external heat sinks. Reverse current at maxi-
Price reductions in some cases greater than 50% will enable hundreds of new users to become acquainted with General Electric’s new silicon controlled rectifier.

Neither a transistor nor a rectifier, this remarkable device combines features of both. In the reverse direction it acts like a standard rectifier. But it also blocks forward current until either a critical breakover voltage is exceeded or a signal is applied to the third lead. Then it switches to a conducting state and performs exactly like a forward-biased silicon rectifier.

The controlled rectifier offers the circuit designer current ratings comparable to thyatrons, blocking voltages useful in industrial circuits, complete control of current turn-on without complicated circuitry, and switching speeds in microseconds.

While in many ways similar to the gas thyatrons, the controlled rectifier provides faster firing and recovery times, very low forward voltage drop, higher efficiency, absence of filament with attendant warm-up delay and power consumption, and higher-temperature operation.

Check the sample ratings and suggested applications at left. Application data and specifications will be sent on request.

For fast delivery, lower prices, see your local G-E distributor!

A recent check shows that General Electric transistors and rectifiers are being sold by local tube distributors for within pennies of the factory price on quantities less than one hundred—with the important difference that transportation charges are prepaid when you buy from your local G-E distributor.

Increased stocking of semiconductors by local G-E distributors means you now have one source for all your electronic needs. General Electric distributors can also furnish you with a wide variety of technical information, application data and spec sheets.

General Electric Company, Semiconductor Products Department, Section S23758, Electronics Park, Syracuse, N.Y.
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.
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.

CIRCLE 122 ON READER-SERVICE CARD

FOR YOUR FREQUENCY DIVIDER PROBLEMS...

This simple device delivers one output pulse for every 2 input pulses. It can be directly cascaded for large division ratios. Feedback taps are provided to make any ratio possible.

Requires 20 to 30 volts DC at less than 15 ma per unit.

Useful for dividing output from frequency standards, in timing and clock circuits, plus many other applications.

Designed for direct assembly on printed circuitboards. Completely sealed. Will withstand a wide range of environmental conditions.

Ask for Engineering Bulletin No. 56.

RIXON ELECTRONICS, INC.
2414 Reedeie Dr.,
Silver Spring, Md.

CIRCLE 124 ON READER-SERVICE CARD

ELECTRONIC DESIGN • July 23, 1958
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

Eimac First for Power Amplifier Klystrons

...Across the RF SPECTRUM

The exceptional ability of Eimac amplifier klystrons to conveniently and reliably generate high RF power at ultra-high and super high frequencies makes them ideal for use in such important aeronautical applications as high-power ground-to-air communications, TACAN and other air navigational systems, super-power radar for missile tracking, tropo scatter communications networks for early warning defense and other UHF microwave systems.

The broad frequency coverage and wide power range now offered by Eimac amplifier klystrons is shown in the accompanying charts. Frequency coverage extends into the SH range, and multi-megawatt pulse output powers are available.

For more detailed information on Eimac's reliable, simplified approach to high power at high frequencies, write for a copy of Klystron Facts Case Five. The Eimac Application Engineering Department will gladly assist you in planning the use of Eimac power klystrons.

CIRCLE 127 ON READER-SERVICE CARD

EITEL-McCULLOUGH, INC.
SAN BRUNO, CALIFORNIA

Eimac First for Power Amplifier Klystrons

EIMAC DESIGNED AND MANUFACTURED PRODUCTS
Negative Grid Tubes Vacuum Tube Accessories
Reflex and Amplifier Klystrons Vacuum Switches
Ceramic Receiving Tubes Vacuum Pumps
Traveling Wave Tubes
Eimac family includes more than 40 ceramic electron tube types
In *Electronic Design*, engineers find not only more new products, but all the new products of significance to electronic engineers in their work. 26-time publishing frequency brings this information quickly to the engineer's attention, timed to a fast-moving industry. *Electronic Design* is more up-to-the-minute, more complete, more helpful, and easier to read than any other electronic publication. No wonder more and more engineers read *Electronic Design* first!

---

**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.


*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*
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

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

NEW...a grid-spaced relay!

Latest development in miniaturized sealed relays is General Electric's new grid-spaced (Type GS) micro-miniature relay. Terminals of this crystal-can size relay—spaced .2 inch apart—are tailored to the .1 inch standard spacing for printed-circuit board layout.

But, it's ideally suited to many other electronic jobs as well, particularly aircraft and missile applications.

All the production “know-how” gained in three years of experience with the popular Type G200 micro-miniature series has been packed into this new grid-spaced sealed relay.

Here are some of the basic specifications for the G-E Type GS relay:
Rating: 3 amps, 100,000 operations; 2 amps, 500,000 operations.
Temperature: -65 C to +125 C.
Shock: 50 G's per MIL-R-5757C.
Sensitivity: 300 milliwatts.
Operating Time: 4.5 ms. nominal.
Release Time: 3.5 ms. nominal.

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
PACKAGING
MICROWAVE
RADAR

APPLICATIONS
CIRCUIT DESIGN
RELIABILITY
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
Excellence in Electronics

80
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

Wheellok SIGNALS
CRYSTAL CASE RELAYS

HIGH TEMPERATURE . . .
UP TO 125°C AND EXCES-SIVE VIBRATIONS . . .
2000 CPS. AT 20 G.
Consistently high reliability inherent in design and performance

These new Wheellok Signals Crystal Case relays will solve all your space problems! Our engineers designed these precision-made relays smaller than small . . . about the size of a quarter . . . lighter than lightweight . . . approximately 35 oz. . . . and sensitive enough for milliseconds operation, yet so rugged to withstand rigid military environmental specifications.

For consistent reliability, extended life and never-failing performance, specify Wheellok Signals Crystal Case relays for your electronic applications. We will help you solve your relay problems . . . we will gladly recommend the relay to suit your needs.

Write for additional literature and complete specs.

Wheellok SIGNALS

RELAYS LONG BRANCH, N.J.
CIRCLE 138 ON READER-SERVICE CARD

ELECTRONIC DESIGN • July 23, 1958
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 1N55B, 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

Keep Up-to-Date on Magnetics

Just published—bobbin core guaranteed performance limits!

We have just published new data which will light the way to ease, sureness and accuracy for the designer who works with tape wound bobbin cores.

First—and this is a "first"—we have published guaranteed maximum and minimum performance limits for all of our bobbin cores. Computer-type designers who would like open-circuit characteristics, guaranteed core flux and guaranteed squareness will find them all here.

Second—and this too is a "first"—we have published the first fundamental data on characteristics of bobbin cores for circuit designers. Need core total flux characteristics as related to core material? Want switching time vs drive levels? How about typical spreads of core characteristics? It's all yours.

Third—and this too is a "first"—we automatically give you test data for prototype orders. With your prototype cores come open-circuit outputs, total flux, and squareness data. You get a basic understanding of the core's characteristics under specific test conditions. More important, when you re-order production quantities, you will be able to duplicate the core around which you designed your circuit.

Last—but still a "first"—to show that we manufacture as well as publish, we have designed the first bobbin core protective cap which will permit normal potting procedures for all sizes of steel and ceramic bobbins. Our "Poly Caps" have virtually no effect on dimensions—and will not soften or deform under manufacturing or operational temperatures. We'd like to show you samples.

At what stage do you want to start? Whether it's design data, prototype data and cores, or production quantities of our "Performance-Guaranteed" bobbin cores—you can get what you need by writing Magnetics, Inc., Department ED-48, Butler, Pennsylvania.

CIRCLE 142 ON READER-SERVICE CARD
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 asymmetrical 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.
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 ensure 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

Guaranteed long-term accuracy 1%

Closer to a laboratory standard than to a conventional test meter! Where accuracy and dependability are required, use the AvoMeter 8.

Accuracy Guaranteed,
1% DC current, 2% DC voltage,
2½% AC current and voltage.
Sensitivity: 20kΩ/v DC, 1kΩ/v AC.
Hand Calibrated • Mirrored Scale
Automatic Overload Protection
AC Current Ranges • Reversing Switch
3 Zeroing Controls
Accessories Extend Ranges

Moderate Price: $89.01

For complete literature and ordering information, call or write Dept. 20888
BRITISH INDUSTRIES CORPORATION
Scientific Instruments Division
Port Washington, New York.

AVOMETER 8
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CIRCLE 146 ON READER-SERVICE CARD

CIRCLE 147 ON READER-SERVICE CARD
BUILD YOUR PRODUCT BETTER

...WITH JOHNSON COMPONENTS!

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.

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" long. This comprehensive line offers types with construction features such as soldered plates; DC-200 impregnated steatite end frames; types with setor support rods soldered directly to ceramic end frames; units with high capacity per cubic inch and low capacity per chassis; and types with special platings and spacings in production quantities.

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!

pilot lights

Save valuable specification time by selecting your panel indicators from Johnson's "preferred" line. Available types include: faceted jewel or wide angle lutea 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
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 ambient temperatures 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**

**HYPERPURE SILICON**

**BETTER THINGS FOR BETTER LIVING... THROUGH CHEMISTRY**
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

BEEDE ELECTRICAL INSTRUMENTS

NOW! AVAILABLE IN COLOR OF YOUR CHOICE

ALL-WAYS ACCURATE TO THE DOT — FOR POWER-UNIT PANELS, INDUSTRIAL TEST UNITS, COMMUNICATION EQUIPMENT — CATALOG ON REQUEST

BEEDE ELECTRICAL INSTRUMENT CO., INC.
PENACOOK, NEW HAMPSHIRE

CIRCLE 150 ON READER-SERVICE CARD
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.
NEW CONCEPTS IN TR TUBES...

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

MINIATURE AND SUB-MINIATURE

relays by Hi-G

Rugged and reliable relays are manufactured at Hi-G in a wide range of standard units... and to customer order with special designs to meet your particular requirements.

Complete experimental and prototype facilities permit Hi-G engineering personnel to study and evaluate your relay needs.

New, complete illustrated specification sheet available. Write for your free copy today.

And for information on special relay units, send your specifications to Hi-G for study and recommendations at no obligation.

rugged / reliable / shock and vibration resistant

A FEW OF THE WIDE RANGE OF HI-G STANDARD RELAYS

HG-2SM
HG-2XC
HG-2SMP
HG-2MS
HG-2SL
HG-2SC
HG-2SL

BRADLEY FIELD WINDSOR LOCKS, CONN.

CIRCLE 191 ON READER-SERVICE CARD

ELECTRONIC DESIGN • July 23, 1958
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.


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.


CIRCLE 156 ON READER-SERVICE CARD

**Hycon**

digital volt-ohmmeter
—for quick, easy measurements with consistent accuracy

Easy to read—the digits are ½” high, white against jet black, and displayed in line for fast, repetitive reading with minimum fatigue.

1% accuracy on DC and Ohms ... 2% on AC. The illuminated decimal point and negative polarity indicator insure readout accuracy. And since the display is direct reading, all interpolation and parallax errors are eliminated. Readings are repeated within one digit.

Complete data in Bulletin 615

Model 615

$300.00

Order from your Hycon representative, or from:

Hycon ELECTRONICS, INC, 370 So. Fair Oaks, Pasadena, Calif.
A SUBSIDIARY OF HYCON MFG. CO.

CIRCLE 157 ON READER-SERVICE CARD

ELECTRONIC DESIGN • July 23, 1958
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.
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).

ACE offers a wide variety of linear and nonlinear precision, wire-wound 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.
NEW PRODUCTS

Logic Units
Contain 17 components

Servo Motor
Miniature size 6

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.

CIRCLE 160 ON READER-SERVICE CARD

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.

CIRCLE 161 ON READER-SERVICE CARD

for highly engineered applications

Giannini specifies

SECON precious metals
POTENTIOMETER WIRE

Giannini specifies only the finest in noble metal wire for the wire-wound potentiometers used in their products, which include: pressure transducers, accelerometers, vanes, gyros, systems, and precision potentiometers. Giannini instruments have wide airborne application in the missile and aircraft fields, where precision and reliability are a must.

If yours is a problem involving metallurgical fine wire, consult Secon.

Write for literature to Dept. ED-7

SECON METALS CORP., 7 Intervale Street, White Plains, N. Y.
WESCON BOOTH 1906-C
CIRCLE 162 ON READER-SERVICE CARD

ELECTRONIC DESIGN • July 23, 1958
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

Commercial — Low-cost
THERMAL TIME DELAY RELAYS
"K", "G" and "W" Series

- For industrial use — economical — stocked
- Time delays — "K" and "G", 3 to 60 seconds. "W", 15 to 90 seconds
- Input voltages — 6.3, 26.5, 117, AC or DC
- "K" and "G" miniature size, glass envelopes
- "W", dust-tight metal envelope

The "K", "G" and "W" relays are part of the new Curtiss-Wright Thermal Time Delay Relay line which includes:

H-Series
- vibration resistant, for missiles, aircraft

S-Snapper
- double-throw, snap-action contacts

IR and STR
- instant reset, voltage compensated

MR and CR
- double-throw, fast reset, no chatter

For our new catalog, write or phone Electronics Division, Components Dept., Carlstadt, New Jersey, GEneva 8-4000.

CURTISS-WRIGHT®
CORPORATION • CARLSTADT, N. J.
CIRCLE 165 ON READER-SERVICE CARD

ELECTRONICS DIVISION
CURTISS-WRIGHT®
CORPORATION • CARLSTADT, N. J.
CIRCLE 165 ON READER-SERVICE CARD

ELECTRONIC DESIGN • July 23, 1958
NEW INSTRUMENTS

by TECHNOITROL

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


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.
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-78U/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

EQUI-TORQUE
Process #25*

...Developed by RADIO CORES
Originators of ENGINEERED ECONOMY IRON CORES

Get even, smooth-running, satisfactory torque control in application of threaded cores to coil forms with EQUI-TORQUE PROCESS #251

- Specially processed tacky wax
- Lubricates at ease torque
- Impregnated in cores
- Compensates for low torque
- Covers all thread form
- Uniform running torque
- Wax withstands 200°F.
- Equilizes Initial and running torque
- Recycling excellent
- No deteriorate in function with aging

Operational tested and now being used by leading television, radio and coil manufacturers.
Write for samples and further information today!

Radio Cores, Inc.
9540 SOUTH TULLEY AVENUE • OAK LAWN, ILLINOIS
Phone: Garde 2-3353
CIRCLE 170 ON READER-SERVICE CARD

ELECTRONIC DESIGN • July 23, 1958
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.


CIRCLE 172 ON READER-SERVICE CARD

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

Fenwal Electronics, Inc., Dept. ED, 1711 W. Hubbard St., Chicago 22, III.

CIRCLE 173 ON READER-SERVICE CARD

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

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

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.


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

NEW FLAT MOTOR / SMALLEST YET

Globe Industries announces a new precision miniature d.c. motor, the smallest we have made. Like all Globe motors, it can be modified easily and quickly to meet your electrical and mechanical requirements. It is called the VS, and takes its place with the SS, MM and LL in Globe’s family of superb quality motors.

The VS weighs 1¼ ozs., is ½ in. thick. A breakthrough in miniaturization, it can deliver .2 oz. in. of torque at 10,000 rpm and is the first precision motor of its size available. Multiple units can be gang-mounted in modules.

The fastest way to get full technical data on the VS motor is to phone or write direct:
Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio, Telephone BALdwin 2-3741.
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 volt meter for microvolt dc readings and eliminates the need for buying dc ac voltms. 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.


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

ELECTRONIC DESIGN • July 23, 1958
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**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.
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
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.
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 $\pm 5\%$ of full scale.

<table>
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<th>Model No.</th>
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<td>0-12 in one scale</td>
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* 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.

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


Altitude-Pressure Table 215


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.

for maximum reliability

PREVENT THERMAL RUNAWAY

Prevent excessive heat from causing "thermal runaway" in power diodes by maintaining collector junction temperatures at, or below, levels recommended by manufacturers, through the use of new Birtcher Diode Radiators. Cooling by conduction, convection and radiation, Birtcher Diode Radiators are inexpensive and easy to install in new or existing equipment. To fit all popularly used power diodes.

with NEW BIRTCHER DIODE RADIATORS

THE BIRTCHER CORPORATION
industrial division
4371 Valley Blvd. Los Angeles 32, California
Sales engineering representatives in principal cities.

CIRCLE 217 ON READER-SERVICE CARD
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 $-65^\circ\text{C.}$ to $+150^\circ\text{C.}$

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.

### Table: MAX. AVG. FWD. CURRENT, 40°C.* (AMPERES)

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* 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

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ANSWERING URGENT MISSILE-GUIDANCE
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TEFLON® Subminiature Tube Lead Insulators. Possess all the fine characteristics of TEFLON—high heat resistance (to 500°F), zero moisture absorption, low loss factor (less than .0005), tough, resilient, withstand shock and vibration.

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TEFLON Compression-mounted Subminiature Tube Sockets. Save space, assembly time. High reliability factor—withstanding extreme shock, vibration, high temperature. Have low loss insulating qualities, zero moisture absorption. Versatile: can be used as chassis-mounted tube lead insulators, adaptable to printed circuit applications.

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TEFLON Compression-mounted, low-loss Transistor Sockets. Also applicable for Subminiature Tubes with "in-line" leads. Save assembly time and space. High Reliability factor—withstanding high temperature, extreme shock, vibration. Adaptable to printed circuit applications.

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Division of United States Gasket Co., Camden 1, New Jersey

Fluorocarbon Products Inc.

CIRCLE 220 ON READER-SERVICE CARD
Phase Inverter

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.

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.

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-
In the quiescent state, transistor 12 is conducting and transistor 10 is cut off. 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**


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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From millimeters to microns... in this region the significant economy of the KINNEY KMB Mechanical Booster Pump is self-evident, as shown by the performance curve above. And, this high efficiency is doubly attractive because these KINNEY Pumps provide clean, dry Vacuum... no backstreaming... automatic operation... no stalling problems from gas bursts.

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CIRCLE 228 ON READER-SERVICE CARD
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 transducers.

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 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

---

SPACE FLIGHT and NUCLEAR PROPULSION

A drastic reduction in vehicle mass ratios...substantially increased specific impulse values...a capability for achieving very high speeds...these are some of the significant advantages that will come from the application of nuclear energy to space flight.

A number of different propulsion systems have been proposed to utilize nuclear reactions. The simplest system consists of a fission reactor through which the propellant is passed, heated, and then expanded through a rocket nozzle. Fission reactors can also be employed as a source of energy to generate electric power, which in turn can be used to accelerate ions or charged particles, or to create and accelerate a plasma. And fusion reactors, when developed, can be used to generate electric power for the same purposes. In addition, in the case of the fusion reactor, there is the attractive possibility that the reaction energy can be used directly without conversion to electric power.

The fission-powered thermal propulsion system will probably constitute one of the next major advances in space technology. As an example of the gain which can be achieved, consider a vehicle with a payload weight of about 25 tons for a manned flight to one of the nearer planets, landing, and returning. Powered by chemical rocket engines, the takeoff weight for such a vehicle would be 50,000 tons. But powered by a fission-thermal propulsion system, weight at launch would not exceed 500 tons...a 100-fold reduction in the mass ratio. Considerably greater gains are predicted for the more advanced systems.

Systems studies and advanced research in the application of nuclear energy to the requirements of space flight are in progress at Space Technology Laboratories. This work illustrates the emphasis at STL on the exploration and development of new concepts and techniques in ballistic missile and space technology.

Both in support of its over-all systems engineering responsibility for the Air Force Ballistic Missile Program, and in anticipation of future system requirements, STL is engaged in a wide variety of analytical and experimental research. Projects are in progress in electronics, aerodynamics, hypersonics, propulsion and structures.

The scope of activity at Space Technology Laboratories requires a staff of unusual technical breadth and competence. Inquiries regarding professional opportunities on the STL Technical Staff are invited.

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Space Technology Laboratories
A Division of The Ramo-Wooldridge Corporation
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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 120 to 135 deg C were exhibited by Gresham Transformers Ltd. These units are intended for airborne equipment continually operated at 100 C environments.

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 npn 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

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.

Audio Frequency Transformer

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, 255 Broadway, New York 7, N. Y.
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 nonlinear 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 0.0005 in.; capacity $\leq 1.8\mu F$ to $\geq 7.3\mu F$, test voltage 1000 v dc, insulation 5000 meg power factor 0.01, torque 2.8 oz.

CIRCLE 249 ON READER-SERVICE CARD

Get better tube and circuitry design
with this powerful electronic computer
ROYAL PRECISION LGP-30

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Compact, simple to use, Royal Precision LGP-30 will today save valuable time in the simulation of optimum designs... will eliminate weeks of detailed mathematical analysis by furnishing you with high-speed, desk-side electronic computation. And at the lowest cost ever for a complete computer system!

Unusual capacity. Operating from a standard wall outlet, performing an almost unlimited range of calculations, LGP-30 gives you the flexibility of stored-program operation combined with speed, memory (4096 words) and capacity equal to computers many times its size and cost. Completely mobile, LGP-30 is easily wheeled from room to room, building to building.

Simple to operate and program. LGP-30 controls have been so thoroughly simplified that it may be operated with only minimum computer experience. Direct print-out of answers - no deciphering required. Programming is easily learned. Library of sub-routines, plus programs for a wide variety of applications, is available.

Wide range of electronics applications. Among the jobs for which LGP-30 is now being used in the electronics industry: evaluation of $8 \times 8$ determinants related to crystallographic studies; solution of differential equations in tube and circuit research; dynamic analysis of flight simulation systems; design of cams for flight and fire control computers; design of electromechanical analog computers.

Exceptional value; complete service. Smallest initial investment ever for a complete computer is combined with low operating and maintenance costs. Service facilities coast-to-coast.

For further information and specifications, write Royal McBee Corporation, Data Processing Division, Port Chester, N. Y.
By applying quantity production methods, Radio Industries can now offer single cell Selenium Disc Rectifier units at surprisingly low costs. Soldered directly to the electrodes, the leads have a positive electrical contact for the life of the rectifier, eliminating all problems of connection intermittency. Uniform performance is assured for every unit.

Write for complete information. We will be glad to quote on your specific requirements.

RADIO INDUSTRIES, INC. • 666 Garland Place
Des Plaines, Illinois

CIRCLE 251 ON READER-SERVICE CARD
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.


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.


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.


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.


Description of a setup to measure the nominal carrier frequency of radio transmitters at the reception point; the accuracy is approximately 0.5 x 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.
Microwave Installations...

...and cover Baseband, IF and Carrier Frequencies of the most sophisticated multi-channel systems. Engineers are now designing. These entirely new instruments are now in production; they meet C.C.I.R. specs, and are flexible to customers' specific needs.

**WHITE NOISE TEST SET Model 1249**

Measures intermodulation distortion in systems handling up to 960 channels. Comprises Noise Generator, Receiver and modular Filter Assembly which facilitates changing filters to suit different systems. Diagram indicates test on 960 channel installation.

**DERIVATIVE TEST SET**

Model 1259

A Sweep Generator and self-calibrating CRT display are provided to measure modulator/demodulator linearity. The first derivative, or slope, of the modulator response is automatically plotted against instantaneous I.F.; discrimination is 0.1 db.

**CARRIER TEST SET**

Model 1248

Includes a Signal Generator with CW, frequency sweep and AM output, a Receiver with square law detector and markers for response measurement, and a Noise Generator with output up to 15 dbm. Equipment already available in 1700-2300Mc band; other bands under development.

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Another TIMES first — A complete range of standard miniaturized low capacitance cables that covers most Radio Frequency, Pulse and Data Transmission applications. Special constructions which fall outside standard range and size are available upon request.

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<th>CABLE O.S.</th>
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<td>.185&quot; ± .004</td>
<td>140 ± 5 ohms</td>
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<td>-40° to 80°C</td>
<td>9.5 ± .5</td>
<td>.012&quot;</td>
<td>.185&quot; ± .004</td>
<td>130 ± 5 ohms</td>
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<td>.007&quot;</td>
<td>.325&quot; ± .010</td>
<td>185 ± 10 ohms</td>
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- Polyethylene dielectric, Nylon jackets.
- All Teflon construction, silverplated conductor and shields.

Write for Bulletin 55 and Sample

TIMES WIRE & CABLE CO., Inc.
An affiliate of THE INTERNATIONAL SILVER CO.
Wallingford, Conn.

CIRCLE 269 ON READER-SERVICE CARD

OK Boss, you tell ‘em how we’re gonna revolutionize the party line telephone system with transistor oscillators controlled by . . .

NEW REEVES-HOFFMAN LOW FREQUENCY CRYSTALS

New Reeves-Hoffman low frequency crystals, type RH8-DP, offer excellent frequency stability over a temperature range of —55° to +105°C. Available from 4 to 15 kc, they are designed for use not only in telephone carrier and communications systems, but in aircraft navigation, guided missile, sonar, telemetering and test equipment as well. These crystals meet MIL-C-3098B specifications for shock, vibration, aging and moisture resistance.

WRITE FOR BULLETIN RH8-DP

REEVES-HOFFMAN SPECIALIZES IN VOLUME PRODUCTION OF CRYSTALS FROM 1 MC DOWN

CIRCLE 270 ON READER-SERVICE CARD
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. Vasi’lyeva 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.


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 Housey'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. Roginsky. 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 $\theta$. The article obtains

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Here is my design idea for possible publications in your Ideas For Design department.
I can expect $10 for this idea if accepted for publication.

(Ideas suitable include: 1. new circuits or circuit modifications, 2. new design techniques, 3. designs for new production methods, 4. clever use of new materials or new components in design, 5. design or drafting aids, 6. new methods of packaging, 7. design short cuts, or 8. cost saving tips)

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)
formulas of Wiener and Booton are derivable from the formula derived in this article for particular cases.

**ELECTRON PHYSICS**

The December 1957 issue of *Radiotekhnička i Elektronika* covers many properties and effects of different types of vacuum tube cathodes.

**PROPAGATION**


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 sub 10 mode.

Longitudinal Electric Waves in Rectangular Wave-guides with Periodic Diaphragms by R. M. Leont'ev. *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.
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**GERMAN ABSTRACTS**

**E. Brenner**

**Load-Independent Oscillators**

**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

$$
V_1 = z_{11} I_1 + z_{12} I_3 \\
V_2 = z_{12} I_1 + z_{22} I_3 \\
0 = z_{13} I_1 + (z_{23} + Z) I_3
$$

Furthermore, if the tube operates ideally then $I_1 = g_m V_2$. The condition for oscillations is therefore

$$
g_m = \frac{1}{z_{11} - z_{13} z_{22} / (z_{23} + Z)}
$$

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

$$
\frac{z_{13} z_{22}}{(z_{23} + Z)} = 0
$$

The condition for oscillations then becomes $g_m = -1/z_{12}$. This last condition is fulfilled if either $z_{12} = 0$ or $z_{23} = \infty$ 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

$$I_3 = I_1 z_{13} / (z_{13} + Z)$$

If the internal impedance of the generator, $R$, equals $z_{23}$ 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 $z_{13}$ as open circuit impedance functions and measuring appropriate voltage ratios. To have $z_{23}$ 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.


![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.](image-url)
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EIA STANDARD RS-209, NEMA PUBLICATION NO. 500, JETEC No. J0-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.

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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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