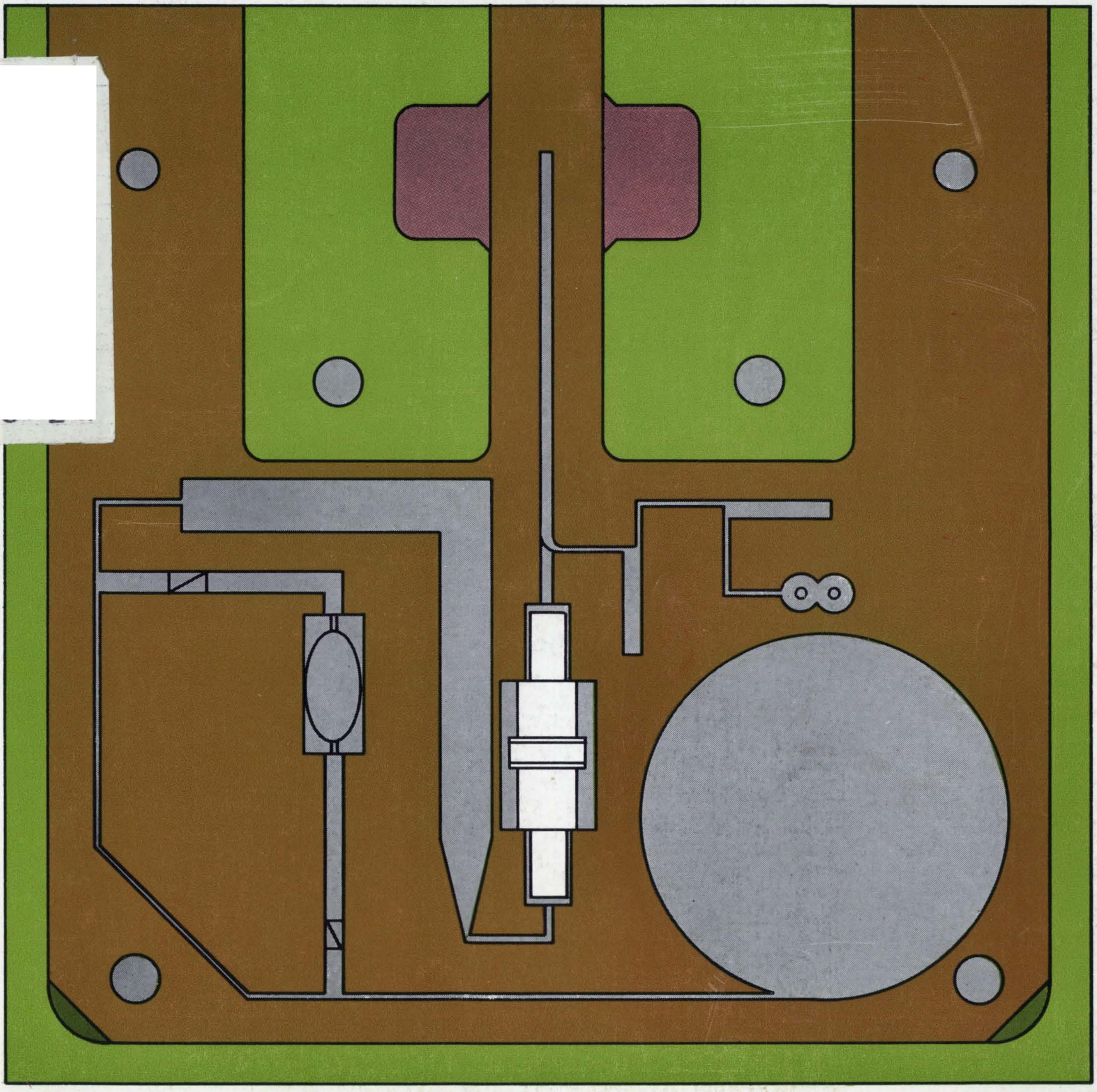
VOL. 14, NO.

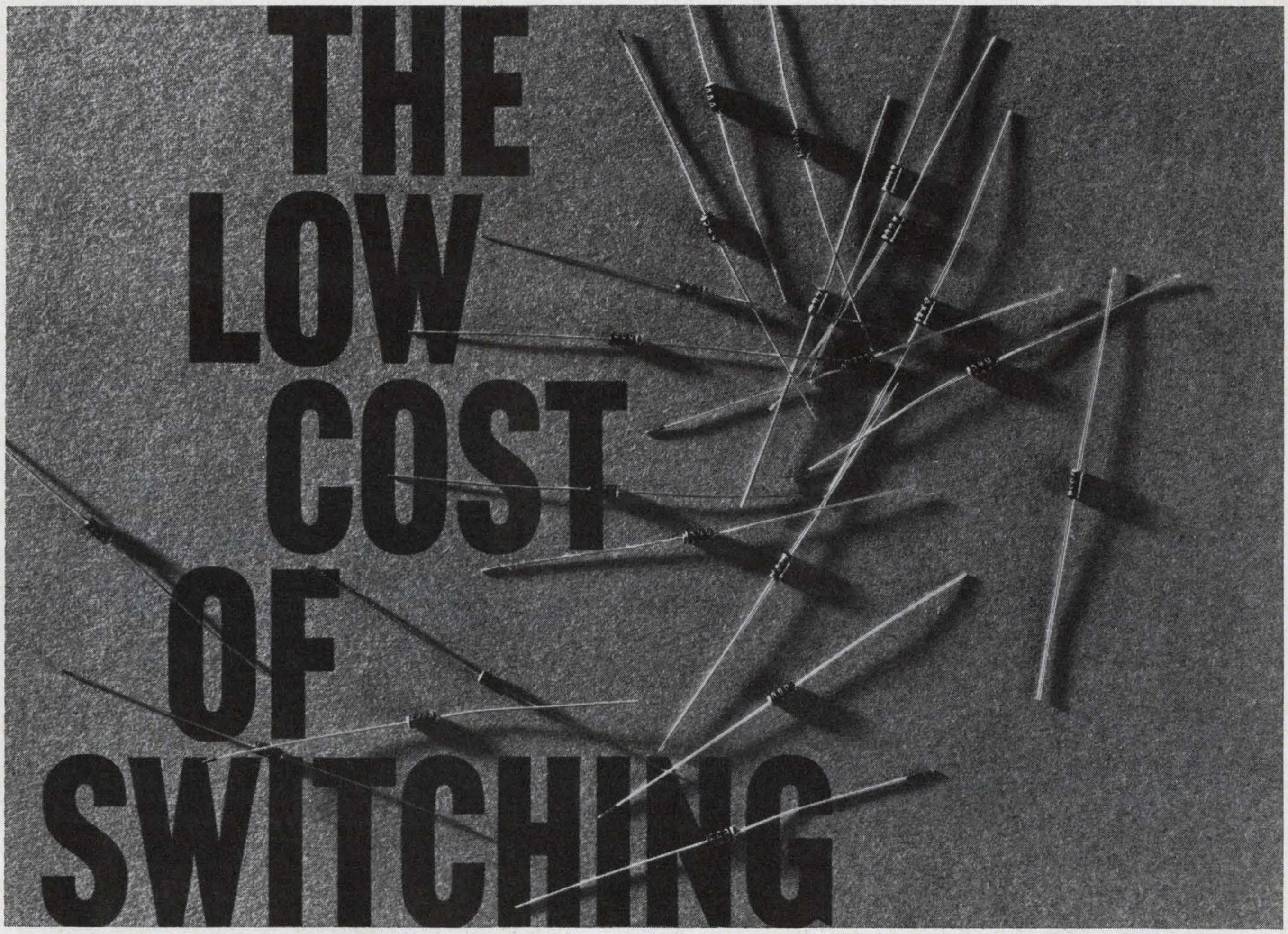
Electronic Design 10

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

APRIL 26, 1966

Backward diodes are great for the detection of microwaves—if the mount is right. A stripline mount, designed with a probe, solves the major problems of this diode: the variation of the output with temperature and with the position of the diode in the waveguide. The examination of the design starts on page 44.





...new value from new pricing on hot carrier diodes from hpa

Ultra-fast switching with hp associates 2900 Hot Carrier Diode is now more economical than ever. New production techniques and experience have reduced the cost of these popular devices, and the savings is passed on to you.

The performance characteristics and pricing listed in the chart make the hpa 2900 ideally suited for use in TV tuners, commercial communications limiters, detectors and mixers, and multiplexing in signal processing.

Contact your Hewlett-Packard field engineer for complete data.

TYPICAL SPECIFICATIONS, hpa 2900

Forward Current I_{F1}	Breakdown Voltage BV_R
20 ma min. @ V_F =1.0 v 1.0 ma min. @ V_F =0.4 v	10 v @ I_R =10 μa

Leakage Current I_R	Lifetime τ	Price
100 na @ V_R =−5.0 v	100 ps	1 to 99, $3.00 100 to 999, $2.25

Data subject to change without notice. Prices f. o. b. factory.

hp associates 620 PAGE MILL ROAD, PALO ALTO, CALIF. 94304, (415) 321-8510
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997

ON READER-SERVICE CARD CIRCLE 2

Electronic Design

VOL. 14, NO. 10

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

APRIL 26, 1966

NEWS

TECHNOLOGY

PRODUCTS

Departments

ELECTRONIC DESIGN is published bi-weekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N. Y., 10022. James S. Mulholland, Jr., President. Printed at Poole Bros., Inc., Chicago, Ill. Controlled-circulation postage paid at Chicago, Ill., and New York, N. Y. 60,237 copies this issue.


BOURNS
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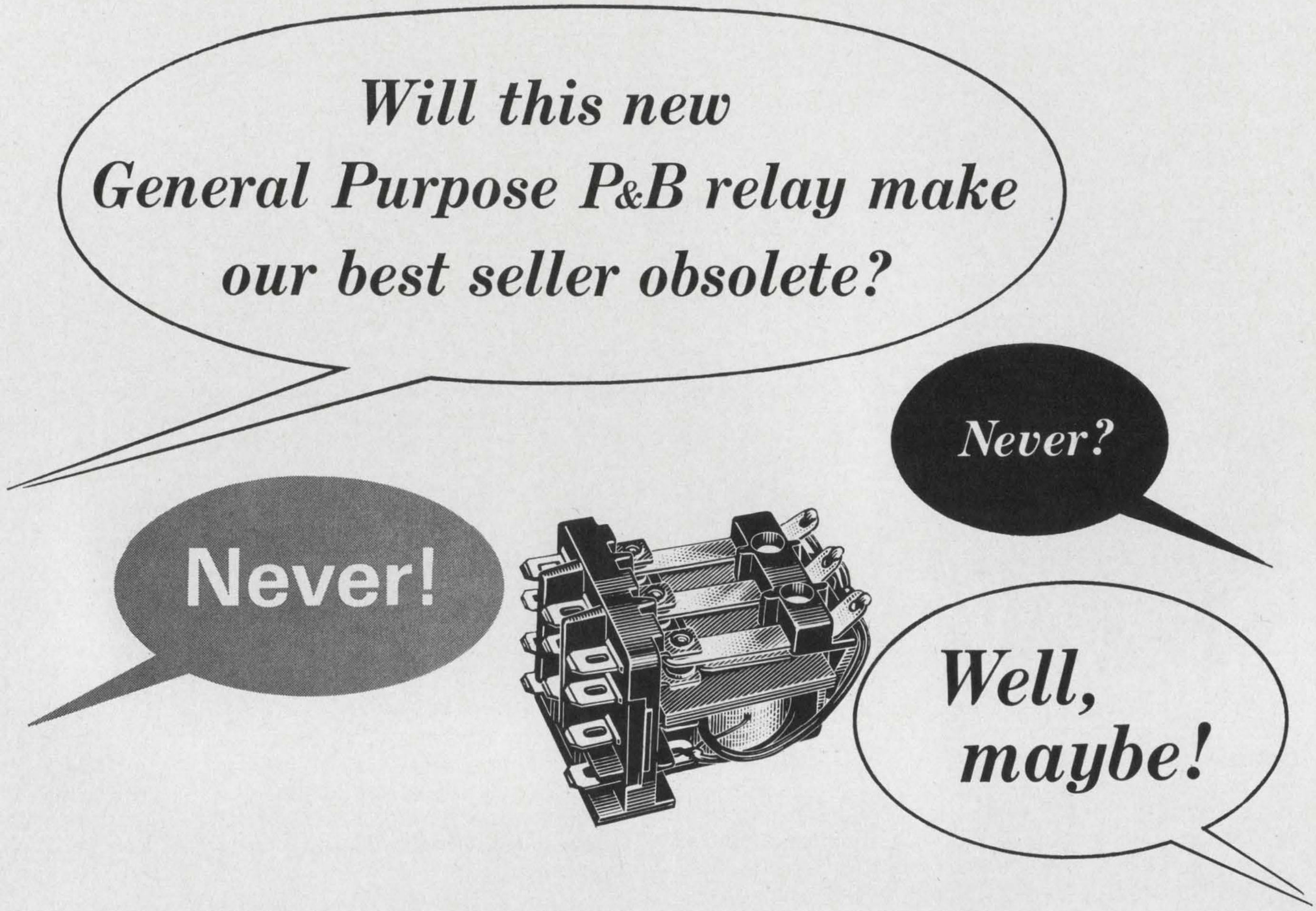
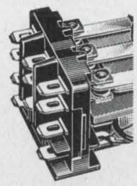


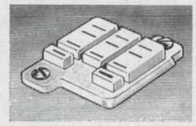
Our new KU relay is quite exceptional. For many relay users, it will be more convenient, more versatile, easier to install and replace . . . and cost substantially less money. Here's why.

MODERN, COST SAVING TERMINALS



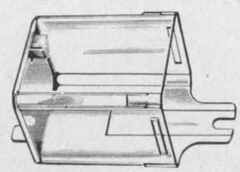
Quick-connect terminals mean faster installation on your production line . . . easier replacement in the field. Standard models have .187″ terminals, but .205″ may be ordered. All terminals are punched for those who prefer solder connections. Barriers molded into the sturdy front meet U/L and CSA requirements.

TRUE 10 AMP NYLON SOCKET



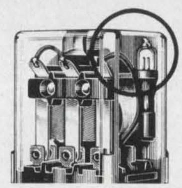
A nylon socket—rated for carrying 10-amperes—can be supplied to make the KU a handy plug-in relay. Covered (KUP) relays, incidentally, cost dramatically less than similar relays having octal-type plugs.

You may specify five- or ten-ampere KU relays. Longer movable arms and a unique method of staking the stationary contacts to the header contribute to the improved reliability and longer life of this new series.



WIDE CHOICE OF FEATURES

Two styles of heat and shock resistant polycarbonate dust covers are available. One, with slotted flanges, provides a quick, convenient method for mounting the relay directly to a chassis. A handy push-button which operates the movable contacts can also be supplied for manually checking circuits. KUP relays are



available with a neon lamp wired in parallel with their coils to indicate that power is reaching the relays.

Longer life, improved reliability, exceptional versatility and, in the case of covered relays, substantially lower costs are all part of the KU Series. Interested? Call your P&B sales representative today, or get in touch with us direct.

KU SERIES SPECIFICATIONS

GENERAL:

Description: 5 or 10 amperes General Purpose Relay.
Expected Life: 10,000,000 cycles, Mech.
Breakdown Voltage: 1,500V rms 60 Hz between all elements; 500V rms 60 Hz between open contacts.

CONTACTS:

Arrangements: Up to 3 Form C.
Rating: 5 or 10 amps @ 28V DC or 115V AC resistive.

COILS:

Voltage: DC to 110V; AC to 230V 60 Hz.
Power: DC 1.2 W; AC 1 and 2 poles 2.0 VA; AC 3 poles 2.7 VA.
Resistance: 16,500 ohms max.

MOUNTING:

(open relay) 6/32″ mtg. stud, 7/32″ locating tab on 7/16″ centers. Socket available.

STANDARD P&B RELAYS ARE AVAILABLE AT LEADING ELECTRONIC PARTS DISTRIBUTORS

POTTER & BRUMFIELD

Division of American Machine & Foundry Company, Princeton, Indiana
Export: AMF International, 261 Madison Avenue, New York, N. Y.

Speed Inquiry to Advertiser via Collect Night Letter
ON READER-SERVICE CARD CIRCLE 4

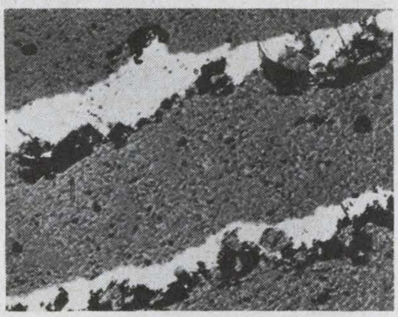
GLAS

New CORNING® GLASS-K Capacitor
gives you 100,000 pf in this case size

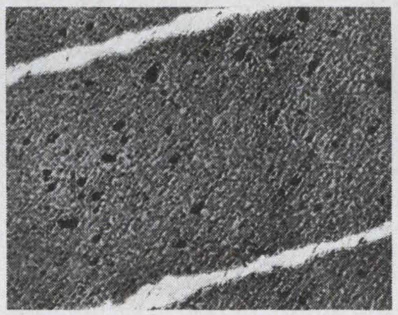
with performance stability and reliability
that no conventional CK-type can match

SS-K

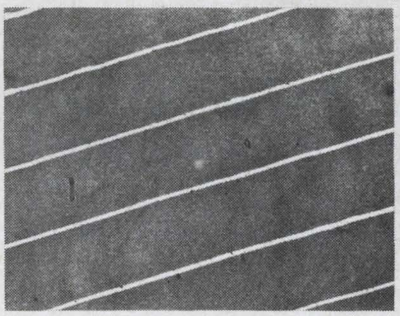
Compare these unretouched photomicrographs of cross-sections of three CK-type capacitors:



Dielectric of a conventional CK ceramic



Dielectric of a second make of conventional CK ceramic



Dielectric of CORNING GLASS-K Capacitor

No holes in the Glass-K dielectric means greater uniformity—so we can make thinner dielectric layers, put more *pf* in a smaller case size.

No holes in the Glass-K dielectric—so naturally the Glass-K gives you more stable performance . . . less change because of environmental fluctuation.

No holes in the Glass-K means uniformity in the dielectric—which means greater performance predictability.

No holes in the Glass-K means greater dielectric density and less chance for failure—so naturally, it gives you more reliability.

That's the reason you get all these good characteristics in the Glass-K:

- ΔC in life as tight as 2%
- IR greater than 10,000 megohms
- D.F. of 2.5% maximum
- *pf* ranges from 1000 to 51,000 in just .250" x .100", from 21,000 to 100,000 in just .250" x .140"

As you can see, now there is a material difference in CK-type capacitors. Yet Glass-K prices are competitive.

Send for complete data today to Corning Glass Works, 3911 Electronics Drive, Raleigh, N.C.

CORNING
ELECTRONICS

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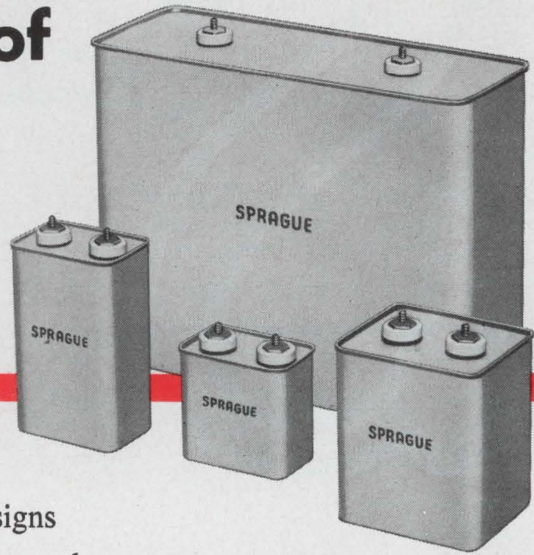
ON READER-SERVICE CARD CIRCLE 6

All from Sprague!

ENERGY-STORAGE CAPACITORS

for every type of discharge application



A pioneer in high voltage capacitors, Sprague has a broader line of designs for energy-storage applications than any other capacitor manufacturer. If your project involves lasers, masers, electronic photoflash, time-control circuits, exploding wire, thermonuclear fusion research, magnetization of permanent magnets, medical equipment, or similar discharge applications, Sprague can provide a capacitor to meet your specific needs.

Light, Moderate, or Heavy Duty Capacitors

Available types range from small, light-weight units for aerospace applications such as satellites, missiles, etc., to heavy-duty capacitors for high-current/high-frequency oscillatory discharges.

Broad Range of Electrical Ratings

Voltages from 2 kilovolts to 24 kilovolts. Energy ratings up to 6700 joules. Self-inductance as low as .0025 microhenry.

Energy-Storage Electrolytic Capacitors

A selected line of cylindrical 'lytics for industrial applications requiring maximum capacitance in minimum space.

Paper, Metallized Paper, and Paper/Film Designs

Metallized capacitors intended for light-weight, space-saving applications . . . one-half the size, one-third the weight of conventional capacitors. Other available designs include castor oil impregnation for extremely long life (assuring a high number of discharges), and non-flammable synthetic askarel impregnation for applications where non-combustibility is a prerequisite.

For complete information or application engineering assistance on Sprague Energy-Storage Capacitors, write to Field Engineering Department, Sprague Electric Company, 347 Marshall St., North Adams, Mass. 01248.

SPRAGUE COMPONENTS

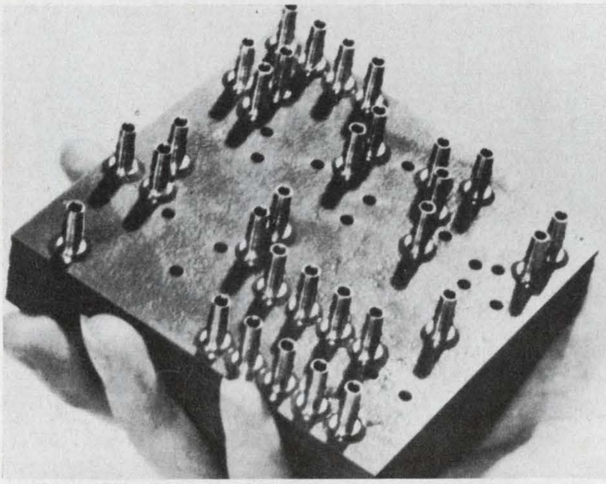
CAPACITORS	PULSE TRANSFORMERS	CERAMIC-BASE PRINTED NETWORKS
TRANSISTORS	INTERFERENCE FILTERS	PACKAGED COMPONENT ASSEMBLIES
RESISTORS	PULSE-FORMING NETWORKS	BOBBIN and TAPE WOUND MAGNETIC CORES
INTEGRATED CIRCUITS	TOROIDAL INDUCTORS	SILICON RECTIFIER GATE CONTROLS
THIN-FILM MICROCIRCUITS	ELECTRIC WAVE FILTERS	FUNCTIONAL DIGITAL CIRCUITS

4SC-5156

SPRAGUE®
THE MARK OF RELIABILITY

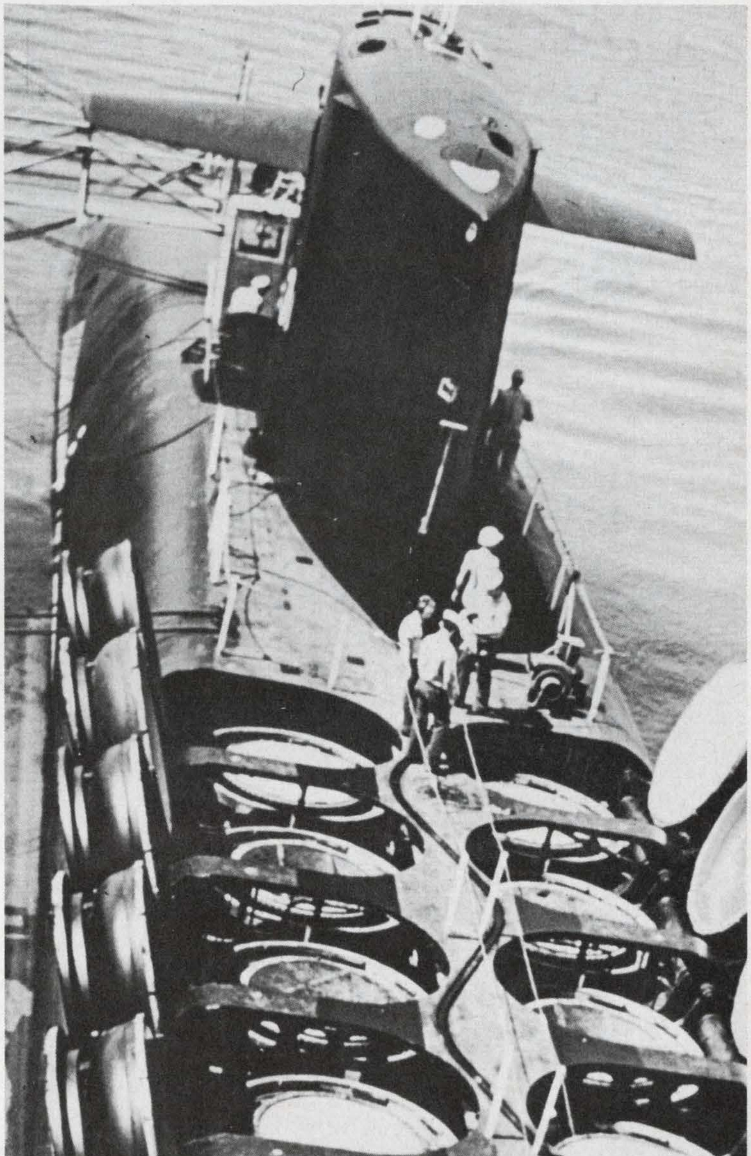
ON READER-SERVICE CARD CIRCLE 7

ED News



The situation is "fluid" . . . 24

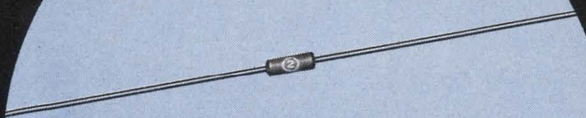
Computer analyzes electrocardiograms . . . 21



New missiles for Polaris subs . . . 26

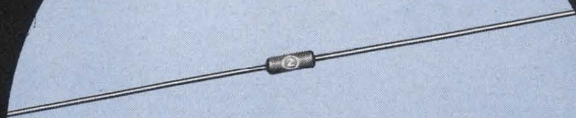
New from Sprague!

This Resistor has 5 Times the Resistance of a Conventional Metal-Film Resistor of Equal Size!



Type	Wattage Rating	Size	Maximum Resistance
Extended-Range Filmistor Resistor	1/10	.095″ D. .250″ L.	1.5 MΩ
Conventional Metal-Film Resistor	1/10	.095″ D. .250″ L.	0.3 MΩ

This Resistor is 21 Times Smaller than a Conventional Metal-Film Resistor with Equal Resistance Value!



Type	Maximum Resistance	Wattage Rating	Size
Extended-Range Filmistor Resistor	1.5 MΩ	1/10	.095″ D. .250″ L.
Conventional Metal-Film Resistor	1.5 MΩ	1/2	.250″ D. .750″ L.

Both Resistors are one and the same...they're Sprague's new EXTENDED-RANGE FILMISTOR® METAL-FILM RESISTORS

Substantial saving of space in all wattage ratings—1/20, 1/10, 1/8, 1/4, 1/2, and 1 watt—with absolutely NO SACRIFICE IN STABILITY!

New manufacturing techniques at Sprague Electric have made possible a major breakthrough in resistance limits for metal-film resistors. Extended-Range Fimistor Resistors now offer, in addition to accuracy . . . stability . . . reliability . . . extended resistance values in size reductions which were previously unobtainable. Size and weight advantages of Filmistor Resistors now make them the ideal selection for applications in high-impedance circuits, field-effect transistor circuits, etc., where space is at a premium. Many designs which previously had to settle for the higher temperature coefficients of carbon-film resistors in order to obtain required resistance values can now utilize the low and controlled temperature coefficients of Filmistor Metal-Film Resistors.

Other key features are ±1% standard resistance tolerance, low inherent noise level, negligible voltage coefficient of resistance, and tough molded case for protection against mechanical damage and humidity.

For complete technical data, write for Engineering Bulletin 7025C to Technical Literature Service, Sprague Electric Company, 347 Marshall Street, North Adams, Massachusetts 01248.

SPRAGUE COMPONENTS

RESISTORS
CAPACITORS
TRANSISTORS
THIN-FILM MICROCIRCUITS
INTEGRATED MICROCIRCUITS
PULSE TRANSFORMERS
INTERFERENCE FILTERS
PULSE-FORMING NETWORKS
TOROIDAL INDUCTORS
ELECTRIC WAVE FILTERS
CERAMIC-BASE PRINTED NETWORKS
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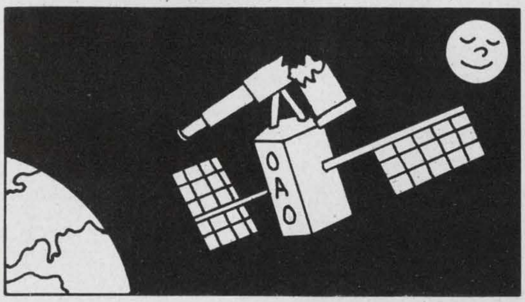
ON READER-SERVICE CARD CIRCLE 8

Galileo had setbacks too.



News Report

Astronomers disappointed by space fizzle

Many in scientific circles still have long faces over the disappointing power failure in the first Orbiting Astronomical Observatory (OAO-1). The heaviest and electronically most complex of our unmanned space vehicles, the OAO-1 was expected to provide astronomers with their first prolonged look at the universe from an extraterrestrial vantage point.

After several delays on the launch pad the OAO was finally orbited successfully, and astronomers put down their telescopes and waited in anticipation. But soon the battery portion of the power system began to falter, and eventually the $50 million satellite went silent. As one scientist put it, "it's like giving a child a toy and then not letting him play with it."

OAO-1 was the first of four such orbiting observatories to be launched by NASA. Astronomers will now have to wait for number two. No date, however, will be set for the second OAO until NASA is satisfied that it has pinpointed the cause of the malfunction in the OAO-1.

Gas industry looks to fuel cells

While the electric utility industry trumpets the desirability of "all-electric living," the gas industry is quietly investigating its own version of one-utility service. But in this case the one utility is gas.

The trump card that the gas industry eventually hopes to play is the air-and-natural-gas fuel cell. Similar in operation to the hydrogen-oxygen fuel cells used in manned space satellites, these cells use air and natural gas for fuel. This would eliminate the cost and handling problems of pure hydrogen and oxygen.

What is reported to be the largest air-and-natural-gas fuel cell built to date has recently been operated successfully by Pratt & Whitney Aircraft. The 4000-watt unit was developed for Columbia Gas Systems, Inc., and will be used by the company in its fuel-cell R&D program. Initially, tests are to be conducted with the cell powering a 1-ton window air conditioner, a 3-ton gas-fired central air conditioner and a central gas-fired furnace. Later the equipment will be moved into the home of a Columbia employee for further tests.

New date for TV picture-tube regulation

The Federal Trade Commission has extended the effective date of its regulation covering acceptable ways of specifying TV picture-tube sizes (ED 6, March 15, 1966, p. 13). The regulation will now become effective January 1, 1967, instead of July 1, 1966, as originally set. According to the FTC, the extension has been allowed because of the financial burdens that TV manufacturers would encounter in order to meet the original date.

The FTC has also stated that it will not object to manufacturers' rounding off the new size designations to the nearest inch, since it believes this will not adversely affect the public interest. Still up in the air is the question of which of the allowable methods for specifying picture size the TV industry will eventually adopt. Most manufacturers are still studying the question on a which-way-do-I-lose-the-least basis. Best guess is that the picture diagonal—measured on a flat plane—will be selected by most, even though this will cut one or two inches from the majority of familiar tubes.

Computers help produce star catalog

By using advanced computer techniques, workers at the Smithsonian Astrophysical Observatory have expanded what was originally planned as an aid to satellite tracking into the most comprehensive star catalog ever published. The 250,000 stars listed in the new catalog were scattered through more than 50 separate catalogs and atlases, many of which employed different formats and reference systems. Computers were first used to correlate the diverse data, and then to update the star information and positions. The updating was necessary because all stars have an actual motion in space with respect to Earth. Although this motion is exceedingly small, it must nevertheless be taken into account if the data are to be usable for satellite tracking. (over)

News Report CONTINUED

The final data were enough to fill 2600 pages. To solve the problem of reproducing this material without errors, a Stromberg Carlson 4020 computer was used to set the type electronically. Twelve magnetic tapes, each containing star data for a particular section of the sky and instructions on how to display the data, were prepared and fed into the computer.

The 4020 computer contains a character matrix and a cathode-ray tube. A light beam scans the matrix, which contains the images of numerical and alphabetical characters. According to the magnetic-tape instructions, the light beam picks the appropriate letter or number image and displays it in its proper place on the face of the cathode-ray tube. In this way, an entire page of data is almost instantly displayed on the tube. A camera inside the computer enlarges the display to actual-page size and records it as a positive film image. The processing of each page takes one and one-half seconds.

Photographs produced by the computer are used to make plates which are then used for printing. The system thus transfers data from magnetic tape to printed page entirely free of any introduced human error.

Japanese receiving tubes on the way out?

Last year 43 million Japanese receiving tubes were imported into the U.S. But if a U.S. Customs Court decision is upheld, the Japanese tubes may be priced right out of the American market.

In a pilot case the Customs Court has ruled that the import duty on such tubes be based on the Japanese distributors' price, rather than on the factory price as in the past. The result would be to double or treble the import duty, and this would all but eliminate the Japanese tubes' price advantage over U.S. tubes.

26,000 Mil. Specs. going on film

Everyone involved in defense work has at one time or another wrestled with the problem of finding, filing and updating Military Specifications. But the problem of the average company is minuscule when compared with that of the Johnson Research Co. of Farmingdale, N. Y. Part of Johnson's business is to provide subscribing firms with updated lists of Mil. Specs. This necessitates Johnson's filing and constantly handling the entire array of over 26,000 Mil. Specs.

As the storage problem threatens to get out of hand at any moment, Johnson has arranged to have the entire file microfilmed by the Thomas Publishing Co. The specs. will be put on microfiche, which are 4- x 6-inch translucent, plastic cards. As many as 72 full-size pages can be placed on each card, so the file will be reduced to fit into a shoe box. At present they take up a whole bookcase 18 feet long and 8 feet high.

Holography claims are exaggerated

Home color movies and television with holography? These are irresponsible claims, protests Dr. Dennis Gabor of the University of London, who is known as the father of holography.

According to Dr. Gabor, "those who talk about a billion-dollar industry within a short time are misleading the public and the investors. First of all, a laser beam is needed. Having a laser in a home is out of the question. Secondly, the bandwidth requirements far exceed our capabilities today—by about 30×30^3. Last, but not least, a transparency that works in real time is essential, and we simply do not have such a device." It is not likely that these problems will be solved by the next year, muses Dr. Gabor.

FETs and integrated circuits have been added to Motorola Semiconductor's HEP program of consumer-oriented electronics for the hobbyist, experimenter and professional. According to a company spokesman, Motorola is the first semiconductor manufacturer to include these relatively sophisticated devices in a program directed at the consumer market.

The most massive nuclear particle yet found has been uncovered by the 13.5-Bev Synchrotron at the Argonne National Laboratory. The new particle, known as N-3245, is about three and one-half times as massive as the proton. It has a lifetime somewhat longer than 10^{-22} seconds, which is more than that of any of its family of nuclear particles.

Congressman Weston E. Vivian (D-Mich.) will be the keynote speaker at the American University's Institute on Systems Science to be held in Wash., D. C., May 9 through 12. Congressman Vivian is the only engineering PHD in the 89th Congress.

An Allen-Bradley announcement of importance to motor designers

The new MO6-C ferrite magnet having 30% higher intrinsic coercive force

■ The new Allen-Bradley MO6-C ceramic permanent magnets provide at least 30% increase in the highest previously available intrinsic coercive force—obtainable with A-B's MO5-C material. This advance is achieved with the same high residual flux density.

Designers of permanent magnet motors have a choice of these advantages—30% higher resistance to demagnetization, or 30% increase in motor output, or 30% increase in cold temperature protection. In fact, where the higher coercive force is not required, the designer can give himself a 30% reduction in magnet size.

This new Allen-Bradley MO6-C material opens the door to such motor designs where permanent magnets heretofore were not practical, namely for motors used in many portable tools and appliances. Like with the MO5-C material, these new MO6-C magnets are radially oriented, and are available in virtually all sizes and shapes currently being produced in segments for motors from ¾″ diameter to 10 hp. While MO5-C magnets will continue to satisfy most needs, MO6-C enables designers to satisfy more exacting motor design requirements because of its unusually high intrinsic coercive force.

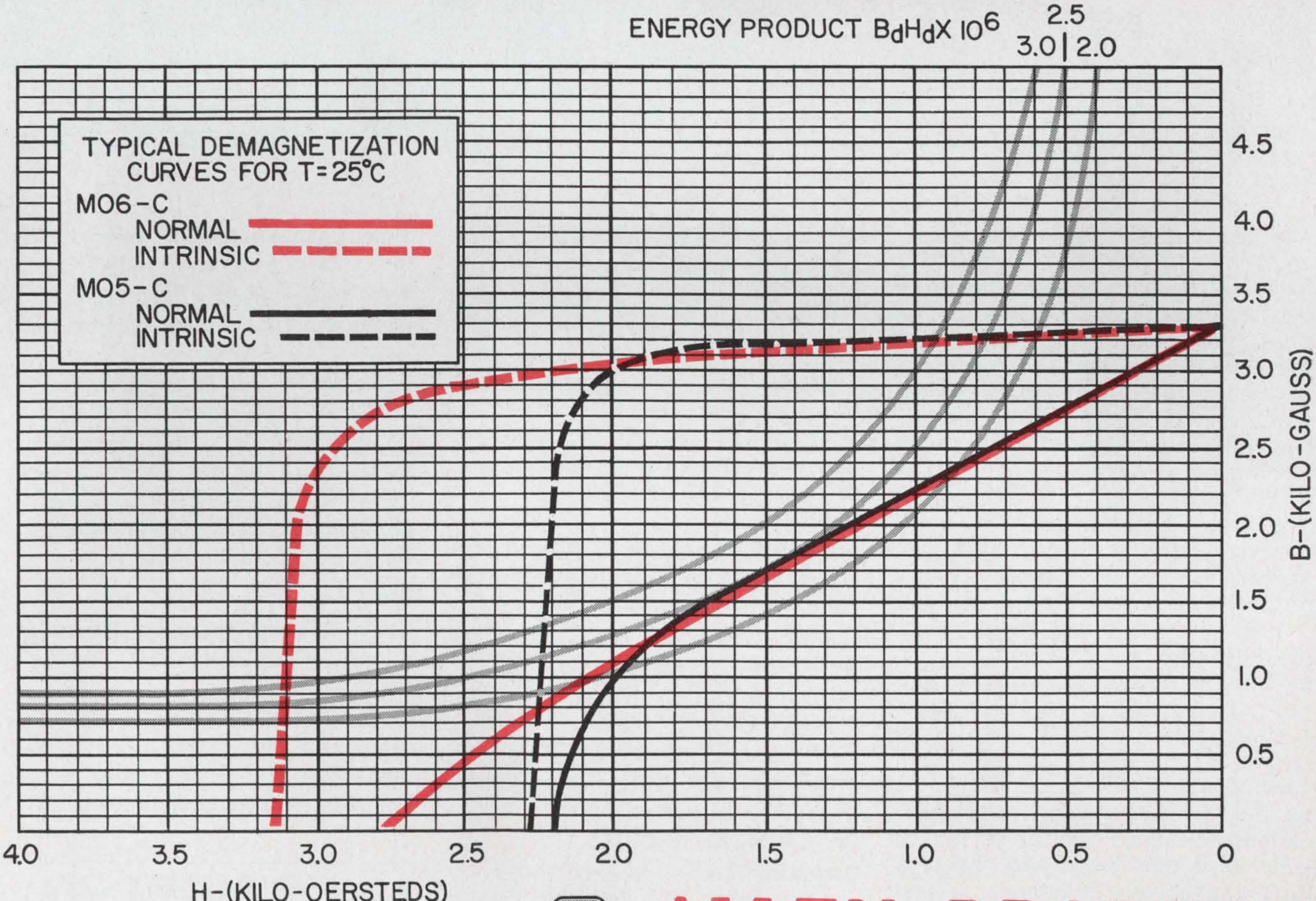
Allen-Bradley application engineers will be pleased to help you obtain maximum economy in your motor design through optimizing magnet performance. Please let us hear from you. Allen-Bradley Co., 1344 S. Second Street, Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

TYPE MO6-C CERAMIC PERMANENT MAGNETS

Typical Characteristics

–stated values have been determined at 25°C.

Property	Unit	Nominal Value
Residual Induction (B_r)	Gauss	3300
Coercive Force (H_c)	Oersteds	2800
Intrinsic Coercive Force (H_{ci})	Oersteds	3100
Peak Energy Product (B_dH_d max)	Gauss-Oersteds	2.5×10^6
Reversible Permeability	—	1.09
Curie Temperature	+°C	450
Temperature Coefficient of Flux Density at B_r	%/°C	–0.20
Specific Gravity	—	4.9
Weight per Cu. In.	Lbs.	0.177



ALLEN-BRADLEY

QUALITY MOTOR CONTROL

QUALITY ELECTRONIC COMPONENTS

366-3B

ON READER-SERVICE CARD CIRCLE 9

Weather satellites go operational

Meteorologists learn much from ESSA II weather satellite, but aerospace electronics has benefited too.

Neil Sclater
Technical Editor

The launching of the ESSA II weather satellite on Feb. 28, 1966, has ushered in a new era in worldwide weather forecasting. Apart from its meteorological implications, ESSA II also represents a giant step forward in aerospace electronic systems and their design. Each passing week of successful operation makes these contributions more apparent. Two of the most noteworthy are:

- An evaluation of the effectiveness of "cross-strapping," which is a technique involving multi-component redundancy within systems.
- An example of how the application of "design margin" principles can result in high operational reliability.

Cross-strapping is incorporated

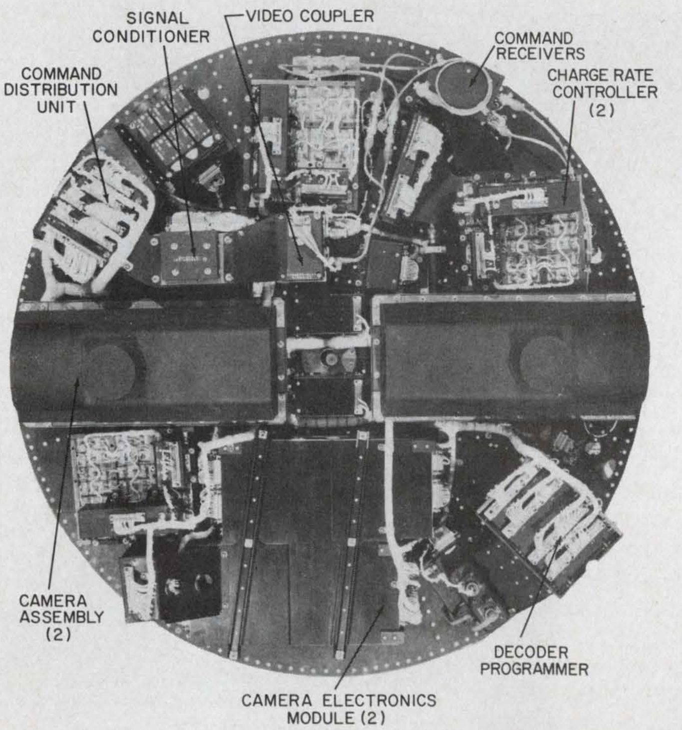
Experience with earlier unmanned space systems indicated the need for the cross-strapping, or multiple redundancy, of subsystems which could be controlled from the ground. Without cross-strapping, loss of a single subsystem can cause loss of the entire system, even though all its other components are operating satisfactorily. But with cross-strapping, any component of one system can be interchanged with the same component of the redundant system.

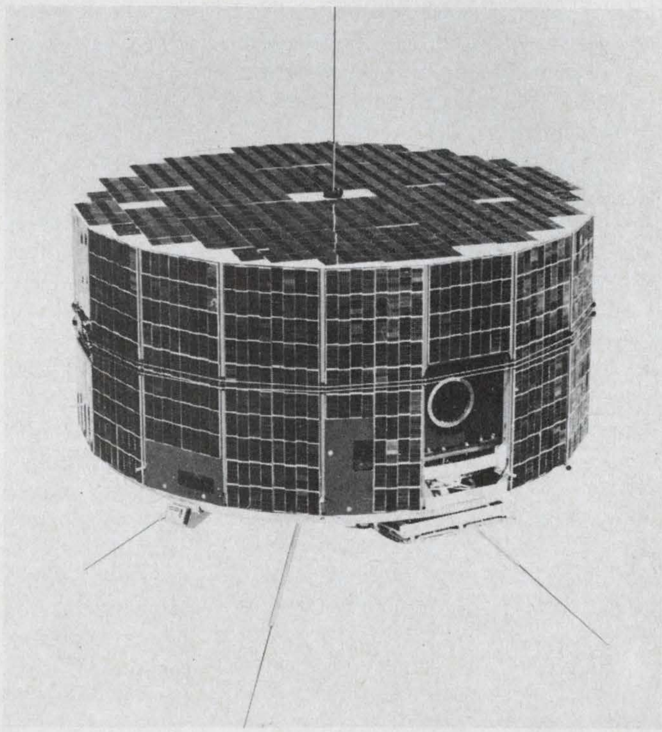
In the ESSA II, cross-strapping is used between two complete onboard camera systems. This component-sharing between the two systems is controlled by ground stations, which receive continuous telemetry signals from the satellite indicating the operational condition of the system components. Should a component fail in the "on" system, a signal is sent to the satellite causing the redundant component to be switched into use. A combination of relay and solid-state circuitry controls the actual switching operation in the satellite.

Design margin proves effective

In an unmanned satellite as complex as ESSA II, mere redundancy of sub-systems is insufficient to secure the required reliability. Solar cells, transistors and other items within subsystem circuitry must also be made redundant to some extent. The problem, though, is how to arrive at an optimum level of redundancy without encumbering the satellite with excessive weight.

The designers of ESSA II applied the techniques of design margin to this problem. They gathered extensive statistical, experimental and operational data on part and component failure, and then based their design for part redundancy on an analysis of this data. What made their design margin analysis particularly meaningful was the actual flight data which had been gained from previous TIROS satellites. Thanks to TIROS IX, this was





ESSA II is the latest of the TIROS-class weather satellites. Its two cameras are mounted 180 degrees apart on the outer rim. Electronic circuitry is arranged around the baseplate (shown at left). Numbers in parenthesis indicate redundancy.

(**ESSA,** *continued*)

especially true in the area of radiation effects.

TIROS IX's improper orbit

TIROS IX was something of a mishap in the weather satellite program, but from an engineering standpoint it was a happy accident. When it was launched, TIROS IX was hurled into an improper orbit by a defective final booster. Although not designed to withstand the damaging effects of space radiation, its improper orbit took TIROS IX well into the Van Allen radiation belt. This inadvertent "worst case" provided engineers with the first tangible evidence of the effects of long-term deterioration on an "unhardened" space vehicle.

The radiation intensity to which TIROS IX was subjected was 50 to 75 times greater than had been planned. Damage to the solar cells exposed directly to the radiation has been extensive, but ample reserve cells still operate the electronics and keep the batteries charged.

Because of TIROS IX, engineers knew where to begin when the time came to build ESSA II, which was to operate within the Van Allen belt. Extensive experimental irradiation programs had been carried out on the ground, but now essential design margin information was available to substantiate findings.

According to TIROS-ESSA project manager Abraham Schanpf of RCA Astro-Electronics Div., Hightstown, N. J., the configuration of the TIROS/ESSA satellites is far from perfect from a radiation standpoint. The ideal would be a spherical shape. Nevertheless, the aluminum shielding (about 1/8 inch thick) over critical electronic packages and the use of heavy equipment as "shadowing" mass has proven successful. The fact that 425 integrated circuits are now working effectively on ESSA II attests to the efficiency of anti-radiation precautions and component layout. Although ESSA II is the first weather satellite to use integrated circuits, later satellites will use them more extensively.

Global system now operational

Now that ESSA II has been put successfully in orbit, the TIROS Operational Satellite (TOS) system is fully functional. Financed by the Environmental Science Services Administration (ESSA) of the U.S. Department of Agriculture, the system aims to provide complete, uninterrupted photocoverage of the Earth's cloud cover on a daily basis.

The TOS system consists of ESSA I, launched Feb. 3, 1966, and ESSA II. Each of these operational satellites plays a separate but complementary role in the over-all system.

ESSA I takes pictures of cloud cover over the entire Earth and stores them for read-out by Command and Data Acquisition Stations near Fairbanks, Alas., and Wallops Island, Va. These pictures are retransmitted to the Environmental Satellite Center at Suitland, Md., where they are processed to provide world-wide cloud-cover maps. When combined with other collected meteorological data, these global maps are extremely useful for long-range weather forecasting.

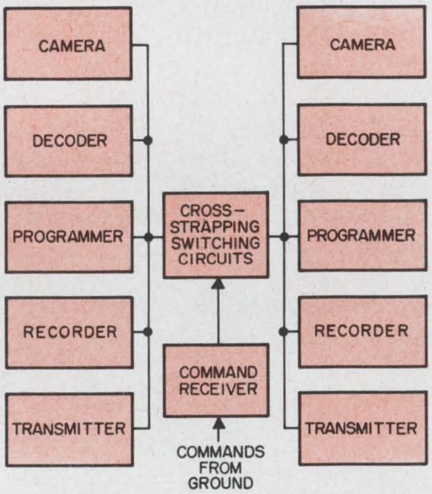
ESSA II also takes pictures of cloud cover over the entire Earth. However, its basic purpose is to provide short-range weather forecasting data on a local or regional basis. It does this by doing away with ESSA I's storage feature and transmitting the pictures back to Earth almost immediately after they are taken. This allows any relatively modest receiving station to receive the pictures and use them for local forecasting. Real-time transmission is accomplished by retention of the picture on a photosensitive layer on the face of the camera vidicon tube during the transmission period, which lasts about 200 seconds.

The future of the TOS system requires that two satellites be operational at all times. One, like ESSA I, will be for long-range forecasting, and will transmit its stored pictures only when requested by certain, suitably equipped ground stations. The second will be for local forecasting and will transmit its pictures at once like ESSA II. Eight substitute ESSA satellites are now "waiting on the bench." One of these, TOS/AVCD, incorporates the "request" feature and will be launched when pictures from ESSA I fall below acceptable quality. It will be dubbed ESSA III only when it is launched successfully.

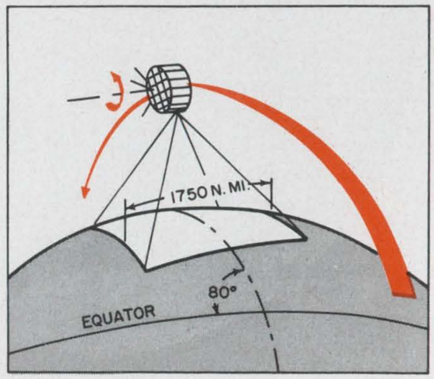
Wheel configuration is used

The present operational TOS system was preceded by nine research and development spacecraft, designated TIROS I through IX. TIROS I through VIII had their cameras mounted in the base of their drum-shaped configuration, and were spin-stabilized in orbits inclined either 48 or 59 degrees to the equator. TIROS IX as well as ESSA I and II have the same shape, but orbit the Earth in a cartwheel configuration. Effectively this means that they roll along in orbit on their sides, much like wheels.

The two cameras on ESSA I and II and TIROS IX are mounted 180 degrees apart on the outer rim of the satellite. As the satellite rolls along in its oribit, each camera



Cross-strapping, under control of ground commands, is used in ESSA II. This allows components to be switched between redundant systems. During normal operation components of the camera systems are regularly switched to balance their use.



ESSA II's orbital altitude of 750 nautical miles results in each TV picture covering an area approximately 1750 miles square.

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(**ESSA,** *continued*)

points toward the Earth in turn. Horizon-sensing equipment in the satellite controls the cameras so that each takes pictures only when it faces the Earth.

ESSA I and II are in near-polar, circular orbits. Their combinations of altitude and orbital inclination make their orbits sun-synchronous.

Technical summary of ESSA II

Spacecraft	Cylindrical, 18-sided polygon, 22 inches high and 42 inches in diameter, weighing 290 pounds.
Mission Objectives	Add automatic picture transmission capability to the TIROS operational satellite system. Provide daily coverage of local weather systems for weather stations around the world equipped with APT receivers.
Launch Vehicle	Three-stage, thrust-augmented improved Delta.
Orbital Elements: Inclination	Near-polar and sun-synchronous; 78.6 degrees retrograde to the Equator.
Period	113.5 minutes.
Orbit	Circular, approximately 865 statute (750 nautical) miles high.
Velocity	Approximately 16,300 miles per hour.
Cameras	Two 1-inch automatic picture transmission vidicons which take more than 140 two-thousand-statute-mile-square pictures daily with a resolution of about two miles at picture center.
Power System	9,100 solar cells which convert sun energy to electrical energy to keep 63 nickel-cadmium batteries charged.
Tracking	Fifteen stations of the worldwide space tracking and data acquisition network (STADAN) operated by the Goddard Space Flight Center.

(*continued on p 28*)

Medical electronics fights heart disease

New techniques coming out of the medical-electronic laboratory promise to reduce heart fatalities.

Frank Egan
News Editor

Three new diagnostic aids developed by medical-electronic researchers have joined the fight against the nation's No. 1 killer—heart disease.

The aids are designed to reveal heart abnormalities early, while there is still hope for surgical and other assistance. Medical men say that early detection might have reduced significantly last year's 700,000 American heart fatalities.

The new electronic aids make different approaches to diagnosis. One detects just one of the specific conditions that can lead to heart failure—pericardial effusion. The second can pinpoint a variety of abnormal conditions. And the third employs a computer to analyze electrocardiograms.

Ultrasonics spots fluid

The pericardial effusion detector uses an ultrasonic technique developed at the University of Rochester School of Medicine and Dentistry, N. Y. Pericardial effusion is evidenced by the presence of fluid around the heart.

Previously, the most reliable means of tracing it were either to puncture the membrane around the heart or to circulate through the blood stream some material opaque to X-rays which would make the heart show up in a radiograph. Both these procedures take considerable time and trouble.

The new technique requires only that an ultrasonic transducer be placed against the patient's chest. Some of the sound waves generated are reflected back to the transducer by structures inside the patient's body. Fluid around the heart has a different density from that of the surrounding tissue, and this affects the intensity of the echo returned to the transducer.

An oscilloscope is used to display the returned signal. It produces one pattern for a patient with a healthy heart and a completely different pattern if there is pericardial effusion.

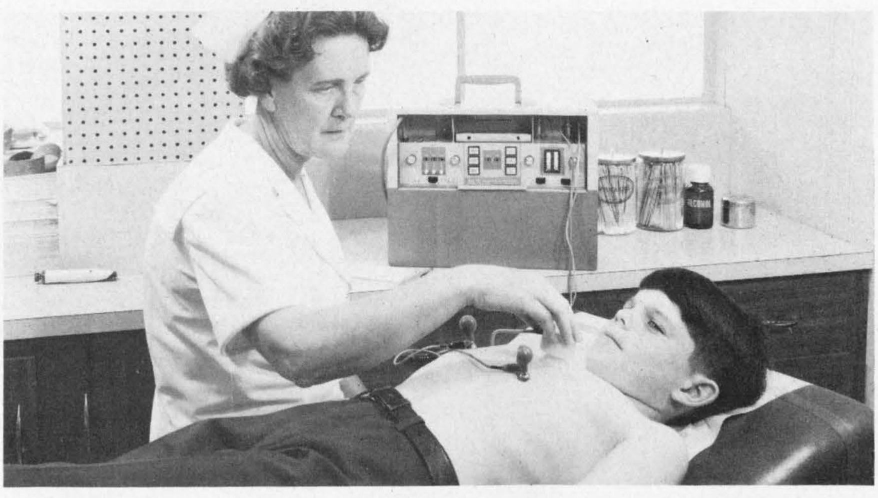
The ultrasonic technique was developed by Dr. Arthur J. Moss, assistant professor of medicine, and Fred Bruhn, a fourth-year medical student.

Instrument hears defects

The new instrument for detecting a variety of heart abnormalities is the PhonoCardioScan, now being marketed by Beckman Instruments, Inc. Developed by the Humetrics Division of Thiokol Chemical Corp. for rapid detection of abnormal heart sounds, the PhonoCardioScan is an electronic instrument about the size of an attache case. It comes with two electrodes and a microphone, which are attached to the patient. The sound of the patient's heart beat is converted into an electrical signal which is then compared in the device with an electrical analog of a normal heart's sound. The result of this comparison is presented visually in digital form.

The digital output of the PhonoCardioScan indicates whether the heart under examination is normal, or whether its beat indicates irregularities. A significant feature of the unit is that the examiner does not have to interpret the test results. He merely records the digital output on cards that are supplied with the unit, and then sends them elsewhere for medical interpretation. This, together with the fact that it requires only two to three minutes for an examination, make the PhonoCardioScan ideal for use as a mass screening aid.

The instrument is currently being tested on 10,000 Chicago school children in a program sponsored jointly by the U.S. Public Health Service, the Illinois Department of Public Health and the Chi-



PhonoCardioScan listens to the heart through an electrical network that distinguishes between normal and abnormal sounds.

Electrocardiograms are recorded and then analyzed by an IBM computer.

(**medical,** *continued*)

cago Heart Association.

Computer analysis on trial

That old stand-by for detecting heart abnormalities—the electrocardiogram—is used in conjunction with a computer in a development recently announced by IBM. The computer is used to analyze electrocardiograms rapidly and with an accuracy that compares favorably with that of the best electrocardiographers. According to Dr. Jacob I. Hirsch of the New York University School of Medicine, this technique "will certainly excel where large volumes of electrocardiograms tax the endurance of the human interpreter." The experimental system has been used on more than 300 patients at Mt. Sinai Hospital in N. Y.

Electrocardiogram signals from a patient are registered on a strip-chart recorder and on a magnetic tape unit, both contained in a special console that can be wheeled to the patient's bed. The strip-chart recorder provides a visual display for immediate interpretation by a physician, if desired. The record on magnetic tape is for transmission to the computer.

To transmit the magnetic-tape data to the computer, a technician places the patient's telephone receiver in a cradle on the console and dials the computer center. He then presses the record button on the console to start transmission.

At the computer center the data is processed by an IBM 1401 data-processing system and a special analog-to-digital converter. The converter includes pre-processing circuits that search out points of interest in the electrocardiogram waveform and convert only these into digital form for processing.

According to Dr. R. E. Bonner of IBM's Advanced Systems Development Div., pre-processing simplifies analysis by reducing the data handled by a factor of 10.

Besides printing out its analysis for the physician, the computer records 200 measurements per patient in its disk storage unit along with the patient's identification. If another ECG comes in later for the same patient, the computer searches its file and compares the two waveforms for differences. ■ ■

Microwave race for power slackening

The race to push up the continuous-wave microwave power limit is "probably drawing to a close", according to the vice-president of research of Varian Associates, Palo Alto, Calif.

The researcher, Dr. Theodore Moreno, told a technical seminar at the recent New York IEEE Convention that in the last 15 years power advances had occurred at the rate of about 2 dB a year. Future advances, he said, would undoubtedly occur at a greatly reduced rate. The high cost of increasing power, he explained during a summary of significant developments in high-power linear-beam tubes, is not justified in view of current and expected microwave power needs. Dr. Moreno indicated, however, that significant advances could still be expected in tube quality.

Peak reached last year

The peak in cw power development, according to Dr. Moreno, was the generation last year of more than 500 kW at X-band (roughly 8 GHz). This feat was performed by a group at Eitel-McCullough, a subsidiary of Varian, with a hybrid tube known as an extended interaction klystron—a cross between a klystron and a traveling-wave tube which combines the best characteristics of both.

Dr. Moreno acknowledged that it was technically feasible to go on increasing power output. But even radio astronomy research, which now has the highest demands for microwave cw power, will demand only several hundred kilowatts of power—well within the limits of existing technology.

There have been many important milestones in the power race in recent years, and some have resulted in important improvements in quality. The 20-kW klystrons of five years ago, Dr. Moreno stated, have vastly improved. Late versions include five motor-tuned cavities which are normally stagger-tuned to achieve stability and far wider bandwidth than had been previously obtained. Electronic bandwidth increased by a factor of nearly three. At the 1-dB level 30 MHz

(**power race,** *continued*)

bandwidth was obtained with an efficiency of about 35%, he reported.

Its wider-electronic bandwidth gives the traveling-wave tube certain advantages over the klystron, Dr. Moreno said. While the klystron's bandwidth is sufficient for most satellite applications, it has to be mechanically retuned to change transmitter channels. The modern TWT, on the other hand, can be switched without this retuning. But the inherent efficiency of the TWT is generally less than that of the klystron, the researcher said, noting that figures of 25% are typical. Even after such considerations as intermodulation distortion, am-to-pm conversion ratios and noise figures, neither type ever has a clear-cut advantage over the other.

Hybrid developed

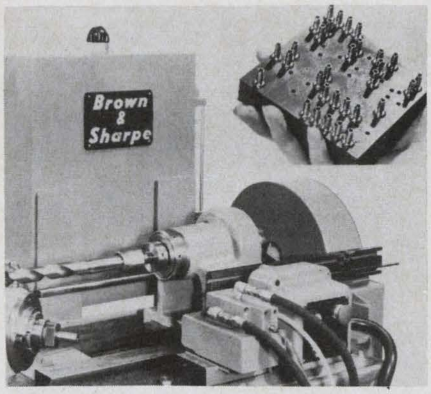
Designers are discovering, Dr. Moreno said, that the advantages of both tubes can be combined. The extended interaction klystron, the present power record-holder, is just such a compromise. A high-powered device, it employs a disc-loaded waveguide as a slow-wave interaction circuit in place of the more conventional klystron TE entrant cavities. Double-slot coupling exists between adjacent structures. The hybrid tube produces power at an efficiency of 35% with a gain of 41 dB.

The hybridization of klystrons and TWTs, Dr. Moreno added, has led to development of a high-performance amplifier suitable for advanced radar systems. ■ ■

Fluids control milling machines

Fluid devices have replaced standard electrical control units on 16-twist-drill milling machines operated by the Brown & Sharpe Manufacturing Co. The machines are being rebuilt for the firm's twist-drill-manufacturing plant in Detroit.

Relay controls and solenoid-operated valves previously controlled a program of speeds and directions of bar stock into each machine's cut-



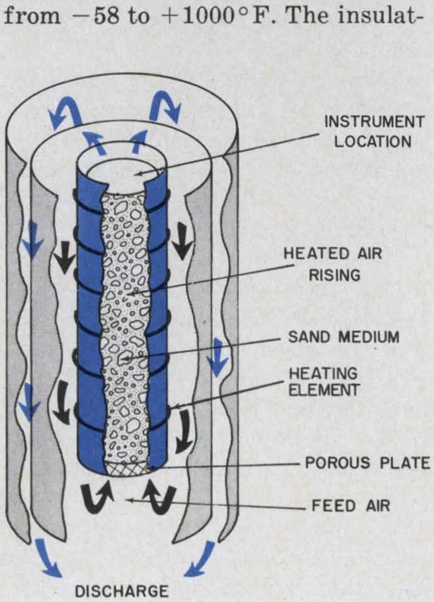
Fluid control unit (shown in insert) controls program of twist-drill milling machine.

ting head. The program is now controlled more reliably, according to the company, by pneumatic-piloted valves and fluidic circuits integrated in monolithic packages by the Fluidic Products Department of Corning Glass Works. ■ ■

Devices bury their heads in sand

A column of sand acts like a liquid in a unique temperature-calibration system. Instruments and devices under test are imbedded in a heat-controlled sand medium for calibration, or heat-reaction testing. The sand, referred to as a "fluidized bed," takes on the properties of the liquids or salts used in more conventional calorimetry systems.

The designers, Procedyne Corp., New Brunswick, N. J., report the system can record temperatures from −58 to +1000°F. The insulat-



Heat controlled sand medium is used for temperature calibration.

(**sand,** *continued*)

ing qualities of the sand permit the use of exposed test leads. In addition the personnel hazards caused by the use of boiling or flammable liquids or corrosive salts are eliminated.

The heart of the system is the calibration cell (see simplified diagram). Essentially a heat exchanger, the cell is made up of annular chambers for air circulation and a coaxially mounted sand column.

Preheated air is directed into the annulus containing the heating element. After it is bubbled up through the medium, the air is removed by way of one of the outer jackets.

New incoming air is preheated while the discharge air is cooled. This exchange action explains the cell's isothermal characteristic; very low sustaining heat is required and practically no temperature gradients exist across the cell.

A closed-loop arrangement including a thermocouple, temperature indicator and proportional band controller regulates the heating element. Accuracy greater than 1/2% of full scale is claimed. ■ ■

Navy developing Poseidon missile

The guidance package for the new Poseidon missile will be designed, developed and produced for the Navy's Special Projects Office by the same industry-university team that supplies the guidance for the Polaris missile system. Responsible for designing the new system will be the Instrumentation Laboratory of M.I.T. Both General Electric Co. and Raytheon Co. will provide industrial support.

Although the Poseidon guidance system reportedly will be more than twice as accurate as that of the most advanced Polaris (the A-3), it will be only slightly larger in size and weight. This will be accomplished by the use of integrated circuits and high-density packaging techniques.

Poseidon was originally announced by President Johnson in his January 1965 defense message to Congress. When deployed on U.S. missile-carrying submarines, the President said, Poseidon's increased

(**Poseidon,** *continued*)

accuracy and striking power "will permit its use effectively against a broader range of possible targets and give added insurance of penetration of enemy defenses." ■ ■

Nuclear submarines that now carry the Polaris A-3 missile will accommodate the Poseidon after modification of their missile tubes.

(*continued from p 20*)

This means that the orbital plane revolves about the Earth's polar axis at the same velocity as that at which the Earth rotates about the Sun. The primary advantage of such an orbit is that solar illumination on the portions of the Earth directly beneath the satellite remains essentially constant on each orbit. This ensures that each TV picture has essentially the same scene-brightness.

When the satellites are on the night side of the Earth their cameras are automatically shut down. On the day side of the Earth they each take a sufficient number of pictures per orbit to cover the entire Earth with some overlap. ESSA I can store over 48 pictures on its tape recorders for later transmission upon command. Stations receiving ESSA II can acquire two or three pictures per orbit on each of one to three orbits. The nearer a station is to the poles, the more frequently the satellite is in range. ■ ■

New tools for criminology

Washington Report

S. DAVID PURSGLOVE,
WASHNGTION EDITOR

Electronics helps in crime control

The Justice Department once again is the latest Federal agency to offer new marketing opportunities to the electronic industry. The Department is holding $7 million to be granted to cities this year for R&D aimed at improving law enforcement. It will be used mainly for development and evaluation of computer files of criminals' habits and physical appearances, closed-circuit-TV police line-ups, and data transmission including high-speed systems for circulating particulars of stolen property.

The grants will be made only to those cities which are developing systems that will key in with those of most other cities in the nation. Systems tailored to meet the specific needs of one city alone will not qualify for assistance, according to Courtney Evans, head of the Department's Office of Law Enforcement Assistance.

Recently it was revealed that the Department's Federal Bureau of Investigation is seeking 35 electronic firms' help in developing ways to transmit fingerprint information over the national crime data computer network that is presently being set up (ED 8, Apr. 12, 1966, p. 32). The FBI is now deciding on which large population area to run a mass test of its new computer system in. The system will contain arrest records filed for a number of years by some 13,000 agencies. The region to be selected will have to have a most comprehensive range of criminal activity, for the test must bring out every conceivable problem that may be encountered in operating a nationwide crime computer system.

Navy readies for future H-bomb losses

The "Missing H-bomb of Palomares" has apparently taught the Navy a lesson. It will be better prepared the next time—and officials see no reason why there may not be a next time.

The Navy is understood to have turned for help to a private operations research firm, which is said to be looking at H-bomb-recovery problems and the associated problem of radioactive-waste disposal.

Hopefully, says a Navy official, the company will come up with practical suggestions on the shape of an organization to cope with recovery, the types of temporary buildings needed in a recovery area and the requirements for instruments, equipment and supplies.

Electronics remains the key to the oceans

Electronics is the key to profitable utilization of the sea. This statement is hackneyed, but never before has it been reaffirmed by a body representative of such a broad spectrum of government and industry interest as that which has just issued a report. The National Security Industrial Association and the Interagency Committee on Oceanography set up a joint panel on exploitation of the Continental Shelves. The panel has now completed a five-month study of five industries concerned and the recommendations in its report have important implications for the electronic industry and designers. The panel points out that inadequate prediction of weather and sea conditions "has been responsible for inefficiency in operation, as well as serious loss of life and equipment." It adds flatly that a major preoccupation of the offshore petroleum industry is "with finding an effective means of killing hurricanes in their early stages and improved services in environmental prediction."

It urges that additional weather stations be established to make records in the mixed layers of the ocean and atmosphere; that more efficient use be made of data furnished by existing weather stations; and that some steps be taken toward achievement of weather modification. The panel also recommended more accurate, reliable and economical all-weather navigation systems, and better information-storage and -retrieval systems for oceanic data. Finally, it called for development of better oceanographic instruments. Toward this latter end, it suggested that a National Oceanographic Instrumentation Center be set up to standardize and calibrate instruments, develop standards and specifications, and consult on instrument development.

The five industries involved in Continental-shelf exploitation that were examined were the petroleum, mining, chemical, fishing and maritime.

"Air buses" will rely on electronics

Vertical take-off and landing (VTOL) "air buses" for use in the Northeast Corridor will depend heavily on electronic navigation, signal and landing-aid systems that have yet to be developed, according to National Aeronautics and Space Agency officials. The Commerce Department has given its support to a proposal by M.I.T. that VTOL aircraft be employed to provide regular commuter services between the heavily populated areas on the eastern seaboard between Washington, D.C., and Boston.

The much discussed M.I.T. proposal, which has met with wide approval, was funded by the Department—an office that is largely concerned with high-speed ground transportation. But it is NASA that has carried out the pioneering civilian work on VTOL aircraft.

For more than a year NASA officials have indicated that one major obstacle to the imminent use of VTOLs for city-center-to-city-center transportation is the lack of tried and proven signaling and landing-aid systems that would permit "air buses" to be truly all-weather operational. NASA's position has been that there is little merit in developing an air commuter network that would be out of service a great part of the time because of bad weather.

The Commerce Department's latest nod toward VTOLs is expected to lead to a better-funded push for the needed electronics.

Study urges "diversify now"

Government officials have been privately urging the electronic industry to study with an open mind a recent report by the Denver Research Institute on the need for the industry to diversify now (ED 8, Apr. 12, 1966, p. 13). The Electronic Industries Association and the Aerospace Industries Association have both been perusing the report and are expected shortly to adopt official public positions. Officials of the Associations, however, have already admitted the validity of the reasoning behind the report's conclusions, even if they are unsure whether they will publicly support its plea for diversification.

Now is the time for electronic firms that rely heavily on military contracts to diversify into non-war areas despite thriving business that they may be doing as a result of the Vietnam war was the main conclusion of the report. Although the Institute's study was undertaken for the Arms Control and Disarmament Agency, it is Defense Department officials who have been among the report's staunchest advocates. Once burned by the near disappearance of an aircraft industry that had depended too heavily on war contracts, the Pentagon is anxious to see the electronic industry spread into other than war areas so that it may remain vital and vigorous and readily available whenever it might be needed in a hurry for military tasks.

The Institute believed this was the time to start diversification because many electronics and military oriented firms have ample cash rolling in from the Vietnam build-up. Pentagon officials agree. Said one: "You people ought to take some of these profits and plow them into new fields so you'll be around the next time we need you." He agreed that military business for electronic and aerospace firms was erratic and could very likely slump again in a few years. But he added that the Defense Department was reluctant to have any push for diversification result in shortages of military material.

Punctuality—keynote to new rail age

The need for new electronic systems to ensure reliable control over the high-speed trains envisioned for the near future was clearly pointed up by a railroader about to embark on a commuter service venture. The Richmond, Fredericksburg & Potomac Railroad is considering joining the Federal demonstration projects by supplying commuter service from Northern Virginia suburbs into Washington, D.C. Because the commuter self-propelled cars would have to be sandwiched into a busy freight schedule, John J. Neubauer, Jr., administrative assistant to the president of RF&P, said schedules would almost have to be split second. "If a commuter got to the station at 8:04." said Neubauer, "he probably would have missed the 8:03."

Government defines competition

New guidelines established by the Bureau of the Budget spell out in detail the policies to be followed in defining Federal competition with private industry. In general, the Government will provide goods and services for its own use only if the cost of so doing is at least ten percent less than that of obtaining them from private sources.

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You have trouble with your breathing: unusual shortness of breath, persistent coughing, too much phlegm—or a combination. Is it serious? It might be.

You know it's not "just a cold." Your trouble has been going on for a long time, or coming and going over months, perhaps years. You are only noticing it now—and wondering. Or perhaps you've been aware of it for a while. But you put it down to "too much smoking" or "just run down" or "getting out of condition." Now you think there might be more to it than that.

Yes, there might.

What Happens?

Your lungs are a complicated system of air sacs with connecting tubes, large and small. Their job is taking in fresh air and forcing out stale air. Trouble comes when the flow of air in and out of the lungs is impaired. Then trouble shows itself in breathlessness, coughing or other such symptoms.

Your air flow may be impeded by one or more of several possibilities. A doctor can usually tell which factors are involved in a particular case. When they consider the overall picture, the general name given to this trouble by medical experts is "chronic airway disease." By this they mean breathing trouble that involves impaired air flow, the cause for which must be found for each patient. It may not be easy.

Having looked into the situation of the patient before him, the doctor may give his trouble a specific name, too, depending on the cause and other features. Asthma, chronic bronchitis, emphysema—these are the three most important of several ailments that come under "chronic airway disease."

Three Ailments

. . . *Asthma* is the collection of breathing troubles that result from an allergy to some normally harmless substance.

. . . *Chronic bronchitis* means long-lasting trouble in the lung tubes that shows itself in coughing, too much phlegm, and breathlessness.

. . . *Emphysema* may show itself in the same way—especially by breathlessness—but it has the added feature that some of the small sacs (air spaces) deep in the lungs are damaged.

These three (and certain other ailments) are lumped together under one heading because they so often overlap. Also, they look and feel much alike.

What Causes?

. . . *Asthma* can be explained, in a general way: You're allergic to some substance, like ragweed pollen or horse dander. But finding the substance (or substances) that are guilty in your particular case may be difficult.

. . . *Chronic bronchitis?* Maybe it's caused by repeated colds, too much smoking, air pollution, or other things that do damage in the lungs—or by a combination of several or all such things.

. . . In *emphysema,* with the overstretched air sacs and destroyed air sac walls that are its outstanding feature, the cause is less clear. But the doctors have strong suspicions about infections, cigarette smoking and air pollution.

Most important for you, the doctors have ways of meeting the challenges of the various causes of chronic breathing trouble and of the very real and known troubles they cause.

If you (or someone in your family) has chronic airway disease, you can be helped. Your doctor has available both advice and medical procedures of several kinds. He has ways to help you breathe better, to combat infection if it is present, and to avoid those things that aggravate your symptoms.

What Should You Do?

If you have breathing troubles, you cannot decide for yourself what is causing them. *Let your doctor decide.* If you turn out to have chronic airway disease, particularly emphysema, you want to know how you can be helped. *Your doctor can tell you.*

Write for the free booklet, "Your Breathing Troubles: Understand Them, Face Them, Treat Them," paid for by Christmas Seals. Use the coupon. Paste it to a postcard.

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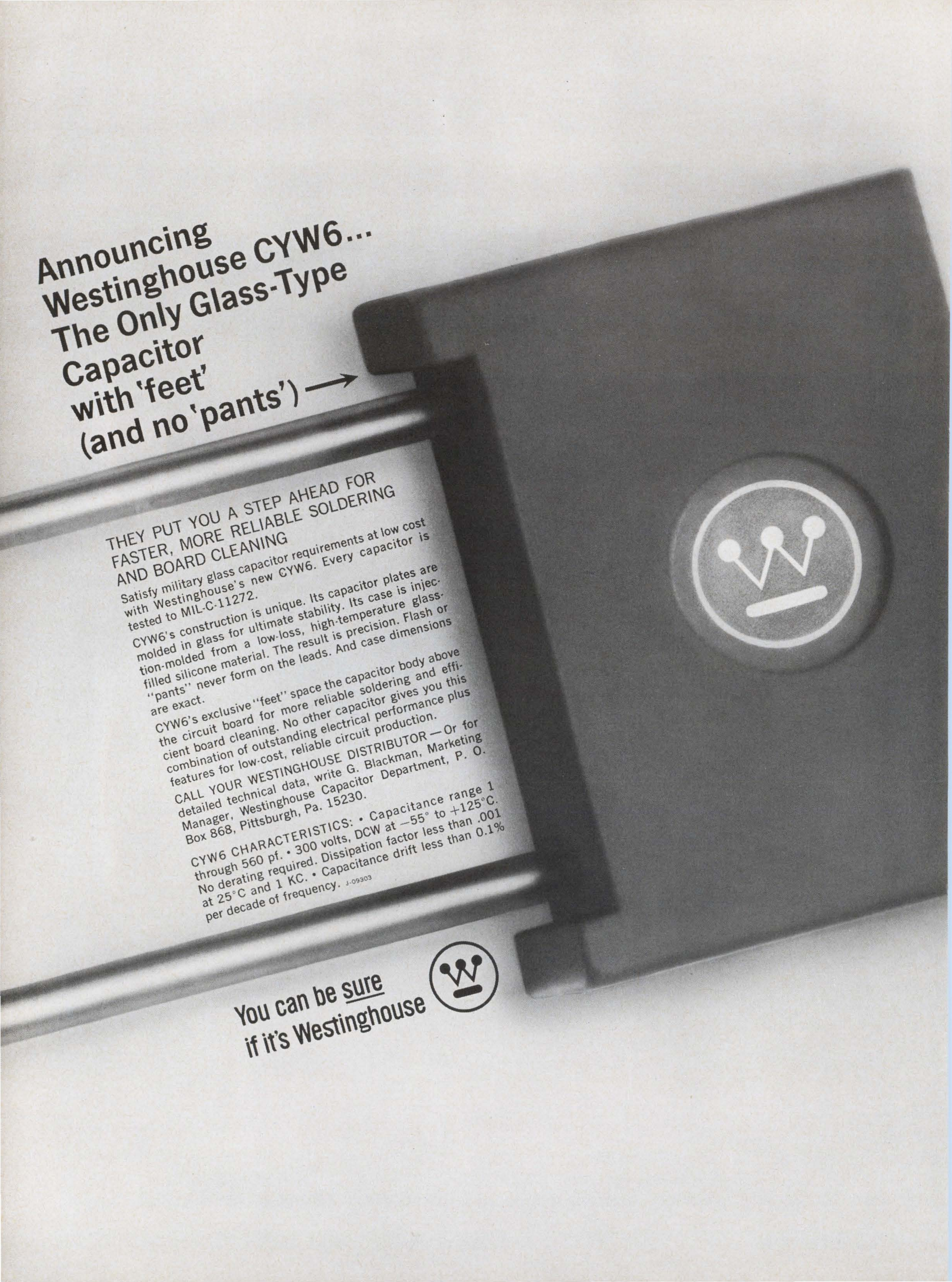

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Letters

Analog-IC suggestions

Sir:

I would like to call two important points to the attention of R. J. Widlar and J. N. Giles in reference to their article "Avoid Over-Integration . . . ," which appeared in the Feb. 1, 1966 issue of ELECTRONIC DESIGN.

My first comment is on the sine-wave oscillator with stable gain. Gain stability is, of course, one of the important requirements in an oscillator design. But frequency stability is also important. Normally gain stability in nearly-sinusoidal oscillators does not lead to frequency stability. To achieve frequency stability, we must use either crystals or non-minimum phase-shift networks in the positive feedback path. Non-minimum phase-shift networks can be realized by using RC networks (notch filters).

The second point I would like to make concerns Eq. 9. This expression can be derived by writing the continuity equation in the base region with the proper boundaries. It can be shown that this expression holds only when $V_{CB} \rightarrow 0$. Also, since Q_1 and Q_2 in Fig. 3 do not operate under the same conditions (Q_2 acts as a diode), the proportionality constants in Eq. 9 for Q_1 and Q_2 are not the same. Thus Eq. 10 must be used with utmost care. I hope this note will stimulate more thoughts and discussions.

Vasil Uzunoglu
Scientific Consultant
ARINC Research Corp.
Annapolis, Md.

The author replies

Sir:

I agree wholeheartedly with Mr. Uzunoglu that non-minimum phase-shift networks make an oscillator less sensitive to variations in components other than the frequency-determining elements. However, operational-amplifier techniques can minimize these variations to the point where the frequency stability is dominated more by the stability of the RC elements than by the characteristics of the amplifier. When this is the case, it does not make much sense to go to non-minimum phase-shift networks, since they are similarly affected by changes in the RF elements.

The emitter-base voltage of a transistor is affected by collector-base voltage. This sensitivity is reflected in Eq. 9 as a change in the unspecified proportionality constant, which means that the equation still holds for any constant emitter-base voltage. Even so, the change in the emitter-base voltage with the collector-base voltage is quite small. At a fixed collector current, it is described by h_{rb}, which is about 10^{-4} for practically all transistors.

In both the logarithmic amplifier and the multiplier, the transistors are matched and operated at essentially equal collector-base voltages (in fact, $V_{CB} = 0$ for the log amp). Hence the error caused by the non-zero collector-base voltage will be about 0.1 mV, which can be neglected. This is demonstrated mathematically by the fact that the proportionality constant in Eq. 9 does not show up in Eq. 10.

As Mr. Uzunoglu mentioned, the fact that Q_2 (Fig. 3) is connected as a diode does introduce an error. The error arises because Eq. 12 also includes the value of base current (I_{B2}) flowing through R_6. With a dc current gain of 50, this decreases the emitter-base voltage of Q_2 by 0.5 mV below its expected value. Since this is small by comparison with the initial offset voltage of the transistor pair, it can also be neglected. The important point is that Q_2 is operating at a constant current, so this error does not alter the logarithmic characteristic generated by Q_1.

Robert Widlar
Section Manager
Linear Microcircuits
Fairchild Semiconductor
Mountain View, Calif.

Mho: yes siemens: no

Sir:

It is heartening to read Mr. Howard Cook's protest (ED 4, February 15, p. 42) against the substitution

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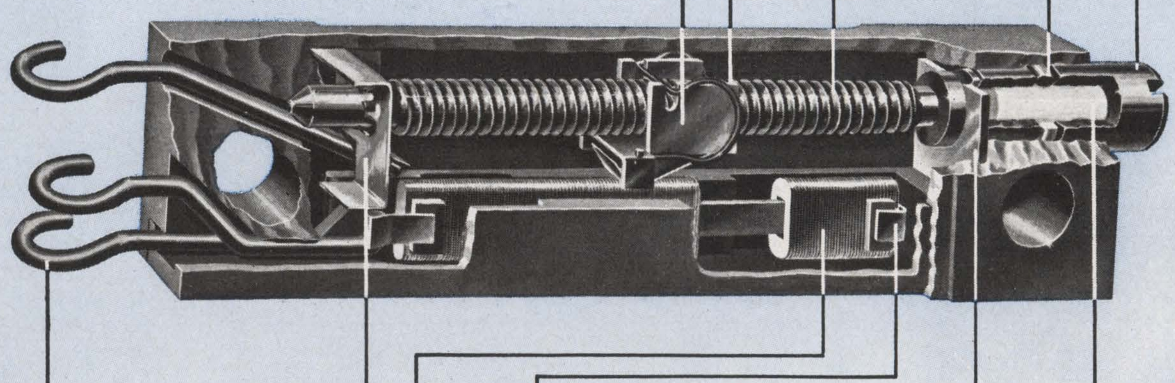

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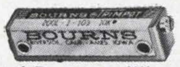

General-Purpose Wirewound Model 200. Max. temp. 105° C / L, S, P terminals / 0.50 watt at 70°C / 10 ohms to 100K.

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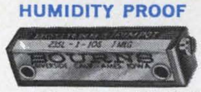
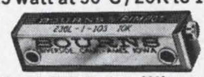


General-Purpose RESISTON Carbon Element Model 235. Max. temp. 135°C / L, S, P terminals / 0.25 watt at 50°C / 20K to 1 Meg.



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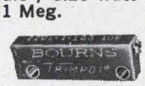
Micro-Miniature High-Temperature RESISTON Carbon Element Model 3001. Max. temp. 150°C / P terminals / 0.20 watt at 70°C / 20K to 1 Meg.



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High-Temperature Wirewound Model 3010. Max. temp. 175°C / L, P terminals / 1.0 watt at 70°C / 10 ohms to 100K / Mil-Spec style RT11 and meets MIL-R-27208A.

High-Temperature RESISTON Carbon Element Model 3011. Max. temp. 150°C / L, P terminals / 0.25 watt at 50°C / 20K to 1 Meg / Mil-Spec style RJ11 and meets MIL-R-22097B.

High-Temperature High-Resistance PALIRIUM Element Model 3012. Max. temp. 175°C / L, P terminals / 1.0 watt at 70°C / 10K to 1 Meg.

⅜"-Square Wirewound Model 3280. Max. temp. 175°C / L, P, W terminals / 1.0 watt at 70°C / 10 ohms to 50K.

⅜"-Square RESISTON Carbon Element Model 3281. Max. temp. 150°C / L, P, W terminals / 0.5 watt at 50°C / 20K to 1 Meg.

½"-Square, High-Temperature Wirewound Model 3250. Max. temp. 175°C / L, P, W terminals / 1.0 watt at 70°C / 10 ohms to 50K / Mil-Spec style RT22 and meets MIL-27208A.

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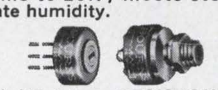

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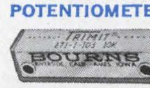

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ON READER-SERVICE CARD CIRCLE 22

of the siemens for the mho. It is high time such a protest was made, for the siemens is a miserable choice for a unit. Who was Siemens, anyway; what did he do? I have not yet found anyone who knows, and this suggests strongly that Siemens does not belong in the company of Faraday, Henry and Ohm. Mr. Cook is also right to point out the impropriety of using a name which is already the name of a company.

There ought to be some way in which the scientific and engineering community can kill this before it is too late. If we had acted quickly and decisively, we could probably have avoided having the hertz thrust upon us. There must be some means available for lodging a formal protest and putting a stop to the siemens.

Thomas W. Parsons
Cardion Electronics, Inc.
Woodbury, L.I., N. Y.

Absolute values needed for standard measures

David Bean seems to have missed his own point in his letter in the March 1 issue, "Down With Standards That are Earthbound." What he wants is not a less arbitrary and more universal system of units. Any system is arbitrary, even his, and is universal only to the extent that it is adopted. What he is really after is an absolute definition of that system.

In this respect his point is well taken. One could hardly measure the second against its standard, tropical year 1900. That standard in itself is lost forever.

We should instead define the metric units in terms of absolute standards. The meter is already defined in terms of the orange-red spectral line of Krypton 86. The kilogram could be defined as 5.9790X10^{26} times the rest mass of the proton.

The time when the world is finally approaching a uniform system of units is hardly an opportune moment to start changing to a new system unnecessarily.

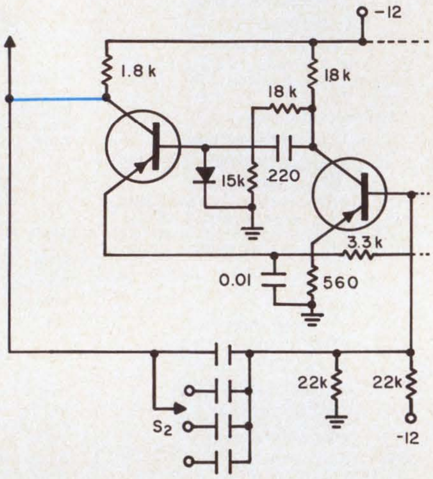
Dennis W. Baker
U.S. Navy Marine Engineering Laboratory
Annapolis, Md.

Accuracy is our policy

The author of "Build a tone-burst generator for $50" in ED 4, Feb. 15, 1966, points out two errors.

On p. 104, the second sentence of the second paragraph should read: "If an oscilloscope can be requisitioned to measure the cycling function . . . . ."

On p. 105, a line was omitted from the lower left portion of the schematic (shown in color below):



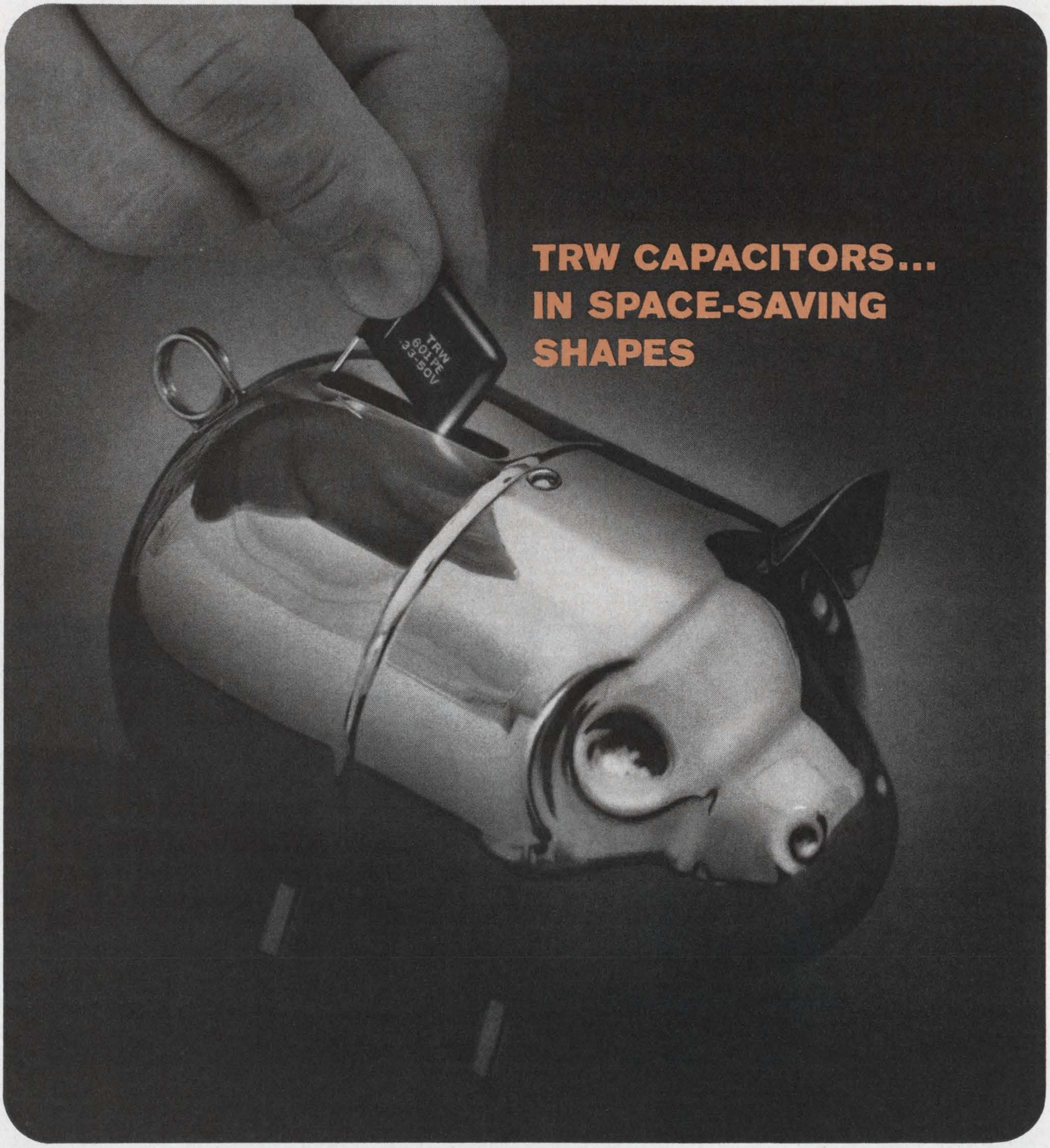
Page U146 of the Mar. 15 issue incorrectly shows Heath's dc scope as General Resistance's volt/ratio meter and GR's meter as Heath's scope.

The caption for the thin-film solar cell photograph on page U70 of the March 15 issue erroneously implied that the cells shown were being developed by RCA. Although RCA is doing work on such cells, the photograph shows thin-film solar cells now under development at the Electronic Research Division of Clevite Corp.

Several errors appeared in the artwork for the article "Try Capacitance Transducers," starting on page 188 of the March 15 issue. First, Figures 7 and 8 were reversed. The illustration appearing with the caption for 7 was actually 8, and vice versa.

In addition, the dimension R on Figure 3j should be the radius to the outside plate, instead of the inner plate as shown.

Finally, in the equation for Figure 3k, the dielectric constant ϵ should appear in the numerator.



14-60

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ON READER-SERVICE CARD CIRCLE 25

Craftsmanship: the mark of the professional engineer

The old-time concept of the craftsman is gradually fading from the scene. The reasons for his decline are manifold—the machine age, the rise of the unions, the sharing of responsibility for a task among many rather than its being given to one worker—all have contributed. And yet, we still need craftsmen.

We do not necessarily mean of the genius of Cellini, da Vinci or Michelangelo, although they will always be welcome. Rather, we mean the ordinary kind of craftsman who spent five or seven years as an apprentice, and then through diligence and energy earned the right to be considered a full-fledged printer, or shoemaker, or whatever. Just learning a certain amount of information was not enough. The true craftsman had to be resourceful and creative. He had to master the tools of his trade and be able, when necessary, to invent tools of his own to further his art.

The sort of ingenuity he sometimes needed can be seen firsthand in museums which display the handtools of old. We happened last year on a whaling museum where many such treasures of the past are kept. It was incredible to see with what few simple tools the whalers fashioned huge, leak-proof whale-oil barrels, sturdy wooden ships, or delicate scrimshaw figures made from whales' teeth and bones.

What pride these men must have taken in their work! What difficulties they must have overcome to produce such fine results with such clumsy implements!

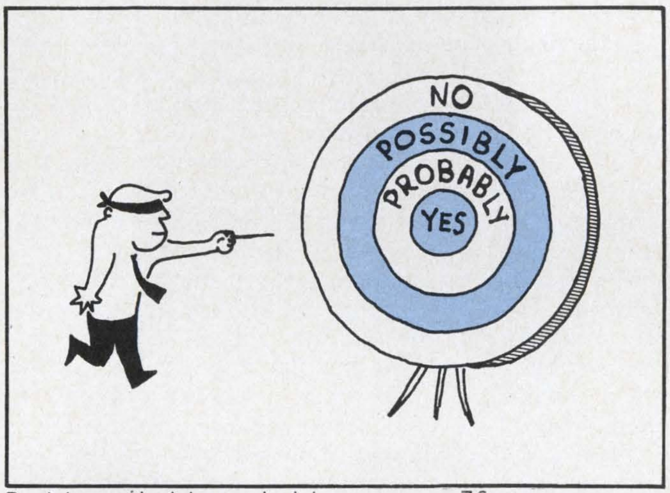
On today's production lines how often does one see this pride in workmanship? Despite such incentives as Zero Defects programs and cash rewards for excellence, the worker who really loves his work and will give his all to achieve something a little better is rare. And as like as not, his fellow workers will gibe at him for wasting so much time and effort to do a good job.

How many engineers are themselves true craftsmen? What percentage becomes so skilled at the craft that it can grapple with all the intricacies of making a complex system operate properly? Faced with new engineering problems, how many of them can evolve at least some approach to a solution?

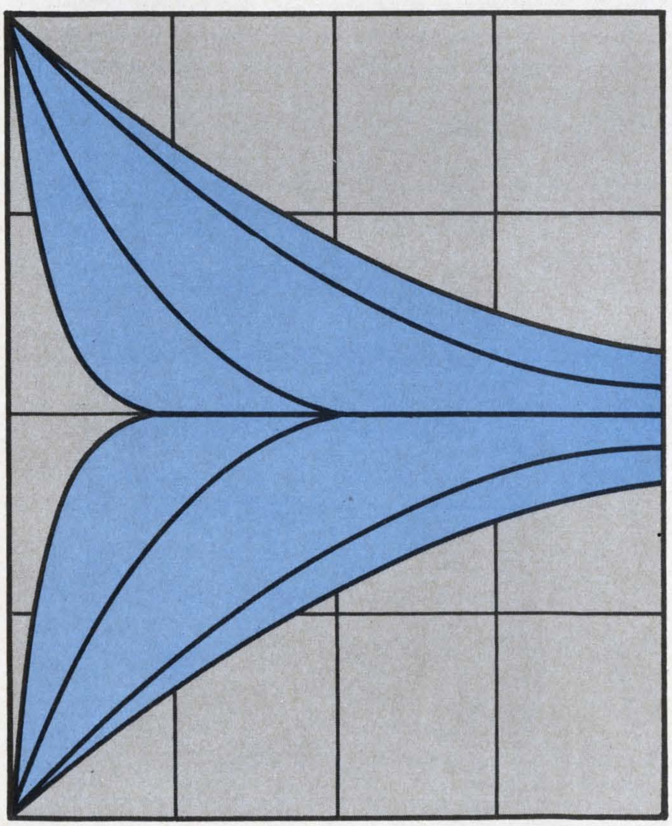
Few companies today demand that their engineers pass the kind of apprenticeship that the craftsmen of yore had to undergo. Nowadays each engineer must, in large part, take it upon himself to deepen his understanding and ability by accepting challenging assignments. But without this extra effort he will never arrive at the grasp of his profession or the degree of expertise which was the hallmark of the old-time craftsman.

ROBERT HAAVIND

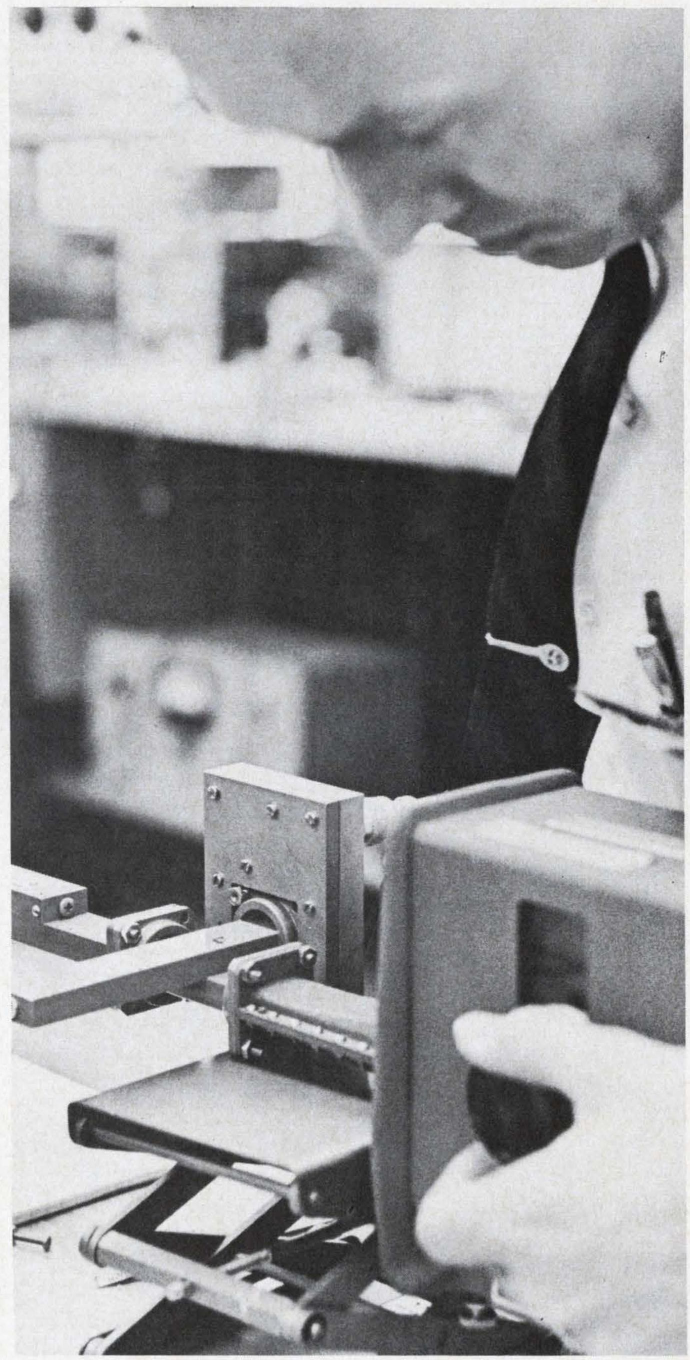
E|D Technology



Decisions, decisions, decisions . . . p 76



Get a line on common-emitters . . . p 52



Going forward with the backward diode . . . p 44

Forward with backward diodes: the vast improvements expected from these diodes in detectors can now be realized with a new stripline mount.

The backward diode appears to have all the qualifications for a great low-level microwave detector.[1] Its temperature coefficient, T_i, is better by several magnitudes than that of conventional diodes. However, its puzzling reaction to temperature changes and its unpredictable behavior in waveguide mounts have discouraged many designers.

Stripline techniques help to solve both of these problems.

A newly designed stripline mount that uses a probe detector should make the backward diode more popular with microwave design engineers. The mount's greatest assets are as follows:

- Its package is extremely rugged and mechanically stable. Components are not easily broken or displaced by vibration and shock.
- It eliminates the critical need to position the diode precisely—a problem with conventional mounts.
- The tuned probe offers good matching. The microwave transmission path can be changed during the initial breadboarding stage.
- The dielectric (irradiated polyethelene) substrate damps out rapid changes in the ambient temperature and increases the diode's temperature stability.

Some of the backward diode's troublesome design problems can be traced to its inherent properties, and some are the result of the way the diode has been used in circuits. Let's explore both of these areas and see why the stripline mount eliminates most of the trouble.

Backward diode resembles zener

The backward diode is a highly doped, alloyed-junction diode that operates on the principle of quantum-mechanical tunnelling. It is actually a special case of the Esaki tunnel diode,[2,3,4] with the pn junction doped just slightly into degeneracy.

For small forward bias, the primary currents are conventional diffusion and drift currents.

For reverse bias, the energy bands overlap and a large reverse current flows. This current is due to the tunneling of electrons and is nearly independent of temperature.

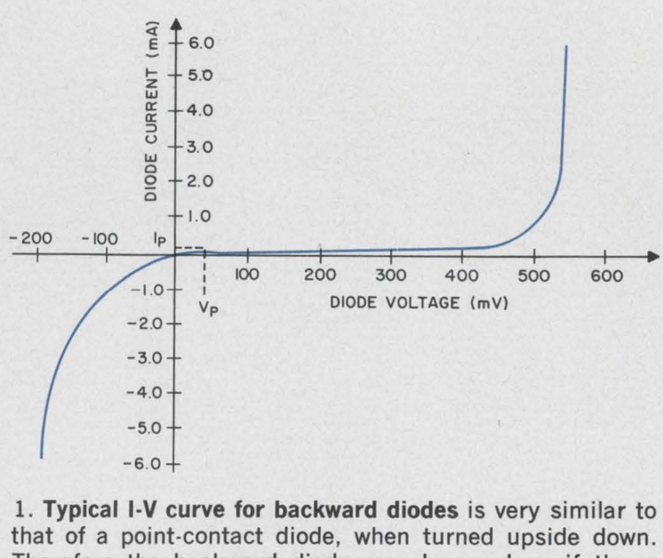
Clarence E. Bowen, member, technical staff, Bell Telephone Laboratories, Greensboro, N. C.

The diode is essentially a zener at the origin. If this point is accepted, then the static I-V curve (Fig. 1) makes it immediately obvious that the diode's RF impedance is unusually low, its current sensitivity unusually high, and it is also clear that it is a low-level device. (The curve shows values for Philco's L4154 diode. Slight changes may be expected with other diodes.)

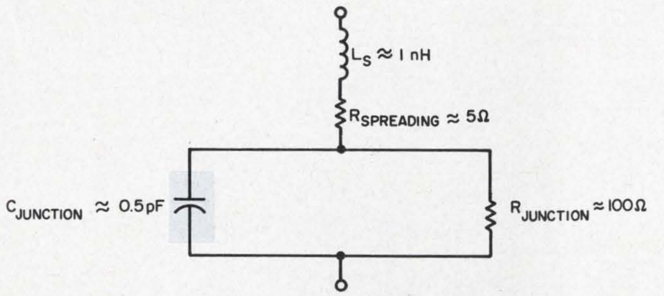
The name "backward diode" derives from the fact that the easy flow of current takes place in the negative rather than the positive region of the characteristic curve. If the n region is considered to be the anode and the p region to be the cathode, then biasing may be applied as if it were a conventional diode. Indeed, looking at Fig. 1 upside down, we see that the shape is similar to that of a conventional I-V curve, with the breakdown occurring at 0.5 volt in the reverse direction.

There is a slight negative resistance region, as shown, with a peak voltage of approximately 50 mV and a peak current of approximately 60 μA. Note from Fig. 1 that there is an optimum amplitude range of impressed ac voltages to be detected. If the voltage swing is too large, leakage currents become excessive, and if the voltage swing is too small, the current sensitivity falls off.

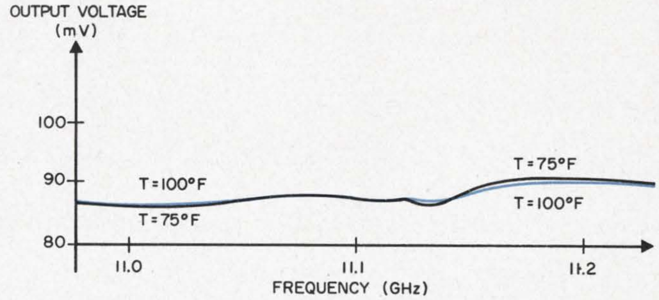
At microwave frequencies, this simple picture is complicated by the shunting effect of the junction capacitance (Fig. 2).



1. **Typical I-V curve for backward diodes** is very similar to that of a point-contact diode, when turned upside down. Therefore the backward diode may be used as if the n region were the anode and the p region were the cathode.



2. **Equivalent circuit** of a backward diode does not include the case capacitance that usually shunts the entire device. The typical values are for a Philco L4154 diode. L_s is the whisker and packaging inductance.



3. **The changes in the diode's capacitance** with temperature are sufficient to change the output voltage. This variation is more apparent at X-band and above, where the reactance of the capacitance is less than 100 ohms.

In most applications the backward diode has a temperature coefficient, T_c, that is vastly superior to that of crystal detector diodes. However, there are many problems in getting a stable temperature coefficient. It is possible to obtain positive coefficients, negative coefficients and coefficients that change sign at some critical temperature. These changes can affect the output radically.

Capacitance plays havoc with output

Especially at high frequencies (X-band), the temperature dependence of the diode's capacitance becomes the critical problem. The capacitance increases with the temperature. At frequencies below X-band, the effects of a temperature-sensitive capacitance become less pronounced and begin to be overwhelmed by the other temperature-varying mechanisms.

As the capacitance increases with temperature, at least three things can happen:

1. The diode's impedance match can improve or degrade, resulting in more or less reflected power, depending on the nature of the original match.

2. The capacitance shunts more current around the rectifying junction and reduces the rectified output voltage. For a capacitance of 0.5 pF or so, this is a noticeable effect in X-band.

3. If the swept frequency output voltage is not flat, as suggested in Fig. 3, the changed reactance can shift the entire response curve up in frequency. Notice that in Fig. 3 some frequencies see a positive and some frequencies see a negative T_c.

The Smith Chart (Fig. 4) shows the changes in impedance as the temperature of the waveguide mount is raised by about 40°F. The over-all impedance was reduced from Z_{cold} to $Z_{hot} \approx 0.9\ Z_{cold}$, while the input vswr improved from 4.25 to 3.60. It was established that only the diode was responsible for these changes.

The improved vswr implies an increase in output voltages—$V_{hot} \approx 1.08\ V_{cold}$, since the detected output voltage should change linearly with the absorbed power level. However, for this diode, this is not quite so. The increase in absorbed power is offset by the increased shunting effect of Z_{hot}, and the output voltage actually decreases to $V_{hot} \approx 0.98\ V_{cold}$. This surprising result has been verified under varying combinations of diodes, mounts and operating conditions.

The conclusion is that the vswr improves while the rectified output voltage can actually decrease with temperature.

Diode position is critical in guide mount

The unpredictable performance of backward diodes in waveguide mounts can be attributed to the fact that it is nearly impossible to insert the diode into the same place each time. Even the slightest variations in the position of the diode changes the impedance match toward the diode.

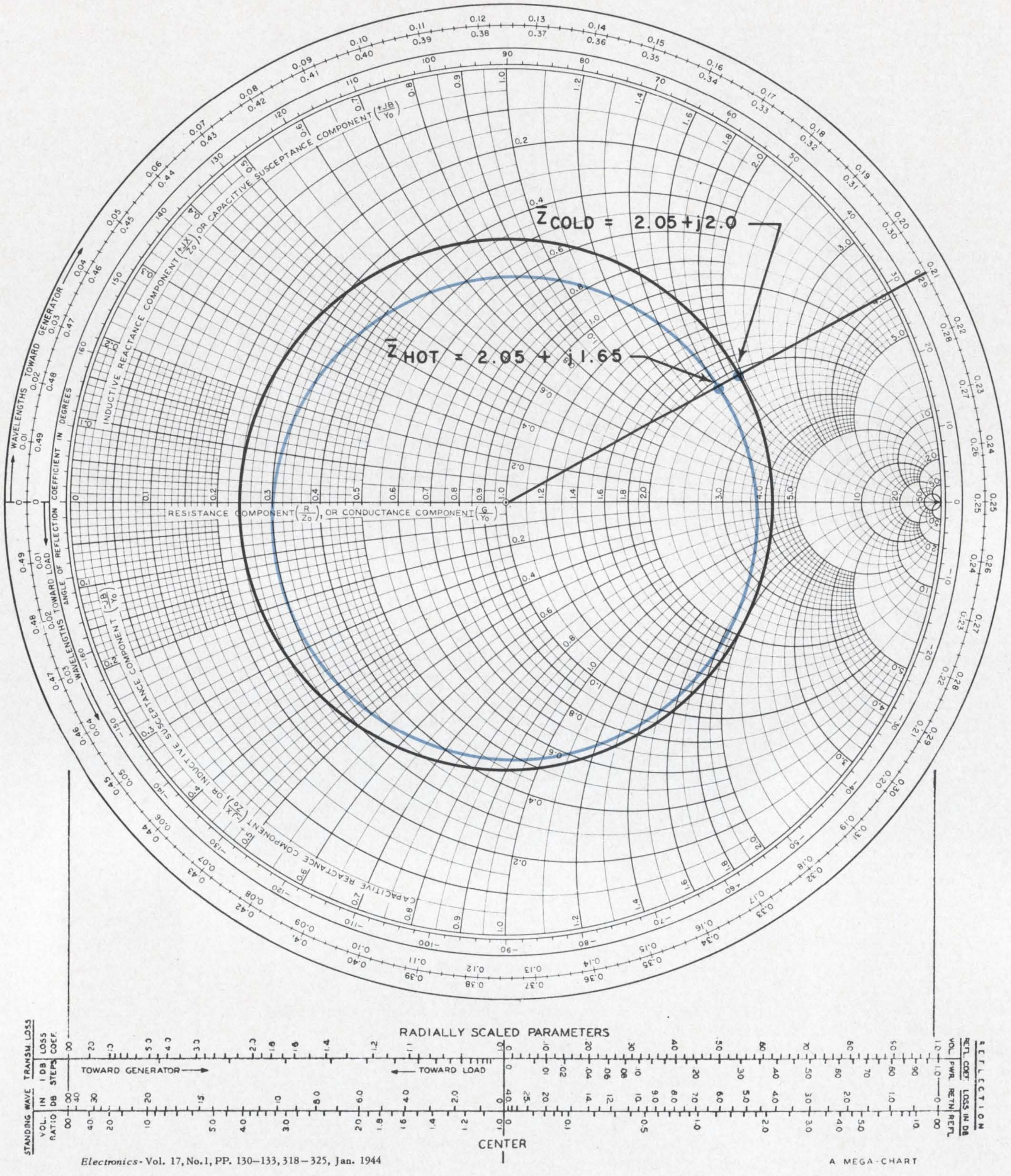
The large-signal impedance of the diode can be thought of as a resistance, whose value is a time-weighted average of the inverse slope at each point on the characteristic curve. The curve is traversed by an alternating voltage. Since the dc load resistor determines the operating region of the characteristic curve and the shape of the curve itself is a function of temperature, the RF impedance becomes a function of load resistor, power level and temperature.

Therefore, if the total impedance match can be changed considerably by the diode's position, a given change in R_L or temperature will improve or degrade the match, as shown in Figs. 3 and 4. This effect can change a positive temperature coefficient to a negative one with a mere change in the diode's axial position.

It becomes apparent that the quality of detection is limited as much by the detector mount as by the diode.

Probe mount tunes out mismatch

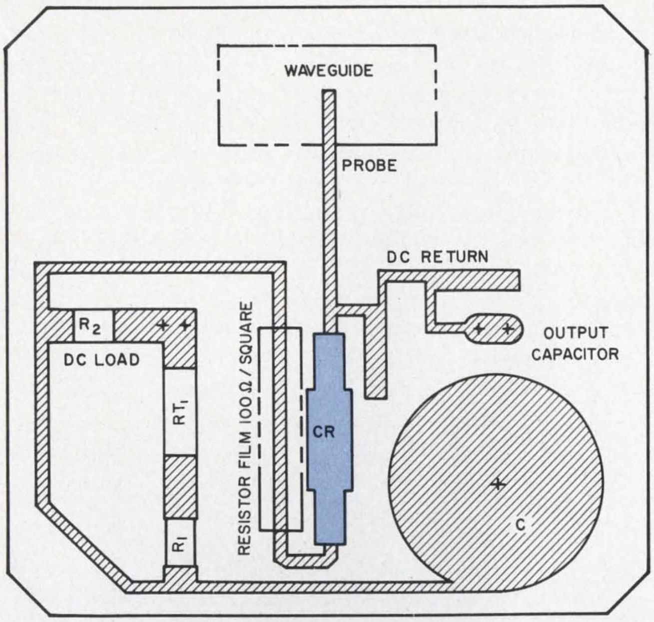
Detection with a probe in a stripline mount solves the matching problem and keeps the diode in a fixed position. A diode shunting a waveguide appears as an inductive post to RF, and its reactance depends on the shape of the package. Since the equivalent circuit of a long thin probe changes from a shunting inductance to a capacitance as the probe is shortened, there is a critical length for which the reactive mismatch is essentially tuned out. Of course, the dc path through the diode to ground must be re-established, but this is easily accomplished with a low-pass filter. The configuration of the detector mount is shown in Fig. 5. Fig. 6 shows the representative return loss obtained from such a stripline detector mount,



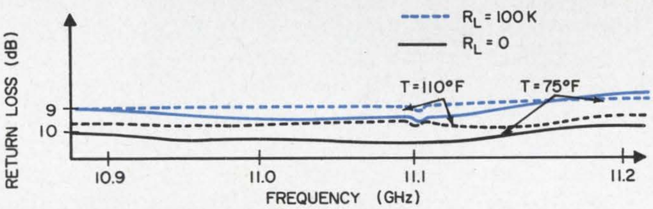
4. **The decrease of the diode's impedance** with temperature improves the vwsr of the detector. However, this improvement does not result in an increased output. The increased shunting effect of Z_{hot} decreases the output.

with a tuned probe, over a band of 200 MHz. Some of the stripline mounts have an input vswr of 1.5, with an average of about 1.7 which is much better than the required vswr of 2.5 for satisfactory performance.[4] Also, the stripline detector mount permits the interchange of diodes without appreciably changing the impedance match.

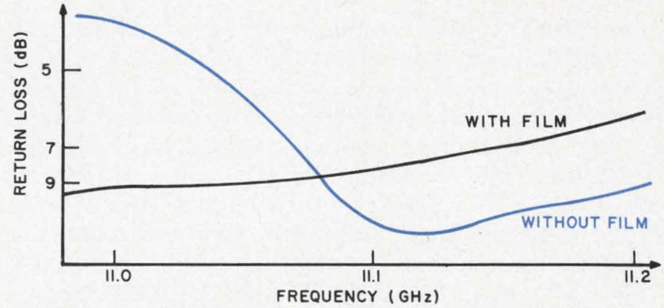
A resistive film is placed on the circuit path following the diode. This film, 100 ohms/square, is lossy to RF but could not affect the dc. It absorbs the RF components that remain after detection and therefore reduces the leakage problem. A metex gasket is used around the edges of the metal backing plates, to insure against leakage caused by higher-order transmission modes. (Striplines are intended to utilize only TEM mode propaga-



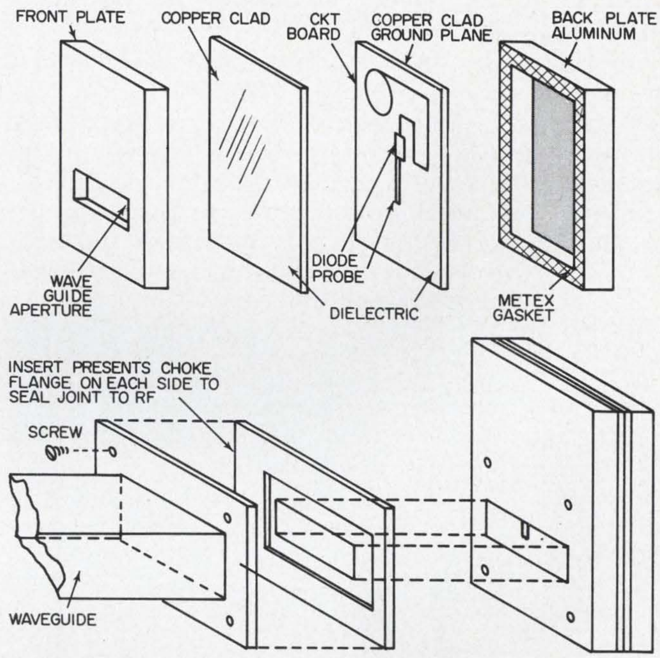
5. **Stripline detector mount** eliminates the critical mounting problems of the diode encountered in waveguide mounts. This mount, when combined with a tuned probe, makes the backward diode a high-quality detector. RT_1, a temperature-sensitive resistor, is usually not needed.



6. **Return loss of the stripline mount** remains fairly constant over a 200 MHz band that centers around 11.1 GHz. A matched load (solid black line) reduces the return loss by about 1 dB. The increase in temperature also reduces the return loss.



7. **Resistive film over the dc path** has a critical effect on the amount of reflected RF energy and therefore on the vswr of the mount. Measurements again were taken in a 200 MHz band around 11.1 GHz.



8. **A sketch of the mount** shows how it is constructed and how it fits on the waveguide flange.

tion, but occasionally higher-order modes exist, yielding larger fringing fields with increased possibility of RF leakage). The precautions reduce the leakage below detectable levels.

The probe extends into the waveguide aperture, as shown, and acts as a small antenna. It is well known that a probe of this type in a waveguide behaves like a tuned circuit—long stubs look inductive and short ones, capacitive. A length can be found experimentally that simulates resonance and tunes out its reactive mismatch. The impedance of the transmission line leading up to the diode is 70 ohms.

The dc return is through a stripline low-pass filter. It provides the necessary dc continuity through the diode to ground, but its impedance is high enough toward the RF signal, so it is not seen by the RF.

The dc level is set at the diode. The resistive film is placed over the circuit path to attenuate the remaining RF components. It has been found that without the film enough RF is reflected back from the dc load to upset the input vswr. The dramatic effect of not using enough film is shown in Fig. 7.

The next component in line is R_2 in Fig. 5, a stripline resistor to ground. (The symbols + + indicate eyelets that make a metallic contact with the ground plane.)

The output capacitor maintains the dc level and shorts out any remaining RF. A large copper area makes a simple parallel plate capacitor with the ground planes. A bellows makes contact with the center of the capacitor and conducts the output level to the center conductor of a type-N coaxial connector.

Fig. 8 indicates how the mount is constructed and how it fits on the waveguide flange.

The X-band detector with this mount is stable within 0.05 dB with age and with temperature variations of ±3°C. It has a vswr of 1.7, negligible RF leakage and operates from −35 dBm to 0 dBm (Fig. 9). The differential sensitivity is typically around 20 mV/dB at 0 dBm. The temperature coefficient is about 3 x 10^{-4} parts/°C at −4 dBm.

Other factors to consider

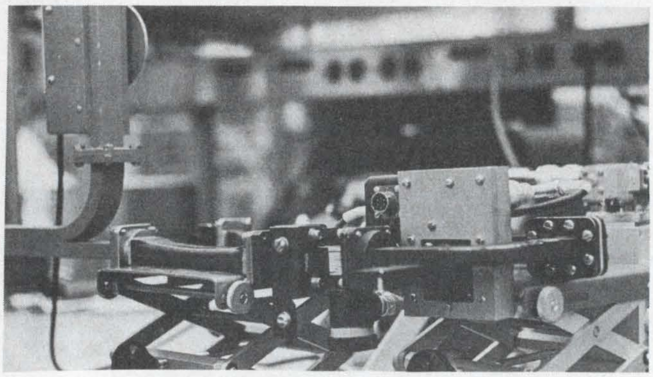
Among the other important considerations affecting the backward diode as a detector, the following should also be included:

■ **Power level**—The backward diode is usually operated at levels below 0 dBm. Its high current sensitivity makes it especially useful for lower levels. When the power becomes too high, this current sensitivity decreases rapidly, as the rectified output voltage saturates at a value somewhat less than 0.3 V. There is an optimum power level that, when exceeded, causes the temperature coefficient to increase as current sensitivity decreases.

■ **Load resistor**—The dc load resistor partly determines the optimum power level, by developing an output voltage that reverse-biases the diode. Generally the dc load should be kept as small as possible without sacrificing too much differential sensitivity. Approximately 100 ohms is a recommended choice.

■ **Impedance match**—Broadband applications would require terminations with a matched load rather than a quarter-wave short. Vswr resonances in the vicinity of the operating frequency can seriously affect the over-all temperature coefficient.

The maximum allowable power level for a given diode-mount combination may be determined with Fig. 10. This figure also helps in the selection of an optimum load resistor for a given power level.



9. **A laboratory bench model** of the backward diode detector is mounted in a leveler.

An important design point is that the detector's *differential sensitivity* (the change in rectified output voltage with respect to a change in incident RF power) is generally a more useful parameter than the level of output detected voltage.

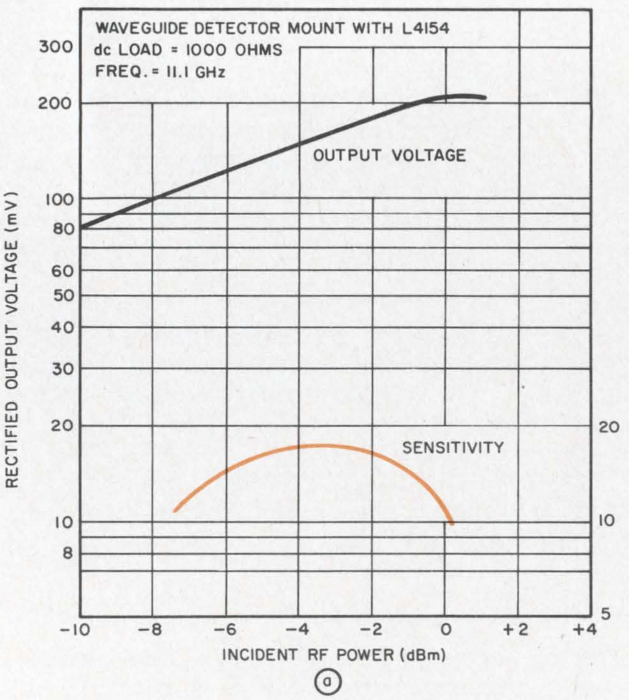
The static, or low-frequency, I-V curves cannot be used directly to determine the maximum allowable voltage swing and the other parameters at microwave frequencies. For example, at X band, an incidental voltage wave does not see the impedance suggested by the I-V curve; it sees the impedance shunted by a capacitive reactance of less than 100 Ω for the L4154.

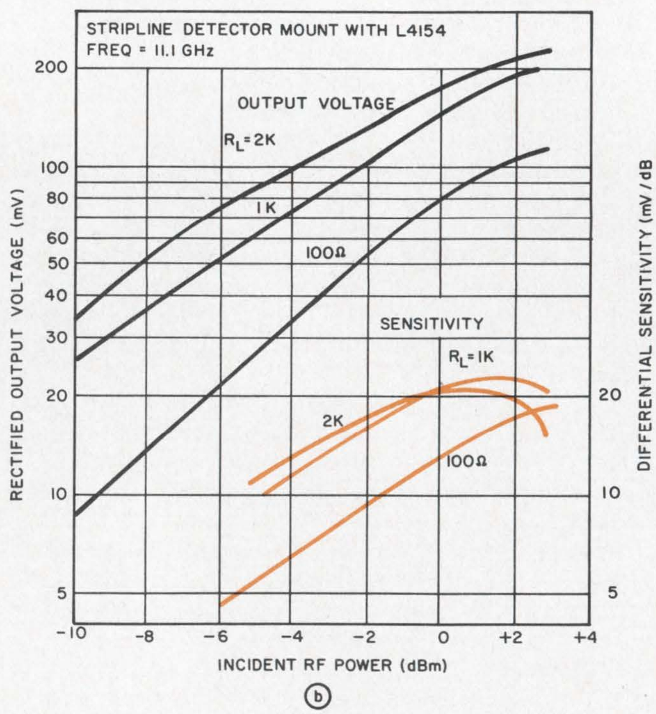
A logical choice of load resistor and power level, therefore, would be a combination that caused operation to be in the vicinity of maximum differential sensitivity, but always on the low-power side of the peak. It is important to realize that a small load resistor, with a low output voltage, does not necessarily imply a low sensitivity to changes in RF power.

It should be noted that for a smaller load resistor, the reduced output voltage allows a higher operating power level before saturating the detector.

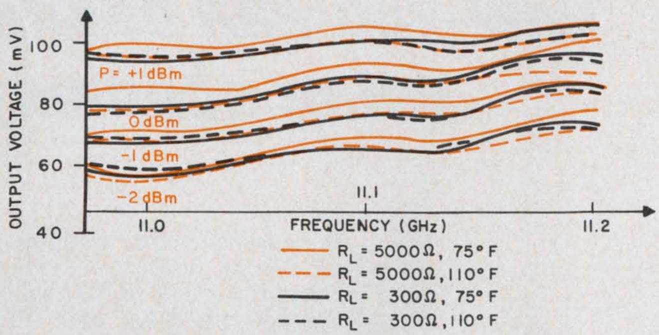
Higher power levels increase the negative tendency of the temperature coefficient, because of the temperature-sensitive diffusion current (see Fig. 11). Here the output voltage is swept over a 200-MHz band. The temperature coefficient with a 300-Ω load resistor is clearly lower than that with a 5000-Ω load. The detector is shown in Fig. 12.

Designers should watch out for another phenomenon. The large majority of backward diodes tested have shown predictable and well-behaved qualities. Several, however, exhibited anomalies that are not well understood. The phenomenon is interpreted as a gross instability in the diode's I-V

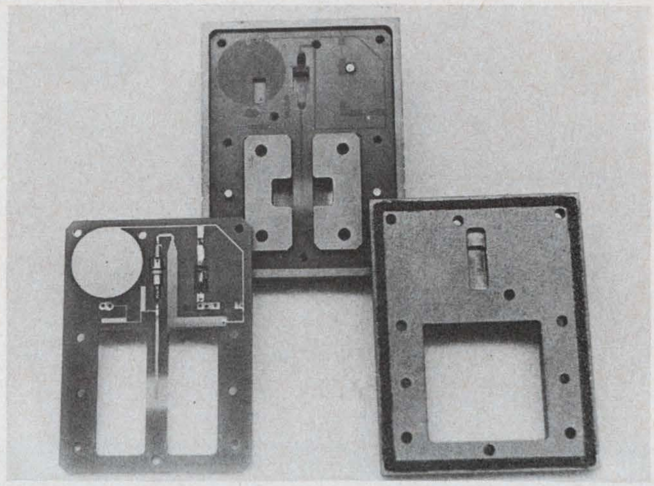




10. **The maximum allowable power** level may be found with these graphs for waveguide (a), and stripline mounts (b).



11. **The detected output voltage** changes with the load resistor (solid lines) and with temperature (dashed lines). Higher power levels increase the negative effect of T_c.



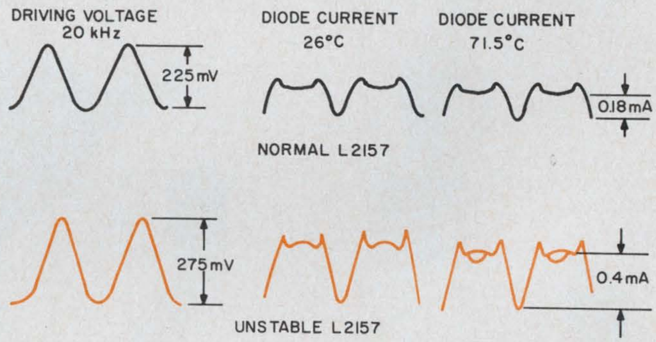
12. **Circuit board** and front and back plates of the detector show compactness of the detector.

characteristic that occurs at a given temperature. Under testing two L2517 diodes have been loaded resistively with 100 ohms and driven by a sinusoidal 20 kHz voltage. The current response of a normal stabilized diode showed no significant change, as the temperature was raised from 26°C to 71.5°C. The other diode showed the beginnings of a double trace with approximately equal intensities (see Fig. 13). Evidently the diode characteristic is switching between two different, but well-defined, states and is spending roughly half its time in each state.

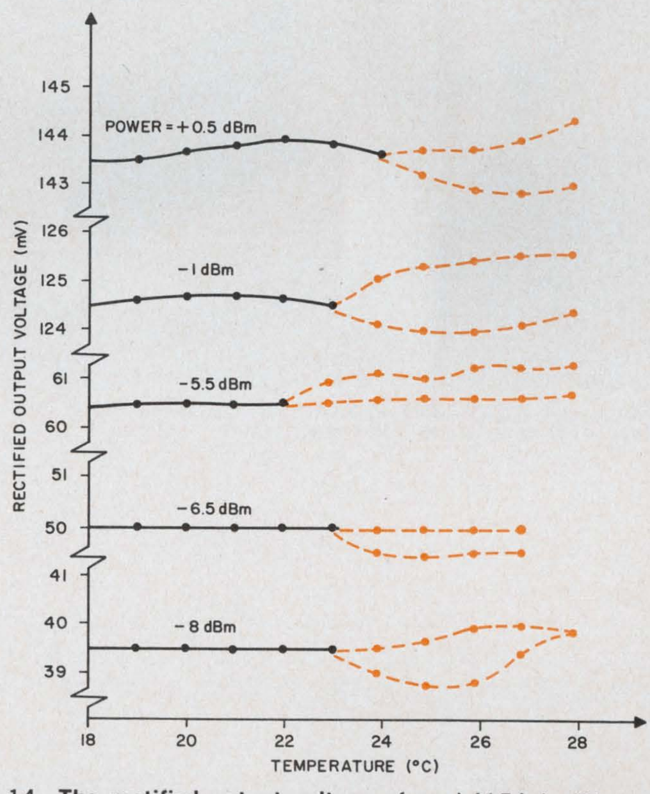
The result of this effect is to produce a different average current and, thus, a measurably changed rectified output voltage when the diode becomes unstable. (The present version of the L2517, used with a properly designed detector mount, is reported to be free of this anomalous behavior.) Fig. 14 represents the rectified output voltages of an unstable L4154 diode with a 330-ohm resistive load and an incident signal at X-band. It is a plot of output voltage, at various power levels, as the detector mount is slowly and uniformly heated. The length of time in either state ranges from 15 seconds to three minutes. It has also been noted that the changes are not instantaneous, but take perhaps 10 seconds to complete.

The temperature at which the instability occurs remains the same under varying conditions of power level, load resistor and detector mount. It is therefore felt that the tendency of a given diode to be stable or unstable is inherent in the diode itself rather than in its operating conditions.

This kind of temperature instability is unusual. However, apparently the effects are exaggerated when there is a poor impedance match to the detector mount. ■ ■



13. **Gross temperature instability** may occur in some backward diode. It appears as a double trace in the output current that changes the average current.



14. **The rectified output voltage** of an L4154 in X-band clearly shows the effects of temperature instability at varying power levels. The diode apparenty switches between two states.

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5. "Power Monitor and Detector Characteristics of Microwave Associates—Diodes," *Micronotes*, Volume 2, Number 7, January 1965.

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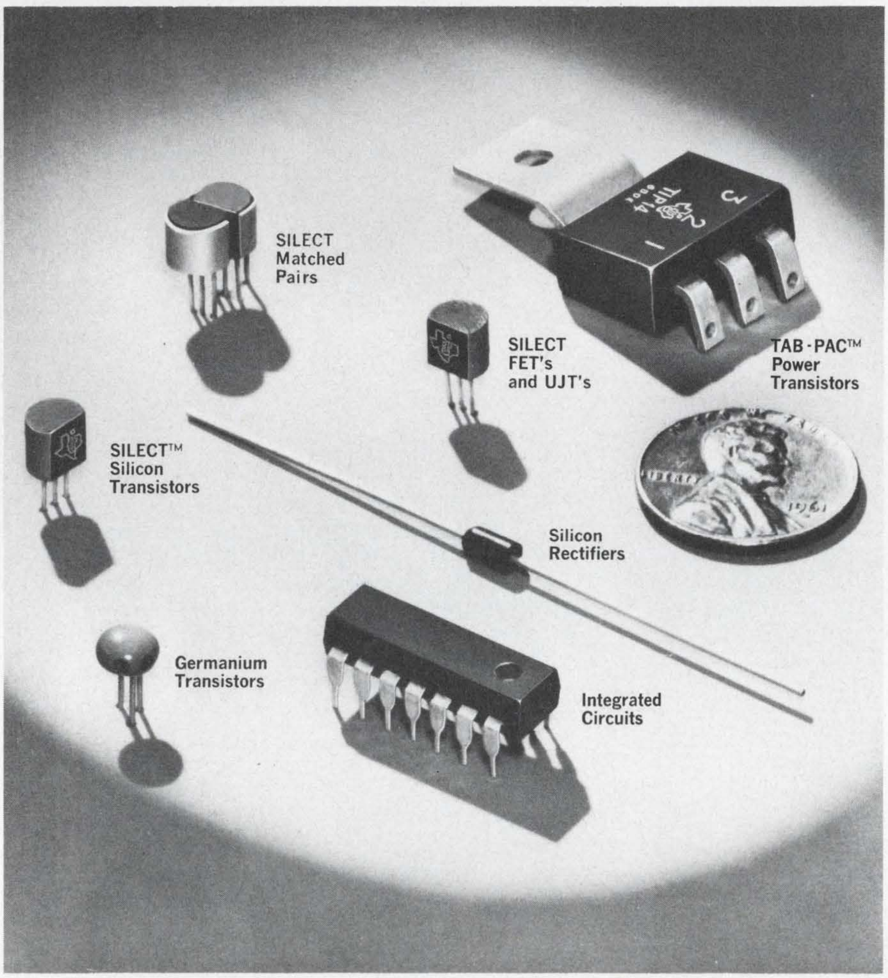

Figure 1. Industry's broadest selection of economy semiconductors helps reduce cost, improve performance of industrial and consumer equipments.

New plastic-encapsulated unijunction features 20-times lower leakage at less than 1/3 the price

TI's new TIS43 plastic-encapsulated unijunction transistor — industry's first — now adds increased savings to the inherent economy of simplified UJT circuitry. Made possible by combining TI's proven planar UJT technology with advanced SILECT plastic packaging techniques, this new transistor offers 20 times lower leakage than the best conventional silicon-alloy TO-18 unijunctions currently selling at more than three times the price.

Extremely low leakage (10 nA max, 0.1 nA typical at 25°C) makes the TIS43 ideal for precision timing circuits. Low leakage also permits the use of smaller, less expensive capacitors. This economy, combined with low initial price and the reduced component count possible with unijunction circuitry, permits important cost savings in a wide range of applications.

Vibration and shock resistance have been increased threefold over alloy UJT's through use of the more rugged planar construction (shown in figure 3) and a solid, one-piece plastic package. The TIS43 will withstand over 60,000 G constant acceleration, making it ideal for use in military fuzes and heavy-duty industrial applications.

Principal electrical characteristics are: I_{EO} = 10 nA max at 25°C; $\eta = 0.55$ min, 0.82 max; r_{bb} = 4.0 kΩ min, 9.1 kΩ max; V_{OB1} = 3.0 V min. (Similar characteristics are available in a metal TO-18 package — designated 2N3980.)

Applications include oscillators, voltage-and current-sensing circuits, multivibrators, waveform generators, and astable and bistable circuits. The TIS43 is also ideal for an economical triggering device for SCR's. Circle 181 on the Reader Service card for data sheet.

New plastic package for TI integrated circuits

This new plug-in economy package has 14 pins on 100-mil centers with rows 300 mils apart. The package is designed for economical flow-soldering techniques and is adaptable to high-speed automatic or manual insertion. Most of TI's more than 150 integrated circuit types are available in this new package.

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For FM RF and IF applications, the NPN

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complete electronic systems semiconductors from TI

2N4254-55 Series provides low feedback capacitance (C_{cb} = 0.65 pF max) for high, stable gain without neutralization and low noise (2.8 dB typical at 100 MHz). High power gain (26 dB typical MAG at 100 MHz) makes possible high performance from low-cost circuits. Circle 183 on Reader Service card for data sheet.

For auto radio RF and IF applications, the PNP TIS37-38 is interchangeable with many popular germanium drift-field transistors, providing higher temperature capability at no added cost. Noise figure of the TIS37-38 is 3 dB typical at 1 MHz, 75 ohms. Circle 184 on Reader Service card for data sheet.

Twelve new SILECT silicon bipolar switching transistors

Twelve new economy devices cover a broad range of popular metal-case types. (JEDEC 2N nearest equivalents are indicated in parentheses): TIS51(3011), TIS47(2368), TIS48(2369), TIS49-(2369A), TIS50(2894), TIS53(3639), TIS54-(3640), TIS44(706), TIS45(708), TIS46(914), TIS52(3014), TIS55(3646). Write for specific data sheets.

Two new SILECT N-channel field-effect transistors

Here is industry's first plastic FET chopper. The new TIXS42 features a low $r_{ds(on)}$ of 70 ohms max and low I_C of 5 nA max at 25°C. It is well suited to high-speed commutators, relay contact replacement, and analog-digital converters. Circle 185 on Reader Service card for data sheet.

For VHF TV, FM radio and communications equipment, the new TIS34 combines low feedback capacitance (C_{rss} <2 pF) and high transconductance ($|Y_{fs}|$ = 3500 — 6500 μmhos), permitting the design of high-gain un-neutralized VHF circuits (grounded-gate connection). Other features include high y_{fs}/C_{iss} ratio (high-frequency figure-of-merit), and low cross-modulation. Circle 186 on Reader Service card for data sheet.

New plastic-encapsulated germanium planar transistors

Two new additions to TI's plastic-encapsulated germanium planar line cover a broad range of AM-FM-TV high-frequency applications.

The TIXM10, for RF amplifier and mixer applications, provides an h_{fe} of 16 dB min, 22 dB max at 100 MHz, $r_b'C_c$ of 6 pF max, and a noise figure of 4 dB max at 200 MHz. The TIXM11, for oscillator and IF amplifier applications, features h_{fe} of 29 dB min, 39 dB max at 10 MHz, 30-50 dB at 455 kHz, and 14 dB at 100 MHz. Circle 187 on Reader Service card for data sheets.

New plastic-encapsulated silicon rectifiers

These new compact, low-cost axial-lead silicon rectifiers help you reduce cost of industrial and consumer equipment. The 1N4001-07 rectifiers are rated at 1 amp, 50 to 1000 volts. They are smaller (0.200" long by 0.100" dia) and less costly than glass, top hat, and flangeless rectifiers. Features include high surge current capability (30 amps single cycle surge), low forward voltage drop (V_F = 1.1 V at 1 amp), excellent moisture resistance, and an isolated package that requires no insulating sleeve. Circle 188 on Reader Service card for data sheet.

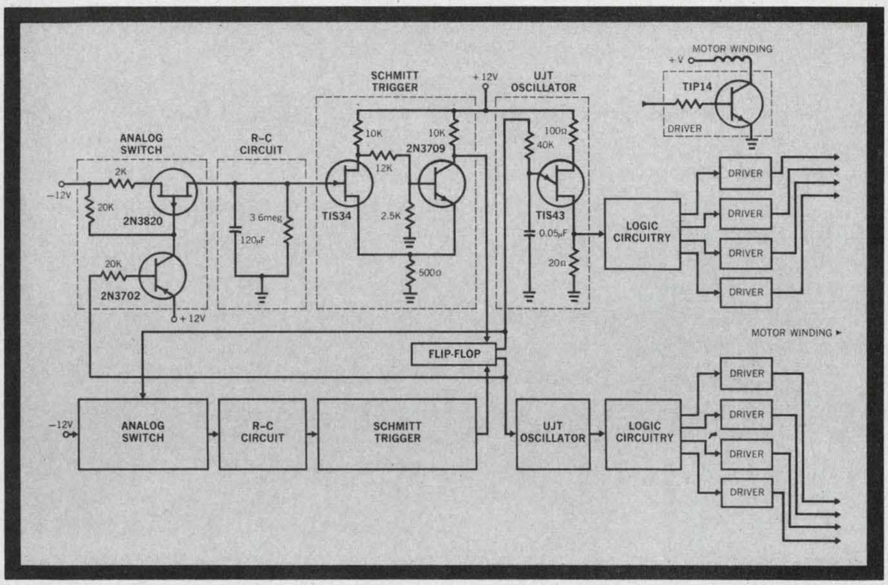

Figure 2. This variable timing control illustrates use of a variety of economy plastic-packaged TI semiconductors — bipolar transistors, unijunctions, FETs, and Tab-Pac™ silicon power transistors.

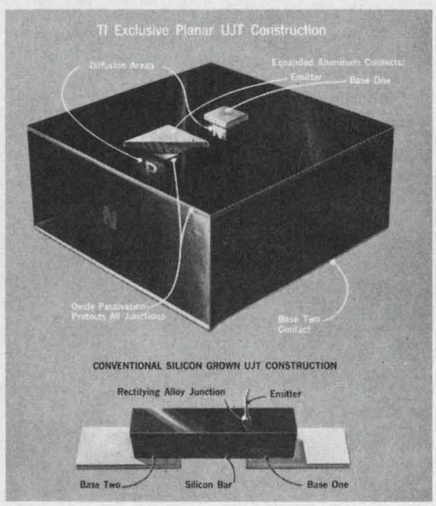

Figure 3. TI's exclusive planar UJT gives lower leakage and greater reliability than conventional silicon alloy UJT's.

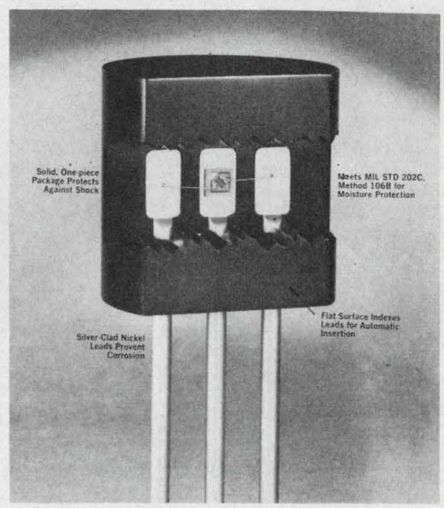

Figure 4. Model illustrates simple, rugged construction of SILECT (SILicon EConomy Transistor) package. Rapidly expanding, mechanized production assures volume availability.

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Predict common-emitter performance

before you build. Use these graphs to determine quickly and accurately its step response as an amplifier.

Examine any modern amplifying or switching system—and chances are you'll find at least one common-emitter stage in it. Now, thanks to a master-graph technique, the performance of these popular circuits can be predicted—well in advance of their design.

These easy-to-use charts quickly present a complete picture of the circuit's response to the very basic step-function input. They provide accurate visual information on rise time, bandwidth, slope, time delay, overshoot and other key performance criteria.

In using the graphs, the engineer needs only a knowledge of transistor and circuit parameters. The design technique itself is free of complex, time-consuming calculations and other laborious steps. It is based upon a combination of the *T*-equivalent and the Giacoletto simplified circuit versions, as used in common-emitter analysis. It marries the comprehensiveness of the former technique with the ease of the latter, and it contains none of the disadvantages associated with either.

Survey master chart for response

For this design technique, the step response of the common-emitter is used to generate a plot (family) of response curves. Master charts are thus formed and then used repeatedly to describe the desired response of a particular case.

The master graphs are directly applicable to single-ended common emitter circuits in amplifier design, and they can be extended to switching circuits through piece-by-piece linearization.

The engineer usually begins his task with vendor specifications and design information on how to load the circuit. These data allow him to solve for the time constants required by the graphic method. With these constants, and the aid of the master graphs, he then determines the desired output waveshape. Visual inspection of this waveshape, in turn, reveals rise time, slope at various waveform points, delay from the start of the input pulse to any convenient point of the output, and the in-phase overshoot. If bandwidth is required, it can be derived from the rise time through well-known bandwidth/rise time relationships.

A typical common-emitter circuit driving an RC load and its associated *T*-equivalent are shown in Fig. 1. The *T*-equivalent model provides a comprehensive representation of the true transistor, but the calculating steps leading to its solution are often prohibitively time consuming.[1,2] Even for a simple case, such as the linear transistor inverter, the combination of loop and node equations requires the laborious calculation of third-order equations for V_{out} in terms of a step input.

The Giacoletto model (Fig. 2) is a simplified equivalent circuit that eases the paperwork, but it gives a poorer representation of circuit performance.[3] While this solution yields acceptable answers for delay and rise time, it fails to reflect the in-phase overshoot that characterizes the step response. The model's forte is the separation of the input and output loops; this facilitates the solution of the input and output time constants.

Models combined for complete analysis

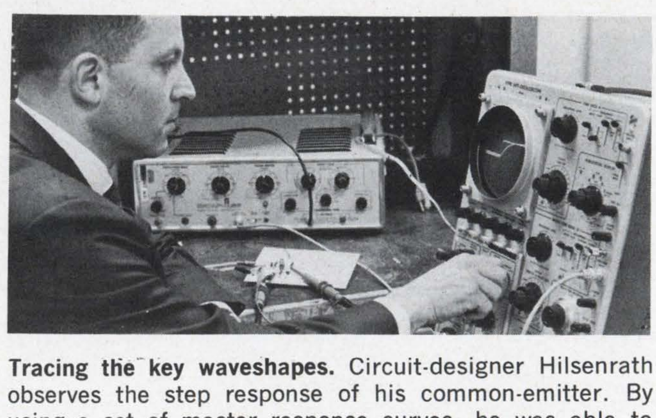
The Giacoletto analysis provides the basic equations for the present graphic technique. However, the well-known, in-phase overshoot, which is maintained in the truer, T-equivalent model, is restored in the graphic analysis by incorporating a simple corrective term.

In accordance with Fig. 2, Eqs. 1 and 2 are written in the Laplace form that describes the relationship between input and output loops. Thus,

$$V_{out} = -\frac{\alpha_o}{r_e}(V'Z_L)\,, \qquad (1)$$

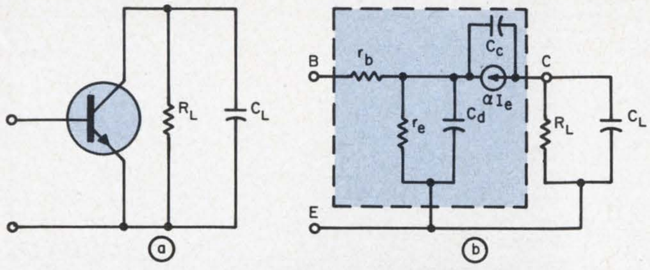
$$V' = -\frac{V_{in}}{s}\left(\frac{Z_e}{Z_e + r_b}\right), \qquad (2)$$

where Z_L is the parallel combination of R_L and C_L and Z_e is the parallel combination of C_{eq} and r_e $(1-\alpha_o.)$ Note that $C_{eq}=C_d+C_c\ [1+(\alpha_o R_L/r_e)]$

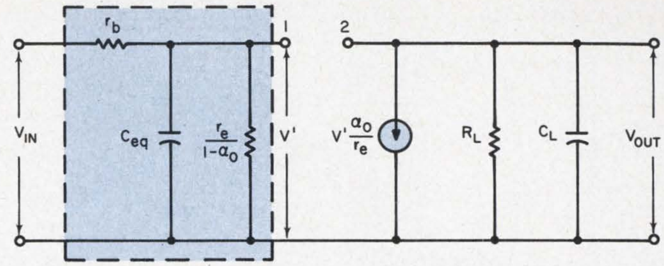


Tracing the key waveshapes. Circuit-designer Hilsenrath observes the step response of his common-emitter. By using a set of master response curves, he was able to predict performance before he built the network.

Fred Hilsenrath, Project Engineer, IBM Systems Development Div., San Jose, Calif.



1. **In a typical common-emitter circuit** (a), RC loads must be driven. The step response for this application is the basis for deriving a set of master response graphs. Solutions for the T-equivalent (b) of the transistor often entail complex cubic equations.



2. **The Giacoletto model** is a simplified version of the common-emitter's equivalent circuit. Quadratic equations are used to solve for its response, but the representation is not as complete as the T-equivalent's. A combination of two models gives the best results.

and $\alpha_o = \alpha(1 + j\omega/\omega_\alpha)$, where ω_α is the cutoff frequency of the collector generator. The resistance of the source (R_s) is lumped with (added to) the base resistance r_b.

It follows that the normalized output voltage, as a function of time, is

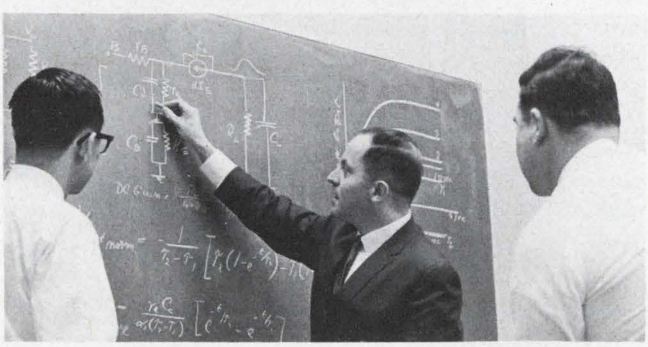
$$V_{out,(norm)} = -\frac{1}{(\tau_2 - \tau_1)} [\tau_2(1 - e^{-t/\tau_2}) - \tau_1(1 - e^{-t/\tau_1})], \quad (3)$$

where τ_1 is the input loop time constant $= r_e r_b C_{eq}/[r_e + r_b(1-\alpha_o)]$ and τ_2 is the output loop time constant $= R_L C_L$. Equation 3, which eliminates unnecessary reference to the output amplitude, is in a convenient form for development of a normalized plot.

Accounting for rise and fall times

Equation 3 will not give explicit solutions for rise and fall times, because of the transcendental nature of the expression. The desired information is obtained indirectly by finding the 10% and 90% points of the output waveshape. These points can be easily located by constructing families of curves of the two exponential expressions $-\tau_2(1-e^{t/\tau_2})$ and τ_1 $(1 - e^{t/\tau_1})$. These curves (Fig. 3), represent a relevant set of parameters and *RC* load values.

Once the graph has been drawn, the appropriate pair of curves for given values of τ_2 and τ_1 can be interpolated from the families of curves and added graphically, to produce the output voltage curve for the particular case under investigation. Inspection of this curve yields the 10% and 90% points from which delay and rise time can then be determined visually. Since the term $1/(\tau_2 - \tau_1)$ is only a multiplier, it has no effect on the waveshape.



Master common-emitter response! Author Hilsenrath shows a colleague how to extend the design technique beyond the realm of simple, small-signal, common-emitter stages, by adding appropriate RC networks.

The curve obtained from Fig. 3 does not reflect the in-phase overshoot component of the output voltage. An approximate expression for this component can be found and plotted for the subsequent addition of this characteristic (as a correction term) to the output voltage curve.

With V' calculated, as in Eq. 2, C_c can be reconnected where it actually belongs—that is, from node 1 to node 2, as shown in Fig. 4. Consider V' as a source with a low output impedance, compared with the combined impedance of C_c and Z_L. Then let the generator $V'\alpha_o/r_e$ go to zero and calculate $V_{overshoot}$ for a step input. Therefore,

$$V_{overshoot} \cong \frac{V_{in}}{s}\left(\frac{Z_e}{Z_e + r_b}\right)\left(\frac{Z_L}{Z_L + Z_{cc}}\right), \quad (4)$$

where $Z_{cc} = 1/sC_c$. The solution, normalized to the same scale factor as Eq. 3, yields:

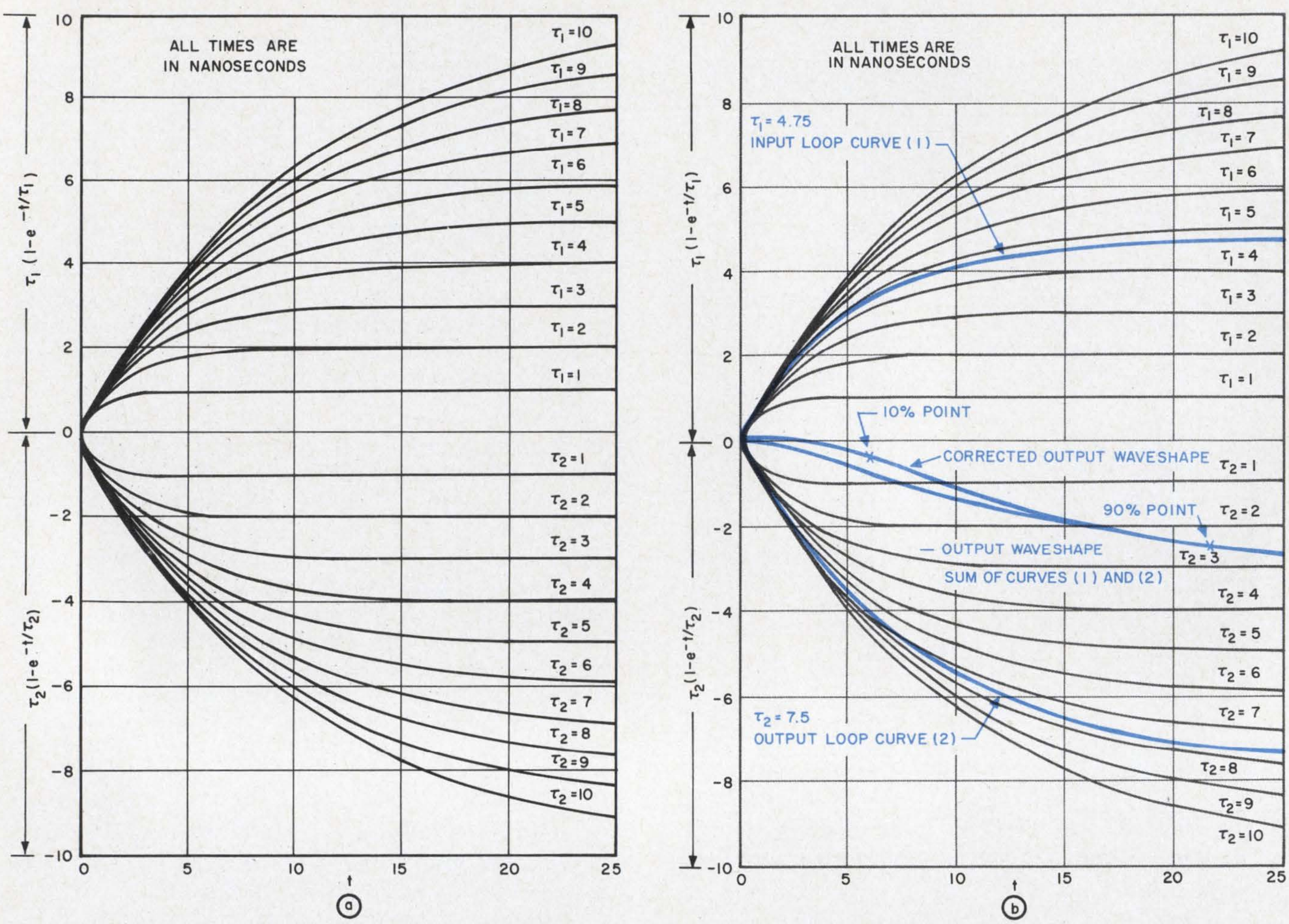
$$V_{overshoot(norm)} = \frac{r_e C_c}{\alpha_o (t_2 - \tau_1)} [e^{-t/\tau_2} - e^{-t/\tau_1}] \quad (5)$$

The exponentials e^{-t/τ_2} and $-e^{-t/\tau_1}$ may be plotted separately and then added graphically to provide the in-phase overshoot curve (Fig. 5).

Making the method more universal

The master graphs can be applied to any common-emitter circuit capable of responding within the range of the indicated time scales and constants. The range, as given, covers any typical medium-speed, common-emitter circuit (a response time of 5 ns or more). The graphs can be extended to slower circuits, by simply multiplying all time scales and constants by one or several orders of magnitude—that is, by 10, 100, 1000, etc. The transistor model described here is not for very-high-frequency applications (such as those involving transistors that respond within 1.0 ns). At these frequencies the model becomes very complex, and the mathematics do not reduce to a form that permits a simple graphic interpretation to be made.

The graphic method was developed specifically for the small-signal, common-emitter circuit. The analysis holds, however, when an *RC* network, consisting of R_E and C_E, is inserted between the emit-



3. **A family of curves** representing a relevant set of transistor parameters and RC load values may be constructed. The graph is then used to predict circuit response. Part "a" is a plot of the exponential portions—here the τ_1 curves refer to the input loop and the τ_2 curves refer to the output loop. The combined waveforms appear in (b).

ter and the circuit common. This is done to achieve dc stability and a high-frequency bypass, and it is valid if the network meets the condition $R_E C_E = r_e C_d$. Under this condition there is no current flowing from node 3 to node 4, and the connection between these nodes can be eliminated. This application is depicted in Fig. 6.

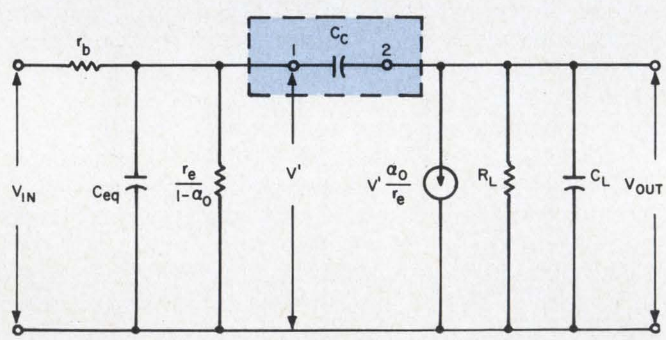
The total impedance in the emitter leg of the model, as shown in Fig. 1b, now becomes r_e', and the diffusion capacitance becomes C_d', where

$$r_e' = r_e + R_E \tag{6}$$

$$C_d' = \frac{C_E C_d}{C_E + C_d} \tag{7}$$

$$C_{eq}' = C_d' + C_c\left(1 + \frac{\alpha_o R_L}{r_e}\right) \tag{8}$$

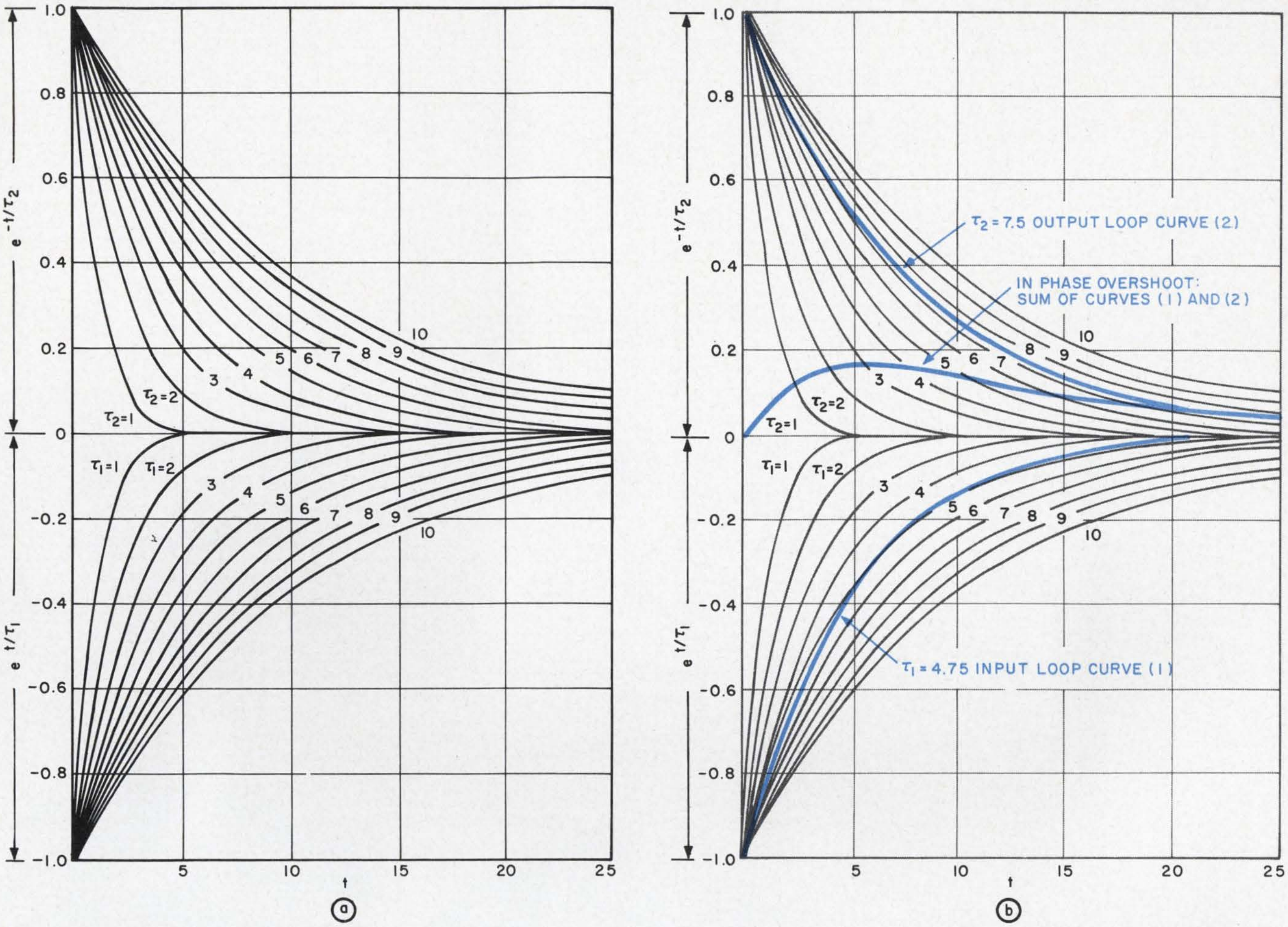
The analysis then proceeds with the time-constant τ_1 calculated with r_e' and C_{eq}'. With this simple modification, the validity of the analysis is thereby extended to another important category—handling signals in Class A operation. Additional extension of the method is achieved through a piece-by-piece linearization that permits application of the technique to the large-signal mode. Observe that the graphic technique described here is limited to the step response, which is the least complicated approach to the analysis of speed response. The mathematics developed for this technique, however, can serve as a guideline to developing similar graphic methods for input functions other than the step and for circuits other than the common-emitter.



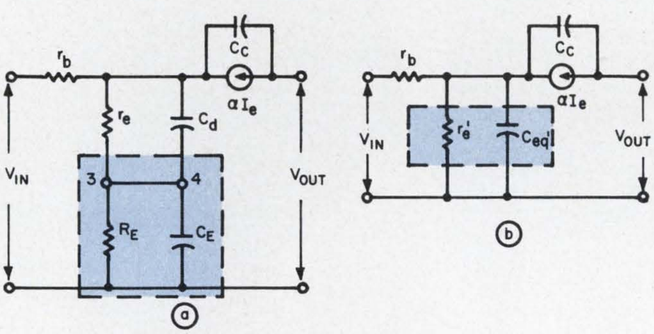
4. **The in-phase-overshoot portion** of the response must be accounted for. This is done by adding capacitor C_c between nodes 1 and 2 in the Giacoletto model (compare with Fig. 2).

Practice makes near-perfect prediction

The simplicity of applying the graphic method is readily illustrated through a typical design problem in which an *RC* network is in the circuit. In this case, performance can be predicted from



5. **This graph permits interpolation** of the in-phase overshoot to be made (a). To the plot of the exponential portions of the normalized overshoot voltage, we graphically add the input and output loop curves to obtain the complete response (b). The graph is applicable to common-emitter circuits.



6. **The design technique may be extended** into another realm of Class A operation, by adding an appropriate RC network between nodes 3 and 4 (a). Because $R_E C_E = r_e C_d$, a simpler equivalent circuit (b) results.

the following set of parameters:

$r_b = 50\ \Omega$	$C_c = 17$ pF
$r_e = 26\ \Omega$	$R_E = 100\ \Omega$
$\alpha_o = 0.99$	$C_E = 15.3$ pF
$\omega_\alpha = 2\pi 100$ MHz	$R_L = 500\ \Omega$
$C_d = 1/r_e\ \omega_\alpha = 61.5$ pF	$C_L = 15$ pF

With this information alone, the designer determines the required response data by serially following these steps:

1. Calculate τ_1 and τ_2, according to the explanatory material after Eq. 3. For the values given, $\tau_1 = 4.75$ ns, and $\tau_2 = 7.50$ ns.
2. Using the τ_1 and τ_2 values, draw two interpolated curves as shown by the heavy lines in Fig. 3.
3. Add graphically the magnitude of the two interpolated curves to obtain the output waveshape shown in Fig. 3.
4. Use the values of τ_1 and τ_2 to draw the two interpolated curves for the exponentials of $V_{overshoot}$ (Eq. 5). These curves are exhibited in Fig. 5.
5. Add graphically the magnitude of the two exponential curves to obtain the in-phase overshoot, as shown in Fig. 5.
6. Correct the scale factor by the constant multiplier $C_c(R_E + r_e)/\alpha_o$, to adjust the curve to the scale of Fig. 3. Here the multiplier is 2.17 ns.
7. Add the adjusted overshoot curve to the uncorrected output waveshape, shown in Fig. 3, to produce the corrected waveshape. For the case under discussion, it can be seen that the 10% point of the corrected waveshape occurs at 6.0 ns, and the 90% point occurs at 21.5 ns. ■ ■

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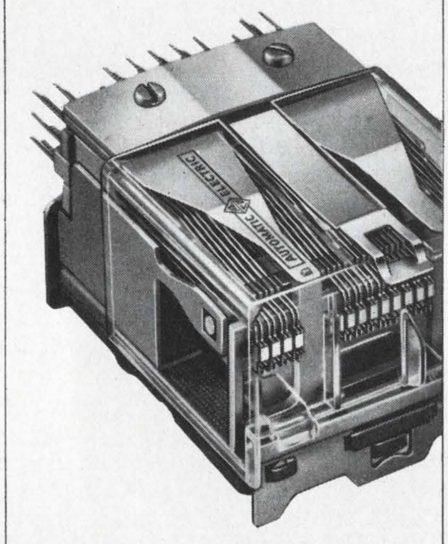

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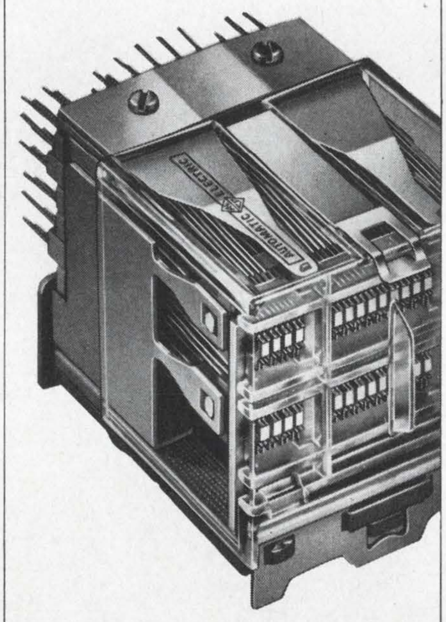

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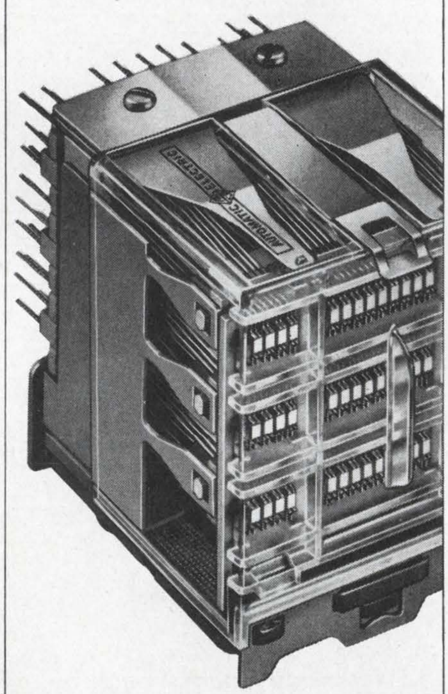

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This graphical presentation of Poisson statistics offers an easy way for engineers to study the probability of events in a series. They allow the rapid calculation of asymmetry, flatness, standard deviation, distribution and frequency. The number of trials, successful events (malfunctions) and the single-unit probability are interrelated with these parameters.

The probability of frequency of failure (success) will be denoted as (PPFF)N. If you want to know the chances of success (or failure) happening exactly N times, the graph in Fig. 1 will provide the answer. This graph determines the frequency of occurrence once the standard deviation and the number of successes (or failures) are known.

The probability that the number of successes or failures will be between zero and N is denoted as (PPDF)N, the Poisson probability of the distribution of failure. The nomograph for this is in Fig. 2. It really determines the distribution of the selected type of events below and above N. If the value of (PPDF)N is known, then either the number of successes (or failures) or the standard deviation may be determined from this graph.

The probability of the number of events occurring above N is represented by 1-(PPDF)N. This function predicts the location and frequency of single events and groupings in a series.

The standard-deviation nomograph (Fig. 3) allows a graphical calculation of the standard deviation from the number of trials, 10^n, and the probability of an event occurring in a single trial, P. The standard deviation may be interpreted as an indication of the shape of the Poisson curve. The Kurtosis value, β, may be read directly from the standard deviation on this graph. This value is an indication of the flatness of the curve, which may be referred to as a normal curve value of three.

The skewness value, or asymmetry, is provided by Fig. 4, from a knowledge of the standard deviation. This value may be compared with a skewness value of zero for a normal curve.

Example:

If a piece of electronic equipment had flown 399 missions with three failures, what would the chances be of a failure on the four-hundredth mission if the equipment had a 0.99 reliability for each mission?

First: The standard deviation σ is determined from the graph in Fig. 3. Enter 400 on the right line, as $4(10^2)$, and 0.01 on the centerline as $1(10^{-2})$. The standard deviation is read at left as 2. Note that this is *not* the error.

Second: The standard deviation of 2, and the number of events (the fourth failure) are entered on the (PPFF)N nomograph (Fig. 1) as follows:

(a) The value of the standard deviation, 2, is entered on σ'. N as 4 is entered on the adjacent slant line. These points are aligned to intersect the right index line with a reference point (line *a*).

(b) N is selected as 4 on the right line. This is aligned with the previously established reference point to intersect a new reference point on the left index line (line *b*).

(c) The standard deviation of 2 is entered on σ, immediately to the right of the left index. This is aligned with the new reference point to intersect the answer at left as 0.2 (line *c*).

Thus the probability of a malfunction on this mission is 0.2%.

In this example, the Kurtosis value is 3.25 and the asymmetry is 0.5, which indicate the shape of the curve. From Fig. 2, the (PPDF)N value is 0.635 and the distribution above N is 0.365.

Thus all the parameters are established without mathematical calculation and with an accuracy that is acceptable for most applications.

Although the graphs are suitable for most applications, the following equations may be used:

$$(\text{PPFF})\ N = e^{-\sigma}\ (mP)\ N/N! \qquad (1)$$

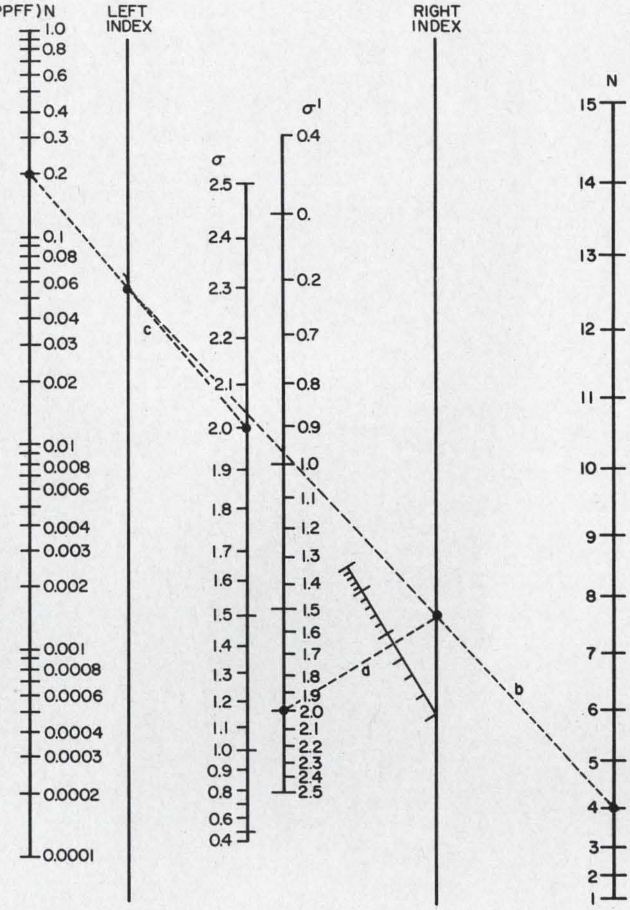
$$(\text{PPDF})\ N = \int_0^N (\text{PPFF})\ N \qquad (2)$$

These equations will provide optimum values. ■ ■

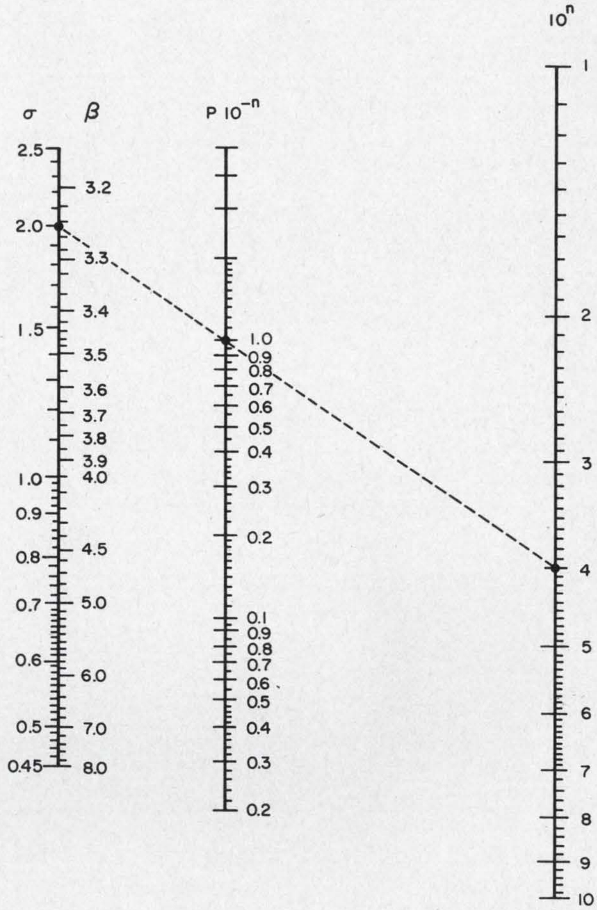
Abbreviations and symbols

N = number of events (successes or failures)
P = probability of an event happening on a single trial
(PPFF)N = probability that an event happens exactly N times
(PPDF)N = Poisson probability that the number of events occuring will be between zero and N
α = asymmetry of the distribution curve
β = flatness of the distribution curve, called Kurtosis
σ = standard deviation, indicates the shape of the distribution curve.

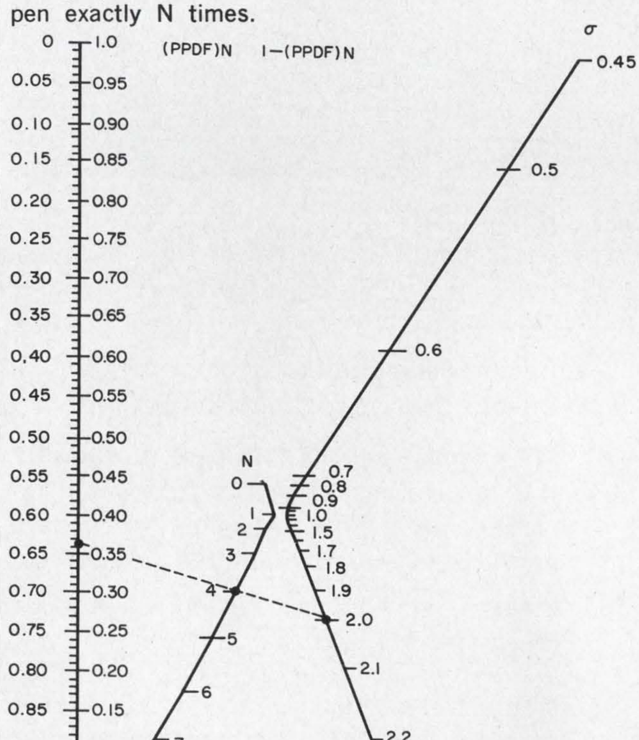
Dr. Robert L. Peters, Consultant, New York, N. Y.



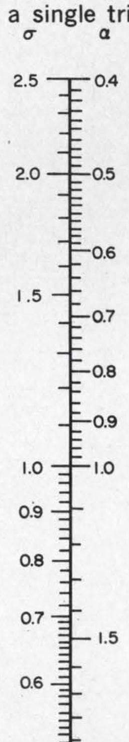
1. **The probability of success or failure** can be found from this graph—that is, the chances that an event will happen exactly N times.



3. **The standard deviation,** σ, can be calculated graphically from the number of trials and from the probability that an event will occur in a single trial.



2. **The Poisson probability** that the number of events occuring will be between zero and N is (PPDF)N. The probability that it will be greater than N is 1 — (PPDF)N.



4. **The relationship** between the standard deviation and the asymmetry, or skewness (α), of the Poisson curve is straightforward.

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14C	1.3400	19	12	.0007	24	.0004	—	—
18C	1.8000	35	23	.0013	46	.0007	—	—
23C	2.3000	60	40	.0022	80	.0011	—	—
27C	2.6093	71	47	.0026	94	.0013	140	.0007
40C	4.000	180	100	.0055	200	.0028	300	.0019
50C	5.000	183	120	.007	240	.004	360	.0025
70C	7.000	377	250	.015	500	.0075	750	.005
100C	10.000	545	360	.020	720	.010	—	—

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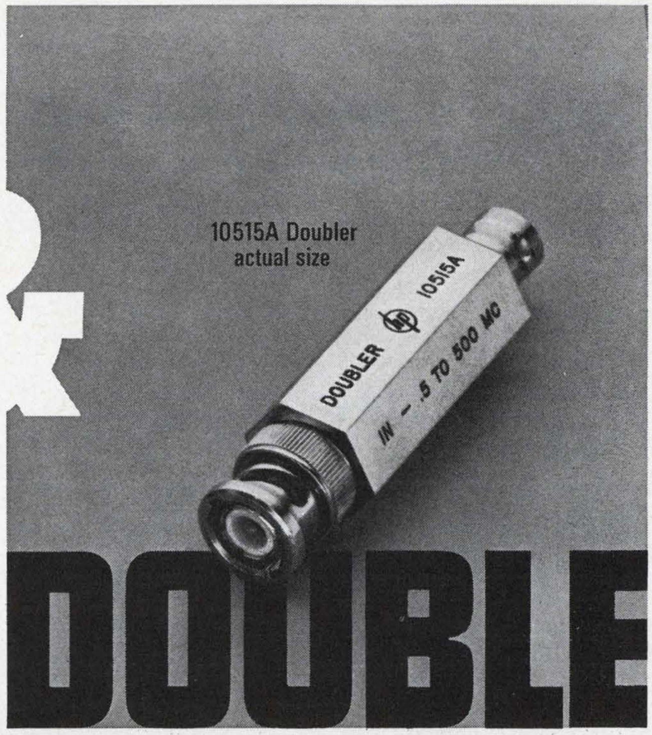

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Such an inverter is used to convert dc to polyphase ac to drive such things as servo tuning systems and cooling motors. The advantages of a digital approach to inverter design include the possibility of using integrated circuits. This can reduce cost and weight and improve reliability.

A block diagram of a three-phase power inverter is shown in Fig. 1. The frequency of the astable oscillator used to drive the counter is equal to the product of twice the number of phases and the desired output frequency. For example, to build a 400-Hz, three-phase power inverter, the oscillator frequency would be 2400 Hz (2 x 3ϕ x 400 Hz).

The counter, a digital frequency divider, provides properly phased switching voltages to the power transistors, which drive the output transformer. Known as a Johnson or a Tarczy-Hornoch modulo-n counter, it is basically a shift register. The output is fed back into the input to achieve a counting operation. The output from each stage of the counter is a square wave at the output frequency. Each successive output is delayed in phase by one full cycle divided by the number of the division. In a divide-by-six counter, each successive output would be delayed by 60 degrees.

Although Johnson counters can be constructed of discrete components, they are best built with the integrated-circuit flip-flops and gates that are commercially available. This makes for an extremely small power inverter.

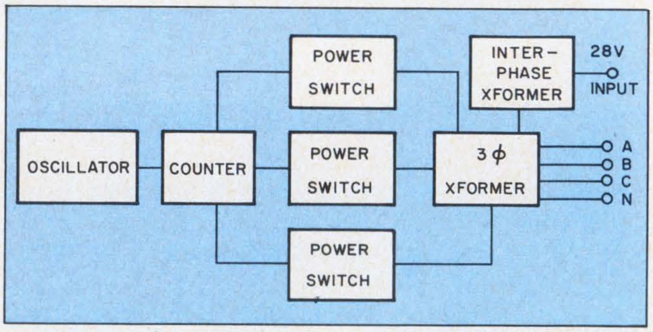
Using this technique, a three-phase, 400-Hz, 115-volt power inverter was developed to drive a blower motor. The inverter operates from a 28-volt dc power source. The internal multivibrator operates at 2400 Hz, and the Johnson counter is used to divide this frequency by six. The counter consists of three IC flip-flops (SN 511A) and one IC combination gate and phase inverter (SN 514A). The devices, manufactured by Texas Instruments, are mounted on the printed-circuit board, shown in Fig. 2.

Good decoupling is achieved by using the emitter-follower outputs of the integrated circuits. Each output from the counter drives an intermediate transistor switch, which in turn drives a two-transistor power switch. These power transistors switch the dc input across each of the primary legs of a three-phase power transformer.

The power transistors are operated in a push-pull arrangement by using a bifilar winding on the primaries of the transformer. An interphase transformer is used to develop a quasi-square waveform, Fig. 3. This lowers the harmonic distortion of the output voltage to less than 30 per cent. Thus, better saturation of the power transistors is possible and a cleaner output waveform results.

The operating characteristics of the inverter are given in the accompanying table, and a complete circuit diagram is shown in Fig. 4. This inverter was designed to operate a 125-watt fan motor.

Wayne Malone, Avco Corporation, Cincinnati, Ohio.



1. **Three-phase inverter** uses four IC packages and 15 transistors. The power-switch block includes two transistor switches in parallel.

Inverter characteristics

	Three-phase inverter	Two-phase inverter
Input		
Operating voltage:	18-29 Vdc	18-29 Vdc
Automatic turn-off:	>33 V	>33 V
Maximum voltage:	80 V for 500 μs	80 V for 500 μs
Power (resistive load):	250 W	65 W
Output		
Voltage (@28 V input):	115/200 Vac, Y-connection, 3—ϕ	115 Vac, 2—ϕ
Frequency (—5%, +15%):	400 Hz	400 Hz
Power:	200 W	40 W
Overload (5 s):	200%	100%
Temperature range:	—55 to 85°C	—55 to 85°C
Size:	60 in.^{3}	18 in.^{3}
Weight:	3.25 lbs	1.5 lbs

A two-phase, 400-Hz power inverter was also developed to operate a small blower motor and a servo system. This inverter consists of an astable multivibrator oscillator that operates at 1600 Hz, a Johnson counter that uses two flip-flops, and a power switch that delivers 15 watts of square wave power for each phase. Its operating characteristics, too, are given in the accompanying table.

The servo and blower motors could have been powered by a single-phase inverter, with the use of a phase-shifting capacitor. However, temperature requirements would have called for extremely large, heavy and expensive components. All three of these factors were greatly reduced by using the integrated-circuit packages and the two-phase system. ■ ■

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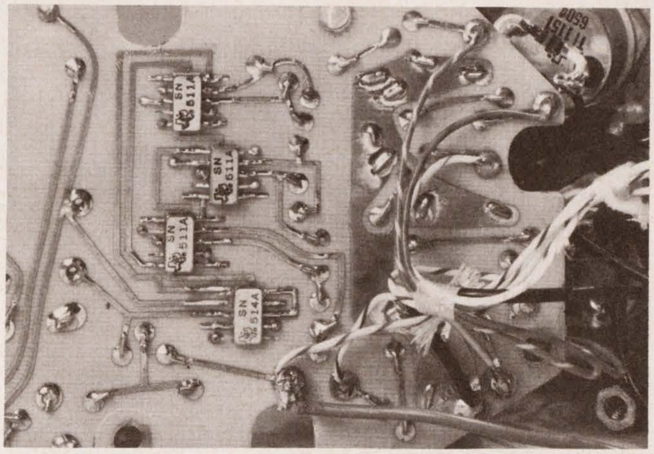
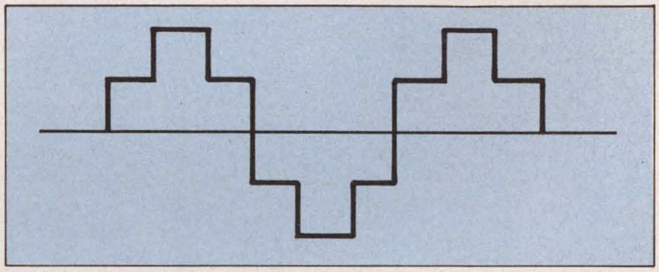
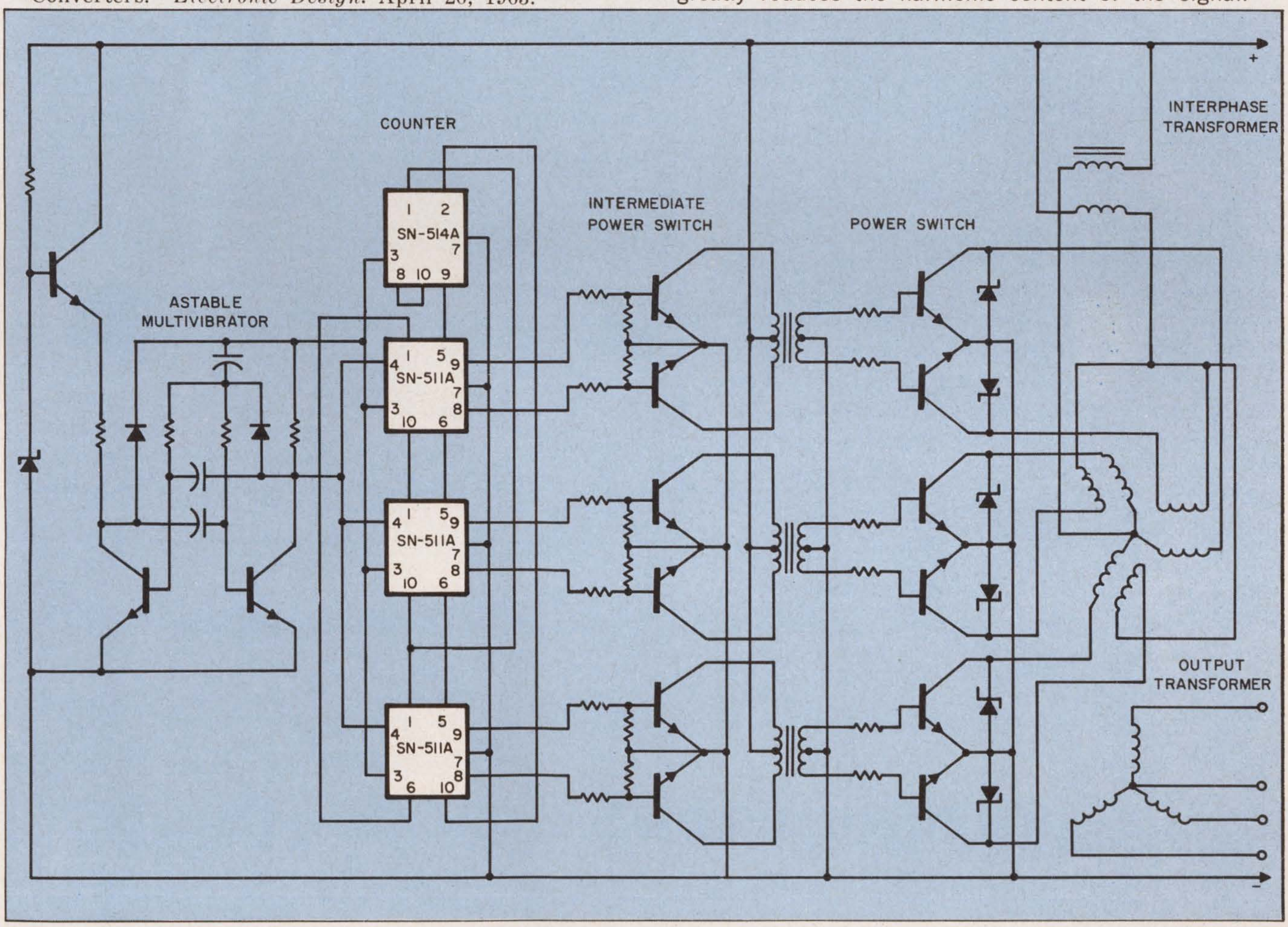


2. **The integrated circuits** are soldered to the printed-circuit board. Their flat shape simplifies the mechanical packaging problem.



3. **Quasi-square waveform** of the output line-to-line voltage greatly reduces the harmonic content of the signal.



4. **Over-all schematic** of the three-phase inverter. The final volume of the inverter package is only 60 cubic inches.

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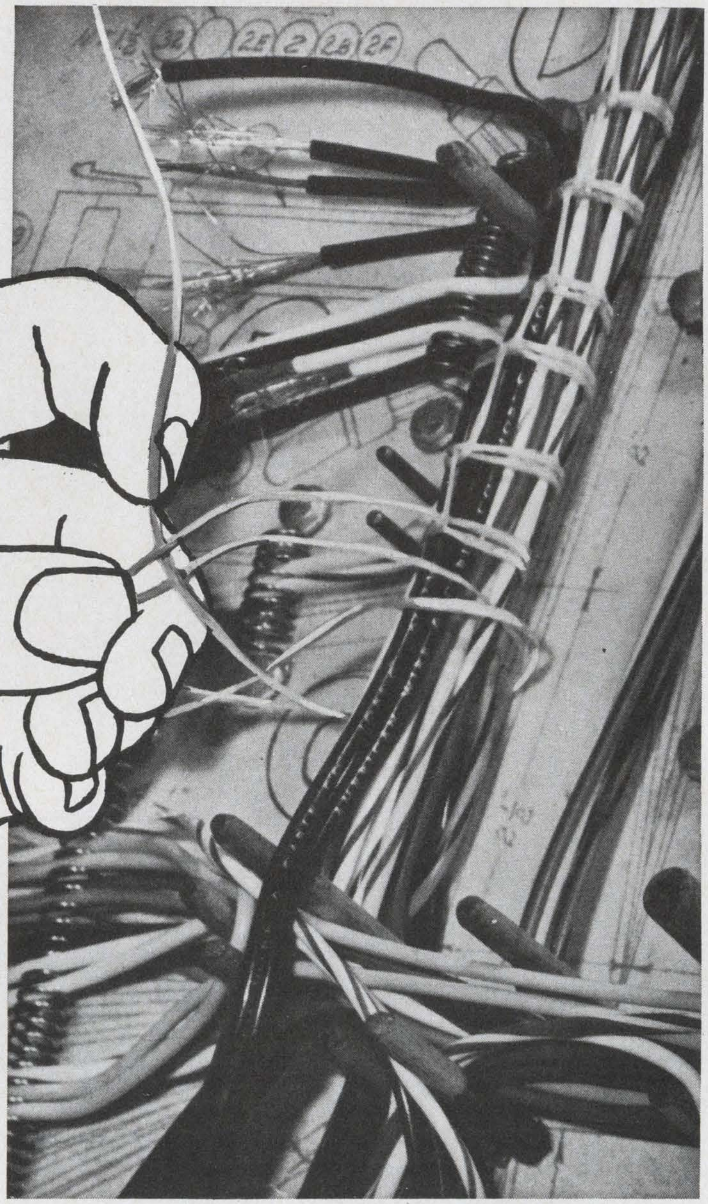

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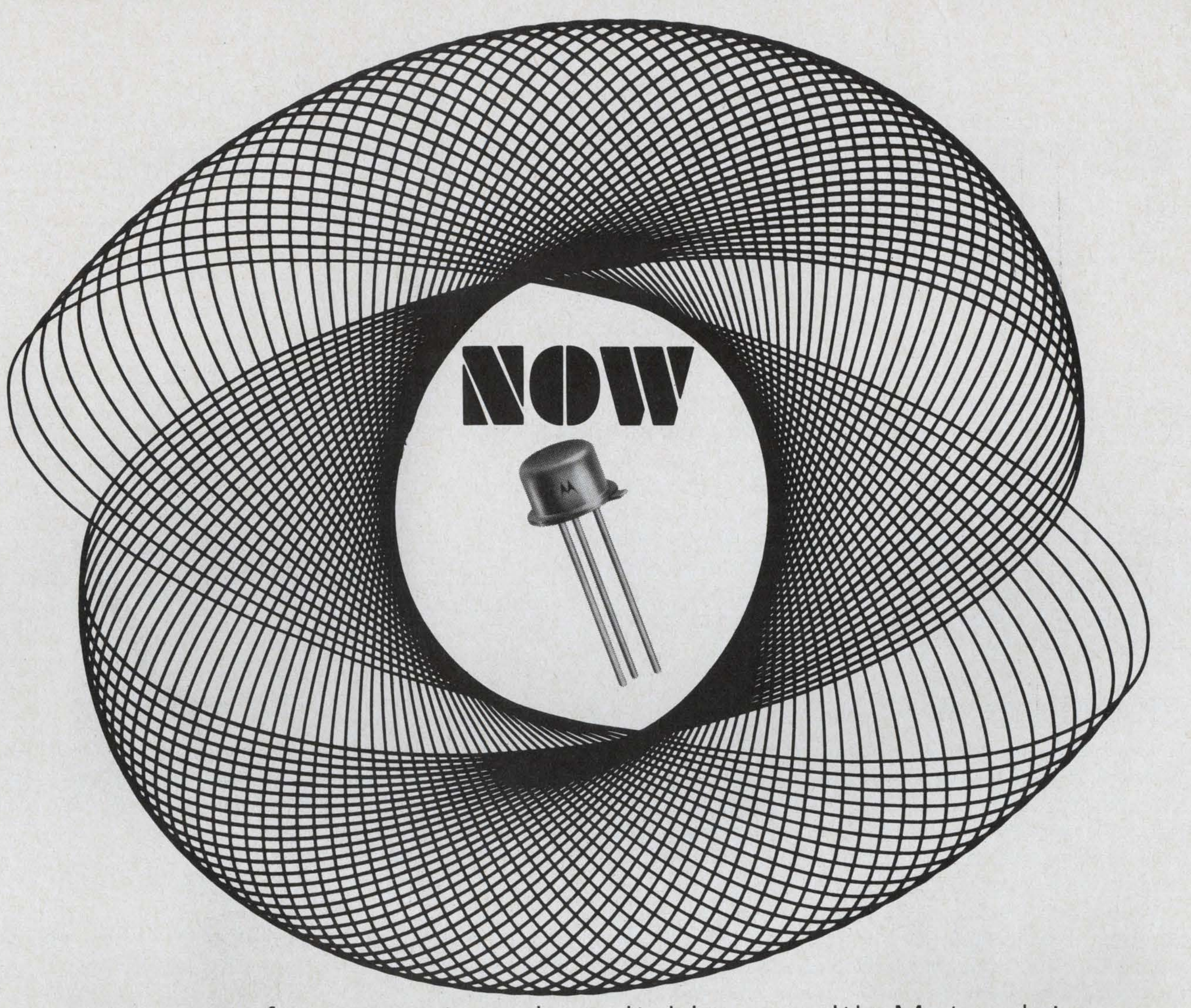

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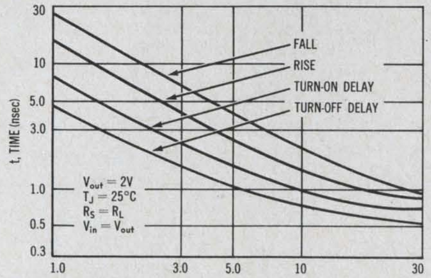
TYPICAL SWITCHING TIMES



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Other high-performance characteristics . . .	
Output Capacitance (C_{obo}) ($V_{CB} = 4$ Vdc, $I_E = 0$, f = 100 Kc)	**2.5 pf max.**
Input Capacitance ($-C_{ibo}$) ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 100 Kc)	**2.5 pf max.**
Collector-Base Time Constant ($r_b' C_c$) ($I_C = 10$ mA, $V_{CE} = 10$ V)	
2N3959	**25 psec max.**
2N3960	**40 psec max.**
Collector-Base Breakdown Voltage (BV_{CBO}) ($I_C = 10\ \mu$Adc, $I_E = 0$)	**20 Vdc min.**
Collector Emitter Breakdown Voltage (BV_{CEO}) ($I_C = 10$ mAdc, $I_B = 0$)	**12 Vdc min.**

*Annular semiconductors patented by Motorola Inc.

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Widen multivibrator ranges by separating the timing and biasing. A constant-current source permits timing ranges up to 200 to 1.

The timing ranges of multivibrators can be increased to as much as 200 to 1 by adding circuitry which essentially separates the requirements of bias and timing.

This technique has been applied to monostable, complementary and astable multis, none of which need be limited to the 20 to 1 timing ranges usually obtained. Thus, the variation on the monostable multis discussed here is 1 to 200 μs; on the astable multis, the frequency may be varied from 25 kHz to 5 MHz.

The monostable multi

Let's first see how the bias and timing requirements are related in a monostable multi, Fig. 1. The timing here depends on capacitor C_1 and a variable resistor, shown as R_2 and a potentiometer P_1. (It's much more economical to vary the timing with a pot instead of a variable capacitor.)

Changing resistor P_1 and R_2 changes the amount of base current into Q_2. The base current variation that can be tolerated depends on the current gain of the transistor. Generally this is, in a worst case, about 20. With the timing capacitor fixed, a bias resistor variation no greater than 20 times in the worst case may be allowed. If the resistor is too small, there is too much base current, causing storage problems. If it is too large, the transistor wlll barely turn on.

Ideally what we'd want is to feed a constant base current into Q_2 that would be turned off during the timing cycle and turned back on at the cycle's end. Then the resistor normally used for both biasing and timing, R_2 and P_1, could be used for timing only. The resistor's minimum value is picked so as not to exceed the maximum base current of Q_2.

Such a switchable base drive is implemented with the four-terminal, current-source network shown in the box in Fig. 1. It works like this:

With Q_1 normally off and Q_2 normally on, the base of Q_3 sits at about 12 volts. Q_3 is forward biased to provide a current of 1 mA to the base of Q_2. A negative-going input pulse cuts off Q_2, which turns Q_1 on. With Q_1 saturated, Q_3 is backbiased.

At the end of the timing cycle, Q_2 begins to turn on, turning Q_1 off, which turns on Q_3. This rapidly saturates Q_2 and ends the cycle.

Gilbert Marosi, Senior Engineer, Link Group, General Precision, Inc., Sunnyvale, Calif.

The design of the four-terminal network proceeds as follows:

$$I_{Cs} = \frac{V_{CC}}{h_{fe3} R_3} \quad (1)$$

$$I_{B3} = \frac{I_{C3}}{h_{fe3}} \quad (2)$$

The current through R_8 and R_9 is designed to be five times I_{B3}.

$$I_{R8,\, R9} = 5\, I_{B3} \quad (3)$$

$$V_{B3} = \frac{V_{CC} R_9}{R_8 + R_9} = aV_{CC} \quad (4)$$

where V_{B3} is the voltage at the base of Q_3 and $a = R_9/(R_8+R_9)$. V_{B3} is picked so as not to exceed the base emitter breakdown of Q_3 when Q_1 is on. Therefore,

$$R_8 = \frac{V_{CC} - V_{B3}}{5\, I_{B3}} \quad \text{and}\; R_9 = \frac{V_{B3}}{5\, I_{B3}}$$

With Q_1 turned off and Q_3 maintaining Q_2 on:

$$I_{E3} = \frac{V_{CC} - V_{B3} - V_{BE3}}{R_1 + R_7} \quad (5)$$

$$R_7 = \frac{V_{CC} - V_{B3} - V_{BE3} - I_{E3} R_1}{I_{E3}} \quad (6)$$

C_3 is a speed-up capacitor which overdrives the base of Q_2 during turn on:

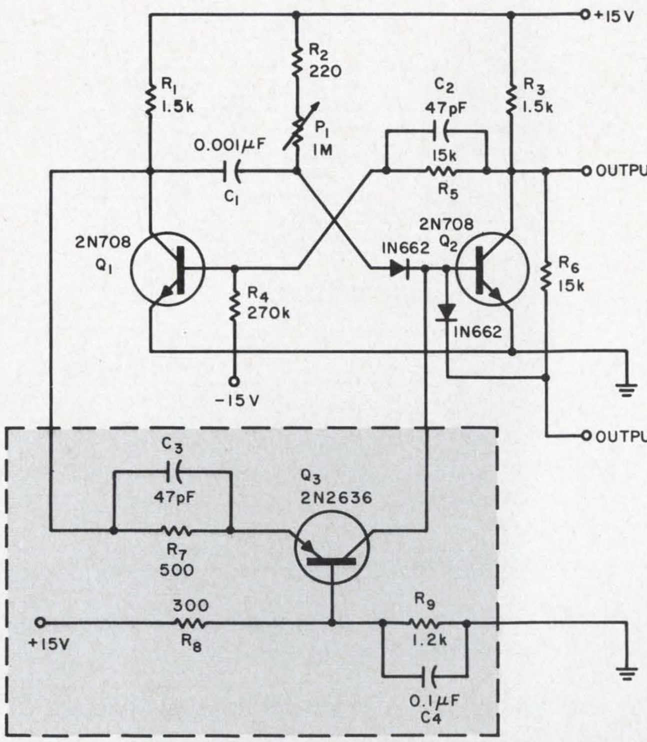
$$C_3 = \frac{Q}{V_{CC} - V_{B3} - V_{BE3}} \quad (7)$$

where Q is the charge stored in Q_2 at the specified collector current of Q_2.

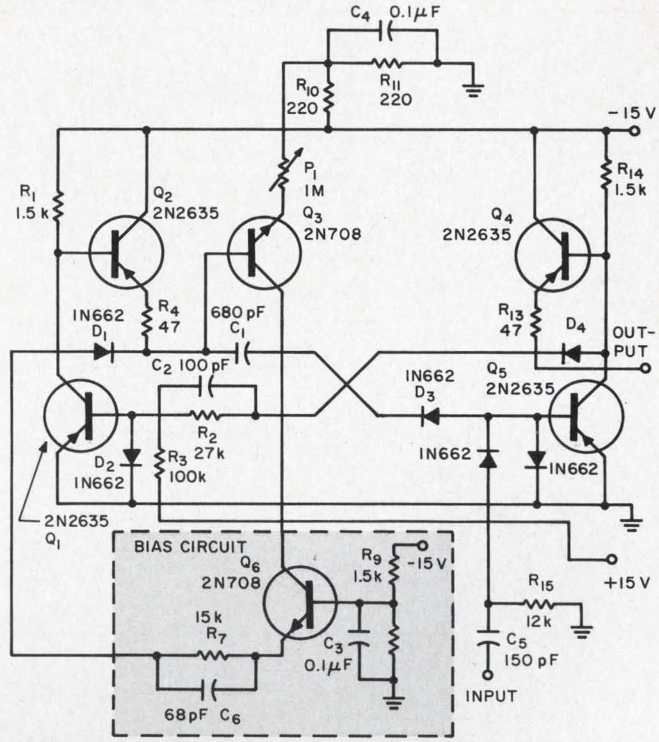
Two advantages are gained by adding this biasing circuit. First, of course, the timing range is greatly increased. This is due mainly to the fact that instead of R_2 and P_1 saturating Q_2 to end the cycle, they now have to provide only enough current to drive Q_2 into the active region. Positive feedback through Q_1 and Q_3 provide the regeneration to end the cycle rapidly.

Also, the turn-on time of Q_2 is now independent of the fall time at the base of Q_2. In a standard monostable multi there has to be an optimum ratio between C_1 and C_2 for long time durations to optimize the turn-on of Q_2. This optimum ratio limits the frequency of operation, since C_2 must be rather large. The positive feedback in the modified circuit allows C_2 to be small—it can be a non-electrolytic capacitor—and therefore it does not limit the frequency.

Adding yet another current source to the mo-



1. **Monostable multi** adjusts its timing by varying potentiometer P_1. But this also affects biasing. Adding the bias circuit allows the resistor combination of R_2 and P_1 to be used for timing only. Range goes from 1 to 200 μs.



2. **More linear operation** is possible by adding still another current source and separating the bias and timing functions even more sharply. Pulse width is more stable because of linear timing capacitor discharge.

nostable multi, Fig. 2, separates the bias and timing functions still more. Pulse width is much more stable because the timing capacitor discharge is linear; Q_3 is a constant-current source.

In the first multi, the total current flowing into the base of Q_2 is the combination of the current through P_1 and R_2 and the bias current provided by Q_3. With P_1 shorted out, considerable current flows into the base of Q_2 at the end of the timing cycle. This drives Q_2 deep into storage, limiting the operating speed.

However, the modified circuit of Fig. 2 cuts off the Q_5 timing current at the end of the timing cycle, or as soon as Q_1 turns off. The storage time involved in the turn-off of Q_5 is due to the turning off of Q_6, introducing overdrive current into the base of Q_5. This is constant no matter what the timing current is. In addition, the storage time introduced by Q_6 when turning on Q_5 is no more than 10 ns with the transistors shown. The operation of the circuit of Fig. 2 is as follows:

Q_5 is normally on, Q_1 and Q_3 are off. Q_6 is forward-biased and provides therefore a steady base current to Q_5. A positive pulse coming in through C_5 cuts off Q_5 and turns Q_1 and Q_3 on. This positive step is transmitted through C_1, which was charged to approximately −15 volts and maintains Q_5 off during the one-shot timing cycle.

C_1 charges through constant-current source Q_3 at a rate determined by the setting of P_1 and the voltage across it, approximately 5.7 volts. When the voltage at the collector of Q_3 has reached −1 volt, Q_5 starts turning on, Q_1 begins to turn off. Q_6 also starts conducting, turning Q_5 on harder. This cycle of events is regenerative so that Q_5 rapidly saturates and cuts off Q_1 which cuts off Q_3.

The circuit effectively separates the charging current through C_1, which varies the timing of the one shot, from the bias current turning on Q_5, which should be constant. The current through Q_3 has to be sufficient to set Q_5 into the active region and start the regenerative action.

Timing current through the capacitor is $V_{CC}/2P_1$. The period is:

$$T = \frac{\Delta E \cdot C_1}{I} \quad \text{or } T = \frac{2\Delta E \cdot P_1 \cdot C_1}{V_{CC}}$$

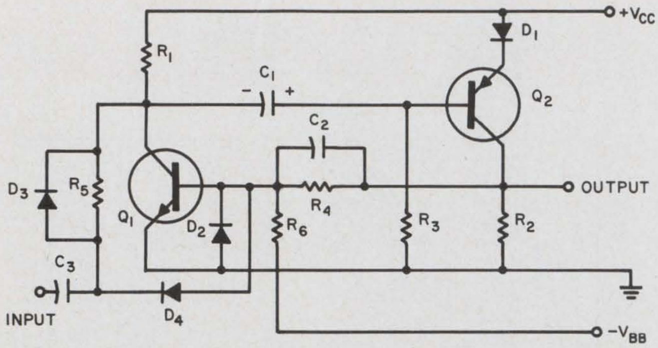
where E is the voltage C_1 is charged to initially. Since C_1 is charged to V_{CC}, the period may be rewritten as $T = 2P_1 \cdot C_1$.

The complementary monostable

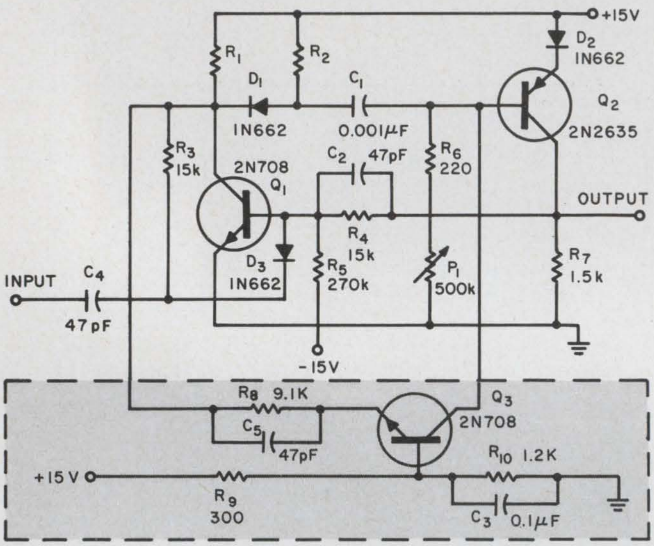
Before explaining the application of this technique to the complementary monostable, let's discuss the multi's operation, since it is not as well known as the ordinary monostable. In the circuit of Fig. 3, Q_1 and Q_2 are normally on. C_1 is charged essentially to the supply voltage, V_{CC}, with the polarity as shown in the figure. A negative trigger through C_3 and D_4 turns Q_1 off. The positive step through C_1 turns off Q_2. C_1 now discharges through R_1 and R_3 until the base-emitter junction of Q_2 becomes forward biased. Q_2 turning on turns Q_1 on and ends the timing period.

The timing equation may be derived as follows:

During the stable state C_1 is charged to $V_{CC} = V_{D1} - V_{BE2} - V_{CS1}$. When Q_1 turns off, the instan-



3. **In a complementary** monostable multivibrator both Q_1 and Q_2 are normally on.



4. **Wide-range technique** can also be applied to the complementary monostable multi.

taneous voltage at the base of Q_2 becomes $V_{CC}= V_{D1}-V_{BE2}-V_{CS1}+V_{CC}\,R_3/(R_1+R_3)$. As soon as the voltage at the base of Q_2 decays to $V_{CC}-V_{D1}-V_{BE2}$, Q_2 turns on and ends the cycle. The voltage at the base of Q_2 as a function of time is:

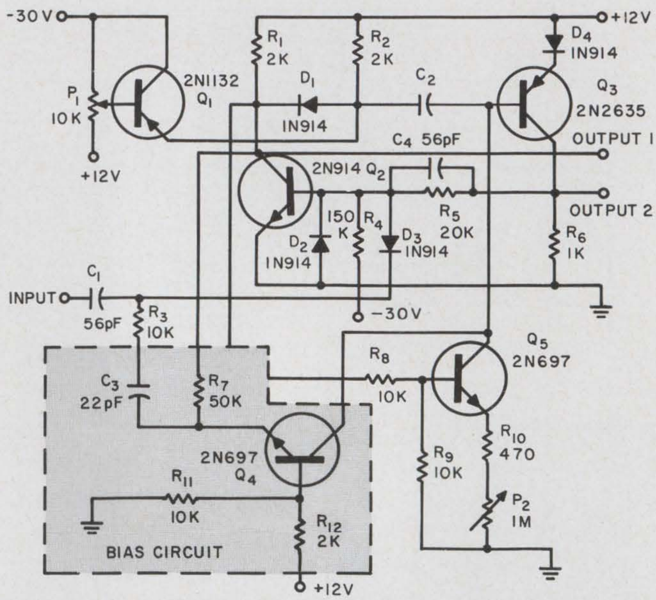
$$E_{B2}=(V_{CC}-V_{D1}-V_{BE2}-V_{CS1}+aV_{CC})\,e^{-t/R_tC} \qquad (8)$$

where $R_t=R_1+R_3$ and $a=R_3/(R_1+R_3)$.
The pulse width may be solved for by substituting $E_{B2}=V_{CC}-V_{D1}-V_{BE2}$ into Eq. 8.

$$T = R_tC\ln\left(\frac{V_{CC}-V_{D1}-V_{BE2}-V_{CS1}+aV_{CC}}{V_{CC}-V_{D1}-V_{BE2}}\right) \qquad (9)$$

If the diode drops are neglected and a is close to 1, the time delay becomes 0.69 R_tc, which is the same as the timing of the standard monostable. At the end of the cycle, C_1 recharges through the saturated impedances of D_1, Q_2 and Q_1. The duty cycle of the circuit approaches 95% making it very useful as a pulse stretcher and frequency divider at high frequencies. The rise and fall times at the collectors of Q_1 and Q_2 are essentially limited by the inherent speed of the transistors.

The wide-range technique may be applied to the complementary monostable multi, Fig. 4. The timing of the circuit is dependent on C_1, R_2, R_6, and P_1. Again, R_6 and P_1 have the dual function of timing and biasing. Q_1 and Q_2 are normally on. Q_3 is forward biased and provides a constant 1 mA



5. **Linear complementary monostable multi** results from still another current source.

to the base of Q_2. A negative trigger through D_3 turns off Q_1. The positive step transmitted through C_1 turns off Q_2. Q_1 turning off back-biases Q_3 which turns off.

As soon as Q_2 enters the active region a regenerative cycle is started. Q_1 starts turning on, which turns on Q_3 and saturates Q_2, thus ending the cycle. D_1 in the circuit decouples the collector of Q_1 from C_1, as the resistance of P_1 drops, so as to be able to keep Q_3 cut off during the timing cycle. With D_1 and R_2 out of the circuit and C_1 connected directly to the collector of Q_1, at the instant of turning off, C_1 is a short circuit.

If the combination of R_6, P_1 and R_1 is such as to make the swing at the collector less than the 13 volts necessary to keep Q_3 cut off, the operation of the circuit will be impeded. The complementary monostable in Fig. 4, is superior to the ordinary monostable of Fig. 1 because of the fast recovery of C_1 through the saturated impedances of Q_1 and Q_2. The ordinary monostable recovers through a resistor.

The design of the network is similar to that of the standard monostable.

$$V_{B3} = aV_{CC} \qquad (10)$$

where V_{B3} is the base voltage of Q_3 and $a=R_{10}/(R_9+R_{10})$.
The current through R_9 and R_{10} should be five times I_{B3}.

$$I_{R9,}\,R_{10} = 5\,I_{B3} \qquad (11)$$

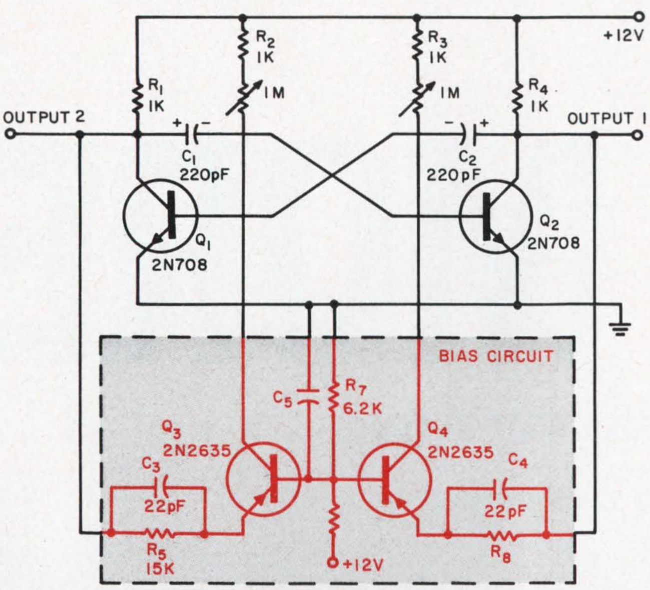
Therefore:

$$R_9 = \frac{V_{CC}-V_{B3}}{5\,I_{B3}} \qquad (12)$$

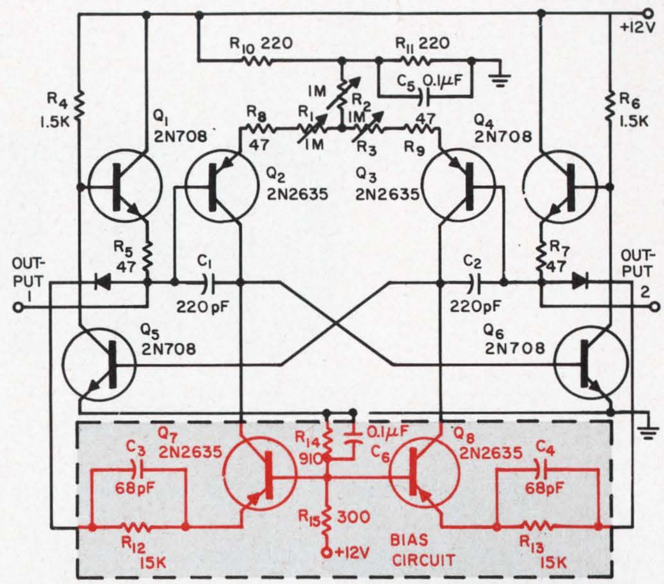
where V_{CC} is the positive supply voltage.

$$R_{10} = \frac{V_{B3}}{5\,I_{B3}} \qquad (13)$$

V_{B3} should not exceed the base emitter breakdown of Q_3. The collector current of Q_3 should



6. **Wide-range astable multi** uses two transistors for constant biasing.



7. **Linear improvement** in the wide-range astable multi is achieved by adding four more transistors.

be able to turn on Q_2 in the worst case.

$$I_{C3} = \frac{V_{CC}}{h_{fe2} R_7} \quad (14)$$

Q_3 supplies current to turn Q_2 on when Q_1 is on, therefore,

$$R_8 = \frac{(V_{B3} - V_{BE3}) h_{fe2} R_7}{V_{CC}} \quad (15)$$

Just as in the linear monostable, Fig. 2, a more linear operation may be obtained by adding another current source to the wide-range complementary monostable, Fig. 5.

The bias current at the end of the timing cycle in the wide-range circuit, Fig. 4, is composed of the current through P_1 and the biasing current introduced by Q_3. Too much storage is introduced as P_1 gets shorted out.

In the circuit of Fig. 5, the timing current provided by Q_5 is turned off at the end of the cycle. Q_4 then rapidly turns on Q_3, introducing very little storage time. The period of this circuit is

$$T = \Delta V \cdot P_2 \cdot C / a \cdot V_{CC},$$

where ΔV is the step transmitted through C_2 to the base of Q_3 when Q_2 turns off. This step is the voltage at the base of Q_1 and also is the portion of V_{CC}—in this case −30 volts—across P_2 and R_{10} when Q_2 turns off.

In Fig. 5, Q_2, Q_3 and Q_4 are normally on, Q_5 is off. A negative trigger to the base of Q_2 turns off Q_2, Q_3 and Q_4.

With Q_2 off, Q_5 is forward-biased. A constant current discharges C_2 towards ground. As soon as Q_3 enters the active region, the collector of Q_2 starts dropping towards ground. Q_4 starts turning on, saturating Q_3 to end the timing cycle.

With Q_2 saturated, Q_5 turns off. Besides the wide range variation afforded by Q_4, clamping the collector of Q_2 to a variable voltage also permits wide timing variations as well as pulse width modulation.

Wide-range astable multivibrator

Extremely wide-range operation may be achieved by using the technique in the astable multivibrator, Fig. 6. Here, two transistors are used for constant biasing. Operation is as follows:

With C_1 charged as shown in Fig. 6, Q_1 turning on back-biases Q_2 and Q_3 which are therefore cut off. Q_2 cut off turns Q_4 on, thereby introducing a constant current into the base of Q_1 and maintaining it turned on. When the potential at the base of Q_2 reaches + 0.7 volts, Q_2 turns on, turning off Q_1 and Q_4. Q_4 turns Q_3 on and the cycle is repeated.

The design of the constant-current source is identical to that of the standard monostable. The frequency may be varied by either P_1 or P_2, the asymetry being varied correspondingly. Wide range is easily attained by insuring a constant drive to Q_1 and Q_2 at the appropriate times. The period of the modified astable multivibrator is

$$T = 0.69(R_1 C_1 + R_2 C_2)$$

Considerable improvement may be achieved by adding four more transistors to the wide-range astable multivibrator, Fig. 7. The sequence of operation is as follows:

Q_5 turning off turns Q_7 on and cuts off Q_2. Q_6 turning on cuts off Q_8 and turns on Q_3. C_1 charges through the low output impedance of Q_1 to the supply voltage, +12 volts. C_2, which has been charged to +12 volts, causes the base of Q_5 to go negative by −12 volts as soon as Q_6 turns on. C_2 then charges linearly through constant-current source Q_3.

When the voltage at the base of Q_5 reaches +0.7 volt, Q_5 turns on and the cycle is reversed. With R_1 and R_3 shorted, the frequency may be controlled symmetrically by R_2. With R_2 shorted, the symmetry may be varied by either R_1 or R_3. The function of Q_1 and Q_4 is to recharge the timing capacitors through a low output impedance, thus permitting widely asymmetrical operation. ■ ■

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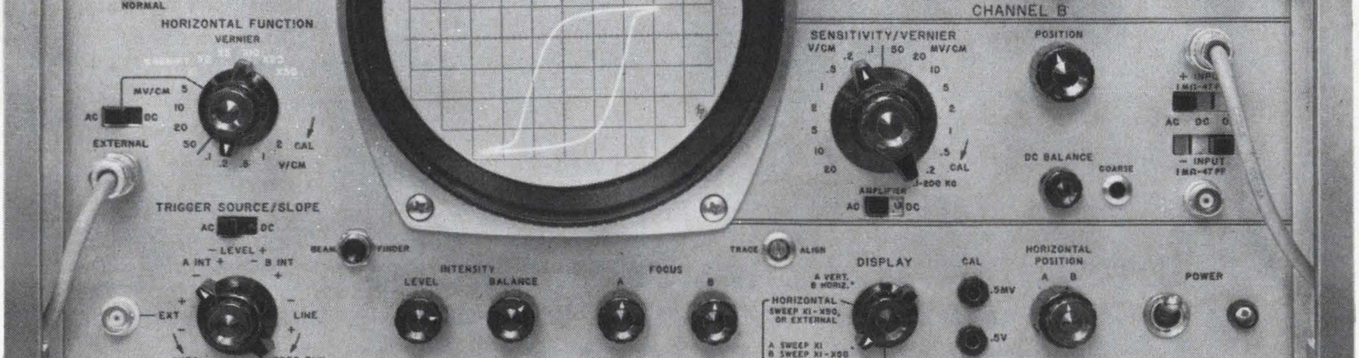


Combine reverse agc and diodes for wide-range gain control in AM command receivers. The design yields low receiver current and high agc loop gain.

An AM command receiver that incorporates an agc scheme requires no agc amplification. It covers a 42-kHz bandwidth centered at 150 MHz.

Designed by RS Electronics of Sunnyvale, Calif., for use in the stratosphere, the receiver had to maintain a stable over-all gain between −65°C and +72°C. Current drain had to be kept low.

Several methods of gain control were investigated. Forward agc would have provided a good control range but at the expense of too much collector current. Reverse agc had the disadvantage of poor signal overloading characteristics.

Primarily to keep the over-all receiver current low, the company decided to use a combination of reverse agc and diodes (Fig. 1). Semiconductor diodes, acting as variable conductance elements in series and in parallel with the signal path, are quite effective as a gain control.

However, the over-all receiver was designed to minimize the demands on the agc. Open loop gain was made stable to ±3 dB over the temperature range, with common-base transistor stages used extensively.

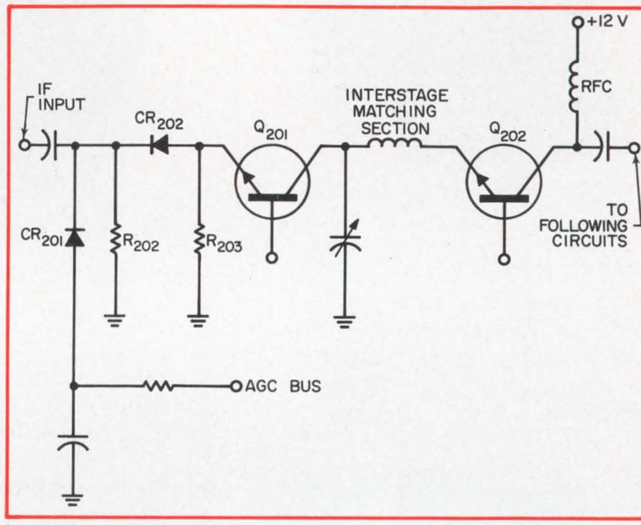
The diode current was offset by the decreased current in the reverse agc stages. The over-all effect was an almost constant receiver current drain, less than 3 dB audio output change and less than 10% distortion at 90% AM, with signal strength varying between 4 μV and 10 mV.

In the circuit of Fig. 1, assume a voltage condition where CR_{201} is not conducting. The series current flow of Q_{201} and Q_{202} is essentially through the ground return provided by CR_{202} and R_{202}. Under this condition the two transistors are operating at their normal current and full gain.

Assume now that the voltage on the agc bus increases in a positive direction. At the onset of forward conduction through CR_{201}, three significant changes take place. First, the forward conduction of CR_{201} increases the shunt conductance across the IF signal path, thus reducing the over-all gain.

Second, the forward current of CR_{201}, now flowing through R_{202}, decreases the current through Q_{201} and Q_{202}, further reducing the gain by the reverse agc characteristics of the transistors.

R. W. Mongeon, Product Manager and **J. Isabeau,** Engineering Manager, RS Electronics Corp., Sunnyvale, Calif.



1. **Basic agc circuit** uses combination of reverse agc and diodes in series and parallel with the signal path.

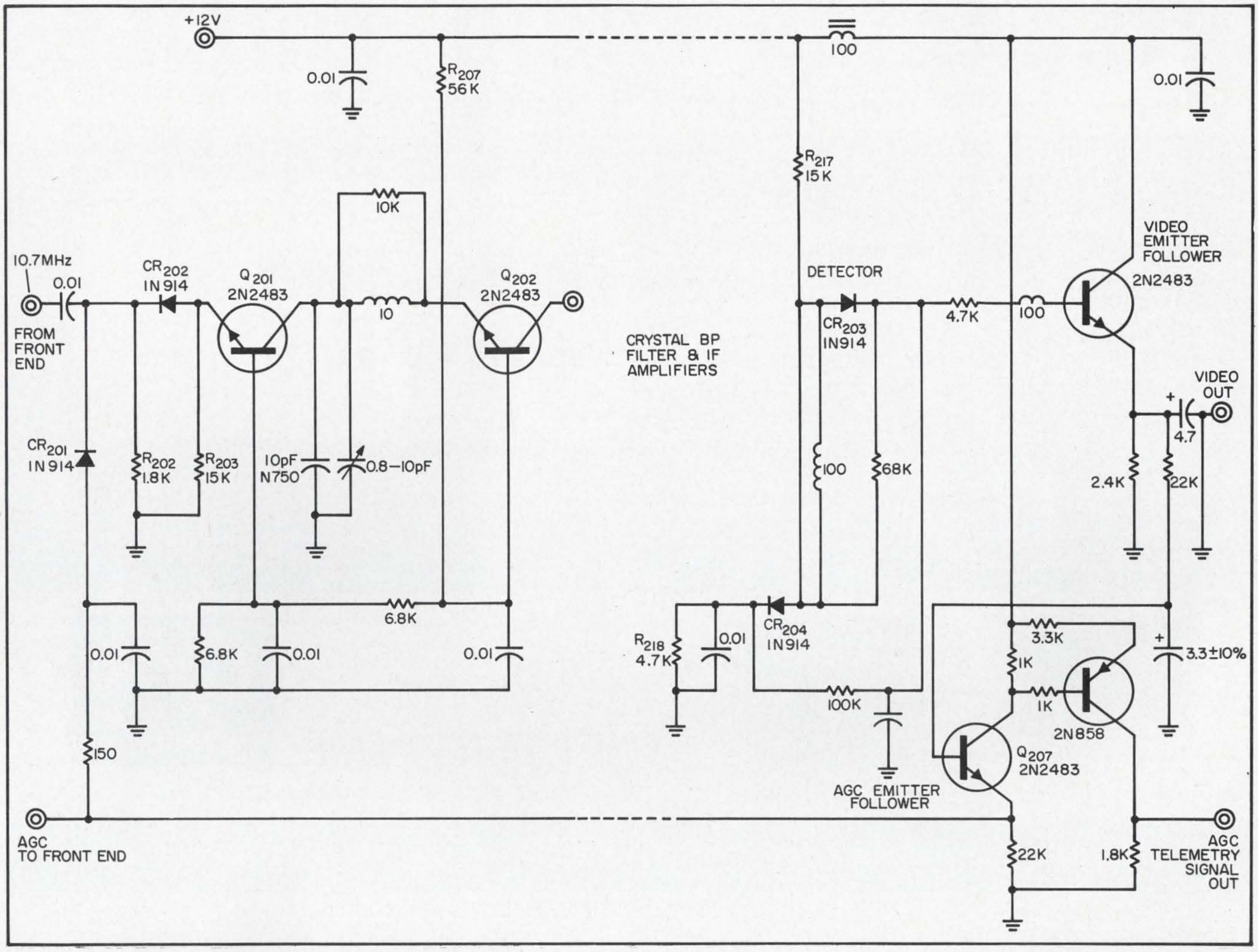
Third, the accompanying decrease in forward current through CR_{202} further reduces the gain, by reduced forward conductance of this diode, which is in series with the IF signal path. R_{203} serves the purpose of maintaining a minimum current through Q_{201} and Q_{202} to prevent distortion.

The combination of diodes and reverse agc provides wide-range gain control for small changes in agc bus voltage. The agc loop gain is inherently high, and no amplification is needed. The agc voltage is derived directly from the AM detector through the agc emitter follower Q_{207} (Fig. 2).

The normal output level of the receiver is set by the AM detector's dc reference level, which is determined by the voltage divider R_{217}, CR_{204} and R_{218}. CR_{204}, in addition to providing forward bias to the detector diode, offers temperature compensation to maintain a constant range.

The agc function on the front end board is the same as that on the IF board, except it is applied to a single transistor instead of a series-connected pair.

There is some difference, however, at the input stage (Fig. 3). The primary function of gain



2. **Agc voltage is derived directly from the AM detector** through the agc emitter follower Q_{207}.

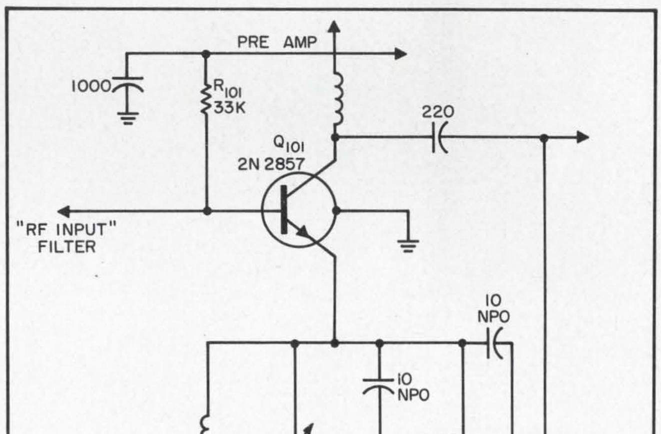
control is provided by CR_{101}, which shunts the collector signal circuit. Forward current through CR_{101} must also pass through R_{103}.

In doing so this current in R_{103} decreases the emitter current of Q_{101} and decreases the gain by the reverse agc characteristics of Q_{101}. In addition the current through CR_{104} also decreases, as does its forward conductance. This results in an increase in emitter degeneration and a consequent further decrease in first-stage gain.

Over-all specifications for the Model 4787 command receiver include:

frequency	142 to 158 MHz
frequency stability	±.005%
input impedance	50 ohms
IF bandwidth	42 kHz min at −6 dB
	100 kHz max at − 60 dB
sensitivity	4 μV max for 20 dB
(50% AM)	(S+N)/N ratio
power input	180 mW at +12 ±.5 Vdc
size	32 in.³
weight	2.5 lbs

Other circuit features of note are the use of a single conversion, with a crystal filter, to obtain the 42-kHz bandwidth at 150 MHz; crystal local oscillator at 160.7 MHz, without multiplication, and a high-level detector that provides good linearity without an audio amplifier. ■ ■



3. **Input stage agc is applied** at Q_{101} through CR_{101}, shunting the collector signal circuit, and R_{103}.

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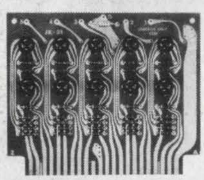

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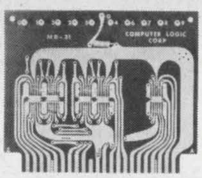

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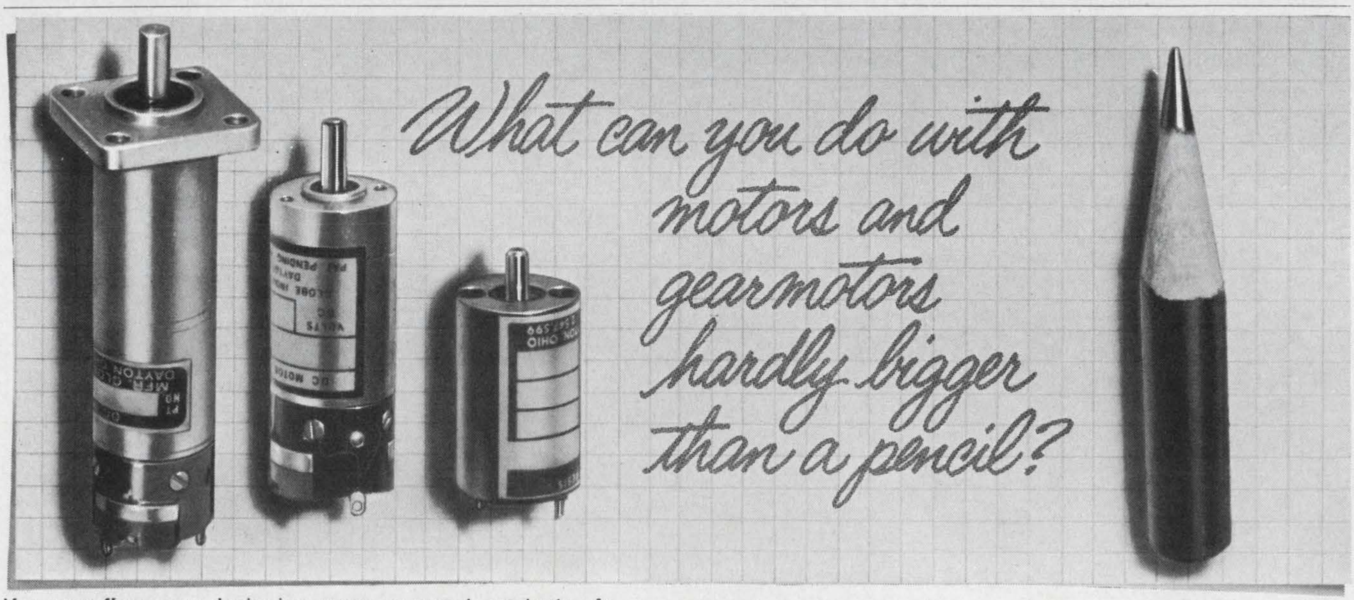

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Tackle those tough decisions with this step-by-step attack. It will help you boost your decision-making score and avoid fumbles.

Can decision-making be learned or effectively improved? Or does it take a special kind of innate talent?

The answer to both questions is yes.

Making a sound decision requires native intelligence. But, more important, the technique involved in making decisions can be learned—and once learned, it can be improved with hard work. Engineers have a head start, because of their training and experience in problem solving.

The busy engineer is constantly expected to make important design or specification decisions. These may involve large sums of money, people's safety, or a company's reputation for engineering competence. With the pressures of business, there isn't always time to seek a place of solitude and reflect on the best solution. Often a quick decision, based on intuition and experience, may be the only—and sometimes the best—alternative. But if you take orderly and logical steps to arrive at a decision, you are more likely to reach a sound one.

There are six characteristics that every capable decision-maker has. Listed in no special order, they are:

- **Analytical ability**—Calls for skill in reducing a complex problem to various elements and identifying truly relevant facts. Includes the capacity for anticipating results following the decision.
- **Ideation ability**—A fancy name for the ability to gather pertinent concepts and facts under a large total picture.
- **Intuitive judgement**—The ability to predict outcomes with reasonable accuracy. Acting on an educated "hunch" is important, if all the facts are not available or if fast action is needed.
- **Courage to act**—Call it "guts," because that best describes what's needed to proceed in view of uncertainties, frustrations, conflicting opinions or opposition.
- **Open-mindedness**—Keeping mental doors open to new avenues or being flexible enough to change direction. What's called for is the ability to sense subtle distinctions or contradictions in available information.
- **Creativity**—The capacity to think of original approaches to solve problems.

With these on your side, there's a step-by-step way to analyze any tough problem and arrive at a decision. If you practice the procedures consciously, they will soon become automatic and comparatively effortless. Here they are:

1. Determine the problem.

State the broad problem or goal simply. Then reduce complex factors to individual problems or situations, for more manageable handling. Pose significant questions: What's really wrong? What causes it? What are the obstacles?

Remember that decision-making isn't only confined to solving problems. Sensing an opportunity to improve a product or a procedure will require you to follow a similar path before you reach your goal.

2. Gather the facts.

If you define your objectives clearly or make a precise statement of your goal, the kind of facts you will need for a sound decision will be apparent. At the same time you'll be able to establish how much time to devote to the search. The more important the decision, the more time that should be allotted for fact-finding, obviously. Bring all the pertinent knowledge, experience and facts you can to bear on the matter.

Here's where investigation, originality and hard work pay dividends. The kind of questions you ask and whom you ask may sometimes seem to have little relationship to the problem under study. But if you're a creative and adventuresome individual, who's not shy about ruffling a few feathers if necessary, you'll dig for all the relevant background on the problem.

Get advice from experts if you can. If it's to be a group decision, have each person contribute knowledge from his own area of competence. Gather facts by your own accurate observations, but be impartial and unemotional. Be sure not to discard those facts that may be opposed to your pet point of view.

3. Analyze alternate solutions

At this point various alternatives appear as solutions.

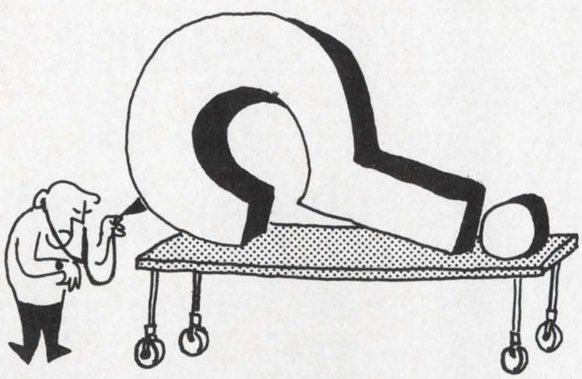
Each has to be weighed logically for its relative importance. A mathematical analysis or construction of a prototype may be helpful. Identify those factors over which you have little or no control.

Reserve critical judgment on a final decision until you are ready to make it.

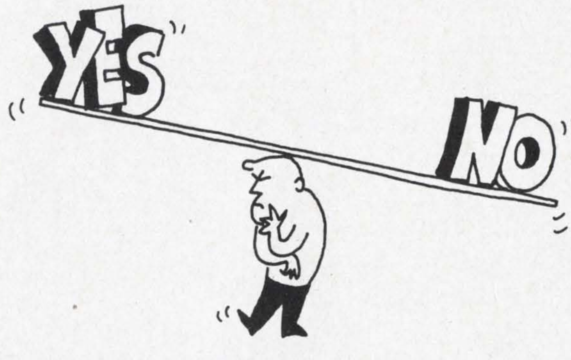
4. Select an alternative and make the decision.

The more the alternatives, the more the need

E. A. Michals, Public Relations Manager, Pyle-National Company, Chicago, Ill.



An accurate diagnosis of the problem is critical, if a successful decision is to be reached. Even simple decisions may involve more factors than are immediately apparent.



Weigh the alternatives logically. Once you've determined their relative importance, you will be well on your way to reaching a sound decision.

for proper evaluation of each alternative. You may have to balance several factors that have no common denominator. Resist making a decision if a change in important information is imminent, or if any important data are incomplete or shown to be unreliable. Avoid, however, needless procrastination, because you'll probably never have all the facts on a particular matter.

Incidentally, deciding to do nothing about a problem for the time being is also making a decision—but often a bad one.

More than one good decision may exist. Is one a little better than the others? There is no substitute for your own commonsense, or even for listening to the "right" advice. The man with more experience in the area under scrutiny, or the one with keener insight, may hold the key to the solution.

5. Put the decision into action.

Top managers are decisive; so—immediately after making the decision, at any rate—stick to your guns, regardless of doubts. Sometimes it may be advisable to test a decision on a small scale, so that adjustments can be made for uncertainties. The probability of success or failure can then be estimated at minimum risk.

If your decision proves to be wrong, admit it (at least to yourself) and change it if you can. Learn from your failures; they will serve as good experience in similar situations. Learn also from your successes; they may be particularly adaptable to new situations in the future.

How an engineer might use the method

Now let's examine a situation where you, as an engineer, might have to make a decision, and let's see how you can put the step-by-step method to work.

Suppose your company is developing a microwave communications system for use by a manufacturer. It will connect his outlying branches with a headquarters. You've been made responsible for selecting the transmission equipment to do the job.

First, *determine the problem.* In this case you'll want to know what type of communication is required (voice, data or maybe video for visual monitoring), so that bandwidth can be established. Next, you'll need to know how much transmitter power and receiver sensitivity will be required for good communications. You may find that your company's "off-the-shelf" gear doesn't have the channel capacity or power to do the job. Now you're faced with the problem of either modifying existing equipment or designing new units.

Gather the facts. Does the customer really need all those channels? Talk to him and find out just exactly what he needs, and where he might change his requirements.

Study the geographical characteristics of transmission paths to determine the number of repeater stations required. How much reliability is needed? What failure reporting features are required? What kind of maintenance facilities does the customer have available?

Armed with the facts, start *analyzing alternative solutions.* Designing new units may be cheaper than modifying existing equipment, because the new equipment might have a broader long-term market. On the other hand, modified units might be put into service faster. Should transmitter power be raised, or receiver sensitivity improved? Or should higher-gain antennas be used? Will equipment improvements reduce the number of repeaters required? Once you've studied all the alternatives, you're ready to take the final step.

Now select the best alternatives and *make your decisions.* If you've followed the preceding steps faithfully, you should come up with a good decision.

Don't get careless

With practice, you'll find that following a logical procedure becomes second nature. When you reach this point, look out! This is the time when almost everyone starts to become careless and begins sliding over some significant step and/or information. Overconfidence resulting from a string of success is an ever-present danger that you'll have to continually guard against. No matter how finely you've honed your decision-making technique, never lose sight of the logical procedure involved. ■ ■

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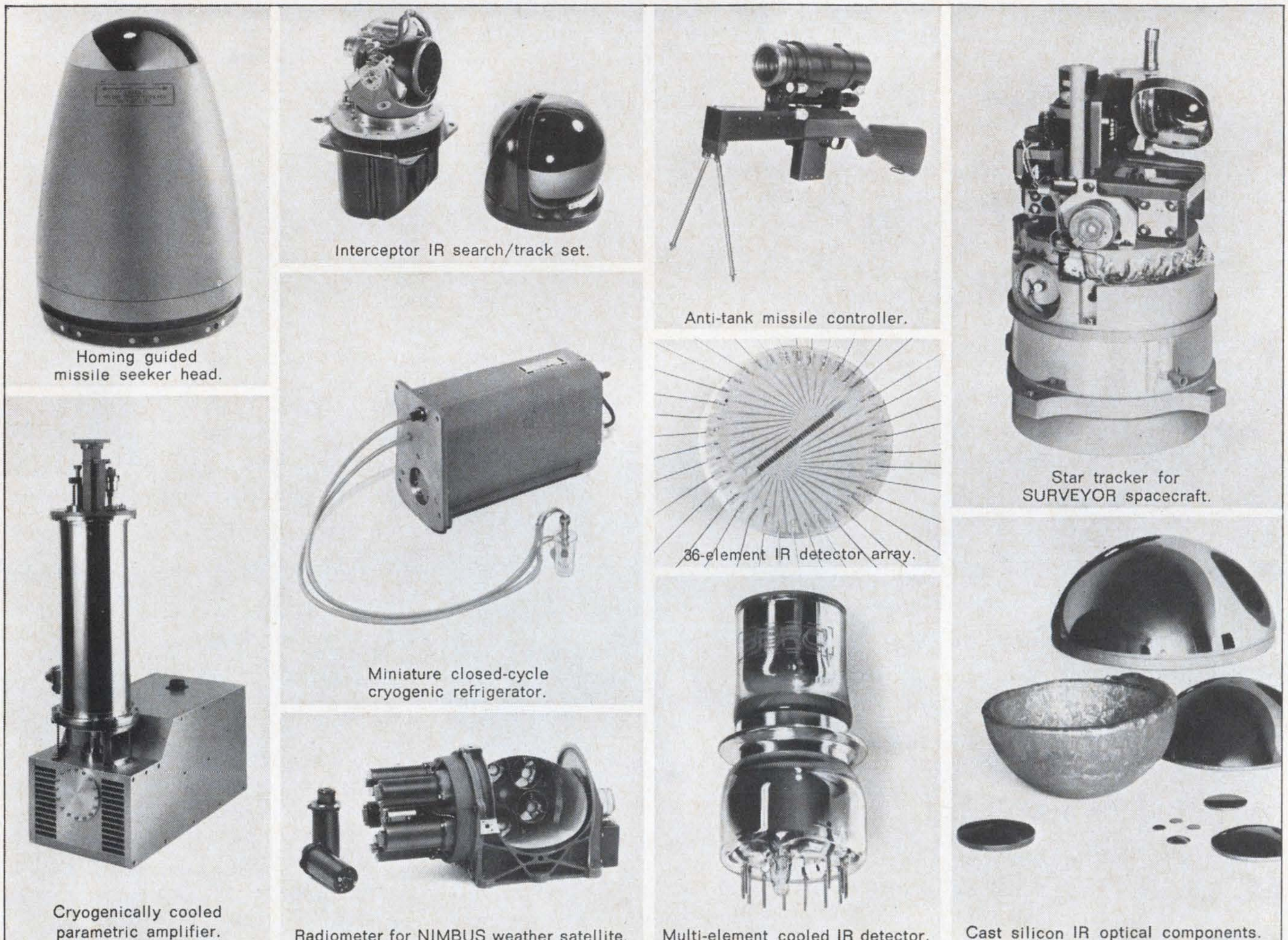

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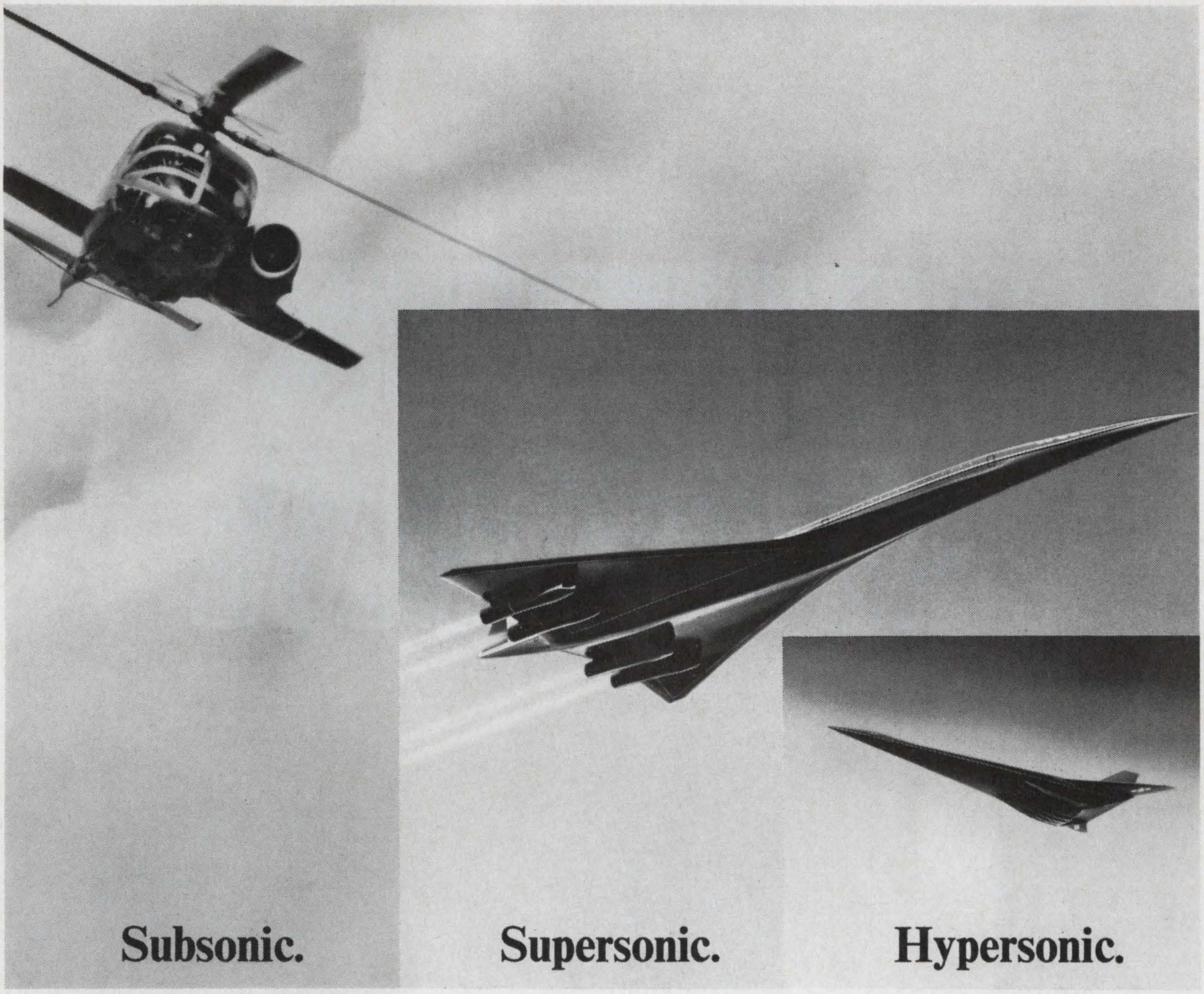

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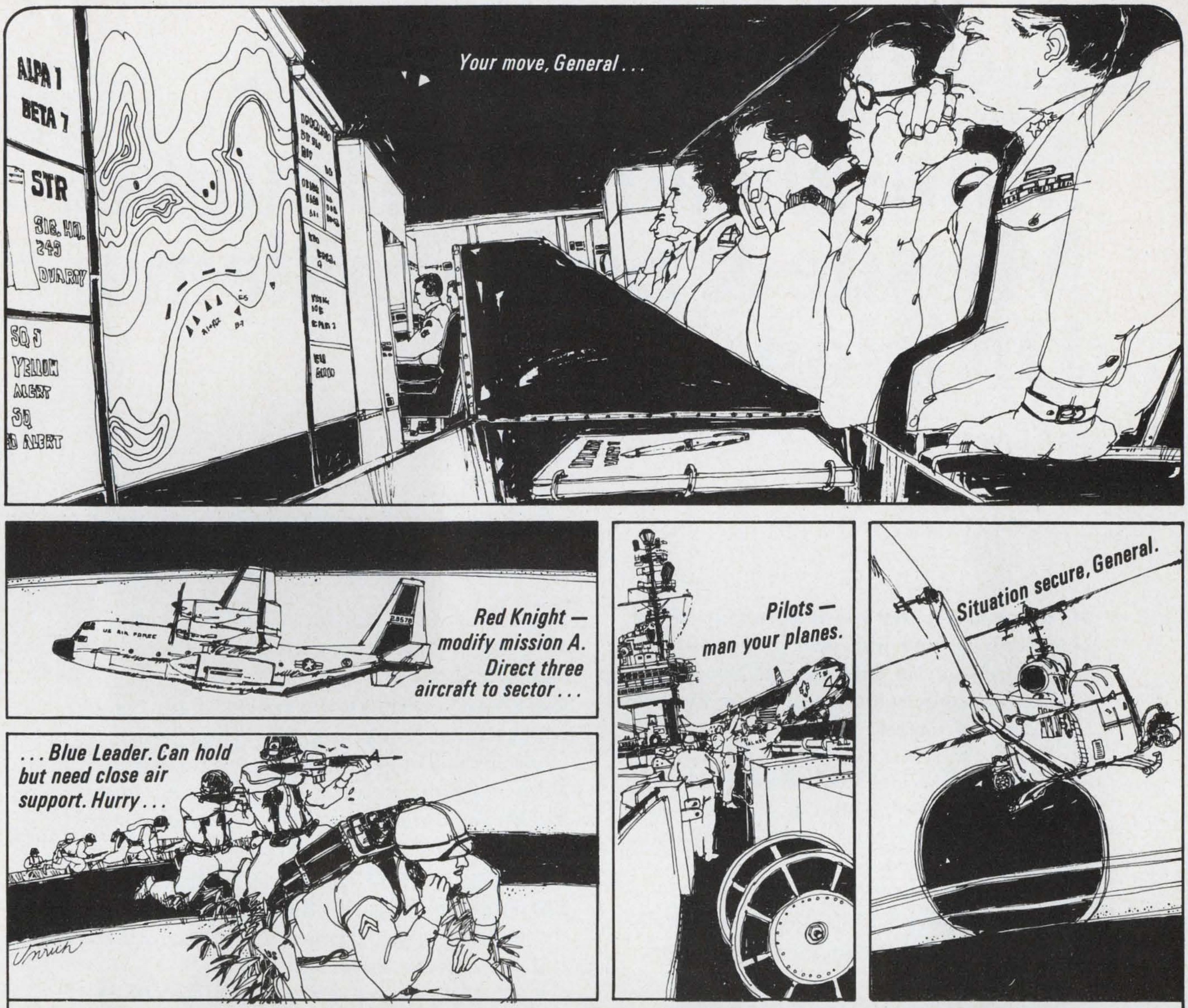

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ON CAREER-INQUIRY FORM CIRCLE 908

Oscillator-multivibrator combo forms super-regenerative detecter

Two standard circuits can be combined in a reflex arrangement to produce a new type of detector. This system offers lower distortion, higher reliability and less total power consumption than conventional types of super-regenerative detectors.

By combining a bi-stable multivibrator (Fig. 1a) with an RF oscillator (Fig. 1b), we develop the reflex circuit (Fig. 2a). The multivibrator action causes the RF oscillations to be switched OFF and ON at a rate of approximately 20 kHz (thus the term digital). The actual point at which the RF oscillations begin (conduction of current in the collector of Q_2) is determined by the sum of the multivibrator waveform and voltage present in the RF tank circuit. Signals present on the antenna are coupled to the transistor emitter through the RF feedback circuit.

Referring to Fig. 2b, we see that the amplitude-modulated signal (A) will be summed with the linear ramp of the switching waveform (B) in transistor Q_2. When the combined levels (A + B) exceed the switching threshold, the collector changes state, and the subsequent pulse-width variation (ΔP) occurs at the received signal modulation rate.

A Twin-T filter coupled to the collector of either Q_1 or Q_2 will allow the detected modulation to pass to an audio amplifier and reject the switching-frequency component. The detector output level is low; however, the linear switching ramp insures low-distortion performance. A standard quartz crystal can be used to control the RF frequency of the detector and simultaneously im-

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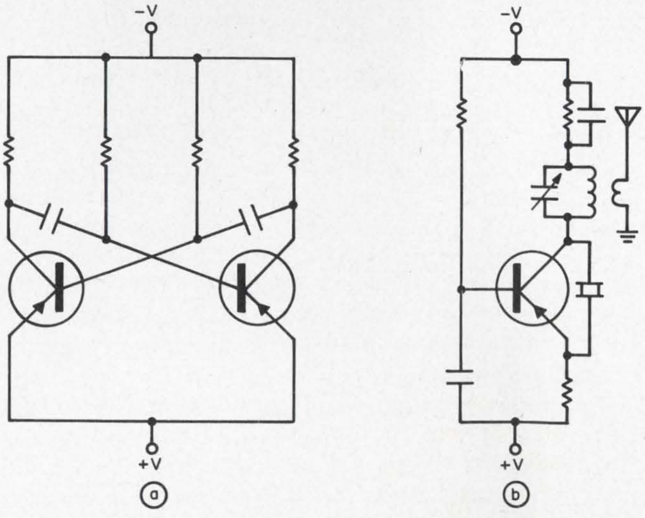
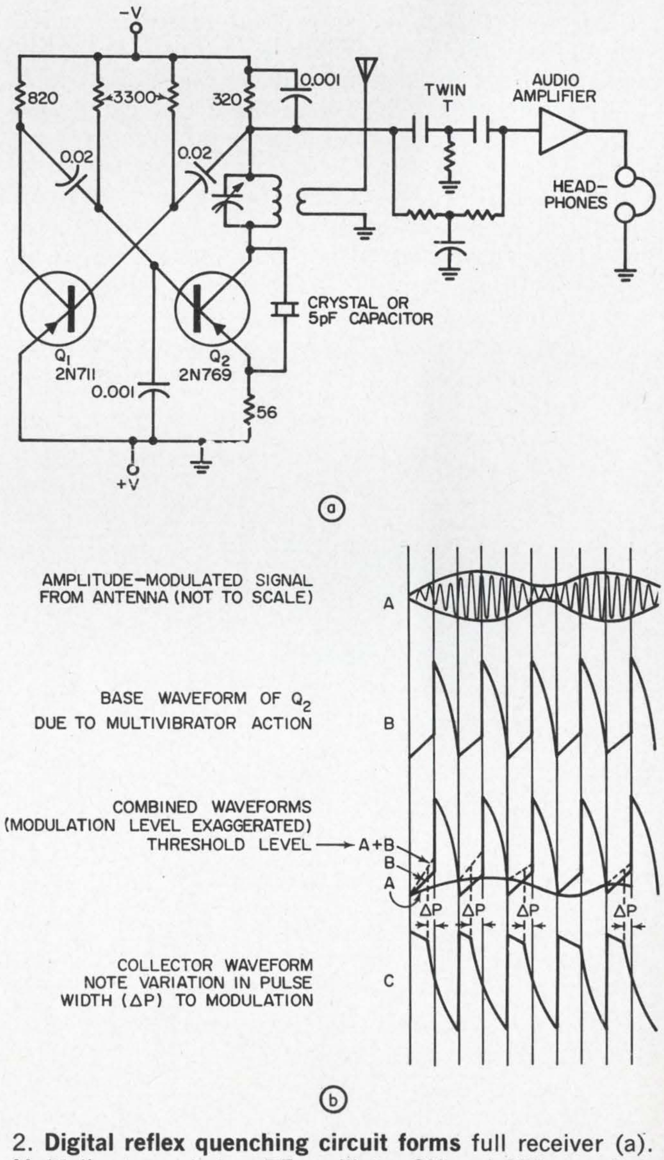


1. **Combination of bi-stable multivibrator** (a) and RF oscillator (b) results in a super-regenerative, reflex-action detector. Low distortion and high reliability accrue.



2. **Digital reflex quenching circuit forms** full receiver (a). Multivibrator switches RF oscillator ON and OFF at a digital rate. System exhibits low distortion, high reliability and little power consumption. Key waveforms appear in (b).

prove circuit Q to provide crystal filter action.

The component values shown may be used in an operational configuration. Microcircuit techniques may alternatively be employed for size reduction. A hearing-aid type of amplifier, coupled to the detector, will form a complete receiver, with excellent sensitivity and selectivity characteristics and low power-consumption needs. The detector shown uses less than 1/4 mW power from a 0.5-volt source. This makes the unit attractive for military field-helmet receivers or similar applications, where a small monitor receiver is required.

R. T. (Ted) Hart, Systems Project Engineer, Collins Radio Co., Dallas, Tex.

VOTE FOR 110

Simple transition detector has unipolar outputs

Only one transistor stage is required to make a simple circuit that produces a positive output pulse on both the leading and lagging edges of an input pulse. The circuit can be employed as a transition detector or in timing and control applications.

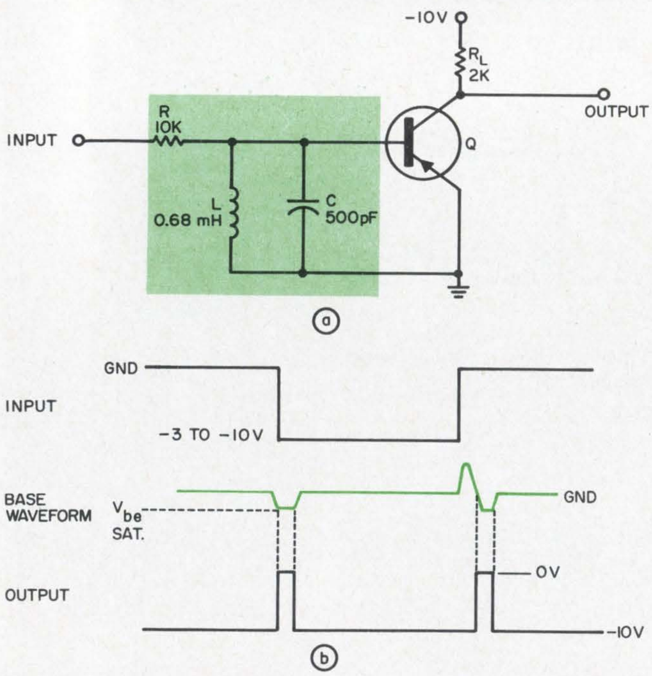
The key to this system lies in the RLC network in the transistor's base circuit (see schematic "a"). With the input at ground, Q is OFF and the output will be at −10 volts. When the input is negative, R and L provide a dc path that clamps the base to ground; therefore the output is restored to the −10-volt level. During the leading or lagging edge of the input waveform, the RLC circuit will resonate, producing a positive-and-negative-going waveform at the base of Q. The negative portion of this signal will drive Q into saturation, causing the output to switch to ground. The result is a positive output pulse for every transition of the input waveform.

Analysis of the unloaded RLC circuit shows that the voltage developed across the inductor will be an underdamped oscillation for a step-function input, provided that $4RC > L/R$. With the base Q connected to the output of the RLC circuit, only one negative oscillation occurs. This is because the low input impedance of Q (as it is driven into saturation) shunts the tuned circuit. Thus the base waveform makes brief excursions into both sides of ground (see schematic "b").

With the component values shown, a 10-volt output pulse is produced for every transition of an input square wave that exceeds three volts in amplitude. The output pulse resulting from positive input rises is slightly delayed, because the base goes positive before going negative for positive input transitions.

Richard J. Bouchard, Electronic Engineer, Sanders Associates, Inc., Nashua, N. H.

VOTE FOR 111



Transistion detector is formed by a one-stage RLC circuit (a). A positive output appears each time the base is driven negative (b). These pulses appear only at the leading and trailing edges of the input pulse.

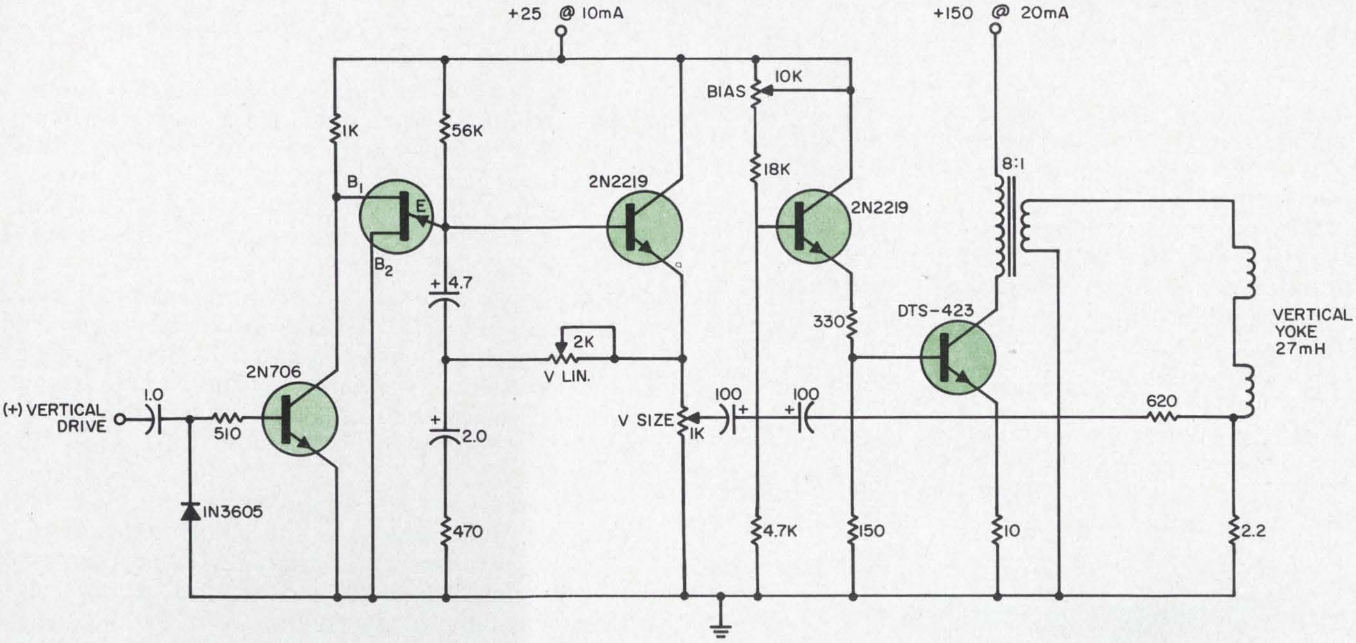
Deflection amplifier shows high efficiency, linearity

Now that high-voltage transistors are available, a specified vertical-deflection power can be easily obtained with little battery power. In this design large, wide-tolerance electrolytic capacitors are not needed.

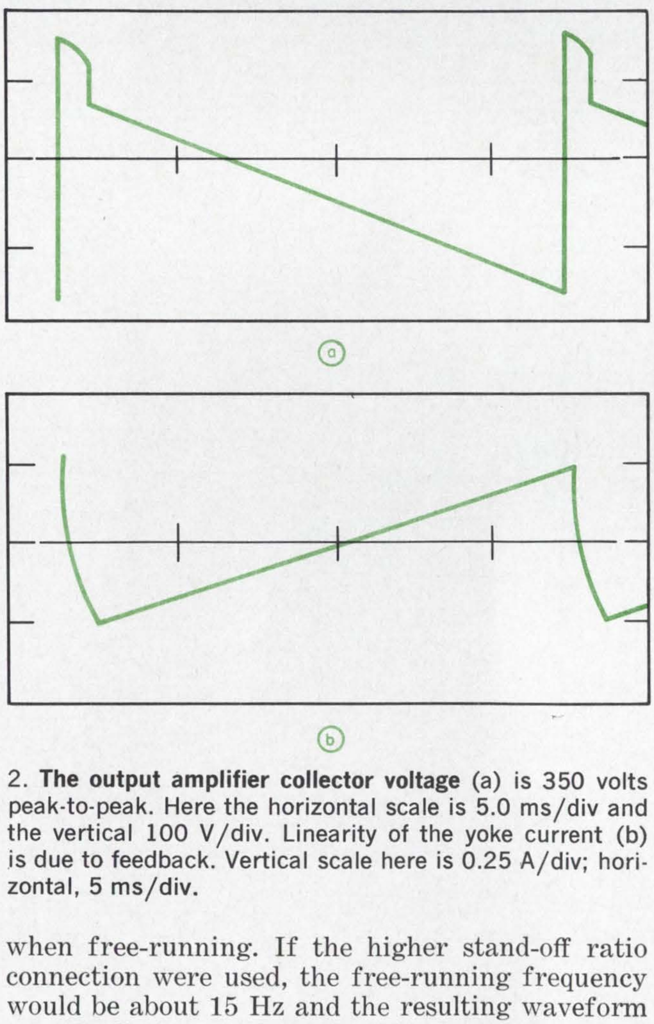
Earlier deflection amplifiers, using low-voltage rated bipolars, were operated typically at high currents. Inefficiency was ascribed mostly to the resulting high I^2R losses. The new circuit (Fig. 1) delivers 0.5 A peak-to-peak of 60 Hz sawtooth current to a 27-mH vertical-deflection yoke. It also provides 90 degrees CRT deflection with a 10-kV acceleration potential. Total input power is slightly over 3 watts. Linearity is adjustable to two percent or better.

With a 150-volt supply, the trapezoidal waveform at the DTS-423 transistor collector (Fig. 2a) is 350 volts peak-to-peak, much as with vacuum tubes. In fact, a vacuum-tube transformer was used to transform collector impedance down by 8-to-1, to match the yoke impedance. (Note that the Stancor VO-100 is connected as an auto-transformer and must be modified to permit grounding of the output winding.)

Feedback is employed in the sawtooth voltage generator and in the output amplifier to improve linearity. No vertical-hold control is necessary, because synchronization is absolute. The UJT bases are interchanged to obtain a lower stand-off ratio. This has no effect upon normal operation but it allows the emitter to fire at a lower voltage



1. **Efficiency and linearity result** when high-voltage transistors and a UJT are used in this deflection amplifier.



2. **The output amplifier collector voltage** (a) is 350 volts peak-to-peak. Here the horizontal scale is 5.0 ms/div and the vertical 100 V/div. Linearity of the yoke current (b) is due to feedback. Vertical scale here is 0.25 A/div; horizontal, 5 ms/div.

when free-running. If the higher stand-off ratio connection were used, the free-running frequency would be about 15 Hz and the resulting waveform greatly distorted. The 10-kΩ bias control is set for minimum DTS-423 collector current without clipping (Fig. 2b).

Howard Stearns, Principal Engineer, Fairchild Hiller Corp., Rockville, Md. VOTE FOR 112

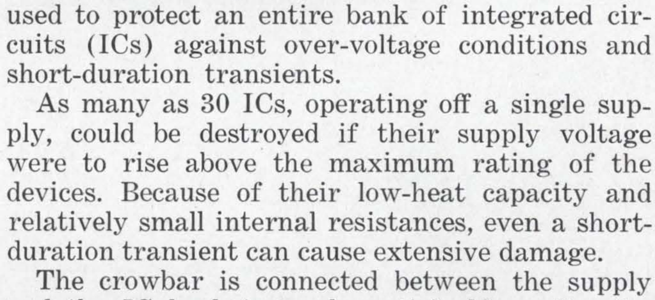
Crowbar circuits protects expensive IC components

A simple, inexpensive crowbar circuit can be used to protect an entire bank of integrated circuits (ICs) against over-voltage conditions and short-duration transients.

As many as 30 ICs, operating off a single supply, could be destroyed if their supply voltage were to rise above the maximum rating of the devices. Because of their low-heat capacity and relatively small internal resistances, even a short-duration transient can cause extensive damage.

The crowbar is connected between the supply and the IC load (see schematic). Normally, the SCR is non-conducting. Its anode is at the same potential as the input to the series regulator. Diode CR_1 is back-biased. The current-limiter stage protects power supply components against output shorts.

When the output voltage exceeds the breakdown voltage of CR_2, the SCR fires and clamps the output at +2 volts. A large current flows through R_1 and the SCR, thus blowing the fuse and shutting off all power to the supply and the ICs. The SCR will reset automatically, if the fault has been



Simple crowbar circuit provides fast shut-off of power supply so that over-voltage transients do not damage integrated circuits.

removed, when the fuse is replaced. By placing a lamp across the fuse, a visual fault indication will be available. The supply must then be shut off to reset the SCR.

The crowbar will operate whether the overvoltage is due to a failure in the regulator or to a short from the output line to a higher voltage line in the system. Since the Zener cannot provide a starting pulse, the SCR must have a good gate-sensitivity characteristic. Although direct Zener-diode firing of SCR's is not recommended for repetitive operations, this method is adequate for the one-shot application discussed here.

Richard A. Karlin, Vice-President, Linear-Alpha, Inc., Evanston, Ill. VOTE FOR 113

Switch-bridge provides versatile load control

A switch-bridge, easily built with four transistor stages, is used to drive an ungrounded load (R_L) with a relative positive or negative current, or no current at all. Control is firmly established, with the direction of the drive source to the load independently varied.

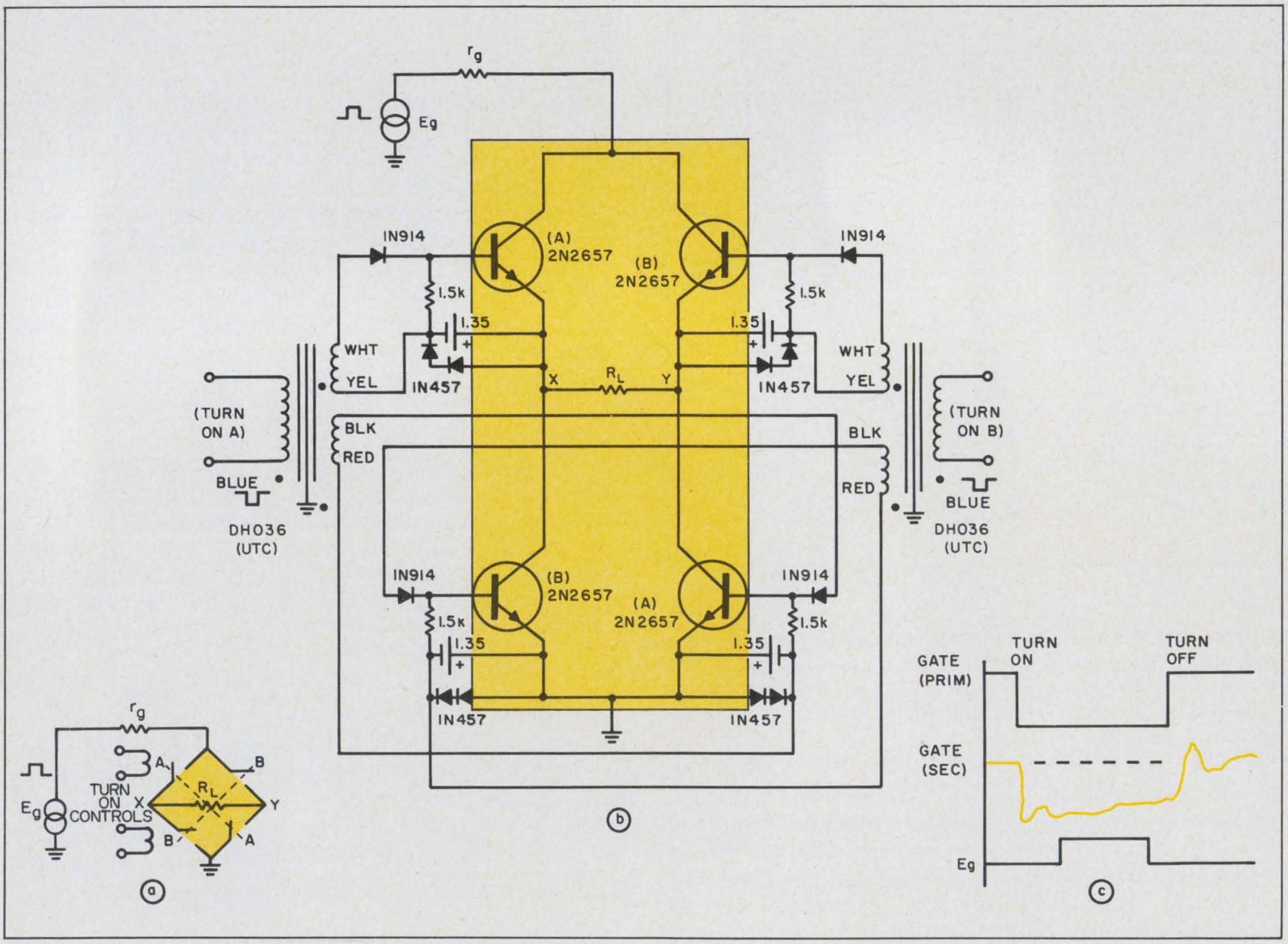
To accomplish this (see schematic), a pair of gates are closed, or all gates are closed. For example, if pair A is closed, current flows from X to Y in the load. Similarly if pair B is closed, current flows from Y to X in the load. Closing both pairs produces a small unbalance current, due to transistor V_{ce} variations.

Turn-on of A or B is accomplished by driving the corresponding DH-036 pulse transformer. The transformer response determines the frequency range over which the switch-bridge is operational. The turn-on waveform should encompass the generator waveform; otherwise pulse splitting will occur.

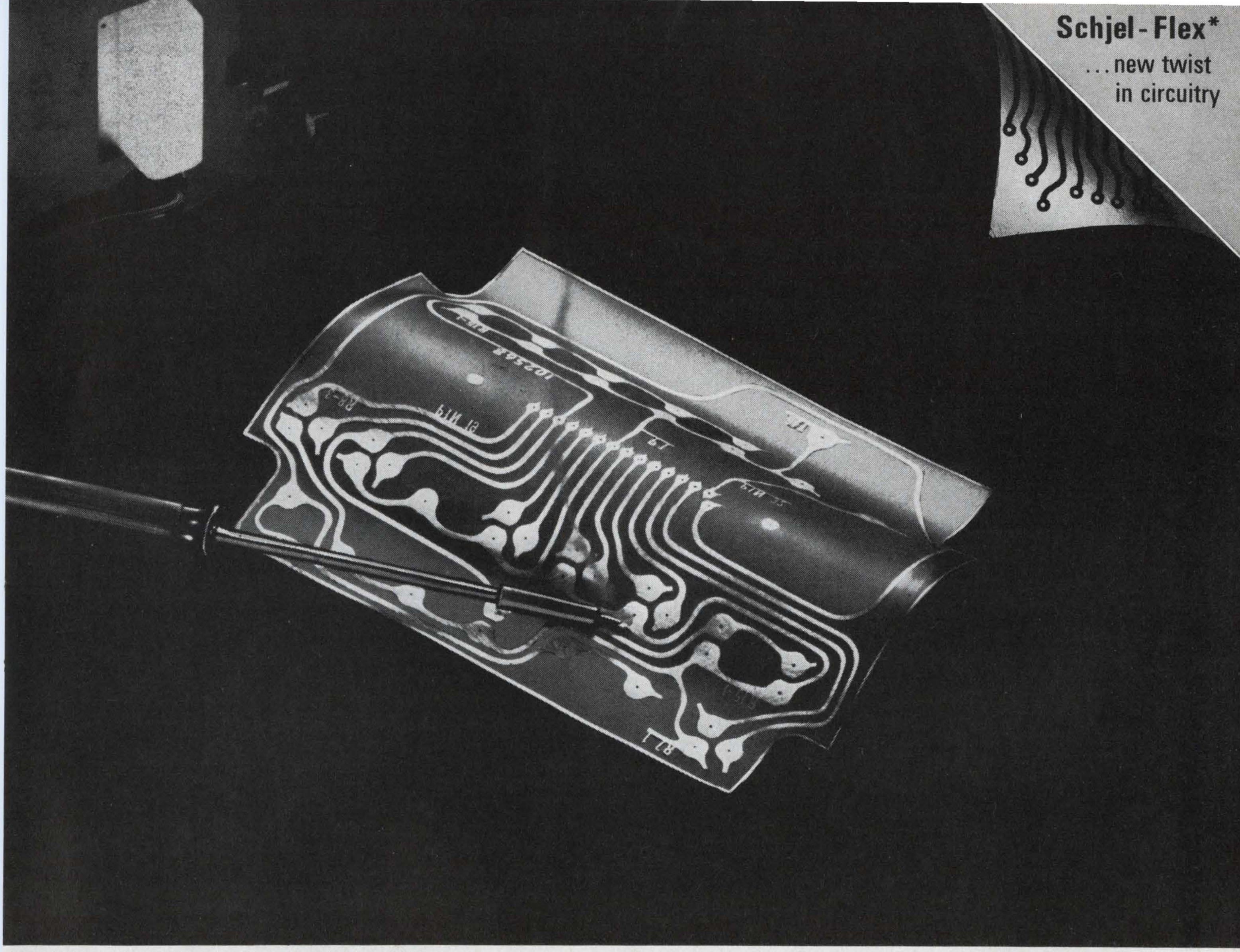
The circuit, when driven from a high-impedance generator, acts as a current switch. Setting $r_g >> R_{sat}$ by using low-leakage transistors, and driving from a fixed E_g, we get an accurate bi-directional current switch.

In one variation a number of switch-bridges may be placed in series, each with an independent turn-on control. In this way a system capability is generated.

Harry Metz, Development Engineer, IT&T Federal Labs, Nutley, N. J. VOTE FOR 114



Switch-bridge controls direction of load drive (a). Complete circuit (b) is used with ungrounded loads as a bi-directional current switch. Waveforms (c) show generator pulse must be narrower than gate, to avoid pulse splitting.



Schjel-Flex Kapton† circuit for Astronautics, Inc., Milwaukee, Wisconsin.

New Schjel-Flex* Kapton circuit beats heat

Of course you wouldn't lay a hot soldering iron on a flexible printed circuit. But if someone *should,* this one wouldn't be a production reject. It takes the heat because the base is Kapton, laminated to copper with a proprietary Schjeldahl adhesive system that approximates the characteristics of the polyimide film.

We've made hundreds of thousands of Schjel-Flex circuits. Most often, we use our polyester laminate, GT-5500 Schjel-Clad.* With polyester's excellent physical, electrical and chemical properties, the circuits are right for most applications. But sometimes extreme processes or service temperature requirements exceed polyester's limits. That's why we've developed the Kapton laminate. It retains polyester properties at much greater temperature extremes.

For example, at room temperature, a Schjel-Flex Kapton circuit has tensile strength of about 25,000 psi. At 260°C, it's 14,000 to 15,000 psi. Typical cut-through temperature, using a weighted probe on heated film, is 435°C. Room temperature dielectric strength is 7,000 volts/mil; 4,000 volts/mil at 260°C. The Kapton base is non-flammable, infusible and unaffected by known organic solvents.

There are other high temperature circuits. But ours is the first to use an adhesive system — instead of fusion-bonding copper to Teflon† or a Teflon-Kapton combination. The adhesive doesn't permit conductor "swimming" during processing. Tolerances of ± 0.1% can be achieved.

Schjel-Flex circuits offer the design freedom of materials you can bend, twist and flex. At the same time, they give you the precision and assembly ease of printed circuit boards. Yet with all their desirable qualities, our continuous roll production keeps unit costs low.

We'd like to help find a Schjel-Flex answer to your circuit problem — whether you want to make or buy. Our list of standard Schjel-Clad laminates will soon include the Kapton-base material (designated GT-7500). We're already making circuits of it. Don't let pronunciation stop you. Say "Shell-Doll."

*Trademark, G. T. Schjeldahl Company †Du Pont trademark

Schjeldahl / ELECTRICAL PRODUCTS DIVISION

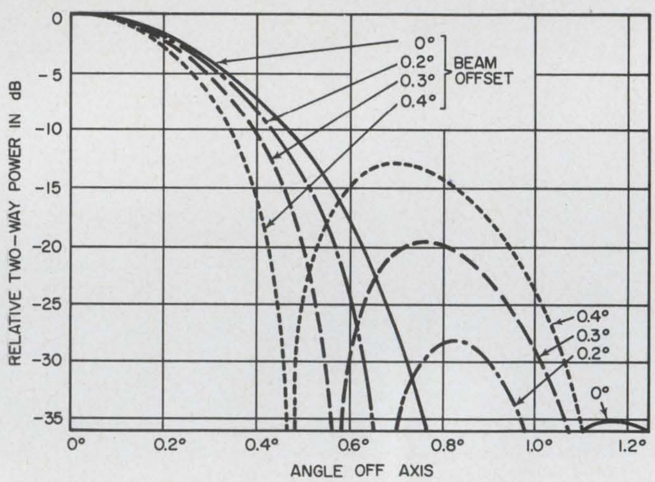
G. T. SCHJELDAHL COMPANY • NORTHFIELD, MINNESOTA 55057 • PHONE 507-645-5633

Antenna-beam offset improves radar resolution

The slope of the main lobe of a high-gain antenna pattern is greatest in the vicinity of the first null. This characteristic can be used to obtain improved resolution, by simply shifting the antenna pattern to one side on transmission and to the opposite side on reception.

A non-reciprocal ferrite device can be used to control the beam shift. Note that this improvement is obtained with some sacrifice in power.

To illustrate this concept, consider the pattern of a uniformly illuminated circular aperture. Assume that the diameter of the antenna is 40 wavelengths. The relative two-way patterns of the antenna for three different beam offsets appear in the accompanying diagram. For an offset of 0.2



Radar resolution is improved if the beam is shifted to different sides during transmission and reception. This benefit is accompanied by a loss in power efficiency.

degree, the two-way power loss is 1.69 dB. For a 0.3-degree offset, the loss is 3.92 dB. And with an offset of 0.4 degree, the loss is 7.16 dB. Observe that the apparent narrowing of the beamwidth also results in greatly increased sidelobes.

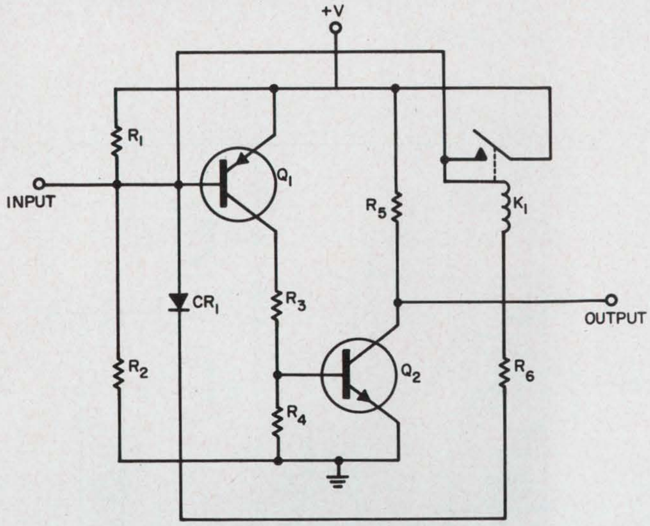
L. A. Zurcher, R. J. Gunderman and H. F. Mathis, Senior Technical Specialists, North American Aviation, Inc., Columbus, Ohio.

VOTE FOR 115

Circuit converts generator into monopulser unit

It is often necessary to obtain a single positive or negative output voltage pulse from a signal generator which is not equipped for single-pulse operation. This can easily be achieved by a two-stage complementary network and a relay.

In effect, the circuit functions as a single-pulse cutoff unit. It avoids the costly, time-consuming



Single pulse cutoff circuit is formed by two-stage complementary network and relay. It converts a signal generator into a monopulser unit.

process of internal modification of the generator.

Such a circuit for use with negative voltage pulses is shown in the schematic. Transistors Q_1 and Q_2 are non-conducting in the absence of a pulse. The first negative pulse on the base of Q_1 causes both transistors to conduct. The feedback loop consisting of R_6 and CR_1 clamps both transistors ON.

This provides a permanent low-impedance path for relay K_1. When the trailing edge of the negative pulse reaches the base of Q_1, pull-in voltage is supplied to K_1. The relay then locks itself on and clamps the input voltage to positive.

Fred W. Kear, Design Engineer, Sparton Southwest, Inc., Albuquerque, N. M.

VOTE FOR 116

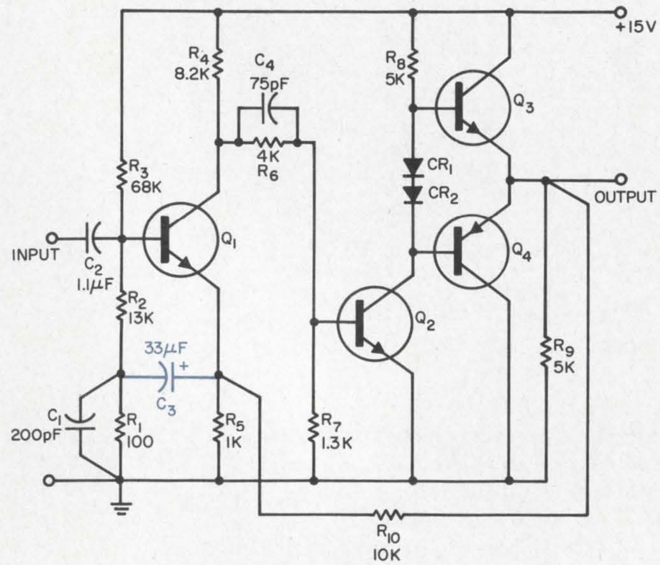
Bootstrap action yields high Z_{in} wideband amplifier

An input impedance of about 35 kΩ in a stable, wideband amplifier is achieved by the bootstrap action of a feedback capacitor. The circuit also shows good temperature stability.

The input of the amplifier (see schematic) is ac-coupled via the 1.1-μF input capacitor. Polarity of the input capacitor is chosen according to application. The first base is biased at approximately two volts.

Bandpass of the amplifier is approximately 40 Hz to 40 MHz using 2N2369 transistors (Q_1, Q_2, Q_3) and a 2N2894 for Q_4. CR_1 and CR_2 are low-conductance silicon diodes. The low-frequency response may be extended by increasing the value of the 1.1-μF and 3-μF capacitors.

Different values of gain and bandwidth may be attained by varying the values of R_1 and C_1. For example, a 60-dB amplifier will show a bandwidth



Bootstrap action of feedback capacitor C_3 yields an input impedance of 35 kΩ in this 40-dB, 40-MHz-bandwidth amplifier.

about 3 MHz; a 20-dB amplifier, a 75-MHz bandwidth.

Dc stability of the output operating point is attained through a compensating system which takes advantage of base-to-emitter voltage changes at temperature extremes. Note that the Q_1 current is equal to the current in R_4 minus the current in R_6. At $-55°C$, V_{BE2} increases by 25% to 30%, causing R_6 to draw more current away from R_4 and thereby decrease Q_1's current. At the same time, V_{BE1} increases, causing a drop in the Q_1 emitter voltage. The resulting decrease in R_5 current is fully compensated for by the decrease in Q_1 current, and the output dc voltage therefore remains constant. A similar but opposite analysis holds for high-temperature operation.

Output impedance of the amplifier is 10 ohms, as provided by the emitter-follower output transistors. If the Q_2 collector is connected directly to the Q_3 base, the network comprising CR_1, CR_2, and Q_4 may be eliminated, sacrificing the capacity to drive large ac-coupled loads.

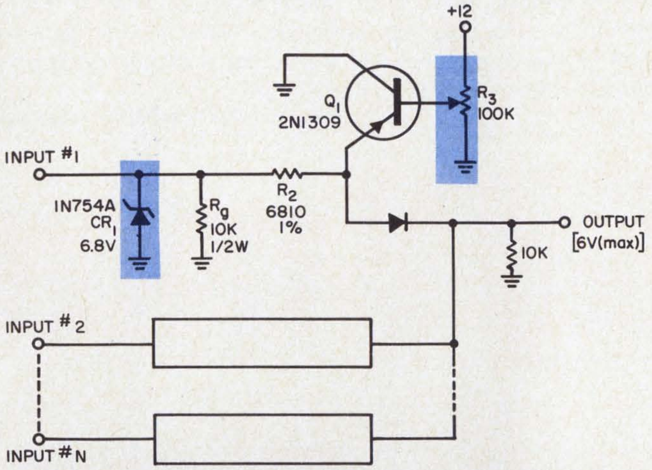
William J. Travis, Design Engineer, Sprague Electric Co., North Adams, Mass.

VOTE FOR 117

Variable pulse limiter uses few components

Only one transistor stage and a Zener diode are needed for a stable, precise pulse limiter. The limiter, moreover, has a continuously variable output capacity.

This circuit (see schematic) was designed to



Few components are required in the variable-output, high-stability, precision pulse limiter. Zener diode CR_1 serves as a coarse limiter, and R_1 is the output level set.

convert input pulses of from 8 to 16 volts in amplitude into a continuously variable output-pulse train of from 0 to 6 volts' amplitude. The output, once set, will vary only 0.001 volt or less.

Because of the circuit's extremely low current-drain, there is virtually no limit to the number that may be placed in parallel. It works equally well with negative pulses when an npn transistor and a negative bias supply are substituted for a pnp transistor and a positive supply. It can also operate with positive and negative pulses simultaneously, through the use of both transistor types together. Its operation is straightforward.

The 10-kΩ resistor is a ground return for an isolation diode at the input (not shown). The input Zener diode, CR_1, has a Zener breakdown voltage that is approximately one volt above the maximum desired output. It thus acts as a coarse limiter. The 6.9-kΩ series load is a high-precision resistor.

The 10-kΩ potentiometer in the base of Q_1 is set to yield the desired output. When the input pulse is less than, or equal to, the desired output, Q_1 is cutoff. When the input pulse exceeds the desired output level, Q_1 acts as a short-circuit to the unwanted portion of the pulse, thus serving as the limiter.

Louis J. Brocato, Professional Engineer, Baltimore, Md.

VOTE FOR 118

IFD Winner for Jan. 18, 1966

Charles Alvine, Project Engineer, University of California at Los Angeles, Los Angeles, Calif.

His idea "Tristable multivibrator forms 3-phase generator" has been voted the $50.00 Most Valuable of Issue Award.

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As Wide-band amplifiers the 2N4068 and 2N4069 easily cover bandwidths to 4.5 Mc/s and higher; as general purpose amplifiers, they operate up to 100 Mc/s. The very high BV_{CEO}, the low collector-to-base feedback capacitance, the low leakage and saturation voltages give assurance of top performance in critical applications. The RCA 2N4068 and 2N4069 also feature exceptionally linear transfer characteristic and high-temperature capability compared with germanium and plastic-encapsulated silicon devices.

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For delivery information, and for your copy of RCA Technical Bulletin 2N4068-2N4069 (which has all pertinent performance curves, applications data and electrical and mechanical specifications), call your local RCA Field Office; or write: RCA Commercial Engineering, Section EG-4-4, Harrison, N.J.

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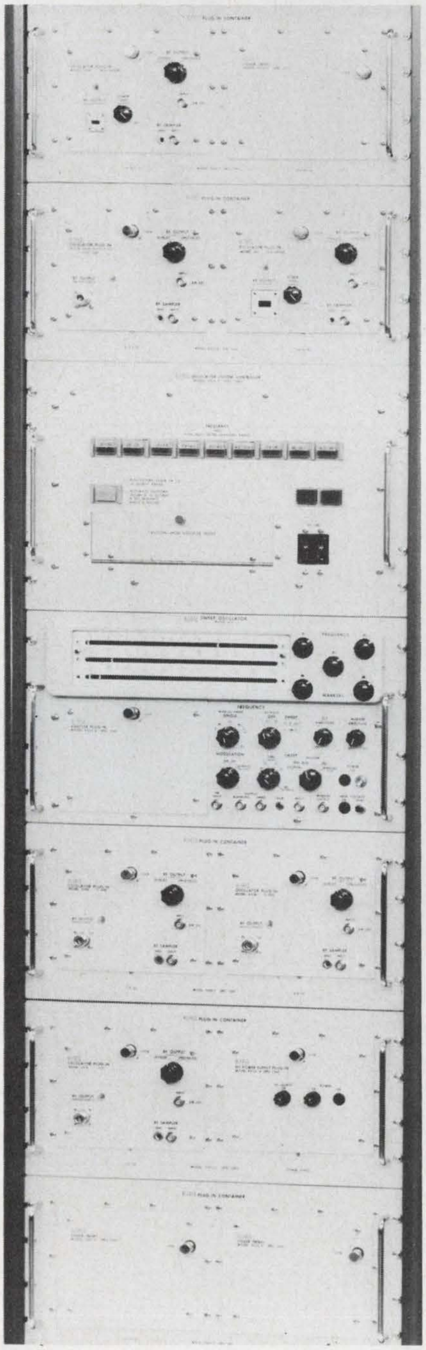
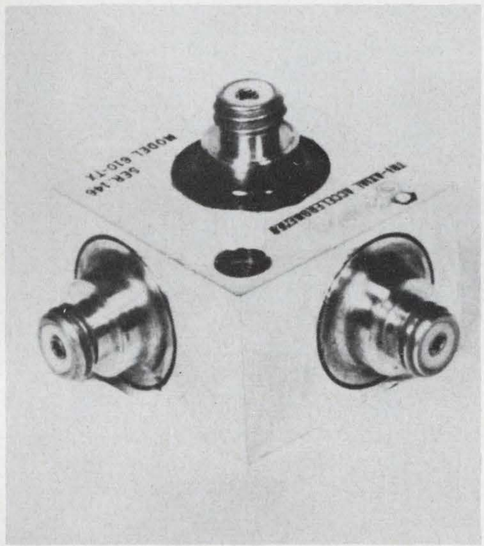
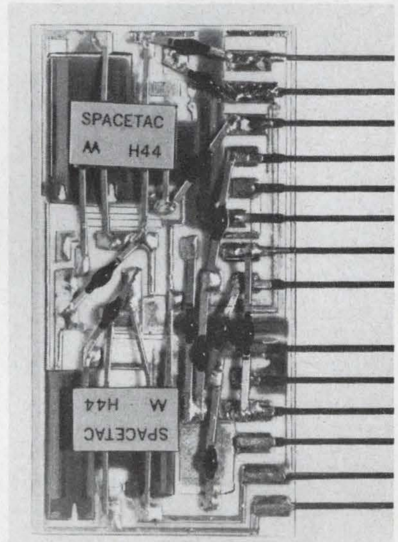


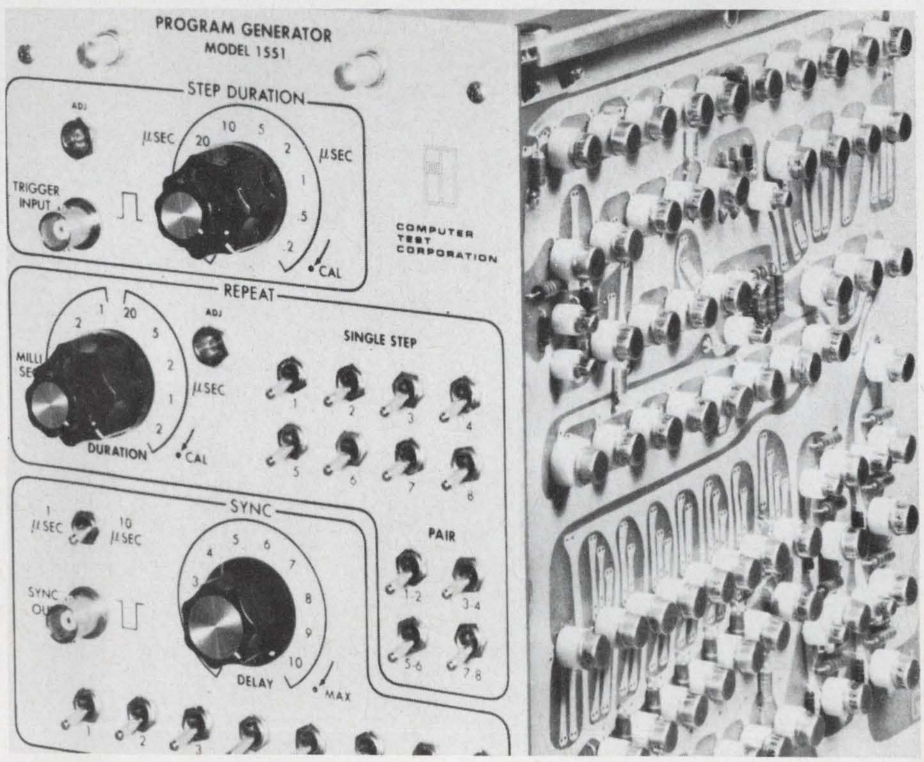
System sweeps 0.25 to 40 GHz 106



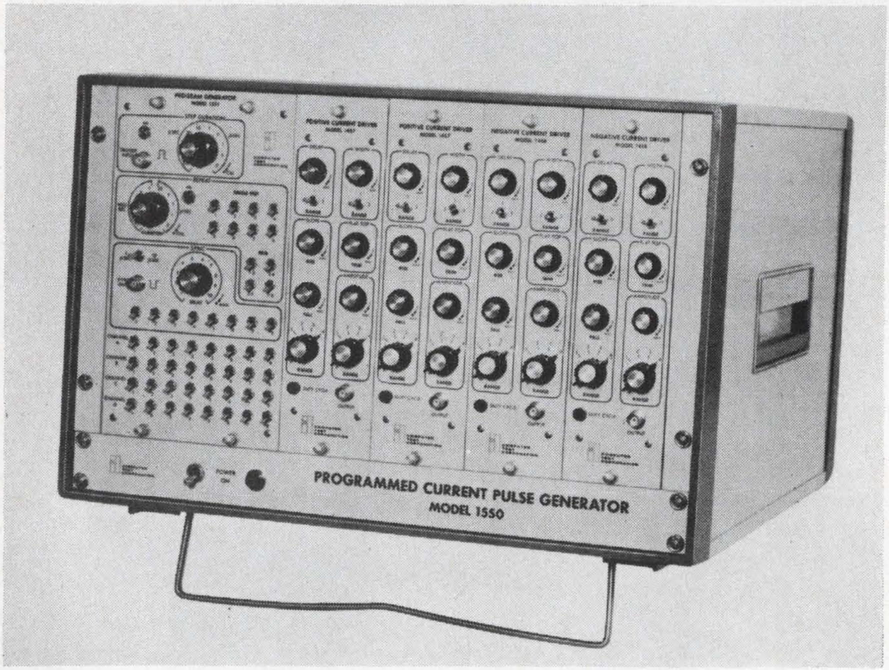
Simultaneous tri-axial measurement. 114



Flip-flop draws 150 μW. 126

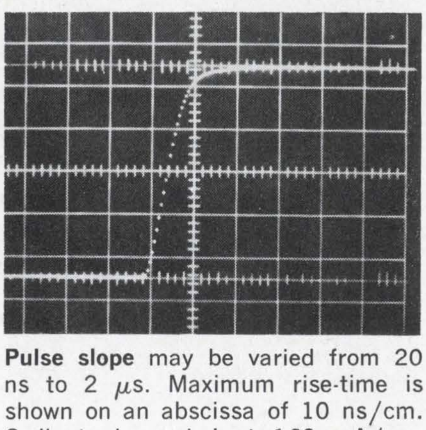


IC logic shrinks memory tester. 98



Memory tester with IC logic has rise times to 20 ns

A programmed current pulse generator tests ferrite memory cores, plated wire memories, planar thin films, multi-apertured devices and other high-speed memory devices. The model 1550 memory tester is completely contained in a 19-3/4- x 21-5/8- x 13-in. package, which incorporates 5 MHz integrated circuit logic, solid-state current drivers and power supplies. The use of integrated circuit logic permits the high pulse programming rates. Increased reliability, inherent in the minimal use of discrete components and solder joints, is claimed. Current drivers are the manufacturer's models 1457 (positive) and 1458 (negative) which are characterized by a highly linear 20 ns rise time capability.



Pulse slope may be varied from 20 ns to 2 μs. Maximum rise-time is shown on an abscissa of 10 ns/cm. Ordinate is scaled at 160 mA/cm.

The program generator in the 1550 provides an eight-step pulse sequence with 5 MHz internal clock that can be set up in any desired pattern by a series of toggle switches at each of the four output channels. The period between successive steps in the program can be continuously varied by a front panel control from 0.2 μs to 0.5 ms. The program can also be advanced through successive steps from an external source. A step/repeat feature of the program generator permits either single steps or odd-even pairs of steps to be repeated within the over-all test pattern. The repeat interval can be varied internally over a range of 0.2 μs to 2 ms or controlled externally for longer intervals.

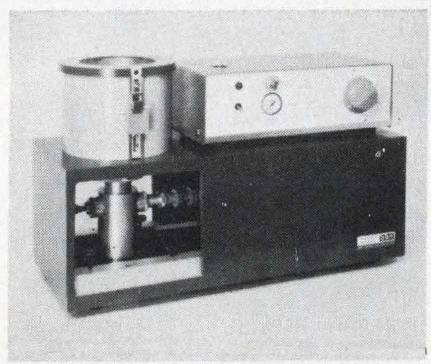
Sync pulses are available at any one of the eight program steps by selecting appropriate toggle switches. This makes it possible to observe the desired output steps on a scope, or to analyze the response of the driver load after the application of the pulse program. The sync pulse can be delayed for periods up to 10 μs from the start of the program step.

The output stages of the 1550 use positive and negative current drivers with highly linear rise and fall times that are independently adjustable to 20 ns. Current pulse amplitude can be varied from 50 mA to 1 A. Rise and fall time remain unaffected by adjustments in pulse amplitude, which helps to reduce test set-up time. An output voltage rating of 50 V and a 60 pF output capacitance make the drivers especially suited to driving inductive loads with high back voltages. The drivers can withstand a 50 V back emf without damage. Current pulse width and pulse delay are both independently variable up to 10 μs.

A protective circuit built into the drivers prevents overload damage to the output stages by automatically shutting the unit off when the duty cycle reaches the 25% point. This is indicated to the operator by a front panel light. Once the overload is removed, the driver automatically resets itself. Input is standard 115 Vac, 50 to 60 Hz. Integral ventilating equipment consists of a blower and air-filter.

P&A: $8450; 30 to 60 days. Computer Test Corp., 12 Fellowship Rd., Cherry Hill, N. J. Phone: (609) 665-5250.

Circle No. 250



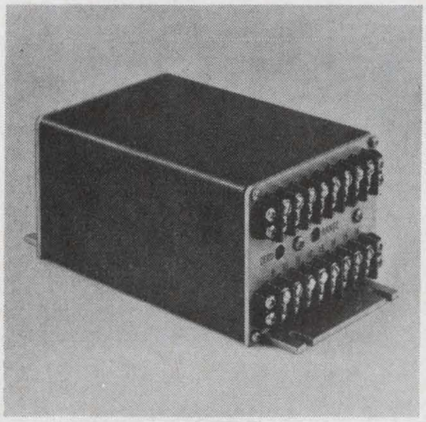
Microphone calibrator

Model 901D variable frequency microphone calibrator can be used as a standard reference for sound pressure calibration. The calibrator generates precise low frequency sound pressures at high levels, within ±0.2 dB. Interchangeable drive modules can provide sound levels from 110 dB to 170 dB in 10-dB steps. Range covered is 3 Hz to 200 Hz.

Bolt, Beranek & Newman Inc., 50 Moulton St., Cambridge, Mass. Phone: (617) 491-1850.

Circle No. 251

Converter

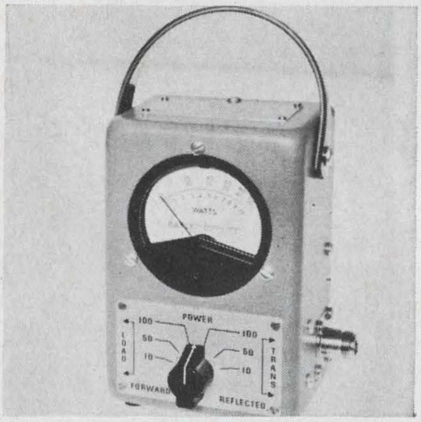


The PI-600 frequency-to-dc converter provides regulated V and I outputs over a 250- to 3000-Hz input range. Full-scale outputs of 0 to 5 V, 1 to 5 mA or 4 to 20 mA are selected by terminal strip jumpers. Input is transformer coupled and accepts sine wave, square wave or pulses. Sensitivity is 0.01 Vrms and accuracy is ±0.05%.

P&A: $350; 3 to 4 wks. Anadex Instruments Inc., 7833 Haskell Ave., Van Nuys, Calif. Phone: (213) 781-6811.

Circle No. 252

In-line wattmeter

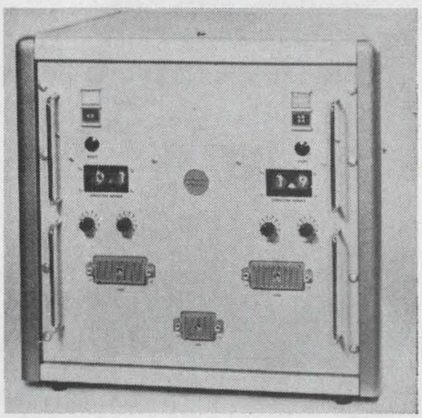


The type IW3-5E wattmeter features a nearly flat frequency response from 30 kHz to 2.0 MHz. Designed for use in 50 Ω unbalanced systems, it can be supplied with type N or uhf female interchangeable connectors. Standard instruments provide power ranges of 10, 25, 100 watts full scale. The meter is available in standard 19-in. rack versions.

Bayly Engineering Ltd., 120 Hunt St., Ajax, Ontario, Canada. Phone: (416) 942-1020.

Circle No. 253

Automatic PC tester



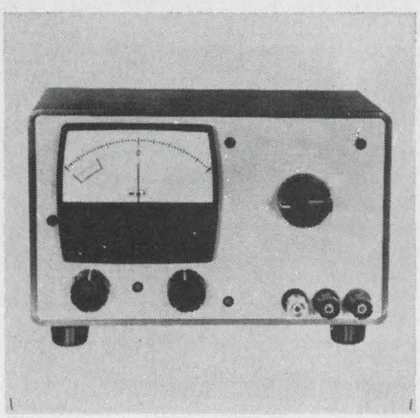
The model QC 400 automatic printed circuit tester offers go/no-go analysis of compact printed assemblies. Continuity resistance, shorts and open circuit tests are performed at five per second.

Points are cross-checked to avoid multipath errors and numerical readouts display pin numbers of faults.

P&A: $2500; 2 wks. Automation Dynamics Corp., Industrial Pkwy., Northvale, N. J. Phone: (201) 768-9200.

Circle No. 254

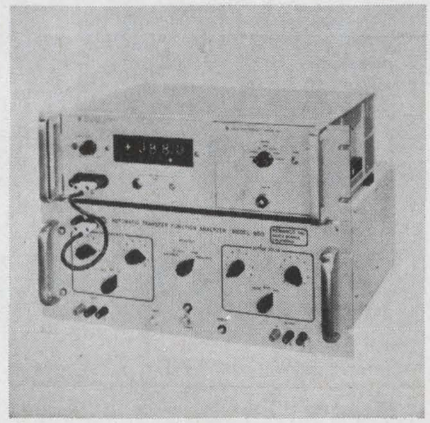
Null detector



The model 810, zero-centered, polarity-sensing null detector provides a usable sensitivity of 1 μV. Input filtering provides more than 70-dB ac pickup rejection. A guarded battery power supply eliminates common mode coupling. Input impedance is 1 Meg and power consumption is less than 30 mW. Zero offset control balances out up to 100 μV.

P&A: $295; 10 days. Electro Scientific Industries Inc., 13900 N.W. Science Park Dr., Portland, Ore. Phone: (503) 646-4141.

Circle No. 263



Servo analyzer

A transfer function analyzer with analog and digital outputs provides an automatic method for determining lf characteristics of any 3- or 4-terminal network. The "Servodyne" accepts a test signal and compares phase and amplitude with the sinusoid it generates. Forcing function amplitude is preset with ±2% accuracy from 10 mV to 10 V peak while frequency is adjustable from 0.1 to 99 Hz. Ratio of drive-to-test signal amplitude is measured with ±0.5-dB accuracy over a 60-dB range. Phase is measured over ±180° with ±1.5° accuracy.

Canoga Electronics Corp., 1805 Colorado Ave., Santa Monica, Calif. Phone: (213) 451-1341.

Circle No. 256

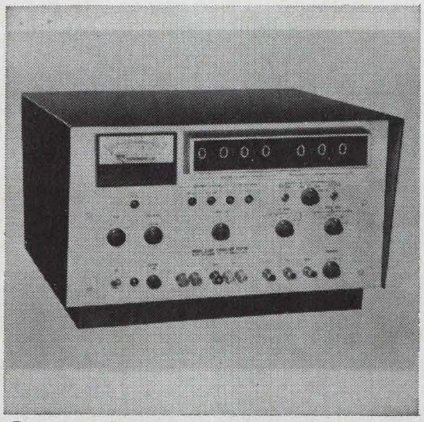
Pulse amplifier

As a pulse modulator for RF amplifiers, or a power supply for pulsed beacon magnetrons, TWTs or klystrons, the model 604 pulse amplifier offers adjustable rise times of 25 to 100 ns to 1500 V and 15 to 100 ns to 500 V. Operating from 115 Vac, the amplifier accepts 10 V inputs from any generator and amplifies it up to 1500 V at 6 A.

Output pulse width is variable from 50 ns to dc. Rep rates are single-shot to 1 MHz. Internal floating deck construction permits ground-based output of either polarity. Overshoot is less than 5%, line regulation is 1% for 10% change and load regulation 1% for no load to full load.

Price: $2900. Cober Electronics Inc., 7 Gleason Ave., Stamford, Conn. Phone: (203) 327-0003.

Circle No. 257

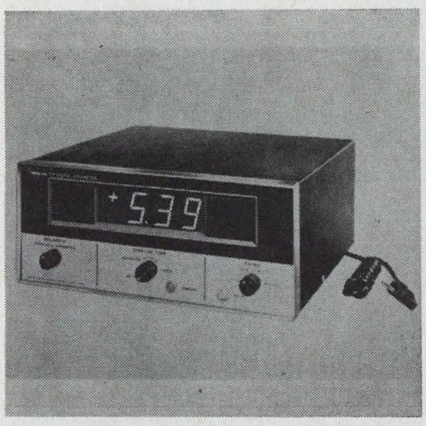


Capacitance tester

A dual-range capacitance tester provides in-line digital readout of capacitance, dissipation factor, equivalent series resistance and dc leakage current over 120 Hz or 1 kHz. Capacitance is measured to ±0.25% full scale accuracy, dissipation factor to ±0.2% and resistance to ±2%. With an internal 0 to 100 Vdc bias supply, dc leakage current is measured to ±1%.

P&A: $4500; stock to 30 days. Micro Instrument Co., 13100 Crenshaw Blvd., Gardena, Calif. Phone: (213) 323-2700.

Circle No. 258



Digital voltmeter

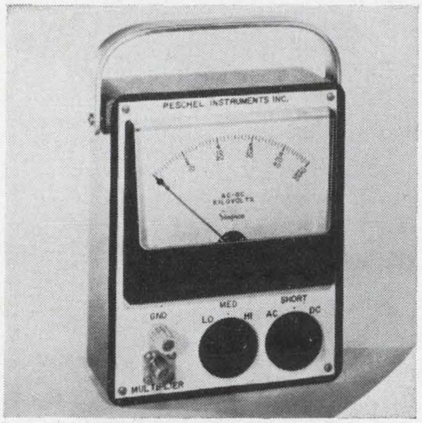
The model 111 dc DVM finds applications in production testing, incoming inspection and quality control. Accuracy of 0.1% is claimed for the 0.001- to 999-V range. The 3-digit segmental display is said to be readable from 20 ft even with high background light.

Printer output and ac capabilities are available as options.

Price: $500. Simpson Electric Co., 5200 W. Kinzie St., Chicago. Phone: (312) 379-1121.

Circle No. 259

Kilovoltmeters

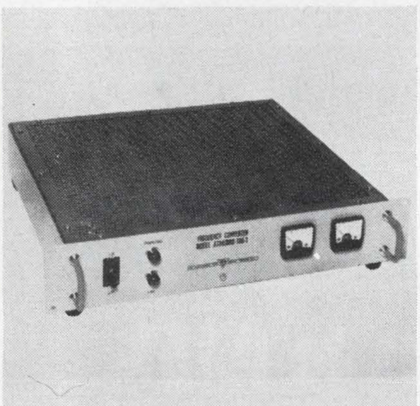


Three triple-range ac/dc kilovoltmeters in ranges of 0-5/10/25 kV, 0-10/25/50 kV and 0-25/50/100 kV ac/dc are available. Measuring 5-1/2-in. wide, 7-in. high, and 3-in. deep, the portable voltmeters weigh 2 lbs. Meter accuracy is stated as ±2% dc or ±3% ac full scale and maximum circuit loading is claimed to be less than 100 μa.

P&A: $160 to $225; stock. Peschel Instruments Inc., Rte. 216, Patterson, N. Y. Phone: (914) 878-3251.

Circle No. 260

Frequency converters

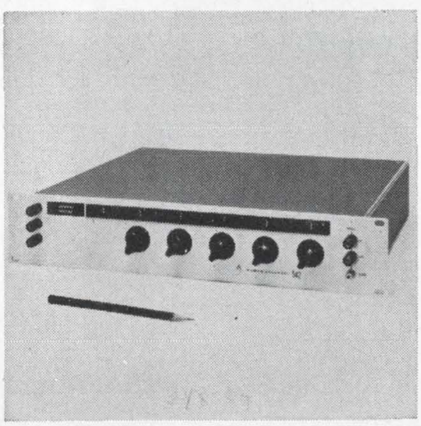


Series ATA frequency converters are stable sources of 400 Hz power operating from 50 to 70 Hz lines. Frequency stability, waveform purity and low dynamic impedance are reported. Output power is 100 to 1000 VA. Voltage regulation, from no load to full load, is 0.5%. Line regulation is ±0.5% from 105 to 125 V.

P&A: $620 to $2300; stock. Del Electronics Corp., 521 Homestead Ave., Mount Vernon, N. Y. Phone: (914) 699-2000.

Circle No. 261

Synchro bridge



This synchro bridge measures electrical angular data of 3-wire synchros to 2 s of arc. As a null detector with a phase angle voltmeter, it can measure all commercially available synchro transmitters. Null meter deviation is used for interpolation of angular error. The instrument has a resolution of 0.0001°.

P&A: $1000; 30 to 60 days. Electric North Atlantic Industries, 200 Terminal Dr., Plainview, N. Y. Phone: (516) 681-8600.

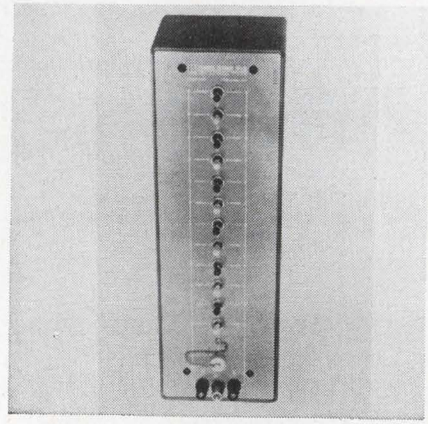
Circle No. 262

Multimeter

With more than 54 ranges, this solid-state multimeter covers dc and ac voltage and current, RF to 1.5 GHz and 2 Ω to 20 Megs center scale. Both Vac and dc have 11 ranges covering 12 mV to 1200 V full scale. Dc accuracy is ±2% with 10 Meg/V input resistance. RF accuracy is ±0.5 dB to 500 MHz. The meter is powered by 3D cell batteries.

Price: $795. Edwin Industries Corp., 5858 E. Molloy Rd., Syracuse, N. Y. Phone: (315) 454-4407.

Circle No. 255

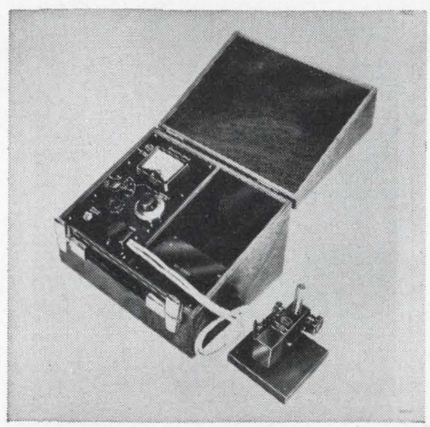


Transfer standard

These standards transfer measurements from a 10-kΩ resistance standard to values up to 110 Megs. The instrument consists of 11 wirewound resistors which can be switched in series, parallel or series/parallel. Models are offered with 100-kΩ, 1-Meg and 10-Meg sections. Accuracy is ±15 ppm for 10 Megs and ±10 ppm otherwise.

P&A: $400 to $775; stock to 30 days. Electro Scientific Industries, 13900 N. W. Science Park Dr., Portland, Ore. Phone: (503) 646-4141.

Circle No. 264



Resistivity bridge

Semiconductor materials can be checked on the production line with a semi-automatic portable direct-reading resistivity bridge.

A 10-turn helical pot with a scale length of 100 divisions covers from 0.01 to 1000 Ω-cm with ±5% accuracy. A high-precision probe is optional. The 10-lb unit is battery powered.

Price: $545. J. A. Radley Research Institute, Elgar Rd., Reading, Berks., England. Phone: Re-82428.

Circle No. 265

Amperex LIDS™

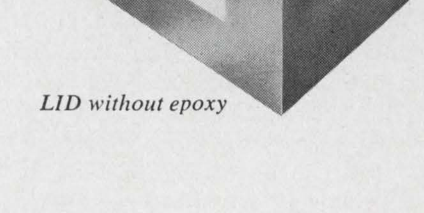
New microelectronic package for semiconductors permits mechanized production of hybrid integrated circuits

From the very first days of microelectronics, designers and manufacturers of hybrid film circuits have sought a semiconductor package truly suited for the new technology.

The ideal package would be of microminiature dimensions; it should be capable of mounting on the substrate by mass production, jigging techniques; capable of being completely characterized for both AC and DC measurements and readily pre-selected (for noise, gain, etc.,) for critical applications.

LIDS (leadless inverted devices) developed by Amperex fulfill all of these requirements... and more.

As a start, Amperex is offering two high-performance silicon planar epitaxial transistor families in the new Amperex LIDS: high-speed switches similar to the 2N2369 and low-noise, high gain amplifiers similar to the 2N930. Dual-diodes will be available next, followed by the entire Amperex line of small signal RF, AF and switching types.

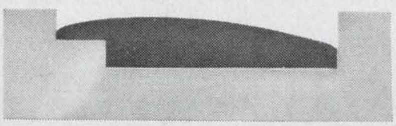


LID without epoxy

The Amperex LID is an all-ceramic package that is smaller (0.075" x 0.045" x 0.032") and less costly than any existing metal package. Its smaller size permits the manufacturer to reduce costs by reducing the substrate size.

Having no external wiring, expensive wire-bonding machinery and the skilled labor to operate it are no longer needed; handling is simpler, breakage is eliminated and production yields of the integrated circuits will be higher.

For complete protection before, during and after assembly, the transistor chip is coated with epoxy after it is mounted in the LID.



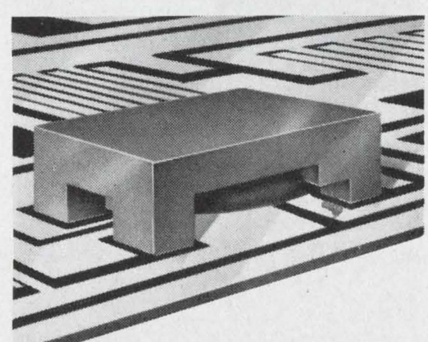
Completed LID with protective coating

In place of delicate, external wire leads, LIDS have four contact legs that are an integral part of the ceramic package. Their surfaces are coated with metallized solderable gold. This construction permits the LIDS to be positioned on the substrate by automatic jigs, without the need for micro-optics for orientation.

Any number of LIDS can be mounted simultaneously for true mass production volume and cost savings. LIDS are bonded to the substrate by low-temperature soldering, which, unlike the usual high temperature techniques does not alter the transistor characteristics.

Unlike chips, LIDS can be characterized, and pre-selected for critical circuits; and unlike chips, they can be color-coded or similarly marked and so identified for easy and efficient production.

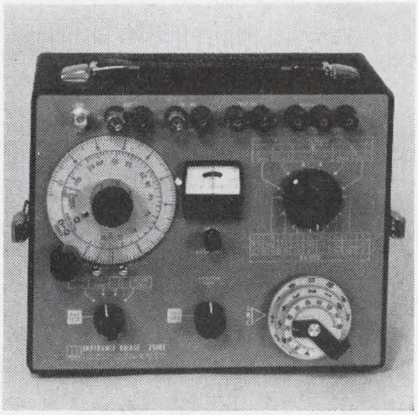
To learn more about Amperex LIDS, write: Amperex Electronic Corporation, Semiconductor and Receiving Tube Division, Dept. 371, Slatersville, Rhode Island 02876.



LID mounted on circuit

Amperex®

Impedance bridge

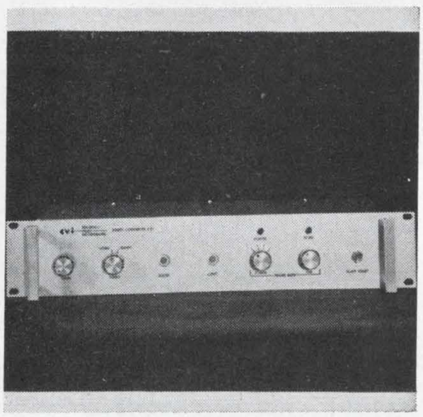


The model 250 DE portable impedance bridge measures up to 12 Megs at 0.1%. Capacitance can be measured to 1200 μF at 0.2% and inductance to 1200 H at 0.3%. Sensitivity is better than 20 μV on dc and 10 μV on ac. Direct D and Q readings for capacitance and inductance measurements are provided. Power is by 4D cells.

P&A: $470; stock to 30 days. Electro Scientific Industries, 13900 N. W. Science Park Dr., Portland, Ore. Phone: (503) 646-4141.

Circle No. 266

Video converter



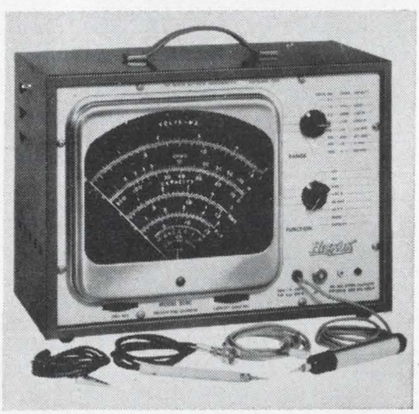
This solid-state video converter provides a "slow-scan" TV signal from "real-time" inputs. The model 201 converts by sampling instead of using storage tubes, providing superior resolution, grey scale and shading characteristics.

Slow-scan frame rates are variable from 5 s to 60 s with analog or digital output.

P&A: $1950; 60 to 90 days. Colorado Video Inc., P. O. Box 928, Boulder, Colo. Phone: (303) 444-3972.

Circle No. 267

Voltmeter

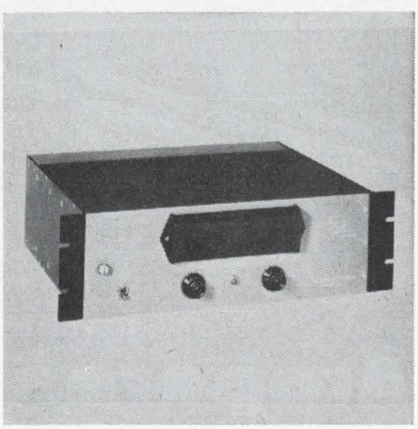


This VTVM features a 9-in. display and covers 0 to 1500 Vdc. Other ranges are 0 to 1500 mAdc, 0 to 1500 Vac rms and p-p, −10 to + 66 dB, 0.2 Ω to 1000 Megs and 50 pF to 2000 μF. Input impedance is 11 Megs on dc and ac tests, with 3% accuracy and ac measurement capability to 200 MHz.

P&A: $184.50; stock. Hickok Electrical Instrument Co., 10514 Du Pont, Cleveland. Phone: (216) 541-8060.

Circle No. 268

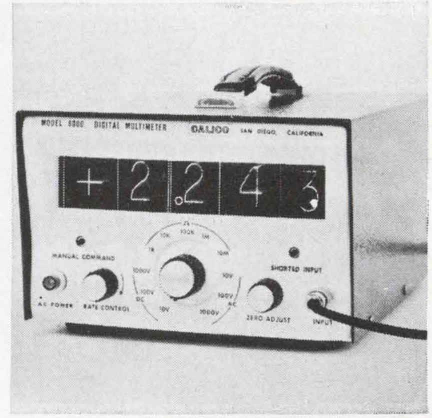
Voltage digitizer



A 3-decimal digit voltage digitizer provides parallel output and sequential output in either serial or serial/parallel. The rack-mount converter is a comparator as well as a "verifier" whereby the flip-flop indicates if input changed during conversion or exceeded range. Featured are transistor PC cards, accuracy of ±0.05%, speeds to 20,000 measurements/s or aperture time of 50 μs.

P&A: $3485; stock. Electronic Development, 423 W. Broadway, Boston. Phone: (617) 268-9696.

Circle No. 269

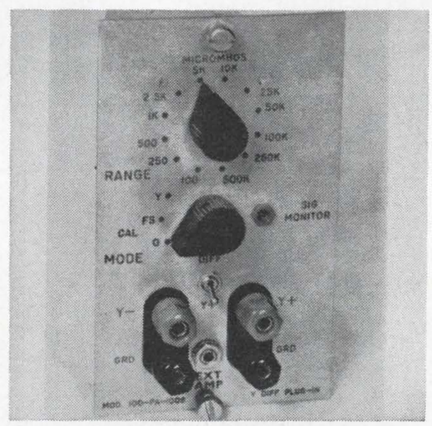


Digital multimeters

The series 8000 digital multimeters feature automatic polarity and over-range indications. Four-digit readout indicates Vac, Vdc and Ω. Input impedance is 10 Megs on all ranges with resolution of 0.01%. Dc accuracy is 0.05%. Models are available in rack-mounting configurations and with print-out capability.

P&A: From $495 to $695; 30 days. California Instruments Corp., 3511 Midway Dr., San Diego, Calif. Phone: (714) 224-3241.

Circle No. 270



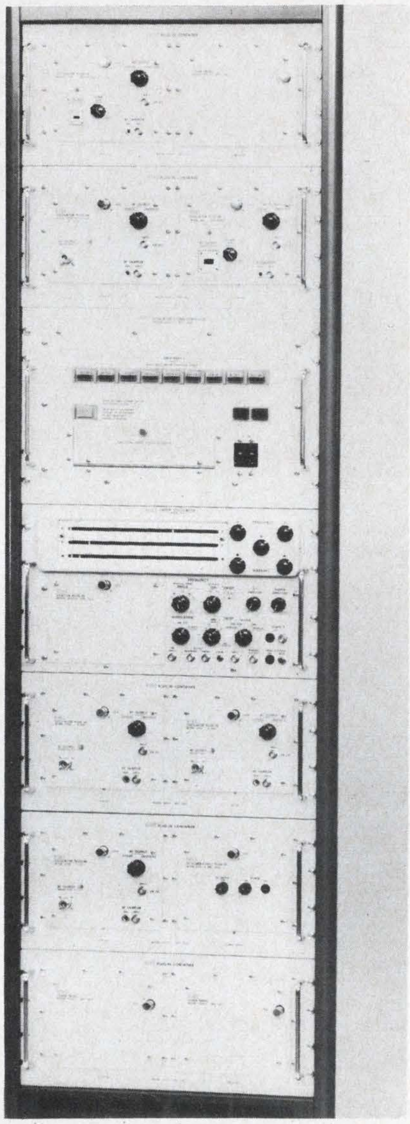
Admittance adapter

The complex plane locus of a 2-terminal black-box admittance or the admittance difference between 2 black-boxes can be measured and plotted using this differential admittance adapter. The 100-Hz to 100-kHz adapter provides 3 Vrms across both admittances and feeds the output to a complex impedance-admittance meter. Twelve ranges up to 0.5 mhos are available.

Drantez Engineering Labs. Inc., 1233 North Ave., Plainfield, N. J. Phone: (201) 755-7080.

Circle No. 271

Modular microwave source covers 0.25 to 40 GHz



A set of flexible plug-in units with a basic sweep oscillator and a push-button control unit are combined into a wide-range microwave signal oscillator system.

Depending on the plug-ins selected, the model 9505 can provide either single-frequency or sweep operation over a range of 0.25 to 40 GHz, or in any band thereof. The sweep speed ranges from 0.01 to 100 seconds. It can be programmed for inter-band switching times of 4 seconds with standby power applied to 65 seconds for maximum microwave tube life.

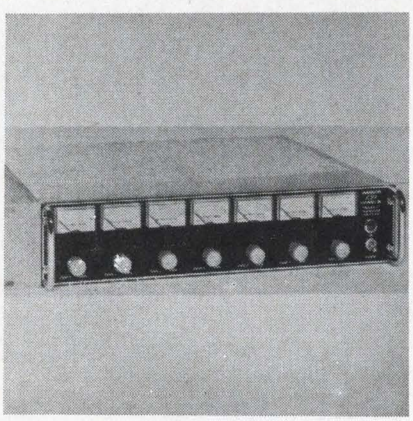
The building blocks making up the system consist of the company's model 650 series plug-in units—a sweep oscillator and from five to nine frequency units—an oscillator system controller and a regulated 26 Vdc power supply. All are contained in a standard rack console.

In addition to local control, the model 9505 can be remotely controlled and programmed by an accessory remote unit, or it can be tailored to a specific test complex configuration. More than one remote unit may be used.

P&A: About $12,000 for a 1 to 12.4 GHz configuration, about $16,000 for 250 MHz to 12.4 GHz coverage; 60 days. Alfred Electronics, 3176 Porter, Palo Alto, Calif. Phone: (415) 326-6496.

Circle No. 272

Frequency translator

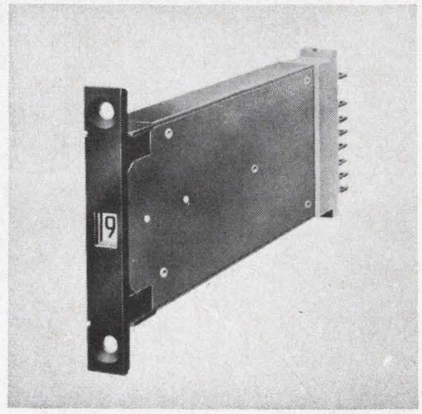


Model FT-4557 frequency translator records pre-detected 455-kHz signals. Up to 6 IF outputs are simultaneously accepted and converted to staggered frequencies between 580 kHz and 1.33 MHz. Inputs are combined into a single output signal wideband tape for recording.

Data bandwidth of the input channels is 50 kHz. Frequency conversion stability exceeds ±0.005%, and harmonic distortion is less than 1%. Required input is 2 to 20 mV rms on channels 1 to 6.

P&A: $2900; 45 days. Communication Electronics Inc., 6006 Executive Blvd., Rockville, Md. Phone: (301) 933-2800.

Circle No. 273

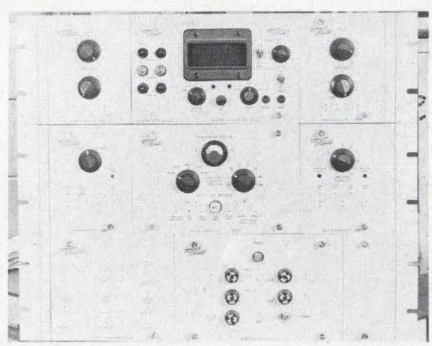


Single decade counter

A series 444 "UNIDEC" single-decade electromagnetic counter with printout capability provides count frequencies of 60 Hz. Individual units can be grouped for high-speed counting or be used individually for control. Counters are fitted with internal contacts to permit serial or parallel operation; they can be remotely reset to zero, provide electrical readout and be used as programmable switches.

ENM Co., 5304 W. Lawrence Ave., Chicago. Phone: (312) 282-8787.

Circle No. 274



Data modem

Model 48M data modem transmits serial digital data at rates up to 4800 bits/s in a synchronous mode over wireline networks. The unit uses a vestigial sideband technique which produces an output spectrum containing two data bits for every cycle of bandwidth. The modem is rated at ±30 Vdc at 120 mA. Input impedance exceeds 5000 Ω.

Rixon Electronics Inc., 2120 Industrial Pkwy., Silver Spring, Md. Phone: (301) 622-2121.

Circle No. 275

If you felt like this the last time your subminiature relay order was rescheduled, next time call Leach

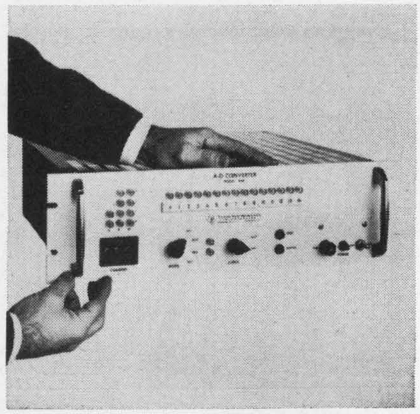
We've got over 7,000 subminiature relays in stock at key locations throughout the country. Ready for immediate delivery. Relays like our SERIES E., a half-size unit rated for top performance in dry circuit to 2 amp switching.

Designed for printed circuit and high environmental applications, this subminiature relay offers you space and weight economies of better than 50% over full size crystal can types. Available in voltages from 6 to 26.5 VDC, the SERIES E has an operate and release time of less than 4 milliseconds maximum, including bounce. It will withstand 100g shock, 30g vibration and operating temperatures from −65 to +125°C. Life is 1,000,000 cycles, dry circuit. Need one tomorrow? A dozen, a hundred? Then call us today. You'll have them right on time.

Leach Corporation, Relay Division, 5915 Avalon Blvd., Los Angeles, California; 90003
Phone (Area code 213) 232-8221
Export: LEACH INTERNATIONAL S. A.

LEACH

A/D converter

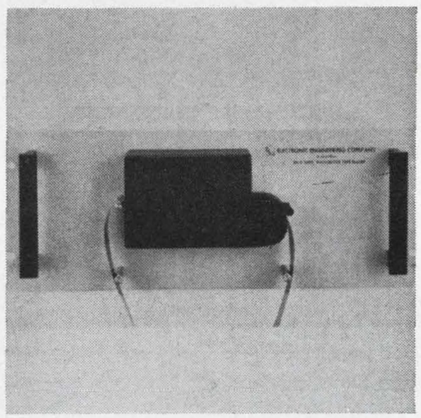


The model 848 A/D converter is a 15-binary-bit unit capable of conversion rates of 30,000/s. Accuracy is ±0.01% ± 1/2 least significant bit. Up to 96 single-ended multiplexer channels can be added with plug-in circuit cards. Sample time is 5 μs and aperture time is less than 50 ns.

P&A: About $5000; 6 to 8 wks. Texas Instruments, 3609 Buffalo Speedway, Houston. Phone: (713) 782-9661.

Circle No. 370

Tape block reader



A perforated-tape block reader with capacities up to 320 bits/frame is available. Capacities are 5 to 40 eight-bit characters, equivalent to 40 to 320 bits per frame. Stepping speeds vary from 2 frames/s to 12/s. Semiconductors step-control and amplify. Outputs may be voltage levels or current switching up to 2 A.

Price: About $1290. Electronic Engineering Co., 1601 E. Chestnut Ave., Santa Ana, Calif. Phone: (714) 547-5501.

Circle No. 371

Digital control counter

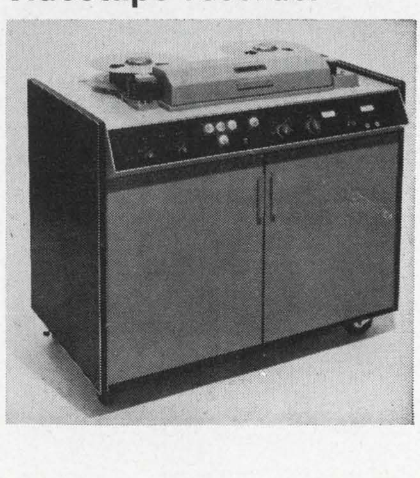
A high-speed, digital control electronic counter, Model PS 102-1, features built-in variable dual preset. The all solid-state counter handles up to 180,000 counts per minute.

With an accuracy of 0.001% per million, the counter has a biquinary digital readout. Standard models have 2, 3, 4 and 5 decades and others are available as options.

Electro-mation, 11762 Western, Stanton, Calif. Phone: (714) 638-2822.

Circle No. 372

Videotape recorder

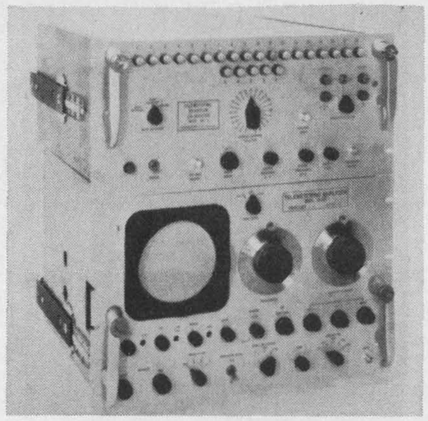


A mobile broadcast videotape recorder, the VR-1100E, is 39 in. high and weighs 550 lbs.

The manufacturer states that the unit meets studio performance specifications for remote taping by broadcast stations and closed circuit TV users. Fully transistorized, the recorder is available in 50- and 60-cycle record/playback and record only models.

P&A: $28,000 to $50,000; May. Ampex, 401 Broadway, Redwood City, Calif. Phone (213) 367-4151.

Circle No. 373

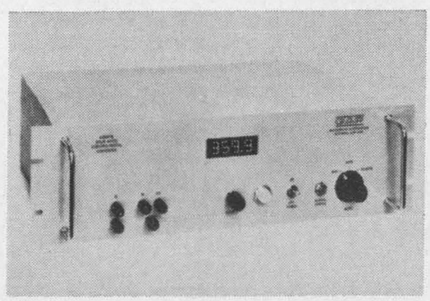


Spectrum analyzer

A calibrator combined with a spectrum analyzer gives visual display of IRIG channels at 3 sideband check points. Sideband sequencing for channels 1 to 18 plus A through E can be automatic. The TCC-1 controls analyzer center frequency, sweep width, resolution and gain in the CAL position at 0.01% of frequency. A max drift rate of ±30 Hz over 24 hours is reported. Both components can be used separately. Visual monitoring in the 350-Hz to 120-kHz range with a scanning unit is possible.

P&A: $13,750; 30 days. Probescope Co. Inc., 211 Robbins La., Syosset, N. Y., Phone: (516) 433-8120.

Circle No. 276

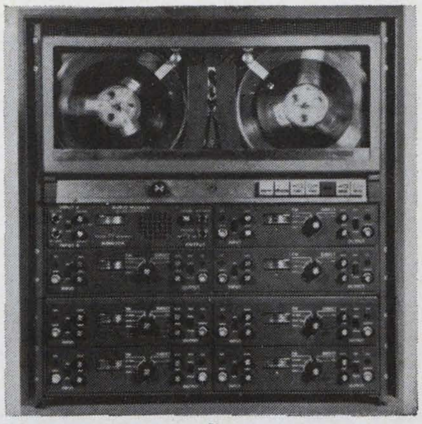


S/D converter

This synchro to digital converter converts 3- or 4-wire synchro data into 11-bit parallel output. It meets MIL-T-21200, and features an average conversion time of 5 ms with an accuracy of ±1 bit. Line-to-line voltages up to 90 V at 400 or 60 Hz are accommodated. Multiplexing capability permits the conversion of any of the 4-input channels.

Gap Instrument Corp., 17 Brooklyn Ave., Westbury, N. Y. Phone: (516) 333-8020.

Circle No. 277

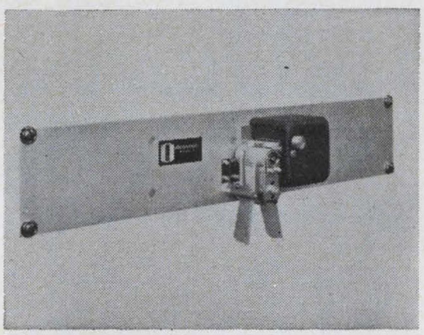


Tape recorder

The PI-6200 is a magnetic recorder featuring 3-speed operation in a 100:10:1 ratio with center speed of 3.75 in./s. In the closed-loop drive system the capstan is an integral part of the drive motor shaft. A crystal-controlled phase-locked servo system is used. FM or direct recording is provided for 8 channels. From 1 to 8 data or audio modules can be added.

P&A: About $5400. Precision Instrument Co., 3170 Porter Dr., Palo Alto, Calif. Phone: (415) 321-5615.

Circle No. 278



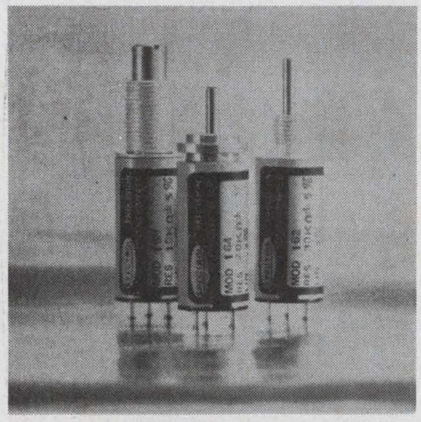
Tape reader

Uni- and bi-directional panel-mounted tape readers operate at a speed of 0 to 30 characters /s asynchronously in either direction. A dual cross-coupled stepping mechanism permits this action. Tape sensing is by star-wheel actuated switches. The series 119 reads blocks of punched data as a conventional block tape reader. Units are available at 24, 48 or 90 Vdc.

Price: About $320; stock. Ohr-Tronics Inc., 111 W. 50th St., New York. Phone: (212) 581-3570.

Circle No. 279

10-turn potentiometer



Resistance values from 100 Ω to 105 kΩ ±5% max are offered by these 10-turn, 1/2-in. diameter pots. Standard linearity is 0.30%. Power rating is 2 W at 40°C and operating range is from −55°C to +125°C. Resolution is 0.101 to 0.015%. Model 163 features a 1/4-in. shaft while model 164 is a servo-mounting version.

Price: $10 (1 to 9). Spectrol Electronics Corp., 17070 E. Gale Ave., City of Industry, Calif. Phone: (213) 964-6565.

Circle No. 385

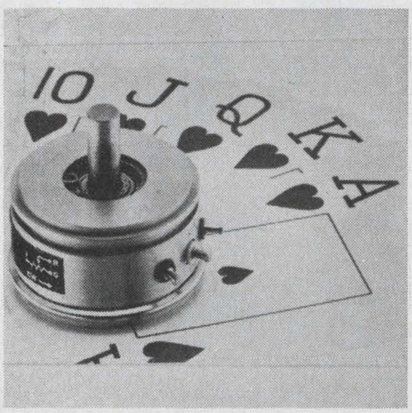
Limit switch

This miniature force ring switch can be installed in existing equipment with limited head space. Either compression or tension actuates contacts at specified loads to 1 ton. They have normally open or closed contacts and are capable of handling 5 A at 125 to 250 Vac. Accuracy and repeatibility of 1% and overload safety factor of 5 are claimed.

Celtic Industries Inc., 14743 Oznard St., Van Nuys, Calif. Phone: (213) 787-3615.

Circle No. 386

Potentiometer



A single-turn pot meeting MIL-R-12934D is available in resistance ranges from 10 Ω to 100 kΩ. Tolerance is ±5% from 10 Ω to 5 kΩ and ±3% from 10 kΩ to 100 kΩ. Power rating is 2 W at 85°C. Gangable with up to 8 cups, it functions at 150°C. The 1-5/8-in. diameter pot is wirewound and offers a ±0.5% independent linearity.

P&A: $23 (1 to 9), $21.85 (10 to 24); 4 to 6 wks. Amphenol, 120 South Main St., Janesville, Wis. Phone: (608) 754-6616.

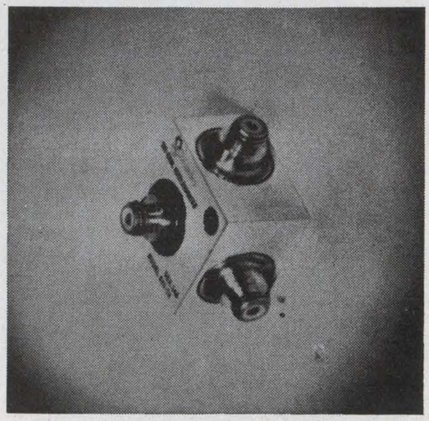
Circle No. 387

Triode

An axial ceramic, conical triode is for dielectric and industrial heating use. Rated to 160 MHz, the tube can be operated to 250 MHz when derated. As a class C oscillator, it will produce 8.2 kW at 82% efficiency, with a 5-kV plate voltage. The tube features thoriated tungsten mesh cathodes and mesh "K" grids. An integral radiator permits forced air cooling.

Amperex Electronic Corp., 230 Duffy, Hicksville, N. Y. Phone: (516) 931-6200.

Circle No. 388



Tri-axial accelerometer

Acceleration in three mutually perpendicular axes is simultaneously measured with the model 610-TX accelerometer. Sensitivity of the piezoelectric transducer is 8 peak mV/peak G and frequency response is ±5 over 1 Hz to 8 kHz with resonant frequency at 40 kHz. Vibration is 2000 peak G max and shock is 10,000 G max for 50 μs. Amplitude linearity is ±1%. Temperature range is −100°F to +250°F with optional high temperature units available.

The unit measures less than 0.3-in.^{3} and weighs less than 15 grams. Electric isolation of each accelerometer from the block minimizes ground loop problems and mechanical isolation of each transducer eliminates spurious signals.

Price: $450 (1 to 9). Columbia Research Laboratories, Inc., MacDade Blvd. and Bullens Lane, Woodlyn, Pa. Phone: (215) 532-9464.

Circle No. 389

Current regulators

These constant current regulators are packaged in an 8-in.^{3} unit containing two regulators. Temperature coefficients of 0.002% to 0.03%/°C and nominal outputs of 1, 5, or 10 mA are available. Series CR can be powered in parallel from unregulated 25 to 35 Vdc sources. Regulation is 0.002% against line and load.

P&A: $110 to $150; stock to 4 weeks. Instrument Components Co., 5220 Lynd Ave., Lyndhurst, Ohio. Phone: (216) 442-4468.

Circle No. 390

BURNDY LABORATORY—MC35 PRINTED CIRCUIT CONNECTORS (35 CONTACTS)

Connectors tested: 172

Hours accumulated per connector: 1500

Connector operating hours (T): 258,000

Contact operating hours (T): 9,030,000

Number of contact failures observed (C): 0

From Poisson distribution for C: 0

and 60% confidence level T: 0.915

connector failure rate $= \lambda \text{ connector} = \frac{\lambda T}{T} = \frac{0.915}{258{,}000} = 0.0000036$

$= \lambda \ 0.36\% / 1000 \text{ hrs.}$

contact failure rate $= \lambda \text{ contact} = \frac{\lambda T}{T} = \frac{0.915}{9{,}030{,}000} = 0.00000010$

$= \lambda \ 0.01\% / 1000 \text{ hrs.}$

FAILURE: Criteria for failure were open circuits or voltage drop in excess of 30.0 millivolts (45.0 MV after salt spray.)

BURNDY RELIABILITY TESTS ARE RELIABLE (HERE'S ABSOLUTE PROOF)

FIELD CONFIRMATION—MC35 PRINTED CIRCUIT CONNECTORS (35 CONTACTS)

Connectors in operation: 9451

Average number of hours accumulated to date: 1422

Connector operating hours (T): 13,439,322

Contact operating hours: 241,907,800

Number of failures observed (C): 0

From Poisson distribution for C: 0

and 60% confidence level λT: 0.915

connector failure rate $= \lambda \text{ connector} = \frac{\lambda T}{T} = \frac{0.915}{13{,}439{,}322} = 0.000000068$

$= \lambda \ .0068\% / 1000 \text{ hrs.}$

contact failure rate $= \lambda \text{ contact} = \frac{\lambda T}{T} = \frac{0.915}{241{,}907{,}800} = 0.0000000038$

$= \lambda \ 0.00038\% / 1000 \text{ hrs.}$

Two years ago a large systems manufacturer installed 9,451 Burndy MC35 printed circuit connectors to be used in a naval weapons system.

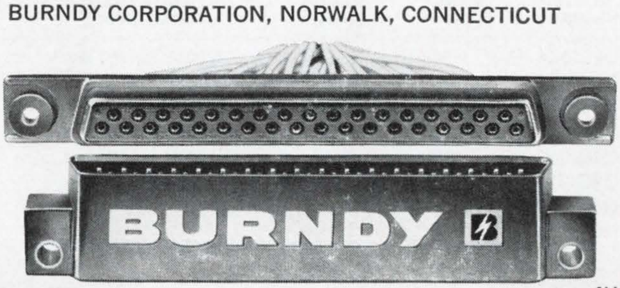
Their engineers reported not a single failure in more than 13 million connector operating hours—not one single contact failure in Burndy printed circuit connectors. In operation, not just the lab. 1422 hours per connector!

Just as Burndy reliability tests predicted, the rate of failure under vibration, varying temperature levels, and other environmental conditions was almost non-existent . . . performance far in excess of field expectations.

The operating performance proves Burndy connectors reliable in every way: millivolt drop, insulation resistance, connector separation force, individual contact separation, crimp-joint strength, capacitance, dielectric strength, resistance to test prod damage. Just as Burndy reliability tests predicted.

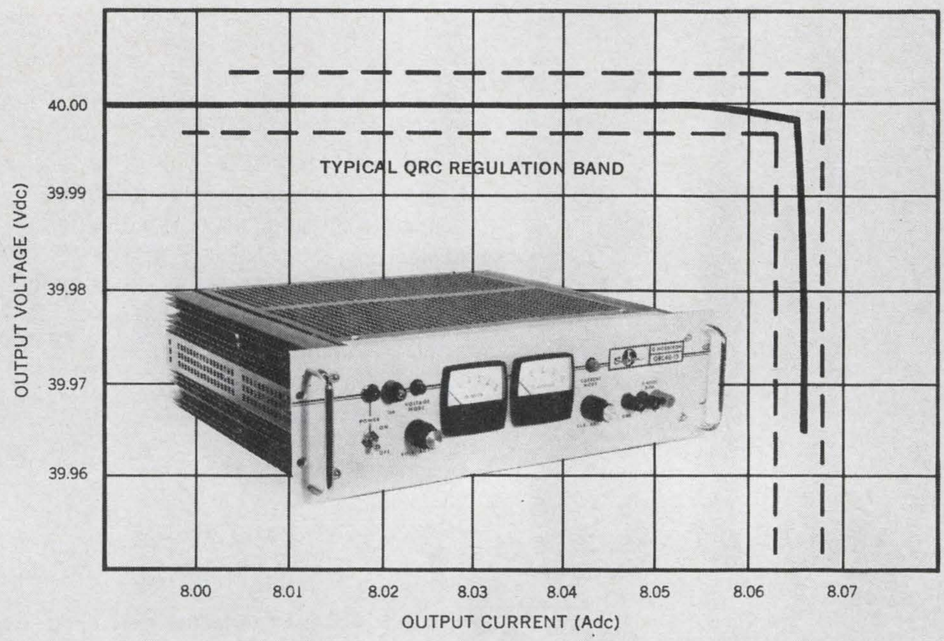
The field tests mark our MC35 printed circuit connectors as reliable as we claim. More important—they prove you can rely on Burndy reliability tests.

BURNDY CORPORATION, NORWALK, CONNECTICUT



64-17

ON READER-SERVICE CARD CIRCLE 48



Automatic crossover between constant voltage and constant current modes

Power Supply Specs That Set The Standard.

The Sorensen QRC series—wide range, transistorized power supplies—provide constant voltage/constant current regulation so sharp the units operate without ever leaving the specified regulation band. Voltage regulation is ± .005% for line *and* load combined. The QRC's are provided with front panel dial set adjustment of voltage and current limits, as well as voltage/current mode indicator lights. Other design features include: Low ripple . . . 1 mV rms • No turn-on/turn-off overshoots • Remote sensing and programming • Series/parallel operation • Input voltage 105-125 or 201-239 Vac, 50-400 c/s • Easily replaceable plug-in control boards • High efficiency and compact packaging. All Sorensen power supplies conform to proposed NEMA standards. For QRC details, or other standard/custom power supplies, AC line regulators or frequency changers, contact your local Sorensen rep, or write: Sorensen, A Unit of Raytheon Company, South Norwalk, Connecticut 06856.

ELECTRICAL & MECHANICAL SPECIFICATIONS

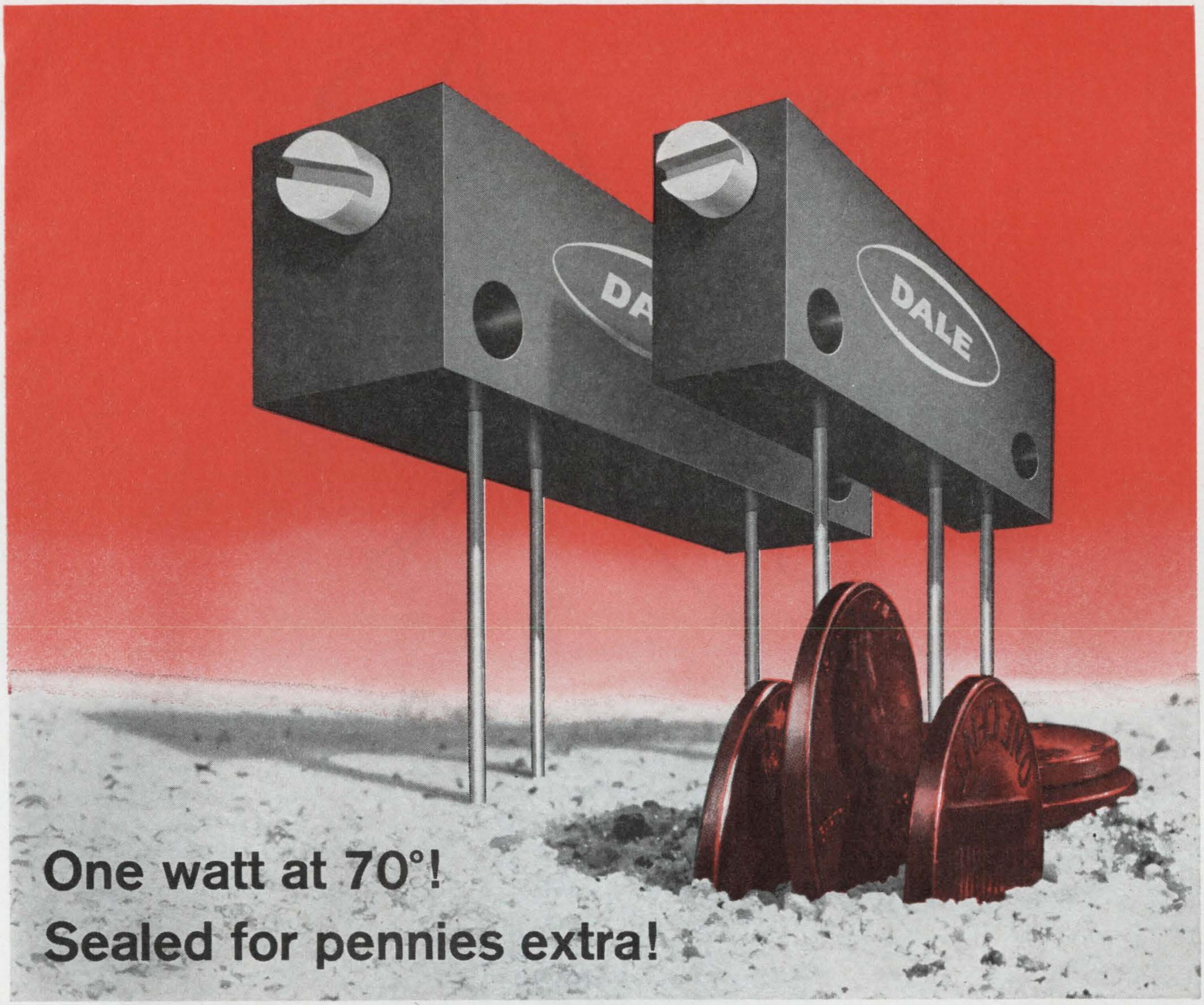
MODEL NUMBER	OUTPUT VOLTAGE RANGE (Vdc)	CURRENT OUTPUT RANGE (Adc)	VOLTAGE REGULATION (LINE & LOAD COMBINED)	RIPPLE VOLTAGE (rms)	CURRENT REGULATION	RIPPLE CURRENT (rms)	RACK HEIGHT (INCHES)	PRICE
QRC20-08	0-20	0-8	± .005% or ± 1 mv	1 mv	± .05% or ± 4 ma	2 ma	3½	$410.00
QRC20-15	0-20	0-15	± .005% or ± 1 mv	1 mv	± .05% or ± 8 ma	4 ma	5¼	525.00
QRC20-30	0-20	0-30	± .005% or ± 1 mv	1 mv	± .05% or ± 16 ma	8 ma	7	700.00
QRC40-4	0-40	0-4	± .005% or ± 1 mv	1 mv	± .05% or ± 2 ma	1 ma	5¼†	315.00
QRC40-8	0-40	0-8	± .005% or ± 1 mv	1 mv	± .05% or ± 4 ma	2 ma	3½	450.00
QRC40-15	0-40	0-15	± .005% or ± 1 mv	1 mv	± .05% or ± 8 ma	4 ma	5¼	575.00
QRC40-30	0-40	0-30	± .005% or ± 1 mv	1 mv	± .05% or ± 16 ma	8 ma	7	775.00

†Half rack

Sorensen represented in California by Ward-Davis Assoc., 770 S. Arroyo Parkway, Pasadena, Phone 213-684-2840; 1020 Corporation Way, Palo Alto, Phone 415-968-7116; 3492 Pickett Street, San Diego, Phone 714-297-4619.

Sorensen

A UNIT OF RAYTHEON COMPANY



2 very good reasons why Dale sells so many Commercial Wirewound Trimmers

PERFORMANCE: Dale's 2100 and 2200 series are the commercial counterparts of RT-11 and RT-10 respectively. They can be sealed for just a few cents per unit, yielding mil-level performance in all areas except temperature.

PRICE: Competitive and then some! Check Dale's new lower commercial prices. They were made possible through an extensive value analysis program which actually improved overall unit quality.

DELIVERY: New automated production facilities plus a factory stocking program combine to put your order in your plant without delay.

Simplify trimmer ordering—a call to Dale will do it. Phone 564-3131, Area Code 402

SPECIFICATIONS

	2100	2200
CASE DIMENSIONS	.28 high x .31 wide x 1.25 long	.18 wide x .32 high x 1.00 long
STANDARD MODELS	**2187**—printed circuit pins, 21 AWG gold plated. **2188**—28 AWG stranded vinyl leads. **2189**—solder lug, gold plated.	**2280**—printed circuit pins, 22 AWG gold plated. **2292**—solid wire, 26 AWG gold plated. **2297**—28 AWG stranded vinyl leads.
POWER RATING	1 watt at 70° C, derating to 0 at 125° C	
OPERATING TEMPERATURE RANGE	−65° C to + 125° C	
ADJUSTMENT TURNS	25 ± 2	15 ± 2
RESISTANCE RANGE	10 ohms to 100K ohms	10 ohms to 50K ohms
STANDARD TOLERANCE	± 10% standard (lower tolerances available)	

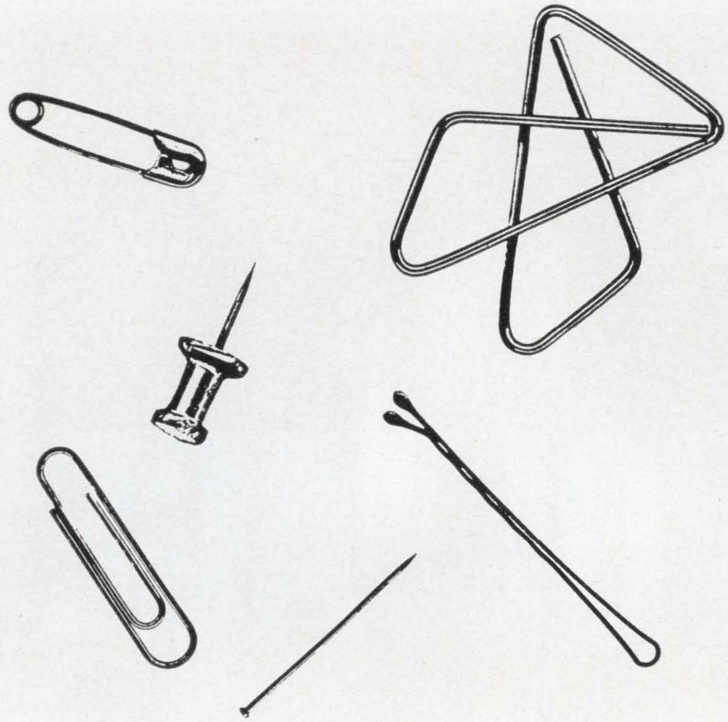
Write for Catalog B

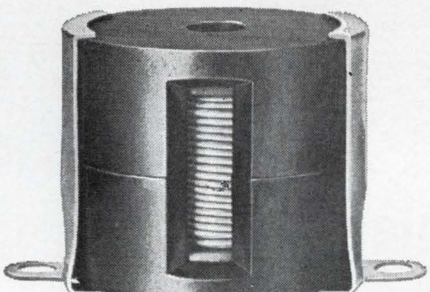
DALE®

DALE ELECTRONICS, INC.
1328 28th Avenue, Columbus, Nebraska
In Canada: Dale Electronics, Canada, Ltd.

SEE OUR SPECIFICATIONS IN THE MICROFILM CATALOG FILE VSMF

ON READER-SERVICE CARD CIRCLE 49

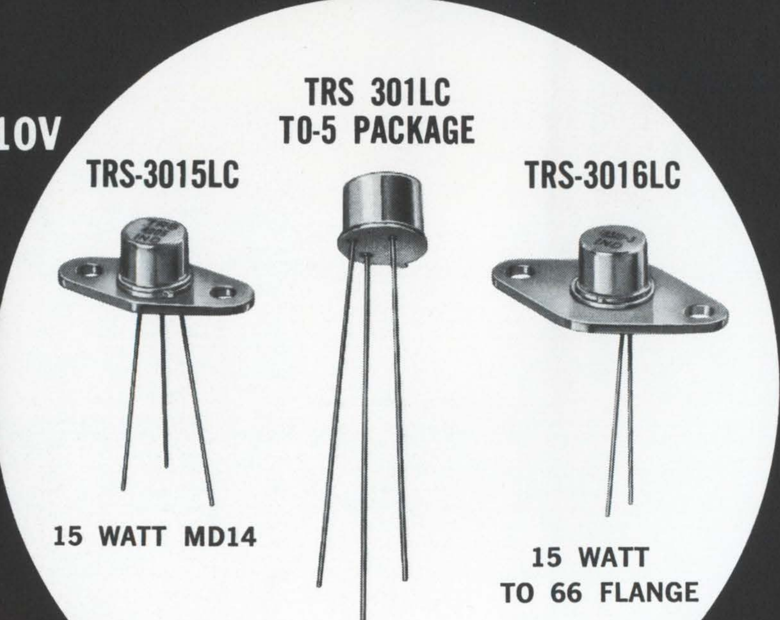




LOW COST
HI-VOLTAGE
NPN SILICON TRANSISTORS

300 VOLT VCER
HFE > 40 IC = 20 MA VCE 10V
5 WATTS 25° C CASE

70¢
TRS 301LC



Also available
LOW COST
400V
500V
600V

INDUSTRO
TRANSISTOR CORPORATION
35-10 36th Ave., Long Island City, N. Y. 11106 · Phone (212) 392-8000

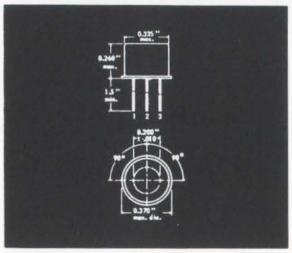
For complete specifications contact any Industro distributor or sales office

MILITARY APPLICATION — PREMIUM LINE

MEDIUM POWER

	BVCEO @IC=25MA Sustained VOLTS	BVCER RBE=10Ω @200 ua VOLTS	BVCBO @200 ua VOLTS	BVEBO @100 ua VOLTS	HFE IC=1MA VCE=.5V	HFE IC=10MA VCE=2V	HFE IC=50MA VC=4V	VCE. SAT. IC=50MA IB=5MA VOLTS	VBE. SAT. IC=50MA IB=5MA VOLTS	ICBO @25°C VCB VOLTS	ICBO @25°C <ua	ICBO @100°C VCB VOLTS	ICBO @100°C <ua	GBW IC=50MA VCE=10V @20MC	MAX COB uuf IE=0 VCB=10V
TRS-2804S	280	340	340	5	20	30	30	1.5	1.0	250	2	250	65	2.5	40
TRS-3204S	320	385	385	5	20	30	30	1.5	1.0	300	2	300	65	2.5	40
TRS-3604S	360	420	420	5	20	30	30	1.5	1.0	330	2	330	65	2.5	40

	BVCEO @IC=25MA Sustained VOLTS	BVCER RBE=10Ω @200 ua VOLTS	BVCBO @200 ua VOLTS	BVEBO @100 ua VOLTS	HFE IC=1MA VCE=1V	HFE IC=10MA VCE=2.5V	HFE IC=25MA VCE=5V	VCE. SAT. IC=25MA IB=2.5MA VOLTS	VBE. SAT. IC=25MA IB=2.5MA VOLTS	ICBO @25°C VCB VOLTS	ICBO @25°C <ua	ICBO @100°C VCB VOLTS	ICBO @100°C <ua	GBW IC=50MA VCE=10V @20MC	MAX COB uuf IE=0 VCB=10V
TRS-4014S	400	480	480	5	20	25	30	1.5	1.0	350	10	350	80	2.5	40
TRS-4404S	440	530	530	5	20	25	30	1.5	1.0	430	10	430	80	2.5	40
TRS-4804S	480	580	580	5	20	25	30	1.5	1.0	480	10	480	80	2.5	40
TRS-5204S	520	625	625	5	20	25	30	1.5	1.0	520	10	520	80	2.5	40
TRS-5404S	540	650	650	5	20	25	30	1.5	1.0	540	10	540	80	2.5	40
TRS-5804S	580	700	700	5	20	25	30	1.5	1.0	580	10	580	80	2.5	40
TRS-6204S	620	750	750	5	20	25	30	1.5	1.0	620	10	620	80	2.5	40
TRS-6604S	660	800	800	5	20	25	30	1.5	1.0	660	10	660	80	2.5	40
TRS-7014S	700	850	850	5	20	25	30	1.5	1.0	700	10	700	80	2.5	40



Total Dissipation @ 25°C Ambient	P.D.		1W
@ 25°C Case Temperature	P.D.		5W
@ 100°C Case Temperature	P.D.		2W
Storage Temperature Range	T_{stg}	−65 to +200	°C
Operating Temperature Range	T_{opr}	−55 to +175	°C
Peak Collector Current	ICM	400	MA
Peak Base Current	IB	50	MA

TO-5 OUTLINE

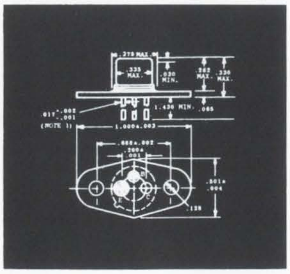
Derate 6.66 mw/°C for TA above 25°C
Derate 26.6 mw/°C for TC above 25°C

MILITARY APPLICATION — PREMIUM LINE

HIGH POWER

	BVCEO @IC=25MA Sustained VOLTS	BVCER RBE=10Ω @200 ua VOLTS	BVCBO @200 ua VOLTS	BVEBO @100 ua VOLTS	HFE IC=1MA VCE=.5V	HFE IC=10MA VCE=2V	HFE IC=50MA VCE=4V	VCE. SAT. IC=50MA IB=5MA VOLTS	VBE. SAT. IC=50MA IB=5MA VOLTS	ICBO @25°C VCB VOLTS	ICBO @25°C <ua	ICBO @100°C VCB VOLTS	ICBO @100°C <ua	GBW IC=50MA VCE=10V @20MC	MAX COB uuf IE=0 VCB=10V
TRS-2805S	280	340	340	5	20	30	30	1.5	1.0	250	2	250	65	2.5	45
TRS-3205S	320	385	385	5	20	30	30	1.5	1.0	300	2	300	65	2.5	45
TRS-3605S	360	420	420	5	20	30	30	1.5	1.0	330	2	330	65	2.5	45

	BVCEO @IC=25MA Sustained VOLTS	BVCER RBE=10Ω @200 ua VOLTS	BVCBO @200 ua VOLTS	BVEBO @100 ua VOLTS	HFE IC=1MA VCE=1V	HFE IC=10MA VCE=2.5V	HFE IC=25MA VCE=5V	VCE. SAT. IC=25MA IB=2.5MA VOLTS	VBE. SAT. IC=25MA IB=2.5MA VOLTS	ICBO @25°C VCB VOLTS	ICBO @25°C <ua	ICBO @100°C VCB VOLTS	ICBO @100°C <ua	GBW IC=50MA VCE=10V @20MC	MAX COB uuf IE=0 VCB=10V
TRS-4015S	400	480	480	5	20	25	30	1.5	1.0	350	10	350	80	2.5	45
TRS-4405S	440	530	530	5	20	25	30	1.5	1.0	430	10	430	80	2.5	45
TRS-4805S	480	580	580	5	20	25	30	1.5	1.0	480	10	480	80	2.5	45
TRS-5205S	520	625	625	5	20	25	30	1.5	1.0	520	10	520	80	2.5	45
TRS-5405S	540	650	650	5	20	25	30	1.5	1.0	540	10	540	80	2.5	45
TRS-5805S	580	700	700	5	20	25	30	1.5	1.0	580	10	580	80	2.5	45
TRS-6205S	620	750	750	5	20	25	30	1.5	1.0	620	10	620	80	2.5	45
TRS-6605S	660	800	800	5	20	25	30	1.5	1.0	660	10	660	80	2.5	45
TRS-7015S	700	850	850	5	20	25	30	1.5	1.0	700	10	700	80	2.5	45



Total Dissipation @ 25°C Ambient	P.D.		2W
@ 25°C Case Temperature	P.D.		15W
@ 100°C Case Temperature	P.D.		10W
Storage Temperature Range	T_{stg}	−65 to +200	°C
Operating Temperature Range	T_{opr}	−55 to +175	°C
Peak Collector Current	ICM	400	MA
Peak Base Current	IB	50	MA

MD-14 OUTLINE

Derate 13.3 mw/°C for TA above 25°C
Derate 66.5 mw/°C for TC above 25°C - 100°C
Derate 133 mw/°C for TC above 100°C

For prices and delivery on these transistors contact INDUSTRO or the following INDUSTRO sales reps.

REPRESENTATIVES: Alpine Industries, 2236 Hepburn Ave., Dayton, Ohio, 513-CR 8-5861 • **Argus Associates, Inc.,** P. O. Box 68, Warminster, Penna., 215-675-4131 • **B & B Associates,** Needham, Mass., 617-444-5562 • **Domac, Inc.,** 1950 Bank St., Ottawa, Ontario, Canada, 613-733-3390 • **Dorado Elec. Reps.,** 13615 Victory Blvd., Van Nuys, Calif., 213-873-4124 • **J. R. Sales Eng'g Co.,** 6446 W. Bloomingdale Ave., Chicago, Ill., 312-889-6662 • **Lectropon Ltd.,** Kinbex House, Wellington St., Slough, Buckinghamshire, England, Slough 27629 • **Machine & Products (European Export),** 52 Wall St., New York, N. Y.. WH 4-4370 • **Melvin Sales,** 113 Camino Real., Millbrae, California, 415-697-6922 • **W. J. Stulgis Co., Inc.,** 698 W. Crockett St., Seattle, Washington, ATwater 2-7870 • **Western Elect. Components,** 4301 Birch St., Newport Beach, Calif., 714-540-1322 • **White Sales Co..** P. O. Box 8432, Minneapolis, Minnesota, 929-5710.

INDUSTRO TRANSISTOR CORPORATION

35-10 36th Avenue, Long Island City 6, N. Y. • EXeter 2-8000

	BVCER RBE @ 1MA VOLTS	BVCBO @ 1C-.5MA VOLTS	BVEBO 200ua VOLTS	MIN. HFE IC-20MA VCE-10V	VCE. SAT. IC-20MA IB-5MA VOLTS	VBE. SAT. IC-20MA IB-5MA VOLTS	ICBO @25°C VCB VOLTS	<ua	GBW IC-20MA VCE-10V @ 100MC	MAX COB uuf IE-0 VCB-20V	PKG. *
TRS-301LC	300	300	5	40	2.5	1	100	10	.2	30	1
TRS-3015LC	300	300	5	40	2.5	1	100	10	.2	30	2
TRS-3016LC	300	300	5	40	2.5	1	100	10	.2	30	3
TRS-401LC	400	400	5	30	2.5	1	200	10	.2	30	1
TRS-4015LC	400	400	5	30	2.5	1	200	10	.2	30	2
TRS-4016LC	400	400	5	30	2.5	1	200	10	.2	30	3
TRS-501LC	500	500	5	30	2.5	1	300	15	.2	30	1
TRS-5015LC	500	500	5	30	2.5	1	300	15	.2	30	2
TRS-5016LC	500	500	5	30	2.5	1	300	15	.2	30	3
TRS-601LC	600	600	5	30	2.5	1	400	20	.2	30	1
TRS-6015LC	600	600	5	30	2.5	1	400	20	.2	30	2
TRS-6016LC	600	600	5	30	2.5	1	400	20	.2	30	3

			* PACKAGE #1 TO—5 OUTLINE	* PACKAGE #2 MD—14 OUTLINE	* PACKAGE #3 TO—66 FLANGE
Total Dissipation	@ 25° Ambient	P.D.	1W	2W	2W
	@ 25°C Case Temperature	P.D.	5W	15W	15W
	@ 100°C Case Temperature	P.D.	2W	10W	10W

Storage Temperature Range	Tstg	—65 to +200	°C
Operating Temperature Range	Topr	—55 to +175	°C
Peak Collector Current	ICM	400	MA
Peak Base Current	IB	50	MA

TO-5 OUTLINE

Derate 6.66 mw/°C for TA above 25°C
Derate 26.6 mw/°C for TC above 25°C

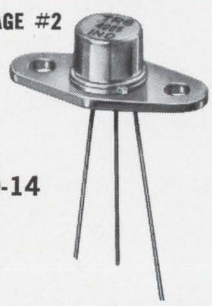
MD-14 OUTLINE and TO-66 FLANGE

Derate 13.3 mw/°C for TA above 25°C
Derate 66.5 mw/°C for TC above 25°C—100°C
Derate 133 mw/° for TC above 100°C

PACKAGE #1

TO-5

PACKAGE #2



MD-14

PACKAGE #3

TO-66 FLANGE

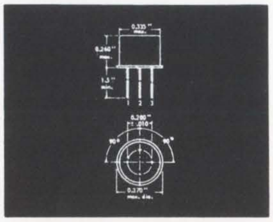
Effective 2/1/66

MILITARY & INDUSTRIAL

MEDIUM POWER

	BVCER RBE 10Ω @200 ua VOLTS	BVCBO @200 ua VOLTS	BVEBO @100 ua VOLTS	HFE IC=50MA VCE=4V	VCE. SAT. IC=50MA IB=5MA VOLTS	VBE. SAT. IC=50MA IB=5MA VOLTS	ICBO @25°C VCB VOLTS	<ua	ICBO @100°C VCB VOLTS	<ua	GBW IC=50MA VCE=10V @20MC	MAX COB uuf IE=0 VCB=10V
TRS-1004	100	100	6	30	1.5	1	75	3	75	200	2.5	40
TRS-1204	120	120	6	30	1.5	1	100	3	100	200	2.5	40
TRS-1404	140	140	6	30	1.5	1	115	3	115	200	2.5	40
TRS-1604	160	160	6	30	1.5	1	150	3	150	200	2.5	40
TRS-1804	180	180	6	30	1.5	1	165	3	165	200	2.5	40
TRS-2004	200	200	6	20	1.9	1	100	2	100	200	2.5	40
TRS-2254	225	225	6	22	1.8	1	180	3	180	200	2.5	40
TRS-2504	250	250	6	20	1.9	1	150	2	150	200	2.5	40
TRS-2754	275	275	6	22	1.8	1	200	3	200	200	2.5	40
TRS-3014	300	300	6	30	1.5	1	200	2	200	100	2.5	40
TRS-3254	325	325	6	22	1.8	1	250	3	250	200	2.5	40
TRS-3504	350	350	6	20	1.9	1	250	2	250	200	2.5	40
TRS-3754	375	375	6	22	1.8	1	300	3	300	200	2.5	40
TRS-4014	400	400	6	30	1.5	1	300	2	300	100	2.5	40
TRS-4254	425	425	6	22	1.8	1	350	3	300	200	2.5	40
TRS-4504	450	450	6	30	1.5	1	350	2	350	100	2.5	40
TRS-4754	475	475	6	22	1.8	1	375	2	375	200	2.5	40

	BVCER RBE 10Ω @200 ua VOLTS	BVCBO @200 ua VOLTS	BVEBO @100 ua VOLTS	HFE IC=25MA VCE=5V	VCE. SAT. IC=25MA IB=5MA VOLTS	VBE. SAT. IC=25MA IB=5MA VOLTS	ICBO @25°C VCB VOLTS	<ua	ICBO @100°C VCB VOLTS	<ua	GBW IC=50MA VCE=10V @20MC	MAX COB uuf IE=0 VCB=10V
TRS-5014	500	500	6	30	1.5	1	350	2	350	100	2.5	40
TRS-5254	525	525	6	22	1.8	1	425	2	425	200	2.5	40
TRS-5504	550	550	6	20	1.9	1	450	2	450	200	2.5	40
TRS-5754	575	575	6	22	1.8	1	475	2	475	200	2.5	40
TRS-6014	600	600	6	30	1.5	1	500	10	500	100	2.5	40
TRS-6504	650	650	6	30	1.5	1	525	10	525	100	2.5	40
TRS-7014	700	700	6	30	1.5	1	550	10	550	100	2.5	40
TRS-7504	750	750	6	30	1.5	1	575	10	575	100	2.5	40
TRS-8014	800	800	6	30	1.5	1	600	10	600	100	2.5	40



Total Dissipation @ 25°C Ambient	P.D.		1W
@ 25°C Case Temperature	P.D.		5W
@ 100°C Case Temperature	P.D.		2W
Storage Temperature Range	T_{stg}	−65 to +200	°C
Operating Temperature Range	T_{opr}	−55 to +175	°C
Peak Collector Current	ICM	400	MA
Peak Base Current	IB	50	MA

TO-5 OUTLINE

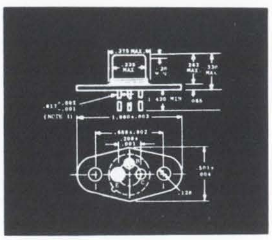
Derate 6.66 mw/°C for TA above 25°C
Derate 26.6 mw/°C for TC above 25°C

MILITARY & INDUSTRIAL

HIGH POWER

	BVCER RBE 10Ω @200 ua VOLTS	BVCBO @200 ua VOLTS	BVEBO @100 ua VOLTS	HFE IC=50MA VCE=4V	VCE. SAT. IC=50MA IB=5MA VOLTS	VBE. SAT. IC=50MA IB=5MA VOLTS	ICBO @25°C VCB VOLTS	<ua	ICBO @100°C VCB VOLTS	<ua	GBW IC=50MA VCE=10V @20MC	MAX COB uuf IE=0 VCB=10V
TRS-1005	100	100	6	30	1.5	1	75	3	75	200	2.5	45
TRS-1205	120	120	6	30	1.5	1	100	3	100	200	2.5	45
TRS-1405	140	140	6	30	1.5	1	115	3	115	200	2.5	45
TRS-1605	160	160	6	30	1.5	1	150	3	150	200	2.5	45
TRS-1805	180	180	6	30	1.5	1	165	3	165	200	2.5	45
TRS-2005	200	200	6	20	1.9	1	100	2	100	200	2.5	45
TRS-2255	225	225	6	22	1.8	1	180	3	180	200	2.5	45
TRS-2505	250	250	6	20	1.9	1	150	2	150	200	2.5	45
TRS-2755	275	275	6	22	1.8	1	200	3	200	200	2.5	45
TRS-3015	300	300	6	30	1.5	1	200	2	200	100	2.5	45
TRS-3255	325	325	6	22	1.8	1	250	3	250	200	2.5	45
TRS-3505	350	350	6	20	1.9	1	250	2	250	200	2.5	45
TRS-3755	375	375	6	22	1.8	1	300	3	300	200	2.5	45
TRS-4015	400	400	6	30	1.5	1	300	2	300	100	2.5	45
TRS-4255	425	425	6	22	1.8	1	350	3	300	200	2.5	45
TRS-4505	450	450	6	30	1.5	1	350	2	350	100	2.5	45
TRS-4755	475	475	6	22	1.8	1	375	2	375	200	2.5	45

	BVCER RBE 10Ω @200 ua VOLTS	BVCBO @200 ua VOLTS	BVEBO @100 ua VOLTS	HFE IC=25MA VCE=5V	VCE. SAT. IC=25MA IB=5MA VOLTS	VBE. SAT. IC=25MA IB=5MA VOLTS	ICBO @25°C VCB VOLTS	<ua	ICBO @100°C VCB VOLTS	<ua	GBW IC=50MA VCE=10V @20MC	MAX COB uuf IE=0 VCB=10V
TRS-5015	500	500	6	30	1.5	1	350	2	350	100	2.5	45
TRS-5255	525	525	6	22	1.8	1	425	2	425	200	2.5	45
TRS-5505	550	550	6	20	1.9	1	450	2	450	200	2.5	45
TRS-5755	575	575	6	22	1.8	1	475	2	475	200	2.5	45
TRS-6015	600	600	6	30	1.5	1	500	10	500	100	2.5	45
TRS-6505	650	650	6	30	1.5	1	525	10	525	100	2.5	45
TRS-7015	700	700	6	30	1.5	1	550	10	550	100	2.5	45
TRS-7505	750	750	6	30	1.5	1	575	10	575	100	2.5	45
TRS-8015	800	800	6	30	1.5	1	600	10	600	100	2.5	45



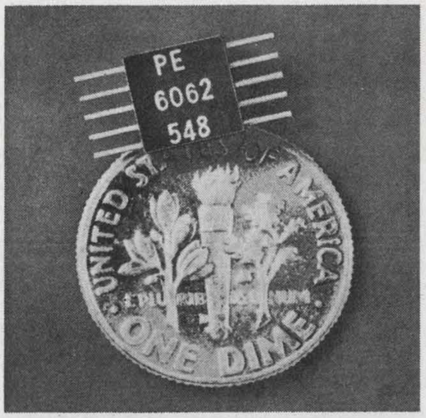
Total Dissipation @ 25°C Ambient	P.D.		2W
@ 25°C Case Temperature	P.D.		15W
@ 100°C Case Temperature	P.D.		10W
Storage Temperature Range	T_{stg}	−65 to +200	°C
Operating Temperature Range	T_{opr}	−55 to +175	°C
Peak Collector Current	ICM	400	MA
Peak Base Current	IB	50	MA

MD-14 OUTLINE

Derate 13.3 mw/°C for TA above 25°C
Derate 66.5 mw/°C for TC above 25°C - 100°C
Derate 133 mw/°C for TC above 100°C

TEAR OUT THIS INDUSTRO TRANSISTOR CORP. INSERT FOR YOUR REFERENCE

Transformers

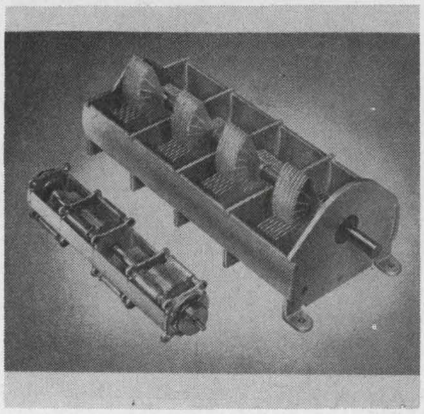


Microminiature transformers of this series can be used with sense amplifiers and discriminator circuitry and as common mode chokes. The "Flat-Tran" is compatible with ICs and standard flat pack connectors. Twelve designs are available from 25 μH to 240 μH. All models have gold-plated kovar leads to TO-91 packages.

P&A: $9 each in 1 to 4 quantity; stock. Pulse Engineering Inc., 560 Robert Ave., Santa Clara, Calif. Phone: (408) 248-6040.

Circle No. 280

Gang capacitor

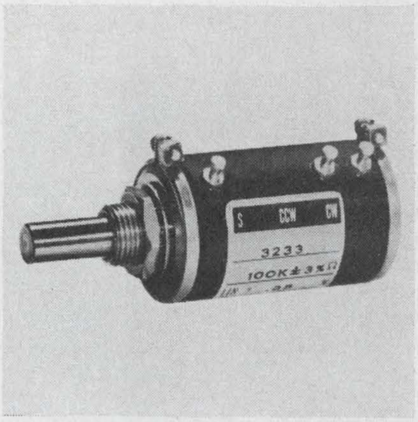


A new gang capacitor, model 6100, measures 1-1/8-in. x 1-3/16- x 5-9/16-in. It has a capacity of 145 pF min at 9.5 pF per section (180° rotation). Shock and vibration resistance are provided by spring-type bearings and alumina support of the rotor stator. Low-temperature coefficient, low torque and smooth tuning are reported.

Johanson Mfg. Corp., 400 Rockaway Valley Rd., Boonton, N. J. Phone: (201) 334-2676.

Circle No. 281

10-turn potentiometer

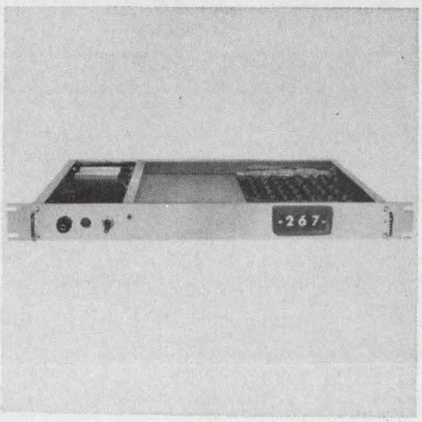


This 10-turn, wirewound pot is mounted with a 7/8-in. bushing. The model 3233 has a resistance range of 10 Ω to 200 kΩ ±3%. Linearity is ±0.25 over −55°C to +105°C. The 2.5 W pot has a lifetime of 2 x 10^6 revolutions. Uniform torque with zero backlash and 100 oz-in. stop strength are reported.

P&A: $7.13 (250 to 499); stock. Duncan Electronics Inc., 2865 Fairview Rd., Costa Mesa, Calif. Phone: (714) 545-8261.

Circle No. 282

B/D display

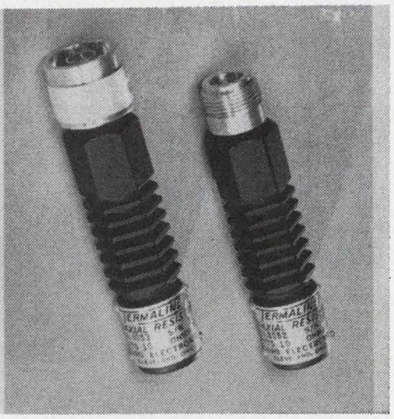


Three binary-to-decimal displays convert parallel binary data into decimals. Models 120 and 120-1 are 9-bit units with 3-digit readouts, but 120-1 is a dual unit. The 17-bit model 121 has a 5-digit readout. Logic is negative (zero=about +4 V). Input is 1 MHz max. Convert command pulse width is 2 μs. Conversion time for the 9-bit models is 260 μs and 33 ms for 17-bit models.

Missouri Research Labs. Inc., 2109 Locust St., St. Louis. Phone: (314) 241-7875.

Circle No. 283

Load resistor

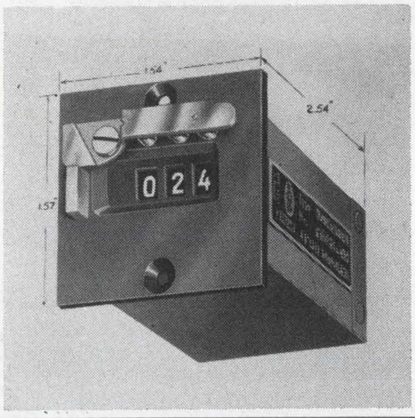


Operating from dc to 4000 MHz with negligible vswr, this precision dry load resistor utilizes broadband RF construction. A 10-W power rating results from new heat transfer materials and the addition of cooling fins to the hexagonal radiator. Available with a male or female N-connector, the resistor is used in 50-Ω transmission line or system attitude-insensitive terminations.

P&A: $30; June. Bird Electronic Corp., 30303 Aurora Rd., Cleveland. Phone: (216) 248-1200.

Circle No. 284

Impulse counter

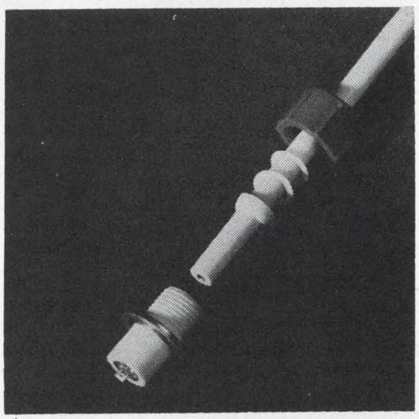


This 3-digit predetermining impulse counter counts down from the pre-set number and actuates an spdt contact at 0. Manual or electrical reset returns the counter to the preset. The preset number is changed with a front-panel adjustment. Operation at speeds up to 50 counts/second from −40°F to +140°F and coil voltages of 4 through 110 Vdc or ac are featured.

Kessler-Ellis Products Co., 46 Center Ave., Atlantic Highland, N. J. Phone: (201) 291-0500.

Circle No. 285

Connectors

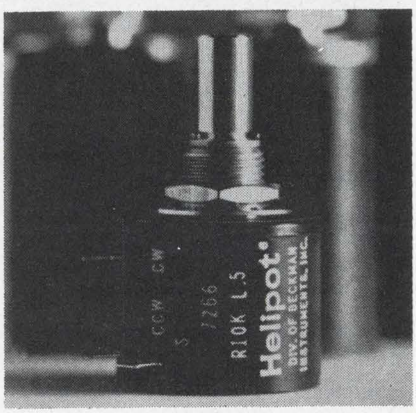


These connectors substitute an integral shoulder for an O-ring in the molded-end heads, thus assuring good contacts. As the hand-screwed cap is tightened, the lead is driven fully home; once locked in place, it cannot be pulled out. The type LGH connectors handle up to 50,000 Vdc with an average of 10 A. With ceramic or glass epoxy receptacles, temperature limits range between − 55 and + 140°C.

Amp. Inc., 155 Park, Elizabethtown, Pa. Phone: (717) 367-1105.

Circle No. 286

10-turn potentiometer

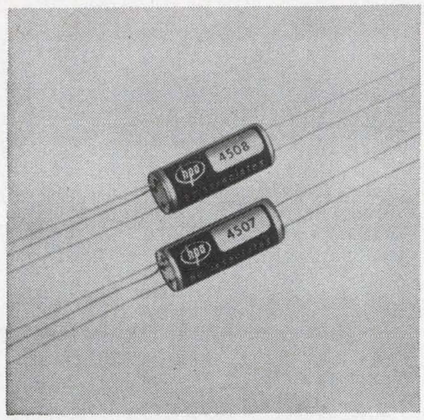


A wirewound, 10-turn pot has 7/8-in. diameter and is 3/4-in. long. Standard values are 10 Ω to 125 kΩ. Tolerance is ±3% with ±0.2% independent linearity.

The bushing-mount version is rated 1.6 W at 40°C, derating to 0 at 85°C. Ganged as well as single units are available.

P&A: $10 (1 to 9); stock. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. Phone: (714) 871-4848.

Circle No. 287

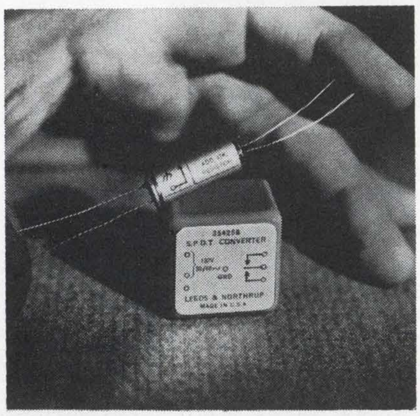


Photoconductor cells

The 4507 and 4508 photoconductor cells are spst switches which operate up to 1 kHz. They can switch or modulate dc signals in the submicrovolt level. Illumination of the photocells with self-contained neon glow lamps actuates the switch. The 4507 has a cell for high-impedance circuits while the 4508 has a cell for low impedance.

Price: $8 (1 to 9), $6.80 (10 to 99). hp associates, 620 Page Mill Rd., Palo Alto, Calif. Phone: (415) 321-8510.

Circle No. 288

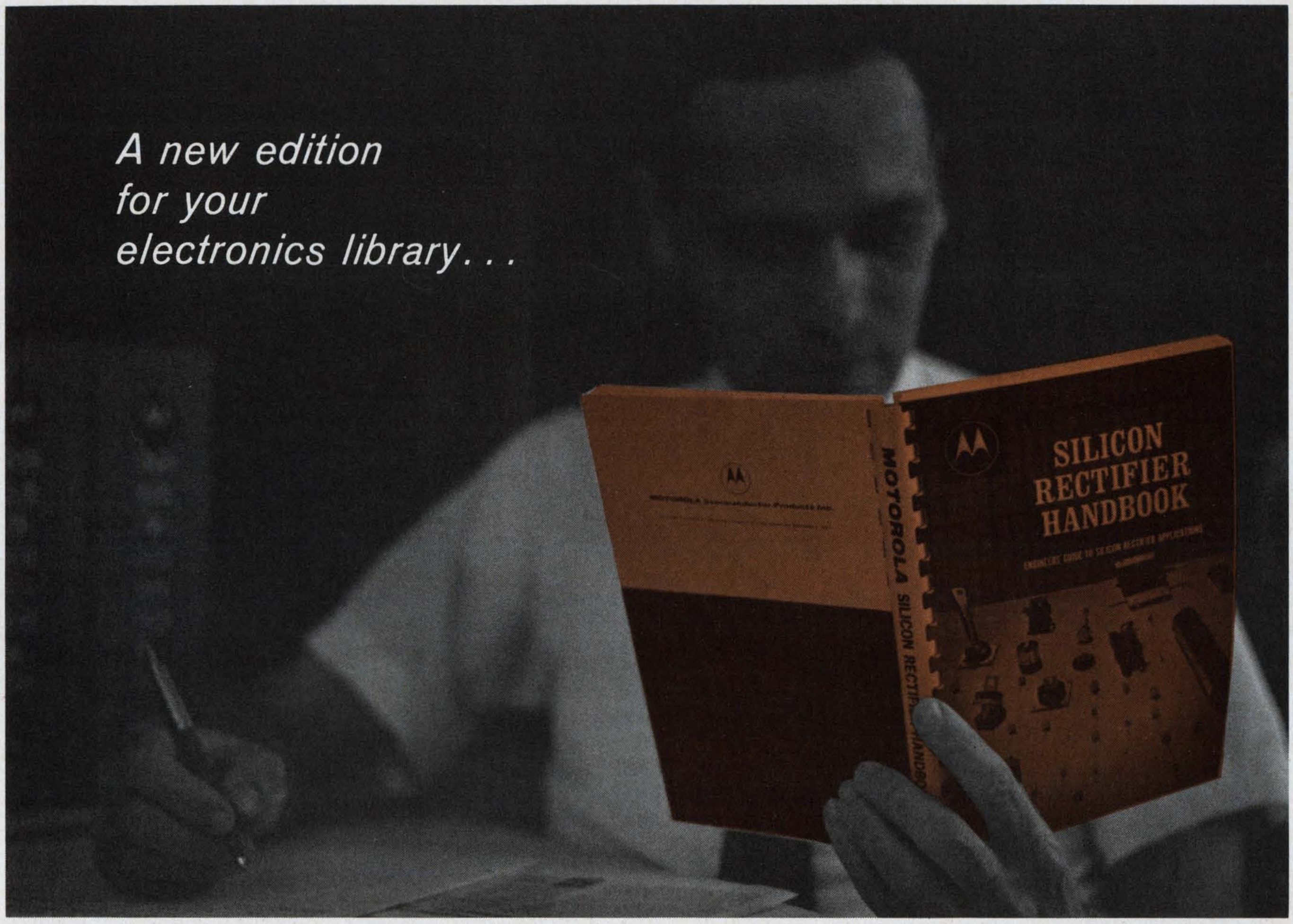


Choppers

Both of these new photoconductive choppers are electro-optical switching devices comprising light sources and photocells for 60-Hz use. They offer less than 1 μVdc offset, approximately 0.5 μV noise at 1 Hz and electrostatic shielding between lamp and cells. A 25,000- to 50,000-hour lifetime is claimed.

Leeds & Northrup, Components Div., North Wales, Pa. Phone: (215) 329-4900.

Circle No. 289



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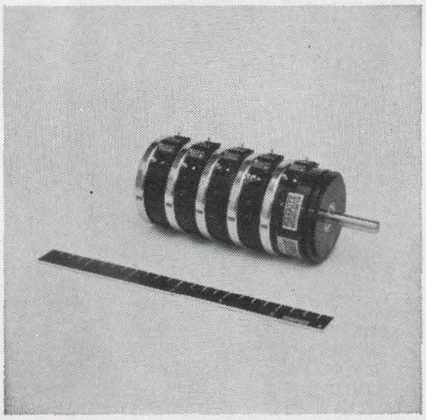
ON READER-SERVICE CARD CIRCLE 52

COMPONENTS

Cryogenic pot

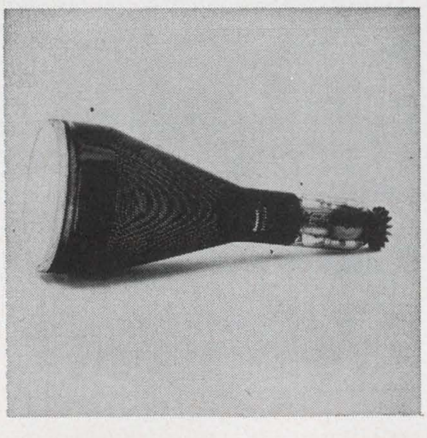


This infinite resolution cryogenic pot was originally designed for Apollo's liquid nitrogen environment. The rotary type AP32 has ambient capability of −300°F to +250°F. This plastic pot is supplied with 26-gauge leads or terminals in single or multi-gang. The element has 350° electrical angle with resistances of 2 kΩ, 5 kΩ, 10 kΩ and 20 kΩ. Standard linearity is 0.5%.

Markite Corp., 155 Waverly Pl., New York. Phone: (212) 675-1384.

Circle No. 374

CRT

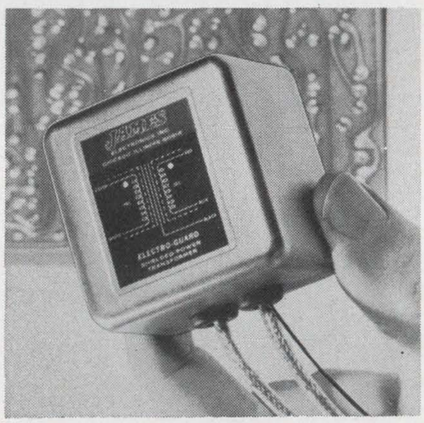


The D13-27 cathode ray tube has a 5-in. face and is 13.5-in. long. The tube features electrostatic focusing and deflection and has vertical sensitivity of 13 V/cm and horizontal sensitivity of 27 V/cm.

Useful scan area is 8 x 12 cm and spot size is 0.012-in. Deflection electrodes allow blanking circuitry to be referenced to ground.

Amperex Electronic Corp., 230 Duffy, Hicksville, N. Y. Phone: (516) 931-6200.

Circle No. 375



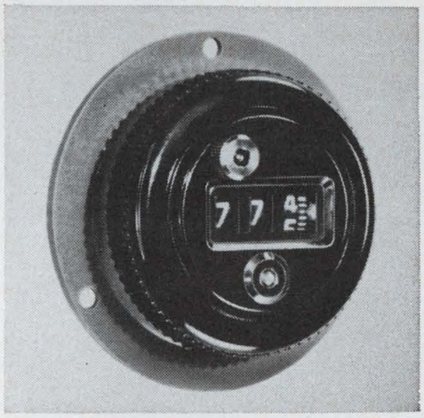
PC transformers

A series of shielded and unshielded transformers for PC or modular circuitry is available with a 2.5, 5, 10 or 25 W rating. Shielded models have primary to secondary capacitance of less than 5 x 10^{-5} pF. Voltage breakdown is 1000 Vac and insulation resistance is 5 GΩ. Eight models, both shielded and unshielded, with 117 V, 50/60 Hz primaries are available.

P&A: $13 to $42; 3 to 5 wks. James Electronics, 4050 N. Rockwell, Chicago. Phone: (312) 463-6500.

Circle No. 376

Counting knob



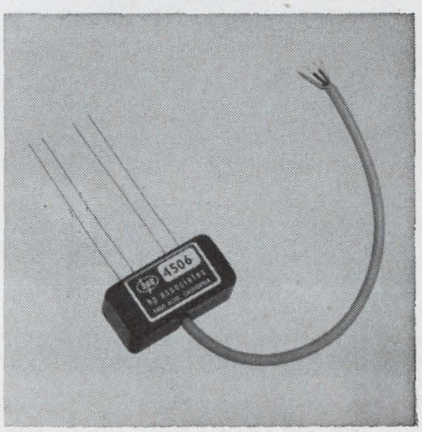
Flush or panel mounted, this rear-drive counting knob fits standard 1/4-in. shafts. One turn of the knob equals 100 counts. First figure wheel has 50 sub-divisions and the knob counts from 0 to 999.

Typical applications cited for the low-torque devices include multi-turn potentiometers and instrument setting.

Landis & Gyr Inc., 45 W. 45th St., New York. Phone: (212) 586-4644.

Circle No. 377

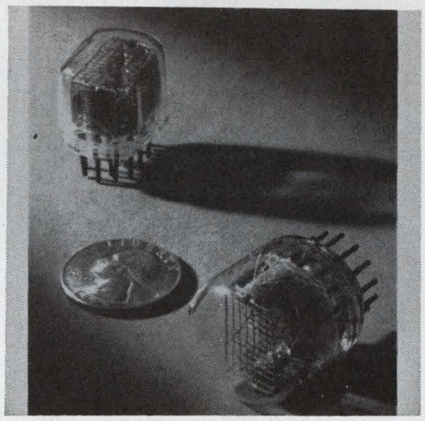
Photomodulators



The 4505 and 4506 2-cell externally driven photomodulators operate at modulating frequencies to 1 Hz. They can also modulate dc signals in the sub-microvolt level. Modulation is by illuminating the photocells with selfcontained neon glow lamps. The 4505 is for use with high-input impedance circuits and the 4506 for low-impedance circuits.

Price: $22.50 (1 to 9), $19 (10 99). hp associates, 620 Page Mill Rd., Palo Alto, Calif. Phone: (415) 321-8510.

Circle No. 378



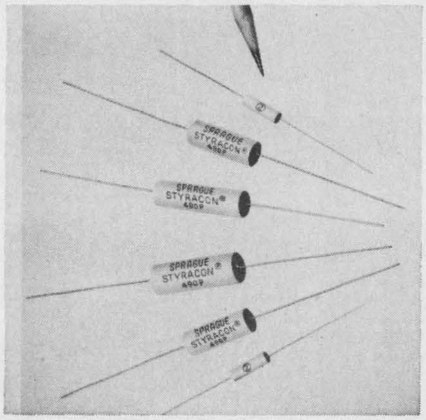
Indicator tubes

Two end-viewing numerical indicator tubes have been introduced. The new "Datavue" tubes have conventionally shaped 5/8-in. numerals from 0 through 9. The tubes can be read from distances up to 30 ft. The CK8421 is round and the CK8422 has a rectangular cross section. Each measures approximately 1-in. by 1-in. max cross section.

P&A: About $15.75; stock. Raytheon Co., Components Div., Lexington, Mass. Phone: (617) 862-6600.

Circle No. 379

Film capacitors

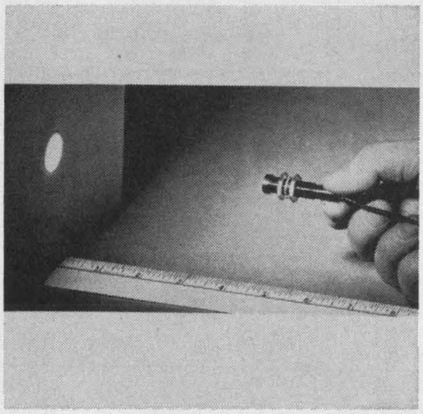


Type 490P polystyrene-film capacitors feature wrap-and-fill construction. Designed for use in filters, computers, precision timing high-Q tuned and integrating circuits, they exhibit high stability and insulation, low dielectric absorption and power factor. Standard capacitance tolerance is ±5%. The capacitors are available in ratings of 35, 50, 100 and 200 Vdc, at values from 0.001 μF to 1.0 μF.

Sprague Electric Co., 347 Marshall St., North Adams, Mass.

Circle No. 301

Beam emitter

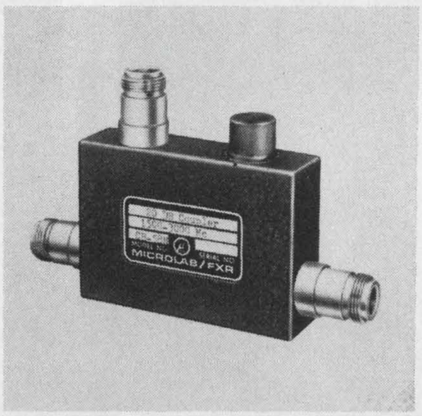


This new beam emitter will project a 4 to 10° cone of infrared and luminous energy at distances of 3 in. to 18 in. As a source of energy to activate photosensors, it has advantages of a 10,000-hour life, 3/4-W consumption and variable 2- to 3-V operating range. It is designed for use with optical limit switches, optical encoders and photo switches.

Chicago Miniature Lamp Works, 4433 N. Ravenswood Ave., Chicago. Phone: (312) 784-1020.

Circle No. 302

Coax couplers



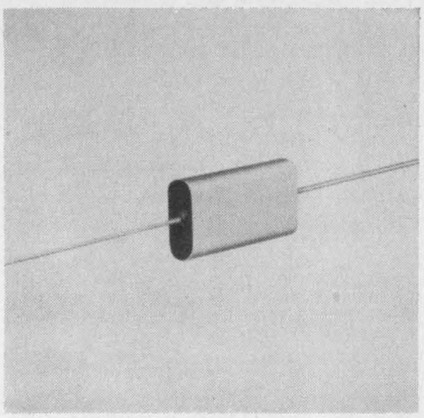
The new series CB 3 or 4-port couplers offer 25-dB directivity over a full octave with ±1 dB coupling variation. They are available in 10, 20 and 30 dB coupling values with a mainline vswr of 1.15, and with type N and TNC connectors.

Six potted units cover from 200 to 4000 MHz in overlapping octave bandwidths.

P&A: $90; stock. Microlab/FXR, Livingston, N. J. Phone: (201) 992-7700.

Circle No. 303

Polyester capacitors

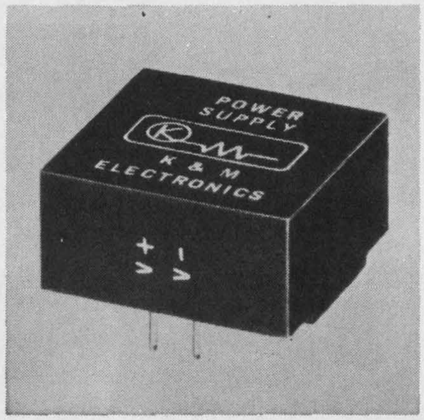


These metallized, polyester film capacitors operate over a −25°C to 85°C range at rated voltages of 200 and 600 Vdc. Capacitance range is 0.2 μF to 2.2 μF. Insulation resistance is 10^4 Megs for less than 1 μF and 10^4 Megs/μF for more than 1 μF.

Power factor is less than 1% at 1 kHz and 25°C.

Nucleonic Products Co. Inc., 3133 E. 12th St., Los Angeles. Phone: (213) 268-3464.

Circle No. 304

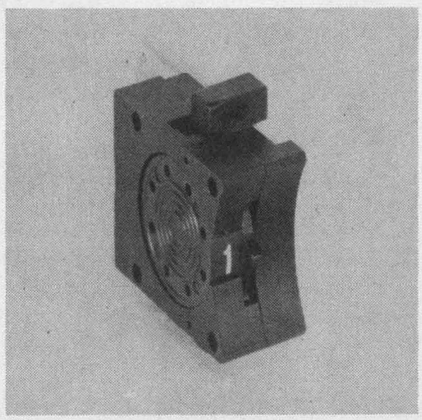


Power supplies

A series of miniature encapsulated power supplies is designed for use with op-amps. The PS-20 modules have dual output excitation. Output voltages are from ±16 V to 100 V at ±20 to 3000 mA. Operating range is ±25°C to +85°C, and regulation is 0.001% to 1%. Temperature coefficients range from 0.0005% to 0.1%/°C.

Price: About $50. K&M Electronics Corp., 102 Hobart St., Hackensack, N. J. Phone: (201) 343-4518.

Circle No. 305



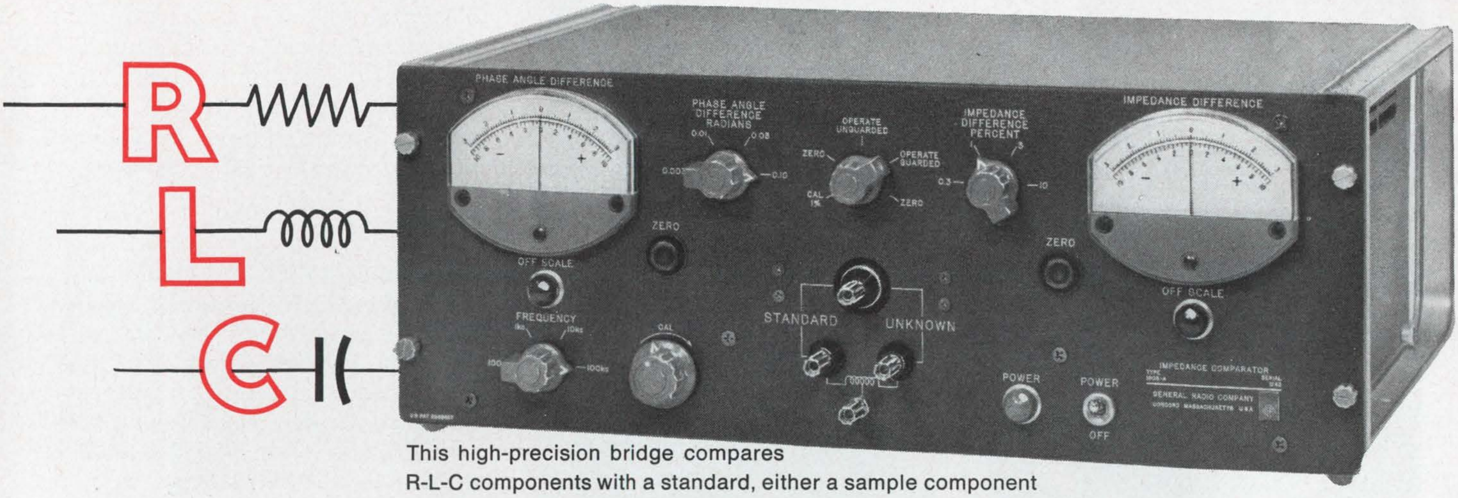
Thumbwheel switch

An 8-position, 45° indexing, miniature thumbwheel switch with binary-coded octal output is available with continuous rotation action. Model 808 has octal output without complement and model 809 has octal output with complement.

Price: $10, 1 to 9. Engineered Electronics Co., 1441 E. Chestnut Ave., Santa Ana, Calif. Phone: (714) 547-5651.

Circle No. 306

For Fast Sorting, Incoming Inspection, and Production-Line Testing



This high-precision bridge compares R-L-C components with a standard, either a sample component or laboratory standard. It is equally useful for tests on etched boards and sub-assemblies and can be operated either manually or in combination with automatic sorting equipment.

Conventional bridges can be too slow for 100% testing. For such high-volume use, a fully automatic device is often the answer, although it usually measures only one of the main parameters (R, L, or C). Where the requirements include versatility and low cost as well as speed, a third alternative, the Type 1605-A Impedance Comparator, is the best choice.

This bridge requires no manual balancing; two meters indicate the difference, in magnitude and phase, between the unknown and an external standard. Comparisons can be made with a precision of better than 0.01% for small differences. Components can be measured as rapidly as the operator can plug them into a test jig.

For matching, sorting, and production testing, the Impedance Comparator offers you the precision of manual-bridge measurements combined with the speed of the production line.

Condensed Specifications:

There are two models of the Type 1605 Impedance Comparator: the 1605-A and the 1605-AH, which differ only in range and sensitivity. Both are available in rack and bench models.

BASIC RANGES:

	Measurement	Impedance Range	Impedance-Mag. Difference Range	*Phase-Angle Difference Range
1605-A	Resistance (or Impedance Magnitude)	2Ω to 20MΩ	±0.3%, ±1%, ±3%, ±10%, full scale	±0.003, ±0.01, ±0.03, ±0.1 radian, full scale
	Capacitance	40pF to 800μF		
	Inductance	20μH to 10,000H	Can be extended to as high as ±50% for limit tests	
1605-AH	Resistance (or Impedance Magnitude)	20Ω to 20 MΩ	±0.1%, ±0.3%, ±1%, ±3%, full scale	±0.001, ±0.003, ±0.01, ±0.03 radian, full scale
	Capacitance	40pF to 80μF		
	Inductance	200μH to 10,000H	Can be extended to as high as ±15% for limit testing	

*Phase-angle difference is very nearly equal to D difference (for C & L) or Q difference (for R) when either D or Q is less than 0.1.

TEST FREQUENCY AND VOLTAGE:

Frequency (both models) — 100 Hz, 1 kHz, 10 kHz & 100 kHz, switch-selected

Voltage (across unknown & standard) — Approx. 0.3 V for 1605-A
Approx. 1 V for 1605-AH

PRICES:

Type 1605-A Impedance Comparator, $995 in U.S.A.

Type 1605-AH Impedance Comparator, $995 in U.S.A.

Write for complete information. Also ask about our completely Automatic Capacitance Bridge Assembly, the Type 1680-A.

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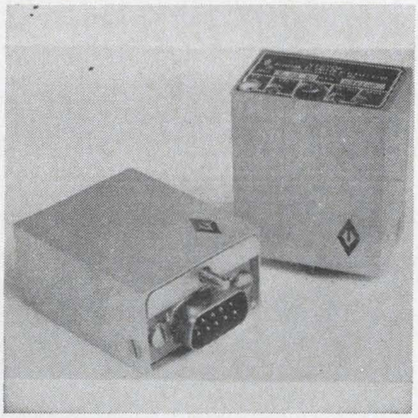
CLEVELAND • TORONTO • MONTREAL
GENERAL RADIO COMPANY (Overseas), ZURICH, SWITZERLAND
GENERAL RADIO COMPANY (U.K.) Ltd., BOURNE END, ENGLAND

GENERAL RADIO

WEST CONCORD, MASSACHUSETTS

Signal conditioners

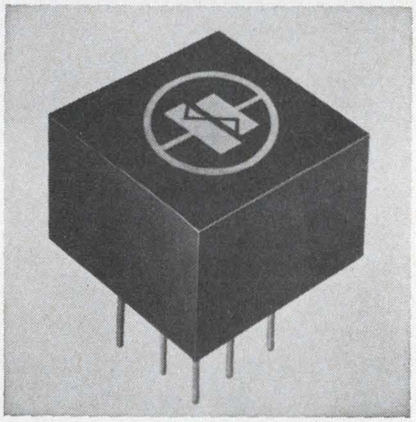


These signal conditioners convert transducer and other source outputs to standard input levels for telemetering. They meet environmental specifications for airborne applications. The TSC series measures 1.640- x 0.825- x 1.365-in. and weighs 2 oz. The units are compatible with the manufacturer's voltage-controlled oscillators and multiplexers for telemetry systems.

Availability: 60 to 90 days. United Aircraft Corp., Southampton, Pa. Phone: (215) 355-2700.

Circle No. 307

Multiplier-divider

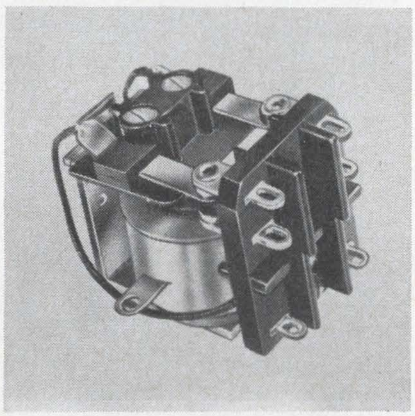


An all-dc 4-quadrant analog multiplier-divider features 1/2% accuracy. As a multiplier, the 1-in.^{3} unit gives the product of two 0 to ± 10 Vdc inputs as a 0 to ± 10 Vdc output. As a divider, an output proportional to the product of two inputs divided by the third is given. For compatibility with op-amp integrated circuitry, ± 15 Vdc is required.

P&A: $100; 4 weeks. Transmagnetics Inc., 134-08 36th Rd., Flushing, N. Y. Phone: (212) 539-2750.

Circle No. 308

Lightweight relays



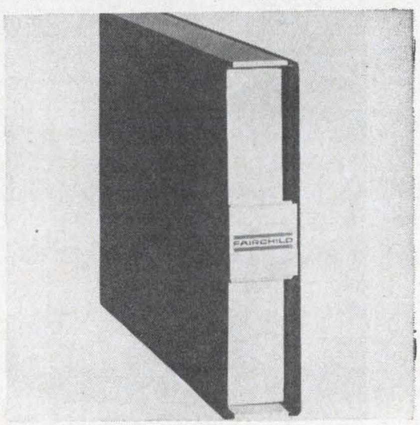
A line of molded bakelite, general purpose, open relays are rated 6, 12, 24, 115 and 220 Vac and 6, 12, 24, 48 and 110 Vdc.

These UL-approved relays are available in spdt, dpdt and 3-pole dt arrangements. They have 5-A contacts of gold-plated silver.

Artisan Electronics Corp., 5 Eastmans Rd., Parsippany, N. J. Phone: (201) 887-7100.

Circle No. 309

Operational amplifier

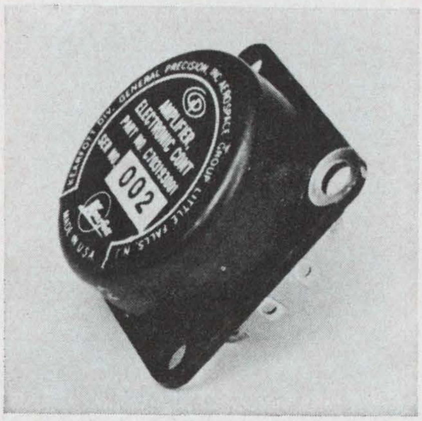


The A00-11 solid-state, chopper-stabilized operational amplifier has less than ± 3 μV/°C drift over the temperature range of -40 to $+100$°C.

Long term drift is said to be ± 2 mV over 100 hours. An MOS device in the modulator achieves this operating performance. Output is ± 40 mA at ± 20 V.

P&A: $190; stock. Fairchild Instrumentation, Palo Alto, Calif. Phone: (415) 962-2451.

Circle No. 310

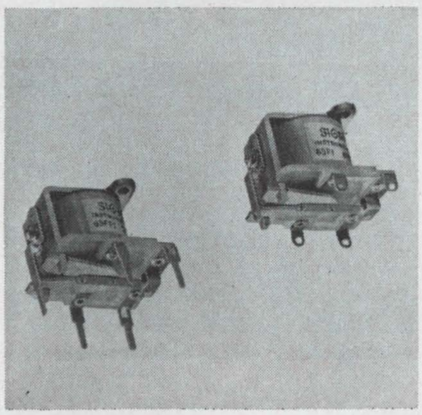


Servo amplifier

The C70 3193 001 transistorized servo amplifier is mounted in a TO-35 case. The amplifier is a 400-Hz potted unit delivering 1.4 W at 0° phase shift. Voltage gain can be adjusted with external resistors. The amplifier meets MIL-E-5400 and delivers its rated power to a 33 V load tuned to an effective impedance of 815 Ω. It may be driven by 28 Vdc or 3-phase 400 Hz rectified power equivalent to 34.5 Vdc at 200 mA.

Availability: Stock. General Precision Inc., 1150 McBride Ave., Little Falls, N. Y. Phone: (201) 256-4000.

Circle No. 311



Relays

The series 65 general-purpose spdt dc-relays are rated to switch 1-A loads 100,000 times at 29 Vdc or 115 Vac from 90-mW input signals. Operation from 6, 12, or 24 Vdc coil voltages is offered.

Sigma Instruments Inc., 170 Pearl St., Braintree, Mass. Phone: (617) 843-5000.

Circle No. 312

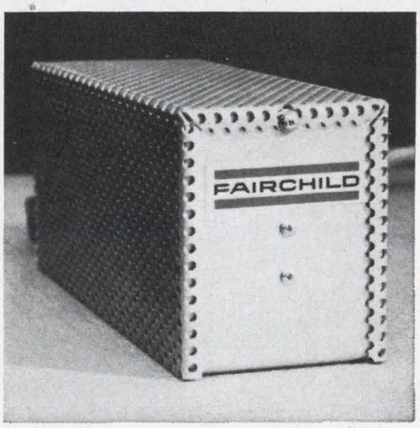
Dc-dc converter

A modified dc-dc converter features fast switching rates, ability to function at 100° C, and rapid response to transient overvoltage. The "Thin-Verter" line has 24 to 30 Vdc input and 3 to 5000 Vdc output at 40 W. The model SHU converter measures 1-5/8- x 3-1/2- x 3-5/8 in. and weighs 26 ounces.

P&A: $195 (depending on output voltage); stock to 5 wks. Arnold Magnetics Corp., 6050 West Jefferson Blvd., Los Angeles. Phone: (213) 870-7014.

Circle No. 313

Amplifier

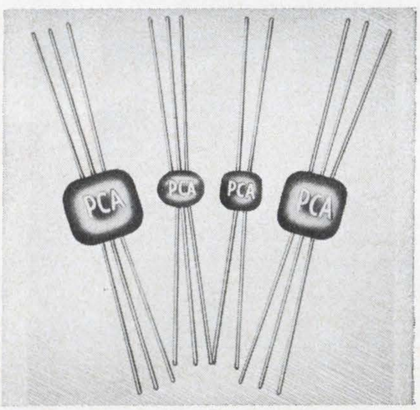


A solid-state plug-in replacement for popular tube-type amplifiers is announced. This amplifier, designated the A00-954, provides ± 40 mA at ± 100 V and ± 10 mA at 140 V. Applications are claimed in place of vacuum tube amplifiers to improve system reliability and avoid downtime. It operates directly on available ±300 V supplies.

P&A: $230; stock. Fairchild Instrumentation, Palo Alto, Calif. Phone: (415) 962-2451.

Circle No. 314

Pulse transformers



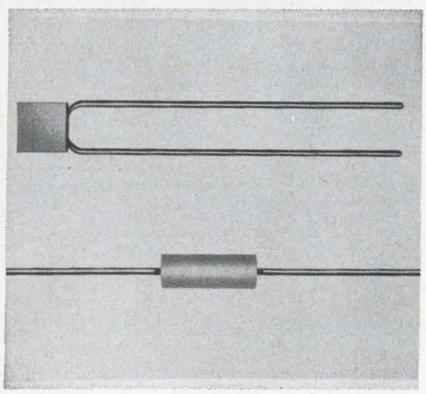
Epoxy transfer molded pulse transformers of the TT and MPT series are suitable where long life and ability to withstand a wide range of environmental conditions are critical.

Standard leads are tin-coated copper, and gold-plated dumet is optionally available.

Availability: Stock to 6 wks. PCA Electronics Inc., 16799 Schoenborn St., Sepulveda, Calif. Phone: (213) 362-0761.

Circle No. 315

Ceramic capacitors

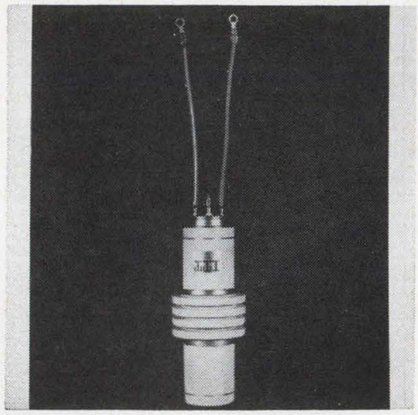


A series of rectangular and tubular ceramic capacitors with capacitance values up to 2 μF at 50 Vdc is available. These small capacitors function at −55°C.

Rectangular cases are 0.5 in. square x 0.15-in. wide with lead spacing of 0.40 in. Tubular cases are 0.312-in. dia. x 0.750-in. long.

San Fernando Electric Mfg. Co., 1509 First, San Fernando, Calif. Phone: (213) 361-8681.

Circle No. 318



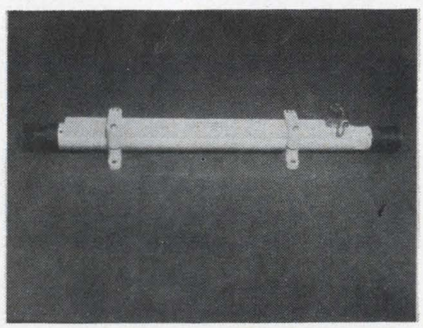
Thyratron

A new type of hydrogen thyratron operates at 100 kV plate potential. The tube obtains the high hold-off voltage rating with 4 potential-dividing grids equally spaced between cathode and plate. External metallic rings connected to the grids protect the ceramic envelope and seals against flashover due to transients. Peak plate current of the 10-mW tube is 200 A and drop during conduction is about 150 V. Typically the tube can be operated in a modulator at a pulse-rep rate of 1000 pulses/second with pulse width of 1 μs.

ITT, 320 Park Ave., New York. Phone: (212) 752-6000.

Circle No. 317

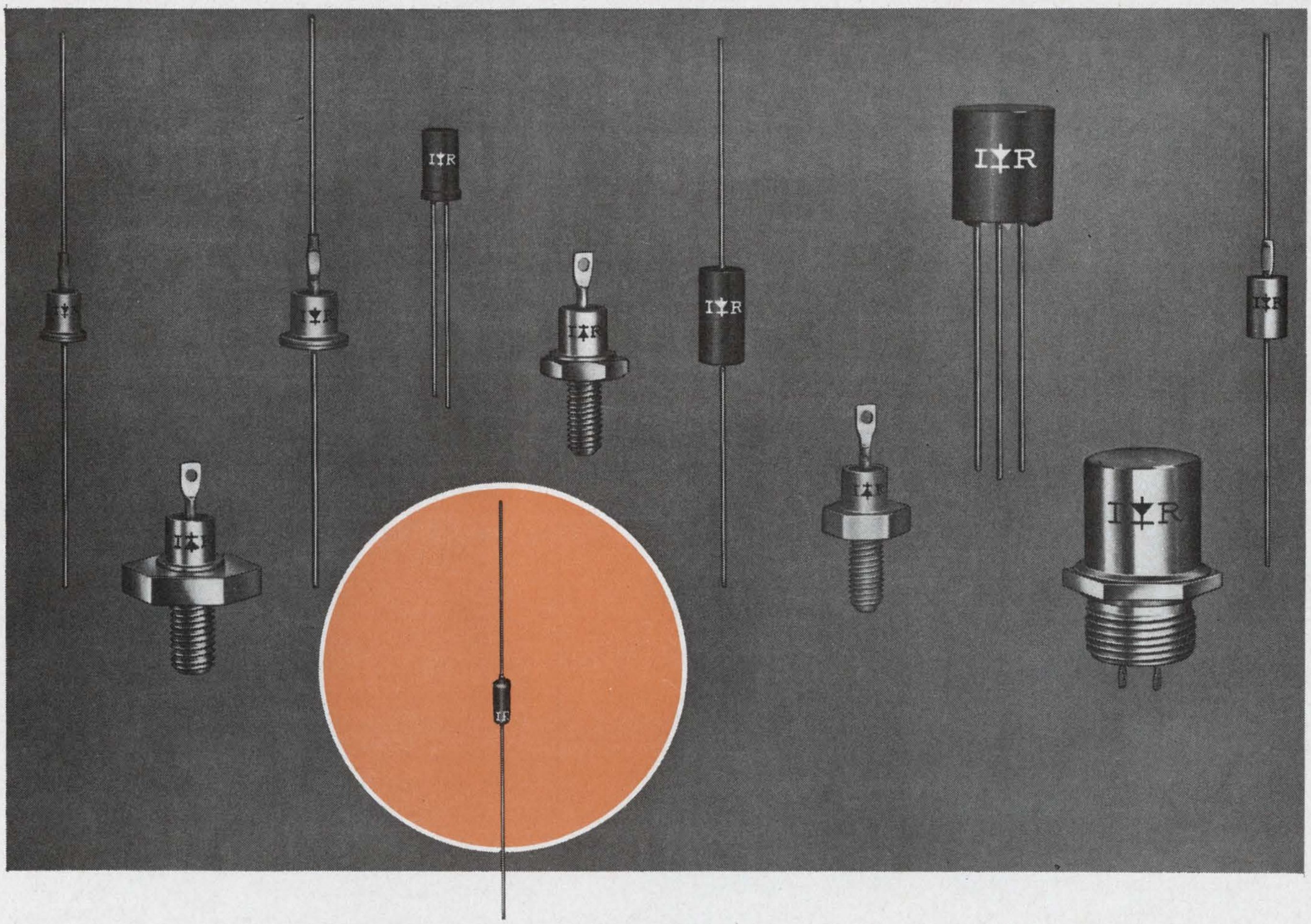
Directional coupler



A new 2-kW, cw, 1-MW peak coupler covers 100 to 200 MHz within a length of 14-in. Mainline vswr is less than 1.1 and insertion loss is less than 0.4 dB. Coupling is 30 ±0.5 dB, with directivity in excess of 20 dB. The coupler operates from −65°F to 203°F. LT female connectors in the mainline and an N coupled-output connector are standard.

Dynalectron Corp., 2233 Wisconsin Ave., Washington, D. C. Phone: (202) 338-4600.

Circle No. 316



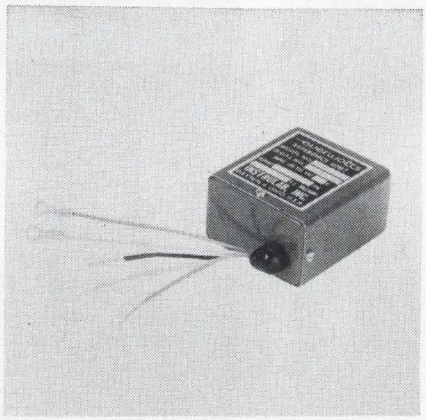
Active limiter

A solid-state active limiter, built to MIL-specs, protects receivers from kilowatt pulse powers and features limiting greater than 60 dB. Switching speed is less than 200 ns. Insertion loss in the "off" condition is less than 0.5 dB.

Dimensions of the limiter (3-1/2- x 1-1/4- x 5/8-in.), make it suitable for airborne and portable radar.

Availability: 45 to 60 days. Micro State Electronics Corp., 152 Floral Ave., Murray Hill, N. J. Phone: (201) 464-3000.

Circle No. 319

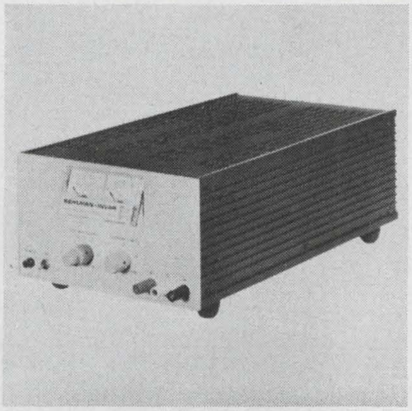


Mercury cell eliminator

A mercury cell eliminator for X-Y plotters, recorders and computer bias circuits features line-to-output isolation of less than the equivalent of 20 pF. Input is 100 to 135 Vac, 50 to 60 Hz and output is 1.345 Vdc at 2.0 mA. Ripple is less than 50 μVrms for 60 and 120 Hz. Any current from 0 to 10 mA can be supplied.

P&A: $44.50; 2 wks. Instrulab Inc., 1205 Lamar St., Dayton, Ohio. Phone: (513) 223-2241.

Circle No. 320



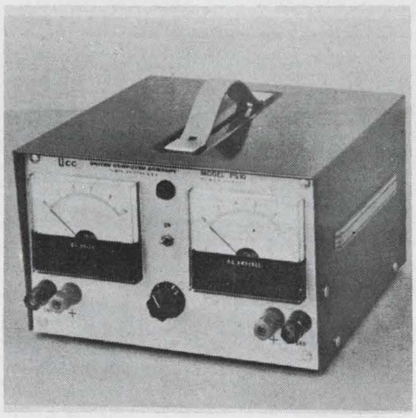
Half-rack dc supply

This new series of half-rack dc power conditioners features high power output and a lifetime warranty. Six models provide ranges of 5, 10, 20, 40, 60 or 100 Vdc, with 19.5, 14.0, 9.0, 5.4, 3.8 or 2.4 A.

Load regulation is 0.01% and stability is ±10 mV/8 hours. Remote V and I programming and constant V and I with automatic crossover are featured.

Behlman-Invar Electronics Corp., 1723 Cloverfield, Santa Monica, Calif. Phone: (213) 393-9611.

Circle No. 321



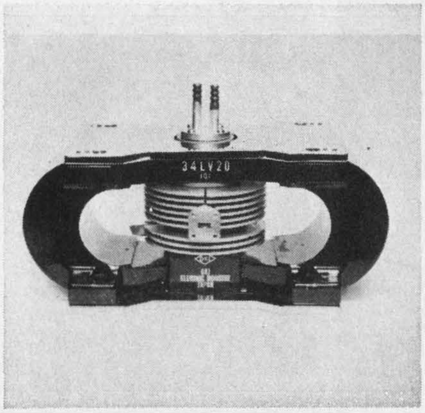
Miniature power supply

The model PS10 power supply is variable from 0 to 10 V. It contains a voltmeter and ammeter, and has optional rack mounting brackets. Low ripple and short circuit protection make it suitable for use with transistors and ICs. Input is 105 to 130 V at 55 to 65 Hz. Line and load regulation is 0.05% + 5 mV. Ripple is 2 mV and max current is 600 mA.

United Computer, 930 W. 23rd St., Tempe, Ariz. Phone: (602) 967-9122.

Circle No. 322

Klystron

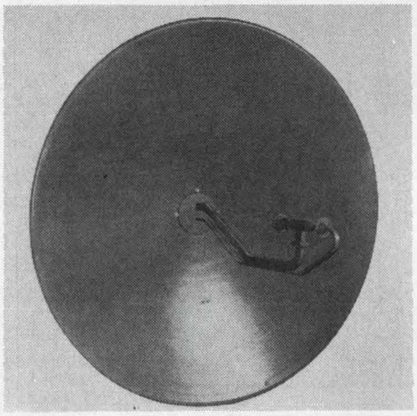


A high-power, mechanically tunable millimeter-wave klystron covers 33.2 to 34.8 GHz. Power output of 10 W at 34 GHz is reported. The 34LV20 "Laddertron" is a single-cavity, multigap klystron for communications or as a measurement power source. Either air or water cooled, the tube tunes in excess of 200 MHz. It is designed for use with 1500 to 1900 V.

Oki Electronics, 202 E. 44th St., New York. Phone: (212) 682-2989.

Circle No. 323

Dual frequency antenna



A new two-port Cassegrain-type antenna operates in the 6.575- to 6.875-GHz and 12.2- to 12.7-GHz bands. Two buttonhook feeds are mated into a common feed having a plane-polarized orthogonally arranged input for each band. Vswr is 1.15 max with polarization discrimination of 20 dB min. Typical midband gain of the 6-ft antenna is 38.8 dB for the 6-GHz band and 44.0 dB for 12-GHz band.

Andrew Corp., P. O. Box 897, Chicago. Phone: (312) 349-3300.

Circle No. 324

Sweep oscillator

A series of microwave swept oscillators covers 1 to 40 GHz in the L, S, C, X, Ku and K bands. Better than 1% accuracy and stability is reported. Output power is 50 mW min in the 8- to 12.4 GHz band. Five independent frequency controls, each with 3-digit readout, are adjustable over the bandwidth.

P&A: $3460 to $6870 (depending on frequency band); stock. E-H Research Labs, 163 Adeline, Oakland, Calif. Phone: (415) 834-3030.

Circle No. 325

C-band klystrons

Two new reflex klystrons, the VA-298 and VA-299, increase coverage of C-band radio relay communication systems. Frequency coverage extends from 5.3 to 8.5 GHz and min power of both types is 2 W. Beam voltage is 750 Vdc and beam current is 85 mAdc max. Reflector voltage ranges between −150 and −160 Vdc.

Varian Assoc., 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

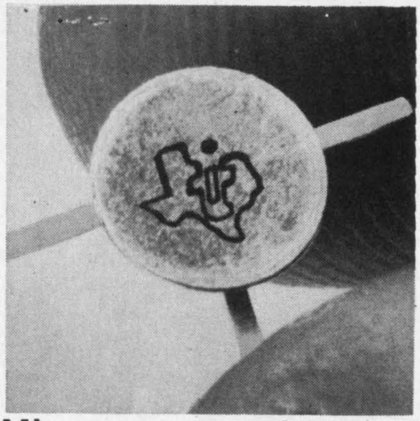
Circle No. 326

X-band klystrons

This 8-oz X-band reflex klystron, VA-272, is suited for pumping paramps or for doppler radar systems. Trimmable ± 100 MHz from center frequency, the klystron produces 500 mW between 8.1 and 11.1 GHz. Mechanical tuning range is ± 100 MHz and electronic tuning range is 40 MHz min. Reflector voltage is − 200 to − 400 Vdc.

P&A: $450; 90 days. Varian Assoc., 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

Circle No. 327



Microwave transistors

Germanium microwave transistors operable in the 1- to 4-GHz range are said to be replacements for certain TWTs and both tunnel-diode and parametric amplifiers. Applications of the planar devices are in L and S band radar, telemetry and ECM systems. Packing is for strip-line circuitry.

The TIXM103 features a typical noise figure of 3.8 dB at 1.5 GHz and 5.5 dB at 3 GHz when adjusted for optimum noise characteristics. Max noise figure is 4.5 dB at 1.5 GHz and 7 dB at 3 GHz. Gain is typically 8.5 dB at 1.5 GHz and 6.5 dB at 3 GHz. The TIXM104 features noise figure of 5.5 dB at GHz and 10 dB at 3 GHz.

The noise figure changes less than 2 dB and gain less than 1.5 dB between −55°C and 85°C. Power consumption is less than 25 mW.

Price: TIXM103: About $82.50 (1 to 99); Texas Instruments; 13500 N. Central Expwy., Dallas. Phone: (214) 235-3111.

Circle No. 328

Wide-band multiplier

Model N802 step-recovery diode multiplier has an octave output range of 6 to 12 GHz. Inputs of 100 to 2,000 MHz feed through a low-pass filter to the step-recovery diode where multiplication results in a harmonic of 6 to 120 times the excitation frequency. Output is available at an N-type connector.

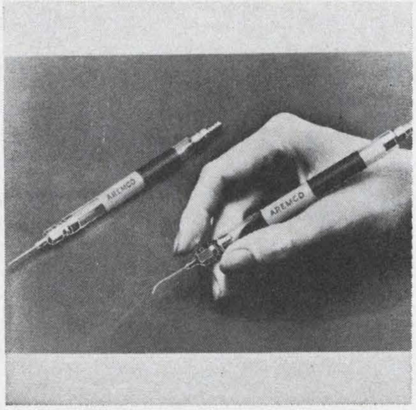
This unit is adapted to stable oscillator, and transmitter service in the lab and classroom.

P&A: $150; 30 days. Somerset Radiation Laboratory, P.O. Box 201, Edison, Pa. Phone: (215) 348-8883.

Circle No. 329

PRODUCTION EQUIPMENT

Vacuum pencils

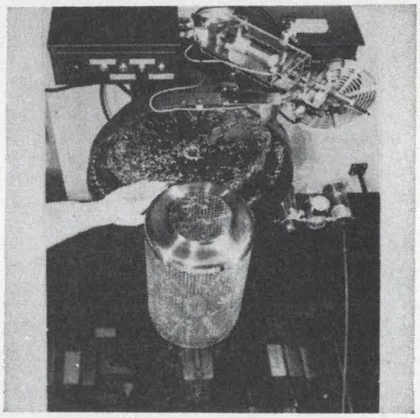


A line of vacuum pencils with 24 interchangeable pickup needles is designed for use in handling semiconductor and microelectronic components. Fingertip vacuum-control permits quick pickup of wafers, pellets or spheres. The body is clear cellulose acetate and the needle is medical hypodermic stainless steel tubing.

P&A: $25, additional needles $8; stock. Aremco Products, Inc., P. O. Box 145, Briarcliff Manor, N. Y. Phone: (914) 762-0685.

Circle No. 330

Lead-gathering machine

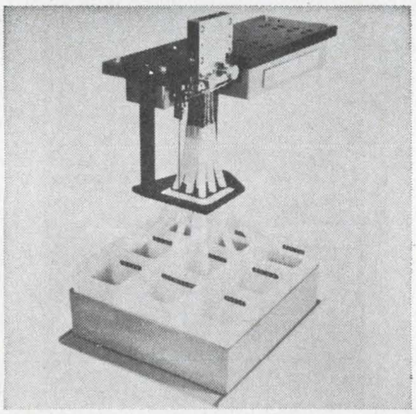


A semi-automatic header and lead-gathering machine speeds production of TO-18 transistors. A stainless-steel perforated drum is charged with 2000 to 2500 headers from the barrel plating process. In 5 minutes, 80% of the assemblies are separated and gravity-fed to a vibrating bowl which channels them to an escapement unit. The machine then gathers the leads. Capacity is 2400 units/hour.

Lane Products Co., P.O. Box 306, Feasterville, Pa. Phone: (215) 355-2888.

Circle No. 331

Component sorter



This new unit automatically sorts axial-lead components such as capacitors, resistors and diodes into nine or more discharge bins at speeds up to two parts per second.

Components to be sorted are manually or automatically dropped into the aligning funnel and automatically routed to the appropriate sorting bin by the "checkerboard sorter."

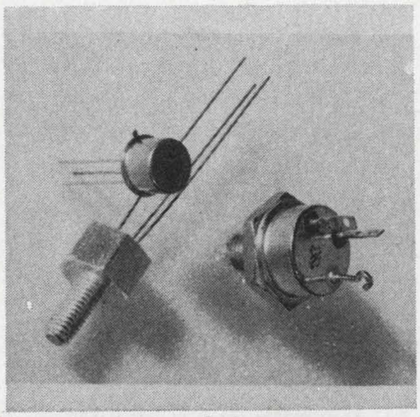
Numerical Control Corp., 3033 Jefferson St., San Diego, Calif. Phone: (714) 297-4977.

Circle No. 332

Circuit bonder

The model 730 bonder uses infrared detection and bonds components and wiring in assemblies, to PC cards or to thin films. It welds, brazes, hard and soft solders and bonds using parallel gap or opposed heads. Temperatures from 300°F to 1400°F are controlled so that, once bonding mode and temperature are selected operation is automatic. The power supply has a capacity of 500 A at 2 V for 10 s.

P&A: About $2000; 6 to 8 wks. Texas Instruments, 3609 Buffalo Speedway, Houston. Phone: (713) 782-9661. *Circle No. 333*



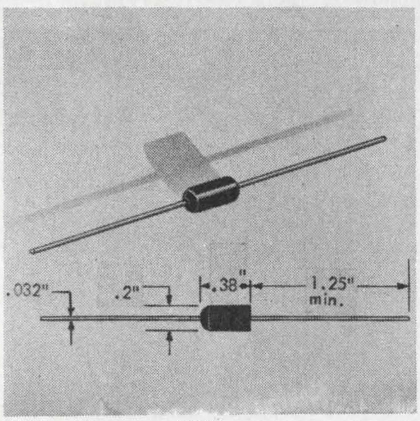
Power transistors

The 2-A epitaxial planar transistor, 2N4300, in a TO-5 can is rated at 15 W at 100°C. Saturation voltage is 0.5 V max at 2 A. Gain is linear from 50 mA to 1 A (h_{fe} is typically 70 at both levels). Switching characteristics are 150 ns on and 1.5 μs off typical at 1 A.

The 10-A 2N4301, in a TO-61 can dissipates 50 W at 100°C. Characteristics include a saturation voltage of 0.5 W at 100°C, voltage of 0.5 V max at 10 A, typical gain of 30 at 10 A and frequency response of 50 MHz min. Drive power requirements are 1.2 V max at 10 A.

Availability: 2N4300, stock; 2N4301; May. Texas Instruments, 13500 N. Central Expwy., Dallas. Phone: (214) 235-3111.

Circle No. 334

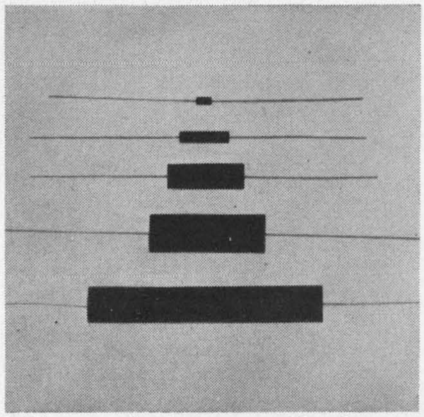


Silicon rectifiers

Bullet-shaped molded silicon rectifiers with 150-ns recovery time are available. They are rated from 800 to 6000 PIV with forward currents from 150 mA to 1 A. The devices measure 0.2 x 0.375-in.

Electronics Devices, Inc., 21 Gray Oaks Ave., Yonkers, N. Y. Phone: (914) 965-4400.

Circle No. 335



Microminiature diodes

A line of single junction high-voltage silicon microdiodes and assemblies handles more than 100 mA. Typical single junction peak inverse voltage ratings are 1000 to 1500 V with leakage ratings better than 20 nA at 25°C. Reliability exceeds MIL-S-19500. Body size is as small as 0.05-in. x 0.1-in.

P&A: $2.50 to $7.50; stock. Microsemiconductor Corp., 11250 Playa Ct., Culver City, Calif. Phone: (213) 391-8271.

Circle No. 336

Germanium planar FET

The p-channel planar germanium FET, TIXM301, is suitable for vhf amplifiers up to 500 MHz. The devices are said to have higher figures of merit and transconductance than many FETs. Transconductance is typically 0.14 to 0.12 mhos from 60 to 300 MHz. Noise characteristics of 1.8 dB are typical at 100 MHz.

P&A: $8.60 (100-999); 90 days. Texas Instruments, 13500 N. Central Expwy., Dallas. Phone: (214) 235-3111.

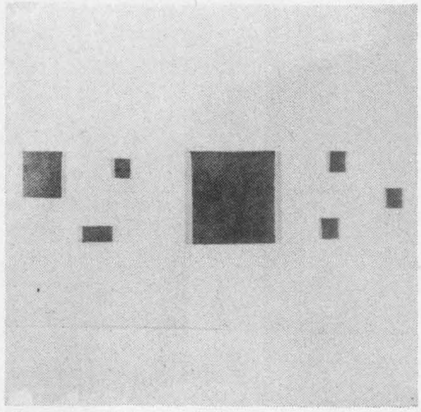
Circle No. 337

Power transistors

Plastic-encapsulated power silicon npn transistors rated at 25 W are available. The B-5000 features collector power dissipation of 25 W at 2.5 A, 10 V and 100°C. Collector-to-emitter voltage is 35 V min, and collector current is 3 A max. Max base current is 1 A and dc current gain ranges from 30 to 25 at 14 V and 0.5 A.

Price: $0.99 (1 to 99), $0.75 (100 to 999); Bendix Semiconductor Div., South St., Holmdel, N. J. Phone: (201) 747-5400.

Circle No. 338



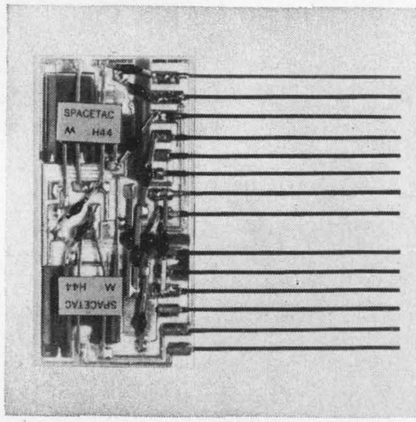
Capacitor chips

A line of new monolithic capacitors is offered in 50 or 100 Vdc from 10 pF through 1.0 μF at ±10% or ±20% tolerance.

The tiny capacitor chips meet MIL-C-11015 and MIL-C-39014, operate within a −55°C to +125°C temperature range and offer a temperature coefficient at 0 V of ±15%.

San Fernando Electric Mfg. Co., 1509 First St., San Fernando, Calif. Phone: (213) 361-8681.

Circle No. 339



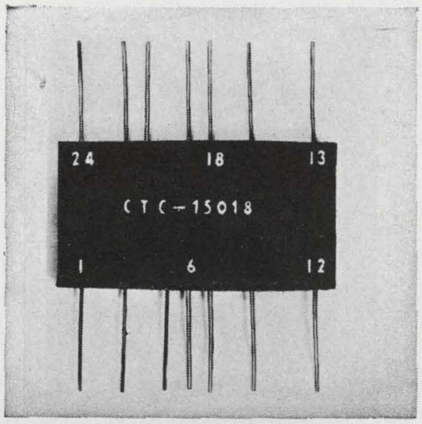
Microwatt flip-flop

With inputs permitting counting, shifting and control to 10 MHz, the MH-44 flip-flop draws only 150 μW from a 6V (±1.5V) source. Operating over a temperature range of −55°C to +85°C, the unit weighs 1-1/2 grams and is 1.2- x 0.6- x 0.080-in. large.

Packaging with nominal component densities in excess of 500 components/in. is offered.

Space & Tactical Systems Corp., One Garfield Circle, Burlington, Mass. Phone: (617) 272-4422.

Circle No. 340

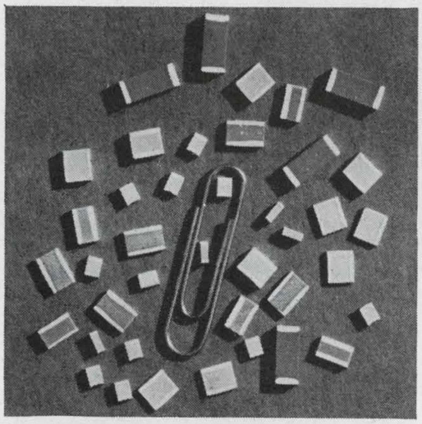


Gated amplifier

Using chip and wire techniques, this epoxy-encapsulated flat-pack employs switching mode and linear circuits. Operating at bandwidths up to 10 MHz, this hybrid cermet film component has a gain of more than 14. Bandwidth of this video amplifier measured from the 10% to 90% amplitude points of the output pulse is less than 45 ns and gate rise and fall time is less than 50 ns.

P&A: $90; 4 weeks. Columbia Technical Corp., Woodside, N. Y. Phone: (212) 932-0800.

Circle No. 341



Capacitor chips

A new line of ceramic multi-layer capacitor chips offers high uniformity of dielectric and electrode layers and high delamination resistance.

Multi-cap capacitors are available in sizes ranging from 0.152- x 0.052- x 0.055-in. to 0.375- x 0.155- x 0.065-in., with capacitance values from 330 pF to 0.5 μF at 25 to 50 Vdc and 100 to 200 Vdc.

P&A: Dependent on value, tolerance and voltage; one week. American Lava Corp., Chattanooga, Tenn. Phone: (615) 265-3411.

Circle No. 342

New Literature

Relay sockets

A 12-page catalog illustrates and describes a new line of relay sockets for subminiature crystal can and power relays. The catalog completely defines the new relay sockets, providing dimensions, electrical characteristics, contact types and configurations, hardware, mounting styles and dielectric composition information. Methode Electronics Inc.

Circle No. 343

Hybrid computer

A 12-page information brochure on an analog hybrid computing system is offered. The brochure describes the features of the system, which include a solid-state addressing and readout system, automatically adjustable pots, parallel digital logic and analog and digital patch panel termination. A typical system is illustrated, and information is given on applications, computer components and system support. Electronic Associates, Inc.

Circle No. 344

Microwave components

This new 3-ring loose leaf binder containing 40 pages in 2 colors lists more than 2000 items. Included are ferrite devices, filters and switches covering the RF spectrum from 100 MHz to 26.0 GHz. Application notes, nomographs and other design information are featured. E & M Labs.

Circle No. 345

Laminations

The 92-page catalog PD-122 covers laminations for transformers, motors, transformer hardware, drawn metal cans and cases and magnetic shields. Illustrations and physical data for all high silicon, 50% nickel and 80% nickel alloy laminations, as well as keepers, ring and notched motor types, are provided.

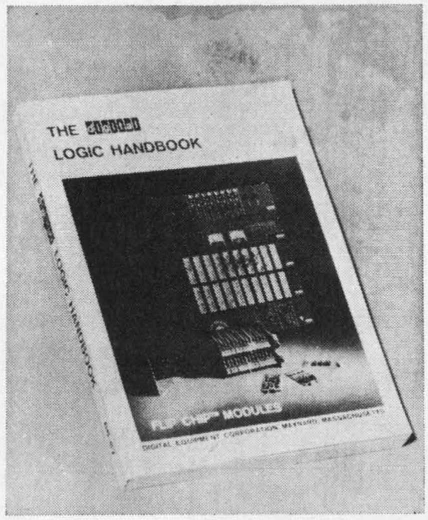
Data on magnetic material properties is given in tables and graphs for unit comparison, computation and specification purposes. Arnold Engineering Co.

Circle No. 346

Digital control counter

Technical data sheet #02 describes a high-speed, digital control electronic counter with built-in variable dual preset. Complete specifications, features and typical applications are included for this solid-state counter. Electro-mation.

Circle No. 347



Logic handbook

A 352-page handbook on "Flip-Chip" modules incorporates material from the company's catalogs, logic handbook, logic lab workbook, application notes and computer brochures.

Included are 14 application notes, specifications and price information for more than 150 modules and accessories, notes on analog-digital conversion theory and techniques, and several experiments. Digital Equipment Corp.

Circle No. 348

Meter catalog

A new 6-page catalog No. 10-90-6 includes electrical and physical characteristics on a complete line of meters. Covered are ammeters, control meters, frequency meters, tachometers, ac and dc voltmeters, wattmeters, power factor meters and phase angle meters.

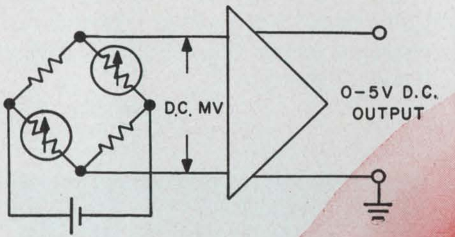
The catalog lists edgewise, rectangular, round panel and switchboard styles in various sizes. American Machine & Foundry Co.

Circle No. 349

AIRPAX Signal Conditioning Amplifier

The Airpax MAS50 Signal Conditioning Amplifier is a dc-to-dc amplifier. It converts a transducer signal (current or voltage) to a standard output range of 0 to +5 vdc. Input is differential and floating. • Voltage gain, 0 to 100 with a stability of ±0.01% per degree C. • Linearity is within 0.1% of full scale. • Zero null stability of 0.5 microvolts per degree C. • Common mode rejection at 60 CPS is 120 db minimum.

STRAIN GAGE AMPLIFIER



FLOATING INPUT

Strain-Gage Amplifier: Extremely high rejection of common mode interference by the MAS50 enables it to operate with a floating input circuit, as in strain gage applications. The signal, after conditioning by the amplifier, can be multiplexed with other conditioned signals because any number of MAS50's can share a common ground at their outputs.

$157

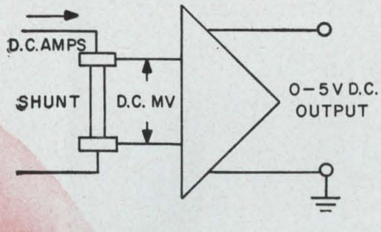
EACH

(1 to 6 pieces)

TYPE MAS50

Delivery from stock

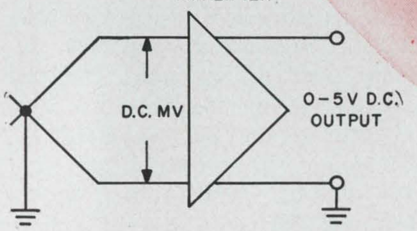
CURRENT MEASUREMENT



HIGH-SIDE MONITORING

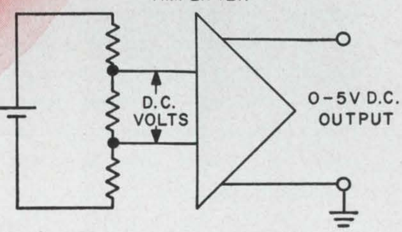
Current Measurement: Having its input well insulated, the MAS50 can be connected across a shunt in the high side of a line if necessary. For example, measurement of the plate or screen current of a power tube operating at high voltages can be done with the case of the MAS50 grounded.

THERMOCOUPLE AMPLIFIER



ISOLATION OF GROUNDS

ISOLATION AMPLIFIER



SCALE CHANGE

Thermocouple Amplifier: In applications such as amplification of a thermocouple output, the MAS50 combines inherently stable high gain with negligible drift in zero offset. Because input and output are electrically isolated from each other, the input can be either grounded or ungrounded while the output has one side grounded. Calibration of thermocouple lead length is unnecessary in normal-length runs because amplifier input resistance is much higher than thermocouple resistance.

Isolation Amplifier. Basically the MAS50 is an active 4-terminal device that produces 0 to +5 vdc output from a 0 to 50 microampere input. The amplifier provides a change of scale and of zero in several ways: by using a resistance in series with the input, by choice of a voltage gain of 1 or of 100 within the amplifier and by a bias current through the auxiliary winding. A screwdriver adjustment on the amplifier changes the gain by about 20% to calibrate the scale change and to compensate for tolerance in metering circuits.

AIRPAX ELECTRONICS incorporated Seminole Division, Fort Lauderdale, Florida

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ON READER-SERVICE CARD CIRCLE 66

Thermocouple references

Technical bulletin 32-B describes the theory, operation and applications of thermocouple references. The 4-page brochure shows circuits for both single and multi-point references. Featured are wheatstone bridge types, oven types and a new type of 25-channel scanning type reference for precision computer and data logging applications. Acromag, Inc.

Circle No. 350

Molded test accessories

This 32-page catalog No. 11-66 describes more than 240 molded electronic test accessories. Included are patch cords, cable assemblies, banana plugs, test and connecting leads and black-boxes.

Photographs, specifications, dimensions, schematics, typical applications, operating ranges and prices are given for all items. Pomona Electronics Co. Inc.

Circle No. 351

NBS services

Complete, up-to-date information on services provided by NBS radio stations WWV, WWVH, WWVB and WWVL is offered. Included in the 12 pages of information are hourly broadcast schedules of NBS standard time and frequency transmissions. Specific Products.

Circle No. 352

Logic unit

A high-speed, high-performance nanosecond logic unit is described in a new technical data sheet. Detailed specifications are provided together with a description of the logic unit and its application. LeCroy Research Systems Corp.

Circle No. 353

Servo motors catalog

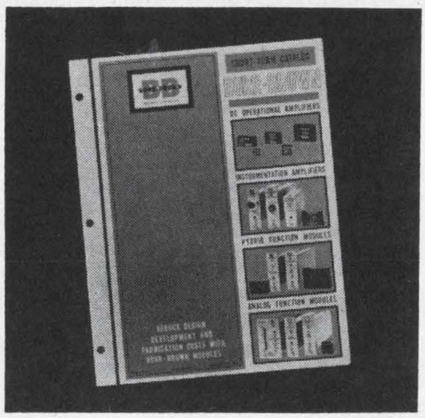
A 6-page catalog gives the complete thru-bore motor characteristics on 36 control servo motors. Included are eight schematic drawings of the basic motor types for reference. The catalog covers seven frame sizes, ranging from 05 to 23. A chart furnishing full shaft and pinion data is shown. Vernitron Corp.

Circle No. 354

Hollow-cathode tubes

A new 16-page hollow-cathode tube guide aids in selection of devices for use in atomic absorption and other spectroscopic applications. Included are max current limits, operating voltages, and reproductions of spectral outputs from devices having wavelengths of interest in atomic absorption. The guide facilitates selection of gas and window and provides application data concerning operating characteristics. Westinghouse, Electronic Tube Div.

Circle No. 355



Operational amplifiers

This catalog covers analog and hybrid plug-in modules including operational amplifiers, instrumentation amplifiers, function modules, power supplies and accessories. The 10-page illustrated brochure includes over 50 op-amps. Detailed comparative specifications are provided for general purpose, FET, IC, wideband, chopper-stabilized and high voltage series. Burr-Brown Research Corp.

Circle No. 356

Infrared devices

A 10-page technical brochure on solid-state infrared detectors and radiation sources is offered. It contains an abstract of infrared characteristics covering such subjects as infrared generation, infrared detection mechanisms, infrared conversions, internal photoeffect, the photoconductive effect, the photovoltaic effect, and definition of detector parameters. American Electronic Laboratories, Inc.

Circle No. 357

Silicon power supplies

Two new series of portable silicon power supplies, designed for applications requiring high regulation and low cost, are discussed in bulletin 109A. Remote sensing and remote programming, automatic series and parallel operation, as well as master-slave programming are additional features described. Deltron Inc.

Circle No. 358

Switching system

A solid-state modular switching system, which can sequentially sample μV signals at rates up to 10 MHz, is covered in bulletin 108. Complete with schematics, the brochure includes applications, theory, performance and circuit descriptions. Santa Barbara Research Center.

Circle No. 359

Solid-state isolators

An illustrated, eight-page condensed catalog contains information on 177 solid state isolator models available as standard product line. The catalog includes specifications and dimensions for the complete line of high, low and medium power, internal and external magnet coax models; waveguide, strip transmission line and Ku-band rotational type isolators. Sperry Microwave Electronics Co.

Circle No. 360

Permanent magnet data

Temperature and radiation effects on permanent magnet materials is the subject of a new 16-page booklet. The booklet compiles information from the company's research laboratories as well as data from government research reports. Eleven pages of schematic diagrams and tables are included. General Magnetic Corp.

Circle No. 361

PC connectors

A 14-page technical catalog covers a group of right-angle plug and socket connectors for printed circuit applications.

Complete technical specifications, outline drawings, and illustrations are included in the catalog. Continental Connector Corp.

Circle No. 362

Germanium diodes

A new catalog specification sheet describes miniature glass germanium gold bond diodes and germanium point contact diodes. Applications cited include computer logic and high-speed switching. Nucleonic Products Co., Inc.

Circle No. 363

Current drivers

A new technical bulletin decribes the company's complete line of 20 ns current drivers. The bulletin gives detailed data on three different sets of positive-negative drivers. A series of waveform photographs shows the output current pulse from the drivers under 3 operating conditions: fastest rise time, minimum pulse width and independent control of rise and fall time. Computer Test Corp.

Circle No. 364

Reed switches

An 8-page circular of specifications and application data is devoted to PC dry reed switches. Dimensional diagrams are used to illustrate ten basic forms. Corresponding tables list coil resistance and turns and the operate/release max voltage for nominal dc voltages. Technical information includes timing curves and explanations of the use of magnetic biasing. Automatic Electric Co.

Circle No. 365

Transformers

A 4-page data sheet on wide frequency response, extremely shielded transformers is offered. Complete with dc resistance, inductance, open circuit impedance, frequency response and common mode rejection specifications, the data sheet includes schematics, physical dimensions and frequency response and insertion loss graphs. James Electronics Inc.

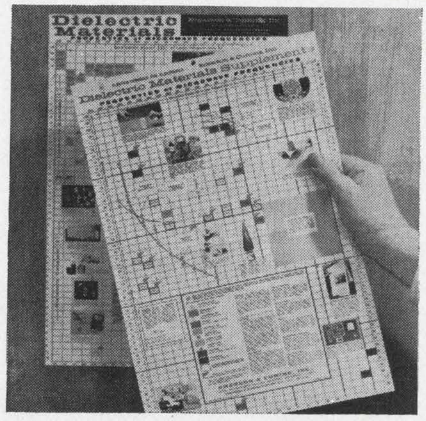
Circle No. 366

Matched crystal filters

A data sheet on matched crystal filters providing optimum signal-to-noise ratios with pulse modulated inputs is offered. A description, typical specifications and attenuation curve are provided. Damon Engineering Inc.

Circle No. 367

Design Aids

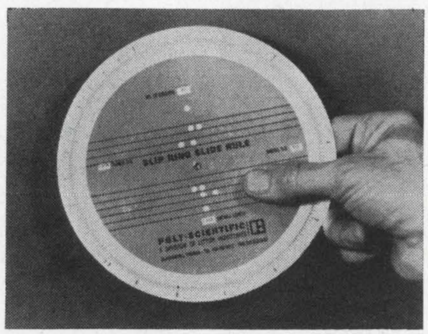


Dielectric materials

A new full-color chart shows dielectric constant and loss tangent at microwave frequencies for many dielectric materials. With dielectric constant as the abscissa and loss tangent as the ordinate, materials are plotted on the chart in the manner of a graph.

Many common and exotic materials from sapphire to dry sandy soil are included. Designed for wall or notebook mounting, the chart lists the maximum use temperature of each material, and the form in which it is available. Definitions of the various dielectric terms used are also presented. Emerson & Cuming, Inc.

Circle No. 368



Slip-ring slide rule

A new slip-ring slide rule is offered. With this circular slide rule, the number of circuits desired is "set," and the barrel OD, flange OD and over-all capsule length are then read. Twenty circuit configurations, from 20 to 100, can be checked out. The conventional slip-ring "C" and "D" scales are included on the slide rule. Litton Industries, Poly-Scientific Div.

Circle No. 369

Application Notes

Vibration transducers

Real-time calibration of vibration transducers is the subject of a two-page application note. The publication describes and pictures a method for achieving direct digital presentation of the calibration ratio between the simultaneously-sensed outputs of a certified transducer and the transducer being tested across a 1 Hz to 100 kHz range. The test equipment consists of a ratiometer and two low-frequency ac converters. Dana Laboratories, Inc.

Circle No. 380

A/D converter

An 11-page application note describes a successive approximation analog-digital converter. The discussion ranges from grounding and shielding considerations to alignment and calibration of the 10-bit unipolar converter. Digital Equipment Corp.

Circle No. 381

Pulse integration

The use of a low frequency current indicator to measure short term high frequency signals is described in a 4-page bulletin. The brochure details the operation and design of a pre-integrator (charge storage) circuit between the signal source and the manufacturer's current indicator and integrator. Complete design specifications and schematics are included. Elcor Div. of Halliburton Co.

Circle No. 382

Strain-gage manual

A manual covers semiconductor strain-gage theory and applications. Piezoresistivity, gage factors, doping, linearity, hysteresis, frequency response, and more are described. Technical data on the manufacturer's line is coupled with circuitry design considerations. Kulite Semiconductor.

Circle No. 383

APPLICATION NOTE

Ratio measurement

The 12-page technical paper 524 considers measurements having as their objective the comparison or ratio of two voltages. Uses arise in testing of amplifiers and transformers which generate a transfer function. Ratiometers which detect both voltages simultaneously and produce a ratio in real time are discussed. Ideal ratiometer characteristics and design are covered. Techniques for making ac measurements, 3- and 4-wire measurements and low-level ratio measurements are fully explained. The brochure is complete with circuit and block diagrams. Dana Labs., Inc.

Circle No. 384

Reprints Available

The following reprints are available free and in limited quantities. To obtain single copies, circle the number of the article you want on the Reader-Service card.

High Volume—Low Cost: Designers' Challenge (No. 740)

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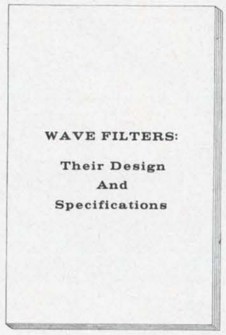
Design Data from

Wave Filters



A 14 page booklet offering guidelines for wave filter design and specification is available from ADC Products. A general discussion of LC wave filter design is coupled with a discussion of the problems encountered in writing wave filter specifications. The booklet is also intended to clarify new terminology associated with modern filter design methods.
Send for a free copy.

ADC Products, Inc.
6325 Cambridge Street
Minneapolis, Minnesota 55416

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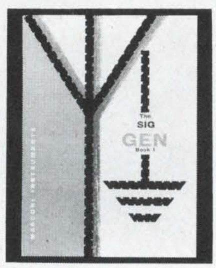
The Sig Gen—Book I



The Sig Gen Book I is a new publication available from Marconi Instruments, 111 Cedar Lane, Englewood, New Jersey. It deals with the use of signal generators in testing receivers and covers such subjects as: Source Impedance of Feeder Connected Receivers, Coupling to Loop Aerials, Signal-to-Noise Ratio, Automatic Gain Control, Plotting Response Characteristics, Measurement of Adjacent Channel Suppression and Spurious Response. A handling and mailing charge of 50¢ is asked. For your copy write:

MARCONI INSTRUMENTS, Dept. WAB
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Englewood, New Jersey

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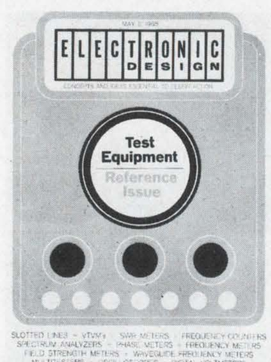
Test Equipment Reference Data



ELECTRONIC DESIGN'S Test Equipment Reference Issue covers 12 important classes of test instruments. Included are complete up-to-date specifications for approximately 2500 off-the-shelf test instruments, arranged for quick and easy reference and comparison, and cross indexed by product category and manufacturer's name. Technical data prepared from the Directory of Technical Specification/Electronic Test Instruments, by Technical Information Corporation. Twelve application-oriented articles by industry experts complete the package. Price $5; check or money order must accompany order.

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850 Third Avenue
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Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-Service Card.

M-F Nylon Insert Lock Nuts

This book can be a valuable guide to the engineer who must specify dependable locking fasteners. It contains sixteen pages and describes all aspects of MacLean-Fogg's complete line of Nylon Insert Lock Nuts. There are tables which outline principal features and applications of the nuts. Other tables list physical properties, chemical properties, and data on tensile strength requirements. Charts on each of the company's eight styles of Nylon Insert Lock Nuts include dimensional data, weights, and part numbers. Circle number on reply card.

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Mundelein, Illinois 60060

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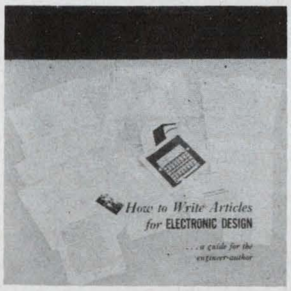
How To Write Technical Articles



A guide for the engineer-author, "How to Write Articles for Electronic Design" shows how easy it is to write for publication—once the engineer knows what to write and how to write it. The Author's Guide includes a complete run-down of the types of articles published by Electronic Design —plus detailed instructions on how to prepare technical articles and short special features. A MUST for every "would-be-writer" in the electronics industry. Send for your complimentary copy by circling the number to the right.

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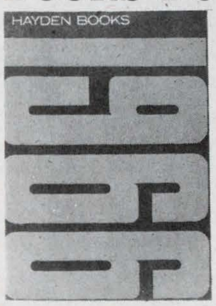
Books For The Electronics Engineer



The 1966 Hayden Book Company, Inc., catalog contains such new titles as "Microelectronic Design," "100 Ideas for Design '66," "The Electron in Electronics," "Synthesis of RC Networks with Arbitrary Zeros," "Transistor and Diode Network Calculations," and "Matrix Algebra for Electronic Engineers." As well as the expanded list for design engineers, the catalog includes Hayden and John F. Rider Publisher training texts at all levels. Send for your free catalog today.

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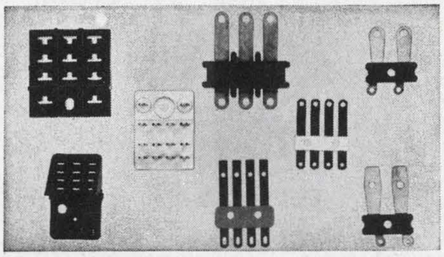

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April 20-22

1966 Intermag (International Conference on Magnetics) (Stuttgart, Germany) Sponsor: IEEE G-Mag; Dr. E. Pugh, IBM Corp., 1000 Westchester Ave., White Plains, N. Y.

April 25-28

Audio Engineering Society Convention (Los Angeles) Sponsor: Audio Engineering Society; John C. Baumann, Ampex Corp., 8467 Beverly Blvd., Los Angeles, Calif.

April 26-28

Spring Joint Computer Conference (Boston) Sponsors: AFIPS, IEEE, ACM; Dr. Harlan Anderon, Digital Equip. Corp., Maynard, Mass.

May 2-4

Aerospace Instrumentation Symposium (Philadelphia) Sponsor: Instrument Society of America; William Redstreake, Moore Products Co., Sumneytown Pike, Spring House, Pa.

May 4-6

Electronic Components Conference (Washington, D. C.) Sponsor: IEEE G-PMP; 345 East 47th St., N. Y.

May 9-12

National Conference of Standards Laboratories (Gaithersburg, Md.) Sponsor: National Bureau of Standards; R. D. Huntoon, N.B.S., Washington, D.C.

May 10-12

National Telemetry Conference (Boston) Sponsors: ISA, AIAA, IEEE; Lewis Winner, 152 W. 42 St., N. Y.

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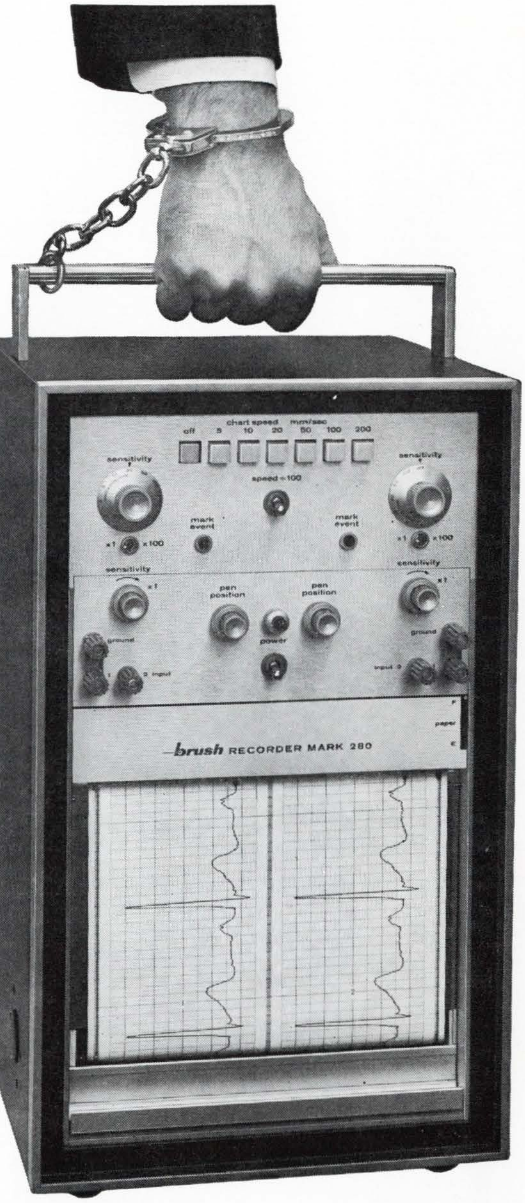

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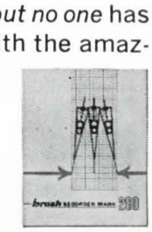

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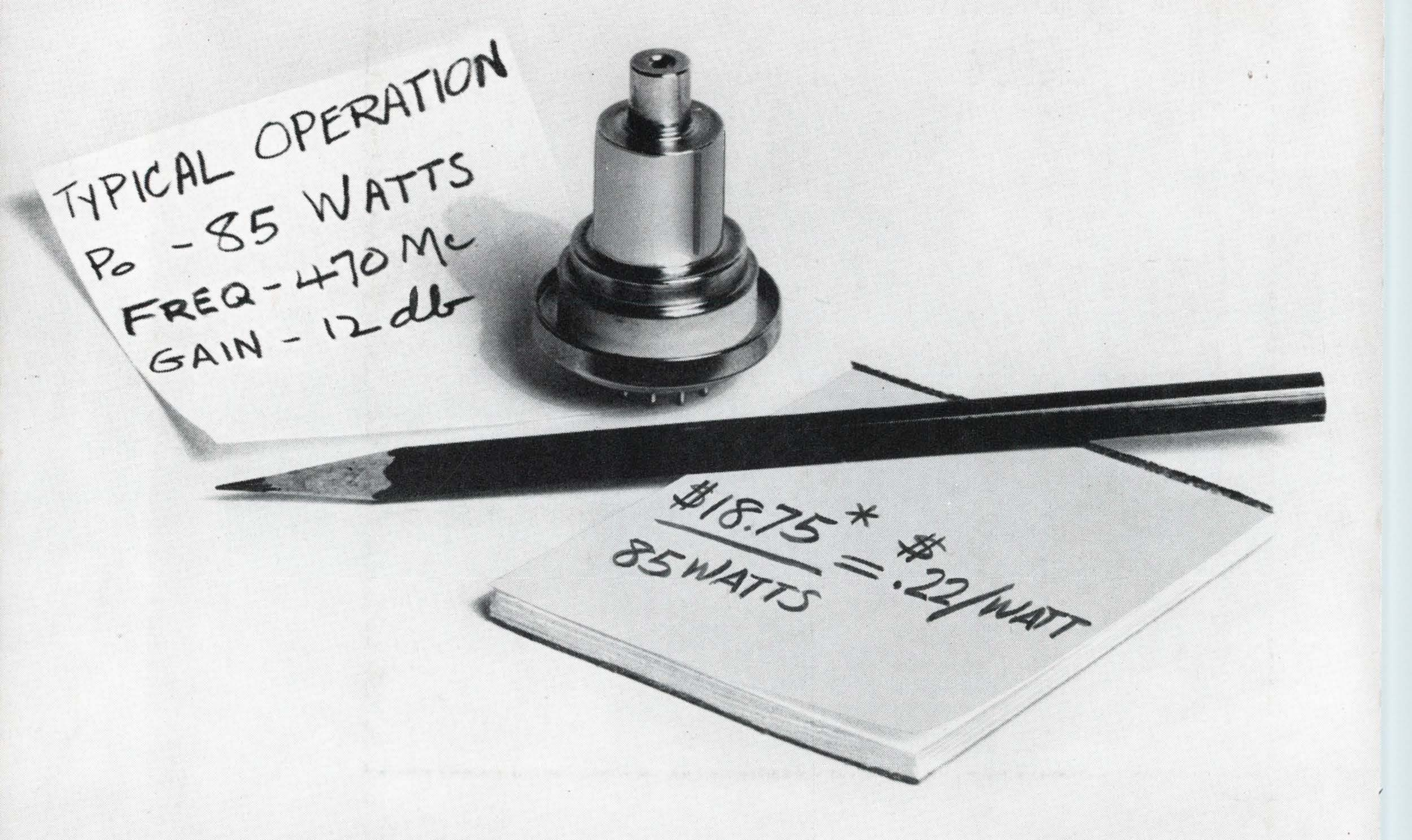

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