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CIRCLE 1 ON READER-SERVICE CARD



COVER: Tunnel diodes, represented by the "S" shape curve, highlight this year's special Diode issue. Scores of diode types, shown within the "S" curve, are tabulated in the latest Department of Defense approved diode listing.

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Power Range: 1μw to 10 mw (with **hp** 431A)
Elements: Four 100-ohm, negative temperature coefficient thermistors permanently installed.
Price: \$145.00



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thermistors.

SPECIFICATION

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SWR: Less than 1.5
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LIFT PAGE

69560

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ELECTRONIC DESIGN • April 26, 1961

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y on all ranges

zeroes all ranges

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able operation

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Thermistor
Mount

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 μ 431A, even in the pres-
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s assured with extremely
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environments for the two

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y installed 100-ohm negative
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or perhaps your power measuring requirements can be met by these μ meters



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Tunnel diodes are gradually being incorporated into equipment designs. Four practical design articles pertaining to the use of tunnel diodes in amplifier and switching applications are presented to assist the design engineer preparing new systems. In addition, the latest Department of Defense list of approved diodes, with their specification numbers, is included.

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Latest military-approved list of semiconductor diodes with their specification numbers

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Small, air-driven clutches yield high torque for their size

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Provides versatile circuiting for heavy-duty power control

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The Ideas for Design in this issue are worth looking at. Each Idea is eligible for the \$1,000 Idea of the Year award recently announced by ELECTRONIC DESIGN.

Tell us which Ideas are of greatest value to you—that is, which suggest a solution to a problem you may have, or stimulate your thinking, or which are just plain clever. That may apply to merely one of the Ideas or to two or more. Feel free to nominate as many Ideas as you wish for the grand award.

Each Idea is numbered. Vote by circling the corresponding numbers on the Reader-Service Card.

And after you've voted, why not send in some Ideas of your own?

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CIRCLE 4 ON READER-SERVICE CARD

Designers Shifting to Wide-Band Communications

Digital Time-Sharing and Continuous-Wave Approaches Are Being Explored To Penetrate Spectrum Congestion

Alan Corneretto
News Editor

BY CHALLENGING intuition, some designers are developing systems in which messages sent over broadband channels would get through congested environments better than those transmitted over narrow-band, exclusively assigned channels.

The apparently logical practice of using narrow-band signals of high power to push through interference is being questioned as not so logical for some types of communications. Two wide-band alternatives being explored are digital systems employing time sharing and continuous-wave systems in which power is distributed over a wide band at low density.

A number of companies, including Motorola, Inc., Martin Co., Radio Corp. of America, General Electric Co. and Philco Corp., have developed random-access, discrete-address digital systems. Users of these systems would time-share wide-band channels randomly and use various message-addressing techniques to lock transmitters to receivers.

A cw type of wide-band communication has been developed by General Electric. In the GE

technique, a double-sideband channel several megacycles wide carries a low-powered coded signal to receivers designed to combine multi-path signals of very low signal-to-noise ratio.

Frequency-Division Sharing Of Spectrum Scrutinized

The renewed interest in wide-band communications is partly a result of information-theory developments that have clarified the relationship between spectrum capacity and various ways of sharing the space. Frequency-division sharing is being re-evaluated as the basic approach to using available space; it has been called a poor choice for many applications.

Much of the current effort in wide-band communications rests on the groundwork laid by Lincoln Laboratory's multi-path diversity RAKE system, built in 1957, and the Army Signal Corps' AN/MRC-66 system of several years ago.

Other spread-spectrum systems have been developed to solve specific technical problems, such as ranging in space applications.

In addition to Motorola and Martin, which have released information on their random-access, discrete-address systems, Collins Radio Co.

and Philco Corp. report they are developing classified spread-spectrum systems. RCA has several such classified systems in design, including at least one discrete-address system, RADAC. Bell Telephone Laboratories says it has built and tested various types of wide-band equipment with complex modulation schemes.

The Signal Corps is reviewing a number of proposals for random-access, discrete-address systems that it has received in response to an invitation. The agency says the spectrum it anticipates in any warfare is so crowded that it doubts standard, assigned-frequency, narrow-band systems would be able to function. The Air Force is said to be considering a discrete-address system for ground use.

Wideband Emergency System Uses Delta Modulation

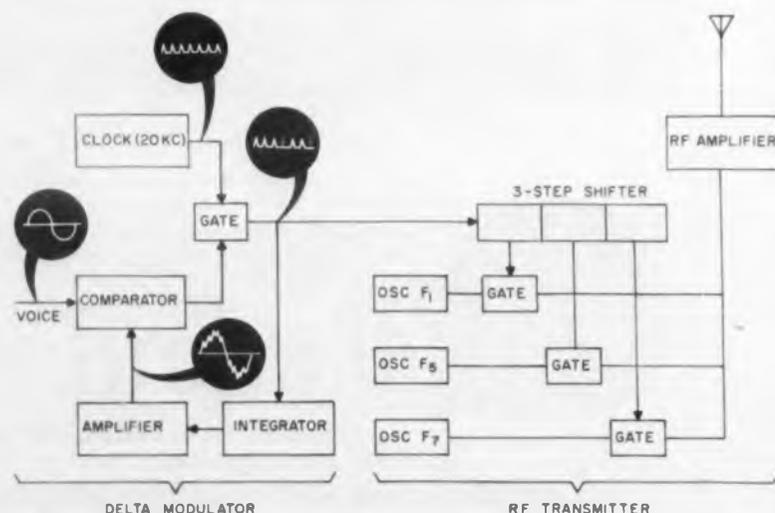
At the 1961 IRE Convention in New York, Henry Magnuski of Motorola, Chicago, described a proposed digital system in which a single wide-band channel could provide emergency, short-range communications in the vhf and uhf bands.

Although the system exists only on paper, some hardware is reported to have been built to test the feasibility of the method.

Delta modulation is used in the proposed system. In this technique, the slope of the voice curve is sampled to provide digital signals from which the original input can be reconstructed. In operation the Motorola system would transmit short pulse groups, each carrying modulation and an address.

To avoid a central control point, transmission of the pulses would not be synchronized. The channel therefore would be time-shared, and pulses from some senders would occasionally interfere with those of others. This interference could be minimized, Dr. Magnuski reports, either by reducing the duty cycle or by transmitting redundant information at the cost of additional transmitter power that would contribute no extra range.

The system is said to be able to accommodate about five talkers per megacycle at an interference level of 30 db.



Delta - modulation transmitter for proposed spread-spectrum communications system transmits discretely addressed digital signals. Feedback loop in Delta modulator integrates and amplifies pulses to reproduce a voice curve. Comparator subtracts reproduced curve from original curve. Positive and negative voltage differences from the comparator close and open the gate, so that pulses from clock will be stopped or passed. Result is that Delta modulation train is formed from clock pulses. Addressing of signal is added by three separate oscillators connected to a common rf amplifier through three gates.



Test model of RACEP random-access, discrete-address communications system consists of encoder-decoder for addressing, left; transmitter, center, and receiver, right. System is said to be capable of supporting up to 700 users on 4 mc.

Martin's concept of a discrete-address, spread-spectrum system is called RACEP, for Random Access Communications with Extended Performance. It has been tested in a breadboard model, the company reports. The system is similar to Motorola's proposal but is believed to use a form of pulse-code modulation. Pem is said to be less vulnerable to jamming than delta modulation.

Martin says that its system would support up to 700 users on one 4-mc channel in a typical 15-mile link at a use factor of 10 per cent. The modulation system used is said to permit either, or both, voice and data transmission with the same equipment, although the system is basically digital. It is intended for use at vhf and uhf.

The system has been discussed with the Federal Aviation Agency for use in air traffic control, Martin says, and has been proposed to military agencies for use in missile guidance and troposcatter communications.

Signals from GE's Phantom System Heard as Noise by Other Sets

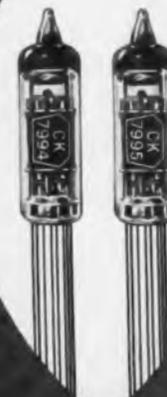
General Electric calls its broadband communications system Phantom I. The company describes it as a double-sideband system for long-haul communications. Average transmitted power is spread over several hundred kilocycles, and the system is intentionally operated at a low data rate in relation to transmission bandwidth to minimize the effects of jamming. Signals are addressed by waveform coding.

Phantom I is operating as a test model in the Southwest, sending to a GE facility near Syracuse, N.Y. Although the company is evaluating the system under an Air Force contract, the Army and Navy are monitoring the tests. The system has been reported successful in first tests, and second-phase testing has begun.

Phantom I is classified, as are most of the broadband systems under development for the military. ■ ■

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CHARACTERISTICS AND TYPICAL OPERATION

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HEATER CURRENT	0.3 Amps	0.3 Amps
PLATE VOLTAGE	100 Volts	150 Volts
GRID #2 VOLTAGE	—	150 Volts
CATHODE BIAS RESISTANCE	82 Ohms	160 Ohms
GRID #1 VOLTAGE	0 Volts	0 Volts
PLATE CURRENT	15 mA	8.0 mA
GRID #2 CURRENT	—	2.0 mA
PLATE RESISTANCE	25 K Ohms	0.1 Meg Ohms
TRANSCONDUCTANCE	18,000 μ mhos	13,000 μ mhos
AMPLIFICATION FACTOR	43	—
Ecl for Ib = 10 μ A	-6 Volts	-6 Volts

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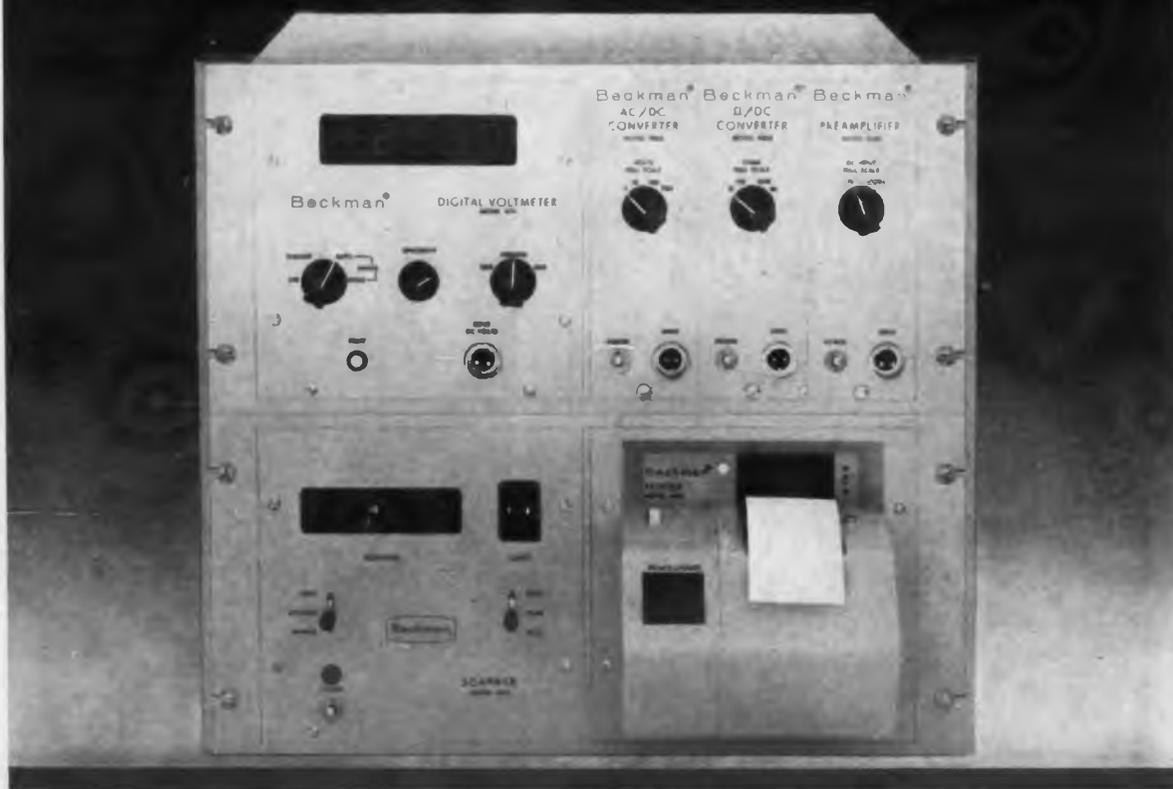
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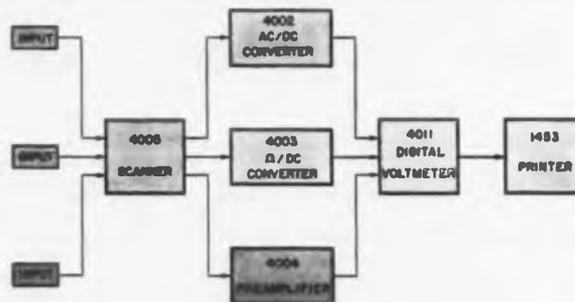
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CIRCLE 7 ON READER-SERVICE CARD

NEWS

Solar-Cell Sensing Used In Novel Accelerometer

Light Beam, Split by a Pendulum, Is Detected by Two Identical Sensors

A NEW accelerometer developed on the West Coast uses a light beam and a pair of identical solar cells for sensing. The beam is split by a pendulum that responds to any acceleration.

The solar cells are formed by scribing a line through the junction layer of a single cell. Changes in illumination on the two cells are detected and compared.

The pendulum is a quartz fiber rod. Illumination from above passes its edges and falls as two discrete beams on the cells. Movement of the pendulum with acceleration decreases the total light flux on one cell and increases it on the other.

In operation, the solar cells respond to the changes in light intensity in nonlinear fashion. However, the cells are used in a push-pull circuit that cancels out nonlinearities.

The accelerometer is the result of a joint effort by Electro Optical Systems, Pasadena, Calif., and Jet Propulsion Laboratory. Electro Optical developed the pickoff.

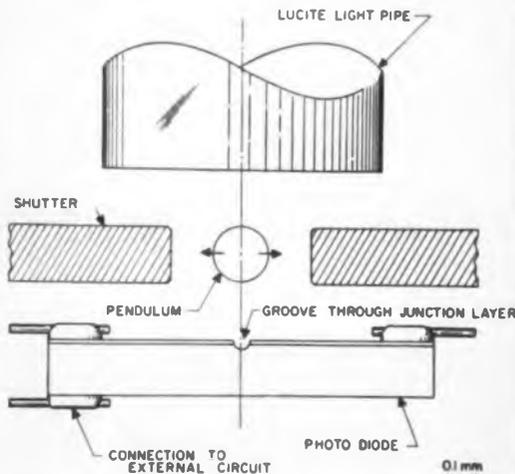
The accelerometer was developed for use in the high energy Vega vehicle, which has been canceled. In Vega it would have been used to sense accelerations useful in orienting the vehicle with respect to the earth.

Acceleration to 1 Part in 10,000 Measured by This Technique

According to JPL's Dr. Alan Johnson, the new accelerometers using this technique are successful; they can measure acceleration to one part in 10,000. Used as simple level detectors or level indicators, they can detect to 1/10 sec of arc.

The accelerometers are 1-in. cubes illuminated by tungsten lamps. They have a condensing lens 0.1 in. in diameter. When the pendulum is in the center position, each of the two slots left between the shutters and the pendulum measures 1 mm by 0.2 mm.

Miniature incandescent lamps obtained by Electro Optical during the development of the device came from Chicago Miniature Lamp Co. and American Cystoscope Makers, Inc. The Chicago Company's lamps were 0.1 in. in diameter, 0.187 in. long, with a 3-v, 60-ma filament rating. The threshold of the larger American Cystoscope No. 540-110 lamps and three of similar construc-



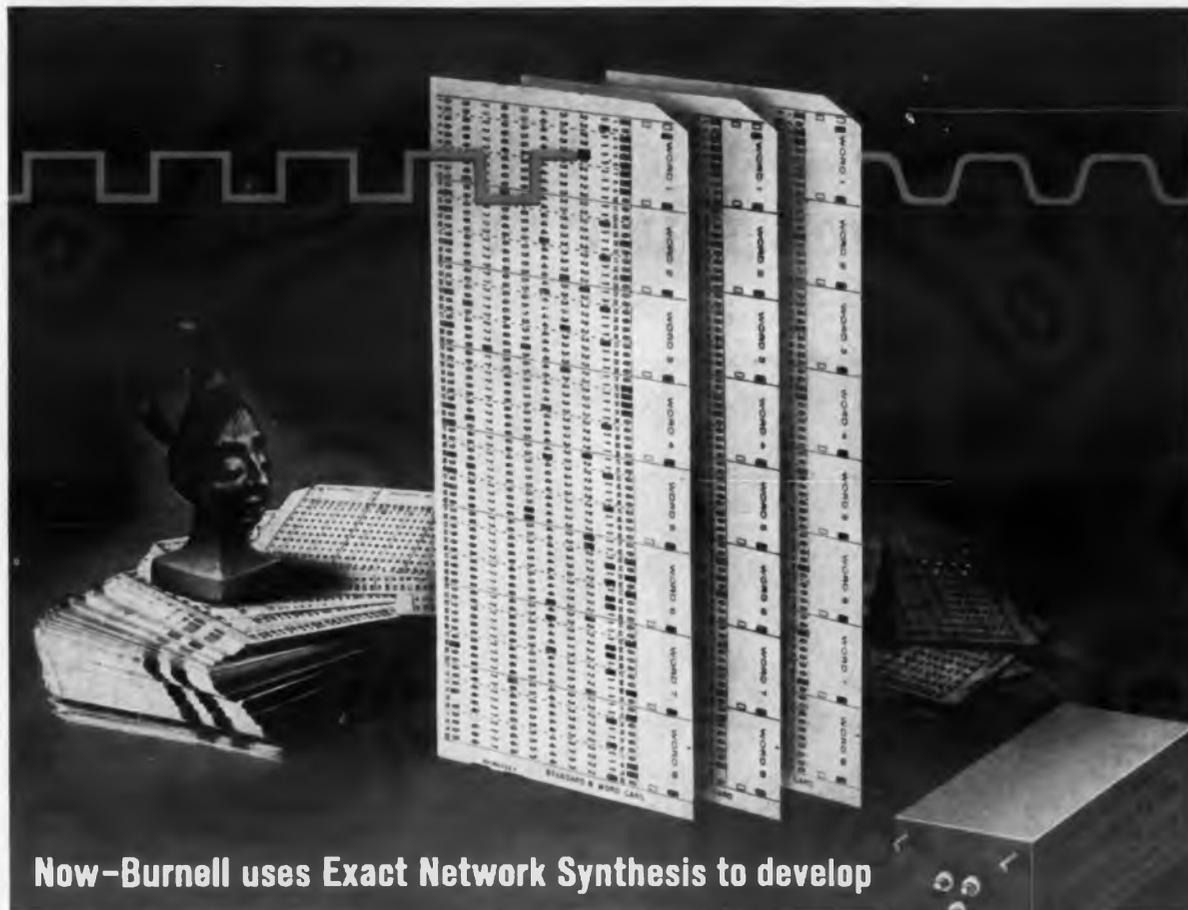
Scribe line splits silicon solar cell into two equal parts in the light-operated accelerometer. Quartz rod pendulum splits light beam into a pair of matched beams at null position. If acceleration is applied the pendulum moves and the change in light flux on the twin cells is compared to get an output proportional to the amount of acceleration.

tion to the Chicago No. CM8-666 lamps but 25 per cent larger, were shaken at rated voltage to 36 g, 20- to 1,500-cycles noise without failure.

Used as a gyro pickoff, according to Electro Optical's manager of the Solid State Div., Irving Weiman, no pendulum would be necessary. A small spot of light would be directed from a mirror on the gyroscope to the scribed line on the solar cell. As the mirror drifted, the spot would move to one side or the other of the scribed line. This would result in unequal output from the two cells.

Some of the characteristics of the dual-cell pickoff were reported by Mr. Weiman. Sensitivity of the solar cell itself is given as $8 \mu\text{a per cm}^2$ in tungsten light. Source impedance is 30 K. Senior research engineer William McClellan chose the doping of the silicon solar cells, so as to provide a 50 per cent greater output than standard solar cells—in terms of short-circuit output current. Symmetry, in terms of difference of output between the two cells on a single wafer, Mr. Weiman said, is 5 per cent over a two-to-one variation in light intensity. The temperature range is from 75 to 180 F.

The pickoff has application anywhere a non-loading readout is required. According to Mr. Weiman, it could be used for high-density photo readouts, optical computers and A-to-D converters (by lining up several cells and constraining an analog-generated light beam to travel across them). The dual cell has been marketed in sample quantities by Electro Optical's manufacturing affiliate, Micro Systems, Inc., Pasadena, Calif. ■ ■



Now—Burnell uses Exact Network Synthesis to develop

New Low Transient Response Filters

New digital computer techniques for network synthesis have enabled Burnell & Co. to produce filters possessing the special time and steady state properties so essential to today's high precision, communication, data and guidance systems. An example of this achievement is the Burnell Type LTR-1 which overcomes problems formerly insoluble through the use of standard design procedure.

More than a linear phase band pass achievement, this new Burnell "low ringing" filter combines the center frequency, band width, rise time and attenuation characteristics that insure minimum phase distortion and low transient response. Hermetically secure, the LTR-1 easily shrugs off shock, vibration, acceleration and

other hazards encountered in extreme environments.

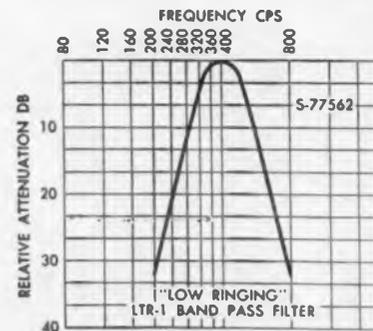
TECHNICAL DATA

Center frequency: 400 cps
 Pass band width: (3db) down +20%
 —16.5% of center frequency
 Attenuation: 30 db at one-half and twice center frequency
 Overshoot: ("low ringing") 1%
 Rise time: (1% to 99%) 6.25 ms.
 Meets MIL-F 18327A specifications.

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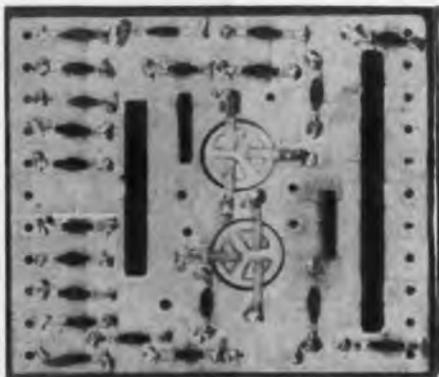
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CIRCLE 8 ON READER-SERVICE CARD

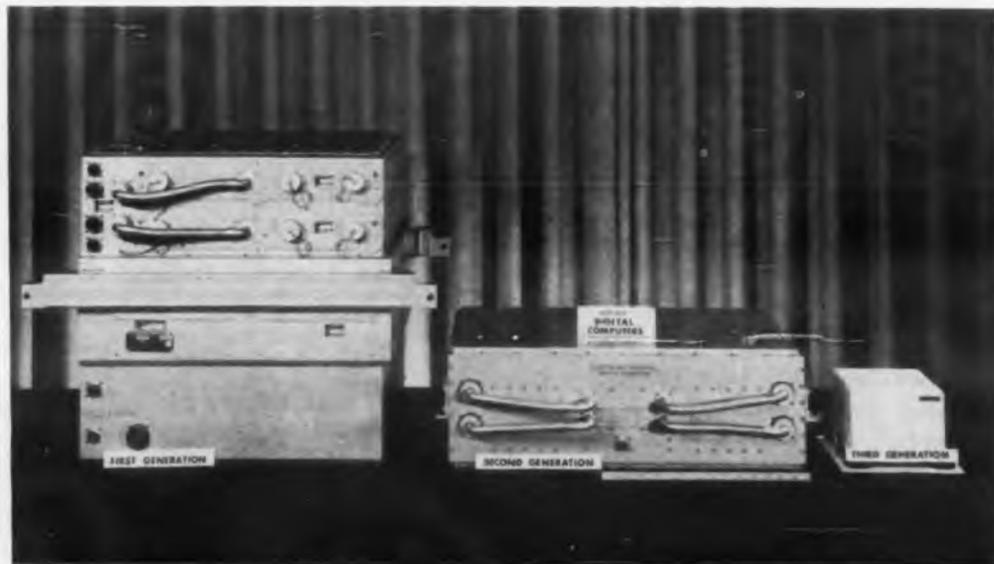
Microminiature Guidance Computer to Use 2-D Approach



2-D circuit, above, has Texas Instruments microtransistors, Pacific Semiconductor microdiodes, and deposited carbon resistors mounted on a 1-in. sq alumina wafer. Holes at the edges of the wafer are for wires used to connect it to a printed-circuit board. All joints are made with solder. Intraconnections on the wafer are made with silk-screened silver conductors. Below, deposited carbon resistors are put on a wafer using an injection printing process, giving good thickness control.



Microminiature guidance computer using 2-D circuits with microcomponents and deposited carbon resistors will weigh 15 lb and occupy 0.3 cu ft. The unit, being developed by American Bosch Arma Corp., will have a 1-mc clock rate and 2,300 words of multiaperture storage, provided by either a ferrite sheet or strips.



Three generations of guidance computers designed by Arma illustrate the progressive size reduction achieved. The first generation computer is the present Atlas ICBM inertial guidance computer. The second generation computer, not yet assigned to a specific project, uses circuitry embedded in foamed polyurethane. It was developed under Air Force contract. The third generation computer is the microminiature unit now in development.

Microcomponents to Be Combined With Deposited Elements in Logic

Robert Haavind
News Editor

A PROTOTYPE microminiature guidance computer, using a combination of ceramic wafer-mounted microcomponents and deposited elements in its logic, is scheduled for completion before the end of this year. A nondestructive multiaperture-type memory, using either ferrite sheets or strips, is planned for the experimental unit.

The techniques, being used by American Bosch Arma Corp., Garden City, L.I., N.Y., are derived from the 2-D packaging approach developed by Diamond Ordnance Fuze Laboratories, Washington (see "Guidelines to Microminiature Designs," *ED*, Nov. 9, 1960, p 61). Although the basic approach to the Arma computer has been decided, according to James P. Maguire, supervisor of the company's microminiaturization group, some design details are not yet settled.

(Continued on p 10)

Arma Guidance Computer Specifications*

	First Generation (Operational)	Second Generation (Prototype)	Third Generation (Developmental)
Weight (lb)	200	60	15
Volume (cu ft)	8	2.5	0.3
Power Dissipation (w)	1,000	120	50
Memory size (words)	**	2,300	2,300
Bits per word	**	29	27
Clock Rate	**	250 kc	1 mc
Add time (μsec)	**	0.128	0.027
Multiply time (μsec)	**	0.896	0.135

*First generation is the present Atlas inertial guidance computer. Second generation uses circuits potted in polyurethane foam. Third generation will use 2-D circuits and a multi-aperture memory.

**Classified information.

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The enviable record of ultra-reliable performance has resulted in the use of Philco transistors in many Military programs. The following types are available to existing Military specifications:

TYPE NO.	APPLICATION	MILITARY SPEC. NO.
2N128	High frequency amplifier	MIL-T-19500/9A
2N240	High speed switch	MIL-S-19500/25A
2N393	High speed switch	MIL-S-19500/77A (Sig C)
2N495	Medium frequency amplifier (Silicon)	MIL-T-19500/54A (Sig C)
2N496	Medium speed switch (Silicon)	MIL-S-19500/85 (Sig C)
2N499	VHF amplifier	MIL-S-19500/72A (Sig C)
2N501A	Very high speed switch	MIL-T-19500/62 (Sig C)
2N502A	VHF amplifier	MIL-S-19500/112 (Sig C)
2N599	Medium speed switch	MIL-S-19500/166 (Navy)
2N1118	Medium frequency amplifier (Silicon)	MIL-S-19500/138 (Sig C)
2N1119	Medium speed switch (Silicon)	MIL-S-19500/139 (Sig C)
2N1158A	VHF oscillator	MIL-S-19500/113 (Sig C)
2N1199A	High speed switch	MIL-S-19500/131 (Sig C)
2N1200	HF amplifier (Silicon)	MIL-S-19500/105 (Sig C)
2N1201	HF amplifier (Silicon)	MIL-S-19500/101 (Sig C)
2N1411	High speed switch	MIL-S-19500/133 (Sig C)
2N1499A	High speed switch	MIL-S-19500/170 (Sig C)
2N1500	Very high speed switch	MIL-S-19500/125 (Sig C)

For information on any of the above types, write Dept. ED42661.

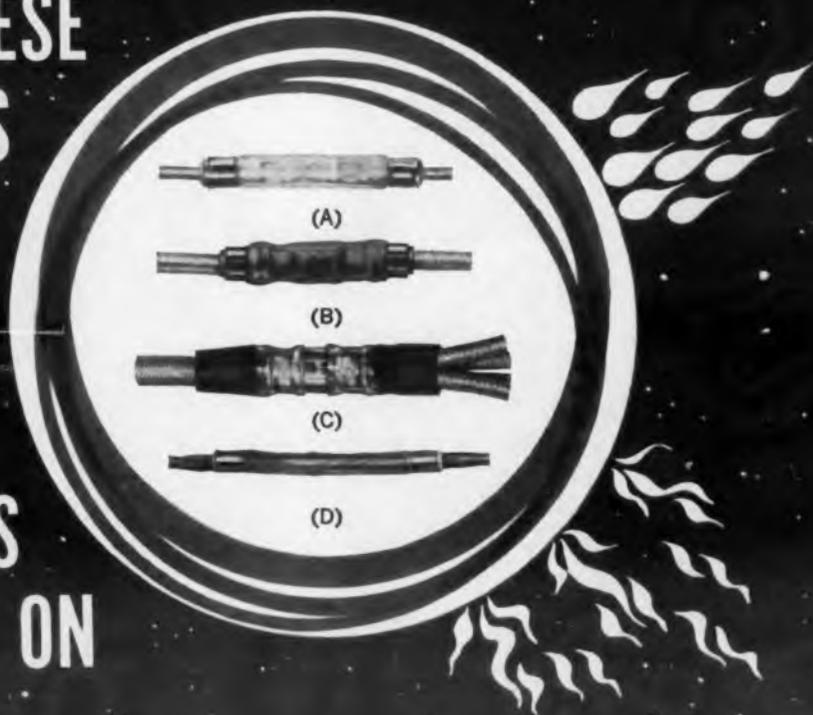
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CIRCLE 10 ON READER-SERVICE CARD

NEWS

(continued from p 9)

Six Basic Circuit Types On 1,000 Wafers To Be Solder-Mounted On Printed Boards

Six basic circuit types, mounted on about a thousand 1-in.-sq alumina wafers, will be used in the computer. Arma plans to join the wafers to printed circuit boards with a flow-solder process. Present test boards contain six wafers each, but a shift to nine wafers on a board is being considered, according to Mr. Maguire.

Conduction paths on the wafers are silk-screened, and resistors are added by injection printing. Silk-screening of resistors was evaluated, Mr. Maguire said, but the injection method was chosen because of better thickness control.

Microcomponents—transistors, diodes and capacitors—are then soldered in place. A fixture, for holding these components in place while the wafer is dipped into a solder pot, is now being designed by Arma for computer production.

Memory Operated in Saturated Mode Insensitive to B-H Loop Changes

Nondestructive read-out of data is the chief advantage of the multiaperture memory under development for the computer. Insensitivity to shifts in hysteresis loop characteristics, caused by temperature variations or other factors, is another advantage of this approach. This is possible because a coincident flux technique, with the ferrite material in saturation, is used by Arma for memory operation. Mr. Maguire declined to give details of the Arma technique.

Prototype memory units have used two-hole cores and conventional copper wiring. Arma is now working on ferrite sheet memories, which would be easier to produce and wire. If eddy currents prove a problem in the sheet approach, the sheet might be cut into multiaperture strips.

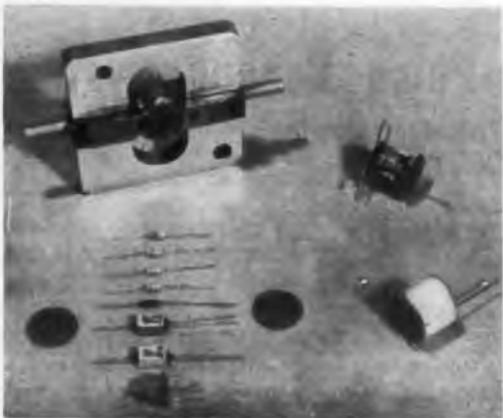
An extruded plastic method for mounting the sheet memory units to boards is being developed, and Arma is also considering the use of deposited conductors rather than wires for interconnecting apertures. The present core memories are mounted on boards in bakelite strips.

Each board in the memory will hold 22 words of stored data. Although the data will be primarily stored programs and constants, provision will be made for external loading from a remote source.

Signal-to-noise ratios of about 15:1 are expected, with drive current requirements of about 500 ma.

Assemblies Holding 8 to 10 Boards Have Slots to Permit Free Air Flow

The memory and logic boards will be fastened to slotted metal assembly frames using Elco Microminiature V-type connectors. Each assem-



Arma's "second generation" computer uses circuits potted in foamed polyurethane. Special jig, top, is used to hold components between pieces of printed circuit board as potting takes place. Circular plugs are then inserted in holes in foam plastic circuit holder. Computer configuration is shown below.



Assembly frame will hold 8 to 10 boards. A central duct in the computer will allow free air flow through the assembly frame slots and over the flat circuit surfaces, carrying away heat.

The use of corrugated cards between boards within each frame is being considered for better shock and vibration protection.

The initial estimated price for the computer is about \$100,000. This is expected to drop as microcomponents become less expensive, and as the computer goes into production. The computer is being developed with company funds.

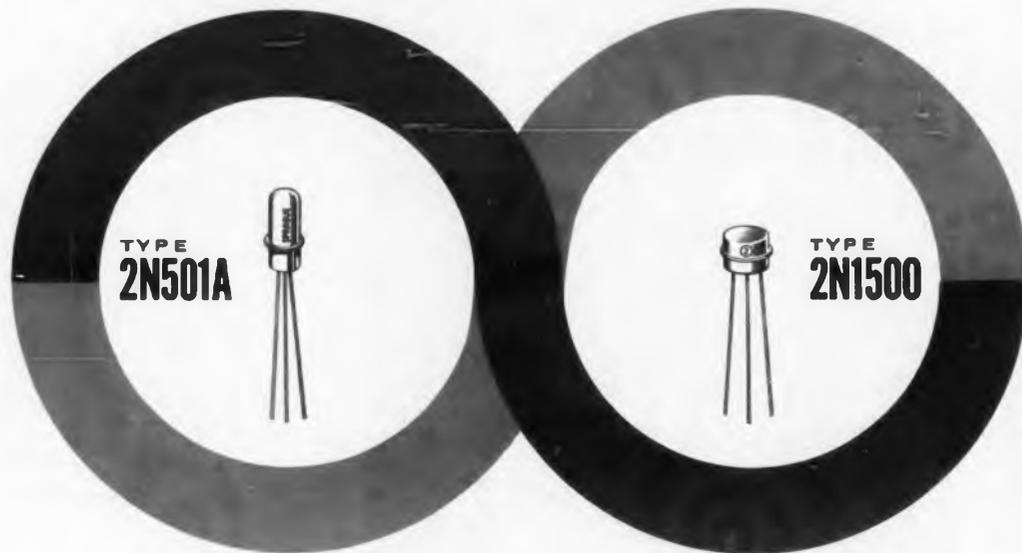
Second Generation Computer Uses Foam Plastic Circuits

Circuits potted in foamed polyurethane are used in a prototype miniature guidance computer already developed by Arma under Air Force contract. Arma terms this unit a "second generation" guidance computer.

Small cylindrical plugs containing up to 15 components embedded in foam plastic are fitted into machined holes in a foam plastic circuit holder. Printed boards on each side of these circuits are used for interconnections, using solder joints.

This all solid-state computer has not yet been assigned to any specific programs. ■ ■

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the reliable switching characteristics of the field-proven 2N501A
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- The well known slim-line Type 2N501A Micro-Alloy Diffused-base Transistor, extensively used in critical military, industrial, and commercial applications, is now joined by the 2N1500, in its low-height TO-9 case.

- The electrical characteristics of the 2N1500 are identical with those of the 2N501A. Both of these ultra-high-speed switching transistors will operate reliably at speeds up to 20 megacycles. They feature excellent high frequency response at very low collector voltages, a characteristic made possible by the placement of the collector in the diffused region of the base.

- A precise, controlled-etching process makes it possible to maintain high frequency characteristics down to saturation voltage. Therefore, you can realize all

the advantages of direct-coupled circuitry with no loss in switching speed.

- Sprague MADT* Transistors are now manufactured with cadmium junctions, providing an extra safety margin. Effects of high temperature, the major destructive factor with transistors, are minimized by the superconductivity of cadmium, assuring cooler operation and greater reliability.

- For prompt application engineering assistance, write Commercial Engineering Section, Sprague Electric Co., Concord, N.H.

- For complete engineering data sheets, write Technical Literature Section, Sprague Electric Co., 347 Marshall St., North Adams, Mass.

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SPECIFICATIONS

Temperature Range—Full rating from -55°C to $+85^{\circ}\text{C}$ and to $+125^{\circ}\text{C}$ with 50% derating.

Insulation Resistance—Greater than 100,000 megohm-mfds. at 25°C —See curve below.

Life Test—250 hours at $+85^{\circ}\text{C}$ and 125% of rated voltage.

Dielectric Strength—Twice rated voltage for one minute.

Winding Construction—Extended foil (non-inductive) MYLAR Dielectric.

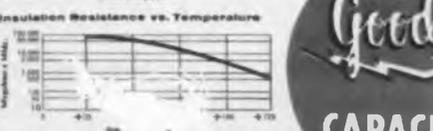
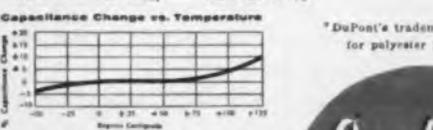
Humidity Resistance—Far exceeds requirements of EIA-Spec RS164 Para. 2, 3, 8.

Tolerance—Standard $\pm 20\%$ $\pm 10\%$ $\pm 5\%$ thru $\pm 1\%$.

Voltage Range—100, 200, 400, 600 and 1000 VDC.

DIMENSIONS (100 Volt Rating)

663UW			663F		
CAP. MFD.	D	L	T	W	L
.001	.154	$\times \frac{1}{2}$			
.01	.154	$\times \frac{1}{2}$			
.022	.303	$\times \frac{5}{8}$.154	.297	$\times \frac{1}{4}$
.047	.334	$\times \frac{3}{4}$.219	.328	$\times \frac{1}{4}$
.1	.381	$\times \frac{7}{8}$.219	.389	$\times \frac{3}{8}$
.22	.328	$\times 1$.328	.547	$\times 1$
.47	.448	$\times 1\frac{1}{4}$.359	.622	$\times 1\frac{1}{4}$
1.00	.593	$\times 1\frac{1}{2}$.453	.859	$\times 1\frac{1}{2}$



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*DuPont's trademark for polyester film.

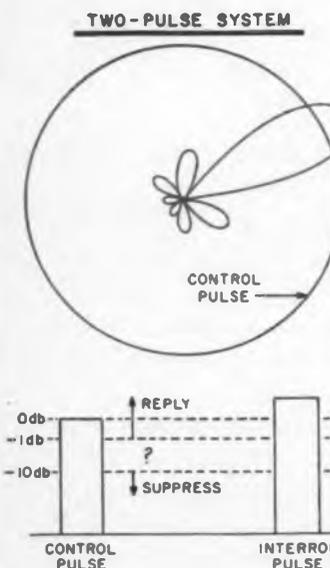
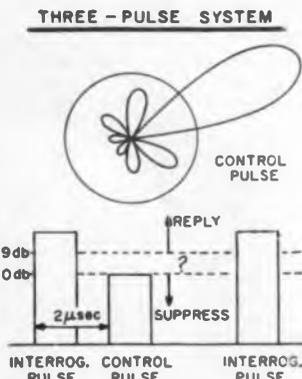


GOOD-ALL ELECTRIC MFG. CO. Ogallala, Neb.

NEWS

FAA Adopts Three-Pulse Beacon System

Symposium Told New Transponders Needed; Progress Slow in Anti-Collision Devices



Three-pulse side-lobe suppression path system adopted by FAA for use in U.S. differs from two-pulse beacon systems in use internationally in that an omnidirectional pulse is sent 2 μsec after first interrogation pulse and a specified time before second interrogation pulse. In standard two-pulse system, control pulse is sent simultaneously with interrogation pulse and with much greater power than side lobes. In both systems replies are suppressed if side lobes are received, but in three-pulse system less omnidirectional power is needed and timing is less critical.

A THREE-PULSE beacon system has been officially adopted by the Federal Aviation Agency for use by aircraft in the United States. The announcement touched off a competition among manufacturers of transponder equipment to supply the market guaranteed by the FAA's decision and by the major airlines' announced intention to equip their aircraft with transponders. These would be compatible with the secondary radar system being installed by the FAA at major air-traffic-control centers.

At least five companies have developed, or have almost developed, transponders capable of meeting the new standard. These are Radio Corp. of America, Bendix Corp., Collins Radio Co., Wilcox Electric Co., and at least one British firm. The RCA and Collins units, reportedly, are basically two-pulse systems that can be modified by adding a module. The Bendix transponder has both capabilities built in.

Announcement of the new standard was made at the First Annual International Aviation Research and Development Symposium held recently in Atlantic City. More than 500 aviation specialists from nearly 30 countries attended the week-long meeting at which the state of research in aviation was discussed. At the symposium, it was stated that:

- The air-height surveillance radar being tested at the National Aviation Facilities Experimental Center near Atlantic City is so far performing as expected. Twenty-beam segments of the 111-beam system are providing altitude readings accurate to ± 200 ft.

- Development of collision-avoidance systems or pilot-warning indicators suitable for general use in aircraft is not probable in the near future, even though one of the three systems under test at NAFEC—the Bendix ground-bounce-ranging system—is meeting specifications. Also under test is a Motorola cooperative pilot-warning indicator and a Sperry system using a microwave antenna.

- Studies designed to aid integration of the Air Force's SAGE system with the FAA's air-traffic-control system are nearly complete and indicate that such integration is feasible.

The FAA's announcement of the three-pulse, side-lobe suppression standard was made during a discussion of the agency's entire radar-beacon program. L. E. Shoemaker, head of the beacon systems section of the FAA's Development Div., said that nearly 60 ground stations were now

equipped with secondary radar beacons and that the FAA planned to install such equipment at all stations that had primary radar. He reported all the major airlines had programs to install transponders in their aircraft, although only a third of the planes are now so equipped.

Besides installing additional equipment, the agency is extending the usefulness of the beacon system by increasing the number of codes that can be used, by adding altitude-reporting capability and by developing transponder equipment suitable for all aircraft other than airline and military. This would comprise about 70 per cent of the planes flying in the U. S.

The 64 codes now available will be increased by doubling the number of pulses in the reply train to form a supplementary set of 64 basic codes. These will provide a total of 4,096 codes. Most secondary radar equipment in development is being designed to operate with the additional codes and to process replies containing altitude information.

Automatic Altitude Reporting Planned in Beacon System

The FAA is confident that altitude reporting by means of beacon replies will prove feasible, according to Kenneth Wise of the agency's beacon section. In a paper at the meeting, he said that development of an automatic altitude-reporting subsystem for radar-beacon systems would reduce the load on aircraft-ground communications channels and give controllers an important third dimension to establish position of aircraft.

In reporting on the FAA's transponder program, Mr. Wise said the agency hoped to start testing by June, five different transponders now being developed for general aviation use. These are being designed by Hazeltine TDC Div., Indianapolis, and Wilcox Electric Co., Kansas City, Mo. The transponders will be lighter, cheaper and have less power drain than units in use on military and airline aircraft, Mr. Wise said.

These transponders will use only 64 codes and a single mode of interrogation, will have limited reply words and will not be as rugged as current types. They will reply only to the common air-traffic control code 3/A, which uses an 8- μ sec separation between leading edges of pulses, and will have only three-pulse, side-lobe suppression. Their range, Mr. Wise said, will be 150 miles. Weight and power drain will be 14 lb and 35 to 60 w. The units are being designed to sell from \$1,000 to \$1,400. The FAA expects to complete testing the transponders by November. Mr. Wise reported.

The FAA representative revealed that the agency planned to develop an improved transponder antenna, with dual aperture and im-

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WITH ASSURED AVAILABILITY through regular Fairchild distributors. The Fairchild name and the 2N numbers protect the circuit designs you base on these specifications.

ELECTRICAL CHARACTERISTICS

(25° C except as noted)

TYPES	DESCRIPTION	JEDEC OUTLINE	f _T TYPICAL	P _C @25° C CASE TEMP.	h _{FE}		V _{CE} R	V _{CB} O	V _{BE} (Sat) MAX.	V _{CE} (Sat) MAX.	I _{CB} @25° C MAX.
					MIN.	MAX.					
2N1985 2N1984 2N1983	Small signal types for AC and DC amplifiers	T0-5	50 mc	2 watts	15° 35° 70°	45° 100° 210°	40	50	—	—	5 μ A
2N1987 2N1986	Switching types	T0-5	50 mc	2 watts	20 60	80 240	40	50	0.9	0.6	5 μ A
2N1989 2N1988	High voltage types particularly suited to video amplifiers and RF oscillators	T0-5	50 mc	2 watts	20 35	60 120	60	100	1.0	2.0	5 μ A
2N1991	PNP complement to the small signal and switching types	T0-5	50 mc	2 watts	15	60	25	30	—1.5	—1.5	5 μ A
2N1990	Neon tube and Nixie® driver type	T0-5	—	2 watts	20	—	60	100	1.0	0.5	—

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* For the small signal types, this specification is h_{FE} at I_B instead of h_{FE} at DC.

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NEWS

proved coverage, and was investigating for commercial application the data-transfer feature of an Air Force transponder that uses parity pulses for error checking.

Three-Pulse Suppression System Believed Better Than Two-Pulse

The adoption of side-lobe suppression during interrogation is part of the program to improve existing equipment, Mr. Shoemaker said. In the standardization of the three-pulse suppression technique, not only will beam paths of interrogating transmission be shaped to minimize interference but effective bandwidth will also not be lost as range increases. This point was made by J. E. Herrmann of the agency's beacon section, who delivered a paper on interrogation path side-lobe suppression.

In a two-pulse system, interrogation and control pulses are sent simultaneously—the control pulse omnidirectionally, the interrogation pulse directionally at slightly greater amplitude. The aircraft transponder compares the received pulse with the last one it received. If the new pulse is stronger than the last, it replies, because it is receiving an interrogation pulse. If amplitude is less, it is receiving a side-lobe and so suppresses its reply.

In the three-pulse system adopted by the FAA, an omnidirectional control pulse is transmitted 2 μ sec after the first directionally transmitted interrogation pulse and is followed by the third pulse. The aircraft transponder compares the control pulse with the first interrogation pulse in delay-line circuitry and replies if the third pulse is at least 9 db greater than the control pulse. If the third pulse is less in amplitude than the control pulse, a reply is suppressed. The elapsed time between the control pulse and the second interrogation pulse determines which transponders will reply.

According to Albert Brown, chief of the Systems Engineering Div. of the FAA, the advantages of this three-pulse system over a two-pulse system are that it requires less omnidirectional power, gives better reflection suppression, is less dependent on timing and synchronization, is compatible with military systems and uses a simpler antenna.

The system was said to be originally developed by Mortimer Setrin of the Air Force. During the meeting D. G. Terrington of the British Ministry of Aviation, reported that Great Britain was still using a two-pulse, side-lobe suppression system, in accordance with an international agreement. It was learned at the meeting that a convincing demonstration of the effectiveness of the FAA three-pulse system has been made

What is a KIN TEL Closed Circuit TV system?

The basic KIN TEL closed circuit TV system consists of a camera, camera control unit, and monitor, each connected by cable. The camera can be located at great distance from the monitor, and any number of monitors may be used to display the same picture.



Cameras are small enough to hold in your hand; rugged enough to operate in virtually any environment; versatile enough to cover (via remote control) almost any area; and sensitive enough to provide excellent pictures of subjects illuminated by a single candle.



The camera control provides automatic operation. The system is continuously self-adjusting for wide variations in light levels (several thousand to one), and features automatic high definition of bright objects. The only control you have to touch is the on-off switch.



The monitor displays a crisp, clear picture...full 650-line resolution, twice that of the best home TV reception.

How are such systems used?

Today, KIN TEL TV systems are performing a number of jobs for hundreds of firms, safely, inexpensively, tirelessly. They are being used to watch operations or events that are tedious, difficult, dangerous, or even impossible for men to watch.



For example: Convair (above), Douglas, Lockheed and Northrop watch rocket tests with KIN TEL systems. U. S. Steel uses one to see inside open hearth furnaces. Westinghouse watches nuclear power reactor tests with one.

They are being used for surveillance.

For example: The San Francisco Naval Shipyard uses one to guard against pilferage.

They are being used for traffic control.

For example: The Alameda Naval Air Station uses a KIN TEL TV system to

observe aircraft landings on the portion of the runway that is not visible from the control tower.

They are being used to transmit visual information quickly and accurately; for remote observation of charts, meters, graphs, schedules, blueprints, photographs, images from microscopes, fingerprints, signatures...the list is almost endless.

For example: E. F. Hutton uses a KIN TEL system to transmit stock market quotations to the offices of the firm's executives. The Los Angeles Department of Water and Power uses one for remote viewing of water-level meters. The University of California teaches physics with one.

They are being used for monitoring any operation that normally requires standby personnel.



For example: American Potash and Chemical (above) monitors conveyor line and warehousing operations with a KIN TEL TV system.

Why do these firms choose a KIN TEL system?

For a variety of reasons.

First, reliability. KIN TEL TV is designed for continuous duty operation in severe environments. Day in and day out, it keeps working. It's the first choice for ICBM and other missile programs that really depend on TV, that can't chance failure, that can't afford to compromise with reliability.

Second, picture quality. KIN TEL TV presents clear, sharp pictures. Full 650-line resolution provides maximum data...essential for quantitative observation of complex operations or transmission of printed material.

Third, automatic operation. KIN TEL TV is the only closed circuit system that provides entirely automatic, through-the-lens compensation for light-level changes of several thousand to one.

Fourth, the KIN TEL closed circuit TV system is extremely sensitive. The light required to read this page is enough for sharp clear pictures, and usable pictures can be provided with less than one-foot candle illumination.

Fifth, KIN TEL TV systems are easy to install and simple to operate. With no changes in lens iris to make, with no difficult, interacting electrical adjustments required, the only thing the operator has to know is the location of the on-off switch.

Sixth, a complete line of shelf-item system components and a variety of cameras and monitors make virtually any application feasible... permit observation of nearly every kind of operation, under all kinds of conditions.



For example, with system components, you can remotely position the camera, remotely select one of several lenses, remotely "zoom" in or out for closeup or wide-angle viewing, operate the camera in extremes of temperature or in explosive or dusty atmospheres, view microscope images. Whatever your viewing problem, KIN TEL probably has a stock solution.

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What can a KIN TEL system do for your business?

It can do what it is doing right now for hundreds of other firms. It can save you time and money...increase efficiency...better your service to clients and customers. To find out how, write direct for catalog 6-205 and the name of your nearest KIN TEL engineering representative.

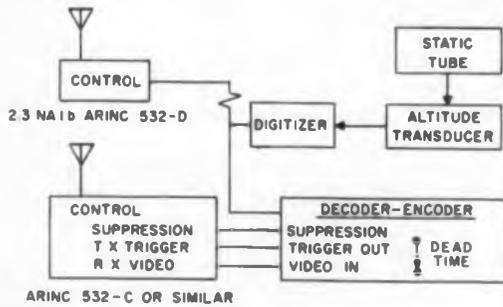


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here today:



Test setup for evaluating beacon transponder methods for reporting altitude from aircraft is installed at FAA's Atlantic City, N.J., facility. Transducer converts static pressure to an analog signal. In a simplified arrangement not requiring decoder-encoder, the digitizer connects directly with the control unit of the transponder. The receiver in a more complex version has if video, modified to include suppression of side-lobes, spikes, long pulses and echoes. In reply to proper interrogation, the decoder-encoder codes a reply corresponding to altitude, and uses it to modulate the transponder reply. The code is cyclic binary-coded decimal.

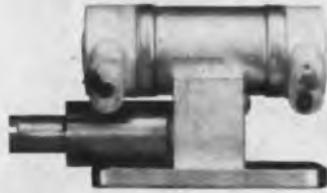
to the British and that they are considering adopting it.

Mr. Wise reported that the three-pulse system, already in test operation at Atlantic City, would be put into general civilian use starting in 1962. It is being recommended for inclusion in the IFF Mark X air traffic control radar-beacon standard, which is a preliminary to recommendation to NATO as a standard system.

In discussing the side-lobe suppression program of the FAA, Mr. Herrmann said that the agency was developing with the Army Signal Corps a traveling-wave-tube switch called a Beacotron for ground-station beacons. In this device the tube output is controlled by voltage applied to the tube's control grid, enabling the switch to control the shape of the beam being transmitted as the beacon antenna is rotated. This feature is particularly valuable, it was said, in areas where several beacons are operating. Output can be suppressed when it will interfere with adjacent beacons. Another high-speed switch being developed for the same purpose would use either diodes or a ferrite device. Both efforts are part of a program to develop a beacon interrogation system that would need only one interrogator to generate both the control and interrogation pulses. They represent adoption of monopulse radar techniques to provide sharpened beam widths of interrogation antennas.

Video Processor in Development Uses Monopulse Techniques

Monopulse techniques, Mr. Shoemaker reported, are being used in equipment about to be introduced to mark the true center of the



Eimac 1K20 Series Reflex Klystrons
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Typical Output: 75 mW



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Small Signal Gain: 60db
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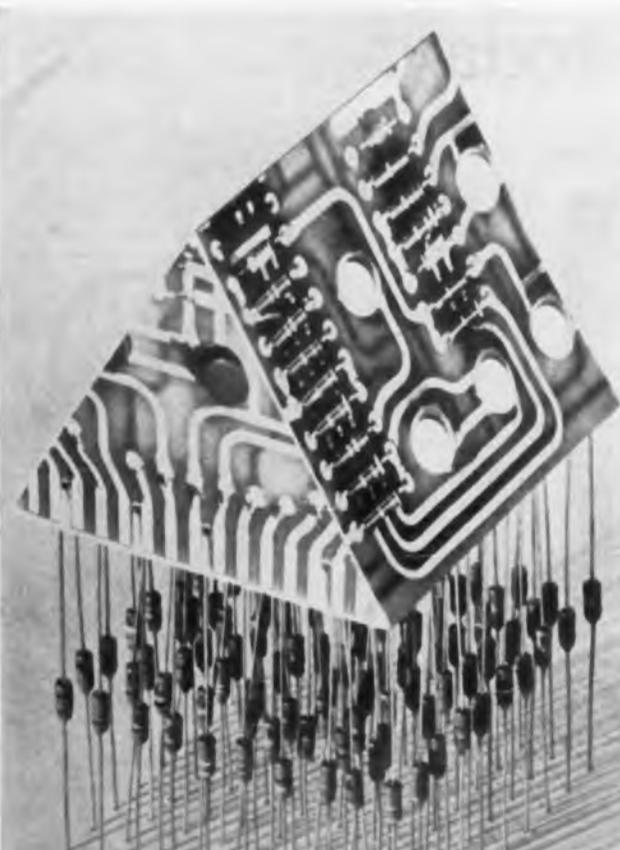
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1N935	0.55 - 0.45	± 0.01	0 to +75	20
1N935A	0.55 - 0.45	± 0.01	-55 to +100	20
1N935B	0.55 - 0.45	± 0.01	-55 to +150	20
1N936	0.35 - 0.45	± 0.005	0 to +75	20
1N936A	0.35 - 0.45	± 0.005	-55 to +100	20
1N936B	0.35 - 0.45	± 0.005	-55 to +150	20
1N937	0.55 - 0.45	± 0.002	0 to +75	20
1N937A	0.55 - 0.45	± 0.002	-55 to +100	20
1N937B	0.55 - 0.45	± 0.002	-55 to +150	20
1N938	0.55 - 0.45	± 0.001	0 to +75	20
1N938A	0.55 - 0.45	± 0.001	-55 to +100	20
1N938B	0.55 - 0.45	± 0.001	-55 to +150	20
1N939	0.35 - 0.45	± 0.0005	0 to +75	20
1N939A	0.35 - 0.45	± 0.0005	-55 to +100	20
1N939B	0.35 - 0.45	± 0.0005	-55 to +150	20

*Measured by superimposing 75 mA rms AC on 7.5 mADC

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NEWS

target arc on the controller's display. This is done in the receiver, he said, by video processing in separate sum and difference channels, and by introduction of an adjusted threshold level. In manual tracking, the width of the displayed arc can be made to correspond to the width of the surveillance radar target, which is about 2 deg.

The video-processing unit that will do this is in development at Burroughs Corp., Paoli, Pa. It was described by W. A. Connolly, an FAA project engineer. It is a 10-channel unit contained in five racks and will be part of major air traffic control radar beacon systems. It will provide beacon tracking, positive identification, and selection and display filtering over a range of one-half to 200 nautical miles, he said. According to Mr. Connolly, this elaborate all-transistorized system will be able to function 10 ways. It will:

- Provide plan position display of replies from aircraft equipped with basic IFF Mark X transponders that answer mode 1, 2, or 3A interrogations. These displays will be blips.

- Provide ppi display of common-system transponders in mode 3 and change a blip display to a bar when the reply code is followed by identification pulses. The number of codes to be handled is expandable to 4,096. An emergency reply produces a double bar, an audible alarm and a display of the letter "E."

- Display as a single blip all aircraft responding to mode 3A and exclude responses from basic IFF Mark X transponders.

- Provide rapid readout and digital display of reply code.

- Provide digital decimal display of all information from planes equipped with mode-C altitude-reporting systems.

- Provide altitude zone filtering by either altitude reply codes or by analog height pulses from 3-D radars.

- Display center marks on each beacon video target equipped with suitable equipment.

- Accept three inputs: basic beacon, all C/S and selective aircraft replies, and analog altitude pulses.

- Control interrogation modes, video definition and display selection.

- Sense code-garble and have nondestructive readout.

Included in the unit will be a storage tube type of defruiter rather than a delay-line type. This subsystem will retain the response pattern of the first interrogation cycle, compare it with the next pattern, and filter out nonsynchronous replies, Mr. Shoemaker said. ■ ■

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Advertisement

Burndy YD Tool Modified For Faster Operation



As a result of wide customer acceptance of BURNDY Omaton Division's YD-2, a new version of this semi-automatic, portable, pneumatic crimping tool has been developed. The new edition, the YD-2-3 is a bench-mounted, foot-operated tool with a magazine holding almost eight times (533 contacts) as many contacts as the original version (70 contacts).

The YD was originally designed as a magazine-fed hand-operated tool for work in and near electronic cabinets. The new version will produce a higher rate of contact installation, making it especially useful in harness wiring.

The bench-mounted, foot-activated increased-magazine-capacity features will allow the contact installation rate of the YD-2 to be greatly increased. The YD-2-3 retains the features of automatic pre-positioning, feeding, and crimping of BURNDY's HYFEN®, STAPIN®, and CRAB-LOK®-MODULOK® lines of contacts. It also features color coded die sets matched with the color of contact-carrying strips. The plastic carry strips are automatically ejected from the tool after the contacts have been used.

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Coax Feed-Thru
Miniature and standard connector (above) and splice (below). All plastic shells—lightweight, durable, impact resistant.



Coax MODULOK®
Modular terminal block with spring-loaded removable contacts.



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Modular HYFEN inserts for all standard or miniature coax or in combination with inserts for single conductors.



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			Min.	Max.
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2N333	MIL-T-19500 /37A (NAVY)	V _{CE} 45	h _{FE} .948	— .976
2N334	MIL-T-19500 /37A (NAVY)	V _{CE} 45	h _{FE} .948	— .989
2N335	MIL-T-19500 /37A (NAVY)	V _{CE} 45	h _{FE} .974	— .989
2N337	MIL-S-19500 /69C (NAVY)	V _{CE} 45	h _{FE} 20	— 55
2N338	MIL-S-19500 /69C (NAVY)	V _{CE} 45	h _{FE} 45	— 150

Unijunction NPN (SILICON, FIXED BED MOUNTING)

Type No.	Mil Spec	Voltage Rating	Current Gain	
			Min.	Max.
2N489	MIL-T-19500 /75 (USAF)	V _{BE} 60	η	.51 — .62
2N490	MIL-T-19500 /75 (USAF)	V _{BE} 60	η	.51 — .62
2N491	MIL-T-19500 /75 (USAF)	V _{BE} 60	η	.56 — .68
2N492	MIL-T-19500 /75 (USAF)	V _{BE} 60	η	.56 — .68
2N493	MIL-T-19500 /75 (USAF)	V _{BE} 60	η	.62 — .75
2N494	MIL-T-19500 /75 (USAF)	V _{BE} 60	η	.62 — .75

Audio PNP (GERMANIUM)

Type No.	Mil Spec	Voltage Rating	Current Gain	
			Min.	Max.
2N43A	MIL-T-19500 /18 (USAF)	V _{CE} 45	h _{FE} .968	— .985
2N44A	MIL-T-19500 /6 (USAF)	V _{CE} 45	h _{FE} 18	— 43
2N526	MIL-S-19500 /60C (JAN)	V _{CE} 30	h _{FE} 53	— 90

Computer PNP (GERMANIUM)

Type No.	Mil Spec	Voltage Rating	Current Gain	
			Min.	Max.
2N123	MIL-T-19500 /30 (USAF)	V _{CE} 20	h _{FE} 30	— 150
2N396A	MIL-T-19500 /64A (NAVY)	V _{CE} 30	h _{FE} 30	— 150
2N404	MIL-T-19500 /20 (USAF)	V _{CE} 25		

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			Min.	Max.
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2N167A	MIL-S-19500 /11A (USAF)	V _{CE} 30	h _{FE} 17	—
2N388	MIL-T-19500 /65 (NAVY)	V _{CE} 25	h _{FE} 60	— 180

GENERAL ELECTRIC

CIRCLE 19 ON READER-SERVICE CARD

NEWS

Bomber IR System Being Designed To Track Enemy While Scanning

A passive infrared surveillance system for bombers is being designed to track while scanning for interceptors or missiles.

Avco Electronics and Ordnance Div., Cincinnati, is developing the system under a \$500,000 classified contract for the Air Force's Wright Air Development Div.

Signals from each target tracked by the system will be processed by separate receiving channels. A special-purpose digital computer, also in development at Avco, will compute tracking information from these signals for automatic injection into the bomber's control system. The display will be digital.

The proposed system is an outgrowth of the company's Avscan scanning system, an engineering model of which is being used as a design aid in the development program.

In operation, the Avscan IR scanner rides in the nose of a bomber and scans a rectangle in the aircraft's path. Its field of view is reported to be 60 deg azimuth and 40 deg elevation. Instantaneous field of view is said to be 0.1 by 1 deg, giving a resolution equivalent to 40 lines with a spin rate of 1,800 rpm. Range is believed to be up to 20 miles. The scanner operates in the 3-5-micron intermediate infrared region.

The detector cell used is an indium antimonide grown-junction type developed by Avco and cooled to liquid-nitrogen temperature by immersion in a stainless-steel Dewar flask.

The scanning head contains a refractive optical system consisting of four two-element arsenic



Engineering model of Avscan infrared scanning system, being used to aid in the development of an IR track-while-scan system that will warn bombers of interceptors and missiles. Avscan's scanning head contains four achromats that spin at 1,800 rpm while nodding 3 times per sec. Arsenic trisulphide dome is of 8.75-in. diam. Stainless-steel Dewar flask, at right, contains a special indium antimonide grown-junction cell that operates in the 3-5-micron region. The model shown here has an extra cylindrical section to house a switch for demonstration purposes. System was developed by Avco Electronics and Ordnance Div.

trisulphide and silicon achromats mounted on a rotating drum. The drum spins at 1,800 rpm while nodding 3 times per sec.

A different optical arrangement might be used in the track-while-scan system, it is reported. Broader scan coverage and probably a faster scan rate may be designed into the new system.

Avco is reported working toward designing a ranging capability into such an IR track-while-scan system. Ranging would be provided by a IR maser that generated coherent radiation.

Cryogenic Accelerometer And Delay Line Ordered

Two new applications of cryogenic technology are under way in separate programs sponsored by the National Aeronautics and Space Administration and the Air Force.

An accelerometer, expected to prove the feasibility of cryogenic techniques for sensing of acceleration, is being developed at General Electric Co., Schenectady, N. Y. The device is to be produced under a \$119,000 NASA contract.

Martin Co. is designing a cryogenic delay line for the Rome (N.Y.) Air Development Center under a \$90,000 Air Force contract.

Design objectives for the accelerometer, which will be an analog, are a threshold and bias of 1×10^{-6} g or less, and linearity and repeatability of one part per million or less, according to GE. The threshold goal is said to be about two orders of magnitude better than that of available analog types and about one order better than the latest digital types. The linearity of typical available accelerometers is about 25 ppm, the company says.

The GE program is related to development of a cryogenic gyroscope, which is proceeding under a previous contract at the company's engineering laboratories. An engineering model of the gyroscope unit has been built and a prototype for testing will be produced, the company states.

As in the gyroscope, the proof mass of the accelerometer will be suspended and rotated in a magnetic field acting on a superconducting surface. The whole structure, including a cryogenic preamplifier, will be enclosed in liquid-nitrogen environment. Data pickoff will be through the preamplifier.

The delay line being developed by Martin is designed for 15,000-ft transmission without energy loss. It is expected to fit in a 3-in. cube. The line will operate at 4.2 K in the microwave region between 4 and 15 Gc and will provide a delay of 20 μ sec. It is to be used in a classified system now in development.

ELECTRONIC DESIGN • April 26, 1961

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Ohmite can supply all eight adjustable resistors to meet every requirement of MIL-R-19365C. Higher resistances using smaller wire sizes are available, also, to meet the performance requirements of this new MIL specification.

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STANDARD MIL-R-19365C ADJUSTABLE RESISTORS

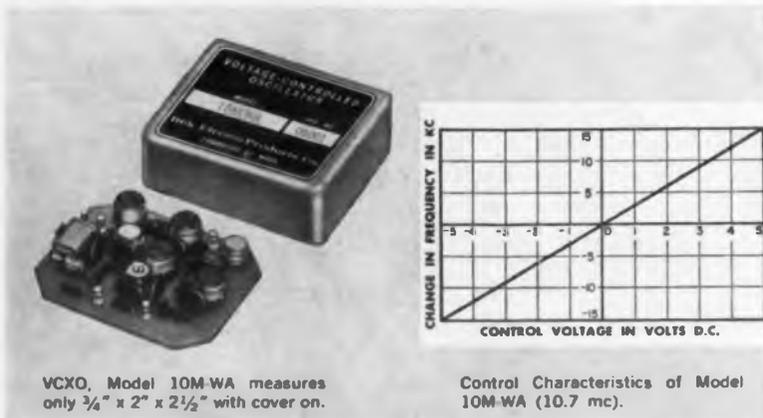
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RX29	11	1½"	¾"	1	470
RX32	17	2"	¾"	1	910
RX33	26	3"	¾"	1	1,500
RX35	55	4"	¾"	1	3,600
RX36	78	4"	1¼"	1	5,100
RX37	113	6"	1¼"	1	8,200
RX38	159	8"	1¼"	1	11,000
RX47	210	10½"	1¼"	1	15,000

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Control Characteristics of Model 10M-WA (10.7 mc).

The new VCXO is a crystal oscillator directly frequency modulated by a control voltage. Direct frequency modulation may be had at any center frequency from 10 kc to 30 mc without frequency multipliers. This all solid-state device produces frequency swings of $\pm 0.2\%$ of its crystal stabilized center frequency while maintaining excellent linearity. Center frequency stability is constant over wide temperature changes.

The standard VCXO, Model 10M-WA, has a center frequency of 10.7 mc. Available off the shelf in sample quantities, the Model 10M-WA has a deviation of ± 20 kc, linear to within ± 200 cps. Measured temperature drift is less than 1 kc from -40°C to $+65^{\circ}\text{C}$. Output power is 5 mw.

Other VCXO's with similar specifications and with center frequencies as indicated above, are available on special order for both commercial and military system requirements.

If you have a frequency modulation problem, call on Itek Electro-Products engineering specialists to assist you in the design of your circuitry and in the selection of a VCXO best suited to your needs.

Write for Bulletin No. 10M-WA

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A DIVISION OF



CIRCLE 21 ON READER-SERVICE CARD

WASHINGTON REPORT



J. J. Christie
Washington Editor

RFI—THE HANDWRITING ON THE WALL

The Defense Department's Electromagnetic Compatibility Program, representing a long overdue effort to combat radio frequency interference from a military standpoint, is gaining momentum.

A big step forward in the program will come with the establishment of an RFI analysis center. This facility, which reportedly will be set up and administered by the Armour Research Foundation and located at Annapolis, Md., will be the focal point of efforts to develop techniques for measuring and predicting RFI environment and emission.

Meanwhile, DOD is collecting spectrum signatures on both new and existing equipments for experimental testing. It has let a few contracts and will award others this year to research measuring and predictive methods.

An example of the type of research required at this stage of the game is a project at Georgia Tech which seeks a short-cut means of measuring antenna field patterns. If efforts to measure far effects at close range are successful, Pentagon officials say the expense of such testing would be reduced by a factor of 10.

Once the nature of the data required for interference prediction and control can be ascertained and the best methods of obtaining it can be determined, it is expected that a considerable amount of R&D will be necessary to upgrade instrumentation capabilities.

As the program matures, manufacturers will be required to furnish spectrum signatures with breadboards and with prototypes. Eventually, DOD officials expect that spectrum signatures can be supplied with design proposals on the basis of circuit designs and components.

The Consequences for Industry of the RFI compatibility program eventually will be similar to those now resulting from the Pentagon's determined effort to impose quantitative reliability specifications.

Initially, as in the case of reliability, the impact of the RFI program will be felt primarily on the systems and equipment level—in the need for specialized personnel and the necessity for increased testing and inspection. But, it won't be long before new obligations permeate the components level. DOD experts believe that by 1963 designers of relays, tubes, transistors and other components will be dealing with RFI requirements. They also foresee a boom in filtering device developments.

A good indication of the growing awareness of the RFI problem is the expectation that some 600 engineers will attend the third national IRE symposium on the subject to be held in Washington June 12-13.

MILITARY COMMUNICATIONS DEFICIENCIES

The Kennedy Administration's re-evaluation of defense policy has resulted in strong emphasis on improving both strategic and tactical communications systems and command and control facilities.

In reference to the strategic requirements, the President told a recent

meeting of the NATO military committee: "In our studies we have found a serious need for a sensitive and flexible control of all arms, and especially of nuclear weapons."

He outlined in his defense budget message requirements for "invulnerable and continuous command posts and communications centers" to insure "controlled and properly authorized response. . . ."

Implementation of these goals involves development of airborne and seaborne command posts as well as mobile land units and underground installations. The plan envisions tying one or more mobile command posts into key communications centers such as the Strategic Air Command headquarters.

Under consideration for airborne centers are either the Lockheed C-130 transport plane or the KC-135 tanker version of the Boeing 707, both of which have the advantage of short runway requirement. The project may lead to new requirements for airborne computers, although it is noted that a good deal of the data processing could be performed on the ground and that the results would then be relayed to the flying command posts.

Underground installations will give added impetus to efforts to propagate low frequency and very low frequency signals through nonconductive rock strata. The program also puts further emphasis on the necessity for shock-resistant communications and for data-processing equipment.

Tactical Communications are under review as much from the point of view of procedures as from the standpoint of equipment. As one DOD communications official put it, "voice transmission is too wasteful of bandwidth to be relied upon under present-day battlefield conditions. We must go to code to the fullest extent possible and even in fairly rudimentary equipment."

Concern over spectrum congestion and both intentional and unintentional interference has Pentagon communications experts anxiously watching developmental work on various modulation schemes and on wideband systems such as random access, discrete address systems. (See story on p. 4). However, they remain noncommittal on these developments, pending determination of cost, weight and complexity as compared to conventional narrow-band systems.

Military communications planners expect to put greater reliance on digital data links for tactical use and point to the need for further development work in this field.

Mobile tactical command posts also have high priority. One feature of these will be smaller versions of the trailer-housed MOBIDIC general purpose digital computer developed for use at Army headquarters level. Smaller versions will go into mobile units at corps and division levels, and perhaps at even lower command echelons.

McNAMARA'S TROMBONES

Drastic alterations in the Pentagon's procurement organization and procedures could result from studies that have been initiated by Defense Secretary Robert S. McNamara. Not only is single-service procurement under study but also the often proposed ministry of supply approach under which procurement for all the services would be unified.

Some 100 or more quick study projects, which have been dubbed "McNamara's Trombones," have been assigned by the Defense Secretary since taking office in January. They range from re-examination of top-level strategic doctrine by the Joint Chiefs of Staff to improved means of preventing classified information "leaks."



rectifier components news

Here comes the ZJ34, looking for trouble . . .

And, if the ZJ34 is half the rectifier our men claim it to be, the trouble had better watch out. Why? Well, you're certainly asking the right party.

The ZJ34 is the first double-diffused all hard-soldered high current rectifier on the market today, and if that fact alone doesn't stagger your imagination, consider its formidable statistics: maximum average single phase forward current ($T_s = 150^\circ \text{Stud}$) . . . 70 A DC; maximum one cycle peak surge current (60 cps, 1 phase basis) . . . 1600 amps; maximum allowable peak reverse voltage, repetitive up to 600 PRV and transient up to 800 PRV.

So if trouble comes to you in the form of high current applications, give a long, hard look at the ZJ34. It's quite a trouble-solver. A complete spec sheet is yours for the asking. Drop a note to Section 23D10.

value of current the device will carry. Notice in our little drawing (we use the term loosely), that the single phase 16 A average corresponds to a 25 A RMS, or 25 A DC. The important point, of course, is that in comparing current rating for SCR's and power transistors, use DC ratings for both.

Now—how about gain? A given 30 amp power transistor requires 10 A base current for a collector (anode) current of 30 A. In an application switching 20 amps at a 100 cps repetition rate at a 10% duty cycle, this transistor would require 100 times more drive power than an SCR.

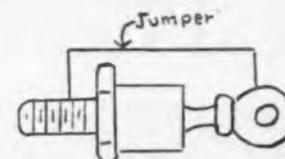
It all adds up to the fact that power transistors have important applications, but when comparing them to SCR's, a lot more than current ratings must be kept in mind. The man to see for all the information on SCR's is your G-E Semiconductor District Sales Manager. He is probably sitting by the phone right now waiting for your call.

Our men in the field have been putting their ear to certain key-holes lately, and report back to us a lot of talk in the industry over plated versus painted finishes on top hat designs. Ever eager to settle an argument, we ran a test recently on six different makes of 1N538's at rated load, and the painted units ran an average of 10°C cooler than the plated ones. Granted, a silver or gold finish certainly looks pretty, but it means hotter operation, reduced life expectancy. At General Electric we paint them. Bless us!

The G-E Semiconductor Rectifier Components Guide is now available. Write for it.

How not to treat our precious products!

For many good reasons, high potential testing on the production line can be a real semiconductor killer, particularly with very low leakage devices. There is only one completely safe rule for any high potting test.



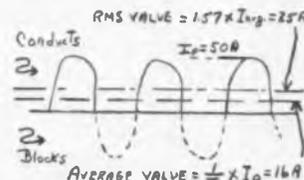
The rule is: Either remove electrical connections or place jumpers across all semiconductors before applying high voltage anywhere in the circuit! Don't be known as a semiconductor killer.

Rectifier Components Department, Auburn, New York. In Canada: Canadian General Electric Co., 189 Dufferin St., Toronto, Ont. Export: International General Electric Co., 150 East 42nd St., New York, New York.

Stomach upset? Nerves on edge?

Possibly you got that way trying to compare SCR's and Power Transistors. Let us try to make life easier for you.

Rectifiers are traditionally rated in terms of average of a half cycle sine wave — they conduct one-half cycle, block the other half.



SCR's are rated the same way. For example, 2N681-689 $I_{avg} = 16A$ in the above half-wave circuit. But power transistors are not rated in a half-wave circuit. They are rated on a DC basis. So in order to compare current ratings we must use the SCR DC rating. For 2N681-689 this is 25 A DC, as shown on the new spec sheet.

Since by definition the RMS value of a wave form is the DC value which would produce an equivalent amount of "resistive heating," the 25 A is also the RMS



GENERAL ELECTRIC

CIRCLE 22 ON READER-SERVICE CARD

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DeJur Digital Transducers are self-contained solid state miniaturized packages designed to measure various parameters (pressure, temperature, flow, acceleration) and supply a digital signal output without the use of auxiliary equipment. The result can be a pulse duration type (PDM) digital signal whose pulse width in time is directly proportional to the amplitude of the input parameter being measured. PPM and PFM outputs also can be made available.

Constructed to meet rigorous conditions of application and exposure, DeJur Digital Transducers produce signals compatible with digital computers and electronic counters found in all military and industrial installations.

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SEE THEM AT DeJUR BOOTHS 2307-2309, I. R. E. SHOW

CIRCLE 23 ON READER-SERVICE CARD

NEWS

Ten Navy Carriers to Get Automatic Landing Systems

Automatic landing systems will be installed aboard 10 Navy aircraft carriers, including the nuclear-powered Enterprise.

Twelve of the landing systems are being produced for the Navy Bureau of Ships by Bell Aerosystems Co., Buffalo, N. Y., under a \$10-million contract. In addition to the 10 carrier installations, two systems will be employed as land-based training devices.

The Bell system electronically guides an approaching aircraft to a landing on the carrier deck without need for the pilot to touch pitch and bank controls or to make visual contact with the carrier.

The system assumes control of an aircraft when it is several miles from the carrier. Radar tracks the airplane and relays its position to a computer. The computer compares the aircraft's position with that of the carrier and generates control commands, which are radioed to the aircraft's automatic pilot.

In addition to the Enterprise, the Bell landing system, officially designated AN/SPN 10, will be installed on the Constellation, Kitty Hawk, Independence, Ranger, Saratoga, Forrestal, Roosevelt, Coral Sea, and Midway.

Components Parley to Consider 'Darnell Report' on Reliability

The expected impact of the "Darnell report" on new parts specifications for reliability should be a high point of the Electronic Components Conference which will be held in San Francisco, May 2-4.

The Darnell report was prepared by a 56-man military-industrial study group led by Paul S. Darnell, director of military reliability engineering at Bell Telephone Laboratories. The formal title of the study is "Parts Specifications Management for Reliability."

The effects of the Darnell report—including new parts reliability specifications by the Defense Dept.—will be discussed at the components conference by William H. von Alven of ARINC Research Corp., Washington, D.C.

Microwave components will be analyzed at the conference at an afternoon session May 3. The following topics will be discussed: "A Vacuum Coaxial Relay for High-Speed, High-Power RF Switching"; "The Output Window—A Critical Item in High-Power Microwave Electron Tubes"; "Solid-State, High-Power Modulator for

Pulsing Microwave Device"; "Microwave Filters Using Ghost-Mode Resonance," and "A Miniature-Package 2,200 Mc Parametric Amplifier Using a Varactor-Loaded Helix."

The keynote speaker will be James Bridges, Defense Dept. director of electronics, who will discuss "New Components and Their Impact on Our Future."

The conference, sponsored by the IRE, AIEE, EIA and Western Electronic Manufacturers Assoc., will be at the Jack Tar Hotel.

Standards for Luminance Available From NBS

A program to provide standards for luminance has been initiated by the National Bureau of Standards.

The program is in response to requests for precision evaluation of the brightness of aircraft instrument dials and panels.

Covering two components—a diaphragmed, flashed opal glass and an electric lamp—the standards are also being used for other standardizing purposes: for example, to achieve uniformity in measuring the brightness of cathode-ray tubes and TV sets, and to calibrate the luminance meters used by engineers.

Luminance standards are issued with a report of calibration containing instructions for their use. They are available at prices ranging from \$63 to \$72 (depending on the size of the lamp component), from the Photometry and Colorimetry Sections, National Bureau of Standards, Washington 25, D.C.

Over 100 Functions Monitored



Engineers test a new system that will check out the launching of this country's first Saturn booster later this year from Cape Canaveral, Fla. Monitoring more than 100 functions, the system will automatically stop the launch sequence in the event of any malfunction. It was developed by the Guidance and Control Div. of the National Aeronautics and Space Administration.

SIMPLIFY YOUR SWITCHING CIRCUITS with the new Shockley 4-layer diode (Type E)*

If simplicity and speed can improve your switching circuits, talk to our engineers about the capabilities of the Shockley 4-layer diode. A few of these circuit applications are shown here.

<p>Pulse Modulator</p>	<p>Flip-Flop</p>	<p>The Shockley 4-layer diode is a fast, pnpn, two lead, silicon switch. It has two stable states—OFF (high impedance) state and ON (low impedance) state. Turn-On time, depending on the circuit, is typically less than 0.1 μs.</p>
<p>Alarm Circuit</p>	<p>*4-times enlargement of the new Type E, subminiature diode.</p>	<p>Crosspoint Switching</p>
<p>Type E Specs:</p> <ul style="list-style-type: none"> • Carries 150 ma steady dc • Carries 10 amps peak pulse • Lower COMMERCIAL prices • Improved temperature stability • Improved shock and vibration resistance 	<p>Relay Driving</p>	<p>Magnetic Memory</p>

For other applications and for specific information, our engineering sales representatives are listed in EDC and EEM.

Shockley TRANSISTOR
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CORPORATION

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There's a Better Way... to cool a transistor. An idea like this, I realize, is liable to give an electronics engineer the midnight creep. Or drive him to drink. That's why I sell Birtcher heat radiators. I don't even have to bend an elbow to come right out and tell you that you'll get from 25% to 27% better transistor efficiency. Lets you increase input wattage, too. And you'll no longer have the spectre of Thermal Runaway haunting your dreams anymore. You can even forget derating curves (but not blondes). □ Now this reminds me, have you written for your membership certificate to my own anonymous *Society*? It's genuine Pergamum parchment (the certificate, that is) of indescribable beauty and portent. Send for my other stuff, too. Catalogs, qualification test reports you'll get, but nothing illustrated above. Write to: Charles F. Booher, Secretary, *There's a Better Way Society of America, Inc.*, **The Birtcher Corporation** / Industrial Division, 745 S Monterey Pass Rd., Monterey Park, Calif.



Cool!
Write for my
sober Transistor
Radiator Catalog



B

Sizes available for just about every commonly used transistor. So yours aren't common? Maybe I'll provide a radiator anyway — but definitely, no libation.

CIRCLE 25 ON READER-SERVICE CARD

NEWS

Leipzig Fair Indicates Slow E. German Progress

Radio and TV Sets On Display Fail to Impress Western Visitors

Gustav Genschow
ELECTRONIC DESIGN W. German Correspondent

WESTERN observers at the Leipzig Spring Fair in Communist East Germany were largely unimpressed with the radio and television models on display. On the whole no important technical advances were evident.

Improvements in sound quality, ease of control and sensitivity appeared to have reached a peak last year. Some of the set cabinets this year were more contemporary in design, though, more in the direction of stylings in West Germany.

Production Emphasis Is Shifting to TV

A slow shift in production, from radio receivers to more television sets, is apparently under way in East Germany, where all plants are Government-owned or controlled. Manufacturing of home radios has been stopped at the Stassfurt plant, as has production of portable and auto radios at Funkwerk Halle. Both plants are now fully engaged in turning out television receivers.

Television production is concentrating on 15 set models, with list prices ranging from \$410 to \$900. Picture tubes for the receivers are standardized; only two types are available for all 15 receiver models. One of the tube types, a 17-in. variety, is being used in five models, and the other, 21 in., in 10 models.

In radio manufacturing, nine East German plants are building a total of 29 models of home receivers. Of the nine plants, two are concentrating on seven combination radio-phonograph consoles. Three manufacturers are building four portable radio models.

Three of the four portable radio models are transistorized.

Output of Semiconductors In Millions at Two Plants

East Germany has two producers of semiconductor devices, Werk Fuer Fernsehelektronik in Berlin-Oberschoeneweide and Halbleiterwerk Frankfurt in Frankfurt on Oder. Plans this year call for producing 3 million transistors and 5 million diodes and semiconductor rectifiers.

The Berlin-Oberschoeneweide plant is developing germanium and silicon diodes for small-

power applications, as well as Zener diodes of up to 250 mw. The Frankfurt plant, in the midst of a long-range expansion program, is making germanium transistors and diodes.

Some of the East German component production is being adapted to printed-circuit requirements, but this field seems in a first stage of development, according to what was shown at Leipzig. There is, however, an over-all plan for the gradual, widest-possible introduction of printed circuits in East Germany.

Satellites Appear to Lag In Radio-TV Styling

Czechoslovakia, Hungary, Poland and other satellite countries exhibited at the fair. Judging by the displays, though, some of these nations are several years behind in radio and television styling and circuitry compared with the West.

Transistorized portable radios were shown by Czech, Polish and Hungarian manufacturers. A Czech model, dubbed Universal, can be used as an auto radio or a normal portable.

A Soviet transistor radio of very small dimensions had an audio output of 800 mw. This model is designed as a home radio, not as a portable in the Western sense of the word.

Television sets from the Soviet Union and some from Czechoslovakia came the closest to Western standards of cabinet design. These sets were equipped with 17- or 21-in. tubes and were relatively flat. ■ ■

EIA Technical Data Service Offered to Microwave Users

Information to avoid possible interference with nearby microwave facilities will be available to microwave equipment manufacturers and users under a new Electronic Industries Association service.

The service, set up after consultation with the Federal Communications Commission, uses a standard form for compiling technical data on all U.S. private and commercial microwave facilities. These data include transmitting frequency and bandwidth; transmitter make, model, and rated power output; antenna type, input power and location; and compass points with which the station communicates.

Photocopies of these data forms are made and distributed weekly to subscribers. Assuming 100 per cent participation in the program, subscribers will have complete data on all microwave operations within a year, since the FCC requires licenses in this class to be renewed annually.

Information can be obtained from the EIA in Washington or from Seabrooke Printing Co., 514 Tenth St. N. W., Washington 4, D.C.



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Avnet penetrates the intricacies of supplying the one right solution to your electronics requirement by creating a totally new Concept of Service. LOCAL plus NATIONAL becomes LOCATIONAL.

Only Avnet's giant NATIONAL network gives you these benefits:

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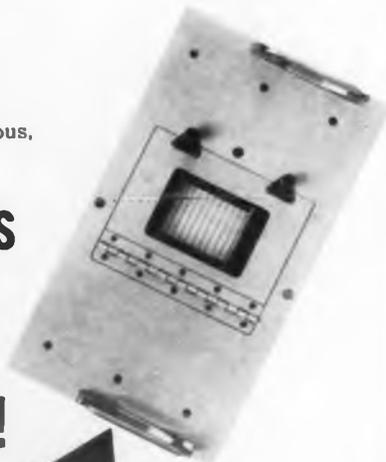
Avnet distributes from its stocking facilities: BENDIX SCINTILLA CONNECTORS, SPERRY SEMICONDUCTORS, GREMAR CONNECTORS, RHEEM SEMICONDUCTORS, ELECTROSNAP & HETHERINGTON SWITCHES, CLARE RELAYS, ROBERTSON SPLICE & CONNECTOR CASES, BABCOCK RELAYS, KING SUBMINIATURE HI-TEMP CERAMIC CAPACITORS, TIC PRECISION TRIMMERS, U. S. SEMCOR SEMICONDUCTORS, SANGAMO CAPACITORS, MICRODOT CONNECTORS, SPRAGUE CAPACITORS

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**this
is the printer
that can
take it!**



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CIRCLE 27 ON READER-SERVICE CARD

NEWS

U. S. Sends Clear Radio Signals To Venus and Back in 6½ Min

Strong, clear radio signals have been reflected back to earth from Venus. The round trip took about 6-1/2 min, the National Aeronautics and Space Administration announces.

The transmission was completed at the Jet Propulsion Laboratory's Goldstone tracking station in the Mojave Desert. It is the first announced success in a two-month experiment to unveil some of the mysteries of Venus.

The laboratory crew at Goldstone started months ago to prepare two 85-ft dish antennas for the experiment. The transmitting antenna, placed 7 miles from the receiving antenna to minimize interference, sent a 2,388-mc signal to Venus using about 10 kw of power. The signal was a conical beam only 0.4 deg wide.

The Goldstone receiver used both a maser and a parametric amplifier.

Other experiments have bounced signals off Venus, but this is the first time such signals have been immediately detectable without elaborate analysis and processing, NASA reports.

R&D in Chicago Region Under Study by 2 Groups

Electronic research and development in the Chicago region is being examined for quantity and quality by the National Electronics Conference, Inc., in cooperation with a group of engineering management personnel.

A study sponsored by the two groups is seeking to determine whether the region's R&D potential is being adequately realized.

The findings are expected to be available for presentation at the 1961 National Electronics Conference, to be held Oct. 9-11 at the International Amphitheatre in Chicago.

French Field-Effect Amplifier With High Impedance Offered

A new French field-effect amplifier reported to have an extremely high input impedance—0.5 to 5 meg, depending on type—is being offered in large quantities in France.

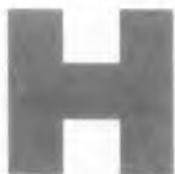
The semiconductor device, called Tecnetron, is made by Thomson-Houston Co. Designed principally for use in fm radios and TV sets, the amplifier has an upper frequency ceiling of 110 mc.

CIRCLE 248 ON READER-SERVICE CARD ►
ELECTRONIC DESIGN • April 26, 1961

Number two of a series



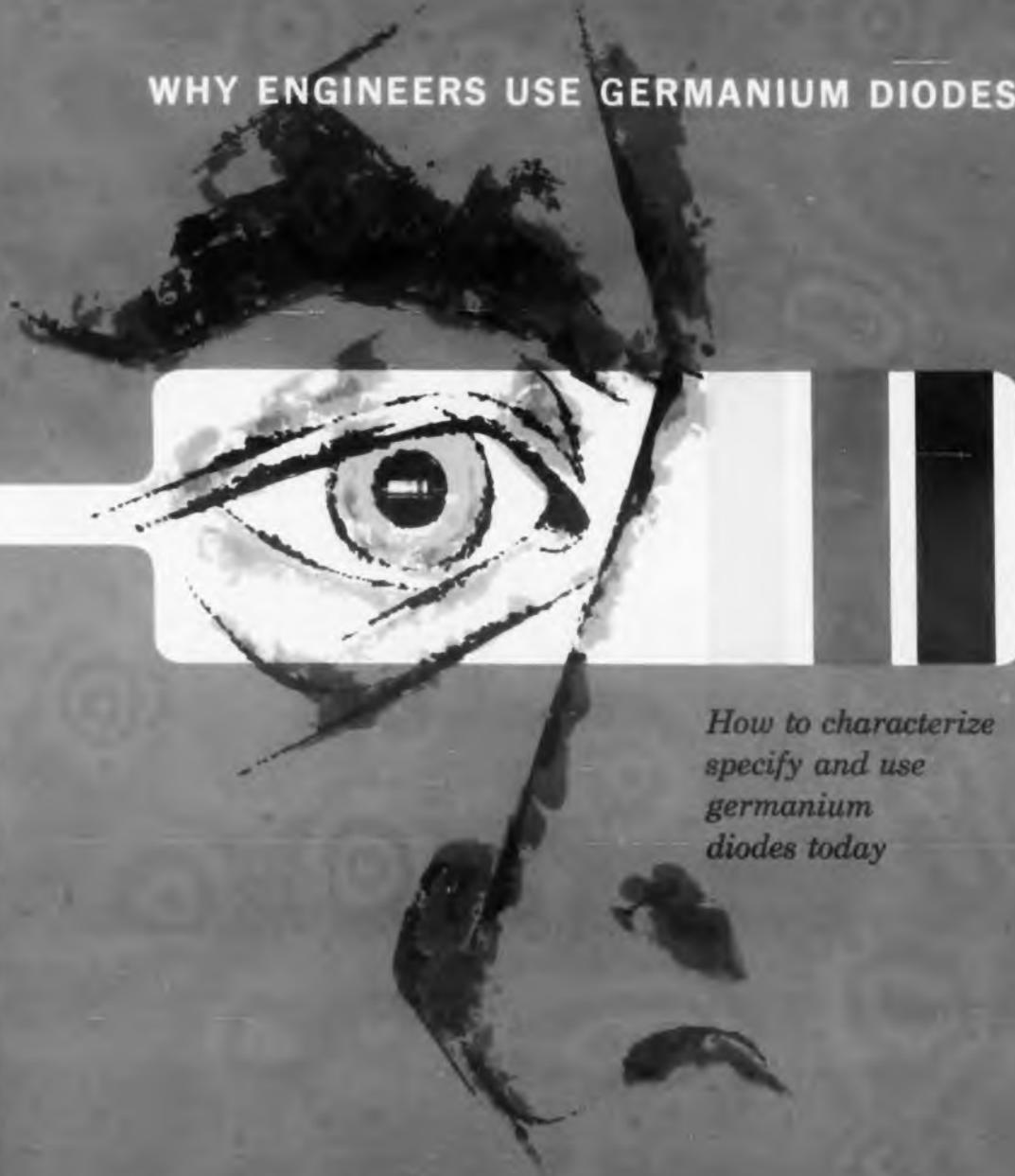
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Why engineers use germanium diodes

Of late, there has been much discussion as to exactly why, with the apparent superiority of the silicon diode, germanium diodes are being purchased and used at all. Especially today when the price gap between silicon and germanium has been appreciably lowered. To the device engineer, the following may appear "old hat"; but, for the engineer who utilizes semiconductor devices intermittently, changing semiconductor technology and market conditions should be constantly examined, summarized and recorded so that he will not lose sight of the exact purpose each component is designed for and where it fits in today's overall engineering picture. Hughes, pioneer of semiconductor devices⁽¹⁾, has attempted to achieve this with the following discussion of the germanium diode.

Price for today's semiconductor devices is a major design factor and should be examined first. Historically, the germanium diode has been less expensive than the silicon. In many instances, however, silicon diodes' costs have been reduced through improved manufacturing techniques so that they now equal those of germanium. But, where requirements call for the characteristics which originally made the germanium diode a valuable and popular device, price is still a most important factor. Where high recovery speed in the millivolt region combined with high conductance is a requirement, the silicon diode is still far more costly

to manufacture and to the purchaser than germanium. Other characteristics available in silicon, inherent in diodes extremely suitable applications. Germanium conducting at low shown in Figure 1. We show a definite lag 0.5V forward voltage low forward voltage some germanium typing as low as 0.2V. 1 at low temperatures loss of efficiency also germanium diode essential is a major requirement.

Device engineers germanium diodes primary electrical characteristics relatively low price when characteristics are too costly

(1) H. G. North, (Hughes Aircraft Company), "A New Germanium Diode," paper presented at the IEEE Conference on Semiconductor Devices, September 14, 1960.

T. E. Firth, M. E. (Hughes Aircraft Company), "Point-to-Point Measurements of Point-to-Point Diodes," paper presented at the IEEE Conference on Semiconductor Devices, August 20, 1960.

R. G. Shulman, M. (Hughes Aircraft Company), "Germanium p-n Junctions," paper presented at the IEEE Conference on Semiconductor Physics, Vol. 24, October, 1963.

GERMANIUM DIODE FAMILIES AND TYPES

Essentially, germanium diodes can be classified into three basic performance groupings:

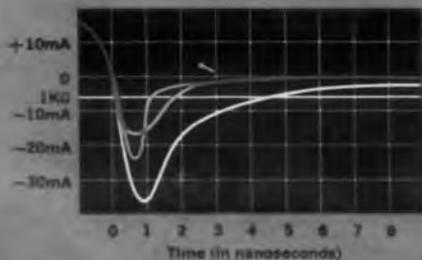
- (a) general purpose (point contact)
- (b) general purpose (gold bonded)
- (c) ultra fast switching (gold alloy)

Figure 2 compares typical forward characteristics of the three germanium families listed above. Note the high forward

conductance of the also dramatizes the of all three at low le

Figure 1 graphically compares the recovery times of the germanium diodes. It should be noted that the data represents the mean of a large number of widely used types in

Fig. 1 - GERMANIUM FAMILY COMPARISONS
Typical Reverse Recovery Characteristics

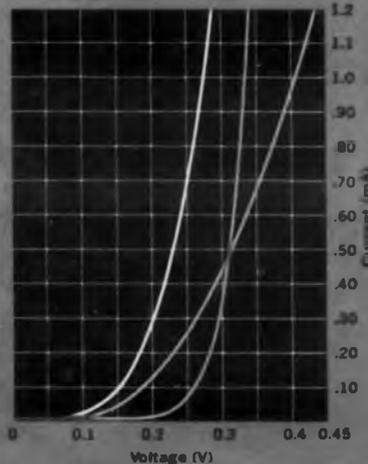


Point Contact Gold Bonded Gold Alloy
For measurements see: Recovery, under Ultra Fast Switching Diodes



Note: If special body markings or codings are required, allow additional .008" for outside body diameter.

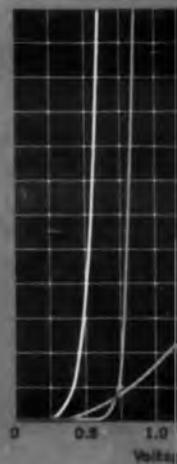
Fig. 2 - GERMANIUM FAMILY COMPARISONS
Expanded Forward Characteristics



Point Contact Gold Bonded Gold Alloy

NOTE: Detailed specifications on all Hughes® germanium diode types are available upon request - see back cover for address of Hughes representative nearest you.

Fig. 3 - SILICON/GERMANIUM
Forward Current



Ge Gold Bonded Ge

and therefore more costly
er than the same device in

istics, presently unattain-
inherently make german-
eremely attractive for cer-
s. Germanium diodes start
low forward voltage as
e 3. Whereas silicon diodes
e lag until approximately
voltage is exceeded. Where
voltage drops are required,
m types will begin conduct-
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cers today then, use germ-
primarily for their unique
acteristics and for their rela-
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ostly to produce in silicon.

, (Hughes Aircraft Company),
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at WSMOON, I.R.S. Convention,
50.

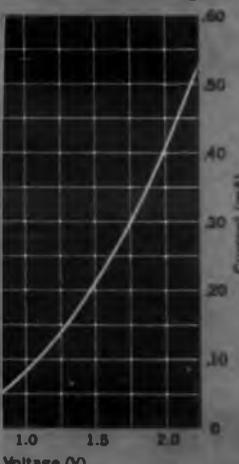
A. E. McMahon, J. F. Rosch
(Hughes Aircraft Company), "Recovery Time
Point-Contact Germanium Diodes"
Presented at WSMOON, I.R.S. Con-
20, 1963.

A. E. McMahon, (Hughes
Aircraft Company), "Recovery Currents in Ger-
manium Diodes," JOURNAL OF AP-
PLIED PHYSICS, Vol. 34, No. 10, pp. 1267-1272.

the latter two. Figure 2
is the forward conduction
ow levels.

hically illustrates typical re-
f the three families for com-
uld be noted that each curve
mean characteristic devel-
arge sampling of the more
pes in each family.

N/GERMANIUM COMPARISON
urrent vs. Forward Voltage



1 Ge Point Contact 2 Si Junction

POINT CONTACT DIODES



GOLD BONDED DIODES

PHYSICAL CHARACTERISTICS The original "point contact" diode is actually one in which the active junction is formed by a pressure contact between the whisker tip and the slice of germanium (i.e. the old crystal radio set with its cat whisker). The modern version of this device consists of a germanium N-type die which is soldered to one lead. The other lead is welded to a molybdenum S-shaped whisker whose tip has been indium plated. The tip is then fused to the germanium slice to form the active junction. Externally, they are fusion sealed in a subminiature glass package to ensure complete isolation of the active elements from damage or contamination. They will withstand severe physical shock and vibration.

HUGHES EIA TYPES

1N34A	1N66	1N70A	1N90	1N116	1N126A*	1N191	1N198B	1N297
1N38B	1N67A	1N81A	1N95	1N117	1N127A*	1N192	1N268	1N298
1N54A	1N68A	1N88	1N97	1N119	1N128*	1N198*	1N290	1N480
1N58A	1N69A	1N89	1N99	1N120	1N142	1N198A	1N294	1N636

*JAN versions available

PHYSICAL CHARACTERISTICS The gold bonded germanium diodes are identical with the point contact types except that the molybdenum whisker is replaced by a gold-gallium doped wire. The forming process or "gold bonding" is a process in which a short pulse of current fuses the gold wire tip into the germanium and forms a small P-N junction, giving fast recovery and low shunt capacitance.

ELECTRICAL CHARACTERISTICS These popular Hughes® diodes represent a high conduction series. They have a range of forward currents from 25 to 600mA at one volt. Inherent in this series is a sharp voltage-current reverse characteristic, more like that which silicon displays. That is, the reverse current is linear with applied back voltage until a sharp breakdown region is reached. The reverse currents and peak inverse voltages, as well

HUGHES EIA TYPES

1N96	1N98A	1N118	1N139	1N143	1N276*	1N279	1N287	1N291	1N770
1N96A	1N100	1N118A	1N140	1N270*	1N277*	1N281*	1N288	1N292	1N835
1N98	1N100A	1N133	1N141	1N273	1N278	1N283	1N289	1N500	

*JAN versions available

ULTRA FAST SWITCHING DIODES

FEATURES These Hughes® diodes are a modification of the "gold bonded" process of diode manufacture. They combine fast recovery with low voltage drop. Devices in this series switch at nanosecond speeds and have rectification efficiencies ranging from 60 to 75% @ 100 mc. Their forward conductances are much higher than the "point contact" germanium types.

APPLICATIONS Designed especially for high speed computer logic, high-frequency transistor circuits, extremely fast reference switching...and, also, low-noise, low-level RF modulation and demodulation.

RECOVERY Measured with the Lumatron scope and attachments, see Illustration 1, when switching from 10mA to -6V. $R_L = 100$ ohms, they recover to 1K ohms in 2 to 5 nanoseconds. Typical capacitance @ 0 Volts = 0.8 to 4 pf (measured on Boonton's Model 75A-S8 capacitance bridge with applied signal voltage 50mV peak to peak). Forward switching speeds are too fast for detectable measurement on the presently available "traveling wave" or "sampling scope" equipment.

HUGHES TYPES Two Hughes house types are currently available, HD2963 and HD2967; and registration procedures for additional types are in process.

ILLUSTRATION 1 REVERSE RECOVERY CIRCUIT



ELECTRICAL CHARACTERISTICS Forward currents range from about 1 to 25 mA at one volt while reverse currents range from 15 to 500uA at 50 volts. Peak inverse voltages range from 50 to over 150 volts. The diode capacity is generally less than 1 pf. Frequency response is about 100 mc. The diode operates efficiently within the range from -55°C to +90°C.

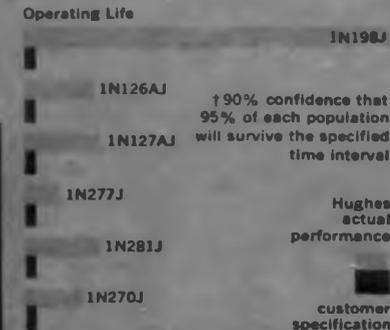
APPLICATIONS The number of uses for these diodes is legion. Examples are tube and transistor driven logic circuits, RF mixers, clampers, modulators, bridge rectifiers, detectors, and instrument rectifiers.

at the temperature ranges, are the same as those of the "point contact" series.

APPLICATIONS The applicability is also much the same as that of the point contact series except the gold bonded devices offer the advantage of higher forward conduction and higher reverse impedance. It should be noted that the alloy formed at the juncture of the crystal and the whisker (gold, gallium, and germanium) is somewhat more brittle than the corresponding alloy formed in the case of the "point contact" diode. Although considerable progress has been made in improving the mechanical ruggedness of these devices to the point where they are almost as rugged as the "point contact" types, careful consideration should be given to this factor when designing equipment which must withstand severe environmental conditions.

Survival Reliability!

Specific reliability data must include a complete definition of test conditions, testing intervals, what constitutes a failure, applicable confidence levels, and many other pertinent facts in order to be at all meaningful. However, the following chart indicates examples of Hughes' actual reliability performance against customer specification for a few representative germanium diode types.



Purchasing Do's and Don'ts



DON'T specify a device that does not exist for your circuits—although this will motivate research and development groups to design better products for the future...the immediate result is long delay in quantity delivery. Be sure you can wait if your requirement is exotic.



DON'T specify inferior products for economical purposes resulting in unreliable circuit performance. This practice creates a vicious reject and replacement cycle between manufacturer and user.



DON'T buy from manufacturers whose facilities are not adequate for testing to rigid military specifications and whose production quantity delivery is questionable.



DON'T attempt to buy reliability by specifying breakdown voltages far in excess of those required. There may be some exceptions, however, this is a very expensive practice. **DO** buy reliability—not reliability by safety factor!



DO make sure that the diodes you buy meet the manufacturer's advertised and registered specifications.



DO make sure your 1N diode type is "registered" with EIA, not "reserved." When using types with a "reserved" status, the manufacturer may alter his specifications at will.



DO make sure the leakage currents are measured at a reverse voltage as high as your present requirement demands.



DO remember that reliability has to be designed in the diode; it cannot be tested in. No amount of testing will undo poor design. However, it is important that the manufacturer have a sound quality assurance program to insure that the reliability is actually there.



DO make sure that a diode that is to be used as a switch meets your speed requirements by actual test in your circuit; this is the only true test. Manufacturers often show values for switch speeds that are optimized.



DO be sure to get the leakage currents you actually need. Specify the measurements which match most closely your actual circuit requirements.



DON'T guess what the parameters will be if your circuit is for intended high temperature operation, but **DO** get the proper data from the manufacturer.

Germanium diode's future at Hughes

Obviously, device engineers *still* need and use germanium diodes and will continue to incorporate them in their circuits for years to come. Hughes also will continue to design and produce better and more efficient germanium devices for the industry. Listed below are some of the goals Hughes' engineers have outlined to achieve that end.

- Leakage current approaching micro-micro-amps
- Minimum parameter change with temperature
- Infinite life expectancy
- Completely defined reliability
- Microminiaturization
- Recovery times in the low nanosecond region

The foregoing information has been gathered from the Hughes Semiconductor Division's reports and records on the germanium diode, compiled with the cooperation of Hughes' staff of skilled engineers. A pioneer in the semiconductor field, Hughes has continued as a top developer and producer of the most advanced semiconductor devices. The Newport Beach plant, with its third of a million square

feet of floor space houses all of the facilities necessary for every phase of design, development and production of diodes, transistors, rectifiers, special devices and semiconductor materials. For further information call or write your nearest Hughes Semiconductor Sales Office. Or write, Hughes Semiconductor Division, Marketing Dept., 500 Superior Ave., Newport Beach, California.

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Wet-Blast Machine Cleans Component Leads Rapidly

Semiautomatic cleaning of component leads prior to circuit board soldering is being done at rates up to 4,000 components per hour with a wet-blast machine at Melpar, Inc., Falls Church, Va.

Other techniques evaluated by Melpar before choosing the automated wet-blast approach included brushing, chemical reaction, wiping, and glass erasing. The disadvantages of these methods included high cost, handling difficulties, and inability to clean all types of leads. The company sought a method that allowed uniform and complete cleaning, conveyor handling of components, and fast loading and unloading.

A modified wet-blast machine manufactured by Pressure Blast Manufacturing Co., Manchester, Conn., was chosen. In operation the machine adjutates an abrasive into a homogeneous water-grit mixture, which is forced out of a blast gun by compressed air.

Mighty Atom-Smasher Tube

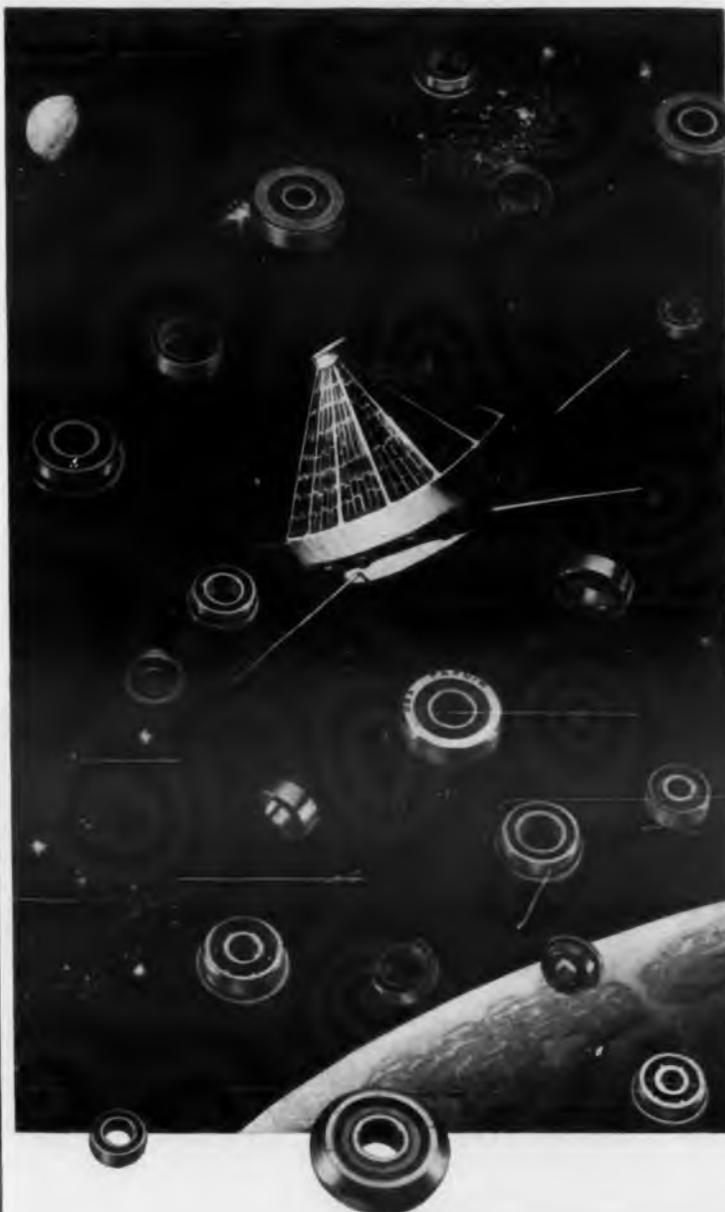


Experimental model of 24-megawatt superpower klystrons, being developed by Sperry Gyroscope Co., Great Neck, N.Y., for a proposed two-mile-long atom smasher, is assembled by Sperry engineers. Energies of up to 10 to 20 billion electron volts are expected to be achieved by driving relatively lightweight electrons along a straight path. Six tubes will be delivered to Stanford University later this year. The accelerator of the atom smasher will require 240 of these klystrons.

◀ CIRCLE 248 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 26, 1961

Look to FAFNIR



for
miniature
ball bearings
of extra-clean
vacuum-melt
steel

Seconds after countdown, a microscopic pit in a miniature bearing could ground the most carefully planned space shot. To eliminate pits and other imperfections, Fafnir helped pioneer miniature ball bearings of vacuum-melt stainless steel. This "extra-clean" steel is completely free of impurities, and makes for flawless bearing performance. Look to *Fafnir* for leadership in ball bearings. The Fafnir Bearing Company, New Britain, Connecticut.



FAFNIR

BALL BEARINGS

CIRCLE 29 ON READER-SERVICE CARD

NEWS

Simulator for B-58 ECM Station Has Automatic Program Control

A complex simulator has been put in operation by the Air Force to train crewmen of the B-58 bomber who man the Mach-2 craft's electronic countermeasures station.

The simulator, which has passed its acceptance tests, according to the manufacturer, Reflectone Electronics Inc., Stamford, Conn., is an exact replica of the bomber's Defense System Operator Station (DSO). In the B-58, the pilot and navigator are too occupied to monitor for tracking, possible attack, and to take countermeasures. The DSO operator, protects the aircraft.

Flexible programming, designed around an automatic programed system, permits the instructor to run the mission manually, automatically by a punched-tape programmer, or both manually and automatically. The programmer has a repeatable capacity for controlling 50 discrete functions over a maximum operating time of 10 hours during a single mission, according to the manufacturer.

A typical mission might include takeoff, use of the craft's passive and active defense systems, and communications and other equipment.

Reactions Are Printed by 300-Channel Printing Recorder for Analysis

Students' reactions are recorded on paper tape; voice communications are recorded on magnetic tape. Fifty channels of a 300-input-channel printing recorder record events as they occur. The remaining channels record the status of student controls or trainer actions on command of the



Student and instructor compartments of simulator for operators of B-58 electronic countermeasures station houses equipment for simulating missions, which can be programed automatically. Three punched matrix cards feed program information into trainer from triple box-like device above and to left of instructor, who may change conditions or insert malfunctions.

ALL-GLASS SUB MINIATURE RF DIODES

FM discriminator circuits
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A series of tiny, more adaptable, military-rugged diodes with axial wire leads designed for maximum convenience in all miniature strip-transmission-line or coaxial circuits.

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instructor at specific times. Only student errors are recorded, to simplify analysis.

Reflectone reports that the trainer simulates two enemy ground radars and three radar-equipped airborne targets. When the operator gets within range of these transmitters and is tracked he gets a warning. He then selects the cem or chaff technique he wants and observes the effects.

Airborne attacks can be simulated one, two or three at a time. Signal generators develop targets for display on radar-system indicators. All functions of monitoring, target selection, and use of armament must be performed to remove the target from the display.

Programing is provided by a Hickock Cardomatic switch into which punched Mylar cards are inserted. Reflectone reports that, for the most part, voltages proportional to the value of the particular parameter are picked off a voltage-dividing network by the switch.

The simulator uses an analog electro-mechanical computer system to produce pursuit or lead-collision attack courses, selection of which may be made by means of the punched cards. Angular quantities are generally indicated by mechanical shaft positions and scaler quantities by dc voltages.

Development of very accurate elevation signals is said not to be necessary because the only elevation indication in the radar system is the relative time sequence in which the several target signals flash on the scope indicator. This function is provided with initial elevation set in as a dc voltage.

The simulator is designed for retrofitting so that changes in configuration of the actual aircraft can be provided for in the simulator. ■ ■



Slide out rack construction is used for simulator's electronic subsystems. Computer for system is an analog-electromechanical unit.

SILICON NEWS from Dow Corning

The Untouchables (Part 3)

Now...Single Crystal Silicon Doped to Your Specification



Single crystal silicon . . . doped to your specific needs . . . is now available from Dow Corning.

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This high quality is the result of a completely integrated production process — a process that starts with the manufacture of trichlorosilanes and other chemicals basic to silicon production. And at every step of the way, rigid quality control assures the ultimate in quality—purity.

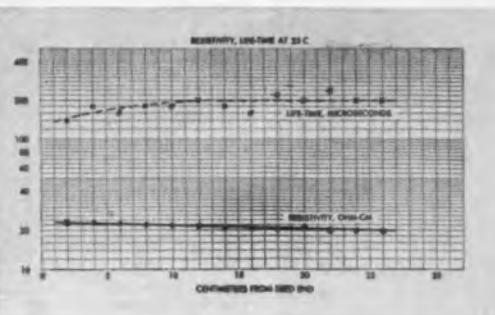
Doped to specification single crystal Dow Corning Silicon contains in the order of 0.1 atoms of minority impurity per billion atoms of P-type material . . . about 0.15 atoms of minority impurity per billion atoms of N-type material.

Low oxygen content of Dow Corning Silicon reduces the undesirable effects on lifetime associated with the diffusion process. Result — few rejects . . . increased device yield! In the picture at left, infrared transmittance at 9 microns is measured to determine oxygen content. Many materials register at pencil point—much higher than Dow Corning Silicon.

Crystal orientation is normally 111, but can be to your specification.

Specify Dow Corning single crystal silicon doped to your requirements. Specific resistivities within narrow tolerances from one to 1000-ohms centimeter P-type . . . one to 400-ohms centimeter N-type. Rod diameters from 3 to 25 mm (1/8" to 1") lengths to 250 mm (about 10").

Whatever your need — polycrystalline rod or chunk; high resistivity P-type single crystal rod; single crystal rod doped to your specifications — Dow Corning should lead your list of sources.



Write for "Hyper-Pure Silicon for Semiconductor Devices." Address Dept. 3316a.

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ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D.C.
CIRCLE 31 ON READER-SERVICE CARD

NEWS

Versatile Computer Is Planned To Process World Messages

Plans are under way for a versatile computer system that would process messages from a variety of worldwide networks.

The system, to be developed by RCA Communications, Inc., of New York City, reportedly will employ many of the techniques and much of the equipment used in the RCA 601.

The special data processor will be designed to store information that will enable it to handle automatically and rapidly all messages sent into it from any channel of communications. The system will be built to handle traffic transmitted by wire lines, microwave, coaxial cable, high-frequency radio, tropospheric scatter propagation or satellite communications systems.

By recognizing the various code symbols preceding a message, the processor will identify the type of message, the country it is destined for, the major city to which it should be sent, the route it should follow, the relay points along the line, and even the priority the message warrants. The system will then send the message through normal transmission channels to its destination.

One of the features of the computer-controlled system will be an automatic check for accuracy.

Two identical systems, to assure reliable operation, will be installed in New York City. They will occupy 3,850 sq ft.

10,000-W Transmitter to Bounce Telephone Signals Off Satellite

A 10,000-w fm transmitting system is being developed for the Air Force to bounce telephone and teletype signals off an Echo satellite. The system will be used on a 2,000-mile experimental relay network between Floyd, N.Y., and Trinidad, West Indies Federation.

The equipment is being built by Radio Engineering Laboratories, Inc., Long Island City, N.Y., under a contract from Page Communications Engineers, Inc. It is designed to provide the reliability and clear-voice reception of wired telephone systems.

The new transmitter will beam its signals from Floyd at the satellite, which will reflect them downward. At Trinidad the highly attenuated signals will be picked up by powerful receiving systems, amplified and demodulated into their original voice, teletype or data messages.

The transmitting system includes a giant 10-kw power amplifier (1,700 to 2,400 mc) and a 10-w exciter, which will operate from an ultra-stable

H. F. Fluorescent Lights

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APPLICATION	A-B FERRITE	PREFERRED CHARACTERISTICS
TELEVISION, RADIO Deflection Yokes	W-03 W-01	High permeability High resistivity
Flyback Transformers	W-04	Low losses, high μ_{max} , high permeability, high Curie temp
Convergence Cores	W-01	Low residual with large gap
I. F. Transformers	R-02	Low losses at low amplitudes. Good temperature stability of permeability
R. F. Tuning Coil (fixed or permeability tuned)	R-02	Low losses. Temperature stable permeability, minimum hysteresis for permeability tuning
TELEPHONE SYSTEMS Interstage and Matching Transformers	W-03	High permeability, low losses
H. F. FLUORESCENT LIGHTS Loading Reactors	W-07	High flux density
Transformers	W-04	High permeability, low losses, high μ_{max}
ELECTRIC ORGANS AND HI-FI STEREO Oscillator Inductors	W-03	High permeability, temperature stable, linear B vs. H
Output Transformers	W-04	High permeability, high μ_{max} , low losses
AUTOMATIC MACHINE TOOLS Magnetic Amplifiers	R-03	Rectangular hysteresis loop, high μ_{max}
Logic elements for high-power levels	R-03	Rectangular hysteresis loop, high μ_{max}
Matching Transformers	W-04	High permeability, low losses, high μ_{max}
MOBILE POWER SUPPLIES Static Inverters	R-03	Rectangular hysteresis loop, high μ_{max}
RADAR, MISSILES Pulse Transformers	W-04 R-02 (for short pulses)	High pulse permeability, high μ_{max} , low losses
PERMANENT MAGNETS	M-01	High energy factor Good mechanical strength

ALLEN-BRADLEY Quality Electronic Components

CIRCLE 32 ON READER-SERVICE CARD

"Atomicon" high-frequency generator.

Page is in over-all charge of the installation of communications equipment, under technical direction of the Rome (N.Y.) Air Development Center.

Watch Converted to Measure Heart Beat Automatically

An inexpensive wrist watch has been converted into an automatic, convenient device for measuring the heart beat.

The device, called a Heart Beat Totalizer, was developed by Lockheed's Missile and Space Div., Sunnyvale, Calif., for two San Francisco heart specialists. It measures a person's heart beat day and night while he continues his normal way of life.

The device employs two electrodes, about the size of a postage stamp, which are taped to the chest. Wires from each electrode connect to a battery-operated amplifier, which can be clipped to a wearer's undergarment.

Amplifier Increases Voltage of Human Heart Beat

Heart-beat voltage is increased by the amplifier and is transmitted by a thin double-wire to the wrist watch. A tiny electromagnet, taking the place of the watch's balance wheel, is powered by the heart-beat amplifier. The electromagnet operates the escapement mechanism of the watch, causing the second, minute and hour hands to move.

One hundred and fifty heart beats will move the second hand one full circle. For the minute hand to make a full circle, 9,000 heart beats are required.

Comparison of the heart watch with a conventional timepiece will tell how fast the heart is beating.

A patient wearing the Heart Beat Totalizer can determine the activities in his daily routine that produce increased strain on the heart.



Heart watch, looking like an ordinary timepiece, measures the heart beat.

THESE ARE THE "HANDS" OF A CRAFTSMAN...

... delicate, precise, nerveless. They're just one of the many sets of automated "hands" Sylvania has developed over two decades of manufacturing high-uniformity Silicon Diodes.

As early as 1942, Sylvania produced its first Silicon Diode, type 1N21. It was painstakingly fashioned by hand for highly specialized radar apparatus.

SYLVANIA SILICON DIODES

Today, Sylvania Silicon Diodes are produced in volume by automated "hands" capable of duplicating diode characteristics with mirror-image fidelity.

Superior Sylvania production facilities also provide diodes of high mechanical reliability. Case in point: Sylvania Silicon Diodes are cycled from -78.5°C to $+100^{\circ}\text{C}$ to "prove out" the rugged, all-glass miniature package. *Every* Silicon Diode is subjected to critical leak-detection Zyglotests to assure high-quality glass-to-metal seals. Too, *every* Silicon Diode is scrutinized by 100% automated test equipment.

Sylvania offers the widest line of Silicon Diode families available. Just one phone call to your Sylvania Sales Engineer or Sylvania Franchised Semiconductor Distributor can fill virtually all your design requirements. For technical data on specific types, write Semiconductor Division, Sylvania Electric Products Inc., Dept. 184, 1100 Main Street, Buffalo 9, N.Y.



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CIRCLE 33 ON READER-SERVICE CARD

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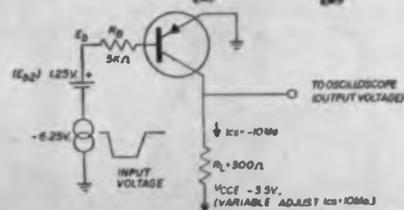
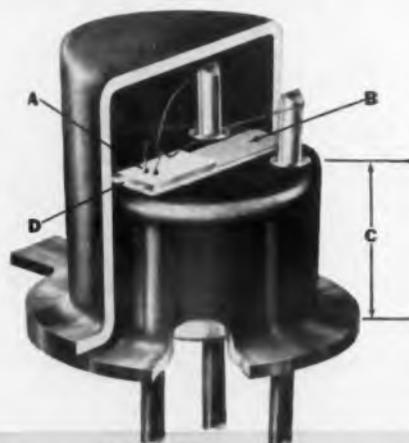
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EDITORIAL

Good Styling a Critical Factor

The majority of electronic instruments now on the market show some evidence of good styling. In walking along the more than two miles of exhibits at last month's IRE Show, one expected almost automatically to see something smart, neat, clean and modern. Only infrequently did some boxed monolith, with camouflaged knobs and markings all in gray or black, turn up to remind us of the day when electronic engineers laid out their own panels.

It's quite certain that any Show attendees who grimaced as they looked at these ghosts of the past did not warm to buying them, regardless of their technical features. If a similar product showed evidence of being well designed both from the inside and the outside, they picked the latter.

The moral is obvious: if you design a product for the marketplace, make sure it meets today's standards of smart appearance.

Obviously silk-screened panel markings, baked on flush lines, and ordinary engravings look cheap. Neither can smart design be achieved now—as in recent years—simply by using fancy panel meters and colored knobs. We have reached a higher standard. Nothing less than completely integrated instrument designs are called for today.

To be properly designed, the product's circuit must not only perform its role and the controls be human-engineered to facilitate operability; the product must fit harmoniously into the total environment, which includes other equipment, test benches, storage shelves and the like. One such total approach to the packaging design of instruments was displayed at the IRE Show. The handiwork of Hewlett-Packard's industrial designer Carl J. Clement showed a single integrated solution to the design problem of panels for both bench and rack mountings, servicing accessibility, and the carrying of small instruments.

Industrial designers try to tell us our unconscious is favorably influenced by impressive appearance. We do not know how much. We acknowledge that good styling may only be in the eye of the beholder. But what our eye sees pleases us, and this should be sufficient warning to those who ignore the outside of their "black boxes."

James G. Kipp

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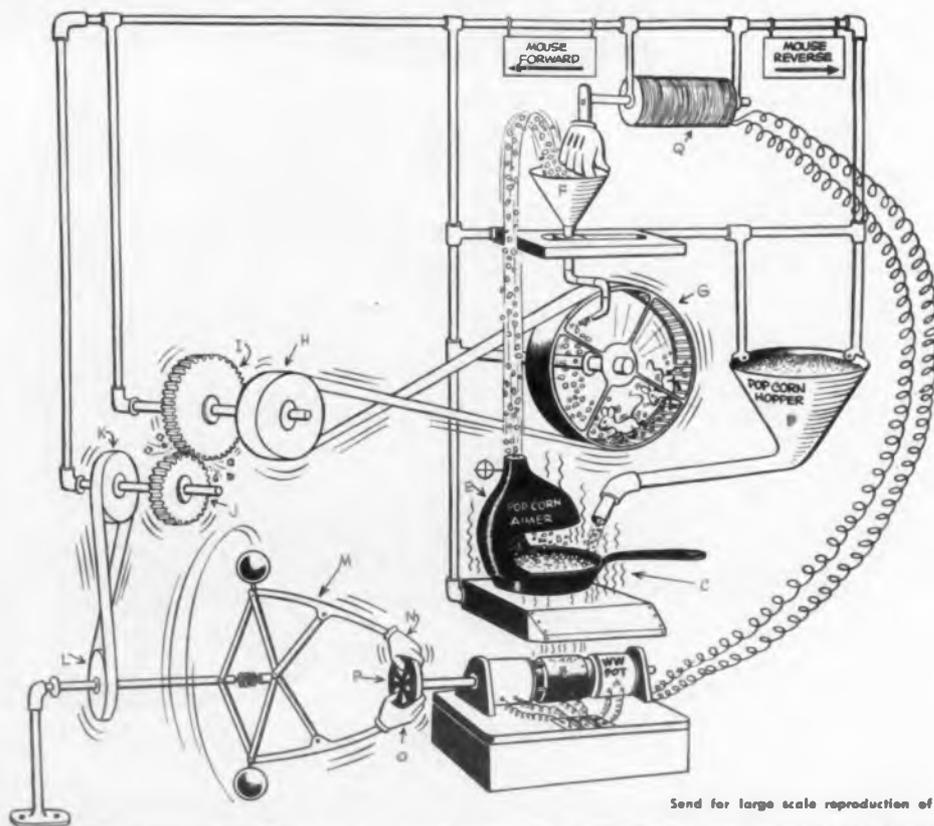
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Governor-Grabber (M). As momentum is increased Governor-Grabber causes spinning Clutch-Hands (N & O) to engage Wheel (P), supplying the additional torque necessary to start servo rotating. Reversing input signal flips Solenoid (Q) to reverse position, sliding Funnel (F) to Mouse-Reverse position. As popcorn is then directed into other side of Power Treadmill, the mice reverse their running action so as to continue catching falling popcorn. Periodic replacement with fresh mice and/or use of cheese-flavored popcorn can be used to increase efficiency of this system.

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	10K	± .5%
	50K	± .5%
1-3/32"	1K	± .25%
	10K	± .25%
	50K	± .25%
	1K	± .5%
	10K	± .5%
	50K	± .5%
2"	5K	± .25%
	20K	± .25%
	50K	± .25%
	5K	± .1%
	20K	± .1%
	50K	± .1%
3"	5K	± .1%
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ELECTRONIC DESIGN • April 26, 1961

diodes



1961

Howard Bierman
Technical Editor

An ELECTRONIC DESIGN Staff Report

At the recent 1961 Solid State Circuits Conference, a rather large number of empty chairs was evident at the evening panel discussion devoted to tunnel diodes. At the 1960 Conference, the turnout for the tunnel diode session was so great that attendees who were fortunate managed to get seated on chairs, stairways or suitcases—many others were forced to stand throughout the three-hour discussion.

Why the drastic drop in interest within the short space of a year? Perhaps too much was promised in terms of application possibilities with too few practical uses demonstrated. Perhaps too little emphasis was placed on the need for adequate time to solve problems imposed by the bilateral device. An interesting and amusing analogy has been drawn between the plot of voltage vs current and intensity of interest vs time for the tunnel diode. The V-I characteristic follows the now famous "S" form—starting from zero, rising sharply to a peak, reversing to a low and then rising rapidly again. In terms of relative interest, zero might be considered the period in 1958 preceding publication of Dr. Esaki's, "New Phenomenon in p-n Junctions" (Physical Review, Vol. 109)—interest soared until 1960, then dipped markedly as evidenced at the 1961 Conference. Will interest reverse its downward trend and demonstrate a sharp upswing? Experts at the Conference discussion predicted that new test equipment and computers will soon be released using tunnel diodes in conjunction with transistors. From these pioneer ventures, it is believed that design engineers will renew activity to incorporate the fast-switching, low-noise, radiation-resistant device into their new equipment.

In this year's special Diode report, ELECTRONIC DESIGN has included four practical design articles directed toward application of the tunnel diode to amplifier, oscillator and switching circuits. In addition, the latest of the Department of Defense approved diodes are listed together with their specification number.

Practical Design Articles

- *Tunnel Diode Square Wave Generator* by J. E. Dalley, of the University of Utah, outlines the design steps leading to a simple and compact generator capable of fast rise time characteristics p 36
- *Practical Aspects of Tunnel Diode Low-Frequency Amplifiers* by Erich Gottlieb of GE contains information on such factors as stability, bias techniques and temperature effects p 42
- *Transistor-Tunnel Diode Combination* by Carl David Todd of Hughes describes a technique for obtaining a composite characteristic bearing the high-speed features of a tunnel diode with the higher voltage capability of a transistor . . p 48

Slide Rule

- *Tunnel Diode Amplifier Calculator* by James J. McDermott represents a valuable tool in the form of a slide rule which can design time by eliminating much of the tedious math involved in tunnel diode amplifier calculations p 52

"MIL-Approved" Diodes

- *Latest Defense Dept. Diode List* gives military-approved diodes p 56

Tunnel Diode Square Wave Generator

Although simple and compact, the circuit described is capable of producing square waves of less than 1 cps to over 2 mc with no sag and only slight overshoot.

James E. Dalley
Electrical Engineering Dept.
University of Utah
Salt Lake City, Utah

TWO TUNNEL DIODES, one coil, one resistor and one capacitor constitute the total component list for a stable square generator capable of operation from less than 1 cps to over 2 mc. The simple and compact circuit consists of a relaxation oscillator driving a bistable switching circuit; rise time of the square-wave output is less than 10 nsec. Although the design procedure outlined results in an approximate rather than exact solution, the method is straightforward and can be applied using commonly published data and circuit values.

Relaxation Oscillator Consists of A Tunnel Diode plus One Coil

The circuit for the relaxation oscillator is shown in Fig. 1a and the exact equivalent circuit is shown in Fig. 1b.

The inductance of the coil is given by L , R_L is the resistance of the coil, R_1 is any added resistance, L_B is the inductance of the tunnel-diode leads, R_B is the series resistance of the tunnel diode, R_D is the incremental resistance of the tunnel diode at a particular operating point and C is the shunt capacitance of the tunnel diode junction. V_1 is the dc voltage source which is assumed to have zero internal impedance for the present discussion. An inspection of Fig. 1b will

reveal that a complicated expression would result if one attempted to write a transfer function. This can be avoided by comparing the output waveshape with the characteristic curve of the tunnel diode and choosing several regions of operation. Simplified equivalent circuits can be applied to some of these regions.

Fig. 2 shows a sketch of the output voltage of the relaxation oscillator with four periods of operation. A sketch of a typical tunnel-diode characteristic curve is shown in Fig. 3 with key voltages and currents indicated.

The operation during period 1 follows the characteristic curve from the origin to the point (V_p, I_p) . During period 2, the current remains constant at a value of I_p and the voltage jumps

The material covered by this paper is the result of independent research carried on by the author at the Sperry Utah Engineering Laboratory during the month of July 1960. Work on the relaxation oscillator was virtually completed before any published material on the subject was seen.¹ The design equations and approach used in this paper are original (unless otherwise noted) with the author to the best of his knowledge. The bistable switching circuit is based on information given in an article by Erich Gottlieb and T. P. Sylvan of General Electric Company.²

1. Dr. C. M. Barrack and M. C. Watkins, "Tunnel Diode Relaxation Oscillators," *ELECTRONIC DESIGN*, June 22, 1960.

2. Erich Gottlieb and T. P. Sylvan, "Tunnel Diodes as Amplifiers and Switches," *Semiconductor Products Dept.*, General Electric Co., Syracuse, New York.

to V_f . Throughout period 3, the operating point follows the curve from the point (V_f, I_p) to the point (V_v, I_v) . When the valley point (V_v, I_v) is reached, the operating point jumps again (period 4) and starts the cycle over from point (V_v, I_v) . The supply voltage must lie between the peak and valley voltages.

Period 1: Experimental results indicate that satisfactory design equations can be obtained if the inductance and capacitance of the tunnel diode are neglected. The simplified equivalent circuit is shown in Fig. 4.

The loop equation in the S-domain is

$$(LS + R_{t1}) I(s) = V_1/S + I_0 L \quad (1)$$

where $R_{t1} = R + R_{D1}$ and R_{D1} is the increment diode resistance during period 1. Solving for the current,

$$I(s) = \frac{V_1/L}{S \left(S + \frac{R_{t1}}{L} \right)} + \frac{I_0}{\left(S + \frac{R_{t1}}{L} \right)} \quad (2)$$

After the first cycle, I_0 becomes I_v and the current in the time domain is

$$i(t) = \left(I_v - \frac{V_1}{R_{t1}} \right) e^{-\frac{R_{t1} t}{L}} + \frac{V_1}{R_{t1}} \quad (3)$$

The output voltage is simply

$$V(t) = i(t) R_{D1} = \left[\left(I_v - \frac{V_1}{R_{t1}} \right) e^{-\frac{R_{t1} t}{L}} + \frac{V_1}{R_{t1}} \right] R_{D1} \quad (4)$$

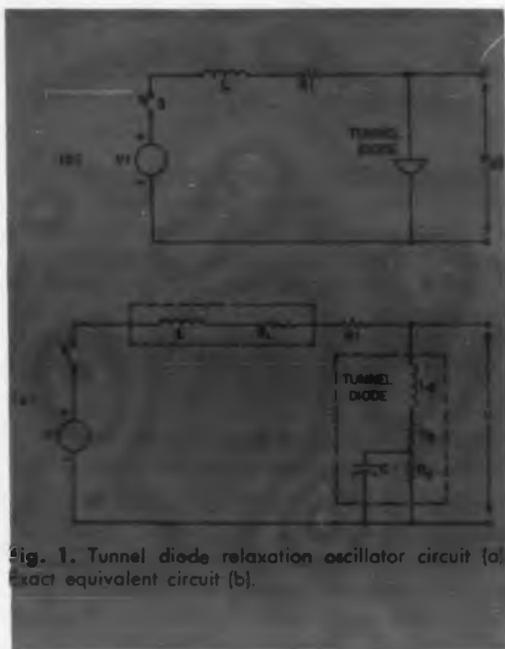


Fig. 1. Tunnel diode relaxation oscillator circuit (a) and exact equivalent circuit (b).

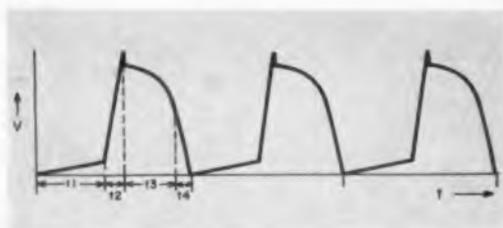


Fig. 2. Waveform of a relaxation oscillator output divided into four periods; periods t_2 and t_4 are deliberately expanded to permit inspection.

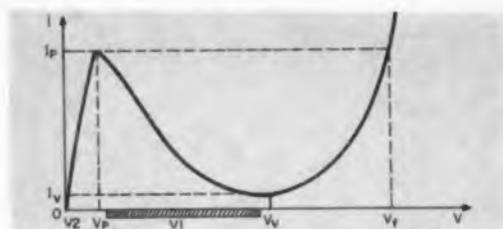


Fig. 3. Typical characteristic curve of a tunnel diode.



Fig. 4. Simplified equivalent circuit valid during period 1. $R = R_2 + R_1$ and $R_{01} = R_0 + R_0$. Generator I_0 inserts the initial conditions into the Laplace transform.

The length of period 1 can be found by setting $V_t = V_p$ and solving Eq. (4) for T . This gives

$$T_1 = \frac{L}{R_{D1}} \ln \frac{V_1 - I_p R_{D1}}{V_1 - \frac{V_p R_{D1}}{R_{D1}}} \quad (5)$$

Now since $R_{D1} = \Delta V / \Delta I$ at any point on the characteristic curve between the origin and the point (V_p, I_p) , it can be seen that R_{D1} is nonlinear and is a function of the operating point. Obviously some average value must be used for R_{D1} if T_1 is to be found in a straightforward manner. A simple solution to arrive at a correct average value for R_{D1} and reduce Eq. 5 to circuit constants and tunnel-diode parameters is to set

$$R_{D1} = \frac{V_p}{I_p} \quad (6)$$

The above definition would be exact if the characteristic curve were a straight line passing through the origin and the point (V_p, I_p) , a fair approximation in actual practice.

Eq. 5 then becomes

$$T_1 = \frac{L}{R_{D1}} \ln \frac{V_1 - I_p R_{D1}}{V_1 - I_p R_{D1}} \quad (7)$$

where $R_{D1} = R + \frac{V_p}{I_p}$

Periods 2 and 4: When the operating point passes the point (V_p, I_p) on the curve, it enters the negative resistance portion of the curve which is unstable. An increase of voltage across the tunnel diode results in a decreased current and a decreased current through the inductance and series resistance results in a further increase of voltage across the tunnel diode. This action is cumulative and tends to reduce the current from I_p to I_v almost instantaneously. The current through an inductance cannot change instantaneously, so the operating point jumps from the point (V_p, I_p) to the point (V_v, I_v) which is on a positive resistance portion of the characteristic curve and stability is again restored. According to Gottlieb and Sylvan³ the switching speed with constant current drive is

$$T_2 = \left(\frac{V_f - V_p}{I_p - I_v} \right) c \quad (8)$$

Using the GE ZJ61-22 tunnel diode, the switching time should be approximately 1.2 nsec which is much faster than the 12-nsec rise time of the oscilloscopes used to observe the pattern.

3. Ibid p 17.

Since the tunnel-diode capacitance is a factor in Eq. 8, it cannot be neglected in the equivalent circuit.

The operation during period 4 is similar to that of period 2 and it is assumed that the switching time is comparable.

The slight amount of overshoot at the ends of periods 2 and 4 can probably be attributed to the series resonance of the inductor and the tunnel-diode shunt capacitance.

Period 3: During period 3, the operating point moves along the characteristic curve from (V_f, I_p) to (V_v, I_v) . Again there exists a problem of determining the value of a nonlinear resistance but the problem is complicated by the fact that a straight line to approximate the curve cannot be drawn through the origin. This can be remedied by drawing a straight line having a slope equal to the average slope of the curve and extending it until it intercepts the voltage axis. The effects of the curve in this region can then be approximately represented by a resistance having a value equal to the reciprocal of the slope of the line in series with a battery having a voltage equal to the voltage axis intercept.⁴ To simplify the equations, remove guesswork in arriving at an average value, and allow a single

4. Martin, Thomas L. Jr., Electronics Circuits, Prentice Hall, Inc. Englewood Cliffs, N. J., 1955, pp 6-7.

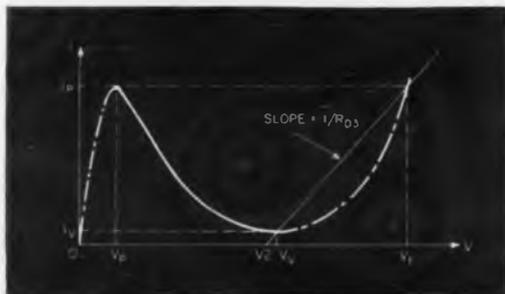


Fig. 5. Graphical representation of R_{D3} and V_2 .

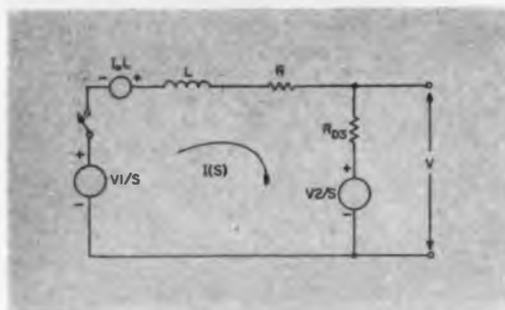


Fig. 6. Equivalent circuit valid during period 3.

approximation to be used, a definite rule will be established. If the straight line is drawn through the points (V_o, I_o) and (V_f, I_p) , the tunnel-diode resistance in this region can be defined as

$$R_{D3} = \frac{V_f - V_o}{I_p - I_o} \quad (9)$$

and the required series voltage (V_s) is given by

$$V_s = V_o - \frac{I_o(V_f - V_o)}{(I_p - I_o)} = V_o - I_o R_{D3} \quad (10)$$

This expression was derived by writing the equation for the line through points (V_o, I_o) and (V_f, I_p) using the slope intercept form where V_2 is the intercept of the voltage axis.

Thus

$$I = \frac{1}{R_{D3}} (V - V_s) = \frac{I_p - I_o}{V_f - V_o} (V - V_s) \quad (10a)$$

Now, set $I = I_o$ and $V = V_o$ and solve for V_s to arrive at Eq. 10. The graphical solutions for R_{D3} and V_2 are shown in Fig. 5.

Using this method to represent the curve in region 3, the simplified equation for the La-

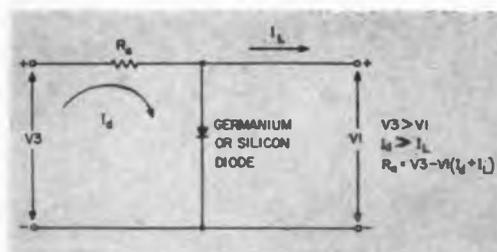


Fig. 7. Circuit for diode voltage regulator.

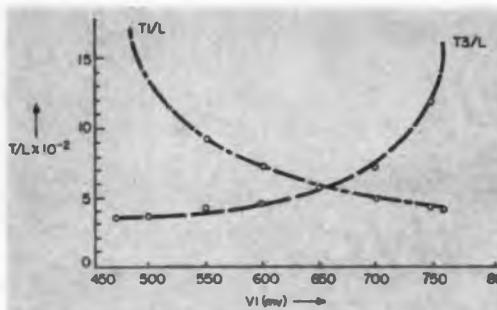


Fig. 8. Plot of T_1/L vs T_3/L vs supply voltage V_1 .

place transform loop equation is shown in Fig. 6.

At the beginning of period 3, $I_o = I_p$. The loop equation is

$$(LS + R_{t3})I(s) = \frac{V_1 - V_2}{s} + I_p L \quad (11)$$

where $R_{t3} = R + R_{D3}$ and the current in the S-domain is

$$I(s) = \frac{V_1 - V_2}{s \left(s + \frac{R_{t3}}{L} \right)} + \frac{I_p}{\left(s + \frac{R_{t3}}{L} \right)} \quad (12)$$

In the time domain this becomes

$$i(t) = \left(I_p + \frac{V_2 - V_1}{R_{t3}} \right) e^{-\frac{R_{t3}t}{L}} - \frac{V_2 - V_1}{R_{t3}} \quad (13)$$

The output voltage is

$$\begin{aligned} V(t) &= i(t) R_{D3} + V_2 \\ &= R_{D3} \left[\left(I_p + \frac{V_2 - V_1}{R_{t3}} \right) e^{-\frac{R_{t3}t}{L}} - \frac{V_2 - V_1}{R_{t3}} \right] + V_2 \end{aligned} \quad (14)$$

Substituting V_o for $V(t)$ and solving for T

$$T_3 = \frac{L}{R_{t3}} \ln \frac{I_p + \frac{V_2 - V_1}{R_{t3}}}{\frac{V_o - V_2}{R_{D3}} + \frac{V_2 - V_1}{R_{t3}}} \quad (15)$$

Several assumptions and approximations were used in deriving the equations for T_1 (Eq. 7) and T_3 . These equations can be solved without the need for characteristic curves by using the parameters given on the manufacturer's specification sheet. As will be shown later, the results are sufficiently accurate for a first approximation in practical situations and adjustments can be made to obtain the exact periods desired.

Power Supply Must Be Free Of Transients and Drift

It was assumed earlier that the power supply had perfect regulation. While this is desirable, power supplies having an internal impedance of 1 ohm or less will operate satisfactorily. If it is not feasible to use an electronically regulated power supply at the desired voltage, a higher voltage supply can be used with a forward biased germanium or silicon diode used as a regulator as shown in Fig. 7. A germanium 1N270 diode can be used to regulate satisfactorily over a range of 350 to 600 mv; a silicon 1N470 diode was used with satisfactory results for voltages between 730 and 830 mv. The diode current must be high enough to bias the diode beyond the knee of its curve. Capacitors are, in general, not satisfactory for bypassing the switching circuits used here.

It will be noted in Eqs. 7 and 15 that the pulse periods are dependent on the supply voltage. Thus the supply voltage must be free from drift also. As the supply voltage (V_1) is increased, the period T_1 decreased while the period T_3 increases. If the total period, or frequency, is of greater importance than the relative pulse widths, it may be possible to find a voltage at which T_1 and T_3 are changing by equal but opposite amounts with changes in V_1 . This would make frequency independent of V_1 over a narrow operating range.

Fig. 3 indicates that V_1 must be somewhat greater than V_p and less than V_o . A method for determining the usable range of V_1 will now be presented. From Eq. 7 note that T_1 approaches infinity as V_1 approaches $I_p R_{t1}$.

$$V_1 > I_p R_{t1} \quad (16)$$

but $R_{t1} = R + R_{D1}$ and $R_{D1} = \frac{V_p}{I_p}$,

$$V_1 > I_p R + V_p \quad (16a)$$

Similarly, from Eq. 15 note that T_3 will increase without limit if

$$\frac{V_v - V_2}{R_{D_3}} + \frac{V_2 - V_1}{R_{t_3}} = 0 \quad (17)$$

Solving for V_1 and substituting Eq. 10 for V_2 , this reduces to

$$V_1 < I_v R + V_v \quad (18)$$

Combining expressions 16a and 18

$$I_p R + V_p < V_1 < I_v R + V_v \quad (19)$$

If R is reduced to zero, this expression becomes

$$V_p < V_1 < V_v \quad (19a)$$

On the other hand, as R is increased, the lower limit of V_1 approaches the upper limit. When these two values are equal, it is impossible for V_1 to be between them and oscillation will cease. The maximum value for R is found by setting the limits equal to each other and solving for R . The result is

$$R < \frac{V_v - V_p}{I_p - I_v} \quad (20)$$

This, incidentally, is the reciprocal of the slope of a line passing through the points (V_p, I_p) and (V_v, I_v) and could be considered as the "average" negative resistance of the tunnel diode.

Step-by-Step Design Procedure And Design Example

For a given tunnel diode, the designer can vary L , R , and V_1 to obtain the desired values of T_1 and T_3 . All of these factors influence both T_1 and T_3 , furthermore, R and V_1 are interwoven in the equations in such a way that it becomes almost impossible to solve for them explicitly. If both T_1 and T_3 are specified in the design requirements, the following six-step design procedure is recommended:

1. Choose the tunnel diode to be used and determine its parameters (I_p , I_v , V_p , etc.), or read them from the tunnel-diode data sheet. If an accurate characteristic curve is available, parametric values can be easily determined; the parameters can be determined experimentally without drawing the complete characteristic curve if necessary.
2. Choose a value of R consistent with the expected values of the inductance and supply voltage.
3. Determine the usable range of V_1 from Eq. 19.
4. Plot T_1/L (from Eq. 7) and T_3/L (Eq. 15) on the same set of coordinates with V_1 as the abscissa. Select V_1 from these curves to

give the desired T_1/T_3 ratio. The power supply should be variable about this value.

5. Solve for L to give the desired values of T_1 and T_3 . Design a variable inductance having this value of L in the center of its range and having the resistance R chosen in Step 2.

6. After the oscillator has been constructed, adjust V_1 for the exact T_1/T_3 ratio and adjust L for the desired frequency.

Example of Design Procedure: The first five steps of the design procedure will be illustrated by means of an example and then the predicted values will be checked against measured values in an experimental circuit. As was previously pointed out, desired values of T_1 and T_2 are usually specified; however, here several available fixed inductors will be used and the periods will be computed and measured for values of V_1 within the usable range.

1. The GE ZJ61-22 tunnel diode will be used. The parameters for the particular unit to be used, determined by direct measurement, are as follows:

$$\begin{aligned} I_p &= 23 \text{ ma} \\ I_v &= 2.0 \text{ ma} \\ V_p &= 125 \text{ mv} \\ V_v &= 730 \text{ mv} \\ V_f &= 1,165 \text{ mv} \end{aligned}$$

Other necessary parameters which may be calculated from the above are:

$$R_{D_1} = \frac{V_p}{I_p} = \frac{125}{23} = 5.44 \text{ ohms}$$

$$R_{D_3} = \frac{V_f - V_v}{I_p - I_v} = \frac{1,165 - 730}{23 - 2} = 20.7 \text{ ohms}$$

$$\max R = \frac{V_v - V_p}{I_p - I_v} = \frac{730 - 125}{23 - 2} = 28.8 \text{ ohms}$$

$$V_2 = V_v - I_v R_{D_3} = 730 - 2(20.7) = 688.6 \text{ mv}$$

2. Let $R = 15$ ohms. This is well below the maximum value, yet it is larger than the resistance of the coils to be used. Thus this value can be realized for all coils used.
3. The minimum value of V_1 is $V_1 > I_p R + V_p = 23(15) + 125 = 470$ mv and the maximum value is given by $V_1 < I_v R + V_v = 2(15) + 730 = 760$ mv.
4. The normalized periods are given by the following equations and tabulated for various values of V_1 in Table 1.

$$\begin{aligned} \frac{T_1}{L} &= \frac{1}{R_{t_1}} \ln \frac{V_1 - I_v R_{t_1}}{V_1 - I_p R_{t_1}} \\ &= \frac{1}{20.44} \ln \frac{V_1 - 2(20.44)}{V_1 - 23(20.44)} \\ &= 4.89 \times 10^{-2} \ln \frac{V_1 - 41}{V_1 - 470} \end{aligned}$$

Table 1. Normalized periods for given values of V_1 .

V_1 (mv)	T_1	T_3
	$\frac{L}{\times 10^{-2}}$	$\frac{L}{\times 10^{-2}}$
470	∞	3.56
500	13.3	3.79
550	9.0	4.24
600	7.09	4.86
650	5.94	5.74
700	5.14	7.25
750	4.54	12.0
760	4.41	∞

$$\begin{aligned} \frac{T_3}{L} &= \frac{1}{R_{t_3}} \ln \frac{I_p + \frac{V_2 - V_1}{R_{t_3}}}{V_v - V_2 + \frac{V_2 - V_1}{R_{t_3}}} \\ &= \frac{1}{35.7} \ln \frac{23 + \frac{688.6 - V_1}{35.7}}{730 - 688.6 + \frac{688.6 - V_1}{35.7}} \\ &= 2.8 \times 10^{-2} \ln \frac{23 + \frac{689 - V_1}{35.7}}{2.0 + \frac{689 - V_1}{35.7}} \end{aligned}$$

The data of Table 1 are plotted in Fig. 8. Usable values of V_1 can be selected that will give T_1/T_3 ratios of from 3.5:1 to 1:2.5.

5. This step will be worked backwards since only discrete values of inductance are available and it is not desirable to design and construct special coils for this example. Calculated and measured values of T_1 and T_3 are given in Table 2 for various values of V_1 . The error was calculated using the following equation.

$$\% \text{ error} = \left| \frac{\text{Calculated value} - \text{measured value}}{\text{measured value}} \right| \times 100 \quad (21)$$

With the 330- μ h coil, oscillations started at a supply voltage of 450 mv and stopped at 710 mv. When the 100- μ h coil was used, the circuit operated over a supply voltage range of 482 to 710 mv.

Some of the predicted values given in Table 2 vary from the measured values by fairly high percentages. When one considers that several as-

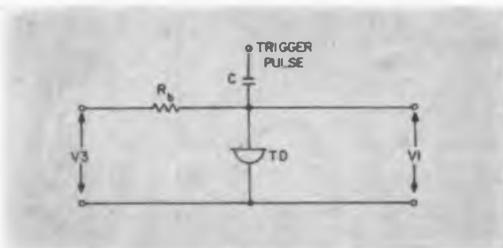


Fig. 9. Tunnel diode bistable switching circuit.

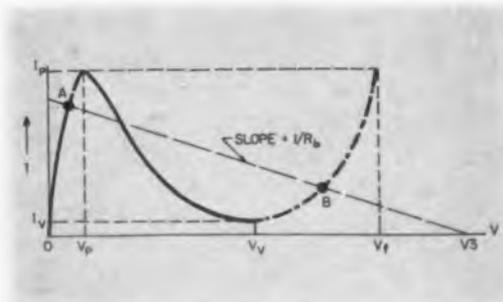


Fig. 10. Tunnel diode characteristic curve with high resistance load line; V_3 represents the power-supply voltage.

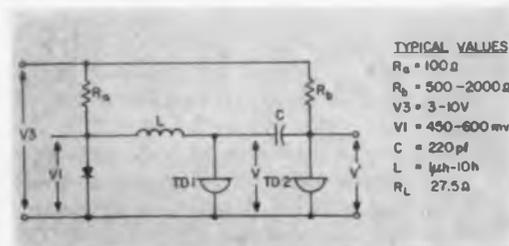


Fig. 11. Complete circuit of the square-wave generator using a single power supply.

TYPICAL VALUES
 $R_a = 100 \Omega$
 $R_b = 500 - 2000 \Omega$
 $V_3 = 3 - 10V$
 $V_1 = 450 - 600 mV$
 $C = 220 pF$
 $L = \mu h - 10h$
 $R_L = 27.5 \Omega$

assumptions and approximations were made in the derivation of the equations, the inductance had a 10 per cent tolerance, that meters and oscilloscopes are not perfectly accurate nor can they be read with perfect accuracy; and that a slide rule was used for all calculations, the results seem to be consistent with the method used. They are sufficiently accurate for practical design purposes if adjustable inductances and power supplies are used.

Operating Characteristics of the Bistable Squaring Circuit

The simple bistable switching circuit suggested by Gottlieb and Sylvan⁵ is shown in Fig. 9. The characteristic curve for a tunnel diode is shown in Fig. 10 with a high resistance load line. It can be observed from the figure that the load line intercepts the curve at two points of positive resistance (points A and B). These are quite stable states. If the operating point is at point A

5. Gottlieb and Sylvan, op. cit. pp 15-17.

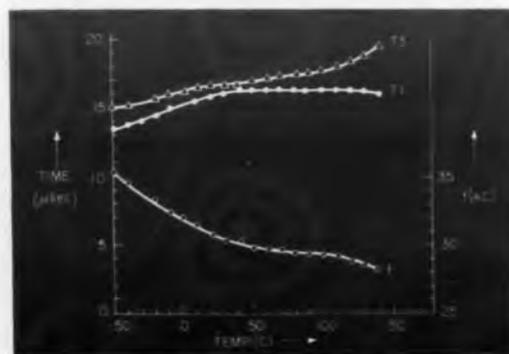


Fig. 12. Variation of period and frequency with temperature.

Table 2. Comparison of measured and calculated values for periods T_1 and T_3 .

L	R	V_1 (mv)	Cal. T_1 (μ sec)	Meas. T_1 (μ sec)	Per cent Error	Cal. T_3 (μ sec)	Meas. T_3 (μ sec)	Per cent Error
330 μ h	15.0 ohms	470	∞	39.0	∞	11.7	10.0	17
		500	44.0	32.0	37.5	12.5	10.1	23.8
		550	29.8	25.0	19.2	14.0	10.4	34.6
		600	23.4	21.0	11.4	16.1	12.5	19.2
		650	19.6	18.0	8.9	18.9	15.0	26.0
		700	17.0	16.0	6.25	23.9	18.0	32.8

and a positive current pulse forces the current through the tunnel diode to a value equal to or greater than I_p , the operating point will switch to point B. The operating point will remain at point B until it is switched back to point A by a negative current pulse large enough to reduce the tunnel-diode current to a value equal to, or less than, I_v . The operating point will remain at point A until it is switched again to point B. Thus there is no sag in either the high or the low state regardless of the frequency.

If a higher load resistance than the one illustrated in Fig. 10 is used, the load line will become more nearly horizontal. Constant current operation is then approached. The value of this constant current is determined by the supply voltage and the load resistance. It should lie midway between I_p and I_v if the positive and negative trigger pulses have equal amplitude.

The coupling capacitor should have the smallest capacitance that will give satisfactory triggering. It passes only the leading and trailing edges of the relaxation oscillator waveform and allows the bistable switching circuit to have a waveform different from that of the oscillator between switching pulses.

Since the leading edge of the oscillator waveform has approximately twice the amplitude of the trailing edge, the positive trigger pulse will be about twice as large as the negative pulse; thus, the constant current load line should intersect the switching diode characteristic curve at about one third the difference between I_p and I_v . The rise time for this circuit can be calculated from Eq. 8. Since the rise time is in the order of a few nanoseconds, it can be considered as being negligible for frequencies up to several megacycles.

The output of the bistable switching circuit is an almost perfect square wave except for a small overshoot, probably due to the series inductance of the tunnel diode and the connecting leads plus the shunt capacitance of the tunnel diode.

A complete circuit of the square wave generator capable of operating from a single power supply is shown in Fig. 11. Resistor R_a and diode D_1 form a regulating voltage divider to supply the proper voltage, V_1 , to the relaxation oscillator which consists of L and TD_1 . R_b and TD_2 form the bistable switching circuit and C is the coupling capacitor between the oscillator and the switching circuit. R_b can be made adjustable over a limited range to provide some variation in the

pulse width due to variation of V_1 . The inductance should be adjustable if frequency variations are desired. Typical values of circuit components for use with the ZJ61-22 tunnel diodes are given in the figure.

Effects of Temperature and Supply Voltage On Performance

The temperature characteristics of tunnel diodes are discussed by Gottlieb and Sylvan.⁶ They point out that V_p , V_v and V_f decrease; I_0 increases and I_p may increase, or increase up to a point, then decrease with increased temperature.

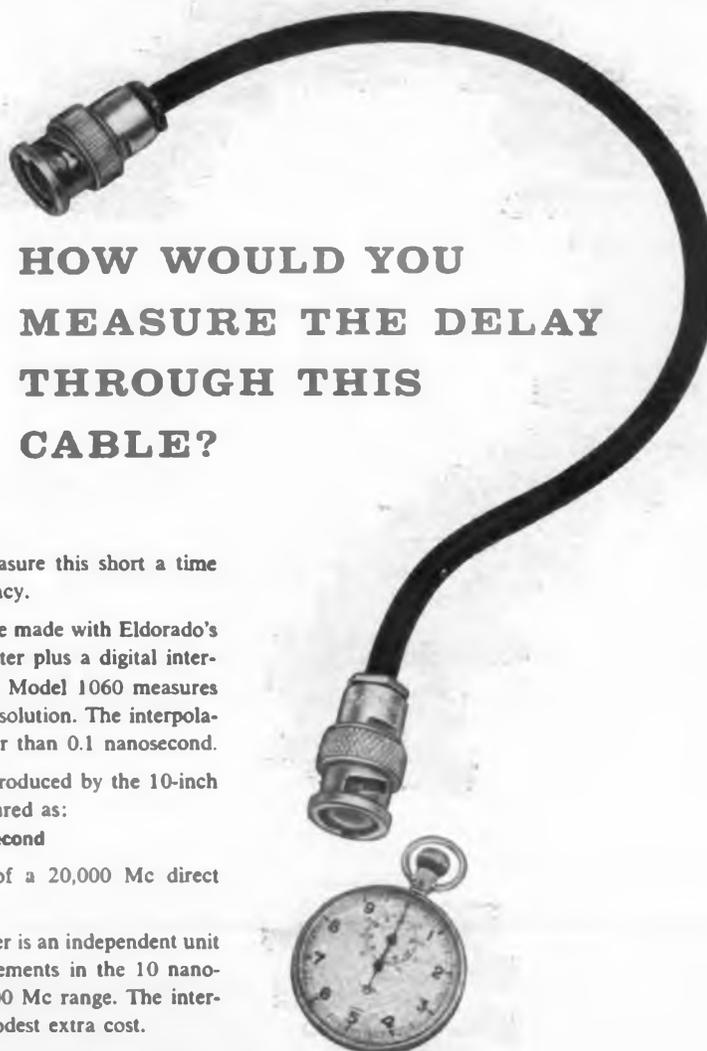
In order to check the temperature effects on the circuit as well as the tunnel diodes, the entire circuit of Fig. 11 (with the exception of R_6 and D_1 which were omitted from the circuit in order to allow for independent control of V_1 and V_3) was placed in a temperature chamber. V_1 was set at 640 mv and V_3 at 6.4 v. A 330- μ h inductance, having a resistance of 11 ohms, was used and R_6 was a 2-K, 1/2-w carbon composition resistor. The relaxation oscillator operated satisfactorily with no adjustment from -50 C to $+140$ C. The periods T_1 and T_3 and the frequency are plotted as a function of temperature in Fig. 12. The oscillator became unstable at 143 C. When V_1 was adjusted to 630 mv, the oscillator operated satisfactorily to temperatures of $+150$ C and back down to 0 C without readjustment.

On the other hand, the supply voltage of the switching circuit (V_3) had to be readjusted upward about every 50 C rise in temperature and the circuit would not operate at temperatures above 130 C. This was probably due to the fact that the load line intersected the characteristic curve too near the valley current (I_v), the valley current increased appreciably at high temperatures, and a carbon composition resistor was used for the load resistance.

The amplitudes of the oscillator and the switching circuit both reduced about 0.1 v for temperatures above 70 C.

It is obvious from the results of the temperature tests that a controlled temperature oven will be required if good frequency stability is required throughout the entire temperature range of from -50 C to $+150$ C. This is not surprising; even quartz crystals are placed in temperature controlled ovens when accurate frequency control is required. If the temperature variation can be limited to the range between 20 C and 100 C, frequency variations on the order of 6 per cent can be expected and 2 per cent accuracy was obtained for the circuit tested in the temperature range from $+50$ C to $+100$ C. ■ ■

6. Gottlieb and Sylvan, *ibid*, pp 5-7.



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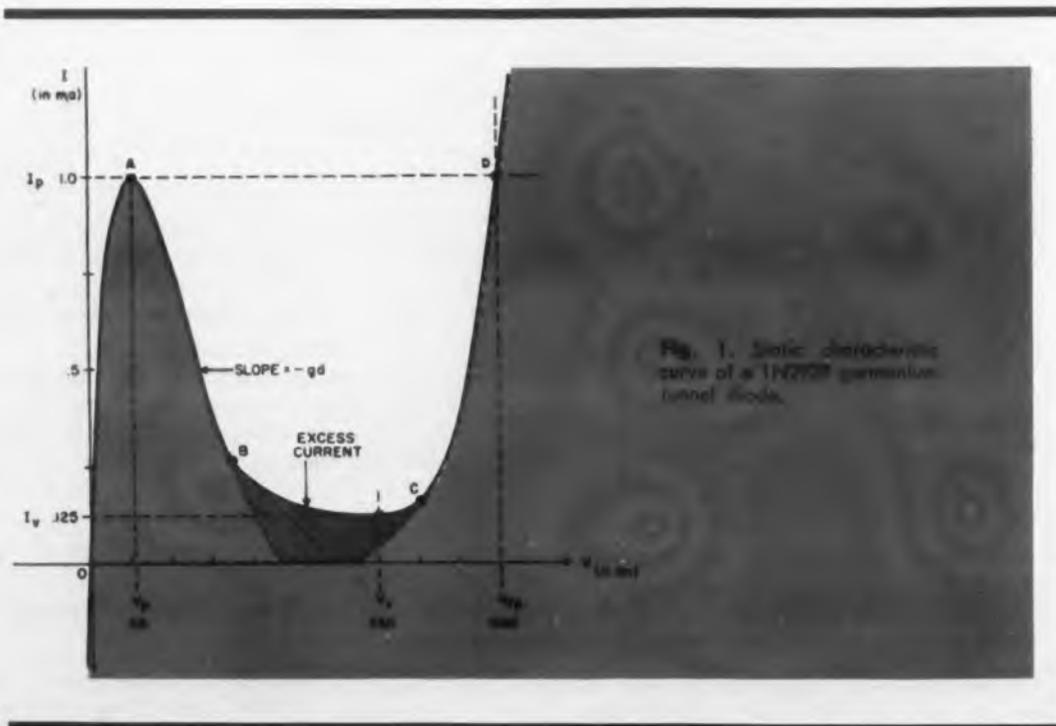
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Practical Aspects Of Low-Frequency Tunnel Diode Amplifiers

A discussion of gain, stability and circuit behavior for a parallel-type amplifier. Factors such as bias requirements and stabilization as well as temperature behavior are analyzed.



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TUNNEL-DIODE amplifiers, offering advantages of small size and simple circuitry, must be carefully designed in terms of layout and conductance matching in order to obtain optimum amplification with adequate stability. In addition, the dc bias must remain stable to avoid nonlinearities and variations in gain. Practical results obtained from a parallel-type amplifier, using a germanium 1N2939 diode, will illustrate the practical problems and design solutions involved in low-frequency applications.

Characteristics of the 1N2939 Germanium Tunnel Diode

The 1N2939 is a three-lead device, housed in the TO-18 package. Pins 1 and 2 are connected internally to reduce lead inductance and are the anode (positive electrode) leads, while pin 3 is the cathode lead and is electrically connected to the case. Having a -55 to $+100$ C operating junction temperature range, the 1N2939 has a peak current of $1.0 \text{ ma} \pm 10$ per cent and a min-

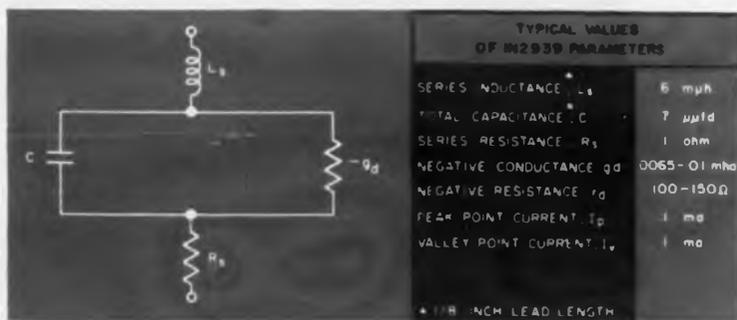


Fig. 2. Equivalent circuit and typical values of the 1N2939 biased in the negative conductance region.

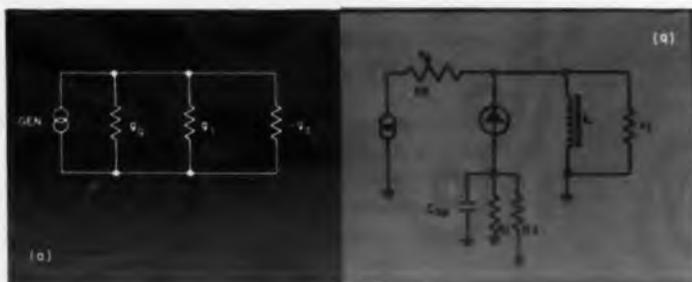


Fig. 3. (a) Low frequency equivalent circuit of a parallel-type negative resistance amplifier. (b) Practical amplifier circuit.

imum I_p/I_v ratio of 8:1, see Fig. 1. It is basically designed for high-speed, low-level switching as well as for small signal, high-frequency operation in communication circuitry. Its speed and frequency limitations are determined primarily by the inductance and capacitances inherent in this type of package. Having a typical total capacitance of 7 pf, of which 1.5 to 2.0 pf is in the header, and a typical inductance of 6 μ h (1/8-in. lead length) the device has a self-resonant frequency (f_{so}) of

$$f_{so} = \frac{1}{2\pi} \sqrt{\frac{1}{L_s C} - \left(\frac{g_d}{C}\right)^2} = 750 \text{ mc typical}$$

Its resistive cut-off frequency¹ (f_{ro}) is

$$f_{ro} = \frac{1}{2\pi} \frac{(g_d)}{C} \sqrt{\frac{1}{R_s (g_d)} - 1} = 2,300 \text{ mc typical}$$

Its other typical parameters are: a negative resistance $-r_d = 1/(-g_d) = -100$ to -150 ohms,

¹The resistive cut-off frequency of the device is the frequency at which the real component of the negative impedance goes to zero, hence the device becomes passive at this point.

a series resistance (R_s) of 1 ohm, typical peak point voltage (V_p) of 55 mv and a typical valley point voltage (V_v) of 350 mv. The equivalent circuit when biased in the negative conductance region can be seen in Fig. 2.

Negative Resistance Amplifier In the "Parallel" Connection

The basic low-frequency equivalent circuit of this connection can be seen in Fig. 3a. Essentially, it consists of a current source driving the parallel combination of the load conductance (g_l) and the negative diode conductance ($-g_d$) of the tunnel-diode characteristic. This latter can be seen between points A and B on the static current-voltage characteristics shown in Fig. 1.

When biased at about the center of the negative conductance region (120-125 mv), the slope (di/dv) of the diode is equal to a negative conductance ($-g_d$) of approximately 0.00714 mhos ($-r_d = 1/(-g_d) \approx 140$ ohms). To obtain maximum dynamic range, it is important to maintain this bias operating point in the center of the negative conductance characteristics.

An actual circuit which would closely satisfy the equivalent circuit of Fig. 3a can be seen in

Fig. 3b. Here the tunnel diode is shown being forward biased by the bypassed voltage divider R_1 and R_2 while choke L acts as a low resistance dc return across the ac line without shunting the ac gain. Transformer coupling could, of course, be used in lieu of RC or direct coupling, thereby eliminating the need for the choke. The total dc loop resistance must be smaller than the negative resistance in order to serve as a constant voltage source. Therefore,

$$R_1 + R_{inductor} < \frac{1}{|g_d|}$$

preventing the device from switching. An extremely small value of total loop resistance might prompt the circuit to oscillate ($R_1 + R_{ind} < Lg_d/C$). Values found to permit stable amplification varied from 1/3 to 2/3 of $1/g_d$. The limit condition is that

$$\frac{L|g_d|}{C} < RT < \frac{1}{|-g_d|},$$

$$\text{where } R_T = R_1 + R_{inductor}$$

Power Gain Expressed as Function of Circuit Conductance

The expression of "available gain" (PG_{av}) for the equivalent circuit of Fig. 3a as rearranged in conductance terms is given by Eq. 1 where $g_o + g_l - g_d$ = the total circuit conductance g_t

$$PG_{av} = \frac{P_o}{P_{t^{max}}} = \frac{\left(\frac{\Delta i}{g_t}\right)^2 (g_l)}{\frac{(\Delta i)^2}{4 g_o}} = \frac{(4) (g_o) (g_l)}{(g_t)^2}$$

$$PG_{av} = \frac{(4) (g_o) (g_l)}{(g_o + g_l - g_d)^2} \quad (1)$$

A number of conclusions can be drawn from this expression:

1. The available power gain would be infinite if $g_t = 0$ (when $g_o + g_l = g_d$).
2. Practical values of power gain can be achieved by various combinations of g_o and g_l , assuming a fixed value of $-g_d$ (the latter depending on the geometric dimensions and current density of the device).

$$\text{Case (a) } g_o \ll g_l = |g_d|$$

$$\text{Case (b) } g_l \ll g_o = |g_d|$$

$$\text{Case (c) } g_l = g_o = \frac{|g_d|}{2}$$

Load Conductance Matches Negative Conductance, Generator Conductance Small

In this case, maximum power gain is obtained when $g_o = g_l + (-g_d)$. If $g_l = g_d$, then $g_l + (-g_d) = 0$ and therefore g_o is zero. This, of course, is the extreme case for infinite gain.

If g_i is almost equal to $-g_d$, practical values of circuit gain can be obtained. The degree of matching required to yield fixed values of gain is therefore of interest.

Gain versus degree of match: Starting with a 10 per cent mismatch, for example, with $-r_d = 100$ ohms and $r_i = 90$ ohms, the parallel resistance would be $-100 \times 90 / -100 + 90 = 900$ ohms. If r_o is equal to 900 ohms, the available gain is

$$PG_{av} = \frac{4 \times \frac{1}{900} \times \frac{1}{90}}{\left(\frac{1}{900} + \frac{1}{90} - \frac{1}{100}\right)^2} = 10 = 10 \text{ db}$$

It is obvious that closer match is needed to obtain an increase in gain. Therefore, if $-r_d = 100$ ohms, but r_i is increased to 99 ohms (for a 1 per cent match), the resultant parallel impedance (Z_{in}) is equal to $-100 \times 99 / -100 + 99 = 9,900$ ohms. Subsequently, if $r_o = 9,900$ ohms, the available power gain is increased to:

$$PG_{av} = \frac{4 \times \frac{1}{9,900} \times \frac{1}{99}}{\left(\frac{1}{9,900} + \frac{1}{99} - \frac{1}{100}\right)^2} = 100 = 20 \text{ db}$$

And, of course, if a 0.1 per cent match could be achieved, the resultant gain would be increased to 30 db. It becomes apparent that this degree of matching is quite critical, especially if higher gain is required; of course, this gain must be maintained reasonably constant over an acceptable range of supply voltages and ambient temperatures.

Stability criteria: Several conditions can be established to determine stability:

1. If the parallel combination of r_o and r_i is greater than the negative resistance of the tunnel diode, the resultant characteristic is a large value of negative resistance making the circuit unstable.

Or, if $g_o + g_i < |g_d|$, then g_i is negative.

2. If the total (dc loop) bias conductance is

smaller than the negative conductance of the diode, the circuit will be bistable and tend to switch between the peak and valley point current extremes.

3. As long as the resonant frequency (f_o) of the circuit is below the resistive cut-off frequency (f_{ro}) of the circuit, the amplifier will tend to oscillate at f_o . This latter criteria may be particularly troublesome in the low-frequency range since it is not simple to design low-frequency amplifiers without the use of wiring and components having a great deal of stray inductances.

The circuit cut-off frequency is still given by

$$f_{ro} = \frac{1}{2\pi C} \sqrt{\frac{1}{R_o g_d} - 1}$$

but R_o is now the sum of R_o (internal) + R_o (external). Since R_o (external) is essentially the matched load resistance, the term under the radical becomes very small, thus reducing f_{ro} . The use of greater shunt capacity to reduce f_{ro} is not recommended since this would also lower the resonant frequency of the circuit (f_o).

Looking at the equivalent circuit of Fig. 4, it can be seen that the circuit resonant frequency

$$f_o = \frac{1}{2\pi} \sqrt{\frac{1}{L_o \times C} - \left(\frac{g_d}{C}\right)^2}$$

is determined largely by C and L_o , both of which are increased by the use of additional lumped constants.

4. To permit stable amplification*

$$\frac{1}{g_d} > R_T > \frac{L_{pd}}{C}$$

where R_T is the total positive circuit resistance, L and C are the total circuit inductance and capacitance.

The limit condition would be $1/g_d = R_T$

*U.S. Davidsohn, Y.C. Hwang, G.B. Ober, "Designing with Tunnel Diode," ELECTRONIC DESIGN, Feb. 3, 1960.



Fig. 4. Equivalent circuit of a tunnel diode plus external circuitry.

in which case $1/g_d > L_{pd}/C$. Assuming the distributed capacitance can be kept down to about 3 pf and the device capacitance is 7 pf, $C = 3 + 7 = 10$ pf,

$$L < \frac{C}{g_d^2} < \frac{10 \times 10^{-12}}{1 \times 10^{-4}} = 100 \text{ m}\mu\text{h}$$

This constitutes an additional stability criteria which is especially difficult to deal with at very low frequencies. It can be seen from this equation, however, that a high capacitance or low conductance diode (high C/g_d^2 ratio) would be easier to stabilize at low frequencies.

5. Since the negative resistance may be affected by dc bias and temperature variations, all above conditions must remain satisfied. In a 20-db stage having only a 1 per cent difference between $-r_d$ and r_i , this 1 per cent difference must be kept constant to maintain a fixed value of gain.

Generator Conductance (g_g) Matches Negative Conductance (g_d), Load Conductance g_l Small

Here the generator conductance must remain closely matched to the diode while reasonable variations in load conductance only affect gain slightly. If, for example,

$$\begin{aligned} r_o &= 109 \text{ ohms } (g_o = 9.18 \times 10^{-3} \text{ mhos}) \\ r_i &= 1,000 \text{ ohms } (g_i = 1 \times 10^{-3} \text{ mhos}) \\ -r_d &= 100 \text{ ohms } (-g_d = 1 \times 10^{-2} \text{ mhos}) \end{aligned}$$

$$\begin{aligned} PG_{av} &= \frac{4 \times 9.18 \times 10^{-6}}{(9.18 \times 10^{-3} + 1 \times 10^{-3} - 1 \times 10^{-2})^2} \\ &= \frac{36.7 \times 10^{-6}}{3.25 \times 10^{-8}} = 1,130 = 30.54 \text{ db} \end{aligned}$$

Now, if both r_o and $-r_d$ remain constant, but r_i varies by ± 10 per cent, the following changes in gain would result:

$$(a) r_i' = r_i - 10\%$$

Thus $r_i' = 1,000 - 100 = 900$ ohms and $g_i = 1.11 \times 10^{-3}$

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$$PG_{av} = \frac{4 \times 9.18 \times 1.11 \times 10^{-6}}{[(9.18 + 1.11 - 10) 10^{-3}]^2} = \frac{40.4 \times 10^{-6}}{8.4 \times 10^{-8}}$$

$$= 481 = 26.8 \text{ db}$$

A loss of 3.74 db

$$(b) r_l' = r_l + 10 \text{ per cent}$$

$$\text{Thus } r_l' = 1,000 + 100 = 1,100 \text{ ohms and } g_l = 0.91 \times 10^{-3}$$

$$PG_{av} = \frac{4 \times 9.18 \times 0.91 \times 10^{-6}}{[(9.18 + 0.91 - 10) 10^{-3}]^2} = \frac{33.3 \times 10^{-6}}{.81 \times 10^{-8}}$$

$$= 4,120 = 36.2 \text{ db}$$

A gain increase of 5.66 db.

Since the gain has gone up in one case and down in the other, a total change of $5.66 + 3.74 = 9.4$ db must be considered.

Stability Criteria: In both cases previously discussed, the value of negative conductance is equally critical, since either g_o or g_i must remain very nearly equal to $|g_d|$ in order to sustain adequate stable gain. Otherwise, the same previously discussed stability criteria apply in both cases.

Load Conductance (g_l) Is Equal to the Generator Conductance g_o While $g_d = g_i + g_o$

In this instance, the generator and load conductances share the responsibility of matching the negative diode conductance thereby distributing the burden somewhat. Here, however, both g_o and g_i must remain extremely constant and all other stability criteria still apply.

Summary of Requirements To Achieve Stability

(1) Regardless of the operating frequency of the amplifier, the latter has to be built with extremely short leads and careful layout, as if it were a vhf stage, in order to keep f_{zo} above f_{ro} and $L < C/g_d^2$.

(2) For adequate amplification and stability, the sum of the load and generator conductances has to be very nearly equal to, but always greater than, the negative conductance of the diode.

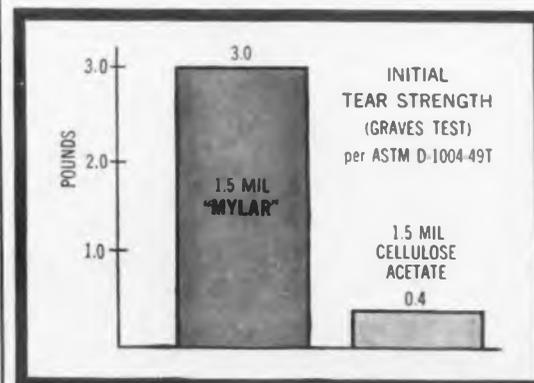
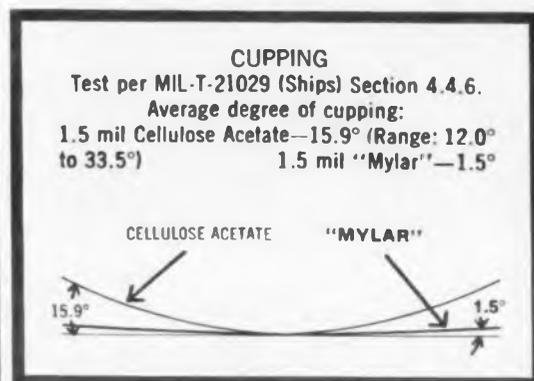
$$G_l > -g_d$$

(3) The total dc loop conductance must be larger than the negative conductance. (Dc bias supply must be a voltage source.)

(4) All above requirements must remain satisfied over a range of supply voltages and temperature conditions.

Several Methods of Obtaining Stable DC Bias

There are two reasons why the dc operating point must remain stable. First, looking at Fig. 5, it is apparent that the maximum voltage



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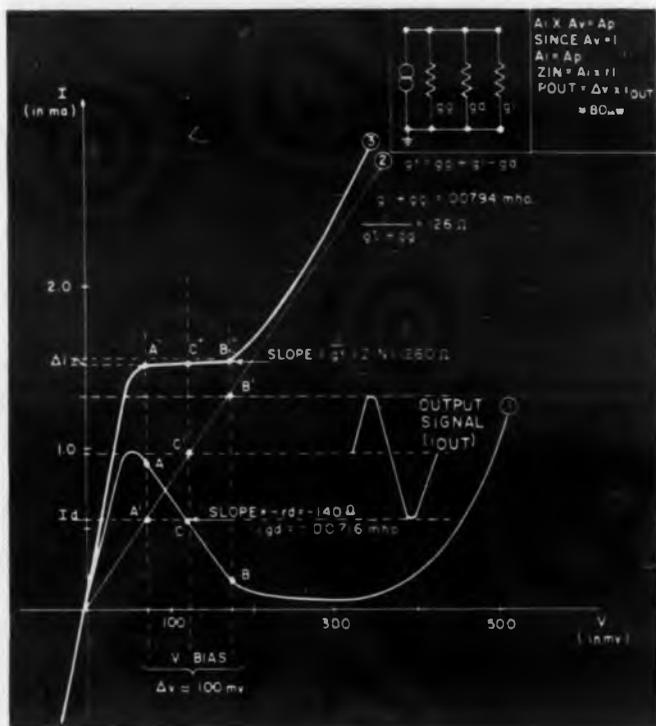


Fig. 5. Load line superimposed on the diode characteristic curve.

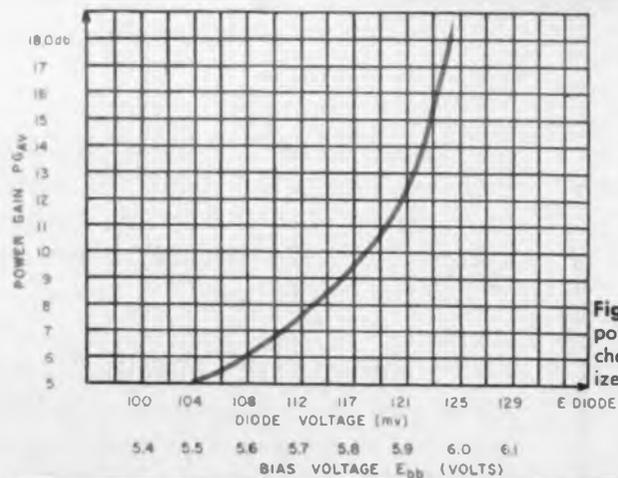


Fig. 6. Variation of power gain vs bias change in a nonstabilized amplifier circuit.

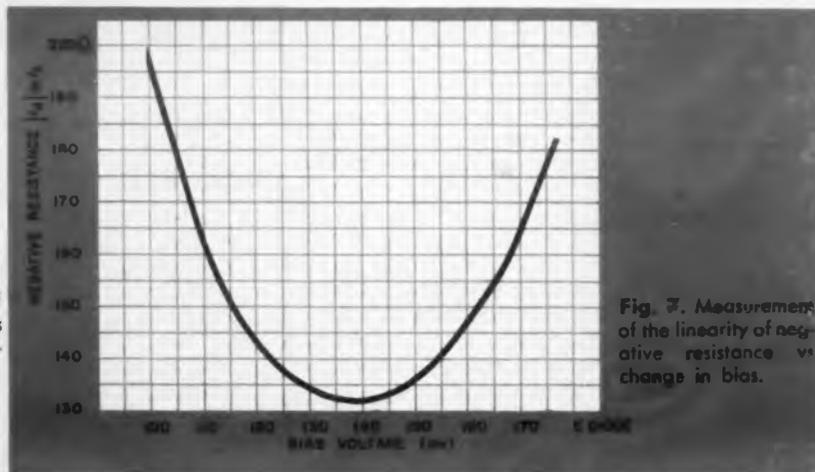


Fig. 7. Measurement of the linearity of negative resistance vs change in bias.

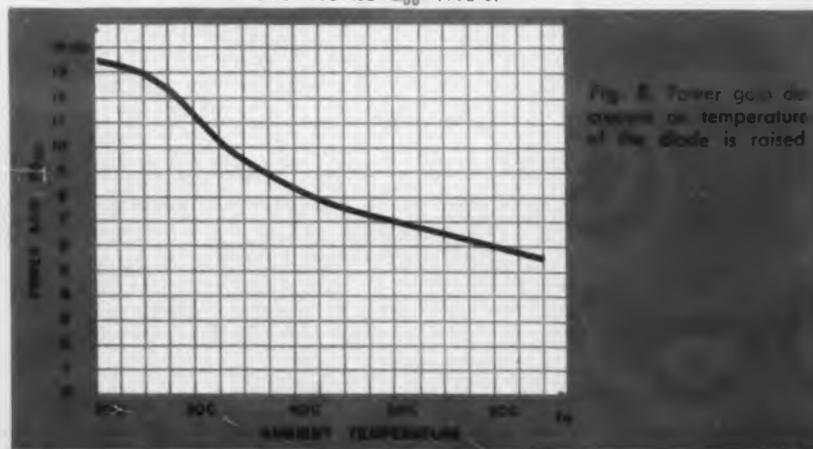


Fig. 8. Power gain decreases as temperature of the diode is raised.

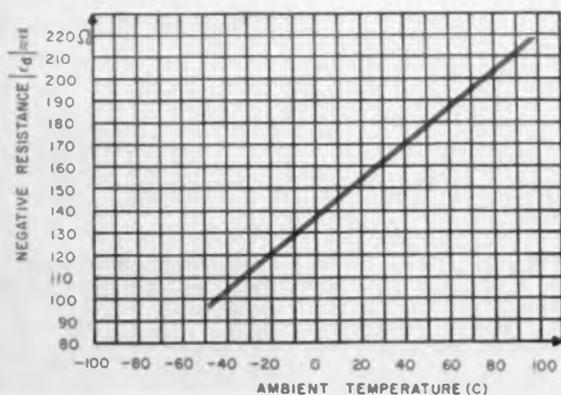


Fig. 9. A linear increase of negative resistance takes place as diode temperature is raised.

swing is limited to about 100 mv (peak-to-peak) by the nonlinearities occurring around points A and B. If point C is allowed to deviate from the center of the linear slope, the dynamic range would be greatly reduced and/or the distortion increased.

Second, even the slightest nonlinearities in the operating portion of the slope ($-g_d$), could create relatively large changes in gain due to the required match conditions. In Fig. 6 the results of such slight nonlinearity have been illustrated by the following test:

The circuit was set up at full supply voltage (6 v) properly biased ($E_{diode} = 125$ mv) and having the following parameters:

$$\begin{aligned} r_l &= 140 \text{ ohms} & e_{in} &= 4 \text{ mv} \\ r_g &= 1,000 \text{ ohms} & e_o &= 3.6 \text{ mv} \\ & & PG_{av} &= 18.1 \text{ db} \end{aligned}$$

Subsequently, the supply voltage was reduced (simulating a lower battery voltage) in steps. The change of output voltage was recorded and the resultant loss in power gain calculated. The cause of the rapid gain fall-off is expected to be a nonlinear change in negative conductance versus bias voltage.

In order to get an idea of the magnitude of this change, the output signal voltage was maintained constant by readjusting the load resistance and thereby sustaining a reasonably constant match. The change in r_i can be considered equal to the change in $-r_d$, see Fig. 7.

Note the fact that the slope changes sign at about 140 mv. From Fig. 7, it is evident that a means to stabilize the bias voltage must be found. Three of the more obvious methods are:

- (1) The use of a mercury cell (stable E_{bi}).
- (2) The use of the relatively constant voltage drop across a forward biased diode.
- (3) The use of breakdown (Zener) diodes as voltage regulators.

Experimental Check of the Temperature Dependence of Tunnel Diodes

An increase in ambient temperature has the following effect on the V-I characteristics of the tunnel diode: the peak current may increase or decrease, the valley current increases and the forward injection voltage (V_{fp}) decreases. The effect on the negative resistance region is to make the value of $-r_d$ temperature sensitive. To obtain a rough estimate of the sign and magnitude of this coefficient for the 1N2939, the following tests were performed:

(1) A circuit was set up having 13.3-db power gain at room temperature. In the first experiment, only the ambient temperature (t_a) was varied and the results can be seen in Fig. 8.

It became quickly apparent that an increase in temperature would result in (1) a change in diode bias voltage and (2) a change in gain which could be caused by the bias change, by a change in negative resistance or both.

In a test setup, with temperature varied from 10 to 50 C while maintaining a 145-ohm load resistance, the bias voltage changed 3 mv and gain decreased by 6.6 db. After readjusting the bias to its original value (131 mv), only a fraction of a db improvement was obtained (0.6 db). Obviously a change in negative resistance took place. By adjusting the load resistance (r_l) to obtain approximately the original value of power gain, the sign and magnitude of this change can be roughly estimated. From Fig. 9, an average change of 0.8 ohm/C has taken place which, when normalized to room temperature, gives approximately a 0.5 per cent/C "positive" temperature coefficient.

Subsequent work on representative production lots of these tunnel diodes have shown that a certain spread in the above coefficients is evident. Hence the above data, although reasonably accurate, are not necessarily typical for the 1N2939 diode. It is therefore recommended that for accurate design specifications, an up-to-date specification sheet be consulted. ■ ■

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Transistor-Tunnel Diode Combination

High-speed switching, at relatively high-voltage levels, is possible using a tunnel diode transistor combination.

Carl D. Todd

Senior Staff Engineer
Hughes Semiconductor Div.
Newport Beach, Calif.

THE HIGH SPEED triggering capability of the tunnel diode may be combined with the higher useful voltage levels of a transistor to produce a composite negative resistance device having an N-type current stable characteristic. The peak voltage is relatively insensitive to temperature variations and transistor leakage current does not generally pose a problem.

Negative resistance devices can be grouped into two major classes, N-type or current stable and S-type or voltage stable. N-type negative resistance devices have a voltage-current plot with the basic shape illustrated in Fig. 1a.

For a range of voltage values between a peak voltage, V_p , and a valley voltage, V_v , three current values are possible for each value of applied voltage. If the current is specified, however, only one voltage may exist for that current. N-type characteristic devices are therefore considered current or open-circuit stable.

S-type negative resistance devices, such as the tunnel diode, have a voltage-current plot as shown in Fig. 1b.

For a range of current values between a valley current, I_v , and a peak current, I_p , three voltages may exist. Specifying the voltage, however, defines the one value of current which may exist. S-type negative resistance devices are therefore considered voltage or short-circuit stable.

Monostable multivibrators and relaxation oscillators using N-type negative resistance devices normally use a capacitor as the energy storing element; S-type devices must use an inductor. Low-frequency oscillators using S-type negative resistance devices are therefore quite bulky and have considerable weight.

Straight-Line Analysis of the Tunnel-Diode-Transistor Combination

The circuit which may be used to convert the S-type, low-voltage characteristic of the tunnel

diode into an N-type characteristic operating at much higher voltage levels is shown in its simplest form in Fig. 2.

The emitter-base diode characteristic may first be assumed to intersect the tunnel diode characteristic in the valley region as illustrated in the drawing of Fig. 3. Since the tunnel diode and the transistor input are directly in parallel, a composite characteristic of these two curves may be constructed as illustrated by adding the two currents for a given voltage value. This composite characteristic must operate along the load line whose slope is determined by the value of R_1 and whose voltage intercept is the terminal voltage, V_1 .

Constructing the plot of the terminal current I_1 , as a function of the terminal voltage, V_1 , by graphical manipulations, the characteristic of Fig. 4a is obtained. While at first glance this does not look exactly like the basic shape shown in Fig. 1a, it will perform switching applications in a similar manner. The line $a'-b'$ is due mainly to resistor R_1 and, to a much lesser degree, to the initial slope of the tunnel diode. The emitter-base diode of the transistor has no effect since it has been assumed that conduction does not begin until a higher voltage level is reached. Since there is no base current, the collector current may, for most cases, be assumed negligible. In the construction of the curve, h_{FE} of the transistor has been assumed to be constant with collector voltage and collector current.

The line $b'-c'$ is due to the negative resistance region of the tunnel diode. Current through the tunnel diode is decreasing as the terminal voltage across the total circuit is decreased. Because the voltage drop across the tunnel diode is larger in the negative resistance region than for the initial positive slope, the value of I_1 produced by a given terminal voltage will be a small amount less. If the value of R_1 is high such that the firing voltage, V_p , is made large with respect to the voltage across the tunnel diode, line $b'-c'$ will fall very close to line $a'-b'$. It is assumed that the emitter-base diode does not conduct in

this region and thus the only current flowing is that through the tunnel diode. Collector leakage currents have also been assumed negligible.

Line $c'-d'$ of Fig. 4a is produced as the operating point in Fig. 3 is moved along the constant current region in the valley of the tunnel diode. The emitter-base diode is still assumed to be nonconducting in this region.

As the terminal voltage V_1 is now increased slightly, the current flowing through the tunnel diode remains the same since the operating point is still in the valley region of the tunnel diode. Base current begins to flow as soon as the value of V_{BE} exceeds the value V_d . This current is multiplied by the current gain of transistor Q_1 , thus producing the rapidly rising current described by line $d'-e'$ in Fig. 4a.

If the value of V_{BE} exceeds the voltage V_f , the tunnel diode current again rises and, under certain conditions, may cause a leveling off in the current I_1 .

Perhaps the most important parameter in any negative resistance device used in a switching application is the firing point, described in the characteristic of Fig. 4 by V'_p which is equal to V_p . For the conditions assumed for this case, V'_p may be very easily computed from the simple relation

$$V'_p = I_p R_1 + V_p \cong I_p R_1 \quad (1)$$

For nearly all cases, the value of V'_p is much larger than the peak voltage of the tunnel diode, V_p , and thus the approximation indicated above in Eq. 1 is very accurate. This means that the firing point is very stable since the peak current of a tunnel diode is not appreciably affected by changes in temperature.

The value of the voltage V'_c is given by:

$$V'_c = I_v R_1 + V_v \cong I_v R_1 \quad (2)$$

V'_c is the valley voltage for the composite device for the exact conditions assumed. The value of I_v of the tunnel diode will be determined by the peak current and the peak-to-valley current ratio, H , of the tunnel diode used. The higher the value

of H for the tunnel diode, the lower the voltage V'_o and the more efficient the composite device becomes when used as a switch. Since the behavior of I_T of a tunnel diode as a function of temperature is not fully understood, it is not possible to accurately predict the variations in valley voltages for the composite.

The voltage differences between V'_o and V'_d has been greatly exaggerated in Fig. 4a. This voltage will actually be the difference between the values of V_o and V_d of the tunnel diode and hence, for most cases, will be negligible. The transistor will thus begin to conduct at a terminal voltage V_1 , approximately equal to the product of I_T and R_1 .

The terminal resistance for the "off" condition is very nearly equal to R_1 and the resistance for the "on" condition will approach the value of R_1 divided by the h_{fe} of the transistor. Any tendency of the current gain of the transistor to decrease with increasing current levels will result in an increase in the "on" resistance at those current levels.

The position of the emitter-base diode characteristic will vary with temperature at a rate of approximately 2.5 mv/C. As long as the knee of this curve falls within the valley region, the effect on the composite characteristic will be negligible.

It is of interest to study the case where base current begins to flow before the valley region of the tunnel diode is reached. For applications using germanium tunnel diodes with germanium transistors, this is the condition most of the time. By proper biasing, the emitter-base diode characteristic may be moved to any portion of the tunnel diode characteristic as will be seen later.

Assume the conditions depicted in Fig. 5. Again, the emitter-base diode is assumed to be nonconducting until a certain voltage, V_c , is reached. The composite characteristic curve shown in Fig. 4b is therefore identical to the one in Fig. 4a up to the point where base current commences. As soon as the voltage across the tunnel diode and the transistor input has reached the value V_c , base current flows. This current is multiplied by the h_{fe} of the transistor thus producing a very rapid rise in the current I_1 as before. There is no flat or constant current region in the characteristic curve representing the tunnel diode and the transistor in parallel, and thus there will be no constant current portion in the over-all composite characteristic curve of Fig. 4b. When conditions are such that the tunnel diode begins to operate in its valley region, however, there will be an increase in the rate of current increase since the effect of the negative resistance slope of the tunnel diode is no longer present.

The change in emitter-base diode characteristics with temperature which produced a very

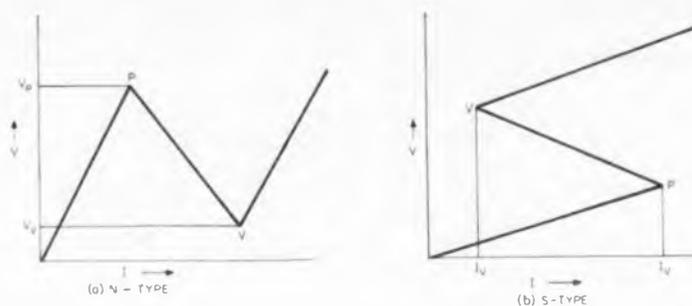


Fig. 1. V-I characteristic curves of negative resistance devices.

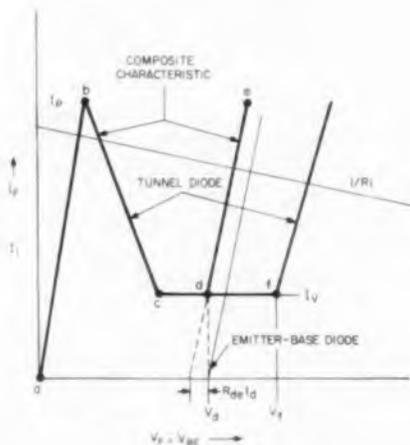


Fig. 3. Straight-line approximation of the composite device input characteristics where the emitter-base diode intersects the valley region of the tunnel diode.

minor change in the over-all results for the first case described must now be considered in light of the conditions illustrated in Fig. 5. Whereas previously, shifts in the transistor characteristics did not change the valley current for the composite curve shown in Fig. 3, such is not the case in Fig. 5. If line $c-d$ shifts downward by a value ΔV mv, I_c , the valley current for the composite, will shift upward by an amount equal to $\Delta V R_{bc}$ ma and the valley voltage for the over-all composite characteristic curve of Fig. 6 will shift upward by $R_1 \Delta V / R_{bc}$ v. Since R_1 is normally much larger than the value of R_{bc} , the resulting change in the valley voltage of the over-all characteristic will be much larger than the value of ΔV and the amount of change for the curve of Fig. 4a.

Development of the Characteristic Curve for the Practical Case

In the preceding analysis, the emitter-base diode was assumed to remain nonconducting until a certain threshold voltage was reached. Beyond this voltage the characteristic was assumed to rise in a linear manner. Actually, the

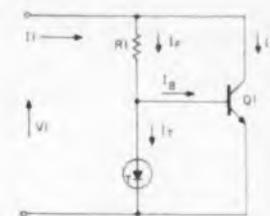


Fig. 2. Basic tunnel diode-transistor combination to convert "S" to "N" type characteristic.

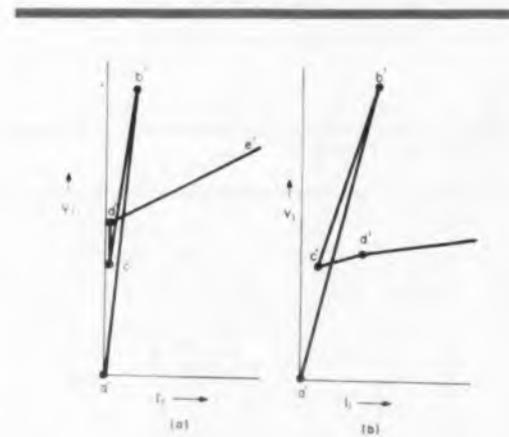


Fig. 4. Terminal voltage vs terminal current for conditions set in Fig. 3 is shown in (a) and for Fig. 4 is shown in (b).

diode characteristic curve is a logarithmic function. This means that for the practical form of the conditions shown in Fig. 3, the line $c'-d'$ will not be constant current but such that the current at any point d' may be much larger than that for point c' . All transitions will be more or less smooth curves rather than the very sharp ones indicated in the previously described straight-line analysis.

The peak voltage of a tunnel diode is low so the current flowing in the emitter-base diode at this level may be negligible as assumed. Triggering will actually occur when the load line of R_1 is tangent to the composite curve; for general considerations, this point will be very close to the peak point. Thus Eq. 1 still holds for the trigger voltage of the practical case and the "off" resistance will still be equal to R_1 .

The slope of the over-all composite characteristic curve bears a definite relationship to the relative values of the magnitude of the tunnel diode resistance, r_d , the transistor input resistance, R_i , and the transistor common emitter current gain, h_{fe} .

(continued on p 50)

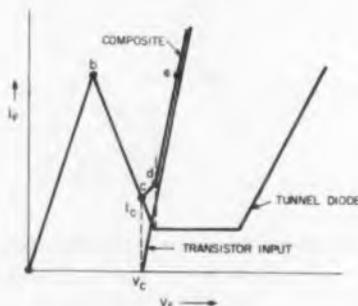


Fig. 5. Straight line representation of the input characteristic when base current flows before tunnel diode valley region is reached.

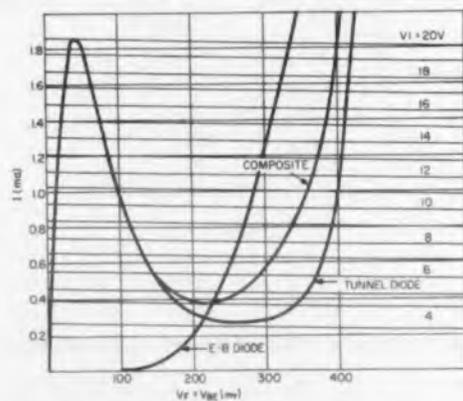


Fig. 7. Operating characteristic curve for a tunnel diode-transistor combination.

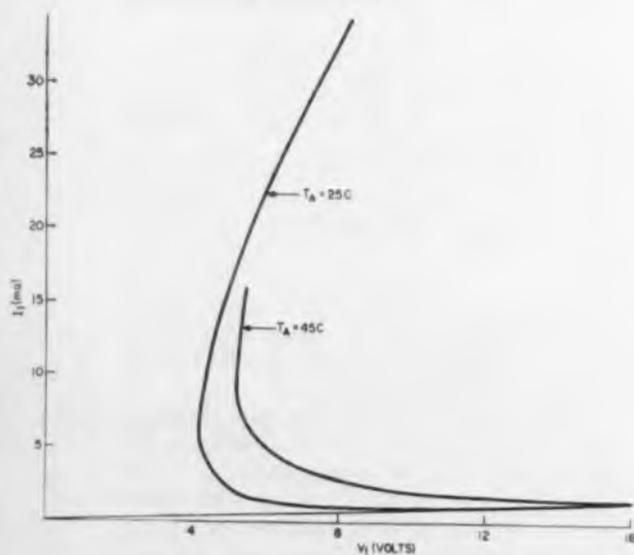
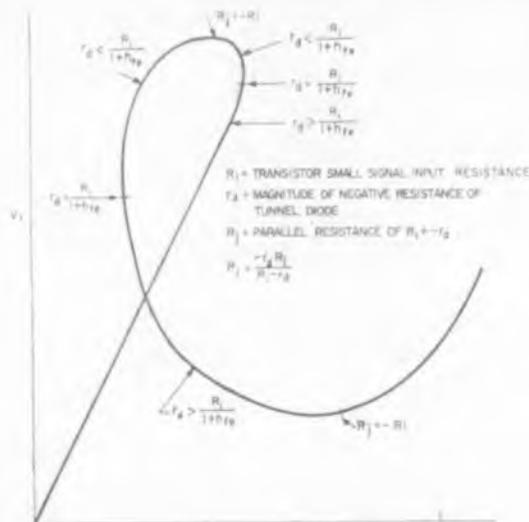
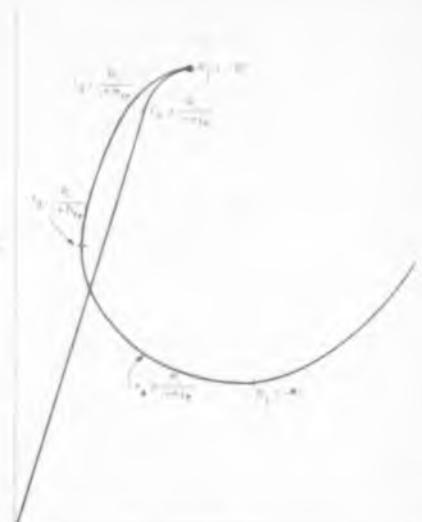


Fig. 8. Over-all characteristic developed from Fig. 7.



(a)



(b)

This relationship is given by Eq. 3 and is illustrated in Fig. 6a and b.

$$R_a = \frac{V_1}{I_1} = \left(\frac{R_1 + R_i}{R_i} \right) \left(\frac{1}{\frac{h_{fe} + 1}{R_i} - \frac{1}{r_d}} \right) \quad (3)$$

The over-all composite characteristic curve obtained will be of the nature shown in Fig. 6a if the value of r_d may be equal to $R_i / (1 + h_{fe})$ near the peak point with $|R_i|$ greater than the value of R_1 . If the voltage necessary to cause r_d to be equal to the value of $R_i / (1 + h_{fe})$ is greater than that necessary for $|R_i|$ to be equal to R_1 , a degenerate loop will be formed as indicated in Fig. 6b. The load conditions necessary for each case is shown in Fig. 6c.

In most cases, the size of the loop is quite small, being most apparent for a low design value of trigger voltage or where the emitter-base diode has a higher conduction voltage. The conditions shown in Fig. 6 have been greatly exaggerated for clarity.

Graphical Example Of Transistor-Diode Combination

As a practical example, a tunnel diode of peak current equal to 1.85 ma was combined with an npn alloy germanium transistor having an h_{fe} of 70 over a wide current range. The characteristic curves for the tunnel diode, the emitter-base diode for the transistor, and the parallel composite for the two are shown in Fig. 7. For the curves including the transistor, the collector voltage was held constant at 1.5 v. In actual use, however, the collector voltage is varying and may be substantially higher than 1.5 v with correspondingly higher junction temperature. The various load line conditions are shown for ter-

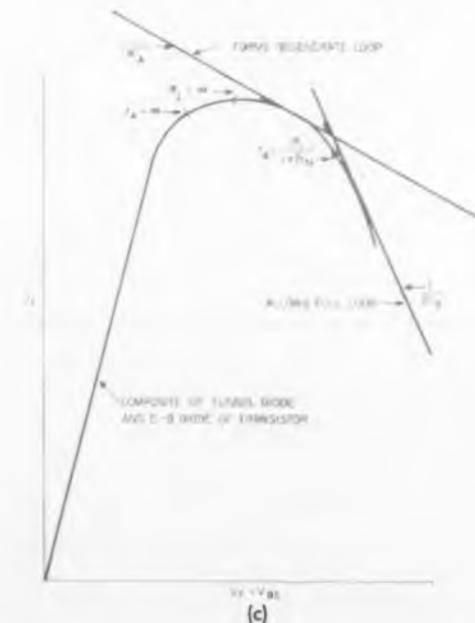


Fig. 6. Exaggerated input characteristics for a practical case. Full (a) or degenerate (b) loops will be formed depending on the load conditions (c).

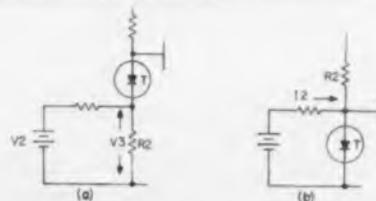


Fig. 9. Voltage bias (a) and current bias (b) used to shift the relative position of the tunnel diode and transistor input characteristics.

minimal voltage, V_1 , values of 4 to 20 v.

The voltage-current characteristic obtained by graphical analysis is shown in Fig. 8. An additional curve included in Fig. 8 is the curve obtained at an elevated temperature of approximately 45 C.

The room temperature characteristic of Fig. 8 has a very sharp peak region which indicates a loop of very small area. As the temperature is increased, the size of the loop becomes smaller.

Addition of Bias To Shift Input Characteristic

Voltage Bias: Voltage bias may be used to shift the relative positions of the tunnel diode and the transistor input characteristic curves. A practical means of obtaining a large region of negative resistance is shown in Fig. 9a. Resistor R_2 should be small in comparison to the tunnel diode resistances. Supply voltage V_2 may be derived from the same source used to supply the entire circuit if point "B" is made common.

Some characteristic curves obtained for various voltage bias conditions are shown in Fig. 10. The dotted lines indicate an approximate condition. The trigger voltage will remain relatively constant and will normally change only by an amount equal to the bias voltage. The application of bias may be extended to use with silicon transistors or may be used to compensate for differences in transistors. By making the bias voltage vary at the same rate as the change in V_{BE} with temperature, the stability of the over-all circuit may be substantially improved.

Current Bias: For an ideal switch, it is desirable that the "off" current and the "on" voltage both be zero. For the basic circuit of Fig. 2, the "off" current is determined mainly by resistor R_1 . The "on" voltage is a function of the relative shapes of the tunnel diode and the transistor input characteristics. From the composite curve shown in Fig. 8, the valley voltage may be determined as that value of V_1 which causes the load line of R_1 to be tangent to the valley region of the composite curve. Thus, the lower the composite valley current, the lower the value of valley voltage on the over-all characteristic of Fig. 8.

The composite curve of Fig. 7 may, in effect, be shifted downward by the application of a current source to the tunnel diode in the manner shown in Fig. 9b. The vertical shift will be equal to the bias current I_2 . The peak current will also be decreased by an amount equal to I_2 , and thus, for the same firing voltage, the value of R_1 must be increased; this will increase "off" resistance.

The three characteristic curves of Fig. 11 illustrate the effect of bias current applied in the manner described. Curve 2 represents a much more efficient switch than the condition with no bias current as shown by curve 1.

There is a limit as to how much bias current may be applied and hence how low the "on" voltage may be made. The current gain of the transistor falls off rapidly as the collector voltage is decreased below a few tenths of 1 v. Also, it is possible to cause a "locking" condition in which the switch may only be turned off upon the application of a reverse voltage pulse.

Characteristic curve number 3 of Fig. 11 shows the effect of applying a voltage bias and a current bias at the same time.

Circuit Predictability Improved by Collector Resistor

The presence of a resistor (R_2) in series with the collector allows the transistor to saturate very quickly thus allowing the "on" condition to be determined by the parallel combination of the two resistors, R_1 (Fig. 2) and R_2 . In Fig. 12 note how closely the curves for the over-all characteristic follow the dotted line representing the parallel combination of the two resistors.

While the addition of R_2 does reduce the efficiency of the switch, it does make it much more predictable. By selecting an operating point in the "on" region which is substantially removed from the turning point, the circuit becomes relatively unaffected by changes in temperature or in changes in transistor parameters. The higher the trigger voltage for which the circuit is designed, the better will be the adherence to the straight-line function.

Composite Device Responds to Short Duration Pulses

Although the N-type negative resistance composite device may be triggered in the same manner as other two terminal negative resistance devices, a third terminal is often desirable.

The junction of the tunnel diode and the transistor base serves as an ideal point at which to apply a trigger. The effect of a momentary trigger is that described earlier. Upon the application of a positive trigger (assuming an npn transistor), the peak trigger voltage will be decreased momentarily. If the normal "off" voltage is larger than the momentary value of the peak voltage, the circuit will fire.

The tunnel diode is a very high speed device and hence it may respond to trigger pulses only a few nanoseconds in length. Thus while the operating speed of the over-all composite device will be greatly dependent upon the speed of the transistor, a trigger of extremely short duration applied directly to the tunnel diode will actuate the circuit. It may be desirable to insert a very small inductance in series with the tunnel diode and the base of the transistor to decrease the effect of the high input capacitance presented by the transistor. ■ ■

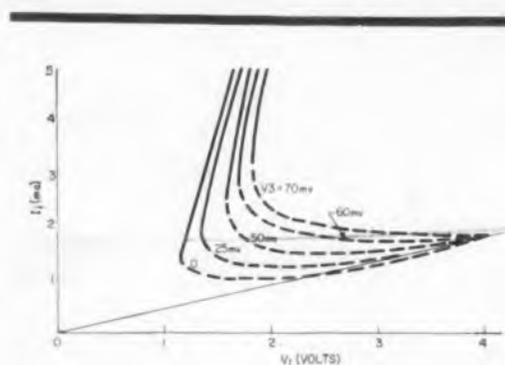


Fig. 10. Over-all input characteristic for various voltage bias conditions.

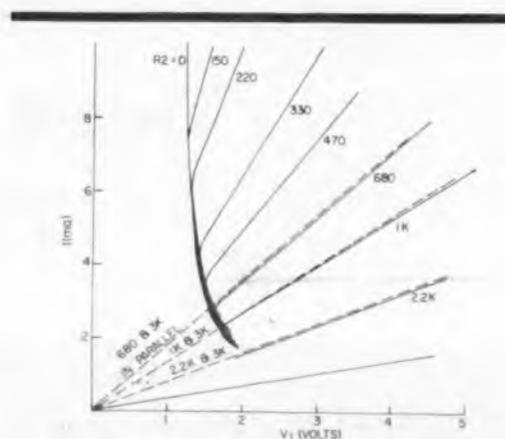


Fig. 11. Effect of current and voltage bias on over-all characteristic curve.

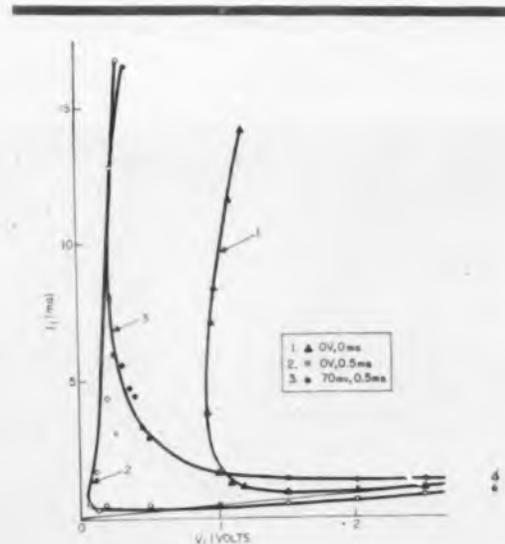


Fig. 12. Effect of series collector load resistor.

diodes
1961

Tunnel Diode Amplifier Calculator

A handy slide rule to reduce tedious calculations involved in the design of tunnel diode amplifier circuits.

Definition of Terms Used in Text

x_d —Tunnel diode barrier separation	r_d —Tunnel diode negative dc resistance
g_d —Tunnel diode negative dc conductance	r_s —Generator resistance
g_c —Generator conductance	r_{eff} —Tunnel diode effective negative resistance at frequency of interest
g_L —Load conductance	r_L —Load resistance
L_a —Added inductance	r_{td} —Tunnel diode bulk resistance
L_d —Tunnel diode lead inductance	R_T —Sum of $r_s + r_d + r_L + r_{td}$
L_s —Sum of L_a and L_d	
r_T —Added resistance	

Schematic diagram of a 100-mc tunnel diode amplifier in a series configuration.

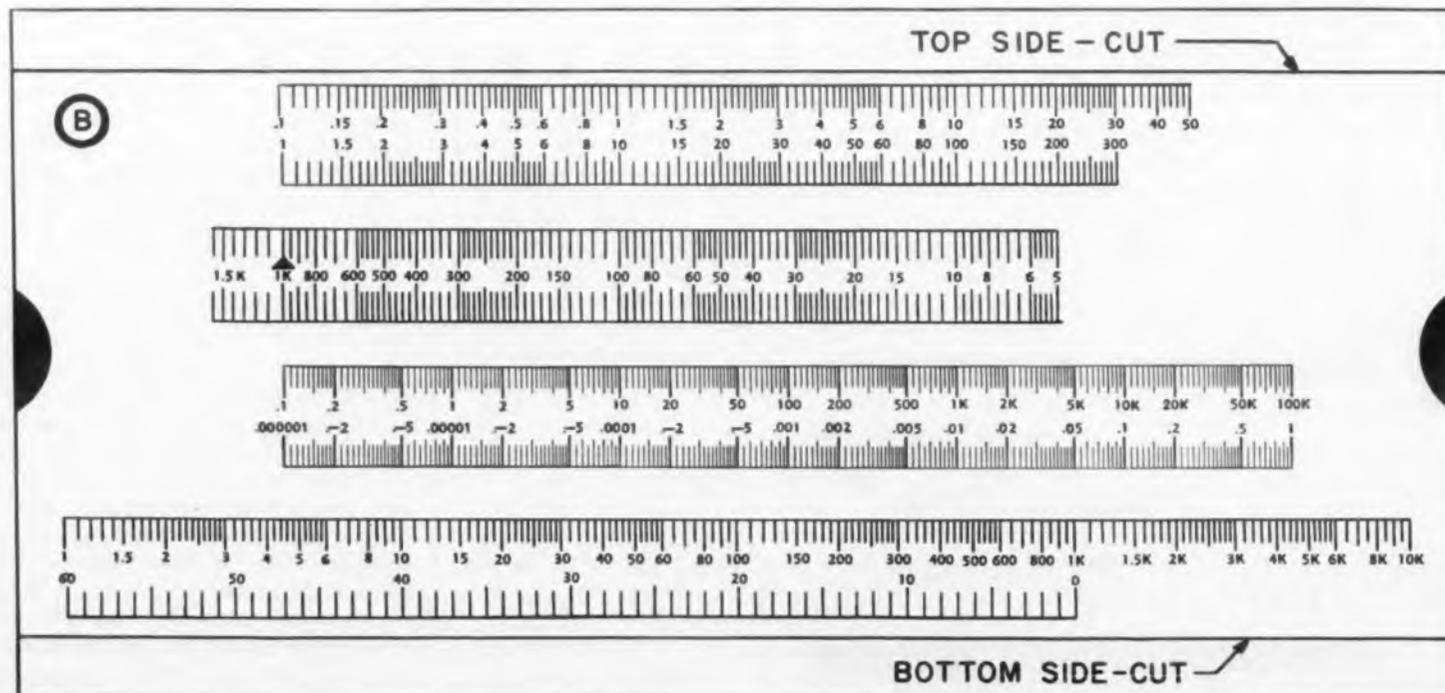
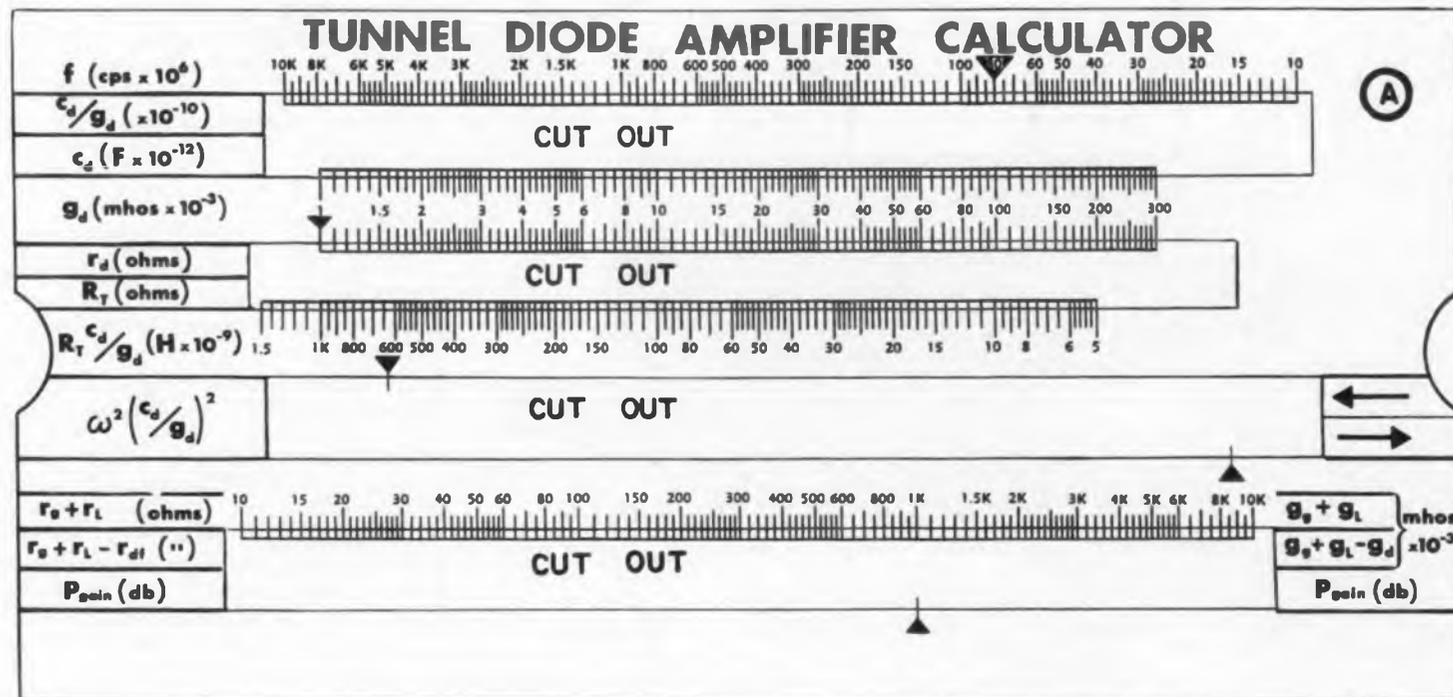
James R. McDermott
Electronics Consultant
McDermott Associates, Inc.
New York, N. Y.

DESIGN of tunnel diode amplifiers involves equations with time-consuming multiplication, division, and squaring of terms with large powers of 10. The Tunnel Diode Amplifier Calculator has been prepared to save substantial time and effort by reducing these calculations to simplified slide-rule operations.

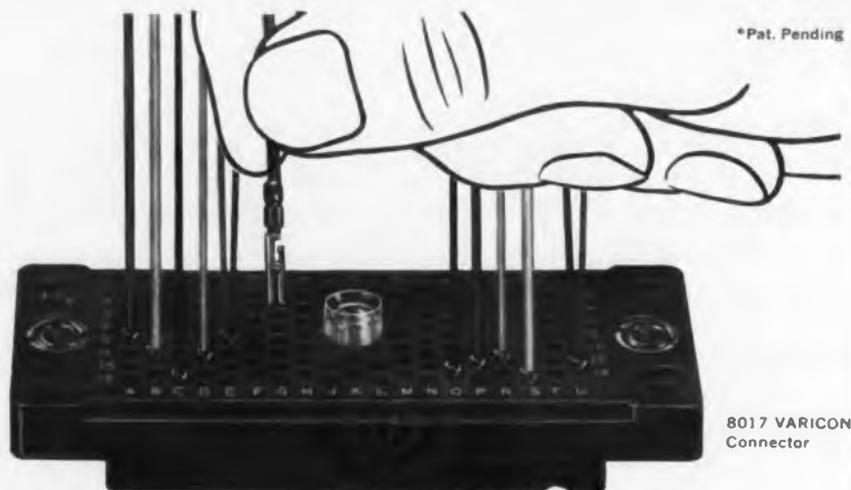
The Tunnel Diode Amplifier Calculator scales can be cut out and easily assembled. The scales are glued onto thin, tough cardboard or bristol board. The A scale is the top, fixed scale while the B scale slides underneath. Cut the edge strips from the B scale and glue them to the back of the A scale. These strips serve as spacers between the front and a solid back sheet and also as guides for the center slide movement.

Design Procedure Using Slide-Rule Calculator

The value of the calculator is demonstrated by an example involving a 100-mc series-type amplifier, operating between two 50-ohm transmission lines, shown in the schematic diagram. An initial requirement is that the amplifier be stable, which is satisfied by meeting the following requirements: (Continued on p 54)



For those engineers who are too busy to cut and paste, a prefabricated Tunnel Diode Amplifier Calculator may be obtained for \$2.00 from McDermott Associates, Inc., 1472 Broadway, New York 36, N.Y.



*Pat. Pending

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diodes
1961

$$L_i(g_d/c_d) < R_t < \frac{1}{g_d}$$

or

$$L_i < R_t (c_d/g_d)$$

In addition, it must be noted that in these amplifiers the resonant frequency is adjusted by variation of circuit resistance, while gain is controlled by adjustment of circuit inductance. With these factors in mind, proceed with amplifier design in accord with the following steps:

1. **Circuit Resistance** required for a given frequency is obtained from the following relations:

$$R_t = \frac{r_d}{1 + \omega^2 (c_d^2/g_d^2)} \quad (1)$$

Negative diode resistance r_d is obtained by aligning the arrow of the g scale with the arrow of the r_d scale, placing reciprocal values opposite each other. From the schematic, read, opposite 7 on the g_d scale, 143 for the value of r_d .

Next, solve for $\omega^2 (c_d^2/g_d^2)$. Move 5 pf of the c_d scale opposite 7 millimhos of the g_d scale. Under the arrow at 80 on the f scale, read $c_d/g_d = 7.2 (x 10^{-10})$. (Note: The arrow coinciding with 80 has no numerical relation to the f scale.) Set 7.2 of the c_d/g_d scale opposite 100 mc on the f scale. The slide is extended to the right, therefore, read the answer on the lower $\omega^2 (c_d^2/g_d^2)$ scale as 0.21. (Note: When the slide is extended to the left for this problem, read the answer on the upper scale, at the lefthand arrow.)

Total circuit resistance R_t is now found by simple pencil division of $143/1.21$, in accord with Eq. 1, thus giving 118 ohms. But the circuit resistance of $r_d + r_s + r_L$ is only 102 ohms, which means an added 16 ohms (r_e) must be connected in series.

2. **Amplifier Gain** is controlled by the value of total circuit inductance L_t , which must be slightly smaller than $R_t (c_d/g_d)$ for maximum stable value. To find the value of $R_t (c_d/g_d)$, set the value of 7.2 on the c_d/g_d scale opposite the 80 arrow on the f scale. Then, read opposite 118 on the R_t scale, a value of 84.3 on the $R_t (c_d/g_d)$ scale, in millimicrohenries. L_t must therefore be somewhat less than this value.

In the schematic, series lead inductance L_s of 6 m μ h is given, but in practice this may vary from 2 to 12 m μ h. Consequently, L_s can fall between 72 and 82 m μ h, and a 50- to 100-m μ h variable inductance is connected in series to provide a wide range of gain adjustment.

3. **Bias Considerations** are few. The operation

of the diode is centered about an inflection point on its characteristic curve. For this example, it is 130 mv at 0.7 ma. The value of battery voltage and adjustable series dropping resistor are chosen so that the inflection point setting may be conveniently obtained. The rf bias decoupling choke has an inductance value which gives not less than 10 K at the operating frequency, in this case 15 μ h.

4. **Power Gain** is determined, for tunnel diodes, in terms of insertion gain. For the series circuit in the example, insertion power gain is given by:

$$P_{gain} = \frac{(r_g + r_L)^2}{(r_g + r_L - r_{df})^2} \quad (2)$$

In most literature, the $-r_{df}$ term is written as $-r_d$, implying the negative diode dc resistance can be used. However, this is incorrect (except for dc applications) since, in the series circuit, the *effective* negative resistance is governed at the frequency of interest by circuit inductance L_t . For this reason, the value of r_{df} is determined in accord with

$$r_{df} = L_t (g_d/c_d) \text{ ohms} \quad (3)$$

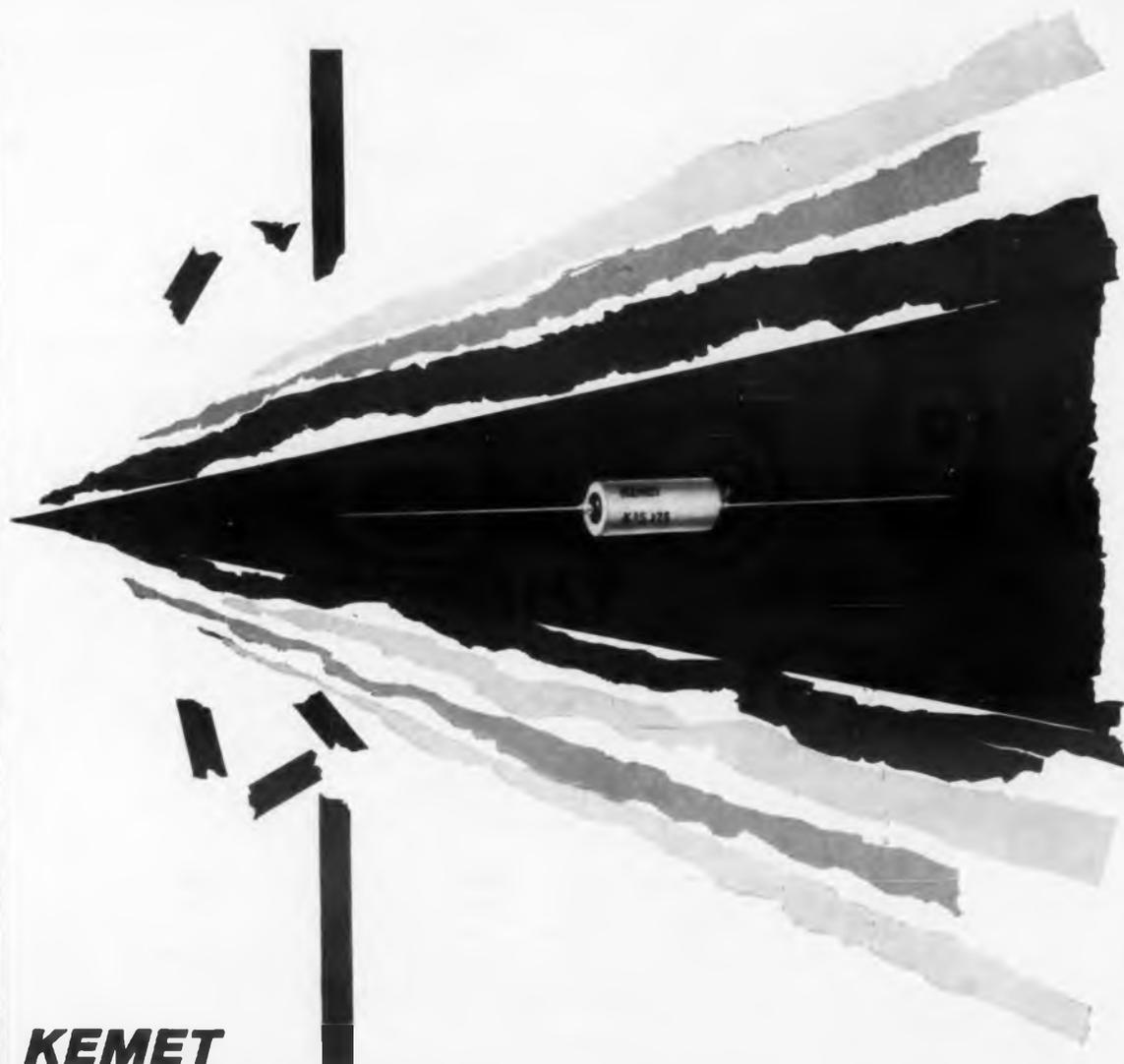
To find (g_d/c_d) on the calculator, align the left hand ends of the c_d/g_d and f scales. Opposite the known value of c_d/g_d , read the numerical value of g_d/c_d on the f scale and raise that value by 10^7 . For the example given, first align scales and then opposite 7.2 on the c_d/g_d scale read 140 on the f scale. Thus 140 by 10^7 or 1.4×10^9 is the value for g_d/c_d .

The solution of the power gain equation is simplified by the Tunnel Diode Amplifier Calculator because it eliminates handling squared terms. It is only necessary to add $r_g + r_L$ and $r_g + r_L - r_{df}$, place the latter term opposite the first on the slide rule and read the gain directly in decibels.

For the circuit given, the inductance L_t was adjusted to give an r_{df} of 103. Thus, $r_{df} = L (g_d/c_d) = 118$ ohms. Thus, $r_g + r_L = 100$, and $r_g + r_L - r_{df} = 3.16$ ohms, providing a power gain of 30 db. Increasing L_t sufficiently provided experimental gains up to 40 db. Much beyond this value, circuit instability becomes a problem.

For parallel-type tunnel diode circuits, the power gain is given by the same scales but the quantities are in terms of conductance in mhos $\times 10^{-3}$. Here, if the frequency of interest is much smaller than ω_s , the diode reactive frequency, the diode admittance is approximately equal to g_d and the dc value can be used.

For additional detailed information on tunnel diode amplifiers and factors affecting circuit gain, refer to "Designing with Tunnel Diodes" by U.S. Davidson et al., *ELECTRONIC DESIGN*, Feb. 3 and 16, 1960. ■ ■



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Latest Defense Department Diode List

The latest military listing of preferred and guidance type semiconductor diodes has recently been approved by the Department of Defense. Although the tabulation has not been officially blessed at the time of this writing, close sources involved in the preparation indicate the listing is complete and accurate.

Table 1. Small signal and power diodes.

V	50 ma	150 ma	250 ma	500 ma	1 A	5 A	12 A	20 A	35 A	50 A	70 A
50	1N483B	—	—	—	—	—	—	—	—	—	—
100	1N485B	—	—	—	—	—	—	1N249B	1N1184	1N2173	1N1397
200	1N486B	*1N645	*1N538	1N3189	*1N1124A	1N1614	1N1202	1N250B	1N1186	1N2174	1N1399
300	—	—	—	—	—	—	—	1N2135A	—	1N168	—
400	—	*1N647	*1N540	1N3190	*1N1126A	1N1615	1N1204	—	1N1188	—	1N1401
500	—	—	—	—	—	—	—	—	—	—	—
600	—	1N649	*1N547	1N3191	*1N1128A	1N1616	1N1206	—	1N1190	—	1N1403
800	—	—	1N560	—	—	—	—	—	—	—	—
1,000	—	—	1N561	—	—	—	—	—	—	—	—

Table 2. High voltage rectifiers.

V	45 ma @ 75 C	75 ma @ 100 C	100 ma @ 100 C	300 ma @ 25 C
1,500	—	—	*1N1731	*1N1130
3,000	—	—	*1N1733	*1N1131
5,000	—	*1N1734	—	—
12,000	1N1147	—	—	—
16,000	1N1149	—	—	—

Table 3. Germanium diodes.

V	30 ma	40 ma	75 ma
50	—	*1N276	—
80	1N933	—	—
100	1N198	1N270	*1N277

Table 4. Microwave diodes.

UHF		SHF		EHF	
L Band	S Band	X Band	K Band		
390 mc	1,550 mc	5,200 mc	10,900 mc		
↑	↑	↑	↑	↑	↑
1,000 mc *1N25 1N25A	3,060 mc *1N21WE *1N32 1N32A	9,375 mc *1N23WE *1N31 1N31A	16,000 mc *1N78 1N78C	23,984 mc *1N26 1N26B	34,869 mc *1N53 1N53B

* preferred

Table 5. Silicon switching diodes.

V	10 ma	100 ma	400 ma
Slow Speed (0.8 μsec — 0.3 μsec)			
75-100	—	—	1N691
Fast Speed (0.3 μsec — 10 μsec)			
75-100	—	—	1N697
175-200	—	1N3070	—
Very Fast Speed (< 10 μsec)			
20-50	1N3064	—	—
75-100	*1N914	—	—

Table 6. Voltage reference diodes.

V	TC			
	0.01%/C	0.005%/C	0.001%/C	0.0005%/C
6.2	1N821	1N823	1N827	—
8.4	1N3154	1N3155	1N3157	—
9.0	1N935B	—	1N938B	1N939B
11.7	1N941B	—	1N944B	1N945B

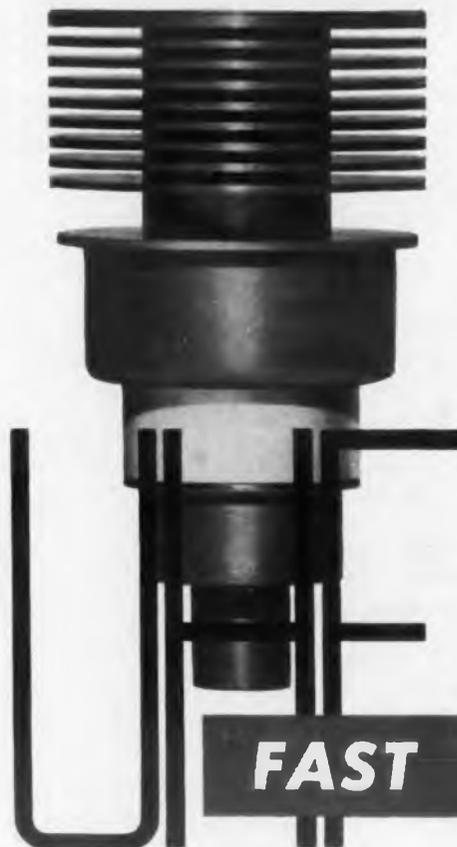
Table 7. Controlled rectifiers.

V	10 A	16 A @ 65 C	50 A
50	2N1771A	2N682	—
100	2N1772A	*2N683	—
200	2N1774A	*2N685	—
300	2N1776A	*2N687	—
400	2N1777A	2N688	—
500	—	2N689	—

Table 8. Voltage regulator diodes.

E _z Nom. V dc	Power			
	400 mw	1 w	10 w	50 w
3.3	*1N746A	—	—	—
3.6	*1N747A	—	—	—
3.9	*1N748A	—	—	—
4.3	*1N749A	—	—	—
4.7	*1N750A	—	—	—
5.1	*1N751A	—	—	—
5.6	*1N752A	—	—	—
6.2	*1N753A	—	—	—
6.8	*1N754A	1N3016B	1N2970B	1N2804B
7.5	*1N755A	1N3017B	1N2971B	1N2805B
8.2	*1N756A	1N3018B	1N2972B	1N2806B
9.1	*1N757A	1N3019B	1N2973B	1N2807B
10	*1N758A	1N3020B	1N2974B	1N2808B
11	1N962B	1N3021B	1N2975B	1N2809B
12	1N963B	1N3022B	1N2976B	1N2810B
13	1N964B	1N3023B	1N2977B	1N2811B
15	1N965B	1N3024B	1N2979B	1N2813B
16	1N966B	1N3025B	1N2980B	1N2814B
18	1N967B	1N3026B	1N2982B	1N2816B
20	1N968B	1N3027B	1N2984B	1N2818B
22	1N969B	1N3028B	1N2985B	1N2819B
24	1N970B	1N3029B	1N2986B	1N2820B
27	1N971B	1N3030B	1N2988B	1N2822B
30	1N972B	1N3031B	1N2989B	1N2823B
33	1N973B	1N3032B	1N2990B	1N2824B
36	1N974B	1N3033B	1N2991B	1N2825B
39	1N975B	1N3034B	1N2992B	1N2826B
43	1N976B	1N3035B	1N2993B	1N2827B
47	1N977B	1N3036B	1N2995B	1N2829B
51	1N978B	1N3037B	1N2997B	1N2831B
56	1N979B	1N3038B	1N2999B	1N2832B
62	1N980B	1N3039B	1N3000B	1N2833B
68	1N981B	1N3040B	1N3001B	1N2834B
75	1N982B	1N3041B	1N3002B	1N2835B
82	1N983B	1N3042B	1N3003B	1N2836B
91	1N984B	1N3043B	1N3004B	1N2837B
100	1N985B	1N3044B	1N3005B	1N2838B
110	1N986B	1N3045B	1N3007B	1N2840B
120	1N987B	1N3046B	1N3008B	1N2841B
130	1N988B	1N3047B	1N3009B	1N2842B
150	1N989B	1N3048B	1N3011B	1N2843B
160	1N990B	1N3049B	1N3012B	1N2844B
180	1N991B	1N3050B	1N3014B	1N2845B
200	1N992B	1N3051B	1N3015B	1N2846B

* preferred



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Table 9. Specification numbers for approved diodes.

Type	Specification	Type	Specification	Type	Specification	Type	Specification
1N21B	MIL-E-1/656	1N249B	MIL-S-19500/134(SigC)	1N663	MIL-E-1/1140(SigC)	1N1345	MIL-E-1/1190
1N21C	MIL-E-1/657	1N250B	MIL-S-19500/134(SigC)	1N664		1N1346	MIL-E-1/1191
1N21E	MIL-E-1/1155(USAF)	1N251	MIL-E-1/1023	thru		1N1347	MIL-E-1/1192
	Cancelled	1N253	MIL-E-1/1024A	1N672	MIL-S-19500/150(SigC)	1N1348	MIL-E-1/1193
1N21WE	MIL-E-1/1115	1N254	MIL-E-1/989B	1N674		1N1353	
1N23B	MIL-E-1/618	1N255	MIL-E-1/990B	1N675		1N1358	MIL-E-1/1236(SigC)
1N23C	MIL-E-1/295B	1N256	MIL-E-1/991B	1N701		1N1361	
1N23CR	MIL-E-1/550A	1N263	MIL-E-1/809B	1N673 and 1N947	MIL-S-19500/149(SigC)	1N1396	
1N23E	MIL-E-1/1231(SigC)	1N269	MIL-E-1/808(SigC)	1N691	MIL-S-19500/132(NAVY)	1N1397	
1N23WE	MIL-E-1/1117A	1N270	MIL-E-1/992A	1N696	MIL-S-19500/121(NAVY)	1N1399	
1N25	MIL-E-1/658	1N276	MIL-E-1/1025	1N697	MIL-S-19500/141(NAVY)	1N1400	MIL-E-1/1202(USAF)
1N26	MIL-E-1/659B	1N277	MIL-E-1/993A	1N709		1N1401	
1N26B	MIL-S-19500/128(SigC)	1N281	MIL-E-1/961	1N716		1N1402	
1N28	MIL-E-1/660A (cancelled)	1N315	MIL-E-1/1088(SigC)	1N718	MIL-E-1/1238(SigC)	1N1403	
1N31	MIL-E-1/661A	1N411B	MIL-E-1/1196(SigC)	1N720		1N1408	MIL-E-1/1172(SigC)
1N32	MIL-E-1/27A	1N412B	MIL-E-1/1151(SigC)	1N722		1N1413	MIL-E-1/1173(SigC)
1N38B	MIL-E-1/492B	1N413B	MIL-E-1/1194(SigC)	1N750		1N1414	MIL-S-19500/148(SigC)
1N39	MIL-E-1/777B(NAVY)	1N429	MIL-E-1/1134A(USAF)	1N746A		1N1415	MIL-S-19500/146(SigC)
1N44	MIL-E-1/377(NAVY)	1N430	MIL-S-19500/140(NAVY)	thru	MIL-S-19500/127(NAVY)	1N1416	
1N48	MIL-E-1/378(NAVY)	1N457	MIL-E-1/1026	1N759A		thru	
	Cancelled	1N458	MIL-E-1/1027	1N821		1N1424	MIL-S-19500/147(SigC)
1N53	MIL-E-1/497B	1N459	MIL-E-1/1028	1N823	MIL-S-19500/159(NAVY)	1N1482	
1N55A	MIL-E-1/487A(NAVY)	1N483B		1N827		1N1483	
1N55B	MIL-E-1/481A(NAVY)	1N485B	MIL-S-19500/118(NAVY)	1N914	MIL-S-19500/116(NAVY)	1N1743	
1N56A	MIL-E-1/549A(NAVY)	1N486B		1N933	MIL-S-19500/119(NAVY)	1N1425	
1N63	MIL-E-1/376B(NAVY)	1N538	MIL-E-1/1086 Cancelled	1N935B		thru	
1N67A	MIL-E-1/508(NAVY)	1N538	MIL-E-1/1084A	1N938B	MIL-S-19500/156(NAVY)	1N1483	MIL-S-19500/145(SigC)
	Cancelled	1N540	MIL-E-1/1087 Cancelled	1N939B		1N1484	
1N67A	MIL-E-1/508 Cancelled	1N540	MIL-E-1/1085A	1N941B		1N1485	
1N69A	MIL-E-1/142D	1N547	MIL-E-1/1083A	1N944B	MIL-S-19500/157(NAVY)	1N1744	
1N70A	MIL-E-1/154D	1N548	MIL-S-19500/97(SigC)	1N945B		1N1614	MIL-E-1/1240(SigC)
1N72	MIL-E-1/780A(NAVY)	1N549	MIL-S-19500/98(SigC)	1N962B		1N1615	MIL-E-1/1241(SigC)
1N78	MIL-E-1/662A	1N560	MIL-S-19500/167(NAVY)	thru	MIL-S-19500/117(NAVY)	1N1616	MIL-E-1/1242(SigC)
1N78B	MIL-S-19500/129(SigC)	1N561	MIL-S-19500/167(NAVY)	1N992B		1N1682	MIL-E-1/1195
1N78C	MIL-S-19500/130(SigC)	1N570	MIL-E-1/1275(USAF)	1N124A		1N1731	MIL-S-19500/142(SigC)
1N81A	MIL-E-1/155D(SigC)	1N592		1N126A	MIL-S-19500/104(NAVY)	1N1733	MIL-S-19500/142(SigC)
1N82A	MIL-E-1/1299(SigC)	1N593	MIL-E-1/1109(USAF)	1N128A		1N1734	MIL-S-19500/142(SigC)
1N93	MIL-E-1/895B(NAVY)	1N594		1N1130	MIL-E-1/1287(SigC)	1N1777	
1N126A	MIL-E-1/156C	1N595		1N1131		1N1778	
1N127A	MIL-E-1/157C	1N643	MIL-E-1/1171(SigC)	1N1147	MIL-E-1/1305(SigC)	1N1781	MIL-E-1/1235(SigC)
1N127B	MIL-E-1/1150(SigC)	1N645		1N1149	MIL-E-1/1306(SigC)	1N1791	
	Cancelled	1N646		1N1183		1N1795	
1N128	MIL-E-1/158B	1N647	MIL-E-1/1143(USAF)	thru	MIL-E-1/1135(USAF)	1N1804	MIL-E-1/1236(SigC)
1N145	MIL-E-1/811(NAVY)	1N648		1N1190		1N1807	
1N198	MIL-E-1/700	1N649		1N1199		1N1816A	
1N212	MIL-E-1/932A(NAVY)	1N658	MIL-E-1/1160(SigC)	thru	MIL-E-1/1108(USAF)	thru	MIL-E-1/1259(NAVY)
1N224	MIL-E-1/713	1N662	MIL-E-1/1139(SigC)	1N1206		1N1836A	
				1N1281		1N2052	MIL-E-1/1237(SigC)
				thru	MIL-E-1/1136(USAF)	1N2053	
				1N1288		1N2135A	MIL-S-19500/134(SigC)
				1N1324	MIL-E-1/1176(USAF)	1N2153	MIL-S-19500/91
				1N1341	MIL-E-1/1186	1N2172	MIL-E-1/1196
				1N1342	MIL-E-1/1187	1N2173	MIL-E-1/1151
				1N1343	MIL-E-1/1188	1N2174	MIL-E-1/1194
				1N1344	MIL-E-1/1189	1N2804B	
						thru	
						1N2811B	MIL-S-19500/114(NAVY)

Type	Specification
1N2813B	
1N2814B	
1N2816B	
1N2818B	
1N2819B	
1N2820B	
1N2822B	
thru	
1N2827B	MIL-S-19500/114(NAVY)
1N2829B	
1N2831B	
thru	
1N2838B	
1N2840B	
thru	
1N2846B	
1N2970B	
thru	
1N2977B	
1N2979	
1N2980	
1N2982	
1N2984	
1N2985	
1N2986	
1N2988	
thru	
1N2993	
1N2995	MIL-S-19500/124(SigC)
1N2997	
1N2999B	
thru	
1N3005B	
1N3007B	
1N3008B	
1N3009B	
1N3011B	
1N3012B	
1N3014B	
1N3015B	
1N3016B	
thru	MIL-S-19500/115A(NAVY)
1N3051B	
1N3189	
1N3190	MIL-S-19500/155(NAVY)
1N3191	
1N3154	
1N3155	MIL-S-19500/158(NAVY)
1N3157	
2N681	
thru	MIL-S-19500/108(NAVY)
2N688	
2N1771A	
2N1772A	
2N1774A	MIL-S-19500/108(NAVY)
2N1776A	
2N1777A	



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SILICON TRANSISTOR CORPORATION

Up to 19.6% less
cost per megohm!

Up to 14.1% more
ohms per pound!

HOSKINS ALLOY

815-R

Precision Resistor Wire



The trouble with using only one type of alloy wire in all of your precision resistors is that very often you and your customers end up paying for something that really isn't required so far as the end use is concerned. Now take Hoskins Alloy 815-R, for example. It's a relatively new custom-quality iron-chromium-aluminum composition. But a number of alert and cost-conscious manufacturers have already found that it possesses all of the physical and electrical properties necessary for many precision resistor applications. High strength, good ductility. Excellent resistance to corrosion. Controlled low temperature coefficient. What's more—and more to the point these days—they've also found that Alloy 815-R's lower density and higher electrical resistivity combine to give them very worthwhile savings. Up to 14.1% more ohms per pound—up to 19.6% less cost per megohm!

Yours for the Asking—If you're a man who fancies such figures, we'd like to send you an eyeful—namely: A handy little "Cost-per-Megohm" Comparator, plus a 12 page catalog that's loaded with technical data. If you also happen to make precision resistors, sample spools of 815-R wire are available for testing and evaluation.



Shaw from .0001" down to .0004"—Bare and enameled—Temperature Coefficients: $0 \pm 10\text{ppm}$ and $0 \pm 50\text{ppm}/^\circ\text{C}$.

HOSKINS MANUFACTURING COMPANY

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Producers of Custom Quality Resistance, Resistor and Thermo-Electric Alloys since 1908

CIRCLE 45 ON READER-SERVICE CARD

Air Clutch Boosts Torque, Cuts Size



A NEW air clutch, in a 1-in. diam case, provides almost five times the torque available with conventional magnetic clutches of the same size. In a 1/2 in. size, the air clutch shows even more dramatic improvement over magnetic clutches—a factor of almost 14.

The 1-in. (size 10) clutch is part of a line developed by Elm Instrument Corp., 30 Chasner St., Hempstead, L.I., N.Y., that now includes a size 5 and a size 10 and will include a size 18 in six weeks. Each clutch has two concentric, stainless-steel shafts extending from one end of the housing. The outer shaft has a 1/4 in. OD while the inner one, extending for a 1/2 in. beyond the end of the outer one, has an OD of 1/8 in. These shafts can be driven independently of each other, or they can be driven simultaneously. They can be driven in the same direction at different speeds or in opposite directions.

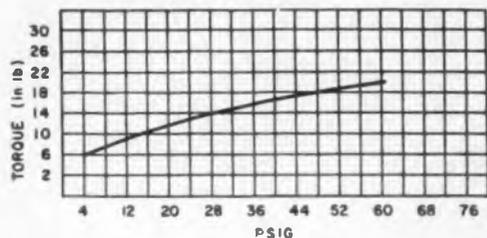
Now—an Even Smaller High-Temperature Trimpot® Potentiometer

Here, just $\frac{3}{4}$ " in length, is a wirewound potentiometer that is completely humidity-proof and operates at 175°C! Ideal for your printed circuit applications, it withstands 30G vibration and 100G shock, dissipates 0.5 watt at 70°C (0.2 watt at 125°C), and has tapered pins for quick, easy mounting.

Sealed against humidity in a high-temperature plastic case, the Model 3000 exceeds the requirements of MIL-STD-202A, Method 106. The 15-turn screwdriver adjustment permits pinpoint settings and the self-locking shaft keeps them accu-

rate. For maximum stability, the unit incorporates a ceramic mandrel. Reliability is outstanding. The exclusive Silverweld® bond between terminal and resistance wire is virtually indestructible under thermal or mechanical stress.

Available within 24 hours from factory and distributor stocks, the Model 3000 is stocked in resistances of 50 ohms to 20K. A Resiston® carbon version, Model 3001, is available with resistances of 20K to 1 Meg. Write for complete data and list of stocking distributors.



Breakaway torque vs inlet-air pressure for a size 10 air clutch.

The units come in green, anodized-aluminum housings. A hose adapter is provided which allows a clutch to be connected to any convenient air supply. The units can easily be driven by a low-cost, fish-tank, air pump.

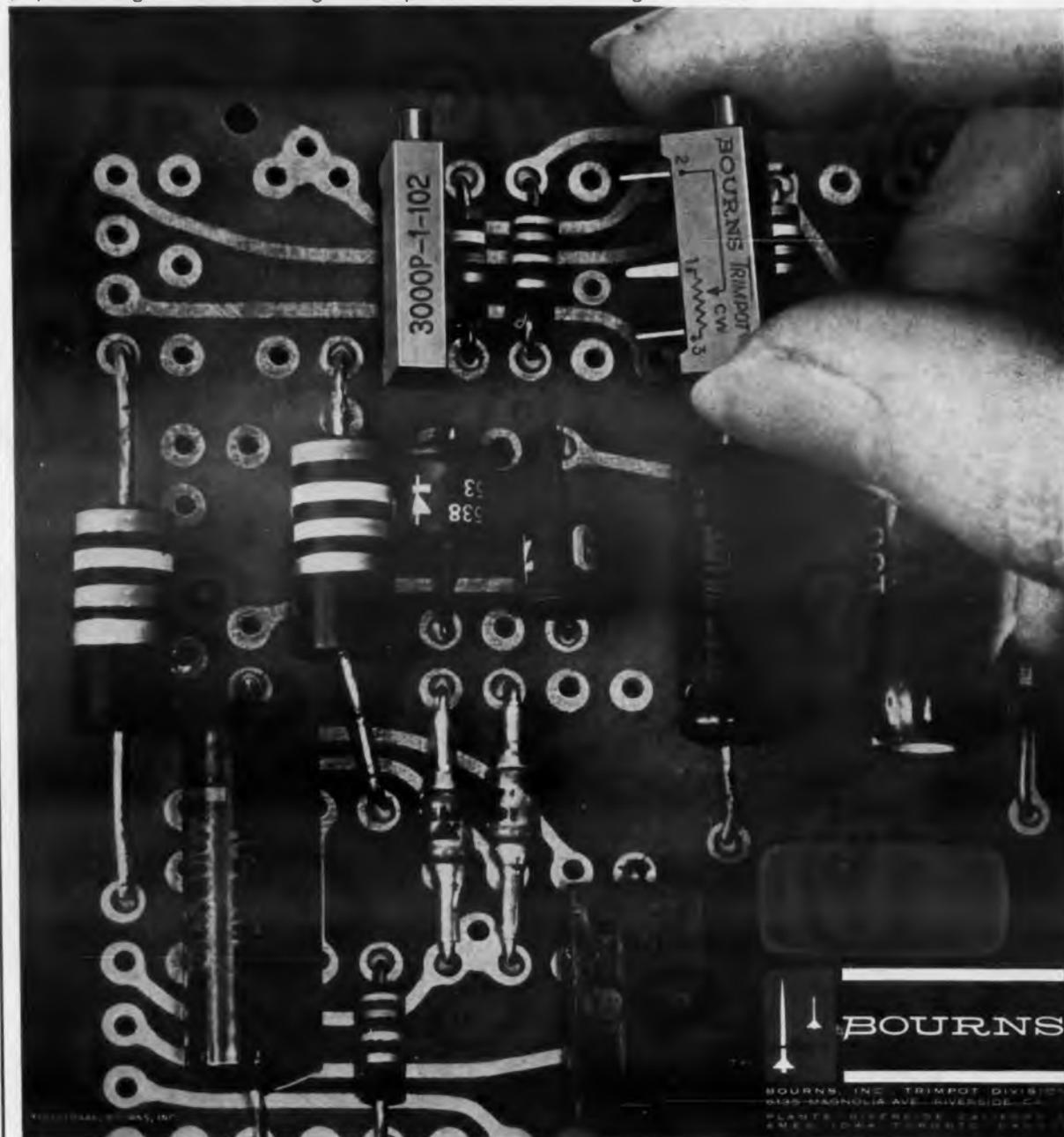
The size 10 air clutch develops a torque differential, of 320 in.-oz (at 60 psi inlet pressure) compared with the 72 in.-oz available with magnetic clutches. At 2 psi, the size 10 air clutch delivers a torque differential of 96 in.-oz. In the size 5, the torque differential at 60 psi is 48 in.-oz compared with 3.5 in.-oz for magnetic clutches.

The clutches are powered by air pressure delivered through a 3/16 in. ID tube. Their response times are less than 4 msec.

Using ABEC Class 5 bearings the air clutches can operate in a temperature range from -5 F to +400 F. They are also available with oil-impregnated bronze bearings at lower cost. The air clutches are all designed to pass the severe environmental specifications in MIL-T-5422.

Unit price for the size 10 clutch is \$138.69 for quantities of 1 to 10. The price drops to \$134.53 for 11 to 25 units, to \$131.76 for 26 to 50 units, to \$128.29 for 51 to 100 units, to \$124.82 for 101 to 500 units, and finally, to \$110.95 for more than 500 units. Prices are about 10 per cent lower for the size 5. The clutches are available for immediate delivery.

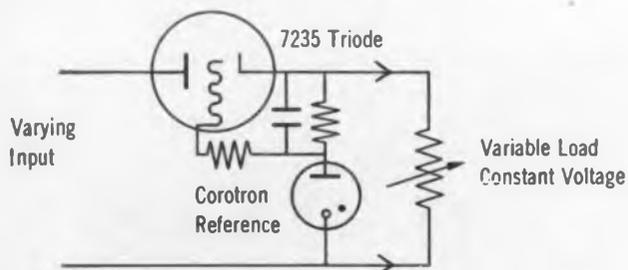
For more information on these small, high-torque, air clutches, turn to the Reader-Service Card and circle 251.



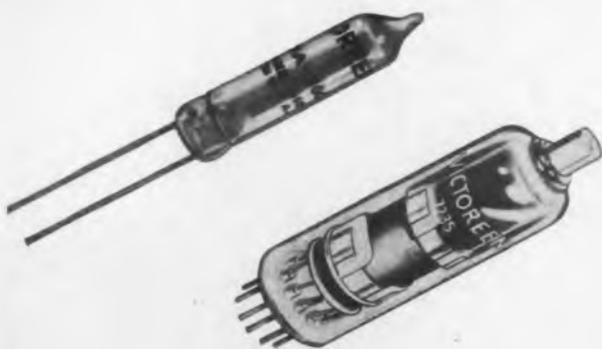
Exclusive designers and manufacturers of Trimpot® potentiometers. Pioneers in transducers for position, pressure, acceleration. CIRCLE 46 ON READER-SERVICE CARD

Hi-Voltage...

$E_0 = \text{Constant}$



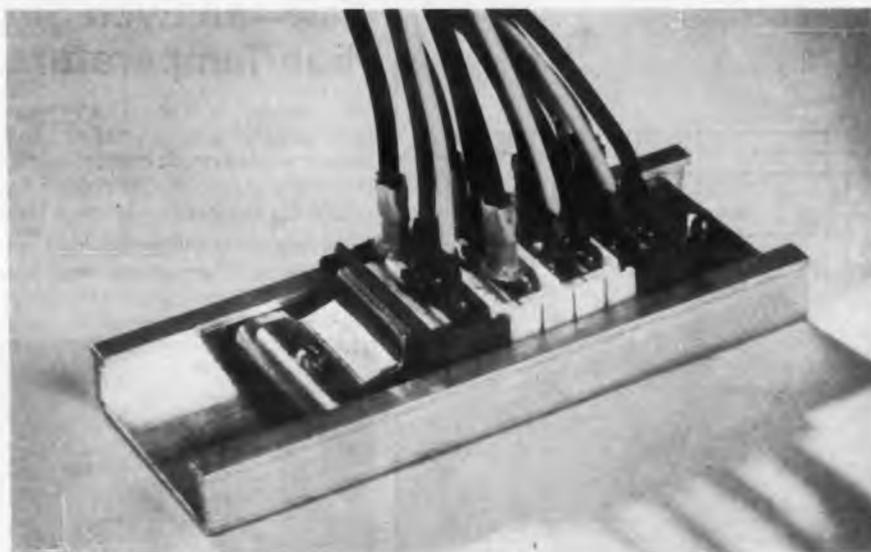
*sophisticated results
from simple circuit*



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- *400 to 25,000 volts*
- *reduces ripple*
- *higher reliability*
- *economy of cost, weight and space*

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CIRCLE 47 ON READER-SERVICE CARD

A-4138A



Assembled terminal block stack is locked into aluminum track.

Modular Terminal Panel Wiring Block



Tab terminals lock into modular cage assembly without use of tools.

VERSATILE power control circuiting for switchboards, control panels, and industrial instrumentation is provided by a newly designed modular terminal block. The modular technique allows rapid, simple change of stack configurations to suit the many variations of wiring logic.

Manufactured by AMP Inc., Eisenhower, Blvd., Harrisburg, Pa., the Termi-Blok uses modular 3-circuit common and 6-circuit common insulated cage assemblies which fit into an extruded aluminum track. The cages are made of tin-plated brass, and are housed in nylon insulators. Within each of the cage assemblies, a slotted, stainless steel spring member accepts tab terminals without necessity of any mechanical adjustment. No tools are needed for insertion or withdrawal. Individual cages can be added anywhere in the stack.

The heavy-duty terminal block is rated at 35-amp continuous current, or maximum wire temperature of 105 C. Voltage drop of the cage assembly, measured

between the end terminals of a 3-way cage, is 10.0 mv maximum at 12 amp. The block has a 125 per cent current-cycling overload capacity; insulation resistance is 1,500 v dc at sea level. Components withstand vibration, corrosion and humidity tests in accordance with military specifications.

The insulated cage assembly is available in two styles: series 3, accommodating 3 circuits per linear inch of track, and series 4, with 4 circuits per inch. One size of track width will accept both series. Series 3 has a higher, thicker nylon insulator to permit an increased creepage distance of 5/8 in. minimum with a 1/4-in. strike distance, for high-current applications or use where heat dissipation is important.

The high density afforded by this cage design, 0.275 in. center-to-center lineal spacing for series 4 and 0.333 in. for series 3, is further complemented by the front-loading feature of the modules.

Tab terminals are joined to circuit wires by a manual or automatic compression crimp. The 0.031-in. thick tab will accommodate wire sizes from 14 to 22 AWG. Insertion force is 2 lb min to 15 lb max; withdrawal force is 5 to 15 lb. The 0.040-in. thick terminal accepts wire sizes from 10 to 12 AWG; withdrawal force is slightly heavier than in the thinner tab. Pre-insulated terminals are color-coded by wire size.

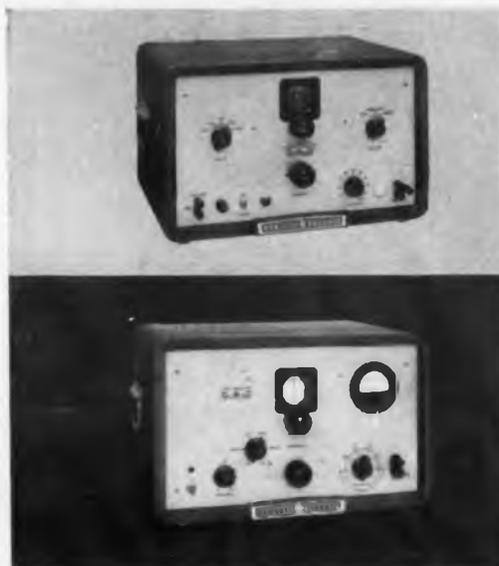
Cage assemblies are available in 10 colors of nylon insulators for color coding of circuitry. An end-barrier nylon insulator, one per stack length, is used to enclose the last cage in the stack.

The extruded aluminum track is supplied either plain or coated with polyvinylchloride. Desired length is cut with a hacksaw from the standard 6-ft section. The 0.200-in. lip on either side of the track permits use of adhesive marking tape for identification of circuits.

A coaxial cable support bracket, to be available on special order, will hold a connector in the track to accommodate 2 coaxial conductors.

Price of the modules is less than \$0.10 per circuit in large quantities, \$0.15 each in small quantities. Standard items are available from stock; special orders are filled in 4 to 6 weeks.

For more information on these modular power control terminal blocks, turn to the Reader-Service Card and circle 252.

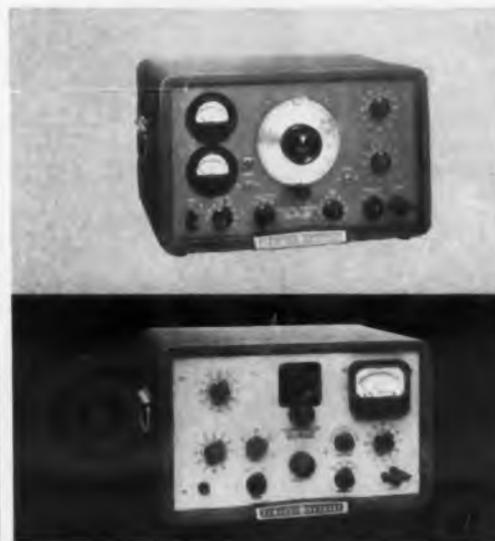


**Easy to operate,
highly stable,
wide range**



PRECISION OSCILLATORS

precision oscillators perform a wide variety of audio, video, and low frequency tests. They offer the outstanding advantages of flexibility and broad usefulness at moderate cost. Employing the pioneered RC resistance capacity circuit, the units combine accuracy and reliability with ease of operation and minimum adjustment.



pioneered the world-famous
resistance-capacity
oscillator circuit

202A FUNCTION GENERATOR—Down to 0.008 cps; transient-free!

Uses: Electrical simulation of mechanical phenomena, vibration studies, servo research and testing, medical research, geophysical problems, subsonic and audio testing.

Advantages: No switching transients, continuously variable 0.008 to 1,200 cps range, 30 v output peak-to-peak constant, hum less than 0.05%, square, triangular or electronically synthesized sine waves, 1% stability, 0.2 db response, less than 1% distortion (sine waves) on all but x 100 range.

Price: \$550.00 (cabinet model), \$535.00 (rack mount).

650A TEST OSCILLATOR—Flat within 1 db, 10 cps to 10 MC!

Uses: Testing TV amplifiers or wide-band systems, measuring filter transmission characteristics and tuned circuit response, determining receiver alignment, making telephone carrier and bridge measurements.

Advantages: No zero set, no adjustments during operation, output voltage range 30 μ v to 3 v, less than 1% distortion, 20 cps to 100 KC; less than 2%, 100 KC to 1 MC; approx. 5% at 10 MC. Hum less than 0.5%, output voltage attenuator, self-contained voltmeter, 2% to 3% stability.

Price: \$550.00 (cabinet model), \$535.00 (rack mount).

205AG AUDIO SIGNAL GENERATOR—Six instruments in one; 20 cps to 20 KC!

Uses: Measure amplifier gain and network frequency response, measure broadcast transmitter audio and loudspeaker response, drive bridges, use in production testing or as precision source for voltages. Monitors oscillator output, measures output of device under test.

Advantages: Self-contained instrument, no auxiliary equipment needed. 5 watts output, \pm 1 db response, less than 1% distortion, hum more than 60 db down, no zero setting, output and input meters read v and dbm; four output impedances.

Price: \$600.00 (cabinet model), \$585.00 (rack mount).

206A AUDIO SIGNAL GENERATOR—Less than 0.1% distortion; 20 cps to 20 KC!

Uses: Convenient, precision audio voltage source; checks FM transmitter response, makes high quality, high fidelity amplifier tests, transmission measurements.

Advantages: Continuously variable audio frequency voltage, (output 15 dbm) 0.2 db response, hum 75 db down, 2% frequency accuracy, less than 0.1% distortion. 111 db attenuator with 0.1 db steps.

Price: \$900.00 (cabinet model), \$785.00 (rack mount).

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

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6428

CIRCLE 48 ON READER-SERVICE CARD



Digital Clock Times Long Periods

676

Designed to serve as a long-duration data timer or as date-time source for data-processing equipment, digital clock provides a binary-coded output of day, hour and minute. Output is contact closure; a visual readout is also provided. With no tubes or transistors, the design gives trouble-free service.

Electro-Logic Corp., Dept. ED, 515 Boccaccio Ave., Venice, Calif.
P&A: \$895; 30 days.

NEW PRODUCTS

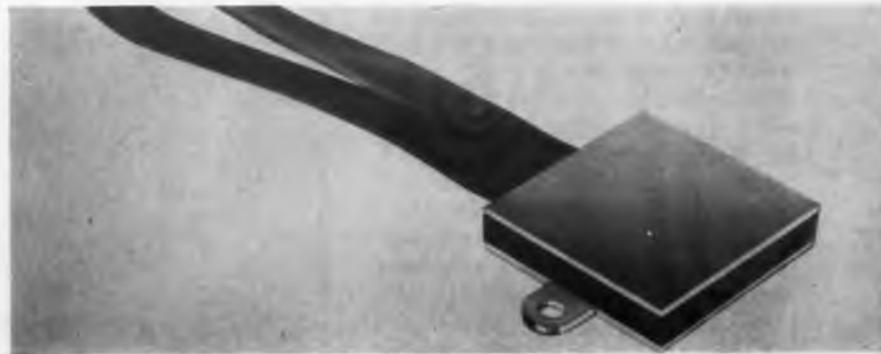
Covering all new products generally specified by engineers designing electronic original equipment. Use the Reader-Service Card for more information on any product. Merely circle number corresponding to that appearing at the top of each description.



Silicon Power Varactors 675 Available in 55 Models

Silicon varactor diodes MA-4351A-G through MA-4358A-F offer a wide variety of piv ratings from 6 to 120 v, and junction capacitance values (measured at breakdown voltage) ranging from 0.1 to 50 pf. The 55 models provide high-efficiency harmonic generation from 1 to 40,000 mc. The pill case has axial prongs, one of which may be removed for mounting on tapped posts. Junction series resistance values range from 1.1 to 21 ohms. The diodes are hermetically sealed and meet military environmental tests. The two large units in the photo show construction of the varactors, four of which are arrayed below the postage stamp.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.
Availability: Sample quantities



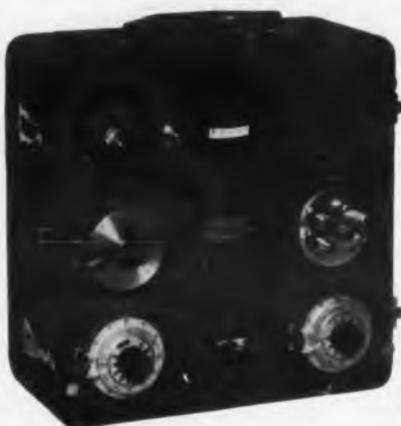
Thermoelectric Junctions In Arrays and Modules

674

Spot cooling of power transistors and other components is provided by the TA-20 array and TA-20M module, both containing a group of smaller junctions. The rigidly constructed module, measuring 1-1/2 x 1-1/2 x 1/2 in., can pump more than 20 w or typically attain a temperature differential in excess of 80 C. With 1/16-in. aluminum plates on top and bottom, the module is ready for use as a complete thermoelectric unit.

Ohio Semiconductors, Dept. ED, 1205 Chesapeake Ave., Columbus 12, Ohio.

Price: TA-20, \$85.19 to \$58.79; TA-20M, \$91.06 to \$60.71.



Capacitance Bridge For Electrolytic Capacitors

677

Model 1W1 capacitance and dissipation factor bridge is for the measurement of both tantalum and aluminum electrolytic capacitors. It has provisions for 2-, 3- and 4-terminal measurements. An optional 0 to 600 v dc polarizing power supply is available. Specifications for capacitance are: range, 0 to 120,000 μ f; accuracy, $\pm 1\%$ +10 pf; sensitivity, $\pm 0.1\%$ +10 pf. Specifications for dissipation factor are: range, 1 to 120%; accuracy, $\pm (2\% + 0.1\%$ dissipation factor); sensitivity, $\pm (0.2\% + 0.05\%$ dissipation factor).

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

P&A: \$845; May 1, 1961.



678

For Solid-State Scalers

All solid-state preset timer model 855-B is designed for use with any transistorized scaler. Two interchangeable time bases, 10-kc crystal controlled oscillator and 60-cps line, are easily changed by inserting plug-in cards. A five-digit neon readout expresses elapsed time in multiples of tenths of a sec for the 60-cps time base and multiples of one hundred thousandths of a minute for the 10-kc time base. Preset circuitry operates on any single digit. Any digit may be preset in any decade, one decade at a time. All other decades are preset to zero automatically.

Eldorado Electronics, Dept. ED, 2821 Tenth St., Berkeley, Calif.

P&A: \$1,600 with 10-kc oscillator, \$1,460 without; 60 days.

SM GROUP

Optional 0.1% or 0.01% regulation:

3½" PANEL HEIGHT

0.1% REGULATION MODELS	DC OUTPUT RANGE VOLTS AMPS	0.01% REGULATION MODELS
SM 14-7M	0-14 0-7	SM 14-7MX
SM 36-5M	0-36 0-5	SM 36-15MX
SM 75-2M	0-75 0-2	SM 75-2MX
SM 160-1M	0-160 0-1	SM 160-1MX
SM 325-0.5M	0-325 0-0.5	SM 325-0.5MX

5¼" PANEL HEIGHT

SM 14-15M	0-14 0-15	SM 14-15MX
SM 36-10M	0-36 0-10	SM 36-10MX
SM 75-5M	0-75 0-5	SM 75-5MX
SM 160-2M	0-160 0-2	SM 160-2MX
SM 325-1M	0-325 0-1	SM 325-1MX

8¾" PANEL HEIGHT

SM 14-30M	0-14 0-30	SM 14-30MX
SM 36-15M	0-36 0-15	SM 36-5MX
SM 75-8M	0-75 0-8	SM 75-8MX
SM 160-4M	0-160 0-4	SM 160-4MX
SM 325-2M	0-325 0-2	SM 325-2MX



SM GROUP

Precise, reliable performance in a wide choice of output ranges.

Three rack sizes: 8¾" H, 5¼" H, and 3½" H. Impervious to operational damage: circuit protection is an inherent function of input transformer and regulator characteristics.

HB GROUP

Optional 0.1% or 0.01% regulation:

3½" PANEL HEIGHT

0.1% REGULATION MODELS	DC OUTPUT RANGE VOLTS MA	0.01% REGULATION MODELS
HB 2M	0-325 0-200	HB 20M
HB 4M	0-325 0-400	HB 40M
HB 6M	0-325 0-600	HB 60M
HB 8M	0-325 0-800	HB 80M



HB GROUP

Exceptional performance: delivers 0-325 v dc at 200, 400, 600 or 800 ma from one standard 3½" H rack-mounting package.

Incorporates many "special" features as standard: constant current mode, remote programming, remote dc on-off control.

PR GROUP

7" PANEL HEIGHT

MODEL	DC OUTPUT RANGE VOLTS	AMP
PR 15-30M	0-15	0-30
PR 38-15M	0-38	0-15
PR 80-8M	0-80	0-8
PR 155-4M	0-155	0-4
PR 310-2M	0-310	0-2



PR GROUP

A flexible new general-purpose line of semi-conductor power supplies. Adjustable wide-range outputs.

$\pm 1\%$ line regulation; semi-regulated for load. Many standard modifications available.

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CIRCLE 49 ON READER-SERVICE CARD

Circuit Designers...

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IN TO-3 PACKAGE
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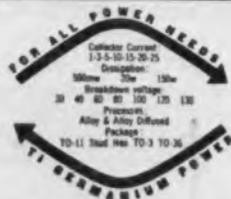
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Replace your low dissipation units with TI 150-watt devices now! Call your nearest TI sales engineer for price, delivery and application information.

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I_{C}	5a	5a	7a	7a	7a	10a	10a	10a	10a	10a	15a	15a	15a	20a	20a	20a	25a	25a	25a
BV_{CBO}	30v	60v	40v	60v	80v	100v	120v	40v	60v	80v									



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NEW PRODUCTS

Acoustic Transducer 650



An acoustic transducer, named the Oyster, is designed to operate under water. Able to tolerate water pressure up to 60 psi, the device has a frequency range from 10 cps to 10 kc. Below resonance, it has a nondirectional, flat, -82 db response referred to 1 v per microbar.

Clevite Ordance Div. of Clevite Corp., Dept. ED, 540 E. 105 St., Cleveland, Ohio.

Porcelain Capacitor 657

In radial design. End radial porcelain capacitor model VY is available in reduced size. Standard thickness of $5/32 \pm 1/32$ in. and width of $9/32 \pm 1/32$ in. provides more stable mounting on printed-circuit boards. The unit is available in capacitance values from 10 pf to 1,000 pf.

Vitramon, Inc., Dept. ED, Box 544, Bridgeport 1, Conn.

DC Voltage Standard 649



New dc voltage standard and null voltmeter, model 302, provides short-term stability better than 25 ppm and 30-day stability better than 50 ppm. Output voltages can be set from 1.000 to 502.110 v in 1-mv increments. Instrument can deliver 20 ma. Output impedance is less than 0.01 ohm for dc, less than 0.2 ohm at 1 kc.

Kin Tel Div. of Cohu Electronics, Inc., Dept. ED, 5725 Kearny Villa Road, Box 623, San Diego 12, Calif.
Availability: 30 days.

◀ CIRCLE 50 ON READER-SERVICE CARD

Accelerometer

651



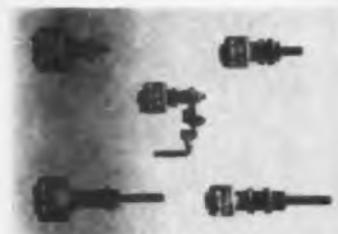
Model 58SC accelerometer includes provision for self calibration even after installation. Acceleration range is from 0.02 g to 40,000 g with maximum cross sensitivity of 5%. Temperature range is -65 to +350 F for standard units and -65 to +500 F for high-temperature units.

Columbia Research Laboratories, Dept. ED, MacDade Blvd. and Bullens Lane, Woodlyn, Pa.

Price: \$295 for 1 to 5 units.

Hermetic Switches

653



A line of hermetically sealed, rugged, control switches includes spdt, dpdt, and 4pdt switches. The 28-vdc switches carry 5 amp for resistive loads, 2.5 amp for inductive loads, 4 amp for motor loads, or 2.4 amp for lamp loads. Ambient temperature range is from -65 to +250 F.

Controls Co. of America, Dept. ED, Control Switch Div., 1420 Delmar Drive, Folcroft, Pa.

Servo Actuator

662

Is self-contained. Model 410 contains a servo amplifier, servo valve and hydraulic cylinder. It can be furnished with any stroke length from 1 to 6 in. and cylinder diameter from 1-1/4 to 2-1/2 in. Power supply is built in and command can be by potentiometer or external signal. Speeds are up to 40-in. per sec and frequency response is to 40 cps with 90 deg lag.

American Measurement and Control Inc., CompuDyne Corp., Dept. ED, Hatboro, Pa.

CIRCLE 51 ON READER-SERVICE CARD ►

SILICON DIODE

All silicon glass diodes of the same type number, regardless of the manufacturer, must meet minimum requirements. Meeting these requirements is one thing, but consistently surpassing them is another.

Princeton silicon diodes are subjected to the most rigid control possible . . . computer control. Computer logic applied to both manufacture and testing produces the most reliable and most predictable silicon glass diodes possible.

Each lot of diodes has a computer control record, containing the complete history of the specific lot. Customers may compare this record with their own standards to analyze and predict the performance of the diodes.

Over 100 types are now available from Princeton Electronics Corporation . . . your most logical source for ultra-reliable, subminiature silicon diodes specifically designed to meet demanding military and industrial computer applications. Write today for short form catalog of available ratings.

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RELIABILITY

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NEW JERSEY

NEW PRODUCTS

Commutator Simulator 654



Two solid-state telemetry checkout instruments, a commutator simulator and a decommutator feature portability and 1 per cent accuracy. The simulator generates repetitive pulse frames for either pam or pdm. It can frame any number of pulses to operate at any repetition rate. The decommutator receives pam or pdm pulses and provides the analog of the information in any desired pulse. Both instruments are available with 30, 45, 60, or 90 channels. They each weigh 7 lb.

Crestmont Consolidated Corp., Dept. ED, Crestmont Electronics Div., 2201 W. Burbank Blvd., Burbank, Calif.

P&A: \$1,200 per unit; 3 weeks.

Miniature Relay 660

Has glass-to-metal hermetic seal. The relay, called the centipede, has eight terminals and four mounting pins which fit on 0.200-in. centers for standard printed-circuit grid mountings. Glass-to-metal sealing and recessed leads set in epoxy are used. A dpdt type, it is available in voltage and current sensitive models with coil resistances from 0.1 to 11,600 ohms. It measures 0.4 x 0.8 x 0.875 in.

Control Dynamics Corp., Dept. ED, 7420 Fulton Ave., North Hollywood, Calif.

Push Button Switch 659

Has quadrant lighting. A cellularized module and associated push rod allows any quadrant of the Quadlite push button switch to be lighted individually. It has a spdt switch rated at 5 amp at 125/250 v ac, 4 amp at 30 v dc, resistive, or 2.5 amp at 30 v dc inductive.

Controls Co. Of America, Control Switch Div., Dept. ED, 1420 Delmar Drive, Folcroft, Pa.

NEW FROM WESTINGHOUSE AT YOUNGWOOD



New Westinghouse High Gain Transistor simplifies circuitry, increases reliability, eliminates driver stage components, reduces cost of assembly.

NEW WESTINGHOUSE SILICON POWER TRANSISTOR PROVIDES

GAIN OF

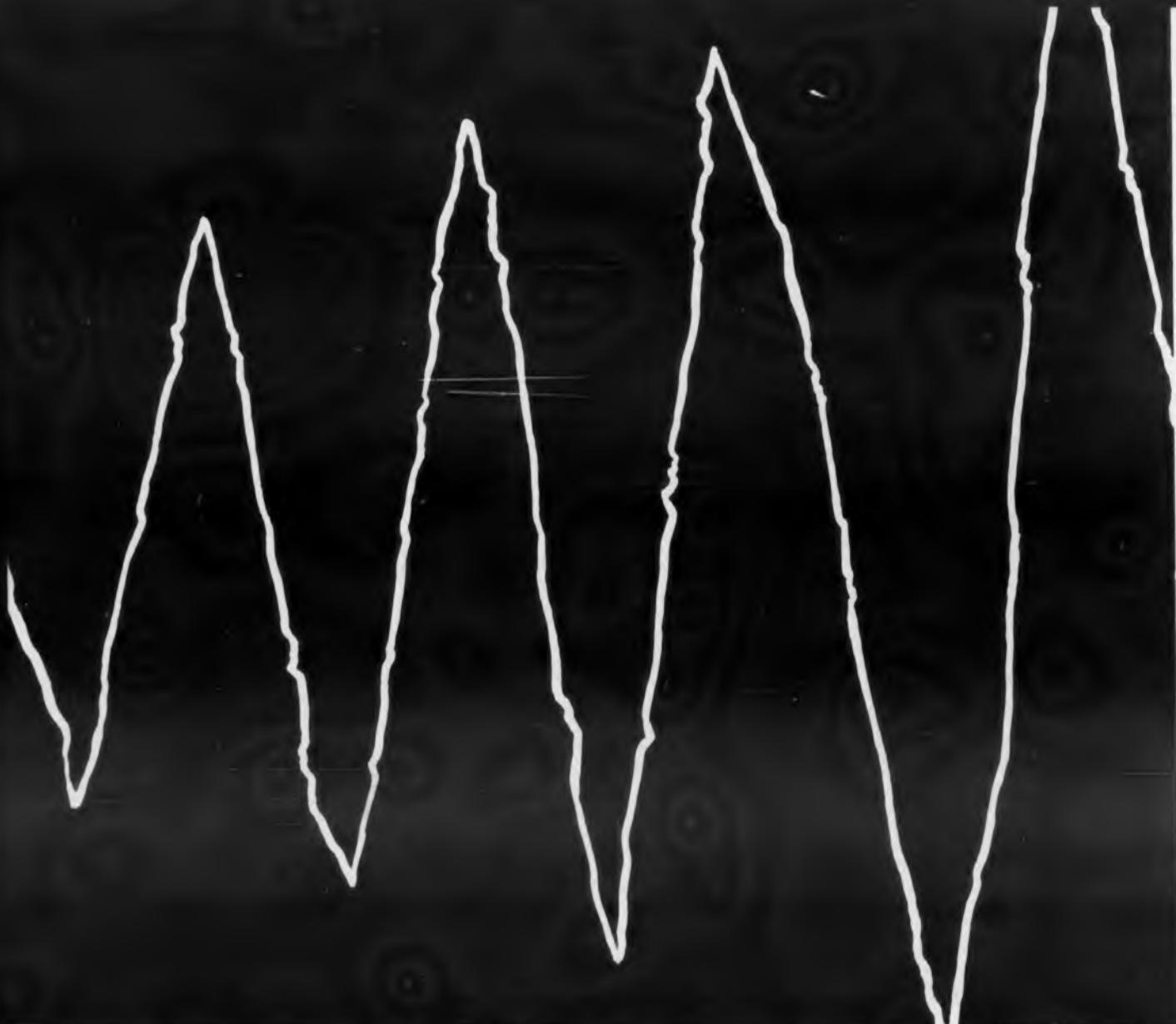
Westinghouse introduces a complete new family of High Gain Silicon Power Transistors providing a gain of 1000 or more at 2 amps . . . with guaranteed minimum gain of 400 at 10 amps (WX118X series) . . . a guaranteed minimum gain of 100 at 10 amps (WX118U series). These devices can substantially reduce circuit components, increase reliability, save space and weight.

They're ideal for application in high power, high efficiency regulators, amplifiers and switching circuits. For example, 1500 watts of power can be easily controlled with a 50 milliwatt signal! For full information call your nearest Westinghouse representative or write to Semiconductor Dept., Youngwood, Penna. You can be sure . . . if it's Westinghouse.

sc-1025

OTHER FEATURES INCLUDE

- True Voltage Ratings to 150 volts
- Power dissipation of 150 watts
- Collector current—10 amperes
- Operating temperature to +150°C.
- Low thermal impedance: .5°C/watt



1000 AT 2 amps!

Prototype quantities now available. Order from these Westinghouse Distributors.

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Melbourne, Florida/PA 3-1441
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PIONEER 6-6520.

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CIRCLE 52 ON READER-SERVICE CARD

◀ CIRCLE 53 ON READER-SERVICE CARD



Now, in
Strain Gage
Pressure
Transducer
Applications...

THROW AWAY YOUR AMPLIFIER!

The Fairchild 3S-G is the industry's first commercially-available line of solid-state strain gage pressure transducers that produce a 5-volt d-c output signal!

This revolutionary new line of precision instruments offers improvement on the desirable characteristics of conventional strain gage pressure transducers, piezo-electric pressure transducers and potentiometer-type pressure transducers.

The 3S-G is small (approx. 3 inches long) and lightweight (approx. 5 ounces) and does not require external amplification.

3S-G pressure transducers are rugged. They are responsive to both static and high-frequency dynamic inputs. They possess extraordinary environmental capabilities, and are extremely accurate. They produce a high-output signal and are completely solid-state which assures the ultimate in reliability. The 3S-G with all these features, is also competitively priced.

3S-G
TRIPLE
Solid State Strain Gage Transducer



3S-G pressure transducers are available in new and versatile performance variations — for military and industrial applications. Write for new catalog.

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CONTROLS CORPORATION

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223 Park Avenue, Micksville, L. I., N. Y.

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TRANSDUCERS • RATE GYROS • POTENTIOMETERS • ACCELEROMETERS

CIRCLE 54 ON READER-SERVICE CARD

NEW PRODUCTS

Panoramic Receiver

632



Range 100 to 150 mc. Model Pan 1F panoramic receiver has no moving parts and features an electronic sweep and inertialess tuning. The highly sensitive receiver scans from 100 to 150 mc at 22 sweeps per sec and furnishes a visual display of all signals through the range. Frequency measurement accuracy is 0.2%; dynamic range is 60 db. Expanded sweep displays 1-, 5- or 10-mc sections. Power requirement is 117 v, 400 cps. The 3-chassis set weighs a total of 60 lb.

Trak Electronics Co., Inc., Dept. ED, Wilton, Conn.

Antenna Multicoupler

633

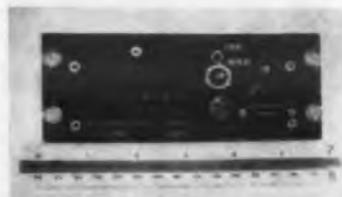


Is transistorized. Model 7 wideband antenna multicoupler operates from 2 to 32 mc, providing outputs for 8 receivers from a single antenna. The solid-state unit has input and output impedance of 75 ohms. Insertion gain is 2 db, noise figure less than 8 db. Input vswr is 1.7:1, output vswr 1.14:1. Unit weighs about 10 lb.

Trak Electronics Co., Inc., Dept. ED, Wilton, Conn.

Switching Deck

628



With narrow switches. Any desired number of switches can be stacked in the series SD101 switching deck. Individual switches measure 7/16 in. wide. Switch depth behind panel is 1-3/4 in., height 1-5/8 in. Number of switching sequences per switch is 1 to 10. The units meet military specifications.

Valor Instruments, Inc., Dept. ED, 13214 Crenshaw Blvd., Gardena, Calif.

“ Say,
what's this
I hear
about LFE
making
read/write
heads for
magnetic drums
and
tape?”

“They have been
making them
for years
for their own
systems!
Now they're
available
to the industry.
Why don't you
write for
further info?”

LFE

LABORATORY FOR ELECTRONICS
DATA STORAGE OPERATIONS
COMPUTER PRODUCTS DIVISION
1079 COMMONWEALTH AVENUE
BOSTON 15, MASS. DEPT. 817 - E

Please send me complete data on
your magnetic read/write heads.

Name _____

Title _____

Company _____

Division _____

Address _____

CIRCLE 55 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 26, 1961

Modular Solderer

652



An automatic soldering system for production-line soldering of pc boards and in-line terminals is made of a number of independent modules. Modules are available for soldering, fluxing, preheating, cleaning, drying, scrubbing, and cooling. Solder temperature and contact time can be varied. Wave soldering can be used or jet soldering.

Compo Shoe Machinery Corp., Dept. ED, Special Products Div., 125 Roberts Road, Waltham 54, Mass.

Static Inverter

655



Solid-state static inverter Model SI-2 converts 22 to 28 v dc to an output of 115 v $\pm 10\%$, single phase, 60 cps. Sinusoidal output waveform has less than 5% total harmonic distortion. Output power is 350 va. Size is 9 x 10 x 11 in. over-all. The inverter meets environmental requirements.

Kidde Aero-Space Div., Walter Kidde & Co., Inc., Dept. ED, 9 Brighton Road, Clifton, N.J.

Electromagnet

663

Has 51,500 gauss field. Model 18A-LI-HI electromagnet has high field, large gap and high homogeneity. The 1-1/2-in. diam pole tips. Maximum power of the magnet is 200 kw for low impedance coils and 12 kw for high impedance coils.

Pacific Electric Motor Co., Dept. ED, 1009 66th Ave., Oakland, Calif.

For

USAF MINUTEMAN:

a never-failing stream of chilled water for 3 years.

Assignment:

For Boeing Airplane Company—design and produce a highly reliable water chiller for constant temperature control of Minuteman's guidance and control section. **Achievement:** A water

chiller designed and produced for an MTBF of 232,558 hrs.; failure rate $.430 \times 10^{-5}$. **Engineering Design**

Features: 1. Elimination of potential breakdown due to electrical contacts by utilizing a "solid state" activated modulating hot gas by-pass valve.

System operates continuously, decreasing failure rate inherent in start-stop operation. 2. Elimination of many moving parts. Example: Capillary tube replaces expansion valve. 3. Hermetic refrigeration system, elimination of rotating seal. Immediately operational, even after prolonged storage. 4. Temperature of supply water controlled to ± 0.2 F. (Exceeded specification requirement of ± 1.0 F.)

5. "Flooded chiller" assures minimum capacity variance in ambient range of 50 F to 110 F. 6. Adjustable temperature

range of supply water from 36 F to 46 F. 7. Withstands

acoustical blast of 140 decibels. 8. Meets the following

specifications: (1) Salt spray — MIL-E-4970; (2)

Shock and vibration (while operating)— ± 7.5 G,

.4" double amplitude, Range 5 to 12 cps.; (3) Radio

interference — (STL) GM07-59-2617A. 9. Main-

tenance requirements extremely low due to features

1 through 4. 10. Reduction of bulk through elimination

of moving parts and simplification of

design. Unit measures 17.75" x 20.75"

x 33.85" h. Highly transportable

and highly adaptable to various

installations where available

space is critical factor. 11. Ellis

and Watts performed all

tests and supplied detailed

reliability analysis

report with water

chiller units.



**ELLIS AND WATTS
PRODUCTS, INC.**

Creative Engineering In

Temperature and Humidity Control

• Air Conditioners • Liquid Coolers

• Dehumidifiers • Console Coolers

P.O. Box 330, Cincinnati 36, Ohio

NEW PRODUCTS

Predetermining Counters

627



Register 1,500 counts per min. Series 1801 predetermining counters use rotary preset switches for convenience. Reset time is 150 msec; up to 1,500 counts per min can be registered. Models are available for original equipment makers and existing equipment users. Units have 1 or 2 rows of preset dials, with 4 or 6 decades.

Electronic Controls Div., Veeder-Root Inc., Dept. ED, Danvers, Mass.

DC Motor

629



Has low rf noise. Low-cost, long-life dc motor series 317 uses a transistor inverter. The unit operates without brushes or governor, for increased reliability and elimination of radio interference.

Bristol Motors Div., Vocaline Co. of America, Inc., Dept. ED, Old Saybrook, Conn.

Heat Sink

642



Requires small volume. Semiconductor cooler model NC-401 is said to require half the space of other standard natural convection units. Thermal resistance is 2.8 to 0.8 C per w for natural convection, and down to 0.25 C per w with forced cooling.

Wakefield Engineering, Inc., Dept. ED, 414 Main St., Wakefield, Mass.

Availability: Stock.

SALESPower

NEW PRODUCTS WITH—

MALLORY MERCURY BATTERIES



A NEW VOICE FOR THE SPEECHLESS

This new electronic larynx developed by Bell Telephone Laboratories and manufactured by Western Electric Company transmits sound waves into the throat cavity of a person whose larynx has been paralyzed or removed. Tiny Mallory Mercury Batteries power the transistor circuit, provide full power throughout their long life.



ELECTRONIC GARAGE DOOR OPERATOR made by H. W. Crane Co. transmits a radio signal to operate garage door from inside car. The compact, transistorized control is powered by Mallory Mercury Batteries. These tiny cells deliver long, dependable service with a constant voltage output.



CONVERTING CURRENT TO VOLTAGE, the new Hewlett-Packard AC current probe simplifies measurements of alternating current. Two Mallory Mercury Batteries provide the instrument's low impedance power supply, with fade-free service of approximately 400 hours.



PLOTTING THE EARTH'S MAGNETIC FIELD is one of the many uses for this portable Gaussmeter from F. W. Bell, Inc. Power source for this sensitive, transistorized instrument, Mallory Mercury Batteries assure good voltage stability over long periods of time and a very high capacity per unit volume.

Want to miniaturize? Make a new product more portable? Get longer battery life, with fewer changes? You'll get all these sales-building extras—and more—from Mallory Mercury Batteries. Here's power that won't fade in use . . . never dies in storage. These tiny cells last many times longer than conventional batteries . . . are packed with much more capacity per unit size. They're leak-proof . . . operate over a wide temperature range . . . provide constant voltage discharge that's ideal for transistor circuitry.

We have a broad line of standard single or multiple voltage cells . . . and we'll develop custom power packs for you. For consultation and engineering data, write Mallory—the mercury battery pioneers.

Mallory Battery Company, North Tarrytown, N. Y.
a division of



In Canada: Mallory Battery Company of Canada Limited
Toronto 4, Ontario

In Europe: Mallory Batteries, Ltd., Dagenham, England

Vacuum Oven

631



Operates at 800 C. Commercial vacuum oven can operate at temperatures to 800 C and pressures as low as 0.000001 mm. Temperature uniformity is ± 3 from 0 to 800 C. Heating and control elements are in the vacuum chamber to afford even temperatures and precise readings of temperature and vacuum.

Tri Metal Works, Inc., Dept. ED, Riverton, N. J.

Line Monitor

640



In portable case. The 400-cycle line monitor of the Shop-Lab series of precision portable instruments uses two expanded-scale meters. Frequency meter accuracy is 0.05%, voltmeter accuracy 0.5%. The rugged instrument is lightweight and compact.

Voltron Products, Inc., Dept. ED, 1020 S. Arroyo Parkway, Pasadena, Calif.

Price & Availability: \$375; 30 days.

Rectifier Cooler

641



Has low thermal resistance. Rectifier cooler model NC-423 offers low thermal resistance per unit volume: 0.8 C per w with natural convection, down to 0.3 C per w with forced air. Special units for high-power rectifier stack designs are available with natural-convection thermal resistance as low as 0.5 C per w.

Wakefield Engineering, Inc., Dept. ED, 414 Main St., Wakefield, Mass.

CIRCLE 57 ON READER-SERVICE CARD

New

CORNING CYFM CAPACITOR

has reliability you can see

You get total protection against environment for less money than ever before

The new Corning CYFM capacitor gives you reliability at a markedly lower cost than that of any like capacitor.

The CYFM goes far beyond MIL-C-11272B specs. It has proved its performance through more than 3,000,000 hours of testing. It took a 50-day MIL moisture test and a 96-hour salt spray test with no measurable effects. We stopped testing only when it became evident that no more significant data could be developed. The CYFM went through other tests, with solvents, fluxes, boiling salt, and steam, to make sure it is the most completely sealed capacitor you can buy.

You'll see why the CYFM can take such torture when you check its design. We stack alternate layers of stable ribbon glass and aluminum foil. Then we weld the foils to the bead-terminal assembly, which has a glass bead sealed to the Dumet wire lead. With heat and pressure, the entire capacitive element is frozen in glass for complete protection

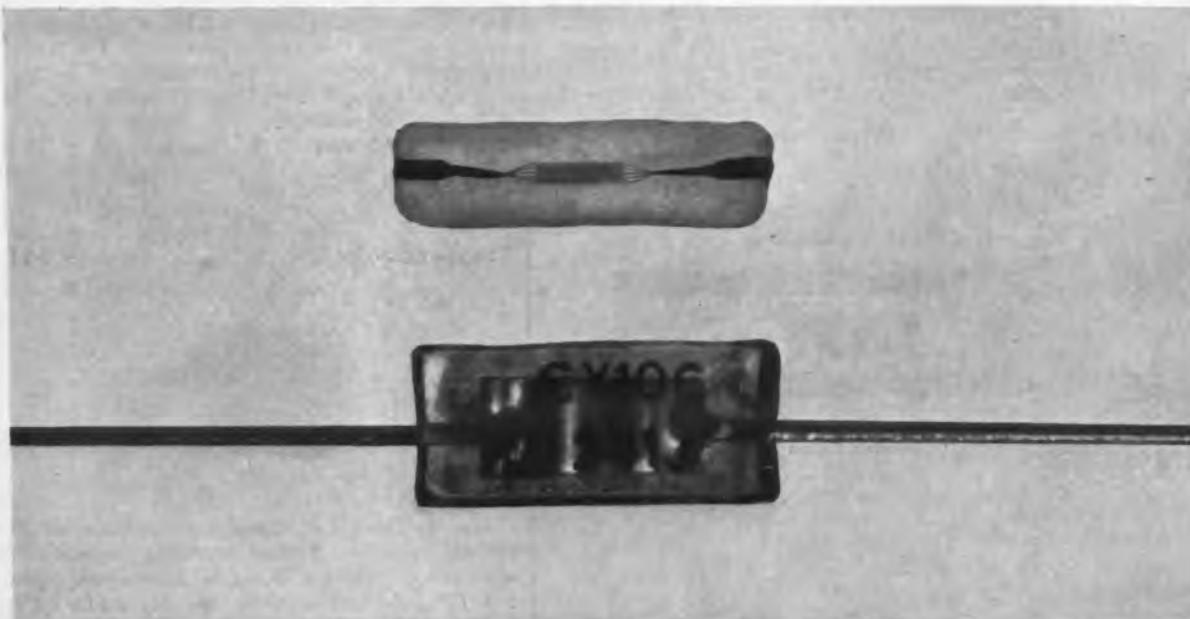
against environment and for structured protection against physical shock.

True glass-to-metal seals at the weld area and along the leads bar moisture. The seal of the leads to the glass shifts stresses from the leads to the entire monolithic unit, guarding the capacitance area. Of course, you get electrical performance to match this environmental stability, since the CYFM has our glass-foil capacitor construction.

The CYFM is machine made . . . each capacitor is the same as every other, to give you uniformity which hand production cannot match.

You can get immediate delivery on the CYFM in two types. The CYFM-10 gives capacitance values from 1 to 300 pf. The CYFM-15 provides values from 220 to 1200 pf.

For the rest of the story on this capacitor, send for our data sheet. Write to Corning Glass Works, 540 High Street, Bradford, Pa.



This is the CYFM capacitor. 6 times actual size. The dark areas between the ends of the glass and the capacitance element are your visual proof of the complete glass-to-metal seal.



CORNING ELECTRONIC COMPONENTS

CORNING GLASS WORKS, BRADFORD, PA.
CIRCLE 58 ON READER-SERVICE CARD

NEW PRODUCTS

Miniature Relay

644



Rated at 10 amp. Designed for space environment, series 200 relay is hermetically sealed and resists moisture and temperature extremes. It withstands shock and acceleration of 50 g, and vibration of 30 g up to 2 kc. Life exceeds 150,000 operations at 10 amp, 26.5 v dc or 115 v ac, at 125 C. The 2.5-oz relay measures 1 x 0.6 x 1.25 in.

Wheelock Signals, Inc., Dept. ED, 273 Branchport Ave., Long Branch, N.J.
Price: About \$8 ea.

Coaxial Connector

639



Meets military requirements. Seven-pin coaxial connector has snap-in contacts that may be removed with an extraction tool. A clamping mechanism retains cable jacketing and braid with a minimum of 15-lb force. Cables retained are RG/58U, RG/187U, RG/188U, and RG/159U. Contacts are copper alloy, rhodium plated; inner insulation material is Teflon.

Viking Industries, Inc., Dept. ED, 21343 Roscoe Blvd., Canoga Park, Calif.

Bearing Counter

626



With clear readout. Integral illumination provides uniform day and night readout in 360-deg bearing counter. Translucent figures 0.187 in. high give high contrast ratio with low gloss and spillage. Counter registers 000.0 to 359.9 and repeat at rate of 600 deg per min. Torque is 1 oz-in. from 67 to 180 F. Weight is 6 oz.

Veeder-Root Inc., Dept. ED, 70 Sargeant St., Hartford 2, Conn.

CIRCLE 909 ON CAREER INQUIRY FORM, PAGE 163 ►
ELECTRONIC DESIGN • April 26, 1961

ELECTRONIC ENGINEERS

AZUSA MARK II

A new precision electronics system — the Azusa Mark II — is now in operation at the Air Force Missile Test Center, Cape Canaveral, Florida. Designed and built by Convair/Astronautics, this remarkable system performs a variety of tasks with exceptional reliability. To the range safety officer, it provides a constant prediction of the impact point of any missile should its engines fail in flight. Engineers can determine exactly the speed and location of the missile at any time during the flight by studying data recorded by the Mark II. It can also be used to calculate satellite rendezvous points in space, track orbiting space vehicles, or determine interception points for satellite-to-satellite test and recovery missions.

Experienced electronic engineers are needed now to continue the refinement of this and similar systems and to develop them for future space missions.

You'll find more complete information, plus details of specific positions now available, on the next page.

If the inquiry card has been removed, or if you wish to furnish or request more detailed information, please write to Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Mail Zone 130-90, Convair/Astronautics, 5666 Kearny Villa Road, San Diego 12, California. (If you live in the New York area, please contact Mr. T. Cozine, manager of our New York placement office, c/o General Dynamics, 1 Rockefeller Plaza, New York City; telephone Circle 5-5034.)

CONVAIR/ASTRONAUTICS



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This battery of precision radar antennas—part of the Mark II system—permit the Air Force to track missiles with incredible accuracy. The system tracks a missile by transmitting radio signals to a small airborne transponder which beams a continuous signal back to earth. This signal is captured by these parabolic receiving antennas and sped into a computing system which translates the missile's flight progress on a large plotting board. Azusa Mark II was designed and built by Convair/Astronautics.

ELECTRONIC ENGINEERS: Specialists are needed now to apply creative solutions to design problems of advanced missile and space vehicle launch and tracking systems.

LAUNCH CONTROL CIRCUIT DESIGN

These are relay and transistorized open loop, and sequential switching circuits for the automatic control of the countdown process for the Atlas missile.

TELEMETERING DESIGN

Communications, modulation and data sampling techniques for telemetering and data acquisition systems.

OPENINGS ALSO EXIST FOR ENGINEERS AND SCIENTISTS IN THESE AND OTHER AREAS:

RELIABILITY

Reliability analysis and test, in San Diego and at off-site bases. BS in EE, AE or ME required.

BASE ACTIVATION

Liaison or design support on launch control equipment, propulsion systems, automatic programming, and missile checkout equipment operations. A degree in ME or EE, plus experience in electrical or mechanical systems required.

PERSONNEL SYSTEMS (Man/Machine Analysis)

To evaluate the personnel function from a system standpoint. Requires analytical approach to applying manpower to an existing system at the customer level. Broad technical systems background with emphasis on human relations essential. Assignments involve analysis of manpower requirements and applications for a weapon system, including equipment, procedures, time studies, logistics, and training. Degree required, preferably in industrial engineering, business administration, or industrial psychology.

Technical openings also exist in many other specialties. Write to Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Department 130-90, Convair/Astronautics, 5666 Kearny Villa Road, San Diego 12, California. (If you live in the New York area, please contact Mr. T. Cozine, manager of our New York placement office, Circle 5-5034.)

TRACKING SYSTEMS DESIGN

Communications, pulse and phase shift techniques for the design of ultra-precise missile and satellite tracking systems.

TEST EQUIPMENT DESIGN

Switching and analogue circuitry for automatic test and checkout equipment. Assignments are of a project nature — from conception to production.

FIELD SERVICE

Technical representation to the Air Force at various Atlas bases. Engineering degree plus field service, flight test, or test engineering required.

MECHANICAL DESIGN

For pneumatic, hydraulic and fluid systems design and test, and missile GSE and missile structures design. BS in ME or AE is required.

ENGINEERING PLACEMENT INQUIRY

This card may be folded and stapled or stapled and mailed in complete confidence. It will enable the professional staff at Convair/Astronautics to make a preliminary selection of your background. A personal interview can be arranged in your city by appointment. Entry completed inquiry will be acknowledged.

NAME _____

STREET ADDRESS _____

CITY & STATE _____ TELEPHONE _____

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COLLEGE GRADUATE: YES NO DEGREE: BS MS PHD

YR _____ YR _____ YR _____

FOLD

MAJOR SUBJECT:

AERONAUTICAL ENGINEERING MECHANICAL ENGINEERING
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YRS _____

ADDITIONAL COMMENTS, IF ANY, CONCERNING YOUR JOB INTERESTS _____

PLEASE SEND CONVAIR/ASTRONAUTICS RECRUITMENT BROCHURE. ED-4

CONVAIR/ASTRONAUTICS



CONVAIR DIVISION OF GENERAL DYNAMICS

Frame-Grid Tubes

362



Subminiature frame-grid tubes CK 7994 and CK 7995 are housed in T-3 button envelopes with nominal outside dimensions of 0.375 by 1.25 in. The CK 7994 is a high-frequency, grounded-grid triode, designed for use in wide-band amplifier stages and grounded-grid amplifier applications. With a ratio of 15 ma plate current to 18,000 μ mhos g_m , the tube has a plate-to-cathode and heater capacitance of 0.25 pf.

The CK 7995 is designed for use as a wide-band rf or if amplifier, especially in equipment with a low plate supply voltage. It has 8-ma plate current, g_m of 13,000 μ mhos, and a grid-to-plate capacitance of 0.03 pf. Tubes operate in environments to 220 C.

Industrial Components Div., Raytheon Co., Dept. ED, 55 Chapel St., Newton 58, Mass.
P&A: \$8.50 ea; sample quantities.

Switching Transistors

352

Germanium pnp mesa transistors 2N705, 2N710 and 2N711 are designed for use in military and commercial data-processing equipment. The diffused-base units meet requirements of MIL-S-19500B. Combined turn-on, storage, and turn-off time is 275 nsec for 2N705 and 2N710, and 450 nsec for 2N711. Power dissipation is 150 mw max at 25 C; minimum beta is 25, alpha cut-off frequency 300 mc. Package is TO-18.

Radio Corp. of America, Semiconductor and Materials Div., Dept. ED, Somerville, N. J.

Scanner Unit

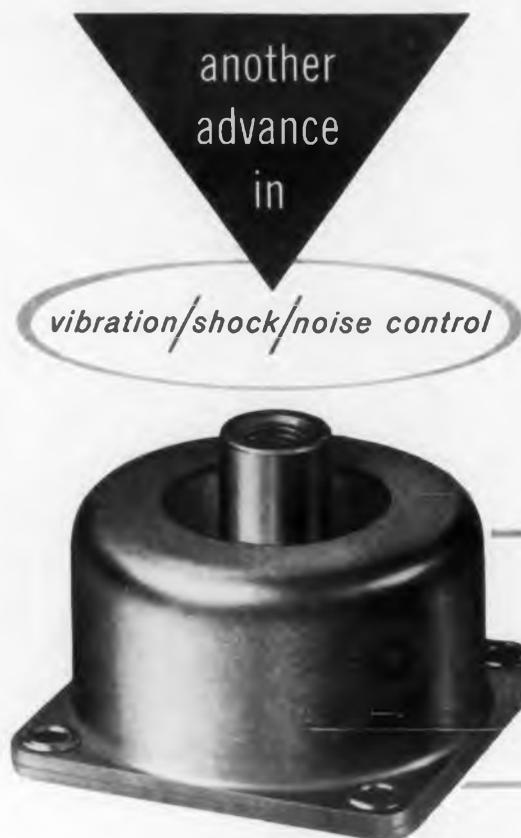
405



All-solid-state scanner unit produces two 17-bit modified time-of-day codes in the Atlantic Missile Range format, and a 1-ppm pulse rate output. The unit fits 19-in. rack mounting, and measures 7 x 17 in. The weight is 27 lb, and the power requirement is 117 v, 50 to 400 cps at 70 w.

Electronic Engineering Co. of California, Dept. ED, 1801 E. Chestnut Ave., Santa Ana, Calif.
P&A: \$5,775; 60 to 90 days.

◀ CIRCLE 909 ON CAREER INQUIRY FORM, PAGE 163
ELECTRONIC DESIGN • April 26, 1961



another
advance
in
vibration/shock/noise control

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LORD BTR (Broad Temperature Range) Elastomeric Mountings cushion high G shock loads, isolate vibration to 2000 cps, give all-attitude protection. Limit resonant amplification to approximately three or less. And this performance is unaffected by extreme environments and temperatures from -65° to $+300^{\circ}$ F. Size for size, ounce for ounce, they pack more load-carrying and energy-storage capacity than any other isolator.

Performance has been repeatedly proved on the most difficult applications. Even ultra-sensitive inertial guidance systems on operational ICBM's are now protected by *standard* production BTR Mountings.

Utilize this advance in vibration/shock/noise control to achieve higher reliability for your project.

Information on BTR Elastomeric Mountings is contained in Bulletin 301, available from your nearest LORD Field Engineering Office or the Home Office, Erie, Pa.



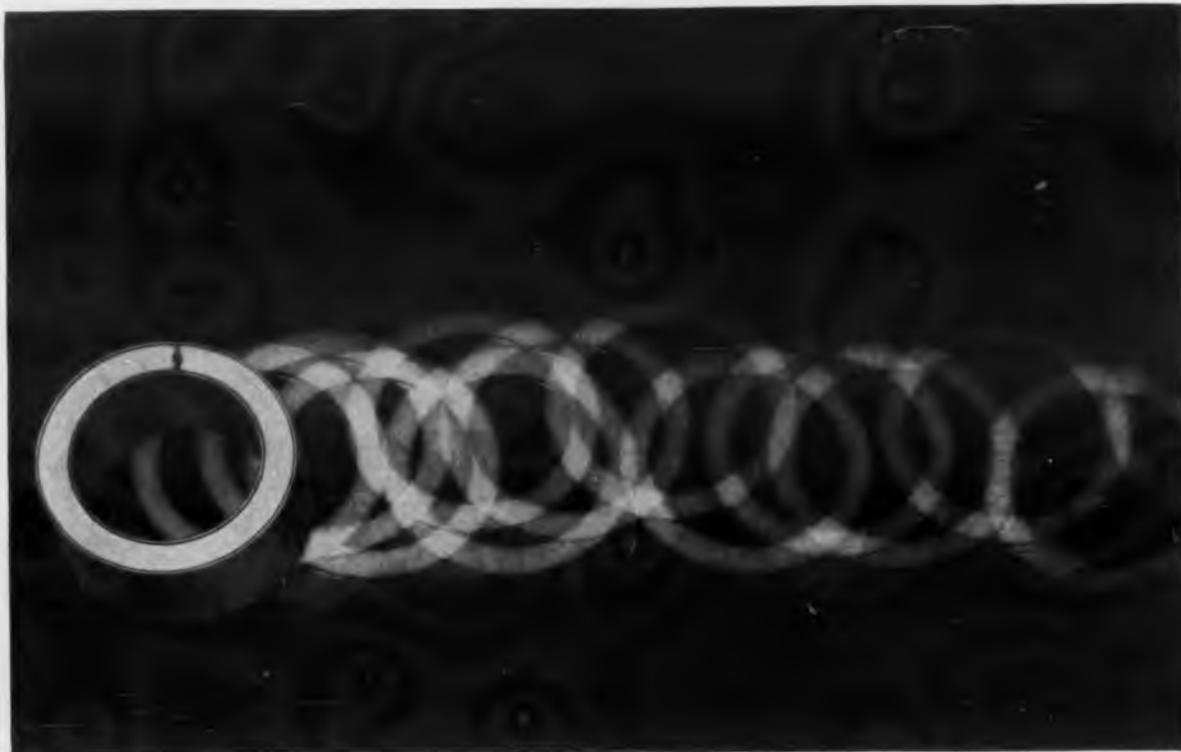
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the strong case for Centricores®

When you're considering magnetic cores it pays to get down to cases. The sturdy aluminum case for Centricores assumes special importance where impact, vibration, heat or mechanical pressure could cause trouble in a control loop you're designing, or where you want to miniaturize an inductive component.

The case is ruggedly rigid, so that you can apply your circuit windings without danger of distorting the core's magnetic properties. And the case is absolutely leakproof. You can vacuum-impregnate Centricores without danger of their damping oil leaking out or foreign matter leaking in. The tightly sealed case also guards against leakage in applications where high ambient temperatures are present, or where Centricores are used in rotating equipment.

Here's a tip on miniaturization. The rugged design of the Centricore case permits use of a thinner gage aluminum that shaves fractions of an inch off their size—fractions that can add up to precious inches where you want to scale down component dimensions. *Centricores are the slimmest magnetic cores on the market.*

Centricores are the most uniform. They give the exact performance you want, from core to core and lot to lot. Their remarkable consistency in insulation, dimensions, squareness, thermal stability and gain is the product of unique quality controls that begin with the very selection of raw materials and extend through final testing.

Write for complete data. Centricores are available from stock from our East and West Coast plants in all standard sizes and magnetic qualities, and in both aluminum and phenolic cases. We will match them within 5 per cent over the entire voltage-current loop, in sets, units or in multiples up to twelve. Write for detailed specifications today.

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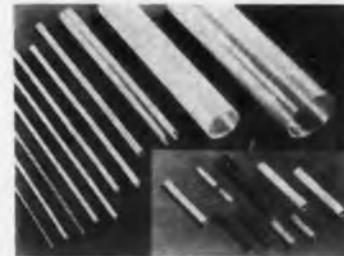


CIRCLE 61 ON READER-SERVICE CARD

NEW PRODUCTS

Mylar Tubing

357



A wide range of inside diameters, from 0.040 in. to 8 in., is available in a new line of Mylar tubing. Wall thicknesses range from 0.001 to 0.050 in. in relationship to diameter. Dielectric strength is 2,500 v per mil. Tubing withstands 300 F continuously and is rated Class B (130 C). Material is impervious to common solvents and resists corrosion and fungus.

Resinite Corp., Dept. EI-2, Dept. ED, 6984 N. Central Park Ave., Chicago 45, Ill.

Time Code Generator

404



Time code generator model 804 supplies time code with a frequency stability of three parts in 10^6 . Three additional auxiliary pulse rates are provided: 20-bit, 24-hour binary coded decimal (BCD) code; 1 mc differentiated square wave; and 1-pps pulse. This all-solid-state unit requires 65 w, 100 to 130 v at 50 to 400 cps. The generator measures 7 x 19 x 17 in.

Electronic Engineering Co. of California, Dept. ED, 1601 E. Chestnut Ave., Santa Ana, Calif.
P&A: \$7,925; 60 to 90 days.

Proximity Limit Switch

399



Sensitive to ferrous and nonferrous metals, the proximity switch includes completely transistorized control and pick-up unit. Contaminants that collect on the pick-up do not affect the operation, and the pick-up will not attract metal chips.

Electronic Signals, Inc., Dept. ED, P. O. Box 3811 Cleveland 10, Ohio.
Price: \$72.00 and up.



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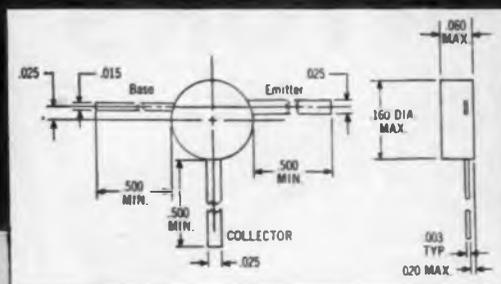
CIRCLE 62 ON READER-SERVICE CARD
CIRCLE 63 ON READER-SERVICE CARD ➤



NEW FROM
Transitron

micro-T

(A MESA MICRO-TRANSISTOR)



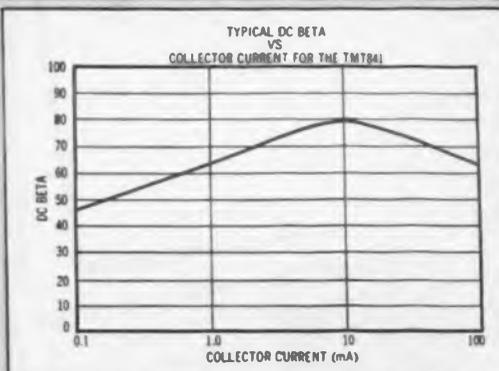
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Development of the MICRO-T — first silicon diffused mesa micro-transistor in an hermetically sealed all-glass package — represents a major step forward in microminiaturization. As compared with conventional "metal can" configurations, the MICRO-T's hard glass packaging embodies a significant improvement in the hermetic seal between leads and package. Reliability is substantially increased; possibility of leakage is sharply reduced.

This new series of 45-volt micro-transistors is the first designed for small-signal low-level applications, with current operating range from 50 microamps to 20 milliamps. Other electrical characteristics include an R_{cs} of 100 to 200 ohms; minimum Betas from 20 to 80; cut-off frequencies of over 50 megacycles. Perfectly compatible with present circuitry, MICRO-T's will facilitate microminiaturizing in such critical areas as airborne, space vehicle and missile application. They are 1/20th the size of the TO-5, and 1/5th that of the TO-18.

The first five types of MICRO-T's are available now. For full information, write for Bulletin No. PB-78, (Amplifier types) and PB-79, (Switching types).



AMPLIFIER TYPES					
Type	Maximum Collector Voltage (Volts)	Minimum AC Beta (h _{fe})	Typical Gain-Bandwidth Product (Mc)	Maximum Collector Leakage Current at 25°C (μA)	Maximum Power Dissipation at 25°C Ambient (mW)
TMT 830	45	20	45	1	150
TMT 840	45	40	45	1	150
TMT 841	45	80	65	1	150

SWITCHING TYPES					
Type	Maximum Collector Voltage (Volts)	Minimum DC Beta (h _{FE})	Typical Gain-Bandwidth Product (Mc)	Maximum Saturation Resistance (Ohms)	Maximum Power Dissipation at 25°C Ambient (mW)
TMT 842	45	20	45	120	150
TMT 843	45	45	65	120	150

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watts—audio and ultrasonic
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Fixed or variable in frequency—1, 2 and 3 phase outputs—with voltage regulated as precisely as 0.1%. Harmonic distortion is as low as 0.1% on sine wave models. Square wave generators with 1% symmetry and less than 10 micro-second rise time are also available.

Here are three popular CML Electronic Generators for laboratory and systems applications.

Write today for complete details on your particular requirements!

**MODEL
1451B**

Output: 500 VA
Frequency range: 350-450 cps, 1400-1800 cps or any single frequency between 50 and 6,000 cps

Frequency stability: To $\pm 0.001\%$ for fixed frequency; $\pm 0.25\%$ for narrow band

Voltage regulation: Better than 1% no load to full load

Voltage stability: $\pm 0.25\%$

Distortion: Less than 1%

Weight: 300 lbs.

Dimensions: 22" width x 28" height x 18" depth



**MODEL
1301A**

Output: 6 VA
Voltage: 12, 60, or 120 (selectable)

Frequency: Any single frequency between 360 and 2000 cps

Frequency stability: To $\pm 0.001\%$

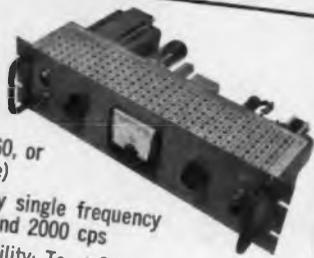
Voltage regulation: Better than 0.2% no load to full load

Voltage stability: $\pm 0.1\%$

Distortion: Less than .1%

Weight: 35 pounds

Dimensions: 5½" x 19" panel x 9½" deep



MODEL M 1435 D

Output: 2,000 VA
Frequency range: 50 to 20,000 cps

Frequency stability: $\pm .25\%$

Voltage regulation: 1.0% no load to full load

Voltage stability: $\pm 0.25\%$

Distortion: Less than 1.0%

Weight: 1.050 lbs.

Dimensions: 66" x 27" x 26" (mobile)



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CIRCLE 64 ON READER-SERVICE CARD

NEW PRODUCTS

Mark II Relay

402

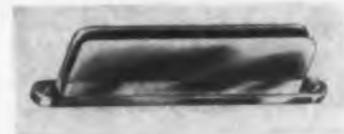


The spdt relay features operation which produces a self-cleaning or brushing action. The relay has a minimum life of 100,000 cycles at rated load. The solenoid for nominal 28.5 v dc operation; other voltages can be supplied. Type 1000 relay meets specifications MIL-R-5757 and MIL-R-25018, Class C, Type II, Grade 3. The unit weighs 4.7 oz.

Electro-Tec Corp., Dept. ED, 10 Romanelli Ave., South Hackensack, N.J.

Thermoelectric Cell

398



Usable thermoelectricity is produced by this power package measuring 6 x 1-1/2 x 3/8. Specifications are: power output 2.5 mw, and current of 5 ma into a 100-ohm load. Its resistance is 100 ohms, and it generates 1 v at 200 F differential. The Seejen weighs 1-1/2 oz.

Harco Laboratories, Inc., New Haven, Conn.
P&A: \$4.95; 14 days.

Linear Amplifier

401



Double delay line, nonoverloading, linear amplifier is based on Oak Ridge National Labs A-8 design. Type N-308 amplifier has a gain of 7,000, adjustable by coarse and fine crystals, stability of 0.25% per day, rise time of about 0.2 μ sec, and integral linearity of 0.1%, 3 to 100 v into 10-K load. The unit is available with integral or differential discriminator. An optional pick-off circuit is for coincidence work in the 50-nsec range.

Hamner Electronics Co., Inc., Dept. ED, Princeton, N.J.

Availability: From stock.

Photoflash Trigger Tube

403



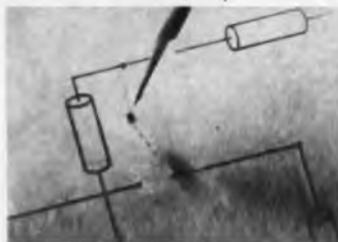
High altitude, subminiature, cold-cathode trigger tube designed for high altitude operation requires an input of 0.25 w and a trigger voltage of 250 v. Type WC-18 requires trigger current of 10 μ a, and a keep-alive current of 30 μ a. The tube is rated at 700 v, and can operate at max ratings to 65,000 ft.

Electronic Industries Inc., Dept. ED, South Norwalk, Conn.

Availability: from stock.

Double-Ended Transistors

361



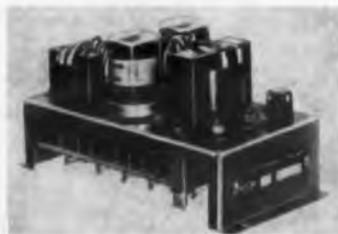
Subminiature silicon npn transistors are available in double-ended configuration. Capable of dissipating 400 mw at 25 C, the types 2N902 through 2N908 are electrically equivalent to the single-ended subminiature 2N789 through 2N793, 2N745 and 2N746, and to the TO-5 units 2N332 through 2N338. Size is 0.130 x 0.160 in. Ambient temperature range is -65 to +175 C. Military specifications are met.

Raytheon Co., Semiconductor Div., Dept. ED, 215 First Ave., Needham, Mass.

Price & Availability: \$8 to \$30; immediate.

Electronic Relay

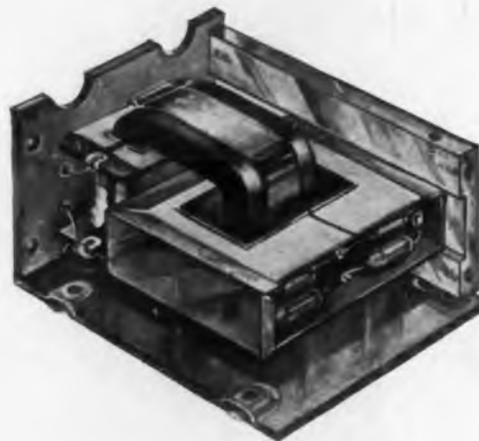
356



No dc power supply is needed for the operation of model 120 solid-state electronic relay. Output is 25 v, 150 ma dc; input is dc or 60-cy ac. Turn-on point is adjustable from 3 to 150 v. An independent hysteresis control determines turn-off point. A dual phase-sensitive detector input provides coherent detection of 60-cps input signals and reduces noise. Size is 8 x 4 x 4 in.

K-F Products, Inc., Dept. ED, 3100 E. 43rd Ave., Denver 18, Colo.

Unique construction of Elcor ISOFORMER® makes efficient isolated power supplies practical



The drawing shows the unique construction of the Isoformer (isolation transformer). This is the key element in new Elcor isolated power supplies... called ISOPLYS.

Significant features of the Isoformer are: (A) Tape-wound magnetic core (B) Shielded primary winding (C) Shielded secondary winding separated from core by air gap.

Results? Distributed capacitance between ground and shield of secondary winding is reduced to the order of 15 to 40 pf, depending on transformer power rating. And in spite of the air gap there is good magnetic coupling between primary and secondary winding. Efficiency is of the order of 90%. When used in D-C power supply, such as the Isoply, rectifiers are enclosed in same shield as secondary winding. With Isoplys you can now create simpler, less costly, and in many cases, better performing circuit designs in applications never before possible.



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CIRCLE 65 ON READER-SERVICE CARD

NEW PRODUCTS

Time Delay Standard 385



Variable, wide-band time delay standard has a constant delay from dc to 2 Gc. The time delay is continuously variable up to 3 nsec. Accuracy is better than 1% at any given point, readability better than 50 nsec. Attenuation is 0.017 db at 100 mc and 0.85 db at 1.5 Gc.

Ad-Yu Electronics Laboratory, Inc., Dept. ED, 249-259 Terhune Ave., Passaic, N.J.

Availability: 1 to 2 weeks.

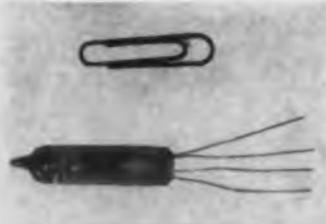
Sensitive Magnetometer 381



Magnetic anomalies of 0.1 gamma or less are detected and relayed in digital or analog form by this instrument. The continuous output is sufficient to drive telemetry systems or recorders. The unit is 7 in. long x 3 in. in diameter. Power consumption is 0.8 w at 200 ma.

Amoux Corp., Dept. ED, 11924 W. Washington Blvd., Los Angeles 66, Calif.

Trigger Tube 384



Subminiature, low-impedance cold-cathode trigger tube model 7711/771U is for use as an inertialess switch and counter in automatic telephone exchanges. The tube has two positive-voltage operated starters. Starter transfer current of 40 μ a makes it suitable for use with diodes and transistors.

Ampere Electronic Corp., Semiconductor Div., Dept. ED, 230 Duffy Ave., Hicksville, L.I., N.Y.

CIRCLE 66 ON READER-SERVICE CARD ►

New
from
NLS



The NLS V60 Digital Millivoltmeter is designed for a wide range of scientific, industrial and military applications including strain gage and thermocouple measurements, calibrating millivolt devices, process monitoring, and semiconductor research and testing.

Make precise millivolt measurements at a glance... aboard ship, in the lab, or on the production line

Here is a new, faster, more precise way to make low-level DC voltage measurements. The NLS V60 full 4-digit millivoltmeter makes 80 measurements per minute, average. It features $\pm 0.01\%$ precision (ability to repeat readings within close limits) — unattainable from pointer meters, strip chart recorders or combination of a digital voltmeter and preamplifier. Accuracy of the V60 is $\pm 0.1\%$ of reading or ± 10 microvolts, whichever quantity is greater.

A span (scale factor) control allows you to set the V60 to display its reading directly in units of pressure, weight, length, strain, stress, speed, etc. And because the V60 is a *digital* voltmeter, you can read it at a glance from close or afar in

total darkness or sunlight, without parallax error.

Other features include: very high AC and DC common mode rejection . . . retention of accuracy under adverse conditions . . . range of ± 99.99 mv. full scale . . . plug-in stepping switches . . . high input impedance . . . precise internal voltage reference . . . filter to attenuate input signal noise . . . full floating, ground isolated input circuit.

V60 complete \$1,625



non-linear systems, inc. Originator of the Digital Voltmeter
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See it in Action . . .

For a demonstration of the new V60 millivoltmeter or any digital measuring instrument, call any of the following NLS offices or sales representatives. If you prefer, please contact NLS for additional information.

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RU 3-4288

Export, Excluding
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301 City St.
San Francisco, Calif.
EXbrook 2-5112

AC-DC Supply

395



Portable power supply model 4372 offers dial selection of voltages from 0 to 125 v dc, or 0 to 140 v ac at 2.5 or 3.0 amp respectively. The bridge rectifier is overload protected, and a special accessory filters the output for a max ripple of 0.075 v at full load. The unit measures 5 x 5 x 7-1/2 in. weighs 7-1/2 lb.

Edler Engineering Co. Inc., Dept. ED, 1568 S. First St., Milwaukee 4, Wisc.

P&A: \$49.50; from the stock.

Counter Indicator

400



Variable radix counter indicator model C-100 is a transistorized counter operating at rates up to 110 kc. Complete "C" Series also includes Preset Counter and Counter Indicator; Set/Reset Indicator; Plus/Minus Indicator.

Electronic Control Products, Dept. ED, P. O. Box 286, Dunellen, N.J.

Price: \$98 to 122.50

Capacitance Measuring System

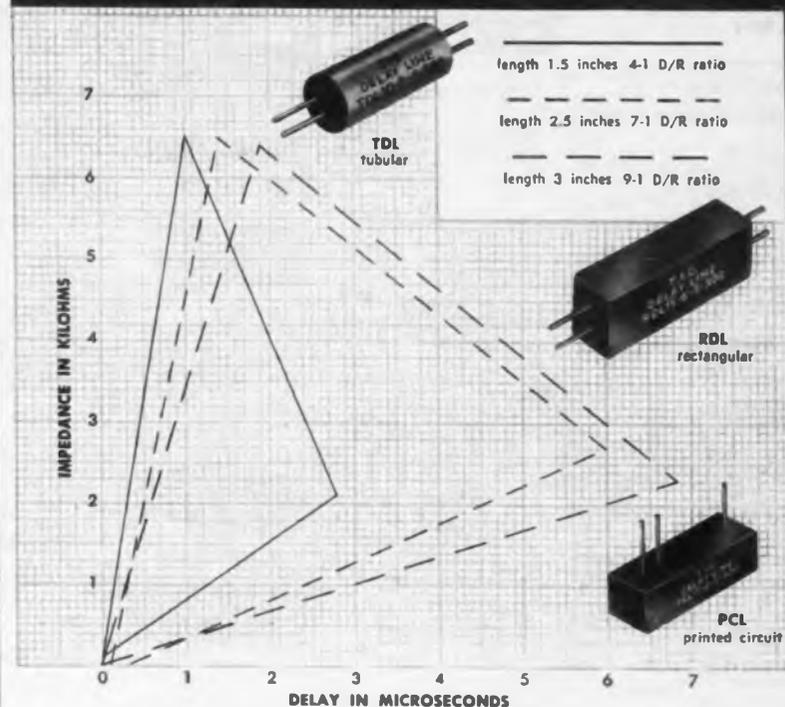
397



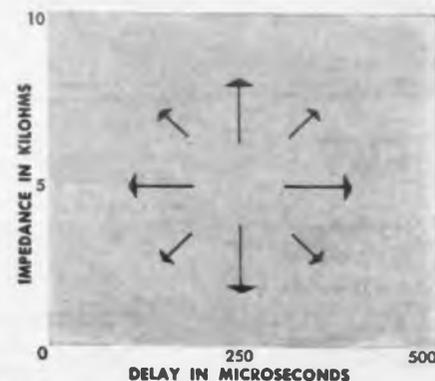
Model 700 measures 2- or 3-terminal capacitors in the range of 0 to 0.12 μ f with a resolution of 0.0001 pf on the lowest range. The system provides five ranges of capacitance readings with 120,000 dial divisions of resolution on any range. Accuracy relative to the standard capacitor is $\pm 0.01\%$ plus one dial division, on the three intermediate ranges; $\pm 0.002\%$ plus one dial division on the highest and lowest range. The unit measures 19 x 10-1/2 x 8 in.

Electro Scientific Industries, Dept. ED, 7524 S.W. Macadam Ave., Portland 19, Ore.

Plot your lumped constant delay line needs on these charts!*



* If your requirements fall within any one of the triangles then the TIC standard type in any configuration is your answer. For other specifications PDL type provides Delay time to 500 microseconds, Impedance 25 to 10,000 ohms, Delay to Rise ratios to 150-1.



DELAY LINES

FEATURE:

- HIGHER RELIABILITY
- LOWER ATTENUATION

TIC's lumped constant delay lines are available in three standard configurations, TDL (tubular), RDL (rectangular), PCL (printed circuit), PDL series (are made to customer specifications). They feature a higher delay to rise time

ratio per cubic inch than is available with conventional techniques. Every TIC Delay Line is hermetically sealed and complies with applicable MIL specs. TIC Delay Lines are M derived, phase and frequency compensated with excellent pulse response characteristics and exceptionally low attenuation. Standard lead lengths of RDL and TDL units is 2". The PCL lead length is 3/4".

Prompt delivery. Write, wire or call.



TECHNOLOGY INSTRUMENT CORP. OF CALIFORNIA

850 LAWRENCE DRIVE, NEWBURY PARK, CALIFORNIA • HUdson 5-2165
Western Sales Offices • BEVERLY HILLS, CALIFORNIA • OLEANDER 5-7861

CIRCLE 68 ON READER-SERVICE CARD

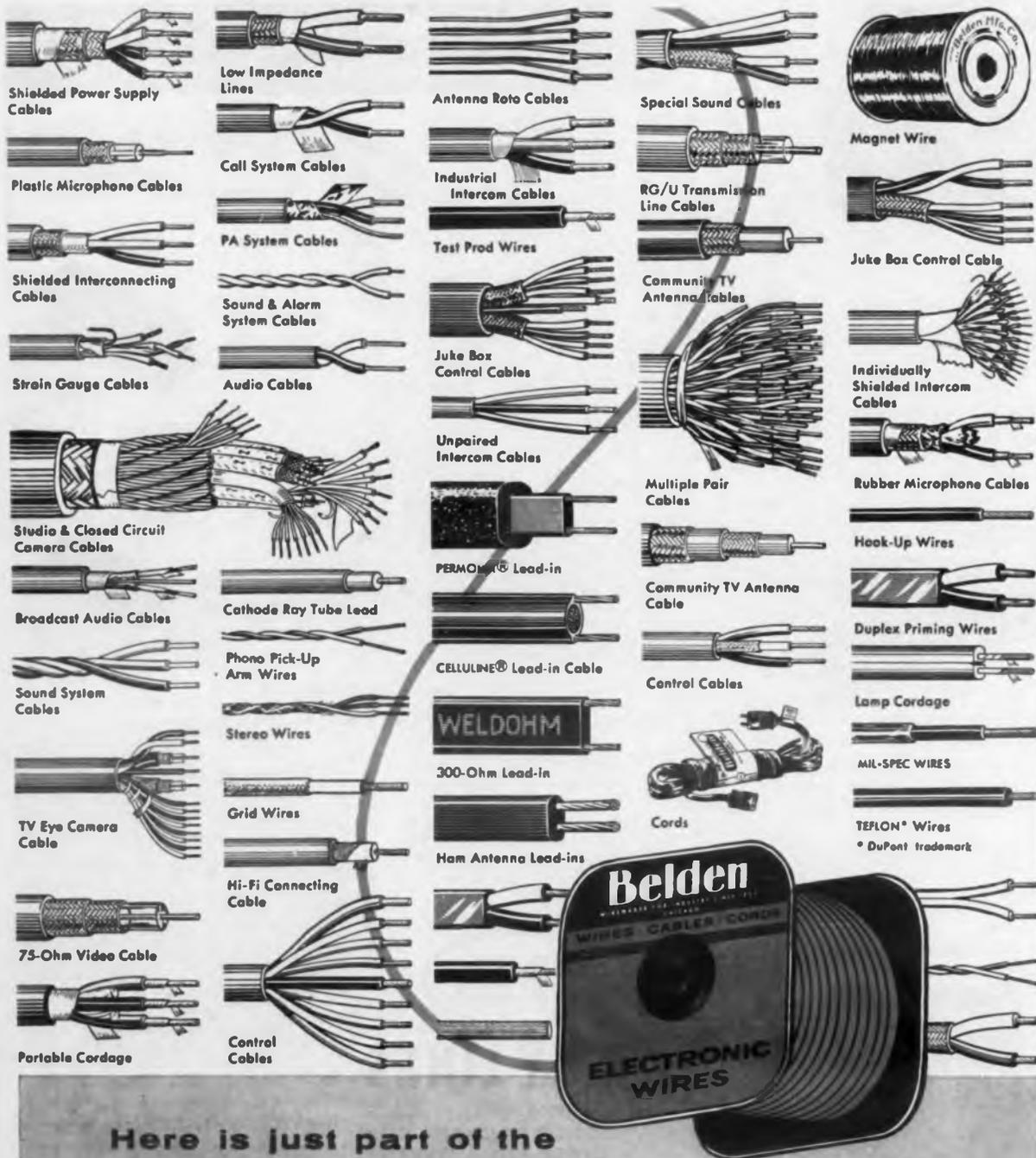


Originator of the Digital Voltmeter

NLS non-linear systems, inc.

DEL MAR, CALIFORNIA

CIRCLE 67 ON READER-SERVICE CARD
ELECTRONIC DESIGN • April 26, 1961



Here is just part of the
WORLD'S MOST COMPLETE LINE
 of Electronic Wire and Cable!

Belden

WIREMAKER FOR INDUSTRY
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Available from Stock

One Wire Source for Everything
 Electronic and Electrical

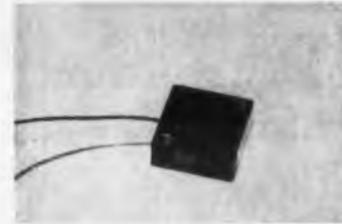
magnet wire • lead wire • power supply cords • cord sets • portable cordage • electronic wire
 • automotive replacement wire and cable • aircraft wire • electrical household replacement cords

8-3-9

NEW PRODUCTS

Subminiature Trimmer

390



A high-temperature, precision trimming potentiometer model 355 measures 1/2 x 1/2 x 0.2 in. It is available in values from 10 ohms to 50 K over an operating temperature range from -55 C to 220 C. Resolution, at 50-K, is 0.0086%. Worm-gear adjusting device provides friction loading and eliminates backlash. Wire leads are 4 in. in length, 30 awg, and Teflon insulated.

Daystrom Inc., Dept. ED, Archbald, Pa.

Thermocouple Hotbox

358



All types of thermocouple wire are joined directly to copper in the universal TC hotbox. No external junctions are used, eliminating the need for wire-matching plugs. Junction temperature of 150 F is maintained; 51 pairs of wires can be accommodated.

Research, Inc., Dept. ED, Box 6164, Minneapolis 24, Minn.

Pulse Modulator

365



Peak power of 1.2 megawatts is provided by pulsed-power signal-source modulator model 344M. Trigger generator, pulser, high-voltage power supply and filament supply are contained in a 7-ft cabinet. Pulse width is 0.1 to 5.0 usec, continuously variable; maximum duty cycle is 0.002. Rise time is less than 0.2 usec min at maximum pulse voltage and current into a linear load.

Radiation At Stanford, Dept. ED, Palo Alto, Calif.

Push-Button Actuator

389



Model A4-195/EF-136 is a spdt actuator which is rated at 5 amp, 125/250 v ac, 2.5 amp at 30 v dc. The unit features 0.250 in. min overtravel, 4-oz min release force, and a movement differential of 0.004 in. max.

Control Switch Div., Dept. ED, 1420 Delmar Drive, Folcroft, Pa.

Insertion-Loss Scanner

355

Measurement of insertion loss as a function of frequency in the range of 50 kc to 8 mc is provided by the PTC 1206 insertion loss scanner. System consists of sender and receiver units with power supply. Dual-trace crt displays insertion loss versus frequency characteristic of system under test. Recorder output is available.

Pye Telecommunications Ltd., Dept. ED, Cambridge, England.

Low Power Recorder

387



Miniature strip chart recorder requires 400 μ w for full response within 0.6 sec. Model A+ Recorder is available in 0 to 1 ma range with moving coil resistances of 140, 350, 1,500, or 5,500 ohms, and a 4,500-gauss flux. Ink pen, hot wire, or Teledeltos writing systems with standard chart speeds can be specified. Panel space required is 5-1/2 x 7-1/3 in. and portable housing is available.

Atkins Technical Inc., Dept. ED, 1276 W. Third St., Cleveland 13, Ohio.

Cooling Unit

393



Operation from -65 to +125 F and altitude from sea-level to 10,000 ft is possible with the RS-100-102 cooling unit. It is rated at 800 w at 125 F condenser temperature and power requirements are 416 v, 3-phase, 400 cps. Weight is 85 lb; size is 16 x 10 x 19 in.

Eastern Industries Inc., Dept. ED, 100 Skiff St., Hamden 14, Conn.

ELECTRONIC DESIGN • April 26, 1961

72 NEW MOTOROLA

MIL type
ZENER DIODES
1N2970B
(SIG. C.) SERIES
10 WATTS / 6.8 to 200 VOLTS

From Motorola, a 10 watt silicon diffused-junction zener diode to meet the requirements of MIL-S-19500B/124 (amendment 1). 1N2970B(SIG. C.) thru 1N3015B(SIG. C.) provide nominal zener voltages of 6.8 to 200 volts . . . 1N2970RB(SIG. C.) thru 1N3015RB(SIG. C.) are equivalent reverse polarity units . . . a total of 72 new Motorola mil-type zeners for your critical military circuits.

Two zener impedance tests - at the practical 1/4 power operating point (Z_{st}) and at the knee (Z_{nk}) - guarantee sharp zener knees, product uniformity and quality. Motorola's zener voltage regulation test (ΔV_z) assures unexcelled regulatory characteristics. Units are packaged in a rugged, hermetically sealed stud case . . . and are able to withstand very high surge currents.



FOR COMPLETE TECHNICAL INFORMATION on these new Motorola 10 watt mil-type zeners, request Data Sheet #DS 7008 from your Motorola Semiconductor district office or write: Motorola Semiconductor Products Inc., Technical Information Department, 5005 East McDowell Road, Phoenix 10, Arizona.

MOTOROLA DISTRICT OFFICES:

Belmont, Mass / Burlingame, Calif / Chicago / Clifton, N. J. / Dallas
Dayton / Detroit / Glenside, Pa / Hollywood / Minneapolis / Orlando, Fla
Silver Spring, Md / Syracuse / Toronto, Canada

USER PREFERRED ZENER DIODE TYPES AVAILABLE FROM MOTOROLA

<p>400 MILLIWATT 1N746A thru 1N759A 1N962B thru 1N992B 3.3 to 200 volts designed to meet requirements of MIL-S-19500B/117 & 127</p>	<p>1 WATT 1N3016B thru 1N3051B 6.8 to 200 volts designed to meet requirements of MIL-S-19500B/115</p>
<p>50 WATT 1N2804B thru 1N2846B 1N2804RB thru 1N2846RB 6.8 to 200 volts designed to meet requirements of MIL-S-19500B/114</p>	<p>Miniature Glass TEMPERATURE- COMPENSATED ZENER DIODES 6.2 volt, 8.4 volt, 9.0 volt, 11.7 volt Coefficients .01 to .0005% /°C</p>

NEW ZENER DIODE/RECTIFIER HANDBOOK

A major revision of Motorola's previous handbook. 185 pages of theory, design characteristics and comprehensive applications data. \$2 per copy, check or cash with order, (no purchase orders, please), from Handbook Department, Motorola Semiconductor Products Inc., 5005 East McDowell Road, Phoenix 10, Arizona.



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CIRCLE 70 ON READER-SERVICE CARD

MICRO/G[®] diode lying on the head of a pin illustrates the extreme smallness—0.040" diameter, 0.060" body length—of the glass hermetic package.

FIRST IN A NEW GENERATION OF SILICON DIODES TI-2 AND TI-6

MICRO/G[®]

MESA DIODES FOR YOUR COMPUTER APPLICATIONS

New MICRO/G diodes — smaller in diameter than the head of a pin — give you electrical characteristics equal or superior to those of conventional-size computer diodes... in 1/50 the volume! • The TI-2 and TI-6 capitalize on diffused silicon mesa wafers whose surfaces are *oxide-passivated* for optimum stability and reliability. The solid construction and extreme simplicity of the smallest hermetic computer microdiodes in the industry represent a revolutionary achievement in high-density packaging. • MICRO/G diodes are priced competitively with their larger counterparts... contact your authorized Texas Instruments distributor or nearest TI Sales Office for evaluation samples today.

*Trademark of Texas Instruments

MAXIMUM RATINGS	TI-2	TI-6	UNITS
V _F Fwd. Voltage Drop at 25°C	1 at I _F = 10 ma	1 at I _F = 5 ma	v
C Capacitance at V _R = 0 Vdc at 25°C	4	10	μμf
I _R Reverse Current at 10 v at 25°C	0.025	1.0	μA
t _{rr} Reverse Recovery Time (10 ma I _F , 10 ma I _R Recovery to 1 ma reverse)	10	100	nsecs
V _R Reverse Voltage	40	20	v

SEMICONDUCTOR COMPONENTS DIVISION

TEXAS  INSTRUMENTS

LIMITED

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P. O. BOX 5012 • DALLAS 22, TEXAS

NEW PRODUCTS

Shielded Transformers 386



Power transformers in five design styles cover the range from 100 w to 50 kva, 120 v input, 120 v output. These transformers are code requirement class I division 1, for use in locations where hazardous concentrations of flammable gasses or vapors exist.

Acme Electric Corp., Dept. ED, Cuba, N.Y.

Miniature Attenuators 383



Printed circuits provide up to 20 steps of attenuation in ladder or potentiometer configuration. Composition or wirewound 1/2-w resistors are available in these units. The attenuators meet standard type specifications.

Cinemo Engineering Div. of Aerovox Corp., Dept. ED, 1100 Chestnut St., Burbank, Calif.

Instrument Switches 382



Type CVS switches have up to 32 adjustable positions and 360-deg rotation. Stop positions can be selected without removing the switch from the panel. Contacts, commutator rings and brush blades are of solid nickel-silver. Terminals accommodate wire up to 18 awg.

Aerovox Corp., Cinema Engineering Div., Dept. ED, 1100 Chestnut St., Burbank, Calif.

◀ CIRCLE 71 ON READER-SERVICE CARD



Four-terminal measurements of forward voltage drop can be made with model 1808 diode test set. Ranges are 1, 3 and 10 v. Adjustable reverse voltage is metered from 0.5 to 2,000 v. Reverse current can be read directly from less than 1 na to 3 ma.

Dynatran Electronics Corp., Dept. ED, 187 Herricks Road, Mineola, N.Y.
P&A: \$1,250; 30 to 60 days.

Stem and Wafer Machine 374

Small production runs on all types of button stems up to 1 1/4 in. diam may be made on this machine. Model 105-BST1 is equipped with gas-air-oxygen or hydrogen-oxygen burners to handle all types of glass parts.

Eisler Engineering Co., Inc., Dept. ED, 750 S. 13th St., Newark 3, N.J.

High-Temperature Furnace 366

Capable of reaching 2,600 C at vacuum of 10⁻⁴ mm Hg, the furnace has heating area 6 in. in diameter by 7 in. high. Heating is accomplished by passing 3,000 amp through a circular tungsten element surrounded by tantalum foil. Vacuum apparatus for the chamber consists of 46-cfm roughing pump and a 6-in. oil diffusion pump. The 10⁻⁴ mm Hg pressure can be reached in approximately 4-min pumping time.

Electro-Optical Systems, Inc., Dept. ED, 125 N. Vinedo Ave., Pasadena, Calif.

Miniature Capacitors 377

High voltage capacitors are available in sizes from 1 5/8 x 1 13/16 x 1 1/6 in. Designated as HI-VAR, these units exceed MIL-C-25C requirements, and range in value from 0.1 uf to 15.0 uf, in voltages from 400 to 12,500 v dc.

Dearborn Electronic Laboratories, Inc., Dept. ED, P.O. Box 3400, Orlando, Fla.

CIRCLE 72 ON READER-SERVICE CARD ►



ELECTROLYTIC CAPACITORS—Reliability is our first ingredient



The "case" for 300-volt Tantalytic* capacitors

The best capacitor case for 300-volt operation is General Electric's High Voltage Tantalytic[®] Capacitor. Its single-cell construction is the smallest and lightest for its rating. It weighs 0.1 ounce and measures only 0.75 inch in length.

Performance of this G-E unit distinguishes it as quickly as its size.

*Reg. Trade-mark of General Electric Co.

Capacitance stays within 10% of original value even after 2000 hours testing at rated voltage and temperature. Impedance is lower at -55C than that of any other high-voltage tantalum capacitor.

These same features characterize the full line of ratings from 200V (.15 uf) to 300V (25 uf). Polar or non-polar designs

are available from stock for 85C and 125C applications.

Data on G-E High Voltage Tantalytic Capacitors is found in Bulletin GEA-7065. Ask your G-E Sales Engineer for a copy today. Or write to General Electric Co., Schenectady, N. Y. Capacitor Department, Irmo, South Carolina. 430-02

Progress Is Our Most Important Product

GENERAL  ELECTRIC

General Electric also offers these reliable Tantalytic capacitors

**HIGH-RELIABILITY
FOIL AND SOLID
CAPACITORS**

Bulletin
GEA-7227



**POROUS-ANODE
TANTALYTIC
CAPACITORS**

Bulletin
GEA-7008



**125C KSR*
TANTALYTIC
CAPACITORS**

Bulletin
GEA-6766



**"A CASE"
TANTALYTIC
CAPACITORS**

Bulletin
GEA-7226



**125C CYLINDRICAL
TANTALYTIC
CAPACITORS**

Bulletin
GEA-7085



NEW PRODUCTS

Module Racks

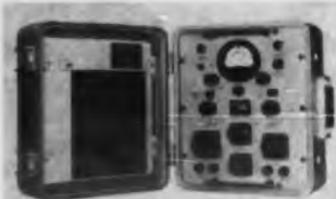
371

Standard S-Block racks can accommodate either 19 or 28 3C-PAC series S plug-in modules. A choice of taper or solder pin type connectors is available, and power and ground busses are factory prewired. Power connections +12-, -6- and -18-v terminals are quick disconnect type. The units are of welded steel construction and measure 19 x 5 1/2 x 9 1/2 in.

Computer Control Co., Inc., Dept. ED, 983 Concord Street, Framingham, Mass.

Cable Tester

532



One-man checkout of interconnecting and power cables is possible with this portable cable test set. Cables are checked for crossed wires, shorts and opens; power cables are checked for proper ac and dc voltages and correct phase rotation. Standard model has a go/no-go meter and handles up to 35 conductors. Set weighs 21 lb and operates from 115-v, 60 to 400 cps, or from internal batteries. Unit can be packaged for commercial or military use.

The Hallicrafters Co., Dept. ED, 4401 W. Fifth Ave., Chicago 24, Ill.

Planetary Lappers

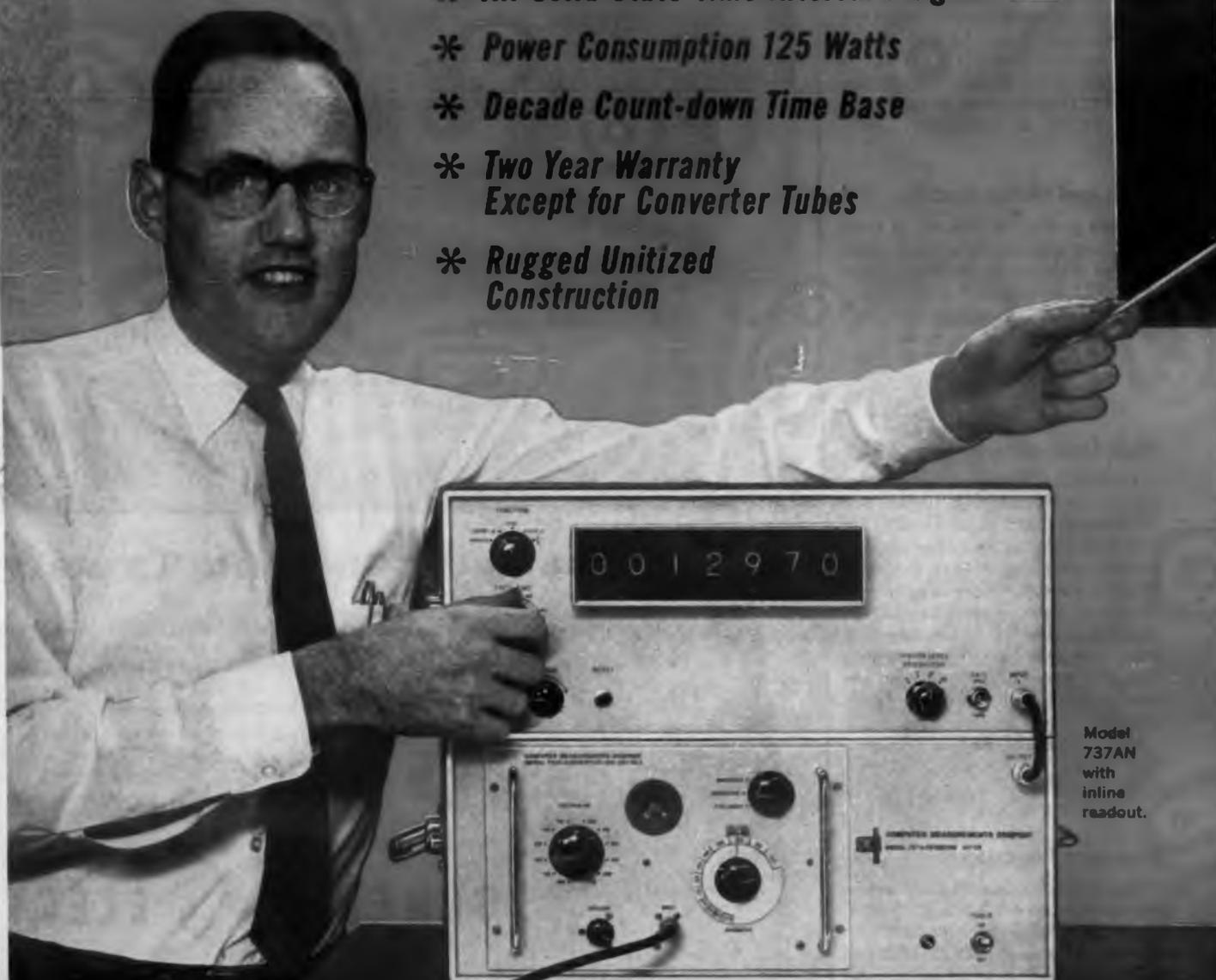
379

Semiconductor crystal processors are capable of lapping both faces of a slice simultaneously, with parallelism in the order of 0.000005 in. Model PL-2875-B features a 2-7/8 in. track and ten carriers, and will lap 10 slices up to a max size of 1-3/4 in. in diameter. Model PL-1875-B has a 1-7/8 in. track and 17 carriers, each holding from one to three slices. This unit can lap 17 slices up to 1 in. in diameter.

Dallons Labs., Inc., Dept. ED., 5068 Santa Monica Blvd., Los Angeles 29, Calif.

WHO CAN SHOW YOU A 220 MC FREQUENCY METER WITH THESE FEATURES?

- * All Solid State 10 MC Counter Section
- * All Solid State Time Interval Plug-in
- * Power Consumption 125 Watts
- * Decade Count-down Time Base
- * Two Year Warranty Except for Converter Tubes
- * Rugged Unitized Construction



Model
737AN
with
inline
readout.

Move it anywhere you want with ease. Rack Mounting simpler, too.

Only CMC can! Only CMC's Frequency-Period Meter offers solid state reliability and 48 pound compactness.

DO ALL THESE JOBS:

- Measure frequency dc to 220 mc
- Measure period to 0.1 microsecond
- Measure time interval 0.1 microsecond to 10^7 seconds
- Count dc to 10 mc

Now - See how the CMC 737A compares with its two closest competitors

	CMC Model 737A	Company A 220 mc unit	Company B 220 mc unit
CIRCUITRY	All solid state counter section	100% vacuum tube	100% vacuum tube
TOTAL NUMBER OF VACUUM TUBES	13	91	75
WEIGHT	Net 48 lbs.	Net 118 lbs.	Net 115 lbs.
SIZE	14" H x 17" W x 13" D (1.8 cu. ft.)	21 1/4" H x 20" W x 23 1/2" D (5.8 cu. ft.)	20" H x 20" W x 19" D (4.4 cu. ft.)
POWER	125 watts	600 watts	380 watts
TIME BASE	Decade count-down type; no divider adjustment	Multi-vibrator type; requires frequent adjustment	
WARRANTY PERIOD	2 years	1 year	1 year
PRICE (Basic unit with vertical decade display)	\$2150	\$2150	\$2275
(converter plug-ins)	\$250 each	\$250 each	\$250 each
(TIM plug-in)	\$300 each	\$175 each	Included

WHAT IT IS

CMC's Model 737A Frequency Meter combines an all solid state 10 mc digital counter and a vacuum tube heterodyne converter. Three converter plug-ins are currently available with more on the way. Model 731A plug-in extends the 10 mc range to 100 mc and Model 732A covers 100 mc to 220 mc. The third available plug-in, Model 751A, is an all solid state 0.1 microsecond to 10^7 second time interval section.

LOW POWER—A KEY ADVANTAGE

The complete instrument uses only 125 watts of power which reduces operating temperatures, prolongs component life, and assures long trouble-free operation. Even at 10 mc, transistors are well derated. Because of this inherent reliability, CMC offers a two year free service warranty except for converter tubes—the first manufacturer to offer this extended guarantee.

THESE FEATURES, TOO

Automatic decimal point * Inline readout available as standard option * Stability, 2 parts in 10^7 standard, 5 parts in 10^8 special. * Accuracy, ± 1 count \pm oscillator stability * Sensitivity, 0.25 v rms * Standardize against WWV * Remote programming without special regard to cable length, type of cable, or impedance matching * Printer output to drive digital recording equipment, punches, inline readout and other data handling gear, \$80.00 extra.

AND HERE'S 100% SOLID STATE RELIABILITY

CMC offers a complete line of transistorized digital instrumentation including universal counter-timers, time interval meters, frequency-period counters, printers and preset counter-controllers. Here are two models especially suited for applications where high reliability and flexibility of function are key factors. These units can also be remotely programmed by simply closing contacts.

Model 727A Universal Counter-Timer



Using only 50 watts, Model 727A measures dc to 1 megacycles and 0.1 μ sec to 10^7 seconds. Three input channels. Decade count-down time base. Price \$2450.

Model 726A Universal Counter-Timer



Only 5 1/4 inches high and weighing just 25 pounds, Model 726A measures dc to 2 mc and 1.0 μ sec to 10^4 sec. Three input channels. Decade count-down time base. Power consumption 40 watts; price, \$1550.

FOR MORE INFORMATION
— contact your CMC representative
for a demonstration, or write
for new technical bulletins.
Please address Dept. 36

CMC

Computer Measurements Company

A DIVISION OF PACIFIC INDUSTRIES, INC.

12970 Bradley Avenue • Sylmar, California
Phone: EMpire 7-2161

Tunable Filter

380

Narrow bandpass, tunable filter model 100 is for use in the 118 to 136 mc range. It has tuning accuracy to within 25 kc. Power rating is 50 w am at 100% modulation and useful bandpass is 100 kc. Type N female connectors are used.

Adams-Russell Co., Inc., Dept. ED, 200 Sixth St., Cambridge 42, Mass. P&A: \$1,175; 30 days.

Card Reader

533



Automatic control of program, formula, position, etc., is provided at low cost with clip cards and reader. Vinyl cards may be cut with scissors; finger length is in direct proportion to command signal. Life is over 1 million readings; accuracy can be 1 part per 30,000. No relays or stepping switches are used. The flush-mounting reader can be supplied to handle cards with up to 40 fingers.

Jordan Controls, Inc., Dept. ED, 3235 W. Hampton Ave., Milwaukee 9, Wis.

Glass Cloth

376

Material for insulating boards withstands soldering temperatures of 450 to 500 F, and is made of silicone-glass laminate. This laminate is applicable in environments of -40 to 160 F; withstands shocks of 30 g for 11 msec.

Dow Corning Corp., Dept. ED, Midland, Mich.

Sealed T-Switch

367

The H-16-200 is a spdt switch which meets MIL-S-6743 electrical ratings. It has a pretravel of 0.012 in., is 0.787 in. in length and weighs 7 g. Operating force is 550 g min.

Controls Company of America, Control Switch Div., Dept. ED, 1420 Delmar Drive, Folcroft, Pa.

◀ CIRCLE 73 ON READER-SERVICE CARD

EMCOR® Standard Cabinets



offer
more



advance
design
and
quality
construction
features!



7" high, 16 gauge steel center strut for ease of equipment mounting and greater over-all structural strength.



14 gauge steel frame construction assures greater ruggedness and rigidity.



Electronically controlled spot welds assure superior strength.



Jig assembly line fabrication provides rigid quality control and assures compatibility of frames.



Key Heliarc* Welds provide for greater structural rigidity.



Continuing research and development by the Roy C. Ingersoll Research Center maintains EMCOR leadership in metal cabinetry.

*Registered Trademark Linde Air Products Co.

From single cabinets to major systems, the hundreds of basic frames of the EMCOR Modular Enclosure System meet your height, width, depth and structural enclosure needs.



WRITE TODAY FOR CONDENSED CATALOG 106

Originators of the Modular Enclosure System

INGERSOLL PRODUCTS

Division of Borg-Warner Corporation
630 CONGDON • DEPT. 1221 • ELGIN, ILLINOIS



CIRCLE 74 ON READER-SERVICE CARD

NEW PRODUCTS

DC Motor

360



A permanent-magnet dc motor, model PM-1 is suitable for military and commercial uses. With efficiencies to 54% through high-flux utilization, the motor requires very low current at full load. Weight is less than 2 oz; length is 2 in., OD 7/8 in. Motor operates from -55 to +100 C, under vibration, shock and acceleration satisfying military specifications. Voltage range is 3 to 30 v dc.

Reflectone Corp., Dept. ED, Stamford, Conn.
P&A: \$14.50 ea in quantity; stock.

Memory Systems

354

Magnetic-core memory systems are available wired, assembled, and tested. Capacity ranges from 256 to 4,096 words of 8 to 32 bits. Read-write cycle time is 5 to 12 μ sec. Systems are built to operate under broad variations in power and temperature. Complete information retention is provided, even in case of full power loss. Standard and custom types are made.

Radio Corp. of America, Semiconductor and Materials Div., Dept. ED, Somerville, N. J.

Power Transistors

353

Drift-field germanium pnp power transistors 2N1905 and 2N1906 have linear characteristics and a wide frequency response. They are useful as high-power, high-speed switches, ultrasonic oscillators, and wide-band linear amplifiers. Power dissipation is 50 w at 25 C. Rise and fall times are less than 1 μ sec. Minimum beta is 50 for 2N1905, 75 for 2N1906. Typical gain-bandwidth product is 7.5 mc.

Radio Corp. of America, Semiconductor and Materials Div., Dept. ED, Somerville, N. J.

Digital Ohmmeter

396



Transistorized, five-digit, ohmmeter featuring a three-position readout with Super-Nixie indicators is accurate up to 0.01%. Model 3500AO indicates the

catalog no. 4C-61

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Whatever your part in engineering and building electronic equipment, here's the NEW catalog that should be at your fingertips for CABLES! New Catalog No. 4C-61 gives complete charts on Royal RG and special application cables, physical and electrical characteristics, testing procedures, engineering tables (impedance, attenuation, etc.). Valuable information, too, on MIL-spec, signal, control and other multi-conductor cables.

WRITE for your copy — TODAY!

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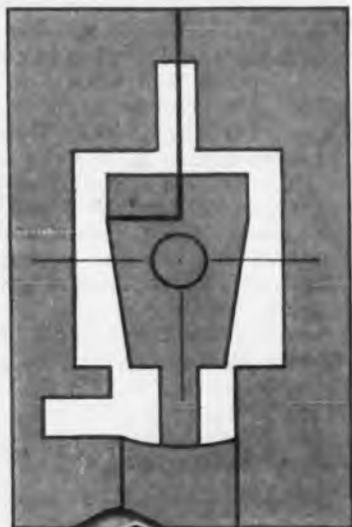
In Canada: Royal Electric Company
(Quebec) Ltd.,
Pointe Claire, Quebec



CIRCLE 75 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 26, 1961

SELECTIVE Gas-Damped SENSITIVITY



GENISCO GMB SERIES ACCELEROMETERS *for airborne applications*

- CONSTANT DAMPING
- POTENTIOMETER PICKOFF OR SWITCH CONTACTS

Genisco's GMB Series Accelerometers feature the advantages of gas damping which remains constant over wide temperature ranges for extreme accuracy and consistency. These units are ruggedly designed and constructed to operate reliably under conditions of high vibration and shock. The GMB Series Accelerometers are hermetically sealed units, available with either precision potentiometer pickoff or switch contacts... Standard or custom models.



2233 Federal Ave., Los Angeles 64, California
CIRCLE 76 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 26, 1961

range of 0.01 ohm to 9.9999 meg. The average reading time is 2 sec, and the test currents meet MIL specifications. Plug-in boards and military-type connectors are used throughout, and printers can be operated directly.

Electro Instruments, Inc., Dept. ED, 8611 Balboa Ave., San Diego 11, Calif.

Neon Distribution Amplifier 391



Three pulse width modulated signals can be applied simultaneously to EECO 880 neon distribution amplifier. The unit supplies a 12-channel output for transmission over two-wire cables for distances up to several miles. The output levels are sufficient to drive camera neon lines to remotely located instrumentation cameras. The all solid-state unit measures 7 x 16 x 19 in.

Electronic Engineering Company of California, Dept. ED, 1601 Chestnut Ave., Santa Ana, Calif.
P&A: \$2,500; 60 to 90 days.

Cooling Unit 394



Laboratory cooling unit has a rating of 18 kw at 80 F. Temperature can be controlled manually or a servo system permits remote control of the unit. Operating conditions are from 32 to 110 F, and from sea level to 5,000 ft altitude. The unit weighs 200 lb, and measures 21-3/8 x 29-3/16 x 34-1/2 in. Power requirements are 440 v, 3-phase, 60 cps.

Eastern Industries Inc., Dept. ED, 100 Skiff St., Hamden 14, Conn.

Power Transistors 351

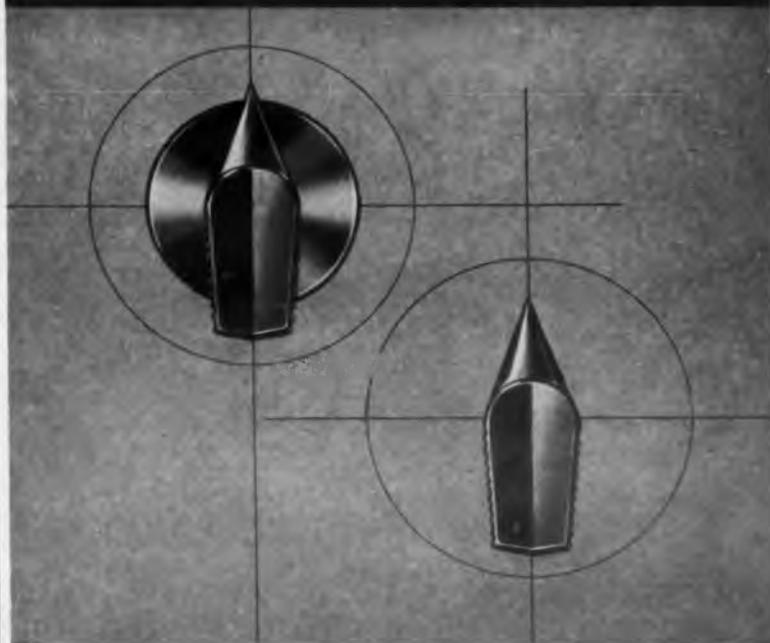
Stud-mounted silicon power transistors use standard stud-mounted rectifier hardware. Increased thermal conductivity allows operation in ambient temperature range of -65 to +200 C. The five stud-mounted types are the 2N1894 through 2N1898, electrically equal respectively to the 2N389, 2N424, 2N1660, 2N1661 and 2N1662.

Raytheon Co., Semiconductor Div., Dept. ED, 200 First Ave., Needham, Mass.

P&A: \$24 to \$60, 100 to 999; immediate.

NEW RAYTHEON 90 SERIES

BAR-POINTER KNOBS REDUCE PARALLAX PROBLEMS



Parallax is practically eliminated with these new 90 series Bar-Pointer Knobs made to fulfill human engineering recommendations of the Department of Defense and the U.S. Air Force.

Dial-skirted and bar-pointer designs, in black or gray, fully meet the requirements of MS 91528B. Nonreflective matte finish for military applications. High-gloss finish for industrial equipment that deserves the precision-engineered look.

For more information about 90 series Bar-Pointer Knobs and the most complete line of high quality control knobs, please write: Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Massachusetts.

For Small Order or Prototype Requirements See Your Local Franchised Raytheon Distributor.



RAYTHEON COMPANY

INDUSTRIAL COMPONENTS DIVISION
CIRCLE 77 ON READER-SERVICE CARD

INCOMPARABLE!

INTERNATIONAL RECTIFIER
diodes and rectifying cells
from 50 ma through 250 amps at
25-1000 volts per junction

Incomparable breadth of line... International Rectifier produces reliable diodes and rectifying cells rated from 50 ma through 250 amps at 25-1000 volts per junction... produces series/parallel combinations through 100,000 amps and 320,000 volts. (Higher ratings available for special applications).

SILICON STUD MOUNTED POWER RECTIFIER CELLS

1.8 AMP HERMETICALLY SEALED TYPES - 100 to 600 PRV rated
6 AND 12 AMP. HERMETICALLY SEALED TYPES - 50 to 500 PRV rated
25 TO 45 AMP. HERMETICALLY SEALED TYPES - 50 to 500 PRV rated
45 TO 150 AMP. HERMETICALLY SEALED TYPES - 50 to 500 PRV rated
70 TO 250 AMP. HERMETICALLY SEALED TYPES - 50 to 500 PRV rated
25 TO 35 AMP. "QUAD-SEALED" ECONOMY TYPES - 50 to 500 PRV rated

SILICON GENERAL PURPOSE RECTIFIER CELLS

SUBMINIATURE GLASS DIODES - High Conductance and General Purpose Types
SUBMINIATURE "TRI-SEALED" ECONOMY 4M SERIES - 400 ma rated, 225 to 600 PRV
MINIATURE "TRI-SEALED" ECONOMY 5A SERIES - 500 ma rated, 200 to 600 PRV
DIFFUSED JUNCTION "PLUG-IN" 5M SERIES - 500 ma rated, 200 to 600 PRV
"TRI-SEALED" ECONOMY 2E4, 5E4, 5E5, 5E6 SERIES - 200 to 500 ma rated, 400 to 600 PRV
HERMETICALLY SEALED MINIATURE AXIAL LEAD SERIES - 200 to 500 ma, 50 to 500 PRV
JAN-APPROVED MILITARY SERIES - 1N253, 1N254, 1N255, 1N530, 1N540, 1N547
HERMETICALLY SEALED AXIAL LEAD SERIES - 200 to 600 ma, 50 to 600 PRV
HERMETICALLY SEALED STUD MOUNTED SERIES - 800 ma rated, 50 to 600 PRV

SILICON VOLTAGE REGULATOR DIODES AND REFERENCE ELEMENTS

SUBMINIATURE GLASS ZENER DIODES - 250 milliwatt rated
HERMETICALLY SEALED AXIAL LEAD STYLE M SERIES - 750 milliwatt rated
HERMETICALLY SEALED AXIAL LEAD STYLE S SERIES - 1 watt rated
HERMETICALLY SEALED STUD MOUNTED STYLE T SERIES - 3.5 watt rated
HERMETICALLY SEALED STUD MOUNTED STYLE T SERIES - 10 watt rated
1N430 VOLTAGE REFERENCE ELEMENTS - 0.4 volts (average) voltage reference
1N1530 MINIATURE VOLTAGE REFERENCE ELEMENTS - 0.4 volts (average) voltage reference
HIGH STABILITY VOLTAGE REFERENCE PACKS - 0.4 and 16.0 volts dc output

MINIATURE SELENIUM RECTIFIER CELLS AND CONTACT PROTECTORS

MINIATURE SELENIUM RECTIFIER CELLS - 250 μ a to 25 ma; 40 to 304 PRV
SELENIUM CONTACT PROTECTORS, AC AND DC TYPES - Diode, cartridge & hermetically sealed types

INTERNATIONAL RECTIFIER



SYMBOL OF QUALITY IN SEMICONDUCTORS

Write for short form catalog
describing comprehensive IR line
of diodes and rectifying cells.

INTERNATIONAL RECTIFIER CORPORATION: EL SEGUNDO, CALIFORNIA • PHONE OREGON 8-6281 • CABLE RECTUSA
REGIONAL OFFICES: IN NEW YORK CITY, CHICKERING 4-0748 • FORT LEE, NEW JERSEY, WINDSOR 7-3311 • SYRACUSE, NEW YORK, HEMPSTEAD 7-8485 • CAMBRIDGE, MASSACHUSETTS,
UNIVERSITY, 4-6520 • ARDMORE, PENNSYLVANIA, MIDWAY 9-1428 • SILVER SPRING, MARYLAND, JUNIPER 9-3305 • CHICAGO, ILLINOIS, JUNIPER 9-3085 • BERKLEY, MICHIGAN,
LINCOLN 9-1144 • LOS ANGELES, CALIFORNIA, GREGON 8-6281 • IN CANADA, TORONTO, ONTARIO, PLAZA 9-2291

NEW PRODUCTS

Pulsed X-Ray System 406

With 1- μ sec pulse duration, Model 5660 pulsed X-ray system is expected to have widespread use in shock and vibration studies, radiation effects, rocketry, medical radiology, ballistics, and crystallography. The long-life tube is pulsed with a square-wave voltage of up to 150 kv; rate of application is 1 to 30 pulses per sec. Resulting X-rays have an effective spot size of 1 x 2 mm, and at 1 in. from the target have an intensity of 10 million roentgens per sec. A Rauland image intensifier tube provides an image suitable for direct viewing or photography.

Zenith Radio Corp., Dept. ED,
6001 W. Dickens Ave., Chicago 39,
Ill.

Automatic Tape Spooler 375

Bidirectional-winding, automatic tape spooler TS-400 can be used with any tape reader. The unit uses standard reels up to 8 in. in diameter, and handles paper or Mylar tape. The unit has a 1,000 ft tape capacity and winds at 15 ips.

Electronic Engineering Company of California, Dept. ED, 1601 E. Chestnut Ave., Santa Ana, Calif.

Price: \$495; 6 to 8 weeks.

PDM Multicoder 370

All-transistor, 48-channel, PDM multicoder has 3-pole, 16-channel subcommutator. It is of modular plug-in design. Silicon semiconductors are used throughout. Unipolar or bipolar models are available with common or insulated ground.

Applied Electronics Corporation of N.J., Dept. ED, 22 Center Street, Metuchen, N.J.

Automatic Solderer 526

Compact, automatic, soldering machine for pc boards can be adjusted quickly for pc boards measuring from 2 x 3 in. to 8 x 12 in. A two-wave solder pot with automatic fluxing can hold 300 lb of solder. The machine handles from 180 to 720 boards per hr.

Devcon Inc., Dept. ED, P. O. Box 616, Westfield, N. J.

Circle 78 on Reader-Service Card

Conductive Inks

368

Printed circuit conductive inks which can be sprayed, roller coated or screened have an approximate resistance of 400 ohms per sq in., when screened through 8XX mesh. Formulation EL-787 is prepared for porous boards, while formulation EL-796 is for thermo-plastic applications. The inks are black in color, and will air dry in 35 min.

Advance Process Supply Co., Inc. Dept. ED, 2315 West Huron Street, Chicago 12, Ill.

Price: \$35 to \$39 per gal.

Telemetry Display

373

Model TDU-1 telemetry display unit has sensitivity of 2 μ v for full deflection. Image rejection is 60 db and gain control range is 80 db. It operates at 30 mc input frequency, and has a continuously adjustable sweep from 0 to 3 mc. This is a companion unit to TMR-1 telemetry receiver.

Defense Electronics, Inc., Dept. ED, 5451-B Randolph Road, Rockville, Md.

P&A: \$685; 30 to 60 days.

Wide-Band Transformer

378

Rf transformer model RFT-130, covers the range of 1 to 30 mc and matches a 50-ohm unbalanced source to a 1,200-ohm balanced load. It has a frequency response of 0 to 3 db in the indicated range. Flat loss is approximately 1 db. The unit is potted in epoxy resin, measures 1-7/16 in. cu, and mounts with two 6-32 x 1/4 in. spade bolts.

Columbia Technical Corp., Dept. ED, 24-30 Brooklyn-Queens Expressway W., Woodside 77, N.Y.

Data Converter

372

A radiosonde balloon data converter accepts analog synchro voltages representing radiosonde elevation and azimuth in degrees. The unit senses and records contact closures, and measures elapsed time in increments of 0.01 min. Completely transistorized, the data converter conforms to MIL requirements, and was designed to operate with existing tracking antennas and recorders.

Datex Corp., Dept. ED, 1307 S. Myrtle Ave., Monrovia, Calif.

a New and important P & B relay . . .

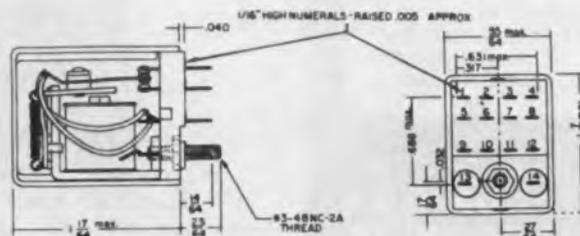


KHP SERIES SHOWN ACTUAL SIZE

having rare longevity

This small, 4-pole relay has the happy faculty of maintaining its original operating tolerances over an exceptionally long life. Example: tests (by customers!) show this relay has variations in electrical characteristics of less than 5% after more than 100 million operations.

But that's far from all. This is a *small* relay . . . about a one inch cube. This relay is easy to install using the conveniently spaced solder lugs or a socket. Thus you save time and production costs. This relay is versatile . . . its 4PDT contacts will switch loads from dry circuit up to 3 amperes. This relay—well, why not order samples and see for yourself! Order today from your P&B representative or call us at Fulton 5-5251, in Princeton, Indiana.



KHP SERIES SPECIFICATIONS

CONTACTS:

Arrangement: 4 Form C, 2 Form Z.

Material: $\frac{1}{8}$ " dia. Silver standard. Silver cadmium oxide and gold alloy available.

Rating: 3 amps @ 30 volts DC or 115 volts AC resistive for 100,000 operations.

COILS:

Resistance: 11,000 ohms max.

Temperature: Operating Ambient: -45°C. to +70°C.

Power: 0.5 watts min operate @ 25°C. 0.9 watts nom. @ 25°C. 2.0 watts max. @ 25°C.

TIMING VALUES:

Nominal Voltage @ 25°C.	Max. Values
Pull-in time	15 ms
Drop-out time	5 ms

INSULATION RESISTANCE: 1500 megohms min.

DIELECTRIC STRENGTH:

500 Volts RMS 60 cycles between contacts.
1000 Volts RMS 60 cycles between other elements.

MECH. LIFE: In excess of 100 million cycles

SOCKET: Solder lug or printed circuit terminals. Available as accessory.

DUST COVER: Standard.

TERMINALS: Solder lug and taper tab.

KHP SERIES RELAY NOW AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR



POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA
IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO

PURITY as high as
99.9975%
 with **LINDE RARE GASES**

MONATOMIC
 DIATOMIC
 RADIOACTIVE
 SPECIAL MIXTURES
 COMBINATIONS

All LINDE atmospheric gases are produced under continuous Mass Spectrometer Control—insuring highest possible purity.

Huge production facilities and a widespread distribution system make it possible for LINDE to supply large quantities of these gases and mixtures throughout the country—in bulbs or in cylinders of various sizes. These unique capabilities are the result of 50 years of pioneering research and development work in rare gases and their behavior.

LINDE gases serve the electronics industry in a wide range of uses, such as electron tubes including thyratrons, Geiger-Muller, and high-voltage regulator tubes; x-ray fluorescence analyzers, electric displays, and insulation for high-voltage terminals; standard and miniature incandescent lamps and high-speed photographic lamps. Many new uses are constantly being developed.

For complete data on gases, write for a copy of F-1002C, "Linde High Purity Gases." Address Dept. ED-044, Linde Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Linde Company, Division of Union Carbide Canada Limited, Toronto 7.

LINDE COMPANY **UNION CARBIDE**

Linde and Union Carbide are registered trademarks.

NEW PRODUCTS

Alkaline Batteries

364



For radio and photoflash service, four alkaline batteries provide long life in continuous or intermittent service. Included are the VS1073, a 1.5-v N cell; the VS1334, a 1.5-v penlight cell; VS1149 a 4.5-v unit for portable radios, and the VS1335, a 1.5-v C cell.

Radio Corp. of America, Dept. ED, 30 Rockefeller Plaza, New York 20, N. Y.

Availability: from distributors.

Indicator Lights

363



Welded indicator light modules for instrument and computer use are made in eight types, WM-2000 through WM-2007. Self-contained units need only external power supplies and trigger signals. Configurations include transistor amplifier with incandescent and glow lamps, positive and negative logic, turn-on and turn-off types.

Industrial Components Div., Raytheon Co., Dept. ED, 55 Chapel St., Newton 58, Mass.

Variable-Speed Drive

359



A static-powered drive for wide range, variable speeds from in-plant ac circuits, the Statatron is available in ratings from 1 to 200 hp. Silicon diodes are used in conjunction with a transistorized power exciter.

Reliance Electric and Engineering Co., Dept. ED, 24701 Euclid Ave., Cleveland 17, Ohio.

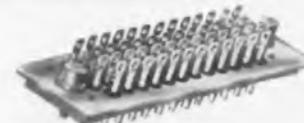
Now
 Design
 from a
 Complete
 Standard
 Line!



Hermetic
 Micro-Miniature



Sub-Miniature



and Miniature



Connectors

With hermetic connectors for every purpose, ESCON simplifies your design problems. Eliminate costly, time-wasting "specials". ESCON connectors offer 4 to 75 contacts, a variety of physical dimensions, meet or exceed MIL specs. New Micro-Miniatures are the ultimate in space and weight savings. If you need a "special", ESCON's creative engineers and ultra-modern facilities can design and produce... fast. What are your requirements?

FREE SAMPLE

Inspect ESCON quality... ask for free sample of typical ESCON connector. ESCON, INC., 733 Branch Ave., Providence 4, R. I. A Subsidiary of Glass-Tite Industries, Inc.



CIRCLE 81 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 26, 1961

Terminal Assemblies 527

A high degree of reliability is claimed for "Cerameterms" ceramic-metal terminal assemblies. They are for use with transistors, relays and condenser banks.

Bendix Corp., Dept. ED, Eatontown, N.J.

Audio Chokes 528

Rated at 350 h at 5 dc ma, audio choke C-2345 has a dc resistance of 5,800 ohms. Type C-2346 is rated at 35 h at 15 ma dc and has a dc resistance of 1,800 ohms. Both units have an insulation breakdown rating of 2,500 v rms.

Chicago Standard Transformer Corp., Dept. ED, 3501 W. Addison St., Chicago 18, Ill.

Price: \$5.11 for C-2345; \$2.87 for C-2346.

Filament Transformers 529

Filament transformer P-6432 has a 5-v center tap, a 21-amp secondary and an insulation breakdown of 2,500 v rms. P-6433 has a 5-v center tap, 15-amp secondary and an insulation breakdown of 2,000 v rms.

Chicago Standard Transformer Corp., Dept. ED, 3501 W. Addison St., Chicago 18, Ill.

Price: From \$11.56 to \$13.89.

Power Transformers 530

Industrial power transformer P-6358 is rated at 300-0-300 v ac at 65 ma. Model PM-8423 is rated at 300-0-300 v ac at 90 ma. Primaries of both units are 117 v 60 cps.

Chicago Standard Transformer Corp., Dept. ED, 3501 W. Addison St., Chicago 18, Ill.

Price: \$9.93, P-6358; \$13.55, PM-8423.

Test Console 531

Universal storage and crt console model 300B is for test of storage tubes having up to two writing guns and one flood gun. Characteristics are: accelerating voltages, screen potential of 20 kv max; positioning voltages, +250 to -250 v; sawtooth frequency ranges, 20 to 16,000 cps; synchronized sweeps, 60 to 15,750 pps.

Automation Laboratories, Inc., Dept. ED, 179 Liberty Ave., Mineola, L.I., N. Y.

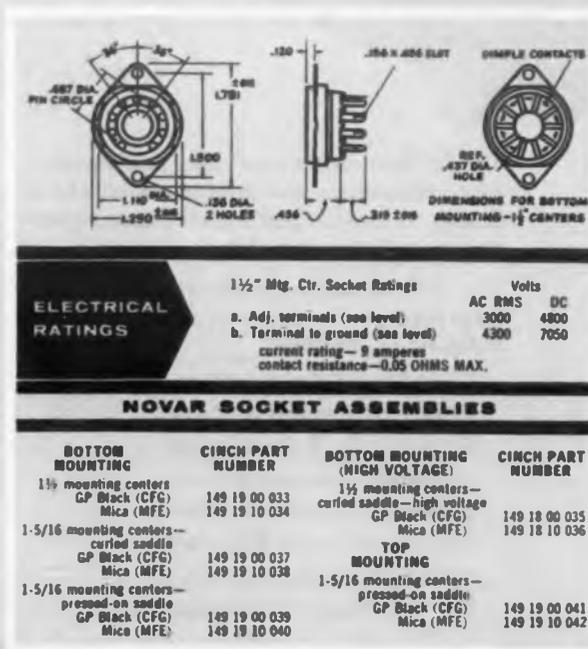
CIRCLE 82 ON READER-SERVICE CARD ▶

ONLY
FROM
CINCH.



NOVAR TUBE SOCKETS

DEVELOPED IN CONJUNCTION WITH THE NOVAR TUBE



- Cinch is the *only* source for Novar Sockets.
- Fits Present Chassis Cutouts. You don't have to redesign chassis to accommodate the Cinch Novar Socket; physical dimensions are the same as octal sockets.
- Electrical and mechanical tests performed according to EIA Standards.
- Contact Design. Contacts are designed for long-lasting resiliency and to withstand fatigue. This means dependable operation and reliability.
- Contact Finishes: insure constant voltage performance. Different finishes are available for extraordinary environmental conditions.

Write for full information today! Complete engineering data and detailed specifications are yours for the asking. Or, phone NEvada 2-2000.



Cinch
ELECTRONIC
COMPONENTS

CINCH MANUFACTURING COMPANY

1026 South Homan Avenue • Chicago 24, Ill.

Division of United-Carr Fastener Corporation, Boston, Massachusetts



Centrally located plants at Chicago, Illinois; Shelbyville, Indiana; City of Industry, California; and St. Louis, Missouri

NEW PRODUCTS

Transmitter Arrestor

388

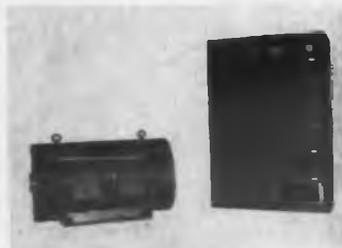


Lightning arrestor Type LA-4 features a high-temperature series capacitor, and a low loss magnetic type spark gap that permits the unit to exceed MIL-A-9094C specification. The arrestor has a mounting flange that may be fitted into an antenna coupler.

Dale Electronics, Inc., Dept. ED., Columbus, Neb.
Availability: 70 days.

Motor-Generator

536



Brushless motor-generators have ratings from 3 to 150 kw. The synchronous motor-powered devices are claimed to have 1% voltage regulation with optional regulation up to 1/2%. Frequency is "exactly" 400 cps. Standard harmonic content is less than 2% with closer tolerances available.

American Electronics, Inc., Dept. ED, Precision Power Div., 1598 E. Ross Ave., Fullerton, Calif.

Potentiometer

537



Wirewound potentiometer series 57-EM is a 2-w unit available in resistances up to 100 K. Glass-sealed terminals permit this high-reliability unit to operate at temperatures up to 150 C.

Clarostat Manufacturing Co., Dept. ED, Dover, N.H.

Entirely New Diode Concept...Combinations



SILICON High Conductance

Pacific Semiconductors, Inc. announces a new approach to the production of silicon diodes to provide performance characteristics never before possible.

The PSI Laminar process makes possible large scale production of diodes having these outstanding features:

- Great Mechanical Stability
- Ultra-Fast Recovery
- Extremely Low Capacitance
- Extremely Low Leakage
- Extremely Low Stored Charge
- High Rectification Efficiency
- Double Hermetic Seal
- 200°C. Storage Temperature

HOW IS SUCH PERFORMANCE AND GREAT MECHANICAL STABILITY POSSIBLE?

Briefly, the PSI Laminar Diode with its many layers, permits extremely low series resistance coupled with a very small junction area to provide a structure yielding a combination of speed, conductance and capacitance never before obtainable.

The laminated silicon element is provided with a glass-like surface layer which passivates the silicon and gives the element complete moisture integrity. This thoroughly sealed element is then welded within the standard PSI package...*double hermetic sealing.*

The front contact of the PSI Laminar Diode



Pacific

12955 CHADRON AVENUE,

ELECTRONIC DESIGN • April 26, 1961

of specs never before possible!

LAMINAR



DIODES Core Driver

is decisively imbedded in a gold lamination on the crystal giving the device complete and absolute protection against failure due to shock and vibration. *Front contact failure is positively eliminated!*

WHAT DIODE TYPES ARE AVAILABLE?

All diode types now being made from conventional mesa and planar processes. This includes the PS9013 high conductance core driver, with the following specifications:

LAMINAR TYPE PS9013

Forward current @ 0.9V > 500mA
Saturation voltage > 80V @ 25°C
 I_{-60} @ 25°C < .20μA, I_{-60} @ 150°C < 50μA
Reverse Recovery* < .2μsec

Capacitance @ 9V reverse < 7 pfd
*Switching 500mA forward to -30V
reverse recovery to 10K ohms

The PS9013 will replace the following:
1N690, 1N691, 1N920, 1N921

LAMINAR LOGIC DIODE 1N3257 will
replace the following:

1N903 thru 1N908A, 1N914, 1N914A,
1N916, 1N916A, 1N251

LAMINAR MEDIUM CONDUCTANCE
DIODE 1N3258 will replace the following:

1N658, 1N662A, 1N663, 1N792, 1N796,
1N800, 1N808, 1N815

All of the above EIA types are also available
in Laminar construction.

Semiconductors, Inc.

HAWTHORNE, CALIFORNIA • A SUBSIDIARY OF THOMPSON RAMO WOOLDRIDGE INC.

CIRCLE 83 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 26, 1961

Stepping Switch

538



Solenoid operated, rotary stepping switch model 100619 has 104 contacts in each deck. Decks may be stacked. Operating voltage is 24-v dc with other voltage coils available. Contact carrying capacity is 2 amp; working voltage between contacts is 3,000 v dc and resistance drop through contacts and slip-rings is 0.05 ohm.

Astral Electronics Inc., Dept. ED, 14620 Arminta St., Van Nuys, Calif.

P&A: From \$604.42 ea; 30 to 60 days.

Spaghetti Tubing

539

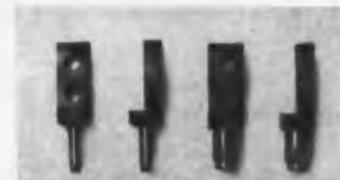


Greater thermal stability, low-temperature toughness and superior dielectric strength is offered by Teflon spaghetti tubing. Designated Chenflour, it is available in 11 colors. Sizes range from AWG 30 to AWG 0.

Chemplast, Inc., Dept. ED, 3 Central Ave., Newark, N.J.

Printed Circuit Hardware

540



Miniature plug and jack assembly is for printed circuit applications and measures 1/8 x 1/8 in. at max cross section. Both plug 2654 and jack 2655 are brass, finished in silver plate with a gold flash.

Cambridge Thermionic Corp., Dept. ED, 445 Concord Ave., Cambridge 38, Mass.

Don't forget to mail your renewal form to continue receiving ELECTRONIC DESIGN.

another Sarkes Tarzian
production breakthrough!

Specifications at 25° C			
Tarzian Type	Zener Voltage (V)	Test Current (MA)	Dyn. Imp. (MAX) (Ohms)
VR6	6	25	4.0
VR7	7	25	5.0
VR8.5	8.5	25	6.0
VR10	10	12	8.0
VR12	12	12	10
VR14	14	12	11
VR18	18	12	17
VR20	20	4	20
VR24	24	4	28
VR28	28	4	42
VR33	33	4	50
VR39	39	4	70
VR47	47	4	98
VR56	56	4	140
VR67	67	2	200
VR80	80	2	280
VR90	90	1	340
VR105	105	1	400

Tarzian Silicon Voltage Regulators now at workday prices

1-watt

Epoxy enclosed

6 to 105 volts, in 20% increments

Standard tolerance is 20%
(all common tolerances available on request)

Immediate availability

Sarkes Tarzian did it in 1957 for silicon rectifiers and has done it again in 1961 for silicon voltage regulators...devised production methods that make it possible to offer quality silicon semiconductor devices at a price level that permits their use not only in Sunday circuits but also in workday circuits.

At the new low prices, more circuits can be better protected or improved in performance by the use of these small and inherently rugged devices as clippers, limiters, and regulators.

Send for price and ordering information.

Where highest quality
is in volume production



SARKES TARZIAN, INC.

World's Leading Manufacturers of TV and FM Tuners • Closed Circuit TV Systems • Broadcast Equipment • Air Trimmers • FM Radios • Magnetic Recording Tape • Semiconductor Devices

SEMICONDUCTOR DIVISION • BLOOMINGTON, INDIANA
In Canada: 700 Weston Rd., Toronto 9 • Export: Ad Auriema, Inc., New York

NEW PRODUCTS

Tape Reader

392



Up to 80 bits of information can be read simultaneously by means of TP 401 tape reader. The unit reads 10 lines and 8 levels across at a time at 6 tests per sec. Special search speed runs at 12 ips. A frame counter indicates the number of frames the tape has advanced from a selected point. TP 401 measures 10-1/2 x 13 x 19 in.

Electronic Engineering Company of California, Dept. ED, 1601 Chestnut Ave., Santa Ana, Calif. P&A: \$1,620; 6 weeks.

Push-Button Switch

534



Rated to 50 w, the S6 series molded push-button switch is 1-7/16-in. long, with OD of 11/16 in. It is available normally open or normally closed, spst or spdt. Maximum working voltage is 115 v. Carter Parts Co., Dept. ED, 3401 Madison St., Skokie, Ill.

Battery Holders

535



Designed to retain C cell mercury batteries under severe shock, No. 2880 holders are of phosphor bronze, with beryllium copper spring washers. They measure 2-3/8 at the base. Cambridge Thermionic Corp., Dept. ED, 445 Concord Ave., Cambridge 38, Mass.

Price: \$0.78 ea, 100 to 249.

Availability: From stock.



Vertically mounted ceramic coil form No. 2501 is for printed circuit work. The grade L-5 ceramic form is silicone-impregnated and is internally threaded for tuning cores. It is available with four different powdered-iron tuning cores having overlapping frequency ranges from 0.2 to 150 mc. Dimensions are 0.255 in. for the form OD and 0.625 in. for mounted height.

Cambridge Thermionic Corp., Dept. ED, 445 Concord Ave., Cambridge 38, Mass.



Designed for use with "Nixie" indicator tubes, models VC 12-170 and VC 28-170 have an output of 170 v dc from 12 and 28 v dc respectively. Full load current is 30 ma for each, enough to power 10 "Nixies."

Burroughs Corp., Electronic Tube Div., Dept. ED, P. O. Box 1226, Plainfield, N.J.

Price: \$48.50 in small quantities.



Broadcast band antenna coil RTC 9252 is for small receivers where no external antenna or large internal loop antenna is desired. The inductance can be screw-driver adjusted from 43 μ h at 2.5 mc ("Q" of 100) to 270 μ h at 790 kc ("Q" of 300).

Chicago Standard Transformer Corp., Dept. ED, 3501 W. Addison St., Chicago 18, Ill.

SHARPEST ZENERS AVAILABLE!

NOW...

G OFFERS YOU A COMPLETE LINE
OF QUALITY ZENER DIODES

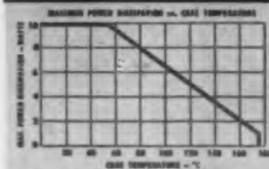
NEW 10-WATT ZENERS...

- Extremely low Dynamic Impedance
- Superior Case Design
- Up to 175° C Operation
- Diffused Junction Type
- 100% Scope Tested

Outstanding Quality—New line of superior quality 10-watt zener diodes provides dependable uniformity of electrical characteristics... completes the family of General Instrument zeners. Unique case design, which employs thermal matching of silicon and package, enables units to withstand rapid temperature cycling and thermal shock. Low junction operating temperature

means high reliability and long life. Conservatively rated diodes show extreme stability under life tests at maximum parameters.

New Diodes Available for Immediate Delivery in Types 1N1808; 1N2044 through 1N2049; and 1N1351 through 1N1362. Voltage ranges from 7.5 to 30 volts (higher upon request).



New 10-Watt Zeners				3.5-Watt Stud Mount			1-Watt Axial Lead			1/4-Watt Axial Lead					
Type	Zener Voltage (V)	Test Cur. @ 25° C (ma)	Max Dyn Imp (ohms)	Type	Zener Voltage (V)	Test Cur. @ 25° C (ma)	Max Dyn Imp (ohms)	Type	Zener Voltage (V)	Test Cur. @ 25° C (ma)	Max Dyn Imp (ohms)	Type	Zener Voltage (V)	Test Cur. @ 25° C (ma)	Max Dyn Imp (ohms)
1N1808	9.1	500	1	1N1588	3.6-4.3	150	2.6	1N1518	3.6-4.3	50	9	1N708	5.6	25	3.6
1N1351	10	500	2	1N1589	4.3-5.1	125	2.3	1N1519	4.3-5.1	40	8.5	1N714	10	12	8
1N1352	11	500	2	1N1590	5.1-6.2	110	1.4	1N1520	5.1-6.2	35	5.5	1N718	15	12	13
1N1353	12	500	2	1N1591	6.2-7.5	100	.58	1N1521	6.2-7.5	30	1.6	1N721	20	4	20
1N1355	15	500	2	1N1592	7.5-9.1	80	.5	1N1522	7.5-9.1	25	1.1	1N723	24	4	28
1N1357	18	150	3	1N1593	9.1-11	70	.7	1N1523	9.1-11	20	1.5	1N731	51	4	115
1N1358	20	150	3	1N1594	11-13	50	1.4	1N1524	11-13	15	2.4	1N736*	75	2	240
1N1359	22	150	3	1N1595	13-16	40	3.4	1N1525	13-16	13	5.4	1N738*	100	1	400
1N1360	24	150	3	1N1596	16-20	35	6	1N1526	16-20	10	11	1N742*	150	1	860
1N1361	27	150	3	1N1597	20-24	30	9	1N1527	20-24	9	18	1N744*	180	1	1200
1N1362	30	150	4	1N1598	24-30	25	13	1N1528	24-30	7	28	1N745*	200	1	1400

Standard types supplied \pm 10% of stated value; \pm 5% tolerances available except as indicated

*Supplied with \pm 10% tolerance only
Intermediate values supplied with \pm 5% tolerances on order

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NEW PRODUCTS

Modulator

542



An electro-optical system is used to perform the modulation in the "Autoverter" microvolt modulator. A power source capable of 200 v dc delivering 200 ma is the only requirement to drive the unit. Two 5-v square wave outputs have less than 2- μ v rms noise level with 2- μ v zero offset. Weight is less than 3.3 oz.

Apollo Electronics Inc., Dept. ED, 301 S. Harbor Blvd., Fullerton, Calif.

Impulse Counter

543



Push-button actuated impulse counter has an automatic reset which counts at a rate up to 500 counts per minute. The start button is integral with the count-setting knob. Four standard counting ranges are available: 1 to 120; 2 to 240; 4 to 480, and 8 to 960.

Automatic Timing & Controls, Dept. ED, King of Prussia, Pa.

Price: \$45.

Modular Connector

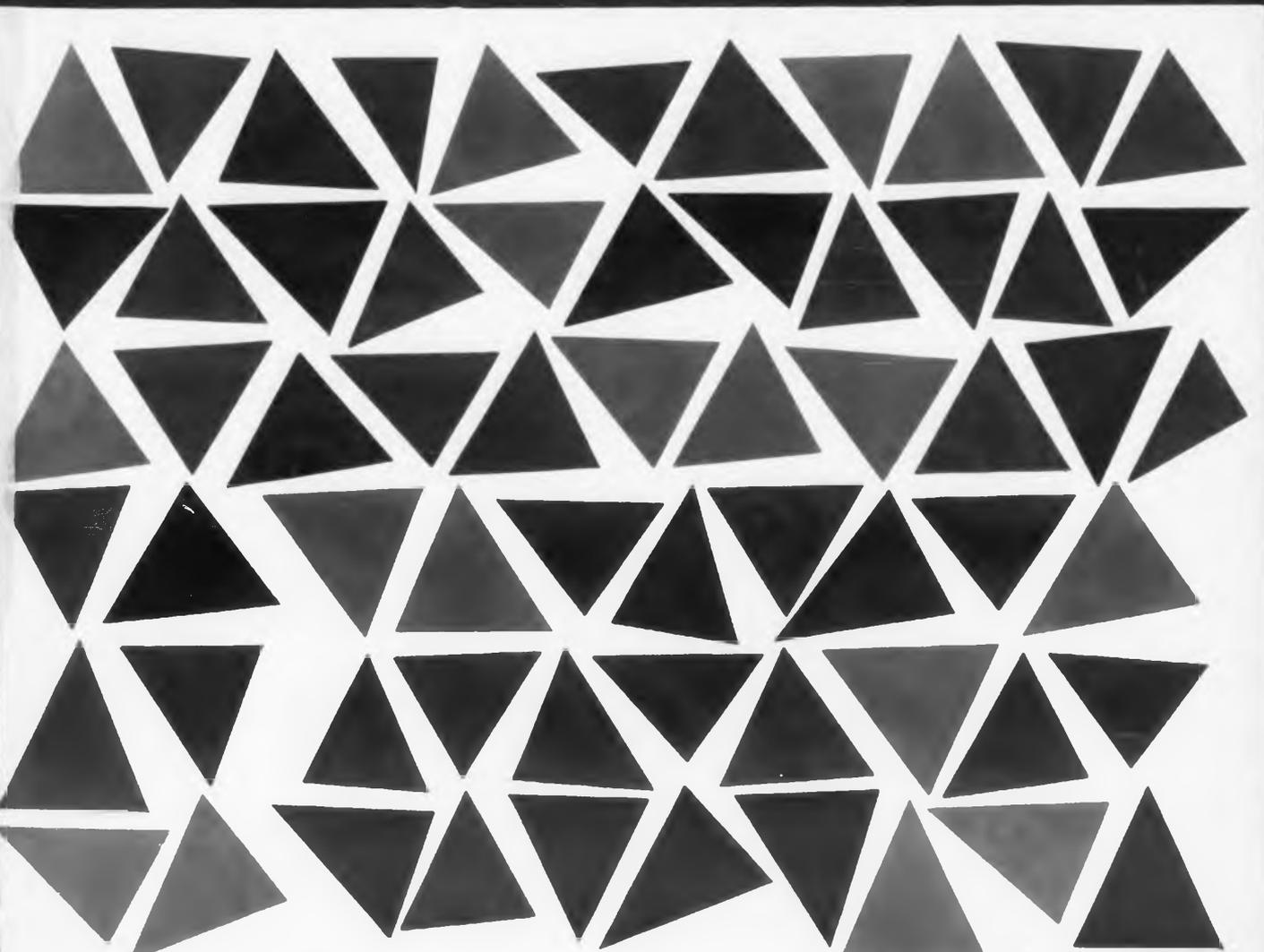
544



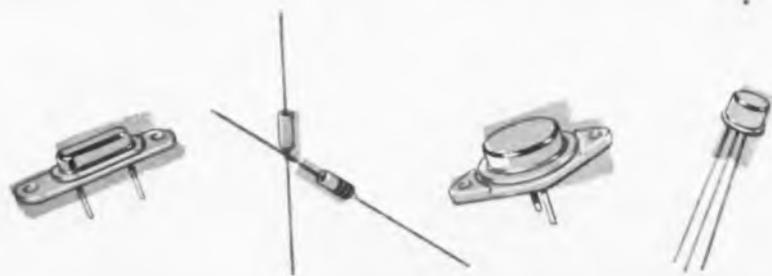
For miniaturized packaging, these connectors will provide 100 connections in 2-1/2 in. of length. Top and side feed nylon modules may be interlocked on a rigid plastic track which may be cut to any length. Burndy Corp., Dept. ED, Norwalk, Conn.

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WALTHAM, MASSACHUSETTS

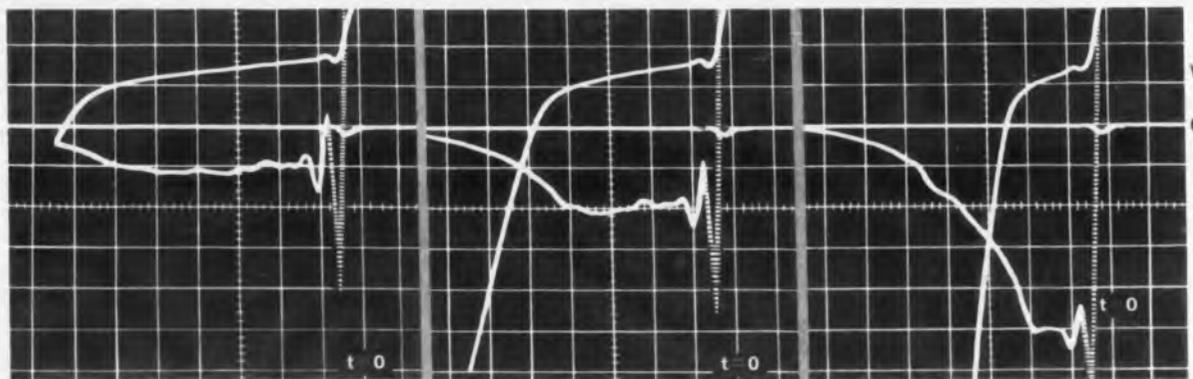


Figure 1 — 1ma., 10nsec., 185mv./div.

The usefulness of diode stored charge measurements

by DAVID E. HUMEZ

Technical Advisor to the Manager of Operations
Clevite Transistor, Waltham, Mass.

Because driving signals usually are of fixed amplitude and duration in a given circuit, it would be desirable to express the transient behavior of diodes in terms of the charge which must be removed during switching. It would be even more desirable if a simple method of measuring stored charge under a given set of circuit conditions could predict the diode behavior under different conditions.

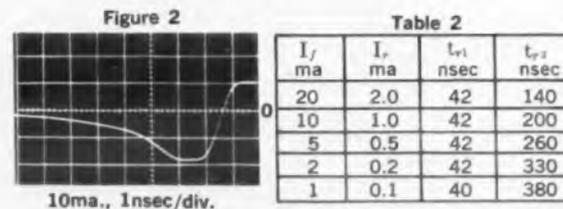
Measurements of the charge represented by the product of reverse current (I_r) and the time (t_r) required for the diode junction voltage to drop to zero have been disappointing. For the same forward current (and therefore the same total stored charge) the charge measured varies widely with changes in the reverse current. Table 1 lists a series of measurements on a single, moderately-fast, diode. Note particularly that the measurement made from 10ma. to 18ma. shows a smaller ratio of t_r to τ , the effective total charge lifetime, than all the other measurements and yet does not show a maximum normalized value of $t_r I_r$. Very small values of t_r/τ do not give more understandable results.

I_f ma	I_r ma	t_r nsec	$t_r I_r$ μcoul	τ nsec	τI_f μcoul
5	2	18	36	31.7	158.5
20	2.0	42	84	33.2	664.0
20	1.0	62	62	31.6	632.0
20	0.5	86	43	33.8	676.0
20	0.1	134	13.4	34.0	680.0
10	18	3.1	55.8	33	330.0
20	1.0	73	73	37.2	
20	2.0	48	96	33.6	
20	5.0	26	130	31.6	

The use of the popular expression $Q = \tau I_f (e^{t_r/\tau} - 1)$ at all, and particularly when $t_r < \tau$, gives rise to large errors because the derivation of the expression makes use of a fundamentally false assumption: viz., that at the time, t_r , the charge contained in the diode will have dropped to zero. Both theory and measurement show that the fraction of the total charge removed during this time is never larger than about one fourth, that it varies widely with the ratio of I_f/I_r , and that it reaches a maximum at I_f/I_r of approximately 1.5 corresponding to $t_r/\tau = 0.35$ approximately.

The current and voltage traces displayed in figure 1 illustrate the variation in the fraction of charge removed during the time, t_r . The diode behavior shown is that of the diode of Table 1. The last three lines of Table 1 were derived from the photographs, whereas the first five lines were obtained with different equipment. Experimental difficulties in achieving simultaneous traces of current and voltage have given rise to small errors.

A general solution of the diffusion equation for a diode whose base is thick compared to a diffusion length ($W > L$) yields the expression, $\text{erf} \sqrt{t_r/\tau} = I_f/(I_f + I_r)$. By the use of this simple expression, values of τ and τI_f (the total stored charge) have been calculated in the last two columns of Table 1. For a wide range of values for I_f/I_r , remarkably uniform values of τ result. From the value of τ can be calculated t_r for any value of I_f/I_r . Assuming a value of $\tau = 33$ nsec, t_r was calculated for $I_f/I_r = 0.55$. The result predicts that the constant current phase of recovery should be over in 3.1 nsec. Figure 2 illustrates this same diode performing under these conditions. The diode is being switched from 10ma forward to 3 volts and approximately 100 ohms external loop impedance. Note that with such a low voltage and loop impedance the voltage drop across the diode itself is not negligible. The reverse current is not 3/100 amperes but rather .018 approximately. Also at this speed the rise time of the generator and CRO are important. It is, none the less, encouraging that a measurement made at 134 nsec and an I_f/I_r of 200 to 1 should predict so well the behavior at 3.1 nsec and an I_f/I_r of 1 to 1.8.



I_f ma	I_r ma	t_{r1} nsec	t_{r2} nsec
20	2.0	42	140
10	1.0	42	200
5	0.5	42	260
2	0.2	42	330
1	0.1	40	380

Table 2 illustrates a simple test for the condition $W > L$. The diode yielding the results listed as t_{r1} satisfies the condition, the other diode does not.

Stored charge measurements can, then, be made at conveniently long times for a large group of moderately to very fast diodes intended for use in the low nanosecond range. A single set of test conditions could well be adopted as standard for a very wide range of end use conditions.

Detailed information on this subject is available. When writing please ask for Applications Bulletin 3.

CT CLEVITE TRANSISTOR
Waltham, Massachusetts

Splice Cap

545

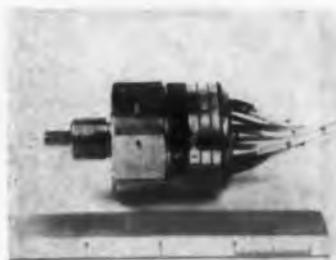


Wire twisting for splicing is eliminated by splice cap 2008S. The steel cap has eight equally spaced flutes to position it in the crimping tool as the connection is made.

Buchanan Electrical Products Corp., Dept. ED, Hillside, N.J.

Lanyard-Operated Switch

546



A 4pdt lanyard-operated switch, type M-479-1 withstands high-level sinusoidal and random noise vibration tests in both axes, in normally open and closed positions, without contact movement. Switch has passed vibration test of 92 g at 2 kc. Contacts are rated at 10 amp dc. Weight is 0.5 lb, length 2.7 in. Life exceeds 5,000 cycles per min.

Kinetics Corp., Dept. ED, 410 S. Cedros, Solana Beach, Calif.

Vibration Tables

547



Lightweight vibration tables are made for electronic reliability testing programs. Model RH-5220, for horizontal vibration, produces 3.2 g; RV-5340, for vertical vibration, will produce 3.6 g. Frequency range is 25 ± 5 cps; test load capacity is 500 lb.

L. A. B. Corp., Dept. ED, 700 Onondaga St., Skaneateles, N. Y.

Price: \$4,000 to \$7000.

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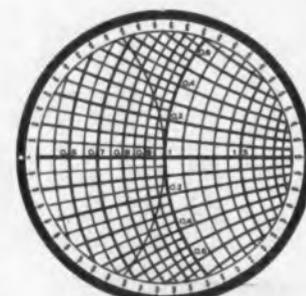
Frequency Range	Type	Ω
30 to 420 mc	ZDU	50 $^\circ$, 60 and 75
300 to 2400 mc	ZDD	50 $^\circ$ and 60

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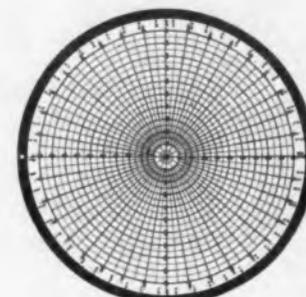
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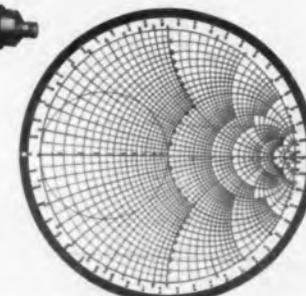
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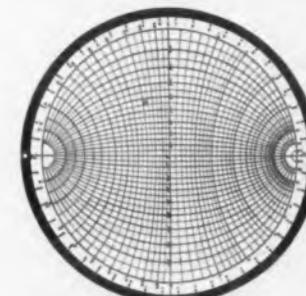
Expanded Smith Chart



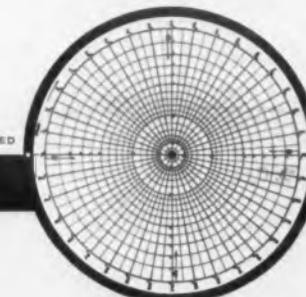
Reflection Coefficient



Smith Chart (Rectangular Coordinates)



Carter Chart (Polar Coordinates)



Attenuation and Phase Angle

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CANNON ELECTRIC COMPANY, 3208 Humboldt Street,
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439



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Panduit Corp., Dept. E1-2, Dept. ED, 17301 Ridgeland Ave., Tinley Park, Ill.

Cryogenic Pumps

436



Flooded electric motors are used in line-mounted cryogenic pumps. Operating temperature range is -290 to -420 F. Motors range in size from fractional to 50 hp, for 60 or 400 cps power. The 50-hp motor uses 3-phase, 400-cps power, measures 6.50 in. in diameter by 7 in. long and weighs 30 lb. At normal speed of 24,000 rpm, efficiency is 90%. Pumps are made for pipe sizes of 1 to 8 in., flange-mounted or welded.

Pesco Products Div., Borg-Warner Corp., Dept. ED, 24700 N. Miles Road, Bedford, Ohio.

Thermostat Module

434



Miniature, liquid-in-glass thermostat offers direct switching of 1, 4.7, and 10 amp or larger loads without external relays or amplifiers. Unit handles output voltages to 400 v at frequencies from 25 to 1,000 cps. Setting accuracies to 0.1 C and differential of 0.05 C can be provided. Package is 0.4 in. in diameter by 1-1/2 in. long for ac, slightly larger for dc.

Precision Thermometer & Instrument Co., Dept. ED, 1434 Brandywine St., Philadelphia 30, Pa.

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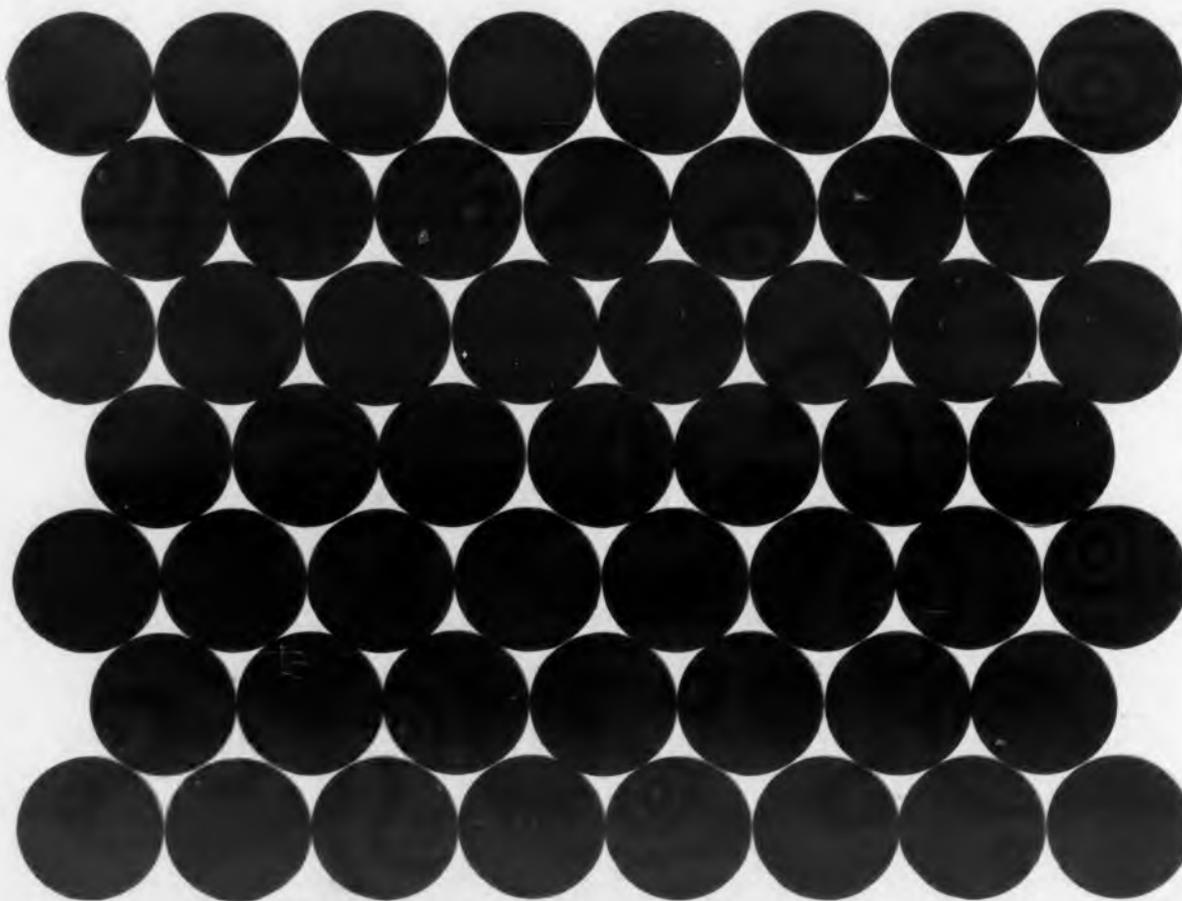
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453



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Electronic Laboratories Corp., Dept. ED, 4221 Spencer St., Torrance, Calif.

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433



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Minneapolis-Honeywell Regulator Co., Micro Switch Div., Dept. ED, Freeport, Ill.

Price & Availability: \$130 ea; stock.

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432



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Mnemotron Corp., Dept. ED, 3 N. Main St., Spring Valley, N. Y.

Silicon Rectifier

431



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Motorola Semiconductor Products Inc., Technical Information Center, Dept. ED, 5005 E. McDowell Road, Phoenix, Ariz.

Price: \$0.58 ea, 10,000 quantity.

Frequency Converter

435



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Pioneer Magnetics Inc., Dept. ED, 850 Pico Blvd., Santa Monica, Calif.

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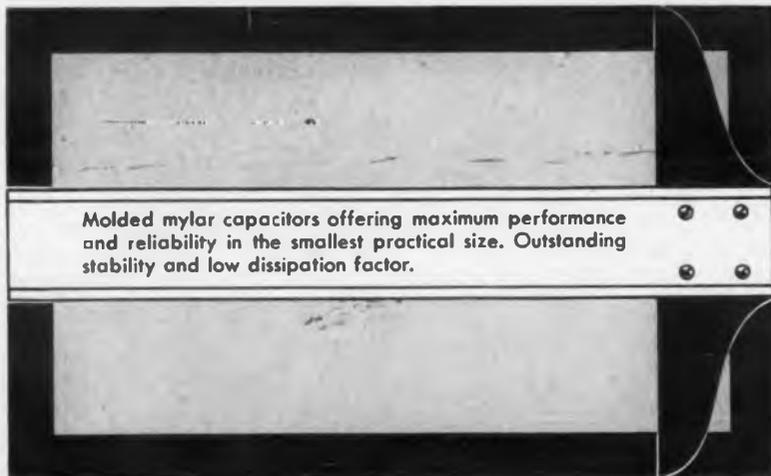
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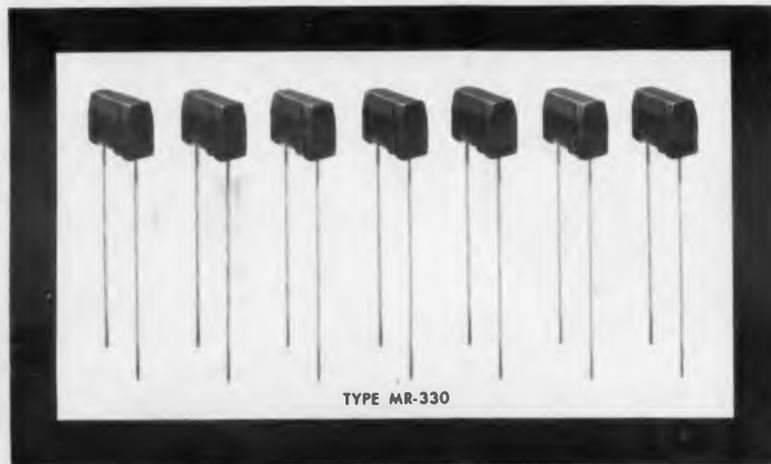
Reading clockwise: Venus, Moon, Mars. Approximate distance from Venus to Earth, 25,000,000 miles; from Moon, 240,000 miles; from Mars, 50,000,000 miles.

Photos courtesy of Mount Wilson and Palomar Observatories.



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Electro Scientific Industries Inc., Dept. ED, 7524 S. W. Macadam Ave., Portland 19, Ore.

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Electronic Processes Corp., Dept. ED, 436 Bryant St., San Francisco, Calif.

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A multi-layer construction is used in silicon laminar diodes. Type IN3257 has greater than 30 ma forward current at 1 v, reverse recovery time of less than 3 nsec, and rectification efficiency of 45% at 100 mc. Type IN3258 has more than 100 ma forward current at 1 v, reverse recovery in less than 4 nsec, and rectification efficiency of 40% at 100 mc. Both types have saturation voltage greater than 100 v at 25 C. Core driver types are also available in laminar construction.

Pacific Semiconductors, Inc., Dept. ED, 12955 Chadron Ave., Hawthorne, Calif.

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- no calibration or zero adjustments.
- instantaneous indication of resistance without zero drift or errors due to thermal EMF's.
- lightweight and portable. Furnished with protective cover and set of four test leads.
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Forward and reverse dc characteristics of diodes and rectifiers are measured by model 1808 diode test set. The forward current supply is metered and adjustable from 50 μ a to 3 amp. The forward voltage is measured in three ranges of 1, 3, and 10 v full scale. Reverse voltage is metered and adjustable from 0.5 to 2,000 v. Reverse currents from less than 1 na to 3 ma are read directly.

Dynatron Electronics Corp., Dept. ED, 178 Herricks Road, Mineola, N.Y.

Servo Motor 442

Size 5 precision servo motor type 5351-01 is 1 in. long, weighs 0.7 oz. and has 0.12 oz-in. torque at stall. Operating temperature range is -55 to $+125$ C. Motor has 47,000 rads per sec² torque-to-inertia ratio. No-load speed is 9,500 rpm min. Power required is 26 v at 400 cps, 1.7 w at stall.

John Oster Manufacturing Co., Avionic Div., Dept. ED, Racine, Wis.

Miniature Relays 477



Rotary and time-delay relays are available in volume of less than 1/3 cu in. The solid-state time-delay relay TD-181 operates on 21 to 30 v dc; delays range from 100 msec to 10 sec, with accuracy to $\pm 10\%$. Single-pole, normally open contacts are rated at 150 ma, 30 v. The M200 rotary unit has 2pdt contacts rated at 2 amp resistive, 1 amp inductive, 26.5 v dc or 115 v, 400 cps. Operate time is 0.005 sec max. Weight is 0.6 oz. The two units combine to form a 2pdt timing relay. Environmental tests are met.

Leach Corp., Controls Div., Dept. ED, Azusa, Calif.

Availability: 4 weeks.

CIRCLE 96 ON READER-SERVICE CARD ▶

New Improved CBS PNP Power Transistors

2N538(A) • 2N539(A) • 2N540(A)

FEATURE MORE POWER,
LESS WEIGHT, LESS SPACE

The CBS 2N538(A), 2N539(A) and 2N540(A) have a maximum dissipation of 30 watts at a base mounting temperature of 25 deg. Centigrade. Yet, each transistor weighs less than 5 grams and requires only 1/3 square inch of chassis space.

Compact and rugged, these hermetically-sealed CBS PNP Germanium Power Transistors are ideal for military and industrial power applications demanding high reliability. They are especially suited for servo motor controls, power amplifiers, converters, power supply regulators and low-speed power switches.

Note the major characteristics and advantages. Call or write today for complete technical data and delivery information from your local sales office or Manufacturer's Warehousing Distributor.



CBS PNP Power Transistors with an improved industrial male package offer:

- Single, sturdy 8-32 mounting stud
- Matched glass-to-metal seal for greater mechanical strength and resistance to thermal shock
- Rugged welded construction through the selection of matched materials having excellent welding properties
- Typical leakage three to five times lower than specification limits.
- High dissipation with minimum size
- High collector-to-base voltage
- High collector-emitter breakdown voltage
- Wide range of operating and storage temperatures

ELECTRICAL CHARACTERISTICS

Type	Max. V _{CB0}	Min. V _{CE} (d=1)	hFE (I _C =2A, V _{CE} =-2V)		V _{BE} (I _C =2A, V _{CE} =-2V)		G _p (mhos) (I _C =2A, V _{CE} =-2V)	
			Min.	Max.	Min.	Max.	Min.	Max.
2N538	-80	-55	20	50	1.33	3.33		
2N538A	-80	-55	20	50	1.33	3.33	17.5	52
2N539	-80	-55	30	75	1.00	2.50		
2N539A	-80	-55	30	75	1.00	2.50	35	105
2N540	-80	-55	45	113	0.75	1.88		
2N540A	-80	-55	45	113	0.75	1.88	71	213

All types have: Max. collector current, 3.5 amps; junction temperature, -65 to $+95^{\circ}$ C; max. saturation voltage 0.6 volts (I_C=2A, I_E=200 mA). Minimum alpha cutoff frequency is 200 KC (I_C=100 MA, V_{CE}=-4 volts); max. thermal resistance, 2.2°C/W.



semiconductors

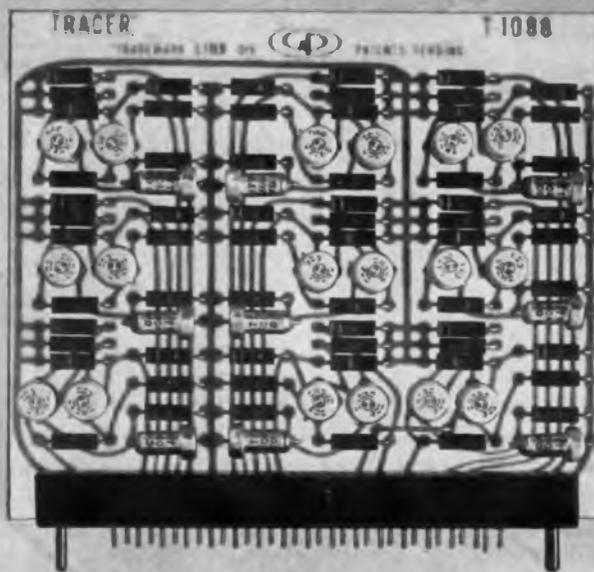
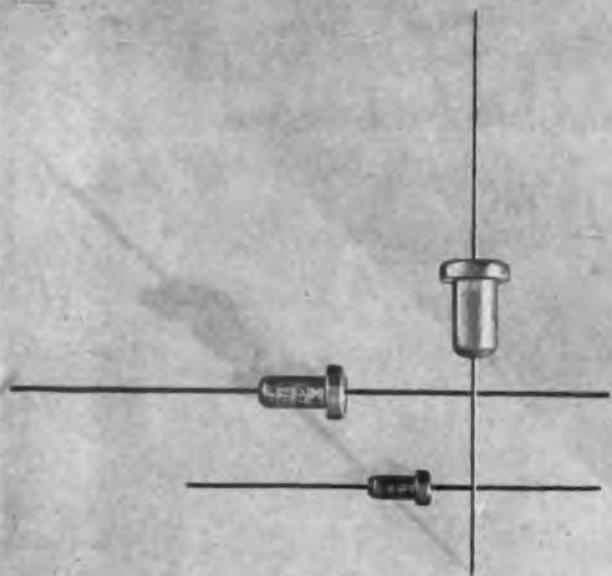
More Reliable Products through Advanced Engineering

CBS ELECTRONICS, Semiconductor Operations, Lowell, Massachusetts

A Division of Columbia Broadcasting System, Inc. • Semiconductors • tubes • audio components • microelectronics

Sales Offices: Lowell, Mass., 900 Chelmsford St., GLenview 2-8961 • Newark, N. J., 231 Johnson Ave., TA1bert 4-2450
Melrose Park, Ill., 1990 N. Mannheim Rd., EStebrook 9-2100 • Los Angeles, Calif., 2120 S. Garfield Ave., RAYmond 3-9081

Toronto, Ont., Canadian General Electric Co., Ltd., LEnnox 4-6311.



Link Division of General Precision, Inc. specified ITT capacitors for this vital portion of its Tracer Identification and Control System, which demands utmost reliability and long life expectancy from every component.

TOTAL PROCESS CONTROL AND DISCIPLINED PRODUCTION DELIVER

HIGH-RELIABILITY WET-ANODE TANTALUM CAPACITORS FROM ITT

ITT wet-anode tantalum capacitors meet MIL-C-3965B—a fact proved by independent laboratory qualifications tests on ITT capacitors. The reliability and long life expectancy of these competitively-priced capacitors are direct results of ITT's total process control and disciplined production procedures, above and beyond testing standards more stringent than normal industry practice—and backed by ITT's world-wide facilities and experience.



Phone these ITT-CD Capacitor Sales Offices:

Albuquerque	AX 9-0013	Los Angeles	MI 6-6325
Boston	CA 7-2980	Miami	MI 4-3311
Chicago	SP 7-2250	Minneapolis	WE 9-0457
Cleveland	GR 5-3080	New York	LO 5-1820
Dallas	EM 1-1765	Philadelphia	TR 6-3737
Dayton	BA 6-9493	Phoenix	WH 5-2471
Denver	KE 4-5091	Rochester	FI 2-1413
Detroit	TO 8-3322	San Francisco	LY 1-7321
Fort Wayne	NA 0841	Seattle	MA 2-5433
Kansas City	JE 1-9236	St. Louis	EV 2-3900

IN STOCK AT ITT DISTRIBUTORS:

- TWO TYPES—M-Type and P-Type, for applications from -55 to 85 and 125 C. respectively
- 29 VALUES—from 1.75 to 330 mfd's over a working voltage range to 125 VDC and maximum surge voltages to 140 VDC
- COMPACT AND RUGGED—sintered tantalum slug in fine-silver cases for 2000-hour life at maximum temperature and working voltage
- GUARANTEED—to 80,000 ft. and accelerations of 20 G's with a 0.1 in. excursion in 50-2000 cps range
- LONG STORAGE LIFE—tantalum-oxide dielectric is completely stable; assures trouble-free operation

COMPLETE SPECIFICATIONS ON ITT wet- and solid-anode tantalum capacitors are available on request. Write on your letterhead, please, to the address below.

ENGINEERS: Your ITT representative has a complete set of qualifications and quality control tests for your inspection.

NEW PRODUCTS

1-W Resistor

446



Vitreous-enameled, wirebound 1-w resistors are made in axial-lead configuration. Length is 9/16 in. max, diameter 1/8 in. max. The resistor shows stability under constant full load, low noise, long life and good overload capability. Resistance range is 1 to 6,000 ohms, tolerance $\pm 5\%$.

Ohmite Manufacturing Co., Dept. ED, 3657 Howard St., Skokie, Ill.

Coaxial Latching Relay

445



Magnetic latch assembly and a balanced rotary armature provide positive latching action in a compact coaxial latching relay. Size is 2-1/8 x 1-1/2 x 0.86 in., weight 5.5 oz. Environmental specifications are met. The pulse-operated relay has a low standing-wave ratio. Armature travel is 0.040 in.

Electro-Actuators Div., Omega Precision, Inc., Dept. ED, 757 N. Coney Ave., Azusa, Calif.

P&A: On request; 6 to 8 weeks.

Voltage-To-Frequency Converter

472



Solid-state voltage-to-frequency converter develops output frequency pro-

◀ CIRCLE 97 ON READER-SERVICE CARD

portional to the input voltage. Used with a standard frequency counter, the device measures dc voltage to 0.1% accuracy. Four-decade voltage ranges cover 0 to 1 kv dc, positive or negative. Sawtooth output wave amplitude is 3 v rms.

Lome Electronics, Inc., Dept. ED, 8526 N. New Braunfels, San Antonio 9, Tex.

Price: \$395.

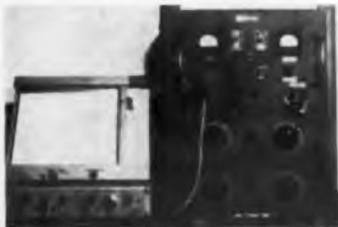
Radiation Instruments 447



Four chassis comprise the Logic 801 system for measuring radioactivity. Preamplifier accepts pulses from Geiger, scintillation, or proportional detectors and provides gain of 1 or 20. High-voltage supply is continuously variable, with positive output from 350 to 5,000 v and negative output from 350 to 1,500 v. The 6-digit scaler has a resolution of 1 μ sec. Timer chassis records duration of count or provides preset stop; drift is 1 ppm per week max.

Nuclear-Chicago Corp., Dept. ED, 359 E. Howard Ave., Des Plaines, Ill.

Magnetic Tester 471



Automatic tracing of flux density vs magnetic force curves is done by the Ferrotracer. Used with an X-Y recorder, the unit makes a permanent record of the core under test in less than 60 sec. Magnetic values can be read directly in kilogauss and oersteds. The solid-state tester has over-all accuracies of $\pm 2\%$.

Lumen, Inc., Dept. ED, P. O. Box 905, Joliet, Ill.

P&A: \$1,575, 60 cps; \$2,300, 400 cps; 14 weeks.

SPECTROL SOLVES EQUATIONS LIKE THIS...

$$\Theta = A \tan^{-1} B \left[(1 + 0.2 \left[C + D \frac{e_0}{E_1} \right]^2)^{7/2} - 1 \right]$$

to design non-linear
potentiometers
—faster, more accurately



The above equation is the mathematical expression for the non-linear function required of a precision pot to relate voltage ratio $\frac{e_0}{E_1}$ to potentiometer shaft position Θ .

This is a typical non-linear problem applied to Spectrol's new IBM 1620 digital computer... equipment which eliminates days of design time, provides error-free results and makes it possible for Spectrol to issue quotations a day or two after receiving your request. For the past three years Spectrol—and only Spectrol—has used this technique.

Basically, it works this way: Computer input data is in the form of programmed equations or tabulated X and Y coordinates. Previously programmed tapes with general equations for non-linear applications (on file at Spectrol) operate on the data, to compute output in terms of winding equipment settings, cam angles

and radii. An electric typewriter prints out this information on a form such as that shown above, which is sent directly to production, eliminating delays and potential transcription errors.

Speaking of production, Spectrol has precision equipment for winding non-linear resistance elements at its plants in New York and Toronto to supplement its California facilities. Using the computer in California, Spectrol can TWX winding instructions to either plant... another reason you can expect results sooner.

One more thought: Call us if you're in a bind. Letters take time.

To assist engineers who have applications for non-linear pots, Spectrol has prepared a detailed specifications brochure. For your copy, contact your Spectrol engineering representative or the factory.

AM	FPN-8,01,10	03366	11	03129	00001
TF	*+18,KOUNT4	03376	26	03996	03952
TFM	,70,10	03390	16	00000	00070
B	NEGK	03402	49	03318	00000
EQUALK	AM KOUNT4,02,10	03414	11	03952	00002
TF	*+18,KOUNT4	03426	26	03444	03952
TFM	,70,10	03438	16	00000	00070
TF	*+30,KOUNT4	03450	26	03480	03952
TF	*+23,KOUNT5	03462	26	03485	03957
TD	.	03474	25	00000	00000
AM	KOUNT5,01,10	03486	11	03957	00001
CM	KOUNT5,FPN,7	03498	14	03957	03137
BNH	EQUALK	03510	47	03414	01100
FLAGK	BNF *+24,FPN	03522	44	03546	03137
TDM	DECK+21,2,10	03534	15	03876	00002
BB		03546	42	00000	00000
POSK	HM FPN-8,02,10	03558	13	03129	00002
S	KOUNT4,99	03570	22	03952	00099
TF	*+18 KOUNT4	03582	26	03600	03952
	30,KOUNT4	03594	16	00000	00070
	23,KOUNT5	03606	26	03636	03952
	4,02,10	03618	26	03641	03957
	NT5,01,10	03630	25	00000	00000
	KOUNT5,FPN,7	03642	11	03952	00002
	BNH *+96	03654	11	03957	00001
	CM KOUNT4,DECK,7	03666	14	03957	03137
		03678	47	03774	01100
		03690	14	03952	03855

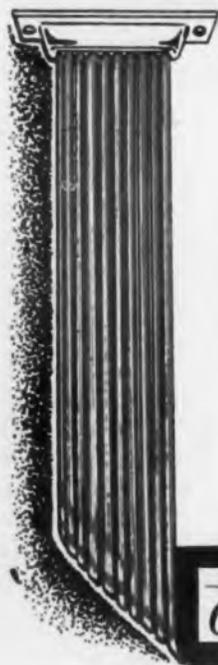
SPECTROL

ELECTRONICS CORPORATION

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Precise separation-distance between conductors can be varied to provide a dependable set of circuit constants. Cables are available in any combination of conductors and wire sizes including shielded and coaxial constructions . . . and with Teflon insulations that RESIST ABRASION (Type AR) . . . RESIST CORONA STRESS (Type CR)—or in combinations of both.

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MINIATURE Electrolytic CAPACITORS

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- Rugged, excellent under severest operating conditions.
- Non-polarized types available for audio, cross-over, and other AC applications.

SMT and SMTU

Aluminum case with patented construction, molded bases with thermoset plastic and silicone rubber seals. Hermetic sealing for wide temperature applications. Supplied with transparent plastic insulating sleeves.

SMT-AXIAL LEAD



SMTU Upright Mounting

Temperature:
-30°C to +65°C
-40°C to +85°C
-30°C to +105°C

Types SMTU and BMTU are available in multiple section units in common cathode and common anode. We invite your inquiry.

BMT and BMTU

Plastic cased with thermoset resin end fill; available in two temperature ranges. Economically priced.

BMT-AXIAL LEAD



Temperature:
-30°C to +65°C
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BMTU Upright Mounting

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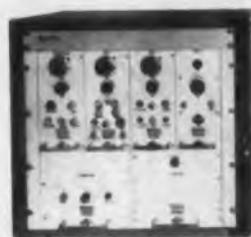
"Foremost manufacturers of Electrolytic Capacitors for almost 30 years"

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NEW PRODUCTS

Pulse Generators

428



Modular subsystems are combined as required to form pulse- and time-delay generating equipment. A wide range of repetition rates, delays, and pulse widths are possible through use of rate, delay, width, pulse-forming, and power supply packages. The model B-9 systems use accurate, largely transistorized circuitry.

Rutherford Electronics Co., Dept. ED, 8944 Lindblade St., Culver City, Calif.

Four-Terminal Clips

449



Designed for rapid, low-resistance, high-accuracy measurements using four-terminal techniques, model ESI Kelvin Klips are constructed of beryllium copper with gold plating. The units may be used with any bridge employing Kelvin circuits and the four-terminal method.

Electro Scientific Industries, Inc., Dept. ED, 7524 S. W. Macadam Ave., Portland 19, Ore.

Encapsulated Inductances

464



For printed wiring applications, the J302 series of miniature encapsulated inductances range in value from 10 mh to 22 μ h with $\pm 5\%$ tolerance. Maximum dc current rating is 60 ma to 1.21 amp. The units are wound with high-temperature wire and encapsulated in epoxy for -55 to +125 C ambient temperature operation. Lead spacing is 0.2 in.

James Millen Manufacturing Co., Inc., Dept. ED, Malden, Mass.

Don't forget to mail your renewal form to continue receiving **ELECTRONIC DESIGN**.

A
NEW



SYSTEM
COMPONENT
FOR--

- GROUND SUPPORT
- COMPUTERS
- TEST EQUIPMENT

MID-EASTERN
SC SERIES
TRANSISTORIZED
POWER SUPPLIES

- High Power - Small Package
- No External Heat Sink Required
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- Designed For Maintainability
- Stock Delivery
- 0.05% Regulation, 1 mv Ripple
- Sealed Case, Gold Anodized

8 MODELS
\$149.00 each

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ELECTRONIC DESIGN • April 26, 1961

where
precision

is a
must



RED/LINE timing relays "Pay Off"!

The design engineers at Victor's Electric-Car Division sought a way of making their Dyna-Powered Maintenance Truck accelerate automatically and smoothly through the three forward speeds. The answer: Two G-V Red/Line Thermal Relays, each providing a two-second delay between steps. This assures smooth, even acceleration every time. A third Red/Line Relay shuts off the dynamic brake after a fixed time interval, conserving battery power. So, at Victor, G-V Red/Line Timing Relays are "paying off".

More and more companies are finding the reliable performance of G-V Red/Line Timing Relays makes them best for their products. G-V Red/Line Relays will "pay off" in your product, too. Your customers appreciate the importance of high quality, reliable components. G-V Red/Line Timing Relays are specially designed for industrial applications. They have the precision, reliability and long life needed to "pay off" in industrial use.

Your G-V distributor has them in stock now. Call him or write for Bulletin 131 today.



G-V CONTROLS INC.
Livingston, New Jersey

Thermosetting Tape

430



Pressure-sensitive, thermosetting resin adhesive in glass cloth tape No. 7020 cures in 1/2 hour at 350 F. Tape operates at Class B temperatures. Other features are high tack, high initial adhesion, and excellent resistance to solvents, abrasion, aging, and chemicals.

Mystik Adhesive Products, Inc., Dept. ED, 2635 N. Kildare Ave., Chicago 39, Ill.
P&A: \$7.94 to \$6.35 per roll, 1 in. x 60 yd; stock.

Data Plotter

452



For analog as well as digital inputs, series 3100 dataplotter provides accuracies up to 0.175% of full scale on 11 x 17 in. plots. Plotting speeds are up to 80 points per min. It is equipped with transistorized control circuitry, provisions for "off-board" origin, and is able to accept punched card, tape or keyboard input.

Electronic Associates, Inc., Dept. ED, Long Branch, N.J.

Operational Amplifier

455



Octal-base, plug-in, operational dc amplifier model C/100/B is for analog computer and instrument applications. Specifications are: gain, 30,000 dc open loop; output, 3 ma over ± 100 v dc; bandwidth, over 400 kc with 0.6- μ sec risetime as unity inverter.

Embree Electronics Corp., Dept. ED, 993 Farmington Ave., West Hartford 7, Conn.

P&A: \$25 in 1 to 5 quantities; 10 days.

CIRCLE 103 ON READER-SERVICE CARD ▶



New equipment without capital outlay ...from Ampex

Ampex data recorders on the newly announced lease program can help you in two ways. Leasing lets you pay for the use of your data recorder only as you need it.

Through installment purchases, you are investing in your Ampex data recorder while it works for you.

Either way, pressure on your working capital is reduced to the minimum. Complete program details and equipment specifications from:

AMPEX

AMPEX INSTRUMENTATION PRODUCTS CO.
Box 5000 Redwood City, California

CIRCLE 102 ON READER-SERVICE CARD
ELECTRONIC DESIGN • April 26, 1961

New B/A model NC-1 performs transistor tests up to

50 amps at peak power levels!



- Minimizes heat sink requirements.
- Under optimum conditions, requires only 6 10ths of 1% of the input power used in conventional DC current tests.
- Permits 750 watts max. power with max. current of 50A or max. voltage of 250V.
- Provides DC meter readings of V_{BE} , I_B , V_{CE} and I_C — common emitter configuration under pulse conditions.
- Measures leakage currents and I_{CO} and I_{EO} by standard techniques.
- Allows breakdown measurements to be performed under variable bias conditions.
- Evaluates switching capabilities of device under dynamic conditions.

Here's the only direct reading, variable duty cycle test set for non-destructive measurement of medium and high-power transistors. The B A Model NC-1 applies suitable pulse drive signals to the transistor under test and then peak detects the resulting current pulses at the same measuring value as steady state DC. Because the average pulse signal power is considerably lower than that of steady state DC, less stress is put on the transistor. This permits power tests to be made at a level many times that of rated device dissipation.

Write today for additional information and name of your nearby Baird-Atomic representative.

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BAIRD-ATOMIC, INC.

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ADVANCED OPTICS AND ELECTRONICS . . . SERVING SCIENCE

NEW PRODUCTS

Digital Converter

469



Used with pointer instruments, digital converter provides input data for digital computers or control systems. Photoelectric scanner operates at up to 10 scans per sec. An electronic unit houses circuitry and display. Typical accuracy is 0.1 ± 1 count, resolution 1 part per 1,000.

MacLeod Instrument Corp., Dept. ED, 4250 N.W. 10th Ave., Fort Lauderdale, Fla.

DC Amplifier

448

A chopper-stabilized vacuum tube type, type 98 dc amplifier completely isolates the recorder from the signal source. Designed for use with the firm's IMA or 100- μ a recorders, it will increase sensitivity up to 10 times. Input resistance is 1 megohm; accuracy and linearity are 0.1%; drift is less than 0.5%.

Rustrak Instrument Co., Inc., Dept. ED, 130 Silver St., Manchester, N. H. Price: \$109.50.

Static Converters

441



Rated at 100 w, dc-to-dc static converters type CN are designed to withstand shock and vibration. Input is 6, 12, 18, 24, or 28 v dc with an allowable variation of $\pm 20\%$. Output voltages are 600, 300, 150 and 100 v dc at 100 w. Ripple is less than 0.5% rms. Units are potted in MIL-T-27A transformer cans; transistors are accessible for service.

PRL Electronics, Inc., Dept. ED, 232 Westcott Drive, Rahway, N. J. P&A: \$70.00 to \$81.25; delivery from stock.

◀ CIRCLE 104 ON READER-SERVICE CARD

Rack Blower

470



Two-speed blower for electronic racks is designed to provide greater air turbulence over the entire rack interior. Output of the 19-in. unit is 500 cfm. Various rack depths are available. Washable filter can be serviced without removing the blower.

McLean Engineering Laboratories, Dept. ED, Princeton, N. J.

Soldering Instrument

443



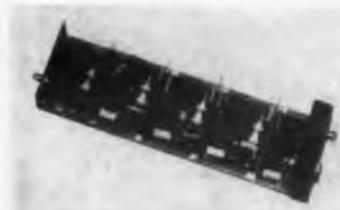
Twin heating elements in this tweezer soldering instrument develop 572 F temperature at the 1/32 in. tips. Used with low-temperature solders, the instrument weighs 1 oz., is 8 in. long, and operates on 6 v dc.

Oryx Co., Dept. ED, 13804 Ventura Blvd., Sherman Oaks, Calif.

Price & Availability: \$14.95; immediate.

Post-IF Amplifiers

444



Military requirements of temperature and service life are met by post-if amplifiers A 106-108. The silicon-transistor units have center frequencies of 30, 45, or 60 mc. Gain is 60 db, bandwidth 9 mc. The amplifiers are capable of -125 C operation, with storage to +150 C.

Orion Electronic Corp., Dept. ED, 108 Columbus Ave., Tuckahoe, N. Y.
P&A: \$550 ea, 1 to 9; 2 to 4 weeks.

CIRCLE 105 ON READER-SERVICE CARD >



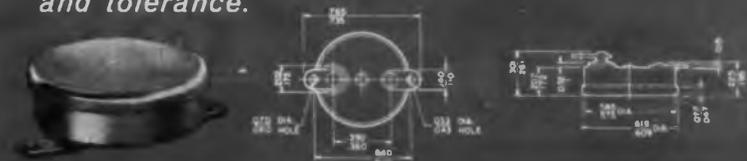
Mach 5...Mach 10...and Beyond

STEVENS *Certified* THERMOSTATS

Up where the "wild blue yonder" becomes inky black, you can't afford to gamble on precise, reliable temperature control. And that's the natural domain of Stevens Thermostats. They are compact and lightweight...withstand high G's...are utterly reliable even under wide temperature swings. For Stevens Thermostats are a product of creative engineering...coupled with the most stringent environmental testing and quality control programs in the industry. If space is your dimension, take the measure of Stevens Thermostats *first*.

2° to 6°F Differential Standard
1° to 4°F Differential Special

*Maximum spread of 6°F including differential and tolerance.



*6°F is difference between maximum open and minimum close.

STEVENS manufacturing company, Inc.
P. O. Box 1007 • Mansfield, Ohio



THERMOSTATS

MIL type rectifiers from General Electric

NEW PRODUCTS

The industry's FIRST MIL type Medium Current Silicon Rectifiers...



Type	MIL Spec	Max. Single Phase PRV (volts)	Max. Single Phase I _{bc} @ Temp.
USA 1N249B	MIL-S-19500/134	125	20 A @ 150°C case
USA 1N250B	MIL-S-19500/134	250	20 A @ 150°C case
USA 1N2135A	MIL-S-19500/134	500	20 A @ 150°C case

The industry's FIRST MIL type Silicon Controlled Rectifiers...

Type	MIL Spec	Max. Single Phase PRV (volts)	Max. Single Phase I _{bc} @ Temp.
USN 2N681	MIL-S-19500/108	25	25 A @ 57°C Stud
USN 2N682	MIL-S-19500/108	50	25 A @ 57°C Stud
USN 2N683	MIL-S-19500/108	100	25 A @ 57°C Stud
USN 2N684	MIL-S-19500/108	150	25 A @ 57°C Stud
USN 2N685	MIL-S-19500/108	200	25 A @ 57°C Stud
USN 2N686	MIL-S-19500/108	250	25 A @ 57°C Stud
USN 2N687	MIL-S-19500/108	300	25 A @ 57°C Stud
USN 2N688	MIL-S-19500/108	400	25 A @ 57°C Stud



and a complete line of Low Current Rectifiers...



Type	MIL Spec	Max. Single Phase PRV (volts)	Max. Single Phase I _{bc} @ Temp.
Germanium			
USN 1N93	MIL-E-1/895B	300	75 ma @ 55°C
USAF 1N315	MIL-E-1/1088	100	100 ma @ 85°C
Silicon			
JAN 1N253	MIL-E-1/1024A	100	1 A @ 135°C case
JAN 1N254	MIL-E-1/989B	200	400 ma @ 135°C case
JAN 1N255	MIL-E-1/990B	400	400 ma @ 135°C case
JAN 1N256	MIL-E-1/991B	600	200 ma @ 135°C case
JAN 1N538	MIL-E-1/1084A	240	250 ma @ 150°C amb.
USAF 1N538	MIL-E-1/1089	200	250 ma @ 150°C amb.
JAN 1N540	MIL-E-1/1085A	480	250 ma @ 150°C amb.
USAF 1N540	MIL-E-1/1089	400	250 ma @ 150°C amb.
JAN 1N547	MIL-E-1/1083A	720	250 ma @ 150°C amb.
USAF 1N547	MIL-E-1/1089	600	250 ma @ 150°C amb.

For complete information call your Semiconductor District Sales Manager or write to Rectifier Components Department, Section 23D12, General Electric Company, Auburn, New York. In Canada: Canadian General Electric, 189 Dufferin St., Toronto, Ont. Export: International General Electric, 150 East 42nd Street, New York 17, N. Y.

For Factory-Low Prices on Selenium, Germanium and Silicon Rectifiers in Quantities up to 999 Call Your Local G-E Semiconductor Distributor.

GENERAL  **ELECTRIC**

CIRCLE 106 ON READER-SERVICE CARD

Microminiature Connectors

457



Hermetically sealed connectors type EHMM will mate with all standard corresponding plastic connectors having socket contacts. Bodies and pins are sealed with glass for reliability which meets or exceeds MIL-C-8384. Current rating is 3 amp; voltage breakdown is 1,200 v rms at sea level.

Escon, Inc., Dept. ED, 735 Branch Ave., Providence, R.I.

Metallized Glass

451



A metallized surface for soldering makes this glass suitable for applications in hermetically sealed units where it is desired to view the operation of components. Details of the process for assembly and design of suitable apertures are available.

Electro-Seal Corp., Dept. ED, 946-A North Ave., Des Plaines, Ill.

Bobbin Resistor

429



Mechanical strength is said to be greatly increased in precision resistors through strain-free bobbin construction. Made in sizes 1/4 x 1/4 x 1/8 in. (No. 20 lead wire) and 3/16 x 3/16 x 1/8 in. (No. 22 lead wire), the units operate in temperatures from -65 to +125 C. Environmental specifications are met. Rating is 150 v, 1/8 w.

National Resistance Corp., Dept. ED, Pearl River, N. Y.

Don't miss an issue of **ELECTRONIC DESIGN**; Return your renewal card.

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Circuit Module



A quadruple unit, for memory or data storage functions in pulse logic systems, this flip-flop circuit module has an operating frequency of 9 to 250 kc. Specifications are: input, 6 to 9 v; rise time for input, 0.1 to 1.0 μ sec; rise time for output, 0.2 to 1.0 μ sec. Two modes of operation are possible: reset-set and trigger.

Electro-Logic Corp., Dept. ED, 515 Boccaccio Ave., Venice, Calif.
P&A: \$65 for 1 to 100 quantities; two weeks.

Rack Cabinet



Designed for maximum flexibility, model FT-192-A standardized electronic rack cabinet has adjustable channels to facilitate mounting slides or chassis. It has a completely adjustable ventilating system for cooling electronic equipment. Height is 77 in., depth and width are 24 in.

Falstrom Co., Dept. ED, 185 Falstrom Court, Passaic, N.J.

Tantalum Capacitors

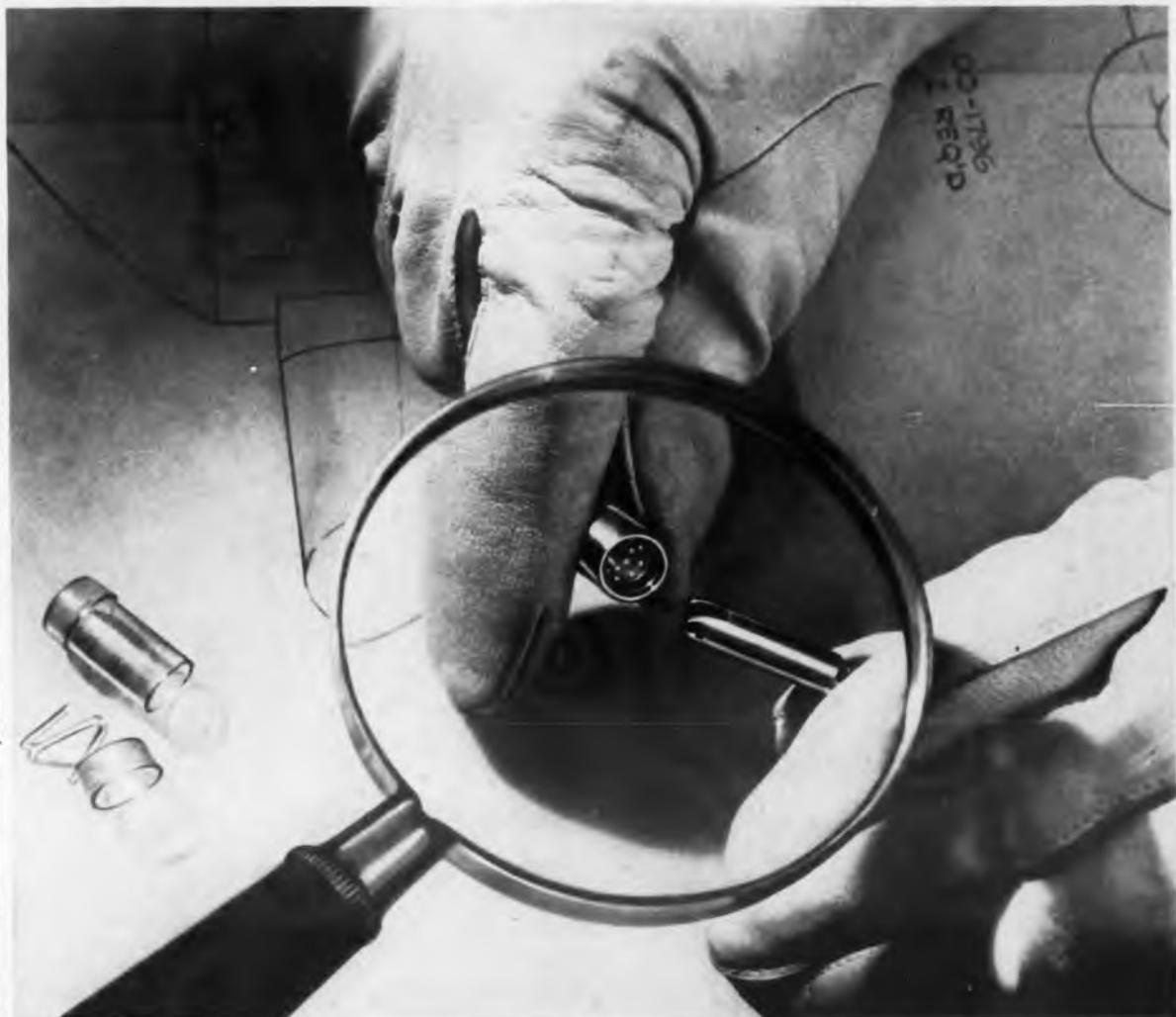


Designed for polar operation, in low-voltage transistorized circuits, the Faratan series is a tantalum solid-electrolyte type. Each unit undergoes a 250-hr life test at rated voltage at 85 C. They are available in two sizes: case A, 0.125 in. diam x 0.250 in. length; case B, 0.175 in. in diameter x 0.438 in. length.

Faradyne Electronics Corp., Dept. ED, 471 Courtlandt St., Belleville, N.J.

480

NEW DEPARTURES IN MINIATURE



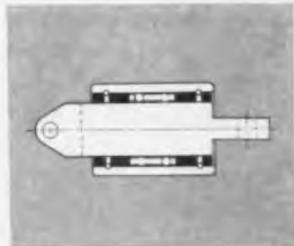
HOW TO GIVE ON-THE-NOSE GUIDANCE TO MODERN "FISH" UNIQUE N/D LINEAR MOTION BEARING FREES GYRO CAGING ACTION

The bearing illustrated is an N/D linear motion precision instrument ball bearing. It was specially designed and built to help solve a critical problem in the guidance system of a high speed anti-submarine torpedo.

PROBLEM: Loss of accuracy in torpedo's guidance system due to hang-up of caging arm in gyro assembly.

SOLUTION: N/D Sales Engineer, in cooperation with manufacturer, found that wear of bushing on caging arm caused hang-up, delaying guidance activation. N/D Engineers set to work to design and build an instrument bearing that operates virtually friction-free. The result: Preservation of the guidance system's pin-point accuracy and reliability.

Should you require ball bearing design information, invite the local N/D Sales Engineer to participate in your early design discussions. He represents one of the industry's largest engineering staffs devoted exclusively to the design and development of miniature and instrument ball bearings. Or, write for new Miniature and Instrument Ball Bearing Catalog, Department L.S., New Departure, Division of General Motors Corporation, Bristol, Connecticut.



This special N/D linear motion instrument ball bearing increased guidance reliability of ASTOR torpedo weapon system developed by Westinghouse.

NEW DEPARTURE MINIATURE AND INSTRUMENT BALL BEARINGS

CIRCLE 107 ON READER-SERVICE CARD

You can put
1/2 TON
on this slide



New Heavy-Duty Slide from Chassis-Trak

Now you can rack-mount your heaviest electronic gear, yet keep it readily accessible for checking and servicing. A new heavy-duty Circulating Ball Slide, developed by Chassis-Trak, will easily support equipment in the 1000 lb. range, even under extreme shock and vibration conditions. Secret of the slide's strength is its Circulating Ball design (see phantom view above). Weight is distributed evenly over the balls which rotate in the direction of the pull, resulting in easy sliding action.

The new Circulating Ball Slide is permanently dry-lubricated with Poxylube 75, a bonded molybdenum disulfide film which assures smooth operation for the life of the slide. Easily assembled with standard hardware, the slide is available in lengths from 16" to 24" in two-inch increments and in lengths up to 60" in six-inch increments. Each track is only 1 1/2" wide and 3" high, requiring much less chassis space than other slides in this heavy-duty range.

Get full details on the new CB Slide today.



for further information contact:

525 South Webster Ave., Indianapolis, Indiana

CIRCLE 108 ON READER-SERVICE CARD

NEW PRODUCTS

Force Gage

456



Three force transducers are incorporated in the same plane in the model 2106 force gage to accurately simulate point force loading. Sensitivity of 7 peak mv per peak lb is obtained. The entire top and bottom surfaces are load-bearing members with stiffness of 2 x 10⁷ lb per in.

Endevco Corp., Dept. ED, 161 E. California Blvd., Pasadena, Calif.

Price: \$425.

Switch Light

467



Rebuilding and modification of the Twist Lite may be done without special tools. Switches include 2pdt and 4pdt momentary action, 2pdt alternate action, and magnetic holding. Display area may be split horizontally or vertically. Unit accepts 4 bulbs at 28, 12 or 6 v. Designed for military or commercial application, the unit meets military requirements.

Master Specialties Co., Dept. ED, 956 E. 108th St., Los Angeles 59, Calif.

Film Capacitors

460



Designed for rapid insertion in printed-circuit boards, series F207 capacitors have right-angle leads. These double-dipped, Mylar film capacitors are available in capacities of 0.01 through 1.0 µf, with ratings of 200, 400 and 600 v dc.

John E. Fast and Co., Dept. ED, 3598 N. Elston Ave., Chicago 18, Ill.

This is the time of our annual subscription renewal; Return your card to us.

EXCITATION!

115-VOLTS...400-CYCLES...FOR BOTH MOTOR AND GENERATOR

Now, a Size 8 servomotor-generator with both motor and generator wound for 115-volt, 400-cycle supplies. It's BECKMAN Model 9008-1106-0, ready now to help cut costs in your system...aid in achieving greater reliability and economy.

Generator specs show an output of 0.30 volts per 1,000 rpm, phase shift is 0° ± 10°. The servomotor turns 6,000 rpm, no-load speed, its stall torque is 0.33 oz. in., and acceleration at stall is 70,700 rad/sec². Length of this motor-generator complete is 1.850" and maximum weight is 2.6 ounces.

For complete facts on BECKMAN Model 9008-1106-0, contact your nearest Helipot Sales Representative, or write directly to us.



Beckman Helipot

POTS : MOTORS : METERS
Helipot Division of
Beckman Instruments, Inc.
Fullerton, California

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Crystal Oven

468



A wide range of crystals is accommodated by the RD-135 mercury thermal switch crystal oven. Useful in low-frequency applications, oven takes crystals up to 1-3/8 in. long. Temperature control is ± 0.005 C at fixed room ambient, and ± 0.025 C from 0 to 60 C. Weight is 7 oz, size 5-3/16 by 1-3/4 in. OD. Unit meets military shock and vibration tests.

Manson Laboratories, Inc., Dept. ED, Stamford, Conn.

Foot Switch

476

Positive control of reversible operations is provided by the Clipper twin foot switch. Each of the switches has momentary contact for spdt circuits rated at 20 amp, 125-250 v ac, and 1 hp, 115-230 v ac. Only one external power cable is used. Variations include maintained contact or dpdt in momentary or maintained contact, one or both sides.

Linemaster Switch Corp., Dept. ED, 432 Woodstock Terrace, Woodstock, Conn.

Magnetic Drum

474



Contact read/write heads in magnetic storage drums provide large-capacity, nonambiguous storage of digital data. Surface air movement separates the heads from drum surface at operating speed. Write current is low, with 300-mv signal amplitude. A 1-v read signal is obtainable.

Computer Systems Laboratory, Litton Systems Inc., Dept. ED, 5500 Canoga Ave., Woodland Hills, Calif.

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YOU'RE THE CIRCUIT JUDGE...

SPERRY

SPERRY SEMICONDUCTOR
DIVISION

OF
SPERRY RAND CORPORATION
NORWALK, CONNECTICUT

...and it's up to us to present the facts.

Here's evidence on Sperry's PNP alloy junction silicon transistors:

1. All units are baked at 200°C for 200 hours and each device is doubly tested for a perfect hermetic seal — through a 150°C hot oil check and a separate hydrostatic test at 100 psi.
 2. Sixty-three QC checks are performed before and during mechanized manufacture.
 3. Our newly-built 65,000 square foot facility in Norwalk, Connecticut incorporates the latest techniques to produce the quality and quantity you require.
 4. We offer you a wide variety of PNP types from which to choose.
- May we have your verdict?

SEMICONDUCTOR IS OUR MIDDLE NAME . . . SEMICONDUCTOR INTEGRATED NETWORKS (SEMI-NETS*), TUNNEL DIODES, MESA AND ALLOY SILICON TRANSISTORS AND DIODES. SALES OFFICES: CHICAGO, ILLINOIS; EL SEGUNDO, CALIFORNIA; WESTWOOD, NEW JERSEY; TEWKSBURY, MASSACHUSETTS; STAMFORD, CONNECTICUT; TOWSON, MARYLAND; MASSAPEQUA PARK, NEW YORK. SEMICONDUCTOR OPPORTUNITIES AVAILABLE TO QUALIFIED ENGINEERS

*Trade Mark, Sperry Rand Corporation



MICRO-STRESS INSTRUMENTATION

Orders of Magnitude More Sensitive SEMICONDUCTOR STRAIN GAGE MICRO-SENSOR MS 105-350

For Application to: Structural Members • Transducer Sensors

FEATURING

- Sensitivity—gage factor 130
- Easily bonded to all types of surfaces for military, industrial, and space applications
- Integral terminal construction
- Superior signal-to-noise ratio
- Resistance—350
- Size: Element— $\frac{5}{8}$ " x .020" Complete Gage—1" x $\frac{1}{2}$ "
- Radius of Curvature— $\frac{1}{2}$ "
- Maximum Operating Strain—over 3000 microstrain

IMMEDIATELY AVAILABLE—

ADDITIONAL INFORMATION ON REQUEST

MS

MICRO SYSTEMS INCORPORATED
208 Aquatic Rd., San Gabriel, California
A Subsidiary of International Systems Inc.

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for exact
frequency
standards

...THIS TUNING FORK OSCILLATOR IS ACCURATE UP TO .002%



- Transistorized, Miniaturized, Stabilized
- Self-Contained—Temperature Compensated
- Hermetically Sealed Box
- Operating Temperature Extremes: -55° C. to 125° C.
- Usual Operating Frequency: 360-12,000 cps
- Extended Range: 1-30,000 cps
- Output Signal: Sine or Square Wave
- Typical Price: \$105 to \$195
- Delivery: 1 week or less for typical prototypes.

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1917 North Harlem Avenue • Chicago 35, Illinois

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with **POWER** to spare...



NICAD

NEW Nickel Cadmium Rechargeable Batteries

SEALED CELLS

Hermetic and rechargeable, boasting exceptionally long life, Nicad batteries are always ready to operate in any position—with power to spare—even under adverse operating conditions.

VENTED CELLS

Vented cells will maintain good voltage even at extremely high discharge rates over a wide temperature range. Get more information on these constant voltage batteries. Write Dept. ED-612.



NICAD DIVISION
Gould-National Batteries, Inc.
St. Paul 1, Minnesota

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NEW PRODUCTS

Power Rheostat

463



Enclosed, dustproof power rheostat is readily adaptable to any linkage for either manual or automatic operation. Design allows operation at full power rating with as little as 25% of the winding in use. The unit is available with standard or tapered windings in ratings of 100, 200 and 300 w. Center tap is optional.

Milwaukee Resistor Co., Dept. ED, 700 W. Virginia St., Milwaukee 4, Wis.

Thermistor Probe

461



Made of stainless steel, this 27-gage hypodermic needle will accommodate a variety of thermistors and is useful as a fast time-constant temperature probe. It has a diameter of 0.022 in.

Fenwal Electronics, Inc., Dept. ED, 51 Mellen St., Framingham, Mass.

Ratiometer

479



A five-digit dc/dc digital ratiometer, type 3500 CR has a ratio range of 0.00000 to 0.99999. Average balance time is 2 sec. An 80-db input filter allows the instrument to operate in the presence of a 10,000 to 1 noise-to-signal ratio. The unit consists of a power module and a switch module.

Electro Instruments Inc., Dept. ED, 8611 Balboa Ave., San Diego 11, Calif.

Epoxy Resins

437

Class H, single-component epoxy resins sustain continuous temperatures of 180 C. Made for impreg-

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nating, potting and casting, the resins have long pot life and low viscosity during cure. Type ER 4251 is clear and unfilled, ER 4287 is opaque and filled. Flexibility allows thermal cycling.

Permacel, Dept. ED, New Brunswick, N. J.

Servo Amplifier

465



In a volume of 1 cu in., the model 1035 servo amplifier can drive a 40-v, 2-phase servo motor up to 3-1/2 w input. The amplifier weighs 1 oz, uses silicon transistors, and operates at 400 cps. Temperature range is -55 to +125 C.

Melcor Electronics Corp., Dept. ED, 48 Toledo St., South Farmingdale, L. I., N. Y.

P&A: \$190 to \$200, sample quantities; 30 days.

Tachometer Pickup

466



Explosionproof magnetic tachometer pickup model 2040 produces high-amplitude, low-modulation sine wave signals proportional to speed. Standard frequencies are 60 or 120 impulses per revolution, adaptable to a range of 1 to 240 impulses per revolution. Speed range is 75 to 10,000 rpm; output is more than 1 v rms at 100 rpm. Weight is 2-1/2 lb.

Electronic Div., Meriam Instrument Co., Dept. ED, 10920 Madison Ave., Cleveland 2, Ohio.

Regenerative Divider

462

A 100-kc output signal is provided from 1-mc input by the RD-126 regenerative divider. Output signal stability of the transistor unit is equal to that of the input. Amplitude of output is 1 v rms, impedance 50 ohms. Power required is 24 v dc $\pm 5\%$ at 30 ma. The 6-oz chassis measures 5-3/8 in. high, 4-1/4 in. wide, and 2-3/4 in. deep.

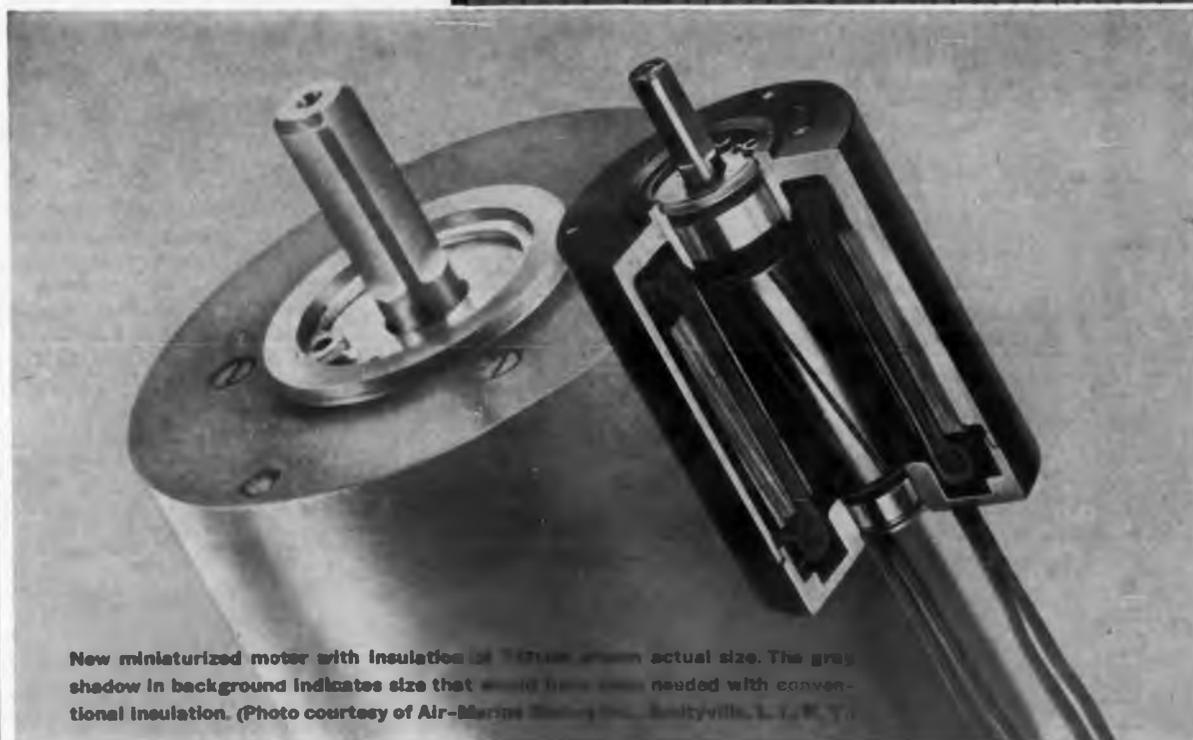
Manson Laboratories, Inc., Dept. ED, Stamford, Conn.

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DU PONT

TEFLON®



New miniaturized motor with insulation of TEFLON shown actual size. The gray shadow in background indicates size that would have been needed with conventional insulation. (Photo courtesy of Air-Martin Company, Salisbury, L. I., N. Y.)

Motor meets specs with 70% cut in weight and space ... thanks to insulation of TEFLON®

CAN YOU AFFORD NOT TO USE TEFLON?

Insulation of TEFLON resins is your logical and most economical choice whenever you encounter problems of corrosion ... heat ... space or weight limitations. Even when environmental conditions are not extreme, these most reliable of solid dielectric materials can enable your products to set the pace for dependable performance.

In your next application involving wire, cable or component insulation, it will pay you to evaluate the design improvements made possible by TEFLON resins, and the dollars-and-cents savings in installation, replacement, maintenance and extended service life they can afford you.

Space and weight were at a premium in this new motor, designed to drive a camera on a missile-tracking radar antenna. Requirements were for a synchronous motor, 1/40 HP at 8,000 rpm, to withstand 180°C for a minimum of 2,000 hours life. Using conventional insulation (Class F), a unit 3 3/8 inches diameter weighing over 3 lbs. would have been required. By using cell insulation of a Du Pont TEFLON TFE fluorocarbon resin, and magnet and lead wire insulated with TEFLON, the manufacturer is able to meet the specifications called for with a motor 2 inches in diameter weighing less than 1 lb.

The high insulating properties of TEFLON resins, coupled with their high resistance to temperature extremes, make possible the miniaturization of electrical and electronic equipment without sacrifice in performance. In addition, tough insulation of TEFLON is completely inert to virtually all chemicals, assuring maximum reliability under a variety of severe environmental conditions. With the advent of new melt-processible TEFLON FEP resins, the remarkable properties of TEFLON are now available in a variety of complex molded shapes and in long continuous wire insulation. For more information, write to: E. I. du Pont de Nemours & Co. (Inc.), Dept. ED-426, Room 2526T, Nemours Bldg., Wilmington 98, Del.

In Canada: Du Pont of Canada Ltd., P.O. Box 660, Montreal, Quebec.



TEFLON®
FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.

BETTER THINGS FOR BETTER LIVING ... THROUGH CHEMISTRY

CIRCLE 114 ON READER-SERVICE CARD

Erie Diffused Junction Silicon High-Conductance, General Purpose and Switching Diodes

I SILICON GENERAL PURPOSE DIODES

Type	MINIMUM SATURATION VOLTAGE @ 100 μ A @ 25°C (volts)	MINIMUM FORWARD CURRENT @ -1.0 VDC @ 25°C (mA)	MAXIMUM INVERSE CURRENT AT MAXIMUM DC OPERATING VOLTAGE (μ A @ volts)		MAXIMUM AVERAGE RECTIFIED CURRENT (mA)	
			@ 25°C	@ 150°C	@ 25°C	@ 150°C
1N456 thru 1N459A	30	40	.025 @ 25	5 @ 25	90	
	200	100	.025 @ 175	5 @ 175	200	70
1N461 thru 1N464A	30	15	.5 @ 25	30 @ 25	60	
	150	100	.5 @ 125	30 @ 125	200	70

II SILICON HIGH-CONDUCTANCE DIODES

Type	MAXIMUM DC INVERSE VOLTAGE (volts)	MAXIMUM AVERAGE FORWARD CURRENT (mA)		MAXIMUM FORWARD VOLTAGE DROP @ 100mA @ 25°C (volts)	MAXIMUM INVERSE CURRENT (μ A @ volts)	
		25°C	150°C		25°C	150°C
1N482 thru 1N485A	36	100	25	1.1	0.25 @ 30	30 @ 30
	180	200	50	1.0	0.025 @ 175	15 @ 175
1N488A	380	200	50	1.0	0.1 @ 380	25 @ 380

III SILICON SWITCHING COMPUTER DIODES

Type	MINIMUM SATURATION VOLTAGE @ 100 μ A (volts)	MINIMUM FORWARD CURRENT @ 25°C at Specified Voltage	MAXIMUM REVERSE CURRENT at SPECIFIED VOLTAGE (μ A @ volts)		REVERSE RECOVERY	
			@ 25°C	@ 100°C	Reverse Resistance (kilohms)	Maximum Recovery Time (μ sec.)
1N663	100	100 @ 1.0	5.0 @ -75	50 @ -75	200	0.5
1N709 thru 1N796	30	10 @ 1.0	1.0 @ -20	30 @ -20	200	0.5
	60	100 @ 1.0	5.0 @ -50	30 @ -50	100	0.5

IV SPECIALS

1. Matched diodes: tested to individual specifications.
2. Assemblies: Series and parallel combinations with leads connected and encapsulated to customer specifications.

Note: Silicon diodes are packaged on reel packs for automated insertion or lead forming and cutting, or bulk packed.

Erie Diffused Junction Silicon, Epoxy Encapsulated Rectifiers

Style	PIV	AVERAGE RECTIFIED FORWARD CURRENT @ 25°C (mA)	FORWARD VOLTAGE @ 25°C	REVERSE CURRENT		Registered Rating Temp. °C
				@ 25°C mA	@ Rated Temp mA	
1N2069 thru 1N2071 thru ED2913	200	750	1.2	01@	05	100
	600	750	1.2	010	05	100
	1000 (tentative)	750	1.2	010	05	100

Note: Rectifiers packaged in bulk.

Samples available upon direct request on your letterhead.

Erie Gold Bond and Indium Bond Germanium Diodes are also manufactured and samples are available.

ELECTRON RESEARCH, INC.

Division of
Erie Resistor Corporation

ERIE, PENNSYLVANIA

Sales offices in principal cities of U.S.A., Canada, Europe.

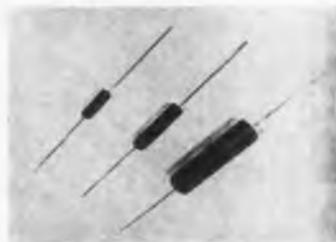
Erie Diodes are also available in quantities under 1,000 pieces from leading electronic distributors.

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NEW PRODUCTS

Tantalum AC Capacitors

507



Continuous duty, solid-slug tantalum ac capacitors are made for military and industrial applications. Ambient temperature range is -80 to $+125$ C. Case sizes range from 0.155 in. diameter and 0.600 in. length to 0.350 in. diameter and 1.600 in. length. Capacitance range is 1.2 μ f to 170 μ f. The hermetically sealed units operate at up to 35 v peak, 60 cps.

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

Price: \$1.70 to \$5.00.

Solenoid Valve

505



Service to 200 psi is provided by solenoid valve for use in fluid control. Available in standard ac and dc voltages, the valve operates in any position with a maximum rate of 1,000 cycles per min at 100 psi. Temperature range is -65 to $+350$ F. The 5-oz valve measures 2-5/8 in. long with a diameter of 1-3/8 in. Inlet connection is 1/2 in., outlet 1/8 in.

General Magnetics, Inc., Dept. ED, 2641 S. Louisiana Ave., Minneapolis 26, Minn.

Hydrogen Thyatron

509

Peak power of 48 megawatts is provided by the GL-7890 hydrogen thyatron. The tube operates at an anode dissipation factor over 55×10^9 with forced air or other coolants. Peak forward anode voltage is 40 kv, peak current 2,400 amp. Average current capability is 4.0 amp, average power over 70 kw. Hold-off capability is over 35 kv dc.

General Electric Co., Power Tube Dept., Dept. ED, Schenectady 5, N.Y.

Availability: immediate.

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ELECTRIC WAVE FILTERS OFF THE SHELF



ORTHO HAS EXACTLY THE FILTER TO DO EXACTLY THE JOB YOU WANT!

Select from many low pass, high pass, band pass, and band eliminate types—each designed to yield networks with a minimum number of elements. Why buy more filter than you need when Ortho offers a wide choice of shape factor and minimum stop band loss. All are tested for use from -40°C to $+85^\circ\text{C}$; all are hermetically sealed; all meet MIL-F-18327A. Elements are temperature cycled to prevent aging. Standard impedances available: 600, 1,500, 3,000, 10,000 ohms unbalanced. Miniaturized and ruggedized versions for missiles and printed circuits also available. All are economically priced and ready for immediate delivery. For complete specifications and prices, write to:

of ortho filter

CORPORATION

a division of ORTHO INDUSTRIES INC.

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ELECTRONIC DESIGN • April 26, 1961

NATIONAL'S



Self locking, wear resistant machined stainless steel threaded inserts for use in aluminum and brass. Easily applied, their dependable grip in the parent metal as well as their permanent self-locking ability make them ideal for a diversity of critical uses. The complete line includes one basic type in four sizes. Each of the four sizes are available for insertion into any of five metal thicknesses. All National Radio Company self locking captive nuts are made to conform with the following specifications:

Material: Stainless steel Class 303 per FED QQ S-763b.

Finish: Passivated per MIL P-12011.

Threads: Size 4, 6, and 8 NC 2B
Size 10 NF 2B

National Radio Company also manufactures other captive nuts and studs including the line of exclusive "Flush Mount" types. Available in five sizes for use in metal thickness from 1/16" up, this type of captive nut fits flush on both sides of aluminum or brass sheet to provide strong permanent tapped holes.

National Radio Company's engineering staff will be glad to discuss your applications and possible variations to best meet your requirements.

NATIONAL RADIO COMPANY, INC.

MELROSE 76, MASSACHUSETTS



A wholly owned subsidiary of...
Export: AD AURIEMA, INC.
York, N.Y., U.S.A. In Canada: A. MARCONI
CO., Toronto 17, Ont.
Specifications subject to change without notice.

Induction Motor

504



Totally enclosed induction motor B-5-1, designed for blower applications, provides 1/100 hp at 5,200 rpm. The 7.55-oz motor is powered by 208 v, 400 cps, 3 phases. Full-load torque is 1.87 oz-in. Starting torque is 214%, pull-out torque 222%.

General Precision, Inc., Kearfott Div., Dept. ED, Little Falls, N.J.

Power Supplies

503



Voltage-regulated power supplies SM 75-5M and SM 75-2M provide 0 to 75 v dc at 5 and 2 amp respectively. Ripple is less than 1 mv rms, regulation and stability 0.1%. Input power is 105 to 125 v, 60 ± 1/2 cps. Unmetered models and units with 0.01% regulation are also available.

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

P&A: SM 75-5M, \$670; SM 75-2M, \$505; 30 to 60 days.

Tape Recorder/Reproducer

623



Wideband, magnetic tape recorder/reproducer VR-2600 has frequency response to 500 kc on direct record, 40 kc on fm, and 1,000 bits per in. parallel recording with pcm techniques. Six selectable speeds are in two ranges from 1-7/8 to 120 ips. The unit has all solid-state modular construction.

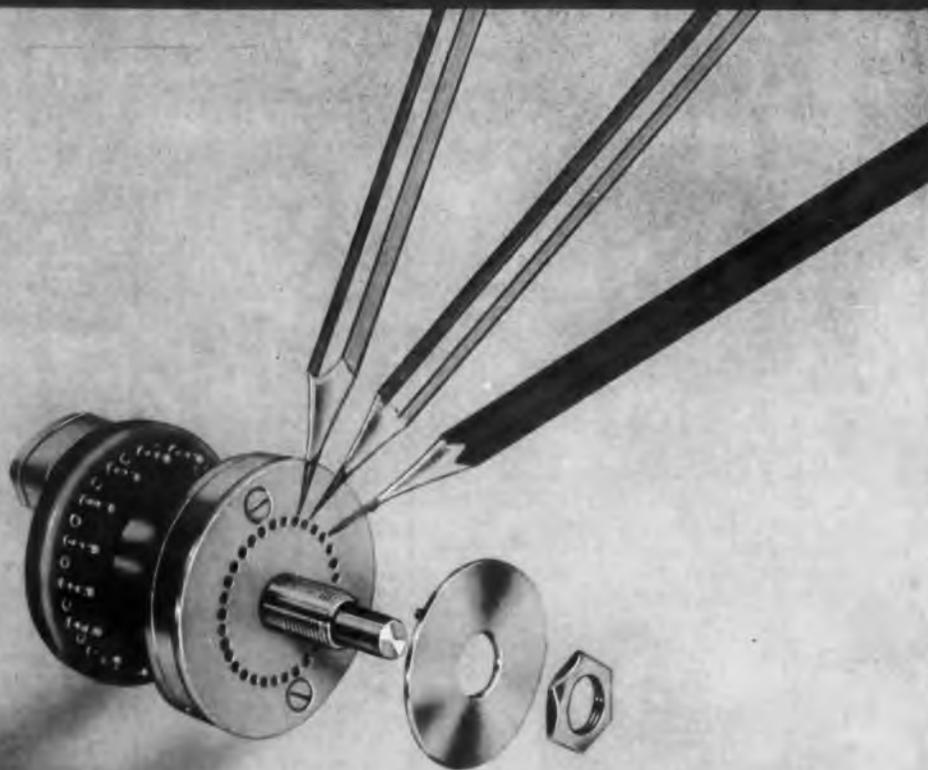
Consolidated Electrodynamics Corp., Dept. ED, 360 Sierra Madre Villa, Pasadena, Calif.

PRECISION IN MINIATURE

Collector's items—the Babcock Gallery of precision miniature and subminiature relays. Complete series in power and sensitive types, single, double and 4 pole with switching capabilities from dry circuit to 10 amps. Hermetically sealed BR-1SZ requires only 5 mw power, features very critical pull-in to drop-out ratios. BR-7 subminiature 10 amp DPDT accepts 30g vibration @ 10-2000 cps, 50g shock @ 11 millisecc. BR-8 AC or DC crystal can, dry circuit to 2 amp, 30g vibration to 2000 cps. BR-9 DPDT magnetic latching, operates on 15 millisecc nom. pulse, dry circuit to 10 amp contacts. BR-12 DPDT 200 grid crystal can, 3 amp contacts, 30g vibration to 3000 cps. BR-14 4PDT, 5, 7½ or 10 amp contacts, temp. range —65° C to 125° C. Technical Bulletins on request.

BABCOCK RELAYS, INC.
1640 Babcock Avenue, Costa Mesa, California

CIRCLE 118 ON READER-SERVICE CARD



Stop it

... where you want it!

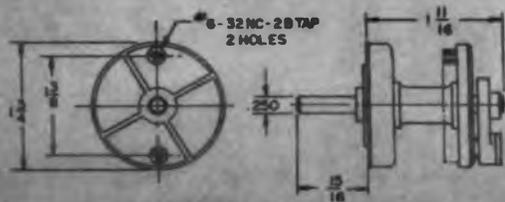
Daven's New Rotary Switch with Adjustable Stop

For flexibility in all types of circuit experimentation, laboratory work, breadboard setups, and in circuitry where the exact number of switch positions might be changed at a later date, the new DAVEN Rotary Switch with an Adjustable Stop is ideal. This unit, as a single pole switch, can have a maximum of either 24 shorting positions with 15° spacing or 32 shorting positions with $11\frac{1}{2}^\circ$ spacing. One, two, three, and four pole units are available in this design.

In common with all other DAVEN Rotary Switches, the Adjustable Stop Switch features sturdy, dependable construction; silver alloy contacts and slip rings; tamper-proof,

KNEE ACTION* silver alloy rotor blades; high grade, accurately machined dielectric; and gold flashed turret-type terminals for ease of soldering.

*Patented



Write for complete information.

THE **DAVEN** CO.

LIVINGSTON, NEW JERSEY



TODAY, MORE THAN EVER, THE DAVEN ROTARY SWITCH IS THE MOST DEPENDABLE!

NEW PRODUCTS

Core Memories

473



Destructive and nondestructive magnetic core memories are available for airborne applications. Random access, linear select techniques, coupled with advanced circuitry, provide 2-usec read-write cycles. Current variation of $\pm 10\%$ and temperature change of $\pm 30^\circ\text{C}$ without external compensation is allowable. The memories meet military specifications.

Litton Systems Inc., Dept. ED, Woodland Hills, Calif.

Storage Tube

515

Target assembly design in the E710 bistable, direct-view storage tube reduces risk of damage from high-beam current. The tube will store information indefinitely and allow continuous or intermittent display. Two or more signals can be stored and simultaneously displayed or instantly erased.

English Electric Valve Co. Ltd., Dept. ED, Chelmsford, England.

Level Switch

475



Ultrasonic liquid level switch uses a dual-crystal design. The light, rugged unit has low power requirements and accuracy within $\pm 1/64$ in. It may be used with any type of liquid for level warning and control, flow monitoring, and other operations. Probe and control unit may be separate or combined. Response time is 0 to 10 sec; probe temperature range is -195 to $+250^\circ\text{C}$.

The Liquidometer Corp., Dept. ED, Long Island, N.Y.

◀ CIRCLE 119 ON READER-SERVICE CARD



Magnetic core instruction memories are made in several standard sizes. Units operate at 1 mc, with access time of 0.4 usec, using nondestructive readout. The BIAX systems are available in 2 standard sizes, 128 and 512 words, with 24 bits per word. Other sizes up to 1,024 words and 36 bits per word can be built. Standard input is punched paper tape. Semiconductors are used throughout; ambient operating temperature is 0 to 50 C.

Computer Products Operations, Aeronutronic Div., Ford Motor Co., Dept. ED, Ford Road, Newport Beach, Calif.

Resistance Bridges 522

Accuracy of synchros or resolvers is measured by the proportional voltage method with these resistance bridges. Stable, dependable units have accuracy of ± 2 arc-sec. Synchro bridge KT 427775-2A and resolver bridge KT 427771-2A can each be indexed to any multiple of 5 deg throughout a range of 0 to 360 deg by light, fingertip control. Standard frequency is 400 cps.

Kearfott Div., General Precision, Inc., Dept. ED, Little Falls, N.J.

Soldering Iron 510



Midget soldering iron offers improved performance, a new handle design and redesigned tip and heater assembly. Irons are available in 1/8 to 1/4 in. tip sizes with 6-v supply, 18 to 35 w.

General Electric Co., Dept. ED, Schenectady 5, N.Y.

Availability: May 1.

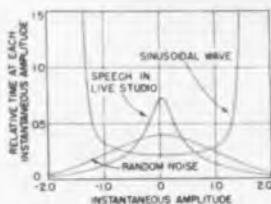
CIRCLE 120 ON READER-SERVICE CARD ▶

Random-Noise Generator



A Fundamental Test Instrument for:

- ELECTRICAL MEASUREMENTS • ACOUSTICAL MEASUREMENTS
- ENVIRONMENTAL TESTING • STATISTICAL INVESTIGATIONS



FREQUENCY RANGE:
 20 cps to 20 kc, ≈ 1 db (5 to 20 cps, ≈ 2 db);
 20 cps to 500 kc, ≈ 3 db;
 20 cps to 500 kc, ≈ 3 db; 500 kc to 5 Mc, ≈ 8 db.

OUTPUT VOLTAGE: 3 volts, 20 kc; 2 volts, 500 kc;
 1 volt (minimum), 5 Mc

OUTPUT IMPEDANCE: Source Z for max. output is approximately 900 Ω ; for attenuated output, 200 Ω .

ACCESSORIES SUPPLIED: Panel extensions for relay-rack mounting (7-inch height for 19-inch relay-rack).

The Random-Noise Generator, mounted in a test console, aids in checking out automatic astro-navigation systems for the Convair supersonic B-58 "Hustler" built for the Air Force.

Since the photoelectric cell used as the primary sensing element in this navigation equipment must detect very weak star signals in the presence of existing large background noise, any additional random signal which may become superimposed is of paramount importance. The Random-Noise Generator's output simulates such operating noise making this instrument an essential component for determining the effect of photomultiplier or other noise.

The Generator also serves as an important unit in various other Kollsman laboratory and production test consoles. It is used for aligning signal amplifiers, filters, and other elements of the "Astro Compass," to test rotary components, and to check fast switching relays to see where noise is being emitted.



Photo courtesy Kollsman Instrument Corp.

If you would like to know whether the Random-Noise Generator will fit your needs, write or phone any of the offices given below.

GENERAL RADIO COMPANY
 WEST CONCORD, MASSACHUSETTS

The Best Instruments
 in Electronics

NEW YORK, WOrth 4-2722
 NEW JERSEY, Ridgefield, WHiney 3-3140

CHICAGO
 Oak Park
 Village 8-9400

PHILADELPHIA
 Abington
 HANcock 4-7419

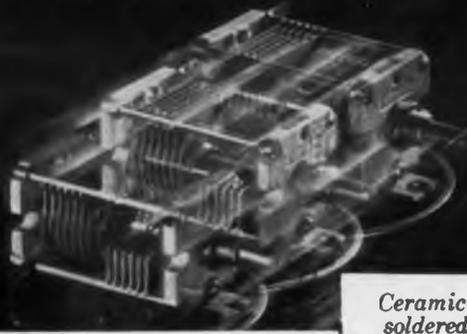
WASHINGTON, D.C.
 Silver Spring
 JUNiper 5-1088

SAN FRANCISCO
 Los Altos
 WHitecliff 8-8233

LOS ANGELES
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capacity can't fluctuate!

Set your frequency . . . these tough Johnson "L" variables will hold it—even under severe conditions of shock and vibration! Designed to provide outstanding strength, rigidity and operating stability—rotor bearings and stator support rods are actually soldered directly to the heavy 3/16" thick steatite ceramic end frames. Parts can't break loose . . . capacity can't fluctuate!

Specially designed split-aleeve tension bearing and silver-plated beryllium copper contact provide constant torque and smooth capacity variation. Plating is heavy nickel—plate spacing .020", .060" and .080" spacing as well as special platings, shaft lengths and terminal locations in production quantities.

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strength!



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capacitor line . . . from
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large heavy duty types!

From the tiny Type "U" sub-miniature, which requires less than 0.2 sq. in. for chassis or panel mounting—to the rugged heavy-duty "C" and "D" types . . . the Johnson variable capacitor line is designed for more capacity in less space—offers you one of the widest standard capacitor lines in the industry! For detailed specifications on all Johnson variable capacitors, write for your free copy of our newest components catalog, described below.



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CIRCLE 121 ON READER-SERVICE CARD

NEW PRODUCTS

Capacitor Test Set

635



Fully automatic capacitor test set type 61 is for low voltage measurement of tantalum capacitors. Capacitance range at 120 cps is 1 to 11,000 μ f in four ranges. Test voltage is 0.7 v rms; accuracy is $\pm 1\%$ over entire range.

Barnes Development Co., Dept. ED, 213 W. Baltimore Pike, Lansdowne, Pa.

Flat Cable Connector

481



Flat conductor cable can be connected to printed-circuit boards or to flexible etched circuitry by means of POS-E-CON connector. A continuous one-piece spring locks the cable into the connector and produces direct contact without solder. It provides a pressure point at each conductor contact.

The Thomas & Betts Co., Dept. ED, Elizabeth, N.J.

Converter

485

A four-decimal digit, solid-state, voltage-to-digital converter, the Transicon Datrac has both automatic and programed ranging. It is fully transistorized and meets MIL specifications. Specifications are: signal input, 0 to 0.9999, 0 to ± 99.99 , 0 to 9.999; conversion speed, 10 usec per bit; accuracy, $\pm 0.015\%$ of full scale ± 1 significant digit.

Epsco, Inc., Dept. ED, 275 Massachusetts Ave., Cambridge, Mass.

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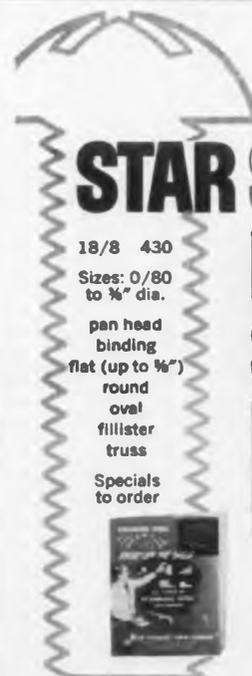
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ELECTRONIC DESIGN • April 26, 1961

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A practical idea for every engineer who wants to save time in circuit layout, assembly, and packaging. . . . Alden "Cir-KITS" are practical "get-started" kits, including everything you need to assemble a wide variety of prototypes and evaluate Alden's proven, time-saving building block techniques—at rock bottom costs. Components cost less than if bought separately, off-the-shelf. "Cir-KITS" are available at prices to meet all budgets, depending on the relative sophistication of your requirements.

Kits range all the way from #25, containing basic elements for building block design, priced at \$11.25; through the sophisticated Kit #40 at \$395.00, which includes a complete building block system for advanced equipment design all the way to the complete Industrial Packaging Laboratory, at \$3,000.00. WRITE TODAY FOR FREE CATALOG AND FULL DETAILS.

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PRODUCTS COMPANY
4139 N. Main Street, Brockton, Mass.

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Brady Pressure-Sensitive, All-Temperature Wire Markers for small gage wires are exactly 3/4" long to fit wires under 1/4" o.d. They cut your small gage wire marking costs in half because:

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2. They go on the wire twice as fast.

You can't drop Brady Wire Markers — they stick to your finger from Card to wire.* Stick and stay stuck — at temperatures to 300° F.! Choose from over 3,000 different stock markers—both Standard and Small Gage Size. Stocked by Brady Distributors in all principal cities. Specials made to order. Write for big new bulletin and free testing samples today!

*Remember, too, Brady makes the only marker that can be machine applied.

W. H. BRADY CO., 787 West Glendale Ave., Milwaukee 9, Wis. Manufacturers of Quality Pressure-Sensitive Industrial Tape Products, Self-Bonding Nameplates, Automatic Machines for Dispensing Labels, Nameplates, Masks and Tape • Est. 1914.

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ELECTRONIC DESIGN • April 26, 1961

Wide-Band Oscilloscope

483



Bandwidth of dc to 70 mc is provided by the LA-270 oscilloscope. Designed to military specifications, unit has 6-cm vertical deflection. Display size is 6 x 10 cm. Single and dual channel plug-in vertical pre-amplifiers and plug-in sweep delays are used. Horizontal sweep circuitry has 24 calibrated ranges with 10X magnifier extending the fastest sweep to 0.01 μ sec per cm.

Lavoie Laboratories, Dept. ED, Morganville, N.J.

IF Amplifier

484



Wide-band IF amplifier model IF301 has a detector and a cathode follower for video output. Typical noise figure at 30 mc is 1.5 db, input vswr less than 2:1. Standard 30 or 60 mc models have 90-db gain, 10-mc bandwidth, and 50-ohm input.

LEL, Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

Limit Switch

498



Snap action limit switch is designed to bridge the gap between the very small and larger, enclosed limit switches. Ratings are as follows: ac, 40-amp make, 15-amp break; dc, 2-amp make and break on single throw forms with 0.040-in. gap.

General Electric Co., Dept. ED, Schenectady 5, N.Y.

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NEW PRODUCTS

Torque Transducer

636



Variable inductance transducers, series C-B4, measure angular twist proportional to torque. Electrical measurement of a torsional strain and a mechanical assembly for producing the strain are provided. Speeds are to 20,000 rpm and torque ranges from 0 to 50 in.-lb through 0 to 12,000 in.-lb full scale.

B & F Instruments, Inc., Dept. ED, 3644 N. Lawrence St., Philadelphia, Pa.

Terminal Boards

497



Miniature terminal boards on 0.100 grid patterns, in any shape, are available with glass-filled epoxy, melamine or silicone insulation. The terminals are brass, phosphor bronze or beryllium copper and are silver or silver and gold plated. Terminals measure 0.062-in. OD x 0.026-in. ID; height above board is 0.156 in. and they are bifurcated with slots 0.025-in. wide x 0.068-in. deep.

Accurate Electronics Corp., Dept. ED, 169 S. Abbe Road, Elyria, Ohio.

Power Supplies

494

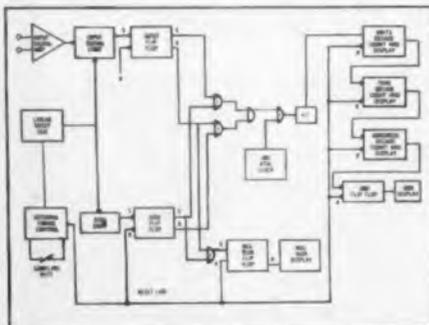


Solid-state, convection-cooled, 12-v power supplies, models ZA-723, -724, -725 and -727 have less than 0.001-v rms ripple. Ratings are from 12-v, 100 ma to 12-v, 3-amp. All units have an operating range of -20 to +65 C.

Engineered Electronics Co., Dept. ED, 1441 E. Chestnut Ave., Santa Ana, Calif.



SIMPLIFIED BLOCK DIAGRAM



DVOM[®] DIGITAL VOLT-OHM METER MEASURES AC, DC VOLTS & OHMS (ONLY 8³/₄" x 5¹/₄" x 13³/₄")

IMPORTANT FEATURES:

- 1) No stepping switches, no relays
- 2) Speed: 2 millise. per conversion (100 independent measurements per sec.)
- 3) Fully transistorized, plug-in construction
- 4) Parallel decimal and 4221 BCD output
- 5) In-line, in-plane display
- 6) Internal and external conversion trigger
- 7) Requires no modification, adjustment or calibration
- 8) Mount two, side by side, in a RETMA rack



KEY SPECS:

- Full Scale Ranges:
AC and DC Voltages, 0 to ±1000 (4 ranges)
Resistance: 1K to ±1000K (4 ranges)
- Accuracy: DC — ±0.1%, AC — ±0.25%,
Ohms — ±0.25%
- Readout: 3 digits (plus 1 overflow digit)

For full details, call or write Epsco. Ask for Bulletin 26002.

Epsco INSTRUMENTS

A division of Epsco, Incorporated, 275 Massachusetts Avenue, Cambridge 39, Mass. Telephone UNiversity 4-4950

CIRCLE 127 ON READER-SERVICE CARD

Tube Socket Preservers

489



Designed to prevent permanently wired sockets from wearing out under constant use, the Thinline socket preservers plug directly into existing sockets. The low silhouette makes them especially suited for portable equipment where space is at a premium.

Forway Industries, Inc., Dept. ED, 122 Green Ave., Woodbury, N.J.

P&A: \$2.20 to \$2.80 in 1 to 9 quantities; from stock.

Motor Control

487

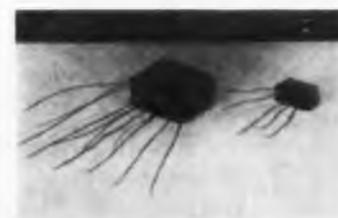


Fractional horsepower motor control relays type CR120E are rated at 600 v. They are available with coils from 6 to 550 v, 60 or 50 cps. They may be used for power devices such as horns, buzzers and lights, solenoids and valves.

General Electric Co., Dept. ED, Schenectady 5, N.Y.

Amplifier Modules

490



Three-transistor, RC-coupled, printed-circuit modules type APC weigh only 0.148 oz. They measure 0.858 x 0.413 x 0.728, including case. Output is 9 mw into a 300-ohm inductive load at over-all distortion of 10% max. Gains are up to 93 db with a frequency response flat within 3 db from 100 cps to 10 kc at signal to noise ratios of -48 db.

Fidelity Electronics, Ltd., Dept. ED, 4120 W. Lawrence Ave., Chicago 30, Ill.

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PUTTING MAGNETICS TO WORK



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Here's free help to enable you to improve yourself—and your position as a magnetic circuit designer. You need it if:

You don't know how to work with $E = n \frac{d\phi}{dt}$ to reduce the size of magnetic amplifier circuits. Most men who design amplifiers for cramped operation in missiles have found it invaluable.

What's more, you may only vaguely remember $H = .4\pi \frac{NI}{\ell_m}$, so how can you use it to cut circuit size by two to ten times, and shorten response time proportionately?

It's quite possible that you, like many engineers, may have bypassed or been bypassed by magnetic circuit theory as a working tool while you were in school. Yet this science has opened frontiers of static control which makes an understanding imperative if you are to do your job—and further your career. For your sake (and for ours, too, because we manufacture and sell high perme-

ability tape wound cores and bobbin cores which are used in amplifier circuits), we have started this course. Lesson 1, "How to Reduce Magnetic Circuit Size and Response Time," will be on its way to you immediately if you use the coupon below.

MAGNETICS inc.

MAGNETICS INC., DEPT. ED-86, BUTLER, PA.

Please enroll me in your free self-improvement course, and send me "How To Reduce Magnetic Circuit Size and Response Time."

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company _____

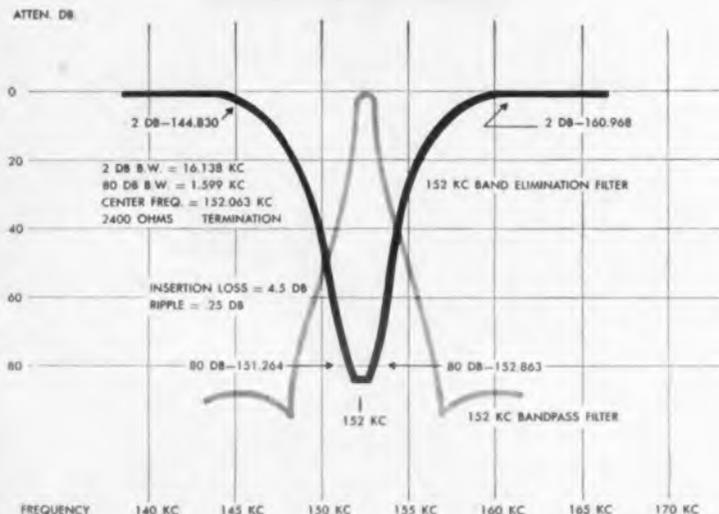
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CIRCLE 128 ON READER-SERVICE CARD

125

High selectivity,
attenuation and precision matching of . . .

NEW HILL FILTERS ASSURE FAST, PRECISE MEASUREMENT OF INTER-MODULATION DISTORTION



Actual operational curves, obtained from point-to-point readings, from Hill 34900 and 34800 filters developed to fulfill customers' specific requirements.

These two highly stable, precision-matched Hill Electronic filters permit fast, exceptionally accurate measurement of inter-modulation distortion in communications systems. A band elimination filter places a narrow, deep notch in the white noise being passed through the equipment under test. Distortion generated in the notch is then isolated for measurement by the narrow band filter.

The high degree of selectivity and attenuation of these filters, and the excellent alignment of one within the other are demonstrated in the actual operational curves shown above. Used together, these filters provide 80 db attenuation from 6 to 252 kc.

This is a typical example of Hill's creative engineering that develops outstanding solutions to customers' specific problems involving LC and crystal control filters as well as precision frequency sources and other crystal devices.

WRITE FOR BULLETINS 34800/900

They contain details and specifications concerning the filters described above.



HILL ELECTRONICS, INC.

MECHANICSBURG, PENNSYLVANIA

CIRCLE 129 ON READER-SERVICE CARD

NEW PRODUCTS

Synchro Transmitter

493



This positive-indexing synchro transmitter has 48 positive detents at 72 deg intervals on the input shaft. The transmitter is electrically zeroed on the 5th detent. The package is 1-17/64 in. sq x 2-1/2 in. long; it weighs 3-1/2 oz.

Clifton Precision Products Co., Dept. ED,
5050 State Road, Drexel Hill, Pa.

Test Set

492



Five-megawatt positive grid region test set is for design, development and production quality control testing of high-power triodes and tetrodes. Peak grid pulse is 10 kv, 500 amp at 2 usec; prf is adjustable from "one shot" to 60 pps. All supplies are controllable from the front panel.

FXR, Inc., Dept. ED, 25-26 50th St., Woodside 77,
N.Y.

Pressure Transducer

491



Absolute, gage or differential pressures of corrosive or noncorrosive gases or liquids in the 0 to 5 and 0 to 500 psi full-scale range can be measured by pressure transducer TP-200. Standard performance data includes the ability to withstand shock of 75 g; a static error band, including independent linearity, hysteresis, repeatability, resolution and friction, of $\pm 2.5\%$ in the 0 to 5 to 0 to 10 psi range and $\pm 1.5\%$ in the 0 to 15 to 0 to 100 psi range.

Fairchild Controls Corp., Dept. ED, 225 Park Ave., Hicksville, N.Y.



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complete line of top
quality Hipersil® cores

Eight stocking locations for Hipersil cores give fastest possible service: Greenville, Pa.; Boston; Chicago; Cleveland; Dallas; Hillside, N.J.; Los Angeles; Minneapolis. Line includes new EIA, RS-217 sizes.

- TYPE C: 12, 4, 2 and 1 mil sizes, in single- and 3-phase, fraction of ounce to 300 pounds.
- RING CORES: Untreated, edge bonded, impregnated and epoxy resin-coated Polyclad.
- SPECIAL CORES: To any specification and shape requirements.

Top quality: Performance of Hipersil cores in "iron-core" components is guaranteed to meet or exceed specifications.

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Longer life, greater stability
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704 standard units
Save space
Save weight
Save money
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No external lead weld
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ELECTRONIC DESIGN • April 26, 1961

Power Supply

501



Packaged indicator power supply model 913 provides 4 kv dc at 500 μ a with an input of 115 v, 400 cps. Measuring 5-3/8 x 2-1/2 x 2-1/4 in., supply has an operating temperature range of -55 to +100 C. Other units at 60 or 400 cps inputs are available with outputs from 1 kv to 20 kv, 50 μ a to 1 ma.

Burmac Electronics Co. Inc., Dept. ED, 142 S. Long Beach Road, Rockville Centre, L.I., N.Y.

Shaft Coupling

488



Designed for light duty electromechanical applications, these zero backlash flexible couplings employ torsion spring elements to cushion starting and braking loads. Shaft to shaft misalignment may be up to 5 deg angular and 1/32-in. parallel offset.

Fourdee, Inc., Dept. ED, P.O. Box 6006, Orlando, Fla.

Price: \$1.90 ea.

Delay Lines

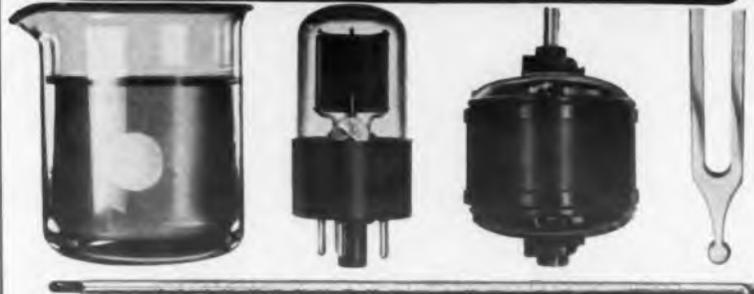
482



Encased in a 13 32-in. diam tube, these distributed constant delay lines have an impedance of 500 ohms. Delay times are 0.05 to 1.0 μ sec, with rise times from 50 to 120 nsec. Operating temperature is from -55 to +125 C.

Richard D. Brew and Co., Dept. ED, 90 Airport Road, Concord, N.H.

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You can spec A.P.I. meter-relays in any range you want, from the minimums mentioned up to 0-50 amps or 0-500 volts, AC or DC. We can calibrate scales in any units you require. Control set-points can be either single (high or low) or double (both high and low). Catalog 4J will give you much useful and interesting information about meter-relays. It will also give you detailed, explicit specs and prices. Yours for the asking, of course.



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CHESTERLAND 17 OHIO

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SA 2398

127

0.1 μa to 1 amp.

10⁻¹³ TO 1 CURRENT RATIO

1 μv to 1000 volts

10⁻⁹ TO 1 VOLTAGE RATIO



Sensitive DC Meter

- 0.1 μa to 1 amp. in 25 ranges
- Drift: $\pm 2 \mu\text{v/day}$ max.
- 1 μv to 1000v in 17 ranges
- Fast response
- Simplicity of range switching
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- 10 megohms constant input resistance on all voltage ranges

Also Available Rack Mounted on a 5 1/4" x 19" Panel. Price \$520.

Boonton ELECTRONICS Corp.

Morris Plains, New Jersey • Jefferson 9-4210

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NEW PRODUCTS

Deviation Calibrator

496



Fm-monitor deviation calibrator, "Monocal 500", provides better than 0.5% deviation accuracy. It combines the functions of five instruments previously needed to determine the peak deviation of an fm signal by the carrier drop-out method. It can be used directly with any fm monitor tuning to 12 mc. Deviation ranges are: 10-, 30-, 100-, and 300-kc peak.

Advanced Measurement Instruments, Inc., Dept. ED, 109 Dover St., Somerville 44, Mass.

Crystal Oven

495



Thermostatically controlled oven, model 1206, has internal temperature stability of $\pm 0.5 \text{ C}$ at 70 C over an ambient range from 0 to 50 C. It is for housing crystals, filters and other circuitry requiring temperature stabilization. Specifications are: power supply, 24 v dc; external dimensions, 2-in. sq x 3-1/2 in.; weight, 7 oz.

Airtronics, Inc., Dept. ED, 5522 Dorsey Lane, Washington 16, D.C.

High-Beta Thermistors

508

Beta of 3,000 K is a feature of a new series of thermistors. Units are made in rod form at 200 to 1,000 ohms, 25 C, with 0.050, 0.112, and 0.173 in. in diameter, and in disk form at 1 and 2.5 ohms at 25 C, with 3/4 and 1 in. in diameter. Beta tolerance is $\pm 5\%$. Maximum standard thermistor temperature rating is 150 C, with higher ratings available on request.

General Electric Co., Specialty Resistor Project, Dept. ED, 7842 S. Neff Ave., Edmore, Mich.

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TEFLON

by Pennsylvania Fluorocarbon

To obtain outstanding results from sheathing for wires, slip-on insulation and bushings, use the unique electrical properties of spaghetti tubing made from Teflon plus the outstanding engineering and manufacturing techniques developed by Pennsylvania Fluorocarbon.

The unique electrical properties of spaghetti tubing made from Teflon include: good dielectric strength (1000-2000 volts/mil); lowest dielectric constant (2.0) and dissipation factor (0.0002) of any solid dielectric; no change of electrical properties with temperature (-25°C . to $+250^{\circ}\text{C}$.), or frequency (60 cycles to 100 mc.); unaffected by moisture. In addition, PF Teflon is not harmed by the hot soldering iron so assembly work is speeded up considerably.

The outstanding engineering and manufacturing techniques developed by Pennsylvania Fluorocarbon include: the tailoring of Teflon with colors for identification or with modifications for improved texture and mechanical properties; stress relieving spaghetti tubing for minimum shrinkage; cleaning and 100% inspection; the manufacture of a wide range of wall thicknesses and special sizes.

Write, wire or call and let us quote on your requirements. We can provide overnight delivery of standard sizes and many special sizes at competitive prices.

**PENNSYLVANIA
FLUOROCARBON CO., INC.**

1115 N. 38th Street, Phila. 4, Pa.
EVergreen 6-0603 TWX: PH 232

*DuPont registered trademark

CIRCLE 134 ON READER-SERVICE CARD
ELECTRONIC DESIGN • April 26, 1961

Analog-To-Digital Converter

500



With a conversion rate of 0.5 μ sec, analog-to-digital converter model 101 has accuracy of $\pm 0.5\%$, $\pm 1/2$ least significant digit. Input amplitude is 10 v at impedance of 250 ohms. Visual display is 2 binary-coded decimals. Size is 6-1/2 x 3-1/2 x 6-1/4 in.

General Data Corp., Dept. ED, 11602 Ninth St., Garden Grove, Calif.

Price & Availability: \$750; 4 to 6 weeks.

Image Intensifier

514

High-gain image intensifier tube provides a photon gain of 100,000 to 200,000. It has an input photocathode, five secondary emitting dynodes, and an output fluorescent screen. Dynode usable diameter is 1 in.

English Electric Valve Co. Ltd., Dept. ED, Chelmsford, England.

Plug-socket Set

499

Subminiature plug and socket combinations for low-current circuits are molded of low-loss, mica-filled phenolic. They may be swaged into metal chassis, cemented to bakelite chassis, mounted with retaining ring, or potted. Units are available with glass-filled diallyl phthalate insulators. Made with 3 to 7 contacts, sets have EIA standard electrical ratings.

Cinch Manufacturing Co., Dept. ED, 1026 S. Homan Ave., Chicago 24, Ill.

Angle Position Indicator

502

Angular displacement of any remote rotational device to which a synchro or resolver transmitter can be coupled is measured and indicated by the KT 427566 angle position indicator. Accuracy is ± 6 min, resolution 1.0 min, and repeatability is 2 min. Indicator operates from 115 v, 400 cps power.

Kearfott Div., General Precision, Inc., Dept. ED, Little Falls, N.J.

High-Voltage Rectifier

506

Ratings up to 636,000 piv are available in a variety of rectifier stacks. A typical assembly is capable of delivering 600 kv at 20 ma dc. Air-cooled units are combined as required.

Selenium Div., Radio Receptor Co., Inc., Dept. ED, 240 Wythe Ave., Brooklyn 11, N.Y.



Solve Computer Assembly, Reliability, And Size Problems...



WITH
PRECISION-WIRED
RCA FERRITE MEMORY STACKS

From miniature stacks to super-size stacks, RCA is ready to custom-build completely wired, ready-to-use memory stacks to meet your most complex system requirements.

Now, RCA memory stacks, in custom and standard designs, are available to help you solve computer assembly problems and meet today's exacting performance specifications. Incorporating RCA ferrite memory cores and planes, with specified wide margins of operation...up to 8 percent...RCA stacks can cope with broad variations in power levels.

RCA magnetic-memory specialists are ready to custom design and deliver virtually any stack you specify. Stacks ranging from 16 words by 5 bits to 16,304 words by 34 bits have been built and are now in operation for coincident-current, word-address, and impulse-switching applications.

Reliability: All RCA ferrite memory stacks are designed and built to meet stringent environmental specifications of shock and vibra-

tion. And all are 100 percent dynamically tested to assure the utmost dependability under actual computer operating conditions.

Adaptability: All RCA memory stacks are compactly assembled to assure most efficient space utilization. In addition, they are designed to provide superior rigidity and accessibility. Stacking frames are available in a wide range of materials.

Service: Your local Semiconductor and Materials Division Field Representative is prepared to provide a completely coordinated application service, covering transistors, tunnel diodes and other semiconductor diodes, ferrites and memory systems. Call him today. For further technical information, write RCA Semiconductor and Materials Division, Commercial Engineering, Sec. D-18-NN-2, Somerville, N. J.

RCA SEMICONDUCTOR & MATERIALS DIVISION FIELD OFFICES:

EAST: Newark, N. J., 744 Broad St., HU 5-3900 • Earleton, N. J., 605 Marlon Pike, HA 8-4802 • Syracuse 3, New York, 731 James St., Room 402, GR 4-5591. NORTH-EAST: Needham Heights 94, Mass., 64 "A" Street, HI 4-7200. SOUTHEAST: Orlando, Fla., 1520 Edgewater Drive, Suite 1, GA 4-4768. EAST CENTRAL: Detroit 2, Mich., 714 New Center Bldg., TR 5-5600. CENTRAL: Chicago, Ill., Suite 1154, Merchandise Mart Plaza, WH 4-2900 • Minneapolis, Minn., 5805 Excelsior Blvd., WE 9-0676. WEST: Los Angeles 54, Calif., Box 54074, RA 3-8361 • Burlingame, Calif., 1838 El Camino Real, OX 7-1620. SOUTHWEST: Dallas 7, Texas, 7905 Carpenter Freeway, FL 7-8167. GOVT., Dayton, Ohio, 224 N. Wilkinson St., BA 6-2366 • Washington, D. C., 1725 "K" St., N.W., FE 7-8500.



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RADIO CORPORATION OF AMERICA



FERRITES



PLANES & STACKS



MEMORY SYSTEMS



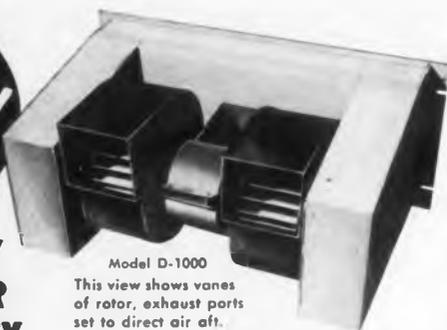
TRANSISTORS



TUNNEL DIODES

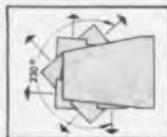
CIRCLE 135 ON READER-SERVICE CARD

New!

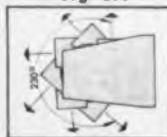


Model D-1000
This view shows vanes
of rotor, exhaust ports
set to direct air aft.

A REVOLUTIONARY ALL-ANGLE BLOWER TO SAVE YOU MONEY



Air flow directed
at any angle
through 230°



Motor-rotor assembly
turned end-for-end
gives this pattern

ONE SOURCE . . .

for VENTILATED RELAY RACK CABINETS,
CONTROL CONSOLES, BLOWERS, CHASSIS,
CHASSIS-TRAK, RELATED COMPONENTS

Ask for complete data—our Bulletin D-1000

ORegon 8-7827

WESTERN DEVICES, INC.

600 W. FLORENCE AVE., INGLEWOOD 1, CALIF.

CIRCLE 136 ON READER-SERVICE CARD

These remarkable new MIL quality All-angle blowers will not only do your cooling jobs more efficiently by more accurately directing air to your exact needs, but their inherent versatility can eliminate purchase of special blowers for many of your applications.

You can rotate their twin scrolls to the angle of your choice through 230°—or, by simply reversing the motor-rotor assembly end-for-end in its housing, create a new and equally diverse air flow pattern.

- Assured 400 CFM output • Mounts as 8 3/4" x 19" standard EIA rack panel—14" max. depth • MIL quality heavy duty construction and finish—or finish to Customer specs
- Easy maintenance without removal from cabinet • Interference-free operation per MIL-I-16910A • Cushion mounted for quiet operation • Sealed ball bearings for long life • Cleanable filter—disposable available.

NEW PRODUCTS

Balun Transformers

519

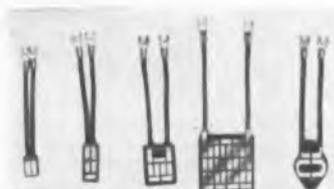


Broad-band balun transformers match 50 to 75-ohm coaxial lines to 600-ohm balanced transmission lines over the hf range. Devices operate from 2 to 30 mc and display essentially flat input impedance vs frequency curves. Model 517 is designed to pass 10 kw cw, and may be pole-mounted. Model 532, a receiving type, passes 500 w.

Granger Associates, Dept. ED, 974 Commercial St., Palo Alto, Calif.

Cooling Modules

518



Thermoelectric solid-state cooling modules are made for military and industrial use. The F1, F4, F8 and F32 Frigistors, designated by a number corresponding to the number of thermocouples in the module, are available in quantity. Heat pumping capacity is about 1 w per couple. The devices, made from Neelium, are capable of producing a no-load temperature difference as high as 80 C. The series operates with currents of 10 to 15 amp. Couples are connected in series, each requires 0.1 to 0.3 v.

General Thermoelectric Corp., Dept. ED, Princeton, N.J.

Silicon Diode Assemblies

486

High-voltage, silicon diode assemblies designed for use as clippers, holding diodes, or power supplies are available with inverse voltage ratings of 1 to 50 kv. Current ratings range from 1 to 750 ma. Units are epoxy cast and hermetically sealed, and measure 3 x 1 x 1-5/8 in. approximately.

Burmac Electronics Co., Inc., Dept. ED, 142 S. Long Beach Road, Rockville Centre, L.I., N.Y.

Have you sent us your subscription renewal form?

FAST



. . . accurate D-C resistance measurements with L&N's 4735 Guarded Wheatstone Bridge

Perform laboratory experiments, make routine resistance measurements or calibrate resistors faster—more accurately—with L&N's 4735 Guarded Wheatstone Bridge.

This advanced instrument has many new features including: high accuracy with a wide operating range . . . guarding of detector circuit to prevent resistance errors due to humidity effects . . . minimizing of thermals by special construction features . . . elimination of tedious plug and block ratio settings due to use of a single rotary switch.

List No. 4735 Guarded Wheatstone Bridge, normally available for delivery from stock.

Range—0.01 ohm to 1,111 megohms.

Limit of Error—±(0.05% + 0.001 ohm) up to 100 megohms; ±0.5% above.

Rheostat Switches—Five decades of enclosed switches in steps of 10 x (1000 + 100 + 10 + 1 + 0.1).

Multiplier Dial—Eleven-position enclosed switch. Multipliers: 10⁻⁵ to 10⁵.

Current Rating (of rheostat arm used as resistance box, determined by highest decade in use)—For 0.1Ω, 1.1 amp; for 1.0Ω, 0.35 amp; for 10Ω, 0.11 amp; for 100Ω, 0.035 amp; for 1000Ω, 0.011 amp.

Galvanometer Sensitivity Keys—Three tap keys provide sensitivities of approximately 1, 1/100 and 1/1000. A battery reverse key is provided.

Case—Metal, gray enamel finish; 19" x 9" x 7" for bench use. Wt. is 13 lbs.

Price—\$475.00 f.o.b. Phila. or North Wales, Pa. (subject to change without notice). Order List No. 4735 from L&N, 4908 Stenton Ave., Phila. 44, Pa.

LEEDS **NORTHROP**
Instruments Automatic Controls • Furnaces

CIRCLE 138 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 26, 1961



"You Rubbed, Sir?"

Reeves-Hoffman transistorized, proportionally controlled ovens do give almost miraculous service—in providing closer frequency control. These highly reliable ovens have no mechanical contacts. There are no spark-producing gaps. Radio interference is eliminated. Although it is difficult to measure temperature excursions beyond ±0.1°C, it is reliably estimated that Reeves-Hoffman ovens provide control in the order of ±0.001°C. If you have a problem involving reliable temperature control, contact Reeves-Hoffman for additional information.

WRITE FOR BULLETIN V1090.



DIVISION OF
DYNAMICS CORPORATION OF AMERICA
CARLISLE, PENNSYLVANIA

CIRCLE 137 ON READER-SERVICE CARD

METERS

You can SEE and READ



New Series 1025-1026
Interchangeable with Round
Bakelite Case Types

Brilliantly new in their high visibility polystyrene cases are these modern type Meters by HOYT which give a true reading at a glance! Here longer scale length and the elimination of shadows plus clean design add up to a topnotch combination to incorporate in any panel.

The Famous HOYT high torque movement with precise and rugged craftsmanship gives you what you've been looking for in Meters. These models are directly interchangeable with all round Bakelite meters, and are available in all AC and DC ranges as Ammeters, Milliammeters, Microammeters, Voltmeters and Millivoltmeters. Similar styles #1037 3½" and #1060 6" meters are also available for any modern panel meter application.



The HOYT square plastic case series (#649 and #653 shown) is available in 2½", 3½" and 4½" types. Just right for use where equipment needs to be revised to meet modern design requirements. These instruments are interchangeable with square Bakelite meters and can be supplied with a frosted or colored band on the case front in any AC and DC range. Extra long scales in shadow free cases give you the most value and quality for your money.

Write us for the NEW HOYT PANEL METER Brochure showing a complete line of plastic and Bakelite models.

Hoyt
SINCE 1904
**ELECTRICAL
INSTRUMENTS**

BURTON-ROGERS COMPANY

Sales Division, Dept. ED-4

42 Carleton Street, Cambridge 42, Mass.

CIRCLE 139 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 26, 1961

Push-Pull Switch

520



Normally open, spdt push-on, pull-off switch No. 30-16 has a positive detent action. Life expectancy is over 100,000 cycles. Contact rating is 1 amp, 115 v resistive, contact resistance 0.010 ohm. Base and button are molded phenolic.

Grayhill, Inc., Dept. ED, 561 Hillgrove Ave., LaGrange, Ill.

Price: \$1.15.

Bridging Amplifier

516

For trunkline installation behind repeater amplifiers, bridging amplifier model BA-4C has 4 isolated distribution line outputs, each providing 3-db gain at channel 2. Bandwidth is 54 to 88 mc, impedance 75 ohms, vswr 1.2:1. Power is 115 v, 60 cps, 25 w.

Entron, Inc., Dept. ED, Box 287, Bladensburg, Md.

Insulating Rod

512

A Class H insulating rod stock, Vitac combines fiber-glass reinforcement with a high-temperature resin system. Properties are said to equal or exceed those of silicone-glass rod, at 25% less cost.

The Glastic Corp., Dept. ED, 4321 Glenridge Road, Cleveland 21, Ohio.

Servo Motor

521

Size 5 servo motor J126-06 is 1/2 in. in diameter by 0.968 in. long and weighs 0.68 oz. Phase 1 voltage is 26 v, phase 2, 36 v, at 400 cps. No-load speed is 9,500 rpm, stall torque 0.12 oz-in. Operating temperature range is -54 to +125 C.

General Precision, Inc., Kearfott Div., Dept. ED, Little Falls, N.J.

Nuvistor Sockets

517

Phenolic sockets for nuvistor tubes are supplied with solder washer for solder fastening or tabs for mechanical mounting. Fastened sockets will resist a pressure of 20 lb. Contacts are copper alloy with cadmium plating.

Cinch Manufacturing Co., Dept. ED, 1026 S. Homan Ave., Chicago 24, Ill.

Teflon-Lined Tubing

438

Neoprene rubber tubing with Teflon liner combines the best features of both materials. Size ranges from 1/8 to 1 in. inside diameter, with 1/8-in. coating of Neoprene or other elastomer. Tubing withstands service temperature of 200 F.

Pennsylvania Fluorocarbon Co., Inc., Dept. ED, 1115 N. 38th St., Philadelphia 4, Pa.

6,000 ELECTRONIC WIRE AND CABLE PRODUCTS

Alpha Wire

YOUR COMPLETE GUIDE TO ELECTRONIC WIRE AND CABLE 52 pages of information

Write **ALPHA WIRE**

ALPHA WIRE CORPORATION
Subsidiary of LORAL Electronics Corporation
200 Varich Street, New York 14, N.Y.
PACIFIC DIVISION:
1871 So. Orange Dr. Los Angeles 19, Calif.

CIRCLE 140 ON READER-SERVICE CARD

6 NEW WIRE & TUBING LINES

- **HEAT SHRINKABLE TUBING** — An irradiated tubing with controlled shrinkage, that, when heated, shrinks in seconds to form a tight-fitting mechanical bond.
- **RETRACTILE COIL CORDS** — A quality line of test leads, power cords, power cord sets and communication cords with the maximum retractility and durability.
- **TEFLON CABLES** — 48 different cables. Available from one to four conductors.
- **ZIPPER TUBING** — New constructions, new techniques with complete data on five tubing types.
- **TEFLON TUBING** — All new tubing for high temperature application (260°C.)
- **SHIELDING AND BRAIDING** — 3 different types including new round shielding to QQ B 575.

SOLUTION

DISSOLVES GLASS

BUT DOESN'T AFFECT

AUTRONEX GOLD PLATE!

Autronex Gold Plated transistor headers were suspended in C.P.—4 solution (nitric, acetic and hydrofluoric with bromine) for several hours... the header's glass seals dissolved, the Gold Plate remained intact.

This dramatic experiment, carried out by one of the country's prominent manufacturers of semiconductor products, demonstrates some of the superior metallurgical properties of electroplate produced with the AUTRONEX ACID GOLD PLATING PROCESS—for all industrial applications.

The simple to prepare bath is mildly acidic (pH 3.5—4.5), operates at room

temperature, and produces deposits which are mirror-bright in any thickness. AUTRONEX electroplates also offer approximately 75% greater resistance to abrasive wear over conventional Gold plate.

For complete details on uses, bath preparation, equipment required, etc., ask for #EG-1.



AUTRONEX EASILY PASSES ALL RIGID PERFORMANCE-ACCEPTANCE TESTS

- SALT-SPRAY TEST
- MANDREL-BEND TEST
- BOILING WATER TEST



SEL-REX CORPORATION

NUTLEY 10, NEW JERSEY

The world's largest selling precious metal plating processes

CIRCLE 141 ON READER-SERVICE CARD

POWER
SUPPLIES

VALUE

QUALITY



RS305A

@ \$55.50

For original use . . . For incorporation into laboratory equipment . . . In 55- to 400-cycle systems. The Trans Electronics Model RS305A Power Supply provides voltage regulation of .05% load and .05% line over the entire 225- to 325-volt range. Operating current range 0-50 ma, continuous duty, with filament output of 6.3 volts CT AC @ 3 amps. Units feature low ripple and noise (5 mv peak to peak); fast recovery time (25 to 50 microseconds). Three versions of Model RS305A offer, respectively, modular construction in package 5 x 4 1/2 x 6 1/2 inches; rack-mounting; and rack-mounted models with 3 1/2-inch meters, in case with 3 1/2-inch panel height. Input is 105-125 volts AC.

SPECIFICATIONS

model*	voltage range	current ma	filament volts/amps	price
RS-110				\$108.00
RR-110	0-100	6-100	6.3/3	133.00
RM-110				169.00
RS-205				55.50
RR-205	150-225	0-50	6.3/3	80.00
RM-205				115.00
RS-217A				87.50
RR-217A	150-225	0-175	6.3/8	112.50
RM-217A				147.50
RS-305				55.50
RR-305	225-325	0-50	6.3/3	80.00
RM-305				115.00
RS-317				87.50
RR-317	225-325	0-175	6.3/8	112.50
RM-317				147.50
RR-450	+300-400		6.3/2	155.50
RM-450	-300-400	0-50	6.3/1.5	196.00
DUAL TRACKING				
RR-473	+300-400		6.3/2	140.00
RM-473	-300-400	0-25	6.3/1.5	175.00
DUAL TRACKING				
RS-505				81.50
RR-505	300-500	0-50	6.3/3	106.50
RM-505				141.50
RR-303	0-300	0-500	6.3/15	320.00
RS-303	0-300	0-500	6.3/15	360.00
RR-550	300-500	0-500	6.3/15	310.00
RM-550	300-500	0-500	6.3/15	350.00

TRANS ELECTRONICS, Inc.

7349 Canoga Avenue, Canoga Park, California

CIRCLE 142 ON READER-SERVICE CARD

NEW PRODUCTS

Photoconductive Cells

596



Similar to the human eye in its sensitivity variation with the color temperature of light sources, this cell measures light accurately, whether the light is tungsten or daylight or whether the color temperature is 2,700 or 6,500 K. A footcandle meter incorporating the cell needs no correction filter.

Clairex Corp., Dept. ED, 22 E. 17th St., New York 3, N.Y.

Thermistor

620

This positive-temperature-coefficient unit can be used for temperature compensation, sensing and control in many applications including motors, transistorized circuitry and crystal ovens. Diameters range from 0.82 to 0.2 in., thicknesses from 0.12 to 0.06 in. and resistances at 37.8 C from 150 to 1,200 ohms.

The Carborundum Co., Refractories Div., Dept. ED, Perth Amboy, N.J.

Cable Breakout Boxes

602



Designed for operating circuit tests, these devices connect in series between existing cables and operating equipment, making test points available at each wire for voltage and waveform checks. Hi-pot, continuity, dielectric or resistance tests can be made.

Angler Industries, Dept. ED, Metuchen, N.J.

P&A: \$16.50 to \$110; 2 weeks.

Silicon-Glass Diodes

679

Forward current is 200 ma. For general-purpose use, types 1N456A through 1N464A also have surge capability. They are compact and can be used in severe environments.

Princeton Electronics Corp., Dept. ED, P. O. Box 127, Princeton, N.J.

THERMOSTATS

BY *Therm-O-Disc*



TYPE A—Adjustable

- Slow make or break contacts
- For operating temperatures up to 550°F.
- Resistive load—1500 watts at 120 VAC



TYPE HL

- Single pole, single throw or double pole, single throw
- Manual or automatic reset
- Preset, snap action, non-adjustable
- For operating temperatures up to 300°F.
- Resistive load—40 amperes at 125 VAC 25 amperes at 250 VAC



TYPE 11T-11

Best suited for controlling temperatures in air streams same ratings as TYPE 11T-21

Designed for surface mounting also available for watertight mounting

- High ratings with minimum size
- Single pole, single throw or single pole, double throw
- Preset, snap action, non-adjustable
- For operating temperatures up to 350°F.
- Blade or screw terminals, exposed or enclosed disc
- Resistive load—6000 watts at 240 VAC 3000 watts at 120 VAC
- Inductive load—10 amps, full load at 120 VAC 5 amps, full load at 240 VAC



TYPE 11T-21

TYPE AF & AL

- For fan motor or limit control
- 3" or 7" sensing element
- Snap action—adjustable
- For operating temperatures up to 300°F.
- Fan or limit rating—1/2 h.p. at 120/240 VAC and 125 volt amperes at 120/240 VAC



TYPE WA

Best suited for controlling temperatures in air streams same ratings as TYPE WC



TYPE WC

Designed for surface mounting (with or without mounting bracket)

- Preset, snap action, non-adjustable
- Single pole, single throw
- For operating temperatures up to 350°F.
- Blade or screw terminals, exposed or enclosed disc
- Resistive load—2500 watts at 240 VAC 1650 watts at 120 VAC
- Inductive load—4.4 amps, full load at 120 VAC 2.2 amps, full load at 240 VAC

TYPE 20T

- Refrigeration and air conditioning control
- Hermetically sealed in all-metal case
- Single pole, single throw
- For operating temperatures up to 200°F.
- Resistive load—1000 watts at 120/240 VAC



Detailed information on request

Minimum production order quantity accepted—25

THERM-O-DISC, Incorporated Mansfield, Ohio

CIRCLE 143 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 26, 1961

Rotary Switches

600

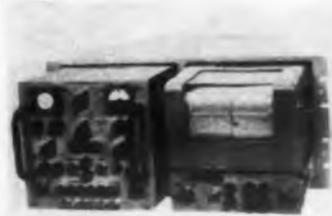


Modular-constructed types C-25 and C-40 are for power switching and motor control. Type C-25 is for 25 hp at 600 v, three-phase; type C-40 is for 40 hp. Each stage has two isolated double-break, silver alloy contacts, up to 24 contacts can be provided.

American Solenoid Co., Dept. ED, Union, N.J.
P&A: 5 to 10 days.

Frequency-Deviation Meter

597



One part in 10^{10} is measured by BTK-36A meter. It consists of two units, having a recorder to pilot the difference in frequency between the primary and secondary standards. Except for a crt, it is completely transistorized.

Aircraft Radio Corp., Dept. ED, Boonton, N.J.

Scale Corrector

603



In-line data linearizers operate on binary or bcd data and translate the data into engineering units. Applications are with multiplexers, digitizers, timers and programmers creating advanced data-acquisition and handling systems.

Applied Development Corp., Dept. ED, 12838 Weber Way, Hawthorne, Calif.

P&A: From \$1,200, 6 weeks.

Frequency Meters

680

Ranges are 3.95 to 40 kmc in these full-waveguide-band units 532 through 538, with each unit covering one waveguide bandwidth. Accuracies are to 0.08%. A 100-in. helical scale is provided.

PRD Electronics, Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N.Y.



TANTALUM CAPACITORS...NEW HEIGHTS IN RELIABILITY ENGINEERED BY PYRAMID

When Pyramid tantalum capacitors with proven dependability are incorporated into essential electronic equipment you manufacture... greater reliability of your product is assured.

To design engineers searching for miniature electrolytic capacitors with unusual capacitance stability and a low dissipation factor over a wide temperature range, soundly constructed tantalum capacitors are gratifying discoveries.

If the equipment you make demands small capacitors with explicit reliability and peak performance, look to Pyramid for tantalum capacitors that meet your most exacting requirements.

For full details write or call: Sales Department

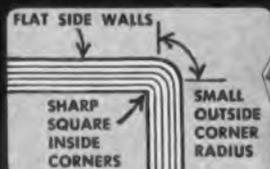
PYRAMID  **ELECTRIC**

Canada: Wm. Cohen, Ltd., 8900 Park Ave., Montreal

Export: Morhan Exporting Co., 485 Broadway, N.Y. 13, N.Y.

CIRCLE 144 ON READER-SERVICE CARD

Better Coils begin with PARAFORMED PAPER TUBES



- No sharp outside edges to cut wire
- No need for wedges to tighten wire
- Permits winding coils to closer tolerances
- Allows faster stacking of wound coils
- Has full rigidity and physical strength

ANY SIZE—SQUARE OR RECTANGULAR

PARAFORMED paper tubes simplify coil winding operations and speed production, yet cost no more. In the exclusive PARAFORM method of tube making, no artificial heat or pressure is used—*Paraforming* takes place at the time of spiral winding. Hi-Dielectric. Hi-Strength. Kraft, Fish Paper, Acetate, Red Rope or any combination wound on automatic machines. *Produced from stock arbors or special sizes engineered for you.* Can also be supplied in regular or with slight bow.

SPIRAL WOUND
Not Die Formed

Write on company
letterhead for
**STOCK
ARBOR LIST**
of over 2000 sizes

PARAMOUNT PAPER TUBE CORP.

608 LAFAYETTE STREET, FORT WAYNE 2, INDIANA
Manufacturers of Paper Tubing for the Electrical Industry Since 1931

CIRCLE 145 ON READER-SERVICE CARD

HIGH VOLTAGE
QUALITY
RELIABILITY

POWER SUPPLIES

Standard power supplies and transformers available from stock. Others built to your specific requirements from stock components.

WRITE FOR COMPLETE SPECIFICATIONS



DEL ELECTRONICS CORPORATION

321 HOMESTEAD AVENUE • MOUNT VERNON, N. Y. • OWERS 9-2000

CIRCLE 146 ON READER-SERVICE CARD

120 KV DC AT 5 MA

- Zero Start
- Reversible Polarity
- Input 115V-60 cycle
- Safety Interlock
- Electronic overload circuits provide full range protection
- Automatic stored energy discharge switch
- No exposed high voltage components



Model PSC 120-5-2

30 KV DC AT 5 MA OR 35 KV DC AT 1 MA

- Completely Self-Contained—Portable
- Ideal as Insulation Test Set and "Hi-Pot" TESTER
- No Exposed High Voltage Components
- Electronic overload circuits settable from 0-120% of rated current and voltage
- Many other features



Model PSC 30-5-1

DEL ELECTRONICS CORPORATION

321 HOMESTEAD AVENUE • MOUNT VERNON, N. Y. • OWERS 9-2000

CIRCLE 146 ON READER-SERVICE CARD

NEW PRODUCTS

Absorptivity Recorder

601



An auxiliary unit, model 2015 is for use with Cary spectrophotometers to record extinction coefficient on a logarithmic scale. It provides spectra with shape unaffected by sample concentration or path-length. Uses are sample identification and qualitative multi-component analysis.

Applied Physics Corp., Dept. ED, 2724 S. Peck Road, Monrovia, Calif.

Meter-Relays

575

Having a taut band movement, these relays can be used with accuracy in the range of 50 μ a. They are particularly suitable for control applications with full-scale sensitivities of 0 to 5 μ a or 0 to 2 mv.

Assembly Products, Inc., Dept. ED, Chesterland, Ohio.

Stepper Motors

599



With increments of 15 and 7.5 deg and rates of 200 to 550 steps per sec, these motors work in conjunction with a logic circuit which controls rate, sequence and direction. They may be driven by electromechanical or electronic logic.

American Electronics, Inc., Instrument Div., Dept. ED, 9503 W. Jefferson Blvd., Culver City, Calif.

Jack-to-Plug Adapter

681

Nickel-plated, completely shielded, with straight-through connections, no. 370 is for connecting cord ends with a phono plug. It has an output 9/64 in. in diameter and 9/16 in. long for the phono-jack input.

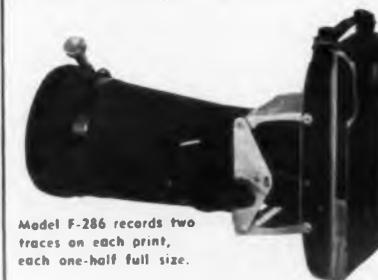
Switchcraft, Inc., Dept. ED, 5555 N. Elston Ave., Chicago 30, Ill.

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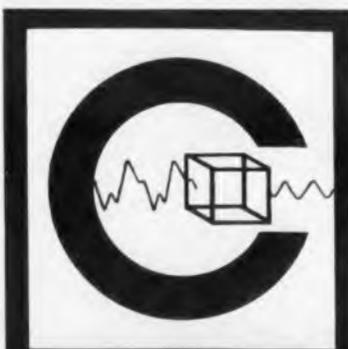
For literature and prices, write to Industrial Products Division, Fairchild Camera and Instrument Corp., 580 Midland Ave., Yonkers, N. Y. Dept. ED-4.



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598



For PAM or PDM standard IRIG and nonstandard inputs, type 3201 operates with pulse repetition frequencies of 75 to 2,700 pps. It has automatic drift and gain correction. Fingertip selection of 10 from up to 99 channels is possible.

American Bosch Arma Corp., Dept. ED, 5000 Parkside Ave., Philadelphia 31, Pa.

Spectrograph Equipment

576

A complete line of modular units, including model 29000 direct-reading spectrometer is offered. Chemical analysis can be made on nearly every material; up to 48 elements can be analyzed simultaneously. It is suited to industrial quality control.

Applied Research Laboratories, Inc., Dept. ED, P. O. Box 1710, Glendale 5, Calif.

Repetitive Scan Accessory

577

For use with spectrophotometers made by Cary, this unit permits the spectrophotometer to operate unattended over a preselected wavelength span. It is suited for kinetic or other time-base studies or for scanning a series of similar samples.

Applied Physics Corp., Dept. ED, 2724 S. Peck Road, Monrovia, Calif.

Servomotor-Generator

608



Weighing 1.1 oz, this size 5 unit is contained in a single housing. Excitation voltage is 28 v at 400 cps. Torque at stall is 0.1 oz-in., acceleration at stall is 37,000 radians per sec² and no-load speed is 10,000 rpm. Generator output is 0.2 v per 1,000 rpm.

Beckman Instruments, Inc., Helipot Div., Dept. ED, 2500 Fullerton Road, Fullerton, Calif.

Silicon Monocrystals

682

Supplied to customer specs, types P and N have boron and phosphorous doping, respectively. Resistivity is 0.05 to 100 ohm-cm. Standard diameter is 3/4 in. Length is up to 6 in.

Solid State Materials Corp., Dept. ED, 5 Erie Drive, East Natick, Mass.

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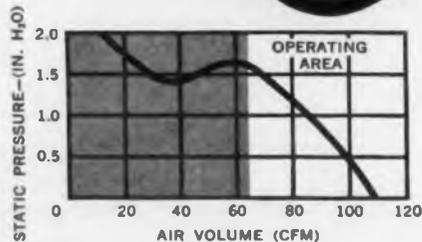
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Rugged mechanical protection is provided by the black anodized aluminum housing and propeller. Mount by clamping to servo ring at either end. Nominal life exceeds 1000 hours. Max. current is 0.47 amps at free air delivery. Request Bulletin GNB from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.

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NEW PRODUCTS

Generator

604



Triple-function type LRG 051 produces these synchronously initiated output waveforms: positive 100-v sawtooth, positive 10-v pulse and positive 10-v pulse delayable within the duration of the sawtooth. Operation can be triggered or gated from an external waveform.

Argonaut Associates Inc., Dept. ED, P. O. Box 273, Beaverton, Ore.
P&A: \$200; 4 weeks.

Magnetic Amplifier

579

For controlling heater power, model FAP-T-601 amplifier meets MIL-E-5272A. Temperature accuracy is ± 0.05 F using a 760-ohm sensor with a temperature coefficient of 0.0025 ohms per deg. Efficiency is 75 per cent at full output. Input is 115 ± 6 v, 60 ± 3 cps.

American Research and Manufacturing Corp., Dept. ED, 920 Halpine Ave., Rockville, Md.

Adapter for Scope Camera

607



For the firm's Oscillotron, this adapter permits the camera to accept holders for standard 4 x 5 films. It also permits ground-glass focusing and can be interchanged with the Polaroid back.

Beattie-Coleman, Inc., Dept. ED, 1006 N. Olive St., Anaheim, Calif.

Frequency Meter

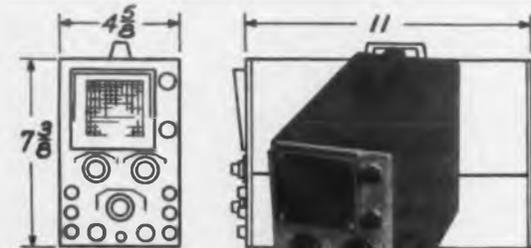
683

Range is 2.4 to 3.7 in the 583-D calibrated precision unit. Accuracy is $\pm 0.3\%$ at room temperature and $\pm 0.8\%$ from -40 to 50 C. Connectors are type N jack. Insertion length is 3-23/32 in.

PRD Electronics, Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N.Y.

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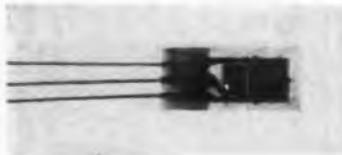
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Strain Gage

606



Having a built-in computer to solve strain-to-stress equations automatically, the SR-4 gage provides electrical responses proportional to stress or strain by using two independent, axial strain-sensing elements oriented 90 deg apart.

Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., Dept. ED, 42 Fourth Ave., Waltham 54, Mass.

Miniature Fittings

580

For use at 10 to 25 kv at low currents, these fittings are for power supplies, infrared detectors, test equipment and instrumentation. Temperature range is -65 to +150 F, they can be exposed to 100% relative humidity and contour tolerance is ± 0.002 in.

American Research and Manufacturing Corp., Dept. ED, 920 Halpine Ave., Rockville, Md.

Motor Generator

581

Brushless, synchronous and with ratings of 3 to 150 kw, series 32 has a voltage regulation of 1%. Closer regulation is possible. Frequency is held to 400 cps. Standard harmonic content is 2 per cent. Little maintenance is needed.

American Electronics, Inc., Dept. ED, 1598 E. Ross Ave., Fullerton, Calif.

Precision Potentiometers

618



With 10-turn design and a diameter of 7/8 in., series 59M14-10 units have resistance values of 1,000 to 100,000 ohms in linear functions. Standard resistance tolerance is ± 5 per cent; independent linearity is ± 0.25 per cent. Power rating is 4.5 w at 40 C. Clarostat Manufacturing Co., Inc., Dept. ED, Dover, N. H.

Transistor Tester

684

For testing 3,600 units per hour, the Vast I is a 20-parameter, go/no-go test unit. Information is recorded on a 2,000-bit program card and is assimilated by card-reader circuits and transposed into circuit adjustments. Two operators are usually needed.

Philco Corp., Lansdale Div., Dept. ED, Lansdale, Pa.

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350

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NEW PRODUCTS

Indicator Tubes

611



New design of Nixie tubes provides flattened tube face and cutaway anode to permit higher positioning of the cathode numerals. Viewing angle is increased from 90 to 160 deg. Life is 200,000 hr. Type B5092 replaces B5031; type B6091 replaces B6033. A completely new large tube is also offered.

Burroughs Corp., Electron Tube Div., Dept. ED, Plainfield, N. J.

Recorder-Reproducer

582

A two-speed, magnetic-tape unit, model R168-C is for mobile use. It accepts 1/4-in. tape on reels to 10-1/2 in. Speeds are 7-1/2 and 15 ips. Signal-to-noise ratio is 40 db or better. Bias frequency is 125 kc. A number of configurations can be furnished.

American Concertone, Inc., Dept. ED, 9449 W. Jefferson Blvd., Culver City, Calif.

Epoxy Pencil

614



A no-mix, single unit, this epoxy pencil can be used in bonding, cementing, sealing and insulating. The epoxy requires no special storage and provides a permanent, waterproof bond that cures in 7 min at 400 F. The pencil comes in an aluminum, collet-type holder.

Cetron Electronic Corp., Plastics Div., Dept. ED, 2265 E. Foothill Blvd., Pasadena, Calif.

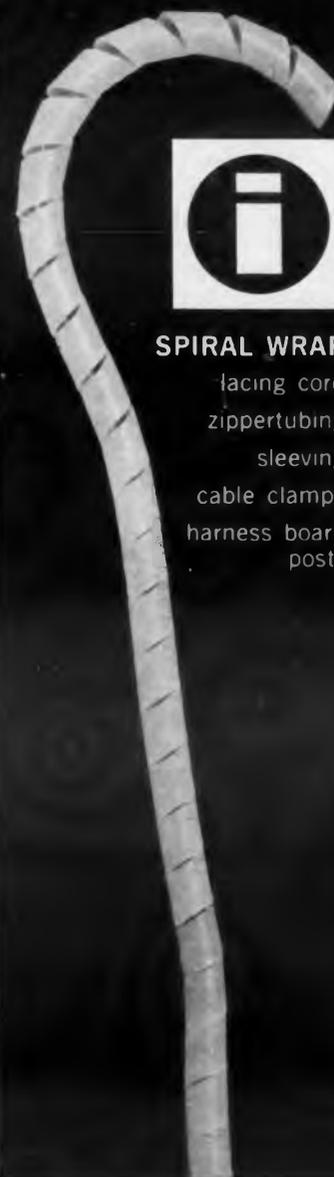
Power Transistors

638

Provide fast switching. The 2N1907 high-frequency/high-current germanium power transistors can switch 5 amp at a typical time of 2.5 usec. Guaranteed min h_{fe} is 50 at 5 amp and 10 at 15 amp, making possible reduced input drive current.

Texas Instruments, Incorporated, Dept. ED, Dallas 22, Tex.

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Mobile Antenna

578

This 30-ft. scanner antenna is designed for easy transport and is erected by a winch or a hydraulic lifting device. It is operable under normal wind conditions without guys and comes with a mesh or a solid surface. Designation is model 111.

Antenna Systems, Inc., Dept. ED, Hingham, Mass.

Planar Acceleration Switch

583

From 0.25 to 100 g is the range of sensitivity for this device. Accuracy is ± 5 per cent. The switch closes a circuit upon the application of a predetermined vector acceleration. Units are produced with almost any vector diagram.

Aerodyne Controls Corp., 90 Gazza Blvd., Farmingdale, N. Y.

Pressure Transducers

613



Having ranges of 20 to 10,000 psig, these units can be over-pressured by a factor of 10 without needing calibration. Nominal output resistance is 350 ohms; power needed is 28 v max. Bonded silicon, strain-gage construction is used. Units are called 750.

Century Electronics & Instruments, Inc., Dept. ED, 1333 N. Utica Ave., Tulsa 10, Okla.

Phase Meters

584

With ranges of 500 kc to 1 cps, the 405 series phase meters provide direct indication of phase angle. Symmetrical waveforms of any shape can be accepted. Drift is less than 0.001 deg for 10 hr of operation. Relative accuracy is ± 0.25 per cent; absolute accuracy is ± 2 per cent at most frequencies.

AD-YU Electronics Lab., Inc., Dept. ED, 249 Terhune Ave., Passaic, N. J.

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Ganged Capacitors

686

For precision tracking, these units come in close tolerances. Made to customer specifications, they permit tracking in both directions of rotation. The entire assembly is shielded. Terminations may be solder or screw type or coaxial.

Hammarlund Manufacturing Co., Inc., Dept. ED, 460 W. 34th St., New York 1, N.Y.



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140

NEW PRODUCTS

Wirewound Resistor

612



Preset and variable, type INS-110 has a mounting plate to insulate the control. It is for hot-chassis or other potentiometer uses and can be furnished with a molded shaft. Diameter is 3/4 in. Rating is 1-1/4 w at 40 C, derated to no load at 105 C.

CTS Corp., Dept. ED, Elkhart, Ind.

Pressure Switch

587

With settings of 5 to 5,000 psi, absolute or gage, this switch has a temperature range of 65 to 250 F. It has metal-welded construction and needs no synthetic seals. It can be used in severe environments. Designation is P/N series 58520.

Century Geophysical Corp., Dept. ED, 515 S. Main, Tulsa, Okla.

Revolution Counter

605



Offered in 11 standard ranges, series 312 shaft-driven counter has a repeat-count accuracy of 0.25 per cent of the dial range. The shaft requires an operating drive torque of 1-1/4 oz-in. Applications include process, batch system and automatic flow control.

Automatic Timing & Controls, Inc., Dept. ED, King of Prussia, Pa.

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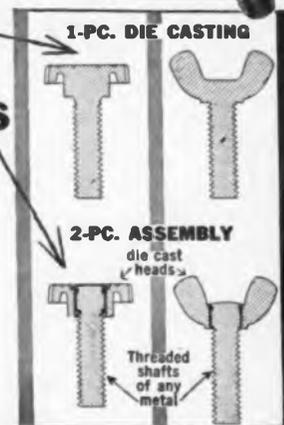
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ELECTRONIC DESIGN • April 26, 1961

Isolation Transformers

595

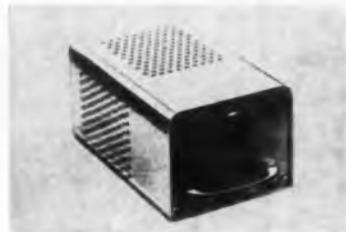
Electrostatically shielded. Designed to closely approach battery performance in freeing laboratory instruments from stray pick-up, these isolation transformers are available in three ranges: 50 va; 150 va; and 500 va. Units are hermetically sealed and meet the requirements of MIL-T-27A.

Newport Scientific Co., Dept. ED, 638 W. 17th St., Costa Mesa, Calif.

P&A: \$33 for the 50 va model; from stock.

Monitor-Receiver

617



Fm-crystal controlled, this unit comes in model RA-52 for low band with a sensitivity of less than 0.5 μ v for 20-db quieting and high-band model RA-150 with less than 0.75- μ v sensitivity for 20-db quieting. Both have a selectivity of ± 30 kc greater than -40 db.

Checker Electronics Corp., Dept. ED, P. O. Box 251, Grayslake, Ill.

Environmental Chamber

588

Capacity is 0.5 cu ft; standard low temperature range is -10 to -60 F. A high temperature range to +500 F can be furnished. Called PENGUIN/5, the unit is suited for transistor testing, miniature bearing manufacture and other uses where space is at a premium.

Cincinnati Sub Zero Products, Dept. ED, 3932 Reading Road, Cincinnati 29, Ohio.

Hermetic Feed-Through Seals

593

Able to operate at 900 C, these seals are for electronic components in high-altitude, military aircraft equipment. Shock limit is 10,000 g. Composed of a threaded ceramic, a flange and a solid feed-through, the units are 1 in. long and 1/2 in. in diameter or 1-3/16 in. long and 3/4 in. in diameter.

Ceramics International Corp., Dept. ED, 39 Siding Place, Mahwah, N. J.

P&A: \$2 in lots of 2,000; 8 to 14 days.

Computer Diodes

687

Diffused silicon mesa types 1N914 and 1N916 operate at 75-ma rectified forward current. Maximum recovery time is 4 nsec; capacitance is low. Internal construction meets military specifications.

Princeton Electronics Corp., Dept. ED, Princeton, N.J.

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Square and rectangular shaped wires are frequently used in modern "wrapped" terminal and pin or plug type connectors. For this application the edges must be finished quite sharp (usually .003 radius corners or less) but without a burr or flashing. Also required are closely controlled dimensional tolerances and smooth finish. Uniformity of temper is essential. Therefore close control of all facets of wire manufacturing is of paramount importance.

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NEW PRODUCTS

Angle-Beam Transducers

609



Offered in a variety of types, these transducers are for use with ultrasonic flaw-detection equipment. Type ZSL, for example, can be used to produce angles of 45 to 90 deg, as specified. Its operating frequencies are 1, 2.5 and 5 mc.

Branson Instruments, Inc., Dept. ED, 40 Brown House Road, Stamford, Conn.

Punched-Tape Reader

615



Having a readout speed of almost 8,000 bits per min, this reader provides 132 parallel, form A contacts rated at 28 v and 150 ma. Forward or reverse operation is possible. Reliability is 99.99997 per cent. It uses 70-mm Mylar tape.

Chalco Engineering Corp., Dept. ED, 15126 S. Broadway, Gardena, Calif.

Vector Analyzer

585

With a range of 20 cps to 100 kc at an accuracy of 2 per cent or 0.02 deg, type 202 measures very small phase angles, phase error between an unknown component and a standard component, voltage across two points both above ground potential and vector relations to 500 mc.

AD-YU Electronics Lab., Inc., Dept. ED, 249 Terhune Ave., Passaic, N.J.

P&A: \$598; 1 to 2 weeks.

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ELECTRONIC DESIGN • April 26, 1961

Crystal Unit

594

Size is intermediate, between JAN HC-6/u and HC-18/u. The range of 250 to 800 kc is covered with DT or CT cuts and the range of 1 to 150 mc, with AT-cut quartz crystals. Principal applications are filters, discriminators and oscillators.

Clark Crystal Co., Inc., Dept. ED, Marlboro, Mass.

Fused Meters

610



Heavy-duty, multi-range meters in this series stand an overload of 10 times greater than normal for 1 hr. Included are the 410 triple-range ac voltmeter, the 420 dual-range ac ammeter, the 430 triple-range dc voltmeter, the 440 triple-range dc ammeter (shown) and the 450 galvanometer.

Buck Engineering Co., Dept. ED, 41 Marcy St., Freehold, N. J.

P&A: \$36 to \$42.

Digital Clocks

592

Up to three independent outputs can be provided by model 2600 or 2700. Outputs are parallel, decimal contact closure patterns based on 12- or 24-hr time. Seconds and tenths of minutes outputs are obtained with a rotary switch.

Chrono-Log Corp., Dept. ED, Box 4587, Philadelphia 31, Pa.

P&A: \$490 to \$640.

Measuring Device

590

For surface finishes of 1 to 1,000 μ m. on metals, plastics, ceramics, and organic materials, model MS 1000 Surfindicator can be used at any point in a production line or inspection area. It is transistorized and uses two 9-v batteries.

Brush Instruments, Div. of Clevite Corp., Dept. ED, 37th & Perkins, Cleveland 14, Ohio.

P&A: \$920; 30 days.

Thin-Film Systems

688

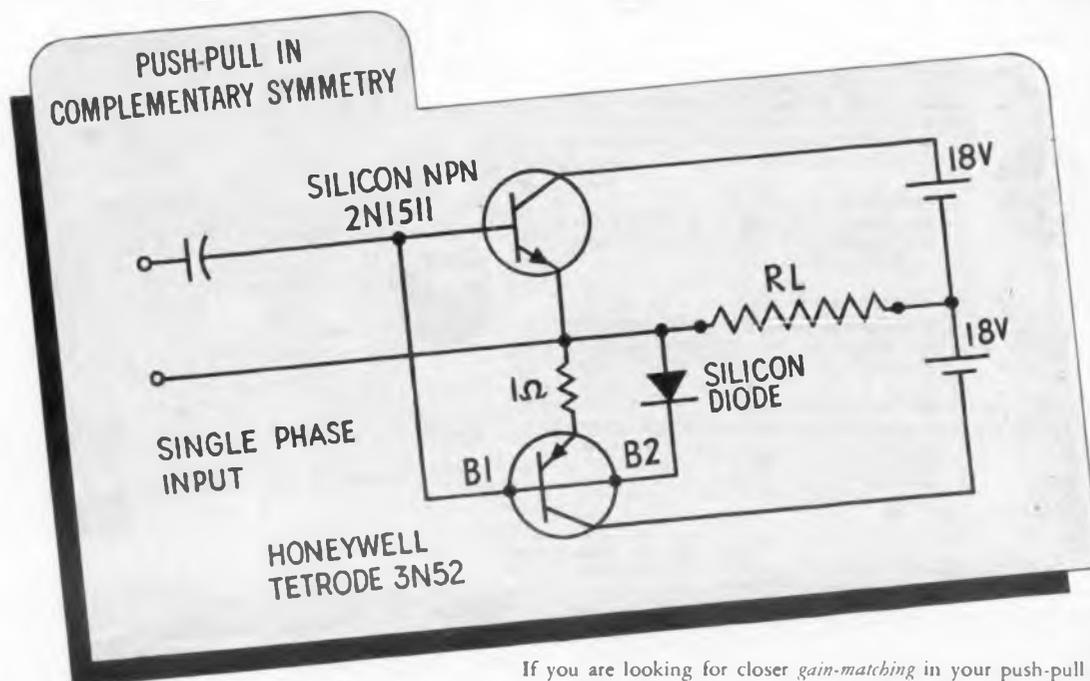
For microcircuits, EB-101 equipment offers standard tolerances and high reliability. This equipment is for the production of complex circuits composed of thin-film conductors and multiple resistors.

GVC Electron Heating Corp., Dept. ED, 81 Hicks Ave., Medford, Mass.

CIRCUIT IDEA FILE

New Transistor Applications

Looking for closer gain-matching?



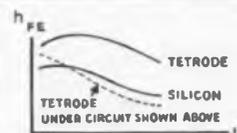
If you are looking for closer gain-matching in your push-pull complementary Symmetry circuits, you will find the answer in these Honeywell Power Tetrodes.

3N49, 3N50, 3N51, 3N52

Power Tetrodes: single-ended, cold welded package mechanically interchangeable with TO-36 case.



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POWER TRANSISTORS	PNP	NPN	TWO-BASE PNP TETRODE
CURRENT GAIN	HIGH	AVERAGE	AVERAGE*
TRANSCONDUCTANCE	HIGH	AVERAGE	AVERAGE*
LEAKAGE	AVERAGE	LOW	LOW



*Because of its controllable gain feature, the Honeywell Power Tetrode is capable of closely matching the current gain, the transconductance, and the leakage of either silicon or germanium NPN transistors when used in the push-pull complementary Symmetry circuit shown above.

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CIRCLE 910 ON CAREER INQUIRY FORM, PAGE 163

NEW PRODUCTS

Variable-Speed Drive

554



Two new 5-hp electronic drive systems, models 1P11-20 and 1P81-20, are available to vary the speed of a 440-v, 60-cps motor. Either system, complete with motor, provides 2% speed regulation from 60 to 2,400 rpm from no load to full load.

Electro-Devices, Inc., Dept. ED, P. O. Box 2308, Paterson, N. J.

Servo Analyzer

616



Modulation rates are 0.005 to 1,000 cps, provided in sinusoidal, step and ramp functions, directly or in suppressed carrier form. Carrier frequencies of 50 to 10,000 cps may be used. Designated model 101, this unit measures phase and gain response on servo systems, amplifiers and other equipment.

Chance Vought Corp., Dept. ED, Dallas, Tex.
P&A: \$2,952; 60 to 90 days.

High-Gain Preamplifier

586

Sensitivity is 10 μ v per chart line in direct-writing recorder use. Input impedance is 10,000 ohms and is floating and guarded. Response to a step input is 90 per cent in 2 msec. In-phase rejection to a differential input is 120 db at dc, 60 and 400 cps. Linearity is 0.2 per cent. The unit is designated RD 4215 20; model RD 4215 00 has 100- μ v sensitivity.

Brush Instruments, Div. of Clevite Corp., Dept. ED, 37th & Perkins, Cleveland 14, Ohio.
P&A: \$550; from stock.

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144

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Digital Clock

591

Requiring 3.5 in. of panel space, model 2500 is a time source for data loggers, computers and other applications where a parallel, decimal contact closure pattern representing 24-hr time is required. Up to three independent outputs can be provided in one clock.

Chrono-Log Corp., Dept. ED, Box 4587, Philadelphia 31, Pa.

Pass-Through Oven

550



Model 1408-M pass-through oven, with lift-sliding doors, can heat large loads of components continuously at 600 F. A 550-cfm blower insures rapid heat transfer and maintains uniform temperatures throughout the 32-in. wide, 25-in. deep, 30-in. high chamber despite frequent loading and unloading. Standard controls include indicating-controlling thermostat, pilot light, three-heat selector, and main switch. Other models are available with chamber volumes up to 60-in. wide, 30-in. deep, and 40-in. high.

Electric Hotpack Co., Inc., Dept. ED, Cottman Ave. at Melrose St., Philadelphia 35, Pa.

P&A: Varies with temperature range; 45 to 60 days.

Thermal-Shock Chambers

589

Accuracy is ± 0.5 F. Model 600 has a range of -100 to +500 F, with 5-min pulldown and 30-min warmup. Model 800 has a range of -320 to +500 F. Designed for bench-top use, the units have inside dimensions of 16 x 8 x 8 in. The door is removable.

Cincinnati Sub Zero Products, Dept. ED, 3932 Reading Road, Cincinnati 29, Ohio.

Analog Controller

689

Is accurate and stable. Analog computer-controller CM-3 provides real time control for petro-chemical processes, simulation, or operator guidance. Stability and over-all accuracy may reach 1/2%. Solid-state system provides 1 to 3 outputs from 5 to 10 inputs.

Dresser Electronics, Dept. ED, 10201 Westheimer Road, Houston 42, Tex.

P&A: \$5,000 to \$10,000; 60 days.

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- shock safety: case isolated from circuit under test

The new Model 109-2 has 12 voltage ranges calibrated to RMS value of a sine wave: 0.001 to 300 VAC full scale, with frequency range of 5-200,000 cps. Accuracy is $\pm 2\%$ full scale. Can measure accurately to 20 microvolts. Input impedance 10 megohms. Low distortion amplifier output voltage can be externally shorted without internal damage. Power: 105-125 VAC, 50-420 cps, 25 watts. Price: \$220.00

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Export Dept. EMEC, 127 Grace St., Plainview, N.Y.

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NEW PRODUCTS

Photometers

622

Double-beam, ratio-recording Spectro-photometers DK-1A and DK-2A have a wavelength range of 185 to 3,500 m μ and a resolution of 2 Å at 220 m μ . The DK-2A is for bench-top use. A unit for far ultra-violet applications is also offered.

Beckman Instruments, Scientific and Process Instruments Div., Dept. ED, 2500 Fullerton Rd., Fullerton, Calif.

Size 8 Synchro

619



A sector switch provides a closed circuit when the position of the synchro exceeds ± 70 deg from EZ. Adding 0.5 in. to the over-all synchro length, the unit can be used wherever switching is required in conjunction with synchro angular positions.

Clifton Precision Products Co., Dept. ED, 5050 State Road, Drexel Hill, Pa.

P&A: 4 to 6 weeks.

Magnetic-Tape Plotter

621

Producing an X-Y plot of digital data, model 570 plots calculated electron ballistics, reliability analyses and other computer outputs. The transport reads tapes with a linear density of 200 bits per in. The recorder uses a bi-directional, rotary step motor.

California Computer Products, Inc., Dept. ED, 8714 Clela St., Downey, Calif.

P&A: \$24,500; 90 days.

Porous Alumina

513

Used in high-power arc applications, porous alumina offers high impact strength and heat resistance. Material helps dissipate arc energy through outgassing and by providing a rough surface. Uses include circuit breakers, lightning arresters, arc diffusion systems, and other insulation applications.

Electronic Mechanics, Inc., Dept. ED, 101 Clifton Blvd., Clifton, N.J.

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Telemetry Transmitter 524



Accurate, stable cw signal for tracking of missiles or vehicles is provided by the TT-1001 Mod 7 uhf telemetering transmitter. Frequency is 225 to 245 mc. Accuracy and stability are better than 0.01%; power output is 260 mw. Silicon transistors are used throughout. Weight is 17 oz with battery, 6.5 oz without. Battery life is 1 hour min.

Frontier Electronics Co., Dept. ED, 4600 Memphis Ave., Cleveland 9, Ohio.

Tape Reader 523

Reading speed of 300 characters per sec is achieved by type 271 tape reader. Fully synchronous operation is possible up to 220 characters per sec. Fast advance and rewind speed is 1,000 characters per sec. The militarized reader is designed for slide or conventional mounting within a special console or standard rack.

Ferranti Electric, Inc., Dept. ED, Industrial Park No. 1, Plainview, N.Y. P&A: quote on request; 120-day delivery.

Life-Test Oven 525



Up to 2,500 test stations are provided by a life-test oven for semiconductors. Design ensures exact exposure and balanced air velocity over all areas. Temperature range is 400 C; oven is equipped with temperature limiting and air flow alarm. Through ports are provided for connections.

Forma Scientific, Inc., Dept. ED, Box 649, Marietta, Ohio.

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Model 860-1500P—handles low level DC data signals in the presence of high common mode



Model 658-3400—drives high frequency optical galvanometers to 5 KC



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Sanborn precision amplifiers

▼ Data Preamplifier — Model 860-1500P

Designed for precise, economical amplification of signals with source impedance of zero to 10,000 ohms, such as thermocouples, strain gage bridges, etc. in presence of severe ground loop noise, and for driving digital voltmeters, scopes, tape recorders and similar devices. Each plug-in unit is only 2" x 7" x 14" deep; 64 channels with blower require only 60" of rack-panel space. Separate 868-500 Power Supply required for every 8 preamplifiers. Power consumption 2.5 watts per channel.

Noise	3 uv peak-to-peak
Gain	100 (10 mv in gives 1 v out) (Model 860-1500PA with gain of 1000 also available)
Output	± 1 v across 300 ohms, DC-70 cps; ± 1.5 v to 40 cps. Output impedance 100 ohms. (10 v across 10K available on special order.)
Linearity	± 0.1% of full scale output (2 v)
Common Mode Performance	120 db rejection at 60 cps, 160 db at DC, with 5000 ohms unbalance in source. Inphase tolerance 220VAC.
Input Impedance	Greater than 200,000 ohms
Gain Stability	± 0.1% for 24 hours
Drift	± 2 uv referred to input
Rise Time	to 99.9% less than 25 ms

▼ Optical Galvanometer Amplifier — Model 658-3400

Eight channels of amplification and common power supply. Each channel provides for sensitivity, compensation, damping and current limiting. Inputs floating and guarded, impedance 100,000 ohms on all ranges. All amplifier elements except output transistors are plug-in assemblies.

Sensitivity	± 10 mv input gives ± 400 ma output into 20 ohm load (max.). Eleven attenuator steps to X2000 in 1-2-5 ratio, smooth gain control.
Common Mode Performance	± 500 volts, max; rejection 140 db min at DC.
Gain Stability	Better than 1% to 50°C and for line voltage variation from 103-127 volts.
Frequency Response	0 to 5 KC within 3 db; can accommodate wide range of galvanometers.
Output	Output networks available for wide range of galvanometers.
Power Consumption	125 watts for 8 channels.

Your Sanborn Sales-Engineering Representative (offices throughout the U. S., Canada and overseas) will provide detailed information and application assistance. Call him or write plant in Waltham, Mass.


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DELAY RELAY? LOAD RELAY? BOTH!



The Type A Silic-O-Netic Relay is a light, small time-delay relay. It weighs a mere three ounces, gives you any delay you spec from 0.25 to 120 seconds. Keeps at it, too, for several million operations; the time-delay element cannot stick, bind, or wear.

The Type A Silic-O-Netic Relay is a light, small load relay. The continuous-duty coil does the trick. The Silic-O-Netic can be energized continuously, eliminating lock-in auxiliary circuits. Saves wire. Saves work. Saves space. Saves money.

Here, then, is a time delay relay that doubles as a load-carrier. The Type A offers SPDT or DPDT switching, with contact capacity up to three amps. Consumes, at most, two watts of AC power, three watts of DC. Available for use on one of twenty standard AC and DC operating voltages, and on request, for others. Costs far less than the two relays you would need to replace it; well worth a closer look. Write for Bulletin 5003.

HEINEMANN ELECTRIC COMPANY

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CIRCLE 181 ON READER-SERVICE CARD

NEW PRODUCTS

Timing Relay

561



Solid-state timing relay, for pulse or squib applications, can turn on a 50-amp load within 10 μ sec of the application of a short, low-energy, voltage trigger having an amplitude of $+17 \pm 11$ v. The relay, model TR-12-50-050, operating from a 12 v dc source, shuts off the load after 50 msec.

Curtiss-Wright Corp., Dept. ED, Inter Mountain Instruments Branch, P. O. Box 8324, Albuquerque, N. M.

Shorting Switch

560



Progressive shorting-type switches have separate collector-ring connection for complete or continuous programming. Switches, which can be ganged, come in a 1-3/4 in. sq for 20 and 24 positions, and in a 2-1/4 in. sq for 24 and 32 positions.

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

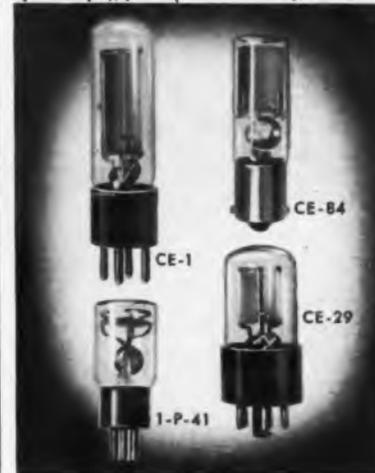
Magnetic Shifters

558



Two-way magnetic shift elements, type CTR 2W-100-P-12, provide outputs in response to shift pulses on either of two shift lines at rates from 0 to

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BIG LOOK panel meters

SELF-SHIELDED DC MECHANISMS FOR GREATER RELIABILITY

SELF-SHIELDED DC MECHANISM is one of the big built-in features you get with General Electric d-c BIG LOOK panel meters. Self-shielding eliminates special calibration problems . . . allows more flexibility in locating meters on panelboards through minimizing interaction.

Here's why: Unlike many other designs, the BIG LOOK's core is around the magnet . . . where it belongs . . . and shields the entire d-c mechanism. This means that interaction is eliminated, even when meters are cluster-mounted. Also, stray magnetic effect is minimized!

For the complete AC and DC BIG LOOK panel meter story, just contact your nearby General Electric Apparatus Sales Office or distributor; or write for bulletin GEA-7034 direct to General Electric Company, Section 597-02, Schenectady 5, New York.

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CIRCLE 183 ON READER-SERVICE CARD
ELECTRONIC DESIGN • April 26, 1961

100 kc. The elements can be used in arrays having two different information paths; hence, they can be used for bidirectional shift registers for reversible ring counters or for matrix registers.

Dian Controls, Inc., Dept. ED, 40 Leon St., Boston 15, Mass.

Price: Approx. \$34 in small quantities.

Availability: From stock to 30 days.

Induction Motor

557



New line of 400-cps induction motors, available in frame sizes up to NEMA 215, uses aluminum construction for frame and end shields to cut weight by as much as 75 per cent. Unit pictured is a 12.5-hp motor with 7,300-rpm full-load speed. It weighs less than 25 lb and has a 6-1/2-in. frame diameter.

Doerr Electric Corp., Dept. ED, 507 N. Fourth Ave., Cedarburg, Wis.

Battery Substitute

556



Constant voltage supply, model BS(TC)-2 can substitute for dry and wet cells for use with precision laboratory potentiometers such as the L&N types K2 and K3 and the Rubicon types B and S. Voltage stability is better than 0.01 per cent for 10 per cent variations in 117 v line. Over 15 C to 35 C temperature range, stability is 0.001 per cent per deg C.

Dynage, Inc., Dept. ED, 75 Laurel St., Hartford, Conn.

P&A: \$95.00; from stock.

CIRCLE 184 ON READER-SERVICE CARD ➤



How CONTINENTAL CONNECTORS show they can "take it"

Most of us think of connectors as merely an indifferent link in the assembly of modern electronic components. Today's critical military and commercial requirements, however, place extra stress on the reliability of every part. Electronic connectors are vital to all missile, aircraft, computer and communication applications.

The humidity test chamber (shown above) is one of many rigorous quality control test procedures Continental uses to make sure its connectors know how to "take it". Other key tests include salt spray, vibration, impact and endurance. Uncompromising quality control schedules with tests such as these assure proven reliability in dimensions, assembly, electrical specifications and dielectric properties.

Why not consult one of our Sales Engineers in the early stages of your next design problem. A condensed catalog of our complete line is available free on request. Write to:

Electronic Sales Division

DeJUR-AMSCO CORPORATION

Northern Boulevard at 45th Street, Long Island City 1, N. Y.

Exclusive Sales Agent



**CONTINENTAL
CONNECTOR
CORPORATION**

AMERICA'S FASTEST GROWING LINE OF PRECISION CONNECTORS

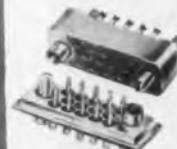
MODELS 1/2 SIZE



MICRO-MINIATURE



SUB-MINIATURE



MINIATURE



PRINTED CIRCUIT



RIGHT ANGLE
PIN & SOCKET



CENTER
SCREWLOCK

"DIMENSIONLESS" INDUSTRIAL TRANSDUCER

for gage, absolute and differential pressure measurement

The P713's unique "Dimensionless" principle eliminates many of the critical aspects of finite distances and dimensional stability in conventional gage configurations. For the first time, it offers industry a high performance electrical transmitter for control, data logging and computer systems.

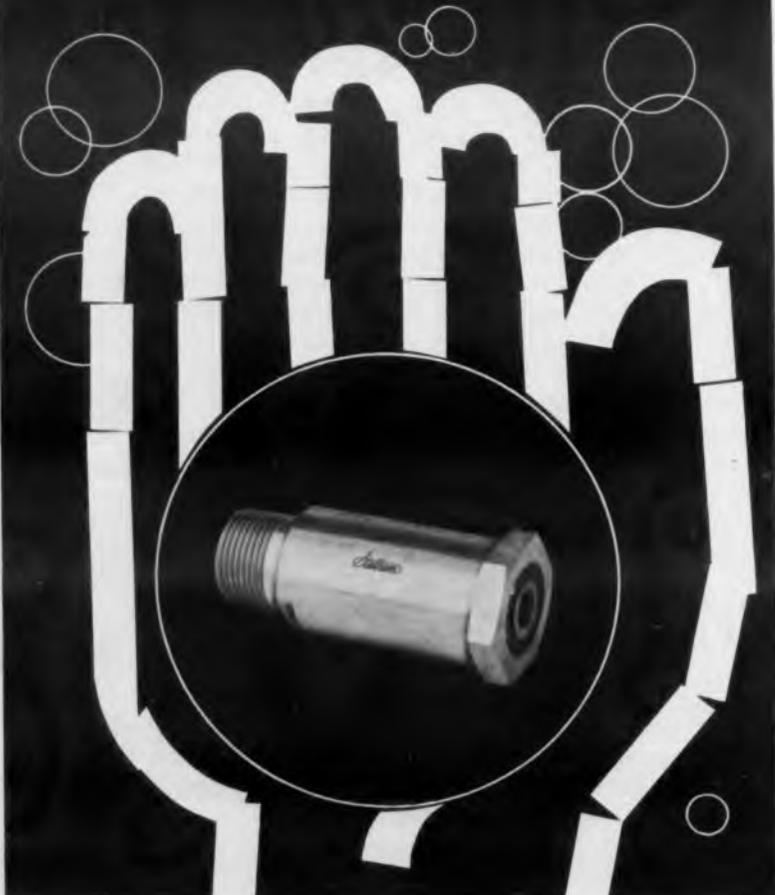
"Dimensionless" principle is described in a free 28-page booklet, "Transducers for Industrial Instrumentation."



Statham
Instruments, Inc.
12401 W. Olympic Blvd.
Los Angeles 64, Calif.
GRanite 8-0361/TWX:
West Los Angeles CAL. 6602

Check these features of the P713:

- Outstanding performance in temperature stability and long term zero drift
- Infinite resolution
- Insensitivity to vibration and shock
- Compact size
- High accuracy calibration accomplished electrically at the control room
- Ultimate in ruggedness, simplicity and reliability

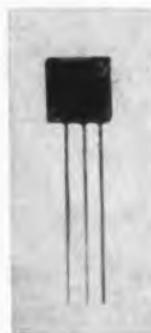


CIRCLE 105 ON READER-SERVICE CARD

NEW PRODUCTS

Trimmer Potentiometer

559



Model 356 trimming potentiometer provides resistance values from 10 ohms to 50 K in a 1/2 x 1/2 x 0.195 in. package. The unit can operate from -55 to +200 C. Circular mandrel design provides 0.086% resolution at 50 K. The trimmer can dissipate 1 w up to 50 C.

Daystrom, Inc., Dept. ED, Potentiometer Div., Archbald, Pa.

Availability: From stock.

Tachometer Indicators

553



Complete tachometer indicator systems use permanent-magnet, instrument-type, dc generators with precision indicating meters to show speed of motor rotation. Various circuit arrangements are available to provide for expanded or suppressed speed scales and automatic selection of speed scale for either direction of rotation.

Electro-Devices, Inc., Dept. ED, P.O. Box 2308, Paterson, N. J.

Transient Protection

562

The FS-101 switch is a fail-safe, solid-state device that protects sensitive components from transients. It will disconnect the power source from the device under test within 1 μ sec after safe current limit is exceeded. The device is for incoming inspection of electronic modules and transistors, for development laboratories, and for training classes.

Alpha-Tronics Corp., 1033 Engracia Ave., Torrance, Calif.

DYNATRAN WIDE RANGE DIODE TEST SET



MODEL 1808

The Dynatran Model 1808 Wide Range Diode Test Set measures the d.c. characteristics of semiconductor diodes and rectifiers... forward currents to 3 amperes... reverse voltages to 2,000 volts... reverse current from less than 1 μ ma to 3 ma...

Complete self contained instrument ideally suited for laboratory, production, quality control and incoming inspection.

Write for information about industry's most complete line of standard and custom designed instruments for semiconductor testing.

DYNATRAN

electronics corporation

178 HERRICKS ROAD
MINEOLA, NEW YORK

Pioneer 1-4141

CIRCLE 186 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 26, 1961



"DRESSES-UP" your panels, switchboards, other products.

BIG LOOK panel meters

**MODERN DESIGN
IMPROVES
END PRODUCT
APPEARANCE**

Now, General Electric's BIG LOOK panel meter styling can help improve the appearance of your switchboards, panels and other equipment. BIG LOOK styling is the result of careful planning, development and field testing. It represents more than 28 years of General Electric leadership in creative panel meter design.

Now, BIG LOOK panel meters are available in your choice of seven attractive color windows to complement the appearance of your products or equipment.

For the complete AC and DC BIG LOOK panel meter story just contact your nearby General Electric Apparatus Sales Office or distributor; or write for bulletin GEA-7034 direct to General Electric Company, Section 597-04, Schenectady, New York.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 187 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 26, 1961

Low-Cost Magnet

555



A 5-lb horseshoe magnet, rated at 2,000 gauss, can lift more than 125 lb. The magnet features a high strength-to-weight-to-cost ratio.

Edmund Scientific Co., Dept. ED, Barrington, N. J.

P&A: \$9.95; from stock.

Airborne Cooling Pack

552



New heat-transfer system, type E/HT-200-214, can dissipate 3,400 w. Intended for equipment miniaturized to the point where neither convection cooling nor fan cooling is adequate, the 25-lb system maintains the coolant (ethylene glycol and water) between 150 and 170 F. The unit operates from -55 C to +55 C and from sea level to 50,000 ft. It requires 208-v, 3-phase, 400-cps power.

Eastern Industries, Inc., Dept. ED, 100 Skiff St., Hamden 14, Conn.

Current Integrator

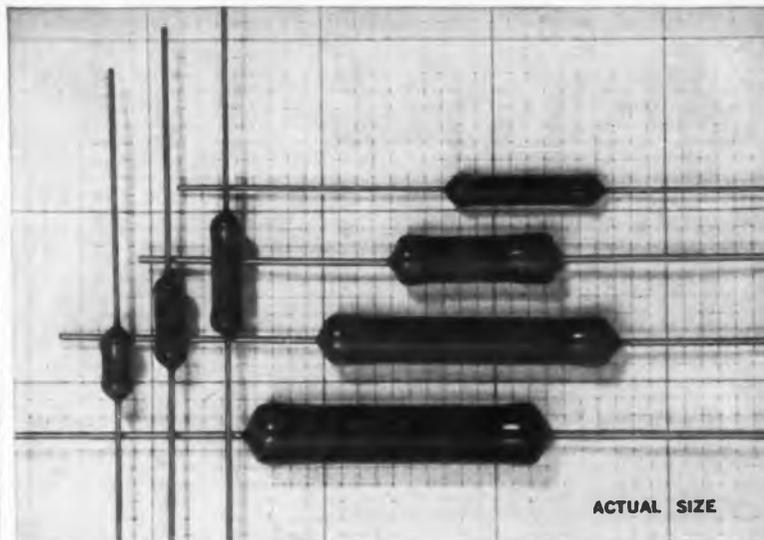
551



Model A309A current indicator and integrator displays the integral of a wide range of input currents as well as the amplitude and polarity of these currents. For current amplitude, 12 switch settings provide full-scale meter deflections from 3×10^{-8} through 1×10^{-8} amp on a 4-1/2-in. panel meter. A five-digit counter shows the current integral (charge), with a 2-1/2-in. panel meter serving for interpolation between successive least significant digits on the counter.

Elcor, Inc., Dept. ED, 1225 W. Broad St., Falls Church, Va.

Price: \$1,674 plus \$32 for cabinet.



ACTUAL SIZE

**THESE "WIRE-WOUNDS" ARE
CIRCUIT SHRINKERS** *newly*

expanded line lets AXIOHM® power resistors go into smaller circuits!

Ward Leonard AXIOHM power resistors are now available in seven sizes—down to 2 watts, up to 12.5.

They're ideal for miniaturization in printed-circuits, industrial instrumentation and automation circuitry. But they're recommended for any electrical or electronic application where the highest stability and maximum overload capacity are required.

The seven AXIOHM sizes come in a

complete range of resistance values (see table) from 0.1 to as high as 75,000 ohms. Naturally, they feature the qualities Ward Leonard has made famous in power resistors:

Vitrohm vitreous enamel; Ward Leonard's specially made ceramic core; specially selected and matched resistance wire; and strong, permanent, low-resistance, spot-welded, lead-to-end-cap junctions. o o

SIZES AND RATINGS						
Rating (in watts)	Type	Resistances (ohms)		Dimensions (inches)		
		Min.	Max.	Length*	Diam.	
2	2X	0.1	5,000	3/8	3/16	
3	3X	0.1	10,000	1/2	3/16	
4	4X	0.1	15,000	5/8	3/16	
5	5XM	0.1	20,000	15/16	3/16	
7	7X	0.1	25,000	1	3/16	
10	10XM	0.1	50,000	1 3/4	5/16	
12.5	12.5X	0.1	75,000	1 3/4	3/8	

*Less leads.

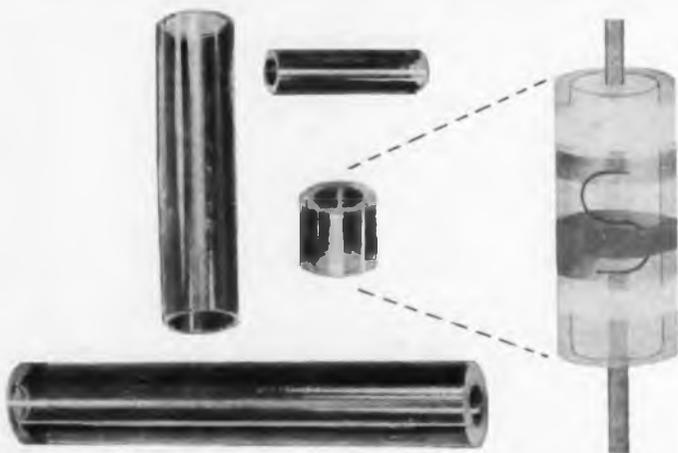
Get complete details in Supplement C to Catalog 15. Write for your copy and a list of stocking distributors today. Ward Leonard Electric Co., 77 South Street, Mount Vernon, New York. (In Canada: Ward Leonard of Canada, Ltd., Toronto.)



RESULT-ENGINEERED CONTROLS SINCE 1892

**WARD LEONARD
ELECTRIC CO.** MOUNT VERNON
NEW YORK

RESISTORS • RHEOSTATS • RELAYS • CONTROLS • DIMMERS
CIRCLE 188 ON READER-SERVICE CARD



glass for your diode packages... precision drawn to specifications

— GARNER provides tighter tolerances... improved roundness and concentricity... squarer and smoother end cuts.

Parts ultrasonically scrubbed, chemically cleaned, and rinsed in deionized water. Shipped ready for your production line.

Meeting your specifications is insured by continuous inspection, starting with raw material.

Fast dependable deliveries based on large stocks of redraw tubing... advanced production equipment, and the ability to move quickly.

Specializing in the unusual

The Garner company provides a wide variety of precision glass parts to the electronics industry. If your requirements are too precise or too unusual for conventional production techniques, Garner may well provide the solution to your problems.

T. H. GARNER CO.

Serving the semi-conductor industry since 1954

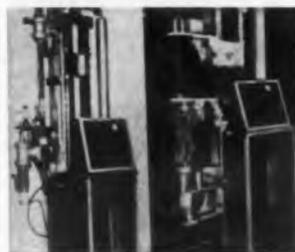
177 S. INDIAN HILL BLVD., CLAREMONT, CALIF. • NATIONAL 6-3526

CIRCLE 189 ON READER-SERVICE CARD

PRODUCTION PRODUCTS

Dual-Purpose Fixture

563



Crystal pulling and floating zone attachments used with model HCP-D dual-purpose unit can be changed from one application to the other with a minimum of time and effort. Model consists of the basic unit with traverse mechanism and controls for operation of the induction heating generator. The same basic support, programming and control unit is used in each adaptation.

Lepel High Frequency Laboratories, Inc., Dept. ED, Woodside, N.Y.

Cartridge Spindle

564



Thinner, smaller diameter wheels usable with the type 2 cartridge spindle are said to speed production and reduce kerf loss. An accessory for automatic wafering machines, the device allows 40 to 100% more slices to be cut from a 1-in. crystal, with kerf losses reduced by 28 to 47%.

Micromech Manufacturing Corp., Dept. ED, 1020 Commerce Ave., Union, N.J.

Marking Machine

565



Compound concave or convex surfaces on molded plastic parts can be imprinted with trademarks and other information at production



for the latest advances in design and performance always specify

Coaxial Connectors by

Automatic

METAL PRODUCTS CORPORATION
323 Berry St., B'klyn 11, N. Y. • EVergreen 8-6057

CIRCLE 190 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 26, 1961



UP TO 28 PERCENT increase in scale length improves meter readability.

BIG LOOK panel meters

DESIGNED FOR AT-A-GLANCE READABILITY

In designing the BIG LOOK panel meter, engineers placed particular emphasis on achieving an important balance between distinctive appearance and excellent readability.

This balance of aesthetic and functional design values makes BIG LOOK panel meters *easier to read*, relieves eye tension and stress—and reduces reading error.

Accurate, at-a-glance readability is a prime requisite for panel meters. To achieve it, G-E first eliminated the problem of shadows by designing a cover to admit light from top, sides and bottom. The color area of the window completely hides the distraction of the moving internal mechanism. This gives you exactly what you want . . . a clear uncluttered view of the scale and an accurate reading.

For the complete AC-DC BIG LOOK story just contact your nearby G-E Apparatus Sales Office or distributor; or write for bulletin GEA-7034 direct to General Electric Company, Section 597-05, Schenectady 5, New York.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 191 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 26, 1961

speeds by the model 25AE marking machine. A direct ink-marking method is used with conforming plates. The imprint can be quickly changed. Specialized inks are available.

Markem Machine Co., Dept. ED, Congress St., Keene, N.H.

Wire Bonder

566



Thermocompression wire bonder model 402 is capable of bonding a wire 0.0002 in. in diameter to a transistor stripe measuring 0.001 x 0.003 in. Developed for making mesa transistors, the bonder can be used in the production of other transistors and diodes. Precision controls allow manual positioning accuracy of 10 to 15 millionths of an inch.

Kulicke and Soffa Manufacturing Co., Inc., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

Resistor Grinder

567

Fully automatic. A completely automatic spiral grinding machine for carbon and metal film resistors, model SMA holds tolerance to $\pm 0.05\%$. It will grind diameters from 1/16 to 3/8 in., lengths from 5/16 to 2 in. It will produce a resistor with 15 ground spirals at the rate of 2,500 units per day. Machine size is 24 x 12 x 14 in. over-all. A voltage-control unit and resistance bridge are furnished.

Associated American Winding Machinery, Inc., Dept. ED, 750 St. Ann's Ave., New York 56, N.Y.

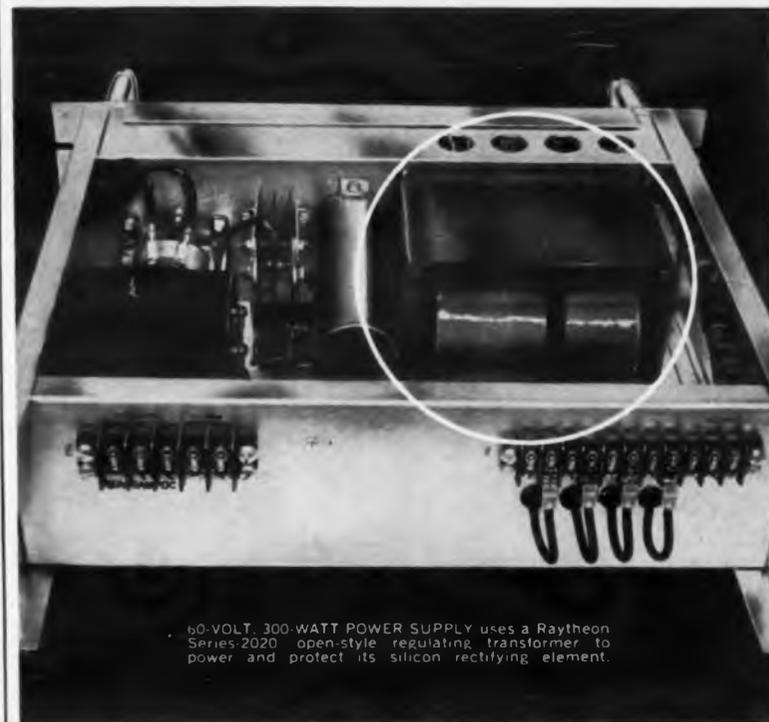
Sealing Machine

568

Tube-to-wire. Hermetic sealing of tube to wire is done without heat, soldering, or welding by this automatic machine. It may be operated by unskilled labor, with an output as high as 2,000 parts per hour. The standard model will seal terminals up to 0.10 in. OD, with larger capacities feasible. First use of the machine has been in the sealing of top-hat diodes.

Micromat Co., Dept. ED, 548 Piermont Ave., Hillsdale, N.J.

Price: About \$2,600.



60-VOLT, 300-WATT POWER SUPPLY uses a Raytheon Series-2020 open-style regulating transformer to power and protect its silicon rectifying element.

**POWER • PROTECTION • REGULATION
ALL THREE
IN ONE TRANSFORMER!**

Does your power transformer protect semiconductor rectifiers?

How do you protect the silicon and germanium rectifiers in that advanced design power supply? Do you use elaborate circuitry or—like many power supply designers—are you using a Raytheon 2020 Voltage Regulating Transformer?

These versatile units provide stabilized voltages within $\pm 1\%$ and are available in any of 2,020 standard models for solid-state and vacuum-tube rectifiers. You match your exact requirement from a full range of standard designs and ratings from 20 to 20,000 VA.

Write today for Catalog 4-265 with convenient Selection Guide and Power Supply Design Data. Raytheon Company, Commercial Apparatus & Systems Division, Keeler Avenue, South Norwalk, Connecticut.

RAYTHEON

RAYTHEON COMPANY

COMMERCIAL APPARATUS & SYSTEMS DIVISION

Raytheon voltage regulators are also available from your local Raytheon distributor
CIRCLE 192 ON READER-SERVICE CARD



test... test... test...

If you feel you *must* make your own pots to get exactly what you need, don't overlook quality control along the way! And this can be a messy business, what with special, elaborate techniques to quality-check every production stage! Oh, you'll get involved in maddening bouts with visual comparators, ratiometers, environmental testing labs — and when you've finished — and made a few hundred revisions — you might have the quality you want!

So, before you go fly a kite — consider Ace. We've been all through this before, and have what is regarded to be the finest quality control system in the industry. It enables us to keep our final costs down, by rejecting sub-standards at each stage, without waiting for the final inspection. Although it's more work this way, we can offer a higher degree of resolution and linearity at a lower price. So, for precision-at-price, see your ACErep!



Here's 0.3% linearity in a 1/2" pot; the Series 500 ACEPOT®. Single-turn, —55° to 125°C range. As with all Ace components, tested in every stage of its manufacture!

ACE ELECTRONICS ASSOCIATES, INC.
99 Dover Street, Somerville 44, Mass.
SOMerset 6-5130 TAX SMVL 181 West. Union WUX

Acepot® Acetrim® Acecot® Aceohm® *Reg. Appl. for
CIRCLE 193 ON READER-SERVICE CARD

PRODUCTION PRODUCTS

Soldering Machine

569

For fuse ends



This machine soft-solders the ends of caps to fuse links at the rate of 3,000 fuses per hour. After soldering by induction heating, fuses are sized to uniform length and tested for continuity. A circuit is provided to feed all fuses on the belt after shut-off, so that no unsoldered fuses will leave the machine.

Induction Heating Corp., Dept. ED, 181 Wythe Ave., Brooklyn 11, N.Y.

Commutator-Fusing Machine

570

Eliminates soldering operation

This machine, for fusing commutators on fractional hp motors, eliminates the soldering operation. It is said to provide better quality work with savings in time and labor. Of the models available, 2 are automatic. All sizes of motor armatures can be accommodated. As many as 550 units per day may be produced.

Joyal Products, Inc., Warner Equipment Co., Dept. ED, 250 McWhorter St., Newark 5, N.J.

Soldering Machine

571

Partially or fully automatic



Semi-automatic or completely automatic soldering may be done on a variety of components with the SD-4 model 1 soldering machine. Used with Solderforms, the machine passes parts through a heating chamber for a preset period, then cools and ejects them for flux removal. Speed and temperature are adjustable.

Kester Solder Co., Dept. ED, 4201 Wrightwood Ave., Chicago 31, Ill.



Aluminum cans for electronic applications are cast accurate, smooth and pressure tight by the unusual foundry methods of Morris Bean & Company, Yellow Springs 24, Ohio.



aluminum
ductile iron
foundries

CIRCLE 194 ON READER-SERVICE CARD
ELECTRONIC DESIGN • April 26, 1961



EASY-TO-READ panel meter scale is nearly 4 inches long.

BIG LOOK panel meters

**NOW INCLUDE
NEW
4½-INCH
DESIGN**

Designed with modern BIG LOOK styling, this new General Electric 4½-inch panel meter features a snap-on, snap-off cover for easy access to the scale face.

Improved readability, even at extreme distances, results from its expanded scale length . . . ideal for multi-scale applications on portable test instruments and panelboards. DC models of this new meter feature the same self-shielded mechanism available on 2½- and 3½-inch designs.

For the complete AC and DC BIG LOOK panel meter story just contact your nearby General Electric Apparatus Sales Office or distributor; or write for bulletin GEA-7034 direct to General Electric Company, Section 597-10, Schenectady 5, New York.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 195 ON READER-SERVICE CARD
ELECTRONIC DESIGN • April 26, 1961

For axial-lead parts
Magazine Loader

572



An accessory for the HD-3 remote spray coater, model ML-1 stacks 40 loaded trays of axial-lead components in a portable magazine, after the parts have passed through the painting station. The loader is 57-in. high and requires a floor space of 14 x 19 in.

Conforming Matrix Corp., Dept. ED, 841 New York Ave., Toledo 11, Ohio.

Automatic Tray Loader

573

For axial-lead components

Model TL-1 tray loader facilitates handling of axial-lead components. The unit automatically takes empty trays from a magazine, a hopper feeds them with straightened components, and stacks the loaded trays into another magazine. Each tray holds 20 to 50 components and each magazine holds 40 trays, thus handling 800 to 2,000 components as a complete unit.

Conforming Matrix Corp., Dept. ED, 476 Toledo Factories Bldg., Toledo 2, Ohio.

Price: \$3,995 ea.

Availability: 2 to 3 weeks.

Lead Trimmer

574

For axial-lead parts

The model II 101 interchangeably cuts, forms, or cuts and forms lead wires of axial-lead components. It has a processing rate of up to 11,000 pieces per hour, a set-up time of 30 sec, and can be run by unskilled personnel. Settings for lead length, bend length, and body size are made with micrometer-type lead screws. Right-angle bend is standard; special dies may be added.

Heller Industries, Inc., Dept. ED, 70 S. Munn Ave., East Orange, N.J.

what's so different
about these
time/delay/relays?



(and how these
AGASTAT
differences benefit
you!)

AGASTATS are electrically actuated, but are pneumatically timed, so their accuracy and reliability are unaffected by voltage variations, and recycling is instantaneous. Adjustment is simple and stepless over 1-o-n-g time ranges. With moving parts held to a minimum, the life span of a typical unit is measured in millions of cycles.

Industrial models (left) are dial-adjusted for delays of .05 sec. to 15 min. in five ranges. Needle valve models are also available, covering the full range (.15 sec. to 5 min.) in one unit. The Miniature Agastat on the right weighs as little as 15 oz. Hermetically sealed or unsealed types for MIL Spec or other demanding applications. Saves weight, saves space.

Timing accuracy and reliability are what you would expect from AGASTAT, pioneers in the development of time delay instrumentation. Single- or double-pole versions, in all standard AC and DC coil voltages. Types to provide delay on pull-in or drop-out. Want complete specs, or further information? Just write Dept. 11-44.



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ELIZABETH DIVISION • ELIZABETH, NEW JERSEY

IN CANADA: ESNA CANADA LTD., 12 GOWER ST., TORONTO 16
CIRCLE 196 ON READER-SERVICE CARD

155

off
the
shelf!



ULTRA-HIGH VACUUM SYSTEMS

Varian's new Ultra-High Vacuum System is now available as catalog-item equipment. Provides base pressures to 10^{-9} mm Hg or lower. Eliminates necessity for custom design of complex systems. A completely integrated system, ready-to-operate. Optional power and electronic accessories are available for special installation requirements. Applications: hyper-altitude simulation, vacuum evaporation, vacuum firing and brazing, etc.

Varian's revolutionary VacIon® pump is a major component. No necessity for liquid nitrogen traps or continuous mechanical pumping. VacIon pumps are all-electronic: pumpdown cycles are automatically fail-safe.

SYSTEM COMPONENTS ■ 400 Litre/second VacIon Pump ■ Ultra High Vacuum Chamber ■ Instrumentation ■ Cabinet and Controls ■ Bakeout Oven ■ Roughing Manifold for Mechanical Pump or VacSorb™ Pump

If your design or processing requirements demand integrated equipment producing extremely low pressures, Varian's Ultra-High Vacuum System may be just what you're looking for. For full technical data, write Vacuum Division.



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Ungrounded Shield Reduces Effective Cable Capacitance 749

Often it is inconvenient to locate a cathode follower stage near the high impedance circuit which drives it. But, if a shielded connecting cable is used with its shield grounded, the cable's

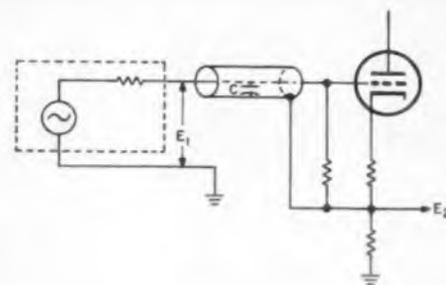


Fig. 1. Effective cable-input capacitance can be reduced by connecting shield to the cathode follower input.

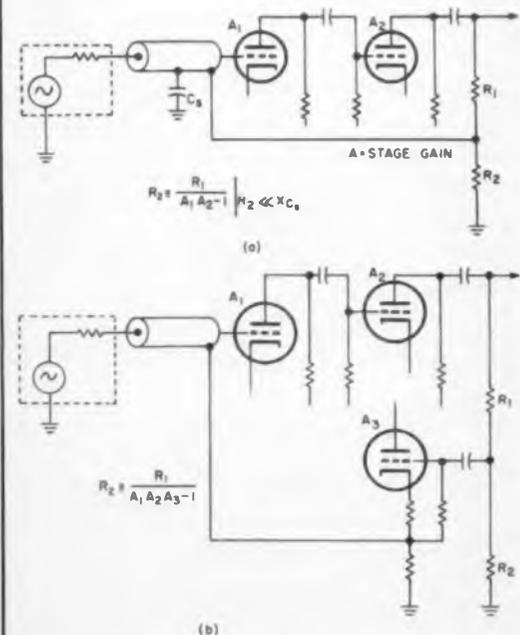


Fig. 2. Similar cable connections can be made for amplifiers of two or more stages.

input capacitance can affect the circuit frequency response.

This equivalent input capacitance, and the effect on frequency response, can be reduced by tying the cable shield to the cathode follower input, Fig. 1, instead of to ground. Very little voltage difference then exists between the inner and outer conductors. Reactive current is reduced to a small value.

If phase shift in the cathode-follower is negligible, the voltage E_1 on the inner conductor is in phase with the voltage E_2 on the shield. Reactive current I_2 is equal to the difference between these voltages divided by the capacitive reactance of the cable X_c :

$$\text{Reactive current, } I_2 = \frac{E_1 - E_2}{X_c}$$

$$\text{Equivalent input reactance, } X_e = \frac{E_1}{I_2}$$

$$\text{Cathode-follower gain, } A = \frac{E_2}{E_1}$$

These terms are substituted to yield the expression for the equivalent input capacitance, C_e .

$$\frac{E_1}{X_e} = \frac{E_1 - AE_1}{X_c} = \frac{E_1(1 - A)}{X_c}$$

$$\frac{X_c}{X_e} = \frac{C_e}{C} = \frac{E_1(1 - A)}{E_1} = 1 - A$$

$$C_e = C(1 - A)$$

Figs. 2a and 2b show similar arrangements for amplifiers of two or more states. Resistance R_2 is selected so that the voltage applied to the cable shield is equal to the voltage on the inner conductor.

H. W. McCord, *Electron Tube Div., Radio Corporation of America, Harrison, N.J.*

Short Trigger Pulse Turns On 744 SCR, Fires Flash Bulb

A photoflash lamp had to be activated by a trigger pulse whose width was only 2 μsec —too narrow to fire the lamp directly. To effectively lengthen it, the pulse was applied to the gate of a silicon controlled rectifier as shown in the figure.

With no signal at the transistor input, the rectifier does not conduct. When the trigger pulse is applied, the rectifier's gate lead falls toward ground, and the rectifier fires. It remains "on"

(continued on page 158)

BE SURE TO VOTE for all of the Ideas you consider valuable! Simply circle on the Reader-Service Card the numbers matching those next to the Idea which appears valuable to you.

SEVENTH ANNIVERSARY AWARDS

IDEAS-FOR-DESIGN

Entry Blank

To: Ideas-for-Design Editor
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New York 22, N. Y.

Idea (State the problem and then give your solution. Include sketches or photos that will help get the idea across.)

(Use separate sheet if necessary)

Here is my Idea for Design for possible publication in ELECTRONIC DESIGN. I understand that it will be eligible for the Seventh Anniversary Awards—\$20 if published, \$50 if chosen Most Valuable of Issue, \$1,000 if chosen Idea of the Year.

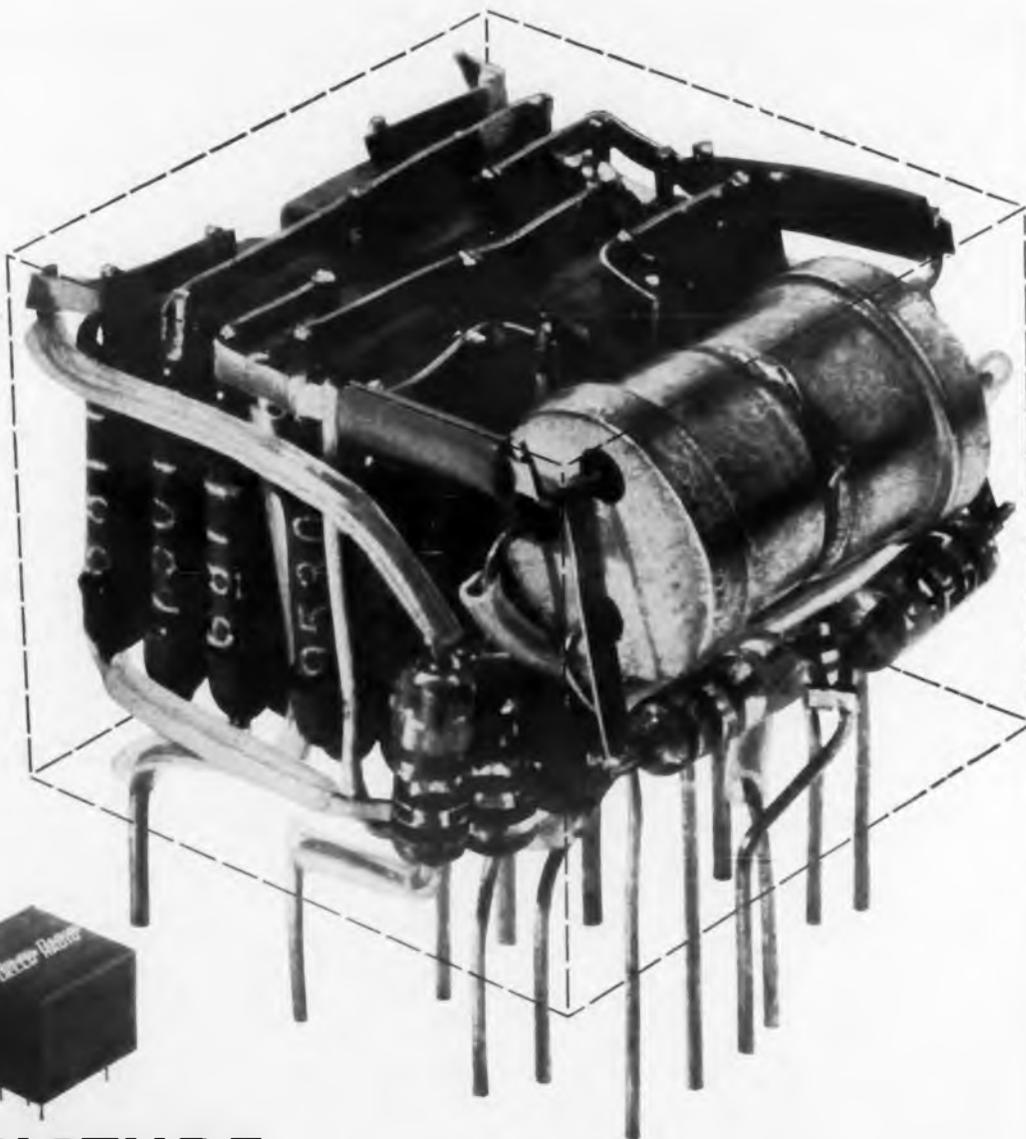
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MINIATURE BUILDING BLOCK MODULES

5 times actual size to better show
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Delco Radio's high density packaging of reliable standard components utilizes the unique three-dimensional welded wiring technique. These miniature modules are available off the shelf in 16 basic types. Or with them, Delco Radio can quickly build for you a compact, reliable digital computer for airborne guidance and control or any other military application. Vacuum encapsulated with epoxy resin, the modules perform all the standard logic functions. They meet or exceed all MIL-E-5272D (ASG) environmental requirements, and operate over a temperature range of -55°C to $+71^{\circ}\text{C}$. Too, these same reliable digital circuits are

available packaged on plug-in circuit cards. And we can also supply circuits to meet your specific needs. For complete details, just write our Sales Department. *Physicists and electronics engineers: Join Delco Radio's search for new and better products through Solid State Physics.*

PIONEERING ELECTRONIC PRODUCTS THROUGH SOLID STATE PHYSICS

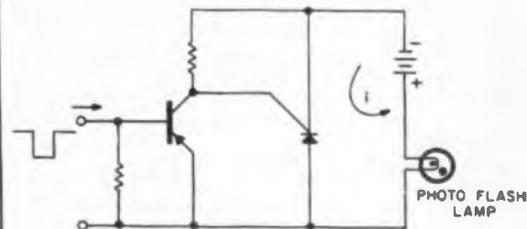
**DELCO
RADIO**
RELIABILITY

Division of General Motors • Kokomo, Indiana

CIRCLE 198 ON READER-SERVICE CARD

IDEAS FOR DESIGN

(Continued from page 157)



Narrow 2- μsec trigger pulse fires silicon controlled rectifier which stays "on" long enough to fire flash bulb.

even after the 2- μsec input pulse has been terminated.

In less than a millisecond, the photoflash bulb is fired by the current i , and its filament opens. The current i is now zero and the silicon controlled rectifier is reset for the next cycle.

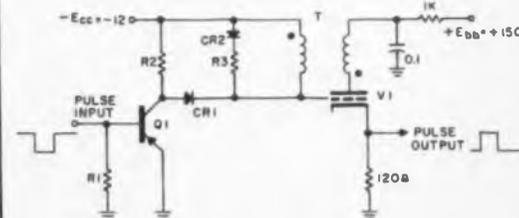
Note that when the bulb filament is opened, the battery voltage is removed from the transistor as well as from the rectifier. When a new bulb is inserted, the rectifier will remain "off" until the next trigger pulse.

Alfred W. Zinn, Engineer, Farrand Optical Co., Inc., New York, N.Y.

Transistor Trigger Pulses Fire 747 Tube & Blocking Oscillator

Trigger sources of limited voltage swing and current capabilities are often regenerated by blocking oscillators. A vacuum-tube blocking oscillator can be triggered by a transistor as shown in the circuit diagram.

Transistor Q_1 is turned on by negative pulses applied to its base. Collector voltage rises from $-E_{cc}$ to ground potential. The grid of V_1 follows through CR_1 . The tube is soon driven from cut-off into conduction and regeneration occurs through



$R_1 = 2.2\text{K}$ $CR_1 = 1\text{N}277$ $V_1 = 1/2 \text{ 12BH7}$
 $R_2 = 22\text{K}$ $CR_2 = 1\text{N}277$ $Q_1 = 2\text{N}404$
 $R_3 = 100\Omega$ $T = \text{PCA } 101-2$

Pulses applied to the transistor stage trigger the vacuum-tube blocking oscillator.

the action of T . As the grid potential of V_1 rises above ground, Q_1 is disconnected by CR_1 . R_3 and CR_2 provide a load for the backswing of T . Resistor R_4 is selected so that the collector potential of Q_1 does not exceed its rating. Resistor R_2 provides a return for CR_1 and the collector of Q_1 . Typical values for the circuit are given in the figure.

Karl Springer, Member Technical Staff, Hughes Aircraft Co., Culver City, Calif.

Standard Joints Used In Improved Dual-Channel Antenna 742

Dual-channel conical scanning antennas have two major weaknesses. One channel is invariably a low power channel, while the other has a high vswr or a high phase shift which cycles with each rotation of the scanner. Consequently, the dual transmitter or dual receiver channels found in monopulse systems, cannot be accommodated.

These difficulties may be overcome by using standard commercial components in the antenna shown in the figure. The dual-channel scanner consists of a parabolic reflector and two rotary joints. One of the rotary joints is a standard type, while the other is an "in line" or L-type joint.

The standard rotary joint, located near the focal plane of the antenna, is fed by a transmission line in an outboard fashion. The L-type rotary joint, mounted in the center of the dish, is fed near the optical axis of the parabolic system. Each joint has a radiating element in the focal plane of the dish and is mechanically joined near the radiating elements.

A drive motor and gear arrangement on the L-type joint causes both radiating elements to rotate about the optical axis of the antenna. This produces two conical scanning beams. The outboard feed line provides good mechanical stabilization for the outboard rotary joint, thus minimizing dynamic unbalance affects.

X-Band Antenna Has 35 Db Decoupling 900-Mc Bandwidth

For best decoupling the radiating elements are placed on opposite sides of the optical axis. An X-band antenna has been constructed that had a decoupling figure in excess of 35 db over a 900-mc bandwidth. The vswr of each channel was less than 1.2:1 over the same band. Because the rotary joints are conventional, the power handling capabilities of the scanner depend upon

(Continued on page 160)

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MicroSemiconductor announces the industry's smallest, most reliable diode

an entirely new concept produces the most significant advance in semiconductor devices since the invention of the transistor

MicroSemiconductor Corporation has perfected a revolutionary surface passivation concept making possible unprecedented size reduction resulting in virtually unlimited reliability in semiconductor devices. Success in stabilizing erratic surface properties of semiconductors has enabled MicroSemiconductor to eliminate more than 90% of device failure mechanisms together with elaborate, bulky packaging and failure due to device-package interaction. In MicroSemiconductor products, circuit designers and packaging engineers now have available discrete, active, micro-size components suited to the ever more critical requirements of advanced electronics.

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To fit your particular component requirements, MicroSemiconductor Corporation offers micro-miniature rectifiers and diodes in smaller-than-ever packages in a variety of configurations. These complete, encapsulated circuits and packaged assemblies combine exceptional reliability, compactness, and extremely rugged construction. Detailed specifications are available to meet individual requirements.



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ACTIVE SUBSTRATES:

Silicon diode micro-matrices — fully-passivated — designed to customer-specified geometry, size, electrical and contact requirements.

SPECIFICATIONS

IA. SILICON MICRO MINIATURE RECTIFIERS									
MSC TYPE	PEAK INVERSE VOLTAGE (v)	MAX. AVERAGE RECT. CURRENT (mA)*		MAX. REVERSE CURRENT @ PIV (μA)		MAX. TEST CURRENT (mA)		FWD. DROP @ 25°C	REV. RECOV. (NANOSEC)
		25°C	150°C	25°C	150°C	25°C	150°C		
MC020	200	200	50	.2	15	400	400		
MC040	400	200	50	.2	15	400	400		
MC060	600	200	50	.2	25	400	400		
MC080	800	200	50	.3	30	200	200		
MC100	1000	200	50	.5	50	200	200		

IB. SILICON ULTRA-FAST COMPUTER MICRO DIODES

MSC TYPE	EQUIV.	FORWARD CURRENT @ 1 VDC	BREAKDOWN VOLTAGE	CAPACITY @ 0 VDC	INVERSE CURRENT 25°C		REV. RECOV. (NANOSEC)
					μA	μA	
MC001	FD100	10	75 @ 5 μA	2	1(-50V)	100(-50V)	2
MC002	FO200	100	200 @ 100 μA	5	1(-150V)	100(-150V)	50

III. PARTIAL LISTING OF MICRO DIODES TO ESTABLISHED SPECIFICATIONS (Types for Fast Recovery)

MSC TYPE	MINIMUM SATURATION VOLTAGE @ 100 μA (VOLTS)	MINIMUM FORWARD CURRENT @ +1.0 VOLT (mA)	MAXIMUM REVERSE CURRENT (μA)		REVERSE RECOVERY CHARACTERISTICS	
			25°C	100°C	REVERSE RESISTANCE (OHMS)	MAXIMUM RECOVERY TIME (μs)
MC547 (1N643)	200	10	.025(10V) 1(100V)	5(10V) 15(100V)	200K	0.3
MC658 (1N658)	120	100	05(50V)	25(50V)*	80K	0.3
MC659 (1N659)	60	6	5(50V)	25(50V)	400K	0.3
MC663 (1N663)	100	100	5(75V)	50(75V)	200K	0.5

* @ 100°C

MSC TYPE	EQUIV.	FORWARD CURRENT @ 1 VDC	BREAKDOWN VOLTAGE @ 100 μA	CAPACITY @ 0 VDC	INVERSE CURRENT 25°C		REV. RECOV. (NANOSEC)
					μA	μA	
MC914	1N914	10	100	4	025(-20V) 5.0(-75V)	50(-20V)	4
MC916	1N916	10	100	2	025(-20V) 5.0(-75V)	50(-20V)	4

II. SILICON GENERAL PURPOSE DIODES

MSC TYPE	EQUIV.	MINIMUM SATURATION VOLTAGE @ 100 μA @ 25°C VOLTS	MINIMUM FORWARD CURRENT @ +1.0 VDC @ 25°C (mA)	MAX. INVERSE CURRENT AT MAX. DC OPERATING VOLTAGE (μA @ VOLTS)		MAXIMUM AVERAGE RECTIFIED CURRENT (mA)	
				25°C	150°C	25°C	150°C
MC459A (1N459A)	200	100	025 @ 175	5 @ 175	200	70	
MC488A (1N488A)	420	100	100 @ -380V	25 @ 380	200	70	



PHYSICAL CHARACTERISTICS

- Hermetic Seal - Stable Surface Films integrally Bonded to the Device Crystal
- Terminals 003 x .018 gold plated leads, lead length 1/2" minimum
- Marking-Type number designated by color of body and color stripes on pointed (cathode) lead
- Encapsulation - not required
- Operating Temperature Range: -65°C to +200°C
- Storage Temperature: 300°C
- Thermal Shock: -65°C to +200°C (no delay in transfer)
- Power Dissipation: 300 mw @ 25°C

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Wright of Sperry Rand offers design engineers faced with new challenges an exceptional source for meeting the most exacting demands. A wide variety of standard models plus superior engineering and production capabilities bring you assured quality.

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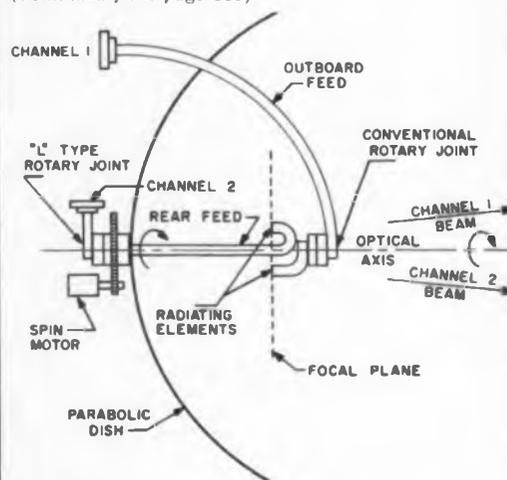
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DIVISION OF SPERRY RAND
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CIRCLE 200 ON READER-SERVICE CARD

IDEAS FOR DESIGN

(Continued from page 159)



Standard rotary and L-type rotary joints are used in dual-channel conical scanning antenna.

the design of the radiating elements. However, it is not difficult to achieve a 200-kw handling capability at X-band.

An open waveguide provides an excellent radiating element from the point of view of dish illumination, power handling and simplicity. The outboard waveguide and rotary joint produces very little shadowing if the diameter at the dish is more than 10 times the diameter of the rotary joint.

Made with conventional rotary joints, the dual channel scanner can be rotated at speeds up to 3,000 rpm. It can provide either broadband single or dual frequency operation for either transmitters or receivers, or both.

Robert B. MacAskill, Project Engineer, The Hallicrafters Co., Chicago, Ill.

Predetermined Input Level 741 Cuts Off Transistor, Sets Output

A simple circuit was required that would recognize a predetermined voltage level. An ordinary cathode-coupled binary could not be used because a positive output signal was desired during the time the chosen level existed, while at any other level the output had to be nearly zero. The circuit shown accomplishes this easily.

The reference is the negative of the level to be recognized. Thus the voltage at A becomes zero when the input and reference are equal. When these voltages are unequal, the line is either positive or negative.

A net positive voltage causes the transistor

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IMPORTANT. 'Baker Analyzed' Reagents have consistently met or exceeded the requirements of the electronics industry. Through a continuing program of establishing additional and more stringent specifications, the 'Baker Analyzed' label consistently defines a degree of purity so high that special electronic labeling is unnecessary.

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Important Guide to Electronic Chemicals

Describes J. T. Baker chemicals of exceptional purity for semi-conductors, vacuum tubes, ferrites, thermistors, etc. Also includes specification sheets that define the high standards for 'Baker Analyzed' Reagents. Write for your copy today.



J. T. Baker Chemical Co.
Phillipsburg, New Jersey

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ELECTRONIC DESIGN • April 26, 1961

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No. 3065

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In 7 "color-coded" precision line widths: 00, 0, 1, 2, 2½, 3, 4. Uses India (or regular) ink for ruling, lettering, tracing or writing with equal facility.

MODEL NO. 3065: A new model with 7 interchangeable drawing point sections, each color-coded to indicate a different line width. Best buy for the professional who requires frequent change of line widths. Each drawing point section complete with airtight refillable ink cartridge. Interchange is accomplished quickly, cleanly. Comes in handy desk top container.

MODEL NO. 3060: The regular Koh-I-Noor Rapidograph "Technical" Fountain Pen with self-contained automatic filling system, and pocket clip is a standard drafting room tool.

No. 3060

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for use with corresponding
Rapidograph Fountain Pen

Rapidoguide: High quality lettering guides with elevating metal rails, developed to fit the seven different point sizes of Rapidograph Technical Fountain Pens. Each has upper and lower case letters, numerals, and characters all on one guide.

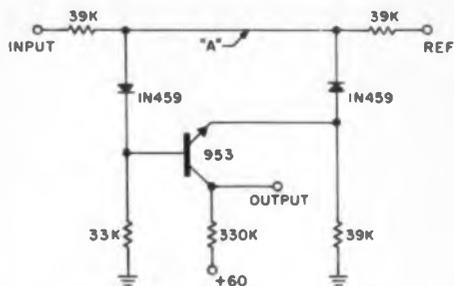
Templates: Precision engineered for use with Rapidograph Pen, Koh-I-Noor Drawing Pencil, Leads and Holders.

Write for Descriptive Literature

KOH-I-NOOR

INCORPORATED
Bloomsbury 24, New Jersey

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ELECTRONIC DESIGN • April 26, 1961



When input voltage is at the reference level, voltage at A is at zero, transistor is cut off and output rises to the supply voltage level.

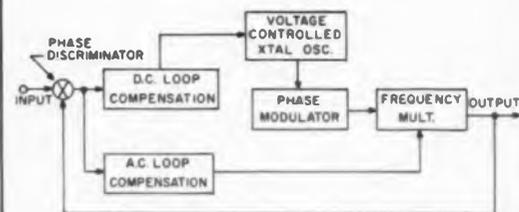
to conduct by raising the base voltage. A net negative voltage lowers the emitter voltage so that the output voltage is nearly zero. When input is at the reference level, the transistor is cut off, and the output voltage rises to the desired positive voltage level.

Lloyd E. Weberg, Senior Engineer, Military Electronics Div., Motorola, Inc., Phoenix, Ariz.

Servo Loop Frequency Modulates 746 Oscillator Outside Deviation Range

A cross-correlation servo loop using a high-stability crystal-controlled oscillator, had to be designed to allow frequency modulation outside the range of maximum oscillator deviation.

The technique employed used a "dc loop" to keep the crystal oscillator phase-locked to the incoming signal. An "ac loop" was used to phase modulate the oscillator output. The phase modulator can provide a modulation index of about 1.0 for virtually any modulating frequency. However, it does not affect the crystal oscillator stability. A frequency multiplier follows the phase modulator only when it is desired to obtain a modulation index greater than 1.0.



Ac loop phase modulates crystal frequency outside of its deviation range, but does not affect oscillator stability.

J. A. Webb, Aircraft Development Engineer
Specialist, Lockheed Aircraft Corp., Marietta,
Ga.

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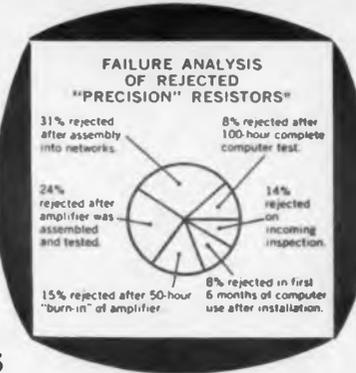
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"PRECISION/STABLE" RESISTORS

MADE BEST VALUE by

- savings from shorter lead time
- reduced equipment rejects
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— be pound wise
and penny foolish



* Documented failure analysis as recorded by conventional "Precision" Resistor, despite acceptable initial accuracy for production-model analog computer.

Accuracy is extremely important when you're specifying resistors — and the Stability of that accuracy is as important for your customers. Rejections due to lack of stability at assembly stage and at final test are intolerably costly in time, money and customer satisfaction. Julie Research has successfully developed another first — a new standard in practical resistor manufacture, "Precision Stable" wire wound resistors with 0.0025% absolute accuracy and 0.0025% stability per year. This CH-1 resistor is a miniaturized production-model of larger laboratory-type resistors. Does reliability cost more — or do failures?



Write for JRL short form catalog, showing complete line of Precision/Stable resistors, 0.0015% to 0.05% and Precision/Stable laboratory standards.



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Paper Tape Puzzler: Start It, Read It, Check It, Stop It— At 1800 Characters Per Second!

Paper tape skims through National's transistorized 360 photoelectric reader at the unprecedented speed of 15 feet per second. Starting and stopping instantaneously at this rate without tearing the tape was an electromechanical problem of the first order.

In solving it, NCR Electronics Division engineers developed a unique direct drive which has independent "bang-bang" servo motors for feed and take up reels. Conventional clutching is eliminated. A 3-foot section of tape remains slack for safe, low-inertia starts, and a photoelectric system reads and checks

data at high speed. Once the last character in the desired record is sensed, the sapphire-hard Sanfordized aluminum brake stops the tape without permitting overshoot to the next character.

To create advanced digital systems, NCR scientists and engineers probe every promising area of technology. If you can make imaginative contributions in any of the pertinent fields, it may well be to your advantage to investigate the expanding opportunities at The National Cash Register Company Electronics Division now.

CIRCLE 901 ON CAREER INQUIRY FORM

DIGITAL COMPUTER ENGINEERS— COMMERCIAL EXPANSION AT NCR CREATES OPENINGS IN LOS ANGELES FOR: COMPUTER ENGINEERS Seniors & Intermediates

Experienced graduate E.E.'s with 3 to 5 years in logic design and transistorized circuit design of digital equipment. Assignments will entail logic and circuit design of buffer storage units and digital peripheral equipment.

SENIOR PRODUCT DESIGN ENGINEER

Expanding commercial program offers excellent opportunity to apply advanced techniques in miniaturization. Applicant should have ME degree and substantial experience in packaging techniques for core-type memories and complex digital systems. Should also be capable of product design analysis and technical liaison to develop a producible product.

PRODUCT ENGINEERS Seniors & Intermediates

Assignments entail design analysis and technical liaison to develop a producible product; establishment of design requirements from a standpoint of cost, product ability and standardization; recommendation of changes for ease of manufacture. Positions require substantial knowledge of manufacturing methods, practices, shop equipment and facilities; solid background in electronic design of digital equipment; E.E. degree.

SYSTEMS ENGINEER

Experience required in formulating functional design specifications for digital computer systems (buffer storage, punch card, paper tape, magnetic tape, random access devices, system organizations, command structures). Training in logical design, data-handling methods and programming techniques desirable. Assignments entail formulating functional specifications for business computers.

SYSTEMS TEST ENGINEERS

A responsible position entailing coordination of scheduling and utilization of both unit and systems test programs. Originate and analyze test requirements; supervise testing and analysis; recommend changes in design specifications and requirements. Determine validity of test data. Requires E.E. degree plus good knowledge of mechanical engineering, instrumentation, and design engineering.

SENIOR SOLID STATE DEVICE ENGINEER

An important position entailing investigation of semiconductor devices for purpose of establishing mathematical models and design parameters used in circuit design. Requires minimum of three years' experience and some background in computer circuitry, transistors, diodes, resistors, and transient phenomena. Should be familiar with characteristics, analysis, and mathematical models of various semiconductor devices, such as alloy transistors, diffused-base transistors, mesa transistors, and diodes.

Confidential interviews at the Western Joint Computer Conference in Los Angeles, May 9-11. Please send your resume immediately to Norval E. Powell, Personnel Manager, at the address below.

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*ELECTRONIC DESIGN, APRIL 1961

YOUR CAREER

NEWS AND NOTES

Get an advanced Degree and marry a home economics major. This is the advice given to June graduates by Lon D. Barton of the employment counselling firm, Cadillac Associates, Inc., Chicago. Mr. Barton believes that within five years the BA or BS degree will become as common as a high school diploma was 35 years ago.

On marriage, Mr. Barton says he has seen more problems among young men attributable to a wife making more money in a competitive-type job. He also advises delaying marriage for a while so as not to be restrained in job mobility at the start of one's career.

• • •

Key to Persuasion

Next time you have to sell somebody on an idea, remember: spotlight the benefits.

Why? Because people don't buy an idea. They buy what an idea will do for them. They buy enjoyment, satisfaction, pleasure, solutions to problems, advantages—in short, benefits. People never accept an idea just because it is new or different. They accept it for what it will do for them.

Want your boss to install a new computer? Don't describe the operation of the special commands. Explain how the computer will eliminate errors, speed up projects, boost engineering department output.

Want a technician to be more workmanlike on your breadboards? Don't tell him how poor breadboard appearance can ruin the impression "your" project makes on your supervisors. Explain how "his" workmanship will create a good reputation for "him."

A reminder: people are most interested in profits (money, time, energy), safety, prestige and approval. Put your ideas in terms of any of these basic areas of self-interest and watch your powers of persuasion grow!

• • •

Company matching of employe gifts to colleges has been announced by Whirlpool Corp., St. Joseph, Mich. Whirlpool said it will match all gifts in cash or securities from \$10-\$1,000 a year made by its employees to colleges of their choice.

Don't forget to mail your renewal form to continue receiving **ELECTRONIC DESIGN**.

Advancement Your Goal? Use CONFIDENTIAL Action Form

ELECTRONIC DESIGN's Confidential Career Inquiry Service helps engineers "sell" themselves to employers—as confidentially and discreetly as they would do in person. The service is fast. It is the first of its kind in the electronics field and is receiving high praise from personnel managers.

To present your job qualifications immediately to companies, simply fill in the attached resume.

Study the employment opportunity ads in this section. Then circle the numbers at the bottom of the form that correspond to the numbers of the ads that interest you.

ELECTRONIC DESIGN will act as your secretary, type neat duplicates of your application and send them to all companies you select—the same day the resume is received.

The standardized form permits personnel managers to inspect your qualifications rapidly. If they are interested, they will get in touch with you.

Painstaking procedures have been set up to ensure that your application receives complete, confidential protection. We take the following precautions:

- All forms are delivered unopened to one reliable specialist at ELECTRONIC DESIGN.
- Your form is kept confidential and is processed only by this specialist.
- The "circle number" portion of the form is detached before the application is sent to an employer, so that no company will know how many numbers you have circled.
- All original applications are placed in confidential files at ELECTRONIC DESIGN, and after a reasonable lapse of time, they are destroyed.

If you are seeking a new job, act now!

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After completing, mail career form to ELECTRONIC DESIGN, 830 Third Avenue, New York, N. Y. Our Reader Service Department will forward copies to the companies you select below.

9

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Name _____ Telephone _____

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Date of Birth _____ Place of Birth _____ Citizenship _____

Position Desired _____

Educational History				
College	Dates	Degree	Major	Honors

Recent Special Training _____

Employment History				
Company	City and State	Dates	Title	Engineering Specialty

Outstanding Engineering and Administrative Experience _____

Professional Societies _____

Published Articles _____

Minimum Salary Requirements (Optional) _____

Use section below instead of Reader Service Card. Do not write personal data below this line. This section will be detached before processing.

Circle Career Inquiry numbers of companies that interest you

900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924
925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949



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"Astounding" is more like it, because we use your principle to buoy the "heart" of our precision gyroscopic instruments. Floatation eliminates frictional forces on pivots and thereby reduces drift rates. Consequently, we are able to develop precise gyros and pendulous accelerometers for missile guidance and ship navigation.

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CIRCLE 902 ON CAREER INQUIRY FORM



CAREER NEWS

Revision of the Taft-Hartley Act through adoption of a "Freedom-of-Association" bill is supported by the National Society of Professional Engineers. At present, the society says, engineering-management informal sounding-board conferences violate the labor law restrictions on nonbargaining discussions.

In fact, says Paul H. Robbins, executive director of the 54,000-member society, which has many engineers in supervisory positions, any informal management-engineer meeting violates the Taft-Hartley Act. The problem, he says, lies in the vagueness of the Taft-Hartley definition of a "labor organization."

The freedom-of-association bill, H.R. 412, which has already been proposed five times by Representative Carroll D. Kearns (R-Pa.), would distinguish engineers and professional groups from labor groups.

• • •

The Gentle Art of Criticism

There is a definite art to criticizing others. If you want your criticism to yield positive results, observe these rules:

Get all the facts. Only then are you prepared to appraise the situation fairly. The best way to get a man to give you the facts is to ask, "What happened?" It boils down the whole issue to *what* went wrong rather than *who* is to blame.

Stay calm. You'll create a climate of "let's-find-the-solution-together," in which you ally yourself with the other fellow against the common enemy—a mistake. He'll respond in kind.

Criticize in private. Test after test has proved this gets better results than criticism in public.

Commend before you criticize. That way you take the sting out of what is to follow. You provide assurances that you still have great regard for the person you are criticizing. And you subtly suggest that you recognize his error as merely a departure from the norm—his customary high-calibre performance. In short, you help him "save face."

Keep your criticism constructive. The purpose of criticism is to "teach better ways." Collaborate with the other fellow to discover "what happened" and indicate ways to prevent the mistake from happening again. That's positive, purposeful, criticism—the only kind that gets lasting results.

PAPER DEADLINES

Convention Program Chairmen have issued the following deadlines to authors wishing to have their papers considered for presentation.

May 1: Deadline for 100-200 word abstracts and 500-1,000 word summaries for the 1961 WESCON show, Aug. 22-25, San Francisco. In addition to regular IRE professional group topics, special sessions on radio astronomy and coherent and infrared electromagnetic radiation are planned. Send papers to *E. W. Herold, WESCON Northern California Office, 701 Welch Road, Palo Alto, Calif.*

May 1: Deadline for papers for 17th National Electronics Conference, to be held Oct. 9, 10, 11 at the International Amphitheatre, Chicago, Ill. Papers covering any subject in the entire range of interests of electronic engineers will be considered. Submit 12 copies of a 150-word abstract, and send two copies of either the completed paper, or a 500-700 word summary to *W. L. Frestone, Motorola, Inc., 4501 W. Augusta Blvd., Chicago 51, Ill.*

July 1: Deadline for 100-word abstract and 500-word informal summary on "Kilomegacycle Computing Systems" for presentation at the AIEE 1962 Winter General Meeting, New York, Jan. 28-Feb. 2.

The papers should be oriented toward the entire system but may deal specifically with such system aspects as:

1. Applications for kmc computing systems; replacement of several machines by one ultra-fast machine; attacks on entirely new classes of problems.
1. Components for kmc computing systems, and effects of their particular characteristics on configuration of the system.
3. Over-all systems aspects; problems of information rate mismatch with external equipment and with people; hierarchies of memories; use of complex programming technique to replace hardware (fixed wiring).
4. Methods of fabricating ultra-fast systems; problems of reliability, circuit modules and interconnections, propagation delays; description of complete computer designs.

Deadline for full text is Oct. 30 for those papers that will also appear in the transactions and Nov. 25 for papers which will only appear as conference reprints. Address papers to *C. E. Day, Assistant Secretary for Technical Papers, AIEE, 33 W. 39th St., New York 18, N.Y.* Other correspondence should be addressed to *J. H. Wright, papers chairman, Div. 12, U.S. National Bureau of Standards, Wash. 25, D.C.*

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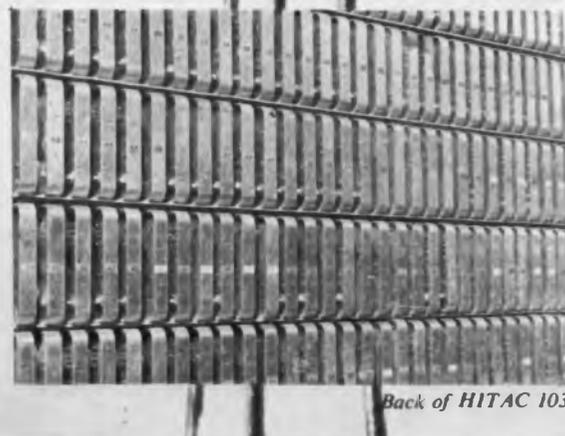
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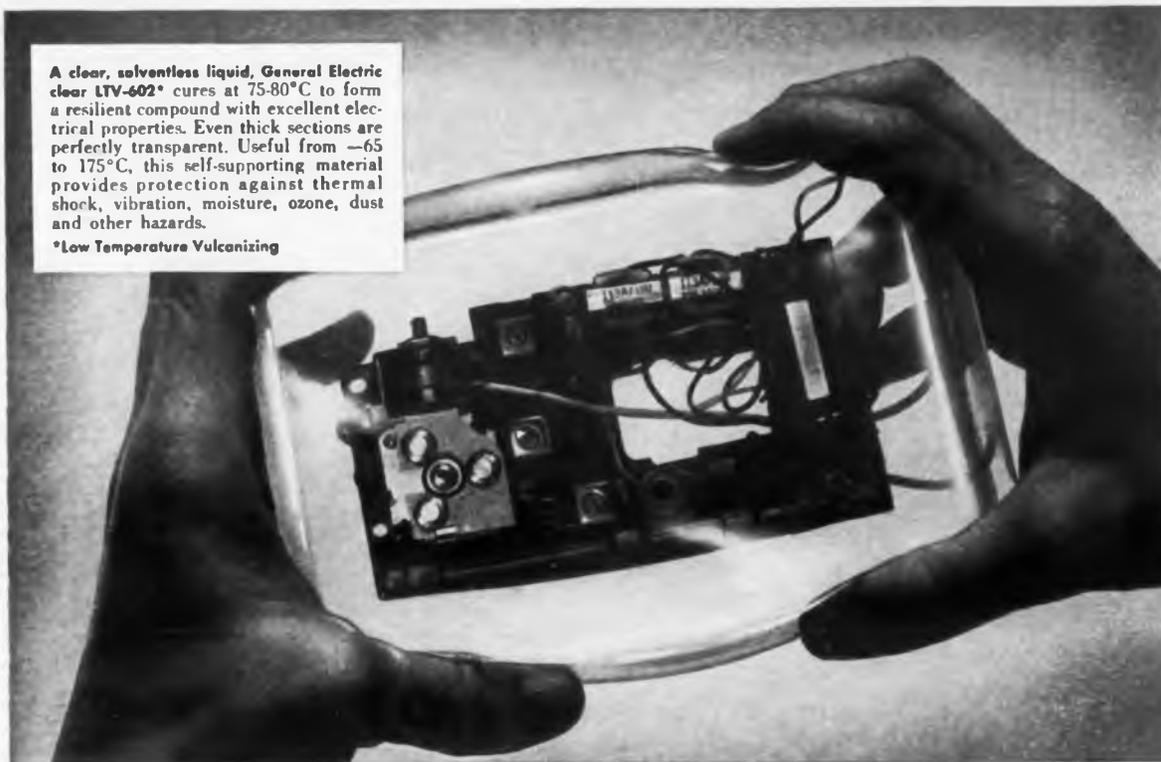
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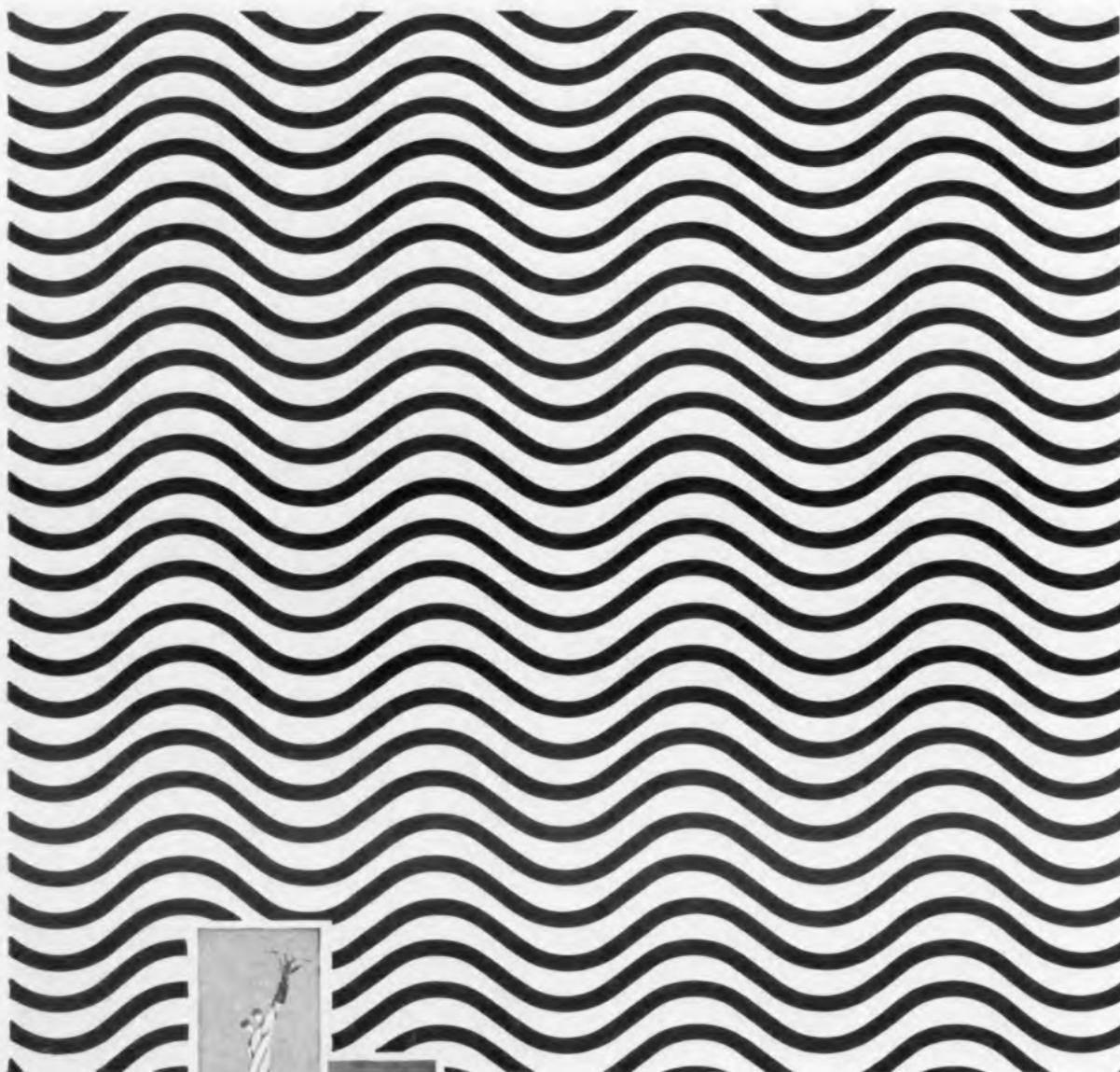


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