

**SPECIFICATIONS FOR
THE LOW LEVEL
OSCILLATOR, THE TL-61:**

WEIGHT: 5 ounces
INPUT IMPEDANCE: 50,000 ohms minimum
MODULATION SENSITIVITY: ± 10 MV for
 $\pm 7\frac{1}{2}\%$ deviation
for standard RDB channels

DRIFT: less than $\pm 0.75\%$ of design bandwidth for a period of 8 hours at normal room conditions following 30 minute warmup

LINEARITY: less than $\pm 0.5\%$ of design bandwidth

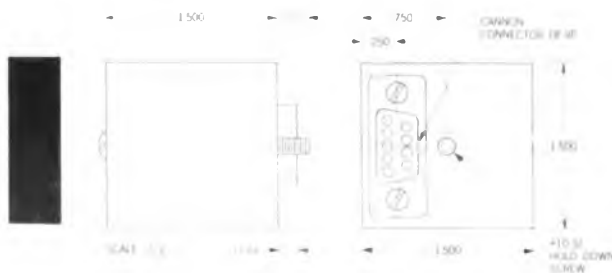
INPUT: differential or single ended. Will operate from ungrounded (floating), grounded or partially grounded input sources

COMMON MODE REJECTION: 100 db or better for DC at levels from +5 Volts to -2 Volts. 80 db or better for AC up to 2 KC at 15 Volts peak to peak

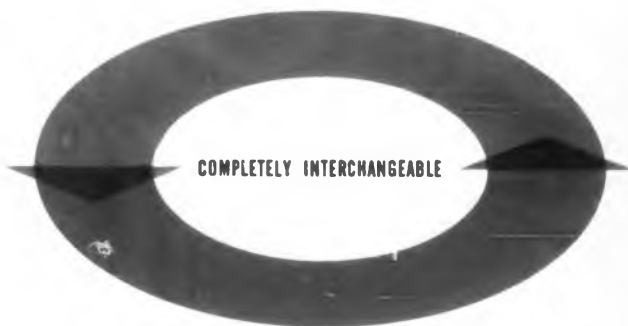
OPERATING RANGE: -55°C to $+125^{\circ}\text{C}$

Center frequency and sensitivity are stable within $\pm 3\%$ of design bandwidth for a temperature change from -20°C to $+80^{\circ}\text{C}$.

COMPLETELY ENCAPSULATED



CIRCLE 247 ON READER SERVICE CARD



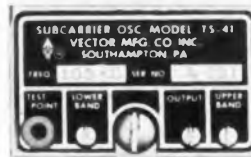
**SPECIFICATIONS FOR
THE HIGH LEVEL
OSCILLATOR, THE TL-62:**

WEIGHT: 4 ounces
INPUT IMPEDANCE: 1 megohm $\pm 20\%$
CURRENT CHARACTERISTICS: less than 0.1 microamp reverse current when the input is grounded through a 10K ohm resistor

STABILITY: From -20°C to $+80^{\circ}\text{C}$ a change in the supply voltage of $\pm 10\%$ will vary the center frequency less than $\pm 0.5\%$ of design bandwidth

DRIFT: less than $\pm 0.25\%$ of design bandwidth for a period of 8 hours at ambient temperatures after a 15 minute warm-up.

SENSITIVITY TO SOURCE IMPEDANCE: a change from zero to infinity varies the frequency less than 0.5% of design bandwidth



INTRODUCING THE FLAT-PACK TELEMETRY OSCILLATOR: THE TS-41

SPECIFICATIONS FOR THE TS-41, SUBCARRIER OSCILLATOR:

WEIGHT: 4 ounces

INPUT IMPEDANCE: 1 megohm $\pm 20\%$

CURRENT CHARACTERISTICS: less than 0.1 microamp reverse current when the input is grounded through a 10K ohm resistor

STABILITY: From -20°C to $+80^{\circ}\text{C}$ a change in the supply voltage of $\pm 10\%$ will vary the center frequency less than $\pm 0.5\%$ of design bandwidth

DRIFT: less than $\pm 0.25\%$ of design bandwidth for a period of 8 hours at ambient temperature after a 15 minute warm-up.

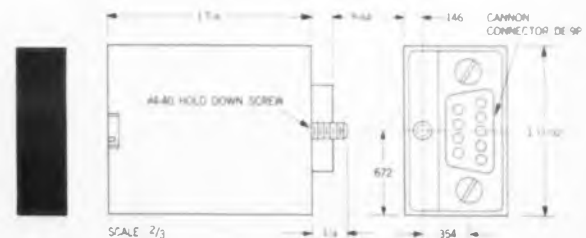
SENSITIVITY TO SOURCE IMPEDANCE: a change from zero to infinity varies the frequency less than 0.5% of design bandwidth

TEMPERATURE: Operating range from -55°C to $+125^{\circ}\text{C}$. At any information input, the output frequency is stable within $\pm 1\%$ of design bandwidth for a temperature change from 0°C to $+80^{\circ}\text{C}$.

The output frequency is stable within $\pm 2\%$ of dbw for a temperature change of -20°C to $+80^{\circ}\text{C}$.

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VECTOR

MANUFACTURING COMPANY, INCORPORATED - SOUTHAMPTON, PENNSYLVANIA
TELEMETRY SYSTEMS AND COMPONENTS

Tape-Controlled Layout Machine To Drill 48,000 Holes an Hour

An automatic layout machine, designed to drill printed-circuit boards under punched-tape numerical control at rates up to 48,000 holes an hour, will be available within a few months.

The machine, developed by Leland-Gifford Co. of Worcester, Mass., will employ a modified General Electric Mark II numerical positioning control to direct as many as four ganged drilling heads simultaneously.

The Mark II controls positioning of the work table at speeds in excess of 200 in. per min and simultaneous drilling at better than 50 hits per min per spindle. The control, coupled to electro-hydraulic machine drives, gives the printed-circuit board a fast positioning response. Positioning accuracy of ± 0.001 in. and repeatable accuracies of ± 0.0005 in. are produced by a closed-loop servo geared to the machine motions.

The machine features a built-in auto-programmer under command of the Mark II. When combined with the Leland-Gifford hole locator, the programmer enables the operator to make a punched tape directly from undimensioned drawings.

Leland-Gifford has awarded contracts for the control equipment to General Electric's Specialty Control Dept. of Waynesboro, Va.

Speech Recognizer Under Study



Automatic speech recognizer unit at Air Force Cambridge Research Laboratories, Bedford, Mass., types words spoken into microphone by researcher, Miss H. M. Willet. Behind the typing unit is the computer, which has a drum memory, and Flexowriter. Vocoder for digitizing speech is in another building; it helps the computer form "masks" representing instantaneous power in frequency bands of speech. Masks of spoken words are stored for comparison with words to be recognized. The system has several modes of operation: it can identify speakers or words, or it can be programmed to translate from language to language.

◀ CIRCLE 247, 248, 249 ON READER-SERVICE CARD



ANNOUNCING ANACONDA ML

FILM-COATED MAGNET WIRE FOR 220 C

Affords continuous high-temperature operation up to 250 C—resists heat shock up to 425 C

The exceptional heat stability of Anaconda ML Magnet Wire makes it ideal for electrical equipment operating at continuous high temperatures up to 250 C—such as high-temperature motors, relays and dry-type transformers. This same heat-resistant characteristic also makes ML Magnet Wire a valuable tool in miniaturization and in reducing the size of larger equipment.

Tremendous overload resistance (as demonstrated by thermo-plastic flow above 500 C and heat shock resistance over 400 C) makes ML Magnet Wire particularly suitable for portable tool armatures and other applications where "stall" conditions or unusual overloads may be experienced.

Essentially zero weight loss to 200 C makes it possible to use ML Magnet Wire for relays that will operate at temperatures up to 250 C with low space factor and comparatively low cost. Using ML Magnet Wire in sealed relays practically eliminates contact contamination due to "outgassing" of wire insulation.

Other ML Magnet Wire advantages: high burn-out resistance and cut-through level; dry dielectric strength over 3,000 V/Mil; excellent flexibility; good windability and scrape resistance.

ML Magnet Wire is coated with a solution of ML Polymer, a new chemical development by duPont that represents a

tremendous improvement in heat resistance over organic coatings. ML Magnet Wire can be used as a replacement for most film-coated magnet wires, except solderable types, and many glass and glass Dacron wires. Where the positive inorganic spacing of glass is required, the combination of ML film and glass serving offers outstanding properties. ML Magnet Wire's combination of high temperature rating, excellent winding characteristics and space factor permits its use in many applications which formerly required the use of much more expensive combinations of ceramics and fluorocarbons.

ML Magnet Wire is available in all sizes of round, square and rectangular. Film additions are single, heavy, triple or quadruple thicknesses, all conforming with NEMA specifications. ML also meets all requirements of Spec. MIL-W-583B for Class 180 Types H, H2, H3, and H4, and Class 200 Types K, K2, K3, and K4. For prices, technical data and applications engineering information, contact Department EFL-1-ED, Anaconda Wire and Cable Company, 25 Broadway, New York 4, New York.

ASK THE MAN FROM
ANACONDA[®]
FOR ML MAGNET WIRE

CIRCLE 23 ON READER-SERVICE CARD

A BASIC CONTROL IDEA

as simple as

$1+2=3$

DESIGN YOUR
NEXT MACHINE
OR PROCESS
CONTROL CIRCUIT
THIS EASY WAY



Start with

THE BULLETIN 780 STEP SWITCH
FOR STEP-BY-STEP
SEQUENCE CONTROL

1. INPUT SIGNALS

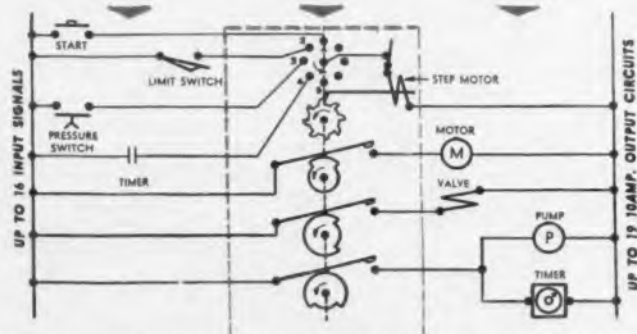
Closure of a control device, actuated upon completion of an operation, advances control to next position.

2. BULLETIN 780 STEP SWITCH

Circuits are opened or closed at each position or step according to preselected cam action.

3. PROGRAMMED SEQUENCE CONTROL

Loads are interlocked thru step switch cams without complicated relay circuitry.



Write for Bulletin 780 or call your local Representative. He's listed in Sweet's Product Design File, Section 7d/EA, or in Thomas Register.



Precision Interval Timers



Plug-in Reset Timers



Multiple Circuit Timers



Multiple Cam Timers



Predetermined Counters



Hermetically Sealed Timers

MANUFACTURERS OF THE MOST COMPLETE LINE OF INDUSTRIAL TIME-COUNTY CONTROLS AVAILABLE

EAGLE SIGNAL COMPANY • Moline, Illinois
INDUSTRIAL DIVISION

DIVISION OF THE GAMEWELL COMPANY, AN E. W. BLISS COMPANY SUBSIDIARY
CIRCLE 24 ON READER-SERVICE CARD

NEWS

AF Orders Telegraph Distortion Monitor

Three-Unit Equipment Will Permit Checking of Signals And Locating of Circuit Troubles Without Halting Traffic



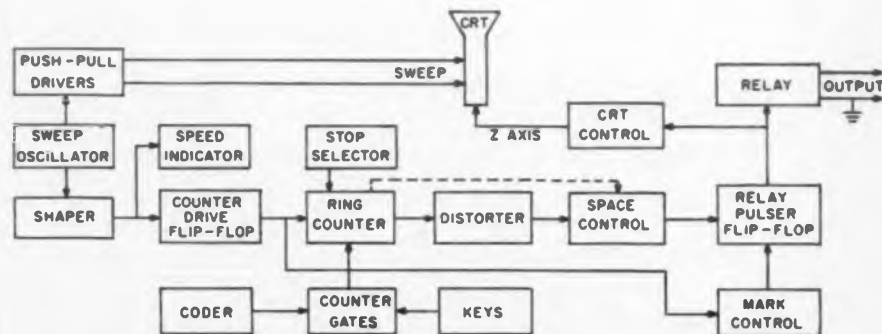
Three-unit telegraph distortion measurement system, mounted above teletype, is designed for teleprinter terminal maintenance and monitoring. Special oscilloscope, at left, analyzes signal reaching receiver, at right, which measures distortion. Unit in center is a transmitter, generating signals at various modulation rates.

AIR FORCE communication centers around the country will soon get a new telegraph distortion measurement system (TDMS), designed to monitor distortion and locate troubles in data circuits without interrupting traffic.

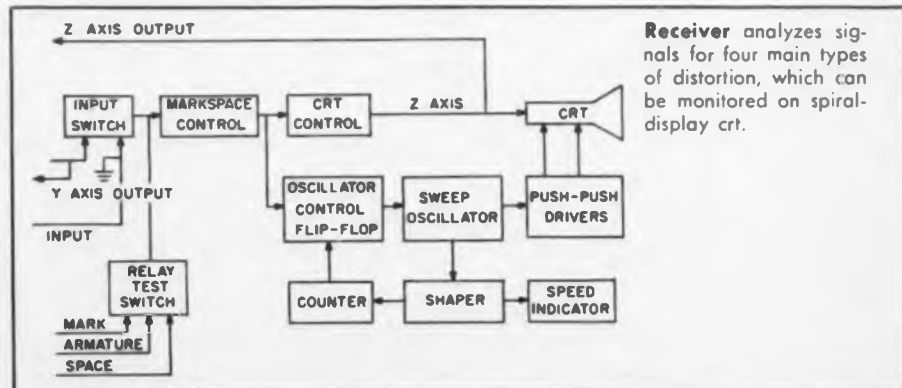
A contract in excess of \$700,000 has been let to Radiation, Inc., of Melbourne, Fla., for production of the TDMS. The company will produce a redesigned version of a basic system developed by Automatic Telephone and Electric Co., Ltd., of London.

TDMS comprises three units: a receiver, a transmitter, and an oscilloscope type of monitor.

The transmitter is primarily a telegraph test-signal generator that transmits six types of signals. Modulation rates range from 50-60, 60-80, to 140-160 bauds. Radiation, Inc., reports that up to 50 per cent short or long start-element distortion can be introduced into any test transmission. The unit measures both distortion in its



Transmitter, set up as signal generator or code transmitter, provides test signals at speeds to 160 bauds. High-stability oscillator controls speed approximating one part in 10^3 for long periods and 5 parts in 10^4 for short periods.



Receiver analyzes signals for four main types of distortion, which can be monitored on spiral-display crt.

own test signal and the distortion of signals received from local or distant external sources.

A cathode-ray-tube display on the transmitter permits selective investigation of outgoing or incoming signals. Each changeover appears as a bright dot. Because the display is on a time base, the speed of an incoming signal may be measured by adjusting the speed of a built-in, high-stability oscillator until the dots become stationary.

In the absence of distortion, all dots will be superimposed. Distortion will displace the dots to form an arc, whose length is a measurement of the distortion present.

The unit can also be used to test and adjust relays while they are operating. One position of the control switch provides for the measurement of transmit time and observation of contact bounce. Another position permits observation of neutrality.

Receiver Monitors Signals And Analyzes for Distortion

The receiving unit is the main analyzer of distortion. It monitors either in series by low-impedance current analysis or in parallel by high-impedance voltage analysis. A time-base crt display is also included in the receiver. With the spiral used, each turn is the exact length of one element of a printed signal. Bright dots show on the spiral to indicate transition of the signal from the marking to the spacing condition, or from spacing to marking. With no distortion, the dots form a straight vertical line.

The receiver reportedly analyzes for four main types of distortion: bias distortion, end distortion, characteristic distortion and fortuitous distortion.

It has limited facilities for measuring transit time and contact bounce of polar relays and similar devices.

Oscilloscope Evaluates Amplitude And Helps Check Waveform

A Tel-A-Scan oscilloscope is the third unit of the system. It is said to have high-gain synchronization and an accurate calibration system. It allows on-line evaluation of the amplitude of the incoming signal and is intended to work with the receiver to provide real-time analysis of the waveform actuating the receiver.

This unit is reported able to measure the voltage of an incoming signal with 5 per cent accuracy without interfering with the waveform presentation. Its vertical amplifier is said to be flat from dc through 7 mc, permitting a rise time display of better than 0.2 μ sec. A modified phantastron circuit gives triggered sweeps linear to 1 per cent in 10 ranges from 30 μ sec to 3 sec, according to Radiation, Inc. ■ ■ ■

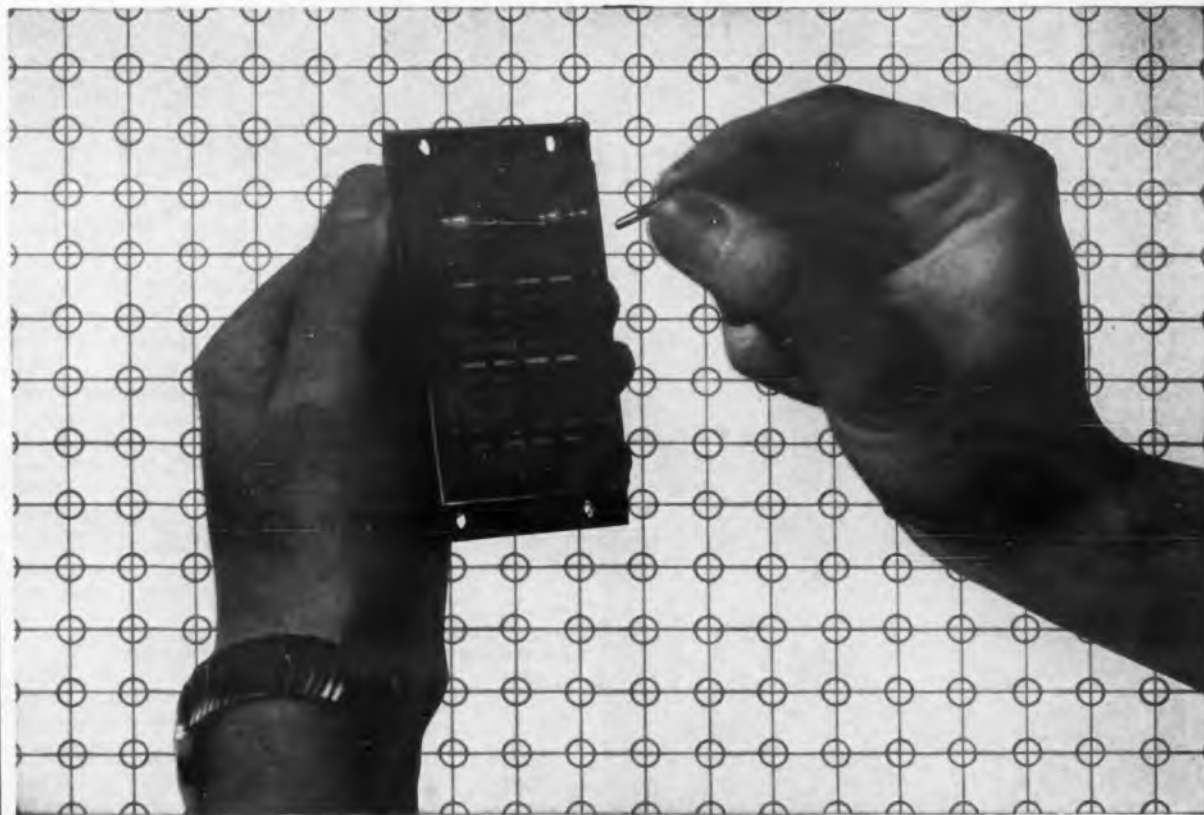
PIN POINT PROGRAMMING

AMP PINBOARDS can do a host of dry circuit switching or commoning functions . . . permit numerous matrixes in one assembly. Complicated switching functions can be accomplished by simply inserting or removing a pin.

You can use these PINBOARDS as modular building blocks for instrumentation applications, automated tooling, test equipment, data processing . . . any variety of size and grid arrangements in multiples of a basic 15 x 5 hole pattern. Contact springs can be bussed in any combination desired. And for safety, there are no exposed conducting surfaces on the rear side of the board. The conducting area of the pin is safely inside board before contact is made with mating springs.

AMP PINBOARDS are factory pre-wired to your specifications . . . with standard or special silk screen legends. Designed for simplicity . . . flexibility . . . reliability . . . with three amperes continuous current rating.

Write for complete specifications.



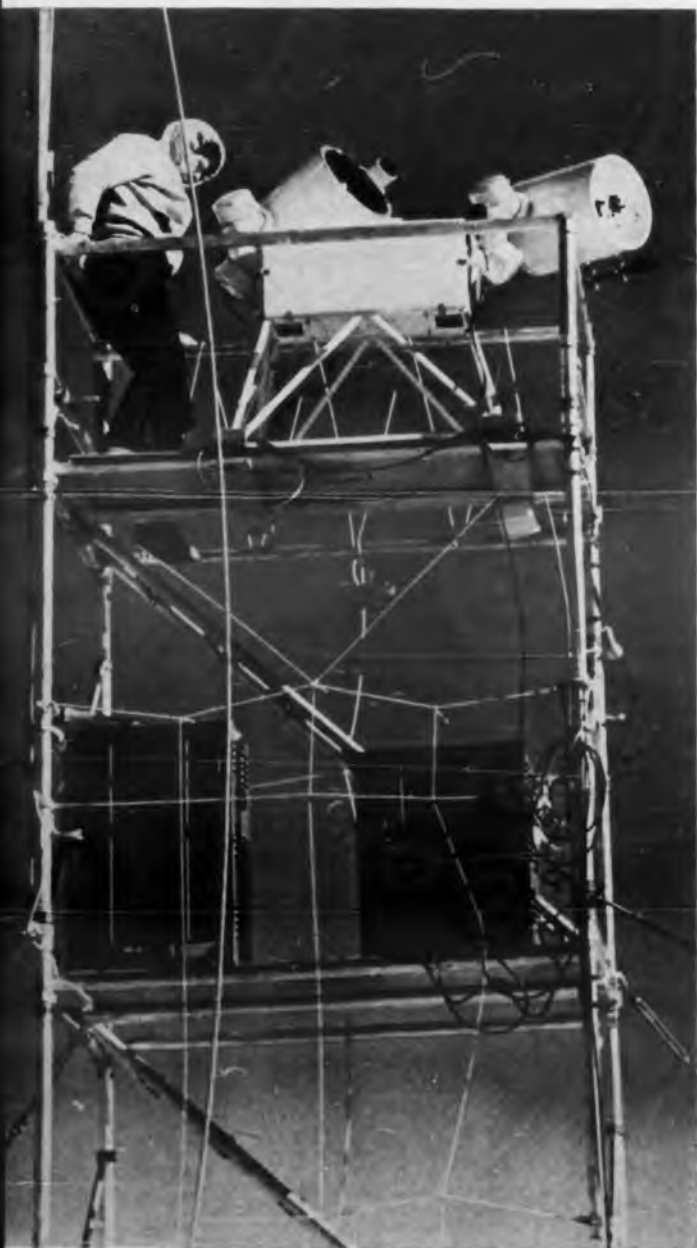
AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • West Germany

CIRCLE 25 ON READER-SERVICE CARD

Sunlight-Modulated Communication in Space Is Found Feasible



Experimental Socom transmitter is tested in desert atop 30-ft tower. Transmitter is at left, receiving unit at corner of tower. The transmitter includes a universal optical joint, between the collecting mirror and modulator, which makes direction of transmission independent of the sun's position.



Light collector for Socom is inspected by scientist of Electro Optical Systems, Inc. The company is developing space optics said to weigh less than 0.4 lb per sq ft. Mirrors can be either rigid or foldable.

| | Max. Transmission (without auxiliary polarizing) | Transmission Bands (microns) | Linear Aperture (max. practically feasible) | Information Bandwidth (cps) | Power requirements (w/cm ² per cycle of bandwidth) | Weight (including auxiliaries) |
|-------------------------------------|--|------------------------------|---|------------------------------------|---|--------------------------------|
| Kerr cell | 80% | 0.4 to 1.0 1.1 to 1.7 | 4" x 4" limited by energy requirements | 10 ⁶ | ~0.02 | <20 lb |
| Pockels cell | 70% | 0.35 to 1.1 | 4" 0.0 limited by crystal optics | 10 ⁵ | ~0.004 | <20 lb |
| Faraday cell | 80% | 0.3 to 1.2 | 2-4" 0.0 limited by energy required | 10 ⁶ | ~10 | <20 lb |
| Stress Optic | 25% | 0.3 to 1.2 | >12" x 12" no serious limitations | 10 ⁴ to 10 ⁵ | ~0.02 | <10 lb |
| Lenticulated Lens plus Grid Shutter | 85% | Full range | No serious limit | 10 ³ or better | ~0.003 | <10 lb |

Characteristics of modulators being considered for use in Socom. No one type has yet shown outstanding advantages in comparison with all the others. Research breakthroughs leading to new classes of optical modulators are needed, Electro Optical Systems says.

But Need for Better Wide-Band, Low-Loss Modulator Is Obstacle

Thomas E. Mount
West Coast Editor

MODULATION of sunlight presents a feasible means for optical communications in space, according to recently completed field tests of a scheme called Socom (Solar Communication). But lack of a really wide-band low-loss optical modulator may restrict this fundamentally promising method.

The Socom approach, developed by Electrical Optical Systems, Inc., of Pasadena, Calif., under a Wright Air Development Div. contract, functioned successfully at simulated distances of up to 10 million miles during tests in the Mojave Desert. With Socom, sunlight collected by a large Cassegrain reflector is beamed through a modulator and on to a distant receiver.

Electro-Optical is recommending to the Air Force that Socom warrants strong consideration wherever tight-beam, secure communication is required. In space vehicles Socom has an edge over rf systems when antenna size and available power are restricted and when the receiving detector is background noise-limited, according to Duane Erway, project supervisor for Socom.

Stressed plate, mechanical and Kerr-cell modulators were alternately employed in the desert tests.

Stressed Glass-Shutter Plate Used to Shift Polarization

The stressed plate modulator, newest of the three types, employs a glass shutter plate, which is deformed by tension applied by a stack of piezoelectric wafers. The resultant stress shifts the polarization of light transmitted by the plate. By interposing the shutter between two crossed polarizers, the transmitted light is thus intensity-modulated, as by a Kerr cell.

The stressed plate shutters tested had a modulation rate of up to 40 bits per sec. At this rate, the message "What hath God wrought" was transmitted in about 5 sec—longer than it would take to say it.

Simulated ranges of several million miles were achieved by interposing dark filters in the beam. Night tests were also conducted, using the full moon and a 100-w bulb as alternate light sources.

In these tests receiver and transmitter were separated by eight miles. At night the beam was

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You and others in the industry have made increasing performance demands on deposited carbon and other film resistors because metal film has been too costly for many applications.

To continue our leadership as suppliers of precision film resistors, we set an objective—to produce a metal film resistor at a price comparable to deposited carbon resistor. *We have met our objective!*

IRC has invested nearly \$2,000,000 in plant, automated equipment and engineering to achieve this new dimension in Metal Film Resistors.

A new technical production breakthrough makes it economically feasible to specify premium performance Metal Film Resistors for commercial as well as military applications.

T-O Metal Film Resistors are available . . . now! Write for Bulletin B-3. International Resistance Company, 401 North Broad Street, Philadelphia 8, Pennsylvania.



MIL-R-10509:

CHARACTERISTIC B—exceeds all requirements.

CHARACTERISTIC C—Meets or exceeds all requirements except for ± 50 ppm. T.C.

CHARACTERISTIC D—meets or exceeds all requirements.

CHARACTERISTIC G—meets or exceeds all performance requirements without hermetic sealing.

TEMPERATURE COEFFICIENT: within ± 150 ppm.

DESIGN TOLERANCE: approximately 5 times tighter than deposited carbon (MIL-R-10509, Characteristic B) resistors and 20 times tighter than carbon composition (MIL-R-11) resistors.

RESISTANCE TOLERANCE: 0.5% and 1%.

COST: Same as molded deposited carbon resistors.



Leading supplier to manufacturers of electronic equipment

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ENGINEERED COMPONENTS

for the Electronics
Industry



As close at hand as your nearest authorized Garlock distributor—
CHEMELEC® Insulators, Subminiature Tube and Transistor Sockets, Connectors.

Availability as well as reliability are two reasons why it is smart to specify Garlock when buying components.

Through a new organization of authorized distributors, Garlock now offers immediate delivery of CHEMELEC Stand-off and Feed-Thru Insulators, Subminiature Tube and Transistor Sockets, Connectors, and other standard components.

As near as the telephone, your authorized Garlock Electronic Products Distributor offers prompt, courteous service. Call him at the nearest of these locations:

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| SCHAD ELECTRONICS 499 S. Market St. San Jose, Calif. | NEW YORK ELECTRONIC CENTER INC. 160 5th Avenue New York 10, New York |
| WESCO ELECTRONICS 1715 E. Colorado Blvd. Pasadena, Calif. | HARRISON RADIO CORP. 225 Greenwich St. New York 7, New York |
| COLORADO INTER-STATE RADIO & SUPPLY CORP. 1200 Stout Street Denver, Colorado | ONTARIO LAKE ENGINEERING CO. LTD. 767 Warden Ave. Scarborough, Ontario, Canada |
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Take advantage of on-the-spot availability—specify these skillfully engineered Garlock electronic components. Reliable under the most severe conditions, they are ideal for high temperature, high voltage, high frequency service on missile guidance, fire control, tracking, and radar systems. Garlock has the technical personnel and modern facilities to produce components of all materials—Teflon† TFE and FEP, Nylon, Delrin†, C.T.F.E.†—and a range of sizes, designs, and tolerances to fit your exact needs. At your disposal, too, for development of new electronic products, Garlock maintains complete electrical, chemical and physical laboratories staffed by top-flight engineers.

Remember, too, the newest of the Garlock electronic products—Flexible Printed Circuitry of Teflon FEP. For complete details on what Garlock has to offer, write for Catalogs AD-169, 171, and 188. Garlock Electronic Products, Garlock Inc., Camden 1, New Jersey.

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NEWS

successfully received even though attenuated by filters to the point where it was invisible to night-accustomed eyes.

Some difficulty was encountered at night with scintillation and shifting of the beam by variations in atmospheric density. Mr. Erway points out that this might also interfere with space-to-earth communications over extremely narrow beams.

The receiver employed an RCA 7265 photomultiplier with an S-20 cathode. Tests indicated a receiver sensitivity of 10^{-15} w.

Still the problem of developing an optimal modulator remains unsolved. Mr. Erway hopes to boost bandwidths and data rates by refinement of existing modulation techniques, but he concedes that a research breakthrough is necessary for maximum exploitation of Socom's capabilities.

Several Modulation-Schemes Are Now Under Study

A variety of modulation schemes are under consideration. Among these are means of varying the imaging properties of the system (such as focal length) through the use of flexible lenses or plastic reflectors, pivoting mirror systems sweeping past a stop (heliographs), and diverse shutter systems.

Mechanical modulators so far are the lightest and smallest available. However, the necessity for high-information transmission rates will result in the ultimate obsolescence of mechanical modulators.

Interlens shutters, for example, have relatively long open-and-close time with a subsequent large pulse rise-and-decay time. With louvre shutters, exposure is not simultaneous. Hence from a satellite some parts of the earth would receive a differently shaped pulse than others. In addition, with louvre shutters, any light that is not axially collimated will be intercepted by the flat of the blade.

It is expected that mechanical shutters will suffer in the extreme environment of space, with crystallization and metal fatigue the principal hazards. Enclosing the shutter in an environmental chamber would eliminate the system's inherent advantages of light weight, small volume and low power.

Other advantages of mechanical systems are band pass over the entire spectrum, lack of high-voltage or high-current circuits, and the utilization of highly developed techniques for design and construction of shutter mechanisms.

Of the new techniques of modulation being investigated, one under study is the diffraction of light at ultrasonic-wave fronts in a medium

G A R L O C K

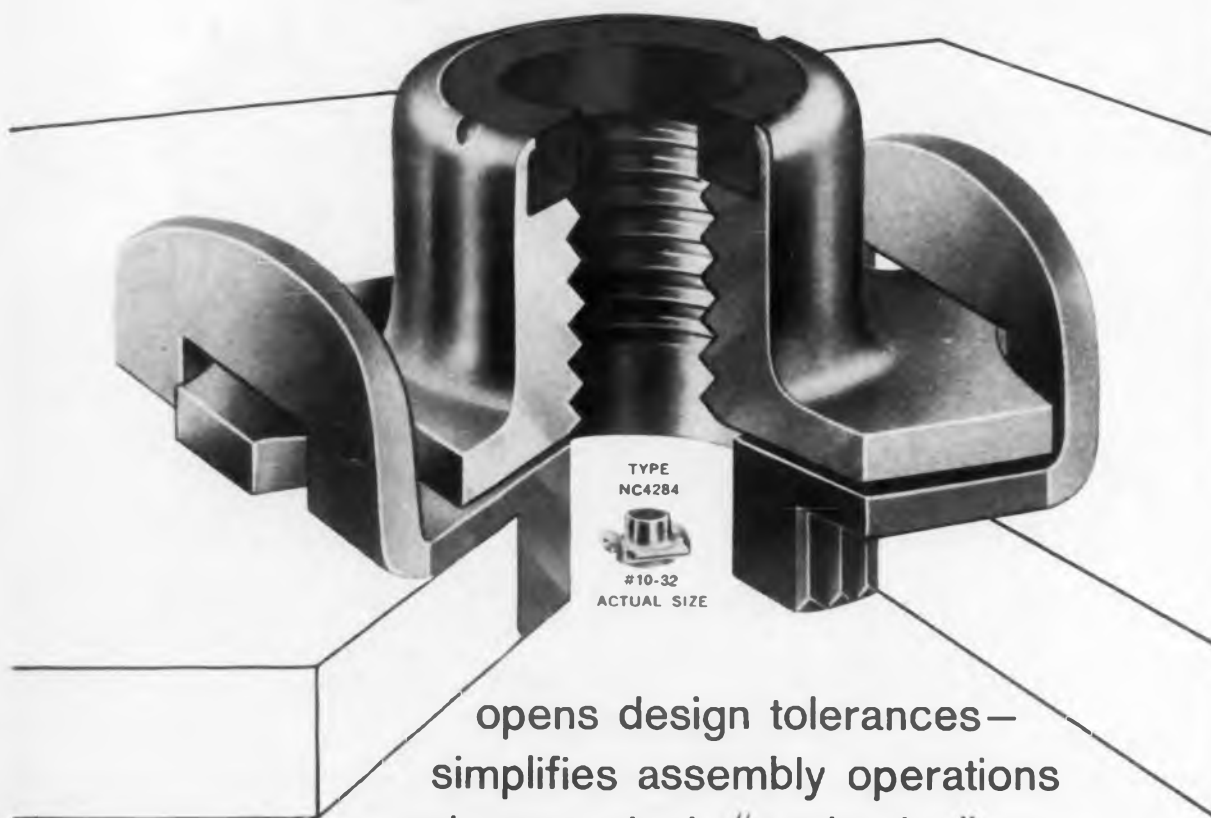
ELECTRONIC PRODUCTS

*Registered Trademark
†DuPont Trademark

‡polychlorotrifluoroethylene

CIRCLE 27 ON READER-SERVICE CARD

NEW MINIATURIZED FLOATING CLINCH NUT



opens design tolerances—
simplifies assembly operations
and cuts avionic "packaging" costs.

Standard ESNA Non-floating Clinch Nut Types

REGULAR 250°F



NC



NKC



NKCFM

MINIATURE



NCFMA
350°F



LKCFM
550°F

Here at last is a reduced-dimension clinch nut and basket assembly that provides .020" minimum radial float. Because the nut is able to compensate for minor bolt hole misalignment in the component to be attached, production line techniques can be simpler and faster.

This very lightweight type NC4284 nut offers the electromechanical engineer new design opportunities in the assembly of electronic chassis, panels, cover plates and many other "packaging" applications. Due to its very narrow basket this fastener requires less flange width for installation than any other similar-purpose press or stake-in type part.

The retaining basket has a precisely knurled shank which standard ESNA punch and dolly tools firmly embed into aluminum or mild steel sheets, for maximum security against twist-out or push-out forces. The new fastener is easily installed in a drilled or punched hole using a regular drill or arbor press.

ESNA's exclusive red nylon locking insert gives this nut a consistent locking torque through more than 50 on/off cycles. It guarantees reliable fastener performance for assemblies that demand frequent disassembly for maintenance or inspection needs. Yet the smooth grip of the nylon collar will not flake cadmium plating from the bolts. The special formula nylon accepts temperature environments from -65°F. to 350°F.

This new floating clinch nut is designed in both carbon steel and 303 FM stainless—in sizes No. 4, 6, 8, and 10. Each thread size is available in 2 shank lengths of .040" and .060" for flush installation in sheets of equivalent or greater thicknesses.

For complete specifications and installation instructions on new part NC4284 and many other lightweight avionic fasteners, write Dept. S58-457 for a copy of the new Aerospace Catalog No. 960.

ELASTIC STOP NUT CORPORATION OF AMERICA

2330 Vauxhall Road, Union, New Jersey
CIRCLE 29 ON READER-SERVICE CARD



NEWS



Experimental Socom receiver. The photomultiplier tube detected signals at simulated distances of several million miles. A complete Socom system for satellite use would weigh about 40 lb.

auxiliary equipment weighs several times more than the cell itself. (A 2-in. long Kerr cell weighs about 0.2 lb per sq in. of aperture.)

Kerr Cell's Bandwidth Large, But So Is Its Power Requirement

The Kerr cell has a large bandwidth but also a large power requirement. The average power is 0.02 w per sq in. of aperture per cps. Present cells have apertures of several square inches and require 10-to-50-kv pulses.

Pockels cells also are electro-optical devices. A voltage is applied to a basal section of uniaxial crystal. Presently used crystals are ammonium or potassium dihydrogen phosphate. The cells have about 70 per cent transmission efficiency between 0.35 to 1.1 microns.

Pockels cells are low-power devices and would seem to be useful as light modulators. However, the cells are as fragile as ice. They are readily heated by sunlight and expand and crack.

Faraday cells, which are magneto-optical devices, are unsuitable as light modulators because of their high power requirements—about 10 w per sq in. of aperture per cycle bandwidth.

Electro Optical is now developing a Kerr cell modulator with a modulation bandwidth of 5 to 10 kc. Such bandwidth, which would permit transmission of speech, is not difficult to obtain in ordinary Kerr cells, but the device under development has a maximum modulation power requirement of only 20 w.

Mr. Erway sums up the application potentials of the various modulators as follows:

- Mechanical methods, where low bandwidths are adequate and reliability is not critical
- Stressed-plate optics, where somewhat higher rates and extremely good reliability are required
- Kerr cells, ultrasonics, where maximum bandwidth (to the megacycle range) is called for. ■ ■

New Interconnection Techniques Used in Micromin Circuit Blocks

New interconnection techniques have been developed for microminiature encapsulated circuit blocks.

In soldering and unsoldering the leads connecting the modules to the circuit-board harnesses, Convair-Pomona, a division of General Dynamics Corp., has developed a reverse-eyelet design. It allows modules to be inserted or removed in seconds.

The leads from the plastic module are cut to protrude about 1/8 of an inch above the front of the board. The hot solder flows between the eyelet and the lead and between the eyelet flange and the printed-circuit pattern on the board. In effect, the eyelet flange serves both as an electrical link and as a fastener.

In the removal of a module from its harness board, a soldering iron is touched to the eyelets. The solder melts, allowing the eyelets to be slipped off the leads and the leads to be slipped out of their holes.

The technique minimizes the possibility of damage to the module from soldering heat and also facilitates visual inspection of the assembled boards. The assembly method uses an expandable jig holding two sheets of film, each printed with a standard grid. These grids form a three-dimensional envelope within which the components and connecting wires are assembled.



Solid block amplifier circuit, developed by Convair-Pomona, is being used in the infrared guidance system of a missile to boost power to the servo amplifiers.

INLAND



first with solid state 100-watt d-c amplifier

Inland's new **Model 579.35** d-c amplifier has a high power output of 100 watts when used with low impedance loads requiring direct current. And this completely transistorized amplifier is packaged in a hermetically sealed can only 2 1/2" x 3 3/4" x 2 1/2".

Designed for use with d-c torquers, in one typical application Model 579.35 provides 65 db power gain between the output of a d-c driver stage and the input terminals of a permanent magnet torque motor. This amplifier has these outstanding performance characteristics:

- The d-c output has magnitude and polarity proportional to the input signal.
- All amplifier circuits use a combination of silicon and germanium transistors (all-silicon models also available).
- Amplifier null and gain are stable and independent of temperature.

Inland also makes a complete line of rotary amplifiers for matched use with Inland's distinctive pancake shape d-c torquers.

A brochure on this new high-power amplifier is available. For your copy and complete data on Inland torquers and amplifiers, write Dept. 3-4.

TYPICAL SPECIFICATIONS

| | |
|---|--|
| Maximum Power Output, watts (6 ohm load) | 100 |
| Power Gain | 4,000,000 |
| Current Gain | 200,000 |
| Voltage Gain | 15 |
| Frequency Response | DC to 1000 cps |
| Input Impedance, ohms | 50,000 |
| Dimensions, inches | 2 1/2 wide 3 3/4 long 2 1/2 high |
| Operating Temperature Range in °C minus 50° to plus 50° | |

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Impact Studies of Telemetry Units Yielding New Design Clues

Findings Are Spurring Improved Transistor Potting Techniques And High-Acceleration Performance Ratings for Many Components

WHEN AN IMPACT vehicle strikes the moon, a sharp shift in telemetry frequency can be expected because of stresses on transistors.

Information on this and many other important factors in impact-equipment design is being gathered through studies of potted telemetry units for high-acceleration projectiles. Already some of the knowledge that has been acquired is being applied in design of the Ranger lunar-impact vehicle. Meanwhile major high-G telemetry programs in this country and Canada have been extended to encompass impact as well as acceleration effects on electronic equipment.

In the U.S. programs are being considered by Diamond Ordnance Fuze Laboratories in cooperation with the Aberdeen, Md., Proving Grounds; by the Naval Ordnance Laboratory, and by Arnold Engineering Development Center (AEDC) of Tullahoma, Tenn. In Canada similar work is pursued by the Canadian Arma-

ment Research and Development Establishment.

In addition to gathering valuable design data for impact equipment, these programs have resulted in improved transistor potting techniques and in acceleration performance ratings for many components.

Tantalum capacitors, for example, have proved unsuitable for high-acceleration or impact missions. Solid tantalums are too brittle and break under stress. The interior portions of wet tantalums shift with high acceleration.

Potting Helps Combat Failure Of Transistors Under Stress

Transistor failure is still one of the biggest problems in these studies, despite the surprise finding that great strength can be expected from them even without potting. Ordinary unpotted transistors can withstand accelerations of 20,000 to 30,000 g, according to Dan Finger, DOFL physicist. One Western Electric transistor, the

2N667, was found capable of withstanding up to 100,000 g without potting.

Since accelerations reached by ordinary impact vehicles, such as bombs, are only about 20,000 g, according to Mr. Finger, the problem with transistors may not be quite as severe as it first appeared.

Potting of transistors has proved quite effective in increasing acceleration tolerance. At first it was found that severe changes in critical parameters resulted from potting of many transistors, and in some cases just exposing the active material to the air was enough to degrade performance significantly. However, transistors have improved, and all of the projectile telemetry groups use greatly improved potting techniques.

The Canadian group uses Araldite 502 mixed with a hardener, type HN951, for potting transistors. DOFL, on the other hand, uses a composition of Shell Chemical's Epon 828 resin and DIMAPA (dimethylaminopropylamine) curing



Plastic sabot fits over projectile inside the gun and breaks away upon firing.



Plastic sabot breaks away from projectile containing telemetry circuits in test at Aberdeen Proving Grounds. Smear camera caught this scene as projectile hurtled from gun muzzle at about 7,000 ft per sec. Some of the plastic pieces are so hot they are self-luminous.

These Passed a G Test

Components for impact vehicles must withstand high-acceleration stresses or their performance deteriorates or fails. The following table shows some of the components tested by the Canadian Armament Research and Development Establishment and the acceleration force that each withstood:

| Transistors (Potted) | Acceleration (G) |
|----------------------|------------------|
| Philco 2N128 | 128,000 |
| Philco 2N345 | 102,000 |
| Philco 2N502 | 142,000 |
| Philco 2N2078 | 165,000 |
| Motorola 2N700 | 133,000 |
| Motorola 2N695 | 100,000 |
| Fairchild 2N697 | 192,000 |
| Fairchild 2N706 | 189,000 |
| GE 2N489 | 192,000 |
| Capacitors | |
| Centralab Hikap | 118,000 |
| Aerovox DM 15 | 142,000 |
| Micamold Missilemite | 181,000 |
| Vitramon | 192,000 |
| Aerovox Cerafil | 189,000 |
| Resistors | |
| Allen-Bradley TR-10 | 192,000 |
| I. R. C. | 100,000 |
| Batteries | |
| Mallory RM-400R | 192,000 |

agent. DOFL coats the transistor junction with Eastman photo lacquer before applying potting compound.

Internal Construction A Factor In Transistor Performance

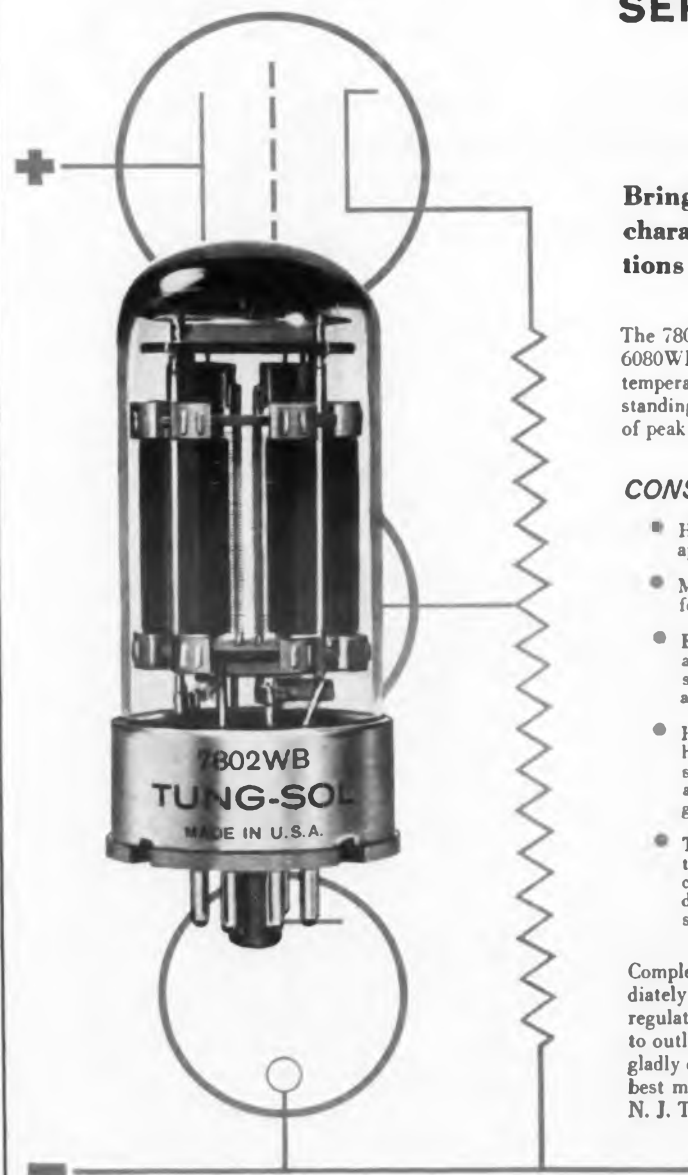
In DOFL's tests, transistors were classified according to internal construction. Some construction approaches gave very poor results at high accelerations, while others gave very promising performance.

Transistors using what DOFL terms framed wafer, or billboard, construction, for instance, gave encouraging performance. In this approach, used by three different manufacturers, a semiconductor wafer is supported over most of one surface by a nickel mask, or frame. The mask acts as a base connection, and fine wires are used for emitter and collector connections.

An RCA 2N384, using this construction, survived 78.5 per cent of tests under accelerations of 100,000 to 189,000 g. A similar Motorola 2N-655 survived 60 per cent of shots, with accelerations from 100,000 to 218,000 g. A Sylvania 2N94 survived 56.2 per cent of tests, with accelerations ranging from 100,000 to 214,000 g.

An example of the impact resistance of potted telemetry circuits was obtained when one of the Canadian projectiles struck a 2-in. aluminum pipe and split in half. One piece contained the

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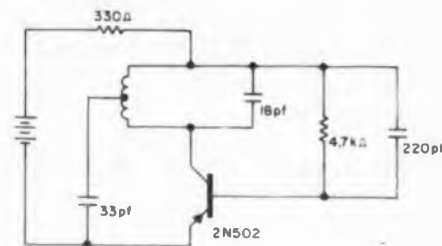


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NEWS



Colpitts-type oscillator with minimum number of components tested successfully in high-acceleration projectiles by Canadian Armament group. The tank coil serves as an rf radiator as well as the inductive element in the tuned circuit. Transmitted power, only a few more watts in this case, can be stepped up by coupling the tank coil to the metallic portion of the carrier, which then would act as the rf radiator. Actual multichannel telemetry system is an fm-fm type in which transducers modulate subcarrier oscillators, which in turn modulate the transmitter.

complete oscillator. When a battery was added to the circuit back in the laboratory, the oscillator was still in good working order.

Tests at the Arnold center indicated the frequency shift that must be expected from transistors on impact. The tests showed that some residual shift can be expected, in addition to the sharp variation at the instant of impact. Further studies of these effects are now in progress. ■ ■

Broadband Analog Divider Designed For Radars and Analog Computers

A relatively simple divider circuit, reportedly with unlimited bandwidth potential, has been designed by engineers at Sperry Gyroscope Co., Great Neck, N.Y. They say it can extend the capabilities of radar systems, analog computers and other systems requiring division of analog signals.

The company declines to describe the circuit in detail, because several proposals for its application are being reviewed by military agencies. Also, "the circuit is so simple we would give everything away if we even hinted at its nature," says one Sperry engineer.

According to the company, closed-loop monopulse radars are generally able to track only one target at a time because of the narrow bandwidth of their gain-control circuitry. If additional amplifiers for open-loop tracking are added to increase the number of signals that can be processed, the problem of making the amplifiers track while under age is multiplied.

The proposed divider, according to Sperry,

would permit a single amplifier to process all arriving signals. It would allow the system to open-loop track many aircraft or missiles simultaneously within its bandwidth, while it close-loop tracked one of the targets or the center of gravity of all of them.

The divider would be put in the if circuit of the receiver, where it would divide the azimuth and error signals by the summing signal in real time much more efficiently than does age circuitry of present monopulse radar systems, according to Sperry.

New Circuit Would End Lag in Feedback Time

Normally in monopulse radar there is a tenths-of-a-second time lag that results from running correction signals through feedback circuits; the new circuit would eliminate this delay. Data on range and on the azimuth and elevation angles would be presented instantaneously.

The circuit would be useful also, the company says, in radars more elaborate than monopulse systems, if they required dividing circuitry. A natural application here is said to be height-finding radars. Because better information on height is afforded by comparing two beams than by using data from one, an efficient height-finding radar could be developed around the idea of monopulsing between two adjacent beams of a series of beams, Sperry believes.

For analog computers, the circuit would be installed wherever two signals had to be divided. With slight modifications, it could be used as a multiplier. According to Sperry, it would reduce the need for servo-mechanistic techniques, which have extremely narrow bandwidths and which complicate division circuitry.

Problems would not have to be translated to the slow time required by the servo circuitry, and time-scaling adjustments needed to compute at frequencies higher than 3 cps would be eliminated. Sperry says bandwidths of 5 mc could be achieved easily.

Engineering models have been built to prove that the broadband analog circuit works, the company reports, but the circuits have not yet been incorporated into any equipment.

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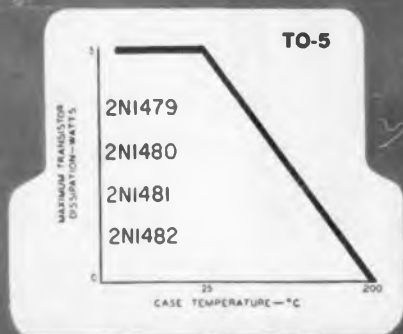
SPECIFICATIONS

| | | | | |
|---------------------|-------------------------------------|--------------|---------------|--|
| Power Rating | 1/4 W at 70°C derated to 0 at 150°C | Length | 1 1/4 ± 1/4 | |
| Max. Voltage | 300 volts | Diameter | 1/4 ± 1/4 | |
| Resistance Range | 5 to 500 K | Leads | 1" ± 1/4" | |
| Tolerance | ± 1% | Lead Spacing | A .125 ± .005 | |
| Temp. Coeff. | —200 PPM to 500 PPM | | B .156 ± .005 | |
| Environmental Char. | MIL-R-10509C Char. B | | C .200 ± .005 | |

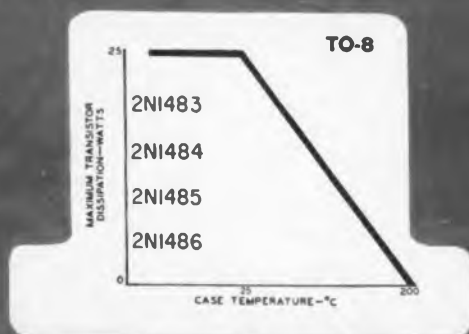
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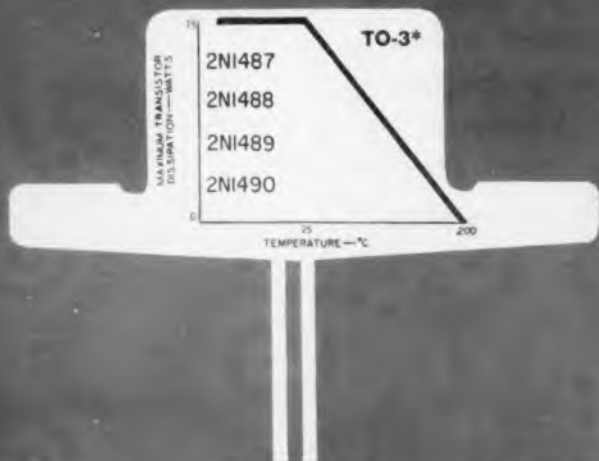
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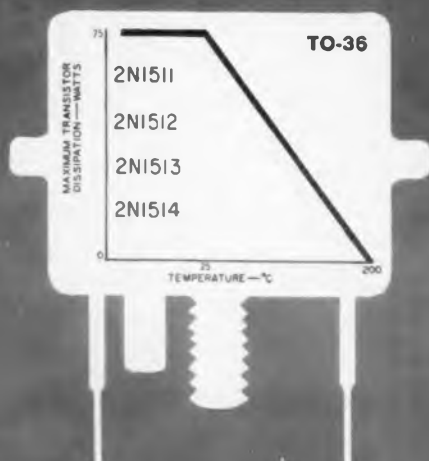
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| COLLECTOR-TO-BASE VOLTS | 60V | 100V | 60V | 100V | 60V | 100V |
| COLLECTOR-TO-EMITTER VOLTS With base open (sustaining voltage) | 40V | 55V | 40V | 55V | 40V | 55V |
| With emitter-to-base reverse biased ($V_{BE} = -1.5$ volts) | 60V | 100V | 60V | 100V | 60V | 100V |
| EMITTER-TO-BASE VOLTS | 12V | 12V | 12V | 12V | 10V | 10V |
| COLLECTOR CURRENT (Amps) | 1.5a | 1.5a | 3a | 3a | 6a | 6a |
| EMITTER CURRENT (Amps) | 1.75a | 1.75a | -3.5a | -3.5a | -8a | -8a |
| BASE CURRENT (Amps) | 1a | 1a | 1.5 | 1.5a | 3a | 3a |
| TRANSISTOR DISSIPATION (Watts) At case temperature of 25°C | 5w | 5w | 25w | 25w | 75w | 75w |
| At case temperature of 100°C | 2.86w | 2.86w | 14.1w | 14.1w | 43w | 43w |
| CASE TEMPERATURE RANGE (°C) Operating and Storage | -65 to +200°C | | | | | |

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EDITORIAL

The Specialist. Can He Be Interdisciplinary?

As you attend an annual IRE Show and Convention, you cannot help but be conscious of two opposites: on the one hand, you are overwhelmed by the advanced knowledge possessed by many experts. A moment later, however, you are struck by the limited specialization of other so-called experts. It is rare indeed to find one key man in an exhibit booth who can explain thoroughly what he is demonstrating. Even when he is a design engineer on the project, he becomes tongue tied when the black box under discussion isn't of his design.

The keynote address of the 1961 Convention Banquet was entitled, "Where Are the Uncommon Men?" An equally provocative title might have been, "Where Are the Broad Men?" We are daily reminded that we need interdisciplinary specialists to cope with the ever complex world. Biomedical electronics, for example, involves an understanding of biology, medicine, psychology, computers, communications.

Is the interdisciplinary specialist possible? The need for him is there. We frankly doubt, however, whether many of us are capable of mastering more than just a few specialties—at least not at the same time. Rather than feed our frustrations with feelings of remorse and make furtive attempts to do more than seems possible for us, we counsel instead: concentrate first on being a competent specialist; then, and only then, tackle one more field. If you are the uncommon man who can take on more, if you are a brilliant generalist as well as a multi-specialist, we salute you.

But for those of us a bit more common, we can take succor in the knowledge that frequently Nobel Prize winners are good at only one discipline. Indeed, had they spread their energies more, they might have accomplished nothing. The first U. S. Nobel Prize winner, physicist Albert Michelson, was a man who curbed his interest. There is a story that E. O. Lawrence of Cyclotron fame, and a more recent Nobel Prize winner, took renewed heart while he was a young man after visiting Michelson. At that time Michelson was the Dean of Science in this country; yet he confessed readily to Lawrence that he knew little or nothing of atomic physics. It was after this visit that Lawrence felt confident to proceed in his ignorance.

James C. Higgins

WHY









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High-Density Electronic Packaging



Design Principles

Part 1

Although semiconductor blocks and molecular devices offer considerable gains in packaging density compared to the high-density packaging technique, the more exotic schemes are still in the developmental stage. High-Density Electronic Packaging (HDEP) is a concept which permits the use of presently available components for miniaturized equipment needed now. Part 1 of this series discusses the concept of HDEP, its applications and the principles involved in the design of a typical systems package. The series will be continued to include layout and design of subassemblies, thermal and structural considerations, the resistance weld process plus tool and jig details.

Paul N. James
The Sippican Corp.
Marion, Mass.

ELECTRONIC equipment for space flight, missiles and satellites must be lightweight, highly reliable, capable of withstanding rigorous environmental shocks and able to operate for a long period without maintenance. Printed-circuit modules do not fully exploit space and weight savings because of connection spacing and supporting structure limitations. More exotic microminiaturization schemes, such as semiconductor circuits or molecular devices, are promising but are not yet available to permit construction of a complete system. To meet the present needs, High-Density Electronic Packaging (HDEP) has been developed and applied in the construction of guidance systems for military applications.

Two major features highlight the HDEP concept, invented in 1957 by Francis Associates, Marion, Mass. First, components are in close physical proximity to take advantage of their compressive strength, thereby eliminating the need for a supporting structure. Second, all-welded construction is used, reducing connection spacing, minimizing thermal-shock damage, up-

grading connection reliability and improving circuit producibility. With further development effort the Instrumentation Laboratory of Massachusetts Institute of Technology, Francis Associates and The Sippican Corp. of Marion, Mass., have refined the HDEP concept with matrix subassemblies, special connector designs, heat-transfer and encapsulation techniques and improved resistance welding methods.

A typical example of size and weight reduction achieved for an electronic systems package is the IX Series Prototype FBM digital guidance computers designed for the Polaris program. Each computer contains about 6,500 components and occupies a volume of 0.12 ft³; total weight, including structural and thermal elements, is approximately 15 lb.

The design and development of a High-Density Electronic Package is based on an analysis of the required system in terms of system logic, circuit capabilities, required reliability, expected maintenance procedures, size and weight requirements and production costs. Once these basic ground rules have been established, the system



Fig. 1. Various stages of assembly for a logic stick designed for the Polaris computer.

is designed, using the following principles:

1. Component layout via the "cordwood" scheme.
2. Fabrication of welded wire matrices.
3. Design of specialized connectors.
4. Encapsulation of all components and back-of-panel wiring.
5. Mathematically predictable heat removal techniques.
6. Compressive structural methods.

The package design that evolves from the application of these principles normally consists of two electronic subassemblies (circuit modules and wiring modules), an integrated structural-thermal assembly and the necessary connectors and cabling.

Component Stacking: The method employed in the construction of circuit modules is termed the "cordwood" technique, in that components are stacked with their bodies in close physical proximity and their leads parallel. Components that vary in size or shape are arranged to accommodate the least possible space, taking into account thermal and electrical characteristics. High-power dissipating components receive special consideration in the component layout.

Matrix Wiring: The matrix wiring technique, developed by The Sippican Corp. for the Polaris computer logic sticks, is used in the majority of HDEP designs. It is employed with both of the modular subassemblies of a package, circuit modules and wiring modules. Circuit module matrices consist of two layers of wires at right angles to each other, separated by a thin plastic film, such as Mylar or Cronaflex. Welds are made through pre-punched holes in the films to make connections between the perpendicular matrix wires or from a matrix wire to a component lead. The films, as displayed in Figs. 2 and 3, are completely coded to show the weld points, component leads and matrix wire materials. The materials in most common use today are 0.015-

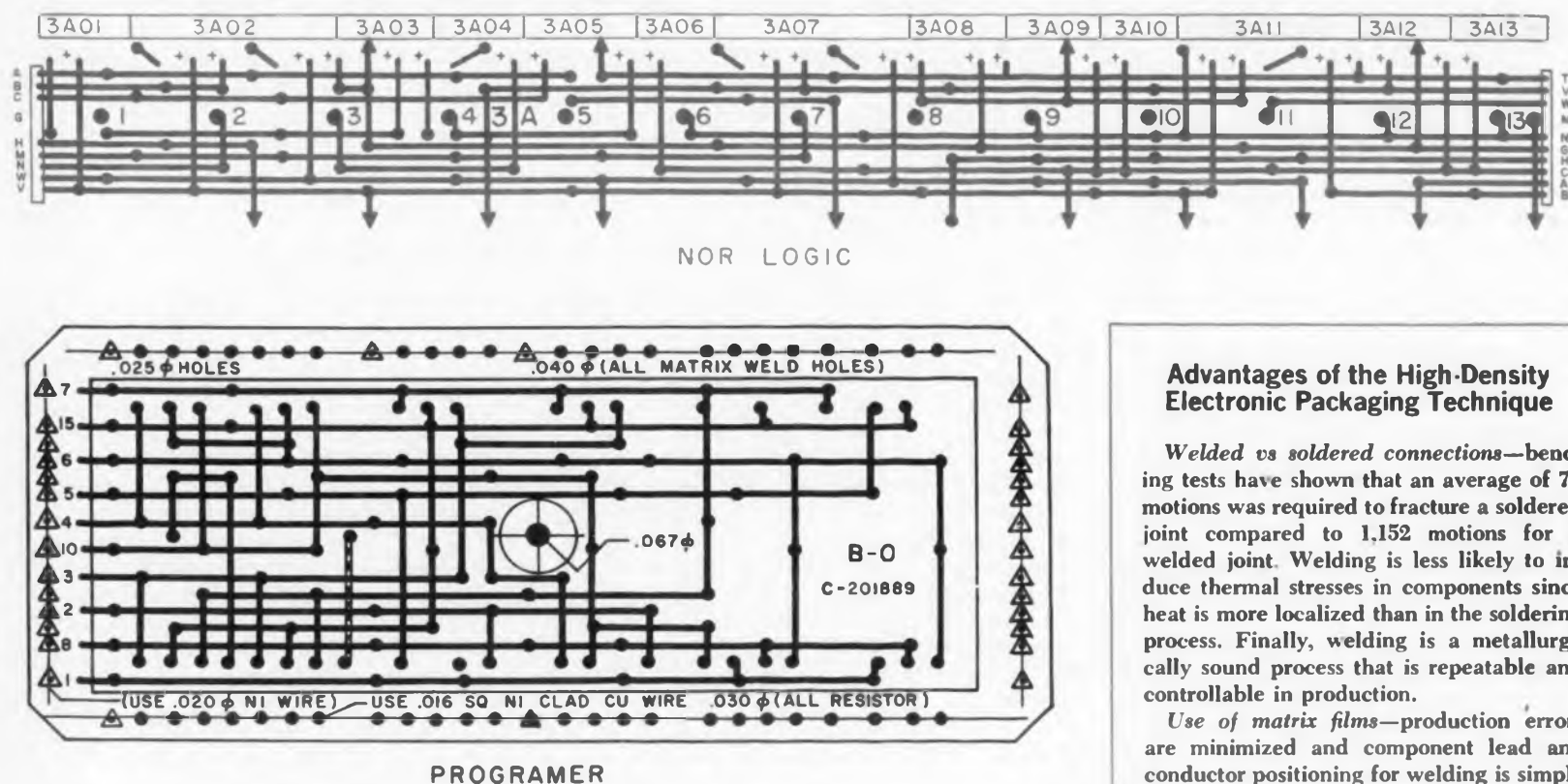


Fig. 2. Several circuit module matrix films.

or 0.020-in. diam nickel or copper-nickel alloy wire and 0.016- x 0.016-in. square nickel-clad copper wire.

Matrix wiring is used rather than the more common point-to-point nickel ribbon connections for several reasons. First, the matrix is a testable subassembly, somewhat similar to an etched circuit board, since the circuit is welded together on the film and only needs correct placement of components to complete the assembly.

Second, the large number of crossovers provides ease of engineering layout and often allows complicated wiring patterns to be laid out in one matrix rather than in two or three point-to-point layers. This feature is desirable not only to reduce electrical testing but also because all the matrix and component welds are available during final test and are not covered by a layer of insulating film.

A third advantage of the matrix technique is the ease with which design constraints may be established to speed the layout process. A fourth advantage is the ease with which different conductor materials may be used within one assembly to insure the compatibility of materials to be welded.

The matrix scheme used in the circuit modules

is also the basis of the wiring module matrix, Fig. 3. In this case all the electrical connections are made between pins in the wiring module rather than between components or components and output pins. Because of the large number of pins involved—it may be as high as 3,600—multiple layers of matrices must be used. As many as 25 layers have been used to interconnect all the pins in the Polaris wiring module.

Connectors: Since the presently available multipin connectors are an order of magnitude less reliable than the standard permanent connection techniques, such as soldering, welding or crimping, other approaches have been selected to solve the separable connector problem. Two techniques are available today.

The first technique to be developed was the weldable tube and wire scheme used in the Polaris project. This design allows between five and 10 disconnects for each circuit module in the life of the machine. Like the split wire-wrap terminal, to be described, each connection is made individually and therefore may possess the reliability normally associated with permanent crimping and welding techniques.

The second technique, the split wire-wrap terminal design, was developed by Sippican in re-

Advantages of the High-Density Electronic Packaging Technique

Welded vs soldered connections—bending tests have shown that an average of 70 motions was required to fracture a soldered joint compared to 1,152 motions for a welded joint. Welding is less likely to induce thermal stresses in components since heat is more localized than in the soldering process. Finally, welding is a metallurgically sound process that is repeatable and controllable in production.

Use of matrix films—production errors are minimized and component lead and conductor positioning for welding is simplified by means of transparent film sheets bearing the wiring path layout. There is also less restriction of component placement since crossovers and connections can be arranged as desired.

Components—presently available parts can be used now and thin-film or solid-state devices can be included when they become available.

Thermal and structural factors—the HDEP concept contributes to the design of a package rather than making demands upon it. Advantage is taken of the compressive strength of encapsulating compounds subjected to preloading and postloading techniques. Thermal control is achieved by the use of mathematically predictable design configurations.

Environmental resistance—totally encapsulated modular subassemblies with compressive structure members offer high resistance to shock and vibration. A 120-module structure was successfully tested through a range of 0.5 to 3,000 cps at an input force level of 30 g on each of three axes. Shock tests were made in each of the three axes up to 50 g with a time duration of 11 msec half-sine and in one axis up to 100 g for 9-msec duration.



response to the need for a connection method possessing the reliability of the tube and wire design but allowing 25 to 50 disconnections within the life of the unit. This terminal is a variation of the original Bell Telephone Laboratories' wire-wrap terminal, developed to replace soldered terminals in Bell's central-office equipment. Because the split terminal uses the wrapping wire only as a means of binding the two half terminals—that is, the solid copper wire is cut off and does not lead to another terminal—the main objection to the original technique in military equipment is eliminated. In this design, fatigue and breakage of the solid wire is not a problem.

These terminals have recently passed tests of 30-g vibration with no detectable difficulties. The units were also subjected to 100-g shock in three axes without any physical damage. They have also been subjected to a full range of standard military environmental tests, including humidity and high and low temperature, after one wrap and after 20 rewaps on each terminal.

Encapsulation: In the HDEP technique, all circuit and wiring modules are encapsulated after welding, regardless of whether they contain components or merely interconnection wiring. This approach offers a considerable increase in environmental resistance that offsets the "throw-away" cost of a defective module. It should be emphasized that environmental resistance includes the ability to withstand a considerable amount of human attack as well as the ability to meet the more standard military specifications. However, circuit module design does not prohibit the fabrication of small, highly reliable modules that have their expensive components, such as transistors and diodes, outside of the potting compound if the environment will allow it. An assembly of a typical circuit module is shown in Fig. 4.

The ideal size and cost of encapsulated circuit modules is a subject of considerable debate at present. Experience has shown that a range of between \$100 and \$1,000 is not unreasonable for military equipment. Factors to be considered in determining the cost per module include:

1. Type of system logic.
2. Required system reliability.
3. Feasible component and circuit reliability.
4. Number of different modules in a system.
5. Total number of modules in a system.
6. Amount of system or circuit logic in a module.

7. Environmental extremes the system must withstand.

8. Individual component costs within the module.

9. Cost of system down-time.

10. Quality of field repair facilities and personnel.

11. System size and weight requirements.

12. Number of terminals in the system.

Although the technique of encapsulating the intermodule cabling is relatively new, it is valid and necessary, since miniature wire used to cable most airborne and satellite equipment is as vulnerable to damage or failure as most electronic components. Therefore the wire-wrap terminal design and structural designs have assumed the use of completely encapsulated intermodule wiring as well as encapsulated modules. Connections to external assemblies are made through removable cables connected to the wiring modules with wire-wrap terminals or by use of the most reliable military connectors available today. Whenever possible the use of redundant contacts is recommended when connectors are used to help overcome the lack of reliability of these devices.

The types of encapsulating compounds currently in use range in specific gravity from 0.2 to 0.33 for foaming epoxys through 0.7 to 1.0 for microballoon-filled compounds, and up to 1.5 to 2.5 for oxide-filled compounds designed for high thermal conductivity. The choice of a specific compound is determined by the required viscosity, weight and thermal conductivity, as well as such physical factors as compressive modulus and creep. With the exception of the foaming types, all the compounds are vacuum-encapsulated in sealed molds to prevent voids.

Structural Design: The High Density Electronic Packaging approach to the structural design of system assemblies makes use of the compressive strength of encapsulated electronic components. In many current designs individual circuit modules are locked up into centrally supported, post-loaded beams held in compression by means of tension bolts through the center of the modules. This technique provides a considerable saving in the volume and weight assigned to primary fasteners in an assembly, while providing the necessary pressures to allow efficient heat transfer to conductive foils inserted between the modules.

It should be noted that the structural and thermal transfer surfaces of a circuit module are perpendicular to the connector and test-point planes. The use of this rather simple principle increases the flexibility of the heat-removal design, since the module interconnections and the heat-transfer structure do not compete for the same space.

The basic box structure that ties together the cold plates, circuit module beam supports and

the wiring module also makes use of the post-stressed concept in its assembly. All the structural pieces of the assembly are fastened to the side frames and mounting feet by means of long bolts that hold the sides of the assembly in compression. The theory underlying this method of assembly has been published in recent literature.¹

Basically the idea is to balance the compressive and tensile stresses in a structure, so that external loads change the relative proportions of compressive and tensile stress but cause very little deflection until one of these is canceled. The fatigue strength is also increased by this technique. A structure designed according to this principle will have a minimum of elements that require stiffness, the most difficult quality to achieve within a limited space and weight requirement.

The use of this concept in electronic package structures requires a close control of tolerances and careful design of the encapsulated wiring module to allow for the inevitable tolerance build-up and the effects of thermal expansion and contraction. Direct casting of the circuit modules to tolerances of ± 0.002 in. has been proved feasible in production lots.

Thermal Design: A major premise in thermal design concerns the use of conductive heat-transfer techniques to carry the heat generated by the electronic components to a heat sink or to a compact heat exchanger. A primary advantage of this approach is the reliability of both conductive heat transfer and compact heat-exchanger calculations and the ability inherent in the design approach to avoid dangerous hot spots in the equipment.

Two methods of conductive heat transfer within the circuit module are used: highly filled epoxy potting compounds and aluminum conductive plates. The choice between these methods is dependent upon a number of factors. If one class of components has a decidedly lower maximum temperature than the others (often true when germanium transistors are used), an aluminum conductive path from the transistors to the final heat sink is desirable. This method may also be indicated if one component dissipates considerably more power than its neighbors. On the other hand, a conductive potting compound will tend to remove heat from all the components more uniformly than a metal conductor tied to a few selected components.

Conduction of heat from the surface of the circuit modules to the final heat sink or heat exchanger is usually obtained by means of aluminum foils clamped between each module of the post-loaded assemblies. These foils carry the heat to cold plates between the rows of circuit modules if a forced air or liquid-cooling technique is

1. *Machine Design*, Sept. 16, 1960, pp 173-174.

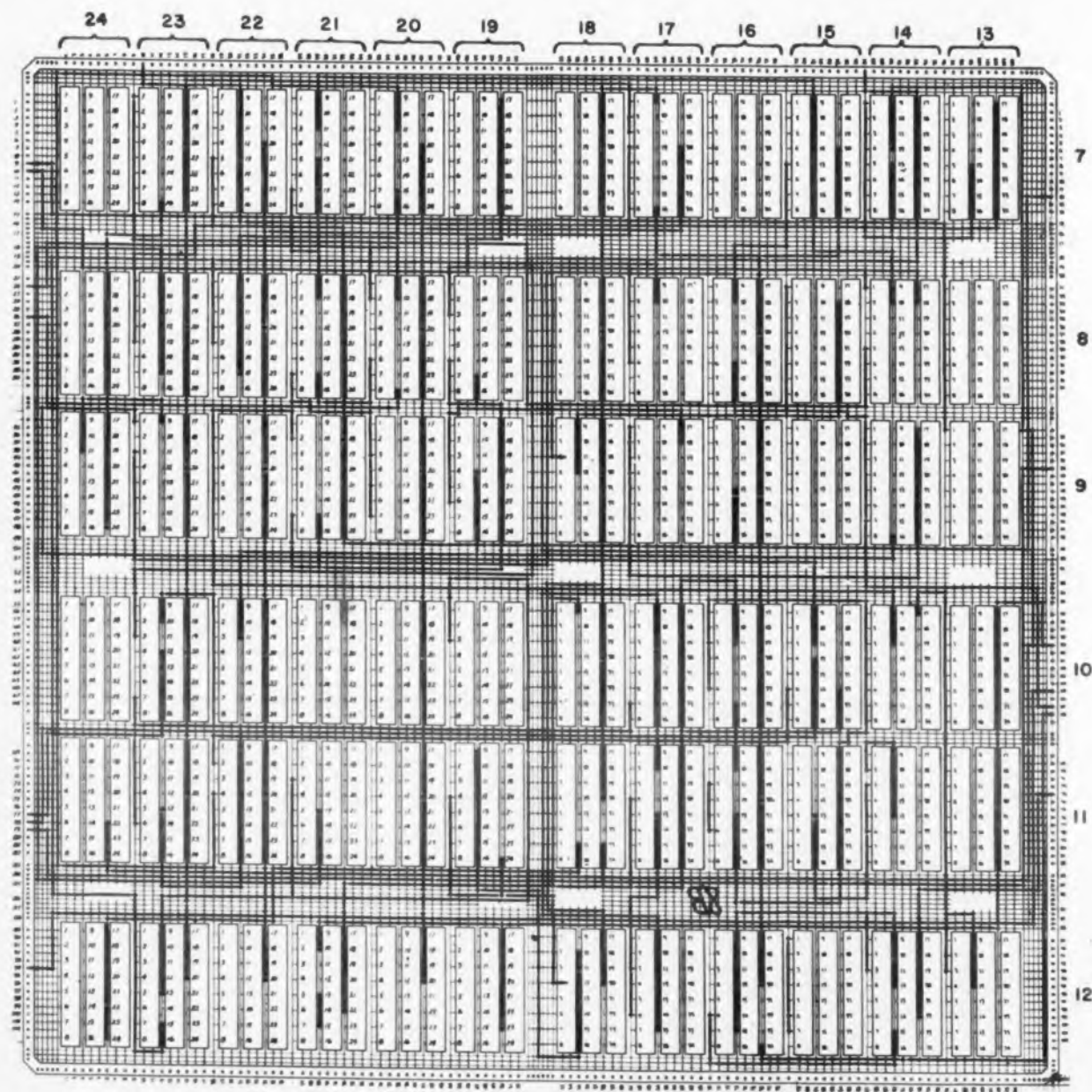
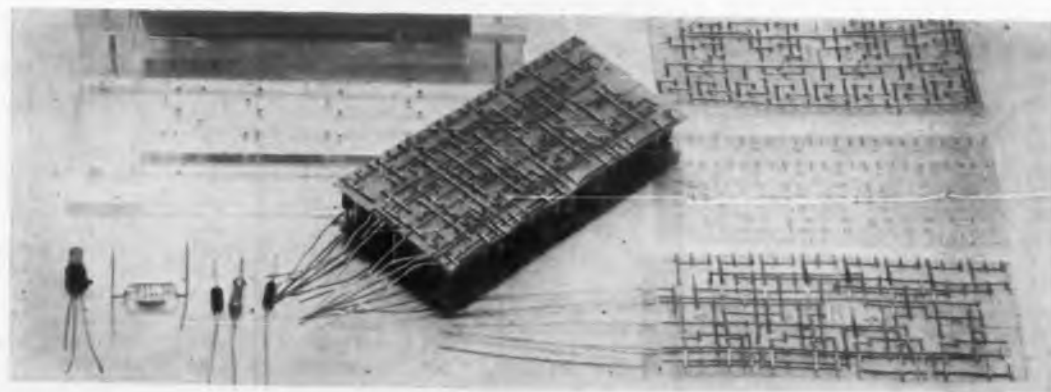


Fig. 3. (left) A wiring module matrix film.

Fig. 4. (below) Circuit module matrices and assembled module; individual components are shown at the left and the assembly jig is in the background.

to be used. Cold plates are highly efficient heat exchangers that can be designed to meet the specific temperatures, pressure drops and mass flow requirements of the system. In addition they provide excellent structural members, having a high stiffness-to-weight ratio.

When a heat sink is used, the foils may be attached to conductive plates that are in turn clamped to the heat sink. Transient cooling techniques may also be incorporated in these systems by making use of the heat of fusion. This can be done by building low-melting-temperature alloys or waxes into the conductive transfer structure. ■ ■



Recommended Transistors for Use in Signal Corps Developmental Equipment

To promote the use of newly developed, newly specified and USASRD evaluated transistor types, the following list has been prepared.

Irving J. Ross

U.S. Army Signal Research and Development Lab.
Fort Monmouth, N. J.

A LIST OF transistors recommended for use by contractors of Signal Corps electronic equipment has been prepared to supplement the existing standard MIL-STD-701A. The following criteria were used in determining which types were to be included.

- The existence of military specifications and qualified sources for transistors.

- The inclusion of newly developed types for which an Army need has been established and which have been thoroughly tested and evaluated by the Signal Corps.

- The inclusion of the entire distribution of transistor generic types where firm military equipment requirements exist.

- The omission of certain types which were included in MIL-STD-701A because newer and better types are available.

The list is published as a Technical Specifica-

Table 1. Numerical listing of recommended transistor types with applicable military specification reference.

| Type | Specification | Type | Specification | Type | Specification | Type | Specification | |
|------|---------------|-----------------|---------------|--------|-----------------|------|---------------|-----------------|
| USAF | 2N167A | MIL-S-19500/11A | USA | 2N427 | MIL-T-19500/43A | USA | 2N1034 | SCL 7002/59 |
| JAN | 2N174 | MIL-T-19500/13A | JAN | 2N428 | MIL-S-19500/44B | USA | 2N1035 | SCL 7002/60 |
| JAN | 2N220 | MIL-T-19500/1 | USA | 2N465 | MIL-T-19500/50A | USA | 2N1036 | SCL 7002/61 |
| USA | 2N274 | MIL-T-19500/26 | JAN | 2N466 | MIL-S-19500/51B | USA | 2N1037 | SCL 7002/62 |
| USA | 2N297A | MIL-T-19500/36A | USA | 2N467 | MIL-T-19500/52B | USN | 2N1039 | MIL-S-19500/89 |
| JAN | 2N326 | MIL-S-19500/40 | USA | 2N495 | MIL-T-19500/54A | USN | 2N1041 | MIL-S-19500/89 |
| USA | 2N327A | SCL 7002/56 | USA | 2N496 | MIL-S-19500/85 | USA | 2N1042 | MIL-S-19500/137 |
| USA | 2N328A | MIL-S-19500/110 | USN | 2N497 | MIL-T-19500/74 | USA | 2N1043 | MIL-S-19500/137 |
| USA | 2N329A | MIL-S-19500/111 | USN | 2N498 | MIL-T-19500/74 | USA | 2N1044 | MIL-S-19500/137 |
| JAN | 2N331 | MIL-T-19500/4A | USA | 2N499 | MIL-S-19500/72A | USA | 2N1045 | MIL-S-19500/137 |
| USN | 2N332 | MIL-T-19500/37A | USA | 2N501A | MIL-T-19500/62 | USN | 2N1046 | MIL-S-19500/88 |
| USN | 2N333 | MIL-T-19500/37A | USA | 2N502A | MIL-S-19500/112 | USN | 2N1047A | in preparation |
| USN | 2N334 | MIL-T-19500/37A | JAN | 2N526 | MIL-S-19500/60C | USN | 2N1048A | in preparation |
| USN | 2N335 | MIL-T-19500/37A | USA | 2N537 | MIL-S-19500/100 | USN | 2N1049A | in preparation |
| USN | 2N336 | in preparation | USN | 2N539 | MIL-T-19500/38 | USN | 2N1050A | in preparation |
| USN | 2N337 | MIL-S-19500/69B | JAN | 2N560 | MIL-S-19500/73A | USA | 2N1079 | SCL 7002/70 |
| USN | 2N338 | MIL-S-19500/69B | USA | 2N600 | SCL 7002/100 | USA | 2N1080 | SCL 7002/71 |
| USN | 2N341 | in preparation | USA | 2N624 | MIL-T-19500/82 | USA | 2N1081 | SCL 7002/89 |
| JAN | 2N342 | MIL-T-19500/16B | USN | 2N656 | MIL-T-19500/74 | USA | 2N1082 | MIL-S-19500/103 |
| JAN | 2N343 | MIL-T-19500/16B | USN | 2N657 | MIL-T-19500/74 | USA | 2N1084 | in preparation |
| JAN | 2N358A | MIL-S-19500/63B | USA | 2N665 | MIL-T-19500/58A | USA | 2N1085 | SCL 7002/80 |
| JAN | 2N384 | MIL-S-19500/27A | USA | 2N696 | MIL-S-19500/99A | USA | 2N1118 | MIL-S-19500/138 |
| USN | 2N388 | MIL-T-19500/65 | USA | 2N697 | MIL-S-19500/99A | USA | 2N1119 | MIL-S-19500/139 |
| USN | 2N389 | in preparation | USA | 2N699 | in preparation | USA | 2N1120 | MIL-T-19500/68 |
| USA | 2N393 | MIL-S-19500/77A | USA | 2N700A | MIL-S-19500/123 | USN | 2N1131 | in preparation |
| USN | 2N396A | MIL-S-19500/64A | USA | 2N702 | MIL-S-19500/153 | USN | 2N1132 | in preparation |
| USAF | 2N404 | MIL-T-19500/20 | USN | 2N705 | MIL-S-19500/86 | USN | 2N1142 | MIL-S-19500/87 |
| USA | 2N416 | MIL-T-19500/56A | USA | 2N706 | MIL-S-19500/120 | USA | 2N1158A | MIL-S-19500/113 |
| USA | 2N417 | MIL-T-19500/57A | USA | 2N716 | MIL-S-19500/154 | USA | 2N1183 | MIL-S-19500/143 |
| USN | 2N424 | in preparation | USA | 2N718 | SCL 7002/91 | USA | 2N1183A | MIL-S-19500/143 |
| USA | 2N425 | MIL-T-19500/41A | USA | 2N1000 | MIL-T-19500/79 | USA | 2N1183B | MIL-S-19500/143 |
| USA | 2N426 | MIL-T-19500/42A | USA | 2N1011 | MIL-T-19500/67 | USA | 2N1184 | MIL-S-19500/143 |
| | | | USA | 2N1026 | MIL-S-19500/78A | USA | 2N1184A | MIL-S-19500/143 |
| | | | | | | USA | 2N1184B | MIL-S-19500/143 |
| | | | | | | USA | 2N1184C | MIL-S-19500/143 |
| | | | | | | USA | 2N1184D | MIL-S-19500/143 |
| | | | | | | USA | 2N1184E | MIL-S-19500/143 |
| | | | | | | USA | 2N1184F | MIL-S-19500/143 |
| | | | | | | USA | 2N1184G | MIL-S-19500/143 |
| | | | | | | USA | 2N1184H | MIL-S-19500/143 |
| | | | | | | USA | 2N1184I | MIL-S-19500/143 |
| | | | | | | USA | 2N1184J | MIL-S-19500/143 |
| | | | | | | USA | 2N1184K | MIL-S-19500/143 |
| | | | | | | USA | 2N1184L | MIL-S-19500/143 |
| | | | | | | USA | 2N1184M | MIL-S-19500/143 |
| | | | | | | USA | 2N1184N | MIL-S-19500/143 |
| | | | | | | USA | 2N1184O | MIL-S-19500/143 |
| | | | | | | USA | 2N1184P | MIL-S-19500/143 |
| | | | | | | USA | 2N1184Q | MIL-S-19500/143 |
| | | | | | | USA | 2N1184R | MIL-S-19500/143 |
| | | | | | | USA | 2N1184S | MIL-S-19500/143 |
| | | | | | | USA | 2N1184T | MIL-S-19500/143 |
| | | | | | | USA | 2N1184U | MIL-S-19500/143 |
| | | | | | | USA | 2N1184V | MIL-S-19500/143 |
| | | | | | | USA | 2N1184W | MIL-S-19500/143 |
| | | | | | | USA | 2N1184X | MIL-S-19500/143 |
| | | | | | | USA | 2N1184Y | MIL-S-19500/143 |
| | | | | | | USA | 2N1184Z | MIL-S-19500/143 |
| | | | | | | USA | 2N1185 | MIL-S-19500/143 |
| | | | | | | USA | 2N1185A | MIL-S-19500/143 |
| | | | | | | USA | 2N1185B | MIL-S-19500/143 |
| | | | | | | USA | 2N1185C | MIL-S-19500/143 |
| | | | | | | USA | 2N1185D | MIL-S-19500/143 |
| | | | | | | USA | 2N1185E | MIL-S-19500/143 |
| | | | | | | USA | 2N1185F | MIL-S-19500/143 |
| | | | | | | USA | 2N1185G | MIL-S-19500/143 |
| | | | | | | USA | 2N1185H | MIL-S-19500/143 |
| | | | | | | USA | 2N1185I | MIL-S-19500/143 |
| | | | | | | USA | 2N1185J | MIL-S-19500/143 |
| | | | | | | USA | 2N1185K | MIL-S-19500/143 |
| | | | | | | USA | 2N1185L | MIL-S-19500/143 |
| | | | | | | USA | 2N1185M | MIL-S-19500/143 |
| | | | | | | USA | 2N1185N | MIL-S-19500/143 |
| | | | | | | USA | 2N1185O | MIL-S-19500/143 |
| | | | | | | USA | 2N1185P | MIL-S-19500/143 |
| | | | | | | USA | 2N1185Q | MIL-S-19500/143 |
| | | | | | | USA | 2N1185R | MIL-S-19500/143 |
| | | | | | | USA | 2N1185S | MIL-S-19500/143 |
| | | | | | | USA | 2N1185T | MIL-S-19500/143 |
| | | | | | | USA | 2N1185U | MIL-S-19500/143 |
| | | | | | | USA | 2N1185V | MIL-S-19500/143 |
| | | | | | | USA | 2N1185W | MIL-S-19500/143 |
| | | | | | | USA | 2N1185X | MIL-S-19500/143 |
| | | | | | | USA | 2N1185Y | MIL-S-19500/143 |
| | | | | | | USA | 2N1185Z | MIL-S-19500/143 |
| | | | | | | USA | 2N1186 | MIL-S-19500/143 |
| | | | | | | USA | 2N1186A | MIL-S-19500/143 |
| | | | | | | USA | 2N1186B | MIL-S-19500/143 |
| | | | | | | USA | 2N1186C | MIL-S-19500/143 |
| | | | | | | USA | 2N1186D | MIL-S-19500/143 |
| | | | | | | USA | 2N1186E | MIL-S-19500/143 |
| | | | | | | USA | 2N1186F | MIL-S-19500/143 |
| | | | | | | USA | 2N1186G | MIL-S-19500/143 |
| | | | | | | USA | 2N1186H | MIL-S-19500/143 |
| | | | | | | USA | 2N1186I | MIL-S-19500/143 |
| | | | | | | USA | 2N1186J | MIL-S-19500/143 |
| | | | | | | USA | 2N1186K | MIL-S-19500/143 |
| | | | | | | USA | 2N1186L | MIL-S-19500/143 |
| | | | | | | USA | 2N1186M | MIL-S-19500/143 |
| | | | | | | USA | 2N1186N | MIL-S-19500/143 |
| | | | | | | USA | 2N1186O | MIL-S-19500/143 |
| | | | | | | USA | 2N1186P | MIL-S-19500/143 |
| | | | | | | USA | 2N1186Q | MIL-S-19500/143 |
| | | | | | | USA | 2N1186R | MIL-S-19500/143 |
| | | | | | | USA | 2N1186S | MIL-S-19500/143 |
| | | | | | | USA | 2N1186T | MIL-S-19500/143 |
| | | | | | | USA | 2N1186U | MIL-S-19500/143 |
| | | | | | | USA | 2N1186V | MIL-S-19500/143 |
| | | | | | | USA | 2N1186W | MIL-S-19500/143 |
| | | | | | | USA | 2N1186X | MIL-S-19500/143 |
| | | | | | | USA | 2N1186Y | MIL-S-19500/143 |
| | | | | | | USA | 2N1186Z | MIL-S-19500/143 |
| | | | | | | USA | 2N1187 | MIL-S-19500/143 |
| | | | | | | USA | 2N1187A | MIL-S-19500/143 |
| | | | | | | USA | 2N1187B | MIL-S-19500/143 |
| | | | | | | USA | 2N1187C | MIL-S-19500/143 |
| | | | | | | USA | 2N1187D | MIL-S-19500/143 |
| | | | | | | USA | 2N1187E | MIL-S-19500/143 |
| | | | | | | USA | 2N1187F | MIL-S-19500/143 |
| | | | | | | USA | 2N1187G | MIL-S-19500/143 |
| | | | | | | USA | 2N1187H | MIL-S-19500/143 |
| | | | | | | USA | 2N1187I | MIL-S-19500/143 |
| | | | | | | USA | 2N1187J | MIL-S-19500/143 |
| | | | | | | USA | 2N1187K | MIL-S-19500/143 |
| | | | | | | USA | 2N1187L | MIL-S-19500/143 |
| | | | | | | USA | 2N1187M | MIL-S-19500/143 |
| | | | | | | USA | 2N1187N | MIL-S-19500/143 |
| | | | | | | USA | 2N1187O | MIL-S-19500/143 |
| | | | | | | USA | 2N1187P | MIL-S-19500/143 |
| | | | | | | USA | 2N1187Q | MIL-S-19500/143 |
| | | | | | | USA | 2N1187R | MIL-S-19500/143 |
| | | | | | | USA | 2N1187S | MIL-S-19500/143 |
| | | | | | | USA | 2N1187T | MIL-S-19500/143 |
| | | | | | | USA | 2N1187U | MIL-S-19500/143 |
| | | | | | | USA | 2N1187V | MIL-S-19500/143 |
| | | | | | | USA | 2N1187W | MIL-S-19500/143 |
| | | | | | | USA | 2N1187X | MIL-S-19500/143 |
| | | | | | | USA | 2N1187Y | MIL-S-19500/143 |
| | | | | | | USA | 2N1187Z | MIL-S-19500/143 |
| | | | | | | USA | 2N1188 | MIL-S-19500/143 |
| | | | | | | USA | 2N1188A | MIL-S-19500/143 |
| | | | | | | USA | 2N1188B | MIL-S-19500/143 |
| | | | | | | USA | 2N1188C | MIL-S-19500/143 |
| | | | | | | USA | 2N1188D | MIL-S-19500/143 |
| | | | | | | USA | 2N1188E | MIL-S-19500/143 |
| | | | | | | USA | 2N1188F | MIL-S-19500/143 |
| | | | | | | USA | 2N1188G | MIL-S-19500/143 |
| | | | | | | USA | 2N1188H | MIL-S-19500/143 |
| | | | | | | USA | 2N1188I | MIL-S-19500/143 |
| | | | | | | USA | 2N1188J | MIL-S-19500/143 |
| | | | | | | USA | 2N1188K | MIL-S-19500/143 |
| | | | | | | USA | 2N1188L | MIL-S-19500/143 |
| | | | | | | USA | 2N1188M | MIL-S-19500/143 |
| | | | | | | USA | 2N1188N | MIL-S-19500/143 |
| | | | | | | USA | 2N1188O | MIL-S-19500/143 |
| | | | | | | USA | 2N1188P | MIL-S-19500/143 |
| | | | | | | USA | 2N1188Q | MIL-S-19500/143 |
| | | | | | | USA | 2N1188R | MIL-S-19500/143 |
| | | | | | | USA | 2N1188S | MIL-S-19500/143 |
| | | | | | | USA | 2N1188T | MIL-S-19500/143 |
| | | | | | | USA | 2N1188U | MIL-S-19500/143 |
| | | | | | | USA | 2N1188V | MIL-S-19500/143 |
| | | | | | | USA | 2N1188W | MIL-S-1950 |

tion Sheet SCL 6200/9 dated Nov. 1, 1960, which forms part of specification SCL 6200 "Parts, Materials, Processes Used in Ground Signal Equipment." It is the purpose of this specification to provide guide lines and procedures for the selection and application of the most suitable parts and materials in the development of military electronic equipments.

The list, divided into two sections, is subject

to periodic revision as types listed become obsolete or newly developed types are added. The list shown, Table 2, uses the format of MIL-STD-701A by categorizing transistors as to application, frequency, and power ranges. There is no division between preferred and guidance types as in MIL-STD-701A. The first part, Table 1, lists the types in numerical order by 2N-number and cites the applicable military specification which

the contractor should use in his purchase orders for transistors.

The notation SCL 7002 indicates that a laboratory specification has been prepared for a given type. In most cases, these SCL 7002 specifications will ultimately be superseded by Signal Corps MIL specifications. However, the SCL specification can be used as a valid procurement document in the interim period. ■ ■

Table 2. Listing of Signal Corps recommended transistor types by application, frequency and power ratings.

| | | Germanium | | Silicon | | | | Germanium | | Silicon | |
|-----------------------------|-------------------------------------|---|---------------------------------------|---|--|--|--|-----------|-----|---------|--|
| | | PNP | NPN | PNP | NPN | | | PNP | NPN | PNP | NPN |
| Low Power <300 mw | Audio Freq < 3 mc | 2N220* 2N331* 2N465* 2N466 2N467 2N526* | | 2N1026* 2N1034 2N1035 2N1036 2N1037 | 2N332 2N333* 2N334 2N335* 2N336 | | | | | | 2N716 2N1505 2N1506 |
| | Med. Freq. 3-30 mc | 2N274 2N416 2N417 2N624 2N1224 | | 2N495* 2N1118 2N1196 2N1197 | 2N338* 2N1082 2N1200 2N1201 2N1528 | | | | | | 2N341* 2N342 2N343* 2N696 2N697* 2N699 2N718 |
| | High Freq. > 30 mc | 2N384* 2N499 2N502A 2N537* 2N700A* 2N1142 2N1158A 2N1225 | | | 3N35* | | | | | | 2N497* 2N498* 2N656* 2N657* 2N1079 2N1081 2N1085 2N1479 2N1183B 2N1184 2N1184A 2N1184B |
| Switching | Low Speed > 5 μsec TOTAL TIME | | | 2N327A 2N328A* 2N329A* | | | | | | | 2N1084 |
| | Med. Speed 1-5 μsec | 2N396A* 2N404* 2N425 2N426 2N427 2N428* | 2N167A 2N358A* 2N388* 2N1000 | 2N496* 2N1119 | 2N337* | | | | | | 2N1481 2N1482 2N1483 2N1484 2N1485 2N1486 |
| | High Speed < 1 μsec | 2N393* 2N501A* 2N705 2N1195* 2N1411 2N1500 | | 2N1131 2N1132* | 2N560* 2N702 2N706 2N1199A | | | | | | 2N389* 2N424* 2N1047A 2N1048A 2N1049A 2N1050A 2N1470 2N1080 2N1487 2N1488 2N1489 2N1490 |

*Listed in MIL-STD-701A, dated 31 Mar 1960

All-Pass Networks — Part 5

When to Stop Designing

The all-pass network is so useful in improving the performance of other networks that the designer is easily tempted to continue improving without limit. The first four articles in this series (ED, Oct. 12, Oct. 26, 1960, Feb. 15, March 1, 1961), showed how all-pass networks could be used to design superior networks. Here, in the concluding part of the series, Mr. Lubkin shows when to stop improving network design and, indeed, when not to use the all-pass network at all.

Reprints of this five-part series of articles are available to readers who write to Public Relations Dept., Loral Electronics Corp., 825 Bronx River Ave., New York 72, N. Y.

Yale Jay Lubkin

Loral Electronics Corp.
The Bronx, N. Y.

WHEN TO STOP designing is a key problem for electronic design engineers. The first four articles in this series showed the value of all-pass networks in designing superior networks. But it is still necessary for the designer to know when to stop designing and how close he is to the theoretical optimum.

The Laurent formula for rise time (Eq. 1), can serve as a valuable guide.

$$t_r = \frac{\pi}{\int_0^{\infty} A(\omega) \cos(\omega t_d - \phi) d\omega} \quad (1)$$

The earlier articles in this series gave examples of improvements possible by judicious choice of all-pass compensating nets. We can now consider an example to illustrate some pitfalls.

Rise Time of Real Amplifier Differs from that of Ideal

We can use the Laurent equation to calculate the envelope rise time of a real and of an idealized if amplifier.

Suppose, for ease in calculation, that both amplifiers have a bandwidth of 2 mc (12.6 megaradians/sec). In calculation of the envelope response, frequency deviations from the if center frequency are important. The envelope response of the if amplifier is the same as the step response of a low-pass filter with a phase and amplitude characteristic at ω which is equal to that of the if amplifier at $\omega_0 + \omega$, where ω_0 is the if center frequency.

In considering the real amplifier, we will take the active elements (tubes or transistors) to be perfectly linear and distortionless. This is a generally satisfactory approximation.

The idealized if amplifier will have an amplitude characteristic that is constant throughout the passband and zero outside the passband. It will have zero phase distortion throughout the passband. This is illustrated in Fig. 1. In Eq. 1 we take $\phi = \omega t_d$ and $A = 1$ for $0 < \omega < 2\pi$ times $(10)^6$, and $A = 0$ for $\omega > 2\pi (10)^6$. The rise time is then calculated to be exactly 0.5 μ sec.

This is a useful relationship to remember: "An idealized if amplifier of bandwidth f cps has an envelope rise time of $1/f$ sec."

The particular if amplifier characteristic chosen for analysis is the triple stagger-tuned circuit described in Seely's "Vacuum Tube Circuits," Second Edition, p 356. The circuit is found in many television sets. The phase error and the amplitude response of the network are readily calculated. One can use Seely's data and calculate phase and amplitude response separately for each of the tuned circuits, then combine the responses to get the over-all characteristic.

The results, shown in Fig. 2, consider the if bandwidth to be the bandwidth between points at which the amplitude response is down 3 db from its peak. By integrating the product $A \cos \Delta\phi$, ($\Delta\phi = \omega t_d - \phi$), we find that the rise time of the if amplifier is 0.35 μ sec,—only 2/3 of the rise time of the idealized amplifier. Thus the real amplifier appears to have a much better transient response than the idealized amplifier.

A Paradox: Real Amplifier Has Better Response than Ideal

At first thought, these results appear wrong. How can the transient response of the real amplifier possibly be better than that of the idealized amplifier?

Consider the curves of Fig. 2. The first thing to note is that the amplitude response falls off rather slowly and the area under the amplitude

curve is much greater than the area under the amplitude curve of the idealized amplifier. It actually is about 60 per cent greater.

Thus, as far as transient response is concerned, the effective bandwidth of the real amplifier is not 2 mc, but about 3.2 mc. The statement that the real amplifier has a bandwidth of 2 mc should be examined more closely. If bandwidth were to be measured at values of attenuation other than at the conventional 3-db points, the results would be quite different. Bandwidth beyond these points contributes substantially to rise time. If the real amplifier has a 6-db bandwidth of 2 mc, the rise time is 0.48 μ sec; for 10 db, it is 0.63 μ sec, and for 20 db, it is 1.0 μ sec.

For the area under the amplitude curve to equal the area under that of the idealized amplifier, the bandwidth would have to be measured at the 8-db-down points. In this case the rise time is 0.57 μ sec, somewhat worse than the idealized amplifier.

Triple-Tuned Circuit Shows Low Phase Distortion

The second thing to note is that the phase distortion is extremely low. Though the 3-db bandwidth is 2 mc, the cosine of the phase error, $\Delta\phi$, is greater than 0.9 over a 4-mc bandwidth and the phase error is less than 90 deg over a 6-mc bandwidth.

For comparison, look at the phase error curve, Fig. 3, for the critically damped transformer analyzed in the second part of the series (ED, Oct. 26, 1960, p 70). Normally it would not pay to provide phase compensation for the triple-tuned amplifier because the Laurent formula shows that the maximum possible gain in rise time is only 14 per cent.

The third thing to notice is that the phase response is overcompensated, i.e., a small excess of

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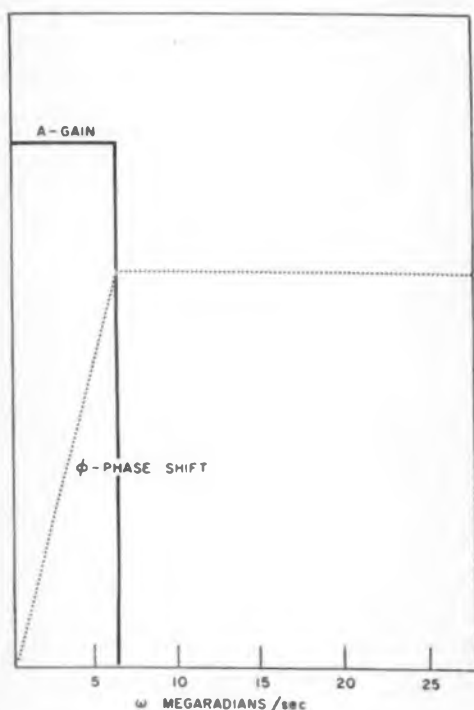


Fig. 1. Gain and phase shift of idealized intermediate frequency amplifier.

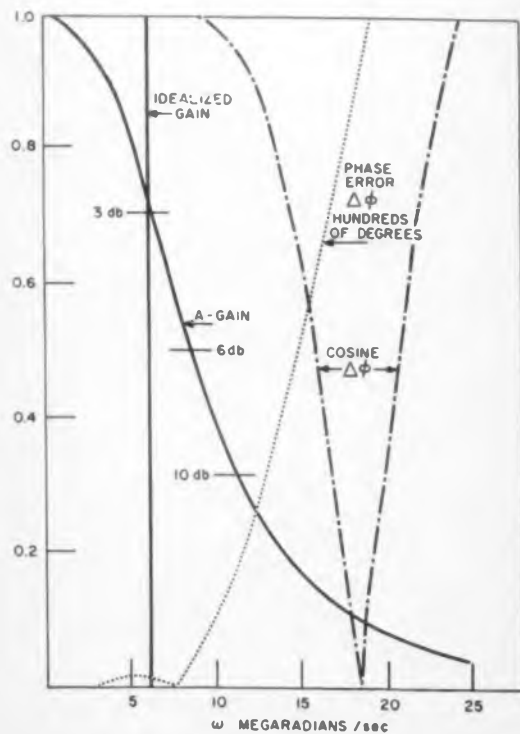
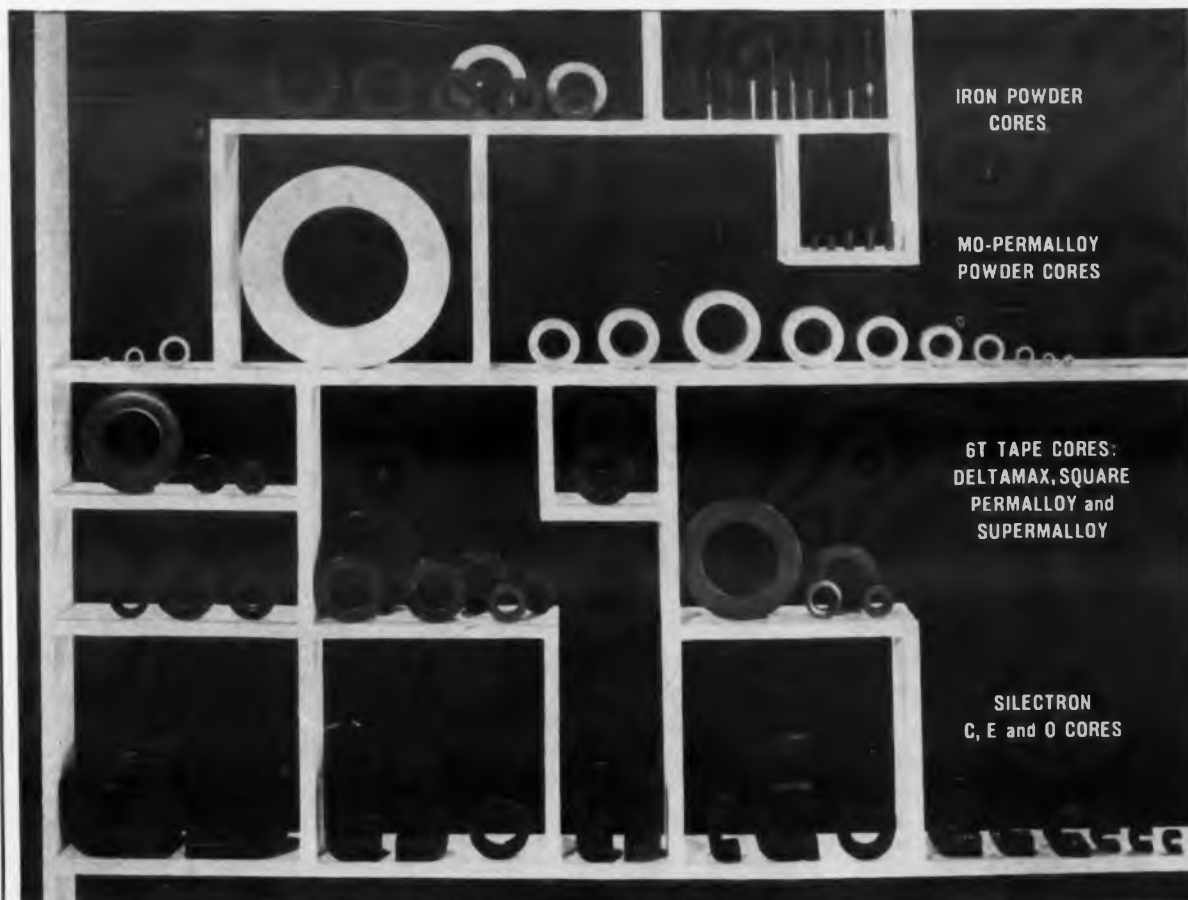
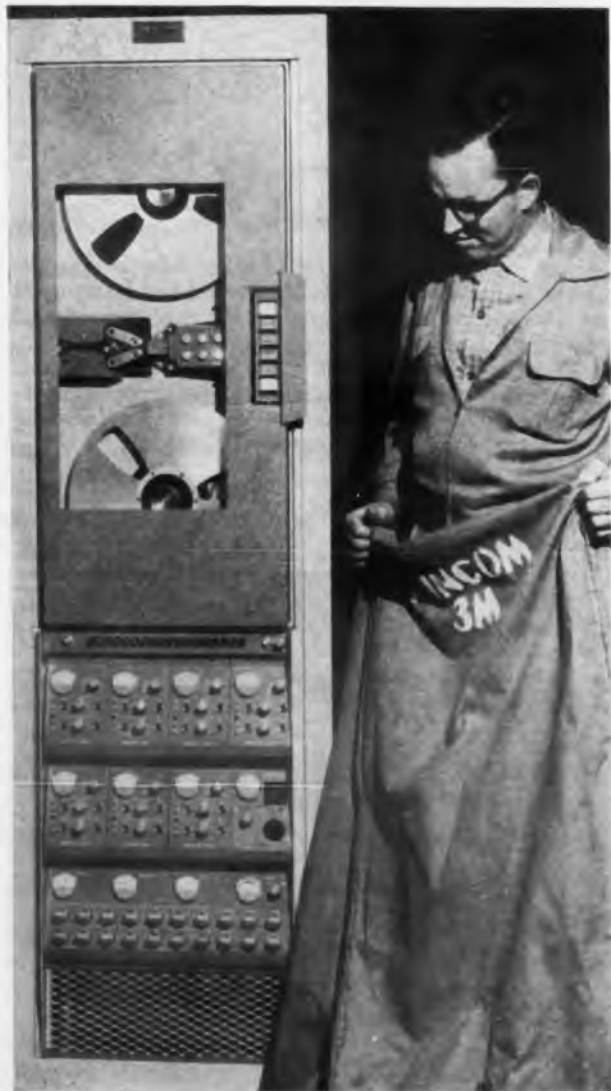


Fig. 2. Gain and phase shift of triple stagger-tuned amplifier.



CIRCLE 37 ON READER-SERVICE CARD

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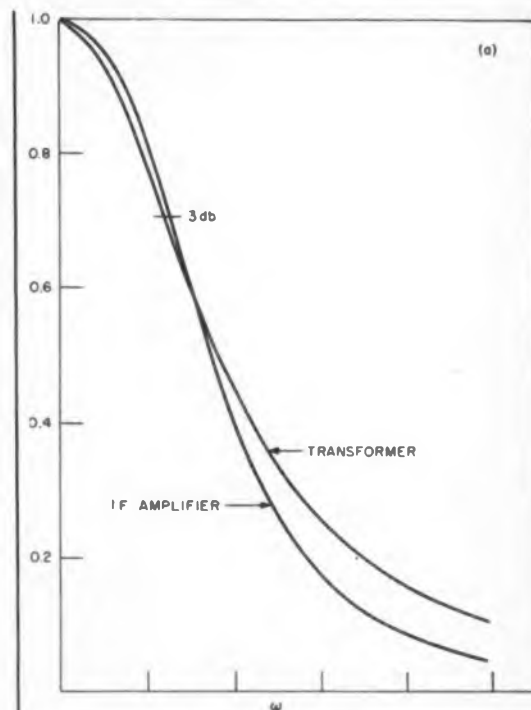


Fig. 3. Comparison of gain (a) and phase error (b) of intermediate-frequency amplifier and critically damped transformer.

phase shift (here about 1.5 deg) is taken in order that the phase error remain low at higher frequencies. This is a generally useful technique to extend the phase bandwidth. Its use has been illustrated in connection with delay-line design and compensation of the critically damped transformer. An excess phase shift of 30 deg is not too much for pulse work.

Finally, note that the cosine of the phase error falls off much more rapidly than does the amplitude response. This is a condition which leads to a small amount of ripple and overshoot.

It is evident that the triple-tuned circuit has rather good transient response. The designer is generally advised to leave it alone—provided he is happy with the amplitude characteristic. This situation will frequently occur. In each case the designer must determine the point at which it no longer is economical to improve his basic circuit.

Some results discussed in this series of articles are here summarized to help the designer concerned with transient response.

Guidelines in Designing For Optimum Transient Response

1. In any situation, improvement of phase linearity is beneficial.

CIRCLE 39 ON READER-SERVICE CARD ▶



SEMICONDUCTORS

BY GENERAL ELECTRIC

Linea



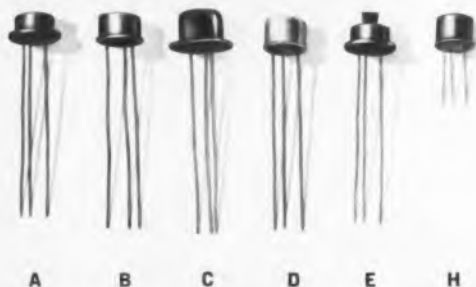
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General Electric transistors have earned a reputation for reliability without equal in the industry. Superior quality is built into all G-E semiconductors — by careful control of every step, from refining the raw materials to packaging the finished products.

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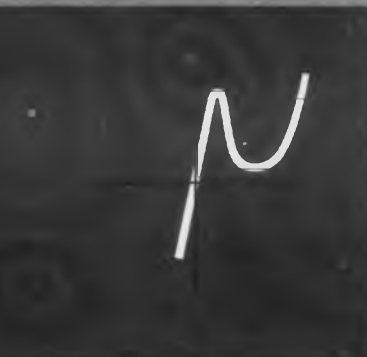
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| GERMANIUM | Type No. | Case | Outline Drawg. | Max. Forward Current (-25 to +100°C) (ma) | Max. Reverse Current (-25 to +100°C) (ma) | Max. Storage Temp. (°C) | Max. Oper. Junction Temp. (°C) | Lead Temp. (From Case for 15 Sec.) (°C) | Peak Point Current (ma) I_p | Valley Point Current (ma) I_v | Valley Point Volt. (mv) V_v | Rev. Volt. (mv) V_R | Forward Peak Point Current Volt. (mv) V_F | Neg. Conductance (mho) -G | Total Cap. (pf) C | Series Inductance (nh) L | Series Resistance (ohm) R | |
|-------------------------|----------|------|----------------|---|---|-------------------------|--------------------------------|---|-------------------------------|---------------------------------|-------------------------------|-----------------------|---|---------------------------|------------------------|--------------------------|---------------------------|-----------------------------|
| | | | | | | | | | | | | | | | | | | Peak Point Volt. (mv) V_p |
| Low Level Switching | 1N2930 | D | 4 | 5 | 10 | -55 to +100 | -55 to +100 | 280 | 1.0 ± 10% | 0.10 | 80 | 300 | 30 Max. | 500 | 6.6 × 10 ⁻² | 5.0 | 1.5 | 1.5 |
| | 1N2940 | D | 4 | 5 | 10 | -55 to +100 | -55 to +100 | 280 | 1.0 ± 10% | 0.10 | 80 | 350 | 30 Max. | 500 | 6.6 × 10 ⁻² | 5.0 | 1.5 | 1.5 |
| | 1N2941 | D | 4 | 25 | 50 | -55 to +100 | -55 to +100 | 260 | 4.7 ± 10% | 0.8 | 60 | 350 | 30 Max. | 500 | 30 × 10 ⁻² | 15 | 6 | 0.5 |
| | 1N2969 | D | 4 | 10 | 30 | -55 to +100 | -55 to +100 | 260 | 2.2 ± 10% | 0.20 | 60 | 350 | 30 Max. | 500 | 16 × 10 ⁻² | 8 | 1.8 | 0.5 |
| | 1N3149 | D | 4 | 50 | 100 | -55 to +100 | -55 to +100 | 260 | 10.0 ± 10% | 1.3 | 60 | 350 | 30 Max. | 500 | 60 × 10 ⁻² | 30 | 6 | 0.25 |
| | 1N3150 | D | 4 | 300 | 100 | -55 to +100 | -55 to +100 | 280 | 22 ± 10% | 2.8 | 60 | 350 | 30 Max. | 500 | 100 × 10 ⁻² | 60 | 6 | 1.5 |
| | 1N2936A | G | 4 | 5 | 10 | -55 to +100 | -55 to +100 | 260 | 1.0 ± 2.5% | 0.10 | 80 | 350 | 30 Max. | 500 | 6.6 × 10 ⁻² | 4.0 | 1.5 | 1.5 |
| | 1N2940A | G | 4 | 5 | 10 | -55 to +100 | -55 to +100 | 260 | 1.0 ± 2.5% | 0.10 | 80 | 350 | 30 Max. | 500 | 6.6 × 10 ⁻² | 4.0 | 1.5 | 1.5 |
| | 1N2941A | G | 4 | 25 | 50 | -55 to +100 | -55 to +100 | 260 | 4.7 ± 2.5% | 0.6 | 60 | 350 | 30 Max. | 500 | 30 × 10 ⁻² | 10 | 6 | 0.5 |
| | 1N2969A | G | 4 | 10 | 30 | -55 to +100 | -55 to +100 | 260 | 2.2 ± 2.5% | 0.20 | 60 | 350 | 30 Max. | 500 | 16 × 10 ⁻² | 8 | 1.8 | 0.5 |
| 1N3149A | G | 4 | 50 | 100 | -55 to +100 | -55 to +100 | 280 | 10.0 ± 2.5% | 1.3 | 60 | 350 | 30 Max. | 500 | 60 × 10 ⁻² | 30 | 6 | 1.5 | |
| Microwave Communication | 1N3218 | F | 7 | 5 | 10 | -55 to +100 | -55 to +100 | 260 | 1.0 ± 10% | 0.10 | 80 | 350 | 20 | 500 | 6 × 10 ⁻² | 7 | 0.3 | 1.5 |
| | 1N3218A | F | 7 | 5 | 10 | -55 to +100 | -55 to +100 | 260 | 1.0 ± 10% | 0.10 | 80 | 350 | 20 | 500 | 6 × 10 ⁻² | 7 | 0.3 | 1.5 |
| | 1N3219 | F | 7 | 5 | 10 | -55 to +100 | -55 to +100 | 260 | 2.2 ± 10% | 0.20 | 60 | 350 | 20 | 500 | 12 × 10 ⁻² | 14 | 0.3 | 0.7 |
| | 1N3219A | F | 7 | 5 | 10 | -55 to +100 | -55 to +100 | 260 | 2.2 ± 10% | 0.20 | 60 | 350 | 20 | 500 | 12 × 10 ⁻² | 14 | 0.3 | 0.7 |

*Inductance will vary 1 - 12 nh (10⁻⁹ henries) depending on lead length.

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RATINGS

| USE | TYPE NO. | CASE | OUTLINE DRAWING | MAXIMUM DISSIPATION @ 25°C | | MAXIMUM RATED VOLTAGE (V _{CE} -I _C) | | MAXIMUM COLLECTOR CURRENT (I _C) | |
|---|--|------|-----------------|----------------------------|-----------------|--|----------------|---|----------------|
| | | | | P _{tot} (mW) | V _{CE} | V _{CE} | I _C | V _{CE} | I _C |
| AMPLIFIER AND COMPUTER NPN (Ceramic Fixed-Bed Construction) | 2N332 (Per MIL-T-19500/37A) (NAVY) | D | 4 | 120 | 1 | 40 | 10 | 20 | 10 |
| | 2N333 (Per MIL-T-19500/37A) (NAVY) | D | 4 | 100 | 1 | 40 | 10 | 20 | 10 |
| | 2N334 (Per MIL-T-19500/37A) (NAVY) | D | 4 | 100 | 1 | 40 | 10 | 20 | 10 |
| | 2N335 (Per MIL-T-19500/37A) (NAVY) | D | 4 | 100 | 1 | 40 | 10 | 20 | 10 |
| | 2N336 | D | 4 | 100 | 1 | 40 | 10 | 20 | 10 |
| | 2N332A | D | 4 | 500 | 4 | 50 | 10 | 20 | 25 |
| | 2N333A | D | 4 | 500 | 4 | 50 | 10 | 20 | 25 |
| | 2N334A | D | 4 | 500 | 4 | 50 | 10 | 20 | 25 |
| | 2N335A | D | 4 | 500 | 4 | 50 | 10 | 20 | 25 |
| | 2N336A | D | 4 | 500 | 4 | 50 | 10 | 20 | 25 |
| | 2N335B | D | 4 | 500 | 4 | 50 | 10 | 20 | 25 |
| | 2N337 (Per MIL-T-19500/69C) (NAVY) | D | 4 | 100 | 1 | 40 | 10 | 20 | 10 |
| | 2N338 (Per MIL-T-19500/69C) (NAVY) | D | 4 | 125 | 1 | 40 | 10 | 20 | 10 |
| | 2M1277 | D | 4 | 100 | 1 | 40 | 10 | 20 | 10 |
| | 2M1278 | D | 4 | 100 | 1 | 40 | 10 | 20 | 10 |
| 2M1279 | D | 4 | 100 | 1 | 40 | 10 | 20 | 10 | |
| UNIUNCTION PN (Ceramic Fixed-Bed Construction) | 2N488 (Per MIL-T-19500/75) (USAF) | D | 5 | 400 | 4 | V _{BE} (MAX) | | I _B | |
| | 2N489 (Per MIL-T-19500/75) (USAF) | D | 5 | 400 | 4 | | | | |
| | 2N491 (Per MIL-T-19500/75) (USAF) | D | 5 | 400 | 4 | | | | |
| | 2N492 (Per MIL-T-19500/75) (USAF) | D | 5 | 400 | 4 | | | | |
| | 2N493 (Per MIL-T-19500/75) (USAF) | D | 5 | 400 | 4 | | | | |
| | 2N494 (Per MIL-T-19500/75) (USAF) | D | 5 | 400 | 4 | | | | |
| | 2M1671 | D | 5 | 400 | 4 | | | | |
| | 2M1671A | D | 5 | 400 | 4 | | | | |
| 2M1671B | D | 5 | 450 | 4 | | | | | |
| AUDIO NPN Mesa | 2N497 | B | 2 | 200 | 4 | V _{CEO} | | I _C | |
| | 2N498 | B | 2 | 200 | 4 | | | | |
| | 2N496 | B | 2 | 200 | 4 | | | | |
| | 2N497 | B | 2 | 200 | 4 | 100 | 10 | 20 | 10 |
| | 2N497A | B | 2 | 200 | 4 | | | | |
| | 2N498A | B | 2 | 200 | 4 | | | | |
| | 2N496A | B | 2 | 200 | 4 | | | | |
| 2N497A | B | 2 | 200 | 4 | | | | | |
| AUDIO PNP | 2N43 | A | 1 | 100 | 1 | | | | |
| | 2N43A (Per MIL-T-19500/18) (USAF) | A | 1 | 100 | 1 | | | | |
| | 2N44 | A | 1 | 100 | 1 | | | | |
| | 2N44A (Per MIL-T-19500/6) (USAF) | A | 1 | 100 | 1 | | | | |
| | 2N526 | B | 2 | 200 | 4 | | | | |
| | 2N525 | B | 2 | 200 | 4 | | | | |
| | 2N526 (Per MIL-T-19500/60C) (JAN) | B | 2 | 200 | 4 | | | | |
| | 2N527 | B | 2 | 200 | 4 | | | | |
| | 2M1175 | B | 2 | 200 | 4 | | | | |
| | 2M1175A | B | 2 | 200 | 4 | | | | |
| 2M1413 | B | 2 | 200 | 4 | | | | | |
| 2M1414 | B | 2 | 200 | 4 | | | | | |
| 2M1415 | B | 2 | 200 | 4 | | | | | |
| COMPUTER PNP | 2M123 (Per MIL-T-19500/30) (USAF) | E | 6 | 100 | 1 | | | | |
| | 2M204A | B | 2 | 100 | 1 | | | | |
| | 2M205 | B | 2 | 100 | 1 | | | | |
| | 2M206 | B | 2 | 100 | 1 | | | | |
| | 2M206A (Per MIL-S-19500/64A) (NAVY) | B | 2 | 100 | 1 | | | | |
| | 2N397 | B | 2 | 100 | 1 | | | | |
| | 2N404 (Per MIL-T-19500/20A) (USAF) | B | 2 | 100 | 1 | | | | |
| | 2N404A | B | 2 | 100 | 1 | | | | |
| | 2N413 | B | 2 | 100 | 1 | | | | |
| | 2N414 | B | 2 | 100 | 1 | | | | |
| 2N450 | E | 6 | 100 | 1 | | | | | |
| 2M1057 | A | 1 | 100 | 1 | | | | | |
| 2M1614 | A | 1 | 100 | 1 | | | | | |
| MEDIUM FREQ. AMPLIFIER NPN | 2N70 | C | 3 | 100 | 1 | | | | |
| | 2M70A (Certified to meet MIL-S-19500/90) | C | 3 | 100 | 1 | | | | |
| | 2M100A | C | 3 | 100 | 1 | | | | |
| COMPUTER NPN | 2M167 | C | 3 | 100 | 1 | | | | |
| | 2M167A (Per MIL-S-19500/11A) (USAF) | C | 3 | 100 | 1 | | | | |
| | 2M277 | B | 2 | 100 | 1 | | | | |
| | 2M205 | B | 2 | 100 | 1 | | | | |
| | 2M206 (Per MIL-T-19500/65) (NAVY) | B | 2 | 100 | 1 | | | | |
| | 2M234A | B | 2 | 100 | 1 | | | | |
| | 2M235A | B | 2 | 100 | 1 | | | | |
| | 2M236A | B | 2 | 100 | 1 | | | | |
| | 2M1100 | C | 3 | 100 | 1 | | | | |
| | 2M1217 | C | 3 | 100 | 1 | | | | |
| | 2M1200 | H | 9 | 100 | 1 | | | | |
| | 2M1209 | H | 9 | 100 | 1 | | | | |
| 2M1204 | B | 2 | 100 | 1 | | | | | |
| 2M1205 | B | 2 | 100 | 1 | | | | | |
| 2M1206 | B | 2 | 100 | 1 | | | | | |
| 2M1310 | C | 3 | 100 | 1 | | | | | |
| 2M100A | C | 3 | 100 | 1 | | | | | |

TYPICAL SPECIFICATIONS

| PART NUMBER | MAXIMUM FREQUENCY | CURRENT GAIN | | | | ALPHA CUTOFF FREQ. f_{α} (mc) | POWER GAIN (db) G_p (1000 Cyc.) (5 mc)* | SATURATION VOLTAGE (VOLTS) $V_{CE(SAT)}$ R_{θ} (ohms)* | COLLECTOR CAPACITY (pF) C_{cb} | COLLECTOR TO BASE CURRENT | | |
|-------------|-------------------|---------------------|------|----------|-------------------|--------------------------------------|---|---|----------------------------------|---------------------------|------------|----------|
| | | h_{FE} | | h_{FE} | | | | | | MAX I_{CB} | I_{CB} @ | V_{CB} |
| | | MIN. | MAX. | MIN. | MAX. | | | | | | | |
| 175 | 100 | 14 typ | 9 | 22 | 10 | 14* | 90* | 7 | 2 | 25°C | 30 | |
| 176 | 100 | 31 typ | 18 | 44 | 12 | 14* | 80* | 7 | 2 | 25°C | 30 | |
| 177 | 100 | 38 typ | 18 | 90 | 13 | 13* | 75* | 7 | 2 | 25°C | 30 | |
| 178 | 100 | 56 typ | 37 | 90 | 14 | 13* | 70* | 7 | 2 | 25°C | 30 | |
| 179 | 100 | 100 typ | 78 | 333 | 15 | 12* | 70* | 7 | 2 | 25°C | 30 | |
| 180 | 100 | 18 typ | 9 | 22 | 10 | 11* | 0.5 | 7 | 20 | 150°C | 30 | |
| 181 | 100 | 27 typ | 18 | 44 | 11 | 11* | 0.45 | 7 | 20 | 150°C | 30 | |
| 182 | 100 | 36 typ | 18 | 90 | 12 | 12* | 0.42 | 7 | 20 | 150°C | 30 | |
| 183 | 100 | 45 typ | 37 | 90 | 13 | 12* | 0.4 | 7 | 20 | 150°C | 30 | |
| 184 | 100 | 78 typ | 78 | 333 | 15 | 12* | 0.4 | 7 | 20 | 150°C | 30 | |
| 185 | 100 | 28 | 90 | 37 | 90 | 13 | 12* | 7 | 500 | 25°C | 30 | |
| 186 | 100 | 29 | 95 | 18 | 30 | 30 | 75* | 1.4 | 1 | 25°C | 20 | |
| 187 | 100 | 45 | 150 | 39 | 45 | 45 | 75* | 1.4 | 1 | 25°C | 20 | |
| 188 | 100 | | 18 | 44 | 30 | 39 | 0.53 | 2 | 50 | 150°C | 30 | |
| 189 | 100 | | 37 | 90 | 30 | 44 | 0.56 | 2 | 50 | 150°C | 30 | |
| 190 | 100 | | 78 | 333 | 34 | 45 | 0.47 | 2 | 50 | 150°C | 30 | |
| 191 | 100 | MIN. ⁷ | MAX. | | f_{MAX} (mc) | R_{BBO} (K ohms) | V_E (SAT) | I_{B2} (ma) | I_{EO} | V_{BEE} | | |
| 192 | 100 | .51 | .62 | | 0.9 | 5.6 | 3.1 | 12 | 20 | 150°C | 10 | |
| 193 | 100 | .51 | .62 | | 0.7 | 7.5 | 3.3 | 12 | 20 | 150°C | 10 | |
| 194 | 100 | .56 | .68 | | 0.8 | 5.6 | 3.4 | 12 | 20 | 150°C | 10 | |
| 195 | 100 | .56 | .68 | | 0.7 | 7.5 | 3.6 | 12 | 20 | 150°C | 10 | |
| 196 | 100 | .62 | .75 | | 0.7 | 5.6 | 3.8 | 12 | 20 | 150°C | 10 | |
| 197 | 100 | .62 | .75 | | 0.65 | 7.5 | 3.9 | 12 | 20 | 150°C | 10 | |
| 198 | 100 | 0.47 | 0.62 | | | 9.1 Max. | 5 Max. | 12 | 12 | 25°C | 30 | |
| 199 | 100 | 0.47 | 0.62 | | | 9.1 Max. | 5 Max. | 12 | 12 | 25°C | 30 | |
| 200 | 100 | 0.47 | 0.62 | | | | 5 Max. | 0.2 Max. | 0.2 | 25°C | 30 | |
| 201 | 100 | MIN. ^{hFE} | MAX. | | f_{α} (mc) | G_p | $V_{CE(SAT)}$ R_{θ} (ohms)* | C_{cb} | MAX. I_{CB} | V_{CB} | | |
| 202 | 100 | 12 | 36 | | 10 | | 25 Max. | | 10 | 25°C | 30 | |
| 203 | 100 | 12 | 36 | | 10 | | 25 Max. | | 10 | 25°C | 30 | |
| 204 | 100 | 30 | 90 | | 10 | | 25 Max. | | 10 | 25°C | 30 | |
| 205 | 100 | 30 | 90 | | 10 | | 25 Max. | | 10 | 25°C | 30 | |
| 206 | 100 | 12 | 36 | | 10 | | 10* | | 10 | 25°C | 30 | |
| 207 | 100 | 30 | 90 | | 10 | | 10* | | 10 | 25°C | 30 | |
| 208 | 100 | 30 | 90 | | 10 | | 10* | | 10 | 25°C | 30 | |
| 209 | 100 | 34 | 95 | 30 | 1.3 | | 0.090 | 40 | 16 | 25°C | 45 | |
| 210 | 100 | 18 | 43 | | 1 | | 0.090 | 40 | 16 | 25°C | 45 | |
| 211 | 100 | 25 | 42 | 18 | 41 | 2 | 0.070 | 25 | 10 | 25°C | 30 | |
| 212 | 100 | 34 | 85 | 30 | 84 | 2.5 | 0.075 | 25 | 10 | 25°C | 30 | |
| 213 | 100 | 53 | 99 | 44 | 86 | 3 | 0.080 | 25 | 10 | 25°C | 30 | |
| 214 | 100 | 72 | 121 | 80 | 129 | 3.3 | 0.090 | 25 | 10 | 25°C | 30 | |
| 215 | 100 | 79 | 140 | 80 | 129 | 4.2 | 0.090 | 26 | 12 | 25°C | 30 | |
| 216 | 100 | 70 | 148 | 80 | 120 | 4.2 | 0.090 | 26 | 12 | 25°C | 30 | |
| 217 | 100 | 25 | 42 | 38 | 41 | 3.2 | 0.070 | 26 | 12 | 25°C | 30 | |
| 218 | 100 | 34 | 85 | 30 | 84 | 3.5 | 0.075 | 26 | 12 | 25°C | 30 | |
| 219 | 100 | 53 | 90 | 44 | 88 | 4.0 | 0.080 | 26 | 12 | 25°C | 30 | |
| 220 | 100 | 30 | 150 | | 5 Min. | | 0.15 | 20 Max. | 6 | 25°C | 20 | |
| 221 | 100 | 30 | 120 | | 5 Min. | | .15 Max. | 20 Max. | 6 | 25°C | 13 | |
| 222 | 100 | 30 | 150 | | 3 Min. | | 0.1 | 20 Max. | 6 | 25°C | 15 | |
| 223 | 100 | 30 | 150 | | 5 Min. | | 0.08 | 20 Max. | 6 | 25°C | 20 | |
| 224 | 100 | 30 | 150 | | 5 Min. | | 0.2 Max. | 20 Max. | 6 | 25°C | 20 | |
| 225 | 100 | 44 | 150 | | 10 Min. | | 0.07 | 20 Max. | 6 | 25°C | 12 | |
| 226 | 100 | | | | 4 Min. | | 0.14 | 20 Max. | 5 | 25°C | 12 | |
| 227 | 100 | | | | 4 Min. | | .15 Max. | 20 Max. | 90 | 80°C | 12 | |
| 228 | 100 | | | | 6 | | | 12 | 5 | 25°C | 12 | |
| 229 | 100 | | | | 7 | | | 12 | 5 | 25°C | 12 | |
| 230 | 100 | 30 | | | 5 Min. | | 0.2 Max. | 20 Max. | 6 | 25°C | 12 | |
| 231 | 100 | 34 | 80 | | 1.3 | | 0.08 | 40 | 16 | 25°C | 45 | |
| 232 | 100 | 18 | 43 | | 1.3 | | .090 | 40 | 25 | 25°C | 65 | |
| 233 | 100 | 45 | 135 | 30 | 200 | 9 | | 3 | 3 | 25°C | 15 | |
| 234 | 100 | 45 | 135 | 30 | 200 | 9 | 31 (455Kc) | 3 | 3 | 25°C | 15 | |
| 235 | 100 | 34 | 200 | | 9 | | 31 (455Kc) | 0.23 | 2.4 | 25°C | 15 | |
| 236 | 100 | | | | 9 | | 28 (455Kc) | | | | | |
| 237 | 100 | 17 | 90 | 20 | 200 | 9 | | 0.35 | 2.5 | 25°C | 15 | |
| 238 | 100 | 17 | 90 | 28 | 200 | 9 | | 0.35 | 2.5 | 71°C | 15 | |
| 239 | 100 | 20 | 60 | | | 6 | | 12 | 20 | 25°C | 25 | |
| 240 | 100 | 30 | 110 | | | 6.0 | | 12 | 35 | 25°C | 25 | |
| 241 | 100 | 80 | 180 | | 5 Min. | | | 12 | 10 | 25°C | 25 | |
| 242 | 100 | 48 | 120 | | 8 | | 0.10 | 12 | 80 | 71°C | 25 | |
| 243 | 100 | 80 | 240 | | 12.5 | | 0.085 | 12 | 80 | 71°C | 25 | |
| 244 | 100 | 100 | 200 | | 17 | | 0.075 | 12 | 80 | 71°C | 25 | |
| 245 | 100 | 17 | 90 | 26 | 200 | 9 | | 0.35 | 2.5 | 25°C | 15 | |
| 246 | 100 | 40 | 100 | | 9.0 | | 0.1 | 2.5 | 1.5 | 25°C | 15 | |
| 247 | 100 | 30 | 300 | | 60 | | 0.2 | 6 | 5 | 25°C | 10 | |
| 248 | 100 | 30 | 300 | | 60 | | 0.2 | 6 | 5 | 25°C | 15 | |
| 249 | 100 | 40 | 200 | | 8 | | 0.10 | 12 | 6 | 25°C | 25 | |
| 250 | 100 | 60 | 300 | | 12 | | 0.09 | 12 | 6 | 25°C | 25 | |
| 251 | 100 | 80 | | | 17 | | 0.08 | 12 | 6 | 25°C | 25 | |
| 252 | 100 | 8 | 90 | | | | 0.26 | | 5 | 25°C | 75 | |
| 253 | 100 | 17 | 90 | | 9.0 | | 0.1 | 2.5 | 1.5 | 25°C | 15 | |



RECTIFIER CELLS

General Electric's work in subduing Thermal Fatigue, a major Semiconductor killer, has helped earn it the reputation of being the quality Semiconductor Rectifier producer of the industry. In addition, the Rectifier Components Department has recognized the problems associated with Transient Voltages and has rated its devices accordingly.

In the medium and high-current rectifiers, General Electric has completely eliminated soft solder joints, thus greatly reducing the problem of thermal fatigue. This means that G-E Rectifiers and Controlled Rectifiers can be worked right up to maximum current and temperature ratings, even on highly cyclical loads.

In addition, all General Electric rectifiers and Controlled Rectifiers carry *transient* PRV ratings which give the user additional protection against voltage transients.

The rectifier cells shown are listed in ascending order based on forward current ratings in each section. Maximum full load voltage drop is taken at full cycle average.

Complete specifications are available through your Semiconductor Products District Sales office or through your authorized G-E Semiconductor Distributor.

GERMANIUM LOW CURRENT RECTIFIER CELLS UP TO 1200 MA UP TO 400 PRV



| JEDEC or GE Type Number | PRV | Max. Inc. at T _C | Max. Peak Current | Max. Rev. Current (Full Cycle Av.) | Max. Full Load Voltage Drop | Max. Oper. Temp. |
|-------------------------|-----|-----------------------------|-------------------|--------------------------------------|-----------------------------|------------------|
| 1N93 | 300 | @ 55° C 75 ma | 25 A | .6 ma | .18V | 95° |
| USN 1N93 | 300 | 75 ma | 25 A | .6 ma | .18V | 95° |
| 1N315 | 300 | 75 ma | 25 A | Min. Fwd./Rev. Ratio- 700 @ 55° C | | 85° |
| USAF 1N315 | 300 | 75 ma | 25 A | Min. Fwd./Rev. Ratio- 700 @ 55° C | | 85° |
| 1N368 | 200 | 100 ma | 25 A | .3 ma @ 150 V.D.C. | .48V | 55° |
| 1N92 | 200 | 100 ma | 25 A | .95 ma | .19V | 95° |
| 1N91 | 100 | 150 ma | 25 A | 1.35 ma | .22V | 95° |
| 1N153 | 300 | 750 ma | 25 A | | | 95° |
| 1N158 | 400 | 1000 ma | 25 A | | | 95° |
| 1N152 | 200 | 1000 ma | 25 A | | | 95° |
| 1N151 | 100 | 1200 ma | 25 A | | | 95° |

COMMENTS

Industry standard for high reliability units. Feature extremely low forward resistance, high back resistance.

SILICON SUBMINIATURE GLASS RECTIFIER CELLS (Lead Mounted) UP TO 400 MA UP TO 600 PRV



| JEDEC or GE Type Number | Repetitive PRV | Transient PRV | Max. Inc. at T _C | Max. Rev. Cur. (Full Cycle Av.) | Max. Full Load Voltage Drop | Max. Oper. Temp. |
|-------------------------|----------------|---------------|-----------------------------|---------------------------------|-----------------------------|------------------|
| | | | | @ 100° C | @ 25° C | |
| 1N645 | 225 | 275 | @ 25° C 400 ma | @ 100° C 15 μA | @ 25° C 1V | 175° |
| 1N646 | 300 | 360 | 400 ma | 15 μA | 1V | 175° |
| 1N647 | 400 | 480 | 400 ma | 20 μA | 1V | 175° |
| 1N648 | 500 | 600 | 400 ma | 20 μA | 1V | 175° |
| 1N649 | 600 | 720 | 400 ma | 25 μA | 1V | 175° |
| 1N677 | 100 | 120 | 400 ma | .2 ma | 1V | 175° |

1N676-1N679, 1N681-1N687 and 1N689 are also available in this package.

COMMENTS

Designed for maximum thermal conductance. Rugged design to meet military requirements.

SILICON LOW CURRENT RECTIFIER CELLS (Lead Mounted) UP TO 750 MA UP TO 1000 PRV



| SEDC or SE Type Number | PRV | Max. In- put F.T. Avg. | Max. Peak 1 cycle Surge | Max. Rev. Cur. (Full Cycle Av.) | Max. Full Load Volt- age Drop | Max. Oper. °C | COMMENTS |
|------------------------------|------|---------------------------|-------------------------------|---------------------------------------|-------------------------------------|---------------------|--|
| 1N440 | 100 | @ 50°C | 15 A | @ 25°C | @ 25°C | 150° | Refer also to 1N440-B-5B Specification Sheet. |
| 1N441 | 200 | 300 ma | 15 A | .3 μa | 1.5V | 150° | |
| 1N442 | 300 | 300 ma | 15 A | .75 μa | 1.5V | 150° | |
| 1N443 | 400 | 300 ma | 15 A | 1.0 μa | 1.5V | 150° | |
| 1N444 | 500 | 300 ma | 15 A | 1.75 μa | 1.5V | 150° | |
| 1N445 | 600 | 300 ma | 15 A | 2.0 μa | 1.5V | 150° | |
| 1N599 | 50 | @ 25°C | 10 A | 1.0 μa | @ 200 ma | 150° | Refer also to 1N440-B-5B Specification Sheet. |
| 1N599A | 50 | 600 ma | 10 A | 1.0 μa | 1.5V | 150° | |
| 1N600 | 100 | 600 ma | 10 A | 1.0 μa | 1.5V | 150° | |
| 1N600A | 100 | 600 ma | 10 A | 1.0 μa | 1.5V | 150° | |
| 1N601 | 150 | 600 ma | 10 A | 1.0 μa | 1.5V | 150° | |
| 1N601A | 150 | 600 ma | 10 A | 1.0 μa | 1.5V | 150° | |
| 1N602 | 200 | 600 ma | 10 A | 1.0 μa | 1.5V | 150° | |
| 1N602A | 200 | 600 ma | 10 A | 1.0 μa | 1.5V | 150° | |
| 1N603 | 300 | 600 ma | 10 A | 1.0 μa | 1.5V | 150° | |
| 1N603A | 300 | 600 ma | 10 A | 1.0 μa | 1.5V | 150° | |
| 1N604 | 400 | 600 ma | 10 A | 1.5 μa | 1.5V | 150° | |
| 1N604A | 400 | 600 ma | 10 A | 1.5 μa | 1.5V | 150° | |
| 1N605 | 500 | 600 ma | 10 A | 2.0 μa | 1.5V | 150° | |
| 1N605A | 500 | 600 ma | 10 A | 2.0 μa | 1.5V | 150° | |
| 1N606 | 600 | 600 ma | 10 A | 2.5 μa | 1.5V | 150° | |
| 1N606A | 600 | 600 ma | 10 A | 2.5 μa | 1.5V | 150° | |
| 1N560 | 800 | @ 30°C | 15 A | @ 150°C | @ 150°C | 150° | Now with transient PRV ratings up to 1200V. |
| 1N561 | 1000 | 600 ma | 15 A | .3 ma | 0.5V | 150° | |
| 1N1692 | 100 | @ 50°C | 20 A | @ 100°C | @ 100°C | 115° | Similar to 1N536-47 series except for lower temp. and current operation. Lowest priced series. |
| 1N1693 | 200 | 600 ma | 20 A | .5 ma | 0.6V | 115° | |
| 1N1694 | 300 | 600 ma | 20 A | .5 ma | 0.6V | 115° | |
| 1N1695 | 400 | 600 ma | 20 A | .5 ma | 0.6V | 115° | |
| 1N1696 | 500 | 600 ma | 20 A | .5 ma | 0.6V | 115° | |
| 1N1697 | 600 | 600 ma | 20 A | .5 ma | 0.6V | 115° | |
| 1N444B | 500 | @ 25°C | 15 A | @ 25°C | @ 25°C | 150° | Very low leakage. Ideal for magnetic-amplifier applications. Premium price. |
| 1N445B | 600 | 650 ma | 15 A | 1.75 ma | 1.5V | 150° | |
| 1N440B | 100 | 750 ma | 15 A | 2.0 ma | 1.5V | 150° | |
| 1N441B | 200 | 750 ma | 15 A | 0.3 ma | 1.5V | 165° | |
| 1N442B | 300 | 750 ma | 15 A | 0.75 ma | 1.5V | 165° | |
| 1N443B | 400 | 750 ma | 15 A | 1.0 ma | 1.5V | 165° | |
| 1N1100 | 100 | @ 50°C | 15 A | @ 150°C | @ 150°C | 165° | Refer also to 1N536-540 Specification Sheet. |
| 1N1101 | 200 | 750 ma | 15 A | .3 ma | 1.5V | 165° | |
| 1N1102 | 300 | 750 ma | 15 A | .3 ma | 1.5V | 165° | |
| 1N1103 | 400 | 750 ma | 15 A | .3 ma | 1.5V | 165° | |
| 1N1487 | 100 | @ 25°C | 15 A | @ 125°C | @ 125°C | 140° | Similar to 1N536-47 series. Intermediate temp. operation. Lower priced. |
| 1N1488 | 200 | 750 ma | 15 A | .4 ma | .55V | 140° | |
| 1N1489 | 300 | 750 ma | 15 A | .3 ma | .55V | 140° | |
| 1N1490 | 400 | 750 ma | 15 A | .3 ma | .55V | 140° | |
| 1N1491 | 500 | 750 ma | 15 A | .3 ma | .55V | 125° | |
| 1N1492 | 600 | 750 ma | 15 A | .3 ma | .55V | 120° | |
| 1N536 | 50 | @ 50°C | 15 A | @ 150°C | @ 150°C | 165° | The popular line. Provides maximum forward conductance at high operating temperatures (165°C). Now with transient PRV ratings up to 800V. |
| 1N537 | 100 | 750 ma | 15 A | .4 ma | .5V | 165° | |
| 1N538 | 200 | 750 ma | 15 A | .3 ma | .5V | 165° | |
| 1N539 | 300 | 750 ma | 15 A | .3 ma | .5V | 165° | |
| 1N540 | 400 | 750 ma | 15 A | .3 ma | .5V | 165° | |
| 1N1095 | 500 | 750 ma | 15 A | .3 ma | .5V | 150° | |
| 1N1096 | 600 | 750 ma | 15 A | .3 ma | .5V | 150° | |
| 1N547 | 600 | 750 ma | 15 A | .3 ma | .5V | 165° | |

SILICON LOW CURRENT RECTIFIER CELLS (Insulated Stud) UP TO 1.5 AMPS UP TO 600 PRV



| SEDC or SE Type Number | PRV | Max. In- put M.T.C. | Max. Peak 1 cycle Surge | Max. Rev. Cur. (Full Cycle Av.) | Max. Full Load Volt- age Drop | Max. Oper. °C | COMMENTS |
|------------------------------|-----|---------------------------|-------------------------------|---------------------------------------|-------------------------------------|---------------------|---|
| 1N2881 | 500 | @ 50°C Case | 22 Amps | @ 120°C | @ 120°C | 150° | Identical to the 1N1115-1N1120 series except the stud is electrically insulated from the junction. |
| 1N2882 | 600 | 1.5 Amps | 22 Amps | .3 ma | .65V | 180° | |
| 1N2883 | 120 | 1.5 Amps | 22 Amps | .4 ma | .65V | 165° | |
| 1N2884 | 200 | 1.5 Amps | 22 Amps | .3 ma | .65V | 165° | |
| 1N2885 | 300 | 1.5 Amps | 22 Amps | .3 ma | .65V | 165° | |
| 1N2886 | 400 | 1.5 Amps | 22 Amps | .3 ma | .65V | 165° | |

SILICON LOW CURRENT RECTIFIER CELLS (Stud Mounted) UP TO 1.5 AMPS UP TO 1000 PRV



| JEDEC or GE Type Number | PRV | Max. In- put 1 cycle | Max. Peak 1 cycle | Max. Avg. Cur. (Full A _r) | Max. Peak Load Volt- age Drop | Max. Oper. Temp. °C | COMMENTS |
|-------------------------------|------------|----------------------------|----------------------|---|-------------------------------------|---------------------------|---|
| 1N256 | 570 | @ 135° Case 200 ma | 1 A, 3ms | @ 135° C 25 ma | 2V @ 500 ma | 150° | Refer also to 1N1115-1120 Specification Sheet. |
| 1N340 | 100 | @ 150° Case 200 ma | .10 A | @ 150° C 1 ma | 2V @ 400 ma | 170° | For applications requiring moderate currents operating up to 170°C. |
| 1N349 | 100 | 200 ma | .10 A | 1 ma | 2V @ 400 ma | 170° | |
| 1N337 | 200 | 200 ma | .10 A | 1 ma | 2V @ 400 ma | 170° | |
| 1N346 | 200 | 200 ma | .10 A | 1 ma | 2V @ 400 ma | 170° | |
| 1N335 | 300 | 200 ma | .10 A | 2 ma | 2V @ 400 ma | 170° | |
| 1N344 | 300 | 200 ma | .10 A | 5 ma | 2V @ 400 ma | 170° | |
| 1N333 | 400 | 200 ma | .10 A | 2 ma | 2V @ 400 ma | 170° | |
| 1N342 | 400 | 200 ma | .10 A | 5 ma | 2V @ 400 ma | 170° | |
| 1N339 | 100 | 400 ma | .15 A | 1 ma | 2V @ 800 ma | 170° | |
| 1N348 | 100 | 400 ma | .15 A | 5 ma | 2V @ 800 ma | 170° | |
| 1N336 | 200 | 400 ma | .15 A | 1 ma | 2V @ 800 ma | 170° | |
| 1N345 | 200 | 400 ma | .15 A | 5 ma | 2V @ 800 ma | 170° | |
| 1N334 | 300 | 400 ma | .15 A | 2 ma | 2V @ 800 ma | 170° | |
| 1N343 | 300 | 400 ma | .15 A | 5 ma | 2V @ 800 ma | 170° | |
| 1N332 | 400 | 400 ma | .15 A | 2 ma | 2V @ 800 ma | 170° | |
| 1N341 | 400 | 400 ma | .15 A | 5 ma | 2V @ 800 ma | 170° | |
| 1N562 | 800 | 400 ma | .15 A | 3 ma | .65V @ 150° C | 150° | 1N560-61 mounted on studs. Popular model. |
| 1N563 | 1000 | 400 ma | .15 A | 3 ma | .65V @ 150° C | 150° | |
| 1N550 | 100 | @ 100° Amb. 500 ma | 4 A, 3ms | @ 25° C .5 μa | 1.5V @ 25° C | 150° | Very low leakage for magnetic amplifier applications. The 1N440B-5B series mounted on studs. |
| 1N551 | 200 | 500 ma | 4 A, 3ms | 1.0 μa | 1.5V @ 25° C | 150° | |
| 1N552 | 300 | 500 ma | 4 A, 3ms | 1.5 μa | 1.5V @ 25° C | 150° | |
| 1N553 | 400 | 500 ma | 4 A, 3ms | 2.5 μa | 1.5V @ 25° C | 150° | |
| 1N554 | 500 | 500 ma | 4 A, 3ms | 3.5 μa | 1.5V @ 25° C | 150° | |
| 1N555 | 600 | 500 ma | 4 A, 3ms | 5.0 μa | 1.5V @ 25° C | 150° | |
| 1N254 | 190 | @ 135° Case 400 ma | 1.5 A, 3ms | @ 135° C .1 ma | 1.5V @ 500 ma | 150° | Refer also to 1N1115-1120 Specification Sheet. |
| 1N255 | 380 | 400 ma | 1.5 A, 3ms | .15 ma | 1.5V @ 500 ma | 150° | |
| 1N607 | 50 | @ 100° Amb. 1 A | 2 A, 1 sec | @ 25° C .025 ma | @ 25° C 1.5V @ 200 ma | 150° | Refer also to 1N1115-1120 Specification Sheet, and the 1N550-5 Specification Sheet. |
| 1N607A | 50 | 1 A | 2 A, 1 sec | .001 ma | 1.5V @ 200 ma | 150° | |
| 1N608 | 100 | 1 A | 2 A, 1 sec | .025 ma | 1.5V @ 200 ma | 150° | |
| 1N608A | 100 | 1 A | 2 A, 1 sec | .001 ma | 1.5V @ 200 ma | 150° | |
| 1N609 | 150 | 1 A | 2 A, 1 sec | .025 ma | 1.5V @ 200 ma | 150° | |
| 1N609A | 150 | 1 A | 2 A, 1 sec | .001 ma | 1.5V @ 200 ma | 150° | |
| 1N610 | 200 | 1 A | 2 A, 1 sec | .025 ma | 1.5V @ 200 ma | 150° | |
| 1N610A | 200 | 1 A | 2 A, 1 sec | .001 ma | 1.5V @ 200 ma | 150° | |
| 1N611 | 300 | 1 A | 2 A, 1 sec | .025 ma | 1.5V @ 200 ma | 150° | |
| 1N611A | 300 | 1 A | 2 A, 1 sec | .001 ma | 1.5V @ 200 ma | 150° | |
| 1N612 | 400 | 1 A | 2 A, 1 sec | .025 ma | 1.5V @ 200 ma | 150° | |
| 1N612A | 400 | 1 A | 2 A, 1 sec | .0015 ma | 1.5V @ 200 ma | 150° | |
| 1N613 | 500 | 1 A | 2 A, 1 sec | .025 ma | 1.5V @ 200 ma | 150° | |
| 1N613A | 500 | 1 A | 2 A, 1 sec | .002 ma | 1.5V @ 200 ma | 150° | |
| 1N614 | 600 | 1 A | 2 A, 1 sec | .025 ma | 1.5V @ 200 ma | 150° | |
| 1N614A | 600 | 1 A | 2 A, 1 sec | .0025 ma | 1.5V @ 200 ma | 150° | |
| 1N1115 | 100 | @ 85° Case 1.5 A | 15 A | @ 150° C 4 ma | .65V @ 150° C | 170° | The popular line. 1N536-40, 1N547, 1N1095-6 mounted on studs. |
| 1N1116 | 200 | 1.5 A | 15 A | .3 ma | .65V @ 150° C | 170° | |
| 1N1117 | 300 | 1.5 A | 15 A | .3 ma | .65V @ 150° C | 170° | |
| 1N1118 | 400 | 1.5 A | 15 A | .3 ma | .65V @ 150° C | 170° | |
| 1N1119 | 500 | 1.3 A | 15 A | .3 ma | .65V @ 150° C | 155° | |
| 1N1120 | 600 | 1.3 A | 15 A | .3 ma | .65V @ 150° C | 155° | |
| 1N253 *at 100° C | 95 Case | @ 135° Case 1 A | 4 A, 3ms | @ 135° C .1 ma | 1.5V @ 1 A | 150° | Refer also to 1N1115-1120 Specification Sheet. |

SILICON HIGH CURRENT RECTIFIER CELLS UP TO 70A UP TO 600 PRV



| JEDEC or GE Type Number | Repeti- tive PRV | Transi- ent PRV | Max. In- put @ 150° C Stud Single Phase | Max. 1 Cycle Surge | Max. Instan- t. Leak- age I at Rated PRV (milli- amps.) | Max. Forward Voltage Drop @ 70A DC Single Phase 150° C | Max. Oper. Temp. °C | COMMENTS |
|-------------------------------|------------------------|-----------------------|--|--------------------------|--|---|------------------------------|--|
| 4JA70B | 200 | 300 | 70 A | 1600 A | 30 | .45V | 200° C | Large area junction rectifiers for applications requiring d-c output as high as 70 amps per rectifying element at rms input voltages up to 420 Volts. The 4JA70 is a "double diffused, all hard solder rectifier," which has high surge current capabilities and is highly resistant to thermal fatigue. |
| 4JA70C | 300 | 400 | 70 A | 1600 A | 25 | .45V | 200° C | |
| 4JA70D | 400 | 525 | 70 A | 1600 A | 20 | .45V | 200° C | |
| 4JA70E | 500 | 650 | 70 A | 1600 A | 15 | .45V | 200° C | |
| 4JA70M | 600 | 800 | 70 A | 1600 A | 13 | .45V | 200° C | |

SILICON MEDIUM CURRENT RECTIFIER CELLS UP TO 25 AMPS UP TO 600 PRV

| Part No. (See Note 1) | Rated Forward Current (See Note 2) | Peak Forward Current (See Note 2) | Peak Inverse Voltage (See Note 3) | Peak Reverse Voltage (See Note 3) | Forward Voltage Drop (See Note 4) | | Peak Reverse Leakage Current (See Note 5) |
|---------------------------|------------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|--------------|---|
| | | | | | @ 150°C Stud | @ 100°C Stud | |
| 1N1341A | 50 | 100 | 6A | 150A | 3 ma | .64V | 200* |
| 1N1342A | 100 | 200 | 6A | 150A | 2.5 ma | .64V | 200* |
| 1N1343A | 150 | 300 | 6A | 150A | 2.25 ma | .64V | 200* |
| 1N1344A | 200 | 350 | 6A | 150A | 2.0 ma | .64V | 200* |
| 1N1345A | 300 | 450 | 6A | 150A | 1.75 ma | .64V | 200* |
| 1N1346A | 400 | 600 | 6A | 150A | 1.5 ma | .64V | 200* |
| 1N1347A | 500 | 700 | 6A | 150A | 1.25 ma | .64V | 200* |
| 1N1348A | 600 | 800 | 6A | 150A | 1.0 ma | .64V | 200* |
| 1N1199A | 50 | 100 | 12A | 240A | 3 ma | .55V | 200* |
| 1N1200A | 100 | 200 | 12A | 240A | 2.5 ma | .55V | 200* |
| 1N1201A | 150 | 300 | 12A | 240A | 2.25 ma | .55V | 200* |
| 1N1202A | 200 | 350 | 12A | 240A | 2.0 ma | .55V | 200* |
| 1N1203A | 300 | 450 | 12A | 240A | 1.75 ma | .55V | 200* |
| 1N1204A | 400 | 600 | 12A | 240A | 1.5 ma | .55V | 200* |
| 1N1205A | 500 | 700 | 12A | 240A | 1.25 ma | .55V | 200* |
| 1N1206A | 600 | 800 | 12A | 240A | 1.0 ma | .55V | 200* |
| 25°C T_J | | | | | | | |
| 1N248 | 50 | | 10A | 200A | 5 ma | 1.5V* | 175* |
| 1N249 | 100 | | 10A | 200A | 5 ma | 1.5V* | 175* |
| 1N250 | 200 | | 10A | 200A | 5 ma | 1.5V* | 175* |
| 1N248A | 50 | | 20A | 350A | 5 ma | 1.5V** | 175* |
| 1N248A | 100 | | 20A | 350A | 5 ma | 1.5V** | 175* |
| 1N250A | 200 | | 20A | 350A | 5 ma | 1.5V** | 175* |
| USA-1N2135A | 400 | | 20A | 250A | 40 ma | 1.5V | 150* |
| @ 145°C Stud | | | | | | | |
| 1N2154 | 50 | 100 | 25A | 300A | 5 ma | 0.6V | 200* |
| 1N2155 | 100 | 200 | 25A | 300A | 4.5 ma | 0.6V | 200* |
| 1N2156 | 200 | 350 | 25A | 300A | 4.0 ma | 0.6V | 200* |
| 1N2157 | 300 | 450 | 25A | 300A | 3.5 ma | 0.6V | 200* |
| 1N2158 | 400 | 600 | 25A | 300A | 3.0 ma | 0.6V | 200* |
| 1N2159 | 500 | 700 | 25A | 300A | 2.5 ma | 0.6V | 200* |
| 1N2160 | 600 | 800 | 25A | 300A | 2.0 ma | 0.6V | 200* |

*@ 25A **@ 30A

COMMENTS

Designed for use in the 2 to 30 ampere range. High junction temperature rating and extremely low forward voltage drop and thermal impedance permit high current operation with minimum space requirements. May be mounted directly to a chassis or fin or may be insulated by using insulating kit provided. All units are also available with negative polarity (stud is anode).

THESE GENERAL ELECTRIC SILICON AND GERMANIUM RECTIFIERS MEET MILITARY SPECIFICATIONS

| Type | Military Specification | Single Phase Max. Ratings | |
|------------------|------------------------|---------------------------|-------------------------|
| | | PRV | I _{FM} @ Temp. |
| Germanium | | | |
| USAF 1N315 | MIL-E-1/1085 | 300 Volts | 75 ma @ 55°C amb. |
| USA 1N249B1 | MIL-E-1/1088 | 100 Volts | 100 ma @ 71°C amb. |
| Silicon | | | |
| USA 1N249B1 | MIL-S-19500/134 | 125 Volts | 30 A @ 150°C case |
| USA 1N249B1 | | 250 Volts | 30 A @ 150°C case |
| JAN 1N253 | MIL-E-1/1024A | 100 Volts | 1 A @ 135°C case |
| JAN 1N254 | MIL-E-1/989B | 200 Volts | 400 ma @ 135°C case |
| JAN 1N295 | MIL-E-1/990B | 400 Volts | 400 ma @ 135°C case |
| JAN 1N296 | MIL-E-1/991B | 600 Volts | 200 ma @ 135°C case |
| JAN 1N300 | MIL-E-1/1084A | 240 Volts | 250 ma @ 150°C amb. |
| USAF 1N530 | MIL-E-1/1089 | 240 Volts | 250 ma @ 150°C amb. |
| JAN 1N540 | MIL-E-1/1085A | 480 Volts | 250 ma @ 150°C amb. |
| USAF 1N540 | MIL-E-1/1089 | 400 Volts | 250 ma @ 150°C amb. |
| JAN 1N547 | MIL-E-1/1083A | 720 Volts | 250 ma @ 150°C amb. |
| USAF 1N547 | MIL-E-1/1089 | 600 Volts | 250 ma @ 150°C amb. |
| USA 1N2135A | MIL-S-19500/134 | 500 Volts | 20 A @ 150°C case |





RECTIFIER STACKS

GERMANIUM LOW CURRENT

Up to 6 amps @ 55°C amb.
Up to 630 PRV.



4JA211 Stacks: The industry's most widely-used semiconductor rectifier series. Hundreds of thousands in use. May be arranged in stacks up to 12 fins to produce more than 160 various circuit configurations. Small, lightweight, excellent regulation.

SILICON LOW CURRENT

Up to 18 amps @ 25°C amb.
Up to 3360 PRV.



4JA411 Stacks: Combine high temperature operation (up to 150° C.) with increased ratings (up to 18 amps d-c). Hundreds of stack combinations to meet a variety of circuit conditions. High efficiency plus excellent regulation.

SILICON MEDIUM CURRENT

Up to 65 amps @ 55°C amb.
Up to 1800 PRV.



4JA2011 Stacks: Provide a wide range of power applications with d-c outputs up to 32 amps.
4JA2511 Stacks: Provide a wide range of power applications with d-c outputs up to 50 amps.
4JA3511 Stacks: Provide a wide-range of power applications with d-c outputs up to 65 amps.

SILICON MEDIUM CURRENT (5" FIN)

Up to 108 amps @ 55°C amb.
Up to 1800 PRV.



4JA3512 Stacks: This 5" square fin assembly makes optimum use of the 1N2154 series 25 Ampere cell. This stack provides a wide range of power applications with d-c outputs up to 108 Amperes.

SILICON HIGH CURRENT

Up to 573 amps @ 35°C amb.
Up to 840 PRV.



4JA6011 Stacks: Hundreds of combinations available in various circuit configurations. D-c outputs up to 573 amps.

POTTED RECTIFIER CIRCUITS

Up to:
4JA220 4 amps @ 55°C amb.
4JA420 2.0 amps @ 50°C amb.
4JA421 .65 amps @ 25°C amb.
4JA422 1.50 amps @ 25°C amb.

Up to:
1800 PRV.
3000 PRV.
10000 PRV.
2000 PRV.



4JA220, 4JA420-421-422 Series: Mounted in standard eight-pin tube base (4JA220-420 Series) or in rectangular design with solder lug connections (4JA221-421-422 Series). Available in a large number of circuit configurations. One to 20 cells may be potted in a single circuit. Individual cell specifications determine ratings. 4JA220 Series utilize germanium 1N91-93 cells. 4JA420-421-422 Series utilize silicon 1N536-540, 1N1095 cells. (See BASIC-RECTIFIER-CELL LISTING.)



SILICON CONTROLLED RECTIFIERS

These revolutionary devices, introduced by General Electric, can do the work of thyratrons, ignitrons, magnetic amplifiers, power transistors, relays, switches and circuit breakers in many power control and switching applications.

Presenting:

A FULL LINE OF SILICON CONTROLLED RECTIFIERS

SILICON LOW CURRENT CONTROLLED RECTIFIERS UP TO 7.0 AMPS UP TO 400 PRV

| Part Number | Current (A) | Case Temp (°C) | Peak Repetitive (V) | Peak Non-Repetitive (V) | Forward Voltage (V) | Reverse Current (mA) | Reverse Leakage Current (μA) | Operating Temp (°C) |
|------------------------|-------------|-------------------|---------------------|-------------------------|---------------------------------|----------------------|------------------------------|---------------------|
| ZJ203 | | | | | | | | |
| ZJ203U | 25 | 1 A @ 82°C case | 125° | 125° | .75V, 200 μA | 25°C T _J | | |
| ZJ203F | 50 | 1 A @ 82°C case | 125° | 125° | .75V, 200 μA | 25°C T _J | | |
| ZJ203A | 100 | 1 A @ 82°C case | 125° | 125° | .75V, 200 μA | 25°C T _J | | |
| ZJ203B | 150 | 1 A @ 82°C case | 125° | 125° | .75V, 200 μA | 25°C T _J | | |
| ZJ203D | 200 | 1 A @ 82°C case | 125° | 125° | .75V, 200 μA | 25°C T _J | | |
| ZJ203H | 250 | 1 A @ 82°C case | 125° | 125° | .75V, 200 μA | 25°C T _J | | |
| ZJ203C | 300 | 1 A @ 82°C case | 125° | 125° | .75V, 200 μA | 25°C T _J | | |
| 2N1929-2N1935 | | | | | | | | |
| 2N1929 | 25 | 1.1 A @ 25°C case | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1930 | 50 | 1.1 A @ 25°C case | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1931 | 100 | 1.1 A @ 25°C case | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1932 | 150 | 1.1 A @ 25°C case | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1933 | 200 | 1.1 A @ 25°C case | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1934 | 250 | 1.1 A @ 25°C case | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1935 | 300 | 1.1 A @ 25°C case | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1770A-2N1777A | | | | | | | | |
| 2N1770A | 25 | 7 A @ 115°C stud | 150° | 150° | 2V, 6 ma @ 150°C T _J | | | |
| 2N1771A | 50 | 7 A @ 115°C stud | 150° | 150° | 2V, 6 ma @ 150°C T _J | | | |
| 2N1772A | 100 | 7 A @ 115°C stud | 150° | 150° | 2V, 6 ma @ 150°C T _J | | | |
| 2N1773A | 150 | 7 A @ 115°C stud | 150° | 150° | 2V, 6 ma @ 150°C T _J | | | |
| 2N1774A | 200 | 7 A @ 115°C stud | 150° | 150° | 2V, 6 ma @ 150°C T _J | | | |
| 2N1775A | 250 | 7 A @ 115°C stud | 150° | 150° | 2V, 6 ma @ 150°C T _J | | | |
| 2N1776A | 300 | 7 A @ 115°C stud | 150° | 150° | 2V, 6 ma @ 150°C T _J | | | |
| 2N1777A | 400 | 7 A @ 115°C stud | 150° | 150° | 2V, 6 ma @ 150°C T _J | | | |
| 2N1770 | 25 | 6 A @ 70°C stud | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1771 | 50 | 6 A @ 70°C stud | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1772 | 100 | 6 A @ 70°C stud | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1773 | 150 | 6 A @ 70°C stud | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1774 | 200 | 6 A @ 70°C stud | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1775 | 250 | 6 A @ 70°C stud | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1776 | 300 | 6 A @ 70°C stud | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |
| 2N1777 | 400 | 6 A @ 70°C stud | 125° | 150° | 2V, 8 ma @ 125°C T _J | | | |

SILICON MEDIUM CURRENT CONTROLLED RECTIFIERS UP TO 25 AMPS UP TO 500 PRV

| Part Number | Current (A) | Case Temp (°C) | Peak Repetitive (V) | Peak Non-Repetitive (V) | Forward Voltage (V) | Reverse Current (mA) | Reverse Leakage Current (μA) | Operating Temp (°C) |
|---------------------------------|-------------|------------------|---------------------|-------------------------|------------------------------------|----------------------|------------------------------|---------------------|
| 2N681-2N689 | | | | | | | | |
| 2N681 | 25 | 25 A @ 57°C stud | 125° | 150° | 3V, 25 ma @ 125°C T _J | | | |
| 2N682 | 50 | 25 A @ 57°C stud | 125° | 150° | 3V, 25 ma @ 125°C T _J | | | |
| 2N683 | 100 | 25 A @ 57°C stud | 125° | 150° | 3V, 25 ma @ 125°C T _J | | | |
| 2N684 | 150 | 25 A @ 57°C stud | 125° | 150° | 3V, 25 ma @ 125°C T _J | | | |
| 2N685 | 200 | 25 A @ 57°C stud | 125° | 150° | 3V, 25 ma @ 125°C T _J | | | |
| 2N686 | 250 | 25 A @ 57°C stud | 125° | 150° | 3V, 25 ma @ 125°C T _J | | | |
| 2N687 | 300 | 25 A @ 57°C stud | 125° | 150° | 3V, 25 ma @ 125°C T _J | | | |
| 2N688 | 400 | 25 A @ 57°C stud | 125° | 150° | 3V, 25 ma @ 125°C T _J | | | |
| 2N689 | 500 | 25 A @ 57°C stud | 125° | 150° | 3V, 25 ma @ 125°C T _J | | | |
| 2N1842-2N1850 | | | | | | | | |
| 2N1842 | 25 | 16 A @ 25°C stud | 100° | 125° | 3.5V, 50 ma @ 100°C T _J | | | |
| 2N1843 | 50 | 16 A @ 25°C stud | 100° | 125° | 3.5V, 50 ma @ 100°C T _J | | | |
| 2N1844 | 100 | 16 A @ 25°C stud | 100° | 125° | 3.5V, 50 ma @ 100°C T _J | | | |
| 2N1845 | 150 | 16 A @ 25°C stud | 100° | 125° | 3.5V, 50 ma @ 100°C T _J | | | |
| 2N1846 | 200 | 16 A @ 25°C stud | 100° | 125° | 3.5V, 50 ma @ 100°C T _J | | | |
| 2N1847 | 250 | 16 A @ 25°C stud | 100° | 125° | 3.5V, 50 ma @ 100°C T _J | | | |
| 2N1848 | 300 | 16 A @ 25°C stud | 100° | 125° | 3.5V, 50 ma @ 100°C T _J | | | |
| 2N1849 | 400 | 16 A @ 25°C stud | 100° | 125° | 3.5V, 50 ma @ 100°C T _J | | | |
| 2N1850 | 500 | 16 A @ 25°C stud | 100° | 125° | 3.5V, 50 ma @ 100°C T _J | | | |
| C40 Series (25V to 300V) | | | | | | | | |
| C40U | 25 | | | | | | | |
| C40F | 50 | | | | | | | |
| C40A | 100 | | | | | | | |
| C40G | 150 | | | | | | | |
| C40B | 200 | | | | | | | |
| C40H | 250 | | | | | | | |
| C40C | 300 | | | | | | | |

Other ratings and characteristics are the same as for 2N681-689, except that turn-off time is guaranteed at less than 12 microseconds. These units are designed specifically for fast turn-off time for inverter applications.



2N1909-2N1916
C55 Series
(25V to 400V)

SILICON HIGH CURRENT CONTROLLED RECTIFIERS UP TO 110 AMPS UP TO 400 PRV

| Part No. | PRV | Current | Temp. Range | Temp. Range | Temp. Range |
|----------|-----|--------------------|-------------|-------------|-----------------------------------|
| 2N1909 | 25 | 110 A @ 59° C stud | 125° | 125° | 3V, 40 ma @ 125° C T ₁ |
| 2N1910 | 50 | 110 A @ 59° C stud | 125° | 125° | 3V, 40 ma @ 125° C T ₁ |
| 2N1911 | 100 | 110 A @ 59° C stud | 125° | 125° | 3V, 40 ma @ 125° C T ₁ |
| 2N1912 | 150 | 110 A @ 59° C stud | 125° | 125° | 3V, 40 ma @ 125° C T ₁ |
| 2N1913 | 200 | 110 A @ 59° C stud | 125° | 125° | 3V, 40 ma @ 125° C T ₁ |
| 2N1914 | 250 | 110 A @ 59° C stud | 125° | 125° | 3V, 40 ma @ 125° C T ₁ |
| 2N1915 | 300 | 110 A @ 59° C stud | 125° | 125° | 3V, 40 ma @ 125° C T ₁ |
| 2N1916 | 400 | 110 A @ 59° C stud | 125° | 125° | 3V, 40 ma @ 125° C T ₁ |
| C55U | 25 | | | | |
| C55F | 50 | | | | |
| C55A | 100 | | | | |
| C55G | 150 | | | | |
| C55B | 200 | | | | |
| C55H | 250 | | | | |
| C55C | 300 | | | | |

Other ratings and characteristics are the same as for C50, except that turn off time is guaranteed at less than 20 microseconds. These units are designed specifically for fast turn-off times for inverter applications.



SELENIUM RECTIFIERS

General Electric's unique ACE* vacuum process provides highly reliable selenium cells, known for long life and high temperature operation. This Vac U-Sel® process assures you of uniformity from cell to cell and excellent margins of safety.

Capitalize on the low cost versatility of design inherent in quality selenium products. Typical G-E types are shown in a variety of voltages and cell sizes, finishes and mountings. Many other types to suit individual needs are available on request.

* Automatic Continuous Evaporation



Three dual diode types are offered as universal replacements for AFC circuits in most TV receivers. The G-E units have proven reliability, with more units in service than any other make. See ECG-459 for more details.



This is a truly high quality device being offered for the first time by G-E to the so-called entertainment market. It can be used for any conventional 65 ma power supply in radios, phonos, intercoms, etc., using this type of product. It has full UL approval and provides both size and cost advantages.



Many special types have been developed to meet unusual requirements. Some of these are (B) the total "bridge" hermetically sealed in oil (O) the metal-clad pee-wee for very low power ratings for extremely dependable service (L) a multi-element unit for a fourteen stage "gate" used on a high speed printer.



Thyrector Diodes are a recent production item in the selenium line. They have unique capabilities which enable them to be used as voltage surge protectors for guarding single crystal rectifiers and transistors against damaging voltage transients. See 180.30 for complete application and catalogue information.



Tubular assemblies house cells from $\frac{3}{32}$ " dia. to $\frac{1}{8}$ " dia. stack up to as many as 250 in series. This provides a range of ratings from a few microamperes at 15 volts up to a few hundred milliamperes at 15,000 volts.



The "paper tube" line is designed for commercial applications with lowest cost at no sacrifice in quality. The package is used on all 3 miniature cell sizes, $\frac{3}{32}$ ", $\frac{1}{32}$ " and $\frac{1}{16}$ " round, in both standard and contact protection (arc suppression) types.

GENERAL ELECTRIC INTRODUCES THE FIRST SILICON CONTROLLED RECTIFIERS TO MEET MILITARY SPECIFICATIONS



| Type | Military Specification | Single Phase Max. Ratings | |
|-----------|------------------------|---------------------------|------------------------|
| | | PRV | I _m @ 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 |

NEW SELENIUM PRODUCTS

Soon to be in production is a complete new line of cartridge (tubular) miniature rectifiers. These will incorporate a new "thin cell" which will greatly reduce the size of the units. The illustration demonstrates this by comparing one of the new types (A) to our present type (and typical competitive units) (B). The substantial improvement is made at no reduction in performance but at a reduction in price. Available now in limited quantity.



The standard stud intermediate line includes some of the most reliable products in its power range - 100 ma to 1 amp, 15 to over 4,000 volts. The cost per watt is particularly attractive.



The riveted (and tube mounted) assembly is limited to a dozen or more cells per unit. It is very compact and can even be provided with no spacing on very tight jobs. No derating is required on Vac-U-Sel rectifiers.



Imbedded cell configurations demonstrate the high temperature ratings of Vac-U-Sel rectifiers. Even though imbedded, no current or voltage derating is necessary. Available in all cell sizes up to 2" square.



Large plate stacks use cells up to 5 x 6" in size, and are rated to 36 Vrms per cell. The high density capabilities of Vac-U-Sel rectifiers very often enable them to be substituted for cells of much more active area with no sacrifice of life expectancy.



Oil immersed units are used to satisfy very unusual operating conditions such as highly corrosive atmospheres, heavy surge currents, etc., where size is no objection.



Copper Oxide rectifiers have been manufactured by General Electric for over 30 years. This line has proven reliability and has been able to do jobs beyond the reach of other semiconductors. Its low voltage drop, high thermal capacity and virtually indestructible characteristics make it unique in the field.

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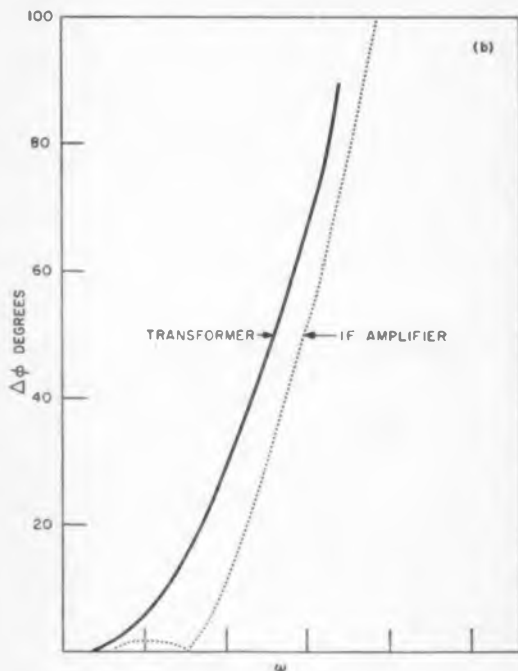
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2. Rise time depends, among other things, on a per cent tolerance of phase deviation from linearity. Phase deviation should not be frequency weighted.

3. Ripple in the response to a step depends, among other things, on a phase deviation weighted inversely with frequency so as to make the low frequencies important.

4. Minimal rise time requires unity gain till the over-all phase deviation is 90 deg. Then the gain should fall away rapidly.

5. Minimal ripple requires a slowly falling gain which is low when the phase deviation is large.

6. Phase linearity should be better than amplitude linearity so cascading will decrease ripple.

7. Complete ripple control requires a lot of bandwidth.

8. The maximum delay-to-rise-time ratio obtainable by cascading sections equals the number of sections for a low-pass section, and double the number of sections for an all-pass or bandpass section.

9. If it is necessary to make a high quality network by cascading sections, it is better to use fewer high quality sections than more low quality sections.

10. Sometimes it is best to leave well enough alone. ■ ■

◀ CIRCLE 39 ON READER-SERVICE CARD

WHO SAID IT COULDN'T BE DONE?



OHMITE'S NEW ONE-WATT Vitreous-Enameled Resistor With Axial Leads

Lots of people thought this tiny "1-watter" was impossible. But here it is. And for the first time in this power rating, circuit designers can get all the advantages of a wire-wound, vitreous-enameled resistor with axial leads—high temperature operation, up to 350°C; $\pm 5\%$ tolerance; low temperature coefficient; low "noise" level; stability; and strong, welded construction.

Construction is the same as Ohmite's 3, 5, and 10-watt sizes—including ceramic core, uniform winding, tough Ohmite vitreous enamel coating, and traditional Ohmite reliability.

Resistance values range from 1 to 6000 ohms. But you can find out all about this exclusive Ohmite development by writing for Bulletin 147F. Do it now!

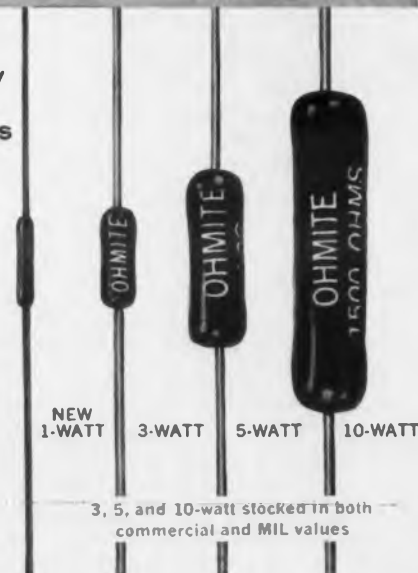
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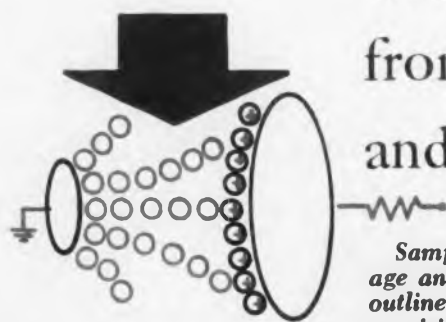
CIRCLE 40 ON READER-SERVICE CARD

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Sizes



Transistor Switching Speed from Base Storage Charges and their Lifetimes

Part 2



Sample predictions are illustrated for determining rise, fall, storage and delay time using the stored charge and lifetime concept outlined in Part 1 (ELECTRONIC DESIGN, March 15, 1961, p 52). The precision of the predictions is within 10 to 15 per cent in most cases. Methods for measurement of carrier lifetime are outlined.

Y. C. Hwang, D. S. Cleverley, D. J. Monsour
General Electric Co.
Syracuse, N. Y.

BASE STORAGE charges and their lifetimes have been shown to be basic quantities which can be used to characterize a switching transistor (Part 1, ED, March 15, 1961, p 52). Predictions of rise, fall, delay and storage time can be made with accuracies in the order of a few nanoseconds in many cases. Sample predictions for alloy and mesa devices show agreement between experimental and predicted rise and delay times in the order of 10 per cent; storage and fall time agreement is within 15 per cent.

Measurement of the Lifetime

Two quantities which have been previously defined are

$$\tau_a = \frac{Q_B}{I_B} \text{ in the active state or below saturation}$$

$$\tau_b = \frac{Q_{BX}}{I_{BX}} \text{ in the static state or in saturation}$$

τ_a applies to the lifetime of the carriers in the active state, during turn-on and turn-off, and τ_b applies to the lifetime when recombination and replenishing charges are in equilibrium and when the transistor has been saturated for a sufficiently long time. Sufficiently, as used here, means that an equilibrium of charge gradient is

assumed for times greater than at least three times the lifetime, τ_a (see Eq. 4).

τ_b is then related to the storage time by

$$t_r \text{ (flat portion)} = \tau_b \ln \frac{I_{B1} - I_{B2}}{I_{BS} - I_{B2}} \quad (18)$$

and τ_a to the rise time by

$$t_r \text{ (10% to 90%)} = \tau_a \ln \frac{I_{B1} - 0.1 I_{BS}}{I_{B1} - 0.9 I_{BS}} \quad (19)$$

when R_L in the collector circuit is negligible, and the forced beta is not small enough to allow the use of Eq. 5. For the measurement of τ_b , the circuit shown in Fig. 7 is used.

By changing V_{IN} through a known ratio, and keeping I_{B2} small, τ_b is obtained by

$$\tau_b = \frac{\Delta t_r}{\ln (\text{current ratio})} \quad (20)$$

For both alloy and mesa transistors τ_b is fairly constant throughout the range tested. An alternative circuit, as shown in Fig. 8, is used for measuring τ_b . By adjusting V_{IN} , a plot of Δt_r vs voltage, on semi log paper, is obtained. Notice that the slope of $\Delta t_r \ln (\text{voltage ratio})$ is constant and equal to τ_b .

Next, τ_a is of interest, not because Eq. 19 is directly to be used for calculating switching time, but because τ_a is fundamentally related to the h_{fe} of the transistor; also, knowing the range of τ_a , predictions of t_r and t_f with constant current drive can be made with assurance by using Eqs. 6 to 9.

From Eq. 19, if $I_{B1} = I_{BS}$ and $R_L \cong 0$, then

$$t_r \text{ (0-90%)} = \tau_a \ln \frac{I_{BS}}{0.1 I_{BS}} = 2.31 \tau_a \quad (21)$$

the circuit, shown in Fig. 9 is used for measuring τ_a . A Tektronix current probe, model P6016, and amplifier, type 131, is used in the collector circuit.

Since the probe impedance is very low (about 0.005 ohms, and 1.5 pf in shunt), the transistor remains below saturation when a constant current drive, I_{B1} , is applied. A plot of τ_a vs current I_C is illustrated by Fig. 10, where it is observed that the variation is similar to h_{fe} vs I_C . The same circuit is used for mesa-type transistors. Since the τ_a for mesa transistors is in the range of 20 to 100 nsec, reasonable readings can still be obtained. A plot of τ_a vs I_C for the ZJ-42 is shown in Fig. 11.

Example of Rise-Time Prediction

Conditions: 2N396 Unit #2-12; $Q_B^*/_{90\%}$ at $V_{CC} = 10$ v.

Q_B^* test results: $V_{CC} = 10$ v; $I_{CS} = 1$ ma;
 $Q_B^*/_{90\%} = 200 \mu\text{C}$.
 $V_{CC} = 10$ v; $I_{CS} = 10$ ma;
 $Q_B^*/_{90\%} = 446 \mu\text{C}$.

Desired results (1) Rise time at $V_{CC} = 5$ v;
 $I_{CS} = 100$ ma; $I_{B1} = 10$ ma.
(2) Rise time at $V_{CC} = 15$ v;
 $I_{CS} = 1$ ma; $I_{B1} = 0.1$ ma.

(a). Rise time at $V_{CC} = 5$ v; $I_{CS} = 100$ ma; $I_{B1} = 10$ ma.

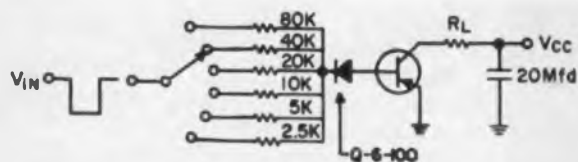


Fig. 7. Circuit used for the measurement of τ_b , carrier lifetime when the transistor has been saturated for a sufficiently long time.

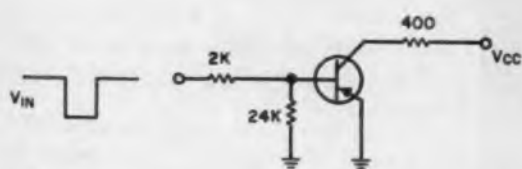


Fig. 8. An alternative circuit for measurement of carrier lifetime τ_b .

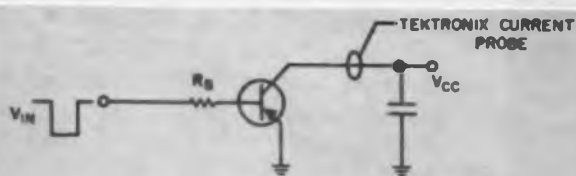


Fig. 9. Circuit for measurement of τ_a , the lifetime of carriers in the active state or below saturation.

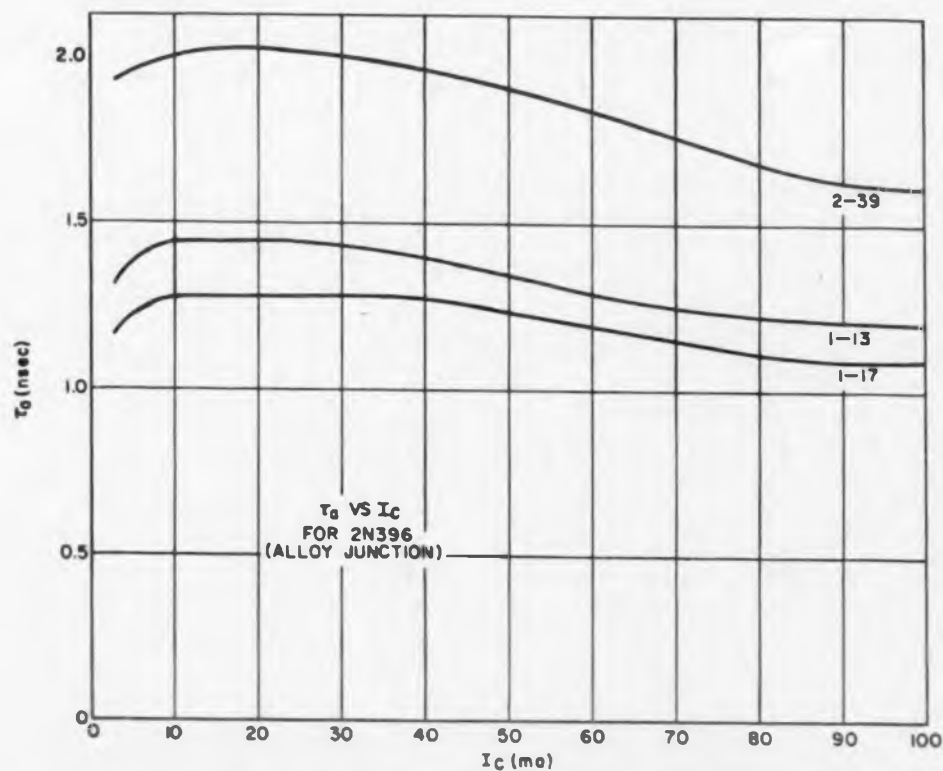


Fig. 10. Carrier lifetime τ_a vs collector current I_c for an alloy transistor.

- (1) Find Q_C at 10-v supply voltage.

$$Q_C(10v) \Big|_0^{90\%} = 200 - \frac{(446 - 200)}{9 \text{ ma}} = 200 - 27.3 = 172.7 \mu\mu\text{C.}$$

- (2) Convert this to Q_C at desired V_{CC} .

$$Q_C(5v) \Big|_0^{90\%} = \left[Q_C(10v) \Big|_0^{90\%} \right] \times \left[\frac{\sqrt{5}}{\sqrt{10}} \right]$$

$$= \frac{Q_C(10v) \Big|_0^{90\%}}{\sqrt{2}} = \frac{172.7}{\sqrt{2}} = 122 \mu\mu\text{C.}$$

- (3) Find Q_B per unit and desired Q_B at current of interest.

$$\frac{Q_B}{\Delta I_C} = \left(\frac{446 - 200}{9 \text{ ma}} \right) = 27.3 \mu\mu\text{C/ma.}$$

$$Q_B \text{ at } 100 \text{ ma} = 27.3 \times 100 = 2,730 \mu\mu\text{C.}$$

- (4) Combine Q_B and Q_C for Q_B^* .

at 5 v, 100 ma.

$$Q_B^* \Big|_0^{90\%} = Q_B + Q_C \Big|_0^{90\%} = 2,730 + 122 = 2,852 \mu\mu\text{C.}$$

(continued on p 52)

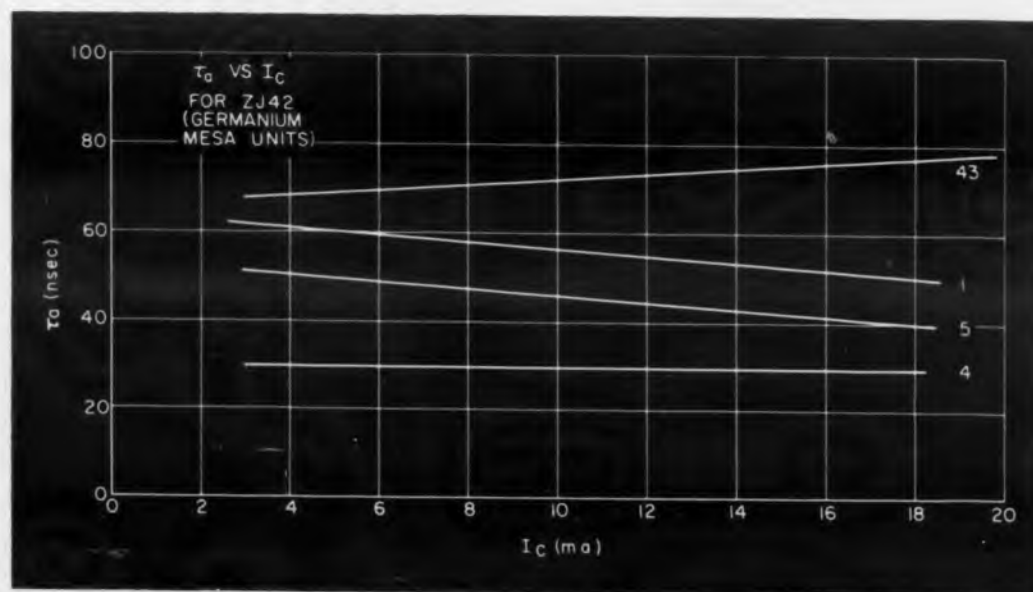
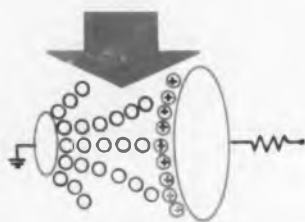


Fig. 11. Carrier lifetime τ_a vs collector current I_c for a mesa transistor.



(5) Find rise time and check with circuit value.

$$t_{r(10-90\%)} = \frac{8}{9} \frac{Q_{B^*} \Big|_0^{90\%}}{I_{B1}} = \frac{(0.89)(2,852)}{10} = 254 \text{ nsec}$$

circuit value = 250 nsec.

deviation predicated $t_r = 4 \text{ nsec} = 1.6\%$.

from measured t_r .

(b). Rise time at $V_{CC} = 15 \text{ v}$; $I_{CS} = 1 \text{ ma}$; $I_{B1} = 0.1 \text{ ma}$.

(1) Find Q_C at 15-v supply voltage using previously obtained Q_C at 10 v.

$$Q_{C(15v)} \Big|_0^{90\%} = Q_{C(10v)} \Big|_0^{90\%} \times \frac{\sqrt{15}}{\sqrt{10}} \\ = 1.228 \times Q_{C(10v)} = 172.7 \\ \times 1.228 = 212 \mu\text{C}.$$

$$1.228 \times Q_{C(10v)} = 172.7 \times 1.228 = 212 \mu\text{C}.$$

(2) From (a) (3), Q_B per unit = $27.3 \mu\text{C}/\text{ma}$.

(3) Combine Q_B and Q_C for Q_{B^*} at 15 v, 1 ma.

$$Q_{B^*} \Big|_0^{90\%} = Q_B + Q_C \Big|_0^{90\%} = 27.3 \\ + 212 = 239.3 \mu\text{C}.$$

(4) Find rise time and check with circuit value.

$$t_{r(10-90\%)} = \frac{8}{9} \frac{Q_{B^*} \Big|_0^{90\%}}{I_{B1}} = \frac{(0.89)(239.3)}{0.1} \\ = 213 \mu\text{sec}.$$

circuit value = 2.20 μsec .

deviation predicated t_r from measured $t_r = 0.07 \mu\text{sec}$.

= -3.3%.

Example of Delay Prediction

Conditions: ZJ-42 Unit #2 $C_B = 6.15 \text{ pf}$ from test results.

$V_{BE2} = V_{BE}$ (after turn on) $\approx 0.4 \text{ v}$ from test results.

In circuit of Fig. 1, when $R_1 = R_2 = 2\text{K}$, $R_L = 400 \text{ ohms}$, $V_{CC} = -5 \text{ v}$.

$V_{IN} = -7 \text{ v}$ pulse, 60 nsec width

Find T_D for $V_{BB} = 0, +1.32 \text{ v}, +2.68 \text{ v}$.

$$T_D = \frac{V_{BE1} \text{ (before turn on)}}{I_{B1}} C_E = \left(\frac{V_{BB}}{2}\right) \left(\frac{C_E}{I_{B1}}\right)$$

At $V_{BB} = 0$: T_D predicted = 0

Actual observed $T_D = 2 \text{ nsec}$.

\therefore Propagation constant = +2 nsec.

At $V_{BB} = +1.32 \text{ v}$: First find I_{B1} ,

$$I_1 = \frac{V_{BE2} - V_{IN}}{2K}; I_2 = \frac{V_{BB} - V_{BE2}}{2K}$$

$$I_B = I_1 - I_2 = \frac{2V_{BE2} - V_{IN} - V_{BB}}{2K}$$

$$I_{B1} = \frac{-0.8 \text{ v} + 7 \text{ v} - 1.32 \text{ v}}{2 \text{ K}} = 2.44 \text{ ma}.$$

$$T_D = \frac{1.32 \text{ v}}{2} \frac{6.15 \text{ pf}}{2.44 \text{ ma}} = 1.7 \text{ nsec}.$$

Adding propagation constant = 2 nsec.

Total T_D predicted = 3.7 nsec.

Actual observed $T_D = 3.8 \text{ nsec}$.

At $V_{BB} = +2.68 \text{ v}$:

$$T_D = \frac{2.68 \text{ v}}{2} \frac{6.15 \text{ pf}}{1.76 \text{ ma}} = 4.7 \text{ nsec}.$$

Adding propagation constant = 2 nsec.

Total T_D predicted = 6.7 nsec.

Actual observed $T_D = 7.2 \text{ nsec}$.

From Eq. 15, $\frac{1}{9} \frac{Q_{B^*} \Big|_0^{90\%}}{I_{B1}}$ must be added to obtain T_D (to 10%)

Storage Prediction For Long Pulse

Conditions: ZJ-42 Unit # 2

From test results, $V_{BE} \approx 0.4 \text{ v}$, $\tau_b = 113 \text{ nsec}$.

$I_{B2} = 0.24 \text{ ma}$

$Q_{B^*}(100\%) - Q_{B^*}(90\%)$ at $V_{CC} = 5 \text{ v}$, is essentially $Q_C(100\%) - Q_C(90\%)$ at $V_{CC} = -5 \text{ v}$, = $6 \mu\text{C}$. Circuit is the same as used in delay time prediction. $V_{IN} = -7 \text{ v}$ pulse, 520 nsec width.

For $V_{BB} = +1.32 \text{ v}$: As shown before, $I_{B1} = 2.44 \text{ ma}$, $I_{B2} = -1.06 \text{ ma}$

$$t_s \text{ (to } 90\%) = \tau_b \ln \left(1 + \frac{I_{B1} - I_{B2}}{I_{B2} - I_{B1}} \right) \\ + \frac{\Delta Q_{B^*} \text{ (100\% to } 90\%)}{-I_{B2}}$$

$$t_s \text{ (to } 90\%) = 113 \text{ nsec} \ln \left(1 + \frac{2.44 \text{ ma} - 0.24 \text{ ma}}{0.24 \text{ ma} + 1.06 \text{ ma}} \right) \\ + \frac{6 \mu\text{C}}{1.06 \text{ ma}}$$

$$t_s \text{ (to } 90\%) = 113 \text{ nsec} \ln(2.69) + 5.7 \text{ nsec}$$

$$t_s \text{ (to } 90\%) = 111.8 \text{ nsec} + 5.7 \text{ nsec} = 117.5 \text{ nsec}$$

Predicted t_s (to 90%) = 117.5 nsec.

Actual observed t_s (to 90%) = 130 nsec.

Prediction Of Fall Time

Conditions = ZJ-42 Unit # 2

The same circuit is used as for delay and storage time predictions.

Given from test results $\tau_a = 50 \text{ nsec}$. Also,

$$Q_{B^*}(90\%) \cong Q_{B^*}(90\%) \text{ at } \frac{4.5 \text{ v}}{400 \Omega}$$

$$\cong Q_{B^*}(90\%) \text{ at } 11.25 \text{ ma} \cong 42.6 \mu\text{C}.$$

$Q_C(90\%)$ at $-5 \text{ v} = 33.8 \mu\text{C}$.

$Q_B = Q_{B^*}(90\%) - Q_C = 8.8 \mu\text{C}$.

At $V_{BB} = +1.32 \text{ v}$ bias: I_{B2} as shown before = -1.06 ma .

$$t_f \text{ (10\% to } 90\%) = \frac{\frac{8}{9} Q_{B^*} \Big|_0^{90\%}}{-I_{B2} + \frac{Q_B}{2\tau_a}} \\ = \frac{\frac{8}{9} (42.6) \mu\text{C}}{1.06 \text{ ma} + \frac{8.8 \mu\text{C}}{2 (50 \text{ nsec})}}$$

Predicted t_f (10% to 90%) = 32.9 nsec.

Actual observed t_f (10% to 90%) = 27 nsec.

Experiments Verify Validity Of Switching Speed Predictions

Rise Time (t_r): Using the simplified relation for rise time prediction, Eqs. 5, 6 and 7, comparison of measured with predicted rise times for typical samples of the alloy 2N396 and the mesa ZJ-42 transistors shows good correlation. For the 2N396 units, the comparison of predicted vs measured rise time was within five per cent. For the ZJ-42 units, using the circuit of Fig. 1 with $R_1 = R_2 = 2 \text{ K}$, $R_L = 1 \text{ K}$, and $V_{CC} = -10 \text{ v}$, and $V_{BB} = +1.32 \text{ v}$ as a typical example, data was taken for square-wave input pulse amplitudes of -10 v , -7 v , -5 v , and -3.5 v . For rise times of about 14 nsec and 20 nsec observed, the error of prediction was within 1.3 nsec. For rise times of about 40 nsec observed, the error of prediction was within 1.5 nsec. For rise times of about 85 nsec, most errors of prediction were within 4 nsec. For the ZJ-42, V_{BE} was measured at $V_{IN} = -5 \text{ v}$, and this average was used to obtain I_{B1} at all input voltages. Greater accuracy of V_{BE} at the input voltages would increase the accuracies of prediction.

Delay plus Rise Time ($t_d + t_r$): For the ZJ-42, using Fig. 1, where $R_1 = 2\text{K}$, $R_2 = 22\text{K}$, $R_L = 1\text{K}$, C_1 (across R_1) = 2 pf, $V_{CC} = -10 \text{ v}$ and $V_{BB} = 0 \text{ v}$, as a typical example, the input pulse

amplitude was changed to the values $V_{IN} = -10$ v, -7 v, -5 v, -3.5 v. The values of charge transferred through C_1 , $[V_{IN} - V_{BB}] C_1$, must be subtracted from Q_B^* for this case so that

$$(t_d + t_r) = \frac{Q_B^* - (V_{IN} - V_{BB}) C_1}{I_{B1}} \quad \text{With } (t_d + t_r)$$

observed values of about 8 nsec, 13 nsec, and 19 nsec, the errors of prediction were within 1 nsec, while for observed values of about 30 nsec, the errors were within 2 nsec.

Delay Time (t_d): For the ZJ-42, calculating t_d as shown in the sample prediction section for $V_{BB} = +1.32$ v, $+2.68$ v with observed delay times of 4 nsec and 8 nsec, the errors of prediction are within 1 nsec.

Fall Time (t_f): For the ZJ-42, fall time, t_f , was calculated as shown in the sample prediction section for $V_{BB} = 0$, $+1.32$ v, $+2.68$ v. For observed fall times of 20 nsec, errors of prediction are less than 3 nsec. For observed fall times of about 30 nsec, errors of prediction are less than 6 nsec for most cases. Where there is no applied off-bias, so that the actual I_{B2} is difficult to determine, the observed fall times were about 90 nsec. Nevertheless, errors of prediction were within 17 nsec for most cases.

Storage Time after Long Pulse (t_s): Storage time, t_s , calculated as shown in the sample prediction section, was within plus or minus 15 per cent for the 2N396. For the ZJ-42, t_s was calculated as shown in the sample prediction section for $V_{BB} = +1.32$ v, $+2.68$ v. For observed storage times of about 65 nsec, the errors of prediction were less than 10 nsec for most cases. For observed storage times of about 110 nsec, the errors of prediction were less than 13 nsec for most cases. At zero bias, where I_{B2} is difficult to predict accurately, the observed storage times were about 220 nsec. Even so, the errors were still within 34 nsec for most cases.

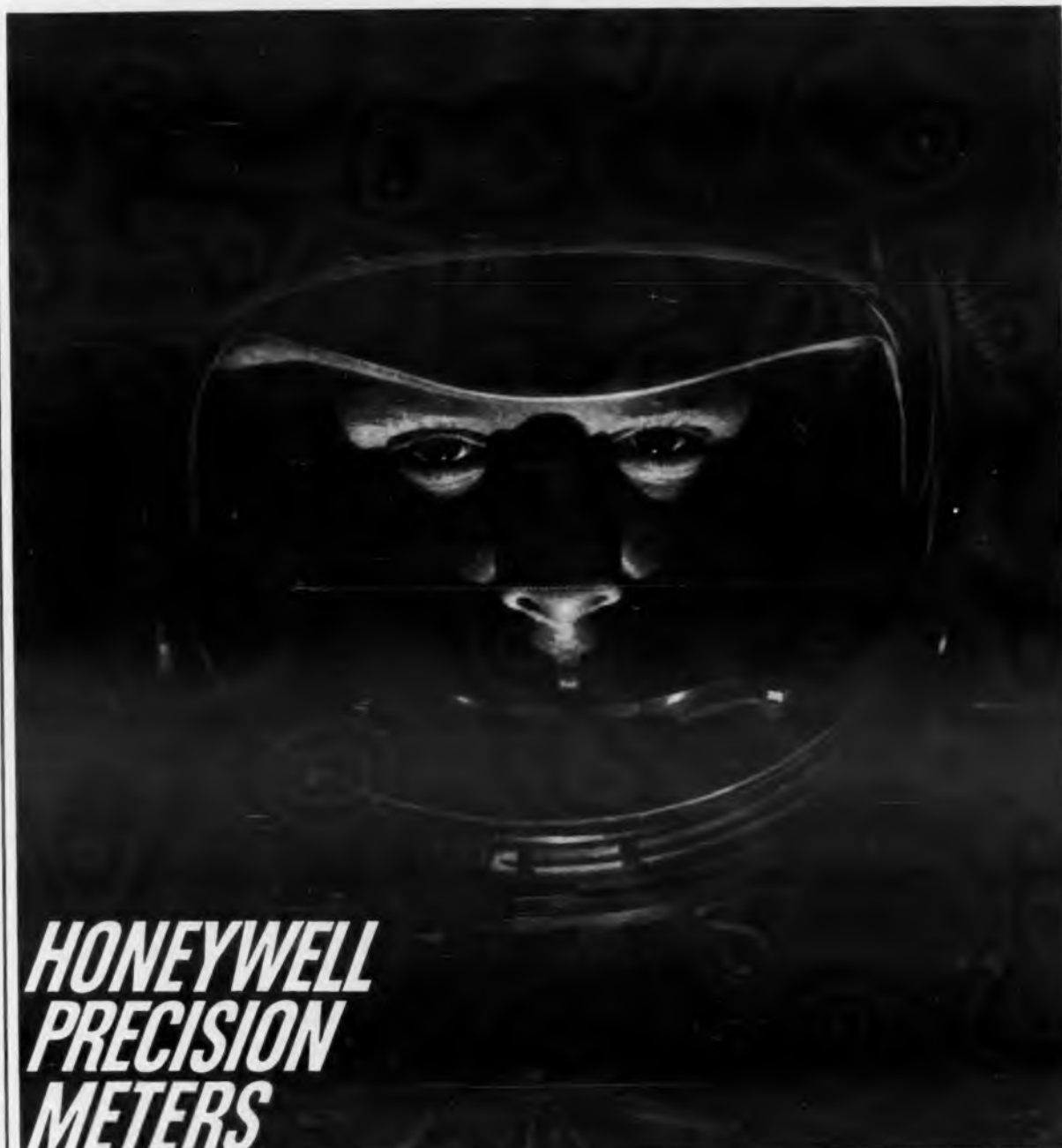
Thus, it may be concluded that Q_B^* , τ_a and τ_b are the most fundamental quantities that define a transistor regarding its ability as a switching device; many other derived parameters can be obtained from them. Most obviously, the ratio Q_B to I_C is one possible parameter, which Sparkes has called τ_c .† Or, the ratio Q_B^* to I_C can be another, which Simmons has called τ_{RE} .‡ ■ ■

Acknowledgments

The authors wish to acknowledge the help given by many of our colleagues, in particular to U. S. Davidsohn and G. B. Ober for their many suggestions and critical review. R Sobus has been of great help in obtaining the data and calculations. This work would never have been compiled without the encouragement of R. P. Frenzel and C. A. Shaw.

†See Reference 6, part 1, *ED*, March 15, 1961, p 55.

‡See Reference 7, part 1, *ED*, March 15, 1961, p 55.



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CIRCLE 41 ON READER-SERVICE CARD

Protective Insulation Can Increase Voltage Breakdowns

Instead of gaining increased high-voltage protection, added insulation can sometimes increase the frequency of equipment breakdowns. Author Rocco tells why.

Vincent Rocco

ITT Laboratories
Nutley, N.J.

THE MINIATURIZATION of electrical equipment has caused the high-voltage-circuit designer to rely more and more on dielectric barriers. In cases where dielectric is used judiciously, good results are obtained. However, in many instances, indiscriminate use of insulating material can actually increase the tendency of the circuit to arc and break down.

Added Dielectric Imposes New Field Conditions

The typical approach to the solution of an arcing problem is simply to cover the danger areas with sheets or cylinders of dielectric, without analyzing the new set of conditions set up in the region. For instance, recently the author was involved in a program for the development of an

airborne radar beacon. Its reliability was seriously hampered by occasional high voltage breakdown in the power supply, particularly in the region of the magnetron anode. The designers, recognizing a potential trouble spot, had designed a thin-walled teflon sleeve to fit over the magnetron anode. The sleeve covered the anode but did not completely fill the air gap with dielectric. This resulted in a change of the electric field configuration in the air region. Rather than help the situation, the insulation had only aggravated the arcing condition further.

The reason for the increased arcing may be understood by referring to a simplified model of an arc-gap, Fig. 1. Here, the gap is treated as a parallel-plate capacitor partially filled with dielectric. Working with the basic definitions for a capacitor, that is, $Q = CE$, $C = K\epsilon/d$, and realizing that the areas of dielectric constant ϵ_1 and ϵ_2 may be considered as capacitors in series, the

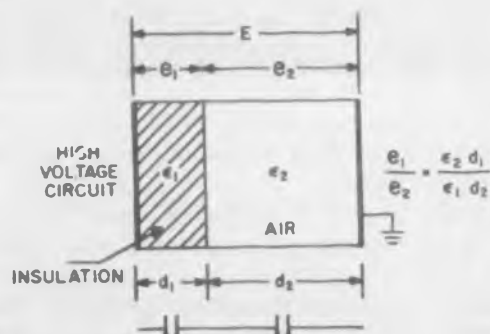


Fig. 1. Breakdown region from equipment to ground is represented by a parallel plate capacitor of gap $d = d_1 + d_2$, partially filled with dielectric of width d_1 , dielectric constant ϵ_1 .

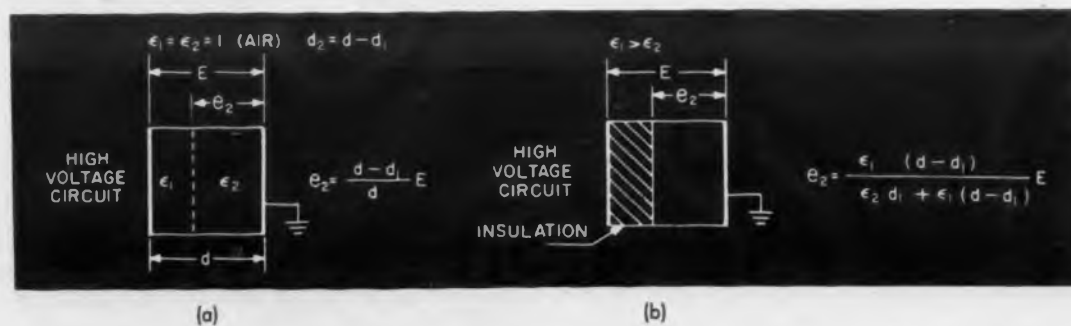


Fig. 2. (a) No protective insulation is added. Voltage e_2 from circuit to ground varies linearly. (b) With added insulation, voltage e_2 depends on thickness, d_1 .

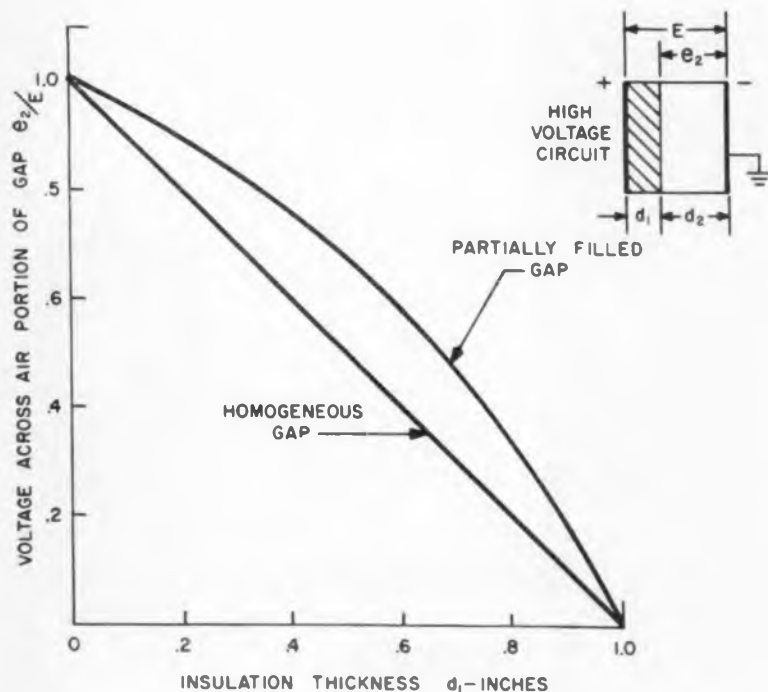


Fig. 3. Partial filling of air gap with insulation causes air gap voltage, e_2 , to be greater than if no insulation had been added, or if insulation completely filled gap (straight line).

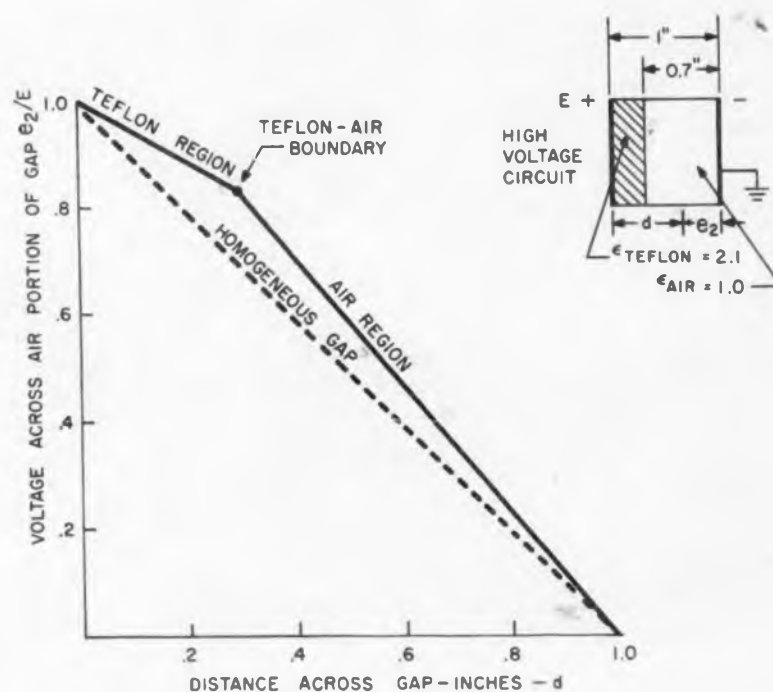


Fig. 4. Example shows that with Teflon partially filling gap, voltage varies discontinuously; voltage across air gap is everywhere increased. Chance of voltage breakdown is, therefore, greater.

following equation for the voltage drop across the insulating material can be derived:

$$e_2 = \frac{\epsilon_1 d_2 E}{\epsilon_2 d_1 + \epsilon_1 d_2} \quad (1)$$

There are two conditions which must be compared. In condition 1, $\epsilon_1 = \epsilon_2$, or the gap is completely homogenous, Fig. 2a. If the gap dielectric is air ($\epsilon = 1$), the voltage at any point in the gap is (from Eq. 1, with $d_2 = d - d_1$):

$$e_2 = \frac{d - d_1}{d} E \quad (2)$$

This is a linear relationship.

In condition 2, $\epsilon_1 \neq \epsilon_2$, or a sheet of dielectric of thickness d_1 has been inserted to partially fill the gap, Fig. 2b. Now the voltage across the air gap is:

$$e_2 = \frac{\epsilon_1 (d - d_1) E}{\epsilon_2 d_1 + \epsilon_1 (d - d_1)} \quad (3)$$

and depends upon the dielectric thickness.

Eqs. 2 and 3 are plotted in Fig. 3 for a gap 1-in. wide, with $\epsilon_1 = 2.1$ (Teflon) and $\epsilon_2 = 1$ (air).

It is clear from Fig. 3 that the voltage across the air portion of the gap, for all thickness of dielectric, is greater than if the dielectric had been completely omitted.

Greater insight into conditions existing in the arc gap may be had by examining Fig. 4. A dielectric of fixed thickness (arbitrarily chosen at 0.3 in.) was inserted in a 1-in. gap. From the previous equations defining e_2 , a plot of e_2 was made. For a gap completely filled with either air or solid dielectric, the voltage gradient follows a conventional path. However, with the insertion of the slab of solid dielectric, the gradient becomes a discontinuous function. Since the slope of the graph, that is, v/d , represents the electric field intensity, it follows that a redistribution of the electric field occurs in the gap. Thus, the presence of the solid dielectric has caused a build-up of electric field intensity in the adjacent air region.

Dielectric Should Fill Completely Rather Than Partially

It can be concluded from the graphs that two principles should be followed for reducing the danger of voltage breakdown.

1. Whenever possible, the breakdown region should be entirely filled with homogenous dielectric material.

2. A dielectric with low dielectric constant in addition to high dielectric strength should be used.

When point 1 cannot be met, it may be useful to know for what dielectric thickness the greatest increase in potential will occur in the air region. This can be calculated from Eq. 3, which expresses the potential, e_2 , at the dielectric-air gap interface, and from Eq. 2, which expressed the potential, e'_2 , at any point in a homogenous air gap. Denoting the difference between e_2 and e'_2 by λ :

$$\lambda = e_2 - e'_2 \quad (4)$$

$$\lambda = \frac{(\epsilon_1 d - \epsilon_1 d_1) E}{\epsilon_2 d_1 + \epsilon_1 d - \epsilon_1 d_1} + \frac{E d_1}{d} - C \quad (5)$$

Differentiating Eq. 5 and setting it equal to zero shows that the maximum increase in potential occurs for a dielectric thickness d_{1max} of:

$$d_{1max} = \frac{d (\sqrt{\epsilon_1 \epsilon_2} - \epsilon_1)}{\epsilon_2 - \epsilon_1} \quad (6) \quad \blacksquare$$



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CIRCLE 42 ON READER-SERVICE CARD



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Yields High Gain-Bandwidth

WITH BOTH control and screen grids using frame-grid construction, a new pentode boasts performance features that far surpass those available in conventional pentodes.

Compared with some of the better pentodes using conventional construction, the new tube, type 7788, is said to offer a gain-bandwidth figure-of-merit of 400 mc (vs 130 mc), a transconductance of 50,000 μ mhos (vs 10,000), an equivalent noise resistance of 100 ohms (vs 200 to 300), and a much higher plate-to-screen-current ratio.

Available from Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L.I., N.Y., the new tube minimizes the shift in characteristics when one switches from low to high anode currents. The rigidly constructed, precisely positioned control and screen grids yield a very low

spread in characteristics from tube to tube as well as very low levels of microphonics. The frame-constructed screen grid gives better than usual screening of the control grid, resulting in the high plate-to-screen-current ratio.

The sturdy construction provided by the grid frames allows the control-grid to be made of wire only 5 microns in diameter—about half the thickness of the finest grid wire normally used. This allows more turns to be wound per inch while it minimizes grid current.

Though the closely spaced grid wires provide rather high input and output capacitances (16 pf at the input and 3.5 at the output), this is more than made up for by the high G_m . Thus, though the capacitances may be twice as large as the capacitances in good pentodes, the G_m is at least five times as large. Hence,

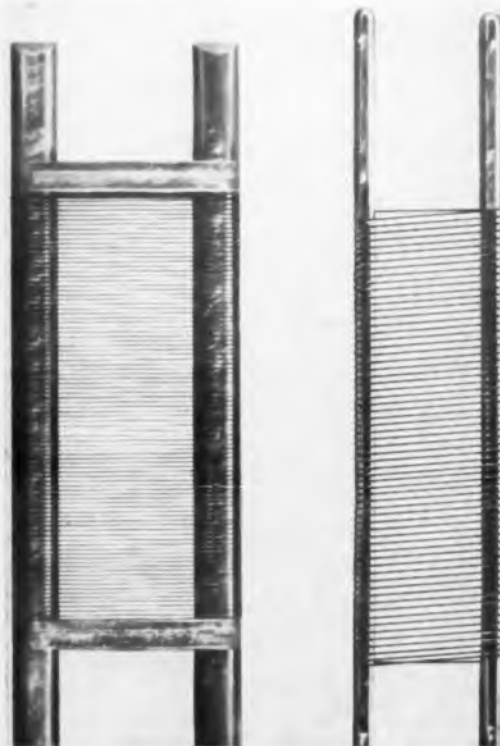
SUPERIOR IN EVERY DETAIL

the G_m -to-C ratio is unusually high, resulting in the very high gain-bandwidth product.

The 7788, with 6.3-v, 340-ma filament requirements is rated, typically, to draw 35 ma of plate current with a 135-v plate supply. Yet the tube can conduct 65 ma for 1,000 hr and 50 ma for 10,000 hr.

The nine-pin miniature tube sells for \$7.95 in quantities greater than 50. In smaller quantities, the unit price is \$10.50. Delivery is from stock.

For more information on this tube, turn to the Reader-Service Card and circle 251.



Frame-grid construction (left) compared with conventional grid construction. Mica spacers, difficult to manufacture to tight tolerances, are used in conjunction with the grid wire to maintain proper spacing of the support rods in conventional grids. In the frame grid, spot welded cross bars keep the grid supports accurately positioned. The grid wire has only an electrical function.



THIS IS **CONHEX** Type 3000/3001 Cable Plug and Jack

Different? Yes. And better, too. "Conhex" sub-miniature r.f. connectors are now in use in the most critical electronic assemblies, and specified by the most discriminating manufacturers of equipment. The many obvious advantages of the "Conhex" design result in easier assembly, greater dependability, and better electrical characteristics. Now "Conhex" is available in two basic styles—Clamp-On for limited runs and easy field replacement, and Crimp-On, designed to save time and money in large production runs. Write for Complete catalog...

Sealectro and only **Sealectro**

MAKES "CONHEX" SUB-MINIATURE RF CONNECTORS
SEALECTRO CORPORATION, 139 HOYT STREET, MAMARONECK, N. Y.
British Branch: Sealectro Corporation, Mersham Factory Estate, Lyon Road, Walton-on-Thames, Surrey, England.
CIRCLE 43 ON READER-SERVICE CARD

NEW---HIGH PERFORMANCE---10 MV SUBCARRIER OSCILLATOR



low level VC-32 subcarrier oscillator

Developed to be compatible with our highly successful high level oscillator, the VC-32 is the smallest and lightest "LC" low-level oscillator available. Stability, linearity and accuracy are consistent with that of the finest high level units.

Input signal connections are completely isolated. High stability design and rigorous quality control eliminate the need for external adjustments. High level output of 4.1 vrms allows the systems designer to use a resistive multiplexing network to feed directly into a transmitter, thereby eliminating the need for mixing amplifiers.

Other advantages most essential to system integration are:

- SUPPLY VOLTAGE VARIATION -- from 24 to 32 volts
- TEMPERATURE -- from -60°F to +185°F
- COMMON MODE REJECTION -- 80 db for common mode signals up to 50 volts
- INPUT IMPEDANCE -- 5000 ohm fixed resistive load for 20 mv full deviation. (higher input resistance available with lower input sensitivity)

UED's soundly-conceived and solidly-built systems and components can help solve your design problems. Data sheets, test reports and technical consultation on request. Write or call:



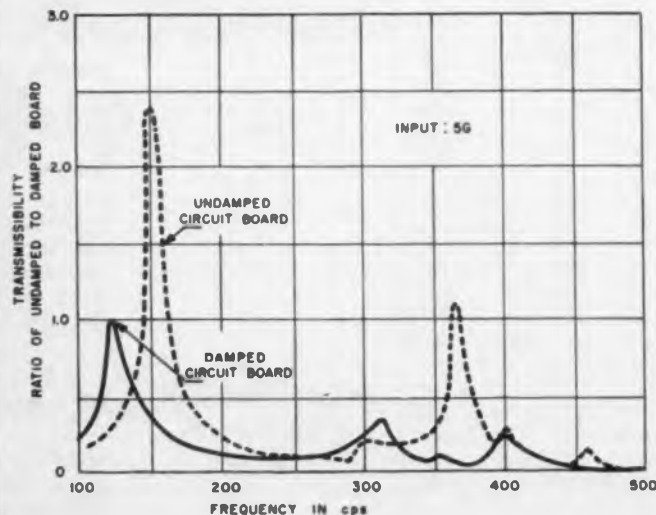
CIRCLE 44 ON READER-SERVICE CARD



Damped Printed-Circuit Boards Reduce Vibration Effects

A RADICALLY NEW, highly damped material for printed-circuit boards will give design engineers another tool for use in raising reliability standards. The material converts vibratory energy into shear strains which are dissipated in an elastomeric layer bonded between elements of epoxy-fiberglass laminate. The elastomer, which adapts to normal processing methods, exhibits unchanging characteristics under all environmental conditions.

Dyna-damp Printed Circuit Boards produced by the Lord Manufacturing Co., Erie, Pa., represent the first successful use of integrally damped material developed for printed circuitry. The new material will greatly extend design freedom and aid miniaturization in high-density electronic packaging. The designer need not worry about structural response characteristics or local circuit board resonances. More sensitive components, smaller and lighter than previ-



Typical curve shows drastic reduction in resonant transmissibility made possible by use of Dyna-damp printed-circuit board material. Degree of reduction depends on specific design and density characteristics of any given board.

ous designs can be used and located to best advantage.

Two Basic Problems Are Caused By Structural Response

The complex dynamic disturbances associated with the operation of high-performance jet aircraft and missiles produce two effects which cause unreliability of printed boards: excessive amplitude and high g-loads. Both are functions of structural response. Current high-performance aerospace craft components are subjected to disturbances of higher frequencies than those which were encountered just a few years ago. The top disturbing frequency in jet specifications used to be 55 cps; today 500 cps is considered nominal and excitations may range as high as 5,000 cps in missiles. The nature of these excitations can be exceedingly complex and, in addition, sustained accelerations up to 25 g can be present.

Resonant Frequency Response Can Cause Failures

Printed-circuit boards are lightly damped, rigid structures incorporating fragile components which are susceptible to destruction under these dynamic conditions. When resonant response occurs either of two things can happen. The board may respond at its resonant frequency, producing oscillation beyond its allotted space envelope and strike adjacent structures; or the energy transmitted through the board may exceed the g levels which the components can withstand.

The damped laminate approach minimizes resonant structural response, thereby controlling amplitude and g load. Tests already completed on the Dyna-damp material show that transmissibility under resonant conditions is reduced from 50 to 66-2/3 per cent over that exhibited by undamped material.

Fabrication techniques used with standard boards can be employed with Dyna-damp boards. Where double-sided boards are concerned, ferrules can be used in the lead holes. Samples of this new material can be had immediately. The Lord Manufacturing Co. plans to produce the printed circuit boards in specified sizes and configurations.

For further information on these circuit boards turn to the Reader-Service Card and circle 253.

PUTTING MAGNETICS TO WORK



Sign up for the Magnetics self-improvement course:

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 $H = .4\pi \frac{NI}{L_m}$, 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.

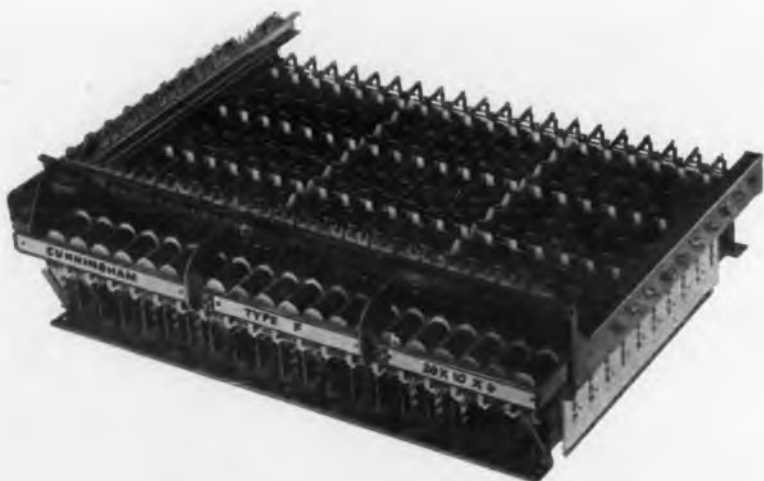
MAGNETICS inc.

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."

name _____
title _____
company _____
address _____

CIRCLE 45 ON READER-SERVICE CARD



Tolerance Buildup No Bugaboo with Punched Laminated Plastics Parts

The compounding of individual tolerances on several punched holes or cutouts over the length of the piece is not the bugaboo that many designers believe. Careful die work and good working knowledge of the laminate used minimizes tolerance buildup. A good example of what can be done is the insulated pusher fabricated by Taylor for a high-performance crossbar switch manufactured by James Cunningham, Son & Co., Inc., Rochester, N.Y.

These switches are 3-dimensional conductor matrices, with from 30 to 1200 switching contacts, which bring intelligence from as many as 600 sources to one or more readout or signal points. They are basic components in computers, machine tool programming systems, high frequency scanning systems, thermocouple and strain gage monitoring, and similar equipment.

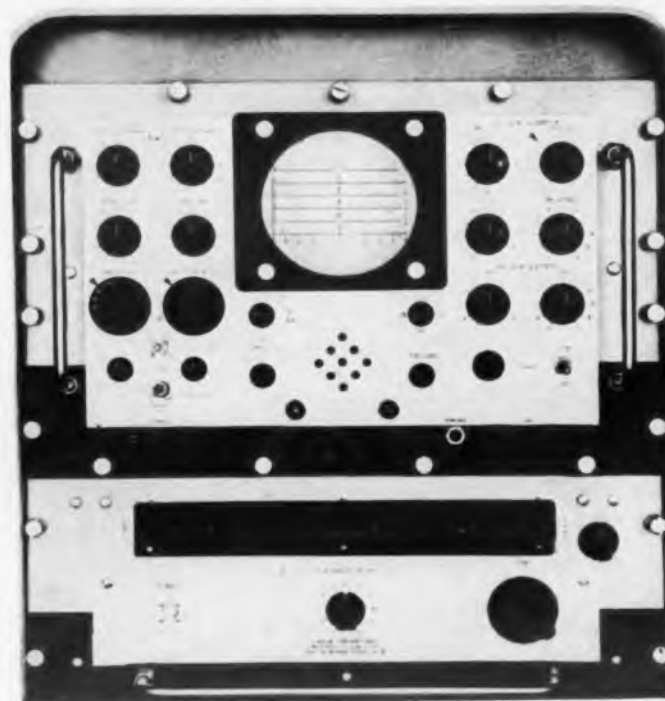
The insulated pusher, only 2.955 in. long and .031 in. thick, and fabricated from Taylor Grade GEC-500 glass epoxy laminate, is a critical part of the crossbar. It must be held flat within $\pm .005$ in., with total over-length buildup not exceeding $\pm .002$ in.

The materials used before to fabricate the pusher proved difficult to hold to the tolerances required. The success of the GEC-500 laminate fabricated by Taylor is evidenced by marked reduction in rejects and a 20% gain in production.

Taylor Fibre's Fabricating Division has the manpower, experience and equipment to produce parts to close tolerances from any of the company's raw materials. Send us your problem—we will recommend the best material for the job and quote on production runs. Write Taylor Fibre Co., Norristown 48, Pa.

Taylor

LAMINATED PLASTICS ■ VULCANIZED FIBRE
CIRCLE 46 ON READER-SERVICE CARD



High-Resolution Spectrum Analyzer Offers Wide Dynamic Range

EVALUATION of a frequency spectrum containing many signals of widely differing characteristics is made possible by the LA-21 spectrum analyzer. Designed for communications work, the instrument covers the most widely used commercial and military frequencies.

An outstanding feature of the LA-21 is its ability to discriminate between signals differing in amplitude by as much as 80 db and separated by only 50 kc. Resolution is extended to 90 db when the signals are 150 kc apart. Narrow resolution of 5 kc can be expected when signal levels are equal in amplitude.

A signal sensitivity of better than 90 dbm is provided over the fundamental frequency range of 10 mc to 680 mc, with slightly reduced sensitivity to 1,180

mc using harmonic operation of the triode local oscillator. Sensitivity can be improved to 110 dbm on special order. Applications of the instrument, made by Lavoie Laboratories, Morganville, N. J., include the evaluation of spurious response, signal stability testing, filter network evaluation, and frequency spectrum monitoring.

The visual display, on a type 5ADP7 cathode-ray tube, is supplemented by an aural monitoring system. A built-in speaker calls attention to changes in the signal and aids in signal identification. A jack for headphones is also provided.

An internal crystal calibrator is used for convenient and extremely accurate calibration of the spectrum being viewed; markers at 100 kc and 1 mc are selected from the front panel. Tuning dial is of the slide-rule type, with one frequency range visible at a time. Maximum stability is provided by electronically regulated plate and filament power supplies. Power requirements are 115 v \pm 10%, 50 to 400 cps, 250 w.

Dual attenuators provide 100 db of continuously variable attenuation of the input signal over the entire frequency range. The if attenuation range is 0 to 60 db, step-variable in 6-db steps. Detection mode is selected from square-law, linear, and logarithmic types. Frequency dispersion is continuously adjustable from 100 kc to 2 mc. Centering controls allow an additional 1 mc on each side of the spectrum center.

Synchronization sensitivity is adjustable at the front panel. A signal of 3.0 v peak is required for external synchronization. Sweep rate is 0.5 to 20 cps, continuously adjustable. Video signal and horizontal drive are brought to front-panel connectors for X-Y and roll-chart recording. Photographic recording is facilitated by intensification of trace on fast rise and decay, with automatic baseline extinction.

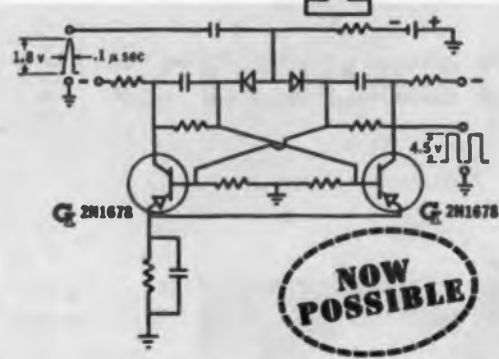
The instrument measures 21-3/4 in. high, 19-1/2 in. wide, and 18-7/16 in. deep. It operates in ambient temperatures ranging from 0 to 55 C.

Price of the IA-21 is \$5,450. Delivery time is 60 days.

For more information on this high-resolution spectrum analyzer, turn to the Reader-Service Card and circle 252.

General Instrument Semiconductor... Design Breakthrough

NEW **G** 2N1678 "DYNAMIC DRIFT"



High Voltage
High Speed
Saturated Circuitry
At Low Cost

General Instrument proudly presents the 2N1678 "Dynamic Drift"... ideally suited for high speed, high voltage saturated circuit applications. The 1 Mc bistable multivibrator, above, is only one example of the multitude of applications for this attractively-priced transistor family.

Life test data proves reliability of the new General Instrument 2N1678 "Dynamic Drift". Close quality control guarantees extremely high electrical uniformity, shipment to shipment.

| 2N1678 PNP Germanium "Dynamic Drift" | | | | |
|--------------------------------------|--|-------|-----------|---------|
| Parameter | Conditions | Min. | Typ. | Max. |
| T _c | T _c = 25°C | -65°C | | +85°C |
| P _c | | | | 120 mw |
| V _{CE(s)} | I _c = 100 μa | 60 v | | |
| V _{CE(s)} | I _c = 25 μa | 60 v | | |
| V _{CE(s)} | I _c = 100 μa | 4 v | | |
| h _{FE} | I _c = 20 ma; V _{CE} = 0.25 v | 25 | 40 | |
| I _{CEO} | V _{CE} = 10 v | | | 5 μa |
| V _{BE} | I _c = 20 ma; V _{CE} = 0.25 v | | | 0.6 v |
| f _α | I _c = 1 ma; V _{CE} = 5 v | 25 Mc | 35 Mc | |
| f _β | I _c = 1 ma; V _{CE} = 10 v | | 50 Mc | |
| h _{re} | I _c = 1 ma; V _{CE} = 5 v; f = 1 kc | | 30 Ω | |
| h _{ob} | V _{CE} = 5 v; I _c = 1 ma; f = 1 kc | | 0.5 μ mho | 2 μ mho |
| C _{ob} | V _{CE} = 5 v; I _c = 1 ma; f = 5 Mc | | 3.5 pf | 5 pf |
| t _r + t _f | I _c = 20 ma; I _b = I _{cm} | | 0.4 μ sec | |
| t _r + t _f | I _c = 1 ma; R _e = 1K | | 0.4 μ sec | |

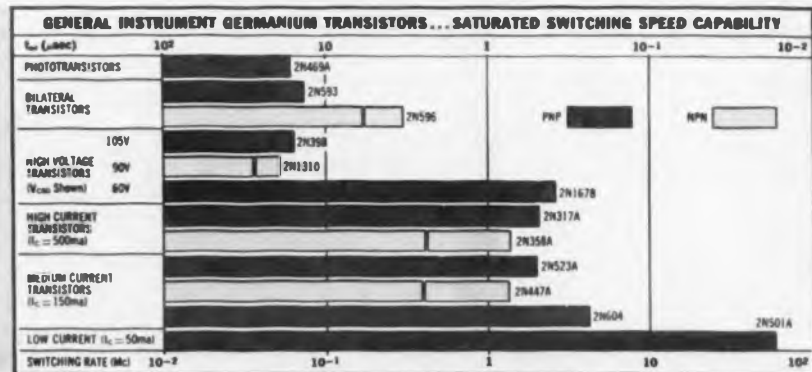
FULL LINE OF QUALITY **G** COMPUTER SEMICONDUCTORS

General Instrument is your major source for high quality computer semiconductors... transistors, as well as companion diodes, rectifiers and logic encapsulations for every type of circuit application. The transistor families shown below indicate the broad range of superior quality units offered by General Instrument.

Write General Instrument for complete engineering and life test data, design curves, and typical circuitry which takes advantage of the unique combination of characteristics offered by the new **G** 2N1678. Data is available, of course, on our full line of computer semiconductors. Our engineers will gladly discuss your specific circuit requirements.

All speeds shown have been attained with conventional saturated circuitry. Total bar length represents rate (period) using speed-up capacitors; broken bar indicates maximum speed without capacitor.

Representative transistors shown are alloyed-junction devices. Types 2N501A, 2N604, and 2N1678 are MADT, Drift, and High-Voltage Drift, respectively.



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TRANSISTORS, DIODES, RECTIFIERS



SEMICONDUCTOR
DIVISION OF GENERAL INSTRUMENT CORPORATION
65 Gouverneur Street, Newark 4, New Jersey



IN CANADA: General Instrument—F. W. Sickles of Canada Ltd., P.O. Box 408, 151 S. Weber Street, Waterloo, Ontario, Canada. Sherwood 4-8101.

CIRCLE 47 ON READER-SERVICE CARD

NEW PRODUCTS

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

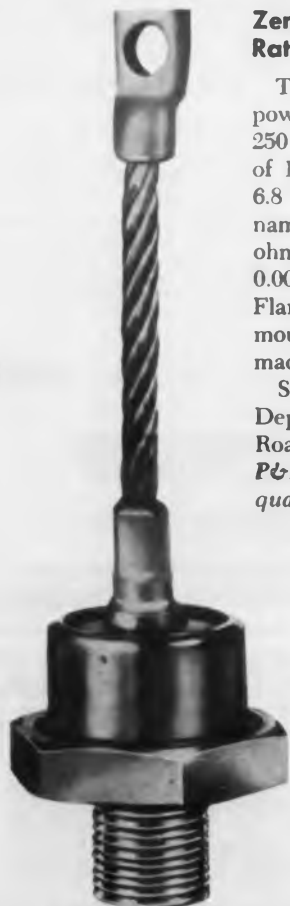


Glass-To-Metal Seal Withstands 600 C

257

Made with ferrous alloys or tungsten and molybdenum, these glass-to-metal seals can withstand sustained temperatures of 500 to 600 C, and are not damaged by temperatures of nearly 800 C for short periods. The low-cost seal is said to be more easily made and formed than ceramic-to-metal seals.

Hermetite Corp., Dept. ED, 100 Ladge Drive, Avon, Mass.
Availability: Immediate.



Zener Diode 256 Rated at 250 W

Type 250 Z is a Zener power regulator rated at 250 w at case temperature of 100 C. Voltage range is 6.8 to 30 v. Typical dynamic impedance is 0.06 ohm max for 30-v type, 0.006 ohm for 6.8-v type. Flange-mounted and stud-mounted packages are made.

Standard Rectifier Corp.,
Dept. ED, 620 E. Dyer
Road, Santa Ana, Calif.
P&A: \$60 to \$75 ea, sample
quantities; 2 to 3 weeks.



Digital Counter Has Continuous Display

255

Type 1130-A digital time and frequency meter uses four decades for storage and continuous display, while the remaining four decades count continuously. At the end of counting interval, total is transferred in 100 μ sec to the storage and display decades. Ranges are: frequency, dc to 10 mc; period, 10 μ sec to 10^7 sec; interval, 1 μ sec to 10^7 sec. Circuits are designed for maximum reliability. Plug-in time-base oscillators are available with stabilities up to 5 parts in 10^{10} per min.

General Radio Co., Dept. ED, West Concord, Mass.
Price: from \$2,585 to \$2,950.



Miniature Photocell 258 Delivers Up to 300 Ma

A light-actuated pnpn silicon switch, the Photran has over 10-meg impedance when off, 10 ohms when triggered on by light. Measuring 0.200 in. long by 0.185 in. OD, the device can deliver up to 300-ma load current at up to 200 v with an efficiency exceeding 98%. Output is determined by load and is independent of light input at all intensities above the triggering level, typically 200 ft-c. High output often allows direct actuation of load without intermediate relays or amplifiers. Anode voltages range from 15 to 200 v in 6 ratings. Surge current is 5 amp, 8 msec.

Solid State Products, Inc., Dept. ED, 1 Pingree St., Salem, Mass.
Price & Availability: \$10 to \$35; 1 week.



Plug-In IF Amplifier 259 With Gain to 80 Db

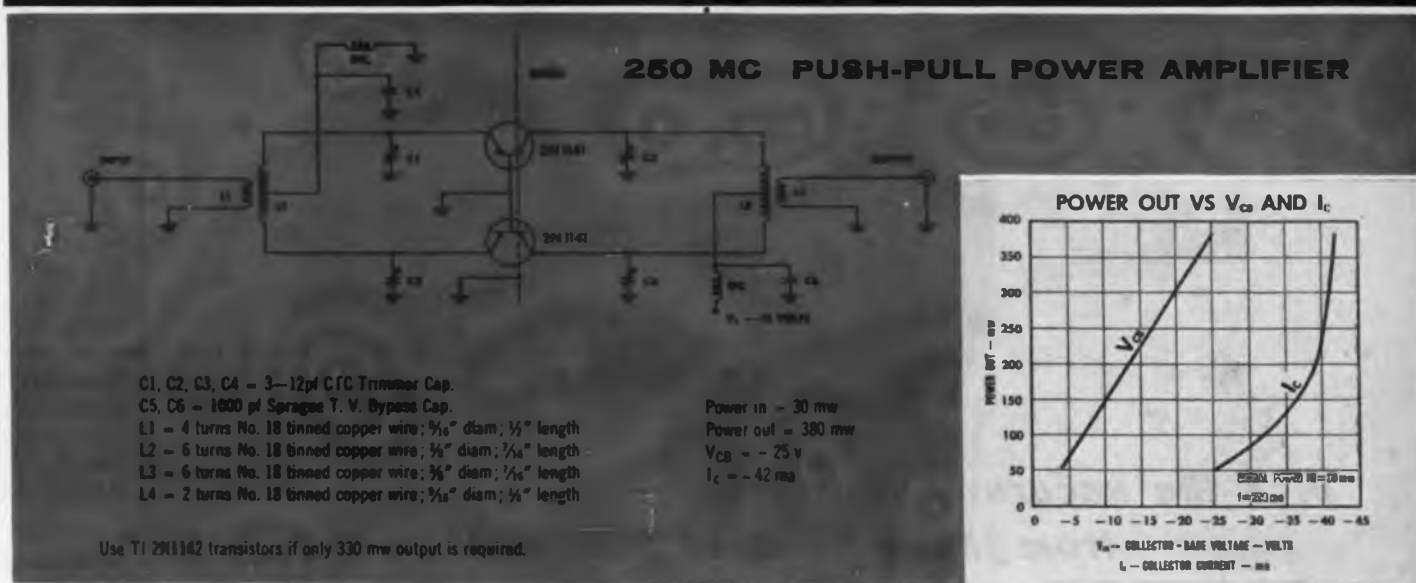
The Amplitran is a transistor if amplifier with single-stage gain from 15 to 20 db, with up to 80 db in cascaded units. Center frequencies are 455 kc, 1.0, 4.3, 10.7, and 30.0 mc. Bandwidth of the 30.0-mc cascaded unit is 1.8 mc, power gain 68 db. A 4-stage unit measures 4-1/2 x 1-1/4 x 2-1/4 in. Dual and triple sizes are also made.

Ferrotran Electronics Co., Inc., Dept. ED, 693 Broadway, New York 12, N.Y.

Price: \$50 to \$60, 1-stage; \$300 to \$340, 4-stage.

CIRCLE 48 ON READER-SERVICE CARD ▶

HOW TO GET 380 mw at 250 mc



Specify TI 2N1141 P-N-P Germanium Mesa Transistor Series



Design-in Texas Instruments 2N1141 series transistors to obtain 380 mw output at 250 mc from your power amplifiers in telemetering applications in missiles and military communication systems.

TI 2N1141, 2N1142, 2N1143 germanium mesa transistors providing maximum dissipation of 750 mw at

25°C case temperature, 35 volts at 100 μ a I_C , and f_{max} to 750 mc are ideal for your VHF power amplifier and oscillator circuits.

Order these TI "Tailored-to-the-Task" 2N1141 series devices *today* from your nearby authorized Texas Instruments distributor. Call him or your local TI sales engineer for price and delivery information including a detailed report on 2N1141 applications.

| TYPICAL CHARACTERISTICS AT 25°C | 2N1141 | 2N1142 | 2N1143 |
|---|-----------------|-----------------|-----------------|
| TYPICAL COMMON-EMITTER SHORT CIRCUIT FORWARD CURRENT TRANSFER RATIO AT 100 mc h_{fe} | 13.5 db | 11.5 db | 9.5 db |
| TYPICAL MAXIMUM FREQUENCY OF OSCILLATION f_{max} | 750 mc | 600 mc | 500 mc |
| TYPICAL COLLECTOR-BASE TIME CONSTANT $r_b' C_c$ | 30 ohm- μ f | 40 ohm- μ f | 50 ohm- μ f |

Specify TI Germanium Transistors For Your: Computer / Power Supply / Communication / Industrial Control / Entertainment • Applications



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MODEL 240

MODEL 241

**pick the accuracy you need
from these Keithley high voltage supplies**

MODEL 241 — 0.05% accuracy

Here is the successor to dc secondary standards that employ mechanical choppers and standard cells. The new 241, featuring a Keithley-designed long-life photo-chopper, offers five-dial resolution from 0 to 1000 volts at up to 20 milliamperes. Stability is within 0.005%. Output — plus, minus or floating — can be dialed from 0 to 1000 volts in 0.01 volt steps, with noise and hum below 1 mv RMS. The 241 is unaffected by shock or vibration and cannot be damaged in ordinary use. It is most useful in calibration of meters and transducers, testing insulation and leakage resistances, and as a voltage reference for analog computers.

MODEL 240 — 1% accuracy

This voltage supply is a general-purpose version of the 241, with similar features and somewhat reduced accuracy and regulation. Three calibrated dials permit dialing any output to 1000 volts in one-volt steps. The switch includes an "off" position, facilitating timed measurements. Stability is within 0.02 volts $\pm 0.02\%$ the first hour, or in subsequent 24-hour periods. The Model 240 can be used to furnish stable dc potentials in checking dc amplifier gains, and for production tests of transistors. Used with a Keithley electrometer, resistances over the range of 0.1 ohm to 10^{16} ohms can be measured.

brief specifications

| Model | Output | | | | Regulation | | | Price |
|-------|---------|---------------|----------|-----------|------------|-------|-------|----------|
| | Voltage | Current ma | Accuracy | Z ohms | Ripple | Line | Load | |
| 241 | 0-1000 | 0-20 | .05% | .05 | 1mv | .005% | .005% | \$800.00 |
| 240 | 0-1000 | 0-10 | 1% | 15 | 3mv | .02% | .02% | \$325.00 |



KEITHLEY INSTRUMENTS, INC.
12415 EUCLID AVENUE
CLEVELAND 6, OHIO

CIRCLE 49 ON READER-SERVICE CARD

NEW PRODUCTS

Pressure Gauge

456



A small, rugged pressure transducer is used with this pressure gauge for measurements from 0 to 2,500 psig. Intended for use in air and gaseous systems, device operates on thermopile principle. Multi-position gages using up to 5 transducers with a single instrument are also made. Transducers are interchangeable without recalibration or adjustment.

Hastings-Raydist, Inc., Dept. ED, Hampton, Va.

Price & Availability: \$257.50; immediate.

Servo Amplifiers

450



A size 18, 60-cps servo motor, rated at 9 w per phase, may be driven with these servo amplifiers. Outputs are identical; inputs differ to accept one-speed ac data (model 748-A), two-speed synchro data (747-A) and dc input signals (747-A and 797-A). Amplifiers include damping networks for proper loop stabilization, and generate the carrier shift necessary for quadrature across the motor. Size is 4 x 8 x 3 in., weight under 36 oz.

Industrial Control Co., Dept. ED, Central Ave. at Pinelawn, Farmingdale, L. I., N. Y.

Linear Amplifier

458



With integral pulse-height analyzer, the N-328 amplifier has high-speed, nonoverload character-

istics plus optional pick-off for 40-nsec range coincidence. Gain is 7,000; amplifier has double delay-line pulse shaping and a choice of integral or differential discriminators. It is suitable for use where large overload signals are present, and in counting at rates to 250 kc.

Hamner Electronics Co., Inc., Dept. ED, P. O. Box 531, Princeton, N. J.

Numerical Comparator

452



Developed for automatic control, digital comparator uses numerical commands to control machinery to 110,000th of an inch at rates up to 30 in. per min. Information is obtained from punched tape program. Unit is composed of command and feedback displacement counters, a differential analog converter and associated circuitry. It is suitable for short-run production and rapid-readout inspection testing.

Hycon Manufacturing Co., Dept. ED, 1030 S. Arroyo Parkway, Pasadena, Calif.

Availability: stock.

Decade Scaler

457



Operating at 10 mc, this decade scaler uses 8-4-2-1 binary code to count random series pulses. Any number of units can be cascaded by front panel connectors. Total count is displayed in lighted decimal digits. Binary and analog outputs are available on front panel. The solid-state unit is compatible with other Data-Bloc modules.

Harvey-Wells Electronics, Inc., Dept. ED, 14 Huron Drive, Natick, Mass.
P&A: \$239.50; 30 days in quantities to 100.

This is the time of our annual subscription renewal; Return your card to us.

ELECTRONIC DESIGN • April 12, 1961

when Time means Money . . .



you can depend on

For small runs, military prototypes, production emergencies or for hurry-up design and engineering projects . . . you can get Coldite 70+ Resistors in short order.

Coldite 70+ are today's best-looking resistors—and every bit as good as they look. Exclusive solder-coated leads stay tarnish free for fastest soldering. Performance exceeds latest MIL-R-11 requirements . . . gives extra dividends in load life and moisture resistance characteristics. They're available in 2-watt (RC-42), 1-watt (RC-32), and ½-watt (RC-20) sizes . . . in all standard values and tolerances . . . direct from distributors' stocks.

STACKPOLE
Coldite 70+
FIXED COMPOSITION
RESISTORS



Get them in 24 hours or less

... from these Leading Distributors!

ALABAMA—BIRMINGHAM
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LONG BEACH—Deane Electronics
LOS ANGELES—H. O. Rising
OAKLAND—Brill Electronics
PASADENA—Wesco Electronics
SAN DIEGO—Radio Parts Co.
VAN NUYS—Tranco

COLORADO
DENVER—Denver Electronics Supply Co.

CONNECTICUT
WATERBURY—Bond Radio Supply Co., Inc.

DISTRICT OF COLUMBIA
WASHINGTON—Electronic Wholesalers, Inc.

FLORIDA
TAMPA—Thruway Electronics, Inc.
WEST PALM BEACH—Goddard Distrib., Inc.

INDIANA
INDIANAPOLIS—Radio Distributing Co.

KANSAS
WICHITA—Interstate Electronic Supply Corp.

KENTUCKY
LOUISVILLE—P. I. Barta Co., Inc.

MARYLAND
BALTIMORE—Kane-Elliott Electronics, Inc.

MASSACHUSETTS
BOSTON—Cramer Electronics Inc.
Super Electrical Supply
H. WILBRAHAM—Industrial Components Corp.

MICHIGAN
BATTLE CREEK—Electronic Supply Corp.

MISSOURI
ST. LOUIS—Interstate Supply Co.

NEW JERSEY
MOUNTAINSIDE—Federated Purchaser Inc.

NEW YORK
BROOKLYN—Electronic Equipment Co., Inc.

NEW YORK
Quad Electronics Inc.
Electronics Center Inc.
Harrison Radio Corp.
Harvey Radio Co.
Milo Electronics Corp.
Sea Radio & Electronics Co., Inc.

SYRACUSE—Morris Electronics of Syracuse

WHITE PLAINS—Westchester Electronic Supply Co., Inc.

NORTH CAROLINA
WINSTON-SALEM—Dallas-Hoge Inc.

OHIO
CINCINNATI—Harringer Distributing Co.
CLEVELAND—Pioneer Electronic Supply Co.
COLUMBUS—Hughes-Peters, Inc.

OREGON
PORTLAND—Leo Johnson Co., Inc.

PENNSYLVANIA
PHILADELPHIA—Almo Radio Co.
SCRANTON—Fred P. Pursell

TEXAS
DALLAS—Wholesale Electronic Supply

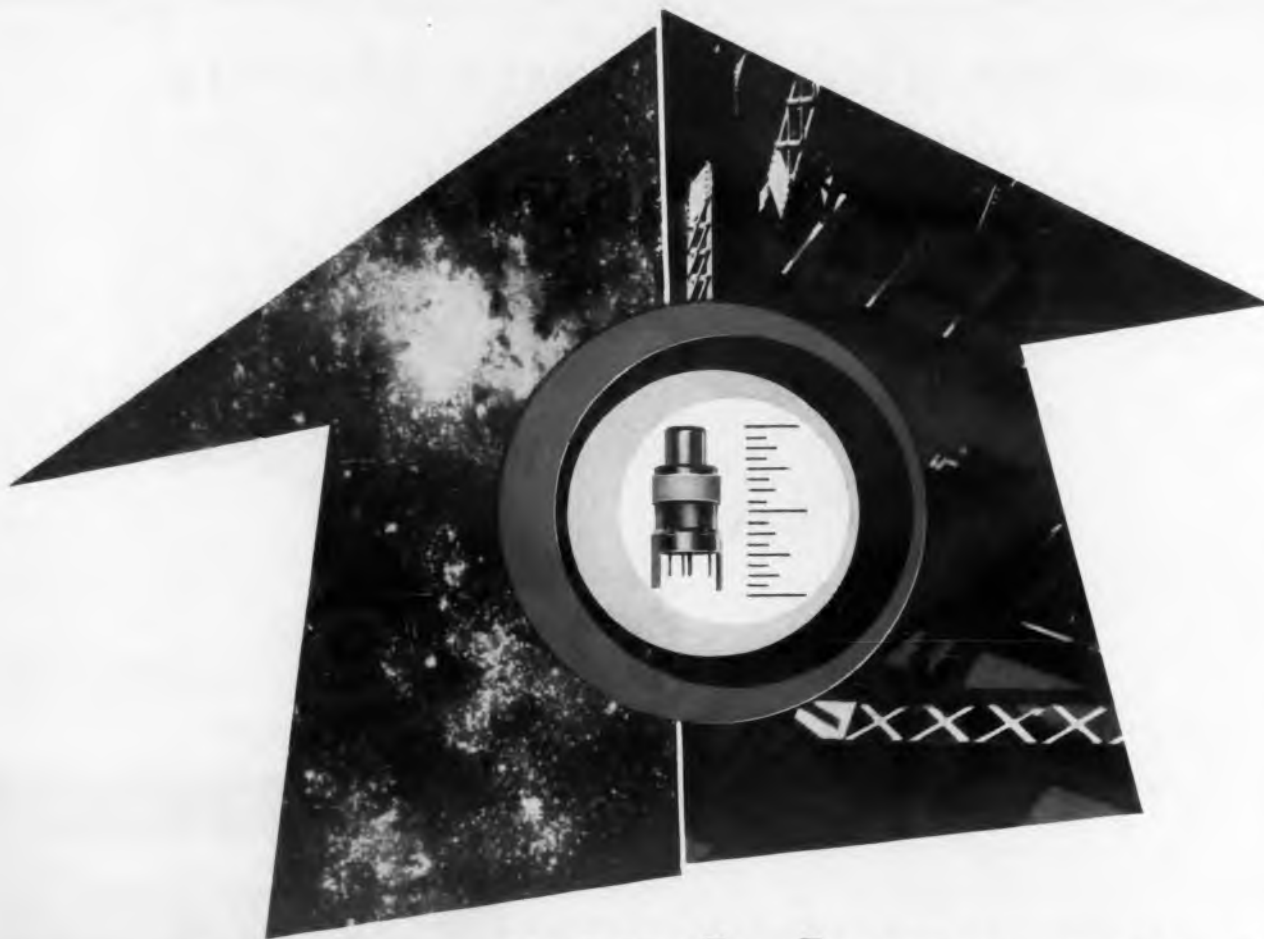
VIRGINIA
ROANOKE—Peoples Radio & TV Supply Co.

WASHINGTON
SEATTLE—C & G Electronics Co.
TACOMA—C & G Electronics Co.

... and G-C/STACKPOLE, TOO!

Attractively packaged by G-C Electronics for service replacement uses, Coldite 70+ Resistors are also available through over 800 G-C distributors.

CIRCLE 50 ON READER-SERVICE CARD



RCA-7587 FIRST nuvistor TETRODE!

Now You Can Nuvistorize Your Equipment Designs with RCA's New General-Purpose Sharp-Cutoff Nuvistor Tetrode—RCA-7587—Now Commercially Available.

FOR HIGH-GAIN, RF, IF, VIDEO AMPLIFIER, & MIXER SERVICE. This new member of the nuvistor family in combination with its companion medium- μ and high- μ industrial triodes (7586-7895) gives you vastly expanded flexibility in design of equipment for critical industrial and military applications where extreme compactness or very high packaging densities are essential requirements.

One third the size of conventional miniature pentodes, and consuming approximately one-half the heater power, this new sharp-cutoff tetrode embodies all the advantages of the nuvistor design: • low power drain • low-voltage operation • high transconductance at low plate voltage • extremely low interelectrode leakage • exceptional uniformity of characteristics from tube to tube • all-ceramic-and-metal construction for extreme resistance to shock and vibration • operation at full ratings at any altitude.

Get the full story from your RCA Field Representative or write to RCA Electron Tube Division, Commercial Engineering, Section D-18-DE, Harrison, N. J.

ELECTRON TUBE DIVISION, Harrison, N. J.

FIELD OFFICES: Newark 2, New Jersey, 744 Broad St., HUmboldt 5-3900 • Detroit 2, Mich., 714 New Center Bldg., TRinity 5-3600 • Chicago 34, Illinois, Suite 1154, Merchandise Mart Plaza, WHitehall 4-2900 • Burlingame, Calif., 1838 El Camino Real, OXFord 7-1620 • Los Angeles 22, Calif., 6801 E. Washington Blvd., RAYmond 3-8361.



The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA

NUVISTOR TETRODE GENERAL DATA

ELECTRICAL:

Heater, for Unipotential Cathode
Voltage (ac or dc) 6.3 ± 10% volts
Current at 6.3 volts 0.15 ampere

DIRECT INTERELECTRODE CAPACITANCES:

Grid—No. 1 to plate 0.01 μ fd
Grid—No. 1 to cathode, grid—No. 2, heater & shell 6.5 μ fd
Plate to cathode, grid—No. 2, heater & shell 1.4 μ fd
Heater to cathode 1.4 μ fd

CHARACTERISTICS, CLASS A₁ AMPLIFIER:

Plate Supply Voltage 125 volts
Grid—No. 2 Supply Voltage 50 volts
Cathode Resistor 68 ohms
Plate Resistance (Approx.) 0.2 megohm
Transconductance 10,600 μ mas
Plate Current 10 ma
Grid—No. 2 Current 2.7 ma
Grid—No. 1 Voltage (Approx.) for plate current of 10 μ a -4.5 volts

INDUSTRIAL SERVICE

MAXIMUM RATINGS, ABSOLUTE-MAXIMUM VALUES: For Operation at Any Altitude

| | |
|--|----------------|
| PLATE SUPPLY VOLTAGE | 330 max. volts |
| PLATE VOLTAGE | 250 max. volts |
| GRID—No. 2 (SCREEN-GRID) SUPPLY VOLTAGE | 330 max. volts |
| GRID—No. 2 VOLTAGE | 110 max. volts |
| GRID—No. 1 (Control-Grid) VOLTAGE, Negative bias value | 55 max. volts |
| Peak positive value | 2 max. volts |
| CATHODE CURRENT | 20 max. ma |
| GRID—No. 1 CURRENT | 2 max. ma |
| PLATE DISSIPATION | 2.2 max. watts |
| GRID—No. 2 INPUT | 0.2 max. watt |

PEAK HEATER-CATHODE VOLTAGE:

Heater negative with respect to cathode 100 max. volts
Heater positive with respect to cathode 100 max. volts

MAXIMUM CIRCUIT VALUES:

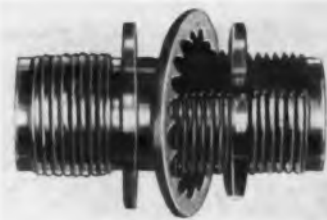
Grid—No. 1 Circuit Resistance*
For fixed-bias operation 0.5 max. megohm
For cathode-bias operation 1 max. megohm

*For Operation at Metal-Shell Temperatures up to 150°C.

NEW PRODUCTS

Firewall Connectors

467



The 6342 series HN firewall connectors are capable of withstanding 2,000 F. Units have a nominal 50-ohm characteristic impedance.

Gremer Manufacturing Co., Inc., Dept. ED, Wakefield, Mass.

Press Control

474



Slide transfer presses are protected from overload due to faulty part transfer by the Autotransfer control device. Provision is also made for sensing end-of-material, buckling, and misfeed.

Wintriss Controls Div., Industronics Controls, Inc., Dept. ED, 20-24 Vandam St., New York 13, N.Y.

Vaneaxial Blower

468



Operating on 115 v, ac or dc, VAX-3-GN vaneaxial blower delivers 68 cfm at 1.5 in. static pressure. Used in ground-support equipment, unit weighs 1 lb. Diameter is 3 in., length 3-1/4 in. Mounting is made by clamping to servo rim. Blower meets pertinent military specifications.

Globe Industries, Inc., Dept. ED, 1784 Stanley Ave., Dayton 4, Ohio.

Phase-Sensitive Voltmeter 480



For use in test panels, this phase-sensitive voltmeter is 3 in. in diameter and 5 in. long. Input signal attenuator is integral with the cylindrical assembly, while meter movement may be remotely located. Quadrature rejection is 50:1, 3rd harmonic rejection —40 db. A 3-mv input gives full-scale deflection. Attenuator range is 3 mv to 300 v in 9 steps. Frequency range is 60 cps to 20 kc, linearity is 2%.

Theta Instrument Corp., Dept. ED, 520 Victor St., Saddle Brook, N.J.

Price & Availability: \$150 ea; 30-day delivery.

Piston Capacitors 477



Variable trimmer piston capacitors TT901 through TT904, for panels or circuit boards, meet requirements of MIL-C-14409A. Minimum capacitance is 0.5 pf; maximum is 2.0, 3.0, 5.0 or 7.0 pf. Overall diameter is 1/8 in., length above panel 35/64 to 1-1/64 in. Units are rated at 500 wvdc. Adjust mechanism has 102 turns per in. Temperature coefficient is low; operating range is —55 to +125 C. The Q factor is 500.

JFD Electronics Corp., Dept. ED, 6101 16th Ave., Brooklyn 4, N.Y.

CIRCLE 52 ON READER-SERVICE CARD ►

13 MOVES TO RELIABLE TRIMMING

SPECTROL'S FULL LINE of trimming potentiometers features 10 of the smallest square trimmers ever made, plus the only *transistor-size* units for solid state circuitry. This selection covers almost every conceivable application—a sure way to avoid checkmate when you need reliable trimmers.

SQUARE TRIMMER DATA. Models 50 and 60 measure 3/8" and 1/2" square respectively • humidity proofing a standard feature • available in resistances to 100K • greater surface contact between mandrel and aluminum case for better heat dissipation, no external heat sinks needed • dual wiper for positive contact under all conditions of shock and vibration.

SINGLE TURN TRIMMER DATA. Model 80 built into TO-9 transistor type case • measures less than 1/3" in diameter, weighs 1 gram—smallest trimmer on the market • completely sealed against moisture and humidity • resistance element twice as long as ordinary trimmers • designed for complete package encapsulation with other printed circuit components • available in 3 case styles with resistance range to 20K.

IMMEDIATE DELIVERY. Your nearby Spectrol distributor stocks standard models of trimmers and miniature potentiometers as well as other standard Spectrol precision potentiometers and turns indicating dials. Prices are \$6 to \$8 in quantities of 1-9 for most styles and resistances.

MORE DATA AVAILABLE. Contact your Spectrol engineering representative or drop us a line at the factory. Please address Dept. 36.

ALL TRIMMERS SHOWN ACTUAL SIZE



ELECTRONICS CORPORATION

1704 South Del Mar Avenue • San Gabriel, California
Phone: ATlantic 7-9761

Adams Court • Plainview, L. I., New York
Phone: WElls 8-4000

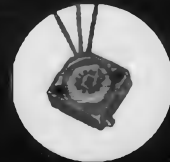
NOW IT'S YOUR MOVE

MODEL 60



Printed circuit pins, top adjust

MODEL 50



Teflon insulated leads

MODEL 60



Teflon insulated leads

MODEL 80



Transistor size case

MODEL 80



Transistor size case, bushing mount

MODEL 50



Printed circuit pins from base

MODEL 60



Printed circuit pins, side adjust

MODEL 50



Bushing panel mount

MODEL 50



Printed circuit pins, top adjust

MODEL 80



Transistor size threaded case

MODEL 50



Printed circuit pins side adjust

MODEL 60



Printed circuit pins from base

MODEL 50



Bushing panel mount

HIGH RELIABILITY

Sub-Miniature MISSILE RELAYS

The history of Dunco FC Relays is one of never ending development to keep these durable, subminiature units fully abreast of the steadily advancing missile and aircraft requirements. As a result, they are prominently identified with many of today's most successful missile programs. Continued engineering of every detail aims to keep them there tomorrow!

Write for Dunco Data Bulletin FC

NEW!

10-AMPERE TYPE with all-welded construction

Constructed for fully dependable 10-ampere DC service, these sturdy little DP-DT Dunco FC-215 relays withstand 30 G vibration to 2,000 cycles and 50 G shock. Throughout, they are uniquely designed to meet or surpass MIL-R-3757 and MIL-R-25018 requirements.

Write for Dunco Data Bulletin FC-215

STRUTHERS-DUNN

Pitman, New Jersey

5,348 RELAY TYPES

Sales Engineering offices in: Atlanta • Boston • Buffalo • Charlotte
Chicago • Cincinnati • Cleveland • Dallas • Dayton • Denver • Detroit
High Point • Kansas City • Los Angeles • Montreal • New York
Orlando • Pittsburgh • St. Louis • San Carlos • Seattle • Toronto

CIRCLE 53 ON READER-SERVICE CARD

NEW PRODUCTS

Printed Cable

455



Multi-conductor Teflon cable can be imprinted with code numbers or letters, eliminating necessity of color-coding. Fluorocarbon resin inks are sintered so that the numbers or letters become a permanent part of the insulation.

American Super-Temperature Wires, Inc., Dept. ED, Winooski, Vt.

Capacitor Shielding

464



Environmental electrical shielding is available for variable capacitors. Full shielding permits capacitor use in any circuit or location under any radiation conditions. Capacitance curve is protected against outside electrical effects.

Hammarlund Manufacturing Co., Inc., Dept. ED, 460 W. 34th St., New York 1, N. Y.

Lamp Adapter

449



T-1 ultraminiature incandescent lamps can be used in any standard bayonet-base socket with this adapter. Lamp, measuring 1/8 in. OD by 3/8 in. long, can be supplied.

Industrial Electronic Engineers, Inc., Dept. ED, 5528 Vineland Ave., North Hollywood, Calif.

P&A: \$0.40 ea, \$3.75 with lamp; stock.

Have you sent us your subscription renewal form?

looking for these silicon transistor types?

available in quantity from Transitron

PNP

- 2N1131
- 2N1132

(multi-purpose medium power)
Write for Bulletin TE-1354-1131

NPN

- 2N696
- 2N697

(multi-purpose medium power)
Write for Bulletin TE-1354-696

- 2N698
- 2N699

(high voltage medium power)
Write for Bulletin TE-1354-698

- 2N1252
- 2N1253

(low storage time, medium power)
Write for Bulletin TE-1354-1252

- 2N706

(high speed logic transistor, small signal)
Write for Bulletin TE-1353-706

NOW! Order these popular types of silicon transistors from Transitron, pioneering developer of silicon transistors and producer of the industry's broadest line of high-quality semiconductors!

- Higher Frequency Requirements
- More Mechanical Ruggedness
- Higher Reliability
- Produced by Gaseous Diffusion Techniques

For full data... including the latest refinements achieved by Transitron's advanced production techniques... write for Bulletins above.

Transitron

electronic corporation
wakefield, melrose, boston, mass.

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THE U.S.A. AND EUROPE. CABLE ADDRESS: TRELCO

CIRCLE 54 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961



Used with electrical connectors having molded backshells, strain relief assembly G77 effectively reduces strain on wires at the solder pots. Assembly consists of body, three straps, and clamp.

Glenair, Inc., Dept. ED, Glendale 1, Calif.

Power Supply

481

Outputs of 225 to 325 v at 0 to 50 ma are provided by model RS305A power supply. A filament output of 6.3 v ac at 3 amp is also furnished. Versions include modular, rack-mounting, and rack-mounting with 3-1/4 in. meters. Voltage regulation is 0.05% load, 0.05% line; ripple and noise are 5 mv max peak to peak. Transient recovery time is less than 25 μ sec. Input is 105 to 125 v ac, 55 to 400 cps. Rack units have 3-1/2 in. panel.

Trans Electronics, Inc., Dept. ED, 7349 Canoga Ave., Canoga Park, Calif.

P&A: \$55.50 up; immediate.

Resistance Standard

479



Five primary resistance standards in the MRS-105 package range from 100 ohms to 1 meg. Accuracy is 0.0015% at values of 1 K to 1 meg and 0.003% at 100 ohms. Stability is better than 0.0015% per year. Case is 9-3/8 x 31/32 x 3 in. Elements are oil immersed and hermetically sealed.

Julie Research Laboratories, Inc., Dept. ED, 603 W. 130th St., New York 27, N.Y.

CIRCLE 55 ON READER-SERVICE CARD ►

Transitron

SILICON CONTROLLED RECTIFIERS

augmenting the industry's broadest line

With the addition of the 50-Amp Silicon Controlled Rectifier, Transitron now offers the industry the broadest line of Controlled Rectifiers available on the market today.

Research and development efforts during the past year have already produced an impressive array of types which include the following series:

TSW31S SERIES (TO-18 package).....operating current range to 200mA
 TCR251 SERIES (TO-5 package).....operating current range to 1 amp
 2N1595 SERIES (TO-5 package).....operating current range to 1 amp
 2N1600 SERIES (7/16" hex package)...operating current range to 3 amps
 TCR505 SERIES (7/16" hex package)...operating current range to 5 amps
 TCR510 SERIES (11/16" hex package) operating current range to 10 amps
 TCR520 SERIES (11/16" hex package) operating current range to 20 amps

NOW AVAILABLE — NEW 50-AMP CONTROLLED RECTIFIER

The latest addition to the Transitron line — the 50 Amp Silicon Controlled Rectifier — is a three-terminal, four-layer device designed to control very large load currents with small gate current signals. A mechanically rugged and electrically stable device, the new Controlled Rectifier is provided in the 1 1/16" hex base stud-mounted package and is hermetically sealed. Wherever high power handling ability is required, the 50-Amp Silicon Controlled Rectifier will find wide application ranging from frequency changing to welding control.

TCR550 SERIES (1 1/16" hex package)
operating current range to 50 amps

| Type | Min. Peak Reverse Volt. and Min. Forward Breakover Volt. (volts) | Max. Average Forward Current at 90°C case (amps) | Package Configuration |
|---------|--|--|-----------------------|
| TCR4050 | 400 | 50 | 1 1/16" hex |
| TCR3050 | 300 | 50 | 1 1/16" hex |
| TCR2050 | 200 | 50 | 1 1/16" hex |
| TCR1050 | 100 | 50 | 1 1/16" hex |
| TCR550 | 50 | 50 | 1 1/16" hex |

Requires 50mA to turn on 50 Amp



For information on any or all of Transitron's line of Controlled Rectifiers, call or write today for Bulletin TE-1356.

WHY BIAS CONTROLLED RECTIFIERS?

THE
BIASING
OF SILICON
CONTROLLED
RECTIFIERS
AND
SWITCHES

Pioneering in new application techniques, Transitron application engineers have assembled information which demonstrates how "gate biasing" will improve the circuit reliability of the SCR. This informative booklet, entitled "The Biasing of Silicon Controlled Rectifiers and Switches," deals individually with each of Transitron's Controlled Rectifiers and Switches. It is an indispensable aid to the design engineer seeking longer life and greater stability in higher temperature applications . . . It's yours for the asking.

Transitron



electronic corporation
wakefield, melrose, boston, mass.

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NEW PRODUCTS

Magnetic Amplifiers

451



Operating with null stability in the 10^{-16} region, these amplifiers withstand severe environmental conditions. Output may be \pm dc, phase-reversing ac, or variable pulse duration. Current gain is stable over temperature range of -55 C to 135 C within about $\pm 5\%$ without optional feedback. Power may be 115 v, 400 cps, or dc from 3 to 28 v.

Inkra-Magnetics, Co., Dept. ED, P. O. Box 137, River Forest, Ill.

Transistorized Inverter

438



Peak loads up to 1,300 w and continuous loads to 500 w are handled by transistorized dc/ac inverter model PI 1341. This unit converts 12 v dc to 115 v 60 cps. It is designed to power ac motors with high peak starting current surges and low starting power factors, efficiency is 80% at full load.

Power Instruments Corp., Dept. ED, 235 Oregon St., El Segundo, Calif.

PIA: \$300 ea; from stock.

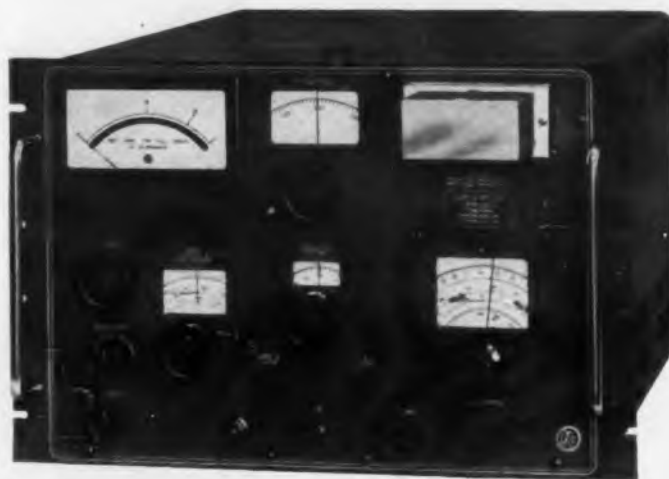
Power Triode

483

Providing 5 megawatts peak output at 250 mc on long pulses and up to 10 megawatts on short pulses, the ceramic-metal RCA-7835 is useful in radar and particle accelerator service. Full ratings may be applied up to 300 mc. Variants of the water-cooled tube can be supplied for cw operation with output levels to 1/2 megawatt.

Radio Corp. of America, Electron Tube Div., Industrial Tube Products Dept., Dept. ED, Harrison, N.J.

Don't miss an issue of **ELECTRONIC DESIGN**; Return your renewal card.



UHF Q METER 210-

—measures **COMPONENTS,**
CAVITIES, SEMI-CONDUCTORS

Description

The new UHF Q Meter Type 280-A is a unique self-contained instrument for measuring the RF characteristics of components in the UHF range. The instrument consists of a specially designed oscillator, Q measuring circuit, and resonance indicator and, in application, is similar to its counterparts in the lower frequency ranges. In addition to performing conventional Q Meter measurements, in which the unknown component is resonated with the internal calibrated capacitor, the output of the oscillator and the input of the resonance indicator are available externally for directly measuring the Q of self-resonant devices.

The UHF Q Meter differs from conventional Q Meters in that it measures the actual percentage bandwidth of the resonance curve and, from this data, computes and reads out circuit Q. The test circuit is first tuned to resonance by adjusting oscillator frequency and/or resonating capacitance. The circuit is then detuned from the half-power point on one side of the resonance curve to the opposite half-power point by adjusting a calibrated dial, coupled to the oscillator frequency control, which directly reads out circuit Q.

Precision Electronic Instruments
since 1934



BOONTON RADIO

BOONTON, NEW JERSEY • Tel. DEERFIELD 4-3200

ELECTRONIC DESIGN • April 12, 1961

- 10-25,000 TOTAL Q RANGE
- SELF-CORRECTING UHF RESONATING CAPACITOR
- DIRECT-READING INDUCTANCE SCALE
- 25 MV RF MEASURING LEVEL
- MEASURES "IN-CIRCUIT" Q OF SELF-RESONANT CIRCUITS

610 MC

by



Specifications

Radio Frequency Characteristics

RF RANGE: 210 to 610 MC
 RF ACCURACY: $\pm 3\%$
 RF CALIBRATION: Increments of approximately 1%
 RF MONITOR OUTPUT: 10 mv. minimum into 50 ohms*
 *at frequency monitoring jack

Q Measurement Characteristics

Q RANGE:
 Total Range: 10 to 25,000*
 High Range: 200 to 25,000*
 Low Range: 10 to 200
 *10 to approx. 2,000 employing internal resonating capacitor
 Q ACCURACY: $\pm 20\%$ of indicated Q
 Q CALIBRATION:
 High Q Scale: Increments of 1—5% up to 2,000
 Low Q Scale: Increments of 3—5%

Inductance Measurement Characteristics

L RANGE: 2.5 to 146 μH *
 *actual range depends upon measuring frequency
 L ACCURACY: ± 11 to 15%*
 *accuracy depends upon resonating capacitance
 L CALIBRATION: Increments of approx. 5%

Resonating Capacitor Characteristics

CAPACITOR RANGE: 4 to 25 μF
 CAPACITOR ACCURACY: $\pm (5\% + 0.2 \mu\text{F})$
 CAPACITOR CALIBRATION:
 0.05 μF increments, 4-5 μF
 0.1 μF increments, 5-15 μF
 0.2 μF increments, 15-25 μF

Measurement Voltage Level

RF LEVELS: 25, 40, 80, 140, 250 mv. nominal*
 *across measuring terminals

Physical Characteristics

MOUNTING: Cabinet for bench use; by removal of end covers, suitable for 19" rack mounting.
 FINISH: Gray wrinkle, engraved panel (other finishes available on special order).
 DIMENSIONS: Height: 12-7/32" Width: 19"
 Depth: 17"
 WEIGHT: Net: 72 lbs.

Power Requirements

280-A : 105-125/210-250 volts, 60 cps, 140 watts
 280-AP: 105-125/210-250 volts, 50 cps, 140 watts

Price: **280-A: \$2,375.00** **280-AP: \$2,375.00**
 F.O.B. Boonton, N. J.



"IN-CIRCUIT" Q MEASUREMENT



COIL MEASUREMENT



DIODE MEASUREMENT

CORPORATION

TWX: BOONTON, NEW JERSEY 866 • CABLE ADDRESS: BOONRACO

CIRCLE 56 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961



A Subsidiary of
 Hewlett-Packard Company

Fractional HP Motor

439



Available from 1/20 through 1/4 hp, type AR is a six-pole motor. Designed for heavy-duty applications, it has higher starting and running torques than conventional shaded-pole motors. It is 4-7/8 in. in diameter.

Redmond Co., Inc., Dept. ED, Owosso, Mich.

Tape Terminator

453



Flexible copper conductive tape is easily connected with the Flex-Term terminator. Crimping action locks tape in terminator. Sleeve is soft annealed copper, tab is beryllium copper; insulation is natural Teflon tubing. Metal surfaces are gold-plated. Contact resistance is less than 1 milliohm. Solder tab type is model FT100, screw lug FT225.

Hi-Shear Corp., Dept. ED, 2600 W. 247th St., Torrance, Calif.

Power Amplifier

441



Distortion is less than 0.25% with full output power of 50 w, mid-band, for model 250B power amplifier. Specifications are: frequency response, ± 0.5 db from 12 cps to 45 kc; output impedance, 0.7 to 600 ohms; hum and noise, 95 db down; sensitivity, 0.5 v rms for full output; input impedance, 100 K.

H. H. Scott Inc., Dept. ED, 111 Powdermill Road, Maynard, Mass.

Price: \$175 fob Maynard.



...and now for a spot of welding!

Still at it? Trying to improve potentiometer reliability by building 'em yourself? Well, you're on the right track about one thing — welding's a sure way to eliminate a lot of operational headaches — like gassing contamination of contact metals at high temperature, from organic solder flux. No chance of "cold joints", either, to increase circuit resistance. No soldered connections to come loose under vibration and shock. Welding is the way to reliability!

But why set the wife's drapes alire to get a reliable, all-welded pot? Utilizing welding techniques, Ace produces reliable potentiometers operable at temperatures exceeding 150°C, and able to withstand 50 G's at 2000 cycles. All this, plus extremely low contact resistance and longer rated life. All taps, end connections, resistance elements, contact assemblies and terminal leads are specially prepared beforehand — then welded with pure nickel or palladium silver. So, for built-in reliability through sounder construction techniques, see your ACErep!



This 2" AIA Acepot® (shown 1/2-scale) incorporates all these exclusive welding construction features, for superior reliability.

ACE ELECTRONICS ASSOCIATES, INC.
99 Dover Street, Somerville 44, Mass.
SOMerset 6-5130 TMY 2MVL 181 West, Union WUX

Acepot® Acatrim® Acecot® Aceohm® *Reg. Appl. for
CIRCLE 57 ON READER-SERVICE CARD

NEW PRODUCTS

Polystyrene Capacitor

446



Hermetically sealed in metal cases with glass-to-metal end seals, polystyrene capacitors have high insulation resistance and low dissipation factor. Negative temperature coefficient is 120 ± 30 ppm per deg C; temperature range is -55 C to $+85$ C. Capacitors meet or exceed requirements of MIL-C-19978, characteristic P.

General Products Corp., Dept. ED, Union Springs, N. Y.

Silicon Diodes

440



MIL-S-19500/118 qualified silicon diodes types 1N483B, 1N485B, and 1N486 B have leakage that is typically $1 \mu\text{a}$ at 150 C. Forward conductance is 100 ma min at 1 v; reverse voltages range up to 250 v. They are in standard glass, hermetically sealed, DO-7 packages.

Rheem Semiconductor Corp., Dept. ED, 350 Ellis St., Mountain View, Calif.

P&A: From \$1.90 to \$3.75, 100 to 999; from stock.

Centrifuge

445

With electronic speed control, model B931 centrifuge holds drift from angular velocity of main rotating arm or outboard table to below 0.001%. A crystal-controlled oscillator is used to determine over-all setting accuracy. The system can be set to maintain a spatially stable platform for the test object or to create several discrete sinusoidal or constant g accelerations. Nominal radius of rotating arm is 24 in. between its center of rotation and that of the outboard table, which is 8 in. in diameter.

Genisco, Inc., Dept. ED, 2233 Federal Ave., Los Angeles 64, Calif.

Don't forget to mail your renewal form to continue receiving ELECTRONIC DESIGN.



ACTUAL SIZE

Amazing, New,
High Inductance

WEE-DUCTOR

with Inductance Range from
0.10-180,000 μH

The R.F. Choke that's so small
you can pack 200,000
to a cubic foot

Tiny, new, WEE-DUCTOR covers a full range of inductances from 0.10 μH to 180,000 μH yet it measures only 0.157" x 0.375".

Unique ferrite sleeve and core construction provides 1,800,000 to 1 inductance range in a tiny package . . . and yet when assembled side-by-side, exhibit less than 2% coupling. Essex WEE-DUCTORS are available immediately from stock. WEE-DUCTORS are the latest addition to Essex's broad line of Standard R.F. Choke Coils.

Essex Electronics Standard Line of R.F. Chokes

| ESSEX PART NO. | WEE-DUCTOR | RFC-S | RFC-M | RFC-L |
|--------------------|------------|----------|-----------|------------|
| L μH | 0.1-180K | .1-100 | 1.0-1,000 | 1.0-10,000 |
| Max. Res. Ω | .035-880 | .02-6.0 | .04-21 | .03-80 |
| I Max. mA | 3000-18 | 4000-220 | 2700-125 | 4000-80 |
| Dia. | .157 | .188 | .250 | .310 |
| Length | .375 | .440 | .600 | .900 |

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ESSEX ELECTRONICS DIVISION, BERKELEY HEIGHTS, N.J.
AUTOMATION PRODUCTS DIVISION, LEXINGTON, KY.
ESSEX ELECTRONICS OF CANADA LTD., TRENTON, ONT.

CIRCLE 58 ON READER-SERVICE CARD



A momentary-action push-button switch is combined with transistor circuitry and neon indicator in a unit mounting on 5/8 in. centers. Lamp is transistor-controlled from small signals; integral switch is offered in A or B forms.

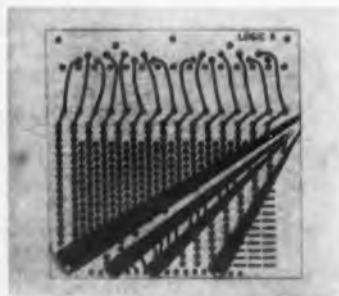
Transistor Electronics Corp., Dept. ED, 3357 Republic Ave., Minneapolis 26, Minn.

Rectifier Stack Assembly 473

Made for high-voltage transmitter use, these rectifier stack assemblies are capable of handling 44 kv at 7.2 amp. Assembly consists of double-diffused silicon junction rectifier stacks in a three-phase bridge assembly, arranged for maximum heat dissipation.

Trans-Sil Corp., Dept. ED, 55 Honeck St., Englewood, N.J.
Availability: 30-day delivery.

Printed Circuits 475



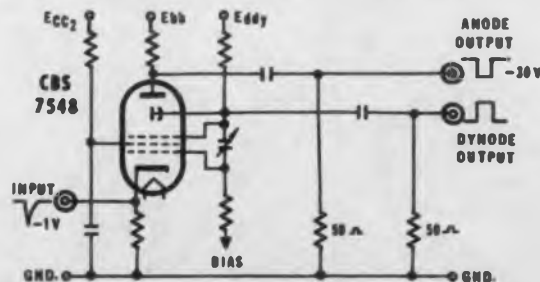
Multi-layered printed circuitry is made with cross-over connections internally bonded. Each layer is 0.006 in. thick; four layers of circuitry make a plane 0.025 in. thick. Connections are brought out to numbered points on the board.

Scientific Components Div., Intellux, Inc., Dept. ED, 30 S. Salspuedes St., Santa Barbara, Calif.

CIRCLE 59 ON READER-SERVICE CARD ▶

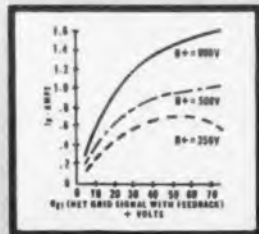
New CBS Advanced Instrument Tubes SOLVE TWO MAJOR CIRCUIT PROBLEMS

• Ultrafast Pulse Amplification



CBS 7548 in triggered pulse amplifier

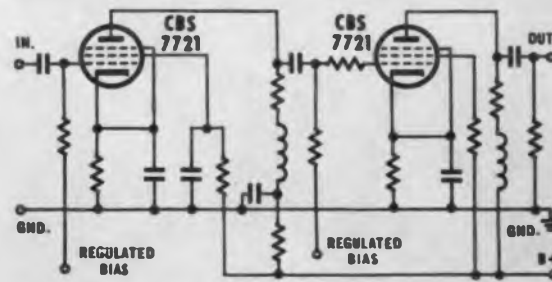
The CBS 7548, a mass-produced long-life secondary-emission pentode, makes possible state-of-the-art advances in generating and amplifying extremely fast rise-time pulses delivering high currents to low impedances. Because the tube can amplify with or without phase inversion, it can be used where conventional circuits would be impractical. For example, in triggered or distributed amplifiers and in impedance-transforming cathode followers. The long life has been achieved through development of a new refractory dynode surface.



CBS 7548 supplies high output over wide voltage range.

As a pulse generator-amplifier the 7548 has a 3 ns rise time with a 1 ampere pulse output. The tube offers a gain-bandwidth product of 350, transconductance of 26,000 μmhos , and 3.4 μmf output capacitance.

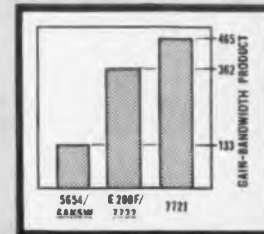
• High-gain Wideband Amplification



CBS 7721 in wideband amplifier

New CBS 7721 frame-grid pentode offers the highest figure of merit for gain-bandwidth product ever achieved . . . 465! With such unequalled performance, you can now design wideband i-f and video amplifiers using fewer stages, tubes, passive components and interconnections to achieve greater reliability and reduced cost.

The 7721 has a transconductance of 36,000 μmhos ; a lower-cost companion type tube, the 7722/E-280F, has 26,000 μmhos . These extremely high transconductances result from true frame-grid construction. Mechanical strength is provided by the welded molybdenum frame, and superior electrical characteristics by the tightly wound, precisely positioned fine tungsten wire.



Comparison of gain-bandwidth products

CBS 7721, 7722, 7548 all have coil heaters, high-conductivity gold-plated base pins, standard 9-pin miniature bases. Call your nearest sales office for complete data.



CBS ELECTRONICS

Danvers, Massachusetts

A Division of Columbia Broadcasting System, Inc.

Tubes • Semiconductors • Audio Components • Microelectronics

Sales Offices: Danvers, Mass., 100 Endicott Street, SPing 4-2360 • Newark, N. J., 230 Johnson Avenue, TAlbert 4-2450 • Melrose Park, Illinois, 1990 N. Mannheim Road, EStebrook 9-2100 • Los Angeles, California, 2120 S. Garfield Avenue, RAYmond 3-9081 • Minneapolis, Minnesota, The Heimann Co., 1711 Hawthorne Avenue, FEderal 2-5457.



"Make It Smaller!"

From miniature to sub-miniature to micro, the electronics industry is constantly striving to reduce the size of electronic components. As a result, there is an increasing demand for ceramic in smaller and smaller sizes. Coors is meeting this demand by making small-scale ceramic parts in mass production quantities at precision tolerances. Write for Design Data Sheet 7002, describing Coors manufacturing methods and facilities for small ceramic parts, and latest examples. Or call your nearest Coors Regional Sales Manager: WEST COAST, William S. Smith, Jr., EM 6-8129, Redwood City, Calif.; MIDWEST, John E. Marozek, FR 2-7100, Chicago, Ill.; CENTRAL, Donald Dobbins, GL 4-9638, Canton, Ohio; EAST COAST, John J. McManus, MA 7-3996, Manhasset, N.Y.; NEW ENGLAND, Warren G. McDonald, FR 4-0663, Schenectady, N.Y.; SOUTHWEST, Kenneth R. Lundy, DA 7-5716, Dallas, Texas; SOUTHWEST, William H. Ramsey, UN 4-6369, Houston, Texas.

Coors

ALUMINA CERAMICS
Coors Porcelain Company
 600 NINTH STREET • GOLDEN, COLORADO



NEW PRODUCTS

Acceleration Switch 470



A spring-mass, fluid-damped device, acceleration switch model 18001 may be used to open or close a circuit in the presence of accelerations caused by vibration and shock. Standard ranges extend from 0.02 to 200 g; accuracy is 0.01 g to 1%. Current rating of spdt contacts is 250 ma resistive, with up to 40 amp on special order. Optional configurations include packaging with latching or unlatching release, time delay devices, solenoids, etc.

U. S. Science Corp., Dept. ED, 5221 W. 102nd St., Los Angeles 45, Calif.

Germanium Mesa Transistors 482

For use in high-speed logic circuits, the pnp diffused-base germanium mesa transistors 2N705, 2N710 and 2N711 are enclosed in completely welded, hermetically sealed TO-18 cases. Switching times are: for the 2N705 and 2N710, 60 nsec; 2N711, 70 nsec.

Raytheon Co., Semiconductor Div., 215 First Ave., Needham, Mass.

P&A: From \$1.95 to \$10 ea, 100 to 999; immediate.

Power Supplies 471



Constant voltage and constant current outputs are available in the Mercury series of transistorized power supplies. There are five output combinations: 15 v, 10 amp; 36 v, 2.5 amp; 36 v, 5 amp; 60 v, 2.5 amp; and 160 v, 1 amp. Current and voltage are continuously variable, zero to maximum. Dynamic regulation is better than 0.05%, with a response time of 50 μ sec. Ripple

◀ **CIRCLE 60 ON READER-SERVICE CARD**

is less than 1 mv rms. Adjustable current limiting is provided. Panel height is 3-1/2 in.

Trygon Electronics Inc., Dept. ED, 111 Pleasant Ave., Roosevelt, L.I., N.Y.

P&A: \$365 to \$485; 4-week delivery.

Zener Diodes

476



Rated at 1 and 10 w, silicon Zener diodes conform to military requirements. Approved 10-w types are the 6.2-v USA 1N1804, the 8.2-v USA 1N1807, the 12-v USA 1N1353, the 22-v 1N1358 and the 27-v USA 1N1361. Approved 1-w types are the 18-v USA 1N1777 and 27-v USA 1N1781.

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

P&A: \$7 to \$12 ea, 1 to 99; stock.

Servo Accelerometers

466



For guidance, navigation and other systems requiring secondary acceleration sensing in two or more planes, servo accelerometers are made in triaxial, biaxial and unidirectional types. Internal axes are oriented orthogonally to within 1 min of arc. Required voltage is ± 15 v dc or 28 v dc.

Gulton Instrumentation Div., Dept. ED, 212 Durham Ave., Metuchen, N.J.


Price & Availability: Unidirectional, \$445; 90 days.

CIRCLE 61 ON READER-SERVICE CARD >

new from

UTICA

a revolutionary air power cutter

 **UA-100 Power Cutter**—an air-operated diagonal head wire cutter with tapered heads . . . designed specifically for high-volume tip cutting and assembly where thousands of cuts per day mean increased production, reduced operator fatigue! Can be used in either hand! And it operates on existing air supplies with 90 psi line pressure. Engineered by the Utica Drop Forge & Tool Division of Kelsey-Hayes Company, the UA-100 has electronically induction hardened jaws and an insulated air cylinder formed of durable plastic. Weight only 6 1/4 oz. Each unit is supplied with an 8 ft. air hose. The UA-100 power cutter is another outstanding addition to the Utica line of quality tools.



UTICA DROP FORGE & TOOL DIVISION • KELSEY-HAYES COMPANY, UTICA 4, N.Y.

More than 107 types standard
solder terminals



WEBSTER KNOWS

In fact, his definition certainly applies to CAMBION® Standard Solder Terminals. As parts which terminate plenty of trouble in electronic circuitry construction, they've gained universal approval from manufacturers, professional technicians and hams.

Starting with top quality brass, each CAMBION solder terminal is precision machined, quality inspected, electroplated with silver, electro-tin or gold — or to your own plating specifications. Close quality control is maintained, and inspections made at each successive manufacturing step to assure that each terminal meets or exceeds applicable MIL specifications, such as MIL-Q-5923C.

That's why, as with all components in the broad CAMBION line, top quality is guaranteed for the more than 30,000,000 CAMBION Solder Terminals in stock . . . in more than 107 different types: single, double and triple turret; feed-through, double-ended, hollow and split.

The broad CAMBION line includes plugs and jacks, solder terminals, insulated terminals, terminal boards, capacitors, shielded coils, coil forms, panel hardware, digital computer components. For a catalog, for design assistance or for both, write to Cambridge Thermionic Corporation, 457 Concord Ave., Cambridge 38, Mass.

CAMBRIDGE THERMIONIC CORPORATION
CAMBION®
The guaranteed electronic components
CIRCLE 62 ON READER-SERVICE CARD



NEW PRODUCTS

Digital Decoder

443



Interrupted tone signals from any voice channel are received and decoded by model RPD-620 digital decoder. Designed primarily for wire-line applications, it works equally well over carrier, microwave and radio circuits in any combination. Decoders provide dry output circuits and can be equipped with selectors which provide up to five separate coded outputs.

Secode Corp., Dept. ED, 555 Minnesota St., San Francisco 7, Calif.

P&A: \$165 to \$190; from stock.

Current-Limiting Relay

448



Protection from excessive current is provided by the CL series current-limiting relay. Contacts lock on a sustained overload and cannot be re-closed, even momentarily, until overload has been corrected. Models are available for a wide range of applications. Electrically insulated dust cover protects against shocks and ambient conditions.

Line Electric Co., Dept. ED, 231 River St., Orange, N. J.

Static Machine Controls

447

With transistor logic, static system controls hydraulic, magnetic, and pneumatic devices. Applications range from one-station assembly to large, integrated systems. Operating speed is about 10 μ sec. Fail-safe action is provided. System design results in longer life for input switches and output devices.

General Motors Corp., Delco Radio Div., Dept. ED, Kokomo, Ind.

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LATEST DATA ON ULTRASONIC DELAY LINES!



THIS NEW CATALOG

gives you up-to-date specs on the industry's most complete line of ultrasonic delay lines for missiles, MTL, radar countermeasures and computer applications. Send for it today.

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LABORATORY FOR ELECTRONICS, INC.
Computer Products Division
1079 Commonwealth Avenue
CIRCLE 64 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

ELECTRON TUBE NEWS

...from SYLVANIA



• INCREASED GAIN!

• DECREASED NOISE FACTOR!

• IMPROVED G_m/I_b RATIO!

...outstanding advantages of new

BIKINI CATHODES plus STRAP FRAME GRIDS

in 4 new Gold Brand
Subminiature Tubes



From Sylvania comes an important new cathode design—*Bikini Cathode*—destined to upgrade industry standards for high performance tubes. Sylvania complements this remarkable cathode design with the advantages of *Strap Frame Grid* in exceptionally rugged, premium-quality Gold Brand Subminiature Tubes. The end effect: high reliability tubes for superlative VHF and UHF performance in compact, environmentalized equipment.

Exceptionally smooth, ultra-uniform in density . . . *Bikini Cathode* is a precast film of emissive material, of precise dimensions, bonded to the *two major sides* of a flat cathode sleeve. *Bikini Cathode* minimizes stray emission. Further, consistent density of cathode material eliminates "hot spots," assures uniform temperature and emission over the entire cathode surface. Smooth cathode surface minimizes possibility of grid-to-cathode arcing.

Bikini Cathode is ideally mated with Sylvania *Strap Frame*

Grid. Both possess exceedingly flat surfaces, providing outstanding uniformity in grid-cathode spacing with resultant narrow dispersion of electrical characteristics, improved cutoff control, high stability and improved speed and uniformity of electron transit time. Add to this the singular advantages of rugged *Strap Frame Grid*—very fine grid wire, high T.P.I., extreme accuracy of grid pitch—and the result is a near ideal combination for high db gain, unusually low noise and exceptional ratio of Gm per mA of plate current.

New Sylvania Gold Brand Subminiature Tubes

featuring Bikini Cathodes and Strap Frame Grids



. . . for cascade RF amplifier-mixer, high-speed multivibrator service.

SYLVANIA SR-2662B is a medium-mu double triode (similar to 6111) featuring very low heater power of 0.7W per section and low E_b of 30V per section. Gm per mA of I_b for a single section is 1120. Gm per section is 9000 μ mhos, 80% higher than Gm of conventional prototypes. It is subjected to the intensive testing characteristic of all Sylvania Gold Brand Subminiature Tubes. Examples: shock tests of 500g; vibrational acceleration of 2.5g; heater life tests of 2000 cycles, one minute "on", four "off." It's capable of withstanding ambient bulb temperatures of 220°C and intense radiation dosage.

SYLVANIA SR-2662C, medium-mu double triode, is a high-performance version of the popular, general purpose 6021 with a Gm of 13,000 μ mhos. Ratio of Gm I_b provides a figure of merit of 1730 per section.

. . . for grounded-cathode RF amplifier applications

SYLVANIA SR-2941A is a high-mu triode with Gm of 12,000 μ mhos. It only draws 125 mA @ 6.3V heater power. Gm per mA I_b is 1300. SR-2941A provides 2.5 db better gain than usually encountered in present high-performance types.

. . . for grounded-grid RF amplifier applications

SYLVANIA SR-2942B, high-mu triode, featuring low heater power of 125 mA @ 6.3V and high Gm of 13,500 μ mhos. It offers a 2.5 to 7 db gain improvement, 1.5 to 4 db noise improvement at 480MC than usually encountered with popular grounded-grid RF amplifier types.

These are the first types to utilize *Bikini Cathodes* and *Strap Frame Grids*. Ask your Sylvania Sales Engineer to keep you up to date on further developments. For technical data on specific types, write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. D1, 1100 Main St., Buffalo 9, N. Y.

| AVERAGE CHARACTERISTICS | | | | | |
|----------------------------------|----------|----------|-----------------------|----------|---------------|
| | SR-2662B | SR-2662C | SR-2941A | SR-2942B | Units |
| E_f | 6.3 | 6.3 | 6.3 | 6.3 | V |
| I_f | 235 | 375 | 125 | 125 | mA |
| E_b | 60 | 100 | 110 | 150 | V |
| E_{c1} | — | — | -1.0 | — | V |
| R_k | 220* | 270* | — | 100 | ohms |
| I_b | 8.0* | 7.5* | 9.0 | 14.3 | mA |
| Gm | 9,000* | 13,000* | 12,000 | 13,560 | μ mhos |
| Gm/ I_b | 1,120* | 1,730* | 1,300 | 945 | μ mhos/mA |
| Mu | 20* | 40* | 58 | 55.2 | |
| Mismatched Conditions | | | | | |
| Grounded Cathode Circuit (200MC) | | | Grounded Grid (480MC) | | |
| Gain | 14.8* | 15.1* | 17.5 | 14.5 | db |
| Bandwidth | 8.0* | 9.5* | 11.8 | 9.5 | MC |
| NF | 4.0* | 4.0* | 4.4 | 7.2 | db |

*Single section



SYLVANIA SPIRAL ACCELERATORS -5BGP-, -5BHP-

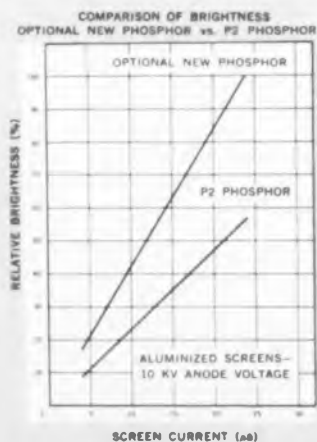
- High deflection sensitivity
- High resolution • High reliability
- High writing speed

*now available with new,
brighter phosphor and "Bonded
Shield" safety cap*

Sylvania Spiral Accelerator cathode ray tubes provide superior-quality displays with minimal pattern distortion. Consider the reasons—guns, for example, are assembled on Sylvania-developed mounting jigs accurate to 0.001". High-magnification optical comparators critically inspect spacings and dimensions. The internal helical resistance coating, too, undergoes extremely tight controls for linear resistance, and uniformity of application. Further, completed tubes receive extensive tests for electrical characteristics, distortion, brightness. Spot size is microscopically measured at extreme corners of required minimum scan. Perpendicularity of horizontal and vertical scan lines is physically measured to meet 1.0° acceptance standards. In addition, Sylvania-5BGP-, -5BHP- must meet severe cycled life tests.

Sylvania Spiral Accelerators are also available with "Bonded Shield" safety cap for increased image readability. "Bonded Shield" improves mounting and styling, strengthens tube face, simplifies cleaning of tube face.

Development is now under way at Sylvania on square-faced Spiral Accelerators. Ask your Sylvania Sales Engineer for price and delivery information. For technical data, write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. D2, 1100 Main St., Buffalo 9, N. Y.



Graph illustrates the improved brightness of new phosphor, a medium-short decay phosphor having green fluorescence and phosphorescence. Sylvania-5BGP-, -5BHP- are available also in a wide range of other phosphors.



Every Spiral Accelerator gun is inspected on a high-magnification optical comparator for spacing and dimensions.

MICROWAVE DEVICE NEWS from SYLVANIA

120KW



20 KW
to
120 KW
peak power output



20KW

with Sylvania Ka Band Magnetrons

Sylvania Ka Band Magnetrons offer a remarkable range of powers, fill virtually all your Ka band requirements. They include extremely compact types with exceptional power-to-weight ratios. All are fixed-frequency types for pulsed operation, utilize stabilized magnets, and exhibit outstanding reliability and longevity.

SYLVANIA-5789, first commercially available U. S. type for Ka band, uses 22-vane "rising sun" anode, and improved dispenser-type cathode. With hermetically sealed input and pressurized output, it is highly adaptable to high altitude operation.

SYLVANIA-6799 features 120KW peak power output and is a proven high-power millimeter wave source. It is available for use with longer pulses and higher duty cycles at slightly reduced power.

SYLVANIA M-4155A, ruggedized version of the 5789, features compact size and weight of only 9 lbs., improved heat dissipation and excellent stability. It utilizes a special cone-shaped cathode support and "building block" mounting arrangement for added mechanical strength. M-4155A possesses both long- and short-pulse capabilities.

SYLVANIA XM-4064, ruggedized magnetron, offers exceptional stability under severe environmental conditions. Only 9 lbs. in weight, it provides peak power output of 70KW for a remarkably good power-to-weight ratio.

SYLVANIA XM-4158, ruggedized magnetron, provides 120KW peak power output. Weight is only 27 lbs. It uses E type magnets for a uniform, flat surface configuration that can be used as a structural part of the chassis. XM-4158 is compatible with either long- or short-pulse operation.

SYLVANIA XM-4218, ruggedized tube, provides a power-to-weight ratio of 8:1 making it especially suited for portable, field-type radar. It uses metal-to-ceramic seals, ceramic cathode capsule, cantilever cathode support. The tube withstands 50g shock, 10g vibration tests. XM-4218 provides a lower pushing factor than tubes of comparable performance.

SYLVANIA XM-4206 is a ruggedized, compact tube with encapsulated cathode. Only 10.5 lbs., it provides 40KW peak power output.

SYLVANIA Ka BAND MAGNETRONS

| | Frequency (KMC) | Peak Power Output (KW) | Max. Duty Cycle | Max. Pulse Width (usec) |
|---------|-----------------|------------------------|-----------------|-------------------------|
| 5789 | f 34.512 | 40 | .0006 | 1.0 |
| | l 35.208 | | | |
| 6799 | f 34.512 | 120 | .0005 | 1.0 |
| | l 35.208 | | | |
| M-4155A | f 34.512 | 40 | .0006 | 1.0 |
| XM-4064 | f 34.512 | 70 | .0008 | 1.0 |
| | l 35.208 | | | |
| XM-4158 | f 34.512 | 120 | .0006 | 1.0 |
| | l 35.208 | | | |
| XM-4218 | f 34.512 | 32 | .0006 | 0.4 |
| | l 35.207 | | | |
| XM-4206 | f 34.7 | 40 | .0006 | 1.1 |
| | l 35.0 | | | |

Investigate the design advantages of Sylvania Ka band magnetrons and associated Ka band TR tubes. Contact your Sylvania Sales Engineer for complete information. For technical data on specific types, write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. MDO-D, 1100 Main St., Buffalo 9, N. Y.

SYLVANIA

SUBSIDIARY OF

GENERAL TELEPHONE & ELECTRONICS



NEW PRODUCTS

Precision Resistors 690

Ceramic bobbin wirewound resistors of series CB feature all-welded construction. Designed for applications requiring long-term accuracy and stability, standard tolerances are 1, 0.5, 0.25, and 0.1%. Temperature coefficient is ± 20 ppm per deg C from -50 to $+85$ C for values above 500 ohms.

Kelvin Electric Co., Dept. ED, 5907 Noble Ave., Van Nuys, Calif.

Control Relay 368



For automation control panel applications, the type BF relay measures 3-1/8 in. high and 1-11/16 in. wide. Current rating is 6 amp at 300 v ac. The relay is available in any combination of normally open or normally closed contacts, two to eight poles, with a maximum of four normally closed. Operating time on pickup is 12.5 to 18.0 msec, dropout 6.25 to 12.5 msec.

Westinghouse Electric Corp., Dept. ED, P. O. Box 2099, Pittsburgh 30, Pa.

Twin Planar Transistor 575

Capable of boosting 10-fold the voltage of a standard battery, the "twin-planar" transistor will be offered initially as a dc chopper-amplifier. The two silicon transistors incorporated in the device share a common collector. Close matching characteristics eliminate the necessity of transistor selection.

Radio Corp. of America, Semiconductor and Materials Div., Dept. ED, 30 Rockefeller Plaza, New York 20, N.Y.

Price: Under \$25 per unit in thousand lots.

CIRCLE 63 ON READER-SERVICE CARD >



How to make a shrewd increase in recorder efficiency

With twice the performance, the Ampex FR-600 is still compatible with earlier equipment.

Doubles tape utilization and obviates standby equipment

Your FR-600 records 125 kc data at 30 ips instead of 60 — gives twice the recording time per reel. For example, you get 48 minutes recording time on 10 1/2-inch reels, 96 minutes on 14-inch at 30 ips. Not only are tape expenditures cut in half, but standby recorders on long sessions may no longer be needed. And for a broader data spectrum in the future, your FR-600 can accommodate 250 kc at 60 ips or 500 kc at 120 ips.

Multiplies available recording time and eliminates error

Two-hour warmup and adjust sessions are reduced to ten minutes by the FR-600's transistorized circuitry. Final calibration is a one-time-per-use operation. Post-warmup stability — less than 1% drift per 24 hours — precludes time-wasting adjustments and minimizes creeping inaccuracies. Because your FR-600 is ready when needed, it works more hours per day, saving both your time and its own.

Updates performance of older equipment

The FR-600 plays back tapes from most existing data recorders. And because playback heads generally determine overall frequency response, use of an FR-600 for playback can permit earlier equipment (with simple adjustment) to record the same high information density as your FR-600.

The essential data

The Model: FR-600 Laboratory Recorder/Reproducer. Number of tracks: up to 14. Reel sizes and tape widths: 10 1/2- or 14-inch NAB, with 1/2-inch or 1-inch tape, interchangeable. Frequency response: 300 to 250,000 cps ± 3 db at 60 ips with direct recordings; 0 to 20,000 cps ± 0.25 db at 60 ips in FM-carrier recording — proportionate response at other speeds. Tape speeds: 60, 30, 15, 7 1/2 ips; 120, 3 3/4, 1 1/2 ips optional. Types of recording: direct, PDM and FM-carrier, by plug-in modules. Compatibility: yes, with Ampex 300 and 800 series; FR-100 and FR-1100 series, and AR-200 and CP-100 series.

For detailed information on the complete Ampex line of data recorders, write:

AMPEX INSTRUMENTATION PRODUCTS COMPANY
Box 5000, Redwood City, California



AMPEX

Experienced engineers eager to contribute to Ampex's pioneering reputation are invited to write the Manager, Technical Recruiting.



Roy Caprarola cooks up a new tube...

This engineer, so absorbed in "cooking" a glass tube base in a concentrated gas jet, has two important responsibilities that directly benefit you.

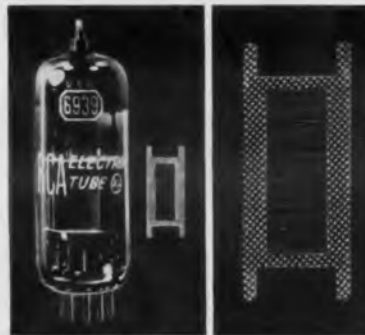
He's Roy Caprarola, Manager of our Receiving Tube Methods and Processes Lab. One of his jobs is to refine manufacturing processes to improve tube performance. Closer interelement tolerances, sturdier cage structures, tighter seals, higher vacuums are his objectives. Above, for example, he's working on an improved pin-sealing technique for the bases of our new developmental NOVAR tubes.

He has another responsibility. When our Advanced Development engineers come up with an idea for a new tube structure, it's Roy's job to develop a practical way to produce it. Case in point: the frame grid shown at right, the key element in the new RCA-6939 industrial twin pentode. The Methods and Processes Lab developed the manufacturing technique—and even took over initial production—for this vital element.

Roy's job has many facets, all of which present challenges. But the solving of these challenges means new advances: improved performance from your RCA Industrial Receiving Tubes. The work of the M & P Lab is typical of our determination to achieve top quality through constant research.



The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA



Frame grid of RCA-6939 holds grid wires under tension. This grid design permits closer spacing and precise positioning of wires to provide more accurate control of electron flow.

RCA ELECTRON TUBE DIVISION—FIELD OFFICES
DETROIT 2, MICH., 714 New Center Building,
TR 5-5600 • NEWARK 2, N. J., 744 Broad St.,
HU 5-3900 • CHICAGO 54, ILL., Suite 1154,
Merchandise Mart Plaza, WH 4-2900 • LOS
ANGELES 22, CAL., 6355 E. Washington Blvd.,
RA 3-8361 • BURLINGAME, CAL., 1838 El
Camino Real, OX 7-1620.

NEW PRODUCTS

Pressure Transducer 617

Medium-to-high range pressure transducer type 4-329 utilizes the unbonded strain gage principle. Specifications are: electrical excitation, 20 v dc or ac rms with a carrier frequency of 0 to 20 kc; sensitivity, 50 mv \pm 0.25 mv measured through a 50-K load; input impedance, 700 ohms min; output impedance, 350 ohms; temperature range, -100 to +300 F; pressure ranges, 0 to 100 through 0 to 5,000 psi.

Consolidated Electroynamics Corp., Dept. ED, 360 Sierra Madre Villa, Pasadena, Calif.

Pulse Generator 363



Rugged and reliable, the Tri-Pulse generator is designed to supply 10, 100 or 1,000 pulses per sec to as many as 10 telemetering devices. Power for the 1-1/2 lb unit is supplied by a miniature 30-v battery. Size is 1-1/2 in. high, 4 in. wide, and 5 in. long. The generator has performed within 1% of selected frequency in rocket sled tests to 40 g acceleration.

The Harwood Co., Dept. ED, 1141 W. Valley Blvd., Alhambra, Calif.

Data Converter 369

The CV-772 radiosonde data converter is designed to operate with the AN/GMD-1 semiautomatic sounding system. The converter senses and records contact closures representing baroswitch reference contact numbers. It measures elapsed time in increments of 0.01 min. Remote control operation is possible from 210 ft.

Datex Corp., Dept. ED, 1307 S. Myrtle Ave., Monrovia, Calif.

Silicon Rectifiers

582

Rated at 20 amp, these stud-mounted, diffused-junction silicon rectifiers are designed for military and industrial power supplies. Types 1N248-C, 1N249-C, 1N250-C, and 1N1195-A through 1N1198-A are also available in reverse-polarity versions. Peak surge-current rating is 350 amp; peak inverse voltage ratings range from 55 to 600 v. In a D0-5 package, temperature range is -65 to $+175$ C.

Radio Corp. of America, Semiconductor and Materials Div., Dept. ED, Somerville, N.J.

Power Supply

367



Capacitor-discharge power supply model 1046 MA is designed for welding extremely fine wires. Low range is 0.004 to 1.3 w-sec, high range 0.04 to 13 sec. Discharge time is about 1 msec. Watt-sec meter and stepless heat control are provided. Rate is 50 to 150 welds per minute. Unit measures 6-1/8 in. high, 8-1/4 in. wide and 13-5/8 in. deep.

Weldmatic Div., Unitek Corp., Dept. ED, 950 Royal Oaks Drive, Monrovia, Calif.

Impulse Magnetizer

378

Automatic or semi-automatic operation is possible with this half-cycle impulse magnetizer. Consisting of an ignitron tube and control circuitry, the device may be triggered as often as desired; no charging interval is necessary. Magnetizer uses 220/600 v ac, single phase; control circuit operates on 110 v ac.

Indiana Steel Products Div., Indiana General Corp., Dept. ED, Valparaiso, Ind.

CIRCLE 65 ON READER-SERVICE CARD >

ELECTRONIC DESIGN • April 12, 1961

Just *Plug it in*

any computer and...

- multiply
- divide
- square
- extract square root

Donner's new all solid state electronic multiplier plugs into any analog computer problem board with 3/4" terminal spacing — all Donner models, all Heathkit models, Boeing (BEAC), Goodyear L3-N3 series, and so forth.

Designed on the quarter-square principle, this compact, single channel multiplier offers four modes of operation selected by a switch:

- Four-quadrant multiplication (output = $-0.01XY$), with static accuracy of 0.3% of full scale voltage (200 volts).
- Two-quadrant division (output = $-100X/Y$).
- Two-channel squaring (outputs of $-0.01X^2$ and $+0.01Y^2$).
- Two-channel square root operation.

As inputs, the Model 3732 accepts $+X$, $-X$, $+Y$, $-Y$, and generates an output current to the summing junction of an external amplifier.

To satisfy your particular needs, Donner furnishes the multiplier in a variety of packages besides the plug-in version shown.



Model 3732 electronic multiplier is available without enclosure for panel mounting or as a single printed card for inclusion in your system. The unit is also available with up to three solid state multipliers on a 3 1/2" x 19" panel for rack mounting.

Price of the Model 3732P is \$350; delivery 30 days. Other prices, detailed specifications and demonstrations available from all Donner representatives or just drop us a line at the factory. Please address Dept. 36.

DONNER
SCIENTIFIC COMPANY

A SUBSIDIARY OF **SYSTRON-DONNER**
Corporation

CONCORD, CALIFORNIA

NEW PRODUCTS

Power Supply

365



Delivering 0 to 36 v dc and 0 to 10 amp, model 809A power supply may be operated as a constant current or constant voltage source. Changeover from either mode is made by plugging in the appropriate circuit card. Line and card regulation is less than 15 mv for constant-voltage operation; ripple and noise are less than 1 mv. Supplies may be paralleled. Panel is 5-1/4 in. high. »

Harrison Laboratories, Inc., Dept. ED, 45 Industrial Road, Berkeley Heights, N. J.
Price: \$625.

Rectifier Test Set

374

An oscilloscope display of the reverse characteristics of high-voltage diodes and rectifiers is provided by rectifier test set model 1826. It provides a wide range of reverse voltages up to 5 kv and reverse currents from less than 1 μ a to 1 amp.

Dynatron Electronics Corp., Dept. ED, 178 Herricks Road, Mineola, N.Y.

Sector Potentiometer

362



Small angular movements are measured with an accuracy within 7.2 min by the CP13-0301-1 circular sector potentiometer. Electrical travel is ± 3 deg; resolution is 0.5%. The 11-oz unit withstands 500 F for 3 min, humidity of 95 to 100% at 160 F, linear acceleration of 50 g and shock of 100 g along 3 axes. Zero adjustment is external.

Humphrey, Inc., Dept. ED, 2805 Canon St., San Diego 6, Calif.



CONVECTION COOLED

No Blowers or Filters
Maintenance Free

Highly efficient, radiator type heat sinks eliminate internal blowers, maintenance problems, risk of failure, moving parts, noise and magnetic fields. Units are rated for continuous duty at 50°C ambient.

EASY SERVICE ACCESS

Dual-deck, swing-out back construction provides simple and fast service access without the need to remove unit from rack. All major component terminals are accessible from rear.

NO VOLTAGE SPIKES OR OVERSHOOT

Lambda's design prevents output voltage overshoot on "turn on, turn off," or power failure.

MIL QUALITY

Hermetically-sealed magnetic shielded transformer designed to MIL-T-27A quality and performance. Special, high-purity foil, hermetically-sealed long life electrolytic capacitors.

| | | | |
|-----------|------------|----------|-------|
| LA 50-03A | 0- 34 VDC | 0- 5 A | \$395 |
| LA100-03A | 0- 34 VDC | 0-10 A | 510 |
| LA200-03A | 0- 34 VDC | 0-20 A | 795 |
| LA 20-05A | 20-105 VDC | 0- 2 A | 350 |
| LA 40-05A | 20-105 VDC | 0- 4 A | 495 |
| LA 80-05A | 20-105 VDC | 0- 8 A | 780 |
| LA 8-08A | 75-330 VDC | 0- 0.8 A | 395 |
| LA 15-08A | 75-330 VDC | 0- 1.5 A | 560 |
| LA 30-08A | 75-330 VDC | 0- 3 A | 860 |

For metered models add the suffix "M" to the model number and add \$30.00 to the price.

SHORT CIRCUIT PROOF

All models are completely protected with magnetic circuit breakers, fuses, and thermal overload.

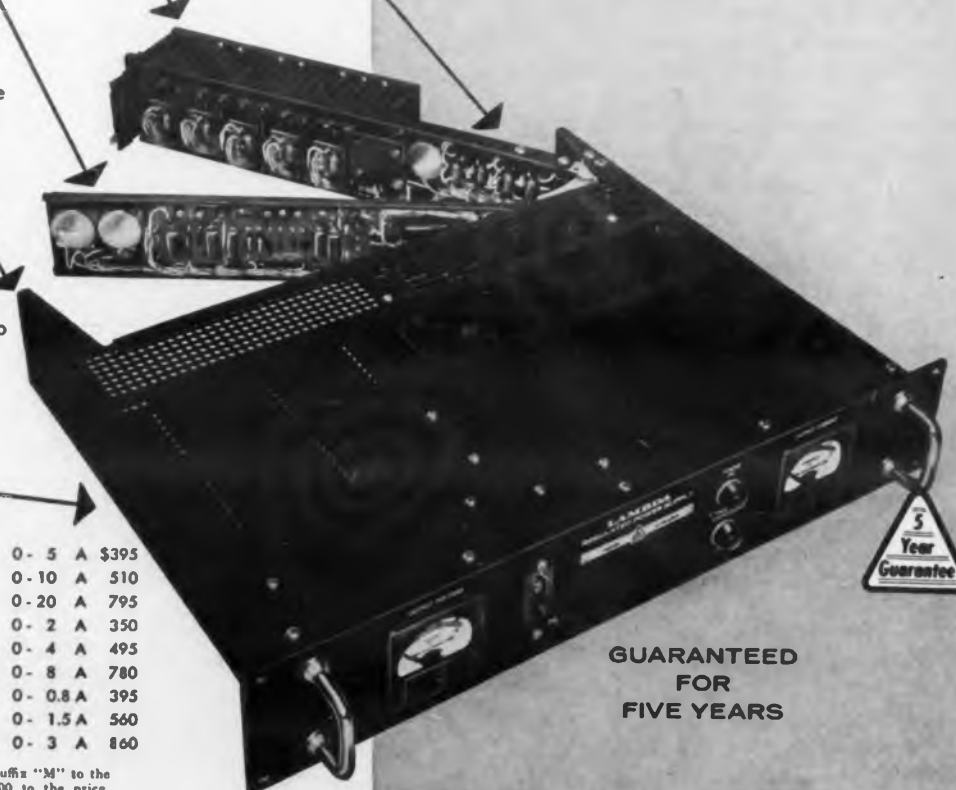
REMOTE SENSING

Minimizes effect of power output leads on DC regulation, output impedance and transient response.

New LAMBDA

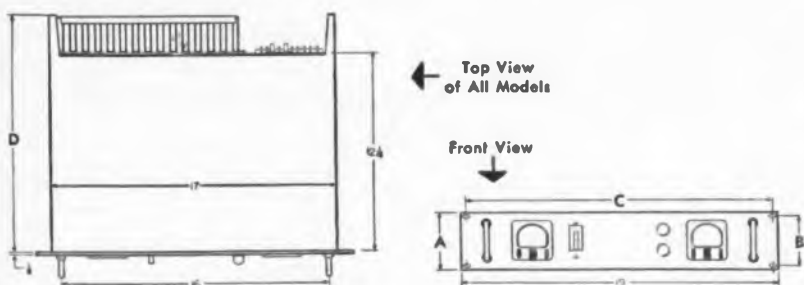
Transistorized REGULATED POWER SUPPLIES

0- 34 VDC 5, 10 and 20 Amp
20-105 VDC 2, 4 and 8 Amp
75-330 VDC 0.8, 1.5 and 3 Amp



GUARANTEED
FOR
FIVE YEARS

DIMENSION DRAWINGS



| MODEL † | | |
|-----------|------------|------------|
| LA 50-03A | LA 100-03A | LA 200-03A |
| LA 20-05A | LA 40-05A | LA 80-05A |
| LA 8-08A | LA 15-08A | LA 30-08A |
| A | 3½" | 7" |
| B | 3" | 4" |
| C | 18¾" | 18¼" |
| D | 14¾" | 14½" |

* These models notched per RETMA Standards
† Includes metered models with suffix "M"

COMPLETE SPECIFICATIONS OF LAMBDA LA SERIES

DC OUTPUT (Regulated for line and load)

| Model | Voltage Range | Current Range | Minimum Voltage (1) | Voltage Steps (1) | Price(2) |
|-----------|---------------|---------------|---------------------|--|----------|
| LA 50-03A | 0-34 VDC | 0-5 AMP | 0 | 2, 4, 8, 16, and 0-4 volt vernier | \$ 395 |
| LA100-03A | 0-34 VDC | 0-10 AMP | 0 | 2, 4, 8, 16, and 0-4 volt vernier | 510 |
| LA200-03A | 0-34 VDC | 0-20 AMP | 0 | 2, 4, 8, 16, and 0-4 volt vernier | 795 |
| LA 20-05A | 20-105 VDC | 0-2 AMP | 20 | 5, 10, 20, 40, and 0-10 volt vernier | 350 |
| LA 40-05A | 20-105 VDC | 0-4 AMP | 20 | 5, 10, 20, 40, and 0-10 volt vernier | 495 |
| LA 80-05A | 20-105 VDC | 0-8 AMP | 20 | 5, 10, 20, 40, and 0-10 volt vernier | 780 |
| LA 8-08A | 75-330 VDC | 0-0.8 AMP | 75 | 15, 30, 60, 120, and 0-30 volt vernier | 395 |
| LA 15-08A | 75-330 VDC | 0-1.5 AMP | 75 | 15, 30, 60, 120, and 0-30 volt vernier | 560 |
| LA 30-08A | 75-330 VDC | 0-3 AMP | 75 | 15, 30, 60, 120, and 0-30 volt vernier | 860 |

(1) The DC output voltage for each model is completely covered by four selector switches plus vernier control. The DC output voltage is the summation of the minimum voltage plus the voltage steps and the continuously variable DC vernier.

(2) Prices are for unmetered models. For metered models add the suffix "M" and add \$30.00 to the price.

| | |
|-------------------------|--|
| Regulation (line) | Better than 0.05 per cent or 8 millivolts (whichever is greater). For input variations from 100-130 VAC. |
| Regulation (load) | Better than 0.10 per cent or 15 millivolts (whichever is greater). For load variations from 0 to full load. |
| Transient Response | Output voltage is constant within regulation specifications for step function: |
| (line) | line voltage change from 100-130 VAC or 130-100 VAC. |
| (load) | load change from 0 to full load or full load to 0 within 50 microseconds after application. |
| Internal Impedance | LA 50-03A less than .008 ohms LA100-03A less than .004 ohms LA200-03A less than .002 ohms LA 20-05A less than .06 ohms LA 40-05A less than .03 ohms LA 80-05A less than .015 ohms LA 8-08A less than .5 ohms LA 15-08A less than .25 ohms LA 30-08A less than .15 ohms |
| Ripple and Noise | Less than 1 millivolt rms with either terminal grounded. |
| Polarity | Either positive or negative terminal may be grounded. |
| Temperature Coefficient | Better than 0.025 %/°C |

| AC INPUT | 100-130 VAC, 60 ± 0.3 cycle ³ |
|-----------|--|
| LA 50-03A | 360 watts ⁴ |
| LA100-03A | 680 watts ⁴ |
| LA200-03A | 1225 watts ⁴ |
| LA 20-05A | 390 watts ⁴ |
| LA 40-05A | 710 watts ⁴ |
| LA 80-05A | 1350 watts ⁴ |
| LA 8-08A | 415 watts ⁴ |
| LA 15-08A | 760 watts ⁴ |
| LA 30-08A | 1450 watts ⁴ |

³This frequency band amply covers standard commercial power lines in the United States and Canada.

⁴With output loaded to full rating and input at 130 VAC.

AMBIENT TEMPERATURE AND DUTY CYCLE

Continuous duty at full load up to 50°C (122°F) ambient.

OVERLOAD PROTECTION:

| | |
|------------|--|
| Electrical | Magnetic circuit breaker front panel mounted. Special transistor circuitry provides independent protection against transistor complement overload. Fuses provide internal failure protection. Unit cannot be injured by short circuit or overload. |
| Thermal | Thermostat, manual reset, rear of chassis. Thermal overload indicator light front panel. |

METERS Voltmeter and ammeter on metered models.

CONTROLS:

| | |
|--------------------|--|
| DC Output Controls | Voltage selector switches and adjustable vernier-control rear of chassis. |
| Power | Magnetic circuit breaker, front panel. |
| Remote DC Vernier | Provision for remote operation of DC vernier. |
| Remote Sensing | Provision is made for remote sensing to minimize effect of power output leads on DC regulation, output impedance and transient response. |

PHYSICAL DATA:

| | |
|--------------|---|
| Mounting | Standard 19" Rack Mounting |
| Size | LA 50-03A, LA20-05A, LA 8-08A 3½" H x 19" W x 14¾"D LA100-03A, LA40-05A, LA15-08A 7" H x 19" W x 14¾"D LA200-03A, LA80-05A, LA30-08A 10½" H x 19" W x 16½"D |
| Weight | LA 50-03A, LA20-05A, LA 8-08A 55 lb Net 85 lb Ship. Wt. LA100-03A, LA40-05A, LA15-08A 100 lb Net 130 lb Ship. Wt. LA200-03A, LA80-05A, LA30-08A 140 lb Net 170 lb Ship. Wt. |
| Panel Finish | Black ripple enamel (standard). Special finishes available to customers' specifications at moderate surcharge. Quotation upon request. |

Impulse Counter

631



Readings in five-unit increments from a maximum reading of 995 to 000 are provided by model 11576 miniature impulse counter. Over-all size is less than 1-in. square by 3-in. long and weight is slightly more than 4 oz. Maximum speed of response is 1320 impulses per minute. The unit is designed for 80%-on-20%-off operation.

Bowmar Instrument Corp., Dept. ED, 8000 Bluffton Road, Fort Wayne, Ind.

High-Purity Silver 376

Silver 99.999+% pure is available in fine crystalline powder, vacuum-cast ingots, or rolled into strip or foil to user specifications. The only spectrographically detectable elements, Fe, Cu, Si, and Mn, amount to less than 1 ppm each.

High Purity Metals, Inc., Dept. ED, 340 Hudson St., Hackensack, N.J.

Coaxial Switches 628



High-power, coaxial switches, series 8000, are spdt units available in 1-5/8- and 3-1/8-in. coaxial sizes. Isolation is in excess of 75 db. High reliability is achieved by use of a direct-bearing flush-type mechanism. Standard models are manually operated with motor drives optional.

Bogart Manufacturing Corp., Dept. ED, 315 Siegel St., Brooklyn 6, N.Y.



LAMBDA ELECTRONICS CORP.

516 BROAD HOLLOW ROAD, HUNTINGTON, L. I. NEW YORK 516 MYRTLE 4-4200

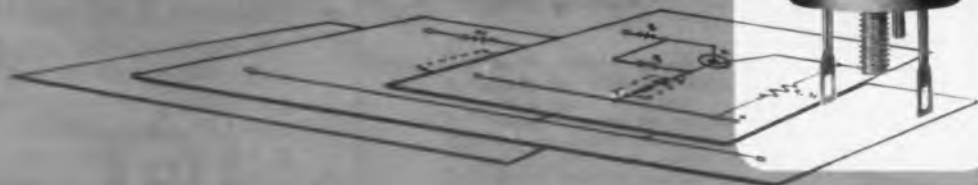
Send for complete Lambda Catalog.

MOTOROLA IS

YOUR MOST COMPLETE
**POWER
TRANSISTOR
SOURCE**



**THE KEY
TO GREATER RELIABILITY
IN YOUR
HIGH-VOLTAGE CIRCUITS**



Motorola Power Transistor Applications Assistance

If you are working with high-voltage circuits you'll find a new report, prepared by Motorola applications engineers, of special interest.

It reviews the use of power transistors in high-voltage circuits and suggests application methods that could result in substantial cost reductions. In addition, the techniques outlined in this report can greatly improve circuit reliability and help simplify procurement problems. Titled "How to Design Economical High-Voltage Circuits," this applications brochure is yours for the asking.



For your copy simply contact your Motorola district office, Motorola distributor, or write: Motorola Semiconductor Products Inc., Technical Information Department, 5005 East McDowell Road, Phoenix 10, Arizona.

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MOTOROLA IS YOUR MOST COMPLETE POWER TRANSISTOR SOURCE

You can achieve marked improvement in *all* your circuits by utilizing the wide selection of field-proven power transistors available from Motorola. Whatever your specific requirements, you'll find a *standard* Motorola unit that meets your needs.

- Both T0-3 and T0-36 packages
- 90 and 150 watts power dissipation
- 0.8°C/W and 0.5°C/W maximum thermal resistance
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- current ratings of 3, 5, 10, 15 and 25 amps
- collector voltages to 120 volts
- variety of gain/voltage combinations
- 6 mil-types
- "Meg-A-Life" mil-quality industrial units

For fast delivery in any quantity, call your nearby Motorola distributor or your Motorola district office.



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NEW PRODUCTS

Power Supplies

734



Voltage-regulated power supplies of SM 160 series deliver 0 to 160 v at 4, 2 or 1 amp. Line and load regulation is 0.1%. Stability is 0.1% or 6 mv, ripple less than 1 mv rms. Recovery time is 50 μ sec, temperature coefficient less than 0.05% per deg C.

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

P&A: \$525 to \$925; 30 to 60 days.

Crystal Oscillator

738



Solid-state, voltage-controlled crystal oscillator 10M-WA can be directly frequency-modulated over a range of $\pm 0.2\%$ of F_o . Center frequency is 10.7 mc, deviation ± 20 kc. Temperature drift is less than 1 kc from -40 to $+65$ C; linearity is ± 200 cps. Output power is 5 mw, sensitivity 3 kc per v. Size is $3/4 \times 2 \times 2-1/2$ in.

Itek Corp., Itek Electro-Products Co. Div., Dept. ED, Cambridge 42, Mass.

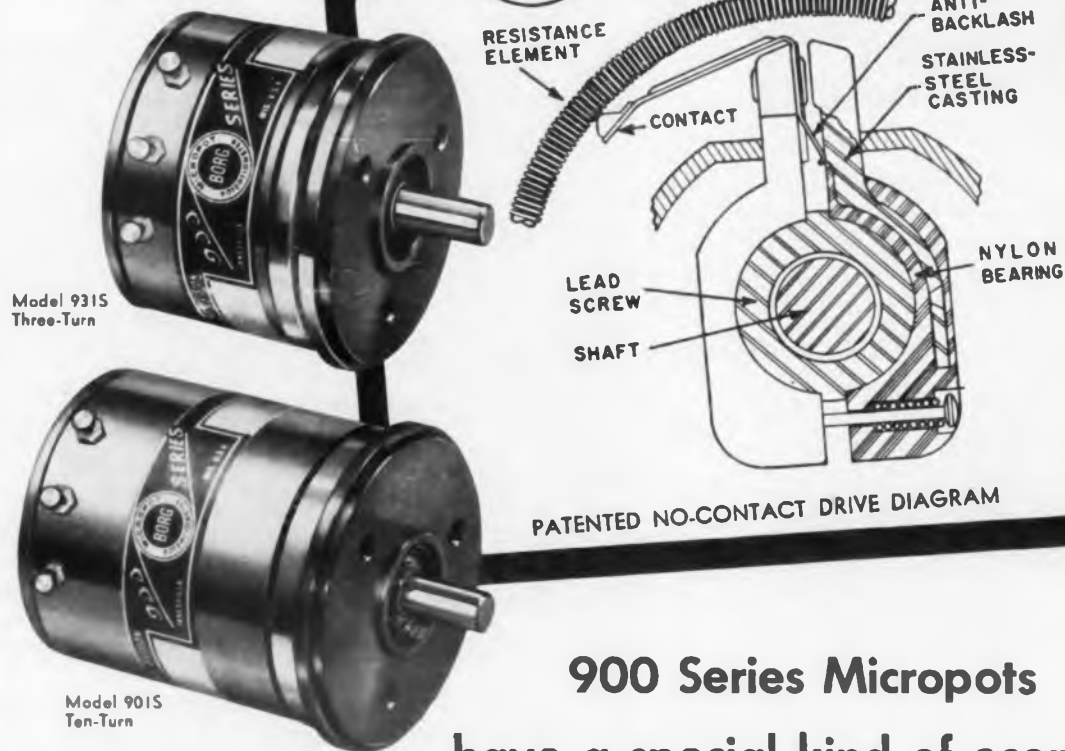
Electrical Tape

661



Acetate film insulation, glass filler and a solvent-resistant, thermosetting adhesive are combined in tape No. X-1131. The 7-mil tape has an electric strength of 5 kv, tensile strength of 130 lb/in. and an electrolytic corrosion factor of 1.00. It will not cause corrosion under prolonged exposure to humidity and stress.

Minnesota Mining and Manufacturing Co., Dept. W1-29, Dept. ED, 900 Bush Ave., St. Paul 8, Minn.



900 Series Micropots

have a special kind of economy

These are Borg 900 Series Micropots. They cost a little more than most potentiometers because they have a special kind of economy — *their precision, accuracy and reliability often permits their use in place of special-design pots.* Anyone who has ever purchased a special will appreciate this kind of economy. Characteristics such as higher concentricities, greater heat dissipation and patented drive assembly provide this inherent quality. The patented drive assembly enables the contact carrier to follow the resistance helix without reference to or contact with it. This feature reduces wear and lengthens life. In addition, the 900 Series is multiturn and completely gangable. Get complete information on Borg 900 Series Micropots. See your nearest Borg technical representative.

CHARACTERISTICS

| | 10-turn | 3-turn |
|---------------------|------------------|--------------------|
| Resistance (ohms) | 25 to 100,000 | 15 to 60,000 |
| Linearity (best) | 0.025% | 0.05% |
| Torque | 1 oz./in. | 1 oz./in. |
| Mechanical Rotation | 3600° + 10° - 0° | 1080° + 10° - 0° |
| Electrical Rotation | 3600° + 5° - 0° | 1080° + 5° - 0° |
| Shaft Extension | servo mount 5/8" | bushing mount 7/8" |

WRITE FOR COMPLETE
SPECIFICATIONS AND INFORMATION



BORG EQUIPMENT DIVISION

Amphenol-Borg Electronics Corporation
Janesville, Wisconsin • Phone Pleasant 4-6616

Micropot Potentiometers • Turns-Counting Microdials • Sub-Fractional Horsepower Motors • Frequency and Time Standards
CIRCLE 68 ON READER-SERVICE CARD

NEW PRODUCTS

Video Amplifier

728



Broad-band, solid-state decade video amplifier VF1399 is designed for rack-panel mounting. For laboratory or system use, it covers frequency band of 50 kc to 50 mc ± 2 db. Voltage gain is 80 db in 20-db steps, input impedance 50 ohms. Maximum output voltage is 3-v peak.

LEL, Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

Power Supply

724

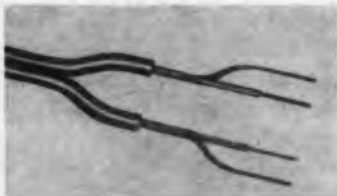


Transistorized, regulated power supply TP-30 delivers 0 to 36 v dc at 30 amp. Line regulation is held to 10 mv max, load regulation 5 mv max, ripple 1.0 mv. Rack-mounting chassis has a panel height of 7 in.

Invar Electronics Corp., Sales Dept., Dept. ED, 323 W. Washington Blvd., Pasadena, Calif.

Audio Cable

727



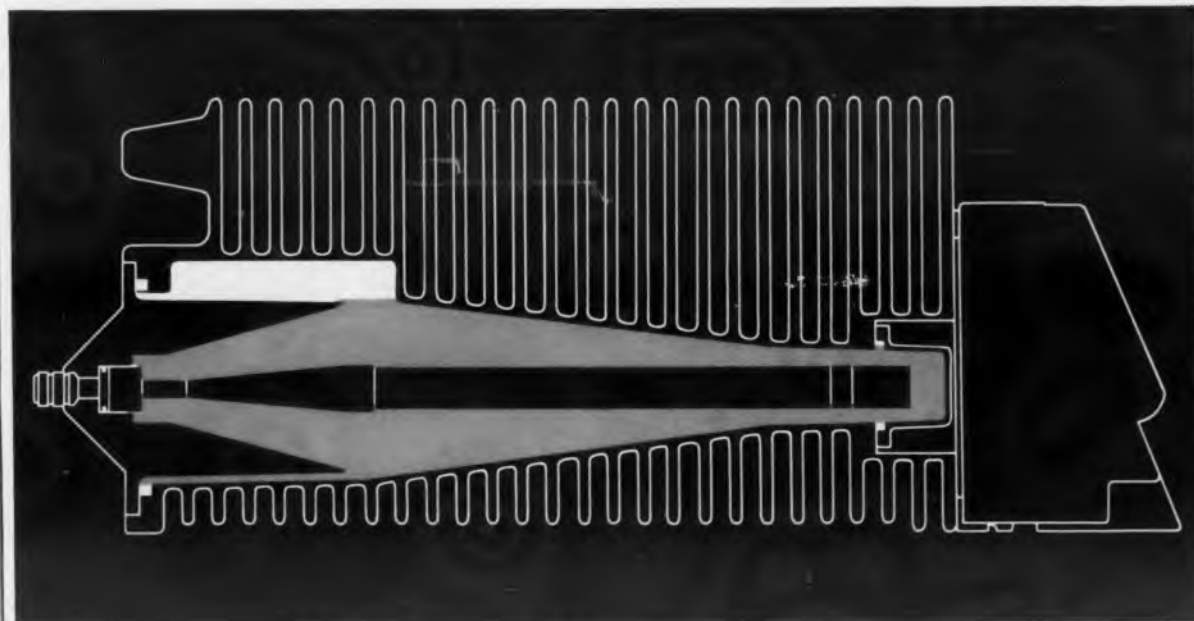
Double-channel audio cable No. 17555 is suitable for use with stereo and binaural systems, and any multiplex system. It is constructed of two tinned copper stranded conductors with color-coded insulation. Spirally wound shield serves as second conductor.

Lenz Electric Manufacturing Co., Dept. EI-2, Dept. ED, 1751 N. Western Ave., Chicago 47, Ill.

Don't forget to mail your renewal form to continue receiving ELECTRONIC DESIGN.

SILICONE NEWS from Dow Corning

How To Combat Heat

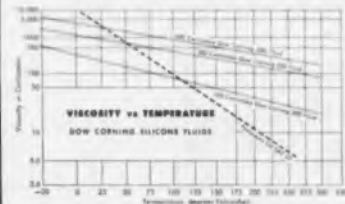


Good heat dissipation with dielectric strength are unique silicone properties

An example: Dow Corning silicone fluids are used as dielectric coolants for rapid dissipation of heat because of their thermal stability and relatively flat viscosity-temperature curves. (See chart below.) They can be pumped at high speeds without breakdown due to shear; maintain consistency from -65 to 250 C; and they will not oxidize or act as corrosives to metals even at high temperatures.

Low vapor pressure is an additional reason why Sierra Electronic Corporation, Menlo Park, California, specifies Dow Corning 200 Fluid as the heat transfer medium in their 100 and 500 watt, 50 ohm coaxial RF loads. Heat losses are dissipated through the dielectric coolant to fins on the cast housing, providing integral liquid cooling without loss of dielectric strength.

These terminations have excellent stability. Prolonged operation within their rating produces no measurable change of characteristics, even with an ambient temperature of 104°F (40°C). From direct current to 3 mc these coaxial line loads have a low VSWR ratio of less than 1.2 . . . are compact and light in weight. And Dow Corning 200 Fluid helped Sierra engineers lick the heat problem by providing a dielectric with good heat conduction.



CIRCLE 800 ON READER SERVICE CARD

For "Silicones for the Electronic Engineer", Write Dept. 3316.



Dow Corning

... Specify Silicones

Silastic Jacket for Heat or Cold

Exposed to environmental extremes of blistering heat and bitter cold, the molded jacket of this flexible wave guide is made from Silastic®, the Dow Corning silicone rubber. According to Co-Operative Industries engineers, the Silastic jacket provides a smooth exterior over the corrugated brass of the wave guide, gives added resistance to dents, corrosion and abrasion. It also helps control flexing characteristics. Rubbery parts made of Silastic retain their physical and dielectric properties over the wide temperature span of -90 to 250 C . . . resist ozone, corona and voltage stress. Initial properties remain unchanged despite rapid thermal cycling or long term storage.



CIRCLE 801 ON READER SERVICE CARD

Silicone Team "Beats" Heat

This solenoid, manufactured by Cannon Electric Company, Los Angeles, California, is subjected to high temperatures and other environmental extremes. One typical use: in pneumatic starters for aircraft turbine engines. To beat the heat, Cannon engineers specify a silicone insulation system consisting of: Dow Corning impregnating varnish; silicone-glass tape; silicone rubber impregnated glass sleeving; silicone fiber glass insulators; silicone compound for sealing terminals; and, Silastic caulking paste. Completed solenoids must withstand environmental tests including salt spray, humidity, high and low temperatures and vibration. Cannon Electric chose the *silicone team* "for its superior characteristics in resisting heat, moisture and abrasion; and, its outstanding dielectric properties."



CIRCLE 802 ON READER SERVICE CARD

Heat-Stable Vacuum Pump Fluid

Dow Corning silicone diffusion pump fluids offer a combination of properties that add up to high production rates and long runs without maintenance. These properties provide heat stability, low vapor pressure, high vacua, rapid recovery, quick pump down, inertness to air and metals and resistance to gamma radiation. Silicone diffusion pump fluid is non-toxic and chemically inert . . . pump vacuum can be released without first cooling the boiler . . . decomposition does not occur when hot fluids are exposed to air. To improve the performance of your diffusion pump, specify a Dow Corning diffusion pump fluid . . . They produce vacua in the range of 10^{-5} to 10^{-7} mm of Hg.



CIRCLE 803 ON READER SERVICE CARD

Magnet Solder

720



Alnico magnets may be soldered to bare steel pole pieces with Orango Flux No. T-64-C. The nonresinous, water-based flux leaves no active residue after water rinsing. Adhesion is good whether metal is bare or plated.

London Chemical Co., Inc., Dept. EI-2, Dept. ED, 1535 N. 31st Ave., Melrose Park, Ill.

Sequence Relay

723



A bi-directional, 12-position sequence relay for remote control, No. 4175 operates in 40 msec min. Coil is rated at 5-K impedance, 0.003-amp drop-out current, and dc input current of 0.020 amp min. Contact rating is 1 amp, 24 v ac. A 117-v, 5-amp switch is provided at zero position. Size is 2.07 in. high x 2.69 in. wide x 2.00 in. deep.

The Lionel Corp., Electronics Div., Dept. ED, Hoffman Place, Hillside, N.J.

Laminated Circuits

721



Reduction of size and weight of electronic packages is possible with etched laminated circuits. Copper-backed glass epoxy is used in up to eight layers. Thickness varies with signal level to be carried. Inductance is lower than with wire harnesses. Capacitance is uniform $\pm 10\%$ throughout a circuit; typical rating is 7 pf per in. on a 30-mil line.

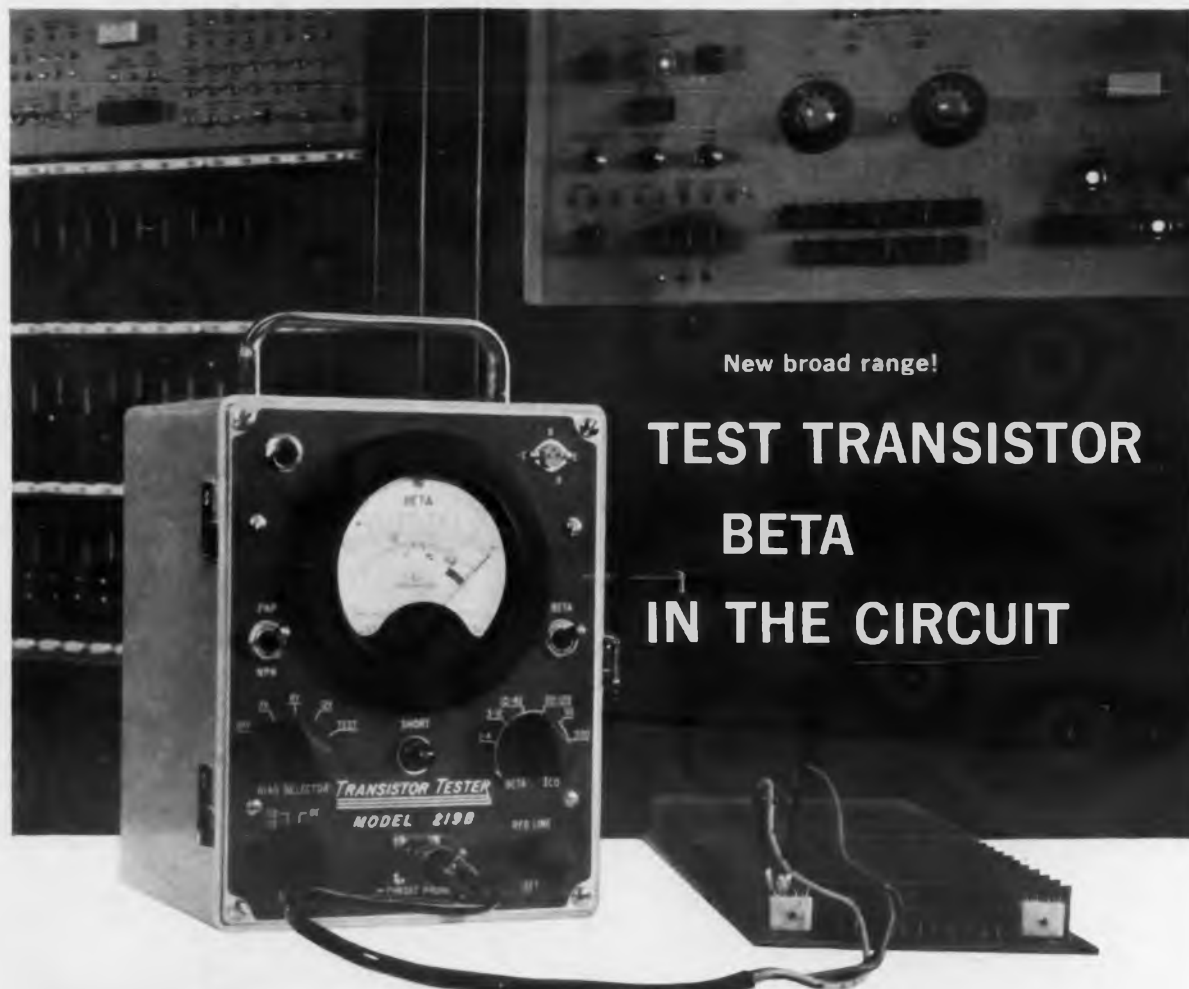
Litton Industries, Inc., U. S. Engineering Co. Div., Dept. ED, 336 N. Foothill Road, Beverly Hills, Calif.

CORPORATION MIDLAND, MICHIGAN

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CIRCLE 800, 801, 802, 803 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

85



New broad range!

TEST TRANSISTOR BETA IN THE CIRCUIT

No leads to unsolder
Four overlapping Beta Ranges • High meter resolution
Direct reading with test circuit power off

New Sierra 219B 4-range Transistor Tester reads Beta directly in the circuit; also measures I_{co} , Beta out of circuit.

Less downtime and less danger of damage to transistors under test with this new Sierra instrument—battery-operated, light weight, portable, easy to use.

Maintenance, quality control, incoming inspection and production testing are just a few of the applications where you save time and money by testing transistors, even complete assemblies, without unsoldering leads. Model 219B reads Beta in the circuit, 1 to 120. I_{co} is measured on a straightforward basis; collector potentials of 3, 6 or 12 vdc may be selected. All controls are on the front panel . . . an instrument of convenience, speed, accuracy.

Write or phone today for information and demonstration.

Sierra **SIERRA ELECTRONIC CORPORATION**
A Division of Philco Corporation

6919K BOHANNON DRIVE • DAVENPORT 6-2060 • MENLO PARK, CALIF., U.S.A.

Sales representatives in all principal areas.

Canada: Atlas Instrument Corporation, Ltd., Montreal, Ottawa, Toronto, Vancouver.

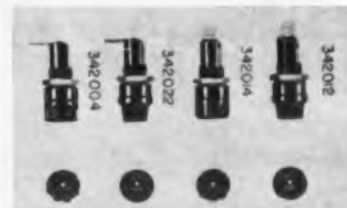
Export: Frazar & Hansen, Ltd., San Francisco.

CIRCLE 69 ON READER-SERVICE CARD

NEW PRODUCTS

Fuse Posts

722



All 3AG miniature fuse applications are covered by a line of four fuse posts with two knobs and connecting terminal arrangements. Current rating is 15 amp max, voltage rating 250 v max. Models 342004 and 342022 require 1-1/64 in. behind panel, models 342014 and 342012 use 1-11/32 in. Posts meet military requirements and are UL-approved.

Littelfuse, Inc., Dept. ED, Des Plaines, Ill.

DC Motor

737



A 9-v, battery-powered motor, model 36-B has less than 2% variation in speed. Capable of 4,000 rpm, it has a 1,500-rpm governor that allows adjustments of 600 rpm. Power consumption is 25 ma in a neutral position.

Jonard International, Inc., Dept. ED, 624 Madison Ave., New York, N.Y.

Ultrasonic Cleaner

729



With tank capacity of 1-1/4 qt, the Maxson ultrasonic cleaner occupies a space 8 x 6 in. Power output is 45 w, operating frequency 70 to 80 kc. Power consumption is 140 w. The cleaner is guaranteed for one year.

L & R Manufacturing Co., Dept. ED, 577 Elm St., Kearny, N.J.

6919

Sweeping Oscillator

735



Frequency range of 2 to 215 mc is covered in 12 bands by the 860-B sweeping oscillator. Sweep rate is continuously variable, 10 to 40 cps, or locked to line frequency; sweep width is up to 30 mc. Sweep output is regular sawtooth; rf output is 1.0 v rms.

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

Heat Exchanger

717



All-aluminum, dip-brazed heat exchanger model INFSK 6.3.10-4-1/2 measures 6 x 4-3/4 x 3-1/2 in. Designed for oil-cooled electronic gear, the unit will dissipate about 1,000 w of heat with fluid temperatures around 80 C.

Lytron, Inc., Dept. ED, 42 Brookford St., Cambridge 40, Mass.

Control Meter

731



Operating without electrical contacts, model 2547 electronic control meter provides continuous output signal past control setting, with accurate, uninterrupted full-scale indication and automatic reset. A power input of 22-1/2 v dc at 10 ma is required for the switching circuit.

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

Don't miss an issue of **ELECTRONIC DESIGN**; Return your renewal card.

ELECTRONIC DESIGN • April 12, 1961



QUALITY CABLES AND CONNECTORS NOW PRODUCED AT NEW BENDIX SANTA ANA PLANT



For users of electronic cables and connectors, Scintilla Division's new plant in Santa Ana, Calif., is an important addition to West Coast industry.

Here are the finest, most complete, environmentally-controlled, air-conditioned facilities in the area devoted exclusively to cable development and manufacture. For West Coast electrical connector users the Santa Ana plant with its complete facilities also offers "short-order" assembly service on the extensive line of Bendix connectors.

The plant is designed to meet the standard and special-purpose requirements of aircraft, missiles and ground-based electronic equipment.

Sales and service for cables and connectors and all other Scintilla Division products will still be handled out of 117 E. Providencia Ave., Burbank, Calif.

Bendix Connectors — Bendix Cables: Designed together to work best together

Scintilla Division
SIDNEY, NEW YORK



Canadian Affiliate: Aviation Electric, Ltd., 200 Laurentian Blvd., Montreal 9, Quebec. Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

CIRCLE 70 ON READER-SERVICE CARD

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- Metals and alloys with *specific impurities* controlled to the lowest levels possible in the industry today.
- Alloys with accurately controlled constituent content.
- Fabrications, shapes and preforms of precisely controlled physical dimensions — metallurgically uncontaminated.
- Compound semiconductors with controlled net carrier concentrations to $10^{14}/\text{cm}^3$.

This means *more uniform performance characteristics* in your finished devices with fewer rejects.

There is a great deal of background experience behind Cominco metals and in particular, the precision refining processes required to reach the *exact* specifications demanded in the production of transistors, tunnel diodes, thermoelectric devices, etc. We are also prepared to assist with research and development work on advanced specifications.

Send for information today . . .

COMINCO PRODUCTS, INC.

SPOKANE, WASHINGTON

933 W. Third Ave.

Phone: Riverside 7-7103

TWX: SP311

CIRCLE 71 ON READER-SERVICE CARD

NEW PRODUCTS

Precision Potentiometer

736



Multigang, multitap precision potentiometers may be obtained in linear and nonlinear functions with up to six gangs. Power rating is 6 w for single, 5 w per gang in multigang units. Resistance values range from 1 K to 400 K. Body is stainless steel or blue anodized aluminum, OD 3 in. Conforming to military specifications, unit withstands acceleration to 30 g, with temperature range of -55 to $+225$ C. Life expectancy is 5 million revolutions. Resistance tolerance is $\pm 5\%$ standard, linearity $\pm 0.1\%$.

Chicago Aerial Industries, Inc., Kintronic Div., Dept. ED, 10134 Pacific Ave., Franklin Park, Ill.

Decade Counter

725



Directly coupled in-line readout in the LA-80 counter is provided by a true decade system with no binary conversion. Time base stability is one part in 10^6 per day; frequency range is 10 cps to 10 mc. With the LA-901B plug-in unit, time interval range is 1 μsec to 10 million sec. Other features are 0.1- μsec resolution, in-line eight-place readout, automatic reset, and automatic decimal point.

Lavoie Laboratories, Inc., Dept. ED, Morganville, N.J.

Accuracy Is Our Policy

The New Product description of a transistor socket made by Augat Bros., Inc., Attleboro, Mass, did not mention the maker of the mating transistor. The socket accepts units of the Clevite Corp. Spacesaver series. The item appeared in ED, March 1, p 123.

ELECTRONIC DESIGN • April 12, 1961

DAYSTROM
SQUARETRIM[®]

subminiature trimming potentiometers

MODEL 300



MODEL 311



MODEL 313



MODEL 315



MODEL 316



MODEL 355



MODEL 200



immediate delivery of
up to 2000 pieces per
type at factory prices
from

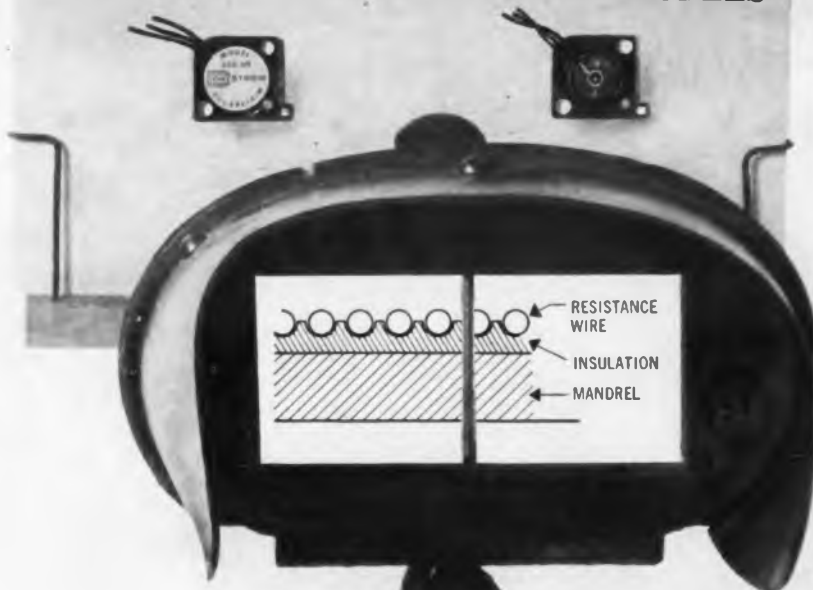
 **Schweber**
ELECTRONICS

60 HERRICKS ROAD, MINEOLA, L. I., N. Y.
PIONEER 6-6520 TWX G-CY-NY-580U

CIRCLE 72 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

SECRETS OF FIFTEEN HUNDRED MODELS



This Design Feature Holds the Secret of the Greater Reliability in All 1544 Daystrom Squaretrim™ Models

All Daystrom Squaretrim potentiometers have this in common: our unique wire-in-the-groove resistive element. We start with an insulated mandrel. We then wrap the mandrel with resistive wire. But...and this is our exclusive process...just ahead of the wire is a tiny diamond tool which cuts a carefully controlled groove in the mandrel's insulation. The wire is then wound tightly into this groove throughout the entire helix. As a result, each turn remains securely separate from the adjacent turns, thus anchoring the wire so that it will withstand severe shock and vibration without piling up and shorting out.

Daystrom Squaretrims, with this unique winding technique, offer you only the most reliable performance. Daystrom's wide line of 1544 Standard Models offers you almost unlimited design latitude.

Send for the catalog of trimming potentiometers that meet your specs and hold your specs under environmental stress...Daystrom Squaretrims.

DAYSTROM, INCORPORATED
POTENTIOMETER DIVISION
ARCHBALD, PENNSYLVANIA • LOS ANGELES, CALIFORNIA

CIRCLE 73 ON READER-SERVICE CARD

Introducing

AMERICAN LAVA CORPORATION

ALSiBASE[®]



**improved ceramics
result from a new method of fabrication.**

Favorable characteristics include:

- 1.** Fabrication of thin sections especially suited for substrates. Marked improvement has been made in flatness or camber control.
- 2.** Flatness and dimensional accuracy within normally accepted ranges without grinding expense, contaminants or scratches. However where especially strict requirements must be met, ALSiBase can be furnished both ground and polished at commensurate cost.
- 3.** Ability to fabricate holes, slots, serrations to tighter than usual tolerances without machining after firing.
- 4.** A superior and uniform surface especially adapted to economical coating or metalizing. Surface finish in 10-25 microinch range is available without grinding or polishing.
- 5.** ALSiBase has exceptional dielectric strength in thin sections. Measurements made to date on ALSiBase in the new thin sections indicate better dielectric strengths than those of similar ceramic formulations processed by conventional methods and tested on 1/4" thick discs in accordance with A.S.T.M. D 667-44. A typical ALSiBase design in alumina had a dielectric strength up to 2000 ACV/mil at 10 mil thickness.

May we see your prints on parts where this might apply?

A subsidiary of
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For service, contact American Lava representatives in Offices of Minnesota Mining & Manufacturing Co. in these cities (see your local telephone directory): Boston; Newton Center, Mass. • Chicago: Bedford Park, Ill. • Cleveland, Ohio • Dallas, Texas • Los Angeles, Cal. • New York: Ridgefield, N. J. • Philadelphia, Pa. • St. Louis, Mo. • St. Paul, Minn. • So. San Francisco, Cal. • Seattle, Wash.
All other export: Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

NEW PRODUCTS

Servo Tachometer

361



A size II servo motor tachometer, model BT1004MA is 1.250 in. long. Designed for transistor circuitry, the unit can be supplied with any gear train. Input to the motor is 115 v, 400 cps fixed phase, 20 v control phase. Tachometer input is 26 v; output is 0.24 v per 1,000 rpm. The 3.2-oz unit meets military requirements; standard operating temperature range is -55 to +125 C.

IMC Magnetics Corp., Dept. ED, Eastern Div., 570 Main St., Westbury, L. I., N. Y.

Resistance Wire

375

Iron-chromium-aluminum alloy 750 wire is intended for small appliances and other uses requiring low-cost elements for service to 2,050 F. Resistivity is 750 ohms per circular mil-ft; increase in resistance at operating temperature is said to be much greater than in similar alloys.

Hoskins Manufacturing Co., Dept. ED, 4445 Lawton Ave., Detroit 8, Mich.

Impedance Measuring System

353



Universal impedance measuring system model 291-A has a resistance accuracy of 0.05%. Inductance and

◀ CIRCLE 74 ON READER-SERVICE CARD

ENGINEERING NEWS-#14

FULL LINE OF MINIATURE SNAP-ACTION SWITCHES

CHECKED *Sm*

ENGR. *DWA*

CONTROL SWITCH DIVISION

capacitance accuracies are 0.1% at 1 kc. Measurement resolution is 120,005 dial divisions. The system includes ac and dc generators and detectors specifically designed for use with the bridge.

Electro Scientific Industries, Inc., Dept. ED, 7524 S.W. Macadam Ave., Portland 19, Ore.

P&A: \$1,095; 30 days.

Digital Readout 359



Characters 1-5/8 in. high are displayed by the series 160000 in-line digital readout. Multiple word messages may be displayed in black and white or color; color backgrounds may be used with any words or digits. The readout operates on a rear-projection principle, and measures 1-9/16 in. wide, 2-5/8 in. high, and 6-1/2 in. long.

Industrial Electronic Engineers, Inc., Dept. ED, 5528 Vineland Ave., North Hollywood, Calif.

Price & Availability: \$18 ea; 30 days.

Translation System 351



Shaft encoder translation system accepts the output of standard shaft encoders and automatically converts these data into 12-bit 8-4-2-1 binary-coded decimal form. These data are then prepared on punched paper tape, complete with parity checks.

Electronic Development Corp., Dept. ED, 423 W. Broadway, Boston 27, Mass.

P&A: \$4,500; 45 days.

CIRCLE 75 ON READER-SERVICE CARD ►



B7001



B7021



T2106



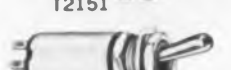
T2108



T2150



T2151



T3103



T3106



T4203



T4205



T-3

SPECIFICATIONS

| Model No. | Amps @ 28 VDC or 120 VAC | | Circuitry | Approx. Weight Lbs. |
|-----------|-----------------------------|--------|-----------|---------------------------|
| | Resist | Induc. | | |
| B7001 | 7 | 4 | S.P.N.O. | .005 |
| B7021 | 7 | 4 | S.P.N.O. | .010 |
| T2106 | 10 | 5 | 2 Cir. | .010 |
| T2108 | 10 | 5 | 2 Cir. | .016 |
| T2150 | 3 | 1 | D.P.D.T. | .010 |
| T2151 | 3 | 1 | D.P.D.T. | .016 |
| T3103 | 5 | 3 | S.P.D.T. | .009 |
| T3106 | 5 | 3 | S.P.D.T. | .013 |
| T4203 | 1 | — | S.P.D.T. | .004 |
| T4205 | 1 | — | S.P.D.T. | .013 |
| T-3 | 7.5 | 2.5 | S.P.D.T. | 1.6 Grams |

NOTE: All models above (except T-3) are available with maintained or momentary action. Self-sealing boot available for any bushing mounted model, as shown on T2150. All models available with flange or bushing type mounting. Basic switch Model T-3 is available with a wide variety of standard and special actuators.

These miniature pushbutton and toggle switches are typical examples of our complete line of miniaturized switches. Whatever your requirements for miniature hand-operated or mechanically-operated switches, we can meet your needs from our hundreds of standard and custom units. We offer an almost unlimited range of variations in configuration, actuation, ratings, operating characteristics, etc.

For more technical information on switches and indicator lights, write for FREE CATALOG No. 100.

CONTROLS COMPANY OF AMERICA

CONTROL SWITCH DIVISION

1406 Delmar Drive • Folcroft, Pennsylvania
TELEPHONE LUDlow 3-2100 • TWX SHRN-H-502

Manufacturers of a full line of switches, controls and indicators for all military and commercial applications. All standard units stocked for immediate delivery by leading electronic parts Distributors.

SUBMINIATURE INDICATOR LIGHTS

Moisture-proof. Only 35/64 inch overall. 60,000 hour life with 5V lamp. Translucent lens colors. Available with MS or commercial type lamp. Three lens styles.



L10,000



L10,100



L10,200



Can a silicon rectifier solve your problem?

It might, if you have a problem in DC power sources. For example, some time ago C & D needed a high efficiency, constant potential, current limiting DC power supply. Output had to be held within $\pm 1\%$ over an AC input variation of $\pm 15\%$. In addition, maintenance would have to be virtually nil.

The answer was found by using a silicon rectifier in combination with simplified components that became the heart of C & D's *AutoReg*® charger. *AutoReg* chargers provide continuous, automatic, unattended charging of industrial storage batteries. With the exception of a timing circuit there are no moving parts. There are no relays to adjust and practically no maintenance is required.

Now, C & D has expanded facilities of the *AutoReg* plant to provide industry with similar DC sources, which incorporate silicon rectifiers and automatic regulation. Final form of these units can supply power in a range from milliwatts to megawatts, depending upon your requirements.

Companies with a problem in DC power sources should write, giving a general outline of their requirements, to: Vice President in Charge of Engineering

AutoReg Power Sources



Manufacturers of Silver-Clad® Industrial Batteries • PlastiCell® and PlastiCal® Batteries for Communications, Control, and Auxiliary Power • Producers of AutoReg® Silicon Chargers and AutoCal® Charger-Battery Combinations

CIRCLE 76 ON READER-SERVICE CARD

NEW PRODUCTS

Marking Machine

733



Teflon wire and tubing can be marked with the air-operated KW-7 marking machine. Wires are marked to an even depth regardless of variations in diameter, without damage to the dielectric. Dwell timer is adjustable in 1/10 sec increments. A dial-type indicating pyrometer shows type head temperature to 500 F and 260 C.

Kingsley Machine Co., Dept. ED, 850 Caheunga Blvd., Hollywood 38, Calif.

Impulse Counter

726

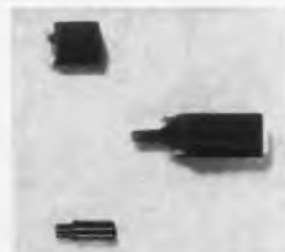


Counting speeds to 250 impulses per sec are attained by type 4TiF6EM counter. It consists of three stages: glow transfer tube, transistorized pulse shaper-amplifier, and totalizing counter. Suitable for flush mounting, unit measures 5-11/16 x 2-3/16 x 8-1/32 in. Power is 110 v, single phase, 16.5 w.

Landis & Gyr, Inc., Dept. ED, 45 W. 45th St., New York 36, N.Y.

Push-Button Switches

718



Compact, lighted push-button switches and pilot lights are available in modular design. With sub-panel, surface and matrix mounting,



ABOUT SELF-TUNING ULTRASONIC CLEANING

to know that the only way to make it foolproof is by feedback control. And I've seen enough to know that the Autosonic cleaner by Powertron is the only one that uses feedback control to keep itself electronically tuned to peak cleaning efficiency. Feedback makes the Autosonic genuinely self-tuning, so anyone who can flip a switch can use it. What's more - it's guaranteed to clean synchros, gear heads, slip rings, or almost anything else, better, cheaper, and faster. That's why we bought self-tuning Autosonics for all cleaning applications.



A complete line of Powertron Autosonic cleaners is available from 2 gals. to 75 gals.-from 100 watts to 3,000 watts-from \$395. to \$6,000.

A ten-minute demonstration in your plant will prove what feedback control can do for your ultrasonic cleaning problems. Just check your cleaning application, and mail the coupon.

- | | |
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| <input type="checkbox"/> Cleaning | <input type="checkbox"/> Removing |
| <input type="checkbox"/> Electrical assemblies | <input type="checkbox"/> Buffing compounds |
| <input type="checkbox"/> Mechanical assemblies | <input type="checkbox"/> Shop dirt |
| <input type="checkbox"/> Circuit boards | <input type="checkbox"/> Fluxes |
| <input type="checkbox"/> Laboratory glassware | <input type="checkbox"/> Waxes and oils |
| <input type="checkbox"/> Surgical instruments | <input type="checkbox"/> Degreasing |
| <input type="checkbox"/> Engine parts | <input type="checkbox"/> Brightening |
| <input type="checkbox"/> Ceramic components | <input type="checkbox"/> Radioactive contamination |
| <input type="checkbox"/> Metal parts | <input type="checkbox"/> Other-describe |
| <input type="checkbox"/> Other | |
| <input type="checkbox"/> Check here if you'd like a free copy of our technical bulletin, "How to Clean Ultrasonically with Self-tuning." | |

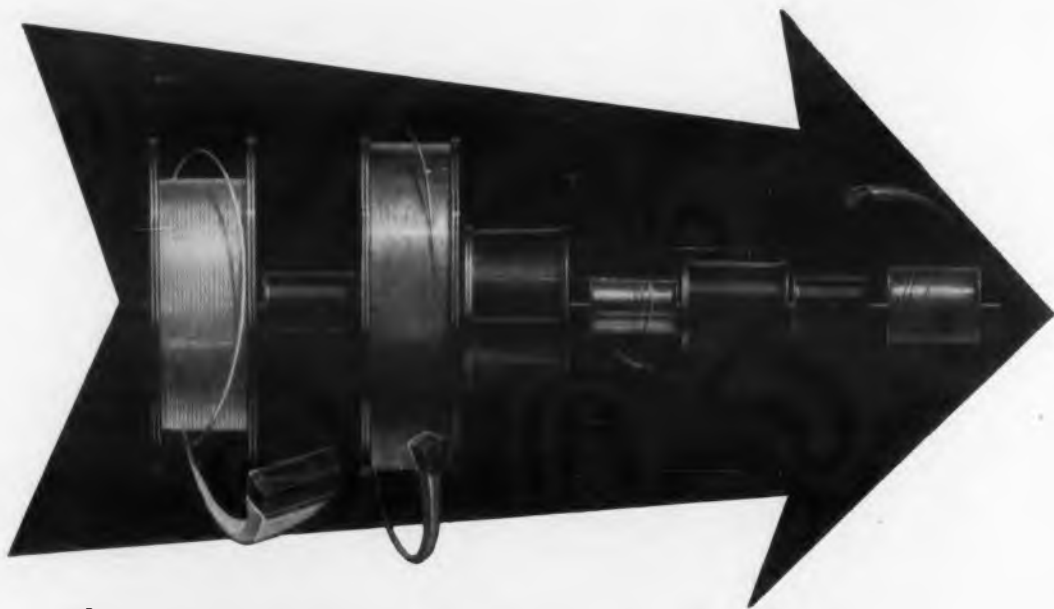
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CIRCLE 77 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961



Magnet Wires that pace the Industry come from Phelps Dodge!

Phelps Dodge Applied Research has developed many outstanding magnet wires that anticipate the requirements for advanced insulation system designs. This widely diversified group of Phelps Dodge "firsts" includes:

CLASS A (105° C)
to
CLASS F (155° C)

POLY-THERMALEZE® (multi-purpose film)

SODEREZE® (solderable); **FORMVAR**® (square and rectangular);

BONDEZE® (self-bonding); **GRIP-EZE**® (solderable self-gripping);

CLASS A (105° C)

S-Y BONDEZE® (solderable self-bonding);

HERMETEZE® (for hermetic motors);

SODEREZE-BONDEZE® (solderable self-bonding).

CLASS B (130° C)

NYLEZE® (solderable)

CLASS F (155° C)

DAGLAS® (flexible glass)

CLASS K

DAGLAS H® (flexible glass)

The complete line of Phelps Dodge magnet wires also includes:
ML (Class H *plus* film); Enamel; Formvar® (round); Epoxy; Nyform; Paper;
Cotton; Multiple Combinations.

®FORMVAR®—SHAWINIGAN RESINS

Any time magnet wire is your problem, consult Phelps Dodge for the quickest, surest answer!

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INCA MANUFACTURING DIVISION, FORT WAYNE, INDIANA

FIRST FOR LASTING QUALITY—FROM MINE TO MARKET

CIRCLE 79 ON READER-SERVICE CARD



NEW PRODUCTS

Miniature Relay

730



Shocks of 100 g and vibration of 40 g, 10 to 2,000 cps, do not affect operation of the Astro-relay series of 4pdt relays. Size is 0.875 x 0.800 x 0.400 in. Available for 6-, 12-, or 24-v operation, relay temperature range is -65 to +125 C. Pull-in power is 250 mw. Operate speed is 8 msec, drop-out 4 msec.

Kurman Electric Co., Dept. ED, 191 Newell St., Brooklyn 22, N.Y.

Magnetic Amplifier

719



Signal is ± 80 mv dc at ± 0 to 40 μ a for model 1269, which combines magnetic amplifier, drive network, and motor in one package. Output is 10 w; excitation is 115 v $\pm 5\%$, 400 cps $\pm 10\%$. Linearity is $\pm 5\%$, zero drift $\pm 1\%$. Dynamic braking operates at 200 to 300 ma dc with zero input signal. Length is 5-5/8 in., OD 3-1/2 in. Weight is 4-1/2 lb including motor.

Lumen, Inc., Dept. ED, P. O. Box 905, Joliet, Ill.

Tapped Delay Line

680



Utilizing magnetostrictive transducers, the ultrasonic torsional mode tapped delay line has taps at 345, 405, 408, 410, 427 and 438 μ sec.

ELECTRONIC DESIGN • April 12, 1961

Specifications are: temperature range, -54 to +100 C; altitude, 100,000 ft; coil impedance, input, 100 ohms, output, 1 K; rise time, input, 0.2 μ sec, output, 0.4 μ sec; noise and spurious signals, less than 2 mv.

Curtiss-Wright Corp., Electronics Div., Dept. ED, Wood-Ridge, N.J.

Electro-Magnet

716



Field intensity of 20,000 gauss over an area of 64 sq in. is provided by the 4 x 16 magnet assembly at 1-1/2 in. gap width. Pole face geometry is a 4 x 16 in. rectangle; faces are soft steel or Inconel. Magnet coils are wound from copper ribbon and insulated with Class B materials. A continuously variable power supply is used.

MHD Research, Inc., Dept. ED, P. O. Box 1815, Newport Beach, Calif.

AGC Amplifier

650



Wide age range of 250:1 is a feature of transistorized agc amplifier model 1020. When used with a variable gain servo, the 400-cps amplifier maintains constant loop gain. The 6.5-oz unit has an ambient temperature range of -55 to +125 C. Control voltage range is 0.1 to 26 v rms; maximum output voltage is 3 v rms. Input impedance is 10 K on error channel, 180 K on control channel.

Melcor Electronics Corp., Dept. ED, 48 Toledo St., South Farmingdale, L. I., N. Y.
Price & Availability: \$270 to \$310; 30 days.

This is the time of our annual subscription renewal; Return your card to us.

ELECTRONIC DESIGN • April 12, 1961

This Baby is Bayonet-Locking

Meet DTK...the best little bayonet-locking electrical connector available today. DTK is short for Deutsch Tri-Kam and refers to the triple cam coupling design that assures fast, positive engagement and lock. As a direct descendant of MIL-C-26482, this baby is interchangeable with existing MS 3110 and 3116 series connectors. The DTK also inherits many desirable features from its Deutsch ancestors including superior silicone inserts and MIL-C-26636 crimp-type contacts that are insertable and removable with military standard tools. Color-keyed mating indexes and 7-point inspection for lock, make this latest generation connector a cinch to couple, even in remote locations. For more vital statistics on the latest addition to the Deutsch family, contact your local Deutschman today or write for Data File C-4.



DEUTSCH

Electronic Components Division • Municipal Airport • Banning, California

ADVANCED SPECIFICATION MINIATURE ELECTRICAL CONNECTORS
CIRCLE 80 ON READER-SERVICE CARD

General Electric's Large Electrostatic Deflection Tubes Are Now Available In Production Designs

Here are eight of the many large General Electric electrostatic deflection tubes which are available now to meet your display system requirements. YOU GET PROVED RELIABILITY and known performance—and at less cost—when you specify G-E production-type cathode ray tubes in your design. AND, EACH TUBE can be supplied to meet MIL-E-1 shock and vibration tests to assure reliable operation under severe operating conditions.

PRICE AND DELIVERY OF SAMPLES ON REQUEST. For complete specifications on these G-E production-type tubes—or any cathode ray tube—send requirements and application description to R. E. McBride, Sales Manager, General Electric Co., Cathode Ray Tube Dept., Electronics Park, Syracuse, N. Y. 555-03

Progress Is Our Most Important Product

GENERAL  ELECTRIC



1. 12AKP7, radar tube. 2. Z-4760, 2-gun, 12". 3. Z-4718, low drive, 12". 4. Z-4778, 2-gun with integral magnetic shield, 12". 5. Z-4701, minimum deflection defocusing, 12". 6. 12 ANP. 14, high performance radar. 7. GL-4623, 16" electrostatic deflection. 8. Z-4652, tetrode tube design, 12".



NEW PRODUCTS

Weatherproof Rectifier 360



Rated 2,500 amp at 225 v dc, the Unitron semiconductor rectifier is designed for outdoor installation. Disconnect switch, oil-cooled transformer, voltage regulator and rectifier section are integrated in a single unit. Area required is less than 80 sq ft.

I-T-E Circuit Breaker Co., Dept. ED, 1900 Hamilton St., Philadelphia 30, Pa.

Stabilized Power Supply 352



Stabilized output voltage within $\pm 1\%$ is delivered by model 200TV. The unit has an output capacity of 200 w at 118 v. Input power factor averages over 90% at related load.

Electromatic Industries, Dept. ED, Hollywood, Fla.

Noise Generator 739



Random voltage source, model 301 noise generator, has an ultra-

◀ CIRCLE 81 ON READER-SERVICE CARD

stable spectral density of approximately 4.0 v^2/cps controlled to ± 0.1 db from 0 to 40 cps. Gaussian amplitude distribution accuracy is better than 1%.

Elgenco, Inc., Dept. ED, 1555 14th St., Santa Monica, Calif.

Voltage Reference Source 740



Precision voltage reference source model VS-111 has a voltage range of -111.11 v dc to $+111.11$ v dc, selectable in 10-mv increments. Absolute accuracy is 0.025% and resolution is one part in 10,000. It is a four-decade, direct-reading instrument.

Electronic Development Corp., Dept. ED, 423 W. Broadway, Boston 27, Mass.

P&A: \$795 fob Boston; from stock.

Digital Instruments 354



Three models of digital instruments include an ac-dc voltmeter, dc ammeter, and a multimeter. Typical accuracy is 1.0% of full scale for ac voltage measurement and 1.0% for current measurement.

Electro-Logic Corp., Dept. ED, 515 Boccaccio Ave., Venice, Calif.
P&A: From \$360 to \$440; 60 days.

Don't forget to mail your renewal form to continue receiving ELECTRONIC DESIGN.

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Contact Redundancy in New UNION Crystal Case Relays

The UNION 2-pole double throw General Purpose Crystal Case Relay is designed to consistently meet the requirements of Mil-R-5757D and Mil-R-5757/10. Its essential features . . . from minimum size to optimum reliability . . . permit it to be used in aircraft, guided missiles, shipboard and ground control electronic equipment.

A unique torsion-wire armature suspension system and a rugged all-welded frame construction provide a high level of vibration and shock immunity. Contact redundancy, which assures reliability in dry circuit and higher level contact loads, is provided through the use of bifurcated contacts.

Available with 0.2" grid-spaced header or "S" type header, with various mountings, terminals, and operating voltages. Write for Bulletin 1064.

New 4-PDT-10-amp Relay Most Compact Rotary Type Available

This new durable relay is designed to meet the requirements of Mil-R-6106. It's a rugged relay featuring exceptionally sturdy terminals and husky contacts for high current applications. Glass-coated cylindrical contact actuators attached to the rotary armature provide square mating of contact surfaces, thereby assuring longer relay life. The balanced rotary armature provides maximum resistance to severe shock and vibration.

This small 4-PDT-10-Ampere relay is currently available with 115VAC and various DC operating voltages. Various mounting styles are provided. Write for bulletin 1069.



For additional information, write for Bulletin 1017 or call Churchill 2-5000 in Pittsburgh.



MEMBER OF THE NATIONAL ASSOCIATION OF RELAY MANUFACTURERS

UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY

PITTSBURGH 18, PENNSYLVANIA

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Why UNION Relays Are So Dependable

There's a good reason why our relays are the standard for reliability. For years, we've been building tough, reliable relays for use in airborne and guided missile electronic equipment and similar vital applications where perfect operation under severe environmental conditions is mandatory.

Our engineers created a compact 6-PDT miniature relay with just three major assemblies . . . instead of a fistful of small parts. This was accomplished by using a balanced rotary-type armature that provided a maximum resistance to the severe shock and vibration environment of aircraft and guided missiles. The rotary principle of operation is utilized in all our relays.

We have a reputation for building reliable electronic components and we intend to maintain our tradition for building reliable relays. And we supply these quality relays in quantity. Stocks are now available for prototype requirements in New York, Pittsburgh, Dallas and Los Angeles.

Precision Parts

732



Tolerances of 0.0002 in. are possible on custom precision parts produced by chemical etching. No deburring is necessary. Metals include Hy-Mu 80 and 800, stainless steel, beryllium copper, phosphor bronze, silicon, nickel silver, and others.

Komak, Inc., Dept. ED, 2632 W. Cumberland St., Philadelphia 32, Pa.

Availability: 2 to 4 weeks.

Power Supply

402



From one to four type 122 preamplifiers may be powered from the type 125 power supply. It provides three different regulated supplies to these preamplifiers through octal interconnecting cables. Output voltages include: +135 v dc at 0 to 20 ma $\pm 3\%$; -90 v dc at 0 to 20 ma $\pm 3\%$; -6 v dc at 0.7 to 4 amp $\pm 5\%$.

Tektronix, Inc., Dept. ED, P.O. Box 500, Beaverton, Ore.

P&A: \$285; immediate.

Vibration Table

407

Ultrasonic shake table model 160 provides vibrations of variable frequency and power from 20 to 100 kc with uniform amplitude of motion. Accelerations of 4,000 g can be obtained.

Ultrasonic Industries Inc., Dept. ED, Plainview, L.I., N.Y.

Price & Availability: \$750; stock.

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MOTOROLA SILICON EPITAXIAL MESA TRANSISTORS

| TYPE NO. | P ₁₀ mW | V _{CB} volts | V _{EB} volts | I _C mA | h _{FE} (typ) @ I _C = 10 mA | f _T mc |
|----------|--------------------|-----------------------|-----------------------|-------------------|--|-------------------|
| 2N706 | 300 | 25 | 3 | 200 | 40 | 450 |
| 2N706A | 300 | 25 | 5 | 200 | 40 | 450 |
| 2N706B | 300 | 25 | 5 | 200 | 40 | 450 |
| 2N707 | 300 | 56 | 4 | 200 | 12 | 450 |
| 2N707A | 300 | 70 | 5 | 200 | 30 | 500 |
| 2N753 | 300 | 25 | 5 | 200 | 75 | 450 |
| 2N834 | 300 | 40 | 5 | 200 | 40 | 500 |
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Your copy of EDC lists 157 different types of potentiometers in its PRODUCT LOCATOR. 27 categories from "AC" to "Wire-wound" are included. Each sub-listing such as "Clutch," "Linear Motion," "Microminiature," "Precision," or "Self-trimming" gives manufacturers' name and thumbnail specs to aid in rapid selection. 52 items are further described by special literature bound in sections 2 or 3 of EDC.

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NEW PRODUCTS

Three-Pen Recorder

672



Solid-state three-pen recorder has encapsulated circuits to form rugged, replaceable modules. The pens travel the full width of the 4-in. chart. Input span of the potentiometer is continuously adjustable from 0 to 5 mv to 0 to 50 mv.

De Var Systems, Inc., Dept. ED, Glenbrook, Conn.

Terminal Strip

664



Produced in polyethylene and polypropylene plastic, these mounting strips are available in standard sizes. They adapt to automated production methods and contribute to the use of pre-assembled circuit modules or sub-chassis assemblies.

Electro-Glass Laboratory, Dept. ED, 4000 S.W. 114th St., Beaverton, Ore.

Multiturn Potentiometers

671



Unitized rotor design incorporated in the 3700 series multiturn potentiometer gives smoother operation while reducing the moment of inertia. Standard linearity tolerance is 0.1% in the 10-turn, and 0.2% in the three-turn unit. Glass-filled diallyl phthalate compounds are used in all molded parts for high insulation resistance.

Duncan Electronics, Inc., Dept. ED, 1305 Wakeham Ave., Santa Ana, Calif.

CIRCLE 86 ON READER-SERVICE CARD ►

ELECTRONIC DESIGN • April 12, 1961

Accutron*

new electronic timepiece
uses ALLEN-BRADLEY
Type TR Miniature
Composition Resistors



A-B Type TR
Resistor
Actual Size

With its miniature tuning fork and electronic circuit, Accutron introduces an entirely new principle to timekeeping—one which promises unprecedented wrist timepiece accuracy. Strapped to your wrist, it is guaranteed not to gain or lose more than one minute a month.

Allen-Bradley Type TR tiny resistors enabled Accutron designers to achieve the required circuit miniaturization for a wrist timepiece—without sacrificing reliability. This circuit controls the 360 pulses of power each second—31 million per day—that drive the tuning fork. Although incredibly small, these Type TR miniature composition resistors are made by Allen-Bradley's exclusive hot molding process that guarantees complete freedom from catastrophic failures! A-B Type TR resistors are conservatively rated 1/10 watt at 70°C.

There are also other Allen-Bradley space-saving potentiometers, capacitors, and h-f filters that can help solve your miniaturization problem. And you obtain the same reliability for which the larger Allen-Bradley components have earned a world-wide reputation. For full details, send for Publication 6024.

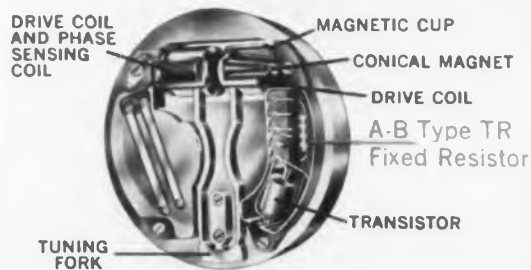
* TRADEMARK BULOVA WATCH CO. INC.



A-B HOT MOLDED COMPOSITION RESISTORS

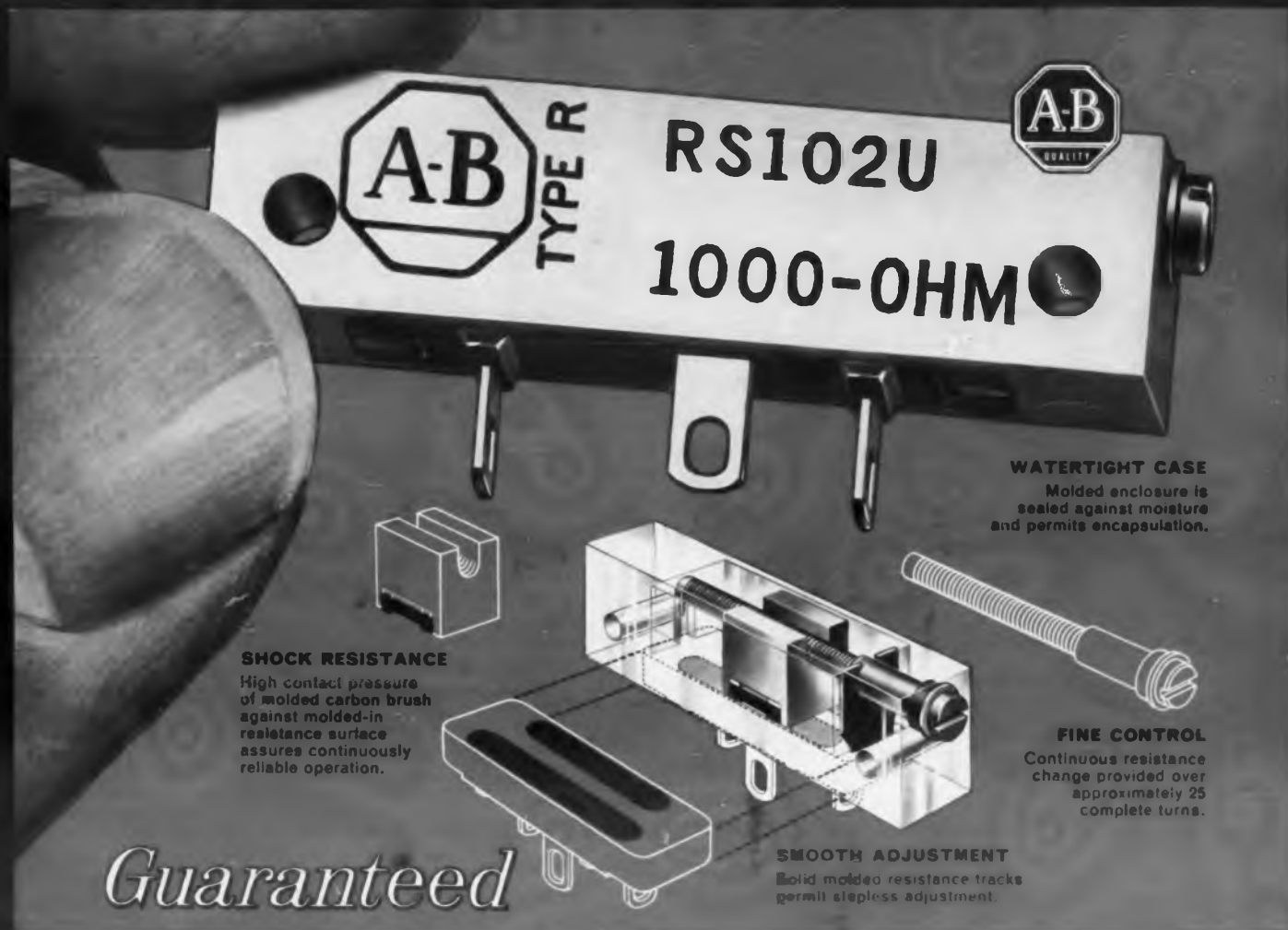
| | |
|-------------------|----------------|
| Type TR 1/10 Watt | MIL TYPE RC 06 |
| Type CB 1/4 Watt | MIL TYPE RC 07 |
| Type EB 1/2 Watt | MIL TYPE RC 20 |
| Type GB 1 Watt | MIL TYPE RC 32 |
| Type HB 2 Watts | MIL TYPE RC 42 |

DRAWING OF ACCUTRON SHOWS BASIC MECHANISM



ALLEN-BRADLEY Quality Electronic Components

Allen-Bradley Co., 222 West Greenfield Avenue, Milwaukee 4, Wisconsin • In Canada: Allen-Bradley Canada Ltd., Galt, Ontario



Guaranteed

*Reliable
Performance
and
Stable
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**UNDER EXTREME
ENVIRONMENTAL
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In critical applications, Allen-Bradley Type R adjustable fixed resistors are *without equal*. For example, in recent tests* Type R resistors successfully withstood acceleration, shock, and vibration *five times* better than the latest MIL Spec requirements. Such wide margin of safety is your assurance of complete reliability. Virtual indestructibility is obtained through an *exclusive* Allen-Bradley process in which the solid resistance elements and the insulating mounting are hot molded into one integral unit. The moving element is self-locking for absolutely stable settings. Also, the Type R control allows "stepless" adjustment of its resistance.

The molded case of the Type R control is watertight and dust-tight. Rated $\frac{1}{4}$ watt at 70°C, these Type R controls are available in values from 100 ohms to 2.5 megohms.

*Test Report #71801, Sept. 1960, United States Testing Co., Inc.



ALLEN-BRADLEY

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

**QUALITY
ELECTRONIC
COMPONENTS**

Power Meter

663



Average reading power meter, model PM-5K, 5 kw full scale, 100 kc to 30 mc is completely self-contained. These absorption type meters are completely shielded and nonradiating. The coaxial load resistor consists of several fused pyrex resistors. The meters are available in 50- and 70-ohm types.

Electro Impulse Laboratory, Inc., Dept. ED, 208 River St., Red Bank, N.J.

Pulse Generator

669



Rise time is 10 nsec for the model 131 pulse generator. It delivers a 50-v pulse into 50 ohms. The unit is designed for laboratory and research applications as well as production line testing of components and solid-state devices.

E-II Research Laboratories, Inc., Dept. ED, Oakland, Calif.

P&A: \$575 fob Oakland; 30 days.

DC Amplifier

665



Signal-conditioning dc amplifier, model 2-181, is designed to amplify the output from strain gages, thermocouples or similar low-impedance transducers. All signals and power are mutually dc isolated. Specifications are: long term stability, $\pm 0.25\%$ of full scale; nonlinearity, less than 1%; common mode rejection, greater than 100,000 to 1; input impedance, 100 K.

Electro Development Corp., Dept. ED, 3939 University Way, Seattle 5, Wash.

◀ CIRCLE 86 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

NEW PLANT NEW ADDRESS

This is the new home of Vought Electronics, a division of Chance Vought Corporation. New ideas shaped this building. These facilities, the most modern in the industry, are organized for fast, economical service, grouping design, fabrication, testing and administrative activities in one efficient floor plan. Here are minds and facilities that can produce results . . . at any point in your

program . . . quickly, reliably, with creative but cost-minded engineering.

Current production includes: Minuteman actuators, Titan check-out equipment, Crusader autopilot systems, advanced antennas and beacons. Among new products: navigational systems, space guidance units, ASW devices, radar enhancement devices and an improved servo-analyzer.

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P.O. Box 1500, Arlington, Texas



ANTENNAS • AUTOMATIC CONTROLS • NAVIGATIONAL ELECTRONICS • GROUND SUPPORT ELECTRONICS

CIRCLE 87 ON READER-SERVICE CARD

NEW PRODUCTS

Time Delay Relay 689

Reversible time delay relay meets all environmental tests for military use. A clutch mechanism allows instantaneous reset. An adjustable load pointer can be set between time limits for outside circuit control. Timer automatically shuts off on reaching zero or maximum time. It operates on 115 v ac and contains its own dc power supply.

McElroy Electronic Corp., Dept. ED, Littleton, Mass.

Meter Indicator 632



Model 470 meter-indicator is packaged complete with transistor amplifier, power supply, and wide-scale meter. It will provide continuous indication of pressure, torque, force, weight or flow when used with strain-gage transducers of the bonded or unbonded type. Standard scale is 0 to 100; proportional secondary output voltage is 0 to 1 v.

Bytrex Corp., Dept. ED, 50 Hunt St., Newton 58, Mass.

P&A: \$490; from stock to 45 days.

Speed Control 692

Speed-sensing control switches of the KC-860 series are 1-3/4 in. high and 2-1/2 in. square. Weight is 15 oz. Flyweight-centrifugal force principle is used to control 1, 2 or 3 snap-action switches. Repeatability and differential can be held to 1%. All models have an AND 10265 pad on one end, a through shaft, and an AND 20005 pad on the other end. Military specifications are met.

Kahn and Co., Inc., Dept. ED, P. O. Box 516, Hartford 1, Conn.



A full line of capacities from 10 to 52 points. Capable of millions of steps without adjustment.

Fast "Off-The-Shelf" delivery

Overnight delivery on many items at factory prices

When standard CLARE relays or switches meet your needs, distributor service saves you time, costs you no more.

Top quality

—the same fine design and long life you get in CLARE custom-built relays and switches.

Easy purchasing

—you can order CLARE relays at the same time you purchase other components...have them delivered together.

Engineering assistance

—always available from CLARE field engineers who work in close cooperation with CLARE distributors.



NOW AVAILABLE

...mercury-wetted contact relay modules for mounting on your own printed circuit board

Type HGM relay module (left) with cut-away (right) showing mercury-wetted switch capsule and coil potted in steel enclosure.

Your nearby CLARE distributor can now supply you with the new CLARE mercury-wetted relays, steel enclosed and ready for mounting. They combine the famous CLARE billion-operation reliability with unusual ease of handling and application. You can choose either the standard CLARE HG relay module or the HGS, super-fast and super-sensitive. Each module contains the CLARE mercury-wetted contact switch capsule with contacts continually wetted by capillary action. They never bounce, never get dirty, never weld and never wear out.



TYPE J RELAY

A compact telephone type relay of unequalled long life and superior performance.



SEALED CONTACT REED RELAY

A highly reliable switching device for single or multiple circuit control... wide mounting versatility.



MERCURY-WETTED CONTACT RELAY

Single or multiple switch capsules potted in steel container. Gives billions of operations with no maintenance.



TYPE F RELAY

A crystal can relay with unusual flexibility and a variety of mounting styles.

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For more complete information on the full line of CLARE components, address:
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C. P. CLARE & CO.

Relays and related control components

Digital Computer 623

Lightweight, airborne digital computer system is used as an active, real-time element for navigation, guidance and control of drone aircraft. A general-purpose, two-address, serial binary data system, it uses a 12,000-rpm memory drum with a 2,048-word capacity. Clock speed of 260 kc permits 78-usec multiplication.

Motorola, Inc., Military Electronics Div., Dept. ED, 8201 E. McDowell Road, Scottsdale, Ariz.

Wirewound Resistors 634



Precision wirewound power resistors, series SR, are sealed in silicone and are impervious to moisture and salt-spray. Ratings from 0.5 to 10 w are available in 15 types. Diameters are 3/32 to 3/8 in.; lengths are from 11/32 to 1-15/16 in. Resistance range is from 0.05 to 210,000 ohms. Insulation strength is 1-kv ac.

California Resistor Corp., Dept. ED, 1631 Colorado Ave., Santa Monica, Calif.

Tone System 579

Remote control of on-off functions is provided by transistorized audio tone channel systems. Both am and frequency shift are available; am channels are used for slow telemetry and simple functions, while frequency-shift channels are used for high-speed telemetry and control functions. Receivers and transmitters are housed in identical modules, which provide 10 channels in 5-1/4 in. of rack panel height. Power required is 110 v ac or 12 v dc.

Quindar Electronics, Inc., Dept. ED, 5 Lawrence St., Bldg. 9, Bloomfield, N.J.

NEW PRODUCTS

Transistor Transformers

675



Encased in drawn steel cans, these two miniaturized transistor transformers have nickel alloy leads on standard 0.1-in. spacings. The BUD configuration is 5/16-in. high and the MITE unit has a diameter of 3/8 in. A total of 42 designs can be supplied in either style.

Decco, Inc., Dept. ED, 2025 Farrington, Dallas, Tex.

Trimmer Potentiometer

677

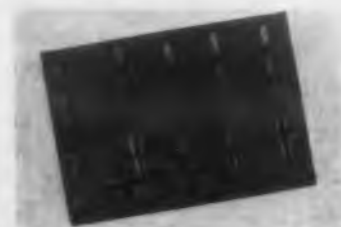


Series 5000 trimmer potentiometer is a 25-turn unit with welded construction of all fixed connections. Rated at 1 w up to 70 C, it has an operating temperature of -65 to $+150$ C. Nine standard resistance values from 100 ohms to 50 K are available with a standard tolerance of 5%.

Dale Electronics, Inc., Dept. ED, Columbus, Neb.

Cable Connectors

678



Coaxial cable connectors, with "crimp-on" construction, have a 50-lb cable pull min. They are provided with only three handling parts to afford convenience in assembly, post-assembly inspection and replacement of damaged connector bodies.

Dage Electric Co., Inc., Dept. ED, 67 N. Second St., Beech Grove, Ind.



ANOTHER LING FIRST! NEW 5000 LB. SHAKER —PROVIDES BUILT-IN PIGGY-BACK CHAMBER CAPABILITY

Ling offers you another design first with its new Model 300 Shaker. This new 5,000-pound-force shaker features Ling's unique closed-loop water-cooling system, a hermetically sealed system which is specifically designed to eliminate coolant contamination of an environmental chamber. Without any special shaker accessories, it operates with a piggy-back chamber, permitting testing to unlimited altitudes and humidity, and at temperatures from -100° to $+300^{\circ}$ F. The specially designed lightweight armature weighs only 41.5 lbs. Ling's unique low-voltage armature and field design eliminates corona problems when operating at altitudes, and the temperature range can be readily expanded above 300° F with the addition of an external thermal barrier. For details on Model 300, write Department ED-461, at the address below.



LING-TEMCO ELECTRONICS, INC.

LING ELECTRONICS DIVISION

1515 SOUTH MANCHESTER, ANAHEIM, CALIFORNIA • PROspect 4-2900

ELECTRONIC DESIGN • April 12, 1961

LING ELECTRONICS

The design of the Model 300 Shaker is an extension of an environmental shaker concept pioneered by Ling. This revolutionary concept, using a closed-loop cooling system for direct cooling of the armature, field coils and for compensation conductors, has greatly improved the efficiency of shaker performance.

In Model 300, Ling hermetically seals the system—so the standard shaker can be used freely in an evacuated chamber without special shaker accessories. Model 300 is particularly suited for mounting with the piggy-back chamber—the technique in which the shaker body acts as one wall of the chamber, and only the table rides into the chamber.

In addition, Model 300 offers Ling's new velocity signal generator for displacement monitoring. Loop-type flexures offer maximum lateral restraint and linear spring constant.



SPECIFICATIONS FOR LING'S MODEL 300 SHAKER INCLUDE:

Force Rating: vector 5,000 lbs.
 Frequency range 5-3,000 cps.
 Stroke, continuous duty...
 1 inch, peak to peak
 Flexure Stiffness 1,000 lbs.
 per inch
 Table Diameter 13 1/2 inches
 Max. Acceleration 100 G
 Stray Field less than 6
 gauss, 3 inches above the table



LING-TEMCO ELECTRONICS, INC.
 LING ELECTRONICS DIVISION

HIGH POWER ELECTRONICS FOR
 VIBRATION TESTING • ACOUSTICS • SONAR
 CIRCLE 90 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

Instrumented Power Supply

674



Rated 30 kv at 3 ma, model PSC 30-3-4 instrumented power supply has a ripple of 0.5% per ma. Regulation is 10% no-load to full-load. The unit has reversible polarity and a shielded, coaxial cable is provided for the output.

Del Electronics Corp., Dept. ED, 521 Homestead Ave., Mount Vernon, N.Y.

Ultrasonic Tester

681



For ultrasonic, nondestructive testing, model 424-D testing instrument has a variable pulse repetition rate. Metals and reasonably elastic materials such as glass, hard rubber and ceramics may be inspected with this unit. It has a built-in video delay circuit and recorder output circuits.

Curtiss-Wright Corp., Princeton Div., Dept. ED, P.O. Box 110, Princeton, N.J.

General Purpose Relays

676



Available with either 0.110- or 0.187-in. wide "push-on" terminals, type DM general purpose relays eliminate soldering from installation operations. Operating coils are 250 v ac or 130 v dc and the unit can also be supplied as a current-sensitive device with standard plate circuit value coils. Contacts are in any combination to 3pdt with 5- or 10-amp ratings.

Davis Electric Co., Dept. ED, Cape Girardeau, Mo.



start clean!

with this new ultra-low distortion,
 stable-amplitude oscillator

When the specs get critical, you need an oscillator that won't add distortion and instability of its own. Here's a stable-amplitude, low-distortion oscillator — Krohn-Hite's new Model 446 — that gives you a cleaner sine wave than any other oscillator you've ever worked with!

Amplitude stability is ultra-high: 0.001 db (0.01%), due to a unique infinite-gain AVC circuit (patent pending). Amplitude bounce near line frequency is no longer a problem — less than 0.05%. Distortion — phenomenally low: less than 0.01%.

But that's not all. The 446 push-button oscillator offers continuous frequency coverage from one cycle to 100 kc. Voltage output is continuously adjustable from 0 to 10 volts, with infinite resolution all the way.

And when you need power along with stable amplitude and low distortion, team up the Model 446 oscillator with Krohn-Hite's Model UF-101A ultra-low distortion 50-watt amplifier. Here's an amplifier which preserves the stability and distortion-free characteristics, even at a full 50 watts. Frequency response of the amplifier — from 20 cps to 20 kc at full power. A convenient load impedance switch offers a choice of 1, 2, 4, 8 and 225 ohms.

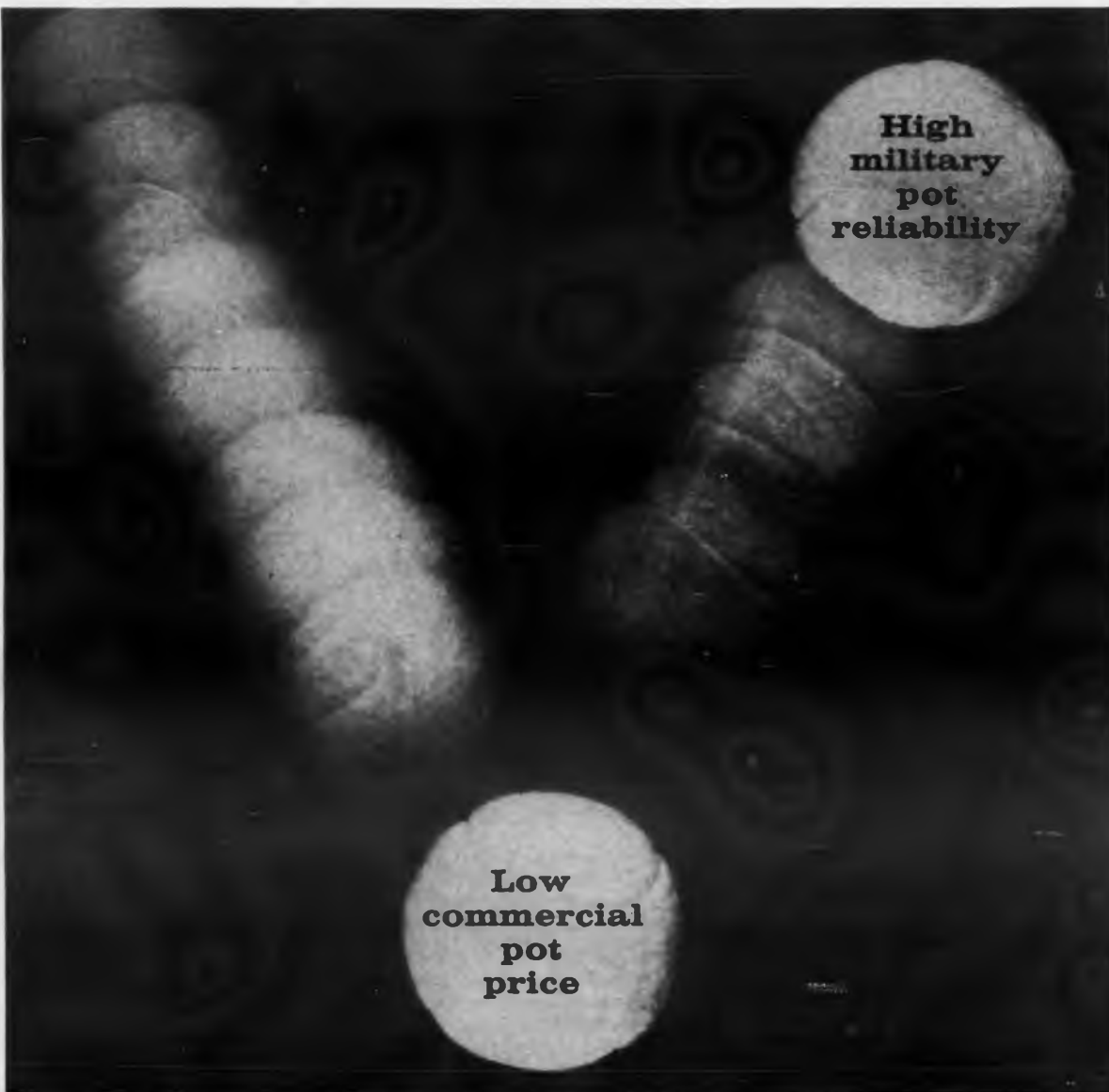
Together, this oscillator and amplifier provide a highly-stable, low-distortion, variable-frequency Power Source (Model LDS-115) — for the most critical meter calibration or measurement needs. Send for technical literature on these new Krohn-Hite instruments.



KROHN-HITE CORPORATION

580 Massachusetts Avenue • Cambridge 39, Mass.
 Pioneering in Quality Electronic Instruments

CIRCLE 91 ON READER-SERVICE CARD



That's how the ball bounces with Waters new PT $\frac{3}{4}$



Dust! Corrosion! Moisture! Vapors! All are foes of potentiometer reliability, yet ordinarily costly to keep out. Now, however, Waters introduces a new $\frac{3}{4}$ " plastic case pot, the PT $\frac{3}{4}$, meeting military sealed pot specs (MIL-R-19/1A), yet priced no higher than many commercial grade pots! "O" ring shaft seal and complete internal sealing virtually eliminate environmental problems. Resistance element is a copper mandrel wound with wire alloy which has a temperature coefficient of 20 PPM/°C. Resistance range 10 to 20,000 ohms \pm 5%. Dissipates 1.5 watts at 40°C. Available with split or plain bushings. Write for Bulletin PT 760.

WATERS MANUFACTURING, INC. • WAYLAND • MASS.

POTENTIOMETERS • COIL FORMS • POT HOOKS • PANEL MOUNTS • TORQUE WATCH GAUGES • TORQUE CALIBRATORS • OSCILLOSCOPES
CIRCLE 92 ON READER-SERVICE CARD



NEW PRODUCTS

Carrier Amplifier

562



A 5-v, 3-kc excitation for bridge and differential transformer transducers is provided by the model SCAS-1008 carrier-amplifier system. The solid-state system has one crystal-controlled oscillator, one dc power supply, and four amplifier plug-in modules. Modulating frequency response is flat from dc to 500 cps within \pm 1.5%.

Plug-In Instruments, Inc., Dept. ED, 1416 Lebanon Road, Nashville 10, Tenn.

Price: \$1,750; 6-week delivery.

Square-Frame Motor

573



Ratings from 125 to 300 hp are available in the D-5000 series of square-frame ac motors. The design has large air intakes at each end of the motor and exhaust outlets at the sides. Class B insulation is standard; frames and louvers are cast iron. The motor is supplied with sleeve or ball bearings. Line voltage may be 220, 440, or 550 for 3,600, 1,800, 1,200, and 900 rpm operation.

Reliance Electric and Engineering Co., Dept. ED, 24701 Euclid Ave., Cleveland 17, Ohio.

Feed-Through Headers

611



Hermetic sealing from -325 to $1,200$ F against high pressures and in radiation environments is claimed for the FT terminal feed-through headers. The parts are available in standard configurations of 1, 2, and 6 pins.

Physical Sciences Corp., Dept. ED, 389 N. Fair Oaks Ave., Pasadena, Calif.



**FOR
IMMEDIATE
LARGE
QUANTITY
DELIVERY
AT
FACTORY
PRICES**

Yes! Schweber can sell
any model of BOURNS TRIMPOT®
at factory prices.
Sizeable quantities are
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ELECTRONICS

60 HERRICKS ROAD, MINEOLA, L. I., N. Y.

PIONEER 8-8520, TWX 9-CV-NY-980U

CIRCLE 93 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

Now—an Even Smaller High-Temperature Trimpot® Potentiometer

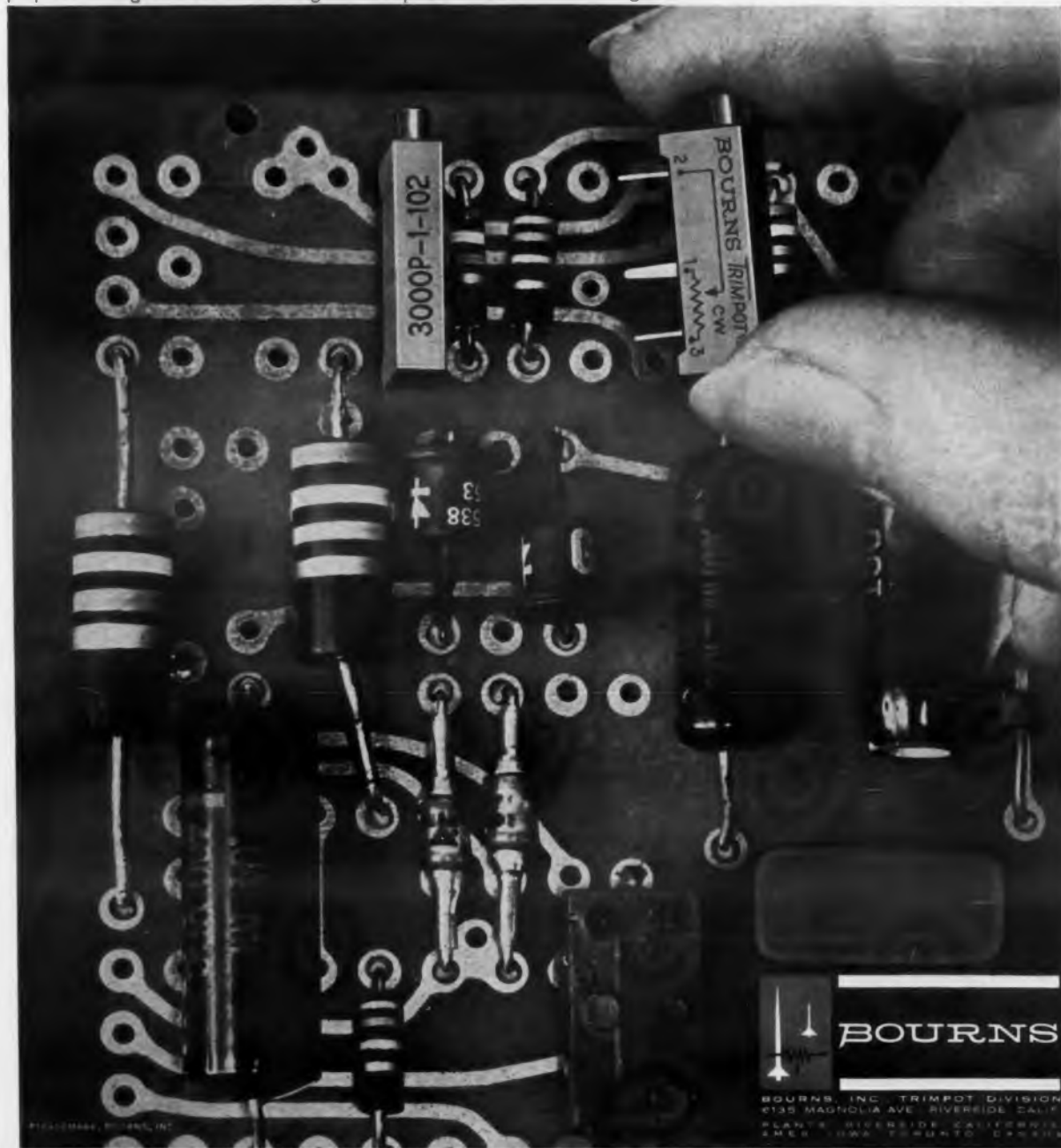
NUMBER 13—NEW PRODUCT SERIES

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.



Exclusive designers and manufacturers of Trimpot® potentiometers. Pioneers in transducers for position, pressure, acceleration.

CIRCLE 94 ON READER-SERVICE CARD

BOURNS
BOURNS, INC. TRIMPOT DIVISION
6135 MAGNOLIA AVE. RIVERSIDE CALIF.
PLANTS: RIVERSIDE, CALIFORNIA
AMES, IOWA TORRATO, DENVER

NEW PRODUCTS

Cast Epoxy Rod 614

Formulated to meet MIL-R-93B specifications, the BMCO 2000 series of cast epoxy rod is available in standard colors and diameters. Volume resistivity is 0.19×10^{16} at 180 C. Resistor bobbins and thin-wall shells machined from this material have good dimensional stability.

Boonton Molding Co., Dept. ED, Boonton, N.J.

Vacuum System 635



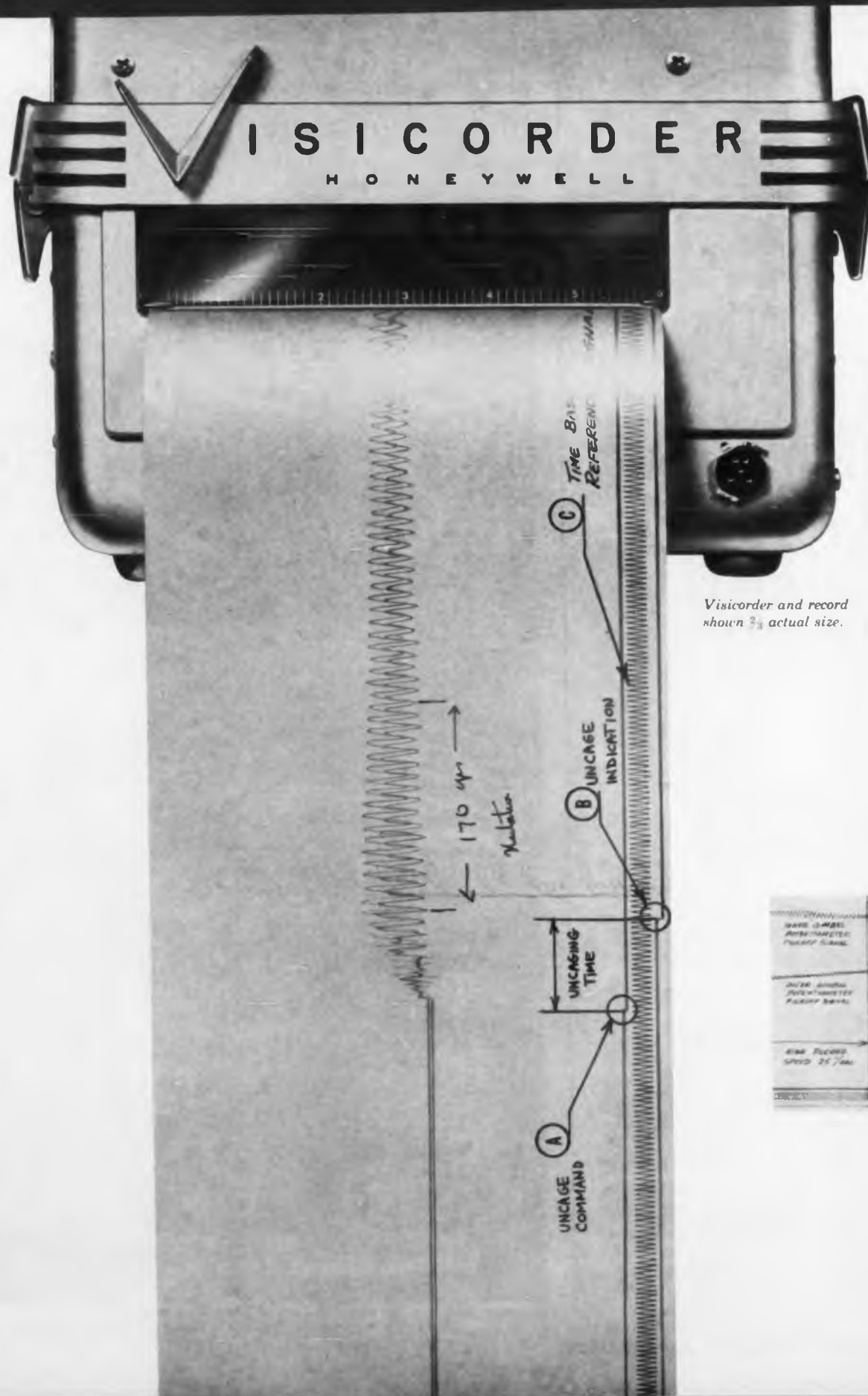
Designed for high-vacuum depositions of lightweight metals, this light-weight, compact vacuum system is for laboratory use. The 18-in. diam, aluminum bell jar can be evacuated in 5-min to 1 micron of mercury with an ultimate vacuum of 2×10^{-6} mm. A water-cooled baffle minimizes back-streaming from the diffusion pump.

Cenco Instruments Corp., Central Scientific Div., Dept. ED, 1700 Irving Park Road, Chicago 13, Ill.
Price: \$3,950.

Tape Device 580

Accessory to pulse-height analyzers, model 52-26 magnetic tape input-output device provides for external storage or re-entry of digital data into the analyzer memory. Data may be transferred from the analyzer to the tape units at 1,000 decimal digits per sec. Multipliers of 10%, 1%, or 0.1% may be selected to operate on data being transferred.

Radiation Instrument Development Laboratory, Inc., Dept. ED, 61 E. North Ave., Northlake, Ill.



Visicorder and record shown $\frac{2}{3}$ actual size.



How the Visicorder helps keep "spring" in a free gyro

by simultaneously recording several
performance characteristics

How do you production-test a spring-wound miniature "free" gyro which has been designed for a limited number of firings without changing its characteristics due to excessive testing? Whether a gyro under actual conditions will reproduce test results depends to a large extent upon how many times it is "fired" before its short but important life begins. The multi-channel high-frequency Visicorder makes it possible for Whitaker Gyro Division of Telecomputing Corp. to test simultaneously all operating characteristics with only one firing of the gyro.

Five channels of a Honeywell 906 Series Visicorder are used in the test for *uncaging time* and *gimbal drift*.

For the uncaging time study, a squib is fired to release the gyro's spring motor. One trace indicates squib firing (A). When the gyro attains correct speed (and uncaged condition) a switch closes to record another trace (B). Between these traces, a 400 cps trace is a convenient time reference (C).

The gyro is mounted on a Scorsby table set to deflect the unit $7\frac{1}{2}$ degrees from the perpendicular about two axes. Potentiometers sensing the gyro's deflection are directly connected to galvos which measure the position of the gyro gimbals as the unit is rotated on the fixture. The potentiometer outputs trace individual sine waves on the record (D) which are easily compared to a zero trace (E) to indicate gimbal drift.

The records shown here in two parts are actually one continuous record. Immediately after the uncaging time test, the record drive was switched to

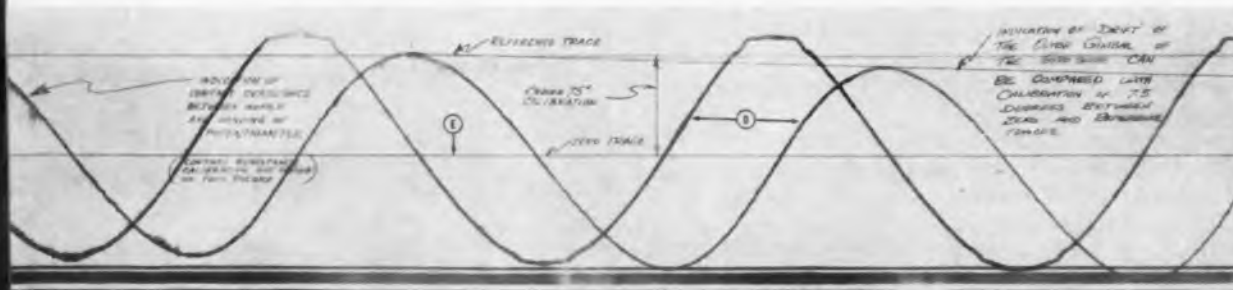


In this simple bench set-up, the 906 Visicorder is at right. Between it and the control panel is the Scorsby table on which the gyro is mounted, ready for test.

lower speed *without* stopping the record. The resulting traces are easy to compare and gimbal drift is measured immediately.

Four different models of the Honeywell Visicorder oscillograph provide immediate readout of analog data from DC to 5,000 cps, with 8, 14, 24 and 36 channel capacity. Prices are as low as \$1845 for a 6-channel system with grid lines and built-in timer (Model 1406). Call your Industrial Sales Office soon for a demonstration of how the world's most versatile oscillograph can save you time and money in data acquisition.

Ask, also, for your free copy of the 36-page Visicorder Applications Manual, an engineering guide packed with problem-solving suggestions.



The record at left was made at a speed of 25" per second. The record above is a continuation, after record speed was changed to 1" per second without interrupting the test sequence.

Heiland Division, Minneapolis-Honeywell
5200 East Evans Avenue
Denver 22, Colorado

Honeywell



Industrial Products Group

HONEYWELL INTERNATIONAL

Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

CIRCLE 95 ON READER-SERVICE CARD

Rate Gyro

592

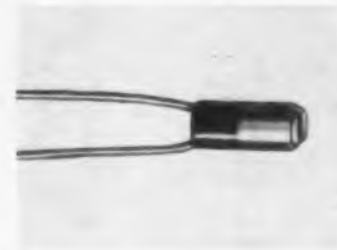


Self-testing features of the GR-H4-T rate gyro provide indication that the spin motor is operating at synchronous speed and that the gimbal is free to rotate. Permanent magnets and pickup coils provide a readout signal in excess of 2.5 v peak-to-peak. The rugged gyro withstands extremes of environment, including shocks of 500 to 900 g.

Northrop Corp., Nortronics Div., Dept. ED,
Northrop Bldg., Beverly Hills, Calif.

Tantalum Capacitors

593



Single-ended lead terminations can be supplied on TW (wire) and TS (slug) wet-electrolyte tantalum capacitors. Leads are properly coded for easy identification. Design enables fast assembly on modules and circuit boards.

Ohmite Manufacturing Co., Dept. ED, 3650
Howard St., Skokie, Ill.

Constant-Voltage Transformers

588



Static-magnetic voltage-regulating transformers maintain output voltages within 1% at inputs from 95 to 130 v. Operating on ferroresonance principle, the units are made in capacities of 15, 30 and 50 va. Any step-up or step-down ratio is available. Single or multiple secondary windings with or without centertaps can be furnished as required.

Neshaminy Transformer Co., Dept. ED,
Neshaminy, Pa.

P&A: \$17.50 to \$8.50; 2 weeks.



FOR MULTIPLE CIRCUIT SWITCHING

NORTH 700 SERIES "GANG" RELAYS

Where reliability is a must—North 700 Series "gang" relays combine fast action multiple circuit switching capabilities with the proven dependability of a telephone type open relay for use in computers, sorting and punching machines and similar applications. North 700 Series relays provide up to 16 pile-ups and are available to 32 form A or to 16 form B or form C contact arrangements.

These relays are also available with double coils for heavy spring loads or extra fast action. Double coil relays are identified as 7200 series and can be supplied with 50 form A or 32 form B or form C contact arrangements.

For applications where the small number of relays in a switching system make a common DC power supply uneconomical, the North 7300 Series is available with AC rectifiers.

North "gang" relays can be supplied with Double Gold Alloy or Solid Silver contacts, with solder type or AMP #78 type contact terminals, and with 12, 24, 48, 75 and 110 volt coils (110 V.A.C. for 7300 Series). Operating speeds range from 30 MS to 70 MS at approximately 2.2 watts. Faster speeds can be obtained with increased power.

For detailed specifications on North "Gang" 700, 7200 and 7300 Series relays, write ...

ELECTRONETICS DIVISION

NORTH ELECTRIC COMPANY

154 SOUTH MARKET ST., GALION, OHIO

CIRCLE 96 ON READER-SERVICE CARD



NEW PRODUCTS

Module Cases

610



Molded component cases are made in a wide range of shapes and sizes. Epoxy, phenolic or other materials may be used. Pin or terminal styles and layouts are made to customer order. The module cases allow the components to be assembled directly into the case.

Plastronic Engineering Co., Dept. ED, 721 Boston Post Road, Marlborough, Mass.

Coaxial Ignitron

587



Rated at 900 amp dc, the NL-1064 coaxial ignitron is a water-cooled mercury pool tube designed for resistance welder and similar ac control applications. Anode voltage is 250 to 600 v rms; maximum averaging time is 17.8 sec at 250 v and 8.9 sec at 500 v.

National Electronics, Inc., Dept. ED, Geneva, Ill.

Cable Clamps

594



Used with cables and hydraulic lines, nylon clamps are available in sizes ranging from 1/8 to 1-1/4 in. diameter. Design provides a true circle, and prevents wire pinching. The lightweight clamps are impervious to nearly all corrosive liquids and fuels.

Olympic Plastics Co., Inc., Dept. ED, 3471 S. La Cienega Blvd., Los Angeles 16, Calif.

ELECTRONIC DESIGN • April 12, 1961

CLEAN • CLASSIC



UNCLUTTERED

Here are meters, free of frills and tinsel, executed in handsome good-taste with sensible proportions to fit and enhance any panel board.

Besides their aesthetic qualities, BECKMAN® Panel Meters do an unbeatable metering job. They are of all-metal construction with steel movement enclosure, and are unaffected by magnetic panel materials or stray RF. They are dust-free and sealed to 2.5" Hg. The 4"x6" model shown has a 4.7" long scale arc for clear, shadowless readability. BECKMAN Panel Meters have a standard mounting configuration, and are interchangeable with other meters of like dimensions. Special scale plates and bezel colors are available.



Best news of all... 30 day delivery! Drop us a line or contact your nearest Helipot representative for details on the BECKMAN line, AC and DC Voltmeters, Ammeters, Milliammeters, Microammeters or Expanded Scale Meters.

Beckman® Helipot®

POTS : MOTORS : METERS
Helipot Division of
Beckman Instruments, Inc.
Fullerton, California

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CIRCLE 751 ON READER-SERVICE CARD
ELECTRONIC DESIGN • April 12, 1961

Servomotor

752

Smallest size 8 is 0.84-in. long
Said to be the smallest size 8, 115 v servomotor sold, the Model 8 SM 461 is 0.84-in. long, weighs 1.1 oz. A precision-control component, it has a rotor inertia of 0.18 gm-cm² coupled with a stall torque of 0.22 oz-in., providing acceleration at stall of 86,500 rad per sec²—three times greater than any equivalent unit, asserts the company. Using stainless-steel and Teflon as insulation throughout permits an ambient temperature rating of -55° to +130° C. Maximum unit operating temperature is 200° C. Helipot Div. of Beckman Instruments, Dept. ED, Fullerton, Calif.

Precision Potentiometer

753

Has matching 7/8-in. turns-counting dial



Model 7216, 7/8-in. diam. precision pot has standard resistance of 10 to 125,000 ohms and ±0.5 per cent standard linearity. A 7/8-in. diam. 2600 series turns-counting dial is also offered for users desiring a precision pot-and-dial package, counts full turns and hundredths. The model 7216 is a ten-turn potentiometer with 1/4-in. diam. shaft and 3/8-32 bushing mount. It is rated at two w at 25° C with a minimum operating temperature of -55° C. The pot has a molded diallylphthalate housing, bronze front lid and stainless-steel shaft.

Helipot Div. of Beckman Instruments, Dept. ED, Fullerton, Calif.

Panel Meters

754

Built to MIL specs



Built to exact conformity with MIL-M-10304A, 4-1/2-in. round, sealed panel meters have plug-in terminal construction, easy disassembly and good linearity. All-metal construction and modern appearance make the 92 standard models suitable for a variety of applications. Available as volt-meters, ammeters, milliammeters and microammeters.

Helipot Div. of Beckman Instruments, Dept. ED, Fullerton, Calif.
Availability: 30 days.

HELIPOT SINGLE-TURN POTENTIOMETERS...a line you can hang your toughest specs on! Don't worry, they can take it... environmentally, electrically, and mechanically! And you pay only for what you need, because Helipot offers 85°, 125°, and 150°C models! Standard linearity: ±0.5%, with ±0.10% available for most.

The Helipot line is simply stacked with stand-out single-turns, linear or non-linear, from 1/8" to 3" diameters. Numerous modifications are available for any of them—things like flatted or slotted shafts, rear shaft extension, shaft lock, anti-fungus treatment, color coding or center tap. And most models allow 8 cups to be ganged!

All these significant single-turns are precision built by Helipot... as are surprisingly large numbers of multi-turns, trimmers, A-C pots, dials, delay lines and in-line packages.

Want all the facts and figures? Just ask for our new catalog.



Beckman® Helipot®

POTS : MOTORS : METERS
Helipot Division of
Beckman Instruments, Inc.
Fullerton, California

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CIRCLE 755 ON READER-SERVICE CARD

NEW PRODUCTS

DC Power Supplies

586



Derated components are used in the Brute Force line of silicon dc power supplies. The current-regulated supplies have less than 1% rms ripple at any output voltage or current within rating. Ammeter and voltmeter with $\pm 2\%$ accuracy are standard. All units may be floated up to 500 v peak above ground; either terminal may be grounded.

NJE Corp., Dept. ED, 20 Boright Ave., Kenilworth, N.J.

Cartridge Rectifiers

603



Rated at 1.5, 3, and 5 kv piv, military type silicon cartridge rectifiers 1N1731, 1N1733 and 1N1734 meet MIL-S/19500, 142 (Sig C). They have higher current ratings, lower voltage drop and better reverse leakage characteristics than previously available types. Case is nonmetallic.

Pacific Semiconductors, Inc., Dept. ED, 12955 Chadron Ave., Hawthorne, Calif.

Temperature-Humidity Chamber

585



Available in 2-, 4- and 8-cu ft sizes, chamber SUB-Z-H has temperature ranges of -100 to $+400$ F and humidity of 20 to 95%. Climatic conditions are controlled by wet and dry bulb indicating controllers. Even temperature is maintained by means of an 8-in. circulator with fin-coil evaporator.

Cincinnati Sub-Zero Products, Dept. ED, 3932 Reading Road, Cincinnati 29, Ohio.

Packaging problems?

Hughes
Semiconductors
offers a complete
packaged assembly
service to save
you time, money,
headaches



Here are the features of this service:

- 1. SEPARATE PACKAGING DEPARTMENT**—This department specializes in the design and production of special assemblies. It is headed by an engineering group that provides personalized service with emphasis on solving your packaging problems quickly and economically.
- 2. LONG EXPERIENCE**—Hughes has already delivered over a million packaged assemblies. We've produced over 600 standard and special designs for firms all over the country.
- 3. QUALITY COMPONENTS**—Our assemblies consist of only the highest quality active and passive components manufactured by Hughes Semiconductors and other reliable sources.
- 4. RELIABILITY**—Hughes packaged assemblies use self-extinguishing epoxy throughout. They are corrosion proof, hermetically sealed, and their marking ink is immune to normal solvents. Hughes assemblies meet the requirements of all applicable MIL specifications.

If you are looking for a special assembly to fill your specific needs, or if you are looking for a standard assembly, specify Hughes. These assemblies are always rugged, reliable, economical, and you'll like the complete service you get.

Call or write your nearest Hughes Semiconductor Sales Office. Or write: **Hughes Semiconductor Division**, Marketing Department, 500 Superior Avenue, Newport Beach, California.



Power Transformers

584



Rectifier power transformers, models P-8193 and P-8194, are designed for use in either full-wave bridge or half-wave rectifier circuits. They can be used with either selenium or silicon rectifiers. P-8193 has outputs from 7 v dc at 2.5 amp to 17 v dc at 4 amp. P-8194 has circuit outputs from 14 v dc at 2.5 amp to 28 v dc at 5.2 amp.

Chicago Standard Transformer Corp., Dept. ED, 3501 W. Addison St., Chicago 18, Ill.

Digital Resolver

615

Model DR-14 digital resolver provides high-speed conversion from Cartesian to polar coordinates or the reverse. Conversion is accomplished in 200 μ sec or less. Completely transistorized and operating at a 1-mc clock rate, the unit accepts two 10-bit inputs representing Cartesian coordinates and converts them to two 10-bit numbers representing polar coordinates. It can provide conversion of 5 channels in less than 1 msec.

Computer Control Co., Inc., Dept. ED, 2251 Barry Ave., Los Angeles 64, Calif.

Digital Converter

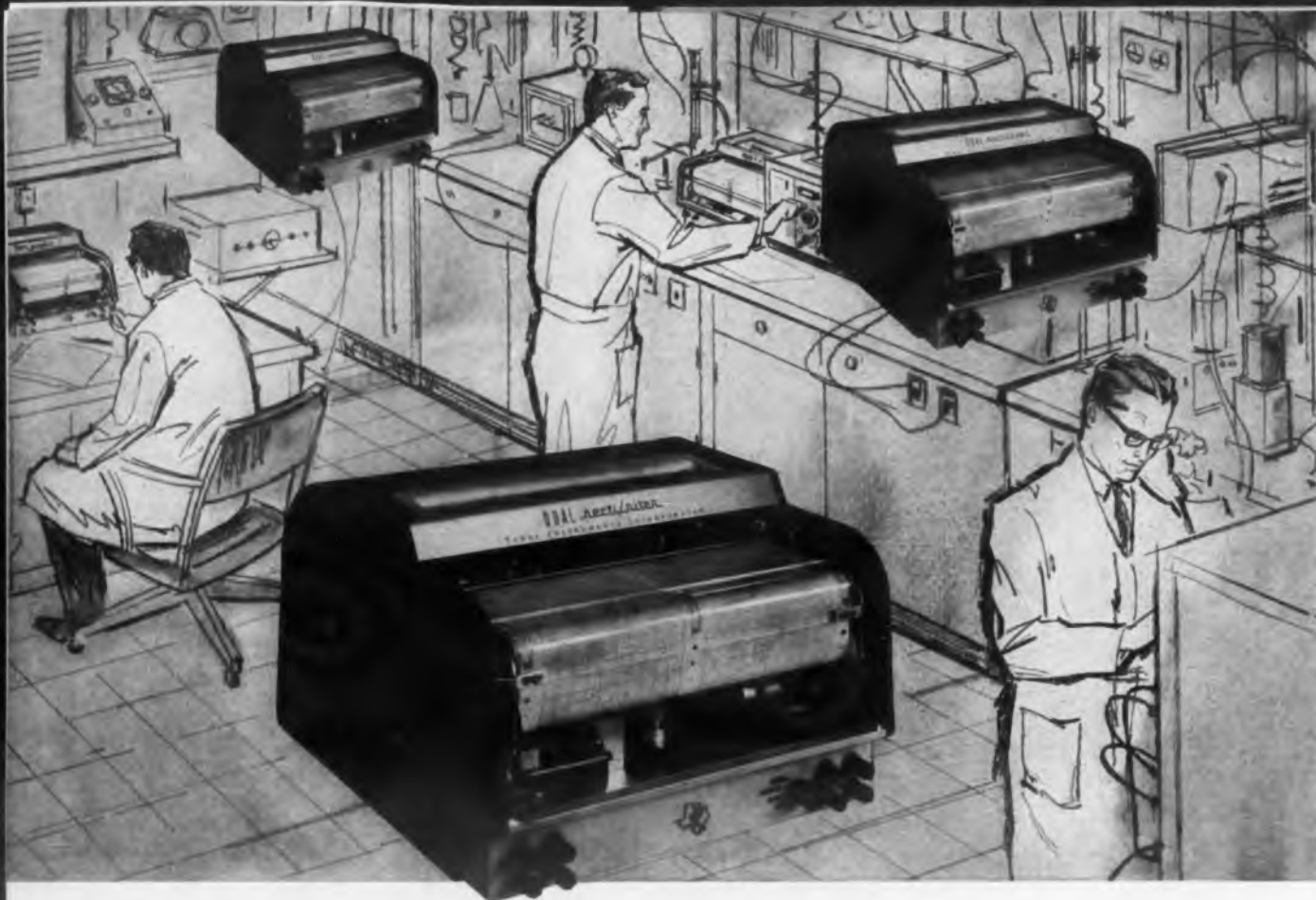
591



Designed for on-line digital telemetering and control applications, the Digi-Tel analog to digital converter operates directly from process transducers. Output is coded for direct digital transmission, display, control and data logging. Input transducers are available for operation from standard variables. Output may be decimal, binary-coded decimal, or special code. Up to three simultaneous output circuits are provided.

Electronics Div., North Electric Co., Dept. ED, Galion, Ohio.

CIRCLE 97 ON READER-SERVICE CARD



operator convenience makes
 the *recti/riter*® recorder
 preferred for laboratory use

The *recti/riter* recorder has become the *accepted* laboratory recorder—is preferred for the exacting tasks of laboratory applications. The portable *recti/riter* is the only galvanometric rectilinear recorder designed specifically as a bench-top instrument with all routine controls and adjustments located up front for extra convenience. The "writing desk" chart carriage permits operators to make the extensive notations usually associated with laboratory use while the instrument is recording.

Ruggedized die-cast construction results in an instrument that can "take it"—yet removal of the one-piece dust cover makes every working part completely accessible and removable without further disassembly. Every *recti/riter* carries a one-year full service warranty.

There is a *recti/riter* to fit your particular requirements—single and dual channel, portable and flush-

mounting models . . . each available in the widest selection of standard ranges in the industry.

Two-Cycle Pen Response
 d-c Milliampere Ranges ½ ma to 100 ma
 a-c Ampere Ranges 0.25 amp to 25 amp
 d-c Ampere Range 100 mv for use with
 standard shunts

Expanded Scale a-c Voltage Ranges
 80-130 V, 160-260 V, 320-520 V
 a-c and d-c Voltage Ranges 10 V to 1000 V
 Frequency Ranges 50, 60, 400 cps

Five-Cycle Pen Response
 d-c Milliampere Ranges 2.5 ma to 125 ma

Special options and accessories further expand the versatility of *recti/riter* recorders. Write now for complete information on this *accepted* laboratory recorder line.

APPARATUS DIVISION
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 AND DALLAS, TEXAS



TEXAS INSTRUMENTS
 INCORPORATED
 3609 BUFFALO SPEEDWAY
 P. O. BOX 6027 HOUSTON 6, TEXAS

NEW PRODUCTS

Thyratron Tubes

636



With milled-grid construction, thyratron tubes C1K, C3J and C6J are always constant in performance characteristics. Checks to select balanced sets are not necessary with these units. They meet all JAN MIL specifications.

Cetron Electronic Corp., Dept. ED, 717 Hamilton St., Geneva, Ill.

Amplitude-Distribution Analyzer 578

The amplitude-probability distribution of random signals is established by the model 317 analyzer. Voltage threshold is preset at front panel; noise levels exceeding that level are read in terms of percentage and time. The solid-state device operates from 5 cps to 500 kc. Amplitude ranges are 100%, 10%, and 1% full scale. Accuracy is $\pm 3\%$ of full scale. Size is 8-1/4 x 5 x 6-3/4 in.; weight is 5 lb.

Quan-Tech Laboratories, Inc., Dept. ED, 60 Parsippany Blvd., Boonton, N. J.

Infrared Detectors

627



Room temperature, indium antimonide, infrared detectors have a time constant of less than 1 μ sec and peak at 6.8 microns. Specifications for a typical cell 1.5 x 6 mm are: black body response, 3×10^7 cm-cps^{1/2} per w; resistance, 20 ohms; time constant, less than 1 μ sec; peak response, 6.8 microns.

Block Associates, Inc., Dept. ED, 385 Putnam Ave., Cambridge 39, Mass.

Instrument Pivots

691

Precision instrument pivots are made for electrical indicating instruments, velocity and pressure gages, and similar applications. They are manufactured to tolerances of 0.0001 in. and have a hardness of 65 on Rockwell C scale. Various point curvatures and non-magnetic pivots are made.

Welton V. Johnson Engineering Co., Inc., Dept. ED, 95 Summit Ave., Summit, N.J.

Precision Relay

624



Only 0.2 x 0.4 x 0.6 in. in size, the "Dyna-Mite" precision relay weighs 0.1 oz. Sensitivity is 100 mw and current rating is 0.25 amp with a contact life of 100,000 cycles min at the rated resistive load of 28 v dc. The unit will operate without variation over the temperature range of -65 to +125 C at the max guaranteed pull-in current of 7 ma max for the 2-K coil, 18- to 30-v rating. Available in spdt, with resistances of 500, 1,000 and 2,000 ohms, and a voltage range of 12 v, 16 v, and 18 to 30 v.

Control Dynamics Corp., Dept. ED, North Hollywood, Calif.

Nuvistor Triode

581

High-mu nuvistor triode 7895 is useful in cascode circuits, rf and if stages, on-off controls, and resistance-coupled amplifier circuits. Transconductance is 9,400 μ mhos at plate current of 7.0 ma, plate voltage of 110 v. Heater drain is 135 ma, at 6.3 v. Amplification factor is 64. The triode is 0.8 in. long and weighs 1/15 oz.

Radio Corp. of America, Electron Tube Div., Dept. ED, 415 S. 5th St., Harrison, N.J.

CIRCLE 99 ON READER-SERVICE CARD ►

READOUT of this world

DOWN-TO-EARTH FACTS

The excellent acceptance given the NIXIE Indicator Tube—the first mass-produced all electronic readout tube—extends throughout the industry. It is understandable when you compare this tube, feature for feature, with any other readout. Check these facts, then specify:

- Lowest Cost
- Smallest Size
- Lightest Weight
- No darkening display
- Most easily read . . . under all conditions
- No shifting focus or misalignment
- All electronic
- No costly replacement or servicing
- Lowest power requirements
- No bulb or filament failure
- Meets maximum temperature, shock and vibration specifications
- No segmented failure
- Longest life . . . 200,000 hours
- No matrix driver required

Write today for your
READOUT FACT FINDER,
AN ENGINEERING
COMPARISON OF
ALL READOUTS



NIXIE[®]

INDICATOR TUBES

ANOTHER ELECTRONIC CONTRIBUTION BY
Burroughs Corporation

ELECTRONIC TUBE DIVISION
Plainfield, New Jersey

NEW PRODUCTS

Frame-Grid Tubes 379

A pair of frame grid tubes are in production, with other types scheduled. The 6DJ8, a twin triode, is designed for industrial use; the 6GK5 triode is used as an rf amplifier in TV tuners. The design gives uniform tube characteristics.

Westinghouse Electric Corp., Dept. ED, Box 2278, Pittsburgh 30, Pa.

Precision Delay Lines 630



For use in IFF equipment, these high-performance delay lines have a total delay of $20.3 \mu\text{sec} \pm 0.05 \mu\text{sec}$. Taps are available at every $1.45 \mu\text{sec}$. Minimum delay-to-rise time is 100 to 1 and characteristic impedance is 470 ohms. Attenuation is less than 2 db and spurious signals are maintained below -20 db .

Richard D. Brew and Co., Inc., Dept. ED, 90 Airport Road, Concord, N.H.

Availability: 4 to 6 weeks.

Miniature Demodulator 620

Solid-state demodulator model D 6004 is a plug-in assembly measuring $1 \times 1 \times 1.375 \text{ in}$. It converts suppressed carrier input signals to dc output with amplitude and polarity proportional to phase sense and amplitude of ac input. A signal of 5.0 v rms provides an output of $\pm 5.0 \text{ v dc}$ with input impedance of 40 K , output impedance 10 K and linearity better than 1%. Frequency may vary from 200 cps to 50 kc.

Natel Engineering Co., Inc., Dept. ED, 15922 Strathern St., Van Nuys, Calif.

Price & Availability: \$60 to \$140; 2 weeks.

High Precision Data Logger for \$3,600



The RS2 Recording Digital Voltmeter — now in volume production at Non-Linear Systems, Inc. — scans up to 20 double-pole input channels . . . measures DC voltage from ± 0.001 to ± 999.9 with $\pm 0.01\%$ accuracy . . . and records input channel number and the 4-digit voltage measurement. Uses include research and development, quality control, environmental and reliability testing.



Plug-in stepping switches in the digital voltmeter section of the RS2 permit replacement of all switches and decade resistors in minutes instead of days. The plug-in feature allows almost instant troubleshooting by the substitution method.



Volume production and simplified controls of the RS2 account for its low cost — half to a third less than custom-built units.



Note the compact, plug-in modular design of the scanner-printer section of the RS2.



NLS Reports on Low-Cost, Standard Data Logger

A low-cost automatic data logger built as an integrated scanning, measuring and printing system — the RS2 Recording Digital Voltmeter — is now in volume production at Non-Linear Systems, Inc.

This economy-priced NLS logger is designed for applications requiring high accuracy and low cost without need for the higher speed and greater input capacity of higher cost NLS systems. Simplified controls offer several automatic and manual modes of operation.

While utilizing many circuits field-tested for six years in thousands of NLS digital voltmeters, the RS2 has undergone extensive testing as a standard, complete system. It is delivered ready to use, without need for additional engineering or complex interconnections.

Call your NLS regional office or representative for a demonstration, or write NLS.

RS2 BRIEF SPECIFICATIONS

Visual Indication: 4-digit voltage reading with correct polarity and range. 2 digits for input channel identification.

Range-Polarity Indication: automatic

Functions: scanning up to 20-double-pole channels; measuring DC voltage from ± 0.001 to ± 999.9 in ranges of $\pm 9.999/99.99/999.9$, printing channel number, 4-digit reading, polarity and decimal point placement.

Accuracy: $\pm 0.01\%$ of full scale on each range.

Speed: 2 seconds average for each data point scanned, measured and recorded.

Scanner Operation Modes: **AUTO CYCLE** — system continually repeats automatic scanning cycle from channel 00 to 19. **ONE CYCLE** — system automatically stops after scanning channel 19. **PRINT** — one input is measured without advancing scanner. Scanner may be manually advanced one channel at a time by depressing front panel **ADVANCE** button.

AC Voltage: Use NLS AC/DC Converter.

Low-Level DC: Use NLS Model 140 Preamplifier.

Input Impedance: 10 mega on all ranges.

Size: 14" high, 15 1/4" deep for 19" rack.

Delivery: From stock. 30 days, maximum, should stocks become depleted.



Originator of the Digital Voltmeter

non-linear systems, inc.
DEL MAR, CALIFORNIA

CIRCLE 101 ON READER-SERVICE CARD
ELECTRONIC DESIGN • April 12, 1961

Battery Charger

668



Dual voltage, constant current, battery charger model T-8-16 is designed to charge nickel cadmium batteries without overheating or overcharging. A two-position switch sets voltage and current for 8- and 16-v batteries. Voltages from 1.4 to 24 v can be accommodated by an internal shunt change.

ELF Inc., Dept. ED, P.O. Box 302, Florissant, Mo.

Price: \$49.95.

Linear Potentiometer

589



Linear-motion, conductive plastic potentiometer has a wirewound element with high resolution and a standard linearity of 0.05%, with closer linearity on order. Length is 2 to 24 in. Taps can be provided on request.

New England Instrument Co., Dept. ED, 1334 Main St., Waltham, Mass.

AC Test Set

607



With output to 150 kv rms, 0.1 amp, model K 150-15 dielectric test set may be supplied alone or with controls for dielectric and corona testing. Power required is 440 v, 60 cps, 1 phase, 27 amp. A scope calibrating unit is optional. Waveform distortion is below 5%; military testing standards are met.

Peschel Electronics, Inc., Dept. ED, Route 216, Towners, N.Y.

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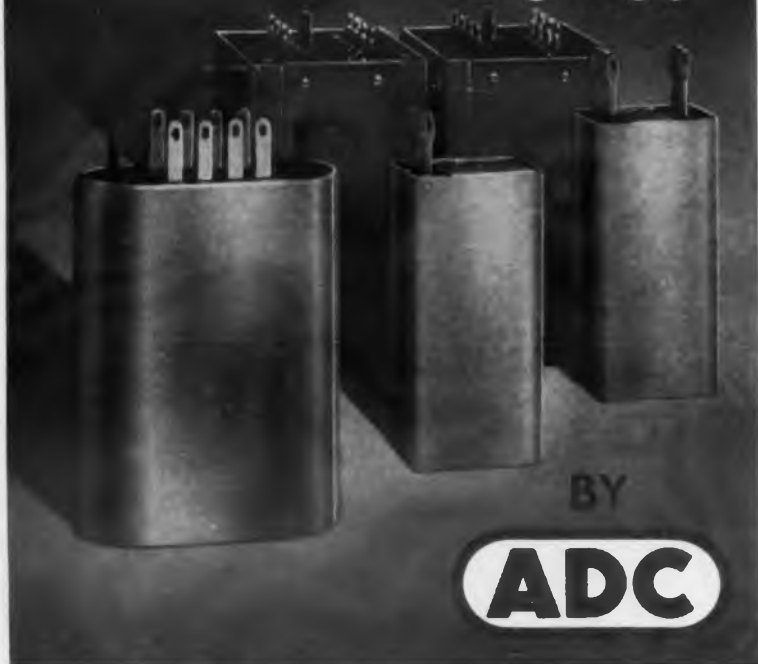
TIME TO TRAVEL... in a bird, or elsewhere, this A. W. Haydon timing motor is unique. We married our successful Vanguard II sub-miniature DC motor, for power, to a tiny new version of our well known (and patented) chronometric governor, for precision. Result: it will drive miniature tape recorders, printed circuit commutators, potentiometers, and such things...and hold its speed to within $\pm 0.1\%$ of the speed you want, even if the shaft load, line voltage and ambient temperature vary widely. It weighs a mere two ounces and measures less than 1 3/4" x 1 5/8", yet delivers at least 30 ounce-inches of torque at 1 rpm. For full information on this #14600 motor, or any other sort of timing device, electronic or motor driven, just write.



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CIRCLE 102 ON READER-SERVICE CARD

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In addition to their regular stock and custom transformers for the electronic industry, ADC has long been a dependable source of transformers and filters to the telephone and telegraph industry. When Western Electric announced they would no longer supply these components to manufacturers, ADC put their 24 years of experience to use designing and tooling a series of "coils" which are electrically and physically interchangeable with similar components made by The Western Electric Company. Many of these are in stock. If you use such components, we suggest that you write for more information. We believe you'll be pleased with both the price and delivery.

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CIRCLE 103 ON READER-SERVICE CARD

NEW PRODUCTS

Limit Stop Assembly

599



Adjustable rotational limit control within an operational range of 30 to 4,530 deg is provided by this precision limit stop assembly. Contained in a size 18 case, the assembly has a 3/16-in. shaft with ball or bronze bearings.

PIC Design Corp., Dept. ED, 477 Atlantic Ave., East Rockaway, L.I., N.Y.

P&A: \$45 to \$75; 10 days.

Photoelectric Control

553



Infrared light-actuated photoelectric control is designed for operation at distances up to 100 ft between the light source and the control. The lens of the control is shielded from normal light so that operation continues day or night, whether lights are on or off. Operation is from 115/230 v, 50 to 60 cps.

Autotron, Inc., Dept. ED, Box 722 IIA, Danville, Ill.

Temperature Transducer

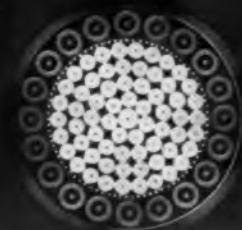
683



For temperature ranges from -320 to $+280$ F, model Y-0218 temperature transducer will measure skin temperatures, the level of liquid nitrogen, as well as acting as the temperature compensation element for constant signal readout. Excitation is in the order of 2 ma. The unit is approximately 1-in. square, less than 0.040 in. thick and weighs less than 1 g. It will stand 100 g at 100 to 700 cps.

Crescent Engineering and Research Co., Dept. ED, 5440 N. Peck Road, El Monte, Calif.

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SPECIAL
IN**



Bring your problem to us.

You'll find we're experienced in handling the very special cable problems encountered in telemetering, data recording, circuit control testing, and electronic computers.

When a major aircraft manufacturer needed a specialized cable with low-loss characteristics, trouble-free operation and long service life they brought their design to us. We produced a cable with 111 conductors, grouped into 37 individually jacketed triplets—complete with insulation jacketing, shielding braid, laminated tape and heavy-duty outside jacket.

Others with similarly knotty cable problems have discovered that Rome's know-how and facilities are just what the situation calls for.

We'd be happy to send you a brief descriptive brochure. Ask for Bulletin RCD-400, "Instrumentation Cables." Or spell out your problem. Either way you'll hear from us promptly. Address inquiries to Rome Cable Division of Alcoa, Dept. 11-41, Rome, N. Y.



CIRCLE 104 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

Operational Amplifier

670

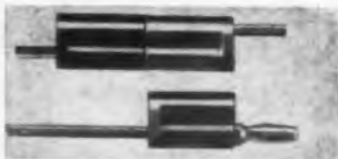


Solid-state, high-gain, direct-coupled amplifier module model A-201 is for general purpose closed-loop use. Amplifier frequency response is flat from dc to 1 kc; open loop dc gain is over 1,000,000. Output is 14 v peak at 3 ma.

Dynamic System Electronics Corp., Dept. ED, 2001 N. Scottsdale Road, Scottsdale, Ariz.

Stacking Patch-Cord

564



Endless extension couplings are possible with the model HB extension-stacking patch-cord. The part is available in 10 colors and standard cord lengths. Banana plugs are beryllium copper spring, fitting standard 0.166-in. jacks.

Pomona Electronics Co., Inc., Dept. ED, 1500 E. 9th St., Pomona, Calif.

Price: \$1.75 to \$1.23 ea.

Tuning Fork Oscillator

673



Transistorized tuning fork oscillator, series DFO-80, is available in any frequency from 400 to 4,000 cps. Frequency tolerance is $\pm 0.15\%$ over the temperature range of 0 to 60 C. It will provide 3 v rms into a 10-K load nominal and a sine wave with less than 10% distortion or 12-v peak-to-peak square wave with a rise time of less than 10 μ sec.

Delta-F, Inc., Dept. ED, 113 E. State St., Geneva, Ill.

P&A: \$66.25 to \$45 depending on quantity; from stock.



Because photomechanical reproduction has been developed to micron accuracy, masks in subminiature sizes are standard production at Buckbee Mears Company. Evaporation masks for mesa transistors, germanium and silicon are no longer a challenge. Anything that can be drawn can be reproduced. Drawings up to 1,000 times size are reduced exactly by special cameras to produce a perfect matrix for *exact* reproduction of the component demanded.

For straight line rulings, cross line rulings, calibrated dials, and concentric circles an especially designed ruling engine produces master rulings up to 2,000 lines per inch with linear accuracies up to 14 inches of $\pm .000039$. Also concentric circles of 10 inch diameter to the same tolerances.

Anything that can be drawn can be reproduced—*exactly*. Before you decide it can't be done, send us your problem.

Our answer could surprise and please you, as it did the designers of a space antenna when a conductor 20 feet long was etched to an accuracy of .015 inches over an area of 17.45 feet; or as it did the Bell Laboratories when they asked for thousands of apertures spaced to .00005 in 1 square inch of nickel.

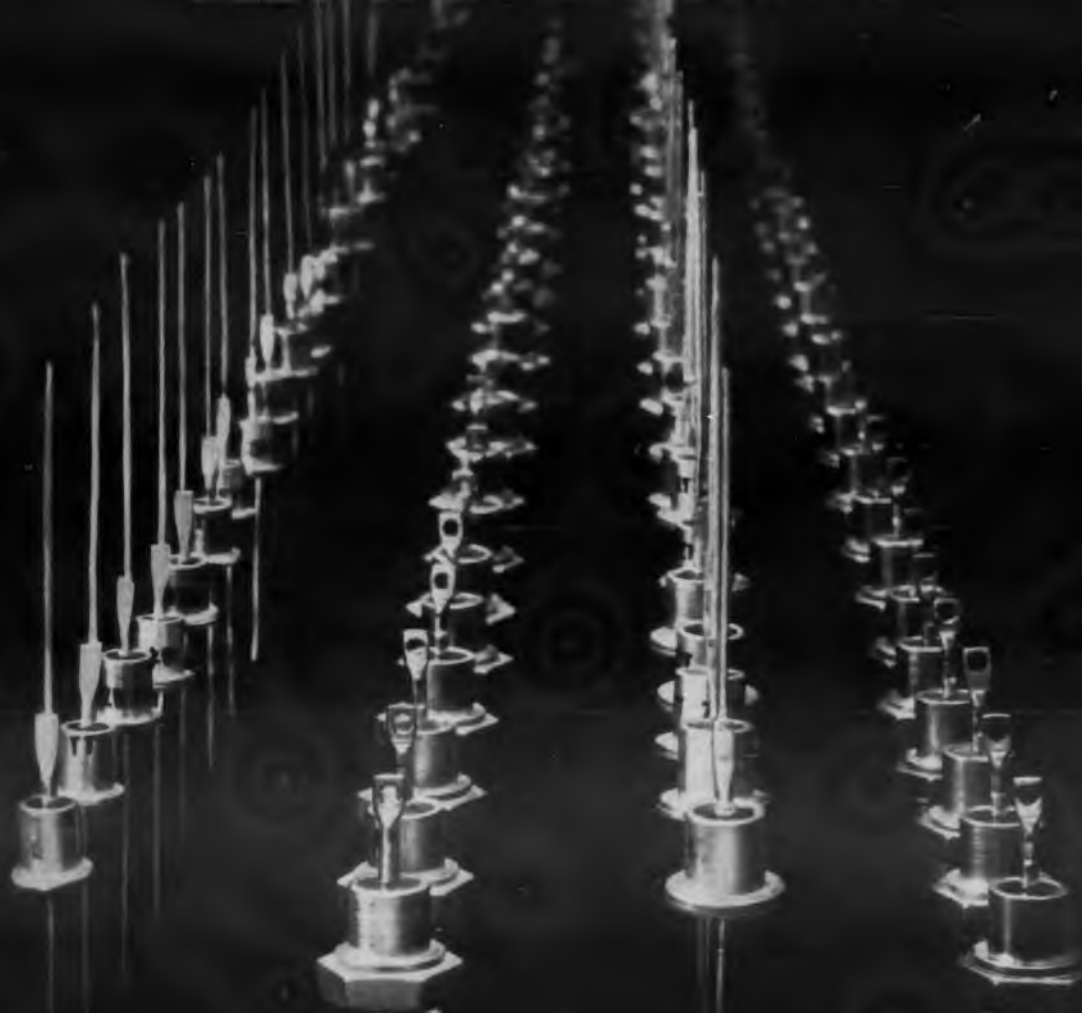
buckbee mears



245 EAST SIXTH STREET • ST. PAUL 1, MINNESOTA

CIRCLE 105 ON READER-SERVICE CARD

ELEVEN DOZEN ZENERS



132 BASIC ITT TYPES COVER 33 VOLTAGES IN 4 POWER RATINGS

The complete ITT "Gold Crown" line of zener voltage regulator diodes offers all the most widely used power ratings in a very extensive range of zener voltages. Backed by the world-wide research, development and production facilities of the great ITT System, these outstandingly reliable diodes

feature sharp zener characteristics, low dynamic impedance and conservative power ratings. Welded cases with hermetic glass-to-metal sealing assure total environmental protection for the most critical commercial and military applications. Write for Bulletin No. 230, containing complete data.



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ITT COMPONENTS DIVISION PRODUCTS: SELENIUM RECTIFIERS • SILICON DIODES AND RECTIFIERS • TANTALUM CAPACITORS • POWER TUBES • IATRON STORAGE TUBES • HYDROGEN THYRATRONS • TRAVELING WAVE TUBES

- 4 power ratings: $\frac{3}{4}$, 1, $3\frac{1}{2}$ and 10 watts
- 33 zener voltages (nominal): 3.9 to 100 volts
- standard tolerances: $\pm 20\%$, $\pm 10\%$, $\pm 5\%$
- temperature range: -65° to 175° C.

NEW PRODUCTS

Inertia Switch

357



Single pole, double throw model 6BC-189 is a unidirectional switch with a range of 2 to 30 g $\pm 5\%$. Response time of the undamped switch is 0.015 sec; reset is automatic. Power rating is 2 amp at 28 v dc, temperature range -65 to $+250$ F. Two insulated terminals and case ground are provided. Switch meets requirements of MIL-E-5272.

Inertia Switch, Inc., Dept. ED, 311 W. 43rd St., New York 36, N. Y.

Vacuum Chambers

577

Diameters from 18 in. to 12 ft with standard lengths to 20 ft are included in the Spacemaster series of vacuum chambers. The standard unit is for vacuum levels to 10 microns while the high-vacuum type, with stainless steel vessel, is for vacuum levels to 0.1 microns.

Bethlehem Foundry and Machine Co., Environmental Engineering Div., Dept. ED, 225 W. Second St., Bethlehem, Pa.

Tantalum Capacitors

626



Microminiature in size, these nonpolar solid tantalum capacitors measure 0.1 x 0.090 x 0.065 in. max. Models are available in a range of values from 0.001 to 0.0047 μ f which operate at 50 v nonpolar and from 0.0068 to 0.047 μ f at lower voltages. Temperature range at full-rated voltage is -55 to $+85$ C.

Components, Inc., Dept. ED, Biddeford, Me.

◀ CIRCLE 106 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

Deviation Voltmeter 358



Voltages to $\pm 1,010$ v dc are measured with accuracy of $\pm 0.1\%$ ± 0.1 v. Circuit is floating; input impedance is greater than 100 meg. Standard cell referenced voltage is adjustable between 0 and 1,010 v. Deviation from reference is indicated on 10 v or 100 v scale. Size is 9-1/2 x 8 x 12 in.

Industrial Measurements Corp.,
Dept. ED, 250 N. Thomas, Pomona,
Calif.

Price: \$460.

Indicator and Controller 576

Designed for use in any bonded strain gage transducer system, type 110 Pointer Indicator and Indicating Controller is an automatic null-balance type instrument. It uses a servo-driven slide wire to balance an internal bridge circuit. Standard models are capable of over-all systems accuracies of $\pm 0.5\%$.

Baldwin-Lima-Hamilton Corp.,
Dept. ED, 42 Fourth Ave.,
Waltham 54, Mass.

Mounting Hardware 633



Continuous mounting hardware permits the user to mount as many of the firm's standard lighted assemblies as necessary in a compact and orderly matrix fashion. The use of this device prevents accidental dual actuation of two switches.

Controls Co. of America, Control Switch Div., Dept. ED, Folcroft, Pa.

CIRCLE 107 ON READER-SERVICE CARD >



Avco and... better communication in combat areas

The newest combat area FM communications equipment standardized by the U. S. Army Signal Corps is Avco's AN/VRC-12.

Designed, developed and produced by Avco's Electronics and Ordnance Division, the AN/VRC-12 series utilizes narrow-band frequency modulation, covers 30-70 megacycles, has 920 channels and offers completely automatic tuning.

Rugged and compact—one-seventh the size and two-thirds the weight of the equipment it replaces—the AN/VRC-12 is compatible in every way with manpack, portable and airborne FM radio sets being developed by the Army for use in forward combat areas.

Reducing the problems and enhancing the effectiveness of communications—whether for the Army, Navy, Air Force or NASA—are among Avco's proven and most highly developed capabilities.

If you have a communications problem, why not consult Avco's Electronics and Ordnance Division. Write: Director of Marketing, Communications Section, Electronics and Ordnance Division, Avco Corporation, Cincinnati 15, Ohio.

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Avco's AN/VRC-12 combat area FM communications equipment.

BIRD

"Termaline" 50 ohm Coaxial Line LOAD RESISTORS



MODEL
888

1200
Watts
Continuous
Duty
1500 Watts
Intermittent Duty
2 to 3 KW
Continuous Duty with
forced air cooling
Input connections are
available to terminate
most coaxial lines.

BIRD "Termaline" Load Resistors are designed to provide a constant impedance of 50 ohm from DC through the useful coaxial frequency range. Each Resistor is intended to simulate an infinite length of 50-ohm line, thus providing an almost reflectionless termination. Low VSWR and freedom from radiation makes the Bird Loads extremely useful during adjustment and testing. Measurements of power are also possible when these Resistors are used as terminations for the appropriate Bird "Thuline" Directional Wattmeters. Accuracy in RF resistance, rugged ability to absorb power and absence of any need for adjustments has long characterized the Bird "Termaline" Load Resistors. For specifications on standard models see chart below. For other requirements please phone or write. Our long experience in this field may assist you in the solution of your problem.

| Model | Max. Power | Freq. Range | Max. VSWR* | Input Connector |
|---------|------------|-------------|------------|---|
| 80-M | 5 W | 0-4 KMC | 1.2 | Type "N" male |
| 80-F | 5 W | 0-4 KMC | 1.2 | Type "N" female |
| 80-CM | 5 W | 0-4 KMC | 1.2 | Type "C" male |
| 80-CF | 5 W | 0-4 KMC | 1.2 | Type "C" female |
| 80-BNCM | 5 W | 0-4 KMC | 1.2 | Type BNC male |
| 80-BNCF | 5 W | 0-4 KMC | 1.2 | Type BNC female |
| 80-A | 20 W | 0-1000 MC | 1.1 | Type "N" female |
| 81 | 50 W | 0-4 KMC | 1.2 | Type "N" female |
| 81-B | 80 W | 0-4 KMC | 1.2 | Type "N" female |
| 82-A | 500 W | 0-3.3 KMC | 1.2 | Coplanar. Adaptor to UG-218 / U supplied |
| 82-AU | 500 W | 0-3.3 KMC | 1.2 | "LC" Jack mates with UG-154 / U plug on RG-17 / U cable |
| 82-C | 2500 W** | 0-3.3 KMC | 1.2 | Coplanar. Fittings and cable assemblies for flexible and rigid coax lines available |

*VSWR on all models is 1.1 max. from DC to 1000 MC.
**Water cooled

Other Bird Instruments



"Thuline"
Directional
RF Wattmeters



"Termaline"
RF Absorption
Wattmeters



Coaxial
RF Filters



Coaxial
RF Switches

BIRD ELECTRONIC CORP.
CHevchill 8-1200
30303 Aurora Road, Cleveland 39, Ohio
Western Representative:
VAN GROOS COMPANY, Woodland Hills, Calif.

CIRCLE 108 ON READER-SERVICE CARD

NEW PRODUCTS

Variable Delay Lines

559



Series 8710 all-metal delay lines are continuously variable, distributed constant units that afford precise selection of extremely short time intervals. Delay times of 1 μ sec to 0.1 μ sec are provided, with rise times less than 10% of total delay time. Life expectancy is one million or more shaft revolutions.

Beckman Instruments, Inc., Helipot Div., Dept. ED, 2500 Fullerton Road, Fullerton, Calif.

Bar Switch-Light

604



A multipole, momentary-contact bar switch-light, series 34 is available in a variety of normally open or normally closed contact arrangements as 1, 2, or 3pdt and 2, 3, 4, or 6pdt. Rated at 28 v dc, 2 amp resistive, mechanism has double-break silent action. Lens is available plain or engraved in four standard colors.

Pendar, Inc., Dept. ED, 14744 Arminta St., Van Nuys, Calif.

Telemetry Calibrator

568



All fm-fm subcarrier channels are automatically calibrated with the model C-005, a three-point telemetry calibrator. All signals derive from transistorized, plug-in crystal oscillators operating at the fundamental frequency. There are two automatic and one manual operating modes.

Probescope Co., Inc., Dept. ED, 8 Sagamore Hill Drive, Port Washington, N. Y.

The
ULTRAGRAPH
444



Direct
Writing
Light Beam

Oscillograph

1 to 6 Channels



MORE DATA PER DOLLAR

- ★ Inexpensive Tungsten Light Source
- ★ Electrically Selectable Speeds
1", 5", 10"
and 50" per second
- ★ Sensitivities from
.4 Mv/inch
- ★ 2000 Cycles per
Second Frequency
Response (\pm 5%)
- ★ Amplitude Grid Lines
- ★ Weight 15 lbs.
- ★ 110 Volts — 60 Cycles

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CIRCLE 109 ON READER-SERVICE CARD

4PDT Relay



Rated to 3 amp at 30 v dc or 115 v ac resistive, the KHP series of relays provides 4pdt in a package slightly larger than 1 cu in. Contact arrangements of four Form C and two Form Z are available. Coil operating voltages range from 6 to 110 v dc. Pull-in time is 15 msec, drop-out 5 msec max. Dust cover is translucent nylon.

Potter & Brumfield Div., American Machine & Foundry Co., Dept. ED, Princeton, Ind.

Compression Accelerometer



A true compression sensing device, model 706 accelerometer is designed for shock and vibration measurement. Sensitivity is 35 mv per g and frequency response is flat within $\pm 5\%$ from 0.2 cps to 10 kc. Resonant frequency is 60 kc. Acceleration range is from 0.2 to 40,000 g with an amplitude linearity of $\pm 1\%$.

Columbia Research Laboratories, Dept. ED, McDade Blvd. and Bullens Lane, Woodlyn, Pa. P&A: \$160 ea in quantities of 1 to 5; two weeks.

Signal Generator



With a 405- to 549.5-mc range, model BSG-9 signal generator displays generated frequencies in 5-digit direct readout form. It has continuous tuning across the frequency band. Accurate to $\pm 0.005\%$ the rf output signal can be modulated to ± 300 kc. Output power is variable over the range of 1.0 to 100,000 μ v.

Babcock Electronics Corp., Dept. ED, 1640 Monrovia Ave., Costa Mesa, Calif.

565

WHY PERMANENT MAGNETS ARE PERMANENT!

Study of Remanence by Indiana Steel Indicates 100% stability can be achieved

Truly permanent permanent magnets are now possible, according to scientists of Indiana Steel Products Division, Indiana General Corporation. Proof of 100% stability of remanence was gained during a special research project conducted by Indiana and supported by funds of the United States Air Force.*

Natural Stability

Materials having a high coercive force displayed the greatest natural stability. For example, a sample of non-oriented barium ferrite (INDOX I) with an H_{ci} of 4,000 oersteds was measured for natural stability over a period of more than 5,000 hours. Relative remanence was 100% $\pm 0.1\%$. An oriented sample of the same material (INDOX V) with an H_{ci} of 2,030 oersteds measured 99.5% $\pm 0.1\%$. The material having the lowest coercive force—ALNICO III—also exhibited the least natural stability, 97.04% $\pm 0.05\%$.

A second important factor affecting natural stability was length-to-diameter ratio (L/D). It was found that rods of ALNICO V, having a greater L/D ratio, proved more stable. For example,

rods with a ratio of 8.7:1 showed no detectable loss in remanence during a year. Rods with an L/D of 2.1:1 logged only 97.6% for the same period.

Where change in remanence was perceptible, it was found that it decreases linearly with the logarithm of time (see figure 2). This relation is expected to hold for all permanent magnets when they are undisturbed at room temperature and made of a material which does not change with time.

Test Conditions

During the study, sample magnets were kept in a special room where they were relatively free from such external demagnetizing influence as temperature variations, stray magnetic fields, short circuiting by iron contact and excessive movement or handling. Temperature was held virtually constant at $24^\circ \pm 2.5^\circ \text{C}$.

The sensitive measuring apparatus was also located in the test room. Developed in 1948 by Dr. Rudolph Tenzer of Indiana Steel, this equipment permits measurements to an over-all tolerance of better than 1 in 10,000.

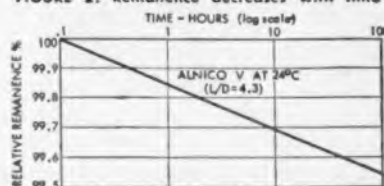
*Contract AF33 (616) — 3385 monitored by the Aero. Res. Lab., WADC.

FIGURE 1. Summary of Experimental Results

| Material | L/D | Remanence Bd kilogauss | Stability Relative Remanence at 24° C 5 log cycles (10,000 hr) after magnetization | Measuring Accuracy |
|------------|------|---------------------------|---|-----------------------|
| INDOX I | 0.9 | 1.4 | 100.0% | $\pm .1\%$ |
| INDOX V | 0.8 | 2.5 | 99.6 | $\pm .1$ |
| ALNICO III | 3.5 | 4.5 | 98.10 | $\pm .04$ |
| | 2.2 | 3.2 | 97.04 | $\pm .05$ |
| ALNICO VII | 3.5 | 4.9 | 99.32 | $\pm .04$ |
| | 2.2 | 3.9 | 98.96 | $\pm .06$ |
| ALNICO V | 8.0+ | 12.3 | 99.95 | $\pm .01$ |
| (long) | 5.8 | 11.9 | 99.81 | $\pm .02$ |
| (medium) | 4.3 | 10.4 | 99.23 | $\pm .02$ |
| (short) | 3.5 | 8.2 | 98.84 | $\pm .04$ |
| | 2.9 | 6.7 | 98.50 | $\pm .05$ |
| | 2.1 | 4.1 | 97.6* | $\pm .07$ |

*Extrapolated 1 to 2 log cycles beyond last measurement.

FIGURE 2. Remanence decreases with time



Artificial Stabilization

Critical space-age applications often require that a magnet be completely stabilized. Many methods for achieving this were surveyed. For critical applications, methods based on repetitive processes were found superior to those based on any sudden, one-time action. Two of these proved successful, both involving artificial reduction of remanence.

- 1. Temperature Knockdown.** ALNICO V magnets were repeatedly exposed to temperatures above and below the temperature of magnetization. Several cycles improved magnetic stability, while remanence was reduced somewhat as a result. Low temperature exposures, to -65°C , produced the greatest improvement in stability, as well as the greatest reduction in remanence.
- 2. Knockdown by Applied AC Field.** ALNICO V magnets were subjected to a cycling diminishing field, which also caused a reduction in remanence. Depending upon the material and its use, magnets were knocked down a predetermined amount between 5 and 15% to achieve complete stability. Variations in remanence were less than $\pm 0.03\%$, which is the limit of measuring accuracy for this size sample.

Conclusions

This study indicates that permanent magnets can be completely stabilized. A magnet, however, that is perfectly stable under these conditions can still be affected by larger temperature variations, stray magnetic fields, vibrations or many other factors. In the case of selected magnets, stability can be guaranteed for a flux change no greater than 0.01% per year.

For complete information on the practical aspects of "Stability," ask for a copy of *Applied Magnetism*, First Quarter, 1959. Write Dept. M-4.



INDIANA STEEL PRODUCTS

VALPARAISO, INDIANA

In Canada: The Indiana Steel Products Co. of Canada Limited, Kitchener, Ontario

INDIANA PERMANENT MAGNETS

CIRCLE 110 ON READER-SERVICE CARD



How can a plant get along with just one SERVOSCOPE®? Especially when everybody wants it at the same time?

Problems. SERVOSCOPE® servo system analyzer users have one major problem...trying to satisfy SERVOSCOPE "in plant" demand. On performance...no problem.

Engineering is complaining that the Design Lab has been hoarding the SERVOSCOPE all week... Production has had to throw together a couple of makeshift servo analysis rigs... and Assembly is counting more bottle-necks, all because... not enough SERVOSCOPIES.

It's hard to understand. Wherever you look, you see SERVOSCOPE. It's the standard. Day after day, this rapid all-in-one servo system analyzer proves how it conserves expensive design and engineering talent... not to mention savings in production time. *How, then, can a plant get along with too few SERVOSCOPIES?*

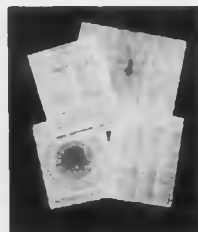
SERVOSCOPE's fast, direct setting and readout give high-accuracy results when you're measuring changes in phase, gain, and frequency response that occur when signals of various frequencies are fed to any servo. The SERVOSCOPE can be applied to new problems immediately without repeated calibration. For example, you can do:

- complete 5-minute analyses of any servo system—electronic, electrohydraulic, electromechanical, electro-pneumatic

- go — no-go production testing of control systems and components
- ready analyses of radar and other tracking systems—in the field, as easily as at the breadboard stage.

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Technical literature will also be sent you on request.

NEW PRODUCTS

Accelerometer

686



An ultraminiature sensing device, model 606-TX is designed for tri-axial use in shock and vibration testing of printed-circuit boards, electronic tubes and similar applications. Sensitivity is 2.0 mv per g; frequency response is flat from 0.5 cps to 8 kc within $\pm 5\%$. Resonant frequency is 50 kc.

Columbia Research Laboratories, Dept. ED, McDade Blvd. and Bullens Lane, Woodlyn, Pa. P&A: \$675 ea in quantities of 1 to 5; two weeks.

Light Flasher

563



Capable of switching 150 w through a long service life, the A-300-P static position light flasher is fully transistorized and potted. The device has automatic fail-safe, is explosion-proof, and resistant to contact with fuels. It fully meets specification MIL-F-26301.

Joseph Pollak Corp., Dept. ED, 81 Freeport St., Boston 22, Mass.

Rotary Indicators

679



Microminiature rotary indicators, designed to use 100 mw or less, are available for any standard voltage to 30 v dc or ac at 400 cps. The smallest model measures 0.375 in. in diameter x 0.562 in. long, and weighs 3.7 g. Temperature range is -65 to $+165$ F.

Daco Instrument Co., Dept. ED, Tillary and Prince Sts., Brooklyn 1, N.Y.

CIRCLE 112 ON READER-SERVICE CARD ➤

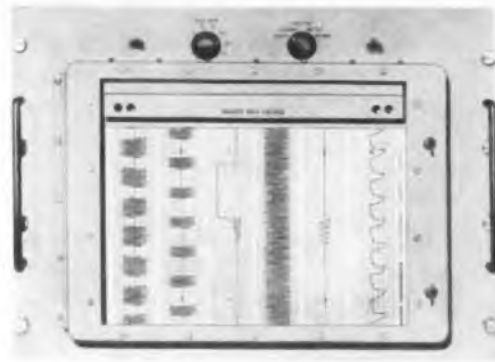
ELECTRONIC DESIGN • April 12, 1961



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Convert Your Counter to a 0.1% Digital Voltmeter...



Vidar 240 cabinet model shown in use with standard electronic frequency counter. Rack mounting also available.

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VIDAR 240 ALL SOLID STATE

VOLTAGE TO FREQUENCY CONVERTER

Vidar transistorized voltage-to-frequency converters develop output pulses at a rate precisely proportional to dc input voltages. Because these instruments combine solid-state reliability with good linearity and high stability, they offer the ideal method of converting any electronic frequency counter into an 0.1% digital voltmeter.

Convert Your Counter to a Precise Integrator

Output pulses generated over any given period of time are directly proportional to the time integral of the input signal. By combining a Vidar 240 with a counter, analog input signals can be accurately integrated. This capability is particularly valuable where a steady or slowly changing signal is contaminated by noise or hum. The average value can be accurately recovered from the noise with ease.

Convert Your Preset Counter to a Go No-Go Test System

A Vidar 240 plus a preset counter provides a convenient, reliable, and economical method of accomplishing production checkout and quality control testing of electrical or electronic equipment and systems.

Use Vidar Converters in Telemetry Systems

FM telemetry systems of 0.1% accuracy can be assembled using Vidar voltage-to-frequency and frequency-to-

voltage converters. For operation at center frequencies from 100 cps to several hundred kc, modified converters are available. Bandwidths to 25 kc can be provided with typical signal-to-noise ratios of 60 db.

In Fact Vidar solid state converters provide "state of the art" excellence wherever you want to interchange analog and digital signals.

KEY TECHNICAL FACTS ABOUT THE VIDAR 240

- Choice of 0-10 kc or 0-100 kc frequency outputs
- Automatic polarity indication
- Long term drift less than $\pm 0.1\%$ per week
- Full scale sensitivities from 0.1 v to 1000 v
- Priced at \$700; no extra charge for rack, cabinet or modular version.

Also Available - Vidar offers the Series 2500 analog to frequency converters for conversion of ac-dc voltages and resistance to frequency.

More Information - For complete technical information, a demonstration, or other data on the Vidar 240 or 2500, call your nearest Vidar engineering representative whose name and phone are listed below, or write directly to the factory.



2296 Mora Drive
Mt. View, California
Phone: YOrkshire 8-6561

VIDAR ENGINEERING REPRESENTATIVES

ALABAMA, Huntsville, S. S. Lee Associates, Inc., Jefferson 6-0631 • CALIFORNIA, Los Angeles (Beverly Hills), Moxon Electronics Corp., BRadshaw 2-9311 • CALIFORNIA, San Francisco (San Mateo), Moxon Electronics Corp., Fireside 5-7961 • CALIFORNIA, San Diego, Moxon Electronics Corp., HUDson 8-2901 • CONNECTICUT, Stratford, Instrument Dynamics, Inc., DRexel 8-0435 • FLORIDA, Orlando, S. S. Lee Associates, Inc., CHerry 1-4445 • ILLINOIS, Chicago, Pivan Engineering Company, KE 9-4838 • INDIANA, Indianapolis, Pivan Engineering Company, Victor 6-1532 • MASSACHUSETTS, Boston (Wakefield), Instrument Dynamics, Inc., CRystal 6-5100 • NEW JERSEY, Ridgewood, G. Curtis Engel & Assoc., Gilbert 4-1400 • NEW YORK, Syracuse, J. D. Ryerson Assoc., Gibson 6-1771 • NEW YORK, New York City and Long Island, G. Curtis Engel & Assoc., REctor 2-0001 • NORTH CAROLINA, Winston-Salem, S. S. Lee Associates, Inc., STate 8-0431 • OHIO, Dayton, Dayton Associates, BALdwin 3-9621 • PENNSYLVANIA, Philadelphia, G. Curtis Engel & Assoc., WALnut 2-3270 • TEXAS, Houston, Datronics • WASHINGTON, Seattle, Comtronics, MAIn 4-5135 • WASHINGTON, D.C. (Towson, Md.), S. S. Lee Associates, Inc., LÖckwood 5-3066

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Size 5 servomotor, model 9005-1502-0, is 0.865 in. in length and weighs 0.6 oz. Torque-at-stall registers 0.1 oz-in, and rotor inertia is 0.18 gm-cm², providing an acceleration-at-stall of 39,000 rad per sec². No load speed is 10,000 rpm. It is powered by 26-v, 400-cps reference voltage.

Beckman Instruments, Inc., Helipot Div., Dept. ED, 2500 Fullerton Road, Fullerton, Calif.

Transistor Enclosure

684



An all-glass enclosure for microtransistors, this unit consists of two parts, a case and a flat cover. Diameter is 150 mils and height, after sealing, is 60 mils; three coplanar, ribbon leads are an integral part of the case. A glaze, with low melting point, applied to the top rim of the case, allows a hermetic seal between case and cover. This eliminates the need for welding or soldering the final closure.

Corning Glass Works, Dept. ED, Corning, N.Y.
Availability: From stock in small quantities.

Circuit Boards

685



A molded, recessed circuit board, this unit has electro-plated conductors in recessed grooves and contoured holes to insure fool-proof, two-sided circuitry. They can be molded of any number of plastic materials, depending on required specifications.

Combined Electronics, Inc., Dept. ED, Cicero, Ill.



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Coats Lighter, More Effective Plastic Lens For Long Range Missile Control System

An exciting new application in the missile control field is the development by the Surface Armament Division at Sperry Gyroscope Company of a silver-coated plastic lens for use with the Navy's Talos missile. As compared to earlier metal versions, the new lens weighs substantially less and provides twice the signal gain at the same production cost! The Talos delivers, with extreme accuracy, a high explosive or nuclear warhead to any altitude at which airplanes now fly, as well as far beyond the range of human visibility.

The silver coat imparts RF reflectivity and electrical conductivity to the lens and is applied in paint form. As the silver base for this paint, Sperry uses Handy & Harman's Silver Flake. An important quality of this flake is that its waferlike particles are asymmetrical and overlap on the surface of the lens, affording up to 35% of the conductivity of an equivalent weight and shape of fine silver.

Handy & Harman Silver Flake finds use throughout the electronic and electrical industries...it is ideal for pig-

ments to make conductive coatings on such non-conductors as ceramics, glass, mica, plastic and paper, as in the manufacture of capacitors, thermistors, carbon resistors, printed circuitry and electrostatic shields.

Handy & Harman has available every form of silver useful to manufacturers and fabricators—flake, powder, paint, paste, sheet, strip, wire bimetals, silver oxide, divalent oxide, etc. Our Research and Engineering Department is always available to assist you in the selection or use of any silver form for any application from brazing to conduction coating. Below are listed six of our Technical Bulletins. Please indicate their numbers for prompt attention.

| | |
|--|--------------|
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CIRCLE 114 ON READER-SERVICE CARD

NEW PRODUCTS

Low-Shrinkage Tape 373

A regular skived, Teflon tape with controlled low-shrinkage, this tape will change no more than 2% in any dimension when heated at 730 F for 15 min. Tensile strength at 0.003 in. is 4,000 psi min and elongation 300% min. Dielectric strength is 2,700 v per mil min.

Dixon Corp., Dept. ED, Bristol, R.I.

Pulse Group Generator 355



A variety of pulse trains useful in testing computers and data-handling equipment is provided by type 5101 pulse group generator. Groups are generated at a repetition frequency variable from 1 to 10,000 groups per sec. Group length is adjustable between 20 μ sec and 0.2 sec; within each group, pulse rate is variable from 10 cps to 100 kc. Accuracy is $\pm 5\%$. A positive gate output is provided; provision is made for single-group operation.

Instrument Corp. of America, Dept. ED, 516 Glenwood Ave., Baltimore 12, Md.

Price & Availability: \$795; 1 month.

Tapped Delay Lines 370

Completely encapsulated in epoxy resin, model TDL-2197 tapped delay line is 4.5 x 1.04 x 0.50 in. in size. Specifications are: delay time, 3.4 μ sec $\pm 5\%$; characteristic impedance, 500 ohms $\pm 10\%$; input rise time, 0.1 μ sec; output rise time, 0.25 μ sec max; dielectric, 250 v dc; distortion, 10% max; attenuation, 1.0 db max.

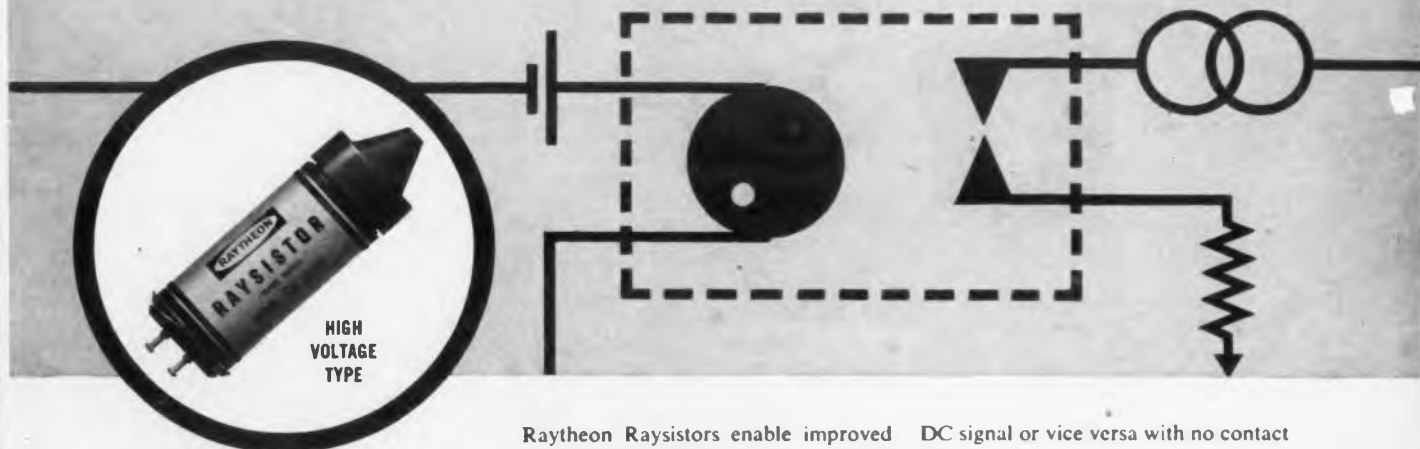
Dresser Electronics, HST Div., Dept. ED, Northridge, Calif.

Price: \$55.

CIRCLE 115 ON READER-SERVICE CARD

RAYTHEON RAYSISTORS*

offer outstanding advantages in 5 important applications



Raytheon Raysistors enable improved circuit designs for switching, controlling, chopping and commutating. This electro-optical device can turn signals on and off with virtual isolation from switching transients and carriers to provide high signal-to-noise ratio, wide dynamic range, and long life. Here are 5 applications in which Raysistors can be used for improved operation:

1. RELAY: In place of a relay or switch it can provide long life with no contact wear or pitting.

2. POTENTIOMETER: As a potentiometer it can control an AC circuit with a

DC signal or vice versa with no contact noise.

3. CHOPPER: Isolation of Raysistor elements assures low noise operation.

4. COMMUTATOR: Freedom from switching transients makes it ideal for low-level signal commutation.

5. HIGH VOLTAGE CONTROL: Signal to control insulation of up to 25,000 volts assures Raysistor's efficiency in controlling high voltage circuits.

For complete technical data and design assistance please write: Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Mass.

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TYPICAL RAYSISTOR OPERATING CHARACTERISTICS

| Control Terminals: | CK-1101 | CK-1102 | CK-1103 | CK-1104 | CK-1105 |
|---|-----------------|-------------------|-----------------|-----------------|-----------------|
| Control Type | Neon | Incandescent | Incandescent | Incandescent | Neon |
| Voltage Range (V DC or Peak) | 120 min | 0-1.1 | 0-5 | 0-24 | 120 min |
| Current Range (mA) | 0.5-3 | 0-55 | 0-180 | 0-40 | 0.5-3 |
| Signal Terminals | | | | | |
| On Resistance (ohms) | 600 | 350 | 40 | 70 | 500 |
| Off Resistance (ohms) | 5×10^7 | 1.5×10^7 | 1×10^7 | 1×10^7 | 4×10^7 |
| Power Dissipation (milliwatts max.) | 75 | 75 | 75 | 75 | 350 |
| Switch On Time (seconds) | .001 | .050 | .055 | .028 | .020 |
| Switch Off Time (seconds) | .070 | .015 | .300 | .130 | 10 |
| Max. Signal Voltage (V DC or Peak) | 60 | 60 | 60 | 60 | 60 |
| Shunt Capacitance (AC μ f) | 4.0 | 4.0 | 4.0 | 4.0 | — |
| Insulation, Signal from Control (Volts) | — | — | — | — | 25,000 |

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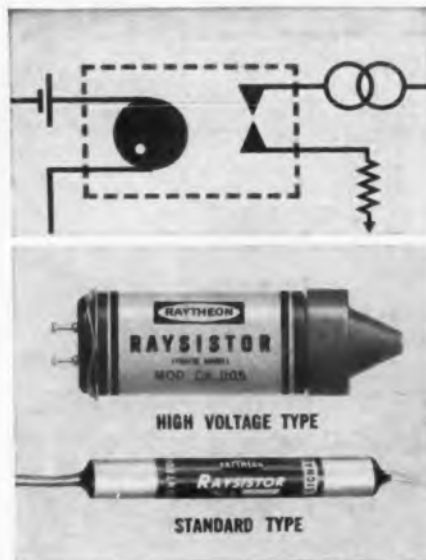
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CIRCLE 116 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961



Binary Counter

364



Counts of any length can be made by cascaded binary counter modules. Model 1231 counters have outputs available at each of four stages through front-panel jack connections. An equivalent printed-circuit board module is made.

Harvey-Wells Electronics, Inc., Dept. ED, 14 Huron Drive, Natick, Mass.

Price & Availability: \$197.50; delivery from stock.

Thin Film Tester

372

Programable pulse generator, type 2104, is for rapid analysis, testing and programing of thin-film and cryogenic devices. Capable of running at a clock frequency higher than 4 mc, at levels having 25 nsec rise times and 50 nsec widths, it will deliver four separate trains of both logical levels and pulses. Each of the eight output trains is separately programable into eight time zones.

Digital Equipment Corp., Dept. ED, Maynard, Mass.

DC Amplifier

356



A solid-state dc amplifier for use with dc torquers, model 579.35 has 100-w output. In a hermetically sealed can measuring 2-1/2 x 3-3/16 x 2-1/2, the unit can provide 65 db power gain between a dc driver stage and a torque motor. Output current waveform has magnitude and polarity proportional to input signal; amplifier null and gain are stable and independent of temperature.

Inland Motor Corp., Dept. ED, Northampton, Mass.

RAYTHEON

NEW PRODUCTS

Triaxial Accelerometer 629



Model 620 triaxial accelerometer is designed to provide high-level signals proportional to component accelerations along the mutually perpendicular axes. Specifications are: dynamic error bands, to $\pm 0.6\%$; resistance, from 1 to 10,000 ohms; cross axis acceleration error, 0.01 g per g max; size, 2 x 3 x 2-3/4 in.

Bournes, Inc., Dept. ED, 6135 Magnolia Ave., Riverside, Calif.

Flexible Curing Agents 371

Used to control flexibility, viscosity, and exotherm in epoxy resins, these curing agents are low-viscosity, almost colorless liquids. They are described as amine-terminated aliphatics with controlled and limited functionality.

Dow Chemical Co., Dept. ED, Midland, Mich.

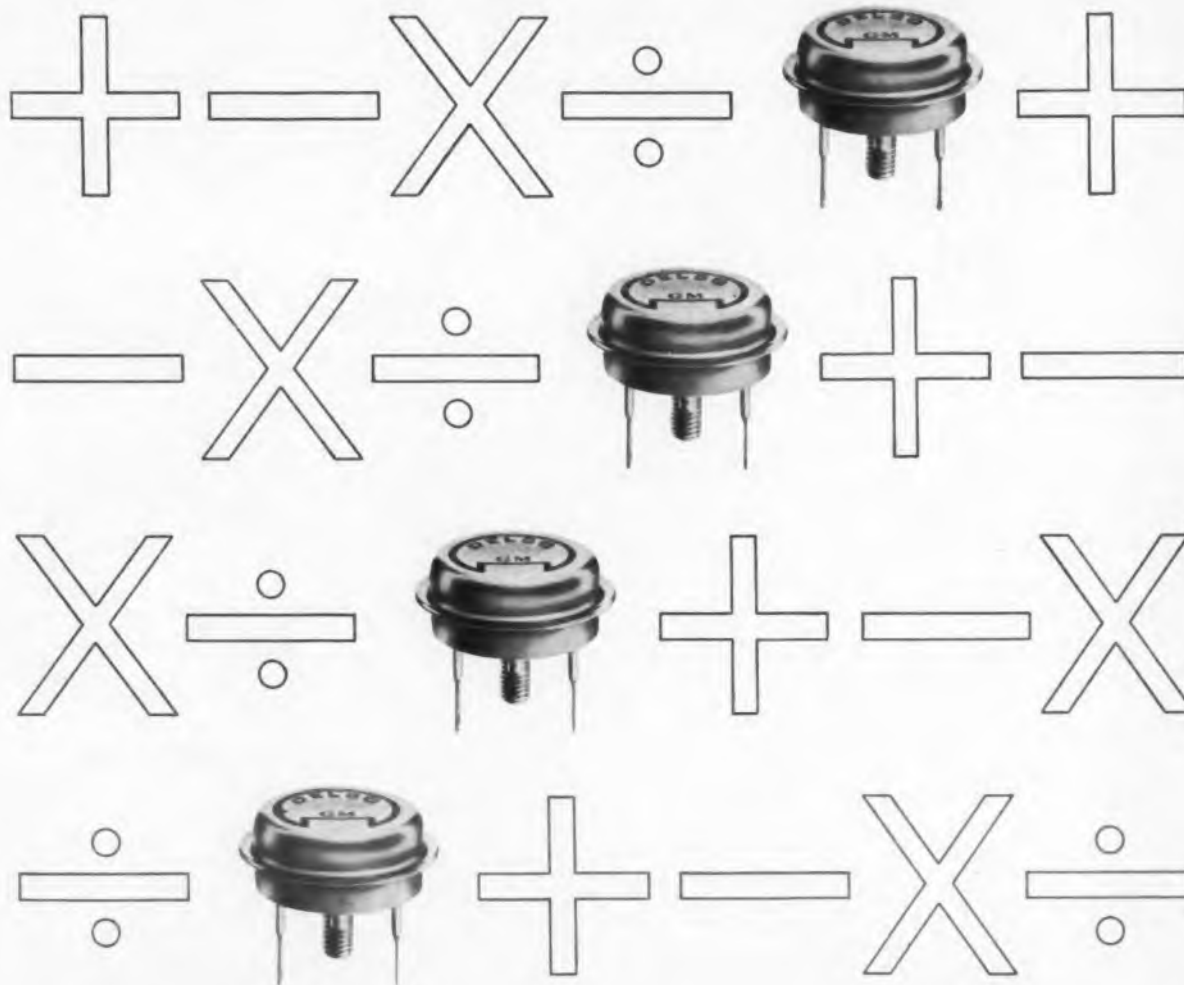
Price: X-3483.1, \$0.605 in drum quantities; X-3483.2 and X-3843.3, \$0.755 in drum quantities.

Elapsed-Time Indicator 366



Commercial elapsed-time indicator registers hours and tenths and minutes and tenths to 99999.9. Resettable and nonresettable models can be supplied with 3-1/2 in. diam round bezel or 3 x 3 in. square bezel. Terminals are screw type. Power is 120 or 240 v ac, 50 or 60 cps.

Haydon Div., General Time Corp., Dept. ED, Torrington, Conn.



DELCO POWER TRANSISTORS PROVED IN COMPUTERS by IBM, UNIVAC®, BURROUGHS, NATIONAL CASH REGISTER

Since Delco Radio produced its first power transistors over five years ago, no transistors have undergone a more intensive testing program to assure reliability—which accounts for their popular acceptance in hundreds of industrial and military uses. Before leaving our laboratories, Delco transistors must pass numerous electrical and environmental tests both before and after aging. This double testing, combined with five years of manufacturing refinements, enables us to mass produce any type of power transistors with consistent uniformity. And we can supply them to you quickly in any quantity at a low price. For complete information or technical assistance on our versatile application-proved family of transistors, just write or call our nearest sales office or distributor.

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Voltmeter

557



A range of 300 μ v to 300 v at frequencies from 10 cps to 11 mc can be measured with model 317 voltmeter. It is useful as a null detector from 5 cps to 30 mc. As a calibrated amplifier it provides a stable gain up to 60 db with a frequency response ± 1 db from 6 cps to 11 mc. Input impedance, with probe, is 10 meg shunted by 5 pf.

Ballantine Laboratories, Inc., Dept. ED, Boonton, N.J.

P&A: \$445 for model 317, \$50 for probe; March 1961.

Epoxy Laminate

616

Glass-fabric epoxy laminate is offered copper-surfaced as Di-Clad 614 or plain as Dilecto 614. Halving and edge-lifting are virtually eliminated in fabrication. Extinguishing time after removal from flame is zero and NEMA specifications for G-10 are met.

Continental-Diamond Fibre Corp., Dept. ED, Newark, Del.

Primary Battery

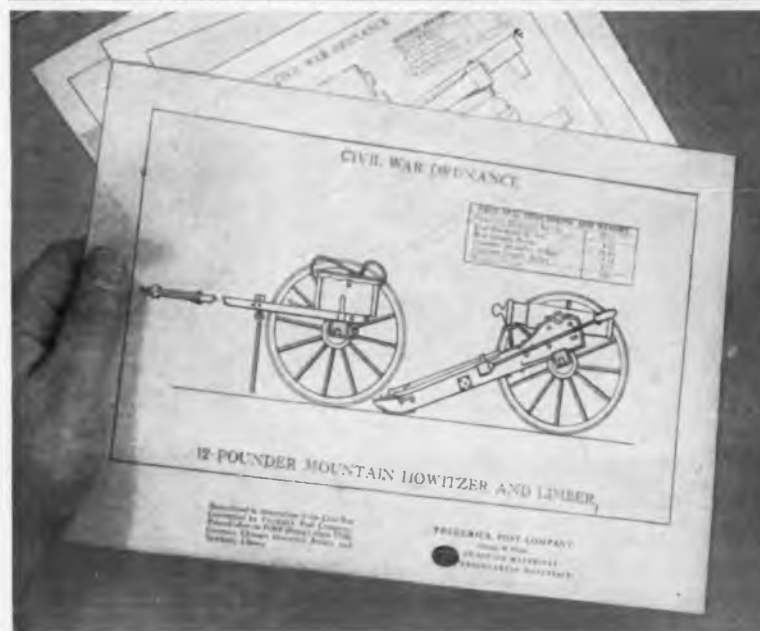
666



A silver-zinc primary battery, model 70, will activate itself within a maximum of 15 sec. Designed to provide power for long-distance transmission, the 28-v battery will discharge for 12 min with a load of 5 amp. Voltage is regulated to limit fluctuation to $\pm 5.4\%$ of the 5-amp load. Weight is 4.2 lb.

Electric Storage Battery Co., Dept. ED, P.O. Box 11301, Raleigh, N.C.

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Blutex is a blue-white sheet with excellent visual contrast. It maintains close to its original degree of light transmission after many trips through the copy machine. There is no appreciable yellowing or ageing after months or years of alternating storage and reprint use. Blutex has faster, more consistent print-back qualities than many sheets which appear more transparent originally.

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With whatever pencils you normally use, test the Blutex sample. Its dry, semi-smooth surface encourages graphite adhesion, outstanding line density. Post transparentizing resins

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Blutex base stock is milled for Post by one of the world's best-known makers of prestige papers; is processed to rigidly controlled quality standards. Blutex Vellum is highly resistant to fracturing; its surface minimizes dirt pick-up and smudging from in-file, out-file handling.

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For your personal, impartial analysis, we'll be glad to mail, without obligation, a 17" x 22" sample of Post Blutex Vellum, 175H, when requested on a business letterhead.

Bonus offer

First, fill in and return the appraisal form furnished with the Post Blutex sample. In appreciation, a handsome portfolio of four Civil War Centennial ordnance prints, on Post Blutex Vellum, suitable for framing, will be sent to you. Write Frederick Post Company, 3644 North Avondale Avenue, Chicago 18, Illinois.



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"Cu-C" plated thru-hole is actually an electro formed copper eyelet—absolute reliability in atomically bonded copper to copper thru hole connection. NOTE absence of undercut, hence elimination of entrapped etchants and other ionic contaminants.



"Cu-C" plated thru-hole offers high strength and continuity at foil to deposit interface. NOTE continuation of foil crystal structure into deposit.

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Division of Cinch Manufacturing Company, 200 So. Turnbull Canyon Road, City of Industry (Los Angeles) Calif.
Offices in 19 Principal Cities throughout United States listed under Cinch Mfg. Co. or United Carr Fastener Corp.

CIRCLE 120 ON READER-SERVICE CARD

NEW PRODUCTS

Power Supply

606



A multiple-output dc power supply, this unit is typical of militarized power supplies built to custom. The supply has outputs from +2.65 to -22 v at up to 20 amp.

Perkin Electronics Corp., Dept. ED, El Segundo, Calif.

Retaining Spring Clips

561



For socket-mounted transistors, these retaining spring clips comply with military requirements for retention of plug-in devices. Designated 3B-714-1 and 3B-714-2 they are designed for use with TO-5 and TO-9 cases. Material is beryllium copper with a silver plate finish.

The Bircher Corp., Industrial Div., Dept. ED, 745 S. Monterey Pass Road, Monterey Park, Calif.

Decade Counter

560



Transistorized decade counting unit, model BEC-10 will count pulse rates up to 20,000 pulses per sec. It has been designed for use in industrial counting applications where in-line visual readout is required. The unit will drive a number 47 incandescent bulb in the readout unit directly.

Binary Electronics Co., Dept. ED, Bldg. E, 824 E. Walnut Ave., Fullerton, Calif.

MINIATURE SNAP ACTION LOW COST Time Delay Relays

For commercial use, economical Curtiss-Wright thermal time delay relays, hermetically sealed in glass, are a compact and reliable design for many control, switching and timing applications. Precision built for high performance and long life. Ambient temperature compensated. Conservatively rated, these new rugged, small sized units are preset for time delays from 3 to 60 seconds.



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TIME DELAY RELAYS • DELAY LINES • ROTARY SOLENOIDS • DIGITAL MOTORS • TIMING DEVICES • DUAL RELAYS • SOLID STATE COMPONENTS

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Electronics Division
CURTISS-WRIGHT CORPORATION

East Paterson, New Jersey

CIRCLE 121 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

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Precision-built Curtiss-Wright thermal time delay relays reset instantly when de-energized—provide the same delay period for each succeeding cycle. Compensated for wide voltage variations. Available in either 28V DC or 115V AC, 60 or 400 cps. Chatter-free operation, under severe shock and vibration conditions. Small sized, hermetically sealed, temperature compensated for precise, reliable operation and long life. Preset time delays from 10 to 180 seconds with SPDT or DPDT snap action contacts.



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Electronics Division
CURTISS-WRIGHT CORPORATION
East Paterson, New Jersey

CIRCLE 122 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

Vibration Analyzer

570



Model 41 vibration signal analyzer and portable balancer uses modular construction and transistor circuitry. The unit is adaptable to any type of transducer, and measures amplitude from 5 μ in. to 0.1 in., peak to peak; frequency from 3 cps to 10 kc; and velocity from 50 μ in. per sec to 100 in. per sec. Accuracy is $\pm 2\%$. A continuously variable frequency filter system is provided. The set operates on 110 v ac or an internal battery pack.

RayData Corp., Dept. R2, Dept. ED, 1078 E. Granville Road, Columbus 24, Ohio.
P&A: \$2,000; 30-day delivery.

Solid-State Multiplexer

619

For data acquisition and computing systems, the model EM-3 multiplexer can switch from 4 to 64 channels. Settling time is 20 μ sec; 64 channels are scanned in 50 μ sec. Input and output limits are ± 10 v with no inversion; the unit will drive a stable load impedance of 25 K or greater. Internal noise is less than 1 mv. Supply is 115 v $\pm 10\%$, 60 cps.

Packard Bell Computer Corp., Dept. ED, 1905 Armacost Ave., Los Angeles 25, Calif.

DC Power Supplies

569



Outputs from 0.2 to 0.5 amp at up to 32 v are provided by the 170 series of dc power supplies. Three configurations are available: bench model with calibrated voltage control, plug-in version with octal plug and screw-driver adjustments, and a terminal-strip version with screw-driver voltage adjustment. Regulation of all models is better than 3 mv, line or load; ripple is less than 250 μ v rms. Case size of models 170 and 172 is 3 x 4 x 5 in., of models 171 and 173 is 3-1/2 x 5 x 5-1/2 in.

Quan-Tech Laboratories, Inc., Dept. ED, 60 Parsippany Blvd., Boonton, N.J.
Price: \$98 to \$129.



actual size

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The Bristol Syncroverter chopper has a long history as a component in U.S. guided missiles. It's the ideal miniature electromechanical chopper for use in d-c analog computers or wherever utmost reliability is required.

BILLIONS OF OPERATIONS have been completed without a failure on Bristol's continuing life tests—aimed at improving the Syncroverter's already superlative characteristics. Just one sample: A group of five choppers, with 400 cps drive and 12v, 1 ma resistive contact load have been going for more than 26,000 hours without failure. That's more than 2.96 years continuous operation or more than 37 billion complete cycles!

No matter what your chopper requirements, we're sure you can find the model you need among the wide selection of Syncroverter choppers and high-speed relays available... including low-noise, external coil types. For complete data, write: The Bristol Company, Aircraft Equipment Division, 150 Bristol Road, Waterbury 20, Conn.

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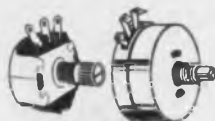
No job is too tough
for Mallory

4



4 WATTS

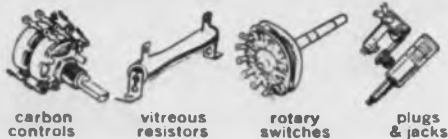
wire-wound controls



Take the 4-watt Type M control, for instance. Can't be beat for long life and dependability. It's constructed to take severe shock and vibration and still maintain positive contact. "Off" position for rheostat type eliminates need for separate switch.

Whatever you need in wire-wound controls, Mallory has it . . . 2 watts, 4 watts, 7 watts . . . in a big assortment of resistance values, tapers, shafts, mounting arrangements and tandem constructions. We build specials, too, to your specifications. Mallory Controls Company, Frankfort, Indiana.

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carbon controls vitreous resistors rotary switches plugs & jacks

CIRCLE 124 ON READER-SERVICE CARD

NEW PRODUCTS

Component Connectors

595



Insulated feed-through and stand-off component connectors offer high tie-point density. Height above board is 0.25 in.; OD is 0.190 in. Sockets accepting wires of 0.010 to 0.022 in. are spaced equally on a 0.120-in. circle. The devices allow simple insertion and changing of circuits and components.

Omega Precision, Inc., Dept. ED, 757 N. Coney Ave., Azusa, Calif.

Carrier Demodulator

600



Used with variable reluctance transducers, the model CD10 provides a dc output signal for recording and control in dc systems. Operating on 95 to 125 v, 60 cps, output is 1 ma into a 1-K load. Ambient temperature range is -65 to +165 F.

Pace Engineering Co., Dept. ED, 13035 Saticoy St., North Hollywood, Calif.

Cam Assemblies

598



For precision timing applications, these adjustable cam assemblies feature positive locking at any predetermined operational setting, within a range of 0 to 180 deg. Machined from No. 303 stainless steel, with clear passivated finish, they are stocked in 0.1248, 0.1873 and 0.2498 in. bore sizes, in pin or clamp hub styles.

PIC Design Corp., Dept. ED, 477 Atlantic Ave., East Rockaway, L.I., N.Y.

Price & Availability: \$45 to \$75; 10 days.



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CIRCLE 125 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

Power Transistors 583

Rated at 40 w, npn silicon mesa transistors 2N1768 and 2N1769 have an offset pedestal-and-stud mounting arrangement for positive heat-sink contact. The units are designed for use in dc-to-dc converters, inverters, choppers, voltage and current regulation, dc and servo amplifiers, and relay-actuation circuits. Saturation resistance is 1 ohm; thermal resistance is low. Temperature range is -65 to 200 C.

Radio Corp. of America, Semiconductor and Materials Div., Dept. ED, Somerville, N.J.

10-Turn Potentiometer 625



With an infinite-resolution film element, model 5010 potentiometer is available in resistances from 5 K to 500 K. Specifications are: mechanical rotation, 3,600 deg; temperature range, -55 to +150 C; power rating, 2 w to 75 C derated to 0 at 150 C; linearity, 0.05%. Life rating is 10 million revolutions per minute.

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

Germanium Transistor 574

With a maximum switching time of 110 nsec, type 2N781, an epitaxial mesa transistor, has a turn-on time of 60 nsec max and a turn-off time of 50 nsec max. Storage time has been reduced to 20 nsec max; saturation voltage is -0.16 v max. Absolute maximum ratings at 25 C are: collector-to-base voltage, -15 v; collector-to-emitter voltage, -15 v; collector current, 100 ma; power dissipation, free air, 150 mw.

Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

P&A: \$11.72 ea, 1 to 99; through distributors.

Advertisement

TEMPERATURE TRANSDUCER 760



Small probe-type device for high and low temperature applications where high pressures and severe flow conditions are imposed. Precise liquid or gaseous measurements to 800°F. Tiny sensing element of deposited platinum film allows high base resistance, extreme linearity, wide range capability, and fast response. Approved for ICBM environments.

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California.

WELDABLE STRAIN GAGE 761

Weldable-to-aluminum strain gage, less than 1-3/16" long by 1/4" wide, is capable of continuous operation at 700°F. Precise, rugged device consists of etched wire filament in swaged stainless steel tube, mounted on a special alloy welding flange. Installation is fast and permanent with stored energy welding equipment—no complicated bonding or curing processes necessary.

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California.

AIRBORN DC AMPLIFIER 762

Solid state, direct-coupled, hermetically sealed instrument is less than 5 cu. in. in volume; weighs only 6 oz. DC gain is 200 to 1000 ±5 V into not less than 20K (single ended).

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California.

CIRCLE 763 ON READER-SERVICE CARD ►

VHF-UHF TRANSMITTERS



Proved in history's most demanding environmental laboratory—outer space—the custom designed unit shown above is typical of the development skill and production capability available from Microdot. The unit shown in miniaturized, pressurized, and features a solid state power supply that cannot be damaged by input/output overloads. Units are available in a complete range of modulation—CW, FM, Phase, and Pulse, with frequency coverage 100 to 5000 mc/s and output from 100 mw to 10 watts.

Telemetry Capabilities at Microdot have been dramatically expanded with the recent acquisition of Spectralab Instrument Company. The highly regarded development skill, production capability, and working experience of Spectralab in the field of VHF and UHF cavities and related instrumentation is available from Microdot's Instrumentation Division. This equipment, outstanding in its attention to miniaturization and ruggedness, is a vital part of such important projects as Pioneer V, Jupiter, Atlas, Pershing, Redstone and Echo I.

UHF Telemetry Transmitters, Models 2406 and 2409, use a unique, automatically stabilized circuit, with the output frequency referenced directly to a quartz crystal. This approach allows a greatly reduced size compared to the multiplier chain conventionally required to achieve crystal stability, as well as increased reliability due to a fewer number of parts.

The transmitters have their own solid state power supply designed to provide a high ratio of rf output power to total power input. The frequency modulation circuitry is sufficiently linear to introduce completely negligible distortion to the modulation signal. For further information, Call Microdot or write for catalog sheet TT-1.

SPECIFICATIONS

| | |
|------------------------|-----------------------|
| Frequency Range | |
| Model 2406 | 2200-2300 mc/s |
| Model 2409 | 1435-1535 mc/s |
| Frequency Stability: | ± 0.001% |
| Power Output | 10 watts |
| Power Output Stability | 1 db |
| Modulation | PCM/FM, PAM/FM, FM/FM |
| Input Voltage | 28 vdc |
| Temperature Range | -40°C to +70°C |
| Vibration: | 10 g, 5-2000 cps |
| Size | 3 1/2" x 7 1/2" x 11" |
| Weight | 12 pounds |

MICRODOT INC.

220 Pasadena Avenue, South Pasadena, Calif.
Murray 2 3351 SYcamore 9-9171





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NEW PRODUCTS

Display Storage Tube

552



Capable of high-speed, selective erasure, the Multi-Mode Tonotron storage tube has a simultaneous display of stored and nonstored information. Information may be written stored or nonstored or rapidly and selectively erased. The tube display has high-resolution light and dark trace displays. Displays are maintained at full brightness until erasure. Erasing takes place while the new trace is being written.

Hughes Aircraft Co., Dept. ED, Florence Ave. and Teale St., Culver City, Calif.

Tantalum Powder

621

Fabrication and performance of electrolytic capacitors is improved with SGP tantalum powder. The material is said to enable pellets to be pressed to lower green densities, lowering dissipation and increasing capacitance per gram. A low-capacitance powder, type SGL, is also in production.

National Research Corp., Dept. ED, 70 Memorial Drive, Cambridge 42, Mass.

Transistor Cards

688



An all-purpose card for transistors, E-Z Circuit cards are designed for the breadboarding of semiconductor circuits. A wide variety of analog and digital circuits may be developed by inserting active and passive components. The card will hold eight transistor circuits. It measures 4-1/2 x 6-1/2 in. with a standard 28-contact connector along one side.

Circuit Structures Laboratory, Dept. ED, P.O. Box 1194, Santa Ana, Calif.

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This 28-page brochure includes dimensional drawings, rating charts, wiring diagrams, and photos of different types and models of Bodine Instrument Motors. Special sections discuss (1) the availability of engineering service, (2) development and testing procedures, (3) typical applications, (4) application guidance, and (5) motors for special instrument applications.

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ELECTRONIC DESIGN • April 12, 1961

Power Supply

608



Outputs of plus and minus 15 v dc are provided at 200 ma by the 6033 power supply. The solid-state unit operates from 115 v ac; regulation against line and load variation is under 0.01%; ripple is less than 1/2 mv. Short-circuit overload protection is built in. The supply is available in bench and plug-in configurations.

George A. Philbrick Researches, Inc., Dept. ED, 127 Clarendon St., Boston 16, Mass.

Price & Availability: About \$285; delivery from stock.

Pin Terminals

613

Designed for printed circuit use, pin terminals Nos. 2970 and 2971 have lengths of 0.3 and 0.15 in. respectively. The pins are machined of brass and finished in with hard gold over silver plate. They are for any 0.040 socket.

Cambridge Thermionic Corp., Dept ED, 45 Concord Ave., Cambridge 38, Mass.

P&A: \$19.53 per thousand in quantities of 5 thousand; from stock.

Induction Heater

572



Constricted areas are easily reached by the model L6H-P induction heating machine. Suitable for brazing, soldering and heat-treating jobs, coil is mounted on a pistol-grip handle. The 2-1/2-kw generator has ac and dc overload circuit breakers and a timer. The flexible rf power cable is 10 ft long, with water-cooled conductors.

Reeve Electronics, Inc., Dept. ED, 609 W. Lake St., Chicago 6, Ill.

Price: \$2,200.



Typical MEMCOR synchro: Size 11 with servo type mounting; Overall length—1.6 in. approx., excluding shaft; Weight—2 3/4 oz.; Input—26 volts, 400 cps, .4 watts; Output—11.8 volts.

Memcor Synchros and Synchro Indicator Packages

If your project calls for economical and accurate indication of position, pressure, flow or other synchro-transmitted information, MEMCOR has or can design a synchro or synchro-operated indicator package for the job. MEMCOR synchros are available in various mounting configurations for incorporation into packages or systems to be servo driven or for use as indicating devices. The same basic component may be supplied for use as either a transmitter, a receiver, or both.

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Filters just recently considered as "state of the art" are now a *production* reality. In addition to its many stock narrow band filters, Midland offers prototype and production quantities of practical Miniature Wide Band Filters in the .5 to 30 mc range. These filters are of exceptional quality.

Shown below are specifications for ten of our stock wide band filters, as well as actual characteristic response curves. These filters are actually being delivered to major weapons system manufacturers in quantities — to specification.

They are essentially free from unwanted spurious modes which have previously limited the realization of many types of wide band filters. Small quantities for engineering evaluation are available *immediately* from stock. Consultation is available at any time to potential filter users.

THESE ARE NOT LABORATORY CURIOSITIES OR IN PROTOTYPE DEVELOPMENT STAGE

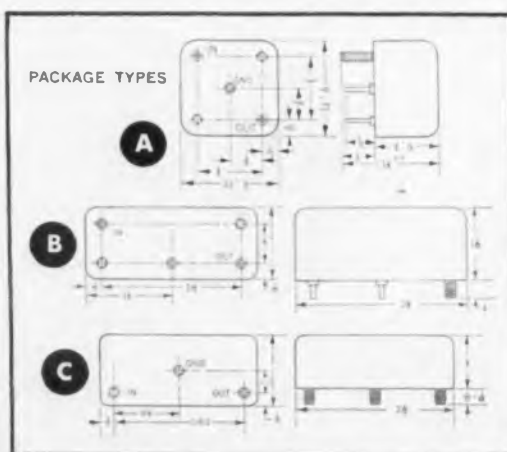
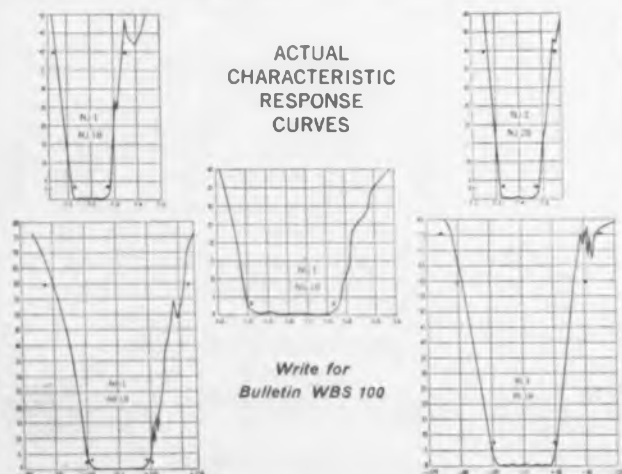
| Type | Center Freq. | 3db Bandwidth Minimum | 40db Bandwidth Max. | 60db Bandwidth Max. | 75db Bandwidth Max. | Ultimate Discrim. Minimum | Insertion Loss Max. | Impedance ohms | Inband Ripple Max. | Package Type |
|-------|--------------|-----------------------|---------------------|---------------------|---------------------|---------------------------|---------------------|----------------|--------------------|--------------|
| NJ-1 | 7.2MC | 160KC | 300KC | | | 60db | 6db | 13K | 1db | A |
| NJ-1B | 7.2MC | 160KC | 300KC | | | 60db | 6db | 13K | .5db | B |
| NJ-2 | 7.4MC | 160KC | 300KC | | | 60db | 6db | 13K | 1db | A |
| NJ-2B | 7.4MC | 160KC | 300KC | | | 60db | 6db | 13K | .5db | B |
| NG-1 | 5.09MC | 160KC | 350KC | | | 60db | 6db | 20K | 1db | A |
| NG-1B | 5.09MC | 160KC | 350KC | | | 60db | 6db | 20K | 1db | B |
| NB-1 | 10.7MC | 200KC | | 450KC | | 75db | 12db | 50 | 1db | A |
| NB-1B | 10.7MC | 200KC | | 450KC | | 85db | 8db | 50 | .5db | B |
| RL-1 | 11.5MC | 80KC | | 160KC | 200KC | 85db | 6db | 50 | .5db | C |
| RL-1B | 11.5MC | 80KC | | 160KC | 200KC | 90db | 5db | 50 | .5db | B |

Operating Temp.: -55°C to +90°C

Shock: 100g

Vibration: 15g to 2KC

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MID 1-61

136

NEW PRODUCTS

Sub-Carrier Oscillator

601



Up to 12 variable inductance transducers may be operated with the model CT10 telemetering subcarrier oscillator system. Any of the IRIG bands 4 through 18 or A through E may be used. Operating voltages range from 6 to 50 v dc at 48 ma. The 2-lb unit is 3 x 3 x 3-3/4 in. It will withstand shock and acceleration of 200 g, any axis, and vibration of 35 g, 50 to 2,000 cps.

Pace Engineering Co., Dept. ED, 13035 Saticoy St., North Hollywood, Calif.

Transistor Amplifier

612

Four-stage transistor amplifier, model TA-12-B, has a gain of 73 db at 1 kc. Nominal input impedance is 2,500 ohms; frequency response is ± 5 db from 300 to 20,000 cps. Power is supplied by a 1.34-v mercury cell. Size is 0.531 in. in diam x 0.228 in. high.

Globe-Union Inc., Centralab Div., Dept. ED, 900 E. Keeffe Ave., Milwaukee 1, Wis.

Power Tetrode

605



A 65-w power tetrode, PL-4-65A is suitable for use as an rf power amplifier and oscillator and as an af power amplifier and modulator. Small size and quick-heating filament make it useful in mobile equipment. It can be operated up to 150 mc.

Penta Laboratories, Inc., Dept. ED, Santa Barbara, Calif.

Don't forget to mail your renewal form to continue receiving **ELECTRONIC DESIGN**.

ELECTRONIC DESIGN • April 12, 1961

DC Motor

596



A single package houses motor, gear train, governor and noise filter in this 1-1/4 in. permanent magnet or reversible motor. Built to meet MIL-M-8609 (ASG) requirements, the unit operates over an ambient temperature range from -65 to +200 F, producing 1/75 hp from 22 to 31 v dc. Current is 0.85 amp max, speed 18,500 rpm at 26 v.

Omega Precision, Inc., Electro-Actuators Div., Dept. ED, 757 N. Coney Ave., Azusa, Calif.
Availability: 4 to 6 weeks.

Transistor Tester

609



In-circuit measurement of ac beta parameter is provided by the 219B transistor tester. Scales for beta are 1 to 4, 3 to 12, 10 to 40, and 30 to 120. There are also two collector current scales of 0 to 50 and 500 μ a.

Sierra Electronic Corp. Div. of Philco Corp., Dept. ED, 3885 Bohannon Drive, Menlo Park, Calif.

P&A: Under \$300 ea; Feb. 1961.

Tape Reader

597



Chopped reflected light and ac-coupled amplifiers are used for stability in the model PTR-7 photoelectric tape reader. Speeds of 10, 30, 75 and 100 in. per sec may be selected, with up to 1,000 characters per sec reading rate. Stop to full speed requires 3 msec; tape stops in less than 1 msec. Output voltage level is 12 v negative. Complete controls are provided. The rack-mounted reader has a panel 5-1/4 in. high.

Omnitronics, Inc., Dept. ED, 511 N. Broad St., Philadelphia 23, Pa.

stitching together a giant radome



Radome designed and built by Long Sault Woodcraft Limited, St. Andrews East, Quebec, for the United States Air Force RADC.



Looking upward from the inside of the world's largest stressed skin sandwich radome built of translucent fiberglass panels, securely joined by hundreds of DUAL-LOCK fasteners.

Radar antennae along the upper perimeter of North America's defense system are enclosed by protective domes which stop ice, snow, and gales up to 150 mph.

This precisely engineered pattern of fiberglass panels is erected quickly and surely, under the most adverse field conditions, using recessed Simmons DUAL-LOCK fasteners.

DUAL-LOCK is ideally adapted to panel fastening for military shelters, demountable shipping containers, aircraft cowlings and guided missiles.

Features:

- High load characteristics. The standard No. 1 DUAL-LOCK withstands 2500-lb. tension, and with modifications, tension loads of 7000 lbs. and over.
- Double-acting take-up provides great closing pressure, with minimum pressure on operating tool.

- Positive-locking. Trigger action insures fully open and fully closed positions.
- Vibration-proof and impact-proof. Will not accidentally unlock or loosen.

Write for catalog #1257. Complete specifications, drawings, details of DUAL-LOCK and other Simmons Fasteners with unlimited money-saving applications.



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FREQUENCIES 60-1000 CPS

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DECODE



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STEVENS INCORPORATED ARNOLD

QUALITY SINCE 1943

7 ELKINS ST., SOUTH BOSTON 27, MASS.

S/A - 2836

CIRCLE 134 ON READER-SERVICE CARD

NEW PRODUCTS

Module Tester

602



Dynamic and dc test of digital modules is done with model MT1 module tester. The maker's 200 kc, 3 mc, and PB 250 modules are tested for parameters including input amplitude, duration, rise time, and repetition rate plus output resistive and capacitive load. The unit is self-testing.

Packard Bell Computer Corp., Dept. ED, 1905 Armacost Ave., Los Angeles 25, Calif.

Price & Availability: \$1,950; 60-day delivery.

Coaxial Attenuators

551



For use from dc to 1 Gc, series AF type 2 fixed coaxial attenuators have a vswr of 1.10 max over their frequency range. They are bidirectional and unaffected by temperature or humidity changes. Specifications are: frequency range, dc to 1 Gc; attenuation, 1 to 40 db; power handling, 1-w, cw, 1-kw, peak; impedance, 50 ohms nominal; vswr, 1.10 max.

Maury and Associates, Dept. ED, 10373 Mills Ave., Montclair, Calif.

P&A: \$55 to \$75; 2 to 4 weeks.

Cabling Tape

618

Laminated aluminum foil and glass cloth are combined with a pressure-sensitive silicone adhesive in 6100 heat-reflective tape. Type 6101 is similar but nonadhesive. Type 4716 is a Mylar tape 1.2 mils thick, used to protect underwater cable. It has high dielectric strength, heat resistance, low moisture-vapor permeability and good elongation.

Permacel, Dept. ED, New Brunswick, N. J.

Don't miss an issue of ELECTRONIC DESIGN; Return your renewal card.

4¢

Kodak
INDUSTRY

photo resist encyclopedia



This 24-page book on the Kodak Photo Resist way to etch dependable circuits tells the whole story about using a simple 6-step KPR routine. Each step is explained so even beginners will catch on fast. The book costs you nothing—only the 4¢ postage on your letter—a tiny investment that could pay the handsome return of more circuits that pass inspection. The 6 KPR steps:

1. Clean the metal. Power brush does it fast.
2. Rinse in acid. A quick way to assure total KPR adhesion.
3. Coat the plate. Dip, whirl, or spray. Stable KPR won't change exposure time even after months of storage, so coating can be done ahead of time.
4. Expose to high-intensity arcs. Always short exposures with KPR, no matter what the temperature, humidity, or storage.
5. Develop. Do it fastest in vapor-spray degreasers. Or in tank or tray.
6. Etch with standard techniques. KPR guards the circuit image in component assembly, strips off clean when panel is skated on tin-lead solder.

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4-252
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ELECTRONIC DESIGN • April 12, 1961



ONLY AO TRACEMASTER OFFERS CONVENIENCE OF TILT-OUT WRITING TABLE!

Only the AO Tracemaster offers this convenient, tilt-out writing table. Smooth, positive linkage lets you tilt the exposed section of the chart out to a just-right 50° angle. An automatic braking device on the paper take-up mechanism maintains taut, wrinkle-free chart surface across the table.

You can tilt the table and measure the record or write on the chart while the Tracemaster is recording... you don't interrupt the trace or interfere with the amplitude of the record in any way. When you're finished, simply snap the table back flush with the front of the cabinet... paper take-up mechanism automatically rolls up loose chart paper.

This extra convenience is another of the plus benefits offered by the AO Tracemaster... the World's newest and finest 8-channel direct writing recorder. Get the complete Tracemaster story in detail. Colorful, 32 page Brochure is yours for the asking. Write for your copy today!

American Optical Company
Instrument Division • Buffalo 15, New York

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ELECTRONIC DESIGN • April 12, 1961

Wirewound Potentiometer

642



Power rating of 12-1/2 w at 40 C ambient temperature is accomplished with special insulating materials in the MG wirewound control. Housed in 4-w case size, the control is derated to 0 w at 300 C. It is used in ground-support and aircraft applications.

P. R. Mallory & Co. Inc., Mallory Controls Co. Div., Dept. ED, Frankfort, Ind.

Power Supplies

644



From 50 kv to 120 kv in the 2-kw average power range is provided by a line of high-voltage power supplies. External polarity reversal is controlled by a lucite jack housed under an easily accessible cover. There are five models, all measuring 30 x 30 in. base x 4-1/2 ft high.

Manson Laboratories, Inc., Dept. ED, Stamford, Conn.

Remote Modulator

643



Remote-control monitoring can be done with this modulator at distances up to 1,000 ft. It can also be used as an integral unit. The modulator provides continuous tuning of a magnetron, and permits work from a tower.

Manson Laboratories, Inc., Dept. ED, Stamford, Conn.



NE-83
ACTUAL
SIZE

NEW G-E GLOW LAMP (NE-83) EFFECTIVELY HANDLES CURRENTS UP TO 10 m.a.

Here's a General Electric Glow Lamp that operates at currents many times higher than most glow lamps. At 10 milliamperes, the NE-83 will hold its breakdown and maintaining voltage within five volts of initial for an average life of 500 hours. At lower currents life increases exponentially.

Although this product is too new for us to establish voltage regulation specifications, it shows considerable promise for this application in the 1 to 10 milliamperere range.

Leads of the NE-83 are plated for easier soldering. It contains a mild radioactive additive to reduce breakdown voltage in darkness.

DIRECT CURRENT SPECIFICATIONS

| | |
|---|--------------------|
| Breakdown Voltage | 60-100 volts d-c |
| Maintaining Voltage at 10.0 m.a. | avg. 65 volts d-c* |
| Design Current | 10.0 m.a. d-c |
| Life (at 10 m.a. d-c for an average change of 5 volts in breakdown and maintaining voltage) | 500 hours |

*Average after 100 hours burning at rated current. Individual lots may vary from average.

There's a General Electric Glow Lamp to suit every circuitry need. For the latest information on Glow Lamps as Circuit Components and Indicators, write for 4-page Bulletin #3-0193. General Electric Co., Miniature Lamp Dept. NE-83, Nela Park, Cleveland 12, Ohio.

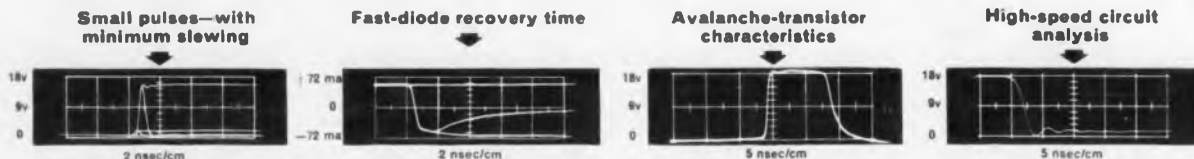
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GENERAL  ELECTRIC

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for clear display of:

Single-Shot Nuclear Events/Transistor Switching/Fast Diode Turn-on/Radio-Frequency Waveforms/Tunnel-Diode Switching



Outstanding trigger capability is illustrated by this multiple-exposure photograph which demonstrates the Type 519 triggered internally by various wave shapes—including one small amplitude signal having 0.3-nsec duration.

Switching and storage times in fast diodes can be measured easily by the Type 519. In this multiple-exposure, diode-recovery-time waveform, the upper trace is 150 ma reference, the middle trace shows the diode turn-off, and the lower trace shows the diode shorted.

A Type 2N430 transistor in avalanche generates the pulse shown. This output pulse is available from the Rate Generator on the Type 519 at 50 ohms impedance—with the repetition rate variable from 3 cycles to 30 kilocycles.

The Type 519 Oscilloscope is an invaluable tool for testing active or passive wideband circuits. In this wideband amplifier waveform, little or no correction is necessary for the inherent risetime of the oscilloscope.

NEW KMC OSCILLOSCOPE TEKTRONIX TYPE 519



... for recording high-speed one-shot occurrences



NOW, you can see and record non-repetitive, high-speed phenomena with a standard oscilloscope—one that does not depend upon sampling techniques. On its distributed-deflection CRT, you can observe bright displays with 100-line-per-centimeter definition. You can photograph fractional-nano-second signals with ease on its full 2 x 6 centimeter display area.

You will find the Type 519 engineered for convenience . . .

Internally—all circuit components of the complete unit fit compactly, yet are readily accessible for easy maintenance. A fixed signal-delay line plus variable sweep-delay control maintains the wide display passband and eliminates any need for adjusting delay-cable lengths.

Externally—the Type 519 features a minimum of controls and connectors for an instrument in this range. A carefully-coordinated front-panel layout facilitates your test setups and procedures and aids greatly in saving engineering time and effort.

You need no auxiliary equipment for many high-speed applications. In fact, for normal operation, you make two connections only: (1) you plug-in the power cord, (2) you couple-in the signal source.

With such operational ease—combined with its inherent Tektronix reliability—the Type 519 is an ideal laboratory oscilloscope for your high-speed measurements up to the KMC region and slightly beyond—especially those applications demanding a photographic record of one-shot occurrences.

CHARACTERISTICS

Passband—from dc, 3 db point typically above 1 KMC. **Instrument Rise-time**—less than 0.35 nanosecond (including trigger takeoff, delay line, CRT, and termination). **Synchronization**—200 mv peak-to-peak, 1 MC to 1 KMC. **Accelerating Potential**—24 kilovolts. **Sensitivity**—10 volts/centimeter, maximum, into 125 ohms. **Time Base**—linear 6-centimeter sweeps from 2 nanoseconds/centimeter to 1 microsecond/centimeter in 9 steps. **Sweep Delay**—through 35 nanoseconds. **Triggering**—jitter-free: **External**—3-microwatt (20-millivolt) pulse of 1-nanosecond duration. **Internal**—2-trace-width pulse of 1-nanosecond duration. Signal waveform undisturbed by trigger takeoff. **Power and High-Voltage Supplies**—electronically regulated. **Calibration-Step Generator. Avalanche-Transistor Rate Generator.**

Tektronix, Inc.

P. O. Box 500 • Beaverton, Oregon

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TEKTRONIX ENGINEERING REPRESENTATIVES: Hawthorne Electronics, Portland, Oregon • Seattle, Washington. Tektronix is represented in twenty overseas countries by qualified engineering organizations. In Europe please write Tektronix Inc., Victoria Ave., St. Sampsons, Guernsey C.I., for the address of the Tektronix Representative in your country.

CIRCLE 138 ON READER-SERVICE CARD

NEW PRODUCTS

DC-to-DC Converter

656



Output of 1 kv dc at 25 μ a is furnished by this dc-to-dc converter. A transistor blocking oscillator type, primary input is 3 v dc at 20 ma. It is supplied in hermetically sealed MIL-T-27A can or in open frame configuration. An epoxy-molded construction with pins or lugs is made on order.

Microtran Co., Inc., Dept. ED, 145 E. Mineola Ave., Valley Stream, N. Y.

P&A: \$3.70 to \$7.90 ea, 100 units; stock.

Circuit Modules

647



Designed for reliable operation in missile uses, a line of 20 modules includes multivibrators, Schmitt triggers, inverters, emitter followers, reset amplifiers, amplifiers, logic gates, etc. Modules occupy less than 0.09 cu in., weigh less than 1/10 oz. Operating temperature range is -55 to $+125$ C. The series F units withstand 20-g vibration from 47 cps to 5 kc.

Marshall Laboratories, Dept. ED, 2008 W. Carson St., Torrance, Calif.

Summing Amplifier

651



Fully transistorized model 1010 booster summing amplifier can drive a size 11, 400-cps resolver or several computing potentiometers. Up to five inputs may be summed; gain is unity $\pm 0.005\%$. Phase shift is less than 5 min. Input impedance is 1 meg, signal level 30 v. The amplifier is encapsulated and sealed.

Melcor Electronics Corp., Dept. ED, 48 Toledo St., South Farmingdale, L. I., N. Y.

Differential Amplifier

648



Solid-state airborne dc amplifier, designed for severe environments, occupies 4.75 cu in. The direct-coupled, differential input amplifier has equivalent input drift of less than 100 μ v for 8 hr. Input is 5 mv differential; gain is 200 to 1,000 \pm 0.75%. Output is \pm 5 v into not less than 20 K. Linearity is \pm 0.25%; gain variation is \pm 1% to 10 kc, 3 db down at 50 kc. Temperature range is -55 to $+100$ C, vibration 20 g to 2 kc.

Microdot Inc., Dept. ED, 220 Pasadena Ave., South Pasadena, Calif.

Silicon Diodes

654



No encapsulation is required for these silicon diodes, which measure 0.075 max x 0.030 max in. Rectifier types have ratings to 1 kv piv; computer diodes are rated to 2 nsec recovery time, 2 pf capacitance. A fast-recovery type and a general purpose diode are also made. Features include storage at temperatures to 300 C, thermal shock resistance over operating range of -65 to $+200$ C with no delay in transfer, and 300 mw dissipation.

MicroSemiconductor Corp., Dept. ED, 11250 Playa Court, Culver City, Calif.

Silicon Rectifier

640

Rated at 600 v maximum piv, type T rectifiers can be used at up to 420 v rms in resistive and inductive circuits, and up to 215 v rms on capacitive loads. It is rated at 750 ma continuous at 50 C ambient temperature, 500 ma at 85 C. Leakage current is 250 μ a max.

P. R. Mallory & Co. Inc., Mallory Semiconductor Co. Div., Dept. ED, Du Quoin, Ill.

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ELECTRONIC DESIGN • April 12, 1961

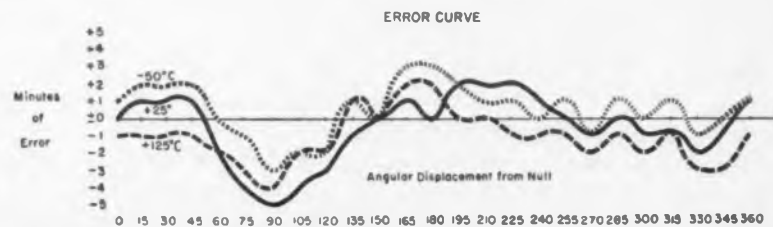


This SYNCHRO offers temperature stability plus lightness

This Size 8 Daystrom Transicoil synchro provides temperature stability without increasing weight.

The encapsulated stator windings permit these units to be operated under severe environmental conditions. And, of greatest importance, in random sampling of Daystrom Transicoil Size 8 synchros, error shift from room temperature has not exceeded 2 minutes over the entire temperature range of -55 C to $+125$ C.

Daystrom Transicoil Size 8 "temperature stable" units are



available as transmitters, differentials, control transformers and resolvers. Standard accuracy is \pm 7 minutes, but 5-minute units are also available on special order.

Data sheets and prints on the "temperature stable" Size 8 synchro are available on request. And remember, too, Daystrom

Transicoil makes a complete line of precision rotating components.

Foreign: Daystrom International Division, 100 Empire St., Newark 12, New Jersey. In Canada: Daystrom Ltd., 840 Caledonia Road, Toronto 19, Ontario. Mid-West: Daystrom Incorporated, 905 W. Hillgrove Avenue, La Grange, Illinois.

DAYSTROM, INCORPORATED

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From the day this plant started it has been shaped by the needs of customers like you. And so you find under one roof at Synthane your complete answer in laminated plastics—sheets, rods, tubes, molded-laminated, molded-macerated and fabricated parts. Synthane has all the facilities necessary for designing and producing tools, dies, jigs and fixtures for fabrication, a mine of information on the proper methods for machining laminated plastics. Versatility from one source. One high quality. One responsibility.

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Synthane Corporation, 42 River Rd., Oaks, Pa.

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Please send me information relating to Synthane as a source for laminated plastic materials and parts.

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NEW PRODUCTS

Crystal Filters

658



Wide band-pass crystal filters in the range of 0.5 to 30 mc have fractional bandwidths of 0.7 to 6.5%. Center frequencies of types NJ-1 and NJ-2 are held within 3 kc of a design center of 7.2 and 7.4 mc respectively, and 3-db bandwidths are held between 160 and 168 kc. The 40-db bandwidths are less than 300 kc. Package size is less than 1 cu in.

Midland Manufacturing Co., Dept. ED, Kansas City, Kan.

Frame-Grid Tubes

571



High transconductance and low noise are features of five miniature frame-grid tubes. Applications include use in rf amplifiers, if amplifiers, driver stages, cathode followers and cathode amplifiers. The tubes and their transconductances are the 6939, a double tetrode with 10,500 μ mhos per section; 6688, pentode, 16,500 μ mhos; 6922, twin diode, 12,500 μ mhos per section; 5842, triode, 25,000 μ mhos; and 5847, pentode, 13,000 μ mhos.

Raytheon Co., Industrial Components Div., Dept. ED, 55 Chapel St., Newton 58, Mass.

Price: \$2.95 to \$7.90.

Cooling Fluid

622

Low viscosity allows pumping of Coolanol 35 at temperatures down to -85 F. The fluid is thermally stable at 400 F. Dielectric strength at 25 C is rated at 47 kv; viscosity at -65 F is less than 950 centistokes.

Monsanto Chemical Co., Dept. ED, 800 N. Lindbergh Blvd., St. Louis 66, Mo.

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So fine a motor, all mating surfaces are machined—not die-cut—for closest possible tolerance! Assures uniformity of air gap for minimum cogging, uniform output. For communications, hospital, dental, metering and hydraulic pump equipment, computers and other applications.

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SPEED:
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Shunt or Compound—12,000 RPM
Full Load: Series—3,000 to 10,000 RPM
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Here Are the Facts

Di-Formed Tubes feature a special patented Precision Paper Tube construction which produces a completely ridgeless surface, thus eliminating wire pile up and resultant coil shorts.

Side walls are straightened under pressure during the winding operation. The bow being thus controlled permits a perfect fit between mandril and tube as provided by Precision's low-cost Related Mandril Service.

Under the Related Mandril Service, Precision supplies the coil manufacturer with accurately ground steel or aluminum mandrils at a price comparable to commonly used unsatisfactory wood or undersized steel mandrils. *This is not a profit-making service.* Its sole purpose is to give the coil manufacturer these advantages:

1. Provide proper tube support.
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3. Prevent coil collapse.
4. Save machine and operator fatigue.
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**SOLENOID VALVES OF
TEFLON*
FOR ETCHING, CLEANING!**



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Valcor's solenoid valves of Teflon are perfect for any process that requires **absolute freedom from contamination!** The molded body and diaphragm of Teflon is chemically inert and corrosion-resistant to virtually every medium. Valcor solenoid valves outlast and outperform steel! Available in a variety of sizes and pressure ratings... immediate delivery. Write today for free 16-page booklet telling how to select solenoid valves for over 500 corrosive media!



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CIRCLE 144 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

Power Supplies

657



Transistorized power supplies are designed for incorporation into customer equipment. Outputs range from 12 v dc, 4 amp, to 40 v dc, 1.5 amp. Output is completely floating. Line and load regulation is 0.05%; ripple is less than 1 mv rms. Overshoot is less than 1%, recovery time less than 50 μ sec. Gold anodized, extruded aluminum case measures 4-1/16 x 6-9/16 x 6-15/16 in. Octal plug and mounting studs facilitate installation.

Mid-Eastern Electronics, Inc., Dept. ED, 32 Commerce St., Springfield, N. J.

Price & Availability: \$149 ea; delivery from stock.

Gallium Arsenide

639

Single-crystal GaAs, in doped and undoped form, is available with carrier concentrations ranging from 10^{16} carriers per cc to degenerate levels. Doping tolerance is $\pm 50\%$; dopants are zinc, tin and tellurium. Ingots to 90 g and 1 in. diam have been made. Polycrystalline material is also available.

Merck & Co., Inc., Dept. ED, Rahway, N. J.

Price: \$8 to \$25 per g.

Ceramic Capacitors

667



Ultraminiature ceramic capacitors offer lower dissipation factors and improved temperature coefficient curves. The EA 12C capacitor is available in values from 39 pf to 560 pf; the EA 16C is in values of 680 through 1,200 pf. Miniature size in the 12-C line measures 0.098-in. in diameter x 0.250 length.

Electramics Corp., Dept. ED, Solana Beach, Calif.

Price: \$0.55 to \$1.12 ea depending on quantity.

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AT 6 FEET?**



ACTUAL SIZE

*Get "Giant Size" Readability
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TIME INDICATOR **MODEL 1440**

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- MEETS REQUIREMENTS OF Mil-M-26550

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BOWMAR INSTRUMENT CORPORATION
8000 Bluffton Rd., Fort Wayne, Ind.

FOR CONTROL OF THE FUTURE
CIRCLE 145 ON READER-SERVICE CARD



NEW Hi-G 4PDT microminiature relay

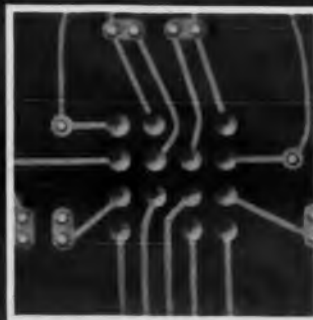
First 4-pole microminiature relay incorporating a balanced armature and featuring a pin arrangement readily adaptable to printed circuit applications. This new relay also features improved sensitivity per pole as compared with two 2-pole microminiature relays.

Type: Type 4B Microminiature
Size: .800" x .800" x .875" max.
Contacts: 4PDT dry circuit to 2 amps resistive
Dielectric Strength: 1000 VRMS at Sea Level
Insulation Resistance: 1000 megohms min.

Optional Terminals: Long or short leads for printed circuit application or hook type for standard wiring. Bracket, studs or straps also available for mounting.

Construction: Balanced armature construction, proven the best approach available for resistance to extremes of vibration and shock, exceeding all present military specifications.

Environmental Characteristics: To meet all military relay specifications for components of this size.



Printed Circuit
Features



Diagram



Printed Circuit Courtesy of The Sibley Co.



SM TYPES

SL TYPES

S & R TYPES

MICRO-MINIATURE B SERIES

Hi-G INC.

BRADLEY FIELD, WINDSOR LOCKS, CONN.



THE ONLY COMPLETE LINE OF BALANCED ROTARY RELAYS

CIRCLE 146 ON READER-SERVICE CARD

NEW PRODUCTS

AC Panel Meters

660



Iron vane ac voltmeters, ammeters and milliammeters are available in Medalist and standard cases. Ranges are 1 to 800 v, 1 to 800 amp, and 10 to 800 ma. Moving iron vane mechanisms feature magnetic damping, impregnated field coils, and selected fixed and moving iron material for reliable operation. Cases are phenolic.

Precision Meter Div., Minneapolis-Honeywell, Dept. ED, Grenier Field, Manchester, N. H.

Data Communications System

638

Simultaneous data processing and communication with other computers is enabled by the H-880 and H-480 data communications control units. Data are transmitted over long-distance networks at the rate of 150 characters per sec. Provision for automatic verification and error correction is included.

Minneapolis-Honeywell Regulator Co., Dept. ED, 2747 Fourth Ave. S., Minneapolis 8, Minn.
Availability: 12 to 18 months.

Lighted Push-Button

659



With single or two-color indication, the 302PB1-T switch measures 0.812 x 0.890 x 1.303 in. Switch is rated at 7 amp resistive and 25 amp inrush, 24 v dc; 7 amp resistive and 15 amp inrush at 115 or 230 v ac. There are five colors for display screen. Lamps are easily replaced.

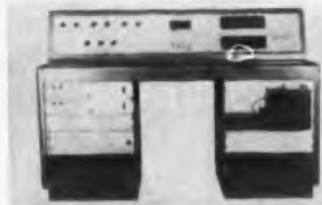
Minneapolis-Honeywell, Micro Switch Div., Dept. ED, Freeport, Ill.
Price & Availability: \$16 to \$13.85; stock.

This is the time of our annual subscription renewal; Return your card to us.

ELECTRONIC DESIGN • April 12, 1961

Data System

662



Automatic digital data acquisition and recording system performs digital recording of analog values at rates up to 10 four-character points per sec. Digital output is five-level punched paper tape suitable for printout or punched card conversion. Rotary switches provide for initial entry of fixed data.

Monitor Systems, Inc., Dept. 6, Dept. ED, Fort Washington Industrial Park, Fort Washington, Pa.

Low-Frequency Adapter

554



Ultrasonic inspection down to 200 kc is possible when this low-frequency adapter is used with standard pulse-echo ultrasonic equipment. Materials previously opaque to ultrasound can be penetrated. Over 24 in. of cast Iconel X has been successfully inspected with the use of this adapter.

Automation Industries, Inc., Dept. ED, 3613 Aviation Blvd., Manhattan Beach, Calif.

Fork Contacts

652



Printed circuit fork contacts of the 400 series have radiused contacting surfaces for smooth mating. Made from spring-tempered phosphor bronze, the gold-plated contacts come in upright, parallel and 45-deg styles.

Methods Manufacturing Corp., Dept. ED, 7447 W. Wilson Ave., Chicago 3, Ill.

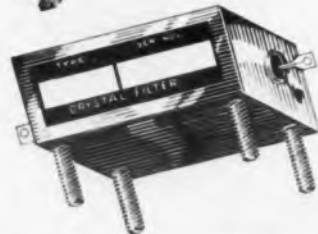
McCoy

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type, or frequency
any crystal
bearing the name

McCoy

can be relied upon to
deliver the ultimate
in frequency control
despite wide temperature
variations and
extreme conditions
of shock
and vibration.



New!

MICRO MODULE CRYSTALS—GLASS

.28" square x .075" thick
frequency range: 7000 kc to 200 mc
Now available in limited quantities



M-1 (HC-6/U)

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shown actual size

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M-20 (HC-18/U)

M-21 (HC-18/U w/pins)

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G-1 (Military HC-27/U)

ALL GLASS STANDARD SIZE AND MINIATURE CRYSTAL UNITS

shown actual size

This vacuum sealed, hard glass crystal unit possesses all of the quality features for which the McCoy M-1 is so famous. It has long term frequency stability five times better than the conventional metal types. Available in frequencies from 500 kc to 200 mc.



G-20 (Military HC-26/U)

G-21 (Military HC-29/U)

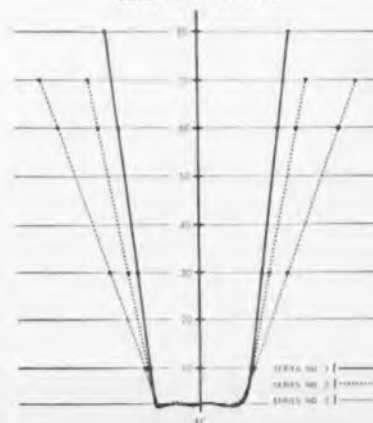
This vacuum sealed, hard glass crystal unit meets the new CR-73/U and CR-74/U specifications. It has long term frequency stability five times better than the conventional metal type. Available in frequencies from 5000 kc to 200 mc.

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655



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Micro State Electronics Corp., Dept. ED, 152 Floral Ave., Murray Hill, N. J.

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637

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Mitronics, Inc., Dept. ED, 1290 Central Ave., Hillside, N. J.

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641



Solid-state static relay model SR1A-1 is designed for airborne and missile applications. Relay controls up to 4 amp at 115 v, 400 cps; turn-on time is 100 usec max with a signal voltage of 5 to 28 v dc. The 0.4-lb unit measures 2 x 2 x 1-1/2 in. and meets requirements of MIL-E-5272B.

Magnetic Controls Co., Dept. ED, 6405 Cambridge St., Minneapolis 28, Minn.

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Miniature Filter

567



Occupying 0.25 cu in. the 75F series filter has the same electrical characteristics as larger units. Low-pass telemetering channels 1 through 18 and band-pass telemetering channels 8 through 18 are covered. Packaging is nonmagnetic metal, epoxy-potted.

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

Wirewound Trimmer

646



High-temperature trimmer 50-M48 is designed to meet requirements of MIL-R-27208. Temperature range of the sealed, wirewound potentiometer is -55 to $+200$ C; temperature coefficient is $\pm 0.005\%$ per deg C. Standard resistance values of the 1-w unit range from 25 ohms to 10 K. Hermetically sealed, it withstands moisture and salt spray. Vibration range is 10 to 2,000 cps, shock 50 g.

Maurey Instrument Corp., Dept. ED, 7917 S. Exchange Ave., Chicago 17, Ill.

Coaxial Connectors

649



Screw-type coaxial connectors in more than 100 standard types are available in 50-, 70- and 93-ohm impedances. Made in conformity to military specifications, they are universally interchangeable, shock and vibration resistant. Standard configurations are straight plugs, angle plugs, receptacles, bulkhead jacks and jacks. Minimum voltage breakdown test is 1.5 kv ac.

Electro-Physics Laboratories, Dept. ED, 1900 Walker Ave., Monrovia, Calif.

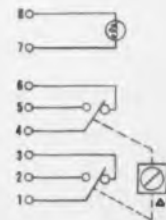


BUILT IN LEAD-LAG ZEROING ADJUSTMENT ELDEMA 6BR SWITCHLITE (DPDT)

A simple precision adjustment is provided within the 6BR to permit setting the DPDT snap-action switch to engage and disengage both poles simultaneously. Adjustment is made from the front of the panel and may be changed by simply snapping off the lens and resetting with a screwdriver. OPERATING LIFE: The 6BR

meets all pertinent mil specs — is guaranteed for 25,000 cycles at 28 VDC — 7 amps resistive. COLOR CODE AND STYLE FLEXIBILITY: The 6BR switchlite is available with standard round or square lens shapes that provide front and side illumination, in all standard colors. Where product styling requires a uniform surface color, translucent or milk white lens accessories may be used in combination with colored lamp caps underneath to provide color coding only when circuits are energized. Legends and symbols can be provided on the switch lenses if desired. ILLUMINATION is provided through a separate circuit utilizing standard two-pin, plug-in incandescent lamp assemblies. Lamp range is from 5 to 28 VDC. OPTIONAL SERIES RESISTORS potted with the lamp assembly provide practically infinite service life by limiting both surge current and operating current drain. The 6BR switchlite has been designed to meet the critical phasing requirements of systems employing interrelated circuitry where power load and time factors bear a vital relationship to system performance.

SPECIFICATION SHEETS covering all electrical and mechanical characteristics, plus scale drawings, available on request.



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Union City, N. J. • Union 4-9577

William Connors • 103 Adams St.
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NEW PRODUCTS

Commutative Scanning System

682



Sequential monitoring of up to 40 channels is possible with model 540 commutative scanning system. Self-contained in a cabinet 48-5/8 in. high, the system consists of a scanner control unit, a zero and gain unit, a digital voltmeter and a printer.

Crescent Engineering and Research Co., Dept. ED, 5440 N. Peck Road, El Monte, Calif.

Controller Panels

590

Proportional power controller panels use magnetic amplifier and silicon-controlled rectifier circuitry to deliver 400, 1,200, and 4,000 w ac or dc to basic loads. The six units have high gain, low time delay, adjustable bias and gain control, multiple control windings, linear amplification, and standard input-output voltages. Supply is 115 v ac; output is 85 v dc or 95 v ac.

Norbatrol Electronics Corp., Dept. ED, 356 Collins Ave., Pittsburgh 6, Pa.

Delay Lines

566



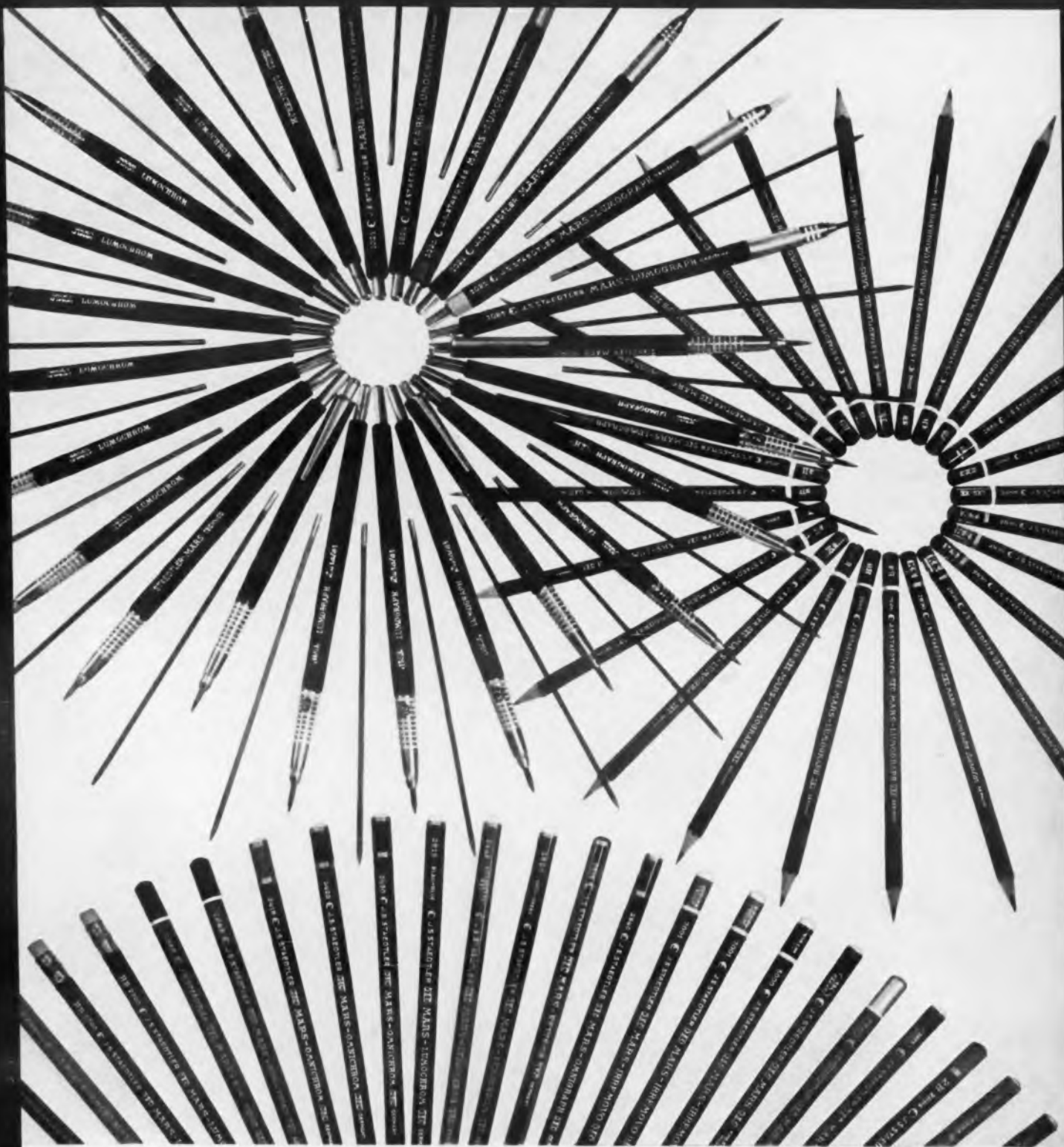
Delays up to 5,000 μ sec, with adjustment of ± 5 μ sec, are provided by the model 2370 magnetostrictive delay line. Temperature coefficient is 20 ppm per deg C standard, 4 ppm on request. Range is -55 to $+70$ C. Insertion loss is about 60 db; signal-to-noise ratio is better than 10:1. Carrier frequency is 250 kc to 1 mc. Transistorized drive and output circuitry can be supplied as integral part of package.

Power-Tronic Systems, Inc., Dept. ED, Pine Court, New Rochelle, N.Y.

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Large fabricated special structure (shaker table shield), approx. 60" dia. and 57" high.



Composite photo demonstrating that magnetic shielding qualities of NETIC alloy material are not affected by vibration, shock, (including dropping), etc.



DigiBits, a series of digital logic packages, has a conservatively rated operating frequency of 10 kc (20 kc input frequency). They can be used over a 30- to 120-F temperature range. Packages available include flip-flops, diode "AND" and "OR" gates, rc gates and emitter followers.

Tech Serv, Inc., Dept. ED, 4911 College Ave., College Park, Md.

Ultrasonic Cleaner

384



Miniature parts and optics can be cleaned with lightweight, portable model US-100 ultrasonic cleaner. Useful in fast removal of solder flux, grinding and polishing compounds, oil, and other contaminants, unit accommodates parts up to 1-1/2 in. square. Transducer is magnetostrictive type.

Union Ultra-Sonics Corp., Dept. ED, Quincy, Mass.

Arbitrary Function Generator

401



Low frequency function generator, model 5846, can reproduce most arbitrary waveforms to requirements in addition to low frequency sine and triangle waveforms. Specifications are: frequency range, 0.001 to 10 cps in four ranges; accuracy, $\pm 3\%$ of set frequency; output voltage, 20 v peak-to-peak; hum, 45 db down from signal level.

Tensor Electric Development Co., Inc., Dept. ED, 1873 Eastern Parkway, Brooklyn 33, N.Y.

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Tests that can be performed with the new Model 720 include:

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- Marginal tests to evaluate logic modules under conditions of lowered or raised supply levels in combination with lowered or raised signal input levels.
- Complete tests of conversion matrices for proper logic, levels.

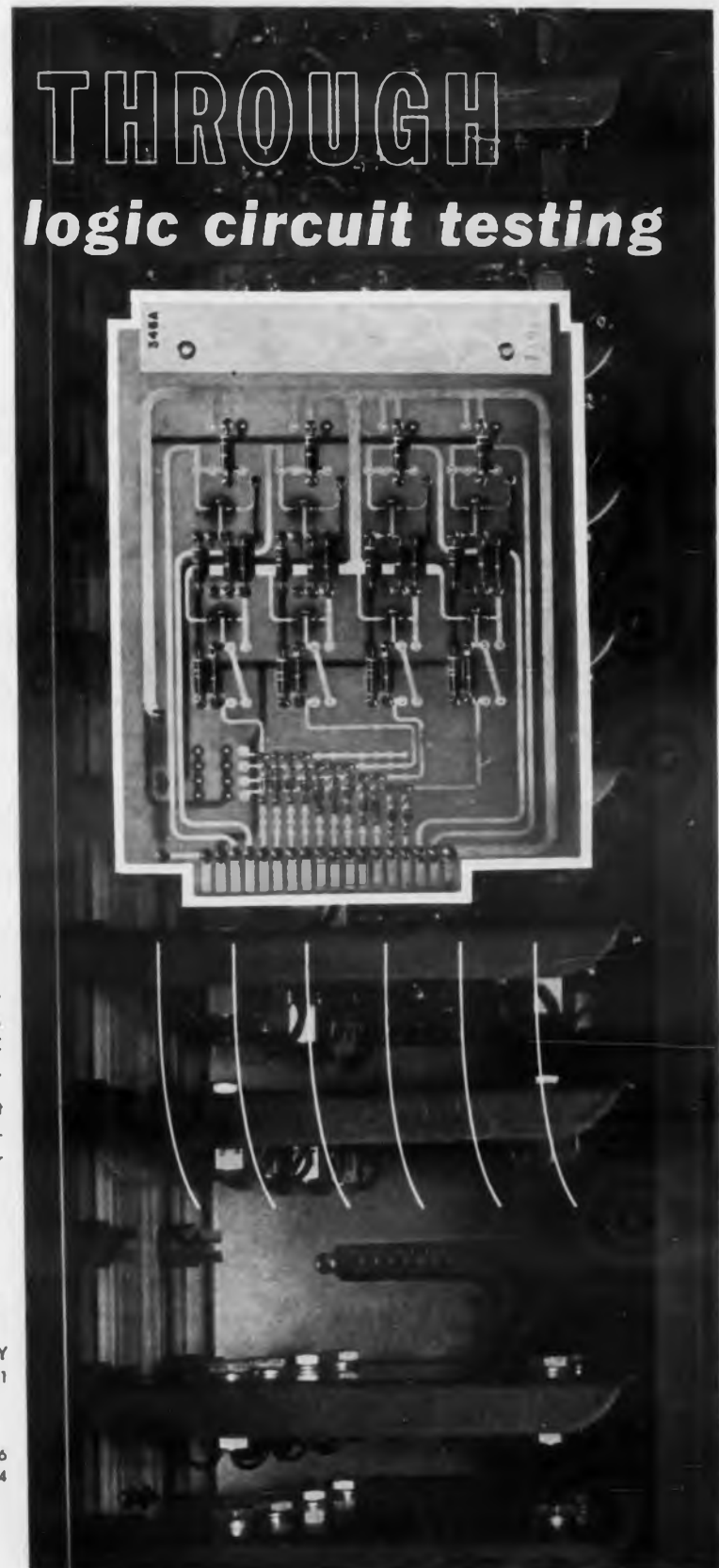
The Tape Programmed DIT-MCO Model 720 will accurately test variables which are required to maintain $\pm 0.5\%$ accuracy, and 3 digit tolerance values can be programmed. Provision is made for programming AC or DC sources and external signals through the tester.

Performance of this entirely new circuit analyzer is backed by the experience and reliability of DIT-MCO, Inc.—the nation's leader in automatic circuit testing.

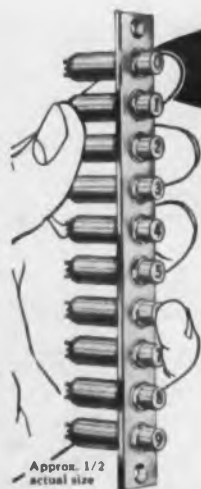


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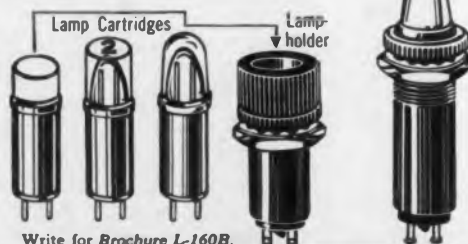


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NEW PRODUCTS

Miniature Tap Switch

404



Molded, miniature tap switch, type 3A, is available with as many as eight decks; up to 12 positions per deck, single pole and six positions double pole; and adjustable stops if a lower number of steps is required. The basic unit is 1-1/4 in. in diameter and weighs 30 g. It has a rating of 1,200 v rms, 2,000 v dc, 5 amp, carrying. Insulating resistance is 100 meg min at 500 v dc.

Tech Laboratories, Inc., Dept. ED, Bergen and Edsel Blvds., Palisades Park, N.J.

Environmental Chamber

393



Walk-in style environmental chamber model WF-2100-125+300H provides temperatures from -125 F to +300 F and relative humidity from 20 to 95%. Usable inside space is 15 x 20 x 7 ft high. Thermal capacity is 56,000 BTU; air stratification is less than 1 deg. Interior is stainless steel, with frost-free viewing windows.

Webber Manufacturing Co., Inc., Dept. ED, P. O. Box 217, Indianapolis, Ind.

Pickup Coil

392



Electromagnetic pickup coil MA-3G has an integral transistor amplifier. Designed for use with turbine flow sensors, it can also be used as a magnetic motion pickup in tachometer applications. It is useful for impedance matching, and in applications where long transmission distances exist between pickup and readout.

Waugh Engineering Co., Dept. ED, 7842 Burnet Ave., Van Nuys, Calif.

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Cable Clamps

462

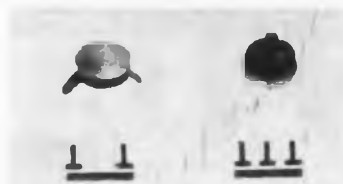


Nylon cable clamps accommodate cables from 1/16 in. to 1-3/4 in. in diameter. Flat clamps, molded half-clips and snap clips are made. Clamps are useful from -60 to +275 F under load, and are unaffected by oil to 300 F. Military requirements are met.

Weckesser Co., Inc., Dept. EI-2, Dept. ED, 5701 Northwest Highway, Chicago 46, Ill.

Thermostat

398



Model SA-5000 thermostat can be used as is or enclosed in various metal housings. It will handle currents to 20 amp, voltage to 240 ac. Bimetal snap-acting disk is open or closed type, 1/2-in. in size. Various types of terminals are available.

Thermostats, Inc., Dept. ED, P.O. Box 303, Chartley, Mass.

RF Tone Generator

396



Distortion testing and adjustment of single sideband receivers can be done with the TTT-5 dual rf tone generator. Used with any af spectrum analyzer, the set provides visual analysis of distortion and hum sidebands over a 60-db dynamic range. Five pairs of crystal-controlled rf signals are furnished in the 3- to 30-mc range. Output level is 0.1 v rms for each tone at 50 ohms, with 0 to 100 db attenuation in 1-db steps. Panel height is 5-1/4 in.

Panoramic Radio Products Inc., Dept. ED, 520 S. Fulton Ave., Mount Vernon, N.Y.

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MODEL 607



MODEL 605



MODEL 601



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The Features:

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SPECIFICATIONS

| MODEL | 650 | 601 | 605 | 607 |
|--------------------------------|--------------|-----------|-----------|-----------|
| FREQ. RANGE | 50-70 c.p.s. | | | |
| KVA RATING | 1 | 3.6-1.8 | 12 6 | 30 15 |
| OUTPUT AMPS | 10 | 30 15 | 100 50 | 250 125 |
| OUTPUT VOLTS ADJ. 10% | 105/125 | 115 | 115 | |
| CORRECTABLE INPUT VARIATION | ±17% | ±10% ±20% | ±10% ±20% | ±10% ±20% |
| RESPONSE SPEED V/SEC | 30 | 10 20 | 5 10 | 2.5 5 |
| WEIGHT (LBS.) | 30 | 45 | 110 | 170 |

Send for complete information.

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ELECTRONICS CORP.
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NEW PRODUCTS

Variable Inductors

395



For printed circuit or breadboard uses, series 387 variable inductors cover a range of 1.5 μ h to 3 mh. Both electrostatically and magnetically shielded, the high-Q units have distributed capacitances ranging from 3 pf to 16 pf in the 3-mh size. A kit of 10 inductors is offered. Military-grade units are made, as well as custom designs to 72 mh. Size is 1/2 in. square and 5/8 in. high.

Wells Electronics Co., Dept. ED, 1701 Main St., South Bend 23, Ind.

Price & Availability: \$1.80 to \$1.90; stock.

Load Cell

385



Made of 100% stainless steel, load cell type PR-35 uses a calibration-quality proving ring coupled inductively to a differential transformer. Output is over 500 mv with 10 v, 60 cps input, more than 1 v with 10 v, 400 cps input. Unit measures static and dynamic forces, tension or compression, in ranges from 25 to 4,000 lb, at temperatures from -115 to +500 F.

United Aero Products Corp., Dept. ED, Columbus Road, Burlington, N.J.

Rectifier Tester

408

Forward and reverse testing of diodes at 100 amp and 2 kv is done with model E-1 dynamic rectifier tester. Used with an X-Y oscilloscope, the tester has independently adjustable forward and reverse voltages. Calibrated resistor is used in forward current test, 0.5% resistors in reverse leakage test. A polarity-reversing unit is also made.

Instrument Development Corp., Dept. ED, 139 Delaney Drive, Pittsburgh 35, Pa.

Price & Availability: \$495; 6 to 8 weeks.

5 SECONDS ^{NOT} HOURS MAINTENANCE TIME



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SERIES RS-15

REMOVABLE WAFER ROTARY SWITCH

No soldering or disassembling.

No wire removing.

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Glass Diodes

400



Microminiature glass diodes, types TI-2 and TI-6, are computer diodes for use in diode gates, transistor-diode logic circuits and high speed switching applications. A package diameter of 0.040 in., a length of 0.060 in. and round leads provide a reduction in volume of 50 to 1 over conventional diodes with similar characteristics. They have reverse recovery times of 10 and 100 nsec respectively.

Texas Instruments Inc., Dept. ED, P.O. Box 5012, Dallas 22, Tex.

Ultrasonic Cleaner

397



Solid-state ultrasonic cleaning equipment is simpler, smaller and lighter, as shown by a 1-kw unit and the tube model it replaces. The new design uses less input power and requires no tuning or warm-up. Ratings range from 125 to 1,000 w, with a 2.5-kw unit scheduled. The 1-kw generator is 8-1/2 in. high, 17 in. wide, and 14 in. deep.

Electronic Equipment Dept., Westinghouse Electric Corp., Dept. ED, 2519 Wilkens Ave., Baltimore 3, Md.

Availability: 3rd quarter 1961.

Piezoelectric Ceramics

411

Three ceramic bodies, models C43B, C43C and C45, have been added to the firm's line of piezoelectric ceramics. Characteristics of the C43B are: dielectric constant at 1 kc, 1,100; planar coupling coefficient, 45%; max operating temperature, 250 C; dissipation factor at 1 kc, 1%.

Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

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SYNTRON COMPANY, Semiconductor Div., Dept. ED-4, Homer City, Pa.

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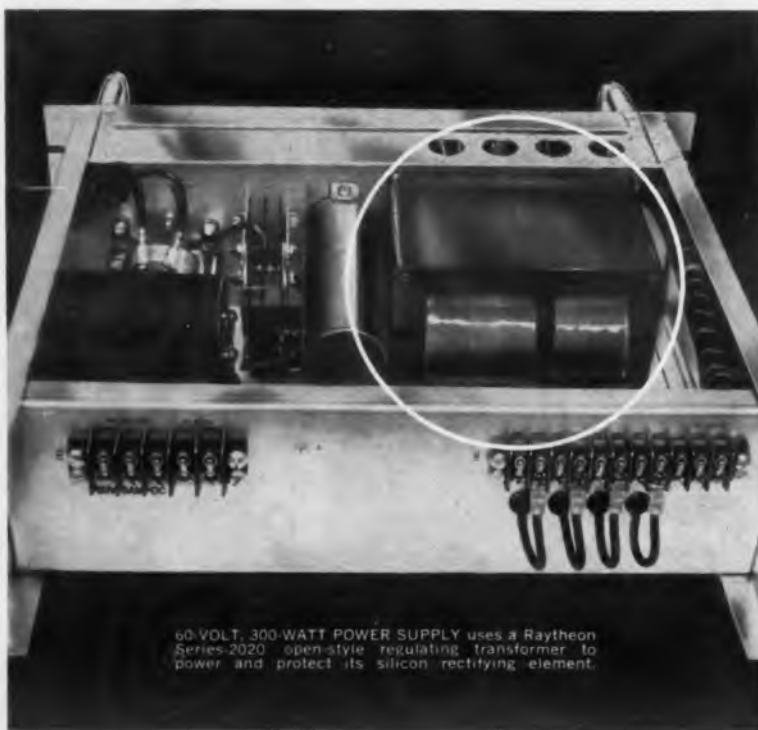
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153



60-VOLT, 300-WATT POWER SUPPLY uses a Raytheon Series-2020 open-style regulating transformer to power and protect its silicon rectifying element.

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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?

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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 COMPANY

COMMERCIAL APPARATUS & SYSTEMS DIVISION

Raytheon voltage regulators are also available from your local Raytheon distributor
CIRCLE 166 ON READER-SERVICE CARD

NEW PRODUCTS

Clock Movement

391



Transistor electronic clock movement, for use in appliances, is accurate to within a few seconds per month. Input is 4.5, 6, 9 or 12 v; power consumption is about 0.30 ma. Movement is self-starting, insensitive to position, and shock-proofed. Size is 2-1/8 x 1-3/4 x 1-1/16 in.

Waller Corp., Dept. ED, Industrial Center, Crystal Lake, Ill.

Logic Circuits

390



Encapsulated, transistorized logic circuits, in 9-pin miniature plug-in form, are encapsulated in hard epoxy resin. Included are AND gates, OR gates, emitter followers and inverters, in single and dual units, with pnp, npn or complementary symmetry circuits. Rates are 250 kc to 1 mc.

Walkirt, Dept. ED, 141 W. Hazel St., Inglewood 3, Calif.

Glow Lamps

380



Starting time is less than 1 msec for these glow lamps, in darkness as well as in light. Breakdown and maintaining dc voltages for type LT2-27-IR are 104 to 112 and 64 to 74 respectively; for type T2-27-IR100, 66 to 74 and 52 to 59; for type T2-27-1WR760, 170 to 200 and 70 to 75.

Signalite, Inc., Dept. ED, Neptune, N.J.

$\pm 1\%$

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on all
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For the first time, accuracy of ± 1 percent is now available in multi-range Panel-Mounting Electronic Voltmeters (PMEV's)

Metronix offers two such instruments: Model 300-1 for DC measurements and Model 311-1 for AC measurements.



Model 311-1

These instruments, like all Metronix PMEV's, also offer these familiar advantages:

- Continuous monitoring of critical parameters
- Minimum panel space—no larger than the meter itself
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METRONIX, INC.

a subsidiary of Assembly Products, Inc.
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Telephone: HAMILTON 3-4440
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ELECTRONIC DESIGN • April 12, 1961

NEW NEON INDICATOR LIGHT

FACTS!

- **Reliable:** 25,000 hrs. min. for NE-2H @ .5 ma lamp current
- **Neon:** low power consumption—120 mW nominal
- **Low voltage operation:** supply 24V DC nominal signal—6V DC to trigger
- **Miniaturized:** hole diameter $\frac{3}{4}$ "; behind panel required, $1\frac{1}{2}$ "
- **Encapsulated:** moisture-fungus proof; withstands vibration, thermal and mechanical shock
- **Terminals:** signal, positive supply, common ground



TELEX miniaturized neon lights indicate visually the logical condition of high speed computer "flip-flop" modules. Countless other applications on portable, battery operated or low voltage equipment.

Transistor driven, combines advantages of low current drain with low voltage operation. Can operate direct from basic power supply or controlled by high impedance signal. Standard model 24V DC supply polarity with -6V DC switching polarity.

Variations of the terminal configurations and voltages designed to specification.

More detailed specifications and information are available on request. Write to Sales Manager,



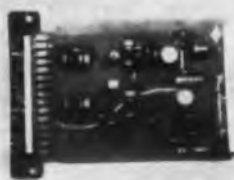
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Digital Modules

386



Operating at 5 mc, the series 5000 line of digital modules is compatible with 200-kc modules. Circuits include flip-flops, multivibrators, nors, and gates. Logical 1 voltage is -6 to -8 v dc; logical 0 voltage is 0 ± 0.5 v dc. Regulated power is not required. Card size is $2\frac{11}{16} \times 3\frac{1}{2}$ in.

Wang Laboratories, Inc., Dept. ED, 12 Huron Drive, Natick, Mass.

Availability: delivery from stock.

High-Voltage Power Supplies

382



General purpose high-voltage power supplies are available in three models. Model 125 has a voltage output of 2 to 3 kv dc at up to 2 ma; model 126 has an output of 1 to 3 kv at 2 ma; model 127 has an output of 0.5 to 3 kv at 2 ma. Available in negative or positive polarity, all models have provision for internally reversing polarity.

Smith-Florence, Inc., Dept. ED, 4228 23d W., Seattle, Wash.

P&A: From \$330 to \$365; 30 days.

Enclosed Rack

389



Steel or aluminum electronic enclosure is made for heavy military or commercial uses. Panels are removable from the outside; enclosure may be made dust-free. Available in standard or custom sizes.

Vent-Rak, Dept. ED, 525 S. Webster, Indianapolis 19, Ind.

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what's so different
about these
time/delay/relays?



(and how these
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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 l-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. 41-44.



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FIVE STANDARD CONFIGURATIONS—Regular Taper, Cylindrical Necks, Spade, Beveled, and Blunt. $\frac{1}{8}$ " dia. stock, 2" long. Specials supplied on short notice.

FOUR STANDARD MATERIALS—

- M3—Mallory 3- Copper Chromium Alloy
- M1—Mallory 100- for low electrical conductivity
- EA—Elkaloy A- for high electrical conductivity
- EM—Molybdenum Tips—for long life and no-stick action

COATING—Insulated coating available on all styles except spade. Mandatory when welds are made adjacent to active components.

Write for Complimentary Electrode Selection Guide:

THE sippican CORPORATION

Marion, Massachusetts



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156

NEW PRODUCTS

Power Supply

388



Continuous overloads or shorts cause no additional internal heat dissipation in the model RB-40V10SS power supply. Continuously variable current-limiting circuit holds maximum current to any selected level between 1.0 and 10.5 amp. Load regulation is 0.01%, transient recovery 50 mv max within 50 μ sec. Provision is made for parallel and series operation, remote error sensing and programing. Panel height is 5-1/4 in., weight 35 lb.

Valor Instruments, Inc., Dept. ED, 13214 Crenshaw Blvd., Gardena, Calif.

Germanium Power Transistor

383



The "pancake" series of germanium power transistors have a dissipation of 150 w, and a guaranteed 0.5 C per w max thermal resistance. Designed for use in computers, converters and regulators, the series includes types 2N1099, 2N173, 2N278, 2N277, 2N441, 2N442 and 2N443. Junction temperature is 100 C and guaranteed h_{FE} ranges are from 20 to 70.

Texas Instruments Inc., Dept. ED, P.O. Box 5012, Dallas 22, Tex.

Power Transistors

381



Diffused-junction, npn silicon transistors types 2N389A and 2N424A have saturation resistance that is less than 0.75 ohm. Designed for high-power switching and amplifier applications their temperature range is -65 to $+200$ C. Maximum ratings are: collector current, 3 amp; emitter to



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WITH RESILIENT WEAVE AND HIGH
DIELECTRIC STRENGTH UNDER STRETCH

Natvar Teraglas is a new flexible insulating material comprising a base fabric, woven from polyester (polyethylene terephthalate, or "Dacron") warp yarns and continuous filament glass filler yarns, coated with an improved varnish, possessing exceptional dielectric strength under elongation. It will withstand Class B (130° C) operating temperatures.

In view of the higher dielectric strength of Natvar Teraglas compared to bias varnished cambric, thinner sections or fewer layers may be used to provide the voltage breakdown protection desired. Consequently, at comparable tape prices, a significant saving may be realized in production costs, while permitting up-grading to Class B (130° C) temperatures. Natvar Teraglas will prove advantageous in many applications—for insulating motors, generators, transformers, cables, switch gear, busbars, and other apparatus and equipment where resiliency and high dielectric strength are desirable.

Natvar Teraglas is available in four thicknesses, .008, .010, .012 and .015"—in tapes, in full width rolls (36"), or in sheets. Ask for Data Sheet and Samples.

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Type 820—Range: 0-10,000 gaussnes
Accuracy: 1/10 of 1% above 2000 gaussnes

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base voltage, 10 v; power dissipation, at case temperature of 25 C, 85 w, at case temperature of 100 C, 45 w.

Silicon Transistor Corp., Dept. ED, 150 Glen Cove Road, Carle Place, L.I., N.Y.

Clock Pulse Generator

399



Solid state clock pulse generators include a 3- to 25-mc and a 25- to 100-mc unit with overlap to provide continuous pulse sources from 3 to 100 mc. Design permits external drive input to provide repetition rates below 3 mc and to permit the operation of several clock pulse generators controlled by a master source. Specifications include: rise/fall times, less than 4 nsec; pulse width, less than 8 nsec at 1/2 pulse height; amplitude, 0 to 4 v; output impedance, 93 ohms.

Texas Instruments Inc., P.O. Box 6027, Houston 6, Tex.

Solenoid Valve

387



Radioactive, corrosive chemical solutions can be handled by this solenoid valve. The valve will operate in radiation fields to 25 million rads, and is usable with nitric and sulfuric acids, ammonium and sodium hydroxide, and hydrogen peroxide. It is supplied normally open or closed in standard ac and dc voltages, in 1/4-in. or larger pipe sizes.

Valcor Engineering Corp., Dept. ED, 365 Carnegie Ave., Kenilworth, N.J.

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For Military and Commercial Applications

Grayhill Miniature Rotary Tap Switches



These switches are designed to meet military and commercial specifications and ruggedly built to precision standards.

Grayhill No. 5000, No. 12, and No. 24 Series. 1.01" dia. Break 1 amp., 115 VAC, resistive. Carry 5 amps. 1 to 10 decks, 2 to 10 positions per deck—1 or 2 poles per deck—shorting or non-shorting. Life 100,000 cycles. Also No. 24 Series, spring return switch.

Concentric Shaft. No. 6 (1 to 3 decks per shaft—Total 6 decks) and No. 36 Series (1 or 2 decks per shaft. Total 4 decks). 1.01" dia. 2 to 10 positions per deck. Break 1 amp., 115 VAC, resistive. Carry 5 amps. Two switches in one. 1/4" shaft controls 1/2 of the decks, 1/8" shaft controls the other half.

No. 45 Series Midget. .640" dia. Single deck only. 60° indexing. Break 1 amp., 115 VAC, resistive. Carry 5 amps. Life 100,000 cycles.



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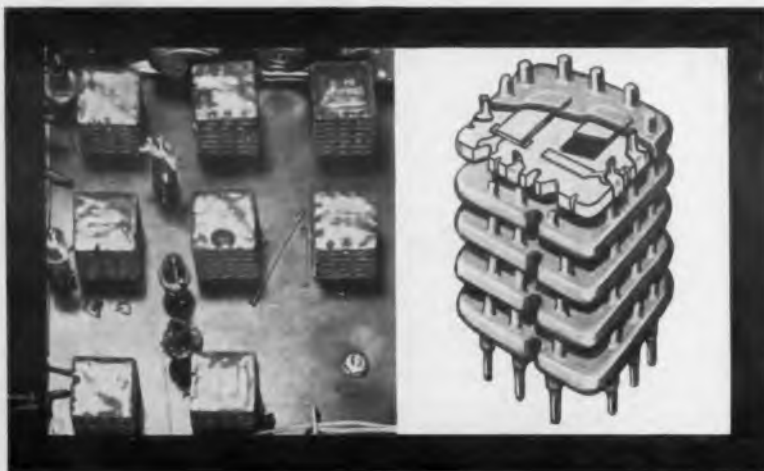
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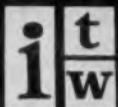


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NEW PRODUCTS

Digital Voltmeter

425



Voltages from 100 μ v to 1.5 kv dc are presented as a four-digit display in decimal form with polarity discrimination in model LM 902.2 digital voltmeter. Voltage measurements are covered in 5 ranges; long term accuracy is $\pm 0.1\%$ of maximum reading on each scale. Readout time is 250 msec regardless of voltage input.

Solartron Laboratory Instruments Ltd., Dept. ED, Cox Lane, Chessington, Surrey, England.

Memory Unit

417

A single magnetic disk memory unit, model 31B has total memory capacity of nearly 10,000,000 bits with 400,000 bits available on a fast access basis comparable to magnetic drum performance. It provides over 9 million bits of random access storage capacity with an average access time of 147 msec. The 31-in. disk has two recording surfaces and incorporates eight movable data heads, 16 fixed data heads and eight fixed control heads.

Telex, Inc., Dept. ED, St. Paul, Minn.

Servo System

426



Solid state servo amplifier model 6102 has a sensitivity of 1 mv. It is completely transistorized with two dc signal inputs and one ac input. No warm-up time is required. The system occupies 1/4 the space of conventional systems and provides up to 400 in.-lb response.

Solar Electronics Co., Dept. ED, 5909 Melrose Ave., Hollywood 38, Calif.

P&A: Amplifier, \$124.50; motor, \$50; 2 weeks.

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The Allison 650 Random Noise Source



HERE'S A NEW TRANSISTORIZED NOISE SOURCE

The new Allison 650 Random Noise Source consists of a silicon diode as the noise source driving a transistorized amplifier. It is non-microphonic and can be used in areas of high ambient noise and vibration. It is suitable for shaker tables or high level environmental acoustic testing; and microphone and other transducer calibration signal.

ALLISON 650 SPECIFICATIONS

- Output—0-1.5 VRMS
- Load impedance—600 ohms
- Size—6 $\frac{3}{4}$ " x 6 $\frac{3}{4}$ " x 6"
- Weight—4 $\frac{1}{2}$ pounds
- Price—Battery powered
\$265.00 F.O.B.
AC powered
\$280.00 F.O.B.
- Rack mount model (650R) available

Miniature noise source



The Allison 655 Random Noise Source has a uniform output over the frequency range of 5 cps to 30 kcps. Characteristics similar to 650. 1" x 1 $\frac{1}{2}$ " x 1 $\frac{1}{2}$ "; 2 $\frac{1}{2}$ oz. \$36.00 each in 100 lots. Write for Technical Bulletin 655.

Write for Technical
Bulletin 650



**Allison
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11301 OCEAN AVENUE
LA HABRA, CALIFORNIA

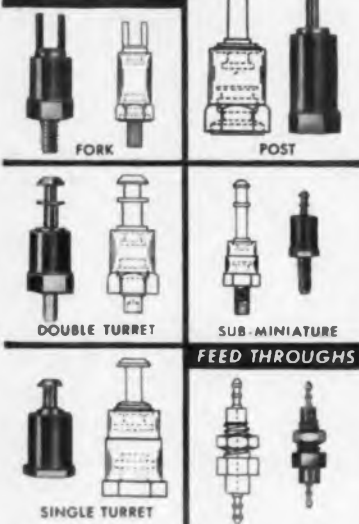
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ELECTRONIC DESIGN • April 12, 1961

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WHITSO, INC.
9326 Byron Street, Schiller Park, Illinois
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ELECTRONIC DESIGN • April 12, 1961

Constant Voltage Transformers

427



Standard sinusoidal constant voltage transformers are completely automatic with continuous regulation. Response time is 25 msec at 60 cps. Standard items are available in 29 different primary-secondary voltage combinations from 60 to 7,500 v amp.

Sola Electric Co., Dept. ED, Elk Grove, Ill.

Power Amplifier

377

Fluoro-chemical cooling of the HC-105 high-frequency linear power amplifier allows delivery of 1 kw with case size of 7-1/2 x 7-1/2 x 6-1/2 in. The amplifier accepts am and single-sideband voice, digital data link, or any modulated signal in the 2- to 36-mc frequency range.

Hughes Aircraft Co., Communications Div., Marketing Dept., Dept. ED, P. O. Box 90-902, Los Angeles 45, Calif.

Core-Transistor Counters

422



Counting to speeds of 10 kc, series 73Z core-transistor counters utilize rectangular hysteresis loop magnetic cores. Type 73Z1 decade counter provides an output signal for every 10 input pulses, then resets in preparation for the next cycle. For higher counting two or more counters may be cascaded.

Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

Counter Tubes

414

Decade counter tubes type CT4251 are dome-shaped, 13-pin, T-9 units with 10 output cathodes. They are for use in compact counting equipment in the zero- to 50-kc frequency range.

Sylvania Electric Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

P&A: \$11.10, 1 to 24; immediate.



SPECIAL PURPOSE PRECISION BEARINGS FROM KEARFOTT

Highest quality, special purpose precision bearings are now available from Kearfott Division, General Precision, Inc. for military and industrial applications requiring utmost reliability, accuracy and stable performance. Over 10 years of research, testing and development have gone into the production of these outstandingly reliable, precision bearings.

Designed to meet the most exacting systems standards, these special purpose precision bearings have more than passed the test of time, delivering long life performance for Kearfott gyros, instruments and other critical airborne equipment. Engineering and technical excellence derived from long experience enables Kearfott to ensure delivery of bearings that provide unsurpassed qualities of roundness, concentricity, curvatures, finish, dimensions and functional tolerance.

Special purpose, high precision bearings from 0.3125 to 4.5 inches O.D. are now ready for production delivery in a wide range of application types including—

- SEPARABLE TYPE BEARINGS for gyro spin axes
- STABLE PLATFORM GIMBALS
- GYRO PRECESSION AXES
- OTHER SPECIALIZED, HIGH PRECISION bearing applications

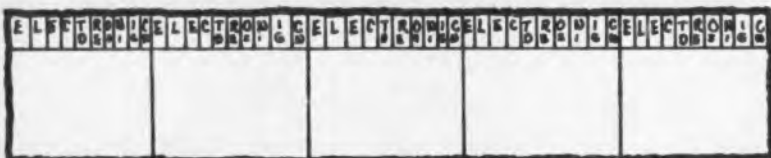
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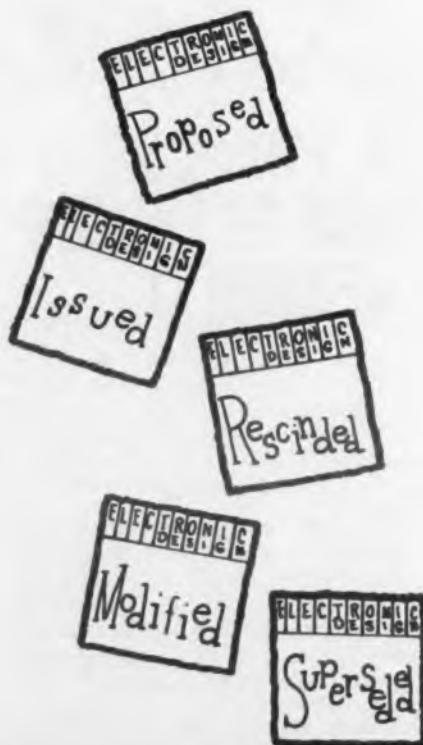
KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE 179 ON READER-SERVICE CARD



standards
are



We select military and commercial standards of interest to the electronic design engineer and brief them in the Standards & Specs Section. Another service that saves you time and keeps you up to date on the latest design developments.

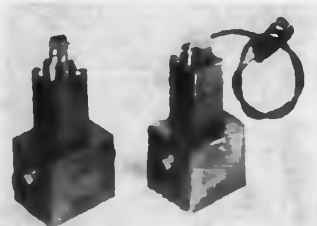


ELECTRONIC DESIGN . . . communicates ideas for ACTION.

NEW PRODUCTS

Flow Transducers

421



Designed for missiles using thrust vector control, series SF2 flow transducers have ranges of 0 to 0.5 gal per sec through 0 to 200 gal per min. A signal-conditioning amplifier can be incorporated in the transducer which will provide a 5-v full scale output. Sensitivity is 4 mv per v; linearity is 2% of full scale; repeatability is less than 0.25%; flow is unidirectional. Infinite resolution permits sensing down to zero flow.

Standard Controls, Inc., Dept. ED, 1130 Poplar Place, Seattle 44, Wash.

Reed Relays

420



Encapsulated reed relays have electrostatic shields completely surrounding their glass switching elements. This isolates the reed contacts from stray electrical noise or random pickup of unwanted signals. They are available in 1, 2, 4, 12, and 20 pole types.

Struthers-Dunn, Inc., Dept. ED, Pitman, N.J.

Miniature Gyro

423



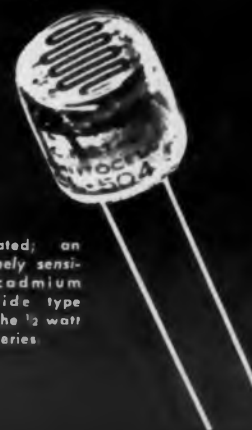
Floated, integrating, miniature gyro SYG-1000 weighs less than 1 lb and is less than 3-in. in length. Drift sensitivity is less than 0.005 deg per hr/g² under vibration tests of 20 g. Random drift cogging tests show standard deviations of 0.007 deg per hr in azimuth position and 0.005 deg per hr in vertical position.

Sperry Gyroscope Co., Dept. ED, Great Neck, N.Y.



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in automation and control"

the
CLAIREX
Photoconductor



Illustrated: an extremely sensitive cadmium selenide type from the 1/2 watt 500 series.

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- Electronic Buyers Guide
- Electronic Design Catalog
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MU 4-0940

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ELECTRONIC DESIGN • April 12, 1961

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*For Quick
Connect/Disconnect
Applications*



Exclusive MALCO
Design eliminates faulty
connections... assures
uniform crimping.

Specially contoured insulating
sleeve accurately guides termi-
nal into position on male tab.
Entry of male tab (outside of
terminal) within the insulating
sleeve is positively prevented.

Malco Terminals are avail-
able in chain form for rapid
machine crimping to wire. In-
sulating sleeves are
also machine applied

REQUEST
BULLETIN
NO. 603



Malco MANUFACTURING CO.
4027 W. Lake St., Chicago 24, Ill.

CIRCLE 102 ON READER-SERVICE CARD
ELECTRONIC DESIGN • April 12, 1961

Flat Ribbon Cable

424



Multicolored, multiconductor flat ribbon cable is designed for ease of handling, full visibility of color-coding, and control of inter-conductor capacitance. Insulation is P.V.C. plastic; gages are from 10 to 30 AWG. Shielded leads, coaxial or thermocouples can be included.

Spectra-Strip Wire and Cable Corp., Dept. ED, P.O. Box 415, Garden Grove, Calif.

Special Purpose Motor

419



Limited duty cycle, dc motor is a special purpose unit designed specifically for missile environments. Weighing only 6.7 lb the motor produces 3.25 hp at 13,700 rpm using 30 v dc. Over-all efficiency is 75%. Use of lightweight radio-noise filters is permitted by improved commutation and attendant low noise level.

Task Corp., Dept. ED, 1009 E. Vermont Ave., Anaheim, Calif.

Germanium Alloy Transistors

413

General purpose npn and pnp germanium alloy transistors types 2N358A, 2N428, 2N526 and 2N396A meet the mechanical and environmental requirements of MIL-S-19500. The hermetically sealed devices are designed for both amplifier and switching applications in the audio frequency range. They use a TO-5 package.

Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.
Price: From \$1.50 to \$6.51.

Crimp Connector

463

Heavy-gauge wire is accepted by UL-approved crimp connector No. 412. It will handle combinations from one No. 14 with one No. 16 up to one No. 6 with two No. 8 wires. Sleeve is cadmium-plated steel, crimped with a standard tool. Locking, wrap-around insulator is polyvinyl chloride.

Ideal Industries, Inc., Dept. ED, 5098 Park Ave., Sycamore, Ill.

Have you sent us your subscription
renewal form?



SHOWN FULL SIZE

MINIATURE, HIGH PERFORMANCE MAGNETIC BRAKES AND CLUTCHES

Typical applications involving these Size 11 magnetic clutches, brake clutches, and brakes include service as output controls in mechanical differential computers, as motor brakes, and as speed changers and uncouplers. Kearfott can also provide magnetic clutches, brake clutches and brakes in various other sizes to suit desired applications. Components also available in sizes 8 and 6 diameters.

CHARACTERISTICS

| Unit No. Size | Magnetic Clutches | | Magnetic Brake Clutch | Magnetic Brake |
|-------------------------------|---------------------------------------|-------------------|---------------------------------------|----------------|
| | R5750-001 | R5750-002 | R5760-001 | R5770-001 |
| Power input (Watts) | 3 | 3 | 3 | 3 |
| Clutch Torque (In. Oz.) | 6 (energized) | | 4 (energized) | — |
| Brake Torque (In. Oz.) | — | — | 6 (de-energized) | 16 (energized) |
| Inertia (gm cm ²) | .82 (energized) .56 (de-energized) | | .82 (energized) .56 (de-energized) | .34 |
| Engaging Surfaces | Steel | Brake Material | Steel and Brake Material | Steel |
| Environmental Performance | Per MIL-E-5272A | | | |
| Life (Cycles)* | 3,000,000 | | | |

*1 Cycle=1 revolution of shaft engaged and 1 revolution of shaft disengaged, at 500 RPM.

Write for complete data



KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE 103 ON READER-SERVICE CARD



THE SPARE PARTS PROBLEM

The Electronics Business may not be the most tranquil enterprise for anyone to get into—either as a buyer or seller—as evidenced by one of the problems currently plaguing both component makers and their customers. In a nutshell, the trouble is “equivalent” parts, made by a low bidder, failing to behave as the originals did. The explanation, while not as simple as this, seems to boil down to the fact that specs and descriptive data alone aren't enough for anyone to duplicate the performance of somebody else's original part. It could be a matter of the inability of the blueprint and the mimeograph machine to be a satisfactory substitute for the original manufacturer's experience, engineering skill, assembly methods and quality control.

No one can argue the merits of saving money, and a good part at the lowest possible cost is a commendable achievement. But when “low quote” means failure of critical equipment and personal hazard,

there's not much to be said for economy. On the other hand, if the low man *does* get all the information he needs to build an exact replacement of the original part (assuming he can build it), he is automatically getting the benefit of a great deal of work done and paid for by the original manufacturer. The polite term is usually “proprietary data.” Understandably, this arouses the “unfair competition” ogre.

We don't like to give away proprietary information any more than the next person. Neither do we like to see unreliable components endangering life and limb. We think part of the answer may be to give the second man the same problem you gave the original supplier—not the blueprinted solution to imitate. Then test his result as carefully as you did the original successful one. This way, the odds are strongly in favor of your getting something that will work—and perhaps work even better.

What do you think the answer is?

* E. W. Schrader, Western Editor of DESIGN NEWS, made some good observations on this whole subject. see pp. 6-7, Jan. 10 issue.

SIGMA

SIGMA INSTRUMENTS, INC.
91 Pearl St., So. Braintree 85, Mass.
CIRCLE 184 ON READER-SERVICE CARD

NEW PRODUCTS

Rear Projection Indicator

418



Model 12-R rear projection indicators contain 12 individual projectors, each centered on a single front screen. The unit measures 3/4 x 1-1/8 x 3-3/4 in. with a viewing screen 0.5 in. high x 0.4 in. wide.

Tasker Instruments Corp., Dept. ED, 7838 Orion Ave., Van Nuys, Calif.

Telemetry Receiver

405

For fm, am, and cw signals in the 30 to 260 mc model 1907 telemetry receiver is compact and lightweight. An am noise limiter is adjustable from the panel; a carrier-operated relay is provided. A bandswitch-controlled coaxial relay switches antenna inputs. Panel control selects if bandwidth and mode. Rack-mounting set is 3-1/2 in. high and weighs 25 lb.

Vitro Electronics Div., Vitro Corp. of America, Dept. ED, 919 Jesup-Blair Drive, Silver Spring, Md.

Analog Memory

412

Drift free analog memory model DAM 18-A makes and stores a digital conversion of an analog voltage. Incidental capabilities of each channel include digital to analog conversion rates up to 100 kc and analog to digital conversion at rates up to 6 kc. One standard rack mounts 18 channels with power supply.

Stony Brook Laboratories, Inc., Dept. ED, 55 State Road, Princeton, N.J.
P&A: \$17,900; 90 days.

Trimming Potentiometer

415

The high-temperature plastic case of this trimming potentiometer eliminates insulation problems. Specifications are: resistance range, 10 ohms to 35 K; power rating, 3/4 w at 50 C; dielectric strength, 500 v ac, 1 min.

Techno Components Corp., Dept. ED, 18232 Parthenia St., Northridge, Calif.

Select the transistorized DYNA-EMPIRE GAUSSMETER best suited to your needs

Completely transistorized Dyna-Empire gaussmeters accurately measure flux density and determine “flow” direction. Ideal for measuring and locating stray fields, plotting variations in strength and performing rapid comparisons of production lots against a standard. Easy-to-operate,—no jerk, pull, ballistic readings or circuit breaking required.



NEW TRANSISTORIZED GAUSSMETER MODEL D-874

This precision instrument reads from 300 to 30,000 gauss full scale, with an accuracy of $\pm 2.5\%$. It fulfills all needs of a quality gaussmeter at a modest price.

Special Features:

FIVE RANGES: 300 gauss full scale, 1,000 gauss full scale, 3,000 gauss full scale, 10,000 gauss full scale, 30,000 gauss full scale.
LINEAR OVER ENTIRE OPERATING RANGE
PORTABLE, OPERATES FROM OWN SELF-CONTAINED BATTERIES
BATTERY LIFE—1,000 HOURS
REQUIRES NO EXTERNAL POWER SOURCE
INTERNAL CALIBRATION STANDARD
WEIGHT—4 LBS.
UNIVERSAL PROBE SUPPLIED IS 0.025" THICK BY 0.200" WIDE. ACTIVE AREA IS ONLY 0.0079 SQUARE INCHES LOCATED NEAR THE TIP OF THE PROBE.

Complete with Universal probe \$195.

TRANSISTORIZED GAUSSMETER MODEL D-855

This quality precision built Gaussmeter reads flux densities to 30,000 Gauss full scale $\pm 2.5\%$. It is a highly sensitive instrument and provides tremendous flexibility. Complete with two linear probes—one high sensitivity probe for measurement of low density fields and one probe for measurement of high density fields. Special probe available for reading 3 gauss full scale.

Write to
Dyna-Empire, Inc.
1075 Stewart Avenue, Garden City, N. Y.

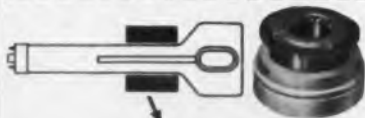


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ELECTRONIC DESIGN • April 12, 1961



a spot is a spot
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resolution spot
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keep spots **smallest**
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keep spots **roundest**
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keep spots **sharpest**



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Immersion Gold 416

Neutral immersion gold offers a fast means of depositing thin plates of 24 carat gold directly on copper, brass, nickel, iron, lead and solder plates without the use of anodes or currents. Direct deposits of 70 millionths of an inch in 30 min are possible over solder.

Technic, Inc., Dept. ED, P.O. Box 965, Providence, R.I.

Price: From \$42 to \$48 per Troy oz.

Vacuum-Coated Metals 406

Refractory metals such as tungsten and molybdenum can be supplied with a vacuum coating diffused into the base metal. Coatings include noble metals, aluminum, nickel, alloys and dielectrics. Selective and patterned coatings are possible. Thickness ranges from a few molecules up to 0.005 in. or more.

Vacuum Technology, Inc., Dept. ED, 7933 Gloria Ave., Van Nuys, Calif.

Rack Devices 409

Rack-mounted chassis capability is improved with a series of packaging devices. Connector drive handles permit disengagement or reconnection of slide-mounted chassis with fixed rear connections. A cable carrier is made to eliminate sagging, binding and twisting. Thin-line chassis slides of 1/2-in. width max carry up to 200 lb.

Jonathan Manufacturing Co., Dept. ED, 720 E. Walnut Ave., Fullerton, Calif.

Silicon Rectifiers 410

Miniature, hermetically sealed, silicon rectifiers, the Trimline series, are designed to replace the top hat type. Current ranges are up to 1,000 ma at piv ratings up to 2,200 v.

Slater Electric and Manufacturing Co., Dept. ED, 241 Sunrise Highway, Rockville Centre, N.Y.

Epoxy Laminate 459

Is flame-retardant. Epoxy resin laminate G-10-839 is a glass-base, flame-retardant material designed for ease of fabrication. It is available in sheets of 40 x 48 in. with thicknesses from 1/32 to 1 in. The 1/16-in. thickness can be sheared and punched with minimum heating. The laminate meets requirements of MIL-P-13949, and can be furnished copper-clad.

Spaulding Fibre Co., Inc., Dept. ED, 310 Wheeler St., Tonawanda, N.Y.



SHOWN TWICE NORMAL SIZE



HIGH PERMEABILITY FERRITE

Kearfott's MN-30 ferrite is a highly machinable, high-permeability ferrite for use in magnetic cores. Its low losses and high saturation magnetization permit efficient application at frequencies up to 500 kc, while eddy current losses are minimal due to the material's high resistivity. Custom shapes and sizes available with dimensional tolerances within $\pm .001$, density ranges from 4.9 to 5.0 gm/cm³. High quality and uniformity are assured through special compounding techniques, automatic control of firing, and rigid quality control.

TYPICAL CHARACTERISTICS

| | |
|---|------------------------|
| Initial Permeability at 21°C and 5 kc | 3000 Min. |
| Maximum Permeability, measured at 2000 gauss | 6000 |
| Flux density at 7 oersteds, using Rowland Ring Test Circuit and Fluxmeter | 4600 gauss |
| Flux Excursion for 1 oersted | 3500 gauss |
| Retentivity (B _r) | 1300 gauss |
| Coercivity (H _c) | 0.13 oersteds |
| Loss Factor 1 μ Q at 50 kc | 7.5 x 10 ⁻⁶ |
| Loss Factor 1 μ Q at 500 kc | 30 x 10 ⁻⁶ |
| Temperature Coefficients of initial permeability (% per °C): | |
| From -30°C to +125°C | 0.28 |
| Curie Temperature | over 180°C |
| D. C. Restivity | 250 ohm-cm |

(All magnetic properties are held within a tolerance of $\pm 15\%$)

Write for complete data



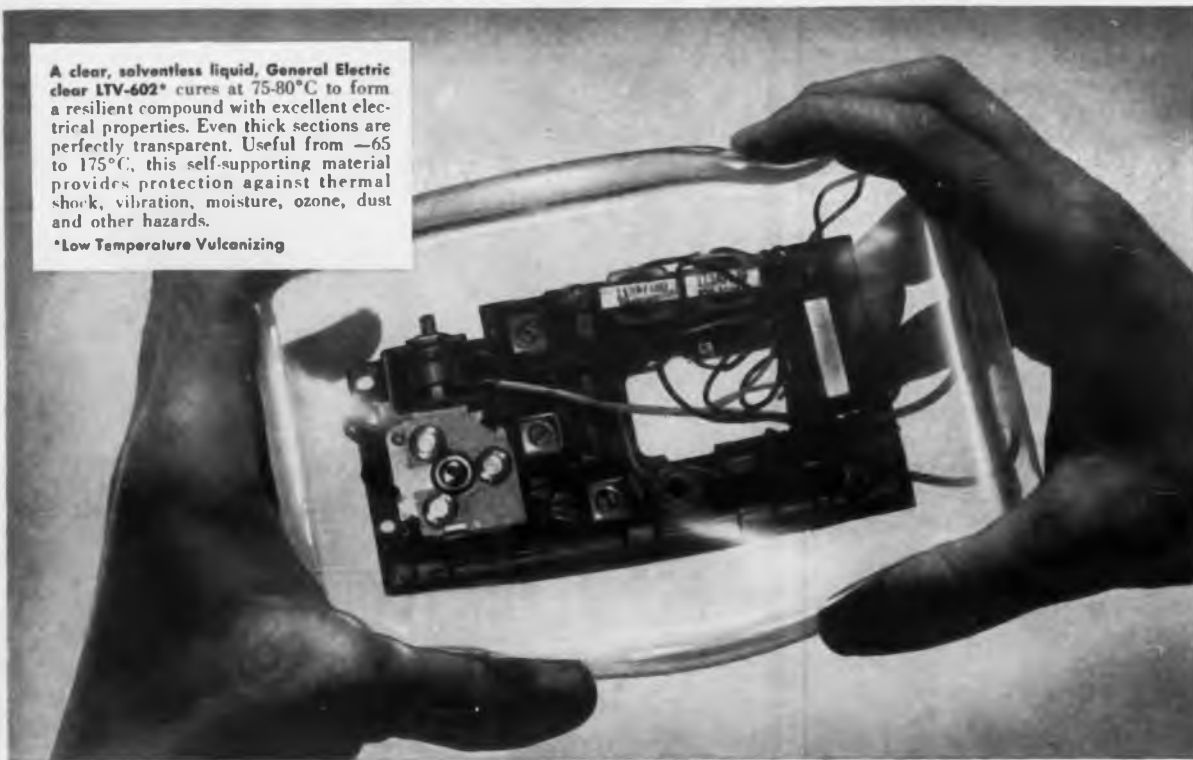
**KEARFOTT DIVISION
GENERAL PRECISION, INC.**

Little Falls, New Jersey

CIRCLE 187 ON READER-SERVICE CARD

A clear, solventless liquid, General Electric clear LTV-602* cures at 75-80°C to form a resilient compound with excellent electrical properties. Even thick sections are perfectly transparent. Useful from -65 to 175°C, this self-supporting material provides protection against thermal shock, vibration, moisture, ozone, dust and other hazards.

*Low Temperature Vulcanizing



General Electric clear LTV silicone compound for potting and embedding

Transparent, resilient, self-supporting and easy to repair



LTV-602 is easily applied, flows freely in-and-around complicated parts. Having a low viscosity in the uncured state, 800-1500 centipoise, LTV is ideal for potting and embedding of electronic assemblies. Unlike "gel-like" potting materials, LTV-602 cures to a flexible solid. Oven cure is overnight, or from 6 to 8 hours at 75 to 80°C.



LTV-602 is easy to work with and easy to repair. To repair parts embedded in LTV, merely cut out and remove section of material, repair or replace defective part, pour fresh LTV into opening and cure. Pot life, with catalyst added, is approximately 8 hours and may be extended with refrigeration. When desirable, LTV may also be cured at room temperature.



Resiliency offers excellent shock resistance. LTV-602 easily meets thermal shock tests described in MIL-STD-202A test condition B which specifies five temperature cycles from -65 to 125°C. Tests indicate that LTV retains protective properties even after 1800 hours aging at 175°C. Other tests confirm LTV's resistance to moisture and water immersion.

LTV-602 is the newest addition to the broad line of G-E silicone potting and encapsulating materials which also include the RTV silicone rubbers. For more information, write to General Electric Company, Silicone Products Department, Section L414, Waterford, New York.

GENERAL  ELECTRIC

CIRCLE 188 ON READER-SERVICE CARD

NEW PRODUCTS

Subcarrier Oscillators

460

Are highly stable. Operating on all standard IRIG subcarrier frequencies, these subcarrier oscillators show stable properties over a wide range of temperatures. The TEX-3000 oscillator has a sensitivity of 5 v peak-to-peak for 100% deviation. Deviation is $\pm 7.5\%$ in channels 1 through 18 and $\pm 15\%$ on channels A to E. The TEX-3100 oscillator has a sensitivity of 0 to 20 mv or ± 10 mv for 100% deviation for channels 1 through 18 and ± 20 mv for channels A through E.

Sonex, Inc., Dept. ED, 20 E. Herman St., Philadelphia 44, Pa.

Receiving Tubes

461

With 26.5-v heaters. Subminiature receiving tubes with 26.5-v heaters are available in three models. Type 7887, a medium- μ double triode for oscillator, amplifier and low-power servo circuits, replaces type 6111. Type 7888, a high- g_m , medium- μ triode for uhf oscillator and low-frequency oscillator and amplifier applications, corresponds to type 5718. Type 7889 is a high- μ double triode similar to type 6112, used in low-level audio circuits.

Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

Parametric Amplifiers

454

For 2,190 to 2,300 mc. Miniature microwave parametric amplifiers make use of a set of variable-capacitance diodes distributively coupled to a helix. Prototype SS-1000 delivers 1 mw with 15-db minimum gain and noise factor of 7.5 db max from 2,200 to 2,300 mc. Variant SS-1000V1 delivers 1 mw with 17-db minimum gain and 6-db noise max from 2,190 to 2,210 mc. Both have excellent stability, do not require a circulator, and are contained in miniature packages without tuning stubs. Pump source frequency is 30% above signal frequency; pump power is 300 to 400 mw. Variants of the amplifier range from 1,750 to 3,000 mc, with bandwidths to 100 mc.

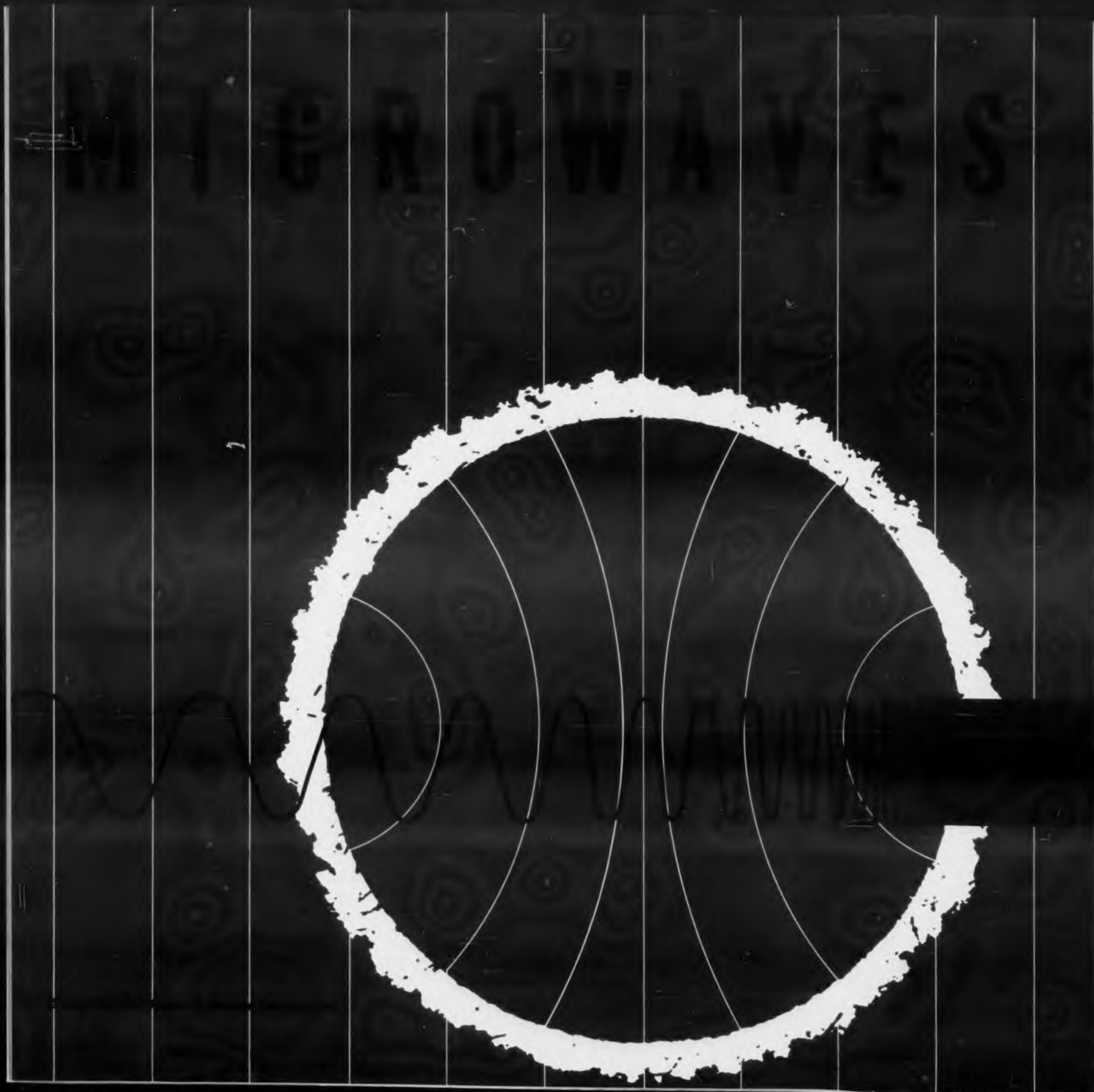
Radio Corp. of America, Electron Tube Div., Dept. ED, Harrison, N.J.

Accuracy Is Our Policy . . .

The New Product description of power supply model 890A, made by Harrison Laboratories Inc., 45 Industrial Road, Berkeley Heights, N.J., gave power rating as 0 to 6 amp. The correct rating is 0 to 320 v dc at 0 to 0.6 amp. The item appeared on p 179 of the March 1 issue.

Don't miss an issue of ELECTRONIC DESIGN; Return your renewal card.

ELECTRONIC DESIGN • April 12, 1961



**From
BOMAC**

An Industry First

4.3 MM BALANCED DUPLEXERS 68.75 - 70.75 kMc

Bomac Laboratories presents a 4.3 Millimeter Balanced Gas Switching Duplexer... an industry first from Bomac's advanced development in radar and microwave components.

The BLP-017D duplexer is the first ever designed for 4.3 mm operation. This rugged short-slot hybrid duplexer assures reliable service under severe environmental conditions. Operable in excess of 500 hours, at temperatures from -40° to $+85^{\circ}$ C. It's lightweight — weighs less than 4 oz. And it's small: volume, only 1.4 cubic inches.

Switches 15 kW peak power at 0.0006 duty cycle. Available in many configurations to meet customer requirements. Applicable to high definition radar systems.



BLP-017D Duplexer
(shown half again actual size)

Electrical Characteristics:

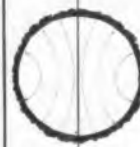
- 68.75-70.75 kMc ■ 2.0 μ s Recovery Time
- 0.005 μ g Spike Leakage ■ 5.0 mw Flat Leakage
- 0.9 db Duplexer Loss ■ 1.3 VSWR

You'll want to know more about the BLP-017D Duplexer, and other quality Bomac microwave tubes and components. Write for technical literature.

BOMAC laboratories, inc.

BEVERLY 21, MASSACHUSETTS
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VARIAN ASSOCIATES, INC.
S-F-D LABORATORIES, INC.
VARIAN ASSOCIATES OF CANADA, LTD.
SEMICON ASSOCIATES, INC.
SEMICON OF CALIFORNIA, INC.
VARIAN A.G. (SWITZERLAND)



MICROWAVES

Shoring Up Microwave Gains

Microwave technology has moved so far so fast, that like a rapidly advancing army, it has outrun its supply lines. One vital area where some backing and filling must now occur is in microwave calibration standards. As the report on the facing page reveals, money spent on standards now is money saved both in the long and the short run.

Another example of how designers can fill in the chinks as the technology matures is the article in this issue describing an elegantly simple concept for electronically scanned antennas.

R&D continues to extend the state of the art, but we can expect considerable achievement in the more prosaic area of following up the breakthroughs with good, sound design.

The damaging lack of microwave standards and joint industry-NBS attempts to solve the problems are described in

Closing the Gap in Microwave Standards 166

Hybrid couplers form the basis of a new scanning matrix that drastically reduces the number of components required in corporate structure antennas. For details and performance, read

Beam-Forming Matrix Simplifies Design of Electronically Scanned Antennas 170

Eliminating RFI and harmonics in microwave testing often calls for nonstandard filters. These can be readily designed and fabricated in-plant from available materials as described in

Rapid Design of Coaxial Low-Pass Filters 174

An 18-Gc backward-wave oscillator and a small traveling-wave tube delivering up to 25 w cw from 5 to 11 Gc are featured in

Microwave Products 178

CIRCLE 189 ON READER-SERVICE CARD

Closing the Gap in Microwave Standards

A GRADUAL attack on glaring deficiencies in microwave standards is under way, thanks to joint action by industry and the National Bureau of Standards. However, a lack of adequate standards will continue to plague industry and hamper the growth of microwave technology unless the pace of research and financing is greatly accelerated.

The vehicle for this industry-NBS teamwork is a continuing series of Measurement Research Conference meetings organized by the quality control committee of the Aerospace Industries Association. These meetings, and an industry survey of measurement needs, were undertaken at the request of the Air Force, with the Sperry Gyroscope Co. serving as project sponsor.

At almost half of the meetings held or scheduled to date microwave standards have been either the sole or principal topic of discussion. The most recently concluded meetings, in late January, dealt with pulse voltage, rf voltage, field strength, rf peak power and noise—all in the microwave spectrum. Earlier meetings in 1960 covered microwave power and attenuation. Forthcoming meetings will discuss impedance (June), material measurements (November), and frequency calibration (early 1962).

At these meetings industry can explain its

particular measurement problems to NBS and recommend how the bureau may invest its limited R&D budget most effectively. Bureau scientists, on the other hand, counter with suggestions of how industry might reduce the work load imposed on NBS.

Snarl in Standards Costs Industry Money and More

With frankness on both sides, some rather grim instances have been revealed of the price industry is paying for inadequate standards.

- A company scheduled to deliver an order of 400 parametric amplifiers last year delivered only 50 and is producing the balance at half the scheduled rate. Lack of proper noise measurement standards has delayed design, production and testing of these \$10,000 amplifiers.

- Test equipment worth \$250,000 is shuttling between vendor and client. They cannot agree on peak power performance of the units because of differently calibrated inspection equipment.

- A large organization has three engineers permanently assigned to resolving discrepancies between its own test instruments and those of the company's suppliers. They've been on the job three years now and look forward to continued equipment.

- Another company spent \$25,000 for radio-frequency-interference measuring equipment and then had no confidence in the indicated results.

- Radars have been closed down because of uncertainty as to their radiation hazard to personnel.

- Almost a million dollars was wasted in the design of a radome because of a lack of attenuation calibration services in Ku band accurate to a few tenths of a decibel in a 60-80 db range.

Overdesigning Among Evils Spawned by Uncertainty

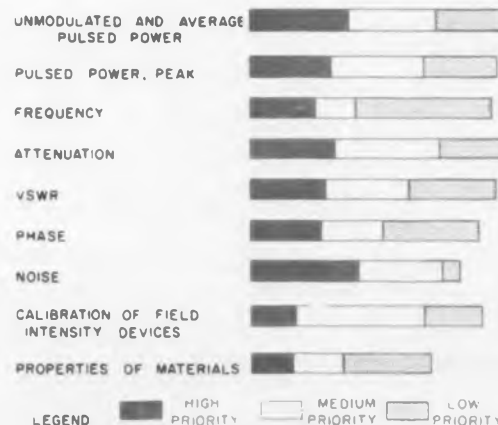
Repeated instances have been cited where equipment was overdesigned to compensate for the uncertainty of test measurements. Often microwave tubes contain built-in adjusters that would be unnecessary if performance could be measured accurately in the first place. Weight, size and cost increases for equipment, caused by uncertainty of calibration, were continuously reported by conference participants.

For its part, NBS complained about the type of equipment sometimes submitted for calibration, unusual calibration requests, and imperfect knowledge of the equipment on the part of those who submit it. For example:

- One of the better known makes of attenua-



Rotary-vane broadband attenuator on table stirs discussion among Sperry Gyroscope engineers (left to right) Allan James, Lloyd Wilson and John Korewick.



Priorities of microwave calibration needs, according to a 40-company survey by Aerospace Industries Association. Highest priority needs are for power, attenuation and noise standards.

NOW... S-BAND, NON-DEGENERATE AMPLIFIERS

with bandwidths up to 75 mc
at 15 db gain!



FOR MILITARY ENVIRONMENTS!

Broadband parametric amplifiers for applications at L, S, C, and X band are available now from Texas Instruments. The S-band model, designed with a TI XD-500 gallium arsenide diode, gives bandwidths up to 75 mc at 15 db gain. Gain variation is no greater than 3 db over temperatures ranging from -40°C to $+50^{\circ}\text{C}$, and the unit meets the vibration requirements of MIL-E-5400D. Noise figure, including circulator loss is 3 db. The associated circulator is a miniaturized, three-port ferrite unit with 0.5 db insertion loss and 20 db isolation.

TYPICAL MODEL S-22 SERIES SPECIFICATIONS

| | |
|----------------------------|--|
| frequency | 2.8 to 2.96 Gc |
| bandwidth | 40 mc |
| gain | 15 db |
| noise figure | 3 db |
| (includes circulator loss) | |
| pump frequency | X band |
| diode | Texas Instruments XD-500 $F_c \approx 70$ kmc at -2 v bias |
| temperature range | -40°C to $+50^{\circ}\text{C}$ |
| vibration. | per MIL-E-5400D |
| pump power | 50 mw |

For details on TI's S-band amplifiers, write for Bulletin No. DLA-1217. For information on specific applications at all frequencies, contact **MARKETING DEPARTMENT**.

TEXAS INSTRUMENTS
INCORPORATED
P. O. BOX 6115
DALLAS 22, TEXAS
APPARATUS DIVISION

CIRCLE 190 ON READER-SERVICE CARD



MICROWAVES NEWS

tors was found to be position-sensitive. The device exhibited substantially different attenuations when oriented vertically and horizontally.

- Attenuators can be thrown out of adjustment by the torque exerted on the unit by poorly mated waveguides. The guides should be carefully fitted to the attenuator.

- Many of the standards submitted for calibration are not designed for interlaboratory transfer. They travel poorly and are difficult to adjust.

- Much of the equipment submitted is of test-bench quality and does not have the inherent accuracy to warrant calibration against a primary standard.

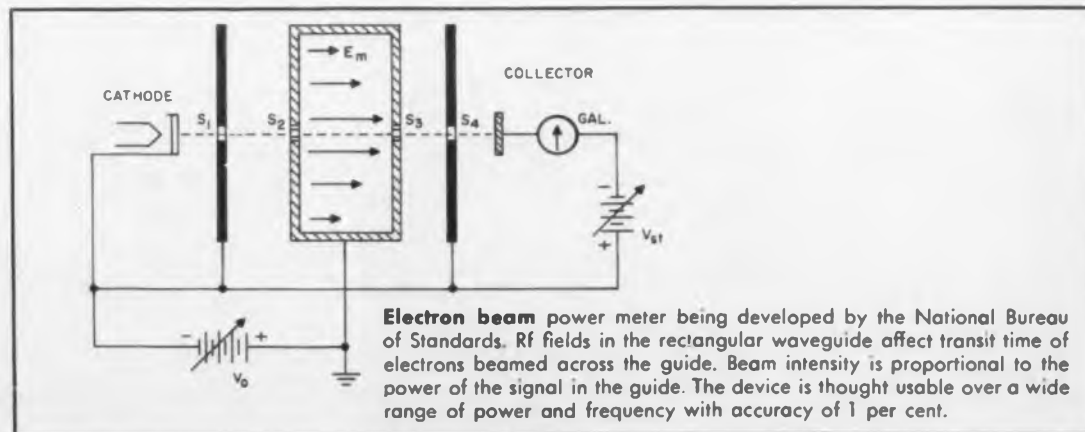
- Requests are received for calibration at non-standard frequencies and power levels. The bureau can process most efficiently calibrations that have been reduced to routine.

- Defective equipment is occasionally submitted. Often adjustment and scale dials have excessive backlash, which destroys whatever calibration accuracy the bureau would specify.

Power, Attenuation and Noise Standards Needed Urgently

Industry spokesmen, on the other hand, complain that NBS is too conservative in specifying calibration accuracies, takes too long to perform calibrations, and offers only a limited range of microwave services.

The most urgent microwave standards requirements are for power, attenuation and noise, according to an AIA survey of 40 microwave companies. Generally these standards should extend beyond X-band and should cover extreme high and low limits of performance.



"The newness and rapid growth of microwave technology has resulted in a serious lack of standards that is costing industry millions of dollars each year," declares Lloyd Wilson, chief of Sperry's primary standards laboratory and a member of the AIA measurements project team. He adds that because of this gap, companies are establishing their own standards, whose compatibility with standards of other companies and the military is questionable.

The present jam-up at NBS is essentially one of too much work and too little money (see Editorial, "A Fair Week's Work for a Fair Day's Pay," Aug. 17, 1960, *ELECTRONIC DESIGN*). Bureau funds were cut during the 1950's and personnel has only now returned to the level of ten years ago.

Microwave instruments are submitted for calibration in large quantities. During the latter half of 1960, the NBS radio standards division at Boulder, Colo., calibrated 156 microwave standards for industry. The time expended was approximately 1,500 man-hours.

Microwave calibration services now available include:

- Attenuation—300 mc to 18 Gc, 0 to 50 db, directional couplers.
- Frequency—300 mc to 75 Gc, cavity meters.
- Power—8.2 to 12.4 Gc, 0.1 to 10 mw, bolometer mounts, and 10 to 100 mw, dry calorimeter.
- Impedance—8.2 to 14 Gc, vswr 1.01 to 1.5, waveguide reflector.

Stringent Budget Slowing Microwave R&D Progress

To expand this range of services, NBS has a budget of only \$300,000 for microwave R&D for

this fiscal year. In response to military and industrial requirements, the bureau is advancing development of several new microwave standards for future introduction. However, Robert Beatty, chief of the microwave circuits section at Boulder, notes that the shortage of funds and personnel restricts development and that some of these new standards may be a year or more removed from operation.

The most likely candidate for early application is a noise standard to operate at several frequencies in X band. The device will calibrate gas-discharge tubes against a hot load. Calibration is expected to cover an excess noise ratio of about 15 db with an accuracy of ± 0.03 db. NBS hopes to make this service available before the end of 1961.

Also on the way is a field-strength standard that will calibrate the gain of microwave horns at X band. Horns will be calibrated over a range of 10 to 20 db gain, accurate to 0.1 db. Introduction of this standard is stalled for lack of a microwave dark room to perform tests.

A new type of microwave power standard employing electron beams is also being developed at NBS. The technique consists of accelerating an electron beam transversely through an evacuated section of waveguide. Intersection between the fields in the guide and the beam makes the transit time of the electrons vary according to the rf power in the guide.

An X-band standard is being built along these lines to measure peak or average power from 100 w to 100 kw. The technique could be extended to cover a wide range of frequencies and powers. Accuracy should be about 1 per cent.

Another novel technique in development at NBS is a two-channel modulated sub-carrier means to measure phase shift but that can also be applied to a variety of other microwave measurements. The channel containing the device under test is audio-frequency modulated. This channel is mixed with an unmodulated channel and fed to a crystal detector. Thus the microwave measurement is essentially performed at a lower frequency, where a variety of accurate standards are already available. When completed, the two-channel phase-shift standard will operate in X band with an accuracy of 0.1 deg.

Also being readied by NBS is a high-power adiabatic calorimeter to measure average power from 1 w to 100 w at X band. The projected accuracy is 1 per cent. ■ ■

NEW! DIRECT READING FREQUENCY METER

a full octave and beyond
3.95 to 11.0 KMc

DELIVERY FROM STOCK

Meet the newest member of the FXR "family" of direct reading frequency meters. This coaxial type, Model No. N414A, has a range from 3.95 KMc to 11.0 KMc and by use of FXR Series 601 coax to waveguide adapters converts to waveguide setups. The unit covers "a full octave and beyond" with an absolute accuracy of 0.1% throughout its range. It is a perfect companion for the FXR Models No. C772 and X772 signal sources.



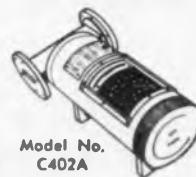
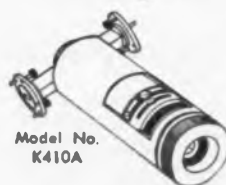
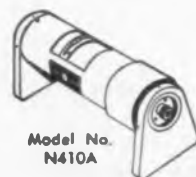
Model No. N414A Price: \$495.00

- Direct reading from 3.95 to 11.0 KMc
- Covers a full octave and beyond
- Reaction type with 0.1% absolute accuracy
- Non-contacting choke for long life and high Q
- Standard Type N Connectors for universal utilization

This newest direct reading frequency meter augments FXR's existing line, recognized as the largest in the industry. Direct reading, reaction type units are available for use up to 39.5 KMc while micrometer types extend FXR's coverage up to 220 KMc.

Write or call now for data sheets on Model No. N414A and other units in the integrated FXR family of precision frequency meters.

FXR "FAMILY" OF DIRECT READING REACTION TYPE FREQUENCY METERS



| Model No. | Frequency Range (KMc) | Absolute Accuracy (%) | Approx. Q | Waveguide Type WG-1/2 U | Flange Type UC-1/2 U | Price (F.O.B. Woodside) |
|------------------------|-----------------------|-----------------------|-------------|----------------------------|-------------------------|-------------------------|
| COAXIAL TYPES | | | | | | |
| N410A | 1.00- 4.00 | 0.10 | 3000 | 1/2" Coax Type N | | \$495.00 |
| N414A | 3.95-11.0 | 0.10 | 500 to 1500 | 1/2" Coax Type N | | 495.00 |
| WAVEGUIDE TYPES | | | | | | |
| W410B | 3.95- 5.85 | 0.08 | 8000 | 49 | 149A | 250.00 |
| C410B | 5.85- 8.20 | 0.08 | 8000 | 50 | 344 | 180.00 |
| W410B | 7.05-10.00 | 0.08 | 8000 | 51 | 51 | 165.00 |
| X410B | 8.20-12.40 | 0.08 | 8000 | 52 | 39 | 150.00 |
| Y410A | 12.40-18.00 | 0.10 | 4500 | 91 | 419 | 210.00 |
| K410A | 18.00-24.50 | 0.10 | 4000 | 53 | 425 | 230.00 |
| U410A | 24.50-39.50 | 0.10 | 3000 | 96 | 381 | 250.00 |
| C402A | 5.85- 8.20 | 0.03 | 8000 | 50 | 344 | 1275.00 |
| X402A | 8.20-12.40 | 0.03 | 8000 | 52 | 39 | 1275.00 |

• With transmission coupling probe.

DELIVERY FROM STOCK

FXR M.M. TYPES (Micrometer Reading)

| Model No. | Frequency Range KMc | Price (F.O.B. Woodside) |
|-----------|---------------------|-------------------------|
| Q410X | 33-50 | \$325.00 |
| M410X | 50-75 | 300.00 |
| E410X | 60-90 | 500.00 |
| F412A | 90-140 | 750.00 |
| G412A | 140-220 | 750.00 |

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MICROWAVES

Beam-Forming Matrix Simplifies Design of Electronically Scanned Antennas

A drastic reduction of components in electronically scanned arrays is achieved by using a matrix of hybrid dividers in place of the usual three-port dividers. A 64 x 64 array would require less than 25,000 hybrids as compared to almost one-half million three-port dividers needed in a conventional design. Authors Jesse Butler (left) and Ralph Lowe also describe an auxiliary combining network to form cosine order beams which require only a few additional hybrids.

Jesse Butler,* Ralph Lowe

Sanders Associates,
Nashua, N. H.

ELECTRONIC scanning of corporate structure antennas ordinarily requires a separate power dividing and phasing matrix for every beam formed. Thus, the number of components needed for large, fully steerable arrays can reach astronomical proportions.

To form a single beam in a conventionally designed 64-element linear array requires 63 power dividers. In the Sanders beam-forming matrix, however, a network of 192 hybrids forms 64 independent beams from the same 64-element array. Each beam has the full gain corresponding to the projected aperture of the array. Beams overlapping at the $2/\pi$ voltage levels essentially cover a full hemisphere of space.

This performance is achieved by utilizing the phase shifts occurring in hybrid dividers.

The basic unit of the system is a 3-db directional coupler combined with a fixed phase shifter or differential length of transmission line (see Fig. 1). A signal fed to one of the four ports is divided into two equal outputs. One output remains in relative phase with the input, while the other is shifted in relative phase by 90 deg. (In Fig. 1 and throughout this article, the 90-deg phase shift occurs between diagonally opposite ports.)

Conversely, two signals 90-deg out of phase applied to different ports are coupled into one of two mutually isolated ports. Isolation between

*Now with Advanced Development Laboratories Nashua, N.H.

ports exceeds 20 db. This signal-combining mode occurs when the array functions as a receiving antenna. In a transmitting array, the hybrids operate as signal dividers.

To form a multiple-beam array, the phase of each radiating element is assigned by the following rule:

In a linear array of 2^m equispaced elements, the phase difference between any two elements 2^{m-1} apart increases (or decreases) 90 deg when the antenna pattern axis is rotated by slightly more than 1/2 of the 1/2-power beamwidth.

Hybrid phase shifter "building blocks" are combined accordingly.



An eight-element, eight-beam array designed in this manner is shown in Fig. 2. Note the separate input terminals corresponding to each beam. All elements radiate regardless of the beam that is being formed, but their phase relationships are varied for each beam by the passage of the signal through the matrix.

To illustrate, signal flow for the "2 Right" beam is shown in color in Fig. 2. Phase shifts are expressed in units of $\pi/16$. Signals traversing a hybrid *diagonally* are shifted 90 deg (eight units). Fixed phase shifters, represented by circles, impose additional phase shift denoted by the number within the circle. Phase shifts at various internal points in the matrix are indicated, as

Table 1. Radiating element phases for eight-beam array

| Beam | Phase Diff. | Radiating Element | | | | | | | |
|------|----------------|-------------------|----|----|----|----|----|----|----|
| | | A | B | C | D | E | F | G | H |
| 4L | $14\pi/16$ rad | 16 | 30 | 12 | 26 | 8 | 22 | 4 | 18 |
| 3L | $10\pi/16$ " | 12 | 22 | 0 | 10 | 20 | 30 | 8 | 18 |
| 2L | $6\pi/16$ " | 10 | 16 | 22 | 28 | 2 | 8 | 14 | 20 |
| 1L | $2\pi/16$ " | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 1R | $-2\pi/16$ " | 24 | 22 | 20 | 18 | 16 | 14 | 12 | 10 |
| 2R | $-6\pi/16$ " | 20 | 14 | 8 | 2 | 28 | 22 | 16 | 10 |
| 3R | $-10\pi/16$ " | 18 | 8 | 30 | 20 | 10 | 0 | 22 | 12 |
| 4R | $-14\pi/16$ " | 18 | 4 | 22 | 8 | 26 | 12 | 30 | 16 |

Note: Phase is expressed in units of $\pi/16$ radians

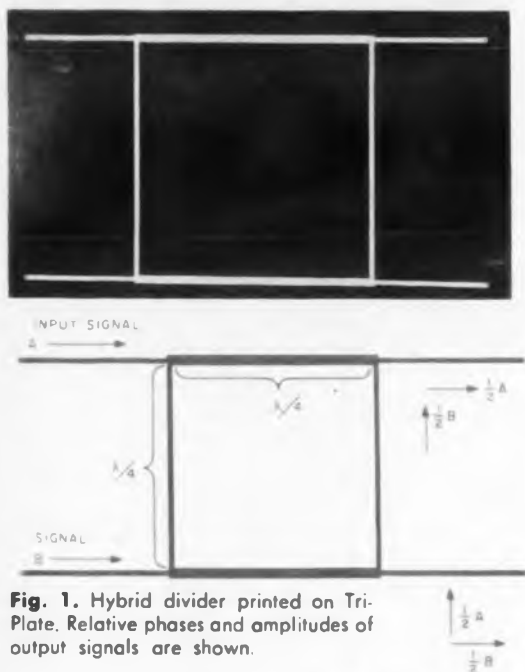


Fig. 1. Hybrid divider printed on Tri-Plate. Relative phases and amplitudes of output signals are shown.

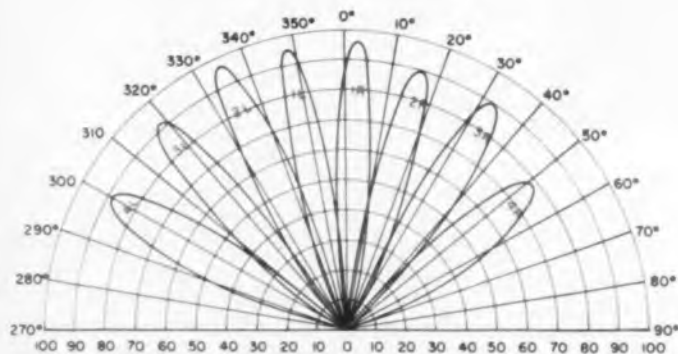


Fig. 3. Eight-beam radiation pattern formed by Sanders matrix. Beams overlap at the -4 -db points. Radiating elements are spaced at half-wavelength intervals. Beams are amplitude-tapered.

are the final shifts at the radiating elements with respect to the input.

Output phases for each of the eight beams are listed in Table 1. The phase differences between adjacent radiators are uniform for any given beam, but vary from beam to beam as shown.

In this array, $2^{m-1} = 4$. As required by the previously stated rule, the phase difference between radiators so spaced changes 90 deg when the beam is shifted. For example, the phase difference between elements A and E is -8 units for the "4 Left" beam. This relationship also holds between elements B and G, elements C and H, etc.

The eight patterns formed by this array overlap at the -4 db points. Elements are spaced

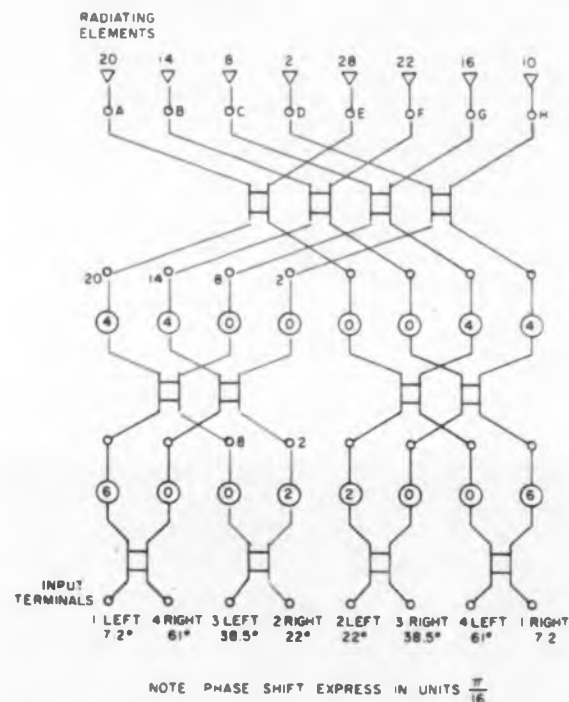


Fig. 2. Eight-element, eight-beam matrix. Signal path for the "2 Right" beam is shown in color. Squares denote the hybrid couplers used in the matrix; circles denote fixed phase shifters. Numbers within the circles indicate the amount of phase shift applied. Relative phase shifts of signals are shown at various points in their passage from the input terminal to the radiating elements. Note that signals crossing a hybrid diagonally are shifted eight units (90 deg).

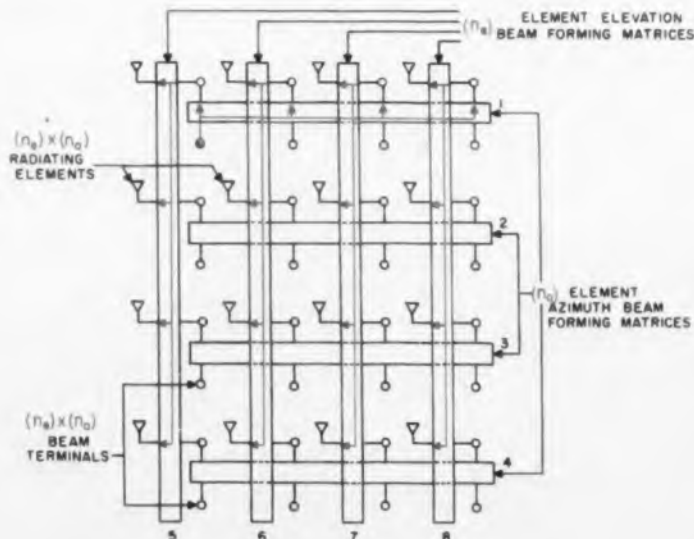


Fig. 4. Two-dimensional, 4×4 hybrid matrix. Signal flow for one beam is shown in color. The azimuth-directive pattern formed by one set of matrices is superimposed on elevation-directive pattern formed by second set of matrices. Result is a choice of 16 pencil beams. Conventional design would require Unit employs 32 hybrids; con-96 three-port dividers.



Fig. 5. System diagram for high-power steerable array transmitter employing beam-forming matrix. Input terminals are scanned by programmer controlling the drivers. Master oscillator can be modulated for communications purposes, and individual amplifiers for each radiator result in high-power system.

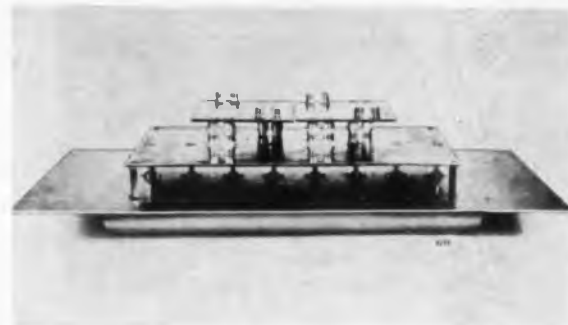
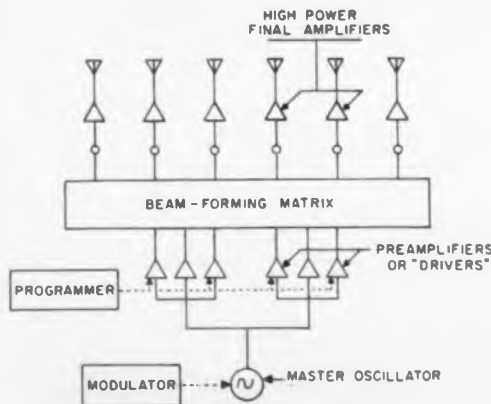


Fig. 7. Eight-element beam-forming matrix built for Jet Propulsion Laboratory. Operating frequency is about 2.1 Gc, bandwidth about 50 mc. Radiators are housed within the cylinder at bottom of unit. Entire assembly is about 40 in. long.

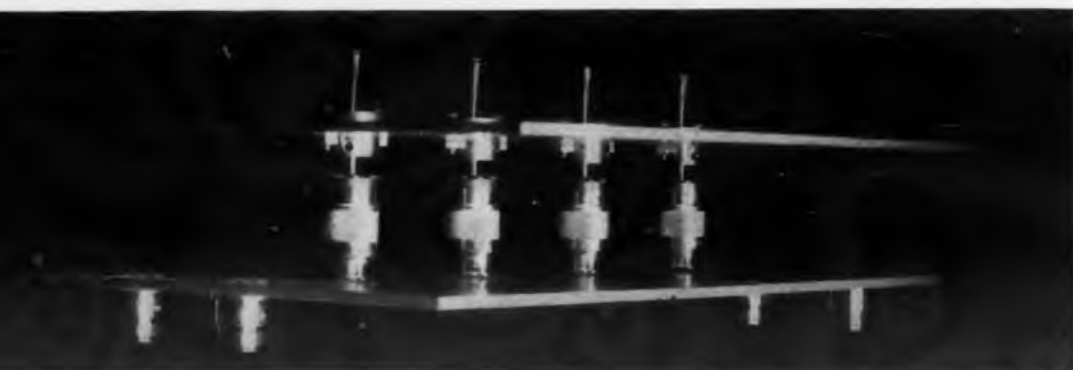


Fig. 6. Four-element beam-forming matrix built on Sanders Tri-Plate. Coax-fed dipole radiators are cut for 3 Gc. Operating bandwidth of unit is about 50 mc.

at half-wavelength intervals and the eight patterns cover almost 180 deg (see Fig. 3).

A 16-element array can be designed by paralleling the matrix of Fig. 2 with an identical network and adding a set of cross-connections through hybrids at the radiating elements.

The extension of this technique to a two-dimensional array is shown in Fig. 4. This simple 4 x 4 array requires eight matrices and a total of 32 hybrids.

Azimuth scanning is controlled by the four horizontal matrices (Nos. 1-4); elevation is controlled by the four vertical matrices (Nos. 5-8). Note that all similar output elements of the horizontal matrices are tied into one vertical matrix. For example, the extreme left-hand outputs of the horizontal matrices are connected to vertical matrix No. 5, while the extreme right-hand outputs are connected to vertical matrix No. 8. Conversely, four identical inputs to the vertical matrices are driven by the same horizontal matrix.

This interconnection scheme permits the vertical matrices to superimpose an elevation-directive phase pattern onto the azimuth-directive phase pattern developed by one horizontal matrix. The result is a choice of 16 pencil beams in two-dimensional space.

The number of hybrid building blocks required to form n beams in either a linear or two-dimensional array of n elements is $n/2 \log_2 n$. Thus, a 64 x 64 array capable of forming 4,096 pencil beams requires 24,576 hybrids. Conventional designs of this capability would require almost 1/2 million power dividers.

The Sanders beam-forming matrix can be considered as a black box with n input terminals and n radiating element terminals. The array could be scanned by a system such as shown in Fig. 5. Medium-power drivers excited by a master oscillator are used as control switches to excite one or more input ports for beam steering. A separate, final amplifier at each element would result in an extremely high power system. In addition, the master oscillator could be modulated for communications purposes. The same black box could also be used in scanning a receiving array with equally flexible applications in radar, countermeasures and communications.

Both the hybrids and fixed phase-shifters can easily be designed for efficient operation over a 50 per cent bandwidth. As the frequency increases, element spacing becomes greater than 1/2 wavelength and the beams narrow and shift toward the broadside axis. However, the same

-4-dB crossover level between adjacent beams is maintained.

Any two beams in the system couple at only one level in the matrix, so that isolation between any two input terminals or two output terminals is greater than the isolation of a single hybrid. Isolations of 25 to 40 db are easily attainable.

The hybrids can be waveguide top-wall or side-wall couplers, or branch-line and parallel-line couplers in waveguide, coax cable or strip-transmission line.

Several experimental arrays have been built to test this design concept. The unit shown in Fig. 6 is a four-element array for 3-kmc operation using directional couplers printed on Sanders Tri-Plate® components. Coaxially fed dipoles serve as radiating elements. A larger, 2.1-kmc array with eight radiating elements was built for the Jet Propulsion Laboratory. (See Fig. 7.) Both of these models were designed for bandwidths of only 50 mc.

Typical beam patterns obtained with the eight-element array are shown in Fig. 8.

The largest matrix built to date is a 16-element unit delivered to Lincoln laboratory. This model operates at 900 mc over a 30 per cent bandwidth.

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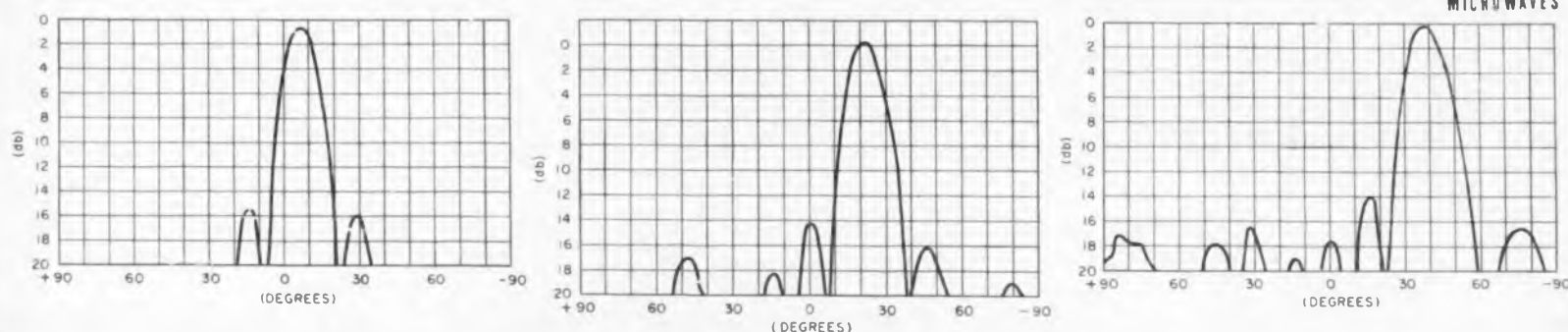


Fig. 8. Three typical beam patterns of unit delivered to JPL. (See Fig. 7.) From left to right: the "1 Right," "2 Right" and "3 Right" beams. Increase in number of sidelobes as beam moves off center is due to reduced projected aperture of the array. Measurements were made at about 2.1 Gc with amplitude tapered illumination. Cosine order beams with reduced sidelobes are discussed in latter half of this article.

Again considering the matrix as a black box, additional hybrid networks can combine adjacent or overlapping beams to form cosine order beams. As contrasted to the -13 -db sidelobes for uniform illumination, cosine taper sidelobes are -23 db, while cosine squared taper sidelobes are -32 db.

Two adjacent beams can be combined with an appropriate phase shifter to form a cosine tapered beam as shown in Fig. 9. The phase shifter adjusts the phase center of one beam to coincide the phase center of the second beam. Isolation between beams is provided by the hybrid coupler, whose unused ports are terminated in a load that matches line impedance.

Several adjacent cosine beams can be formed as shown in Fig. 10. The combining network imposes a 3-db insertion loss, as the power in the matrix beams must be divided between the adjacent beams formed by the network. This power loss is partially compensated by the tapered illumination of the cosine beam.

Individual and adjacent cosine squared beams, which combine three matrix beams, are formed in similar fashion, as illustrated in Figs. 11 and 12, respectively. Again, hybrids provide inter-beam isolation.

In general, the number of adjacent higher order cosine beams that can be formed by an n -beam matrix is $n-y$, where y is the order of the cosine function.

Preliminary study has shown that dissipation losses in the beam-combining network are less than would result from loss tapering the amplitude of each antenna element in the array.

As the order of the cosine function increases, network losses are proportionately reduced as compared to the losses suffered in tapering the individual antenna elements.

In cosine taper illumination, however, network and antenna amplitude tapering losses are approximately equal. ■ ■



Fig. 9. Hybrid connected to form cosine taper illumination beam. Phase shifter adjusts the phase center of one matrix beam to coincide with the phase center of the second matrix beam.

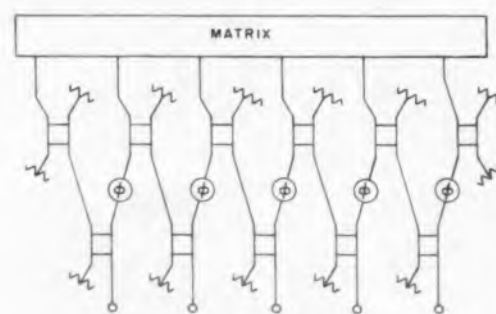


Fig. 10. Several adjacent cosine tapered beams are formed by this pairing of matrix beams. Any one of five cosine beams can be generated by this network.

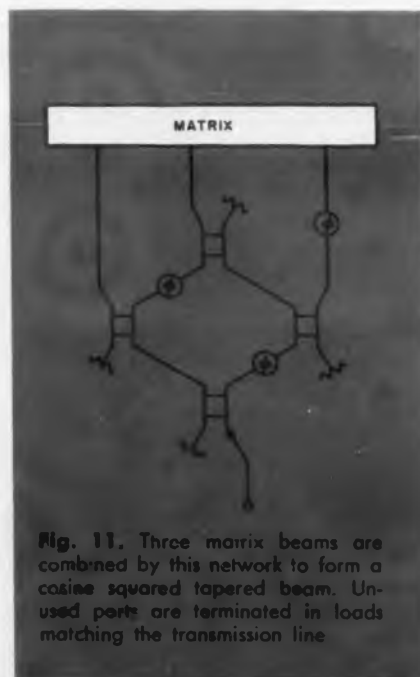


Fig. 11. Three matrix beams are combined by this network to form a cosine squared tapered beam. Unused ports are terminated in loads matching the transmission line

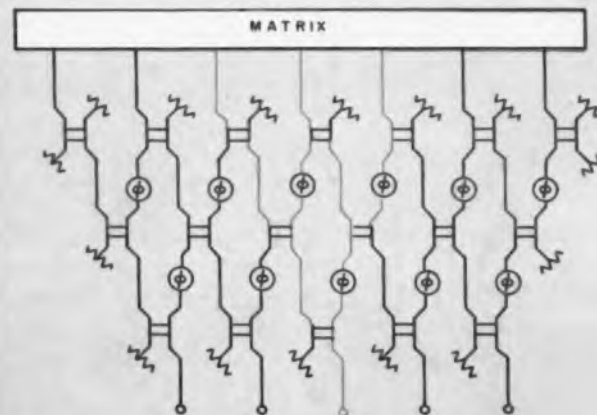


Fig. 12. Matrix beams are combined three at a time by this network to form adjacent cosine squared taper beams. Signal flow for one of the cosine squared beams shown in color.



MICROWAVES

Rapid Design of Coaxial Low-Pass Filters

A convenient method of designing nonstandard, low-pass coaxial filters with pass bands in the 1- to 8-kmc range. Author Bostick has designed more than 25 such units to eliminate RFI and harmonics in field and laboratory testing of radar gear. The filters are readily assembled from stock materials.



Glyn Bostick
Chief Engineer
Radar Design Corp.
Syracuse, N. Y.

THE "varying impedance" type filter can be readily tailored for a desired cut-off frequency in the 1 to 8 kmc frequency range and machined from stock tubing, rod and connectors.

The filter (See Fig. 1) derives its periodic changed characteristic impedance from periodic changes in center conductor diameter. The unit is assembled within a tube chosen to match the diameter of connectors employed in the rest of

the system. Impedance matching sections at each end provide sharp cut-off.

The following design procedure yields the number, thickness and spacing of the filter discs and of the end sections. Insulation is assumed to be Rexolite, styrene, or other suitable plastic with a dielectric constant of about 2.50.

Equations are given for quick computation of average and peak power. Charts of insertion loss and vswr are included to indicate "safe" operating specifications.

The pertinent design specifications are:

- F_c —Cut-off frequency (the frequency for 3-db attenuation)
- A_1 —Attenuation (in db at a specified frequency $F_1 > F_c$)
- Power handling (average and peak)

Once the above are specified and a tube of diameter (D) compatible with the required line size and connectors is chosen, all filter dimensions can be computed from Table 1.

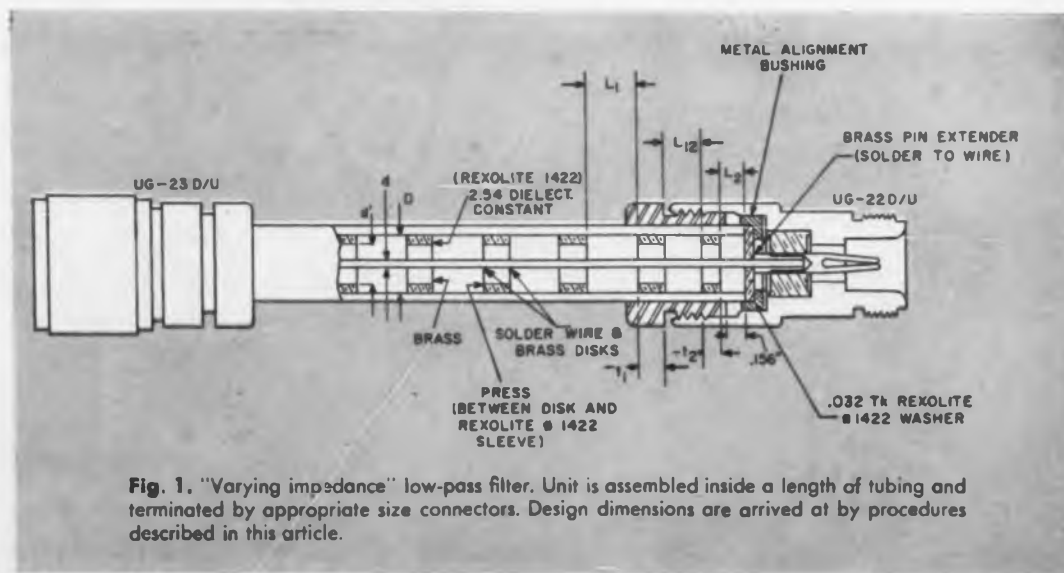


Fig. 1. "Varying impedance" low-pass filter. Unit is assembled inside a length of tubing and terminated by appropriate size connectors. Design dimensions are arrived at by procedures described in this article.

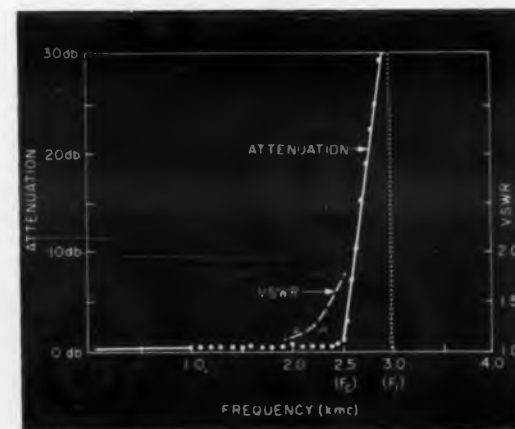


Fig. 2. Performance curves of low pass filter. Unit was designed for cut-off frequency (F_c) of 2.5 kmc, and for 30 db attenuation at 3 kmc. Design exceeds performance specifications.

Table 1. Design data for "varying impedance" low-pass filters

| Dimension | Value |
|----------------------|---|
| D/d' | 1.42 |
| D/d | 8.5 |
| θ_2 (radians) | $= 2 \tan^{-1} (\tan 15^\circ - 4.2 DF_c \times 10^{-6})$ |
| θ_1 (radians) | $= 2 \tan^{-1} (\tan 15^\circ - 3.2 DF_c \times 10^{-6})$ |
| t_2 | $\frac{\theta_2 \lambda_c}{13.1}$ |
| t_1 | $\frac{\theta_1 \lambda_c}{10}$ |
| L_{12} | $\frac{\lambda_c}{9.09}$ |
| L_2 | $\frac{\lambda_c}{21}$ |
| L_1 | $\frac{\lambda_c}{8}$ |

NOTE: physical dimensions in inches
angles in radians
frequency in Mcps

Note that the inside diameter of the tube determines the diameters of the center conductor and of the filter disks.

The designer next computes θ_1 and θ_2 —the effective electrical lengths between filter disks and between the filter and end disks. These dimensions, together with the cut-off wavelength, determine the thicknesses of the disks.

The spacing between each pair of filter disks is L_1 ; the spacing between end disks and filter disks is L_{12} ; and spacing between end disks and the end of the filter is L_2 . Each of these spacings is a fraction of the cut-off wavelength as indicated in the table.

The total number of filter disks (N) is given by:

$$N = \frac{A_1}{35 \left[\frac{F_1}{F_c} - 1 \right]} \quad \text{(Rounded up to the next higher integer)} \quad (1)$$

Where:

- F_1 = attenuation frequency
- A_1 = attenuation in db at F_1
- F_c = cut-off frequency

All frequencies are expressed in megacycles.

Average power rating is established as that power which can be handled without filter tem-

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• broadband coaxial ferrite isolators

Excellent electrical characteristics with extreme versatility! $\frac{1}{8}$ " coaxial line construction allows higher power operation with $\frac{1}{8}$ " connectors, up to 20 kw peak, 400 watts average. (Normally supplied with Type N, $\frac{3}{8}$ " connectors; 10 kw peak, 10 watts average.) Features 15 db isolation and 1 db max. insertion loss. VSWR is 1.25 max. based on 2:1 load mismatch; 1.15 max. into matched load. Model 1233: 2.0-4.0 kmc; model 1233-1: 3.0-5.5 kmc; \$450. each.



• low power broadband waveguide ferrite isolators

Provide maximum load isolation and minimum insertion loss over full standard waveguide frequency ranges. Extremely useful for maintaining signal source stability and eliminating long line and frequency pulling effects. Front-to-back ratios are the highest available on the market today: C Band—26:1, \$250; XN Band—25:1, \$225; XB Band—30:1, \$235; X Band—30:1, \$220.



• high power broadband waveguide ferrite isolators

The only line of high power isolators that covers all of X Band with just two models (8.2-10.0 kmc and 10.0-12.4 kmc), each with front/back ratio of 40:1. Input power rating: 250 kw peak, 300 watts average, achieved through use of special high Curie temperature ferrite materials. VSWR is 1.05 max. with matched load; 1.10 max. with 3:1 mismatch. Only \$175 each. Model with same VSWR, 28:1 front/back ratio, 300 kw peak, and 300 watts average, for 7.05-10.0 kmc, \$195.



• other ferrite devices— consult NARDA for:

- Circulators • Phase shifters • Modulators • Attenuators • Special Isolators

For more information, write to Dept. ED-1.



the narda corporation

118-160 HERRICKS ROAD, MINEOLA, L. I., N. Y. • PIONEER 6-4650

CIRCLE 192 ON READER-SERVICE CARD



Now! Get premium features in a DVM priced at only \$940

Cubic Corporation announces the V-45 — the first low-cost digital voltmeter with premium features. Now industrial users can buy a top-quality, precision four-digit instrument at a price they can justify—only \$940. Here are the premium features you get in a V-45:

Floating Input: Both sides of the input may be floated above or below ground. The floating input circuit provides more than 80 db rejection to 60-cps common-mode signals. A grounded input is also supplied.

Extended Range: A 10% extension is incorporated in each of the V-45's three ranges. Voltages up to 10.999 may be read on the 10-volt range; voltages up to 109.99 may be read on the 100-volt

range; and voltages up to 1099.9 may be read on the 1000-volt range. Therefore, the operator need not constantly shift back and forth between ranges when reading close to the normal upper limit of a range.

Transistorized Logic and Drive Circuit: The V-45 DVM uses construction techniques representing the latest state-of-the-art, with all-transistorized circuitry driving reliable stepping switches.

Cubic manufactures a complete line of quality digital instruments, including a-c and d-c voltmeters, ohmmeters, ratiometers, scanners and printer controls. Write for literature to Dept. ED-103, Industrial Division, Cubic Corporation, San Diego 11, California.

CIRCLE 193 ON READER-SERVICE CARD

SPECIFICATIONS

MODEL V-45 DIGITAL VOLTMETER

Input Impedance: 10 megohms at balance.

Ranges: Manually selected, 10% extended range

Low ± 0.000 to ± 10.999 vdc

Mid ± 00.00 to ± 109.99 vdc

High ± 000.0 to ± 1099.9 vdc

Sensitivity: 1 millivolt

Sensitivity Control: Continuously variable from 1 digit to standby lockout.

Power Input: 105-125 vac, 50-60 cps, 25 watts standby, 30 watts operating.

Dimensions: 19" wide, 5 1/4" high, 14" deep, rack or bench mounting with dust-proof switch and bridge section.

Average Balancing Time: Less than 2 sec.



cubic
CORPORATION



MICROWAVES

perature exceeding 70 deg C at 25 deg C ambient. The appropriate equation is:

$$P_{ave} \cong \frac{\pi \lambda_c D}{60} (65N+100) \text{ w} \quad (2)$$

The cut-off wavelength (λ_c) and D are expressed in inches.

Peak power, at which arcing will probably occur, is:

$$P_p \cong \frac{d^2}{4} \times 10^5 \text{ w} \quad (3)$$

Again, d is expressed in inches.

Procedure Demonstrated By Design of Typical Filter

As an illustration of this method, we can consider the design of a filter to the following specifications:

$$F_c = 2,500 \text{ mc}$$

$$F_1 = 3,000 \text{ mc}$$

$$A_1 = 30 \text{ db minimum}$$

Connectors = Type N (3/8-in. line)

$$P_{ave} = 10 \text{ w}$$

$$P_p = 15 \text{ kw}$$

A convenient size tube, requiring little alteration of the type N connectors is 7/16-in. OD (0.312-in. ID) brass tubing.

Next compute the number of filter sections (N) according to Eq. 1.

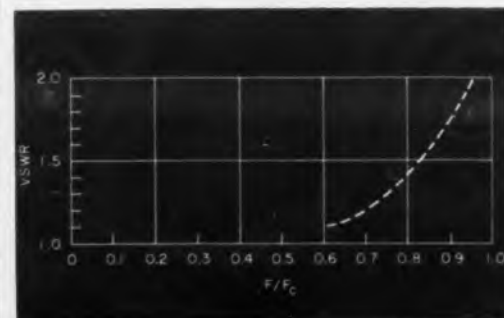


Fig. 3. VSWR characteristic of "varying impedance" filters. Ratio increases sharply as operating frequency approaches cut-off frequency.

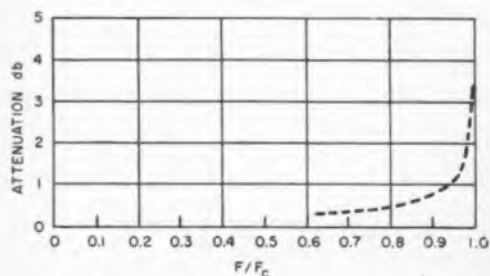


Fig. 4. Insertion loss characteristic of filter. As in Fig. 3, curve shows advantage of operating well below the cut-off frequency.

$$N = \frac{A_1}{35 \left[\frac{F_1}{F_c} - 1 \right]} = \frac{30}{35 \left[\frac{3,000}{2,500} - 1 \right]} = 4.3 \text{ (5 rounded up)}$$

Next check the power rating of the filter by use of Eqs. 2 and 3.

$$P_{ave} = \frac{\pi \lambda_c D}{60} (65N + 100) = \frac{\pi \times 4.72 \times 0.312}{60} [(65 \times 5) + 100] = 32.8 \text{ w}$$

For the peak power calculation, the design table shows $D/d = 8.5$, and $d = 0.0367$ in.

$$P_p = \frac{d^2}{4} \times 10^8 = \frac{(0.037)^2}{4} \times 10^8 = 34.2 \text{ kw}$$

Ratings exceed requirements by a wide margin.

If ratings are too low a larger tube diameter is required. Physical dimensions specified in the table are:

$$\begin{aligned} L_2 &= 0.224 \text{ in.} \\ L_{12} &= 0.520 \text{ in.} \\ L_1 &= 0.590 \text{ in.} \\ t_1 &= 0.225 \text{ in.} \\ t_2 &= 0.167 \text{ in.} \end{aligned}$$

Performance of this filter is illustrated in Fig. 2. Attenuation at 3 kmc (F_1) is well above the required 30 db. The vswr is minimal over most of the passband.

The designer can minimize filter insertion loss and vswr for a given frequency range in the pass band by choosing a sufficiently high cut-off frequency as determined from Figs. 3 and 4. ■ ■

2 NANOSECOND MICROWAVE SWITCHING with SOLID STATE RELIABILITY



Microwave Associates' new coaxial switches provide:

- Efficient switching across the microwave spectrum
- Solid-state reliability for military applications
- Lightweight (approx. 5 oz.) ruggedized construction
- Low driving power — from 10 to 100 milliwatts
- Power handling capability \uparrow 4 watts CW (S.P.S.T. unit)
 \uparrow 150 watts peak at 0.001 duty cycle
- Low insertion loss — as low as 0.2 db

Solid-state switches are as good as the semiconductors they incorporate. All units described use the most advanced microwave silicon diodes available, specifically developed for this function by Microwave Associates Semiconductor Division.

LOW POWER LEVEL COAXIAL SWITCHES

| Frequency (Mc) | Insertion Loss (Max) | Isolation (Min) | Switching Power |
|----------------|----------------------|-----------------|-----------------|
| 210-240 | 0.2 db | 20 db | 10 mw |
| 260-340 | 0.2 db | 18 db | 10 mw |
| 400-500 | 0.3 db | 20 db | 10 mw |
| 570-630 | 0.3 db | 20 db | 10 mw |
| 900-1000 | 0.3 db | 20 db | 10 mw |
| 1250-1350 | 0.5 db | 20 db | 10 mw |

MEDIUM POWER LEVEL COAXIAL SWITCHES

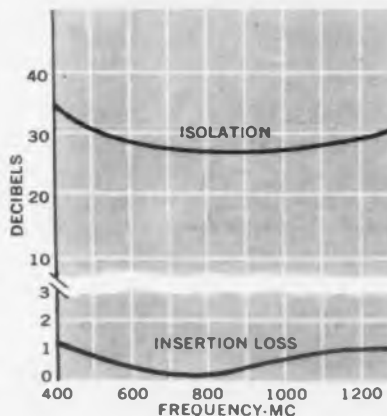
| | | | |
|-----------|--------|-------|-------|
| 200-1000 | 1.5 db | 22 db | 70 mw |
| 1000-2000 | 1.5 db | 20 db | 70 mw |
| 2000-4000 | 2.0 db | 16 db | 70 mw |

LOW POWER LEVEL VOLTAGE VARIABLE ATTENUATORS

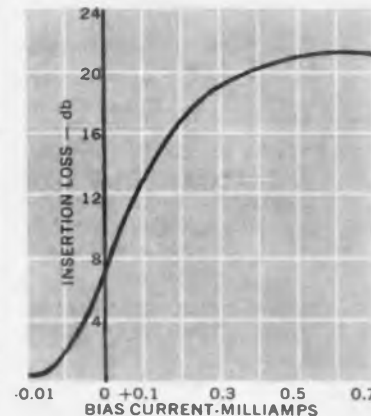
| Frequency (Mc) | Attenuation Range |
|----------------|-------------------|
| 260-340 | 0.2 db-18 db |
| 400-450 | 0.3 db-20 db |
| 570-630 | 0.3 db-20 db |
| 1250-1350 | 0.5 db-20 db |

Narrow-band higher frequency units are available with lower loss and increased isolation.

TYPICAL PERFORMANCE BROADBAND MICROWAVE SWITCH SPST



TYPICAL PERFORMANCE VOLTAGE VARIABLE ATTENUATOR (425 Mc=25)



Units for handling higher powers are now in development. Microwave Associates has capabilities for meeting your requirements for single-pole multiple-throw and waveguide switching devices. Our switches invite comparison. We invite your inquiries.

A quotation/data sheet will be sent on request.

MICROWAVE ASSOCIATES, INC.
ELECTRON TUBE AND DEVICE DIVISION, Burlington, Mass.



Western Union FAX • TWX: Burlington, Mass., 942 • BRowing 2-3000

CIRCLE 194 ON READER-SERVICE CARD

NEW!

DC to 15 mc



ETC Model K-120 OSCILLOSCOPE

...for the *Ultimate in Waveform Observation*

WIDE BANDWIDTH—DC to 15 mc.

PLUG-IN SWEEP DELAY—1) Delays main sweep, 2) Brightens segment to be delayed, 3) Substitutes for main sweep.

PLUG-IN PRE-AMPLIFIERS

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High-Frequency—50 mv/cm, DC to 15 mc.
High-Gain—5 mv/cm, DC to 12 mc.

100x SWEEP MAGNIFIER—5 ranges.

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PLUG-IN, CRYSTAL-CONTROLLED TIME-MARK GENERATOR—10,000 to 1 range.

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MICROWAVES

MICROWAVE PRODUCTS



Backward-Wave Oscillator

693

Range is 12.4 to 18 Gc

Model OD 12-18 backward-wave oscillator delivers 10 mw min power output from 12.4 to 18 Gc. With uniform power over the range, it is suitable for swept signal generators and similar uses. The helix-type tube is made of hard glass and metal. It is enclosed in a protective metal capsule, with an RG91/U output connector on RG55U coaxial cable.

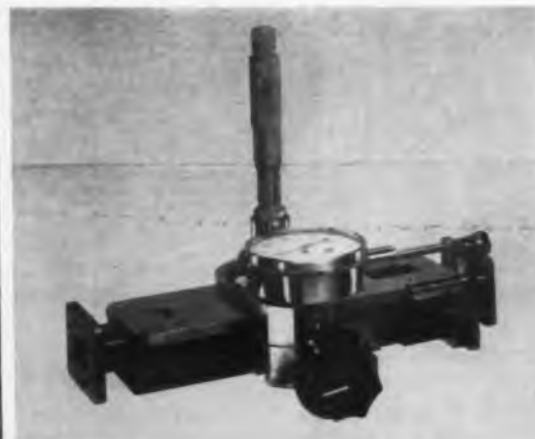
Stewart Engineering Corp., Dept. ED, Santa Cruz, Calif.

Price: \$1,000.

Slide-Screw Tuner

695

Cancels small reflections



Precision slide-screw tuner adjusts to very small values of return loss or vswr. Micrometer and dial gage indicators allow precision measurement of phase and amplitude positions. Models 732 through 739 cover frequency spans between 2.60 and 18.0 Gc. The device will tune a 25:1 vswr to near unity, and provides at least one guide wavelength linear travel of probe at each frequency range.

Omega Laboratories, Inc., Dept. ED, Rowley, Mass.

P&A: \$250 to \$375; 2 weeks.

**Waveguide Switch**

694

For RG-51/U systems

MA-1064 is a spdt waveguide switch for use in RG-51/U waveguide systems over 7.05 to 10.0 Gc range. Switch is rated at 300 kw peak power unpressurized, and 500 kw peak power when pressurized to 2 atmospheres. Insertion loss is 0.15 db, vswr 1.10 max; isolation exceeds 35 db. Holding current is 150 ma; switch may be operated at ambient temperatures to 125 C. A 28-v rotary solenoid provides high operating torque. Switch body is a cube of 1-7/8 in. Switching time is 55 msec max.

Waveguide Systems Div., Microwave Associates, Inc., Dept. ED, Burlington, Mass.

P&A: \$395; stock to 30 days.

**Traveling-Wave Tube**

696

Produces 28 w cw

Up to 28 w of continuous power has been produced over a range of 5 to 11 Gc by the STX-182 traveling-wave tube, with 40 w expected. Using a column of permanent magnet rings as the focusing structure, the tube is 9 in. long and weighs 1 lb. Gain is 32 db. Tube life of more than 2 years under continuous operation in space environment is expected.

Sperry Rand Corp., Sperry Gyroscope Co. Div., Electronic Tube Div., Dept. ED, Great Neck, N. Y.

P&A: Depends on user specifications; 6 months.

3 new Microwave Amplifiers designed by request

* 1 watt — 12.4 to 18 Kmc

* 2 watts — 8 to 12.4 Kmc

* 5 watts — 7 to 11 Kmc

Available now
from
Alfred Electronics

FEATURES

- * Rated gain and power output over each range at one setting of controls
- * 30 db gain at rated power; flat response
- * Compact, simple to operate
- * Rack or bench mounting
- * RF connectors out of front or rear



A number of Alfred's customers asked for—and now have—amplifiers with 1 and 5-watt outputs covering the ranges listed above. The new units can be used as broadband power amplifiers; stable power oscillators using external resonant feedback networks; narrowband amplifiers providing more than rated gain and power and for frequency multiplication. Each amplifier consists of a TW tube, its focusing magnet, and a completely regulated supply for obtaining optimum performance from the TW tube.

For more information, call your Alfred engineering representative or drop a line to Palo Alto. Please address Dept. 36

ALFRED ELECTRONICS

897 Commercial Street
PALO ALTO, CALIFORNIA
Phone: DA 6-6496

| BASIC DATA | 526 | 527 | 528 |
|---------------------|------------------------|---------------|---------------|
| Frequency Range | 12.4 to 18 Kmc | 8 to 12.4 Kmc | 7 to 11 Kmc |
| Power Output | 1 watt | 2 watts | 5 watts |
| Gain (Small Signal) | 30 db | 30 db | 30 db |
| Gain (Saturation) | 25 db | 30 db | 30 db |
| VSWR (Input/Output) | 2:1 | 2.5:1 | 2.5:1 |
| RF Connectors | P Band Flange VG-419/U | Type N Female | Type N Female |
| Price | \$4,950 | \$3,490 | \$3,490 |

CIRCLE 196 ON READER-SERVICE CARD

EL84 6BQ5

high slope output pentode

Output pentode rated for 12W anode dissipation, primarily intended for use in a.c. mains operated equipment.

characteristics

| | | |
|---------------|------|------------|
| V_a | 250 | V |
| V_{g1} | 250 | V |
| I_a | 48 | mA |
| I_{g1} | 5.5 | mA |
| V_{g2} | -7.3 | V |
| g_m | 11.3 | mA/V |
| r_a | 38 | k Ω |
| μ_{g1-g2} | 19 | |

SUPPLIES AVAILABLE FROM:

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81 Spring Street, New York 12, N.Y.
Worth 6-0790

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Rogers Electronic Tubes & Components
116 Vanderhoof Avenue, Toronto 17, Ontario,
Hudson 5-8621



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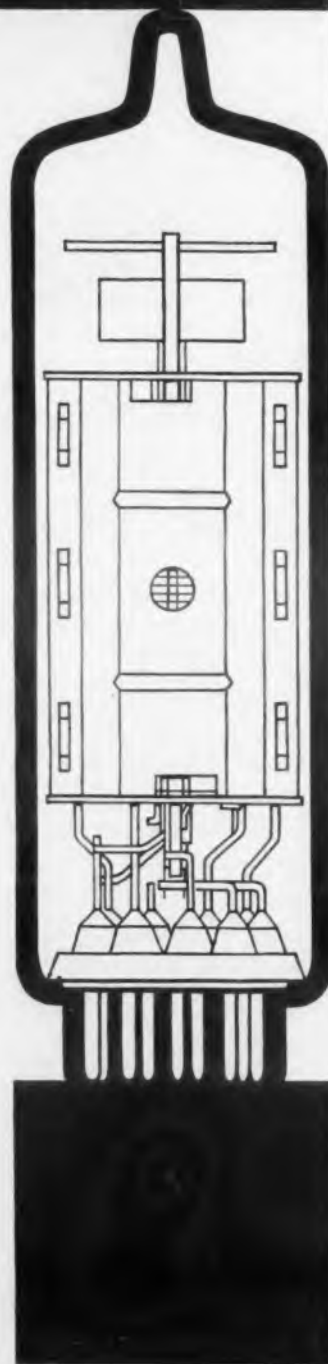
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MICROWAVES PRODUCTS

Ferrite Modulator

428

Range is 8.2 to 10 Gc



The X-band ferrite modulator model XL400 has a frequency range of 8.2 to 10 Gc and an attenuation range of 40 db min. The vswr is 1.25:1, max; insertion loss is 0.6 db, max. The modulation frequency is 100 kc; solenoid field is 0 to 50 gauss. Similar units are available in frequency ranges from S-band to Ku-band.

Micromega Corp., Dept. ED, Venice, Calif.
Availability: 30 to 90 days.

Nuvistor Preamplifier

528

The IF71 preamplifier, using nuvistor tubes, is small, light, and requires minimal power. Bandwidth is 8 mc, gain 30 db, noise figure 1.5 db. Intended for use with microwave mixers, input operates from a 300-ohm, 22-pf source.

LEL, Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

C-Band Oscillator

429

Output is 1 kw



A C-band pulsed triode oscillator, the model 301C has an output of 1 kw. Frequency is adjustable from 5,400 mc to 5,900 mc. There is no mode skipping; pushing figure is less than 1 mc, and no special pulse shaping is required. Temperature drift is 20 kc per deg C. The unit will withstand 20-g vibration, 20 to 2,000 cps, ± 1 mc fm, and 100-g shock for 6 msec in all planes.

John Gombos Co., Inc., Dept. ED, Webro Road, Clifton, N.J.

MEV 106

Decade Attenuator

500

For dc to 1,250 mc



Model TAD-50 attenuator is designed for rf signals in the range of dc to 1,250 mc. The unit contains three separate turret attenuators, two covering 0 to 50 db in 10-db steps and one for 0 to 10 db in 1-db increments. Internally connected in series, the three provide a total of 110-db attenuation, adjustable in 1-db steps. Power rating is 1 w. Input and output impedance is 50 ohms. The rabbit-box construction used provides for an insertion loss of 0.1 db in the 0-0-0 position at 300 mc, 0.3-db at 500 mc and 0.6 db at 900 mc.

Telonic Industries, Inc., Dept. ED, Beech Grove, Ind.

Price: \$325.

Availability: Immediate, in production quantities.

Power Supply

430

For klystron pumps



Designed to provide stable klystron pump oscillator voltages for parametric amplifier applications, the MA-2S power supply gives 0.1% regulation despite line voltage changes of ± 10 v and frequency changes from 58 to 62 cps. Beam supply is -200 to -400 v at up to 50 ma, with ripple less than 2 mv. Load regulation is 1% max. Reflector supply is 0 to -400 v at 100 μ amp max; ripple is less than 1 mv. Heater supply of 6.3 v, up to 2 amp, is provided. The 30-lb unit measures 10-3/16 x 10-13/16 x 14-3/4 in. deep.

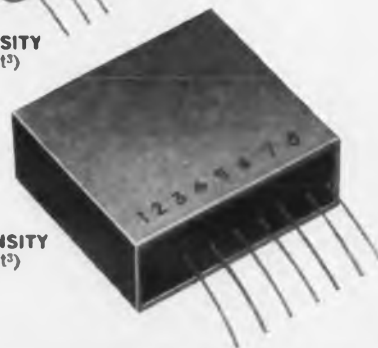
Microwave Associates, Inc., Dept. ED, Burlington, Mass.



miniaturized transistor amplifiers are production units at Centralab



1 1/8" x 5/8" x 1/4"
COMPONENT DENSITY
120/in³ (208,000/ft³)




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19.8/in³ (34,200/ft³)

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Centralab

Laboratory curiosities? Absolutely not! These miniature amplifiers are available NOW as standard production units, at realistic prices.

Use them confidently in dozens of applications, in audio, instrumentation, and specialty products. They permit practical circuit miniaturization in your current projects, thanks to the CENTRALAB  technique that achieves component densities as high as 2,500,000 per cubic foot.

These units range in output from 0.5 mw. to 3 mw., and can be supplied with frequency curves to meet your specific requirements. For detailed specifications and application information, write to CENTRALAB and request Technical Bulletin 42-1018.

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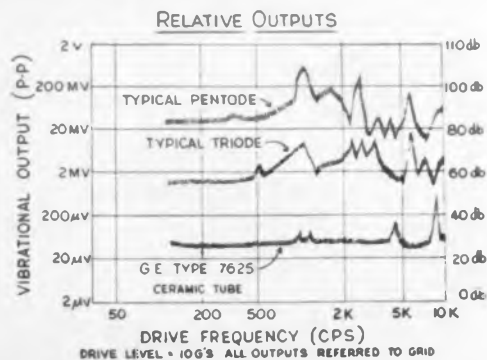
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Modernize Circuit Design...Use G-E Ceramic Tubes

CUT NOISE UP TO 1000 TIMES

Comparison between G-E type 7625 ceramic tubes and military-type glass tubes, in low-noise audio circuits, shows up to 1000 times lower vibrational output for the 7625. These graphically illustrated results show that the 7625, with its high input impedance, is ideally suited for such applications as threshold infrared, audio, and sub-audio detectors, even under conditions of severe shock and vibration.



Low noise is only one of many benefits ceramic tubes provide over glass tubes and solid-state devices. Depending on the tube type, such specific advantages as high gain, wide VHF-UHF frequency response, outstanding nuclear radiation tolerance, and high temperature resistance are available.

Numerous industrial and military projects currently under development would benefit greatly from the flexibility of ceramic tubes in a wide variety of applications. Many of these applications are discussed in detail, and the entire line of G-E ceramic tubes shown, in the Ceramic Tube Information Folder available by writing to:

General Electric Company, Receiving Tube Department,
Room 7091B, Owensboro, Kentucky

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GENERAL ELECTRIC



MICROWAVES PRODUCTS

Strip-Line Devices

703



A 3-db coupler for L and S bands provides isolation greater than 25 db, with coupling of 3 db to ± 0.1 db. The directional strip-line device can be also used for a broadband matched power divider, a duplexer or a 90-deg phase shifter. The vswr is less than 1.20. A four-port ferrite circulator, for C and X bands, is also made. Over a 6% band, the 4-oz strip-line device shows less than 0.4 db insertion loss, with input vswr less than 1.3:1. Arm 1 isolation is greater than 20 db, arm 2 isolation greater than 40 db.

Hycon Manufacturing Co., Dept. ED, 1030 S. Arroyo Parkway, Pasadena, Calif.

Coaxial Tuner

701



Model 872A coaxial slide-screw tuner simplifies balancing out small reflections in coaxial systems. It operates over the frequency range of 0.5 to 4 Gc, and can correct a vswr of 5 from 0.5 to 1 Gc and up to 10 from 1 to 4 Gc. Probe insertion is varied with a micrometer drive; position along the line may be read directly on a recessed scale. Probe travel is at least $1/2$ wavelength at 0.5 Gc so that any phase reflection may be easily compensated.

Hewlett-Packard Co., Dept. ED, 1501 Page Mill Road, Palo Alto, Calif.

Price: \$525.

◀ CIRCLE 199 ON READER-SERVICE CARD

MICROWAVES

Antenna Amplifier 711



Wide-band antenna amplifier models 780 through 785 provide gain from 19 to 29 db with noise figures from 3.2 to 5.0 db. Five models have pass bands in ranges between 200 and 500 mc; band widths are 40 to 140 mc. Designed for outdoor use, the unit is normally mounted 3 to 5 ft from the antenna. It can be operated continuously at temperatures between -30 and 180 F, with a service expectancy of 10,000 hr or more.

Resdel Engineering Corp., Dept. ED, 330 S. Fair Oaks Ave., Pasadena, Calif.

Price & Availability: \$1,250 to \$1,485; 15 days.

Bandpass Filter 709



For 2.2 to 2.3 Gc frequency band, model FS-205 bandpass filter has insertion loss of 0.25 db in passband and 50 db in stopband. Designed for space environments, the filter withstands 20 g from 25 to 3,000 cps. The vswr is less than 1.2:1; filter can handle 15 w cw at any altitude. Size is about 6 x 2 x 2, weight 14 oz.

Rantec Corp., Dept. ED, Calabasas, Calif.

P&A: \$250 to \$400 ea; 30-day delivery.



One of a series of advertisements featuring tubes for MOPA chains

MOPA
S-BAND
CHAIN



Raytheon pulsed-type Amplitron* produces 3-megawatt S-band output at efficiencies of 75 to 80%

QKS 622 tubes are used as driver and final amplifier stages of broadband MOPA chain.

Raytheon Amplitrons are ideally suited for high power MOPA applications where extremely high efficiency is required. For example, a single QKS 622 Amplitron can produce up to 15 kw average and 3 megawatts peak power with 70 to 80% efficiency. Easily achieved parallel operation doubles these power outputs. Adequate drive power is supplied by the QKS 622 operating at lower levels.

This unusually compact 2,900 to 3,100 mc Amplitron has been operated at 30-microsecond pulse widths, and can be expected to perform satisfactorily at far greater widths. A companion tube, the QKS 783, covers 2,700 to 2,900 mc. Both tubes are specified for 1,000 hours.

QKS 622 GENERAL CHARACTERISTICS (Typical Operation)

| | DRIVER | FINAL AMPLIFIER |
|--------------------------------|-------------------------|------------------------|
| Pulse Duration | 11 μ sec | 10 μ sec |
| Duty Cycle | .0055 | .0050 |
| Peak Anode Voltage | 48-52 kv | 50-54 kv |
| Peak Anode Current | 20 a | 66 a |
| Peak Power Output | 600 kw | 3.0 Mw |
| RF Driver Peak Power | 48 kw min | 550 kw min |
| Cold Insertion Loss | 0.5db | 0.5 db |
| Heater Power | None Required | |

Write for detailed information and application service to Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario. *Raytheon Trademark

RAYTHEON COMPANY

MICROWAVE AND POWER TUBE DIVISION



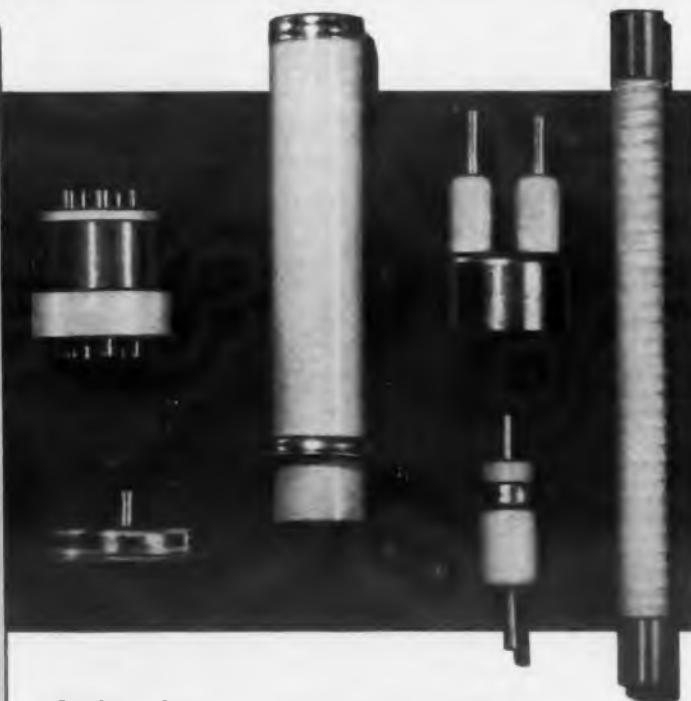
CIRCLE 200 ON READER-SERVICE CARD

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- VACUUM-TIGHTNESS
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- PRECISION TOLERANCES



Looking for ways to improve reliability, reduce maintenance problems? The unique advantages of Alite high-alumina ceramic-to-metal seals may be just what you need!

With maximum working temperatures in the range 1300°-1600°C., Alite can be metallized and brazed to metal parts to form rugged, vacuum-tight seals which, in turn, can be welded into final assemblies.

From design to finished part, every manufacturing step — including formulating, firing, metallizing and testing — is handled within our own plant and carefully supervised to assure strict adherence to specifications, utmost uniformity and reliability.

Over 100 standard sizes of Alite bushings in a range of types are available to simplify design problems and speed delivery. However, when special units are called for to meet unusual requirements, a team of Alite engineers stands ready to help you take advantage of Alite's superior properties.

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CIRCLE 201 ON READER-SERVICE CARD



MICROWAVES PRODUCTS

RF Wavemeter

531

Insertion length is 2-1/4 in.



Model 3170T1000 rf wavemeter, designed as a system component, has an insertion length of only 2-1/4 in. The device will tune to 0.25 cycle per mc per deg F, for any frequency between 5,929 and 7,125 mc over a temperature range of -5 to 140 F. Crystal detector delivers a minimum crystal current of 20 μ a to a 3-K load with 100 mw floating in the main line. The vswr is 1.08:1 max; unit weighs 4 lb. The main line is RG-50/U waveguide, terminated in UG-344/U cover flanges.

Telerad Div., The Lionel Corp., Dept. ED, Flemington, N.J.

Price & Availability: \$250 ea; 6 to 8 weeks.

Waveguide Duplexers

431

Rated at 2 megawatts



Using two atr tubes and one tr tube, these waveguide duplexers minimize incoming signal loss and eliminate the need for a critical transmitter line length. The L-band duplexer, for 1.25 to 1.35 Gc, is rated at 2 megawatts max, average power 4 kw max. The vswr is 1.6 max, and duplexer loss is 0.7 db. Weight is 49 lb. Similar units are available for V, Ka, K, C, S, and P bands.

Bomac Laboratories, Inc., Dept. ED, Salem Road, Beverly, Mass.

MICROWAVES

Broadband Antennas

512

Provide bandwidth of 10 to 1



Vertical, horizontal, left-circular and right-circular polarizations are provided in bandwidths of 10 to 1 or greater by this line of broadband antennas. Model 12E1-10 has a frequency range of 100 to 1,000 mc with a gain of 8 ± 1 db and a vswr of 2.0 to 1 max. Model 13E1-5 has a range of 1 to 5 Gc with a gain of 7 ± 1 db and a max vswr of 2.2 to 1.

Litton Systems, Inc., Maryland Div., Dept. ED, 4900 Calvert Road, College Park, Md.

Microwave Absorber

524

Is flexible

Flexible microwave absorber material, type RS, in the form of thin sheets of plastic can be supplied with resonance at any frequency between K- and S-bands. Performance is better than 25 db at resonance. Weight is 0.5 to 2 lb per sq ft depending on frequency. Positive adhesive mounting from -60 to 400 F.

B. F. Goodrich, Dept. ED, Shelton, Conn.

Parametric Amplifiers

513

For L-, S-, C- and X-bands



Environmentally qualified parametric amplifiers for L-, S-, C- and X-bands are designed to utilize a number of varactor diodes now commercially available. An S-band nondegenerate model has a noise figure of less than 3 db, including circulator loss, from -10 to $+70$ C. A transistorized pump power supply is available as optional equipment.

Hughes Aircraft Co., Dept. ED, Culver City, Calif.

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EVERY USE!

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ARCO electronics inc. Transformer Division
Community Drive, Great Neck, New York • HUinter 7-0500

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IN 1961



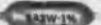
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Reliability Of

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MINIATURE WIREWOUND RESISTORS

Product design engineering at Sage is highly specialized. We concentrate solely in the area of bridging that gap between *precision* and *stability* on the one hand and *power rating* on the other.

Now, for flat card assembly as well as for other component cluster approaches to circuit squeezing, SAGE offers industry's smallest grouping of 1, 2, and 3 watt resistors.

| Actual Size | Style | Rated Watts at 25°C | Nominal, inches | | Range, Ohms |
|---|-------|---------------------|-----------------|----------|-------------|
| | | | length | Diameter | |
|  | SA1W | 1 | .406 | .094 | 5—10,000 |
|  | SA2W | 2 | .500 | .125 | 5—15,000 |
|  | SA3W | 3 | .500 | .187 | 5—18,000 |

Performance features of MIL-R-26C are easily met. SA2W is in fact RW59, presently the smallest unit detailed in MIL-R-26C.

Sage Impervohm silicone resin provides moisture and voltage protection, and may be safely operated at temperatures to 350°C.

Above styles available in non-inductive windings, also with weldable leads on special order.

Test samples available on request

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Country Club Road • East Rochester, N. Y.

CIRCLE 203 ON READER-SERVICE CARD



MICROWAVES PRODUCTS

Diplexer

504

For 755 to 985 mc



Model 77-001 diplexer is designed for use from 755 to 985 mc. The vswr is less than 1.03; pass band insertion loss is less than 0.1 db and reject attenuation is greater than 75 db.

Antenna Systems, Inc., Dept. ED, Hingham, Mass.

Microwave System

527

For duplex service

Duplex, multichannel service for point-to-point communications of voice, control and data transmission applications is provided by this 6-Gc microwave system. Systems can be installed initially with a few carrier channels and expanded as necessary by adding more channeling equipment.

Lynch Communication Systems Inc., Dept. ED, 695 Bryant St., San Francisco 7, Calif.

Delay Lines

509

Insertion loss is 3 db



Lightweight band-pass delay lines for systems requiring time delay in the vicinity of a fixed center frequency are available in various combinations of operating frequencies and time delays. Typical time delay values of 0.22 μ sec at an operating frequency of 60 mc and a bandwidth of 10 mc are available in a unit measuring 1 x 2 x 10 in. Standard 50-ohm cables are terminated in BNC-type connectors.

PCA Electronics, Inc., Dept. ED, 16799 Schoenborn St., Sepulveda, Calif.

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Lines



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IC-601 Inductance Comparator

NEW MODEL S—the first with fully transistorized In-Line Digital "Read Out" Counter and 11 interchangeable winding heads.

NEW MODEL TVW—for toroidally winding New Vertical Deflection Coil being adopted by Television Industry.

NEW MODEL LS-1 LABORATORY SLIDER-TYPE WINDER—with Model "S" interchangeable winding heads, #20-46 AWG, Fin. I.D. .065".

NEW MODEL BW TRUE BANK WINDER—for winding variable auto-transformers. Wire range #20-30 AWG.



Send for further information

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The most COMPLETE line of TOROIDAL equipment in the world.

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RADIATION MODEL 3115
FM TELEMETRY TRANSMITTER PROVIDES...

- Carrier frequency stability to within $\pm 0.01\%$
- Frequency response within 0.5 db from 100 to 100,000 cps
- 2 watts minimum output
- Virtual immunity to extreme environments
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- Reliability proven in Tiros I, Redstone, Jupiter, Snark and other missile programs
- Off-the-shelf availability

For complete information on the Model 3115 ask for: Technical Bulletin RAD B-102. Write Dept. ED-4.



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ELECTRONIC DESIGN • April 12, 1961

MICROWAVES

Oscillator Assembly

503

Plate voltage is 185 v



X-band cw oscillator assembly has a minimum of 3 mw over a 1% tuning range from 8.5 to 9.6 Gc. Vernier tuning is the only adjustment. Requiring a plate voltage of 185 v and 6.3 v filament, the unit weighs 8 oz.

John Gosbos Co., Inc., Dept. ED, Clifton, N.J.

Waveguide Windows

519

Are solderable

Solderable waveguide pressure windows provide an air-tight seal within waveguide systems and are transparent to microwave energy. Designed for use with EIA sizes WR-90, WR-112, WR-187, and WR-284, all windows are silver plated to reduce rf loss.

Microwave Development Laboratories, Inc., Dept. ED, 92 Broad St., Babson Park 57, Wellesley, Mass.

Directional Coupler

497

Peak power is 5 megawatts



S-band directional coupler, model 45,000, will handle a peak power of 5.0 megawatts at a pressurization of 15 psig. The unit utilizes strip-line techniques and weighs approximately 4 lb. Coupling is $-54 \text{ db} \pm 1 \text{ db}$, flat to $\pm 1 \text{ db}$. Directivity is 20 db min; vswr is 1.10 to 1 on main waveguide over a 15% bandwidth and 1.35 on auxiliary line.

Transco Products, Inc., Dept. ED, Los Angeles, Calif.

In RF connectors



GREMAR

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VERSATILITY

MOST COMPLETE LINE!

GremaR makes more series of RF connectors and components than are available from any other source... and then some! GremaR exclusives include *Red Line* miniature RF connectors for use with MIL-type sub-miniature coaxial cables; power dividers; impedance transformers... and others.

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GremaR always has more than 750,000 assembled RF connectors of more than 2000 types on the shelf... plus over 8,000,000 component parts always ready for speedy assembly of standard connectors or quick adaptation to your special requirements.

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Because GremaR *connectronics*® concentrates engineering, production and quality control on RF connectors and components only, you can depend on GremaR to solve your design, delivery and reliability problems quickest. Try us and see. Address your inquiry to:

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187

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| ■ leads | ■ connectors |
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Niagara Filters • United States Gauge • Rahm Instruments • Lamb Electric Co. • Hunter Spring Co. • Glaser-Steers Corp.

CIRCLE 209 ON READER-SERVICE CARD



MICROWAVES PRODUCTS

Cavity Amplifiers

444

For L- and S-band use



Four miniature, continuous wave cavity amplifiers, series 30, operate in the frequency range of 215 through 2,325 mc. The units are precision fabricated from light metal alloys and completely gold-plated. Specifications for model P-30 are: low power gain, 16 db; low power output, 2.5 w; high power gain, 10 db; high power output, 25 w; plate power requirements, 600 v at 0.090 amp.

Resdel Engineering Corp., Dept. ED, 330 S. Fair Oaks Ave., Pasadena, Calif.

CW Amplifier

516

For X-band use

Model 30TWA1 cw X-band amplifier produces a nominal output power of 1 kw over a 5% band with a drive power of 50 to 100 w. A bandwidth of 2% is obtained at a fixed voltage and a 5% tuning range is available by varying the beam voltage.

Elliot Bros., Ltd., Dept. ED, 34 Portland Place, London, England.

Bi-Directional Coupler

432

Adjustable from 5 to 70 db



This broadband, precision calibrated variable directional coupler is adjustable from 5 to 70 db. The Delta Coupler may also be used as a variable attenuator. Accuracy is to within ± 1 db. A direct-reading dial is provided. Maximum power handling capability is 200 w. The coupler is

backward wave oscillators— \$1 an hour



For an interesting look into the economics of BWOs — or, any other specialized electronic tubes — may we suggest that you spread the cost of the last one that needed replacement over the number of hours it was operated? No matter what hourly rate you come up with, such an evaluation will point up the fact that service life is a much better index of value than purchase price.

Backward wave oscillators made by Stewart Engineering have a built-in life insurance policy in the form of a minimum 500 hour guarantee. Though it is seldom exercised (Stewart backward wave tubes characteristically outlive their guarantees by a wide margin) the guarantee enables you to put high-performance BWOs on your payroll at a known low maximum rate per hour.

Now available:
Type OD 12-18 BWOs
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minimum of 10 MW
in range 12.4-18 kmc.
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We've prepared an interesting new brochure and specifications on backward wave oscillators, and would like to send you a copy. Details also available on tubes custom-engineered to your specifications. Write today.

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SANTA CRUZ • CALIF.

CIRCLE 210 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

MICROWAVES

available in frequency ranges from 0.5 to 1 Gc through 4 to 8 Gc.

General Precision, Inc., Kearfott Div., Microwave Branch, Dept. ED, 14844 Oxnard St., Van Nuys, Calif.

Mixer Preamplifiers

433

Range is from 1 to 36 Gc



Two series of coaxial and waveguide mixer-preamplifiers, one fully solid-state, the other employing nuvistor tubes, cover the range from 1 to 36 Gc. Both series have an if output of 30, 60 or 70 mc, a bandwidth of 8 mc and gain of 20 db. Typical noise figures for the transistor type are 10.5 db; for the nuvistor types, 7.5 db.

LEL, Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

Planar Triode

550

Range to 3 Gc



Designed for use as an oscillator, frequency multiplier or power amplifier, the ML-7698 is a high- μ , planar triode with a frequency range up to 3,000 mc. With low inter-electrode capacitance, high transconductance and high mechanical strength, the tube has a metal and ceramic coaxial construction suiting it for use in line-type circuits and cavity resonators. The cathode is an indirectly-heated, oxide-coated disk; the anode is cooled by conduction and convection.

Raytheon Co., The Machlett Laboratories, Inc., Dept. ED, Springdale, Conn.

Price: \$100.

Availability: 60 days.

NOW

easy—0.05% voltage measurement under severe environmental conditions



MODEL 8011A MILITARIZED DIFFERENTIAL DC VOLTMETER

Meets all environmental requirements of MIL-T-945A

Designed for continuous operation: —from -54°C to $+65^{\circ}\text{C}$
—with 95% relative humidity
—up to an altitude of 10,000 feet
Designed for extended storage: —from -65°C to $+85^{\circ}\text{C}$
—with 100% relative humidity
—up to an altitude of 50,000 feet.

FEATURES

- Accuracy of 0.05% of input voltage from 0.1 to 500 volts.
- Infinite input resistance at null.
- No zero adjustments.
- Eight search and VTVM ranges.
- Four potentiometric ranges.
- Temperature controlled Zener reference.

Model 8011A is a true potentiometer built to provide accurate voltage measurements under adverse environmental conditions. Housed in a light grey enameled combination case, it is portable, and virtually impossible to damage by overload. ■ Chopper stabilized null detector, precision Kelvin-Varley resistors (hermetically sealed in oil), temperature controlled Zener reference, and drift free 500 volt reference supply, all contribute to the outstanding performance of this instrument. ■ For your application requiring accuracy, reliability, plus ease of operation specify the John Fluke Model 8011A.

ONE PIECE CASE

Combination transit and instrument case of deep drawn aluminum construction protects the electronic circuitry from dust, moisture and drafts. This unique feature enables the Model 8011A to provide laboratory performance under the most severe environmental conditions.

PARTIAL SPECIFICATIONS

VOLTAGE RANGES: $\pm 0.5, 5, 50$ and 500V DC
ACCURACY: $\pm 0.05\%$ from 0.1 to 500V
 $\pm 0.1\%$ of input voltage or 50 μV , whichever is greater below 0.1V
NULL SENSITIVITY RANGES: 10V, 1V, 0.1V & 0.01V
MAXIMUM METER RESOLUTION: 50 μV
INPUT RESISTANCE: Infinite at null from 0 to 500V
DIMENSIONS: Case covered, 11½" high, 19" wide, 19½" long
WEIGHT: 57 pounds complete
PRICE: Available on request

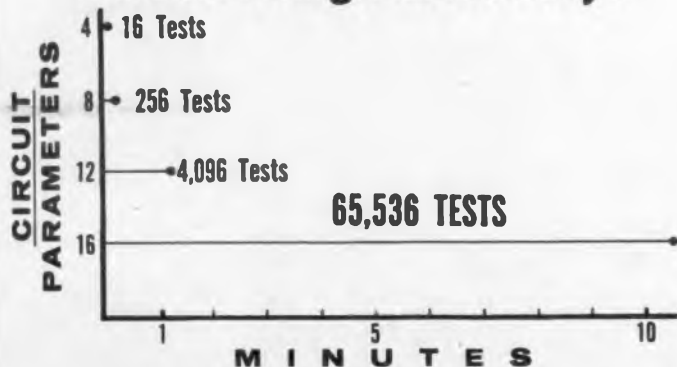
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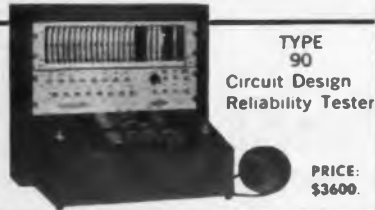


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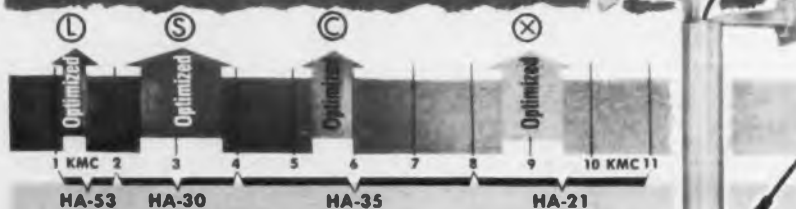
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TWT's OPTIMIZED for NARROW BAND USE

GREATER POWER OUTPUT
INCREASED SMALL SIGNAL GAIN



- (L) **1.1 - 1.4 kmc** The PPM focused type HA-53, normally operated from 1 - 2 kmc, when optimized is capable of > 35 DBM power output and 40 db small-signal gain.
- (S) **2.4 - 3.8 kmc** Cataloged as a 2 - 4 kmc amplifier, the PPM focused HA-30 exhibits > 40 db small-signal gain, with 33 DBM minimum power output over the narrow band.
- (C) **3.3 - 6.0 kmc** The HA-35, a 4 - 8 kmc solenoid focused amplifier, displays narrow-band performance of 32 DBM minimum power output, and > 45 db small-signal gain.
- (X) **8.5 - 9.5 kmc** Normally operated from 8 - 11 kmc, the PPM focused type HA-21 is capable of > 45 db small-signal gain, and 31 DBM minimum power output when optimized.

If your system application requires a high-performance, narrow-band traveling wave tube amplifier, contact Huggins Laboratories. We may have a TWT with the exact characteristics for your system.



HUGGINS LABORATORIES INC.

999 East Arques Ave. • Sunnyvale, Calif. • RE 6-9330

CIRCLE 213 ON READER-SERVICE CARD



MICROWAVES PRODUCTS

Parametric Preamplicifier

434

Gain is 25 db



Built as a weatherproofed, sealed unit for antenna mount use, the RA-1 parametric preamplifier is suited for distant range tracking, tropo-scatter links, or radio astronomy applications. Passband is 225 to 260 mc; gain is 25 db. Noise figure is less than 2 db. Input and output impedances are 50 ohms.

LEL, Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

Varactor Diodes

523

Gallium arsenide type

Six varactor diodes, series AP-1, range in cut-off frequencies from 60 to 150 Gc min at an operating bias of -2 v measured at 10 Gc. Power dissipation rating is 150 mw at 25 C measured at 10 Gc. Breakdown voltage rating is 6 v for a reverse current of 10 μ a at 25 C.

Tyco Semiconductor Corp., Dept. ED, Hickory Lane, Bear Hill, Waltham, Mass.

Reflex Klystron

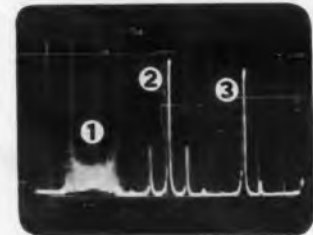
442

Has single-screw tuning



Reflex klystron model VA-250 is a compact unit designed for applications requiring good frequency stability in severe environments. It has single-screw tuning and waveguide output. Electrical characteristics are: frequency, 68 to 74 Gc;

Lab setup shows SB-15a versatility. (1) FM display measures dynamic deviation. (2) and (3) are AM and SSB signals, respectively, with sine wave modulation.



**MORE ULTRASONIC
ANALYSES** *faster
easier
high accuracy*



**PANORAMIC'S
NEW, IMPROVED
SB-15a
spectrum analyzer
0.1 kc to 600 kc**

Find, identify and analyze more types of ultrasonic signals with Panoramic's advanced Model SB-15a . . . economical, compact and completely self-contained.

• Noise, vibration & harmonic analysis • Filter and transmission line checks • Telemetry analysis • Communication System Monitoring . . . and more—Power Spectral Density Analysis and Frequency Response Plotting (with companion equipment).

SB-15a specifications:

• Frequency Range: 0.1 kc to 600 kc • Sweep-width, variable, calibrated from 1 kc to 200 kc • Center Frequency, variable, calibrated from 0 to 500 kc • Marker crystal controlled at 10 kc and 100 kc intervals • IF Bandwidth, variable, 100 cps to 4 kc • Sweep rate, variable, 1 cps to 60 cps • Amplitude Scales: Lin, 40 db log (extendable to 60 db), 2.5 db expanded • Sensitivity: 200 μ v to 200 v full scale • Accuracy: \pm 0.5 db.

Write today for detailed technical data on the SB-15a . . . NEW CATALOG DIGEST . . . and regular mailing of THE PANORAMIC ANALYZER, featuring application data.



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DEPENDABLE SWITCHING



of contact loads to 25 amps . . .

"Diamond H" Series W Relays—The simple, functional construction of this high-quality general-purpose relay assures long-time dependable switching. For a broad range of applications, specifying "Diamond H" Series W Relays makes good sense. Here are some reasons:

Reliable—Mechanical life in excess of 10,000,000 cycles.

Versatile—a-c or d-c units available with choice of eight different combinations.

Compact—Measures $1\frac{1}{2} \times 1\frac{1}{2} \times 1\frac{1}{2}$ inches—weighs less than 10 oz.

High Contact Rating—Conservatively rated up to 25 amps, 240 v a-c or 28 v d-c.

Easy to mount—Plug-in design. Panel or side mounts also available.

Underwriters Laboratory Approval—U/L File 31481.

Cost-saving—Low in initial cost, the Series W is easy to install, saves space, and is easy to service.

Send for complete facts—in new 8-page Series W Relay Guide.



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210 Bartholomew Avenue, Hartford 1, Conn.

Phone JACKSON 5-3491

CIRCLE 215 ON READER-SERVICE CARD
ELECTRONIC DESIGN • April 12, 1961

MICROWAVES

power output, 10 mw min, 20 mw avg; bandwidth, 100 mc avg.

Varian Associates, Dept. ED, 611 Hansen Way, Palo Alto, Calif.

Rotary Joint

435

For X-band



A dual-channel microwave rotary joint, model RJXD-1C, operating in the X-band, consists of sections of waveguide, waveguide to coaxial transitions, and a coaxial, noncontacting choke joint. The entire joint employs ball bearings and is sealed for pressurization. The high-power channel operates in a frequency range of 8.5 to 9.6 Gc; power rating is 250 kw, and vswr is 1.2. Insertion loss is 0.4, vswr wow is 0.04 db. Flanges are UG-137A/U.

Canoga Corp., Dept. ED, P. O. Box 550, Van Nuys, Calif.

Price: \$1,800 ea.

Availability: 60-day delivery.

Coaxial Couplers

436

Have high directivity



Dual coaxial couplers models 3020 and 3022 are designed for use in coaxial reflectometer setups and have high directivity and a four-to-one frequency range. Directivity of these couplers is 35 to 30 db respectively. Model 3020 covers the 250-mc to 1-Gc range and model 3022 covers the 1- to 4-Gc range. Coupling of each arm is held to 20 db \pm 1 db over the frequency range and the coupling of the forward and reverse arms track each other within 0.3 db total.

Narda Microwave Corp., Dept. ED, 118-160 Herricks Road, Mineola, N.Y.

P&A: Model 3020, \$160; model 3022, \$150; from stock.

D-C AMPLIFIER EVALUATION number 1 in a series

AMPLIFIER NOISE

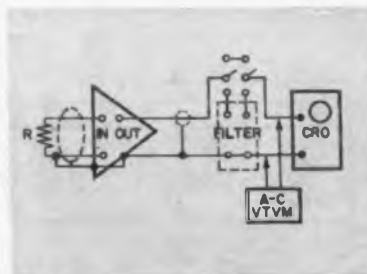
Accuracy is the basic objective in amplifier selection. When evaluating amplifiers for specific applications all errors must be considered. One such error, the noise level, determines the ultimate accuracy of the amplifier since the smallest observable signal cannot be less than the noise level. However, noise outside the frequency response range of the amplifier load can be filtered out or ignored with such read-out devices as galvanometer oscillographs.

Noise in an amplifier is any voltage component appearing at the output that has no counterpart in the input signal. Usually only the a-c component of the output is termed noise. The d-c component is called zero drift and its evaluation will be covered in another of this series.

Internally generated a-c components must be evaluated as to amplitude and frequency range. Noise may be divided into two general classes and measured as described below. (a) *Random voltages* of a broad band nature arising from thermal agitation in resistors and random tube or transistor noise . . . measurements on a peak-to-peak basis are often 10 times or more larger than the measured rms value over the same frequency band. (b) *Narrow band voltages* induced within the amplifier by line voltage or chopper excitation . . . these voltages are generally sinusoidal so that peak-to-peak values are only about 2.8 times larger than the measured rms values.

Testing amplifiers for noise

If the input signal is zero, any voltage components detected at the



amplifier output can be identified as noise. A standard technique for measuring noise is shown.

The oscilloscope measures the peak-to-peak values, the VTVM in rms values. Equivalent input noise (eq. in) is the measured noise divided by the amplifier gain. For details write for Bulletin BE AN121.

Noise less than 0.04%

With a full scale input signal of 10 mv, Honeywell's AccuData III Amplifier has a wide band (0-100 kc) noise specification of 4 μ v (eq. in) and a peak-to-peak noise over a 0-10 cps band of 4 μ v (eq. in) . . . less than 0.04% of full scale!



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Honeywell



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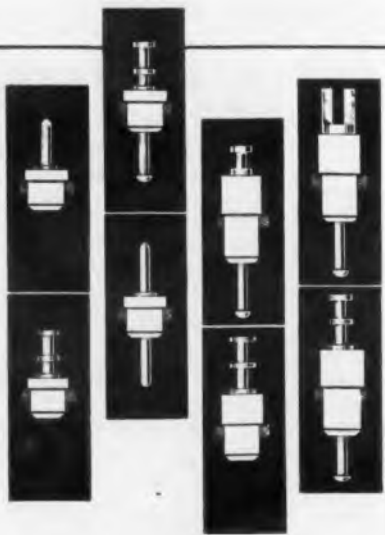
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| M60-2.5 | 0-60 | 0-2.5 | 450 |
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Rantec Corp., Dept. ED, Calabasas, Calif.

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517

Life is 500 hr

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Elliot Bros, Ltd., Dept. ED, 34 Portland Place, London, England.

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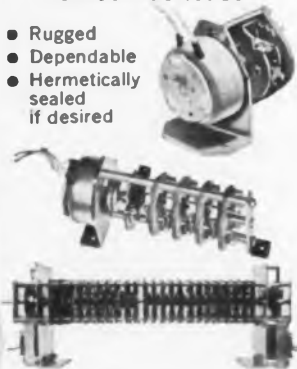
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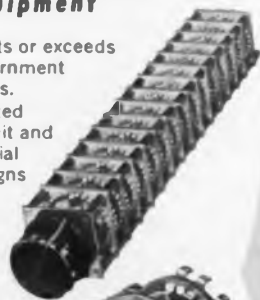
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required; a matched balun provides a characteristic impedance of 50 ohms and is an integral part of the assembly.

Stoddard Aircraft Radio Co., Inc., Dept. ED, 6644 Santa Monica Blvd., Hollywood 38, Calif
P&A: \$135; from stock.

Variable Attenuator

506

For S-band use



Flat, continuously variable, S-band attenuator model 4664-20A is capable of being remotely controlled. Electrical characteristics are: attenuation vs frequency, ± 1 db from 2.5 to 4.0 Gc; frequency range, 2.5 to 4.0 Gc; attenuation range, 0 to 20 db; vswr, 1.50 max; insertion loss, 0.5 db max; power capacity, 10 w avg, 5 kw peak.

Antenna and Radome Research Associates, Dept. ED, 27 Bond St., Westbury, N.Y.
P&A: \$450; 4 to 6 weeks.

Pattern Simulator

394

For monopulse circuitry



This monopulse antenna pattern simulator, in the 5.4- to 5.9-Gc range, performs checkouts and system analysis on monopulse circuitry. It simulates signals normally derived from sum and difference circuitry, and provides adjustable electrical line lengths in both signal and local oscillator branches.

Rantec Corp., Dept. ED, Calabasas, Calif.

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IDEAS FOR DESIGN

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Be sure to vote for the Ideas which you think deserve the \$50 Most Valuable of Issue Award. You may vote for one or more by circling the corresponding number on the Reader-Service card. Choose the Ideas which suggest a solution to a problem of your own, or which stimulate your thinking. The Most Valuable of Issue Ideas will be eligible for the \$1,000 Idea of the Year Award, with each idea published receiving a \$20 honorarium.

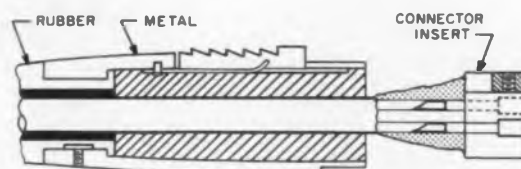
Microphone Connector Is Potted 743 In Three Sections For Easy Disconnect

A conventional microphone connector, used on precision instrumentation buried in the snow of Northern Greenland, had to be potted so that changes in humidity and the presence of snow and ice would not change its insulation resistance. Further, the potting had to be such that the connector, an Amphenol Type 91-857, could be readily disconnected with a heavily gloved hand. This disconnecting feature ruled out conventional potting. Instead, a combination of three potting materials, molded into different sections on the connector, was used.

After the wire leads were securely soldered, a temporary, cone-shaped mold, tapering away from the connector, was formed by wrapping masking tape around the wire-to-connector junction area. Small quantities of Scotchcast Resin No. 4, made by Minnesota Mining and Manufacturing, were thoroughly mixed and poured into the cone with the connector mounted vertically in a clamp support. The poured "cone" of potting compound was cured for about one hour at room temperature. When the tape support was removed, the potted cone section was quite plastic and could be hand molded to any desired shape.

The connector body was then slipped over the cone in proper mounting position. With the insert section held at about 1/8 in. from "home," Dow Corning's No. 4 (high-dielectric grease) was injected into the central section of the connector as indicated in the drawing. Then, as the insert section was slipped into the shell, grease was forced into all voids of the moving parts of the connector yielding a potted, but flexible, central section. The set screw for locating and securing the insert was next placed in position.

This cable strain relief section was potted by injecting Dow Corning Silastic RTV-731 into the strain relief from the cord side of the connector.



- SILASTIC RTV 731 (DOW CORNING) POTTING COMPOUND
- ▨ DOW CORNING # 4 COMPOUND
- ▤ SCOTCHCAST POTTING COMPOUND (MINN. MIN. & MFG.)

Amphenol Type 91-857 microphone connector was potted by applying three insulating compounds at the darkened sections. Despite potting protection, connector could still be rapidly disconnected.

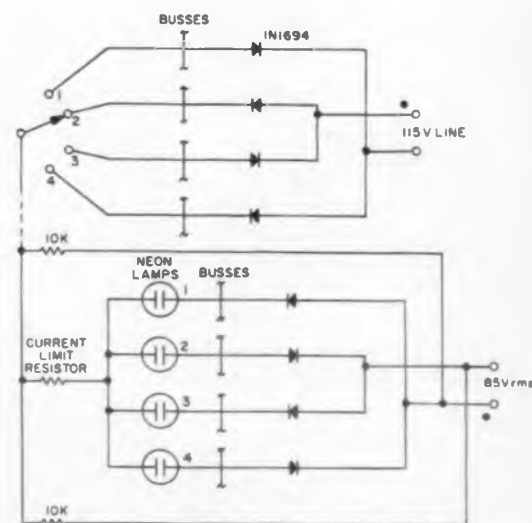
A room temperature curing rubber, this material forms very well and bonds readily to the connector rubber. However, contact must be avoided with the skin because it can be a severe irritant. Hands must be thoroughly washed immediately after it is used.

Edward J. Kolb, Physicist, U. S. Army Snow, Ice and Permafrost Research Establishment, Wilmette, Ill.

Separate Lamps Controlled Over Single Line 749

Four separate lamp circuits can be remotely activated over a single control wire by using the rectifier arrangement shown in the figure. The circuit uses the four possible combinations of phase and polarity that can be obtained by half-wave rectification of the ac line. Relative polarity of the 115-v source and the "remote" 85-v lines are indicated by the plus and minus signs.

The desired bulb can be lighted by connecting the control wire to the corresponding switch po-



Four (or more) remotely located lamps can be controlled over a single interconnecting line.

Firing of more than one lamp is prevented by reducing the remote ac voltage to about 85 v rms. The 10-K, 2-w resistors connected from the control wire to the 85-v supply help to minimize the effect of stray control line capacity which could cause improper lamp firing.

It is possible to extend the circuit so that more than four lamps can be controlled. One control wire is required for every four lamps, with the same eight diodes sufficient for all lamps. Also, relays can be substituted for the neon lamps.

Note that, with appropriate switching, several lamps may be energized simultaneously. Thus, a binary coding may be employed, with decoding accomplished by using diode AND circuits, relays, etc. In this way, 15 functions may be switched over a single control line.

K. C. Herrick, System Engineer, Reflectone Electronics Corp., Stamford, Conn.

Reprinted from ED, Feb. 15, p. 218.

SEVENTH ANNIVERSARY AWARDS

IDEAS-FOR-DESIGN

Entry Blank

How You Can Participate

Rules For Awards

Here's how you can participate in Ideas for Design's Seventh Anniversary Awards: All engineer readers of **ELECTRONIC DESIGN** are eligible.

Entries must be accompanied by filled-out Official Entry Blank or facsimile. Ideas submitted must be original with the author, and must not have been previously published (publication in internal company magazines and literature excepted).

Ideas suitable for publication should deal with:

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

Awards:

1. Each Idea published will receive an honorarium of \$20.
2. Ideas judged Most Valuable of Issue will receive \$50.
3. The Idea judged to be Idea of the Year will receive the Grand Prize of \$1,000 in cash.

The Idea of the Year will be selected from amongst those judged to be Most Valuable of Issue.

Most Valuable of Issue and Idea of the Year will be selected by the readers of **ELECTRONIC DESIGN**. Votes will be cast by circling keyed numbers on Reader-Service Cards. Payment will be made eight weeks after Ideas are published.

Exclusive publishing rights for all Ideas will remain with the Hayden Publishing Co.

Note to Previous Contributors

Ideas already submitted to the Ideas for Design department, but not yet published, will be eligible for the Seventh Anniversary Awards.

For Additional Entry Blanks, circle 750 on Reader-Service Card.

To: Ideas-for-Design Editor
ELECTRONIC DESIGN
830 Third Ave.
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.

I have not submitted my Idea for Design for publication elsewhere. It is entirely original with me and does not violate or infringe any copyrights, patents or trademarks or the property rights of any other person, firm or corporation.

Hayden Publishing Company, Inc. shall have the exclusive publication rights to these Ideas for Design selected for publication in **ELECTRONIC DESIGN**. This right extends to the subsequent use of the Idea for Design by Hayden in any of its other publications. Honorariums, if any, for subsequent publication shall be solely in the discretion of Hayden Publishing Company, Inc.

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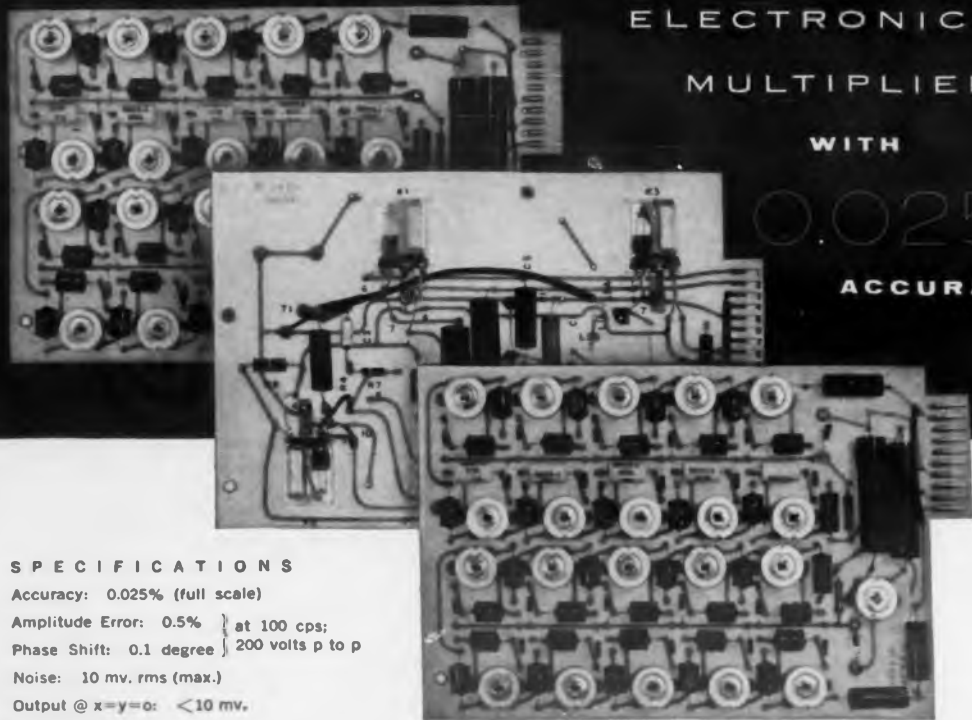
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IDEAS FOR DESIGN

Signal Light Indicates Out-of-Bounds Ripple

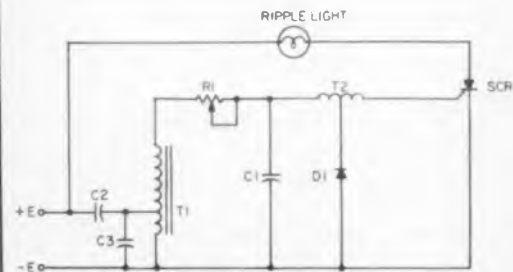
747

We needed a circuit, on a transistorized power supply, to detect and indicate rises of ripple voltage above the allowable 10 mv.

The circuit shown was chosen because we found it to be simple, reliable, and accurate.

The supply to be monitored is connected to the detector with the proper polarity. Capacitor C_2 isolates the ripple signal from the direct current. The signal is then stepped up by transformer $T1$ which is tuned to the ripple frequency by capacitor $C3$.

When the peak ripple signal causes the current through the tunnel diode, $D1$, to exceed its full value, the diode will switch to a higher voltage. The autotransformer action of $T2$ creates a larger voltage pulse on the gate of the silicon controlled rectifier, $SCR1$. This pulse turns both the controlled rectifier and the ripple light on. The value of ripple voltage at which this occurs is determined by the turns ratio of $T1$ and the value of $R1$.



Amplified ripple voltage triggers silicon controlled rectifier which lights indicating light.

Capacitor $C1$ is included to provide a low source impedance for the firing pulse to the controlled rectifier. Tuning $T1$ with $C3$ and including the $R1-C1$ combination filters out and delays transient voltage pulses which could trip the SCR. If desired, a reset switch can be placed in series with the light.

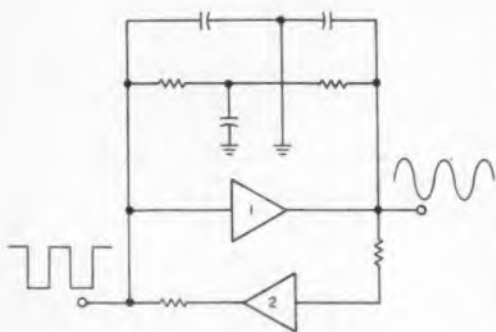
Bruce Hicks, Development Engineer, Universal Match Corp., St. Louis, Mo.

Feedback Around Filter Provides 741 Sine and Square Wave Outputs

Sine and square wave outputs of equal frequency were produced by providing positive feedback around an active, twin-T filter.

The twin-T, RC network and amplifier 1 of the figure form a bandpass amplifier with gain

IRV61



Sine waves at 1 and square waves at 2 are produced by feeding back around the active filter network.

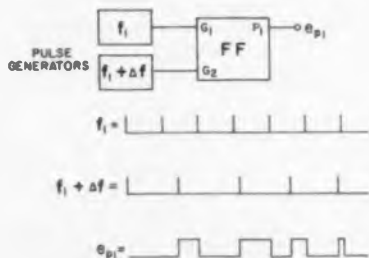
and narrow bandwidth. Amplifier 2 is of three direct-coupled stages, with an over-all gain of 65 to 90 db. It can be overdriven with but a small input signal and produces a constant-amplitude square wave at its output. This signal feeds back positively to amplifier 1 and the circuit oscillates. Thus, both sine and square waves are produced at the points indicated. The oscillating frequency depends only on the parameters of the twin-T network and can be varied over a wide range.

Wilbur Du Vall, Chief Engineer, Datrax Div., W. W. Henry Co., Maywood, Calif.

A Random Pulse Generator 742

To check coupling and clamping circuits, a quick and inexpensive random pulse generator was needed which would vary its pulse width at a random rate.

The problem was simply solved with the cir-



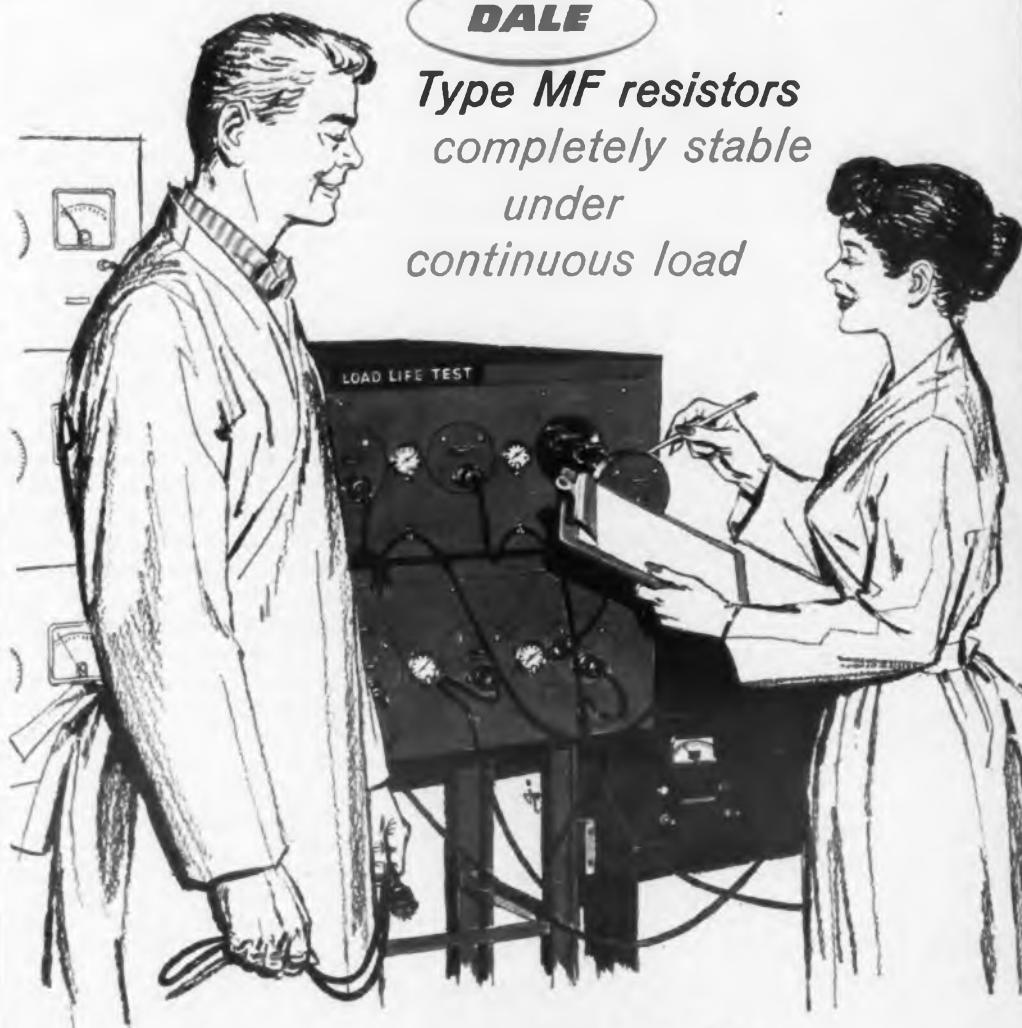
cuit shown. It is an arrangement that has been accidentally connected many times before.

Any variation in the output can be obtained by varying the frequency of $f_1 + \Delta f$.

Irving Bayer, Budd Electronics, Long Island City, N.Y.

Reprinted from ED, Feb. 15, p 218.

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IDEAS FOR DESIGN

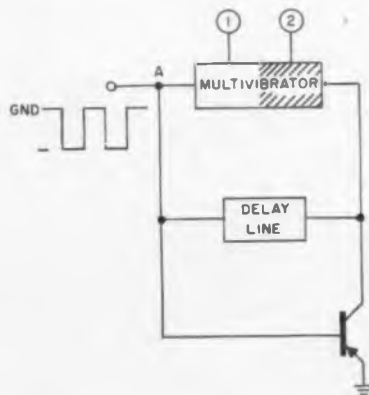
**Constant Output Signal Main- 748
tained by Continuous Pulse Train**

Certain logic circuits require that the presence of pulses at a given point be detected and indicated by a constant signal level. The multivibrator and delay line combination shown provides this constant (negative) level at point *I* as long as periodic input pulses are present at point *A*. If a pulse in the train is missing, the output at *I* will be triggered to zero.

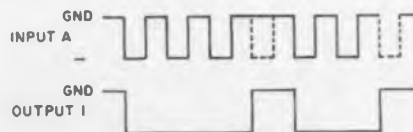
The circuit is designed so that point *A* rests at ground potential. If a negative-going pulse train is present, the first pulse will both trigger the multi and start a negative pulse propagating down the delay line. The total delay time of the line is equal to the period of the train.

If an adjacent pulse is present the transistor remains forward biased and point *B* remains at ground potential. Thus, the multi will not be triggered by the propagated pulse and the level at *I* remains constant. If an adjacent pulse is missing the delayed pulse will trigger the multi and the output level at *I* will change.

For a negative-going-to-ground pulse train the circuit merely requires an npn transistor for the gate. Also, the multi has to be designed to trigger on a positive pulse.



(a) Output at point *I* will be at constant level only if continuous train of input pulses is present at point *A*.



(b) Pulse train at point *A* and corresponding output at point *I* show that output "flips" when input pulse is missing.

Joseph F. Martin, Design Engineer, Stromberg-Carlson Div., Rochester, N.Y.

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Z-Axis Blanking Helps Determine Lag or Lead

744

Oscilloscopes of even modest caliber provide reasonably accurate measurements of sinusoidal phase angles by means of Lissajous patterns. This technique falls short in determining whether the unknown voltage or current vector leads or lags the reference vector.

By simply applying a blanking pulse to the Z axis, one can easily determine leading or lagging conditions.

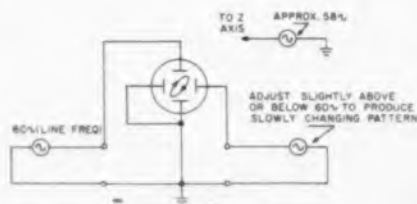
Assume an unknown voltage vector lags the reference voltage vector anywhere between 0 and 180 deg. Connect the reference vector to the Y axis, the unknown to the X axis. Though not apparent to the eye, except at very low frequencies, the resultant Lissajous pattern is formed by the electron beam moving in a clockwise path. This path remains clockwise for phase shifts anywhere between 0 and 180 deg.

If the unknown voltage vector leads the reference voltage vector anywhere between 0 and 180 deg, the electron beam will move in a counter-clockwise path.

The time required for the beam to complete one revolution is the same as the period of the applied frequency.

It follows that a blanking pulse (practically any wave shape) applied to the Z axis, with a frequency equal to that present at the X and Y axis, will tend to blank out a portion of the Lissajous pattern. The blanked out portion will appear stationary. Decreasing the blanking frequency slightly forces the blanked portion to move in the direction of beam rotation; clockwise for lagging phase shifts, counter clockwise for leading phase shifts.

The foregoing applies to oscilloscopes that display a 0-deg phase shift in the first and third quadrants.



Slowly changing Lissajous pattern illustrates direction of beam rotation for leading and lagging phase shifts from 0 to 180 deg.

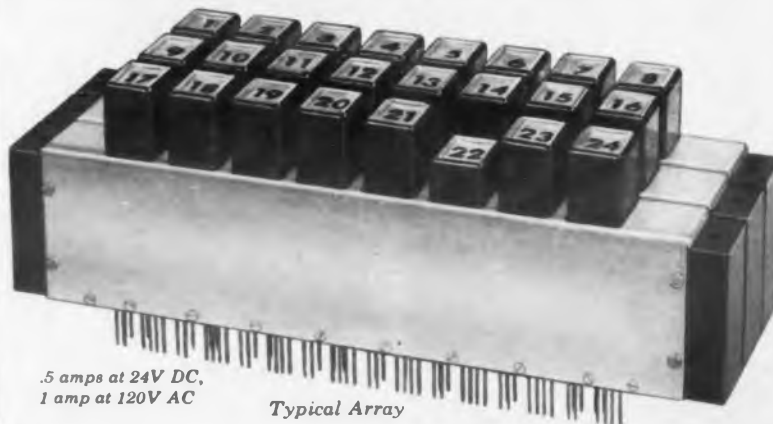
Michael Rakochy, Bell Telephone Labs., Allentown, Pa.

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ANY number of arrays
- **Miniaturized:** behind panel dimensions: 1¹⁹/₃₂" x 3/4"



.5 amps at 24V DC,
1 amp at 120V AC

Typical Array

Design simplicity and special modular construction of these TELEX switches allow more circuits than other units approximately the same size and weight. Each button is 8-pole single throw—normally opened or closed—or 4-pole double throw or any combination. Magnetic detent assures longer life.

All or any buttons may be interlocked but the complicated multiplicity of parts required by conventional switches for latching and releasing and preventing multiple actuation has been eliminated. Also available in momentary make configurations.

Exceptionally versatile, this switch may be used with printed circuits or plugged into standard wire harness to perform for test equipment, binary coding problems, digital coding problems and standard keyboard or countless other custom uses. Switch resistance is .070 ohms nominal. Insulation resistance @ 500V DC between adjacent switch contacts and open is 40,000 megohms. Choice of colored buttons and numerals and optional light indicators. Variations designed to meet individual specifications.

More detailed specifications and information are available on request. Write to Sales Manager,



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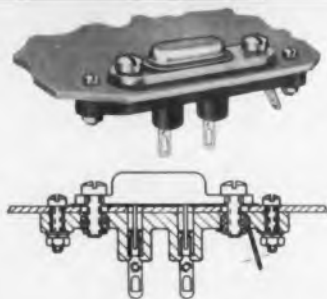
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Designed for the Complete Series of Clevite Spacesaver Power Transistors

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The socket's narrow width per-



mits full utilization of the space saving size of its mating transistor.

For complete specifications, write for Data Sheet No. 760.

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IDEAS FOR DESIGN

Low-Cost Scope Traces Transistor Characteristic Curves 745

Transistor characteristic curves can be easily traced by using the low-cost oscilloscope attachment shown in Fig. 1. It can be connected to any oscilloscope having calibrated horizontal and vertical sweeps. A 400-cps power supply is required. However, the use of this frequency led to a reduction in circuit complexity and, hence, like reductions in size, weight and cost.

Transistors can be tested only in the common emitter configuration. Other user requirements could be met with additional switching. The 4-pole polarity switch reverses the collector supply, bias current, and meter connections as required for pnp or npn transistors. The collector has a half-wave sinusoidal voltage sweep, set with a variable transformer, which is supplied through an isolation transformer. The transformers are selected with combined ratios that yield a peak output of the maximum desired collector voltage, and with a power rating that will accommodate the largest transistors to be tested.

Base bias current is supplied from a 24-v transformer secondary with a filtered, full wave rectifier. This source is controlled by the dropping resistance of a 3-gang potentiometer. This limits the maximum base bias to 100 ma as read on the panel meter. Three current ranges (0-1, 1-10, 10-100 ma) are selected by a 2-pole switch that also changes the meter shunts. The shunts must be experimentally wound to match the impedance

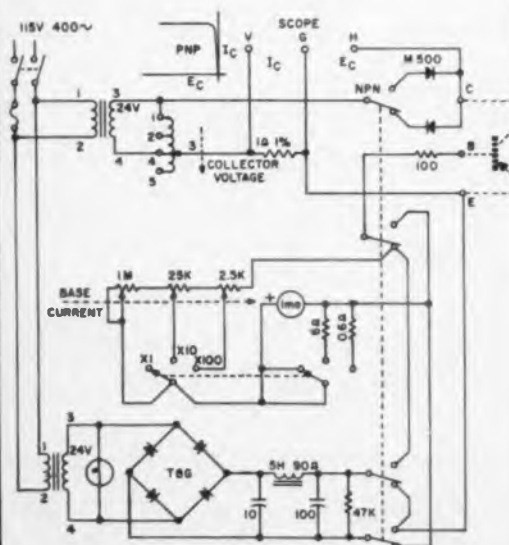


Fig. 1. Transistor curve tracing attachment can be used with almost any oscilloscope.

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The new Genistron Thermo-Ref provides a constant reference temperature of 100°C., ±0.1°C., with a 10-channel uniformity of ±0.1°C. Maximum drift is less than 0.5°C. over an ambient temperature range of -55°C. to +85°C. Power consumption is a nominal of 1.0 watts over a voltage variation of 95 to 125 volts AC. These specifications and its small size and light weight make the Thermo-Ref ideal for airborne applications. Standard models are available for reference temperatures of 100°C., 121°C. and 150°C.

The Thermo-Ref measures 3 1/4" x 3 1/4" x 2" and weighs approximately 12 ounces. Packaging and environmental conditions meet or exceed MIL-E-5272 and MIL-E-16400.

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Genistron
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ELECTRONIC DESIGN • April 12, 1961

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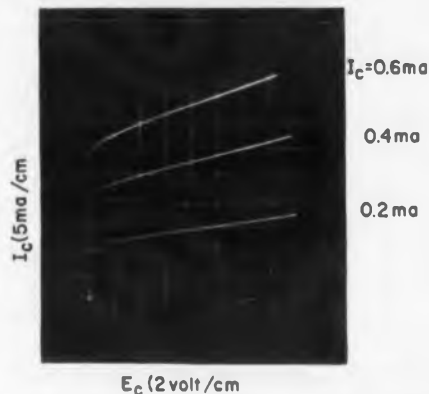


Fig. 2. Characteristic curves for 2N188 pnp transistor are obtained by taking multiple exposure photos for different base current values.

of the 1-ma meter by using a series calibrating meter.

The characteristic curves are presented on an oscilloscope connected to the terminals marked *H* and *V* respectively, and to *G*. A sensitive scope with directly calibrated control knobs (such as a Hewlett-Packard 130A) is particularly convenient for changing scale-factors during the test procedure. The collector current is sampled across a ± 1 per cent shunt, giving a one-to-one correspondence between current and vertical scope deflection. The sinusoidal collector-to-emitter voltage produces the horizontal sweep.

The power is turned on, and the "Collector Voltage" and "Bias Current" controls are turned to the full counterclockwise position. With the polarity switch and "Base Current" switch properly set, the transistor is inserted into the socket, or if more convenient, the *C*, *B* and *E* 5-way terminals are used. The characteristic curve will be presented on the scope as a second or fourth quadrant display for pnp or npn transistors respectively. This form of display gives the correct relative sense to the collector voltage deflection while connecting the common emitter to the common ground terminal found on most scope inputs.

Next, the collector voltage is brought up to the desired operating value. The collector current is varied through desired values by adjusting the base bias current. While this is done it is necessary to avoid exceeding transistor ratings. Families of curves are conveniently obtained by resetting the bias control. Multiple exposure photographs can be taken for a permanent record. Shown in Fig. 2 is a family taken for a 2N188 pnp transistor with three different values of bias current.

Chester B. Shapero, Research Engineer, Cupertino, Calif.

Reprinted from *ED*, Jan. 18, p 160.

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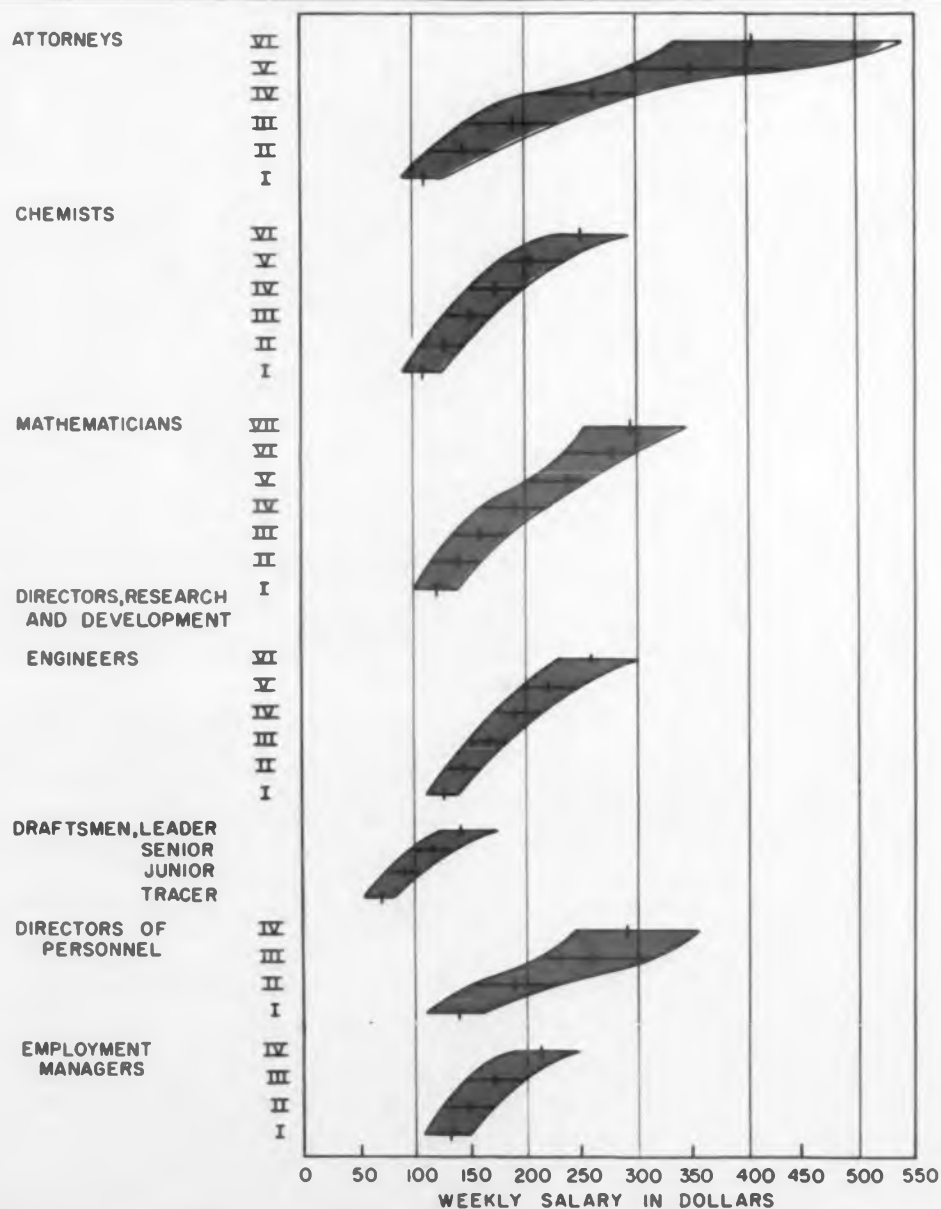
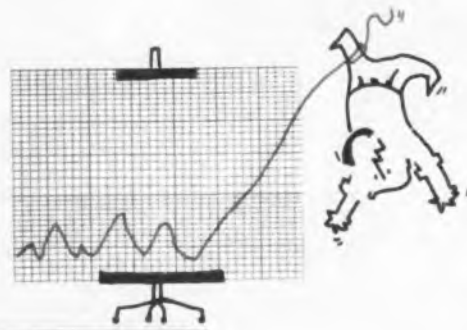
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CIRCLE 233 ON READER-SERVICE CARD

Engineer's Salaries Still Start High, End Low But Some EE's Are Breaking Out of the Mold



Weekly salary ranges for various professional occupations indicate to what extent engineers start ahead but end behind. Bars indicate spread of middle range while mark in middle of bar indicates median.

A GOVERNMENT survey of salaries for engineering and similar occupations last year indicates that engineers still start with higher salaries than most other college graduates—and end up mostly with lower salaries. However, a more recent sampling of EE salaries by *ELECTRONIC DESIGN* shows that some electronic engineers are now doing as well as men in any profession.

The Government survey was made by the Dept. of Labor during January to June, 1960, and was published in October in the department's Bulletin No. 1286. A chart from the survey, Fig. 1, has been redrawn by *ED* to include only information on occupations whose status is comparable to that of engineers. Included are weekly salary bars for attorneys, chemists, mathematicians, draftsmen and directors of R&D. Also included are directors of personnel and employment managers, to provide some indication of what other white-collar persons in industry are receiving.

The engineers' median starting weekly wage was found by the survey to be \$123, compared with \$110 for mathematicians, \$105 for chemists, and \$106 for attorneys.

However, at the highest classification (VI), the median weekly salary for the engineers (\$264) was found to be only slightly better than that for the chemists (\$249) and actually less than that for the mathematicians (\$269).

But the real difference was between engineers and attorneys. For while the engineer starts out earning \$17 a week more than an attorney, the lawyer, in his profession's top classification, ends up earning \$139 per week more than an engineer in the top engineering classification.

However, there are definite signs that some electronic engineers are breaking out of this mold. For whereas the survey showed that the top-middle-range salary for an engineer in class VI did not exceed \$17,000 per year, *ED* has confirmed that top EE's are now able to earn more than \$20,000 a year. These men would still be within the survey's VI classification; they would be working as engineers, not as managers. Thus competitive pressure for top EE's, particularly

Legend For Chart

As an aid to evaluating the chart on weekly salary distribution, the end values of the middle range are given for each engineering classification along with a brief job description of that classification:

- 1—\$115-\$130. Works under close supervision of superior. Typically receives formal classroom or on-the-job instruction.
- 2—\$127-\$150. Supervisor screens assignments to eliminate difficulty problems and select procedure to be followed.
- 3—\$146-\$176. Works independently on conventional projects but jointly with supervisor on unusual problems.
- 4—\$170-\$206. Performs engineering work requiring originality and judgment, though in areas generally covered by precedent. Characteristically supervises small group of engineers and technicians.
- 5—\$197-\$245. Both supervisory and non-supervisory: Supervisory positions include coordination and review of small staff of engineers and technicians. Nonsupervisory positions involve carrying out novel or complex research pertaining to new or improved techniques.
- 6—\$235-\$302. Programs, plans and coordinates a number of large and important projects in either supervisory or nonsupervisory capacity.

creative computer circuit designers, has finally brought about engineering salaries comparable to the \$21,000 median for top attorneys.

This happy state of affairs in the electronic engineering profession will probably not show up on across-the-board surveys of the whole engineering profession, such as this Government survey, for some time. As yet, these "over \$20,000" EE's are only a fraction of the total picture. But for the man who loves engineering and does not want to be forced into management for money considerations, this "lifting" of the traditional ceiling on engineers' salaries should be a cheering phenomenon. ■ ■

ELECTRONIC DESIGN • April 12, 1961

(F101, AIR FORCE PHOTO)



National*

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New growth in Military and Commercial Lines creates opportunities at Dayton, Ohio, for the following personnel:

TEST EQUIPMENT ENGINEERS: A B.S.E.E. degree plus at least 2 years' experience in the design of airborne, ground, or special test equipment. Applicant must be familiar with analog or digital circuit design, as applied to worst case design conditions. Must be capable of assuming project responsibility and carrying project through to completion.

MECHANICAL ENGINEERS: A B.S.M.E. degree plus at least 2 years' experience in the design and development of electro-mechanical or electronic assemblies and equipments. Applicant must be familiar with methods of shock mounting and packaging of airborne and ground support equipment.

CIRCUIT DESIGN ENGINEERS: A B.S.E.E. degree plus 2 to 5 years' experience in the design and development of solid state digital circuitry. Applicant should have experience in circuit design for reliable operation under worst case conditions. Background in airborne and ground support test equipment desired.

LOGIC DESIGN ENGINEERS: A B.S.E.E. degree plus 2 to 5 years' experience in the field of logical design of airborne electronic equipment. Must have a good background in system logic design.

DIGITAL COMMUNICATIONS ENGINEERS: At least a B.S.E.E. degree plus 4 to 6 years' experience airborne and ground base digital communications. Must be familiar with the many facets of digital communications including encoding and decoding techniques. Background in RF, IF, and digital circuits desirable.

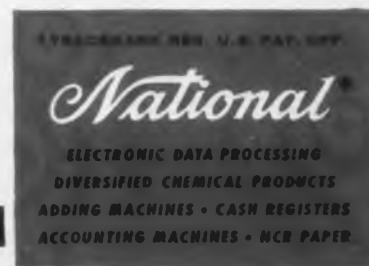
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This four-cryotron flip-flop can be switched in *two billionths of a second*. It was developed by an IBM team investigating the possibilities of low-temperature devices for basic binary storage in digital computers.

IBM scientists and engineers designed the flip-flop around a primary law of low-temperature physics: A superconductive metal loses its superconductivity in the presence of a magnetic field. In the IBM device, a small control current is used to destroy the superconductivity of one of two parallel lines. This sets up a resistance in the first line and causes current to switch to the second.

The new flip-flop offers another advantage in addition to speed. Its eight layers of thin metallic and insulation films operate in a temperature range where chemical deterioration is nonexistent. As a result, the device should have an unusually high degree of reliability.

Creative careers start here. A good deal of this project's success came from the creative interplay of different technical areas. IBM physicists and mechanical and electrical engineers worked together to develop new films, improved vacuum equipment and more reliable test circuits.

Perhaps you'd like to work . . . and grow . . . in a professionally stimulating atmosphere like this. You may be interested in the progress IBM is making in such areas as solid state, magnetics or IBM Tele-Processing.* If you have a degree in engineering, mathematics, or one of the physical sciences, plus experience in your field, write, briefly describing your background, to:

Manager of Technical Employment
IBM Corporation, Dept. 555D2
590 Madison Avenue
New York 22, New York

IBM
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YOUR CAREER NEWS AND NOTES

High salaries for nonsupervisors, the dream of the creative engineer, have become a reality. The concept of the individual contributor who can earn more than his boss is being achieved in practice, according to Harry L. Brisk of the Accredited Employment Agency, Philadelphia. Mr. Brisk says he knows of many engineers who earn from \$12,000 to \$23,000 a year, though they supervise no one. These enviable positions usually are in special departments of the larger companies, Mr. Brisk says, and result from realization that a "creative engineering type," unhampered by supervisory chores, can be vital to the company's future earnings.

10 Ways to Create New Ideas

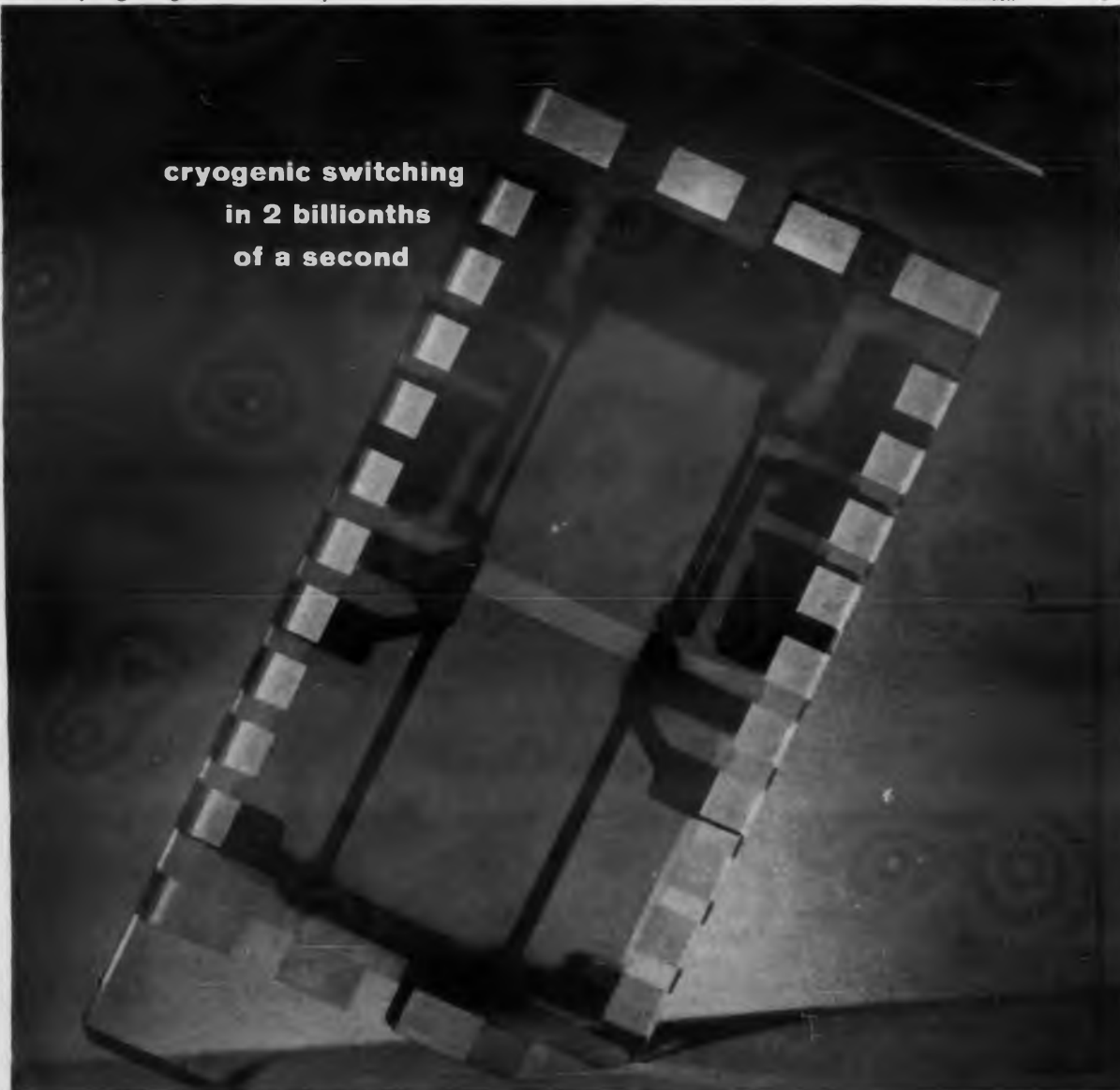
Looking for a fresh idea? Pinpoint a need. In terms of your own job or business, answer these questions:

- What made me mad today?
- What took too long?
- What was the cause of a complaint?
- What was misunderstood?
- What cost too much?
- What did we waste?
- What was too complicated?
- What is just plain silly?
- What job took too many people?
- What job involved too many motions?

The answers will almost certainly give you a long list of needs. Once you have them, look for ways to fill them. And there you are: ideas!

Higher earning power is always available to the engineer who keeps pace with technological advances.

In agreement with this statement, Ned Boggs of Boland & Boyce, Inc., N.Y., says he continually must turn down engineers he would only be too glad to hire at much higher salaries than they are now earning, because they have not kept up with changing trends in engineering. Along with many electronics employers, Mr. Boggs is looking hardest for and willing to pay most for solid-state digital circuit men. He says many of the men he has to turn down would be eligible if they had only started educating themselves in digital circuitry techniques a few years earlier. Then they would at least be able to get started in the digital field today. Once started, they can rapidly build up their abilities for the higher salaries available in this growing specialty area.



CIRCLE 902 ON CAREER INQUIRY FORM

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!

ELECTRONIC DESIGN CAREER INQUIRY SERVICE

USE BEFORE MAY 24, 1961

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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.

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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 |
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Outstanding Engineering and Administrative Experience _____

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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
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ENGINEERS • SCIENTISTS

THE A TO Ω IN SYSTEM ENGINEERING

The chalk moves across the blackboard, pausing, crossing out... yet giving mathematical form to a new idea. This may be the beginning of a command and control system that will not be on-line until the 1970's. It is also the first step toward solving the many complex problems inherent in large scale system engineering.

Today, MITRE is active in every system area — from advanced design through prototype development to operational evaluation. Here your individual contribution — whether in command and control system engineering, air traffic control, or experimental electronic development — will be in the forefront of a new technology.

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CAREER NEWS

What are the "job shops" paying? Hourly rates for job-shopping electronic engineers range from \$4.50 to \$9. The men at the lowest level, \$4.50 to \$5 an hour, are recent EE graduates. They are not too much in demand, however. Men with a year to a year and a half experience command \$6 to \$7.50 an hour. Those in most demand—men with five years of experience and up, particularly men with backgrounds in solid-state digital logic circuitry—command \$8 to \$8.50 an hour. The very top rates of \$9 an hour are for men with 10 years' computer circuitry experience. In addition to the hourly rate, if the man is away from home, he receives the usual \$8 to \$9 per diem expense allowance. The spokesman for a New York "job shop" who gave ELECTRONIC DESIGN these figures says that although the demand has softened somewhat in the last six months, he expects an upswing in the next few months.

• • •

Energy Boosters

The "gift" of abnormal energy that some people seem to have is regarded longingly by others. Actually, health factors being equal, it is not a gift but a conscious (or unconscious) knack these men possess for stimulating normal supplies of energy into a rushing geyser. They increase personal productivity by developing attitudes and creating situations that quicken their energy supply. You can too, if you:

Vary your tasks. Plugging at the same job interminably saps energy. Varying your chores stimulates you, provides the change that rests your mind. Been calculating circuit stabilities? Try listing possible solutions for your next project. Been at your desk all day? Get on your feet for a while. Visit the laboratory to see how your projects are coming along.

Motivate yourself. Before you achieve, stick your neck out by announcing your goals to people whose esteem you value. You'll surpass your own expectations, because you've made a definite commitment. (However don't at the same time dream of the honors you will receive, or you will spend your time dreaming instead of producing.)

Associate with enthusiastic people. Enthusiasm is contagious. By mixing with men who are excited about their work, you will "catch" their zestful spirit and be inspired to do your very best.

POSITIONS OPEN FOR INQUIRING MINDS IN MANUFACTURING RESEARCH ENGINEERING!

ENGINEERING SPECIAL PROJECTS

Bendix of Kansas City, Missouri needs three Manufacturing Research Engineers to do original work with new materials, and close, more exacting work with ordinary materials—Minds that will inquire into the many branches of technology and bring together that combination of techniques capable of producing a unique product. As a Prime Contractor for the Atomic Energy Commission, our function is to give the Weapon Designer the greatest possible latitude in exploiting new materials and techniques. We do this by paralleling his design work with advanced development of manufacturing processes during the design phase. The control of processes must frequently be so precise that automation is required for that reason alone—production quantity notwithstanding.

Engineers who can fill these positions must combine original thought with solid training in the basic physical sciences. They must be able to combine the reasoning of several disciplines in the development of a solution. Minimum requirements include:

- * Bachelor's Degree in Mechanical, Chemical or Electrical Engineering.
- * Strength in one or more of the following fields: subminiature transformer and toroid production, plastic and rubber formulation and fabrication, sheet metal fabrication, heavy and small parts machining, and fabrication and assembly of precise and delicate electrical and electronic assemblies requiring special environmental facilities.

These are responsible positions for engineers who are qualified to do original and creative work, and who can demonstrate by a record of past professional accomplishment that they possess this ability. Ours is one of the nation's most vital industries. We offer unusually generous company benefits in a Midwestern community which is famous for its beauty and low cost-of-living. All replies will be strictly confidential.

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CIRCLE 903 ON READER-SERVICE CARD

For the ambitious technician: International Correspondence school's new general catalogue 1125N describing over 250 standard home-study courses. Included are 25 technician-level electronics courses, of which 11 are new in 1961. They range from a short course on electronic fundamentals to electrical engineering with special electronics optional section. New 1961 courses cover the fields of radio-electronic telemetry, electronic computers, ultrasonics, mono and hi-fi, special sound systems, communications technology, industrial electronics technology, 1st and 2nd class FCC radiotelephone licenses and semiconductor transistor circuits. Write to ICS, Scranton, Pa.

Emotional fireworks in electronics are covered in a new novel about the inner problems of humans in an electronics company. "The Annals of Logan," by Robert Graham, is a series of verse monologues describing individual reactions when members of the company's advertising department plot to have one man fired.

The engineers, for the most part, escape Mr. Graham's analysis. There is, however, a brief mention of a visit by one member of the advertising department to the plant laboratory. The visitor is "revolted" by the professional pride of the engineers in a "cute, lovely, little fuzing device for thermonuclear warheads."

Author Graham was formerly a member of the sales promotion staff of Ford Instrument Div., Sperry-Rand Corp., N.Y.

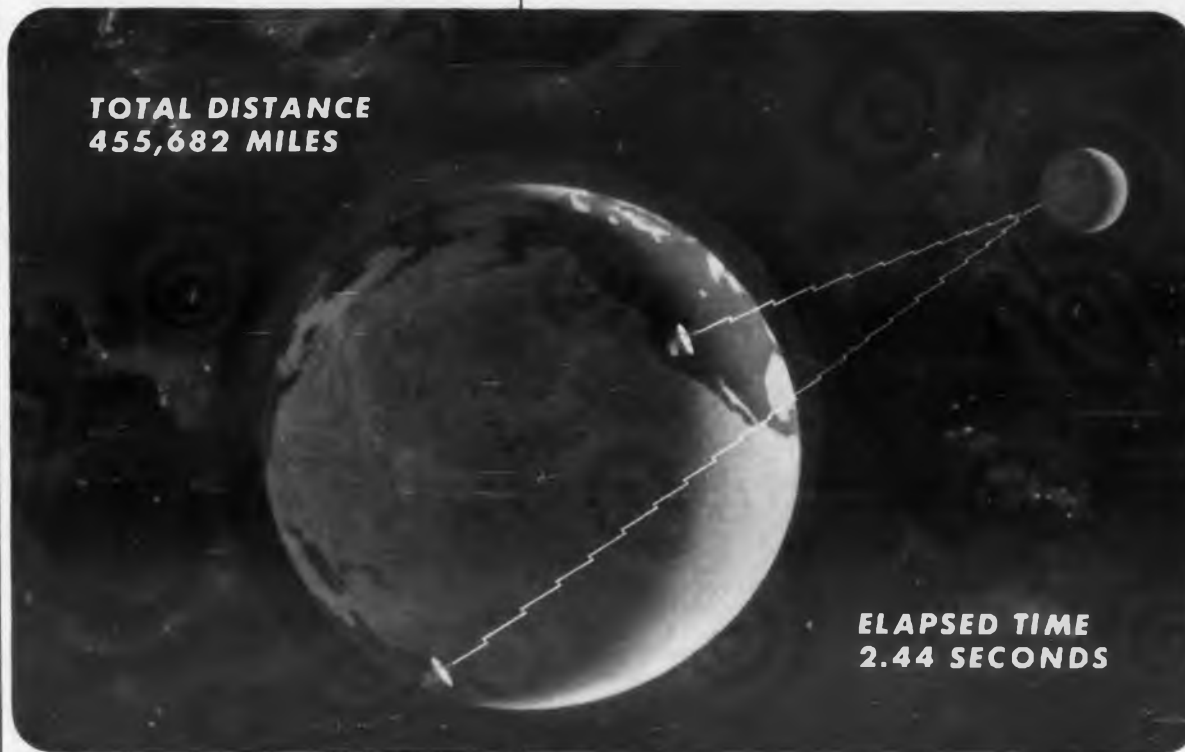
How do you develop underdeveloped countries? British author M. Zvegintzov, in the Unesco publication "Impact," says:

"The technical problem [in underdeveloped countries] is not so much to install complicated machinery, then find personnel to operate and maintain it, but to think out modern production problems in terms of breaking them down into the simplest and most foolproof component jobs, which could then safely be entrusted to unskilled personnel with no industrial tradition."

In explaining why Russia has been so successful in industrializing backward areas, Mr. Zvegintzov writes:

"In general the principle of make-do-and-mend is sound: to establish in which fields half a loaf is better than no bread and build accordingly on what human resources and materials can be made available. This principle has been consistently adopted by Russia—even before the 1917 revolution—and is one of the reasons for its great recent successes and the ease in its dealings with underdeveloped territories."

Notable Achievements at JPL



CAREER OPPORTUNITIES AT JPL IN THESE FIELDS—NOW

Electronic Engineers

... for component and system design of deep space communications, instrumentation, and automatic control equipments.

... for microwave and RF solid state circuit design and flight evaluation.

... for project management assignment on advanced development and contracted effort in space communications.

Physicists

... for analysis in communications theory, orbital mechanics, guidance and control, and systems performance.

... for analysis of digital communication and control systems: real-time digital computer and closed-loop systems.

... for research and development of servo and control mechanisms for large ground based and spacecraft antenna systems.

Other opportunities exist for electronic engineers and physicists in many areas at JPL which has been assigned the responsibility for the nation's Lunar, Planetary and Interplanetary unmanned exploration programs.

MOON BOUNCE...a collaborative project of the National Aeronautics and Space Administration, the Jet Propulsion Laboratory, and the Australian Ministry of Supply to link two continents by radio signals bounced off the Moon

CAREERS

On February 10, 1961, California and Australia were linked in the first international space communication experiment that bounced voice messages between the two points via the Moon. The words were beamed at the Moon from the Jet Propulsion Laboratory transmitter at Goldstone, California to the receiver at Woomera, Australia.

Principals in the conversation were Dr. Hugh L. Dryden, NASA Deputy Director, whose voice was relayed from Washington by telephone; Dr. Lee DuBridg, President of California Institute of Technology, who spoke directly from Goldstone; and Alan Hulme, Australian Minister of Supply at Woomera.

The occasion tested the new Australian station, the second of three Deep Space Instrumentation stations developed and directed for the National Aeronautics and Space Administration by the Jet Propulsion Laboratory.

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JET PROPULSION LABORATORY
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Engineering doctoral degrees in certain southern universities will be strengthened by a recent \$3 million Ford Foundation grant. Georgia Institute of Technology was given \$680,000; University of Florida, \$695,000; North Carolina State College, \$760,000, and the University of Texas \$975,000. The funds will be used to hire new faculty members with the academic stature to conduct graduate courses and supervise graduate theses as well as to strengthen the present graduate staffs by further education.

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Paper Call: Awards for essays on that hard-to-get-rid-of phenomenon, gravity, have been announced by Roger Babson's Gravity Research Foundation, New Boston, N.H.

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The deadline is April 15.

PAPER DEADLINES

Convention Program Chairmen have issued the following deadlines to authors wishing to have their papers considered for presentation.

April 15: Deadline for papers for 1961 annual NEREM (Northeast Electronics Research and Engineering Meeting) which will be held Nov. 14-16 in the Commonwealth Armory and Somerset Hotel, Boston. Papers should describe R&D aspects of original developments. New feature of this year's meeting will be the invited state-of-the-art tutorial sessions and discussion panels which will be held in addition to the contributed papers. Send either complete papers or 400-500 word abstracts in triplicate, plus 50-word summaries for advance program mailings, to F. K. Willenbrock, Pierce Hall, Harvard University, Cambridge 38, Mass.

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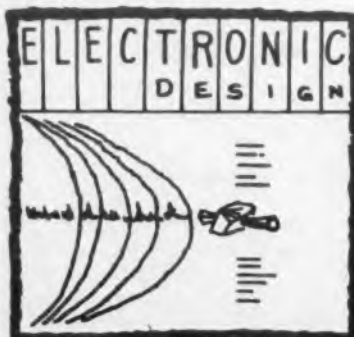


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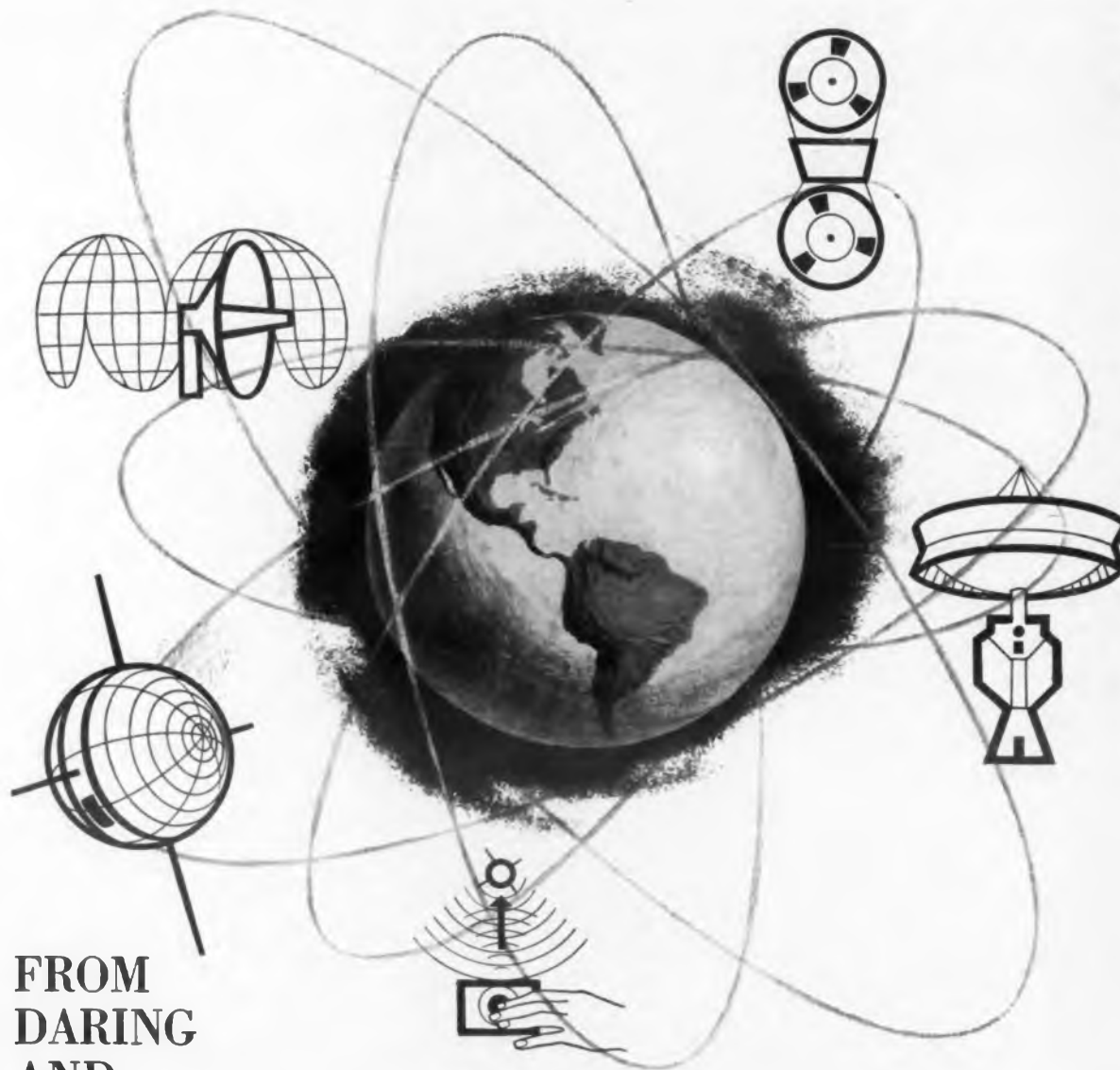
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hp 400H Vacuum Tube Voltmeter

Voltage Range: 0.1 mv to 300 v, 12 ranges
Frequency Range: 10 cps to 4 MC
Accuracy: With nominal line voltages from 103 to 127 v, overall accuracy is within
 $\pm 1\%$ of full scale, 50 cps to 500 KC
 $\pm 2\%$, 20 cps to 1 MC
 $\pm 3\%$, 20 cps to 2 MC
 $\pm 5\%$, 10 cps to 4 MC
Price: Cabinet, \$325.00, rack mount, \$330.00



hp 400L Logarithmic Voltmeter

Voltage Range: 0.3 mv to 300 v, 12 ranges
Decibel Range: -70 to +52 db, 12 ranges
Frequency Range: 10 cps to 4 MC
Accuracy: At nominal line voltage $\pm 10\%$, overall accuracy is within
 $\pm 2\%$ of reading or $\pm 1\%$ of full scale, whichever is more accurate, 50 cps to 500 KC
 $\pm 3\%$ of reading or $\pm 2\%$ of full scale, 20 cps to 1 MC
 $\pm 4\%$ of reading or $\pm 3\%$ of full scale, 20 cps to 2 MC
 $\pm 5\%$ of reading 10 cps to 4 MC
Price: Cabinet, \$325.00, rack mount, \$330.00



hp 425A DC Microvolt-Ammeter

Voltage Range: Pos. and neg. voltages 10 μv to 1 v full scale, 11 ranges
Accuracy: $\pm 3\%$ of full scale
Ammeter: Current range, pos. and neg., 10 μa to 3 ma, full scale, 18 ranges; accuracy $\pm 3\%$ of full scale
Price: Cabinet, \$500.00, rack mount, \$505.00



hp 412A DC Voltmeter-Ohmmeter-Ammeter

Voltage Range: Pos. and neg. voltages 1 mv to 1,000 v full scale, 13 ranges
Accuracy: $\pm 1\%$ full scale on any range
Ammeter: Current range, pos. and neg. currents from 1 μa to 1 a full scale, 13 ranges; Accuracy $\pm 2\%$ of full scale on any range
Ohmmeter: Resistance range, 1 ohm to 100 megohms center-scale, 9 ranges; accuracy $\pm 5\%$ of reading, 0.2 ohm to 500 megohms $\pm 10\%$ of reading, 0.1 to 0.2 ohm and 500 megohms to 5,000 megohms.
Price: Cabinet, \$400.00, rack mount, \$405.00

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RCA CERMOLOX TUBES...

a new concept in Beam Power Tube technology

To meet the increasing demand for dependable UHF power, RCA has developed Cermox Tubes, a wide line of coaxial, ceramic-metal beam power tubes with precision-aligned grids. These Cermox tubes are especially well suited to the requirements of aircraft, missile and guidance applications in CW, Pulse, and Hard-Tube-Modulator service.

Already they have set an enviable record of performance in such exacting applications. In Pioneer V, for instance, Cermox tubes were used in the guidance systems, and in the satellite's high-power transmitter.

Some outstanding features of RCA Cermox tubes which contribute to long life and reliability are:

- Precise alignment of grids for outstanding efficiency.
- Coaxial-electrode structure adaptable for use either in coaxial-cylinder or parallel-line circuits.
- Exceptionally sturdy structure.
- Low rf-loss ceramic insulation.
- High temperature operation.
- Brazed construction involves no spot welding and assures low rf losses and low internal stresses.
- Compact, ceramic-metal construction.
- Flexibility of cooling techniques: conduction, liquid, and forced air (with RCA's high-efficiency radiator).

The family of RCA Cermox tubes is shown in the adjacent table. For more information, contact the RCA Field Office nearest you.



The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA

| RCA CERMOLOX BEAM POWER TUBES | | | | |
|--|------------------------|----------------------------|------------------------|----------------------|
| Type | Max. Plate Input Watts | Max. Freq. at Max. Ratings | Max. Plate Diss. Watts | Heater Volts/Amperes |
| CW APPLICATION | | | | |
| 7870 Conduction Cooled | 52.5 | 3,000 | 25 | 6.3/1 |
| 7801 Conduction Cooled | 52.5 | 3,000 | 25 | 12.6/5 |
| 6816 Forced-Air Cooled | 180 | 1,215 | 115 | 6.3/2.1 |
| 7844 Conduction Cooled | 180 | 1,215 | 115 | 6.3/2.1 |
| 7842 Ruggedized Conduction Cooled | 180 | 1,215 | 115 | 6.3/3.0 |
| 7457 Ruggedized Forced-Air Cooled | 180 | 1,215 | 115 | 6.3/3.0 |
| 7843 Conduction Cooled | 180 | 1,215 | 115 | 26.5/52 |
| 6884 Forced-Air Cooled | 180 | 1,215 | 115 | 26.5/52 |
| 7650 Ruggedized Forced-Air Cooled | 1,250 | 1,215 | 600 | 6.3/7.5 |
| A-2663* Conduction Cooled | 1,250 | 1,215 | 600 | 6.3/7.5 |
| 7213 Forced-Air Cooled | 2,500 | 1,215 | 1,500 | 5.5/17.5 |
| A-2545-A* Forced-Air Cooled | 28,000 | 400 | 10,000 | 8/88 |
| PULSED RF APPLICATION | | | | |
| A-2587-A* Conduction Cooled | 3,750 | 3,000 | 25 | 12.6/41 |
| 7649 Ruggedized Forced-Air Cooled | 9,000 | 1,215 | 115 | 6.3/3.0 |
| 7651 Ruggedized Forced-Air Cooled | 72,000 | 1,215 | 600 | 6.3/7.5 |
| 7214 Forced-Air Cooled | 180,000 | 1,215 | 1,500 | 5.5/17.5 |
| A-2581-A* Forced-Air Cooled | 2,000,000 | 600 | 10,000 | 18/12 |
| HARD-TUBE-MODULATOR APPLICATION | | | | |
| A-2638* Ruggedized Forced-Air Cooled | 8,000 | — | 115 | 6.3/3.0 |
| A-2624* Ruggedized Forced-Air Cooled | 60,000 | — | 600 | 6.3/7.5 |
| A-2627-A* Ruggedized Conduction Cooled | 300,000 | — | 1,500 | 5.5/17.5 |
| A-2625* Conduction Cooled | 1,500,000 | — | 10,000 | 18/12 |

The chart shown above includes all RCA Cermox Tube types available as of February 4, 1961.

*Development Type—Available on Sampling Basis

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