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

**WEIGHT:** 5 ounces

**INPUT IMPEDANCE:** 50,000 ohms minimum

**MODULATION SENSITIVITY:** ± 10 MV for ± 7½% deviation for standard RDB channels

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

**LINEARITY:** less than ± 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°C

Center frequency and sensitivity are stable within ± 3% of design bandwidth for a temperature change from -20°C to +80°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 ± 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°C a change in the supply voltage of - 10% will vary the center frequency less than ± 0.5% of design bandwidth

**DRIFT:** less than ± 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 ±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°C a change in the supply voltage of ±10% will vary the center frequency less than ±0.5% of design bandwidth

DRIFT: less than ±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°C. At any information input, the output frequency is stable within ±1% of design bandwidth for a temperature change from 0°C to +80°C.

The output frequency is stable within ±2% of dbw for a temperature change of -20°C to +80°C.

COMPLETELY ENCAPSULATED

CIRCLE 249 ON READER SERVICE CARD

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 electrohydraulic 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.

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-5838 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
AF Orders Telegraph Distortion Monitor

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

AIR FORECE 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...
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 μsec. A modified phantastron circuit gives triggered sweeps linear to 1 per cent in 10 ranges from 30 μsec to 3 sec, according to Radiation, Inc. • • •

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.
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.

<table>
<thead>
<tr>
<th>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.</th>
<th>Max. Transmission (without auxiliary polarizing)</th>
<th>Transmission Bands (microns)</th>
<th>Linear Aperture (max, practically feasible)</th>
<th>Information Bandwidth (cps)</th>
<th>Power requirements (w/cm² per cycle of bandwidth)</th>
<th>Weight (including auxiliaries)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerr cell</td>
<td>80%</td>
<td>0.4 to 1.0</td>
<td>4'' x 4'' limited by energy requirements</td>
<td>10⁹</td>
<td>~0.02</td>
<td>&lt;20 lb</td>
</tr>
<tr>
<td>Pockels cell</td>
<td>70%</td>
<td>0.35 to 1.1</td>
<td>4'' 0.0 limited by crystal optics</td>
<td>10³</td>
<td>~0.004</td>
<td>&lt;20 lb</td>
</tr>
<tr>
<td>Faraday cell</td>
<td>80%</td>
<td>0.3 to 1.2</td>
<td>2.4'' 0.0 limited by energy required</td>
<td>10⁶</td>
<td>~10</td>
<td>&lt;20 lb</td>
</tr>
<tr>
<td>Stress Optic</td>
<td>25%</td>
<td>0.3 to 1.2</td>
<td>&gt;12'' x 12'' no serious limitations</td>
<td>10⁴ to 10⁵</td>
<td>~0.02</td>
<td>&lt;10 lb</td>
</tr>
<tr>
<td>Lenticulated Lens plus Grid Shutter</td>
<td>85%</td>
<td>Full range</td>
<td>No serious limit</td>
<td>10³ or better</td>
<td>~0.003</td>
<td>&lt;10 lb</td>
</tr>
</tbody>
</table>
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 whenever 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 transmitted in a plane that was, to simulate the missing sun, crossed by the moon of the Earth.

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.

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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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Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.
Stressed-plate modulator used in desert tests of Socom. Action is similar to Kerr cell, but polarization is shifted by stressing the glass-shutter plate by means of the piezoelectric stacks. The advantages of this shutter are said to be high reliability, low power requirements and low thermal absorption. The modulation rate, however, is limited to the low kc range.

Like water, a signal carrier is applied to a piezoelectric transducer, and a train of ultrasonic pressure waves travels down the medium.

Thus the medium is broken up into minute, alternate bands of high and low optical density—the equivalent of a defraction grating. The light is defracted around a stop placed on the optical axis.

The maximum bandwidth of this device is about 20 mc. For small bandwidths, a maximum transmission efficiency of about 70 per cent is possible.

Present Polarization Devices Fail To Approach Optimum Requirements

As mechanical modulation becomes obsolete, it will probably not be superseded by presently known polarization devices. None of these approaches optimum requirements.

A disadvantage of all ordinary polarizers is inefficiency. The first polarizer reduces the peak intensity of the light by at least 50 per cent.

One type of polarizer essentially is mechanical. It intercepts a light beam by a wave plate, which is rotated in accordance with a signal. The light transmitted through the plate is polarized in accordance with the degree of rotation.

The large rotation angle needed for adequate changes in the degree of polarization, as well as the use of mechanical equipment, give this scheme no advantage over mechanical shutters.

The Kerr cell is an electro-optical device. Light transmitted through a liquid has its polarization changed in accordance with an electrical signal impressed on the liquid.

The Kerr cell, however, requires auxiliary equipment—a high-power source, low-voltage driving modulator and a power modulator. This

Announcing the
TDA 875 SOLID STATE
Differential and Single-Ended
AMPLIFIER

- Recovery from 500% overload in 300 microseconds.
- Output voltage clamped at ±13 volts, can’t burn out delicate recording equipment.
- Completely isolated, 3000 megohm leakage path to ground.

Built to meet the needs of the engineer designing low-level multiplexing systems, Epsco-West’s new TDA 875 Differential Amplifier features high reliability, high gain, wide band-width, negligible drift, high ac/dc common mode rejection, low noise, fast rise time, fast recovery time, integral power supply, and high input impedance. No other amplifier combines all these design parameters to such a useful degree.

DESCRIPTION

The Model TDA 875 contains an integral power supply which operates from a 117-volt, 60-400 cps line, requiring only 13 watts of power. Chopper drive circuits are included with each amplifier.

Two modes of operation are available: differential and single-ended (potentiometric); selection is made by means of a front panel control. Five fixed gains are also chosen by a front panel switch.

In its differential mode, the amplifier provides 10 volts at 10 milliamperes as its full scale output; in its single-ended mode, full scale output is ±10 volts at 50 milliamperes. High input impedance ensures that all transistor voltage will appear at the amplifier input terminals. Changes in transistor or line resistance will have little consequence.

The Model TDA 875 Amplifier may be mounted in the Model TDA 870A Carrying Case for easy portability, or in the Model TDA 870 Rack Adapter which holds 5 amplifiers in a standard 19-inch relay rack.

*One of six new E-W amplifiers now available to meet your low-level instrumentation needs.

Ask your nearby Epsco-West engineering representative to demonstrate these new amplifiers. For complete technical information, write for Brochure No. 875.

Epsco-West

240 E. Palais Rd., Anaheim, Calif. • Prospect 2-1000

ELECTRONIC DESIGN • April 12, 1961
NEW MINIATUREIZED FLOATING CLINCH NUT

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

Here at last is a reduced-dimension clinch nut and basket assembly that provides 0.020” 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 bolt. 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.

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.

ELENTRONIC DESIGN • April 12, 1961
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'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 1/4 x 3 1/4 x 2 1/4.

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.
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 Armament 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 tantals 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 HN851, for potting transistors. DOFL, on the other hand, uses a composition of Shell Chemical's Epon 828 resin and DIMAPA (dimethylaminopropylamine) curing...
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.

<table>
<thead>
<tr>
<th>Transistors (Potted)</th>
<th>Acceleration (G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philo 2N128</td>
<td>128,000</td>
</tr>
<tr>
<td>Philo 2N345</td>
<td>102,000</td>
</tr>
<tr>
<td>Philo 2N502</td>
<td>142,000</td>
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<td>Motorola 2N700</td>
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<td>Fairchild 2N706</td>
<td>189,000</td>
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<th>Capacitors</th>
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<tr>
<td>Centralab Hikap</td>
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<td>Aerovox DM 15</td>
<td>142,000</td>
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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 180,000 g. A similar Motorola 2N655 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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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 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.

**Telefile System Permits Long-Range Banking**

A new Telefile system allows savings account transactions to be made at a distant bank.

Small banks not related to one another reportedly can use a joint Telefile center and benefit from all its services at nominal cost to each.

The system was developed by Teleregister Corp. of Stamford, Conn.
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New high-temperature ratings on 16 popular RCA silicon transistors for improved performance in military and industrial applications at no increase in price

Here are 16 RCA N-P-N diffused-junction silicon power transistors immediately available in quantity, to meet the more exacting performance requirements of today's industrial and military equipment. Check out the remarkable improvements these RCA high-performance industrial transistors now offer:

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All of these features provide greater flexibility in the design of power switching devices such as dc-to-dc converters, inverters, choppers, solenoid and relay controls; oscillators, regulators, and pulse amplifiers; and class A and class B amplifiers for servo and other audio frequency applications.

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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.
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, upgrading 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 ft; 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 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. 1. Various stages of assembly for a logic stick designed for the Polaris computer.
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 rewraps 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 epoxies through 0.7 to 1.0 for microballon-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.

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 buildup 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 used.

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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 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 Specification.

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

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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 prefered 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.

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**Electronic Design**

April 12, 1961

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45
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.

$$t_r = \frac{\pi}{\int_0^\infty A(\omega) \cos(\omega t - \phi) \, d\omega}$$

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
Diffs 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 megahertz/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 \( \omega \) which is equal to that of the if amplifier at \( \omega_0 + \omega \), where \( \omega_0 \) 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 through the passband and zero outside the passband. It will have zero phase distortion through the passband. This is illustrated in Fig. 1. In Eq. 1 we take \( \phi = \omega t_0 \) and \( A = 1 \) for \( 0 < \omega < 2 \pi \) times \( 10^4 \), and \( A = 0 \) for \( \omega > 2 \pi \) times \( 10^4 \). The rise time is then calculated to be exactly 0.5 usec.

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 336. 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 of the amplitude and phase error, \( A \cos \Delta \phi \), we find that the rise time of the if amplifier is 0.35 usec,—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 usec; for 10 db, it is 0.63 usec, and for 20 db, it is 1.0 usec.

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 usec, 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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ELECTRONIC DESIGN • April 12, 1961
Guidelines in Designing For Optimum Transient Response

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

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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.
TRANSISTORS

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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But life testing is only one of the product quality assurance procedures through which all General Electric semiconductors must pass. The average is sixteen separate tests—electrical, mechanical and environmental, as well as life.

General Electric has also introduced a series of design improvements which have raised reliability expectations to a new peak. G-E’s Fixed Bed Mounting, for example, almost overnight changed delicate grown-junction devices into rugged units with extreme stability and inherently higher power dissipation. One Fixed Bed Mounted Series, types 2N332A through 2N336A, can dissipate up to 500 mw without a heat sink at 25°C, providing an unusually wide safety factor.

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G-E germanium tunnel diodes provide switching times of 2 millimicroseconds and self-resonant frequencies covering the S band. The new microwave tunnel diode stripline package has inductance less than .000,000,000,4 henries. This small stripline type package is designed for microwave communications, radar, very high frequency amplifiers, and oscillator applications.

See your G-E Semiconductor District Sales Manager for additional application data and specifications.
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<td>0.95</td>
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</tr>
<tr>
<td>1.0</td>
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<tr>
<td>1.5</td>
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<tr>
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<tr>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>
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**

<table>
<thead>
<tr>
<th>Type</th>
<th>Max. in. at 25°C</th>
<th>Max. Full Voltage Drop</th>
<th>Max. Cycle Voltage</th>
<th>Max. Full Load Voltage Drop</th>
<th>Max.</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1N93</td>
<td>300 ma</td>
<td>75 ma</td>
<td>1.8 V</td>
<td>200 ma</td>
<td>95'</td>
<td>Industry standard for high reliability units.</td>
</tr>
<tr>
<td>1N93</td>
<td>300 ma</td>
<td>75 ma</td>
<td>1.8 V</td>
<td>200 ma</td>
<td>95'</td>
<td>Feature extremely low forward resistance, high back resistance.</td>
</tr>
<tr>
<td>1N93</td>
<td>300 ma</td>
<td>75 ma</td>
<td>1.8 V</td>
<td>200 ma</td>
<td>95'</td>
<td>Feature extremely low forward resistance, high back resistance.</td>
</tr>
<tr>
<td>1N93</td>
<td>300 ma</td>
<td>75 ma</td>
<td>1.8 V</td>
<td>200 ma</td>
<td>95'</td>
<td>Feature extremely low forward resistance, high back resistance.</td>
</tr>
<tr>
<td>1N93</td>
<td>300 ma</td>
<td>75 ma</td>
<td>1.8 V</td>
<td>200 ma</td>
<td>95'</td>
<td>Feature extremely low forward resistance, high back resistance.</td>
</tr>
</tbody>
</table>

### SILICON SUBMINIATURE GLASS RECTIFIER CELLS (Lead Mounted)

**UP TO 400 MA**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1N645</td>
<td>225</td>
<td>15 ma</td>
<td>15 ma</td>
<td>120 ma</td>
<td>175°</td>
</tr>
<tr>
<td>1N647</td>
<td>400</td>
<td>15 ma</td>
<td>15 ma</td>
<td>120 ma</td>
<td>175°</td>
</tr>
<tr>
<td>1N648</td>
<td>500</td>
<td>15 ma</td>
<td>15 ma</td>
<td>120 ma</td>
<td>175°</td>
</tr>
<tr>
<td>1N649</td>
<td>600</td>
<td>15 ma</td>
<td>15 ma</td>
<td>120 ma</td>
<td>175°</td>
</tr>
<tr>
<td>1N677</td>
<td>100</td>
<td>15 ma</td>
<td>15 ma</td>
<td>120 ma</td>
<td>175°</td>
</tr>
</tbody>
</table>

**COMMENTS**

**SILICON SUBMINIATURE GLASS RECTIFIER CELLS (Lead Mounted)**

**UP TO 600 PRV**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1N665</td>
<td>225</td>
<td>15 ma</td>
<td>15 ma</td>
<td>120 ma</td>
<td>175°</td>
</tr>
<tr>
<td>1N667</td>
<td>400</td>
<td>15 ma</td>
<td>15 ma</td>
<td>120 ma</td>
<td>175°</td>
</tr>
<tr>
<td>1N668</td>
<td>500</td>
<td>15 ma</td>
<td>15 ma</td>
<td>120 ma</td>
<td>175°</td>
</tr>
<tr>
<td>1N669</td>
<td>600</td>
<td>15 ma</td>
<td>15 ma</td>
<td>120 ma</td>
<td>175°</td>
</tr>
<tr>
<td>1N677</td>
<td>100</td>
<td>15 ma</td>
<td>15 ma</td>
<td>120 ma</td>
<td>175°</td>
</tr>
</tbody>
</table>

**COMMENTS**

- Designed for maximum thermal conductivity. Rugged design to meet military requirements.
# Silicon Low Current Rectifier Cells

## Lead Mounted

### Up to 750 mA

<table>
<thead>
<tr>
<th>Model</th>
<th>Nominal Voltage</th>
<th>Max. Forward Current (mA)</th>
<th>Max. Reverse Voltage (V)</th>
<th>Max. Forward Voltage Drop (V)</th>
<th>Max. Reverse Voltage Drop (V)</th>
<th>Max. Operating Temperature (°C)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1N440</td>
<td>100</td>
<td>200</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>150</td>
<td>Refer also to 1N440-B-5B Specification Sheet.</td>
</tr>
<tr>
<td>1N441</td>
<td>200</td>
<td>300</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>150</td>
<td>Specification Sheet.</td>
</tr>
<tr>
<td>1N442</td>
<td>300</td>
<td>400</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>150</td>
<td>Similar to 1N536-47 series except for lower temp. and current operation. Lowest priced series.</td>
</tr>
<tr>
<td>1N443</td>
<td>400</td>
<td>500</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>150</td>
<td>Very low leakage. Ideal for magnetic-amplifier applications. Premium price.</td>
</tr>
<tr>
<td>1N444</td>
<td>500</td>
<td>600</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>150</td>
<td>Similar to 1N536-540 Specification Sheet.</td>
</tr>
<tr>
<td>1N581</td>
<td>800</td>
<td>1000</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>150</td>
<td>The popular line. Provides maximum forward conductance at high operating temperatures (165°C). Now with transient PRV ratings up to 800V.</td>
</tr>
</tbody>
</table>

## Insulated Stud

### Up to 1.5 Amps

<table>
<thead>
<tr>
<th>Model</th>
<th>Nominal Voltage</th>
<th>Max. Forward Current (Amps)</th>
<th>Max. Reverse Voltage (V)</th>
<th>Max. Forward Voltage Drop (V)</th>
<th>Max. Reverse Voltage Drop (V)</th>
<th>Max. Operating Temperature (°C)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1N681</td>
<td>100</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>150</td>
<td>Identical to the 1N1115-11120 series except the stud is electrically insulated from the junction.</td>
</tr>
<tr>
<td>1N682</td>
<td>200</td>
<td>2.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>150</td>
<td>Identification</td>
</tr>
<tr>
<td>1N683</td>
<td>300</td>
<td>3.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>150</td>
<td>Identification</td>
</tr>
<tr>
<td>1N684</td>
<td>400</td>
<td>4.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>150</td>
<td>Identification</td>
</tr>
<tr>
<td>1N685</td>
<td>500</td>
<td>5.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>150</td>
<td>Identification</td>
</tr>
<tr>
<td>1N686</td>
<td>600</td>
<td>6.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>150</td>
<td>Identification</td>
</tr>
</tbody>
</table>

## Insulated Stud

### Up to 600 PRV
### SILICON LOW CURRENT RECTIFIER CELLS (Stud Mounted)
**UP TO 1.5 AMPS**
**UP TO 1000 PRV**

<table>
<thead>
<tr>
<th>Code or GE Type Number</th>
<th>Max. Inc. A</th>
<th>@ 125°C</th>
<th>Max. Peak 1 Cycle Surge</th>
<th>Max. DC Cur. (Forward)</th>
<th>Max. Peak Volt @ 1 Cycle Surge</th>
<th>Spec. Oper. °C</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1N256</td>
<td>570</td>
<td>200 ma</td>
<td>1.3 A, 3 ms</td>
<td>2 V @ 500 ma</td>
<td>150°</td>
<td></td>
<td>Refer also to 1N1115-1120 Specification Sheet.</td>
</tr>
<tr>
<td>1N340</td>
<td>100</td>
<td>200 ma</td>
<td>10 A</td>
<td>2 V @ 400 ma</td>
<td>150°</td>
<td></td>
<td>For applications requiring moderate currents operating up to 170°C.</td>
</tr>
<tr>
<td>1N349</td>
<td>100</td>
<td>200 ma</td>
<td>10 A</td>
<td>2 V @ 400 ma</td>
<td>150°</td>
<td></td>
<td>1N560-61 mounted on studs. Popular model.</td>
</tr>
<tr>
<td>1N350</td>
<td>100</td>
<td>400 ma</td>
<td>200 ma</td>
<td>2 V @ 800 ma</td>
<td>150°</td>
<td></td>
<td>Very low leakage for magnetic amplifier applications. The 1N4408-58 series mounted on studs.</td>
</tr>
<tr>
<td>1N550</td>
<td>100</td>
<td>400 ma</td>
<td>200 ma</td>
<td>2 V @ 800 ma</td>
<td>150°</td>
<td></td>
<td>Refer also to 1N1115-1120 Specification Sheet.</td>
</tr>
<tr>
<td>1N559</td>
<td>100</td>
<td>400 ma</td>
<td>200 ma</td>
<td>2 V @ 800 ma</td>
<td>150°</td>
<td></td>
<td>Refer also to 1N1115-1120 Specification Sheet, and the 1N550-5 Specification Sheet.</td>
</tr>
<tr>
<td>1N1115</td>
<td>100</td>
<td>15 A</td>
<td>4 ma</td>
<td>65 V @ 150°</td>
<td>150°</td>
<td></td>
<td>The popular line. 1N536-40, 1N547, 1N1095-6 mounted on studs.</td>
</tr>
<tr>
<td>1N1116</td>
<td>100</td>
<td>15 A</td>
<td>4 ma</td>
<td>65 V @ 150°</td>
<td>150°</td>
<td></td>
<td>Refer also to 1N1115-1120 Specification Sheet.</td>
</tr>
<tr>
<td>1N119</td>
<td>100</td>
<td>15 A</td>
<td>4 ma</td>
<td>65 V @ 150°</td>
<td>150°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1N120</td>
<td>100</td>
<td>15 A</td>
<td>4 ma</td>
<td>65 V @ 150°</td>
<td>150°</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>JEDCO or GE Type Number</th>
<th>Repetitive PRV</th>
<th>Transient PRV</th>
<th>Max. In. @ 150°C</th>
<th>Max. Instant. Leakage @ 150°C</th>
<th>Max. Forward Voltage Drop @ 780 DC Single Phase 150°C</th>
<th>Max. Oper. Temp. °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>4AJ78B</td>
<td>200</td>
<td>300</td>
<td>70 A</td>
<td>1600 A</td>
<td>25 ma</td>
<td>200°C</td>
</tr>
<tr>
<td>4AJ78C</td>
<td>300</td>
<td>400</td>
<td>70 A</td>
<td>1600 A</td>
<td>25 ma</td>
<td>200°C</td>
</tr>
<tr>
<td>4AJ78D</td>
<td>400</td>
<td>500</td>
<td>70 A</td>
<td>1600 A</td>
<td>25 ma</td>
<td>200°C</td>
</tr>
<tr>
<td>4AJ78E</td>
<td>500</td>
<td>600</td>
<td>70 A</td>
<td>1600 A</td>
<td>25 ma</td>
<td>200°C</td>
</tr>
</tbody>
</table>

**COMMENTS**

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 4AJ70 is a "double diffused, all hard solder rectifier," which has high surge current capabilities and is highly resistant to thermal fatigue.
SILICON MEDIUM CURRENT RECTIFIER CELLS
UP TO 25 AMPS
UP TO 600 PRV

**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

![Military Types](image)
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 3380 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 IN2154 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 @ 38°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 .85 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 IN91-93 cells. 4JA420-421-422 Series utilize silicon IN515-540, IN1095 cells. (See BASIC-RECTIFIER-CELL LISTING.)
SILICON CONTROLLED RECTIFIERS

These revolutionary devices, introduced by General Electric, can do the work of thyatrons, 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**

<table>
<thead>
<tr>
<th>Model</th>
<th>Rated Current</th>
<th>DC Voltage</th>
<th>AC Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZJ203</td>
<td>25 A</td>
<td>250 V</td>
<td>250 V</td>
</tr>
<tr>
<td>2N1929</td>
<td>25 A</td>
<td>250 V</td>
<td>250 V</td>
</tr>
<tr>
<td>2N1930</td>
<td>50 A</td>
<td>250 V</td>
<td>250 V</td>
</tr>
<tr>
<td>2N1931</td>
<td>100 A</td>
<td>250 V</td>
<td>250 V</td>
</tr>
<tr>
<td>2N1932</td>
<td>150 A</td>
<td>250 V</td>
<td>250 V</td>
</tr>
<tr>
<td>2N1933</td>
<td>200 A</td>
<td>250 V</td>
<td>250 V</td>
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<tr>
<td>2N1934</td>
<td>250 A</td>
<td>250 V</td>
<td>250 V</td>
</tr>
<tr>
<td>2N1935</td>
<td>300 A</td>
<td>250 V</td>
<td>250 V</td>
</tr>
</tbody>
</table>

### SILICON MEDIUM CURRENT CONTROLLED RECTIFIERS

**UP TO 25 AMPS**

**UP TO 500 PRV**

<table>
<thead>
<tr>
<th>Model</th>
<th>Rated Current</th>
<th>DC Voltage</th>
<th>AC Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N681</td>
<td>25 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N682</td>
<td>50 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N683</td>
<td>100 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N684</td>
<td>150 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N685</td>
<td>200 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N686</td>
<td>250 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N687</td>
<td>300 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N688</td>
<td>400 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N689</td>
<td>500 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N1842</td>
<td>25 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N1843</td>
<td>50 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N1844</td>
<td>100 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N1845</td>
<td>150 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N1846</td>
<td>200 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N1847</td>
<td>250 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N1848</td>
<td>300 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>2N1849</td>
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<td>125 V</td>
</tr>
<tr>
<td>2N1850</td>
<td>500 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>C40U</td>
<td>25 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>C40F</td>
<td>50 A</td>
<td>125 V</td>
<td>125 V</td>
</tr>
<tr>
<td>C40A</td>
<td>100 A</td>
<td>125 V</td>
<td>125 V</td>
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<tr>
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<td>125 V</td>
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<tr>
<td>C40C</td>
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<tr>
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<tr>
<td>C40C</td>
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Other ratings and characteristics are the same as for 2N681-2N689, 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

<table>
<thead>
<tr>
<th>Type</th>
<th>Amps</th>
<th>Diode Type</th>
<th>Max Rating</th>
<th>Temp Rating</th>
<th>Form Factor</th>
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<td>125°C</td>
<td>40 ma</td>
<td>@125°C</td>
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</table>

Other ratings and characteristics are the same as for C50, except that turn off time is guaranteed at less than 50 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-Sele® 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.

*Auto-mate 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 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 \( \frac{3}{8} \)" dia. to \( \frac{3}{16} \)" 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, \( \frac{3}{8} \)", \( \frac{5}{16} \)" and \( \frac{1}{8} \)" round, in both standard and contact protection (arc suppression) types.
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.

**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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Military Specification</th>
<th>Single Phase Max. Ratings</th>
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<tr>
<td>U3M 2N686</td>
<td>MIL-S-19500/106</td>
<td>25 A @ 57°C stud</td>
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<tr>
<td>U3M 2N686</td>
<td>MIL-S-19500/106</td>
<td>50 A @ 57°C stud</td>
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<td>100 A @ 57°C stud</td>
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<td>MIL-S-19500/106</td>
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</tr>
<tr>
<td>U3M 2N686</td>
<td>MIL-S-19500/106</td>
<td>400 A @ 57°C stud</td>
</tr>
</tbody>
</table>
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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.

11. 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-enamedled resistor with axial leads—high temperature operation, up to 350°C; ±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!
Transistor Switching Speed from Base Storage Charges and their Lifetimes

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.

From Eq. 19, if \( I_{b1} = I_{RS} \) and \( RC \ll 0 \), then

\[
\tau_t = \frac{\Delta t_c}{\ln (\text{current ratio})}\quad (21)
\]

the circuit, shown in Fig. 9 is used for measuring \( \tau_t \). 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 \( \tau_t \) 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 \( \tau_t \) for mesa transistors is in the range of 20 to 100 nsec, reasonable readings can still be obtained. A plot of \( \tau_t \) vs \( I_c \) for the ZJ-42 is shown in Fig. 11.

Example of Rise-Time Prediction

Conditions: 2N396 Unit 22-12; \( Q_{b}^{*}/0.90\% \) at \( V_{cc} = 10 \) v.

\( Q_{b}^{*} \) test results:

- \( V_{cc} = 10 \) v; \( I_{cb} = 1 \) ma;
- \( Q_{b}^{*}/0.90\% = 200 \mu \text{C} \);
- \( V_{cc} = 10 \) v; \( I_{cb} = 10 \) ma;
- \( Q_{b}^{*}/0.90\% = 446 \mu \text{C} \).

Desired results (1) Rise time at \( V_{cc} = 5 \) v;
- \( I_{cA} = 100 \) ma; \( I_{b1} = 10 \) ma.
(2) Rise time at \( V_{cc} = 15 \) v;
- \( I_{cA} = 1 \) ma; \( I_{b1} = 0.1 \) ma.
(a). Rise time at \( V_{cc} = 5 \) v; \( I_{cA} = 100 \) ma; \( I_{b1} = 10 \) ma.

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

\[
\tau_a = \frac{Q}{I_B}\quad \text{in the active state or below saturation}
\]

\[
\tau_b = \frac{Q_{nx}}{I_{b1}}\quad \text{in the static state or in saturation}
\]

\( \tau_a \) applies to the lifetime of the carriers in the active state, during turn-on and turn-off, and \( \tau_b \) 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, \( \tau_b \) (see Eq. 4).

\( \tau_b \) is then related to the storage time by

\[
\tau_a (\text{flat portion}) = \tau_b \ln \frac{I_{b1} - I_{b2}}{I_{b2} - I_{b3}}
\]\n
and \( \tau_a \) to the rise time by

\[
\tau_a (\text{rise set}) = \tau_a \ln \frac{I_{b1} - 0.1 I_{RS}}{I_{b2} - 0.9 I_{RS}}
\]\n
when \( R_c \) 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 \( \tau_a \), the circuit shown in Fig. 7 is used.

By changing \( V_{IV} \) through a known ratio, and keeping \( I_{b3} \) small, \( \tau_b \) is obtained by

\[
\tau_b = \frac{\Delta t_c}{\ln (\text{current ratio})}
\]\n
For both alloy and mesa transistors \( \tau_b \) is fairly constant throughout the range tested. An alternative circuit, as shown in Fig. 8, is used for measuring \( \tau_a \). By adjusting \( V_{IV} \), a plot of \( \tau_a \) vs voltage, on semi log paper, is obtained. Notice that the slope of \( \tau_a \) \( \ln \) (voltage ratio) is constant and equal to \( \tau_a \).

Next, \( \tau_a \) is of interest, not because Eq. 19 is directly to be used for calculating switching time, but because \( \tau_a \) is fundamentally related to the \( h_{fe} \) of the transistor; also, knowing the range of \( \tau_a \), predictions of \( t_r \) and \( t_f \) with constant current drive can be made with assurance by using Eqs. 6 to 9.
Fig. 7. Circuit used for the measurement of $\tau_b$, carrier lifetime when the transistor has been saturated for a sufficiently long time.

Fig. 8. An alternative circuit for measurement of carrier lifetime $\tau_b$.

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

(1) Find $Q_c$ at 10-v supply voltage.

$$Q_c(10v) \bigg|_{0.95\%} = 200 - \frac{446 - 200}{9\text{ ma}} = 200 - 27.3 = 172.7 \mu\text{C}.$$  

(2) Convert this to $Q_c$ at desired $V_{cc}$.

$$Q_{c(10v)} \bigg|_{0.95\%} = \left[ Q_{c(10v)} \bigg|_{0.95\%} \right] \times \left[ \frac{\sqrt{5}}{\sqrt{10}} \right] = Q_{c(10v)} \bigg|_{0.95\%} = \frac{172.7}{\sqrt{2}} = 122 \mu\text{C}.$$  

(3) Find $Q_a$ per unit and desired $Q_a$ at current of interest.

$$Q_a = \frac{446 - 200}{9\text{ ma}} = 27.3 \mu\text{C/ma}.$$  

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

(4) Combine $Q_a$ and $Q_c$ for $Q_a^*$.

at 5 v, 100 ma.

$$Q_{a^*} \bigg|_{0.95\%} = Q_a + Q_c \bigg|_{0.95\%} = 2,730 + 122 = 2,852 \mu\text{C}.$$  

(continued on p 52)

Fig. 10. Carrier lifetime $\tau_a$ vs collector current $I_c$ for an alloy transistor.

Fig. 11. Carrier lifetime $\tau_a$ vs collector current $I_c$ for a mesa transistor.
(5) Find rise time and check with circuit value.

\[ t_r(10\% - 90\%) = \frac{8 \times Q_b t}{9 \times I_{B1}} = \frac{(0.89) (2.832)}{10} = 254 \text{ nsec} \]

circuit value = 250 nsec.
deviation predicted \( t_r = 4 \text{ nsec} \) = 1.6%.
from measured \( t_r \).
(b). Rise time at \( V_{CC} = 15 \text{ v} \); \( I_{EB} = 1 \text{ ma} \); \( I_{B1} = 0.1 \text{ ma} \).
(1) Find \( Q_c \) at 15-v supply voltage using previously obtained \( Q_c \) at 10 v.

\[ Q_{c(15v)} = \frac{Q_{c(10v)}}{\sqrt{15/10}} = \frac{1.228 \times Q_{c(10v)}}{1.228 \times 212} = 172.7 \times 212 = 27.3 \mu \text{C/mA}. \]

(2) From (a) (3), \( Q_b \) per unit = 27.3 \mu\text{C/mA}.
(3) Combine \( Q_b \) and \( Q_c \) for \( Q^* \) at 15 v, 1 ma.

\[ Q^* = \frac{Q_b + Q_c}{10} = 27.3 + 212 = 239.3 \mu \text{C}. \]

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

\[ t_r(10\% - 90\%) = \frac{8 \times Q^*}{9 \times I_{B1}} = \frac{(0.89) (239.3)}{10} = 2.13 \mu \text{sec} \]

circuit value = 2.20 \mu\text{sec}.
deviation predicted \( t_r \) 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.
\( V_{BB2} = V_{BB} \) (after turn on) = 0.4 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 v, +2.68 v.

\[ T_D = \frac{V_{BB}}{I_{B1}} \text{ (before turn on) } C_B = \left( \frac{V_{BB}}{2} \right) \left( \frac{C_B}{I_{B1}} \right) \]

At \( V_{BB} = 0 \): \( T_D \) predicted = 0
Actual observed \( T_D = 2 \text{ nsec} \).
Propagation constant = +2 nsec.
At \( V_{BB} = +1.32 \text{ v} \): First find \( I_{B1} \).

\[ I_1 = \frac{V_{BB} - V_{IX}}{2K} ; I_2 = \frac{V_{BB} - V_{BE}}{2K} \]

\[ I_B = I_1 - I_2 = \frac{2V_{BE} - V_{IX} - V_{BB}}{2K} \]

\[ I_{B1} = -0.8 \text{ v} + 7 \text{ v} - 1.32 \text{ v} = 2.44 \text{ ma.} \]

\[ T_D = \frac{1.32 \text{ v} + 0.08 \text{ v} + 7 \text{ v} - 1.32 \text{ v}}{2.44 \text{ ma}} = 1.7 \text{ nsec}. \]

Adding propagation constant = 2 nsec.
Total \( T_D \) predicted = 3.7 nsec.
Actual observed \( T_D = 3.8 \text{ nsec} \).
At \( V_{BB} = +2.68 \text{ v} \):

\[ T_D = \frac{2.68 \text{ v} + 0.65 \text{ pf} + 1.76 \text{ ma}}{2} = 4.7 \text{ nsec}. \]

Adding propagation constant = 2 nsec.
Total \( T_D \) predicted = 6.7 nsec.
Actual observed \( T_D = 7.2 \text{ nsec} \).

From Eq. 15, \( \frac{1}{9} \times Q^* = \frac{90\%}{I_{B1}} \) must be added to obtain \( T_D \) (to 10%)}

Storage Prediction For Long Pulse

Conditions: ZJ-42 Unit # 2
From test results, \( V_{BB} = 0.4 \text{ v}, t_b = 113 \text{ nsec} \).
\( I_{BS} = 0.24 \text{ ma} \).
\( Q^* \) (100%) = \( Q^* \) (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, \( I_{B1} = 2.44 \text{ ma} \), \( I_{B2} = -1.06 \text{ ma} \).

\[ t_r(10\% - 90\%) = t_b \ln \left( 1 + \frac{I_{B1} - I_{B2}}{I_{B1} - I_{B2}} \right) + \Delta Q^* (100\% \text{ to } 90\%) \]

\[ = \frac{t_r(90\%)}{1.06 \text{ ma} + 6 \mu\text{C}} \]

\[ = \frac{113 \text{ nsec \ln (2.69)} + 5.7 \text{ nsec}}{1.06 \text{ ma} + 6 \mu\text{C}} \]

\[ t_r(90\%) = 111.8 \text{ nsec} + 5.7 \text{ nsec} = 117.5 \text{ nsec} \]

Predicted \( t_r(90\%) = 117.5 \text{ nsec} \).
Actual observed \( t_r(90\%) = 130 \text{ nsec} \).

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 \( t_f = 50 \text{ nsec} \).
Also,

\[ Q^* \text{ (90\%)} \geq Q^* \text{ (90\%)} at 4.5 \text{ v} \]

\[ \geq Q^* \text{ (90\%)} at 11.25 \text{ ma} \geq 42.6 \mu\text{C} \]

\[ Q_c \text{ (90\%)} \text{ at } 5 \text{ v} = 33.8 \mu\text{C} \]

\[ Q_r = Q^* \text{ (90\%)} - Q_c = 8.8 \mu\text{C} \]

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

\[ t_f(10\% - 90\%) = \frac{8}{9} \times Q^* \text{ (90\%)} \]

\[ - I_{B2} + \frac{Q^* \text{ (90\%)} - I_{B2}}{2r_n} \]

\[ = \frac{8}{9} \text{ (42.6) \mu\text{C}} \]

\[ = \frac{1.06 \text{ ma} + 8.8 \mu\text{C}}{2(50 \text{ nsec})} \]

Predicted \( t_f(10\% - 90\%) \) = 32.9 nsec.
Actual observed \( t_f(10\% - 90\%) \) = 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, \( V_{BB} \) was measured at \( V_{IN} = -5 \text{ v} \), and this average was used to obtain \( I_{B1} \) at all input voltages. Greater accuracy of \( V_{BB} \) 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, when \( R_1 = 2 \text{ K}, R_2 = 22 \text{ K}, R_L = 1 \text{ K}, C_1 \) (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 \( V_{18} = -10 \, \text{v}, -7 \, \text{v}, -5 \, \text{v}, -3.5 \, \text{v} \). The values of charge transferred through \( C_i \), \([V_{in} - V_{BB}] C_i\), must be subtracted from \( Q_{n}^* \) for this case so that
\[
(t_d + t_f) = \frac{Q_{n}^* - (V_{in} - V_{BB}) C_i}{I_{B1}}
\]
With \( t_d + t_f \)

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 \( V_{BB} = +1.32 \, \text{v}, +2.68 \, \text{v} \) 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 \( V_{BB} = 0, +1.32 \, \text{v}, +2.68 \, \text{v} \). 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 \( V_{BB} = +1.32 \, \text{v}, +2.68 \, \text{v} \). 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 \( Q_{n}^* \), \( t_d \) and \( t_s \) 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 \( Q_{n}^* \) to \( I_{C} \) is one possible parameter, which Sparkes has called \( \tau _{C} \). Or, the ratio \( Q_{n}^* \) to \( I_{B} \) can be another, which Simmons has called \( \tau _{BB} \).

**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.

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1See Reference 6, part 1, ED, March 15, 1961, p 55.
2See Reference 7, part 1, ED, March 15, 1961, p 55.
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, \( Q = CE, \) \( C = \varepsilon_1 d / \varepsilon \), and realizing that the areas of dielectric constant \( \varepsilon_1 \) and \( \varepsilon_2 \) may be considered as capacitors in series, the...
following equation for the voltage drop across the insulating material can be derived:

\[
e_2 = \frac{e_1 d_1 E}{e_2 d_2}
\]  

(1)

There are two conditions which must be compared. In condition 1, \(e_1 = e_2\), or the gap is completely homogenous, Fig. 2a. If the gap dielectric is air \((e = 1)\), the voltage at any point in the gap is (from Eq. 1, with \(d_2 = d - d_1\)):

\[
e_2 = \frac{d - d_1}{d} E
\]  

(2)

This is a linear relationship.

In condition 2, \(e_1 \neq e_2\), 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:

\[
e_2 = \frac{e_1 (d - d_1) E}{e_2 d_2 + e_1 (d - d_1)}
\]  

(3)

and depends upon the dielectric thickness.

Eqs. 2 and 3 are plotted in Fig. 3 for a gap 1-in. wide, with \(e_1 = 2.1\) (Teflon) and \(e_2 = 1\) (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, \(e/\alpha\), 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 \(\lambda\):

\[
\lambda = e_2 - e_2
\]  

(4)

\[
\lambda = \frac{(e_1 d_1 - e_1 d_1) E}{e_1 + e_1 d_1} - C
\]  

(5)

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

\[
d_{1,\text{max}} = d \left( \frac{\sqrt{e_1 e_2} - e_1}{e_2 - e_1} \right)
\]  

(6)
FAST RESPONSE?

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DOUBLE-FRAME-GRID PENTODE

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 µmhos (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 microphonic. 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,
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.
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 86-2/3 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.
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 ±.005 in., with total over-length buildup not exceeding ±.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.

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 dbm.
Applications improved include cathode-ray capability from Power Law, controls able facilitated panel horizontal fast deep. High, linear, internal attenuation for the instrument, shown below indicate the broad range of superior quality units offered by General Instrument.

Sensitivity is 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 5ADF7 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 ±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. Photograph 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.
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**

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 Lodge Drive, Avon, Mass.

*Availability: Immediate.*

---

**Zener Diode**

**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**

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 µsec to the storage and display decades. Ranges are: frequency, dc to 10 mc; period, 10 µsec to 10¹ sec; interval, 1 µsec to 10¹ sec. Circuits are designed for maximum reliability. Plug-in time-base oscillators are available with stabilities up to 5 parts in 10¹⁰ per min.


*Price: from $2,585 to $2,950.*
**MINIATURE PHOTOCELL**

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.


**Price & Availability:** $10 to $35; 1 week.

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**PLUG-IN IF AMPLIFIER**

The Amplitrans 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.

---

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TI 2N1141, 2N1142, 2N1143 germanium mesa transistors providing maximum dissipation of 750 mw at 25°C case temperature, 35 volts at 100 μa Ic, and fmax to 750 mc are ideal for your VHF power amplifier and oscillator circuits.

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**TYPICAL CHARACTERISTICS AT 25°C**

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**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 ±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 $10^{14}$ ohms can be measured.

**brief specifications**

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**NEW PRODUCTS**

**Pressure Gauge**

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.


Price & Availability: $257.50, immediate.

**Servo Amplifiers**

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**

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.

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

Numerical Comparator

Developed for automatic control, digital comparator uses numerical commands to control machinery to 0.0001 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

Operating at 10 kc, 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.

Price: $239.50; 30 days in quantities to 100.

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ELECTRON TUBE DIVISION, Harrison, N. J.

FIELD OFFICES: Newark, N. J., 744 Broad St., Wilmington 5, Del.; Los Angeles 22, Calif., 4601 E. Washington Blvd., Raymond 2-8361.

The Most Trusted Name in Electronics

RADIO CORPORATION OF AMERICA

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NUVISITOR TETRODE GENERAL DATA

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater, for Unipolar Cathode</td>
<td>6.3 volts</td>
</tr>
<tr>
<td>Current at 6.3 volts</td>
<td>0.15 amp</td>
</tr>
<tr>
<td>DIRECT INTERELECTRODE CAPACITANCES:</td>
<td></td>
</tr>
<tr>
<td>Grid-No. 1 to plate</td>
<td>0.01 μF</td>
</tr>
<tr>
<td>Grid-No. 1 to cathode, grid-No. 2, heater &amp; shell</td>
<td>1.6 μF</td>
</tr>
<tr>
<td>Plate to cathode, grid-No. 2, heater &amp; shell</td>
<td>1.4 μF</td>
</tr>
<tr>
<td>Heater to cathode</td>
<td>1.4 μF</td>
</tr>
<tr>
<td>CHARACTERISTICS, CLASS A, AMPLIFIER:</td>
<td></td>
</tr>
<tr>
<td>Plate Supply Voltage</td>
<td>125 volts</td>
</tr>
<tr>
<td>Grid-No. 1 Supply Voltage</td>
<td>30 volts</td>
</tr>
<tr>
<td>Cathode Resistor</td>
<td>68,000 ohms</td>
</tr>
<tr>
<td>Plate Resistance (Approx.)</td>
<td>0.2 megohm</td>
</tr>
<tr>
<td>Transconductance</td>
<td>10,000 μhos</td>
</tr>
<tr>
<td>Plate Current</td>
<td>10 mA</td>
</tr>
<tr>
<td>Grid-No. 2 Current</td>
<td>2.7 mA</td>
</tr>
<tr>
<td>Grid-No. 1 Voltage (Approx.) for plate current of 10 μA</td>
<td>±0.5 volts</td>
</tr>
</tbody>
</table>

INdUSTRIAL SERVICE

MAXIMUM RATINGS, ABSOLUTE-MAXIMUM VALUES:

- For Operation at Any Altitude
- For Operation at Low Altitude

- PLATE SUPPLY VOLTAGE: 320 max. volts
- PLATE VOLTAGE: 320 max. volts
- GRID-No. 2 (SCREEN-GRID) VOLTAGE: 200 max. volts
- GRID-No. 1 (Central-Grid) VOLTAGE: 100 max. volts
- Grid-No. 1 Circuit Resistance: For fixed-bias operation, 0.5 max. megohm
- Grid-No. 2 Circuit Resistance: For cathode-bias operation, 1 max. megohm
- Grid-No. 2 Circuit Resistance: 100 max. volts

NEW PRODUCTS

**Firewall Connectors**

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


**Press Control**

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., Industrionics Controls, Inc., Dept. ED, 29-24 Vandam St., New York 13, N.Y.

**Vaneaxial Blower**

Operating on 115 v, ac or dc, VAX-3-CN 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.

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 is 1/4 to 1.64 in. Units are rated at 500 wvde. 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.

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 ¾" and 1½" 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 ½" 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 $5 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.

SPECTROL ELECTRONICS CORPORATION
1704 South Del Mar Avenue • San Gabriel, California
Phone: Atlantic 7-9761
Adams Court • Plainview, L.I., New York
Phone: WElls B-4000

CIRCLE 52 ON READER-SERVICE CARD
NEW PRODUCTS

Printed Cable

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.


Capacitor Shielding

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

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.


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

Have you sent us your subscription renewal form?
Strain Relief

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

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 5 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 μsec. 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

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 31/8 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.

NOW AVAILABLE — NEW 50-AMP CONTROLLED RECTIFIER

The latest addition to the Transistor 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 1½ 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.

For information on any or all of Transistor's line of Controlled Rectifiers, call or write today for Bulletin TE-1358.

WHY BIAS CONTROLLED RECTIFIERS?

Pioneering in new application techniques, Transistor 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 Transistor'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.

Transistor

electronic corporation

wakefield, melrose, boston, mass.

SALES OFFICES IN PRINCIPAL CITIES THROUGHOUT THE U.S.A AND EUROPE - CABLE ADDRESS: TRELCO
NEW PRODUCTS

Magnetic Amplifiers

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

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

Transistorized Inverter

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.

P&N: $300 ea; from stock.

Power Triode

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.

New!

TYPE 280-A

UHF Q METER 210-
—measures COMPONENTS, CAVITIES, SEMICONDUCTORS

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.

BOONTON RADIO
BOONTON, NEW JERSEY • Tel. DEERFIELD 4-3200

ELECTRONIC DESIGN • April 12, 1961
Specifications

Radio Frequency Characteristics
RF RANGE: 210 to 610 MC
RF ACCURACY: ±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: ±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 mH*
- *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 26 µF
CAPACITOR ACCURACY, ±(5% + 0.2 µF)
CAPACITOR CALIBRATION:
- 0.05 µF increments, 4-5 µF
- 0.10 µF increments, 5-15 µF
- 0.50 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).

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.

Fractional HP Motor

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.


Tape Terminator

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

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 job Maynard.
NEW PRODUCTS

Polystyrene Capacitor

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-19547, characteristic P.

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

Silicon Diodes

MIL-S-19500 118 qualified silicon diodes types 1N483B, 1N4858, and 1N486 B have leakage that is typically 1 μA 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.

Pkg: From $1.90 to $3.75, 100 to 999; from stock.

Centrifuge

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, 2333 Federal Ave., Los Angeles 64, Calif.

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

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

<table>
<thead>
<tr>
<th>Essex Part No.</th>
<th>Wee-Ductor RFC-S</th>
<th>RFC-M</th>
<th>RFC-L</th>
</tr>
</thead>
<tbody>
<tr>
<td>L μH</td>
<td>0.1-100</td>
<td>1.0-1,000</td>
<td>10-10,000</td>
</tr>
<tr>
<td>Max. Res. μH</td>
<td>.035-850</td>
<td>.02-60</td>
<td>.04-21</td>
</tr>
<tr>
<td>I Max. mA</td>
<td>3000-18</td>
<td>4000-229</td>
<td>2700-125</td>
</tr>
<tr>
<td>Dia. mm</td>
<td>.157</td>
<td>.188</td>
<td>.250</td>
</tr>
<tr>
<td>Length cm</td>
<td>.375</td>
<td>.440</td>
<td>.600</td>
</tr>
</tbody>
</table>

WRITE TODAY

Free Descriptive Literature Available

ELECTRONIC DESIGN • April 12, 1961
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**

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**

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. Salsipuedes St., Santa Barbara, Calif.

---

**New CBS Advanced Instrument Tubes SOLVE TWO MAJOR CIRCUIT PROBLEMS**

---

**Ultrafast Pulse Amplification**

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.

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 μf output capacitance.

---

**High-gain Wideband Amplification**

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.

---

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, SPring 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.
NEW PRODUCTS

Acceleration Switch

A spring-mass, fluid-damped device, acceleration switch model 18001 may be used to open or close a circuit in the presence of acceleration. It is immune to large 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

For use in high-speed logic circuits, the npn 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.


P0A: From $1.95 to $10 ea, 100 to 999; immediate.

Power Supplies

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 μsec. Ripple

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 4-9618, Canton, Ohio; EAST COAST, John J. McManus, MA 7-3996, Manhasset, N.Y.; NEW ENGLAND, Warren G. McDonald, FR 4-9963, Schenectady, N.Y.; SOUTHWEST, Kenneth R. Lundy, DA 7-3718, Dallas, Texas; SOUTHWEST, William H. Ramsey, UN 4-6369, Houston, Texas.

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

a revolutionary air power cutter

**UTICA** 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 6⅛ 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.

**Zener Diodes**

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 9.2-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**

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.


**CIRCLE 61 ON READER-SERVICE CARD**
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, electro-plated 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 Thermonic Corporation, 457 Concord Ave., Cambridge 38, Mass.

WEBSTER KNOWS

NEW PRODUCTS

Digital Decoder

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

Protection from excessive current is provided by the CL series current-limiting relay. Contacts lock on a sustained overload and cannot be reclosed, 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

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 usec. 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.

Have you sent us your subscription renewal form?
ELECTRON TUBE NEWS
...from SYLVANIA

- INCREASED GAIN!
- DECREASED NOISE FACTOR!
- IMPROVED Gm/Ib 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 cascode 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 Ib for a single section is 1120. Gm per section is 9000 Ωmhos, 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 Ωmhos. Ratio of Gm Ib 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 Ωmhos. It only draws 125 mA § 6.3V heater power. Gm per mA Ib 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 Ωmhos. 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.
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.
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 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.

<table>
<thead>
<tr>
<th>SYLVANIA Ka BAND MAGNETRONS</th>
<th>Frequency (KMC)</th>
<th>Peak Power Output (KW)</th>
<th>Max. Duty Cycle</th>
<th>Max. Pulse Width (usec)</th>
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<tbody>
<tr>
<td>5789</td>
<td>34.512</td>
<td>40</td>
<td>.0006</td>
<td>1.0</td>
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<tr>
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<td>XM-4206</td>
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<td>1.1</td>
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</tbody>
</table>

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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.
NEW PRODUCTS

Precision Resistors 690
Ceramic bobbin wirewound resistors of series CB feature allwelded 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 volts 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 15.0 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 1/2-inch or 1-inch tape, interchangeably. Frequency response: 300 to 250,000 cps ± 1 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, 30, 1 1/4, 1 1/4 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

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.

NEW PRODUCTS

Pressure Transducer 617

Medium-to-high range pressure transducer type 4-329 utilizes the un-bonded 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 ±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 Electrodynamics 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

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

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

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.

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.

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 Systrom-Donner
CONCORD, CALIFORNIA
NEW PRODUCTS

Power Supply 365

Delivering 0 to 36 v dc and 0 to 10 amp, model 806A 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: $825.

Rectifier Test Set 374

An oscilloscope display of the reverse characteristics of high-voltage diodes and rectifiers is provided by rectifier test set model 182d. It provides a wide range of reverse voltages up to 5 kv and reverse currents from less than 1 μa 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.

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

For metered models add the suffix "M" to the model number and add $30.00 to the price.
Impulse Counter

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

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

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.
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.

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 TO-3 and TO-36 packages
- 90 and 150 watts power dissipation
- 0.8°C/W and 0.5°C/W maximum thermal resistance
- 100°C continuous junction temperature
- 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.
NEW PRODUCTS

Power Supplies

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 μsec; temperature coefficient less than 0.05% per deg C.

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

P&A: $525 to $925; 30 to 60 days.

Crystal Oscillator

Solid-state, voltage-controlled crystal oscillator 10M-WA can be directly frequency-modulated over a range of ±0.2% of Fc. 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 x 2 x 2-1/2 in.


Electrical Tape

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 multturn and completely gangable. Get complete information on Borg 900 Series Micropots. See your nearest Borg technical representative.

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>10-turn</th>
<th>3-turn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance (ohms)</td>
<td>25 to 100,000</td>
<td>15 to 60,000</td>
</tr>
<tr>
<td>Linearity (best)</td>
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<td>0.05%</td>
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<td>Torque</td>
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<td>1 oz./in.</td>
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<td>1080° + 10° - 0°</td>
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<tr>
<td>Electrical Rotation</td>
<td>3600° + 5° - 0°</td>
<td>1080° + 5° - 0°</td>
</tr>
<tr>
<td>Shaft Extension</td>
<td>servo mount ½&quot;</td>
<td>bushing mount ½&quot;</td>
</tr>
</tbody>
</table>

WRITE FOR COMPLETE SPECIFICATIONS AND INFORMATION

BORG EQUIPMENT DIVISION
Amphenol-Borg Electronics Corporation
Janesville, Wisconsin • Phone Pleasant 4-6616

Micropot Potentiometers • Turns-Counting Micradials • Sub-Fractional Horsepower Motors • Frequency and Time Standards

CIRCLE 68 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961
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.

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.


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.

For "Silicones for the Electronic Engineer", Write Dept. 3316.

Dow Corning

ELECTRONIC DESIGN • April 12, 1961
...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.

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 heat the heat, Cannon engineers specified 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."

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^-3 to 10^-7 mm of Hg.

Magnet Solder

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

A bi-directional, 12-position sequence relay for remote control, No. 4175 operates in 40 msec min. Coil is rated at 5-K 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

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 ±10% throughout a circuit; typical rating is 7 pf per in. on a 30-mil line.
New Sierra 219B 4-range Transistor Tester reads Beta directly in the circuit; also measures $I_{cc}$, 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. $I_{cc}$ 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.

**NEW PRODUCTS**

**Fuse Posts**

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**

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.


**Ultrasonic Cleaner**

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.
Sweeping Oscillator

The best from the West...

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 Av., Pine Brook, N.J.

Heat Exchanger

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 90 C.

Lytron, Inc., Dept. ED, 42 Brookford St., Cambridge 40, Mass.

Control Meter

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


CIRCLE 70 ON READER-SERVICE CARD
COMINCO FOR ELECTRONIC MATERIALS

ULTRA-PURE METALS AND ALLOYS
ANTIMONY ARSENIC BISMUTH CADMIUM INDIUM LEAD SILVER TIN ZINC also ALUMINUM GOLD

* COMPOUND SEMICONDUCTORS INDIUM ANTIMONIDE

* STANDARD FORMS INGOTS BARS RODS RIBBON SHEET SHOT POWDER WIRE

* PREFORMS DISCS DOTS SQUARES SPHERES WAFERS WASHERS

* CHEMICALS SALTS SOLUTIONS

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Can purity of this order be controlled?
Yes, COMINCO 69 Grade High Purity Metals have specific impurities controlled to less than 0.1 parts per million. We offer a range of metals of the above order of purity on a production basis.

Our ultra-pure metal products are widely accepted by leading firms throughout the electronics industry who benefit from:
- 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

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 \(\pm 0.5\%\) standard, linearity \(\pm 0.1\%\).


Decade Counter

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 \(10^5\) per day; frequency range is 10 cps to 10 mc. With the LA-901B plug-in unit, time interval range is 1 usec to 10 million sec. Other features are 0.1-usec 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
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.
Introducing

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?

NEW PRODUCTS

Servo Tachometer

A size 11 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

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.


Impedance Measuring System

Universal impedance measuring system model 291-A has a resistance accuracy of 0.05%. Inductance and

AmERICAN LAVA

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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, III. * Cleveland, Ohio * Dallas, Texas * Los Angeles, Calif.

All other export: Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

 узнать больше ➝
capacitance accuracies are 0.1% at 1 kc. Measurement resolution is 120,000 dial divisions. The system includes ac and dc generators and detectors specifically designed for use with the bridge.

P&A: $1,095; 30 days.

Digital Readout 359

Characters 1-5/8 in. high are displayed by the series 160,000 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.


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.

P&A: $4,500; 45 days.

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.
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 ± 1% over an AC input variation of ± 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

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.


Impulse Counter

Counting speeds to 250 impulses per sec are attained by type 4TF6EM counter. It consists of three stages: glow transfer tube, transistorized pulse shaper-amplifier, and totaling 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

Compact, lighted push-button switches and pilot lights are available in modular design. With sub-panel, surface and matrix mounting,
contacts may be arranged up to 8pst. Actions include solenoid, momentary, alternate action, lock-out and interlocking.
Luminator, Inc., Display-Control Div., Dept. ED, Costa Mesa, Calif.

Volt-Ohm-Milliammeter

Only one scale is visible at any one time, and all scales are direct-reading, on the V O Matic 360 automatic volt-ohm-milliammeter. The meter is protected against extreme overload and burnout. Sensitivity is 20,000 ohms per volt dc, 5,000 ohms per volt ac; frequency response is 5 to 500,000 cps; accuracy is ±3% dc, ±5% ac.
B & K Manufacturing Co., Dept. ED, 1801 W. Belle Plaine Ave., Chicago 13, Ill.
Price: $59.95.

Tape Recorder

Voice and frequency program material is recorded simultaneously in up to 20 channels by the T-1000 magnetic tape recording and reproducing system. Speed is 1-7/8 or 15-16 in. per sec; frequency response is ± 2 db, 300 to 4,000 cps at 1-7/8 in. per sec. Flutter is less than 0.5% rms at 1-7/8 in. per sec, harmonic distortion less than 3% at 500 cps.

Have you sent us your subscription renewal form?

ELECTRONIC DESIGN • April 12, 1961
**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.

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:

- **POLY-THERMALEZE** (multi-purpose film)
- **SODEREZE** (solderable); **FORMVAR** (square and rectangular)
- **BONDEZE** (self-bonding); **GRIP-EZE** (solderable self-gripping)
- **S-Y BONDEZE** (solderable self-bonding)
- **HERMETEZE** (for hermetic motors)
- **SODEREZE-BONDEZE** (solderable self-bonding)
- **NYLEZE** (solderable)
- **DAGLAS** (flexible glass)
- **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.

Any time magnet wire is your problem, consult Phelps Dodge for the quickest, surest answer!

**Magnetic Amplifier**

719

Signal is ±80 mv dc at ±0 to 40 μA for model 1269, which combines magnetic amplifier, drive network, and motor in one package. Output is 10 w; excitation is 115 v ±5%, 400 cps ±10%. Linearity is ±5%, zero drift ±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 μsec.
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-28636 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.
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.

Progress Is Our Most Important Product

GENERAL ELECTRIC

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.


Stabilized Power Supply 352

Stabilized output voltage within ±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-
stable spectral density of approximately 4.0 \text{ v}^2/\text{cps} controlled to \pm 0.1 \text{ db} from 0 to 40 \text{ 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 \(-111.11 \text{ v dc} \text{ to } +111.11 \text{ v dc}, \) 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.


**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.

Introducing **IMPERIAL**

Think of every feature, every benefit, you would design into a soldering iron if you could...and you have IMPERIAL! Only UNGAR experience and research could have developed this cool, lightweight, easy-handling iron. From tip to cord...the ultimate in interchangeability. There are so many revolutionary new ideas in IMPERIAL we had to put them all in an 8-page brochure. Send for your free copy now!

**UNGAR ELECTRIC TOOLS ED-U61-2A-4**
Electronic Division of Eldon Industries, Inc. 1475 E. El Segundo Blvd., Hawthorne, Calif.

Please send me free full-color IMPERIAL brochure!

CIRCLE 82 ON READER-SERVICE CARD

**UNGAR**

designed to keep pace with the space age
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.

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.

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

CIRCLE 83 ON READER-SERVICE CARD

Relay NEWS from Union Switch & Signal

NEW PRODUCTS

Precision Parts

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.

Availability: 2 to 4 weeks.

Power Supply

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 ±3%; −90 v dc at 0 to 20 ma ±3%; −6 v dc at 0.7 to 4 amp ±5%.

Tektronix, Inc., Dept. ED, P.O. Box 500, Beaverton, Ore.
P&A: $255, immediate.

Vibration Table

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.

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

ELECTRONIC DESIGN • April 12, 1961
MOTOROLA SILICON EPITAXIAL MESA TRANSISTORS are immediately available from these DISTRIBUTORS

MOTOROLA DISTRICT OFFICES:

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Juniper 5-4485

SUPERIOR performance...greater reliability...extreme uniformity...mil-quality! These are the dramatic design advantages you gain from Motorola Silicon Epitaxial Mesa transistors. Performance characteristics include: faster switching speeds, higher voltage breakdowns, reduced capacitance, increased power handling capabilities with reduced saturation resistance, and vastly improved VHF power gain performance. The result—outstanding switching and amplifying devices with a wide range of application potential.

For complete technical information on specific Motorola Silicon Epitaxial Mesa transistors, contact your Motorola district office, distributor, or write: Motorola Semiconductor Products Inc., Technical Information Department, 5005 East McDowell Road, Phoenix 10, Arizona.

MOTOROLA DISTRICT OFFICES:


MOTOROLA SILICON EPITAXIAL MESA TRANSISTORS

<table>
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<tr>
<th>TYPE NO.</th>
<th>Pn</th>
<th>Vce (V)</th>
<th>Vce (V)</th>
<th>Ils (mA)</th>
<th>Icw (Typ) @ Ifso (10 mA)</th>
<th>fT (MHz)</th>
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<td>40</td>
<td>500</td>
</tr>
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</table>

Immediate availability — All Motorola Silicon Epitaxial Mesa transistors are available "off the shelf" from your Motorola Semiconductor distributor.

MOTOROLA Semiconductor Products Inc.
A SUBSIDIARY OF MOTOROLA, INC.
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CIRCLE 84 ON READER-SERVICE CARD
looking for a special potentiometer?

...reach for EDC

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.

This is only one example of the more than 7,000 products from 2,212 companies which are displayed. Handy Inquiry Cards or Application Data Forms are bound in to make it easier for you to obtain additional data — and manufacturers' reps are also listed if you wish to phone for quick price and delivery information.

Electronic Designers' Catalog is one more service provided by the publishers of Electronic Design.

NEW PRODUCTS

Three-Pen Recorder

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

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 preassembled circuit modules or sub-chassis assemblies.

Electro-Glass Laboratory, Dept. ED, 4000 S.W. 114th St., Beaverton, Ore.

Multiturn Potentiometers

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 dialylyl phthalate compounds are used in all molded parts for high insulation resistance.

Duncan Electronics, Inc., Dept. ED, 1305 Wakeham Ave., Santa Ana, Calif.
Accutron...
new electronic timepiece
uses ALLEN-BRADLEY
Type TR Miniature
Composition Resistors

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.

ALLEN-BRADLEY Quality Electronic Components

Allen-Bradley Co., 222 West Greenfield Avenue, Milwaukee 4, Wisconsin  •  In Canada: Allen-Bradley Canada Ltd., Galt, Ontario
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 1/4 watt at 70°C, these Type R controls are available in values from 100 ohms to 2.5 megohms.

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

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-H Research Laboratories, Inc., Dept. ED, Oakland, Calif.

P&A: $575 fob Oakland; 30 days.

DC Amplifier

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, ±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.

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.
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.

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: $180; from stock to 45 days.

Speed Control 692
Speed-sensing control switches of the KC-980 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 10285 pad on one end, a through shaft, and an AND 20006 pad on the other end. Military specifications are met.
Kahn and Co., Inc., Dept. ED, P. O. Box 516, Hartford 1, Conn.

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.
of top-quality Clare relays

PACIFIC COAST
1. Puget Electro Products
   3068 First Avenue,
   Seattle 1, Washington
2. Bell Electronic Corporation
   366 E. Alondra
   Gardena, California
3. Bell Electronic Corporation
   1070 O'Brien Drive,
   Mano Park, California
4. Engineer Supply Company
   8000 Denton Drive,
   Dallas 36, Texas
5. Harrisson Equipment Co., Inc.
   1422 San Jacinto St.,
   Houston 1, Texas
6. Arrowhead Electronics Equipment Co., Inc.
   1210 West Clay St.,
   Houston 19, Texas

SOUTHWEST
7. Radio Speciality Co., Inc.
   6223 Acoma Road, S.W.
   Albuquerque, New Mexico
8. Radio Speciality Co., Inc.
   500 Penn Avenue,
   Alamogordo, New Mexico
9. Engineering Supply Company
   8000 Denton Drive,
   Dallas 36, Texas
    1422 San Jacinto St.,
    Houston 1, Texas
11. Arrowhead Electronics Equipment Co., Inc.
    1210 West Clay St.,
    Houston 19, Texas

EAST
12. R & D Supply, Inc.
    1426 Highland Ave.,
    Needham 88, Massachusetts
13. Avnet Electronics Corporation
    70 State Street,
    Westbury, L.I., New York
14. Electronic Wholesalers, Inc.
    1201 Hibiscus Boulevard
    P. O. Drawer 1888,
    Melbourne, Florida
15. Electronic Wholesalers, Inc.
    91 N.E. Ninth Street,
    Miami 30, Florida
16. Reliable Sales, Inc.
    P. O. Box 188,
    West Chicago, Illinois
17. Bresco, Inc.
    311 Leo Street, Dayton 4, Ohio
18. Pioneer Electronics Supply Company
    2115 Prospect Avenue,
    Cleveland 15, Ohio
    201-3 South 16th Street,
    Birmingham 3, Alabama

For more complete information on the
full line of CLARE components, address:
C. P. Clare & Co., 3101 Pratt Blvd.,
Chicago 45, Illinois.
In Canada: C. P. Clare Canada Limited
840 Caledonia Road, Toronto 16, Ontario.
Cable Address: CLARELAY

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 sys-
tem, it uses a 12,000-rpm memory drum with a 2,048-word capacity.
Clock speed of 260 kc permits 78-
μsec multiplication.
Motorola, Inc., Military Electronics Div., Dept. ED, 8201 E. Mc-
Dowell Road, Scottsdale, Ariz.

Wirewound Resisters 634
Precision wirewound power resis-
tors, series SR, are sealed in sili-
cone and are impervious to mois-
ture 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. Insula-
tion 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 chan-
nels are used for slow telem-
etry and simple functions, while
frequency-shift channels are used
for high-speed telemetry and con-
trol functions. Receivers and trans-
mitters are housed in identical mod-
ules, 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

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

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

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°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 ELECTRONICS

The design of the Model 300 Shaker is an extension of the 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 ............ 13¼ inches
- Max. Acceleration .......... 100 G
- Stray Field ............... less than 6 gauss, 3 inches above the table

Instrumented Power Supply

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

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

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.

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
**NEW PRODUCTS**

**Carrier Amplifier**

A 5-v, 3-ke excitation for bridge and differential transformer transducers is provided by the 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 ±1.5%.  
Plug-In Instruments, Inc., Dept. ED, 1416 Lebanon Road, Nashville 10, Tenn.  
P&A: $1,750; 6-week delivery.

**Square-Frame Motor**

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**

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.

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**That's how the ball bounces with Waters new PT ¾**

Dust! Corrosion! Moisture! Vapors! All are foes of potentiometer reliability, yet ordinarily costly to keep out. Now, however, Waters introduces a new ¾" plastic case pot, the PT ¾, 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 ±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 HOODS • PANEL MOUNTS • TORQUE WATCH GAUGES • TORQUE CALIBRATORS • OSCILLOSCOPES

CIRCLE 92 ON READER-SERVICE CARD

106
Now—an Even Smaller High-Temperature Trimpot® Potentiometer

Here, just 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 accurate. 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.

Yes! Schweber can sell any model of BOURNS TRIMPOT® at factory prices. Sizeable quantities are available for immediate shipment from stock from Schweber's warehouse.
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 $0.19 \times 10^{14}$ 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 $2 \times 10^{-6}$ 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.

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 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 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.

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.

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

Rate Gyro

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.


Tantalum Capacitors

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.

Olmite Manufacturing Co., Dept. ED, 3650 Howard St., Skokie, Ill.

Constant-Voltage Transformers

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 center taps 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...

ELECTRONICS DIVISION

NORTH ELECTRIC COMPANY

134 SOUTH MARKET ST., GALION, OHIO

CIRCLE 96 ON READER-SERVICE CARD

NEW PRODUCTS

Module Cases

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

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.


Cable Clamps

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
**Servomotor**

Smallest size is 0.84-in. long

Said to be the smallest size 8, 115 V servomotor sold, the Model 8 SM 461 is 0.840-in. long, weighs 1.0 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 80,500 rad per sec³—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°C to +130°C. Maximum unit operating temperature is 200°C.

Helipot Div. of Beckman Instruments, Dept. ED, Fullerton, Calif.

**Precision Potentiometer**

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**

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 microameters.

Helipot Div. of Beckman Instruments, Dept. ED, Fullerton, Calif. Availability: 30 days.

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**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 ±0.1% available for most.

The Helipot line is simply stacked with stand-out single-turns, linear or non-linear, from ½" 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 gauged!

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.
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 ±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, 30 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/19500.412 (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.
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 qualified 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**

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, III.

**Digital Resolver**

Model DR-14 digital resolver provides high-speed conversion from Cartesian to polar coordinates or the reverse. Conversion is accomplished in 200 msec 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**

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.

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: 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.

NEW PRODUCTS

**Thyratron Tubes**

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**

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 ±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**

Room temperature, indium antimonide, infrared detectors have a time constant of less than 1 μsec and peak at 6.8 microns. Specifications for a typical cell 1.5 x 6 mm are: black body response, 3 x 10⁵ cm-cps⁻¹ per w; resistance, 20 ohms; time constant, less than 1 μsec; peak response, 6.8 microns.

**Instrument Pivots**

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 nonmagnetic pivots are made.

Welton V. Johnson Engineering Co., Inc., Dept. ED, 95 Summit Ave., Summit, N. J.

**Precision Relay**

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**

High-mu nuvistor triode 7885 is useful in cascode circuits, rf and if stages, on-off controls, and resistance-coupled amplifier circuits. Transconductance is 9,400 umhos 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 0.5 in. long and weighs 1/15 oz.

Radio Corp. of America, Electron Tube Div., Dept. ED, 415 S. 5th St., Harrison, N. J.

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**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

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**READOUT of this world**

**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 μsec ±0.05 μsec. Taps are available at every 1.45 μsec. 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 x 1 x 1.375 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 ±5.0 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.
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: 6-digit voltage reading with correct polarity and range. 2 digits for input channel identification.

Range-Polarity Indication: automatic

Functions: scanning up to 10 double-pole channels; measuring DC voltage from +0.001 to ±999.9; in range of ±9,999 to ±99,999, 6-digit running, and flexible panel placement.

Accuracy: ±0.01% of full scale on each range.

Speed: 3 seconds average for each data point scanned, measured and recorded.

Scan Mode Operation: AUTO CYCLE—system automatically scans an input channel 00 to 19, ONE CYCLE—system automatically scans an input channel 18. PRINT—one input is measured without advancing scanner.

AC Voltage: Use NLS AC/DC Coupler.

Low-Level DC: Use NLS Model 140 Preamplifier.

Input Impedance: 10 megohms on all ranges.

Size: 14″ high, 15" deep for 18″ rack.

Delivery: From stock 30 days, maximum; should stocks become depleted.

NLS

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.

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 ±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 1½" x ½", 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.

A. W. HAYDON COMPANY
227 NORTH 11TH STREET, WATERBURY, CONNECTICUT

CIRCLE 102 ON READER-SERVICE CARD
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.

**NEW PRODUCTS**

**Limit Stop Assembly**

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.

POA: $45 to $75; 10 days.

**Photoelectric Control**

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 HA, Danville, Ill.

**Temperature Transducer**

For temperature ranges from —320 to +250 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.

**NEXT TIME YOU NEED SOMETHING 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.
Operational Amplifier

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

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

Transistorized tuning fork oscillator, series DFO-80, is available in any frequency from 400 to 4,000 cps. Frequency tolerance is ±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 μsec.

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 ±.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

ELECTRONIC DESIGN • April 12, 1961
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.

- 4 power ratings: ¾, 1, 3½ and 10 watts
- 33 zener voltages (nominal): 3.9 to 100 volts
- standard tolerances: ±20%, ±10%, ±5%
- temperature range: −65° to 175° C.

SEMICONDUCTOR DEPARTMENT ■ COMPONENTS DIVISION

NEW PRODUCTS

Inertia Switch

Single pole, double throw model 6BC-189 is a unidirectional switch with a range of 2 to 30 g ±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

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.


Tantalum Capacitors

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 μf which operate at 50 v nonpolar and from 0.0068 to 0.047 μf at lower voltages. Temperature range at full-rated voltage is −55 to +85 C.

Components, Inc., Dept. ED, Biddeford, Me.
Deviation Voltmeter

Voltages to ±1,010 v dc are measured with accuracy of ±0.1% and ±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

Designed for use in any bonded strain gage transducer system, type 110 Pointer Indicator and Indicating Controller is an automatic null-balancer 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 ±0.5%.

Mounting Hardware

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.

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 narrowband 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.
NEW PRODUCTS

Variable Delay Lines

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 µsec to 0.1 µsec 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

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.

Telemetering Calibrator

All fm-fm subcarrier channels are automatically calibrated with the model C-005, a three-point telemetering 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.
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_C of 4,000 oersteds was measured for natural stability over a period of more than 5,000 hours. Relative remanence was 100% ± 0.1%. An oriented sample of the same material (INDOX II) with an H_C of 2,030 oersteds measured 99.5% ± 0.1%. The material having the lowest coercive force—ALNICO III—also exhibited the least natural stability, 97.04% ± 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° ± 2.5°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.

Artificial Stabilization
Critical space-time 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 remanience.

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 to predetermined amount between 5 and 15% to achieve complete stability. Variations in remanence were less than ±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.


INDIANA STEEL PRODUCTS
VALPARAISO, INDIANA

IN CANADA; THE INDIANA STEEL PRODUCTS CO. OF CANADA LIMITED, KITCHENER, ONTARIO

INDIANA PERMANENT MAGNETS
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 SERVOSCOPES.

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 SERVOSCOPES?

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.

It's so easy, as a matter of fact, that even a new man can plot Nyquist, Bode, and Nichols diagrams after only a few minutes familiarization.

You know your own time and cost picture best. A small investment stands to save you many times the purchase cost. Can you really afford not to be equipped with these remarkable servo standards?

If you're one of the minority who has never seen SERVOSCOPE work (or who may still have doubts), prove it to yourself. Ask for a demonstration. No obligation.

And if you're all out of SERVOSCOPE Worksheets, send for another set. They're free.

Technical literature will also be sent you on request.
in direct writing recording systems
only Brush designs specifically for mil specs

From every nut and bolt to the shipping crate, fully militarized Brush Direct Writing Recording Systems are originally built to meet military specifications.

That's why they are performing every imaginable task of data acquisition and recording at U.S. and NATO installations throughout the world. These electric writing systems have proved their unexcelled reliability— from the Operations Monitor that will record 120 separate operations at the instant they occur— to the Analog and Sequence Recorder that simultaneously records both analog data and sequential events. And, they are built for maximum performance in the hands of non-technical personnel.

Brush equipment is already at work putting evaluation data in writing for a whole new generation of weapons. When the weapons become operational, Brush MIL Recorders are a vital part of the system. This experience is unique in the industry. Before prototype design becomes a problem— call, write or wire Brush for complete details.

Brush INSTRUMENTS

37th AND PERKINS CLEVELAND 14, OHIO
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 + 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.

**VIDAR CORPORATION**

2296 Mora Drive
Mt. View, California
Phone: Yorkshire 8-6561

**VIDAR ENGINEERING REPRESENTATIVES**


CIRCLE 113 ON READER-SERVICE CARD
Servomotor

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

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 scaling, 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

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.

HANDY & HARMAN SILVER FLAKE
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 pigments 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.

Fine Silver ................................ Bulletin A-1
Silver-Copper Alloys ........................ Bulletin A-2
Silver-Magnesium-Nickel ................. Bulletin A-3
Silver Conductive Coatings ............... Bulletin A-4
Vacuum Tube Grade Brazing Alloys ...... Bulletin 23

HANDY & HARMAN
General offices: 850 Third Ave., New York 22, N.Y.

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 µsec and 0.2 sec; within each group, pulse rate is variable from 10 cps to 100 kc. Accuracy is ±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 µsec ±5%; characteristic impedance, 500 ohms ±10%; input rise time, 0.1 µsec; output rise time, 0.25 µsec 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.

*TRADEMARK

For Small Order or Prototype Requirements See Your Local Franchised Raytheon Distributor

** TYPICAL RAYSISTOR OPERATING CHARACTERISTICS **

<table>
<thead>
<tr>
<th>Control Terminals:</th>
<th>CK-1101</th>
<th>CK-1102</th>
<th>CK-1103</th>
<th>CK-1104</th>
<th>CK-1105</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Type</td>
<td>Neon</td>
<td>Incandescent</td>
<td>Incandescent</td>
<td>Incandescent</td>
<td>Neon</td>
</tr>
<tr>
<td>Voltage Range (V DC or Peak)</td>
<td>1.20 min</td>
<td>0.1-1.1</td>
<td>0.5-1.1</td>
<td>0.24-0.40</td>
<td>1.20 min</td>
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<tr>
<td>Current Range (mA)</td>
<td>0.5-3</td>
<td>0.5-5</td>
<td>0.5-5</td>
<td>0.24-0.40</td>
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<table>
<thead>
<tr>
<th>Signal Terminals:</th>
</tr>
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<tbody>
<tr>
<td>On Resistance (ohms)</td>
</tr>
<tr>
<td>Off Resistance (ohms)</td>
</tr>
<tr>
<td>Power Dissipation (milliwatts max.)</td>
</tr>
<tr>
<td>Switch On Time (seconds)</td>
</tr>
<tr>
<td>Switch Off Time (seconds)</td>
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<tr>
<td>Max. Signal Voltage (V DC or Peak)</td>
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<tr>
<td>Shunt Capacitance (F/F)</td>
</tr>
<tr>
<td>Insulation, Signal from Control (Volts)</td>
</tr>
</tbody>
</table>

Raytheon Company

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RAYTHEON DISTRIBUTORS

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RAYTHEON RAYSISTORS

...at no penalty in price

If no Raytheon Distributor is listed for your area, we will be pleased to send you the name of the Distributor nearest you. Please write: Raytheon, Distributor Products Division, 411 Providence Turnpike, Westwood, Massachusetts.

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DISTRICT OF COLUMBIA
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NEwton 5-6421
Orlando
Wholesale Radio Parts Co., Inc.
West Palm Beach
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Temple 3-5701
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Graybar Electric Co.
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Lafayette Radio Corp. of Mass
Hubbard 2-7850
Cambridge
Electrical Supply Corp
UNiversity 4-6300
MICHIGAN
Detroit
Ferguson Electronics, Inc.
UN 1-6700
MISSISSIPPI
Jackson
Ellington Radio, Inc.
FL 3-2769
MISSOURI
Kansas City
Burstein-Applebee Company
Baltimore 1-1155
St. Louis
Graybar Electric Company
Jefferson 4-7000
University City
Olive Industrial Electronics
Volunteer 3-4051
NEW HAMPSHIRE
Concord
Evans Radio
CAPital 5-3358
NEW JERSEY
Camden
General Radio Supply Co., Inc.
Mountainside
Federated-Purchaser Inc.
AD 8-2800
NEW YORK
Binghamton
Stack Industrial Electronics, Inc.
RA 3-6326
Buffalo
Genesea Radio & Parts Co., Inc.
Elma
Stack Industrial Electronics
Temple 3-5701

THIN FILM TESTER

Programmable pulse generator, type 2104, is for rapid analysis, testing and programming 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 programmable into eight time zones.


DC AMPLIFIER

A solid-state dc amplifier for use with dc torque wires, 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.


RAYTHEON DISTRIBUTOR PRODUCTS DIVISION  411 PROVIDENCE TURNPIKE  WESTWOOD, MASS.

RAYTHEON COMPANY

DISTRIBUTOR PRODUCTS DIVISION
CIRCLE 116 ON READER-SERVICE CARD

ELECTRONIC DESIGN  April 12, 1961
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 ±0.6%; resistance, from 1 to 10,000 ohms; cross axis acceleration error, 0.01 g per g max; size, 2 x 3 x 3-1/4 in.

Bourns, Inc., Dept. ED, 6135 Magnolia Ave., Riverside, Calif.

Flexible Curing Agents 371

Flexible 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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POrtsmouth 7-3500

Detroit, Michigan
57 Harper Avenue
TRinity 3-6560

Haydon Div., General Motors
Kokomo, Indiana

Price:
X-3483.1, $0.605 in drum quantities;
X-3483.2 and X-3843.3, $0.755 in drum quantities.
A range of 300 μv 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.


Epoxy Laminate

Glass-fabref epoxy laminate is offered copper-surfaced as Di-Clad 614 or plain as Di reform 614. Haloing 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

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 ±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.
NEW PRODUCTS

Power Supply

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

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

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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Built-in Quality Control

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Graphik Circuits

DIVISION OF CINCH MANUFACTURING COMPANY

CIRCLE 120 ON READER-SERVICE CARD
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 µin. to 0.1 in., peak to peak; frequency from 3 cps to 10 kc; and velocity from 50 µin. per sec to 100 in. per sec. Accuracy is ±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

For data acquisition and computing systems, the model EM-3 multiplexer can switch from 4 to 64 channels. Settling time is 20 µsec; 64 channels are scanned in 50 µsec. 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 ±10%, 60 cps.


DC Power Supplies

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 µv 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.
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wire-wound controls

Take the 4-watt Type M control, for instance. Can't 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.

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.
Power Transistors 583

Rated at 40 w, npn silicon mesa transistors 2N1768 and 2N1769 have an offset pedestal-and-stud mounting arrangement for positive heatsink 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.

TEMPERATURE 760

TRANSDUCER

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 Ave., South Pasadena, California.

WELDABLE STRAIN 761

GAGE

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 Ave., South Pasadena, California.

AIRBORN DC 762

AMPLIFIER

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 Ave., South Pasadena, California.

CIRCLE 762 ON READER-SERVICE CARD ▶
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Need quick delivery on special toroidal components?
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NEW PRODUCTS

Display Storage Tube

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

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

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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CIRCLE 872 ON READER-SERVICE CARD

Just published! New brochure...

BODINE INSTRUMENT MOTORS

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.

Write on your company letterhead for a copy of Bulletin IM-1.

Bodine Electric Co., 2528 West Bradley Place, Chicago 18, Ill.
Power Supply

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.


Price & Availability: About $295; delivery from stock.

Pin Terminals

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 Thermonic Corp., Dept ED, 45 Concord Ave., Cambridge 38, Mass.

P & A: $19.53 per thousand in quantities of 5 thousand; from stock.

Induction Heater

Constricted areas are easily reached by the model L61H-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.
Miniature Wide Band-Pass Crystal Filters Delivered In Quantity...To Specification

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.

**THESE ARE NOT LABORATORY CURIOSITIES OR IN PROTOTYPE DEVELOPMENT STAGE**

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<td>180KC</td>
<td>300KC</td>
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<td>NJ-2B</td>
<td>7.4MC</td>
<td>180KC</td>
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<td>NG-1</td>
<td>5.09MC</td>
<td>160KC</td>
<td>350KC</td>
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<td>NG-1B</td>
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<tr>
<td>NB-1</td>
<td>10.7MC</td>
<td>200KC</td>
<td>450KC</td>
<td>75db</td>
<td>12db</td>
<td>50</td>
<td>1db</td>
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<td>NB-1B</td>
<td>10.7MC</td>
<td>200KC</td>
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<td>85db</td>
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<tr>
<td>RL-1</td>
<td>11.5MC</td>
<td>80KC</td>
<td>160KC</td>
<td>85db</td>
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Operating Temp. 
-55°C to +90°C
Shock: 100g
Vibration: 15g to 2KC
Units hermetically sealed

**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 vac at 48 ma. The 2-lb unit is 3 x 3 x 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.


**Power Tetrode**

605

A 65-w power tetrode, PF-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.
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 (ASC) 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.

*Availability: 4 to 6 weeks.

Transistor Tester

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 μA.

Sierra Electronic Corp. Div. of Philco Corp., Dept. ED, 3885 Bohannon Drive, Menlo Park, Calif.

Tape Reader

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.


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.

**SIMMONS FASTENER CORPORATION**

1763 North Broadway, Albany 1, New York

**QUICK-LOCK** • **SPRING-LOCK** • **DUAL-LOCK** • **ROTO-LOCK** • **LINK-LOCK** • **HINGE-LOCK**

CIRCLE 133 ON READER-SERVICE CARD
NEW PRODUCTS

Module Tester

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.


Price & Availability: $1,950; 60-day delivery.

Coaxial Attenuators

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.

Price: $55 to $75; 2 to 4 weeks.

Cabling Tape

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.
**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 milliamps, 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 milliampere 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.

*Progress Is Our Most Important Product*

**GENERAL ELECTRIC**

Circle 137 on Reader-Service Card
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-nanosecond 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 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 an 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 Risetime—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 volt/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-microvolt (20-millivolt) pulse of 1-nanosecond duration. Internal—2-tracewidth 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. Type 519 KMC Oscilloscope (f.o.b. factory) $3800

Please call your Tektronix Field Engineer for complete specifications and demonstration of the Type 519 in your own applications.

Tektronix, Inc.
P. O. Box 500 • Beaveron, Oregon
Phone Mitchell 4-0161 • TWX—BEAV 311 • Cable: TEKTRONIX

NEW PRODUCTS

DC-to-DC Converter 656

Output of 1 kv dc at 25 µA 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.

Microtrac 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 F. The series F units withstand 20-g vibration from 47 cps to 5 kc.


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 ±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

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 µv for 8 hr. Input is 5 mv differential; gain is 200 to 1,000 ±0.75%. Output is ±5 v into not less than 20 Ω. Linearity is ±0.25%; gain variation is ±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

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

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 µa max.


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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 -55C to +125C.

Daystrom Transicoil Size 8 “temperature stable” units are available as transmitters, differentials, control transformers and resolvers. Standard accuracy is ±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.
EVERYTHING in Laminated Plastics From One Source

An Example of Synthane You-shaped Versatility
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.

SYNTHANE CORPORATION
OAKS, PENNA.

Gentlemen:
Please send me information relating to Synthane as a source for laminated plastic materials and parts.

Name:
Address:
City. Zone. State.

CIRCLE 140 ON READER-SERVICE CARD

NEW PRODUCTS

Crystal Filters

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

High transconductance and low noise are features of five miniature frame-grid tubes. Applications include use in rf amplifiers, rf amplifiers, driver stages, cathode followers and cathode amplifiers. The tubes and their transconductances are the 6939, a double tetrode with 10,500 µmhos per section; 6698, pentode, 16,500 µmhos; 6922, twin diode, 12,500 µmhos per section; 5842, triode, 25,000 µmhos; and 5847, pentode, 13,000 µmhos.

Raytheon Co., Industrial Components Div., Dept. ED, 55 Chapel St., Newton 16, Mass.

Price: $2.95 to $7.90.

Cooling Fluid

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 850 centistokes.

Monsanto Chemical Co., Dept. ED, 800 N. Lindbergh Blvd., St. Louis 66, Mo.

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MACHINED MATING SURFACES!

HOWARD The Ultimate in Universal Motor Quality—at Lowest Cost Available!

UNIVERSAL & DC 29-300 MOTOR 1/2 to 1/4 H.P.

So fine a motor, all mating surfaces are machined—not die-cut—f or 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.

Write today for complete details!

TO SATISFY ALL YOUR ELECTRONIC REQUIREMENTS

NYLON or DACRON FLAT BRAIDED LACING TAPES—LACING CORDS!

HEMINWAY & BARTLETT

These specially processed, fungus-proof lacing cards and tapes satisfy every harness requirement—every lacing need. They’re available in Nylon or Dacron and they come wax-coated, wax-free or with G.F. Finish. For special high temperature work, Teflon coated Fiberglas Tapes are also available.

All Heminway & Bartlett specially-processed lacing cards and tapes meet Government specifications. Write today for free samples.

THE HEMINWAY & BARTLETT MFG. CO.
Electronics Division: 500 Fifth Avenue, New York 36
Also distributed by Aloha Wire Co., New York.

CIRCLE 142 ON READER-SERVICE CARD

CIRCLE 141 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961
Here Are the Facts

Di-Formed Tubes feature a special patented Precision Paper Tube construction which produces a completely ridgedless 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 mandrels. This is not a profit-making service. Its sole purpose is to give the coil manufacturer these advantages:
1. Provide proper tube support
2. Facilitate stacking operations
3. Prevent coil collapse
4. Save machine and operator fatigue
5. Permit a smaller core, thus decreasing coil size and eliminating pressing.

Get full details on Precision Di-Formed Tubes and Related Mandril Service. Write, wire or phone today.

**POWER SUPPLIES**

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 μsec. 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**

Single-crystal GaAs, in doped and undoped form, is available with carrier concentrations ranging from 10⁶ carriers per cc to degenerate levels. Doping tolerance is ±5%; 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**

Ulraminiature 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.

Electronics Corp., Dept. ED, Solana Beach, Calif.
Price: $0.55 to $1.12 ea depending on quantity.
**NEW PRODUCTS**

**AC Panel Meters**

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 500 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**

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**

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
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.


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.


Regardless of its size, 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.

The crystals that made the name of McCoy a synonym for quality. Metal encased, HC-6/U size is available in frequencies from 500.0 kc to 200.00 mc.

Fills the need for miniature crystals in frequencies from 2.5 mc to 200.0 mc. Meets specs MIL-C-3098B and ARINC No. 401.

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.

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.

Our many years experience in designing and producing top quality oscillator crystals have enabled us to develop and produce filters of equal desirability. Current production includes filters in the 1.0 mc to 30 mc range, with bandwidths of 0.1% to 4.0% of center frequency. A number are available without costly design and prototype charges.

Actual Size for Series 3 Types

New!

MICRO MODULE CRYSTALS—GLASS

.28” square x .075” thick
frequency range: 7000 kc to 200 mc
Now available in limited quantities
NEW PRODUCTS

Gallium Arsenide

Single-crystal and polycrystalline GaAs is made in 3/4-in. diam semicircular ingot form. Mobility of N-type single-crystal material ranges from 3,500 to over 5,500 cm² per v-sec. High-purity and doped materials are available. Mobility and resistivity data are supplied with all single-crystal material.

Micro State Electronics Corp., Dept. ED, 152 Floral Ave., Murray Hill, N. J.
P&A: $7 to $30 per g; stock to 30 days.

Transistor Housing

Hermetically sealed transistor housings are made from 96% alumina ceramic, metalized with molybdenum manganese and braze-sealed to Kovar members. Scans withstand temperatures to 1,300 F. Body OD is 0.080, base 0.125 in. Housings may be designed to customer specifications.

Mitronics, Inc., Dept. ED, 1290 Central Ave., Hillside, N. J.

Static Relay

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 μsec max with a signal voltage of 5 to 25 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 26, Minn.

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ASSURED RELIABILITY

Miniature Filter

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.


Wirewound Trimmer

High-temperature trimmer 50-M48 is designed to meet requirements of MIL-R-27208. Temperature range of the scaled, wirewound potentiometer is -55 to +200 C; temperature coefficient is ±0.005% per deg C. Standard resistance values of the 1-w unit range from 50 ohms to 10 K. Hermetically sealed, it withstands moisture and salt spray. Vibration range is 10 to 2,000 cps, shock 50 g.

Maury Instrument Corp., Dept. ED, 7917 S. Exchange Ave., Chicago 17, Ill.

Coaxial Connectors

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.

G-M provides continuous quality control

Your need for a full margin of reliability in servo systems is matched by the continuous quality of G-M Servo Motors and Generators. The extra design experience that goes into every G-M unit is guided through production by test, after test, after qualification test. Sizes range from 5 to 18, with prompt availability that promises quick adaptation to your servo development and production programs.

Qualify G-M Servos for all of your projects, now, in advance of actual need. Send procurement specs and prints today.

Phone: PEnnacola 6-1800 (TWX CG-3266)

G-M Servo Motors

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 milky 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.
Another new product development from Metex... Combo-Strip... for quick, low-cost prototype or on-the-job shielding of cabinets, black boxes and cans. Combo-Strip Features: RF, pressure and atmosphere seals • manufacturing techniques allow a full size range to fit your design • available in Mil. Spec. rubber or silicone with aluminum or Monel Metex. The Metex Product Line: Electronic Weatherstrip® • RF gaskets • combination gaskets (RF and pressure seal) • new Combo-Strip • new Metact® electrical contact • tube shield inserts.

Field Engineering available from the following Metex representatives:

Thomas L. Stevens Co • 15222 South Gervais Ave., Lawndale, Cal. • Osborne 9-1419
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William Connors • 103 Adams St., No. Abington, Mass. • Triangle 8-2939

or contact one of 52 General Cable sales offices coast-to-coast. Our fact filled "DATA FILE" mailed on request. Metal Textile Corporation, Electronics Division, Roselle, N. J. Phone Chestnut 5-3000. TWX Roselle, N. J. 760.

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 65 v dc or 95 v ac.


Delay Lines 566

Delays up to 5,000 μsec, with adjustment of ±5 μsec, 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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Use this SINGLE CONVENIENT SOURCE for all magnetic shielding requirements. Saves you countless design hours...helps speed your project...lowers your costs.

We recommend NETIC and CO-NETIC magnetic shielding materials because they are non-shock sensitive, non-retenitive, do not require periodic annealing and provide completely effective shielding for optimum results.

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1322 N. Elston Avenue, Chicago 22, Illinois
Originators of permanently effective NETIC CO-NETIC magnetic shielding

Composite photo demonstrating that magnetic shielding qualities of NETIC alloy material are not affected by vibration, shock, (including dropping), etc.
Digital Logic Packages

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

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

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, ±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.
NEW PRODUCTS

Miniature Tap Switch

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 Blvd.s, Palisades Park, N.J.

Environmental Chamber

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

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.
Relays by Stromberg-Carlson

Telephone-type quality • reliability durability

If you require reliable, durable, top quality relays in the equipment you manufacture, you’re well advised to consider the relays made by Stromberg-Carlson.

Hundreds of companies have found here the advantages based on our over sixty years of specialization in providing equipment and parts to the independent telephone world.

What’s more, we go beyond just the manufacture of relays. If you desire, we can provide a wide range of types, of which these are representative:

**TYPE A**: general-purpose. Up to 20 Form "A" spring combinations.

**TYPE B**: gang-type. Up to 60 Form "A" spring combinations.

**TYPE DB**: up to 100 Form "A" springs.

**TYPE C**: (illustrated) two on one frame. Ideal where space is tight.

**TYPE E**: characteristics of Type A, plus universal mounting. Interchangeable with other makes.

Types A, B, and E are available in high-voltage models. Our assembly know-how is available to guide you in your specific application.

Details on request from these Stromberg-Carlson offices: Atlanta—750 Ponce de Leon Place N.E.; Chicago—564 W. Adams Street; Kansas City (Mo.)—2017 Grand Avenue; Rochester—1040 University Avenue; San Francisco—1805 Rolls Road.

Cable Clamps

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.


Thermostat

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

Distortion testing and adjustment of single sideband receivers can be done with the TTG-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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CIRCLE 159 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 12, 1961

CIRCLE 160 ON READER-SERVICE CARD

151
**NEW PRODUCTS**

**Variable Inductors**

For printed circuit or breadboard uses, series 395 variable inductors cover a range of 1.5 µh 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**

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**

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 33, Pa.

Price & Availability: $495; 6 to 8 weeks.
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.

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.

Availability: 3rd quarter 1961.

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%.


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ELECTRONIC DESIGN • April 12, 1961
POWER • PROTECTION • REGULATION

ALL THREE
IN ONE TRANSFORMER!

Does your power transformer protect semiconductor rectifiers?

How do you protect the silicon and germanium rectifiers in that advanced design power supply? Do you use elaborate circuitry or —like many power supply designers—are you using a Raytheon 2020 Voltage Regulating Transformer?

These versatile units provide stabilized voltages within ±1% and are available in any of 2,020 standard models for solid-state and vacuum-tube rectifiers. You match your exact requirement from a full range of standard designs and ratings from 20 to 20,000 VA.


NEW PRODUCTS

Clock Movement

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

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

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 LT2-27-1R are 104 to 112 and 64 to 74 respectively; for type T2-27-1R100, 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.

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
- Maximum reliability
- Easy adaptability to special needs

Call, wire or write for data sheets. We welcome inquiries on special voltage monitoring problems.

METRONIX, INC.
A subsidiary of Assembly Products, Inc.
Chesterland, Ohio
Telephone: Hamilton 3-4440
CIRCLE 168 ON READER-SERVICE CARD
**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 3/4"; behind panel required, 1/4"
- Encapsulated: moisture-fungus proof; withstands vibration, thermal and mechanical shock
- Terminals: signal, positive supply, common ground

Digital Modules

Operating at 5 mc, the series 5000 line of digital modules is compatible with 200-ke modules. Circuits include flip-flops, multivibrators, nor, and gates. Logical 1 voltage is -6 to -8 v dc; logical 0 voltage is 0±.5 v dc. Regulated power is not required. Card size is 2-1/16 x 3-1/2 in.

Wang Laboratories, Inc., Dept. ED, 12 Huron Drive, Natick, Mass.

Availability: delivery from stock.

High-Voltage Power Supplies

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, 428 33d W.,
Seattle, Wash.

P&A: From $330 to $365; 30 days.

Enclosed Rack

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 AGASTAT differences benefit you!)

AGASTAT's 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 long 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. A 44.
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 usec. 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

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 $h_{pF}$ ranges are from 20 to 70.

Texas Instruments Inc., Dept. ED, P.O. Box 5012, Dallas 22, Tex.

Power Transistors

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
PRCISE SHAFT POSITIONING EASY

WITH GURLEY RESOLVER TEST STAND

The new Gurley Resolver Test Stand solves the long-standing need for a reliable instrument in production tests of resolvers, synchros, potentiometers and other such equipment.

The Gurley Model 7530 test stand is a precision shaft-positioning device, consisting of an optical coincidence reading system with ± 0.2 second accuracy, a rack and gear for precise shaft positioning, and an adapter plate and coupling.

For an illustrated bulletin, write on your letterhead to Industrial Division, W. & L. E. Gurley, 625 Fulton Street, Troy, N. Y.

W. & L. E. GURLEY
TROY, 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 radians, 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.

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

Digital Voltmeter 425

Voltages from 100 μV 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 ±0.1% of maximum reading on each scale. Readout time is 250 msec regardless of voltage input.

Solartron Laboratory Instruments Ltd., Dept. ED. Coy Lane, Chessington, Surrey, England.

Memory Unit 417

A single magnetic disk memory unit, model 31B has total memory capacity of nearly 10,000-600 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.

Telrex, Inc., Dept. ED, St. Paul, Minn.

Servo System 426

Solid state servo amplifier model 6102 has a sensitivity of 1 mv. It is completely transisterized 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.

P&A: Amplifier, $124.50; motor, $50; 2 weeks.

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Constant Voltage Transformers

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

Fluo-ro-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

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.


Counter Tubes

Decade counter tubes type CT4251 are dimeshaped, 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.
standards
are

NEW PRODUCTS

Flow Transducers

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 Popular Place, Seattle 44, Wash.

Reed Relays

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

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.
**New... Malco**

**TABON TERMINALS and Insulating Sleeves**

*For Quick Connect/Disconnect Applications*

Exclusive MALCO Design eliminates faulty connections...assures uniform crimping.

Specially contoured insulating sleeve accurately guides terminal into position on male tab. Entry of male tab (outside of terminal) within the insulating sleeve is positively prevented.

Malco Terminals are available in chain form for rapid machine crimping to wire. Insulating sleeves are also machine applied.

**Flat Ribbon Cable**

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**

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. Overall 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**

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 $8.51.*

**Crimp Connector**

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?**
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 microphone 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" bogey.

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 blueprint 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. Schreder, Western Editor of DESIGN NEWS, made some good observations on this whole subject. see pp. 6-7, Jan. 16 issue.

SIGMA

SIGMA INSTRUMENTS, INC.
91 Pearl St., So. Braintree 85, Mass.
CIRCLE 184 ON READER-SERVICE CARD

NEW PRODUCTS

Rear Projection Indicator

Model 12-R rear projection indicators contain 12 individual projectors, each centered on a single front screen. The unit measures 3 1/4 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

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 switch-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

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

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.
Immersion Gold

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 millimols 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

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.


Rack Devices

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

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 pivot ratings up to 2,200 v.

Slater Electric and Manufacturing Co., Dept. ED, 241 Sunrise Highway, Rockville Centre, N.Y.

Epoxy Laminate

Is flame-retardant. Epoxy resin laminate C-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.
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.

NEW PRODUCTS

Subcarrier Oscillators

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 ±7.5% in channels 1 through 18 and ±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.


Receiving Tubes

With 26.5-v heaters. Subminiature receiving tubes with 26.5-v heaters are available in three models. Type 7887, a medium-mu double triode for oscillator, amplifier and low-power servo circuits, replaces type 6111. Type 7888, a high-gm, medium-mu triode for uhf oscillator and low-frequency oscillator and amplifier applications, corresponds to type 5718. Type 7889 is a high-mu 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

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.
From BOMAC

An Industry First

4.3MM 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° C. It's lightweight - weights 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.

Electrical Characteristics:

- 68.75-70.75 kMc
- 2.0 µs Recovery Time
- 0.005% 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

A Varian Subsidiary

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 areas 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 28 w cw from 3 to 11 Gc are featured in

Microwave Products.......................... 178

ELECTRONIC DESIGN • April 12, 1961
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 employment.

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 adjustors 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-

---

**Unmodulated and Average Pulsed Power**

**Pulsed Power, Peak**

**Frequency**

**Attenuation**

**VSWR**

**Phase**

**Noise**

**Calibration of Field Intensity Devices**

**Properties of Materials**

**Legend**

| High Priority | Medium Priority | Low Priority |

**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.**
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°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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>2.8 to 2.96 Gc</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>40 mc</td>
</tr>
<tr>
<td>Gain</td>
<td>15 db</td>
</tr>
<tr>
<td>Noise figure</td>
<td>3 db</td>
</tr>
<tr>
<td>Pump frequency</td>
<td>X band</td>
</tr>
<tr>
<td>Diode</td>
<td>Texas Instruments XD-500 Fz ≥ 70 kmc at -2v bias; -40°C to +50°C</td>
</tr>
<tr>
<td>Temperature range</td>
<td>per MIL-E-5400D 50 mw</td>
</tr>
</tbody>
</table>

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.

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**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 introduction 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 by 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.

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.

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.

**DELIVERY FROM STOCK**

**DELIVERY FROM STOCK**
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 conventional design 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/π 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 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^n equispaced elements, the phase difference between any two elements 2^{n-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 π/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>
<thead>
<tr>
<th>Table 1. Radiating element phases for eight-beam array</th>
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<tbody>
<tr>
<td><strong>Beam</strong></td>
</tr>
<tr>
<td>4L</td>
</tr>
<tr>
<td>3L</td>
</tr>
<tr>
<td>2L</td>
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<tr>
<td>1L</td>
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<tr>
<td>1R</td>
</tr>
<tr>
<td>2R</td>
</tr>
<tr>
<td>3R</td>
</tr>
<tr>
<td>4R</td>
</tr>
</tbody>
</table>

Note: Phase is expressed in units of π/16 radians

*Now with Advanced Development Laboratories Nashua, N. H.
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
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.
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 interbeam 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. 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.

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. Anyone 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.
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 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)
- \( A \) — Attenuation (in db at a specified frequency \( F_i > F_c \))
- 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.](image)

![Fig. 2. Performance curves of low pass filter. Unit was designed for cut-off frequency \( F_c \) of 1.5 kmc, and for 30 db attenuation at 3 kmc. Design exceeds performance specifications.](image)
Table 1. Design data for "varying impedance" low-pass filters

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>D/d₀</td>
<td>1.42</td>
</tr>
<tr>
<td>D/d</td>
<td>8.5</td>
</tr>
<tr>
<td>θ₂ (radians)</td>
<td>2 Tan⁻¹(Tan 15° - 4.2 Df, x 10⁻¹)</td>
</tr>
<tr>
<td>θ₁ (radians)</td>
<td>2 Tan⁻¹(Tan 15° - 3.2 Df, x 10⁻¹)</td>
</tr>
<tr>
<td>f₀</td>
<td>13.1</td>
</tr>
<tr>
<td>f₁</td>
<td>10</td>
</tr>
<tr>
<td>λ₀</td>
<td>9.09</td>
</tr>
<tr>
<td>λ₁</td>
<td>21</td>
</tr>
<tr>
<td>λ₂</td>
<td>8</td>
</tr>
</tbody>
</table>

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 θ₁ and θ₂—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 L₁; the spacing between end disks and filter disks is L₀; and spacing between end disks and the end of the filter is L₂. 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:

\[ N = \frac{A_1}{35 \left[ \frac{f_1}{F_s} - 1 \right]} \]  

(Rounded up to the next higher integer)  \( (1) \)

Where:

- \( F_1 = \) attenuation frequency
- \( A_1 = \) attenuation in db at \( F_1 \)
- \( F_s = \) cut-off frequency

All frequencies are expressed in megacycles.

Average power rating is established as that power which can be handled without filter tem-

new!
NARDA ferrite isolators
designed and manufactured by NARDA MICROWAVE!

- broadband coaxial ferrite isolators

Excellent electrical characteristics with extreme versatility! 1/4" coaxial line construction allows higher power operation with 1/4" connectors, up to 20 kw peak, 400 watts average. (Normally supplied with Type N, 1/4" 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.
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-eps 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 10999 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.

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: ±0.000 to ±109.99 vdc
High: ±0.000 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 1/2" high, 14" deep, rack or bench mounting with dust-proof switch and bridge section.
Average Balancing Time: Less than 2 sec.

perature exceeding 70 deg C at 25 deg C ambient. The appropriate equation is:

$$P_{net} = \frac{\pi \lambda D}{60} (65N + 100) \text{ w}$$ (2)

The cut-off wavelength ($\lambda_c$) and $D$ are expressed in inches.
Peak power, at which arcing will probably occur, is:

$$P_p \leq \frac{d^2}{4} \times 10^4 \text{ w}$$ (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:

$$F_L = 2,500 \text{ mc}$$
$$F_H = 3,000 \text{ mc}$$
$$A_1 = 30 \text{ db minimum}$$

Connectors = Type N (3/8-in. line)

$$P_{net} = 10 \text{ w}$$
$$P_p = 15 \text{ kw}$$

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. 4. Insertion loss characteristic of filter. As in Fig. 3, curve shows advantage of operating well below the cut-off frequency.

\[ N = \frac{A_1}{35 \left[ \frac{F_c}{F_1} - 1 \right]} = \frac{30}{35 \left[ \frac{3000}{2500} - 1 \right]} = 4.3 \text{ (5 rounded up)} \]

Next check the power rating of the filter by use of Eqs. 2 and 3.

\[ P_{inc} = \frac{\pi \lambda D}{60} \left( 65N + 100 \right) = \frac{\pi \times 4.72 \times 0.312}{60} \left( 65 \times 5 \right) + 100 = 32.8 \text{ W} \]

For the peak power calculation, the design table shows \( D/d = 8.5 \), and \( d = 0.0387 \) in.

\[ P_p = \frac{B^2}{4} \times 10^4 = \frac{(0.037)^2}{4} \times 10^4 = 34.2 \text{ kW} \]

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:

- \( L_3 = 0.224 \) in.
- \( L_{12} = 0.520 \) in.
- \( L_1 = 0.590 \) in.
- \( t_1 = 0.225 \) in.
- \( t_2 = 0.167 \) in.

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.
NEW! DC to 15 mc

Model K-120 OSCILLOSCOPE

...for the Ultimate in Waveform Observation

WIDE BANDWITH—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
Dual-Trace—50 mv/cm, DC to 15 mc
High-Frequency—50 mv/cm, DC to 15 mc
High-Gain—5 mv/cm, DC to 12 mc.
100X SWEEP MAGNIFIER—5 ranges.
SENSITIVE SWEEP TRIGGER—Normal, Automatic (with preset stability) High-Frequency. Single sweep also.
PLUG-IN, CRYSTAL-CONTROLLED TIME-MARK GENERATOR—10,000 to 1 range.
BEAM POSITION INDicators
... and many other features for maximum performance & long-life reliability.

PRICE $1050.00 less plug-ins.
Send today for complete specifications

electronic tube corporation
1200 E. Mermaid Lane, Philadelphia 18, Pa. Telephone: Chestnut Hill 7-4800
CIRCLE 195 ON READER-SERVICE CARD

MICROWAVE PRODUCTS

Backward-Wave Oscillator

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

Conceals 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.


PGA: $250 to $375; 2 weeks.

ELECTRONIC DESIGN • April 12, 1961
Waveguide Switch

For RG-51/U systems

MA-1064 is a split 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 usec max.

P&A: $395; stock to 30 days.

Traveling-Wave Tube

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.

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 the 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

CIRCLE 196 ON READER-SERVICE CARD
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.

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.

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.
Decade Attenuator  
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 rabbet-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  
For klystron pumps

Designed to provide stable klystron pump oscillator voltages for parametric amplifier applications, the MA-28 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 µamp 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.


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.
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 7091 B, Owensboro, Kentucky.

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.
Wide-band antenna amplifier models 780 through 785 provide gain from 19 to 29 db with noise figures from 3.2 to 50 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.


Price & Availability: $1,250 to $1,455; 15 days.

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.

Bantec Corp., Dept. ED, Calabasas, Calif.

P&A: $250 to $400 ea; 30-day delivery.

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.

Raytheon Company

MICROWAVE AND POWER TUBE DIVISION

One of a series of advertisements featuring tubes for MOPA chains.

MOPA S-BAND CHAIN

QKS 622 AMPLIFIER

ISOLATOR

QKS 627 DRIVER AMPLIFIER

ISOLATOR

QKS 755A TWT

QKS 622 GENERAL CHARACTERISTICS

(Typical Operation)

<table>
<thead>
<tr>
<th>DRIVER</th>
<th>FINAL AMPLIFIER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse Duration</td>
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<tr>
<td>Duty Cycle</td>
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<tr>
<td>Peak Anode Voltage</td>
<td>48-52 kv</td>
</tr>
<tr>
<td>Peak Anode Current</td>
<td>20 a</td>
</tr>
<tr>
<td>Peak Power Output</td>
<td>600 kw</td>
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<tr>
<td>RF Driver Peak Power</td>
<td>48 kw min</td>
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<tr>
<td>Cold Insertion Loss</td>
<td>0.5 db</td>
</tr>
<tr>
<td>Heater Power</td>
<td>None Required</td>
</tr>
</tbody>
</table>

Write for detailed information and application service to Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario. *Raytheon Trademark
ALITE® HIGH-ALUMINA
HERMETIC SEALS AND BUSHINGS

Combine...
- VACUUM-TIGHTNESS
- SUPERIOR MECHANICAL STRENGTH
- HIGH TEMPERATURE AND HEAT-SHOCK RESISTANCE
- RELIABLE ELECTRICAL CHARACTERISTICS
- HIGH RESISTANCE TO NUCLEAR RADIATION
- 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.

Write for FREE Helpful Bulletins

ALITE
U.S. STONEWARE
DIVISION
BOX 119
ORRVILLE, OHIO

CIRCLE 201 ON READER-SERVICE CARD

RF Wavemeter
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 μA 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
Rated at 2 megawatts

Using two atri 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.

ELECTRONIC DESIGN • April 12, 1961
Broadband Antennas

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 Rd., College Park, Md.

Microwave Absorber

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

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. A 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.
MINIATURE SAGE specialized.
other 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.

<table>
<thead>
<tr>
<th>Actual Size</th>
<th>Style</th>
<th>Rated Power at 25°C</th>
<th>Nominal Wires</th>
<th>Range, Ohms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Style</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S1W</td>
<td>1</td>
<td>0.06</td>
<td>5—10,000</td>
</tr>
<tr>
<td></td>
<td>SA1W</td>
<td>2</td>
<td>0.125</td>
<td>5—15,000</td>
</tr>
<tr>
<td></td>
<td>SA2W</td>
<td>3</td>
<td>0.187</td>
<td>5—18,000</td>
</tr>
</tbody>
</table>

Performance features of MIL-R-26C are easily met. SA2W is in fact RW/99, 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 solderable leads on special order.

Test samples available on request

SAGE ELECTRONICS CORP.
Country Club Road • East Rochester, N. Y.
CIRCLE 203 ON READER-SERVICE CARD

Diplexer
For 755 to 985 mc

Model 77-001 diplexer is designed for use from 755 to 985 mc. The vswr is less than 1.00, pass band insertion loss is less than 0.1 db and reject attenuation is greater than 75 db.


Microwave System
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
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 μsec at an operating frequency of 60 mc and a bandwidth of 10 mc are available in a unit measuring 1.5 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.
get the
Goshen Rubber...
IDEA*
*t to precisely fabricate parts, seals, and components from selected compounds, and for specific applications only!

IN SILICONE

Developing Silicone rubber compounds that embody properties to meet today's product requirements, is a Goshen specialty. GRC-engineered Silicone rubber parts, seals and components have no superior when it comes to resistance to chemicals, acids, extreme temperatures, moisture, weathering, oxidation, ozone and other factors that defeat organic rubbers. That's why they're in increasing demand in today's vital electronic, automotive, aero-space and other industries. Let us know your problem.

Write, wire or phone: Goshen Rubber Co., Inc.
3941 S. Tenth St., Goshen, Indiana
Phone Keystone 3-1111 TWX: GOSH 8701

Oscillator Assembly 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 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 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 db ±1 db, flat to ±1 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.
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.


CW Amplifier
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.


Bi-Directional Coupler
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
available in frequency ranges from 0.5 to 1 Gc through 4 to 8 Gc.
General Precision, Inc., Kearfott Div., Microwave Branch, Dept. ED, 14544 Oxnard St., Van Nuys, Calif.

**Mixer Preamplifiers**

*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 input 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**

*Range to 3 Gc*

Designed for use as an oscillator, frequency multiplier or power amplifier, the ML-7698 is a high-mu, 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 suited 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:* $1000.

*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°C
- Designed for extended storage: –from –65°C to +85°C

**Features**

- Accuracy of 0.05% of input voltage from 0.1 to 500 volts.
- Eight search and VTVM ranges.
- Infinite input resistance at null.
- Four potentiometric ranges.
- Temperature controlled Zener reference.
- No zero adjustments.

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.

**Partial Specifications**

- **Voltage Ranges:** ±0.5, 5, 50 and 500 V DC
- **Accuracy:** ±0.05% from 0.1 to 500V
- **Null Sensitivity Ranges:**
  - 10V, 1V, 0.1V & 0.01V
- **Maximum Meter Resolution:** 50μV
- **Input Resistance:** Infinite at null from 0 to 500V

**Dimensions:**
- Case covered, 11½" high, 19" wide, 19½" long

**Price:** Available on request

*Prices and data subject to change without notice*
How Fast Can You Test Circuit Design Reliability?

<table>
<thead>
<tr>
<th>Circuit Parameters</th>
<th>Tests</th>
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<td>256 Tests</td>
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<td>2</td>
<td>4,096 Tests</td>
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<td>4</td>
<td>65,536 Tests</td>
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MINUTES

Yes, you can test all combinations of high and low values of as many as 16 circuit parameters in less than 11 minutes!

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**GREATER POWER OUTPUT**

**INCREASED SMALL SIGNAL GAIN**

**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.

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**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.

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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.

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**MicroWaves PRODUCTS**

**Parametric Preamplifier**

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 Akr St., Copiague, N.Y.

**Varactor Diodes**

Golium 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 µa at 25 C.

Tyco Semiconductor Corp., Dept. ED, Hickory Lane, Bear Hill, Waltham, Mass.

**Reflex Klystron**

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;
power output, 10 mw min, 20 mw avg; bandwidth, 100 mc avg.

Varian Associates, Dept. ED, 611 Hansen Way,
Palo Alto, Calif.

**Rotary Joint**

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For X-band
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A dual-channel microwave rotary joint, model B1X6-1C, 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 UC-137A/U.

Canoga Corp., Dept. ED, P. O. Box 550, Van Nuis, Calif.

**Price:** $1,500 ea.

**Availability:** 60-day delivery.

**Coaxial Couplers**

```
Have high directivity
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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 ±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.
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We are specialists in manufacturing STANDOFF & FEEDTHRU TERMINALS insulated with Teflon®. Simplest terminal to install by forcing into undersize chassis hole.

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**MORE VERSATILITY PER DOLLAR**

**MicroWaves PRODUCTS**

Amplitude Modulators

With low drive power

At a given frequency in the specified band, this series of Faraday rotation amplitude modulators will produce an attenuation range of 0.5 db max to 25.0 db min. High modulation frequencies with low drive power are a feature of the units. Seven models ranging from the MS-100 for 2.6 to 3.5 Gc to the MKU-101 for 14.0 to 18.0 Gc are available.

Rantec Corp., Dept. ED, Calabasas, Calif.

**Klystron Oscillators**

Life is 500 hr

Four klystron oscillators in the 4-, 6-, and 12-mm bands are designed to produce output signals exceptionally free from thermal drift and hysteresis. The 4 FK1 is capable of a power output greater than 100 mw at a fixed frequency of 75 Gc. Average life expectancy is 500 hr min.


**UHF Antenna**

Range is 375 to 1,000 mc

Broadband bow-tie antenna model 91597 is an aid in rapid frequency scanning over the range of 375 to 1,000 mc. It has a sensitivity similar to that of a tuned dipole and does not require tuning adjustments. Matching devices are not

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**SELECTIVE SIGNALING**

Yes, YOU make the decisions, selectively . . . to activate or alert over 11,000 individual groups of decoder-equipped units. The 12 tone 4 pulse sequential transmission eliminates the need for continuous receiver monitoring.

Although designed primarily to operate in conjunction with decoders, the versatile encoder is ideally suited for use in almost any encoding system.

The BT12-4 Encoder employs our highly stable "Resonant" Resonant Reed Oscillator controls as frequency determining devices. The infinite life characteristic and low power consumption of Resonators coupled with transistors as active elements, provide years of economical trouble-free service.

Complete specifications and application data on request.
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

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

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.
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. This disconnection feature ruled out conventional potting. Instead, a combination of three potting materials, molded into different sections on the connector, was used.

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.

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, II.

Separate Lamps Controlled 749
Over Single Line

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 position. 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.

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.

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Name
Company Name
Address

(Use separate sheet if necessary)
IDEAS FOR DESIGN

Signal Light Indicates Out-of-Bounds Ripple

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 C₂ is isolated by 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
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.


### A Random Pulse Generator

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 circuit shown. It is an arrangement that has been accidentally connected many times before.

Any variation in the output can be obtained by

\[ f_1 + \Delta f \]

Irving Bayer, Budd Electronics, Long Island City, N.Y.

Reprinted from ED, Feb. 15, p 218.

Under any circumstance...placed under continuous load, or held "in reserve" for months...operating under severe environmental conditions of shock, vibration, or humidity... Dale precision resistors retain their stability.

Stability is inherent in Dale resistors because it has been firmly infused by design and methods of manufacture... methods which have reached new levels of achievement as the result of Dale's super-high reliability development program.

SPECIAL PROBLEMS? Let us help you with your requirements for special resistance products. We make modifications of standard products, resistor networks, matched pairs, etc. Send us your specs.

PROMPT DELIVERY: Whether your need is for a short "test run" or a large production release, Dale offers prompt service, direct from the factory and through a widespread network of distributors.

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DALE ELECTRONICS, INC.

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DALE TYPE MF RESISTORS

METAL FILM • MOLDED • PRECISION

These new resistors combine the advantages of Dale molding techniques with advanced high vacuum evaporated metal film procedures to provide the best characteristics of wire wound resistors, while retaining miniature size. Inherently good R.F. characteristics and low noise levels.

- RATED AT 1/2 watt, 1/4 watt, 1/8 watt, 1 watt, 2 watts
- RESISTANCE RANGE from 100 ohms to 4 megohms, depending on type
- TOLERANCE ± 1%
- TEMPERATURE COEFFICIENT ± 50 and ± 100 P.P.M.
- FULL POWER to 125° C.
- COMPLETELY INSULATED; complete protection against moisture and salt spray

Write for Bulletin R 43 and handy cross reference file card

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BE SURE TO VOTE for all of the ideas you consider valuable! Simply circle on the Reader-Service Card the numbers matching those next to the idea which appears valuable to you.
1 IF YOUR CHILD HAS
A BAD SORE THROAT...
call your doctor, especially if there is
difficulty in swallowing, swollen neck
glands, high fever, nausea or vomiting.
Prompt treatment of "strep" throat
can prevent rheumatic fever and rheumatic heart disease.

2 IF YOU THINK YOU HAVE
HIGH BLOOD PRESSURE...
see your doctor. Only he can tell. He
can usually control it and decrease the
chances of heart damage or "stroke".

3 STROKES ARE NOT HOPELESS...
Many patients can be treated effectively. Invalidism can be prevented or reduced.
Your Heart Fund dollars helped to produce these advances. But heart disease is still the nation's #1 health
disease. Further progress depends upon your support of medical research.

IDEAS FOR DESIGN

Constant Output Signal Maintained 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 1 as long as periodic input pulses are present at point A. If a pulse in the train is missing, the output at 1 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 1 remains constant. If an adjacent pulse is missing the delayed pulse will trigger the multi and the output level at 1 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 1 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 1 show that output "flips" when input pulse is missing.

Joseph F. Martin, Design Engineer, Stromberg-Carlson Div., Rochester, N.Y.
**Z-Axis Blanking Helps Determine Lag or Lead**

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 counterclockwise 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, counterclockwise 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.
AUGAT SPACESAVER SOCKET

Designed for the Complete Series of Clevite Spacesaver Power Transistors

The Spacesaver Socket fastens beneath the chassis, allowing direct mounting of the transistor, with a mica insulator, to the chassis. In this way, the transistor is provided with maximum heat dissipation by conduction.

The socket's narrow width permits full utilization of the space saving size of its mating transistor.

For complete specifications, write for Data Sheet No. 760.

AUGAT BROS., INC.
31 PERRY AVENUE, ATTLEBORO, MASS.

CIRCLE 229 ON READER-SERVICE CARD

IDEAS FOR DESIGN

Low-Cost Scope Traces Transistor Characteristic Curves

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.
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 C. 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 ohm = 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.

BE SURE TO VOTE for all of the Ideas you consider valuable! Simply circle on the Reader-Service Card the numbers matching those next to the idea which appears valuable to you.
Engineer's Salaries Still Start High, End Low But Some EE's Are Breaking Out of the Mold

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

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.
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, often in areas generally covered by precedent. Characteristically supervises small group of engineers and technicians.
5—$197-$245. Both supervisory and nonsupervisory. Both supervisory positions include coordination and review of small staff. 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.

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 equipment. 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.

Direct all replies to:
Thomas F. Wade, Technical Placement G 3-2
The National Cash Register Company
Main and K Streets
Dayton 9, Ohio

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
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

VIB

*Trademark

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 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 circuit 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.
**Advance 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!
THE ENGINEERING blackboard, Advanced System engineering.

Appointments to MITRE's Technical Staff are currently being made in the following areas:

Operations Research • System and Sub-system Feasibility Studies • Prototype System Development • Advanced System Concepts and Design • System Cost Analysis • Operational Evaluation

Inquiries may be directed to
Vice President—Technical Operations

MITRE, formed under the sponsorship of the Massachusetts Institute of Technology, is a system engineering organization engaged in the design, development and evaluation of large scale command and control systems. Its convenient location in suburban Boston offers excellent opportunities for advanced study under MITRE's liberal educational assistance program.

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 that 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.
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."

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 DuBridge, 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.
Are you beginning to have doubts about achieving the professional goals you set for yourself? Fretting over the lack of opportunity for growth in your present job? If you are, this will interest you: Our philosophy at Motorola is to select engineers and scientists with extreme care. Then we assign them to a Project Group — composed of men whose combined experience and talents cover a broad spectrum. To the group we give challenging state of the art assignments — and the technological tools to solve the problems. By thus affording our professional personnel maximum opportunities for individual growth and achievement, we are convinced — beyond a shadow of a doubt — that we strengthen our own ability to maintain leadership in the field of military electronics.

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CARER NEWS

Engineering doctoral degrees in certain southern universities will be strengthened by a recent $3 million Ford Foundation grant. Georgia Institute of Technology was given $690,000; 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.

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. The five awards, from $100 to $1,000, will be for the best 1,500-word essays on the possibilities of discovering:
- Some partial insulator, reflector or absorber of gravity.
- Some alloy, or other substance, the atoms of which can be agitated or rearranged by gravity to throw off heat.
- Some other reasonable method of harnessing, controlling or neutralizing gravity.

"Only one essay will be accepted from anyone who is seriously interested in the application of gravity . . . for the benefit of humanity." (Kibitzers can send in as many as they like.) 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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To arrange a convenient interview appointment, send resume in confidence to R. W. McCarthy.

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Patrick Air Force Base, Florida

GUIDED MISSILES RANGE DIVISION

PATRICK AIR FORCE BASE, FLORIDA

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to
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To arrange a confidential interview:
forward a brief resume to Mr. John Whiston.

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A recent circulation estimate revealed that 95% of ELECTRONIC DESIGN's readers receive the magazine at their plants—on the job where it is most effective as a design workbook.

By receiving ELECTRONIC DESIGN at work, you're getting extra values from it. These extra values—known to marketing people as time and place utilities—add to the usefulness of any item. Only in-plant distribution gives you: Time Value—because ELECTRONIC DESIGN arrives precisely when you can use it best ... while you're working. Place Value—because it arrives where it can really be put to work ... on the job, at the point of design.

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If you don't receive your copies where you work, write to our Circulation Department and request that your subscription be addressed to you at your plant. By putting ELECTRONIC DESIGN on the job you'll be getting the most value from it.
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PHILCO Western Development Laboratories pioneers in all phases of space communications, with important and growing projects that include satellite instrumentation, range design and operation, missile tracking, data handling and control equipment.

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FIELD ENGINEERING

These openings involve assignments at our laboratories located in suburban Washington, D.C. and the New York metropolitan area at Paramus, New Jersey. Pleasant residential neighborhoods provide readily available housing. Your advanced studies may be conducted at many, high-ranking nearby universities.

Send resume to:
Mr. Robert J. Reid
Professional Employment Supervisor
at our Riverdale facility, Dept. 429

ACF ELECTRONICS DIVISION
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*Manufacturers' catalog appears in 1960-1961 ELECTRONIC DESIGNERS' CATALOG.
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  Pesco electric motors...AC, DC, or miniaturized series...are built to the exacting standards of Mil-M-7969 and Mil-M-8609. When ordered, any Pesco motor will be qualified to these specifications.

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This new standard of \( V \) accuracy assures you that each voltmeter scale is calibrated to the exact characteristics of its individual meter movement. Scale tracking error is eliminated, and you get improved performance at the same moderate price.

Further, this calibration and inspection procedure at \( V \) automatically rejects faulty meter movements. Tracking characteristics of each meter movement are determined over its entire range, and rigid tolerance control assures optimum performance.

These are the first commercial voltmeters wherein the meter tracking error is eliminated. Check the specifications below for the meter which meets your requirement. You are assured of improved performance, with this source of error eliminated—plus all the other advantages you expect in \( V \) instruments: dependability, ruggedness, convenience. They're yours at no increase in cost.

This new standard of calibration is another part of \( V \)'s continuing effort to produce more accurate, more dependable, more useful instruments for measurement...and to produce them at moderate cost for highest value to the user.

---

**Brief Specifications of the \( V \) individually calibrated voltmeters**

\[V\] 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:
  - \( \pm 3\% \) of full scale, 50 cps to 500 KC
  - \( \pm 3\% \), 20 cps to 1 MC
  - \( \pm 1\% \), 7000 cps to 3 MC
  - \( \pm 5\% \), 10 cps to 4 MC
- **Price:** Cabinet, $325.00; rack mount, $330.00

\[V\] 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
  - \( \pm 3\% \), 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

\[V\] 425A DC Microvolt-Ammeter

- **Voltage Range:** Pos. and neg. voltages 10 mV to 1 x full scale, 11 ranges
- **Accuracy:** \( \pm 3\% \) of full scale
- **Ammeter:** Current range, pos. and neg., 10 mV to 1 x full scale, 18 ranges; accuracy \( \pm 1\% \) of full scale
- **Price:** Cabinet, $500.00; rack mount, $505.00

\[V\] 412A DC Voltmeter-Ohmmeter-Ammeter

- **Voltage Range:** Pos. and neg. voltages 1 mV to 1,000 v full scale, 12 ranges
- **Accuracy:** \( \pm 1\% \) of full scale on any range
- **Ammeter:** Current range, pos. and neg., 20 mV to 1 x full scale, 13 ranges; accuracy \( \pm 5\% \) of reading, 0.2 ohm to 500 ohms \( \pm 10\% \) of reading, 0.1 to 1 ohm
- **Ohmmeter:** Resistance range, 1 ohm to 100 megohms center scale, 9 ranges; accuracy \( \pm 1\% \) of reading, 0.2 ohm to 500 megohms \( \pm 10\% \) of reading 0.1 to 1 ohm and 500 megohms to 5,000 megohms
- **Price:** Cabinet, $400.00; rack mount, $405.00

First to bring you individually calibrated VTVM's at no increase in cost!

**HEWLETT-PACKARD COMPANY**

1070K Page Mill Road Palo Alto, California, U.S.A.

**Cable:** HEWPACPA **DA**nport 6-7000

Sales representatives in all principal areas

**HEWLETT-PACKARD S.A.** Rue du Vieux Bilard No. 1 Geneva, Switzerland

**Cable:** HEWPACKSA **Te**l. No. (022) 26, 43, 36

CIRCLE 237 ON READER-SERVICE CARD
RCA CERMOLOX TUBES...  

a new concept in Beam Power Tube technology

To meet the increasing demand for dependable UHF power, RCA has developed Cermolox Tubes, a wide line of coaxial, ceramic-metal beam power tubes with precision-aligned grids. These Cermolox tubes are especially well suited to the requirements of aircraft, missile and guidance applications in CW, Pulse, and Hard-Beam-Modulator service. Already they have set an enviable record of performance in such exacting applications. In Pioneer V, for instance, Cermolox tubes were used in the guidance systems, and in the satellite's high-power transmitter.

Some outstanding features of RCA Cermolox tubes which contribute to long life and reliability are:
- Precise alignment of grids for outstanding efficiency.
- Coaxial-electrode type 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 Cermolox tubes is shown in the adjacent table. For more information, contact the RCA Field Office nearest you.

RCA CERMOLOX BEAM POWER TUBES

<table>
<thead>
<tr>
<th>Type</th>
<th>Max Plate Input Watts</th>
<th>Max. Freq. at Max. Ratings</th>
<th>Max. Plate Diss. Watts</th>
<th>Heaters Volts Ams.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7870 CW</td>
<td>52.5 3,000</td>
<td>25</td>
<td>6.3/1</td>
<td></td>
</tr>
<tr>
<td>7801 CW</td>
<td>52.5 3,000</td>
<td>25</td>
<td>12/2.5</td>
<td></td>
</tr>
<tr>
<td>6816 Forced-Air Cooled</td>
<td>180 1,215</td>
<td>115</td>
<td>6.3/2.1</td>
<td></td>
</tr>
<tr>
<td>7644 Conduction Cooled</td>
<td>180 1,215</td>
<td>115</td>
<td>6.3/2.1</td>
<td></td>
</tr>
<tr>
<td>7642 Ruggedized Conduction Cooled</td>
<td>180 1,215</td>
<td>115</td>
<td>6.3/3.0</td>
<td></td>
</tr>
<tr>
<td>7657 Ruggedized Forced-Air Cooled</td>
<td>180 1,215</td>
<td>115</td>
<td>6.3/3.0</td>
<td></td>
</tr>
<tr>
<td>7643 Conduction Cooled</td>
<td>180 1,215</td>
<td>115</td>
<td>26.5/52</td>
<td></td>
</tr>
<tr>
<td>6884 Forced-Air Cooled</td>
<td>180 1,215</td>
<td>115</td>
<td>26.5/52</td>
<td></td>
</tr>
<tr>
<td>7650 Ruggedized Forced-Air Cooled</td>
<td>1,250 1,215</td>
<td>600</td>
<td>6.3/7.5</td>
<td></td>
</tr>
<tr>
<td>A-2663 Conduction Cooled</td>
<td>1,250 1,215</td>
<td>600</td>
<td>6.3/7.5</td>
<td></td>
</tr>
<tr>
<td>7213 Forced-Air Cooled</td>
<td>2,500 1,215</td>
<td>1,500</td>
<td>5.5/17.5</td>
<td></td>
</tr>
<tr>
<td>A-2545-A Forged-Air Cooled</td>
<td>28,000 400</td>
<td>10,000</td>
<td>8/88</td>
<td></td>
</tr>
</tbody>
</table>

PULSED RF APPLICATION

<table>
<thead>
<tr>
<th>Type</th>
<th>Max Plate Input Watts</th>
<th>Max. Freq. at Max. Ratings</th>
<th>Max. Plate Diss. Watts</th>
<th>Heaters Volts Ams.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-2587-A Conduction Cooled</td>
<td>3,750 3,000</td>
<td>25</td>
<td>12.6/41</td>
<td></td>
</tr>
<tr>
<td>7649 Ruggedized Forced-Air Cooled</td>
<td>9,000 1,215</td>
<td>115</td>
<td>6.3/3.0</td>
<td></td>
</tr>
<tr>
<td>7651 Ruggedized Forced-Air Cooled</td>
<td>72,000 1,215</td>
<td>600</td>
<td>6.3/7.5</td>
<td></td>
</tr>
<tr>
<td>7214 Forged-Air Cooled</td>
<td>180,000 1,215</td>
<td>1,500</td>
<td>5.5/17.5</td>
<td></td>
</tr>
<tr>
<td>A-2581-A Forged-Air Cooled</td>
<td>2,000,000 600</td>
<td>10,000</td>
<td>18/12</td>
<td></td>
</tr>
</tbody>
</table>

HARD-TUBE-MODULATOR APPLICATION

<table>
<thead>
<tr>
<th>Type</th>
<th>Max Plate Input Watts</th>
<th>Max. Freq. at Max. Ratings</th>
<th>Max. Plate Diss. Watts</th>
<th>Heaters Volts Ams.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-2638 Ruggedized Forced-Air Cooled</td>
<td>8,000 –</td>
<td>115</td>
<td>6.3/3.0</td>
<td></td>
</tr>
<tr>
<td>A-2624 Ruggedized Forced-Air Cooled</td>
<td>60,000 –</td>
<td>600</td>
<td>6.3/7.5</td>
<td></td>
</tr>
<tr>
<td>A-2627 A Ruggedized Conduction Cooled</td>
<td>300,000 –</td>
<td>1,500</td>
<td>5.5/17.5</td>
<td></td>
</tr>
<tr>
<td>A-2627 A Ruggedized Conduction Cooled</td>
<td>1,500,000 –</td>
<td>10,000</td>
<td>18/12</td>
<td></td>
</tr>
</tbody>
</table>

The chart shown above includes all RCA Ceromox Tube types available as of February 4, 1961.

*Development Type - Available on Sampling Basis

RCA ELECTRON TUBE DIVISION FIELD OFFICES