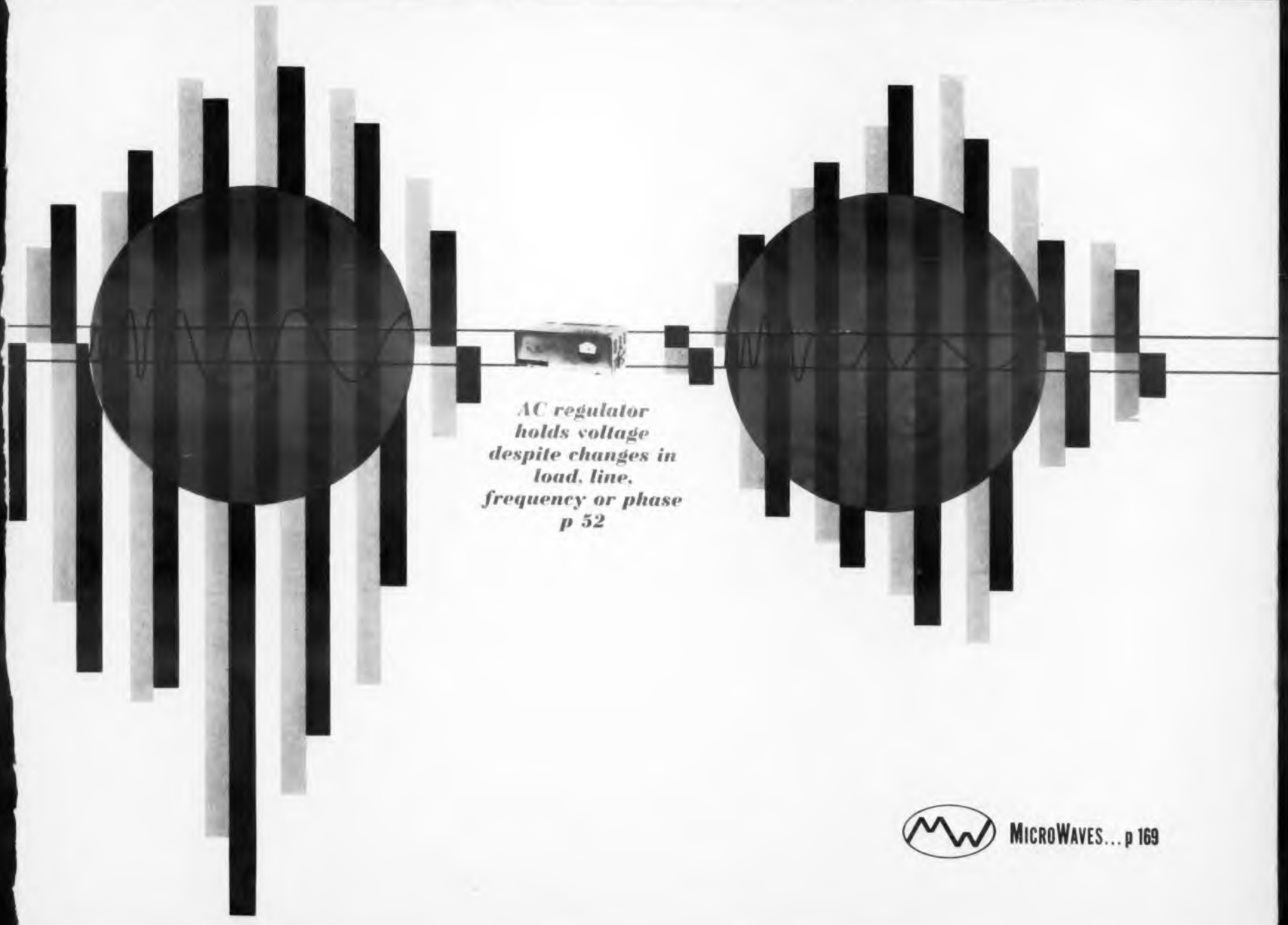
ELECTRONIC DESIGN

VOL. 10, NO. 2



AC regulator holds voltage despite changes in load, line, frequency or phase
p 52

MICROWAVES... p 169

COVER: The two prominent circles on the cover suggest crt views of the waveforms into and out of the ac-line regulator. Gray and black vertical bars represent uniformly spaced timing marks. Frequency of the waveforms has been exaggerated to show fast response of the regulator to line voltage changes despite changes in frequency.

Selected Topics In This Issue

CIRCLE 1 ON READER-SERVICE CARD

ELECTRONIC DESIGN · ONE DAY SERVICE

USE BEFORE JUNE 21st, 1961 **A**

Name ______________________ Title ______________________

Company ______________________

Company Address ______________________ City ______________ Zone ______ State ______

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Highlights of This Issue

The Jet-Age Challenge

Designers of air-traffic-control equipment, who have had their hands full trying to solve the many problems put to them by Federal Aviation Agency and military controllers, will soon be faced with new challenges.

Government planners are considering integration of the civil air-traffic control system with the SAGE network. The object is to improve control by taking advantage of SAGE's data-processing equipment and surveillance radars.

With missiles replacing aircraft as the main threat from the air, some of the capacity of SAGE is becoming available for other uses. FAA engineers inform us that the more integration is studied, the more feasible it appears. Project Trailsmoke, conducted last year in the Chicago and Detroit area, showed that air-traffic-controllers operating Air Force equipment could provide radar advisory service for aircraft of the Strategic Air Command.

Another limited trial of air-traffic-control integration is getting underway in the Washington, D.C., area, where, as part of project Shape, military surveillance radars are being used by controllers to keep high-altitude jet traffic under positive control—the type of control used by the military but only planned for the civil system.

The most elaborate attempt at integration will start next year, when a complete en-route high-altitude environment will be controlled by SAGE equipment modified for the task.

The modifications—bright displays, input-output buffers and electrographic printers—typify the type of system redesign that may be necessary on a large scale if integration takes place.

The article on p 4 of this issue explores some of the implications in the present air-traffic-control turmoil. The story originated at a recent FAA R&D Symposium in Atlantic City and was developed on a long round of visits to FAA headquarters in Washington.

Diode Hi-Fi Amplifier

Don't miss the article on the hi-fi amplifier that uses no tubes, no transistors—just diodes. It's the lead story in the Design Decisions section, p 216.

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U. S. Faces Difficult Decision on Air-Traffic Control

Plans for New Computer Centers Competing With Scheme For Integrating Military's SAGE into Civil Flight System

Alan Corneretto
News Editor

THE UNITED STATES will have to decide soon on the type of air-traffic control it wants in a maturing jet age.

Under consideration are three possible approaches:

- The much publicized Data Processing Central (DPC) system, in which computers would handle much of the information flow now processed manually.
- Integration of the civil system with the military's SAGE aircraft-surveillance network.
- An integrated system for areas now covered by SAGE and a compatible data-processing central system in areas beyond the range of the military network.

A decision is important, because the Federal Aviation Agency, investigating both the DPC and SAGE systems, is spending money on expensive projects that are competitive. The longer the decision is delayed, the more money will be spent.

A clouded future looms for the Data Processing Central system. This results from the increasing obsolescence of the SAGE network as a military defense and its availability for other duties, the most obvious being civil air-traffic control. SAGE was designed originally for early detection of enemy aircraft but is considered unreliable for tracking the supersonic missiles that are now commonplace in the world's military arsenals.

Before the availability of the SAGE system, DPC was considered the logical successor to the present manual system of civil air-traffic control. Now Government planners are frankly undecided about the scope DPC will have.

Control team station and equipment for Satin experiment, in which high-altitude air traffic over the New York-Boston area will be controlled by integrating facilities of the present FAA air-traffic network and the SAGE air-defense system.

SAGE-Civil Air System Due for Experimental Test

To get the maximum value from SAGE, a special FAA division is supervising a Mitre Corp. test of a sample SAGE-civil integrated system. The form of the experimental system—in particular, the degree of integration—will be known by July 1, when an FAA committee is scheduled to make recommendations on the subject.

To aid in the decision, the agency is making a study of 10-year costs of an integrated SAGE system and of the most likely alternative system that would be developed during the 10 years. This alternative, FAA spokesmen indicate, appears to be the Data Processing Central system—computer-dominated centers where much of the manual work of processing flight data strips and other air-traffic-control functions would be done semi-automatically.

Preliminary results of the cost study suggest that close integration of the civil system with SAGE would be less costly initially but would entail higher recurring costs than the Data Processing Central system. Included in the final evaluation, however, must be such factors as the more severe dislocation anticipated with SAGE integration and the greater flexibility expected with a newly designed DPC system. In addition the effects of varying degrees of integration have to be evaluated. FAA spokesmen indicate that the most likely arrangement will be to use the SAGE radars, some of which are now used jointly by the FAA and the Air Force, and much of the data-processing equipment at major SAGE sites. However, the standard SAGE computer, IBM's AN/FSQ-7, would probably not be used, nor would the Air Force's direction-center buildings.

But two important factors would have to be resolved before SAGE could be integrated. In SAGE, video information is digitized at radar sites and sent to processing centers over telephone links. In the present FAA system, raw video is sent over broadband microwave channels. If integration is chosen, this discrepancy

will probably be resolved on economic grounds.

Another point of difference is SAGE's use of a Cartesian-coordinate system of area division. The FAA uses uneven geographical sectors. The agency has indicated that it will probably shift to a grid system, although one different from the present SAGE grid.

To test the feasibility of integration, the Air Force has turned over to the FAA the evaluation sector of the SAGE system for use in a sample integrated system, Project Satin. In this test, high-altitude, en-route aircraft in the New York-Boston area will be controlled with the aid of a new program written for a SAGE computer. Most of the Satin system equipment is already available in SAGE; the rest—including brighter displays, and electrographic printers—is available off-the-shelf. The system is expected to be functioning by December.

Preliminary tests of some of the Satin concepts are under way in the Washington, D.C., area in a separate exercise. This is project Shape, in which surveillance radars are being used for positive control of high-altitude aircraft.

The Satin system differs from the present air-traffic control system in that it makes fuller use of computers to process flight plans, transfer control of aircraft and detect potential collision courses aloft. It also uses more radar and beacon data to acquire position data, and it correlates these data automatically with the flight plans. In Satin, information is presented to controllers as situation displays rather than as tabular data in flight-strip form. Satin uses keyboard entry devices to insert flight plans, progress reports and weather data.

Data Processing Centrals Probable If Systems Are Not Integrated

If Satin proves unfeasible, or if integration is not decided on for other reasons, the FAA will probably go ahead with its long-range plan of installing data-processing centrals throughout the air-traffic control system. The first of these is scheduled to be commissioned in the Boston area next year. A complete DPC, Data Processing Central system, as planned by the FAA, consists of about 50 different subsystems. These serve nine basic functions, which may be included in the over-all system piecemeal as individual equipments are developed.

Essentially the DPC and Satin concepts are in competition as means of controlling en-route air traffic. If integration is decided on, the long-planned and elaborate DPC-based system may not be implemented on a large scale. The main design effort then will be in modifying the SAGE system and in extending similar coverage to the areas of the country not now served by SAGE.■■

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Industry Preparing for Push in FM Stereo

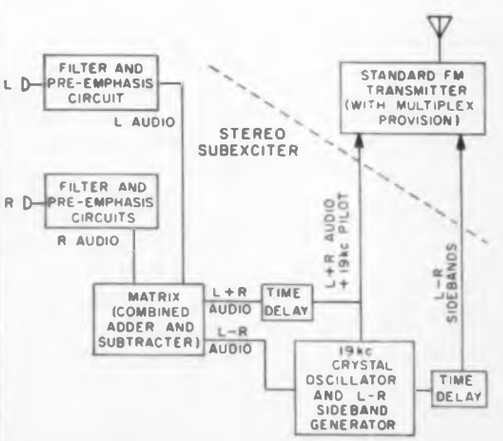
Choice of GE-Zenith System by FCC Starts Drive by Manufacturers

TRIGGERED by the Federal Communication Commission's approval of suppressed-carrier-am as the multiplex standard for fm stereo broadcasts, manufacturers are preparing to produce the special equipment needed for stereo transmitting and receiving.

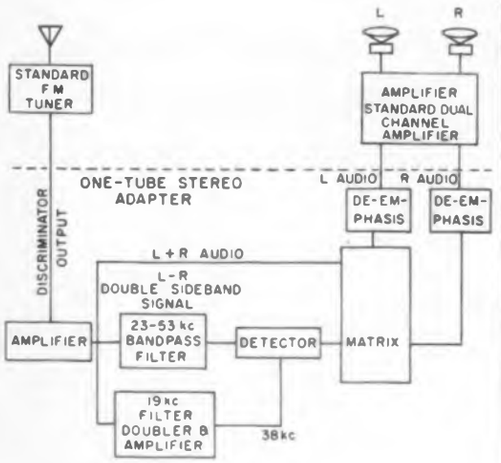
In the system to be used, the main carrier is frequency modulated by the sum of the left and right microphone signals and by the sidebands of a suppressed subcarrier. The subcarrier is amplitude modulated and suppressed by a left-minus-right difference signal. This suppressed subcarrier is restored at the receiver by a pilot signal transmitted between the subcarrier and the main carrier.

Transmission equipment required for the system includes an exciter, a subcarrier inserter capable of accepting a composite signal, a signal generator to generate the composite signal, and a monitor receiver adapted for stereo. Stations already equipped for storecasting or other multiplex transmissions would only have to modify their present equipment.

To receive the broadcasts requires that an adapter be added to a standard fm tuner and



Transmitting system adopted as standard for stereo broadcasts is based on sum and difference matrixing, with the sum transmitted as the main carrier frequency modulation and the difference signal transmitted as suppressed carrier amplitude modulation of a subcarrier. Half-frequency pilot signal is transmitted to help restore suppressed signal.



Receiving equipment for stereo broadcasts could be a standard hi-fi set plus a relatively simple adapter. Left-plus-right signal transmitted as fm modulation of main carrier for stereo would be signal used by monophonic sets. The left-right sidebands and pilot signal would not be heard in a monophonic receiver. In stereo sets they must be decoded to produce left-right signal. This happens when pilot signal is filtered and doubled to recover carrier, which is mixed with filtered sidebands to form normal am signal for detection.

dual-channel amplifier. General Electric Co., Utica, N.Y., believes that a one-tube–double triode–adapter would give satisfactory results, although it says addition of a preamplifier as well would make possible good reception by a wider variety of amplifiers. Cost of the adapter would be minor compared to that of the complete stereo system.

The system is compatible with existing fm broadcasting standards. Monophonic receivers tuned to stereo transmissions would receive the left-plus-right signal and would produce sound only slightly reduced in quality.

Adapters, Some FM Stations To Be Ready by June 1st

General Electric says it has adapters in production and that they will be on the market by June 1, at which time stations in Syracuse, Schenectady, Boston, Chicago and on the West Coast expect to be broadcasting stereo fm programs.

The adopted system is said to be the same as the one GE proposed to the FCC and very similar to one proposed by Zenith Radio Corp., Chicago. The Zenith system has been modified to include the subharmonic carrier. Its phasing and frequency parameters have also been changed. Both GE and Zenith plan to produce complete high-fidelity systems capable of receiving stereo broadcasts. ■■

Pyrolytic Graphite Investigated as Organic Semiconductor

Researchers Are Hoping to Make Use of Highly Anisotropic Properties In Easily Made Material, If Appropriate Applications Can Be Found

PYROLYTIC graphite, an organic semiconductor now used nonelectronically in industrial controls and missile nose cones, may become an important electronic material if suitable applications for its unusual properties can be found.

New research has established that the anisotropic conductivity of the relatively easy-to-make material is on the order of 1,000 to 2,000. Because of this and its good carrier mobilities, pyrolytic graphite (PG) appears to be one of the most promising organic semiconductors so far investigated, according to Dr. C. A. Klein of Raytheon Co., Waltham, Mass.

However, says Dr. Klein, much more research is needed before the material can be considered a semiconductor suitable for electronic devices. Carrier lifetime has yet to be established; lifetimes are short for most known organic semiconductors. Two applications understood to be under consideration for PG are in energy-conversion devices and in nonreciprocal networks. Another form of the material, pyrolized carbon, is reportedly being investigated as a resistor substance. Resistance values would be controlled by heat treatment, which is said to be a simpler method than the present technique of adjusting chemical content.

At the Inter-Industry Conference on Organic Semiconductors, held in Chicago, Dr. Klein reported that two of the three directional resistivities of PG were strongly dependent on the temperature at which the graphite was deposited during manufacture. He said the room-temperature resistivity of speciments deposited at 2,500 C had been measured at about 2×10^{-4} ohm-cm in the basal plane and about 0.5 ohm-cm in the perpendicular plane.

In both the basal plane and the perpendicular plane, resistance increases with decreasing temperature. But in the basal plane, Dr. Klein reported, resistivity first decreases as the temperature drops from 1,500 K to 600 K, then rises as temperature nears cryogenic levels. In the perpendicular direction, resistance rises evenly from high to room temperature, which is characteristic of semiconductors, then levels off at low temperature. As a function of temperature, electrical anisotropy was said to go through a maximum of about 1,000 at slightly above room temperature and to decrease sharply at high temperatures.

Carrier concentration in n-type pyrolytic graphite has been measured at about 1×10^{18} cm^{-3} at 300 K. This increases linearly with temperature and is said to be equivalent to that of germanium.

The material is reportedly easily produced by pyrolyzing carbonaceous gases in either an induction furnace or a resistance-heated furnace at temperatures of about 1,000 to 2,000 C. The breakdown of hydrocarbons results in a polycrystalline polymer that can be deposited on a substrate in considerable thickness.

Photo-induced Hall effect in an organic semiconductor is studied with flash tube apparatus at Armour Research Foundation. So far, 10 μsec-single pulses focused on anthracene crystals to generate carriers have not resulted in measurable effects. Researchers are trying to detect these by noting the effects of magnetic fields on Hall currents. Armour's W. D. Brennan, shown here, reports apparatus is being modified.

Many Groups Are Studying Semiconduction in Organic Polymers

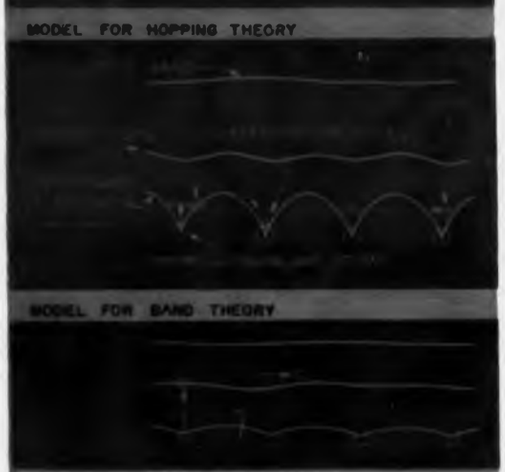
Other organic polymers exhibiting semiconduction are under study in many organizations, including most of the major chemical companies, several electronic firms, and schools and research organizations. At Princeton University, Dr. H. A. Pohl reported, nearly 150 polymers have been created by pyrolysis and by direct synthesis. Carrier concentration in the created materials ranges from 10^{13} to 10^{19} per cm^{-3} for pyrolytically produced polymers and from 10^{13} to 10^{17} per cm^{-3} for directly synthesized polymers. Germanium, by comparison, has concentrations that may be varied from 10^{13} to 10^{18}, it was said.

The conductivities of the material produced at Princeton range from 10^{3} to 10^{12} reciprocal ohm-cm for pyrolized polymers or pyropolymers, and 10^{-2} to 10^{20} for synthesized organics. The corresponding figure for germanium is said to be about 10^{-3}.

Ranges of other characteristics of the variety of polymers produced at Princeton were:

- Temperature coefficient of resistance—from positive to zero to negative for pyropolymers, and negative for synthetics.
- Form—from thermosetting to thermoplastic.
- Mobilities—from about 10^{-8} to more than 100 cm^2 per v-sec for pyropolymers, and from 10^{-5} to 300 cm^2 per v-sec for synthetics.
- Thermoelectric powers—from 3 to more than

'Hopping' Model Is Now Favored For Studying Organic Conductance



A "hopping" model for investigating conduction in organic materials is now considered better than a "drift" model based on band theory.

In the hopping model, excited electrons or holes, leaving the parent atom or molecule, tend to be drawn back by a mountain-like configuration of potential energy unless they can be excited over the potential mountain and be drawn to a neighboring unit. Electrons or holes may also "hop" to a neighbor by tunneling if the mountains of binding potential are too high. Transfer is limited to one neighbor at a time.

In the band theory model, the basic assumption is that electrons and holes are free to wander anywhere among basic units of matter. If atoms or molecules are packed closely together, energy variations are smoother, and the excited unit may travel easily through material until scattered by impurities. The general acceptance of the hopping model may speed understanding of conduction in organics and so remove one of the main bottlenecks to development of useful organic semiconductor materials for electronics.

300 μv per deg C for pyropolymers and from 3 to 900 μv per deg C for synthetics.

■ Magnetic characteristics—diamagnetic to ferromagnetic for pyropolymers, and diamagnetic to paramagnetic for synthetics.

According to Dr. Pohl, the resistance temperature coefficients of the pyropolymers may be regarded as energy gaps, ranging in the materials

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NEWS

studied from about −0.0005 to +1.0 electron volts. This gap permits such high densities of carriers that the materials can be classified as degenerate semiconductors. Synthetics, however, show a considerably lower level of carrier concentration, no degeneracy, and lower mobilities.

In general, it was stated, the carrier mobilities of most organic semiconductors are so low that none so far examined can be considered suitable for such devices as transistors, which require mobilities of about 1,000 cm^2 per v-sec. However, some resistors, said Dr. Pohl, require only medium mobilities—of from about 5 to 1,000 cm^2 per v-sec. Some organics show such mobilities.

For useful thermoelectric effects, materials capable of higher powers than those so far studied are needed. At Princeton thermoelectric powers of up to 300 μv per deg C have been measured by pressing a polymer crystal between two platinum foil electrodes. One electrode was heated, and a measurement was taken of the voltage across the two electrodes and each thermocouple.

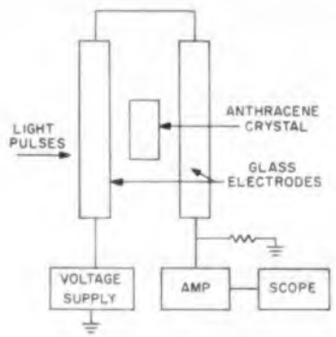
Organic semiconductors, according to J. F. Bourland, general manager, Central Research Div., American Cyanamid Co., New York City, have the following advantages:

- They offer an unlimited variety of characteristics. Synthetic chemists are able to tailor organic molecules to whatever atomic interrelationship is needed.
- They are plentiful and relatively cheap, in contrast with many inorganic semiconductors.
- They have low thermal conductivity, characteristic of most large organic molecules, and might make better thermoelectric materials than do the inorganics—though not thermoelectric power generators.
- They can be made to have plastic properties, promising films, filaments and molded shapes, all produced without expensive machining and metal-forming techniques.

Electrically Reversible Units To Desalt Sea Water Seen

Dr. Pohl foresaw the possibility of materials in which the semiconductor properties of organics would be combined with the absorptive ion-exchange properties of polymers to create electrically reversible units that could desalt sea water. He envisioned organic semiconductors in use in flexible and transparent plates for panel lighting and heating, in ferroelectric devices, in hydromagnetic equipment, in cold-emission cathodes, and in light amplifiers.

Organic semiconductors under study in the United States include, among the polymers, pyro-



Elegant method for measuring drift mobilities in anthracene, an organic semiconductor, opens the way for study of carrier drift and lifetimes and of how a charge is transferred in organics. When light, in 1 to 2 μsec pulses, is applied to a transparent, charged glass electrode acting as a capacitor plate, charge carriers move through the crystal of ultra-pure antracene. Current through the resistor is proportional to carriers. The method indicates anthracene charge carriers have mobilities of about 1 cm^2 per v-sec.

lytic graphite, pyrolyzed polyacrylonitrile, and phenolphthalein; among simple molecules, phenazine, imizole, benzimidazole, trans-butadiene, naphthalene, quinoline, and isoquinoline; among the charge-transfer complexes, which show high conductivities and paramagnetism, tetracyanoquinodimethan (TCNQ), pyrene-iodine, and phthalocyanine.

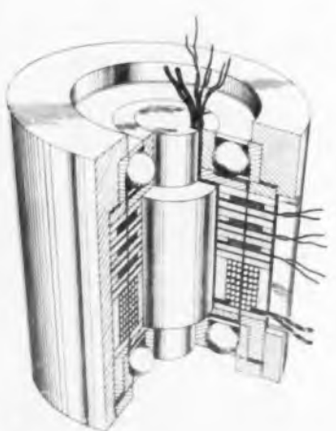
The most studied organic semiconductor is anthracene crystal, a simple molecule, which shows no promise of being a useful electronic material because of its low carrier mobilities, high activation energy and short charge-carrier lifetime. Anthracene is, however, relatively well understood and is proving a useful model for studying more complex organics.

Liquid, as well as solid-state organic semiconductors, are under examination. Several materials show better properties in their liquid form than they do as solids. It was predicted at the meeting that if organic semiconductor devices were developed, some might well be liquid-state.

Several specialists in organic semiconductors see possibilities for their technology that range far beyond electronic devices. W. O. Baker, vice president of research at Bell Telephone Laboratories, Murray Hill, N.J., said that polarization and conduction appeared basic to organic living systems and that once their mechanisms were understood, scientists might be able to solve some of the most difficult and important problems in medicine and biology. ■ ■

Frictionless Rotary Transformer Designed

Ferrite Rings Linked Magnetically Across Air Gap In Device That Eliminates Slip-Rings and Brushes



Axial arrangement of contactless rotary transformers along a shaft. Lower transformer, with larger diameter windings, is of the power type, and the three units above are signal types. Bearings separate rotating and stationary ports.

Secondary windings for axial arrangement of power transformers along a shaft are shown. Epoxy resin holds ferrite rings to windings.

ROTARY transformers using frictionless magnetic coupling rather than conventional slip-rings and brushes have been developed for use in inertial guidance systems.

The technique, however, is expected to find many applications in electrical and electronic equipment. It was developed by Randall L. Gibson, research engineer with the Massachusetts Institute of Technology's Instrumentation Laboratory for inertial systems.

The concept was used previously in a signal transformer to couple an antenna to a receiver in a vlf direction finder developed by Stanford Research Institute, Menlo Park, Calif. The direction finder used a loop antenna to pick up signals in the 15- to 300-kc range.

Ferrite rings or cup cores are used in the primary and secondary portions of the rotary transformers. The ferrite pieces are coupled magnetically across a narrow air gap. One portion can then be rotated with respect to the other without causing fluctuations in the magnetic circuit, because the total dimensions of the air gap do not change with rotation. Slight fluctuations are caused at high speeds because of the inhomogeneity of the ferrite material, according to Mr. Gibson, but this is not a serious problem. The high Q and low losses of ferrites at lower frequencies made them ideal for this application, according to SRI designer Leonard Orsak.

Use in Electromechanical Systems And Electric Motors Envisioned

A major application of the technique will probably be in taking signals from gimbals in electromechanical reference systems, such as autopilots. Rotary transformers could also be used to eliminate slip-rings in synchronous electric motors.

Chief advantages of the technique are long operating life, lower noise in low-level circuits, and a reduction in torque required to turn the rotating portion. The almost perfect power-trans-

fer efficiency of coupling with slip-rings and brushes cannot be achieved, but a device that was more than 98 per cent efficient was built without difficulty by MIT researchers.

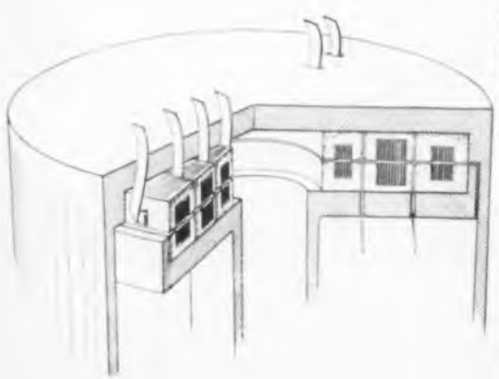
Rotary transformers have proved rugged in laboratory tests, according to MIT, even though the ferrites are somewhat brittle. It was found that cracking of the ferrites in a radial direction did not impair performance.

Epoxy resin is used to hold the ferrite rings or cup cores to primary and secondary windings. Precision finish grinding is done only on completely assembled transformers to avoid eccentricities. Tests have shown less than 0.1 per cent amplitude variation with rotation due to eccentricities in the rings. Conventional surface and cylindrical grinders were used, with tolerances held at 0.0001-in. throughout.

Rotary Transformers Built by MIT Use Both Axial and Radial Design

Rotary transformers arranged in both axial and radial configurations, as shown in the diagrams, have been built by MIT researchers. Where sufficient shaft length is available, different rotary transformers can be arranged one after the other along the shaft. If shaft length is limited, a radial design can be used with complete transformers arranged one outside of the other at one point on the shaft.

The development of the rotary transformer was undertaken by the Instrumentation Laboratory for use with pendulous integrating gyroscope accelerometers in inertial systems. It eliminates friction problems associated with the use of slip-rings and brushes to provide the accelerometers with wheel power, microsyn excitation current, torquing correct, and output signals proportional to angle and temperature. ■ ■



Radial arrangement of power transformers, with three units, one outside of the other, around one point on the shaft. This configuration can be used where shaft length is limited.

NEWS

Bell Building Antenna in Maine For Satellite Communication Test

A quiet, wooded site in Maine is being prepared for the harnessing of satellites for commercial uses.

On a mountain-encircled, 1,000-acre area near Rumford, Bell Telephone Laboratories is building a high-directivity, low-noise horn antenna for communication to Europe via an experimental active repeater satellite. The isolated Maine valley was chosen to minimize the possibilities of interference from American Telephone & Telegraph's national microwave network. The frequencies approved by the Federal Communications Commission for the experiments—6,325 to 6,425 mc for ground-to-air and 4,100 to 4,200 mc for air-to-ground—are in common carrier bands used for microwave links.

AT&T Wants Experimental Satellite In Operation by Next Spring

Bell Laboratories spokesmen say they hope to have an experimental satellite operating by the time the National Aeronautics and Space Administration's Relay satellite is in the air—probably about May, 1962.

Construction of the experimental ground station is expected to cost about $7 million. Satellite and launching costs are expected to add $15 million more. If the experiment is successful, AT&T plans to build the ground equipment for a commercial satellite system between here and Europe. Four other antennas and a string of some 25 satellites in 5,000-to-6,000-mile orbits

Commercial satellite communications station envisioned by Bell Telephone Laboratories would use five horn antennas in secluded area near Rumford, Me. Plastic domes, inflated with warm air, would protect the sensitive sending and receiving antennas from snow and ice. The antennas would work in tandem, with one following a setting satellite and the other picking up a rising one. One of the antennas is being built by Bell for an experimental test of the system.

would be sufficient to start commercial operations, according to James E. Dingman, vice president and chief engineer of AT&T. The forecast is based on the assumption that similar ground equipment would be installed at the European end.

The first experimental satellite will be launched into an eccentric orbit, probably with an apogee of about 5,000 or 6,000 miles and a perigee of 300 miles, Mr. Dingman said.

Wide-Deviation FM Planned With Bandwidth Held to 40 Mc

Only 40 mc of the 100-mc bands will be utilized in the first tests, A. C. Dickieson, Bell Laboratories director of transmission development, reports. A wide-deviation, fm modulation method will be used with a baseband of about 5-mc and 15-mc deviation. A 2-w traveling-wave tube will be used for signal amplification in the satellite after a frequency shift has been applied.

The antennas in the Maine valley will be protected from snow and ice by an inflated plastic bubble containing warm air. The domes will be about 161 ft high and 210 ft in diameter.

Checkout Study Aims to Improve Complex AF Weapon Systems

A 14-month study of checkout equipment being conducted by Battelle Memorial Institute, Columbus, Ohio, is expected to improve the efficiency of complex weapon systems.

The study is being made under a contract from the Wright Air Development Div., Air Force Air Research and Development Command.

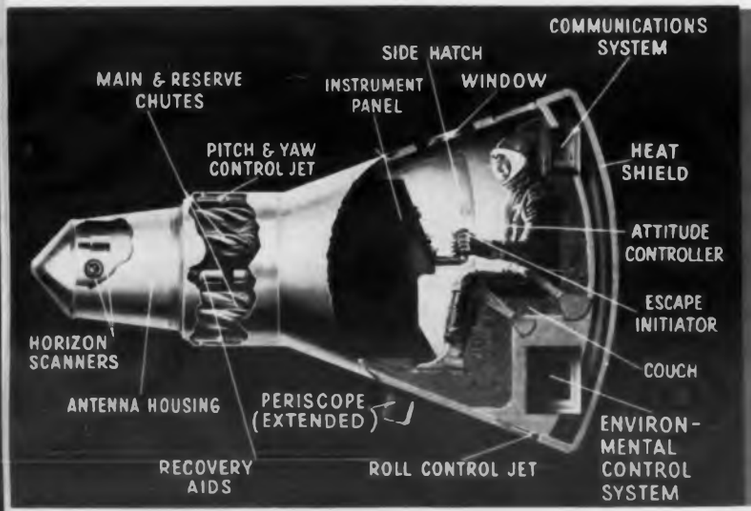
Battelle specialists are considering the following questions:

- What is the weapon system supposed to do?
- When may it be considered ready for use?
- How can you identify parts of the weapon that are not functioning properly?
- To what extent will these malfunctioning parts interfere with the weapon's basic performance?
- What techniques are needed to communicate information about these malfunctions?
- Are there situations where the disadvantages of a checkout system outweigh its advantages?
- Can checkout techniques be systematized and made automatic?

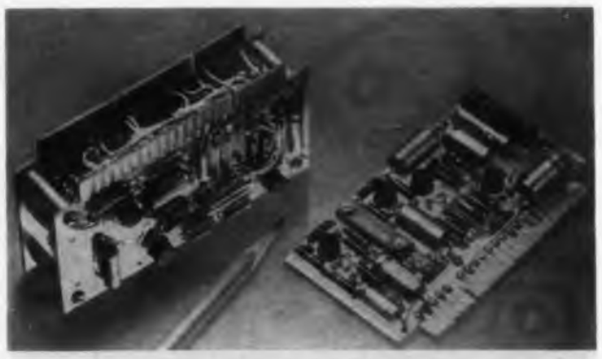
Since humans will always be the most important factor in determining the success or failure of these techniques, the research team includes psychologists concerned with the reliability of men working with complex weapons.

U. S. Space Man Relies on Advanced Systems Design

Complex Electronics Guide Project Mercury Capsule

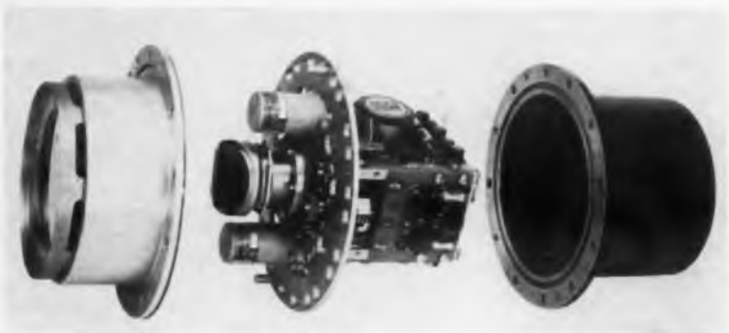


Project Mercury capsule includes a variety of advanced electronic equipment for control and communications. Infrared horizon scanners provide reference for stabilizing the space vehicle during re-entry. Not shown in this cutaway is a Minneapolis-Honeywell gyro-referenced attitude control system that maintains the capsule in its desired attitude in orbit. This system includes visual presentation of roll, pitch and yaw to permit manual control by the astronaut. He can also monitor a globe that indicates the vehicle's position in relation to the earth. The globe is controlled by a dead-reckoning computer.



Transistorized amplifiers help keep track of astronaut's physiological reactions during space flight. Ground stations receive data on body temperature, oxygen consumption and heart rate from signals amplified by these units. The circuits, designed to operate up to 200 F, were developed by Thompson Ramo Wooldridge, Inc.

Logic panel containing over 3,000 connections gets extra careful check before installation in the Mercury capsule. This panel is used in the altitude stabilization and control system, along with gyroscopes and reaction jets, to prevent tumbling and to position capsule during flight and re-entry. Minneapolis-Honeywell built the system.



Infrared horizon-scanning sensors in nose of capsule furnish voltages for stabilization controls. Barnes Engineering Co.'s sensor package has three main parts. From left: front cover with germanium window; rotating prism assembly on metal base plate with synchronous choppers, drive motor, detector, power supply and signal-processing electronics; and rear electronics cover. The package is completely sealed and pressurized.

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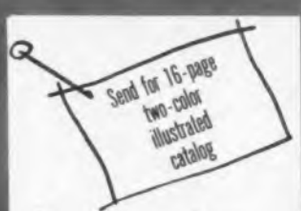

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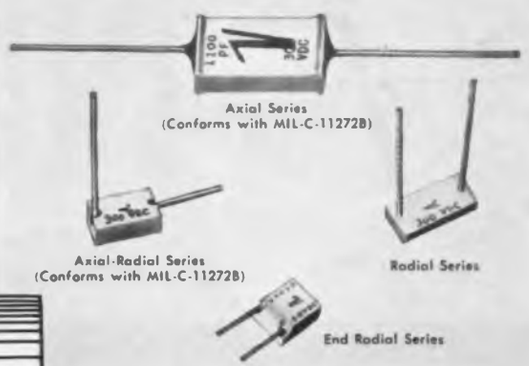

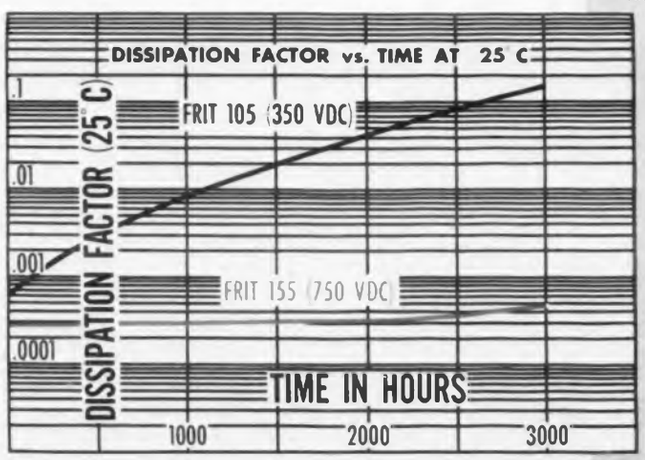

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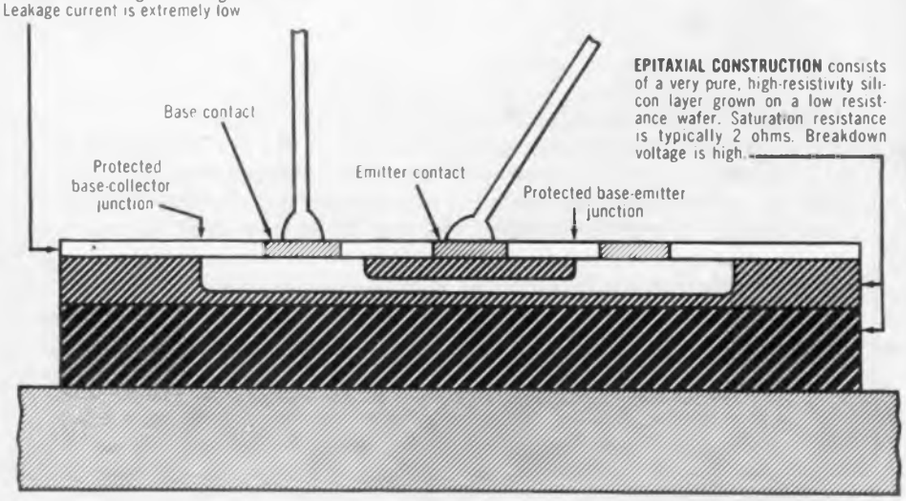
PLANAR CONSTRUCTION features an integral passivated surface of silicon oxide over the junctions, protecting them against contamination during manufacture and against change with time. Leakage current is extremely low



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EPITAXIAL

High speed, low saturation resistance and high breakdown voltage rating are features of EPITAXIAL construction. The thin epitaxial layer contains the junctions. Of high purity, it provides low capacitance and high breakdown voltage. The thicker, low resistivity supporting wafer provides a low resistance path to the header and collector lead.

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PLANAR and EPITAXIAL advantages are additive, satisfying the circuit designer who seeks the ultimate in device performance. The combination makes possible the design of improved circuits: faster computer logic circuits, faster high current drivers and more efficient high frequency oscillators and amplifiers. Planar and Epitaxial together also achieve usable current gain over a broader current range than either can achieve alone.

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Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions	
h_{FE}	DC Pulse Current Gain	30		120		I_C = 10 mA	V_{CE} = 1.0 V
h_{FE}	DC Pulse Current Gain		25			I_C = 200 mA	V_{CE} = 5.0 V
$V_{CE(sat)}$	Collector Saturation Voltage		.40	.70	Volts	I_C = 200 mA	I_B = 20 mA
$V_{CE(sat)}$	Collector Saturation Voltage			2	Volts	I_C = 10 mA	I_B = 1 mA
h_{fe}	High Frequency Current Gain f = 100 mc	3.0				I_C = 20 mA	V_{CE} = 10 V
I_{CBO}	Collector Cutoff Current			25	mμA	I_E = 0	V_{CB} = 20 V
BV_{CBO}	Collector to Base Breakdown Voltage	40			Volts	I_C = 1.0 μA	I_E = 0
$V_{CEO(sust)}$	Collector to Emitter Sustaining Voltage	15			Volts	I_C = 30 mA (pulsed)	I_B = 0

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CIRCLE 18 ON READER-SERVICE CARD

WASHINGTON REPORT

J. J. Christie
Washington Editor

ANOTHER ROUND ON PATENT POLICY

The longer the controversy rages over whether the Government should take title to its R&D contractors' inventions or simply require royalty-free licenses, the more it becomes apparent that no unified patent policy for all Government agencies is necessary or even practical.

Testimony at another series of hearings by the Senate Judiciary subcommittee on patents appears to have substantially lessened justification for legislation that would reverse the Defense Dept.'s policy of permitting the contractors to take title to their inventions.

The department's position has been fortified by efforts of the National Aeronautics and Space Administration to get Congress to permit it to follow a similar policy. Indeed, legislation granting the NASA request got as far as House passage at the last session of Congress. Moreover other Government agencies, while not seeking a change in their practice of taking title, at least are recognizing special circumstances where a waiver of title is desirable.

The Federal Aviation Agency, on the other hand, can easily justify its policy under which rights to inventions are shared in proportion to the extent that development costs are shared by the agency and its contractors. This is because patentable developments arising out of FAA-sponsored research very often have a ready-made commercial aviation market: the agency can make adoption of the new equipment mandatory in the interest of air safety.

Although a strong case for a flexible patent policy has evolved, Congressional hearings also have underscored the desirability of a set of legislative criteria defining conditions under which the public interest requires vesting of the patent title in the Government. The need for administrative machinery for making these determinations also has been brought out.

Tightening of Defense Dept. Policy by a recent armed services procurement regulation revision has gone part way in answering Congressional charges that the Pentagon is engaged in a colossal "give-away." The revision notes certain conditions under which taking full title would be clearly in the public interest. One of these is when R&D is in a trail-blazing field, in which a patentable discovery of commercial value could give the contractor a monopolistic position.

The weakness in the procurement regulation revision, from a Congressional standpoint, is that determination of exceptions to basic policy are left to contracting officers. There should be some high-level review procedure, some Congressional critics contend.

The Defense Dept. also has shown a willingness to negotiate contracts with clauses vesting title in the Government when undertaking joint research projects with such agencies as the Atomic Energy Commission and FAA. The Senate subcommittee, however, wants a standard policy applicable to all agencies "in dealing with the same contractors in any given field of research."

A Federal Inventions Administration is called for in a bill introduced by Sen. Russell B. Long (D., La.). The bill would give the government title to all inventions arising out of any Government-financed R&D program, with provision for a waiver of title when it could be shown that the equity of the contractor predominates. A highly involved adminstrative procedure would be required to get a waiver.

The Defense Dept., in its testimony opposing this legislation, held that the prescribed administrative procedure was so cumbersome as to virtually nullify the concession of permitting pre-contract waivers. Noting that in fiscal 1960 the department let approximately 20,000 separate RDT&E contracts, officials warned that the procedures would preclude getting pre-contract waivers except in very rare instances.

Another aspect of the Long bill that has aroused the opposition of both the Defense Dept. and the Electronic Industries Association is a provision relating to Government ownership of technical information. As the department interprets it: "In the absence of clearance by the Federal Inventions Administration, we could not use the material for competitive procurement; scientists could not give papers at technical seminars or publish in scientific journals; and manufacturers could not use the information for follow-on procurement."

The chances for passage of legislation as drastic as the Long bill are extremely remote.

AUTOMATION IN THE SPOTLIGHT

The Administration's economic policymakers are engaged in an all-out effort to get management, labor and appropriate Government agencies to focus on automation—both its positive and negative aspects.

The President's recent tax message, proposing tax credits for increased capital outlays, represents one side of the coin—an encouragement to step up automation. On the other side is action by the Secretary of Labor in setting up an Office of Automation and Manpower—a move to deal with the negative side of automation.

Charged with considering both sides of the coin is the President's Labor-Management Advisory Committee, which significantly had "automation and unemployment" as the sole item on the agenda for its first working session May 1.

Managements Planning Automation Moves will be under increasing pressure to make provisions for job retraining, personnel transfers and special financial benefits for unassignable and untrainable workers. Thus the electronics industry, faced with the necessity of substantially increasing automation in response to new techniques, particularly in componentry, will have a considerable stake in Government efforts to induce labor and management to work out joint programs.

Labor Secretary Arthur Goldberg stated the Administration's philosophy and objectives in these words: "If management must automate, and I believe it must, then it must also assume a larger role than it has in the past to ease transition . . . Retraining programs, allowance payments, vesting of pensions, care in location and relocation of plants, and a host of other schemes should receive management's most serious attention . . .

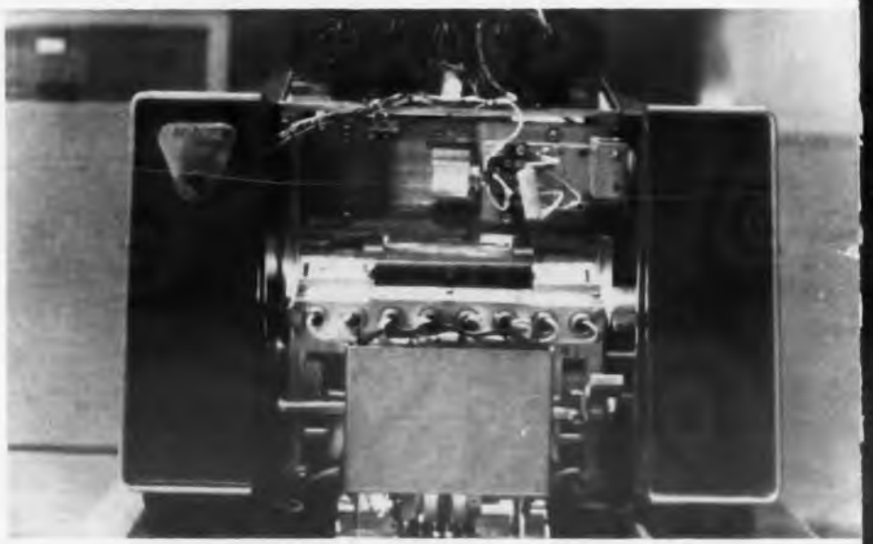
"Labor, for its part, must meet management half way. It must abandon restrictive practices. Both sides must think out the operations of seniority systems. Both sides must concentrate on devices to increase labor mobility."

The Labor Dept.'s new Office of Automation and Manpower will be charged with assisting management and labor toward these goals by developing guidance programs, serving as a clearinghouse of information and by initiating Government-sponsored retraining programs.

Electronics Branching Out as New Clerk in Nation's Offices

Computers and Peripheral Devices Stir Interest at Business Show

Patch panel programing is accomplished with plug-in jumper wires in this digital-to-digital code converter offered by Friden, Inc., at the Office Equipment Manufacturers Institute Exhibition at New York's Coliseum. The code converter is set up here to convert eight-channel Flexowriter code into five-channel teletype code.



Punched-card reading at 2,250 cards per minute, said to be the fastest rate in the industry, is claimed by Philco Corp. for this card reader now standard with the 2000 series of computers. Bright violet lights are used for photoelectric reading in the machine, produced under license from Uptime Corp.

Airline ticket agent's set used in Remington Rand Univac system is operated by Eastern Airlines salesgirl. Communications control unit, tying many agents' sets into a central computer, is shown in the background. Remington Rand will deliver a new Univac 490 Real-Time Computer to Eastern's facilities at New York International Airport before the end of this year for handling ticket data, sources at the exhibition disclosed. A Univac File Computer is being used with the present Eastern system.

Desk-sized National Cash Register 390 Computer features fold-out magnetic-core memory unit (lower left) and all-solid-state circuitry. Input and output are by the company's photoelectric paper-tape reader, magnetic-tape ledger cards, punched cards or typewriter.

Teaching machine for language training is tested by visitor to Dictaphone Corp.'s exhibit. Plug-in earphones are provided for listening and a microphone for recording.

Last-minute adjustments are made on A. B. Dick Co.'s Videograph electrostatic address-label printer, which uses digital-pulse code input.

Line drawings or diagrams can be sent over private telephone lines (schedule 2) using this Dictaphone Datafax system. Light from fluorescent lamps is reflected from the drawing through a 0.01-in. sq. aperture, which is mechanically scanned. The light strikes a photomultiplier tube, and the tube's output modulates a carrier. A helix printer at the receiving end marks electrostatic paper in synchronism with the scanning aperture. A seven-tone gray scale is provided. George Theofanis, service representative, adjusts receiver-printer.

Potentiometer That Uses Light Beam For Pick-Off Is Headed for Production

First Application of Versatile Device Will Be in Gyroscope, With Elimination of Conventional Wiper-Arm Drift Effect

Photoelectric potentiometer in the initial stages of assembly is held by C. A. Mounteer, project manager.

Thomas E. Mount
West Coast Editor

A POTENTIOMETER using a light beam rather than a conventional wiper arm as a pick-off element is moving from the research stage into production.

The light beam causes semiconductor material, bridging the gap between a conductor and a resistance element, to become conductive. As the light travels along the semiconductor element, the potentiometer's output changes. Because of the lack of friction, long life is expected for the device.

First application of the photoelectric potentiometer, developed at Giannini Controls Corp., Pasadena, Calif., is as a gyroscopic pick-off. The big advantage of the new device, called Photopot, is that it will have no loading effect on the gyroscope, because the light beam is the only connection between the gyro and the potentiometer. A mirror attached to the gyro directs the light beam onto the potentiometer.

Space vehicle gyroscopes and inertial platforms are required to have drift rates on the order of 0.1 degree per day or better; it is important that no torque be exerted on them. Current conventional pick-offs may contribute to gyro drifts of 0.5 deg per min, according to Carlyle A. Mounteer, prototype development manager of GCC's laboratories.

Mr. Mounteer says the Photopot besides having no effect on drift can also be used to provide output and sensing to orient a space vehicle with respect to the sun or a star. It can be used as a long-lived analog computer element, as a sensitive pressure transducer in conjunction with a Bourdon tube, and—if the light intensity as well as position is varied—as a multiplier. Typical outputs of a few volts, with high resolution over the entire range, are provided.

Other advantages of the Photopot are reported to include a wide range of resistance values and inherent infinite resolution in operation. Output resistance could run from 1 K to thousands of megohms since the potentiometer design is not limited to the composite materials that can withstand a wiper's abrasion. Production units to be marketed in September, however, will have values of total resistance from 50 to 100 K. Specifications call for tolerance of any potentiometer resistance to be plus or minus 15 per cent of the specified total resistance.

Electron bombardment of a Photopot's crystal surface is performed in tests at Giannini's laboratories. Modifications of the properties of the photoelectric potentiometer under bombardment are studied.

Development of the Photopot results from basic research undertaken by Giannini Controls director of research Alex Moncrieff-Yeates. The potentiometer has as its basic element a composite crystal mounted on a substrate with cement. The substrate is placed on a transistor header, making the device familiar to handle. A resistive material is deposited on crystal and substrate. Terminals come up through the substrate to contact the resistance material.

A conductor is then deposited on the crystal just 0.002 in. away from the resistance element. Then, when light is directed at a point on the gap, current flows between the conductor and the resistance element at that point.

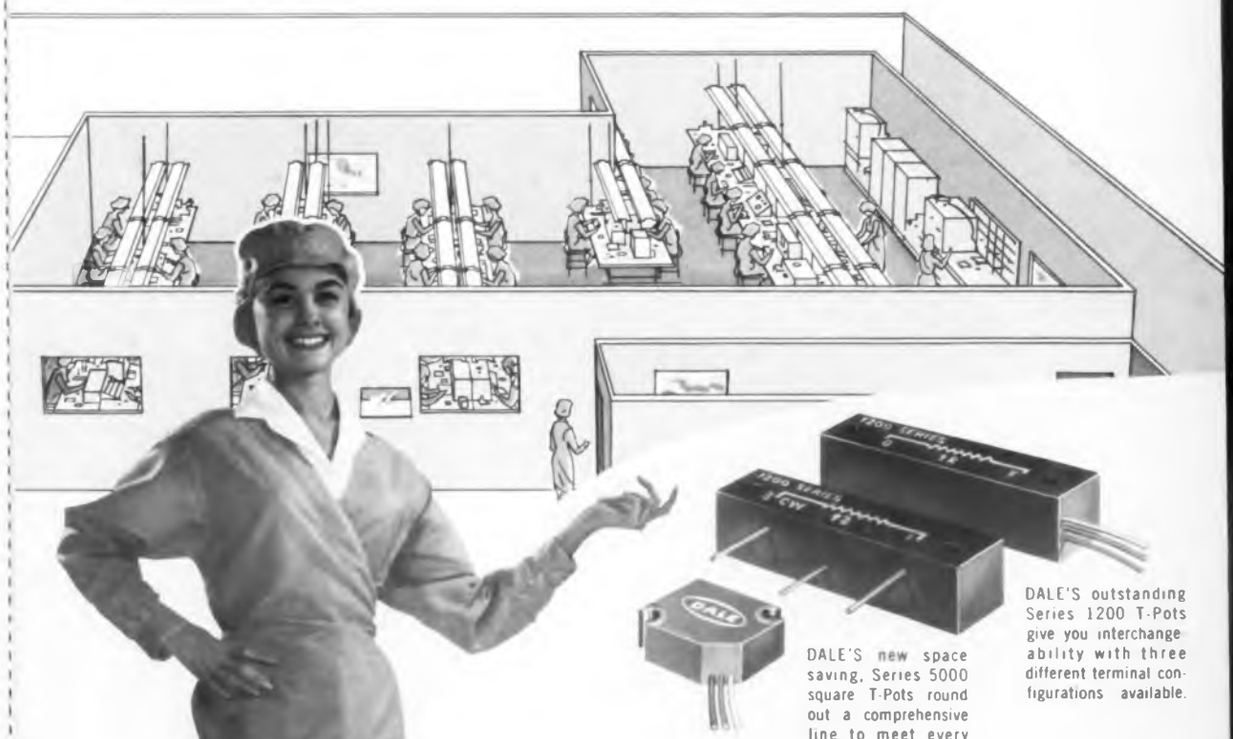
"The life of the Photopot," Mr. Mounteer asserts, "is unaffected by the wear normally associated with contact-type, brush-wiper potentiometers. It must therefore be described as an overload property."

Not enough time has elapsed under test to predict with any exactitude the lifetime of the Photopot, but Mr. Mounteer believes it to be in the neighborhood of a million million cycles.

Purity of the semiconductor crystals is critical to the operation of the Photopot. At present laboratory models of the device have exhibited a light resistance of 10,000 ohms. This is mainly the resistance of the bridge across the semiconductor gap. Depending on the type of semiconductor material used, production models may have 30 K light-path resistance instead of 10 K.

in DALE T-POTS

Advanced Design plus Stringent Production Controls equal Unprecedented Reliability



DALE'S new space saving, Series 5000 square T-Pots round out a comprehensive line to meet every need.

DALE'S outstanding Series 1200 T-Pots give you interchangeability with three different terminal configurations available.

A Dale worker dressed for the "room within a room" in special smock and head covering

THE ROOM WITHIN A ROOM...

scene of the modern production techniques by which Dale Electronics absolutely controls temperature, humidity, dust, corrosive gases and all other environmental factors to assure the highest quality and reliability in Dale Trimmer Potentiometers.

Within this surgically clean room, temperature and humidity are maintained at a constant level. The air is electrostatically filtered and pressurized to maintain purity. The skilled workers who operate the precision tools, fixtures and optical equipment necessary for sub-miniature and micro-miniature assembly, wear special smocks and head coverings as a further safeguard against dust, lint and other foreign materials.

Hathaway INSTRUMENTS INC

DALE ELECTRONICS, INC. PACIFIC DIVISION

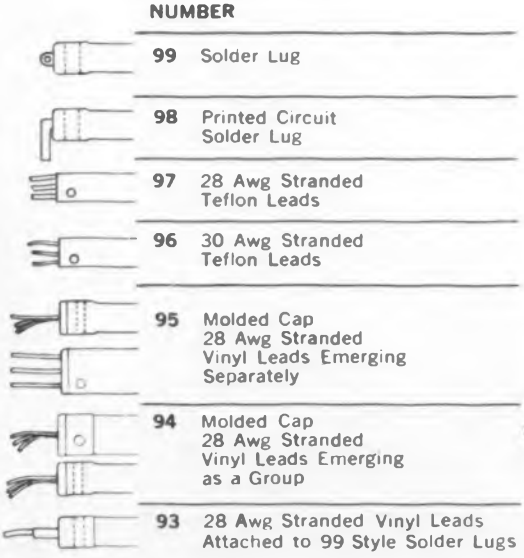
P. O. Box 747, Burbank, Calif. Home Office Columbus, Nebraska

A Subsidiary of HATHAWAY INSTRUMENTS INC.

DALE TRIMMER POTENTIOMETER SPE

PART NUMBER	TOLERANCE	RESISTANCE RANGE	HUMIDITY PROOF	POWER RATING	RESOLUT DEPEND ON VAL
199 and A10W	± 5%	10 Ohms to 50K Ohms	NO	.8 Watt	.12% to
198 and A10WPC	± 5%	10 Ohms to 50K Ohms		.8 Watt	.12% to
195 and A10WML	± 5%	10 Ohms to 50K Ohms		.8 Watt	.12% to
194 and A10WML-1	± 5%	10 Ohms to 50K Ohms		.8 Watt	.12% to
193 and A10WL	± 5%	10 Ohms to 50K Ohms		.8 Watt	.12% to
299 and B11W	±10%	10 Ohms to 50K Ohms	NO	.5 Watt	.12% to
298 and B11WPC	±10%	10 Ohms to 50K Ohms		.5 Watt	.12% to
295 and B11WML	±10%	10 Ohms to 50K Ohms		.5 Watt	.12% to
294 and B11WML-1	±10%	10 Ohms to 50K Ohms		.5 Watt	.12% to
293 and B11WL	±10%	10 Ohms to 50K Ohms		.5 Watt	.12% to
399 and C12W	±15%	100 Ohms to 20K Ohms	NO	.25 Watt	.6% to
398 and C12WPC	±15%	100 Ohms to 20K Ohms		.25 Watt	.6% to
697 and 750WL-1	± 5%	10 Ohms to 30K Ohms	YES	1 Watt	.23% to
692 and 750W	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to
691 and 750WP	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to
690 and 750WT	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to
686 and 751WL	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to
685 and 751W	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to
684 and 751 WT	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to
683	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to
997	± 5%	10 Ohms to 30K Ohms	YES	1 Watt	.23% to
996	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to
983	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to
1289	± 5%	10 Ohms to 50K Ohms	YES	1 Watt	.12% to
1288	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to
1287	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to
1597 and 1000-WL-1	± 5%	10 Ohms to 50K Ohms	YES	1 Watt	.12% to
1592 and 1000W	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to
1591 and 1000WP	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to
1590 and 1000WT	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to
1586 and 1001WL	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to
1585 and 1001W	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to
1584 and 1001WT	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to
1583	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to
1580	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to
5050	± 5%	100 Ohms to 50K Ohms	YES	1 Watt	.10% to

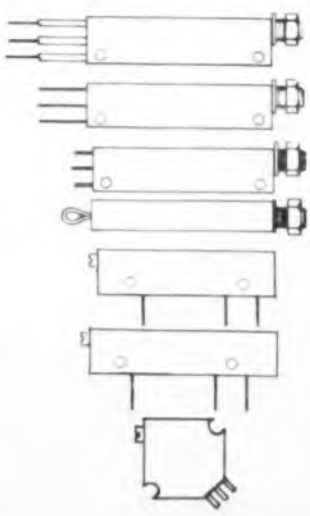
TERMINAL CONFIGURATIONS



PECIFICATION SUMMARY

OLUTION ENDING VALUE	MAXIMUM OPERATING TEMP (°C.)	CASE DIMENSIONS			MOUNTING HOLE CENTERS	MECHANICAL ADJUSTMENT turns
		WIDTH	HEIGHT	LENGTH		
% to 1.2%	135°	.310	.220	1.250	1.000	25
% to 1.2%	135°	.310	.220	1.250	1.000	25
% to 1.2%	135°	.310	.220	1.320	1.000	25
% to 1.2%	135°	.310	.220	1.320	1.000	25
% to 1.2%	135°	.310	.220	1.250	1.000	25
% to 1.2%	105°	.310	.220	1.250	1.000	25
% to 1.2%	105°	.310	.220	1.250	1.000	25
% to 1.2%	105°	.310	.220	1.320	1.000	25
% to 1.2%	105°	.310	.220	1.320	1.000	25
% to 1.2%	105°	.310	.220	1.250	1.000	25
% to 1.2%	85°	.310	.220	1.250	1.000	25
% to 1.2%	85°	.310	.220	1.250	1.000	25
% to 1.82%	175°	.300	.180	1.000	.750	17
% to 1.82%	175°	.300	.180	1.000	.750	17
% to 1.82%	175°	.300	.180	1.000	P.C.	17
% to 1.82%	175°	.300	.180	1.000	.750	17
% to 1.82%	175°	.300	.180	1.000	Panel	17
% to 1.82%	175°	.300	.180	1.000	Panel	17
% to 1.82%	175°	.300	.180	1.000	Panel	17
% to 1.82%	175°	.300	.180	1.000	P.C.	17
% to 1.82%	175°	.300	.180	1.000	.750	17
% to 1.82%	175°	.300	.180	1.000	.750	17
% to 1.82%	175°	.300	.180	1.000	P.C.	17
% to 1.13%	150°	.280	.310	1.250	1.000	25
% to 1.13%	150°	.280	.310	1.250	1.000	25
% to 1.13%	150°	.280	.310	1.250	P.C.	25
% to 1.13%	175°	.300	.180	1.250	1.000	25
% to 1.13%	175°	.300	.180	1.250	1.000	25
% to 1.13%	175°	.300	.180	1.250	P.C.	25
% to 1.13%	175°	.300	.180	1.250	1.000	25
% to 1.13%	175°	.300	.180	1.250	Panel	25
% to 1.13%	175°	.300	.180	1.250	Panel	25
% to 1.13%	175°	.300	.180	1.250	Panel	25
% to 1.13%	175°	.300	.180	1.250	P.C.	25
% to 1.13%	175°	.300	.180	1.250	P.C.	25
% to .72%	150°	.500	.190	.500	.520	25

NUMBER	
92	26 Awg Solid Wire Leads
91	Printed Circuit Pins 22 Awg
90	Hook Type Wire Solder Terminal
89	Solder Lug
88	30 Awg Stranded Teflon Leads
87	Printed Circuit Pins 21 Awg



NUMBER	
86	Panel Mounted Style with 28 Awg Stranded Teflon Leads
85	Panel Mounted Style with 26 Awg Solid Wire Leads
84	Panel Mounted Style with Hook Type Wire Solder Terminal
83	Printed Circuit Pins 22 Awg
80	Printed Circuit Pins 22 Awg
50	30 Awg Stranded Teflon Leads

ADVANCED DESIGN Illustrated by HIGH PERFORMANCE

DALE

SERIES 1200 T-POT

ENLARGED CUTAWAY ILLUSTRATION
Four Times Actual Size

1. Welded termination
2. Longer winding mandrel (ceramic) giving better resolution, better heat dissipation, higher values and allows use of larger wire diameter
3. Lightweight precious metal wiper with low weight-pressure ratio provides best performance under vibration and shock
4. "O" ring seal provides protection against humidity, dust and salt spray
5. Thrust spring maintains constant position of lead screw eliminating lead screw backlash
6. Polished stainless steel lead screw is ultrasonically polished for smooth operation and long rotational life
7. Collector provides dual current path for improved reliability and low rotational noise level
8. Wide selection of terminal configurations is available to meet any requirements

A DALE T-POT TO MEET EVERY DEMAND

DALE SERIES 1200 WIRE WOUND
A miniature (.280" x .310" x 1.250"), humidity proof, precision T-Pot with welded construction throughout, three different terminal configurations for standard and printed circuit mounting; 10 to 50K ohms; 5% tolerance; 1 watt up to 85° C, derating to 0 at 150° C.

DALE SERIES 900 WIRE WOUND
A sub-miniature (.300" x .180" x 1"), humidity proof, precision T-Pot with welded construction throughout, three different terminal configurations for standard and printed circuit mounting; 10 to 30K ohms; 5% tolerance, 1 watt up to 70° C, derating to 0 at 175° C.

DALE SERIES 600 WIRE WOUND
A sub-miniature (.300" x .180" x 1"), humidity proof, precision T-Pot with welded construction throughout; eight different terminal configurations for standard, panel and printed circuit mounting; 10 to 30K ohms; 5% tolerance; 1 watt up to 70° C, derating to 0 at 175° C.

DALE SERIES 1500 WIRE WOUND
A miniature (.300" x .180" x 1.250"), humidity proof, precision T-Pot with welded construction throughout; nine different terminal configurations for standard, panel and printed circuit mounting; 10 to 50K ohms; 5% tolerance; 1 watt up to 70° C, derating to 0 at 175° C.

DALE SERIES 5000 WIRE WOUND
A new, humidity proof, precision T-Pot with new space saving square configuration (.500" x .190" x .500") and welded construction throughout; 100 to 50K ohms; 5% tolerance; 1 watt up to 70° C, derating to 0 at 150° C.

DALE SERIES 100 WIRE WOUND
A miniature, precision T-Pot, ideal for computers and laboratory type applications; five different terminal configurations for standard mounting; 10 to 50K ohms; 0.8 watt up to 70° C, derating to 0 at 135° C.

DALE SERIES 200 WIRE WOUND
A miniature T-Pot offering dependable performance in normal circuits where economy is important; five different terminal configurations for standard mounting; 10 to 50K ohms; 10% tolerance; 0.5 watt up to 70° C, derating to 0 at 105° C.

DALE SERIES 300 WIRE WOUND
A miniature T-Pot for commercial applications; two different terminal configurations for standard mounting; 100 to 20K ohms; 15% tolerance; 0.25 watt up to 70° C, derating to 0 at 85° C.

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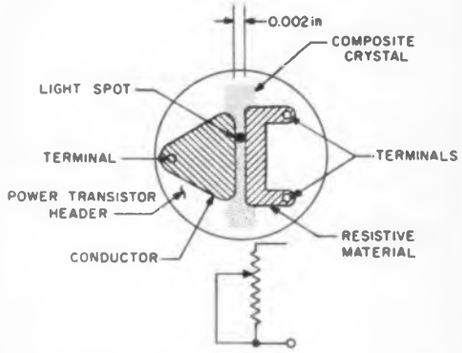
Circle 98 on Reader Service or Inquiry Card



Composite semiconductor crystal is cemented to transistor header in Giannini's Photopot. Light spot makes the semiconductor material conductive and connects the conductor and resistive material. As the light beam travels along the semiconductor material, it acts as a wiper arm, varying resistance of the pot.

Dark resistance—when no light beam bridges the gap—is said to be 10^{12} ohms.

Other specifications for the production units call for a high-resolution threshold sensitivity. The Photopots will be required to sense a light spot motion of 1 micron. This is about 0.01 per cent of the entire 0.3-in. swept length.

Linearity—defined at Giannini as the deviation of the output voltage ratio from the best straight line through the calibration points—will not exceed 1.5 per cent of full scale from 15 to 85 per cent of full scale, Mr. Mounteer predicts. Beyond these limits, he says, deviation will not exceed plus or minus 5 per cent of full scale.

"Linearity," Mr. Mounteer admits, "is not as good as that specified for many other potentiometers. But our repeatability is so good that it doesn't matter."

Production units will have a repeatability of the output voltage ratio within 0.05 per cent full scale, he says, with nothing changed except the location of the light spot on the Photopot's surface. This tolerance would include any transient change in voltage ratio resulting from local heating (from the light beam) of the semiconductor element.

With the use of one kind of semiconductor material, the time required for the light spot to cause the crystal to become conductive is said to be no greater than 0.001 sec. Specifications require the crystal to become insulating within 0.01 sec after the illumination ceases.

Another semiconductor crystal type should feature a 200-μsec rise time and a 1-μsec fall time.

By depositing a resistance layer on a glass

NEWS

substrate, a semiconductor layer on to the top of it and a rather transparent (4-micron-thick) layer of gold conductor on top of that, a thin-film photopotentiometer could be built, Mr. Mounteer says. The light beam would shine through the gold layer and make the semiconductor layer conductive. The length of the current path across the semiconductor material would be only 0.00002 in., and light-path resistance "could be 50 ohms," according to Mr. Mounteer.

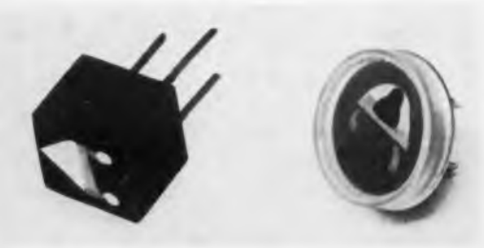
The Photopot is meant to be marketed exclusive of the light source and optics, Giannini reports. Spectral response could be specified, within limits, by the customer. But preliminary tests for gyroscopic pick-off and inertial-platform applications show there may be problems in providing an artificial light source.

"We started out with the idea that there would be no light problem," says Mr. Mounteer. "The customer would supply the light and optics and would encounter no real problems. But in missile and space applications the military specs call for vibration testing at 2,000 cycles while the bulb is hot. Tungsten filament lamps are delicate and burn out under these conditions."

The problem can be, and has been, solved for short flights, Mr. Mounteer reports. Difficulties remain for long-term applications.

As part of the research on Photopot, therefore, Giannini scientists are investigating the use of tritium-filled bulbs coated with a phosphor that will glow in the presence of a radioactive material. Such a lamp—if the intensity could be raised to the proper level—would be useful for very long periods without requiring power. Another possibility, which would increase the versatility of the device, would be the use of a phosphor swept by an electron beam.

At least one other company in the Los Angeles area is known to be working on a similar development. Duncan Electronics, Santa Ana, Calif., still has a photoelectric potentiometer in the research stages. The company declines to disclose design details at present. ■ ■



Research version of Giannini's Photopot, left, and planned compact commercial version.

Airborne Video Instruction Tested in Midwest Schools

Airborne television for classroom instruction is being demonstrated in rural elementary and secondary schools in six Midwest states.

The demonstration, designed to reach areas beyond the transmitting limits of ground-based educational TV stations, is giving teachers, school administrators, students and parents a chance to see how effective such instruction would be in the classroom. The tests of the system are in preparation for its use for a full academic year beginning in September. (*ED*, May 11, 1960, p4).

In the present experiment a DC-6, equipped by Westinghouse Electric Corp., cruises at 23,000 ft, producing signals on classroom sets at least 200 miles in every direction from Montpelier, Ind. This takes the programs into Indiana, Illinois, Wisconsin, Michigan, Ohio and Kentucky.

Four hours of instruction are being televised on two uhf channels four days a week. In the fall the schedule will be stepped up to six hours daily.

The planning body for the operation is the Midwest Program on Airborne TV Instruction, consisting of a 15-man council of industry representatives and educators, based at Purdue University. The $7,775,000 program is being financed by the Ford Foundation and private industry.

Most of the schools have been equipped for the experiment without cost by nine manufacturers of television equipment: The equipment includes antennas, distribution systems and up to 12 receiving sets to each school.

The sponsoring manufacturers are Admiral Corp.; General Electric Co.; Motorola, Inc.; Philco Corp.; Radio Corp. of America; Westinghouse; Zenith Radio Corp.; Jerrold Electronics Corp., and Blonder-Tongue Systems, Inc.

Closed-Circuit TV System Used To Verify Check Signatures

A closed-circuit TV system used for verification of check signatures has been installed in the First Pennsylvania Banking and Trust Co. of Philadelphia.

The system, developed by John F. McCarthy, Inc., Philadelphia, uses cameras and components furnished by Philco Corp.

The teller, using a one-piece telephone, dials the bank's Signature Dept., identifies his numbered station, and requests the specific account. The clerk at the other end pulls the card from its alphabetical file, places it face down on one of two cameras, and the reproduction appears on the monitor.

ANOTHER FIRST FROM

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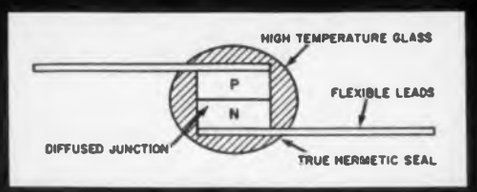

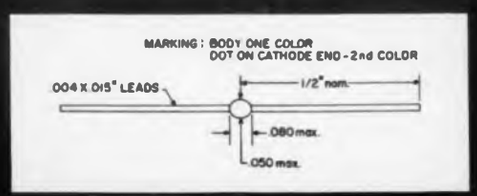

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MICRO ZENER DIODES

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Development by Transitron scientists and engineers of a new concept in glass packaging has now made it possible to introduce the industry's first micro-diode with true hermetic sealing. This is the new micro voltage regulator ("zener") series . . . a series in which the glass is melted *around* the silicon body that forms the working part of the device. Achievement of a direct high-temperature glass-to-metal seal means that there are no plastics . . . no multi-part packaging . . . no "gunk" . . . no degrading of characteristics with humidity. Absolute hermetic sealing makes this the most reliable and efficient micro-regulator ever developed, ideal for voltage regulating and reference service wherever space and weight economies are required.

Micro Zener Diodes are produced exclusively by Transitron. The first series is available immediately; other diodes are under development and will be marketed shortly.

For more information write for Bulletin PB-71E.

SPECIFICATIONS @ 25° C			CURRENT RATINGS	
TYPE	Voltage ① @ Iz = 5ma (Volts)	Maximum Dynamic ② Resistance (ohms)	Maximum Average ③ Operating (ma) Current @ 25° C	@ 100° C
TMD-01*	5.1	15	17.8	4.4
TMD-02	5.6	15	15.5	4.8
TMD-03*	6.2	15	14.5	3.7
TMD-04	6.8	15	13.0	3.3
TMD-05	7.5	15	12.0	3.1
TMD-06	8.2	15	11.0	2.8
TMD-07*	9.1	15	10.0	2.5
TMD-08	10.0	15	9.0	2.3

① Voltage tolerance ± 10%. For ± 5% Voltage Tolerance use "A" suffix (e.g. TMD-03A).

② Dynamic Resistance is measured by superimposing a small (10% of DC bias) AC current upon the DC Test Current, 5 MADC.

③ Assume linear derating between 25° C and 100° C.

*Production types

ADDITIONAL CHARACTERISTICS AND RATINGS

Operating and Storage Temperature Range −55° C to +150° C

Maximum power dissipation at 25° C 100 mW

Typical forward voltage at 5.0 mA 0.75 volt

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EDITORIAL

Systems Engineers or Slick Salesmen?

There are a few signs being left here and there to shake our confidence in some of the nation's top systems scientists and engineers. One disturbing sign is the very image that the systems men are projecting of themselves. A bit too frequently we get the impression they are overselling themselves.

This "sell" is apparent in the system organization's company brochure. One expects to see impressive, smartly designed publications particularly from successful industrial firms but when our nonprofit organizations formed (and paid) to serve the nation's best interests issue lavish editions with engraved covers, tip-ins, fold-outs and cover overlays our suspicions are aroused. Why all the sizzle? Isn't the steak sufficient?

One such brochure uses a fold-out to portray an organization chart that could have appeared in one column. Another giant fold-out was used to portray a life-sized face of a scientist. To be sure the blow-up got across the point that here was a serious thinker—one able to cope with the world's greatest problems. But is such costly visual imagery superior to a paragraph describing accomplishments?

We are also concerned about the elaborate format of the reports turned in by some of these systems organizations. As publishers we turn green with envy when we see huge 4-color charts used to demonstrate fairly simple points. We can only conclude that either the Generals and Admirals reading these reports are tinsel-minded or that the systems people are subtly disguising a rather skimpy fare with garnishments of green ink (in six shades). If either of these conclusions are unwarranted we must be living in a more affluent society than many of us suspect.

We are also a bit skeptical of some of the lofty reasons glibly stated for the need for nonprofit brain trusts—to get true objectivity because of the removal of opportunity for private profit or gain. From where we sit, our vision is restricted, but we suspect some of our sacrosanct nonprofit organizations are nice sinecures and that objectivity can still readily be confused if interests of self-perpetuation arise.

We honor the fine brains that have given us the tremendous achievements in the scientific and technical realm. We applaud every manifestation of forthright self confidence. We are a bit shaken, however, by shades of self-serving salesmanship.

What the Electronic Engineer Should Know About Epoxies

Epoxy resins can do much more for electronic designers than they are now doing. The combined abilities of an epoxy resin which permit it at the same time to structurally support and fasten, to electrically insulate, and to thermally conduct heat away from electronic circuits have opened the doors for many clever integrated packaging designs. In addition, epoxies are about as easy to use on short production runs as they are on long. The catch is that epoxies are sold by chemists who talk a language of their own. Mr. Harper's intent in the series, of which this article is the first, is to quickly sketch in enough of the total "chemical" picture of epoxies that an electronic engineer can begin to talk intelligently with epoxy suppliers.

Charles A. Harper
Air Arm Div.
Westinghouse Electric Corp.
Baltimore, Md.

THE ENGINEER who wishes to seriously apply epoxy resins must sooner or later learn something of the "chemical" aspects of this material. Until he does, his ability to use epoxies in a design will be at the mercy of the seemingly endless "trade-name" jargon of this primarily chemically oriented field.

Therefore, this article will not skirt the basic problem; basic chemical terms and thinking will be used forthrightly. There is no other way.

The Nature of Epoxy Resins

Chemically, most commercial epoxy resins are defined as special condensation products of *epichlorohydrin* and a *polyhydric phenol*. The latter is usually *diphenylol propane*. A *bisphenol A* type epoxy is the short way of saying this.

Practically, this means that an epoxy resin, or epoxide as it is sometimes called, is the product of a reaction between two not-so-common chemicals known as *epichlorohydrin* and *diphenylol propane*. The product is called epoxy resin due to the existence of a carbon-oxygen chemical arrangement in the polymer known as an *epoxide group* or an *oxirane ring*. This is shown in Fig. 1.

The nature and advantages of the epoxy resin can be best explained by comparing it to the polyester polymer, which is shown in Fig. 2.

The epoxy resin polymer unit, like the polyester unit, is, in its uncured state, a thermoplastic material and is of limited usefulness until it is further reacted to form a hard thermosetting material. In the case of polyester, the reaction required to produce a thermosetting cured material end product takes the form of a peroxide, or heat catalyzed reaction between a *monomer* such as styrene and the polyester resin *polymer* unit. The addition of the styrene to the polyester polymer unit is through an unsaturated double carbon-to-carbon bond. See Fig. 2.

Epoxy's Bonds are Reason Why it is Superior to Polyester

In the case of the epoxy resin, there are no unsaturated (double) bonds. Therefore, the epoxy resin curing reaction must proceed through some different type reactive point, and utilize a different curing agent system than is employed with a polyester. The epoxide group is suitable as a reactive point.

The absence of chemical unsaturation as a reaction mechanism provides one of the key advantages of epoxy resins. Shrinkage is due to a rearrangement of the unsaturated double bonds and

For what Applications are Epoxies Best?

If your application demands any of the following, epoxy resins may prove your best embedment selection:

1. ***Environmental resistance.*** In military systems, epoxy resin has become a standard and has replaced lower cost resins (such as polyesters) for many uses.
2. ***Good packaging.*** Even in nonmilitary applications where the cost of the rest of the package is significantly greater than the embedment material, epoxies should be considered.
3. ***Close dimensional control.*** The low shrinkage of epoxy resins makes them an excellent choice. Diallyl phthalates are also good dimensionally but require much more elaborate tooling.
4. ***Adhesion.*** Its adhesive properties makes an epoxy resin good for mechanically joining and sealing applications. For example, in imbedding, the epoxy will adhere to the terminals and effectively seal out moisture.

However, once it is decided to use epoxy, the designer's job has not ended. As author Harper explains, there are many, many combinations possible in the epoxy family, and each of these has its own particular combination of properties. Without at least the basic understanding of the chemistry of epoxies presented in his article, Mr. Harper believes an engineer would be unable to take advantage of this versatile, important plastic.

a corresponding readjustment of the bond forces. Since there are no double bonds in epoxy resins, there is less shrinkage.

In addition to cross-linking through the epoxide group, the *hydroxyl* (*—OH*) group shown in the epoxy resin molecule is also a reactive point through which cross-linking can occur to form a solid thermosetting material (a material in which the molecules are both long and interlocked for resistance to change). Although reaction with an *amine* curing agent is shown in Fig. 1, other curing agents are also used. Depending on the curing agent, the cross-linking reaction may be through either the *epoxide* or *hydroxyl group*, or through both.

Curing Temperature Depends on Resin, Catalyst, Fillers

The curing reaction of epoxy resins, like that of polyesters and other thermosetting resins, is exothermic. That is, it gives off heat, causing the temperature to rise during the cure.

The actual exothermic temperature curve is controlled by the resin-catalyst system, the initial curing temperature, the mass of the curing resins, and (to a lesser degree) by the fillers and other modifiers used in the compound. Very high or very low thermal conductivity fillers will cause considerable variations in the temperature-time exotherm curve. An example of exotherm variation with mass of resin being cured is shown in Fig. 3. The curing temperature is important in electronics because of the effect it can have on temperature sensitive semiconductor components.

In the curing reaction, the resin gradually changes from a liquid gel to a final cured end

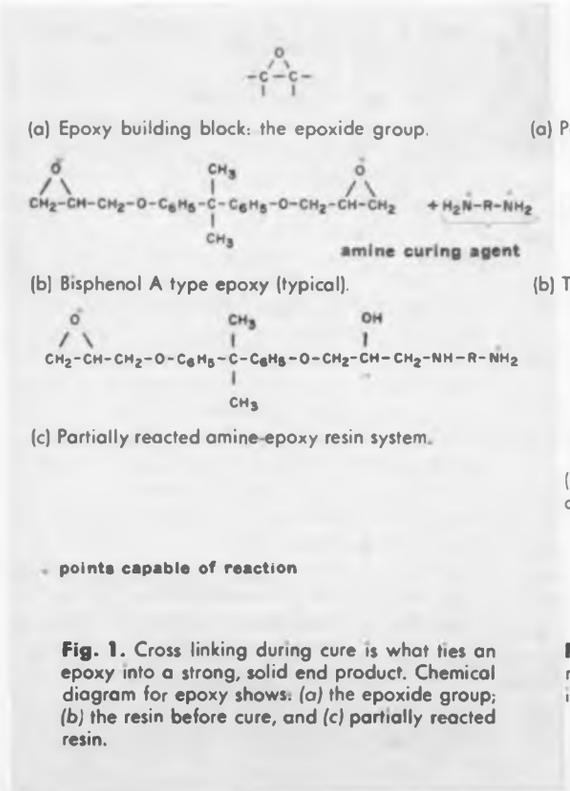


Fig. 1. Cross linking during cure is what ties an epoxy into a strong, solid end product. Chemical diagram for epoxy shows: *(a)* the epoxide group; *(b)* the resin before cure, and *(c)* partially reacted resin.

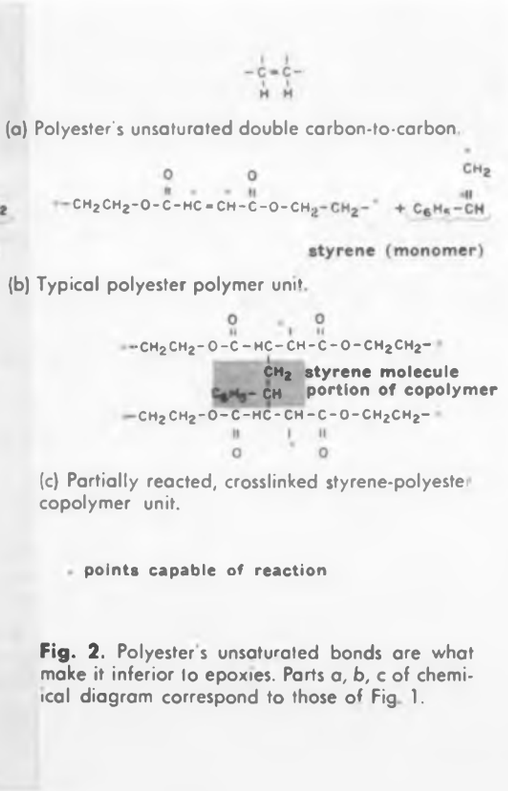


Fig. 2. Polyester's unsaturated bonds are what make it inferior to epoxies. Parts *a*, *b*, *c* of chemical diagram correspond to those of Fig. 1.

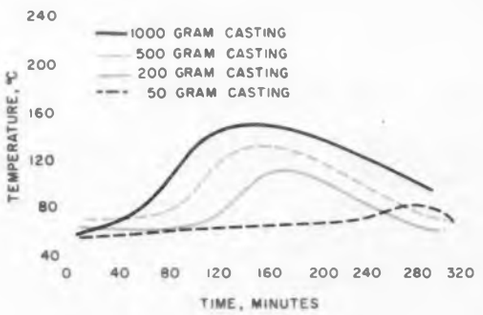


Fig. 3. Temperature rise of an epoxy during cure "exotherm" indicates that the larger the casting, the sooner and higher the peak cure temperature will be reached. Since cure temperatures can exceed the limits of some electronic components, they are of practical interest in potting applications.

Fig. 4. Equipment cover cast from a nearly perfectly clear epoxy resin illustrates one extreme of the many forms which a cured epoxy can take. This clear epoxy can also be had in varying degrees of flexibility depending on how much curing agent was used. It was formulated by Marblette Corp., N.Y.

product. The useful working life of the liquid resin and catalyst mixture is referred to variously as "pot life," "tank life" or "gel time."

The *bisphenol* type epoxy resin described above is the more widely used epoxy. Some other types will be discussed briefly in later parts of this series. Some of the widely used bisphenol epoxy resins and their room-temperature viscosities are listed in Table I. The viscosities are of course important in a potting operation as they would affect the flow of resin into and amongst the circuit components.

A Few Basic Suppliers, But Many "Formulators"

The resins listed in Table I are marketed by a few basic resin processors and suppliers. They are usually light straw brown in color, but purified grades are available as water-clear liquids. (See Fig. 4).

The "formulators," however, are the ones the

Table 1.—Basic Epoxy Resins and Their Suppliers

Resin	Viscosity 25C	Supplier
Epon 828	5,000-15,000	Shell Chemical Co.
Epi-Rez 510	9,000-18,000	Jones-Dabney Co.
Araldite 6010	Approx. 16,000	Ciba Products Corp.
DER 331	11,000-16,000	Dow Chemical Co.
ERL 2774	10,500-19,500	Union Carbide Plastics Co.

Table 2.—Properties of Epoxy Resins

Property	Value
Mold shrinkage, in./in.	0.001-0.004
Specific gravity	1.11-1.23
Tensile strength, psi	4,000-13,000
Modulous of elasticity in tension, psi	4.5×10^5
Flexural strength, psi	14,000-21,000
Thermal conductivity, cal/sec x cm^2 x C x cm	$4\text{-}5 \times 10^4$
Thermal expansion, 1/C	$4.5\text{-}6.5 \times 10^{-5}$
Resistance to continuous heat, F	250-600
Heat distortion temperature, F	115-550
Volume resistivity, ohm-cm	$10^{12}\text{-}10^{17}$
Dielectric strength, 1/8-in thickness, volts/mil	
short time	400-500
step-by-step	380
Dielectric constant, 60 cycles	3.5-5.0
10^3 cycles	3.5-4.5
10^6 cycles	3.3-4.0
Dissipation (power) factor, 60 cycles	0.002-0.010
10^3 cycles	0.002-0.02
10^6 cycles	0.030-0.050
Arc resistance, sec	45-120
Machining qualities	good

Table 3.—Trade Names and Suppliers of Epoxy Formulations

Trade names	Suppliers
Airtemp	Aries Laboratories, Inc., 45-33 Davis St., Long Island City 1, N.Y.
Alfane	Atlas Mineral Products Co., Wilmington 99, Del.
Araldite	Ciba Products Corp., Fair Lawn, N.J.
Bakelite	Bakelite Co., Div. of Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N.Y.
Cadco	Cadillac Plastic and Chemical Co., 15111 Second Ave., Detroit 3, Mich.
Cardolite	Irvington Chemical Div., Minnesota Mining & Mfg. Co., 500 Doremus Ave., Newark, N.J.
Cellobond	British Resin Products, Ltd., London S. W. 1, England.
Cordopreg	Cordo Molding Products, Inc., 230 Park Ave., New York 17, N.Y.
Corrocate	Chemical Coatings and Engineering Co., Inc., Brooke St., P.O. Box 305, Media, Pa.
D.E.R.	The Dow Chemical Co., Midland, Mich.
Devcon	Chemical Development Corp., Endicott St., Danvers, Mass.
Ecco	Emerson and Cuming, Inc., Canton, Mass.
Epiphen	The Borden Chemical Co., Div. of the Borden Co., 350 Madison Ave., New York 17, N.Y.
Epi-Rez	Jones-Dabney Co., 1481 S. 11th St., Louisville 8, Ky.
Epocast	Furane Plastics, Inc., 4516 Brazil St., Los Angeles 39, Calif.
Epolac	Lawrence Adhesive and Chemical Co., Inc., Lawrence, Mass.
Epon	Shell Chemical Corp., 380 Madison Ave., New York 17, N.Y.
Epoxylite	Epoxylite Corp., 10829 E. Central Ave., El Monte, Calif.
Helix	Carl H. Biggs Co., 2255 Barry Ave., Los Angeles 64, Calif.
Hysol	Hysol Corp., 322 Bush St., Olean, N.Y.
Marblette	Marblette Corp., 37-21 30th St., Long Island City 1, N.Y.
Nureco	Nureco Inc., 1100 Pontiac Ave., Cranston 10, R.I.
Oxiron	Food Machinery and Chemical Corp., 161 E. 42nd St., New York 17, N.Y.
Polykast	Poly Resins, Sun Valley, Calif.
Polytool	Reichhold Chemicals, Inc., 525 N. Broadway, White Plains, N.Y.
Ren	Ren Plastics, Inc., 3179 S. Cedar Rd., Lansing 4, Mich.
Rezolin	Rezolin, Inc., Santa Monica, Calif.
Scotchcast	Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.
Stycast	Emerson and Cuming, Inc., Canton, Mass.
Tygofil	United States Stoneware Co., Tallmadge Ave., Akron 9, Ohio.
Tygoweld	United States Stoneware Co., Tallmadge Ave., Akron 9, Ohio.
Tylene	Tylene Plastics, Inc., Freyer Rd., Michigan City, Ind.

(Courtesy Modern Plastics Encyclopedia)

engineer usually comes into contact with. They take the basic resin and add fillers and other modifiers to the basic resin and market their mixed compounds along with curing agents under their own trade names as two- or three-package systems. A large portion of the compounds marketed by the "formulators" are based on the resins listed in Table 1, or similar resins produced by the basic resin suppliers.

A comprehensive list of properties of epoxy resins is given in Table 2 and a list of resin and formulated-compound suppliers is given in Table 3. The number of formulators is so large that this list is necessarily not complete.

Curing Agents Very Important In Determining Final Epoxy Properties

The actual curing agent controls the end properties of the final cured epoxy. This is in contrast to polyester resins. Referring to the chemical structure comparisons of Fig. 1, the reason for this can be seen. With polyester resins, the peroxide merely catalyzes the reaction between the polyester polymer and styrene. No matter what peroxide is used, the end-product is still the same styrene-cured polymer. The peroxide catalyst controls the rate and degree of reaction. It is not a part of the end product molecule.

In epoxies, however, the curing agent actually reacts with the polymer unit and both become part of the cured end product. Hence it is obvious that a different curing agent will yield a different end product.

This dependence of epoxies upon their curing agents is the main reason why there is a seemingly endless number of epoxy compounds. The many fillers, diluents and colorant modifications increase the possibilities for different epoxies still further.

The different curing agents for epoxies can be broadly divided into three classes:

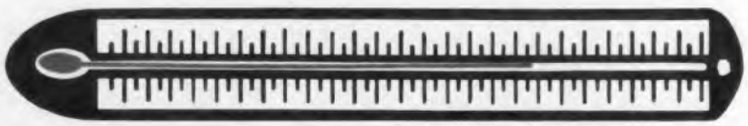
- *Organic nitrogen* compounds, usually *amines* or *polyamines*.
- *Organic acids* or *acid anhydrides*.
- Resins such as *polysulfides* and *polyamides*.

Thus, it has been shown in this article that though most epoxy formulations are based on the same basic resin, *bisphenol*, the varied selection available comes from different curing agents. The next article will indicate the relationship between some of these curing agents and the properties they produce in cured epoxies. This will help the electronic engineer as he searches for "his epoxy answer" amongst the myriad sales bulletins of the "formulators." ■ ■

Acknowledgments

This series is based upon a forthcoming book by Mr. Harper, "Electronic Packaging with Resins," scheduled by McGraw-Hill Book Co. for publication in May. Tables II and III are from the Modern Plastics Encyclopedia.

Temperature Measurements in Crystal-Oven Design



Most of the projects Hal Ryner has worked on have involved heat transfer and temperature-measurement problems. But none of these projects has been as exacting as those in crystal-oven design. Mr. Ryner has had to meet requirements for low power drain, long thermostat life, low cost, close temperature control over wide ambient-temperature ranges, and limited space. As this article shows, the measurement technique can be as critical as the oven design.

Hal Ryner
Lenkurt Electric Co., Inc.
San Carlos, Calif.

THE design of an oven to control the temperature of quartz oscillator-crystals requires three significant measurements:

1. The mean control temperature of the quartz crystal.
2. The maximum temperature excursion due to the on-off heat cycle of the oven.
3. The time required for the oven cavity temperature to stabilize at the lowest ambient temperature requirement, following the initial power application.

Such measurements require a "thermometer" that is very small, one with negligible thermal inertia, and one which can be tucked conveniently into any corner of the crystal oven.

A uniquely satisfactory element, the bead thermistor, will satisfy all of these conditions. It has the added advantage of permitting extremely precise temperature readings. However, if the thermistor is used improperly, the resulting measurements will be valueless and misleading.

Bead-Type Thermistor Satisfies All Requirements

The bead thermistor is a tiny metallic-oxide resistor which, unlike metals, has a high negative temperature coefficient of resistance. As temperature rises, resistance of the bead decreases. Resistance plotted against temperature on a graph may be used to convert bead resistance measurements to temperatures.

Because of the relatively small mass of the bead, it responds quickly and contributes little thermal inertia to the object being measured. This characteristic is important if small and frequent temperature changes are to be recorded. Also, because of the small-diameter connecting leads, very little heat is drawn from the object or area being measured. This is an especially desirable feature if the actual temperature must be known.

Care must be taken not to heat the bead internally with the current flow in the measurement circuit. Most thermistor specs specify the power required to raise the bead 1 C above its surroundings (dissipation constant). The power dissipation must be kept well below this point over the complete range of temperatures to be measured.

Same Circuit Serves For Measurement and Calibration

The circuit used in calibrating the thermistor and that used for actual measurements of temperature are the same (Fig. 1), except that, in calibration, the thermistor is in a constant temperature oil bath.

A 1.5-kc generator is set for an amplitude of 0.1 vac which is applied across opposite corners of a wheatstone bridge. A low-frequency ac source is used in this circuit for four reasons:

1. The ac signal can pass through a step-up transformer to increase sensitivity of the bridge output.
2. At 1.5 kc, small distributed capacities have negligible detrimental effect.
3. A simple LC filter network can be used to eliminate unwanted harmonics and noise introduced in the bridge circuit.
4. Small ac voltages are easier to amplify and measure than equal dc voltages.

When R_v (a resistance decade box with 1-ohm steps) equals the resistance of R_t (the thermistor bead), the bridge is balanced. The thermistor

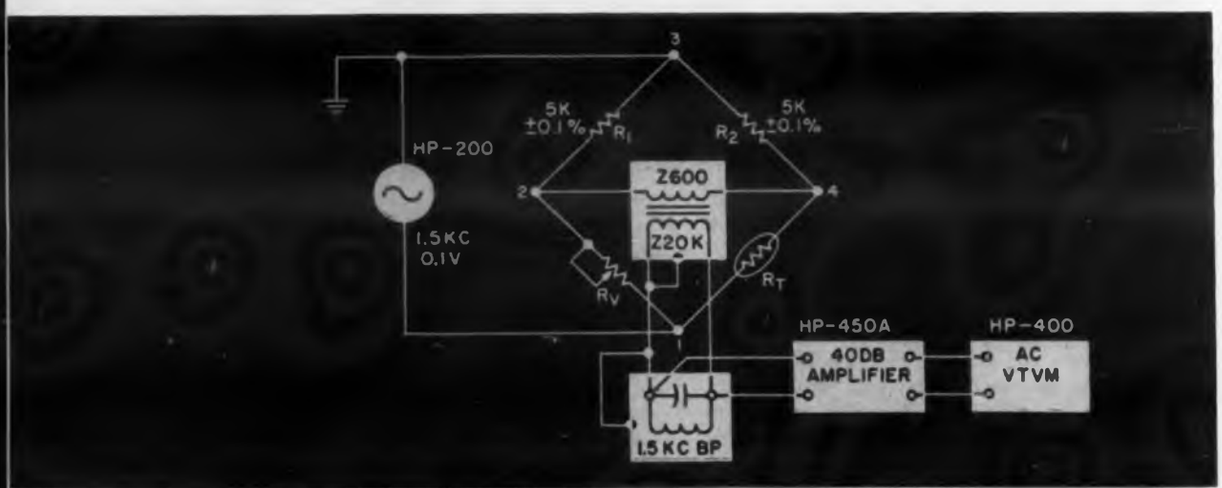


Fig. 1. This circuit is used for calibrating a thermistor as well as for measuring temperature.

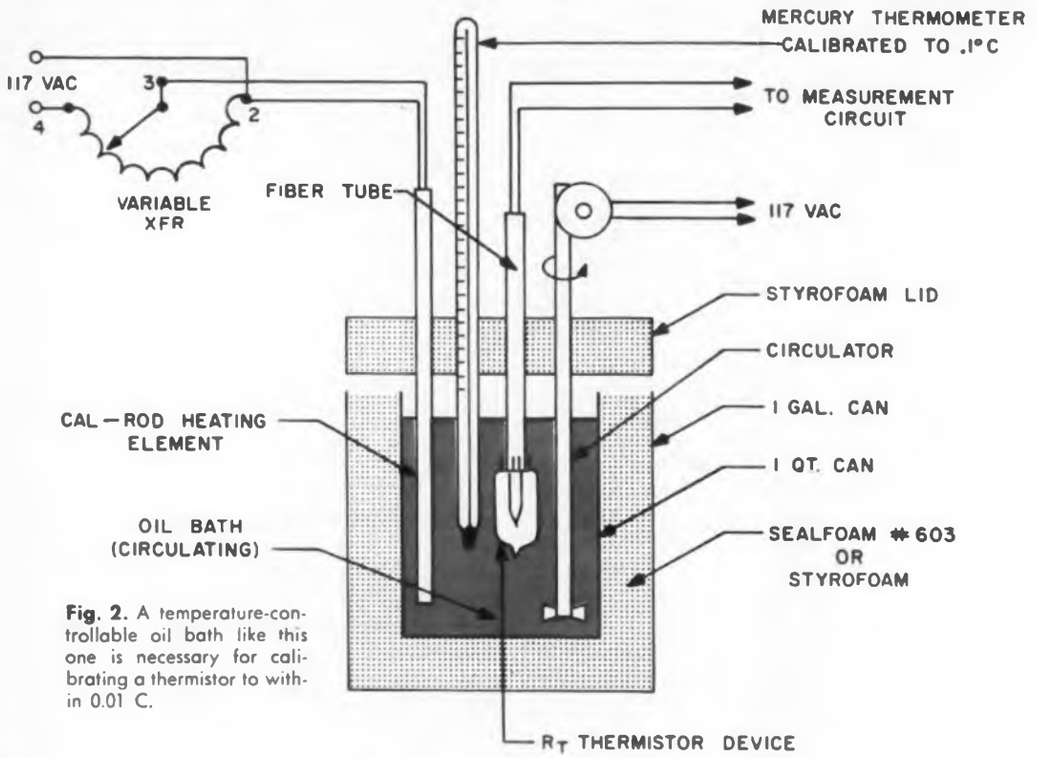


Fig. 2. A temperature-controllable oil bath like this one is necessary for calibrating a thermistor to within 0.01 C.

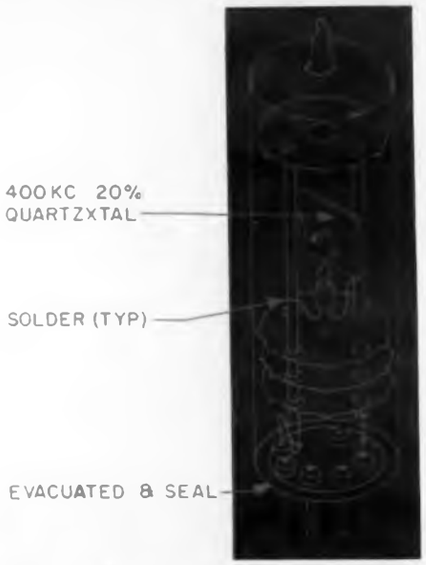


Fig. 3. This packaging configuration can help one evaluate and calibrate a thermistor under conditions most closely approximating those the thermistor will face in an evacuated crystal oven. Here, the gold is removed from one surface of a crystal and the thermistor bead is cemented to that surface. The standard crystal-mounting assembly is mounted in a T-5-1/2 envelope.

used in this circuit, similar to Fenwal GB34J2, has approximately 1,000-ohm resistance at the temperature to be measured. The ratio of this bridge allows the bead to draw only 2.5 μw under balance condition which is well below its dissipation constant.

After passing through the transformer, bandpass filter, and amplifier, the resultant output is fed directly to an ac vtvm that will measure at least 0.1-v full scale. It should be possible to see the result of 1-ohm changes of the thermistor at the meter as the bridge approaches balance.

Controllable Oil Bath Needed For Fire Temperature Calibration

In the design or evaluation of a device such as a crystal oven, it is often necessary to sense temperature variations of 0.01 C or less. It is possible to calibrate a thermistor to this degree of accuracy with the aid of the "temperature-controllable oil bath" shown in Fig. 2.

Four items are suspended in the oil bath:

1. Cal-Rod heating element. The power of this heat source is controlled by a variable transformer across the 117-v line. The oil can be held at a particular temperature within 0.01 C for lengths of time exceeding one-half hour with little difficulty. This is done by balancing the power input of the heat source, a variable, against the heat loss of the insulation which is a constant.

2. Mercury thermometer. This thermometer should cover the temperature range to be sensed by the thermistor and be calibrated in 0.1 C increments. (Calibration of the thermistor produces a curve which can easily be interpolated to 0.01 C).

3. Circulator. Any motor-driven impeller that keeps the oil circulating will do.

4. The "thermistor device" (Fig. 3). In the example given, the thermistor, in an evacuated crystal enclosure, is suspended at the end of a fiber tube and completely immersed in the oil. The leads run up the tube and over to the measuring circuit.

Plotting the Curve Requires Care and Time

The power input of the oil bath is set at a particular point and the temperature allowed to stabilize for a few hours. When the thermometer indicates no change for a period of not less than 15 min, the resistance of the bead is measured and plotted against temperature on a graph.* One should raise or lower the power input to the oil bath slightly, allow time to stabilize (about 15 min), and locate another resistance-temperature point on the graph. One should repeat this operation as many times as necessary to draw an accurate curve between the points. The completed curve is valid for only this one thermistor.

*In this example, the thermistor is in an evacuated glass tube. Sufficient time must be allowed to compensate for the thermal lag across the vacuum to the head.

Careful Thermistor Placement Needed for Reliable Measurements

The thermistor bead must be located properly if dependable results are to be obtained. Throughout the development of a new "long life" crystal oven, the following observations were made concerning thermistor location:

A thermistor merely suspended in the oven cavity recorded greater variations due to thermostat cycling than the actual vacuum enclosed crystals would experience. The special assembly shown in Fig. 3 better simulated actual operating conditions and gave results which accounted for heat losses through the crystal's tube pins and leads, and for the insulating effect of the evacuated glass envelope.

The evaluation of measurement data plays such an important part in any design that if careless measurement techniques are employed, a design that appears to be optimum may actually fall short of requirements, or conversely, may be expensively over-designed. ■ ■

How to Specify Analog-to-Digital Converters

ANALOG-to-digital voltage converters have important characteristics that should be carefully investigated by electronic design engineers before they select one for a new system design. Some of these features are well known and well understood. Some are less well known and only poorly defined in the minds of many engineers.

For any given data-reduction application, a designer's choice of an analog-digital converter will probably depend on a compromise between some of the properties defined here and a careful consideration of cost.

Conversion Speed

Conversion speed must be sufficient to take the required number of samples per second. It must also be high enough to allow for switching and transients which must take place to read in and out of the converter.

Frequently, even a medium-speed system making a total of only 1,000 measurements per sec requires an analog-to-digital converter capable of operating at several times that speed to allow for multiplexer switching, amplifier settling, and digital-code readout times.

Absolute Accuracy

Absolute accuracy relates to the accuracy of measurement which would be obtained with the primary voltage standards maintained by the National Bureau of Standards, with no restraints on the time allowed for each measurement. Unfortunately, many applications of this term can be seriously misleading.

In defining the absolute accuracy of an analog-to-digital converter, one must consider the entire measurement scale or range of the unit. Further, one must distinguish between short-term absolute accuracies and long-term absolute accuracies. It is obviously possible to adjust the "accuracy" of any single point on a converter range to any desired degree of accuracy over a short-term operating period.

However, in practice, the unavoidable molecular action of resistors, aging of other electronic components, temperature variations, etc., make it impossible to obtain absolute accuracies in the over-all measuring device better than 0.01 per cent with today's state of the art. Achieving this accuracy level requires extreme quality control, experience, and patience in manufacture.

It must be recognized that perfect absolute accuracy is impossible in an analog-to-digital converter. The reference-voltage source and the absolute transfer accuracies of the input-buffer unit, comparators, and digital-to-analog converters all contribute to total inaccuracy.

Also, in a high-speed converter, the dynamic characteristics of the various components must be considered as well as their static measurement characteristics. The first two major contributions to inaccuracy are the primary reference-voltage source and the precision wirebound resistors which are used in the input devices and the digital-analog networks.

In practice, great design care can produce reference voltages with long-term stabilities of 0.003 per cent and high-speed wirewound resistors which can maintain their absolute stability to about 0.003 per cent with temperature coefficients of one to three parts per million degrees. Secondary contributing factors of importance are comparator offset and digital-analog network switching elements. However, the experienced designer can design around these variations.

Relative Accuracy

Relative accuracy, resolution, precision, monotonicity, and linearity are characteristics that are best considered as a group. Before defining these terms, one can consider the conversion of a continuously variable voltage into numbers:

Any voltage-to-digital converter can yield, at its output, only a finite set of numbers. For example, a 10-bit binary number can yield 1,024 different output numbers; a three-decimal digit plus sign converter can yield 2,000 different numbers; and a four-decimal digit unit with sign, can yield 20,000 different numbers, etc.

The accuracy of each and every one of these

numbers relative to the corresponding voltage input must be considered. It is possible to build voltage-to-digital converters in such a way that not all of the numbers of the complete set are available. In considering the accuracy of a unit, it is first necessary to state that all integral numbers of the complete set must be produced during a full-scale, input-voltage excursion.

For any condition, and for any degree of design quality, there must always be some "dead band" at each quantization level. However small this "dead band" may be, there must be some voltage increment over which either one of two adjacent numbers can be obtained at the output. This necessarily presents an ambiguity of quantization decision. By quality and design, however, it is possible to make this "dead band" smaller and smaller, until it approaches zero. It can never be completely eliminated with the present state of the art.

Relative accuracy relates to nominal full-scale level, without reference to the absolute accuracy of that full-scale level. Thus, for example, if a 50 per cent measurement code is produced in a converter at a voltage exactly equal to 50 per cent of the voltage which provides the full-scale quantization code, the unit has complete relative accuracy at that point.

However, relative accuracy must relate to all points over the complete range, and is usually defined as the maximum percentage of deviation from a perfect straight line passing through zero and the nominal full-scale measurement value. It should be clear, then, that an analog-to-digital converter always has a better relative accuracy than absolute accuracy, since the absolute-accuracy contribution of the voltage-reference source is not considered in the definition of relative accuracy.

Resolution relates to the ability of the converter to distinguish between adjacent values. Normally, in a properly designed converter, the resolution is considered limited only by the number of bits carried. In practice, however, the ultimate resolution of a given design is limited by the noise in the various analog and switching circuits and also by the linearity and monotonicity of the unit.

There is generally no point in carrying bits of less significance than the bit level corresponding to the total uncertainty caused by noise and component inaccuracies. Some designers, however, have chosen to carry more bits in the equipment than the noise level would seem to justify and have rationalized these extra bits on the assumption that the noise is averaged out by repetitive measurements.

However, in most system applications, particularly higher-speed systems, measurements are made on a one-shot basis, and averaging is not always possible. It is the author's opinion that the specification for resolution of a converter should be compatible with the number of bits and vice-versa. Otherwise, it is possible to imply falsely that the readings convey a higher degree of accuracy than actually exists.

Precision relates to the repeatability of successive measurements. Precision is limited in practice by noise and also by the inescapable finite quantization error that always exists in some "dead band" at each successive numerical value.

When the unknown voltage lies within any of the dead bands around the possible values, the repeatability can never be greater than plus or minus one bit. One measure of the quality of design of a high-speed analog-to-digital converter is the ratio of the dead band to the full quantization level for each value across the entire range.

Monotonicity relates to an increasing output code for every increasing value. It is the lack of monotonicity that often shows up as codes missing from the set. A properly designed converter must be able to produce each integral value within the range defined by the number of bits carried.

A subtle point that has escaped many designers is that it is possible to force either nonuniform spacing of quantization carry points or totally missing codes. These can come about if the sum of the errors for any given number of successive lesser significant bits is more than the error in the next most significant bit. The errors can be kept down by constraining the accuracies of the various resistors in the digital-to-analog converter network and the offset voltages in the switching electronics.

Another factor contributing to missing codes in the higher-speed converters is inadequate compensation for transient signals during major carries. Absolute requirements for monotonicity are that all codes be obtainable and that the quantization level of each code be within one-half a least significant bit of the ideal, linearly related, quantization level.

Linearity in a high-speed converter is governed primarily by the design of the digital-to-analog conversion network, the type of comparator employed and the linearity of the input transfer devices. Linearity relates to the conformance of transfer accuracy; that is, the relationship of input voltage to linearly related, continuous, integral codes in a perfect straight line between zero and full-scale levels. Quite clearly, equipment cannot have linearity without having relative accuracy and vice-versa.

Stability

Stability simply relates to the ability of a converter to maintain the aforementioned character-

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Everybody seems to talk of analog-to-digital converters. But, too few engineers know all the characteristics that should be understood before making an intelligent purchase. Bernard Gordon (foreground) and Bruce Smith wrote this article to help eliminate some of the confusion. Their qualifications for writing a definite article on A/D converters are hard to match.

Mr. Gordon, with almost 100 patents related to data reduction, control, computation, and communications, invented the first high-speed, analog-to-digital converter. Mr. Smith, with extensive background in designing high-speed digital computers (Flac and Larc), was active in conceiving and designing Epsco's high-speed Videoverter and Transicon converters.

In a subsequent article, the authors will show the bases for some of the converter limitations which are discussed in this article.

istics over a defined operating interval. Lack of stability is brought about primarily by two major factors—drift in the voltage reference and resistors and poorly designed conversion networks.

One should distinguish between short-term and long-term stability. In many control systems, particularly in controls involving rates of change, short-term instability can produce violent excursions in the control function, whereas longer-term instability will require recalibration in the equipment.

The instrumentation-system engineer should rightfully inquire into both the gross specifications of the "black box" which he contemplates using and the specific stability specifications of the voltage-reference source and precision resistors. He should make sure that there is appropriate derating to assure adequate safety within his system requirements.

He should make sure that the definition of accuracy involving stability covers the temperature range that he anticipates encountering and, of particular importance, that it is valid over the range of primary powerline voltage to be supplied. In addition, he should check to see if the definitions of stability include the environmental conditions of shock, vibration, humidity, etc., which will be encountered.

Calibration Requirements

Consideration of stability naturally leads to an examination of calibration requirements. The properly designed analog-to-digital converter should have a minimum of calibration adjustments and, for most applications, it should require no field calibration adjustments whatsoever.

In units containing a specification for absolute accuracy, it is always necessary to provide some sort of initial factory adjustment to relate the unit to the specific, absolute, reference-source value used. In the authors' opinion, the number of potentiometers employed in an equipment of given functional capability is inversely proportional to the experience and capability of the designer.

It should be borne in mind that, very often, instrumentation engineers require and specify a converter with accuracy greater than that obtainable in rugged-environment voltage-reference sources. Further, experience has shown that most test-instrumentation departments do not maintain equipments capable of making measurements much greater than perhaps 0.02 per cent.

Regardless of skill in design, manufacture, and component selection, the ultimate accuracy of a converter can always be "touched up" by some form of fine calibration. However, the designer must insure that these "touch-up" calibrations do not build in a source of instability.

Synchronous or Asynchronous

The programer of an analog-to-digital converter may be synchronous or asynchronous. If the timing that controls the successive approximations is controlled by delay lines, or strings of cascaded, self-delay-determining blocking oscillators, the equipment may be considered asynchronous, making it impossible for an external clock to control the serial-output bit rate.

If the successive approximations are controlled by magnetic shift registers, digital logic networks, or similar devices, then the bit rate may be controlled by a clock external to the converter.

Input Impedance

The inputs available with a converter and their loading characteristics are often governing factors in determining whether it can be mated with other equipment with the desired over-all accuracy. First, input impedance must be sufficiently high to mask all variations in source impedance which will be encountered.

Second, the input impedance should be stable on both a long-term basis and, preferably, during the encoding cycle so as not to reflect variations and perturbations back into the source. Analog-to-digital converters that provide direct entry into the comparator at low impedance usually force the user to provide a buffering unit whose transfer accuracy may or may not be compatible with the over-all accuracy desired. This places the responsibility for system measurement accuracy on the user rather than on the manufacturer.

In many applications, the signal to be measured is floating with respect to system ground, or contains common-mode voltages which must be ignored. For these applications it is essential that a floating or differential front end, preferably with high common-mode rejection, be an integral part of the analog-to-digital converter.

Absolute Value or Complementary Codes

Since, in most applications, both positive and negative voltages are encountered, it is necessary to be able to encode over the full range of bipolar values. One way of doing this is to consider the most significant digit to be a sign digit and to bias off the internal measuring range by an amount equal to one-half of full scale. This approach has the advantage of simplicity but the disadvantage of yielding complementary output codes for negative values and requiring special output-code usage.

Of still greater significance, it places the zero point of conversion at the most critical internal carry point. That is, the measurement of zero voltage, often a critical value point, is no longer referred to the ideal, equipment-zero-point ground. Instead, it relates the definition of zero point to the stability of the wirewound resistors and voltage-switching circuitry.

Another way to obtain absolute value is to use an absolute-value amplifier at the input to the converter. This technique has the disadvantage of additional cost, but in a properly designed unit it does not introduce additional error and it provides a true, zero-reference-based definition of zero volts.

When the accuracy of a given analog-to-digital converter design is obtained, a unit using an absolute-value amplifier should be able to produce twice the ultimate range of one using the complementary code technique. This is because the total number of switching bits can be used over the positive range, and again, over the negative range. In contrast, in the complementary-code technique, one of the bits—the most significant one—must be used to indicate sign.

A third method used is to switch reference voltage from positive to negative, or to switch from one complete set of networks to another. This approach usually has an economic disadvantage and introduces discrepancies between positive and negative range control elements. However, it does yield absolute-value output coding.

Serial or Parallel Outputs

A converter that provides both serial and parallel code output offers the user a higher degree of flexibility than one with one or the other. Frequently a serial-code output, particularly when subject to synchronous clocking, can yield significant system design economies by eliminating buffers which might otherwise be required for communication with serial computers or magnetic-tape recorders.

Available Output Power

If available output power is not adequate, one may have to use buffer units with a cost and space penalty. It is necessary to study the effect of the load impedance on the converter circuitry to insure that the static and dynamic accuracies are not affected. The analog-to-digital converter

should provide heavy code-power output, both to effect over-all system design economies, and to insure proper operation within specifications, regardless of loading.

Coding Flexibility

By proper design, a converter can be built in modular form to provide a high degree of coding flexibility, either in terms of the number of bits carried or in bit definition; i.e., binary, 8-4-2-1 decimal, two-star decimal, etc. To a large extent, this flexibility is governed by the manner in which the modules are organized, and the exact nature of the converter networks.

Provision for Sample and Hold

When sample and hold is required, the unit should preferably be an integral part of the analog-digital converter. A unique approach places the plug-in sample-and-hold module within the feedback loop of the input buffering system, so the sample-and-hold unit, for all practical purposes, does not introduce errors within the system.

Settling Time of Input Buffer

The system designer should assure himself that his design takes into account the settling time of the input network when successive measurements are to be made of independent voltage sources. A high-speed converter, while capable of a given number of conversions per second, will usually be limited in the number of independent measurements which can be made per second with full-scale to full-scale deviations because of the time required for the input buffer to settle. And, if a sample-and-hold unit is used, time must be allotted for the sampling unit to be activated.

Wide-Range Ratio Measurement

It is frequently desirable to make measurements relative to an external reference, i.e., to measure a voltage as a ratio. The nature of the digital-to-analog converter network which refers to the reference voltage may or may not make this possible. The voltage drops in the switching elements, relative to the magnitude of the reference voltage, must be carefully considered.

The range of reference voltage over which an accurate ratio measurement is obtainable will be governed by the switching means employed. For example, if the network is switched through silicon diodes having 0.7 v drop, the range of voltages over which the reference voltage may be changed is clearly much less than if the switching were accomplished by a saturated transistor having a drop of about 1 mv.

Normalization

In many systems, high-speed analog-to-digital converters are used to carry out functions that might otherwise be required of any accompanying computer. The ability to perform these functions is largely determined by the logical organization and modular construction.

Reversibility

In many systems that require both analog-digital and digital-analog conversion, it is possible to time share a single unit for both functions inasmuch as nearly all analog-digital converters use an internal digital-analog converter. Equipment specifications should be reviewed to determine the ease and manner of reversibility, as well as the provision for low-impedance analog output in the digital-to-analog mode.

Mean Time to Failure

It should be obvious that in a measurement device where precision and accuracy are prime operating specifications, the mean time to failure should be defined as the mean time to failure within prescribed accuracy specifications and not just the time to fail to function.

Construction Technique

The construction technique used in a converter must be compatible with the system in which it is to be incorporated. In ground-system installations, the construction should be compatible with whatever cooling system is available. For example, in a cabinet using vertical cooling, the converter should not present a major obstruction to the air path.

Size, Weight, Power

These factors must be considered in the light of the system application and in some cases it may be necessary to realize that compromises are desirable to effect the best engineered system design. This may seem obvious but, frequently, the analog-to-digital-converter designer is faced with impossible demands for extreme accuracy and stability in equipments of minimal volume under extremes of shock, vibration, temperature, and humidity.

Visual Display

Since the human cannot assimilate information at rates much in excess of two numerical code sets per second, in actual system applications the numerical display of the high-speed converter is usually used for test or monitoring purposes only. The type of visual display is usually more a question of individual taste and judgment. ■ ■

Step-by-Step Design of Phantastrons

Dr. Morris Levin feels that a careful analysis of how circuits work can provide logical design rules for selecting individual components to improve circuit performance and improve reliability. In this article, he shows how to design phantastron circuits from just such a basic analysis.

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PROPER design of a phantastron is far from obvious. As a result, designers often resort to cut-and-try procedures with erratic results. The straightforward design procedure in this article should be very helpful to engineers who want to take advantage of this most useful circuit.

Simple and reliable, the phantastron produces an exceptionally linear sawtooth and a pulse time delay closely proportional to the applied control voltage.[1,2] It can be used as a linear sweep generator, a delayed pulse generator, a pulse-width or pulse-time modulator, or a stable frequency divider.

Two phantastrons triggering each other can form an oscillator whose frequency is a linear function of an applied control voltage.

Screen-Coupled Phantastron Operation:

The basic screen-coupled phantastron (Fig. 1), uses a pentode with a suppressor grid having good control over plate current. The control grid of this tube returns to E_b through a high resistance. Therefore in the stable quiescent state the grid voltage, e_{c1}, remains at zero and a constant cathode current, i_k, flows. Since the suppressor voltage, e_{c3}, is sufficiently negative to cut off plate current, the cathode current flows to the screen.

A positive pulse triggers the suppressor at time t_1. Plate current begins to flow and the plate voltage goes down. This voltage drop is coupled through capacitor C to the control grid, thus reducing cathode current. Since most of the cathode current flows to the screen, the screen voltage rises. This rise is coupled back to the suppressor by voltage divider R_1-R_2. It further increases suppressor voltage and starts a regenerative feedback-switching action.

This requires only a fraction of a microsecond and ends with the suppressor at a positive voltage so now the plate takes most of the cathode current. The plate potential drops by several volts and this drop, coupled to the control grid, drives it negative enough so that only a small cathode current flows. The screen current drops sharply so the screen voltage jumps to nearly the supply voltage, E_b.

After the switching is completed the circuit undergoes the well known Miller sweep genera-

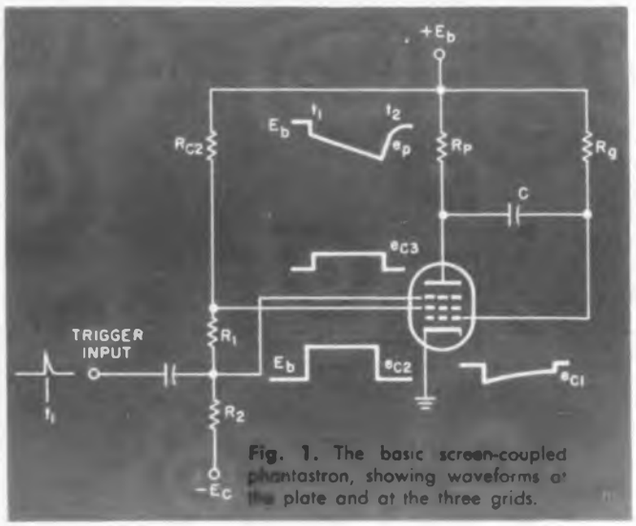

Fig. 1. The basic screen-coupled phantastron, showing waveforms at the plate and at the three grids.

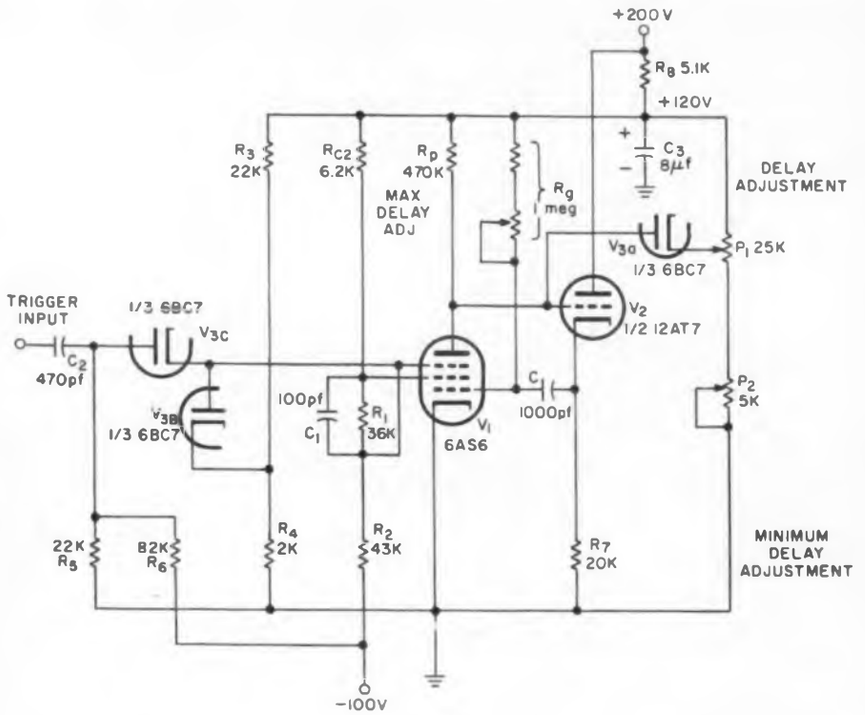

Fig. 2. A more sophisticated version of the screen-coupled phantastron with values taken from the design procedure in the text.

tion. Among several ways of considering this, a simple one is as follows: The grid is several volts negative but since it returns to E_b through R_g its voltage must rise at a rate depending on how fast the voltage across C can change.

As the grid voltage goes more positive the plate potential drops. There is a large amount of negative feedback from plate to grid through C so the drop at the plate is very nearly linear. In practice the departure of the sawtooth from linearity is only about 0.1 per cent.

The linear decrease of plate voltage continues until the plate is only a few volts above ground. At this point the knee of the plate current curve is reached; the plate voltage is so low it can no longer conduct the additional cathode current resulting from the steadily rising grid voltage.

Therefore the screen starts to take the additional current, causing a drop in screen voltage. This drop couples through divider R_1-R_2 to the suppressor, making it more negative and reducing plate current still further. This initiates a second regenerative switching action after which the tube elements return to their original quiescent state.

Various refinements that improve performance are incorporated in the circuit of Fig. 2.

- The length of the sawtooth can be adjusted by varying the voltage to which the plate of the pentode can rise. This is accomplished by V_{3a} and potentiometer P_1. As soon as the plate reaches the voltage set by P_1 the diode conducts and prevents it from going higher.
- The chief factor limiting the recovery of the phantastron after the second switching action is the time required to recharge C to its initial voltage through R_p. This time is greatly shortened by the cathode follower, V_2. A plate supply higher than E_b is needed for the cathode-follower because the grid of the cathode-follower reaches E_b when the circuit is quiescent.
- A small capacitor from screen to suppressor couples the voltage transitions rapidly.
- Diode V_{3b} and voltage divider R_5-R_4 stabilize the positive voltage to which the suppressor rises during sawtooth generation.
- A desirable trigger uses V_{3c} to prevent the changes in suppressor voltage from coupling back to the trigger source.

Screen-Coupled Phantastron Design:

The basic steps in designing a screen-coupled phantastron follow, together with an example for a circuit using a maximum delay of 1,000 μsec.

Step 1. First select V_1. The 6AS6 is often used but for very fast waveforms or low-impedance circuits a heavier current-carrying tube like the 7AK7 is necessary.

Step 2. Choose E_b. A larger voltage increases the size of the waveforms. Since the screen voltage nearly reaches E_b during sawtooth generation, E_b should be limited to the maximum screen-voltage rating of the tube. E_c should be chosen as large as convenient.

The maximum screen voltage rating of the 6AS6 is 140 v, so for conservative design E_b is set at 120 v. E_c is set at −100 v.

Step 3. Set an operating point for the screen when the circuit is quiescent. At this time the plate current is cut off and the grid voltage is zero. A large screen current is desirable for fast switching.

For $e_{c2} = 60$ v, $i_{c2} = 7$ ma (from tube curves). Screen dissipation is 60 x 0.007 = 0.42 w. This is safely within the rating of 0.75 w.

Step 4. Choose a value for e_{c3} during quiescence that is safely below cut-off. Then determine R_{c2}, R_1 and R_2.

(Continued on p 42)

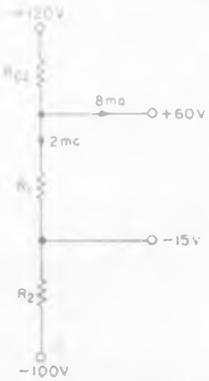

Fig. 3. Voltage divider whose values must be determined before completing the design shown in Fig. 2.

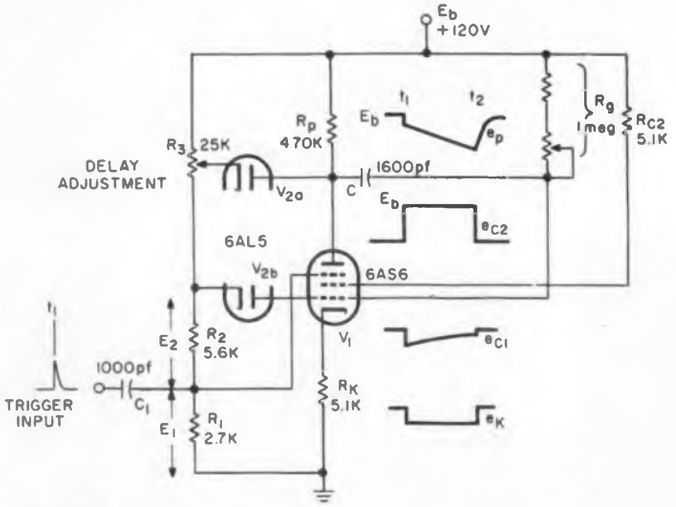

Fig. 4. The cathode-coupled phantastron is simpler than the screen-coupled version though not quite so linear. Design procedure is given in the text.

Set $e_{c3} = -15$ v. The R_1-R_2 divider should draw enough current so small changes in i_{c3} will not affect e_{c3}. Choose this value as 2 ma and solve for the parameters of the voltage divider shown in Fig. 3. The results are indicated in Fig. 2 after they are rounded off to standard values.

Step 5. Check the resulting value of e_{c3} during the Miller-sweep period when e_{c2} rises to E_b. It should be well into the region where the plate takes most of the cathode current.

Thus, $e_{c3} = +21$ v which is well above the minimum necessary value.

Step 6. The divider R_5-R_6 should return the suppressor to a voltage well below its cut-off value so only an external trigger will allow the suppressor to begin plate conduction.

A value of -20 v is used.

Step 7. Choose the components which determine the maximum duration of the sawtooth. The slope of the plate sawtooth is about $E_c/(R_gC)$ v/sec and the maximum delay is slightly less than RC sec. C should be considerably larger than the stray capacities but an excessively large value will increase the recovery time. R_g should be large enough to prevent excessive grid current flow but not so large as to produce too much impedance in the grid circuit.

For a maximum delay of 1,000 μsec choose $R_g = 1$ meg and $C = 1{,}000$ pf. A potentiometer in series with R_g can be used to adjust the maximum delay exactly.

Step 8. Choose the plate load resistor. A high resistance improves sweep linearity but a lower value shortens the recovery time and the minimum delay time.

This design has a recovery time of about 50 μsec. It could easily be shortened by reducing R_p or C or by using a different tube, carrying a larger current for V_2.

Step 9. R_3 and R_4 fix the maximum value of e_{c3}. This voltage should be sufficiently positive so the plate conducts most of the cathode current. For stable operation the suppressor should always reach this voltage. Hence, it is wise to set it 5 or 10 v below the value found in Step 5.

A value of $+10$ v is used.

Step 10. For fast waveforms make R_7 as small as possible. Its minimum size is determined by the condition that when the phantastron is quiescent the grid of V_2 is at E_b and the triode should be within its ratings.

If $R_7 = 20$ K then when $e_p = 120$ v the current through R_7 is approximately 6 ma and the plate dissipation for V_2 is 0.48 w. This is within the ratings for the 12AT7.

Step 11. Choose P_1 and P_2 so P_1 covers the desired range of delays. For linearity of control the resistance of P_1 should be less than about 1/10 R_p.

Step 12. R_8 drops the 200-v supply to 120 v for V_1. To determine the proper resistance one must know the average current taken by the circuit. The pentode draws appreciable current during the quiescent period but practically none during sawtooth generation. Changes in duty cycle will affect E_b and this may have a secondary effect on circuit operation. This effect can be reduced by drawing a relatively large fixed current through the resistive dividers. For very precise time delays with a widely varying duty cycle a VR tube or a separate power supply is desirable.

The fixed current is 12 ma and the variable current 8 ma. For a 50 per cent duty cycle the average current is 16 ma so $R_K = 5.1$ K. Experimentally it is found that changes in duty cycle have very little effect.

Cathode-Coupled Phantastron Operation:

This variation of the phantastron circuit has the advantages that it requires somewhat fewer components; it does not need a negative voltage supply; and it produces a negative as well as a positive rectangular output pulse. But it is not so linear as the screen-coupled circuit because the cathode resistor decreases the pentode gain.

The circuit, shown in Fig. 4, functions as follows: In the quiescent state the grid is at the potential $(E_1 + E_2)$ which is set by the divider R_1-R_2-R_3. The cathode voltage is slightly higher. The suppressor is at E_1, which is sufficiently negative with respect to the cathode to cut off the plate current. Therefore the screen takes all the cathode current.

At time t_1 a positive trigger to the suppressor allows the plate to conduct. This results in a drop in plate voltage which is coupled through C to the control grid. This reduces the total cathode current so the cathode voltage drops and the suppressor-to-cathode voltage e_{c3-k} goes more positive, allowing still more plate current.

The regenerative switching action proceeds swiftly and ends when the drop in plate voltage coupled to the grid has driven the grid negative enough to nearly cut off the cathode current. The suppressor-to-cathode voltage is then sufficiently positive so the plate takes practically all the remaining cathode current. The screen current is very small so the screen voltage rises practically to E_b.

A negative sawtooth is produced at the plate by Miller action as in the screen-coupled phantastron. When the plate voltage falls to the knee of the plate-voltage vs plate-current curve the plate can no longer take additional current. The grid voltage rises very rapidly, initiating a second switching action that returns the circuit to its quiescent state. As in the screen-coupled phantastron, the variation of the voltage to which the plate is allowed to rise controls the duration of the sawtooth.

Cathode-Coupled Phantastron Design:

This example will be worked out for a maximum delay of 1,000 μsec. The fast cathode-follower recharging is omitted so the recovery time is several times the maximum delay.

Step 1. Choose the supply voltage, E_b. Since e_{c2} approximately equals E_b during generation of

the sawtooth, E_b is limited by the maximum rated screen voltage.

The maximum rated screen voltage of the 6AS6 is 140 v so for conservatism 120 v is used.

Step 2. Set a value E_1 for the positive suppressor-to-cathode voltage e_{c3-k} so the plate will take the major share of the cathode current. However, this must be compromised with the consideration that for best linearity the cathode resistor R_k, must be small. Consequently E_1 and E_2 (mentioned below) should be as small as possible. During the Miller action i_k is very small so $c_k \cong 0$ and $e_{c3-k} \cong +E_1$.

For the 6AS6 choose $E_1 = +10$ v.

Step 3. Choose a value $-E_2$ for the negative suppressor-to-cathode voltage during quiescence that reliably cuts off plate current. At this time $e_{c1} = E_1 + E_2$ so $e_k \cong E_1 + E_2$ and $e_{c3-k} \cong E_1 - (E_1 + E_2) \cong -E_2$.

From tube curves -12 v appears adequate so choose -20 v for reliability.

Step 4. Fix the grid-cathode voltage and the operating point for the screen when the phantastron is quiescent. To compensate for tube aging it is desirable that e_{c1-k} be slightly negative. This value should reduce the cathode current to roughly three-quarters of its zero-bias value. For fast waveforms i_{c2} should be as large as possible but within tube ratings. Then R_{c2} can be found.

Choose $e_{c1-k} = -0.5$ v and $i_{c2} = 6$ ma. Then $e_{c2-k} = 60$ v (from tube curves) and $P_{c2} = 60 \times 0.006 = 0.36$ w which is satisfactory. Since $E_1 + E_2 = 10 + 20 = 30$ v, $e_k \cong 30$ v and $e_{c2} = e_{c2-k} + c_k \cong 60 + 30 \cong 90$ v. Therefore the screen resistor R_{c2} must produce a drop of 30 v. $R_{c2} = 30/0.006 \cong 5.1$ K.

Step 5. In the quiescent state $R_k = c_k/i_k \cong (E_1 + E_2)/i_k$.

$R_k = 30/0.006 \cong 5.1$ K.

Step 6. Choose R_g and C. For the cathode-coupled phantastron the slope of the sawtooth is also very close to E_b/R_gC v/sec. Because of the initial drop in the plate voltage before the sawtooth begins, the maximum duration of the sawtooth is reduced to about $0.6 \times R_gC$ sec. The amplitude of the initial drop is approximately $E_1 + E_2$.

If $R_g = 1$ meg and $C = 1{,}600$ pf then $0.6 \times R_gC = 960$ μsec $\cong 1{,}000$ μsec.

Step 7. Choose R_p from the same considerations.

Step 8. Determine R_1, R_2, and R_3 so as to provide the proper values of E_1 and E_2 These resistances should be small compared with R_g and R_p so the currents taken by the tube elements will not appreciably affect E_1 and E_2.

References

1. B. Chance, et al. Waveforms, Vol. 19, MIT Rad. Lab. Series, McGraw-Hill, 1949, pp 195-204.
2. J. Millman and H. Taub. Pulse and Digital Circuits, McGraw-Hill, 1956, pp 221-228.

High Density Electronic Packaging—
Module Layout and Design

The concept and basic description of High-Density Electronic Packaging were covered in the first article of this series (ED, April 12, 1961, p 40). In this article, the design of circuit modules and wiring modules is outlined in terms of module size, cost and efficient layout. Ground rules are presented for various design approaches.

Alfred J. Coutu
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HOW expensive should a "throw-away" module be? How large should a module be? How can interconnections between modules be reduced? These are but a few of the challenging questions which face the design engineer confronted with a project involving microminiaturization. The compromises and factors affecting the decision, as applied to High Density Packaging, are revealed as the layout and design procedures are outlined.

The High Density Electronic Packaging (HDEP) technique employs two basic modular electronic subassemblies: circuit modules and wiring modules. These modules, both encapsulated, are electrically united within a given system package by means of specially designed separable connectors, having the reliability of permanent connection techniques.

Connections between circuit module and wiring module terminal pins are made by the wire-wrap technique. Figs. 1 and 2 illustrate the circuit module–wiring module relationship and show the wire-wrap connector method.

How Large Should A "Throw-Away" Module Be?

The "throw-away" concept applies to circuit modules alone, in that replacement of a module can be expediently made on a "plug-in" basis should component failure occur. Component costs may indeed be higher, but system downtime and maintenance are reduced. These factors must be equated in the preparation of requirements for a particular system. Oftentimes, expensive components can be located outside of the encapsulated circuit modules so as to be salvageable should the module require replacement.

Reliability is the most important consideration in subassembly size determination for packaging designs. It is generally assumed that the greater the number of connections that are permanently made, i.e. welded and encapsulated, the greater will be the over-all reliability of the system. This philosophy tends to keep the number of separable or nonencapsulated connections to a minimum. In order to achieve this end, more and more components are added to a circuit module and more of the logical wiring is done within the circuit module. The ideal functional unit would have only those logical input and output lines and power connections necessary to operate the unit at the external terminations. There are, of course, physical as well as economical limits to which this philosophy can be carried.

The second desirable feature gained in using a large circuit module is the high component density which can be achieved.

An opposing factor is generally economic, i.e. the smaller the circuit module, the cheaper the throw-away package becomes.

Another desirable feature of small circuit modules is the added flexibility of system design. Heat-producing components may make small module sizes a decided advantage, because these components may be placed near the surface of the module and closer to the conductive foils that are attached to the heat sinks.

Thus, the main factors to be considered in the determination of circuit module size and, ultimately, wiring module size are a compromise between the reliability and component density of the system vs the economic considerations or the dollar value of the throw-away package and the flexibility desired for the system.

Circuit Module Assemblies

Size of Circuit Modules: Construction of circuit modules for a given system package is based essentially on a determination of module size. This determination is made by means of mechanical, electrical and thermal evaluations of the system schematics and block diagrams.

It is helpful, but not necessary, to have all circuit modules in an electronic system package identical with respect to physical size. The minimum requirement is to hold two dimensions of all encapsulated circuit modules in the system constant. The approximate size of the over-all system and of the individual circuit modules is obtained by a mathematical analysis of all the components of the system circuits. From a preliminary breakdown of the system block diagram into individual circuits to be packaged, component size evaluations are made which include dimension and "squared area" determinations and calculation of volume. "Squared area" refers to the square of the diameter of the component.

By this mathematical analysis, and by adding certain constant dimensions to each circuit module for matrix wiring, encapsulation, terminal pin connections, wiring module volume and structure, it is possible to accurately predict the volume of a complete system.

The number of modules in a system helps to determine the size of each circuit module. For most digital computers, a greater number of modules of a few types are required if logic is not incorporated. Fewer modules are required if logic is involved, but each module becomes a specific type, increasing the number of spares required for most systems. An analog system will generally require a group of completely different circuit modules, except for multichannel equipment where advantage can be taken of identical circuits to reduce the number of module types in the system.

The number of interconnections required for each circuit module must also be determined, because as modules are grouped together or functionally split, the pin count of the new circuit module will be different from that derived from the logical breakdown. The pin requirements of the system per circuit module are dictated by the circuit module with the greatest terminal pin requirement. Therefore, it is desirable to keep

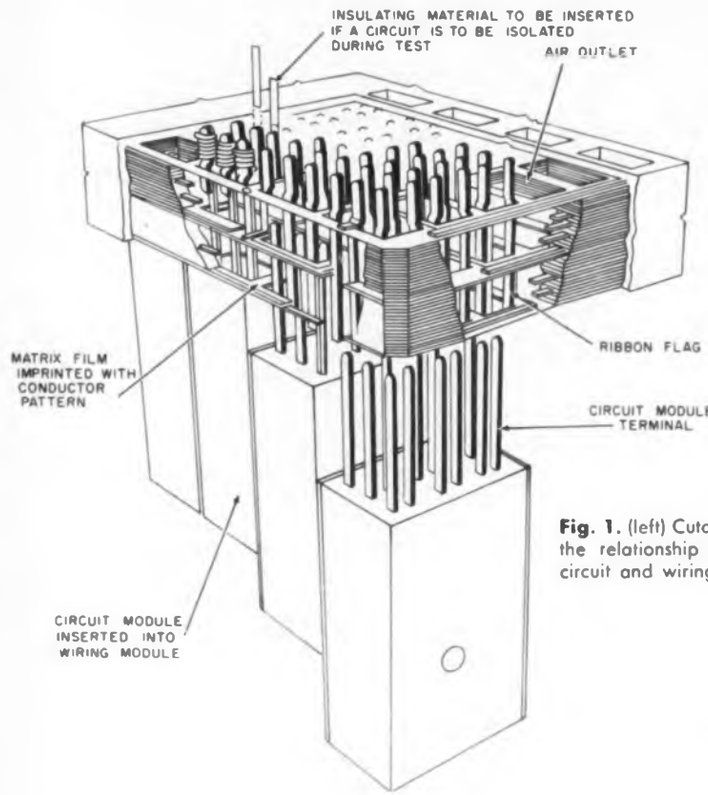


Fig. 1. (left) Cutaway showing the relationship between the circuit and wiring module.

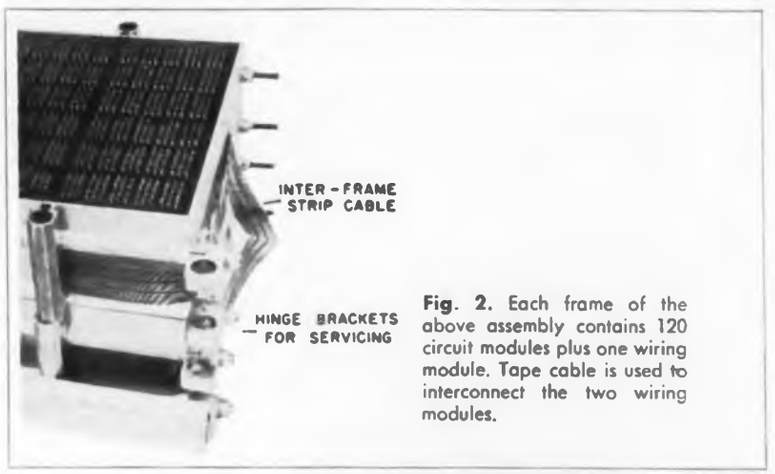


Fig. 2. Each frame of the above assembly contains 120 circuit modules plus one wiring module. Tape cable is used to interconnect the two wiring modules.

Fig. 3. (right) Typical analog circuit module, unpotted.

the pin count equal for all circuit modules.

If, for example, the wire-trap technique is used to interconnect circuit modules with a wiring module, the minimum spacing between the terminals is 0.150 in. on centers. From the height of the tallest component placed upright in the circuit module, it can be ascertained whether two, three or four rows of terminals are feasible. The number of terminals also determines the width of the circuit module for maximum pin density. With two dimensions of the circuit module fixed, a circuit module layout can be started. The sum of the component areas divided by the width results in the approximate length of the circuit module without encapsulation or circuit module connector provisions. A typical circuit module is shown in Fig. 3.

Layout Design Procedures: Once these mechanical factors have been fixed, layout design of a circuit module can proceed. Components are located so that output lines are as short as possible and conductor paths are minimized. Density is increased by associating components of similar dimensions along the same centerlines and obtaining a repetitive grid pattern for a matrix that will allow components to be located in a regimented fashion (quite difficult with analog circuits).

Heat-producing components are located in proximity to the heat exchanger, if one is used. Heat-sensitive components must be kept away from heat-producing components. Power terminal locations for all modules must be standardized, and input circuits must be kept separate from output circuits.

Another important step in layout design of a circuit module is refinement of wiring to obtain maximum functional simplicity, producibility and weld reliability. Components and wiring are "juggled" within the limits of the layout dimensions and within the limitations of the design mechanics until the wiring is made as simple as possible. The extra time spent in optimizing the design results in a circuit module which is simpler to assemble and fabricate.

Component Assembly: High density construction is three-dimensional as opposed to a two-dimensional or standard printed-circuit approach. The three-dimensional approach allows the layout designer the freedom of aligning or stacking components of different dimensions. The two-dimensional approach has also been incorporated with the welded technique by using one matrix in place of a printed circuit board and welding to various component leads at the extremities of the matrix.

Components are laid out with their maximum dimensions tangent to insure that there will be no interference at assembly. This method provides the best compromise between high density, i.e. a large number of components per unit area, and the ability of the component leads to move toward the rigidly supported matrix wires during the welding operation.

Thin (0.004 in.) Mylar or Cronaflex films, with the cross-sectional dimension of each component shown to scale, are used to arrange the components in proper order during assembly. Dots on these "positioning films" indicate where holes must be punched for passage of the component leads.

Matrix Design: The current approach to design of circuit modules uses the matrix wiring technique developed by Francis Associates for the Polaris FBM Computer logic sticks. A matrix consists of two layers of conductors at right angles to each other, separated by a Mylar insulating film. The films, photographically reproduced and reduced to scale from an original drawing, depict the wiring paths and are coded to indicate where holes are to be made to accept component leads and weld intersections.

To fabricate a circuit matrix, a welding jig can be used to position the conductors and the film,

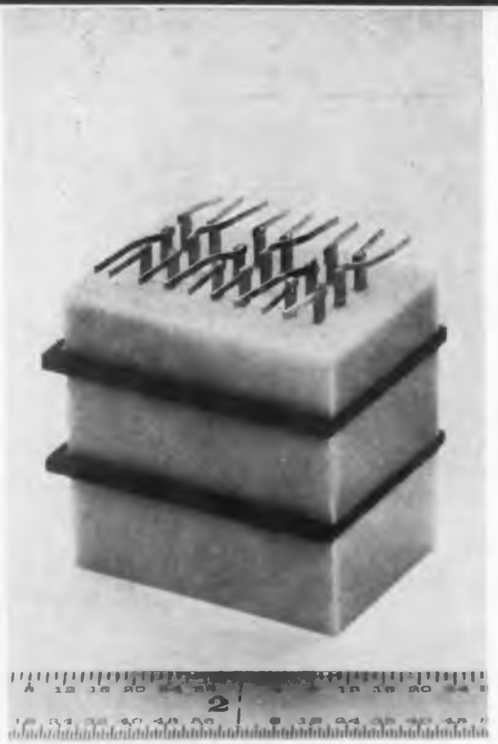


Fig. 4. A circuit module header housed in an assembly jig.

or the matrix film itself can be used as a jig by providing loading holes to locate the position and the conductors for welding. Once the conductors are properly positioned on the matrix film, the intersections of the conductors to be electrically united are welded through prepunched holes in the matrix film. Intersections of conductors where no connection is required are insulated by the film between the conductor layers.

In this manner, a matrix can be programed for automatic welding: a weld is attempted at every matrix intersection, but will only be made where holes occurred in the film. After all the matrix intersections are welded, excess conductor material is clipped away, leaving a conductor pattern identical to the image on the matrix film.

An advantage of matrix use is the versatility that can be added to a matrix by fabricating it of different conductor materials or sizes to increase the welding compatibility of the component lead and conductor. Until more manufacturers of basic electronic components provide their components with terminal leads that are more compatible to welding, matrix conductors must be chosen from different materials which are compatible to the various lead materials.

Experience in layout design of a circuit module teaches the designer the number and type of matrices that are required by a circuit module. In general, more than one matrix is required on each side of a module if the ratio of the number of components to the number of terminal pins is less than four to one. Another factor that contributes to additional matrices in a circuit module is a high percentage of components with a diameter of about 0.100 in., or transistors which are of the small hearing aid type.

Three general ground rules are followed in the layout design of matrices to assure maximum producibility and ease of fabrication:

1. Electrode Clearance: For pincer-type electrodes used to weld a matrix conductor to a component lead, a minimum of 0.040 in. clearance to another conductor on either side of the conductor or lead must be provided. This allows the electrodes to be positioned without interference from other conductors, and to be properly seated to avoid the loss of weld pressure.

2. Matrix Conductor Spacing: Part of this problem is recognized in electrode clearance, but the conductors on the first level of the matrix should allow a minimum of 0.050 in. edge-to-edge clearance from any component lead that is being bypassed. In the layout of the matrix, the designer must avoid parallel conductors having less than 0.025 in. clearance between them. This allows room for diagonal cutters to be used in clipping out the extra conductor material from the matrix.

3. Component Hole Sizes: If the component lead is rigidly fixed, the electrodes must force the lead and the matrix together for welding and some welding pressure is lost; therefore, the hole in the matrix film is made 0.010 to 0.015 in. oversize to allow the component lead to move freely. This procedure is based on the theory that it is easier to move the lead of a component (and possibly the component) than it is to move a short length of conductor rigidly welded to the matrix.

A sound ground rule to follow in the layout of matrices is to place the conductors that go to the terminal pins on the first level beneath the matrix film, leaving the perpendicular conductors that are welded to the component leads on top. If more than one matrix is stacked on a circuit module, conductors going to terminal pins should be on the under-side of the outermost matrix. The lower-level matrix should make all the basic component connections, so that the module is a testable subassembly before the outer matrices are assembled and welded. The outer matrices should only connect with input-output and power connections. A component lead should never be welded to both matrices; however, the use of cross-through wires does allow welding to both matrices. Also, it is simpler to design the circuit module header, described next, if it is known that all conductors going to terminals are so located that connections to the header can easily be made.

Header Design: The circuit module header serves as a transition between the matrix wiring of the circuit module and the "outside world" back-panel wiring module.

A header is composed of terminal pins for connections to the wiring module, and "flags" which are transition connections between the terminal pins and the circuit module matrix conductors (Fig. 4). Because the terminals must be properly oriented and located within the header, the header is usually a fabricated part that will accept and position all the "flagged" terminals.

An alternate method is to individually position the "flagged" terminals in one side of the module encapsulating mold and weld the "flags" to the matrix conductors just prior to encapsulation. This method eliminates the need for a separate header.

Circuit headers are a necessary part of a circuit module, since it is impractical to allow the matrix wires to come directly out of the encapsulation due to their close spacing. The use of headers makes it possible to design a wiring module that has terminal symmetry. The type of terminal pin required in the header is a function of the system back-panel wiring scheme of interconnections. At the present time, most designs use a split wire-wrap terminal that mates with a similar terminal in the wiring module to achieve a reliable connection.

Very close tolerances are required in the positioning and aligning of the header in relation to the matrices. At assembly, the flags must be located directly adjacent to the matrix wire, in order that welding pressure is not lost in bringing the flag and conductor together for welding. In extreme cases, it may be necessary to prebend the matrix wires in order to meet the flags. The majority of alignment problems are taken care of by the adequate design of positioning and holding jigs.

Wiring Module Assemblies

Design Concept: A wiring module is composed of several layers of ribbon matrices welded to wire-wrap terminals and encapsulated with an epoxy compound. At the present time a wiring module fabricated in this manner is the only electronic cabling system on the market that will interconnect High-Density encapsulated electronic circuitry and also offer the connector reliability, extreme compactness of back-panel wiring, and the ability to accept a tolerance

build-up in the physical size of the circuit modules without the requirement of floating pins.

High on the list of causes of failure of electronic equipment is the use of a conventional connector, due to the number of pins required in the complex systems being built today. These connectors, of necessity, have floating pins with some sort of spring to add pressure for contact connections. The floating pins continually subject the attached wires to high stresses and ultimate breaks or open connections. These reasons for failure are virtually eliminated by using a wiring module and the wire-wrap technique for interconnections.

Wire-Wrap Connector Design: The wire-wrap technique was originally developed by the Bell Telephone Laboratories. It has been modified to join two connector pins by wire-wrapping them together. One of the two pins originates from the circuit module, and the other from the wiring module. Internally, the wiring module pin is welded to a matrix signal path that interconnects with other wiring module terminal pins, and is connected via wire-wrap terminals to other circuit modules. This system permits 50 or more connects and disconnects with little or no decrease in reliability.

The wrapping or unwrapping of a connection is very easily performed by the use of inexpensive standard manual or power-driven wire-wrap tools. The wire-wrap technique demands that each connection be made individually, assuring positive visual evidence that each and every interconnection has been made.

The wire-wrap terminals are composed of hard, gold-plated beryllium copper, and the actual wire-wrap is composed of soft copper. When the copper is wrapped around the sharp, hard corners of the terminals, the copper is physically deformed, creating a gas-tight connection with its inherent high reliability. With four to seven turns around the two wrapped terminals, multiple conductive paths are created between the two terminals.

The use of wire-wrap terminals has two other unique features of interest to the designer. An outstanding feature is that *every* terminal of the system is accessible for probing and testing. The other equally important feature is that, by unwrapping one or two connections and inserting an insulating material between the terminals, a circuit can be isolated from the system for testing or probing without physical removal of the circuit module. Fig. 5 shows an array of wire-wrap terminals.

Matrix Design: All wiring module matrices are custom-built for a particular system. The obvious reason for this is that all systems will have different locations for the various types of circuit modules and not all systems are composed of the same number and types of modules. From outside physical appearances, all wiring modules are the same, differing only in the number of circuit modules that they will interconnect. The difference between them is in their internal matrix design.

The ribbon matrix method of back-panel wiring is the core of the wiring module. The matrices enable the designer to perform many interconnections between circuit modules and to complete this in a thickness of only about 0.025 in. per matrix. Several of these matrix layers stacked one above the other will contain all the intermodule signal and power connections required by the system.

More specifically, a wiring module matrix is composed of a photosensitive film (usually 0.004 in. Mylar) imprinted with lines that the signal conductors will overlay, plus other information necessary for fabrication. The conductors on either side of the film are welded to each other where indicated by the coding via holes prepunched in the film.

The films are exactly reproduced from original drawings on which the logic interconnections are laid out. Practically all of the information necessary for the fabrication of the matrix is shown on the film. Mylar is used because it possesses excellent insulating qualities, high tensile strength, extreme resistance to tearing and, above all, dimensional stability even at extreme temperatures. The conductors are usually nickel ribbon, nickel wire, nickel-clad copper, or combinations of these materials. A blank film sheet is inserted between each matrix layer to insulate one matrix wiring layer from another.

Layout Design Procedures: A wiring list is generated prior to design and layout of the master matrix film. It is easier to work with a wiring list than a multipage diagram.

This list is prepared from the master block diagram of the system, which indicates the logical connections from one circuit module to any other module or modules. The block diagram, previously prepared from the system logical schmatic, identifies each circuit module and indicates module header pin numbers for each circuit entering or leaving the module. The main function of the list is to indicate a point in a circuit and list all other points in the system which are directly connected to that circuit. When this procedure has been completed for each circuit in the system, the list thus generated becomes a description of the complete system with respect to logical interconnections.

Other information pertinent to design and layout must be received either prior to or at the same time as receipt of the list. Some circuits, because of the type of signal involved, require shielding to prevent pickup due to capacitance effects from other nearby circuits. Generally, circuits known to require shielding are so indicated on the wiring list and are placed on special shielded layers. Circuits which may or may not require shielding, depending on their length, are listed as such; during layout, if their length exceeds a certain limit, these circuits are set aside to be included on shielded layers. Matrix layers requiring shielding are sandwiched between planes of copper which are ultimately connected to ground.

Fig. 5. A series of wire-wrap terminals illustrating the technique.

Cabling Technique: A unique method has been devised to provide for the few input-output and power cabling requirements required by an electronic system composed of circuit modules interconnected by a wiring module. The cabling is accomplished by means of connecting as many as sixteen wires of the cable directly to the header of a circuit module. This is then encapsulated in a manner identical to a circuit module. As many of these "cable modules" as required by the system are connected into the wiring module. The cable modules are wire-wrapped into the wiring module in the same manner as other circuit modules. The wiring module matrices then perform the function of bringing the cable connections to the correct circuit module. ■ ■

NEW PRODUCTS

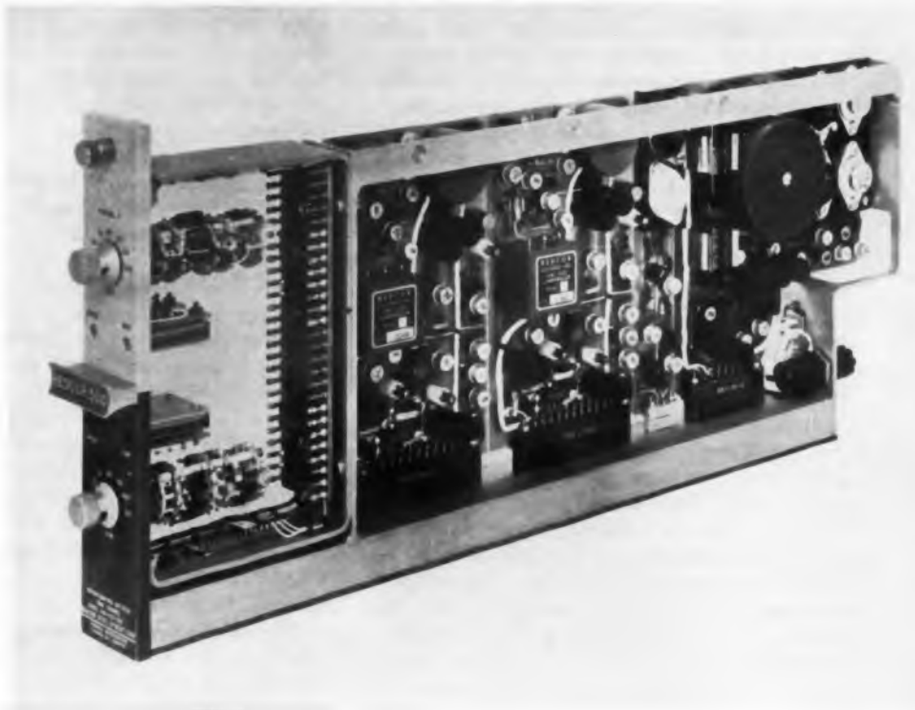
Covering all new products generally specified by engineers designing electronic original equipment. Use the Reader's Service Card for more information on any product. Merely circle number corresponding to that appearing at the top of each description.

Silicon Solar Cells Have Efficiency Of 13% — 259

A new collector strip process enables conversion efficiencies as high as 13% for these silicon solar cells. A number of secondary collector strips protruding from the main or primary strip affords a better collection of current from the active cell area. The new cells are named gridded cells because the collectors form a grid network over the active area of the cell. An increase in cell output power of up to 20% over nongridded cells under given light and load conditions is claimed.

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

P&A: *$2 to $6, depending on efficiency in 1 to 99 lots; from stock.*



Wide-Band DC Amplifier Is Single Ended — 257

Adjustable gains from 10 to 1,000 and an adjustable bandwidth from 10 cps to 100 kc. are features of model 500 single-ended, wide-band, dc amplifier. Input impedance is more than 1,000 megohms and output capability is ±10 v at 100 ma. The unit contains two single ended amplifiers in one package using a common power supply. Choice of gain and bandwidth characteristics is by plug-in input modules. The unit is completely solid-state design.

Packard Bell Computer Corp., Dept. ED, 1905 Armacost Ave., Los Angeles, Calif.

P&A: *From $765 per channel; 60 days.*

Wirewound Resistor For Microminiature Circuits — 258

Wirewound resistor model TC-1 measures 1/16 x 1/16 in. and is available in power ratings of 0.02 w. The units have tolerances of from 1 to 0.1% for resistive values from 1 ohm to 50 K. Resistance wire as small as 0.00045-in. diam is wound on a spindle and an epoxy bonding agent is applied for structural strength. The resistor can be secured directly to a printed wiring board with a bonding agent to become an integral part of the board.

Reon Resistor Corp. Dept. ED, 155 Saw Mill River Road, Yonkers, N.Y.

P&A: *From $1 to $3 ea; 4 weeks.*

Digital Logic Element Operates To 250 Kc — 256

A single one of the CTL-250 series of core-transistor logic elements can perform the following functions: OR, Inhibit, Branch, AND, Transfer, Drive, Count, or Complement. Combinations can perform any logical function in the digital equipment field. It is available with positive or negative input/-output pulse polarity. Minimum ONE to ZERO ratio is 15 to 1. Standard units operate to +65 C at 100% duty cycle. Military versions are obtainable for operating temperatures to +125 C.

Di/An Controls, Inc., Dept. ED, 944 Dorchester Ave., Boston 25, Mass.

P&A: $24 ea; 2 to 4 weeks.

Narrow Pulse Generator For High Repetition Rates — 255

Model PG-10 pulse generator is for use where high repetition rates and narrow pulses are required. Three overlapping ranges cover a frequency range of 1 to 20 mc. External sine wave trigger can be used to provide repetition rates down to zero. Specifications are: frequency accuracy, 3% of dial setting; output, positive or negative; rise and fall time, less than 6 nsec; pulse width, less than 20 nsec at 50% amplitude min, 0.3 μsec max; output impedance, 93 ohms; max duty factor, 0.35. Weight is 60 lb and size is 17 x 17 x 7 in.

General Applied Science Laboratories, Inc., Dept. ED, Merrick and Stewart Aves., Westbury, N.Y.

P&A: $1,250 fob Westbury; 90 to 120 days.

NEW PRODUCTS

Two-Coil DC Solenoid 566

Rated for 1,000,000 cycles of operation, model 12SD535 can in some uses perform 2,000,000 cycles. Response time is 12 msec with a 1-lb force at 0.125 in. of stroke and at 60 v dc. Able to operate over a temperature range of —65 to ±160 F, it meets MIL-S-4040C.

IMC Magnetics Corp., Western Div., Dept. ED, 6058 Walker Ave., Maywood, Calif.

Paper-Tape Reader 565

With rates to 20 characters per sec, this photoelectric device reads any 5-, 7- or 8-hole perforated paper tape. Uses include process control, automatic checkout and telemeter data reduction. Dimensions are 6 x 4-5/8 x 4 in.

Invac Corp., Dept. ED, 14 Huron Drive, Natick, Mass.

Slide-Wire Potentiometer 567

Linearity is to 0.25%, temperature constant is 20 ppm and noise is less than 25 ohms per NAS 710 in model 85176. For low-impedance use, the unit comes in complete or partial turns from 1 to 10 with resistances from 1 to 10 ohms per turn.

Giannini Controls Corp., Dept. ED, 1600 S. Mountain Ave., Duarte, Calif.

Regulated Power Supply 560

Output is 117 v ac at 60 cps from an input of 12 v dc. Type IFA-1260-25 has a continuous power rating of 250 w and a maximum rating of 375 w. Output is regulated to ±1 cps over a load range of 20% to 100% and an input range of 11 to 16 v.

Kupfrian Mfg. Corp., Dept. ED, 167 Prospect St., Binghamton, N. Y.
Price: $175.

Trimmer Potentiometers 573

Resistance is 100 ohms to 100 K ±20% in model 50-T-1 0.5-in. pots. Resolution is the same in low and high-resistance units. Starting torque is 7.5 oz-in. Linearity is 3%; power rating is 0.25 w.

Computer Instruments Corp., Dept. ED, 92 Madison Ave., Hempstead, L. I., N. Y.

AC-DC Digital System 572

Ac power converter, model AC-45 is for use with the V-45 dc digital voltmeter. The converter has a floating input which may be utilized at 500 v dc above ground. It permits measurement of 1 mv to 1,099.9 v ac in three ranges at 0.25% accuracy.

Cubic Corp., Dept. ED, San Diego 11, Calif.
Price: $1,500 (for system).

Saturable Core Reactors 587

In 9 sizes. Ratings of 0.25, 0.5, 0.75, 1, 1.5, 2, 3, 5, 7.5 and 10 kva are available in saturable core reactors for use at 60 cps, 600 v and below. Reactor is used in series with a load of constant resistance to vary current, or in series with a load of variable impedance to maintain a constant current. Class B insulation is used throughout.

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

Silicon-Controlled Rectifiers 585

At 10 and 16 amp. silicon-controlled rectifiers 2N681 through 2N689 are rated at 16 amp, types 2N1842 through 2N1850 at 10 amp. Both have piv ratings to 500 v, low forward voltage drops and uniform gating characteristics. Package is double-ended stud configuration. Devices meet military requirements.

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

Pressure Transducer 584

For low-pressure applications. Made for use where small size and accuracy are required, model 2-51 transducer has operating ranges of 0 to 5 to 0 to 350 psia, psig, or psid. Linearity is ±0.5%. Operating temperature is −65 to +165 F, with up to +300 F obtainable.

Edcliff Instruments, Dept. ED, 1711 S. Mountain Ave., Monrovia, Calif.

P&A: $400 ea, 1 to 10; 45 days.

Solid-Tantalum Capacitors 582

Capacitance is up to 330 μf and voltage ratings are to 35 v. Type CT units have working-voltage ratings of 6, 10 and 20 v dc and surge-voltage ratings are 8, 12 and 23 v. Dimensions are 0.27 x 0.285 x 0.06 in. Temperature range is −80 to +125 C.

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

Time Delay Relay 583

Is inexpensive. Thermal time delay relay is available with spst normally closed or open contacts, spdt, or 2 independent circuits. Rating is 100 ma to 10 amp, up to 115 v ac. The relay has enclosed bakelite housing, 2 mounting styles, and quick-connect or solder terminals.

E-T-A Products Co., Dept. ED, 6285 N. Cicero Ave., Chicago 46, Ill.

Price: $0.90 ea, lots of 100.

Color-Striped Markers 854

Of transparent polyester film, no. 964 markers are for coding resistors and other components. They stand temperatures to 150 C. Stripe and spacing are 0.03 or 0.015 in. wide. EIA and MIL STD 681 are met.

W. H. Brady Co., Dept. ED, 727 W. Glendale Ave., Milwaukee 9, Wis.

AC Regulator Holds Voltage Despite Changes in Load, Line, or Frequency

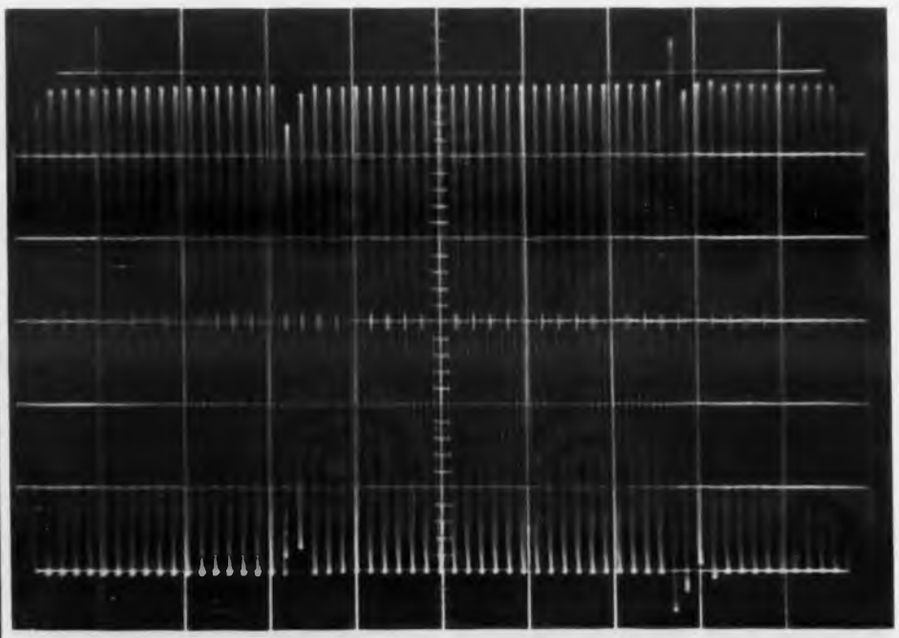
A NEW ac-voltage regulator combines fast, 2-cycle response, high reliability, and tight, 1 per cent regulation with insensitivity to variations in frequency, power factor, or temperature. The regulator thus combines the most desirable features of saturable-transformer-type resonant stabilizers, electronic stabilizers, servo regulators, and magnetic-amplifier regulators.

In the past, it was necessary to make one type of compromise or another in selecting a regulator. According to the manufacturer of this one, Twinco Inc. of 10 Cheney St., Roxbury, Mass., each regulator had important drawbacks.

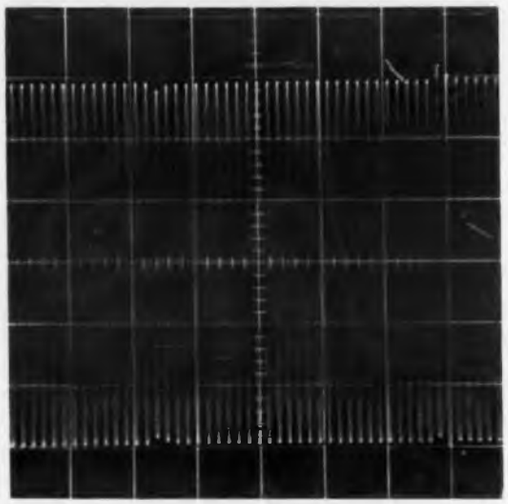
For example, the fastest type, the resonant stabilizer, can provide 2-cycle response and its output can be shorted without damage. But it cannot maintain 1 per cent regulation if the 60-cps line frequency should change by more than 1/2 cps, or if the load power factor should fall below about 0.98. And it cannot provide remote sensing or adjustable output.

The three other popular types, electronic stabilizers, servo regulators, and magnetic-amplifier regulators can all hold good regulation over the 57- to 60-cps range, they can all regulate against power-factor changes, and they can all provide adjustable output with remote sensing; but none provides 2-cycle response, and none can be shorted safely.

The Twinco regulator provides an output that is adjustable from 110 to 120 v with local or remote voltage sensing. It



Output of the line-voltage regulator shows fast response to load transients from half load to full load to half load.



Regulator's output responds quickly to 10 per cent changes in line voltage.

holds the output voltage to the adjusted value despite changes in the load from no load to full load, changes in power factor (leading or lagging) from 1.0 to 0.7, changes in the line from 95 to 135 vac, changes in line frequency from 57 to 63 cps, and changes in temperature from 0 to 50 C.

For line-voltage or resistive-load changes, the regulator responds, typically, in two cycles. For frequency changes or reactive-load transients its response is slowed to no more than 12 cycles.

Output distortion is never more than 5 per cent. Typically it is 2 per cent; for most extremes it may reach 3 per cent. In fact, the regulator can often reduce the harmonic distortion found in the input waveform.

The regulator uses only low-Q magnetic elements and diodes, so it is highly reliable. It uses a doubler-type magnetic amplifier with feedback to serve as a controllable saturable transformer.

Models are available to deliver 250, 500, 1,000, or 2,000 va, and they can be obtained with cabinet or rack mounting, with open or cased transformers, and with or without a panel meter.

Prices vary with model chosen. A 500-va unit with rack mounting, with the meter, and with open transformers costs $675 in small quantities and is available in 4 to 12 weeks.

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

New Uses for Cold Cathode Tubes

SWISS manufacturers have developed new uses for an old device. Cold cathode tubes have been around for 30 years, but until recently, their applications have been restricted in the main to voltage regulators and indicator lights. Now, because of technological improvements, these tubes merit recognition for their usefulness in trigger circuits and data-processing applications.

Cerberus AG, of Mannedorf, Switzerland regards the U.S. as a good potential market for the line of cold cathode tubes they have developed. Their representative in this country, Electronic Engineers International, 156 N. Franklin St., Hempstead, N. Y., will offer several versions of the basic tube to original equipment manufacturers.

The use of pure-metal molybdenum cathodes has increased tube life substantially. For continuous operation these tubes have a minimum life expectancy of 25,000 hours. In actual operation the tube is "on" only a fraction of the time, so its operating life is practically unlimited. Trigger tube characteristics of short firing time and stable control are the result of "pre-ionization." This is achieved by a keep-alive current of a few microamperes to an auxiliary anode. Ionization time using this method is in the microsecond range. Thus the tubes have applications in multivibrator circuits up to 500 cps.

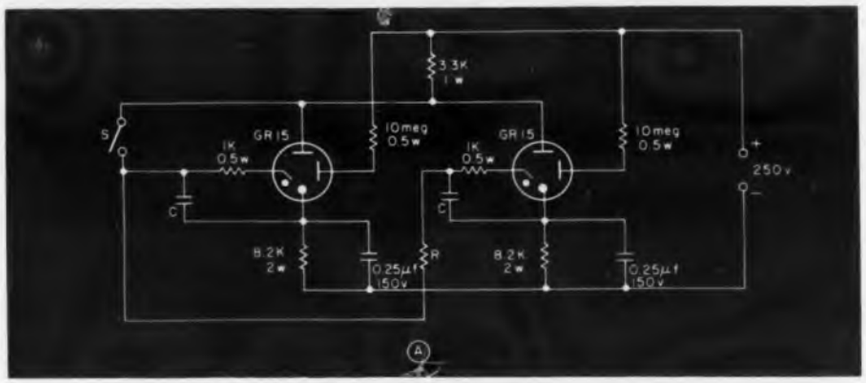
A multivibrator circuit using a Cerberus GR-15 tube is illustrated in Fig. (a). The frequency of oscillation is determined by the values of R (1 to 20 meg), and C (150 pf to 16 μf). The upper limit is 450 cps. The circuit goes into oscillation upon closure of switch S. The univibrator circuit shown in Fig (b) requires triggering pulses of 90-v amplitude with a rise time of 10^6 v per sec. Typical values of R and C are 1 to 20 meg and 150 pf to 16 μf, depending on the amount of pulse stretching that is desired. The flip-flop circuit shown in Fig. (c) combines features of circuits shown in Figs. (a) and (b). It should be noted that the tube uses the "keep alive" anode for pre-ionization.

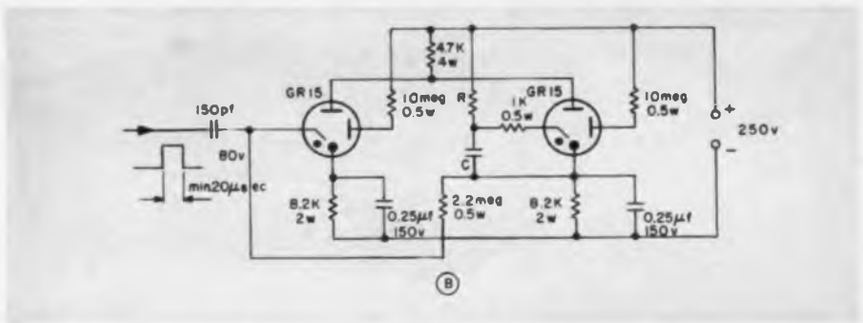
Another design feature that distinguishes the above circuitry from those using thyratrons is the use of a capacitor in the trigger circuit. By plotting the breakdown voltage (anode + cathode) against the control current (starter to cathode) the current control characteristic is obtained. A relatively high value of starter current is needed if the tube is to break down at lower anode voltages. If a 100-μf capacitor is placed between the starter and the cathode the tube will fire as soon as the control current has charged this capacitor to the starter breakdown voltage of 125 v. The capacitor then discharges from starter to cathode. For that instant the peak starter current is quite high and depends only on the value of the capacitor.

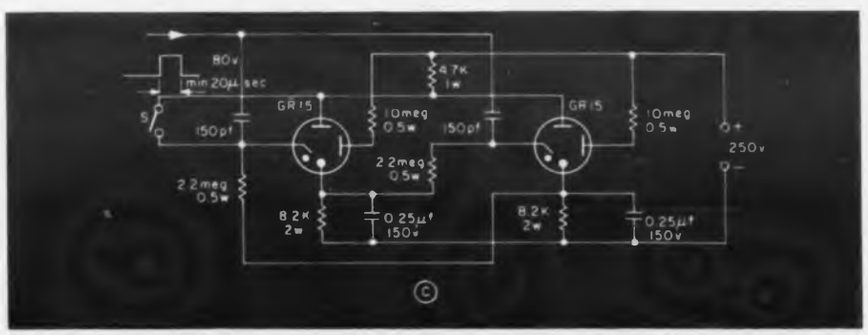
Miniature cold cathode tube, GR-21, type is so designed that the glow is visible when the tube is observed head-on. Two starters permit new uses as forward and backward counters for logic circuits. Fig (d) illustrates a counter circuit which can either add or subtract. Pulses coming in at the top line will add; pulses appearing on the next lower line will subtract. By picking off the cathode voltages of the individual tubes, predetermined counters can be designed. A counting speed up to 2,000 impulses per second is possible.

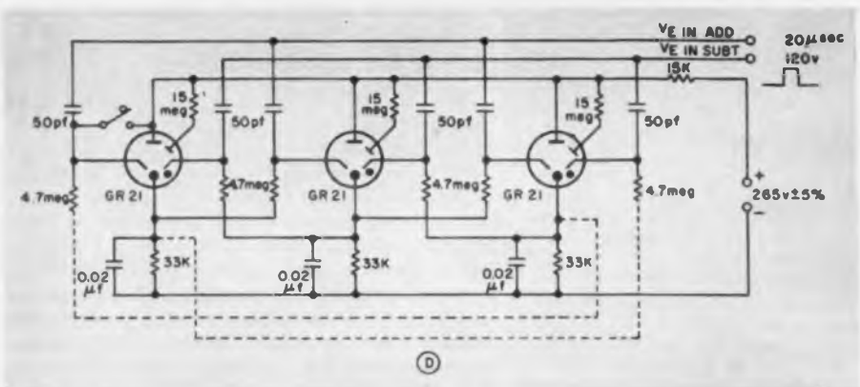
One of the tubes being offered, the Arcatron, is to be pegged at between $18 and $20 each for the 3-amp series.

For more information on this line of cold cathode tubes, turn to the Reader-Service Card and circle 252.

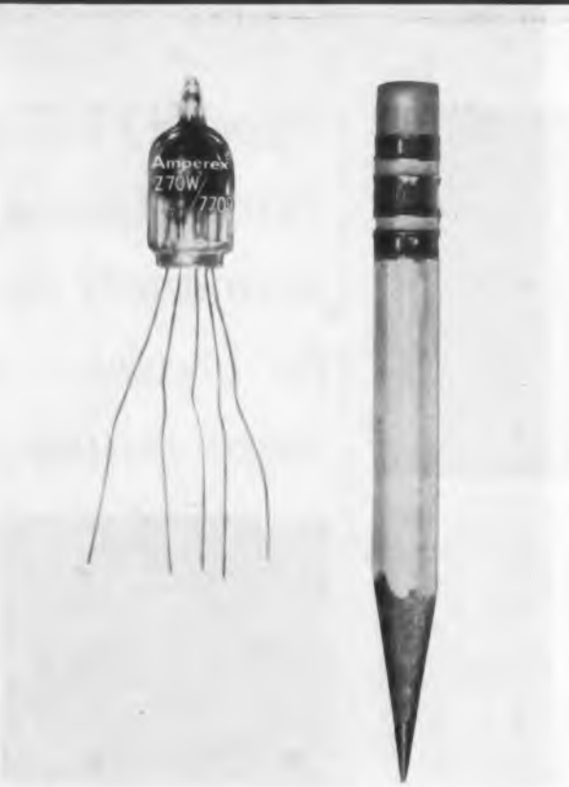








Multivibrator circuit (a) using a GR-15 tube has upper limit of 450 cps. (b) Univibrator circuit shown requires a triggering pulse of 90-v amplitude with a rise time of 10^6 v per sec. (c) This flip-flop circut combines the features of circuits shown in Figs. (a) and (b). (d) A counting speed up to 2,000 impulses per second is possible with this add-subtract counter circuit.



Trigger Tube Has Two Starters 320

A subminiature, gas-filled, cold-cathode trigger tube, type 7709/Z70W is designed for counting, timing, selecting, automation and read-out applications. The tube is equipped with two starters which makes possible its use in forward-backward counters, gates and reset applications. When used for reset, no additional tube is required. A starter current of 30 μamp is sufficient to insure discharge. The cathode is of molybdenum and the tube is designed for over 30,000 hr of operation.

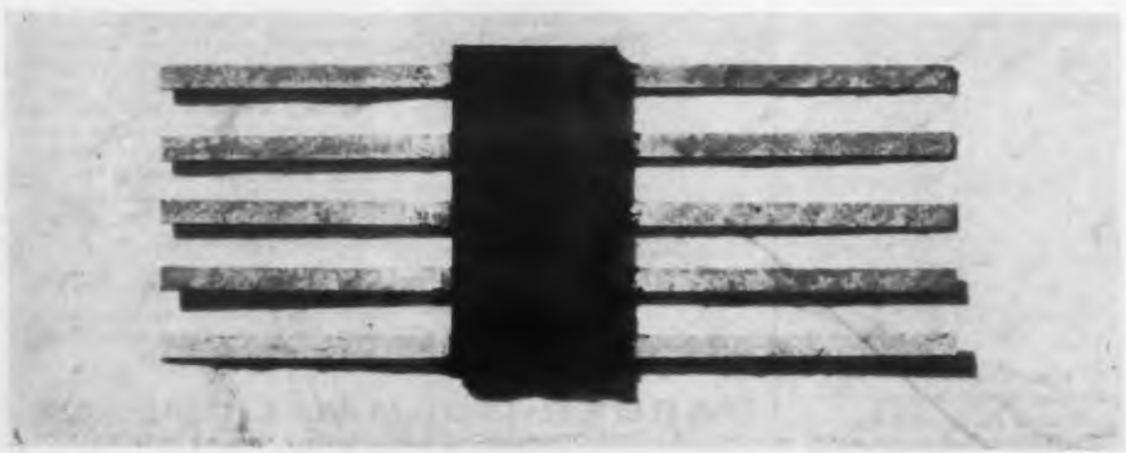
Amperex Electronic Corp., Dept. ED, 230 Duffy Ave., Hicksville, Long Island, N.Y.

P&A: *$2.10 ea in production quantities; immediate.*

Universal Counter-Timer For Dc to 100 Mc 319

General purpose counter-timer 728B measures and displays frequencies directly without heterodyning techniques from dc to 100 mc, measures time intervals and periods, and counts at rates to 100 mc with self-contained time base. The solid-state unit uses derated components for reliability. Paired pulse resolution is 10 nsec; oscillator stability is ±2 parts in 10^9 for short terms. Output information from each of the decade counting units is available in binary-coded decimal form to operate accessory equipment. Sensitivity is 1.0 v rms, input impedance 50 ohms from 10 to 100 mc and about 50 K from dc to 10 mc.

Computer Measurements Co., Dept. ED, 12970 Bradley Ave., Sylmar, Calif.



Silicon Microdiode Modules 318

Silicon micrologic circuits are made with 4, 6, or 8 diodes in a package measuring 0.030 × 0.125 × 0.250 in. Circuits can be designed per specification of lead arrangement, internal contacts and diode characteristics. Leads are gold-plated, suitable for welding and soldering. Individual diode parameters are available in excess of 2 nsec recovery and 2 pf capacitance. The entire logic block can be subjected to all military environmental testing including thermal shock and temperature-humidity cycling without degrading diode characteristics. Individual diodes are surface passivated so that in their uncased form they meet MIL-S-19500B and MIL-STD202 requirements. Microminiaturization techniques used increase reliability as size is reduced.

MicroSemiconductor Corp., Dept. ED, 11250 Playa Court, Culver City, Calif.

Standby Power System 545

Has zero switchover time. Made for use with computer, telemeter, and control systems, the Electro-Pac A standby power system cuts in with zero switchover time when ac line drops below a preset level. System provides ac from a battery source, with voltage regulated to ±7%, harmonic distortion 3%. In standby state, system regulates line voltage and harmonic distortion to ±3%.

Electro-Seal Corp., Dept. ED, 938 North Ave., Des Plaines, Ill.

Electrometer 317

Has fast response. Electrometer model E-302 has full-scale ranges covering 10^{-12} to 10^{-3} amp. Switching between ranges does not cause transients. Accuracy is ±2%, drift 0.1% per day. Response is 0.3 to 30 msec; output is 1 to 50 mv. Panel height is 3-1/2 in.

Gyra Electronics Corp., Dept. ED, Washington & Elm Sts., La Grange, Ill.

P&A: $495; stock.

Power Supply 316

Delivers 20 amp. Convection-cooled power supply in the LA series provides 0 to 34 v dc at 20 amp. Line regulation is 0.05% or 8 mv for input change from 100 to 130 v; load regulation is better than 0.10% or 15 mv, zero to full load. Panel height is 10-1/2 in.

Lambda Electronics Corp., Dept. ED, 515 Broad Hollow Road, Huntington, L.I., N.Y.

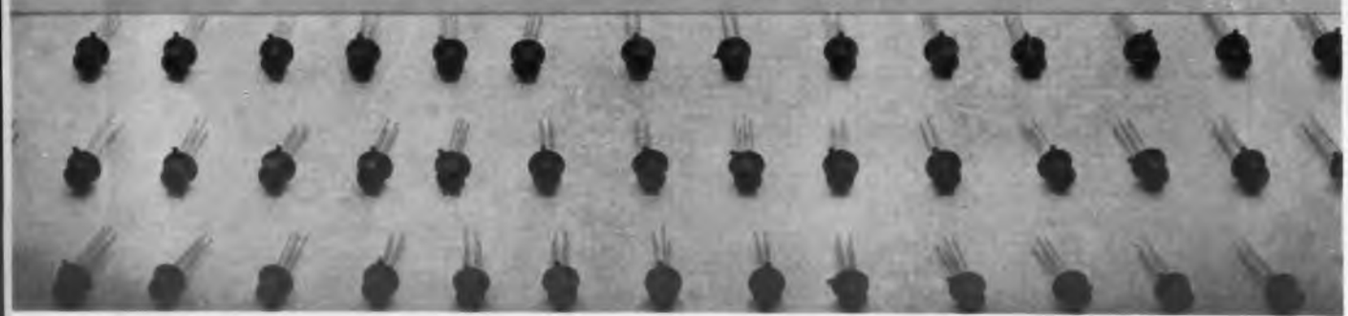
Price: $795 less meters.

MIL type

NOW... a mil-type Motorola Mesa for amplifier & oscillator applications to 1000 mc

2N700A (SIG. C.)

MOTOROLA MESA TRANSISTOR



The new Motorola 2N700A (SIG. C.) is the highest-frequency amplifier transistor yet available to mil-specs. Supplied to meet MIL-S-19500/123 requirements, this device is ideal for use in communications equipment, radar IF strips in the 60 mc range, fixed IF strips, wide-band amplifiers, precision oscillators and telemetering applications in the 200 mc band.

The 2N700A (SIG. C.) offers excellent high-frequency performance (f_t to above 1000 mc, 25 db power gain at 70 mc) and the mechanical ruggedness and extreme parameter uniformity of the Motorola Mesa structure. Units are rated for operation to 100°C.

MOTOROLA AMPLIFIER MESAS are available for a wide variety of UHF-VHF amplifier and oscillator applications.

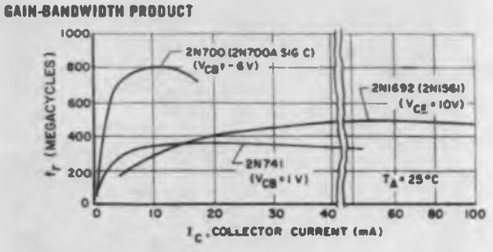
2N700 / 2N700A(SIG. C.) ..... For 40 to 1000 mc communications applications. TO-17 package with fourth lead providing high-frequency shielding.

2N741 / 2N741A ..... For communications applications up to 100 mc. 300 mW device dissipation. Power gain of 22 db at 30 mc. Excellent for video amplifiers, RF and IF amplifiers, oscillator and multiplier applications. TO-18 case.

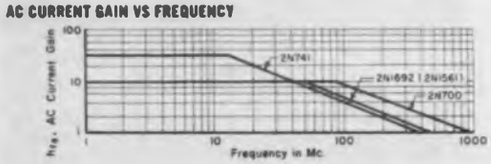
2N1692 / 2N1561 ..... For medium power transmitter applications. Provides ½ watt RF power output at 160 mc with 8 db gain. Useful from below 70 mc to 350 mc.

TYPICAL PERFORMANCE — MOTOROLA AMPLIFIER MESAS

GAIN-BANDWIDTH PRODUCT



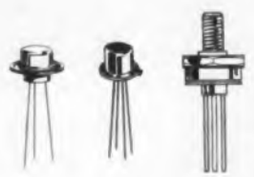
AC CURRENT GAIN VS FREQUENCY



For complete technical information — The above charts show typical performance of the Motorola Mesa amplifier transistors. Detailed specifications on specific devices may be obtained by calling your Motorola District Office, Motorola Distributor or by writing: Motorola Semiconductor Products, Inc., Technical Information Department, 5005 East McDowell Road, Phoenix 10, Arizona.

MOTOROLA
Semiconductor Products Inc.
A SUBSIDIARY OF MOTOROLA, INC
5005 EAST McDOWELL ROAD • PHOENIX 10, ARIZONA

MOTOROLA MESA TRANSISTORS



are available from these DISTRIBUTORS

BIRMINGHAM
Ack Semiconductors, Inc.
3101 Fourth Ave., So.
FAirfax 2-0588

BOSTON
Cramer Electronics, Inc.
811 Boylston St.
COpley 7-4700

Lafayette Radio
110 Federal St.
HUbbard 2-7850

BUFFALO
Summit Distributors, Inc.
916 Main St.
TT 4-3450

CAMDEN
General Radio Supply Co., Inc.
600 Penn St.
WOodlawn 4-8560

CEDAR RAPIDS
Deeco, Inc.
618 First St., N. W.
EMpire 5-7551

CHICAGO
Allied Radio Corp.
100 N. Western Ave.
TAylor 9-9100

Newark Electronics Corp.
223 W. Madison St.
STate 2-2944

Semiconductor Distributor Specialists, Inc.
5706 W. North Ave.
NAtional 2-8860

CINCINNATI
Sheridan Sales Co.
Roselawn Center Bldg.
MElrose 1-2460

CLEVELAND
Pioneer Electronic Supply Co.
2115 Prospect Ave.
Superior 1-9411

DALLAS
Texas, Inc.
4308 Maple Ave.
P.O. Box 6567
LAkeside 6-8763

DENVER
Inter-State Radio & Supply Co.
1200 Stout Street
TAbor 5-8257

DETROIT
Radio Specialties Co., Inc.
12775 Lyndon
BRoadway 2-4200

HOUSTON
Lenert Co.
1420 Hutchins
CApitol 4-2663

JAMAICA, N.Y.
Lafayette Radio
165-08 Liberty Ave.
AXtel 1-7000

LOS ANGELES
Hamilton Electro Sales
11965 Santa Monica Blvd.
EXbrook 3-0441
BRadshaw 2-9154

Kierulff Electronics, Inc.
820 W. Olympic Blvd.
Richmond 8-2444

MELBOURNE, FLA.
Electronic Wholesalers, Inc.
1301 Hibiscus Blvd.
PArkway 3-1441

MIAMI
Gulf Semiconductors, Inc.
7210 Red Road
MOhawk 5-3574

NEWARK, N.J.
Lafayette Radio
24 Central Ave.
MArket 2-1661

NEW YORK
Lafayette Radio
100 6th Ave.
WOrth 6-5300

Milgray Electronics, Inc.
136 Liberty St.
REctor 2-4400

OAKLAND
Elmar Electronics
140 11th St.
TEmplebar 4-3311

PHOENIX
Electronic Specialties Co.
917 N. 7th St.
ALpine 2-5794

SAN DIEGO
San Delco
3831 Park Blvd.
CYpress 8-6181

SEATTLE
Almac Electronics Corp.
6301 Maynard Ave.
PArkway 3-7310

WASHINGTON, D.C.
Electronic Wholesalers, Inc.
2345 Sherman Ave., N.W.
HUdson 3-5200

CANADA
Canadian Motorola Electronics Co.
105 Bartley Drive
Toronto 16, Ontario
PLymouth 9-2222

MOTOROLA DISTRICT OFFICES

BELMONT, MASS. ..... IVanhoe 4-5070
CHICAGO, ILL. ..... AVenue 2-4300
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DETROIT, MICH. ..... BRoadway 3-7171
HOLLYWOOD, CALIF. ..... HOllywood 2-0821
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CLIFTON, N.J. ..... GRegory 2-5300
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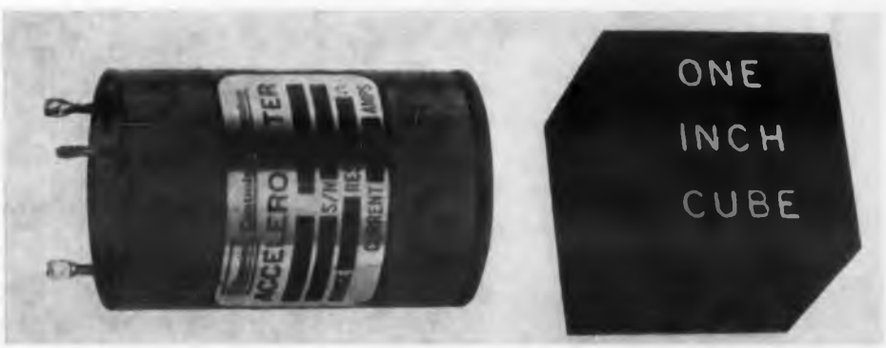
GLENSIDE, PA. ..... TUrner 7-7020
from **PHILADELPHIA** ..... WAverly 7-6144
BURLINGAME, CALIF. ..... DIamond 2-3228
SYRACUSE, N.Y. ..... GRanite 4-3321
SILVER SPRING, MD. ..... JUniper 5-4485

NEW PRODUCTS

Plug-In Regulator 310

With 5% regulation. Designed for applications where close regulation is not required, the E-1014 provides economical regulation for transistor circuits. A typical model provides 6 or 12 v at 1 amp.

Baker Manufacturing Co., Dept. ED, 5660 N. River Road, Marine City, Mich.



Axial Accelerometer 307

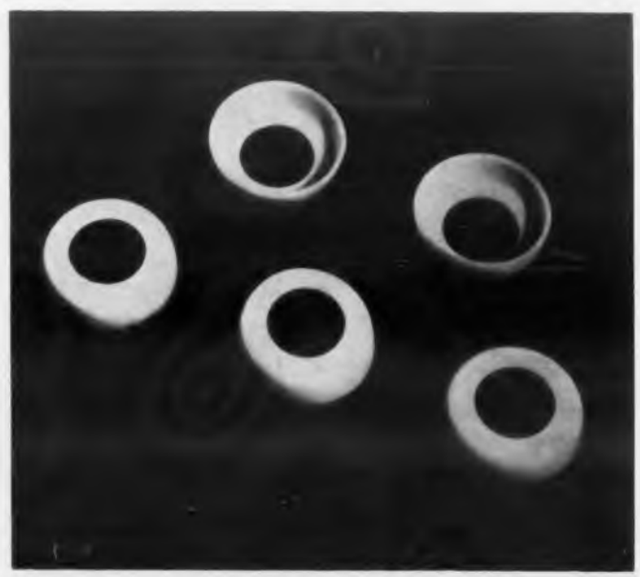
With gas damping. Model 24163 accelerometer is available in standard ranges of ±1 to ±15 g and standard resistances of 2 to 10 K. Crosstalk is 0.01 g per g plus resolution; gas damping minimizes variation over temperature extremes. Linearity, hysteresis and repeatability are 1% max each. Undamped natural frequency is 16 cps to 54 cps; damping is 0.6 ±0.1 of critical at room temperature wtih 0.15 maximum variation from −54 to +100 C.

Giannini Controls Corp., Dept. ED, 1600 S. Mountain Ave., Duarte, Calif.

Electric Furnace 309

Heats to 2,300 F. The compact Dyna-Trol electric furnace heats to 2,000 F in 1 hr, to 2,300 F in 1-1/2 hr. Constant temperature can be maintained from 300 to 2,300 deg. Gradients are indicated by thermocouples and a pyrometer. Model P76 measures 6 x 6 x 6 in.

L & L Manufacturing Co., Dept. ED, 804 Mulberry St., Upland, Chester, Pa.



End Caps 308

Made of Teflon. End caps are made for use in capacitors and other electronic components. The Teflon parts are made in a wide range of sizes and shapes. The caps are useful in electronic applications due to their outstanding electrical, thermal, chemical and sealing characteristics.

Tri-Point Industries, Inc., Dept. ED, Albertson, L.I., N.Y.

◀ FOR COMPLETE TECHNICAL INFORMATION, CIRCLE 40 ON READER-SERVICE CARD

NEW PRODUCTS

AC Regulator 861

Response is 0.05 sec. Model MTLR-1000 provides a regulated ac output that is adjustable from 110 to 120 v with an accuracy of ±0.1%. The unit uses a silicon Zener diode reference circuit and has harmonic distortion of 3% max. The static device will handle 1 kva.

Perkin Electronics Corp., Dept. ED, El Segundo, Calif.

UHF Tubes 542

For missile applications as well as use in mobile and fixed communications equipment, types 7801 and 7870 Cermolox tubes have an over-all length of 1-1/4 in. At 3,000 mc, they provide 3.2 w of cw output with 1-w driver power. They can provide 9-db gain with 50-mw driver power.

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

Electronic Voltmeter 867

Calibrated in rms voltage of a pure sine wave. Model V-100 has the voltage scale calibrated in rms voltage of a pure sine wave. It is designed for measurements of ac voltages from audio frequency level to rf level as well as hum and noise measurement. Measurements include direct reading of −72 to +52 db in 12 ranges and from 0.001 to 300 v ac over a frequency range of 10 cps to 4 mc. Internal impedance is 50 ohms.

Orion Electronic Corp., Dept. ED, 108 Columbus Ave., Tuckahoe, N. Y. *P&A: $198 ea; three to four weeks.*

Silicon Rectifiers 859

With axial leads. Series A rectifiers have current ratings up to 0.5 amp at 100 C. Maximum allowable peak reverse voltage is 50 to 600 v. Length is 0.375 in. max, diameter 0.220 max. Rectifiers are encapsulated for humidity protection. Ambient operating temperature is −55 to +125 C, with storage to 150 C.

Mallory Semiconductor Co., Dept. ED, Du Quoin, Ill.

Price: *$0.39 to $0.69 ea, 1,000 to 4,999.*

Low-Radiation Glass 841

For photomultiplier tubes. Lorad glass 7285, developed for use in radiation measuring equipment, has radioactivity of less than 10 counts per min per kg. The material also has good μv transmittance. It may be formed into bulbs up to 16 in. diameter and sealed to metals such as Dumet alloys and Sylvania #4.

Corning Glass Works, Industrial Bulb Sales Dept., Dept. ED, Corning, N. Y.

Electrostatic Charge Amplifier 851

Linearity and gain stability are 0.5% or better. The unit is designed for use with the firm's natural-quartz accelerometer for oscilloscopes, recorders and telemetry devices. Called model 560, it is line powered and occupies 5-1/4 in. of panel space.

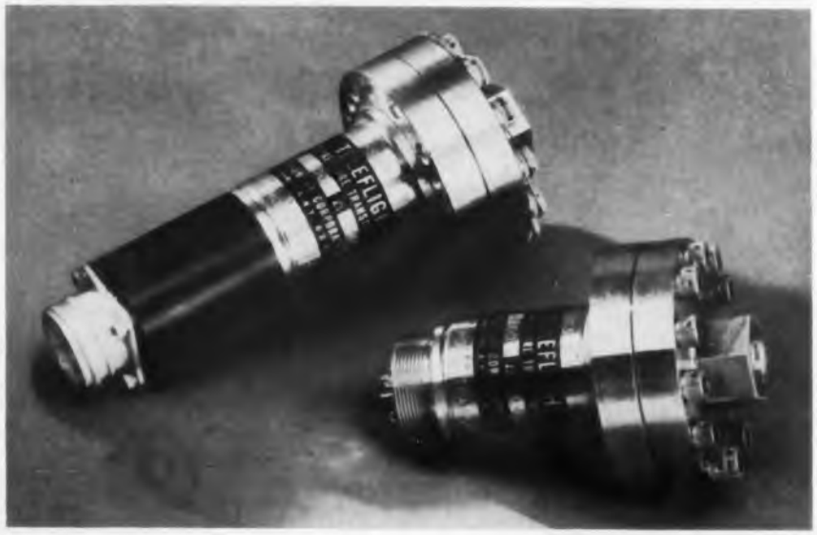
Kistler Instrument Corp., Dept. ED, 15 Webster St., North Tonawanda, N. Y.

Phase Shifter 852

Accuracy is ±1 deg; readability is 0.5 deg. Designed for applications requiring a known phase angle or the measurement of an unknown phase angle, it provides a constant output voltage continuously variable in phase from 0 to 360 deg. Designation is C03 721 018.

Kearfott Div., General Precision, Inc., Dept. ED, Little Falls, N. J.

◀ CIRCLE 41 ON READER-SERVICE CARD



Pressure Transducer 315

Measures to 200 psi. Built to withstand high acceleration and vibration, model 183 transducer measures fluid and gas pressures up to 200 psia or psig with accuracy of 0.25%. The device will handle corrosive substances, and withstands 3 times full-scale pressure without damage.

Taber Instrument Corp., Dept. ED, 107 Goundry St., North Tonawanda, N. Y.

Recording Amplifier 311

For low-level transducers. Model 114 is a chopper-stabilized amplifier used with recorders. Input impedance is 100 K. Sensitivity is 9 mv full scale, with variable gain. Output impedance is 0 to 5 K. Drift and linearity are better than 1/2%.

Rustrak Instrument Co., Dept. ED, 130 Silver St., Manchester, N. H. *Price: $110.*

Synchro Tester 314

Accurate to 3 min. Portable synchro tester model TE-2B is made for laboratory and shop testing of synchro transmitter and indicator systems. Accuracy is 3 min of angle, or 1 min after correction. A self-checking electrical zero transformer is used to adjust for temperature changes. Weight of the tester is 12 lb.

United States Gauge Div., American Machine & Metals, Inc., Dept. ED, Sellersville, Pa.

Angle Counter 312

In small package. Counter model 11646 provides readings from 000.0 to 359.9 deg with characters 1/8 in. high. Package size is 1-1/3 in. long, 3/4 in. high, and 1 in. deep. One revolution of input shaft gives 1 revolution of tenths wheel and 1 deg of angular change. Counter is for 200-rpm continuous operation.

Bowmar Instrument Corp., Dept. ED, 8000 Bluffton Road, Fort Wayne, Ind.

Zener Diodes 313

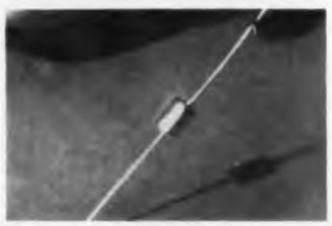
In wide voltage range. Subminiature Zener glass diodes have a voltage range of 3.3 to 30 v and are rated at 250 mw dissipation. Types QZ3.3T10 through QZ30T5 are made in 5% and 10% voltage tolerances. Zener impedance is 5 to 70 ohms. Size is 0.265 x 0.110 in. in diameter.

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

P&A: $2.60 to $4.00 in 1 to 99 quantities; from stock.

NEW PRODUCTS

Silicon Rectifiers 548



Rated at 1 ma. Double-diffused silicon rectifiers are rated for 1 ma continuous duty from 400 to 1,000 piv. They can be supplied with single-ended leads or axial leads. Case measures 1/4 x 5/16 in. Package is metal and epoxy, or hermetically sealed glass and metal.

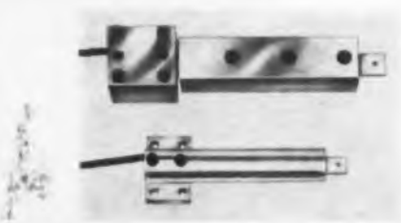
Electronic Devices, Inc., Dept. ED, New Rochelle, N. Y.

Infrared Radiometer 578

Accuracy is 0.05% in this miniature unit designed for rocket use. Ratings are: spectral band with response of 4 to 40 microns and a linearity of 5%; radiation input range of 1.75×10^{-5} to 3.5×10^{-2} w per cm^2; signal input of 2.5×10^{-3} to 5 v dc. Output impedance is 100 ohms max.

Radio Corp. of America, Missile Electronics and Controls Div., Dept. ED, 30 Rockefeller Plaza, New York 20, N. Y.

Semiconductor Load Cells 562



Output is 1 v min at capacity load. Standard cells come in ranges from ±0.5 to ±100 lb. Repeatability is better than 0.1%. Temperature compensation is about 0.01% per deg F for thermal coefficient of sensitivity.

Kulite-Bytrex Corp., Dept. ED, 50 Hunt St., Newton 58, Mass.

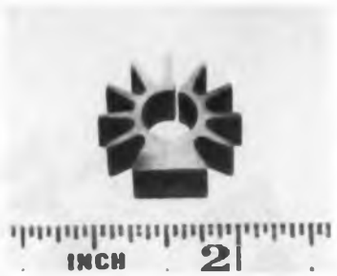
P&A: $275; 30 days.

Telemetry Receiver 586

For satellite tracking. Type 1440 fm telemetry receiver has a noise figure of 6 db. Tuning range is 130 to 140 mc. Panel meters show tuning, output level, deviation, and signal strength. Outputs are provided for spectrum display unit, frequency monitor, and signal-strength recorder.

Vitro Electronics Div., Vitro Corp. of America, Dept. ED, 919 Jesup-Blair Drive, Silver Spring, Md.

Heat Radiator 574



For TO-18 transistors, model 3AL-724 increases transistor efficiency 25% to 27% and prevents thermal runaway. The material is aluminum per QQ-A-268 and anodize per MIL-A-8625. The 8-fin base can be tapped for vertical or horizontal mounting.

The Birtcher Corp., Industrial Div., Dept. ED, 745 S. Monterey Pass Road, Monterey Park, Calif.

Synchronous Motor 552

Torque is 0.70 oz-in. Precision synchronous motor is 1-3/8 in. in diameter by 2-1/8 in. long. Made for operation at 24 v, 60 cps, motor can be supplied for other voltages to 300 v, 60 cps. At synchronous speed of 1,800 rpm, motor has starting and synchronous torque of 0.70 oz-in. Weight is 7 oz, ambient temperature range 0 to 140 F.

Thomas A. Edison Industries, McGraw-Edison Co., Instrument Div., Dept. ED, 61 Alden St., West Orange, N. J.

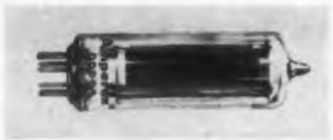
Sequency Timing Switches 569

Periods are 0 to 30 sec. Series 7000 switches have an accuracy of 0.3%. Power requirement is 1.5 w from 28 v dc. Reset is automatic. Complete circuitry for up to three times sequences is available in a single unit occupying 10.6 cu in.

Donner Scientific Co., Systron-Donner Corp., Dept. ED, Concord, Calif.

NEW PRODUCTS

Cadmium Sulphide Cell 575



Dark current is 2.5 μa and average cell current is 10 ma with 5 ft-c illumination. Type ORP90 miniature photoconductive cell actuates relays without an amplifier and has a 7-pin base. Dissipation is 1 w. Type ORP for large relays has a cell current of 6 ma avg and a dissipation of 0.2 w.

Amperex Electronic Corp., Semiconductor and Special Purpose Tube Div., Dept. ED, 230 Duffy Ave., Hicksville, L. I., N. Y.

Servo Motor 550

With integral brake. Size 11 servo motor has integral friction brake controlled by an electromagnet. The brake stops and holds the rotor at a desired position. Braking time is 8 revolutions max measured from a no-load speed of 6,200 rpm. Motor operates on 115 v, 400 cps.

Thomas A. Edison Industries, McGraw Edison Co., Instrument Div., Dept. ED, 61 Alden St., West Orange, N. J.

Crystal Discriminator 555

Center frequency is 10.7 mc and peak-to-peak bandwidth is 15 kc in model D-1020. Linearity is ±5 kc within 5% of a straight line, stability is ±0.005% of center frequency from −20 to +80 C, input impedance is 10 K and output impedance is 500 K. The unit occupies less than 1 cu in.

The Keystone Electronics Co., Dept. ED, 65 Seventh Ave., Newark 4, N. J.

Computer Relay 564

For 100,000,000 operations, these transistor circuit relays operate in less than 750 μsec and have polarized driving systems with center-tapped driving coils. Driving voltage is 20 v. Models include dpdt and spdt.

James Electronics Inc., Dept. ED, 4050 N. Rockwell St., Chicago 18, Ill.
P&A: $25 up; from stock.

Transistor Test Equipment 576

For 8-parameter tests, the Virtue-201 records findings on punch cards in 12.5 sec. About 275 transistors can be processed and recorded per hour. The unit is designed in accordance with advanced computer techniques. A 20-socket magazine and life-test racks are also available.

Philco Co., Lansdale Div., Dept. ED, Lansdale, Pa.

Bonding Machine 549

Is fully automatic. Model SP-2 thermal-compression, nail-head bonding machine is complete with microscope, illuminator and temperature control unit. An automatic cutting torch assures gold ball uniformity. Wire sizes down to 0.0005 in. have been bonded to silicon and metallized surfaces.

Electroglas Inc., Dept. ED, 841 Warrington Ave., Redwood City, Calif.

Motor Generator 554

Range is 400 to 500 cps. This revolving-field unit has ±1% regulation. It is rated at 2.5 kva with an 80% pf, has 14 poles and develops a top frequency of 3,428 rpm. The motor is 5 hp, three phase, 220 v. The unit measures 56 x 26 x 22 in.

Kato Engineering Co., Dept. ED, Mankato, Minn.

NEW PRODUCTS

Operational Amplifier 862

Less than 2 mv drift. Model 1704 transistorized dc operational amplifier has a range of dc to 250 kc. Drift is less than 2 mv from 0 to 50 C. The unit delivers 10 v into a 1-K load with gains of −1 to −100. Plug-in construction provides simple installation.

Melcor Electronics Corp., Dept. ED, 48 Toledo St., South Farmingdale, L. I., N. Y.

P&A: $375 to $450; 30 days.

Edgewise Meters 863

Dc and ac types. Long-scale, 3-in. edgewise dc and ac meters, model MDE-3, are for use in control console and equipment applications under severe environmental conditions. The unit, hermetically sealed, is available in a broad selection of dc current and voltage ranges and rectifier-type ac styles. Case size of 3.7 x 6.1 x 1.3 in. allows in-line read-out mounting.

Minneapolis-Honeywell Regulator Co., Dept. ED, Grenier Field, Manchester, N. H.

Availability: 60 days.

Multiturn Potentiometer 840

With infinite resolution. Precision multiturn potentiometer has linearity of ±0.005% and infinite resolution. Model MJ 20-10 is 2 in. in diameter, model MJ 30-10 is 3 in. Both accommodate taps in any location.

Litton Industries Potentiometer Div., Dept. ED, 200 E. Third St., Mt. Vernon, N. Y.

◀ CIRCLE 47 ON READER-SERVICE CARD

Crystal Oscillator 865

Range is 1 kc to 100 mc. Model K3 crystal oscillator is designed for frequency requirements from 1 kc to 100 mc. Temperature range is −55 to +95 C. The case measures 1-1/2 x 1-3/4 x 1 in. Specifications are: input, 28 v dc; output, 1 v peak-to-peak into 100 ohms to 1 mc, 1 v peak-to-peak into 50 ohms to 100 mc.

Monitor Products Co., Dept. ED, 815 Fremont Ave., South Pasadena, Calif.

Availability: *3 to 4 weeks.*

Limit Stops 849

Adjustable from 0 to 14,400 deg, these mechanical devices are BUORD sizes 5 and 8. Repeatability is within 3 min of arc. Torque rating is 80 oz-in. on the size 5 and 160 oz-in. on the size 8. They meet MIL-E-5272C.

Northfield Precision Instrument Corp., Dept. ED, 4400 Austin Blvd., Island Park, L. I., N. Y.

Power Supply 866

Transistorized. Dc power supply, model TR-18-3 has a power output of 0 to 18 v, 0 to 3 amp. Specifications include: load regulation, ±0.03%; ripple, 2-mv peak-to-peak; response time for full load step, 50 μsec; automatic load removal for sustained overloads. Either positive or negative output terminal may be grounded, or the entire output may be floated 500 v above or below ground.

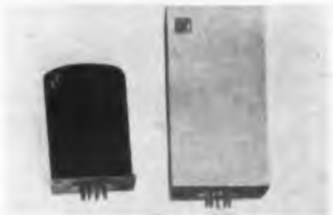
NJE Corp., Dept. ED, 20 Boright Ave., Kenilworth, N. J.

Price: *$249 ea.*

CIRCLE 48 ON READER-SERVICE CARD

NEW PRODUCTS

Magnetic Regulator 869



Control power in kw. The "Ortho-Trig" magnetic regulator series is for the control of silicon controlled rectifiers. They are capable of firing and controlling pomer in kw. The circuit controls the leading edge of the silicon controlled rectifier gate voltage wave over a range of 0 to 180 deg. Control is accomplished by varying an impedance or voltage in the control circuit.

Ortho Filter Corp., Dept. ED, 7 Paterson St., Paterson, N. J.

Miniature Push-Switch 868

Over-all length is 1-3/4 in. This push-switch can be used individually or in interlocked, ganged groups. The individual unit measures 1-3/4 in. in length and occupies less than 1 in. behind the panel. Silver alloy contacts provide operation of over 100,000 cycles at rated load. Rated at 5-amp resistive or 3-amp inductive, the switch is a snap-action type. Versions available are: spdt; dpdt and 6pdt.

Pepco, Inc., Dept. ED, 2080 Placentia Ave., Costa Mesa, Calif.

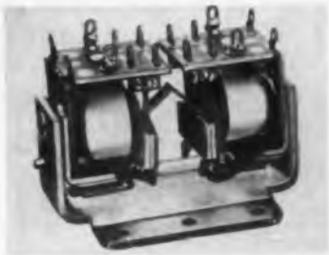
Impedance Plotter 855

Range is 10 to 3,000 mc. The Smith chart plotter displays impedance as a continuous function of frequency with a high degree of accuracy. The vswr uncertainty is as low as 1.01. The oscilloscope trace may be directly photographed or an X-Y recorder may be used.

Dielectric Products Engineering Co., Dept. ED, Raymond, Me.

◀ CIRCLE 49 ON READER-SERVICE CARD

Latch-In Relay 858



For ac and dc. Latch-in relay class 88L has 2 complete class 88 relays, with interlocking latch-in levers, mounted on a common base. When the armature on one relay is pulled in it is latched by the interlocking levers while the other armature drops out. The independent relays may be equipped with contact combinations to 3pdt and contacts rated to 10 amp.

Magnecraft Electric Co., Dept. ED, 3350D W. Grand Ave., Chicago 51, Ill.

Price: *$9.50 to $13.50 ea, 1 to 9.*

Tachometer 860

Measures to 2,500 rpm. Electronic tachometers model 101, for speeds 0 to 60 rpm, and model 102, for speeds to 2,500 rpm, provide fast response for read-out of shaft speeds. Standard panel measures 4-3/4 x 6-1/2 and has a 3-in. meter.

Rampe Manufacturing Co., Dept. ED, 14915 Woodworth Ave., Cleveland 10, Ohio.

Bead-Chain Timer 844

For complex sequencing problems, this electromechanical device uses a bead chain, not unlike a simple key chain. To establish the cam action which actuates the switch at a certain time, large beads are applied to the chain. It accurately handles microsecond timing.

Eagle Signal Co., Div. of the Gamewell Co., Dept. ED, 202-20th St., Moline, Ill.

Availability: *Available on a custom basis.*

CIRCLE 50 ON READER-SERVICE CARD ▶

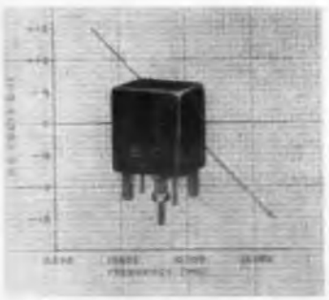
NEW PRODUCTS

DC Power Supply 546

Output is 12 v. Model PS-30 power supply provides 12 v at 30 amp with less than 1% ripple. Input is 115 v, 50 to 60 cps. Up to 50 amp may be supplied intermittently. Otuput impedance is low.

Electro Products Laboratories, Dept. ED, 4500 N. Ravenswood Ave., Chicago 40, Ill.

Crystal Discriminator 547



Has high linearity. Crystal discriminator CD-106B has a center frequency of 10.7 mc and excellent linearity over a range of ±5.0 kc. Distortion is less than 1.5%. Output is 2 v peak-to-peak over ±5.0 kc; ambient temperature range is −55 to +85 C.

Electronic Laboratories Corp., Dept. ED, 4221 Spencer St., Torrance, Calif.

Corner Reflector 553

Is balun-fed. Wide-band 80-deg corner reflector, model XCR108/216 is balun-fed for maximum dipole efficiency and balance pattern. Electrical characteristics are: frequency range, 108 to 216 mc; gain, 9 to 11 db over a tuned half wave dipole; power rating, 500 w, vswr less than 2 to 1; polarization, horizontal or vertical.

Telrex Laboratories, Dept. ED, Asbury Park, N.J.

CIRCLE 916 ON CAREER INQUIRY FORM, PAGE 253 ➤

An important message for Scientists and Engineers

SCIENTISTS AND ENGINEERS:

Follow-On Atlas Programs Mean New, Long-Range Opportunities.

Now operational, the Atlas weapon system stands as a unique symbol of scientific, engineering and military achievement. The design, development and testing of this reliable missile was an undertaking of immense complexity.

Scientists and engineers at Convair/Astronautics worked constantly at the most advanced state of the various arts involved. Boldly, they introduced and proved entirely new concepts of rocketry, and in record time they developed the Atlas.

The same depth of imagination and technical daring is now at work modifying and adapting this sophisticated machine for a variety of civilian and military space missions. Dozens of specialized orbiting and inter-planetary vehicles will depend upon the power of Atlas to thrust them into space.

These programs reach far into the future and require the skills of highly resourceful engineers and scientists in many technical disciplines.

Atlas is the free world's first intercontinental ballistic missile; the first missile to travel more than 9,000 miles across the earth's surface; the only one to lift itself into orbit. Atlas marked the first use of swivel engines for directional control and it was the first to use airframe skins as fuel cells.

Many more "firsts" lie ahead for this reliable rocket. If you are the sort of inventive engineer or scientist who can contribute ideas and solutions to the problems surrounding the mastery of space, you and Convair/Astronautics have a common interest.

You'll find most of the details on this and the following page, plus a convenient inquiry card. If the card has been removed, or if you wish to furnish or request more detailed information, write to Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Mail Zone 130-90, Convair/Astronautics, 5659 Kearny Villa Road, San Diego 12, Calif. (If you live in the New York area, please contact Mr. J. J. Tannone, Jr., manager of our New York Placement Office, 1 Rockefeller Plaza, CIrcle 5-5034.)

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CONVAIR / ASTRONAUTICS

CONVAIR DIVISION OF GENERAL DYNAMICS

ENGINEERS AND SCIENTISTS

Convair Astronautics is located in San Diego, California, the third fastest growing community in the United States. It is situated 10 miles north of the Mexican border and a little over 100 miles south of Los Angeles.

Immediate openings exist in the following areas:

SCIENTISTS & ANALYTICAL ENGINEERS with Ph.D or Sc.D for electronics and physical research; computer analysis and application; and instrumentation development.

ELECTRONIC DESIGN & TEST: communication systems and data transmission design; logical circuitry; automatic control systems; and electronic packaging. BSEE plus appropriate experience required.

MECHANICAL DESIGN: BSME or AE for pneumatics, hydraulics, and fluid systems design and test. Also missile GSE and missile structures designers.

RELIABILITY: BSEE, ME, or AE to perform reliability analyses and test both in San Diego and offsite bases.

ENGINEERING PSYCHOLOGISTS & INDUSTRIAL ENGINEERS with a hardware background to develop manning documents, perform task analysis, and develop tables of organization and equipment for the Atlas Weapons system.

ENGINEERING WRITERS with 2 years college and 3 years experience in preparation of TCTO's; Operations, Maintenance, and Overhaul manuals.

BASE ACTIVATION: Design or liaison engineers with BS in ME or EE and experience in electrical or mechanical systems are required for liaison work at missile launching complexes, or design support work on launch control equipment, propulsion systems, automatic programming and missile checkout equipment operations. Assignments are at Salina, Kansas; Lincoln, Nebraska; Altus, Oklahoma; and Abilene, Texas. Also some openings in San Diego.

FLIGHT TEST: BS in AE, ME or EE for analysis of flight test data, and systems performance analysis leading to flight test reports. Background in instrumentation and testing desired.

If you desire to become part of this great team, we urge your prompt inquiry on the attached Engineering Placement Inquiry.

Technical openings also exist in other specialties. Write Mr. R. M. Smith, Industrial Relations Administrator - Engineering, Dept. 130-90, Convair Astronautics, 5659 Kearny Villa Road, San Diego 12, California. (If you live in the New York area, please contact Mr. J. J. Tannone, Jr., manager of our New York placement office, CIrcle 5-5034.)

CONVAIR / ASTRONAUTICS

CONVAIR DIVISION OF GENERAL DYNAMICS

ENGINEERING PLACEMENT INQUIRY

This card may be folded and sealed or stapled and mailed in complete confidence. It will enable the professional staff at Convair/Astronautics to make a preliminary evaluation of your background. A personal interview can be arranged in your city by appointment. Every completed inquiry will be acknowledged.

NAME _____

STREET ADDRESS _____

CITY & STATE _____ TELEPHONE _____

NEAREST MAJOR CITY (IF APPLICABLE) _____

COLLEGE GRADUATE YES ☐ NO ☐ DEGREE BS ☐ MS ☐ PHD ☐

YR ____ YR ____ YR ____

FOLD

MAJOR SUBJECT:

AERONAUTICAL ENGINEERING ☐ MECHANICAL ENGINEERING ☐

ELECTRICAL ENGINEERING ☐ MATHEMATICS ☐

ELECTRONIC ENGINEERING ☐

CIVIL ENGINEERING ☐ PHYSICS ☐

OTHER _____

EXPERIENCE:

PRIMARY SPECIALTY _____ YRS _____

SECONDARY SPECIALTY _____ YRS _____

ADDITIONAL COMMENTS, IF ANY, CONCERNING YOUR JOB INTERESTS:

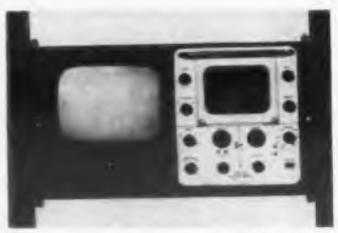
PLEASE SEND CONVAIR/ASTRONAUTICS RECRUITMENT BROCHURE ED 5 ☐

Resistivity Tester 413

For semiconductors. The Crystal Resistivity Meter, an ac instrument, measures bulk and slice resistivity of semiconductors. Bulk or slice modes can be selected by a switch. An adapter is available for measuring 0.007 to 0.37 in. slice resistivities. Ten full-scale ranges from 0.01 to 300 ohm per cm are covered with one switch.

Texas Instruments, Incorporated, Dept. ED, Houston 6, Tex.

Waveform Monitor 407



For TV broadcast. The model 527 5-in. waveform monitor is available in rack-mount and portable types. It provides three calibrated time-base rates. 0.125 h per cm, 0.025 h per cm with 5X magnifier, and 0.005 h per cm with 25X magnifier. A 4-kv accelerating potential over a full 6-cm by 10-cm viewing area assures bright displays.

Tektronix, Inc., Dept. ED, Box 500, Beaverton, Ore.

***Price:** $1,000, portable; $1,075, rack mount.*

Punched Card Switch 408

Provides 1,000 automatic switches. The model K-1000 punched card switch has a separate switch for each of 1,000 hole positions. A card is inserted, operating lever pushed, and punched holes close switches. Volume of unit is less than 0.5 cu ft. Highly applicable to automatic machine control.

The Taurus Corp., Dept. ED, Academy Hill, Lambertville, N.J.

◀ CIRCLE 916 ON CAREER INQUIRY FORM, PAGE 253

NEW PRODUCTS

Time Switch 425

Can provide bell signal. Series 45,000 and 46,000 "Mark-Time" switches have a maximum circuit capacity of dpdt. They use a 15-amp 125 v ac switch. If the knob is turned left, the switch is off-on. If turned right, a timing function is supplied. The bell is optional. Timing ranges from 60 sec to 12 hr.

M. H. Rhodes, Inc., Dept. ED, Hartford, Conn.

Nonpolarized Capacitors 411

Offered in complete line. The type 151D Tantalex capacitors are solid-electrolyte tantalum units of nonpolar design. They can be used full rated up to 85 C. Many ratings are available in voltages from 6 to 35 v dc. Small unit in illustration is 0.11-μf 35-v dc type, measuring 9/64-in. in diameter by 9/16 in.

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

Single Sideband Receivers 469

Airborne hf units. Model HC-130 is for air-to-ground transmissions on LSB, USB and compatible AM; model HC-150 is for fixed point-to-point communications. The first unit receives six frequencies in 1-kc steps simultaneously in the range of 2 to 30 mc. The other offers selection of 10 channels in the same range.

Hughes Aircraft Co., Dept. ED, P. O. Box 90-902, Los Angeles 45, Calif.

P&A: $80,000 and $40,000; 90 days.

Etched Circuits 454

Replace wire harnesses. Flexible etched circuits are useful in replacing wire harnesses in curved or bent areas. Circuits are backed by Teflon, Kel-F, or polyester materials. The smaller, lighter circuits reduce assembly time and chance of error. Materials used resist chemical action.

U. S. Engineering Co., Dept. ED, 13536 Saticoy St., Van Nuys, Calif.

Servomotors 510

Size 8, 6-pole, 400-cps units have a moment of inertia of 0.147 g-cm². Time constant is 0.00613 sec, temperature range is −55 to +125 C and stall torque is 0.22 oz-in. Weight is 1.25 oz and diameter is 0.75 in. Units meet MIL-E-5272.

Wright Machinery Co., Div. of Sperry Rand Corp., Dept. ED, Durham, N. C.

P&A: $40 up; 30 to 60 days.

Solid-State Converter 513

Analog-digital-analog converter model 430 A-D-A makes 14-bit conversions at rates to 35 kc. Digital outputs are available in parallel form at the end of the cycle. Basic speed is 1.5 μsec per bit plus 4.5 μsec per conversion. Accuracy is ±1% of input voltage. Dynamic range is above 80 db.

Texas Instruments, Incorporated, Dept. ED, P. O. Box 6027, Houston 6, Tex.

Phenolic Laminate 486

Has high punching stability. Insurok T-755 is a paper base, phenolic laminate which has stable punching properties over a wide range of low temperatures. Other features: long shelf life; high solvent resistance; good reproducibility. It has many applications for printed circuits, components parts, terminal boards. Standard sheet sizes 36 x 42 in. unclad. Also 37 x 37 and 37 x 42 in. copper clad.

The Richardson Co., Dept. ED, 2724 Lake St., Melrose Park, Ill.

CIRCLE 56 ON READER-SERVICE CARD ➤

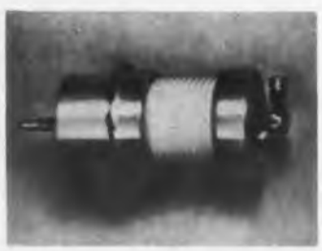
NEW PRODUCTS

Pulse Height Analyzer 415

Provides 400 channels. The model 404 analyzer uses a magnetic-core-memory system and stores data in parallel binary-coded-decimal form. Data can be read out directly into a printer. It accommodates four detectors at the same time. A companion unit, model 500, permits high-speed paper tape printing. The units operate from 110 v ac.

Technical Measurement Corp., Dept. ED, 441 Washington Ave., North Haven, Conn.

Switch Tube 405



Efficiency is 95%. The L-3408 is made for high-voltage, high-switch-rate floating deck modulator applications. With current characteristics similar to a pentode, the switch tube has collector voltage of 150 kv max, collector current 20 amp peak, collector dissipation 10 kw max. Length is 20 in., OD 8 in., weight about 45 lb.

Litton Industries, Electron Tube Div., Dept. ED, 960 Industrial Road, San Carlos, Calif.

Limit Switch 406

Has neon indicator lamp. A built-in indicating lamp in model 1LS501 flashes when switch is operated. Lamp can be installed to make contact with either the normally open or normally closed contacts. Switch is rated at 10 amp, 1/2 hp, at 120 v ac. Replaceable element has 2-circuit, double-break contact arrangement.

Minneapolis-Honeywell Regulator Co., Micro Switch Div., Dept. ED, Freeport, Ill.

P&A: $20; stock.

Variable Transformer 511

Ratings are 0.28 to 4.8 kva. Series IV units are built for a 120-v, 50-cps input and provide an isolated output of 0 to 140 v ac. For electrical under- and over-voltage testing, units come in 3 sizes, all portable, cased and metered.

Standard Electrical Products Co., Dept. ED, 2240 E. Third St., Dayton, Ohio.

Magnetic Tape Heads 485

Offered in R&D kit. The DD-6-1 kit contains sixteen 1/4 and 1/2 track heads, both in stereo and mono types. Electronics and mountings are varied. These M/M tape recording heads are enclosed in a 20-drawer cabinet, 9 x 10 x 6 in.

Robins Industries Corp., Dept. ED, Flushing, N.Y.
P&A: $309; from distributors.

Electrolytic Capacitors 505

Cases are very small, ranging from 3/16 to 1/2 in. in diameter and from 1/2 to 1-1/2 in. in length. Range is 1 to 450 μf. Uses are in electronic timing and tracking devices, missiles and computers telemetry and radio receivers. Units are type NLW and NLP.

Cornell-Dubilier Electronics Div., Federal Pacific Electric Co., Dept. ED, 50 Paris St., Newark 1, N. J.

Proximity Limit Switch 500

Operating remotely, the CR115 D switch senses nonferrous materials up to 1/2 in. and ferrous material up to 1 in. away. All transistorized circuitry is self-contained in the operating head. Rating is 30 v dc, input; 30 v dc at 250 ma, output. Repetitive accuracy is 0.005 in.

General Electric Co., Dept. ED, Schenectady 5, N. Y.

CIRCLE 59 ON READER-SERVICE CARD ▶

NEW PRODUCTS

Pressure Transducer 526

Ranges are 0 to 5 through 0 to 5,000 psi, for measuring absolute and gage pressures. Type P707TC is for aircraft, space probes and ballistic missiles. The gage model requires 5-v excitation and the absolute model, 7 v. They have outputs of 25 and 35 mv. Combined error is less than ±0.75% full scale.

Stathan Instruments, Inc., Dept. ED, 12401 W. Olympic Blvd., Los Angeles 64, Calif.

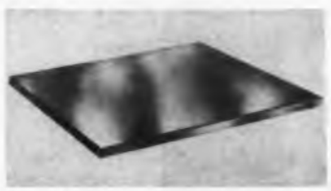
Mylar Capacitors 460

Are thoroughly tested. All units in this line of Mylar capacitors are checked during manufacture for dielectric strength, insulation resistance, capacitance, and dissipation factor. Tape-wrap units from 0.001 to 1 μf are made in ratings of 100, 200, 400 and 600 wvdc, tolerances from 1% to 20%; epoxy-dipped, flattened units range from 0.01 to 0.33 μf, 50 wvdc.

Midwec Corp., Dept. ED, 601 S. Jason St., Denver 23, Colo.

Availability: 3 weeks.

Delay Line 519



Has high resolution. Magnetostrictive delay line model 165 has fixed delay time of 5 to 6 msec. Input pulse width is 0.5 μsec, prf 1 mc. Signal-to-noise ratio is 10:1 min, insertion loss about 60 db. Input impedance can vary from 50 to 1,500 ohms while output impedance is fixed at 1 K.

Deltime, Inc., Dept. ED, 139 Hoyt St., Mamaroneck, N.Y.

Magnetic Head 456

Is completely encapsulated. Type 1580 magnetic recording and reproducing head is a compact, encapsulated unit with smooth response and low hum pickup. Inductance is 3 mh, impedance 20 ohms at 1 kc. Head is available with 1/2-mil or 1/4-mil gap.

Westrex Corp., Recording Equipment Dept., Dept. ED, 6601 Romaine Ave., Hollywood 38, Calif.

Events Counter 527

For data processing, missile range applications and other sequential series of events, the EMC-1 indicates from −999 min, 60 sec through 000:00 to −999 min and 60 sec. It can be expanded to hours, days, etc. Outputs are available for remote recorders.

Telemetrics, Inc., Dept. ED, 12927 S. Budlong Ave., Gardena, Calif.

Availability: 60 days.

Dip-Solder Machine 416

One printed circuit every 17 sec. This automated straight-line machine dip-solders printed circuit boards at a cycle rate of one each 17 sec. It avoids hand or semimanual fluxing operations as well as bridging and dross problems.

Snyder Corp., Dept. ED, 3400 E. Lafayette, Detroit 7, Mich.

RF Chokes 520

In 26 types. Video peaking coils of the 1300 series range in inductance from 20 μh to 950 μh. All but 3 are wound on phenolic forms; Nos. 1307 and 1313 are on 22-K resistors, No. 1310 on a 30-K resistor. Solid wire leads are 1-1/2 in. long.

Delta Coils, Inc., Dept. ED, 1128 Madison Ave., Paterson 3, N.J.

Availability: From stock.

If you want ELECTRONIC DESIGN to reach you without interruption mail your renewal form now!

NEW PRODUCTS

Digital Conversion Switch 518

Offers additional codes. New models in the series 7300 and 7500 line of Digiswitches expand conversion capabilities. Digital input fingerwheels with 8, 10, 12, or 16 positions can now convert to one of 18 different coded electrical outputs.

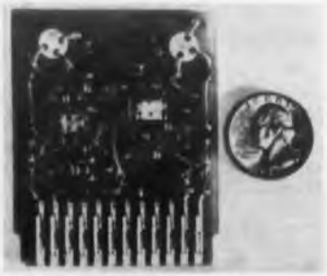
The Digitran Co., Dept. ED, 660 S. Arroyo Parkway, Pasadena, Calif.

Turret Terminal Riveter 508

Speed is 2,000 per hr for inserting and setting all makes of terminals and base pins. Called model 900, the unit is suitable for setting terminals in printed-circuit boards. It has a 1/3-hp, 110-v ac motor and is operated by an electric footswitch.

Eyelet Tool Co., Dept. ED, 31 Carleton St., Cambridge 42, Mass.

Digital Modules 516



Operate at 300 kc. Solid-state digital modules capable of operating at 300 kc include flip-flops, inverters, clock pulse shapers and clock amplifiers. Modules are 2.75 x 2.175 in. and can be spaced on 0.375 in. centers.

Dynamic System Electronics Corp., Dept. ED, 2001 N. Scottsdale Road, Scottsdale, Ariz.

Dynamic Servo Analyzers 492

For missile and aircraft systems, the DSA series combines functions of signal generation, dynamic servo-response analysis and data presentation. Frequency-response test time is the time required for one cycle plus 1/2 sec.

Giannini Controls Corp., Dept. ED, 1600 S. Mountain Ave., Duarte, Calif.

Multiplier Package 517

For analog computers. Miniature, solid-state electronic multiplier is packaged in a plug-in unit for 3/4-in. terminal spacing. Unit offers 4-quadrant multiplication, 2-quadrant division, or 2-channel squaring. Case size is 3 x 2-1/2 x 2 in. Designation is model 3732P.

Donner Scientific Co., Dept. ED, Concord, Calif. *P&A: $350; 30-day delivery.*

Frequency-Standard Amplifier 478

Rf outputs are 3.25 to 283.5 mc. Model 500 has a nominal rf output level of 1 w into 50 ohms. Continuous coverage of useful harmonics is 42 to 10,000 mc. Frequency stability is 0.0001% for 1 min and 0.002% for 2 hr or per deg C.

PRD Electronics, Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N. Y.

Silicon-Oxide Capacitors 525

Operating temperature to 300 F. The OXSIL units are for use in digital computers and other applications requiring stable capacitance. Features include high insulation resistance, low dissipation factor and low self-inductance.

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

Time-Standard System 474

With vlf receiver, model 399 permits calibration and measurement of local frequency sources to an accuracy of a few parts in 10,000,000. The equipment is for phase-locked detection of WWVL, NBA and GBR signals. Any station in the range of 14 to 25 kc can be selected.

Textran Corp., Dept. ED, P. O. Box 9207, Austin 17, Tex.

P&A: $4,750; 60 to 90 days.

NEW PRODUCTS

Filters 592

For data-processing uses, these filters eliminate electrical feedback or back circuits and prevent interference with adjacent circuits. The Delta type has a load rating of 2. The Gamma has a load rating of 12.

Raytheon Co., Panel Wires Inc., Dept. ED, 213 E. Grand Ave., South San Francisco, Calif.

Machine Monitors 593

Range is 2 cps to 10 kc in series 18 monitors. They can be used with any machine or process in which off-normal conditions can be detected in frequency changes or changes in amplitude of signals. The unit is powered by 12 v dc.

RayData Corp., Dept. ED, Columbus, Ohio.

Test Jack 594

Leakage path is 0.187 in. The SKT-27 is rated at 2,000 v rms at sea level; it accepts test probes 0.45 in. long and 0.093 in. in diameter. Temperature range is −55 to +200 C.

Sealectro Corp., Dept. ED, 610 Fayette Ave., Mamaroneck, N. Y.

◀ CIRCLE 64 ON READER-SERVICE CARD

Running Time Meter 512

For use with radar and other ground-support equipment, this 120-v, 400-cps unit meets applicable military specifications. It is claimed to provide high accuracy and long life.

Stewart-Warner Corp., Dept. ED, 1826 Diversity Parkway, Chicago 14, Ill.

DC Microammeter 488

Rating is 50 μa. The unit can be supplied to operate from 120 v ac at 50 to 400 cps or from a 12-v battery. It can be used with photoelectric cells, vibration pick-ups, thermocouples, phototronic devices and audiometers. It stands temperatures of −20 to +120 F.

Esterline Angus Instrument Co., Inc., Dept. ED, 1201 Main St., Speedway, Ind.

Inertial Switch 595

Subminiature self-locking, resettable device performs from 5 to 25 g's, from 25 to 200 msec. Factory preset, model 1056 is designed for missiles, space vehicles, etc. It is impervious to salt, spray, sand, dust and humidity, and has a minimum life of 25,000 cycles.

Sanders Assoc., Inc., Instrument and Controls Div., Dept. ED, 95 Canal St., Nashua, N. H.

CIRCLE 65 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Decade Amplifier 530

Consisting of four amplifiers, this unit occupies no more space than one. Two-stage feedback circuits with 20-db gain are used, allowing the units to be used separately or in cascaded combinations with gains of 40, 60 or 80 db. Push-pull operation may be used. A regulated power supply is included.

Prenco, Inc., Dept. ED, 246 Park Ave., Garden City, L. I., N.Y.

Switching Transistor 483

Total switching time 46 nsec. Type 2N783 is claimed to be the world's fastest silicon switching transistor. Turn-on and turn-off times are 16 and 30 nsec, for a total of 46 nsec. The unit combines the advantages of mesa construction with epitaxial manufacturing. A similar unit, 2N784, has extremely low saturation voltage.

Sylvania Electric Products, Inc., Dept. ED, 730 3rd Ave., New York 17, N.Y.

P&A: 1 to 99 at $22.50; from distributors.

DC-DC Miniature Translator 531

For measuring pressure or acceleration in airborne or laboratory telemetry systems, the A-801 is for use with variable permeance or variable reluctance transducers. Power required is 6 to 12 v dc. At an input of 9 v ±33%, the output changes 0.2% or less.

Physical Sciences Corp., Dept. ED, 389 N. Fair Oaks Ave., Pasadena, Calif.

Frequency Meters 480

RF peak pulses are 0.5 mw to 50 w. The cw input range is 5 mw to 1 w and the pulse input is 250 to 10,000 pps. Models 560 and 560-S1 have ranges of 2.4 to 3.4 and 2.7 to 3.7 kmc. They are calibrated precision units.

PRD Electronics, Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N. Y.

Magnetic Reed Switches 528

Ratings are 12 va max, up to 1/2 amp resistive, up to 250 v ac. Contact resistance is 40 to 60 milliohms; lead resistance is 40 milliohms. Body diameter is 1/8 in., body length is 3/4 in. and over-all length is 1-1/2 in. Rated for 5,000,000 operations, the unit is designated type MRG-1.

Hamlin, Inc., Dept. ED, Lake Mills, Wis.

Modular Switch 484

Permits 96-button array. The modular construction of the General-Purpose Pushbutton Switch permits the use of two or more pushbuttons in any array. The switch is momentary or interlocked and can be remotely cleared. Each button represents an 8pdt or a 4dpdt switch; other combinations are available. Rating is 0.5 amp at 24 v dc or 1 amp at 120 v ac.

Special Products Div., Telex, Inc., Dept. ED, 1633 Eustis St., St. Paul 1, Minn.

Device to Secure Wires 529

For use on harness boards of all types, Wiretainers can be made to hold each wire with a single motion until the wires are ready for lacing. A narrow gage type is offered for wires of 0.01 to 0.04 in. and a broad gage for wires of 0.045 to 0.08 in.

Holtronics, Div. of Holister Spring Coil Co., Inc., Dept. ED, 7100 Avalon Blvd., Los Angeles 3, Calif.

Vertical Sensing Element 497

Sensitivity is 20 ±3 mv at 1 arc min. Linearity is within ±10 mv up to 3 arc min. Excitation is 3 v at 400 cps, single phase. Voltage output is 150 mv at 30 arc. The unit can be used to initiate self-alignment of a gyro platform. Type is C70 1806 002.

Kearfott Div. of General Precision, Inc., Dept. ED, 1150 McBride Ave., Little Falls, N. J.

NEW PRODUCTS

Compression Accelerometer 522

Sensitivity is 50 mv per g. Compression accelerometer model 304 is made for general shock and vibration work under severe environments. Frequency response is flat within ±5% from 0.09 cps to 10 kc; resonant frequency is 55 kc. Range is 0.02 g to 40,000 g. Amplitude linearity is ±1%, operating temperature ranges are from −65 F to +350 F and +500 F.

Columbia Research Laboratories, Dept. ED, MacDade Blvd. & Bullens Lane, Woodlyn, Pa.

P&A: $150.00 to $127.50; 2-week delivery.

Planar-Epitaxial Transistor 507

Collector saturation voltage is 0.18 v max at 10-ma collector and 1-ma base current. At 200-ma collector and 20-ma base, it has a saturation voltage of 0.7 v. Designated type 2N914, it is a logic transistor and is somewhat similar to type 2N708.

Fairchild Semiconductor Corp., Dept. ED, 545 Whisman Road, Mountain View, Calif.

P&A: $15.35 to $23; from stock.

VHF Receiver 523

Range is 30 to 300 mc. Type 901 receiver provides am, fm and cw reception from 30 to 300 mc. Ceramic and nuvistor tubes are used along with transistors. Noise figure is 3 to 6.5 db; agc is applied to rf and if amplifiers. Audio output is available. Panel height is 3-1/2 in. Receiver weighs 20 lb.

Communication Electronics, Inc., Dept. ED, 4900 Hampden Lane, Bethesda 14, Md.

Switchboard Instruments 502

Accuracy is 1%. Type AB-30 and DB-30 instruments have a face scale spanning a 5.1-in. arc over 180 deg. Readability is possible at a 120-deg angle. Voltmeters, ammeters, frequency meters, power factor meters and other instruments are offered.

General Electric Co., Instrument Dept., Dept. ED, West Lynn, Mass.

CANNON PLUGS

Schweber

CANNON AUTHORIZED PLUG SPECIALIST

Schweber

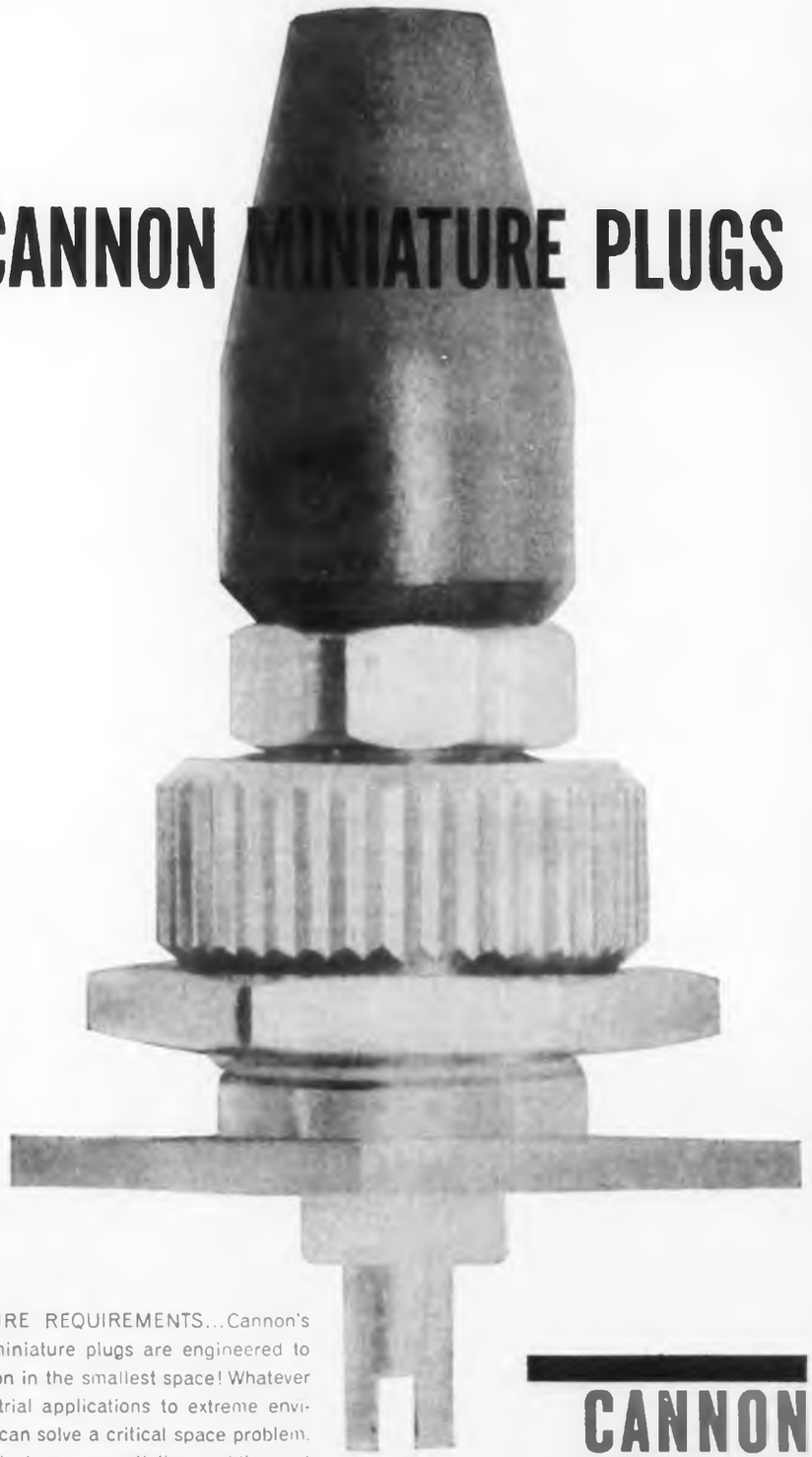
ELECTRONICS

60 HERRICKS ROAD, MINEOLA, L. I., N. Y.
PIONEER 6-8520. TWX G-CY-NY-880U

CIRCLE 68 ON READER-SERVICE CARD

ACTUAL SIZE

CANNON MINIATURE PLUGS



SCALED TO YOUR MINIATURE REQUIREMENTS... Cannon's full line of miniature and subminiature plugs are engineered to provide safe electrical connection in the smallest space! Whatever your requirements — from industrial applications to extreme environmental conditions — Cannon can solve a critical space problem. Another reason why you should always consult the world's most experienced plug manufacturer... why you should consult Cannon for all your plug requirements. Write for literature to:

CANNON ELECTRIC COMPANY, 3208 Humboldt St., Los Angeles 31, Calif.

CIRCLE 69 ON READER-SERVICE CARD

CANNON PLUGS

NEW PRODUCTS

Random-Noise Generator 596

Range is 2 cps to 1.5 mc on 811B generator. A source of white noise for laboratory applications, unit has pink noise filter for equal noise power per octave from 20 cps to 100 kc. Amplitude distribution is gaussian.

H. H. Scott, Inc., Instruments Div., Dept. ED, 111 Powdermill Road, Maynard, Mass.
Price: $240.

Casting Resin 489

For components and circuits. Stycast 3180M is particularly suitable for embedment of coils and transformers. It bonds well to most materials and can cure at room temperature. It is two-part, with a mixing ratio of 1:1 by weight or volume.

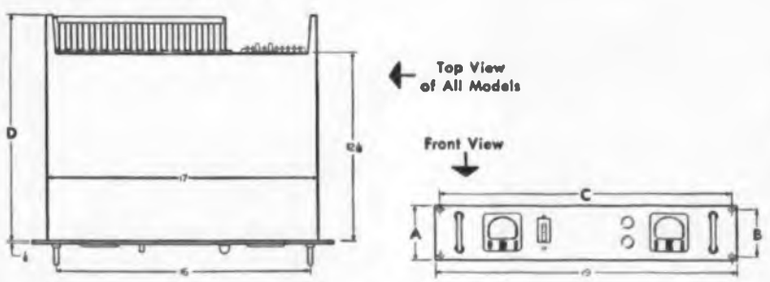
Emerson & Cuming, Inc., Dept. ED, Canton, Mass.
P&A: $0.55 to $0.66 per lb.

Temperature Probe 600

Range is −100 to +400 F with a calibration accuracy of ±5 F. Model R146 is for industrial control and military use. A continuous-resistance output unit, it has a nominal resistance of 5,000 ohms, ±200 ohms at 77 F. Time constant is less than 4 sec from 100 to 0 C to reach 63.2% of total change.

Quantatron, Inc., Instrumentation Div., Dept. ED, 4201 Redwood Ave., Los Angeles, Calif.

DIMENSION DRAWINGS



	MODEL †		
	LA 50-03A LA 20-05A LA 8-08A	LA 100-03A LA 40-05A LA 15-08A	LA 200-03A LA 80-05A LA 30-08A
A	3½"	7"	10½"
B	3"	*4"	*7½"
C	18⅜"	18¼"	18¼"
D	14⅜"	14⅜"	16½"

* These models notched per RETMA Standards
† Includes metered models with suffix "M"

COMPLETE SPECIFICATIONS OF LAMBDA LA SERIES

DC OUTPUT (Regulated for line and load)

Model	Voltage Range (1)	Current Range	Minimum Voltage (1)	Voltage Steps (1)	Price(2)
LA 50-03A	0- 34 VDC	0- 5 AMP	0	2, 4, 8, 16, and 0- 4 volt vernier	$ 395
LA100-03A	0- 34 VDC	0-10 AMP	0	2, 4, 8, 16, and 0- 4 volt vernier	510
LA200-03A	0- 34 VDC	0-20 AMP	0	2, 4, 8, 16, and 0- 4 volt vernier	795
LA 20-05A	20-105 VDC	0- 2 AMP	20	5, 10, 20, 40, and 0-10 volt vernier	350
LA 40-05A	20-105 VDC	0- 4 AMP	20	5, 10, 20, 40, and 0-10 volt vernier	495
LA 80-05A	20-105 VDC	0- 8 AMP	20	5, 10, 20, 40, and 0-10 volt vernier	780
LA 8-08A	75-330 VDC	0- 0.8 AMP	75	15, 30, 60, 120, and 0-30 volt vernier	395
LA 15-08A	75-330 VDC	0- 1.5 AMP	75	15, 30, 60, 120, and 0-30 volt vernier	560
LA 30-08A	75-330 VDC	0- 3 AMP	75	15, 30, 60, 120, and 0-30 volt vernier	860

(1) The DC output voltage for each model is completely covered by four selector switches plus vernier control. The DC output voltage is the summation of the minimum voltage plus the voltage steps and the continuously variable DC vernier.

(2) Prices are for unmetered models. For metered models add the suffix "M" and add $30.00 to the price.

Regulation (line) ..... Less than 0.05 per cent or 8 millivolts (whichever is greater). For input variations from 100-130 VAC.

Regulation (load) ..... Less than 0.10 per cent or 15 millivolts (whichever is greater). For load variations from 0 to full load.

Transient Response ..... Output voltage is constant within regulation specifications for step function:

(line) ..... line voltage change from 100-130 VAC or 130-100 VAC.

(load) ..... load change from 0 to full load or full load to 0 within 50 microseconds after application.

Internal Impedance ..... LA 50-03A less than .008 ohms
LA100-03A less than .004 ohms
LA200-03A less than .002 ohms
LA 20-05A less than .06 ohms
LA 40-05A less than .03 ohms
LA 80-05A less than .015 ohms
LA 8-08A less than .5 ohms
LA 15-08A less than .25 ohms
LA 30-08A less than .15 ohms

Ripple and Noise ..... Less than 1 millivolt rms with either terminal grounded.

Polarity ..... Either positive or negative terminal may be grounded.

Temperature Coefficient ..... Less than 0.025 %/°C

AC INPUT ..... 100-130 VAC, 60 ± 0.3 cycle[3]
LA 50-03A ... 360 watts[4]
LA100-03A ... 680 watts[4]
LA200-03A ... 1225 watts[4]
LA 20-05A ... 390 watts[4]
LA 40-05A ... 710 watts[4]
LA 80-05A ... 1350 watts[4]
LA 8-08A ... 415 watts[4]
LA 15-08A ... 760 watts[4]
LA 30-08A ... 1450 watts[4]

[3] *This frequency band amply covers standard commercial power lines in the United States and Canada.*
[4] *With output loaded to full rating and input at 130 VAC.*

AMBIENT TEMPERATURE AND DUTY CYCLE ..... Continuous duty at full load up to 50°C (122°F) ambient.

OVERLOAD PROTECTION:

Electrical ..... Magnetic circuit breaker front panel mounted. Special transistor circuitry provides independent protection against transistor complement overload. Fuses provide internal failure protection. Unit cannot be injured by short circuit or overload.

Thermal ..... Thermostat, manual reset, rear of chassis. Thermal overload indicator light front panel.

METERS ..... Voltmeter and ammeter on metered models.

CONTROLS:

DC Output Controls ..... Voltage selector switches and adjustable vernier-control rear of chassis.

Power ..... Magnetic circuit breaker, front panel.

Remote DC Vernier ..... Provision for remote operation of DC vernier.

Remote Sensing ..... Provision is made for remote sensing to minimize effect of power output leads on DC regulation, output impedance and transient response.

PHYSICAL DATA:

Mounting ..... Standard 19" Rack Mounting

Size

LA 50-03A, LA20-05A, LA 8-08A 3½" H x 19" W x 14⅜"D
LA100-03A, LA40-05A, LA15-08A 7" H x 19" W x 14⅜"D
LA200-03A, LA80-05A, LA30-08A 10½" H x 19" W x 16½"D

Weight

LA 50-03A, LA20-05A, LA 8-08A 55 lb Net 85 lb Ship. Wt.
LA100-03A, LA40-05A, LA15-08A 100 lb Net 130 lb Ship. Wt.
LA200-03A, LA80-05A, LA30-08A 140 lb Net 170 lb Ship. Wt.

Panel Finish ..... Black ripple enamel (standard). Special finishes available to customers' specifications at moderate surcharge. Quotation upon request.

LAMBDA ELECTRONICS CORP.
515 BROAD HOLLOW ROAD, HUNTINGTON, L. I., NEW YORK 516 MYRTLE 4-4200

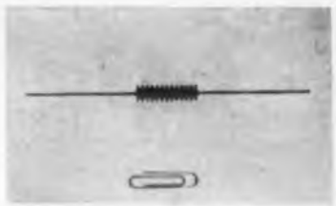
Send for complete Lambda Catalog.

Temperature Transducers 598

Range is −50 to +250 F with calibrations of 5 points and standard accuracies of ±0.5 F. For solid and liquid temperature measurement in telemetering and computer uses, the R157 units weigh 2.5 g. Time constant is 2 sec nominal. Excitation is 5 ma.

Quantatron, Inc., Instrumentation Div., Dept. ED, Los Angeles, Calif.

HF Resistor 599



Offered in values to 1 meg, these wirewound units have an accuracy of 0.005%. Rise time is less than 0.2 μsec and capacitance is less than 0.1 pf. Applications include use in digital computers.

Reon Resistor Corp., Dept. ED, 155 Saw Mill River Road, Yonkers, N. Y.

Straight Cable Plug 597

For 50-ohm cables, type 6000 provides screw-on connection with cable and bulkhead jacks, bulkhead receptacles, cable feedthroughs and printed wiring receptacles. Crimping of connection is done with standard crimping tool.

Sealectro Corp., Dept. ED, 610 Fayette Ave., Mamaroneck, N. Y.

◀ CIRCLE 70 ON READER-SERVICE CARD

NEW PRODUCTS

Linear Amplifier 524

Output is 500 w. Linear amplifier model 30L-1 provides 500-w output for single sideband and cw from 3.4 to 30 mc. It may be used with any exciter having a 70-w nominal output. The portable set weighs 38 lb. Size is 7-3/4 x 14-3/4 x 13-1/4 in.

Collins Radio Co., Dept. ED, P. O. Box 1891, Dallas 21, Tex.
P&A: $520; July 1961.

Magnetic Reed Switch 498

Life is 3,000,000 cycles. Model MR-400 permits the use of relays and cross-points in circuit boards or modules based on a 0.1-in. center. Glass length is 7/8 in. Over-all length is 2-3/4 in. Leads can be welded, soldered or bent.

Gordos Corp., Dept. ED, 250 Glenwood Ave., Bloomfield, N.J.

High-Temperature Probes 601

Thermocouples measure temperatures from 3,000 to 6,000 F. The series 4500 probes, for use on missile and aircraft problems, are available in sizes from 3/16 in. diameter by 2 in. long, through 1 in. diameter by 3 ft long.

Propulsion Development Labs., Inc., Press-Temp Products Div., Dept. ED, 1120 E. El Segundo Blvd., El Segundo, Calif.

Frequency Meters 481

Direct reading models 555 to 579 are for laboratory and production-line testing or use as secondary standards. Ranges are from 0.925 to 1.65 through 32 to 39 kmc. Accuracies are 0.015% to 0.075%.

PRD Electronics, Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N. Y.

IMMEDIATE DELIVERY OF ELMENCO *capacitors*

IN QUANTITIES UP TO
500 Per Item
CONTACT THESE AUTHORIZED
ELMENCO INDUSTRIAL DISTRIBUTORS

ARIZONA: Radio Specialties & Appl. Corp., 917 N. 7th St., Phoenix.

CALIFORNIA: Brill Elect., 610 S. 10th St., Oakland; Elect. Supply Corp., 2085 E. Foothill Blvd., Pasadena; Federated Purchaser Inc., 11275 W. Olympic Blvd., L. A. 64; Hollywood Radio Supply Inc., 5606 Hollywood Blvd., Hollywood 28; Newark Electronics Corp., 4747 W. Century Blvd., Inglewood; Pacific Wholesale Co., 1850 Mission St., San Francisco 3; Peninsula Elect., 656 S. 1st St., San Jose; Shanks & Wright Inc., 2045 Kettner Blvd., San Diego; Shelley Radio Co. Inc., 2008 Westwood Blvd., L. A. 25; R. V. Weatherford Co., 6921 San Fernando Rd., Glendale 1; Zack Electronics, 654 High St., Palo Alto.

COLORADO: Denver Electronics Supply Co., 1254 Arapahoe St., Denver 4.

DISTRICT OF COLUMBIA: Capitol Radio Wholesalers Inc., 2120 14 St., N.W., Wash., D. C.

FLORIDA: Elect. Supply, 1301 Hibiscus Blvd., Melbourne; Elect. Supply, 61 N. E. 9th St., Miami.

ILLINOIS: Newark Electronics Corp., 223 W. Madison St., Chicago 6.

MARYLAND: D & N Distributing Company, Inc., 2025 Worcester St., Baltimore 30; Kann-Ellert Electronics, Inc., 2050 Rock Rose Avenue, Baltimore; Wholesale Radio Parts Co. Inc., 308 W. Redwood St., Baltimore 1.

MASSACHUSETTS: Cramer Electronics Inc., 811 Boylston St., Boston 16; Radio Shack Corp., 730 Commonwealth Ave., Boston 17.

NEW JERSEY: Federated Purchaser Inc., 1021 U.S. Rte. 22, Mountainside; General Radio Supply Co., 600 Penn St., Camden 2; Radio Elec. Service Co., Inc., 513 Cooper St., Camden 2.

NEW MEXICO: Electronics Parts Co., Inc., 222 Truman St., N. E., Albuquerque; Midland Specialty Co., 1712 Lomas Bl. N.E., Albuquerque; Radio Specialties Co., Inc., 209 Penn Ave., Alamagordo.

NEW YORK: Arrow Elect. Inc., 525 Jericho Turnpike, Mineola, L. I., Elect. Center Inc., 211 W. 19th St., N. Y. 11; Harvey Radio Co., Inc., 103 W. 43rd St., N.Y. 36; Lafayette Radio, 100 Sixth Ave., N.Y. 13; Stack Industrial Electronics, Inc., 45 Washington Street, Binghamton; Terminal Elect. Inc., 236 W. 17 St., N. Y. 17.

NORTH CAROLINA: Dalton-Hege Radio Supply Co., Inc., 938 Burke St., Winston-Salem.

PENNSYLVANIA: Almo Radio Co., 913 Arch St., Philadelphia; George D. Barbey Co. Inc., 622 Columbia Ave., Lancaster; George D. Barbey Co. Inc., 2nd & Penn Sts., Reading; D. & N. Distributing Co., Inc., 2535 N. 7th St., Harrisburg; Philo. Elect. Inc., 1225 Vine St., Phila. 7; Radio Elec. Service Co., Inc., 701 Arch St., Phila. 6; A. Steinberg & Co., 2520 N. Broad St., Phila.; Wholesale Radio Parts Co., Inc., 1650 Whiteford Rd., York.

TENNESSEE: Electra Distributing Co., 1914 West End Ave., Nashville 4.

TEXAS: All-State Dist. Co., 2411 Ross Ave., Dallas 1; Busacker Elect. Equip. Co. Inc., 1216 W. Clay, Houston 19; Engineering Supply Co., 6000 Denton Dr., Dallas 35; Midland Specialty Co., 500 W. Paisano Dr., El Paso; The Perry Shankle Co., 1801 S. Flores St., San Antonio.

UTAH: Carter Supply Co., 3214 Washington Blvd., Ogden.

WASHINGTON: C & G Radio Supply Co., 2221 Third Ave., Seattle.

CANADA: Electro Sonic Supply Co., Ltd., 543 Yonge Street, Toronto 5, Ont.

ARCO ELECTRONICS, INC.
NEW YORK • DALLAS • LOS ANGELES
Exclusive Supplier of ELMENCO Capacitors to Distributors and Jobbers in U.S.A. and Canada

CIRCLE 72 ON READER-SERVICE CARD

Another New High Order of Reliability!

El-Menco

*MYLAR-PAPER DIPPED CAPACITORS

TYPE MPD

ASSURE A LOW FAILURE RATE OF

Only 1 Failure in ~~7,168,000~~ 14,336,000 Unit-Hours for 0.1 MFD Capacitors*

Setting A New High Standard Of Performance!

★ Life tests have proved that El-Menco Mylar-Paper Dipped Capacitors — tested at 105°C with rated voltage applied — have yielded a failure rate of only 1 per 1,433,600 unit-hours for 1.0 MFD. Since the number of unit-hours of these capacitors is inversely proportional to the capacitance, 0.1 MFD El-Menco Mylar-Paper Dipped Capacitors will yield ONLY 1 FAILURE IN 14,336,000 UNIT-HOURS.

CAPACITANCE AND VOLTAGE CHART
• *Five case sizes in working voltages and ranges:*

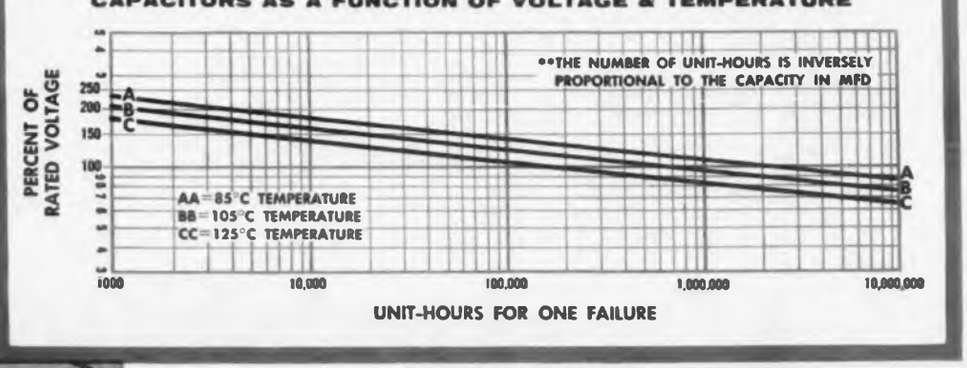
200 WVDC —	.018 to .5 MFD
400 WVDC —	.0082 to .33 MFD
600 WVDC —	.0018 to .25 MFD
1000 WVDC —	.001 to .1 MFD
1600 WVDC —	.001 to .05 MFD

SPECIFICATIONS

- TOLERANCES: 10% and 20%. Closer tolerances available on request.
- INSULATION: Durez phenolic, epoxy vacuum impregnated.
- LEADS: No. 20 B & S (.032") annealed copper clad steel wire crimped leads for printed circuit application.
- DIELECTRIC STRENGTH: 2 or 2½ times rated voltage, depending upon working voltage.
- INSULATION RESISTANCE AT 25°C: For .05MFD or less, 100,000 megohms minimum. Greater than .05MFD, 5000 megohm-microfarads.
- INSULATION RESISTANCE AT 105°C: For .05MFD or less, 1400 megohms minimum. Greater than .05MFD, 70 megohm-microfarads.
- POWER FACTOR AT 25°C: 1.0% maximum at 1 KC

These capacitors will exceed all the electrical requirements of E. I. A. specification RS-164 and Military specifications MIL-C-91B and MIL-C-25C.
Write for Technical Brochure

MINIMUM LIFE EXPECTANCY FOR **1.0 MFD *MYLAR-PAPER DIPPED CAPACITORS AS A FUNCTION OF VOLTAGE & TEMPERATURE



*Registered Trade Mark of DuPont Co.

THE ELECTRO MOTIVE MFG. CO., INC.
Manufacturers of El-Menco Capacitors
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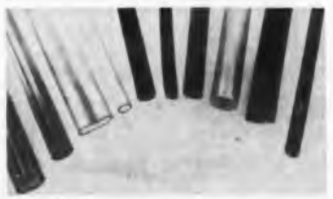
CIRCLE 73 ON READER-SERVICE CARD

NEW PRODUCTS

Plastic Tubing 602



Flexible or rigid vinyls, polyethylene, polypropylene and other tubing up to 3 in. O.D. are manufactured on spools, coils or pieces cut in lengths from 1/32 in. to 250 ft. Tubing may be extruded to exact wall thickness, inside diameter, etc.

Petro Plastics Co., Dept. ED, 16 Quine St., Cranford, N. J.

Display Scanner 472

A plug-in unit, model 166C provides an output to duplicate, on an X-Y recorder, any repetitive waveform appearing on the crt trace. It converts high-speed signals to slower signals with the same shape. The scanning speed keeps the Y output within the bandwidth of most recorders.

Hewlett-Packard Co., Dept. ED, 1501 Page Mill Road, Palo Alto, Calif.

Servo Analyzer 603

Having no moving parts, model 900 provides phase and amplitude measurement vs frequency. Units have ranges of 0.1 to 100 cps; 0.01 to 100 cps and 0.001 to 100 cps, sine or square wave, modulated or unmodulated.

Remanco, Inc., Dept. ED, 1805 Colorado Ave., Santa Monica, Calif.

UHF Frequency Meter 482

Range is 250 to 1,000 mc. Model 587-A has an accuracy of ±0.2% above 400 mc and ±0.5% below 400 mc. Nominal insertion loss is 6 db. Dip is 20% min and dial resolution is 0.5 mc or better. Type N connectors are used. Spiral scale length is 60 in.

PRD Electronics, Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N. Y.

Differential Amplifier 604

For airborne use. Model DA-20 differential dc amplifier has linearity better than ±0.3% for 5 v maximum output. Input impedance is 100 K, common-mode rejection 160 db; unit operates from unregulated 28 v dc. Gain is varied between 100 and 500. Volume is 10 cu in., weight 8 oz.

United ElectroDynamics, Inc., Customer Requirements Dept., Dept. ED, 200 Allendale Road, Pasadena, Calif.

Silicon Rubber 503

Tensile strength is 1,500 psi. Designated SE-5504U, this self-bonding silicone rubber is for use in shock mounts and oil seals. It can be bonded to steel, chrome steel and stainless steel.

General Electric, Silicone Products Dept., Dept. ED, Waterford, N.Y.

P&A: $5.20 per lb; from stock.

Surge Tester 605

For silicon rectifiers. Model 220 permits surge testing with currents continually adjustable from 25 to 630 amp peak. It has single half-wave sinusodial pulse output, sync and calibrated output monitor for oscilloscope display, and provision for sequential testing. Monitoring sensitivity is 1 mv per amp, accuracy within 1%. Tester weighs 140 lb.

Wallson Associates, Inc., Dept. ED, 912-914 Westfield Ave., Elizabeth, N. J.

P&A: $1,200; delivery from stock.

NEW PRODUCTS

Multi-Pole Relays 606

Rated at 10 amp. Available in 2, 3, or 4-pole double throw forms, Nyline relays may be equipped with coils for ac operation to 230 v max and dc to 115 v max. Contacts, rated at 10 amp, are self-aligning and self-cleaning.

Ward Leonard Electric Co., Dept. ED, Mount Vernon, N. Y.

Silicon-Transistor Oscillator 473

Range is 15 to 125 kc. Crystal- and heater-controlled, model C110 stands 20-g vibration from 50 to 2,000 cps. Stability is ±5 ppm. Requirements of MIL-E-5272 are met. The unit is encapsulated in lockfoam.

Solid State Electronics Co., Dept. ED, 15321 Rayen St., Sepulveda, Calif.

P&A: $220 up; 6 weeks.

Adjustable Blower 607

Has 400 cfm output. Twin scrolls of this panel-mounting blower can be rotated and set at any angle through 230 deg. Motor-rotor assembly may be reversed. Panel height is 8-3/4 in. for standard rack mounting. Construction is military quality. Designation is model D-1000.

Western Devices, Inc., Dept. ED, 600 W. Florence Ave., Inglewood 1, Calif.

P&A: $89.50 ea; 14 days.

Miniature Computer Unit 504

The size of a cigarette pack, the TIMM is a three-bit parallel adder containing 16 NOR modules. In typical use the unit needs 240 mw of power. It operates at 580 C. Input information consists of positive signals from a 15,000-ohm source. Output is binary.

General Electric Co., Receiving Tube Dept., Dept. ED, Owensboro, Ky.

Fort Monmouth Laboratory Control Panel used for the tracking of NASA's Tiros Weather Satellite. Note McLean rack-mounted cooling equipment at the base of each rack. Operator at left checks the TV picture being transmitted. Recording camera is located directly above eyepiece.

TIROS Weather Satellite Gets McLEAN Cooling Equipment Into The Picture

When TIROS, the first Weather Satellite, was launched, it shed new light on the world's weather conditions by transmitting TV pictures to ground stations around the globe. And back at the U.S. Army's ground readout station in Fort Monmouth, New Jersey, McLean cooling equipment was very much in the picture, contributing to the accuracy and reliability of the Laboratory's Control Panel.

McLean cooling equipment was selected for this critical project because McLean is the leader in the field of cooling sensitive electronic systems. The company is the largest supplier of packaged cooling equipment. Choose from over 100 models in various panel heights and CFM's.

Also a complete line of fractional horsepower motors

MODEL 2E408, Over 15,000 in use all over the world.

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World Leader in Packaged Cooling
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TWX Princeton, New Jersey 636

CIRCLE 80 ON READER-SERVICE CARD

NEW PRODUCTS

Load Sensor 630

Monitors motor duty. Used with a clip-on probe or current transformer connected to 1 lead of a motor, the Load Sensor will distinguish between no load and partial or full load. Output spdt relay can operate a counter, pen recorder, or running time meter. Sensitivity is 60 ma, maximum signal 100 amp. Relay circuit is monitored by panel lamps.

Trott Electronics, Inc., Dept. ED, 412 Smith St., Rochester 8, N. Y.

Servo Amplifier 645

In small package. Model 500 miniature, solid-state servo amplifier provides 3.5 w to drive a center-tapped size 11 servo motor. Package is 1 x 1 x 1-3/16 in. max. Gain is 2,500, stability ±3 db from −65 C to +125 C, ±2 db from −35 C to +125 C. Input impedances of 10,000 ohms to 1/2 meg are available; life exceeds 1,000 hours.

White Avionics Corp., Dept. ED, Terminal Road, Plainview, L. I., N.Y.

***Availability:** 1 to 2 weeks.*

Shielded Tubing 647

For rf cables. Type SH shielded zipper tubing has 1-mil aluminum foil laminated to vinyl-impregnated glass cloth. Braid is provided for grounding the shield. The flexible tubing is easily opened and closed, or may be permanently sealed if desired.

The Zippertubing Co., Dept. ED, 13000 S. Broadway, Los Angeles 61, Calif.

Ortho's complete new line of wire wound resistors is highly stable, highly reliable — and available for **immediate delivery!** Accuracies of ±1.0% to ±0.001% are standard on low TC resistors. All DC resistors, with the exception of the low values, are reverse-wound for low reactive effects. High speed resistors are available in most styles. A resistor may be designed to act as a specific complex impedance, thus reducing the number of components necessary. Ortho also offers **one-week delivery on specially designed resistors** to your specifications! Write today for a new 6-page catalog describing 20 standard types in detail, plus data on specials.

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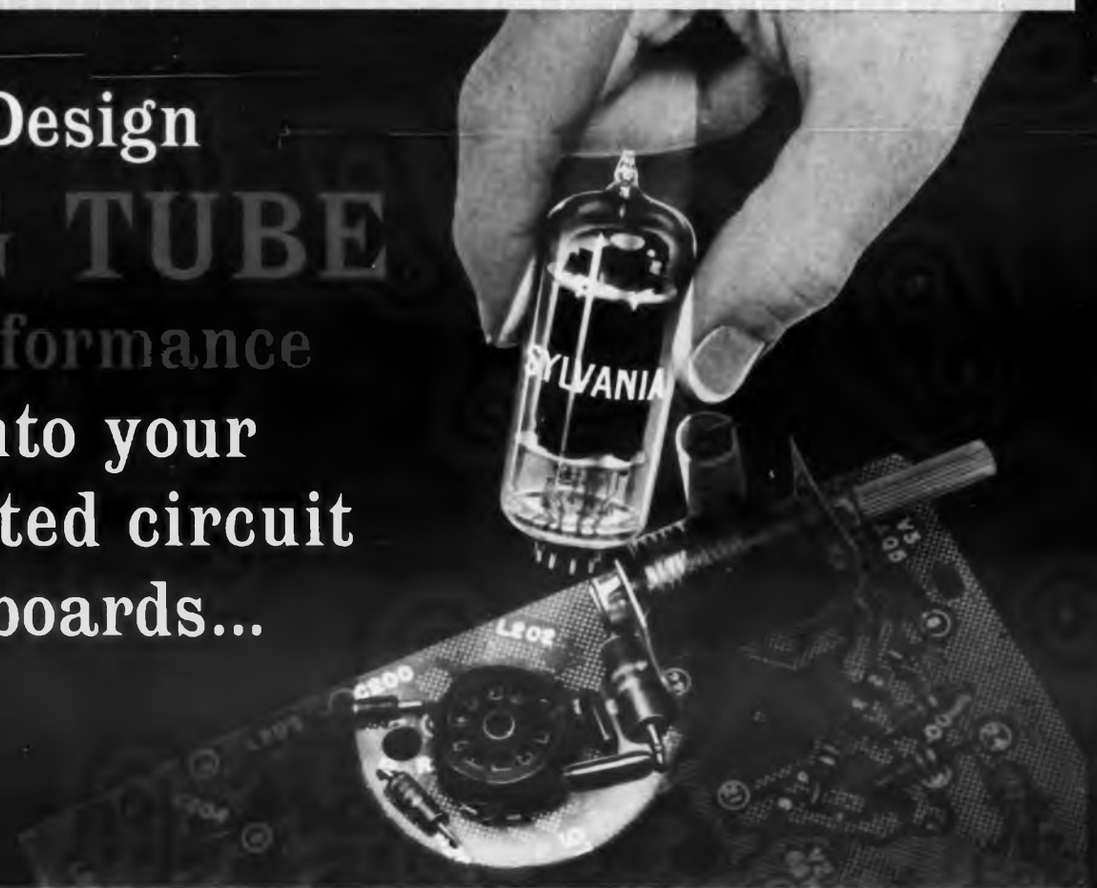
CIRCLE 81 ON READER-SERVICE CARD
CIRCLE 82 ON READER-SERVICE CARD ▶

ELECTRON TUBE NEWS ...from SYLVANIA

Design BIG TUBE performance into your printed circuit boards...



NEW SYLVANIA 9-T9 TYPES!

Improve tube performance! Increase chassis efficiency! Extend tube life! Reduce equipment costs! Sylvania-originated 9-T9 type tubes can help you achieve all four vital design requirements. Here's how: 9-T9 enables the use of large tube structures capable of high plate dissipation in printed circuit designs. Sylvania 9-T9 eliminates the octal base, uses conventional T-6½ sockets – improves volumetric efficiency and reduces socket costs.

9-T9 Types for Vertical Deflection Oscillator-Amplifier Service

6/10EW7, dissimilar double-triode . . . triode #1: mu of 17.5; triode #2: 10 watts plate dissipation.

6/17HC8, triode-pentodes . . . triode section: mu of 68; high perveance beam power pentode: 11 watts plate dissipation.

6/10/13FD7, dissimilar double-triodes...triode #1: mu of 68; triode #2: 10 watts plate dissipation.

9-T9 Beam Power Pentodes for Audio Amplifier Applications

6GC5 . . . for quantity-produced hi-fi equipment; features high power sensitivity. In Class A1 it delivers 2.1W output with a B+ voltage of 110V. Electrically similar to octal-based 6DG6GT.

6GM5 . . . delivers 43W output in Class AB_1 push-pull service, with total distortion of only 1.5%. In ultra-linear circuits it delivers 32W with a B+ supply of 400V. Similar to octal-based 7591.

7695 . . . features exceptionally high power sensitivity. Offers 4.5W output with a B+ supply of only 140V. Utilizes 50V heater. Plate dissipation is 16W. 7754 is 6.3V version of 7695.

Examine the design advantages of 9-T9 types with your Sylvania Sales Engineer. Or, for data on specific types, write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. E, 1100 Main Street, Buffalo 9, New York.

MICROWAVE DEVICE NEWS from SYLVANIA

NEW!
GRIDDED TWT's for PULSED or CW operation in S band frequencies

CHARACTERISTICS	TW-956L Min.	TW-956L Max.	TW-4002M Min.	TW-4002M Max.	Units
Cathode Current	—	50	—	4.5	mAdc
Helix Current	—	7	—	3.2	mAdc
Grid Current	—	7	—	1.0	mAdc
CW RF Power Output (sat)	2W	—	10mW	—	
Small Signal Gain					
(– 30dbm input)	37	—			db
(– 40dbm input)			35	—	db

Designed for Airborne ECM . . .

Sylvania TW-956L, TW-4002M are PPM-focused, magnetically shielded, weigh only 4 lbs., are just 15" long, 1.4" in diameter, temperature compensated for −65° to +72° C.

Utilizing a unique TWT design incorporating grids, both types exhibit sharp cutoff characteristics. They feature relatively flat frequency response over the full 2.0–4.0 kMc frequency range.

TW-956L is capable of 2W CW saturated power output. TW-4002M features CW saturated power output of 10mW. Both types can be provided with virtually any mounting.

For full data on these types contact your Sylvania Sales Engineer, or write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. MDO-E, 1100 Main St., Buffalo 9, New York.

FIRST DC BLOCK COVERING 2.5 TO 10,000 MC

Sylvania SB-100, wideband coaxial device providing dc and low frequency isolation, features low VSWR of 1.3 : 1 or less over its rated frequency range and maximum insertion loss of 0.2db. CW power rating is 100W, peak power is 2KW, voltage isolation of 2KV dc. SB-100 offers excellent stability over a temperature range of −50° to +100° C. It is available with type N connectors. Soon to be available are the SB-101 having BNC connectors and the SB-102 featuring TNC connectors.

SYLVANIA

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GENERAL SYSTEM

P-129-3

Spade and Ring Terminals 637

Available in chain form. Spade and ring terminals designed to accommodate a wide range of wire and insulation sizes are available in chain form. Brass or tinned-brass terminals are in three crimp styles: with insulation support; without insulation support; with an insulation pierce crimp. Insulation ranges are from 0.035 to 0.110 in. and wire ranges are from 20 to 27. A machine for rapid, semiautomatic crimping of all terminals is adaptable to production line setups. Skilled operators are not needed.

Malco Manufacturing Co., Dept. ED, 4025 W. Lake St., Chicago 24, Ill.

Telemetry Filters 666

Measure 1 x 2 x 4 in. A series of passive telemetry filters designed for application with fm discriminators. Networks are constructed to minimize time delay variations and maximize rejection of adjacent channels. All standard IRIG telemetry channels are packaged in cases approximately 1 x 2 x 4 in.

PCA Electronics, Inc., Dept. ED, 16799 Schoenborn St., Sepulveda, Calif.

Temperature Controller 646

With digital set and display. Platinum resistance temperature transducer is used in the model 4050 Digitrol, a digital, set-point, on-off temperature controller. Range is 0 to 2,000 F; output is a set of relay contacts rated at 2 to 15 amp, 115 v ac. Temperature differential is less than 2.5 F over the entire range, repeatability ±2.5 F under greatest line voltage and temperature variation. Resolution is ±0.5 F. Case size is 7 x 5 x 4 in.

Winsco Instruments & Controls Co., Dept. ED, 11789 W. Pico Blvd., Los Angeles 64, Calif.

If you want ELECTRONIC DESIGN to reach you without interruption mail your renewal form now!

NEW PRODUCTS

Voltmeter 420

Transistorized and portable. Model TR voltmeter has 11 ranges from 0.003 to 300 v full scale. Decibel range is −50 to +50, in 10-db steps. Accuracy is ±3% of full scale, 50 cps to 600 kc, and ±5%, 30 cps to 1 mc. Weight is 2 lb. The unit is battery powered.

Stewart Brothers, Div. of Instrument Laboratories, Dept. ED, 315 W. Walton Place, Chicago 10, Ill.
Price: $245 fob Chicago.

Logic Modules 661

For computer applications. Three series of digital logic modules include: collector gated series 1200; general purpose series 2100; and the NOR/NAND 3000 series. Series 1200 is for airborne and ground equipment use with frequency range to 200 kc and temperature range of −62 to 100 C. Series 2100 is for large load-handling use and has an operating temperature range of 0 to +65 C and frequency response of 200 kc. The 3000 series is a compatible clocked flip-flop with temperature range of 0 to 55 C and frequency response of 100 kc.

Computer Techniques, Inc., Dept. ED, 3300 Northern Blvd., Long Island City, N.Y.
P&A: $5 to $20 in production quantities; two weeks.

HF Transceiver 470

For airborne uses requiring high-power and long-range communications, type HC-101 consists of a receiver-transmitter group and a single sideband converter. In transmitting, it changes an audio signal to a single sideband, suppressed carrier or compatible am signal with an if of 1.75 mc.

Hughes Aircraft Co., Dept. ED, P. O. Box 90-902, Los Angeles 45, Calif.
P&A: 60 days.

CIRCLE 86 ON READER-SERVICE CARD FOR BROCHURE ➤
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with Amperex®
P·A·D·T40
PNP Germanium Switching Transistor

Specify the new Amperex® P·A·D·T 40
the *2 times faster* PNP Germanium Switching Transistor

$$* \quad U = \frac{1}{\text{nanoseconds} \times \text{pennies}}$$

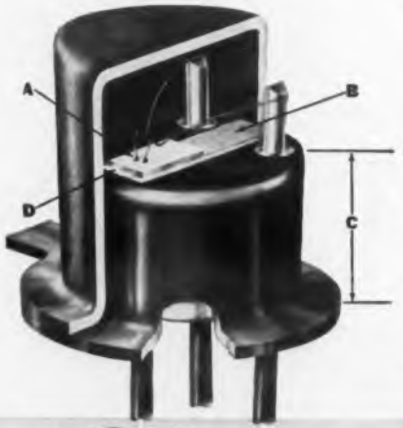
Right from the sketch-pad stage, plan your computer switching circuits with the new PADT-40. *The extreme speed and efficient design of the PADT-40 gives more U (usefulness factor) and lower cost x switching time. This results in fewer transistors to buy, less complicated circuits to design, and the elimination of many costly components because of multi-function circuit usage. But speed, of course, is only one of the cost-and-production advantages inherent in the PADT-40; **RELIABILITY**, as only the revolutionary Post Alloy Diffusion Technique can provide, is another; **AVAILABILITY**, as only the mass-production techniques employed at the new Amperex plant in Slatersville, R. I., can provide, is still another; **LOW PRICES** (no higher than for low-speed transistors) . . . plus **INTERCHANGEABILITY** with many conventional mesa transistors, round out our 'package'. Yes, the new Amperex PADT-40 is truly worth specifying . . . *now!*

High Speed, plus . . .

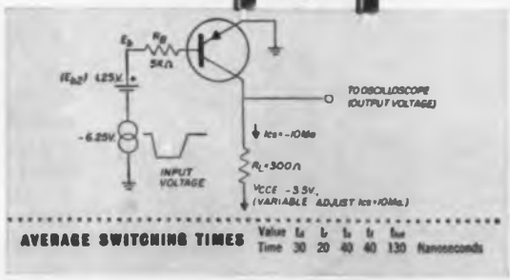
MECHANICAL RUGGEDNESS – guaranteed by the *only* process that combines the best qualities of both the alloy and the diffusion methods. As a result, the PADT-40 is resistant to vibration and shock.

PADT RELIABILITY – Hermetically sealed in a standard TO-18 case, the PADT-40 has a deep diffused and extremely thin active base region. As a result, the h_{FE} and switching time are virtually independent of surface effects and temperature changes.

- **A** *Rugged, mechanically reliable eutectic solder joints*
- **B** *Flat bed attachment for good heat dissipation*
- **C** *Long path prevents weld contamination of transistor*
- **D** *Gold doped for high speed*
- *Extremely high cut-off frequency*
- *High Beta • Low resistivity germanium*



TOTAL SWITCHING TIME
including Rise, Fall, Delay and Storage
...130 NANOSECONDS!



AVERAGE SWITCHING TIMES

Value	t_d	t_r	t_s	t_f	t_{on}
Time	30	20	40	40	130 Nanoseconds

ask Amperex for complete data and new transistor brochure

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ROME ELECTRONICS, Rome, N. Y.

TEXAS
ADLETA COMPANY, Dallas 1, Texas; Fort Worth, Texas

ask Amperex

NEW PRODUCTS

Decade Inductors 424

For experimental work. The type 850W inductor boxes are available in four standard models with 10 steps of 0.001, 0.01, 0.1, and 1 h, respectively. They can be connected in series for a total of 11,110 steps up to 11.11 h. The inductors are used for work in the 150 to 20,000 cps range. Tolerances of ±1% and ±2% are offered.

Special Products Div., Sprague Electric Co., Dept. ED, North Adams, Mass.

Test Chamber 423

High and low temperatures. Bench model 1507 "Hi-Lo" chamber tests or conditions components between −100 and +400 F, within 1 deg. It also offers rapid drop to −100 F. The unit can be provided with a program recorder-controller. It can be equipped with dual timers for automatic cycling. Chamber is 22 x 18 x 20 in. high.

The Electric Hotpack Co., Inc., Dept. ED, Cottman Ave. at Melrose, Philadelphia, Pa.

Thermionic Converter 476

Output is 10 w. This sealed-off cesium vapor device has an integral radiator and reservoir. It offers 168 hr of steady state operation. Power output of 2.4 w per sq cm and efficiency of 11% are possible at a cathode temperature of 1,300 C.

General Electric Co., Dept ED, Schenectady 5, N. Y.

Semiconductor Progress Center

Lowell Progress Center *concentrates on the engineering and production of CBS semiconductors for computer circuitry. Functional design gives the 200,000 square feet of plant space built-in flexibility to help in achieving highest standards of quality and reliability. Close cooperation with CBS Laboratories promises new and exciting solid-state developments for the future.*

Mass Production *of MADT high-speed switching transistors is accomplished on the most up-to-date equipment in the semiconductor industry. Exceptional reliability and uniformity are assured by automatic in-line production permitting 100% in-process quality control of each transistor.*

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More Reliable Products through Advanced Engineering

CBS ELECTRONICS, Semiconductor Operations, Lowell, Massachusetts

A Division of Columbia Broadcasting System, Inc. • Semiconductors • tubes • audio components • microelectronics

Sales Offices: Lowell, Mass., 900 Chelmsford St., GLenview 2-8961 • Newark, N. J., 231 Johnson Ave., TAlbert 4-2450 • Melrose Park, Ill., 1990 N. Mannheim Rd., EStebrook 9-2100 • Los Angeles, Calif., 2120 S. Garfield Ave., RAymond 3-9081 • Toronto, Ont., Canadian General Electric Co., Ltd., LEnnox 4-6311.

FM Transmitters **421**

In highly compact designs. New developments in these transmitters provide space savings up to 45%. The "Add-A-Unit" design permits the station operator to expand equipment from 250 w to 20 kw, as required. The units also provide for multiplexing with 30- to 15,000-cps bandpass on both main and subchannel for fm/fm stereo broadcast. Another feature makes it possible to bypass any amplifier at any time.

Standard Electronics, Dept. ED, Rt. 524, Lakewood Road, Farmingdale, N.J.

Lineal Switches **446**

Life is 50,000,000 cycles. Units have no measurable contact resistance. Operating temperature range is −60 to +250 F. Each of 16 contact arrangements is offered in four different coil voltages. Coils are 6, 12, and 24-32 v ac, and 115 v dc.

Elotec Corp., Dept. ED, 1425 N. Lidcombe, El Monte, Calif.

Availability: From stock.

Cable Tester **451**

Is tape-programed. Automatic cable tester model LA-350 is designed to test complex assemblies in or out of circuit. The unit tests continuity and hi-pot, and measures resistance, voltage, and impedance. Parameters are programed by binary-coded punched tape. A single tester provides from 256 to 65,536 test points.

Lavoie Laboratories, Inc., Dept. ED, Morganville, N. J.

◀ CIRCLE 88 ON READER-SERVICE CARD

NEW PRODUCTS

Oscillator 419

Battery-powered transistor unit. Model TO oscillator has a 6:1 knob ratio, for accurate setting. Frequency span is 5.5 cps to 600 kc in five bands. Dial span is 10:1. Maximum output voltage is 5 v into 600 ohms. Voltage stability is less than 1%; frequency stability is instantaneous and longtime less than 2%. Weight with batteries is 4 lb.

Stewart Brothers, Div. of Instrument Laboratories, Dept. ED, 315 W. Walton Place, Chicago 10, Ill.
Price: *$250 fob Chicago.*

Ceramic Capacitor 656

With axial leads. Ceramic capacitor model VK is made in 3 sizes, the smallest measuring 0.12 x 0.12 x 0.060 in. Axial lead design makes units adaptable to modular packaging. Gold-coated Dumet leads are weldable or solderable to within 0.030 in. of body. Made in values from 10 to 10,000 pf, the capacitors are coated for environmental protection.

Vitramon, Inc., Dept. ED, Box 544, Bridgeport 1, Conn.

Explosive Tester 443

For missile-launch checkout and other uses, the IRB-111 impulse resistance bridge measures circuit resistance to determine if the explosive system will work. A single sensing pulse is applied for 1 msec. No more than four pulses can be released per second. Resistance is read at a ±2% or ±0.02-ohm accuracy.

Fleming Industries, Inc., Dept. ED, 2433 Moreton St., Torrance, Calif.

◀ CIRCLE 89 ON READER-SERVICE CARD

Miniature Cam Followers 445

For precision applications, these devices have outside diameters of 1/4 to 5/8 in. and face widths of 0.1406 to 0.196 in. A shielded ABEC 7 tolerance ball bearing is fitted on a concentric ground shaft.

PIC Design Corp., Dept. ED, 477 Atlantic Ave., E. Rockaway, L.I., N. Y.

Availability: *From stock.*

High-Power Resistors 457

Handle up to 6 kw. Low-reactance film resistors type HL are made in 5 models, 12 to 72 in. long, with ac power ratings at 25 C to 250, 500, 1,000 3,000 and 6,000 w. Forced-air cooling will triple ratings. Values range from 20 to 100 ohms for continuous film, 70 ohms to 2.4 meg for spiraled types.

Corning Glass Works, Public Relations Dept., Dept. ED, Corning, N. Y.

Regulated Power Supply 664

Supply is 0 to 600 v dc. Model RTS-601 regulated power supply is rated at 0 to 600 v dc at 1-amp max. Regulation for input line voltage variations of ±10% is ±0.05% or ±20 mv, whichever is greater. Ripple is less than 1-mv rms. The unit has remote programing (850 ohms per v) and remote sensing.

PRL Electronics, Inc., Dept. ED, 232 Westcott Drive, Rahway, N.J.

P&A: $854 for rack mounting unit; 21 to 28 days.

Silicone Rubber Tape 458

Has high tensile strength. Silicone rubber tape ES 5215 is made of 2-mil glass cloth with 3 mils of unvulcanized silicon rubber on 1 side. Tensile strength is 70 lb per in. width. When vulcanized, tape bonds to homogeneous mass with excellent electrical properties and moisture resistance.

Permacel, Dept. ED, New Brunswick, N. J.

CIRCLE 90 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Snap-Action Relay 643

At low cost. Plug-in, enclosed 2pdt snap-action relay model SS120 is simple and inexpensive. Contacts are each rated at 10 amp, 120 v ac, 5 amp, 240 v ac, and 1/3 hp at 120 or 240 v ac. Size, including nylon enclosure, is 2-3/16 x 1-1/2 x 1-13/16 in. Octal plug is standard.

Warco Industries, Inc., Dept. ED, 569 Melville, St. Louis 30, Mo.

Power Control 397

For electric furnace. Saturable reactor and power transformer is packaged with meters and manual control; automatic control is optional. Typical unit has input 220 v, 60 cps, 1 phase; output, 40 v, 500 amp, 1 to 20 kva control range. Models are available to 100 kva. Size is 35 x 24 x 32 in.

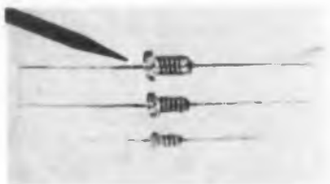
Light Electric Corp., Dept. ED, 212 Lackawanna Ave., Newark 4, N.J.

Low-Speed Generator 436

Unit delivers 0.5 kva, three phase, 60 cps at 1,200 rpm. Designated the Nobrush, the unit has high overload capacity and short-circuit protection. It measures 6.5 x 10.5 x 9 in. and weighs 50 lb.

Georator Corp., Dept. ED, Manassas, Va.

Tantalum Capacitors 435



Units resist shock and vibration. They are sintered anode liquid-electrolyte type. Uses are in missiles and aircraft. Type TZ operates from −55 to +85 C at full rated voltage; type TZH, from −55 to +125 C. Capacitance is 1.7 to 330 uf at 6 to 126 v dc in type TZ or 4 to 85 v in type TZH.

Cornell-Dubilier Electronics Div., Federal Pacific Electric Co., Dept. ED, Providence Highway, Norwood, Mass.

Precision Resistors 668

With tolerance to ±0.05%. Made in 1/8-, 1/4-, and 1/2-w sizes, Metohm resistor tolerance is ±1% standard, with ±0.05% available. Standard temperature coefficients range from ±150 ppm down to ± ppm over a range of −55 to +165 C. The metal-film resistors meet requirements of MIL-R-10509C.

Ward Leonard Electric Co., Dept. ED, Mount Vernon, N. Y.

Magnetic Clutches and Brakes 437

Output torque is 80 oz-in. min. Series 11, size 11 units consume 3 w at 24 v dc. They are suitable for computer, control and servo positioning systems. Backlash and endplay are nonexistent. Slip rings are eliminated.

Guidance Controls Corp., Dept. ED, 110 Duffy Ave., Hicksville, L. I., N. Y.

Temperature Probe 670

For measurement in gases. Type TD temperature probes are made for accurate measurement in gases at velocities of 100 to 2,000 ft per sec, temperatures to 500 F. Thermocouple elements can be furnished in iron-constantan, copper-constantan, and chromel-alumel wires. Element is coiled to expose maximum surface to the gas. Bled slot area is varied to give best accuracy at mean flow velocity.

United Sensor & Control Corp., Dept. ED, P.O. Box 149, Glastonbury, Conn.

NEW PRODUCTS

Size 18 Motor Generator 439

Linearity is less than 0.03%, frequency sensitivity is 0.015% per cycle, voltage sensitivity is 0.008% per v and temperature sensitivity is 0.05% for the motor section. Power required is 115 v, 400 cps; rated load is 100 K. Type designation is V860-22B.

Kearfott, Div. of General Precision, Inc., Dept. ED, 1150 McBride Ave., Little Falls, N. J.

Temperature Transducers 648

Weigh less than 1 oz. Small element diameter of miniature temperature transducers provides minimum interruption of fluid flow. Diameter of element is 0.100 in. Time response is 20 msec or less with tungsten elements. Calibration is repeatable within ±0.05% of resistance value at 77 F. Pressure rating is 6,000 psi; transducer meets shock and vibration tests.

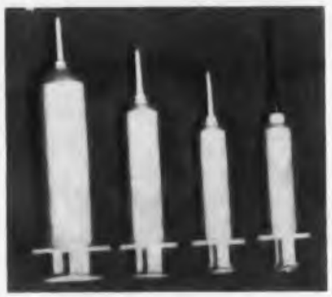
Winsco Instruments & Controls Co., Dept. ED, 11789 W. Pico Blvd., Los Angeles 64, Calif

Precision Meters 438

Accuracy is 0.025%. The Selective-Expansion meters provide electrical expansion of any of 10 divisions to cover a 100-division scale, 5-ft long. They are compact. Multi-ranges are possible on one unit.

Greibach Instruments Corp., Dept. ED, 315 North Ave., New Rochelle, N. Y.

Manual Potting Syringes 433



For electronic uses such as potting and encapsulating, 6-cc, 12-cc and 30-cc size syringes are made of polyethylene. They emit the correct amount of material without starving, dripping or flooding and are especially useful in difficult to reach areas.

Philip Fishman Co., Dept. ED, 7 Cameron St., Wellesley 81, Mass.

Vinyl Sleeving 634

For electric-motor insulation and over transformer leads, Resinite Hi-Heat 105C resists heat, fungus and oil. It is self-extinguishing in 5 sec. Tensile strength is 2,900 psi min; burst strength is 75 psi. Dielectric strength is 1,000 v per mil. Temperature range is +221 to −10 F.

The Borden Chemical Co., Dept. ED, 1 Clark St., North Andover, Mass.

Dynamic Force Gage 431

Sensitivity is 7 peak-mv per peak-lb. The stiffness is at least 2 x 10^5 lb-in. Frequency response is ±5%, 2 cps to 1/5 resonance frequency with a 1,000-meg load and 5 cps to 1/5 resonance frequency with a 100-meg load. Designation is model 2016.

Endevco Corp., Dept. ED, 161 E. California Blvd., Pasadena, Calif.

P&A: $425; from stock after May 30.

Psychrometer 625

Using small thermistor beads as resistance elements and living a built-in fan system, this device has a very rapid response time. It gives wet and dry bulb readings for relative humidity, absolute humidity, dew point and enthalpy in air and other gases.

Atkins Technical, Inc., Dept. ED, 1276 W. Third St., Cleveland 13, Ohio.

NEW PRODUCTS

Single Sideband System 427

Rating is 100 w. Type SC-910 locks into any of 28,000 frequencies from 2 to 30 mc. It has digital tuning. It consists of a separate receiver, exciter and power amplifier. Continuous-wave, frequency-shift keying and independent sideband capability are offered.

Stromberg-Carlson, Div. of General Dynamics, Dept. ED, Rochester 3, N. Y.

Silicon-Junction Diodes 464

Quick-recovery types include 1N-625 to 1N629, 1N645 to 1N649, 1N658 to 1N663, 1N676 to 1N679, 1N681 to 1N689, and 1N789 to 1N804. They are high-speed, high-voltage units and are applicable for flip-flop, modulator, demodulator, detector circuits, discriminator, clamping and gating.

Princeton Electronics Corp., Dept. ED, P. O. Box 127, Princeton, N. J.

Multifunction Devices 465

For radio and TV receivers, the Compactron units include the 6FJ7 dissimilar double triode, the 6B10 duplex-diode twin triode, the 6K11 three-section triode and the 6AX3 damper diode. Two units can do the work of seven transistors and take up less space.

General Electric Co., Receiving Tube Dept., Dept. ED, Owensboro, Ky.

Counting Shield 466

For radiation-counting use, model A-500 is lined with 1/8-in. aluminum. The shield screens the enclosure with 2-1/2 in. of iron on all sides. The iron used is free of cobalt 60 activity and is said to afford attenuation equal to 1.85 in. of lead.

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

Crystal Filters 442

Range is 10 kc to 30 mc. Applications are in single sideband, telemetering, missile guidance, radar and navigation equipment. One unit, a 5-mc filter, has a case that occupies 3/8 cu in.

Collins Radio Co., Western Div., Dept. ED, 19700 San Joaquin Road, Newport, Calif.

Sweep-Delay Generator 471

Delay time is 1 μsec to 10 sec. Delaying sweep is in 18 calibrated ranges of 2 μsec per cm to 1 sec per cm. Delayed length is to 10 cm. Model 166D delays the sweep of 160B and 170A oscilloscopes for detailed examination of a complex signal or pulse train.

Hewlett-Packard Co., Dept. ED, 1501 Page Mill Road, Palo Alto, Calif. *P&A: $325; from stock.*

Hermetic Switch 658

Has one-hole mounting. Constructed of stainless steel, the H11-2 hermetic switch meets MIL-E-5272-1. It contains 2 spdt switches with 6 terminals for multicircuit control. Electrical rating to 100,000 ft is 4 amp at 28 v dc resistive.

Controls Co. of America, Control Switch Div., Dept. ED, 1420 Delmar Drive, Folcroft, Pa.

Flush Circuits 452

For rotary switches. Electrical noise and rotor contact wear is reduced by flush circuits. Circuits can be pressed into epoxy backing, or the recessed space between carriers can be filled. Copper carriers are plated with gold, rhodium, or other metal over a nickel base. The technique also produces commutators for printed-circuit motors.

U. S. Engineering Co., Dept. ED, 13536 Saticoy St., Van Nuys, Calif.

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NEW PRODUCTS

Telemetry Filter 444

Unit weighs 25 g and occupies 0.6 cu in. for 400-cps application. It has a 3:1 shape factor for 15-db attenuation. Standard impedance level is 10,000 ohms. Units are offered for all IRIG channels; they are suitable for airborne systems.

Genistron, Inc., Dept. ED, 6320 Arizona Circle, Los Angeles 45, Calif. *Availability: Immediate.*

Heterodyne Frequency Meter 477

Range is 100 to 10,000 mc for measurement; the unit generates 500 to 900 mc and harmonics. Calibrator accuracy is 0.002% at 5 mc and interpolation accuracy is 0.03%. Input sensitivity is 30 dbm at 500 mc and over, 5 dbm at 100 mc. Type is 504.

PRD Electronics, Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N. Y.

Manual-Reset Thermostat 475

Rating is to 350 F at 25-amp resistive, 120 to 240 v ac. When an unsafe temperature is reached, a snap-acting disk opens the contacts. Current-carrying parts are independent of the reset button, permitting the limiting of temperature if the button is accidentally depressed. Type is WA-14.

Therm-O-Disc, Inc., Dept. ED, Mansfield, Ohio.

Silicon Computer Diodes 461

Fast-recovery types 1N789 through 1N804 have low leakage. Enclosed in subminiature, hermetically sealed glass packages, the units stand severe environments. Also offered is type 1N643A 175-v diode for high-voltage, high-speed computer applications.

Princeton Electronics Corp., Dept. ED, P. O. Box 127, Princeton, N. J.

◀ CIRCLE 97 ON READER-SERVICE CARD

Dual RF Tone Generator 434

For checking single sideband receivers, TTG-5 provides five pairs of almost distortion-free signals, crystal-controlled, in the 3 to 30 mc range. Frequency differences between tone pairs is adjustable from 0 to 0.1% of mean frequency.

Panoramic Radio Products, Inc., Dept. ED, 520 S. Fulton Ave., Mount Vernon, N. Y.

Mylar Capacitors 624

Flat and round designs are offered. Type 32M (round) replaces conventional tubular units, but takes less space. Type 33M (flat) is for terminal-board and printed-circuit use where thickness is important. Epoxy end seals are used.

Atlee Corp., Wesco Div., Dept. ED, 27 Olive St., Greenfield, Mass.

DC Relay 638

Occupies less than 1/2-cu-in. of space. The MK series miniature relay measures 51/64 x 31/32 x 5/8 in. and weighs 11 g, unenclosed. Three types of enclosures are available. Specifications are: contact arrangement, spdt and dpdt; duty cycle, continuous; contact rating, 1-amp resistive, 0.6-amp inductive, at 115 v ac; pull-in power, spdt, 0.75 w, dpdt, 1 w.

Elgin National Watch Co., Electronics Div., Dept. ED, 2435 N. Naomi St., Burbank, Calif.

Cable Retractor 672

Is inexpensive. Designed to military specifications, low-cost cable retractor withstands environmental extremes and temperatures from −100 to +330 F. Solid-film lubricant is used; expansion cord is stainless steel. Retractor is made from cold-rolled steel, cadmium-plated and dipped in iridite. The versatile unit fits standard mounting systems.

Vent-Rak, Dept. 106, Dept. ED, 525 S. Webster, Indianapolis 19, Ind.

NEW PRODUCTS

Mercury Switch 440

Weight is 1.9 g. Height is 1-1/8 in. and diameter is 11/32 in. The unit is hermetically sealed, low-power, and has low contact resistance. It performs well after long periods of inactivity.

General Electric Co., Wiring Device Dept., Dept. ED, Providence 7, R. I.

Transistor Probe 432

Range is 0 to 20 kc for frequency of vibration and relative amplitudes. The device measures mechanical shaft rotation to 120,000 rpm. Operation is by remote sensing. Called model 219A, it is suited for complex-wave environmental tests.

OPTOmechanisms Inc., Dept. ED, 216 E. Second St., Mineola, L.I., N. Y.

P&A: $112 to $102; from stock.

Impedance Testing Device 430

For measuring mechanical impedance, model 2110 incorporates three force transducers and three accelerometers. Nominal force sensitivity is 7 peak-mv per peak-lb and high nominal acceleration sensitivity is 80 peak-mv per peak-g. Frequency response is ±5%, 2 to 4,000 cps with a 1,000-meg load and 5 to 4,000 cps with a 100-meg load.

Endevco Corp., Dept. ED, 161 E. California Blvd., Pasadena, Calif.

P&A: $750.

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

Dielectric Test Set 398

Rated at 4 kva. Designed to simultaneously test 10 reels of wire, model K3-4Y dielectric test set automatically disconnects faulty specimens. Rated at 0 to 3 kv rms and 4 kva, the set has continuously adjustable output voltage. Weight is 220 lb. Input is 115 v, 6 cps, 35 amp.

Peschel Electronics, Inc., Dept. ED, Patterson, N.Y.

P&A: *$1,500; 3 to 4 weeks.*

Snap-Action Thermostat 671

Weighs 0.3 oz. A nonoverheating thermostat, the snap-action Dualstat has a temperature differential of 3 F or better. Current rating is 2 amp at 28 v, 150 w at 120 v ac or dc. The hermetically sealed device is preset up to 300 F.

Valverde Laboratories, Dept. ED, 252 Lafayette St., New York 12, N. Y.

Price & Availability: *$15 ea; 1 week.*

Binary-to-Decimal Converter 429

With in-line Nixie readout and internal storage, model 100 TBD is used with shaft-position digitizers. It displays up to 13 bits of information from voltage sources or contact closures. Display time is 0.2 to 6 sec.

Erie Pacific, Dept. ED, 12932 S. Weber Way, Hawthorne, Calif.

Power Relay 468

Life is 10,000,000 operations at two operations per second with 50% dwell time. Rated load life is 100,000 operations at 14 operations per minute. Designated the PM series, these are 4pdt units, rated at 115 v, 50 to 60 cps. Dimensions are 3-11/32 x 2-41/64 x 2-1/2 in.

Potter & Brumfield, Div. of American Machine & Foundry Co., Dept. ED, Princeton, Ind.

NEW PRODUCTS

Torque Transducer 399

Uses strain gages. Torque transducer for sensing torque of any rotating device is available in ranges from 50 oz-in. to thousands of lb-in. Use of bonded strain gages eliminates all friction error sources. No slip rings are employed in the device.

Lebow Associates, Dept. ED, 14857 W. 11 Mile Road, Oak Park 37, Mich.

Insulating Tape 667

With high dielectric strength. Insulating fabric and tape 5J30 is a black, flexible, varnish-treated material composed of Dacron and glass fibers. Dielectric strength is 2,000 v per mil. It conforms to irregular surfaces without need for bias weave, has improved heat and aging characteristics, good slip for tight wrap, and high tensile strength. Tape is made in 36 and 72 yd rolls, fabric in rolls 50 yd long and 36 in. wide.

Micarta Div., Westinghouse Corp., Dept. ED, Trafford, Pa.

Wirewound Potentiometer 400

For space applications. Linear translatory potentiometer provides output voltage proportional to shaft displacement. All components are enclosed within a sealed housing; unit meets environmental requirements. Resolution is 0.1% full scale, linearity 0.2%.

Lido Transducers, Dept. ED, 1970 Placentia, Costa Mesa, Calif.

P&A: On request; 30 to 45 days.

Tantalum Capacitor 669

Rated at 75 wvdc. Solid tantalum capacitors are available with rating of 75 wvdc. Unit is made in standard EIA capacitance values to 15μf, at tolerances of ±20%, ±10%, and ±5. The capacitors are hermetically sealed in the four case sizes specified in MIL-C-26655A, and operate at temperatures ranging from −55 to +125 C.

Kemet Co., Dept. ED, 11901 Madison Ave., Cleveland 1, Ohio.

Toggle Switches 441

Life is 10,000,000 cycles. Units are available in spst, spdt, dpst and dpdt designs. Rating is 10 amp at 250 v ac. Screw-type or solder-type terminals can be furnished. Temperature range is −60 to +250 F.

Elotec Corp., Dept. ED, 1425 N. Lidcombe, El Monte, Calif.

Availability: *From stock.*

Telemetry PDM Multicoder 673

A completely transistorized, 48-channel PDM multicoder with 3 pole, 16 channel subcommutator for satellite probes. Characteristics of the digital multicoder are: small size, low power consumption, silicon semiconductors used throughout, and availability in either unipolar or bipolar form with either common or isolated ground.

Applied Electronics Corp. of New Jersey, Dept. ED, 22 Center Street, P.O. Box 43, Metuchen, N.J.

Cushion Clamps 409

Withstand 1,500 F. The 1500 series cushion clamps are made of type 321 stainless steel. Corrugations provide spring action for high frequency, low amplitude vibrations. Size range is 1/4-to 4-in. ID. The clamps are interchangeable with any standard 1/2-in. AN, MS or commercial cushioned loop clamps.

TA Manufacturing Corp., Dept. ED, 4607 Alger St., Los Angeles 39, Calif.

Semiconductor Test Set 665

For general purpose use. Type 310 semiconductor test set is for testing all types of small and medium-power transistors, rectifiers and Zener diodes. It will measure transistor h-parameters at 1 kc, Zener voltages and dynamic impedances. Internal dc supplies furnish up to 30 v and 100 ma.

Owen Laboratories, Inc., Dept. ED, 55 Beacon Place, Pasadena, Calif.

Price: *$785 fob Pasadena.*

NEW PRODUCTS

High-Voltage Capacitors 509

Have 10,000-hour life. Compact, lightweight plastic film capacitors are made in 11 voltage ranges from 2 to 30 kv dc. They are suitable for continuous use as temperatures between −60 and +60 C. Footed brackets are supplied wtih the hermetically sealed units.

Corson Electric Manufacturing Co., Dept. ED, 540-39th St., Union City, N. J.

Electronic Rack Cabinets 506

A ventilating system is provided. Duct outlets can be positioned anywhere. Construction is heavy duty, dimensions are 77 x 24 x 24 in., finish is cold-rolled steel or aluminum and type designation is FT-192-A. Mil specs are met.

Falstrom Co., Dept. ED, 185 Falstrom Court, Passaic, N. J.

Differential Voltmeter 487

Has 0.05% absolute accuracy. Features of the model 851 differential voltmeter include: solid-state design: range, 1 mv to 1 kv; in-line five-dial read-out; standard cell plus Zener reference; polarity reversal; 0 to 10 v dc precision source; and recorder output. Offered in cabinet and rack types with weights of 15 and 17-1/2 lb.

Smith-Florence, Inc., Dept. ED, 4228 23rd Ave. W., Seattle 99, Wash.

Frequency Meters 479

Accuracy is ±0.08%, absolute, at room temperature in the 585, 586, 588 and 590 direct-reading units. Reading precision is 1 mc. Ranges are from 5.1 to 5.9 through 8.2 to 10 kmc. Insertion length is 3.75 to 7 in.

PRD Electronics, Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N. Y.

◀ CIRCLE 106 ON READER-SERVICE CARD

AC-DC Test Set 514

For up to 1,000 v, model KS1-50 has 4-in. voltmeters for ac rms and dc, plus a common ac-dc current meter. Current capacity is 50 ma on ac and 25 ma on dc. Output is continuously adjustable from zero to maximum. The unit is for testing in accordance with ASTM standards or for use as a power supply.

Peschel Electronics, Inc., Dept. ED, Towners, Patterson, N. Y.
P&A: $395; one week.

Audio Programer 422

Actuates relays automatically. The REL-A-TRON has separate sound and inaudible signal channels. It is basically a tape recorder with an electronic timing unit which enables it to operate cycled motion type equipment. Cycling signals can be changed by pushbutton. Specifications include: 115/120 v ac; dimensions 6 x 8 x 8 in.

Tecni-Art Engineering, Dept. ED, Box 96, Glendale, Calif.

Tubular Capacitor 499

Rated at 50 wvdc. Temperature range is −55 to +150 C. Called the CT 10 series, the units are ceramic and measure 0.1 in. in diameter and 0.26 in. in length. Values are 10 to 1,000 μf in tolerances of ±5%, ±10% and ±20%. Uses are in computers, airborne equipment and guidance systems.

Gulton Industries, Inc., Materials and Ceramics Div., Dept. ED, 212 Durham Ave., Metuchen, N. J.

CIRCLE 107 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Axial Seal 403

With jewel bearing. Compact, hermetically sealed axial seal provides a jewel-end bearing at each end of a gimbal within a fluid-filled gyro. It permits an axial adjustment of the gimbal for proper orientation with respect to gyro case. Size is 0.140 in. in diameter, 0.070 in. long, depth 0.025 in.

Mechtronics Corp., Dept. ED, 11431 Joanne Place, Culver City, Calif.

RF Inductors 402

For military and commercial use. Slug-tuned, shielded rf inductors of the series 1500 cover a range of 100 μh to 7.5 mh in 9 sizes. Average Q in 0.1 to 1.0 range is 60. Winding is sealed with epoxy, housing OD is 5/8 in.

North Hills Electronics, Inc., Dept. ED, Glen Cove, L. I., N.Y.

Combination VTVM-VOM 418

Has automatic scale indication. The model SM112 "Service Master" can be used as a vacuum-tube voltmeter from 115 v ac, with six ac and dc voltage ranges, six resistance ranges and a zero center scale. It also can serve as a portable voltohmmeter with six ac-dc voltage ranges, two resistance ranges, and one dc current range. Arrows light up to show which scale should be read.

Sencore, Dept. ED, Addison, Ill.

P&A: $69.50; from distributors.

Power Supply 404

Has ±0.01% load regulation. Controlled-rectifier dc power supply model CR-18-30 provides up to 18 v at 30 amp in 7-in. panel height. Ripple is 0.003 v peak-to-peak, recovery time 40 μsec. Features include remote sensing, remote programing, and electronic current-limiting. Units may be connected in parallel. Weight is 70 lb.

NJE Corp., Dept. ED, 20 Boright Ave., Kenilworth, N.J.
Price: $845.

Counter-Timers 428

Four types are offered. Model 722 combines frequency measurement and both one-period and ten-period measurement. Model 723 measures elapsed time between two events. Model 724 preset ratio counter displays 1 to 10,000 times the ratio of two signals. Model 740 frequency counter allows a direct conversion to physical units.

Erie Pacific, Dept. ED, 12932 S. Weber Way, Hawthorne, Calif.

Wirewound Resistors 426

Can be adjusted by user. Unusual feature of this line of two-terminal precision wirewound resistors is that the user makes the final adjustment and then seals the unit. One end of the winding may be unravelled as required, stripped of enamel and then soldered to a terminal. Adjustment range is 0.001 ohm to 5 meg, with power ratings through 5 w.

Rotohmeters, Inc., Dept. ED, 46 Prospect Ave., Yonkers, N.Y.

Have you sent us your subscription renewal form?

NEW PRODUCTS

Capacitance Bridge 410

Test voltages to 1,000 v ac. This high-voltage bridge is for studies of dielectric losses as a function of test voltage and for capacitance measurements from 1 pf to 100 μf. Accuracy is 0.1% ±1 pf. Frequency range is 50 cps to 10 kc. Maximum test voltage is 1,000 v ac.

Rohde & Schwarz Sales Co., Inc., Dept. ED, 111 Lexington Ave., Passaic, N.J.

Heat Sink 459

For TO-36 power transistor. Designed for use with industrial power transistors in the TO-36 (doorknob) package, heat sink MS-15 enables operation at higher power levels. The natural-convection dissipator is made of aluminum alloy with a black finish.

Motorola Semiconductor Products Inc., Technical Information Center, Dept. ED, 5005 E. McDowell Road, Phoenix 10, Ariz.

Oscilloscope 414

Double-beam instrument. The CD 1016 is a compact rack-mounted double-beam oscilloscope. Features include: two identical Y amplifiers; dc to 5-mc bandwidth; rise time, 70 nsec; nine sensitivity ranges from 100 mv per cm to 50 v per cm, with fine control giving coverage to 100 v per cm. Six additional ranges have maximum sensitivity of 1 mv per cm.

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

Silicon-Glass Diodes 463

High-conductance types 1N482 through 1N488, 1N482A through 1N488A and 1N482B through 1N486B are for use in small areas. Reserve current is low. Suited for use in severe environmental conditions, the units have rugged internal structure and hermetically sealed glass packages.

Princeton Electronics Corp., Dept. ED, P. O. Box 127, Princeton, N. J.

Ampex's Advanced Recorder/Reproducer, the FR-600 used for testing the Minuteman Missile.

A Quality Product requires ALLEN-BRADLEY Electronic Components

This shows a few of the A-B components in one of the Ampex recorder's modules.

In the design of the highly sophisticated circuitry for this advanced recorder, engineers at Ampex selected Allen-Bradley quality electronic components to meet the critical requirements for reliability, long life, and quiet operation. For example, the use of Allen-Bradley potentiometers—with their exclusive solid, hot molded resistance element—assures smooth control at all times. There are never any abrupt changes in resistance during adjustment as in wire-wound resistors. Also the "noise" factor is extremely low initially, and it decreases with use.

Allen-Bradley composition fixed resistors—also made by an *exclusive* hot molding process—are fantastically uniform. Their electrical characteristics are so consistent from resistor to resistor that performance over long periods of time can be accurately predicted. *And catastrophic failure is unheard of*—when you use Allen-Bradley composition resistors.

For the ultimate in reliability and performance, insist on Allen-Bradley *quality* electronic components. Send for Publication 6024 today.

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

Portion of one of 14 CRT monitors, each containing 8 A-B Type G Potentiometers.

A-B QUALITY ELECTRONIC COMPONENTS USED IN AMPEX WIDE-RANGE RECORDER

Fixed Composition Resistors

Adjustable Fixed Resistors

Type G Potentiometers

Type J Potentiometers

ALLEN-BRADLEY

QUALITY ELECTRONIC COMPONENTS

4-61-E

A-B QUALITY

Dependability PROVED!

...in tests at 5 Times mil specs for shock, vibration and acceleration

Potentiometers Type J and Type K | Potentiometers Type G and Type L | Adjustable Fixed Resistors Type R | Hermetically Sealed Ceramic Encased Resistors Type TS Type CS Type ES

About the test

At the United States Testing Co., Inc.* the above Allen-Bradley resistors and potentiometers were subjected to a constant acceleration of 300g, impact shock of 150g and vibration of 50g from 55 to 2,000 cps. All tests were conducted in accordance with procedures outlined in the latest Mil Specs.

*Test Report #71801, Sept. 1960.

In these severe tests, Allen-Bradley resistors and potentiometers have demonstrated their complete dependability in environmental extremes.

The ruggedness of A-B fixed resistors is obtained through an *exclusive* process in which the resistance element and the insulating jacket are hot molded into an integral unit of unusual mechanical strength. This unit is then hermetically sealed in a ceramic tube. Also, please remember, A-B fixed resistors are *completely free from catastrophic failures.*

A-B potentiometers have the resistance elements molded into, and are an integral part of, the base; therefore, they are virtually indestructible. In addition, operation is quiet and smooth when the potentiometer is new, and these characteristics improve with use.

For maximum reliability under severe operating conditions, insist on Allen-Bradley *quality* electronic components.

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

4-61-E

ALLEN-BRADLEY | QUALITY ELECTRONIC COMPONENTS

Indicator Switch 417

Pushbutton is illuminated. This switch takes indicator lamps from 4 to 48 v; a change in circuits merely requires a change in lamps. The pushbutton is also a removable plastic cap available in five colors. Four contacts provide for separate indicating and load circuits. Rated 5 amp at 250 v, the switch is spdt.

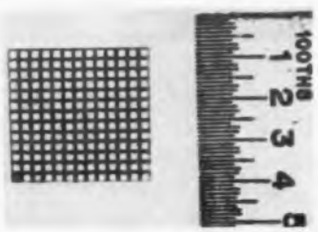
Sylvania Lighting Products, Dept. ED, 60 Boston St., Salem, Mass.

Digital Computer 467

Capacity is 256 to 512 words. Type 44K has a basic instruction rate of 125,000 per sec. Subtractions and various manipulations take 8 μsec; multiplications take 32 μsec. It uses separate program and data memories in conjunction with fully-parallel processing and 5-mc transistor circuits.

Harvey-Wells Electronics, Inc., Dept. ED, 14 Huron Drive, Natick, Mass.
P&A: $4,400; 90 days.

Silicon Matrices 401



In substrate diode arrays. Fully passivated, common silicon-diode arrays are designed to customer-specified geometry, size, and electrical requirements. Matrices will withstand long-term storage at 300 C.

MicroSemiconductor Corp., Dept. ED, 11250 Playa Court, Culver City, Calif.

Preamplifier Package 450

For millivolt signals. For use with thermocouples, strain gages and resistance bulb elements, packaged preamplifier provides stable potentiometric amplification of low-level dc signals. Output is dc current or voltage, up to 20 ma or 14 v. A 3-kc square-wave carrier signal with 2-v output is also available in the solid-state device.

De Var Systems, Inc., Dept. ED, 494 Glenbrook Road, Glenbrook, Conn.

◀ CIRCLE 112 ON READER-SERVICE CARD

NEW PRODUCTS

Trimming Potentiometer 533

Resistance is 10 ohms to 50 K and temperature range is −55 to +200 C in model 358. Off-board dimension is 0.195 in. Applications include matching, balancing and adjusting in control, computing and telemetering circuits.

Daystrom, Inc., Potentiometer Div., Dept. ED, Archbald, Pa.

Availability: From stock.

Pulse-Distributed Amplifiers 491

For high-power transmitting systems, these units have outputs of 10 w to 100 kw and power gains to 24 db over a 16:1 hf band range. Model 116, for example, has an output of 100 kw, a gain of 22 db from 4 to 32 mc; model 126 produces 30 kw and has a gain of 17 db from 4 to 64 mc. No tuning is needed.

Granger Associates, Dept. ED, 974 Commercial St., Palo Alto, Calif.

DC Voltmeter 608

Range is 1 mv to 999.9 v. Model V-70 has an accuracy of 0.01% (plus or minus 1 digit) and provides over-voltage protection. Output can be made to drive data printer. Input impedance is 10 meg at balance. Input power is 105 to 125 v at 50 to 60 cps.

Cubic Corp., Dept. ED, San Diego 11, Calif.

Microminiature Lamps 609

Two types are offered. The 13-7 consumes 0.009 w at 1.35 v. Response to pulsing at half-brightness is 4 μsec or better. The 30-30 provides 250 millilumens at 3 v. Diameter is 0.03 in. and lead length is 0.1 in. Type 13-7 has a 1/64-in. diameter and a 1/16-in. lead length.

Kay Electric Co., Dept. ED, 14 Maple Ave., Pine Brook, N. J.

Electromagnetic Brakes 610

Two sizes are offered. Size 100 has a braking torque of 10 oz-in. min and is rated at 2-w power input. Body diameter is 1-7/64 in. and mounting flange diameter is 1-9/16. Slightly larger, size 130 has a braking torque of 30 oz-in. and an input rating of 3-1/2 w.

Dial Products Co., Dept. ED, 19 Cottage St., Bayonne, N. J.

Price: size 100, $49; size 130, $52.

Status Control Switch 611

A module of communications consoles, this switch is for use in command radio equipment. Signals appear on remote boards or maps. The unit can be furnished with a six-position control knob.

Westrex Recording Equipment Dept., Litton Industries, Dept. ED, 6601 Romaine St., Hollywood 38, Calif.

Thermal Wire Stripper 612

Dual-position type WS17B handles AWG 6 to 36 and coaxial cable. It strips Teflon, nylon and other plastics. The alloy tip is designed for long life. No additional instruments are needed.

American Missile Products Co., Inc., Dept. ED, 15233 Grevillea Ave., Lawndale, Calif.

Epoxy Systems 613

Highly flexible, types 41, 42 and 44 can be adjusted to various concentrations. Type 44 has these typical properties: dielectric, 460 v per mil; tensile strength, 33,000 psi; flex strength, 50,000 psi; specific gravity 1.3.

Isochem Resins Co., Dept. ED, 221 Oak St., Providence 9, R. I.

NEW PRODUCTS

Commutating Switch 614

For 20-cps operation, model 210 is offered in one-pole and multipole designs for 64 and 100 channels. It is available with a 1,200-rpm, 115-v, 60-cps hysteresis drive motor. A jet of mercury replaces the wiper arm, making the unit suitable for continuous use without repairs.

Advanced Technology Laboratories Div., American-Standard Corp., Dept. ED, 369 Whisman Road, Mountain View, Calif.

Availability: From stock.

Power Supplies 615

Inverters and converters are included. The three-phase sinusoidal inverters are suitable for missile and aircraft use with outputs from 15 to 300 va. Distortion is held to below 5% and regulation for line and load is 1% to 5%.

Bergen Laboratories Inc., Dept. ED, 60 Spruce St., Paterson 1, N. J.

Computer Simulator 616

A solid-state system, this unit enables users of the 650 computer to run 650 routines on the new 1410 system. It must be equipped with 40,000 core-storage positions, the 1402 card-read punch and input-output devices comparable to the 650.

International Business Machines Corp., Data Processing Div., Dept. ED, 112 E. Post Road, White Plains, N. Y.

Airborne Data System 617

For recording up to 31 analog inputs in digital magnetic-tape form, this unit is of plug-in, printed-circuit card construction. It includes a multiplexer, a digital converter and a tape-recording unit. The output is suitable for computer processing.

Monitor Systems, Inc., Epsco, Inc., Dept. ED, Ft. Washington Industrial Park, Ft. Washington, Pa.

Transistor Testers 618

Two units are offered. Model T-4 is for testing germanium units including low-level, rf, if, mixer, low- and medium-power types. Model T-5 is for silicon and special-purpose units. Its leakage current ranges are 0 to 50 μa and 5 to 50 ma.

J. H. Mims Electronics, Dept. ED, 307 Sudbury Road, Linthicum, Md.

P&A: $19.50, $24.50; from stock.

Synchro Switch 619

Mounted on size 8 synchro. Sector switch provides a closed circuit whenever the position of the synchro exceeds ±70 deg. Switch angle may be selected for the application. Package is 1.700 in. long and weighs about 2 oz.

Clifton Precision Products Co., Inc., Dept. ED, 5050 State Road, Drexel Hill, Pa.

Availability: 4 to 6 weeks.

NEW PRODUCTS

Power Supplies 620

Regulation is 0.1%. Models 325-2M, 325-1M and 325-0.5M provide 325 v at 2, 1 and 0.5 amp. Load regulation is 0.1% or 3 mv for no-load to full-load changes. Features include circuit protection, reduced number of elements in power stage, simplified circuitry and output adjustability. Design is compact.

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

P&A: $505, $670, $905; 30 to 60 days.

Standard Resistor 621

Accuracy is ±0.002% for initial calibration reading. Adjustment tolerance is better than ±0.005% of nominal value; long term stability is better than ±0.005%. Two, three, and four-terminal measurements are possible.

Electro Scientific Industries, Inc., Dept. ED, 7524 S.W. Macadam Ave., Portland 19, Ore.

Digital Voltmeter 622

Accurate to 0.01%. Digital voltmeter 501B measures positive or negative unknowns between 100 μv and 1 kv. Single-plane readout has 4 digits plus an over-ranging digit. Range is selected automatically. Input filter provides 60 db attenuation at 60 cps; input impedance is 10 meg.

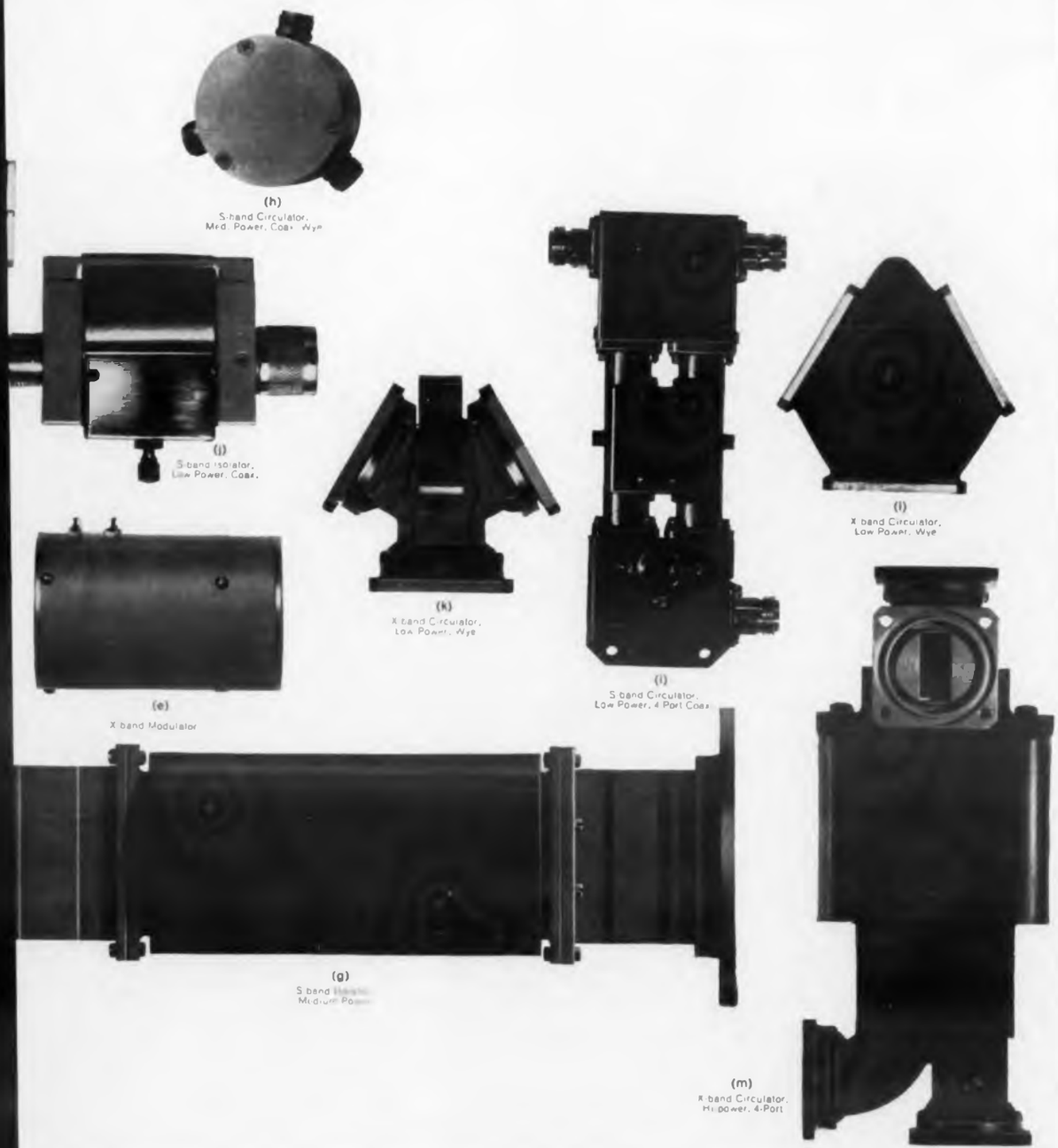
Kin Tel Div. of Cohu Electronics, Inc., Dept. ED, 5725 Kearny Villa Road, San Diego 12, Calif.

P&A: $2,995; 1 week.

Tape-Preparation Equipment 623

For industrial and military use, the TAPE system automatically programs punched tape. Logic circuitry converts word-group and keyboard commands into complete coded programs.

McDonnell Aircraft Corp., Dept. ED, St. Louis 66, Mo.



	(g) S-band Isolator, Medium Power	(h) S-band Circulator, Med. Power, Coax, Wye	(i) S-band Circulator, Low Power, 4-Port Coax.	(j) S-band Isolator, Low Power, Coax.	(k) X-band Circulator, Low Power, Wye	(l) X-band Circulator, Low Power, Wye	(m) X-band Circulator, Hi-power, 4-Port
	2600-3700 mc	2700-2900 mc	2600-2900 mc	2700-2900 mc (tunable) (30 mc bandwidth)	8000-9800 mc	7100-8700 mc	8400-9600 mc
	10 db min.	20 db min.	20 db min.	25 db min.	20 db min.	20 db min.	25 db min.
	0.5 db max.	0.5 db max.	0.3 db max.	0.5 db max.	0.5 db max.	0.5 db max.	0.4 db max.
	1.3 max.	1.25 max.	1.25 max.	1.1 max.	1.2 max.	1.2 max.	1.15 max.
	300 kw 100 watts	25 kw 25 watts	— 500 mw	5 kw 10 watts	2 kw 10 watts	3 kw 15 watts	300 kw 400 watts
	1013-A	1012-A	1005-A	1008-A	1001-A & AA	1009-A	1004-A

CIRCLE 118 ON READER-SERVICE CARD

Digitizer Kit 626

For strip chart recorder. Kit adapts the CP series decimal digitizer to 1/4-sec Minneapolis-Honeywell Brown recorders, permitting data recording in digital form to accompany the strip chart record.

The unit provides 1,000 counts for full-scale deflection of the recorder pen.

Coleman Electronics Inc., Dept. ED, 133 E. 162 St., Gardena, Calif.

Video Amplifier 627

Operates to 11 mc. Solid-state model 1011 video amplifier provides high resolution in closed-circuit TV applications. Bandpass is 15 cps to 11 mc, ±3 db, 20 cps to 8 mc, ±0.5 db. Input is 1 v peak-to-peak, output 10 v peak-to-peak max. Unit is equalized for up to 2,000 ft of coaxial cable.

Community Engineering Corp., Dept. ED, 234 E. College Ave., State College, Pa.

Temperature Transducers 628

For liquid or gas. A complete line of temperature transducers is available for measurement from −450 to +1,500 F. Sensing elements are tungsten, platinum, balco, or nickel. There is a selection of probe lengths, resistance ranges of 20, 200, 500, and 20,000 ohms, and calibration points at 32 and 212 F.

Astra Technical Instrument Corp., Dept. ED, 12930 Panama St., Los Angeles 66, Calif.

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NEW PRODUCTS

Delay Line 629

With variable delay. Model V172 is a lumped constant delay line variable from 0 to 0.55 μsec. Rise time is 0.08 μsec, impedance 1 K, resolution 1/1000. Temperature coefficient is less than 50 ppm. Sealed package measures 1/2 x 1-1/2 x 4-1/2 in. Other lumped and distributed types are available with delays up to 2.5 μsec.

Computer Devices Corp., Dept. ED, 6 W. 18th St., Huntington Station, N. Y.
P&A: $75 ea; 2 to 3 weeks.

Relay Test Set 631

For dry circuits. Model 927 relay test set measures performance of relay contacts at currents of 1 to 20 ma. The 1-kc test voltage may be varied between 0.5 and 10 mv; cycle rate of 4 to 20 cps is controlled by electronic switching. Set contains dc power supply for relay coils. It will accommodate up to 10 relays.

Couch Ordnance, Inc., Dept. ED, 3 Arlington St., North Quincy 71, Mass.

Tube Ager 632

For photomultipliers. Model 350 photomultiplier tube aging test set is capable of checking 2 groups of 24 tubes sequentially. All tubes are operated continuously; single tube anode and cathode currents are checked. Illumination adjustment is provided for each group.

Automation Laboratories, Inc., Dept. ED, 179 Liberty Ave., Mineola, L. I., N. Y.

Panel Meters **633**

Are all-metal. Rectangular panel meters have a scale length of 4.7 in. for best visibility. Case size is 4 x 6 in. Movement is fully shielded against magnetic and rf fields. Standard meter finish is flat black; bezel can be provided in any color.

Beckman Instructions, Inc., Helipot Div., Technical Information Service, Dept. ED, 2500 Harbor Blvd., Fullerton, Calif.

400-Cps Filter **635**

With low transient response. Filter LTR-1 has a center frequency of 400 cps. Attenuation is 30 db at 200 and 800 cps; passband width is down 20% at 16.5% of center frequency. The hermetically sealed filter meets and exceeds standard MIL-F 18827A.

Burnell & Co., Inc., Dept. ED, 10 Pelham Parkway, Pelham, N. Y.

Solid-State Scaler **636**

Resolving time is 50 usec. Models E-110 and E-115 are for use with Geiger-Mueller detectors. Cold-cathode counting tubes display pulses. Model E-115 has preset counts of 500, 1,000, 5,000 and 9,000. Input is 115 v, 60 cps, 1/4 amp.

Radiation Equipment & Accessories Corp., Dept. ED, 665 Merrick Rd., Lynbrook, N. Y.
P&A: $199.50 and $249.50.

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NEW PRODUCTS

Humidity Chamber 639

For MIL-202B. Vapor-temp controlled relative humidity chamber VP-206A is designed to perform the humidity cycle of MIL-202B and method 103A, procedure 2. Chamber cycles automatically between 25 and 65 C ±1 deg. Humidity is constant to ±1% throughout the cycle.

Blue M Electric Co., Dept. ED, 138th & Chatham St., Blue Island, Ill.

TR Tube Tester 640

For production test. Test set BLP-043K makes low-level production tests of single and dual tr tubes at 5 preselected frequencies. Set measures isolation or insertion loss and vswr; two test results are displayed simultaneously. Klystron oscillators are used. Virtually any range can be accommodated.

Bomac Laboratories, Inc., Dept. ED, Salem Road, Beverly, Mass.

Tapped Delay Lines 641

Size is 4.5 x 1.04 x 0.5 in. Input impedance is 500 ohms, dielectric is 250 v dc, attenuation is 1 db and terminals are AWG 20 tinned copper. Model TDL-2194 has a 1-μsec delay time, 0.08-μsec input rise time and 0.2-μsec output rise time. Model TDL 2195 has a 0.5-μsec delay, 0.05-μsec input rise time and 0.1-μsec output rise time.

Dresser Electronics, HST Div., Dept. ED, 555 N. Fifth St., Garland, Tex.

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The Deoxo Catalytic Purifier removes oxygen to less than one part per million from hydrogen gas. It can also be used with other gases such as Nitrogen, Nitrogen-Hydrogen Mixture, Argon, Helium, and Carbon Dioxide. • A combination unit, the Deoxo Dual Puridryer, contains the Deoxo Catalytic Purifier plus an extremely efficient automatically operated drying unit. Removes oxygen to less than 1 PPM from hydrogen and dries the purified gas to a low point of minus 100°F. It will also purify and dry other gases in a similar manner.

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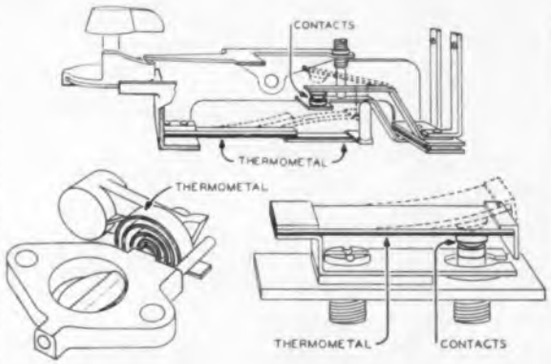

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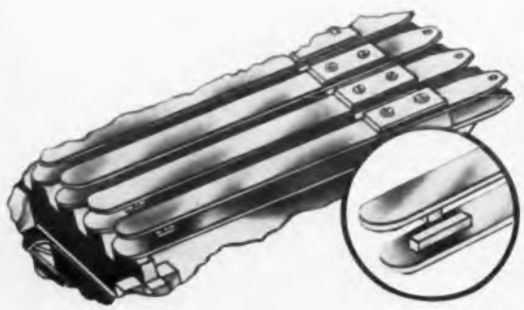

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Multiturn Trimmer 642

For printed circuits. Series C140PC trimmer potentiometer is rated at 0.2 w, 70 C, with operation to 125 C max. The device has a 25-turn lead screw with clutch stops. Resistance range is 500 ohms through 1 meg, linear taper. Case size is 1-1/4 x 19/64 x 21/64 in.

CTS Corp., Dept. ED, Elkhart, Ind.
P&A: $1.63 to $1.85 ea, 500 up; 2 to 5 weeks.

Bobbin Cores 644

For computer applications, series 300 cores use 1/8-in. mil molybdenum permalloy tape wound on stainless-steel bobbins and enclosed in an Armag outer jacket. They have EIA flux values with a tolerance of ±10%. A wide range of core sizes is offered.

Dynacor, Inc., Dept. ED, 10431 Metropolitan Ave., Kensington, Md.

Synchronous Motors 649

Vane-cooled hysteresis motors are available in seven speeds, 360 to 3,600 rpm. Single phase is available for 110 to 120 and 220 to 240 v ac, three phase for 220 to 240 v. Ambient temperature is from −32 to +135 C.

Rotax, Inc., Dept. ED, 2209 Federal Ave., Los Angeles 64, Calif.

Data Plotter 650

System accuracy is to 0.175% of full scale. Input can be keyboard, punched card or tape. Plotting speeds are up to 80 points per min. The unit accepts analog and digital inputs and is adaptable to any computer system. Designation is 3100.

Electronic Associates Inc., Dept. ED, Long Branch, N.J.

NEW PRODUCTS

DC Power Supplies 532

Outputs are 1 to 50 v and are adjustable over a 1-v band in models PI 82, PI 241 and PI 50.5. Current ranges up to 2 amp are available. Other units in the PI series cover up to 100 v. Uses are in built-in applications requiring regulated power.

Deltron Inc., Dept. ED, 4th and Cambria Sts., Philadelphia 33, Pa.

Coaxial Relay 538

For frequencies to 300 mc, series CB relays are for use on 52-ohm coaxial lines as well as lines with other impedances. Ratings are 2-w pull-in power for dc and 9 to 10 va ac. Contact is 5 amp resistive, 2 amp inductive at 26.5 v dc or 115 v ac. Internal contacts are spdt.

Elgin Advance Relays, Electronics Div., Elgin National Watch Co., Dept. ED, 2435 N. Naomi St., Burbank, Calif.

Availability: *On order.*

Component Test Equipment 495

For quality assurance testing with combinations of 10 parameters, SATE is semi-automatic. It accepts or rejects 1,800 components per hr. Design is modular; the modules have binary-type logic circuitry for go/no-go tests.

Librascope, Div. of General Precision, Inc., Dept. ED, Glendale, Calif.

Price: *$16,000 up.*

◀ CIRCLE 122 ON READER-SERVICE CARD

Portable Oscilloscopes 534

Bandwidth is dc to 7.5 mc. Units in the Graph series weigh 20 lb. The plug-in amplifier provides a sensitivity of 1 mv per cm with reduced bandwidth. Calibration on both axes can be checked against a self-contained 1% calibration circuit. Sweep is variable from 1 to 1.5 sec per cm.

Interlab Inc., Dept. ED, 116 Kraft Ave., Bronxville, N. Y.
Price: $395.

Thermocouple 490

Having nine channels, the Em-T-101 system is accurate to ±6 deg from 32 to 165 F. Channels are interchanged by using a resistance thermometer as one leg of a bridge circuit. Bridge excitations are supplied by individual power supplies.

Engineered Magnetics, Dept. ED, 13041 Cerise Ave., Hawthorne, Calif.
Price: *$2,000 up.*

Krypton-85 Battery 544

Rating is 3 kv per cell, open circuit. Current is 600 μμa at no voltage and capacity is 50 uf. Temperature range is −75 to +75 C. External radiation is less than 50 milliroentgens per hr at 4 in. from surface, unshielded. The unit is available to those licensed by the Atomic Energy Commission.

Radiation Research Corp., Dept. ED, 1150 Shames Drive, Westbury, L. I., N. Y.
P&A: *$95; 30 days.*

Bus Duct 591

With low-voltage drop. High-frequency bus duct is designed to transmit power in frequencies from 180 to 20,000 cps. Voltage drop is less than 1 v per 100 ft at 400 cps. Duct measures 9-5/8 in. wide by 3-7/8 in. high and weighs 13 lb per ft. Ten-foot lengths are standard.

Westinghouse Electrical Corp., Dept. ED, Standard Control Div., Beaver, Pa.

CIRCLE 123 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Freezers 535

With temperatures to −200 F, the Cryostor units are suitable for laboratory use. Temperature-range control is automatic. Vapor-proof, units have a 1-1/2 cu ft standard capacity. The first-stage compressor is a 1/2-hp motor, the second, a 1/4-hp motor.

Instrumentation Associates, Dept. ED, 17 W. 60th St., New York 23, N. Y.

Pressure Gage 493

Accuracy is ±1% at room temperature and ±2.5% at temperature extremes. Model 451218 is miniature and is suited for missile, aircraft and telemetering use. Ranges are from 0 to 10 and up to 150 psia, psig or psid. Acceleration is 20 g, operating, 40 g max.

Giannini Controls Corp., Dept. ED, 1600 S. Mountain Ave., Duarte, Calif.

Tantalum-Foil Capacitor 501

Ratings are 12 to 1.4 μf at 6 to 50 v. These A-Case units are double-ended for nonpolar applications and single-ended, if necessary, for polar use. Single-ended units are 0.47 in. long and 0.131 in. in diameter. Life is 2,000 hr.

General Electric Co., Special Capacitor Product Section, Dept. ED, Irmo, S. C.

Induction Motor 496

For airborne-compressor use as well as pump and switching applications, BF-15-8 has an operating speed of 10,000 rpm. Other ratings are: 0.03 hp; torque, 3 oz-in. full load and 400% starting; current 0.26 amp full load and 0.8 amp starting.

Kearfott Div. of General Precision, Inc., Dept. ED, 1150 McBride Ave., Little Falls, N.J.

Production quantities of the type 115 family are now available. Westinghouse also offers the 2N1015 and 2N1016 series of Silicon Transistors, ideal as companion drivers. Military and industrial applications include: power supplies/regulators/amplifiers/high-power switching/inverters.

For more information call your nearest Westinghouse representative or semiconductor distributor. Or write: Westinghouse Electric Corp., Semiconductor Dept., Youngwood, Pa. SC-1012

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◄ CIRCLE 125 ON READER-SERVICE CARD

NEW PRODUCTS

Flaw Detector 651

Operates without liquid. Metalloradar model 6 flaw detector uses a synthetic membrane to couple the transducer to object under test. Six frequency steps from 0.5 to 10 mc are available. A barium titanate transducer is used. The set will detect flaws and discontinuities within the object as well as the opposite side. A 7-in. crt displays the reflected vibrations.

Circo Corp., Dept. ED, Terminal Ave., Clark, N.J. *Price: $2,750.*

Electronic Commutator 652

Operates at +125 C. Low-level electronic commutator model CE-12 provides reliable, high-speed switching at temperatures to +125 C. Contact resistance averages 12 ohms. Reverse current is less than 1 na per channel, common-mode rejection better than 1 million to 1.

United ElectroDynamics, Inc., Customer Requirements Dept., Dept. ED, 200 Allendale Road, Pasadena, Calif.
Availability: In production.

Trimmer Controls 653

End resistance less than 1%. Models PC-1 and PC-2 potentiometers are wirewound units available in values from 100 ohms to 10 K. The stud-mounted PC-1 and the lead-mounted PC-2 have a diameter of 1/4 in. and a length of 1/4 in. Designed for potting, these units have open construction. Specifications include: end resistance, less than 1%; resolution, 0.25% to 1%; power rating, 0.25 w. weight, 0.02 oz.

Miniature Electronic Components Corp., Dept. ED, Holbrook, Mass.

Induction Heater 536

For continuous operation at 3 kw, this 40-mc unit can be used to heat high-resistance materials such as semiconductors. Glass and ceramic can also be heated. Depth of penetration at 40 mc is 0.0005 in. The unit has a three-phase power supply.

Induction Heating Corp., Dept. ED, Brooklyn, New York, N. Y.

Computer Diodes 588

Recovery time of 5 μsec is featured in these silicon units, types 1N925 through 1N928. They are said to have the fastest recovery time and lowest capacitance available at this power rating.

Princeton Electronics Corp., Dept. ED, P.O. Box 127, Princeton, N. J.

Cable Tracing Device 590

For locating up to 10 cables simultaneously, model CT-10 operates from a 1.5-v battery. When an indicator button is depressed, a circuit is identified. Each test made identifies a conductor. Standard receptacle handles wire sizes to no. 10.

Pyramid Instrument Corp., Dept. ED, Lynbrook, N.Y.

Switching Transistor 541

For medium-speed computer use, the 2N40-A germanium unit is designed for military and industrial use. Ratings are: collector-to-base, −40 v; collector-to-emitter, −35 v; emitter-to-base, −25 v; collector-current, −150 ma; emitter-current, 150 ma.

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

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NEW PRODUCTS

Subcarrier Oscillator 654

For low-level signals. Model VC-32 subcarrier oscillator will operate from signal sources as low as ±10 mv full scale with accuracy of 1% or better under all environmental conditions. Output of 4.1 v rms into 2 K eliminates the need for multiplexer amplifiers. Volume is 2.1 cu in., weight 2.5 oz.

United ElectroDynamics, Inc., Customer Requirements Dept., Dept. ED, 200 Allendale Road, Pasadena, Calif.

Availability: In production.

Power Supply 655

For transmitter. MIL-E-5400, Class II transmitter power supply provides 4 kw in multiple outputs. Five high-voltage outputs range from 150 to 650 v dc at currents from 0.12 to 3.5 amp. Other outputs are 28 v dc at 25 amp, 6.3 v ac at 5 and 8 amp, 6 bias outputs from −3 to −60 v dc, and short-circuit proof bias outputs of −18 v dc and 4 v dc at 0.2 amp. Power input is MIL-STD-704,115v.

Transistor Devices, Inc., Dept. ED, 40 Factory St., Cedar Grove, N.J.

Audio Multicoupler 657

With throwaway modules. Model 5102 audio multicoupler provides 10 outputs from single input. Output circuits, low-noise amplifier, and rectifier are housed in modules 1-1/4 in. high by 5/8 in. in diameter. Range is 25 cps to 25 kc, harmonic distortion less than 2% at 1 v output.

Ortronix, Inc., Dept. ED, P. O. Drawer 8217, Orlando, Fla.

P&A: $200 ea; 30 days.

Analog-Digital Converter **659**

With up to 40 channels, this system translates varying voltage data into 13-bit, 8-4-2-1 binary-coded decimal form. It handles ±20 mv to ±700 v. Sampling speed is 80 samples per sec; any sequence is possible. Designation is model 8040.

Electronic Development Corp., Dept. ED, 423 W. Broadway, Boston 27, Mass.

Digital Comparator **660**

Having a **high accuracy,** this unit controls speed, flow rate, pressure or other functions able to produce a proportional pulse rate or frequency. It delivers a series of beat pulses to correct errors. Solid-state components are used.

Jordan Controls, Inc., Dept. ED, 3235 W. Hampton Ave., Milwaukee 9, Wis.

Electronic Timers **662**

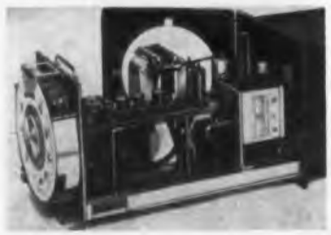
Transistorized devices have timing cycles from 0.005 to 900 sec ±1% during input voltage change of ±25%. Units feature variable or fixed timing cycles, ac or dc input, and recycle time down to 5 msec.

Slip Ring Co. of America, Dept. ED, 3612 W. Jefferson Blvd., Los Angeles 16, Calif.

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

NEW PRODUCTS

Indicating Controllers 663



For process control. Indicators and indicating controllers are made in more than 50 range scales and calibrations for use with all standard sensing elements. Controllers provide off-on or 3-position control for processes. Instruments require 56 sq in. of panel space. Accuracy is 0.25% of full scale, sensitivity 0.125%.

Thermo Electric Co., Inc., Dept. ED, Saddle Brook, N. J.

Instrumentation System 674

Used with transducers. Small, rugged model 96 RC contains a signal amplifier, transducer power supply, bridge balance circuits, and calibration circuits. System can be used with any bridge transducer having 1 to 4 active arms. Output signal is ±5 v dc at 350 ohms impedance.

Video Instruments Co., Inc., Dept. ED, 3002 Pennsylvania Ave., Santa Monica, Calif.

Stepping Relay 675

For machine control. Complete industrial control stepping relay assemblies are supplied ready for installation. Count-up, count-down and combination systems are available with or without instantaneous reset. Standard units provide 4, 5 and 10 points. Life expectancy is 200 million steps.

Programation Div., Guardian Electric Manufacturing Co., Dept. ED, 1621 W. Walnut St., Chicago 12, Ill.

Circuit-Board Vise 676

Can be rotated. A convenient means of holding printed-circuit boards during assembly operations is provided by the Quick-Clip vise. Board can be rotated in an arc of more than 180 deg, and is accessible on both sides. Vise is 6 in. long with jaws 13/32 in. deep.

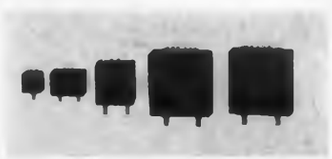
Western Electronic Products Co., Dept. ED, 2420 N. Lake Ave., Altadena, Calif.
P&A: $9.65 ea; stock.

Oscilloscope Probes 677

General-purpose type. The 24 low-capacitance probes in series P6000-P6005 offer choice of attenuation ratios of 1:1, 10:1, and 100:1 in four cable lengths. Made for use with dc to 30-mc oscilloscopes, termination is BNC or uhf connector. Types P6017 and P6022, made for use with dc to 15-mc instruments, have attenuation ratios of 10:1.

Tektronix, Inc., Dept. ED, P. O. Box 500, Beaverton, Ore.
Price: $12.50 to $21.50 ea.

Noise Suppressors 678



For inductive switching. No shielding is required for this line of devices used in suppressing rf noise generated by switching inductive loads. Units also provide contact arc suppression.

Relcoil Products Corp., Dept. ED, Spring St. & Route 75, Windsor Locks, Conn.

Starters and Combinations 679

Redesigned, the M60 EPC starters and combinations are offered in 7, 9, 11 and 13 in. to take sizes 0 to 5 starters and combinations. Features include: one or two pilot lights, pushbutton stations, selector switches and covers with plugged openings.

Crouse-Hinds Co., Dept. ED, Syracuse 1, N.Y.

NEW PRODUCTS

Insulation Tester 680

Measures high resistances. The Teraohmmeter makes resistance measurements over a range of 2 meg to 5 x 10^{15} ohms at potentials up to 1 kv. A pair of 7-in. meters accurate to 0.5% are used for voltage and resistance indications.

Rohde & Schwarz Sales Co., Inc., Dept. ED, 111 Lexington Ave., Passaic, N. J.

RF Connectors 681

In crimp-on design. ConheX crimp-type connectors are available in screw-on and snap-on styles. Assembly time is reduced by 66%. The process does not affect impedance value as there is no dielectric collapse.

Sealectro Corp., Dept. ED, 610 Fayette Ave., Mamaroneck, N. Y.

Power Supply 682

Provides 15 kv. A dc power supply, model LAB-10 is continuously variable from 0 to 15 kv. Regulation is better than 1%; current is 2 ma. Supply is available with positive or negative output. Panel height is 8-3/4 in. Automatic overload and sensitivity control are optional.

Spellman High Voltage Co., Inc., Dept. ED, 1930 Adee Ave., Bronx 69, N. Y.

Price: $275.

Wirewound Resistor 683

Rated at 2 w. Miniature 2-w insulated-shell wirewound resistor type 248E has a top resistance value of 3 K in size 15/64 in. OD, 7/16 in. long. Ceramic-insulated wire is used in multi-layer winding. Outer shell is nonporous, tubular ceramic.

Technical Literature Section, Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

Power Transducer 684

Accurate to 0.5%. Hall effect power transducer PC-500 produces a dc voltage output proportional to true power. Frequency range is 50 to 1,000 cps, linearity 0.5% or better. Output is 0.4 mv per w +20%, −10%. Output is constant within 0.5% from −5 to +75 C. Case size is 4-1/4 x 3-7/8 x 3-5/16 in.

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

P&A: $143.59 ea. 1 to 24; 2 weeks.

Oscilloscope Bay 685

Provides 7 monitors. Model 260 oscilloscope bay has 7 solid-state monitor oscilloscopes in a 3-1/2 x 19-in. rack mount. Scope modules have frequency response of dc to 1 mc within 3 db; vertical sensitivity is 0.5 to 5 v rms per in. Sweep rate is 10 cps to 100 kc. A 2-in. flat face cathode-ray tube is used.

Electro Instruments, Inc., Dept. ED, 8611 Balboa Ave., San Diego 11, Calif.

NEW PRODUCTS

Frequency Standards 686

Are transistorized. Portable frequency standard, weighing less than 7 lb, maintains frequency stability of 1 part in 1 billion per day. A laboratory model uses a vlf syncro phase receiver to provide automatically corrected output signals stable to ±2 parts in 1 billion. The portable unit provides 1-mc and 100-kc outputs; the laboratory model has an additional 10-kc signal.

Motorola, Inc., Dept. P-126, Dept. ED, 4501 W. Augusta Blvd., Chicago 51, Ill.

Resolver Tester 687

Checks sine or cosine function. Resolver function bridge model RF-3M shows as a percentage the difference of a computing resolver's output from ideal sine or cosine function. The device will not introduce more than 0.002% error into the test. Range is 360 deg, quadrature rejection 50:1. Bridge will test all resolvers with phase shifts between −5 and +20 deg and outputs between 5 and 50 v.

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

P&A: $2,000; stock.

Television Camera 688

Image orthicon type. Designed for use in closed-circuit television situations where a minimum amount of light is available, the transistor camera combines the advantages of low weight, small size, and high light sensitivity, with a reduced cost. Preamplifiers are integrated into the camera socket to decrease lead length and stray pick-up from the otherwise normal impedance of the camera tube.

Thompson Ramo Wooldridge, Inc., Dage Div. Dept. ED, Michigan City, Ind.

NEWEST ULTRA HIGH SPEED

saturated logic switching

TRANSISTORS FROM PSI

2N919

(formerly PT706)

MEDIUM h_{FE}

2N920

(formerly PT706-1)

HIGH h_{FE}

- Low V_{CE} (sat)
- Low T_s
- High Power
- High Current

LAMINAR™ CONSTRUCTION

Meet or exceed all epitaxial characteristics . . . **and delivery now!**

TECHNICAL DATA

TYPE	V_{CBO}	V_{CER}	V_{CEO}	V_{EBO}	h_{FE}*	V_{CE}(sat)*	T_s max.*	Pkg.
2N919	25	20	15	5	20-60	.2	25 ns	TO-18
2N920	25	20	15	5	40-120	.2	25 ns	TO-18

NOTE: GUARANTEED 15 ns Max. T_s available in both types. Specify "A" versions.
*See data sheet for exact test conditions.

Phone, wire or write a nearby PSI field office for full details, delivery schedules and quantity prices.

Off-the-shelf delivery from PSI distributors everywhere.

PSI

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A SUBSIDIARY OF THOMPSON RAMO WOOLDRIDGE INC.

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2 NEW TRANSISTORS

for 3 SPECIAL APPLICATIONS

- Newest Core Driver
- Medium Power Switch
- Clock Pulse Generator

PT600
Medium h_{FE}
PT601
High h_{FE}

• Low V_{CE} (sat) • High Current • Fast Switching • Controlled h_{FE}

TRIPLE DIFFUSED MESA CONSTRUCTION

TECHNICAL DATA

TYPE	V_{CBO}	V_{CER}	V_{EBO}	h_{FE}*	$V_{CE(sat)}$* max	t_{on} typ.*	P_C 25°C	Pkg.
PT600	60	45	4	15-45	1.0	40 ns	13w	TO-8
PT601	60	45	4	30-90	1.0	30 ns	13w	TO-8

*Measured at 1 Amp collector current. See data sheet for exact conditions.

Phone, wire or write a nearby PSI field office for full details, delivery schedules and quantity prices.

Off-the-shelf delivery from PSI distributors everywhere.

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Palo Alto – 701 Welch Road – Suite 205, Palo Alto, Calif. • DAvenport 1-2240
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Detroit – 1204 No. Woodward Ave., Royal Oak, Michigan • Lincoln 8-4722
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PENNSYLVANIA – No. 4 Township Line Road, Philadelphia 17, Pa. • Pilgrim 2-8089
Baltimore – 1811 North Rolling Road, Baltimore 7, Md. • Windsor 4-3622

DISTRIBUTORS IN MAJOR ELECTRONIC CENTERS COAST-TO-COAST

Cathode-Ray Tube 689

For direct optical printing at high speeds on film, type E1E11 has fiber optic-light pipes. The pipes conduct the light from the phoshor on the vacuum side to the atmospheric side of the face plate without dispersion. Complete digital descriptions can be recorded in 50 msec. The code matrix provides up to 1,024 bits.

Litton Industries, Display Devices Dept., Dept. ED, 960 Industrial Road, San Carlos, Calif.

Pressure Switch 690

For automatic control, this pressure switch has applications in air compressors and automatic industrial controls. The contact block assembly is designed to be replaced in a minimum of time.

Lanes Industries Corp., Dept. ED, 612 Colorado Ave., Santa Monica, Calif.

Line Equalizer 691

For telephone data transmission. The TEM series of line equalizers is used to offset the amplitude and delay distortion inherent in telephone lines. The compact unit is adjustable for line lengths to 25 miles.

SEG Electronics Co., Inc., Dept. ED, 12 Hinsdale St., Brooklyn 7, N. Y.

◀ CIRCLE 140 ON READER-SERVICE CARD

NEW PRODUCTS

Differential Indicator 692

For pressure systems. Differential pressure indicator is used as an automatic control instrument for balancing two interconnected pressure systems. Pressure rating is 12,000 psi, with resolution of 0.05 psi full scale. Indicator may also be used to seal pressure fluid in a gaging system against liquids and gases in a system under test.

Ruska Instrument Corp., Dept. ED, 6121 Hillcroft Ave., Houston 36, Tex.

Switching Transistors 693

Are epitaxial mesa types. Silicon 2-w transistors handle 500 ma of collector current in a total switching time of 105 nsec. The npn devices have storage time of 25 nsec max, and saturation voltage of 0.45 v max. Storage temperature is −65 to +300 C. Type designations are 2N1958 and 2N1959.

Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.
Price: *$13 and $14 ea, 100 to 999.*

DC Amplifier 694

Accuracy is 0.1%. The 121A dc amplifier is a solid-state, wide-band unit with 11 gain steps from 0 to 1,000, each step adjustable. Gain accuracy is ±0.1% at dc, ±0.25% to 2 kc. Output is ±15 v dc or peak ac into 200 ohms or more, ±100 ma dc or peak ac into 10 to 100 ohms. Combined ripple, intermodulation and distortion is less than 0.1% of output to 2 kc, 0.25% to 10 kc at any gain.

Kin Tel Div. of Cohu Electronics, Inc., 5725 Kearny Villa Road, San Diego 12, Calif.
P&A: *$1,000; 30 days.*

SILICON FAST SWITCHING COMPUTER DIODE

Jedec Type	Min. Breakdown Voltage @100μA (V)	Min. Forward Current @+1V unless noted (mA)	Max. Reverse Current @ Specified Test Voltage (μA) @25°C	@100°C	Volts	Power Dissipation	Reverse Recovery (μsec)	(K ohms)
1N625	30	4@1.5	1	30	−20	200	1••	400
1N626	50	4@1.5	1	30	−35	200	1••	400
1N627	100	4@1.5	1	30	−75	200	1••	400
1N628	150	4@1.5	1	30	−125	200	1••	400
1N629	200	4@1.5	1	30	−175	200	1••	400
†1N643	200	10	1	15	−100	200	0.3♦	200
1N643A	200	100	1	15	−100	200	0.3♦	200
†1N658	120	100	.050	25@150°C	−50	200	0.3♦	400
1N659	60	6	5	25	−50	200	0.3♦	200
1N660	120	6	5	50	−100	200	0.3•	400
1N661	240	6	10	100	−200	200	0.3•	400
†1N662	100	10	20	100	−50	200	0.5♦	100
1N662A	100	100	20	100	−50	200	0.5♦	100
†1N663	100	100	5	50	−75	200	0.5♦	200
1N663A	100	100	.1	15	−75	200	0.3•	200
1N837	100	150	.1	15	−75		0.5•	400
1N837A	100	150	.1	15	−80		0.3•	400
1N838	150	150	.1	15	−125		0.5•	400
1N839	200	150	.1	15	−175		0.5•	400
1N840	50	150	.1	15	−40		0.3•	400
1N841	150	150	.1	15	−120		0.3•	400
1N844	100	200	.1	15	−80		0.5•	400
1N845	200	200	.1	15	−160		0.5•	400

••Measured in modified IBM "Y" test circuit when switched from 30mA forward current to −35V.
♦Measured in JAN 256 test circuit and switched from 5mA forward current to −40V.
•Measured in JAN 256 test circuit and switched from 30mA forward current to −35V.
†Signal Corps Single-Service Approved.

Memory System Exercizer 695

Simulates computer environment. Model 2032 memory system exercizer is an automatic, high speed digital computer simulator that tests and evaluates for a wide range of operating parameters, complete memory systems. Of modular construction, it simulates exact computer environment for testing during development various types of memories.

Rese Engineering, Inc., Dept. ED, A and Courtland Sts., Philadelphia 20, Pa.

P&A: $25,800 ea; from stock.

Disk Thermostats 696

Are snap-acting. Bimetal disk thermostats type A and AY are made in many ranges, tolerances and differentials for operation from −20 to +300 F. Typical rating is 4 amp resistive at 120 v ac for 100,000 cy. Disk may be enclosed or exposed; a variety of terminals and mounting provisions can be supplied.

Stevens Manufacturing Co., Inc., Dept. ED, P. O. Box 1007, Mansfield, Ohio.

Zener Diodes 703

Rated at 10 w. Military 10-w Zener diodes are made in 36 voltages, ranging from 6.8 through 200, and in 2 polarities. Junction and storage temperature range is −65 to 175 C; tolerance is ±5%. Types are 1N2970-3011B(RB) (Sig. C) and 1N3012-3015B(RB) (Sig. C.).

Motorola Semiconductor Products Inc., Technical Information Center, Dept. ED, 5005 E. McDowell Road, Phoenix, Ariz.

Price: $9.45 to $14.90 ea, 100 up.

NEW PRODUCTS

Split Capacitor Motor 709

Diam is 4-7/8 in. Type CR fractional horsepower electric motor is for a wide range of applications. It is available in 4- and 6-pole design, from 1/20 through 1/4 hp. It is claimed the motor combines higher starting torques with increased efficiency.

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

Heat Dissipators 711

For power transistors. Heat dissipators are designed to use a minimum of space while maintaining low thermal resistance with natural or forced draft cooling. Devices are made to accommodate TO-3 transistors and diodes, TO-36 transistors, and Westinghouse 2N1015 transistors.

Augat Bros. Inc., Dept. ED, 33 Perry Ave., Attleboro, Mass.

Power Relay 715

Has inverted coil. Series 2300 power relay is compact with an inverted coil. Contacts are rated for 15 amp at 115 v ac noninductive, or 1 hp at 115/230 v ac 60 cps.

Guardian Electric Manufacturing Co., Dept. ED, 1550 W. Carroll Ave., Chicago 7, Ill.

Legend Light Capsules 716

In three colors. Indicator light capsules have legend areas illuminated in any one of three colors. Designated R2401 and R2402, they use white lamps with colored filters. They can be mounted in compact modular arrangements flush with the panel, side by side, or stacked vertically.

Radar Relay, Inc., Dept. ED, 2322 Michigan Ave., Santa Monica, Calif.

Induction Heat Generator 717

Continuous output is 15 kw. The unit can be switched from 300 kc to 7 mc almost instantly. A saturable reactor is used for output control; manual control is possible. The unit is suited for virtually any induction heating process.

Induction Heating Corp., Dept. ED, 181 Wythe Ave., Brooklyn 11, N.Y.

Display Scope 718

Transistor-driven, this unit has a variety of applications in data systems. The MS-2 occupies 17.5 in of rack space and consumes 230 w. All circuitry but the picture tube is solid state. Power supply is self-contained.

Kauke & Co., Inc., Dept. ED, 1632 Euclid St., Santa Monica, Calif.

NEW PRODUCTS

Digital Recording System 719

For unattended data acquisition over long periods, type 6150 accepts asynchronous data by a tape-stepping method. It handles 38 hr of continuous recording on one tape reel. Nominal speed is 30 steps per sec. It operates from two 12-v batteries or 125 v ac.

Minneapolis Honeywell Regulator Co., Industrial Systems Div., Dept. ED, 10721 Hanna St., Beltsville, Md.

Solid-State Converter 720

Produces 10-bit binary output. A solid-state converter for high speed voltage-to-digital and digital-to-voltage conversion, the Digilog-1011 is designed as a reliable input source for computers, control systems and storage systems. Output is serial or parallel 10-bit binary plus polarity indication. Voltage-to-digital conversion rate is 5,000 per sec; digital-to-voltage conversion rate is 100,000 per sec.

General Precision, Inc., Librascope Div., Dept. ED, Glendale, Calif.

Pulse Rate Detector 721

Delivers up to 15 w. This pulse rate detector is designed to serve as a supervisory control where time rate function of pulsing contacts or special signal pulsing systems require alarm when contacts fail or vary from set parameters. Units are either fixed or adjustable types and are capable of delivering up to 15 w for actuation of an alarm relay or other type of control devices.

Guardian Electric Manufacturing Co., Dept. ED, 1621 W. Walnut St., Chicago 12, Ill.

Pulse Generators 722

Have high repetition rates. Solid-state pulse generating equipment has high repetition rates and fast rise and fall times. Line includes two clock pulse generators and a programed pulse generator. The clock pulse units have repetition rates of 3 to 25 mc and 25 to 100 mc; rise and fall times of less than 4 nsec, and pulse width less than 8 nsec. Amplitude is continuously variable from 0 to 4 v.

Texas Instruments, Incorporated, Dept. ED, P. O. Box 6027, Houston 6, Tex.

Rotary Accelerator 723

With low-noise design. Solid gold slip rings are used for power and signal connections in a rotary accelerator. Designed for testing at controlled variable accelerations to 150 g, the device accommodates test specimens up to 100 lb. Drift is 0.1% max per minute, g variation within 0.1% at all speeds. Maximum test specimen size is 18-in. cube.

Schaevitz Engineering, Dept. ED, Route 130 at Schaevitz Blvd., Pennsauken, N.J.

Centrifugal Switch 724

Used with tachometers. Designed for automatic range changing on 2-scale tachometers, the Syncro-Snap switch is suitable for automatic detection and control of a high and a low speed on one or many circuits at speeds from 0 to more than 15,000 rpm.

Torq Engineered Products, Inc., Dept. ED, 32 W. Monroe St., Bedford, Ohio.

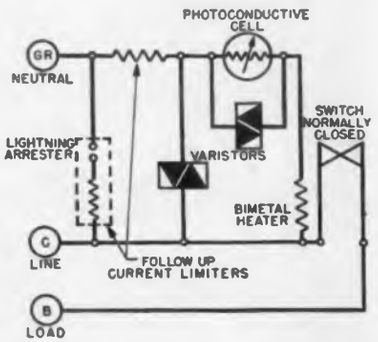
Electronic Products NEWS
by **CARBORUNDUM®**

Photo-electric street light controls protected against transient voltages by Carborundum's Varistors

Millions of street lights are now switched on and off automatically by photo-electric controls such as the Lumatrol® unit made by Micro Balancing Inc., Garden City Park, Long Island, N. Y.

Basic components are a cadmium sulphide cell in series with the heater winding of a thermally actuated snap switch. Resistance of the cell, which changes with light, controls current in the heater winding around a bimetal strip and thus operates the switch.

While cells are quite rugged, they are extremely sensitive to over-voltage caused by switching transients or static discharges. To guard against damage, Lumatrol controls make use of the voltage-sensitive resistance characteristic of Carborundum's GLOBAR varistors. These are silicon carbide resistors which exhibit an instantaneous decrease in resistance with an increase in applied voltage.



Connected across the cadmium sulphide cell and from line to neutral, they effectively bypass harmful transient voltages.

If you have any application requiring surge voltage or similar protection, maybe Carborundum varistors can help. For information on types and sizes, write Dept. EDV-51, Globar Plant, Refractories Division, The Carborundum Co., Niagara Falls, N. Y.

Circle 246 on Reader-Service Card

Precision tuners use CARBORUNDUM CERAMIC SHAFTS

Shown above is a rotor of a precision-RF tuning device used in a military transmitter-receiver unit. It is manufactured by the Radio Condenser Company, Camden, N. J.

The ceramic shaft with attached brass bands, nose piece and bearing sleeve is supplied by Carborundum's Latrobe Plant.

Proper meshing of the gears requires that concentricity between the nose piece and the bearing surfaces be held to .0015 T.I.R. and concentricity between the rotor sleeves be held to .002 T.I.R. The ball race must have an eight micro inch finish to meet Government requirements. Extreme precision must be maintained to avoid changes in capacitance during operation of the unit.

Precision ceramic or ceramic-to-metal assemblies like this are a specialty of our Latrobe Plant. If you have any problems of this kind, write to Dept. EDC-51, Latrobe Plant, Refractories Division, The Carborundum Co., Latrobe, Pa.

Circle 247 on Reader-Service Card

NEW BOOKLET AVAILABLE ON GLOBAR® Type BRN VARISTORS

Non-linear, voltage sensitive resistors are finding many applications for stabilization or voltage control in electronic circuits. This booklet gives full information. For your copy, write Globar Plant, Refractories Division, Dept. EDV-51, Carborundum Co., Niagara Falls, N. Y.

Circle 248 on Reader-Service Card

For ceramic parts and metallized assemblies, Kovar alloy, ceramic resistors, varistors and thermistors . . . count on **CARBORUNDUM®**

CIRCLE 246, 247, 248 ON READER-SERVICE CARD

NEW PRODUCTS

Time Code Generator 725

Stability is 1 in 10^8 per day. Model 6190 time code generator is designed to generate up to three time code formats of any family of time codes. All formats are presented as amplitude-width-modulated outputs on sine-wave carriers and also as width-modulated dc level shifts. Pulse rates from 100,000 pps to 1 pulse per hr and parallel logic levels are supplied simultaneously. The unit has stability of one part in 10^8 per day.

Epsco West, Dept. ED, 240 E. Palais Road, Anaheim, Calif.

Circuit Card Module 726

Dual flip-flop card. The CD-200 dual flip-flop digital circuit card module can be used as shift register stages, binary computer stages, static storage and the implementation of other logic and control functions. Each flip-flop is transient gated through a five diode AND gate for both set and reset. The circuit will drive five loads and operate over a temperature range of −40 to +71 C at a toggle speed of 200 kc.

General Motors Corp., Delco Radio Div., Dept. ED, 700 E. Firmin, Kokomo, Ind.
Price: 1 to 99, $40.60 ea.

Power Amplifier 727

Output is 25 w. Model 2A, for uses such as temperature control, is completely potted for airborne and missile environments. Power required is 115 v at 400 cps. Control signal input is 0 to 5 mv dc to provide 0 to 35 v dc into a 50-ohm load.

Bergen Laboratories Inc., Dept. ED, 60 Spruce St., Paterson 1, N.J.

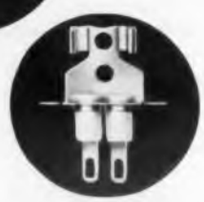
This is the time of our annual subscription renewal; Return your card to us.

AUGAT

CRYSTAL SOCKET ASSEMBLIES

Horizontal Mounting for printed circuits

Horizontal Mounting for sub-miniature crystal



Vertical Mounting for sub-miniature crystal

Augat Crystal Socket Assemblies are especially designed to reduce overall package size and weight. They combine modern packaging techniques with top quality materials to assure dependable mechanical and electrical life.

Once the crystal is installed, it will never shake loose . . . even under the most severe conditions.

Available for horizontal or vertical mounting, for use with hook up wire or printed circuits.

SOCKET SPECIFICATIONS
FOR USE WITH THE FOLLOWING CRYSTAL CASE SIZES: HC-6/U & HC-13/U. HC-18/U with .040 diameter pins or .018 wire leads. McCoy M-25 or equivalent.
CONTACT MATERIALS: Phosphor bronze and beryllium copper. FINISHES: silver plate with gold flash; cadmium or tin plated.
INSULATION: DuPont's Teflon or Blue Nylon
HOLDING CLIP: Beryllium copper or steel, cadmium plated.

For detailed specifications, write for Data Sheets.

AUGAT BROS., INC.
31 Perry Avenue, Attleboro, Mass.

CIRCLE 151 ON READER-SERVICE CARD

Heat Sinks 728

Are beryllium oxide. Used to insulate semiconductor devices from the chassis, beryllium oxide dielectric heat sinks have thermal conductivity equalling that of aluminum. Resistivity exceeds 10^{15} ohms per cm. Dielectric loss is less than 0.0008. The devices are made to match common transistor packages.

National Beryllia Corp., Dept. ED, First & Haskell Ave., Haskell, N.J.

Telemetry System 729

For airborne use. Consisting of model 203 multiplexer, model 205 programer, and model 127 digitizer, airborne pcm telemetry system multiplexes, and digitizes with 8-bit accuracy, low-level transducer signals in the range of 0 to 20 mv. Output amplitude is ±2.5 v into 75 ohms. A complete 48-channel system occupies 250 cu in, and weighs less than 14 lb.

Electro-Mechanical Research, Inc., Dept. ED, Sarasota, Fla.

Film Resistor 730

Rated at 1/8 w. The Vamistor (model 9848-2) uses a low-temperature coefficient alloy, fused to the inner glazed surface of a ceramic tube, and helically grooved for resistance value. It is 0.430 in. long by 0.162 in. in diameter, conforming to MIL-R-10509D characteristics C and E. The resistor is suited for use in high gain servo amplifiers, preamplifiers for nuclear detectors, and analog computers.

Daystrom, Inc., Weston Instruments Div., Dept. ED, Newark, N.J.

INTRODUCING THE

VIDEOGRAPH

MODEL 980 CHARACTER GENERATOR

A low-cost, off-the-shelf "machine language" decoder compatible with any digital system

New from A. B. Dick electronic laboratories . . . a compact decoder (5¼" high x 17" deep x 19" wide) that nests in one cubic foot of space. Realistically priced at $6675.

The Model 980 receives digitally coded signals and converts them to readable alphanumerics at speeds up to 20,000 characters per second—in any size, style or type font. Output can be displayed on any conventional CRT; standard rack mounting construction keeps intercabling to a minimum.

The Model 980 decoder also incorporates highly advanced electronic circuitry and component design. Use of transistors assures lasting reliability; printed circuit boards are highly accessible, readily removable.

For further information and specifications, contact: Mr. G. T. Gerlach, Marketing Manager, Videograph Data Presentation Systems, A. B. Dick Company, 5700 West Touhy Avenue, Chicago 48, Ill.

A. B. DICK ELECTRONIC RESEARCH LABORATORIES: CHICAGO, ILLINOIS • PALO ALTO, CALIFORNIA

A·B·DICK
ELECTRONIC DATA PRESENTATION

Videograph is a trademark of A. B. Dick Company

CIRCLE 152 ON READER-SERVICE CARD

NEW PRODUCTS

Indicator Tube 731

Diameter is 0.210 in. The E1-23 Subminiature Indicator Thyratron is designed for use as a readout device in miniaturized computer panels or where space is at a premium. Measuring a maximum of 0.210-in. in diam, the tube provides a high-intensity glow with a grid swing of 4.5 v and negligible grid current. Specifications are: filament, 1.25 v ac; anode supply voltage, 65 or 85 v ac; anode series resistance, 56 K.

Electronic Industries, Inc., Dept. ED, 18 Marshall St., South Norwalk, Conn.

Delivery: 5 days.

Transistorized Recorder 732

Built on single chassis. This compact recorder has fully transistorized circuitry, positive drive action, a built-in voltmeter, and a direct-reading range dial. It provides a stable, noise-free, magnetic flow-meter ac potentiometer mounted on a single removable chassis. Circuit networks are mounted on plug-in cards that can be replaced in seconds.

Fischer and Porter Co., Dept. ED, 862 Jacksonville Road, Warminster, Pa.

Rate Gyro 733

Diameter is 15/16 in. Fluid-damped miniature gyro has resolution below 0.03% of maximum rate. Linearity is 0.5%, zero calibration 0.01 to 0.02% of maximum rate. The gyro is insensitive to 100 g shock along any axis, and withstands 20 g vibration up to 2 kc. Length overall is 2-1/2 in.

R. C. Allen, Aircraft Instrument Div., Dept. ED, Grand Rapids, Mich.

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Differential Thermometer 734

Measures to 0.001 C. Designed for use in measuring temperature fluctuations to 0.001 C, this differential thermometer reads directly in degrees C. It can be used as a single point of difference-between-two-points measuring device in a range from −60 to +300 C.

Fiske Associates, Inc., Dept. ED, Bethel, Conn.

Mixing Valve 735

Is motor-operated. Mixing valves in the 21300 series have a traverse time of 0.230 sec and a service life of 500 hours minimum continuous operation. Operating pressure is 3,000 psi, temperature −85 to 400 F continuous, to 1,000 F intermittent. Motor input is 26 v, 400 cps, 0.180 amp.

Aerodyne Controls Corp., Dept. ED, 90 Gazza Blvd., Farmingdale, N.Y.

Record Play Head 736

In any inductance to 1 h. An all-metal face, 1/4-track record play head for audio applications is available in any inductance to 1 h. It has a mumetal case for full shielding and a 40-μin. gap gives wide frequency response.

General Instruments Corp., Magna-Head Div., Dept. ED, 3216 W. El Segundo Blvd., Hawthorne, Calif.

Component Coating 737

In 1-part system. HumiSeal type 1F19 dries at room temperature within 30 minutes, and is then oven-cured. The transparent material is suitable for temperatures up to 350 F and down to −90 F. Coating is said to provide excellent resistance to moisture, chemicals, corrosive gases, fungus, weathering and salt spray.

Columbia Technical Corp., Dept. ED, 24-30 Brooklyn-Queens Expressway, West Woodside 77, N.Y.

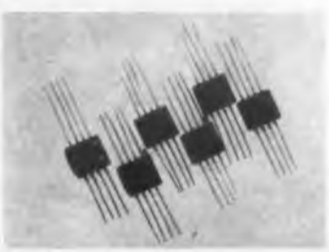
NEW PRODUCTS

Instrumentation System 412

Has modular design. This analog-to-pulse duration instrumentation system is for use with thermocouples, resistance thermometers or other dc, low-impedance sensing sources. It directly converts a low-level electrical input signal to a pulse linearly related in duration to the input signal amplitude. The pulse duration is then digitally measured and displayed, recorded, or processed further for input to digital computing equipment. Modular design permits building systems of several hundred channels.

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

Resistor Combinations 551



From 1 to 1,222,221 ohms in 1-ohm steps. Wafer-thin, miniature package Resist-O-Stat combinations provide any resistance value between 1 ohm and 1,222,221 ohms in 1-ohm steps. Each unit measures 23/32 x 7/32 x 9/16 and contains four selected precision resistors with relative values of 1, 2, 4 and 4. Accuracies range from ±0.1% for values from 1 K to 1.1 megohm to ±1% for resistors from 1 to 11 ohms.

General Resistance, Inc., Dept. ED, 430 Southern Blvd., New York 55, N.Y.
Price: $8 to $14 ea.

Thermal Analyzer 382

For semiconductor materials. Vacuum-pressure inert furnace is used in thermodynamic and thermochemical studies of composition and behavior of materials by a variety of analytic methods. One or more samples may be heated; transducers measure temperature of sample, reaction products or holders.

Testing Equipment Sales Co., Dept. ED, Murray Hill, N. J.

Sweep Generators 353

Provide 4 w. The rf range from 5 to 1,000 mc is covered by 6 models of sweep and signal generators. Designated PD-1 through PD-6, their output is 14 v rms into 50 ohms. Swept rf or cw modes may be modulated by 1-kc square wave. Turret attenuator has a range of 0 to 59 db in 1-db increments.

Telonic Industries, Inc., Dept. ED, Beech Grove, Ind.

Epoxy Adhesive 379

For 1-min curing at room temperature, Mini-Cure cures in 45 sec with infrared heat. Applications include bonding metal to metal, plastic to metal and plastic to plastic. It is a resin-hardener system.

Allaco Products, Dept. ED, 238 Main St., Cambridge 42, Mass.

P&A: $6; trial kits.

Snap-Action Thermostat 369

Operates to 350 F. Type 24T, a low-cost, snap-action disk thermostat, is UL-listed for accurate repeatability over 100,000 cycles at temperatures up to 350 F. Rating is 10 amp resistive, 1/8 hp inductive, at 120/240 v ac. Unit is made with bimetal disk enclosed or exposed, in various mounting flange and terminal arrangements.

Therm-O-Disc, Inc., Dept. ED, Mansfield, Ohio.

Miniature Condensers 378

For printed circuit use. Poly carbonate condensers are available in a complete line for printed circuit applications. Units operate at 75 v, and are made in flat and round types.

Components Specialties, Inc., Dept. ED, 3 Foxhurst Road, Baldwin, L.I., N. Y.

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NEW PRODUCTS

Code Converter 361

Card to tape. Model K-177 card-to-tape converter perforates 5-, 6-, 7- or 8-channel tape of any code structure and of any width from 11/16 to 1 in. It consists of a tape punch and a control module. Parity checking of both odd-bit and even-bit tape code systems, controlled by plug-board wiring, is a standard feature. Multiple card layouts including complex header card and detail card programs can be processed.

General Instrument Corp., Systematics Div., Dept. ED, Hawthorne, Calif.

Transistor Tester 368

Checks h paramters. The Parameter Tester will check the four h parameters of signal transistors to an accuracy of 2%, over wide operating ranges, in either grounded base or grounded emitter configurations. All dc circuitry is isolated from testing circuits. Unit can be mounted in rack or cabinet.

Tenco Electronics, Inc., Dept. ED, 108 Cumington St., Boston 15, Mass.

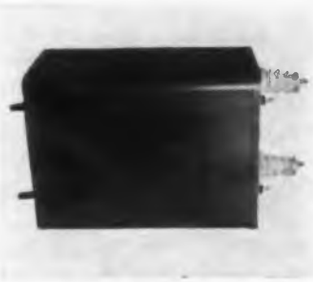
P&A: $150; 30-day delivery.

Strain Gage 360

For welding to aluminum alloys, 20- and 120-ohm gages are offered. Applications include welding to missile skins. Each gage will operate at 750 F for short periods. The nominal gage factor is 1.75. An 80-w, capacitor-discharge welder is to be used.

Microdot Inc., Dept. ED, 220 Pasadena Ave., South Pasadena, Calif.

Power Supply 366



Has output of 30 kv dc. Measuring 5.9 x 4.6 x 8 in. high, exclusive of terminals, this miniaturized power supply has an output of 30 kv dc at 1 ma. The output voltage is continuously variable by adjusting the ac input. Ripple is less than 1% at rated output.

Film Capacitors, Inc., Dept. ED, 3400 Park Ave., New York, N.Y.

Availability: From stock.

NOR Logic 371

Uses no diodes. NOR logic circuit cards operating at 50 kc and 250 kc use resistors instead of diodes for the basic logic element. Combinations of elements can be used to solve all logical equations with the exception of time delays. There are 15 types of NOR elements available, all constructed on 4-1/2 x 5 in. epoxy-glass cards.

Ransom Research, Inc., Dtpt. ED, 374 W. 8th St., Sand Pedro, Calif.

P&A: $20 to $35 ea; immediate.

Temperature Monitor 350

With alarm system. Solid-state temperature monitoring and alarm system, designed for reactor control, may be applied to industrial process controls for temperatures to 1,500 F. It has remotely adjustable, sensitive over- and under-temperature alarm with manual or automatic reset. System accuracy over-all is 0.5%.

Astra Technical Instrument Corp., Dept. ED, 12930 Panama St., Los Angeles 66, Calif.

NEW PRODUCTS

Altitude Chamber 537

With up to 200,000 ft simulated altitude and a temperature range of −100 to +240 F, the Inreco chamber is for testing electronic components. Pull-down time to −90 F is 45 min and heat-up time to +240 F is 15 min. Dimensions are 20 x 20 x 20 in.

Industrial Refrigeration Co., Inc., Dept. ED, 8940 Ellis Ave., Culver City, Calif.

Fans and Blowers 589

Ranges are 150 to 600 cfm at moderate pressures. Model 15-20, a typical unit, consists of two axial flow fans driven by 1/80-hp motors and delivers 413 cfm. It draws 100 w and occupies 1.23 cu ft. All units are for minimum-space use.

Propellair Div., Robbins & Myers, Inc., Dept. ED, Springfield, Ohio.

Delay Filters 539

Low, high, and bandpass units are offered with wide bandwidths and sharp roll-offs. The PPC units are for data transmission and processing and other applications where a complex signal or group of signals must be passed without distortion.

SEG Electronics Co., Inc., Dept ED, 12 Hinsdale St., Brooklyn 7, N.Y.

Germanium Transistor 540

For logic circuits, type 2N934 high-speed, epitaxial unit has a collector-current rating of 200 ma max. Collector-to-emitter saturation voltage is 0.3 v at an Ic of 40 ma. At an Ic of −100 ma and a V_{CE} of 0.5 v.

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

Punched Card Receptacles 349

For up to 25 cards, these units are for use in the control of emergency vehicles by command consoles and dispatching centers. The card actuates a switch that indicates the status of the vehicle on a central control panel.

Westrex Recording Equipment Dept., Litton Industries, Dept. ED. 6601 Romaine St., Hollywood 38, Calif.

Programed Data Quantizer 348

Handles 400 test points. The PDQ programed data quantizer is a universal test stand combining the speed and reliability of automatic equipment with the versatility of manual operation. It handles up to 400 test points and scans them at a rate of 4 points per sec. The readout may be in any numerical order form 1 to 400, or in any other sequence selected by the program tape.

General Dynamics Corp., Convair Pomona Div., Dept. ED, Pomona, Calif.

Ceramic Magnet 347

Withstands low temperatures. Oriented barrium ferrite ceramic magnet F-620 has a coercive force of 3,000 oersteds; maximum energy product is 2.5 x 10^6 gauss-oersteds. Irreversible loss of field strength in cycling from +150 to −75 deg C is very low. Size is 0.30 in. inside diameter by 0.15 in. thick, with OD of 1.20 in. and 0.85 in.

D. M. Steward Manufacturing Co., Dept. ED, East 36th St., Chattanooga, Tenn.

P&A: $1.50 to $4.50 ea, 10,000; 30 to 60 days.

NEW PRODUCTS

Digital Converter 346

Used with transducers. Solid-state digital converter model 4310 changes the output of potentiometric transducers into a variable frequency for display or recording. Input impedance is 500 to 3,000 ohms; output frequency deviation is 7.5% at 5 v ac, frequency range 400 cps to 70 kc. The 4-oz converter measures 1.5 x 2 in.

Winsco Instruments & Controls Co., Dept. ED, 11789 W. Pico Blvd., Los Angeles 64, Calif.
Price: $159 ea.

Precision Plating Machine 345

Dimensions are 30 x 26 x 18 in. All operations are controlled from a panel board incorporating a dual-scale ammeter, a powerstat control for rectifier, circuit breakers and an automatic timer which provides an alarm.

The Meaker Co., Sel-Rex Corp., Dept. ED, Nutley 10, N. J.

Temperature Sensor 344

For nuclear applications. Model 177A temperature sensor is designed to measure absolute or differential temperatures from −70 to +300 C. It will withstand a radiation level of 500 radians per hour. Time constant is less than 5 sec for 63.2% change.

Rosemount Engineering Co., Dept. ED, 4900 W. 87th St., Minneapolis 24, Minn.

Magnetic Shift Register 343

Multidirectional, this unit steers information under control of a single flipflop. It is a 10-bit unit for use as a preset decade counter with outputs available for each unit of the count. Frequency of operation is 100 kc max.

Magnetics Research Co., Inc., Dept. ED, 179 Westmoreland Ave., White Plains, N. Y.
P&A: $175; stock to 45 days.

Power Supply 342

For teletype systems. The G1.5A power supply provides output of 120 v at 1.5 amp. Ripple and regulation are within 10%. Military construction is used; panel height is 5-1/4 in. Power requirement is 105 to 125 v. Supply is also available in 2- and 3-amp models.

Spellman High Voltage Co., Inc., Dept. ED, 1930 Adee Ave., Bronx 69, N. Y.
Price: $195 to $230.

Magnetic Pick-up 341

For measuring speed, counting revolutions, reversing the direction of motion, speed control and proximity detection, the Kineflux pick-up generates a voltage-frequency from mechanical motion without contact. The output can be regulated by controlling the dc excitation.

Kinelogic Corp., Dept. ED, 1256 N. Fair Oaks Ave., Pasadena, Calif.
P&A: $30; from stock.

NEW PRODUCTS

Linear-Motion Potentiometers 340

For missile and aircraft use, type 2986 units have independent linearities of ±0.5% or better. Resistances are 250 ohms to 50 K. Dielectric strength is 1,500 v rms. Shaft stroke is 1.3 in. The units are best suited for use in servo-control systems and instrumentation transducers.

Markite Corp., Dept. ED, 155 Waverly Place, New York 14, N. Y.

Switching Transistor 339

Operates to 175 C. Silicon epitaxial mesa switching transistor 2N753 has a dc forward current gain range of 40 to 120 at 10 ma. The npn device has a typical storage time of 18 nsec. Housed in the TO-18 package, the unit is rated for 300-mw dissipation in free air.

Motorola Semiconductor Products Inc., Technical Information Center, Dept. ED, 5005 E. McDowell Road, Phoenix 10, Ariz.
P&A: $12.35 ea, 100 up; immediate.

Trimmer Potentiometer 338

Dimensions are 1/2 x 1/2 x 0.2 in. Model 357 provides resistance values of 10 ohms to 50 K over a range of −55 to +200 C. It can be used in matching, balancing and adjusting in all types of precision control, computing and telemetering circuits

Daystrom, Inc., Potentiometer Div., Dept. ED, Archbald, Pa.
Availability: From stock.

Ultra-Sensitive Relay 337

Available in two sizes. Ultra-sensitive sealed relay type 1520 has a 5-mw sensitivity and occupies a 0.970 x 0.970 x 1.750 in. space. Type 1540M has a sensitivity of 10 mw and occupies a space of 0.970 x 0.970 x 1.250 in. Mechanical design affords freedom of adjustment and permits a "make before break" contact.

North Electric Co., Dept. ED, Galion, Ohio.
P&A: $17 ea for 1 to 9 quantities; 5 weeks.

Liquid-Level Gage 336

With visual readout, the Gage-O-Matic provides constant information as to the status and behavior of hot or cold liquids. Single or multiple control switches provide for operation of valves, pumps, signal circuits or whatever the application requires.

H. H. McKinnies Co., Dept. ED, 3131 W. Mill Road, Milwaukee, Wis.

Availability: Made to order.

Power Transistors 335

From 10 to 100 w. Silicon power transistors include the 2N1936-2N1937 rated at 100 w, the 2N1722-2N1724 at 50 w, and the 2N1714-2N1718 series rated at 10 w in TO-5 case. All the units were designed for application in a wide range of power uses in airborne, missile, communications, and industrial equipments.

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

Industrial Load Controls 334

Power or frequency is recorded on a strip-chart recorder which incorporates control switches. A governor motor contactor is energized by the switches to operate the turbine governor motor.

General Electric Co., Instrument Dept., Dept. ED, West Lynn, Mass.

Recording Heads 333

Have high density. Digital read-write heads of series RW11700 provide 8 in-line tracks for each 1/8 in. of tape. Track width of each channel is 0.008 in. with nominal inductance of 1.5 mh. Crosstalk between channels is −20 db at 10 kc.

Applied Magnetics Corp., Dept. ED, Box 368, Goleta, Calif.

Progressive Shorting Switches 332

With 20, 24 or 32 positions, these switches can be used as control decks for rotary solenoid operation, capacitor decade switching, sequential power distribution and network applications.

The Daven Co., Dept. ED, Livingston, N.J.

NEW PRODUCTS

DC Tachometers 331

Two models. Model R9608-001 is an uncompensated unit designed to function as a stabilizing element in a standard dc servo mechanism. Model R9608-002 is temperature-compensated to maintain high accuracy from −15 to +71 C.

General Precision Inc., Kearfott Div., Dept. ED, 1150 McBride Ave., Little Falls, N.J.

VSWR Probe 330

For open-wire lines. Model 2988 is a noninsertion device for measuring incident power and vswr on open wire transmission lines. Probe is clamped on transmission line as desired; monitor-alarm unit has front-panel display of incident rf power and vswr. Range is 2 to 50 mc at 50 kw max. Directivity is in excess of 30 db.

Trak Electronics Co., Inc., Dept. ED, Wilton, Conn.

Acoustic Calibrator 329

Needing no power source, type 1417 is for periodic calibration of sound-level meters. It covers a wide frequency range centered at 1,500 cps. Noise is repeatable within ±1 db. A noise level as high as 90 db at 4 in. is produced.

The Korfund Co., Inc., Dept. ED, 22F Cantiague Road, Westbury, N. Y.

Time Code Generator 328

Code in AMR 17-bit format. The 802 M2 time code generator is for generating precision instrumentation signals identical with those produced at the Atlantic Missile Range. Code in the AMR 17-bit, 24-hr binary format can be used to check out ballistic missiles and space vehicles at plant development facilities. Time drift on the unit is less than 1 sec per month, with a frequency stability of 3 x 10⁻⁸ per day.

Electronic Engineering Co. of California, Dept. ED, 1601 E. Chestnut Ave., Santa Ana, Calif.

Leak Detector 327

Designed for vacuum technology, model 600 features: an air sensitivity of 10 to 12 cm^3 per sec; sensitivity ranges of 5 x 10 to 11, to 5 x 10 to 8 cm^3 per sec for full-scale deflection; 2/3 of maximum response in 2 sec or less; sensitivity to helium only.

Crosby-Teletronics Corp., Dept. ED, Westbury, N. Y.

Dual Counters 326

For sequential control. Dual predetermined counters are made with 3 to 6 Nixie readout tubes. Designed for control of 2 separate functions in sequence, the series 61 counters operate at 100 kc. Output is 5-amp contact closure, momentary and latching. Remote readout to 1,000 ft may be used.

The Redford Corp., Instrument Div., Dept. ED, 262 Saratoga Road, Scotia 2, N. Y.

Fluctuation Adapter 325

Reading an input of 0 to 0.5 v ac, continuously, from any of the firm's primary transmitters, the A41A/1 computes magnitude of fluctuation and transmits a proportional signal to a controller. It is suitable for any application where magnitude of fluctuation is more important than the value of highs and lows reached by the variable.

Swartwout Div., Crane Co., Dept. ED, Hooksett Industrial Park, Manchester, N. H.

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NEW PRODUCTS

Diode Tester 324

Checks to 3 kv. The DT 924 is a back-current and saturation voltage tester with meter ranges of 0 to 3 kv, 0 to 3,000 μa, and 0 to 3,000 na. Regulation is better than 0.1%, ripple and noise 0.05%. Output current is 0 to 1 ma, output voltage 0 to 3 kv. Features include recorder output and 4-1/2-in. mirror-backed 1% meter in fully protected metering circuit.

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

Precision Transducers 323

For measurement and control of rotary motions to 1 sec of arc and linear motions to 0.0001 in., the Inductosyn units can be used in missile control and gyro pick-offs as well as other military and industrial applications. Rotary units have 0.1-sec resolution.

Del Electronics Corp., Dept. ED, 521 Homestead Ave., Mt. Vernon, N. Y.

Helium Magnetometer 322

Sensitivity is 0.01 gamma. Helium magnetometer operates from −40 to +125 F and offers precise measurement of both magnetic field variations and total magnetic field. No change occurs in the measured value of the field as a function of optical axis orientation with respect to the magnetic field axis. The device weighs 6 lb and measures 13 x 7 x 7 in.

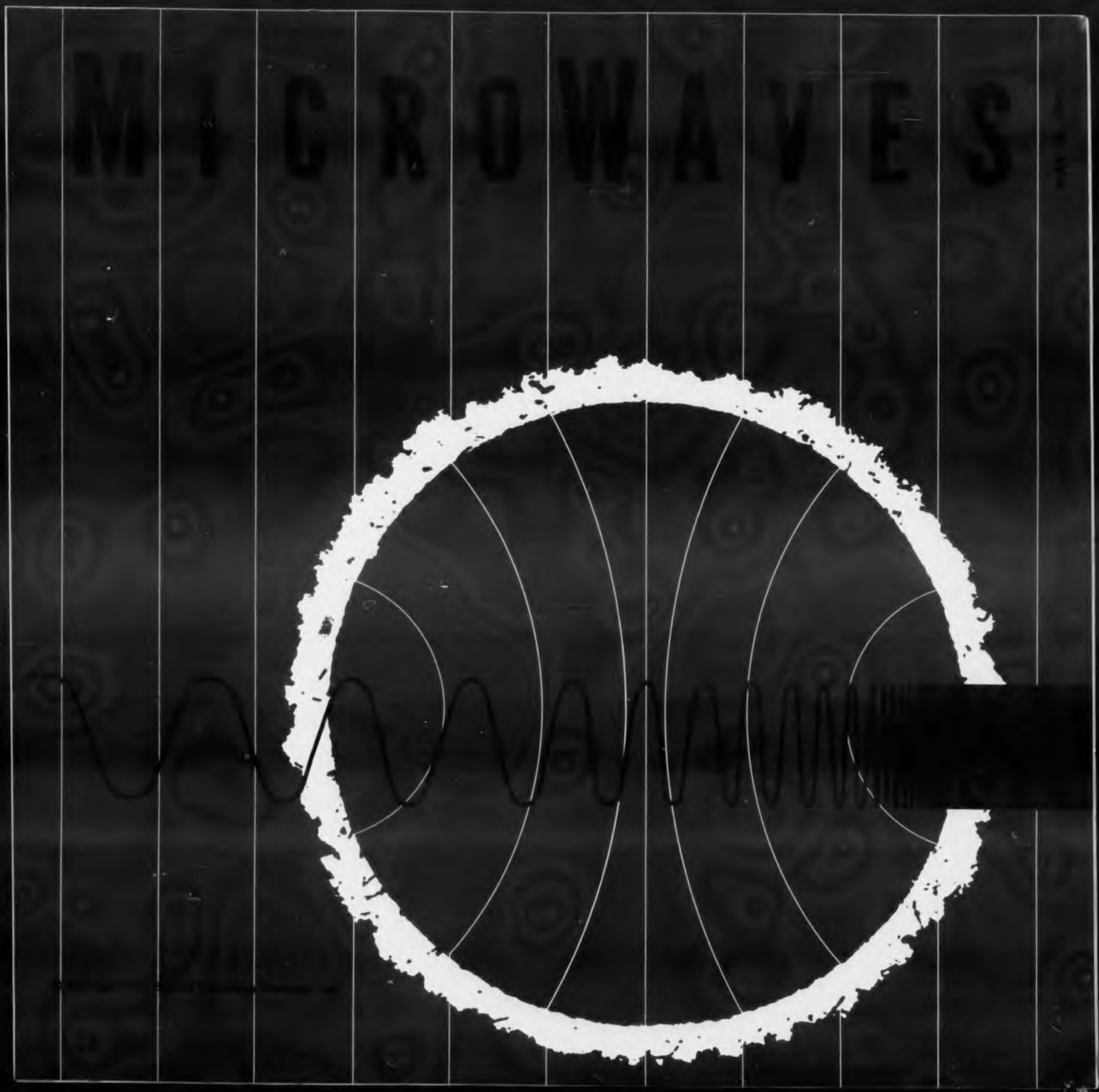
Texas Instruments Incorporated, Dept. ED, 6000 Lemmon Ave., Dallas 22, Tex.

Audio Transistors 321

Provide 200 mw. High-voltage units 2N1186, 2N1187, and 2N1188 offer a collector-to-base voltage of 60 v at 50 μa. High-gain types 2N1185 and 2N1194 have betas of 190 to 400 and 500. The units are housed in TO-5 package. Typical turn-on and turn-off time is 2 μsec.

Motorola Semiconductor Products, Inc., Technical Information Center, Dept. ED, 5005 E. McDowell Road, Phoenix 10, Ariz.

MICROWAVES



MICROWAVES

Beating the Spectrum Squeeze

Tired of mucking around in X-band? Rfi got you down? Try the wide open spaces above 100 Gc. Of course the reason they're wide open is that we haven't got much in the way of rf sources, components and systems that will work in the rarefied atmosphere of millimeter waves.

But as the report on the opposite page shows, a large number of scientists are doing their best to fill that gap; who knows but that they may succeed all too well and that by 1970 we'll be aiming at a new and higher frequency frontier. So best stake your claim in that region before it too becomes obsolete.

Good, useful design ideas, however, are always in style. This issue of MicroWaves includes two articles that should be likely candidates for the microwave designer's reference file—shortcuts in antenna simulation and coaxial cavity design.

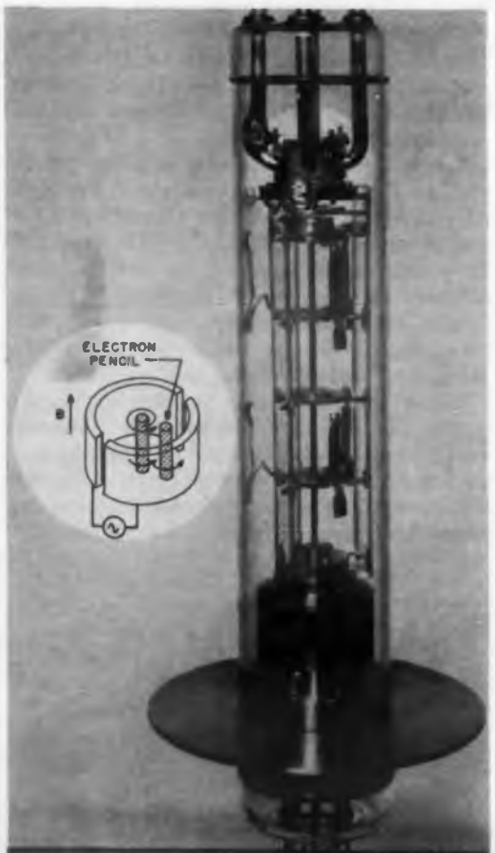
Millimeter-wave sources for systems application are rapidly nearing realization. Plasma devices fast-wave structures and the Tornadotron are described in

Why build an antenna when you can simulate it with a resistance card? Find out how it's done in

Design of tunable coaxial cavities is often determined by volume restrictions. The correct size and the effect of compromises can be quickly found with this

Tunnel diodes for frequencies up to 4.6 Gc, a direct reading phase meter and a broadband duplexer tube covering 275 to 600 mc are among the new products described in

Millimeter-Wave Generators Approaching Pay-off Stage



Experimental Tornadotron built to check characteristics of electron pencil. Radiation is generated within circled chamber near top of the tube. The chamber is about 1/2 in. long. In use, the tube would be housed within Helmoltz coils that develop the required magnetic field. Inset shows spiral path of the electron pencil which is caused by cyclotron action of the Tornadotron.

RESEARCH into millimeter and submillimeter wave generators may soon pay off in devices delivering substantial power at the upper end of the microwave spectrum. More than 60 research teams in industry, Government and universities are reported to be active in this area, and designers are beginning to consider seriously the possibility of radar, Doppler, and communications systems above 100 Gc.

The designer shopping for power at 100 Gc or above now has three choices:

- Raytheon's new QKK 971 klystron (100 to 120 Gc).
- A COE-20 Carcinotron (130 to 145 Gc), made by Compagnie Generale de Telegraphie Sans Fil (CSF).
- Harmonic generators (several hundred Gc).

The two tubes deliver about 10 mw each at the top of their ranges, while the output of crystal and diode harmonic generators is more commonly measured in microwatts at low millimeter wavelengths.

While such power levels may be adequate in the laboratory, generators of far higher power are well along in development. Tubes delivering up to several hundred watts at 1 mm or beyond are thought to be entirely feasible.

First Tornadotron Tests To Be Performed at 4 Mm

Later this month, for example, the first trial operation of the Tornadotron is planned at the Bayside, N.Y., laboratories of General Telephone and Electronics. The device will be operated at 4 mm. Emphasis will not be on power output but to prove out the design concept. The Tornadotron is inherently a pulsed device that should be capable of high instantaneous power at repetition rates on the order of 100 per sec.

Wright Air Development Div. is supporting development of a 1-mm Tornadotron. Gerhard Weibel, developer of the tube, expects it to generate 1 w at 1 mm in a 10 μsec pulse. By reducing the pulse length to 1 μsec, however, power might be raised to perhaps 1 kw. Dr. Weibel envisions Tornadotrons operating far into the submillimeter region. A tube operating at 0.1 mm might generate more than 10 kw in microsecond pulses, he believes.

Tube Refinements Showing Promise of Achieving 1 Mm

Despite the apparent limitations of conventional tubes, however, many organizations are continuing to scale down klystrons and crossed-field tubes and are gradually edging their way to 1 mm. The backward-wave O-type Carcinotron is the most successful example of a continuously refined conventional tube. The prototype COE-15 tube is said to deliver 1-mw minimum between 180 and 205 Gc, while the prototype COE-10 generates 1 mw minimum between 250 and 294 Gc. A still more advanced laboratory model has shown some power at 355 Gc.

Raytheon is also concentrating on refinement of existing types, particularly klystrons. The company is also considering scaling down its high-power Amplitron tube to millimeter-wave dimension. Since power generally decreases as the square of the frequency, the company reasons that an extremely powerful low-frequency tube would also be ahead of the game at 1 mm.

Nevertheless, scaling down of conventional tubes has obvious limitations in power and frequency. Interaction structures become impossibly small at high frequencies. CSF retained its interdigital slowing structure down to its 4-mm tube but has since gone to a slotted-vane structure whose fabrication might prove a challenge to the watchmaker's art.

Traveling-wave tubes might also be adapted for miniaturization. Hughes is designing a 50-w-cw twt at 6 mm. CSF is working on a 1-w

MICROWAVES NEWS

average twt at 2 mm, and Bell Telephone Laboratories is reportedly planning a 1-w-cw twt at 1 mm.

Several high-frequency magnetrons are also reported in development. These include a 107-Gc unit with 2.5-kw peak output, built by the Columbia University Radiation Laboratory; a 79-Gc unit of 5-kw peak output, built by SERL in England, and a 300-Gc magnetron, planned by the General Electric Co. of England. Here again, fabrication of small dimensions is a limiting factor. Anode vanes in the 79-Gc magnetron are only 0.003-in. thick, while the 300-Gc magnetron will use a photoetched anode.

Limitations of conventional devices have thus prompted research into a wide variety of exotic approaches. Plasmas, because of their unusual but little understood properties, have attracted considerable interest.

A simple resonator utilizing a plasma column within a Fabry-Perot interferometer is being developed by J. Stafford at the University of Illinois. A strong axial magnetic field is applied to the plasma, which then radiates at a characteristic resonant frequency. In this, as in all plasma devices, there arise difficulties in creating and containing the plasma, as well as in coupling energy into and out of the medium.

Plasmas may also make possible application of the Doppler effect to generate millimeter waves, since a wave reflected by a moving mirror is increased in frequency. Here, a "plasma piston" would be magnetically accelerated toward the wave to provide a "mirror" of suffi-

Miniaturization problems in conventional millimeter-wave tubes are illustrated by this slotted-vane slow-wave structure employed in the COE-20 135-Gc Carcinotron. Actual length of the structure is about 1 in.

ciently high velocity. Similarly moving striations for the same purpose might be established in a plasma column by ultrasonic waves or cyclic magnetic fields. The Doppler approach is particularly interesting, as the power of the reflected wave is increased as the square of the frequency increase.

The plasma piston has been used by O. G. Zagorodnov in the Soviet Union to obtain frequency increases of several megacycles at about 27 mc. Moving striations are being studied at the University of Illinois, Polytechnic Institute of Brooklyn and CSF.

Plasmas may also find eventual use in the Rebatron—a Cerenkov radiation device under development by Dr. Paul Coleman at the University of Illinois. In this device a frequency-bunched electron beam grazes the surface of a dielectric. If the velocity of the beam exceeds that of the speed of light within the dielectric, radiation is generated at harmonics of the bunching frequency. To date Dr. Coleman has reported outputs of 1 w at 40 Gc, using a 1-Mev beam bunched at S band. He believes that the use of tensor media, such as plasmas or ferrites in place of the dielectric, could yield perhaps 1 kw at 1 mm.

Fast-Wave Tubes in Development At GE and Stanford University

Fast-wave structures offer another possible means of overcoming the limitations in conventional tubes. A fast-wave structure can be considered the dual of a slow-wave structure, such as the traveling-wave tube. In the twt the electron beam supplying the energy to the rf wave is maintained at a constant velocity, while the wave is retarded by passing along a helix, comb or vanes.

The opposite effect occurs in the fast-wave tube. The rf wave is not retarded; rather the electron beam is forced into a spiral, sinusoidal or other cyclic path by external magnetic fields. By synchronism of electron and wave motions, the electron surrenders energy to the rf wave. Since the tube is essentially a straight piece of waveguide, there are no dimensional limitations on frequency.

One fast-wave tube now in development is the Ubitron (Undulating Beam Interaction), suggested by R. Phillips of General Electric's Power Tube Dept., Palo Alto, Calif. In the original Ubitron concept the electron beam traveled in a plane, a sinusoidal path down a length of rectangular waveguide. Lately Mr. Phillips has

substituted a circular waveguide with the beam following a corkscrew, undulating path. The circular waveguide permits larger diameter electron beams for the same frequency, or conversely, reduces the problem of small waveguides at high frequencies. A power improvement factor of about 50 is reported for the circular guide.

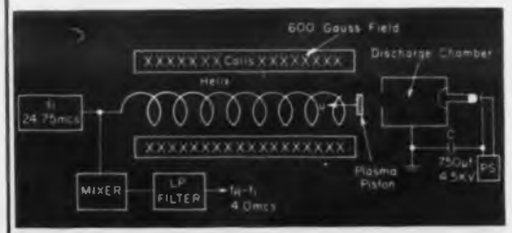
The Ubitron has recently won a Wright Air Development Div. contract and has since been classified secret. However, Mr. Phillips reports that in recent experiments "We have generated about four times the peak power ever obtained by other methods in the Ku band."

At Stanford University, R. H. Pantell is developing a fast-wave device in which a hollow, cylindrical electron beam undergoes helical rather than undulating motion. Magnetic fields in excess of 100,000 gauss would be required to spiral the electron beam at a rate necessary to generate 300 Gc. Strong fields are in fact required for a number of proposed millimeter-wave devices, but recent progress in superconducting magnets may solve this problem.

Tornadotron Generates Radiation By Accelerating Electrons

Acceleration of electrons to produce radiation, a fundamental deduction from Maxwell's equations, is the principle applied in the Tornadotron. A pencil of electrons is formed at the center of a cylindrical chamber. The chamber is formed in two halves and is located along the axis of a magnetic field to form what is, in effect, a cyclotron. An rf signal applied to the two halves of the chamber causes the electron pencil to spiral outward. The signal is then removed, and the electron pencil continues in a circular path some distance out from the center of the chamber.

A strong axial magnetic field is then briefly



"Plasma piston" generator built by Russian scientists to test Doppler method of microwave generation. Device shown achieved frequency increase of 4 mc. Helix slows phase velocity of incident wave to increase the Doppler shift caused by reflection of wave from moving plasma.

applied to the chamber. The pencil spirals sharply inward, and the electrons thus accelerated generate the radiation in the Tornadotron. The pencil is then reformed at the center of the chamber, and the process is repeated.

Since a strong, sharply pulsed magnetic field results in rapid acceleration of the electrons, extremely high frequencies can be generated in this manner. Power is a function of the number of electrons involved in the process and can be increased by lengthening the chamber or by tighter packing of the pencil. One-mm radiation would require a field of about 100,000 gauss, while 0.1-mm waves could be generated by a field of 1 million gauss.

Solid-state devices are also being considered as millimeter-wave sources. Perhaps furthest along in this area is a pulsed-ferrite generator being developed by H. J. Shaw at Stanford University. This device is essentially a solid-state Tornadotron in which radiation is developed by electron spins in a small sphere of yttrium iron garnet.

New Applications Are Foreseen With Millimeter-Wave Advances

With this variety of research and development, much of it well-supported by the Air Force, it should be only a matter of time before a number of millimeter and submillimeter wave generators suitable for application in systems become available.

Studies are now under way to locate spectrum windows, especially in the little-known region above 300 Gc.

Apart from their obvious advantages of high-channel capacities, high resolution, precise aiming and reduced equipment size, millimeter waves may open entirely new application areas for electronics. Weather forecasting, for example, could be greatly improved by detection of clear air turbulence, believed possible with 60-Gc and 120-Gc waves. Air navigation and study of aerodynamic phenomena would also benefit greatly.

Radio astronomers would like to tune in on an ever-wider spectrum of interstellar signals. Millimeter waves could make practical the radar mapping of planets and the sun, to say nothing of high-resolution terrestrial mapping and reconnaissance. The accuracy and velocity range of Doppler navigation systems would increase directly as the frequency of the transmitted signal. In fact, Air Force support of a 140-Gc Carcinotron development giving 50-w peak output and 1-w cw is related to such Doppler applications. ■

How to Simulate Antennas In Systems With Waveguides

Rotating the edge of a variable-resistance disk in a slot cut into a waveguide is a simple, inexpensive and very flexible way of simulating an antenna. It can be used in any system that has a waveguide.

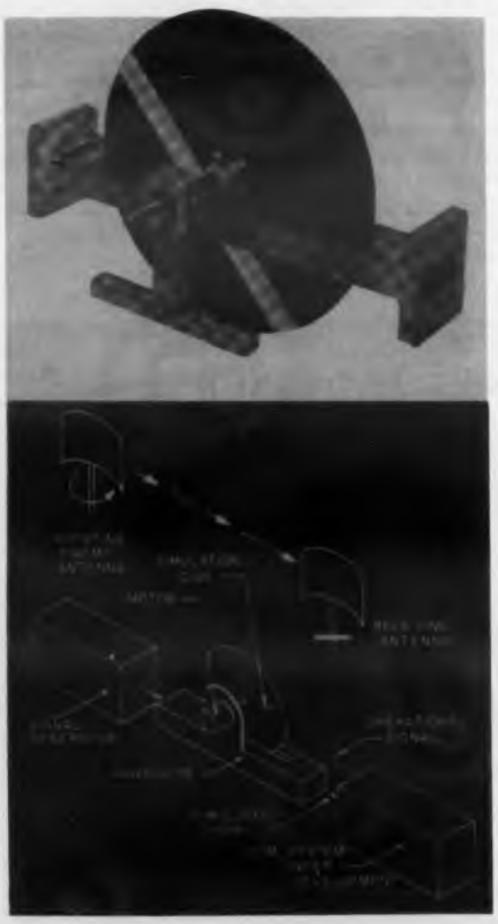


Fig. 1. Sketch of test set up indicates how the resistance cards were mounted so that their edges could be rotated in slots in the waveguide.

William Krushinski, Thomas E. Watson
Sr. Engineer, Group Engineer
Electronics Div., The Martin Co.
Baltimore, Md.

ANTENNA radiation patterns can be simulated by the controlled insertion of a shaped resistance card into a slot cut along the centerline of the broad face of a waveguide.

The reception of a pattern from a rotating antenna can be simulated by rotating the rim of a disk-shaped card. The pattern beamwidth can be varied by varying the card resistance distribution.

Beamwidths from 3.5 to over 143 deg were simulated with 6-in. diam disks in a RG51/U waveguide (Fig. 1). The design steps were:

- Determining the resistance patterns of the disks.
- Developing a method of fabricating the disks.
- Solving mounting problems.

How the Card Resistance Characteristics Were Determined

Results of tests performed at X band to determine maximum attenuation of various values of resistance cards (ohms/sq) when inserted into RG51/U waveguide are shown in Fig. 2. All the cards were of the configuration shown on the graph. They were 0.027 in. thick and consisted of a carbon base film (a few thousandths of an inch thick) bonded to a sheet of paper-phenolic laminate. The tolerance in their rated resistance per square was ±10 per cent. Fig. 3 gives maximum attenuation as a function of resistance card values from 30 to 1,000 ohms/sq at a frequency of 10 kmc.

The graphs show that the most appropriate value for maximum attenuation with insertion is 100 ohms/sq. The tolerance on resistivity probably accounts for the irregular shape of the curve in the 50-to-100-ohm/sq region. For a given value of resistance card of fixed shape, maximum attenuation occurs when the card comes in contact with the bottom of the waveguide. Greater values of attenuation may be produced by placing a longer piece of resistance card inside the waveguide. A comparison of the attenuation characteristics of two differently shaped cards of 100 ohms/sq is shown in Fig. 4.

Care should be taken to shape the leading edge of the resistance card depending upon the maximum vswr that can be tolerated in the system. Slight irregularities and raggedness of resistance card edges can cause proportionately larger mismatches. Because of the dissipative nature of the resistance card, it is only necessary to ensure that the rf looking into the card will not see a serious discontinuity in order to achieve vswr values of less than 1.1:1 over the waveguide frequency band.

By using the 100-ohm/sq material in the form of 6-in.-diam disks, it was possible to simulate 3-db antenna beamwidths from 3.5 to 143 deg. The disks were inserted in a slot on the centerline of the broad face of RG51/U waveguide. Slots cut into waveguide in this manner intercept little or no lines of current and thus radiation from the slots is virtually non-existent.

The minimum beamwidth attained with single-slot penetration (Fig. 5) is 17 deg. If the disk is allowed to penetrate both sides of the waveguide through two slots (Fig. 6), beamwidths as narrow as 3.5 deg are attainable. These beamwidths

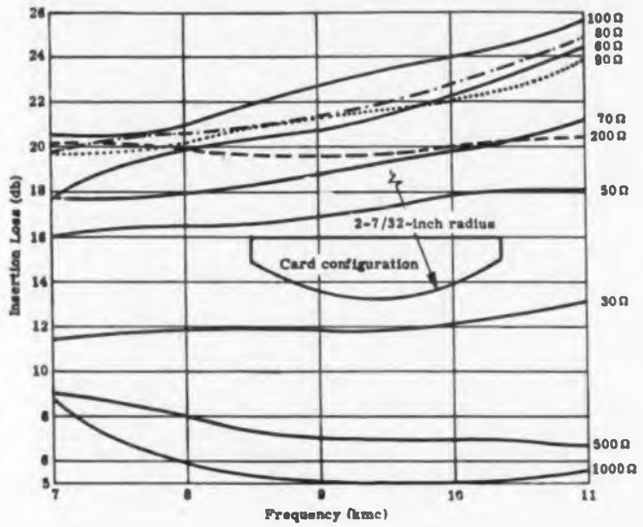


Fig. 2. Tests of cards with various resistances can be used to determine how the attenuation varies with frequency.

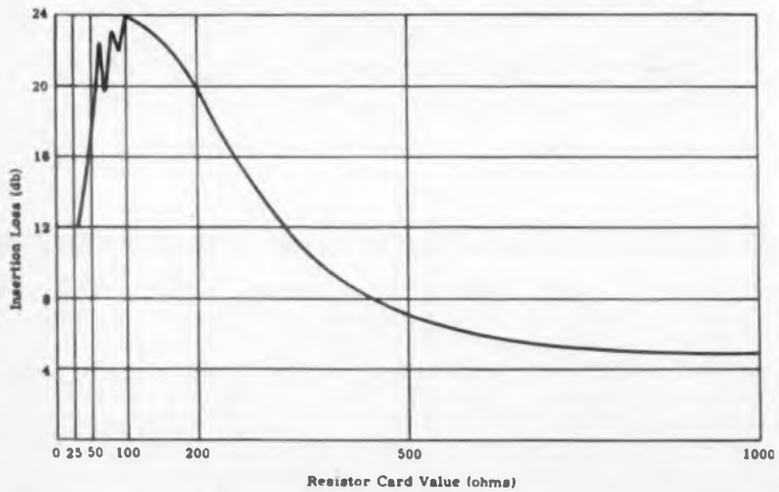


Fig. 3. The best resistance value for maximum attenuation was 100 ohms/sq.

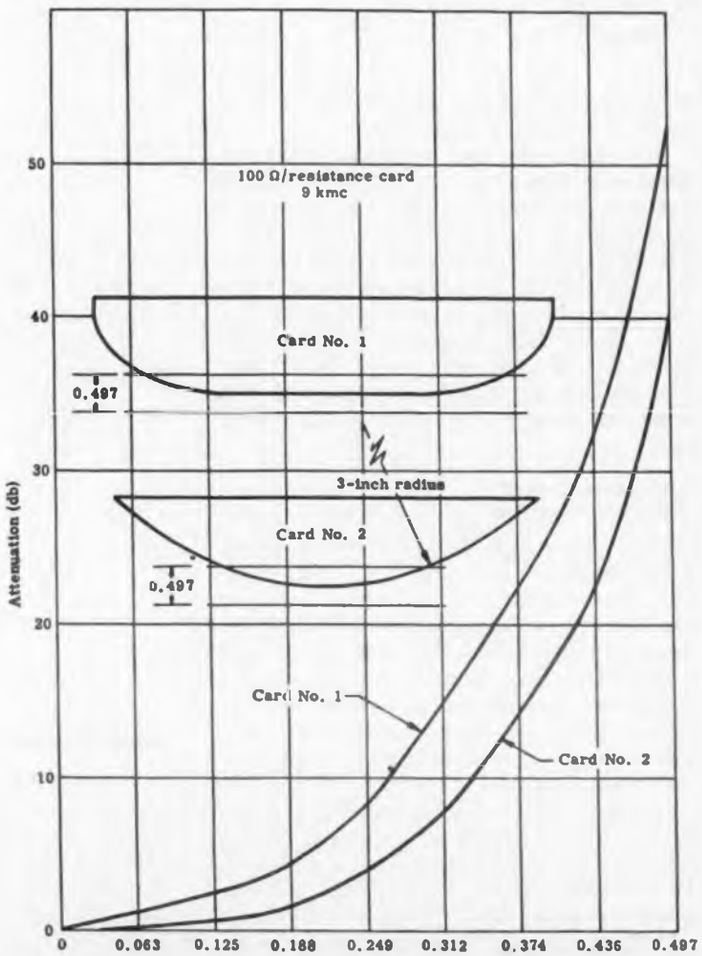


Fig. 4. A comparison of the attenuation characteristics of two differently-shaped cards.

are a function of frequency, as is the case with actual antennas. The beamwidths become larger as the frequency is reduced. Typically, a 3.5 deg beamwidth at 11 kmc will become 4.5 deg at 8 kmc.

Minimum Beamwidths When Rate of Attenuation Is Maximum

Minimum beamwidths are produced when the rate of attenuation is maximum as the disk is rotated from the minimum attenuation position. At the position of minimum attenuation, there is no resistance material in the waveguide. From these initial conditions, larger beamwidths are shaped by appropriate removal of the resistance material from the cards, as shown in Figs. 5 and

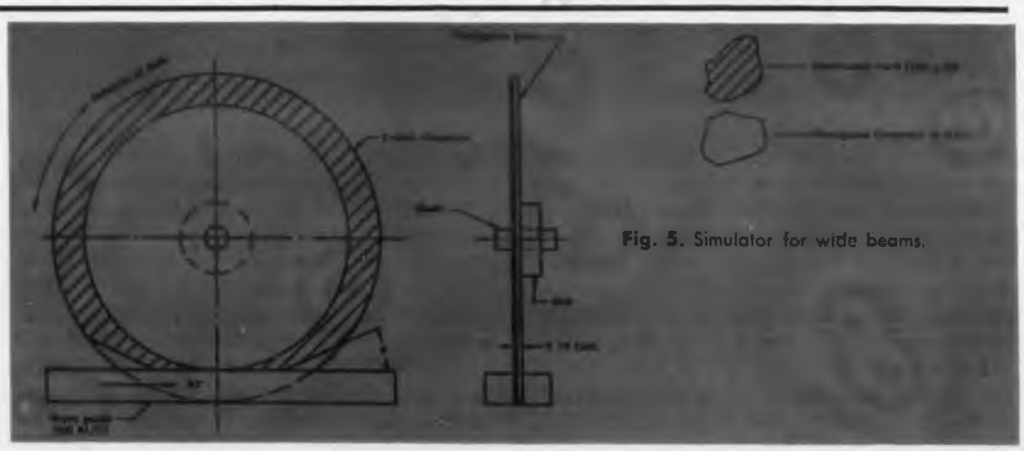


Fig. 5. Simulator for wide beams.

6. Beamwidths narrower than 3.5 deg can be attained with larger diameter disks.

However, in the case where the disk penetrates both sides of the waveguide, problems of disk warpage become apparent as the disk is made larger. There will be some warpage with a 6-in.-diam disk. Accompanying this warpage will be a tendency for the disk to brush the side of the waveguide slot as it rotates within the slot, thus causing irregular rotation because of the variation of loading on the disk drive motor. Also, the resistance material may scrape the sides of the slot changing the resistance value of the card.

Fabrication Method Eliminates Warpage

The warpage problem is alleviated in the following manner. First, to protect the resistive surface from damage, the resistance surface is bonded face-down to a plexiglass disk. The bonding material should be of low dielectric constant to prevent a serious mismatch in the waveguide. A dielectric constant about the same as plexiglass or lower (i.e., approximately 2.5) is satisfactory. Fig. 7 compares attenuation characteristics of an attenuator before and after bonding.

To remedy the warpage resulting from the bonding and/or the inherent warpage in the plexiglass, the entire disk is faced on a lathe. In the case where the disk penetrates only one side of the waveguide, facing is not necessary since only the rim of the disk is plexiglass, the remainder being fabricated from metallic plate for good support. (There will be some additional warpage due to the differences of thermal expansion between the plexiglass and resistance card.)

Lobe Simulation By Shaping Resistance Card

In some cases, it may be desirable to simulate side or back lobe structures on the pattern. Any practical configuration of side and back lobe structure may be incorporated on the attenuator disk by properly shaping the resistance card. In fact, if the disks are not perfectly aligned along the axis of the guide through 360-deg rotation of the disk, side and back lobes are inherent in the pattern produced by the disk. The magnitude and position of these lobes will be a function of the location and degree of off-the-axis travel. During rotation, if the disk moves to either side of the centerline, a condition of slight excitation (due to shunt coupling) of the slot occurs. This causes the energy to bypass the dissipation action of the card. Typical lobe structure is shown in Fig. 8. The lobe maximums are normally down 30 to 40 db from the main lobe maximum.

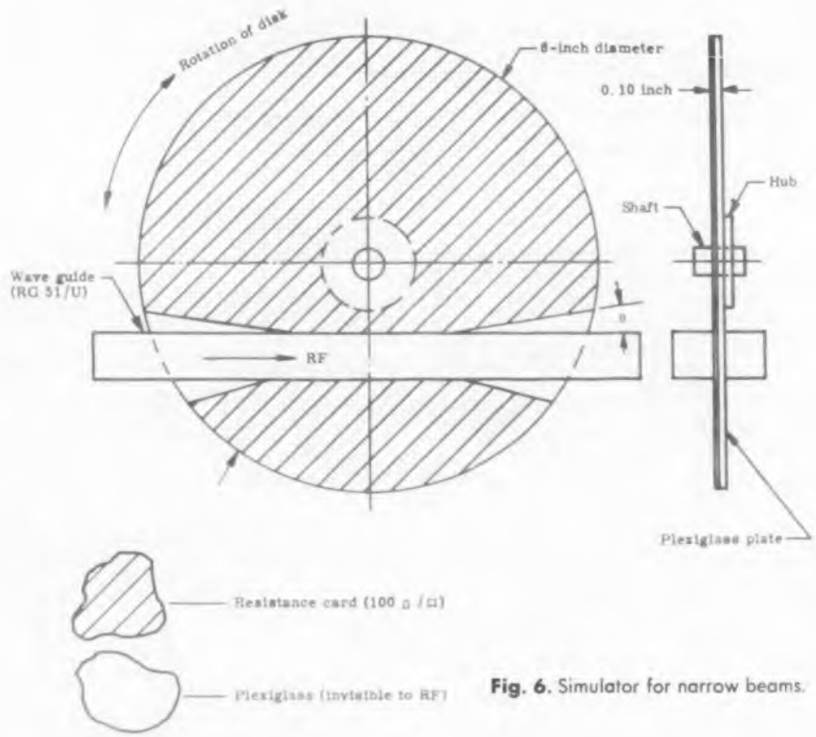


Fig. 6. Simulator for narrow beams.

Mounting Problems: Alignment and Slot Width

When designing the disk-type attenuator, consideration should be given to the waveguide slot width and to the location and positioning of the resistance card within the slot. If the slot is located off the centerline of the broad face of the waveguide, shunt coupling of energy from the guide will exist in increasing amounts as a function of off-axis displacement. This coupling causes a radiating mode to exist. In addition to the requirement that the slot be centered along the axis of the guide, the slot should be less than 1/8 in. wide to prevent the interception of excessive series currents on the waveguide walls, a condition which will produce a condition of radiation. The accuracy of locating a 1/8-in. slot on the centerline of the broad face of the guide depends upon the amount of radiation which can be tolerated from the slot. With normal tolerance of a few thousandths of an inch on the location and width of the slot, radiation from the slot (with the resistance card inserted) is on the order of 70 to 80 db down from the reference level.

The antenna radiation pattern beamwidths simulated were from 3.5 to 143 deg, using a 6-in. diam disk (Figs. 9 and 10). Beamwidths wider than 143 deg could have been produced using the 6-in.-diam disk. On the other hand, the 3.5-deg beamwidth can be considered as the lower limit for the 6-in. diameter. A slightly narrower beamwidth may be produced with a given diameter disk by having the disk shaft pass through the narrow walls of the waveguide. However, the mechanical mounting problems involved in producing extremely narrow beamwidths by this technique probably rules it out in favor of using larger disks mounted as described. Therefore, using RG51/U waveguide (7.05 to 10 kmc), the design parameters given may be considered as near optimum. ■ ■

Note
Resistance cards were from International Resistance Co., Philadelphia, Pa.

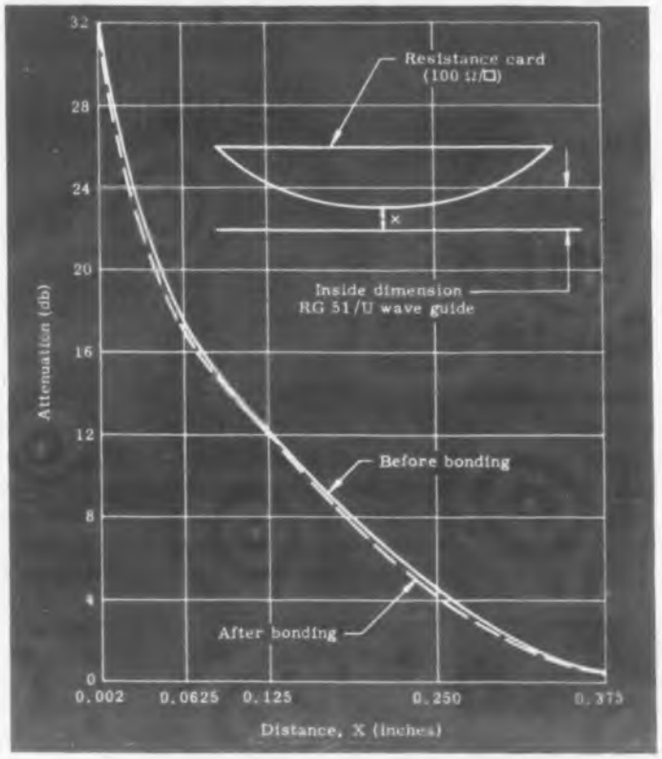


Fig. 7. If the backing and bonding materials have low dielectric constants, the reinforcement and protection of the resistance card can be accomplished with little change in characteristics.

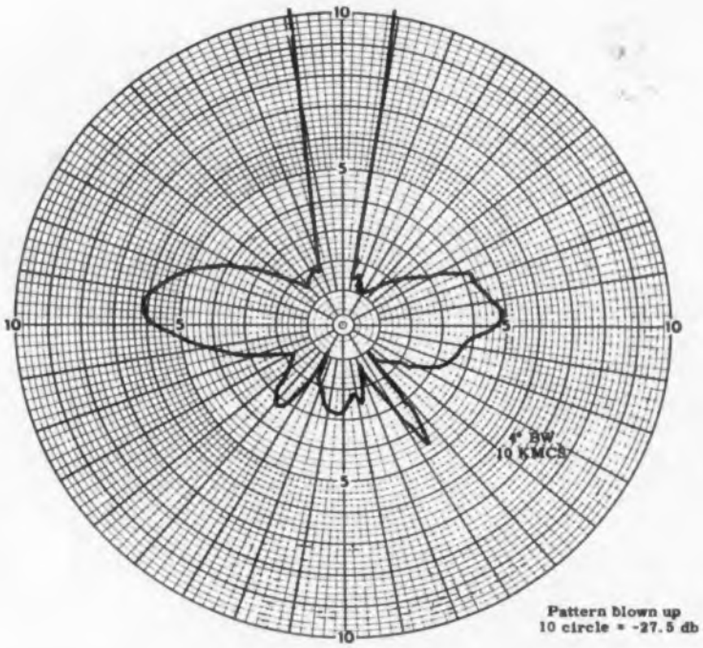
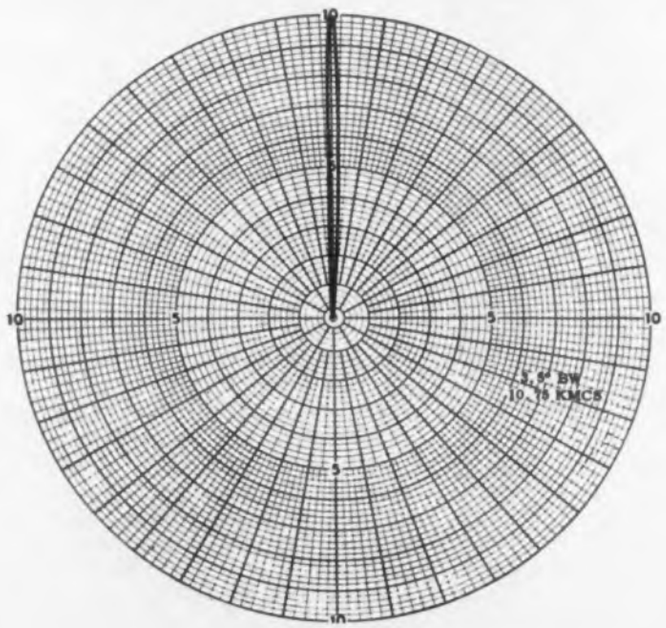
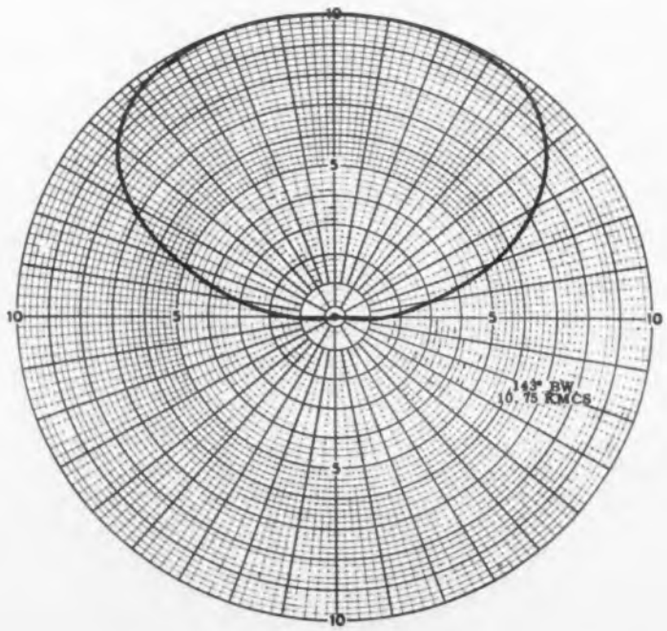


Fig. 8. Any practical side and back lobe configuration may be achieved by shaping the resistance cards. The beamwidth was 4 deg and the frequency 10 kmc. The pattern was blown up and the "10" circle represented —27.5 db.





Figs. 9, 10. Beam widths from 3.5 to over 143 deg can be simulated with 6-in. disks. Fig. 9 is a 3.5-deg pattern and Fig. 10 is a 143-deg pattern. Both were at 10.75 kmc.

Nomograph Speeds Design Of Tunable Coaxial Cavities

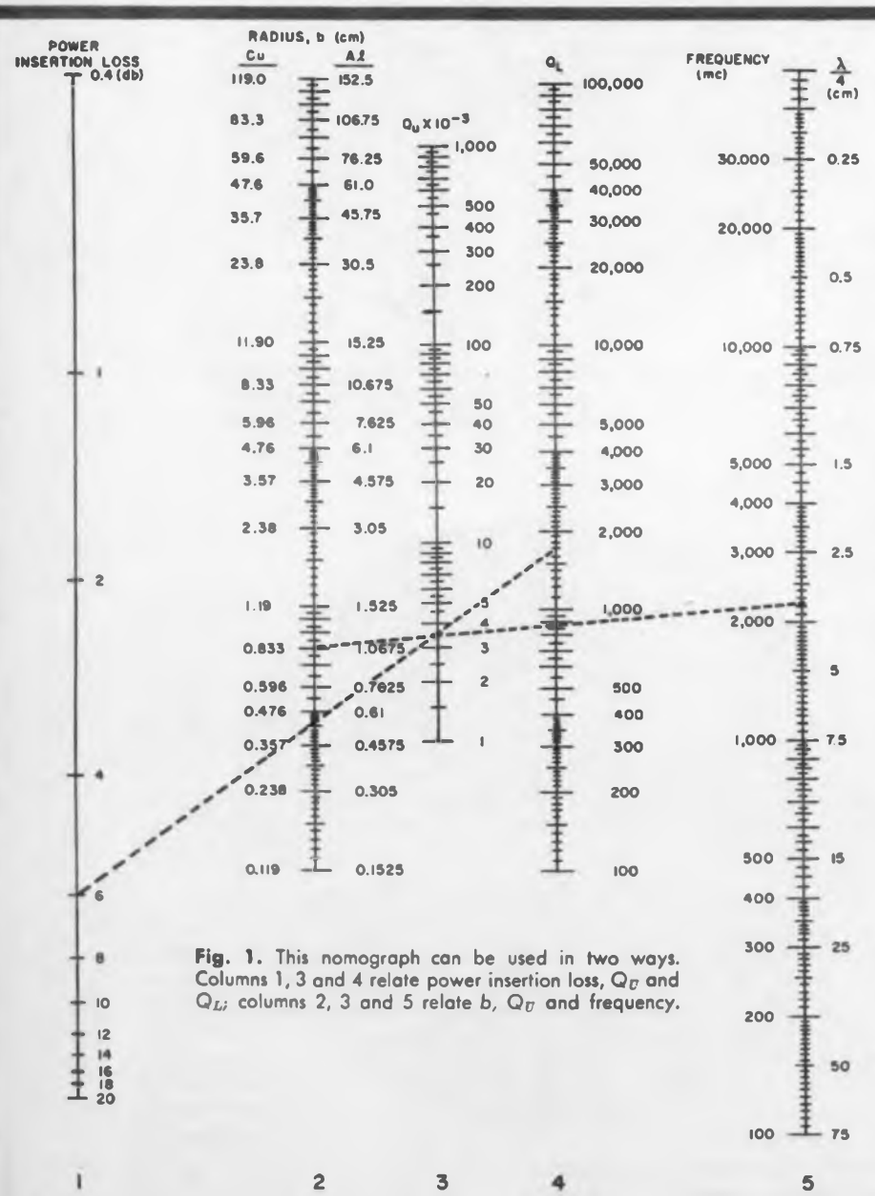


Fig. 1. This nomograph can be used in two ways. Columns 1, 3 and 4 relate power insertion loss, Q_U and Q_L; columns 2, 3 and 5 relate b, Q_U and frequency.

Author Jenkins formulated this nomograph to help him design a small, lightweight cavity for use as an rfi-limiting bandpass filter in an S-band transmitter. The design could have been time-consuming because a compromise between size and selectivity was necessary. The nomograph was used to obtain rapidly a promising combination of design parameters, after which the more detailed calculations were confidently performed.

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Radiation, Inc.
Melbourne, Fla.

THE PRINCIPAL specifications in design of tunable coaxial cavities are: tuning range centered about a frequency f_o; band width at f_o; and maximum allowable power insertion loss at f_o. From these parameters one obtains the loaded Q of the cavity (Q_L), cavity inner radius (b), and nominal inner length ($2b + \lambda_4$).

However, available volume may limit the size of the cavity, and the designer should first determine the power insertion loss of the cavity for a given volume. Another important size limitation is that $2b < \lambda_4$. Therefore, $2b$ should be approximated before other design procedures are begun.

The nomograph (Fig. 1) determines if initial design specifications for the cavity are feasible. It can be used in the following cases:

- Knowing f_o, Q_L, and power insertion loss in db, find b, and $2b + \lambda_4$.
- Knowing f_o, Q_L, and b, find the power insertion loss in db.
- Knowing f_o and Q_L, find the best compromise between cavity volume and power insertion loss.

To use the nomograph, read across columns 1, 3 and 4, or across columns 2, 3 and 5. For example, a cavity with $Q_L = 1{,}690$ and a power insertion loss of 3 db yields $Q_U = 3.5 \times 10^{-3}$ (columns 1, 3 and 4). At 2,250 mc, b for this cavity (in aluminum) is approximately 1.06 (columns 2, 3 and 5).

If a metal other than copper or aluminum is

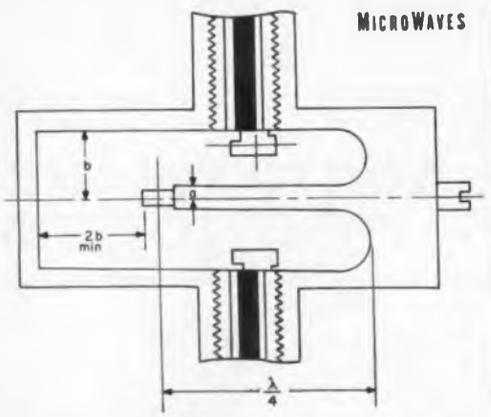


Fig. 2. Tunable coaxial cavity. Pertinent dimensions are the inner radius *(b)*, λ/4, and the outer radius of the inner conductor *(a)*.

specified, multiply the *b* scale for copper by the square root of the relative resistivity of the desired metal.

The nomograph was constructed from equations and curves by Terman[1] and assumes an optimum *Q* corresponding to *b/a* ratio (see Fig. 2) of 3.6. If other *b/a* ratios are desired the constant *H* in the nomograph equations is modified.[1] Then multiply the *b* scale in the nomograph by the reciprocal of the new *H* value to obtain the new *b* value. The copper and aluminum *b* scales can both be modified this way.

Characteristics of concentric and two-wire transmission lines used as resonant circuits may also be determined from the nomograph. Again, a suitable multiplier is applied to the *b* scale, as determined by the equations.[1] For copper two-wire lines of optimum *Q* with air dielectric, the *b* scale for copper is multiplied by 0.903. Design of concentric lines requires no change in the *b* scale.

Note that the tuning range of the cavity does not enter into use of the nomograph. The tuning range only affects coupling loop area and position. However, the upper frequency of the tuning range does determine the maximum allowable *b* value, as $2b < \lambda_4$ must be satisfied at all frequencies in the tuning range. Design methods for the loop area and position are given.[2] Additional information on design of tunable coax cavities may be found.[3] ■ ■

References

1. "Electronic and Radio Engineering" by F. E. Terman, Fourth edition, McGraw-Hill Book Co., Inc., N. Y., 1955, Chapter 4, pp 106-107.
2. "Design of Coaxial Cavities—Tunable Transmission Type." Design Method Series, Radar Design Corp., Syracuse, N. Y., Chapter 5.1.
3. "Very High Frequency Techniques," McGraw-Hill Book Co., Inc., N. Y., 1947.

MICROWAVES

MICROWAVE PRODUCTS

Crystal Switch Driver Adapter 393

Constant impedance match is provided beween the nonlinear forward to reverse impedance of a crystal switch and the modulation input. Forward and reverse modulation is clamped to the optimum level for operation of the crystal switch. Specifications are: voltage to turn switch on, +20 v; voltage to turn switch off, −20 v; switching rate, min, 0 cps; modulation input impedance, 620 ohms. Connectors are type BNC

AEL, Inc., Dept. ED, 121 North 11th St., Philadelphia, Pa.

P&A: $75 ea; from stock.

Germanium Tunnel Diodes 396

Inductance is 400 ph for the 1N3218, 1N3218A, 1N3219 and 1N3219A germanium tunnel diodes. Housed in a hermetically sealed "stripline" package, they have total capacities of 7, 4, 14 and 7 pf respectively. Typical peak point current ratings of the 1N3218 and 1N3218A are 1.0 ma while the others have a rating of 2.2 ma. This parameter is controlled to within ±10%. Operating frequencies are up to 4.6 Gc.

General Electric Co., Dept. ED, Kelley Building, Liverpool, N.Y.

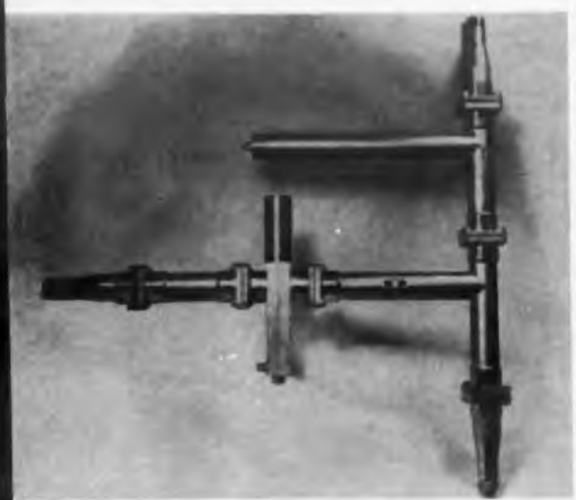
P&A: $20 to $30 ea; immediate.

Microwave Phase Meter 395

Direct reading microwave phase meter model 300 is for checking the relative phase between two signals in the 0.3- to 4-Gc range. Phase is measured on a meter with 0.1-deg resolution at the microwave frequency. A "servo output" is for automatic feedback phase control. The unit can be adapted for automatic swept frequency phase measurement with recorder output.

Wiltron Co., Dept. ED, 717 Loma Verde Ave., Palo Alto, Calif.

P&A: $2,500; six weeks.



Broadband Duplexer 394

Frequency range is 275 to 600 mc and average power input of the T4248V5D duplexer tube is 1 kw with a transmit and receive vswr of 1.5 to 1. Insertion loss is 0.6 db and noise level on the receive cycle is less than 6 db over absolute temperature in Kelvin degrees. Isolation at full power is 30 db and a minimum firing level without keep-alive is 50 w.

Tucor, Inc., Dept. ED, 18 Marshall St., South Norwalk, Conn.

P&A: Approximately $1,000; 14 days.

MICROWAVES PRODUCTS

AFC Unit 380

For klystron frequency control. Designed to control the frequency of a klystron local oscillator in pulse radar systems, the IF42 afc unit is available at 30 to 60 mc f_o. It utilizes a diode-phantastron control circuit and has a sensitivity of 40 v per mc.

LEL, Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

Waveguide Transitions 381

Frequency range is 1 to 12.4 Gc. Coaxial-to-waveguide transitions model 18T10 have a frequency range of 1 to 12.4 Gc. Specifications are: coaxial connector, type N; vswr 1.10 to 1 max; waveguide flange, UG 435A/U.

Applied Microwave Electronics, Inc., Dept. ED, 114 W. 25th St., Baltimore 18, Md.
Price: $150 ea.

Rotary Joints 362

Rated at 3 megawatts. Model S 60-1 rotary joint covers the frequency range from 5.25 to 5.75 Gc and is rated for a peak power of 3 megawatts when pressurized to 30 psig with air. Other models operate between 1 and 9.5 Gc. The vswr is less than 1.15:1. Unit operates at 10 megawatts when pressurized to 20 psig of sulfur hexafluoride.

FXR, Inc., Microwave Div., Dept. ED, 25-26 50th St., Woodside 77, N.Y.

Traveling-Wave Tube 363

Rated at 10 w cw. Traveling-wave tube L-3472, operating from 7 to 11 Gc, will handle a minimum of 10 w cw. Saturation gain is within 3 db of the 36-db min small-signal gain. Output power is linear; coaxial input and output circuits have minimum frequency dependence. The 2.5-lb tube is less than 12 in. long, with a body diameter of 1-3/8 in.

Litton Industries Electron Tube Div., Dept. ED, 960 Industrial Road, San Carlos, Calif.

X-Band Switch 365

Has long life. Series 1900 microwave switch, for use at 8.2 to 12.4 Gc, has a life of 100,000 operations. Switching time is less than 5 msec. Isolation is 50 db min, insertion loss 0.1 db, vswr 1.03:1. Made in brass or aluminum, the switch can be operated remotely.

Guide Manufacturing Co., Dept. ED, 7602 San Fernando Road, Sun Valley, Calif.

Ferrite Isolator 367

Is tunable. The Ferimat, a tunable ferrite isolator, is designed for the A, V and E bands. Typical performance ratings are: vswr, 1.25 max; isolation, 20 db min; loss, 1.5 db max. The Ferimat is one of a line of millimeter components covering the 26.5-Gc region.

Technical Research Group, Inc., Dept. ED, 9 Union Square, Somerville, Mass.

MICROWAVES *PRODUCTS*

Microwave Radio System 358

Broadband. Type 74B is a broadband microwave radio system for use in the common carrier, industrial and government bands. It can be supplied with arrangements for hot standby and space or frequency diversity. Standby transfer time is 1 msec. Transmitter stability is ±0.02%; klystron output is 1 w.

Lenkurt Electric Co., Inc., Dept. ED, San Carlos, Calif.

Shorting Switches 391

Operate in 10 msec. Single and dual waveguide shorting switches of series 90SW cover two frequency ranges: 8.5 to 9.6 Gc and 9.2 to 10.0 Gc. Unaffected by external magnetic fields, the switches can be used near ferrite and other magnetic devices. Both types have excellent vibration characteristics. The dual switch is free of cross-coupling.

Microwave Development Laboratories, Inc., Dept. ED, 15 Strathmore Road. Natick Industrial Center, Natick, Mass.

Dual-Mode Discriminator 389

Operates at 35 Gc. Dual-mode transmission-type discriminator cavity WX 4334 provides a stable frequency source for parametric amplifiers, navigation systems, and beacon radars. Typical frequency variation is ±8 mc in temperature shift from 25 to 100 deg C. Loaded Q for each output is 3,000, frequency difference between outputs is 10 mc. The device is a cube measuring 0.900 in. on a side; weight is 3.1 oz.

Westinghouse Electric Corp., Electronic Tube Div., Dept. ED, P. O. Box 284, Elmira, N. Y.

◀ CIRCLE 189 ON READER-SERVICE CARD

Radio Relay System 352

Has 600 voice channels. Covering common carrier, industrial and government frequencies between 5,925 and 8,400 mc, model RF-7 provides 600 voice channels. Transmitter power is 1 w. Transistor circuits and plug-in construction are used. Power supply is a charger and battery system.

General Electric Co., Communication Products Dept., Dept. ED, Lynchburg, Va.

Crystal Diode Mixers 359

Adjustable local oscillator coupling. Double or single ended mixers, model CM 6, are available with fixed or variable local oscillator coupling. Specifications are: input, type N; frequency, 570 to 630 mc; vswr, 1.5 to 1 max; frequency bandwidth, 10%; if, 30 mc.

Applied Microwave Electronics, Inc., Dept. ED, 114 W. 25th St., Baltimore 18, Md.

Price: $390 ea.

TR Tube 392

A quartz folded-cylinder tr tube for high-power applications, model T48-U15 operates at uhf and L-band frequencies with multi-megawatt input. Gap spacing accuracy is better than ±0.006 in.

Tucor, Inc., Dept. ED, 18 Marshall St., South Norwalk, Conn.

Availability: 30 days.

CIRCLE 190 ON READER-SERVICE CARD ▶

MICROWAVES PRODUCTS

Rotating Probe Sections 357

For circular waveguides. Model 55R5C circular waveguide rotating probe sections provide continuous 360-deg probe rotation for measuring electrical field mode orientation in circular waveguide. Specifications are: operating bandwidth, 5.0 to 5.9 Gc; residual vswr, 1.02 to 1; frequency range, 3.95 to 18.0 Gc.

Applied Microwave Electronics, Inc., Dept. ED, 114 W. 25th St., Baltimore 18, Md.
Price: $850 ea.

Varactor Diodes 384

Operate to 150 Gc. Gallium-arsenide diffused-junction, mesa varactor diodes MS 262 through MS 266 are designed for use in parametric amplifiers, microwave switches and harmonic generators. In a package measuring 0.120 in. OD by 0.050 in. high, the diodes have typical parasitic inductance of 300 ph and total capacitance of 1.5 pf max. All units are rated at 6-v min breakdown at 10 ma.

Micro State Electronics Corp., Dept. ED, 152 Floral Ave., Murray Hill, N. J.

Tunnel Diodes 383

Cut-off frequency is 3.5 Gc. Germanium tunnel diodes, designed for uhf and microwave amplifier and oscillator applications in communication systems, exhibit superior noise characteristics. The diodes are packaged in a pillbox configuration, 0.120 in. in diameter and 0.050 in. high. The service includes types MS 222, 223, 224, and MS 242.

Micro State Electronics Corp., Dept. ED, 152 Floral Ave., Murray Hill, N. J.

◀ CIRCLE 191 ON READER-SERVICE CARD

Microwave Absorber 390

For all-weather use. Resonant foam microwave absorber of the Salisbury Screen type has a value of 25 db min at resonance. Thickness of type RF absorber is 1/8 wavelength; bandwidth is sufficient to cover a complete band.

B. F. Goodrich Sponge Products, Dept. ED, Shelton, Conn.

Flexible Waveguide 386

Pressurized to 45 psi. High-pressure flexible waveguide, for frequencies from 1.2 to 1.70 Gc, operates at 50-kw cw and 25-megawatt peak power. Waveguides are available in a wide variety of flange combinations.

Technicraft Div., Electronic Specialty Co., Dept. ED, 116 Waterbury Road, Thomaston, Conn.

Ferrite Modulator 387

For X band. Ferrite modulator X158A provides 25 to 60 db of dynamic attenuation at coil currents of 100 ma. Insertion loss is 0.9 db max. input and output vswr 1.20:1 max. Used with WR-90 waveguide, modulator insertion length is 5.30 in.

FXR, Inc., Dept. ED, 25-26 50th St., Woodside 77, N. Y.

Waveguide Twists 385

In L-band tubing. Large waveguide twists are available in standard L-band tubing with lengths of 18 in. and up. Both coaxial and offset twists are made in bronze tubing (type RG-69/U) and aluminum tubing (type RG-103/U).

F. C. Kent Corp., Dept. ED, 135 Manchester Place, Newark, N. J.

Rotary Joints 388

In variety of styles. A complete line of rotary waveguide joints is available in uhf, L, C, S, X and Ku bands. Configurations include I-shaped, L-shaped, U-shaped and dual-channel types.

Canoga Electronics Corp., Dept. ED, 15330 Oxnard St., Van Nuys, Calif.

Availability: From stock.

MICROWAVES PRODUCTS

Cavity Amplifiers 364

For aerospace applications. Five models of this line of miniature amplifiers are each available in 6 output frequency ranges from 215 to 1,100 mc. Specifications for the model R-10 using 7552 and 7554 coaxial pencil triodes are: gain, 15 db; bandwidth, 5 mc; plate power requirements, 150 v at 0.015 amp.

Resedel Engineering Corp., Dept. ED, 330 S. Fair Oaks Ave., Pasadena, Calif.

P&A: $695; 40 to 45 days.

Traveling-Wave Tube 374

For airborne equipment. Model A-1225 is a lightweight, ruggedized traveling-wave tube focused by periodic permanent magnets. It is designed for use in airborne equipment. Ku band, 12 to 15 mc with 1-mw drive, produces power output of 1-w min with 30 db gain.

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

Power Supply 372

For traveling-wave tubes. The WJ-180 is a low-noise traveling-wave-tube power supply designed to operate WJ-211, WJ-212 S- and L-band tubes. Solid-state components are unnecessary; two front panel controls are used.

Watkins-Johnson Co., Dept. ED, 3333 Hillview Ave., Palo Alto, Calif.

P&A: $3,500 ea; 4 to 6 weeks.

S-Band Antenna 375

Vertically polarized. Model 3001 vertically polarized antenna is designed for use as a ground beacon when used over a ground screen, or in transmitting from an aircraft. Electrical characteristics are: cw power rating, 500 w; vswr, 1.5 max from 2.4 to 3.6 Gc. The unit is completely sealed.

Adams-Russell Co., Inc., Dept. ED, 200 Sixth St., Cambridge 42, Mass.
P&A: $410 per unit; 45 days.

Shorting Plugs 356

Are weatherproof. Used to cap and short a circuit simultaneously, weatherproof shorting plugs operate from −65 to +260 deg F. The TNC type operates at 1,500 v rms, TM at 500 v rms. Metal parts are silver-plated brass; contacts have gold plate over silver. Dielectric is Teflon, shield contact fingers are heat-treated beryllium copper.

General RF Fittings, Inc., Dept. ED, 702 Beacon St., Boston 15, Mass.

Microwave Receivers 376

Designed as complementary units. The series 40 amplifiers provide matched sets of equipment for microwave receiver prototype or production runs. Specifications are: if frequency, 60 mc; input, from balanced mixer; output, video cathode follower; bandwidth, 4 mc; main amplifier gain, 130 db.

LEL, Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

192

MICROWAVES PRODUCTS

Waveguide Switches 370

Switch under power. Remotely controlled spdt waveguide switches of the Delta series switch under rf power with 7 msec operating time. The 7-oz units cover the frequency range from 7.05 to 40.0 Gc in 5 waveguide sizes. Designed to meet all requirements of MIL-E-5272, the switches are suited for space and shipboard use.

Don-Lan Electronics, Inc., Dept. ED, 1131 Olympic Blvd., Santa Monica, Calif.

Polarized Connectors 355

Reversed internal components of these polarized TNC and TM connectors eliminate the possibility of mismatching cables. Insertion loss and vswr are low; requirements of MIL-E-5272 are met. All metal parts are brass, except female contacts and shield fingers, which are heat-treated beryllium copper. All connectors have threaded couplings.

General RF Fittings, Inc., Dept. ED, 702 Beacon St., Boston 15, Mass.

Waveguide Transitions 373

For connection of different size waveguides. Transitions, also known as tapers, provide a means of connecting one waveguide size to another. Sections that connect standard military RG waveguide to commercial WR are also available. Standard units are silver-plated brass assemblies.

Waveline, Inc., Dept. ED, Caldwell, N.J.

Slotted-line Sections 354

For circular waveguides. Model 55SC circular waveguide slotted line sections maintain rotation of the electric field orientation to a minimum to ensure true readings. Slot length is a minimum of 8 in. Specifications are: bandwidth, 5.0 to 5.9 Gc; residual vswr, 1.02 to 1; frequency range, 3.95 to 18.0 Gc.

Applied Microwave Electronics, Inc., Dept. ED, 114 W. 25th St., Baltimore 18, Md.
Price: $725 ea.

Tube Cavity 351

For C-band. A new metal-ceramic triode design configuration is used in a tube-cavity combination operating over the 5,250- to 6,050-mc frequency range. Output power is 4 to 10 mw. The design functions as a stable local oscillator or parametric amplifier pump.

General Electric Co., Receiving Tube Dept., Dept. ED, Owensboro, Ky.

Parametric Amplifier 377

For AN radar systems. L-band diode parametric amplifier, model X-217, is for installation in AN/TPS-1D, AN/TPS-1G and AN/FPS-36 radar systems. It sets the system noise figure at 2 db or better. The unit has an instantaneous bandwidth of 10 mc or more, which is tunable from 1.2 to 1.4 Gc.

Melabs, Inc., Dept. ED, 3300 Hillview Ave., Palo Alto, Calif.

◀ CIRCLE 195 ON READER-SERVICE CARD

CIRCLE 196 ON READER-SERVICE CARD

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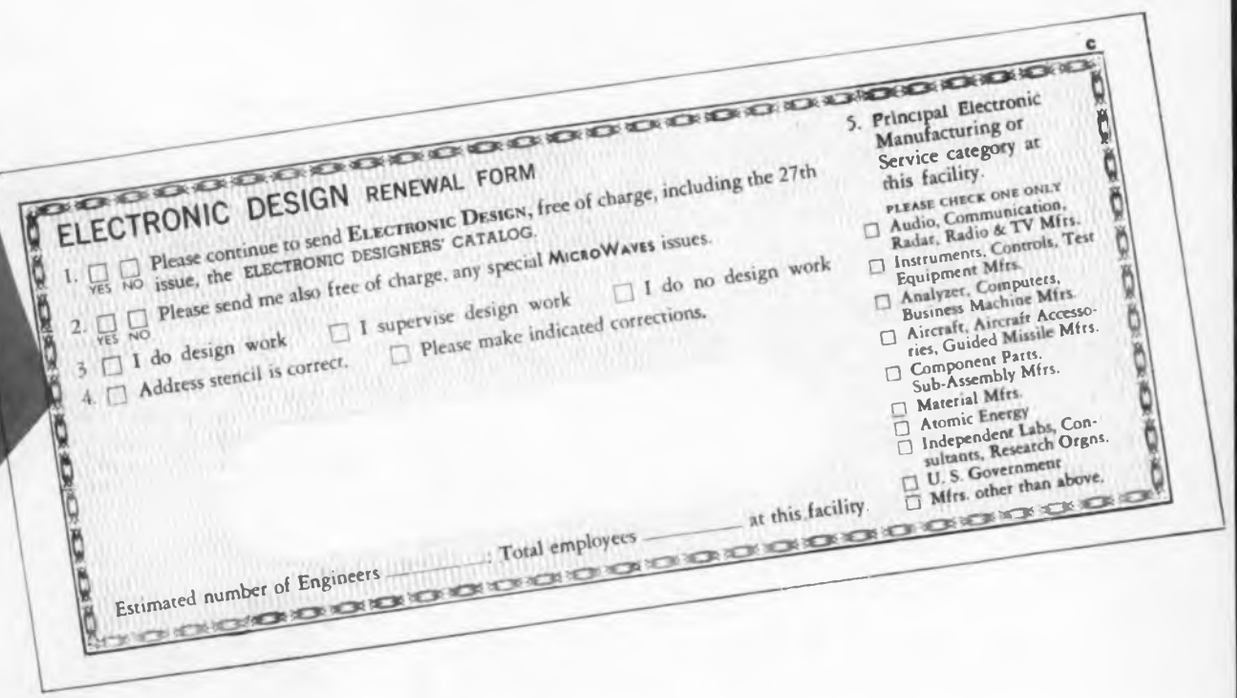

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MICROWAVE GENERATORS

500 mc to 50,000 mc

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- ☐ Model MSG-34
- ☐ Model KSS
- ☐ Model PMX
- ☐ Model CSG
- ☐ Model PMK
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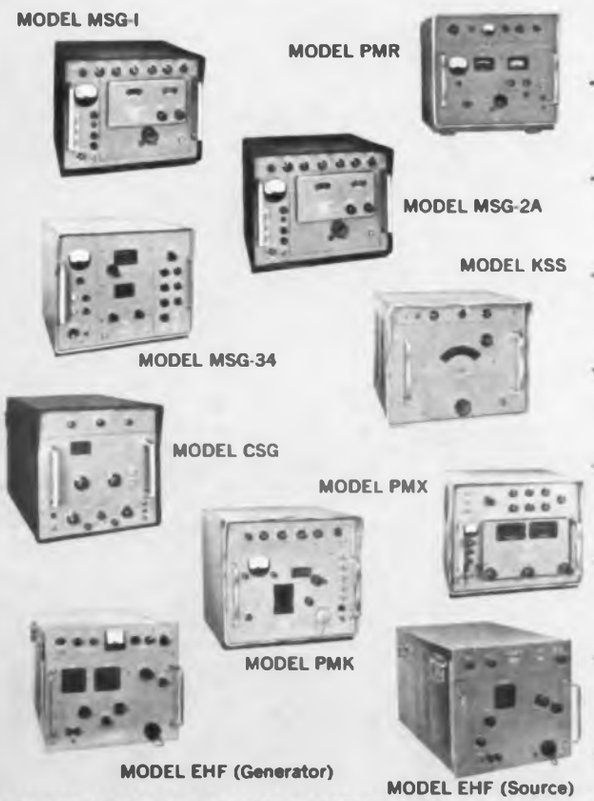
MICROWAVE GENERATORS

500 mc to 50,000 mc



MOST FEATURES

MODEL PMR	500 to 1,000 mc	Complete modulation capabilities — internal pulse modulator or FM modulator
MODEL MSG-1	950 to 2,400 mc	Complete modulation capability including square wave modulation
MODEL MSG-2A	2,000 to 4,600 mc	Complete modulation capability including square wave modulation
MODEL MSG-34	4,200 to 11,000 mc	Widest frequency range in a single instrument
MODEL KSS	1,050 to 11,000 mc	Compact high power signal source with plug-in tuning units — internal modulation
MODEL PMX	4,450 to 11,000 mc	Calibrated 1 milliwatt signal generator with complete modulation capability
MODEL CSG	1,000 to 16,000 mc	Higher power sweep generator
MODEL PMK	10,000 to 21,000 mc	Wider modulation capabilities — calibrated 10 milliwatt output
MODEL EHF (generator)	18,000 to 39,700 mc	High frequency signal generator — operates on fundamentals
MODEL EHF (source)	18,000 to 50,000 mc	Widest and highest continuous frequency range — operates on fundamentals

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Planar Triode Cavities 704

For commercial and military use, the Universal 10 series of planar triode cavities meet specification of MIL-E-5272C. They are made for frequencies between 220 and 4,300 mc, in pulse and cw units. Pulse oscillators deliver up to 2 kw at 1 Gc; cw amplifiers deliver 12 to 13 db gain at 1 Gc. Over-all width is 2-1/2 in.

J-V-M Microwave Co., Dept. ED, 9300 W. 47th St., Brookfield, Ill.
Price: *From $15 ea.*

Ka-Band Magnetrons 698

With 40-kw peak power output, type M-4155A magnetron is smaller, lighter and stronger than the type 5789 it replaces. Type XM-4218, designed for missile and airborne use, weighs 4 lb and produces 32 kw. It operates unpressurized at 33,000 ft and withstands 10-g vibration. At 27 lb, type XM-4158 is 6 lb lighter than type 6799. The airborne unit delivers 120 kw peak. Type XM-4064 withstands 20-g vibration, 54 to 2,000 cps. Power output is 70 kw. The 9-lb magnetron is made for airborne applications. All four units operate in the Ka band.

Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

Stability Tester 714

Model 5024 stability tester measures frequency variations as small as 1.5 parts per 10 billion. There are eight full-scale ranges for fm deviation from 10 cps to 30 kc. Plug-in heads are available for bands between 1 Gc and 11 Gc. Minimum peak fm deviation measurable is 0.3 cps in L band to 2 cps at Ku band. Oscilloscope output is provided; metered displays include 2nd if signal, fm peak deviation, drift, signal level and current level. Rack-mounting unit is 12-1/4 in. high, weighs 65 lb. Cabinet model is also made.

Laboratory For Electronics, Inc., Dept. ED, 1079 Commonwealth Ave., Boston 15, Mass.
P&A: *$5,400 basic, heads $750 to $1,050; 90 to 120 days.*

◀ CIRCLE 198 ON READER-SERVICE CARD

MICROWAVES PRODUCTS

Fixed Attenuator 707

Rated at 50 w, model A-500 fixed attenuator can be supplied in values from 0 to 20 db. Overall accuracy is 1/2 db; vswr with type N connectors is 1.2:1 max from dc to 1 Gc. Peak power rating is 50 kw; impedance is 50 ohms. Units are calibrated at 0.95 Gc.

R L C Electronics, Inc., Dept. ED, 805 Mamaroneck Ave., Mamaroneck, N. Y.
P&A: $250 to $260; stock to 2 weeks.

Klystron Oscillator 455

Frequency is 13.3 Gc. Two-resonator klystron oscillator VA-504B is a rugged, liquid-cooled, medium power unit designed for fixed frequency Doppler radar navigation and similar applications. Electrical characteristics are: frequency, 13.3 Gc; power output, 19.0 w avg; beam-modulation coefficient, 30 kc per v.

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

Klystron Tube 705

A single cavity oscillator model LKC-5 klystron requires no magnetic field. It is made for operation at frequencies from 0.8 to 13 Gc. Power output is 5 w cw; efficiency is 7% to 12%. Height is 1.70 in., weight 5 oz. Tube performs in any position.

Lewis and Kaufman Electronic Corp., Tube Div., Dept. ED, P. O. Box 337, Los Gatos, Calif.
Availability: 5-week delivery.

Ferrite Isolators 699

For use in X-band communications systems, ferrite isolators FD-7511 through FD-7516 give 20, 40 or 60 db isolation from 10.7 to 11.7 Gc, and 25, 40 or 60 db isolation from 12.2 to 12.7 Gc. Mounting in WR-75 waveguide, the units range in length from 1-1/2 to 2-1/2 in. All types are rated for 2 kw peak or 10 w cw input. The minimum isolation-to-insertion loss ratio for the FD-7511 is 50:1; the ratio is about 60:1 for the others.

Sylvania Electric Products Inc., Sales Dept., Dept. ED, Box 997, Mountain View, Calif.
P&A: $115 to $125; 4 to 5 weeks.

Tunnel Diode Amplifier 697

Broadband, low-noise tunnel diode amplifier OTA 250 operates from 250 to 500 mc. The hybrid coupled unit has a noise figure of 3.5 db. The amplifiers can be used with conventional traveling-wave tube and vacuum-tube amplifiers in the uhf region.

Micro State Electronics Corp., Dept. ED, 152 Floral Ave., Murray Hill, N.J.

Varactor Diode 710

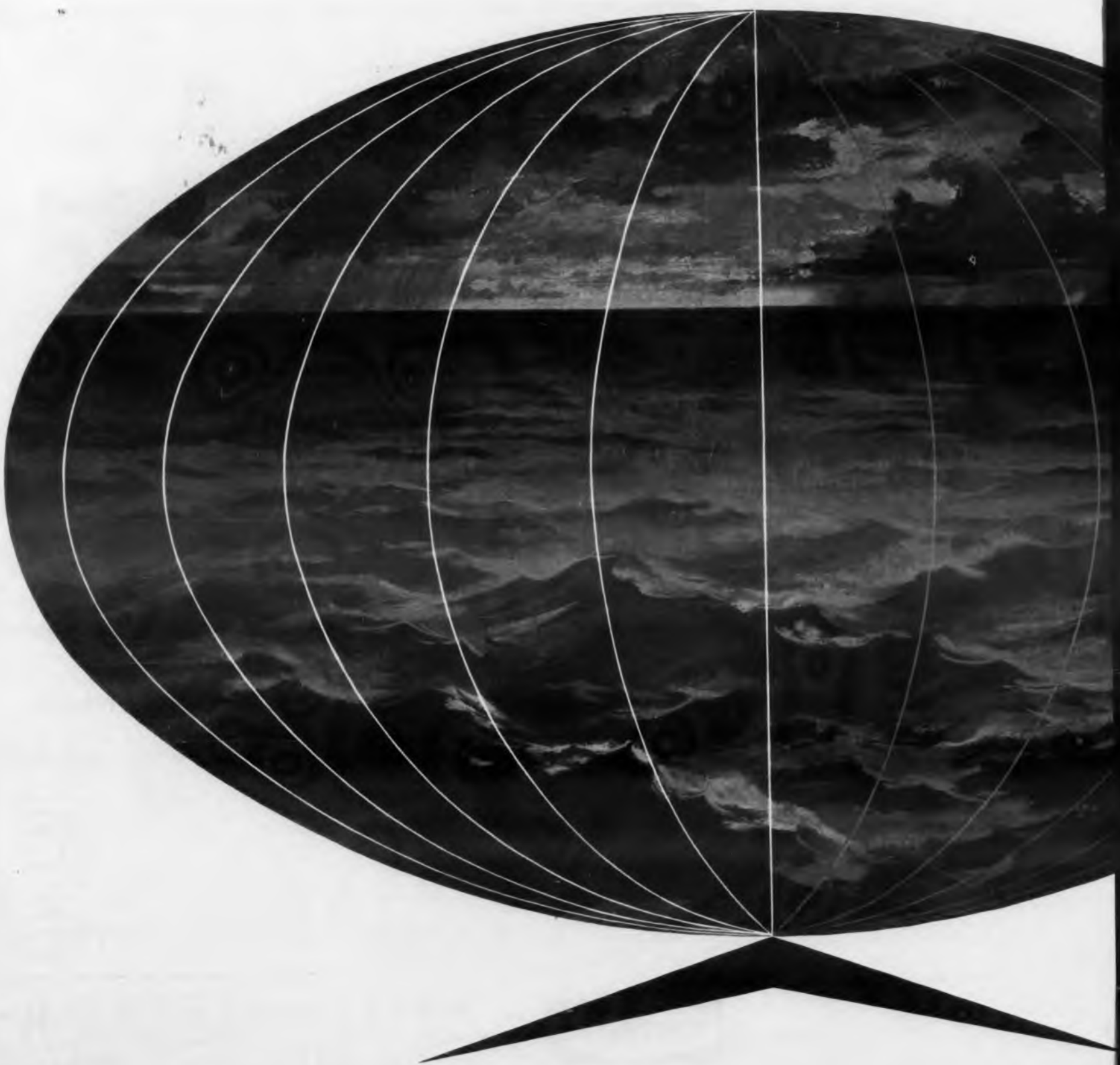
Gallium arsenide varactor diode provides low-noise amplification to a cut-off frequency of 150 Gc. The diode uses a reverse-biased pn junction with voltage-dependent capacitance. Length is 11/16 in., diameter 1/4 in.

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

Biaser 706

Useful from 0.5 to 11 Gc, the X-193 biaser has an insertion loss of less than 1.5 db; vswr is less than 1.5:1. Uses include dc isolation of two components, dc biasing and dc return. Minimum dc resistance between terminals is 1 meg; bias current is 250 ma max. Maximum voltage across rf connectors is 1 kv. Size is 3/4 x 1-3/4 x 2 in.

Melabs, Dept. ED, 3300 Hillview Ave., Palo Alto, Calif.



"A revolutionary and practically invulnerable ballistic missile system."

President Eisenhower thus characterized the POLARIS Fleet Ballistic Missile – capable of being launched from hidden nuclear submarines anywhere in the oceans of the world.

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MICROWAVES PRODUCTS

Coaxial Termination 700

A sliding coaxial termination, model 906A provides a movable, low-reflection load for terminating 50-ohm coaxial systems. The load moves at least 1/2 wavelength at 1 Gc. Power rating is 1 w; over-all frequency range is 1 to 12.4 Gc. A movable center conductor insures a vswr of less than 1.05. Adapters for type N male or female connectors are included.

Hewlett-Packard Co., Dept. ED, 1501 Page Mill Road, Palo Alto, Calif.

Directional Couplers 713

Frequency range of 2.60 to 40.0 Gc is covered by eight models of waveguide directional couplers in five basic designs. Included are cross-guide, narrow-wall, and precision broad-wall versions. All are available with standard values of coupling. Electrical characteristics are optimized over the complete frequency range.

Waveline, Inc., Dept. ED, Caldwell, N. J.

Coaxial Attenuators 702

Stable film resistors permit the use of these coaxial attenuators under severe environmental conditions. Frequency range is dc to 2 Gc. Typical vswr is 1.2:1, deviation 5 db. Values range from 3 to 40 db in eight sizes. Standard connectors are available.

Coax Devices, Dept. ED, Box V, Chelsea 50, Mass.

Price: $30 to $40.

Power Meter 712

Power levels to 10 mw are measured directly with type 451 microwave power meter. It is designed to operate with a variety of 100 and 200 ohms, positive or negative temperature coefficient bolometers. Full-scale ranges of 0.1, 0.3, 1.0, 3.0 and 10 mw are provided; higher power levels may be measured with attenuators. Decibel scales are −10 to +10 dbm in five scales. Accuracy is ±5% of scale reading.

General Microwave Corp., Dept. ED, 47 Gazza Blvd., Farmingdale, N. Y.
P&A: $235; stock to 30 days.

Y-Circulator Switch 708

Designed for S-band operation, the SS-903 is a Y-circulator nonreciprocal spdt switch. Capable of handling average power in excess of 100 w, the unit provides 20 db of isolation with less than 0.5 db insertion loss over bandwidths greater than 20%. Square-wave modulation at 100 cps with rise time of 2.5 msec is possible; the device can also be used as an electronic attenuator.

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

Waveguide Protective Covers 701

Available in a large variety of waveguide flange and choke sizes, these trade-marked polyethylene protective covers come in five colors.

Omega Electronic Corp., Dept. ED, Rowley, Mass.

MICROWAVES PRODUCTS

Telemetry Receiver 521

For 2.2 Gc use

Telemetry receiver model 9-100 is designed primarily for use in the 2.2- to 2.3-Gc telemetry band. Circuitry includes a phase-lock demodulator, phase-locked klystron first injection oscillator and low-noise crystal mixer. A buffered 50-ohm output circuit is provided to permit magnetic recording of the undetected if signal. Specifications are: frequency stability, ±0.005%; input, 50-ohm source; noise figure, 8.5 db max; image rejection, 65 db min.

Radiation, Inc., Dept. ED, Melbourne, Fla.

Coaxial Switch 581

For use to 1.5 Gc

The TS-1 coaxial switch is a dpdt unit covering frequencies from dc to 1 Gc, and useful to 1.5 Gc. The vswr rating is less than 1.1:1 to 1 Gc; insertion loss is less than 0.1 db. Cross talk is less than 70 db at 1 Gc, and less than 45 db at 1.5 Gc. It can be used wherever rf switching is required, in airborne or ground installations. Operating life is 10,000 cycles per min. All 6 connections are BNC type. The 8-oz unit is 3-1/2 in. in diameter by 3 in. long.

Telonic Industries, Inc., Dept. ED, Beech Grove, Ind.

Price: $45.

Reflex Klystron 453

Fixed-frequency type

Reflex klystron, VA-204 is a fixed-frequency type designed for the public service radiolocation band. Electrical characteristics are: frequency, 10.525 ±0.010 Gc; power output, 40 mw avg; beam voltage, 300 v dc; beam current, 23 ma dc; reflector voltage —40 to —50 v dc.

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

P&A: $95; 30 days in small quantities.

Voltage Reference 494

Accuracy is 0.025%

VRS-611, a fully transistorized voltage reference source, will generate voltages in 1-mv steps to ±11.112 v at an accuracy of 0.025%. It will deliver 10 ma of current. Vernier provides continuous variation over 2 mv. Battery and ac units are made. The short-proof source has a polarity switch. Portable and rack-mounting configurations are available.

Epsco, Inc., Instruments Div., Dept. ED, 275 Massachusetts Ave., Cambridge, Mass.
P&A: $625 ea; stock after March 20.

Laboratory Receiver 563

For L through Ka bands

Model LR1723 laboratory receiver combines a wide-band if amplifier, a switch-type attenuator, and a power supply. It is designed for use with microwave-mixer preamplifiers. Power for the mixer units is available from a front panel connector. Control circuitry is included for mixer-preamplifiers having provision for external gain control. In conjunction with a standard mixer-preamplifier and a suitable local oscillator, the unit covers L through Ka bands.

LEL, Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

Waveguide Windows 515

Are silver-plated

Flange-type waveguide pressure windows provide an air-tight seal within waveguide systems. Designed for use with EIA waveguide sizes WR-42, WR-90, and WR-112, these units mount between two choke flanges. They are silver-plated to reduce rf loss.

Microwave Development Laboratories, Inc., Dept. ED, 92 Broad St., Babson Park 57, Wellesley, Mass.

MICROWAVES PRODUCTS

Broadband Amplifier 577

Range is 490 to 1,000 mc

The model HFW-8(A)-49100 broadband amplifier covers an octave range of frequencies from 490 to 1,000 mc. Synchronously tuned stages are used, with planar low-noise triodes as amplifiers. Gain is greater than 20 db; noise figure is 10 db max. Input and output vswr is 1.75. The unit is contained in a 19-in. rack-mounted chassis 5-1/4 in. high by 15-in. deep. A regulated anode and heater power supply are provided.

Applied Research Inc., Dept. ED, 76 S. Bayles Ave., Port Washington, N.Y.

Pulse Amplifier 462

Is liquid-cooled

The VA-126 pulse amplifier is designed for use in advanced, frequency-agile coherent radar systems. It is self-centering in its electromagnet. Characteristics are: bandwidth, 500 mc; frequency coverage, 5.4 to 5.9 Gc; power output, 3.3 mw peak, 6 kw avg; gain, 30 db; weight, 75 lb; dimensions, 33 x 16 x 16 in.

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

Rotary Joints 561

U-style, 4.25 to 10 Gc

U-style waveguide rotary joints are available in WR90 EIA waveguide sizes for operating ranges from 8.5 to 9.6 Gc, in WR112 sizes for ranges between 7 and 10 Gc, in WR137 size for

5.4 to 5.9 Gc, and in WR187 for ranges between 4.25 and 6.0 Gc. There are 14 models, of aluminum or copper alloy, in a variety of finishes. There are several 30-psig pressurized models.

Microwave Development Laboratories, Inc., Dept. ED, 92 Broad St., Babson Park 57, Wellesley, Mass.

Coaxial Termination 557

10 w at 10 Gc

A 10-w coaxial termination, the T-130 is designed for operation from dc to 10 Gc. The vswr, with type N connectors, is 1.1 max from dc to 1 Gc, 1.2 max from 1 to 4 Gc, and 1.3 from 4 to 10 Gc. Power rating is 10-w average and 10-kw peak. Impedance is 50 ohms. Diameter is 1-1/2 in. and length is 3 in.

RLC Electronics, Inc., Dept. ED, 805 Mamaroneck Ave., Mamaroneck, N.Y.

Price: $125 to 132.50.

Availability: 1-week delivery.

Amplifier Klystron 447

Frequency is tunable

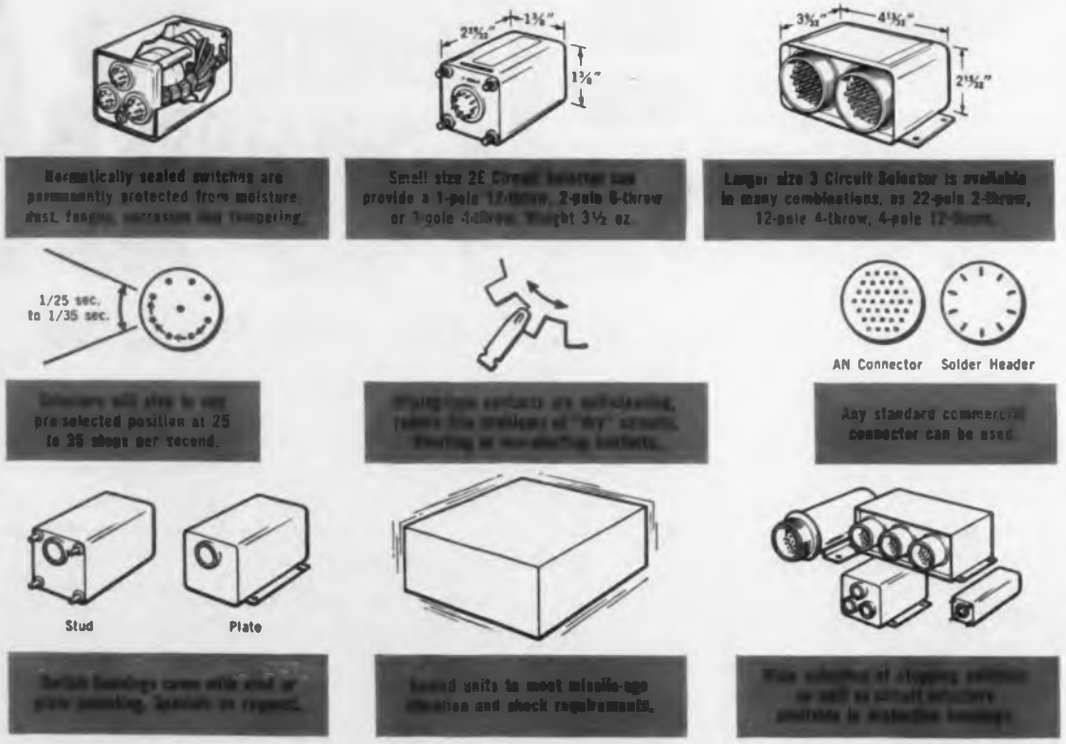
A high-power, high-gain cw amplifier klystron, the VA-853 is designed for multichannel, high-quality communication service. It operates from standard 5-w exciter units. Electrical characteristics are: frequency, tunable, 0.755 to 0.985 Gc; power output, 10 to 75 kw; gain, 50 db; weight, 200 lb.

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

Ledex

Hermetically Sealed Rotary Switch

BASIC INFORMATION



Hermetically Sealed Circuit Selectors and Stepping Switches contain an atmosphere of dry nitrogen which provides a permanent environment for the operation of the switch. They are designed to meet MIL-E-5272A, and will withstand extreme moisture and high altitude conditions in military and industrial installations. Sealed Switches are available in various wire sizes for operation from 6 to 350 VDC. Self-contained plug-in types allow rapid field installation. More than 3000 standard designs are shown in Bulletin D-460.

Other Ledex products include Rotary Solenoid, *Syncramental* Stepping Motor, *Digimotor* Stepping Motor and Indexing Device, Rotary Solenoid Selector Switch, *Digimotor* Selector Switch.

Switching applications include circuit selecting, stepping, counting, programming and sequencing.

Mechanical applications of other Ledex products include actuation of valves, vanes, printers, shafts. Write for literature, mentioning application, to Ledex Inc., Dayton 2, Ohio; Marsland Engineering, Ltd., Kitchener, Ont.; NSF Ltd., 31 Alfred Place, London, Eng.

CIRCLE 216 ON READER-SERVICE CARD

MICROWAVES PRODUCTS

Traveling Wave Tubes 448

Ranges are from 0.5 to 14 Gc

Traveling wave tube HA-86 has a range of 0.5 to 1 Gc, a 7-db max noise figure and 25 db min small-signal gain. Model HA-61 has a range of 7 to 14 Gc with 15 db max noise figure and 25 db min small signal gain. Four other models are also available.

Huggins Laboratories, Inc., Dept. ED, 999 E. Arques Ave., Sunnyvale, Calif.

X-Band Filters 571

Range is 7 to 10 Gc

These low-loss, tunable X-band filters, in frequency ranges from 7 to 10 Gc, have a single tuning control and are available with a counter-dial and calibration chart or screwdriver adjustment. Drift is less than 3 cps per mc per deg C. Insertion loss is under 2 db; vswr is less than 1.5 at f_o. Bandwidth is 8 to 12 mc at the 3-db points. Filters provide a minimum rejection of 38 db at $f_o \pm 60$ mc.

Frequency Standards, Dept. ED, P. O. Box 504, Asbury Park, N.J.

Price: *$350 to $400 ea.*

Availability: *2-week delivery.*

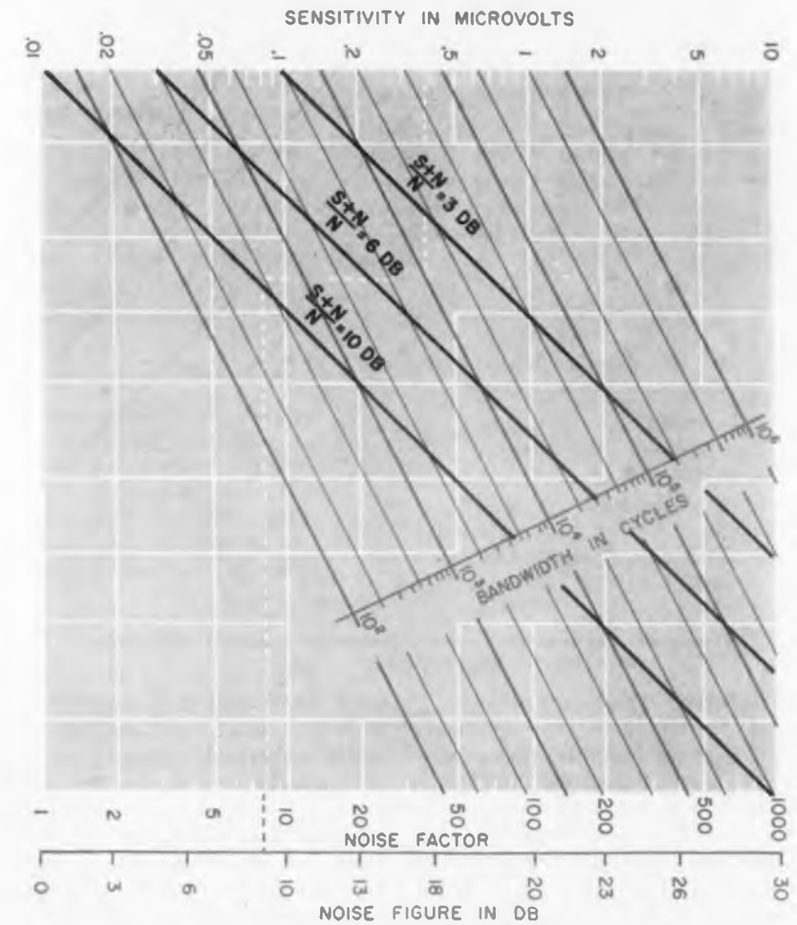
High-Gain Tube 449

Frequency is 1.25 to 1.4 Gc

A grid-pulsed, high-gain tube, the VA-133 can be used as an element driver in phased-array radars. Deviations from phase linearity are kept to a minimum. Gain over 10% bandwidth is ±0.25 db. Electrical characteristics are: frequency, 1.25 to 1.4 Gc; bandwidth, 150 mc; power output, peak, 5 kw; gain, 50 db.

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

Sensitivity-Noise Figure Nomograms Aid Receiver Calculations



Nomogram for receiver with equivalent noise resistance of 50 ohms.

Gilmer S. Pittard, Jr.
Professional Engineer
W. Hyattsville, Md.

RECEIVER designers often have to consider sensitivity requirements for a desired output signal plus noise to noise ($[S+N]/N$) ratio. With the nomograms given here this calculation can be made rapidly and easily. They are based on the equations relating noise figure, F, and sensitivity, E_s.

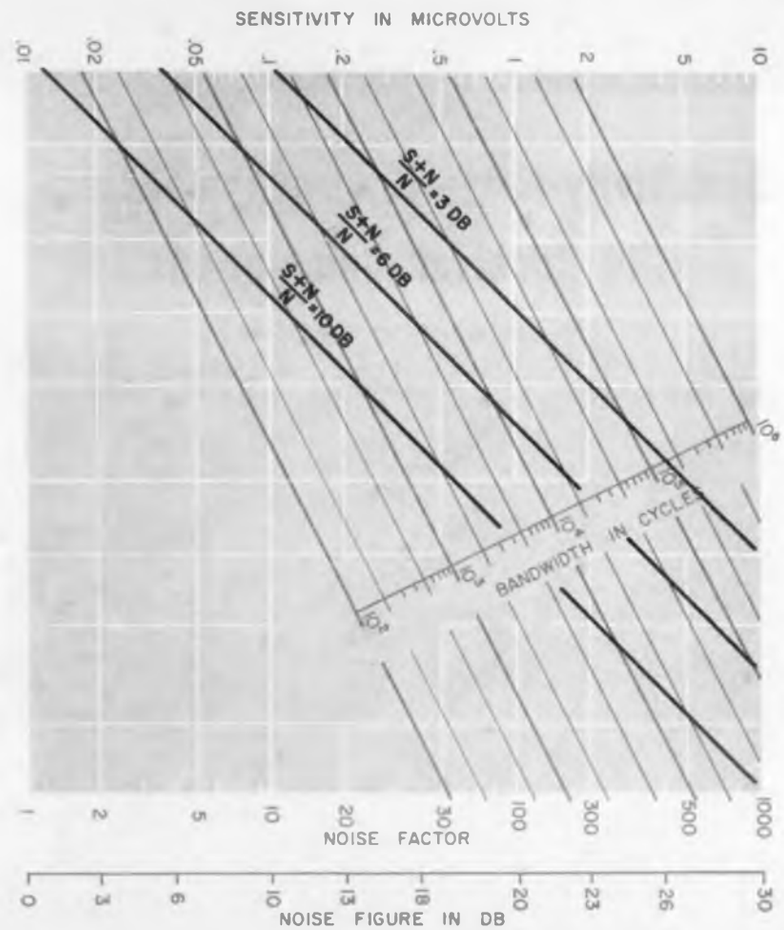
Sensitivity in microvolts is given by

$$E_s = \sqrt{\left(\frac{S+N}{N} - 1\right) RFKTB} \text{ in volts} \quad (1)$$

With T taken at 290 K (63F) and K a constant at 1.38×10^{-23}:

$$E_s = 6.32 \times 10^{-5} \sqrt{\left(\frac{S+N}{N} - 1\right) RFB} \ \mu v \quad (2)$$

(continued on p 208)



Nomogram for receiver with equivalent noise resistance of 75 ohms.

where B is the effective receiver bandwidth in cycles and

R is the equivalent receiver noise resistance

If it is desired to convert from sensitivity to noise figure we can solve Eq. 2 for F:

$$F = \frac{E_s^2}{6.32 \times 10^{-5} RB\left(\frac{S+N}{N} - 1\right)} \qquad (3)$$

Two nomograms have been prepared to solve Eq. 3 for $R = 50$ ohms and $R = 75$ ohms, two very common values.

In preparing the nomograms Eq. 3 was rewritten as

$$F = C/\left[\frac{S+N}{N} - 1\right] \qquad (3a)$$

where

$$C = E_s^2/6.32 \times 10^{-5} RB \qquad (3b)$$

The equation for C was plotted on the nomogram with C as the horizontal axis. The equation for F was then plotted, using the same C scale. Since C is of no direct use, the horizontal axis was not calibrated.

To use the nomograms, start on the vertical axis for noise figure (or noise factor) and draw a horizontal line to the desired $(S + N)/N$ ratio. From that intersection draw a vertical line to the bandwidth and finish by drawing another horizontal line to the sensitivity axis.

If sensitivity is known and the equivalent noise figure is desired the above procedure can be repeated in reverse order.

It is necessary to use either the noise figure or noise factor with $(S + N)/N$ ratio and sensitivity with bandwidth.

Example. If you have a 50-ohm receiver with a noise figure of 8 (or a noise factor of 9 db) and a 10-kc bandwidth, what sensitivity is required to give an $(S + N)/N$ ratio of 10 db? This example is shown in dotted lines on the 50-ohm nomogram and gives a sensitivity of 0.379 μv. ■ ■

NEW LITERATURE

Thermocouples and Pressure Probes 261

Complete specifications, details and prices on thermocouples, pressure probes and allied components are given in a 60-page catalog. The stock line of industrial components is made to aircraft quality and sold at competitive prices. Advanced Dynamics Inc., 16321 Rockside Road, Cleveland 37, Ohio.

Black Glass

Information on a special black glass for encapsulating diodes is given in an eight-page brochure. Available as beads or cases, the glass is said to protect diodes sensitive to visible and IR wavelengths. Transmittance and other properties are detailed in a chart and a table. Sizes, sealing techniques, and recommended applications are included. *Write on company letterhead to Corning Glass Works, Receiver Bulb Sales Dept., Dept. ED, Corning, N.Y.*

Algebraic Language 262

Based on the Algol international algebraic language system, Algo is used in programing the G-15 general purpose digital computer. A 32-page manual gives procedures for the representation of numerical data and control statements. A complete typical program is included. Bendix Corp., Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.

Beam-X Switch 263

Illustrated brochure BX-535, 24 pages, covers theory of operation, circuit design information and characteristic curves of the Beam-X switch. Applications include counting, coding, distributing, converting, multiplexing, switching and sampling. A maintenance and trouble-shooting section and a glossary are included. Burroughs Corp., Electronic Tube Div., Plainfield, N.J.

Clamps and Couplings 264

Industrial band clamps, couplings, hose clamps, flanges and V-band joints for all applications are described in a 44-page catalog, No. 803. Products include band clamps for automotive uses, identification tag clamps, pipe repair, joining, and sealing clamps, and V-band couplings and flanges. Design information and dimensional and operating diagrams are given. Aeroquip Corp., Marman Div., 11214 Exposition Blvd., Los Angeles 64, Calif.

Electronic Controls 265

The Electrionic Handbook, 24 pages, covers the application of electronic and electric controls in commercial and industrial air-conditioning installations. It explains the theory of electronic and electric control and makes comparisons between electronic and pneumatic controls. The information in this illustrated booklet is directed to heating, ventilating and air-conditioning applications. Barber-Colman Co., 1300 Rock St., Rockford, Ill.

Microwave Anechoic Chambers 266

Eccosorb microwave anechoic chambers are described in this 32-page brochure. The box type, the transverse baffle type, the aperture type and the longitudinal baffle type are illustrated. Typical specifications, diagrams and performance curves are given. Emerson & Cuming, Inc., Canton, Mass.

Electronic Components 267

More than 4,000 standard electronic component parts are listed, with buying and engineering information, in a 60-page catalog. Detailed schematic illustrations and technical data are given. The electrical ratings of most plugs, jacks and other connectors are included. Herman H. Smith Inc., 2326 Nostrand Ave., Brooklyn 10, N.Y.

Silicone Products 268

A complete discussion of silicone properties and applications for the aerospace industry is given in a 16-page reference guide, "Silicones for the Spage Age." Photos, charts and data on silicone rubber for insulation and potting, silicone varnishes and dielectric fluids are included in brochure CDS-276. General Electric Co., Silicone Products Dept., Waterford, N.Y.

Standards and Guides 269

Standards, reports, and guides of the EIA are listed with price and ordering information in bulletin No. 61-127(19). Included are engineering standards for mobile communications systems, phonograph stylus tips, and tube rating systems; two reports on maintainability of electronic equipment, and a guide to procurement of electron tubes. Electronic Industries Association, Engineering Dept., Room 2260, 11 W. 42nd St., New York 36, N.Y.

Radiation Effects 270

Bulletin ETD 2564, entitled "Minimizing the Effects of Nuclear Radiation on Electronic Equipment," reviews known effects of pulse and steady-state radiation on various types of circuits and components, and presents comparative data showing that thermionic integrated micromodule circuits are least susceptible to damage or temporary malfunction. General Electric Receiving Tube Dept., Owensboro, Ky.

Planar Semiconductors 271

Planar transistors and diodes are described in a 12-page brochure. Manufacturing processes and advantages over standard techniques are discussed. Performance and specifications of six transistors and three diodes are given. Fairchild Semiconductor Corp., 545 Whisman Road, Mountain View, Calif.

Antennas and Accessories 272

Specifications for antennas and accessories for frequency ranges between 25 and 470 mc are given in a 16-page booklet. Vertical and horizontal ground plane antennas are described along with Yagi arrays of three to 14 elements. Also included are antennas for WWV reception at 5, 10, 15 and 20 mc. Mosley Electronics, Inc., 4610 N. Lindbergh Blvd., Bridgeton, Mo.

Oscilloscope Accessories 273

Plug-in units for oscilloscopes are described in a 32-page booklet. Complete specifications and performance characteristics of the 16 units are given, with waveform patterns and other illustrative material for various measurement applications. Prices are included. Tektronix, Inc., Advertising Dept., P. O. Box 500, Beaverton, Ore.

Welding Metallurgy

Ferrous and nonferrous welding metallurgy is described in this 122-page, pocket-size booklet. Illustrations, tables and diagrams are given. Reprinted from the *Welding Handbook*, the material covers temperature changes in welding, structure and mechanical properties of metals, and weldability of various steel, nickel, copper, aluminum, magnesium, and titanium alloys. A bibliography is included. *Send $2 to American Welding Society, Dept. ED, 33 W. 39th St., New York 18, N.Y.*

NEW LITERATURE

Magnetic Latching Relays 276

Bulletin No. BR-594, two pages, describes series BR-9 magnetic latching relays for aerospace and undersea applications. Electrical and mechanical data and illustrations of standard mounting configurations are given. Babcock Relays, Inc., 1640 Babcock Ave., Costa Mesa, Calif.

Variable Resistor 277

Dimensional drawings and electrical and mechanical specifications on the firm's 3/4-w, style RV 6 variable resistor are given in this one-page data sheet. It exceeds MIL-R-94B and has a unique carbon-ceramic resistance element. Chicago Telephone Supply Corp., Elkhart, Ind.

Mass Spectrometer 278

Illustrated bulletin 21110, eight pages, gives the specifications and applications of type 21-110 mass spectrometer. It can be used as a standard analytical tool for laboratories conducting advanced-materials research. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

Direct-Writing Recorders 279

This illustrated brochure, four pages, describes the Mark II portable direct-writing recorders. It discusses the choice of ink or electric writing for specific applications. Operating data and a diagram of an adapter for rack mounting is given. Clevite Corp., Brush Instruments Div., 37th & Perkins, Cleveland 14, Ohio.

Ignitron Excitation Circuits 280

Bulletin PT-50, 16 pages, details typical ignitron excitation circuits which assure accurate and reliable firing. Schematics, graphs and charts are included to illustrate the technical data. General Electric Co., Schenectady 5, N.Y.

Electronic Digital Voltmeter 281

Bulletin 44-1, six pages, describes model V44 all-electronic digital voltmeter for high-speed measuring and data logging applications. Features, drawings and technical information on digital output data, specifications, applications and operating information are given. Non-Linear Systems, Inc., Del Mar, Calif.

Switching Diodes 282

Bulletin No. 2105, 12 pages, gives the characteristics of series 1N690 and 1N920 high-current switching diodes. The diodes are compared as to current characteristics, recovery time, diode capacitance and power rating. Typical performance curves are included. Sperry Rand Corp., Sperry Semiconductor Div., Norwalk, Conn.

Oscilloscope 283

Eight pages of application notes and four pages of accessory description for model 185A oscilloscope are given. Application notes Nos. 44A and 44B describe methods of synchronizing high-frequency oscilloscopes, and pulse and waveform analysis with the 185A. The unit is for circuit and component testing. Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif.

Direct-Writing Recorders 284

The design, principles and applications of direct-writing recorders are discussed in this 12-page bulletin, No. 5601. The firm's Dynograph recorder is considered in particular, and block diagrams accompany the description of its operation. Offner Electronics, Inc., 3900 River Road, Schiller Park, Ill.

Valve Data 285

A quick reference brochure, Abridged Valve Data, 38 pages, gives brief informations for all this company's electronic tubes up to the time of going to press. English Electric Valve Co., Ltd., Chelmsford, England.

NEW LITERATURE

High-Ratio Frequency 286

Bulletin A-2024, four pages, describes high-ratio frequency comparisons using roulette patterns on the crt of types 502, 503 and 536 oscilloscopes. Circuitry for displaying roulette patterns, schematic diagrams and waveforms for various frequency ratios are given. Tektronix, Inc., P.O. Box 500, Beaverton, Ore.

Computing System 287

Bulletin QC-020-R110 describes the firm's model G-20 high-speed computing system. Basic, medium and large systems and recent improvements are included in the brochure. Bendix Corp., Bendix Computer Div., 5630 Arbor Vitae, Los Angeles 45, Calif.

Data Acquisition Components 288

Applications, features and specifications of four products essential to data acquisition systems are listed in this eight-page bulletin, No. SCE-1. A differential wideband-dc amplifier, a floating wideband amplifier, a wideband-impedance converter, and a differential isolator are described. Computer Engineering Associates, Inc., 350 N. Halstead, Pasadena, Calif.

Nuclear Instruments 289

Nuclear instruments and systems, designed to perform analyzing or counting functions, are described in this 40-page catalog. It includes specifications and applications of both instruments and systems. Hamner Electronics Co., Inc., Box 531, Princeton, N.J.

Measuring Techniques 290

Application Note No. 50, four pages, illustrates the equipment setup and describes measuring techniques for obtaining accuracies of 1 in 10^6, or higher, in one hour using vlf standard broadcasts. Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif.

Magnetic Transducer Pickups 291

This booklet, No. CPM-50, describes the operation of magnetic transducer pickups for mechanical-electrical conversion without power supplies. A chart data on physical size, electrical output, temperature range and mating connectors of models available. Typical output curves and block diagrams are included. Electro Products Laboratories, 4501 N. Ravenswood Ave., Chicago 40, Ill.

Variable Resistors 292

Specifications on six types of model 7 linear motion variable resistors are contained in bulletin 42-1051, four pages. It contains dimensional drawings of encapsulated and nonencapsulated types. Globe-Union, Inc., Centralab Div., 900 E. Keefe Ave., Milwaukee 1, Wis.

Thermion 293

Brochure No. 7-8-9, four pages, describes the Thermion's use in determining thermal reliability for vacuum tubes. Operational characteristics are given. The Thermion is a device that measures the thermal environments encountered by vacuum tubes. A tube equivalence chart is included. Rescon Electronics Corp., 151 Bear Hill Road, Waltham 54, Mass.

Wire Products 294

Catalog 109, 40 pages, contains industrial listings of wire and wire products for the electrical and electronics industries. Illustrations and technical information describe in detail the entire line. Columbia Wire and Supply Co., 2580 W. Irving Park Road, Chicago 18, Ill.

Socket Adapters 295

Catalog AS-1, 12 pages, contains descriptions of 42 different varieties of socket adapters for the testing of solder terminal components such as relays and transformers. Electronic Engineering Co. of Calif., 1601 E. Chestnut Ave., Santa Ana, Calif.

NEW LITERATURE

Time Delays and Relays 296

Catalog No. 860 describes the firm's line of balanced rotary-armature relays, electronic time delays, constant pull-in relays, solid-state modules, voltage sensors and special products. Environmental characteristics, electrical specifications and diagrams, and drawings are given. Hi-G, Inc., Bradley Field, Windsor Locks, Conn.

Bistable Amplifier 297

Bulletin CS60-3, four pages, gives specifications and design data for the firm's ultra-sensitive bistable amplifier. Applications include detection of reverse current and over current in dc power-supply systems. Tables, charts and graphs are included. Norbatrol Electronics Corp., 356 Collins Ave., Pittsburgh 6, Pa.

Digital Instruments 298

Bulletin No. 481-1, 12 pages, gives 17 applications of the NLS-481 digital voltmeter and the NLS-781 digital ohmmeter. Features, wiring diagrams and conversion to ac and low-level dc measurements for the 481 are given. Specifications and operation information on both instruments are included. Non-Linear Systems, Inc., Del Mar, Calif.

Semiconductor Circuits 299

Selected semiconductor circuits, using precision-etch process transistors are shown in Application Notes No. 38004, 11 pages. The circuits described provide a reference of contemporary circuits suitable for military and industrial electronic equipment. Sprague Electric Co., North Adams, Mass.

Angular Accelerometers 300

Features, applications and specifications for angular accelerometers are included in this six-page brochure. The units described are for control and measurement of missile and aircraft flight dynamics, structural analysis of in-

duced angular acceleration, monitor and control of servo systems and closing the loop in inertial guidance systems. Donner Scientific Co., Concord, Calif.

Ferrule-Terminal Resistors 301

Bulletin No. 7350, 12 pages, describes and illustrates the F, NIF- and SIF-series glass-jacketed power-wirewound resistors. Ratings on standard, non-inductive, and super non-inductive winding designs are given. Dimensional diagrams, characteristics and applications are included. Sprague Electric Co., North Adams, Mass.

Traveling-Wave Tubes 302

This catalog lists over 85 traveling-wave tubes covering the vhf through Ku-bands. Included are low-noise amplifiers, solenoid, ppm and electrostatically focused forward-wave amplifiers, voltage-tuned backward-wave amplifiers and oscillators and special-purpose tubes. Characteristics and application data are given. Huggins Laboratories, Inc., 999 E. Arques Ave., Sunnyvale, Calif.

Transistorized Power Supply 303

This two-page bulletin gives performance characteristics for model HC40-50 transistorized power supply. The unit is for powering computing equipment where low ripple, close regulation, freedom from transients and fast response are important. Specifications, price and delivery information is included. Mid-Eastern Electronics, Inc., 32 Commerce St., Springfield, N.J.

Magnetic Reed Switches 304

This six-page bulletin describes models DRG-1 and DRS-5 magnetic reed switches. It contains charts and diagrams on actuation methods and mechanism, test charts for life expectancy, the method of code identification, and a permanent magnet chart. Specifications are given. Hamlin, Inc., Lake and Grove Sts., Lake Mills, Wis.

"No Tubes, No Transistors in Hi-Fi Amplifier— Just Diodes"

ATTENDEES at Dr. William Shockley's lecture on four-layer diodes, given recently at the Eighth Annual Cleveland Electronics Conference, were treated to a demonstration of music played through an amplifier devoid of tubes or transistors—diodes were the only active elements. Response of the amplifier extended from dc to over 15 kc, with average audio power about 2 w. The improved version of the amplifier, shown in Fig. 1, delivers about 10-w average audio power into a speaker or resistive load.

Pulse-Width Modulator Activates Flip-Flop Output

In basic principle the device consists of two sections—a pulse-width modulator operating from the input signal, and a bistable multivibrator or flip-flop producing a square wave which will vary in symmetry in accordance with the applied signal. A transducer such as a loudspeaker can be used to sense changes in symmetry and thus reproduce the original signal.

Fig. 1 shows a modulator which operates at 37.5 kc, more than double the highest audio frequency to be amplified. The modulator consists of a relaxation oscillator using a four-layer Shockley diode switch which fires at 40 v. When this device fires, it discharges capacitor C_1 through resistor R_2, producing a 40-v negative pulse; a sawtooth waveform is produced at B the top of $C_1 - D_1$ (see Fig. 3).

The second section of the modulator is another Shockley four-layer semiconductor relaxation oscillator operating at 37.5 kc with this oscillator operating from a negative supply voltage to produce a negative going sawtooth waveform at the top of $C_3 - D_2$.

A voltage divider, consisting of R_3 and R_4, allows a small portion of the positive going sawtooth which appears at the top of $C_1 - D_1$ to be applied to the bottom of D_2; thus D_2 fires when the combined negative and positive sawtooth signals reach a difference potential equal to the firing voltage of D_2 (in this case 50 v). When D_2 fires, it discharges C_3 through R_7 producing a negative pulse of approximately 40 v.

The two relaxation oscillators operate in synchronism because of their interconnection and the phase relation between these oscillators is affected by the sawtooth slope as well as the firing voltage of each diode. A small ac signal applied as shown changes the firing point of D_1 and thus phase modulates the pulses from D_1 and D_2. Symmetry is adjusted with R_5 or R_6.

The output stage is a bistable multivibrator consisting of two Shockley switching devices and is switched from side to side with the pulses supplied by the two relaxation oscillators. When no modulation is present, the speaker sees a square wave of 37.5 kc and a net audio signal of zero. As the symmetry is varied from side to side with an audio input signal, the transducer sees one diode conducting for a longer time than the other one; thus the transducer sees an audio component in the form of a zero-line shift.

Up to Several Kw Possible At Efficiencies Up to 100%

Since Shockley switching diodes are available with switching voltages ranging from 20 to 200 v and currents from 50 ma to 5 amp, it is possible to match almost any load from 2 ohms to 30,000

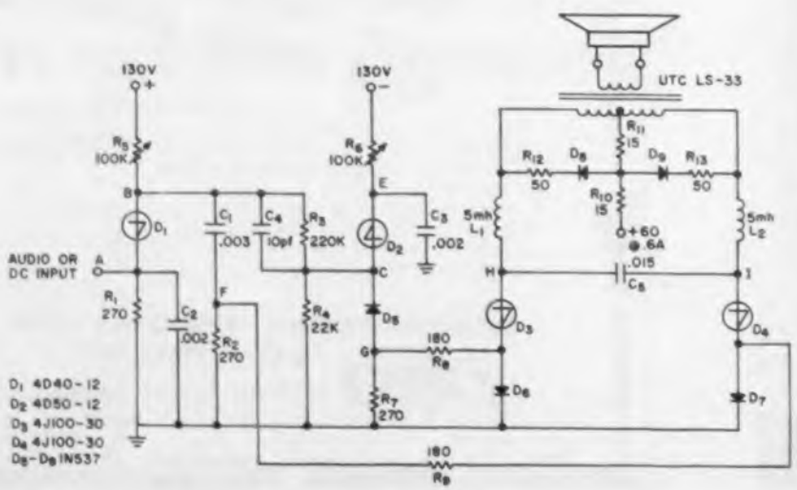


Fig. 1. The diode-equipped amplifier shown delivers approximately 10-w average audio power to a speaker load.

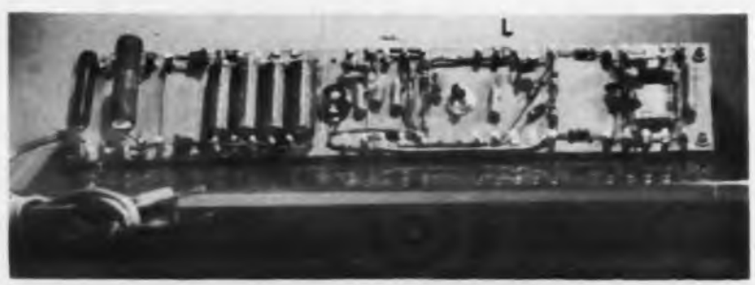


Fig. 2. Breadboard model of the diode amplifier.

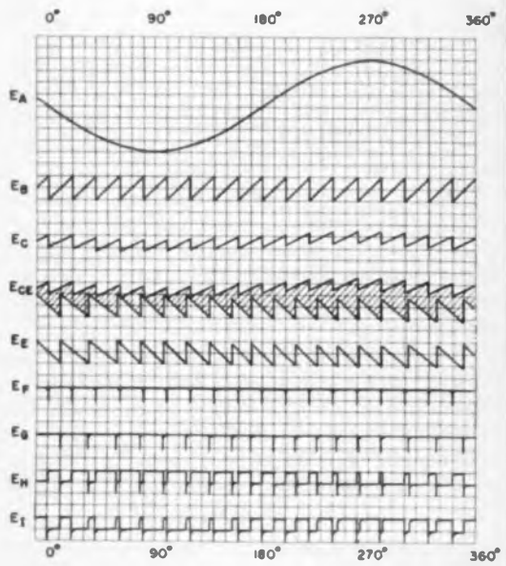


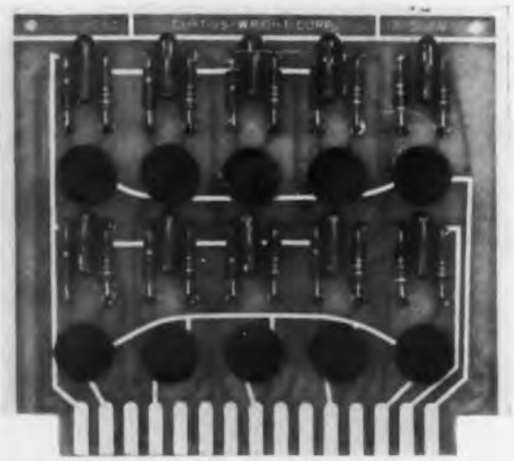
Fig. 3. Waveforms at various sections of the pulse-width modulator and output flip-flop.

ohms without the use of an output transformer. Power input from one watt to several kilowatts is practical with various loads, and peak power efficiency approaching 100 per cent could result from careful design.

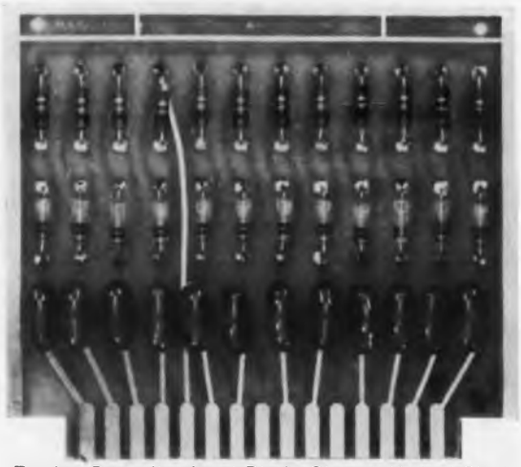
The modulator stage shown in Fig. 1 requires between 1- to 2-v rms audio signal for full modulation and this input signal may be injected in either low or high impedance points in the circuit; very high impedance is seen, for instance, between the point of R_3 and R_4 and diode D_2. The sensitivity of the modulator may be changed by altering the ratio of R_3 to R_4; a smaller sawtooth injected into D_2 produces greater sensitivity, but problems of noise and instability will result from too much reduction in the sawtooth amplitude. Power gains in the order of 10^{10} to 10^{11} are possible with modulator sensitivity unaltered by output power level.

Practical applications of the amplifier might include high-power public address systems, transmitter modulators, servo systems, instrumentation amplifiers, vibration table exciters, sonar, electric organ amplifiers, and high-fidelity and phonograph amplifiers.

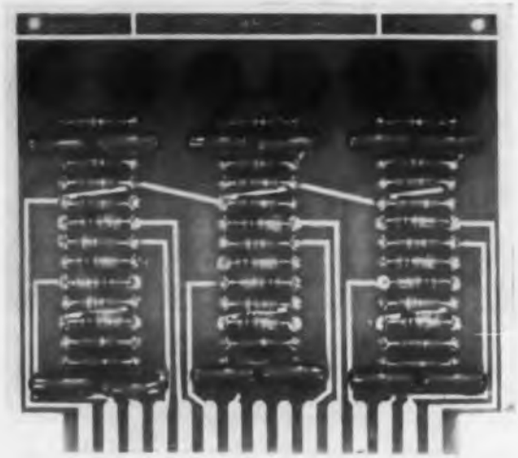
Michael J. Cudahy, Cozzens and Cudahy, Skokie, Ill.



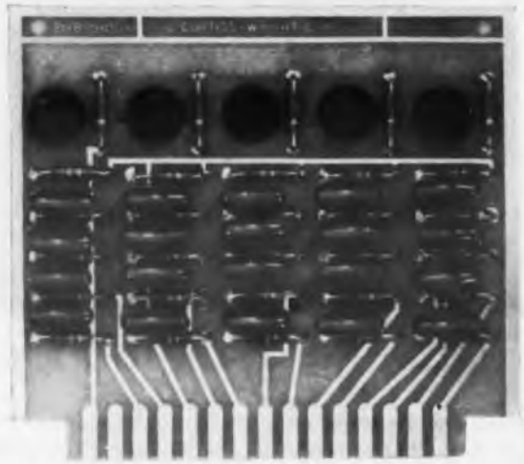
Two 4-Bit Transfer Gates (Actual Size)



Twelve Capacitor Input Diode Clamps (Actual Size)



Three Binary Circuits with Set-Reset Gates (Actual Size)



Five 4-Input NOR Gates (Actual Size)

DESIGN DECISIONS

Painted Checks and Stripes Help Cool Explorer VIII

A novel application of protective coloration helps keep the instrumentation in Explorer VIII within a temperature range of 0 to 50 C. Almost 1,400 squares of red, iron-oxide, silicone paint cover 347 sq in. of the satellite's skin while strips and patches of silver paint cover an additional 610 sq in. Together, these paints cover 38 per cent of the satellite's sandblasted aluminum surface.

The red, an insulating paint, is highly resistive to ultraviolet radiation. Though the silver, a conductive paint, is not as effective thermally as the red, it was used to keep the satellite's skin as conductive as possible to minimize its effect on the ionosphere.

The effects of the exterior paints, which were sprayed on through masks, were supplemented by the use of a white silicone paint on the interior of the satellite's skin.

This application of paint as a thermal-design element was developed at the Marchal Space Flight Center of NASA in Huntsville, Ala.

Squares of red and stripes and patches of silver paint help keep instruments in Explorer VIII comfortably cool.

Half-Disk Mounted Circuits Save Space, Provide Access

An unusual packaging configuration saves space and maximizes circuit access in a Bernoulli-Disk recorder designed for satellite instrumentation. Manufactured by Laboratory for Electronics, Inc., the BD-48A includes 14 half-disks on which almost all the circuitry is mounted.

Each half-disk can be swung through a wide

Swing-out half-disks provide access to circuitry in compact, magnetic-disk recorder for satellite instrumentation.

arc to give access to any mounted component. In operation, the half-disks are anchored in place by rods which slide down through sleeves on the outer edges of the cards. The centers of the cards are supported on slits on the center column.

The rotating, flexible, magnetic disk on which information is recorded is in the lower part of the housing shown in the photo.

High Speed Rotary Switch Uses Rotating Magnet To Close Reeds

A new rotary switch uses a novel but simple technique to provide high-speed operation with very long life. Switch decks consist of rings of 24, gold-plated, reed contacts, hermetically sealed in nitrogen. These contacts, completely isolated from each other, are closed in sequence by the rotation of a permanent magnet.

The magnet can be driven by a rotary solenoid as in the accompanying photograph, or it can be driven by a small motor for commutator applications. When motor driven, the switch can be operated at 6,000 rpm. The manufacturer, Hathaway Instruments, Inc. of Denver, rates the contacts to pass 100 ma for 10 million operations. The reeds can close in 0.1 msec.

Rings of reed contacts surround solenoid-driven permanent magnet in high-speed rotary switch. The cover has been removed from the deck at the right to expose the glass-enclosed reed contacts.

DESIGN DECISIONS

"Oceanated" Roof Simulates Sea For Ship Antenna System

A 6,000 sq-ft cement slab, covered with copper-sprayed zinc, serves as the sea for extensive tests of shipboard antennas. The slab, which has the conductivity of the sea, serves with a large area of wire mesh as an effective ground plane. On the roof of Developmental Engineering Corp.'s laboratories at Leesburg, Va., the sea-like antenna-test facility includes the largest turntable built by private industry, a circular, rotating base with a 15-ft diameter.

In testing antenna structures, DECO engineers mount copper-sprayed, wooden, scaled ship models at the center of the turntable; they cover the superstructure with brass or copper; and they duplicate every exterior detail of the ship which can affect communications.

The ship, with its scaled-down antenna structure is rotated about 65 ft away from three, different-sized, discone antennas, transmitting scaled-up frequencies (50 to 2,000 mc). By measuring the reception of the model antenna, at an instrumentation room under the turntable, the engineers can improve or relocate the antenna to conform with the ship's design.

Often, they can incorporate parts of the ship's superstructure, like the smoke stacks and masts, in the antenna design. Occasionally, they can recommend changes in the ship's superstructure.

The superstructure of a ship invariably causes problems for antenna designers because it radiates under antenna excitation. In one application, engineers encountered difficulty in designing a broadband wire antenna with good omnidirectional coverage and good impedance characteris-

Scaled-down model of Essex-class carrier helps engineer design shipboard antenna. Model is rotated on 15-ft-diam turntable, 65 ft away from the discone antennas in the background. A copper covering on a zinc-coated, cement slab serves as the ground plane between the turntable and the discones.

tics over a three-to-one frequency range. This problem was magnified by parasitic radiation from the ship's superstructure and from other antennas.

In this case, incorporating two smoke stacks, the main mast, and two boat cranes as part of the antenna eliminated the problem.

Buoy, Oh Buoy Buttered Popcorn!

Buttered popcorn serves as the filler for rhw encapsulent in a rugged, light-flashing, marker buoy. A buoy which may be dropped into the sea from any altitude must be very rugged if it is not to shatter on impact. Its electronic components must be held rigidly in place. This rigidity requirement would normally call for a very tough and heavy encapsulent.

But a buoy has to float. Designing a floatable device to take as much as 10,000 g of impact shock can call for unusual measures The tasty solution by engineers at ACR Electronics Corp., 551 W. 22nd St., New York, was remarkably simple.

They filled the compartment containing the electronics with buttered popcorn. They then poured Araldite epoxy over the filler. It filled the interstices but didn't saturate the popcorn because the butter prevented its penetration.

This unusual encapsulation technique saved 80 per cent of the weight of full encapsulation. According to ACR's David Rush, there was no loss in strength. Mr. Rush admits, however, to a mysterious loss of popcorn—on the production line.

Good-enough-to-eat filler for epoxy encapsulent keeps busy buoy buoyant. Buttered popcorn does it.

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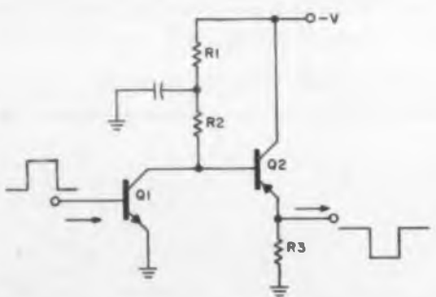
The Most Valuable of Issue Ideas will be eligible for the $1,000 Idea of the Year award.

And after you've voted, why not send in an Idea of your own?

High-Gain Pulse Amplifier Uses Complementary Transistors 738



Second stage in high-gain pulse amplifier is prevented from saturating by voltage drop across R1.

High-current gain without excessive storage time can be easily obtained from a two-stage transistor pulse amplifier by using complementary transistors connected so that the second stage is prevented from saturating.

By biasing $Q1$ (network not shown) so that the voltage drop across $R1$ is one volt, the voltage from the collector to base of $Q2$ can never go below this value. $Q2$ cannot saturate and storage time is held to a minimum.

The circuit is well suited for driving 50- to 90-ohm transmission lines with 4- to 8-v pulses. For opposite polarity pulses substitute npn transistors and a positive battery voltage.

H. F. Stearns, Engineer, Technical Products Operation, General Electric Co., Syracuse, N.Y.

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Pulsing Capacitor Eliminates False Triggers Due To Switch Bounce 743

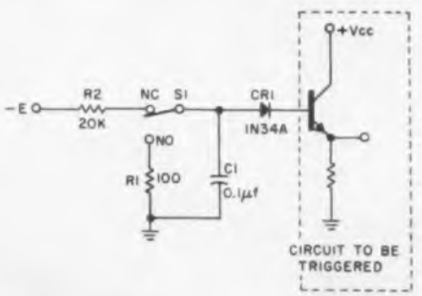
In circuits using inexpensive spring-loaded pushbutton or toggle switches for single pulse triggering, switch bounce can produce unwanted trigger pulses following the initial trigger. These false trigger pulses can cause erratic or unstable operation in many triggering circuits.

The circuit shown produces a single trigger pulse with a sharp leading edge and suppresses all other unwanted triggers.

Before the switch is depressed, C_1 is charged to $-E$. Thus, the voltage on C_1 reverse biases CR_1 and isolates $-E$ from the circuit to be triggered. When S_1 is depressed, C_1 discharges rapidly through the low resistance of R_1 producing a sharp positive-going pulse on the plate of CR_1. With CR_1 now forward biased, the pulse passes through to the circuit.

When the switch is released, the armature may bounce against the normally closed contact due to the spring tension. This bouncing action causes the generation of the undesired triggers.

The suppressing action of the circuit takes place the instant the switch is released and returns to the NC contact. Capacitor C_1 immediately tries to recharge to $-E$, but cannot do so because of the large value of R_2. This long time constant (R_2C_1) does not allow C_1 to charge to a sufficient level fast enough to produce another trigger pulse. As the armature bounces off the NC contact, C_1 merely retains its charge. Each successive bounce allows C_1 to charge slightly more to $-E$. This continues until the switch is at rest on the NC contact at which time C_1 completes its charge to $-E$ in an exponential manner. Resistors R_1 and R_2 also act as arc suppressors to protect the switch.



False trigger pulses due to contact bounce are eliminated by push-button triggering the circuit from charged capacitor C_1, instead of directly from the power source. Diode CR_1 isolates the triggered circuit after the switch is spring-returned from its NO position and bounces on the NC contact.

For negative going triggers, the voltage E is positive and the diode connections are reversed.

With this simple arrangement, any inexpensive switch can be used for stable triggering without any additional circuitry for suppression of unwanted pulses.

Richard C. Sylvesta, Senior Technician, Lumatron Electronics, Inc., New Hyde Park, L. I., N. Y.

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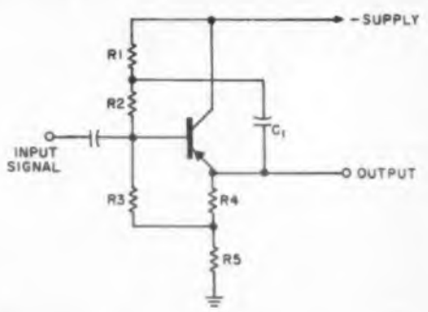
Bypassed Bias Resistor Increases Emitter-Follower Input Z 741



Bypassing of base-bias resistance by capacitor C_1 reduces the resistor's effect on input impedance of emitter follower.

In conventional transistor emitter-follower circuits, the input impedance is limited by the values of the base bias resistors. This limitation can be removed by connecting the circuit as shown in the figure.

Forward bias resistor $R_1 + R_2$ is divided into two equal parts and by-passed to the emitter by capacitor C_1. The emitter resistor is tapped as high as possible by resistor R_3 while still maintaining proper temperature bias conditions.

The value of R_3 does not affect the input impedance because of regenerative action in the emitter load. Capacitor C_1 puts R_2 and R_3 effectively in parallel for alternating currents. Resistor R_1 has no effect on the input impedance because it is in parallel with the low output of the stage.

Donald W. Bramer, Engineer, General Railway Signal Co., Rochester, N. Y.

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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.

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SEVENTH ANNIVERSARY AWARDS

IDEAS-FOR-DESIGN

Entry Blank

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(Use separate sheet if necessary)

Here is my Idea for Design for possible publication in ELECTRONIC DESIGN. I understand that it will be eligible for the Seventh Anniversary Awards—$20 if published, $50 if chosen Most Valuable of Issue, $1,000 if chosen Idea of the Year.

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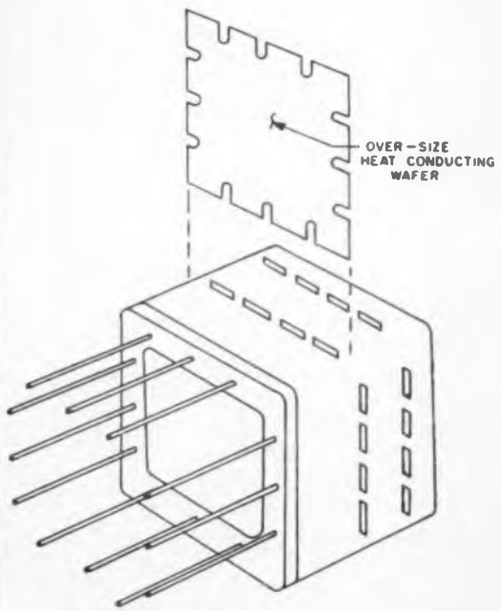
IDEAS FOR DESIGN

Heat-Conducting Wafers Dissipate Heat in Micromodules 744

The heat-dissipating ability of micromodule package designs can be considerably increased by building into the package wafers whose sole function is to transfer heat.

These wafers can be placed in the package in close proximity to the heat-producing components. They are made slightly over-size so that their edges protrude through the outer package shell.

The wafers absorb heat produced within the package and conduct it to their outer edges. There, the heat is either released into the air or conducted down through the supporting wires. Or, the wafer edges can be contacted by an over-all package heat sink.



Oversize heat-conducting wafers, made of materials such as Berlox (BeO), can be added to micromodules to increase their ability to dissipate internal heat. Wafer conducts heat from interior of package to its outer edges.

The wafers can be made from materials such as Berlox (BeO). This material has good heat conductivity and high insulation qualities. It can also be readily formed or molded into thin (0.020 in.) wafers.

Donald J. Abel, Section Head, Du Mont Military Electronics Div., Fairchild Camera & Instrument Corp., Clifton, N.J.

Vote this Idea the Most Valuable of Issue by circling its Reader-Service number.

Low-Pass Filter Converts Square Waves To Sine

742

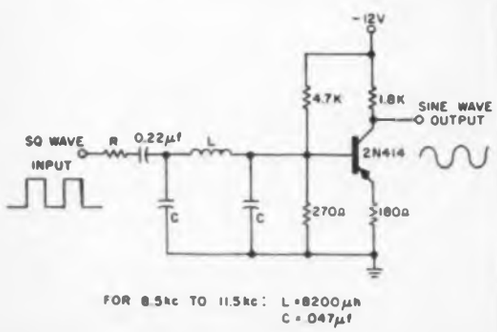
A square-to-sine wave converter can be readily designed by passing the square wave into a low-pass filter whose cut-off frequency is the same as the square wave's fundamental.

A constant-k, low-pass filter has zero attenuation from zero to its cut-off frequency. Above this frequency its response falls off at the rate of approximately 12 db per octave. Therefore, if the cut-off frequency and the fundamental of the input square wave are the same, the output waveform will contain almost all of the fundamental. However, it will contain only about 25 per cent of the second harmonic and only about 12 per cent of the third harmonic. Since the relative harmonic contents of a square wave are 0 per cent second and 33 per cent third, the resulting sine wave will have less than 5 per cent distortion.

The transistor amplifier is used to isolate against load variations and to restore the amplitude losses. Thus, several filters may be cascaded to obtain lower distortion without having the losses accumulate. This also allows operation at slightly higher square-wave frequencies—above the filter cut-off frequency.

With 5 per cent tolerance components a square-wave frequency range ratio of 1.35:1 is permissible for output distortion less than 5 per cent and amplitude stability of ±3 db. Thirteen different circuits were developed to cover a continuous frequency range from 6.4 kc to 265 kc without the need for tuning.

In the circuit shown an output sine-wave amplitude of 6 v peak-to-peak is obtained from an input square-wave amplitude of 8 v peak-to-peak with $R = 3.9$ K. Lower values of R require less input amplitude for 6-v output.



Square wave input is converted to sine wave output after it is passed through the low-pass filter. Transistor stage amplifies signal to desired level.

William H. Ferwalt, Senior Engineer, Engineered Electronics Co., Santa Ana, Calif.

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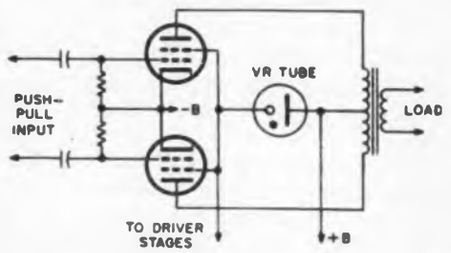
IDEAS FOR DESIGN

VR Tube Replaces Screen Resistor in Push-Pull Output Stage 745

A voltage regulator tube can be used as a series regulator to maintain a constant difference voltage between two loads.

For example, in an audio output stage it is desirable to operate the screen grids of a push-pull output stage at 75 to 150 v below the plate supply voltage. Use of a dropping resistor poses a problem because of variation in screen current between signal and no signal conditions.



Use of VR tube eliminates screen dropping resistor, reduces screen voltage swing.

The use of a voltage regulator tube eliminates the need for high dissipation resistive networks.

H. A. Wittlinger, Engineer, Radio Corp. of America, Harrison, N.J.

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RC-Discharge Display Rapidly Measures Tantalum Capacitors 740

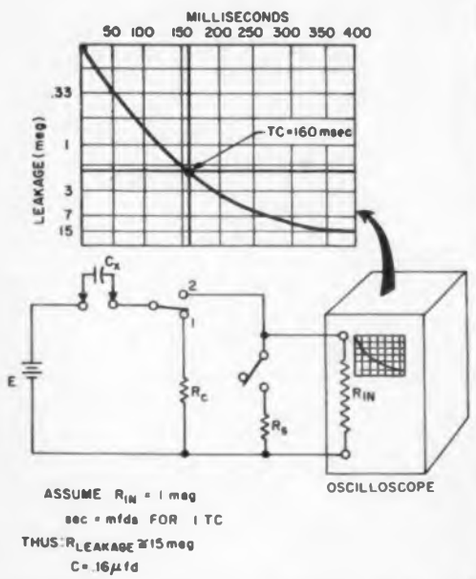
Often it is necessary to make fairly accurate measurements of the leakage resistance and capacity of tantalum capacitors. Commercial testers operating at comparatively high voltage and signal levels cannot do the job.

A simple method, based on the fundamental equation of the capacitor's discharge curve

$$V_1 = V_0 e^{-t/RC}$$

leads to the use of a circuit that can check both capacity and leakage with one measurement in a minimum of time.

The circuit uses a battery whose value is approximately the rating of the capacitor, a switch and a scope with a calibrated time scale. The capacitor is charged in position *1* and discharged into the known input impedance of the scope, position *2*. Usually this impedance is about 1 meg. The scope traces the discharge curve of the capacitor. The capacitance value can be found from the point at which $t = RC$ or the point where the voltage is 37 per cent



Tantalum Capacitor, C_x, is discharged into the vertical plates of an oscilloscope. Values of capacitance and leakage resistance are used from the discharge curve.

of the initial value.

The point at which the voltage has discharged, close to zero, reveals the leakage resistance of the capacitor. The ratio between the voltage remaining across the scope probe and the discharge voltage is the ratio of the known scope impedance to the capacitor's leakage resistance.

Calibrating or marking the scope template can make all these readings instantaneous and lends itself to go-no-go testing operations.

For very low values of capacity on the order of 0.01 μf. the 10:1 attenuator probe of a typical manufacturer is 10 meg. This gives a time constant of 0.1 sec which provides a rapid and convenient value for display on the most inexpensive of scopes. It should be noted that only the value of the battery is necessary for vertical calibration of the scope since all measured quantities are ratios or functions of this voltage.

In the example shown, the low value of leakage, 15 meg, would result in a slight correction if the discharge value is figured on the basis of the entire vertical scale. Allowable tolerances on the value of C would indicate whether or not a smaller value of R should be used to eliminate this correction. In the circuit R_s represents a smaller value of R used with high capacity values to reduce the time constant to less than 1 sec. When switching back to the higher impedance a determination of leakage could then be made.

Melvin Guberman, Test Engineering Manager, ASW Div., Loral Electronics Co., Bronx, N.Y.

Vote this Idea the Most Valuable of Issue by circling its Reader-Service number.

J. George Adashko

Matrix Tables for Transistor Two-Port Networks

Matrices ↓	Circuit 1 
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22} & Y_{12} \\ -Y_{21} & -Y_{11} \end{bmatrix}$
[y]	$\begin{bmatrix} Y_{11} & Y_{12} \\ -Y_{21} & -Y_{22} \end{bmatrix}$
[d]	$\frac{1}{Y_{11}}\begin{bmatrix} -Y_{12} & 1 \\ -\lvert Y\rvert & -Y_{21} \end{bmatrix}$
[f]	$\frac{1}{Y_{22}}\begin{bmatrix} -Y_{21} & -1 \\ \lvert Y\rvert & -Y_{12} \end{bmatrix}$
[a]	$-\frac{1}{Y_{21}}\begin{bmatrix} Y_{22} & 1 \\ \lvert Y\rvert & Y_{11} \end{bmatrix}$
$\lvert Y\rvert$	$Y_{11}Y_{22}-Y_{12}Y_{21}$

THE ANALYSIS of elaborate circuitry by two-port network theory is made easier by tables of matrices for the component two-port networks. Tables have been published for networks with passive elements and with vacuum tubes,[1] and also for transistors[2,3] in terms of the $Z(R)$ parameters.

The matrix tables presented here have been calculated for transistor circuits with passive elements. To illustrate the procedure used to determine each of the matrices, we will derive the matrices for circuit 2—a grounded-emitter configuration. The generalized method of node voltages is used in the derivation; [4,5,6] the nodes of the circuit are marked on the diagram.

Derivation of Matrices For Grounded Emitter Circuit 2

The derivation is based on the use of the generalized transistor matrix,[5] and on the formula for converting the determinant of the node-voltage method to the z-matrix of the equivalent two-port network.[6]

The generalized matrix of circuit 1 is:

	1	2	0
1	$Y_{11}+Y$	Y_{12}	$-(Y_{11}+Y_{12}+Y)$
2	Y_{21}	Y_{22}	$-(Y_{21}+Y_{22})$
0	$-(Y_{11}+Y_{21}+Y)$	$-(Y_{12}+Y_{22})$	$Y_{11}+Y_{12}+Y_{21}+Y_{22}+Y$

and the determinant of the equivalent matrix is:

$$|Y| = \begin{vmatrix} Y_{11}+Y & Y_{12} \\ Y_{21} & Y_{22} \end{vmatrix} \quad (1)$$

To derive the z-matrix,[6] we determine the cofactors of determinant 1:

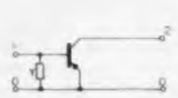
$$|Y|_{11} = |Y|_{11} = Y_{22}; \quad |Y|_{mm} = |Y|_{22} = Y_{11}+Y$$
$$|Y|_{m} = |Y|_{12} = -Y_{21}; \quad |Y|_{m1} = |Y|_{21} = -Y_{12} \quad (2)$$

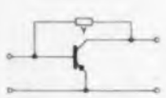
and then expand the determinant:

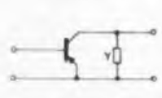
$$|Y| = (Y_{11}+Y)\,Y_{22} - Y_{12}\,Y_{21} \quad (3)$$

With the notation of determinants 2 and 3, the

(text continued on p 230)

Matrices ↓	Circuit 2 
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22} & Y_{12} \\ -Y_{21} & -(Y_{11}+Y) \end{bmatrix}$
[y]	$\begin{bmatrix} Y_{11}+Y & Y_{12} \\ -Y_{21} & -Y_{22} \end{bmatrix}$
[d]	$\frac{1}{Y_{11}+Y}\begin{bmatrix} -Y_{12} & 1 \\ -\lvert Y\rvert & -Y_{21} \end{bmatrix}$
[f]	$\frac{1}{Y_{22}}\begin{bmatrix} -Y_{21} & -1 \\ \lvert Y\rvert & -Y_{12} \end{bmatrix}$
[a]	$-\frac{1}{Y_{21}}\begin{bmatrix} Y_{22} & 1 \\ \lvert Y\rvert & Y_{11}+Y \end{bmatrix}$
$\lvert Y\rvert$	$(Y_{11}+Y)Y_{22}-Y_{12}Y_{21}$

Matrices ↓	Circuit 3 
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22}+Y & Y_{12}-Y \\ Y-Y_{21} & -(Y_{11}+Y) \end{bmatrix}$
[y]	$\begin{bmatrix} Y_{11}+Y & Y_{12}-Y \\ Y-Y_{21} & -(Y_{22}+Y) \end{bmatrix}$
[d]	$\frac{1}{Y_{11}+Y}\begin{bmatrix} Y-Y_{12} & 1 \\ -\lvert Y\rvert & Y-Y_{21} \end{bmatrix}$
[f]	$\frac{1}{Y_{22}+Y}\begin{bmatrix} Y-Y_{21} & -1 \\ \lvert Y\rvert & Y-Y_{12} \end{bmatrix}$
[a]	$\frac{1}{Y-Y_{21}}\begin{bmatrix} Y_{22}+Y & 1 \\ \lvert Y\rvert & Y_{11}+Y \end{bmatrix}$
$\lvert Y\rvert$	$Y_{11}Y_{22}-Y_{12}Y_{21}+Y\,Y_S$

Matrices ↓	Circuit 4 
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22}+Y & Y_{12} \\ -Y_{21} & -Y_{11} \end{bmatrix}$
[y]	$\begin{bmatrix} Y_{11} & Y_{21} \\ -Y_{21} & -(Y_{22}+Y) \end{bmatrix}$
[d]	$\frac{1}{Y_{11}}\begin{bmatrix} -Y_{12} & 1 \\ -\lvert Y\rvert & -Y_{21} \end{bmatrix}$
[f]	$\frac{1}{Y_{22}+Y}\begin{bmatrix} -Y_{21} & -1 \\ \lvert Y\rvert & -Y_{12} \end{bmatrix}$
[a]	$\frac{1}{Y_{21}}\begin{bmatrix} Y_{22}+Y & 1 \\ \lvert Y\rvert & Y_{11} \end{bmatrix}$
$\lvert Y\rvert$	$Y_{11}(Y_{22}+Y)-Y_{12}Y_{21}$

Matrices ↓	Circuit 5
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22}+Y_2 & Y_{12}+Y_2 \\ Y_2-Y_{21} & -(Y_{11}+Y_1+Y_2) \end{bmatrix}$
[y]	$\begin{bmatrix} Y_{11}+Y_1+Y_2 & Y_{12}+Y_2 \\ Y_2-Y_{21} & -(Y_{22}+Y_2) \end{bmatrix}$
[d]	$\frac{1}{Y_{11}+Y_1+Y_2}\begin{bmatrix} Y_2-Y_{12} & 1 \\ -\lvert Y\rvert & Y_2-Y_{21} \end{bmatrix}$
[f]	$\frac{1}{Y_{22}+Y_2}\begin{bmatrix} Y_2+Y_{21} & -1 \\ \lvert Y\rvert & Y_2-Y_{12} \end{bmatrix}$
[a]	$\frac{1}{Y_2-Y_{21}}\begin{bmatrix} Y_{22}+Y_2 & 1 \\ \lvert Y\rvert & Y_{11}+Y_1+Y_2 \end{bmatrix}$
$\lvert Y\rvert$	$(Y_{11}+Y_1)\,Y_{22}-Y_{12}Y_{21}+$ $+\,Y_2(Y_2+Y_1)$

Matrices ↓	Circuit 6
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22}+Y_1+Y_2 & Y_{12}-Y_1 \\ Y_1-Y_{21} & -(Y_{11}+Y_1) \end{bmatrix}$
[y]	$\begin{bmatrix} Y_{11}+Y_1 & Y_{12}-Y_1 \\ Y_1-Y_{21} & -(Y_{22}+Y_1+Y_2) \end{bmatrix}$
[d]	$\frac{1}{Y_{11}+Y_1}\begin{bmatrix} Y_1-Y_{12} & 1 \\ -\lvert Y\rvert & Y_1-Y_{21} \end{bmatrix}$
[f]	$\frac{1}{Y_{22}+Y_1+Y_2}\begin{bmatrix} Y_1-Y_{21} & -1 \\ \lvert Y\rvert & Y_1-Y_{12} \end{bmatrix}$
[a]	$\frac{1}{Y_1-Y_{21}}\begin{bmatrix} Y_{22}+Y_1+Y_2 & 1 \\ \lvert Y\rvert & Y_{11}+Y_1 \end{bmatrix}$
$\lvert Y\rvert$	$Y_{11}(Y_{22}+Y_2)-Y_{12}Y_{21}+$ $+Y_1(Y_2+Y_2)$

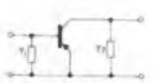
RUSSIAN TRANSLATIONS

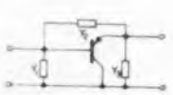
z-matrix is:

$$[z] = \begin{bmatrix} \dfrac{Y_{22}}{(Y_{11}+Y)\,Y_{22}-Y_{12}\,Y_{21}} & \dfrac{Y_{12}}{(Y_{11}+Y)\,Y_{22}-Y_{12}\,Y_{21}} \\ \dfrac{-Y_{21}}{(Y_{11}+Y)\,Y_{22}-Y_{12}\,Y_{21}} & \dfrac{-(Y_{11}+Y)}{(Y_{11}+Y)\,Y_{22}-Y_{12}\,Y_{21}} \end{bmatrix} \tag{4}$$

Using 3 for the denominator of each element

(text continued on p 232)

Matrices ↓	Circuit 7
	
$[z]$	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22}-Y_3 & Y_{12} \\ -Y_{21} & -(Y_{11}+Y_3) \end{bmatrix}$
$[y]$	$\begin{bmatrix} Y_{11}+Y_3 & Y_{12} \\ -Y_{21} & -(Y_{22}+Y_3) \end{bmatrix}$
$[d]$	$\frac{1}{Y_{11}+Y_3}\begin{bmatrix} -Y_{12} & 1 \\ -\lvert Y\rvert & -Y_{21} \end{bmatrix}$
$[f]$	$\frac{1}{Y_{22}+Y_3}\begin{bmatrix} -Y_{21} & -1 \\ \lvert Y\rvert & -Y_{12} \end{bmatrix}$
$[a]$	$-\frac{1}{Y_{21}}\begin{bmatrix} Y_{22}+Y_3 & 1 \\ \lvert Y\rvert & Y_{11}+Y_3 \end{bmatrix}$
$\lvert Y\rvert$	$(Y_{11}+Y_3)(Y_{22}+Y_3)-$ $-\,Y_{12}Y_{21}$

Matrices ↓	Circuit 8
	
$[z]$	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22}+Y_3+Y_2 & Y_{12}-Y_2 \\ Y_2-Y_{21} & -(Y_{11}+Y_3+Y_2) \end{bmatrix}$
$[y]$	$\begin{bmatrix} Y_{11}+Y_3+Y_2 & Y_{12}-Y_2 \\ Y_2-Y_{21} & -(Y_{22}+Y_3+Y_2) \end{bmatrix}$
$[d]$	$\frac{1}{Y_{11}+Y_3+Y_2}\begin{bmatrix} Y_2-Y_{12} & 1 \\ -\lvert Y\rvert & Y_2-Y_{21} \end{bmatrix}$
$[f]$	$\frac{1}{Y_{22}+Y_3+Y_2}\begin{bmatrix} Y_2-Y_{21} & -1 \\ \lvert Y\rvert & Y_2-Y_{12} \end{bmatrix}$
$[a]$	$\frac{1}{Y_2-Y_{21}}\begin{bmatrix} Y_{22}+Y_2+Y_3 & 1 \\ \lvert Y\rvert & Y_{11}+Y_3+Y_2 \end{bmatrix}$
$\lvert Y\rvert$	$(Y_{11}+Y_3)(Y_{22}+Y_2)-Y_{12}Y_{21}+$ $+Y_2(Y_3+Y_3+Y_2)$

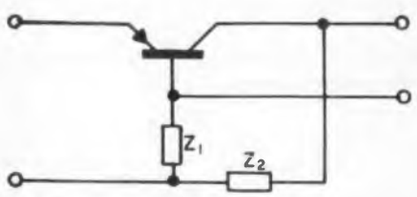


Fig. 1. Illustrative example derives the d-matrix for this circuit.

Matrices ↓	Circuit 9
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22} & -(Y_{12}+Y_{22}) \\ Y_{21}+Y_{22} & -Y_S \end{bmatrix}$
[y]	$\begin{bmatrix} Y_S & -(Y_{12}+Y_{22}) \\ Y_{21}+Y_{22} & -Y_{22} \end{bmatrix}$
[d]	$\frac{1}{Y_S}\begin{bmatrix} Y_{12}+Y_{22} & 1 \\ -\lvert Y\rvert & Y_{21}+Y_{22} \end{bmatrix}$
[f]	$\frac{1}{Y_{22}}\begin{bmatrix} Y_{21}+Y_{22} & -1 \\ \lvert Y\rvert & Y_{12}+Y_{22} \end{bmatrix}$
[a]	$\frac{1}{Y_{21}+Y_{22}}\begin{bmatrix} Y_{22} & 1 \\ \lvert Y\rvert & Y_S \end{bmatrix}$
$\lvert Y\rvert$	$Y_{11}Y_{22}-Y_{12}Y_{21}$

Matrices ↓	Circuit 10
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22} & -(Y_{12}+Y_{22}) \\ Y_{21}+Y_{22} & -(Y_S+Y) \end{bmatrix}$
[y]	$\begin{bmatrix} Y_S+Y & -(Y_{12}+Y_{22}) \\ Y_{21}+Y_{22} & -Y_{22} \end{bmatrix}$
[d]	$\frac{1}{Y_S+Y}\begin{bmatrix} Y_{12}+Y_{22} & 1 \\ -\lvert Y\rvert & Y_{21}+Y_{22} \end{bmatrix}$
[f]	$\frac{1}{Y_{22}}\begin{bmatrix} Y_{21}+Y_{22} & -1 \\ \lvert Y\rvert & Y_{12}+Y_{22} \end{bmatrix}$
[a]	$\frac{1}{Y_{21}+Y_{22}}\begin{bmatrix} Y_{22} & 1 \\ \lvert Y\rvert & Y_S+Y \end{bmatrix}$
$\lvert Y\rvert$	$(Y_{11}+Y)Y_{22}-Y_{12}Y_{21}$

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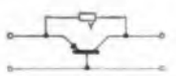
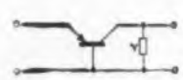
of this matrix, and bringing the denominator outside the matrix sign, we obtain:

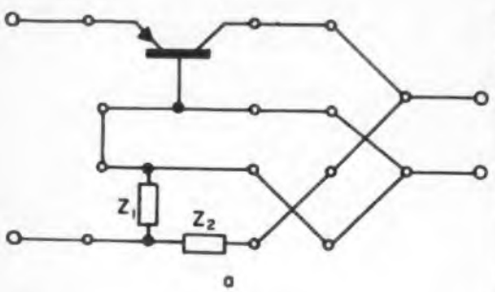
$$[Z] = \frac{1}{[Y]}\begin{bmatrix} Y_{22} & Y_{12} \\ -Y_{21} & -(Y_{11}+Y) \end{bmatrix} \qquad (5)$$

The z-matrix is given in the table in this form, with the determinant $|Y|$ also given for each circuit. To convert to the other matrices we use

(text continued on p 234)

Matrices ↓	Circuit 11 
$[z]$	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22}+Y & -(Y_{12}+Y_{22}+Y) \\ Y_{21}+Y_{22}+Y & -(Y_S+Y) \end{bmatrix}$
$[y]$	$\begin{bmatrix} Y_S+Y & -(Y_{12}+Y_{22}+Y) \\ Y_{21}+Y_{22}+Y & -(Y_{22}+Y) \end{bmatrix}$
$[d]$	$\frac{1}{Y_S+Y}\begin{bmatrix} Y_{12}+Y_{22}+Y & 1 \\ -\lvert Y\rvert & Y_{21}+Y_{22}+Y \end{bmatrix}$
$[f]$	$\frac{1}{Y_{22}+Y}\begin{bmatrix} Y_{21}+Y_{22}+Y & -1 \\ \lvert Y\rvert & Y_{12}+Y_{22}+Y \end{bmatrix}$
$[a]$	$\frac{1}{Y_{21}+Y_{22}+Y}\begin{bmatrix} Y_{22}+Y & 1 \\ \lvert Y\rvert & Y_S+Y \end{bmatrix}$
$\lvert Y\rvert$	$Y_{11}(Y_{22}+Y)-Y_{12}Y_{21}$

Matrices ↓	Circuit 12 
$[z]$	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22}+Y & -(Y_{12}+Y_{22}) \\ Y_{21}+Y_{22} & -Y_S \end{bmatrix}$
$[y]$	$\begin{bmatrix} Y_S & -(Y_{12}+Y_{22}) \\ Y_{21}+Y_{22} & -(Y_{22}+Y) \end{bmatrix}$
$[d]$	$\frac{1}{Y_S}\begin{bmatrix} Y_{12}+Y_{22} & 1 \\ -\lvert Y\rvert & Y_{21}+Y_{22} \end{bmatrix}$
$[f]$	$\frac{1}{Y_{22}+Y}\begin{bmatrix} Y_{21}+Y_{22} & -1 \\ \lvert Y\rvert & Y_{12}+Y_{22} \end{bmatrix}$
$[a]$	$\frac{1}{Y_{21}+Y_{22}}\begin{bmatrix} Y_{22}+Y & 1 \\ \lvert Y\rvert & Y_S \end{bmatrix}$
$\lvert Y\rvert$	$Y_{11}Y_{22}-Y_{12}Y_{21}+Y\,Y_S$



a

Fig. 2. (a) Circuit of Fig. 1 is broken down into simpler two-port networks.

Matrices ↓	Circuit 13
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22}+Y_3 & -(Y_{12}+Y_{22}+Y_3) \\ Y_{21}+Y_{22}+Y_3 & -(Y_3+Y_1+Y_2) \end{bmatrix}$
[y]	$\begin{bmatrix} Y_3+Y_1+Y_3 & -(Y_{12}+Y_{22}+Y_3) \\ Y_{21}+Y_{22}+Y_3 & -(Y_{22}+Y_3)) \end{bmatrix}$
[d]	$\frac{1}{Y_3+Y_1+Y_2}\begin{bmatrix} Y_{12}+Y_{22}+Y_3 & 1 \\ -\lvert Y\rvert & Y_{21}+Y_{22}+Y_3 \end{bmatrix}$
[f]	$\frac{1}{Y_{22}+Y_3}\begin{bmatrix} Y_{21}+Y_{22}+Y_3 & -1 \\ \lvert Y\rvert & Y_{12}+Y_{22}+Y_3 \end{bmatrix}$
[a]	$\frac{1}{Y_{21}+Y_{22}+Y_3}\begin{bmatrix} Y_{22}+Y_3 & 1 \\ \lvert Y\rvert & Y_3+Y_1+Y_3 \end{bmatrix}$
$\lvert Y\rvert$	$(Y_{11}+Y_1)(Y_{22}+Y_2)-Y_{12}Y_{21}$

Matrices ↓	Circuit 14
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22}+Y_1+Y_3 & -(Y_{12}+Y_{22}+Y_1) \\ Y_{21}+Y_{22}+Y_1 & -(Y_3+Y_1) \end{bmatrix}$
[y]	$\begin{bmatrix} Y_3+Y_1 & -(Y_{12}+Y_{22}+Y_1) \\ Y_{21}+Y_{22}+Y_1 & -(Y_{22}+Y_1+Y_3) \end{bmatrix}$
[d]	$\frac{1}{Y_3+Y_1}\begin{bmatrix} Y_{12}+Y_{22}+Y_1 & 1 \\ -\lvert Y\rvert & Y_{21}+Y_{22}+Y_1 \end{bmatrix}$
[f]	$\frac{1}{Y_{22}+Y_1+Y_2}\begin{bmatrix} Y_{21}+Y_{22}+Y_1 & -1 \\ \lvert Y\rvert & Y_{21}+Y_{22}+Y_1 \end{bmatrix}$
[a]	$\frac{1}{Y_{21}+Y_{22}+Y_1}\begin{bmatrix} Y_{22}+Y_1+Y_2 & 1 \\ \lvert Y\rvert & Y_3+Y_1 \end{bmatrix}$
$\lvert Y\rvert$	$Y_{11}(Y_{22}+Y_1)-Y_{12}Y_{21}+$ $+Y_1(Y_3+Y_1)$

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the following conversion equations.

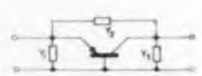
To convert from the z-matrix to the y-matrix:

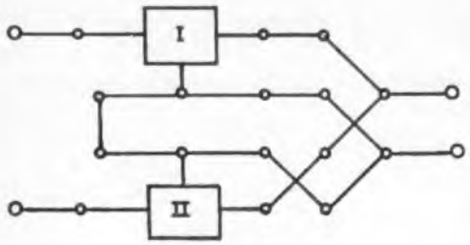
$$[y] = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} = \begin{bmatrix} \frac{z_{22}}{|z|} & -\frac{z_{12}}{|z|} \\ -\frac{z_{21}}{|z|} & \frac{z_{11}}{|z|} \end{bmatrix} \quad (6)$$

Substituting in Eq. 6 the corresponding ele-

(text continued on p 236)

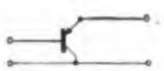
Matrices ↓	Circuit 15 
$[z]$	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22}+Y_2 & -(Y_{12}+Y_{22}) \\ Y_{21}+Y_{22} & -Y_S+Y_1) \end{bmatrix}$
$[y]$	$\begin{bmatrix} Y_S+Y_1 & -(Y_{12}+Y_{22}) \\ Y_{21}+Y_{22} & -(Y_{22}+Y_2) \end{bmatrix}$
$[d]$	$\frac{1}{Y_S+Y_1}\begin{bmatrix} Y_{12}+Y_{22} & 1 \\ -\lvert Y\rvert & Y_{21}+Y_{22} \end{bmatrix}$
$[f]$	$\frac{1}{Y_{22}+Y_2}\begin{bmatrix} Y_{21}+Y_{22} & -1 \\ \lvert Y\rvert & Y_{12}+Y_{22} \end{bmatrix}$
$[a]$	$\frac{1}{Y_{21}+Y_{22}}\begin{bmatrix} Y_{22}+Y_2 & 1 \\ \lvert Y\rvert & Y_S+Y_1 \end{bmatrix}$
$\lvert Y\rvert$	$(Y_{11}+Y_1)Y_{22} - Y_{12}Y_{21} + Y_2(Y_S+Y_1)$

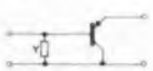
Matrices ↓	Circuit 16 
$[z]$	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_{22}+Y_2+Y_3 & -(Y_{12}+Y_{22}+Y_2) \\ Y_{21}+Y_{22}+Y_2 & -(Y_S+Y_1+Y_2) \end{bmatrix}$
$[y]$	$\begin{bmatrix} Y_S+Y_1+Y_2 & -(Y_{12}+Y_{22}+Y_2) \\ Y_{21}+Y_{22}+Y_2 & -(Y_{21}+Y_2+Y_3) \end{bmatrix}$
$[d]$	$\frac{1}{Y_S+Y_1+Y_2}\begin{bmatrix} Y_{12}+Y_{22}+Y_2 & 1 \\ -\lvert Y\rvert & Y_{21}+Y_{12}+Y_2 \end{bmatrix}$
$[f]$	$\frac{1}{Y_{22}+Y_2+Y_2}\begin{bmatrix} Y_{21}+Y_{22}+Y_2 & -1 \\ \lvert Y\rvert & Y_{12}+Y_{22}+Y_2 \end{bmatrix}$
$[a]$	$\frac{1}{Y_{21}+Y_{22}+Y_2}\begin{bmatrix} Y_{22}+Y_2+Y_3 & 1 \\ \lvert Y\rvert & Y_S+Y_1+Y_2 \end{bmatrix}$
$\lvert Y\rvert$	$(Y_{11}+Y_1)(Y_{22}+Y_2) - Y_{12}Y_{21} + + Y_2(Y_S+Y_1+Y_2)$



b

(b) General representation of the two port configuration.

Matrices ↓	Circuit 17 
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_S & -(Y_{11}+Y_{12}) \\ Y_{11}+Y_{21} & -Y_{11} \end{bmatrix}$
[y]	$\begin{bmatrix} Y_{11} & -(Y_{11}+Y_{12}) \\ Y_{11}+Y_{21} & -Y_S \end{bmatrix}$
[d]	$\frac{1}{Y_{11}}\begin{bmatrix} Y_{11}+Y_{12} & 1 \\ -\lvert Y\rvert & Y_{11}+Y_{21} \end{bmatrix}$
[f]	$\frac{1}{Y_S}\begin{bmatrix} Y_{11}+Y_{21} & -1 \\ \lvert Y\rvert & Y_{11}+Y_{12} \end{bmatrix}$
[a]	$\frac{1}{Y_{11}+Y_{21}}\begin{bmatrix} Y_S & 1 \\ \lvert Y\rvert & Y_{11} \end{bmatrix}$
$\lvert Y\rvert$	$Y_{11}Y_{22}-Y_{12}Y_{21}$

Matrices ↓	Circuit 18 
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_S & -(Y_{11}+Y_{12}) \\ Y_{11}+Y_{21} & -(Y_{11}+Y) \end{bmatrix}$
[y]	$\begin{bmatrix} Y_{11}+Y & -(Y_{11}+Y_{12}) \\ Y_{11}+Y_{21} & -Y_S \end{bmatrix}$
[d]	$\frac{1}{Y_{11}+Y}\begin{bmatrix} Y_{11}+Y_{12} & 1 \\ -\lvert Y\rvert & Y_{11}+Y_{21} \end{bmatrix}$
[f]	$\frac{1}{Y_S}\begin{bmatrix} Y_{11}+Y_{21} & -1 \\ \lvert Y\rvert & Y_{11}+Y_{12} \end{bmatrix}$
[a]	$\frac{1}{Y_{11}+Y_{21}}\begin{bmatrix} Y_S & 1 \\ \lvert Y\rvert & Y_{11}+Y \end{bmatrix}$
$\lvert Y\rvert$	$Y_{11}Y_{22}-Y_{12}Y_{21}+Y\,Y_S$

ments of the matrix 5, we obtain after transformation:

$$[y] = \begin{bmatrix} Y_{11} + Y & Y_{12} \\ -Y_{21} & -Y_{22} \end{bmatrix} \tag{7}$$

The d, f, and a matrices are:

$$[d] = \frac{1}{Y_{11} + Y} \begin{bmatrix} -Y_{21} & 1 \\ -|Y| & -Y_{21} \end{bmatrix} \tag{8}$$

Matrices ↓	Circuit 19
$[z]$	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_S+Y & -(Y_{11}+Y_{12}+Y) \\ Y_{11}+Y_{21}+Y & -(Y_{11}+Y) \end{bmatrix}$
$[y]$	$\begin{bmatrix} Y_{11}+Y & -(Y_{11}+Y_{12}+Y) \\ Y_{11}+Y_{21}+Y & -(Y_S+Y) \end{bmatrix}$
$[d]$	$\frac{1}{Y_{11}+Y}\begin{bmatrix} Y_{11}+Y_{12}+Y & 1 \\ -\lvert Y\rvert & Y_{11}+Y_{21}+Y \end{bmatrix}$
$[f]$	$\frac{1}{Y_S+Y}\begin{bmatrix} Y_{11}+Y_{21}+Y & -1 \\ \lvert Y\rvert & Y_{11}+Y_{12}+Y \end{bmatrix}$
$[a]$	$\frac{1}{Y_{11}+Y_{21}+Y}\begin{bmatrix} Y_S+Y & 1 \\ \lvert Y\rvert & Y_{11}+Y \end{bmatrix}$
$\lvert Y\rvert$	$(Y_{11}+Y)Y_{12}-Y_{12}Y_{21}$

Matrices ↓	Circuit 20
$[z]$	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_S+Y & -(Y_{11}+Y_{12}) \\ Y_{11}+Y_{21} & -Y_{11} \end{bmatrix}$
$[y]$	$\begin{bmatrix} Y_{11} & -(Y_{11}+Y_{12}) \\ Y_{11}+Y_{21} & -(Y_S+Y) \end{bmatrix}$
$[d]$	$\frac{1}{Y_{11}}\begin{bmatrix} Y_{11}+Y_{12} & 1 \\ -\lvert Y\rvert & Y_{11}+Y_{21} \end{bmatrix}$
$[f]$	$\frac{1}{Y_S+Y}\begin{bmatrix} Y_{11}+Y_{21} & -1 \\ \lvert Y\rvert & Y_{11}+Y_{12} \end{bmatrix}$
$[a]$	$\frac{1}{Y_{11}+Y_{21}}\begin{bmatrix} Y_S+Y & 1 \\ \lvert Y\rvert & Y_{11} \end{bmatrix}$
$\lvert Y\rvert$	$Y_{11}(Y_{22}+Y)-Y_{12}Y_{21}$

$$[f] = \frac{1}{Y_{22}}\begin{bmatrix} -Y_{21} & -1 \\ |Y| & -Y_{21} \end{bmatrix} \quad (9)$$

$$[a] = -\frac{1}{Y_{21}}\begin{bmatrix} Y_{22} & 1 \\ |Y| & Y_{11}+Y \end{bmatrix} \quad (10)$$

Each of these matrices is listed in the table.

(text continued on p 238)

Matrices ↓	Circuit 21
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_3+Y_2 & -(Y_{11}+Y_{12}+Y_2) \\ Y_{11}+Y_{21}+Y_2 & -(Y_{11}+Y_1+Y_2) \end{bmatrix}$
[y]	$\begin{bmatrix} Y_{11}+Y_1+Y_2 & -(Y_{11}+Y_{12}+Y_2) \\ Y_{11}+Y_{21}+Y_2 & -(Y_3+Y_2) \end{bmatrix}$
[d]	$\frac{1}{Y_{11}+Y_1+Y_2}\begin{bmatrix} Y_{11}+Y_{12}+Y_2 & 1 \\ -\lvert Y\rvert & Y_{11}+Y_{21}+Y_2 \end{bmatrix}$
[f]	$\frac{1}{Y_3+Y_2}\begin{bmatrix} Y_{11}+Y_{21}+Y_2 & -1 \\ \lvert Y\rvert & Y_{11}+Y_{12}+Y_2 \end{bmatrix}$
[a]	$\frac{1}{Y_{11}+Y_{21}+Y_2}\begin{bmatrix} Y_3+Y_2 & 1 \\ \lvert Y\rvert & Y_{11}+Y_1+Y_2 \end{bmatrix}$
|Y|	$(Y_{11}+Y_2)\,Y_{22}-Y_{12}Y_{21}+$ $+Y_1(Y_3+Y_2)$

Matrices ↓	Circuit 22
[z]	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_3+Y_1+Y_2 & -(Y_{11}+Y_{12}+Y_1) \\ Y_{11}+Y_{21}+Y_1 & -(Y_{11}+Y_1) \end{bmatrix}$
[y]	$\begin{bmatrix} Y_{11}+Y_1 & -(Y_{11}+Y_{12}+Y_1) \\ Y_{11}+Y_{21}+Y_1 & -(Y_3+Y_1+Y_2) \end{bmatrix}$
[d]	$\frac{1}{Y_{11}+Y_1}\begin{bmatrix} Y_{11}+Y_{12}+Y_1 & 1 \\ -\lvert Y\rvert & Y_{11}+Y_{21}+Y_1 \end{bmatrix}$
[f]	$\frac{1}{Y_2+Y_1+Y_2}\begin{bmatrix} Y_{11}+Y_{21}+Y_1 & -1 \\ \lvert Y\rvert & Y_{11}+Y_{12}+Y_1 \end{bmatrix}$
[a]	$\frac{1}{Y_{11}+Y_{21}+Y_1}\begin{bmatrix} Y_3+Y_1+Y_2 & 1 \\ \lvert Y\rvert & Y_{11}+Y_1 \end{bmatrix}$
|Y|	$(Y_{11}+Y_1)(Y_{22}+Y_2)\ -Y_{12}Y_{21}$

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(continued from p 236)

To simplify the notation, we use the symbol:

$$Y_s = Y_{11} + Y_{12} + Y_{21} + Y_{22} \qquad (11)$$

The determinants of these matrices are some-

Matrices ↓	Circuit 23
$[z]$	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_S+Y_2 & -(Y_{11}+Y_{12}) \\ Y_{11}+Y_{21} & -(Y_{11}+Y_1) \end{bmatrix}$
$[y]$	$\begin{bmatrix} Y_{11}+Y_1 & -(Y_{11}+Y_{12}) \\ Y_{11}+Y_{21} & -(Y_S+Y_2) \end{bmatrix}$
$[d]$	$\frac{1}{Y_{11}+Y_1}\begin{bmatrix} Y_{11}+Y_{12} & 1 \\ -\lvert Y\rvert & Y_{11}+Y_{21} \end{bmatrix}$
$[f]$	$\frac{1}{Y_S+Y_2}\begin{bmatrix} Y_{11}+Y_{21} & -1 \\ \lvert Y\rvert & Y_{11}+Y_{12} \end{bmatrix}$
$[a]$	$\frac{1}{Y_{11}+Y_{21}}\begin{bmatrix} Y_S+Y_2 & 1 \\ \lvert Y\rvert & Y_{11}+Y_1 \end{bmatrix}$
$\lvert Y\rvert$	$Y_{11}(Y_{22}+Y_2) - Y_{12}Y_{21} + + Y_1(Y_S+Y_2)$

Matrices ↓	Circuit 24
$[z]$	$\frac{1}{\lvert Y\rvert}\begin{bmatrix} Y_S+Y_2+Y_3 & -(Y_{11}+Y_{12}+Y_2) \\ Y_{11}+Y_{21}+Y_2 & -(Y_{11}+Y_1+Y_3) \end{bmatrix}$
$[y]$	$\begin{bmatrix} Y_{11}+Y_1+Y_3 & -(Y_{11}+Y_{12}+Y_2) \\ Y_{11}+Y_{21}+Y_2 & -(Y_S+Y_2+Y_3) \end{bmatrix}$
$[d]$	$\frac{1}{Y_{11}+Y_1+Y_2}\begin{bmatrix} Y_{11}+Y_{12}+Y_2 & 1 \\ -\lvert Y\rvert & Y_{11}+Y_{21}+Y_2 \end{bmatrix}$
$[f]$	$\frac{1}{Y_S+Y_2+Y_3}\begin{bmatrix} Y_{11}+Y_{21}+Y_2 & -1 \\ \lvert Y\rvert & Y_{11}+Y_{12}+Y_2 \end{bmatrix}$
$[a]$	$\frac{1}{Y_{11}+Y_{21}+Y_2}\begin{bmatrix} Y_S+Y_2+Y_3 & 1 \\ \lvert Y\rvert & Y_{11}+Y_1+Y_3 \end{bmatrix}$
$\lvert Y\rvert$	$(Y_{11}+Y_3)(Y_{22}+Y_3) - Y_{12}Y_{21} + + Y_3(Y_S+Y_2+Y_3)$

times used in design. These are:

$$|y| = -|Y|;\ |z| = -1/|Y|; \qquad \left.\begin{matrix}|d| = -z_{11}/z_{22}\\ |a| = -z_{12}/z_{21}\end{matrix}\right\},$$
$$|f| = -z_{22}/z_{11}; \tag{12}$$

We see from 12 that the determinants of all matrices can be expressed in terms of quantities listed in the matrix table.

Illustrative Example Derives d-Matrix For Circuit of Fig. 1

Let us derive the d-matrix for the circuit of Fig. 1. Fig. 2a shows the same circuit, broken up into simpler two-port networks (series-parallel connection). The matrix of the resultant two-port network is equal to the sum of the d-matrices of the simpler networks. Fig. 2b is the general representation of such a connection.

From the table (circuit 10) we determine the d-matrix of the upper network, that is, the d-matrix of the grounded-base transistor:

$$[d] = \frac{1}{Y_e}\begin{bmatrix} Y_{12}+Y_{22} & 1 \\ -|Y| & Y_{21}+Y_{22} \end{bmatrix} \tag{13}$$

The d-matrix of the lower L-network is:

$$[d] = \frac{Z_1}{Z_1+Z_2}\begin{bmatrix} -1 & Z_1 \\ -Y_1 & -1 \end{bmatrix}. \tag{14}$$

The sum of the two matrices can be readily shown to be:

$$[d] = \begin{bmatrix} \dfrac{Y_{12}+Y_{22}}{Y_e} - \dfrac{Z_1}{Z_1+Z_2} & \dfrac{1}{Y_e} + \dfrac{Z_1 Z_2}{Z_1+Z_2} \\ -\dfrac{|Y|}{Y_e} - \dfrac{1}{Z_1+Z_2} & \dfrac{Y_{21}+Y_{22}}{Y_e} - \dfrac{Z_1}{Z_1+Z_2} \end{bmatrix} \tag{15}$$

Thus, the general formulas of two-port theory yield all the design relations for the circuit of Fig. 1. This example is illustrative of the simplicity of the method.

Translated from "Matrix Tables For Transistor Two-Port Networks," E. N. Garmash, Radiotekhnika, *No. 12, December, 1960, pp. 43-50.*

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E. Brenner

Incremental Network Properties— A Generalized Compensation Theorem

OCCASIONALLY it is of interest to consider how the performance of a network changes if the elements in the network change characteristics incrementally. In the case of linear networks one deals with small changes in element values, while in the case of nonlinear networks one may be concerned with a small change in the characteristic curves that describe the elements.

Nonlinear Networks Analyzed by Superimposing Increments

Consider a stable nonlinear resistance network with constant voltage sources (or an analogous system such as a magnetic circuit) consisting of B branches and J junctions. In general, each branch consists of a voltage source E_n and a series element with voltage-current characteristics $v_n(i_n)$ where i_n is the branch current. Reference polarities are as in Fig. 1a. If a small change occurs in the voltage-current characteristic from $v_n(i_n)$ to $v_n^*(i_n)$, as indicated in Fig. 2, the new typical branch is as shown in Fig. 1b. The direct application of Kirchoff's laws to both the original and the modified network, together with the assumption of small change, yields:

$$v^*(i_n + \Delta i_n) \approx v_n^*(i_n) + \left[\frac{dv_n^*}{di}\right]_{i=i_n} \Delta i_n \qquad (1)$$

This shows that the increment Δi_n can be calculated if each branch is replaced by the branch of Fig. 1c. Each branch carries the increment of current Δi_n, has an incremental source Δe_n and incremental resistance r_n, where:

$$\Delta e_n = v_n^*(i_n) - v_n(i_n) \qquad (2)$$

$$r_n = \left[\frac{dv_n^*}{di}\right]_{i=i_n} \qquad (3)$$

Note that the elements of the "incremental" network depend only on the currents in the original network and on the incremental characteristics. Thus the increments can be calculated by superimposing the increments caused by one element change at any one time. (The stability of the network is assumed in the entire discussion.)

Linear Networks Yield Compensation Theorem

Application of the above ideas to linear networks results in the familiar compensation theorem: An incremental resistance change in a branch of a linear network can be accounted for by an incremental source $i_n \Delta R_n$, Fig. 3. The same procedure applies for linear networks with ac sources if phasors and complex impedances are used.

A further result is the generalization of Vratsanos' theorem (see *ED* "A Network

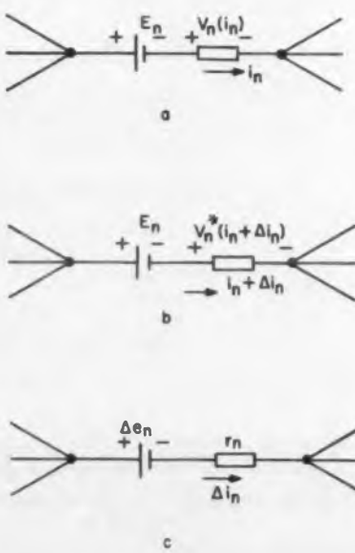

Fig. 1. (a) A typical branch; (b) Changes in branch caused by incremental characteristics; (c) "Incremental" branch; Δe_n and r_n are defined in Eqs. (2) and (3) respectively.

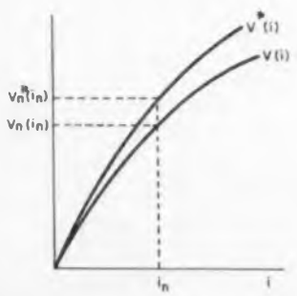

Fig. 2. Voltage current characteristic changes from $v(i)$ to $v^*(i)$.

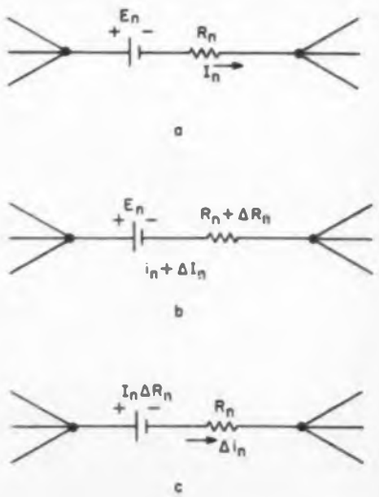

Fig. 3. Application of Fig. 1 to linear network results in compensation theorem.

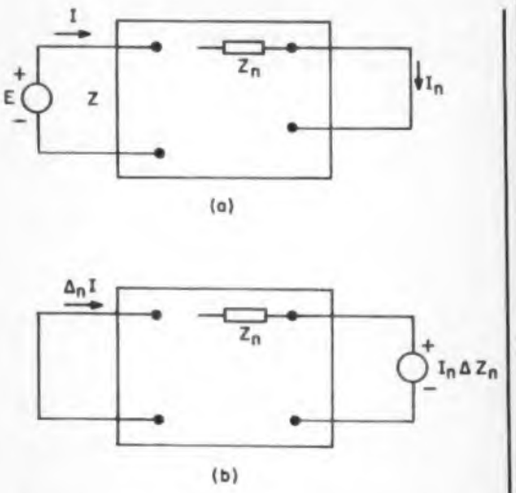

Fig. 4. Increment in Z_n can be represented by a compensating source.

Theorem," Sept. 15, 1957, p 174). To calculate the change in driving point impedance Z due to a small change in a branch impedance $\Delta Z_n \ll Z_n$ one relates the change in input current caused by the change in Z_n to the change in driving point impedance:

$$Z + \Delta_n Z = \frac{E}{I + \Delta_n I} \approx Z\left(1 - \frac{\Delta_n I}{I}\right) \qquad (4)$$

$$\text{or} \quad \frac{\Delta_n Z}{Z} = -\frac{\Delta_n I}{I} \qquad (5)$$

and, representing the increment in Z_n by a compensating source, Fig. 4, one obtains, from the reciprocity theorem:

$$\frac{E}{I_n} = \frac{-I_n \Delta Z_n}{\Delta_n I} \qquad (6)$$

$$\text{or} \quad \Delta_n I = -\frac{I_n^2 \Delta Z_n}{E} \qquad (7)$$

If N impedances experience small fractional changes, then the total change in input current is

$$\Delta I = -\frac{1}{E} \sum_{n=1}^{N} I_n^2 \Delta Z_n$$

and the change in input impedance is

$$Z = \sum_{1}^{N} \left[\frac{I_n}{I}\right]^2 \Delta Z_n$$

From a dual proof, the input admittance increment Y is related to changes in branch admittance by

$$\Delta Y = \sum_{1}^{N} \left[\frac{V_n}{E}\right]^2 \Delta Y_n$$

Abstracted from an article by E. Schwartz, Archiv der Elektrischen Uebertragung, *Vol. 14, No. 9, September 1960, pp 405-410.*

Development Trends in Telephone Systems

TECHNICAL advances in telephony during the next ten years will revolve around the progressive introduction of new devices such as semiconductors and new techniques such as digital transmission schemes.

The advent of transistors has made it possible to introduce amplification into the telephone sets with the power coming from the exchanges. This would permit a better quality transmitter than the present carbon granule types. The attenuation in the local networks would be increased still further, though this would lower the cost of the line plant only slightly.

Although the familiar bell signal is adequate, there is the alternate possibility of using a transistor conversion of the ringing current to a voice-frequency current which operated a signal generator, possibly in the receiver itself. The sound would be much pleasanter but the price might be prohibitive and price rules at this level.

Keysets will definitely replace dials. The Bell Laboratory concept is a voice-frequency system, each digit consists of two frequencies, each from two groups of four frequencies. This appears to be the best system devised so far. It is insusceptible to speech interference and does not require polarity reversal in keying position.

These new features, speech amplification, call-signalling devices and keyset impulsing, are characteristic of the telephone sets for electronic systems which are now at advanced stages of study. Amplifying and active units must be provided for calling and impulsing, the former because an electronic exchange cannot send ordinary current, only voice frequency. It was there-

fore a natural step to introduce transmitter amplification as well.

Automatic Switching—Humble Crossbar Has Its Day

The past decade has been characterized by the breakthrough of the crossbar systems on a broad front. The crossbar switch has remained essentially unchanged for more than 40 years, the only modification being its adaption to other manufacturing methods. The crossbar systems have achieved a high degree of perfection. Their build-up has been governed by system engineering philosophy with a sound economic compromise between functions and components. It may appear strange that nowhere in the world has a cheaper switch been developed with equal performance. The reason, of course, is that the whole direction of developmental work has been towards electronic systems.

The developmental work on electronic exchanges has now reached the point at which the first field trial at Morris, Ill., is under way. But it is already clear that, apart from military applications, the future of electronics in telephone exchanges is more a question of price than of new and improved functional facilities. Part of the economic problem is that entirely new telephone sets would be required with electronic systems.

The Ferreed, Interim Electromechanical Device

The very fact that new telephones will be required, and that no suitable semiconductor has been found for the switching networks, is the reason for Bell's production of the ferreed. This is a relay with a magnetic lock built around a square-loop ferrite core. The relay has two "make" contacts in two separate glass tubes. They are used in hybrid systems in which they perform the switching functions while electronic devices perform the memory and logic functions. The ferreed relay is extremely rapid for an electromechanical device, requiring only one 60-usec pulse to operate. (The speed of an electronic marker can be used.) However more relays must be introduced for transmitter feed, ringing, ring-trip and clearing. Therefore, though the ferreed is compatible with electronic devices, the resulting hybrid system is far removed from an all-electronic system.

Integrated Systems Are Another Possibility

Which way telephone systems will go—towards conventional systems with limited interspersion of electronic elements, or all-electronic systems—is not easy to say. There is still another possibility, an integrated switching and transmission system. The Bell Laboratories ESSEX sys-

tem is an example of this. It has time division multiplex throughout with line concentrators based on pulse amplitude modulation (PAM). In the line concentrator, a change is made to pulse-code modulation (PCM) and all other communication in the system is on PCM basis.

First "Full-Integrated" System Proposed In Sweden

A more radical system has been proposed in Sweden. This system also employs time division multiplex with PCM transmission between exchanges. In principle, the subscriber's line network also works on a four-wire basis. On the grounds of cost, however, four wires cannot be used physically. Instead, ordinary analog transmission is used in one direction and delta modulation in the other. The delta modulation takes place in a central data processor which stores the last amplitude value for each conversation. The difference between the present and stored amplitudes constitutes the value in the delta-modulation sequence which is forwarded to line concentrator and telephone set. The telephone set demodulates the signal for the receiver. The system may embody the TASI (Time Assignment Speech Interpolation) method entirely and achieve a radical savings in circuits.

The advantages of integrated systems unfortunately only become noticeable if fairly large portions of a telephone are converted. The advantages come from the same information carriers throughout the system.

Transistor Systems Cheaper For Transmission

For carrier systems, the trend has been towards larger bandwidths in coaxial cables. Systems up to 12 mc exist. In a few years, 36-mc systems should be both technically feasible and economically desirable.

Carrier systems are being progressively transistorized. Transistor amplifiers for 12-mc coaxial systems are within reach. The only doubt concerns the shock resistance of high-frequency transistors. Otherwise transistor systems are proving cheaper than tube systems.

Even if bandwidth on the whole has become cheaper, there is a tendency to cut the bandwidth on expensive circuits. On the Atlantic cables, the compromise of 3 kc instead of 4 kc spacing on the telephone channels is logical. In the TASI system, which is on the verge of a switching technique, the number of channels has been doubled. In the TASI sytem, a channel is seized only if there is speech on the line. Vocoder systems that would permit large reductions in

bandwidth are under development but it appears doubtful if they will be low enough in cost for commercial telephony.

Short Haul Systems Have Been Disappointing

There has been much talk during the fifties of short-haul carrier systems. The results have been disappointing. It seems impossible to cut the costs below a certain level, and there would be no economic gain at distances below about 40 kilometers. Among the cost items must be counted the line signal receiving equipment. The line signals must be sent at levels which can be transmitted over the system. These levels are an order of magnitude too low for operating the relays and other equipment in the exchanges. A radically new idea is needed.

Two other "short-haul" systems have been discussed: the TJ and the PCM systems.

The TJ system is a radio link system for the frequency range 10,700-11,700 mc. It can handle 240 telephone channels or one TV channel. It has a base band of 5 mc, fm modulation, and a 400-mw output direct from a klystron. The maximum length of the entire link is 500 kilometers. Line of sight transmission is used between the relay stations which are 40-60 kilometers apart. Otherwise the TJ system is based on the same principles as the TH system and may be said to be an intermediate step between the TD and TH systems.

Digital Systems A Possibility

The PCM system, T-1, is a 24-channel, time-division multiplex system with a 1,536-mc bit frequency. Total length for one system planned is 200 km. Transmission is in existing four-wire cables. Repeater spacing is about 2 km. As in all digital systems the terminal equipment is fairly complicated while the relay stations are very simple.

It is doubtful when a PCM system will become profitable. The present prices of semiconductors are much too high.

Cost Is Factor In Waveguide Systems

In the fields of radio link and waveguide systems, the AT&T group in the USA has been the leader. The critical question is whether the millimeter wave generators (klystrons or backward-wave oscillators) can be built cheaply enough. It is possible that tunnel diodes may be used instead of traveling-wave tubes for the regenerative amplifiers.

Abstracted from: Trends of Development in Telephony. C. Jacobaeus, Ericsson Review, *Vol. XXXVII, No. 4, 1960, Stockholm, Sweden.*

LETTERS

Designers to Blame? Objections!

Sir:

Your editorial in the Jan. 18 edition of ELECTRONIC DESIGN stating "that the design engineer did not know what he was doing," is—to quote a well-worn but applicable phrase—"putting the shoe on the wrong foot."

Let's review the arguments from the design engineer's point of view. I contend that the main reason that equipment arrives at a site with system discrepancies is that the systems engineer did not do *his* job in the first place.

I'll be gracious enough to overlook the fact that the systems engineer was inadequately trained and far inexperienced and assume that the error was not premeditated. But unintentional or not, the fact remains: the design engineer is forced to make assumptions when the detailed information is not or cannot be had from a systems group used to dealing in generalities. When the assumptions later cause a discrepancy, the blame is laid on the design engineer, when, in reality, the original cause lies with insufficient information from a systems group.

And don't say it's the design engineer's fault if he did not get the information. Sincere efforts cannot avail against the paper-work ramparts of a solidly built systems group—especially one oriented on military paper work "procedures" and classified information "channels." Only head-knocking, from the top down, can clear congested "channels," and the design engineer is in a poor position to slice through the red tape from the bottom up and procure the information.

In addition so many systems men consider themselves such hardware geniuses (some are, some are not) that they spend most of their time telling the design group *how* to build a piece of gear and not *what* to build in terms of functional requirements.

Your choice of examples to illustrate the ineptitude of the design group was ill-chosen. For example:

". . . the impedance match between units was way off."

You politely ignore the problem of whether the output or input impedances of a unit were within the specified tolerances. This is the logical checkout procedure—not the measurement of "impedance match."

Specifically impedances may be purposely mismatched. Maximum power gain is not always the prime consideration in some circuits. Very often maximum voltage transfer to a fixed load or opti-

mum noise or distortion conditions will dictate a mismatch.

So I say stick to measuring the output and input impedances to see if they meet specs, and do systems engineering on matching source and load at the site. . . .

Therefore I say to the systems engineer, if you had not waited until you got to the site to start engineering, you would not have had the problems in the first place. Correct information on *what* is required in early phases of the project will reduce these headaches much more than recriminations from the launching pad.

Arnold E. Larson
Project Engineer
Philco Corp.
Los Gatos, California

Sir:

Your editorial "Don't Trust the Design Engineer" misrepresents a grievous problem. The systems engineer is in a hot seat, and only the most competent people should ever reach this position. However, using the design engineer as a scapegoat is like the captain of a ship blaming a lowly seaman for difficulties or shipwreck.

It has been a scandal in this industry that systems engineers often do not even attempt to specify the performance, inputs or outputs or other characteristics of the building blocks from which their systems are assembled. A typical specification is 99 per cent "boiler plate": legal forms, Buy American, wage-hour laws and trivia.

The only way to return engineering to the lab is to start at the source, at the captain of the ship. Components, subassemblies, pieces of equipment are not created in a vacuum. If the systems engineer does not or cannot define the functions to be performed, that systems engineer and that project will always be in trouble.

Noel B. Braymer
Project Engineer
Electro Instruments Inc.
San Diego, Calif.

Sir:

I am writing in reference to your editorial in the Jan. 18 issue. As a wave-filter engineer, I don't like the assumption that "the design engineer must be assumed to be wrong."

I am not familiar with the number of rejects received at Canaveral, but I do know that all fields of engineering are specialized, and I believe that changes made by people at the working end only prove that the requirements set forth to the design engineer were not correct in the beginning.

As an example, you stated that impedance measurements were made and presumed errors

LETTERS

were corrected. In the wave-filter field, it is sometimes desirable to purposely mismatch for better results. People changing termination can affect the original design performance that the design engineer desired. Instead of outward blaming of the design engineer, I think that the whole system should be reviewed from start to delivery.

Ed Dombrosky, Wave Filter Engineer
Interference Control Field Service Laboratory
Sprague Electric Co.
Dayton, Ohio

• • •

'World's Fastest' Disputed

On p. 45, bottom col. 1, of your Nov. 23 issue, you mention exhibition of the Creed punch, which "it claims is the world's fastest." Since our 3,000-word-per minute Model GP-2 was released more than two years ago, it is a relief to see others beginning to enter the field of high-speed, punch-tape recording. . . .

Charles F. West, President
Soroban Engineering, Inc.
Melbourne, Fla.

▸ *See p 150, ED, September 16, 1959, for a description of the GP-2.*

Electronic Chewing Gum Editorial Draws Big Response

The closest thing—silver wax . . .

In regard to your editorial in the Feb. 1, 1961 issue of ELECTRONIC DESIGN, about an electronic chewing gum, I would like to call your attention to a product which meets or could meet your requirements. Several years ago we developed a conductive wax for making internal connections in our wafer cell batteries such as the 2U6 and the P6M. "Silver Wax" is a suspension of silver plated copper powder in a suitable binder. It is very conductive.

The "silver wax" is usually applied with a small amount of heat, less than 100 C in temperature, to one or both parts to be joined. The joint is later made by pressing the parts together. Temporary connections could be made without heat by simply pressing the leads and a wad of silver wax together. The leads will not be damaged so they can be soldered at a later time if desired. The silver wax can also be re-used.

The melting point, strength of the joint, and other physical properties of the silver wax can be altered by changing the binder. A gum, adhesive, epoxy, lacquer, or almost any other vehicle could be used to obtain the special properties to meet various requirements.

Silver wax is presently sold in bulk form to

other manufacturers at about $4.50 per pound. We welcome further inquiries.

C. J. Vander Yacht
Burgess Battery Co.
Freeport, Ill.

▶ *The sample tested by this editor did not test well in shear or tension. Other vehicles mentioned may be better.*

Room curing epoxy silver solders . . .

After reading your editorial on electronic chewing gum in the Feb. 1 issue of ELECTRONIC DESIGN, we thought you might be interested in hearing a little bit about our epoxy silver solder. We think it's the closest thing you'll find to electronic chewing gum on the market.

Epoxy silver solder has extremely low resistance—0.0001 ohm-cm (approximately the resistance of mercury). It can be applied at room temperature and therefore can be conveniently carried for use any place it's needed. Unlike soldering, it doesn't require an electrical outlet. We think it's ideal for heat-sensitive components such as transistors and diodes, since even when a rapid cure is desired, heat curing temperature can be as low as 85 C.

Like all epoxy materials, it has excellent bonding characteristics and outstanding shear strength. The shear strength of a steel-to-steel bond is 320 psi. Since it will bond dissimilar materials, it finds useful applications in the cap on vacuum tubes and grounding aluminum components to steel chassis.

Actually, the electronics industry is just beginning to scrape the surface of potential uses for this product. We think the future will see its uses increase until it literally becomes an electronic chewing gum.

Samuel Ringel
Epoxy Products, Inc.
Irvington, N.J.

▶ *The only drawback is that curing is in terms of hours and not seconds.*

Encapsulate joint in acrylic resin . . .

Your editorial in the current issue of ELECTRONIC DESIGN prompts us to advise you—and your readers—of a new acrylic resin, Quickmount, which may have specific application in the electronic field.

While it may never replace Wrigley's, it has its own compensating advantages such as solubility, self-curing, moldability and time saving factors perhaps even more beneficial—no sticky fingers!

Quickmount is a powder and liquid combination which mixed in a few minutes time, pours into a mold or mounting ring and solidifies into a relatively clear, hard substance in a short while. Its primary use, since its introduction a few

LETTERS

months ago, has been rapid, multiple preparation of metallurgical specimen mounts without the application of heat or pressure.

Our literature has been directed to metallurgists, mostly to those connected with steel, where such tests are commonplace. However, inquiries indicate that the missile, aircraft, and electronic fields may also have use for such a product. It can be poured in a thin film over a circuit board for instance and bind all wires, components, etc. together quickly, efficiently and in no time at all. The wires would still have to be twisted together, however!

An important manufacturer of power tubes is buying a lot of the product, and we suspect its use is other than metallurgical.

We enclose for your information a little folder on the product and if you feel it would have application anywhere in your field, we would be delighted to send data along to any who request.

Edward M. Power III
Fulton Metallurgical Products Corp.
Pittsburgh, Pa.

Do away with connections . . .

I would like to comment on your recent editorial in ELECTRONIC DESIGN discussing "electronic chewing-gum." Although the chewing-gum idea is attractive at first glance, a little reflection will show some of its inherent disadvantages. My conclusions are based on several years experience with various quick-assembly systems.

The need for chewing-gum assembly methods arises from the "seat of the pants" method of circuit development. In these days when short lead time from block diagram to finished hardware is the rule, there is seldom sufficient time available to develop a circuit by starting with an approximate design and then "tweaking" the circuit parameters until proper output operation is obtained.

A more efficient way to develop circuits uses a *directed* testing approach which follows a thorough analytical design of the circuit. If layout is not a factor in the circuit performance a quick assembly using essentially self-supported components soldered with a blob technique is sufficient to check the design. This method of design-testing is especially useful for lumped circuits, particularly digital circuits, where worst case design tolerancing is being checked in the quick assembly.

With other classes of circuit, particularly low-level analog types, the assembly includes distributed parameters which cannot generally be predicted, nor reproduced by any "chewing-gum" assembly. In these cases it is necessary to start

with a design which is as complete as a practical mathematical solution allows and then test the design in the final layout. In these cases a chewing-gum breadboard may confuse results by introducing parameters which are not adaptable to final layouts.

In summary, I am suggesting that variations in circuits be handled mathematically rather than experimentally, and that the design be based on extreme value parameters so that a large number of intermediate-value cases do not need to be physically assembled and tested. If most of the development time is spent in analysis, the need for quick assembly methods is not apparent.

Howard J. Carter
EPSCO-West
Anaheim, Calif.

▶ *Do you "tweakers" have anything to say for yourselves?*

Suggests RF shielding knitted wire . . .

Your Electronic Chewing Gum editorial may have been tongue in cheek. However, on p 85 of the same issue is an advertisement of a metallic mesh, called knitted wire, that is designed for use as contacts. RF shielding such as metallic mesh "weatherstripping," or the type used by Robinson for bonding of their shock mounts, is a similar material, as is plain steel wool.

The material could be formed in a small cube, or it could be mounted on an insulated mounting base.

The application would, of course, be limited, however, you did say "electronic chewing gum."

Marvin Tepper
Raytheon Co.
Burlington, Mass.

Nomograph in Error

Dear Sir:

Your March 15 issue contains a "Nomograph for Determining Surface Areas of Paraboloidal Devices."

This nomograph purports to solve the area as a function of the parameters a, the focal length, and L, the depth of the dish.

In terms of a and L it can be shown that the area of a paraboloid is

$$A = \frac{8\pi}{3a}[(a^2 + aL)^{3/2} - a^3].$$

The nomograph in your magazine is a solution only for $a = 1$ and $L = 1$. For other values of the arguments it is in error by a large (but no constant) factor.

Fred W. Wills
Bell Telephone Labs
Whippany, N.J.

▶ *The proper nomogram for the formula above will be published in a future issue.*

YOUR CAREER

NEWS AND NOTES

Turnover among engineering and scientific staffs costs U.S. industry more than $300 million annually, says Dr. Frederick J. Gaudet, Stevens Institute of Technology, Hoboken, N.J.

A National Society of Professional Engineers newsletter quotes the director of Stevens' Laboratory for Psychological Studies as saying this figure includes recruiting and training but not the more elusive costs in project slowdowns and loss of contracts.

• • •

Three Recent Discoveries That Can Make You More Efficient

Want to get things done faster? Research has discovered easily used ways and means:

- **Experiments at the Max Planck Institute indicate that in an eight-hour day three spaced five-minute coffee breaks are more beneficial than one 15-minute break. Reason: the first five minutes of a rest period give the most relaxation.**
- **Long Island University researchers have found that most people are more alert on their feet than when sitting down. Pacing back and forth can help you think better (though it may not help your fellow engineers).**
- **Carefully controlled experiments show that in the execution of physical labor, grunting and groaning on the job can actually increase your strength by as much as 5 per cent!**

• • •

Four Radio Corp. of America engineers are seeking advanced degrees under RCA's David Sarnoff Scholarship Awards. The grants, which range as high as $6,000, include full tuition costs, allowances for books, and a stipend of $2,500 to $4,000, depending on marital status. The men are in the following RCA divisions:

Surface Comm. Div., Defense Electronics Prods., Camden, N.J.—Jack Y. Robertson, 20, University of Calif.

RCA Laboratories, Princeton, N.J.—Karl H. Zaininger, 31, Princeton University, and Steven R. Hofstein, 22, Princeton University.

RCA Victor Co., Ltd., Montreal—William R. Atkins, 26, University of London.

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Direct Energy-Conversion Systems
University of Wisconsin, May 23-24

One of the University of Wisconsin's Engineering Institute courses. These courses are usually 2-5 days duration and are designed to keep engineers up on recent developments. For this and other courses throughout the year, write: Engineering Institutes, University Extension Div., 3030 Stadium, University of Wisconsin, Madison 6, Wisc.

Four Courses Subject of Summer Sessions at University of Philadelphia

A coordinated presentation of engineering developments of the past five years in each of the following four fields will be the subject of University of Pennsylvania summer sessions from June 4 to July 15: Modern Radar Techniques, New Devices for Amplification and Switching, Communication Theory and Information Handling, Logic, Switching Systems, and Automata, Four Summer Sessions at University of Pennsylvania. Participants will attend class six hours a day, five days a week, 60 hours in all. Teaching staff is being assembled "from the forward ranks of industry." Enrollment fee is $250 per program. For further details, write to: Professor Morris Rubinoff, coordinator, 1961 special summer session, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia 4, Pa.

Math for Operations Research at Purdue, June 5-15

Ten-day course at Purdue University will cover construction of mathematical models representing the operation of industrial management or a military organization, inventory control models, waiting line models, linear programing, simplex method, transportation methods, production scheduling models, search theory, cost-effectiveness studies, and system analysis. Write: Division of Adult Education, Purdue University, Lafayette, Ind.

Engineering Writing Courses
MIT, June 19-23

The fifth special summer program in Scientific and Engineering Reports is designed to help technical persons who are involved in writing and editing scientific and engineering reports to improve their writing skills. Contact Robert R. Rathbone, director, Summer Sessions, Massachusetts Institute of Technology, Cambridge 39, Mass.

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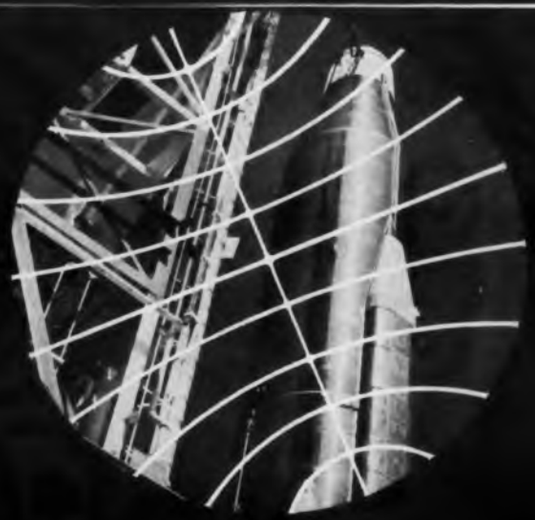

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CAREER COURSES

Design of Experiments at Purdue, June 7-17

A course for those concerned with planning and interpreting industrial experiments will be given at Purdue University, June 7-17. It will be an advanced course intended for persons whose previous statistical training includes tests on hypotheses, linear correlations, and at least an introduction to the analysis of variance. Topics will include: a review of analysis of variance, principles of experimental design, variance component analysis, radomized blocks and latin squares, factorial experiments, split plot designs, confounding in factorial experiments, incomplete block designs, fractional replications, and introduction to evolutionary operations. Write: Division of Adult Education, Purdue University, Lafayette, Ind.

Two-Week Summer Courses at MIT, Cambridge, Mass.

Beginning Tuesday, June 13: experimental techniques, materials science, and industrial dynamics.

Beginning Monday, June 19: industrial photoelasticity (one week only), engineering magnetohydrodynamics, elements of textile structural mechanics (one week), probabilistic methods in the control of operations, planning marketing strategy and tactics, technology of reinforced plastics (one week), and scientific and engineering reports (one week).

Beginning Monday, June 26: nondestructive testing (one week), advanced mechanics of textile structures (one week), dynamics and control of chemical engineering processes, fundamentals and applications of selected surface phenomena, and science of adhesion (one week).

Beginning Monday, July 10: Fundamentals of strain gage techniques (one week).

Beginning Monday, July 17: applications of strain gage techniques (one week), the continuous glass making process, city and regional planning, and infrared spectroscopy-technique (one week).

Beginning Monday, July 24: infrared spectroscopy-applications.

Beginning Monday, July 31: techniques of high-speed photography (one week), and problems of high-powered radar system design.

Beginning Monday, August 14: Advanced highway engineering (one week), and radar astronomy (one week).

Beginning Monday, August 28: shear strength behavior of cohesive soils.

For details on course subject matter and tuition fees, write: Special Summer Programs, Massachusetts Institute of Technology, Cambridge 39, Mass.

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PROJECT ENGINEER—AIRBORNE EQUIPMENT DESIGN: MSEE and 5-7 years' experience in design of airborne military equipment of comm. and digital type crystal oscillator and crystal filter experience desired.

PROJECT ENGINEER—RELIABILITY: BSEE and 5-7 years' experience with reliability techniques applied to military electronic equipment.

SENIOR ENGINEER—SUBCONTRACT LIAISON: BSEE and 3-5 years' experience procurement of electronic equipment, contracts, and specifications.

LOGIC ENGINEER: BSEE and 3-5 years' experience in design of logic systems in digital data processing equipment.

COMMUNICATIONS ENGINEER: BSEE with 3-5 years' communications experience specializing in long distance propagation techniques with particular emphasis on solutions to multipath effects in the high frequency range.

CIRCUIT DESIGN ENGINEER: BSEE and 3-5 years' experience in design and development of solid state digital circuitry. Must have experience in circuit design for reliable operation under worst case conditions. Background in airborne and ground support test equipment desired.

TEST ENGINEER—ENVIRONMENTAL: BSEE 2-3 years' experience planning and performing environmental tests on military electronic equipment.

ENGINEERING SPECIALIST: BS and 3-5 years' experience in preparation of technical reports and documents. Must have good working knowledge of electronic equipment.

FILTER DESIGN ENGINEER: BSEE and 3-5 years' experience in design and development of bandpass filter networks.

COMPONENT ENGINEERS: BSEE and 3-5 years' experience in specifications and testing components for reliability determination in military environments.

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CAREER COURSES

Two-Week Analog Computer Course in Los Angeles, June 5-16

A two-week course designed to give the student a working knowledge of the analog computer, its programing, scaling, and application to problems in such fields as mechanical and electrical engineering, chemical and process industries, and aircraft and missile systems. Sponsored by Electronic Associates, Inc., Long Branch, N.J. For further information on this and other West Coast EIA courses during the year, contact, Director, Los Angeles Computation Center, 1500 East Imperial Highway, El Segundo, Calif.

Colorado State University, July 10-14

A one-week course and workshop for writers, engineers and administrators. The course will cover technical communication from basic report writing to public relations writing. Designated "Workshop JT-161," it carries two quarter credits. Tuition is $50.00. Contact Director, Institute in Technical and Industrial Communications, Colorado State University, Fort Collins, Colo.

Radio Propagation Course Boulder, Colo., July 31-Aug. 18

National Bureau of Standards' central radio propagation laboratory, Boulder, Colo., will conduct a three-week course on the fundamentals and design considerations of modern radio propagation communication systems.

The course will consider communication via the entire range of usable radio frequencies and will extend into the modes of propagation which are being explored for the future. System design and frequency allocation will be the two predominant emphasis of the course. It will be divided up into tropospheric propagation (to Aug. 4) and ionospheric propagation (starting Aug. 7). Tuition will be $100 for the first part, $200 for the second and $300 for both parts.

Contact Edmund H. Brown, educational director, Boulder Laboratories, NBS, Boulder, Colo.

Quality Control Course at Purdue, Sept. 5-15

Purdue University will hold a 10-day course on quality control from Sept. 5 to Sept. 15. Topics will include significance tests and confidence intervals, significance of differences, linear correlation and regression, single sampling for measurements, sequential sampling for measurements, multiple correlation, and analysis of variance. Write: Division of Adult Education, Purdue University, Lafayette, Ind.

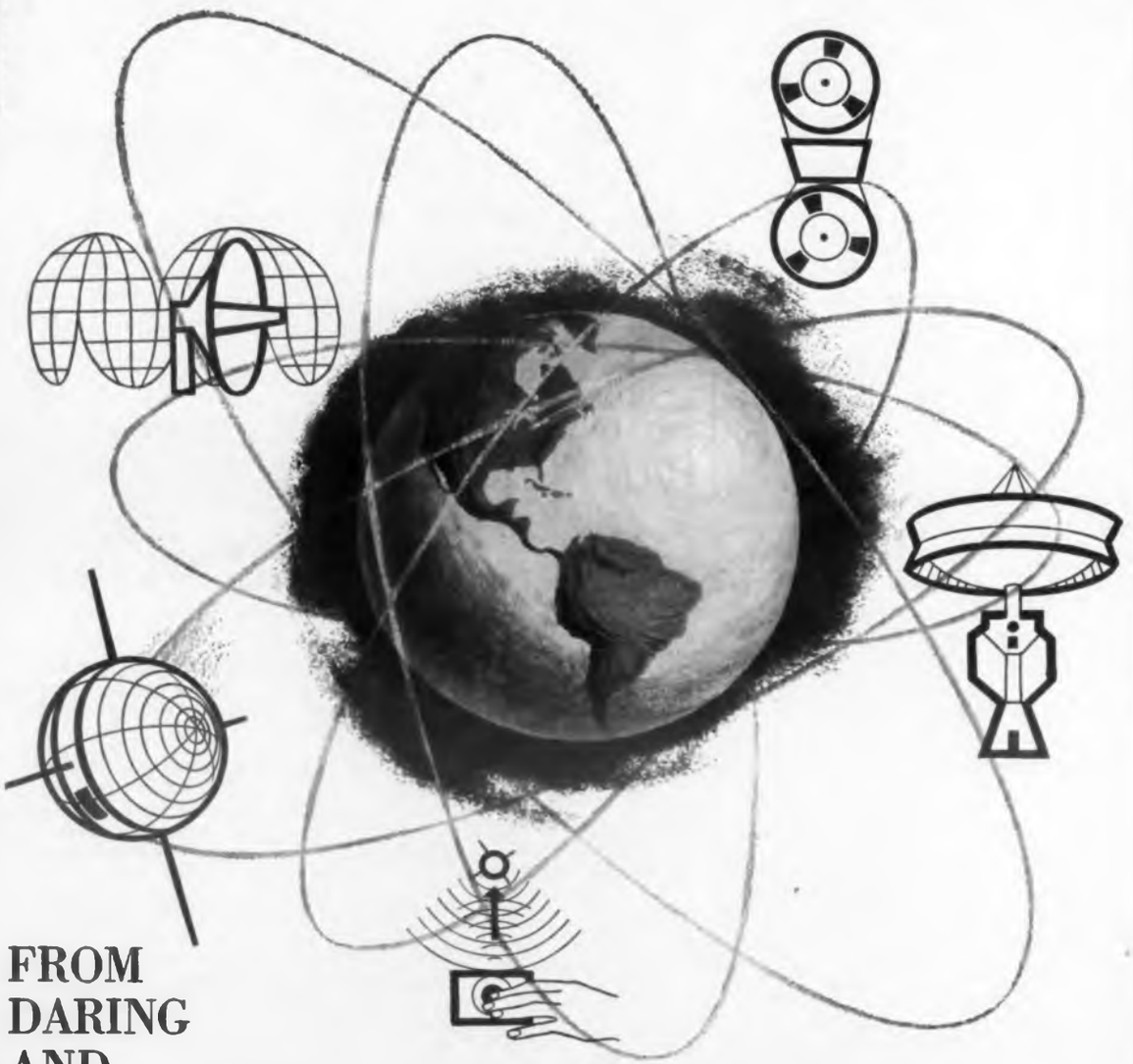
PAPER DEADLINES

June 20: Deadline for 100 word-abstracts and two-page summaries for the **1961 Eastern Joint Computer Conference**, to be held **Dec. 12-14** at the **Sheraton-Park Hotel, Washington, D.C.** The conference theme will be "Computers—Key to Total Systems Control," and papers are being requested in such areas as business-management control, military and space command control systems, industrial-process control, real-time systems, network control, man-machine systems, self-organizing systems, high-speed digital data, and high-speed digital data communications. Send information to *Bruce G. Oldfield, program chairman, IBM Federal Systems Div., 326 E. Montgomery Ave., Rockville, Md.*

July 1: Deadline for rough draft and 500-word abstract of 25-minute papers for the **International Symposium on Aero-Space Nuclear Propulsion,** to be held in **Las Vegas, Nev., Oct. 23-26.** It will be sponsored jointly by the IRE, Atomic Energy Commission and National Aeronautics and Space Administration. Subjects include instrumentation, control systems, engine simulation, and engine dynamics aspects of aero-space nuclear propulsion and nuclear auxiliary power, as well as radiation and temperature effects on instruments and controls. Send information to *P. M. Uthe, University of California, Lawrence Radiation Laboratory, Box 808, Livermore, Calif.*

July 15: Deadline for 500-word summaries of papers on theme "Communicating Ideas—The Modern Engineer's Function." These will be for the **IRE's East Lansing Symposium on Engineering Writing and Speech**, which will be held **Oct. 16-17** at the Kellogg Center for Continuing Education, **Michigan State University,** East Lansing, Mich. Send papers to J. D. Chapline, program chairman, Philco Corp., 3900 Welsh Road, Willow Grove, Pa.

August 15: Deadline for abstracts of papers for the **13th** annual fall convention and technical exhibit of the **Audio Engineering Society,** to be held **Oct. 10, 11, 12 and 13** at the **Hotel New Yorker,** New York City. Suggested topics: disc recording and reproducing; magnetic tape recording; loudspeakers and systems; artificial reverberation; stereophony; architectural acoustics; amplifiers; standards of measurement and performance; electronic musical instruments; speech analysis and synthesis; compression and expansion; bioacoustics; psychoacoustical engineering; other audio applications (hearing aids, etc.), and tuners. Send abstracts and complete papers to *Hermon H. Scott, chairman, convention committee, AES, 111 Powder Mill Road, Maynard, Mass.*



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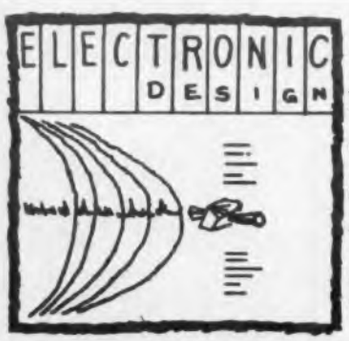

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604	614	624	634	644	654	664	674	684	694	704	714	724	734	744	754	764	774	784	794	804	814	824	834	844	854	864	874	884	894
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608	618	628	638	648	658	668	678	688	698	708	718	728	738	748	758	768	778	788	798	808	818	828	838	848	858	868	878	888	898
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