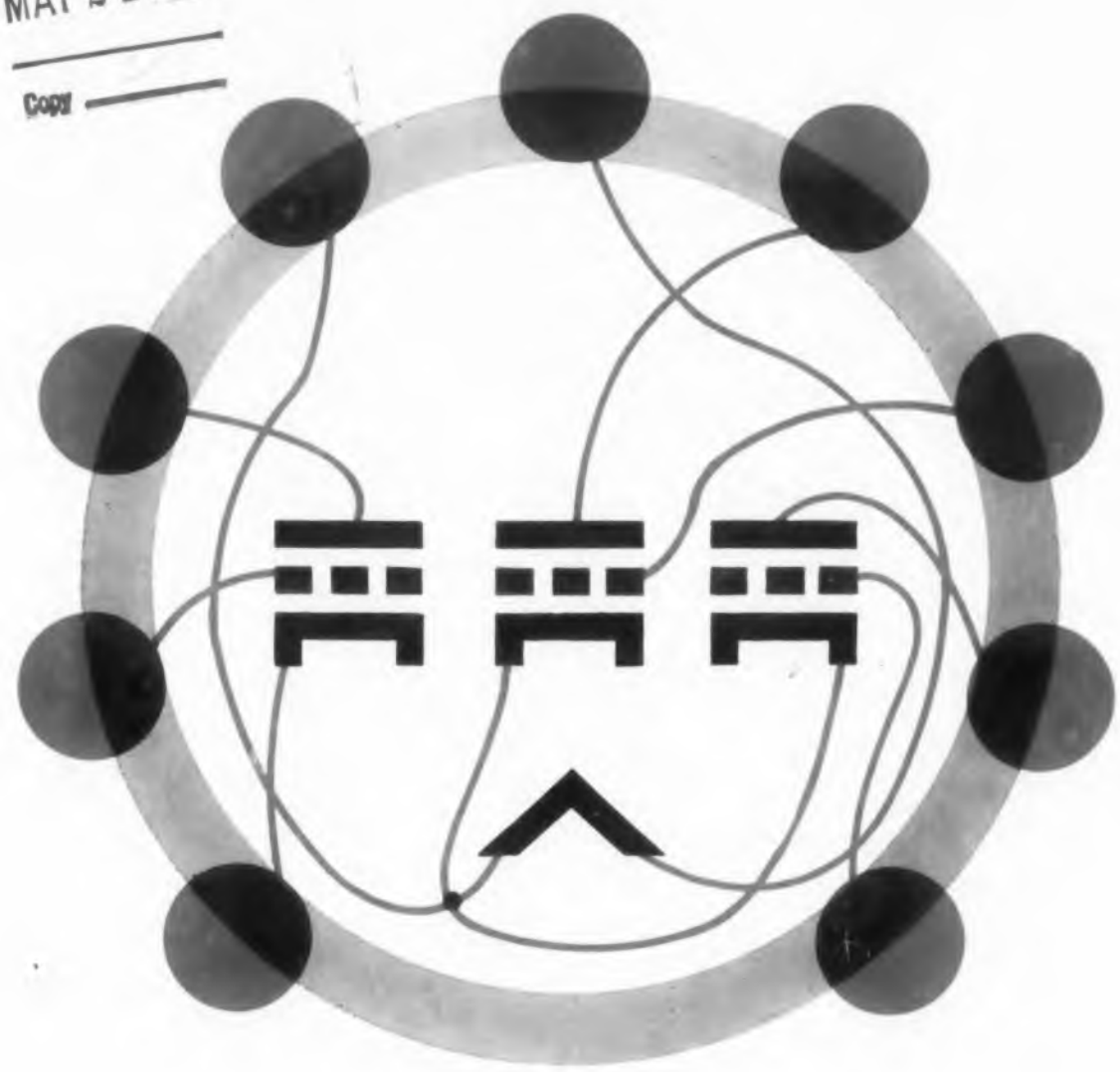
ELECTRONIC DESIGN

MAY 13, 1959



First Triple Triode Tube Saves Space ... page 36

HIGHLIGHTS OF ISSUE

Three Triodes Packed Into One Tube (Cover) **35**

With three triodes packed into one envelope, this tube can help designers save space. The miniature unit can serve as a one-tube tuner for frequencies as high as the fm band. Other applications include rf amplifier, oscillator and mixer.

Methods of Encapsulating with Epoxy **26**

Appearing in this issue is the first of a series of articles on plotting and encapsulating. Military electronics are demanding better protection from environmental conditions and better insulation for delicate components. Thus designers are faced with the important decision of whether or not to "pot." Their decision is based upon characteristics of available materials and methods. In this article, author C. H. Carter covers the subject of potting with epoxy. Future articles will discuss other phases of this important field.

Worst Case Design Equations for Transistor-Logic Circuits **32**

Design philosophy suggests calculation of individual components at their most detrimental steady-state conditions rather than use overdesign policy.

Effects of Reactive Loading on Phase Shifter **38**

A simple method of designing reactively-loaded phase shifters is given by Paul Ryan, Dytronics. In this article he presents equations and a graphical design approach to these circuits.

◀ CIRCLE 1 ON READER-SERVICE CARD

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NUMBER 10

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NBP BPA

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'Custom-Grown' Germanium Joins Microelectronic Competition

AN INDUSTRIAL sprint for compact equipment accompanies the race toward outer space, bringing new developments in microelectronics. To the expanding achievements in this field, a new approach has been added: the "growing" of germanium crystals in the exact size in which they are to be used in transistors and similar devices.

At present germanium crystals are produced round. Tedious and wasteful slicing and polishing reduce the material to the desired shape.

With the new technique, according to its developer, Westinghouse Electric Corp., it may be possible to build electronic equipment up to a thousand times smaller and lighter than by any present method.

Westinghouse has received a $2 million development contract for its method from the Air Research and Development Command.

Molecular Discovery Indicated

Dr. S. W. Herwald, vice president for research at Westinghouse, described the new process as a "basically new approach to the building of electronic systems through the use of our new knowledge of the structure of materials."

The germanium is produced in thin, uniform, flat "dendrites," ready for use. Involved, Dr. Herwald indicated, is basic knowledge of the molecules and "not just an improved method of packaging present-day components with already developed philosophies."

Practical Uses Predicted

Among the uses envisioned for Westinghouse's method are drastic reductions of complex electronic systems, the shrinking of pocket-sized transistor radio circuitry (exclusive of power supply and speaker) to the size of the head of a match.

"Dendritic germanium has broadened our thinking about the whole technology of solid state devices of the future," Dr. Herwald said. "One can envision, for example, the process at work in a machine that continuously, automatically and at high speed turns out finished transistors directly from an input of raw germanium and the two or three other materials required

A ribbon of germanium rises from molten pool in a crystal-growing furnace at Westinghouse laboratory as technician observes progress.

BEHIND THE NEWS

Mirror-like surfaces of long germanium "dendrites" developed by a new technique are inspected by Dr. A. I. Bennett, Westinghouse research physicist who worked on the project.

to put a transistor into final form."

The new process was the work of two Westinghouse research physicists, Dr. R. L. Longini and Dr. A. I. Bennett.

Other Advances Noted

At least two other concerns have announced advances in microelectronics recently. In both a production step was involved. [See *ED*, April 15 p. 14.]

Texas Instruments, Inc., reported it had made working circuits with a theoretical packaging potential of more than 25 million parts per cubic foot. The procedure calls for controlled masking through vacuum evaporation and etching techniques. The components—transistors, capacitors, resistors and diodes—are built up on the raw materials—germanium, silicon, gallium, arsenide and indium phosphide.

Radio Corp. of America said that its development of a computer logic circuit made possible packaging densities up to 100 million parts per cubic foot. The technique involves combining active and passive circuit elements into a single semiconductor solid similar to that of TI. ■ ■

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

Write in Magnetic Ink For Reading by Computer

Magnetic devices to speed the tedium of paper work in banks are on the way.

Burroughs Corp. has displayed three new machines in its Magnetic Ink Character Recognition program. One is the Magnetic Character Sorter, designed to handle the flood of checks, deposit slips and other documents that pour into banks daily. The new machine sorts 10 times faster than a person working manually.

It is designed for use in conjunction with Burroughs' two other new devices: the Magnetic Imprinter and the Magnetic Amount and Account Number Printer. Both these machines print numbers and symbols in magnetic ink on checks and other items, providing the "trigger" for the bank's automatic equipment.

International Business Machines Corp. has also announced the development of magnetic character-sensing bank equipment. It, as well as Burroughs' devices, will make use of a "common language" of magnetic ink characters adopted by the American Banking Assoc.

Geiger Counter Detects Polluted Air

Polluted air and industrial gases are now being studied through application of the Geiger counter principle.

L. E. Maley of Mine Safety Appliances Co. told the recent A.I.E.E. conference in Philadelphia that ion currents had been utilized to detect dangerous gases and vapors and to guide the control of chemical processes in industry.

The Geiger counter operates through the ion current that radio-activity produces between two high-voltage electrodes. The air detector contains its own radioactive ionizing material and makes use of the chemical formation of solid particles from the gas or vapor, Mr. Maley said.

Split-Second Missile Tracker

An electronic system that computes flight position and impact area at the rate of two times a second is helping the Air Force guard against wild missiles.

If an IRBM or ICBM strays off course during tests, the Missile Impact Prediction System (MIPS) can spot the deviation at once and notify the safety officer, who can explode it harmlessly with a signal.

The MIPS was designed by Packard Bell and has as its central element a Bendix G-15 digital computer.

BEHIND THE NEWS

IBM Computer Turns Out Braille

Translating a book into Braille—a job that might take a skilled translator more than six days—can now be done in an hour with a standard electronic computer.

The new technique, demonstrated by the International Business Machines Corp., utilizes an IBM 704 data-processing computer.

From a printed text, the electronic computer creates in minutes a raised Braille plate suitable for the printing of books for the blind.

Complicaetd Rules Involved

Braille consists of 63 combinations of six raised dots, with complicated rules of usage.

Texts to be translated are transferred to punched cards. These are then fed into the computer, which has stored in its "memory" a set of Braille rules. The machine executes as many as 600 instructions a word in less than a fortieth of a second.

The translated text emerges on coded cards. After editing, the cards are fed to an embossing machine, whence they emerge as metal plates for use in a rotary press.

A 300-page book can be translated in an hour.

Braille printing plate produced by electronic computer is held by Dr. Joseph Flanagan, manager of IBM's mathematics department, which developed the technique.

BEHIND THE NEWS

Pot Electronic Components in New Low-Melting Glass

Low-melting glass compositions have been developed that may prove useful in protecting moisture-sensitive devices.

The product of research by Dr. S. S. Flaschen and A. D. Pearson of Bell Telephone Laboratories, the glasses are composed of proportions of sulfur or selenium and the heavy metals arsenic and thallium. They become very fluid at temperatures between 125 and 350 deg C—lower than any previously known low-melting glass.

In the fluid state, the glasses have viscosities roughly equal to that of castor oil at room temperature. This makes them suitable for coating devices by a simple dipping procedure.

The glasses range electrically from semiconductors to insulators with a minimum resistivity of 10^6 ohm-cm. The maximum resistivity of both sulfur and selenium ternary compositions is more than 10^{14} ohm-cm.

Chemically the glasses exhibit the same durability of any glass. They are insoluble in water, dilute alkalis, acids—including hydrofluoric acid—and organic solvents. But they are vulnerable to concentrated alkalis.

The compositions show extremely low permeability to both water and helium, and they possess good wetting characteristics with respect to most metals. These properties may not normally be available in organic coating materials.

Bell reports the development has opened new possibilities for encapsulating semiconducting devices, capacitors, resistors and printed circuit boards. Already under study is the coating of semiconductors, with good initial characteristics reported in silicon diode experiments.

Highway P. A. System Gives Aural Aid to Motorists

A roadside radio system that automatically would broadcast information and safety signals to drivers is under experimentation.

Called Hy-Com, it has two basic parts: low-frequency transmitters spaced along the highway and transistorized receivers in cars. The receivers can be installed separately or combined with a standard car radio.

Hy-Com operates regardless of whether the car radio is on. If on, the radio is muted momentarily to allow the message from the road transmitter to get through. If the radio is off, the transmitter signal can switch it on.

The Delco Radio Division of General Motors, which developed the system, reported it was de-

signed to operate in the 10-20 kc range, far removed from standard broadcast bands. Highway broadcast zones can be arranged to prevent overlapping.

One Hundred Elevation Beams Detected by Radar Height Antenna

An air-traffic radar system that will add a third dimension—altitude—to the information now received by controllers has been ordered by the Government.

Present two-dimensional systems give the controller the range and bearing of approaching aircraft. The key element of the new system will be a three-sided fixed antenna 150 ft high. It will receive radar energy reflected by flying aircraft in any of 100 elevation beams.

The equipment is to be designed to give accurate height information on planes up to a range of about 57 miles.

A $1.7 million development contract has been awarded to W. L. Maxson Corp. by the Bureau of Research and Development of the Federal Aviation Agency.

The system will be known as Air Height Surveillance Radar, and it will be used along with existing airport radar to vector aircraft to and from terminal areas.

The contract calls for experimentation to start in December, 1959. Completion of the prototype system is scheduled for October, 1960.

Artist's conception of the Air Height Surveillance Radar Antenna. Radar signals reflected by aircraft from as many as 100 different elevation levels are detected.

Activity in Sonic Testing BOOMS

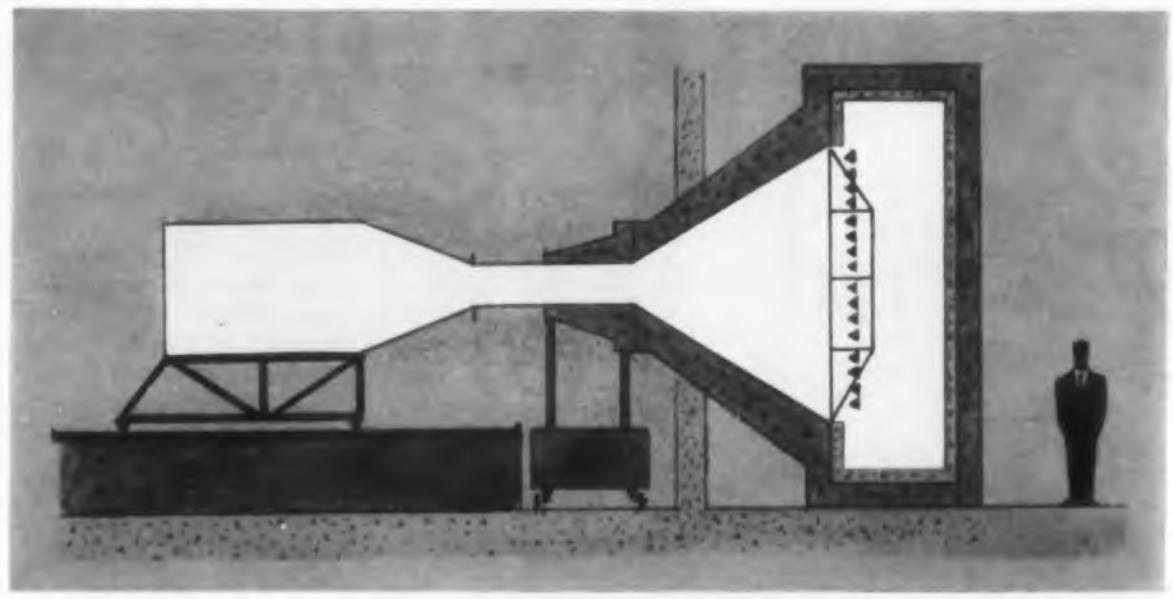
ROARING Space Age vehicles that approach or exceed the speed of sound are spurring activity in acoustical testing.

Two of the recent announcements by concerns in this field describe:

- Plans for installing one of the world's largest acoustic chambers for testing electronic components.
- The development of a 200-kw amplifier for testing Polaris missile components and subassemblies.

But even as this activity was made known, two scientists cautioned on the need for techniques to conduct failure tests of equipment.

One reason for the new acoustic chamber is that the powerful engines in today's supersonic planes and missiles can generate enough sound waves to shatter elec-



Acoustic chamber that will be installed by Goodyear Aircraft Corporation in near future. Hundred-ton exponential horn assembly will be of reinforced concrete. Assembly is part of million-dollar expansion program.

tronic equipment in the vehicles. The shattering can take place even during warm-up periods on the ground.

The acoustic chamber will be installed in Litchfield Park, Ariz., by the Goodyear Aircraft Corp. It is part of an expansion program that will cost more than a million dollars.

SPL of 150 db Produced in Chamber

The chamber will be able to produce sound-pressure levels of 150 db in a frequency range of 37.5 to 10,000 cps. The output for each octave will be independently variable over a range of at least 40 db.

(For purposes of comparison, noise with a pressure level of 160 db is equivalent to sound a few feet from the nozzle of an operating jet engine on a transport. At 150 db, a person's eyeball begins to spin and blurring vision occurs. Physicians call it nystagmus.)

Attenuators will be used to produce various spectrums, such as "white," or jet, noise. This is noise of a statistically random nature, having equal energy per unit frequency bandwidth over a specified total frequency band.

Basically the system will be of the plane-wave type, with one plane-wave chamber having an inside working space of 33 x 33 x 54 in. Another has an inside working space of 17 x 17 x 24 in. The reverberant chamber has an inside working space of approximately 72 x 72 x 72 in.

The 33-in. chamber may be used in conjunction with a 5000-lb force shake table to perform combined acoustic and vibration tests. Electrical measuring devices can be attached to the specimens being tested by means of a large number of conductor terminals on the chamber walls.

The exponential horn assembly, which will direct the sound to the selected chambers, will weigh 100 tons and will be of reinforced concrete. Its inner surface will be coated with an epoxy resin material to minimize acoustic absorption.

Amplifier Doubles Previous Power

The 200-kw amplifier, said to be twice as powerful as any similar system produced in the past, will transmit signals to a test platform. It will be possible to play through the amplifier vibration tape recordings retrieved from recovered missiles. Components attached to the platform will thus be tested under simulated missile-flight conditions.

None of the amplifier's output is for audible applications, although high-quality sound reproduction is within the unit's capability.

Measuring 24 x 7 x 3 ft and weighing about 10 tons, the amplifier is valued at more than $100,000. It was built by the Westinghouse Electric

BEHIND THE NEWS

Corporation's industrial and electronics department in Baltimore.

Questioning Voices

At about the same time that reports from industry showed huge sums being spent for acoustical test equipment, a cautious evaluation was voiced. It said: "There is at present no satisfactory technique for running failure tests on even simple components."

The authors of the statement were Dr. J. J. Baruch and G. W. Kamperman, writing on "Sonic Failure" in a recent issue of Environmental Engineering.

They pointed out that a vacuum tube could be made to fail in a 150-db sound field but could remain operational in a 170-db field. If the tube were attached to a vibrating panel in a 150-db field, the chances of it failing would be good. But if the tube were mounted on a concrete block, hardly any increase in sonic field would cause it to fail.

"Unless we are willing to test our vacuum tube in all possible mountings," the authors asserted, "simple immersion in a sound field is not the way to perform a test program."

They also noted that "an acoustic system as a whole must be analyzed and that component analysis is virtually worthless without the testing and knowledge of the over-all acoustic system."

"It is hoped," Dr. Baruch and Mr. Kamperman concluded, "that the funds expended in this field are expended in an integrated, solid research program rather than the hit-or-miss type of test program which is so easy to carry out, so flashy in its large masses of statistical data and so useless in its final results." ■ ■

New Transistor in New Package

Newly packaged transistors with a maximum frequency of oscillation of 3000 mc have been developed for Philco Corp.'s Lansdale (Pa.) Tube Co.

The MADT germanium component exhibits a power gain of 9.8 db at 1000 mc. It has been produced in both the JETEC TO-9 standard package and in a new co-axial type with holder matched for direct insertion into a 50-ohm co-axial network.

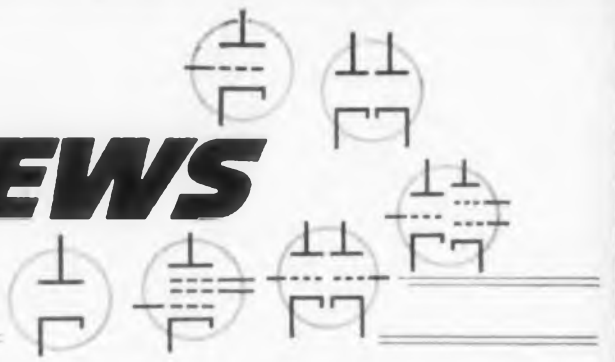
The new packaging is considered a first step toward the possible design of transistors as integral parts of distributed transmission line networks, in a manner similar to microwave mixer diodes.

CIRCLE 608 ON READER-SERVICE CARD

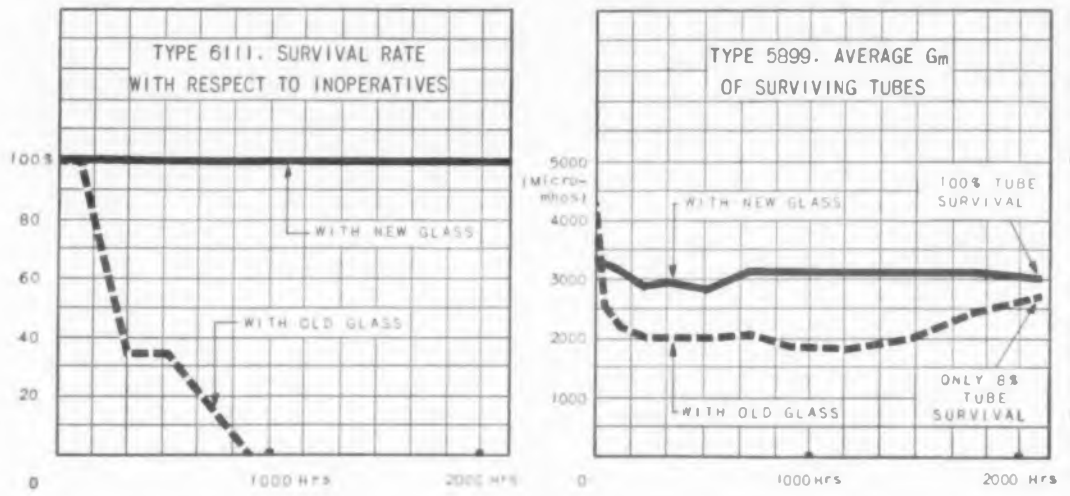
GENERAL ELECTRIC

TUBE DESIGN NEWS

FROM THE RECEIVING TUBE DEPARTMENT OF GENERAL ELECTRIC COMPANY



G-E Subminiatures with New High-Resistivity Glass Show *NO* Inoperatives after 2000-Hr Tests at 300°C!



Life tests above to military specifications except for bulb temperatures, raised to 300 C. Left: shows 2000-hour inoperative percentages for Type 6111, a subminiature known to suffer from glass electrolysis at higher-than-rated temperatures. Right: shows reduced G_m drop for new glass versus old, Type 5899. At high temperatures this tube had a tendency to slump in transconductance.

The G-E Receiving Tube Department has taken an important step forward in tube technology by applying Corning Glass Works' new high-resistivity glass to 5-Star subminiature types. Test results, as indicated at left, show a spectacular increase in tube reliability.

First with high-resistivity glass for tubes, General Electric now is building subminiatures able to withstand heats that before have shortened tube life materially. Glass electrolysis—cause of 90% of subminiature failures at high temperatures—is "stopped in its tracks."

Resistance Factor 20 Times Greater

The new glass in G-E subminiatures actually has a factor of resistance 20 times that of the old. A designer can use in two ways the improved tube performance now offered him:

1. He can design with a greater safety factor.
2. He can work with assurance to equipment specifications that call for high-temperature tube operation.

Ask any General Electric tube office on the next page for further facts!

Three Advanced Tubes Now in Production by G.E.

TYPE 6EZ8. First triple triode ever designed and manufactured! General Electric's pioneering 6EZ8 is an entertainment tube for use in FM radio tuners . . . . . makes possible a *one-tube tuner*, boon to space-cramped set designers. Saves extra tube cost, too. By itself, the new 6EZ8 will handle either of these jobs: (1) r-f amplifier, oscillator, and mixer. (2) oscillator, mixer, and AFC tube.

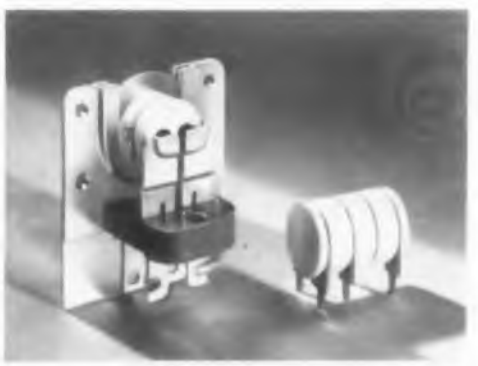
TYPE 6222. Extra-sensitive high-mu subminiature triode. A 5-Star military type, for first-stage amplification in infra-red detection circuitry. Noise level is extremely low—a maximum of 1.2 microvolts at the grid, in a test circuit of 200 cycles band width. The 6222's low noise characteristic, especially at very low frequencies, makes the tube useful in other advanced applications.

TYPE 6814. Only subminiature computer type! A 5-Star high-reliability triode intended for military use in airborne fire-control computers. Designed for binary-counter or cathode-follower applications. The 6814's extremely small size assists in optimum miniaturization of equipment.

Ready Soon: New Printboard Version of 7077 Triode

Type 7077 ceramic triode—famous as the General Electric tube which sent information to earth from Pioneer IV sun satellite for a world record distance of 407,000 miles—soon will be available for standard printboard circuitry. The new lug version has ratings which are approximately the same as those of the 7077.

The short, solderable lugs of the new tube, cut lead inductance and capacitance to a minimum. This helps make the lug version of the 7077 ceramic triode an ideal tube for application in distributed amplifier circuits.



Side by side: socket-mounted 7077 ceramic triode and new lug version (at right) for standard printboard use. Both are shown actual size. Note smaller mounted height for printboard tube, aiding the circuit designer who is faced with rigid space limitations.

Tear off and keep this sheet for reference. It contains useful tube-application data.

FOR BROAD-BAND WORK, WHAT TUBE GIVES BEST NOISE PERFORMANCE?

The Answer Is Found by Evaluating Both Tube and Circuit Parameters

As an equipment designer, you have today a choice between several low-noise, high-frequency, high-performance triodes for broad band amplifier service. Selection becomes your problem. Which tube—in the new circuit on your drawing-board—will give optimum noise performance?

High-definition radar, to name one of several applications, requires that first-stage tubes show consistent low noise over band widths of 10% to 15%. At the same time, tube gain must be sufficiently high to meet the needs of subsequent circuit stages.

In obtaining high first-stage gain, two parameters predominate —transconductance and tube capacitances. For grounded-grid work, the principal tube capacitance is the output, or grid-to-plate. Input capacitance plays a minor part.

In order to calculate power gain, you may employ this simplified expression:

$$\text{P.G.} = \frac{\mu R_L}{rp + R_L} \quad \mu >> 1 \qquad \text{—where } R_L = \frac{1}{2\pi \triangle f C_t}$$

$\triangle f$ = band width in cycles

C_t = total interstage capacitance in farads

For minimum noise figure, it is necessary to know first the equivalent noise resistance (R_{eq}) and equivalent shunt noise conductance (G_n). The expression follows:

$$NF_{min} = 1 + 2\sqrt{\frac{R_{eq}}{G_n}}$$

The optimum source resistance under this condition is:

$$R_{s\ opt} = \sqrt{\frac{R_{eq}}{G_n}}$$

After calculating $R_{s\ opt}$ it becomes evident that minimum noise figure and maximum power gain can both be obtained only when input to the tube amplifier equals $R_{s\ opt}$, and a power-match condition exists at the input network. The value R_{in} for a grounded-grid amplifier can be estimated to be:

$$R_{in} = \frac{rp + R_L}{\mu + 1}$$

Therefore, we find that input impedance depends not only on tube parameters, but also upon plate load, which in turn is dependent on the desired band width and inter-stage capacitance.

With second-stage noise, first-stage gain, and input conditions at each stage entering into the picture, it becomes clear that the available noise figure of an amplifier tube is affected by system band width, as well as tube parameters.

In order to help the designer choose between three low-noise, high-gain, high-frequency tubes—all of advanced design, but with widely different size and cost—these determining factors are calculated below for the grounded-grid case:

	TYPE 7077	TYPE 6299	TYPE 6280
Transconductance, micromhos	10,000	15,000	50,000
Amplification factor	90	115	200
Capacitance (G-P), micromicrofarads	1.0	1.7	1.5
Equiv. noise resistance (R_{eq}), ohms	285	167	50
Equiv. shunt noise conductance (G_n), micromhos at 425 mc	3,120	5,280	11,400
Minimum NF at 425 mc, in decibels	4.6	4.6	4.0
Opt. Source resistance ($R_{s\ opt}$), ohms	300	178	66
Grounded-grid input ($R_L = rp$), ohms	200	133	40
Grounded-grid gain ($R_L = rp$), decibels	16.5	17.6	20.0
Inter-stage capacitance (C_t); $C_{g-p} + 3$ micromicrofarads*	4.0	4.7	4.5
Plate load in ohms (R_L); $\triangle f = 50$ mc	800	680	710
Grounded-grid gain in decibels; $\triangle f = 50$ mc	8.6	9.7	14.8
Over-all NF in decibels, two stages**	6.8	6.4	5.7
Over-all NF in decibels, at 1/2 power points	7.2	6.7	5.8

* *Assumes 1 micromicrofarad for socket and 2 micromicrofarads for strays and tuning.*

** *Assumes power match at input.*

Minor factors have been omitted from the above calculations, but the results check fairly closely with known and published figures. They emphasize that:

1. Under optimum conditions, tubes with widely different transconductance may have similar noise levels.
2. For broad-band applications, tubes with high transconductance generally give more gain per stage with less over-all noise.
3. In broad-band work, high G_m is needed not alone for low noise, but also for enough gain at band edges to assure a relatively flat noise level across the over-all band pass.

Noise and gain at other band widths can be calculated in the same manner, to help the designer obtain optimum tube performance in line with size and cost limitations. More detailed information is available from any G-E tube office listed below.

For further information, phone nearest office of G-E Receiving Tube Department below:

200 Main Avenue, Clifton, New Jersey
Phones: (Clifton) GRegory 3-6387
(N.Y.C.) WIsconsin 7-4065, 6, 7, 8

3800 North Milwaukee Avenue
Chicago 41, Illinois
Phone: SPring 7-1600

11840 West Olympic Boulevard
Los Angeles 64, California
Phones: GRanite 9-7765; BRadshaw 2-8566

Progress Is Our Most Important Product

GENERAL ELECTRIC

2-411-103

Electrostatic Chucks Can Hold Metals, Or Non-Metalics

Any electrical conductor such as aluminum, brass, stainless steel or magnesium, as well as the ferrous metals, can be held on an electrostatic chuck with equal efficiency. Furthermore it is possible to check ceramics or plastics if these are first "flashed" on the holding surface with a metallic coating as little as five millionths of an inch in thickness.

Basic equipment, in the system recently announced by Electroforce Inc. of Fairfield, Conn., consist of: the chuck, designed for use on standard surface grinders, or adaptable to many special requirements; a compact power supply which may be located adjacent to the machine; the "Dribox," in which the work is kept moisture-free at slightly above room temperature and the coolant pump and filter unit required to furnish a supply of clean dielectric coolant. Except for the use of a dielectric, non-aqueous coolant and care in maintaining moisture-free and metal-particle-free cleanliness on the holding surfaces, no special procedures are required. Work is instantly gripped and released by a simple control switch.

There is, of course, no "residual magnetism" with this system, even when used with ferrous materials. Equipment operates on standard 110 v, 60 cps ac single-phase current from a 3-wire grounded circuit; total power consumption is approximately 250 w.

USSR Technical Information Service Gets Engineer's Spare Time Help

Success of the Soviet Union's centralized scientific "Institute of Information," the activities of which constitute the most complete and intensive attack on the problem of disseminating technical information in the world, is partly due to the extracurricular help given by engineers according to R. K. Honaman, a recent visitor to the USSR. This desire to serve is induced by a real consciousness by all of the need for prompt dissemination of information, by the prestige gained through staff membership, and by extra material rewards such as new homes and cars which, as in the U. S., are status symbols.

What makes mica the unique dielectric?

Mica is as old as the earth itself. Ancient Hindu writings show that mica was thought to be the remains of lightning flashes from which sparks had emanated and had become preserved in the earth. It was therefore regarded as being endowed with extraordinary properties, and was used in medical ritual. The replacement of such charming stories with modern technical knowledge has, however, not altered the fact that mica is endowed with extraordinary properties.

Mica is found in pegmatite rock, formed in the early stages of the cooling of the earth's mass. Crystals of mica were formed under high heat and pressure, and in the presence of moisture vapor and magnetic fields. The physical and chemical changes during this period served to impart a unique stability in physical, chemical and electrical properties. The chemical structure of mica is represented as $H_2KAl_3(SiO_4)_3$ which is Muscovite; India Ruby is one of the grades of exceptional quality and is used in most mica capacitors. Other types of mica, to name a few, are Phologopite, Lepidolite and Biotite, of which only Phologopite is of limited interest in experimental capacitors for very high temperature operation.

Mica is found in varying degrees of purity, some with less mineral or vegetable constituent, or stain, and some with more nearly perfect physical integrity — that is, free from cracks or air inclusions. As a result, raw mica must undergo careful physical examination and be graded according to quality and size. Sangamo has had over 35 years experience in the selection and processing of mica, together with a knowledge of mica capacitor production. Capacitor grades of mica film are generally obtained from the Bihar, Bengal, or Madras provinces of India. Mica for other purposes may be found in Canada, Brazil, Argentina, Madagascar, Africa, Russia, New Hampshire, South Carolina and South Dakota. This list is by no means complete. An idea of the magnitude of the task of selecting suitable mica can be obtained from the fact that only an estimated ten per cent of all the world's mica deposits are suitable for use in mica capacitors.

The earliest mica capacitor was probably made by Matteuci, a contemporary of Faraday's, about 1845. However, capacitors did not become commercially interesting until the advent of radio in the early years of this century, as a result of the growth of electrical technology. Both the electrical and electronics industries have depended significantly upon mica. Mica insulation between commutator segments in rotating machinery and the mica spacers in vacuum tubes are still vital to these industries.

In capacitors, the choice of dielectric material is as important as the method of construction. Mica, because of its sheet form, lends itself to stacked construction, resulting in a lower inductance assembly than can be obtained in wound capacitors. Mica capacitors are therefore suitable for very high frequency operation.

The mechanical or dimensional stability of mica allows blanking or die-cutting of dielectric plates to a desired size with only a very few thousandths of an inch variation. Precise assemblies may therefore be obtained and result in a greater ability to achieve accurate miniaturization. Electrodes may be permanently bonded to the mica dielectric plates by screening on conducting silver paste. This process has been refined to a high degree of accuracy, and results in superior electrical stability when compared to laying foil between mica plates to form the electrodes. Silvered mica capacitors exhibit exceptional stability in extremes of temperature.

The Q and dielectric constant (therefore, the capacitance) of mica change very little over wide ranges of frequency and temperature. Such small changes are due to the fact that the molecular structure of mica is essentially non-polar — that is, the molecules of mica do not have an unbalanced electrical charge. Thus they are not free to swing freely as magnets do (mica is practically non-magnetic) when in the presence of an electric field. Such fields are present when the capacitor is charged. Movement of the molecules would result in heating by the friction of their motion. Poor dielectrics exhibit considerable heating, as is shown by the heat developed in wood and glue in the process of laminating plywood in dielectric heating devices.

Heating effects may become very pronounced when high frequency alternating voltages are applied. The rapid changes in the direction of current flow cause polar molecules to literally vibrate about their rest position. The low heating of mica under such conditions is evidenced by the fact that certain types for transmitting applications will carry apparent currents to 50 amperes, at a few megacycles, resulting in only few degrees temperature rise.

Minimum dielectric heating is very essential since it has been shown that the life expectancy of a capacitor is reduced by a factor of approximately one-half for each ten degree centigrade rise in temperature.

All mica capacitors do not possess the ultimate characteristics of natural mica, since designs and manufacturing procedures differ according to original intent and application. However, the characteristics shown in the table could be realized under ideal conditions.

Characteristic	Approximate or Ideal Value
Dielectric Constant	7 (resulting in a moderate degree of miniaturization)
Q	3000 or greater
Power Factor	0.05% or less
Self Resonant Frequency	Up to 500 megacycles
Insulation Resistance	100,000 megohms or greater
Operating Temperatures	Up to 230°C. (85°C standard for commercial types)
Temperature Coefficient of Capacitance	0 to +70 parts per million per degree centigrade
Capacitance Drift or Capacitance Retrace	0.05% or less

At Sangamo all mica capacitors are designed and manufactured to exceed the physical and electrical requirements of applicable military specifications. The wide variety of Sangamo mica capacitor types allow flexibility of design and superior products for the most critical applications to meet individual specification requirements. Engineering catalog and bulletin giving full information on types and characteristics are available upon request for your examination.

Radar Contact With Venus

RADAR signals traveled a round-trip distance of 56 million miles for contact with the planet Venus, according to scientists at the Lincoln Laboratory of M.I.T. The experiment in radar astronomy, recently revealed, took place Feb. 10 and 12, 1958 and was conducted by a research team headed by Dr. Robert Price, Jr. and Dr. Paul E. Green, Jr. The achievement represents a one hundredfold increase in the longest range ever attained with radar and is the first instance of a direct two-way contact with any celestial body beyond the moon.

Contact with Venus was made by the Lincoln Laboratory's powerful research radar (Fig. 1) on Millstone Hill in Westford, Massachusetts, using a low-noise solid-state maser preamplifier and sophisticated mathematical and electronic computing techniques.

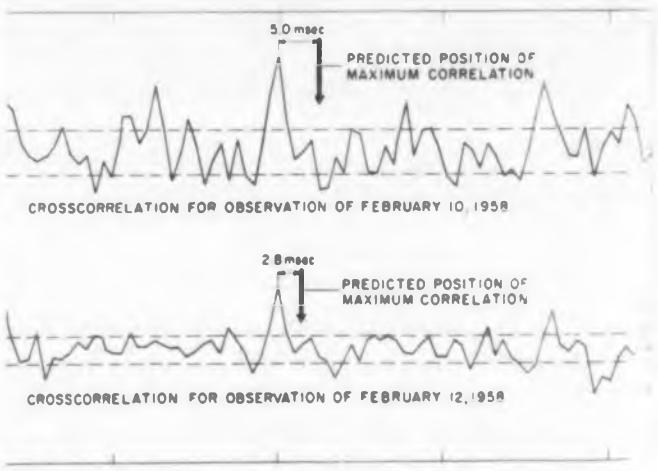


Fig. 2. Correlation curves showing radar returns fro Venus. The central peaks indicate the exact travel ti of the radar waves from Earth to Venus and back. Ea peak is the result of elaborate calculations by a hig speed digital computer on many thousands of t echoes.

Fig. 1. M. I. T. Lincoln Lab's Millstone Radar Observatory.

One Year Analysis Required

Since the returning radar pulses were too faint to be directly observed or measured individually, the received signals were recorded on magnetic tape and subjected to exhaustive analysis by a high-speed digital computer. Approximately a year has been required to develop and use the intricate electronic computing methods which were necessary to isolate the returned radar signals from the electrical noise mixed in with the recorded data. Weeks of analysis by a large, high-speed digital computer have been required to establish with certainty the existence of the radar signals returned from Venus.

Radio Astronomy More Precise Than Optical

In recent years, astronomers have been eagerly awaiting the first radar detection of any one of the planets, because of the great accuracy with which radar can measure distances. Distances in the solar system are already known to a very high degree of precision relative to one another, but alsolute distances are only roughly known, and optical techniques have been pushed to the limit to get even this rough degree of accuracy. The determination of any one distance more accurately would then make it possible to calculate all other interplanetary distances more accurately. It was anticipated that, if a planet were detected at all by radar, it would be detected with very high accuracy in distance.

The Lincoln Laboratory experiment has produced two highly accurate measurements of the round-trip travel time of radar signals from Earth to Venus and return. When properly interpreted, these measurements of time should make it possible to fix the size of the solar system to an accuracy of one-thousandth of one per cent, an ac-

BEHIND THE NEWS

curacy approaching 100 times greater than has been possible by the most refined optical methods. Preliminary calculations from the Lincoln data indicate that the dimensions of the solar system are somewhat smaller than the previously accepted value, but this interpretation requires further study.

Two Test Runs For Accuracy Check

Discrimination of the weak radar returns from the concurrent background of celestial and electrical noise was a difficult task. The conclusion that the radar detection had, in fact, been successfully accomplished is based on the presence of echo returns in two completely processed runs. The measured change in the distance from Earth to Venus over the two-day interval between February 10 and 12 is in excellent agreement with accepted astronomical data of high accuracy.

The distance from the earth to Venus was measured in terms of the round-trip travel time of the radar signals. On February 10 this round-trip time was 295.5065 seconds. Further study will be required to determine the exact distance from the earth to Venus based on this travel time. However, with certain assumptions, such as that radar signals travel throughout the journey at a constant speed equal to the speed of light, this travel time would place Venus approximately 27,530,000 miles from the earth. This is in good general agreement with astronomical data. On the second day, February 12, the round trip time was 302.9842 seconds, which placed Venus approximately 28,227,000 miles distantat that time.

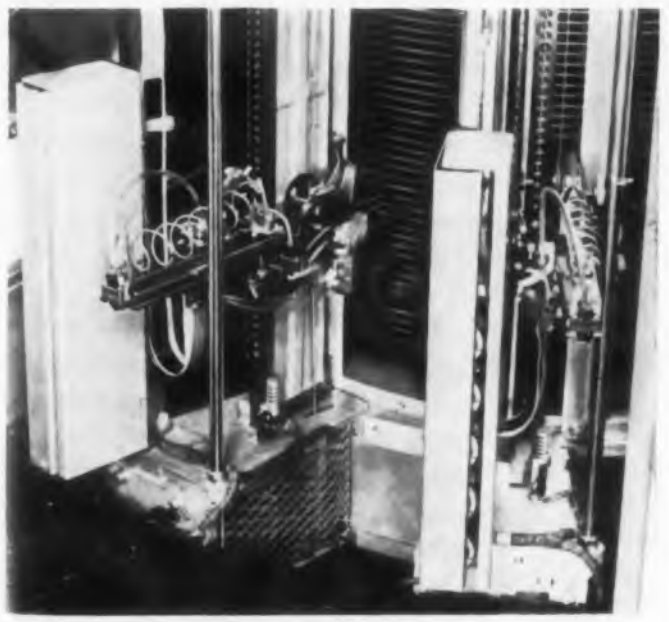
When the exact absolute distances have been determined by further study, these results may lead to a considerable improvement in the accuracy of all computed interplanetary distances. Distances within the solar system are commonly measured in terms of the "astronomical unit," which is defined as the mean radius of the earth's orbit around the sun (about 93,000,000 miles). Preliminary calculations indicate that this unit, and hence all interplanetary distances, may be 0.0013 per cent smaller than the presently accepted value. Further investigation is required to establish the validity of this indication.

The measured difference between the round trip travel times of the radar signals on the two days was 7.4777 seconds, indicating that Venus had moved 696,640 miles farther away from the earth during this two-day interval. This is in close agreement with the distance increase calculated from astronomical data of high accuary; the measured value differed from the predicted value by only 0.0022 second, or one part in 4000, corresponding to about 200 miles in the distance of almost three-quarters of a million miles. ■ ■

Disk Capacity Doubles for Longer Memory

Double capacity disk storage files for the IBM 650 and 7070 Data Processing Systems, introduced by IBM's Data Processing Division, each provide a random access memory of 12,000,000 digits of information. Increased capacity has been achieved within each disk area by doubling the number of tracks used for recording data. A total of 48,000,000 digits can be obtained by using up to four of the double capacity files with either the IBM 650 or IBM 7070, any of which can be located in less than a second.

Doubling of memory capacity extends the advantages of in-line data processing to business and scientific applications requiring very large random access storage. One double capacity file does the work of two to handle an application requiring 12,000,000 digits of random access storage capacity. Since the Model 1 and Model 2 disk files can be installed either singly or in any combination of up to four units—providing storage capacities of 6, 12, 18, 24, 30, 36, 42, or 48,000,000 digits—the new files further increase the flexibility of both the 650 and 7070 systems to meet individual application memory requirements. Reduced access time to stored information is permitted because of greater density of data storage. For example, data which required 50 disks of storage on the 6,000,000-digit file can be stored on 25 disks of the new file, so that the movement of the access arms used to seek data will be less and the seek time will be proportionately reduced.



Three independent access arms used to read or record data onto the disk storage files of the IBM 650 and 7070 data processing systems. The magnetic disks in each unit continuously rotate past the access arms at 1200 RPM, and the arms move rapidly up and down and between the spinning disks to reach any particular group of stored data in a fraction of a second.

BEHIND THE NEWS

Grinding Technique Merits Miniaturization Award

Development of a radically new centerless internal grinding machine for manufacture of miniature ball bearing races captured the 1958 Miniaturization Award given by Miniature Precison Bearings Corporation for Heald Machine Company, Worcester, Mass. The company's Model 090 Centerless Internal Grinding Machine can produce bearing races as small as 0.040 in. inside diam. that can be ground to 0.00015 tolerance and 5 micro-inch finish in a fully-automotive 15 sec cycle.

Stored Image Tube Evokes New Uses

Commercial queries at the IRE Show opened up potential applications for Raytheon's kiloline storage tube. A request from a Yonkers Raceway official sought the bypassing of film processing in nose-to-nose photofinishes when he learned of the tube's capability of receiving and storing images for immediate as well as for leisure playback. (A Westinghouse tube for this purpose was described Apr 15, 1959, *ED*, p 11.)

Another interesting concept was offered by a sales representative who perceived application for the kiloline storage tube in freight car classification. Ability of the tube to synchronize its fast image-storing capabilities with the speed of oncoming trains would eliminate the necessity of approaching trains to slack speed in order to be viewed and checked.

Medical applications broadened the scope of suggestions to include the storing of pictures of heartbeat impulses from a scope for waveform

analysis. Instantaneous playback during an operation would provide valuable data for analysis in the event of waveform deterioration.

A further suggestion involved the adjustment of glass cutting equipment to avoid expensive waste when huge cutters get out of line, leaving damaging shear marks on glass. Raytheon's tube would overcome this deficiency by taking an immediately viewable picture of the high-speed process; after cutter adjustments are made another picture can be taken to check improvement.

Missing Credits

The author and editors of the series Microwave Test Instruments, *ED*, Dec. 10 through March 18, are indebted to many manufacturers as sources of information. We are especially indebted to De Mornay Bonardi, Pasadena, Calif. for the illustration in Part I of the series which pictorially classifies all microwave measurements.

"CODES" Detect Target

Blip on scope is presentation of detection of infrared radiation of lighted cigarette by the new "CODES" (Commutating Detection System) developed by the Avion division of ACF Industries. Each CODES cell output is stored in a passive LC "tank" network before commutator causes the amplifier to sample each tank output in turn, so that each cell simultaneously sweeps out its assigned portion of the field. Presence of a target within a cell's field is announced in the tank. This ac signal is sampled by the commutator, and amplified for presentation.

BEHIND THE NEWS

APT System of Machining

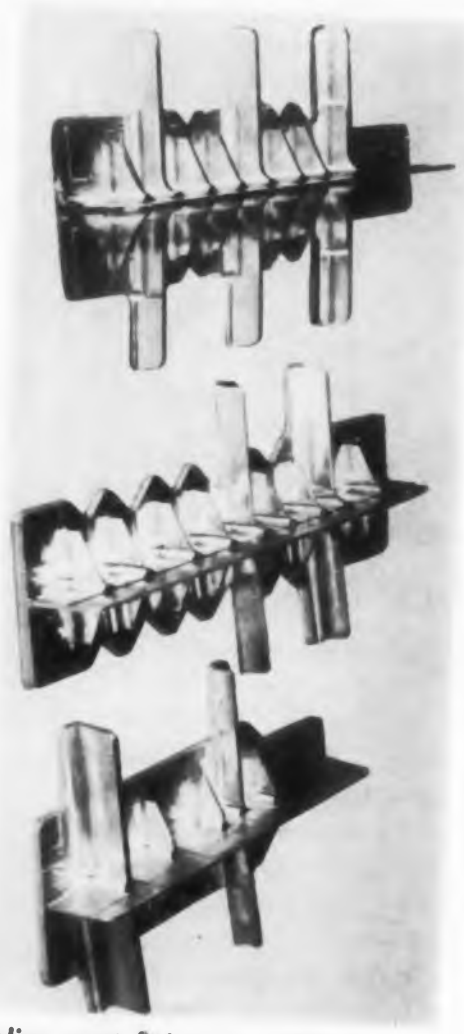
Machining of complex aircraft and missile parts has been efficiently and economically performed, in the past few years, by having punched paper tape operate a metal-cutting machine. The main disadvantage of the system has been the time required by a programmer to calculate the moves of the tool and then express this information into numerical form for the tape.

In a recent development, called APT (Automatic Programmed Tool), a high-speed digital computer prepares the numerical data necessary; savings in skilled manhours as high as 95 per cent are expected. APT was developed by the Massachusetts Institute of Technology, under an Air Force contract, with the cooperation of member companies of the Aircraft Industries Association.

APT Language

Thousands of separate machine control instructions can be developed through the use of a special language fed to a general purpose digital computer. For example:

"ON KUL, ON SPN, GO RGT, TL LFT, CIRCLE/CTR AT, +2, +3, RADIUS, 5."



Splice vent fittings for B52G bombers are typical of units turned out faster and at less cost through application of the APT System.

Translated this sentence means: Turn on the coolant, turn on the spindle, go right with the tool on the left side along the circle whose center is located at x equals 2, y equals 3, with a radius of 5."

The "language" consists of some 100 words, none containing more than six letters.

System Operation

The APT system then works as follows: A designer makes a rough drawing of a new part and turns the sketches over to a draftsman for a drawing. The part programmer takes the drawing and makes a general outline of the machining sequence. The outline is then written in the easily-learned APT language. These directions are punched on cards which are used to feed the problem to the computer. Ordinarily, a general-purpose computer could not understand these English-like directions, but by first reading-in a fixed master set of program cards, the general purpose computer is effectively transformed into a specially-designed APT computer. This computer can then understand the directions and transform the general information supplied by the designer into the numerous detailed instructions required to produce the part.

APT is the first system that can adapted by any company with a large computer, and is the first designed to meet the long-range requirements of advanced numerical control applications. Its simple language allows persons with no knowledge of computers to control the complex calculations that are required to program the machining of parts.

Savings

An example of the savings possible is evident in the programming task for a wing rib shape which required 200 manhours to program manually and only five hours by the APT-computer method.

NEWS BRIEF . . .

. . . **THE NATIONAL ELECTRICAL** Manufacturers Association and the International Association of Electrical Inspectors have concluded extensive cooperative studies with agreement to sponsor jointly a proposed revision to the 1959 National Electrical Code concerning the interchangeability of circuit breakers.

As announced by the Molded Case Breaker Section of NEMA, the proposed revision will require that circuit breakers be non-interchangeable in equipment rated within the range of 0.250 volts, ac, and not more than 100 amperes. Exceptions to the revision are circuit breakers which operate under conditions of maintenance and supervision which assure that overcurrent protective devices and branch circuit wiring will be maintained at proper rating.

WASHINGTON REPORT

Ephraim Kahn

Congress Questions Patents

Patent policy problems of the federal government appear to be almost ready to break the surface. Congress is getting more involved in the patent question. Not only must it decide whether to extend for five years the Atomic Energy Commission's stiff compulsory patent licensing rules, but the question of patents in the space field is sure to arise. At present, the electronics industry, for example, is working with ground-rules on patents that are subject to change in its dealings with the National Aeronautics and Space Administration. Patents resulting from NASA-sponsored research activity, unless waived, belong to the government. [See *ED*, April 1, p 17 for details on waiver conditions.]

The mood of Congress in the matter of patent rights seems to tend toward greater restriction. Industry, on the other hand, is becoming less and less inclined to voluntarily place itself in situations in which its hard-won high-cost know-how can be freely licensed to its competitors.

The patent question will come to a head in connection with atomic energy patent rules, which have been opposed by industry and most patent lawyers since they were enacted in 1954. Under the law, AEC may require that patents of "primary importance" to atomic energy be licensed. Though AEC has made it clear that it considers its compulsory licensing rights a "reserve power," not to be used unless essential, firms involved in development of the peaceful uses of atomic energy feel that the existence of this provision constitutes an ever-present threat. Two of three experts on the AEC's Patent Advisory Panel have urged that compulsory licensing be dropped. The third member suggested that the law be clarified so as to show that compulsory licensing is a reserve power. None of them suggested extending the licensing policy beyond its scheduled expiration, September 1, 1959.

But atomic affairs are inextericably interwoven with national defense, and here Congress often assumes a very rigid position. Despite the many differences between atomic and electronic research, however, Congress also shows a strong disposition to look upon any industry effort connected with the space program as being also related to defense. Electronics firms seeking more palatable deal in connection with their work

on space research will have to contend with opponents who will ring the changes on this position, expressed by President Eisenhower when he sent proposed atomic energy legislation to the Congress in 1954: "Until industrial participation in the utilization of atomic energy acquires a broader base, conditions of fairness require some mechanism to assure that the limited number of companies, which as government contractors now have access to the program cannot build a patent monopoly which would exclude others desiring to enter the field."

Even AEC—which has made no bones about being less than pleased with compulsory patent licensing—wound up making this equivocal statement when it decided to steer clear of a political fracas by requesting that its patent rules be unchanged for another five years: "The Commission feels, as it did in 1954, that patent incentives are a necessary and desirable stimulus to the development of peacetime uses of atomic energy. At the same time the Commission believes that the desirability of patent incentives must be balanced against the possibility of enlarging the preferred position of the necessarily limited number of companies, many of whom have developed their experience at public expense." Extension of this hard line to defense-related electronics and other primarily civilian industries has a surface appeal that many politicians might find difficult to resist.

Army Eases on Short Lead Times

The Army appears to be pulling in its horns in advocating the proposal of its former R & D chief, Dr. William H. Martin, that drastic steps be taken to cut lead-times. Dr. Martin had urged that the normal sequence of steps in weapons development be telescoped, so that several would take place simultaneously. Under this system, weapon evaluation, development, and prototype fabrication might all go on at once.

(Continued on following page)

WASHINGTON REPORT

Though Dr. Martin had not suggested that this system be applied across the board, he had proposed it for "more important projects" and had said that, in general, there should be good reasons for not using this approach. Normal development and production sequences and procedures, he implied, took so much time that there was a grave risk of finding that new weapons were obsolescent by the time they rolled off the production line.

Now, the Army concedes that there are disadvantages to overly rapid weapons development. But it continues to maintain that where speed is of the essence in obtaining new materiel of critical importance, the telescoping of normal sequences can pay off handsomely.

High-speed development contemplates that industry will take more risks, the Army says. Since a number of phases of development would go on concurrently, the results of one group's activities might force modification in (or even scrapping) the work of another. A certain amount of waste of money, labor, and materials is inevitable in such a program, the Army notes. It adds that an appropriate allowance for waste would have to be made in the planning and contracting for projects authorized under such a system of expedited development. Nevertheless, this technique is supported as a means of buying time (at an admittedly high price) when high-priority weapons are urgently needed.

Electronics Monopolies Developing?

Electronics firms are among the prime targets of the Justice Department's Antitrust Division this year. The question of the impact of mergers on competition in the field will be stressed, with the objective of preventing, "in the incipient stage the development of industrial market structures which, if not inhibited by government action, would ultimately expand the concentrated sectors" of the economy.

Growth industries are the logical and most fertile fields for such investigations—and high Justice Department officials have mentioned electronics specifically, along with chemicals and plastics. No "crash" program of antitrust actions is contemplated. The Justice Department plans to launch court actions only when it is fully prepared.

No segment of the electronics industry can look forward to immunity from the effects of the Justice Department's activities.

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

EDITORIAL

Consumers Should Get Reliability Too

There has been much talk in recent years that to maintain industry at a high level we must build obsolescence into our products. Advocates of this philosophy claim our products should become out of style in a year or so and plain junk not much later.

We disagree. We think electronics products should be made to last longer. We think brand new kinds of products should be marketed rather than continual reselling of face-lifted models.

Last year the nation spent more for repair and installation of electronics in the home than they did for new devices—$2.4957 billion for servicing and installation according to EIA's marketing data department director, Frank Mansfield, compared to $1.9 billion for new radios, phonos and TV.

This may suggest that consumer products should be designed to be less repairable so that they are junked faster. (Currently some estimate average life of a TV set is about nine years—ours has never lasted beyond four years.) But these figures also suggest that sets be made for easier and cheaper servicing.

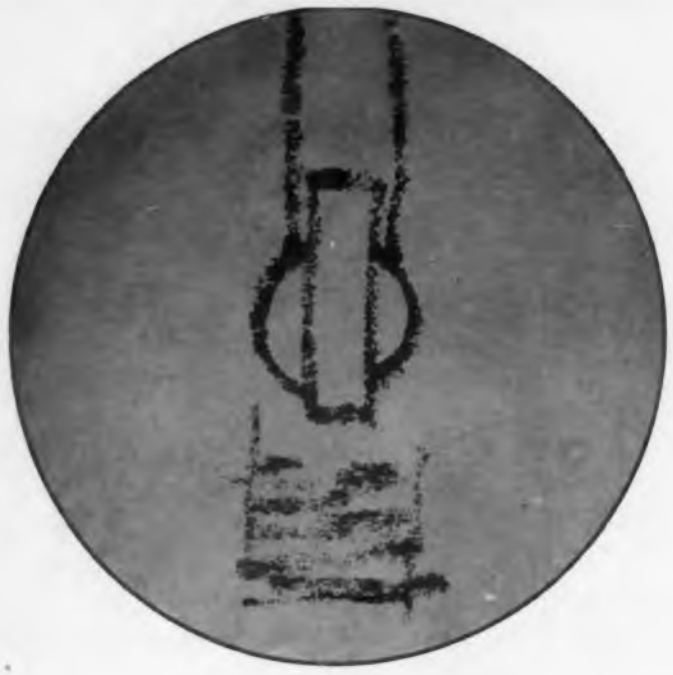
It is our fear that if sets are not made better and easier to service, there may be a consumer rebellion. It has been predicted by a household appliance expert that the housewife who lives in an all-electric home of the future will have to budget $800-$900 a year for repair of appliances. Such prospects will certainly keep many purchases from being made.

The time is here to improve reliability of consumer products. Motorola recently announced a new tuner that will use a reliable frame-grid tube. Although slightly more costly, Motorola will sell quality—fortunately with the frame-grid tube they can boast both better performance and longer life. Motorola hopes to eventually offer a warranty equaling that of refrigerators. RCA earlier this year announced components with a five year life. With a super reliable microelectronic component just around the corner, we can envision "life-time" radios.

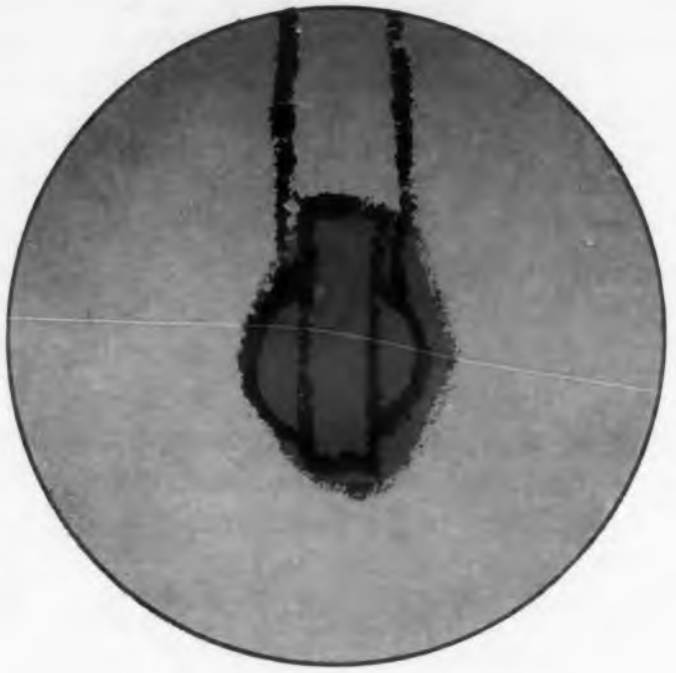
In the past our economic philosophy has been simply one of abundance of goods. Goods are tangible wealth. The tendency to use the word "consumerism" as the key to our philosophy is more subtle and possibly dangerous. It corrupts into: sell somebody this year and sell them the same product next year. This may stimulate productivity but it also fills the nation's dump pile and does not add to our national wealth.

We think the country will be better off if every consumer invested in ten different electronic products of lasting value rather than reinvesting his money every other year in a new model of the old product. This is the consumerism we'd like to see.

James G. Ryan



Methods of Encapsulating Electronic Parts in Epoxy



C. H. Carter
Project Manager
Insulating Resin Products
Minnesota Mining and Manufacturing Co.

C. H. Carter was an application engineer for Minnesota Mining for 10 years before assuming his present position. He is certainly in a position to speak with authority on the subject of potting.

What do you gain by potting? A great deal if it's done properly. In this article, the author discusses the questions involved in deciding whether or not to "pot." Then he discloses various methods of potting with epoxy resins and their advantages.

MORE RIGOROUS performance requirements for electronic components are turning more engineers and designers to encapsulation in epoxy resins. Particularly in the realm of military applications where rigid specifications must be met, the physical and electrical properties of this family of synthetic plastics are being employed to insulate and protect delicate components from rugged environmental conditions.

The decision to "pot" a given component poses a number of questions for the designer and for the production engineer:

- Does the part require complete impregnation of the component by the resin or is a surface coat providing a moisture barrier sufficient?
- What molding and curing facilities are available?
- Will the encapsulated unit be subjected to extreme thermal shock requiring a flexible resin coat or can a more rigid coating be used?
- Is physical abuse expected in operation and which type of resin will best withstand the type of physical shock the unit will undergo?
- Does the shape of the component lend itself to molding or should a dipping resin be used if possible? Answers to these questions will decide the type of epoxy.

Impregnating Epoxy Resins

In some cases epoxy resins are used in much the same manner as insulating varnishes were formerly used—to hold wires in place in moving equipment, to prevent electronic hum and to provide additional insulation and moisture proofing to the interior as well as the surface of the unit.

For such applications a resin which has great "wetting" power and penetration ability is used. Usually such epoxies are supplied in a two part form and mixed in proper proportion before using. These resins require molds surrounding the component, usually machined from steel or aluminum and coated with some release material to prevent the resin from adhering the mold

Fig. 1. Units dipped in thixotropic resin will meet military specs without the necessity for molding.

to the component. After the mold is poured full, it is placed in an oven and cured. Because of the 100 per cent solids composition of most epoxies, this curing does not dry the resin but causes it to "kick over" or catalyze under heat to become a solid mass. Just prior to "kicking over" the resin becomes very fluid and is capable of penetrating even small voids between wires in a tightly wound coil.

One company used a flexible version of such a resin to obtain an increase of 1000 volts output from a small magneto used for a variety of small motors. A production increase of over 50 per cent was also realized by switching from the previously used polyester resin to an epoxy.

Test magnetos were out with the winding to determine the degree of penetration the resin was achieving.

Encapsulating Epoxy Resins

Some components are so designed as to need very little of such impregnation. These components are frequently encapsulated or encased in a shell of epoxy resin to present a void-free, moisture proof case of insulating material which pro-

Fig. 2. (above) Male master for a single piece transformer mold is made of highly polished aluminum to provide a good release from the low-melting alloy mold metal and impart a smooth finish to the interior of the mold.

Fig. 3. (left) Male master is dipped into a heated pot of mold metal where the aluminum conducts the heat away from the molten metal surrounding the master, forming a thin shell of solidified metal for the mold.

Fig. 5. (below) Transformer assembly is positioned in the mold in preparation for pouring.

Fig. 4. (right) Master is withdrawn from the shell formed around it in the pot while the mold metal is hot for easy release.

vides electrical, moisture and physical protection for the encased unit.

Encapsulating resins are usually thicker than impregnating resins, after the resin and catalyst are mixed. They cover the component but do not impregnate, except near the surface.

Such encapsulating resins can be (1) case around the component in a mold or (2) the unit can be dipped into the resin until the proper buildup is achieved.

One aircraft company completely redesigned a delicate transformer to take advantage of the properties of an epoxy encapsulating resin. The transformer was wrapped in an epoxy impregnated tape which was allowed to protrude beyond the ends of the unit. Then the bottom cup formed by the protruding tape was filled with a thixotropic resin and the encapsulating resin was poured into the top opening to complete the encapsulation.

This system provided a transformer that not only met the requirements of Mil-T-27A but also passed a more difficult test devised by the manufacturer. The unit was given three thermal shock cycles according to Mil Std. 202. Then it was placed in cold water which was brought to a boil and held there for two hours. After the boil, the insulation resistance of the unit was tested and found to be unaffected by the punishment.

Another electronics firm used a dipping resin to meet the same military specification with no molding at all—simply by dipping the units into a thixotropic resin (Fig. 1).

The transformer coil was heated and then dipped into the resin and evacuated. Then it was placed on a vibrating table to drain with the vibration smoothing the resin to a porcelain-like finish with excellent moisture resistance and finished appearance. The process is repeated for the second dip and the resin "baked out." The finished transformer passed Mil-T-27A with no waiver.

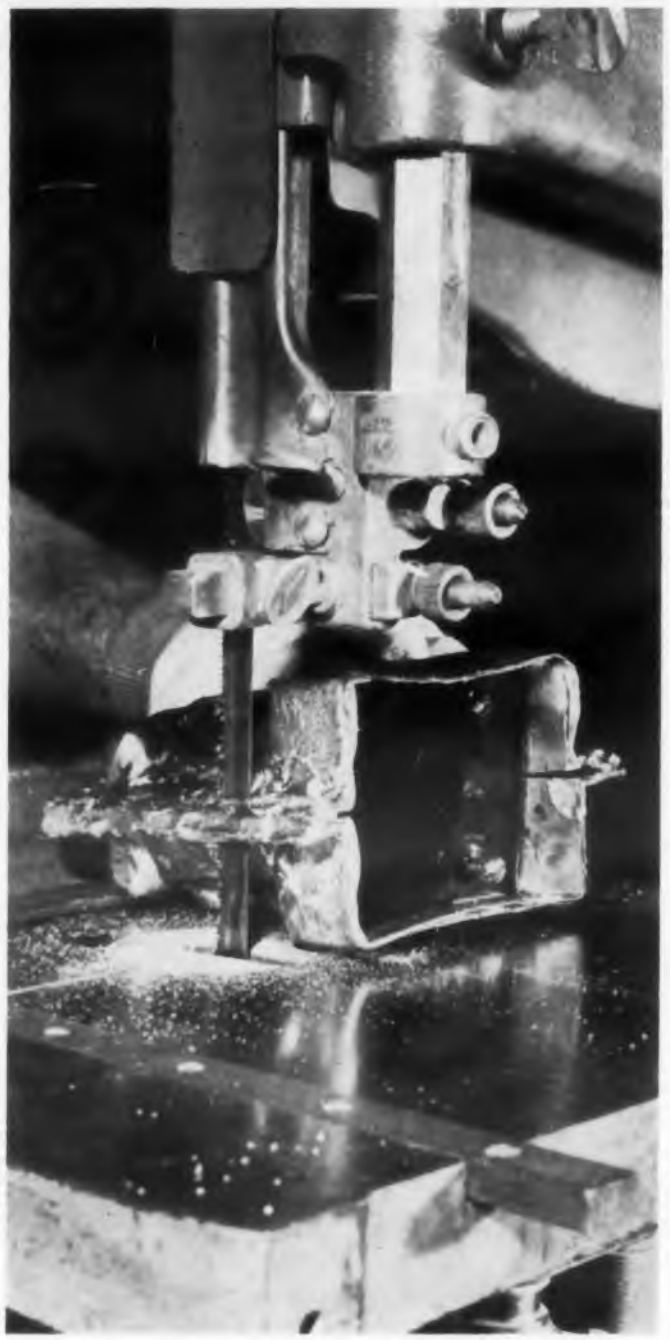
To Mold Or To Dip?

Which application process to use must be determined by the end properties desired in the completed unit, whether impregnation is necessary and of course, by the production costs involved.

Generally speaking, it is cheaper and easier to dip a unit than to cast it into a mold. Making and maintaining molds and the limiting of production amounts to the number of molds available can be expensive. Molding is generally re-

Fig. 7. (right) With the flanges cut on a band saw or by some other method, the completed transformer can be easily removed by tapping the mold edges. If this is done carefully, the mold can be re-used.

Fig. 6. (below) With the transformer in position, the mixed resin is poured and the molds placed in an oven for baking.



quired for impregnation.

However, cases which call for encapsulation but which have many sharp corners might cause edge voiding under a dipping resin. These may require molds.

Arma Division of American Bosch-Arma Corpp solved its molding problem by adapting the foundry slush-casting technique to a mold making process. A highly polished metal master die (Fig. 2) is machined to the desired shape of the mold from aluminum and is dipped into molten low melting alloy. The die is cooler than the metal and conducts heat away from it, forming a thin shell of the metal around the die (Fig. 3). When the die is removed from the melting pot, the shell slides off the polished surface of the die and a mold is ready for pouring (Fig. 4). The remaining operations are shown in Figs. 5-7.

As many or few molds as are needed can be made easily and can be re-melted and used over and over.

Components which require two piece molds are made with a die having a dividing flange which is cut off the formed mold and re-sealed around the unit with a hot iron.

This system, using an alloy obtained from the Cerro De Pasco Co., eliminates the problems of mold maintenance and replacement since damaged molds are simply tossed into the pot and reused.

Why A Flexible Resin?

Generally speaking, the more critical the part to be treated, the more difficult the encapsulating of that part will be. Functions of very delicate parts can be easily thrown off by the shrinking of resin as it is cured around them.

One way around this problem is to use a resin which is flexible—having enough "give" to allow for a reasonable amount of shrinkage during cure without inflicting physical damage to the component. Also, applications subject to extreme temperature variations nearly demand a flexible resin to avoid cracking under thermal shock.

Some rigid resins can be made flexible by adding flexibilizing agents. Others are furnished in a flexible form. Minnesota Mining and Manufacturing Co. offers a family of resins that have an inherent "give." These resins look and feel glass-hard but inch thick cast plates can be pounded with a hammer without leaving a dent due to the shock absorption and recovery abilities of the resin.

Components which are expected to withstand extremes of temperature usually require a flexible resin to give with the expansion and contraction caused by heating and cooling. Encapsulated units meeting military specifications nearly always use flexible resins as an encapsulant.

New Epoxies

A recent development in epoxies is a completely dry resin furnished as a powder and used as a dipping resin for encapsulation. The powder is placed in the upper chamber of a divided cylinder and compressed air is forced into the lower chamber, through a dividing membrane and up through the resin powder. This imparts the characteristics of a simmering liquid to the powder.

Heated parts are then dipped into the powder where the heat melts the resin surrounding the part, causing it to adhere to the part. Coating thickness is controlled by temperature of the dipped unit, length of dip, and number of dips used.

Advantages of this system are numerous. The resin has a virtually infinite pot life since no mixing in of a catalyst is necessary. No resin is wasted, no molds are necessary and the coating can be accomplished neatly and quickly.

Still developmental are resins having the flexibility of rubber with the application ease and insulating qualities of epoxies. Resins in this family are said to be so resilient as to bounce like rubber balls and yet not sacrifice the familiar properties of now known resins.

A casting system that uses sand particles that are coated with a resin catalyst and then molded around the part, with the resin then being introduced by capillary action, is in the experimental stage.

Existing products and those in development indicate casting and coating in epoxies are techniques which will become more important as aids to the electronic designer for some time to come. ■ ■

DESIGN FORUM

Millimeter Power Meters

MILLING COPPER WAVEGUIDE down to 0.01 in. and using clever heat isolation techniques permitted production of mm-wave calorimeters that will measure power down to 0.2 mw—with better than one per cent accuracy.*

Heat isolation and the construction of accurate 2 mm waveguides—2 mm is smaller than the cross-section of a paper match—were the principal problems faced by Microwave Engineering Laboratories, Inc., 843 Industrial Ave., Palo Alto, Calif., in building the calorimeters. The outer box is aluminum and is filled with styrofoam for insulation. Aluminum foil lines the inner cavities where the waveguide graphite load elements are located, as in Fig. 1.

Heat Isolation

Heat had to be prevented from backing up the copper waveguide—a good thermal as well as electrical conductor.

Preliminary attempts to produce by electroforming a good heat isolating section that would also be a good mm-wave-conducting section resulted in failure. When the stainless-steel mandrel was pulled out, the 0.0005 in. copper buckled. Likewise, when an aluminum mandrel was used and etched out of the copper shell, the walls proved uneven. A number of other approaches were tried without conspicuous success, until standard waveguide was milled down to 0.010 in. and the walls physically cut.

This was done by soldering a flange on one end and potting an inch of the flanged end with epoxy resin. The hardened resin was turned on a lathe so it would fit closely into a sleeve made of standard polystyrene tubing.

At this point the potted waveguide section was sawed through transversely, and a 0.075 in. section removed. The waveguide was then put together again inside the polystyrene sleeve with a 0.0005 in. sheet of Teflon separating the two sections. Heat isolation is very good, with low insertion loss and vswr.

In the 4 mm unit, the graphite load is about one inch long and has a vswr of less than 1.20; and a loss of about 40 db. It has solderable copper contacts on each end so dc power can be dissipated in it for calibration. The 0.0005 in. mica

* There are no standards to check the calorimeters against. While dc calibration shows the above accuracy figure, there is still a question of what the systems' efficiency at some 300 kmc is. It is presumed, however, to be very close to 100 per cent.

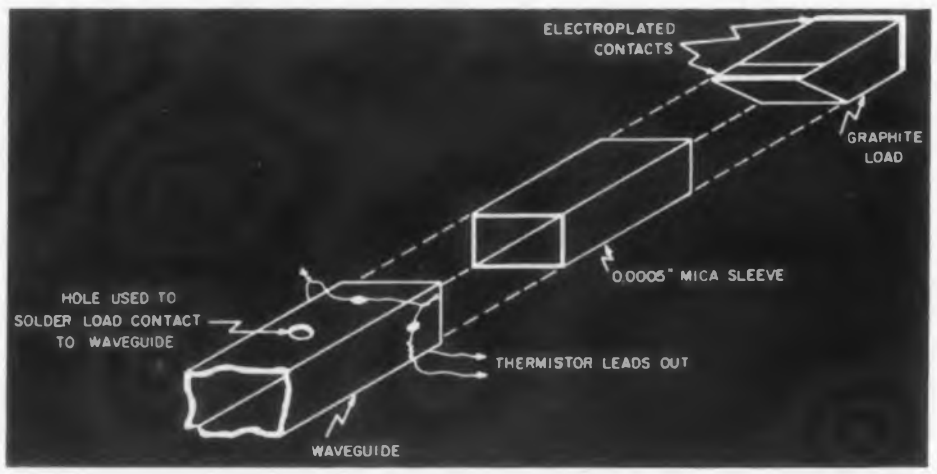


Fig. 1. Exploded sketch of load end of waveguide used in calorimeters. Potting and transverse cut described in the test not shown.

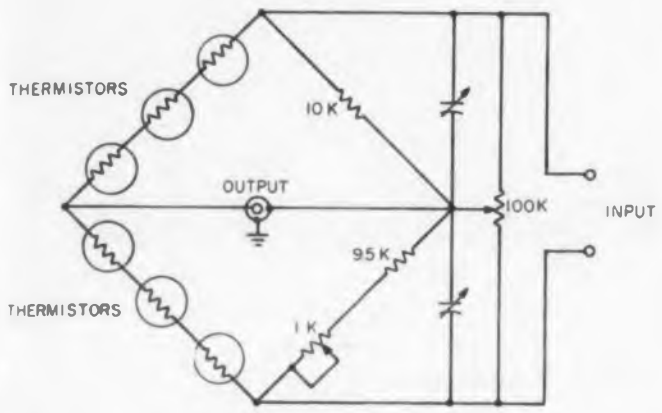


Fig. 2. Calorimeter bridge circuit. Each string of three thermistors is cemented to a waveguide section in the calorimeter. Each string of three thermistors has the same resistance—about 10.5 K at 25 C.

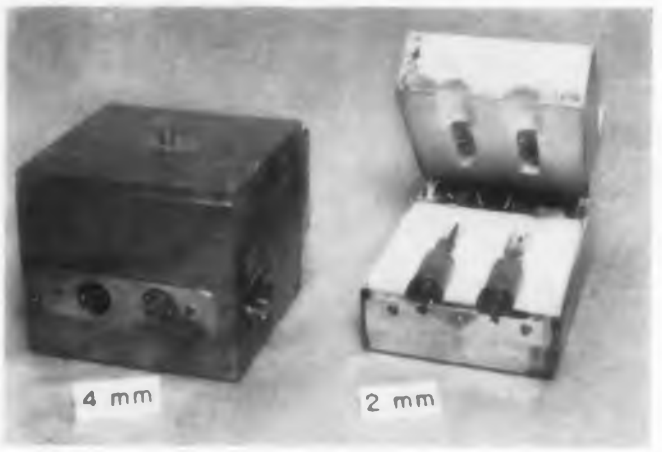


Fig. 3. Calorimeters for use in that hazy upper limit of the EHF band—300 kmc. Sensitivity of 4 mm meter is 0.2 mw with practical upper limit of 20 mw. At 2 mm range is 20 db from 0.35 mw to about 35 mw.

sleeve shown in the drawing insulates the remainder of the load from the waveguide; in this way the dc resistance from one end to another is not affected by contacts to the waveguide.

All the leads into the calorimeter are of #40 copper wire and contribute negligibly to thermal leakage.

Shown in Fig. 2 is the temperature indicating bridge. Input is 1000 cps sine wave; the output indicator is a tuned amplifier in the form of a standing wave indicator. It is used as a deflection bridge, rather than a null bridge. It is balanced with the two thermistor strings at the same temperature; then a known load of dc power is dissipated in one of the loads. Bridge unbalance is recorded as a function of time for calibration.

For further information on these mm-wave calorimeters, turn to the Readers Service Card and circle 475.

Worst Case Design Equations for Transistor Logic Circuits

Carl W. Campbell, Jr.
Burroughs Research Center
Paoli, Pa.

Under some circumstances, it becomes necessary to operate Resistor-Transistor Logic (RTL) circuits at extreme conditions, such as high temperature, or with special transistors, such as silicon types. Previous approaches do not provide for such unusual circumstances. A more rigorous approach is developed and presented to permit a wider range of application.

WORST-CASE design philosophy involves consideration and calculation of individual circuit components at their most detrimental steady-state conditions rather than conventional design with a safety factor thrown in.

Diode-Clamped Resistor Transistor Logic

A diode-clamped resistor-transistor logic (or *RTL*) circuit is shown in Fig. 1. In this circuit, if all the inputs are at ground potential, the base will be at, or more positive than, ground because of the positive bias provided by R_3 to plus V_3. Therefore, the transistor will be "off," and the output will be clamped at minus V_2 by the diode, since V_1 is much larger than V_2.

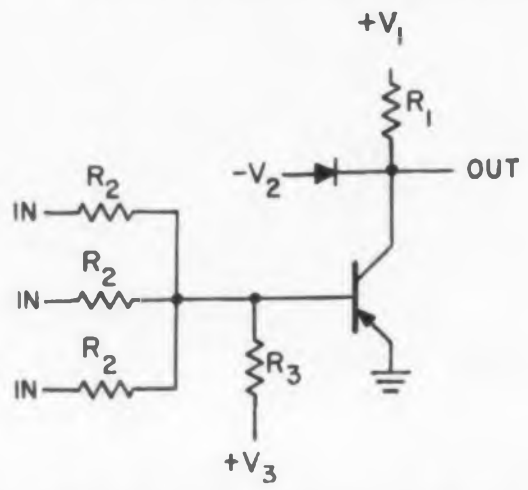


Fig. 1. Basic Diode-Clamped Resistor-Transistor Logic (RTL) Circuit. Voltage V_1 is much larger than V_2, permitting diode to conduct when transistor is cutoff.

Now if any one or any combination of inputs is lowered to −4 v, the transistor will be caused to conduct and saturate, thus bringing the output to ground potential. Clearly this device functions as a negative "or" positive "and" gate along with an inverter.

It is possible to have *RTL* without the diode clamp. However, certain advantages make the clamp often worthwhile. First, it now becomes possible to make V_1 a high voltage and R_1 a large resistor so that the combination approximates a constant current source. This means that the current available in the "minus V_2 state" to drive other stages becomes more nearly equal to the required collector current when the transistor is conducting. Second, if only a few stages are being driven from the collector, they will not be saturated any harder than if many stages were driven. Third, it can easily be assured that the transistor will never exceed its emitter to collector breakdown voltage. The analysis will assume that the diode is present, although most of the equations developed would apply even if it were not.

Derivation of Design Equations

In Fig. 2, one *RTL* stage is shown driving up to "*N*" other such stages. Each of these "*N*" stages is assumed to be driven from a maximum of "*M-1*" other such stages. In the development presented, four different conditions are assumed, each leading to an equation. These equations are then solved simultaneously for the unknown quantities.

Condition I: T_1 on, T_2 . . . $T_N + 1$ on.

It is first necessary to calculate the maximum collector current which will ever be required to flow through the collector of T_1 when this transistor is conducting. Collector current can flow:

(1) Into the collector resistor, R_1.
(2) Into the N driven base resistors.
(3) Into the diode, as leakage current.

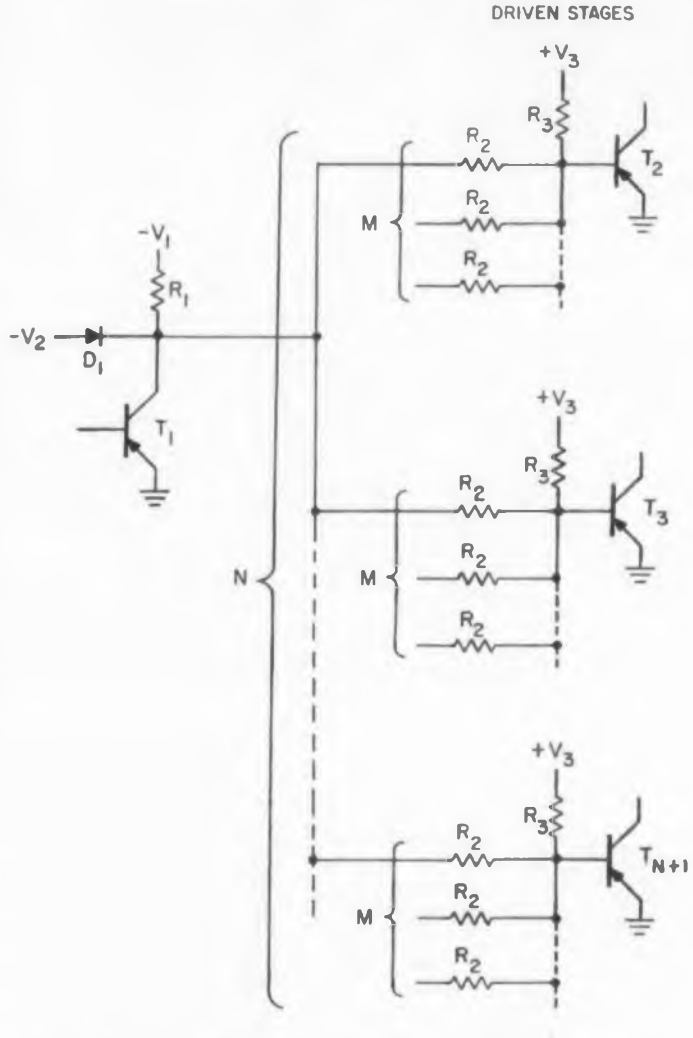


Fig. 2. One RTL stage driving up to "*N*" other stages. Each of the "*N*" stages is assumed to be driven from a maximum of "*M-1*" stages.

Each of these three currents must be calculated. The collector current is their sum:

(1) Current into the collector resistor:
The maximum value of this current is given by:

$$\text{(Equation 1)}\quad \bar{I}_{R_1} = \frac{\overline{V}_1 - \underline{V}_{CE}}{\underline{R}_1}$$

where a bar over a quantity indicates the maximum possible value of this quantity, while a bar under a quantity means that its value is at a minimum.

I_{R1} is the current flow through R_1. V_{CE} is the emitter to collector drop across a saturated transistor. The other quantities are defined by Fig. 2.

This equation states that the maximum current through the resistor R_1 occurs when the resistor is at the minimum possible value, and the voltage drop across it is at a maximum.

(2) Current into the N base resistors:
The maximum value of this current is given by:

$$\text{(Equation 2)}\quad \bar{I}_{NR2} = N\,\frac{\overline{V}_{BE} - \underline{V}_{CE}}{\underline{R}_2}$$

where I_{NR2} is the current through the N base resistors, and V_{BE} is the forward base to emitter drop across a transistor.

The equation states that the maximum current flow into the base resistors will occur when the driving collector is at its least negative potential, the driven bases are at their most negative potential (hence the driven stages are assumed conducting, being driven by one or more of the other base resistor inputs), and the resistors, R_2 are all minimum.

(3) Current into the diode, as leakage current:
This current is a function which depends upon the diode to be used, and the maximum possible operating temperature. It will be designated: $\bar{I}_{LD}$: maximum diode leakage current.

Adding these three currents gives us the maximum possible collector current, $\bar{I}_C$, that can possibly occur:

$$\text{(Equation 3)}\quad \bar{I}_C = \frac{\overline{V}_1 - \underline{V}_{CE}}{\underline{R}_1} + N\,\frac{\overline{V}_{BE} - \underline{V}_{CE}}{\underline{R}_2} + \bar{I}_{LD}$$

Condition II: T_1 on; T_2 off.
In order to assure that T_2 is truly off, its base must be equal to or more positive than the emitter potential, ground.

In addition, base to collector leakage current must be supplied to the base. This is current which flows into, rather than out of the base. In order to accomplish this, a large resistor (R_3) to a large positive voltage (V_3) is provided as shown to approximate a constant-current source.

This constant current must do two things:
(1) It must cause enough drop across the M base

resistors to assure that the base will be at or more positive than ground.

(2) It must supply the base to collector leakage current. Under worst case conditions, V_3 will be at a minimum, and R_3 at a maximum, so that the constant current will be at the minimum possible value. The currents required by the M base resistors will be a maximum, meaning that all M of them are at the minimum possible value, and that the input to each is driven by an "on" transistor, with the maximum possible emitter to collector drop. In addition, worst case conditions call for the base to collector leakage current, I_{LB} to be at a maximum value. Expressing these conditions mathematically, we have:

$$\text{(Equation 4)}\quad \frac{\underline{V_3}}{R_3} = M\,\frac{\overline{V_{CE}}}{\underline{R_2}} + \overline{I}_{LB}$$

The $\overline{I}_{LB}$ which appears in the above equation is actually the reverse base-current. In many applications, it is desirable to provide a large reverse base-current to more quickly overcome the effects of hole storage. The actual value of this current can best be determined experimentally for the required turn-off time and for the transistors in question. If this value turns out to be larger than the base leakage current, this larger value is inserted in all equations in place of I_{LB}.

Condition III: T_1 off: T_2 on, with $\overline{R_2}$.

It is necessary to assure, when the collector of T_1 is at its least negative value (with T_1 off), that enough base current will be drawn to saturate T_2. Under these conditions, three currents will flow through R_2:

1. Base current from T_2. This must be sufficient to saturate the transistor.
2. The current provided by R_3 to plus V_3.
3. The reverse current flowing through the other M-1 base resistors, assuming each is connected to a conducting transistor and hence at a less negative potential than the base of T_2.

The sum of these three currents composes the current which must flow through the R_2 which is connected to T_1. Under worst case conditions, this resistor will be at its maximum possible value, the base of T_2 will be at the most negative possible potential, and the collector of T_1 will be at the least negative potential possible when T_1 is off. In addition, the three currents mentioned above will all be at their maximum possible values. This means:

(1) Maximum collector current and minimum beta, β, causing maximum base current.

(2) Maximum V_3 and minimum R_3, together with maximum V_{BE}.

(3) Minimum R_2 and minimum V_{CE}, together with maximum V_{BE}.

From this information we can write the following relationship:

$$\text{(Equation 5)}\quad \frac{\underline{V_2} - \overline{V_{BE}}}{\overline{R_2}} = \frac{\overline{V_3} + \overline{V_{BE}}}{\underline{R_3}} + (M-1)\,\frac{\overline{V_{BE}} - \underline{V_{CE}}}{\underline{R_2}} + \frac{\overline{I_C}}{\underline{\beta}}$$

In this equation, $\underline{V_2}$ is used as the minimum negative potential for the collector of T_1. The worst case conditions here call for V_2 to be at its minimum negative value, and the drop across the diode to be at its minimum possible value, assumed to be 0. Thus when the diode, D_1, is conducting, the least negative possible collector potential is given by $\underline{V_2}$. It is now assumed that when the maximum current is flowing through R_1 from the driven bases, the potential of the collector will still be equal to or more negative than V_2. This will be considered in Condition IV.

Condition IV: T_1 off; T_2 on with $\overline{R_2}$; T_3 . . . $T_N + 1$ on with $\underline{R_2}$.

A driven stage, when its R_2 is a maximum, will not function under worst-case conditions unless the collector potential of the drive stage is equal to or more negative than $\underline{V_2}$. Assume that this will be true under conditions which make the collector its least negative possible potential. This will be the case when a maximum current is being drawn from the N-1 other driven stages, or in other words, when the other N-$1R_2$ resistors are all at their minimum value. In addition, the worst-case condition will exist when the current-handling capability of the T_1 collector circuit is at a minimum. This will occur for a minimum value of V_1 and a maximum value of R_1. Furthermore, collector leakage current, I_{LC}, will be a maximum. Under these limiting conditions, the diode will not be conducting as the voltage drop across it is O, or it is back biased so that it may be neglected for this set of conditions. Thus one driven stage exists with a maximum value of R_2, and N-1 stages with this value a minimum. V_1 is assumed to be a minimum and R_1 a maximum. Collector leakage current is also maximum. Under these conditions assume that the collector potential will be equal to or more negative than $-\underline{V_2}$, in order to assure saturation of that transistor with the $\overline{R_2}$ base resistor. The situation can be expressed mathematically by the following equation:

$$\text{(Equation 6)}\quad \frac{\underline{V_1} - \underline{V_2}}{\overline{R_1}} = \frac{\underline{V_2} - \overline{V_{BE}}}{\overline{R_2}} + (N-1)\,\frac{\underline{V_2} - \underline{V_{BE}}}{\underline{R_2}} + \overline{I}_{LC}$$

The first term represents the available drive current. The second term represents the current which must be drawn from that transistor with the maximum base resistor. The third term represents the current which the N-1 minimum base resistors will require. The last term represents collector leakage current.

There are now four equations (Eq. 3 to Eq. 6) each describing a different operating condition for the circuit. Consider the voltage values as known, and the value of M as given. There are now four equations with four unknowns, where the values of resistors and N are unknown.

In order to solve these equations, express the maximum and minimum resistor values in terms of the nominal value and the fractional tolerance, T_R. Thus R maximum is given by: $R\,(1 + T_R)$, and R minimum by $R\,(1 - T_R)$. This fractional tolerance must include both the variation possible in any one resistor value, and the spacing between existing resistor values.

The only unknowns in equations 4 and 5 are R_2 and R_3. Therefore, these two equations may be solved simultaneously to give the following results:

$$\text{(Equation 7)}\quad R_2 = \frac{AD - EB}{CE + AF}$$

$$\text{(Equation 8)}\quad R_3 = \frac{AR_2}{B + CR_2}$$

where:

$$A = \frac{\underline{V_3}}{1 + T_R}$$

$$B = \frac{M\,\overline{V_{CE}}}{(1 - T_R)}$$

$$C = \overline{I}_{LB}$$

$$D = \frac{\underline{V_2} - \overline{V_{BE}}}{(1 + T_R)} - (M-1)\,\frac{(\overline{V_{BE}} - \underline{V_{CE}})}{(1 - T_R)}$$

$$E = \frac{\overline{V_3} + \overline{V_{BE}}}{(1 - T_R)}$$

$$F = \frac{\overline{I_c}}{\underline{\beta}}$$

Having calculated the values of R_2 and R_3 check the table of available resistor values and pick the nearest existing value. The maximum

and minimum value of these resistors are now found.

To find R_1 and N from equations 3 and 6:

$$\text{(Equation 9)}\quad R_1 = \frac{H/J + K/P}{G/J + L/P - 1}$$

where:

$$G = \bar{I}_c - \bar{I}_{LD}$$

$$H = \frac{\bar{V}_1 - \underline{V}_{CE}}{(1 - T_R)}$$

$$J = \frac{\bar{V}_{BE} - \underline{V}_{CE}}{\underline{R}_2}$$

$$K = \frac{\underline{V}_1 - \underline{V}_2}{(1 + T_R)}$$

$$L = \frac{\underline{V}_2 - \bar{V}_{BE}}{\bar{R}_2} + \bar{I}_{LC}$$

$$P = \frac{\underline{V}_2 - \underline{V}_{BE}}{\underline{R}_2}$$

Once R_1 has been calculated, its value is selected from the resistor value table. Its maximum value is then found and put into the following equation to determine N.

$$\text{(Equation 10)}\quad N = \frac{\underline{V}_1 - \underline{V}_2}{\bar{R}_1 P} - \frac{L}{P} + 1$$

Conclusion

The equations which have been presented are considered completely rigorous insofar as the assumptions concerning the behavior of resistors, power supplies, transistors, and diodes are valid. Factors such as diode and base leakage current, neglected under previous approaches, have been considered. One would expect, since the conditions imposed in this approach are more stringent than those of previous approaches, that the calculated results would be considerably less favorable. From the standpoint of M to N relationships, this is not the case. The calculated results obtained are about as favorable as those previously calculated. This is due to a somewhat different logical approach which avoids over worst-case designing.

Circuits using the values calculated by the present method have been tried and found to function quite satisfactorily. ■ ■

Mr. Campbell is Project Engineer at the Burroughs Corp. Research Center, Paoli, Pa. He is in charge of a group responsible for the design of all digital circuits in a military computer project. In his opinion, Resistor-Transistor Logic circuits will become more common as transistors are further applied to computer switching applications.

Triple-Triode Tube Saves Space, Money

THREE triodes are packed into this tube which can help designers save both space and money. Labeled the 6EZ8, the tube is claimed to be the first one of its type being made.

The 9-pin miniature unit packs a cumulative plate dissipation of 5 w in one T-6-1/2 envelope. Thus it is less expensive and less space-consuming than the equivalent string of transistors necessary to do the same job.

Applications

Made by General Electric, Receiving Tube Dept., Owensboro, Ky., the tube can serve as a

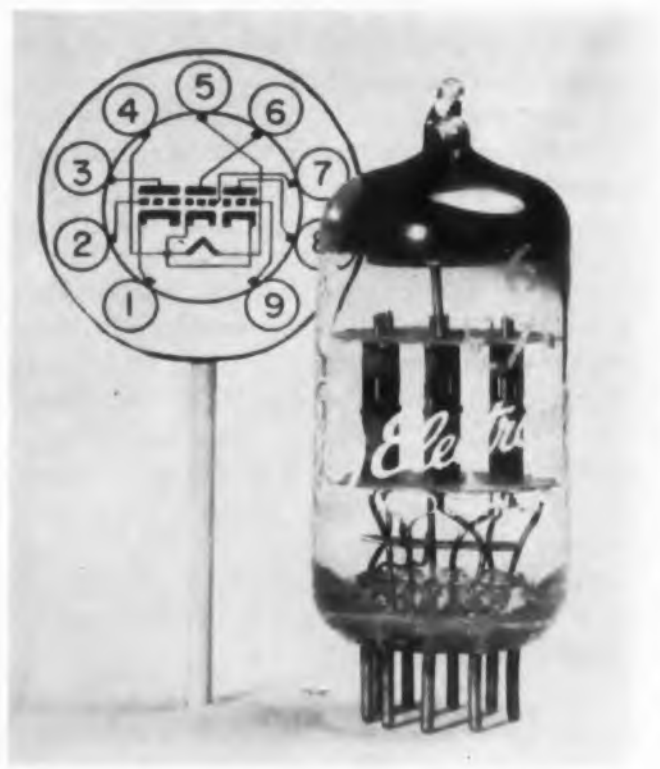


Fig. 1. Having three triodes packed into one envelope, this tube can serve as a one-tube tuner for frequencies as high as the fm band.

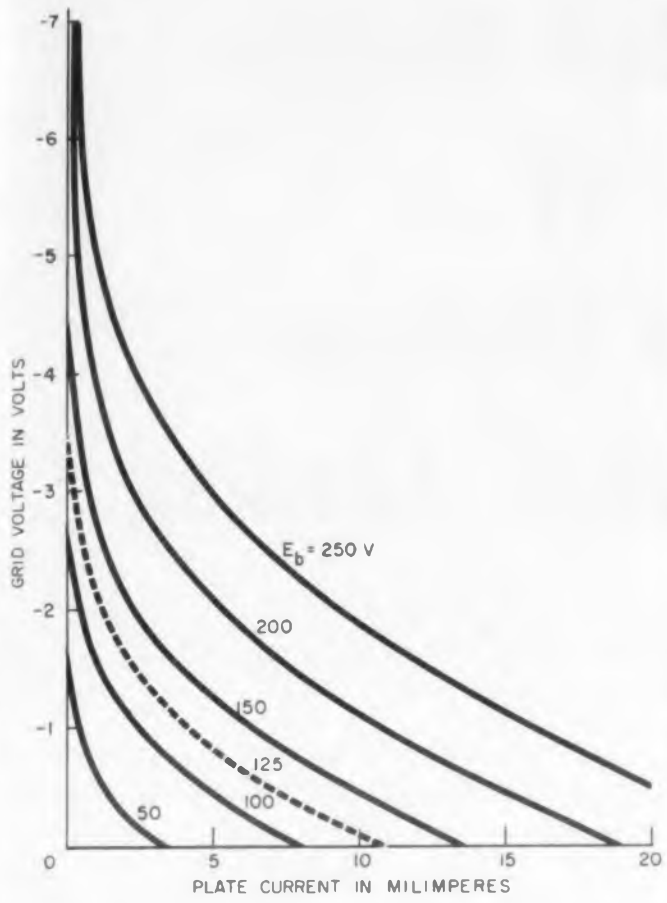


Fig. 2. Average transfer characteristics of each triode section of the 6EZ8 are given above.

one-tube tuner for frequencies as high as the fm band. Other applications include:

- Rf amplifier.
- Oscillator and mixer.
- Oscillator, mixer and afc tube.

Similar to the 12AT7 tube, the 6EZ8 has interelectrode capacitances that vary by only a few tenths of a micromicrofarad from those of the 12AT7. The cathodes of two of the three 6EZ8's sections have a common connection with one side of the heater. But the tube's third cathode is brought out to a separate pin. Each triode in the tube is rated for a maximum of 330 plate volts, and 50 v negative dc on the grid.

Electrical Ratings

In typical operation with 125 v on the plate and −1 v on the grid, each section has an amplification of 57 and a transconductance of 4200 micromhos. The plate resistance is 13,500 ohms and the tube draws 4.2 ma.

Heater voltage for the tube is 6.3 ±10% v and the heater draws 0.45 amp. Although the total plate dissipation is rated at 5 w, the plate of each tube has a maximum rating of 2 w. Grid to plate capacitance for each triode section is 1.5 μμf with or without a shield. The tube can be mounted in any position.

For more information on this triple-triode tube, turn to the Reader's-Service card and circle number **102**.

Graphical Design of Phase Shifters With Reactive Loading

Paul A. Ryan
Dytronics Co.
Columbus, Ohio

DESIGNING phase shifters under ideal conditions is relatively easy. But when these phase shifters are loaded reactively, complications set in. The equations and graphical design approach given here can simplify the design of these circuits.

Probably the most common form of phase shifter in use is the one illustrated in Fig. 1. This circuit is the three-terminal equivalent to an all-pass, half-lattice type, four-terminal network. The active element as the phase splitter makes possible the common input and output ground terminals.

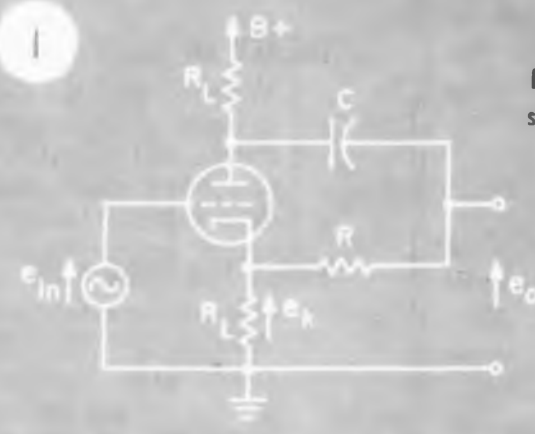


Fig. 1. Basic phase shift circuit.

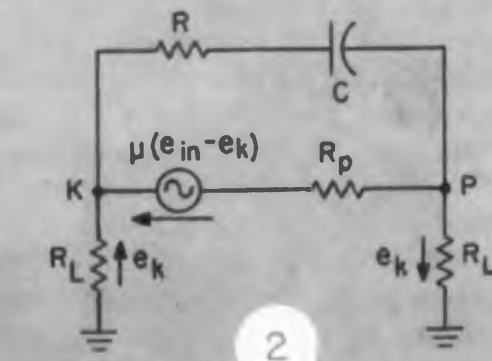


Fig. 2. Linear equivalent network associated with the basic phase shifter.

Paul Ryan, graduate of Ohio State U., has had extensive experience in developing a line of phase measuring instruments.

The graphs he presents in this article will help many engineers design a very popular phase shift circuit more accurately. Many engineers have been using design approximations which can result in very significant errors.

Provided the impedance of the network formed by R and C is very high, the phase shift introduced by this circuit will be

$$\phi \text{ (lag)} = 2 \tan^{-1} \omega RC \qquad (1)$$

and the magnitude of the circuit transfer function will be independent of phase shift.

However, the complex impedance formed by the elements R and C will always be of finite value and the circuit will not follow the idealized equations.

Development of Equations

The linear equivalent network for the circuit of Fig. 1 is shown in Fig. 2. In this figure as well as in the circuit in Fig. 1, the unorthodox designations for the cathode resistor and the plate voltage are used to stress that the two resistors and ac voltages are equal. The equations hold only if this is true. As a result, the phase splitter has the very nice property of supplying a balanced set of voltages in phase opposition, regardless of the impedance connected between plate and cathode.

It should be noted also, that in this article, the term "phase shifter" refers to the entire circuit, while "phase splitter" excludes the RC network. Also, all the voltages are steady-state values.

Solving the equivalent network for e_k/e_{in}, we get

$$\frac{e_k}{e_{in}} = A\left[\frac{1 + j\,\omega RC}{1 + j\,\omega RC\left(1 + \dfrac{2A}{RG_m}\right)}\right] \qquad (2)$$

where the gain of the tube

$$A = \frac{\mu R_L}{r_p + R_L(\mu + 2)} \qquad (3)$$

(Continued on page 40)

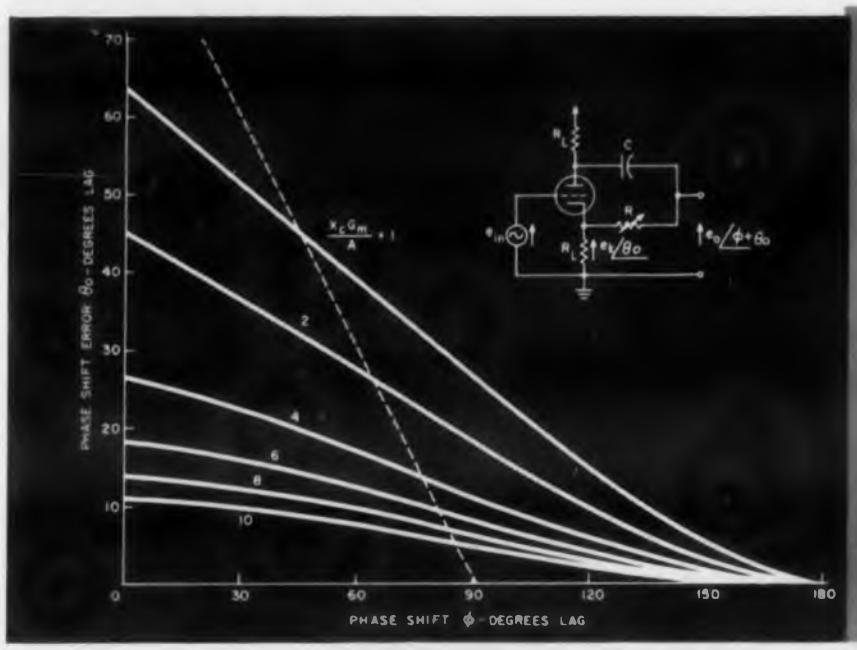


Fig. 3. Variation of phase shift error θ_o with circuit phase shift φ, when R is varied.

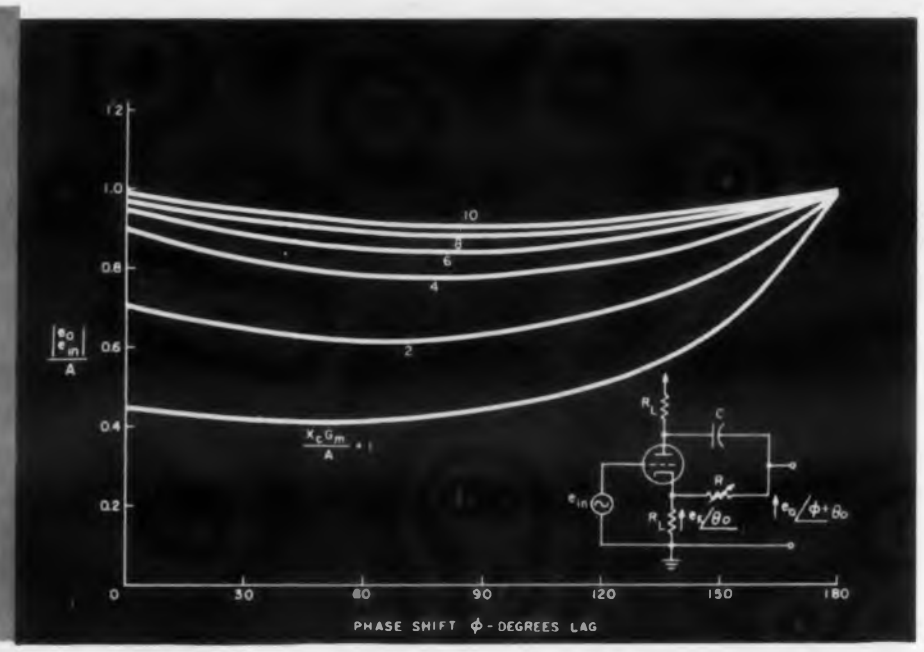


Fig. 4. Variation of circuit gain with circuit phase shift when R is varied.

Notice that regardless of loading by the RC element, the plate voltage will always be equal to and in phase opposition with the cathode signal. The ratio e_o/e_k can therefore be expressed as

$$\frac{e_o}{e_k} = \frac{1 + j\,\omega\,RC}{1 - j\,\omega\,RC} \tag{4}$$

or

$$\frac{e_o}{e_k} = 1.0 \angle \phi \tag{5}$$

where ϕ is given by Eq (1) and is expressed in degrees lag, to omit the conventional negative sign.

Combining Eq (1), (2), and (4) to solve for the phase angle of e_k/e_{in} results in

$$\tan \theta_o = \frac{\sin \phi}{\left(1 + \frac{RG_m}{A}\right) - \cos \phi} \tag{6}$$

where

$$\frac{e_k}{e_{in}} = \left|\frac{e_k}{e_{in}}\right| \angle \theta_o$$

and θ_o, the phase error which must be added to ϕ to determine the total circuit phase shift, is also expressed in degrees lag to avoid the negative sign.

Eq (6) shows this phase shift error in the phase splitter as a function of the angle ϕ with constant R and constant tube parameters.

For constant C and constant tube parameters, the phase shift error is given by

$$\tan \theta_o = \frac{1 + \cos \phi}{\left(\frac{X_C\,G_m}{A}\right) + \sin \phi} \tag{7}$$

The gain variation due to the reactive loading of the RC element with constant R and constant tube parameters is

$$\left|\frac{e_k}{e_{in}}\right| = \frac{A}{\sqrt{1 + \left(\frac{4A}{RG_m}\right)\left(1 + \frac{A}{RG_m}\right)\sin^2\left(\frac{\phi}{2}\right)}} \tag{8}$$

The gain variations with constant C and constant tube parameters is

$$\left|\frac{e_k}{e_{in}}\right| = \frac{A}{\sqrt{1 + \left(\frac{2A}{X_C\,G_m}\right)\left[\sin \phi + \frac{2A}{X_C\,G_m}\cos^2\left(\frac{\phi}{2}\right)\right]}} \tag{9}$$

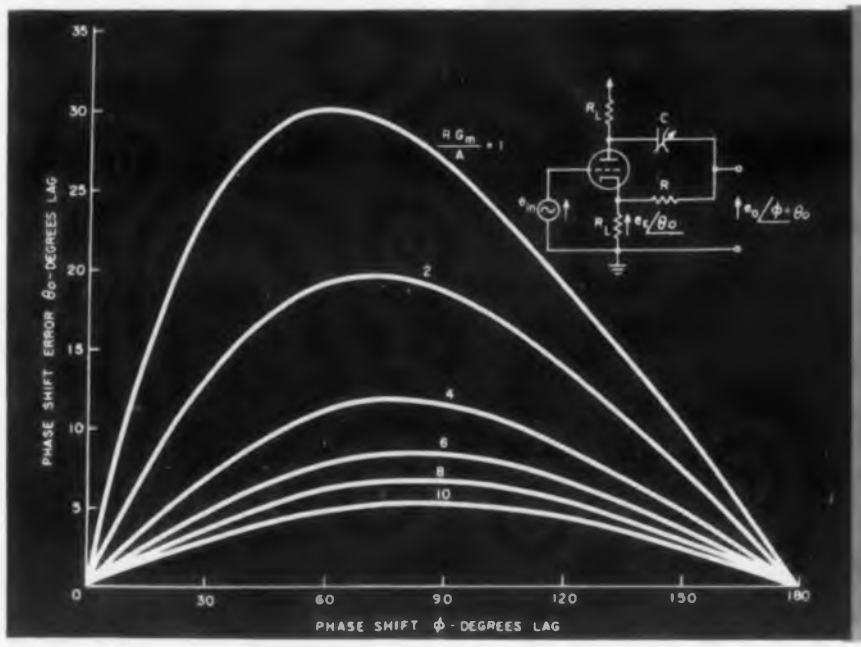


Fig. 5. Variation of phase shift error when either C or the frequency is varied.

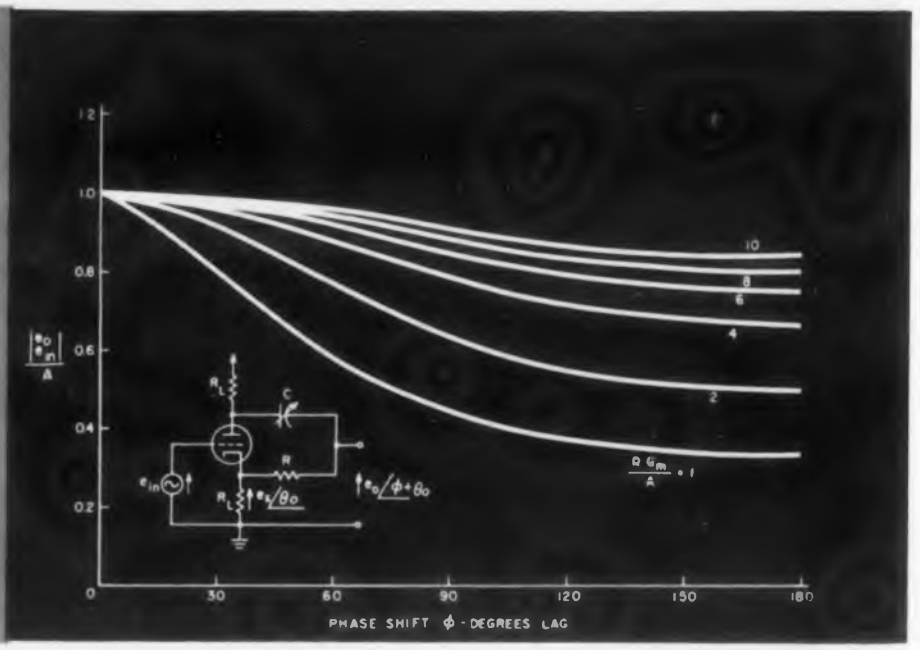


Fig. 6. Variation of circuit gain when either C or the frequency is varied.

How To Use The Equations and Curves

For a phase shifter in which R varies the circuit phase shift, Eq (7) can be used to determine the angle θ_o as a function of ϕ. The angle ϕ would be the circuit phase shift if there were no loading. This function is plotted in Fig. 3 for values of $X_C G_m/A$ ranging from 1 to 10.

It should be noted that A/G_m depends somewhat on the ouput impedance at the cathode of the phase splitter.* The angle θ_o represents a phase error due to reactive loading of the phase splitter. It must be added to the angle ϕ to determine the total circuit phase shift.

Eq (9) and Fig. 4 show the variation in circuit gain when R is the variable element.

To determine the phase shift and gain variation when either C or the frequency is used as the variable, use Eq (6) and (8), and Figs. 5 and 6.

Sample Design

Suppose we want a 90 degree phase shifter to operate at 10 kc. From the tube characteristic curves, we select a tube with a G_m of 1000 μmhos, and $A = 0.87$. Suppose we select a capacitor with a capacitance of .0047 μf ($X_C = 3490$ ohms).

Then we have the value for $X_C G_m/A$ of about 4. Now we want to use the data in Fig. 3 to find a value for R that will give a total circuit phase shift of 90 deg.

On Fig. 3, we construct a straight line representing a constant phase shift of 90 deg. The dotted line represents the locus of all possible values for ϕ and θ_o giving a total phase shift of 90 deg. The line is easily constructed since it intersects both coordinate axes at 90 deg.

Where this constant phase line crosses the $X_C G_m/A = 4$ curve will be the desired point of operation. In this case a value of $\phi = 76$ deg is indicated. This means that the RC phase shift network must be designed for $\phi = 76$ deg to make the total phase shift equal 90 deg. Using Eq (1) we find that $R = 2727$ ohms.

The circuit gain can now be found from Fig. 4. The curve for $X_C G_m/A = 4$ at a value of $\phi = 76$ deg indicates that the total gain will be the gain of the phase splitter ($A = 0.87$) multiplied by the value indicated on the curve (0.78) for a total circuit gain of about 0.68.

Notice that if we had neglected the effects produced by the reactive loading of the RC phase shift network on the phase splitter, the phase shift calculations would have been in error by about 14 deg, and the circuit gain would have been in error by 22 per cent. ■ ■

*The exact relation would be $(A/G_m) = R_o - (A/\mu)R_L$ where R_o is the output impedance from the cathode of the phase splitter.

Hall-Effect Unit Combined With Magnetic Circuitry

Fig. 1. An efficient combination is achieved by integrating a Hall-effect device with a magnetic circuit.

BOTH a Hall-effect generator and the required magnetic circuitry are integrated in this package, shown in Fig. 1. Advantages of the combination include (1) reduced ampere-turn requirements in the magnetic circuitry, and (2) maximized output of the Hall-effect device.

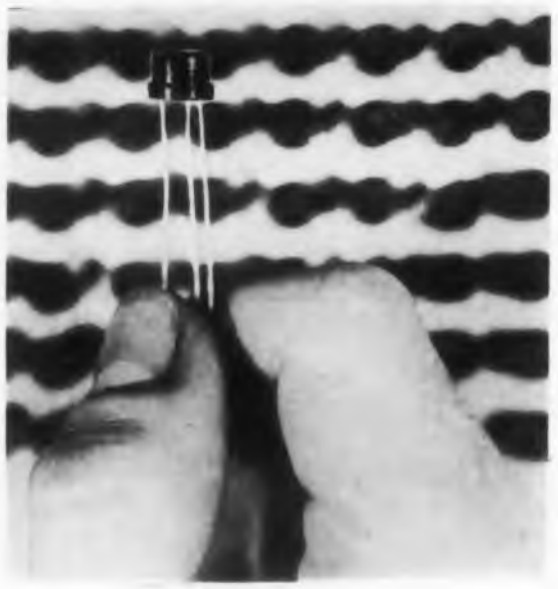
Hall-effect devices, available as individual units, have an output voltage that is a function of a current flowing through them and a magnetic field perpendicular to the unit. The devices can be used as multipliers, amplifiers, and choppers. Detailed information is given in ELECTRONIC DESIGN, March 4, page 28.

Made by Ohio Semiconductors, Inc., 1035 West Third Ave., Columbus, Ohio, the packaged unit is called the MC-1 Halltron Magnetic Circuit.

Output Is Maximized

Maximized output of a Hall-effect device is achieved by using an efficient heat sink and a thin Hall element. Thin elements are used in this unit since they are incorporated in the magnetic circuit and

Diode Device Switches In Fractions Of A Microsecond



THIS diode switch can transfer from a blocking to a conductive condition in 10 to 15 musec. The switching time is claimed to be about 1/10 shorter than that of switching transistors of comparable power handling capabilities. Made of germanium, the device is a multijunction, two-terminal unit.

News of the diode switch, which is called the Dynistor and has applications in computer and core-driver circuitry, was announced last year. It is now commer

Fig. 1. Available with a 200 mw rating, the Dynistor can be used in computer and core driver applications.

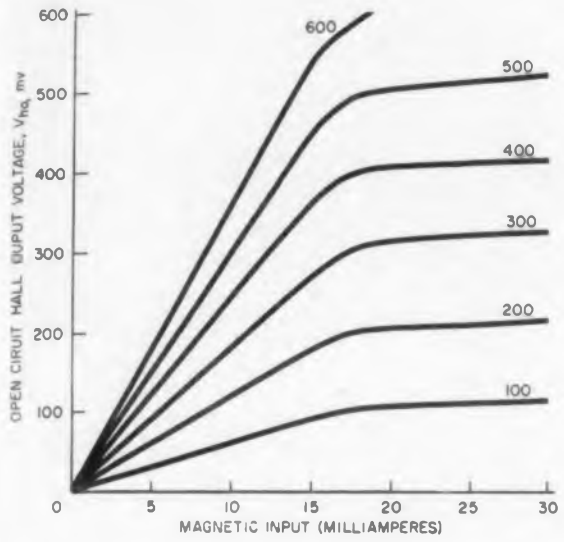


Fig. 2. Magnetic circuit characteristics are shown in this graph for various values of control current.

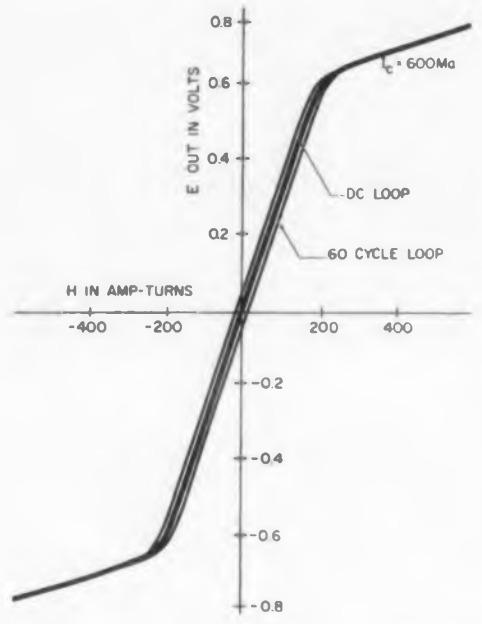


Fig. 3. Typical hysteresis characteristics for a Hall-effect magnetic circuit. Control current is 600 ma.

do not have to be encapsulated. The use of a thin element also permits a thin air gap with the consequent reduction of ampere-turn requirements. This allows lower level operation.

The entire package is encased in a Mumetal shield and the leads are brought out to post terminals on the base. The use of four coils permit multiple magnetic inputs. This coil configuration minimizes coil resistance and flux leakage, and also reduces the size of the overall package.

Electrical Characteristics

The output of the unit is linear to within ±0.05% of maximum output over the operating range. A value for maximum linear output cannot be specified since this is a function of the control current waveform. Typical dc operating characteristics are shown in Fig. 2. The hysteresis effect of the dc characteristics are too small to be shown. The ac characteristics are shown in Fig. 3.

For more information on this unit turn to the Reader Service card and circle number **101**.

cially available and is made by Westinghouse Electric Corp., P.O. Box 2088, Pittsburgh 30, Pa.

How It Works

In operation the Dynistor diode is triggered by a short duration trigger pulse. The pulse can be less than one-microsecond duration. But it must have sufficient magnitude to insure raising the voltage of the device above its breakover voltage.

To turn the diode off the control voltage must be momentarily reduced to zero. Or the current through the device must be reduced below minimum sustaining current.

In effect, the diode unit is an on-off switch similar in operation to a gas discharge tube or neon bulb. The major difference is that the voltage drop in the conducting condition of the diode is less than a volt. Other differences are: faster switching times; ranges of breakover voltages; and small size.

Applications

Besides being applicable to computers and core-driver circuitry, the diode switch can also be used as a protection against transient overvoltages, as an oscillator, and as a saw-tooth wave generator. Other applications include its use as a phase controlled rectifier and a fast acting relay.

Encapsulated in a JETEC Type 30 case, and rated at 200 mw, the Dynistor is presently available in four breakover-voltage categories. Units and their breakover voltages are: 806-02, 50 to 74 v; 806-03, 75 to 99 v; 806-04, 100 to 149 v; 806-05, 150 to 200 v. The diode has a diameter of 0.325 in., a height of 0.23 in., and the lead length is 1.5 in.

For more information on this diode switch turn to the Reader Service Card and circle number **104**.

BRIDGED T OSCILLATOR EQUATION DERIVATION

The bridged-T network shown in Fig. 1(a) has as its T equivalent the circuit of Fig. 1(b), where the quantities *a*, *b*, and *c* are, in general, complex impedances. From Fig. 1(b) it can be seen that the term a^2/b gives rise to a negative resistance under certain conditions, so that the T equivalent shown is not always physically realizable. The T equivalent can be used for purposes of calculation, however, without regard to its realizability.

The basic oscillator circuit to be analyzed is shown in Fig. 2(a), with the equivalent circuits for pentode operation shown in Fig. 2(b) and 2(c). The quantities *a*, *b*, *c*, *d*, *f*, and *P* are assumed to be complex impedances, and *P* is the load impedance. The analysis to follow is based on Class-A conditions, and therefore assumes tube linearity and no grid current. The conditions for oscillation are established by the customary method of setting the feedback factor equal to −1. The relation provides two sets of terms, one involving the load impedance *P* and the other involving only the network parameters. For load independence, each of these terms is equated to zero, giving a total of four simultaneous relations (the real and imaginary parts of each set of terms). It is thus apparent that only four of the five network parameters can be defined, and the fifth is arbitrary. In the design relations given in the referenced paper,[1] the fifth variable, corresponding to impedance *f* in Fig. 2, was merely stated to be a "trimmer" and its value was not included. As will be seen, when the fifth variable is included in the analysis, an interesting minimum occurs as this component is varied, in the impedance *a*. Selection of the operating point at this minimum results in some extremely simple design relations for all five of the circuit components.

Referring to Fig. 2, assume that a voltage e_1 from a zero-impedance source is applied in series with impedance *f*. If *Z* is the total impedance seen by the tube, then the ac plate voltage, with polarity as indicated for an assumed negative e_1 is given by

$$e_p = i_p Z \tag{1}$$

Voltage e_2 in Fig. 2(c) is given by

$$e_2 = Z_2\left(i_p - \frac{e_p}{d}\right) = i_p Z_2\left(1 - \frac{Z}{d}\right) \tag{2}$$

where Z_2 is the impedance shown in Fig. 2(c), to the right of *a*-*a*. The feedback voltage, e_f, of polarity indicated, is given by

$$e_f = f/(A + f) = \beta e_2 \tag{3}$$

and since for pentode operation, $i_p = g_m (e_1 - e_f)$ very closely, the plate voltage e_p is

$$e_p = \frac{g_m Z e_1}{1 + \beta g_m Z_2\left(1 - \frac{Z}{d}\right)} \tag{4}$$

For oscillations to occur, it is necessary that

$$\beta g_m Z_2 (1 - Z/d) = -1$$

and since

$$Z = \frac{d(B + Z_2)}{d + B + Z_2}$$

then

$$(1 - Z/d) = 1 - \frac{B + Z_2}{d + B + Z_2} = \frac{d}{d + B + Z_2}$$

The oscillation condition is therefore

$$(g_m \beta d + 1) Z_2 + (d + B) = 0 \tag{5}$$

For Eq. (5) to be independent of load impedance *P*, it must also be independent of Z_2, so for oscillations independent of load, two relations must be satisfied, at the same frequency:

$$\begin{aligned} (g_m \beta d + 1) &= 0 \\ (d + B) &= 0 \end{aligned} \tag{6}$$

Placing the values for β (from Eq. (3) and *B* (from Figs. 1 and 2) into Eqs. (6) and arranging in normalized form with $R = 1/g_m$, two relations must be simultaneously satisfied:

$$\left.\begin{aligned} \frac{R}{a} + \frac{2R}{b} + \frac{R}{f} + \frac{d}{a} + \frac{2d}{b} &= 0 \\ \frac{a}{b} + \frac{c}{a} + \frac{2c}{b} + \frac{d}{a} + \frac{2d}{b} &= 0 \end{aligned}\right\} \tag{7}$$

(*Continued on page 46*)

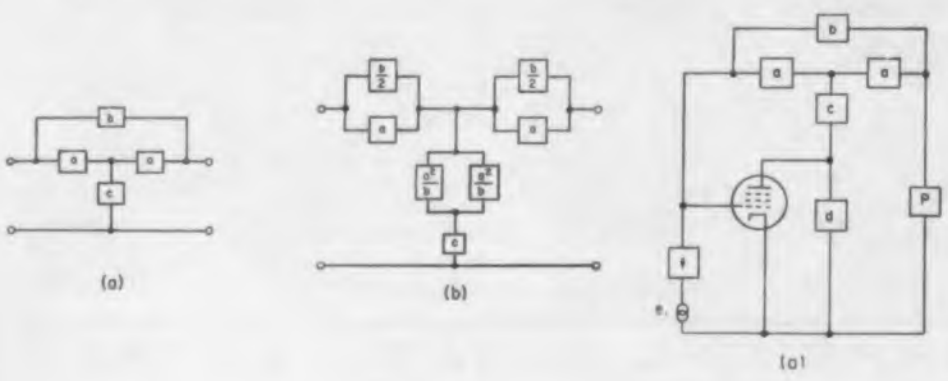


Fig. 1. T equivalent of bridged-T

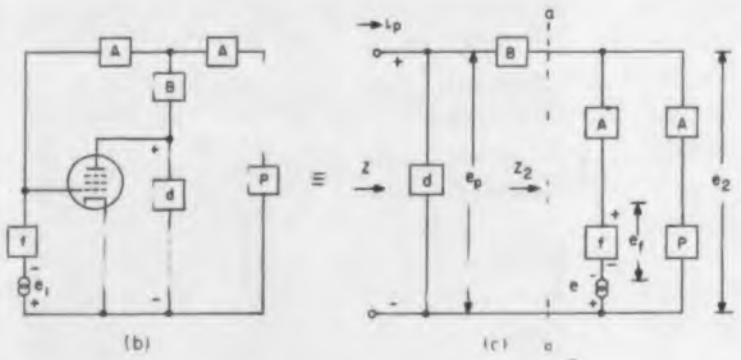


Fig. 2. Bridged-T oscillator equivalent circuits

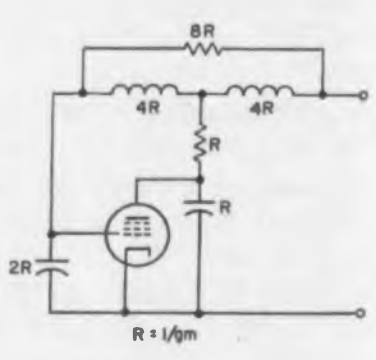


Fig. 3. Basic bridged-T oscillator circuit.

BRIDGED T OSCILLATOR

R. W. Johnson
The R. W. Johnson Co.
9372 Hillview Road
Anaheim, Calif.

While studying a German Abstract[1] in a recent issue of ELECTRONIC DESIGN, the author of this article speculated that a more simplified set of equations could be established for design engineers. The article covers his analysis and practical tests on frequency-stable, load-independent bridged-T oscillators. Heading a firm of consulting engineers, author Johnson has acquired extensive experience in the fields of nuclear energy, industrial electronics, and military communication systems.

STABLE frequency output, independent of load impedance variation, can be achieved with bridged-T oscillators. Properly designed three-terminal-pair networks can establish criteria for oscillation and simultaneously provide a coefficient of zero for the term involving load impedance.

Such oscillators, although requiring more components than ordinary types, have application in situations where for economic or space reasons, it is not feasible to isolate the oscillator from its load. An example would be in telemetry, where in some cases a uhf oscillator may be required to feed an antenna directly, yet still maintain reasonable stability.

The bridged-T, investigated by Frisch and Herzog,[1] is a convenient type of network that can be used for load-independent oscillators. It is possible to reduce the design equations of the bridged-T oscillator to a particularly convenient form, with each reactance and resistance of the network being a simple arithmetic multiple of the reciprocal of tube transconductance.

For those interested in the complete analysis of the steps involved, a separate "Equation Derivation" section is included.

As finally concluded from the Equation Derivation section, the various parameters shown in Fig. 3 may be expressed in terms of $R = 1/g_m$ as stated in Eq. (15). Converting this information in terms of frequency for minimum inductance L_a, results in:

$$\left.\begin{aligned} C_d/C_f &= 2 \\ \omega_o^2 &= 2/L_a C_f \\ R_b &= 8/g_m \\ R_c &= 1/g_m \end{aligned}\right\} \qquad (16)$$

and generally, $R_b C_f = L_a g_m$.

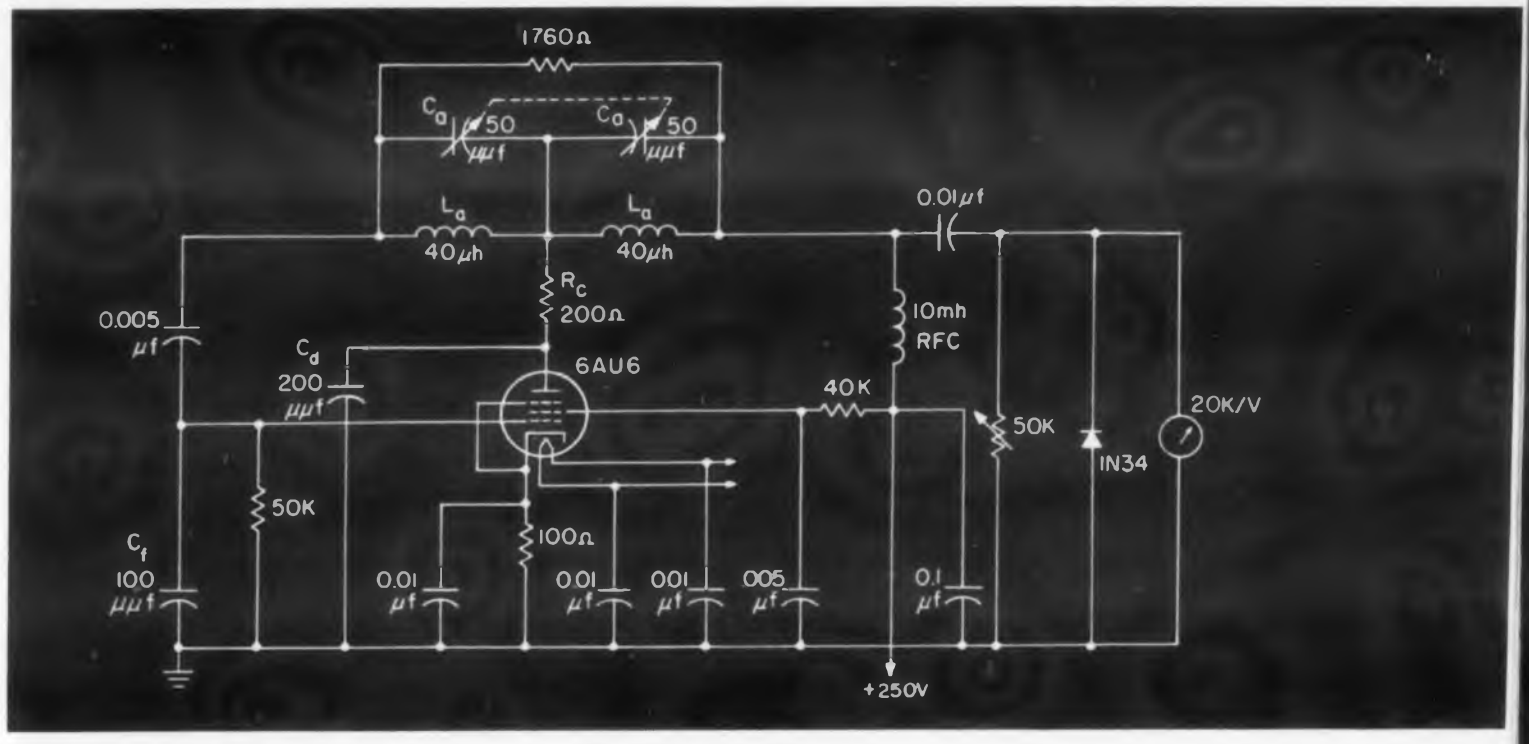


Fig. 4. Bridged-T oscillator test circuit

Test Circuit

An oscillator designed according to the relations given in Eqs. (15) is shown in Fig. 4. Components were selected from standard values available and therefore, do not exactly satisfy the design equations. Output voltage was measured by shunting a 1N34 diode across a 50 K ohm potentiometer, capacity coupled to the output, in parallel with a 20,000-ohms-per-volt meter. Output as measured on the meter was fairly constant at 3.6 v over the band 2.65-3.35 mc as C_a was tuned, falling to about 1.6 v at the high end of the band. Grid current was 0.005 ma. At the point nearest the optimum design situation given by Eqs. (15), the output load resistance could be changed by a factor of 4:1 with but a few cycles change in frequency. It is evident from the design equations that tuning by the simple process of placing C_a across L_a produces optimum insen-

1. E. Frisch and W. Herzog in Nachrichtentechnische Zeitschrift, Vol. 10 No. 1, January 1957, pp 35-38; abstracted in ELECTRONIC DESIGN, July 23, 1958, p. 108.

Eqs. (7), with complex notation substituted, give four defining equations (reals and imaginaries) for the five variables. One variable is therefore arbitrary, insofar as satisfying Eqs. (7). Furthermore, study of Eqs. (7) for the cases of each component being either *pure* resistance or *pure* reactance discloses that for nontrivial, passively-realizable cases, it is essential that there be *two* pure resistances and that these must be elements *b* and *c*. Assigning *a*, *d* and *f* as pure (assumed positive) reactances, *b* and *c* as pure resistances, the four defining relations resulting from Eqs. (7) are

$$d/a + 2R/b = 0 \tag{8}$$

$$2d/b - R/a - R/f = 0 \tag{9}$$

$$d/a + 2c/b = 0 \tag{10}$$

$$2d/b + a/b - c/a = 0 \tag{11}$$

From Eqs. (8) and (10) it can be seen by inspection that

$$c = R \tag{12}$$

Substituting $a = -bd/2R$ from Eq. (8), and also Eq. (12) into Eqs. (9) and (11),

$$2b/d + 2R^2/bd + R/f = 0$$

$$2b/d + 2R^2/bd - d/2R = 0$$

from which it is evident by inspection that

$$d = 2R^2/f \tag{13}$$

Thus the required solutions of Eqs. (8) through (11) are, normalized to $R = 1/g_m$,

$$\begin{aligned} a/R &= -(f/R + 4R/f) && \text{(pure reactance)} \\ b/R &= (f/R)^2 + 4 && \text{(pure resistance)} \\ c/R &= 1 && \text{(pure resistance)} \\ d/R &= 2R/f && \text{(pure reactance)} \\ f &\ \textit{arbitrary} && \text{(pure reactance)} \end{aligned} \tag{14}$$

It will be noted that the expression for reactance a/R in Eqs. (14) exhibits a minimum absolute value of 4 at $f/R = 2$. For reasons of stability, this is a desirable operating condition, provided that the remaining parameters do not become unreasonable. So for minimum reactance of a/R, substitute $f/R = 2$ into Eqs. (14) to obtain (corresponding signs used together)

$$\begin{aligned} a/R &= \mp 4 && \text{(pure reactance)} \\ b/R &= 8 && \text{(pure resistance)} \\ c/R &= 1 && \text{(pure resistance)} \\ d/R &= \mp 1 && \text{(pure reactance)} \\ f/R &= \mp 2 && \text{(pure reactance)} \end{aligned} \tag{15}$$

It will be noted from Eq. (14) that elements *a* and *d* must be of opposite sign, and that *d* is of the same sign as *f*. Fig. 3 is the oscillator for Eqs. (15), using capacitance at *f* and *d*. Reactances *f* and *d* are conveniently made capacitive, since these shunt the tube input and output capacitances.

sitivity to load impedance only at one frequency; but practically, little difference was observed over a 10 per cent frequency band around the optimum point.

Modified Bridged-T Oscillator

The circuit of Fig. 4 suggests that a center-tapped coil might be used in the series arm. The design relations for this case can be derived using the T equivalent of the center-tapped coil, which has a negative mutual inductance in series with the center-tap connection, thus making impedance *c* of Fig. 2(a) complex instead of a pure resistance as was assumed in the original analysis. (The mutual inductance of a center-tapped coil can be estimated from the length/diameter ratio of the coil.[2]) A sixth variable, the reactive component of *c*, is now obtained, and a new set of four relations results from Eqs. (7). In terms of the (arbitrary) variables X_c and f, the solutions are

$$a/R = -[f/R + (R/f)(1+S)^2]$$

$$b/R = 2\left[\frac{(f/R)^2 + (1+S)^2}{(1+S)}\right]$$

$$R_c/R = 1 + \frac{f}{R}\,\frac{X_c}{R}\,\frac{1}{1+S} \tag{17}$$

$$d/R = (R/f)(1+S)$$

$$S = \sqrt{1 + 2(f/R)(X_c/R)}$$

$$R = 1/g_m$$

f/R arbitrary

X_c/R arbitrary

These relations reduce to those of Eqs. (14) for $X_c = 0$.

In Eqs. (17), b and R_c are pure resistances; a, d, f and X_c are pure reactances. Examination of Eqs. (17) for the minimum a/R with f/R shows that the lowest minimum a/R is obtained at $S = 0$, for which case $f/R = \mp 1$ and $X_c/R = \pm 0.5$. Eqs. (17) reduce to those given below, in which Eqs. (15) are repeated for comparison [top

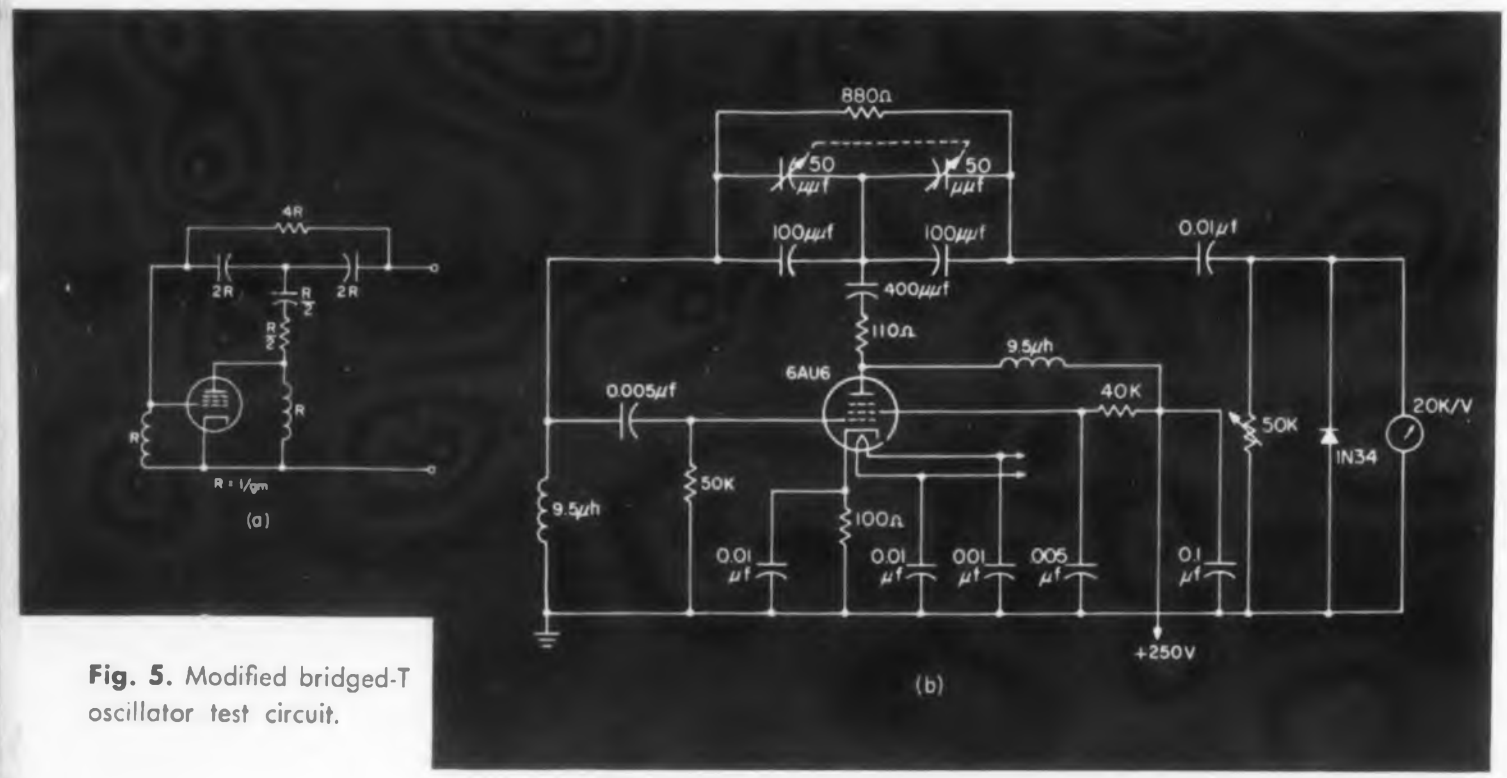


Fig. 5. Modified bridged-T oscillator test circuit.

2. R. W. Johnson, "Designing Wide-Range Tuning Circuits," *Electronics*, Aug. 1954, Fig. 9, p. 176.

(or bottom) signs must be used together]:

$$\underline{X_c = 0} \qquad\qquad \underline{X_c = \pm R/2}$$

$$\left.\begin{aligned} a/R &= \pm 4 \\ b/R &= 8 \\ c/R &= 1 \\ d/R &= \mp 1 \\ f/R &= \mp 2 \\ R &= 1/g_m \end{aligned}\right\} \quad (15) \qquad \left.\begin{aligned} a/R &= \pm 2 \\ b/R &= 4 \\ R_c/R &= 0.5 \\ d/R &= \mp 1 \\ f/R &= \mp 1 \\ X_c/R &= \pm 0.5 \\ R &= 1/g_m \end{aligned}\right\} \quad (18)$$

Thus by adding an additional reactance at c, it is possible to reduce still further all component values in the circuit and still obtain the required conditions of oscillation criteria independent of load. Unfortunately, as can be seen from Eqs. (18), reactance X_c and a must be of the same sign for this minimum condition, which precludes the simple use of a center-tapped coil for a, since the mutual inductance is negative in this case, of opposite sign to the coil halves, if the winding direction remains the same. The two coils comprising a can be coupled ($K = 0.25$) to give a positive mutual inductance in series with c, however, or reactances f and d can be made inductive, with a and X_c made capacitive. The latter choice is somewhat convenient from a circuit standpoint, since it obviates the need for an rf choke for shunt feed at the plate end of the network.

Test Circuit

A circuit of this type that has been tested is shown in Fig. 5. As the variable capacitor was tuned, oscillation frequency varied from 3.56 to 3.8 mc, output as measured with a 20,000 ohms-per-volt meter across the diode was constant within 10% of 1.0 v over the band, and grid current was 0.02 ma. At the point nearest the optimum design situation given in Eqs. (18), the output load resistance could be changed by a factor of 4:1 with but a few cycles change in frequency.

Output Impedance

Output impedance of the bridged-T oscillator can be computed from Fig. 2(c). Since $(d + B) = 0$ at the design frequency as a condition for oscillation, it is evident by inspection of Fig. 2(c) that the impedance seen by load P looking back into the network is merely impedance A, which by reference to Fig. 1(b) can be seen to be impedances a and $b/2$ in parallel. From Eqs. (15) and (18) it can be seen that for the "optimum" cases, a is a pure reactance of magnitude $4R$ (Eq. 15) or $2R$ (Eq. 18), and $b/2$ is a pure resistance of magnitude $8R$ (Eq. 15) or $4R$ (Eq. 18), depending on whether the extra reactance at c is used. For maximum power transfer into load P, it is evident that this output impedance must be matched properly.

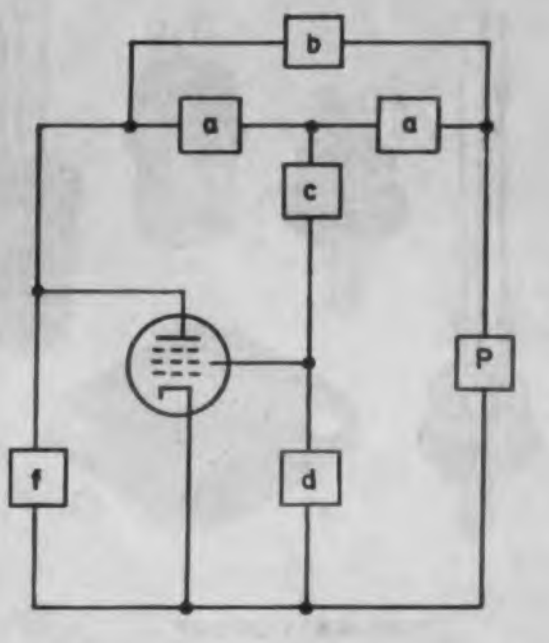


Fig. 6. Reversed bridged-T oscillator

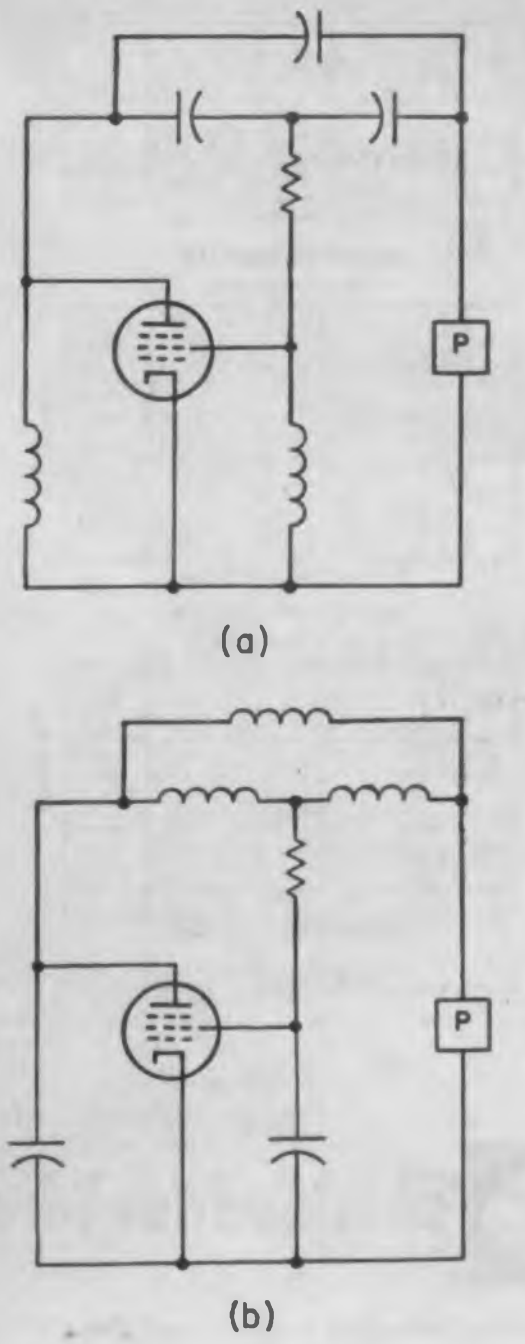


Fig. 7. Possible configurations of reversed-bridged-T oscillator

Reversed Connections

A usable oscillator also results when the grid and plate connections are interchanged in Fig. 2. A similar analytical approach for this case shows that now only one resistance is required in the network, and that this is impedance c. Furthermore, it turns out that there are only three defining relations for this case, instead of four as were obtained previously. Two of the five variables are now arbitrary. For the circuit of Fig. 6, the following relations apply:

$$\left.\begin{aligned} a &= -d(2 + f/d) \\ b &= -f(2 + f/d) \\ c &= df/R \end{aligned}\right\} \quad (19)$$

From Eqs. (19) it can be seen that for resistance c to be positive, reactances f and d must be of the same sign, so that reactances a and b are therefore also of the same sign, but opposite to the sign of f and d. The two possible configurations of the reverse-bridged-T oscillator are shown in Fig. 7. Expressing the variables of Eqs. (19) in terms of c and f as the arbitrary variables, there results

$$\left.\begin{aligned} a &= -(2Rc/f + f) \\ b &= -f(2 + f^2/R_c) \\ d &= Rc/f \end{aligned}\right\} \quad (20)$$

Again it is noticed that a exhibits a minimum as f is varied, at $f^2 = 2Rc$. At this operating point, the following simple design relations apply to the reverse-bridge T oscillator (c replaced by R_c):

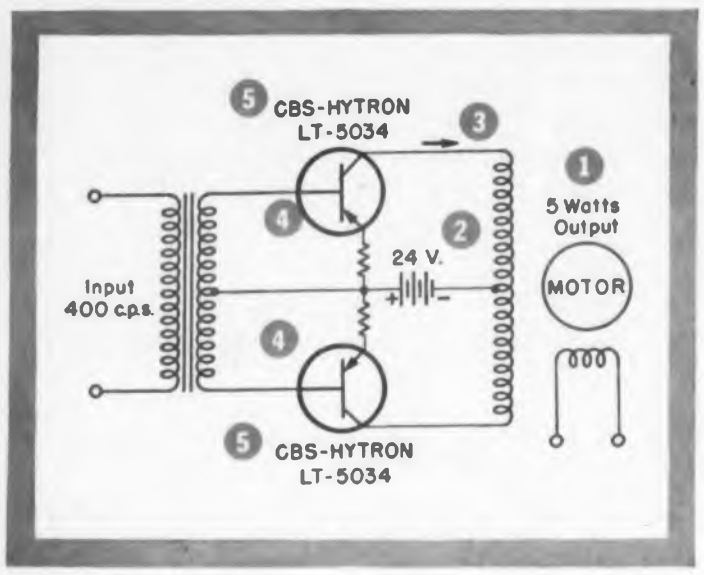
$$\begin{aligned} a &= \mp 2(2RR_c)^{\frac{1}{2}} \\ b &= \mp 4(2RR_c)^{\frac{1}{2}} \\ R_c &= \text{arbitrary resistance} \\ d &= \pm(RR_c/2)^{\frac{1}{2}} \\ f &= \pm(2RR_c)^{\frac{1}{2}} \end{aligned}$$

The output impedance for this case is a pure reactance $-f$.

Conclusion

From the design relations given, it can be seen that use of a high-transconductance tube results in very low values of the circuit components, minimizing the effects of stray and tube capacitances on frequency stability. The circuit does not appear to be particularly critical to component values, and seems suitable as a stable oscillator. Variation of frequency over a range of a few percent is possible by varying only one circuit element, and does not serious affect the load-independence of the circuit. A modified form of this circuit should also find application as a selective bandpass filter of high Q, stable with respect to load changes. ■ ■

Selection of the Right Power Transistor made easy



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Current Gain‡					Package#
60	LT-5028	LT-5034	LT-5042	LT-5051	Diamond
	LT-5027	LT-5033	LT-5041	LT-5050	Male
	LT-5026	LT-5032	LT-5040	LT-5049	Female
40	LT-5025	LT-5031	LT-5039	LT-5048	Diamond
	LT-5024	LT-5030	LT-5038	LT-5047	Male
	LT-5023	LT-5029	LT-5037	LT-5046	Female
20	LT-5022	2N157	2N157A	LT-5045	Diamond
	LT-5021	LT-55	LT-5036	LT-5044	Male
	LT-5152	LT-5153	LT-5035	LT-5043	Female
	30V	60V	100V	120V	

Minimum Breakdown Voltage†

30-WATT GROUP
Types Available

Current Gain‡					Package#
100	LT-5060	LT-5069	LT-5078	LT-5087	Diamond
	LT-5059	LT-5068	LT-5077	LT-5086	Male
	LT-5058	LT-5067	LT-5076	LT-5085	Female
60	LT-5057	LT-5066	LT-5075	LT-5084	Diamond
	LT-5056	LT-5065	LT-5074	LT-5083	Male
	LT-5055	LT-5064	LT-5073	LT-5082	Female
30	LT-5054	LT-5063	LT-5072	LT-5081	Diamond
	LT-5053	LT-5062	LT-5071	LT-5080	Male
	LT-5052	LT-5061	LT-5070	LT-5079	Female
	30V	60V	80V	100V	

Minimum Breakdown Voltage†

40-WATT GROUP
Types Available

Current Gain‡					Package#
160	LT-5096	LT-5105	LT-5114	LT-5123	Diamond
	LT-5095	LT-5104	LT-5113	LT-5122	Male
	LT-5094	LT-5103	LT-5112	LT-5121	Female
80	LT-5093	LT-5102	LT-5111	LT-5120	Diamond
	LT-5092	LT-5101	LT-5110	LT-5119	Male
	LT-5091	LT-5100	LT-5109	LT-5118	Female
40	LT-5090	LT-5099	LT-5108	LT-5117	Diamond
	LT-5089	LT-5098	LT-5107	LT-5116	Male
	LT-5088	LT-5097	LT-5106	LT-5115	Female
	30V	60V	80V	100V	

Minimum Breakdown Voltage†

‡Minimum large-signal current gain: 40-watt group at 1.0 A, 30-watt group at 0.75 A, 20-watt group at 0.50 A.
†Minimum breakdown voltage, collector to base with emitter open.
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CIRCLE 38 ON READER-SERVICE CARD

Etched-Foil Precision Resistors Equipment Simplify Design

ADJUSTED after production, these resistors, etched out of copper-nickel alloy foil, can replace complete assemblies of conventional precision components.

In some applications, such as meter shunts and attenuator pads, these resistors lead to economies in cost, space, and design simplification. For critical applications, they can be produced with a built-in aluminum heat sink, and can, in some environments, withstand power dissipations to 30 watts per square inch.

Manufactured by Photocircuits Corp. of 31 Sea Cliff Ave., Glen Cove, N. Y., the resistance units are stable even in high humidity, and can

This English multimeter saves space and assembl time by using etched resistors and an etched select switch plate.

withstand 100 per cent overloads without damage.

Resistances are available from a small fraction of an ohm up to a maximum of 100 ohms per square inch of board area. Tolerances vary from one per cent for resistances less than one ohm, to 0.1 per cent for resistances greater than 10 ohms.

Average power dissipation varies depending on the base to which the foil is applied. Depending on the environment, the dissipation per square inch of board area approximates the values given in the table.

A typical application of these space-saving resistors is shown in the photograph of the compact volt-ohm-milliammeter made by Avo, Ltd. of England. The instrument, which features 10,000 ohms per volt sensitivity on the dc scales, uses two of the Photocircuits components, both shown in the other photograph.

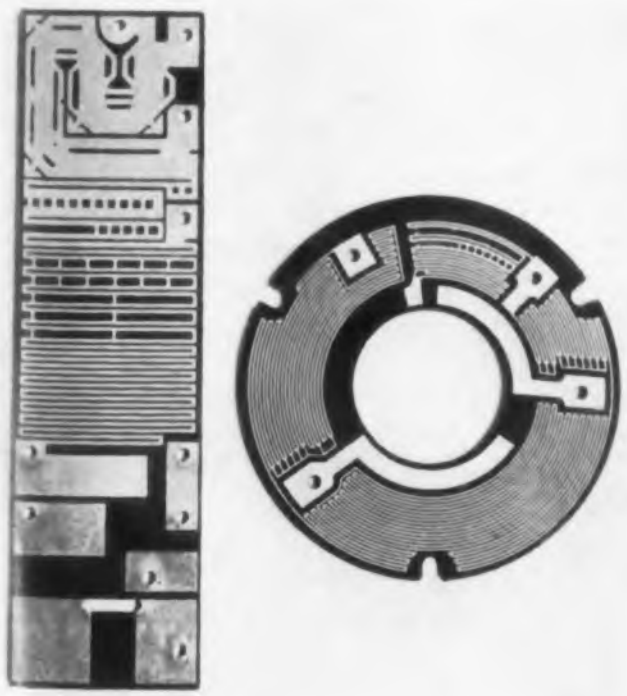
The round board is the selector switch plate which includes a 10.4 ohm, one percent resistor, and a 113 ohm resistor of the same tolerance. These serve as series resistors for the "Ohms" measuring function.

The rectangular board includes three meter shunts for current measurements. They have resistance values of 0.25, 2.25, and 22.5 ohms.

For more information on these etched resistors, turn to the Reader-Service card and circle **103.**

Average Power Dissipation Per Square Inch of Board Area

Paper base	2 w
Glass fibre base	5 w
Paper and aluminum sandwich	15 w
Special designs	30 w



Three precision meter shunts are included in the rectangular board, while the round selector switch plate includes two precision resistors.

Cap Loaded Folded Antenna

Elwin W. Seeley
U. S. Naval Ordnance Lab.
Corona, Calif.

In 1953 Mr. Seeley joined the Fuze Division of the National Bureau of Standards, Corona, Calif., and remained with that laboratory when it was transferred to Naval Ordnance. Mr. Seeley is currently in the electonics division of the research department where he is head of the antenna and rf components branch. This branch is attempting to find new methods to miniaturize antennas and rf components.

Smaller, more efficient quarter-wave antennas can be designed by using top loading and folding techniques.

QUARTER-WAVE antenna can be reduced in height without deteriorating its electrical characteristic by using top loading and folding techniques. It is possible to build efficient antennas as low as 0.03 wavelength high with resonant resistance of 50 ohms and a half-power bandwidth of 8 per cent.

Usually top loading has devastating effects upon the input impedance and bandwidth since it lowers them considerably. The resonant resistance of a 0.03 wavelength high monopole antenna is 1.42 ohms and the half-power bandwidth is 1 per cent. These values are much too low to feed power to such an antenna efficiently. But by adding folding to a top loaded antenna the resonant resistance may be chosen over wide ranges by varying the ratio of diameters of folded to driven conductors. In practice input resonant resistances up to 50 ohms can be achieved with an antenna 0.03 wavelength high and up to several hundred ohms for an antenna 0.09 wavelength high. The bandwidth is increased several times by folding.

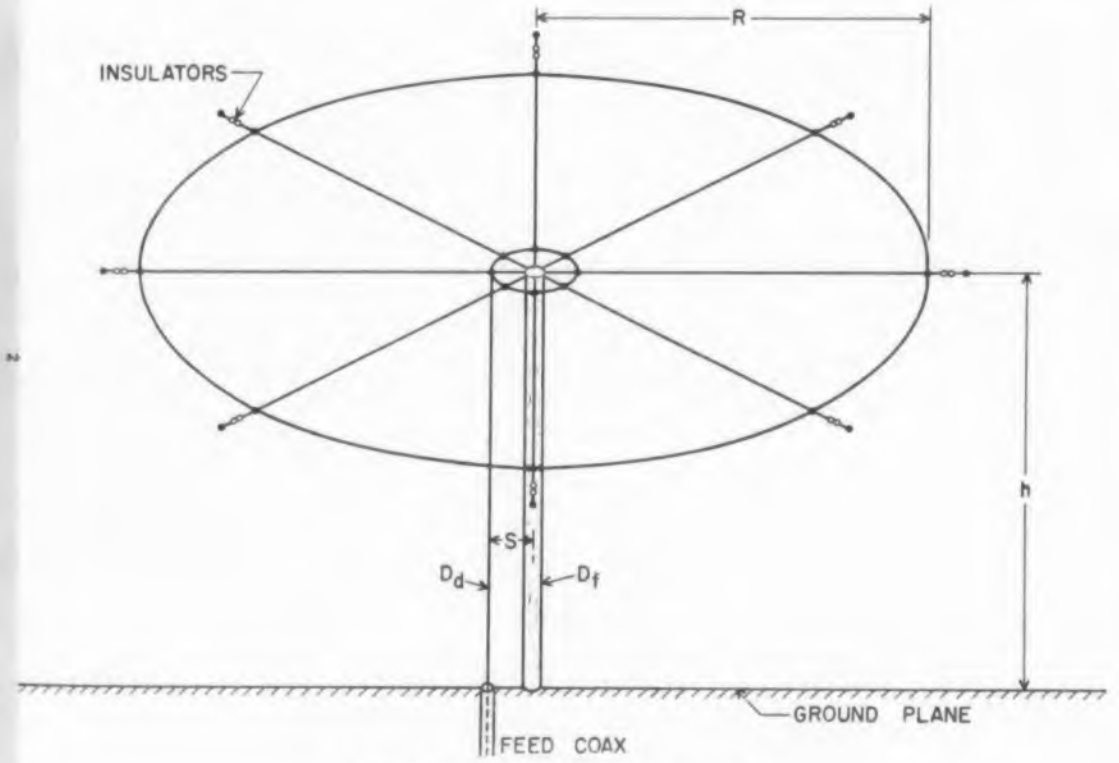


Fig. 1. Cap loaded folded antenna.

How It's Designed

The loaded folded antenna is a capacitive top hat connected to a grounded vertical conductor with a driven conductor parallel to this grounded conductor. The top loading consists of horizontal radials connected to a skirt forming the periphery of the top hat. The physical configuration is shown in Fig. 1. In order to reduce ground losses, the ground plane should be at least 100 radials $\lambda/2$ wavelength long if the antenna is less than 0.05 wavelength high.

Electrical Characteristics

Such characteristics as resonant height, resonant resistance, bandwidth, efficiency, and input impedance are a function of the antenna height, size of top hat, diameters of driven and folded conductors, and the spacing between them. An equation for the input impedance at the base has already been derived.[1] The results are:

If $Z_{IN} = Ra + jX$

$$Ra = 40\,(Kh)^2\,|\,1 + n\,|^2 \qquad (1)$$

$$X = 60Kh\left\{\frac{\left(-\frac{\pi}{2}\frac{N_1(KR')}{J_1(KR')}+\ln KS\right)^2 - \left(-\frac{\pi}{2}\frac{N_1(KR')}{J_1(KR')}+\ln\frac{KD_f}{2}\right)}{\left(-\frac{\pi}{2}\frac{N_1(KR')}{J_1(KR')}+\ln\frac{KD_f}{2}\right)^2 + \left(\frac{2}{3}Kh\right)^2} - \left(-\frac{\pi}{2}\frac{N_1(KR')}{J_1(KR')}+\ln K\frac{D_d}{2}\right)\right\} \qquad (2)$$

$$\text{Where } n = \frac{I_f}{I_d} = \frac{-\frac{\pi}{2}\frac{N_1(KR')}{J_1(KR')} + \ln KS}{-\frac{\pi}{2}\frac{N_1(KR')}{J_1(KR')} + \ln K\frac{D_f}{2} + j\frac{2}{3}hK}$$

Ra = antenna resistance

X = antenna reactance

R' = effective radius of top hat

$K = \frac{2\pi}{\lambda}$

D_f = diameter of folded conductor

D_d = diameter of a driven conductor

S = spacing between driven and folded conductor centers

h = height of antenna

J_1 = Bessel function of the first kind

J_2 = Bessel function of the second kind

Eqs. (1) and (2) are obtained by fitting the solutions of the wave equation in cylindrical coordinates to the boundary conditions, which are assumed to be: first, a constant current, I_d, and I_f, along the length of driven and folded conductors; second, zero electric field along each conductor; and third, the sum of the electron and displacement current between the top hat and ground equals zero. The conductors are also considered to be sufficiently far apart so that the magnetic field of one would be uniform over the other and thus would not affect a net current in the conductor being acted upon.

Resonant Resistance

When the antenna is operated at second resonance and I_f and I_d are in phase R_a the input resistance reduces to

$$R_{o2} = 160\,\pi^2\left(\frac{h}{\lambda_o}\right)^2\left[\frac{\log\frac{4\,S^2}{D_f\,D_d}}{\log\frac{2\,S}{D_f}}\right]^2 \qquad (3)$$

The term in the bracket in Eq (3) is the resistance multiplication factor for a folded dipole which is also applicable in this case.[2] The remainder of the right-hand part of Eq (3) is the resonant resistance of a simple loaded monopole. For practical low and medium frequency antennas, resistance multiplication factors of from 4 to 70 can be obtained by single folding, and much higher by multiple folding. Only single folding is considered in this paper however.

Resonant Frequency

If the reactance, Eq (2), is set equal to zero and some simplification made, an equation evolves that contains the resonant wavelength, which is

$$\frac{\pi}{2}\cdot\frac{N_1\left(\frac{2\pi R'}{\lambda_{o2}}\right)}{J_1\left(\frac{2\pi R'}{\lambda_{o2}}\right)} = \frac{1.05+1.74\,n-n\ln\frac{\lambda_o}{S}-\ln\frac{\lambda_o}{D_d}}{n+1} \qquad (4)$$

Where $$n = \frac{\ln\frac{2\,S}{D_d}}{\ln\frac{2\,S}{D_f}}$$

The frequency at which second resonance occurs can be deduced from the above equation. The effective top hat radius, R', in addition to the physical dimensions of the antenna, must be known to solve for λ_{o2} from Eq (4) and hence to find the resonant frequency. The effective radius is the radius required to account for the capacitance, assuming the parallel plate capacitance formula to hold, and assuming a circular plate. Value of R' for both a solid plate and various other cap configurations are plotted as ratios of R'/R vs h/R in Fig. 2.

To facilitate solution of Eq (4), the left part of the equation involving Bessel's functions has been plotted vs the parameter $2\pi R'/\lambda_{o2}$ in Fig. 3. The equation can be solved for λ_{o2} by trial and error with only a few trials since the portion on the right changed very slowly with λ_{o2}.

Bandwidth

The bandwidth to a large extent depends upon the resonant height of the antenna and to a lesser extent upon the spacing between driven and folded conductors. Experimental points have been plotted in Fig. 4 to show the half-power bandwidth vs the resonant antenna height. A generator impedance equal to the resonant antenna resistance is assumed in all cases. No attempt is made to draw a curve through these experimental points because bandwidth is a function of more than one variable. The bandwidth is much greater than a resonant loaded monopole of the same height. This increased bandwidth is due to the large effective diameter

$$\left(\frac{S}{2}\sqrt{D_f\,D_d}\right)$$

of the radiating part of the antenna. Some bandwidth increase is due to the loaded folded antenna operating at second resonance, while the loaded monopole operates at first resonance. The loaded folded antenna bandwith also compares favorably with a thin quarterwave monopole. A

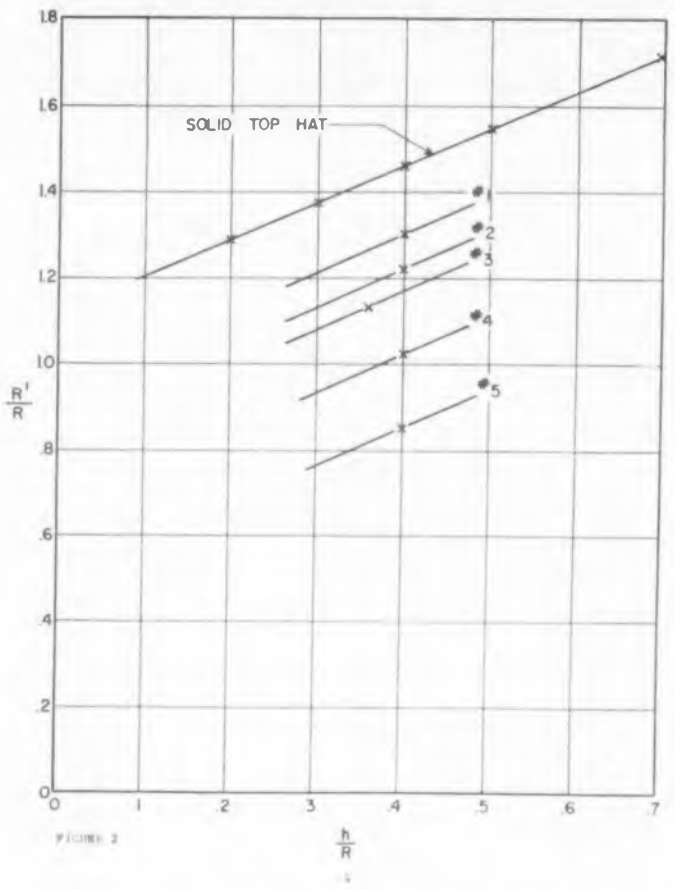


Fig. 2. (above) Cap loaded folded antenna, effective top hat radius vs antenna cap configuration. *1*—8 horizontal radial wires with two skirts, one a peripheral skirt and the other 0.8% the diameter of the first. *2*—8 horizontal radials and one peripheral skirt. *3*—Same as 2 except different ground plane. *4*—12 horizontal radials. *5*—8 horizontal radials.

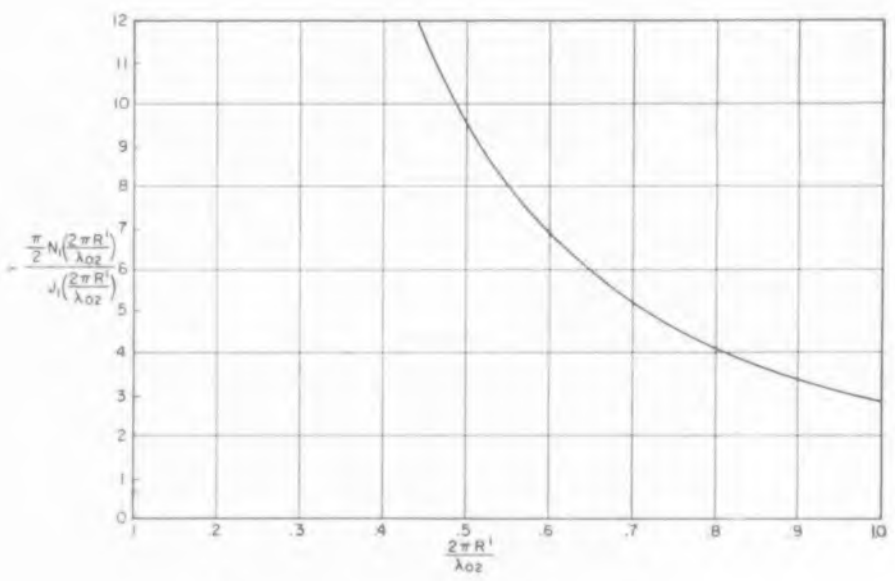


Fig. 3. Bessel function solution.

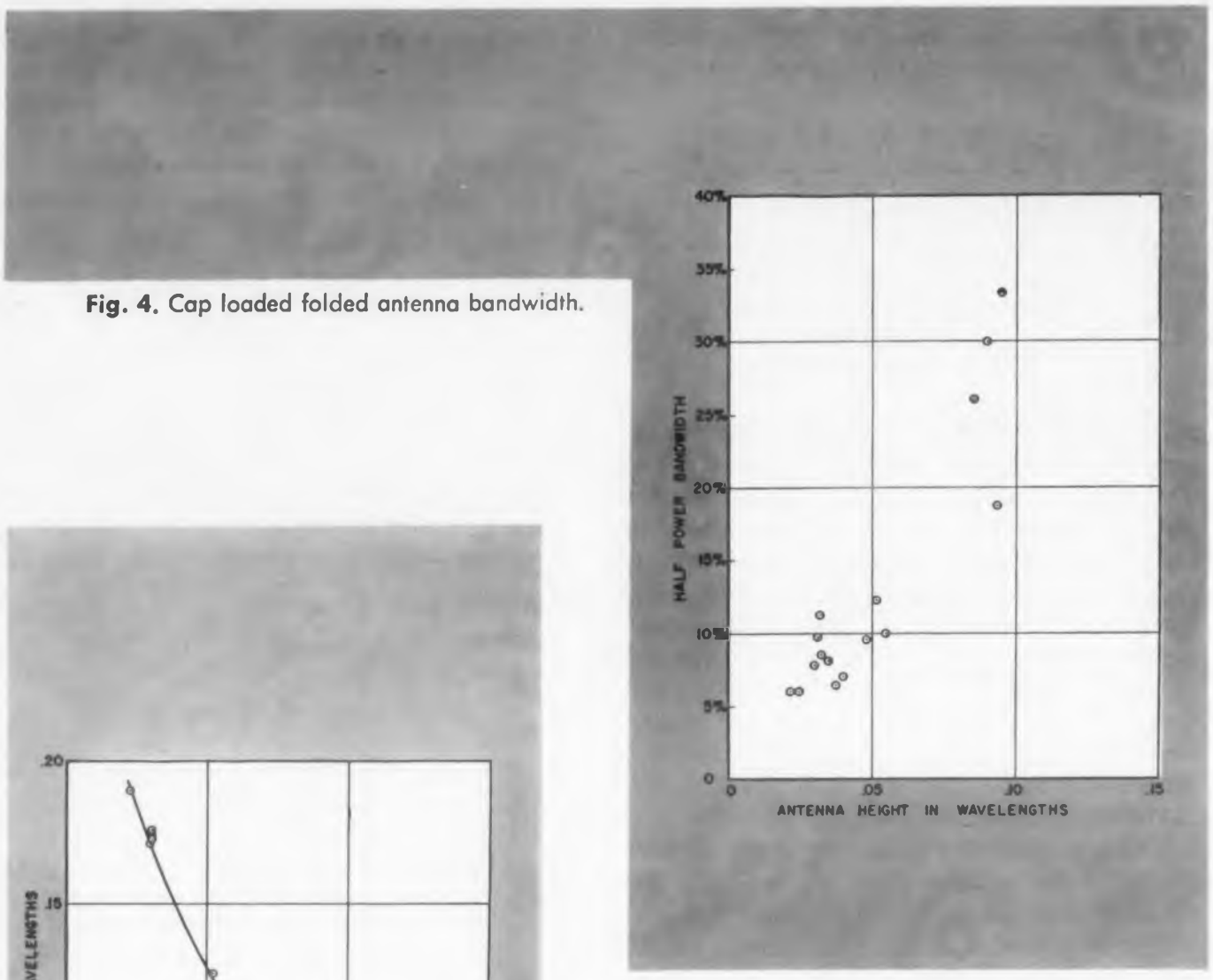


Fig. 4. Cap loaded folded antenna bandwidth.

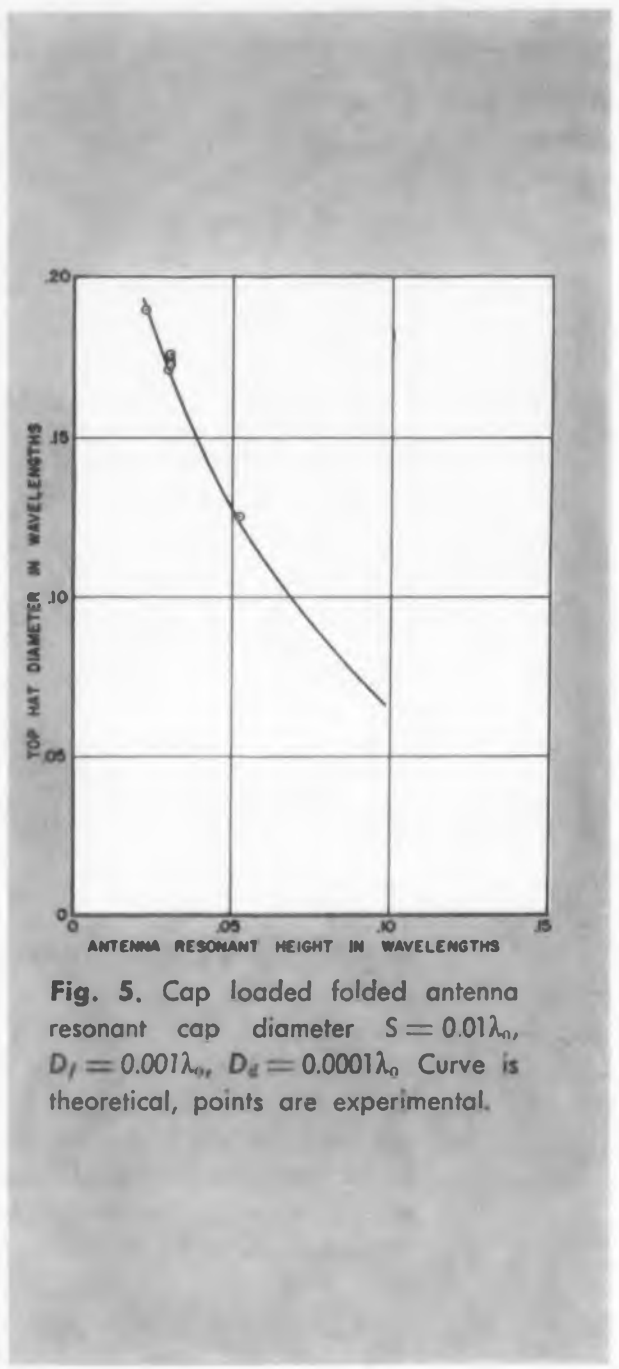


Fig. 5. Cap loaded folded antenna resonant cap diameter $S = 0.01\lambda_o$, $D_f = 0.001\lambda_o$, $D_d = 0.0001\lambda_o$ Curve is theoretical, points are experimental.

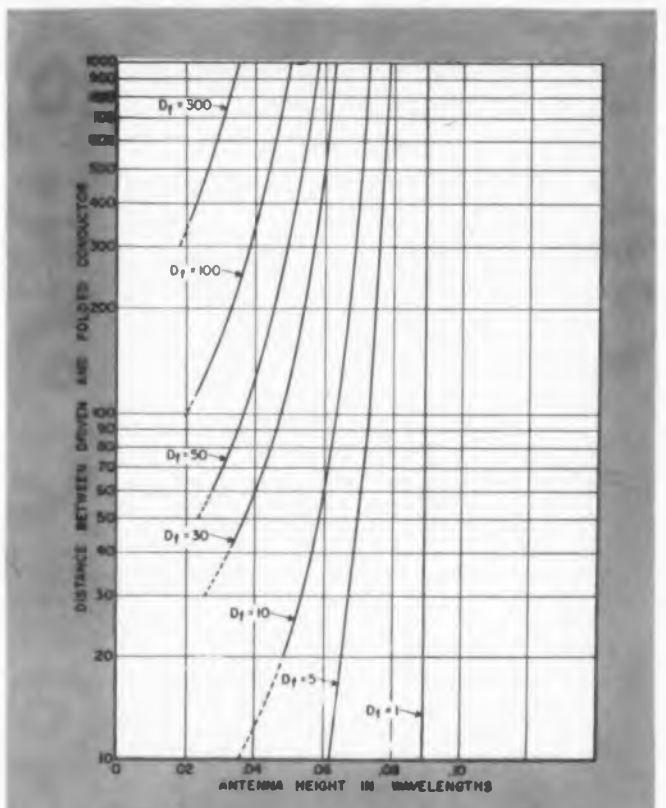


Fig. 6. Cap loaded folded antenna. $R_0 = 50$ ohms, $D_d = 1.0$.

$\lambda/4$ antenna with a length to diameter ratio of 38,000 has a half-power bandwith of 16.8 per cent.

Efficiency

The $\lambda/4$ monopole described above is used to determine the losses in the loaded folded antenna. These losses depend chiefly on the ground plane. One model, 10 ft or 0.036 wavelength high and resonant at 3.54 mc had a loss of 0.6 db. When the top hat was increased the resonant height was 0.023 wavelength, the resonant frequency 2.42 mc, and the losses were 2.4 db. The ground plane consisted of 120 radials 0.7 wavelength long in the first case, and 0.5 wavelength in the second. The driven conductor was 0.080 inch in diameter, the folded conductor was 3.1 inches in diameter, and the spacing between them was 12 in. The $\lambda/4$ monopole over the same ground plane as described above was 98 per cent efficient.[3]

Some Helpful Curves

Curves in Figs. 4, 5, and 6 can be used to get a rough idea of what can be achieved with this type antenna. Bandwidth depends to a great extent upon the resonant height of the antenna. Fig. 4 shows bandwidths that have been obtained.

To show how large the top hat must be in order for the antenna to be resonant, the relative size of top hat to the height of the antenna is plotted in Fig. 5. The points shown are experimental. A typical set of physical parameters is used to compute the curve, $S = 0.01\ \lambda_o$, $D_f = 0.001\ \lambda_o$ and $D_d = 0.0001\ \lambda_o$. These parameters change the resonant wavelength very slowly so this curve will not be in gross error for values different from the typical values given above.

The resonant resistance depends upon the relative diameters of the driven and folded conductors, the distance between them and the height of the antenna. A plot of these physical parameters for a constant 50 ohm resonant resistance is plotted vs resonant height in Fig. 6 to show the relative dimensions needed to match a 50 ohm cable. The diameter of the driven conductor, D_d is 1; D_f and S are in the same units.

A more exact design can be achieved by using Eqs 3 and 4 and the graphs. An antenna operating at a certain frequency may be restricted to a certain height and must be designed to have a resonant resistance to match a given feed line. The diameter of the folded and driven conductors and the distance between them can more or less be picked from structural considerations. The absolute size is not so important as long as the relative sizes satisfy Eq 3. The folded conductor must be large enough to hold up the top hat and both the folded and driven conductors must be large enough to carry their proportion of the in-

put current without excessive losses. The only other physical parameter, the radius of the top hat, can be obtained from Fig. 2 after $2R'/\lambda_0$ has been taken off Fig. 3. The other variable in Fig. 3 is the left-hand portion of Eq (4) which can be solved for when D_f, D_d and S are selected.

Table 1. Useful Antennas

Antenna Characteristics	1 mc Commercial Broadcast Transmitting Antenna	3.54 mc Antennas	200 kc Antennas
Height (ft)	36	10	170
Driven Conductor (inches)	0.5	0.08	1.0
Folded Conductor Diameter (ft)	2	0.25	9
Spacing Between Conductors (ft)	6	1.0	17
Top Hat	8 horizontal radial wires with a skirt 100 ft in radius	8 horizontal radial wires with a 27 ft radius skirt	8 horizontal radial cables 500 ft in radius
Resonant Resistance (ohms)	50	42	50
Half-Power Bandwidth	10%	8%	8%
Efficiency	90% with ground radials 500 ft long	45% with 100 ground radials 200 ft long	

Some Useful Antennas

A few examples of useful antennas that can be designed from the data presented are listed in Table 1. These are not necessarily optimum for any one characteristic but represent possible designs. At the lower frequencies, coil loading and multiple folding may be advantageous to reduce the top hat diameter. ■ ■

References

1. Small Antenna Study, J. D. Burns, E. W. Seeley and J. G. Hoffman, NOLC Report No. 388, Quarterly Report, Foundational Research Projects, July-Sept. 1957.
2. Impedance Transformation in Folded Dipoles, Rudolph Guertler, *Proceedings of IRE*, Vol. 38, p. 1042-1047, Sept. 1950.
3. Performance of Small Antennas, Carl E. Smith and Earl M. Johnson, *Proceedings of IRE*, Vol. 35, p. 1026-1038, Oct. 1947.

Mr. Graham (left) and Mr. Rudin designed the equipment they describe here to provide a novel and efficient approach to testing control loop stability.

Both authors have had extensive experience in control system design and development; Mr. Graham in advanced missile systems, and Mr. Rudin in Doppler and other spectral radars and in electronic countermeasures.

Test Feedback Systems Quickly With A

Phase-Gain Margin Tester

M. B. Rudin
Aeronutronic Systems, Inc.
Glendale, Calif.

R. F. Graham
Raytheon Manufacturing Co.
Hollywood, Calif.

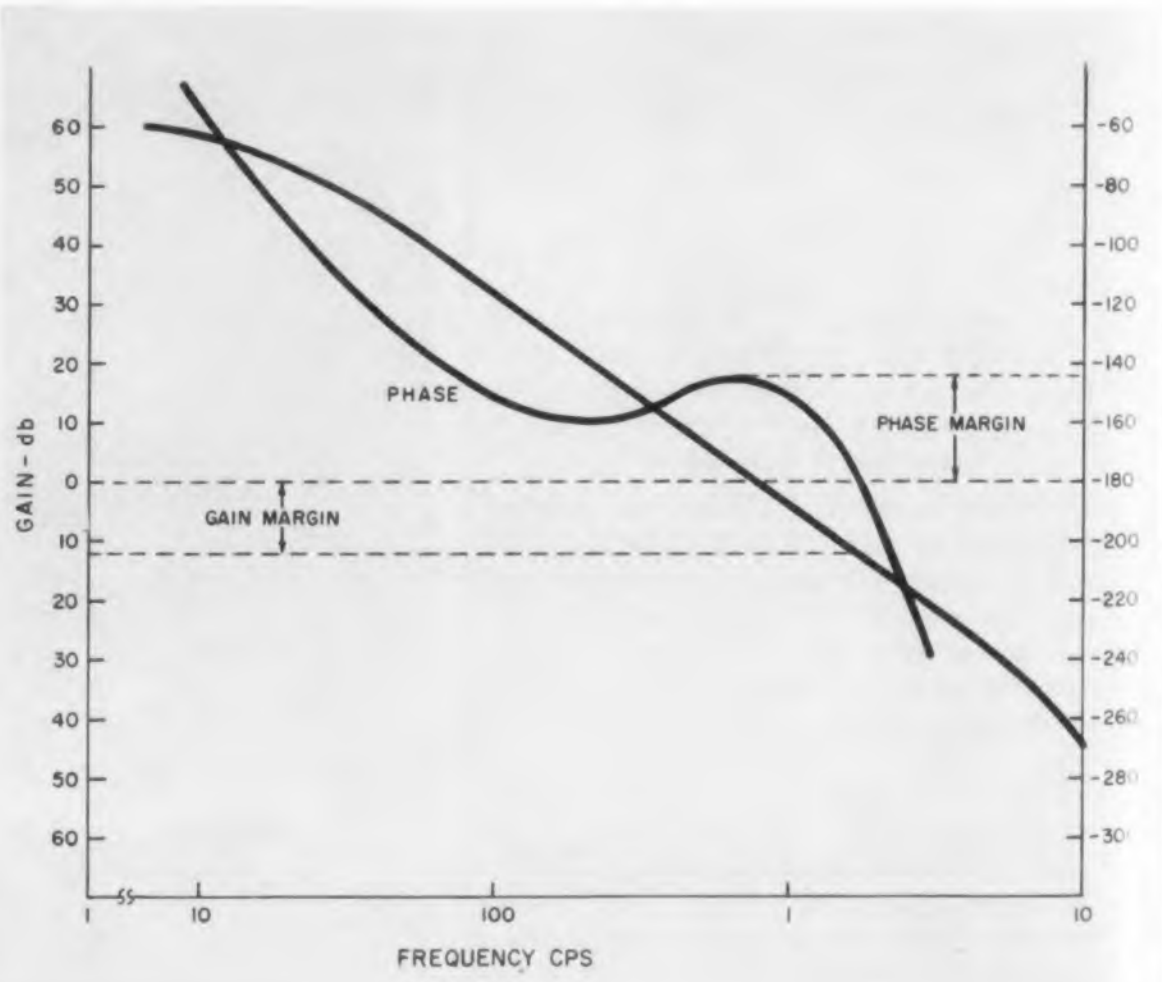


Fig. 1. This Bode plot for a frequency controlled oscillator is similar, in form, to Bode plots for mc / feedback systems.

THE EQUIPMENT described here will measure both phase and gain margin for a frequency stabilized microwave oscillator. With minor modifications, the equipment can be used to measure phase and gain margin of many other feedback control systems as well.

The instrument solves a problem common to all feedback control systems—that of assuring stable operation with maximum speed of response. Stability is usually expressed in terms of the "gain margin" and "phase margin" as shown in the typical Bode plot of Fig. 1.

To Measure Gain Margin

Gain margin is measured by inserting the instrument in the feedback loop and increasing the loop gain in known increments until oscillations occur. The increased gain is, of course, the gain margin. Care must be taken that no appreciable phase shift accompanies the increased gain in the frequency range of interest since, in many cases, the exact Bode characteristics are not known, or their determination is not economical, and hence the frequencies of marginal gain may be over a wide frequency range.

This requires an ultra-broadband amplifier with response flat through several octaves. It must be recognized that typical phase and gain margins are about 10 db and 30 degrees, and that if reasonable accuracy is desired, say 10 per cent, that the tester is only accurate where its response is flat within 1 db and 3 degrees.

To Measure Phase Margin

Phase margin is measured by increasing the phase shift with constant gain until oscillations occur in the loop. One method uses a gain compensated capacitor, but a more convenient tech-

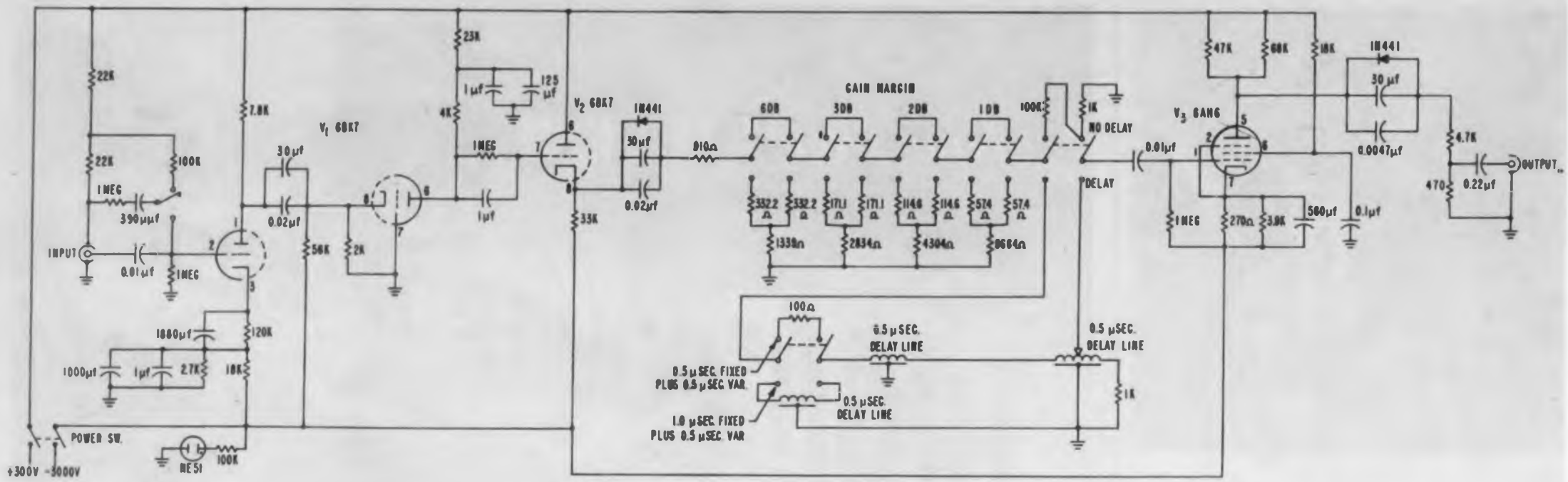


Fig. 2. Schematic for the phase-gain margin tester.

nique, if the frequency band permits, uses a delay line for constant-gain phase shifting.

The actual phase shift in cycles can be computed by multiplying the delay time by the frequency of oscillations

$$\phi = f\tau \text{ cycles.}$$

PGM Tester Design

The circuit for the phase-gain margin tester is shown in Fig. 2. It uses a cascode 6BK7 input for low-noise gain preceding the variable phase-gain section.

Low noise operation was needed for this design because the tester was to be inserted at a point of low signal level. In some control loops, large noise signals can trigger oscillations before zero phase or gain margin is reached.

The variable gain channel consists of a *T*-pad chain with switchable sections capable of inserting a total of 12 db attenuation. With full attenuation in, the overall test set again is designed to be unity.

Variable phase shift is inserted by means of three 0.5 μsec pulse delay lines, two fixed and one continuously variable. This provides variation from 0.5 to 1 μsec or from 1 to 1.5 μsec. Time delay can be easily set to within 0.002 μsec with a ten turn dial.

Both the attenuator and the delay line are designed for 1000 ohm characteristic impedance; hence a cathode follower with series output resistor is required to assure impedance match. This is essential since reflections on the delay line, hence gain variation with frequency change, can result from impedance mismatch.

The PGM tester shown in Fig. 2 has a flat phase and gain response within 1/2 db and 2 degrees up to beyond 600 kc. Further increase of the bandwidth is difficult because peaking coil techniques have to be discarded in favor of minimum phase° circuits, due to the flat phase requirement.

This restricts design techniques for extension of the high frequency response to minimizing stray capacities, lead inductance, and introducing a very small amount of phase lead in the amplifier cathode circuits. The circuit is mounted on a Bakelite sheet to reduce stray capacity, and short, large hookup wire is used in circuit layout to reduce lead inductance.

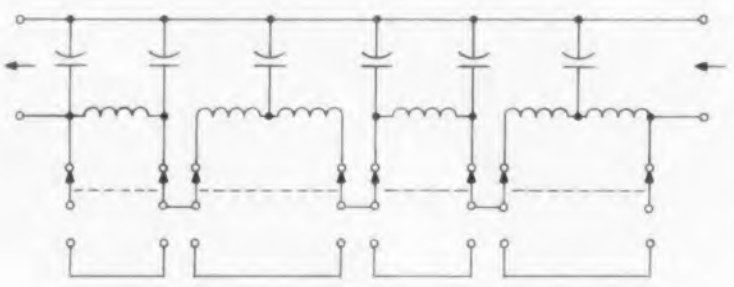


Fig. 3. A convenient delay technique for low frequency phase shifts uses alternate *T* and π sections.

Noise Testing

Many control loops are nonlinear and will oscillate when triggered by noise impulses long before they reach the zero phase or gain margin. To test this aspect, an impulse circuit is provided by a momentary contact switch and an *RC* charging circuit at the grid of input tube *V1*.

Dc cathode degeneration to a —300 v supply is used to assure constant plate current control and to provide gain stability with tube aging.

General Applications of the Tester

For measuring phase and gain margin of feedback control systems in general, a means of providing 0 to 30 deg phase variation with flat gain over a broad band of frequencies is the principal problem.

Gain can be varied with flat phase up to 100 mc using the *T*-pad switched attenuator, and is therefore no problem. But the use of delay lines for phase measurement is not practical beyond about 5 mc because of line cutoff and reflections in the high frequency lines (some of which operate to 40 mc).

Delay lines are also of limited use in servomotor systems because the delay time needed would require thousands of feed of delay line requiring many gain repeaters. One method of providing delay for low frequency phase shifts uses a recirculating magnetic tape mechanism or wire recorder.

A more convenient technique at low frequencies obtains incremental time delay by alternate *LC*, π and *T* sections, as shown in Fig. 3. These can be switched in and out for variation of time delay by dpdt switches, in the same manner as for the *T*-pad attenuator.

As an example, a system with unity gain crossover in the 5 cps to 1 kc region might use some sections with practical values as large as

° Bode, H. W., Network Analysis and Feedback Amplifier Design, D. Van Nostrand Co., Inc., New York, 1945.

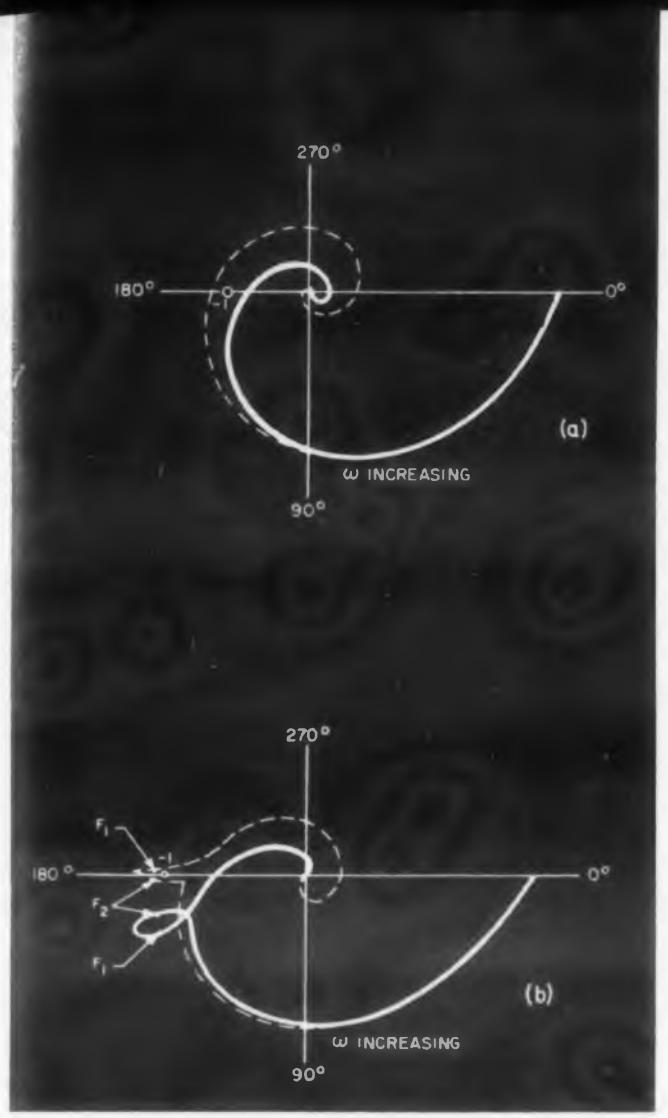


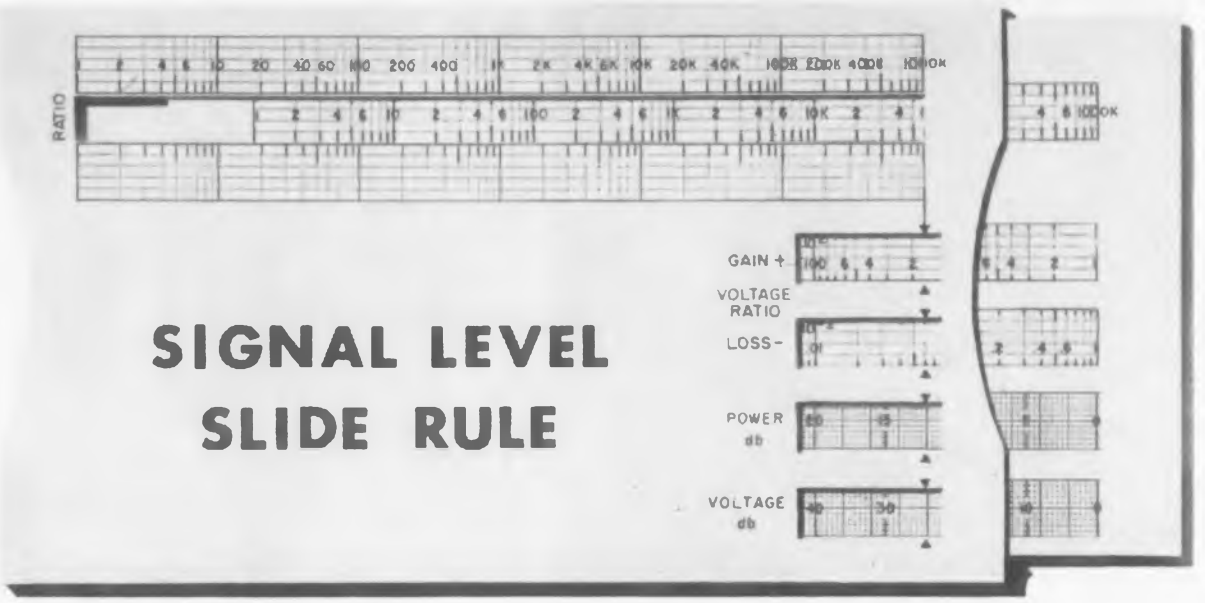
Fig. 4. If the polar plot encloses the —1 point, instability results. In (*a*), the usual case, increased gain or increased phase shift (dashed line) causes the curve to enclose the —1 point. In (*b*), an unusual situation, oscillation will take place at a higher frequency before it does at a lower frequency.

$L = 10$ hy, $C = 10$ μf for delay per section of 0.010 sec, and perhaps incremental sections with $L = 0.1$ to 1 hy and $C = 0.1$ to 1 μf for 0.1 to 1 msec steps.

Special Problems

For some special types of feedback control systems, circling of the —1 Nyquist points on a polar plot may be such as to produce oscillations of a frequency other than that correspondent to unity gain in the control loop. This can happen because the delay line does not rotate the entire polar plot by a single angle, which is required to determine the exact phase margin by the oscillation approach.

Instead the curve is rotated by an angle which increases linearly with increasing frequency. For the vast majority of systems, no error will result, as shown in Fig. 4a, but in some cases, like the one shown in Fig. 4b, the delay line phase slope causes the polar plot to loop below the —1 Nyquist point and the higher frequency side reaches —1 first, and oscillations take place. ■■



SIGNAL LEVEL SLIDE RULE

Ralph Davidson
Sperry Gyroscope Co.
Division of Sperry Rand Corp.
Great Neck, N. Y.

THIS CUT-OUT slide rule is constructed to provide a fast, accurate method for calculating the ratios of power, voltage, and current levels in a network, amplifier, or system. It solves the basic formula:

$$Loss\ or\ gain = V_{out}/V_{in} = I_{out}/I_{in} = P_{out}/P_{in}$$

The application is limited to cases where input and output impedances are equal.

There are similar slide rules available. With this one, however, ratios do not have to be calculated prior to using the slide rule.

Fig. 1. Cardboard spacers are inserted as above. Spacers should be the same width as the inside slider to provide the proper amount of friction.

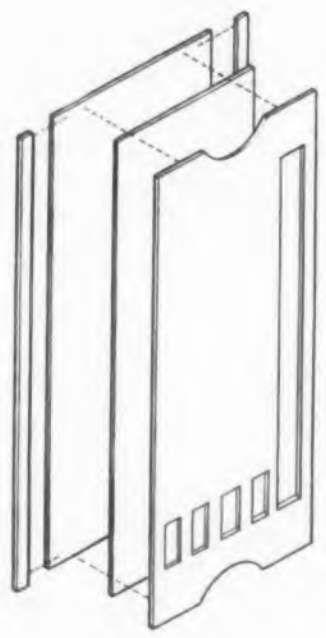


Fig. 2. Exploded view of slide rule. Staple along edge through spacers.

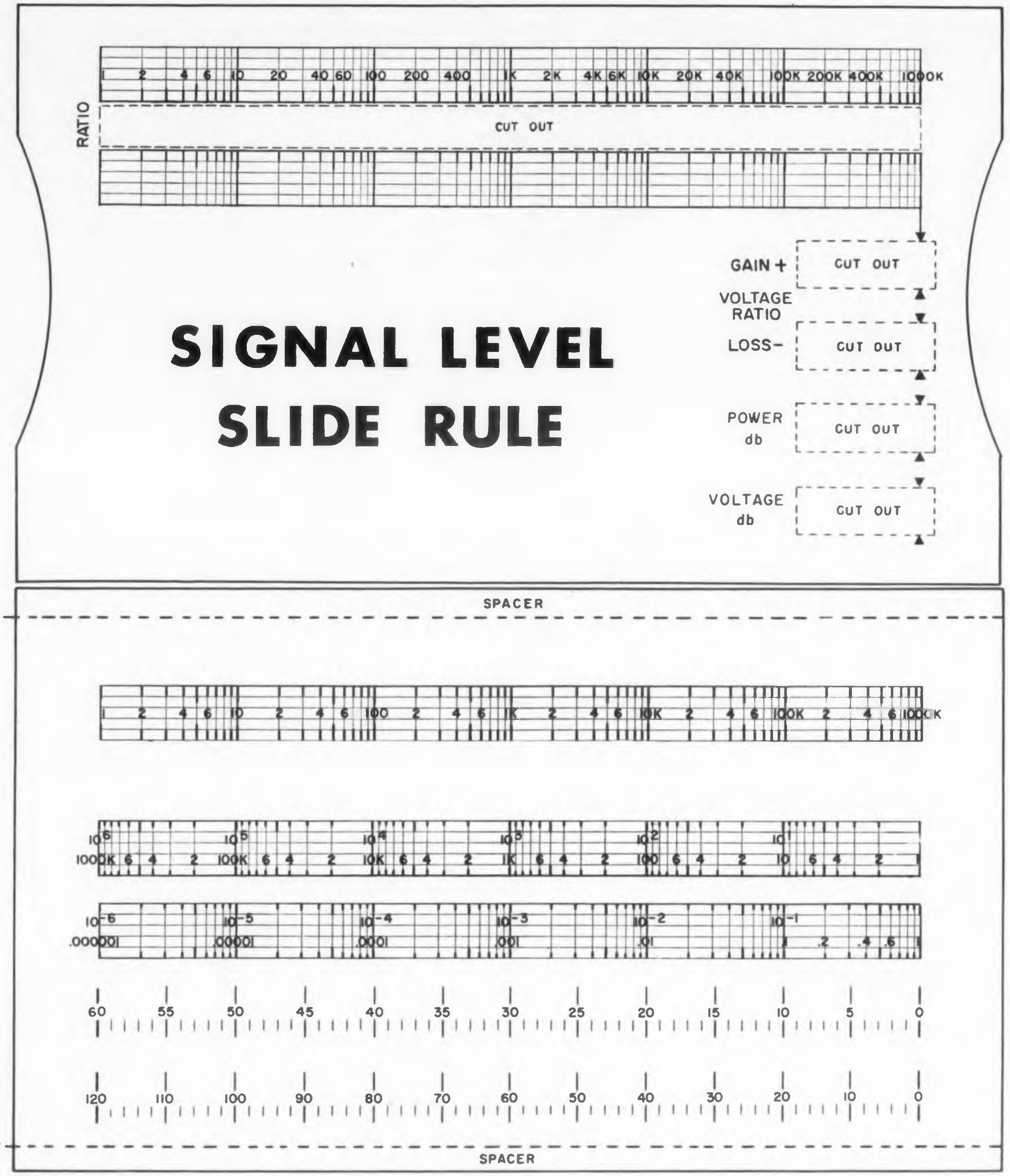
Construction

1. Glue all templates to hard cardboard.
2. Cut out along marked lines.
3. Place spacers between front and rear sides of slide rule (template not shown for rear).
4. Staple along edge (through spacers).
5. Place slider into center section.

How To Use The Slide Rule

Example 1. Suppose an amplifier has an output of 2200 mv and the signal on the input is only 67 mv. On the stationary section of the upper scale of the slide rule, locate the value 2200. Place the value 67 on the movable scale opposite 2200 and read the positive gain scale (because output is larger than input) of 30 times and the voltage gain of 30 db.

Example 2. In a particular receiver having a sensitivity of 11 mv, the image signal comes in at a level of 2750 v. To determine the image rejection ratio, place the value of 11 on the movable scale under 2750 on the stationary scale. The voltage ratio is then read as 48 db. ■ ■


RATIO
1 2 4 6 10 20 40 60 100 200 400 1K 2K 4K 6K 10K 20K 40K 100K 200K 400K 1000K
CUT OUT
GAIN +
CUT OUT
VOLTAGE RATIO
LOSS–
CUT OUT
POWER db
CUT OUT
VOLTAGE db
CUT OUT
SIGNAL LEVEL SLIDE RULE
SPACER
CUT
1 2 4 6 10 2 4 6 100 2 4 6 1K 2 4 6 10K 2 4 6 100K 2 4 6 1000K
10^6 10^5 10^4 10^3 10^2 10^1
1000K 6 4 2 100K 6 4 2 10K 6 4 2 1K 6 4 2 100 6 4 2 10 6 4 2 1
10^-5 10^-5 10^-4 10^-3 10^-2 10^-1
.000001 .00001 .0001 .001 .01 .1 .2 .4 .6 1
60 55 50 45 40 35 30 25 20 15 10 5 0
120 110 100 90 80 70 60 50 40 30 20 10 0
CUT
SPACER

Designing Microstrip Radio Frequency Components

L. David Baldwin
Project Engineer

and

Thomas E. Hattersley
Senior Engineer

Stromberg-Carlson Div.
General Dynamics Corp.
Rochester, N.Y.

CHARACTERISTIC impedance and velocity of propagation, two important line parameters necessary for designing rf components, can be readily calculated for microstrip lines containing two dielectrics. In this type of transmission line the necessary measurements are made using either an ordinary coaxial or waveguide slotted section. By applying suitable microstrip techniques, a number of rf components, such as an X-band hybrid ring duplexer and a six section low pass filter, can then be constructed.

Characteristic Impedance

The presence of two dielectrics in a microstrip line sufficiently complicates matters so that a rigorous theory has not yet been developed. However, one method of obtaining a very good approximation of the characteristic impedance is to assume that the two dielectrics are nearly equivalent to a uniform dielectric of intermediate dielectric constant. This is equivalent to making the assumption that a TEM mode exists in the microstrip line. Two simple relations for a transmission system operating in this mode are:

$$Z_0 = \frac{1}{\sqrt{\epsilon}} Z_{(Free\ Space)} \qquad (1)$$

$$v = \frac{c}{\sqrt{\epsilon}} \qquad (2)$$

where Z is the characteristic impedance of the

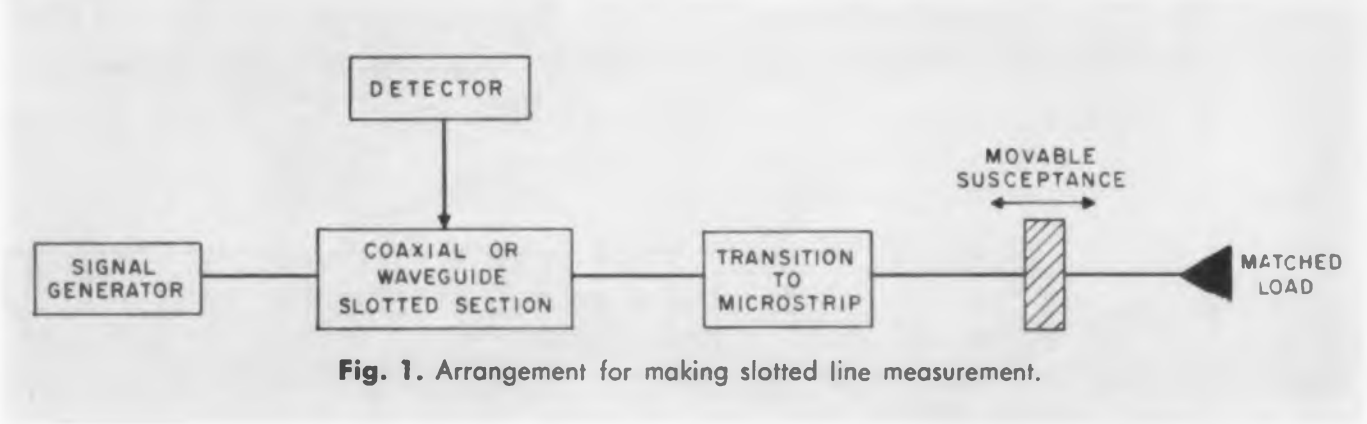


Fig. 1. Arrangement for making slotted line measurement.

Fig. 2. (left) Microstrip slotted section.

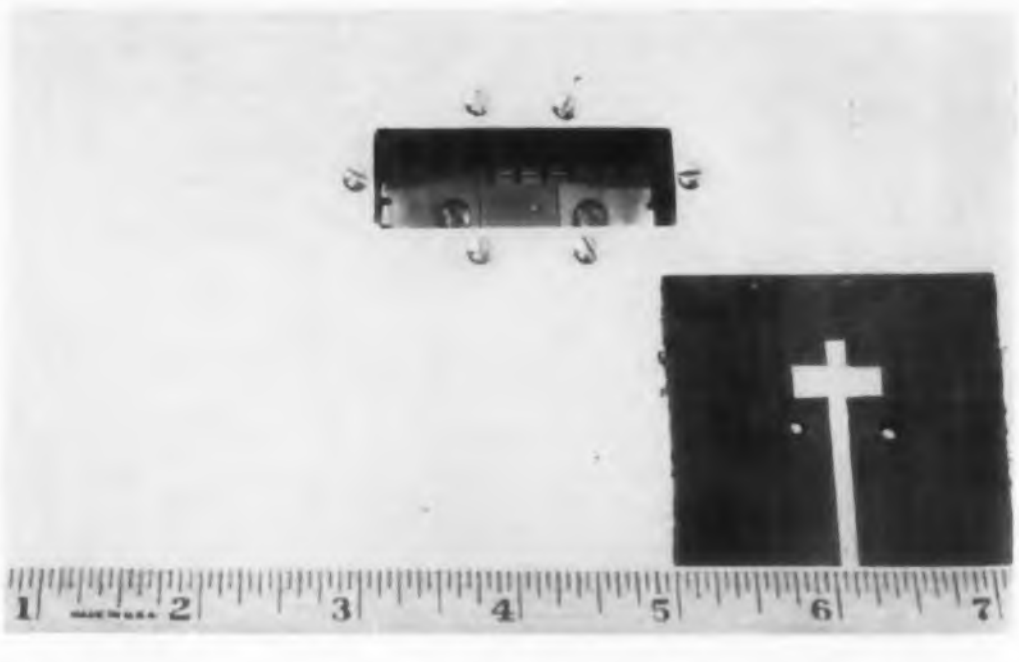


Fig. 3. (right) Slot antenna with microstrip feed.

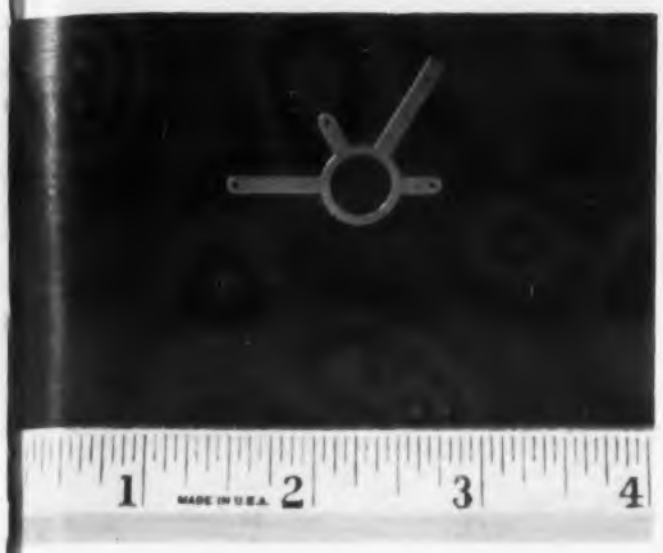


Fig. 4. X band hybrid ring.

ransmission system; $Z_{(Free\ Space)}$ is the character-istic impedance of the same transmission system with air dielectric; E is the dielectric constant; is the velocity propagation; and c is the velocity of light in free space. In the above the magnetic permeability has been assumed equal to unity.

Velocity of Propagation

The procedure used to obtain the approximate characteristic impedance of microstrip line was to measure the velocity of propagation and, using this, calculate the equivalent dielectric constant using Eq. (2). Using the free space data of Black and Higgins, the characteristic impedance was found by the use of Eq. (1).

Microstrip Measurements

The design of microstrip rf components has been complicated by the lack of suitable measuring techniques in this type of transmission line. One successful method of making these measurements, using an ordinary coaxial or waveguide slotted section,[1] uses a modification of the method described by Deschamps for making measurements through transmission line discontinuities.

The equipment is arranged as shown in Fig. 1. Here the susceptance is moved along the microstrip line and slotted wave measurements are taken every 1/16th of a wavelength of line. The data is plotted on a Smith Chart and a graphical calculation yields the characteristics of the transition to the microstrip. The load to be measured is substituted for the dummy load and another measurement taken. Another graphical calculation yields the impedance of the load relative to the characteristic impedance of the microstrip. All of the above must be repeated at each frequency where data is desired and also a matched lead made for each frequency.

Because of the complexity of this system, particularly if a wide band of frequencies is to be

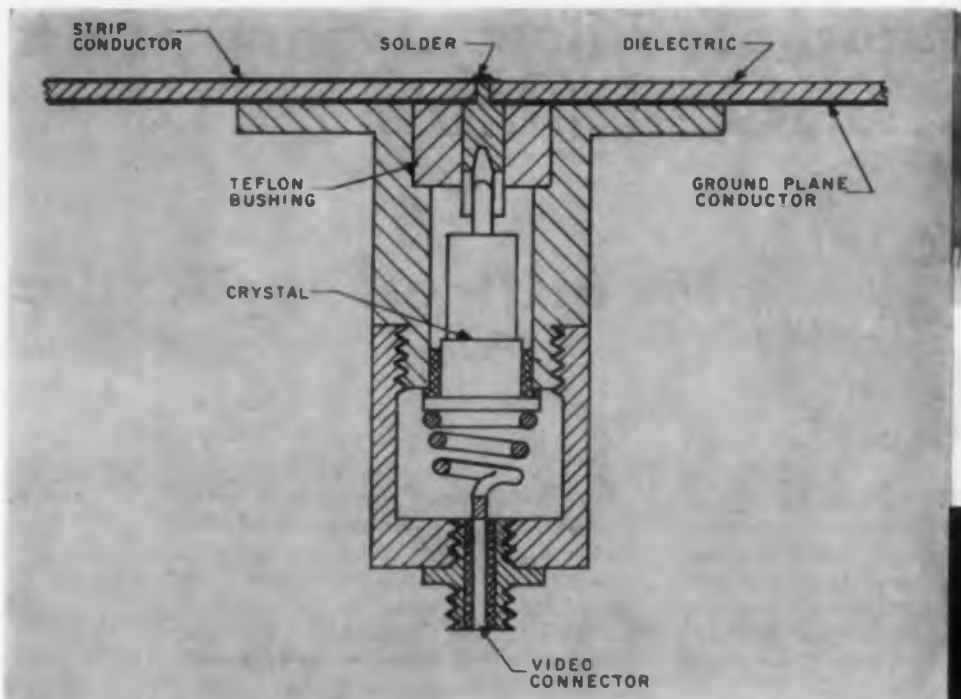


Fig. 5. Crystal mount.

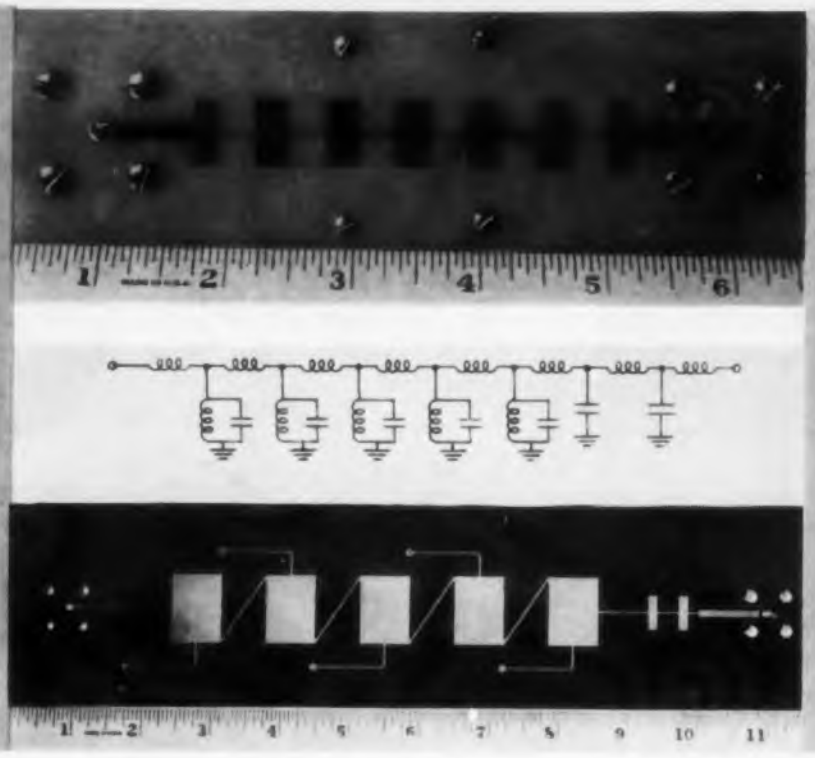


Fig. 6. Six section low pass filter.

Fig. 7. 320-700 mc band pass filter.

covered, it is desirable to have a slotted section in microstrip line. Measurement techniques would then be the same as those used with waveguide or coaxial line. Early attempts at making a slotted section in microstrip made use of a traveling probe over the strip conductor. This method yields very poor results because the field above the line is small at this point. It is found that any radiation field above the line is generally sufficient to mask the nulls and give inconsistent results.

By placing a shield around the microstrip line, it is possible to correct the deficiencies of this method. A very simple method of constructing a shielded slotted section is to mount a section of microstrip line along the bottom of a conventional slotted waveguide as shown in Fig. 2. Here a Hewlett-Packard Universal Carriage was used with the 3/4 in. x 1-1/2 in. slotted waveguide. Two aluminum bars are used to force the microstrip line to lie flat on the bottom of the waveguide. These are forced down by set screws from the top of the guide.

This slotted line was found to operate well up to 5000 mc. Above this frequency radiation fields again cause trouble because the waveguide is above its cut-off frequency. Another slotted microstrip section was made using WR62 (Ku band) waveguide which operates satisfactorily to 9000 mc.

Tests made with these slotted sections show that the velocity of propagation with and without the shield differ only by a small fraction of one per cent. Also, the change in impedance between shielded and unshielded line is quite small resulting in a vswr less than 1.05.

The velocity of propagation of microstrip line as a function of the strip width on a Teflon impregnated fibre-glass base of 0.028 in. thickness was investigated. Data taken at several frequencies shows no significant change in the velocity of propagation as the frequency is changed. This data was used to compute the dielectric constant mentioned earlier.

The impedance of microstrip line is computed by Black & Higgins[2] using the dielectric constant. Data is taken with a 0.110 in. strip width in the slotted line and the impedances are relative to the impedance of this width of line. Agreement between the calculated curve and the data is very good. Impedances from 14 ohms for a strip width of 3/8 in. to 90 ohms for a strip with of 0.028 in. are available on 0.028 in. Teflon impregnated fibre-glass.

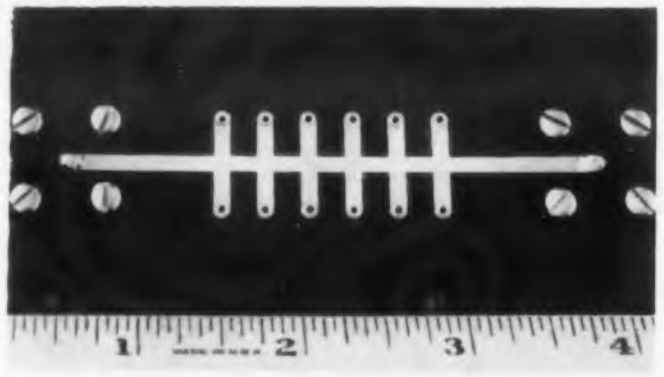


Fig. 8. 5400-9000 mc band pass filter.

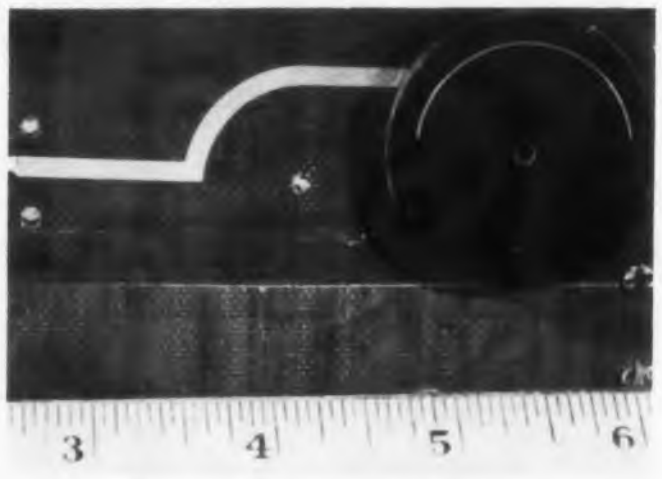


Fig. 9. Adjustable single stub tuner.

Microstrip Components

A slot antenna which has been adapted for a microstrip feed system is shown in Fig. 3. The slot is backed up by a reflecting cavity so that radiation will take place only in one direction. The Teflon-fibre-glass card with the microstrip line is placed over the slot. The copper backing is removed from the area that goes over the slot.

The probe extending over the slot was designed experimentally using strips of copper foil held in place with cellophane tape. The antenna has a vswr less than 2:1 from 3400 to 6800 mc. Its pattern is similar to that of an ordinary slot antenna.

An X-band hybrid ring duplexer made with microstrip line is shown in Fig. 4. The diameter of the circle is such that the electrical length around the circle is 3/2 wavelength. Thus, energy going in one arm will not appear at an arm 120 deg away because the path lengths differ by a half wavelength and cancellation takes place. When used as a duplexer, the transmitter and receiver are connected so as to be isolated from each other. One of the other arms is connected to the antenna and a dummy load is placed in the fourth arm for balancing. Isolation of about 40 db can be fairly easily achieved at X band.

A crystal mount which may be used with

microstrip is shown in Fig. 5. As can be seen, the crystal is essentially mounted in a conventional coaxial crystal holder and a transition made to microstrip.

Microstrip techniques have been found particularly adaptable for the construction of microwave filters. The electrical design is similar to that of coaxial and waveguide filters,[3] but the physical construction is much simpler because printed circuit techniques are used with microstrip filters.

A six section low pass filter constructed on 1/16 inch epoxy resin impregnated fibre-glass is shown in Fig. 6. Investigation showed that the spurious response around 7000 mc is due to direct radiation between the coaxial to microstrip terminations. Radiation was found to be much less troublesome with 1/32 inch material.

A 320-700 mc band pass filter is shown in Fig. 7. This filter is essentially of the lumped constant type—that is, the transmission line lengths are short enough that they may be approximated by lumped reactances as shown in the equivalent circuit. This particular configuration for a band pass filter was selected because it does not require a series capacitance which would be difficult to construct with microstrip. The shunt inductance stubs are shorted to the ground plane conductor by means of eyelets. Two low pass sections have been added to suppress the spurious responses which normally occur at the higher frequencies with microwave filters of this type.

In the investigation of the response of this filter, insertion loss was 2 db maximum in the pass band. Spurious response was at least 30 db down.

An example of another type of construction for a band pass filter is shown in Fig. 8. In this filter, the elements are a large fraction of a wavelength in length. This type of filter is useful at the higher frequencies where the elements of the other type of filter become quite small. The bandpass is 5400-9900 mc with only one-half db insertion loss over most of the passband.

In Fig. 9, a method of constructing a variable single stub tuner is shown. Here the main transmission line is shaped to form an arc of a circle. The stub is printed on a dielectric wheel which is mounted over the transmission line. The length of the stub may be adjusted by rotation of the wheel. ■ ■

References

1. Characteristics and Applications of Microstrip for Microwave Wiring, M. Ardita, *IRE Transactions*, vol. MTT-3, p. 31-56; March 1955.

2. Rigorous Determination of the Parameters of Microstrip Transmission Lines, Kenneth G. Black and Thomas J. Higgins, *IRE Transactions*, vol. MTT-3, p. 93-113.

3. Very High Frequency Techniques, Radio Research Laboratory Staff, McGraw-Hill, chaps. 26-27.

Bernard Lee is an Advanced Servomechanisms Engineer concerned with the analysis and design of Missile and Weapon Systems. He has had experience in the design and development of Inertial Navigation and Missile and Pilotless Aircraft Flight Control and Guidance.

Self-Saturating Reactor Circuit

Amplifies AC Signals Directly

Bernard Lee
Electronics & Avionics Division
Emerson Electric of St. Louis

BY PROVIDING a circulating path for induced currents, a self-saturating reactor circuit can be used to directly amplify ac signals. There need be no rectifiers in the input circuit which cause high drift levels and necessitate large input signals.

Before an explanation of this reactor circuit becomes meaningful, it is necessary to examine the limitations of conventional magnetic amplifiers used to magnify ac signals.

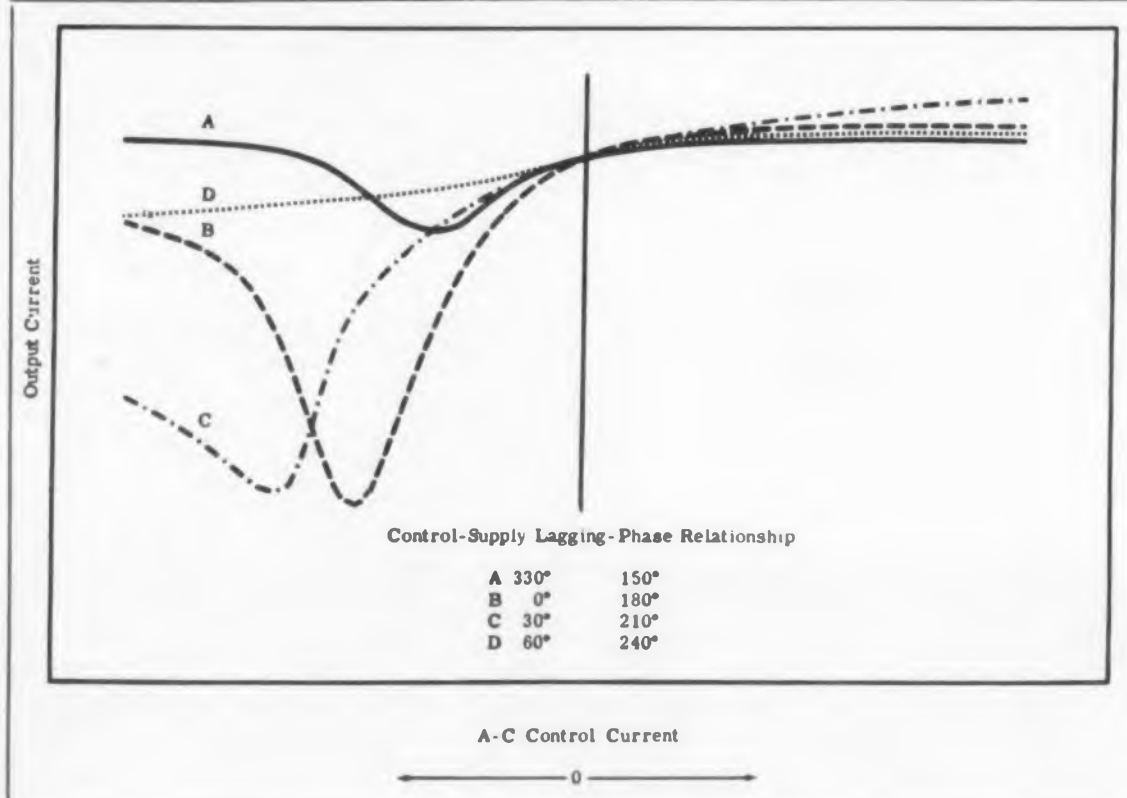
Conventional AC Control

The effect of ac signals on self-saturating reactor circuits is a function of their phase relationship with the supply source. A group of characteristics associated with a half-wave amplifier and a simplified schematic is shown in Fig. 1. Ac signals with a so-called acceptable phase relationship produce control characteristics having relatively high cut-off values. Beyond cut-off, a characteristic "lifting of the tail" is displayed.

Small ac signals control the magnetic state of the core during the nonconducting cycle of the supply voltage. Control occurs on the back flank of the hysteresis curve and is most effective after the collapse of flux in the core is completed. An in-phase signal would take the core through a minor hysteresis excursion and cause it to end at some lower position of the magnetization curve. The reduced value of the flux density in the core at the start of the forward alternation of line voltage acts to increase the ac impedance of the reactor. This results in less of the supply voltage appearing across the load. That is, the amplifier is driven downward.

The in-phase ac signal is opposed by the fundamental and higher ordered odd harmonic line voltages induced into the control winding during the time when the flux in the output coil is collapsing. The resulting induced current in the control winding opposes a change of flux and the amplifier sustains a loss of gain.

The normally high quiescent output is a direct result of the increased residual magnetism of the



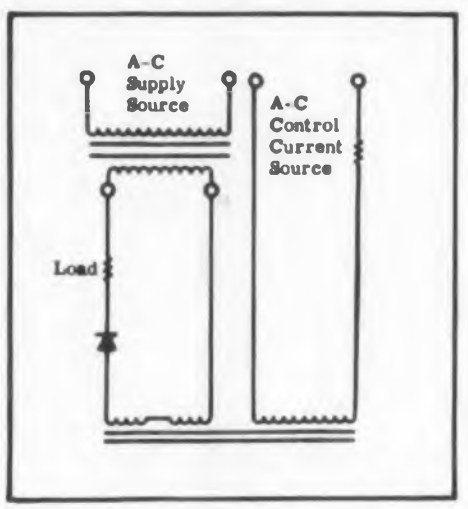


Fig. 1. (Left and above.) Conventional half-wave rectifier circuit with typical operating characteristics.

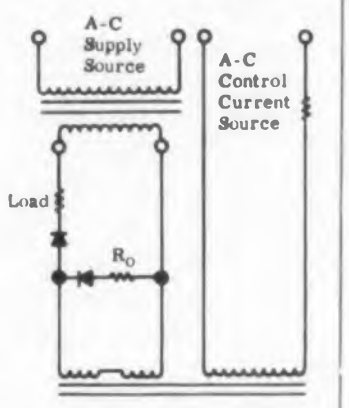


Fig. 2. (Above) Half-wave amplifier with closed current path around output winding.

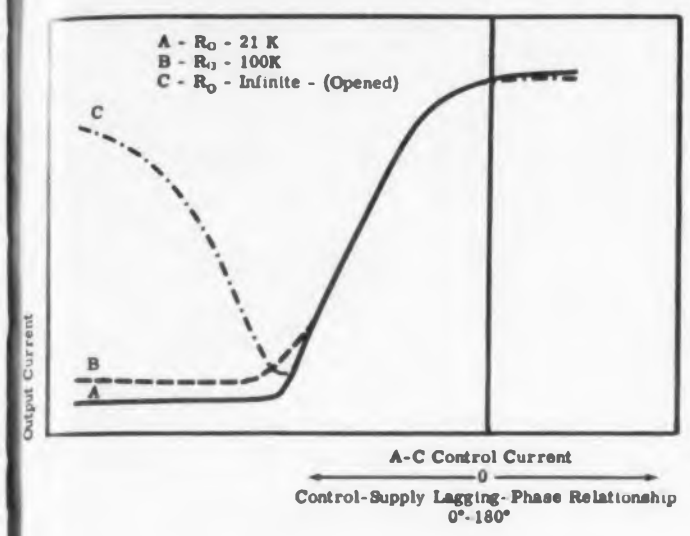


Fig. 3. Operating characteristics of half-wave amplifier with closed current path around output winding.

core material. This condition is caused by the magnitude of the induced line current. Minimum output occurs when the signal reaches such a magnitude that the induced voltage in the output winding is equal and opposite to the instantaneous value of the sum of the supply and load voltages.

Magnetizing ampere turns are shared equally between the supply and signal source. As the signal is increased beyond cut-off, the in-phase signal is of sufficient magnitude to control the core during the conducting period of the supply voltage. The total magnetizing current is supplied from the signal source. The current measured through the load element increases and the familiar "lifting of the tail" of the control characteristic curve is encountered.

New AC Amplifier Circuit

The ac magnetic amplifier described here provides a circulating path for induced control currents. In this manner, the negative slope of the control characteristic curve beyond cutoff may be eliminated. The term negative slope is relative. It is applicable when the slope of the high gain portion from cut-off to maximum output is considered positive. Fig. 2 shows such a circuit in the form of a rectifier and limiting resistor shunted across the output winding of a half-wave magnetic amplifier. Current is drawn through the output coil when operating beyond cut-off to generate the desired desaturating magnetomotive force.

The resistance value should be such as to allow sufficient circulating current in the closed path. Sufficient current sets up a flux condition wherein the magnitude of line voltage that may be absorbed by the reactor will maintain minimum output through the desired range in the region beyond cut-off.

Optimum value of the resistance may be found experimentally. It is varied over a wide range to get the control characteristic desired in any particular case, as indicated in Fig. 3. Large enough values may normally be selected so as to have negligible effect on the speed of response of the amplifier. Minimum values are dictated by the magnitude of shunt impedance corresponding to a total loss of control of the reactor.

A workable value of the resistor R_o in the shunt circuit may be found with the following equation:

$$R_o = \frac{E}{I_m}\left(\frac{N_1}{N_2}\right)^2 - R$$

where R is the total effective resistance of the rectifier and the winding in the closed current path; E is the voltage across the reactance or output winding at minimum output (the supply voltage is a close approximation of E because at minimum output almost all of the supply voltage will appear across the output winding); I_m is the magnetizing current associated with the output winding and the voltage E (the load current at minimum output is often near the value of the magnetizing current); N_1 is the number of turns on the winding in the closed current path; and N_2 is the number of turns in the output winding.

In the circuit shown in Fig. 2, the closed current path and output windings are the same, and $N_1 = N_2$. Actually the closed current path may include a portion or all the output, control or an auxiliary winding. The latter two configurations are shown in Figs. 4 and 5.

The rectifier selected in the closed current path must be capable of blocking the maximum induced voltage in the pick-up winding and passing the necessary demagnetizing current.

The circuit is relatively more phase insensitive than the normal half-wave amplifier. The magnitude of the in-phase component of capacitive current drawn through the output winding at cut-off is a function of the line-signal phase relationship and is therefore most favorable for a range of from −30 to +15 degrees.

The ac magnetic amplifier circuit described here may be adapted to all of the well known practical configurations: full wave, bridge and doubler, and in both the single ended and push-pull arrangement.

Feedback Circuit

The burdened output winding of the ac magnetic amplifier may be used to control a second half-wave amplifier by placing a tertiary winding of the second core in series with the closed current path. Induced current is allowed to circulate through the tertiary windings in such a direction

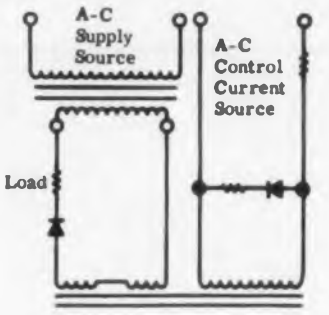


Fig. 4. Circuit for measuring inductance by the droop test method.

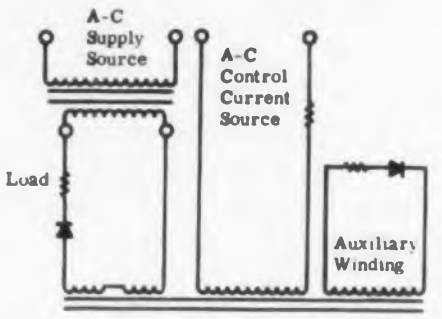


Fig. 5. Half-wave amplifier with closed current path around an auxiliary winding.

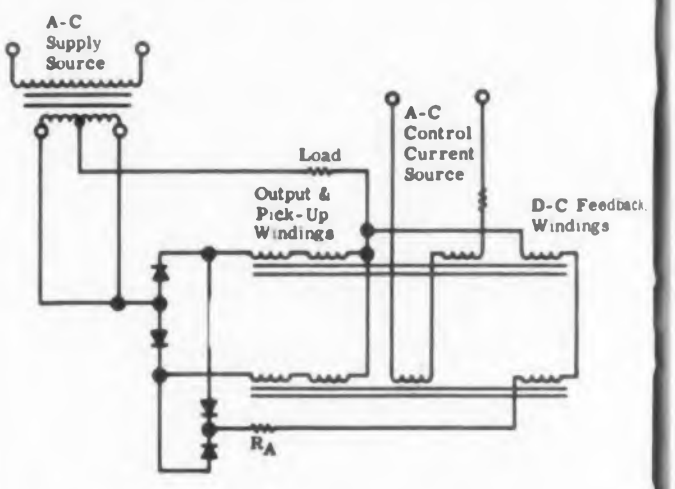


Fig. 6. Full-wave amplifier with closed current path around output and dc feedback windings.

as to aid in driving the amplifier toward cut-off. An example of this use as applied to the full wave magnetic amplifier circuit is shown in Fig. 6. The auxiliary feedback circuit has a configuration exactly like the conventional output circuit with the dc connected tertiary control windings taking the place of the load in the output circuit.

Fundamental supply voltage is induced into the pick-up windings of the auxiliary circuit in the linear region of the control characteristic curve. The induced current is allowed to circulate in a desaturating direction through the tertiary control winding of the core associated with the non-conducting side of the supply cycle. Negative dc control of the collapsing core is thus established, aiding the ac signal in driving the

output of the amplifier downward. The feedback signal increased as the amplifier is driven further and further toward cut-off.

When the signal is 180 degrees out of phase with the supply voltage and intended to drive the output upward, less voltage is induced into the pick-up windings. The dc feedback current becomes conveniently negligible.

The auxiliary circuit produces a form of positive feedback, resulting in an increased amplifier gain with the tendency to pivot the control characteristic curve about its upper knee. Enormous values of gain with this circuit are possible.

The signal voltage induced in the auxiliary circuit at cut-off is approximately equal to the product of the line voltage and the ratio of pick-up to output winding turns N_1/N_2. The voltage induced into the tertiary turns, N_3, are ideally bucked out. The effective ampere-turns of demagnetizing current must be calculated on a basis of the sum of the pick-up and feedback turns in series. The value of resistance R_a to be placed in series with the feedback winding turns expressed as a function of the resistance R_o computed across the full output winding is

$$R_A = \frac{N_1 (N_1 + N_3) R_o}{N_2^2}$$

R_A may be reduced to 30 per cent of this value to attain a good compromise between gain and sustained cut-off. A group of control characteristic curves showing the effect of variations in R_A are shown in Fig. 7.

The rectifiers selected in the auxiliary feedback circuit must be capable of blocking the sum of the maximum pick-up voltage and the drop across the limiting impedance and tertiary windings. They must be able to pass the maximum feedback current.

The circuit is relatively insensitive to the control-supply phase relationship. Characteristics of the new ac magnetic amplifier are demonstrated for a band of 60 degrees in Fig. 8. It is possible to obtain ratios of power gain to time constant, using this special ac magnetic amplifier, that are in excess of those attained with conventional dc configurations.

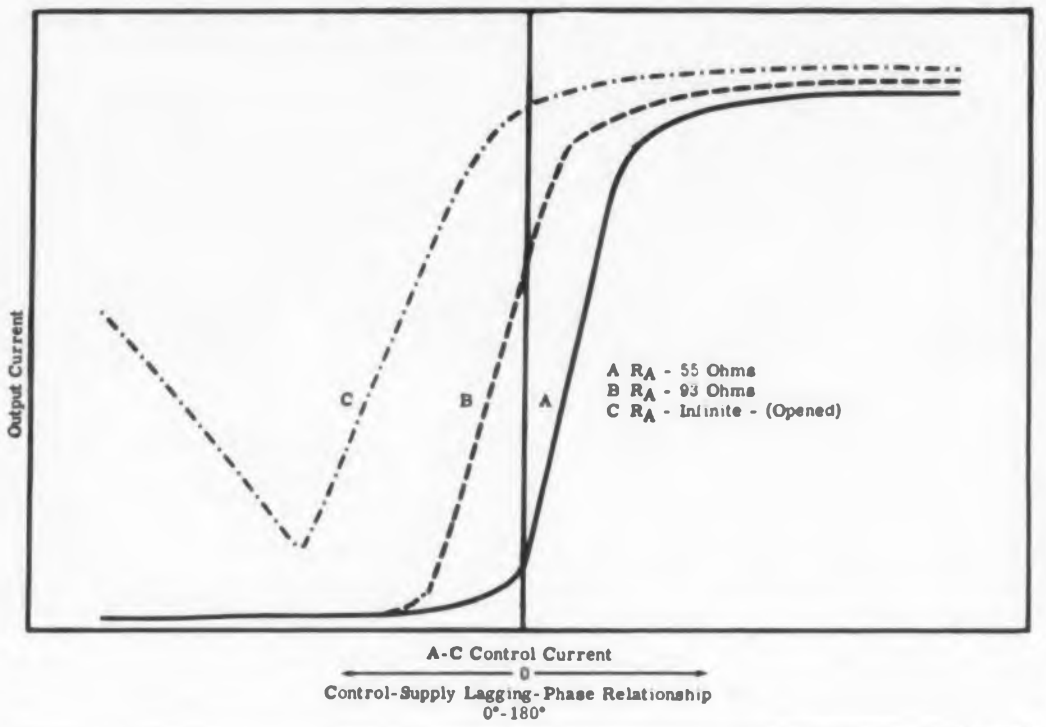
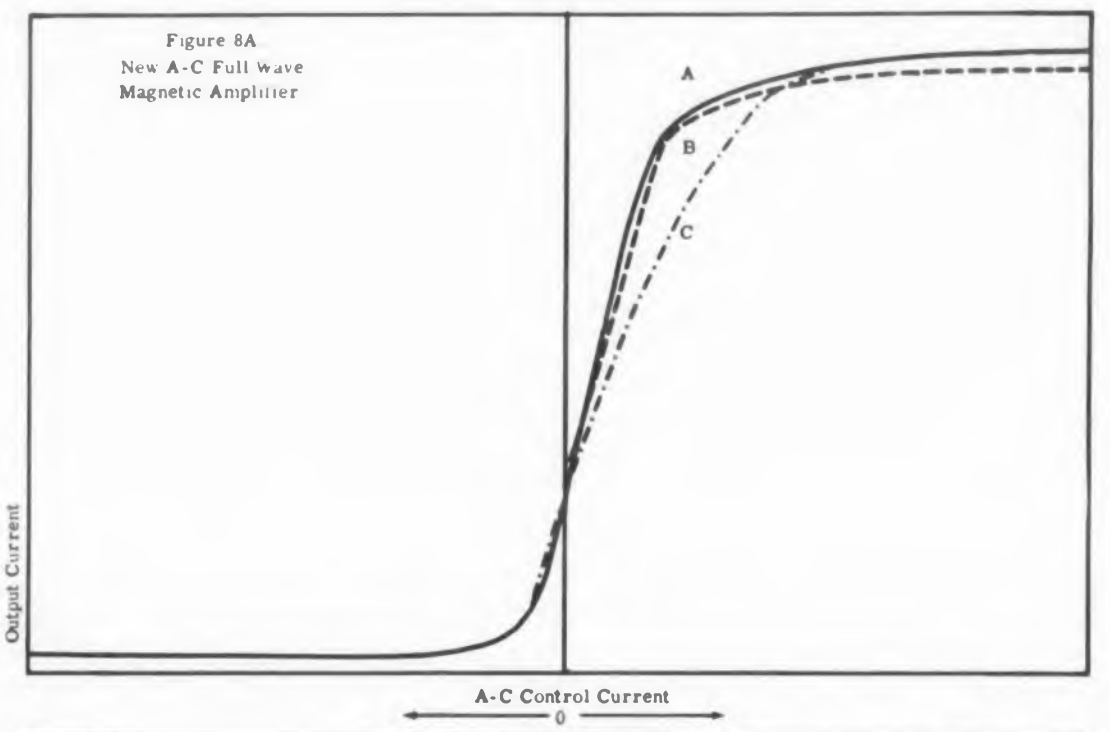


Fig. 7. Operating characteristics of full-wave amplifier with closed current path around output and dc feedback winding.



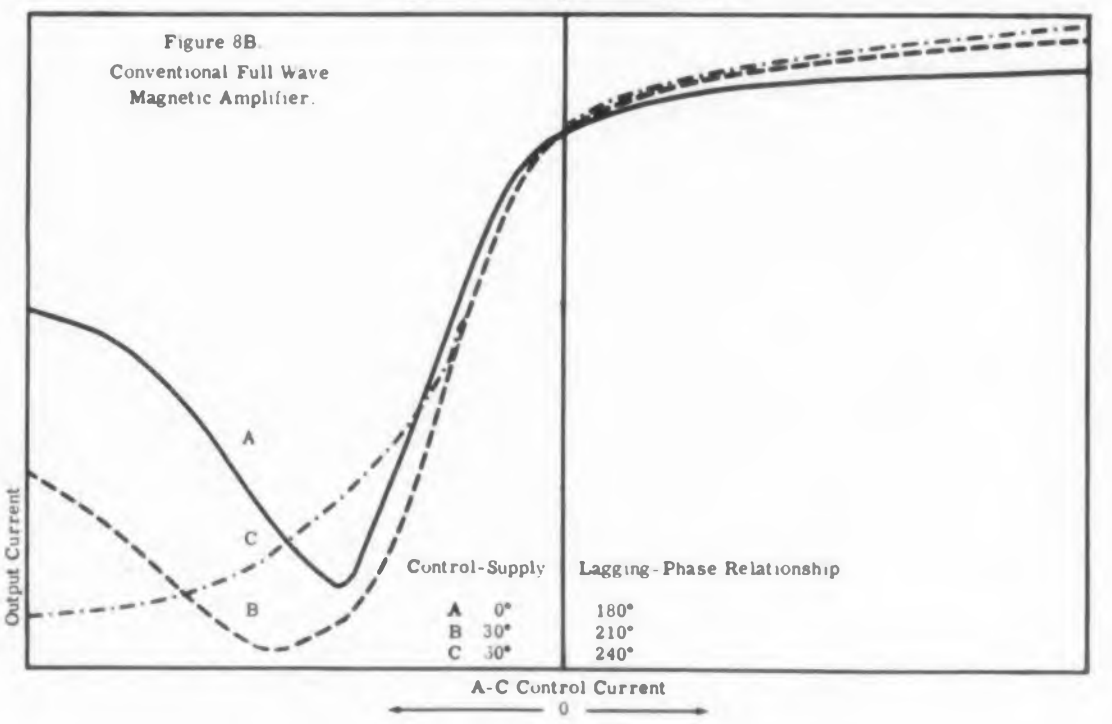


Fig. 8. Operating characteristics of ac full-wave magnetic amplifier.

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2. Magnetic Amplifiers, Storm, H. F., John Wiley & Sons, Inc., New York, 1955, Chs. 26 and 27.
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4. Magnetic Amplifier, Lee, B., U. S. Patent No. 2,780,771.
5. Self-Saturating Reactor Circuits, Lee, B., U. S. Patent No. 2,780,772.

Just over a year ago, the initial 2-year product design portion of the Army Micro-Module program was started with RCA as the prime contractor. This article describes, in somewhat more detail than our staff report last issue. "Microelectronics—a new concept in packaging," the progress that has been made to date. Future work being planned is disclosed.

Progress in the Army Micro-Module Program

Vincent J. Kublin
U. S. Army Signal Research & Development Laboratory
Ft. Monmouth, N. J.

MICRO-MODULES are a logical and practical step toward obtaining the ultra-compact assemblies demanded for Army electronics. It should be clear that it is actually a new viewpoint being applied to known principles and proven techniques. Among these known principles is the Navy Tinkertoy assembly technique (Fig. 1).

This technique called for the fabrication of parts on standard shaped ceramic wafers. The dimensions selected were keyed to the miniature vacuum tube and did not stress miniaturization as a particular attribute. At best, densities up to 10,000 parts per cubic foot could be realized. The technique does, however, offer an attractive automatic assembly feature which represents another step forward in electronic development.

Industry is now integrating active parts into ceramic modules. Fig. 2 shows a single stage transistor audio amplifier with a parts density of over 700,000 parts per cubic foot.

But the overall usefulness of this technique has been limited, first by the lack of a complete family of parts in these systems, and second by the random geometries which yield poor integration efficiencies.

Accordingly, the first basic need is to provide all electronic parts functions in an essentially two dimensional system and further such a complete family of parts must have a uniform geometry to permit efficient integration. It is towards these ends that the Micro-Module program is directed.

In Fig. 3 for example, are a few of the basic parts elements in the standard 0.3-in. square shape. The resistors, capacitors, inductors, transistors and diodes are all essentially two dimensional. An assembled micro-module is shown at the center, made by stacking and inter-connecting the individual micro-elements.

Three experimental micro-modules, Fig. 4, are typical of the construction just described. One of these is a receiver converter circuit and two are 455 kc i-f amplifier sections. Parts densities are about 600,000 parts per cubic foot.

Range of Functions

The micro-module system will be capable of performing a full range of basic electronic circuit functions involving a 1 to 2 watt maximum power

Fig. 1. (left) Forerunner of the Army's micro-module program was Navy's Tinkertoy assembly method shown here.

Fig. 2. (left) Single stage transistor audio amplifier showing size reduction possible with microminiature construction.

Fig. 3. (right) Examples of some basic microelements.

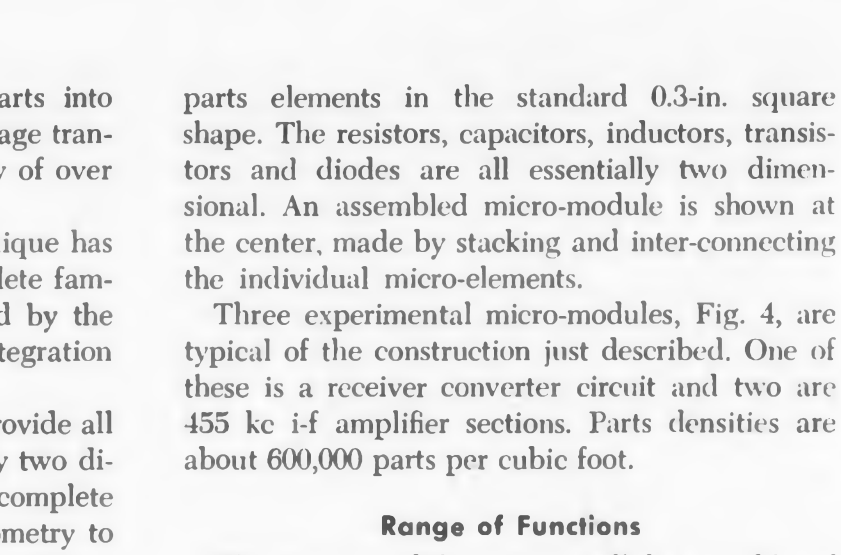

Fig. 4. (right) Experimental micro-modules made up of the microelements of Fig. 3.

	TEMPERATURE °C	ALTITUDE (FT)	VIBRATION (CPS)	SHOCK (G)	SPIN (RPM)	MEAN HOURS TO FAILURE
PORTABLE	-55° / 85°	10K	10–55	50	—	15K / 100K
VEHICULAR	-55° / 85° 125° 200°	10K	10–55	50	—	15K / 100K
MISSILE	-55° / 85° 125° 200°	150K	10–2000	50	—	8K
PROJECTILE	-55° / 85°	150K	10–2000	15,000	20,000	8K
SATELLITE	-55° / 85°	VACUUM	10–2000	15,000	20,000	15K / 100K

Fig. 5. (left) Military requirements for equipment subject to various environmental conditions.

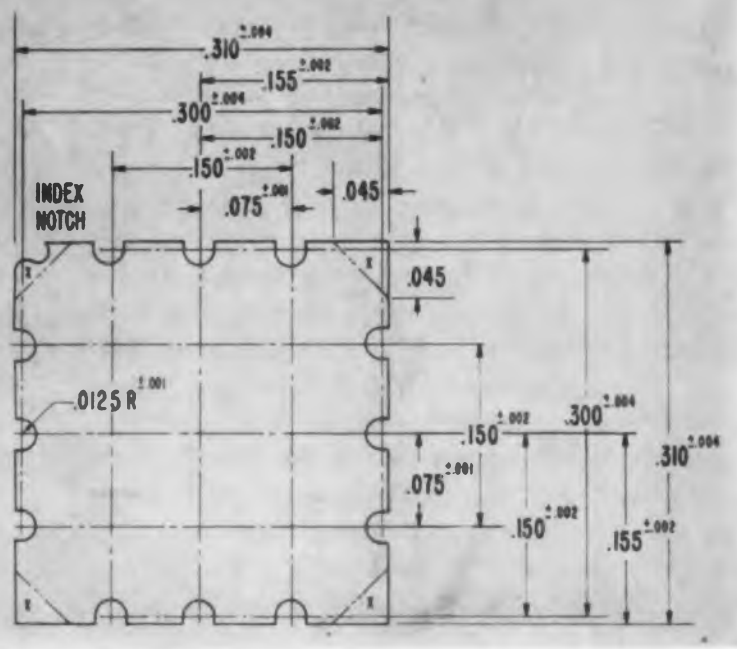

Fig. 6. (right) Dimensions of standard substrate micro-module wafer.

dissipation per module, an initial upper frequency limit of 70 mc with progressive capability to 150 mc and a maximum digital switching rate of 10 mc.

Specific micro-modules are being designed and constructed to demonstrate and to provide for adequate evaluation of a full range of basic audio, i-f, rf, digital computer, and oscillator circuit capability. It is important to stress this broad circuit capability from dc to rf to permit effective system size reduction.

Army equipment is divided into five categories each of which is associated with a unique set of environmental requirements. These requirements are spelled out quantatively as the goals of the full program in Fig. 5.

Temperature requirements for these equipments range from —55 to 85 C for ground portable devices, projectiles and satellites; up to 200 C for vehicular and missile applications. The range from 85 to 125 C is the goal for the first two-year phase of the program.

Vibration requirements range from the standard 10 to 55 cps for the ground and vehicular equipments to 10 to 2000 to 20 g's for the other equipment categories. The ability of Army equipments to work in their extreme air pressure environments is defined by the following requirements: Portable and vehicular equipments must operate without malfunction of any kind at altitudes up to 10,000 ft. Missile and projectile altitude extremes have been set down as dead vacuum for all practical purposes.

All micro-modules will be required to withstand 50 g, 8 millisecond shocks as a minimum. In addition the projectile and satellite modules will be required to withstand 15,000 g's of 2 millisecond duration as well as a spin of 20,000 rpm.

Other standard tests such as high and low temperature and long term storage moisture and temperature cycling and salt tests complete the list of tactical environments to which the micro-modules will be subjected.

Reliability goals have been expressed in terms of mean time to failure for a 50 part module. Basically, the 50 part module reliability requirement is for 15,000 hours or about 21 months mean time to failure within the temperature range —55 to 85 C and under the various Service environments just discussed. Probably a more familiar way to express this initial goal is an average part failure rate of about one-tenth of one per cent per thousand hours.

Parts Already Available

Current design of the standard wafer has 12 notches and is 0.3-in. sq and 0.010-in. thick (Fig 6). Wherever possible, the substrate wafer will be a functioning part of the micro-element. In certain applications, it will be used as a support for the element. Of the many substrate materials being used, alumina and glass show the most immediate promise.

Metal Film Resistors

Present capabilities for nichrome film resistor elements are up to 200,000 ohms per pattern. Two patterns can be accommodated on each wafer side with a temperature coefficient between 20 to 60 ppm/C and a maximum dissipation of 1/2 watt per wafer. In addition, tin oxide resistors have been produced in values up to 20,000 ohms per wafer with a T. C. of 12 to 24 ppm/C. Thus we have 1, 5 and 10 per cent film resistors with individual ratings of 1/8 watt and resistance ranges adequate to meet the resistor requirements.

Universal Resistor Pattern

A universal resistor pattern, Fig. 7, can be custom terminated for the specific circuit application. Preliminary conclusions indicate that it is not possible to standardize the termination of all micro-elements without resulting in excessive riser wire cuts and addition of interconnecting wafers. The resistor therefore will be deposited first and the terminations will be deposited later on a custom basis.

Universal Capacitor Pattern

Similar to the resistor pattern is a universal capacitor pattern (Fig. 8) to which appropriately

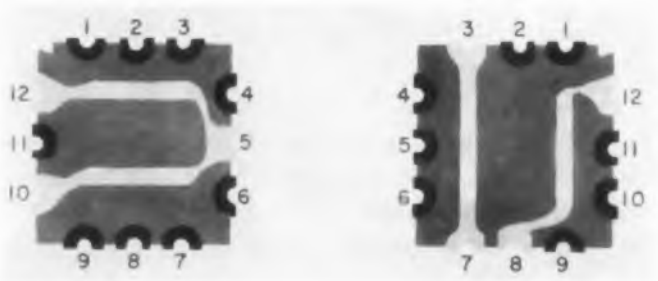

Fig. 7. Universal resistor pattern that can be terminated in a number of ways, depending upon wiring requirements. Custom terminations can be deposited on the wafer after the resistor is made.

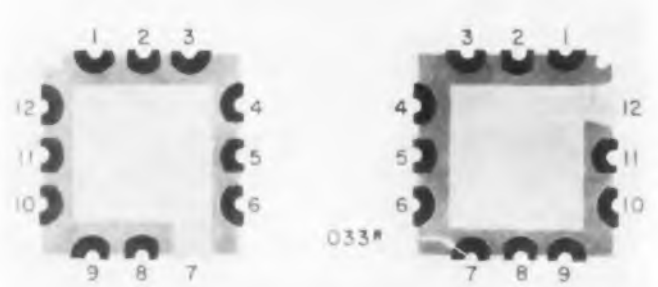

Fig. 8. Universal capacitor pattern. Terminations can be added as required.

located terminations are added as required. The substrate is actually the dielectric for the capacitor. By using different materials as the dielectric, the characteristics of such units can range from precision temperature coefficient types to general purpose, high capacitance, by-pass and coupling units. Capacitance values as high as 400 μμf for the precision types have been obtained on the single wafer. By making use of the extremely high dielectric constant materials we are able to achieve capacitance values as high as 0.01 μfd per wafer.

In addition to the basic ceramic wafer capacitor an evaluation is being made of the multi-layered capacitor. In this case a number of layers of dielectric and electrodes are alternately deposited on a ceramic substrate. The dielectric is approximately 2 mil. Precision units of this type have a capacity of 1300 μμf with a dissipation factor of less than 0.1 percent and zero temperature coefficient. General purpose hi-K capacitors of this design have capacitive values to 0.3 μf.

Electrolytic Capacitors

Electrolytic capacitors will be used to cover the capacitance range from 0.2 to several microfarads. The solid tantalum capacitor is ideally suited for this application. A sintered slug approximately 10 mils thick and 0.250 in diameter has been produced and adopted to the micro-element design yielding a voltage-capacity product of 40 with dissipation factors less than 5 per cent and dc resistance of 20 megohms. Operating voltages are up to 35 volts.

Bell Laboratories has developed gold-plated, tantalum oxide capacitors prepared on a glass substrate. These capacitors were made by vacuum "sputtering" tantalum in an established pattern, and anodizing the surface to form the tantalum oxide dielectric. This novel "sputtering" technique enhances the dielectric strength by further purifying the tantalum through distributing or "homogenizing" the impurities. In this manner no large conducting impurities are concentrated in small areas to degrade the leakage.

Tests show that these dry oxide tantalum capacitors are equivalent to stable K1200 ceramic capacitors but with volume efficiencies better than those of electrolytic capacitors. Of further importance is that these anodically formed capacitors do not need any liquid, paste, or solid fill electrolyte. Typical electrical characteristics obtained on early experimental samples show that up to 0.2 μfd per wafer at 10 volts can be obtained. Other characteristics are:

- Dissipation factors of approximately 0.9 per cent or Q = 100 at 1 Kc.
- Cap/in^2 = 1 μf/in^2 at 100 volts, 10 μf at 10 volts
- Insulation resistance 25,000 megohms at 10 vdc applied (0.008 μf)
- Temp. coeff. = 250 ppm/C.

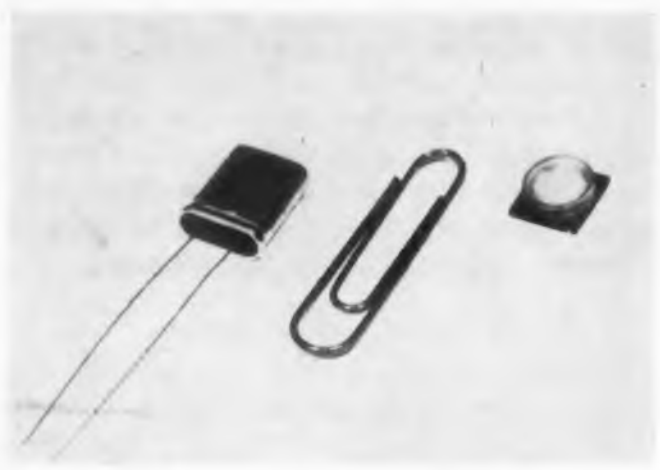

Fig. 9. Conventional crystal (left) compared to a typical micro-module crystal.

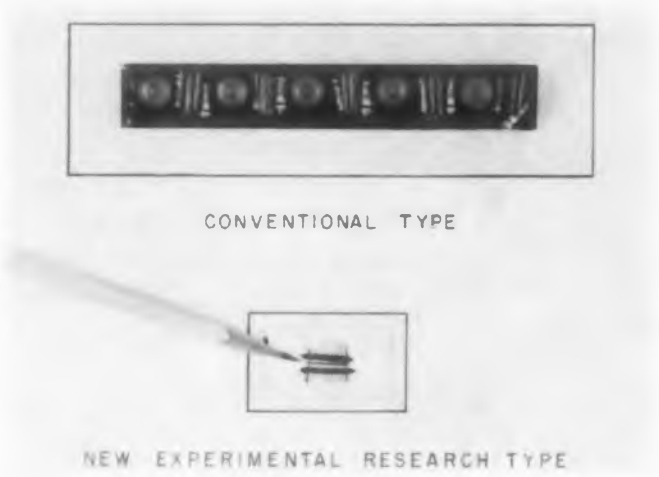

Fig. 10. Conventional shift register (top) shown with the micro-module version.

Ferrite Cores

Temperature coefficient of a 4.3 mc ferrite with an initial permeability of 50 is about 30 ppm/C with a Q of 120. Higher frequency material has an initial permeability of 10 and a Q of 110 at 70 mc.

Toroids have initially been chosen for inductors since they permit achievement of higher inductances and less stray magnetic fields compared to other known configurations.

Since coil characteristics are almost completely controlled by the ferrite core material, major effort has been expended on control of material properties. Work to date has been concentrated on temperature stable ferrites for the 4.3 mc i-f inductors as well as material for 50 to 100 mc operation. Several methods for controlling the temperature coefficient of permeability have been developed. One method entails the addition of various amounts of carbon black and the other by control of ferrite particle size.

The matching of such essentially zero temperature coefficient ferrite bodies with available NPO ceramic capacitors will yield self-compensating tuned circuits over the frequency-temperature range of interest.

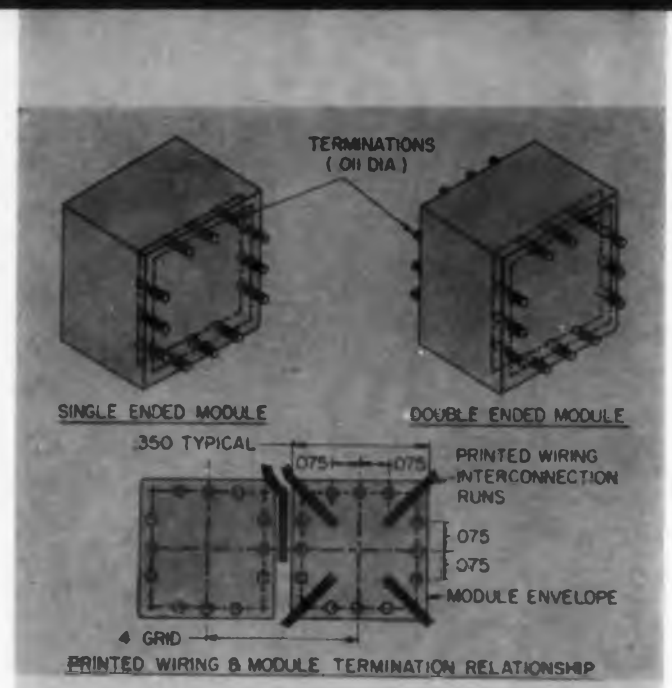

Fig. 11. One way of terminating a 12-termination 25-mil grid module (single ended) or the 24-termination (double-ended) module. Only four interconnecting runs can be brought into each module envelope as shown at the lower right. This method is not as efficient as the 50 mil grid module which provides twice that number.

Crystals

Quartz crystal units (Fig. 9) for frequency control applications, are capable of being reduced in size to be compatible with other portions of the Micro-Module Program. Presently crystal units in the 7 to 70 mc range are under development. Final fabrication would contemplate a ceramic holder 1/16 the size of the unit on the left of Fig. 9. Present plans call for fundamental crystals from 7 to 20 mc and overtone units from 20 to 70 mc.

Fig. 12. Micro-module subassembly with printed-wiring interconnection board.

Shift Registers

Included in the family of micro-parts are solid state advances of the type shown in Fig. 10. The conventional 5-bit shift register shown at the top can be functionally replaced by the single germanium element shown at the bottom. As a matter of fact, the germanium unit has a 10 digit potential. It can be adopted to the micro-element shape as can other solid state advancements along these same lines.

Interconnections

Various methods are being used to integrate micro-elements in micro-modules, terminate micro-modules and the further integration of micro-modules into sub-assemblies and equipment.

A 25 mil grid module arrangement, Fig. 11, can be a single-ended termination with twelve leads or a double-ended termination scheme with twenty-four leads. This configuration requires no bending of riser wires—all module terminations are straight continuations of existing riser wires. This approach provides for the capability of eight circuit interconnection runs per each end, using two-sided printed wiring board.

Another approach is based upon the 50 mil grid pattern and is "geared" for direct integration in the present day 0.1-in. grid system. The 50 mil grid module requires bending of eight riser wires and provides for 16 interconnection runs per end, again using a two-sided printed wiring board.

Shown in Fig. 12 is a typical micro-module receiver sub-assembly consisting of three modules and printed wiring integrating board. Module terminations are arranged for direct integration in the 0.1-in. grid system. This is a very compatible combination of printed wiring and single ended modules, forming a circuit assembly. Appropriate connectors are now being constructed.

Alternate methods of interconnecting modules with flat riser ribbons or wires are being studied. Flat riser ribbons are especially useful for notchless wafers and are more adaptable to welding than round wires. One technique uses a parallel-plane type of modular sub-assembly with the flat riser wires of individual modules crimped over the edge of the printed wiring strips. These will probably be welded or spot-soldered.

In another technique, the printed-wiring mounting strips are arranged in an orthogonal array. Also being used is a "honeycomb" array of wedge type modules mounted on a special space-saving type of printed wiring assembly.

Detailed information on other developments in this field will be found published in our Proceedings of the Symposium on Microminiaturization of Electronic Assemblies. For further information on the Proceedings, turn to Reader Service Card and circle **100.**

NEW PRODUCTS

To provide a complete coverage of ALL new products generally specified when designing electronic original equipment, the New Product section has been extended. To include the larger number of items, products which are best suited to a brief description have been noted at the end of the section.

SILICON DIODES

Subminiature silicon diodes 1N696 and 1N697 were designed for high speed switching applications. Having a typical switching speed of 1.5 μsec, the 1N696 has shown a life expectancy in excess of 100,000 hr after aging at room temperature and 100 C. Maximum power in free air at 25 C is 100 mw. Typical reverse recovery time is 30 μsec for the 1N697. Maximum power dissipation in free air at 25 C is 250 mw. The units are available only to U. S. Government agencies and their contractors.

Western Electric Co., Radio Div., Dept. ED, 120 Broadway, New York 5, N. Y.

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MICROMINIATURE POTENTIOMETER

Having a 0.5 in. diameter, the model C-050 potentiometer is completely enclosed by molded covers with integrally cored, solid terminals that cannot loosen or transmit foreign matter into the unit. The unit is rated at 1.5 w with a maximum temperature rise of 60 C. Its rotational life is over one million cycles, and a maximum torque of 1 in.-oz is required. Available with resistance values of 1, 5, 10, 25, and 50 K, the variation is ±5% on standard units to ±1% on custom units.

DeJur-Amsco Corp., Dept. ED, 45-01 Northern Blvd., Long Island City 1, N.Y.

CIRCLE 51 ON READER-SERVICE CARD

POWER SUPPLY

Power requirements for high intensity cathode ray tubes with pre and post acceleration including focus and intensity controls and gate coupling capacitors are provided by this power supply that measures less than 2.5 × 4 × 5.5 in. It meets applicable Mil specs and is operational to more than 70,000 ft without pressurization. Input is 115 v, 380 to 1500 cps, single phase. Output is 6.3 v, 1 amp filament insulated for 3 kv, +2.5 kv to 100 μa, −2.5 kv to 500 μa with appropriate control and focus voltages.

Avionics Research Products Corp., Dept. ED, 1215 El Segundo Blvd., El Segundo, Calif.

CIRCLE 52 ON READER-SERVICE CARD

MULTI-RANGE RESISTORS

For research and development work, these units have four separate 10 w wirewound resistors, all encased in a common steatite housing. The component resistors are of either two or four different values, each with its own pair of axial leads. By various connection of these leads up to 47 different values can be had. Five basic units deliver 200 fixed resistance values.

International Resistance Co., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

CIRCLE 53 ON READER-SERVICE CARD

ENCLOSURE SYSTEM

This enclosure system has a framework that is completely hand assembled with built in locking devices that eliminate the use of any hand tools, bolts or screws. Members for the aluminum system are available from 7 in. to 20 ft. A complete range of standard 1/8 in. aluminum panels, plain or painted, conforming to EIA mounting standards, is available as well as side, top and bottom panels.

Amco Engineering Co., Dept. ED, 7333 W. Ainslie St., Chicago 31, Ill.

CIRCLE 54 ON READER-SERVICE CARD

NEW PRODUCTS

Synchros

Operate from −54 to +200 C

Type CX size 11 and type CT size 8 synchros are designed to operate effectively from −54 to +200 C. Both types are 400 cps units and have a maximum error from electrical zero of 10 min.

Kearfott Co., Inc., Dept. ED, 1500 Main Ave., Clifton, N.J.

CIRCLE 56 ON READER-SERVICE CARD

Thermal Time Delay Relays

Withstand 50 to 75 g shock

Made to MIL-R-5757 and MIL-STD-202 specifications, Hi-Gee thermal time delay relays withstand 50 g shock and 10 g vibration at 10 to 500 cps. Special models can withstand 75 g shock. The units have factory adjusted preset time settings from 1/4 to 300 sec and a life expectancy of 50,000 to 100,000 operations at rated load. They operate from −55 to +125 C and may be ordered for 150 C use. Standard insulation resistance is 1000 v ac and contact arrangement is spst normally open or normally closed. The silver contacts are rated at 3 amp resistive, 115 v ac. Operating voltages can be supplied from 2 to 230 v ac or dc, and power drain is 4 w. The units are available in 7, 8 and 9 pin plug-in types and in a 7 pin hooked terminal type with mounting flange.

Ortron Electronics, Dept. ED, 29 Lincoln Ave., Orange, N.J.

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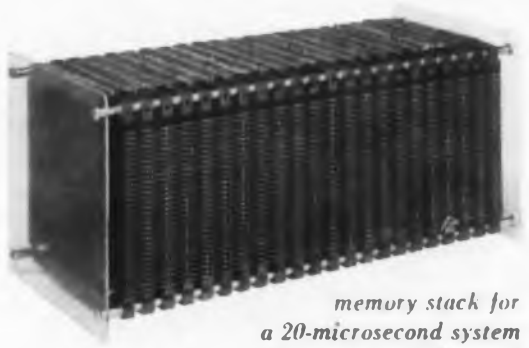

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NEW PRODUCTS

Terminal Block

Side entry

Model T-1010 side entry terminal block can be installed in flat, crowded spaces and is designed for use with ground support equipment such as missile launchers, trailers, and test stand equipment. It is made of a molded phenolic base with reinforced barriers between the numbered terminal cavities. One cavity will accommodate four terminals, and up to 40 connections can be made with one block. Also, adjacent terminals can be bussed together with jumpers. The block measures 5 x 1-1/4 x 11/16 in. and has gold plated sockets.

Twin Lock Inc., Dept. ED, 1024 W. Hillcrest Blvd., Inglewood, Calif.

CIRCLE 60 ON READER-SERVICE CARD

Toggle Switch

Miniature

The 2SB1-1 miniature toggle switch assembly consists of two of the company's type USM5 switches secured in a mounting bracket with a two-position toggle mechanism. The 1/4 in.-40 threaded bushing permits single-hole mounting in panels up to 1/4 in. thick, and the assembly requires a 25/32 x 21/32 x 21/32 in. space behind the panel. The two basic switches meet MIL-S-6743 specifications and are each rated at 2.5 amp, 30 v dc inductive; 5 amp, 30 v dc, resistive; or 5 amp, 125 or 250 v ac, spdt.

The W. L. Maxson Corp., Unimax Switch Div., Dept. ED, Ives Rd., Wallingford, Conn.

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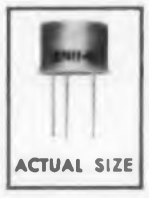
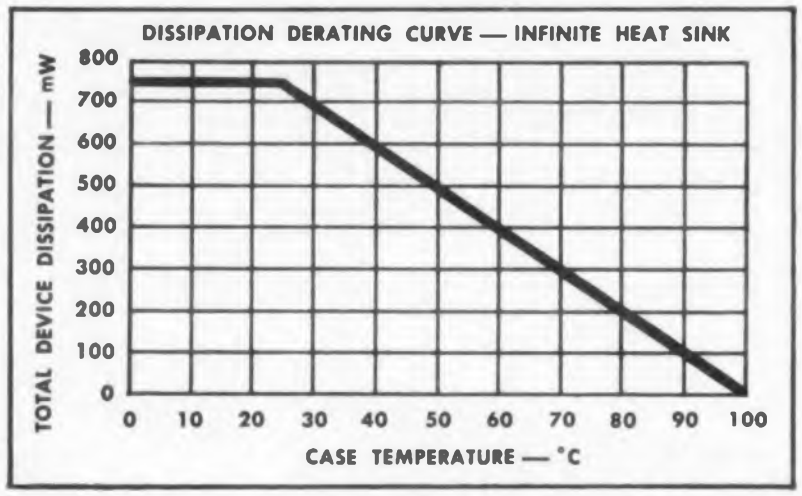


Guaranteed current gains of 12, 10 and 8 db minimum at 100 mc with new TI 2N1141, 2N1142 and 2N1143 diffused-base germanium transistors! Alpha cutoff ratings up to 750 mc coupled with 750 mW power dissipation at 25°C case temperature make these newest TI transistors ideal for military high frequency power oscillators and amplifiers where assured reliability and performance are of primary importance.

All units are 100% production stabilized at temperatures well above their 100°C rated junction operating point . . . exceed MIL-T-19500A specifications . . . and are *in stock now*.

Contact your nearest TI sales office or nearby TI distributor *today* . . . for immediate delivery.



absolute maximum ratings @ 25°C case temperature	2N1141	2N1142	2N1143	
Collector Voltage Referred to Base	−35	−30	−25	V
Emitter Voltage Referred to Base	−1	−0.7	−0.5	V
Collector Current	−100	−100	−100	mA
Emitter Current	100	100	100	mA
Device Dissipation (infinite heat sink)	750	750	750	mW
Collector Junction Temperature	+100	+100	+100	°C
Storage Temperature Range		−65 to +100		°C
typical characteristics @ 25°C case temperature				
Frequency Cutoff (Common Base)	750	600	480	MC
Collector Reverse Current, $V_{CB} = -15V$, $I_E = 0$	1	1	1	μA
Saturation Voltage, $I_C = -70mA$, $I_B = 17.5mA$	2	2	2	V
Thermal Resistance Junction to Mounting Base	0.1	0.1	0.1	°C/mW
Small Signal Short Circuit Forward Current Transfer Ratio,	$10\ I_C$	$50\ I_C$	$100\ I_C$	mA
$V_{CB} = -10V$, f = 1000cps	0.97	0.85	0.75	

from THE WORLD'S LARGEST SEMICONDUCTOR PLANT

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POST OFFICE BOX 312 • 13500 N. CENTRAL EXPRESSWAY
DALLAS, TEXAS

NEW PRODUCTS

Driver Amplifier

Has 1/4 w output power

Model REL-122 is a balanced input, balanced output amplifier with a gain of 1 ±0.05. It is essentially an impedance transformation device without any insertion loss. Output power is 1/4 w; input impedance, 40 K to ground from either balanced input; output impedance, less than 1 ohm from any balanced output terminal to ground. Distortion averages less than 0.1%, and frequency response is flat from dc to 1 mc. The unit is completely transistorized and has a self-contained power supply. Six units can be mounted into a standard rack panel.

Rheem Mfg. Co., Defense and Technical Products Div., Dept. ED, 11711 Woodruff Ave., Downey, Calif.

CIRCLE 65 ON READER-SERVICE CARD

Vinyl Coated Steel Sheet

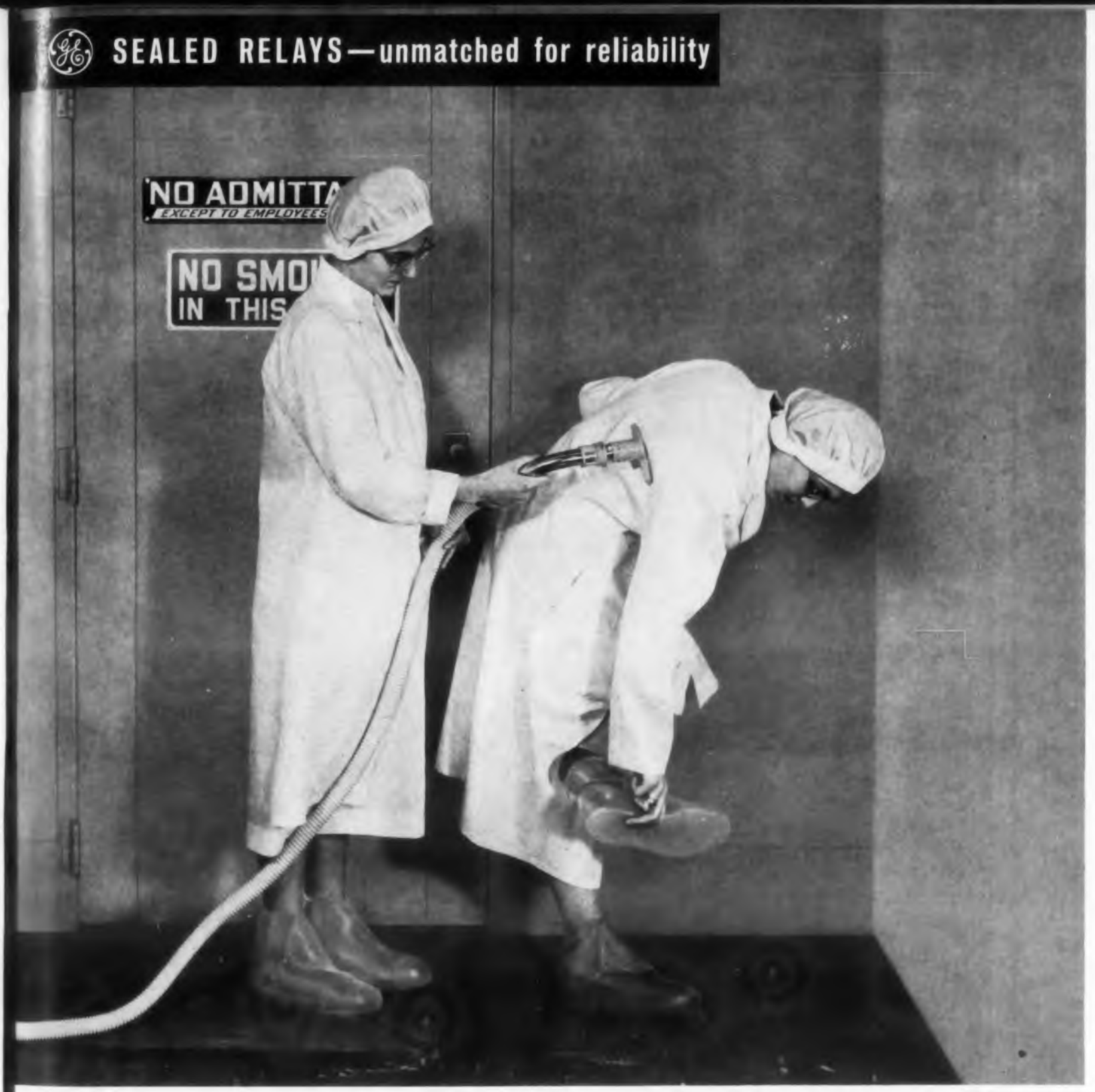
Stands rough usage

For appliance cabinets and many other uses, this vinyl coated steel can be sheared, slit, punched, lock seamed, stamped, drawn, or roll-formed without damage to the coating. It can also be welded and fastened in almost as many ways as plain steel. The material will stand up under 160 F continuously, or under 212 F for two days. It is resistant to scratches and stains and will not support combustion. The sheet can be provided in a wide variety of colors and textures.

United States Steel Corp., Dept. ED, 525 William Penn Place, Pittsburgh 30, Pa.

CIRCLE 66 ON READER-SERVICE CARD

CIRCLE 67 ON READER-SERVICE CARD



Have you ever taken an air bath?

Special clothing, nylon overshoes, dust-particle counts, air baths—all are part of manufacturing the industry's most reliable miniaturized sealed relays.

The demand for greater and greater reliability of all electronic components has forced manufacturers to find new and improved production techniques. At General Electric a special "white room" was built to assure the closely controlled atmospheric conditions needed for the assembly of ultra high-reliability relays. In highly critical applications, particularly those involving dry-circuit switching, absolute cleanliness of relay interiors is vital. Equally important is the extra care and precision with which "white room" relays are processed, tested, and inspected.

In General Electric's "white room" every precaution is taken to eliminate dust, dirt, and any other particles (as small as one micron) which might clog the contact points of hermetically sealed micro-miniature relays.

To maintain the controlled atmosphere within the room, dust counts and air samples are taken regularly. Employees wear special clothing and take air baths before entering the room through the pressurized air lock. Temperature and humidity are continuously controlled and charted to provide optimum assembly conditions.

Obviously all relays do not require the exactness and care which is taken with these "white room" relays, but whatever your reliability requirements —there's a General Electric sealed relay to meet your needs. 792-13

Progress Is Our Most Important Product

GENERAL ELECTRIC

There's a G-E sealed relay for every circuit need—every reliability requirement

G-E miniature, sub-miniature, and micro-miniature relays combine small size with unusual reliability under severe temperature, shock, and vibration conditions to make them ideal for electronic jobs, both military and commercial. In addition to short shipment on production orders, G.E. is equipped to give rapid service on samples and prototypes.

MINIATURE: Long-life type; rated 5 amps at 28 volts d-c at 85 C; in 2-, 3-, and 4-pole double throw and 6-pole normally open forms.

SUB-MINIATURE: 2 amps at 28 volts d-c, 115 volts a-c, double-pole double-throw; .651 in. in diameter, 1.6 in. long, weighs one ounce.

MICRO-MINIATURE: Crystal-can type, 0.5 oz. Rated 2 amps at 28 v d-c or 115 v a-c. Grid-space type (terminals spaced for printed circuits) available.

For more information contact your G-E Apparatus Sales Office, or mail coupon.

General Electric Company
Section D792-13
Schenectady, New York

Please send me a free copy of the sealed relay catalog.

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Address _____

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GENERAL ELECTRIC

CIRCLE 68 ON READER-SERVICE CARD

Magnetic Core Tester

Tests up to 10 cores per sec

Designed for production testing and laboratory analysis of bobbin type or ferrite memory cores, the REACT 2040 is a fully automatic tester that accurately measures peak or instantaneous values of core response directly. It tests at rates up to 10 cores per sec and can test on a go, no-go basis or on a core grading basis. Reliability is assured by use of an internal reference core which is measured a few hundred microseconds before the test of each unknown core. If the reference core doesn't test properly, test of the unknown core is automatically considered invalid. If an invalid test is shown for 15 consecutive test cycles, the unit sounds an alarm and shuts off. Accuracy of the core voltage measuring circuits is better than 0.5 mv absolute.

Rese Engineering, Inc., Dept. ED, 731 Arch St., Philadelphia 6, Pa.

CIRCLE 69 ON READER-SERVICE CARD

Pressure Switch

Has 1 to 500 psig operating range

For use in all types of systems, this 1/4 oz pressure switch detects surge, leak, and variance. Setting limits are 1 to 100 psig, operating range is 1 to 500 psig, and proof pressure is 3000 psig. The unit operates in temperatures from −65 to +250 F and under 0 to 2000 cps, 10 g vibration.

Century Electronics & Instruments, Inc., Dept. ED, Box 6216, Tulsa, Okla.

CIRCLE 70 ON READER-SERVICE CARD

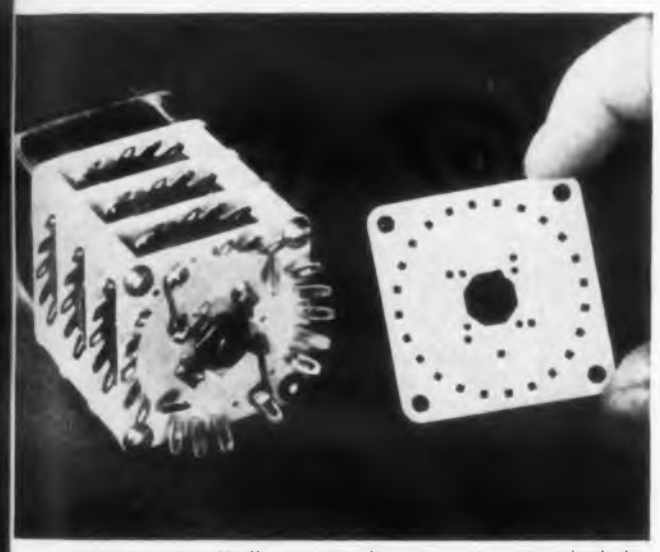
ow Corning Silicone Dielectrics

AiResearch miniature motar combines Sylkyd wire and silicone varnish.

REDUCE SIZE, WEIGHT WITH SILICONE INSULATING MATERIALS

Specify Sylkyd® enameled magnet wire to help reduce the size and weight of transformers, servo motors, and other devices by as much as 50%. Equal in diameter to Class A magnet wires, it serves at 180 C . . . withstands the higher temperatures of miniaturization. Impregnated with Dow Corning 997 Varnish, Sylkyd enameled magnet wire and other silicone insulating components are bonded into moisture resistant insulation systems having high dielectric strength, maximum reliability over a wide range of temperatures and environmental conditions. Write for new, illustrated brochure.

CIRCLE 150 ON READER-SERVICE CARD



Shallcross Manufacturing rotary switch decks.

SILICONE-GLASS LAMINATES RESIST CONTINUOUS 250 C HEAT

Laminates made of glass cloth bonded with Dow Corning silicone resins provide heat-stable structural and insulating materials . . . withstand soldering heat during assembly of electronic equipment . . . resist continuous exposure to temperatures up to 250 C. Silicone-glass laminates resist moisture, arcing, corona. They are lightweight, strong, rigid . . . supplied in many shapes and forms by leading laminators.

CIRCLE 151 ON READER-SERVICE CARD

SILASTIC ENCAPSULATION ABSORBS VIBRATION, SHOCK

Sensitive electronic parts withstand vibration and shock longer when encapsulated with Silastic®, the Dow Corning silicone rubber. That's because Silastic retains all its superior properties on aging. Silastic has low moisture absorption, stays resilient over a wide temperature range . . . is easy to apply. Available in many forms, including molded parts, extrusions, tapes, sheets and pastes.

CIRCLE 152 ON READER-SERVICE CARD

Electronic tube encapsulated with Silastic.

For further information on these products, write Dept. 1617

Precision Computing Resolvers

2-1/4 in. maximum length

For use in cascaded, amplifierless, resolver systems at 900 cps, these precision computing resolvers are compensated to provide phase shift and transformation ratio stability, under temperature, when working into their iterative impedance. In size 11 Model YZH-11-F-1, all compensation is incorporated as an integral part of the unit within a maximum length of 2-1/4 in. The compensation for model EZH-11-W-1 is incorporated in a stainless steel box 1-1/2 x 1 x 1/2 in.

Clifton Precision Products Co., Inc., Dept. ED. 9014 W. Chester Pike, Upper Darby, Pa.

CIRCLE 71 ON READER-SERVICE CARD

Log Electrometer

Measures small currents

For precision measurement of small currents over a wide dynamic range, the model LE-1 log electrometer is particularly suited for use as a reactor control instrument. It measures eight decades of current in the range of 10^{-5} to 10^{-13} amp. Trip circuits can be incorporated on special order. Logarithmic measurement of current is obtained by using the log characteristic of screen feedback to the input of the electrometer tube, eliminating the need for a separate diode device. The unit can be rack, panel, or console mounted.

The Victoreen Instrument Co., Dept. ED, 5806 Hough Ave., Cleveland 3, Ohio.

CIRCLE 72 ON READER-SERVICE CARD

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NEW PRODUCTS

Magnetic Amplifier

Withstands 100 g shock

The model 405 precision magnetic amplifier is designed to drive electrohydraulic servo valves used in missiles, aircraft, and industrial control systems. Its response characteristics to 50 cps permit it to be used in critical response systems. Hermetically sealed in a self-contained, plug-in package, the unit requires less than 3 w of 115 v, 400 cps power and weighs under 9.5 oz. It withstands temperatures to 125 C and shocks to 100 g.

Acromag, Inc., Dept. ED, 22519 Telegraph Rd., Detroit 41, Mich.

CIRCLE 73 ON READER-SERVICE CARD

Multiplexer

20,000 samples per sec

Maximum rate of multiplexing for Model 115 is 20,000 samples per sec. Ten separate channels can be sampled at a rate of 2000 samples per sec per channel. The unit can be driven either externally or internally. The number of channels, the frame rate and sample rate are crystal controlled, and can be selected by rotary switches. Unit has transistorized plug-in units for ease of maintenance. The unit is completely self-contained with power supply. Cabinet: 5-1/4 x 17 x 19 in.

Digital Instrument Lab., Dept. ED, 152 S. Atlantic Blvd., Los Angeles 22, Calif.

CIRCLE 74 ON READER-SERVICE CARD

CIRCLE 75 ON READER-SERVICE CARD

Glass Capacitors

Fusion sealed

Fused around the edge and at the juncture of lead and body, CFY-15 glass capacitors are impervious to moisture and meet MIL-STD-202A and MIL-C-11272A specifications. Temperture coefficient from −55 to +125 C is +115 to +180 ppm per deg C; capacitance drift is under 0.05% or 0.1 μμf; and insulation resistance is above 500,000 meg. Voltage capacitance ratings are 500 wvdc, 160 to 510 μμf and 300 wvdc, 560 to 1200 μμf. The units operate from −55 to +125 C with no derating and last 2000 hr at 125 C with 150% of rated voltage applied.

Corning Glass Works, Electronic Components Dept., Dept. ED, Bradford, Pa.

CIRCLE 76 ON READER-SERVICE CARD

Differential DC Amplifier

Wideband

A differential dc amplifier with isolated input and output terminals, the model 2340 has a 7.5 kc bandwidth and over 1 million to 1 common mode rejection from dc to 60 cps with 1 K unbalance in either input lead. It will operate accurately with common mode signals of ±300 v dc or 117 v, 60 cps between input and output terminals. Transient common mode signals do not cause overloading. Voltage gain range is 25 to 1000, and output capability is ±10 v and ±20 ma.

Dynamics Instrumentation Co., Dept. ED, 1118 Mission St., South Pasadena, Calif.

CIRCLE 77 ON READER-SERVICE CARD

CIRCLE 78 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Capacitance Bridge

Measures 0.0002 to 11,000 μμf

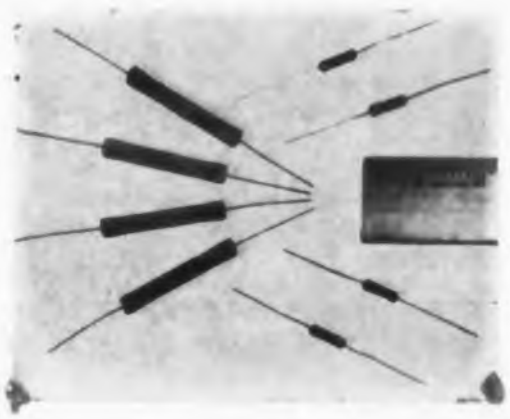
The model 74-CS8 three terminal capacitance bridge measures 0.0002 to 11,000 μμf with an accuracy of 0.25% pulse range factor. Differential capacitance measurement can be made with a readability of ±1 ppm on nominal values above 200 μμf and a conductance measurement of 0.01 to 1000 μmhos with a test frequency of 100 kc. A dc voltage source can be applied as a bias to the component under test. Bias voltage adjustment range is −5 to +100 v.

Boonton Electronics Corp., Dept. ED, 738 Speedwell Ave., Morris Plains, N.J.

CIRCLE 79 ON READER-SERVICE CARD

Power Film Resistors

2.5, 5, and 10 w



Model ST60, ST65, and ST70 power film resistors are respectively rated at 2.5, 5, and 10 w at 25 C with derating to 350 C. Their respective resistance ranges are to 4, 14, and 42 K. The glass based units meet most Mil-R-26C operational requirements and can be held to ±2% tolerances. Diameters are 11/64 to 19/64 and lengths are 19/32 to 21/16.

Corning Glass Works, Electronic Components Dept., Dept. ED, Bradford, Pa.

CIRCLE 80 ON READER-SERVICE CARD

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why 3 Polaroid Land cameras for scopes?

CHECK THESE THREE FACILITIES—EACH SATISFYING A DISTINCT NEED

General Purpose for 5" Scopes

TYPE 302

Makes single or multiple exposures per frame on transparent or opaque Polaroid Land Film. Extremely useful for multi-trace comparison records. Camera back is detented for three equally spaced exposures; scale and pointer assist for more than three. Data card facility provides picture identification. Accessories available for use of cut, pack or roll film.

PRICE:* f/1.9 lens **$395**
f/2.8 lens **$350**

For 3" Scopes

TYPE 339

Establishes the conveniences of Polaroid Land recording for 3" scopes. The **only** such camera commercially available. Provides 1:1 object-to-image ratio records on 2¾" x 3¼" prints. Distortionless images are obtained by Wollensak f/2.8, 50mm lens. Light weight durable construction. Kit available to adapt camera to **any** 3-inch oscilloscope.

PRICE:* $246

For Full-Sized Records From 5" Scopes

TYPE 353

Produces full-sized, non-reversed records from 5-inch scopes on 2⅞" x 3¾" prints **or** negatives. Transparent emulsions used with this camera provide ready-made slides for immediate projection and display. Detented back and rotatable barrel permit multiple exposures per frame on either frame dimension. Roll, cut or pack film usable with available accessories.

PRICE:* f/1.9 lens **$350**
f/2.8 lens **$295**

*f.o.b. Clifton, N. J., U.S.A.

Write for complete details

DU MONT® **ALLEN B. DU MONT LABORATORIES, INC.**
760 Bloomfield Ave. • Clifton, N. J. • Phone Swarthmore 1-1000

CIRCLE 82 ON READER-SERVICE CARD

Fibrous Silicone Rubber

Usable from —65 to +500 F

A mat of silicone rubber fibers oriented at random, Cohrlastic FSR has high permeability, a density of 20 lb per cu ft, and good tear resistance, tensile strength, and compression-deflection characteristics. It is usable from —65 to 500 F and comes in sheets 1/4 in. thick, 9 in. wide, and 6 ft long.

The Connecticut Hard Rubber Co., Dept. ED, 407 East St., New Haven 9, Conn.

CIRCLE 83 ON READER-SERVICE CARD

Backward Wave Oscillator

Voltage tunable

Voltage tunable model QK625 backward wave oscillator has a 2500 to 3300 mc bandwidth and provides a minimum power output of 180 w and a nominal power output of 250 to 350 w over the band. Tuning sensitivity is about 0.35 mc per v. The unit has an integral permanent magnet, is liquid cooled, and may be mounted in any position. The rf output is standard 7/8 in. coaxial. Suited for countermeasures and fm cw operation, the tube can be amplitude and frequency modulated at rates to 10 mc. It weighs approximately 25 lb.

Raytheon Mfg. Co., Microwave and Power Tube Div., Dept. ED, Waltham 54, Mass.

CIRCLE 84 ON READER-SERVICE CARD

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DURANT

DIGITAL READ-OUT COUNTERS

Model "Y" SERIES

Model "D" SERIES

for MISSILE TRACKING, RADAR CONTROLS, COMPUTERS, NAVIGATION INSTRUMENTS, GAUGING INSTRUMENTS, and ANY other indicator applications.

- Meets military specifications.
- High speeds, lower torque, lower moment of inertia for long life.
- Nylon wheels with legible figures, nylatron pinions.
- Single, 1½, or double width wheels.
- One-piece aluminum die cast frame.
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- Right or left hand drive, clockwise or anti-clockwise rotation.
- "Y" Series, single or dual bank types.
- Component parts can be purchased separately to meet design requirements.

Your answer to an infinite number of variable demands for PRECISION CONTROLS.

Send for Catalog No. 400

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CIRCLE 85 ON READER-SERVICE CARD

NEW PRODUCTS

Data Reduction System

For test facilities

For test facilities, the RW-300 on-line data reduction system provides for fully automatic collection, interpretation, computation, and presentation of test data. It can scan over 500 transducers, convert analog signals to digital form, and transfer the data to magnetic tapes. It can also provide closed loop control of the test by feeding back input data and compute partial results while a test is in progress. The system incorporates a magnetic tape unit consisting of a magnetic core buffer and one to eight tape transports, each with a capacity of up to 1.3 million 18-bit words. Maximum storage rates of 2550 words per sec are available.

The Thompson-Ramo-Wooldridge Products Co., Dept. ED, P.O. Box 90067, Airport Station, Los Angeles 45, Calif.

CIRCLE 86 ON READER-SERVICE CARD

Power Supply

Isolated from line voltage and ground

Model 21 isolated power supply provides 0 to 20 v at 1 amp regulated dc power and is isolated from line voltage and line ground. A voltmeter and ammeter are provided to monitor output. The transistorized unit is portable and suitable for rack mounting. Its dimensions are 7 x 9 x 14 in.

Moeller Instrument Co., Electronics Div., Dept. ED, 132nd St. and 89th Ave., Richmond Hill 18, N.Y.

CIRCLE 87 ON READER-SERVICE CARD

CIRCLE 88 ON READER-SERVICE CARD

Servo Indicator

For varied applications

Model 143 digital servo indicator can be used to show forces, fluid 7-300) or can be used to show forces, fluid pro vide flow, weights, rpm, or any linear on, inter variable that can be converted into l prese ac or dc millivolts. The unit pro- can ove vides a readable, digital counter alog sig type indication in a space-saving nsfer th lush-mounted case. The 6 x 5-3/8 can al in. front dimensions of the unit re- l of th quire less than 1/4 the panel space dat a of a standard indicator.

ile a te Gilmore Industries, Inc., Dept. incorpo ED, 13015 Woodland Ave., Cleve- and 20, Ohio.

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CIRCLE 89 ON READER-SERVICE CARD

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lable.

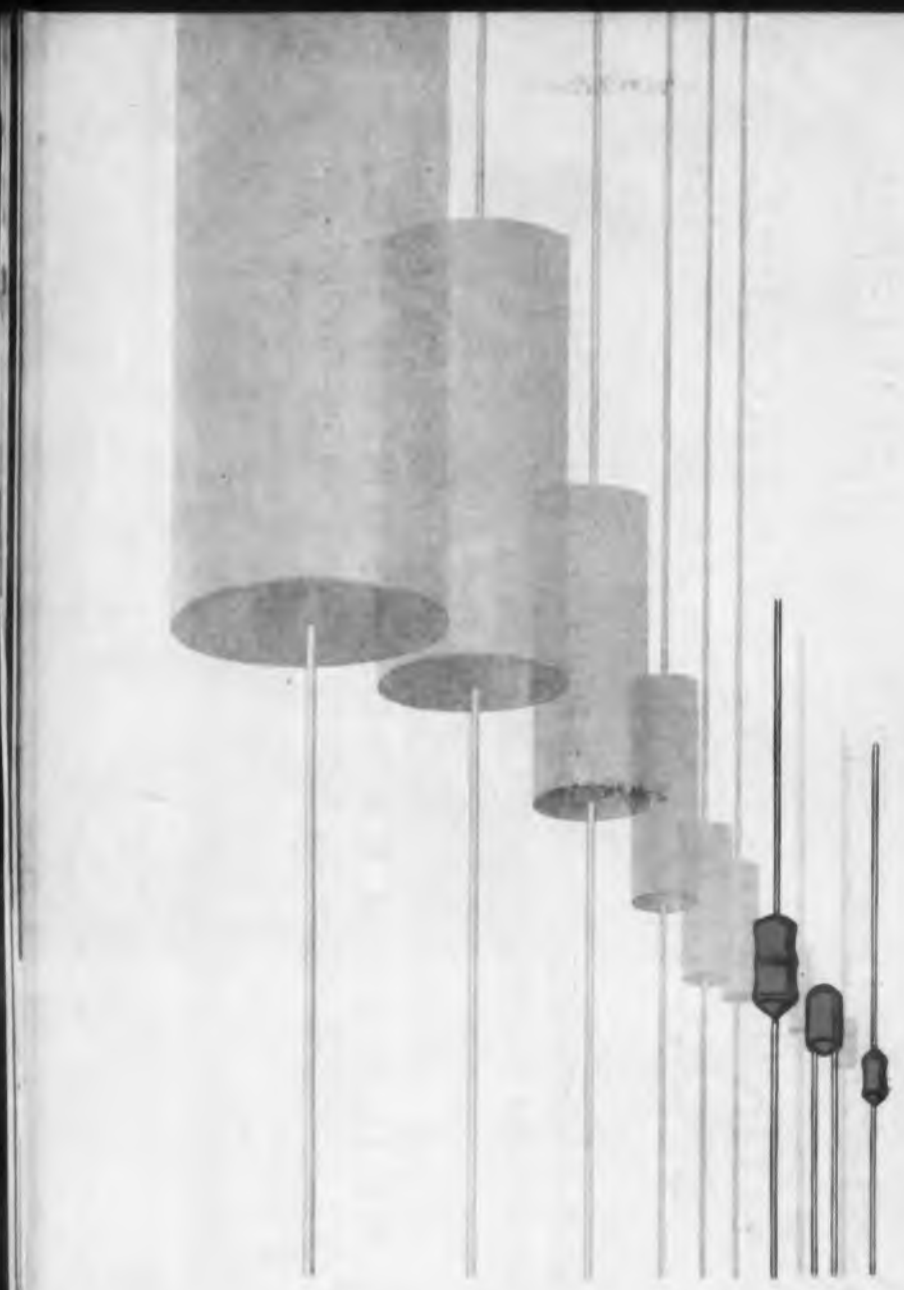
Phase Shift Control

For GE silicon controlled rectifiers

The Silicontrol is a 400 cps phase shift peaking control for GE silicon controlled rectifiers. It provides sharp pulses of constant amplitude and 180 deg variable phase angle to control the rectifier output proportionately from zero to maximum with a 1 to 2 mw dc signal. Its four control windings are isolated from the rectifier power circuits, and loss of the control signal turns off the rectifier. Linear and fail safe in operation, the Silicontrol has a time constant of 1 msec for control current changes, and one unit will control one half-wave or two full-wave silicon controlled rectifiers. Compact, lightweight, and hermetically sealed, the control has wide application in the aircraft and missile field.

VecTroL Engineering, Inc., Dept. ED, P.O. Box 1089, Stamford, Conn.

CIRCLE 90 ON READER-SERVICE CARD



NEW PRODUCTS

Toroid Inductors

Come in 3 sizes

Series KT toroid inductors are available in three forms: uncased with protective wax coating; hermetically sealed in steel cases to MIL-T-27A specifications; and encapsulated in hi-temp plastic to withstand extreme humidity and severe mechanical shock. Temperature range is from —55 to +125 C.

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

CIRCLE 91 ON READER-SERVICE CARD

Relay

For military applications

Relay 325 ST, 3pst, and rated at 25 amp, has been designed to meet the requirements of airborne and missile applications, per MIL-R-5757B, and MIL-R-6106B. Units for 200 C or higher operation are available. This unit operates on as little as 1.5 w, and is available for 400 cps ac operation internally rectified. It measures 1-1/2 x 1-3/4 x 2-1/2 in.

Electro-Mechanical Spec. Co., Inc., Dept. ED, 1016 N. Highland Ave., Los Angeles 38, Calif.

CIRCLE 92 ON READER-SERVICE CARD

Infrared Elements

Unidirectional

For industrial processing applications, these quartz slab infrared elements are unidirectional and radiate long wave infrared rays directly on the work, minimizing dissipation of energy from the sides. They are noncolor selective and require no maintenance. They are designed as unit building blocks for the construction of radiant surfaces. The units may be used to cure epoxy resins, printed circuits, adhesives, molding compounds, laminating and casting resins, sealants, and coatings.

Ampere Industries, Dept. ED, 60 Boston St., Newark 3, N.J.

CIRCLE 93 ON READER-SERVICE CARD

◀ CIRCLE 94 ON READER-SERVICE CARD

RF Amplifier Tube

For use up to 1000 mc

Designed for use as an rf amplifier in the uhf band at frequencies up to 1000 mc, type 7377 tube is a radiation cooled, indirectly heated, twin tetrode unit. Having a transconductance of 10,500 umhos, the tube delivers 4 w into a load continuously or 5 w intermittently. Heater voltage is 6.3 v and current is 0.6 amp. In class C operation the plate voltage is 350 v and plate current of each unit is 30 ma. Plate dissipation of each unit is 6.5 w.

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

CIRCLE 95 ON READER-SERVICE CARD

Drift Transistors

For high speed switching

Drift transistors 2N643, 2N644, and 2N645 are pnp alloy types designed for high speed switching applications in electronic computers. They are intended for nonsaturating computer circuits such as inverters, flip-flops, and logic gates where high gain bandwidth product and pulse repetition rates to 10 mc are required. The units have minimum gain bandwidth products of 20, 40, and 60 mc, respectively, permitting the design of switching circuits with total rise, fall, and propagation times of 20 musec. They are provided in metal cases with welded hermetic seals and the dimensions of the JEDEC TO-9 outline.

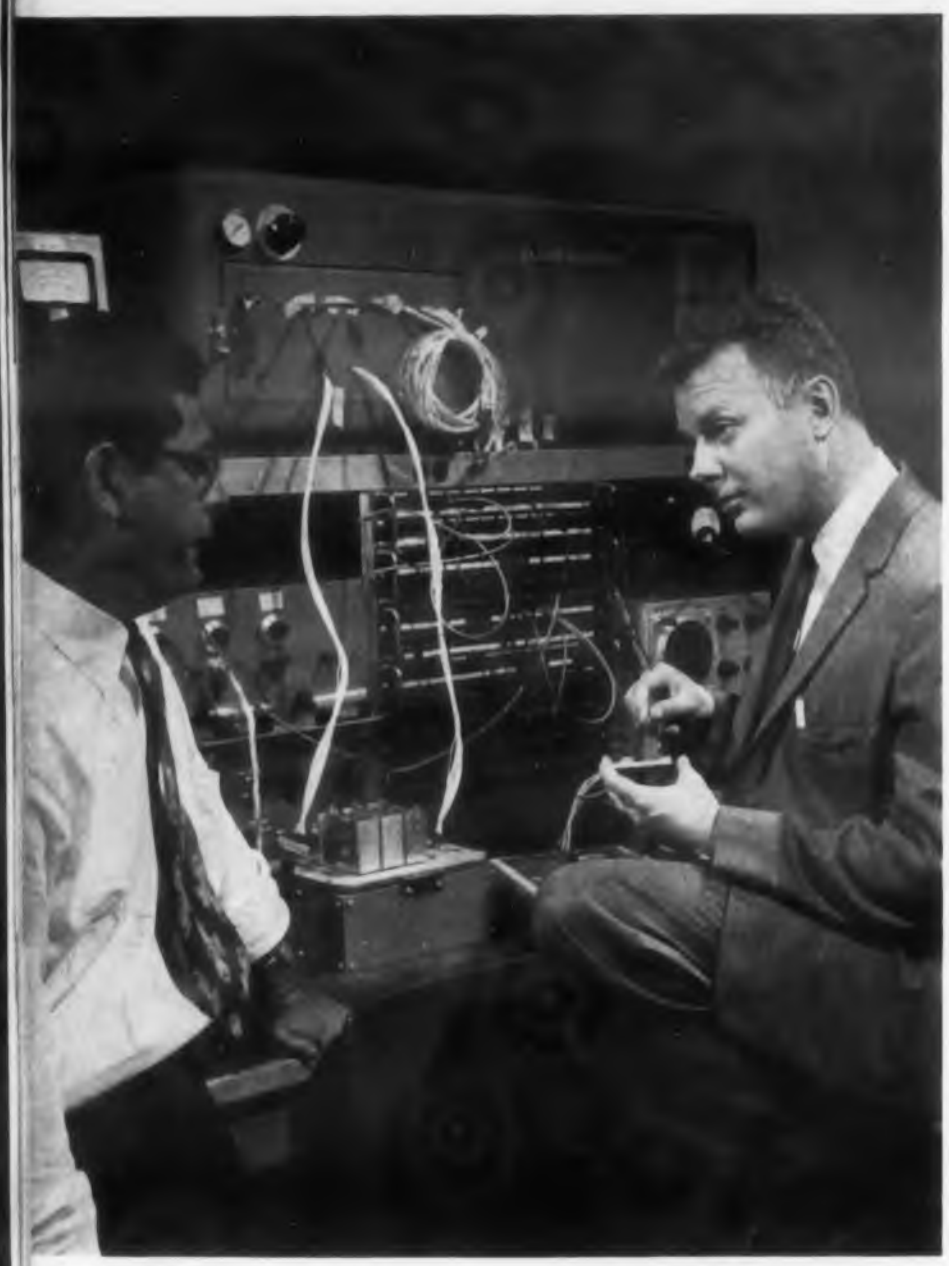
Radio Corporation of America, Semiconductor and Materials Div., ED, Somerville, N.J.

CIRCLE 96 ON READER-SERVICE CARD

CIRCLE 97 ON READER-SERVICE CARD ➤

FLIGHT CONTROLS

Expanding the Frontiers of Space Technology



Transistorizing missile flight control systems by Lockheed scientists has meant significant reductions in weight and space requirements.

Flight Controls offers one of the most challenging areas of work at Lockheed's Missiles and Space Division.

From concept to operation, the Division is capable of performing each step in research, development, engineering and manufacture of complex systems. Rapid progress is being made in this field to advance the state of the art in important missile and spacecraft projects under development at Lockheed.

Flight controls programs include: analysis of flight data and sub-systems performance, design and packaging of flight control components, development of transistorized circuits, operation of specialized flight control test equipment, and fabrication of flight control prototypes. Other work deals with the design, development and testing of rate and free gyros; accelerometers; programmers; computer assemblies; guidance control systems; circuitry; and hydraulic systems and components.

In the flight controls simulation laboratory, mathematical representations of elements in a control system are replaced one by one with actual hardware to determine acceptability of specific designs. From these studies, Lockheed obtains information which is used in further refinement and improvement of final control systems designs.

Lockheed Missiles and Space Division is weapons systems manager for such major, long-term projects as the Navy Polaris FBM; Discoverer Satellite; Army Kingfisher; Air Force Q-5 and X-7; and other important research and development programs.

Scientists and engineers desiring rewarding work with a company whose programs reach far into the future are invited to write: Research and Development Staff, Dept. E-21, 962 W. El Camino Real, Sunnyvale, California, or 7701 Woodley Avenue, Van Nuys, California. For the convenience of those living in East or Midwest, offices are maintained at Suite 745, 405 Lexington Avenue, New York 17, N.Y., and at Suite 300, 840 N. Michigan Avenue, Chicago 11, Ill. U.S. Citizenship required.

"The organization that contributed most in the past year to the advancement of the art of missiles and astronautics."

NATIONAL MISSILE INDUSTRY CONFERENCE AWARD

Pre-flight check-out on final assembly on X-7 missile. The X-7 holds free-world's speed and altitude records for air breathing missiles.

One of Lockheed's test stands with dynamic thrust mount to simulate flight environment.

Lockheed / **MISSILES AND SPACE DIVISION**

Weapons Systems Manager for Navy POLARIS FBM; DISCOVERER SATELLITE; Army KINGFISHER; Air Force Q-5 and X-7.

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA
CAPE CANAVERAL, FLORIDA • ALAMOGORDO, NEW MEXICO • HAWAII

NEW PRODUCTS

Transistorized Amplifier

Stable from −60 to +150 C

For servo and audio use, the model 198S plug-in transistorized amplifier has a bandwidth of 5 cps to 50 kc and good closed-loop gain stability from −60 to +150 C. Open-loop gain is 90 db and closed-loop gain is variable from 2 to 1000. Two external feedback resistors and an external bypass capacitor are required to select the desired gain and low frequency cut-off. The unit uses silicon transistors and is potted in a resilient compound. There is no significant increase in noise with vibration to 40 g at 60 cps.

Taber Instrument Corp., Dept. ED, North Tonawanda, N.Y.

CIRCLE 98 ON READER-SERVICE CARD

Miniature Inductors

For 10 to 500 kc operation

Inductance value of these toroidal inductors ranges from 1 mh to 3 h with a useful frequency range of from 10 to 500 kc. Designated series 783, units measure 1 in. in diameter and 1/2 in. high. Weight is 0.5 oz. Built to meet MIL-E-527A and MIL-27A, units are fully encapsulated and hermetically sealed, for maximum resistance to high temperature and extreme shock. They are designed with a 6-32 threaded insert for printed circuit boards, or with a center hole for stacking on a single screw in chassis mounting.

Arnold Magnetics Corp., Dept. ED, 4613 W. Jefferson Blvd., Los Angeles 16, Calif.

CIRCLE 99 ON READER-SERVICE CARD

CIRCLE 105 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Vacuum Tube Volt-Ohm-Capacity Meter

Also measures inductance

The model 107A vacuum tube volt-ohm-capacity meter measures: peak to peak voltages in six ranges from 0.2 to 2800 v; ac rms voltages in six ranges from 0.1 to 1000 v; capacity in six ranges from 50 μμf to 5000 μf; resistance in six ranges from 0.2 to 1000 meg; and inductance in four ranges from 1.4 to 140,000 h. The meter cannot burn out.

Electronic Measurements Corp., Dept. ED, 625 Broadway, New York 12, N.Y.

CIRCLE 106 ON READER-SERVICE CARD

Power Amplifier

For pulse or cw operation

Model 1012 power amplifier is designed to amplify the power of sine waves, square waves or pulse signals whose amplitudes range from 1 to 40 v. The unit is completely dc coupled and its input circuit is provided with a level control for matching it to any input from −20 to +20 v dc. The unit has a dual range input-step attenuator for either normal or inverted output with attenuation steps of either 25%, 50%, 75%, or 100% of the input amplitude. Frequency response: dc to 6 db down at 12.5 mc corresponding to a rise time of 0.032 μsec and available output current is 0.75 amp. Output voltage range with a 1000-ohm load is +30 to −30 v; voltage gain is 2.0.

Technitrol Engineering Co., Dept. ED, 1952 E. Allegheny Ave., Philadelphia 34, Pa.

CIRCLE 107 ON READER-SERVICE CARD

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Yes! You can now order up to 2500 each of such popular Cannon Connector types as Miniature D, KO, DPD, DPA, DPX, etc. Immediate shipment at factory prices.

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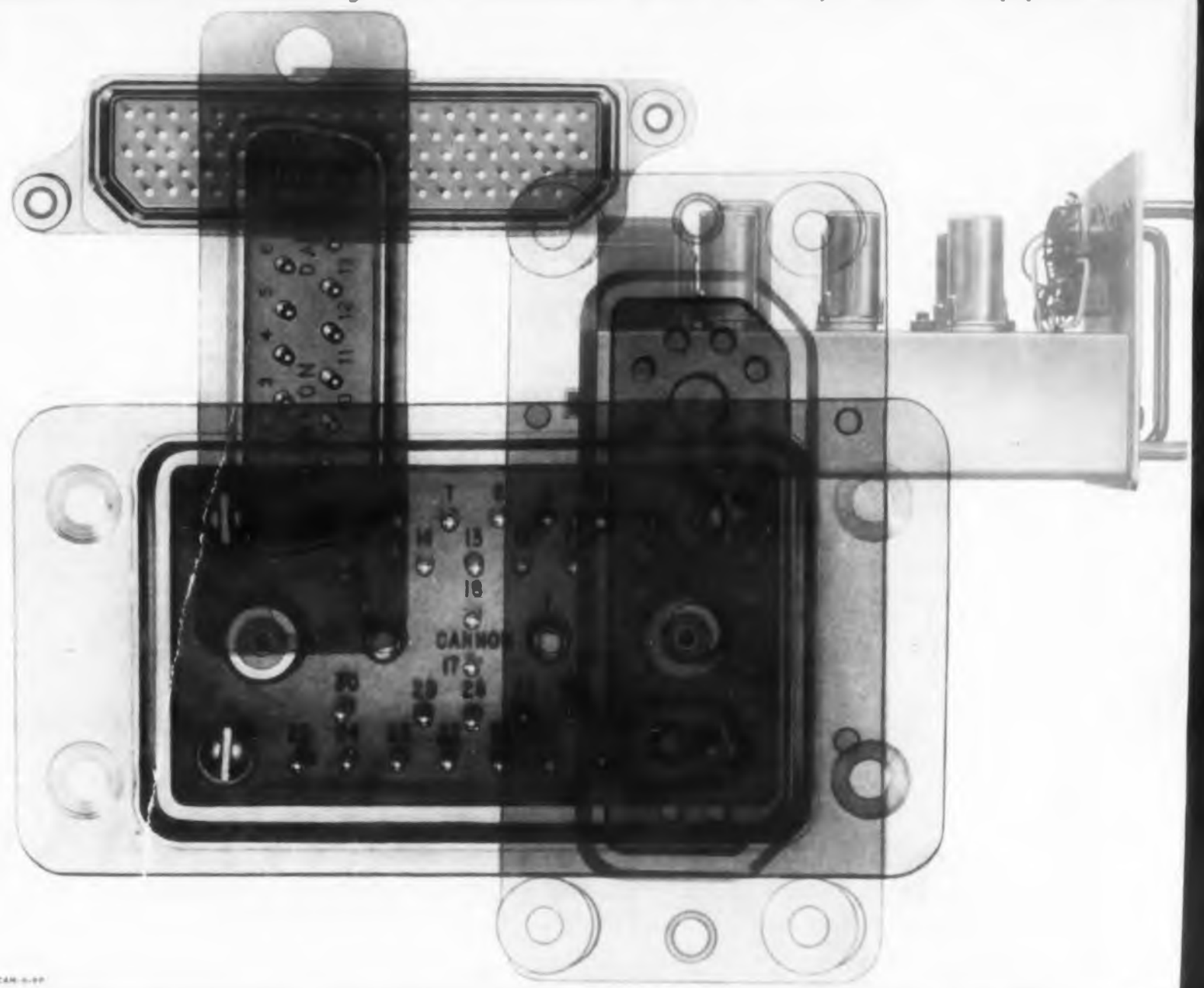
PIONEER 6-6520 TWX G-CY-NY-580

CIRCLE 108 ON READER-SERVICE CARD

The assembling of highly-flexible electronic systems and sub-systems into a modular package . . . for fast inspection, testing, service, and replacement of components . . . calls for standardized-type plugs throughout the system. Reliability and optimum flexibility in shell designs and types of layouts are the design criteria for the more than 18 different basic Cannon Modular and Rack/Panel Plug Series. This Series is available in standard, miniature, or subminiature sizes . . . standard or printed circuitry. Up to 180 contacts and a varied combination of contacts for control, aud thermocouple, co-ax, twin-ax, and pneumatic connections. Single or double-gang. With or without she The Rack/Panel Series ranges from the tiny "D" subminiature to the heavy-duty DPD Rack/Panel Plug. further information on Cannon Modular and Rack/Panel Plugs write for Cannon DP Catalog, Cannon Elec Co., 3208 Humboldt St., Los Angeles 31. Please refer to Dept 3". Factories in Los Angeles, Santa Ana, Sale Toronto, London, Paris, Melbourne, Tokyo. Distributors and Representatives in the principal cities of the wo

CANNON PLUGS

Maximum Flexibility for Modular and Rack/Panel Applications

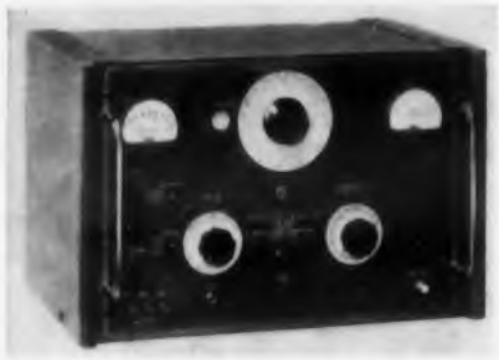


CIRCLE 109 ON READER-SERVICE CARD

NEW PRODUCTS

FM-AM Telemetering Signal Generator

Has 195 to 270 mc rf range



Accurate to ±0.5%, the type 202-G fm-am telemetering signal generator has an rf range of 195 to 270 mc and continuously adjustable frequency deviation ranges from 0 to 24, 80, and 240 kc. Maximum open circuit output is 0.4 v and fm distortion is under 2% at 75 kc, 10% at 240 kc. Internal amplitude modulation is available from 0 to 50%.

Boonton Radio Corp., Dept. ED, Boonton, N.J.

CIRCLE 110 ON READER-SERVICE CARD

Rectifier Analyzer

Has forward current range to 5 amp

Model 138A is a completely self-contained, dynamic rectifier analyzer that tests any semiconductor rectifier in accordance with JETEC specifications. It can test forward current adjustable independently of reverse voltage and vice versa. Forward current range is 0 to 5 amp, and reverse voltage range is 0 to 1000 piv. The unit measures average forward voltage drop, 0 to 1 v and average reverse current 0 to 0.1, 1, 10, and 100 ma. It has four 1% meters; all four parameters can be viewed on an oscilloscope. Power input is 120 v, 60 cps, 250 w. The analyzer is housed in a steel cabinet 23-1/4 x 16 x 16 in. and weighs about 60 lb. It can also be supplied for standard 19 in. rack mounting.

Wallson Associates, Inc., Dept. ED, 35 E. Runyon St., Newark 8, N.J.

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WASHINGTON
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C & G Radio Supply Co.
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BRoadway 2-3181

CIRCLE 112 ON READER-SERVICE CARD

Operations Monitor

30 channel

Operations monitor model RE 3303-00 records 30 channels of on-off, open-shut, pulse, or event type information providing a chart record of all operations and their duration. A wide range of chart speeds provides signal resolutions down to 0.004 sec.

Brush Instruments, Div. of Clevite Corp., Dept. ED, 37th and Perkins, Cleveland 14, Ohio.

CIRCLE 113 ON READER-SERVICE CARD

Blade Antenna

L-band

For use in high speed aircraft and missiles, the model 9955 blade antenna is designed for the 1400 mc telemetry band. Polarization is perpendicular to the mounting surface, and the resulting radiation pattern is circular. The unit has a maximum vswr of 1.5 over a 25% frequency band. It is 3.55 in. long, extends 1.7 in. from the skin of the airframe, and weighs 7 oz. Other applications include beacons, data links, command control, and IFF.

Underwood Corp., Canoga Div., Dept. ED, 15330 Oxnard St., Van Nuys, Calif.

CIRCLE 114 ON READER-SERVICE CARD

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NEW PRODUCTS

Resistance Bridge Potentiometer

Furnishes dc power

A portable, battery-powered re sistance bridge potentiometer, mode M calibrates or measures strai gages or resistance bridge tran ducers. It furnishes dc power to th input bridges from its own suppl and has a zero balance control tha provides for zero readout at no load Its accuracy is 0.25%. Bridges of 5 to 500 ohms may be calibrate without changing the calibration o the instrument.

Datran Electronics, Dept. ED Manhattan Beach, Calif.

CIRCLE 115 ON READER-SERVICE CARD

Power Supply

Has 3 to 1000 v output

This 500 ma laboratory powe supply has a voltage range from 3 t 1000 v dc. Unit is continuously var able throughout the range. A vernie voltage control permits fine setting The 500 ma output can be drawn from this supply at any voltage se ting down to the lowest. A secon output supplies 6.3 v ac at 10 amp Dc regulation: 450 mv or 0.045 whichever is greatest. Regulatio for line: 0.045% or 450 mv, whic ever is greatest. Maximum ripple 8 mv rms. Unit measures 19 x 17 10.5 in.

Dressen-Barnes Corp., Dept. ED 250 N. Vinedo Ave., Pasadena Calif.

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FLIGHT DATA and CONTROL ENGINEERS

Cross new frontiers in system electronics at The Garrett Corporation.

High-level assignments in the design and development of system electronics are available for engineers in the following specialties:

1. ELECTRONIC AND FLIGHT DATA SYSTEMS AND CONTROLS A wide choice of opportunities exists for creative R & D engineers having specialized experience with control devices such as: transducers, flight data computers, Mach sensors, servo-mechanisms, circuit and analog computer designs utilizing transistors, magamps and vacuum tubes.

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1) **DESIGN ANALYSIS** Requires engineers capable of performance analysis throughout preliminary design with ability to prepare and coordinate related proposals.

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Forward resume to:
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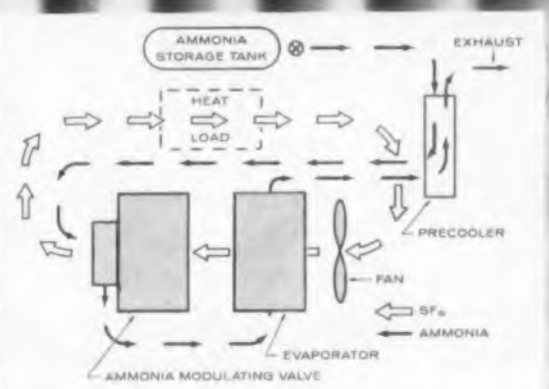
CIRCLE 878 ON READER-SERVICE CARD

LIGHTWEIGHT airborne electronic cooling package



PERFORMANCE CHARACTERISTICS –
Heat Rejection: 200 watts . . . Inlet Gas Temperature to Component Housing: 130°F. . . . Weight of Fan, Evaporator and Controls: 1.25 lb.

Spans the gap between direct ambient cooling and closed cycle systems

● *This AiResearch open-cycle cooling unit* is designed for environmental conditioning of electronic and electromechanical equipment in problems of low total heat dissipation aboard aircraft and missiles.

Much lighter and less complex in operation than closed cycle systems, this compact package is recommended when required total heat dissipation is low . . . large heat loads for short periods of time, or small heat loads for long periods of time. It also replaces direct ambient cooling systems when ambient sink is not low enough or not easily available.

Ammonia in this expendable evaporative system cools sulfur hexafluoride (SF_6) which passes over the hot electronic components. The SF_6 then recirculates for cooling, and the ammonia is dumped overboard.

Applications of this system include: inertial guidance system cooling, missile transient cooling, and spot cooling where ambient sink is not available.

AiResearch has designed and manufactured cooling systems of all types . . . direct ambient, closed and open-cycle systems handling all magnitudes of cooling loads and utilizing various working fluids. We invite you to send us details of your problem.

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Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC NUCLEAR AND INDUSTRIAL APPLICATIONS

CIRCLE 118 ON READER-SERVICE CARD

NEW PRODUCTS

Buffer Storages

Modular design

Based on coincident-current magnetic storage elements, these sequential-to-sequential buffer storages are designed to implement digital data transfer between asynchronous systems. Their modular control-system design permits selection of 1 to 16 independent control and programming features as well as any capacity and bit rate within standard ranges. The equipment operates at any loading and unloading rate from 0 to 200,000 characters per sec, and characters can be loaded serially, in parallel, or in any combination of both. Signals may be either pulse or level, and level signals can be either RZ or NRZ type. Standard units have capacities to 4032 characters and handle from 4 to 12 bits per character.

DI/AN Controls, Inc., Dept. ED, 40 Leon St., Boston 15, Mass.

CIRCLE 120 ON READER-SERVICE CARD

Receiving Tubes

Eliminate noise and hum

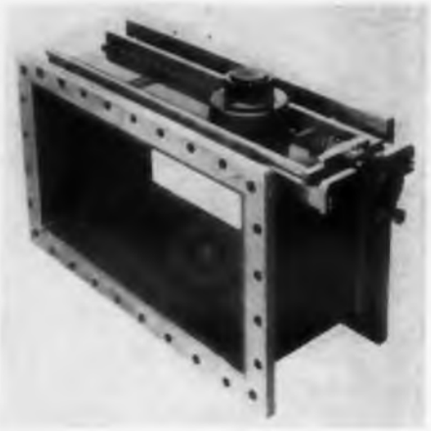
These four receiving tubes virtually eliminate the noise and hum encountered in audio applications. Type 12AX7 is a high-mu twin triode that serves both as an audio amplifier and phase inventer. It has separate cathodes and a center tapped heater for operation at 12.6 or 6.3 v. Type 7025 is a double triode with an equivalent noise and hum voltage of 1.8 μv rms average and 7 μv rms maximum. Type 7199 is a 9-pin miniature medium mu triode and sharp cutoff pentode. The triode is normally used as a phase inventer, while the pentode is used as a high gain audio amplifier. Type 6CA4 is a double anode, indirectly heated, common cathode rectifier. It delivers 150 ma maximum dc output current.

Sylvania Electric Products Inc., Sylvania Electronic Tubes, Dept. ED, Seneca Falls, N. Y.

CIRCLE 121 ON READER-SERVICE CARD

Rotary Standing Wave Indicators

Simplify vswr measurement



These waveguide rotary standing wave indicators simplify the measurement of vswr, reflection coefficient angle, and impedance in the low frequency range. Operating by means of a probe rotating in the plane of circular polarization of a waveguide, they provide a nonambiguous readout of the sign of reactive components. The units have 10 in. insertion length and eliminate the need for slotted sections or Reflectometers in the large waveguide sizes. Two proper handling models are available on special order; the low power, broadband —LW models for laboratory bench-power requirements, and the high power, 12% bandwidth —HN models for operation under kilowatts and megawatts of power.

Polytechnic Research & Development Co., Inc., Dept. ED, 202 Tillary St., Brooklyn, N.Y.

CIRCLE 123 ON READER-SERVICE CARD

Encoder Assembly

Resolves shaft positions to 1 part in 10,000

Resolving shaft positions to 1 part in 10,000, the CG-701 encoder assembly consists of two shaft position encoders and a gear box. The encoder used on the input shaft provides 1000 positions of the least significant digit per 360 deg rotation. The input unit is geared 10 to 1 to a 10 position encoder. The assembly is 3 in. in diameter and 3 in. long without the shaft. It has ±1 count accuracy.

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

CIRCLE 124 ON READER-SERVICE CARD

NEW PRODUCTS

High Power Triode

Handles 8 megawatts peak

For radar pulse modulator service, the WL-7418 high power triode can handle 8 megawatts of peak power. It needs 40 kw peak driving power and has a plate voltage of 50 kv. The platinum clad grid can dissipate an average of 2 kw and has a thermal capacity for 1000 μsec pulses. Plate dissipation capability is 70 kw.

Westinghouse Electric Corp., Electronic Tube Div., Dept. ED, P.O. Box 284, Elmira, N.Y.

CIRCLE 126 ON READER-SERVICE CARD

Solid State Decade Dividers

Provide timing pulses to 100 kc

These solid state decade dividers provide accurate frequency dividing or timing pulses up to 100 kc with minimum components, size, and power consumption. Counting is accomplished with two cores, one for quantizing and one for counting. The quantizing core develops a standardized pulse to drive the counting core, which will accumulate 10 counts before an output pulse is obtained. The devices are available in three forms: type DC-190 individual 10 kc decades, type DC-191 individual 100 kc decades, and model DC-192 complete five decade time base units with 100 kc crystal sources.

Burroughs Corp., Electronic Tube Div., Dept. ED, P. O. Box 1226, Plainfield, N. J.

CIRCLE 127 ON READER-SERVICE CARD

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Coaxial Standing Wave Detector

Obsoletes large units

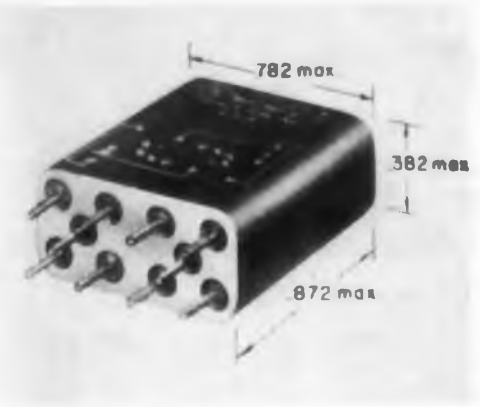
Designed to obsolete 8 ft units, the type 219 nding wave detector permits direct reading of gle of reflection coefficient and measures im-dance and vswr from 100 to 1000 mc. It pro-es direct readings of vswr and reactive com-ent signs and is supplied with a matched load self calibration. It is adaptable to most coaxial es including the company's LT and TNC series. aracteristic impedance is 50 ohms; residual wr is under 1.03; and minimum input signal is at 100 mc, 0.1 v at 1000 mc for measuring a tched load.

Polytechnic Research & Development Co., Inc., pt. ED, 202 Tillary St., Brooklyn, N.Y.

CIRCLE 128 ON READER-SERVICE CARD

Miniature Relays

For automatic printed circuit mounting



To permit mounting on printed circuit boards automatic assembly, these miniature relays ve terminals located on 0.2 x 0.2 in. co-dinates. Single coil action type SCG units have ht pins located in two rows of four, while dual l, magnetic latching type SLG units have ten s, two located midway between rows. Type G relays pull in at 260 mw at 25 C; type SLG, 230 mw. All coil connections are polarized. th types have dpdt contacts rated at 2 amp, 28 dc, resistive, and operate under 100 g shock and g vibration to 2000 cps with no contact open-gs in either armature position.

Potter & Brumfield, Inc., Dept. ED, Princeton, d.

CIRCLE 129 ON READER-SERVICE CARD

NEW PRODUCTS

Dual Boom Oscilloscope

Covers dc to 30 mc

The type 555 dual-beam oscilloscope has a separate deflection system for each beam. The two main vertical amplifiers have 10 mμsec rise times and are designed for use with the company's plug-in preamplifiers. With type K units, passbands are dc to 30 mc. The two time base generators provide 24 calibrated sweep rates from 0.1 μsec per cm to 5 per cm, and one can function as a delay generator for the other, providing accurate sweep delay from 0.5 μsec to 50 sec.

Tektronix, Inc., Dept. ED, P.O. Box 831, Portland 7, Ore.

CIRCLE 131 ON READER-SERVICE CARD

Recording-Projecting Oscillograph

Has 4 in. viewing screen

Handling any type of physical variable, the Datascope oscillograph permanently records transient phenomena ranging from dc to 5000 cps and immediately projects them as enlarged images on its 4 in. viewing screen. Data may be moved backward and forward for detailed inspection, and recorded wave forms may be projected directly to a wall screen.

Microsound, Inc., Dept. ED, 4627 Leahy St., Culver City, Calif.

CIRCLE 132 ON READER-SERVICE CARD

FLUOROCHEMICAL FC 75 pours at −148°F. has a wide liquid range of −148°F. 212°F. at atmospheric pressure, th low viscosity. In addition, it ers these useful properties: high lectric strength of 37KV; self- ling, maintaining dielectric strength er repeated high voltage arcing. mpatible with most materials used high temperature equipment. Ther- lly stable in excess of 800°F., it pre- ts development of hot spots in uipment. Prevents sludge formation e to hydrolysis or oxidation.

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Microwave Power Supply

Universal

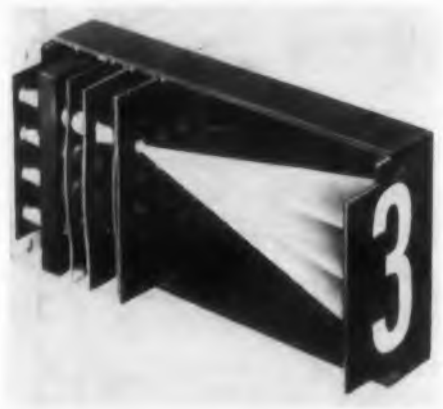
The type 813 bwo-twt power supply is designed to power backward wave oscillators, backward wave amplifiers, voltage tuned magnetrons, and traveling wave amplifiers. Its features include: individual adjustment of delay time, collector, anode grid and heater elements; provisions for both internal and external sweep and amplitude modulation; automatic gain control at the grid when used with external detectors; counter type readout for delay line supply; internal sequential time delays between applications of filament and other electrode voltages; and dual output jacks for parallel tube operation or external metering.

Polytechnic Research & Development Co., Inc., Dept. ED, 202 Tillary St., Brooklyn, N.Y.

CIRCLE 134 ON READER-SERVICE CARD

Projection Type Readout

Visible from 100 ft



Series 80,000 in-line readouts have rear projection type displays and a fully illuminated viewing screen. They have two condensing lenses and one projection lens and display 3-3/4 x 2 in. digits and characters which can be seen 100 ft away. Their aluminum body case is 3-1/4 x 5-1/4 x 11-1/2 in.

Industrial Electronic Engineers Inc., Dept. ED, 3973 Lankershim Blvd., North Hollywood, Calif.

CIRCLE 135 ON READER-SERVICE CARD

HIGH SPEED, Sensitive Polarized RELAYS

"DIAMOND H"

SERIES P Relays

FOR ELECTRONIC AND COMMUNICATIONS APPLICATIONS

Engineered to provide extremely fast action with high sensitivity, freedom from bounce and excellent stability, "Diamond H" Series P Polarized Relays give consistent performance with low distortion. Under some conditions they will handle over 1,000 pulses per second.

Magnetically latched SPDT, with two independent coils, Series P Relays are available with various coil resistances from 10 to 4,000 ohms each coil. Contact ratings will vary with switching speeds desired, but range from 60 milliamperes to 2 amperes.

Extremely compact, to save space and weight, they fit standard octal sockets. Their impact and vibration resistance is excellent for relays of this type, thanks to extra-rugged construction.

"Diamond H" engineers are prepared to work out a variation to meet your specific requirements. Write or phone us your needs.

THE HART MANUFACTURING COMPANY

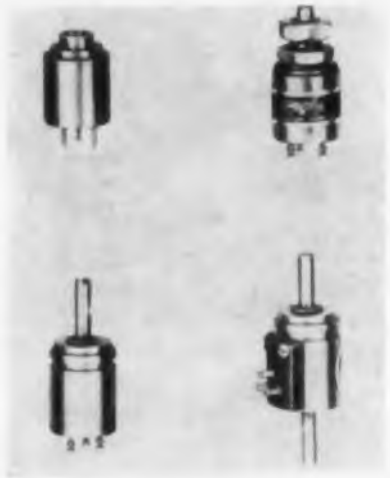
210 Bartholomew Ave., Hartford, Conn.
Phone Jackson 5-3491

CIRCLE 136 ON READER-SERVICE CARD

NEW PRODUCTS

Precision Potentiometers

Dissipate 2 w at 85 C



For precision servo and trimmer applicati these four RVG type potentiometers measure in. in diameter and provide resistance ranges f 10 ohms to 100 K. They dissipate 2 w at 85 derating to 0 at 150 C, and have linearities ra ing from ±0.5 to ±3%. Some values are availa with 3-1/2 w dissipation. The four designs incl a regular precision servo type; a precision se type with terminals on the side to allow rear sh extension and ganging; a regular trimmer ty and a trimmer type for printed circuit appl tions.

Gamewell Co., Dept. ED, 1238 Chestnut S Newton Upper Falls, Mass.

CIRCLE 138 ON READER-SERVICE CARD

Transistorized Circuit Modules

Plug-in

Transistorized plug-in circuit modules in t Economy Line include binary counters, flip-flo triggers, and similar digital circuits. The bina counter circuit, type PM7253, permits operati at any voltage supply level between 3 and 24 either plus or minus. It operates to 800 kc wi a square wave output swing of 6 v and a ri time of under 0.2 μsec. All the units have sol epoxy encapsulation. They are 7/8 in. in diamet and 2-1/16 in. high and have a 9-pin glass se plug base. Circuits similar to those in the Econo Line are available for missile and airborne u These units are supplied in crystal cans weighi less than 1 oz and occupying 3/8 cu in. per sta They have pulse repetition rates up to 1 mc.

The Walkirt Co., Dept. ED, 141 W. Hazel S Inglewood 3, Calif.

CIRCLE 139 ON READER-SERVICE CARD

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Current and Voltage Panel Meters

Have full scale sensitivities to 0.2 μa

Series 700 current and voltage panel meters are rect measurement instruments with full scale nsitivities to 0.2 μa and up to 23 ranges in one it. Their low resistance, 2 mv drop on the 1 range, is combined with an ability to with- nd overload surges of 100,000%. The units also ture frictionless movements, permanent cali- tion, elimination of parallax errors, and energy mption to 8 x 10^{-10} w. They permit direct asurement of transistor parameters without dification. Overload protection of better than illion per cent on all ranges is available on cial order.

Greibach Instruments Corp., Dept. ED, 315 rth Ave., New Rochelle, N.Y.

CIRCLE 140 ON READER-SERVICE CARD

Voltage Reference Packs

Have 8.4 or 16.8 v dc outputs

These miniature voltage reference packs oper- directly from an unregulated power source have a temperature coefficient of ±0.001% deg C from −55 to +100 C and a voltage gul tion of ±0.01% at ±10% line voltage varia- n. Output voltages of either 8.4 or 16.8 v dc are aila le in five types for operation from 28 or 5 v lc, 400 and 60 cps power supplies.

Int rnational Rectifier Corp., Dept. ED, 1521 Gr nd Ave., El Segundo, Calif.

CIRCLE 141 ON READER-SERVICE CARD

NEW PRODUCTS

Transistorized Power Supplies

Overload proof

Model 812 B transistorized power supplies, intended primarily for fixed voltage applications, are designed to deliver 0 to 10 amp at any fixed voltage from 0 to 32 v dc when powered by a 105 to 125 v, 50 to 65 cps, single phase output. They provide instantaneous protection against overloads and direct short circuits across the output terminals. Further protection for both the supply and the equipment being used is provided by conventional fuses. Drift is less than 20 mv in eight hours; internal impedance is under 0.01 ohm from 10 cps to 1 kc; and noise and ripple are 1 mv rms under any line or load combination. The units have 20 mv change in output for 0 to 100% load change and 10 mv change for any line voltage from 105 to 125 v.

Harrison Labs, Inc., Dept. ED, 45 Industrial Rd., Berkeley Heights, N.J.

CIRCLE 146 ON READER-SERVICE CARD

Miniature Power Transformers

For 400 cps applications

Designed for 400 cps applications, these miniature power transformers are available in a range of 2 to 35 va for 105, 115, or 125 v input to 6.3, 18, 26, 57.5, and 115 v output. They have solder lug terminations and color code dots for terminal identification and can be supplied in open frame or epoxy encapsulated styles. The units are built to Mil-T-27A specifications type R and X for 40 C temperature rise.

Minitran Corp., Dept. ED, 5 Oliver St., Newark 2, N.J.

CIRCLE 147 ON READER-SERVICE CARD

Alphanumeric Printer

Prints up to 48,000 digits a second

The model 3260 alphanumeric printer is an integrally housed drum type printer and electronic storage and control system which accepts data from any digital information source and provides printout rates to 48,000 digits per sec. As a logger it digitized data from a series of analog to digital converters, it can realize a scan and printout rate of 200 three digit numbers. The print wheel design permits tailoring of type fonts to individual requirements with up to 40 columns of numeric or alphanumeric characters. Type is arranged horizontally, and up to 63 characters are available in alphabetical, numerical, and special symbols in any combination.

Potter Instrument Co., Inc., Dept. ED, Sunnyside Blvd., Plainview, N.Y.

CIRCLE 157 ON READER-SERVICE CARD

Digital Clock

Supplies remote time displays

Supplying exact time displays in remote locations, this digital clock consists of six of the company's DC-106 counters with power supply and a selector switch for each decade to allow time preselecting. Two remote time displays are shown 8 and 10 ft from the counters. Each display consists of six Nixie readout tubes which indicate real time hours, minutes, and seconds.

Burroughs Corp., Electronic Tube Div., Dept. ED, Box 1226, Plainfield, N.J.

CIRCLE 158 ON READER-SERVICE CARD

NEW PRODUCTS

Pulse Oscillator

S-band

A 20 oz S-band pulse oscillator for radar microwave systems, model 306 has a power ou of 1.5 kw peak minimum at 0.001 duty cyc μsec pulse width 1000 pps. It withstands 2 20 to 2000 cps vibration and operates from to +100 C. Dimensions are 6-1/4 x 2 x 1-7/ excluding connector.

ACF Industries, Inc., Avion Div., Dept. EI Park Place, Paramus, N.J.

CIRCLE 160 ON READER-SERVICE CARD

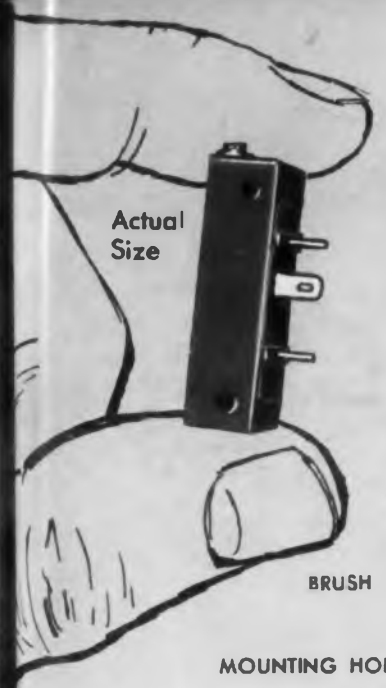
Frequency Calibrator

10 to 3000 mc range

The Mega-Stub frequency calibrator pro sharply defined harmonic responses in three tral ranges from 10 to 3000 mc. Passive net consisting of various lengths of coaxial terminated in a short circuit provide a cho responses at multiples of 10, 100, and 100 An rf signal is applied to the input termina the detected output is observed on an oscillo or a sensitive dc voltmeter. Resonance is cated by a sharp drop in the detected outp the applied frequency approaches a multi the frequency for which the cable is cut. Th is useful in calibrating oscillators and swee erators. Calibration accuracy is ±0.1%; drift than 0.01%; dimensions, 8-3/4 x 19 x 13 in.

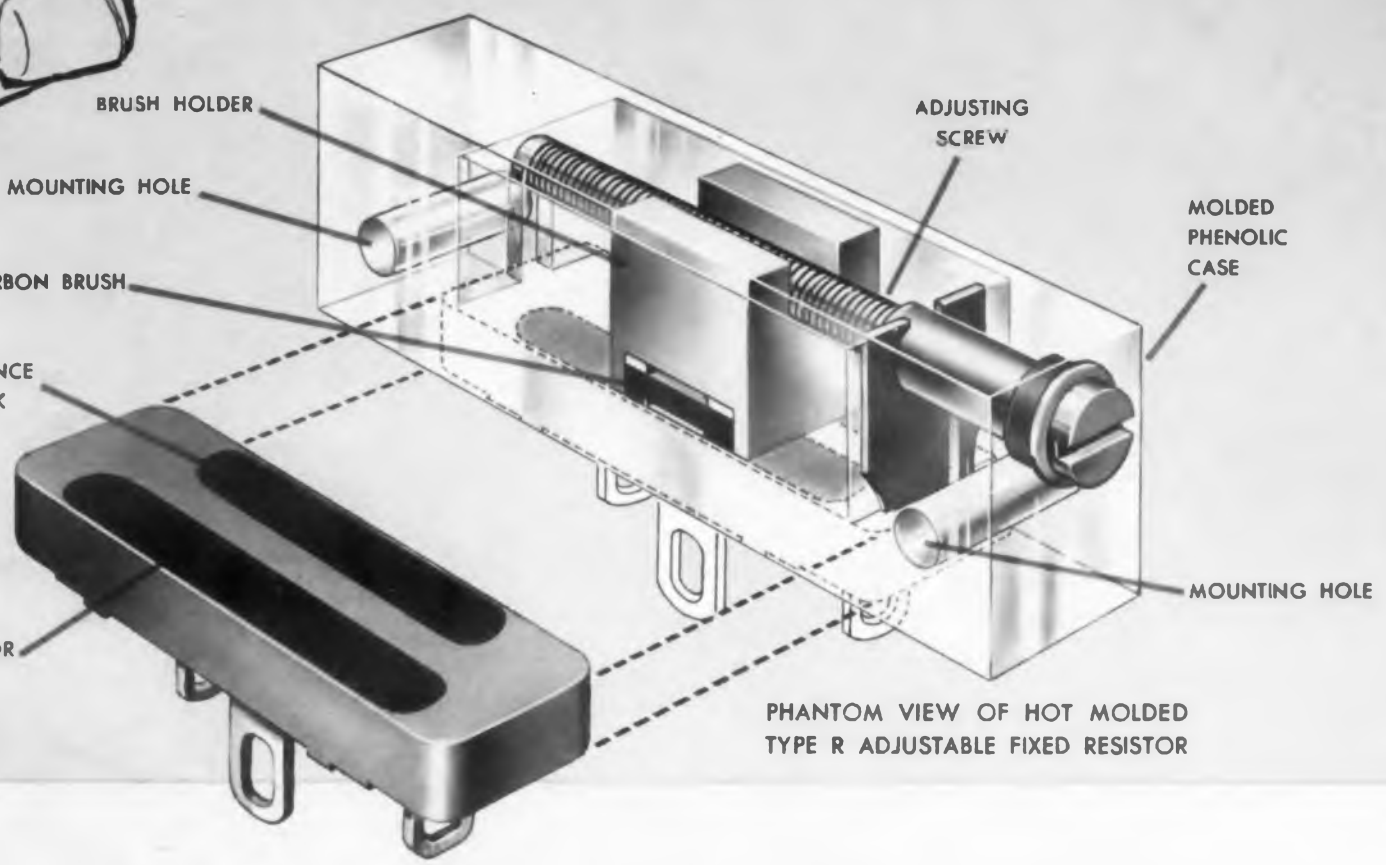
Kay Electric Co., Dept. ED, Maple Ave Brook, N.J.

CIRCLE 161 ON READER-SERVICE CARD



NEW ALLEN-BRADLEY

Adjustable Fixed Resistor



PHANTOM VIEW OF HOT MOLDED TYPE R ADJUSTABLE FIXED RESISTOR

Exclusive hot molded dual track resistance element and carbon brush give unmatched reliability and long life

SPECIFICATIONS

Power Rating: ¼ watt at 70°C ambient

Voltage Rating: 350 volts maximum

Temperature Range: −55°C to 120°C

Resistance Range: total resistance values from 100 ohms to 2.5 megohms ±10% or ±20%

Adjustment: approximately 25 turns

Dimensions: approximately 1¼" x 21/64" x ¼"

Terminals: lug and pin type terminals on 0.1" grid system and are gold plated for ease of soldering.

Here's a new, compact, adjustable fixed resistor—the Type R—with Allen-Bradley's exclusive hot molded resistance element. It's the same type resistance element used in the popular Type J and Type G units . . . which have proved unequaled for reliability and long life. Operation is exceptionally smooth—no abrupt resistance changes occur with adjustment. The molded case of the Type R adjustable fixed resistor is watertight and dust-tight. The mounting for the moving element is self-locking to assure stable setting—and the entire unit can be "potted" after adjusting. The adjustment screw has a "free wheeling" clutch to prevent damage.

Send for complete information on this latest addition to the Allen-Bradley line of *quality* potentiometers.

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

A-B QUALITY

ALLEN-BRADLEY

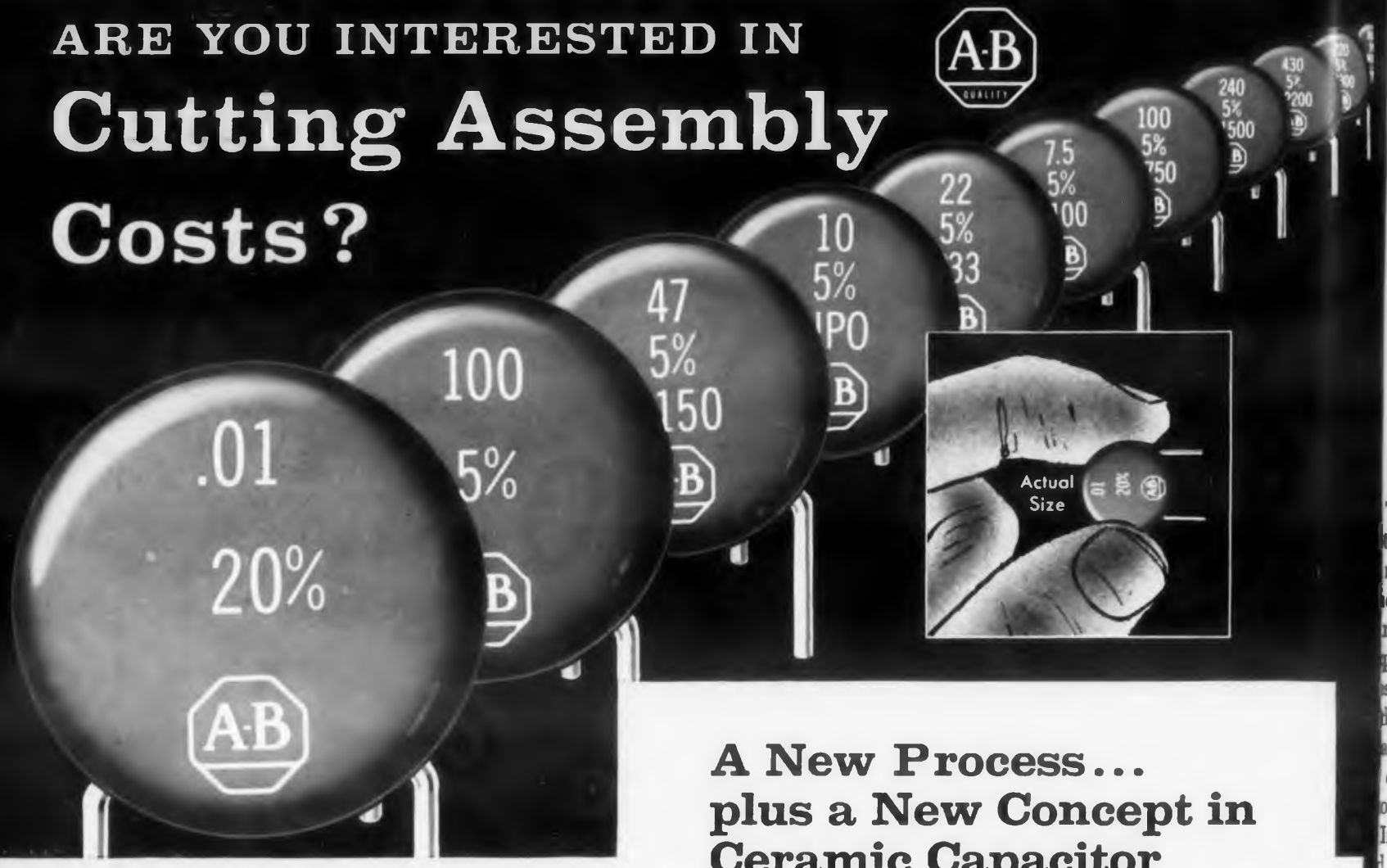
QUALITY

ELECTRONIC COMPONENTS

2-59-E

ARE YOU INTERESTED IN

Cutting Assembly Costs?

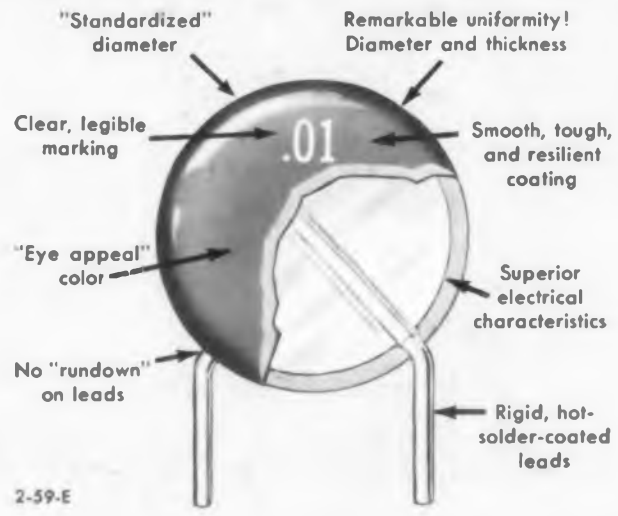


New "Auto-Coat process" makes high speed machine assembly possible—but it also makes manual assembly quicker—at lower cost!

Allen-Bradley's new "Auto-Coat process" provides a tough, smooth insulating coating of uniform thickness—it does not use wax or other sticky impregnants which are bound to clog automatic machines. The physical uniformity of these capacitors permits accurate mechanical or manual insertion on printed boards.

With "rundown" on leads eliminated, the capacitor is permitted to rest directly on printed boards—for solid, three-point mounting. Costly cleaning or crimping of wires to prevent soldering failures is a nightmare of the past; lead inductance is less.

Allen-Bradley Type A Ceramic Capacitor



A New Process... plus a New Concept in Ceramic Capacitor Standardization!

... provides superlative electrical properties

Standardization on only *one size* of capacitor—0.55" diam—for most values, permits scientific selection of ceramic materials with the *optimum* dielectric constant for *each* capacitance value. Through such advanced design technique, Allen-Bradley Type A ceramic capacitors provide greater dielectric strength and greater breakdown voltage . . . creepage paths are also increased. In addition, the coefficients of temperature, frequency, and voltage are lower . . . and the power factor is lower, too.

Allen-Bradley's standardizing on *one size* for all capacitance values has produced a *superior* capacitor that can be assembled by machines on printed boards at lower cost. Manual assembly costs are reduced, and capacitor inventory costs are also reduced.

Allen-Bradley Type A capacitors are available in general purpose, stable, and temperature compensating types in the most frequently used values. Send for new data sheets.

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY
ELECTRONIC COMPONENTS
QUALITY

Rotary Switch

Has low contact resistance

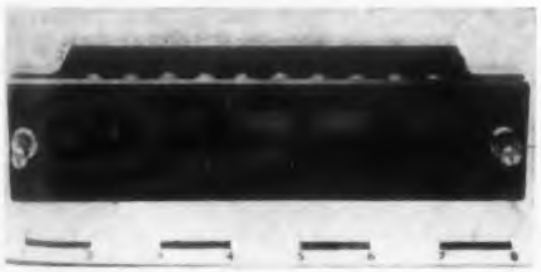
The series 2000 is a 12-position, shorting type tary switch with contact resistance of less than milliohm. It is available with one to six poles d has a voltage breakdown rating of over 1000 rms. It has high insulation resistance and low pacitance between contacts and ground and is signed for use above 250,000 cycles of rotation, her continuous or limited. Stop positions are dily adjustable without disassembly. The unit enclosed in a dust proof, high temperature, ock and vibration free housing.

Industrial Devices Inc., Dept. ED, 982 River d., Edgewater, N.J.

CIRCLE 163 ON READER-SERVICE CARD

Panel Display Units

Have up to four colors



The Amflite panel display units permit the il- mination of up to four colors in one area with- t accompanying hot spots. The 2000 series com- e illuminated pushbutton switching and asso- ted color display in a single unit. They will cept any standard pushbutton switch and may equipped with a momentary or alternate action tch. They may be used as indicators only ere required to match other switching applica- ns. The 7000 series provide a larger surface a and, when used in multiple assembly, permit tting of the illuminated face. The 6000 series ts are custom designed to provide an infinite iety of window and indicator combinations. ese units display up to three color combinations window.

American Machine & Foundry Co., Alexandria ., Dept. ED, 1025 N. Royal St., Alexandria, Va.

CIRCLE 164 ON READER-SERVICE CARD

CIRCLE 602 ON READER-SERVICE CARD

NEW PRODUCTS

Miniature Terminal Blocks

Snap together

Miniature series G alpha blocks are semielast units with snap action lugs and slots that requi no tools for assembly or disassembly, yet cann shake loose or be pulled apart when mounte Available in ten colors for simple circuit codin the units are 3/8 in. wide, 1/4 in. high, and 3/4 i long. Full insulation protection is provided b tween blocks, fastening screws, and panel, and al between block pairs. Contact screws are nick plated 4-40 binding head, and electrical conne tion between pairs is an integral part of the bloc Each block has a countersunk mounting scre hole, but up to 15 blocks can be snapped togeth and mounted with one screw at each end. Th units are rated 20 amp at 110 v.

Alpha Electric Products Co., Dept. ED, 3625 N Halsted St., Chicago 13, Ill.

CIRCLE 167 ON READER-SERVICE CARD

AC Power Source

Provides 150 va output

Portable model 151-C-1 E Invertron powe source requires an input of 115 v, 60 cps, singl phase and produces an output of 150 va, 0 t 130 v ac, 400 cps, single phase. The output fre quency is held to an accuracy of 0.5%. A fron panel jack will permit the use of an external sig nal over the range of 100 to 4000 cps, for use as power amplifier. The unit is also available wit other fixed output frequencies.

Behlman Engineering Co., Dept. ED, 291 Winona Ave., Burbank, Calif.

CIRCLE 168 ON READER-SERVICE CARD

Electrolytic Capacitors

Miniature

Miniature Trans-Lytic electrolytic capacitors are stable units with a maximum leakage of 0.15 μa per μf per v. Designed for use in transistorized circuitry, they are rated at 3 and 10 wvdc with capacitances from 2 to 100 μf. The low cost units are metal cased with a protective insulating sleeve and have solder-coated leads. They are available with diameters of 1/2 and 3/4 in. and lengths from 3/16 to 13/32 in. Tolerance at 25 C is —10%, +200%.

Fedtro, Inc., Federal Electronics Sales, Dept. ED, Federal Electronics Bldg., Rockville Centre, N.Y.

CIRCLE 169 ON READER-SERVICE CARD

Explosion Proof Motor

Rated at 1/2 hp

Rated 1/2 hp at 4500 rpm ±5%, the model 6VG3 is a totally enclosed explosion proof motor designed for 200 or 115 v ac 400 cps 3-phase operation. It requires 4.5 amp, operates at 75% efficiency, and has a minimum life of 1000 hr. The unit incorporates permanently lubricated shielded ball bearings and a corrosion resistant shaft. Diameter is 4-15/16 in.; length, 6-1/2 in.

Western Gear Corp., Electro Products Div., Dept. ED, 132 W. Colorado St., Pasadena, Calif.

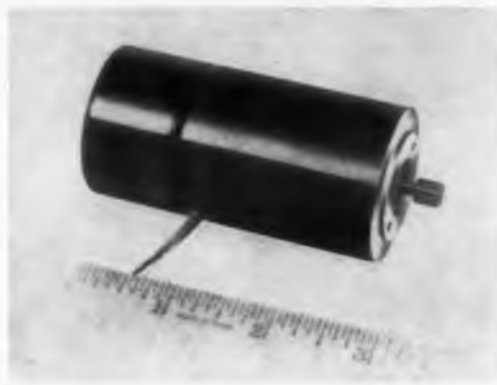
CIRCLE 170 ON READER-SERVICE CARD

Have you sent us your subscription renewal form?

NEW PRODUCTS

AC Motor

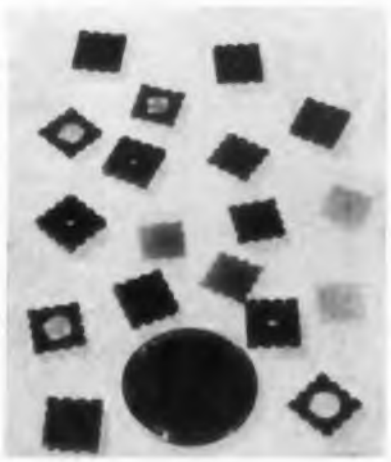
For aircraft and missile use



Designed for aircraft and missile applications where 400 cps ac power systems are used, the AYLO motor passes MIL-M-7969A tests and has a life of 1000 hr. Its built-in, 400 cps magnetic brake has a minimum life of 300,000 cycles. The 115 v, 400 cps ac single phase motor has a 4-pole field and two balanced windings that permit reversal with an spdt switch. Rated horsepower is 0.02; ambient temperature range, —65 to +250 F; weight including explosion proof enclosure, 0.8 lb; and size, 1.5 x 3.09 in.

Barber-Colman Co., Electrical Components Div., Dept. ED, Rockford, Ill.

CIRCLE 173 ON READER-SERVICE CARD



Miniature Wafers

Useful to 500 C

These miniature precision wafers have good electrical characteristics, high strength, and an operating temperature of over 500 C. Made of Fotoceram, a rugged, glass ceramic, they can serve as resistor, transistor, capacitor, and diode bases in micromodule circuit assemblies. Formed by a photoetching process, they lend themselves to low-cost mass production of consistently accurate parts. Recesses and through holes can be made and design changes effected by art work rather than tooling. The wafers are 1/3 in. sq and can be made with thicknesses down to 0.01 in. They are nonporous, abrasion resistant, dimensionally stable, and free of internal flaws.

Corning Glass Works, Dept. ED, Corning, N.Y.

CIRCLE 174 ON READER-SERVICE CARD

DC Amplifier

Chopper stabilized

The M-10 multipurpose, chopper stabilized dc amplifier has a current output proportional to a millivolt input. With 0 to 1 ma meter movement recorders, it may be used to record inputs of 0 to 10 mv at an input impedance level of 10 meg. The combination can record the output of strain gages, remote thermocouples, or other transducers in the 0 to 2 cps range. Used with a 0 to 1 ma or 0 to 100 μa meter, the unit becomes a 0 to 10 mv or 0 to 1 mv dc vacuum tube millivoltmeter, and with suitable shunts it may be used as a current or voltage amplifier. Accuracy is 1%; linearity, 0.5% drift, less than 50 μv referred to the input. A trim adjustment provides for precise calibration for loads from 0 to 5 K.

Houston Instrument Corp., Dept. ED, 1717 Clay Ave., Houston 3, Tex.

CIRCLE 175 ON READER-SERVICE CARD

Flip-Flop Package

Plug-in

A transistorized modular logic card, the model TF3 plug-in flip-flop package contains three Eccles Jordan flip-flops and nonlinear feedback diodes. Threshold bias affords effective noise discrimination, and clamping diodes are provided on both outputs to give a stable voltage level. The unit has ac couple set and reset inputs which act on the positive voltage swing, permitting the use of tail end logic.

Digitronics Corp., Dept. ED, Albertson Ave., Albertson, N.Y.

CIRCLE 176 ON READER-SERVICE CARD

MEDIUM POWER SILICON RECTIFIERS

High current — 7/16 stud base

MAXIMUM CASE TEMPERATURE RATINGS

NAE Number	Peak Inverse Voltage	Maximum Average Rectified Current (amps) 50°C	150°C	Maximum Surge Current (5 milliseconds)	Forward Voltage at Specified Current at 25°C	Maximum Average Inverse Current (ma)
NA17	100	10	3	60 amps	1.1v at 3 amps	.5
NA27	200	10	3	60 amps	1.1v at 3 amps	.5
NA37	300	10	3	60 amps	1.1v at 3 amps	.5
NA47	400	10	3	60 amps	1.1v at 3 amps	.5
NA57	500	10	3	60 amps	1.1v at 3 amps	.5
NA67	600	10	3	60 amps	1.1v at 3 amps	.5

NORTH AMERICAN ELECTRONICS, INC.

212 Broad Street, Lynn, Massachusetts

CIRCLE 178 ON READER-SERVICE CARD

NEW PRODUCTS

Vaneaxial Blower

For high altitude use

These 8 oz, 2 in. vaneaxial blowers deliver relatively large quantities of air at high back pressures. They provide high performance at high altitudes and can be designed so that the motor speed automatically increases as the air density decreases. They are available in three models: BC 1307V, rated 115 v, 400 cps, 1 phase; BT 1307V, rated 115 or 200 v, 400 cps, 2 or 3 phase; and BD 1206V, rated 28 v dc.

Induction Motors Corp., Dept. ED, 570 Main St., Westbury, N.Y.

CIRCLE 179 ON READER-SERVICE CARD

Environmental Rooms

Portable

These portable environmental rooms are designed for electronic quality control processes requiring closely controlled atmospheres. They have air filtering and purifying equipment to assure dust free atmosphere and can maintain constant temperatures from 70 to 100 F and constant relative humidities from 20 to 98%. They can accommodate through wall connections and are furnished with tiers of adjustable shelves. An automatic overtemperature controller prevents dangerous heat increases in case of thermostat failure. The rooms are easily assembled and may be enlarged by the insertion of additional center sections.

Electric Hotpack Co., Inc., Dept. ED, 5074 Cottman Ave., Philadelphia 35, Pa.

CIRCLE 180 ON READER-SERVICE CARD

Miniature Power Relay

Heavy duty

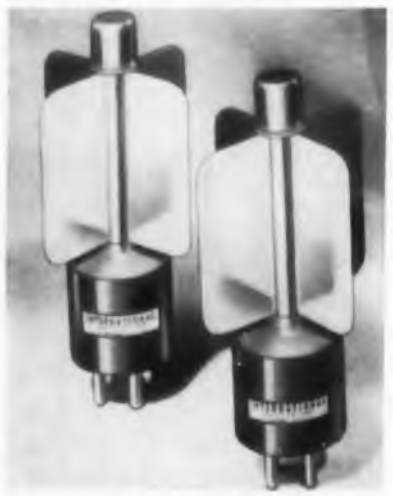
Hermetically sealed model 26S20 relay has a contact rating of 25 amp at 115 v ac, resistive loads and will handle most power applications with a minimum of 100,000 operations at this rating. Longer life can be expected at reduced loads. The high speed, dp throw unit has a standard operating power of 4 va. It has self-wiping contacts and can be externally wired for double make or break operations. Dimensions are 1-3/4 x 1-5/8 x 2-11/16 in.

Kurman Electric Co., Dept. ED, 191 Newel St., Brooklyn 22, N.Y.

CIRCLE 181 ON READER-SERVICE CARD

Silicon Rectifier Cartridge

Rated at 6400 piv



The type ST-7 silicon rectifier cartridge is designed to replace the type 866 mercury vapor rectifier tube and its concomitant filament transformer. The multiple junction cartridge is 5 in. long with a 2-3/8 in. diameter and weighs 7 oz. Rated at 6400 piv, it provides dc output currents of 250 ma at 75 C ambient temperature. The housing and cooling fins act as heat exchangers to dissipate the inherently low internal power losses of silicon. The unit is hermetically sealed and equipped with tube bases to allow direct insertion into existing tube sockets.

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

CIRCLE 182 ON READER-SERVICE CARD

NEW PRODUCTS

Trimmer Potentiometer

Hermetically sealed

The model 50-M34 trimmer potentiometer has a glass header soldered on its housing to insure a perfect hermetic seal. The unit mounts in a 1/4 in. panel hole and may be soldered in place. It has mechanical stops and locks to hold the shaft in place. Of rugged construction, it meets Mil-R-19A, Mil-E-5272A, Mil-R-19518, Mil-R-12934B, and NAS 710 requirements. Resistance range is 25 ohms to 10 K.

Maurey Instrument Corp., Dept. ED, 7924 S. Exchange Ave., Chicago 17, Ill.

CIRCLE 185 ON READER-SERVICE CARD

Adjustable Inductances

Single and double winding types

Adjustable Vari-Henry inductances are available in two models: a single winding type with a maximum to minimum inductance ratio of over 6 to 1 and a two winding type, for series or parallel connection, with a maximum to minimum inductance ratio of over 24 to 1. The spacing between the core and armature, controlled by an adjusting screw, determines the inductance, and any setting within the operating range can be made with a suitable power supply and meters. Core sizes and windings are engineered to individual requirements. In 60 cps ac applications, volt-ampere ratings range from 150 to 800 va.

Magnetic Specialties, Inc., Dept. ED, P.O. Box 476, Trenton 3, N.J.

CIRCLE 186 ON READER-SERVICE CARD

Silicon Rectifiers

Have low back currents

These diffused junction silicon rectifiers have good stability, high surge current handling capacity, and low back currents at high temperatures. They are ruggedly constructed to meet Mil-T-19500A specifications. Types 1N1115 through 1N1120 and 1N253 through 1N256 are stud mounted units; types 1N536 through 1N540 and 1N1096, and 1N547 and top hat models.

Motorola, Inc., Semiconductor Products Div., Dept. ED, 5005 E. McDowell Rd., Phoenix, Ariz.

CIRCLE 187 ON READER-SERVICE CARD

Moving Coil Instruments

Have ±0.2% full scale accuracy

These Goerz multirange milliammeter-ammeter and voltmeter instruments have ±0.2% full scale accuracy and are equipped with range selector switches, universal terminals, 6 in. mirror scales, blade type pointers, calibration certificates, and molded Bakelite cases with a leather carrying strap. The milliammeter-ammeter has ranges of 15, 30, 75, 150, and 750 ma and 1.5, 3, 7.5, 15, and 30 amp. The voltmeter ranges are 60 mv and 0.3, 0.75, 1.5, 3, 7.5, 15, 30, 75, 150, 300, and 750 v. Physics Research Labs, Inc., Dept. ED, P.O. Box 555, Hempstead, N.Y.

CIRCLE 188 ON READER-SERVICE CARD

Have you sent us your subscription renewal form?

NEW PRODUCTS

Static Power Inverter

Produces 250 va output

This power inverter uses transistor and magnetic amplifier circuitry to convert a 26 to 30 v dc source to a 115 v, 400 cps, single phase ac source. Designed to produce a stable power output of 250 va, it can be used in missiles, checkout systems, aircraft and ground equipment, airborne computers, and radar. It has a life expectancy of 20,000 hr and can withstand 30 g shock and 10 to 2000 cps vibration. Output voltage is adjustable to ±5% and regulation is 1.5% no load to full load. The unit measures 8-1/16 x 8-1/16 x 4 in. and weighs 12-1/2 lb. It is built to Mil-E-5400 and Mil-E-5272 specifications.

Magnetic Amplifiers, Inc., Dept. ED, 632 Tinton Ave., New York 55, N.Y.

CIRCLE 191 ON READER-SERVICE CARD

Frequency Selective Amplifier

Gain of over 80

Model M-10001-PB is a plug-in, 400 cps frequency selective amplifier with a gain of over 80 and a Q greater than 35. Provision is made for an external Q adjustment so that the bandwidth may be adjusted as required. A nominal supply voltage of 250 v dc is needed. The unit is 5-1/4 x 2-7/8 x 1-1/8 in. and designed for guide rail mounting.

Plug-In Instruments, Inc., Dept. ED, 141 Lebanon Rd., Nashville, Tenn.

CIRCLE 192 ON READER-SERVICE CARD

FM Deviation Meter

Measures instantaneous peak deviation

Designed as an aid in adjusting fm transmitters, e Deviometer uses an oscilloscope to present a ual picture of instantaneous peak deviation. It minates assuming that a true sinusoidal wave- m of modulation exists. The unit has frequency ges of 25 to 55 and 145 to 175 mc with pro- ions for installation of a 450 mc tuner. It has its n power supply that operates from a standard cps, 110 v source.

Radio Specialty Mfg. Co., Dept. ED, 2023 S.E. th Ave., Portland 14, Ore.

CIRCLE 193 ON READER-SERVICE CARD

Automatic Relay Tester

Measures pull-in and drop-out values

This automatic relay tester provides an accu- means of inspecting pull-in and drop-out acteristics on a production line basis. A motor en variable voltage transformer provides con- t automatic increases and decreases in voltage, an automatic voltage increase is impressed on relay coil before the drop-out cycle, causing relay to pull in harder before the decrease e starts. Pushbuttons stop or start the motor, control circuits automatically stop the trans- mer at the moment or relay contact make or ak. The unit has a voltage range of 0 to 50 v a current range of 0 to 500 ma dc, and a power t of 105 to 125 v, cps. Contact current in the y under test is 6 μa at 6 v dc.

Mid-Eastern Electronics, Inc., Dept. ED, 32 mmerce St., Springfield, N.J.

CIRCLE 194 ON READER-SERVICE CARD

Electronic Products NEWS
by CARBORUNDUM
Registered Trade Mark

Having transistor troubles?

THERMISTOR AND VARISTOR TEST KITS
available for development and experimental work

Interest in the temperature-sensitive and voltage-sensitive characteristics offered by GLOBAR® ceramic type non-linear resistors is now being demonstrated in many electronic applications. In transistorized circuits, for example, GLOBAR thermistors help to stabilize I_c variations with temperature and to prevent thermal run-away. GLOBAR varistors protect transistors against over-voltage.

For those who would like to experiment with possible applications, test kits are available at a very nominal charge. Bulletins GR-2 on varistors and GR-3 on thermistors give physical and electrical characteristics, types and sizes available and other pertinent data. Just drop a line to Globar Plant, Refractories Division, Dept. EDR 59, The Carborundum Company, Niagara Falls, N. Y. **153**

GRADED SEALS—KOVAR® ALLOY
to Pyrex-type Laboratory Glass

One of the many examples of glass-to-metal sealing made possible by KOVAR alloy is the graded seal shown here. This is a tubular transition piece for hermetically joining metal tubing to laboratory Pyrex-type glassware. The metal end, which can be joined to other metals, is of KOVAR alloy. Its thermal expansion characteristics are almost identical with those of borosilicate hard glass, which is used for the first glass section, fused to the metal. Succeeding glass sections, graded in thermal expansion coefficient, connect the borosilicate glass to the Pyrex-type glass, which can be fused to laboratory Pyrex systems.

Stock sizes are from ⅛" to 1.9" diam. at the metal end and from 4⅜" to 14" overall length. For further information, write to Latrobe Plant, Refractories Division, Dept. EDS 59, The Carborundum Company, Latrobe, Pa. **154**

Large Ceramic-to-Metal Assembly solves problem in new electronic devices

The problem of sealing a heavy metal ferrule to a large ceramic cone was brought recently to Carborundum's Latrobe Plant. Team effort involving research and long experience in producing high strength, high temperature, vacuum tight ceramic to metal assemblies resulted in the final design shown above. The ferrule is bonded to a dense, 96% alumina cone. It will withstand assembly and operating temperatures far above the range of soft solders and is extremely rugged.

Carborundum has facilities for manufacturing ceramic-to-metal assemblies to meet a wide range of specialized requirements. Our engineers will welcome the opportunity of discussing your particular problems. Write to Latrobe Plant, Refractories Division, Dept. EDC 59, Carborundum Company, Latrobe, Pa. **155**

NEW DATA SHEET ON HIGH TEMPERATURE RESISTORS

New Technical Data available on high temperature resistors—type SP. All essential technical information, including watt ratings, sizes, resistance ranges, terminations, temperatures, overload capability etc., are included. For your copy, write to Globar Plant, Refractories Division, Dept. EDR 59, Carborundum Company, Niagara Falls, N. Y. **156**

CIRCLE 153, 154, 155 OR 156 ON READER-SERVICE CARD

NEW PRODUCTS

Electric Counters
Pulse grouping

These pulse grouping electric counters cou pairs, quads, and other group quantities witho pulse divider circuits. In operation, a counter d signed to count pairs accumulates one pulse an then registers one unit count on the second puls Five number wheels are provided to register un counts, and a sixth can be arranged to regist accumulated partial counts. The units are ava able in knob reset base mount and knob and ke reset panel mount models for ac or dc, and in a standard voltages to 150. The ac models hav built-in full wave rectification for operation fro 25, 40, 50, or 60 cps.

General Controls Co., PIC Automation Contro Div., Dept. ED, 8078 McCormick Blvd., Skoki Ill.

CIRCLE 197 ON READER-SERVICE CARD

Commutating Switch
Handles B+ switching

Commutating switch model 500411 is design to handle B+ switching at about 150 v dc. operates from a 6 v dc supply to provide 6 r pole speeds. The switching section is compris of a single pole with 12 make-before-break co tacts with a maximum of 5% shorting time b tween contacts. The unit weighs 2 lb and is co tained in a hermetically sealed case 2-3/4 x 2-3 x 6 in. It can operate at —40 F and 200,000 while undergoing 20 g vibration from 20 to 20 cps.

Instrument Development Labs., Inc., Dept. E 67 Mechanic St., Attleboro, Mass.

CIRCLE 198 ON READER-SERVICE CARD

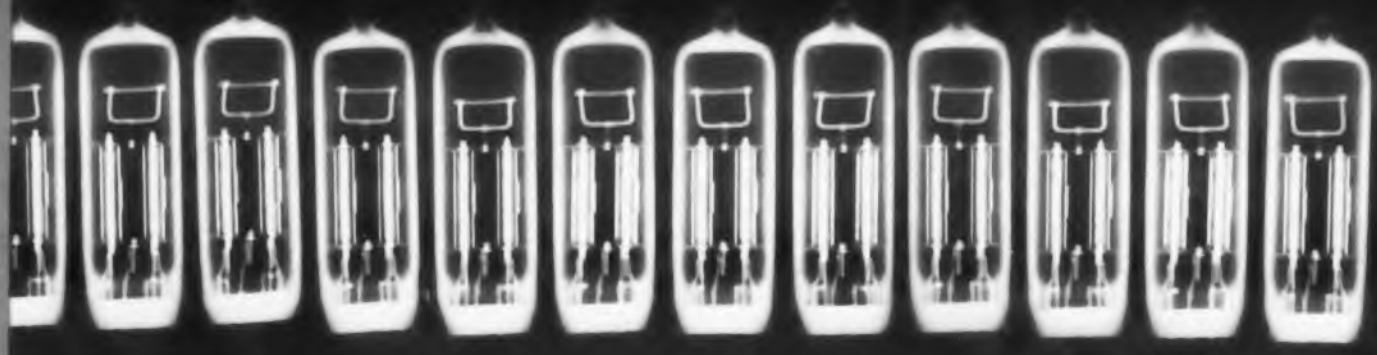
CIRCLE 199 ON READER-SERVICE CARD

Electron Tube News
—from SYLVANIA

SYLVANIA CREATES A

New Profile of Dependability

IN GOLD BRAND TUBES



RADIOGRAPH PROFILE shows the superior uniformity of Gold Brand Tubes

Exclusive design, production and identification techniques add extra reliability and efficiency to Gold Brand Tube performance

The perfect uniformity of its physical profile is symbolic of the new level of reliability in Sylvania Gold Brand Tubes. It represents the results of exclusive design and production techniques developed and refined at one of the world's most advanced tube facilities, The Sylvania Gold Brand Plant in Burlington, Iowa.

The unmatched reliability of the Gold Brand "New Concept Bulb" is evident in latest test data. Hourly thermal shock tests (100°C to 0°C) indicate less than 2/10% tip failure during the past two years. This record is due to Sylvania-developed automation equipment, such as the "New Concept" tubulated bulb machines, and to tight quality controls maintained throughout the entire Gold Brand manufacturing process.

The Production Lot Letters etched on its envelope are another indication of the extra dependability of Sylvania Gold Brand Tubes. They are the key to a profile of lot production and test data that offers the user more precise application information and provides for better quality control.

THE EXCLUSIVE LOT LETTERS on each Sylvania Gold Brand Tube identify a complete file of production and test characteristics for individual tube lots

SYLVANIA CREATES A NEW PROFILE OF

SYLVANIA'S ORIGINAL folded coil heater design is processed in this ultra-clean room to prevent contamination

ALL TUBE MOUNTS are precision-welded under stereo microscope

New heater design increases tube efficiency

Sylvania has increased the efficiency profile of Gold Brand Tubes by an exclusive heater design, automatic cathode tabbing and by extra control over the environment in which cathode and heater operations are performed.

The Sylvania-pioneered folded coil heater used in Gold Brand Tubes permits use of heavier wire for extra ruggedness, permits use of heavier insulation, and allows the cathode to run at higher temperatures for added efficiency at lower heater voltages. The U shaped coil used in double section tubes requires but two welds instead of four, giving extra reliability.

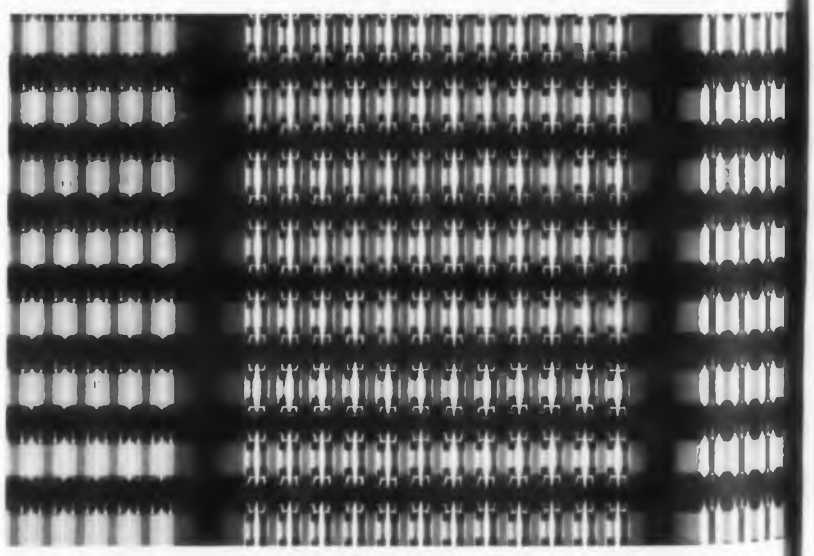
All coating and tabbing operations for heaters and cathodes are performed in a specially air conditioned and filtered room within Sylvania's Gold Brand air-conditioned plant in Burlington, Iowa. Greater cleanliness is achieved to eliminate possible impurity contamination.

Microscopic welding adds ruggedness

All fine welding operations such as heater welds for Gold Brand Tubes are made under stereoscopic microscope to assure weld perfection.

Specially developed weld energy sources such as phase control, slope control and stored energy units are utilized. Weld pressure and current are constantly controlled through Sylvania-patented measuring devices to obtain the strongest and most reliable welds.

EXCLUSIVE FLAME SHIELD firing of grids and parts removes microscopic lint particles



RADIOGRAPH PROFILES of Gold Brand mounts insure against hidden defects

Exclusive flame shield process improves tube performance

All Gold Brand grids and parts undergo Sylvania's exclusive flame shield firing just prior to processing in a high-temperature reducing atmosphere. Contaminations such as lints, oxides and gases are eliminated. The flame shield removes microscopic lint particles.

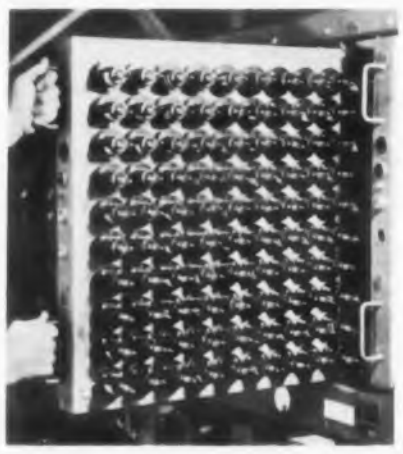
X-ray reveals mount reliability

Even though every mount for Gold Brand Tubes undergoes 100% microscopic inspection, Sylvania carries quality control a step further by using X-ray as a process control on all Gold Brand mounts. X-ray is also used as a 100% inspection tool where appropriate throughout the entire manufacturing process.

DEPENDABILITY IN GOLD BRAND TUBES

OVER 1.5 MILLION TUBES a month receive burn-in stabilization on specially designed stabilization equipment

ALL SYLVANIA GOLD BRAND TUBES receive thermal and electrochemical aging on Sylvania designed equipment



Advanced testing techniques insure top Gold Brand performance

Through continual improvement of its processing and testing methods, Sylvania Gold Brand Tubes are setting new performance records.

All Gold Brand Tubes receive thorough burn-in to insure optimum stability of electrical characteristics both initially and throughout life. Sylvania burn-in facilities are among the industry's largest. Up to 2 million tubes are stabilized each month!

Every Gold Brand Tube also receives highly refined thermal and electrochemical aging on Sylvania designed automatic equipment. Specialized Cyclic processing is used for optimum pulse emission levels and reduced hum levels.

In addition to heater cycle life tests, environmental tests and thermal shock tests, every Gold Brand Tube goes through a final electrical test for pulse emission, AF noise, mutual conductance at rated and reduced EF, static characteristics, shorts, and continuity. Gold Brand Tubes are also subjected to 100% microscopic inspection.

Better vacuums achieved for Gold Brand Tubes

More efficient vacuums have been achieved for Gold Brand Tubes through the use of improved exhausting and gettering techniques. Evacuation is performed on automatic equipment with tubes individually evacuated on oil diffusion pumps.

Control charts are maintained over all phases of sealex operation including vacuum measurements on individual heads to improve vacuums. An emission activation control chart is also maintained to reflect control of emission related items.

After sealing, pure barium getters are post flashed to insure maximum gas elimination. Specially designed RF induction heating installations are used so that other tube elements are not affected.

EVACUATION AND SEALING are rigidly controlled automatically

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD

First Class Permit No. 2833 Sec. 34.9 P.L.&R., Buffalo 9, N.Y.

SYLVANIA ELECTRIC PRODUCTS INC.
1100 Main St.
Buffalo 9, N.Y.

SYLVANIA GOLD BRAND LINE is comprised of Military Types, Guided Missile Types, Commercial and Industrial Types and Computer Types

The Sylvania Gold Brand Line—premium tubes designed for specific applications

There are over 100 types of Sylvania Gold Brand Reliable Tubes ranging in size from subminiature to miniature and larger. They include types specifically designed to cover electronic circuits in four main application areas: Military Applications, Guided Missile Applications, Commercial and Industrial Applications and Computer Applications.

Sylvania Gold Brand Military Types, originally used in proximity fuzes, are now designed for application in a wide range of ground, sea and air equipment. Nearly 20 of the types are currently used in the control system of the F-106 fighter.

Sylvania Gold Brand Guided Missile Types are specifically designed to meet the tough requirements of military missiles and rockets. Today some 14 Sylvania Gold Brand originals are used in the Falcon missile alone.

Sylvania Gold Brand Commercial and Industrial Types are used in commercial airline equipment, mobile communications equipment and in industrial control equipment.

Gold Brand Reliable Computer Types, designed to meet the special requirements of data processing equipment, are used in many of the major computers on the market today. When dependability counts, specify Sylvania Gold Brand Tubes.

SYLVANIA

SYLVANIA ELECTRIC PRODUCTS INC.
1740 Broadway, New York 19, N. Y.
In Canada: Sylvania Electric (Canada) Ltd.
P. O. Box 1190, Station "O," Montreal 9.

LIGHTING · TELEVISION · RADIO · ELECTRONICS · PHOTOGRAPHY · ATOMIC ENERGY · CHEMISTRY-METALLURGY

Please send additional information on the items checked below:

- ☐ Gold Brand Military Types
- ☐ Gold Brand Commercial & Industrial Types
- ☐ Gold Brand Guided Missile Types
- ☐ Gold Brand Computer Types

Name_____

Address_____

Company_____

Use this handy business reply card to request additional information on these important new Sylvania developments

Miniature Induction Motors

1/300 to 1/30 hp

For use in tape recorders, communication equipment, and other electronic devices, type 9200 miniature induction motors have ratings from 1/300 to 1/30 hp. They feature low level magnetic hum, reduced external magnetic field, low temperature rise, and minimum cogging and hunting. Frame size is 2-7/8 x 2-7/8 in. with an overall length of 4-1/32 in. for frame 9210, and 4-13/32 in. for frame 9214. The units are permanent split capacitor, single phase, 50 or 60 cps models in induction, torque, and synchronous types. They are also available in two or three phase designs.

Howard Industries, Inc., Dept. ED, 1760 State St., Racine, Wis.

CIRCLE 200 ON READER-SERVICE CARD

Accelerometers

Single axis

Single axis accelerometer models D1754-01 and D1756-01 use a spring mass system that is sensitive to linear accelerations along an input axis, but insensitive to accelerations normal to that axis. Built to operate in high vibration environments, they are especially suited to missile inertial guidance applications. Respectively, the units are size 20 and 22 and have linearities of ± 0.25 and $\pm 0.02\%$, threshold sensitivities of 10^{-4} and 10^{-5} g, and frequency responses flat to 220 and 120. Both have a ± 10 g range and a frequency of 4000 cps. They are rated at 3.4 v.

Kearfott Co., Inc., Dept. ED, 1500 Main Ave., Clifton, N.J.

CIRCLE 201 ON READER-SERVICE CARD

CIRCLE 199 ON READER-SERVICE CARD

NEW PRODUCTS

Connector Contact

Miniature

The REMI re-entrancy miniature connector contact can be removed or replaced with pliers or by hand. It has metallic sleeves with long cantilever springs designed to permit interchangeability of male and female contacts. Mechanical stresses are confined between metallic elements rather than between plastic and metallic elements, and additional polarization and keying can be accomplished with dummy pins. The contact is removed from the wiring side without disengaging the connector.

U. S. Components, Inc., Dept. ED, 454 E. 148th St., New York 55, N.Y.

CIRCLE 204 ON READER-SERVICE CARD

Fixed Coaxial Attenuator

Handles up to 10 w

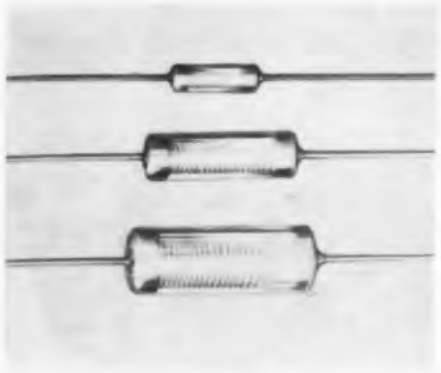
Model 10 fixed coaxial attenuator can handle up to 10 w and is designed to dissipate this power without appreciable change in characteristics. Made to MIL-A-3933 specifications, the unit features bilateral matching, a black anodized aluminum body, and stainless steel type N connectors. It has a 50 ohm impedance, a dc to 1 kmc frequency range, and a 1 to 10 db attenuation range. Maximum input vswr is 1.15, bilateral.

Weinschel Engineering, Dept. ED, 1050 Metropolitan Ave., Kensington, Md.

CIRCLE 205 ON READER-SERVICE CARD

Sealed Resistors

For severe environments



Rated at 1/8, 1/4, and 1/2 w, Mil series Pyro-al resistors can withstand shock at 500 g, ac-eration at 100 g, and vibration of over 15 g. ey are hermetically sealed and maintain their aracteristics through long storage periods at gh humidity and temperature.
Pyrofilm Resistor Co., Inc., Dept. ED, U. S. ghway 46, Parsippany, N.J.

CIRCLE 206 ON READER-SERVICE CARD

Circuit Breaker

Miniature

Called the Mite T Breaker, this electrical circuit aker is vacuum sealed in a glass envelope 1-1/8 long and 3/8 in. in diameter. Designed for air-ft controls, computer equipment, business chines, and diversified automatic industrial trol systems, it can be operated at 12 to 115 v h a maximum current of 5 amp. The unit has a metal thermal element which curls when heated, s breaking a circuit. Trip time ranges are 7 to sec at 75 F and 3 sec minimum at 180 F. No-rent trip temperature is a minimum of 200 F. Sylvania Electric Products Inc., Sylvania Light-g Products, Dept. ED, Salem, Mass.

CIRCLE 207 ON READER-SERVICE CARD

on't forget to mail your renewal rm to continue receiving *LECTRONIC DESIGN*.

NEW PRODUCTS

Sequence Timer

Energizes power supply series

Sequence timer model HYS89 is designed energize a series of power supplies in successi so that voltage is developed in a predetermin order. Except for the first, each power supply turned on about 7 sec after the preceding o Reset time is retarded to permit the voltage decay in each part of the circuit in the prop order. The timer has 26 load switches which clo in pairs to provide fail-safe operation and also motor cutoff switch to stop the motor after a to lapsed time of 90 sec. Reset time, controlled b an escapement, is 5 to 10 sec. The unit requir 115 v, 400 cps for the motor and 20 v dc for t clutch. Removing the clutch voltage resets t timer. Hermetically sealed, the unit operates at 5 300 cps vibration and —55 to +85 C temper ture. It is 4-1/2 x 2-1/2 x 8-1/2 in. and weig 60 oz.

Eagle Signal Corp., Dept. ED, Moline, Ill.

CIRCLE 210 ON READER-SERVICE CARD

Transistor Transformer Kit

Has 12 matched units

For breadboarding, this transistor transfor reference kit has 12 precision matched miniatu units covering the normal range of impeda ratios used in transistor circuitry. It also inclu a test socket, a design manual, and Co-Ne shielding foil.

James Vibrapowr Co., Dept. ED, 4050 N. Ro well, Chicago 18, Ill.

CIRCLE 211 ON READER-SERVICE CARD

Transistorized DC Amplifier

Low level

Transistorized dc amplifier model DA-10 operes in extreme flight environments and handles pical low level strain gage and thermocouple puts. It consists of an electronic chopper, a able ac amplifier, a synchronous demodulator, a rrier oscillator, and a voltage regulator. The dc tput signal is proportional to the amplitude of e input voltage. At maximum gain an input sigl range of either 0 to +10 mv or 0 to −10 mv ll produce output signals for full deviation of a ltage-controlled subcarrier oscillator. By adsting gain control, input signals up to 250 mv n be used. The unit measures 2.62 x 1.87 x 3 in. d weighs 11 oz.

United Electrodynamics, Dept. ED, 1200 S. arengo Ave., Pasadena, Calif.

CIRCLE 212 ON READER-SERVICE CARD

AC Tachometer Generator

Provides linear voltage from 1000 to 3000 rpm

Type AYAE reversible shaded-pole motor serves an ac tachometer or rate generator. With rated voltage applied to the main winding, the voltage generated in the shading windings is proportional to the speed at which the rotor is driven. Voltage is nearly linear from 1000 to 3000 rpm, and typical generated voltage is 2 v per 1000 rpm with low impedance shading coils.

Barber-Colman Co., Small Motors Div., Dept. D, Rockford, Ill.

CIRCLE 213 ON READER-SERVICE CARD

NEW PRODUCTS

Self-Balancing Calibrator

Has 0.1% full scale accuracy

This self-balancing calibrator is designed f 0.0 calibration and direct reading of high resoluti d a transducers or sensing devices and for other olu and dc voltage measurements of 10 mv full sc m or above. An automatic, servo driven, null balan ce s type device, it has an internal mercury standa 111 which provides a means of calibration to an ac. T ternal standard. Also, the reference voltage heat adjustable to allow calibration of the instrume e as for direct readout in millivolts. The unit has 0. pply full scale accuracy, 0.05% full scale resolution. a Gen 10 mv minimum full scale input sensitivity. ac dc. It operates from a 110 v, 60 cps power supp and measures 11 x 8 x 9 in.

Moran Instrument Corp., Dept. ED, 170 Orange Grove Blvd., Pasadena, Calif.

CIRCLE 216 ON READER-SERVICE CARD

Printed Circuit Connectors

Have engraved lettering

Molded of Plaskon 8200 nylon, these print circuit connectors are available in any color w engraved lettering for easy assembly and id tification. Called Ezi-Connectors, they have be lium contacts and provide positive contact 1000 or more insertions. The units are moist proof and available in all standard size

Space Products, Dept. ED, 2235 E. Artesia Long Beach 5, Calif.

CIRCLE 217 ON READER-SERVICE CARD

Wheatstone Bridge

Measures resistors with 0.0035% accuracy

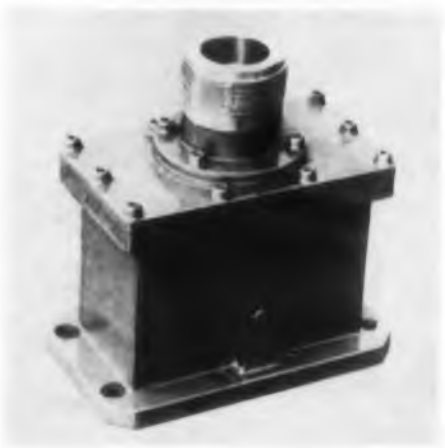
At production speeds, this go, no-go Wheatone bridge permits the measurement of resistors 0.0035% accuracy. It has a sensitivity of 0.0005% d a six-dial decade corresponding to 0.0005% solution. It operates as a go, no-go limit bridge m 100 ohms to 11.111 meg with full scale toler- ce selections from 0.01 to 10%, and from 1 ohm 111.11 meg with full scale selections of 0.1 to %. The unit may also be used as a standard heatstone bridge from ohm to 111 meg. Both associated galvanometer and the dc power pply are provided internally.

General Resistance, Inc., Dept. ED, 577 E. 156th , New York 55, N.Y.

CIRCLE 218 ON READER-SERVICE CARD

Waveguide to Coaxial Adapter

2350 to 3600 mc range



ype 2500 waveguide to coaxial adapter han- s 500 w and has a 2350 to 3600 mc frequency ge. For LT coaxial connectors, it has a 1.2 to 1 r and 0.1 db insertion loss. It meets Mil-E- 2 specifications, measures 4 x 4 x 2.5 in., and ghs 15 oz.

Tamar Electronics, Inc., Dept. ED, 2339 Cotner e., Los Angeles 64, Calif.

CIRCLE 219 ON READER-SERVICE CARD

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NEW PRODUCTS

Low Impedance Comparator

0.001% accurate

Low impedance comparator model B-821 compares impedances in the order of 1 K against a known standard with 0.001% accuracy. It covers ratios between standard and unknown of 0.8 to 1 and 1.2 to 1 in steps of 0.00001. The design is based on a three terminal transformer ratio arm ac bridge circuit, with an external audio frequency source and detector required. The maximum effective impedance, looking back into the bridge is a few milliohms. Measurement frequency can be between 500 cps and 5 kc.

Wayne Kerr Corp., Dept. ED, 2920 N. Fourth St., Philadelphia 33, Pa.

CIRCLE 222 ON READER-SERVICE CARD

Time Delay Relays

Miniature

These time delay relays have an accuracy of ±2% over a range of −65 to +125 C and a voltage variation from 18 to 30 v dc. Dimensions are 1 x 1 x 2 in. for a dpdt unit with up to 60 sec time delay. Reset time is 20 msec. Longer time delays and a variety of contact arrangements are also available. The units withstand 20 g vibration 50 to 2000 cps and 50 g operating or 100 g non-operating shock. They are designed to Mil-R-5757C Class B specifications.

Natel Engineering Co., Dept. ED, 15336 Roscoe Blvd., Van Nuys, Calif.

CIRCLE 223 ON READER-SERVICE CARD

Voltage Measuring Instruments

Go, no-go

Designed for go, no-go voltage measurements, ese two instruments can be programmed by ther analog or digital methods. One unit, a ltage indicator, shows if voltages are within edetermined limits by visual means. The meter s an expanded scale marked in arbitrary units d can be programmed to represent a wide range voltages. Accuracy is 0.25% for dc and 0.5% ac. A variant of this unit is the Voltrip voltage mparator. In this unit, a relay and amplifier are bstituted for the indicating meter; the relay erates when the voltage exceeds set limits. ndard time delay is 75 msec, but delays to 2 c can be had. Trip point accuracy is 0.25% for and 0.5% for ac in military units and 1% in dustrial units. Signal voltage ranges are —500 to 1 v and 1 to 5000 v in dc units and 5 to 5000 v ac units.

Voltron Products, Dept. ED, 1010 Mission St., uth Pasadena, Calif.

CIRCLE 224 ON READER-SERVICE CARD

Temperature Measuring Systems

For —320 to +2000 F

Modular Uni-Temp B and P resistance temperre measuring devices are provided as compots or complete systems and cover —320 to 2000 F. They offer system accuracies to ±0.1 F. Cardinal Instrumentation Corp., Dept. ED, 01 Redwood Ave., Los Angeles 66, Calif.

CIRCLE 225 ON READER-SERVICE CARD

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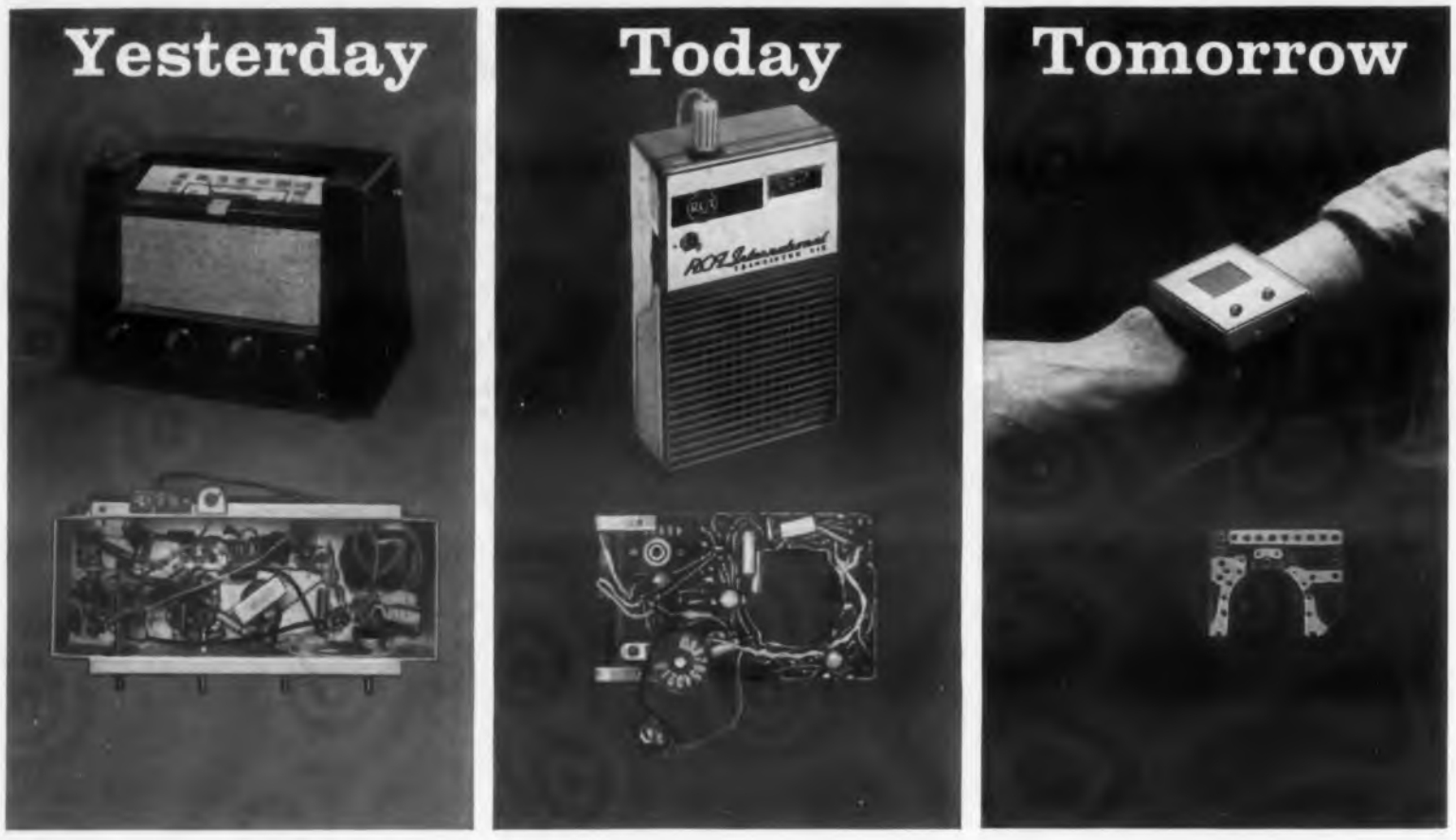
Miniaturization of electronic components highlights need for Synthane plastic laminates



The tremendous increase in miniaturized electronic components emphasizes a need for the combined properties of Synthane laminated plastics.

Miniaturization, as you know, reduces the insulated path between terminals or conductors, placing a premium upon the insulation resistance of the laminate.

Printed Circuitry Adds to Problem

Printed circuitry, the development that made so many miniature circuits possible, also magnifies the insulation resistance problem because there is a temptation to save space by shortening the distance between conductors. And often the insulation resistance requirement is complicated by printing on both sides of the laminated circuit board.

Test for insulation resistance as conducted by Synthane Corporation.

Other Properties Influence Choice of Laminates

There are many other properties of a laminate which help to make miniaturization practical. For example, miniaturization brings the holes for terminals closer together, a result usually accompanied by a reduction in the size of holes. Punchability of the laminate, therefore, becomes an important consideration. Mechanical strength, after punching, is also worth attention.

In addition, climatic conditions greatly affect electronic equipment. Frequently, laminated plastics must retain their excellent characteristics even under the influence of heat, cold and change of humidities.

Choice of a Synthane laminate with good insulation resistance will finally rest upon the atmospheric conditions of the application, mechanical, electrical and chemical properties required, and, to a degree, upon the economics of the situation.

Synthane Laminates for Insulation Resistance

Usually high insulation resistant Synthane laminates for printed circuits are processed with selected core and surface sheets to obtain the proper balance of electrical and moisture resistance values and to provide an excellent bonding surface for the metal foil.

Synthane Grades G-10 and G-11 (glass epoxy grades) are the top plastic laminates for insulation resistance. G-11 is the stronger flexurally at elevated temperatures. Synthane Grades XXXP, XXXP-IR and P-25 have very good insulation resistance, and are easier to machine and cost less than the epoxy grades. Grade P-25 may be cold punched. Where there must be high impact strength as well as good insulation resistance Grade N-1 may be the logical choice.

Applications: Among the high insulation resistance applications of Synthane laminates are wiring cards for computers, printed circuits for television, switch rotors, automation circuits, automobile dashboard wiring.

You are urged to write directly to us or to call in a Synthane representative for help in choosing the proper grade for your application.

SYNTHANE CORPORATION, OAKS, PENNA.
Laminated Plastics for Industry
Sheets, Rods, Tubes, Fabricated Parts Molded-laminated, Molded-macerated

CIRCLE 227 ON READER-SERVICE CARD

NEW PRODUCTS

Transistorized Power Supplies

Continuously variable

These continuously variable, regulated d power supplies have transistorized circuitry, si con diffused junction rectifiers, coarse and fi controls, short circuit protection, and voltage an current metering. Outputs are 1.5 to 50 v, 0 to amp and 1.5 to 32 v, 0 to 3 amp, and typic transient response is 40 mv for 50 μsec. Regul tion is 0.1% for line and 25 mv typical for loa ripple is less than 0.02%; and maximum outp impedance is 0.5 ohm from dc to 5 kc. Input 105 to 125 v, 60 or 400 cps. The unit weighs 15 l

Valor Instruments, Inc., Dept. ED, 13214 Cre shaw Blvd., Gardena, Calif.

CIRCLE 228 ON READER-SERVICE CARD

Shaft Encoder

1.062 in. in diameter

Designed for airborne equipment, the AD11 shaft encoder has a diameter of 1.062 in. and 1.828 in. maximum length. It has a current car ing capacity of 3 ma per brush and a resoluti of 256 per shaft revolution or 1 part in 8192 o the full range. Starting torque is 0.3 oz-in., runn torque, 0.05 oz-in.; continuous shaft speed, rpm; and moment of inertia, 0.04 oz-in.^{2}. The bit unit has a life of over 2 x 10^6 revolutions der temperature, shock, and humidity extrem In operation, analog input to the shaft is c verted to binary numbers through coded d scanned by double pick-off brushes.

Litton Industries, Inc., Components Gr Dept. ED, 336 N. Foothill Rd., Bever Calif.

CIRCLE 229 ON READER-SERVICE CARD

Primary Standard Resistors

Have 0.0015% accuracy

Series NB-1 laboratory standard resistors and ratio sets have an absolute accuracy of 0.0015% and a relative accuracy of 0.0005%. Resistor stability is 0.001% per year; ratio stability, 0.0005%. Temperature coefficient is 5 ppm per deg C standard or 2.5 ppm special for resistors and 2 ppm per deg C standard or 0.5 ppm special for ratios. Self-heating coefficient is 10 ppm per w, and all thermally induced transient effects are less than 0.0005% at rated current. The range of individual resistances is 0.1 ohm to 10 meg, and the ratio range extends to 10^7 to 1, depending on the overall resistance.

Julie Research Labs, Inc., Dept. ED, 556 W. 168th St., New York 32, N.Y.

CIRCLE 230 ON READER-SERVICE CARD

Silicon Rectifiers

50 to 600 piv

Type SR alloy junction silicon rectifiers have values from 50 to 600 piv with 500 ma output. They are 100% tested for forward and reverse static and dynamic characteristics at high temperatures.

Arco Electronics, Inc., Dept. ED, 64 White St., New York 13, N.Y.

CIRCLE 231 ON READER-SERVICE CARD

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TEKTRONIX TYPES 545A, 541A, 535A & 531A

Redesigned for:

EASIER OPERATION

Simplified Panel Layout.

Color-Correlated Controls.

Single-Knob Sweep Time Control.

Simplified Display Control.

Internal Triggering for Sweep Delay.

Single-Knob Calibrator Control.

Improved One-Shot Sweep Operation in Types 535A and 545A.

HIGHER PERFORMANCE

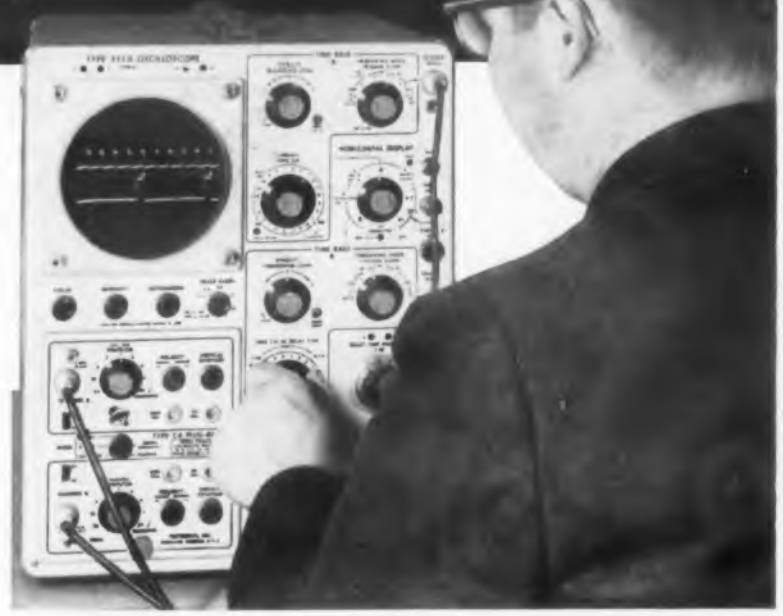
New DC-to-15 MC Vertical Amplifiers in Types 531A and 535A.

New Wider Sweep-Delay Range in Types 535A and 545A.

GREATER RELIABILITY

New Frame-Grid Twin Triodes Replace Older Types.

Silicon Rectifiers Replace Selenium in Power Supplies.



Type 545A
Fast-Rise Oscilloscope
with Sweep Delay

VERTICAL SPECIFICATIONS

DC-to-30 MC passband, 12-mμsec risetime, 50-mv/cm deflection factor with Type K Plug-In Preamplifier.

Many other plug-in units available for specialized applications.

Signal delay permits observation of leading edge of waveform that triggers the sweep.

HORIZONTAL SPECIFICATIONS

Two Time-Base Generators—

Time Base A—0.1 μsec/cm to 5 sec/cm in 24 calibrated steps.

Continuously adjustable from 0.1 μsec/cm to 12 sec/cm.

5x magnifier increases calibrated range to 0.02 μsec/cm.

Single sweep provision for one-shot applications.

Time Base B—Also functions as a sweep delay generator. 2 μsec/cm to 1 sec/cm in 18 calibrated steps.

Sweep Delay—Two modes of operation

Triggered—Delayed sweep started by signal under observation. Steady display, even of signals with inherent jitter.

Conventional—Delayed sweep started by delayed trigger. Time jitter less than one part in 20,000.

Range of Delay—1 μsec to 10 sec in 18 calibrated ranges, each range divisible into 1000 parts by 10-turn control with incremental accuracy of 0.2%.

OTHER CHARACTERISTICS

10-KV Accelerating Potential

Amplitude Calibrator—0.2 mv to 100 v.

Electronically-Regulated Power Supplies

Price—Type 545A, without plug-in units **$1650**

Type 541A Fast-Rise Oscilloscope
Same as Type 545A, except that it does not have Time-Base B or provision for sweep delay or single sweeps.
Price—Type 541A, without plug-in units **$1200**

Type 535A Wide-Band Oscilloscope with Sweep Delay
Same specifications as Type 545A, except for main vertical amplifier. DC-to-15 MC passband, 23-mμsec risetime, 50-mv/cm deflection factor with Type K Plug-In Preamplifier.
Price—Type 535A, without plug-in units **$1400**

Type 531A Wide-Band Oscilloscope
Same as Type 535A except that it does not have Time-Base B or provision for sweep delay or single sweeps.
Price—Type 531A, without plug-in units **$995**

Rack-Mounting Models Also Available

Prices f.o.b. factory

Tektronix, Inc.

P.O. Box 831 • Portland 7, Oregon

Phone CYpress 2-2611 • TWX PD 311 • Cable: TEKTRONIX

TEKTRONIX FIELD OFFICES: Albertson, L.I., N.Y. • Albuquerque • Atlanta, Ga. • Bronxville, N.Y. • Buffalo • Cleveland • Dallas • Dayton • Elmwood Park, Ill. • Endwell, N.Y. • Houston • Lathrup Village, Mich. • East Los Angeles • West Los Angeles • Minneapolis • Mission, Kansas • Newtonville, Mass. • Orlando, Fla. • Palo Alto, Calif. • Philadelphia • Phoenix • San Diego • St. Petersburg, Fla. • Syracuse • Towson, Md. • Union, N.J. • Washington, D.C. • Willowdale, Ont.

TEKTRONIX ENGINEERING REPRESENTATIVES: Hawthorne Electronics, Portland, Oregon; Seattle, Wash.; Hytronic Measurements, Denver, Colo.; Salt Lake City, Utah.

Tektronix is represented in 20 overseas countries by qualified engineering organizations.

CIRCLE 232 ON READER-SERVICE CARD

NEW PRODUCTS

Rotary Joint

Ku-band

This step twist rotary joint provides a mean of transmitting Ku-band microwave energy a high power levels through oscillating trunnion like those used in scanning radar antennas. It ha integral stops that prevent damage to the gea train from excessive angular rotation. Frequenc range is 15.2 to 17.2 kmc; vswr, less than 1.09 to over the Ku band; peak power handling capacity 100 kw; and maximum insertion loss, 0.1 db. Th unit has a 180 deg rotary movement, a 55 to 10 C ambient temperature range, and a 22 in.-o torque. Dimensions are 1-7/8 x 1-7/8 in. an weight is 14 oz for steel models and 7 oz fo aluminum models.

Stavid Engineering, Inc., Dept. ED, Plainfield N.J.

CIRCLE 234 ON READER-SERVICE CARD

Pulse Height Analyzer

400 channel

Using a ferrite core memory system, the 400 channel model 34-9 pulse height analyzer provides rapid, accurate spectrum analysis. The unit has a linearity of better than 0.5%, an average dead time of 120 μsec, and a normal capacity of 65,545 counts per channel. It includes an Auto-Print, memory subgrouping, external programming, and a spectrum transfer circuit. Maximum input counting rate without distortion or shift of data is greater than 5×10^6 counts per min.

Radiation Instrument Development Lab. Inc., Dept. ED, 5737 S. Halsted St., Chicago 21, Ill.

CIRCLE 235 ON READER-SERVICE CARD

CIRCLE 603 ON READER-SERVICE CARD

BACKGROUND OF QUALITY

. . . and the quality *starts* in the foreground!

For when it comes to Roebling Magnet Wire, *quality* means—unsurpassed ingredients of consistent excellence . . . wire-making skill based on decades of experience . . . and exacting testing and inspection.

You pay no more for Roebling Magnet Wire—you get more in terms of satisfying performance. And *you* choose the packaging that will give you utmost efficiency and economy. Write today to Electrical Wire Division, John A. Roebling's Sons Corporation, Trenton 2, New Jersey, for information about types and sizes of Roebling Magnet Wire exactly suited to your applications.

ROEBLING

Branch Offices in Principal Cities
Subsidiary of The Colorado Fuel and Iron Corporation

Waveguide Switch

Covers 8500 to 9600 mc

The model 4438 miniaturized waveguide switch vers the full radar band of 8500 to 9600 mc th greater than 60 db isolation. It has a switch- g time of under 50 msec. Three and four port rsions are available in RG-67/U and RG-68/U aveguide sizes.

Bogart Mfg. Corp., Dept. ED, 315 Seigel St., ooklyn 6, N.Y.

CIRCLE 236 ON READER-SERVICE CARD

AC to DC Converter

Has ±1% regulation

The model 804 converter is an ac to dc system t supplies 56 w of regulated 28 v dc power m a 117 v, 60 or 400 cps source. For airborne d ground support equipment, it can be supplied h germanium elements or with silicon tran- ors for 100 C temperature requirements. It is kaged in a standard Mil-T-17A case and en- sulated to meet Mil-E-5272B requirements. gulation is ±1% for line or load, and ripple is than 0.01 v rms. A 4 pin, solder type header tandard, but the system can also be furnished h hook or eyelet headers.

lectrolog Corp., Dept. ED, 169 N. Halstead St., sadena, Calif.

CIRCLE 237 ON READER-SERVICE CARD

on't miss an issue of *ELECTRONIC ESIGN;* return your renewal card.

NEW PRODUCTS

Digital Ohmmeters

Four and five digit

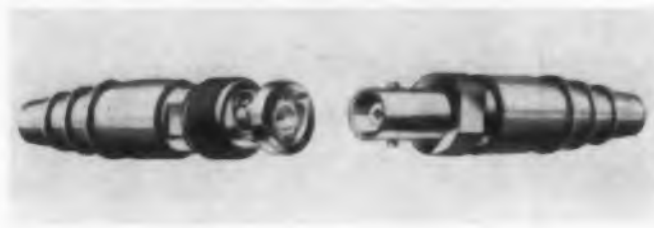
Model O-41 and O-51 four and five digit ohmmeters provide high accuracy on all ranges and have a sensitivity of 100 μv per digit, decreasing to 1 mv per digit. Resistance ranges are 0 to 9.999 meg on the four digit model, 0 to 9.9999 meg on the five. The meters are powered by the company's C-2 control unit.

Cubic Corp., Dept. ED, 5575 Kearny Villa Rd., San Diego 11, Calif.

CIRCLE 240 ON READER-SERVICE CARD

BNC RF Connectors

Permit quick assembly



Partially preassembled into three basic parts, Quick-Crimp BNC rf connectors can be quickly put together. Center contacts are gold plated and feature the company's captivated contact construction. Voltage rating is 500 v peak and vswr is low up to 10 kmc.

Amphenol-Borg Electronics Corp., Amphenol Connector Div., Dept. ED, 1830 S. 54th Ave., Chicago 50, Ill.

CIRCLE 241 ON READER-SERVICE CARD

Miniature Relays

For aircraft and missile use

Miniature series R/S relays are now available with AN type connector mounting arrangements. Suited for aircraft and missiles, these 4pdt, hermetically sealed units operate at 200 C and withstand 50 g shock. Standard contact ratings include 30 v dc and 115 v ac, 2, 5, 7.5, and 10 amp resistive, and 2 and 5 amp inductive. The units are also available in nine other standard mounting arrangements.

The Hart Mfg. Co., Dept. ED, 110 Bartholomew Ave., Hartford 1, Conn.

CIRCLE 242 ON READER-SERVICE CARD

Rack-Panel Plugs

Accommodate up to 75 contacts

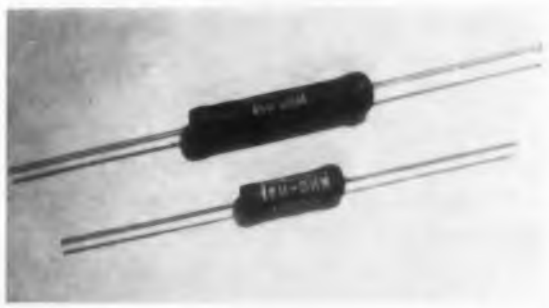
The contact-insulation web of D-Subminiature glass-seal rack-panel plugs offers many arrangements in multiple mountings on single header plates accommodating up to 75 contacts.

Cannon Electric Co., Dept. ED, P.O. Box 3765, Terminal Annex, Los Angeles 54, Calif.

CIRCLE 245 ON READER-SERVICE CARD

Vitreous Enamel Resistors

3, 5, 10, and 20 w types



These fixed, wirewound vitreous enameled resistors are available in 3, 5, 10, and 20 w models. Humidity resistant, they operate continuously at 134 deg maximum at 40 C ambient. They have steatite type cores, 5 and 10% tolerances, and axial leads.

Tru-Ohm Products, Div. of Model Engineering and Mfg., Inc., Dept. ED, 2800 N. Milwaukee Ave., Chicago 18, Ill.

CIRCLE 246 ON READER-SERVICE CARD

Transistorized Oscillator

For telemetry

Voltage-controlled oscillator model AOV-5G is a low cost, fully transistorized unit available for all IRIG channels. For modulation of 5 or greater, the intelligence frequency response is within 0.2 db of the dc response; and response is down less than 1 db at a modulation index of 1. Deviation is ±7.5 or 15% as prescribed in IRIG standards; input voltage is 0 to +5 v according to specification; and supply voltage is 18 v dc ±20% at 10 ma. The unit is about 9 cu in.

Data-Control Systems, Inc., Dept. ED, 39 Rose St., Danbury, Conn.

CIRCLE 247 ON READER-SERVICE CARD

NEW PRODUCTS

Glow Readout Tube

0 to 9 numeral

The NUP102 Inditron is a 0 to 9 numeral glow readout tube with a minimum 150 dc anode voltage, a nominal 2 ma anode current, and a 6 K minimum resistor. Slightly over 1 in. in diameter, it has a seated height of 1-1/16 in. and a numeral height of 5/8 in. It has a standard 13-pin base.

National Union Electric Corp., Dept. ED, Bloomington, Ill.

CIRCLE 250 ON READER-SERVICE CARD

S-Band Filter

Has 300 mc tuning range

For radar system applications, this 12 oz S-band microwave filter has a tuning range in excess of 300 mc. Insertion loss is less than 1.5 db for a 15 mc bandwidth. Input and load vswr's are less than 1.5 to 1 and overall dimensions are 2 x 3 x 1-1/4 in.

ACF Industries, Inc., Avion Div., Dept. ED, 11 Park Place, Paramus, N.J.

CIRCLE 251 ON READER-SERVICE CARD

Resistance Bridge

Finds line and cable faults

Resistance bridge model ZM-U is a Wheatstone bridge designed for determining line or cable faults, their type and approximate location. It can be used for ordinary resistance measurements, picking ungrounded wires, Murray loop tests, simple and multiple Varley loop tests, and Hilborn loop and fault location checks on quadded cable or pairs. Provided in a water-proof metal case, the unit is 5-3/4 x 7-1/4 x 8-3/4 in. and weighs 8 lb.

Industrial Instruments, Inc., Dept. ED, 89 Commerce Rd., Cedar Grove, N.J.

CIRCLE 253 ON READER-SERVICE CARD

RF Power Amplifier

For missiles

Miniature model REL-08 is a high frequency rf power amplifier designed for use in satellites and long range ballistic missiles. One tuning adjustment covers its full 215 to 260 mc frequency range. Power output of 10 to 15 w is achieved with the use of a ceramic power triode with 1.5 to 2 w of drive, and automatic protection is provided against damage resulting from loss of drive. The unit is 3.46 x 2.12 x 1.79 in. and weighs 18 oz.

Rheem Mfg. Co., Defense and Technical Products Div., Dept. ED, 11711 Woodruff Ave., Downey, Calif.

CIRCLE 254 ON READER-SERVICE CARD

NEW PRODUCTS

Magnetic Amplifiers

Several types available

Model SR-4 magnetic amplifier comprises eight different types covering output powers up to 18 w. These units, which may be used for driving servo motors, are designed for 400 cps power and are hermetically sealed. Model SS-4 has a power gain of 300,000 and weighs under 3 lb. It has provisions for external feedback and also operates from a 400 cps source.

Westbury Electronics, Inc., Dept. ED, Westbury, L.I., New York.

CIRCLE 258 ON READER-SERVICE CARD

Decade Counter

Resolves pulses up to 110 kc

Designed to meet extreme environmental conditions, decade counter type DC-130 resolves pulses up to 110 kc, is directly cascadable, and provides 10 individual outputs which can operate remote Nixie indicator tubes and printout devices and perform a variety of decimal functions.

Burroughs Corp., Electronic Tube Div., Dept. ED, P.O. Box 1226, Plainfield, N.J.

CIRCLE 259 ON READER-SERVICE CARD

Power Supply

Provides 0 to 35 v output

Transistor series elements and a tube amplifier are used in model RS 355 power supply. The output voltage range is 0 to 35 v dc and output current is 0 to 5 amp. Load regulation: 10 mv. Line regulation: 10 mv. Power required is 105 to 125 v ac, 60 cps. Recovery time is less than 10 μsec.

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

CIRCLE 260 ON READER-SERVICE CARD

Indicator Tubes

Have 10,000 hr life

Type B-4032 miniature all-electronic Nixie readout is visible at distances up to 20 ft. The super-size tube, type B-6033, is readable up to 75 ft. Both have a minimum life of 10,000 hr. This new tube line of long life readout devices may be interchanged with the standard tube line with only minor circuit modifications.

Burroughs Corporation, Electronic Tube Division, Dept. ED, P. O. Box 1226, Plainfield, N.J.

CIRCLE 262 ON READER-SERVICE CARD

Wideband Oscilloscope

Has 0.06 μsec rise time

The model S31 dc to 6 mc oscilloscope is time calibrated from 1 μsec per cm to 0.5 sec per cm in 18 steps and voltage calibrated from 100 mv per cm to 50 v per cm. It has automatic sync and trigger level selection as well as a built-in sync differentiator and integrator. Rise time is 0.06 μsec with less than 2% overshoot. The unit provides Z modulation and a 1 v, 60 cps square wave for checking calibration. It is portable, weighs 16 lb, and measures 6-1/2 x 8-1/2 x 13-1/2 in.

The Scopes Co., Inc., Dept. ED, P.O. Box 56, Monsey, N.Y.

CIRCLE 263 ON READER-SERVICE CARD

High Frequency Generator

Develops 300 w

At 6000 cps, with shaft speeds up to 60,000 rpm, model D-1309 generator develops 300 w and can be driven by a hot-gas turbine or other suitable means. The unit has low inertia and short circuit protection. It weighs 6.5 oz. and its measurements are 1.5 in. in diameter and 1.67 in. long.

D. & R., Ltd., Dept. ED, 402 E. Gutierrez, P. O. Box 1500, Santa Barbara, Calif.

CIRCLE 264 ON READER-SERVICE CARD

NEW PRODUCTS

Variable Toroids

For panel mounting, printed circuits

Designed for small space and rugged environment applications, Adjustoroids are now available for panel mounting and with knob adjustment to insure easy access wherever slotted controls are difficult to reach. Another stud mounted, encapsulated unit was designed for printed circuit use. Hermetically sealed, they meet MIL-E-15305A.

Burnell & Co., Dept. ED, 10 Pelham Parkway, Pelham, N.Y.

CIRCLE 268 ON READER-SERVICE CARD

Frequency Standards

For ground support equipment

Model TQ 60C low cost frequency standards are designed for military ground support equipment and industrial use. They have a 50 to 100 cps frequency range, ±0.1% accuracy, and a 1000 hr minimum operating life. They provide a square wave output signal of 6.5 ±1 to 8 ±1 peak v into a 100 K load. Power input is 28 ±2 v dc, 1.5 w maximum.

The Gyrex Corp., Dept. ED, 3003 Pennsylvania Ave., Santa Monica, Calif.

CIRCLE 269 ON READER-SERVICE CARD

Message Relay

Receives 60 to 200 words per min

Model 28 RT is a high capacity, self-contained, punched tape message relaying facility for receiving wire signals at speeds ranging from 60 to 200 words per min. It converts these signals into perforations in paper tape and transmits them at the same speed or at a different speed to local or remote receiving stations.

Teletype Corp., Dept. ED, 4100 Fullerton, Chicago 39, Ill.

CIRCLE 270 ON READER-SERVICE CARD

Line Voltage Regulator

For 110 to 220 v lines

This line voltage regulator may be used to regulate either 110 or 220 v lines. With a 115 v ac input, the output is adjustable to give 210 to 220 v ac. Regulation is ±1% at 6 kva with a range of ±15 v correction and 115 v ac input, and ±30 v correction with 230 v ac input. Unit is available in both rack and wall mounting styles.

Electronic Measurements Co., Inc., Dept. ED, Eatontown, N.J.

CIRCLE 272 ON READER-SERVICE CARD

Thermal Switch

Operates at 600 F

This bimetal thermal switch which can be supplied with contacts for either close-on-rise or close-on-fall in temperautre. It can be calibrated at 600 F max or at −20 F min with a possible close temperature tolerance of 2 F. Temperature differential and repeatability for a given switch is about 1 F. An overshoot to 800 F or undershoot to −100 F can be tolerated. Hermetically sealed, it will meet the shocks and vibration requirements of MIL-E-5272A Procedure I.

Control Products, Inc., Dept. ED, 306 Sussex St., Harrison, N.J.

CIRCLE 273 ON READER-SERVICE CARD

Electroluminescent Panels

All-plastic construction

These all-plastic electroluminescent panels provide light intensity in the 100 to 200 v range. Lighter in weight than metal or glass bulbs, the panels may be formed, machined or inscribed after fabrication. Consoles and other contours may be completely fabricated after the bulb is made. These lamps are available in a wide range of shapes, sizes, and colors.

Sierracin Corp., Dept. ED, 903 N. Victory Blvd., Burbank, Calif.

CIRCLE 274 ON READER-SERVICE CARD

NEW PRODUCTS

Differential Transformers

For 115 v service

These linear differential transformers can be excited at 115 v 60 cps. Model 200XS-H LVDT's have low "zero phase" frequency. When excited at this frequency an LVDT has minimum change in sensitivity as a result of temperature and frequency variation. The completely enclosed and magnetically shielded units are designed for nominal excitation frequency range of 50 cps to 5 kc, and ambient temperatures of −65 to +155 F.

Schaevitz Engineering, Dept. ED, Pennsauken, N.J.

CIRCLE 278 ON READER-SERVICE CARD

Microwave Equipment

Operates to 140 kmc

This equipment was designed for generating, detecting and measuring microwave frequencies from 2.6 to 140 kmc. The line includes crystal multipliers, crystal mounts, E-H tuners, cavity wavemeters, standing wave detectors, phase shifters, attenuators, elbows, twists, terminations, standard gain horns, movable shorts, and magic T's.

De Mornay-Bonardi, Dept. ED, 780 S. Arroyo Parkway, Pasadena, Calif.

CIRCLE 279 ON READER-SERVICE CARD

Limiting Amplifier

Has 0.1 μsec recovery time

For radar or missile receiving systems, the IF 90 limiting amplifier has a recovery time of under 0.1 μsec and a dynamic range of more than 120 db for an essentially constant output. It will amplify cw or pulse signals from 0.1 μsec up.

LEL, Inc., Dept. ED, 380 Oak St., Copiague, N.Y.

CIRCLE 280 ON READER-SERVICE CARD

NEW DESIGN CONCEPTS WITH ALUMINUM STRIP

by Robert R. Cope, Aluminum Company of America, Pittsburgh, Pa.

Light weight, better space factor, better heat dissipation, low voltage between turns, less point-to-point contact . . . these characteristics of aluminum strip have long intrigued designers of electrical windings. Today, this aluminum application is a practical reality.

Intensive research and testing by ALCOA have contributed to important technical breakthroughs. New techniques are solving problems relating to edge effect, joining and insulation.

Recently, ALCOA purchased the transformer division of Automation Instruments, Inc., to perfect winding techniques and to produce prototype coils for customers' evaluation. With this added facility, the electrical windings division of ALCOA Research Laboratories is equipped to wind coils from small solenoids up to distribution transformer sizes for testing by manufacturers--an important, new service for the electrical industry.

ALUMINUM'S NATURAL ADVANTAGES

Aluminum weighs less. In general, an aluminum strip winding weighs only half as much as an equivalent winding of copper. Based on equal current-carrying capacity, 0.48 pounds of aluminum replaces one pound of copper. (Figures are for 61.0 per cent conductivity aluminum, 97 per cent conductivity hard-drawn copper.) ALCOA No. 3 EC alloy has been developed expressly for electrical windings. Space factor of aluminum strip can be 90 per cent and higher; for copper wire, 55 per cent to 65 per cent is typical. Thus, although an aluminum strip requires more conductor volume than a conventional wire winding, the total space occupied by each is about the same. Variations in space factor will depend on the strip-to-insulation thickness ratio.

Aluminum strip windings permit higher current densities because each turn has an outside radiating edge that provides effective heat dissipation. Layer-to-layer temperatures are constant; hot spots are virtually eliminated. The inner turns of a wire-wound coil cannot radiate heat as efficiently as the outer turns.

In most cases, aluminum strip windings can be manufactured at lower cost than equivalent wire windings. Aluminum strip lends itself to automation; new high-speed winding techniques have reduced fabrication costs by eliminating much of the hand labor necessary with wire.

Conventional wire windings require heavier insulations to withstand (1) abrasion during winding, (2) abrasion from point-to-point contact between turns, (3) layer-to-layer voltage, which may be many times the turn-to-turn voltage. Aluminum strip insulation needs to withstand only turn-to-turn voltage because a single turn occupies the entire width of the coil. Thus, thinner and less abrasion-resistant insulations can be used, such as interleaved sheets of Mylar or Kraft paper . . . coatings of varnish, lacquer or epoxy . . . anodized films or vitreous enamel.

ALCOA has tested every known method of joining aluminum. Some techniques proved impractical or costly. But successful joining has been accomplished with ultrasonic welding, high temperature soldering, shielded inert arc welding, cold pressure welding, resistance welding and mechanical joining. Cold pressure welding is quite practical; joints have high strength and conductivity. Ultrasonic welding requires no heat, precleaning or flux; joints are made quickly between parts of different thicknesses, or of multiple thicknesses—and the weld can be made through many types of insulation.

Where is the best application for aluminum strip windings? In power devices or electronic equipment, the economics of aluminum strip windings are indicated when customary wire sizes are 24 gage or larger. However, in many aircraft and missile applications, where weight is a critical factor, aluminum strip is a natural application regardless of size.

Here, at a glance, are the main areas of comparison:

PROPERTY	HARD-DRAWN COPPER WIRE	ALUMINUM STRIP No. 3 EC
Weight (lb/cu in.)	0.321	0.098
Specific gravity	8.89	2.70
Coefficient of linear expansion (/°C)	0.000017	0.000023
Thermal conductivity at 20°C $\left(\frac{\text{watts/sq in.}}{\text{in./°C}}\right)$	9.7	6.0
Electrical conductivity at 20°C, per cent IACS	97	61.0
Electrical resistance at 20°C (microhms/sq in./ft)	8.40	13.14
Temperature coefficient of electrical resistance at 20°C (/°C)	0.00381	0.00409
Modulus of elasticity	17×10^6	10×10^6

ALCOA Aluminum Electrical Windings will reduce your costs and improve your product. We'd like to prove it. Send your specifications to us and we will wind sample coils. Then make your own test.

ALUMINUM COMPANY OF AMERICA, 2263-E Alcoa Building, Pittsburgh 19, Pennsylvania.

Interleaving sheet-type insulation with aluminum strip.

Specially designed equipment for winding smaller coils.

Preliminary testing of foil-wound transformer.

Send for Alcoa's new *Conductor Selector Chart*, a convenient slide rule for converting standard wire sizes to equivalent strip conductor.

ALCOA ALUMINUM

Silicon Rectifiers

Rated at 12 amp

Series X12F silicon rectifiers will provide a 12 amp output over a piv range from 50 to 500 v. Ruggedized, welded construction assures high resistance to vibration, shock and temperature extremes. Each unit is gold-plated to provide minimum contact resistance and prevent corrosion. Eyelet construction of the solder lead of these stud-mounted devices insures fast, easy wiring.

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

CIRCLE 282 ON READER-SERVICE CARD

Electronic Switch

Has transistorized circuitry

Model 129A electronic switch performs these functions: gating of pulse bursts; standardizing pulses to Navcor system-Vk pulse; and provides a "one-shot gate" is used to generate an output signal the first time an input is applied, but not thereafter. A control flip-flop and a transistor gate can transmit or inhibit input pulses in accordance with external "Start" and "Stop" signals. The output of this gate is standardized by a flip-flop to prevent any partial "one" outputs.

Navigation Computer Corp., Dept. ED, 1621 Snyder Ave., Philadelphia 45, Pa.

CIRCLE 283 ON READER-SERVICE CARD

General Purpose Relay

Rated at 2 amp

Type FC, two pole, relay has silver contacts riveted to a molded panel. It is rated at 2 amp resistive at 26.5 v dc or 115 v ac. As a spst relay, the unit can operate on as low as 200 mw. As a dpst relay it can operate on up to 2 w. Coils are available for operation up to 115 v dc.

Allied Control Co. Inc., Dept. ED, 2 East End Ave., New York 21, N. Y.

CIRCLE 284 ON READER-SERVICE CARD

for MINIMUM SIZE

...the exceptionally reduced sizes and lightweight of Aerovox metallized-paper capacitors makes them ideal for those applications where space is at a premium.

for MAXIMUM PERFORMANCE

...the unique properties of Aerovox metallized-paper capacitors—ruggedness, reliability, and high safety factor assure you of longer equipment life.

for WIDEST OPERATING TEMPERATURES

...Aerovox metallized-paper capacitors are available in a wide variety of case styles for operation at temperatures ranging from −65°C to +125°C.

Complex electronic equipment such as guided missiles, computers, airborne receivers, transistorized radios and color TV have successfully applied Aerovox metallized-paper capacitors. You are invited to consult with our capacitor specialists for experienced assistance in selecting the right metallized-paper capacitor for your particular needs. Complete detailed information, quotations, delivery schedules, available on written request.

AVAILABLE NOW...

50 VDC METALLIZED — PAPER MINIATURE CAPACITORS

AEROVOX CORPORATION

NEW BEDFORD, MASSACHUSETTS

In Canada: AEROVOX CANADA LTD., Hamilton, Ont.

CIRCLE 286 ON READER-SERVICE CARD

NEW PRODUCTS

Multitester

1000 ohm per v unit

Model TS-55A is a compact 1000 ohm per v multitester with a wide angle meter and 1% precision shunts and resistors. It has ac and dc voltage ranges of 0 to 10, 50, 250, 500, and 1000 v; dc current ranges of 0 to 1 and 500 ma; and a resistance range to 100 K. Ranges are selected with pin jacks on the front of the 3-1/4 x 1-3/8 x 5 in. case.

ALCO Electronics Mfg. Co., Dept. ED, 3 Wolcott Ave., Lawrence, Mass.

CIRCLE 288 ON READER-SERVICE CARD

Yttrium Iron Garnets

In single crystals to 0.4 in.

These single crystal yttrium iron garnets come in all sizes up to 0.4 in. and weigh up to 2 g. Available in limited quantities for research and development, they have a resonance line width of less than 5 oersteds at microwave frequencies. Curie point is 292 C ±1 C. They can be used in parametric amplifiers, as substitutes for microwave ferrite single crystals, and in other microwave applications.

Microwave Chemicals Lab., Inc., Dept. ED, 282 Seventh Ave., New York 1, N.Y.

CIRCLE 289 ON READER-SERVICE CARD

Metal Film Resistors

From ⅛ to 2 w

Rated at 2, 1, 1/2, 1/4, and 1/8 w, the MF type resistors range in sizes from 9/64 x 13/32 in. to 3/8 x 2-1/4 in. Resistance range is from 100 ohms to 4 meg, depending on size. Temperature coefficient is ±50 or ±100 ppm. Operating temperature range is —55 to 150 C. The molded housing provides protection from moisture and salt spray.

Dale Products, Inc., Dept. ED, Box 135, Columbus, Neb.

CIRCLE 290 ON READER-SERVICE CARD

Decimal Scaler

Has 1 μsec resolution

Designed for general radiation counting, the model SC-700 decimal scaler is especially suited to accelerator counting room service. It has seven decades of decimal count storage, a stable feedback input amplifier with 25 mv sensitivity, a precision integral discriminator, and a built-in line frequency test circuit. Resolution is better than 1 μsec. Made from plug-in circuit packages, the unit occupies a panel space 3-1/2 in. high and 19 in. wide. It weighs 16 lb.

Eldorado Electronics, Dept. ED, 2821 10th St., Berkeley 10, Calif.

CIRCLE 294 ON READER-SERVICE CARD

Cathode Ray Tubes

3 to 12 in. models

For military, industrial and commercial use, these cathode ray tubes range from 3 to 12 in. Type 3MP1 is a round glass oscilloscope tube with electrostatic focus and deflection and a P1 phosphor. Types 3KP1, 4, 7, 11, and 16 have various phosphor coatings and use electrostatic focus and deflection. Types 6DP1, 2, 7, 11, 14, 19, and 25 are three gun aluminized tubes that use post deflection acceleration and electrostatic focus and deflection. Types 8CP2, 4, 5, and 11 also use electrostatic deflection and focus and post deflection acceleration. Types 10WP7A, 14, 14A, 19, and 19A are round glass, gray face, radar indicator tubes which use a non-ion trap construction, a high resolution gun, magnetic deflection, and electrostatic focus. Type 12-DP7C is an aluminized radar indicator tube which employs a high resolution gun and magnetic deflection and focus.

Sylvania Electric Products Inc., Sylvania Electronic Tubes, Dept. ED, Seneca Falls, N.Y.

CIRCLE 295 ON READER-SERVICE CARD

NEW PRODUCTS

PROXIMITY CONTROL UNITS.—Used with a proximity pickup, these units provide positive on-off action at the rate of 3600 operations per min to control counting, batching, and transfer machines and afford accurate positioning control. Model 4907-JIC is protected by a rugged enclosure that meets JIC standards, and model 4907-L has long legs that permit mounting on a flat panel.

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

CIRCLE 301 ON READER-SERVICE CARD

FM MONITOR RECEIVER.—Type MR2A amplifies an off-the-air fm signal, using the common type fm-TV receiving antenna, and presents its output to the station fm modulation-frequency monitor, which is then located at the studio. Low impedance output power is over 3 w under normal signal conditions, and input connection is for 75 ohm coaxial cable.

Continental Electronics Mfg. Co., Dept. ED, 4212 S. Buckner Blvd., Dallas, Tex.

CIRCLE 302 ON READER-SERVICE CARD

VACUUM GAGE.—The Magnevac constant temperature gage has good sensitivity in two ranges: 1 to 100 microns, and 1 micron to 500 mm. Available with one to four stations, it is suited for measuring pressures in impregnation, transistors, and hermetically sealed relays.

Consolidated Electrodynamics Corp., Rochester Div., Dept. ED, 1775 Mt. Read Blvd., Rochester 3, N.Y.

CIRCLE 303 ON READER-SERVICE CARD

TOROIDAL INDUCTORS.—Small and light, series 785 inductors provide inductance from 1 mh to 7 h with a useful frequency range of 1 to 100 kc. The high Q units meet MIL-E-5272A and MIL-T-27A specifications and may be used for printed circuits or stacked on a single screw for chassis mounting.

Arnold Magnetics Corp., Dept. ED, 4613 W. Jefferson Blvd., Los Angeles 16, Calif.

CIRCLE 304 ON READER-SERVICE CARD

GEAR DRIVEN SWITCH.—Prewired for easy assembly into customer equipment, this unit has 72 positions and 20 poles. In a rugged aluminum frame, it is available in phenolic and glass epoxy deck materials with nickel or coin silver contacts.

Aerovox Corp., Cinema Engineering Div., Dept. ED, 1100 Chestnut St., Burbank, Calif.

CIRCLE 305 ON READER-SERVICE CARD

ELECTRONIC SURFACE THERMOMETER.—This Thermophil thermometer measures temperature down to −328 F with standard accuracy of ±0.25 F. Response time in liquids is 0.72 sec, on surfaces, 2.2 sec. The portable 7 x 5 x 2-1/4 in. unit is operated by standard batteries and can also be furnished for use on ac voltage lines.

Atkins Technical, Inc., Dept. ED, 709 Marion Bldg., Cleveland 13, Ohio.

CIRCLE 306 ON READER-SERVICE CARD

PORTABLE WIRE AND CABLE MARKER.—Electrically controlled tool 8-1/2 in. long that rapidly imprints identification on wire and cable. A detachable bracket adapts it for bench mounting. Marks all wire diameters from 26 through 4.

Ackermann-Gould Co., Dept. ED, 92-96 Bleecker St., New York 12, N.Y.

CIRCLE 309 ON READER-SERVICE CARD

DRAWING INSTRUMENT.—The Proco-Rule is a five-in-one drawing tool that does all the jobs of the protractor, compass, ruler, parallels, and angles. The device is 6 x 2 in. and has a set of gripping wheels which permit it to roll and still hold exact alignment.

Smith-Drake Corp., Dept. ED, 1206 S. La Brea, Inglewood, Calif.

CIRCLE 310 ON READER-SERVICE CARD

MESH SCREENS.—Standard size stainless steel mesh screens with 5 x 5 in. internal dimension, 200 x 200 mesh with a 0.002 in. wire diameter, and 0.003 in. aperture size. Designed to lay down any conductive pattern to the requirements of A.S.T.M. specification D-257.

Rowe Engravers, Dept. ED, Lyon at E. 16th St., Paterson 4, N.J.

CIRCLE 311 ON READER-SERVICE CARD

COMMUNICATION UNIT.—Model M permits point of work communication in checking and aligning facilities. Two units and any existing conductors allow communication to another location. Can be heard 20 to 30 ft.

Stewart Brothers, Div. of Instrument Labs., Dept. ED, 315 W. Walton Place, Chicago 10, Ill.

CIRCLE 312 ON READER-SERVICE CARD

THERMOSTAT.—The Dual Microtrol hydraulic bulb type thermostat provides setting of two preselected temperatures for quick duplication. It may also be used for safety control or for programming at low cost. Response sensitivity is ±1 deg F. Ranges of 50 to 220 and 100 to 550 F are available for 115 or 230 v.

Blue M Electric Co., Dept. ED, 138th and Chatham St., Blue Island, Ill.

CIRCLE 313 ON READER-SERVICE CARD

DC ACCELEROMETERS.—Combining a solid-state carrier oscillator and ring demodulator with a variable-reluctance pickup, these units use dc excitation and provide 0 to 5 v dc output. They are suited for missile testing and for use in airborne and ground based data systems.

Wiancko Engineering Co., Dept. ED, 255 N. Halstead, Pasadena, Calif.

CIRCLE 314 ON READER-SERVICE CARD

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

NEW PRODUCTS

INJECTON MOLDING AND EXTRUSION PLASTIC.—A transparent acrylic-type thermoplastic polymer, PL-11 has a heat distortion temperature of 250 F. Available in limited quantities for market evaluation.

J. T. Baker Chemical Co., Dept. ED, Phillipsburg, N.J.

CIRCLE 317 ON READER-SERVICE CARD

FORCED AIR COOLED TETRODE.—For high vhf TV service, type 7007 can be used in broadcast transmitters with two to 12 tubes of this type per unit. The anode is rated for 10 kw dissipation with an air flow of 350 cfm.

Sylvania Electric Products Inc., Sylvania Electronic Tubes, Dept. ED, Seneca Falls, N.Y.

CIRCLE 318 ON READER-SERVICE CARD

TRANSISTOR HEAT RADIATOR.—Model 3AL-672 offers an inexpensive method of cooling diamond shape transistors as much as 30 C under typical operating conditions. The one piece aluminum unit provides 12 sq in. of radiating surface and is especially suited for cooling transistors when they are used above ground potential and heat cannot escape into the chassis.

The Birtcher Corp., Dept. ED, 4371 Valley Blvd., Los Angeles 32, Calif.

CIRCLE 319 ON READER-SERVICE CARD

PRECISION GEAR BOX.—For use in servo and instrument equipments, this unit provides a choice of gear reductions from 1 to 1 to 3125 to 1. Unit may be assembled in an almost unlimited number of gearing configurations from stocked shafts, gears, antibacklash gears, and slip clutches.

Precision Mechanisms Corp., Dept. ED, 577 Newbridge Ave., East Meadow, N.Y.

CIRCLE 320 ON READER-SERVICE CARD

POLYSTER RESINS.—Type 10 and 14 Hetrofoams can produce rigid polyurethane foams with permanent high level fire resistance, high temperature strength, dimensional stability, low thermal conductivity, good adhesion, low moisture permeability, and outstanding permanence. The foams may be used for potting on encapsulating electrical parts.

Hooker Chemical Corp., Dept. ED, Box 344, Niagara Falls, N.Y.

CIRCLE 321 ON READER-SERVICE CARD

RADIANT ENERGY HEATER.—Provides a low cost source of high temperatures for X-ray diffraction, hot stage microscopy, permeability studies, and zone refining. Also for specimen heating during mechanical testing, it can locally heat a specimen to 900 C. No electrical or mechanical interaction may occur with either the specimen or surroundings.

Materials Research Corp., Dept. ED, 47 Buena Vista Ave., Yonkers, N.Y.

CIRCLE 322 ON READER-SERVICE CARD

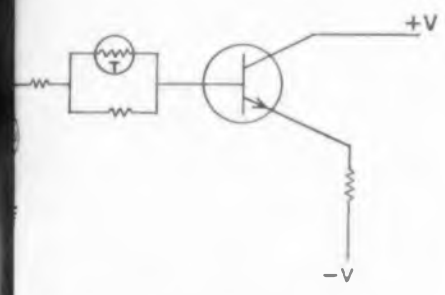
Using Thermistors

Edited by
FENWAL ELECTRONICS

—

COMPENSATING TRANSISTOR NETWORKS

It is relatively simple to extend the erating temperature range of a nsistor, or to stabilize its output der temperature fluctuations. A rallel network, consisting of a ther- stor and a fixed resistor, is inserted series with the base. Since thermis- resistance increases with lower mperature, the network automati- ly reduces the input signal to com- sate for increased transistor gain. sign-wise, the tiny thermistor in- s no size or weight penalties.



Three typical Fenwal Electronics rmistors being used for the above plication are: WB11W1 (washer); 21J1 (disc); 6B32J2 (bead). In ad- ion, hundreds of other types are ailable to cover a wide range of cir- requirements. All have precisely roduceable characteristics and ex- mely high stability, whether in s of 10 or 10,000 . . . the result of modern processing and quality trol methods under which they made. Write for Catalog EMC-2. for thermistor engineering as- tance — just ask. FENWAL ELEC- ONICS, INC., 34 Mellen Street, ramingham, Mass.

Choosing the "right" thermistor is ier using the G200 Experimental which contains 12 different ther- tors, each with complete operating aracteristics. Available from nwal Electronics Distributors or Framingham plant, $19.95 net.

Fenwal Electronics

Making Precision Thermistors
Make Your Design Ideas Come True

CIRCLE 324 ON READER-SERVICE CARD

PUSHBUTTON ACTUATOR.—Series 12MA includes 1/2 and 1 in. button sizes for use with a variety of basic switches. Both sizes fit panels from 0.06 to 0.312 in. thick and come in several colors.

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

CIRCLE 325 ON READER-SERVICE CARD

INDICATING CIRCUIT BREAKER.—The Klixon model 8150 has ratings at intervals from 5 to 25 amp and is designed for remote, overcurrent protection of 110 v ac motors through 1/2 hp. It has an indicating band for locating tripped circuits. It can be used for rectifier and cable protection on control equipment; for wire protection of mobile equipment; and for component protection in units such as battery chargers.

Metals & Controls Corp., Dept. ED, Attleboro, Mass.

CIRCLE 326 ON READER-SERVICE CARD

PRECISION V-O-M.—This improved model 120 has a chromed mirrored scale plate to eliminate parallax; a dc polarity reversing switch which increases the number of ranges to 59; and an ac frequency response that is flat from 15 cps to 100 kc, ±1 db.

Precision Apparatus Co., Inc., Dept. ED, 70-31 84th St., Glendale 27, N.Y.

CIRCLE 327 ON READER-SERVICE CARD

SPLICING KIT.—For making overlapping or butt splices on damaged or broken programming tape, kit model A4809 includes a splicing block; a supply of prepunched, pressure sensitive tape; and a tube of cement.

Unicorn Engineering Corp., Dept. ED, 1040 N. McCadden Place, Hollywood 38, Calif.

CIRCLE 328 ON READER-SERVICE CARD

PORTABLE SPECTROMETER.—Model 50-8 may be used for alpha, beta, gamma, or neutron detection by a direct interchange of detecting crystals. Dimensions are 17 x 5 x 12 in.; weight, 14 lb.

Radiation Instrument Development Lab., Inc., Dept ED, 5737 S. Halsted St., Chicago 21, Ill.

CIRCLE 329 ON READER-SRVIECE CARD

MINIMUM SPACE MOUNTING.—For missile telemetry units, type 1405 Mini-Mount is a prewired, welded T-shape which is designed to accept the company's 1213A subcarrier oscillators and 1106A wideband amplifiers.

Tele-Dynamics Inc., Dept. ED, 5000 Parkside Ave., Philadelphia 31, Pa.

CIRCLE 330 ON READER-SERVICE CARD

POCKET SIZE WIRE STRIPPER.—Model T-6 strips, loops, and cuts wire, has six individual stripping holes for 16 through 26 gage. Especially designed for fast stripping of smaller gage wires in electronic instruments and appliance hookups.

Ideal Industries, Inc., Dept. ED, 5098 Park Ave., Sycamore, Ill.

CIRCLE 331 ON READER-SERVICE CARD

NEW PRODUCTS

TANTALUM CAPACITORS.—Two ratings, 35 μf at 12 v dc and 50 μf at 4 v dc have been added to the polarized miniature TNT line.

P. R. Mallory & Co. Inc., Dept. ED, 3029 E. Washington St., Indianapolis 6, Ind.

CIRCLE 334 ON READER-SERVICE CARD

WATER-COOLED SOLENOIDS.—These units produce high intensity magnetic fields and are espepecially designed to develop 140,000 amp-turns and dissipate 50 kw of dc power.

Nothelfer Winding Labs, Inc., Dept. ED, P.O. Box 455, Trenton, N.J.

CIRCLE 335 ON READER-SERVICE CARD

REMOTE AUTOMATIC POSITIONER.—Low cost and accurate, the D-52 Dialtrol is designed to control valves, variable displacement pumps, machine tools, or variable speed drives.

The Jordan Co., Inc., Dept. ED, 3235 W. Hampton Ave., Milwaukee 9, Wis.

CIRCLE 336 ON READER-SERVICE CARD

PRECISION POTENTIOMETERS.—Single turn Dynamic Balance potentiometers now have a unitized contact arm that permits reliable performance at 225 C. The unit has a 5 million cycle life, 2000 cycle life at 30 g rotational speeds to 3500 rpm, and linear or functional windings with 0.2% standard linearity.

Kintronic, Div. of Chicago Aerial Industries, Dept. ED, 10134 Pacific Ave., Franklin Park, Ill.

CIRCLE 337 ON READER-SERVICE CARD

SLIP RINGS.—These coin gold rings have stainless steel backshafts. The AC258 line, one to ten rings, has an OD of 0.081; the AC263, 1 to 37 rings, has an OD of 0.22. Companion brush blocks are available for both.

Poly-Scientific Corp., Dept. ED, Blacksburg, Va.

CIRCLE 338 ON READER-SERVICE CARD

SHIPPING CONTAINERS.—Reusable Kennett cases are available in standard padded, dunnage board, and shock cradle types.

National Vulcanized Fibre Co., Dept. ED, 1059 Beech St., Wilmington, Del.

CIRCLE 339 ON READER-SERVICE CARD

FLOW CONTROL SERVOVALVES.—Series 71 valves, designed for industrial hydraulic control systems, are available in 1, 2.5, 5, and 10 gpm sizes with 1000 psi valve drop and 20 ma input. System pressures from 500 to 4500 psi may be used.

Moog Valve Co., Inc., Dept. ED, East Aurora, N.Y.

CIRCLE 340 ON READER-SERVICE CARD

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

PHOTOELECTRIC EQUIPMENT.—The MEK-5590-AA miniature side view, and MEK-5585-AA miniature and view phototube holders are designed for use with the company's MEK-5500 series photoelectric relays.

Machinery Electrification, Inc., Dept. ED, 56 Hudson St., Northboro, Mass.

CIRCLE 343 ON READER-SERVICE CARD

TOGGLE SWITCHES.—Available in spst, spdt, dpst, and dpdt types with either screw or solder lug terminals, these units pass MIL-S-3950A specifications. Dimensions are 1-1/8 x 5/8 x 1-3/64 in. for single pole, slightly larger for double pole units.

Kulka Electric Corp., Dept. ED, 633-643 S. Fulton Ave., Mount Vernon, N.Y.

CIRCLE 344 ON READER-SERVICE CARD

SMALL ANALOG COMPUTER.—Designed for classrooms and industrial laboratories, the precision model 500 Collegiate is moderately priced and small enough to be rolled about. All components have their own front panels and are not permanently associated with one another.

Electro Precision Corp., Dept. ED, Arkadelphia, Ark.

CIRCLE 345 ON READER-SERVICE CARD

MINIATURE CONNECTOR TERMINAL BLOCKS. These units use solderless taper pin connections. They are designed to Mil-M-14E specifications.

Excellex Electronics, Inc., Dept. ED, 335 Van Siclen Ave., Brooklyn 7, N. Y.

CIRCLE 346 ON READER-SERVICE CARD

COOLING UNIT.—Designed to tool electronic gear in air-transportable shelters, model A-9 has a cooling capacity of 9000 BTU per hr.

Ellis and Watts Products, Inc., Dept. ED, Box 33 Z, Cincinnati 36, Ohio.

CIRCLE 347 ON READER-SERVICE CARD

OSCILLATOR-AMPLIFIERS.—Series 690 units provide an ac power source of frequency and sufficient power to drive motors that consume up to 80 va at 117 v. They can be supplied to cover any one frequency betwen 45 and 1800 cps or several frequencies in this range.

Fairchild Recording Equipment Corp., Dept. ED, 10-40 45th Ave., Long Island City 1, N. Y.

CIRCLE 348 ON READER-SERVICE CARD

MULTICHANNEL PULSE HEIGHT ANALYZER.—Model 4100 has a double pulse resolution of 0.5 μsec and a fixed dead time of 0.1 μsec. It accepts 10^5 counts per sec without baseline distortion or use of temporary storage. Channel width is 1 v; scaler capacity, 10^6 counts per channel; window amplifier input, 20 v; window position range, 5 to 105 v. Unit has 20 channels.

Eldorado Electronics, Dept. ED, 2821 Tenth St., Berkeley 10, Calif.

CIRCLE 349 ON READER-SERVICE CARD

DRAFTING TRENDS

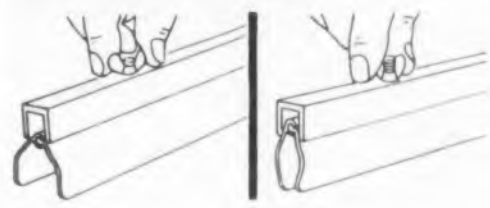
This Rolling Stand is one of many new Plan Hold units recently developed to make vertical filing more efficient.

New efficiency in vertical filing equipment

Vertical filing is a real space-saver, but home-made or "Rube Goldberg" systems have always created problems. Holes must be punched or drilled in blueprints and maps. Unsightly supports and devices must be built to hold groups of drawings and plans. None of these methods have ever been entirely satisfactory.

Now, with any one of the dozen modern Plan Hold Vertical Filing units, these problems can be eliminated.

Spring-actuated binder holds up to 100 sheets



The keystone of all Plan Hold units is the individual binder. It holds one to 100 prints safely and securely. The spring-actuated clamp is controlled by wing nuts to open and close the binder. The sheets hang wrinkle-free without curling. Binders are available for all popular sheet sizes.

Space-saving units provide maximum flexibility

The trend toward vertical filing is growing rapidly because of the flexibility offered. Plan Hold units can be installed anywhere . . . on the wall, at a table, in cabinets, closets, vaults or in rollaway units. Even hard-to-file items can be accommodated in special vertical pocket files.

The range of Plan Hold units that can handle various vertical filing situations includes space-saving wall racks, carousel-type units, rolling stands, swing-away racks and complete cabinets. They protect drawings, eliminate folding, rolling and stacking. And they provide an orderly, efficient system to accommodate and identify all large drawings.

For a complete 16 page catalog showing the full range of Plan Hold vertical filing equipment, write Frederick Post Company, 3662 N. Avondale, Chicago, Illinois.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

CIRCLE 350 ON READER-SERVICE CARD

PRODUCTION PRODUCTS

Footage Numbering Machine

For trench wire or cable

This combination marking and numberi machine meets REA requirements for consec tive footage marking and numbering on tren wire and cable. It consists of two separate uni one for marking and the other for controlled dri ing and measuring. The marking head is a rotati member with a barrel type automatic numberi head and an interchangeable die holder mount at 180 degrees to each other. The numberi head advances consecutively and numbers eve 2 feet. Major moving parts of the numberi head and tripping mechanism are heat treat and permanently lubricated to prevent corrosio galling, seizing, and wear under operating te peratures up to 600 F. The unit marks 1/8 t 3 in. diameter cables with 1/8 in. characters a rate of 300 ft per min. The driving and measu ing unit has a driving accuracy of better th 0.5%.

The Acromark Co., 411 Morrell St., Elizabet N.J.

CIRCLE 352 ON READER-SERVICE CARD

Drilling, Milling, and Feed Unit

Drills to 1-1/2 in. diameter

The Luft Line is a drilling and milling pne matic power and feed unit that drills to 1-1/2 i diameter and also reams, taps, bores, and faces. incorporates the company's AM 12 or AM 48 a motors, their DMH-15 or DMH-30 drilling a milling heads, and their ASF 260 feed un Through a gear reduction, the feed unit provid thrusts to 2400 lb. It can be started mechanicall or by remote control. The Luft Line provide range of speed and torque from 30,000 rpm 12 lb. to 200 rpm/1440 in.-lb. The power and fe units are available separately.

Automation Tools Inc., Dept. ED, P.O. B 331, La Jolla, Calif.

CIRCLE 353 ON READER-SERVICE CARD

Production Welder

For high temperature reactive metals

The model B-1520 Beamatron high vacuum induction welder uses a focused beam of high velocity electrons to weld the high temperature reactive metals and superalloys used in nuclear, electronic, and missile hardware. It handles parts of tubing with diameters to 3-1/8 in. and lengths to 10 ft and welds metals ranging from aluminum to zirconium, including tungsten, tantalum, and molybdenum.

High Vacuum Equipment Corp., Dept. ED, 2 Churchill Rd., Hingham, Mass.

CIRCLE 354 ON READER-SERVICE CARD

Component Lead Former

Processes 8000 units an hour

The Mark V pneumatic machine automatically and semiautomatically cuts component leads to length and forms the legs for assembly. It handles fragile diodes or large capacitors and processes up to 8000 units an hour.

Technical Devices Co., Dept. ED, 2340 Centinela Ave., Los Angeles 64, Calif.

CIRCLE 355 ON READER-SERVICE CARD

PRODUCTION PRODUCTS

Parts Cleaner

Handles 600 units an hour

Precision parts cleaner model RT-S-8-6 critically spray cleans sensitive switches, relays, choppers, semiconductors, and other components and assemblies at the rate of 600 units an hour. It safely removes soluble and insoluble contaminants without depositing films or residue.

Cobehn, Inc., Dept. ED, Caldwell, N.J.

CIRCLE 358 ON READER-SERVICE CARD

Spaghetti Tube Marker

Bench model

The model 1002 bench mounted machine marks PVC and other types of spaghetti tubing from size 12 up to 1/2 in. in diameter. In operation, the tubing is pulled through a guide which assures proper placement and is cut off manually. The machine cycles 100 times per min and imprints up to 22 characters or a 2-7/16 in. maximum length. It is air operated and requires 40 psi pressure.

Markem Machine Co., Dept. ED, Keene 75, N.H.

CIRCLE 359 ON READER-SERVICE CARD

Marking Machine

All pneumatic

An all pneumatic bench unit, the model 509 marking machine imprints round, flat, or irregular pieces with permanently indented inscriptions. Depth of the mark is controlled by preset air pressure. Vertical air stroke is 1/2 in.; die slide stroke, 3-1/2 in.

Noble & Westbrook Mfg. Co., Dept. ED, Westbrook St., East Hartford 8, Conn.

CIRCLE 360 ON READER-SERVICE CARD

Have you sent us your subscription renewal form?

Printed Circuit Etcher

Processes two sides at once

This high speed pump spray etcher uses ferric chloride or chromic acid to etch both sides simultaneously on boards up to 16 x 22 in. The transparent unit has a 25 gal capacity and measures 48 x 25 x 36 in. It operates from 115 v ac, 60 cps at 15 amp.

Centre Circuits, Inc., Dept. ED, P. O. Box 165, State College, Pa.

CIRCLE 363 ON READER-SERVICE CARD

Automatic Marking Machines

High speed

These automatic, high speed marking machines use the electrolytic marking process and are specially engineered to suit the part to be marked and its production requirements. Three marking methods are available: plating, etching, and ac or oxide mark. Any type of lettering or line drawing can be permanently marked on any conductive material.

The Electromark Corp., Dept. ED, 2093 E. 19th St., Cleveland 15, Ohio.

CIRCLE 364 ON READER-SERVICE CARD

Terminal Attaching Machine

Automatic

A machine for the automatic attachment of individual insulated electric terminals to wires, the Vibra-Stake installs three of the company's Sta-Kon terminal series covering AWG wire sizes 22 to 18, 16 to 14, and 12 to 10. The unit also permits single stroke operation controlled by a foot switch. It is 15-1/2 x 23-1/4 x 21-1/4 in.

The Thomas & Betts Co., Dept. ED, 36 Butler St., Elizabeth, N.J.

CIRCLE 365 ON READER-SERVICE CARD

SERVICES FOR DESIGNERS

Vibration Engineering Consultants

Former executive engineers of MB Manufacturing Company have announced the formation of a new organization which offers professional engineering services on vibration problems. The new firm is set up to provide professional services on an advisory, training or task basis, covering the full scope of vibration problems including fatigue, shock and shake testing, design to withstand dynamic loads, suspension systems, noise control, and equipment and controls associated with dynamic testing. The Unholtz-Dickie Corporation has been organized to provide practical, economical solutions to vibration problems, whether they are in existing products or in early development stages of new products, in the words of the president.

Presently engaged in work for the Department of Defense, the firm has begun the preparation of a series of "Vibration Testing Topics", which cumulatively are intended to provide a basic manual on the art and science of dynamic testing. First of the series is the "Vibrating Testing Primer" which will be available to industry and the military services without charge.

Unholtz-Dickie Corporation, Dept. ED, 2544 State St., Hamden 17, Conn.

CIRCLE 368 ON READER-SEVICER CARD

New Process Gives Longer Life

Electronic potentiometers are destined for longer life when potentiometer mandrels are made of aluminum and hard coated by the Hardas Process, which provides the use of a combination of favorable characteristics such as: dielectric strength, thermal-conductance, high megohm resistance and a fine surface finish. This new application of the Hardas Process was developed by Anachrome Corp. of South Gate, Calif. affiliate company of Anacite, Inc., as a result of developing a new process for insulating circuitry chassis for dielectric strength and heat conductance. Transistors can now be mounted directly to the chassis thus eliminating the use of silicon oil and mica washers. The Hardas Process is the only hard coating that can be applied to all aluminum alloys. Dielectric tests at 500 v have indicated a resistance of several thousand megohms which is many times more than adequate for existing or proposed power circuitry. This new development in the field of potentiometer mandrels increases reliability because it gives assurance of no breakdown due to non-heat conductance.

Anadite Inc., Dept. ED, 10630 Sessler St., South Gate, Calif.

CIRCLE 369 ON READER-SERVICE CARD

HOW TO USE REGOHM

the plug-in device that regulates input voltage down to ±0.05%

Wherever system performance requires precision regulation of input voltage, REGOHM earns a place. And wherever circuitry includes vacuum tubes, REGOHM will substantially extend tube life. The REGOHM is a voltage regulator of great sensitivity and stability, providing stepless continuous control over a wide frequency range. Light in weight, low in cost, its applications are almost unlimited. Here are typical applications:

- **General Electric Co.—for Halogen Leak Detectors**
- **Empire Devices Products Corp.—for Noise & Field Intensity Meters**
- **Consolidated Electrodynamics—for Diatron Mass Spectrometers**
- **Stoddard Aircraft Radio—for Power Supplies**
- **Hevi-Duty Electric Company—for Airport Lighting Brightness Control**

How you may use REGOHM in your own applications will become clear to you from design data, performance specs and case histories, available to you on request.

REGOHM®

ELECTRIC REGULATOR CORPORATION
NORWALK CONNECTICUT

CIRCLE 371 ON READER-SERVICE CARD

Environmental Test Package

Propulsion Test Facilities, Inc., an affiliate of MB Manufacturing Company, is a new company that offers complete environmental test facilities to meet the need for improved aircraft and missile reliability. According to the president of the company, the firm is "systems oriented" with engineering, design, production, and construction capabilities to create complete "packaged" environmental test facilities for customers in the aircraft and missile industries. The facilities will simulate accurately all the stresses which effect ultra-high speed aircraft and space vehicles in service. The close coordination between Textron's MB Manufacturing Company division and PTF will afford users of environmental and performance test equipment, a single-responsibility source.

Propulsion Test Facilities, Inc., Dept. ED, 781 Whalley Avenue, New Haven 8, Conn.

CIRCLE 372 ON READER-SERVICE CARD

Service on Gear Trains and Servomechanisms

Dynamic Gear Company has now made available an engineering service on gear trains and servomechanisms which can now be extended to final, complete drawings or even fabrication. As a result of customer demand, the company has extended the engineering service to take the customer's spec sheets and work them into a complete set of finalized drawings, or if the customer desires, do complete fabrication. The company is known for their stock, precision Dynaco line. Dynaco gears are presently being utilized in the manufacture of guided missiles and their guidance systems.

Dynamic Gear Company, Inc., Dept. ED, 20 Merrick Road, Amityville, L.I., N.Y. Thomas J. Smith, Sales Manager.

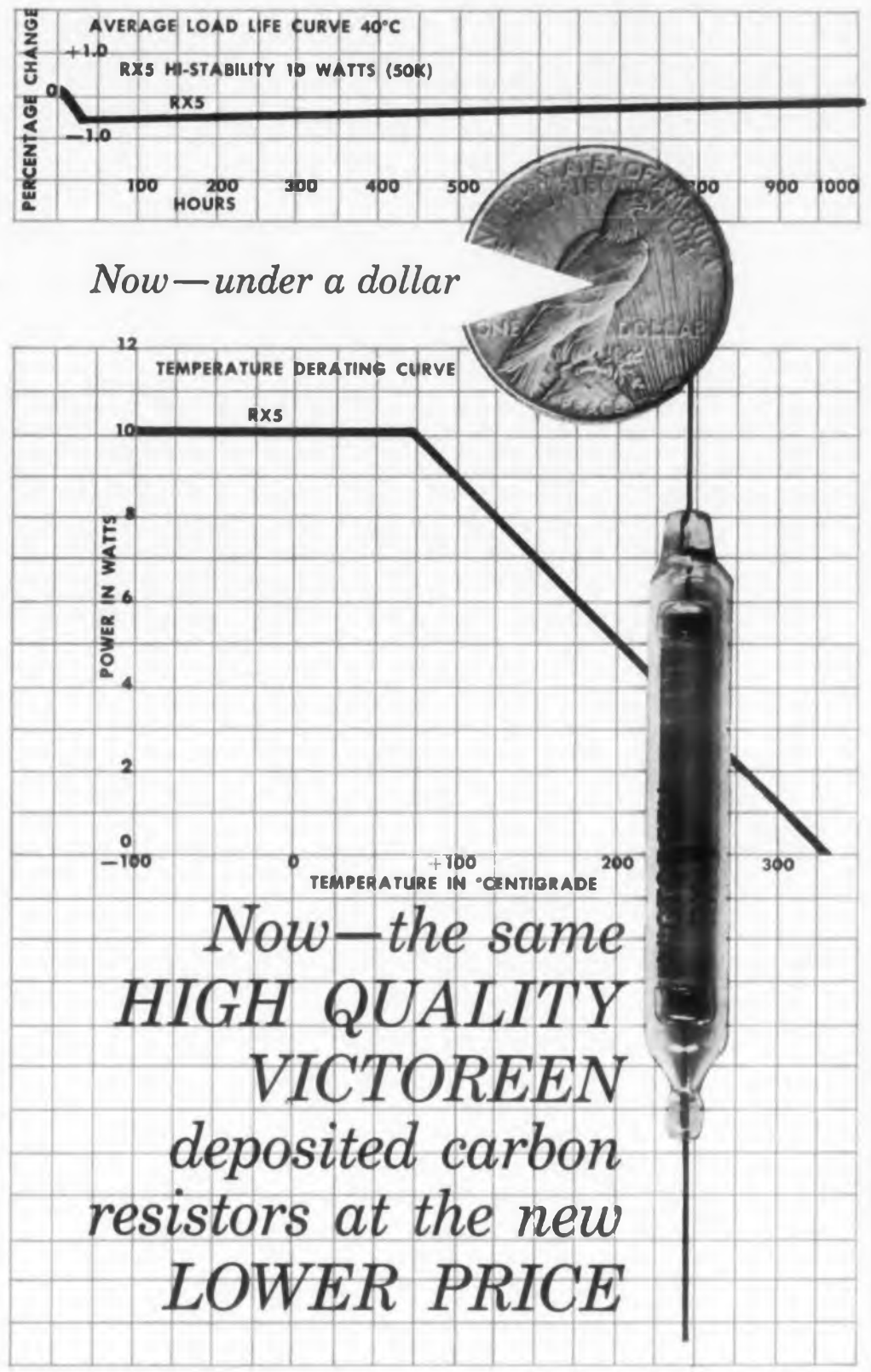
CIRCLE 373 ON READER-SERVICE CARD

Testing for Reliability

A new environmental temperature altitude chamber capable of simulating altitudes up to 200,000 feet has been especially designed to test components that will go into the manufacture of space vehicles and missiles. The chamber will be used in connection with an overall reliability program instituted by government agencies to bring performance of components used in space aircraft, missiles and rockets up to 100% efficiency under any possible conditions. The Lab will screen all subcontractors and suppliers of strategic materials to insure reliability of the entire unit.

New York Testing Laboratories, Inc., Dept. ED, 47 West Street, New York, N.Y.

CIRCLE 374 ON READER-SERVICE CARD



Victoreen Glass-Sealed Resistors have always been synonymous with the highest product quality. You get high power with high stability . . . absolute independence from unfavorable environments . . . closer production and inspection tolerances.

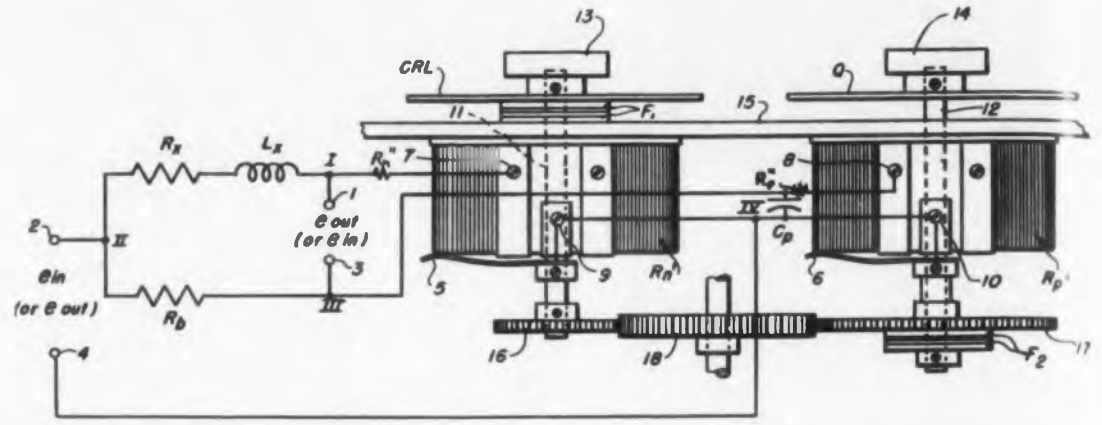
And now—because of new quality-volume production techniques—Victoreen can offer these superb components at highly competitive prices. New pricing structure, with large quantity discounts, brings prices down below a dollar. The trend is to Victoreen Deposited Carbon Resistors—get with it *now*.

Victoreen

5806 Hough Avenue • Cleveland 3, Ohio

CIRCLE 375 ON READER-SERVICE CARD

PATENTS



Electrical Bridge and Method

Patent No. 2,872,639. Henry P. Hall. (Assigned to General Radio Company.)

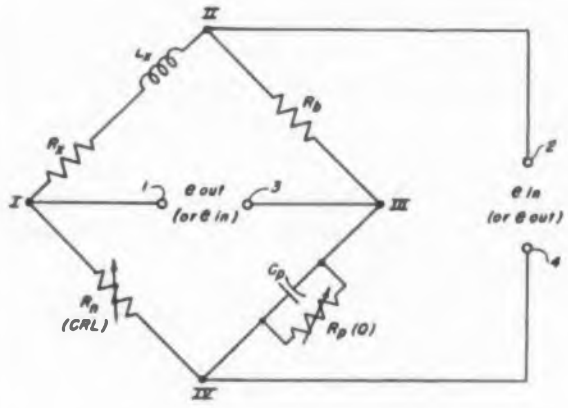
Null balance in an ac bridge is obtained rapidly, even for low Q, by separate and independent adjustment of the real and reactive quantities. In the new General Radio Type 1650A Impedance Bridge, the apparatus facilitates observations and increases overall accuracy.

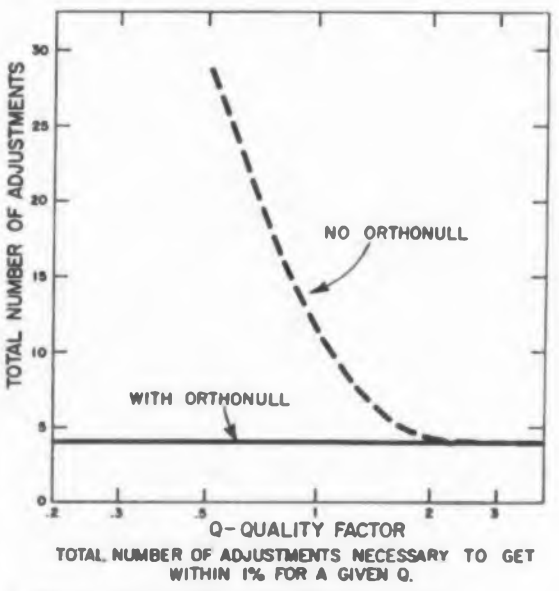
Conventional sliding-null apparatus, by contrast, is limited since many successive adjustments must be made to achieve balance. In particular, for low Q components, balance may never be obtained (see Fig. 1).

The balance conditions for the Maxwell Bridge (Fig. 2) is defined as:

$$R_x + jwl_x = R_n/R_p\ R_b + R_n\ (jwR_bC_p)$$

Orthogonal adjustment of the real and reactive quantities is obtained when R_p is separately adjusted and also when R_n/R_p is constant as R_n is changed. The assembly, shown in Fig. 1, permits separate and independent adjustments. Rotation of knob *14* drives contact *6* on the surfact of exponential potentiometer R_p' to allow the first adjustment. Likewise, rotating knob *13* friction-couples to position contact *5* on exponential potentiometer R_n' and, in addition, causes gear *16* to drive gear *17* which is friction-coupled to position contact *6* on potentiometer R_p'.

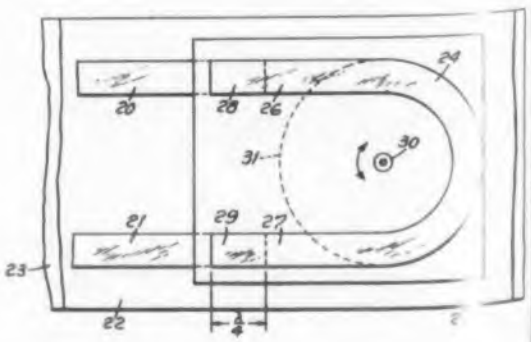


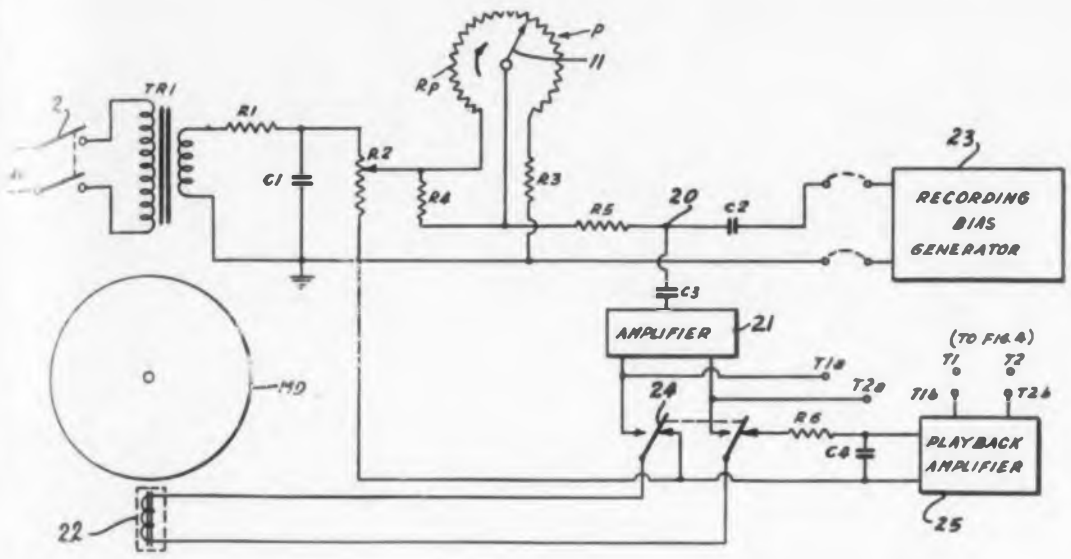


Microwave Switch

Patent No. 2,866,167. Harold Seidel. (Assigned to International Telephone and Telegraph Corp.)

Microstrip transmission is attenuated 25 db and, in addition, higher order coupling is reduced when the switch is opened. However, rotation to the closed position causes a $\lambda/4$ overlap over the ends of strips *20* and *21*, effectively producing a choke which shorts the energy at each end of U-shaped element *24*.





Spiral Sweep Generator

Patent No. 2,857,553. Gordon van B. King.

A spiral raster is generated on the face of a cathode ray tube by applying to the deflection plates the linearly attenuated sine wave recorded upon a continuous magnetic medium.

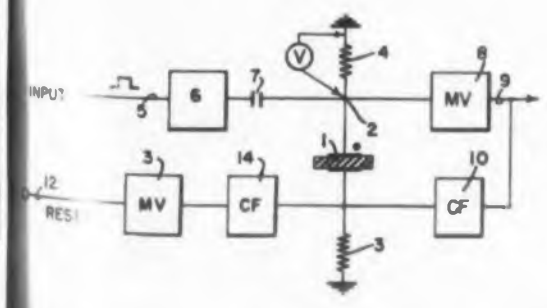
Motor driven potentiometer *P* effectively amplitude modulates the 60 cps waveform in the secondary of transformer *TRI*. Several or more cycles of the dampened wave are recorded on magnetic driven *MD*. On playback, the drum may be driven at any selected speed such that the recorded pattern after phase shift will control the vertical and horizontal scans to generate the spiral pattern on the screen.

Ferroelectronic Counter

Patent No. 2,872,661. Donald R. Young and Howard L. Funk. (Assigned to International Business Machines Corp.)

Step-charging-type counters are simplified by ferroelectric storage capacitors.

Pulses to be counted are shaped by network 6 which couples the intermittent current to ferroelectric capacitor *1*. Multivibrator 8 triggers after a predetermined number of pulses have been stored and cathode follower *10* feeds back a pulse to reset the internal polarization of the capacitor to start a second count.



Electronic Gate Circuit

Patent No. 2,831,971. Carl R. Wischmeyer. (Assigned to Esso Research and Engineering Co.)

Since the output signal and the gating signal are of opposite phase, the two signals are combined in a sample resistance adder to cancel the gating signal from the output.

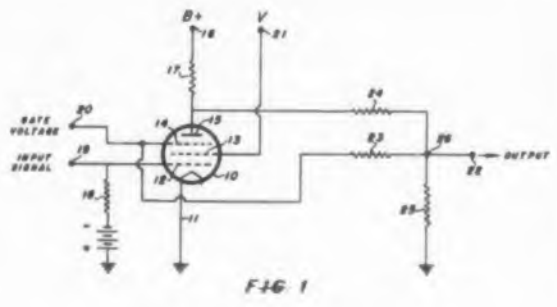


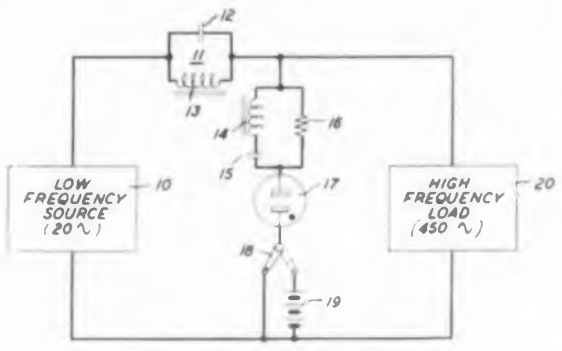
FIG. 1

Oscillation Generator

Patent No. 2,870,332. John K. Mills. (Assigned to Bell Telephone Labs, Inc.)

A sub-audible alternating signal shock excites an LC network in series with a symmetrical gas tube to generate an audible output.

When the amplitude of source *10* is sufficient to fire neon tube *17*, capacitor *25* charges and a voltage is induced in inductance *14* to cut the tube off. Capacitor *25* discharges and the tube conducts again. The process repeats for each half cycle of the control signal.



PATENTS

Microwave Duplexer

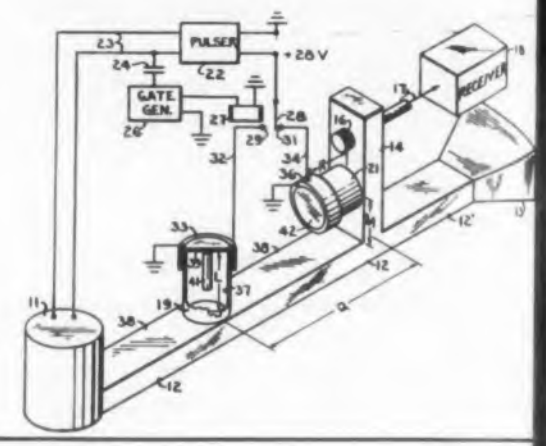
Patent No. 2,866,165. John F. Zaleski. (Assigned to General Precision Laboratory.)

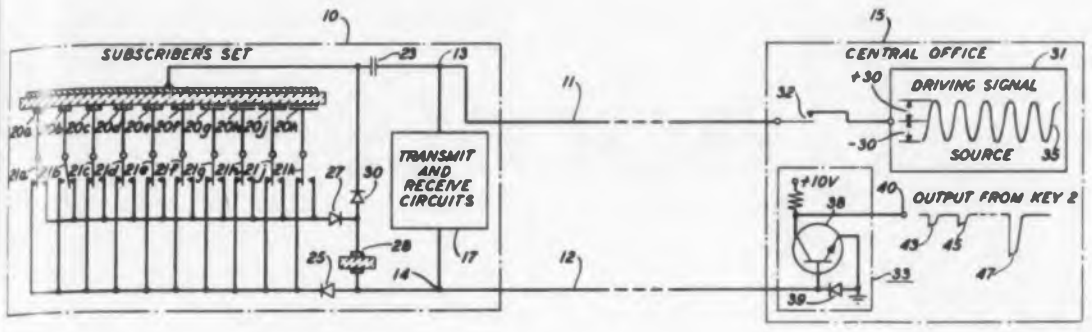
Gyromagnetic field rotators are combined to isolate the receivers from the transmitter in a duplex radar system. When compared to TR/ATR devices, gyro rotators are preferred since they are sensitive to lower power levels and may be controlled by direct current. The rotator comprises essentially a quarter wavelength guide closed at one end and supporting a ferrite rod along its axis. A ferrite rod in a magnetic field rotates by 90 deg the direction of polarization of microwaves such that the guide becomes an open circuit.

As shown in assembly, rotator *19* joins to guide *12* intermediate magnetron *11* and horn *13*. A second rotator *21* joins guide *14 at* $\lambda_g/4$ from the junction of guides *14* and *12*; rotator *19* is equally distant from the said junction.

Pulser *22* triggers magnetron *11* and closes dc through switch *29* and coil *33*. Rotator *19*, energized, becomes a half wave shorted stub in shunt with guide *12*, essentially an open circuit so that the magnetron pulse passes unimpeded to horn *13*. No energy goes to the receiver since rotator *21* unexcited presents a short circuit across guide *14*.

To receive the radar return, relay 27 closes dc through coil *36* and rotator 21 decoupled from guide *14*, allows the signal to pass through demodulator *16* to receiver *18*. By contrast, the unenergized rotator *19* presents a short across guide *12* at $\lambda_g/4$ from the junction so that none of the target return is passed to magnetron *11*.





ulse Signaling Circuit

atent No. 2,864,079. John R. Anderson. Assigned to Bell Telephone Labs., Inc.)

Push botton telephone dialing in a re-ertive digital signaling circuit is ob-ined by switching selected ferroelectric apacitors in series with a charge-meter-g ferroelectric capacitor. When ferro-lectric capacitors are connected in se-es, the number of pulses required to ompletely reverse the remanent polar-ation varies as the areas of the capaci-rs.

The revertive circuit is described by e network comprising central office *15* nnecting driving signals *31* by line *11* subscriber's set *10* which contains the pacitors and selector switches to digi-tize data fed back to central by line *12*. The area of capacitor *28* equals the area of capacitor *20a*. In addition, the areas of capacitor *20b* to *20k* are consecutively increasing integral multiples of the area of capacitor *20a*.

When the receiver connects to central, all capacitors are polarized negative. Assume capacitor *20b* is selected by closing switch *21b*. Positive going driving pulses will cause the polarization of metering capacitor to reverse twice so that the remanent polarization of capacitor *20b* becomes completely reversed and two pulses will be coupled by transistor amplifier *38* to terminal *40*. In similar manner any digit up to 10 may be push buttoned.

BOOKS

Fundamentals of Radio Telemetry

Marvin Tepper, John F. Rider Publisher, Inc., 116 W. 14th St., New York 11, N. Y., 136 pp, $2.95.

Purpose and techniques of radio telemetry is explained in this book. Special sections are devoted to missile and satellite telemetry and hardware, and to data recording and processing. Illustrations are used to clarify important telemetry fundamentals. Only a basic understanding of electronics is necessary for comprehension of the material contained. The book does not assume any previous experience with telemetry by the reader. It provides an overall picture of telemetry without getting involved in minute details.

Noise in Electron Devices

Louis D. Smullin, Hermann A. Haus, Editors, The Technology Press, MIT; John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 413 pp, $12.00.

A comprehensive discussion, stressing the mathematical theory and basic physical phenomena, rather than detailed design techniques, is presented here. The most modern points of view are presented regarding cathode noise phenomena, signal amplification in microwave tubes, solid-state noise, and methods of designing low-noise tubes. Since the emphasis is on fundamental processes, the material presented can well serve as background for the understanding of such devices as masers and parametric amplifiers.

Conductance Design of Active Circuits

Keats A. Pullen Jr., John F. Rider Publisher, Inc., 116 West 14th St., New York 11, N.Y., 344 pp, $9.95.

The nonlinearity of electron tubes and transistors has for many years greatly complicated the design of active circuits associated with these devices. This book presents a proven method of overcoming these complications. The conductance approach utilizes a technique whereby a nonlinear circuit may be linearized on a point-by-point basis. This definitive book explains and illustrates the theory and mathematics involved in this technique. It presents the conductance technique as applied to the design of a wide variety of vacuum tube and transistor amplifier, mixer, and oscillator circuitry in the broadest sense. To make the mathematics completely understandable, practical numerical examples are given throughout.

Tube and transistor circuit design by the first coordinated method of static and small-signal design techniques is presented and new methods of reducing power dissipation and improving reliability of electronic devices and circuits are explained.

Liquid Scintillation Counting

C. G. Bell, Jr., F. N. Hayes, Pergamon Press Inc., 122 East 55th St., New York 22, N.Y., 292 pp, $10.00.

The first volume published on this technique of radiation measurement, it summarizes the theory, techniques and applications of the subject. It covers all the advances in the field and reviews literature and progress through 1957. The subject matter for the conference on which the book is based was chosen by members of the liquid scintillation counting group of the Los Alamos Scientific Laboratory and ranges from the physical theory to applications in industry, engineering, medicine and several other physical sciences. Six main headings cover instrumentation, chemistry of the counting sample, general applications, specific applications, and developments in foreign laboratories.

The volume is vital to those entering the liquid scintillation field; scintillation counters being one of the most versatile and important instruments in modern nuclear research: nuclear physicists, physical chemists, electronic engineers, radio chemists, and medical researchers.

BOOKS

Theory of AC Circuits

Sylvan Fich, James L. Potter, Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N.Y., 453 pp, $11.35.

Purpose of the text is to develop the basic theory of ac circuits to establish a sound foundation for the study of modern network and communication theory. Attention is focused on the relations between the time and frequency domain. Each new topic is first considered in terms of a differential equation in the time domain; it is then transformed into the frequency domain, solved by phasor methods, and transformed again into the time domain in order to bring out clearly the relationship between the phasor and instantaneous solutions.

The authors begin with the development of basic energy and power relations; proceed to the rigorous development of the theory and application of phasors, the definition of a complex frequency, resonance, poles and zeros, and the fundamentals of network theory. This is followed by a thorough treatment of polyphase circuits and an extended coverage of Fourier analysis and Laplace tran forms. The last chapter is devoted to th synthesis of lossless networks fro pole and zeros.

Treatment is essentially mathe atica but there are no prerequisites othe tha a conventional first course in math matic and physics. Includes over 300 proble with answers.

Design of Transistorized Circuits for Digital Computers

Abraham I. Pressman, John F. Rider Pub lisher Inc., 116 W. 14th St., New York 1 N.Y., 324 pp, $9.95.

This book is concerned with the desig of transistorized digital computer an digital type circuits. Written from th viewpoint of the circuits designer, it is i tended both for those who have no pri knowledge of either transistor or com puter type circuits, and those with knowledge of computer type circuitry b who have not yet converted to transistor Using worst-case design, the author e plains how switching time and drive c pabilities and requirements of all the e sential digital computer building block may be calculated, and how these block may be assembled in chains to perfor

mputer-type logical operations. Methods or performing computer logic to obtain aximum operating speed and pyramiding factor are analyzed in detail. Well illustrated.

rocessing of Thermoplastic Materials

rnest C. Bernhardt, Ed., Reinhold Publishing Corp, 430 Park Ave., New York 22, Y. 690 pp, $18.00.

Designed to fill the need for a basic text n processing of thermoplastics, this olume reviews the engineering fundamenals on which the design of plastics proccing equipment is based, and demonrates the practical application of these ndamental concepts in the analysis of ermoplastics processing problems. Dealg with the specific area of polymer rocessing, the volume is divided into hree major sections: fundamentals decribe the basic theories of flow behavior, eat transfer, and mixing; applications overs design of major categories of procsing equipment and demonstrates how quations may be derived which describe he behavior of plastic materials in a given iece of equipment; processing properties resent a compilation of the viscous and hermal properties of thermoplastics needed for the design of processing equipment. Contributed by experts in the various branches of this field under the auspices of the Society of Plastics Engineers, the material is aimed at the engineer, but does not require previous knowledge in plastics processing technology.

Semiconductors

N. B. Hannay, Ed., Reinhold Publishing Corp., 430 Park Ave., New York 22, N.Y., 767 pp, $15.00.

Emphasis on basic principles and phenomena underlines this reference work on physical chemistry and fundamental physics of semiconductors, including detailed analysis of important semiconducting materials. The chemical aspects and the physics of semiconductor behavior are exhaustively treated. Semiconducting materials are treated individually. Each chapter is preceded by an introduction which places it in perspective with semiconducting as a whole. Contributors are all leaders in semiconductor research. This monograph is of outstanding importance to physical chemists, solid-state physicists, inorganic chemists and metallurgists, electrical engineers, electrochemists, the electronics and chemical industries.

NEW LITERATURE

Magnetic Amplifiers 391

The 400 cps series precision magnetic amplifiers are described in bulletin 401-A, four-pages. Included in the bulletin are two pages of drawings showing basic circuits and typical applications. Acromag, Inc., 22519 Telegraph Road, Detroit 41, Mich.

Translator 392

Translator T-121 is described in Bulletin 121. The unit was designed to be used with encoders where either continuous indication of encoder position is required or where read-out while encoder is in motion is not required. Datex Corp., 1307 South Myrtle Ave., Monrovia, Calif.

Data/Log Equipment 393

Series MC-200 data/log equipment is described in bulletin 200. The units were designed for use in the field of automatic data recording. The four page bulletin provides photographs, technical and descriptive material. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

Potentiometers 394

The potentiometers described are built around a conductive plastic for sereve environmental conditions. Using this element these types have been created: rotary, rectilinear, linear, non-linear, single-element as well as dual-element units. These potentiometers are capable of a rotational life of 50 million revolutions. Although a limited number of specific potentiometers are described in this 48-page brochure, special potentiometers can be created from stock elements with short lead time. Markite Corp., Dept. 12, 155 Waverly Pl., N. Y., 14, N. Y.

Transformers 395

An expanded line of variable transformers is described in Bulletin 151. No-overvoltage transformers are listed for the first time. Operating data and dimensions on tandem assemblies and enclosed or portable transformers is provided. Included are tables to facilitate selection by type or by application. Ohmite Mfg. Co., 3681 Howard St., Skokie, Ill.

Data Overlay Reader 396

A data overlay reader that enables the operator to read an entire time history of oscillographic type recording without readjusting the reader is described in this data sheet. Electro-Kinetics Co., P. O. Box 869, Lancaster, Calif.

Oscillator 397

In two pages, this bulletin gives complete electrical and physical specifications on variable frequency oscillator Model 1011 which has a frequency range from 100 cps to 5 mc. Technitrol Engineering Co., 1952 E. Allegheny Ave., Philadelphia 34, Pa.

Electronic Cabling 398

Entitled "This is Cable Systematics" this 4-page illustrated booklet describes capabilities and facilities in the field of custom electronic cabling for the aircraft and missile industries, from design and development through fabrication and installation. Robertshaw-Fulton Controls Co., Aeronautical & Inst. Div., Santa Ana Freeway at Euclid Ave., Anaheim, Calif.

Mica Isolators 399

Eight-page Data Sheet K-5 contains 2 outline drawings and dimensions of mica wafer shapes available without tooling costs, and describes how transistor reliability is increased when mica wafers are used as isolators in heat sink applications. Perfection Mica Co., Magnetic Shield Div., 1322 N. Elston Ave., Chicago 22, Ill.

Relay Data Sheet 400

Bulletin 161, one page, provides technical, mechanical, and descriptive information on the Model "TO" telephone type relay designed for dc operation. Ohmite Mfg. Co., 3671 Howard St., Skokie, Ill.

Tube Catalog 401

Four-page condensed catalog, Form T291, covers the following tube lines: klystrons, magnetrons, display tubes, traveling wave tubes, backward wave oscillators, miniature noise sources, duplexers, and TR tubes. Litton Industries Electron Tube Div., 960 Industrial Rd., San Carlos, Calif.

ealing Material 402

Kovar alloy, used in making pressure d vacuum-tight seals with hard glasses, described in this two-color eight-page talog. Typical applications of the ma-rial: vacuum or gas-filled tubes; semi-nductors; capacitors; relays; trans-rmers; and other components. The Car-rundum Co., Refractories Div., Perth mboy, N. J.

lectric Heaters 403

Chromalox flexible and molded electric eaters are described in four-page, two-lor bulletin J-1003. Specifications and ictures are included to show the units, hich may be used to meet electronic d missile heating requirements. Edwin Wiegand Co., 7500 Thomas Blvd., ttsburgh 8, Pa.

uarded Galvanometer 404

Type E Guarded Galvanometer is scribed in data sheet ED2(1), two-ges. Specifications, pictures and a sche-atic diagram are included. Leeds & rthrup Co., 4934 Stenton Ave., Phila-lphia 44, Pa.

illivoltmeters 405

In 28 pages, catalog CIO-1 covers op-ating principles, specifications, fea-res, and ordering information on non-ntrol and control millivoltmeters. The talog includes information on all ntrol models such as Pyr-O-Vane, lse Pyr-O-Vane, Protect-O-Vane, and Pyr-O-Volt controller. Minneapolis-neywell Regulator Co., Industrial Di-ion, Wayne and Windium Avenues, iladelphia 44, Pa.

otors, Blowers 406

This 16-page catalog describes the nd rd line of sub-fractional horse-wer motors and blowers. Photographs d detailed diagrams illustrate 2 and 4 le induction motors, capacitor motors, niversal motors, gearmotors, single and ubl blowers, and blower heater units. nve nient tables provide technical data horsepower, voltage ratings, load eed, rotation, and mountings. Heinze ectr c Company, 685 Lawrence Street, owel , Mass.

Potentiometer 407

Data Sheet 1357, 4 pages, describes the 1-3/4 in. Series 5500 single-turn precision potentiometer. Complete specifications (including environmental), dimensional drawings, power rating curve, and photograph provide the engineer with all necessary information. Beckman Instruments, Inc., Helipot Div., 2500 Fullerton Rd., Fullerton, Calif.

Function Generator 408

A digital controlled function generator that provides accurate timing and digital logic to create voltage waveforms such as sinusoids, steps and sawtooth type ramps is described with pictures, block diagrams, and graphs in this 12-page report. Navigation Computer Corp., 1621 Snyder Ave., Philadelphia 45, Pa.

Transformers 409

Bulletin HT-325, 2 pages, illustrates designs of high temperature transformers produced for applications where ambient temperatures approach 350 C operational requirements. Acme Electric Corp., Cuba, N. Y.

Indicator Unit 410

Model 101N-022 indicator unit, with built-in 22,000 ohm resistor, is described in this data sheet. The unit was designed for use with neon lamp NE51H. Dimensional and other data are given. Drake Manufacturing Co., 1711 W. Hubbard St., Chicago 22, Ill.

Antenna Handbook

Basic antenna reference material is contained in this 28-page, two color handbook. Designed as a comprehensive aid for engineers on radar and microwave antenna systems, the book provides detailed material for making mathematical conversions and for estimating: performance of a given antenna system; physical antenna characteristics required to achieve desired performance. The book contains 25 graphs and charts which furnish data on losses, pattern tests, beam widths, range coverages, wind loadings, waveguide wavelengths and power distribution in large antenna arrays. *Write on company letterhead to I-T-E Circuit Breaker Co., Dept. ED, 1900 Hamilton St., Philadelphia, Pa.*

NEW LITERATURE

Mechanisms, Components 413

Bulletin 102-58, six-pages, describes a complete line of predesigned mechanisms and components for the servo and instrument fields. An unlimited variety of geared mechanisms for use in breadboarding, prototype, and production applications may be assembled from the units listed. Precision Mechanisms Corp., 577 Newbridge Ave., East Meadow, N. Y.

Cables 414

Information on a complete line of miniature coaxial cables, to meet both military and commercial specifications, is supplied in this 4-page catalog. Included is data on: electrical characteristics; temperature rating for each type of jacket; and minimum tensile strength. The Rex Corp., Aircraft & Electronics Div., West Acton, Mass.

Instruments 415

Instruments described in 2-page bulletin G-100 include representatives of those used in data processing and calibration equipment, force instrumentation, electronic weighing units, and special recording units for strain gage and thermocouples. Gilmore Industries Inc., 13015 Woodland Ave., Cleveland 20, Ohio.

Printed Circuits 416

The relationship between various factors affecting printed circuits is discussed in the booklet entitled "Reliability and Cost in Printed Circuits." It is pointed out in the 14-page booklet that the proper printed circuit design may reduce cost and at the same time increase reliability. Drawings are included. Arthur Ansley Mfg. Co., New Hope, Pa.

Ferrites 417

Illustrated with diagrams showing the magnetic characteristics of various ferrite combinations and photographs of ferrite products, this paper describes the characteristics of the four types of ferrites: hard; soft; square-loop; and those for gyromagnetic effects. Included is a forecast on ferrites of the future. General Ceramics Corp., Keasbey, N. J.

Amplifiers

"Audio Frequency Amplifiers," a 12-page brochure contains charts, diagrams and photographs. Complete information is given for laboratory types, line amplifiers, oscillators and preamps for magnetic recording and equalizer for magnetic film playback. *Copies available from G. M. Smith, Cinema Engineering Div., 1100 Chestnut St., Burbank, Calif.*

Electronic Components 419

New 8-page illustrated folder features a wide assortment of relays, steppers, solenoids, contactors, rectifiers and related components. Contact Universal Relay Corp., 42 White St., N.Y. 13, N.Y.

Load Isolator Magnets 420

Catalog No. 20, describing Alnico V permanent magnets for microwave load isolators, describes the basic sizes and shapes of "C" type magnets available for this microwave application, as well as information on how design engineers can help solve load isolator design problems. The Indiana Steel Prod. Co., Valparaiso, Ind.

Data Processing Equipment 421

Describing off-line processing of data to permit full utilization of computers data processing systems, a new six-page brochure, "Computer Language Translator for Data Processing Systems," details the ZA-100 which can solve 200 translation problems, end the punched card phase in computer/computer translations, and speed up conversions from one media to another. The brochure also shows typical commercial, industrial, and scientific installations. Electronic Engineering Co., 1601 E. Chestnut St., Santa Ana, Calif.

Instrument Brochure 422

The March 1959 issue of the Bourns Instrument Brochure, 8-pages and illustrated, summarizes key information on a complete line of linear motion potentiometers, pressure transducers, accelerometers and angular position transducers. General information on each line is included, giving typical applications, construction features and operating principles plus specifications. Bourns Laboratories, Inc., P. O. Box 2112, Riverside, Calif.

NEW LITERATURE

Epoxy Resin Sysems 426

Complete data on fast curing, one-part epoxy resin systems in the form of "Scotchply" brand reinforced plastic tape for electrical applications is given in these data sheets. The data sheets cover types 1002, 1001, and 2004. Electrical properties of the four tapes include: 0.05% water absorption in 24-hour emersion; dielectric strength of 750 vpm; and insulation resistance of 3.3 x 10^{8} meg at 90% relative humidity, 23 C. Each type of material is moldable, thermosetting and designed for low molding pressures and production cure cycles. Minnesota Mining and Manufacturing Co., 900 Bush Avenue, St. Paul 6, Minn.

Latches 427

This publication on latches is actually a drawing aid, laid out so that housings may be traced from one set of pages and suitable fittings may be traced from a matching set of pages. Typical application of the latches are: radomes, access doors, and radar consoles. Simmonds Aerocessories, Inc., Tarrytown, N.Y.

Commutators

"Abbreviated Catalog of Electro-Mechanical Commutators" is a 12-page switch catalog that illustrates and details model and specification drawing numbers, number of poles and channels, drive and brush type, mechanical features, and application. *Request copy on company letterhead. General Devices, Inc., P.O. Box 253, Princeton, N.J.*

Pulse Transformers 42

This technical bulletin describes the P Series miniature encapsulated pulse transformers, designed especially for printed circuit and automatic assembly applications. The P Series transformers are wound on high permeability ferromagnetic cores, resulting in a transformer design with a high pulse-width to rise-time ratio. The units are available in a number of case styles with a range of pulse widths from 0.05 to 10 μsec for either vacuum tube or transistor applications. Technitrol Engineering Co., 1952 E. Allegheny Ave., Philadelphia 34, Pa.

ectronics Catalog 430

This 232-page catalog contains detailed ice and product information on an exsive variety of electronic components d equipment for service, industrial, and mmunications applications. Freck Radio pply Co., Asheville, N.C.

ener Voltage Tester 431

Technical bulletin No. 115 contains deiptive material on zener voltage tester, del DT100. The bulletin provides deiptive material, circuit and operational on this instrument which is intended laboratory and factory measurements zener diodes, transistors, rectifiers and types of semi-conductor devices. Elecnic Research Associates, Inc., 67 Fac- Pl., Cedar Grove, N.J.

rvo Actuators 432

In 15 pages this booklet describes linear rotary hydraulic servo actuators. klet includes design nomographs for ick determination of actuator size, pres- e, and flow requirements needed to et specified servo loop performance figs Dalmo Victor Co., Belmont, Calif.

Strain Gages 433

"How to Select A Strain Gage," 24-page article compares the characteristics of resistance strain gages made by eight U.S. manufacturers. Specifies selection criteria for various strain gage properties under different operating conditions. Stein Engineering Services, 5602 E. Monte Rosa, Phoenix, Ariz.

Coated Tubings 434

Physical and electrical data, application information and the main features of a complete line of coated tubings are contained in this six-page catalog. Tubings covered in the catalog include: silicone rubber coated tubing, silicone varnished glass cloth tubing, varnished glass cloth tubing, varnished rayon tubing and vinyl coated glass cloth tubing. A cross-reference chart gives the NEMA temperature rating of each type of tubing, the class and type, voltage grades, standard and special sizes, standard and other colors, standard packaging lengths and appropriate military specifications met by the tubings. Irvington Division, Minnesota Mining and Manufacturing Co., 900 Bush Avenue, St. Paul 6, Minn.

NEW LITERATURE

Synchro Components 438

Complete electrical characteristics, mechanical characteristics and drawings are given for all types of synchros, size 8 through 22 in this catalog. Similar information is given on a wide line of precision computing resolvers and linear transformers (induction potentiometers). A large section of the book is devoted to complete electrical and mechanical information on servo motors and motor generators, sizes 8 through 11. Speed torque curves are included. In addition, information is given on CPPC's gearhead motors and size 8 DC motors. Clifton Precision Products Co., Inc., 9014 West Chester Pike, Upper Darby, Pa.

Rotary Switch 439

This brochure illustrates and describes a rotary switch with wafers that lift out instantly without unsoldering or disassembling for fast, easy-cleaning or instant replacement. Chicago Dynamic Industries, Inc., Precision Products Div., 1725 Diversey Blvd., Chicago 14, Ill.

AC Drive Motors 44

That data sheet, tabulates a complet line of −55 to +85 C missile quali drive meters, listing size, voltag fr quency, no. phases (supply), n lo speed (rpm), capacitor (μf), runnin cu rent amperes, running watts input, ou put, weight, gear ratio and type numbe John Oster Manufacturing Co., Avion Div., 1 Main St., Racine, Wis.

Tape Recorder 44

In eight pages this two-color brochur describes the PS-200 magnetic tape instru mentation recorder. It outlines complet specifications and describes the instru ment's transistorized electronics a unique magazine loading feature. Com bining these features has enabled th manufacturer to produce a complete channel recorder/reproducer that weig only 65 pounds and requires only 250 of power. Comparable existing equipme weighs 1000 lb and requires 1200 w power. Precision Instrument Co., 10 Commercial St., San Carlos, Calif.

oaxic l Attenuators 443

Four-page 2-color engineering catalog, 259, presents a complete line of coaxial enuators for use at microwave frequen-s. Units covered include three types of ividual attenuator pads and four vari-le (step) attenuators having either six or elve positions. Engineering data covers ch things as typical applications. In art form are listed such items as fre-ency range, vswr, standard attenuation tios, accuracy, rated power, dimensions, d weight for every attenuator in the e. Empire Devices Products Corp., nsterdam, N.Y.

able Data Sheet 444

Data Sheet C-1 completely describes d illustrates new low pickup, minimum diation Inter-8 cable with realizable d reductions up to 20 db. Included e present test data, external field pickup t and applications. Illustrated are con-uction features, evaluation test set up d comparative field effect of a twisted ir vs Inter-8 Weave. Magnetic Shield v., Perfection Mica Co., 1322 N. Elston ve., Chicago 22, Ill.

Tubings 445

Manual 59T, an illustrated 24-page catalog on Turbo extruded and coated tubings, provides complete specifications and customer service information concerning Turbo extruded tubings. Turbo heat-treated glass sleeving, Turbo coated tubings, and Turbo identification markers. Also included are footage requirements for cut pieces. The William Brand & Co., Inc., Willimantic, Conn.

Photorectifier Plate 446

Basic information on the Rex-Array photorectifier plate is given in this data sheet. The plate extends the range and increases the flexibility of digital computer systems by behaving like a diode array. It requires practically no soldering and uses approximately 1/20 the space of diode arrays. The plates are applicable to existing digital computers as well as new units. They can be used in conjunction with any punched card system replacing mechanical methods of film reading, card reading, character recognition, language translation. Rex Corp., Electronics Components Div., West Acton, Mass.

CIRCLE 447 ON READER-SERVICE CARD

NEW LITERATURE

Plastics Data

Product engineering and application considerations, dictated by the unique properties of Teflon resins, are subjects of a new, engineering publication. Designed to aid engineers specifying teflon for its numerous applications, the publication is called Plastips. *Write to: Tri-Point Plastics, Inc., 175 I.U. Willets Road, Albertson, L.I., N.Y.*

Toroidal Inductor 451

This two-color data sheet gives detailed technical data on Series 781 miniature toroidal inductors. Plug-in design is for use in printed circuits. Hooked pins on periphery allow stack-mounting of up to 12 units on a single screw. Units have inductance values ranging from 1 mh to 7 henries. Fully encapsulated and hermetically sealed, units meet MIL-E-5272-A and MIL-T-27A specifications. Case size measures only 1 in. in diameter and less than 0.5 in. thick. Arnold Magnetics Corp., 4613 W. Jefferson Blvd., Los Angeles 16, Calif.

Packaging 45

Parametric pack is described in th four-page folder. It outlines 4 basic poin engineers must consider when planni packaging; weight, shape, characteristi and special storage conditions. Showi how padding can be custom-engineer to meet every packaging need of all typ of articles in transit and/or storage, t folder is illustrated with photographs actual packs developed for both comm cial and military needs. Featured are su products as radar units, missiles and m chanical brain units. Blocksom & Co pany, Michigan City, Ind.

Capacitor Catalog 45

Service Replacement Catalog AC covers technical data on the compan full line of capacitors and filters for ra and electronic applications. The illu trated, 16-page booklet provides pictur physical dimensions, electrical charact istics and costs. Astron Corp., East Ne ark, N.J.

Magnetic Tape Recorders 455

Five new instrumentation bulletins technically describing a series of ruggedized, miniaturized magnetic tape recorders designed for use in rockets, missiles and other airborne applications are available. The Model MR-1B is designed to record information during the flight testing of missiles and rockets. The unit is capable of recording 16 tracks of information simultaneously. The Model MR-2B is a seven track ruggedized recorder, essentially similar in other respects to the Model MR-1B. The Model MR-100, is designed for multichannel, single speed recording and telemetering in other than extreme environments. BJ Electronics, Borg-Warner Corp., 3300 Newport Blvd., Santa Ana, Calif.

Transformers 456

This one-page data sheet describes contour molded clipper series transformers for 400 cycle operation. The units, small in size and weight are made for aircraft, servo and other miniature applications. Sterling Transformer Corp., 297 North 7th St. Brooklyn 11, N.Y.

Electroluminescent Lamps 457

This four-page booklet describes a line of devices for the display of luminous letters and numerals in various types of dials and indicators in readout equipment. The new indicator devices produce light by the phenomenon of electroluminescence. Flat panels of glass with an electrical conductive film are coated with a special phosphor. When electricity is applied, the panel glows. A sketch in the pamphlet shows how electrical contact with the readout lamps is made through bins molded into the back plate of the lamp. Westinghouse Lamp Division, Bloomfield, N.J.

Telemetering Equipment Catalog

This 36-page catalog of multichannel telemetering equipment gives clear-cut illustrations, descriptions and specifications of representative multichannel equipment for telemetry and for other instrumentation applications. *Request copy on company letterhead: Multichannel Products, Div. of General Devices, Inc., P.O. Box 253, Princeton, N.J.*

NEW LITERATURE

Analog to Digital Converter 462

Milli-V-Meter, a miniature analog-to-digital converter, with a 144-inch tape-slidewire potentiometer of 0.1% accuracy and digital readout, is described in this 4-page, 4-color bulletin, No. BH100. The slidewire, embedded in a Mylar tape, may be calibrated (linear or non-linear) and geared to its in-line digital "counter" or have calibration printed on the tape to measure and indicate frequency, pressure, temperature, weight, etc. B & H Instrument Co., Inc., 3479 West Vickery Boulevard, Fort Worth 7, Tex.

Control Meter 463

This new 4-page engineering data sheet describes model 2545 miniature electronic control meter. This sheet provides full electrical and other specifications on unit, which differs from conventional meters of this type by operating without the use of contacts at the set points. Complete dimensional data is also provided by the sheet. International Instruments Inc., P.O. Box 2954, New Haven 15, Conn.

Potentiometer Catalog 46

This is a complete catalog of sing turn, wirewound precision potenti mete from 0.5 in. to 3 in. diameter. Comple specifications such as size and dime sions, mechanical requirement and ele trical properties are described. The units are useful primarily for high reliab ity use in aircraft, missile and grou support equipment. Maurey Instrume Corporation, 7924 S. Exchange Aven Chicago 17, Ill.

Coaxial Cables 46

This brochure (E502ED) provides a n merical listing of all known RG type axial cables and their characteristics. D shown includes impedance, capacitan dielectric, size and type of conducto jacket materials, shields, diamet weights and other pertinent data. It p sents a numerically indexed guide to axial cables. Standard Wire and Ca Co., 3440 Overland Ave., Los Angeles Calif.

elsyn Units 467

Bulletin GEC-1527, six pages, illustrated with photographs and diagrams, describes in detail selsyn systems for a wide variety of applications. Operation, applications, and ordering instructions are included in the bulletin along with selection and mounting charts, torque-resistance curves, and dimension charts and drawings. General Electric Co., Schenectady 5, N.Y.

strument Catalog 468

New J F, C-59, Instrument Catalog contains 16 pages of all j[f] products with complete details, specifications and application for each unit. John Fluke Manufacturing Co., Inc., 1111 W. Nickerson, Seattle 99, Wash.

C Amplifier 469

New dc amplifier, model 2HLA-4a, with isolated differential input is described in 4-page catalog, No. B-C2HLA-4, containing photographs, block diagrams, outline drawings, detailed performance specifications, and descriptions of 14 applications showing how the unit is used in the laboratory, production and process control. Minneapolis-Honeywell, Boston Div., 40 Life St., Boston 35, Mass.

Electron Tube Directory

This directory of electron tubes contains most every tube made by American manufacturers. It has all the popular top name brands as well as specialized brands. Receiving, television and special purpose tubes are listed by type number. *Write on company letterhead to: Metropolitan Supply Company, 1133 Broadway, New York 10, N.Y.*

Connector Catalog

This 12-page, illustrated technical catalog gives specifications, outline drawings and general information on a complete line of miniature rectangular power connectors. This series is available in a variety of contacts from 7 to 104, with optional polarizing screwlocks, aluminum hoods and protective shells. For Series 250 catalog, write: *Electronic Sales Div., DeJur-Amsco Corp., 45-01 Northern Boulevard, Long Island City 1, N.Y.*

Two-Element Matching Network Nomograph

Huo-Bing Yin
RCA Victor Television Div
Camden, N. J.

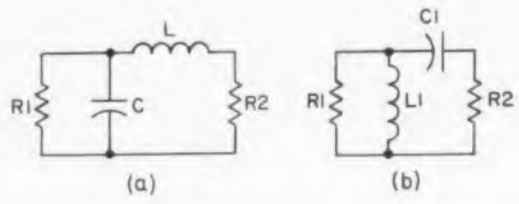
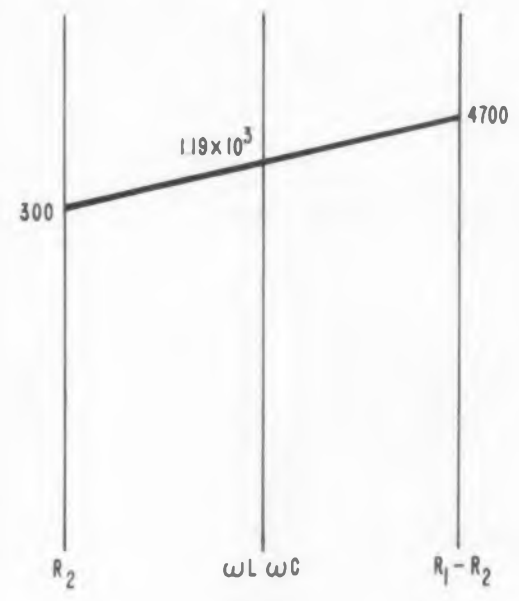
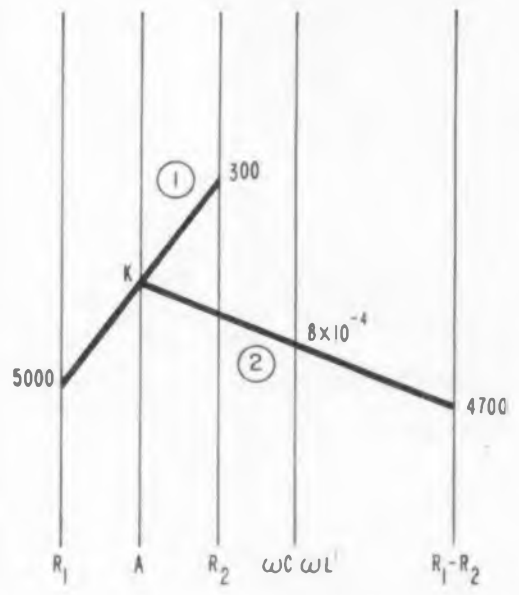


Fig. 1. Typical matching networks with series inductance (a) and series capacitance (b).





ANY TWO resistances can be matched by re active elements with a minimum insertio loss. The simplest matching network uses tw reactive elements (Fig. 1). The values of L and C are functions of frequency and terminating re sistances, R_1 and R_2. For the network of Fig. 1(a these functions are:

$$\omega L = \sqrt{R_2 (R_1 - R_2)} \qquad (1)$$

$$\omega C = \frac{\sqrt{R_1 - R_2}}{R_1 \sqrt{R_2}}$$

Similarly for the network of Fig. 1(b):

$$\omega L' = \frac{R_1 \sqrt{R_2}}{\sqrt{R_1 - R_2}}$$

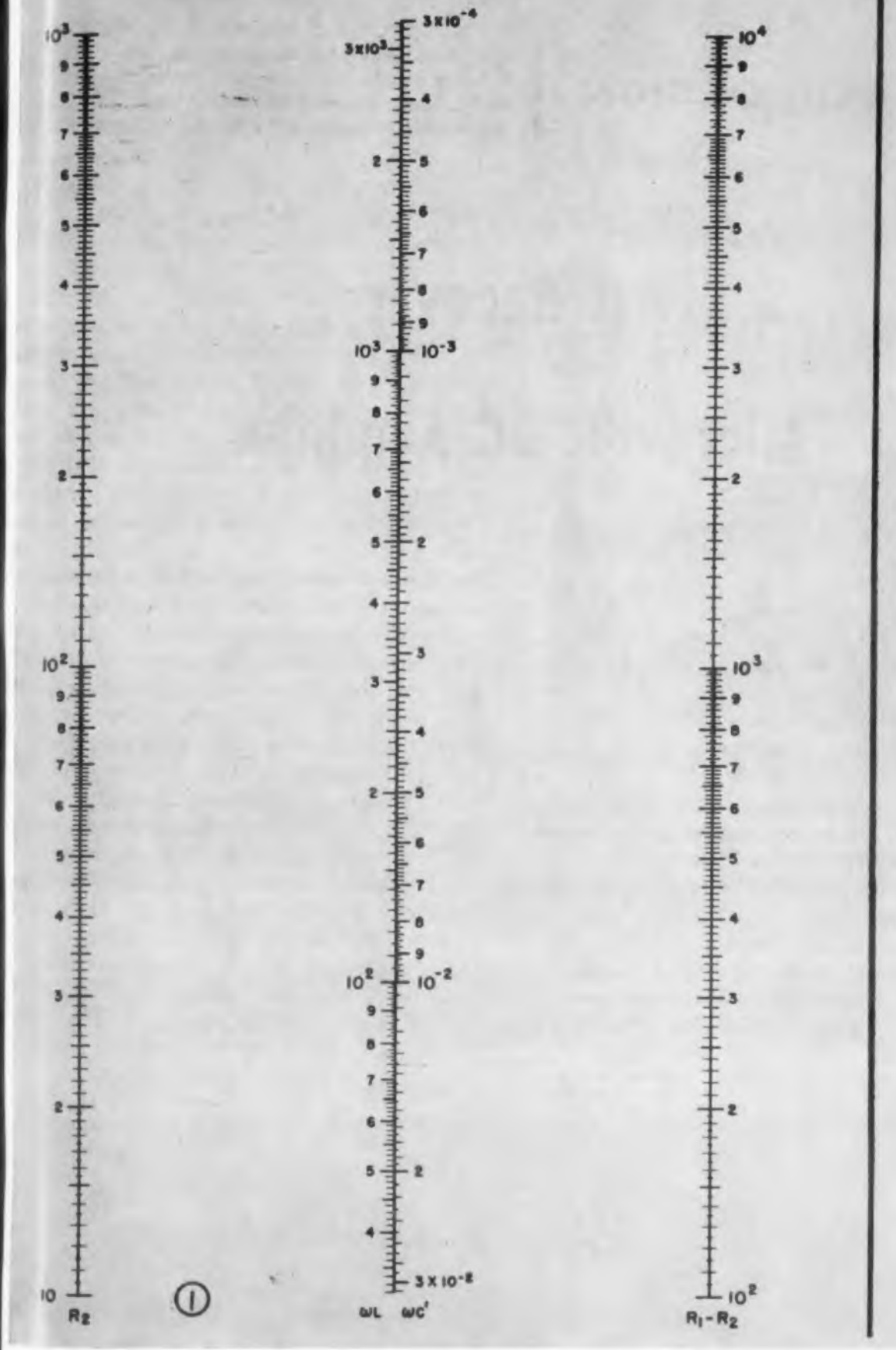
$$\omega C' = \frac{1}{\sqrt{R_2 (R_1 - R_2)}} \qquad (2)$$

Equations (1) and (2) are valid when $R_1 > R_2$ and are plotted as nomographs in Fig. 2 and for any value of R_1 and R_2.

Example: Given $R_1 = 5000$ ohms and $R_2 = 30$ ohms. (This is a typical case for matching amplifier to an antenna.) Use Fig. 2 to find ωL. Connect a line from the point $R_2 = 300$ to th point = 4700 of the $(R_1 - R_2)$ axis. ωL is rea off from the intersection point of the ωL axis an the line, or 1.19×10^3 ohms. Use Fig. 3 to find ωC. First draw a line from $R_1 = 5000$ to $R_2 = 30$ the point k is found on the AA' axis. From th point k draw another line to the point = 4700 o $(R_1 - R_2$ axis). Then ωC is read off from the in tersecting point on ωC axis, or 8×10^{-4} mhos.

When R_1 falls within the 1-100 ohm scale, u $1 - 10^4$ scale for ωC. Similarly, R_2 ($10^2 - 10$ and ωC ($10^{-1} - 10^{-5}$) are companion scales. R and $(R_1 - R_2)$ scales are independent.

If the circuit of Fig. 1b is used, then $\omega L'$ an $\omega C'$ of Equation (2) are reciprocals of ωC an ωL respectively of Equation (1). For this reason the inverse of ωL and ωC are also plotte along the ωL and ωC axis. ■ ■



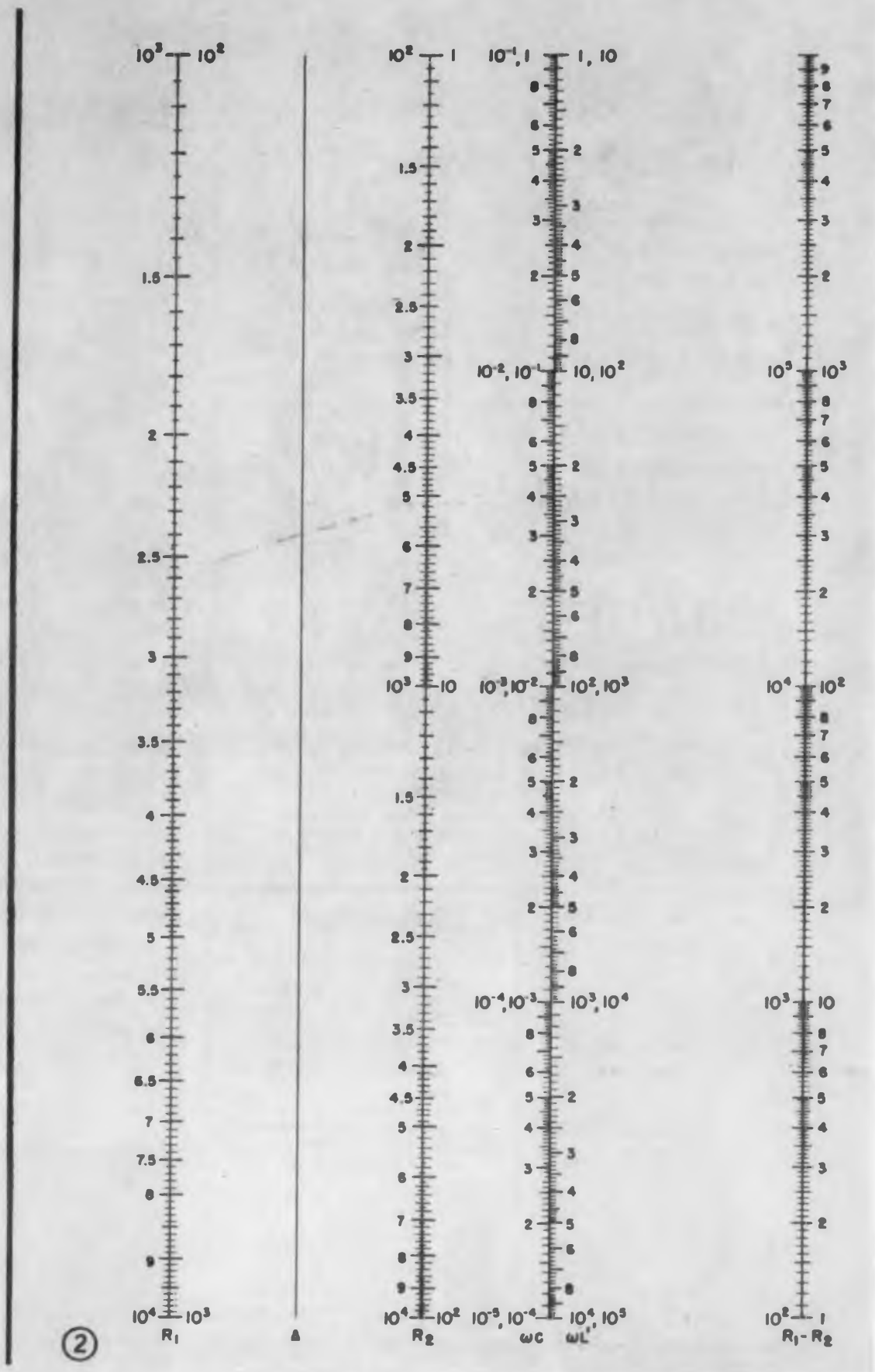


Fig. 2. (above left) Nomograph for finding ωl or reciprocal of ωc.

Fig. 3. (above right) Nomograph for finding ωc or reciprocal of ωl.

ABOUT THE AUTHOR

A graduate of the University of Shanghai, Huo-Bing Yin has been with RCA since 1951. In his work on design and development of rf and i-f circuitry for TV receivers, he evolved this relatively simple nomograph. Its simpler than a Smith chart, he says. Besides you don't have to remember a formula.

IDEAS FOR DESIGN

Get $10.00 plus a by-line for the time it takes you to jot down your clever design idea. Payment is made when the idea is accepted for publication.

Fast Recovery Microvolt DC Amplifier

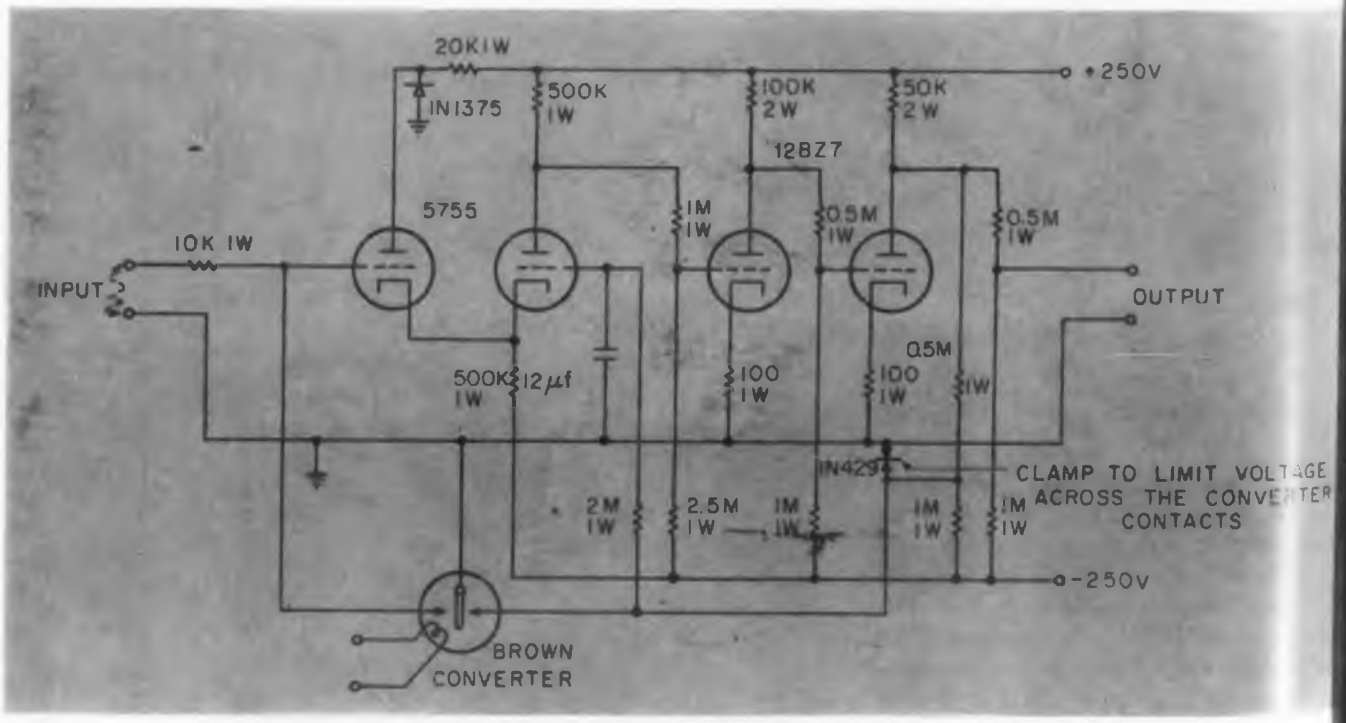
A LARGE decrease in recovery time can be achieved for a microvolt dc amplifier subjected to an input overvoltage. Usually microvolt dc amplifiers have a long recovery time following an overvoltage at the input. This is caused by energy being stored in the components, particularly in the coupling capacitors of the amplifiers of a chopper-input type circuit.

However, if only one capacitor is employed in the circuit, and if it is used to store drift information and not signal information, then a large decrease in recovery time may be achieved. In Fig. 1 a mechanical chopper periodically shorts the input grid. During this interval, any output voltage due to drift is applied as negative feedback and stored in the capacitor. While the input is open and the amplifier is operating at full gain, the feedback path is interrupted to prevent overload information from reaching the capacitor.

Note the input-circuit limitation which requires a low enough resistance to prevent errors due to grid leak bias. The capacitor-resistance time constant in the other grid should be long enough to prevent a drift during the amplification interval and short enough to respond to amplifier drift rates. Two such amplifiers operating with 180 deg difference in chopper phase and with inputs and outputs mixed will amplify continuously.

Tests conducted with an amplifier built with the circuit show that ten thousand times normal operating voltage can be applied without producing an observable increase in recovery time.

Alfred A. Windsor, Radiation Lab., University of Calif., Berkeley, Calif.



Capacitor stores drift information, not signal information in this dc amplifier.

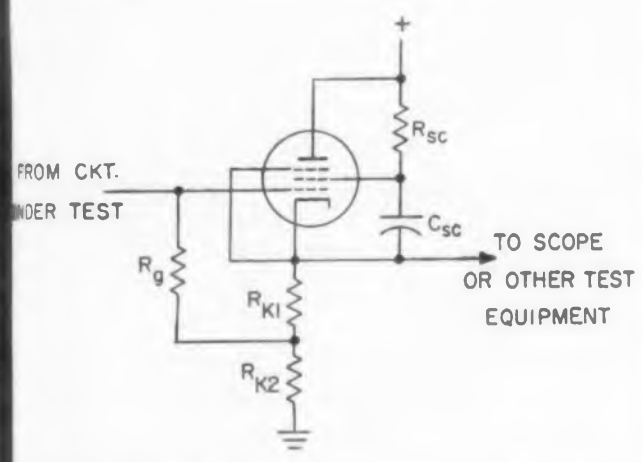
Pentode Cathode Follower For Low-C Probe

A low capacity probe can be made with the pentode cathode follower shown in the accompanying figure.

If the cathode follower has unity gain, no capacitance exists between control grid and cathode. By dropping the screen voltage and by-passing to the cathode, the screen will rise with the cathode and no capacitive current will flow from control grid to screen. By tying the suppressor to cathode, again no capacitive current flows. Returning the grid resistor to a tap on the cathode keeps the transconductance of the tube high while still approaching unity gain.

The only capacitance that exists now, with a perfect cathode follower, is the input wiring capacity and the extremely low grid to plate capacity.

Arthur M. Goldschmidt, Moorestown, N. J.



Pentode cathode follower serves as nearly ideal low capacity probe.

Color Coding for Small Cartridge Fuses

Many times one is faced with a drawer full of fuses of mixed ratings. When examining the fuses for ratings, one also finds a wealth of unwanted knowledge which many times prolongs the search for the desired rating. Such information as manufacturers' names, "made in USA by union labor," manufacturers' type number, length, and other information cause frustration and confusion by being more conspicuous than the current rating.

It is hereby proposed to use a standard color code for indicating fuse current rating. It can consist of colored dots or bands on the fuse along with the printed rating so that people with the ability to read the color code can benefit from it.

If placed properly on the fuse the code will not hide the fuse element, and will help tell the fuse current rating at a glance.

Victor P. Holec, Engineering Dept. 5-C, Collins Radio Co., Cedar Rapids, Iowa.

IDEAS FOR DESIGN

Easy Resistance Temperature Conversions

The design of magnet coils and transformers requires frequent reference to wire tables which give the resistance in ohms per thousand feet at 20 C. Coils and transformers designed with 105 C insulating materials usually run with copper temperatures about 85 C. Conversion of resistance values to the higher temperatures requires additional computation.

In reading the wire table one can use the resistance corresponding to the next smaller wire size and obtain directly the resistance per thousand feet at 85 C.

A second wire size smaller provides a reading equivalent to 170 C wire temperatures (Class H).

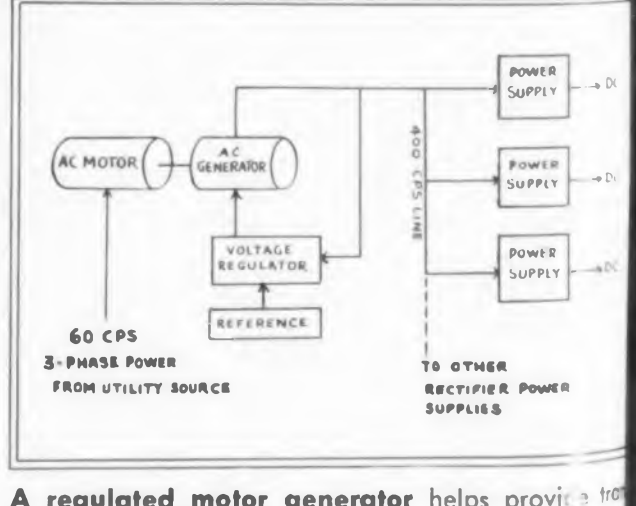
The ohms per thousand feet column in a wire table likewise serves as a convenient reminder of the resistance change to be expected in a coil at normal Class A temperatures. For example, a 10 ohm coil (20 gage in table) will show 13 ohms hot resistance (21 gage in table).

Laurence G. Cowles, Electronic Design Engineer, The Superior Oil Co., Bellaire, Tex.

Computer Power Supplies Use M-G Sets, Brute Force Filters

Freedom from line transients and output voltage changes due to variations in primary supply voltage is obtained by isolating dc rectifier power supplies from the utility lines with a motor generator.

In addition to line isolation, the use of a motor generator set offers other advantages. The m-g set converts 60-cycle utility power to 400 cps. This higher ripple frequency makes filtering easier, and permits the use of smaller transformers which cost less than those required at 60 cps. The higher fre



A regulated motor generator helps provide tra sient-free dc voltages.

quency also shortens the response time of magnetic amplifier regulators.

This technique is being used in computer power supplies developed by Bogue Electric Manufacturing Co. of Paterson, N.J. Several rectifier power supplies which provide various dc voltages, isolated from each other, are operated from three phase, 400-cycle ac furnished by a closely regulated m-g set.

Transients caused by step loading changes are minimized and impedance, looking back into the rectifier, is reduced to a very low value by using storage capacitors of exceptionally high value. Up to seven farads (7,000,000 μfd) are used in a single multiple-output power supply.

When required, the individual dc power supplies can be regulated to provide a very high order of regulation. Response time of magnetic amplifier regulators is sharply shortened because of the higher ripple frequency. While 400 cps has been cited as an example, Bogue has developed power supply systems in which the m-g set delivers 800 cps power. As frequency gets higher, filtering and regulator response time are improved.

New look in horizontal output transformers. With wider and wider angle picture tubes and smaller and smaller available space, miniaturization has become important consideration in TV receiver design. The horizontal output transformer itself is quite a problem, only because of the high pulse voltages it deals with. In this respect, the French Orega model shown in the accompanying photograph is an example of functional design and reliability.

It uses a ferrite core and molded parts to carry the windings and soldering lugs on one hand, and the high voltage rectifier and its heater winding on the other end. The production is entirely automatized. These transformers are made for all types of tubes. The one shown is a 90 degree, 20,000 volt model.

Dr. A. V. J. Martin, Carnegie Institute of Technology, Pittsburgh 13, Pa.

IDEAS FOR DESIGN

Switch Operated One Shot Triggers

Here are two refinements on the trigger circuit shown in your October 1, 1958 issue.

Fig. 1 shows the original circuit. Fig. 2 shows a circuit based on the same idea of allowing the capacitor to discharge completely before bounce can occur. This circuit uses half the number of components used in the previously published circuit, without sacrificing performance.

Fig. 3 shows a method invented by Dr. George Nonnemaker of RCA's Missile Electronics and Controls Dept. This is a method to generate pulses of arbitrary width, not restricted to being narrower than the bounce time of the switch.

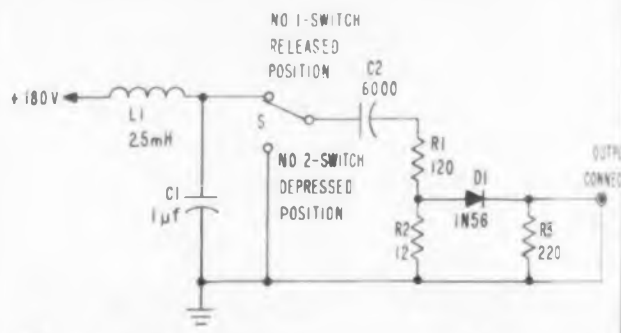


Fig. 1. Switch operated, one shot trigger, as it was originally published (*ED*, Oct. 1, 1958, p. 63)

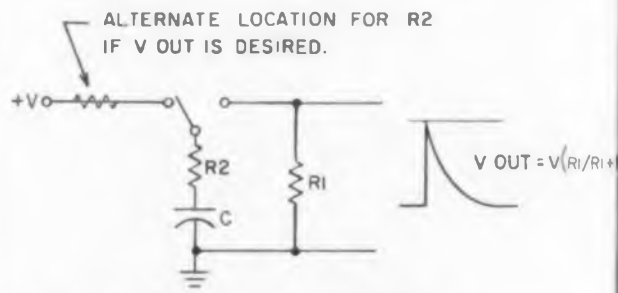


Fig. 2. Modified trigger using the same basic concept employed in Fig. 1.

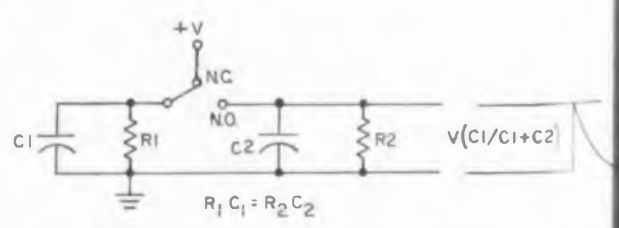


Fig. 3. This trigger will generate bounce-free pulses of arbitrary width.

Initially *C1* is charged to +V. When the switch pole contacts the normally open contact, the charge on *C1* is redistributed between *C1* and *C2*, giving a step on *C2*. *C1* and *C2* both discharge through *R1* and *R2*, giving the pulse an exponential trailing edge. If the switch bounces, *C1* and *C2* are disconnected, but both discharge

independently at the same rate, having the same RC time constant.

Thus, there is no additional transient when the switch contact makes again since *C1* and *C2* are at the same voltage at the time of contact reclosure. In practice, a small resistor is inserted in series with the switch pole to prevent excessive surge currents through the switch. This resistor decreases the initial voltage on *C1* slightly, producing the same effect as using a slightly lower supply voltage. This effect is easily calculated and can be made arbitrarily small with proper design.

This circuit works best when *R1 C1* is at least several times larger than the time required for the pole of the switch to move from the *N.C.* contact to the *N.O.* contact.

N. O. Sokal, Senior Engineer, Di-An Controls, Inc., Boston, Mass.

Fluorescent Lamp Helps Identify Lenses

A large lot of lenses for 35 mm slide projectors was received without identification. It was known that all the lenses had identical focal length. Some had but two lens elements, while others had three. In this latter group, some had symmetrical components, while others were asymmetrical.

It was necessary, without disassembling the cases, to identify each lens type as well as to determine if any of the asymmetrical ones had been mounted in reverse.

Each lens was examined beneath a single fluorescent lamp. The two-element lenses showed four images, while the three-element ones showed six.

The symmetrical, three-element lenses showed identical size and curvature of the images when viewed from either end. The asymmetrical ones were all examined from the "front" end and separated into the two types of images. Then, by comparison with a known, identified lens, the reversed ones were picked out.

In addition, by comparing the size and curvature of the images, one could obtain an idea of the curvature of each lens surface, thus permitting the detection of an improper element. Also, flaws of the images enabled one to gage the uniformity of the coating on each surface.

The fluorescent lamp was used instead of a point source because it gave a line image whose length and curvature could readily be analyzed.

Robert A. Le Massena, Senior Engineer, Guidance Lab. Div., Minneapolis-Honeywell, Denver, Colo.

IDEAS FOR DESIGN

Phase-Varying, Constant Voltage Error Signal

In computer circuits, in thyratron circuits, and in controlled rectifier type servo amplifiers, it is often necessary to provide a constant voltage error signal, whose phase varies linearly with the difference between two shaft positions.

One solution uses two resolvers as a data transmission link as shown in Fig. 1. A voltage in phase with the line is connected to one stator winding of the transmitter. The other stator winding of the transmitter gets a voltage 90 deg out of phase.

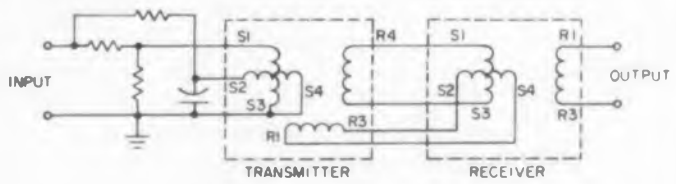
With these connections, the two rotor windings will have equal voltages, 90 deg out of phase. This circuit forms the standard resolver phase shifter.

As the rotor shaft turns, the two rotor voltages retain their phase relationship, but shift phase (in respect to the line) by an amount equal to the shaft rotation. When these voltages are connected to the receiver stators, the receiver operates like a phase shifter, just as the transmitter does.

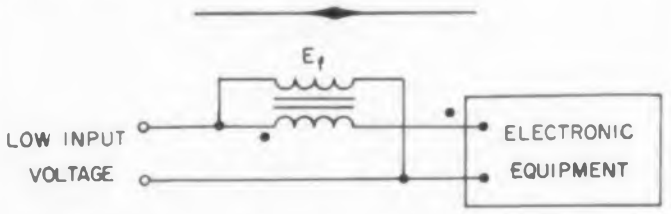
With proper phasing, an equal rotation of the receiver and transmitter shafts will cause an equal but opposite phase shift of the rotor voltages in the two units. The net phase shift is zero.

If one shaft is turned more or less than the other, the output voltage is shifted in phase by an amount equal to the difference in the angle between the two rotations.

Franklin G. Fink, Senior Development Engr., Loral Electronics Corp., New York, N. Y.



Resolver data transmission system provides constant voltage, phase-varying error signal.



Simple boost for low line voltage can be provided by adding the secondary of a filament transformer in series with equipment being operated from low lines. The transformer must be wired-in with due respect to polarity. The transformer winding must be able to pass the current required by the equipment being powered.

Reuben Wasserman, Hycon Eastern, Inc., Cambridge 42, Mass.

Two Phase from Three

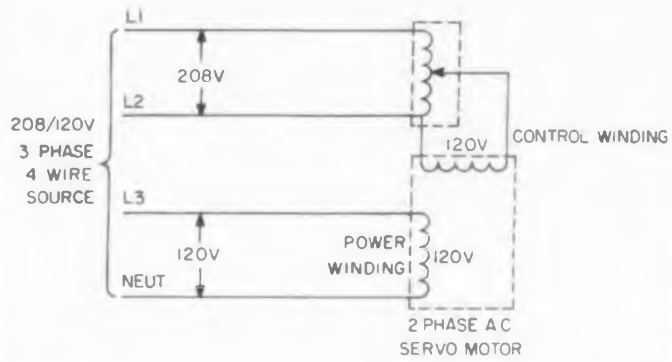
Our problem was to operate a 200-watt 2-phase servo motor with varying loads. We had no 2-phase supply. The varying loads excluded the use of a motor running capacitor to obtain two phases from one, and a rush schedule would not allow us to buy a custom-made Scott connected transformer.

We had a 208/120-v 3-phase, 4-wire system. By using a small 230-v variable autotransformer from stock, and connecting it as shown in the sketch, we were able to provide 2-phase power to the servo.

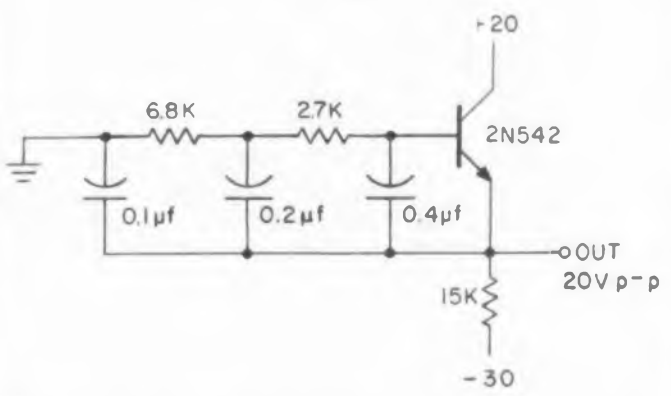
We realized an added bonus. We could provide motor speed control by varying the autotransformer.

It's advisable to provide a mechanical stop on the autotransformer to prevent exceeding the voltage rating of the control winding.

M. K. Kessie, Senior Design Engineer, Atomics International, Canoga Park, Calif.



Variable autotransformer helps provide 2-phase power from 3-phase line.



Simple phase-shift oscillator requires fewer parts than conventional counterparts. With the values shown, the circuit oscillates at about 5 kc.

McKenny W. Egerton, Jr., Engineer, Hoover Electronics, Timonium, Md.

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

REPORT BRIEFS

Radio Research Reports

Naval Research Laboratory progress reports in radio for Jan. 1959 include an interim report on the effects of ambient illumination, crt bias, and noise upon target detectability with a B-display; antenna applied research, and microwave antenna basic research. Object of the first study was to determine optimum settings for a typical radar indicator as part of a program of research on visual factors in crt displays. The interim report found optimum values of receiver gain and crt bias for most favorable target detectability and that these values held for all possible levels of ambient illumination. A basic study of ferrite materials and their associated electrical characteristics at microwave frequencies is being carried on. Results will be applied to the design of new types of microwave components and antennas. A further problem under study is the development of antennas which achieve their rapid scanning without moving the entire antenna structure; especially important when the antenna is very large. Rapid scanning of the antenna beam is essential in many radar search, target-acquisition, and fire-control systems which have requirements for resolution, angular coverage, and information rate which make rapid scanning of the antenna beam essential. One method of achieving low-inertia scanning is to use an array of circularly polarized elements, getting the required interelement phase shifts by using the phase-shifting properties of rotating circularly polarized radiators. *Report of NRL Progress, U. S. Naval Research Laboratory, Washington, D. C., January 1959, $1.25 single copy. Order PB151334 125 from OTS, Department of Commerce, Washington 25, DC.*

Emissive Materials for Electron Tubes

The effect of varying three exhaust-processing factors (pressure, time, and temperature) during electronic tube manufacture was investigated. The quality of the diodes as evidenced by the levels of emission and the variations in the work factors generally diminished with decreasing total heating time, increasing pressure at the preliminary low-vacuum heating step, and low-temperature heating at exhaust in combination with a low-vacuum heating step. A repeated determination of the amount of sublimation from 330 alloy, melt 9855 showed satisfactory reproducibility. *Emissive Materials for Electron Tubes, Charles J. Baldsley and Frederick T. Hill, Raytheon Mfg. Co., Newton, Mass. Mar. 58, 102 pp, microfilm $5.70, photocopy $16.80. Order PB 135382 from Library of Congress, Washington 25, D.C.*

Human Response Studies Applied to Aircraft Design

This report represents one phase of a program aimed at the application of human response studies to aircraft design. Sought specifically were mathematical or analog descriptions representing the pilot as a system element. Available experimental and analytical work performed in the area of human dynamic response are summarized and correlated. All of the quasilinear describing function data obtained, including some said to be presented for the first time, were curve-fitted to yield simple mathematical expressions descriptive of the linear portion of the operator's response for varying machine dynamics and forcing functions. It was concluded that it is possible, within limits, to define mathematically the dynamic behavior of the operator for certain tasks, although the definition becomes less effective as the tasks grow more complex. The simple tasks can be used to define a "preferred" operator describing function for so that definitive criteria for improvement of a man-controlled machine is established. *Dynamic Response of Human Operators, D. T. McRuer, Control Specialists, Inc. and E. S. Krendel, The Franklin Institute for Wright Air Development Center, U. S. Air Force, Oct. 1957, 265 pp, $4.00. Order PB 131823 from OTS, U. S. Department of Commerce, Washington 25, D. C.*

Low-Cost Relay Design

A novel relay design described as suitable for low-cost, automatic fabrication and assembly is the subject of this report. The high-speed relay is said to be simple, flexible, and dependable. The hermetically sealed unit occupies a volume of 0.249 in., weighs 0.576 oz., requires less than 0.2 w power, and operates in temperatures from —65 to 125 C. Unique features of the electro-magnetically actuated relay are a Cunife permanent magnet used to retain the contacts in the normally closed position, thus eliminating the spring return normally employed, and the use of the armature for both the actuating and the contracting member. The magnetic pole-pieces are also multiple purpose units comprising both the normally open and the normally closed contacts. A compact single-pole double-throw relay can be used in multiple to provide additional poles as required. *Investigation of Printed Circuit Methods for Relay Applications, H. R. Reeve, R. L. Traas, P. R. Mallory & Co. for Wright Air Development Center, U. S. Air Force, Aug. 1958, 233 pp, $3.50. Order PB 157259 from OTS, U. S. Dept of Commerce, Washington 25, D.C.*

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REPORT BRIEFS

Electronic Components for 500 C Operation

An experimental study of dielectric properties of ceramic materials and the fabrication of these materials into a form and substance suitable for capacitor dielectrics and wire insulation. A large number of ceramic bodies, both commercially available and laboratory prepared, were evaluated at 500 C for dielectric constant, dissipation factor, resistivity, dielectric strength, and aging effects. *Electronic Component for 500 C Operation, Morton E. Goldberg, Harlan G. Hamre, and Richard D. Noble. Rept. for 1 Apr 56-31 Aug 57 on Improved Electronic Components. July 1958 9 pp $2.25. Order PB 151320 from OTS, U. S. Department of Commerce, Washington 25, D.C.*

Reduction and Prevention of UHF Interference

Three methods of detecting double-sideband zero-carrier signals are described. Two methods derive the missing carrier from information in the sidebands but use different arrangements for demodulation. Three methods of accurately recovering single-sideband zero-carrier signals and correction for Doppler shift were investigated. *Reduction and Prevention of UHF Interference, Floyd P. Holder, Howard L. McKinley, Technical Rept. 1 Oct 56, 187 pp, microfilm $8.40, photocopy $28.80. Order PB 135248 from Library of Congress, Washington 25, D.C.*

Calculated Magnetic Fields in Non-Ellipsoidal Ferrite Bodies

A method is presented for obtaining valid approximations of the magnetic fields in nonellipsoidal ferrite bodies for use in the design or analysis of ferrite devices. The field values of rods, discs, or other simple configurations are calculated by extending the known methods for determining the fields present in ellipsoidal bodies. The field relationship for an ellipsoid having major axes equal to the corresponding dimensions of the nonellipsoidal body is calculated. Variations in comparative volumes of the materials are then determined. Development of the calculation is detailed in this report. Several plots for determining the field values in various configurations are included, and instructions for using the plots are provided. *Calculated Magnetic Fields in Ferrite Rods, Discs, and Slabs, G. R. Jones, Diamond Ordnance Fuze Laboratories, Ordnance Corps, U. S. Army, Apr. 1958, 19 pp, $0.75. Ord PB 131938 from OTS, U. S. Dept. of Commerce, Washington 25, D. C.*

Electron Mirror Microscopy

This report describes electronic mirror microscopy as a feasible and independent method for electronically depicting magnetic patterns, thus greatly increasing the versatility of this important research instrument. The first part of the two-part study concerned the use of artificial specimens with known magnetic patterns to establish basic facts of image contrast formations. The second part dealt with specimens which actually contained magnetic domains, barium ferrite and nickel ferrite. Patterns derived from this method were compared with patterns obtained by the conventional powder technique. Results are described as being final proof of the feasibility of electron mirror microscopy in depicting magnetic patterns. Among the advantages described for this method, the polarity of the normal component of the magnetic field on the surface of a domain can be concluded immediately. Being practically free of any time delay, it is ideal for investigations concerned with dynamic behavior of magnetic domains. It is also applicable within a much wider temperature range. *Research To Investigate The Feasibility of Electron Mirror Microscopy in the Study of Magnetic Domains, L. J. Mayer, General Mills, Inc. for Wright Air Development Center, U. S. Air Force, Sept. 1957, 32 pp, $1.00. PB 131624 from OTS, U. S. Department of Commerce, Washington 25, D.C.*

"Slurry Ceramics" Technique

Deposition of "slurry ceramics," a combination of ceramic and an inorganic binder, onto metal substrates proved the best of several techniques studied for the fabrication of capacitors and insulated wire. The methods were evaluated as part of an investigation of ceramic materials and their fabrication into forms suitable for use in components of electronic equipment operating at 500C. A slurry containing AL_2O_3 with monoaluminum phosphate and additions of Nalcoag showed most promise for both capacitors and wire. Coatings as thin as 0.001 in. were applied to 24-gauge nickel wire. The coating was such that the wire could be wound on a one-half in. mandrel prior to curing. A 0.001 in. aluminum foil was also coated and formed into capacitors of both the stacked and rolled tubular varieties. An overcoating of polyvinyl chloride-acetate copolymer applied to coated wire and foil was found to seal the ceramic from dehydration and provide abrasion protection. *Electronic Component Parts Research for 500 C Operation: Part 2, M. E. Goldberg, H. G. Hamre, R. D. Noble, Armour Research Foundation for Wright Air Development Center, U. S. Air Force, July 1958, $2.25 91 pp. Order PB 151320 from OTS, U. S. Dept of Commerce, Washington 25, D. C.*

REPORT BRIEFS

Magnetron Performance and Reliability

Investigation of field reliability and performance of magnetrons RK6410/QK338, RK6517/QK538, and RK6518/QK254. The study included visits by magnetron engineers to radar installations of the Air Defense Command. Results indicate that most field problems are caused by insufficient information by field personnel concerning handling, installing, and operating the magnetrons. Direct liaison between the field environment and tube manufacturer is needed. Refinements for improving compatibility of equipment and magnetron will result from the cooperative efforts of manufacturers. *Magnetron Performance and Reliability, A. F. Hastie, Raytheon Mfg. Co., Waltham, Mass. Nov. 56, 115 pp, microfilm $6.00, photocopy $18.30. Order PB 135184 from Library of Congress, Washington 25, D.C.*

AEC Research Reports For Sale

A new free price list of Atomic Energy Commission unclassified research reports for sale by the Office of Technical Services, U. S. Department of Commerce, is now available from OTS on request. This cumulative listing of some 4000 AEC reports in the OTS collection includes new documents acquired since July 1958. *To obtain a free copy, request AEC Research Reports Price List No. 31 from OTS, U. S. Dept. of Commerce, Washington 25, D.C.*

Reactor Shielding Research

Research was conducted to find transformations of solutions of diffusion equations in certain two-medium situations for isotropic sources having simple geometric shapes. It is thought that the results will be applicable to some shielding problems. Sources of the transformations were obtained for the following: paint, disk, infinite plane, and solid cylinder sources interior to a semi-infinite medium joined at an infinite plant surface to a source-free semi-infinite medium of a different material. Transformations were also obtained for spherical shell or solid sphere sources interior to a spherical medium imbedded in an infinite medium of a different material. *Transformations of Solutions of Diffusion Equations in Two-Medium Geometrics, Visvaldid Mangulis, TRG, Inc., for Wright Air Development Center, U. S. Air Force, Aug. 1958, 27 pp, $0.75. Order PB 151313 from OTS, U. S. Dept. of Commerce, Washington 25, D.C.*

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Research on Electro-Optical and Magnetic Core Logic

Research described in the first part of this report was aimed at advancing digital computer techniques through the study of the application of phosphor-photoconductor elements. A description is given of the physical properties of electroluminescent and photoconductive materials. Ways are demonstrated in which circuit elements can be constructed by a combination of such materials to perform the logical "OR" and "AND" functions for use in digital computers. In the second part, research work on magnetic core logic system is summarized. This system allows a substantial reduction in the number of active elements in the circuit and increases the utilization of those remaining. Brief descriptions and references to transistor circuits and magnetic core circuits, used as components or the system, are included. Functional units of small size and high reliability were developed. These devices are described as potentially useful in magnetic digital computer systems based on inhibit-current drive techniques. *Research on Electro-Optical and Magnetic Core Logic, T. G. Marshall, Jr., L. J. Andrews, National Cash Register Co., for Wright Air Development Center, U. S. Air Force, Sept. 1957, 51 pp, $1.50. Order PB 151257 from OTS, U. S. Dept of Commerce, Washington 25, D.C.*

High-Speed Electronic Printer

A high-speed electronic printer for digital computer output which can write 12 characters in parallel across a five-inch chart as a speed of 2160 characters per second is described in this final report. The printer has a single timer unit, a single numeric function generator, and 12 identical character elements. Each character unit has the necessary circuitry to produce any decimal digit 0-9, a minus sign, and a decimal point. With the addition of 24 character elements and minor design changes, up to 36 columns of characters can be printed. Up to 90 columns of characters can be printed leaving two styli blank as spacing between each column; with the use of only one blank stylus, spacing up to 102 columns can be printed. An increase in the amount of characters printed per second may be achieved simply by increasing the chart speed. With the use of an analog-to-digital converter in the input of the printer, it could operate in conjunction with analog computers. The amount of printable characters available is said to be unlimited. It is possible to include the complete alpha-numerics and symbols. *A High-Speed Electronic Printer For Digital Computer Output, W. Scott Grant, Radiation Inc., for Wright Air Development Center, U. S. Air Force, Nov. 1957, 111 pp, $2.50. Order PB 151331 from OTS, U. S. Dept. of Commerce, Washington 25, D.C.*

REPORT BRIEFS

Nuclear Batteries

In Task A, the conductivity under high energy irradiation was studied during this contract year for diamond, sapphire, polystyrene, inhibited polystyrene, and polyester. The 'decreasing conductivity' effect was not always observed. A new strontium battery using a laminated dielectric was designed to increase life. The laminated structure is applied to a new krypton battery designed in Task B. In Task B, the construction of radioactive batteries using gaseous isotopes was proved feasible. Both krypton 85 and tritium batteries were completed. Characteristics of a tritrium battery using both a vacuum and a solid dielectric were examined. In Task C, the design and cost of a carbon 14 battery were studied. *Nuclear Batteries, John H. Coleman and Jerome Goodman, Radiation Research Corp., West Palm Beach, Fla. Aug. 56, 31 pp, microfilm $3.00, photocopy $6.30. Order PB 135277 from Library of Congress, Washington 25, D.C.*

Electron Gun for Microwave Tubes

The theory of hollow beams is summarized and applied to a particular design of current interest: a convergent beam that requires no structure inside the beam, except in the region of the electron gun. The focusing scheme is a variant of "Brillouin" flow. The effect of departing from a prescribed radial distribution of current density (to the extent of permitting the use of a uniform current density at the cathode, and no 'transition' section) is investigated and found to be sufficiently small for the proposed design. *Electron Gun for Microwave Tubes, C. Susskind, Stanford Electronics Labs. Stanford U., Calif., June 56, 54 pp, microfilm $3.60, photocopy $9.30. Order PB 134986 from Library of Congress, Washington 25, D.C.*

Semiconductor Nuclear Radiation Detectors

This bibliography is the outgrowth of a program initiated by the Basic Instrumentation Research Group of the Oak Ridge National Laboratory. The purpose of the program is to investigate the potential uses of semiconductors as nuclear radiation detectors. Most references on the uses of cadmium sulfide have been omitted, except for recent articles, because excellent bibliographies have already been prepared. Seventy-two listings are alphabetically arranged. *Bibliography on Semiconductor Nuclear Radiation Detectors, James L. Blankenship, Oak Ridge National Laboratory, Oak Ridge, Tenn., operated by Union Carbide Corporation for the U. S. Atomic Energy Commission, 9 pp, $0.50. Order ORNL-2583 from OTS, U. S. Dept. of Commerce, Washington 25, D.C.*

emiautomatic Production of lectronic Subassemblies

To permit fabrication of the plug-in assembly, was necessary to develop several unique process- concepts. Among these developments were following: Method of wiring pattern fabrica- n, component cap attachments, component sub- embly fabrication machinery, and pot solder- automatic potting equipment. The assembly ocess is such that all of the individual processes be made completely automatic if production lume warrants the cost of automatic equipment. wever, the break-even point for the production 1000 units per hour permits automation of 17 the 29 individual process steps. The assembly ocess can be adapted to at least 11 and probably circuits presently used in military electronic ipment. *Semiautomatic Production of Elec- nic Subassemblies, Final Development Rept. 31 May 51-51 Oct 56, lv, microfilm $4.80, pho- copy $13.80. Order PB 136673 from Library of ngress, Washington 25, D.C.*

operties of Matched Filters

Matched filters are defined and their properties optimum signal detectors discussed. The con- ion under which matched filters are realizable enumerated. The conditions for realizability unduly restrictive and a variety of synthesis thods are applicable. The method providing atest flexibility and adaptability is the synthe- procedure which employs tapped delay lines. his mode of synthesis is based upon the sam- ng theorem of frequency limited time functions. *operties of Matched Filters, D. W. Lytle, Stan- d Electronics Labs., Stanford University, Cali- nia. June 1957, 194 pp, microfilm $8.70, photo- py $30.30. Order PB 134991 from Library of ngress, Washington 25, D. C.*

mponent Evaluation Study

The major part of the program was a study of failure-rate characteristics of carbon-composi- n resistors during an extended operational load of 10,000 hours. In addition, other environ- ntal conditions were studied in an attempt to tablish a failure pattern for this type of resistor. e resistors used in the program were obtained m three manufacturers in order to represent a jor cross section of the present production ca- city. *Component Evaluation and Specification gineering, C. A. Shearer, E. N. Wyler and hers, Battelle Memorial Inst., Columbus, Ohio. al Report on Task 34, Carbon-Composition sistor Failure Rates, Oct. 1957, 51 pp, microfilm 60, photocopy $9.30. Order PB 133883 from brary of Congress, Washington 25, D. C.*

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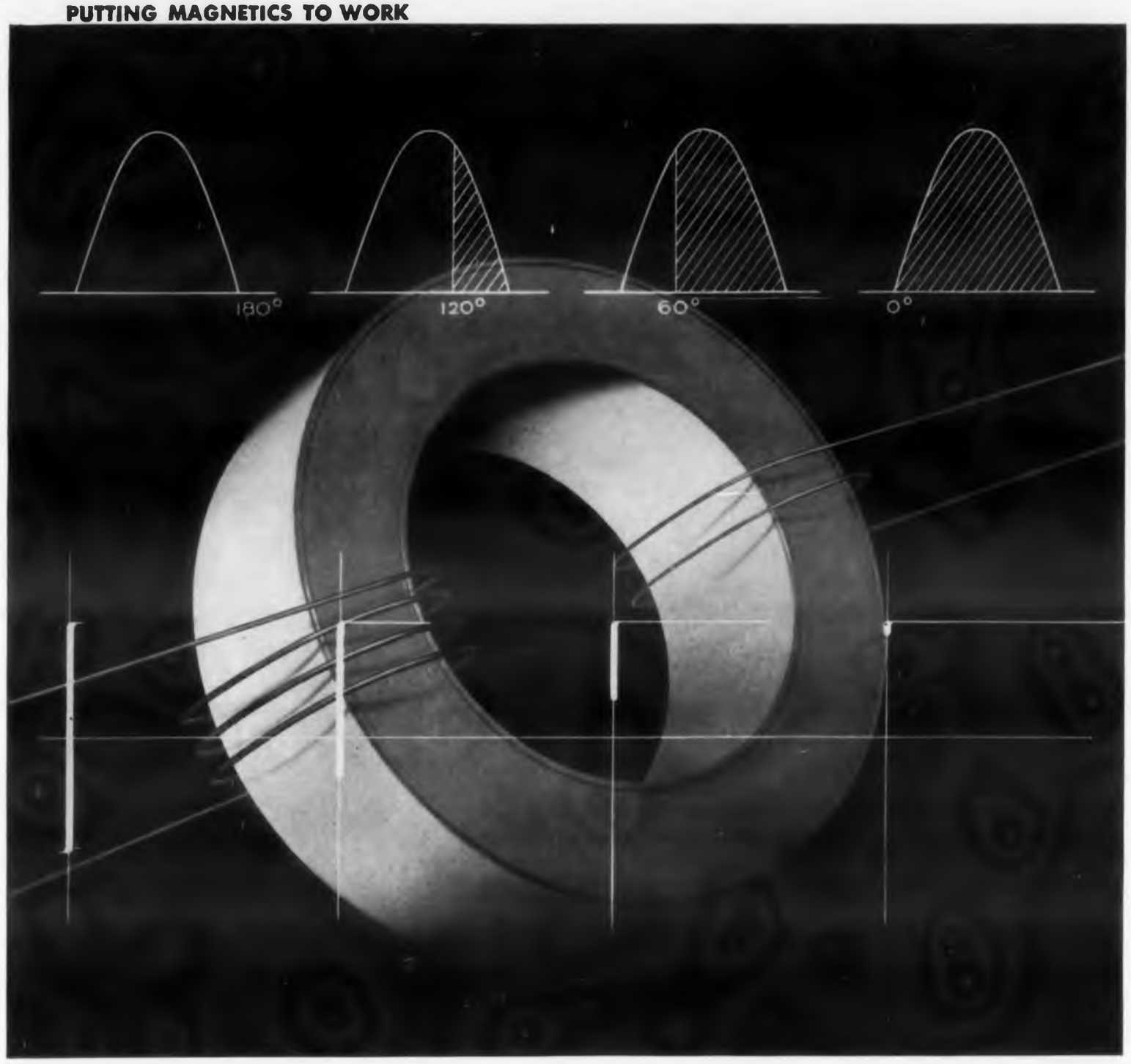


Nonlinear and Parametric Phenomena in Radio Engineering

Part 18

A. A. Kharkevich

(Translated by J. George Adashko)

Chapter 3

Response of Nonlinear Systems To External Signals

IN Chapter 1 we considered circuits with nonlinear resistances and the principal electronic processes that are based on phenomena in such circuits. In this chapter we shall consider more complex phenomena, which occur in nonlinear circuits containing reactances.

We shall also consider the forced modes of several self-oscillating and potentially self-oscillating systems. The last term denotes a system which can, under certain circumstances, generate oscillations, but whose initial state (in the absence of an external signal) is stable ("underexcited" system).

31. Rectifier Operation

A rectifying circuit always contains a filter of some sort to attenuate the alternating component of the rectified voltage. Thus, any real rectifying circuit should contain reactances. The simplest circuit is shown in Fig. 112. Let us find the output voltage U.

Assume for simplicity that the characteristic of the rectifier is specified in the form of the following dependence of the admittance on the voltage:

$$Y = \begin{cases} 0 \text{ when } U_r < 0 \\ \infty \text{ when } U_r > 0 \end{cases}$$

(Actually the forward and backward admittance are finite, but in a good rectifier their ratio is very large.)

If the resistance of the rectifier is constant over a certain voltage interval, its behavior within this interval is described by a linear equation. In the neighboring interval the relationship may also be a linear, but not necessarily the same. In our case the operation of the circuit is described by the following linear equations:

$$U = E \qquad (U_r > 0)$$

$$U + RI = 0 \quad (U_r < 0).$$

The rectifier voltage is obviously

$$U_r = E - U$$

Taking

$$E = E_m \sin \omega t$$

d expressing the current in (2) in terms of the oltage, we get

$$U = E_m \sin \omega t \qquad (E > U)$$

$$\frac{dU}{dt} + \frac{1}{RC} U = 0 \quad (E < U)$$

We obtain a periodic solution for our nonear equation by recognizing that the voltage U annot change abruptly. Consequently, the voltge within one interval (i.e., at $E > U$) can be set qual to the corresponding value of the voltage within the second interval (i.e., when $E < U$) at e common boundary of the two intervals (i.e. at $= U$). This is called the method of joining.

A qualitative picture of the phenomenon, which quite evident beforehand, is shown in Fig. 113. he voltage varies sinusoidally up to $t = t_1$; at is instant the capacitor voltage starts decreasing ss rapidly than the sinusoidal voltage E. The ctifier becomes blocked and the capacitor is disarged into resistance R. The discharge process ntinues until the instant $t = t_2$, when U and E come equal. In this instant the rectifier unocks and the subsequent variation in the voltge is sinusoidal until $t = t_1 + T$.

The discharge process obeys the exponential w

$$U = U_1 \epsilon^{-\alpha (t - t_1)} \qquad (3)$$

here

$$\alpha = 1/RC$$

he unknowns are the coordinates of points 1 and i.e. the quantities U_1, U_2, t_1 and t_2. To determine ese we need four equations.

The first equation relates U_1 and t_1:

$$U_1 = E_m \sin \omega t_1 \qquad (4)$$

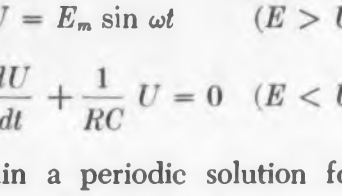
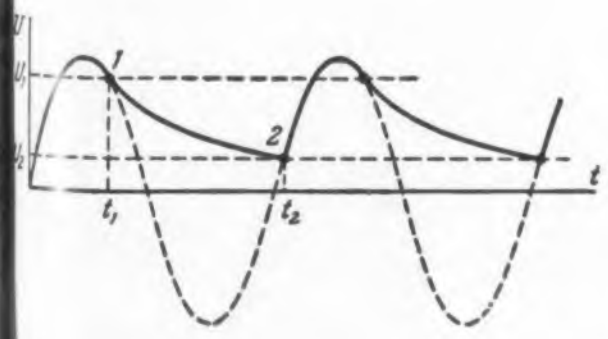


Fig. 112. The simplest type of rectifier.



g. 113. Voltage variations across the load of a mple half-wave rectifier.

RUSSIAN TRANSLATIONS

The second equation is obtained by equating, at this point, the derivatives of the exponential curve (3) and the sinusoidal one (2). This yields

$$-\alpha U_1 = \omega E_m \cos \omega t_1 \qquad (5)$$

Next we have, on the one hand,

$$U_2 = E_m \sin \omega t_2 \qquad (6)$$

and on the other

$$U_2 = U_1 \epsilon^{-\alpha (t_2 - t_1)} \qquad (7)$$

The system of equations (4) to (7) determines the unknown quantities. From (4) and (5) we get

$$\tan \omega t_1 = -\frac{\omega}{\alpha}$$

Expressing the sine in eq (4) in terms of the tangent, we get

$$U_1 = \frac{E_m}{\sqrt{1 + \frac{\alpha^2}{\omega^2}}}$$

Equating the right halves of (6) and (7), we obtain for t_2, a transcendental equation which cannot be solved analytically.

Grapically, however, this equation is very readily solved; the exponential curve (3) is drawn through point *1*, whose coordinates U_1 and t_1 are already known, until it intersects the sinusoidal curve at point 2. The coordinates of this point are indeed the sought values of U_2 and t_2. Depending on the value of the time constant 1 $\alpha = RC$,

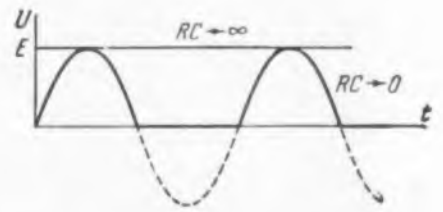


Fig. 114. The time constant *RC* of Fig. 112 determines the limits of the voltage variation of the exponential part (1-2) of the rectified signal.

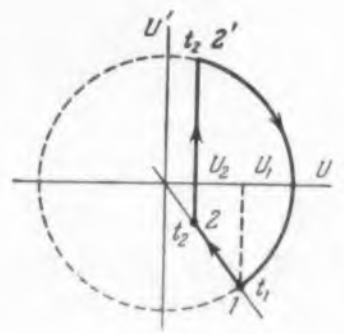


Fig. 115. The rectified voltage plotted on the *U*, *U'* plane.

we obtain a voltage that varies within the limits indicated in Fig. 114.

Let us plot the voltage diagram in the U, U' plane. A sinusoidal function is represented in this plane by a circle (if the coordinates are suitably selected). The plot of the exponential curve is obtained by differentiating (3).

$$U' = -\alpha U_1 \epsilon^{-\alpha (t-t_1)} \tag{8}$$

Dividing (8) by (3) we get

$$U'/U = -\alpha$$

The exponential variation of the voltage is thus represented in the U, U' plane by a straight line passing through the origin and having a slope $-\alpha$.

The diagram is of the form shown in Fig. 115. Segment *1–2* represents the exponential curve. At point 2 the derivative has a step discontinuity and the representative point jumps abruptly from position 2 to position 2′. The representative point then moves along the circular arc 2′–*1*, which corresponds in the time domain to the sinusoidal variation of the voltage.

The limiting cases shown in Fig. 114 are represented in the diagram as follows: As RC goes to zero, the inclined line becomes vertical and the diagram degenerates into a semicircle. When RC goes to infinity, the straight line becomes horizontal and the diagram contracts into a single point on the U axis, with coordinate $U = E_m$.

The $RC \rightarrow \infty$ mode is used as a particular application, in peak voltmeters, instruments that measure the maximum value of voltage.

32. Resonance in Nonlinear Circuits

Resonance in a circuit containing nonlinear elements, has certain substantial pecularities. We shall consider resonance in a series circuit containing a nonlinear capacitance.

We write the voltage equation for a series RLC circuit, assuming R and L to be constant and C to be dependent on the charge

$$LQ'' + RQ' + \frac{1}{C(Q)} Q = E_m \sin \omega t$$

or

$$Q'' + 2\alpha Q' + F(Q) = B \sin \omega t \tag{1}$$

We assume $F(Q)$ to be an odd function and put

$$F(Q) = \omega_0^2 (Q + \lambda Q^3) \tag{2}$$

Thus, the degree of nonlinearity in all the following relations is defined by the parameter λ; when $\lambda \rightarrow 0$ we return to the usual linear equations.

We seek a steady-state solution of (1) in the form

$$Q = a \sin \omega t + b \cos \omega t \tag{3}$$

RUSSIAN TRANSLATIONS

where a and b are constants. The amplitude of the charge is

$$A = Q_m = \sqrt{a^2 + b^2}$$

Substituting the solution (3) into (1) and equating the coefficients of sin ωt and cos ωt separately, we get the two equations

$$\left.\begin{aligned}(\omega_o^2 - \omega^2)\, a - 2\,\alpha\,\omega b + \frac{3}{4}\,\lambda\,\omega_o\, aA^2 = B \\ (\omega_o^2 - \omega^2)\, b + 2\,\alpha\,\omega a + \frac{3}{4}\,\lambda\,\omega_o\, bA^2 = 0\end{aligned}\right\}$$

Multiplying in turn by a and b, adding, and subtracting we obtain an equation containing only $A^2 = a^2 + b^2$:

$$\left(\frac{3}{4}\,\lambda\right)^2 \omega_o^4\, A^6 + \frac{3}{2}\,\lambda\,\omega_o^2\,(\omega_o^2 - \omega^2)\, A^4 + [(\omega_o^2 - \omega^2)^2 + \omega_o^2\omega^2 d^2]\, A^2 - B^2 = \phi\,(A^2, \omega^2) = 0 \qquad (4)$$

Solving for A we obtain the amplitude of the charge as a function of applied voltage B and frequency ω, i.e., an expression for the resonance curve.

However, a difficulty arises here, connected with the fact that equation (4) is cubic with respect to A^2. It is therefore better to solve it, not with respect to A^2, but with respect to ω^2, for which eq (4) is quadratic (it is biquadratic for ω). Rewriting (4) in the form

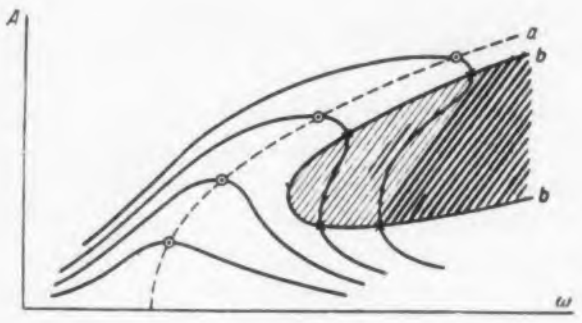
$$\omega^4 - 2\,\omega_o^2\left(1 + \frac{3}{4}\,\lambda\,A^2 - \frac{1}{2}\,d^2\right)\omega^2 + \omega_o^4\left(1 + \frac{3}{4}\,\lambda\,A^2\right)^2 - \frac{B^2}{A^2} = 0$$

we find a solution for this equation

$$\omega^2 = \omega_o^2\left[1 + \frac{3}{4}\,\lambda A^2 - \frac{1}{2}\,d^2 \pm \sqrt{\frac{B^2}{A^2} - d^2\left(1 + \frac{3}{4}\,\lambda A^2\right) + \frac{1}{4}\,d^4}\right]$$

The fact that we did not determine the amplitude as a function of the frequency, but, to the contrary, found the frequency as a function of the amplitude, does not change anything. From a graphical point of view this means only that the abscissa and the ordinate change places.

The high power of the equation for A indicates that the solution can be multiple valued. It is therefore useful to investigate the connection between A^2 and ω^2 by examining the extreme positions of the tangents to the curve that represents this relation. The derivative can be expressed in



(6.

Fig. 116. A family of resonance curves showing the charge variations A on a nonlinear capacitor in a series *RLC* circuit. The shaded area is an unstable region.

terms of the partial derivatives of the implicit function (4), namely°

$$\frac{dA^2}{d\omega^2} = -\frac{\frac{\partial \phi}{\partial \omega^2}}{\frac{\partial \phi}{\partial A^2}} \tag{5}$$

The tangent is horizontal when the derivative vanishes, i.e., when

$$\frac{\partial \phi}{\partial \omega^2} = 0 \tag{6}$$

This equality determines the position of the maxima of the resonance curve. The tangent becomes vertical when the derivative (5) goes to infinity, i.e., if

$$\frac{\partial \phi}{\partial A^2} = 0 \tag{7}$$

Let us find both partial derivatives; setting them equal to zero, we obtain

$$\omega^2 - \omega_o^2\left(1 - \frac{3}{4}\lambda A^2 - \frac{1}{2}d^2\right) = 0 \tag{8}$$

$$3\left(\frac{3}{4}\lambda\right)^2 \omega_o^4 A^4 + 4\left(\frac{3}{4}\lambda\right)(\omega_o^2 - \omega^2)A^2 + (\omega_o^2 - \omega^2)^2 + d^2 = 0 \tag{9}$$

Eq (8) is the equation of the locus of the maxima of the family of resonance curves. Eq (9) is the locus of the points where the resonance curve has a vertical slope.

The family of resonance curves is shown in Fig. 116. We see that the curves are inclined to the right. The greater the maximum amplitude, when the nonlinearity manifests itself more strongly, the greater the slope (Note that with $\lambda < 0$, the curve would slope to the left). The

° By examining the connection between A^2 and ω^2 (instead of the connection between A and ω) we do not change the character of the singular points of the curve. All that changes is the scale of the graph, i.e., the linear scale is replaced by a quadratic one.

RUSSIAN TRANSLATIONS

graph shows also the plots of eq (8) (curve *a*) and eq (9) (curve *b*). The maxima of the resonance curves are marked by circles. The points at which the tangents to the resonant curves are vertical are marked by crosses.

If a nonlinear resonance curve of the type shown in Fig. 116 is plotted experimentally, the following phenomena take place. As the frequency is increased, the amplitude of the oscillation increases, reaches a maximum, and then diminishes to a value corresponding to the point of vertical tangency. At this place the amplitude decreases abruptly to a value corresponding to the lower branch of the curve (Fig. 117) and then continues to decrease monotonically.

If the curve is plotted for decreasing frequency, the amplitude first increases monotonically, and then breaks away to the upper branch of the curve, as shown in the same Fig. 117. Thus, the discontinuity in amplitude occurs at two different values of the frequency, depending on whether the frequency is increasing or decreasing. The portion of the resonance curve between the discontinuity points (dotted line on Fig. 117) corresponds to the unstable modes, which cannot be observed when the resonance curve is plotted. Consequently, the region bounded by curve *b* is the instability region, which is shown shaded in Fig. 116.

Analogous phenomena are observed also in the case of a nonlinear inductance, i.e., if the circuit contains inductors with ferromagnetic cores. The

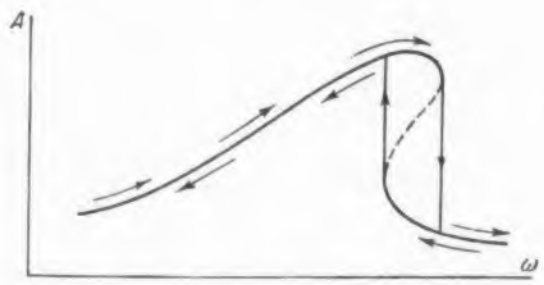


Fig. 117. A nonlinear resonance curve. The amplitude of charge *A* can change abruptly at two different frequencies, depending on whether the frequency is increasing or decreasing. The dotted line represents an unstable mode.

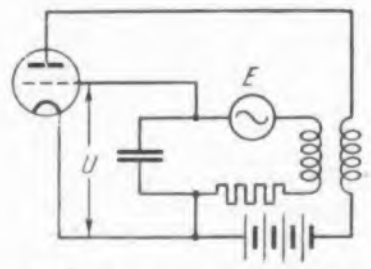


Fig. 118. A tuned grid oscillator.

resonance phenomena in such a circuit is usually called ferroresonance.

In conclusion we note that resonance is possible in a nonlinear circuit also at a fractional frequency, i.e., at a frequency equal to a certain fraction of the frequency of the applied voltage. In other words, resonance in a nonlinear circuit can be used for frequency division. For example, ferroresonant frequency dividers with a 1:3 ratio are used quite frequently.

33. Self Oscillating Systems Excited by An External Signal

In this section we shall derive several general relations which will be used later to analyze many technical problems. We shall deal with a self-oscillating system excited by an external voltage. Any self-oscillating system is nonlinear; an external voltage produces in such a system many unique nonlinear phenomena that are used in radio engineering.

Let us derive the equation of the circuit of Fig. 118, which shows a tuned grid oscillation. This circuit differs from that previously considered that it contains an additional applied voltage $E = E_m \cos \omega t$. Denoting the grid voltage by U, we get

$$U'' + 2\beta U' + \omega_o^2 U = \omega_o^2 E_m \cos \omega t \quad (1)$$

where as before, we denote

$$\omega_o^2 = \frac{1}{LC}, \; 2\beta = 2\alpha - \omega_o^2 MS$$

Let the characteristic of the tube be approximated by a third-degree polynominal; then

$$S = a_2 + 3a_3 U^2, \; 2\beta = 2\beta_o + \gamma U^2$$

where

$$2\beta_o = 2\alpha - \omega_o^2 MS_o, \; \gamma = 3\omega_o^2 Ma^3$$

Using these relations and symbols, we rewrite (1) in the form

$$U''' + (2\beta_o + \gamma U^2) U' + \omega_o^2 U = \omega_o^2 E_m \cos \omega t \quad (2)$$

We seek a solution of eq (2) in the form

$$U = A \sin (\omega t + \phi) \quad (3)$$

where A and ϕ are the unknown amplitude and phase, which in general are functions of time, a factor that must be taken into account when differentiating. Thus, the first derivative of (3) will be

$$U' = A' \sin (\omega t + \phi) + A (\omega + \phi') \cos (\omega t + \phi)$$

Let us insert the solution (3) into (2), and discard terms containing the third harmonic in the substitution for U^2U'. We also discard the term containing A'' (since A is a slowly varying function

RUSSIAN TRANSLATIONS

compared with sin ωt). We then expand the right half of (2) by using the formula

$$\cos \omega t = \cos \phi \cos (\omega t + \phi) + \sin \phi \sin (\omega t + \phi)$$

and equate separately the coefficients of sin $(\omega t + \phi)$ and cos $(\omega t + \phi)$ in the right and left halves. This gives us two equations

$$\left.\begin{aligned} \left(2\beta_o + \frac{3}{4}\gamma A^2\right) A' + (\omega_o^2 - \omega_1^2)\, A &= \omega_o^2\, E_m \sin \phi \\ 2\omega_1 A' + \left(2\beta_o + \frac{1}{4}\gamma A^2\right) \omega_1 A &= -\omega_o^2\, E_m \cos \phi \end{aligned}\right\} (4)$$

Here we denote

$$\omega_1 = \frac{d}{dt}(\omega t + \phi) = \omega + \phi'$$

We are interested principally in the steady state, when

$$A' = \phi' = 0$$

Under this condition we obtain from (4) equations for the steady-state amplitude and phase

$$\left.\begin{aligned} (\omega_o^2 - \omega^2)\, A &= \omega_o^2\, E_m \sin \phi \\ \left(2\beta_o + \frac{1}{4}\gamma A^2\right) \omega A &= -\omega_o^2\, E_m \cos \phi \end{aligned}\right\} \quad (5)$$

In the absence of an external voltage, i.e., when $E_m = 0$, the first equation gives us the self-oscillation frequency

$$\omega = \omega_o$$

and the second equation gives us the steady-state amplitude of a self excited oscillator

$$A_o = \sqrt{-\frac{8\beta_o}{\gamma}} = \sqrt{\frac{4}{3}\,\frac{a_1 - R\,\dfrac{C}{M}}{a_3}} \quad (6)$$

which we already know from Section 21. Squaring eq (5) and adding, we get

$$\left[(\omega_o^2 - \omega^2)^2 + \omega^2\left(2\beta_o + \frac{1}{4}\gamma A^2\right)^2\right] A^2 = \omega_o^4\, E_m^2 \quad (7)$$

This relation makes it possible to find the amplitude of the steady-state oscillations. This amplitude depends: (1) on the amplitude of the external voltage E_m, (2) on the detuning $\omega_o^2 - \omega^2$, (3) on the initial damping $\beta_o = \alpha - 1/2\ \omega_o^2\, MS_o$, and (4) on the nonlinearity of the characteristic, expressed by the coefficient $\gamma = 3\omega_o^2\, MA_3$.

If we find the amplitude A as a function of frequency, using eq (7), we obtain an expression for soft resonance curves. Here, however, we come up against the same difficulty as in the preceding section and in the investigation of nonlinear

resonance; we obtain a sixth order equation with respect to A. This difficulty is overcome in the same manner—by inverting the relationships of interest to us.

Under certain conditions the solutions of eq (7) are unstable. The limits of the instability region can be determined as the locus of the points at which the tangents to the resonance curves are vertical, in analogy with the procedure used in the preceding section.

Let us assume that the detuning is small, i.e., $\omega \cong \omega_o$ and let us denote

$$\Delta\omega = \omega_o - \omega$$

Using in addition eq (6), we can transform (7) into

$$\left[\frac{\Delta\omega^2}{\beta_o^2} + \left(1 - \frac{A^2}{A_o^2}\right)^2\right]\frac{A^2}{A_o^2} = \frac{\omega_o^2 E_m^2}{4\beta_o^2 A_o^2} \qquad (8)$$

or, putting for brevity

$$\frac{\Delta\omega}{\beta_o} = x, \quad \frac{A^2}{A_o^2} = y, \quad \frac{\omega_o^2 E_m^2}{4\beta_o^2 A_o^2} = E$$

in the form

$$y[x^2 + (1-y)^2] - E = F(x,y) = 0 \qquad (9)$$

Thus eq (7) for the resonance curves has been reduced to eq (9) in the variables x and y. The first variable is proportional to the detuning, and the second is the square of the relative amplitude (i.e., of the amplitude A in the presence of an external voltage, referred to the amplitude A_o of the self oscillations in the absence of an external voltage). The plot of y vs x represents, on a certain scale, the resonance curves.

Eq (9) is cubic with respect to y and quadratic with respect to x. The calculations are therefore simpler if it is solved with respect to x. The geometric meaning of such an inversion was explained previously.

Let us investigate the derivative

$$\frac{dy}{dx} = -\frac{\frac{\partial F}{\partial x}}{\frac{\partial F}{\partial y}}$$

The equation for the coordinates of the maxima is obtained by setting the derivative equal to zero, which yields $\delta F/2x = 0$. We have

$$\frac{\partial F}{\partial x} = 2yx = 0 \qquad (10)$$

It follows therefore that the maxima lie on the vertical line $x = 0$, which corresponds to the absence of detuning, i.e., to $\omega = \omega_o$; the x axis, whose equation is $y = 0$, is the asymptote of the family of resonance curves.

The derivative dy/dx goes to infinity (the tan-

RUSSIAN TRANSLATIONS

gents to the resonance curves are vertical) at the points for which

$$\frac{\partial F}{\partial y} = 0$$

This equality is the limit of the region of stable solutions. Differentiating (9) with respect to y we get

$$\begin{aligned} \partial F &= x^2 + (1-y)^2 - 2y(1-y) \\ \partial y &= x^2 + (1-y)\,(1-3y) = 0 \end{aligned} \qquad (11)$$

This is the equation of an ellipse whose center is at the point $x = 0$, $y = 2/3$ and whose vertical semi-axis is equal to 1/3. The upper horizontal tangent to the ellipse thus passes through $y = 1$. The region inside the ellipse corresponds to the unstable modes. A detailed analysis of the stability shows that in addition to condition just found there exists still another stability condition, namely

$$y > \frac{1}{2}, \text{ i.e. } A > \frac{1}{\sqrt{2}} A_o$$

Thus, if the amplitudes of the "forced" oscillations are small, the mode becomes unstable. The horizontal line

$$y = \frac{1}{2}$$

is the lower limit of the stability region.

The plots of functions (9) together with the boundary lines (11) and (12) are shown in Fig. 119. The instability regions are shown shaded.

It must be noted that to explain the character

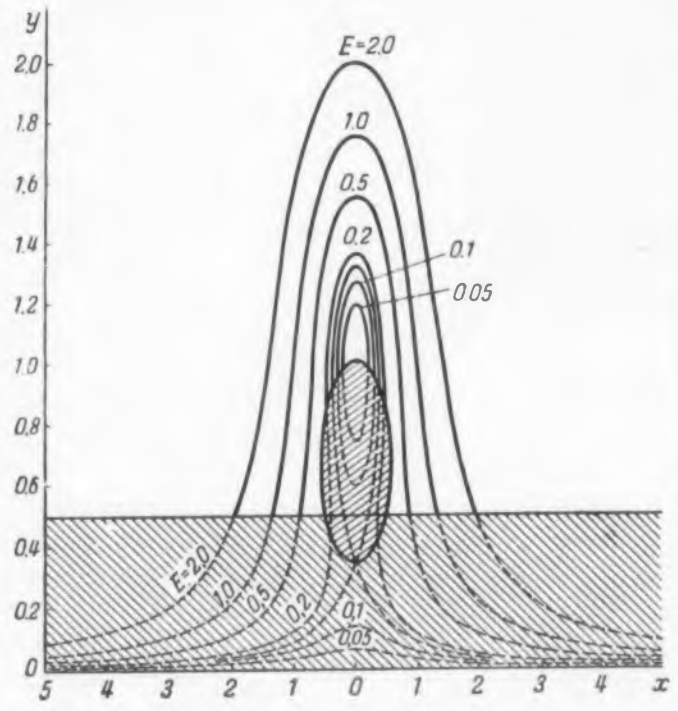


Fig. 119. A plot of eq (9) and the boundaries given by eq (11) and (12). The unstable regions are shaded.

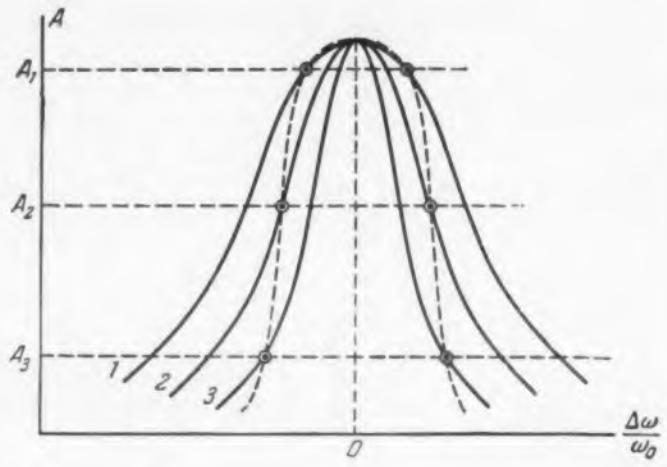


Fig. 120. A family of ordinary resonance curves.

of the relationship (7) a non-rigorous but very lucid device is frequently resorted to. This consists of rewriting formula (7) in the form

$$A = \frac{E_m}{\sqrt{\left(\frac{\omega_o^2 - \omega^2}{\omega_o^2}\right)^2 + \frac{\omega^2}{\omega_o^2}\left(\frac{2\beta_o}{\omega_o} + \frac{1}{4}\,\frac{\gamma}{\omega_o}A^2\right)^2}}$$

or, assuming the detuning to be small

$$A \cong \frac{E_m}{\sqrt{\epsilon^2 + \left(d_o + \frac{1}{4}\,\frac{\gamma}{\omega_o}A^2\right)^2}} \qquad (13)$$

where $E = 2\Delta\omega/\omega_o$ is the usual symbol for the relative detuning, and $d_o = 2\beta_o/\omega_o$ is the initial damping.

The last formula serves as the expression for the resonance curve. It differs from the usual one in that the damping depends on the amplitude (the second term under the square root).

In this way it is possible to proceed to set up eq (13) by starting with a family of ordinary resonance curves for various values of damping. Such a family is shown on Fig. 120. At large amplitudes (A_1 in Fig. 120) the damping is large and corresponds to resonance curve *1*. At a smaller amplitude A_2, the damping is correspondingly smaller, and we have the narrower resonance curve *2*. A still smaller amplitude A_3 and a still smaller damping correspond to resonance curve *3*. By joining the points marked on the diagram with a dotted line we obtain the outline of the resonance curve.

Let us remark in conclusion that the stability condition based on the first equation in (5) can be expressed in terms of the angle ϕ (which determines the phase shift between the external voltage and the free self oscillation) in the form

$$-\frac{\pi}{2} < \phi < \frac{\pi}{2}.$$

(To be continued).

GERMAN ABSTRACTS

E. Brenner

Frequency Stability of Os

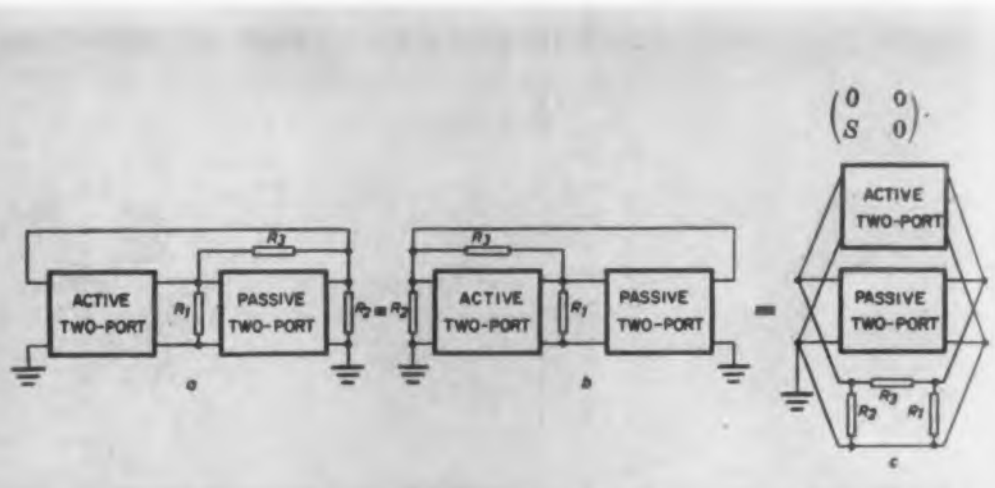


Fig. 1. Three equivalent methods of representing the losses in an oscillator for linear analysis.

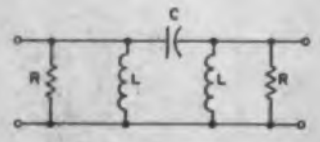


Fig. 2. Coupling network with fixed losses.

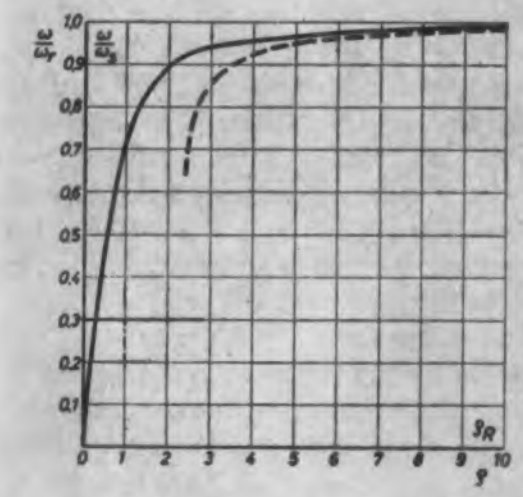


Fig. 3. Relationship between oscillator frequency and loss factor for the two-ports of Fig. 2 (solid line) and Fig. 5 (dashed line).

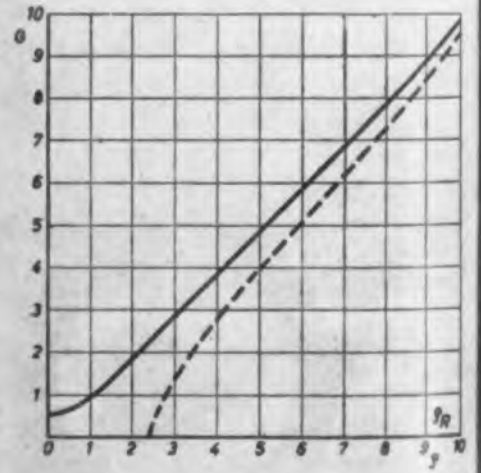


Fig. 4. Stability factor G for oscillators using frequency selective two-port Fig. 2 (solid line) and Fig. 5 (dashed line).

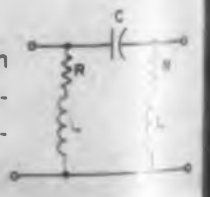


Fig. 5. A two port which when represented as in Fig. 1b has resistances which are frequency dependent.

y of Oscillators

REQUENCY stability of oscillators is determined, to a large extent, by the phase-frequency characteristics of the open loop. These characteristics in turn are determined principally by the phase response of the frequency selective feedback network. If $\theta(\omega)$ is the output phase-frequency characteristics of the feedback two port, a stability factor, G, is defined as

$$G = \left[\frac{d(\tan\phi)}{d\omega} \cdot \frac{\omega}{2}\right]_{\omega=\omega_o}$$

where ω_o is the (nominal) frequency of the oscillator.

While the losses in the oscillator may be represented either as part of the active or of the passive two-port, these representations are equivalent as long as linear operation is assumed (Fig. 1). Nevertheless when the general form is analyzed, the equivalent resistances of R_1, R_2 and R_3 may or may not be functions of the frequency depending on where, in the actual circuit, the losses occur.

Analysis of the lossless feedback coupling network with constant resistance termination shown in Fig. 2, shows that the resonant frequency is related to the loss-factor by the solid curve of Fig. 3 and the stability factor G is given by the solid curve of Fig. 4. The parameters are defined by

$$\omega_r^2 = 1/(2\,LC),\ \rho_r = R/(\omega_r L)$$

When the losses occur in the reactive branches of the frequency selective network, as in Fig. 5, the frequency and stability characteristics are shown by the dashed curves of Figs. 3 and 4. The parameters in the case are

$$\omega_s^2 = 1/(2\,LC),\ \rho = \omega_s L/R$$

In the original paper similar results are given for a more elaborate frequency selective two-port.

Abstracted from an article by W. Herzog, Nachrichtentechnische Zeitschrift, *Vol. 12, No. 1, January 1959, pp 21-28.*

oscilla-
ve two-
Fig. 5

GERMAN ABSTRACTS

E. Brenner

Microwave Ca

FOR THE precise measurement of high pea power in microwave systems, a variety calorimeters have been devised. In most of thes the lossy element is placed in the region of highe electric intensity within the waveguide proper. A a result, the possibility of electric breakdown generally great. This defect can be overcome in broadband (X-band, 8.2-12.4 kmc) calorimeter which the dissipative structure is not inserted

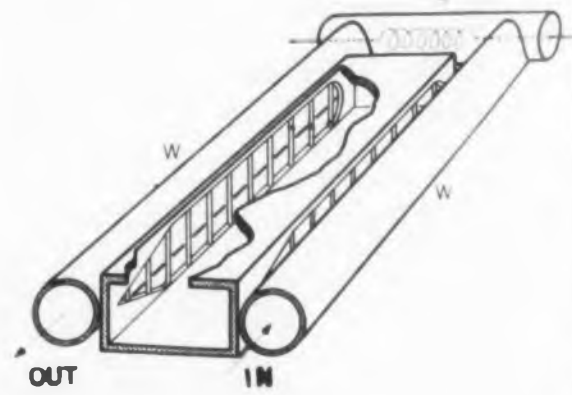


Fig. 1. Schematic of the calorimeter. The coupled wav guide section is *W*, the heat sensitive element is *H*. Th arrows show the circulation of the lossy dielectr liquid. The entire unit is contained in a metal case.

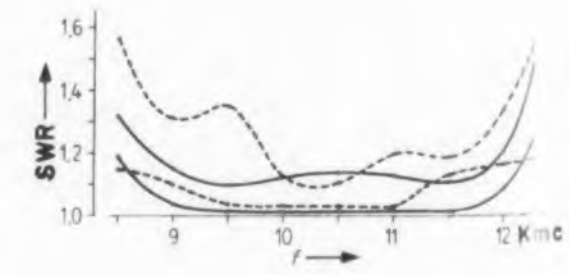


Fig. 2. Maximum and minimum SWR as a fu frequency for a coupling section 210 mm lon spacing 13 mm, tube diameter 12 mm. The so were obtained with glycol, the dotted curves co to distilled water.

CTS

Brenner

...wave...calorimeter

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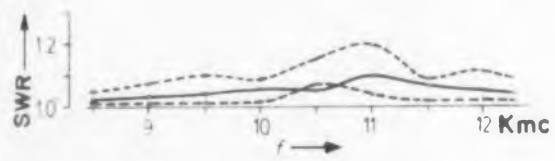


Fig. 3. Broadband characteristics as in Fig. 2 but for 20 mm coupling section. For glycol the minimum and maximum SWR curves coincide.

The main guide but coupled to it by means of a grid structure in the side walls. A substitution method is used to measure power and the total error is below 2 per cent.

The physical structure of the calorimeter is shown in Fig. 1. The wire grid is chosen as the coupling element to avoid interrupting the current flow lines in the side walls over long distances. Compared to a long coupling slit, the wire structure has lower coupling factor, disturbs the field distribution to a lesser extent and consequently is less subject to breakdown.

The design of the coupled structure is carried out experimentally by investigating the influence of wire spacing, diameter of lossy guide sections and dielectric constant on the standing wave ratio (swr). A variable short at the end of the guide structure is used to determine the maximum and minimum swr. Using a wire of 1 mm thickness and spaced at 10, 13 and 16 mm, the minimum swr was found to be 13 mm spacing for both Ethlyn-glycol and distilled water. The result is independent of tube diameter within the range 9-16 mm.

Because the dielectric constant of glycol ($\varepsilon_r \cong 7$) is much smaller than that of distilled water ($\varepsilon_r \cong 60$) glycol has favorable broadband characteristics (Figs. 2 and 3).

Abstracted from an article by T. Jaeger, Archiv der Elektrischen Uebertargung, *Vol. 13, No. 1, January 1959, pp 21-25.*

LETTERS

Electronics in Israel

Dear Sir:

During a recent visit to the Weizmann Institute, one of your contributing editors, Mr. J. G. Adashko, suggested your magazine might be interested in a short article on Electronics in Israel. Enclosed is a brief resume of the history, present development, and future prospects of electronics in Israel. Much of the historical data has been obtained through the help of Dr. E. H. Frei, head of the Department of Electronics at the Institute. My own background includes the position of staff member and later, project engineer at the Microwave Standards Section of the National Bureau of Standards (1945-1957) and Member of the technical staff, Microwave Laboratories, Hughes Research and Development Labs (1957). I am presently spending a year at the Weizmann Institute of Science doing instrument design.

Albert A. Feldmann
The Weizmann Institute of Science
Rehovoth, Israel

▶ We hope our readers will be interested in Mr. Feldman's article, which is summarized here.

Among the most important aims of Israel is the industrialization of its economy. Inevitably, in today's terms, this means the utilization of electronics for industrial processes and the actual production of electronic components and equipment. Thus, a number of steps have been taken towards the establishment of an electronics industry.

Like many other of Israel's fledgling industries, the electronics industry was started during the second World War. The country, then part of the British Mandate of Palestine, was the arsenal and the repair shop of the Allied armies in the Middle East. Much know-how was acquired in the repair and re-building of all kinds of communications equipment and the production of small components was started with a guaranteed market. Here the transmitting and receiving equipment was built to supply much of the European underground. Among the skills acquired was that of grinding crystals for communications purposes. Today the "Tadir" Company supplies crystals for all needs, civilian and military. A number of companies were started to build radio receivers.

Competition and gradual saturation of the local market cut them down to about four which are producing 25,000 sets a year. The receivers are of good quality, though somewhat expensive by American standards. For the most part, all-band receivers are manufactured and sold in well-styled wooden cabinets of careful workmanship.

A number of small companies make coils, relays and transformers, both power and if type. Amrad, a company which manufactures receivers also produces variable capacitors, Mica capacitors, trimmers and permanent magnet speakers for low and high frequencies (woofers and tweeters). Several years ago, an American company, the New London Instrument Company, entered the electronics field. The local company, "American-Eastern Company," continues to supply a line of electronic instruments such as VOM's VTVM's signal generators, frequency meters and the like. A manufacturer of electrical switches and circuit breakers has recently started to add electronic control equipment to his products. In general, production quantities are small by American standards, some items being produced on a semi-custom basis. But the know-how is there and production can be increased by many times over the present rate. In the communication field such as telephone, telegraph and radio services, all equipment used is efficient and up-to-date. Automatic telephone exchanges permit direct dialing between major cities and microwave installations are used in point to point communications. Some of this equipment is produced locally by companies like "Telrad" which make telephone sets and some radio equipment.

Skilled manpower is important in the process of industrialization. The Israel Institute of Technology in Haifa turns out graduates in all branches of engineering and physics, including electronics. The scholastic level is high as testified to by the good and often brilliant record of students accepted at American universities for graduate studies. Active research is carried on in many fields, one of the most notable being the utilization of solar energy. Research work and training on a graduate level is offered at the Hebrew University in Jerusalem and at the Weizmann Institute of Science in Rehovoth. At present some semi-conductor work and investigations in solid state physics are pursued at the University. The Electronics Department of the Weizmann Institute is charged with scientific instrumentation for other departments in addition to its research activities. The most spectacular achievement so far has been the design and construction of a 40-digit binary electronic computer similar to the type developed at the Institute for Advanced Study in Princeton, N.J. In addition, a good deal of hardware has come out of the laboratories.

(continued on following page)

LETTERS

Some such as a precision viscometer and a microviscometer are used by researchers at Yale and Birmingham Universities. The research work is at present concentrated in the field of magnetism, dealing with permanent magnets in general and ferrites in particular. The work of all three institutions appears frequently in American scientific journals.

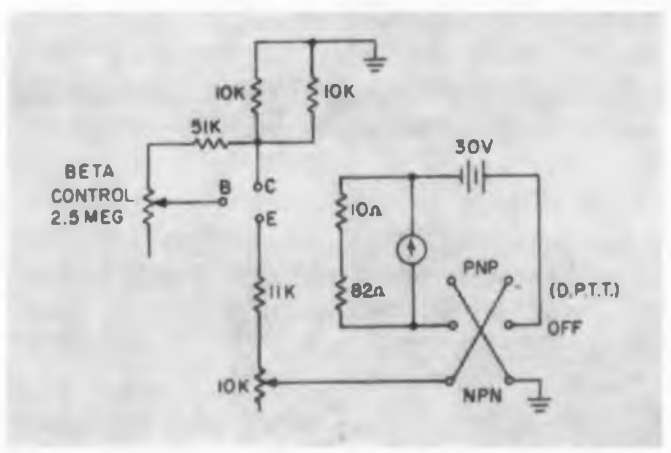
At present, the electronics industry in Israel needs markets. A lasting peace with her neighbors would be, among other things, a great benefit commercially to this country.

Design Ideas Utilized

Dear Sir:

The article, "Simple Beta Tester for Small PNP's" by J. M. Tewksbury in the November 26, 1958 issue of ELECTRONIC DESIGN (p. 91), was the inspiration for a handy, portable Beta Tester with some versatility (Fig. 1). Pnp's or npn's can be tested at the one milliamp and five volt level. This unit is easily built out of "scrap box" parts with possibly the additional cost of a meter (one milliamp sensitivity) and a battery.

A current of one milliamp is set (with the transistor installed, Fig. 2), by adjusting the Beta Con-



trol. The shunted meter then reads at the center of the scale. Beta is then read directly from the calibrated dial of the potentiometer.

Calibration of the dial is accurate enough using a reliable ohmmeter and, neglecting the error in emitter-base voltage, using Ohm's Law to calculate base current at five volts. Then DC Beta is simply $\beta = Ic/Ib$ and can be plotted on the dial face. Diodes can be tested quickly by clipping them into the emitter and collector terminals. Then a flip of the switch from pnp to npn compares forward and reverse characteristics. Current limiting series resistors prevent excessive currents from damaging the diodes.

An additional control was used to compensate for aging of the battery.

The portability of the device makes it a handy addition to almost any laboratory or shop.

Richard E. Risely
Systems Research Laboratory
Motorola, Inc.
Riverside, Calif.

▶ We are glad to see another of our "Ideas for Designers" put to good use. We occasionally get carbon copies of correspondence between readers and contributors (a practice we like to encourage) and are aware that many of you profit by the Ideas for Design department.

Go, No-Go, and Maybe

Dear Sir:

Your editorial entitled "Go, No-Go, No Good," which appeared in the December 10, 1958 issue of ELECTRONIC DESIGN, was read with great interest here at DIT-MCO, Inc. For some time we have been concerned with the ideas presented in your editorial—injecting intelligence or information into a "Go, No-Go decision" where necessary. Since we have found a solution to this problem, we believe you will be interested in our approach.

We design and manufacture automatic checkout equipment for electrical circuitry and wiring systems. This equipment is essentially of the "Go-No Go" type in that it will accept or reject the circuits under test. Let us suppose the circuit under test is "good." The equipment advances to the next circuit. If the circuit is "no good", the equipment does not advance. However, after each decision, the equipment *can* provide information on which a human, intelligent decision can be based. Also we know "how good" each "good" circuit is and can easily determine "how bad" each "bad" circuit is. If no decision-making information is required, the equipment can function solely as a "Go-No Go" tester.

Let us assume the decision of the equipment on a given circuit is "good." Because the decision was

(continued on following page)

LETTERS

"good" we know the following things are true about the circuit.

1. There is continuity.
2. The continuity resistance is below a predetermined engineering standard ("how good" information).
3. The circuit is not shorted to any other circuit.
4. The insulation resistance or leakage resistance is above a predetermined engineering standard ("how good" information).
5. Relays, solenoids or other resistive devices which are an integral part of the circuit under test, are operating properly.

If more explicit information is required, a vacuum-tube ohmmeter can be switched into the circuit to read the actual values of continuity resistance and insulation or leakage resistance. (More "how good" information).

Now let us assume the decision of the equipment on a given circuit is "no good." With this decision the equipment immediately stops. Instantly, the nature and location of this fault is known merely by looking at the equipment. If a short circuit is present, the "short" light will glow; if an open circuit is present, the "open" light will glow. In addition, two lights cross-referenced on the Matrix Chart to indicate exactly which circuit is faulty. The cross-referenced position on the Matrix Chart contains a condensed summary of all circuit information, including identifying numbers, connector and pin numbers, terminal connections, wire number, etc. The following data, which may be termed "how bad" information, can be obtained by merely switching the vacuum-tube ohmmeter into the circuit.

1. Open circuit indication—the circuit is actually open, (infinite resistance reading on meter), or circuit continuity resistance is above predetermined engineering standard (finite resistance reading).
2. Short circuit condition—the circuit is actually shorted to another circuit (very low resistance reading), or the insulation or leakage resistance is below the predetermined value (resistance reading below engineering standard).

This, briefly, is the way we inject decision making information or intelligence into a machine "Go-No Go" decision. We would be very interested in your criticisms of our solution to this timely problem.

W. Sherm Timmons
Sales Dept., DIT-MCO, Inc.
Kansas City, Mo.

▶ Mr. Timmon's approach sounds good to us. We'd like to hear what others think. Frankly we thought our Editorial would be criticized by some but we failed to get any negative comments. (One company thought it worthwhile enough to reprint.) Your opinions are welcomed.

MEETINGS

Calendar of Events

May

18-29 Electronic Parts Distributors Show, Chicago, Ill.

19-20 Fifth National Symposium on Instrumental Methods of Analysis, Instrument Society of America, Hotel Shamrock Hilton, Houston, Tex.

19-21 AIEE Middle Eastern District Meeting, Baltimore, Md.

20-22 National Spring Meeting, Society for Stress Analysis, Sheraton Park Hotel, Washington, D.C.

22 Regional Technical Conference, Society of Plastics Engineers, Van Orman Hotel, Fort Wayne, Ind.*

25-27 National Telemetry Conference (IAS, ISA, AIEE, ARS), Denver, Colo.

25-28 1959 Design Engineering Show and ASME Conference, Convention Hall, Philadelphia, Pa.*

25-29 International Convention on Transistors and Associated Semi-Conductor Devices, London, England

June

1-3 IRE-PGMTT National Symposium, Paine Hall, Harvard University, Cambridge, Mass.*

1-3 National Symposium in Microwave Theory and Techniques (IRE), Cambridge, Mass.

3-5 Armed Forces Communications and Electronics Association Annual Meeting, Washington, D.C.

4-5 Third National Conference on Production Techniques (IRE), San Mateo, Calif.

8-11 Semi-annual Meeting, American Rocket Society, San Diego, Calif.

10-12 Second International Symposium on Gas Chromatography (ISA), East Lansing, Mich.

14-18 American Society of Mechanical Engineers, Semi-annual Meeting, Chase-Park Plaza Hotel, St. Louis, Mo.

15-18 Summer Meeting, Institute of Aeronautical Sciences, Los Angeles, Calif.

15-20 First International Conference on Information Processing, Paris, France*

15-20 Symposium on Electromagnetic Theory, Univ. of Toronto, PGAP, URSI, University of Toronto, Ont., Canada

16-18 International Symposium on Circuit and Information Theory (IRE), Los Angeles, Calif.*

17-20 1959 Engineering Progress Exposition, National Society of Professional Engineers, Hotel Commodore, New York City, N.Y.

17-27 International Plastics Exhibition, London, England

21-26 Summer and Pacific General Meeting AIEE, Olympia Hotel, Seattle, Wash.

22-26 ASEE-ASTM Symposium on Education in Materials, Atlantic City, N.J.

24-26 Second Nuclear Instrumentation Symposium, Idaho Falls, Idaho

24-28 International Conference on Medical Electronics, UNESCO, Rockefeller Institute, IRE-PGME, Paris, France

29-1 National Convention on Military Electronics (IRE), Washington, D.C.

* Indicates meetings described herewith.

MEETINGS

Regional Technical Conference, Society of Plastics Engineers, May 22.

Van Orman Hotel, Fort Wayne, Ind. Co-sponsored by the Northern Indiana Section of the Society of Plastics Engineers and the SPE Professional Activity Group on Plastics in Electrical Insulation, the meeting is of interest to all engaged in electrical and electronic applications. The program will feature encapsulation, printed circuits and fluidized bed process. Advance registration arrangements may be made with F. C. Avila, c/o General Electric Co., Laboratory, 1635 Broadway, Ft. Wayne, Ind.

1959 Design Engineering Conference and concurrent Design Engineering Show, May 25-28.

Sponsored by ASME, Convention Hall, Philadelphia, Pa. Sessions will be devoted to Engineering Design Overseas, Materials, Power and Control, Mechanical, and General Engineering topics. The Show will consist of more than 400 exhibitors representing manufacturers in the fields of: mechanical components, power transmission equipment, electrical and electronic components, metals, nonmetalic materials, fasteners and adhesives, finishes and coatings, shapes and forms, hydraulic and pneumatic components, engineering equipment. Reservations through: Mr. S. C. Mitri, ASME, 29 West 39th St., New York 18, N.Y.

1959 IRE National Symposium, June 1-3.

Sponsored by PGMTT, Paine Hall, Harvard University, Cambridge, Mass. Papers to be presented include those on microwave amplifiers, phase shifters, and filters. Another group includes microwave research in Japan, various universities, and industrial laboratories. An evening session involves a visit to the Cambridge Electron Accelerator. Other topics cover masers, analytical technical techniques, ferrites, variable reactance diodes and their use in parametric amplifiers. Arrangements can be made through W. H. From, Ewen Knight Corp., 206 A Street, Needham, Mass. Registration fee is $3.00 for IRE members, $5.00 for non-members, students, free. Ladies program included.

International Symposium on Circuit and Information Theory, June 16-18

University of California, Los Angeles, Calif. The purpose of the Symposium will be to consider recent advances in Information Theory and Circuit Theory, and in particular to explore areas

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of interest common to two disciplines. For information contact: *Dr. G. L. Turin, Hughes Research Laboratories, Culver City, Calif.*

1st International Conference on Information Processing, June 15-20

UNESCO House, Paris. The conference program has been expanded to six major topics: 1. Method of Digital Computing; 2. Logical Design of Digital Computers; 3. Common Symbolic Language for Digital Computers (includes Automatic Programming); 4. Automatic Translation of Languages; 5. Collection, Storage, and Retrieval of Information; 6. Pattern Recognition and Machine Learning. The formal technical program will be held in plenary sessions. Thus there will be time to visit AUTOMATH 1959, a major technical exhibit, which opens before these sessions and closes afterwards.

Third National Convention on Military Electronics, June 29-July 1.

Sponsored by the IRE Professional Group on Military Electronics, Sheraton-Park Hotel, Washington, D.C. The technical program includes more than 100 papers to be presented at 5 classified and 18 unclassified sessions, covering these topics: missile guidance, radar techniques, operations research and tacts, data transmission and processing, space electronics, instrumentation (two sessions) navigation, surveying and reconnaissance, communications (two sessions), space propulsion, missile electronics, radar systems and equipment, computers, components, space communications, detection and tracking, space guidance and tracking, sumulation, navigation and reconnaissance, guidance, reliability. Exhibits of the latest military components and equipment representing the products of more than 100 companies will be held concurrently with the program. Advance registration, including the Proceedings, are $2 for IRE members, $3 for non-members, $1 for students. For more information contact *L. R. Everington, Radiation Inc., Orlando, Fla.*

Paper Deadlines

June 1: Deadline for technical papers for the **1959 National Automatic Control Conference** to be held **Nov. 4-6** at the Sheraton Hotel, Dallas, Tex. Before the deadline, four copies of summaries should be submitted to the *Technical Program Chairman, Mr. G. S. Axelby, Westinghouse Electric Corp., Box 746, Baltimore 3, Md.*

June 22: Deadline for final manuscripts to be presented at the **4th Annual Magnetic Amplifiers Conference, Sept. 23-25,** in Washington, D. C. Contact *F. G. Timmel, 4601 Forest Park Ave., Baltimore 7, Md.*

June 30: Deadline for abstracts of approximately 100-150 words dobue-spaced, in triplicate, for

MEETINGS

papers to be considered for the **Fifth National Communication Symposium,** scheduled for **October 5-7,** Hotel Utica, Utica, N.Y. Abstracts should be submitted with name, position title, company affiliation, and brief biographical sketch. Two major areas will be covered: communications systems and communications equipments and related techniques. Papers delineating new or proposed system standards and approaches taken to date to provide integrated communications systems are especially sought. Send to: *Mr. Ralph L. Marks, Technical Program Chairman, Fifth National Communications Symposium, Griffiss Air Force Base, N.Y.*

July 15: Deadline for completed papers to be presented at the first congress of **International Federation of Automatic Control** in Moscow in 1960. Agenda to cover three main areas: Theory; Components and Measurement; and Applications. Contact *W. E. Vannah, American Automatic Control Council, 330 West 42 St., New York 36, N.Y.*

Courses and Seminars

A series of one-day **Cost Cutting Clinics** will be offered **May 13** and **27** at the **Alden Research Center,** Westboro, Mass. Clinics are free of charge to qualified people in administrative management, operating management and supervision, engineers, consultants, and educators. However, reservations must be made in advance by contacting *Mr. Robert E. Johnson, "Clinic" Registrar, Alden Research Center, PO Box 125, Westboro, Mass.* Covers all phases of the Center's System the standardized approach to integrated, line and automated production. New "manufacturing laboratory" approach to production, new time and motion study tools, and "stepping stone" approach to Automation will be incorporated.

New York University's College of Engineering will present four programs intended primarily for practicing engineers during the summer of 1959. A one-week course on "Thermoelectric Materials" (week of **June 15**) will include a series of lectures designed to inform engineers of the latest theory and materials in the field and the newest devices based on thermoelectric effects. A similar one-week course on "Ductile Iron" (week of **June 29**) is planned. It will consist of lectures and panel discussions on the technology of ductile iron by experts from industry and research laboratories.

Four courses on polyvariable experimentation are being offered by the **Statistical Engineering Institute** for **June, 1959.** Featured will be the random balance technique for conducting experiments in many variables—10, 20, or more. Four courses have been scheduled with an enrollment

limited to 15 persons each. June 5-6 features and course on Process Engineering, emphasizing trouble shooting, tolerancing, process optimization, evolutionary operation, and other experimental programs conducted in the factory. Research and Development, stressing programs involving expensive experimentation and longer time cycles, will be given June 12-13. June 16-17 schedules Reliability, covering attainment of reliability levels in the range of 10^{-3} to 10^{-10}. Finally, June 19-20 stresses Mathematics, for mathematicians, statisticians, and computation specialists servicing experimental and reliability programs. For detailed information on these courses and a booklet on polyvariable experimentation, contact *F. E. Satterthwaite, Statistical Engineering Institute, 8 Fuller Road, Wellesley 81, Mass.*

For the sixth consecutive year **Cornell University** presents its annual Industrial Engineering Seminars, consisting of eleven seminar workshop sessions led by qualified discussion leaders in each of eight major areas of industrial engineering and management, **June 16-19** in Ithaca. The seminars will cover: Industrial Management, Manufacturing Engineering, Engineering Administration, Small Plant Management, Methods and Work Measurement, Computers in Production Planning, Applied Industrial and Engineering Statistics, and Statistical Aspects of Component Reliability. For further information address inquiries to: *J. W. Gavett, Seminars Coordinator, Upson Hall, Cornell University, Ithaca, N.Y. Cost of a seminar is $125 per person.*

Colorado State University is sponsoring an Institute in Technical and Industrial Communications **July 6-10** which involves an intensive one-week course and workshop for writers, editors, journalists, scientists, engineers, and administrators and information specialists in government research agencies. It is designed for those engaged in technical communications work. Features of the Institute will be presentations by authorities from industry, government and the University; group discussions, laboratory writing exercises, personal consultations, and daily problem clinics. $50.00 covers the five day session. Register through: *Chairman, Department of English and Modern Languages, Colorado State University, Fort Collins, Colo.*

The University of Wisconsin Extension Div. Engineering Institutes are meetings of two to five days presenting current information to technical personnel from industry. Specialists from research laboratories, consulting firms, and the faculty of the University and other educational institutions are selected when the subject matter is appropriate. Forward inquiries to *Engineering Institutes, 3030 Stadium University Extension Div., The University of Wisconsin, Madison 6, Wisc.*

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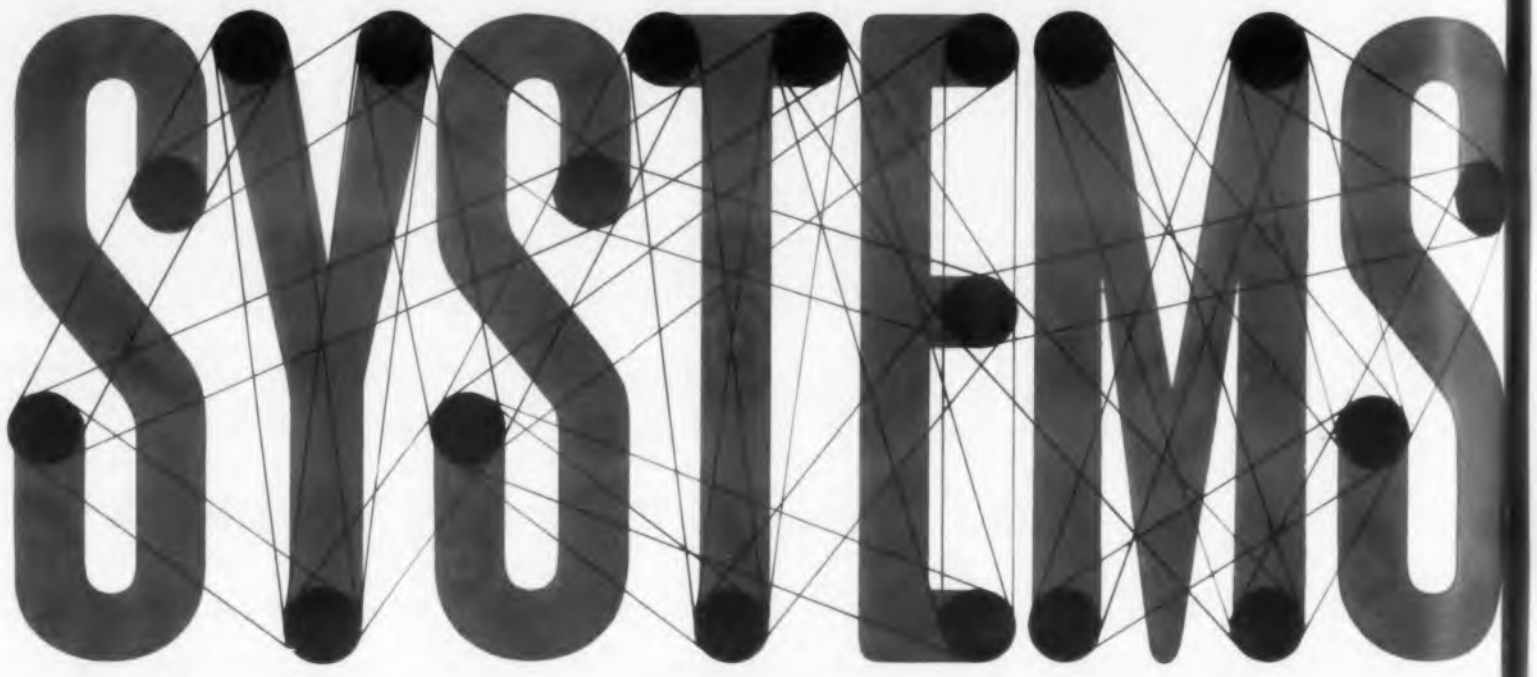

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Because of their preconceived ideas, newcomers to Kansas City are always surprised. Visitors from overseas tell us this is one of America's most beautiful cities. Easterners are first puzzled, then envious when they encounter the midwesterner's casual living, open friendliness and enthusiasm. Many visiting editors have rushed home to write barbed editorials prodding their civic leaders to follow our example in rejuvenating depressed areas, in solving traffic problems and in providing adequate well-rated schools.

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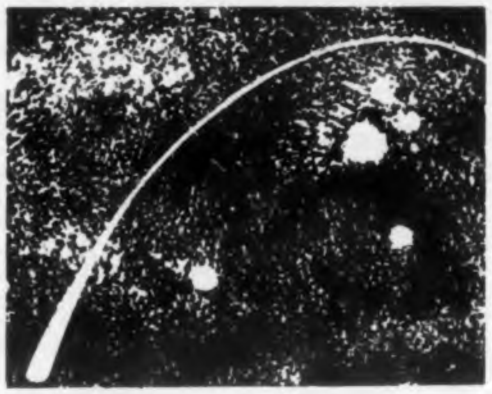

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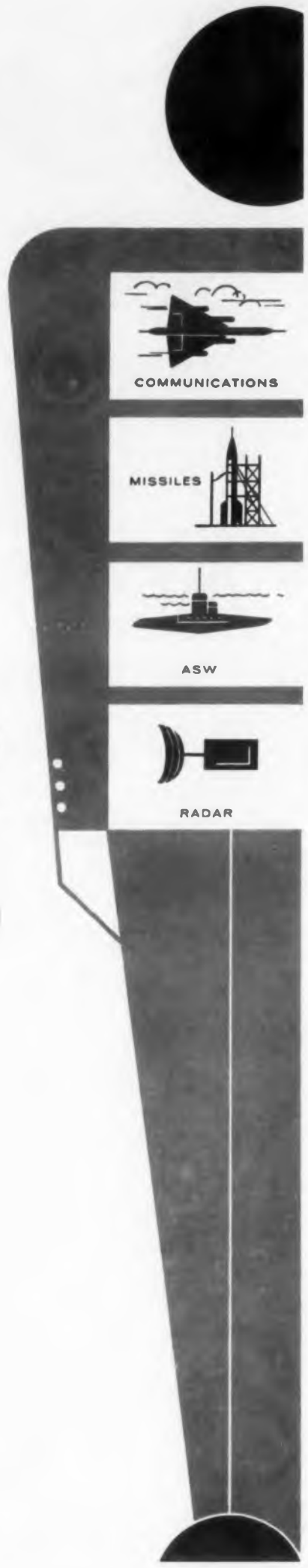

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CIRCLE 607 ON READER-SERVICE CARD

To include the more significant products received shortly before *ELECTRONIC DESIGN* rolls from the presses, the following section has been added to the New Products Department. Design engineers will now be able to review all new products available to them—plus the most significant of the latest ones. The New Products Department, which will include many of the latest products, will be found in the last section of following issues.

Infrared Detector Covers 2 to 40 Micron Range

SPECTRAL response of this infrared (ir) detector is from 2 to 40 microns, with peak sensitivity occurring at about 37 microns. And the time constant is less than 0.01 μsec, which extends the capabilities of ir for rapid scanning applications and observation of very fast phenomena.

According to the manufacturer—Perkin-Elmer Corp., Norwalk, Conn.—the spectral range is about four times better than was previously available in detectors. The speed of response is rated to be roughly ten times better.

For military purposes the unit's full coverage of the 8 to 14 micron region of the ir spectrum permits effective detection of ir radiation from all bodies—even those cooler than climatic temperatures.

The model R-E 536-1 Zip (zinc-impurity-photoconductor) detector has a D factor of 4×10^9 cm $\sqrt{w}$. The D factor is defined as the square root of the detector's sensitive area in square centimeters divided by the noise equivalent power in watts.

The unit's high sensitivity is achieved by cooling it to the temperature of liquid helium. Construction of detector unit and the double dewar flask is shown in Fig. 1.

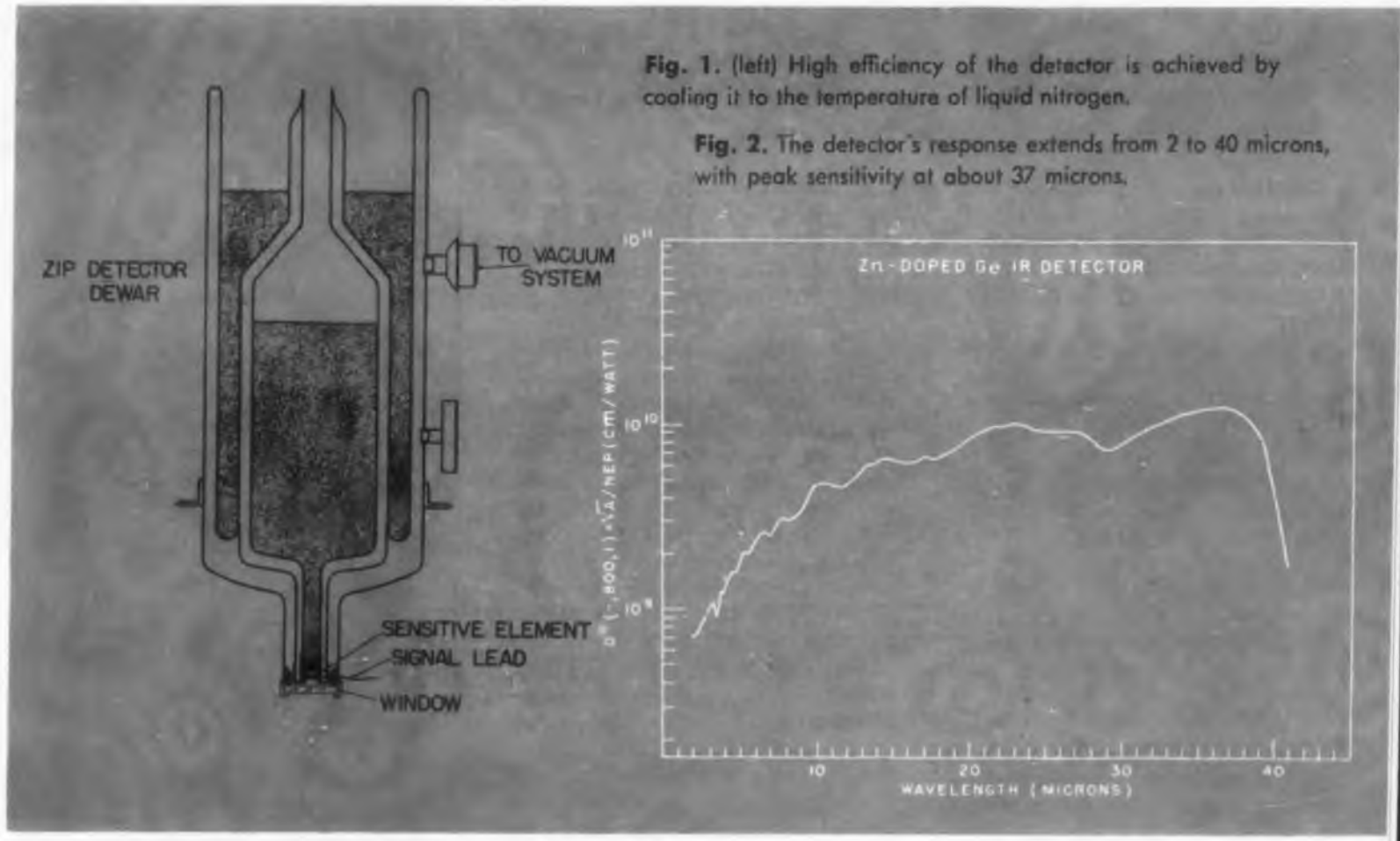


Fig. 1. (left) High efficiency of the detector is achieved by cooling it to the temperature of liquid nitrogen.

Fig. 2. The detector's response extends from 2 to 40 microns, with peak sensitivity at about 37 microns.

In addition to military applications such as reconnaissance and air warning, this device is expected to increase the use of ir instrumentation in navigation, space exploration and laboratory research.

For more information on this sensitive ir detector, turn to the Reader Service card and circle number **615**.

An engineer probes radiated interference from an aircraft hoist in the Los Angeles laboratory of Sprague's Interference Control Field Service Dept.

Improved Service For Radio Interference Control

Fast-growing Department of Sprague Electric Company Greatly Expands its Measurement, Control, and Consulting Engineering Facilities to Provide Fast Service.

Contractors responsible for the design and manufacture of electric/electronic equipment and weapon systems which must conform to military interference requirements will get a major assist from Sprague Electric's expanded industry service in the field of r-f interference and susceptibility.

The service includes: interference and susceptibility measurements up to frequencies of 10,000 mc; complete analysis of all test results; and comprehensive recommendations of appropriate control techniques to bring about a suppression system having the lowest weight, the lowest cost, and the greatest reliability.

Sprague's consulting service applied at the design stage already has proven to be the best approach to interference and susceptibility control. Experienced Sprague engineers invariably save valuable time in the preparation of test plans and their subsequent approval. Sprague engineers prefer to work from the design conception, analyzing original schematics and equipment drawings. This permits them to recommend optimum shielding, isolation, and decoupling techniques before cases and layouts are finalized. Space allowances for suppression components can be made with proper attention to economy of weight and cost.

Once the equipment reaches the prototype stage, Sprague specialists will conduct tests either in the manufacturer's own plant or in one of Sprague's interference laboratories. Sprague will also direct compatibility tests on end equipment or complete weapons systems, and recommend solutions to any integration problems which might develop.

Sprague Interference Control Laboratories are located on the Pacific Coast, in the Mid-West, and on the East Coast. These laboratories are staffed by top interference and susceptibility control specialists, and are equipped with the most advanced instrumentation and model shop facilities.

For further information, write to Interference Control Field Service Manager, Sprague Electric Co. at 12870 Panama Street, Los Angeles 66, California; 224 Leo Street, Dayton 4, Ohio; or 347 Marshall Street, North Adams, Massachusetts.

CIRCLE 574 ON READER-SERVICE CARD

Fully Transistorized

Desk-Top Analog Computer Solves Most Design Problems

Not quite inconspicuous on a desk top, but still very small for a computer, this machine can solve many engineering problems without auxiliary equipment.

COMPLETELY transistorized, this very small computer can do about 95 per cent of the mathematics encountered by engineers in most designs.

It weighs only about 80 pounds and takes up not much more desk space than the average "Out" box—certainly no more than the "In" box. The actual desk area covered is 15 x 17 in. The computer is 24 in. high.

This compact analog computer boasts a high order of reliability and a one-tenth per cent accuracy. It was designed by Long Branch, New Jersey's Electronic Associates, Inc. to solve engineering problems which aren't large enough or complex enough to justify the use of large, general purpose, precision machines.

Christened the PACE TR-10, the unit lends itself to expansion by addition of various linear and nonlinear components. For example, the basic model includes 10 attenuators, six summing amplifiers, and four integrating amplifiers.

The standard expanded model can have as many as 20 attenuators, 10 summers, and 10 integrators, in addition to multipliers, function generators, comparators, and other components.

For static problems, where a constant value solution is called for, the nullmeter on the computer's control panel provides an answer useful to three places of accuracy. For problems in dynamics, it is best to use other readout equipment such as plotters or recorders.

Color Coding Convenience

One of the handy features offered with this computer is the system of color coding. The patch cords, made of RG 598 coax cable, are color coded according to length, with lengths available in multiples of six inches. The cable's color instantly tells the engineer its length.

The patch panel is also color coded—according to function, so a multiplier, an attenuator, a comparator or a function generator can be recognized right away.

Applications Are Many

It is impossible to list all the applications of an analog computer—even for the electronics engineer alone. This machine will lend itself very nicely to small data acquisition tasks, to the study of electronic subsystems, and servomechanisms. It is particularly useful in analyzing the transient performance of circuits and in breadboarding automatic control devices.

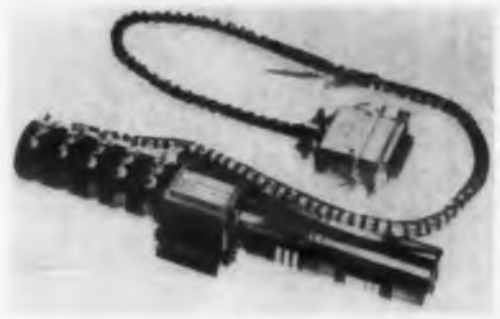
In general, where a design does not require solution of a large number of equations, this machine provides a very useful tool for the engineer at his desk.

For more information, turn to the Reader-Service card and circle 616.

DEADLINE PRODUCTS

In-Line Servo Modules

Variety of sizes



These in-line servo packages are available with size 8, 11, 15, and 18 servomotors; servomotor-rate generators; and inertia and velocity damped servomotors. They include a wide variety of matched potentiometers and other components for servo position indicators, integrators, and other servosystem assemblies. Typical is a size 11 system module with a 115 v, 400 cps servomotor-rate generator; a gearhead; a mounting pad; and five ganged single-turn potentiometers. The unit is 7-3/4 x 1-3/4 x 1-1/2 in.

Beckman Instruments, Inc., Helipot Div., Dept. ED, 2500 Fullerton Rd., Fullerton, Calif.

CIRCLE 579 ON READER-SERVICE CARD

Miniature Rectangular Connectors

Have closed entry contacts

Series 2000 heavy duty rectangular connectors are available in three contact arrangements for various power applications requiring combinations of coaxial and conventional contacts, contacts for 16 and 18 AWG wire, and 41 contacts for 18 AWG wire. They have self-aligning polarizing shells and closed entry contacts. Current rating is 7.5 amp for the 0.058 diameter solder cup and 10 amp for the 0.076.

DeJur-Amsco Corp., Dept. ED, 45-01 Northern Blvd., Long Island City 1, N.Y.

CIRCLE 580 ON READER-SERVICE CARD

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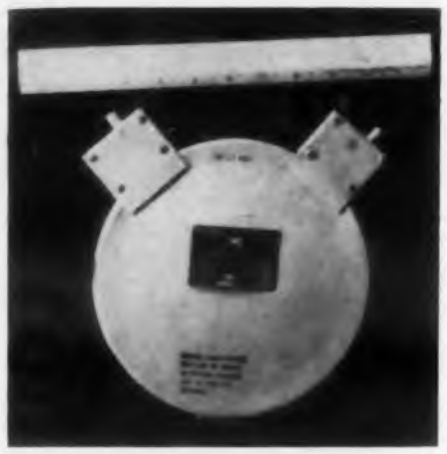
Ultrasonic Delay Lines

Light and compact



Series C ultrasonic delay lines are designed with a 20% smaller diameter and 40% less weight than former models. A 1500 μsec line in this series has a 32 mc center frequency, a 3 db bandwidth of 20 mc, a 60 db insertion loss into 50 ohms, and a 100 μμf transducer capacity. It has BNC or subminiature connectors and weighs 2 lb, 14 oz. Its aluminum case is 7/8 in. thick and has an 8-1/4 in. diameter. This design has been scaled up to 3300 μsec with comparable performance at center frequency and half the bandwidth of the 1500 μsec size.

Arenberg Ultrasonic Lab., Inc., Dept. ED, 94 Green St., Jamaica Plain 30, Mass.

CIRCLE 582 ON READER-SERVICE CARD

Fastener

For one-side access

A snap-on U type nut plate for cabinet assemblies, the SL 88 Clip-Nut is designed to cut costs for one-side-only access on a wide range of panel thicknesses. It eliminates riveting and setting operations, requires only one hole, and meets MIL-N-25027 specifications.

Shur-Lok Corp., Dept. ED, 879 S. East St., Anaheim, Calif.

CIRCLE 583 ON READER-SERVICE CARD

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DEADLINE PRODUCTS

Low Level Magnetic Modulator

Wideband

The model 404 magnetic modulator is a wideband unit that operates with an excitation frequency of 100 kc. It is particularly useful as the key component in low level, stable, wideband dc amplifiers. Output is a second harmonic signal of the exciting frequency, whose amplitude and phase are functions of the amplitude and polarity of the input signal. Current controlled, the unit has inherently low input impedance. High input resistance is obtained by adding series resistors.

ACF Industries, Inc., Avion Div., Dept. ED, 11 Park Place, Paramus, N.J.

CIRCLE 587 ON READER-SERVICE CARD

Write-Read Amplifiers

For digital magnetic tape transports

For use with digital magnetic tape transports model 921 write-read amplifiers provide a wide choice of characteristics for virtually any current or advanced application. Tape speeds from 1 to 150 ips can be accommodated with a response to minimum signal levels of 150 μv.

Potter Instrument Co., Inc., Dept. ED, Sunnyside Blvd., Plainview, N.Y.

CIRCLE 588 ON READER-SERVICE CARD

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Insulating Oil Tester

High Voltage

The model 4505-A Hypot is designed to perform high voltage breakdown tests on the insulating oils used in oil immersed electronic assemblies and oil filled components. The test voltage is continuously adjustable from 0 to 35 kv ac at a 2 kva rating to meet ASTM specifications. The unit is portable, measures 8-1/2 x 16 x 8 in., and weighs 42 lb. It operates on 110 to 120 v ac. Other insulating oil testers with built-in motor driven automatic rate of rise control to increase the test voltage at 3 kv per sec are also available.

Associated Research, Inc., Dept. ED, 3777 W. Belmont Ave., Chicago 18, Ill.

CIRCLE 589 ON READER-SERVICE CARD

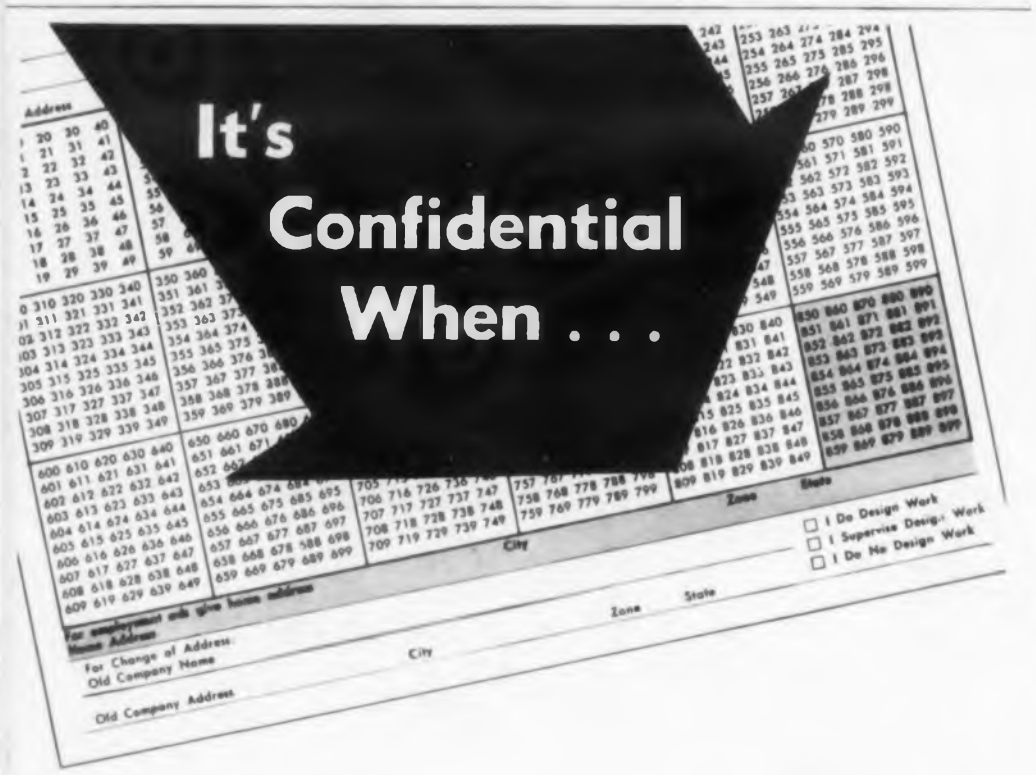
Servo Nulling Amplifiers

Weighs 5 to 10 oz

Series 2200 magnetic servo nulling amplifiers are for 3 to 16 w output power and weigh from 5 to 10 oz. Compatible with silicon or germanium transistor drive circuits, they have a 12 msec response and withstand high line transients. The 400 cps units are hermetically sealed, operate from -55 to +150 C, and meet MIL-T-27, MIL-E-5400, and MIL-E-8189. The 3 w model 2201 is 1-3/16 x 1-3/16 x 2 in., while model 2204, largest of the series, is 6 cu in.

Penn on Electronics Inc., Dept. ED, 7500 S. Garfield Ave., Bell Gardens, Calif.

CIRCLE 590 ON READER-SERVICE CARD



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DEADLINE PRODUCTS

Low Pass Filter

Isolates uhf from L band

Designed to isolate uhf from the L band, low pass filter LP-267 provides an insertion loss of 100 db in the 900 to 1300 mc stop band and 0.5 db in the dc to 400 mc pass band. Input vswr is 1.4 in the pass band. The unit handles 50 w average power, weighs 5 oz, and has type N connectors.

Electronic Specialty Co., Dept. ED, 5121 San Fernando Rd., Los Angeles 39, Calif.

CIRCLE 592 ON READER-SERVICE CARD

High Power Terminations

Cover 0.9 to 13 kmc

Series TD terminations have a 150 w power rating in ambients to 125 C and operate from 900 to 13,000 mc with a 1.2 vswr. Available with type N, BNC, TNC, C, or HN male or female connectors, they are 11.2 in. long and weigh 8 oz. Impedance is 50 ohms.

Microlab, Dept. ED, 71 Okner Parkway, Livingston, N.J.

CIRCLE 620 ON READER-SERVICE CARD

Power Supplies

Precision calibrated

These precision power supplies have a three section decade for obtaining voltage values in 1 v steps from 0 to 300 v dc. A vernier covers a continuous range of 0 to 1 v for fractional values. Current ratings are 100, 200, or 300 ma. Decade accuracy is 0.1%; vernier accuracy, 0.05 v.

Electronic Measurements Co., Inc., Dept. ED, Eatontown, N.J.

CIRCLE 621 ON READER-SERVICE CARD

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Photoelectric Tape Reader

Handles up to 330 characters per sec

An all transistorized, self-contained, photoelectric tape reader, the model TR5 operates at any speed to 330 characters per sec and stops on the stop character. It accepts 5, 7, or 8 hole tape widths and operates on 115 v, 60 cps.

Ferranti Electric Inc., Dept. ED, 95 Madison Ave., Hempstead, N.Y.

CIRCLE 624 ON READER-SERVICE CARD

Inertia Switch

Mounts in any plane

This spdt inertia switch mounts in any plane to detect acceleration forces caused by roll, pitch, and yaw. Standard units are 1 to 3 g; special units to 50 g. Temperature range is —55 to +100 C; accuracy, ±5%; time constant at 25 C, 1 sec; contact rating, 100 ma at 28 v dc.

Magnavox Co., Government & Industrial Div., Dept. ED, Fort Wayne, Ind.

CIRCLE 625 ON READER-SERVICE CARD

200 W Termination

For 7 to 10 kmc

This 200 w termination has a vswr of 1.1 and a frequency range of 7 to 10 kmc. It uses neither fins nor forced air cooling. Its absorbing material is the company's Radamic, a plastic that remains dimensionally stable to 2000 F.

Radar Design Corp., Dept. ED, Pickard Drive, Syracuse 11, N.Y.

CIRCLE 626 ON READER-SERVICE CARD

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ADVERTISERS' INDEX
May 13, 1959

...nounce the first major improvement

...gnal is passed through a narrow-band crystal filter, amplified and metered.

Frequency Restorer

A frequency restorer circuit makes accurate frequency measurements possible at each component's frequency of the input wave. This circuit supplies a sinusoidal signal at the frequency of the specific component which can be measured on an electronic counter or observed on an oscilloscope. The amplitude of this signal is determined by the level of the selected component. When the mode selector switch is in the normal or AFC position, the signal appears at the output terminals if the meter is indicating.

Model 302A is also particularly useful for measuring small signals on noisy systems or transmission lines. When the mode selector is switched to "BFO" the instrument becomes an oscillator and tuned voltmeter automatically tuned by one control to the same or oscillator frequency. The selective tuned voltmeter then discriminates against the noise and measures the desired signal.

Speed and accuracy of measuring is enhanced by a linearly calibrated tuning control giving the same "tuning feel" throughout range.

Basic Laboratory Instrument

Covering the frequency range of 20 cps to 50 KC, the new hp 302A is equipped to perform a wide variety of daily measurements. It has broad usefulness not only in audio measurements but in vibration work, telemetry, and carrier applications. The instrument is compact, rugged and features conservative design and high quality throughout.

Specifications

Frequency Range: 20 cps to 50 KC.

Frequency Calibration: Linear graduation 1 division per 10 cycles. Accuracy ± (1 % + 5 ~).

Voltage Range: 3 μv to 300 v, full scale readings of:

300 v	300 mv	300 μv
100 v	100 mv	100 μv
30 v	30 mv	30 μv
10 v	10 mv	
3 v	3 mv	
1 v	1 mv	

Ranges provided by an input attenuator switch and a meter range switch in steps of 1:3 or 10 db. Meter range is indicated by a dial mechanically linked to input attenuator. An absolute-relative switch, in conjunction with a variable 10 db control is provided for adjustment of intermediate values.

Warm-Up-Time: None.

Voltage Accuracy: ±5% of full scale value.

Residual Modulation Products and Hum Voltage: Greater than 75 db down.

Intermediate Frequency Rejection: Intermediate frequency present in input signal rejected by at least 75 db.

Selectivity: ± 3½ cycle b.w.—at least 3 db down
± 25 cycle b. w.—at least 50 db down
± 70 cycle b.w.—at least 80 db down
beyond ± 70 cycle b.w.—at least 80 db down

Input Impedance: Determined by setting of input attenuator: 100,000 ohms on 4 most sensitive ranges, 1 megohm on remaining ranges.

Selected Frequency Output: 1 v open circuit at output terminals for full scale meter deflection. Output level control provided. Frequency response ±1 db, 20 cycles to 50 KC. Output impedance approximately 600 ohms.

B. F. O. Output: 1 v open circuit at output terminals. Output level control provided. Frequency response ±1 db, 20 cps to 50 KC. Output impedance approximately 600 ohms.

Automatic Frequency Control: Range of frequency holdin is ±100 cycles minimum.

Power: 115/230 v ±10%, 50/1600 cycles, 3 watts (approximately). Terminals provided for powering instrument from external battery source. Battery supply range 28 v to 18 v.

Weight: Net 43 lbs. Shipping 63 lbs. (cabinet mount). Net 35 lbs. Shipping 55 lbs. (rack mount).

Dimensions: Cabinet Mount: 20¾" wide; 12½" high; 14½" deep. Rack Mount: 19" wide; 10½" high; 13½" deep.

Price: $1,475.00 (cabinet); $1,460.00 (rack mount).

Data subject to change without notice.

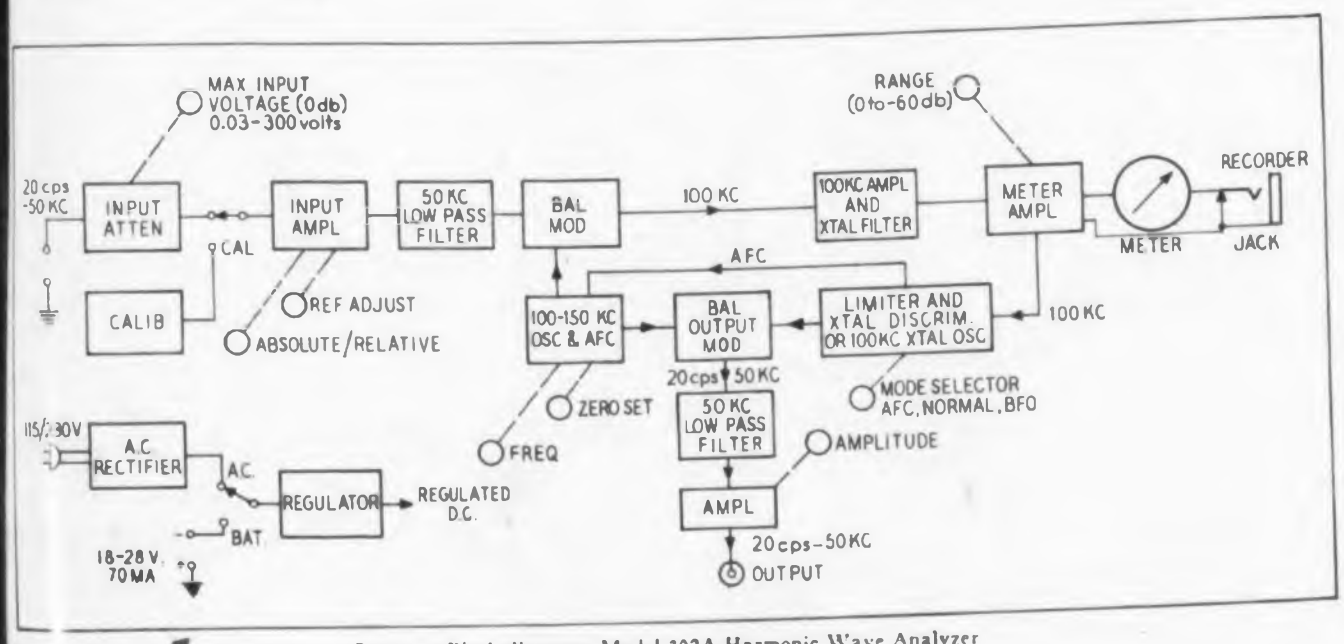

Figure 1. Block diagram, Model 302A Harmonic Wave Analyzer

HEWLETT-PACKARD COMPANY
4387K Page Mill Road, Palo Alto, California, U.S.A.
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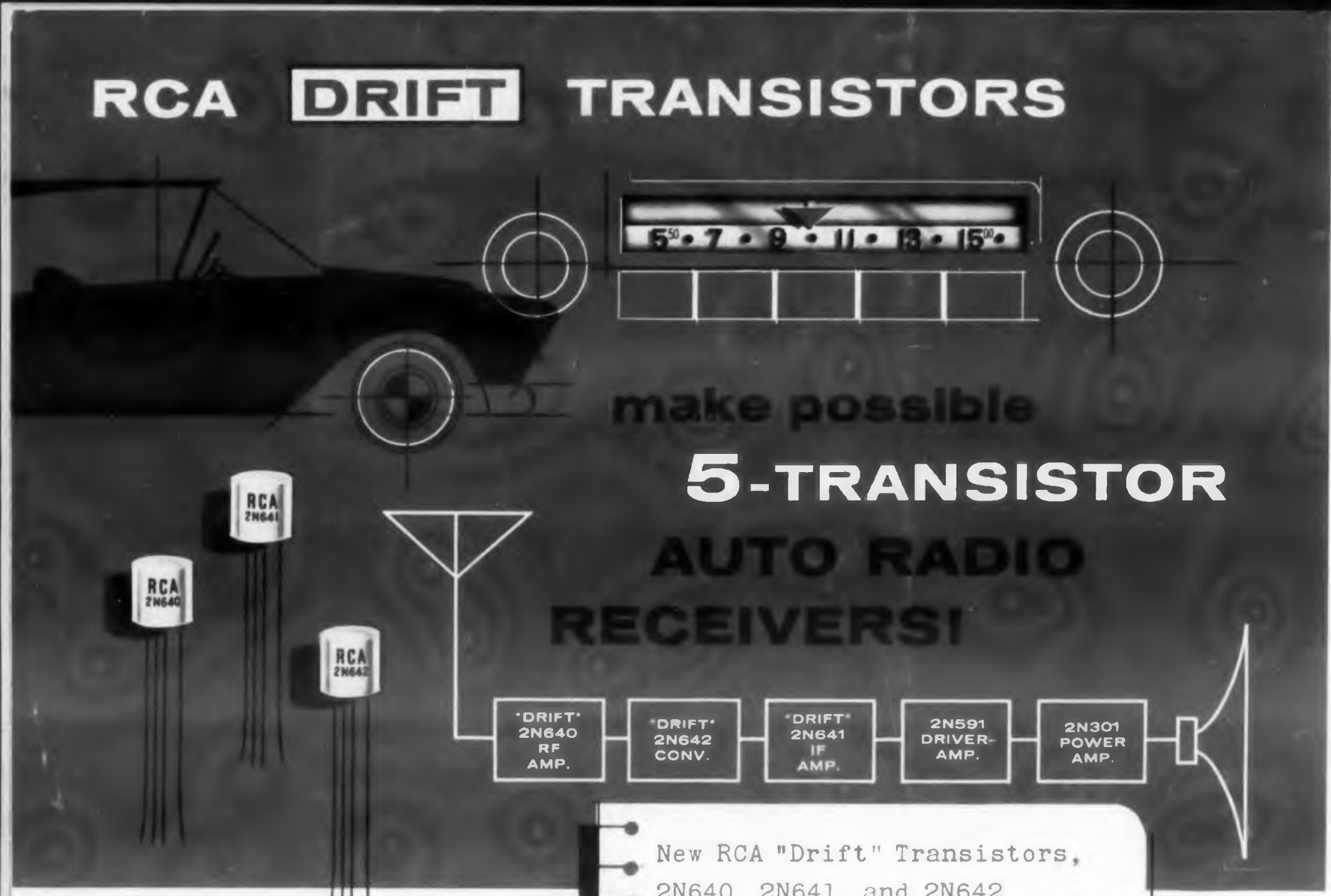
◄ CIRCLE 610 ON READER-SERVICE CARD

RCA DRIFT TRANSISTORS



make possible 5-TRANSISTOR AUTO RADIO RECEIVERS!

New RCA "Drift" Transistors, 2N640, 2N641, and 2N642 together with the RCA-2N591 and RCA-2N301 now make all-transistor broadcast-band receivers completely practicable for automobile service.

These "Drift" Transistors are designed and controlled specifically for operation in automotive radio receivers for the frequency range of 535 kc to 1640 kc. For example, the 2N640 in an unneutralized circuit is capable of providing a useful power gain of 28 db at 1.5 Mc; the 2N641 in a neutralized circuit, a power gain of 41 db at 262.5 kc and 40 db at 455 kc; and the 2N642, a useful conversion power gain of 40 db at 1 Mc.

RCA "Drift" Transistors feature low feedback capacitance, controlled power gain characteristics to insure unit-to-unit interchangeability, and excellent stability. In addition, close manufacturing controls of the small-signal parameters make the 2N640, 2N641, and 2N642 especially desirable for use in *quantity-produced* automobile radio receivers.

Now is the time to create your new designs for 5-transistor automobile radio receivers. RCA "Drift" Transistors not only make them possible, but economically practicable. Present receiver manufacturing costs can compare favorably with those of conventional-type "hybrid" sets. For details, contact the RCA Field Office nearest you. For technical data, write RCA Commercial Engineering, Section E-18-NN1, Somerville, N. J.

RCA TYPE	Typical CURRENT GAIN Measured at 1 Kc (Beta)		Useful POWER GAIN DC Collector-to-Emitter Volts = −12			Maximum DC Collector Cutoff Current (I_{CBO})	
	DC Collector Ma	Current Gain	Signal Frequency Kc	DC Collector Ma	Power Gain db	DC Collector-to-Base Volts	I_{CBO} Ma
2N640	−1	60	1500	−1	28	−12	−5
2N641	−1	60	262.5	−1	41	−12	−7
2N642	−1	60	1000	−0.6	40●	−12	−7
2N591	−2	70	1	−2	41	−1	−7
2N301	−1000	70▲	0.4	−1800■	33	−0.5	−100

●Conversion Power Gain. ■Peak value. Zero-Signal DC Collector Ma = −900. ▲DC Current Gain.

Illustrated is an experimental all-transistor broadcast-band automobile radio using 5 transistors. The 3 RCA "Drift" units described here used with an RCA-2N591 driver-amplifier, and an RCA-2N301 class A power amplifier provide a high-efficiency transistor complement capable of producing 1-watt audio output for a 2-microvolt RF-signal input. This receiver can provide a maximum power output of 4 watts with less than 10% distortion.

RADIO CORPORATION OF AMERICA
Semiconductor & Materials Division
Somerville, N. J.

EAST: 744 Broad St., Newark, N. J. HUmboldt 5-3900

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