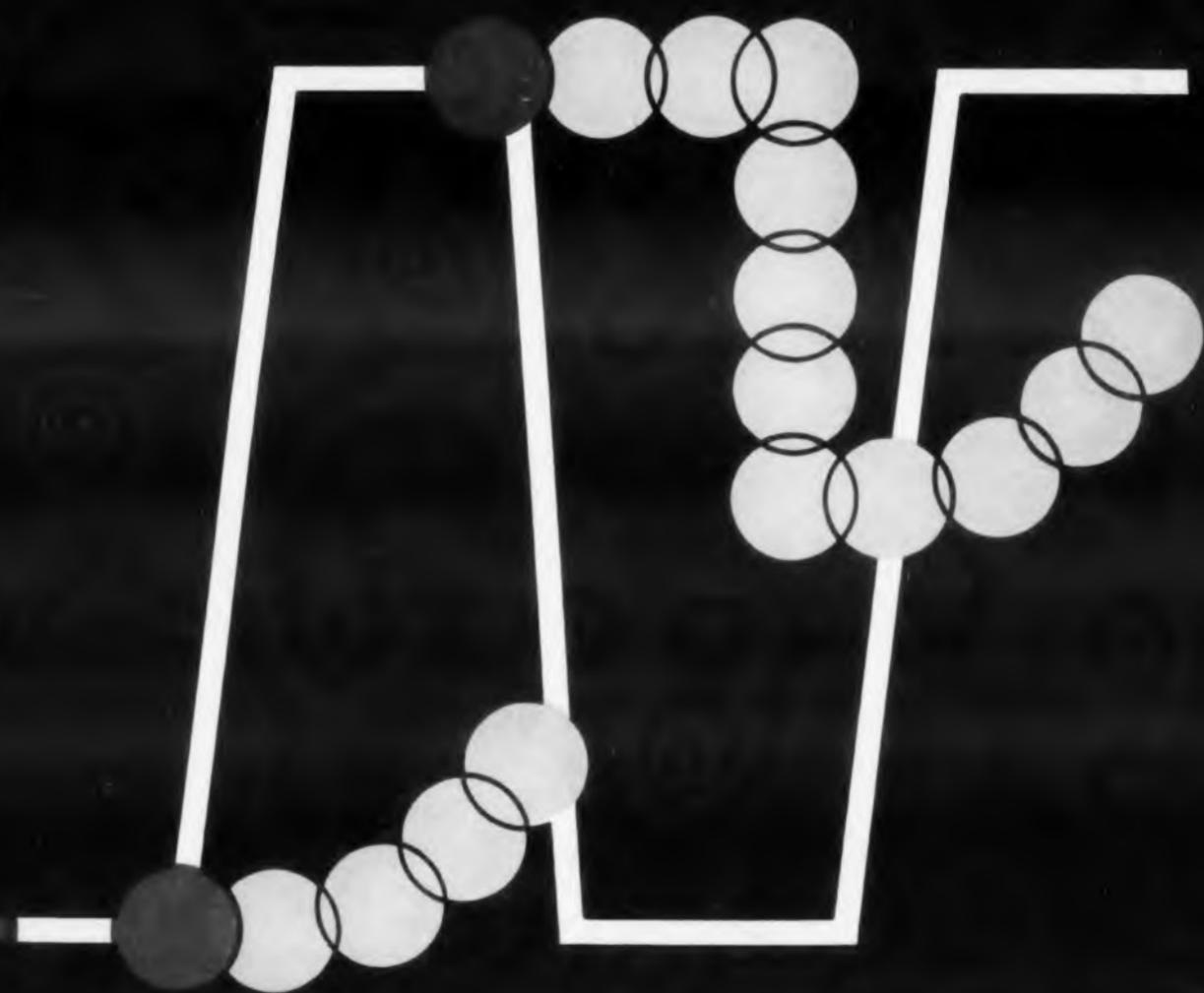


# ELECTRONIC DESIGN

FEBRUARY 3, 1980



DIGITAL READOUT SCOPE

<i>mV</i>	<i>μS</i>
7.69	34.7
7.67	34.5
7.64	34.2
7.63	34.1
7.61	

## SPECIAL THIS ISSUE:

### CONQUERING

RFI... p. 21

An *ELECTRONIC DESIGN* Report

### DESIGNING

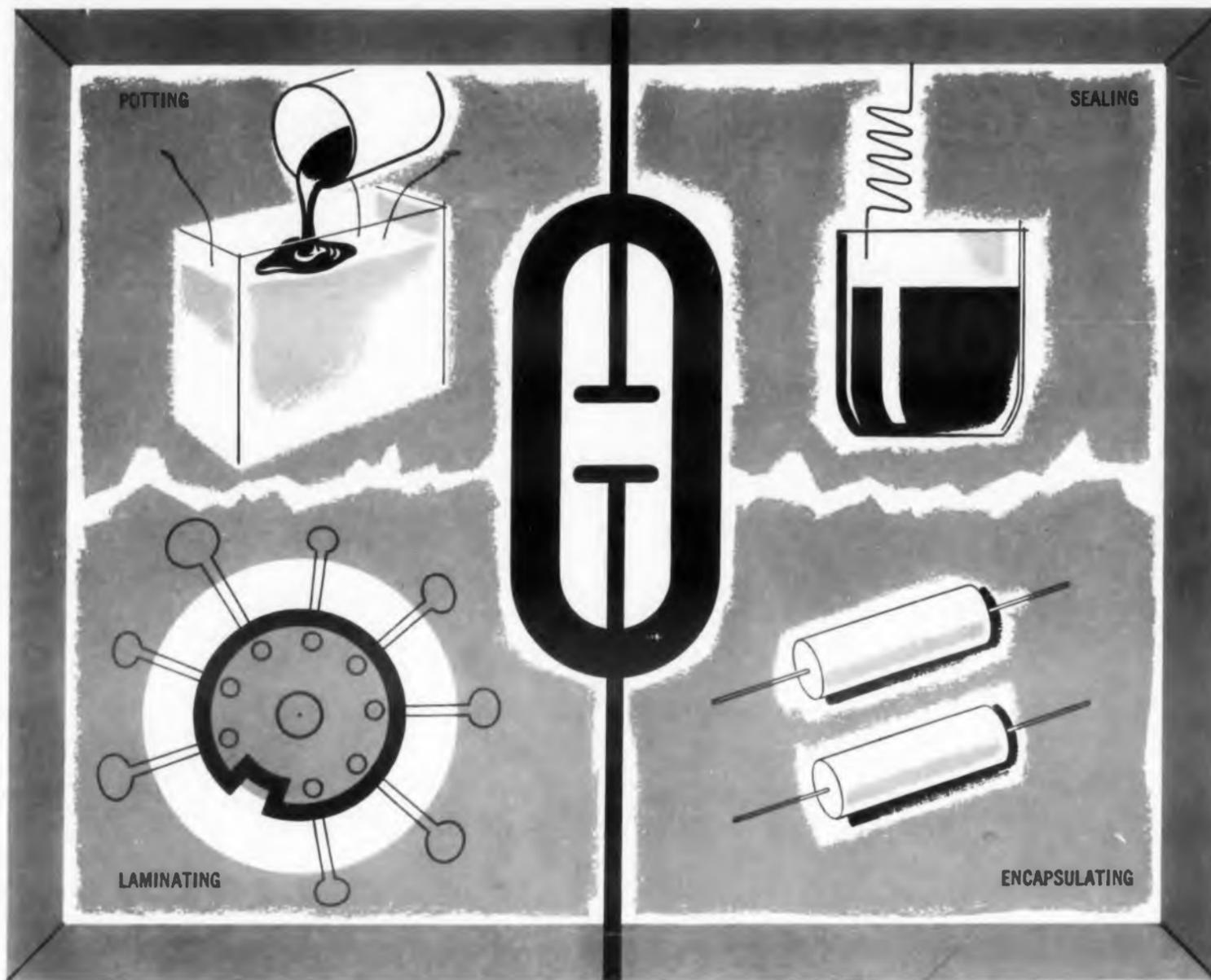
WITH

TUNNEL

DIODE

CIRCUITS... p. 50

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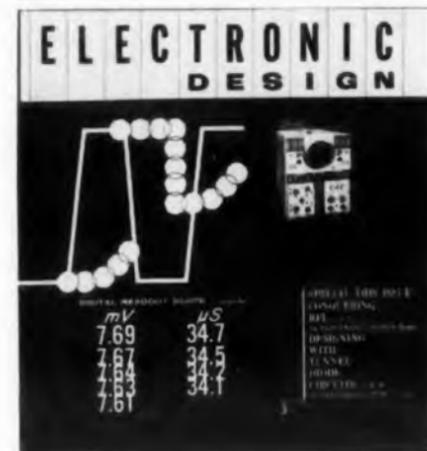
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CIRCLE 1 ON READER-SERVICE CARD



COVER: Digital readout, joystick positioning, and electronic switching in X, Y, and Z axes are just a few of the features of this new oscilloscope. On the cover, our artist has shown his impression of the movement of the indexing and scaling dots, set up for digital readout of the waveform amplitude.

### Selected Topics In This Issue

#### Systems

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- RFI Developments ..... p 26
- Techniques for Measuring ... p 127

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#### Design

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- How to Trouble-Shoot  
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#### Semiconductors, Circuits

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- Tuned Transistor Amplifiers .. p 130

**RFI—Peril to Progress**

Formerly scorned as a minor imperfection, radio frequency interference (RFI) now looms as a major peril to electronic progress. Because of the disturbances that result from interference, an impasse has been reached in the quest for higher sensitivity and greater reliability. The question many design engineers are now asking is, "How can RFI be effectively eliminated?"

Aware of the urgency of the problem, *ELECTRONIC DESIGN* is pleased to present a revealing Special Report on the subject. Howard Bierman, after contacting experts in various phases of interference work, has organized their findings into a series of articles dealing with the latest developments made in the field. Beginning in this issue, developments in the critical areas of design precautions, trouble-shooting, and measurement techniques are presented and discussed in detail. The series will continue in subsequent issues.

**A First!  
Tunnel Diode Circuits**

Since tunnel diodes first made their appearance on the electronic scene, engineers have been interested in possible practical applications of the devices. This issue contains the first article ever to appear on practical tunnel diode circuits. Authors are U. S. Davidsohn, Y. C. Hwang, and G. B. Ober of General Electric Co. Designing With Tunnel Diodes, Part 1 of a two-part series, begins on page 50. Part 2, which will appear in a subsequent issue, deals with measurement of tunnel diode characteristics.

**Selected Topics  
In This Issue (Cont.)**

**Microwaves**

RFI Developments in Radar .... p 26

Magnetron Packs 25 kw into  
2  $\mu$ sec Pulse ..... p 11

Circulator With Low  
Insertion Loss ..... p 17

CIRCLE 2 ON READER-SERVICE CARD ➤

At Macarr Inc....

# where dependability comes first



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FEB 17 1959

## RED/LINE timing relays "Pay Off"!



After trying several other time delay devices in their automatic control equipment for carbon arc lamps, design engineers at Macarr Inc. turned to G-V Red/Line Timing Relays. By holding in a current limiting resistor in the circuit until the arc had struck, the Red/Line Relay provides complete continuity of operation and lengthens the life of the DC power supply feeding the carbon arc. As an added advantage, it also facilitates smooth, soft starting of the carbon arc. **So, at Macarr, the high quality of G-V Red/Line Timing Relays is "paying off".**

More and more companies are finding the reliable performance of G-V Red/Line Timing Relays makes them best for their products. G-V Red/Line Relays will "pay off" in your product, too. Your customers appreciate the importance of high quality, reliable components. G-V Red/Line Timing Relays are specially designed for industrial applications. They have the precision, reliability and long life needed to "pay off" in industrial use.

Your G-V distributor has them in stock now. Call him or write for Bulletin 131 today.



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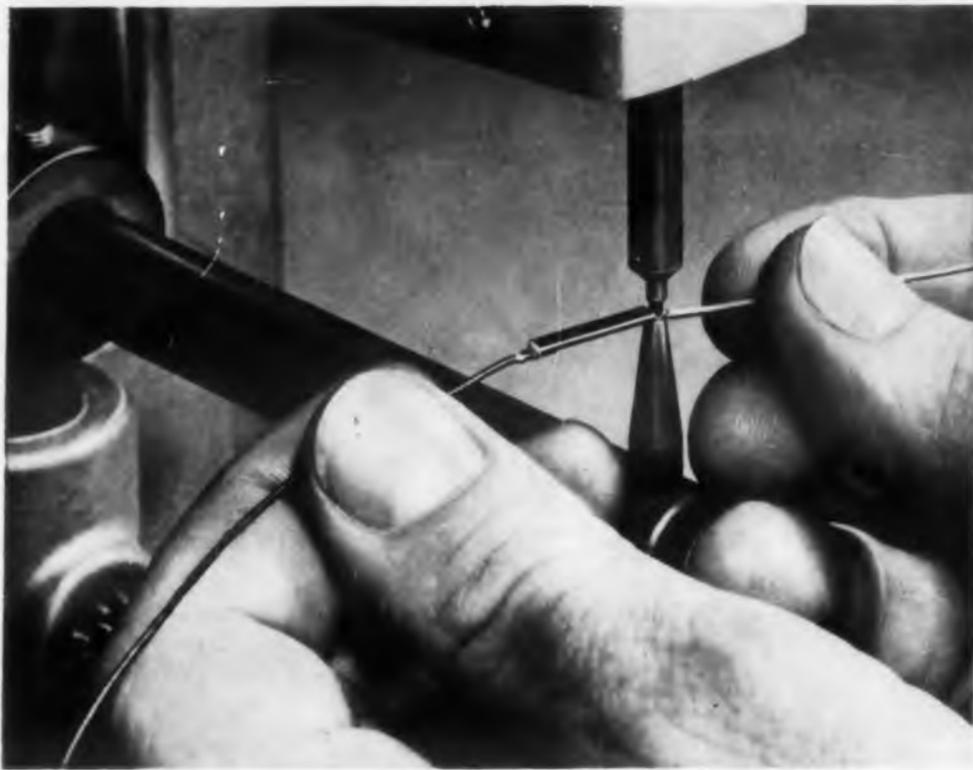


photo courtesy of Bourns Laboratories

## HOW WELDMATIC WELDING BEATS HEAT DAMAGE TO COMPONENTS...STOPS REJECTS! Case in point: Bourns TRIMPOT® potentiometers

Weldmatic welding means precise, *controlled-heat* welding. Each weld is made with a millisecond pulse of stored energy. No chance for heat to affect dimensions, temper, or temperature coefficient of materials. No danger of weak, "cold", or high-resistance joints, either. Weldmatic welding is the *modern* method of electronic assembly—used by hundreds of famous firms. Take Bourns Laboratories, for example:



This beryllium-copper clip must exert a constant pressure against the potentiometer element. Too much heat in attaching the lead to it would destroy the spring temper, impair the accuracy of the instrument. Weldmatic's millisecond welding pulse solves the heat problem completely.

Dimensions of this U-shaped platinum-palladium contact bar are critical. Too much heat would warp the .003-inch-thin bar out of shape. How to attach the lead to it? Weldmatic is the solution—the *only* solution.

This finely wound resistance element is the heart of the potentiometer. In attaching leads to it, care must be taken not to apply extreme heat over too long a period—the temperature coefficient of the resistance wire might change. Safest solution: Weldmatic *instantaneous* welds.

Weldmatic precision welding cuts rejects, maintains accuracy, boosts reliability. It's faster, more economical, too. Often, it's the *only* way. Write today for further information.

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CIRCLE 3 ON READER-SERVICE CARD

U. S. Must Demand Radio-Frequency Interference Control ..... 23  
An Editorial

### SPECIAL REPORT

Radio Frequency Interference—An ELECTRONIC DESIGN Staff Report ..... 24

Radio frequency interference, RFI, poses a serious threat to equipment and system reliability. Major steps are being taken to control RFI by consideration during initial design.

RFI—An Up-To-Date Survey ..... 26

A thorough coverage of RFI developments in communication and radar systems, measurement techniques and components—R. B. Schulz, H. M. Sachs, G. C. Vallender

RFI Check-List ..... 38

Over 50 points to remember to reduce RFI where it does the most good—in the early design stage—L. W. Thomas

Interference Trouble-Shooting With Clamp-On Devices ..... 44

How to trouble-shoot wire-coupled interference in complex electronic installations conveniently, without cutting cables, by using clamp-on ammeters and injectors—T. H. Herring

Optimum Shielding Of Equipments Enclosures ..... 48

How to select shielding materials and determine their effectiveness—A. L. Albin

Designing With Tunnel Diode: Part 1 ..... 50

A thorough, practical discussion of how to design working circuits using tunnel diodes—U. S. Davidsohn, Y. C. Hwang, G. B. Ober

Digital Readout Scope ..... 56

A 35-mc oscilloscope has three-digit readout of voltage and time

Worried About Tape Stretching? ..... 58

Capstan-speed servo offsets distortions

Miniaturized Control Regulates DC Motor's Speed To Accuracy Of 0.1 Per Cent ..... 60

The operation of this new control, which uses a reference frequency generator is explained

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Direct View Battery TV Due ..p 10	A \$100 Citizens' Transceiver ....p 12
Electronic Sales Reach \$9.2 Billion .....p 10	News Briefs .....p 14
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**Coming in the Next Issue**

Paul Wrablica, industrial designer, begins a series of articles dealing with the introduction of human factor engineering in industry. No longer concerned with product appearance alone, industrial designers are focusing on the need to modify equipment to more functional styling. At the same time, serious consideration must be given to the human operator who will work with the product. Meet Paul Wrablica in our next issue and follow him through a series of articles in which he describes this fresh approach to knobs, panels, housings, and other electronic components.



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Engineering notes from the  
**SMI REPORTER**

By STANLEY M. INGERSOLL, Capabilities Engineer



**Report No. 1 Pressure Switch**

A new advance in pressure switching is embodied in our TR 2065. Through the use of solid state switching circuits\*, SMI has developed a pressure switch which is extremely accurate and highly reliable. This new unit supplies a switch closure or opening on either an increasing or decreasing pressure and is ideally suited to applications where severe environments of temperature, vibration and shock are encountered.

For example, exhaustive tests of a 500 PSI unit have shown that it will not chatter when subjected to 50G's vibration when the pressure input is only 0.2% away from the switch point.

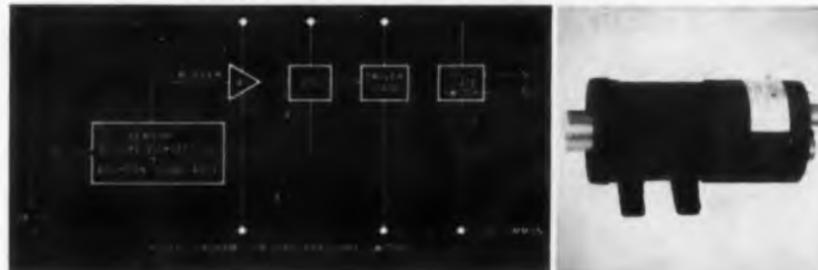
Essentially the TR 2065 is an SMI Bourdon Tube Pressure Transducer coupled with unique solid state switching circuits. The result is a pressure switch which is friction free and contains no moving parts in contact.

**Principles of Operation** As switching pressure is applied to the interior of the helically twisted Bourdon Tube, the tube rotates the armature attached to its end. The armature is positioned in a miniature, balanced, inductive bridge. A solid state electronic circuit receives the signal from the bridge and performs an extremely reliable switching function using minute amounts of energy, due to the elimination of friction and the minimizing of inertial forces.

Additional switch points may be added to the TR 2065 without adding more pressure sensing elements. Thus, as the number of operations increases, the size, weight and cost per switching point decreases.

**Typical Specifications**

- Switch Point**
- Dynamic Stability:**  
Less than 0.25% of full scale when subjected to 60G's shock (10 m.s.) and vibration and 100G's shock
- Vibration:**  
(10-55 cps 0.2" SA) (55-2000 cps 60g)
- Hysteresis**  
0.1% of the pressure cycle experienced by the tube
- Temperature:**  
(zero shift) 0.005% per °F  
(scale factor) 0.001% °F
- Long Term Drift**  
0.2% per year (approx.)
- On-Off Differential**  
0.1% or better
- Repeatability**  
0.1% of full scale



Pressure Switch, Type TR 2065.

**What are your needs?** If your immediate or future applications call for pressure switching, write or wire for complete information. Address your inquiry to Stanley M. Ingersoll, Capabilities Engineer.

\*Patent applied for

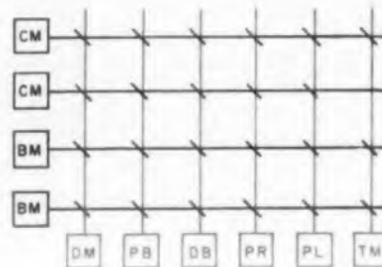


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CIRCLE 4 ON READER-SERVICE CARD

## Computer Networks Are on the Way



**How two types** of elements are connected in Thompson Ramo-Wooldridge's polymorphic computer. At left are control modules and buffer modules. These connect with subordinate drum modules, peripheral buffers, display buffers, printers, plotters, and tape modules. If required, other computer elements can be similarly connected—high-speed buffers, Flexowriters, analysis consoles and control consoles.

**D**ATA-PROCESSING scientists are wondering whether it's time to take a "system" look at current computing needs. Sometime soon, they reason, computers will have to be teamed to keep capacity abreast of increasing demands for data processing.

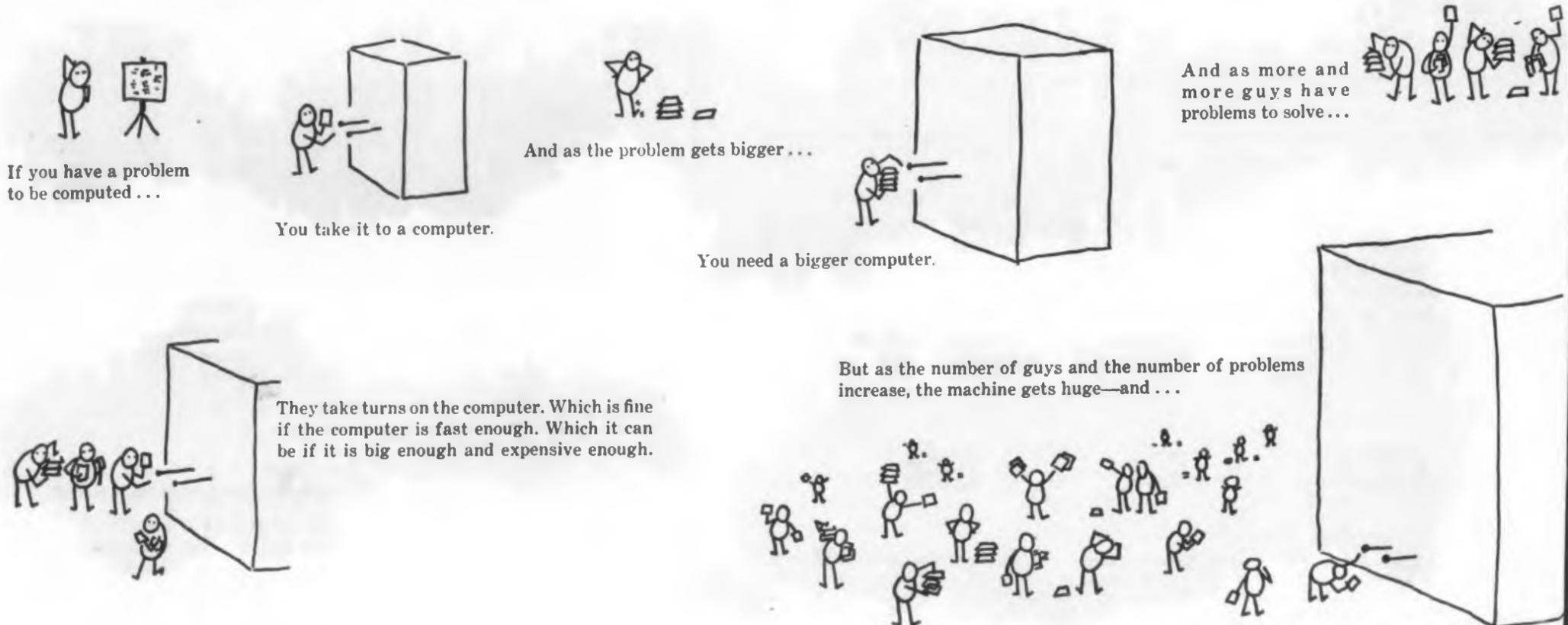
Computers and translators linked in a network could handle more work more efficiently and economically than the same equipment operating independently.

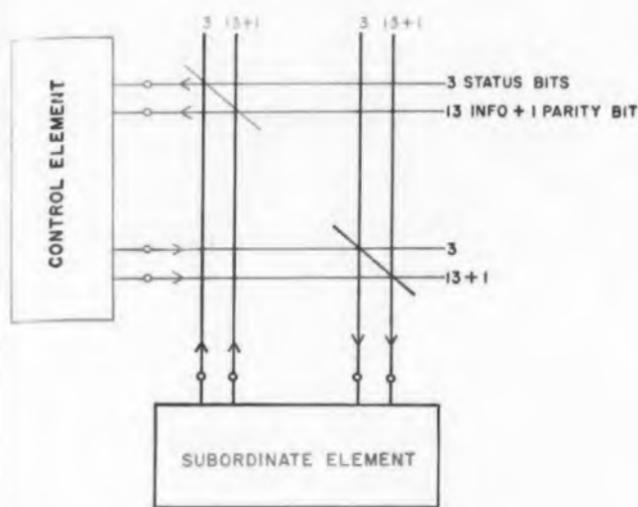
Some of the first steps toward computer networks have been taken: data-processing centers are in operation and more are being organized; digital computers have been linked by microwave radio, and the first "polymorphic" computer is nearing completion.

The polymorph, being developed by Thompson Ramo-Wooldridge, Inc., is made of many small modules of a few basic types that can organize themselves in different ways to do different jobs.

The first of these systems, the RW-400, is being built for the military at Dr. Simon Ramo's Intellectronics Laboratory, Canoga Park, Calif.

It has two kinds of controlling elements: a digital computer and a buffer module. These are connected by a central "switchboard" to drum modules, peripheral buffers, display buffers, printers, plotters, tape modules, translating devices, high-speed buffers, Flexowriters, analysis consoles and control consoles.





The polymorphic computer being built for the military can transmit 13 information bits, one parity bit and three status bits to and from each control element and each subordinate element.

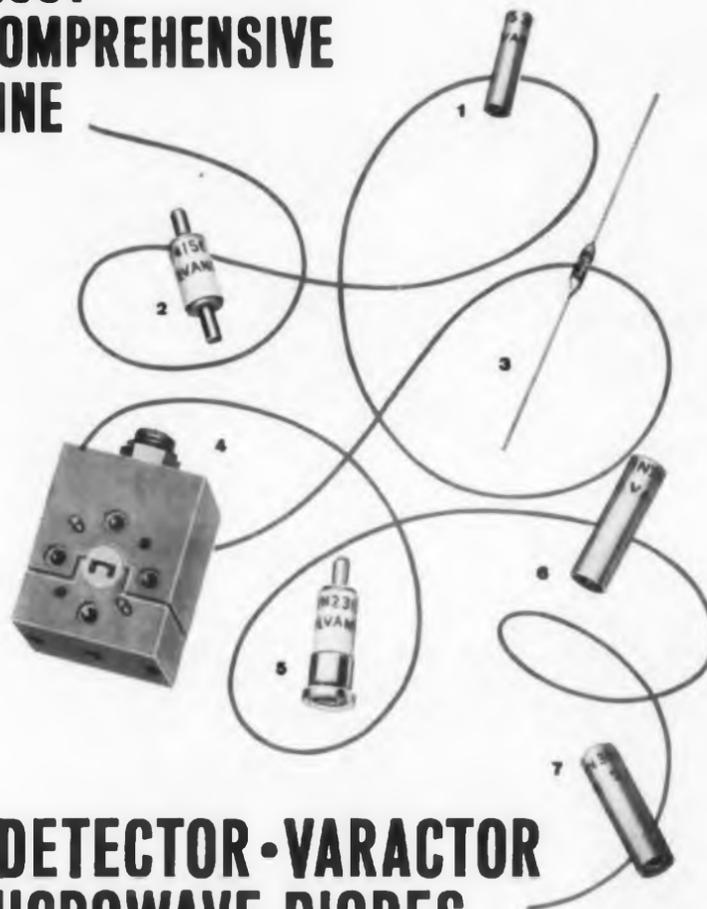
The switchboard is a transfluxor matrix capable of 5- $\mu$ sec switching. Through the switchboard, controlling elements—those with “dials” on their “telephones”—can talk to any subordinate component.

The central exchange matrix is not a bus bar: the computer doesn't have to “talk” to many different devices simultaneously. It needs only to communicate with one line, and there can be as many simultaneous conversations as there are

Isn't that a waste, because while Joe is using the computer to solve an easy problem—using .01 of the computer—everyone else has to wait—unless you spend still more money and buy still more computers.



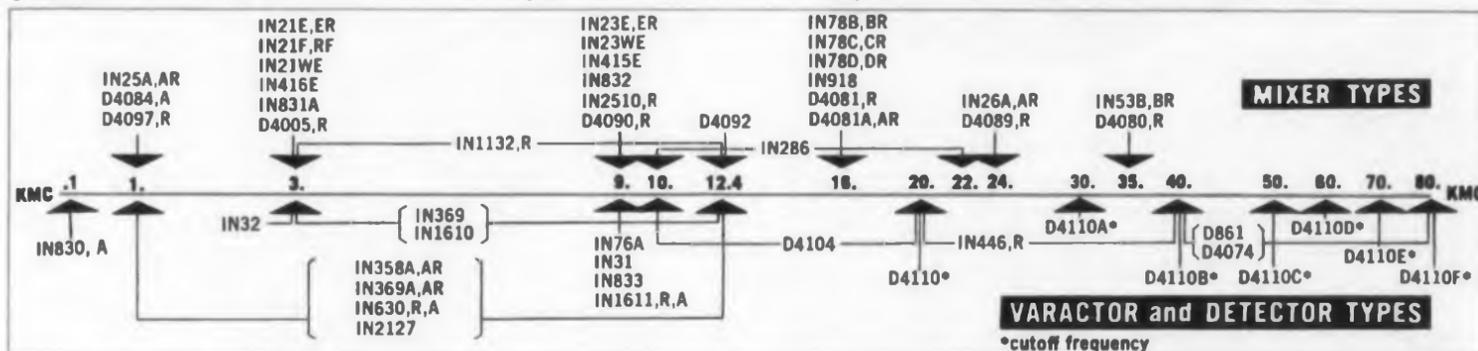
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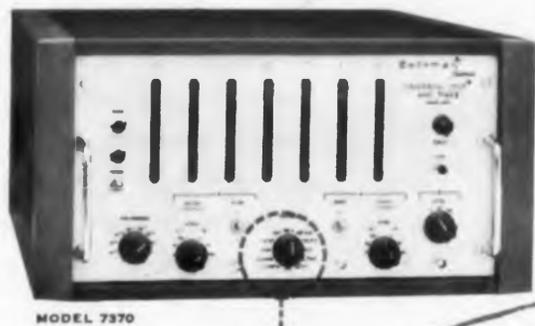
SYLVANIA MICROWAVE DIODES utilize the point-contact structure in those units specifically for MIXER and DETECTOR service, and the MESA structure in the VARACTOR types. Advanced processes and techniques developed by SYLVANIA assure MICROWAVE DIODES capable of withstanding the most severe environmental conditions of shock, vibration, and temperature. Extraordinary quality-controls assure low-noise figures, high sensitivity and high Q in units where those characteristics are essential to equipment design.

If you are designing radar, counter-measure, missile control, TV or telephone relay, test or special-purpose equipment operating at microwave frequencies, send now for your copy of “SYLVANIA MICROWAVE CHARACTERISTICS AND REPLACEMENT GUIDE.” This valuable new booklet contains data for more than 125 Sylvania Microwave Diodes, the most comprehensive line in the industry. You are certain to find here the right unit for your design. Write to Sylvania Semiconductor Division, Dept. 18-2 Woburn, Mass.

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SCAN

E/B

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E/Bx10

COUNT-E

OFF E/B-A

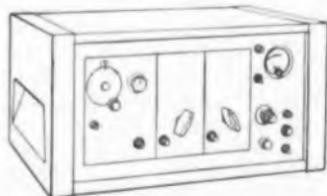
COUNT  
Frequency counting to 10Mc with 0.1v sensitivity

TIME  
Period measurements in 0.1μsec units

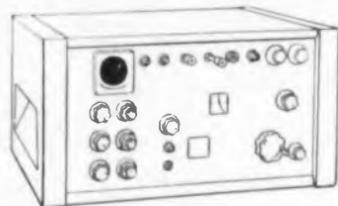
TIME  
2-channel time interval measurements

TIME  
Phase difference measurements

COUNT  
Frequency ratio measurements



Add this heterodyne unit (Model 7570 Series) to measure frequencies up to 1000Mc.



Or add this computing transfer oscillator (Model 7580) to get a counter display of frequencies up to 15,000Mc.

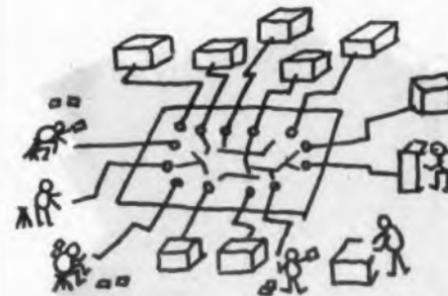
Complete specifications on Models 7370, 7570 and 7580 will be sent on request.

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CIRCLE 6 ON READER-SERVICE CARD

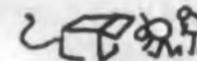
## NEWS



So the users all wish they could divide the huge computer into little pieces and make a flexible, loose "switchboard" connection, distributing the control and the memory and the arithmetic and everything else. Then they can all use it at once, with switching combining a large or small collection of computer units, as the case may require.



Then if users get the busy signal too often, they buy more capacity and connect the added components to the system—or connect new "subscribers" as they move in—or add more displays, so they can see what they have.



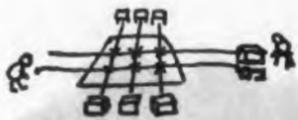
And, if one piece quits, it's no great catastrophe—they switch over to another.

controlling devices. All elements talk in one common language in the switchboard complex.

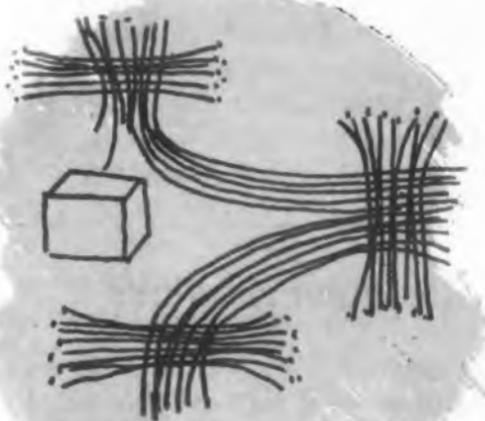
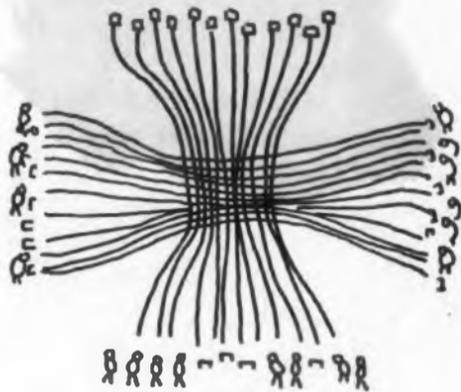
Polymorphic computers have large memories, useful because a minimum-size system installed as a starter can be expanded easily later. There are more profound implications. One is that with two buffer modules, the computer effectively has an infinite memory, says E. E. Bolles, associate head of the Digital Control Dept. at Intellectronics Laboratory. Normally, with a program that requires much data, the data are pulled in and worked on until they are complete; then more data are pulled in and processed.

With a polymorphic computer having two buffers, the computer module can start by operating on the data gathered and supplied by one buffer, while setting the second buffer to gathering the next batch of data. When the computer is finished with the first batch, it ties to the second buffer memory and sets the first to sorting and accumulating data.

Therefore two intelligent buffer modules



And now—when you put together a complex of human brains and electronic boxes—you can start with a few components. When you need more and can afford them, you can build to a big, or even a really, really big system without over-investing early or throwing anything away. So you save money and all the while have better reliability and multiple use and better access.



You can't even join two complexes—or three or four—by means of switching like a telephone system, connected in a giant computer as an element. If the "super-system" scale justifies, you can also keep some lines private by opening some switches permanently, so some information won't be available to "nosy" subscribers.

switching in and out, interpreting and sorting data to help the computer operate most efficiently, give the system what amounts to a very large memory.

In systems with more than one computer module, one is assigned the job of master. It then assigns tasks and subtasks to the other controlling elements, as well as to the subordinate elements. In this way different computers can be working on different problems or all working on subtasks of the same problem.

The polymorphic system that Thompson Ramo-Wooldridge is readying for the military comprises



### Good anywhere in or out of this world

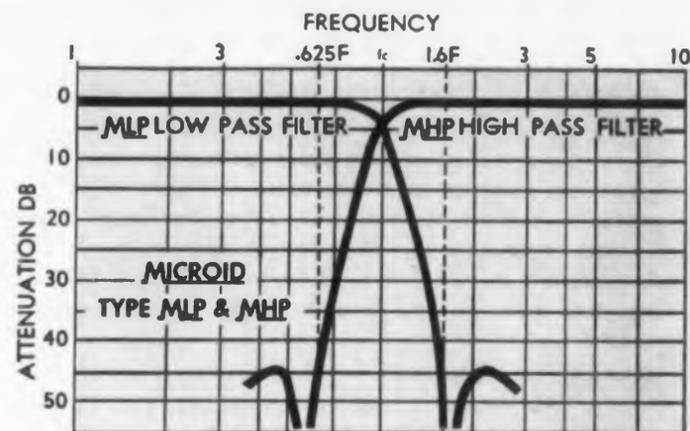
This system adds greatly to your credit when applied to the development of communications, telemetering, control and other devices. Under terms of membership, a wide range of toroids, filters and related networks are available. These include a complete line of inductors, low pass, high pass and band pass filters employing the new micro-miniature **MICROID**® coils so valuable in transistorized circuitry. Type **MLP** and **MHP MICROIDS** are micro-miniature counterparts of the popular Burnell types TCL and TCH low pass and high pass filters. The band pass filter results when cascading a TCL with a TCH filter.

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2 kcs to 4.9 kcs —  $1\frac{1}{16} \times 1\frac{5}{8} \times \frac{1}{2}$   
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Weight of all MLP and MHP Microids—approx. .3 ozs. each

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Catalogue #104 describing Burnell's full line of toroids, filters, and related networks, please ask for it.



Note: First informal meeting of Club members will be held in Burnell Booths 2919-2921 during the IRE Show, New York Coliseum, March 21-24. See you there.

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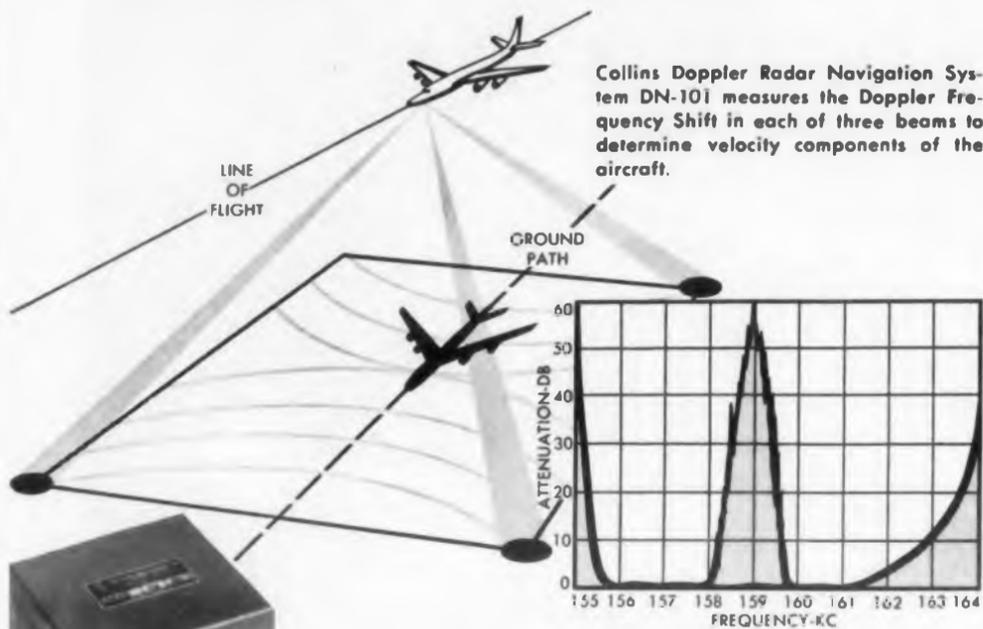


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CIRCLE 7 ON READER-SERVICE CARD

## FIRST Airborne Doppler Radar Navigation System

with Simplified Transistor Circuitry  
Uses HERMES CRYSTAL FILTER



Collins DN-101 Doppler Radar Navigation System is an airborne radar transmitting and receiving system which directs three beams of X-band energy towards the earth and then accurately measures the amount of frequency change between the transmitted and reflected signals to determine the lateral, vertical, and horizontal velocities of the aircraft.

In order to eliminate an undesired leakage sideband in the Radar Sensor, a system selectivity with a very sharp cut-off on the lower frequency end of the passband had to be provided. Hermes Crystal Filter, Model 669 U, not only met this requirement by establishing the desired selectivity in the second IF amplifier but also made it possible to reduce the number of transistors in the accompanying circuit. Close cooperation between the engineering departments of the two companies contributed to the rapid solution of this critical selectivity problem. Hermes Crystal Filter characteristics, Model 669U . . . Center Frequency is 159.0 Kc. Bandwidth at 2 db is 6 Kc min. Attenuation increases from 2 db to 53 db in 8.1% of the passband. Insertion Loss is 10 db max. Temperature Range is  $-40^{\circ}\text{C}$  to  $+55^{\circ}\text{C}$ .

Whether your selectivity problems are in transmission or reception. AM or FM, mobile or fixed equipment, you can call on Hermes engineering specialists to assist you in the design of your circuitry and in the selection of filter characteristics best suited to your needs. Write for Crystal Filter Bulletin.

*A limited number of opportunities is available to experienced circuit designers. Send Résumé to Dr. D. I. Kosowsky.*



**Hermes Electronics Co.**

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CIRCLE 8 ON READER-SERVICE CARD

## NEWS



And so now you see, it wasn't exactly a computer you wanted but a group of guys with brains and a group of electronic "brains," consoles and displays—all connected in varying ways and growing together, so that the combine can do more per dollar than each group, alone in processing information and reaching conclusions.

And that's all there is to the data-processing approach known as "polymorphic" (many shaped) or "multiple-mode" or the "matrix concept" or maybe just the common-sense switchboard idea in data-processing systems.

one computer module, two buffer modules, a printer, a plotter, three tape units and a drum storage unit.

Thirteen information bits and one parity bit can be transmitted either to or from the module. Three additional "status" bits go along with the information, to give the receiving module advice on how reliable the information is.

This means that the transmitting module's best information about the validity of the information is sent as status bits. If a tape breaks, for example, along with the noise of the break comes status information that alerts the computer elements. (Continued on opposite page)

### The Language Problem in Computer Networks

In a paper delivered at the Northeast Electronics Research and Engineering Meeting in Boston last year, Jerry Rothstein of Edgerton, Germehausen & Grier, Inc., discussed some aspects of computer networks. Here, in simplified form, are some of his observations on communication among computers:

For computers to cooperate, they must "speak" the same language. Very often this requires an intermediate "translator," which accepts the output of one system and changes it into a form suitable for use by the other system.

A translator can be considered part of either of the two computers, or all three elements can be viewed as a single system. Similarly existing systems can be broken down into many subsystems.

For  $n$  computers capable of individual operation, each with its own language and with co-operation required between every pair, there would have to be  $(n-1)$  one-way translators at each computer to permit any computer to understand any other.

There would be  $n(n-1)$  translators required

altogether. If a common language were devised, however, each computer would need two one-way translators ( $2n$  altogether), namely, those to translate its language to the common language and back again. Two-way translators could, of course, replace a pair of one-way translators in either case.

The common language is important because computers in existence speak different languages, and it is not likely that all computers of the future will speak the same language. A computer is generally built with some particular class of problems in mind. The language chosen is appropriate to that class of problems. The economies inherent in an appropriate choice are too large to be sacrificed to a common language.

Fortunately computer languages have sufficiently simple and similar logical constructions to make translator design a soluble problem.

Unlike machine translation of natural languages, translation between computer languages is feasible in practice and not just in principle.

If one of the elements breaks down, the computer is not disabled. The element's task is simply distributed among other elements. Clearly this means better reliability without duplicating the whole system.

For the time being, Thompson Ramo-Wooldridge believes, the principle use of polymorphs will be for command-control systems. These have large enough problems to make the system a necessity. Air-traffic control, air defense and other large systems will also probably be polymorphs. For industry, the company sees the possibility of a network of computers communicating with one another by central exchanges and digital data-transmission links.

In one form or another, computer networks seem only a matter of time. Some problems within the reach of programmers' capabilities, and others soon to be, are too large for individual computers and too important to be excluded from the schedule of problems to be analyzed automatically.

Jerome Rothstein of Edgerton, Germehausen & Grier, Inc., put the problem this way to an audience of computer specialists at the Northeast Electronics Research and Engineering Meeting:

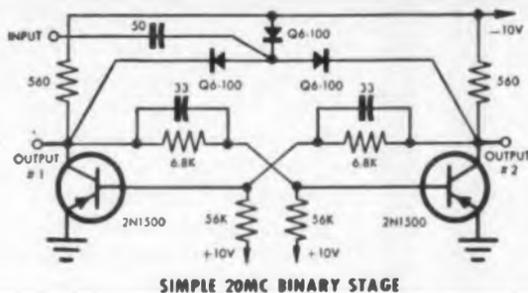
"In economic science the labor expended in treating data absorbs so many man-hours that relatively few penetrating questions are ever formulated, let alone answered. In public health and vital statistics there are dozens of hypotheses worth testing and mountains of data in hospitals, insurance companies and elsewhere that should be processed by high-capacity computer systems. Worldwide weather prediction and literature searching are other giant but vital problems that will probably be solved only by new approaches to data processing.

"The chief technological problem of computer co-operation reduces to one of organizing a number of independent computers into a cooperating network without prejudice to their ability to operate independently when desired."

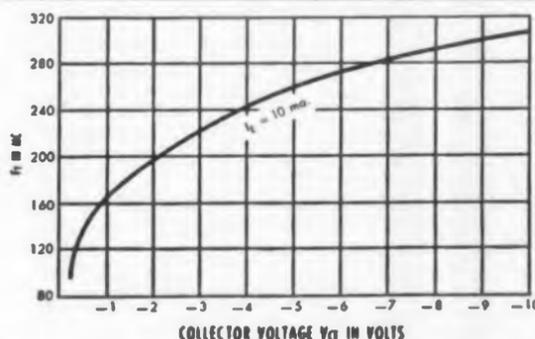
PHILCO ANNOUNCES

# NEW ULTRA HIGH-SPEED SWITCHING TRANSISTOR

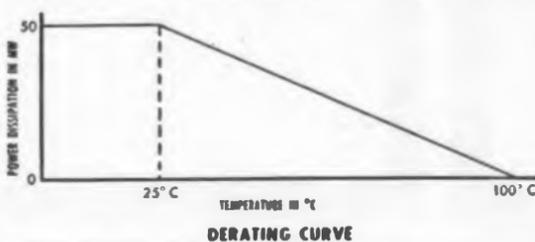
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Here is another Philco "break-through" in the design and manufacture of high frequency, ultra high-speed switching transistors! This new Micro Alloy Diffused-base Transistor (MADT\*) uses cadmium electrodes in place of indium. The higher thermal conductivity of cadmium insures cooler-running junctions for any given power dissipation and provides an extra margin of safety as added assurance of reliable performance.

The new 2N1500 offers the designer these important advantages:

- 100° C maximum junction temperature
- high Beta and excellent Beta linearity with temperature and current
- low collector capacitance
- low hole storage time (Typical: 7  $\mu$ sec)
- low saturation voltage

In electrical characteristics, the 2N1500 is similar to 2N501, which has been thoroughly field-proven in many military and industrial computer applications. It is manufactured on Philco's exclusive fully-automated production lines to the highest standards of uniformity. For complete specifications and applications data, write Dept. ED-260.

Max. Ratings		Typical Parameters				
$T_{STG}$ ° C	$V_{CE}$ volts	$t_r$ m $\mu$ sec	$t_s$ m $\mu$ sec	$t_f$ m $\mu$ sec	$h_{FE}$	$V_{CE(SAT)}$ volts
100	-15	12	7	4	35	-0.1

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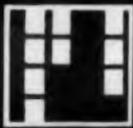
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Kearfott's rugged shaft position-to-digital converters are resistant to high shock and vibration and high and low temperature environments. Ideally suited for missile applications, these converters are available for many uses, including latitude, longitude, azimuth or conventional angular shaft displacement conversion and decimal count conversion. Exclusive drum design provides large conversion capacity in smallest size. Combination counter converter assemblies for both visual and electrical readout also available.

**TYPICAL  
CHARACTERISTICS**

Kearfott Unit No. .... P1241-11A  
Code ..... Cyclic Binary  
Range ..... 0-32,768 (2<sup>15</sup>)  
Bits per Revolution ..... 16  
Revolutions for Total Range  
2,048  
Volts D.C. .... 10.5  
Current (ma.) ..... 20  
Inertia (gm. cm.<sup>2</sup>) ..... 20  
Unit Diameter (in.) ..... 1 1/8  
Unit Length (in.) ..... 3  
Life 10<sup>6</sup> Revolutions or 10<sup>3</sup> hours  
Static Torque (in.-oz.) .. 2 (break)  
1 (running)  
Weight (oz.) ..... 5  
Maximum Speed (RPM) ..... 600

Write for complete data.

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**20 SECOND  
SYNCHRO**

This synchro, just one of a broad line offered by Kearfott, provides the extreme accuracy required in today's data transmission systems. Kearfott synchro resolvers enable system designers to achieve unusual accuracy without the need for 2-speed servos and elaborate electronics. By proper impedance, matches up to 64 resolver control transformers can also operate from one resolver transmitter.

**TYPICAL  
CHARACTERISTICS**

	SIZE 25	Control
Type Resolver	Transmitter	Transformer
Part Number	Z5161-001	Z5151-003
Excit. Volts (Max.)	115	90
Frequency (cps)	400	400
Primary Imped.	400/80°	8500/80°
Secondary Imped.	260/80°	14000/80°
Transform. Ratio	.7826	1.278
Max. Error fr. E.Z.	20 seconds	20 seconds
Primary	Rotor	Stator

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**INTEGRATING  
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Kearfott integrating tachometers, special types of rate generators, are almost invariably provided integrally coupled to a motor. They feature tachometer generators of high output-to-null ratio and are temperature stabilized or compensated for highest accuracy integration and rate computation. Linearity of these compact, lightweight tachometers ranges as low as .01% and is usually better than ± .1%.

**TYPICAL  
CHARACTERISTICS**

	Size 11 (R860)
Excitation Voltage (400 cps)	115
Volts at 0 rpm (RMS)	.020
Volts at 1000 rpm (RMS)	2.75
Phase shift at 3600 rpm	0°
Linearity at 0-3600 rpm	.07
Operating Temperature Range	-54° +125°

Write for complete data.

**NEWS**

**Direct-View Battery TV Due**



Fully transistorized, direct-view portable TV set made by Sony Corp. will be marketed in Japan next month and in the U.S. within eight months. It has an 8-in. screen and weighs 13 lbs with its 2-lb battery. This model, to be priced at about \$200 on the Japanese market, operates on 100-v, 60-cycle ac or on a self-contained, sealed-type rechargeable 12-v battery, using 15 w of power. Battery is a 3 amp-hr unit and lasts about 2 1/2 hr.

**1959 Electronics Sales Reach  
All-Time High of \$9.2 Billion**

Total 1959 factory sales for the electronics industry established an all-time high of \$9.2 billion, reported David R. Hull, president of the Electronic Industries Association, releasing the official EIA totals for 1959. He added that the industry is expected to pass the \$10 billion mark in 1960.

"Manufacturers of consumer products made a substantial comeback from the 1958 recession with a 1959 sales total of \$2.05 billion, or \$450 million better than last year," Mr. Hull stated. "The 1959 figure of \$1.1 billion for replacement parts, tubes, and semiconductors is \$240 million higher than 1958. Industrial and military products set new highs with totals of \$1.55 and \$4.5 billion. These were, respectively, \$170 and \$400 million over 1958."

**U.S. Leads in Semiconductors Says  
Solid-State Conference Chairman**

Assisted by heavy financial backing from government agencies, the U.S. is well ahead of Japan, Russia and the rest of the world in solid-state technology, believes A. P. Stern, chairman of the 1960 Solid-State Circuits Conference, which is about to open in Philadelphia.

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West Coast Office: 253 N. Vinado Avenue, Pasadena, Calif.

Mr. Stern, manager of General Electric's Electronic Components and Applications Laboratory, also told *ELECTRONIC DESIGN* that he thinks it's time for companies engaged in microminiaturization to co-operate in an evaluation of all microminiature programs.

The situation in microminiaturization is disturbing because of confusion in goals and nomenclature, Mr. Stern stated. He would like to see a schedule set up for each program, against which progress could be measured. This would permit, Mr. Stern said, concentration on the most promising work and elimination of many programs.

About 2500 engineers are expected to attend the conference, which will be held Feb. 10, 11, and 12. Over 43 papers, arranged for by program chairman T. J. Lynch of Bell Labs, will be presented.

### Radar With 0.02-Musec Pulse So Sharp It Tracks People

A new magnetron that packs 25 kw of 8-mm power into a 0.02- $\mu$ sec pulse has been developed for airport surveillance radars and other applications. Resolution of the tube in a millimetric radar system is so sharp that traces of people and of vehicles as small as jeeps can be displayed clearly.

Amperex Electronics, which is distributing the Philips-designed tube, reports that range and azimuth resolution of 4.5 yd at 1000 yd has been achieved.

The new magnetron, Type 7093, achieves the rise-time of 600 kv per  $\mu$ sec needed for a 0.02- $\mu$ sec pulse.

"The short pulse length enables a radar to detect objects as close as 10 or 12 ft from the antenna," Amperex reports. "This makes the tube ideal for small-craft harbor vehicles and airport surveillance applications."

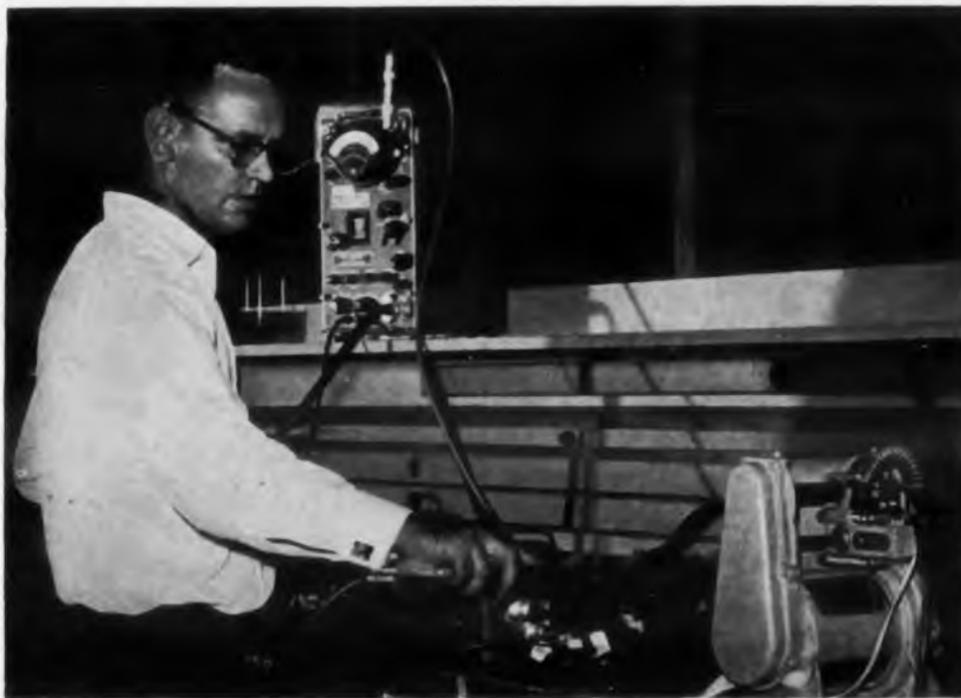


Jeep

Aircraft

People

Map-like ppi presentation, using new tube, shows people walking on airport apron and jeep rounding corner and heading along runway.



A technician 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.



### SPRAGUE SUBMINIATURE THRU-PASS® CAPACITORS

solve noise filtering problems

Sprague THRU-PASS Capacitors display insertion loss characteristics that are truly remarkable, especially at very high frequencies.

THRU-PASS Capacitors reduce to a negligible value the effect of external connection inductance on the capacitor. They also provide a minimum length of internal path for radio interference currents. Their performance is closer to that of a theoretically ideal capacitor than that of any other paper capacitor ever made! THRU-PASS Capacitors are designed to meet all the electrical, mechanical, and environmental requirements of MIL-C-11693.

Both Type 102P and Type 103P are impregnated with Vitamin Q, Sprague's exclusive inert synthetic impregnant, in order to provide maximum insulation resistance and minimum temperature/capacitance change. Type 102P units are processed for -55 C to 85 C operation; Type 103P for -55 C to 125 C. Maximum feed-thru current for which both are rated is 5 amperes d-c continuous or equivalent.

For complete data on THRU-PASS Capacitors, write for Engineering Bulletin 8015 to Technical Literature Section, Sprague Electric Company, 347 Marshall St., North Adams, Mass.

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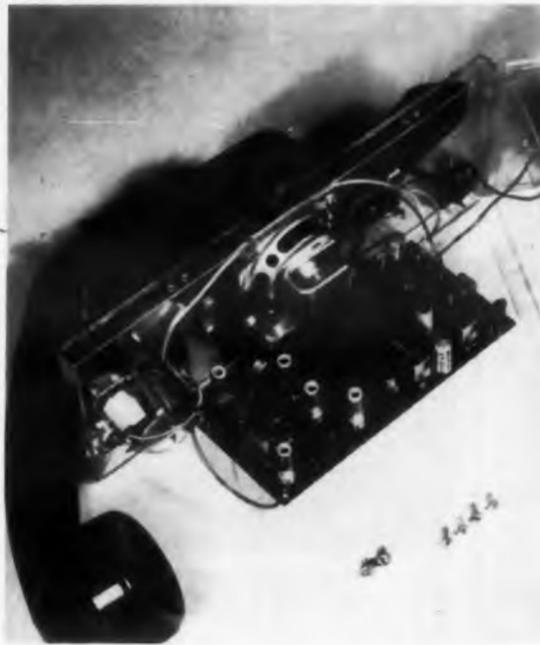
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CIRCLE 12 ON READER-SERVICE CARD

## NEWS



Micro-Pak Citizens' set made by Micro Electronics has a transmitter with a crystal-oscillator-driven, class-C power amplifier. Power output is 15 mw for 60-mw input. Signals off by  $\pm 20$  kc from operating frequency are attenuated 45 db. Sensitivity of single-conversion, superheterodyne receiver for useful audio output is 0.5  $\mu$ v. This provides audio power output of 50 mw.

## Designers Producing \$100 Citizens' Tr

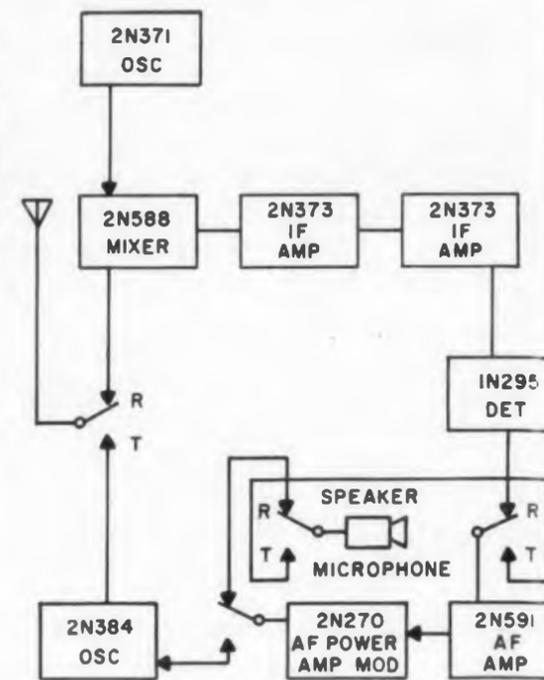
THE popularity of Citizen's Radio is triggering design of a new class of communications equipment—walkie-talkie sets that retail for about \$100, less than half the price of standard portable transceivers.

Designers are hitting the \$100 target by keeping circuits simple, leaving out frills, and by going to single-frequency operation.

Three low-priced sets have already been introduced, and manufacturers are reported developing similar devices in anticipation of a huge market. Available at present are:

- A 27-mc transceiver made by Radio Manufacturing Engineers, Inc., with seven transistors and two diodes. Only one transistor is used in the rf portion of the transmitter. To reduce components, the designers made the receiver audio amplifier double as the transmitter modu-

## Three Approaches To Low-Price Trans



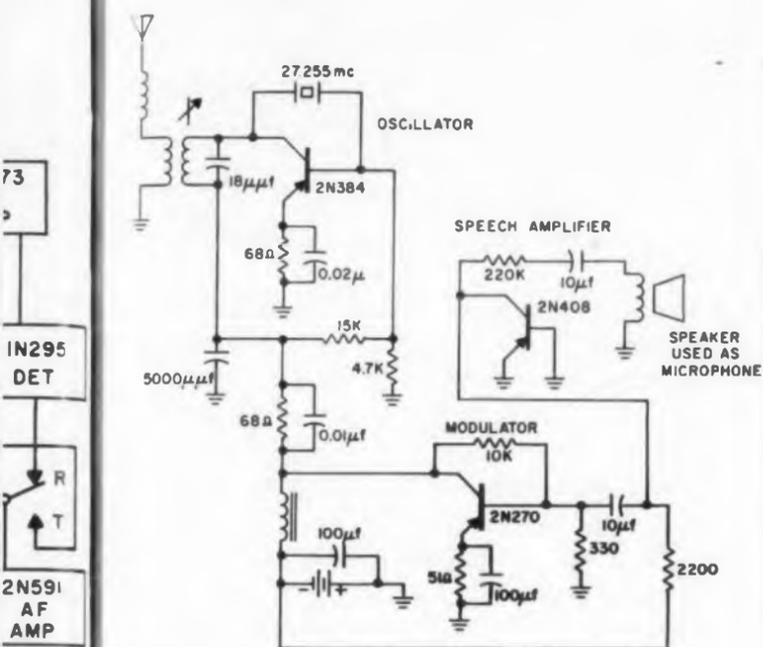
AM transceiver, Radio Manufacturing Engineer's 4303, also uses only one transistor in the rf portion of the transmitter. The 2N384 operates a crystal-controlled oscillator with 90-mw input. The local oscillator is continuously tunable between 26.965 and 27.255 mc. To switch circuits from receive to transmit, the operator uses a multipole switch, coupled to the press-to-talk button, instead of a relay.

lator system. The built-in loudspeaker also serves as the microphone.

- A WEPHONE transceiver manufactured by Wightman Electronic Engineering Co., with seven transistors and one diode. The WEPHONE's designers provide a modulator system independent of the receiver audio amplifier. The receiver is a single-conversion superheterodyne designed for single-frequency operation. With appropriate crystals, it can receive and transmit on any frequency in the 27-mc Citizens' band.

- The Micro-Pak, a more elaborate low-priced transceiver developed by Micro Electronics. It has squelch operation, more complex circuitry than the other sets and a price tag of more than \$100. Receiver sensitivity for useful audio output is reported to be 0.5  $\mu$ v. Receiver drain is 20 mw and transmitter drain, 70 mw.

## W-Phone Transceiver Design



The W-Phone transmitter developed by Wightman Electronic Engineering is paired with a single-conversion, superheterodyne receiver. The 2N384, used as a crystal-controlled oscillator, constitutes the transmitter rf section. This stage is modulated by the 2N270, which is driven by the 2N408 speech amplifier. The loading coil feeds a 48-in. antenna. Standby drain is 7 ma and transmitting drain, 17 ma. The set can operate anywhere in the 27-mc band with appropriate crystals.

## Transceivers

The Federal Communications Commission requires that sets for unlicensed operation transmit between 26.77 and 27.27 mc, restrict power input to the final rf stage to 100 mw or less, use a single-element antenna not more than 5 ft long, and attenuate emissions outside the 26.97-27.27-mc band by at least 20 db.

In addition to meeting these requirements, Citizens' equipment designers must meet these needs of the market:

- Transmitter range of at least one mile.
- No transmitter tuning adjustments for the user to make.
- Selectivity ample to avoid adjacent channel interference and adequate to permit reception from a similar unit one mile away.
- Small, light equipment operated by self-contained batteries.

Despite the limitations, designers are delivering sets that give surprisingly good performance for the stringent requirements under which they must operate. ■ ■

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CIRCLE 14 ON READER-SERVICE CARD

## NEWS

### Gallium Arsenide Tunnel Diode Has 60-to-1 Peak-Valley Ratio

Latest from the tunnel diode labs is General Electric's announcement of a tiny gallium arsenide device with these features:

- Peak-to-valley current ratio of 60 to 1, 5 to 10 times that of previously described tunnel diodes;
- The ability to handle current densities ranging from 5,000 to 10,000 amp per sq cm, roughly the capability of No. 12 gage copper wire, and four times that of germanium tunnel diodes. Current densities handled by germanium tunnel diodes range from 0.4 to 0.45 v per sq cm.
- Voltage swing of from 0.9 to 1.1 v.
- Resistance to temperatures up to 500 C.

Gallium arsenide, the company believes, performs better than any other tunnel-diode material tested so far, and may prove the ultimate material.

Company spokesmen report that the best peak-to-valley current ratio of germanium so far observed is 14 to 1. Silicon diodes have exhibited no greater than 6-to-1 ratios.

GE expects to have samples ready for circuit designers in six months; these will cost an estimated \$75 each.

## NEWS BRIEFS . . .

. . . THE INSTRUMENT SOCIETY OF AMERICA will collect and publish a "comprehensive compendium" of up-to-date information on all known transducers. Expected publication of the first volume is January 1961.

. . . A NEW WATT-MEASURING DEVICE, the Hall multiplier, developed by Westinghouse Corp., operates as a watt transducer, converting ac watts to a dc millivolt signal. In control circuitry, the unit has a response speed in microseconds, compared with a time constant of about one second for a thermal converter, Westinghouse reports. Two versions have been designed: one provides an unfiltered dc current output in the milli-ampere range; the other produces a filtered dc millivolt output.

. . . THE AMERICAN POWDER METALLURGY INSTITUTE has been formed for metallurgists and "anyone having a bona fide interest in powder metallurgy." Address of the new organization is 60 E. 42nd St., New York 17, N.Y.

... LUNAR GLOBES showing the moon's far side as photographed by the Soviet's third cosmic satellite have been constructed at the Moscow Planetarium and are being readied for mass production.

... TELEVISION SETS AND ANTENNAS currently cause more than 4% of lightning-originated fires, reports the Lightning Protection Institute.

... WESCON (Western Electronic Show and Convention) will be held in Los Angeles' new Sports Arena in 1960, Wescon's board of directors reports.

... ELECTRONIC SYSTEMS engineering and electronic cabling contracts in excess of \$500,000 have been awarded to Pacific Automation Products, Inc., by Lockheed Missile Systems Div., Convair, Fischbach & Moore, and Sperry-Utah. An initial Lockheed contract is for work on the Samos-Midos reconnaissance satellite program. The contract includes systems integration and systems engineering on Lockheed's satellite tracking and data-acquisition station.

... DIGITAL AND ANALOG airborne magnetic tape recorders will be designed by Oliver-Shepherd Industries, Inc., Nutley, N.J., under a \$215,000 contract from Airborne Instruments Laboratory.

... RELIABILITY of communication equipment could be greatly improved if designers could use principles believed to underlie operation of the brain and nervous system, according to Kenneth W. Jarvis, a panel chairman at the Winter General Meeting of the AIEE. He told an audience of computer engineers: "Scientists have long been aware of the remarkable powers of the human brain and nervous system to utilize astonishingly small quantities of sense data to arrive at reliable decision regarding the external world. It seems that one factor in this remarkable capacity is that parallel sensory paths are utilized and their outputs compared at various levels. Most probable values of the sense data are computed and cross-compared, resulting in a high degree of reliability. In essence, operation is parallel rather than serial."

#### Correction

Two captions were transposed on pages 3 and 4 of the Dec. 23, 1959 issue of ELECTRONIC DESIGN. The drawing on page 3 actually shows a Centralab flip-flop wafer; the schematic on page 4 illustrates a module made by Arthur Ansley Manufacturing Co.

# 5 GUARANTEES

## for Tung-Sol 2N1313 Computer Transistor mean new freedom for designers



THERMAL BOND

And there's still another. For a nominal additional charge any specific electrical design characteristic will be 100% guaranteed not to exceed its distribution limits. These guarantees add up to a marked upgrade in circuit design accuracy... high reliability in operation... and consistent repeat performance. In specifying the Tung-Sol 2N1313 high speed switching transistor, you're selecting a transistor which features an ideal balance of the most wanted characteristics as revealed by a survey of computer designers. You're also choosing a transistor which offers improved performance at lower cost over most

of today's popular computer types.

The 2N1313 is designed to meet vigorous military environmental standards. It features "Thermal Bond" construction, exclusive with Tung-Sol. The transistor junction tab is securely joined to the base of the transistor. The bonding material provides high heat dissipation while maintaining complete base-to-case electrical isolation.

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$BV_{CBO}$	-30 Volts
$BV_{EBO}$	-20 Volts
$BV_{CEX}$ ( $V_{BE} = 0.1V$ )	-20 Volts
$BV_{CEO}$	-15 Volts
$I_C$ (continuous)	400mA
$I_B$ (continuous)	50mA
$T_j$	-65°C to +100°C
$P_C$	180mW



#### Typical Characteristics (@ 25°C)

Parameter	Conditions	Min.	Design Center	Max.	Units
$I_{CBO}$	$V_{CB} = -0.5V$	-	1.5	2.5	$\mu A$
$I_{CBO}$	$V_{CB} = -15V$	-	2	3.5	$\mu A$
$h_{FE}$	$I_B = 1mA, V_{CE} = -0.25V$	40	70	125	
$h_{FE}$	$V_{CE} = -0.35V, I_C = 400mA$	20	30	50	
$f_{\alpha b}$	$V_{cb} = -6V, I_C = 1mA$	6	12	-	Mc
$C_{OB}$	$V_{CB} = -6V, I_E = 1mA, f = 1Mc$	9	14	20	$\mu\mu f$
$(t_r + t_d)$ (rise plus delay time)	$I_{B1}$ (turn on current to base) = 1mA $I_{B2}$ (turn off current) = 1mA $I_C = 10mA$ $R_L = 1K$	-	0.45	0.70	$\mu sec$
$t_s$ (storage)		-	0.30	0.60	$\mu sec$
$t_f$ (fall)		-	0.25	0.40	$\mu sec$

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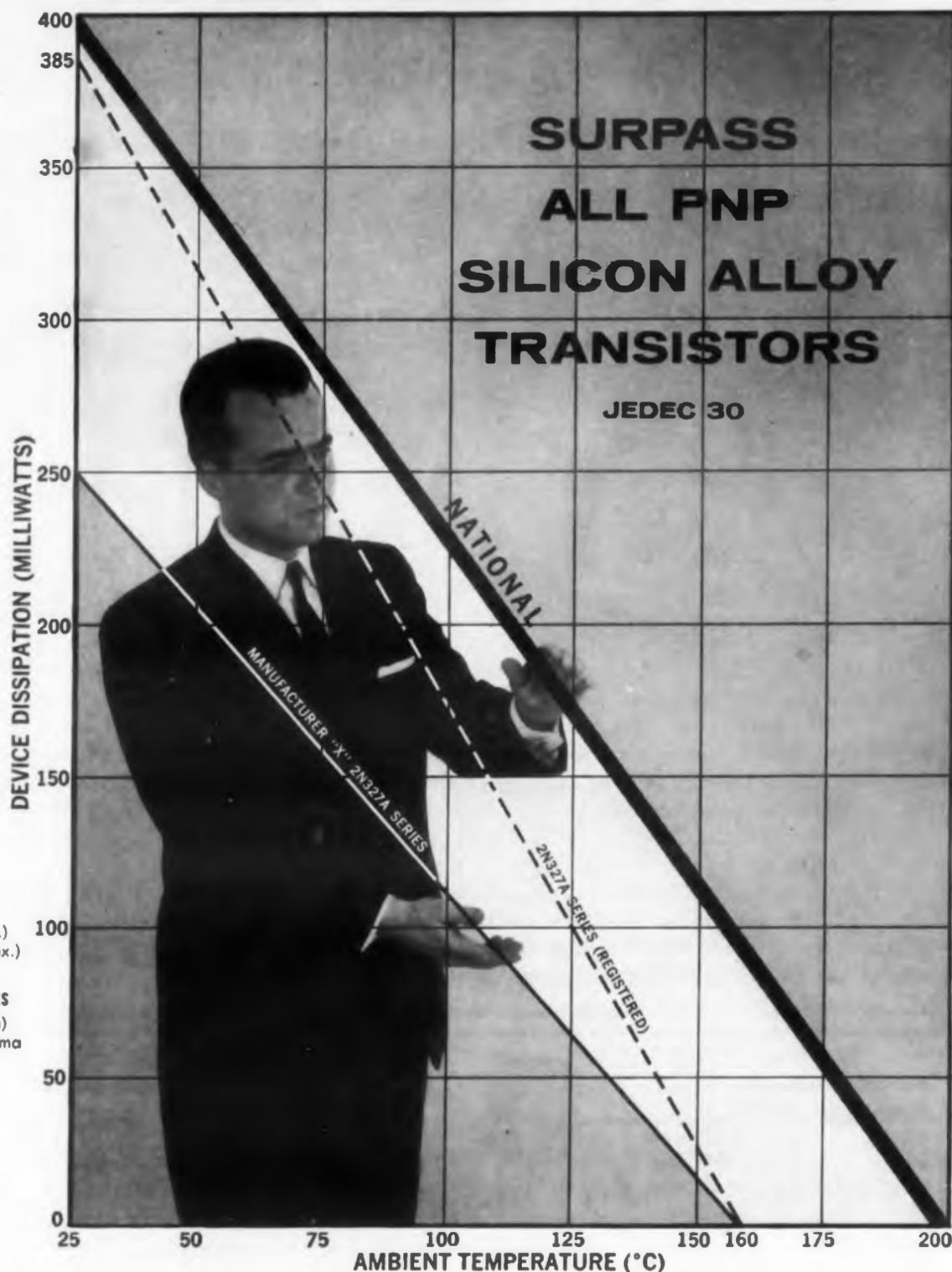
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and  $I_E = 1.0$  ma)

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## NEWS BRIEFS ...

... A MATHEMATICAL FORMULATION that predicts microwave absorption in ferrites is being evaluated for the Diamond Ordnance Fuze Laboratories by the National Bureau of Standards. NBS reports that prediction could cut the testing required to determine behavior and properties of ferrites. The work could also lead to more effective use of existing materials and to easier synthesis of new materials.

... ENGINEERS JOINT COUNCIL will invite foreign scientists to this country in the next six months to broaden engineering teaching and research. The scientists will exchange information with educational groups here and will receive an opportunity to visit engineering society meetings and non-university research organizations.

... A COMPUTER able to operate at 500,000 operations per second is under development at the University of Illinois. The unit will provide high-speed storage for nearly 250,000 bits of information.

... "RESEARCH AND DEVELOPMENT expenditures by industry, government, universities and private laboratories will rise to more than \$20 billion annually over the next seven or eight years, against \$10 billion today," predicts Donald C. Power, chairman and chief executive officer of General Telephone and Electronics Corp.

... SCIENTISTS AND ENGINEERS employed by American companies totaled 780,000 in January, 1959, the National Science Foundation reports. A foundation survey found that industry accounted for two-thirds of the scientists and engineers employed in the nation. The other third work for government agencies, educational institutions and non-profit organizations, or are self-employed.

... A TECHNICAL ADVISORY COMMITTEE of university scientists has been established by Daystrom, Inc., to aid in long-range R&D planning. The committee will review the programs of all Daystrom divisions and provide them with the latest research information.

... RECIPIENT of the annual National Reliability Award for the best technical paper delivered at the Fifth National Symposium on Reliability and Quality Control in Washington was H. G. Friddell of the Boeing Airplane Co. His paper, "System Operational Effectiveness (Reliability, Performance, Maintainability)", included a procedure for obtaining an operational-effectiveness value for systems.

...GENERAL CHAIRMAN for next year's reliability symposium will be W. T. Sumerlin of the Philco Corp. He succeeds C. M. Ryerson of the Radio Corporation of America.

...1959 ANNUAL AWARD of the IRE Professional Group on Reliability and Quality Control was presented jointly to J. A. Connor and H. L. Wuerffel in "recognition of their contributions to the profession." The citation recalled their work in report TR 1100, which included an assemblage of guiding principles, data and graphs for the design of reliable electronic equipment. Mr. Wuerffel, a systems engineer, is in the reliability analysis and measurement engineering section at RCA. Mr. Connor is manager of the Reliability and Component Engineering Dept., Communications Div., Hughes Aircraft Co.

## PRICES AND AVAILABILITY...

...TANTALUM POWDER, both "Lo-Cap" and "Hi-Cap," has been reduced 15 per cent in price by the Kawecki Chemical Co. of Boyerton, Pa. The powder is now available at \$49.80 a pound in minimum 200-pound shipments.

...MULLARD, LTD., London, has developed an S-band Faraday rotation circulator with an insertion loss of less than 0.2 db. The circulator's low insertion loss represents an increase of less than 14 K in noise temperature. The circulator provides an isolation of more than 30 db in any unwanted transmission path. Bandwidth is about 30 mc. An S-band ferrite switch also developed by Mullard, and designed for a maser amplifier, has an insertion loss of 0.3 db. The device is designed for switching between two waveguide outputs, isolation between the paths being greater than 20 db. Bandwidth is 100 mc and switching time is less than 100 µsec.

...SILICON-CONTROLLED rectifiers have been reduced 20 to 40 per cent in price by General Electric Co., Liverpool, N.Y. The new prices range from \$18.50 to \$95 each on the eight models in the 16-amp line; from \$14 to \$71 each on the eight types in the 10-amp line, and from \$24 to \$114 each on the seven devices in the inverter series. All prices are for production quantities to original-equipment manufacturers.

Is your company making changes in prices or availability of its products? Send the details to ELECTRONIC DESIGN, 830 Third Ave., New York 22, N.Y.

Here is a totally new method for attaching disconnect splices to coaxial cables that will create new standards of performance... on chassis connections, computers, test equipment—in fact, anywhere that two coaxial cables need fast and reliable disconnect splicing.

Easily attached to coaxial cables by AMP's modern compression method, the all new A-MP COAXICON assures you of uniformity, absolute reliability and new low cost—in either free-hanging or through-panel units. In addition, the COAXICON supports cable shielding against vibration while offering fully insulated positive electrical performance.

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COAXICON offers not only the fastest method of attaching disconnects to your shielded wire... it is not only the most reliable disconnect you can buy—for either free hanging or panel mounted applications... not only the most economical on the market... but... COAXICON now fits shielded cable sizes up to 1/4" O.D. with interchangeable contacts that permit a wide variation of inner conductor diameters in each cable size.

Further, COAXICON mounting clips accommodate a wide range of panel thicknesses for through-panel applications. Whether your requirements include RG type coaxial cable, standard coaxial cable or other shielded cable types, with solid or stranded conductors, look to AMP for the precise Coaxicon Disconnect you need.

If you're not now using the A-MP Coaxicon, send for literature today. It can solve many shielded circuit problems for you.

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Lever type actuator for use with low operating force



Basic "SM" switches are available in over 300 different variations



Roller type actuator for use with two Type "SM" switches



Leaf type actuator for use with two Type "SM" switches



Integral leaf actuator for use with slow-moving cams and slides



Leaf type actuator with special bend to follow slow-moving cams or slides



Integral roller-leaf actuator for use with fast moving cams and slides

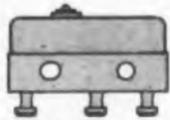


Roller lever actuator for high-speed, low-friction applications

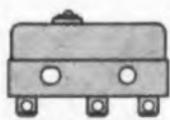


## Ten different ways to actuate this small, dependable switch

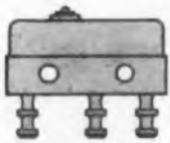
ACTUAL SIZE



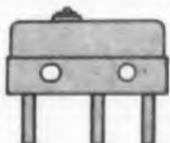
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Solder post



Double turret



Quick connect

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## WASHINGTON REPORT



Ephraim Kahn

... RECORD R&D spending is planned by the Government during the fiscal year that starts July 1. The Defense Dept. alone will be ready to commit \$5.8 billion, while the National Aeronautics and Space Administration contemplates \$600 million worth of R&D. The Federal Aviation Agency will allot \$56.2 million, much of it for electronic development and modernization of air-traffic-control and navigation systems. President Eisenhower's new budget includes a request for total Government R&D spending of \$8391 billion, 5 per cent more than was requested for the last fiscal year. Basic research accounts for \$600 million of this.

... ELECTRON TUBE procurement procedures proposed by the Air Force as purchasing agent for the military have been submitted to the Defense Department for approval. If they satisfy the Assistant Secretary for Supply and Logistics, the Air Force will first compile total military requirements of types of tubes used by all the services, work out a buying schedule and place contracts. Expectations are that the Air Force will be ready to do its first buying before March 31.

... BIDDING MODIFICATIONS for military electronic contracts have been urged by J. K. Sprague, president of Sprague Electric. He suggests weighting bids by grading manufacturers on the quality of their products and their past records in meeting military specifications. At present, he asserts, producers of top-quality items must compete on a straight price basis with those "who have not demonstrated a capability for producing to the required standards."

... COMPONENT RELIABILITY is the keystone of a successful weapons system, says the Navy's chief of development, Vice Adm. J. T. Hayward. Components "have been overlooked completely" in the glamor of many large systems, he charges, adding that "the results have shown we should have paid more attention to our homework on the components." He notes, too, that reliability starts with "the lowest component" and that "all the quality control in the world" cannot compensate if engineering and design are inadequate.

... **JAPANESE COMPETITION** may soon make itself felt in color TV sets. A major incursion of the U.S. market is believed planned. The competitive weapon is believed to be a 21-in. color set priced to retail in the U.S. market at less than \$300 (with a short margin for the seller). Production capacity is expected eventually to exceed 500,000 sets a year.

... **MACHINE TOOLS** owned by the Government and furnished to defense contractors will be audited by the General Accounting Office. Investigators have already found a number of cases in which tools furnished for defense work are being used improperly for production of civilian goods. The GAO will put "particular emphasis on the adequacy and effectiveness of controls exercised by the military department to assure that the use of such tooling does not give one contractor a competitive advantage over another and that adequate rental or other consideration is received by the Government for the tooling."

... **R&D MANAGEMENT** may become a primary job for the Advanced Research Projects Agency. The object would be to help the Defense Department avoid "uneconomic development of obsolescent weapons systems, procurement of unnecessary hardware, and undesirable misuse of resources." Another project for the agency is exploration of advanced concepts and theories that will enable it "to identify and make contributions of a conceptual nature to the basic technical problems vital to national defense, which may not now be receiving adequate attention by the scientific community."

... **DEFENSE-MATERIALS** research should be subject to "maximum coordination" among Government agencies, states the Joint Congressional-Defense Production Committee. Defense needs for materials that can withstand extremes of temperature, corrosive conditions, and great pressures have far outstripped civilian technology. The Congressmen note that there exist theoretical designs "which are dependent upon new or improved materials in order to move forward to construction."

... **RETALIATORY FORCES** must be "economical enough to support without undue drain on the Treasury," according to the director of the Navy's Guided Missile Div. Endorsing "a modest force of approximately 45 Polaris submarines" as the keystone of U.S. defense, Adm. K. S. Masterman nevertheless asserted that the U.S. should never become completely dependent on a single weapons system.



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# IDEAS FOR DESIGN—ENTRY BLANK

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Here is my design idea for possible publications in your *Ideas For Design* department. I can expect \$10 for this idea if accepted for publication.

(Ideas suitable include: 1. new circuits or circuit modifications, 2. new design techniques, 3. designs for new production methods, 4. clever use of new materials or new components in design, 5. design or drafting aids, 6. new methods of packaging, 7. design short cuts, or 8. cost saving tips)

## STATEMENT OF THE PROBLEM—

MY SOLUTION. AND WHY—(Please be explicit. Include sketches or photos that will help the idea across)

Name \_\_\_\_\_

Title \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

(Place illustrations on separate sheet if necessary)

# MEETINGS

## Calendar of Events

### February

- 3-5 1960 Winter Convention on Military Electronics, PGME, Ambassador Hotel, Los Angeles, Calif.
- 10-12 7th Annual Solid-State Circuits Conference, IRE, AIEE, Hotel Sheraton, Philadelphia, Pa.
- 11-12 7th Annual Cleveland Electronics Conference, IRE, ISA, AIEE, Engineering and Scientific Center, Cleveland, Ohio.
- 11-13 1st Annual Electronics Representatives Association, Drake Hotel, Chicago, Ill.
- \*14-18 Annual Meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers, Sheraton Atlantic Hotel & Statler-Hilton, New York, N.Y.
- 16-18 1st National Symposium on Nondestructive Testing of Aircraft & Missile Components, SRI, Hilton Hotel, San Antonio, Tex.
- \*19-23 3rd International Electronic Parts Show, Paris, France.
- 25-26 Scintillation Counter Symposium, PGNS, AIEE, AEC, NBS, Washington, D. C.

### March

- 6-9 Gas Turbine Power and Hydraulic Conference, ASME, Hotel Rice, Houston, Tex.
- 21-24 IRE National Convention, All PG's, Waldorf-Astoria Hotel and New York Coliseum, New York, N.Y.
- 23-26 Electrical Industry Show and Lighting Exposition, EMEA, Shrine Exposition Hall, Los Angeles, Calif.
- 24-25 1st Annual Symposium on Human Factors in Electronics, IRE, New York, N.Y.
- 29-31 22nd Annual American Power Conference, Illinois Institute of Technology, Hotel Sherman, Chicago, Ill.

### April

- 3-8 6th Nuclear Congress, N. Y. Coliseum, New York, N.Y.
- 6-8 Structural Design of Space Vehicles Conference, ARS, Biltmore Hotel, Santa Barbara, Calif.
- 18-19 3rd Annual Conference on Automatic Techniques, ASME, IRE, AIEE, Cleveland-Sheraton Hotel, Cleveland, Ohio
- 19-21 International Symposium on Active Networks & Feedback Systems, Department of Defense Research Agencies, Polytechnic Institute of Brooklyn, IRE, Engineering Societies Bldg., New York, N.Y.
- 20-22 1960 Southwestern IRE Conference, Shamrock Hilton Hotel, Houston, Texas
- 20-22 National Symposium on Manned Space Stations, IAS, NASA, Ambassador Hotel, Los Angeles, Calif.

\*Includes meetings described herewith

**Annual Meeting of American Institute of Mining, Metallurgical, and Petroleum Engineers, Feb. 14-18**

A special forum on Navy Materials problems.

constituting a new concept of communication between military and civilian scientists and presenting high defense officials as spokesmen will be a major feature of the Annual Meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

Current critical program areas will be discussed and will include the following: "Thermoelectric Materials," B. D. Rosenbaum, Bureau of Ships; "Semiconductors," W. W. Scanlon, Naval Ordnance Laboratory; and "Effect of Radiation on Magnetic Materials," E. I. Salkovitz, Naval Research Laboratory.

The national convention will run five days, beginning Sunday, February 14. The Metallurgical Society Forum will be held at the Sheraton-Atlantic Hotel on February 15. The Society of Mining Engineers of AIME and the Society of Petroleum Engineers of AIME will hold concurrent sessions at the Statler-Hilton Hotel.

#### 3rd International Electronic Parts Show, February 19-23, Paris, France

The 3rd International Electronic Parts Show, for electronics specialists, will present a full range of elements used in the construction of radio-electrical and electronic appliances. Many new exhibitors from all countries will be taking part alongside the larger international firms. The show is organized by the National Federation of French Electronics Industries, 23 rue de Lubeck, Paris 16, France.

#### 7th Scintillation Counter Symposium, Feb. 25-26

The objective of the Scintillation Counter Symposium is to bring together those interested in scintillation counters for the purpose of exchanging information on advanced techniques, recent equipment developments and new components. The meetings are on a high technical level and treat both the theoretical and practical aspects of the field. The symposium will consist of four sessions of a half-day each treating the following topics: scintillators, photomultipliers and associated electronics, scintillation track imaging, and astrophysical and space applications of scintillation counters.

The symposium to be held at the Hotel Shoreham in Washington, D.C. is sponsored by the American Institute of Electrical Engineers, the Atomic Energy Commission, the Institute of Radio Engineers, and the National Bureau of Standards. Committee Chairman is G. A. Morton, Scintillation Counter Symposium Committee, RCA Laboratories, Princeton, N.J.

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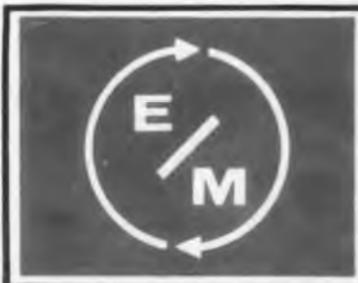
There are other advantages too: Chopper stabilization provides for exceptionally high repeatability of voltage control settings . . . enhances

remote control operation.

And chopper stabilization can be specified at any time. The compact plug-in unit can be installed at the factory as an original accessory, or it can be installed in the field. A complete kit is available for field installations. Instructions and all hardware are included.

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## NEW PRODUCT

### Versatile Crimped Connector For Miniature Coax Cable

A highly versatile crimp-type snap-locked modular HYFEN® connector for miniature coaxial cable has been introduced by the Omaton Division of the Burndy Corporation, Norwalk, Connecticut. This modular HYFEN offers the facility of simple removal of individual snap-locked contacts or gang disconnect.



Both inner and outer contacts are crimped to the conductors, simplifying a previously complicated and difficult process. In addition this process eliminates many of the parts formerly used, and also eliminates any heat in the connection process. The result is a reliable coax connection, easily and quickly installed.

The new plug-and-receptacle unit will presently connect RG195U and #24 shielded miniature coax cable. Connectors for other sizes of miniature coax will be available soon.

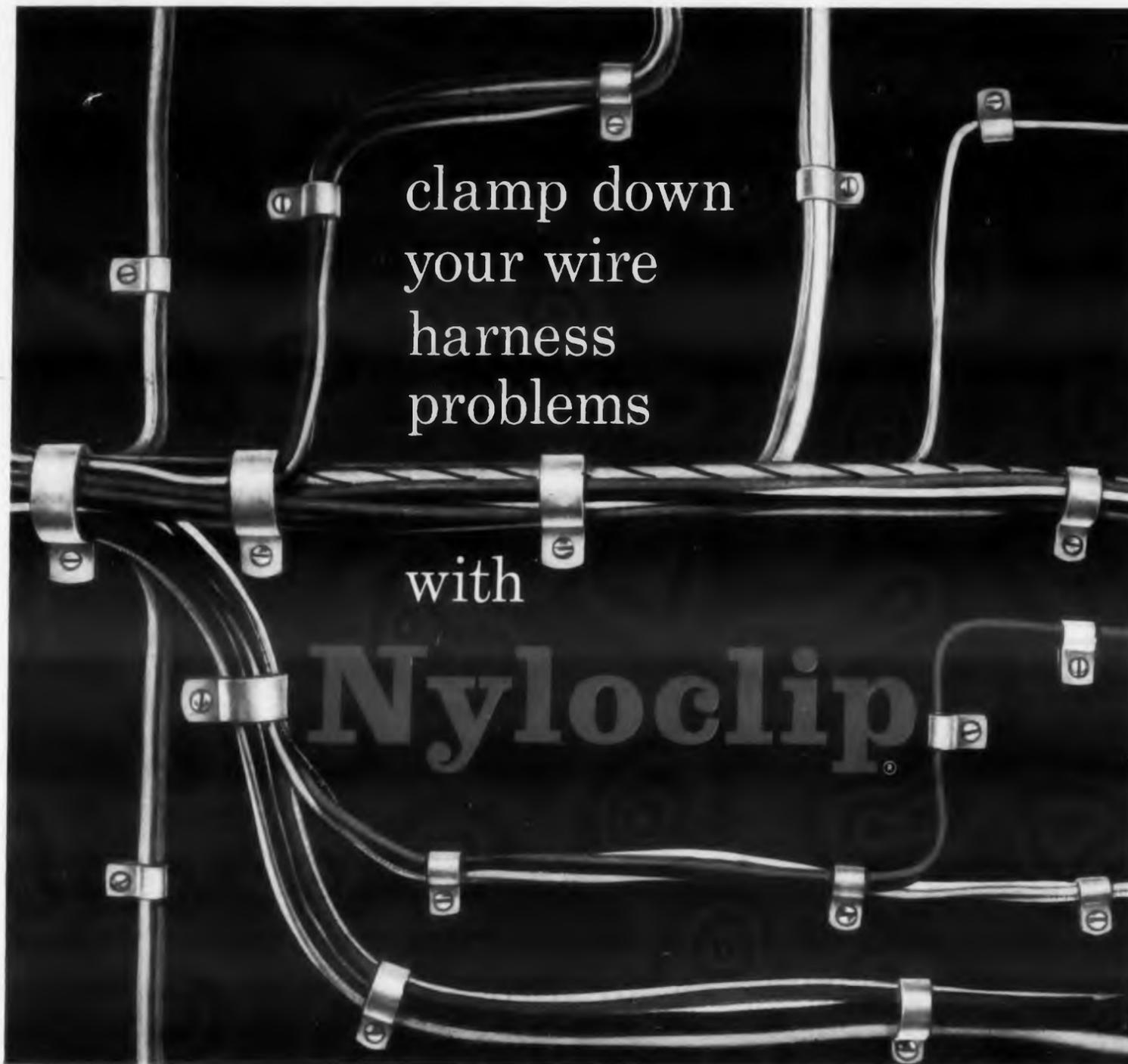
Connector frames, of die-cast anodized aluminum, accommodate three, five, or eight inserts, snapped in from either front or back. Inserts for coax cable, of glass-filled diallyl phthalate, accommodate up to 21 contacts. A plug or receptacle insert may hold male or female contacts, or they may be intermixed. Coax cable inserts and standard wire inserts (35 contacts) may be mounted in the same frame.

Contacts can be crimped to cable ends either before or after the harness is in place. Engaging and disengaging forces of low magnitude make it easy to insert, remove, and replace contacts and inserts individually for flexibility and economy in circuit changes and checks.

Burndy Corporation, Norwalk, Connecticut.

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ELECTRONIC DESIGN • February 3, 1960



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# EDITORIAL

## U. S. Must Demand Radio-Frequency Interference Control

Just how important is the problem of radio-frequency interference?

On boarding an airliner at Chicago last fall, I, along with all the passengers was reminded over the PA system that all portable radios were to be turned off during flight. It was World Series time, however, and several passengers could not resist "sneaking a listen" from transistor radios concealed under their jackets.

Departure was delayed. Soon the stewardess announced that take-off was impossible; the flight engineer was picking up extraneous signals. Again the passengers were requested to cooperate, and this time they complied. The trip proceeded.

Could serious consequences or a major disaster have resulted if just one avid fan decided to check the score? How scornful can we become of the seriousness of radio-interference? Already missile failures, loss of key communication in defense links, computer errors and blanked radar screens demonstrate the havoc resulting from radio-frequency interference.

Considerable engineering effort has been expended to create receivers with less than one-tenth microvolt sensitivity. Similar zeal has been applied to engineer sharp-pulse, high-power transmitters, complex military systems, and high-speed computers.

At the same time the number of electronic devices for office, home and industry is increasing. But these achievements only aggravate the problem of RFI; each new device is a potential source of interference.

All major countries except the U. S. impose close restriction on radiation and have engineering teams checking and locating RFI sources. While U. S. military agencies limit and control interference in defense equipment and installations, the Federal Communications Commission ruling on non-military devices does not make it mandatory that the manufacturer produce interference-free devices. Instead the consumer or user is responsible for controlling interference!

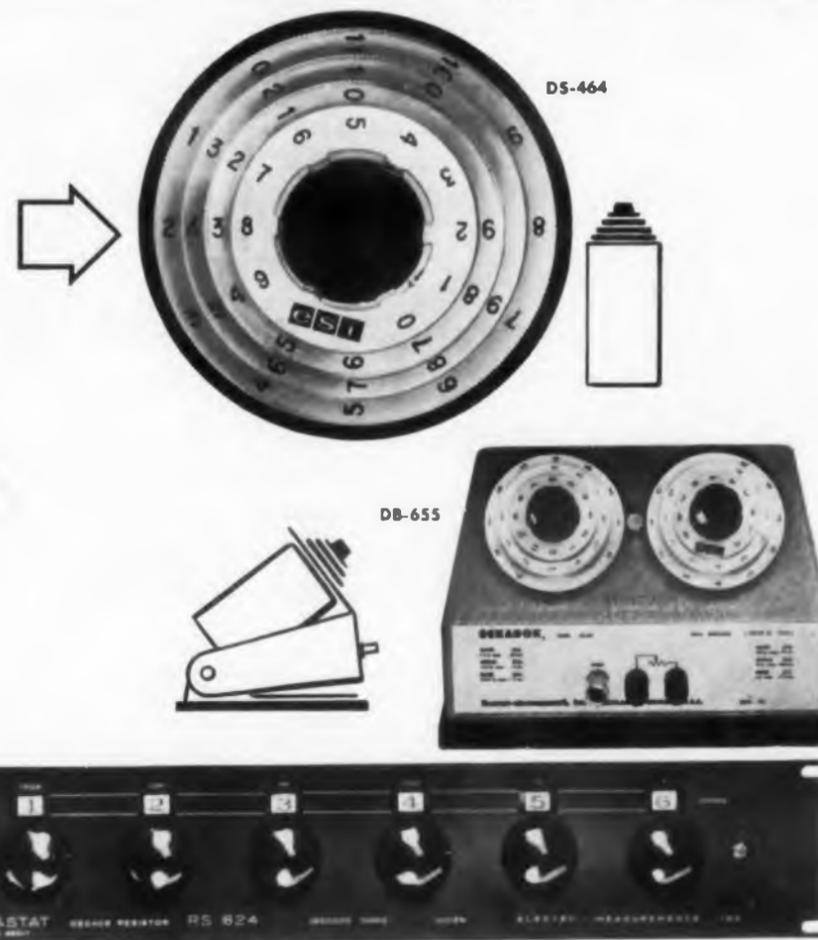
Why approach the problem from the wrong end? Interference complaints pile up under this system, and only the most flagrant can be checked and corrected through the limited facilities of the FCC.

It is up to the Government to insist on strict interference-control by the manufacturer. The sooner the better!

*Howard Bierman*

esi

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# Radio Frequency Interference

An *ELECTRONIC DESIGN* Staff Report

Howard Bierman

Associate Editor

## Causes and Effects

## Suppression Techniques

## Measurement Methods

## Prediction Approaches

## Trouble Shooting Procedures

**M**OUNT a costly, highly sensitive receiver near equipment containing pulse and switching circuits, relays and oscillators and what do you have? An expensive and impressive guarantee of unreliable and ineffective performance—unless pains have been taken to eliminate radio-frequency interference.

Years ago many design engineers who were cautioned on the need for RFI suppression in-

quired, "Why bother?" After viewing missile failures, listening to garbled communications and inspecting blanked radar screens, their question has now changed to, "How can RFI be effectively eliminated?"

### Interference Sources

Before attempting to eliminate it, however, let's examine its nature.

Radio interference may be defined as any electrical disturbance that causes undesirable response or malfunctioning of electronic equipment. Basic sources of interference include:

- Sine-wave signals from transmitter harmonics, diathermy or oscillator leakage.
- Wide-band output from bearings, belts or fluorescent fixtures.
- Impulse or sharp-pulse waveforms from high-voltage supplies, ignition systems or switching transients.

### Basic Phases of RFI Efforts

Interference control and suppression may be basically subdivided into four categories:

- **Prediction**—by careful analysis and examination of circuit parameters, equipment charac-

teristics and operating frequency, it is possible to predetermine the location and level of interference. Steps can then be taken to allocate frequencies and separate systems for minimum interaction.

- **Early design precautions**—by keeping RFI in mind during each phase of development, interference-free "building blocks" can be tied together in a final package relatively free of RFI.

- **Trouble-shooting**—crowding many systems in a small area, such as aircraft, submarines or remote base shacks, often poses problems due to mutual interaction. Cables may require re-routing or power line feeds additional filtering. Individual shielding enclosures may also be necessary. Rapid and direct pin-pointing of trouble spots is a must for effective trouble-shooting.

- **Measurement techniques**—methods of measuring and tolerable limits must be established and followed. Standards set by the military are presently adhered to, since the Government is the biggest buyer of electronic equipment.

### 'Brute Force' Vs Planned Attack

Two basic methods of attack are possible. First is the "Christmas tree" approach of hanging

chokes and capacitors on equipment previously designed without regard to RFI. This is expensive, creates additional size and weight problems and is conducive to inefficiencies since it is generally applied in a frenzied haste.

Preventive design steps in the early stages of equipment or system development offer a second means of control, one more professional and intelligent. Careful evaluation of shielding needs, late developments in components and circuit layout can be coupled with previous experience in RFI problems to meet even the most rigid specs. By carefully guarding interference leakage at individual stages of progress, the possibility of overall deterioration at the project's completion is drastically reduced. Also, a steady, well-planned suppression program is always more efficient than the last-minute "brute-force" remedy.

This does not mean that final touchup will be unnecessary; minor modifications often arise due to interaction when several units are interconnected. But such changes are obviously more readily applied than those resulting from designs devoid of RFI forethought.

### Growth of RFI 'Missionaries'

The military was introduced to the destructive effects of RFI during World War II. Radar and communication transmitters created havoc with nearby receivers, airborne equipment and sensitive instrumentation. Messages were distorted or lost completely, radar displays were blanked out, and tragic losses were directly attributed to interference.

Consequently specifications were prepared by the military branches, and tolerable limits with methods of measurement were outlined. Unfortunately only a handful of engineers were experienced in the rather ticklish task of locating and controlling RFI. Government manuals were distributed as an aid to the design engineer confronted with curbing RFI on a crash-program basis.

A giant step in the dissemination of RFI suppression techniques and measurements was made in 1954 through the organization of the First Conference on Radio Frequency Interference, jointly sponsored by Government agencies and the Armour Research Foundation of the Illinois Institute of Technology. In 1957 the Professional Group on Radio Frequency Interference was established within the IRE. More recent conferences have since been sponsored by the Government, the Armour Foundation and the IRE group. From these meetings, heavily attended by engineers from all parts of the country, important advances have been announced. Suppression techniques have been presented as an extremely helpful guide to design engineers, and moves have been

launched to standardize measurement definitions and methods.

### Rigid Specifications Demanded

Almost every piece of electrical equipment now purchased for military use must comply with rigid specifications. Generators, hand tools, motor vehicles and table radios are typical potential interference sources; each could conceivably disrupt communications, computer accuracy or telemetry—hence the rigid specs. Needless to add, electronic equipment must pass a wide variety of tests to qualify as trouble-free. As difficult as these specs may appear, experienced RFI engineers realize

that careful consideration during initial design offers the means to success.

### RFI Elimination a 'Must'

To escape chaos, complete control of RFI will be a necessity in the coming years. More computers, TV sets, electronic toys, space vehicles, communication links, machinery and countless other devices will be crammed into an already crowded spectrum. Or, as Rexford Daniels, president of Interference and Testing Laboratory, Inc., put it: "Mankind can no longer hope to operate a micro-volt civilization in a millivolt environment." ■ ■

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## There's More Ahead — ELECTRONIC DESIGN RFI Series Will Appear in Several Issues

Thousands of design engineers are directly or indirectly involved in suppressing radio frequency interference. Because editorial material for the engineer seeking theoretical and practical RFI information is somewhat limited, ELECTRONIC DESIGN invited specialists in the field to prepare a series of special RFI articles.

Interference-control engineers, who have spent years trying to get other engineers to heed their warnings, responded with enthusiasm. The opportunity to "spread the word," many felt, would help hammer home the serious message predicted at recent IRE conferences:

"Unless interference control is completely effective, communications and electronic automation will be severely limited in operation and reliability."

ELECTRONIC DESIGN's RFI report will include articles covering the important phases of interference work: prediction, preventive design, troubleshooting and measurement. The articles will appear in several issues. Following are the titles and authors of the articles devoted to RFI:

### RFI—Today and Tomorrow

● RFI—AN UP-TO-DATE SURVEY, R. Schulz, Armour Research Foundation.

FCC CONTROL OF RFI, J. Deitz, Federal Communications Commission.

RFI IN SPACE VEHICLES, J. Lee, Melpar, Inc.

### Prediction Techniques

METHODOLOGY OF INTERFERENCE PREDICTION, W. Floyd of Melpar, Inc.

Bailey, Georgia Institute of Technology.

PREDICTION OF RECEIVER INTERMODULATION, C. E. Blakeley, Georgia Institute of Technology.

PREDICTION OF TRANSMITTER INTERMODULATION, R. N. Preventive Design and Trouble Shooting

● CHECKLIST OF RFI, L. W. Thomas, Navy Bureau of Ships.

RFI GASKETING, O. P. Schreiber, Technical Wire Products, Inc.

● OPTIMUM SHIELDING DESIGN, A. Albin, Filtron Co., Inc.

DISSIPATIVE FILTERS FOR SWITCHING CONTACTS, R. Schulz, Armour Research Foundation

GENERATION OF HIGH-POWER SIN<sup>2</sup> VIDEO PULSES, A. F. Standing, Avco Corp.

● INTERFERENCE TROUBLE SHOOTING, T. H. Herring, Boeing Airplane Co.

### Measurement Techniques

GOVERNMENT SPECIFICATIONS AND MEASUREMENT TECHNIQUES, A. R. Kall, Ark Engineering Co.

CALIBRATION OF RADIO NOISE INTERFERENCE METERS, M. J. Rodriguez, Polarad Electronics Corp.

● appearing in this issue.

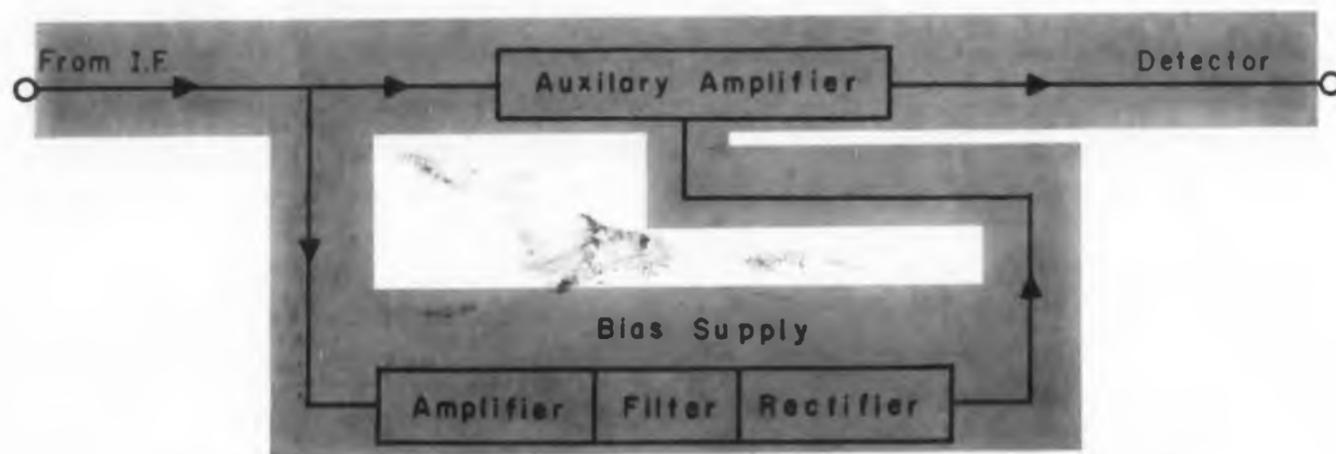


# RFI

## An Up-to-Date Survey

R. B. Schulz, H. M. Sachs, G. C. Vallender  
 Armour Research Foundation of  
 Illinois Institute of Technology  
 Chicago, Ill.

*With government agencies insisting on tighter RFI control, design engineers are becoming increasingly aware of the need for interference reduction in early design stages of equipment and systems. Since many interference-suppression devices, components and techniques have been innovated recently, this roundup of the latest in RFI developments brings the design engineer up-to-date in all important phases of a relatively new field.*



**Fig. 1.** Block diagram of a variable-gain device which permits if-bandpass control. Desired signals cannot pass through bias-supply filter and therefore no rectified bias voltage appears to cut off the auxiliary amplifier. Undesired signals are passed by the filter and develop sufficient bias to cut off the auxiliary amplifier to prevent output to the detector stage.



**W**ITH THE ever-increasing number of electronic system installations, interference problems associated with operation of electronic devices in close proximity have multiplied drastically. Missile failures, communication jamming and radar blanking are but a few of the direct catastrophes traced to radio-frequency interference.

To maintain a semblance of order and intelligence in the growing chaos of spurious signal radiation, considerable research and development efforts have been devoted to the suppression and control of RFI. Recent advances in communication and radar systems plus latest instrumentation techniques are presented to acquaint the design engineer with the up-to-date "state-of-the-art" picture.

## Communications Systems

Theoretical and experimental investigation of the interference problems in the area of communications systems has shown that a major cause of interference is receiver intermodulation. Intermodulation is defined as the production of a signal at a receiver response frequency by the mixing of two undesired signals in the receiver's rf amplifier and/or converter stages. Receiver intermodulation susceptibility can be decreased by improved if-circuit dynamic range, improved rf preselection, and use of if-circuit bandwidths no greater than necessary for information-handling requirements.

Rf-circuit dynamic range can be improved by the extensive utilization of age circuits. Although other specialized circuits can be used, age is the simplest method of implementation.

Rf preselection can be obtained by active or passive devices which reduce the bandwidth of rf stages. The state-of-the-art is such that coupling networks and cavities can be produced which

Dick Schulz has devoted the past 15 years to the task of keeping RFI under control. He became involved in interference work as a research associate at the University of Pennsylvania, followed through as a consultant in private practice and joined ARF in 1955. He holds several patents on RFI suppression devices and has authored and delivered numerous papers on the subject. ARF Conferences on Radio Interference Reduction and Electronic Compatibility are well-known for high quality papers and presentations—Dick is one of the active organizers responsible for their success and popularity.

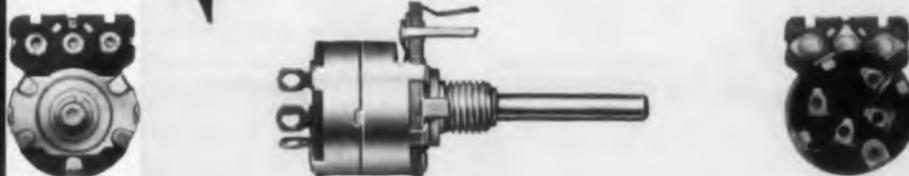
provide improved selectivity; however, the major problem lies in the "ganged tracking" of tunable rf and converter circuits. Within the past year, narrow-band cavities have been used in uhf equipment, resulting in improved off-frequency rejection, even though tracking techniques require further development.<sup>5(k)</sup> In addition to reducing intermodulation effects, preselection also helps in reducing local oscillator radiation.

The third intermodulation-reduction technique requires the use of if-circuit bandwidths that are minimized with respect to the various modes of intelligence transmission. An example is the different number of sidebands required, and hence different bandwidths necessary, for voice and cw operation. A second example is a search receiver where a wide if-circuit bandwidth is needed to search a given band as rapidly as possible to find a desired signal; afterwards, a narrow bandwidth is used to reduce the sensitivity of the receiver to near-channel distracting signals.

In present-day systems, mechanical and crystal filters are being used to provide necessary bandwidth. Recently, circuits have been devised which make possible an electronically controllable band-pass for if amplifiers. One method<sup>14</sup> provides a change in bandpass as high as 20 to 1 in a 30-mc strip with very little change in the on-frequency gain. The circuit varies the bandwidth by adjusting the bias of a control tube. The output of this stage results in an effective change of circuit Q in a narrow-band amplifier stage.

The block diagram for a variable-gain circuit is shown in Fig. 1.<sup>5(a)</sup> The signal from the last stage of the if amplifier is fed into both the unity-gain auxiliary and bias-supply amplifiers. When the incoming signal is at the center frequency of the if system, it passes through the auxiliary amplifier to the input of the second detector. The stop-band filter after the bias-supply amplifier prevents the signal from reaching the bias-supply rectifier. If the signal is not at the if center fre-

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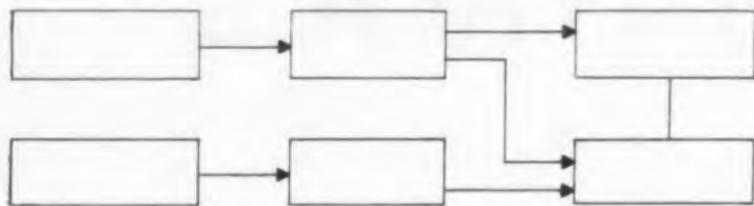


Fig. 2. Block diagram of a gating arrangement to eliminate interference from antenna side lobes.

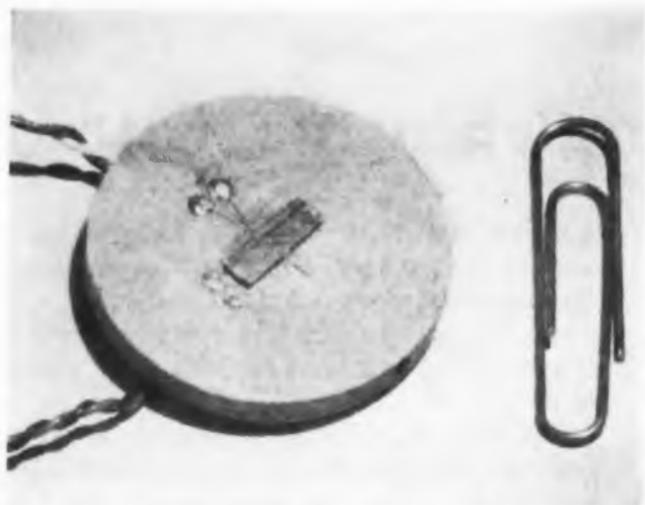


Fig. 3. Hall-effect sensor on a ceramic mount.

quency, it is amplified in the bias-supply amplifier, passed by the stop-band filter, rectified and fed as a negative voltage to the auxiliary amplifier. By adjusting the gain of the bias supply amplifier, the circuit allows control of the if bandpass. Some information can be lost if the desired and undesired signals appear simultaneously. To minimize the loss, the recovery time of the circuit must be small.

## Radar Systems

In recent years, many methods have been proposed and investigated to reduce the effects of rf interference relative to radar systems. These include blanking techniques, moving-target indicators, pulse length and/or interpulse length selection, pulse compression, pulse shaping, noise correlation, delay-line video integration, and others.<sup>15</sup> A discussion of all these techniques would fill many pages; therefore, only a few will be mentioned.

### Intra-Site Systems

One of the most serious problems confronting radar operators is intra-site radar interference. The problem is very critical at air fields and long-range radar sites where several radars of different pulse-repetition rates are being operated. Two basic methods are used to reduce the interference.

In the first method, all the radars at a site are synchronized. The technique requires all radars to operate at the same or at a multiple of the pulse-repetition rate of the slowest. If all radars are operated at the same repetition rate, all mutual interference will be eliminated. In the case of synchronized high- and low-repetition-rate ra-

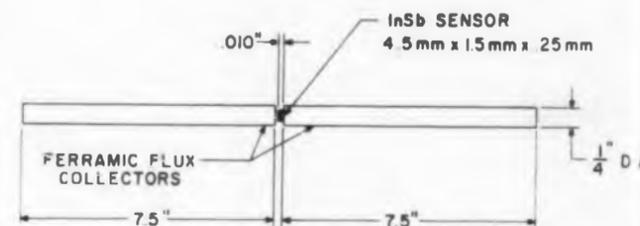


Fig. 4. Sensitivities better than  $10^{-6}$  oersted are possible with Hall-effect sensors using flux collecting rods.

dar, interference will appear as fixed range targets.

The second method, which is proving more successful, is receiver blanking. A pre-knock pulse from the interfering radar is sent to the victim. This pulse is used as the trigger to blank the victim receiver for the duration of the interference period. The effect of target return loss due to blanking reduces the range of the radar.<sup>5(b)</sup> However, a very weak relationship exists between the number of returns lost and the decrease in range. Therefore, a reasonable degree of blanking will not have a serious effect upon the efficiency of the radar.

Interference received via antenna side lobes can be eliminated by the system shown in Fig. 2. The overall gain of the secondary channel is adjusted so it is more than that of the primary receiver at any side lobe, but less than the primary receiver at the main lobe. In operation, the signal passes through both channels; if the output of the primary channel is the larger, no gate is generated and the signal is applied to a presentation system. However, if the secondary channel produces the larger signal, a gate is generated to blank the video.

Table I. Commercial and military RFI equipment.

Parameter	Stoddart NM-40A AN/URM-41	AN/URM-85*	Empire Devices NF-105 AN/URM-7	Polarad FIM	Stoddart NM-60A AN/URM-42	Empire Devices NF-112
Frequency Range	30 cps - 15 kc	150 kc - 1000 mc	150 kc - 1000 mc	1 - 10 kmc	1 - 10.7 kmc	1 - 15 kmc
Sensitivity	1.5 - 10 $\mu$ v @ $10^5$ ohms	1 $\mu$ v	1 $\mu$ v	20 $\mu$ v @ 50 ohms	5 - 15 $\mu$ v	10 $\mu$ v @ 50 ohms
CW Noise	(20 db S/N ratio)	1/BW $\mu$ v/mc	1/BW $\mu$ v/mc			10/BW $\mu$ v/mc
Bandwidth (6 db)	13 - 90 cps			5 mc	1.5 mc	1 and 5 mc
Calibration	400 cps sine wave	Impulse	Spot sine wave and impulse	Sine-wave	Impulse	Impulse
Detecting Circuits	Avg, QP, Peak, RMS		Avg, Peak	Avg, QP, Peak	Avg, QP, Peak	Avg, Peak
Antenna System	Loop and rod	Dipoles, loop, rod, discone	Rod, dipoles, loop, discone	Omni-directional and directional	Omni-directional and directional	Horn
Spurious Response Rejection	-55 db			-60db	-60 db	
Image Response Rejection	-60 db				-60 db	

\* For information on special heads see Reference 5 (k).

### Pulse Shaping

Energy distribution resulting from the high-amplitude sidebands associated with rectangular pulses can cause interference to other nearby radars and communications-electronic systems. Reducing the amplitude and/or number of these sidebands allows operation of more equipments without mutual interference within a given frequency band.

One technique for reducing the rf spectrum bandwidth is the use of shaped pulses. Theoretical investigations have shown that an ideal shape is the gaussian shape;<sup>16</sup> however, the major obstacle to the use of this shape pulse is its generation at high power levels. The cosine-squared shape is a somewhat more practical pulse shape to produce, and offers good narrow-spectrum characteristics. The major obstacle to the use of shaped pulses is the inability to modulate high-power microwave tubes.

### Instrumentation

Recent development work on radio-interference field-intensity meters has been concerned largely with improved accuracy of measurement and an extended frequency range. The major efforts in the latter case have been in the 30 cps to 15 kc and the 1- to 15-kmc regions. Present system development efforts include improved calibration methods and application of miniaturization techniques. Some of the latest commercially available and military interference-measuring equipments are tabulated in Table I.

### Pickup Devices

In order to measure conducted radio interference, a clamp-on type rf transformer has been developed by Stoddart Aircraft Radio Company (Model 91550-1). The transformer serves as an accessory for use with interference instrumentation over the frequency range of 14 kc to 100 mc. It measures rf current up to 1 amp with power line currents (dc or ac) of up to 350 amp.

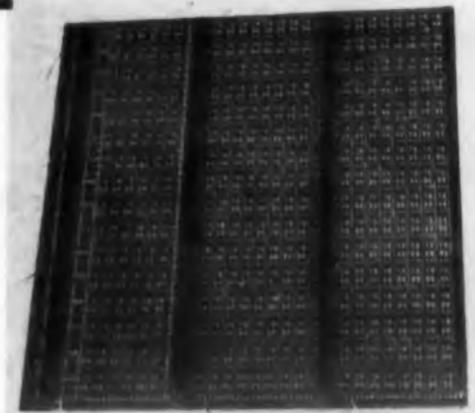
The need for greater accuracy in the measurement of interference fields has accelerated research and development work in another area of special probe design. One device presently under development uses the Hall effect to measure magnetic fields<sup>17</sup> in the range of 30 cps to 15 kc. A sensor based on this principle has the advantage of being small (Fig. 3), gives good signal-to-noise ratio and has a sensitivity which is independent of frequency down to zero frequency. The output of the Hall device is fed into a low-noise pre-amplifier to increase the level of the signal at the input of a noise meter. Present sensitivities are of the order of  $10^{-4}$  oersted for the Hall-element alone, and less than  $10^{-6}$  oersted for the element with flux-collecting rods added to it (see Fig. 4).

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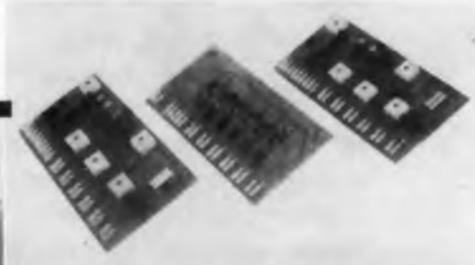
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Front panel of matrix, shown with Elco Varicon contacts and guides.

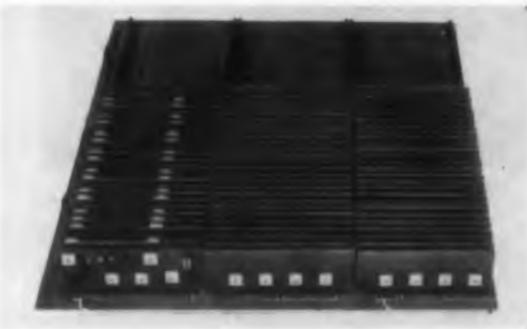
Plug-in modules, shown with Elco Varicon contacts.



PHILCO, one of the world's leaders, demanded reliability, design versatility and production ease in the contact selected for the very "heart" of its Input-Output Processor—the matrix panel. And that is why PHILCO selected ELCO's Series 5201, from our Series 5000 board-to-board printed circuit Varicon connectors! Furnished on disposable plastic strips,

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Plug-in module, shown mounted on matrix panel utilizing Elco Varicon contacts.



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## Up-to-Date Survey *cont.*

Increased sensitivity is possible using refined techniques.

### Thermistor Bridge

The accuracy of amplitude calibration of radio-interference/field-intensity meters frequently suffers because the input impedance of the instrument may vary with frequency and may not provide a matched load for the calibration generator being used as a known source. Consequently, the voltage across the interference meter input terminals may not be that indicated by the generator output controls. Even for cases of proper loading of the signal generator, its output may be incorrect due to a change in its calibration since its previous calibration check.

A calibration instrument containing a thermistor bridge is being developed to measure the rf voltage directly across the terminals of the interference meter.<sup>6(b)</sup> In order to achieve 5-mv sensitivity with good stability, temperature compensating thermistors are used in the bridge proper. When the bridge is used with coaxial attenuators in a special measurement procedure, the overall calibration instrument is useful to 50 mv.

### White Noise Generator

Inconsistencies had been noted in the calibration of random noise generators. A generator is presently being developed as a laboratory standard source of noise from which other types of noise generators can be calibrated.<sup>18</sup> The generator, which is useful up to 1000 mc, uses the basic Nyquist relation to determine the noise power available from a heated resistor. This noise power is proportional to the resistor temperature, a quantity which can be controlled and measured.

### Traveling-Wave Tubes

There are many advantages which can be obtained by employing an rf amplifier in a microwave interference meter. In a recent paper by J. L. Smith,<sup>6(c)</sup> the particular advantages of a low-noise traveling-wave tube for this purpose are presented. A TWT with low-noise figure and adequate amplification will make the overall system noise figure independent of the properties of the mixer crystal. In addition, such an amplifier has the ability to saturate, and will provide the crystal mixer protection during periods of rf overload.

The tube can provide 40 to 60 db of isolation between the instrument input and its local oscillator. TWTs have been built with 3- to 4-db noise figures. When such units become commercially available, they should be well suited for

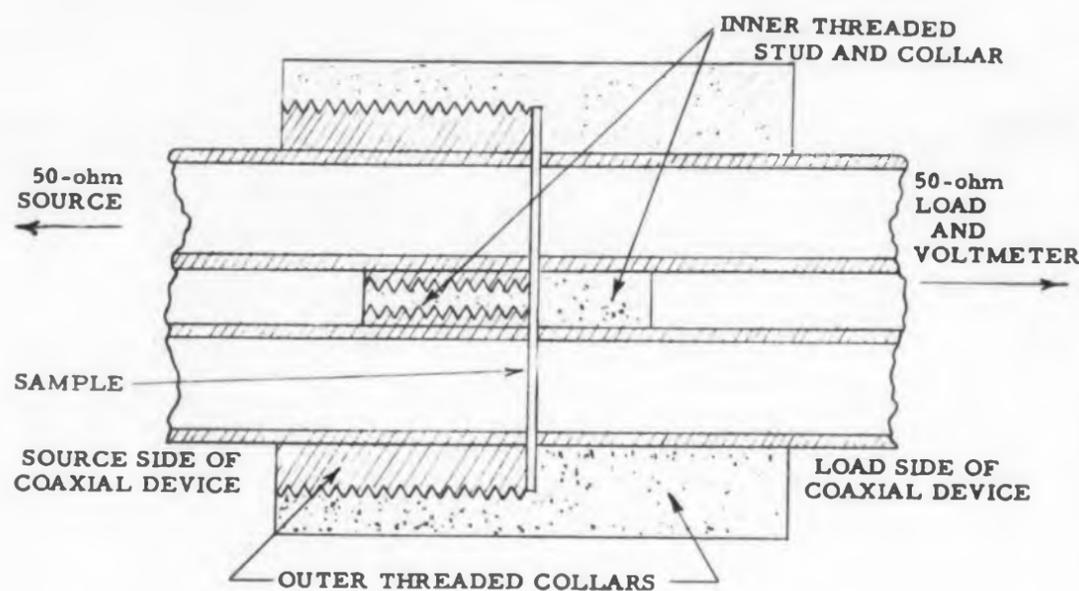


Fig. 5. Construction of a coaxial device to measure the shielding performance of conducting materials.

use in microwave interference-measuring equipments.

### Shielding Measurements

In order to measure the performance of conducting materials as shield against electromagnetic radiation, a coaxial testing device was recently developed.<sup>6(d)</sup> Within the coaxial structure, the field of a TEM mode has an impedance equal to that of a plane wave. When such fields are incident upon a lamina inserted in the sample-receiving portion of the device (Fig. 5), the measured ratio of the transmitted-to-incident waves is a measure of shielding performance for plane-wave impedance fields.

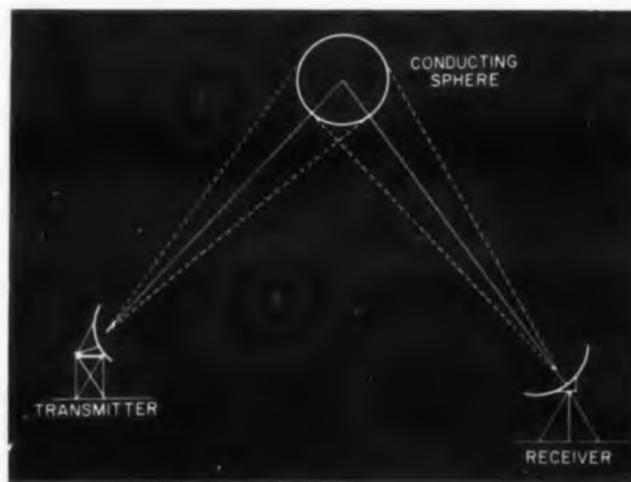


Fig. 6. (right) One technique of obtaining antenna-pattern data involves the use of a reflecting target from which radiated energy is redirected to ground and recorded.

When the shielding material is used as the walls of an enclosure, the effects of power inlets, metallic junctures, and other imperfections will cause the shielding capability of the room to be less than might be predicted on the basis of material alone. New techniques have been investigated for evaluating the performance of complete shielded enclosures over the frequency range of 14 kc to 10 kmc.<sup>6(e)</sup> Tests at three different portions of this spectrum are suggested.

At 15 kc, large transmitting loops which surround the enclosure are used to immerse it in a low-impedance field. An average indication of shielding effectiveness is obtained by the use of a pickup loop in the center of the room.

In the mid-frequency range, the shielded enclosure is illuminated by radiation from a half-wave antenna at the enclosure's lowest natural resonant frequency, which generally occurs in the region of 20 mc to 100 mc. The field inside the shielded enclosure is detected by a short-dipole antenna.

Tests near 9 kmc include the illumination of the shielded enclosure by plane waves from a high-energy source. The effect of shield separation, in the case of doubly shielded rooms, and the size of perforation openings, in the case of screening-type material rooms, were investigated.

These techniques are presently being examined as a basis for revision of military specification MIL-STD-285, and also as a basis for an IRE specification on techniques for measuring shielded enclosures.

### RF Leakage of Transmitters

Substitution techniques are certainly not new, but their application to the measurement of in-

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interference radiated from cabinets and external wiring of high-power transmitters is a novel approach.<sup>6(e)</sup> The transmitter is operated into a well-shielded dummy antenna to obtain only case and wiring radiation. The substitute power is an rf signal source used in conjunction with a dipole antenna located at a distance within three feet of the transmitter. Thus, essentially the same path is utilized between either the transmitter or the substitute rf signal source and a receiver or sensitive frequency-selective voltmeter operated at some remote point. If the substitute power and the received power ratios are measured, the transmitter power can then be determined at the measurement frequency, which could be a harmonic. The technique is independent of local topography because path loss is automatically taken into account. A suitable site is limited principally by the availability of sufficient remote points which lie in the distant or radiation field.

### Antenna Pattern Measurements

In the microwave region, the antennas used confine much of the energy to a relatively narrow beam. However, there are still many side and back lobes which can contain sufficient gain to give rise to serious interference problems. To be able to predict interference levels, it is necessary to obtain information on the three-dimensional antenna-gain characteristics. This information is required for all spurious and harmonic frequencies as well as the fundamental frequency of operation.

Various methods have been considered to obtain the necessary pattern data. These include:

- An airborne platform flying a predetermined course through the antenna-radiation field. From an operational standpoint, the method is costly and very difficult to implement.
- Space-probing with a mobile antenna mast moved to various locations (and heights) around a transmitting antenna. This method also has disadvantages as far as cost and implementation is concerned, as well as the additional effect of pattern distortion. Complete hemispherical patterns are not possible.
- A modeling technique, where scale-model antennas are used at an adjusted frequency of operation. It is not possible to build models which are scaled exactly in physical or electrical characteristics. Scaled analysis at other than the fundamental system operating frequency has not been attempted.
- Mounting the antenna whose pattern is to be measured on a special platform which, in turn, can be oriented so that the antenna will effectively be laying on its side. Then azimuthal pattern cuts with respect to the platform can be related to elevation cuts of the antenna. In addition to requirements im-



posed on a platform, one must be able to interpret the recorded patterns in terms of the actual antenna orientations.

- Use of a reflecting target from which the antenna radiated energy may be redirected toward the ground<sup>(17)</sup> and there recorded. (See Fig. 6.) A field-intensity meter is used in conjunction with a highly directional antenna

to measure the reflected signal. This approach is currently being evaluated.

- Representation of the statistical distribution of antenna gain, instead of the gain characteristic itself. Fig. 7 shows the normal representation of antenna gain versus azimuth for a given antenna. Fig. 8 shows the statistics of the pattern of Fig. 7, that is, the probability that the gain of the antenna in any particular direction (where any direction is equally likely) is above a specified level.<sup>22,23</sup> It is hoped that this approach will lead to considerably simpler methods of obtaining and

describing three-dimensional antenna characteristics.

New communications-electronics applications in radar, radio astronomy and the reception of weak signals emanating from orbital vehicles and space probes have led to the development of very large, high-gain electronically and mechanically steerable antennas. At the same time, more emphasis has been placed on decreasing antenna side lobes and reducing major-lobe beamwidths. These large gains and physical sizes may require modification of the above methods before the gain information can be obtained.

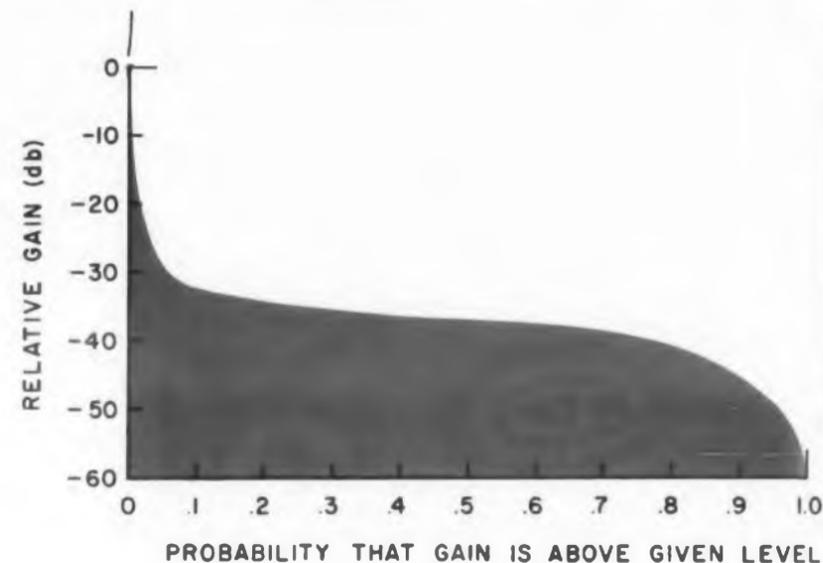
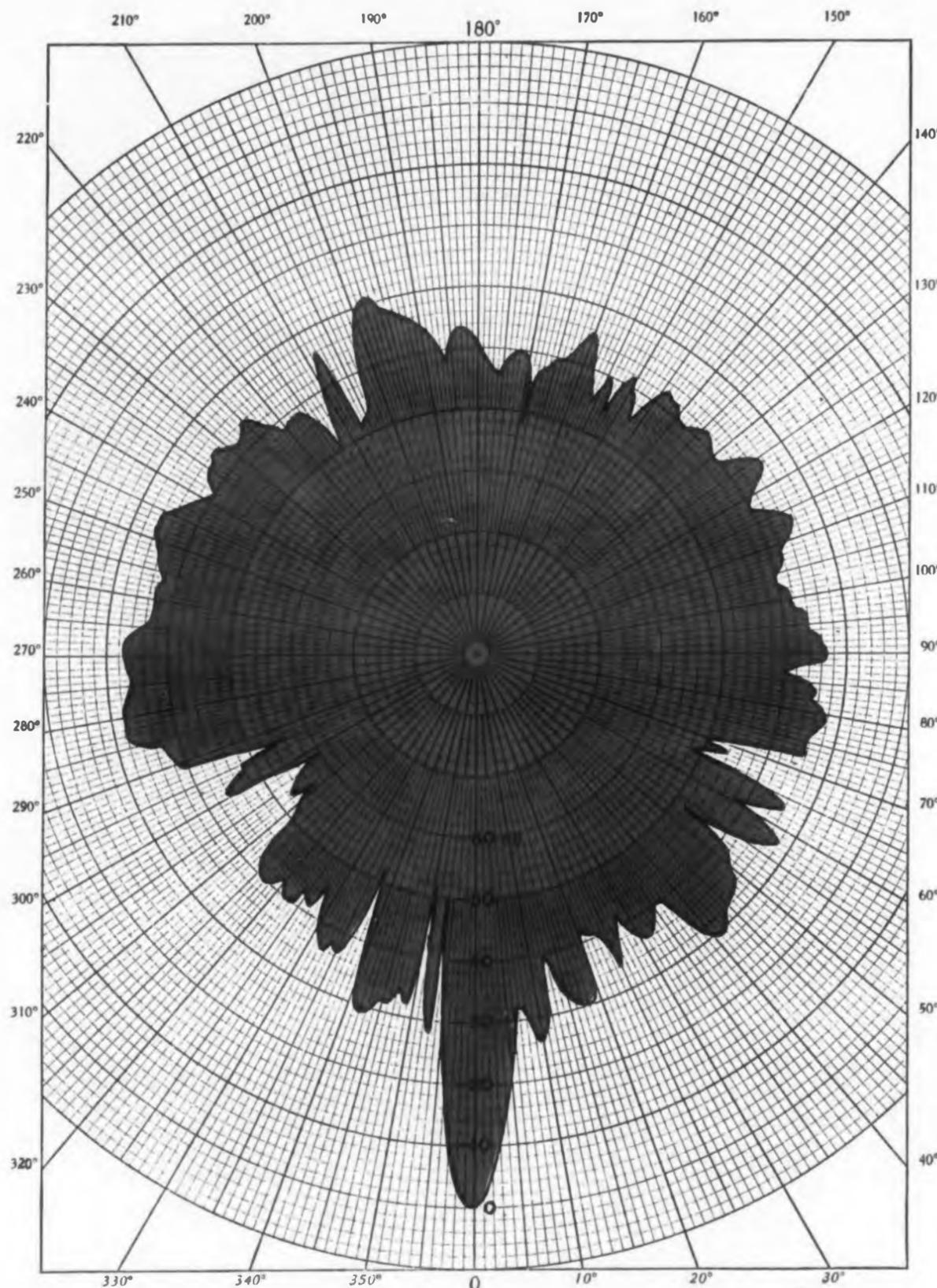


Fig. 8. (above) Statistical distribution of the antenna gain shown in Fig. 7.

Fig. 7. (left) Typical pattern of antenna gain vs azimuth.

Table II. Shielding Effectiveness Factor (SEF) data, for coaxial cables at 350 mc, show good agreement between a new triaxial technique and the free space method.

Type of Cable	Free-Space Method (Electric Field Basis)	Tri-Axial Tester
RG-59/U (S)	$1.2 \times 10^{-3}$	$2 \times 10^{-3}$
RG-8/U (S)	$8.5 \times 10^{-4}$	$9.2 \times 10^{-4}$
RG-29/U (S)	$7 \times 10^{-4}$	$1.1 \times 10^{-3}$
RG-158/U (D)	$8 \times 10^{-5}$	$1.8 \times 10^{-4}$
RG-6/U (D)	$1.3 \times 10^{-5}$	$1.1 \times 10^{-5}$
RG-55/U (D)	$9 \times 10^{-6}$	$1.0 \times 10^{-5}$
RG-13/U (D)	$8 \times 10^{-6}$	$7.3 \times 10^{-6}$
RG-X9B (D)	$8 \times 10^{-6}$	$1.2 \times 10^{-5}$
RG-5/U (D)	$1.3 \times 10^{-5}$	$1.1 \times 10^{-5}$
RG-9/U <sub>a</sub> (D)	$1.3 \times 10^{-5}$	—
RG-9/U <sub>b</sub> (D)	$5 \times 10^{-6}$	$9.4 \times 10^{-7}$

(S) - Single Braid  
(D) - Double Braid

## Components

Within the past few years, many advancements have been made in the development and evaluation of components. Again, the list is extremely long and only the most recent and useful will be discussed at this time. These include areas of microwave filters, rf coaxial cables, semiconductors, ferrites, and low-noise components.

### Filters

Filters have been developed, for operation in the S-band microwave region,<sup>24</sup> with a harmonic rejection ratio of 60 db and are capable of handling approximately 1 megawatt of peak rf power. It has been noted that, on the average, the strongest harmonic of a transmitter is 45 db below the output of the fundamental; thus, application of such a filter would reduce the maximum harmonic output to 105 db below the fundamental. It is expected that present developmental effort will reduce the level to -150 db by the mid-sixties. One program, in progress to develop high-powered filters, is also investigating the sources which generate spurious and harmonic frequencies, and considering methods for decreasing these undesired outputs.

### Rf Coaxial Cable

A study has been undertaken by Robl and Schatz to define the shielding effectiveness of braided coaxial cable.<sup>25</sup> The triaxial measurement system which has been used previously provides information for frequencies below 350 mc. At higher frequencies, measurements are more difficult and the complex results are often hard to interpret. With the new technique, measurements are made of the leakage fields from a short-circuited coaxial cable radiating as a monopole antenna above a ground plane, and the results are compared with a theoretical analysis of radiation due to a current source having the same distribution as the current within the coaxial cable. A Shielding Effectiveness Factor (SEF) has been defined as the ratio of the experimentally determined leakage field to the theoretical calculation, for a given current. For perfect shielding, the SEF is zero and for no shielding it is one. In the far field, either the electric or magnetic fields can be used as a reference for SEF. Table II provides SEF data for the axial component of the electric field. The data shown in column three, which was taken using a triaxial technique, shows good agreement with the free space method.<sup>26</sup>

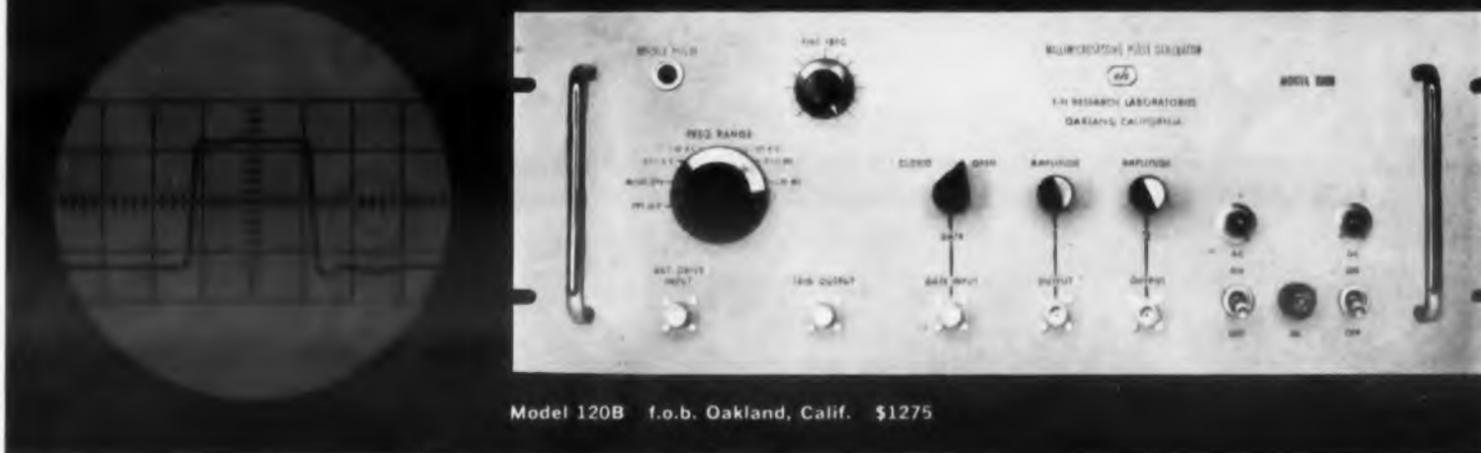
### Silicon Diodes

Radio-interference measurements performed on silicon diodes show that their noise output is ex-

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## Up-to-Date Survey *cont.*

tremely high—far in excess of military specification MIL-1-6181C. An oscillogram of diode current shows that interference is produced by a large reverse-current spike. In an investigation by Nichols,<sup>5(h)</sup> two different diodes were evaluated, and it was found that the IN337 was a much better unit than the IN345 from a radio-interference standpoint. Nichols also gave some important "rules of thumb" to help the design engineer to select the proper diode:

- Select a diode which will operate at the lowest current density in proportion to the manufacturer's maximum rated current.
- Select a diode with the highest rated working and peak inverse voltage.

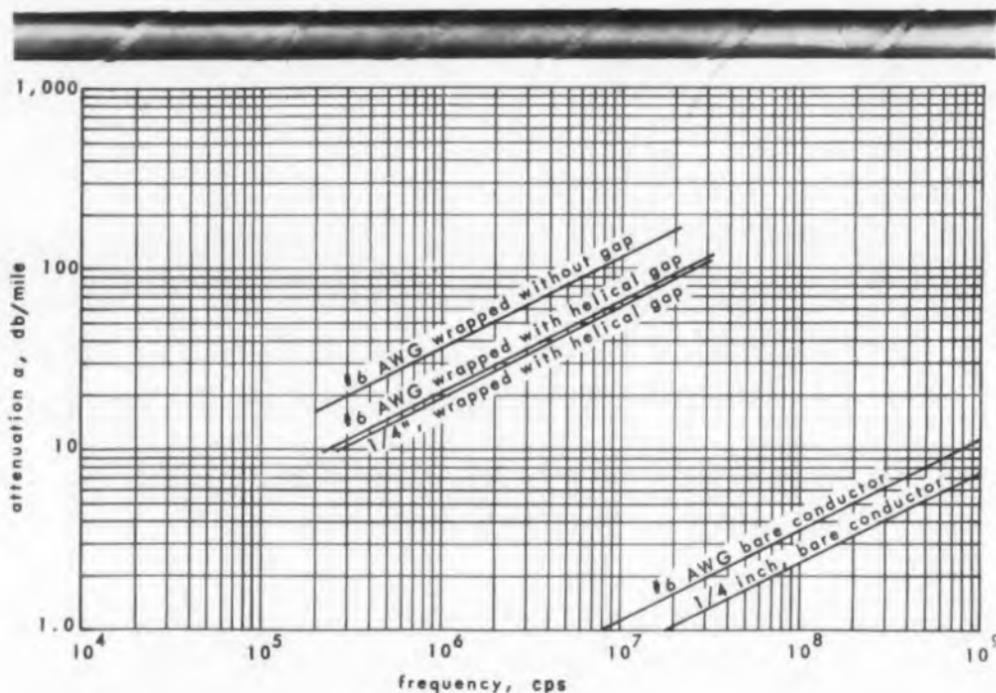


Fig. 10A. Power-transmission line wrapped with high- $\mu$  tape to attenuate RFI radiation.

Fig. 10B. Measured data on experimental power-line conductors wrapped with high permeability tape.

- Use the lowest possible switching rate. This approach is contrary to normal application since the maximum switching rate, that is a three-phase bridge over a simple bridge, is usually preferred to reduce ripple and the need or subsequent ripple filtering. However, in most applications, the audio filter and rf filter combined will be smaller in size than the ripple capacitor-rf filter for the higher ripple frequency.
- Select diodes with the slowest recovery time.
- After several diodes have been selected on the above basis, they should be measured to determine which is the best diode from an rf standpoint.

- Corrective measures for reduced rf output can be taken, as shown in Fig. 9. All of the circuits or component additions reduce both the current spike and/or present a low impedance load to the high frequency oscillations of the current spikes.

Circuits A and C should be used for currents under 1 amp while circuit C is preferred as the power line frequency is increased. The capacitors shown are in addition to the normal electrolytics used to regulate ripple. Foil or pellet types of tantalum capacitors can be used for both rf bypass and ripple filter. Table III gives the range

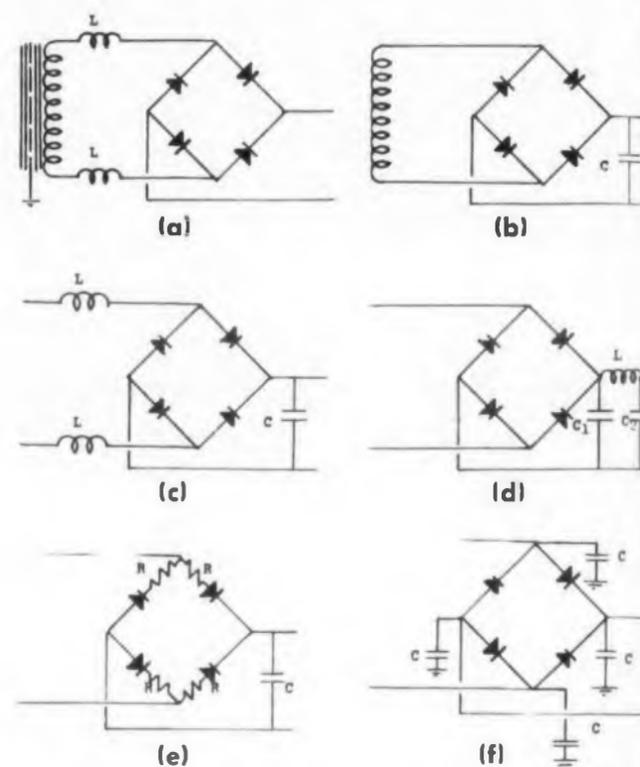


Fig. 9. Corrective measures to reduce RFI in full-wave bridge rectifiers.

Table III. Component values for the corrective circuits shown in Fig. 9.

Fig. 9	Component	60 cps	400 cps
A	L	100 to 300 $\mu$ h	250 to 750 $\mu$ h
B	C	0.1 to 0.5 mfd	0.1 to 1.0 mfd
C	L	100 to 300 $\mu$ h	250 to 750 $\mu$ h
	C	0.1 to 0.5 mfd	0.1 to 1.0 mfd
D	C <sub>1</sub>	0.1 to 0.5 mfd	0.1 to 1.0 mfd
	C <sub>2</sub>	Ripple capacitor	
	L	Ripple and rf inductance	
E	R	1 to 10 ohm	1 to 10 ohm
	C	—	0.05 to 0.25 mf
F	C	0.05 to 0.25 mfd	0.05 to 0.25 mfd

Table IV. Basic characteristics of recent low-noise devices.

Techniques	Frequency Range	Typical Operation			Remarks	
		Noise Figure	Gain	Band Width		
<b>A. Maser</b>	300 MC to 30 KMC	Nearly ODB	13 DB	67 MC @ 6 KMC	Super Cooling Needed	
<b>B. Parametric</b>	1.5 KMC Up	?	60 DB	2 MC @ 6 KMC	Electromagnet Needed	
			< 2 DB	20 DB	2 MC @ 6 KMC	Most Advanced Design
			< 2 DB	30 DB	150 MC @ 600 MC	In Early Development Stages
<b>C. Low Noise TWT</b>	1 KMC to 12 KMC	2 DB	25 DB	2 KMC @ 2 KMC	Significant Improvement over Past Performance	

of values required for effective suppression. Whenever possible, electrostatically shielded transformers<sup>1</sup> should be used to reduce radio interference conducted along the ac lines.

### Ferrites

Recent investigations into the use of ferrites for low-frequency filter systems have been undertaken, since the combination of high permeability and dielectric constant cause the propagation velocity of electrical energy within the ferrite to be much lower than that in air. The reduced propagation velocity allows resonance within small structures. This property permits small ferrite shapes to be combined with capacitors for use in miniaturized radio-interference filters. Such filters should be additionally effective because of the loss characteristics<sup>5(4)</sup> of ferrites.

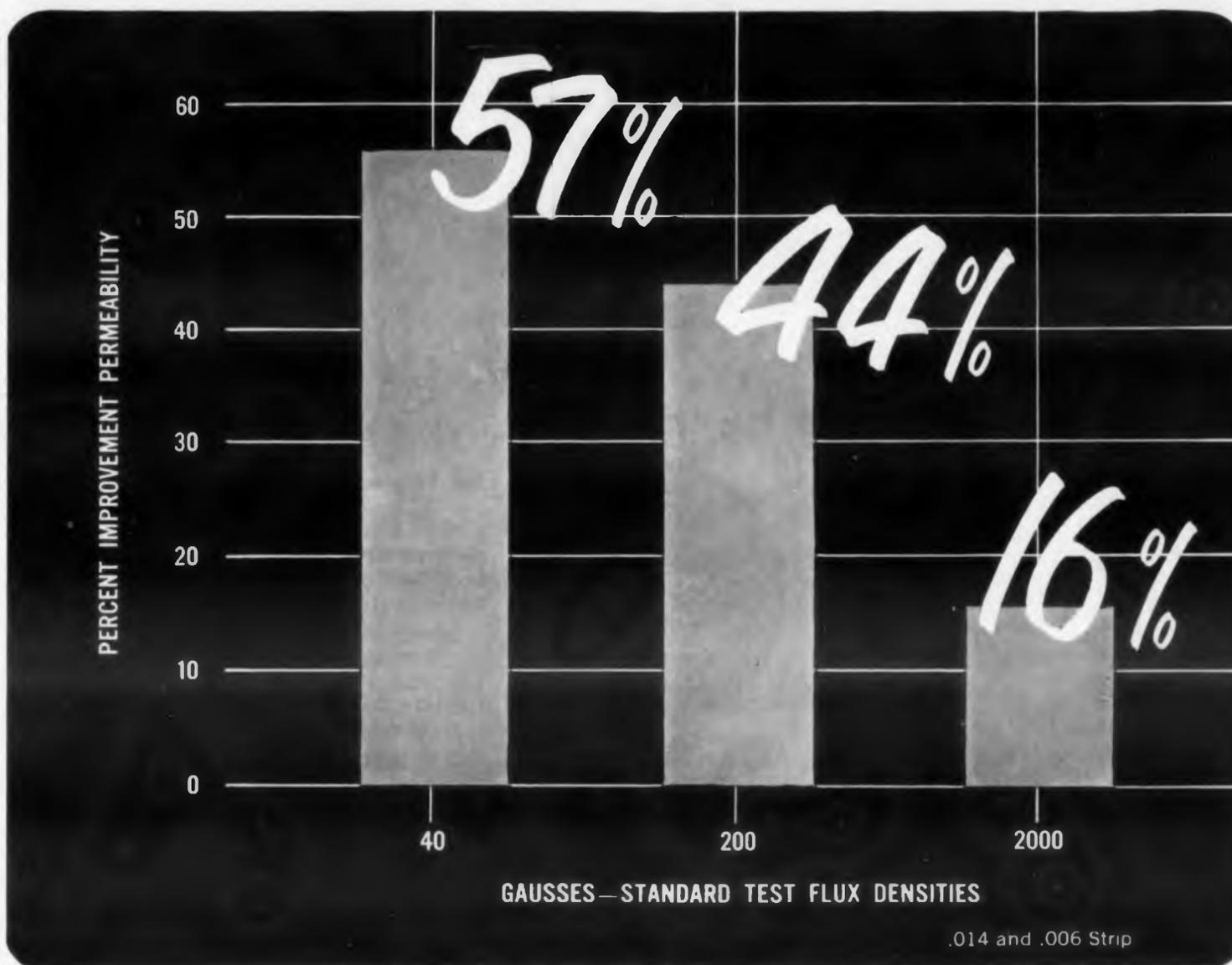
Despite the apparent advantage of ferrites as the dielectric in coaxial filters, results of investigations have not yet arrived at practical units.<sup>5(7)</sup>

The application of a high-permeability SiFeMg tape to a transmission line, as in Fig. 10A, can result in high attenuation of radio-frequency energy in the range of interference frequencies normally encountered on power transmission lines.<sup>6(1)</sup> Analysis of conductors coated with a high-permeability material shows a large increase in skin-effect losses at frequencies above the power transmission frequency. Experimental data made on three conductors wrapped with a thin, high-permeability tape is shown in Fig. 10B. A small helical air gap was formed in the wrapping of two of the transmission lines to reduce saturation effects which might occur on lines distributing power. The attenuation measured on these lines was about half that of the fully wrapped line, but gave much lower standing wave ratios and a low characteristic-impedance phase shift. The attenuation of these lines was large compared to the attenuation of a bare line. It is expected that high-permeability tape coatings with a gap will prove to be a useful and practical technique for reducing interference on power transmission lines.

### Low-Noise Devices

During the past several years, radically new types of microwave amplifiers have been developed. These include low-noise traveling-wave tubes; masers; diodes electron beam, and ferrite parametric amplifiers noted in Table IV. In the very near future, these extremely low-noise devices will find applications in communications and radar equipments, and may impose problems in equipment compatibility.<sup>6(9)</sup> Even before such problems are treated, the significant improvement in the noise level of these devices over conventional components will require the investigation of new and refined methods of improving the electromagnetic environment. ■ ■

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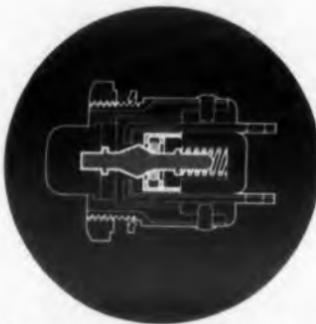
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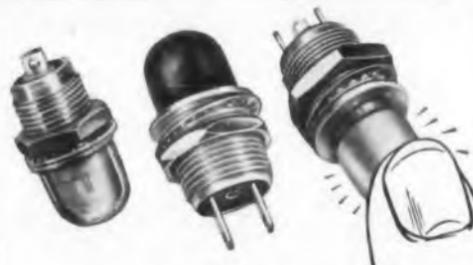
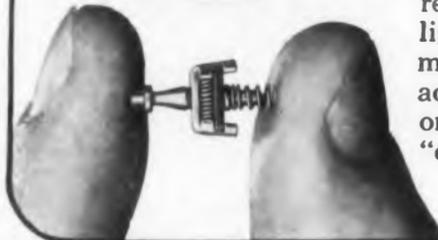
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#### SPECIFICATIONS

Dielectric	Mylar Film
Case	Epoxy Dip
IR at 25°C	75,000 megohms
Voltage Rating	50VDC
Temp. Range	-55°C to +125°C
Capacity Tolerance	To ±5%

#### TYPICAL 50 VOLT SIZES TYPE 601 PE

CAP.	T	W	L
.01	.187	.310	.562
.047	.203	.531	.453
.1	.225	.650	.525
.22	.296	.718	.687
.33	.312	.812	.950



663F 663FR

### EDGE MOUNTING

AXIAL OR RADIAL LEADS

These special-purpose versions of popular Good-All Type 663UW use precious space efficiently. Their ratings are conservative, and are equally suited for military and instrument grade applications.

#### SPECIFICATIONS

Dielectric	Mylar Film
Case	Plastic Wrap
End Fill	Thermo-setting epoxy
Voltage Range	100, 200, 400 & 600VDC
Temperature Range	-55°C to +125°C
IR at 25°C	100,000 meg. x mfd.
Humidity Resistance	Superior

#### TYPICAL 100 VOLT SIZES TYPES 663F and 663FR

CAP.	T	W	L
.01	.125	3/4	3/4
.047	.140	3/4	3/4
.1	.171	3/4	3/4
.47	.281	3/4	1 1/4
1.0	.375	3/4	1 1/2



627G

617G

### Hermetically Sealed

50 VOLT RATING

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Dielectric	Mylar Film
Case	Hermetically Sealed
Winding	Extended Foil
IR at 25°C	40,000 meg. x mfd.

#### Type 627G

Temperature Range	Full rating to 85°C, 50% derating at 125°C
DC Voltage Rating	50 volts only

#### Type 617G

Temperature Range	Full rating to 125°C, 50% derating at 150°C
DC Voltage Rating	50, 150, 400 & 600

#### TYPICAL 50 VOLT SIZES TYPE 627G

CAP.	DIA.	L
.01	.173	23/32
.047	.313	23/32
.1	.313	27/32
.47	.500	1 3/16
1.0	.560	1 1/8

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## Check-List

It is often possible, in the design stages of exotic and complex equipment, to overlook basic factors which may not affect performance but lead to flagrant interference problems. Excessive costs, time delays and "sweat and tears" are expended to remedy the situation. The check-list presented should be scanned as a reminder during early design considerations where RFI is most efficiently reduced.

### Leonard W. Thomas

Head, Radio Interference Section  
Bureau of Ships, Dept. of the Navy  
Washington, D. C.

**A**N OUNCE of prevention is worth a pound of cure—Perhaps radio-frequency interference suppression and control engineering is the most flagrant example of this old cliché.

Top experts engaged in RFI suppression

quickly point out the easy road to freedom from interference.—"To avoid interference, don't generate any." Vast amounts of energy, time, and money are expended in searching out RFI offenders in equipment: often, outlandish cost and size increases accompany the final steps of eliminating interference sources.

A remarkable number of interference problems arise in early design stages due to simple oversights and forgotten basic engineering theory. In an effort to recall the more important, although seemingly obvious, areas and sources of potential interference, the following check-list has been prepared from the "Standard Inspection Procedures for Interference Control", compiled for the Dept. of the Navy, Bureau of Ships, Electronics Division.

#### Preliminary General Check-List for Equipment

- The chassis or frame must be grounded or a means of grounding must be provided.
- Shockmounts must be by-passed with ground straps.
- Whenever a metal-to-metal contact is required for shielding or grounding, the insulated protective finish must be removed (Fig. 1).
- All openings for access, ventilation and case-mounted components shall be shielded to prevent case leakage. (See Fig. 2).
- Blower motors should be ac non-commutating types.
- All access doors should be metal textile or finger strip type, as shown in Fig. 3.

- Drawer- and door-locking devices must provide firm pressure against metal gaskets.

#### Communication Transmitters

- Heaters should be wired with twisted or isolated leads. (Field report data point to heater wiring as a major RFI culprit.) Two heater leads should be used and twisted together to cancel interference fields. The practice of using one "hot" lead and the other connection grounded should be avoided. Examples are illustrated in Fig. 4.
- Isolate the oscillator stage from other stages.
- Use interstage decoupling networks to reduce transfer of undesired harmonics and spurious radiations.
- To avoid undesired signal transfer to the high power stage of a transmitter, use link or parallel-tuned circuits.
- Apply parasitic suppression devices such as plate and grid resistors or chokes.

#### Communication Receivers

- Keep local oscillator power at a minimum level.
- Decouple oscillator heater and B supply sources.
- Isolate the oscillator from the antenna by rf amplifiers or preselectors.
- Use a shielded oscillator compartment when necessary.

#### Radar Transmitters

- Magnetrons should be contained in a shielded

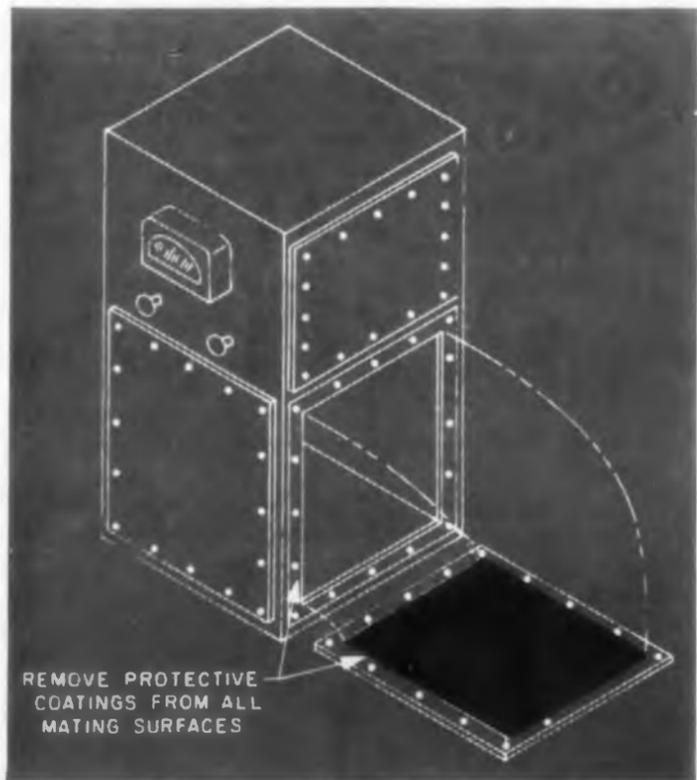


Fig. 1. Protective finish must be removed to achieve reliable metal-to-metal contact essential for shielding.

enclosure located as close to the pulse transformer as possible.

- Keep the pulse transformer close to the pulse cable entry. Rf shielding integrity must be maintained where the waveguide enters the cabinet.
- Direct coupling of the waveguide into the magnetron should be made whenever possible.
- The "keep-alive" voltage should be isolated and decoupled.

#### Radar Modulators

The square wave pulse used to fire the magnetron is the major source of interference from radar equipment. In many cases, the sharp leading edge of this pulse may shock excite the magnetron into oscillating at more than one frequency. In addition, the modulator pulse can shock and often overdrive the input stages of radio receivers, resulting in severe interference.

- The pulse network shall be isolated and all leads associated with the pulse network should be decoupled.
- The pulse transformer should be isolated so that the magnetic field of this transformer will be prevented from modulating the thyatron keyer tube.
- The grid despiking network shall be isolated and all leads associated with this network shall be decoupled.
- The pulse cable inside the thyatron-shielded enclosure and inside the pulse-transformer-shielded enclosure should be kept to a minimum length.
- A multiple-shielded pulse cable should be used to prevent pulse circulating ground currents. Multiple-shielded cable is a triaxial cable with the two inner shields of the cable connected to the thyatron cathode at one termination and to the low side of the pulse transformer at the other termination.
- The blower motors and the motor-driven pulse rate mechanisms should be synchronous type ac motors. If dc motors must be used, these motors should be designed with interference reduced to acceptable levels.
- Sharp projections in high-voltage circuits are possible sources of corona or arcing and thus are potential sources of interference. Construction with sharp projections therefore should be avoided.
- Sharp bends should be avoided in high-voltage wiring. The possibility of insulation breakdown is increased and, in the case of coaxial cable, the characteristic impedance of the cable may be changed and the attenuation increased.

#### Antenna Control Unit

This unit generally contains thyatron-rectifier circuits for the antenna servo system and antenna

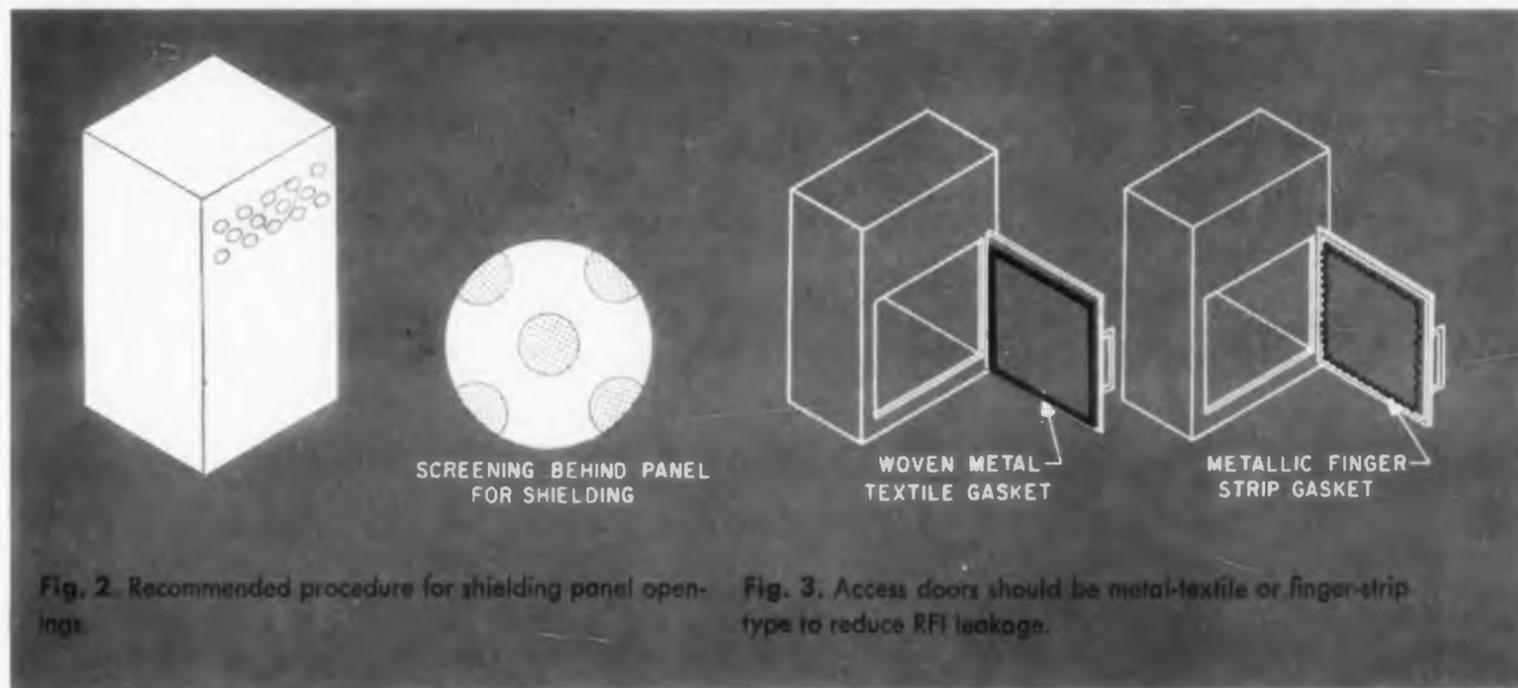


Fig. 2. Recommended procedure for shielding panel openings.

Fig. 3. Access doors should be metal-textile or finger-strip type to reduce RFI leakage.

drive motors. Many of the interference problems could be eliminated through the use of an ac servo system and the possibility of using ac should be fully investigated.

Particular attention given to the following items will greatly aid in designing an antenna control unit with low interference levels.

- The thyatron-rectifier circuits should be isolated from other circuitry.
- The thyatron-filaments leads shall be decoupled at their entry to the tube base shield. The tube-base shield should be constructed in a manner which will provide complete shielding of the thyatron-tube base.
- The output leads from the thyatron to the antenna motor should be decoupled. These output leads can be decoupled without affecting antenna rotation.
- The antenna control unit should not be used as a terminal box for wiring not associated with this unit. The practice of using the antenna control unit as a terminal box for wiring from other sources only complicate the problem of providing complete isolation of the thyatron.
- Pulse and rf rotary joints should be thoroughly shielded.

#### Pulse Generators

- Waveforms in the pulse-generator circuits should be checked for unnecessary spikes. The presence of these spikes may not affect the operation of the circuit but may produce interference.
- Pulse-circuit wiring should be kept as short as possible.
- Return for the pulse stage should go to the cathode of the stage rather than to ground in order to reduce pulse ground currents.
- All pulse energy should be fed to succeeding

stages in coaxial leads where possible. Precautions should be taken to guard against distortion of the waveform introduced by the capacitance of the coaxial cables.

#### Radar Receiver

In the radar receiver, as in the communication receiver, the principle area of concern is the oscillator unit. Parasitic oscillations are not uncommon in receivers and every effort should be made in the design stages to prevent them.

#### Radar Indicator

Unless special precautions are taken, the radar indicator may be the source of many magnetic fields which can be serious interference problems. The problem is primarily that of isolating the fields at their sources. If attention is given to the following design principles, interference from the indicator unit can be kept within allowable limits.

- Control and power leads must be decoupled by the use of feed-through bypass capacitors.
- The deflection coils for the cathode-ray tube must be isolated.
- Glass or plexiglass with a coating of conductive material should be used to cover the opening for the indicator-tube face. This, in conjunction with the indicator case, provides a continuous shield for the indicator.
- The range-oscillator coils and the coils used in the blocking oscillator must be individually isolated to confine the magnetic field to the coil producing that field.
- The rf high-voltage power supply should be isolated. Input and output leads must be decoupled at their entry into the shielded enclosure isolating this power supply.
- All stages of the indicator should be decoupled

# S.S. White DRIVE AND CONTROL IDEAS FOR ENGINEERS

*Tips on better designing with flexible shafts*

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The use of flexible shafts enabled the designers to use only one motor to drive each pair of actuators, thus solving synchronization problems and at the same time cutting down on the number of motors needed.

Flexible shafts (1) and (2) rotate the trunk lid locking screws in and out of engagement. Flexible shafts (3) and (4) drive a pair of screw-jack actuators to raise or lower the trunk lid. Flexible shafts (5—not shown) and (6) drive a pair of actuators and their associated linkage to raise or retract the roof.



### POWER DRIVE:

Powering a movable component... is easily accomplished with flexible shafts. Position of barrel type feeder on this new Detroit Power Screwdriver is highly adjustable, because it is driven by a flexible shaft. Power take-off is at the main drive motor.



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## Check List

to prevent interference signals from being conducted between stages.

### DC Machines

Among rotating electrical equipment, the principle offenders as a source of interference are dc machines. In the design of dc machines (either generators or motors), care must be taken to minimize the effects of the commutation process. This is essentially a switching process in which high currents are continuously switched. The problems of good interference-free design are then, in reality, the problem of good commutator design.

- Commutation transients can be reduced by use of interpoles. A more rapid change in the armature-coil current at the beginning of the commutation period is achieved, reducing the steepness of the transient at the end of the commutation period.

- Compensating windings produce the same effect as interpoles but to a smaller degree. Field distortion is also minimized.

- A greater number of armature coils and commutator bars can reduce interference by lessening the current broken per bar.

- The use of laminated brushes will reduce arcing and interference by lowering the resistance presented to the approaching commutator bar and raising the resistance presented to the receding bar. This would favor the load-current flow in the approaching bar and introduce a higher resistance in the coil undergoing commutation, thereby reducing circulating currents.

- Commutation interference can be caused by the generation of thermo-electric voltage which is proportional to current density in the contact areas. With an increase in current density, greater heat is generated in the contact resistance with a resulting rise in temperature of the brush and commutator surfaces. Since current density is the important factor, large brush surface areas should be used. However, if to obtain low current density it becomes necessary to make the brush size excessive, grooving and rapid wear of the commutator surface may occur. General design practice calls for a current density of 55-65 amps per sq. in. at full load for graphite-carbon brushes and 65-90 amps per sq. in. for metal-graphite brushes. Use of the design figures should give a brush which has good "wear" qualities as well as low-interference generation properties.

- Proper mechanical design and construction will reduce inherent interference. Electrical and me-

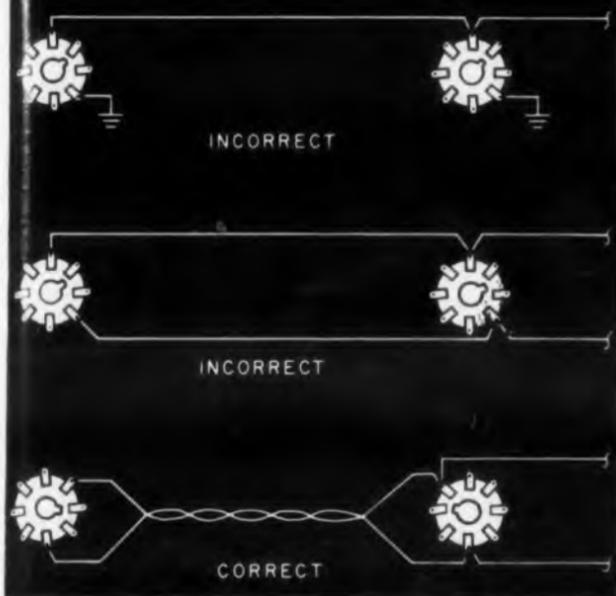


Fig. 4. Examples of proper and poor heater wiring techniques.

mechanical symmetry, accuracy of machined parts and good quality control will aid in eliminating the dc machine as a source of interference.

#### AC Generators

Ac rotating equipment as a source of interference does not present nearly the problem as do dc machines. The principle problem lies with ac generators. This problem is that of the prevention of harmonic generation and the prevention of resonant conditions within the circuits associated with the ac generator.

- If in the design of an ac generator, the designer considers the criteria of obtaining a pure sine-wave output as one of his most important design objectives, the resulting product will present very little difficulty as a source of interference.

- A sinusoidal distribution of the flux around the armature is necessary.

- Mechanical and electrical symmetry cause cancellation of even order harmonics; electrical pole pieces and uniform winding of the armature will provide symmetry.

- In three-phase alternators, the use of "Y" or star connection with a grounded neutral will cause the third harmonic to be present in the voltage from any phase to neutral. The use of delta connections will cause the third harmonic and its multiples to be cancelled within the machine.

- By making the number of armature slots per pole pair an odd number, tooth ripples can be eliminated.

#### AC Motors

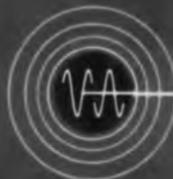
Induction and synchronous motors are practically free of interference sources. These sources

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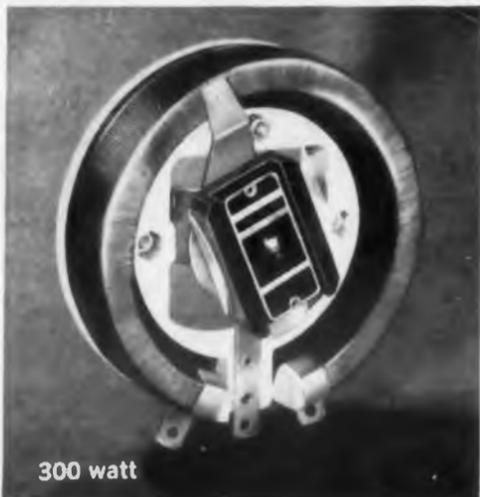
50 watt



100 watt



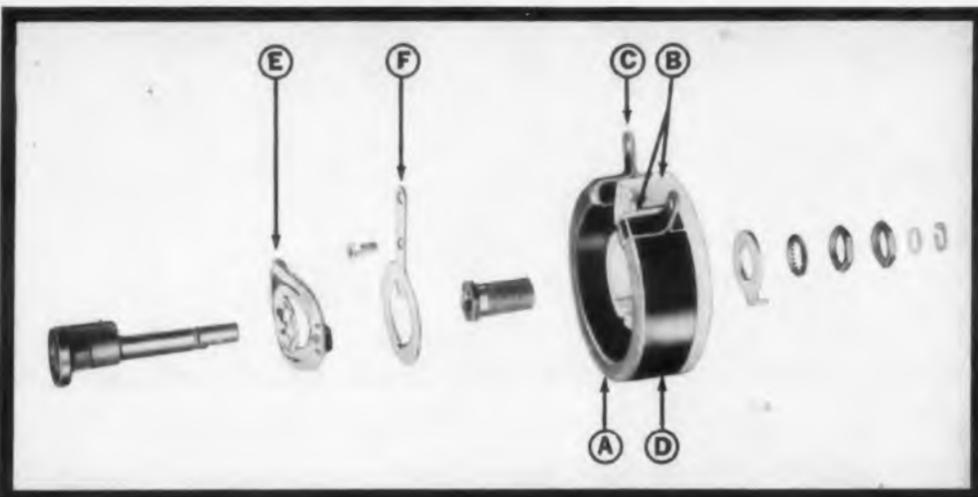
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300 watt



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## Checklist

when they do exist can generally be traced to mechanical failures. Loose laminations in the armature and pole pieces, and loose or faulty slip ring or brushes may cause interference. An exception is that several instances have arisen where

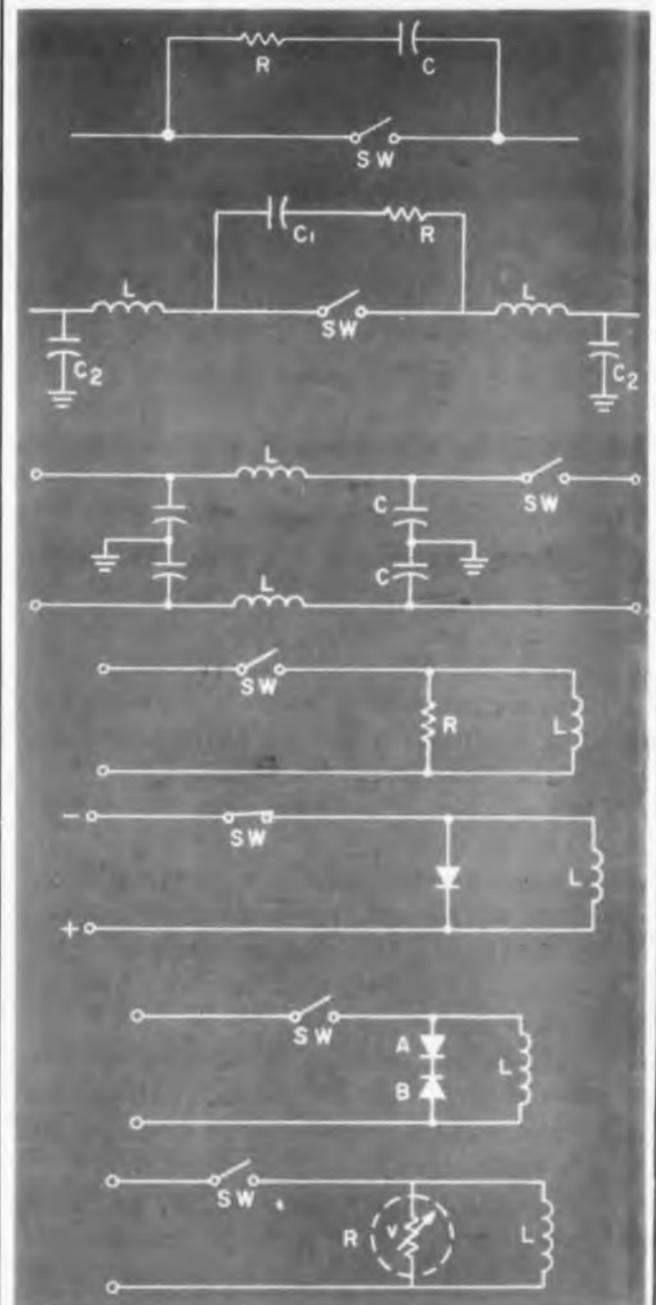


Fig. 5. Various methods used to reduce arcing due to switch and break transients. (a) simple RC network (b) low-pass filter added to RC network (c) double-pi filter (d) high resistance across an inductive circuit (e) rectifier used in place of the high resistance in (d) for dc applications (f) back-to-back rectifiers and (g) negative-voltage characteristic resistors.

high-speed rotating electrical machinery (above 2000 rpm), employing antifriction (ball or roller) bearings, has exhibited an impulsive type of radiated interference, the frequency distribution of which was related to that length of shaft which was a quarter wavelength. Such interference has been termed "bearing static", and research is continuing one means for its control or reduction.

#### Electrical Contacts

■ Many methods are available to reduce the arcing that occurs when a switch or contact makes or breaks. There is no single method of interference reduction which is universally applicable, so various methods which can be used are given in Fig. 5; these methods can be used either singly or in combination, depending upon the particular case upon the interference reduction required.

■ If the methods shown in Fig. 5 do not sufficiently reduce interference levels, shielded enclosures and shielded leads should be employed. The addition of feed-thru capacitors in the input and output leads of the shielded enclosure may be required. The mechanical design or a relay should be such as to prevent chattering or bouncing of the contacts.

#### Power Supplies

■ The most common type of interference associated with electronic power supplies results from high impedances in filters. If the power-supply filter impedance is low for rf as well as for power line frequencies, this trouble is reduced. Additionally, line filters and electrostatically shielded power transformers are recommended.

■ Gas-tube rectifiers are prone to generate interference. In addition to line filters and electrostatically shielded transformers, hash-suppression chokes are required in the plate and cathode leads of these rectifier tubes.

■ Electronically regulated power supplies should be provided with decoupling circuits to prevent oscillations in the regulator. Long lead lengths should be avoided in plate and grid circuits.

#### Gas-Tube Equipment

The category of gas-tube equipment includes such items as rectifiers, sweep generators, electronic switching devices, relay controls, modulators, and pulse generators. Unless the proper steps are taken in the design of this type of equipment, serious interference problems may result. Isolation and decoupling are of prime importance in circuits employing gas tubes.

■ The heater supply of a gas tube should be well decoupled and isolated. The output leads should be isolated and decoupled to prevent interference from being conducted and radiated along those leads. ■ ■

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The deterrent striking force of SAC could well be likened to the spines of the Diodon. Most certainly anyone foolish enough to try to gobble up this country would experience a fatal case of indigestion. Many SAC attack bombers are equipped with countermeasure devices of types built by I.F.I. which assure completion of their missions.



*The world is a mass of defensive "bristles" but none are longer or sharper than ours.*

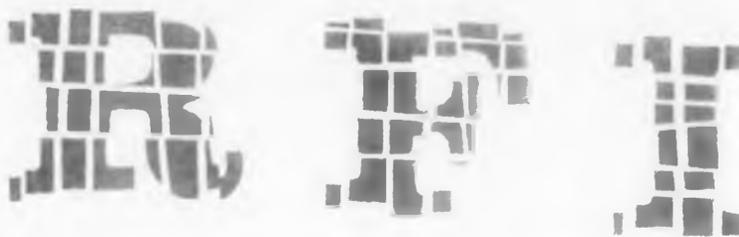


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# Interference Trouble-Shooting with Clamp-On-Devices

**Thomas H. Herring**  
Interference Group Control  
Boeing Airplane Co.  
Seattle, Wash.

**Magnetic clamp-on devices are well adapted for the electronic installation trouble-shooter who must cope with the characteristic inaccessibility of interconnecting circuit terminations, generally with a lack of detailed knowledge of the installation. Many practical problems are described and their solution outlined.**

**I**NTERFERENCE resulting from magnetic coupling is difficult to reduce by shielding; proper cable bundling and re-routing are generally the most effective means of suppression. Clamp-on ammeters and injectors permit rapid and convenient radio-frequency interference measurements without the need to clip wires or open cable harnesses.

## Clamp-On Devices

A clamp-on device is an incomplete transformer. The ferro-magnetic core may be easily opened to admit one or more turns of wire, thus completing the transformer. When the clamped wire is the primary, the device is termed a "clamp-on ammeter" and when the clamped wire is the secondary, a "clamp-on injector". Clamp-on ammeters measure current and clamp-on injectors inject voltage. Used separately or together these devices can perform many measurement and analysis functions.

The physical size of clamp-on devices is determined by the amount of iron needed, the size of the largest cable to be clamped, and the over-all rule that compactness is essential if the full potential of convenience is to be realized. A bulky unit that cannot be clamped around cables in tight places is of little use.

## Ammeters

Clamp-on ammeters operate on various principles. Some operate on the principle of the "current transformer", used in accurate high-

power measurement wherein the secondary is heavily loaded so as to minimize the range of core flux changes. Others use an unloaded (v/vm load) secondary. Rf clamp-on ammeters work into a 50-ohm load. Also, there are dc clamp-on ammeters which make use of various ingenious principles.

Those ammeters having a nearly unloaded secondary coil will have a voltage output heavily dependent on frequency. Rf units are of this type and the impedance reflected into the line is very low. Clamp-on ammeters with unloaded secondaries will reflect a reactive impedance into the line. Clamp-on ammeters other than those of the "current transformer type do not need low reluctance cores because close coupling is not required.

Two properties of clamp-on ammeters are common to all types and are the basis of their utility in trouble-shooting. First is the ability to sense a current without opening the circuit under test. The advantage of this property in testing installed systems is quite evident. Second is the ability to perform a vector addition of all currents which are simultaneously linked and to thus read the net current. Using this property, one can, in a single measurement, determine whether two currents are complementary (whether or not they differ by exactly 180 deg in phase and are otherwise identical). This property makes it possible to determine if all wires of a circuit are included in a given bundle. This knowledge is often useful in locating the path taken by either an interference producing current or by a sensitive circuit.

If a current is contained entirely in a bundle (the smaller the better) it will cause less interference and/or will be less susceptible to interference than if it is spread out over a wide area. Used as a simple ammeter, the clamp-on ammeter can accurately measure interference producing current. Comparison of this measurement with previously established limits will give an indication of whether or not a given current is causing trouble.

## Injectors

Clamp-on injectors as discussed here may be used in two ways. With the jaws closed around a wire ( $N$  turns may be taken), a known flux  $\Phi$  is caused to link the wire resulting in an induced voltage in the wire

$$V(\text{Volts}) = 2\pi f n \Phi \text{ (webers per sec)}$$

This voltage can be calibrated in terms of the energizing current, or, almost as conveniently, a wire turn may be taken around the core and lead to a monitoring voltmeter which reads the injected voltage directly. The accuracy with which the injected voltage is measured depends on the degree to which the region surrounded by the core is free of flux. Moving the wire around in the core space should not change the amount of voltage induced in the wire by more than a percent or so. If the injector is linked around all wires of a circuit, and if structure is not carrying part of the circuit, then no amount of flux linkages will induce a voltage in the circuit. This is a good test of the actual path taken by a circuit.

When the clamp-on injector is applied to a

After RFI trouble-shooting the interior of a bomber literally "wallpapered" with wiring, Mr. Herring became a dedicated interference control engineer. During the past eight years devoted to this work, he (and others) have been plagued with

designers who don't know or don't care what paths their interference may take. With clamp-on devices, lengthy and costly checks can be accelerated without extensive studies of circuit configuration or system details; splicing wires is unnecessary.

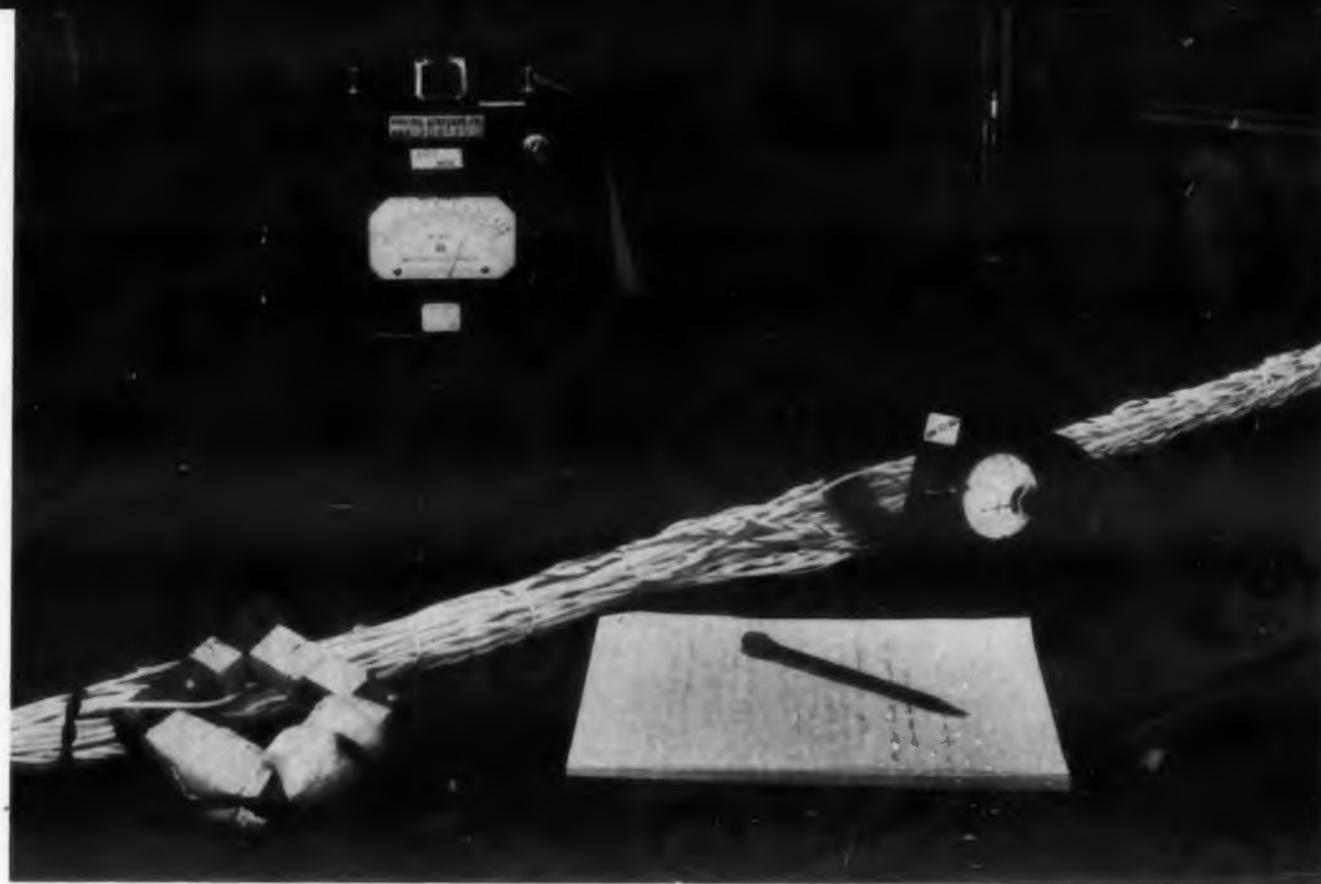


Fig. 1. For impedance or continuity measurement, an af injector (left) has ten monitor turns fed to a voltmeter. The clamp-on ammeter at the right reads the resulting current.

cable with the jaws open, the flux is no longer concentrated in a well-defined path but spreads out over a wide region. Thus the number of lines linking the cable under test is not known. However, this mode of operation is very useful for rapid qualitative analysis of cables which are well tied, or in a sheathing, and which are not to be cut open. Only with the jaws open can flux be threaded between the wires of the cable without untying the cable. This usage approximates actual wire coupling since actual wire coupling is strictly an "air-core" transformer situation. Cables which do not respond to the closed-jaw test may respond to the open-jaw test and may in practice be quite susceptible. Thus, with the clamp-on injector, we have both an accurate producer of flux linkages and a handy qualitative source of diffused flux.

For audio-frequency injectors, a magnetic circuit of reluctance comparable to that of a good power-transformer core is required. The iron should be able to handle at least 200 amp-turns of excitation. The phase of the injected voltage can be controlled by energizing the injector from the system power supply.

#### Applications

Typical problems which are tailored to the use of clamp-on devices are grouped into categories of:

- (a) measurement of interference sources
- (b) threshold determination
- (c) circuit pathfinding and

(d) re-routing recommendations.

#### Measurement of Interference Sources

**Problem:** Several bundles of wires are suspected of generating interference in the audio-frequency band. Locate the wire or wires at fault.

**Approach:** Select a clamp-on ammeter responsive to the frequencies of interest and clamp each bundle. Readings below 0.5 amp generally indicate innocence. Untie the guilty bundle and clamp individual wires. The best fix is to twist together the complementary wires—if both are available.

**Problem:** An rf noise source has been located, but the means of coupling to the affected equipment is not known.

**Approach:** To tell whether the wires to the source are carrying the interference, clamp them with an rf ammeter. Compare the readings with the limits given in specification MIL-I-26600. Generally, readings within these limits indicate innocence.

#### Threshold Determination

**Problem:** The ripple on a dc reference voltage is suspected of causing trouble. The ripple is measured at 100 mv rms, 60 cps. Is the ripple really causing any trouble?

**Approach:** Control the ripple by injecting additional ripple and check the system for any change in the observed trouble. Use a closed-gap injector energized at 60 cps with a monitor turn around the iron. The monitor turn is connected to an ac

voltmeter which can read 100 to 500 mv. Inject, if possible, either in or exactly out of phase with the ripple. If phase cannot be controlled, simply inject several times the 100-mv existing ripple so that the injected ripple dominates.

**Problem:** A wire connected to a sensitive equipment is suspected of being sensitive to interference at 50 kc. The wire cannot be cut or opened and is shielded. What is the threshold sensitivity of this wire?

**Approach:** Use a closed-jaw injection energized at 50 kc having a monitor turn connected to an ac voltmeter. Inject increasing amounts of voltage until an equipment response is obtained.

**Problem:** A system shows signs of interference. Cable coupling is suspected as the cause. Is this a reasonable supposition?

**Approach:** Energize an injector to its maximum rated number of ampere turns (with the jaws open) at the frequency or frequencies of interest. At power frequencies, about 1000 lines of flux in the gap is a good figure. Apply the open gap to each cable of the system. If there is no response, then cable coupling is not involved. The injection flux should be a few times larger than any actual flux linkage which could exist. If both wires of a two-wire sensitive circuit are linked by the injection flux lines, less voltage is induced than if most of the injection flux threads between the wires. Hence, the injector would be moved around a bit to cover both these possibilities. (To estimate the actual flux linkages which could exist, assume the worst case, that is, both the source circuit and

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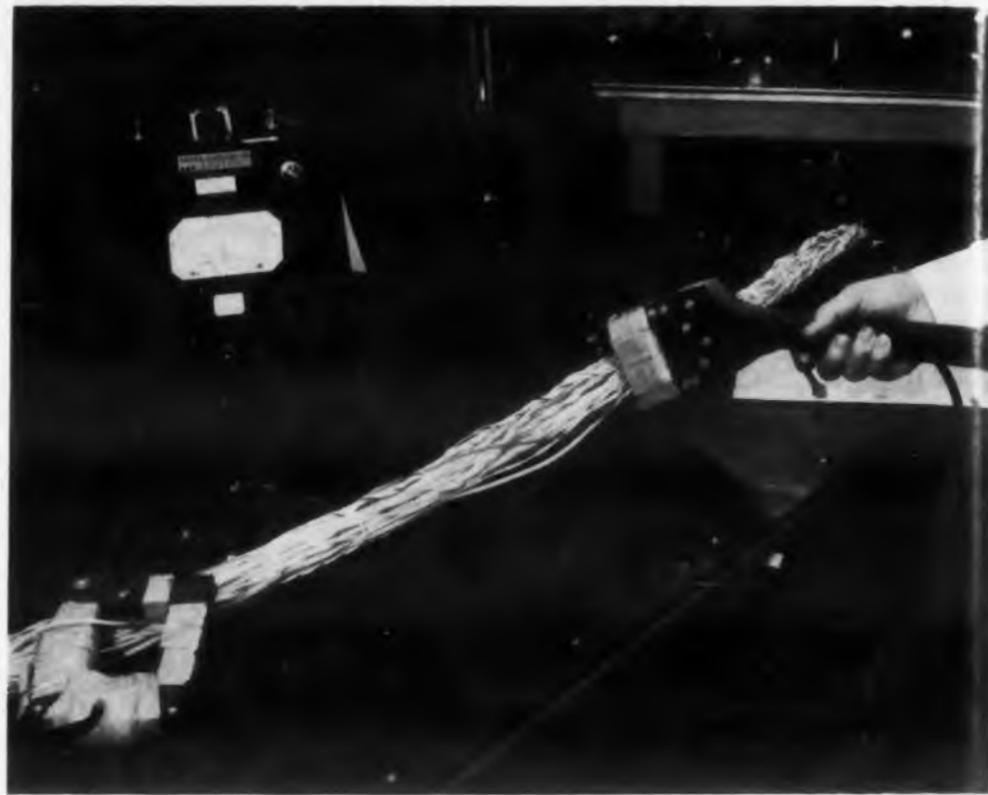
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## Clamp-on Devices *cont.*



**Fig. 2.** Only a few minutes time is required to locate current carrying wires using a clamp-on ammeter.



**Fig. 3.** For threshold determination, an open jaw injector (at right) is threading 400 cps flux through the cable at simulated environmental level. The injector (at left) is being used as an ammeter to detect the resultant RFI current flowing in a signal return wire of a sensitive circuit.

sensitive circuit consisting of single wires with structure return, spaced an inch apart. This situation has a coupling of about 200 linkages per 10 ft/amp.).

### Circuit Pathfinding

**Problem:** A circuit is known to be highly sensitive. Can this be corrected, or is it an intrinsic property?

**Approach:** Use an injector to determine whether the circuit is confined to as small a space as possible. If it is not so confined, then considerable improvement can be gained by this confinement. Use a closed-jaw injector on the cable at the signal frequency and apply a very large injection voltage. Lack of circuit response shows that the circuit is confined to the cable. A response will prove that an additional, possibly remote, circuit path exists. Locate this path, if any, and re-route it with the circuit cable. (If this path is structure, one is confronted with a somewhat classic problem.)

If one is working with a non-energized system, the above approach can be used if a clamp-on ammeter is placed on the signal return wire or around the entire bundle. Either location should show no response if the circuit is complete in the bundle. The lack of response should be equivalent to an isolation resistance of 1 megohm.

**Problem:** A bundle is known to contain a power circuit, or at least part of it. Is the circuit completely contained in the bundle, and if not, where

is the rest of it?

**Approach:** The clamp-on ammeter will read zero if the circuit is complete (all wires of the circuit linked). If not complete, clamp all likely bundles for the missing wire while cycling the power circuit on and off. If this search fails, structure is probably carrying the rest of the current. Any power bundle which has a clamp-on net current reading over 0.5 amp is a potential source of interference. If the clamp-on reading is 0, the bundle may still have an appreciable induction field, but twisting will reduce it greatly.

**Problem:** A continuity check is being made on a circuit, and/or the loop impedance of a circuit is to be determined.

**Approach:** Inject a small ac voltage at a convenient location by clamping one wire of the circuit and use a clamp-on ammeter nearby (but not too near) to measure the induced current.

### Re-Routing Recommendations

The problem of re-grouping wires and of re-routing the groups in order to reduce interference is basically a mutual inductance ( $M$ ) calculation problem. One starts with the flux sensitivity threshold (in webers) ( $\Phi_t$ ) of the sensitive circuit. If the voltage threshold ( $V_t$ ) was measured, then  $\Phi_t = V_t \div 2\pi f$ . The aim is to reduce the flux linkages to a figure less than  $\Phi_t$  by reducing the effective width of the sensitive circuit (proper bundling, choice of cable type, twisting), reducing the effective width of the source circuit (proper

bundling, choice of cable type, twisting) and by increasing the separation between the circuits. The following method is suggested:

Consider a model pair of circuits, each of two wires, with the circuits in parallel planes spaced a distance  $X$  apart. Let the width of the sensitive circuit be  $D_v$  and that of the source circuit be  $D_s$ . With proper choice of parameters, this model configuration is equivalent to the actual case. The mutual inductance, or flux linkages per ampere, of the model arrangement is easily figured by hand-book methods. All one needs to know to solve the problem is the flux threshold of the sensitive circuit,  $\Phi_t$ , the "noise" producing current  $I_s$ , the coupled length  $L$ , the existing values of  $D_v$  and  $D_s$ , and the minimum values of these latter quantities which can practically be obtained.

Clamp-on devices can measure all five existing quantities,  $I_s$ ,  $\Phi_t$ ,  $L$ ,  $D_s$  and  $D_v$ . The first two are obtained directly from ammeter and injector data. The circuit widths  $D_s$  and  $D_v$  are obtained through the "Circuit Pathfinding" methods previously described in which the paths of the current and return current are located. When the ammeter reads 0 around a bundle, one merely assumes the circuit width to be the width of the bundle; if one knows that the circuit is twisted, then a width of approximately 0.02 in. may be assumed. The coupled length  $L$ , common to both source and sensitive circuits, likewise is found by the "Circuit Pathfinding" methods. To solve the problem one first assumes that  $D_s$  and  $D_v$  are re-

duced to a minimum by bundling and twisting. Then, calculate the flux linkages  $\Phi$ . If  $\Phi$  is still too large, increase the separation  $X$  until the calculated  $\Phi$  does not exceed  $\Phi_t$ .

#### Actual Field Problem

An airborne air data computer was reported to give inconsistent output. The interference engineer who was called in knew only that the computer used a signal carrier frequency of 400 cps (the same as the aircraft's power system), that three "black boxes" were involved, and that the interconnecting cables were numbered CA-30, CA-121, CA-122 and CA-60.

The engineer first selected a clamp-on injector to use in finding the sensitive cable, if any. He energized the injector at 400 cps to a standard number of ampere-turns, energized the computer, opened the jaws of the injector about 1 in. and started to probe the computer cables. It was found that two cables, CA-121 and CA-122, produced computer responses many times more intense than those of the other cables. Next, completely closing the magnetic circuit around each cable in turn, the engineer obtained large and equal responses from each cable. No response was obtained when the injector was closed around both cables simultaneously.

By these three steps, the engineer had located the sensitive cable, and further, had learned that the sensitive circuit was divided, with signal "high" in one cable and signal "return" in another cable, and that the circuit was entirely contained in these two cables. To check that electrostatic coupling was not involved, a wire energized to 110 v, 400 cps, was laid parallel to the computer cables in turn; no response was obtained.

To locate the source of the interference, the interfering circuit was identified by systematically turning aircraft circuits on and off until computer response was obtained. The culprit proved to be the wing-flap-position indicating circuit. Location of the interfering wires was made evident immediately by using a clamp-on ammeter (on the 5-amp range) on all aircraft cables in the vicinity of cables CA-121 and CA-122. The path taken by the interfering wires was traced by having a person cycle the flap-indicator power on and off while the trouble-shooter worked along the interfering cable with the clamp-on ammeter. The interfering current was found to be contained in a single cable. Since the ammeter had a non-zero reading with its jaws shut, the return current was, in part, returning by some other (evidently remote) path. The investigator now knew the precise path taken by all wires of the sensitive circuit and he knew that the interference was magnetically coupled from a cable carrying a net, unbalanced, 400-cps current. It was then a simple matter to specify the re-cabling and re-routing required. ■ ■

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1N1193A	22A	150V	150°C	1.2V at 60 amps.	5.0 MA
1N1194A	22A	200V	150°C	1.2V at 60 amps.	5.0 MA
1N1183A	40A	50V	150°C	1.1V at 100 amps.	5.0 MA
1N1184A	40A	100V	150°C	1.1V at 100 amps.	5.0 MA
1N1185A	40A	150V	150°C	1.1V at 100 amps.	5.0 MA
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# Optimum Shielding of Equipment Enclosures

Electromagnetic shielding may be applied to radiating devices to prevent escape of rf energy from an enclosure or may be used in receivers to minimize extraneous pickup. The factors influencing shielding material selection and the use of design curves to determine shield thickness are discussed.

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Project Director  
Systems Engineering Div.  
Filtron Co., Inc.  
Flushing, N. Y.

**R**ADIATING equipment is shielded to limit the transmission of spurious signals which may cause objectionable interference to nearby devices; receiving equipment is housed in shielded cabinets to minimize pickup of external rf fields which might produce direct or heterodyne interference and render communication useless.

## Shielding Theory

One concept of shielding theory is that an rf field is produced by a wave which impinges on the shield, which in turn induces a current in the shield; the induced current is in a direction opposite to the original current. An opposing magnetic field results, which reduces the transmission of energy.

The classical shielding theory relates a shield to a transmission line.<sup>1</sup> An rf field is reflected and attenuated in passing through a metal. See Fig. 1. This is analogous to propagation of traveling waves on a transmission line. It is possible, by

consideration of the transmission-line analogy, to compute the attenuation and reflection which will be experienced at each surface of the shield, and in passing through the shield.<sup>2</sup>

The relationship is shown in Eq. 1:

$$S = R + A \quad (1)$$

where:

$S$  = total shielding efficiency (db)

$R$  = total reflection loss (db)

$A$  = dissipation or absorption loss (db)

These losses depend on the frequency involved and the thickness of material. Losses are also functions of material resistivity, permeability, and conductivity; reflection losses are related to the electromagnetic field characteristics. Since these losses vary with the characteristic "wave impedance" of the field, they may also vary with distance.

Low impedance or magnetic fields occur in the vicinity of coils or small loop antennas. (An rf field has both electric and magnetic components; the

ratio of the components is what permits description as either an "electric" or "magnetic" field.) Since reflection losses for magnetic fields are small for most materials, the shielding depends primarily on absorption losses. High impedance or "electric" fields are easy to shield against, since large reflection losses are easily obtained. The absorption loss, which is essentially independent of the wave impedance, is the same for both electric and magnetic fields.

## Material Selection

Figs. 2 and 3 show typical values of reflection and absorption losses for selected shielding materials (copper and iron). It is seen that at reasonably high frequencies, the dissipation of the field by absorption loss in metals of reasonable thickness is by far the most important factor in shielding. Reflection losses play only a minor role in this regard.

For the electric or high-impedance field, the

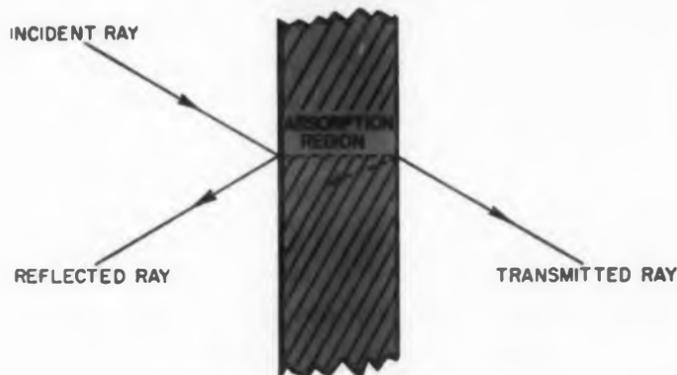


Fig. 1. Reflection and absorption in an rf shield.

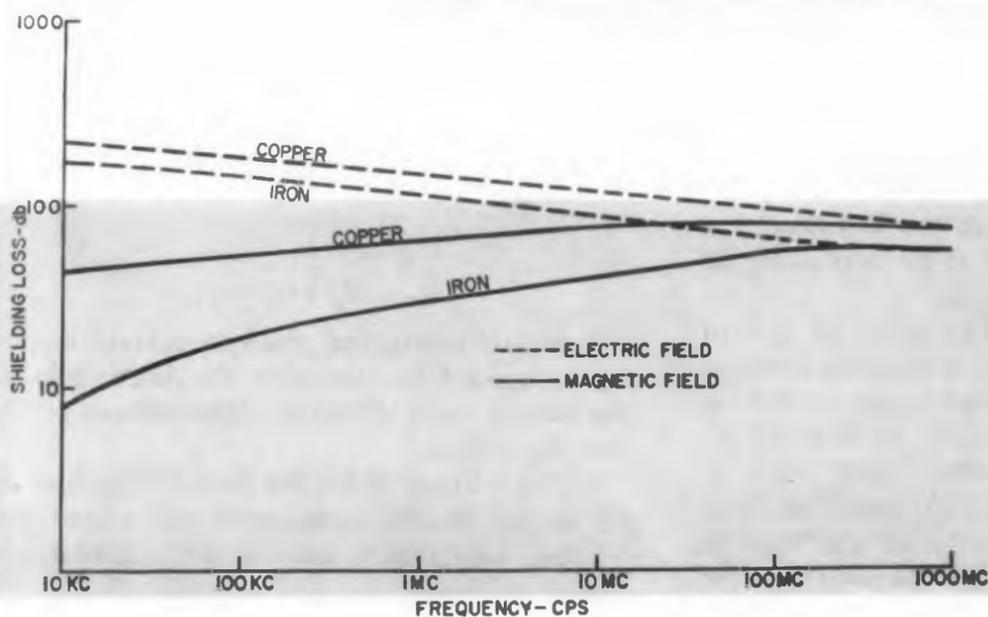


Fig. 3. Attenuation due to reflection.

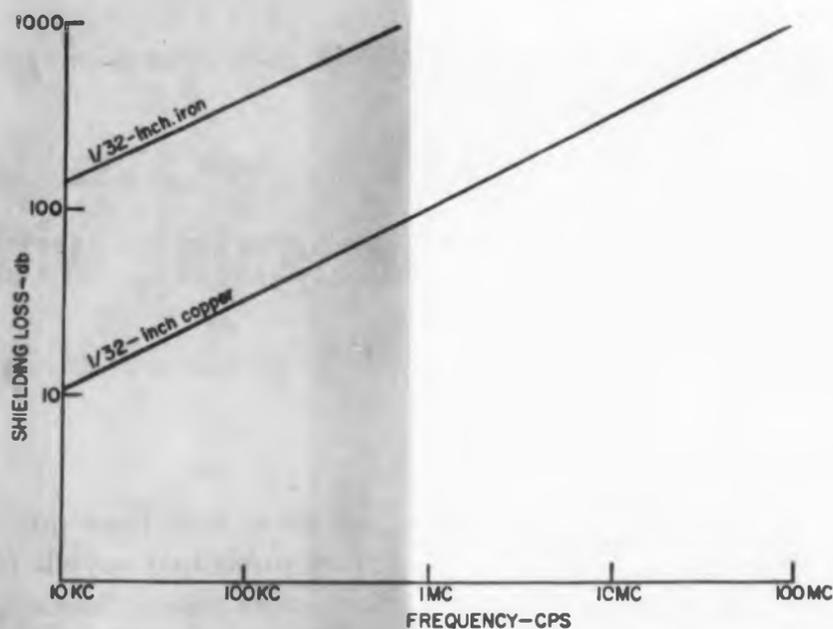


Fig. 2. Attenuation due to dissipation or absorption losses.

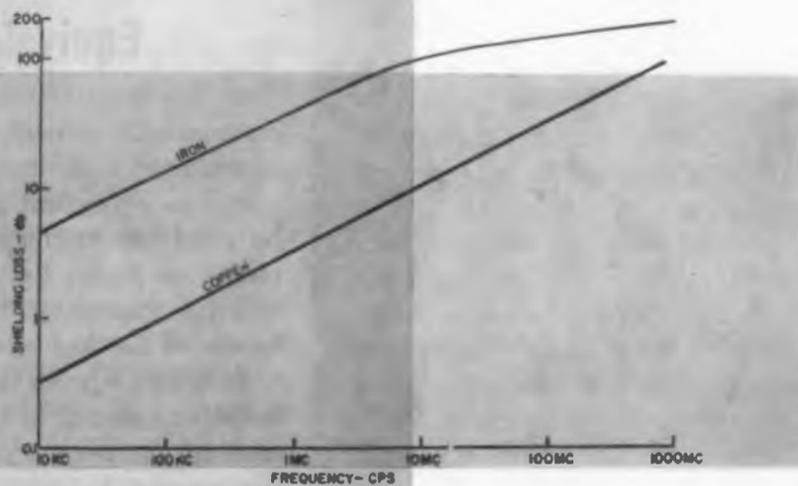


Fig. 4. Dissipation loss for one-mil thickness material.

shielding due to reflection increases at lower frequencies. Highly conductive materials, such as copper, aluminum, or magnesium give the best results. The shielding for low-impedance (magnetic) fields decreases at lower frequencies.

Both the reflection and absorption losses are small at low frequencies and the shielding problem is thus severe. Since magnetic materials, such as iron or Mu-Metal, have high permeability at low frequencies, they are more effective as shields. However, the resulting increase in absorption loss is obtained at the expense of a reduction in reflection losses.

This suggests the following general rules for selection of shielding materials:

- Good conductors (copper, aluminum, magnesium) should be used for high-frequency shields.
- Magnetic materials (iron, Mu-Metal) should be used for low-frequency shields.

Although seldom practical for equipment

shields, composite layers of copper-iron are used in commercial shield enclosures. Such shielded rooms provide optimum performance over a wide frequency range.

#### Design Procedure

As a rule of thumb, any shield which is structurally sound will be thick enough for shielding at radio frequencies. This approximation does not hold at audio-frequencies or for critical applications; however, Fig. 4 shows representative values of absorption loss per mil thickness of material. By multiplying the thickness and the absorption loss factor, and then adding the reflection loss, the total shielding effectiveness can be computed.

For example, suppose it is necessary to determine the shielding effectiveness for magnetic fields at 100 kc, using 0.025 in. copper.

**Procedure:** From Fig. 3, the reflection loss at 100 kc is 50 db. The corresponding dissipation loss for 1 mil copper, as obtained from Fig. 4, is 1 db.

Hence, from Eq. 1:

$$S = R + A$$

$$R = 50 \text{ db}$$

$$A = at = 1 \times 25 = 25 \text{ db}$$

Therefore,

$$S = 50 + 25 = 75 \text{ db}$$

When it is necessary to provide a given degree of shielding, say 60-80 db, reference to the curves permits quick estimates of the required material and thickness. In most applications, however, it is required to reduce the interference field to some specified level. By measuring the field without the shield, and comparing with the specific limits, the shielding requirements can be determined. ■ ■

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1. S. A. Schelkunoff, *Electromagnetic Waves*, D. Van Nostrand Co., Inc., 1956, pp 303-315.
2. C. S. Vasaka, *Problems in Shielding Electronic Equipment*, Proceedings of the First Conference on Radio Interference Reduction, Armour Research Foundation, 1954, pp 86-103.

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# Designing with Tunnel Diodes

## Part I

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General Electric Co.  
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Three experts have pooled their talents to write this first practical design article on tunnel diodes published anywhere. In Part I, these GE authors discuss characteristics of the tunnel diode, operational limitations imposed on the designer by these characteristics and their effect on circuitry stability. In order to include some special examples of practical amplifier design, the article is somewhat longer than usual. Part 2 will describe methods of measuring tunnel-diode characteristics.

WITH THE advent of the tunnel diode<sup>1, 2, 3</sup> the circuit designer has been supplied with a new tool which promises to be extremely valuable in producing entirely new circuit characteristics; or which will simplify the design of present special circuitry.

Inspection of the voltage-controlled negative-conductance characteristics shown in Fig. 1 (as distinguished from the current-controlled negative-resistance devices; such as the unijunction transistor, the controlled-rectifier, the 4-layer and avalanche switching devices, etc.) suggests applications as oscillators, mixers, autodyne converters, logic switching and storing elements, detectors and feedback elements in operational amplifiers.

As with any component, the eventual applications of the device are limited by the ingenuity of the circuits engineer, who is in turn limited by the reproducibility of the components in his circuit complex.

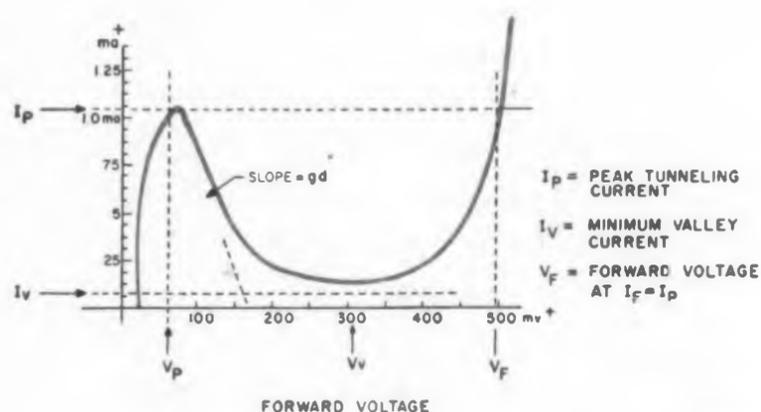


Fig. 1. Negative conductance characteristic of the tunnel diode.

## Equivalent Circuit

As has been mentioned in the literature<sup>3, 5</sup> a reasonable equivalent circuit of the device may be represented as shown in Fig. 2.

For an equivalent circuit to be useful it must be physically meaningful for a range of frequencies (even if only for a limited range), so that we will be able to mathematically predict the response of the device within this range.

In order to prove that our equivalent circuit is, in fact, an analog of the device, we shall have to measure the parameters of the device at different frequencies. However, measurements of a two-terminal active element are complicated by the obvious requirement that the device "hold still" to be measured. We must insure that the tunnel diode will not oscillate in the measuring circuit; and for this reason we shall first consider the circuit-stability requirements.

## Stability Criteria

Successful linear operation of a tunnel diode depends critically on the stability of the complete system; including, in particular, the internal impedance of the bias supply and the source impedance of the signal, if any. In the following we shall examine the condition of stability either as a sinusoidal oscillator or as an amplifier. The basic circuit can be reduced to that shown in Fig. 3, where  $R_l$  represents the load resistance;  $R_g$ , the generator resistance;  $L$ , the sum of the inherent lead inductance of the diode,  $l_s$  and the load inductance  $l_l$ ;  $C$ , the diode capacitance;  $-g$ , the diode negative conductance at the specified bias current and voltage.

Fig. 3b is the equivalent of Fig. 3a, with the following substitutions:

$$L = l_1 + l_s$$

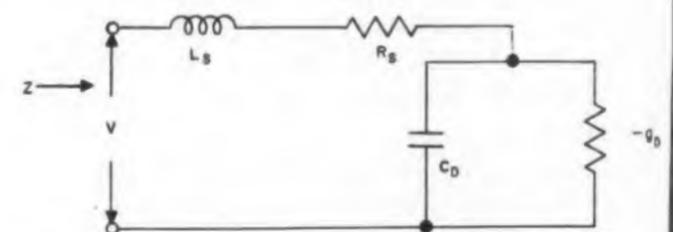
$$R_T = R_g + R_l + R_s$$

It is well known that the system stability can be determined by examining the distribution of the poles or zeros of the circuit determinant in the complex S-plane.<sup>4</sup>

Suffice it to say that if the zeros of  $Z(s)$  seen at "X" of Fig. 3b, fall in the right half side of the S-plane, the system is unstable and nonlinear operation results. Further nonlinear analysis will not be considered. If the zeros fall on the real frequency axis, the system will have a "free" sinusoidal oscillation. If the zeros are in the left half side of the S-plane the system is stable.

Now the input impedance is given as

$$Z(s) = \frac{S^2 LC + (R_T C - Lg) S + (1 - R_T g)}{SC - g}$$



- $L_s$  = LEAD INDUCTANCE
- $R_s$  = BULK RESISTANCE
- $C_D$  = DIODE BARRIER CAPACITANCE
- $g_D$  = NEGATIVE TUNNELING CONDUCTANCE

Fig. 2. Equivalent circuit of a tunnel diode.

and zeros are

$$s = -\frac{1}{2} \left( \frac{R_T}{L} - \frac{g}{C} \right) \pm \sqrt{\frac{1}{4} \left( \frac{R_T}{L} - \frac{g}{C} \right)^2 - \frac{1 - R_T g}{LC}}$$

Then S will have a negative real part only if both

$$\frac{R_T}{L} - \frac{g}{C} > 0$$

$$\text{and } 1 - R_T g > 0$$

or it may be written

$$\frac{Lg}{C} < R_T < \frac{1}{g}$$

This is the condition for stable operation, and is shown graphically in Fig. 4.

#### Free Oscillation

The condition for free oscillation requires the real part equal to zero, namely

$$\frac{R_T}{L} - \frac{g}{C} = 0 \quad (\omega = 2\pi F)$$

$$\text{and then } \omega_0 = \left( \frac{1 - R_T g}{LC} \right)^{\frac{1}{2}}$$

Evidently, one cannot change the frequency by changing one of the four variables alone and still maintain free oscillations.

#### Amplifier

For amplifier design, we are interested not only in stability, but also in the gain and the frequency bandwidth. This can best be explored by examining the Nyquist plot of the input impedance (impedance is used here for convenience; one can equally use admittance analysis if he wishes)<sup>4</sup>.

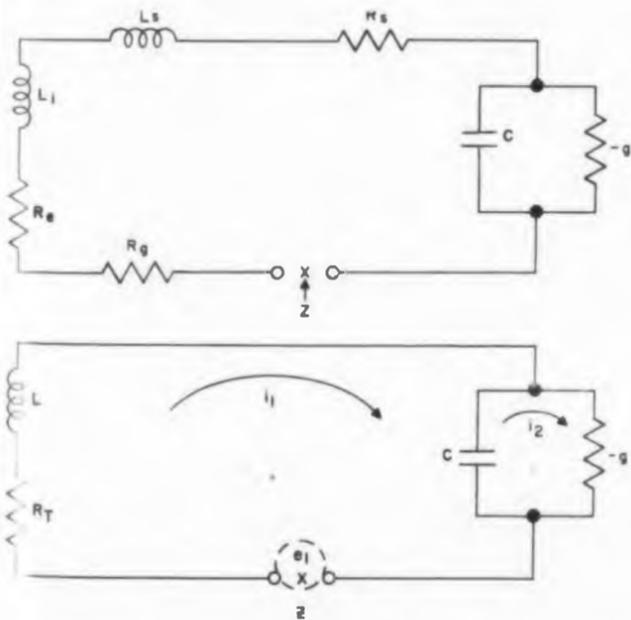


Fig. 3. Basic circuit of an oscillator or amplifier. With substitutions for L and  $R_T$ , (b) becomes equivalent of (a).

Table 1—Number of Positive Encirclements (P-N) of the Origin of the Plots in Fig. 5.

Case	P-N	P	N	Stable
1	-1	1	2	No
2A	-1	1	2	No
2B	+1	1	0	Yes
3	0	1	1	No
4	0	1	1	No

Note: P = Number of poles and N = number of zeros in the right half of the "S" plane.

The input impedance  $Z(s)$  on the real frequency axis of the contour integration in the S-plane is obtained by substituting  $jW$  for S. Thus (replacing  $\omega$  by W):

$$\begin{aligned} Z(W) &= \frac{W^2 R_T C^2 - (1 - R_T g) g}{W^2 C^2 + g^2} \\ &\quad + j \frac{W (L g^2 - C) + L C^2 W^3}{W^2 C^2 + g^2} \\ &= R_T - \frac{g}{W^2 C^2 + g^2} \\ &\quad + jW \left( L - \frac{C}{g^2 + W^2 C^2} \right) \end{aligned}$$

The Nyquist plots for the above are shown in Fig. 5.

As given by Bode,<sup>4</sup> the number of times the plot encircles the origin in the positive direction (counterclockwise) is equal to the difference of the number of poles minus the number of zeros in the right half of the S-plane. By inspection of the equation for  $Z(s)$  we see there is one pole in the right side of the S-plane, when

$$s = + \frac{g}{C}$$

and the number of zeros can be obtained as shown in Table 1.

The only stable case is 2(b), Fig. 5. Fig. 6 is an enlarged picture of 2(b).

Defining two critical frequencies:  $W_1 = W_R$  is the frequency at which the real part

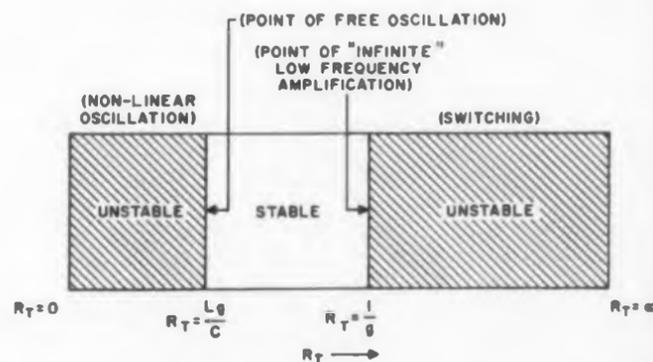
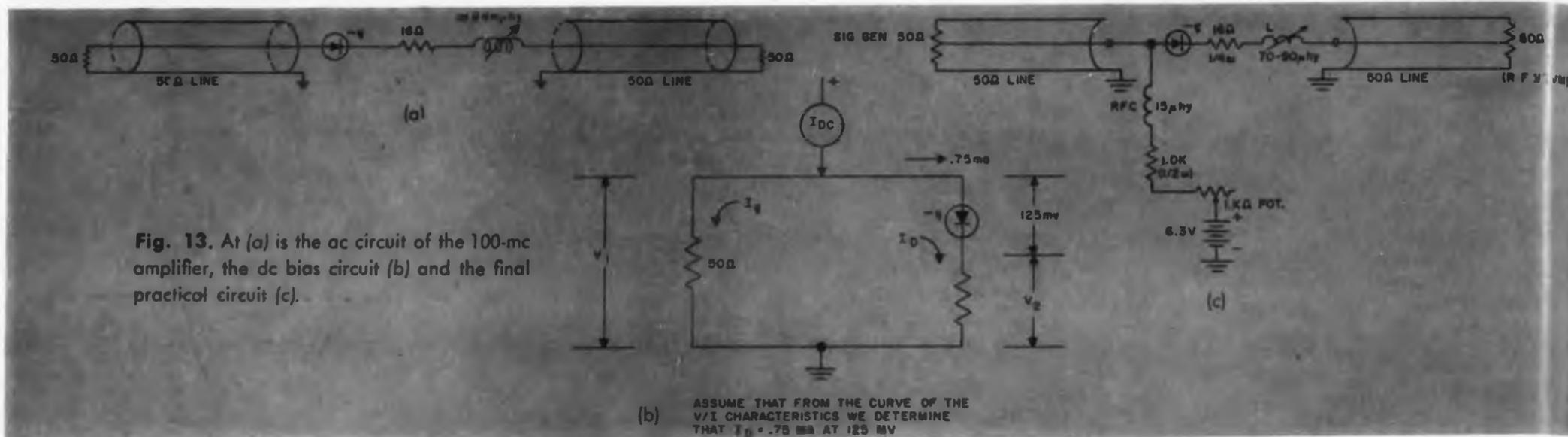


Fig. 4. Condition for stable operation shown graphically.







diode characteristics with frequency as shown in Fig. 10, offsetting the original origin by the magnitude of  $R_i + R_g$  and comparing the square of the vectors from the new origin, of  $Z_T$  and  $(R_i + R_g)$  at the desired frequency. In Fig. 11 we illustrate a process by which the design of the circuit can be changed to emphasize the gain at a particular frequency.

A set of circles corresponding to different  $(R_i + R_g)$  values are superimposed on a diode characteristic with the centers  $o(\alpha)$ ,  $o(\beta)$ ,  $o(\gamma)$  located inside the loop to insure stability. We can see that circle  $\gamma$  intercepts the diode characteristics at  $\pm W\gamma$ . Above this frequency the current amplification is positive, while below this frequency the amplification is negative. For circle  $\alpha$ , the intercepts are at  $\pm W\alpha$ . This means that current amplification is positive for all frequencies up to  $W\alpha$ .

## Amplifier Design Procedure

Let us consider the characteristics of a typical tunnel-diode with the specifications and response shown in Fig. 12.

### Example 1:

Required: 100-mc amplifier to operate between two 50-ohm transmission lines.

Let:

$$R_T - \frac{g}{g^2 + W^2 C^2} = 0,$$

Then:

$$R_T = \frac{1}{g \left( 1 + \frac{W^2 C^2}{g^2} \right)}$$

$$\text{for } \frac{C}{g} = \frac{5 \times 10^{-12}}{7 \times 10^{-3}} = 7.15 \times 10^{-10},$$

$$\left( \frac{C}{g} \right)^2 = 51 \times 10^{-20}$$

$$\frac{W^2 C^2}{g^2} = 39.4 \times 10^{16} \times 51 \times 10^{-20}$$

$$= 3.94 \times 5.1 \times 10^{-2} = 0.21$$

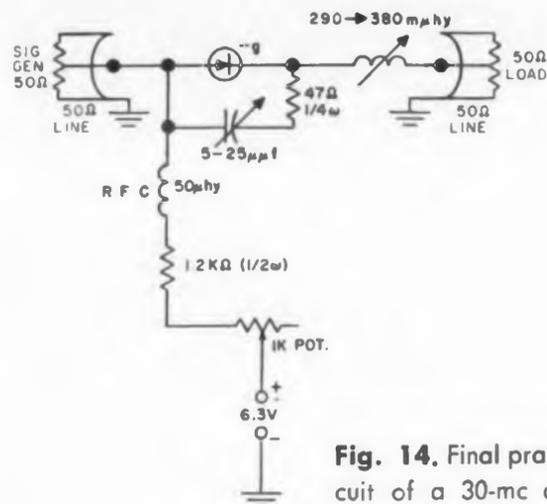


Fig. 14. Final practical circuit of a 30-mc amplifier.

$$\therefore R_T (\text{required}) = \frac{143}{1.21}$$

$$= 118\Omega, R_T - (R_i + R_g + R_s) = 16\Omega (\text{to be added})$$

$$\text{and } L = \frac{R_T C}{g} = 1.18 \times 10^2 \times 7.15 \times 10^{-10} \\ = 8.43 \times 10^{-8} = 84.3 \text{ m}\mu\text{hy}$$

Therefore: the ac circuit is as shown in Fig. 13a, and for dc bias, Fig. 13b.

$$V_2 = 7.5 \times 10^{-4} \times 66 = 49.5 \text{ mv}$$

$$\text{therefore } V_1 = 125 + 49.5 \text{ mv} \cong 175 \text{ mv}$$

$$\text{so that } I_o = \frac{175}{50} \text{ ma} = 3.5 \text{ ma}$$

$$\text{and } I_{DC} = I_o + I_D = 4.25 \text{ ma}$$

Assume we wish to use a 6.3-v battery, then

$$R_B = \frac{6.12}{4.25} \times 10^3 = 1.44 \text{ K}\Omega$$

We should decouple the dc supply from the amplifier by at least a 10 K-ohm inductor.

$$l_B \geq \frac{X_c}{W} \approx \frac{10^4}{6 \times 10^8} \approx \frac{10 \times 10^{-5}}{6} \approx 15 \mu\text{hy}$$

or: (allowing for battery changes), the final prac-

tical circuit is shown in Fig. 13c. Experimental results obtained were:

$$f_o = 100 \text{ mc}, G = 32 \text{ db}, \text{ bandwidth} \cong 20 \text{ mc}$$

When  $L$  was increased so that  $G = 40$  db, bandwidth was approximately 8 mc but very nonsymmetrical.

### Example 2:

Required: A 30-mc amplifier to operate between two 50-ohm transmission lines. Following the procedure in Example 1:

$$R_T = \frac{1}{7 \times 10^{-3} (1 + 39.5 \times 9 \times 10^{14} \times 51 \times 10^{-20})}$$

$$R_T = \frac{143}{(1 + 0.018)} \cong 140.5\Omega$$

Now this is entirely too close to  $|T/-g|$  for reasonable stable dc operation.

We can approach this problem from a different aspect and attempt to increase the parallel capacitance, thereby reducing  $g/C$ . However, Fig. 12 shows us that  $W_A$  internal  $<$   $W_R$  internal; and therefore merely paralleling the tunnel-diode with a capacitor will inevitably cause oscillation. Therefore: Consider the stability requirement of the device at very high frequency.

Assuming that the distributed inductance of socket and leads (including capacitor leads) is in the order of 30 m $\mu$ hy.

$$\text{with } l = 3 \times 10^{-8} \text{ hy,}$$

$$W_{x'} = \left( \frac{1}{3 \times 10^{-8} \times 5 \times 10^{-12}} - 2 \times 10^{+18} \right) \\ = (6.67 - 2) \times 10^9$$

$$f_x' \cong \frac{2.2 \times 10^9}{6.28} = 350 \text{ mc}$$

If we add a new  $R_T$  in series with the capacitor

such that

$$R_T' > \frac{Lg}{C_D} \left( \frac{3 \times 10^{-8} \times 7 \times 10^{-3}}{5 \times 10^{-12}} = \frac{21}{5} \times 10 \right)$$

> 42 ohms, the second loop will also be stable at 350 mc.

To be safe let us use  $R_T' = 47$  ohms. Since  $W_X \ll W_c$  internal we can neglect  $l_s$ .

$$\text{Now the required } C_{Total} = \frac{g}{W} \left( \frac{1}{gR_s} - 1 \right)^{-1}$$

$$= \frac{7 \times 10^{-3}}{1.88 \times 10^8} \sqrt{0.43}$$

$$\therefore C_T = 3.73 \times 10^{-11} \times 0.655 = 24.4 \mu\mu\text{f.}$$

$$C_{Req} = C_T - (C_D + C_{stray}) \cong 24.4 - 6.5 \cong 18 \mu\mu\text{f}$$

$$X_c \text{ at } 30 \text{ mc} = \frac{1}{1.88 \times 10^8 \times 1.8 \times 10^{-11}}$$

$$= \frac{1}{3.38 \times 10^{-3}} = 296 \Omega \cong 300 \Omega$$

$$X_c \text{ at } 350 \text{ mc} = \frac{1}{2.2 \times 10^9 \times 1.8 \times 10^{-11}}$$

$$= \frac{1}{3.96} \times 10^2 \cong 25 \Omega.$$

Since  $X_c = 6.3 R_T'$  the apparent capacitance will only be reduced by about 3 per cent or 1/2  $\mu\mu\text{f}$  at 30 mc.

From the proceeding we can now design the 30-mc amplifier:

With  $R_T = 100$  ohms,  $C = 24 \mu\mu\text{f}$ ,  $g = 0.007$  mho then

$$L_{total} = \frac{R_T C_T}{g} = \frac{10^4 \times 2.4 \times 10^{-11}}{7 \times 10^{-3}} = 0.343 \mu\text{hy.}$$

$$L_{total} = L_1 - L_{strays} \cong 300 \text{ m}\mu\text{hy.}$$

The same procedure as in Example 1 is now followed for the dc supply and decoupling rf choke and Fig. 14 shows the practical amplifier circuit. Results were:  $G = 32$  db at 30 mc for bandwidth of 10 mc.

#### Alignment

To align the amplifier, one first reduces  $L_1$  to its minimum value. A 0.1 mv signal at 30 mc is injected and the generator is "rocked" in frequency while adjusting  $C_1$  for a peak at 30 mc.  $L_1$  is then increased until the required gain is obtained. The generator should be turned off at this point to check that the amplifier is not oscillating. (Otherwise one must reduce  $L_1$  slightly, and/or increase  $C_1$  slightly). Since the amplifier becomes critical on a adjustment when more than 30 to 50 db of  $G_1$  are required, it is not recommended for higher-

gain operation.

One precaution in the use of this amplifier must be mentioned. From the characteristic curve of Fig. 1 one sees that the peak linear current excursion is approximately 0.5 ma. Therefore the peak-to-peak voltage across the 50-ohm output must be less than 25 mv for linear operation (that is,  $e_{out} \leq 8.5$  mv rms).

Since we can obtain over 30 db of gain, then the maximum input voltage to the amplifier is in the order of 0.5 mv.

It is to be noted that the solution of the quadratic equation for the  $g/C$  ratio required, results in two values; namely:

$$\left( \frac{g}{C} \right) = \frac{1}{2Ch_T} \pm \sqrt{\frac{1}{4C^2 R_T^2} - W^2}$$

$$\text{and } C_{\text{maximum}} \leq \frac{1}{2WR_T}$$

also if given a specific  $C$  (provided  $C \leq 1/2WR_T$ ) the permissible values of  $g$  are:

$$g = \frac{1}{2R_T} \pm \sqrt{\frac{1}{4R_T^2} - W^2 C^2}$$

so that for a 6-1/2  $\mu\mu\text{f}$   $C$  total,  $|1/g| = 125$  ohms or 500 ohms which implies that a 1.0-ma unit or a 0.25-ma unit of the same capacitance may be used.

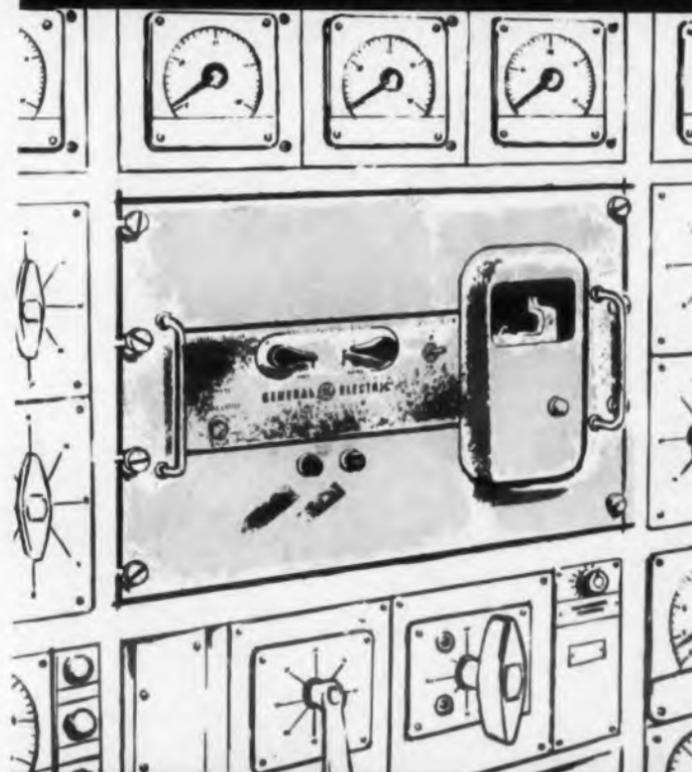
Since the amplifiers are bilateral, a possible application for those described is as a low-level "repeater" amplifier in transmission lines. ■ ■

Part 2 of this article will appear in a subsequent issue of ELECTRONIC DESIGN, and will discuss measurement of tunnel-diode characteristics.

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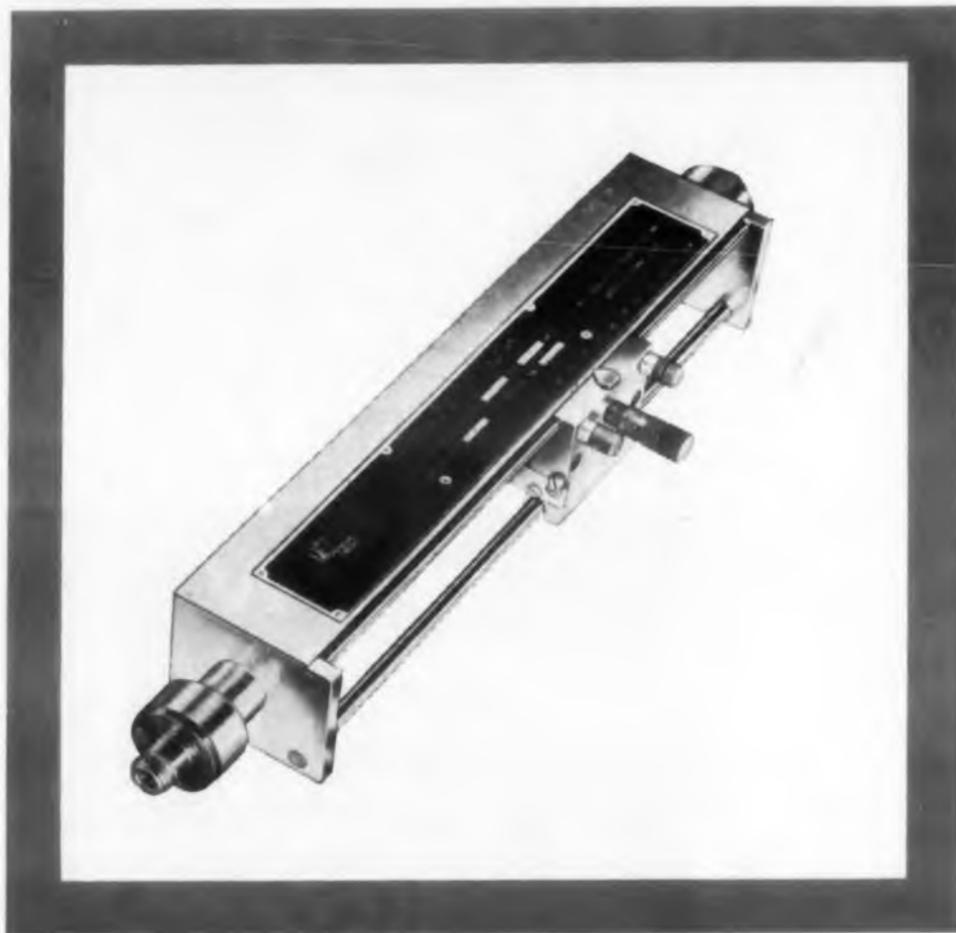
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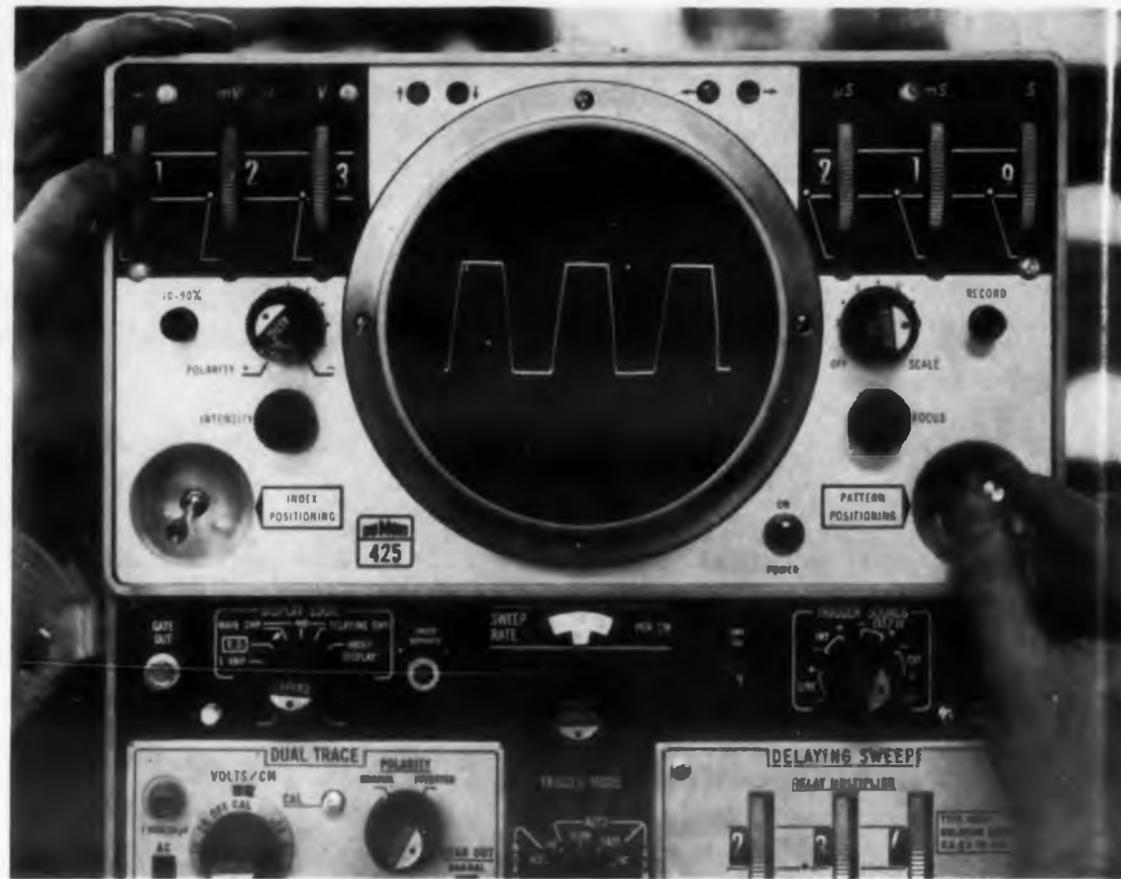


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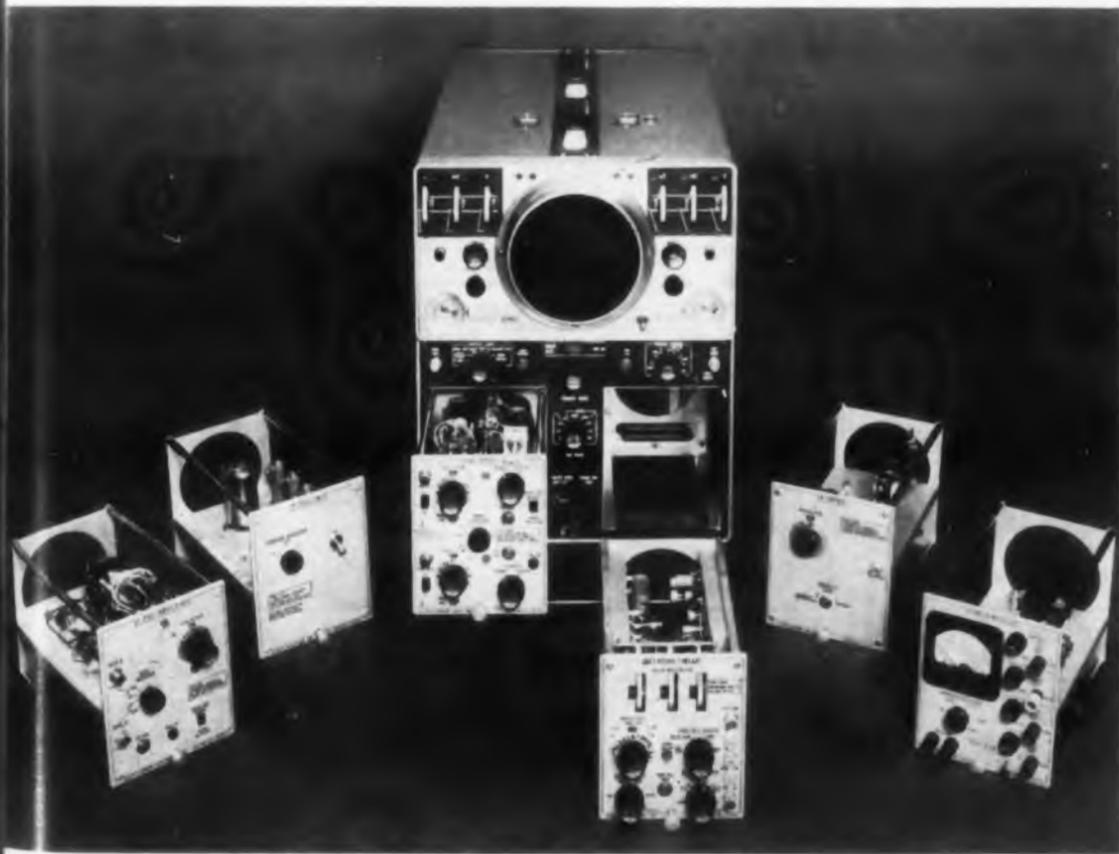
Outputs from two 40-pin connectors on top of the 425 can be used to print out each voltage and time digit, decimal point, and multiplier. Also available at these connectors are analog voltages, proportional to the three-digit voltage and time readings. These may be used to drive a pen-recorder-type XY plotter or to feed an analog computer.



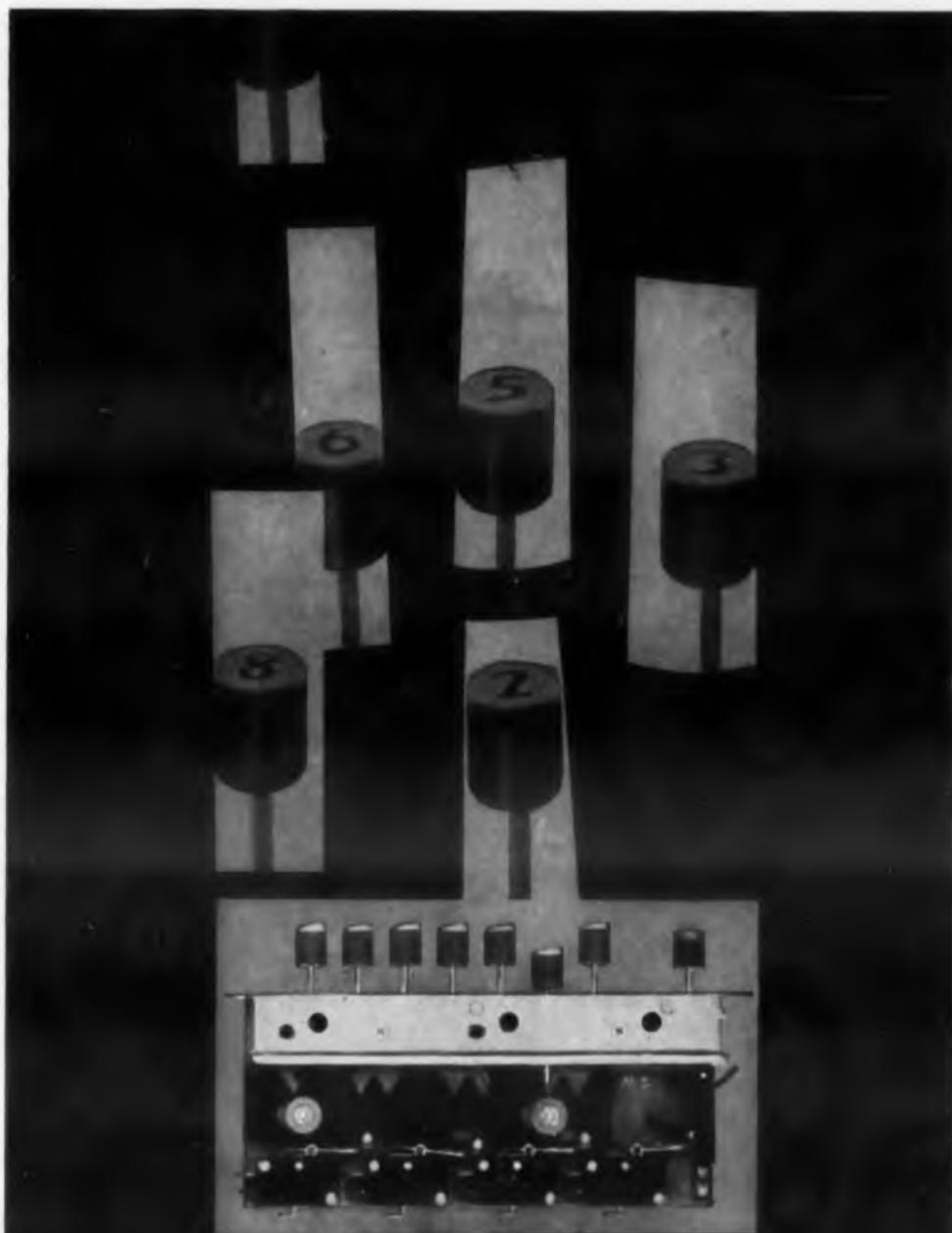
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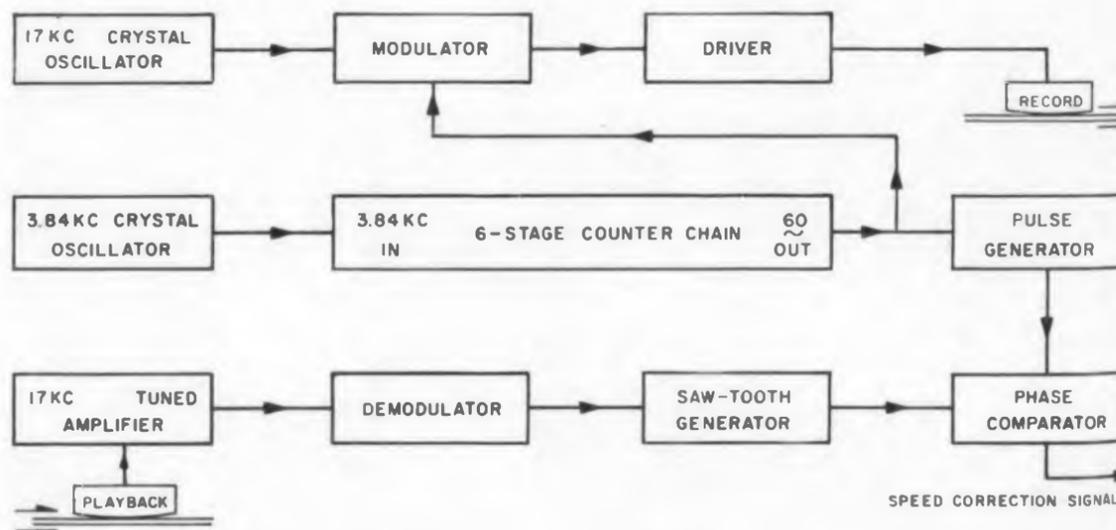
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During reproduction the carrier is demodulated, the 60 cps recovered and compared with the original reference signal. If there is a difference in frequency, a dc correction voltage is sent to the capstan-speed control. Since the capstan motor is a dc shunt one, the correction signal controls the speed through a simple amplifier.

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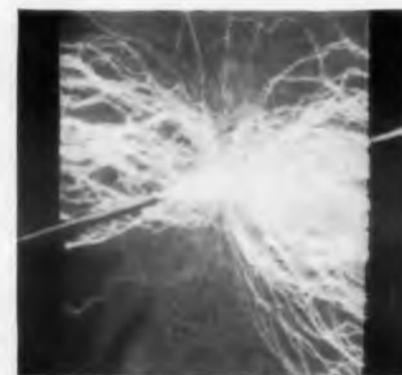
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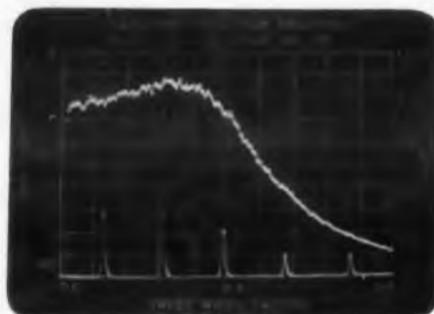
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## Miniaturized Control Regulates DC Motor's Speed To Accuracy of 0.1%

**T**HE SPEED of dc motors can now be regulated to a reported accuracy of 0.1 per cent by a new control unit that uses, in effect, pulse-width modulation. Previous methods of control, which varied either the voltage or current, achieved regulation accuracies of only 1 or 2 per cent. No change in speed is required to initiate correction by the new control unit.

Unaffected by ambient temperature changes, vibration, shock, voltage and load fluctuations, the speed-control unit operates from the same power source that drives the motor. The device was designed by and is being manufactured by Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio

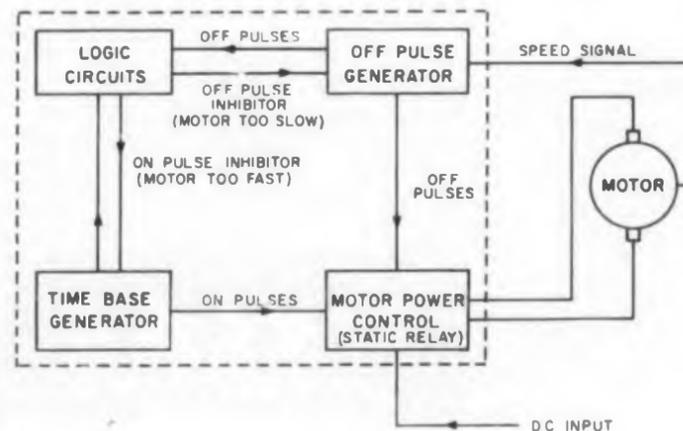
One version of the control is housed in a 2-cu-in. enclosure that includes a resistor-capacitor time base and a transistorized regulating circuit. Motor speed is sensed by an electrical transducer (such as a coil) in the motor. This pick-off transmits pulses having a frequency function exactly equal to armature speed. In a logic circuit these pulses are compared with the pulses generated by the

time-base generator, and appropriate "off" or "on" signals are applied to the motor control. These integrated pulsed command signals are delivered at a high rate, on the order of 1000 per sec.

The motor remains in exact synchronism with the time base, and the only speed error is that introduced by the time base, according to the maker. The amplitude, duration or wave shape of the command pulses caused by various conditions are said to introduce no error into this system.

Since with this off-pulse-on-pulse technique the motor's speed is, in effect, locked onto the time base, the frequency generator is the main cost and accuracy variable.

When power is applied to the motor, it develops its full starting and running torque characteristics until the precise instant that the specified speed is reached. Dc motors characteristically develop about five times more starting torque than similarly rated ac synchronous motors, and this extra torque is available for both starting and running overloads. The designer is thus offered a



Functional diagram of the dc motor speed control.

choice of improving torque for a given size of motor or of reducing the motor size while retaining the desired torque. And higher operating efficiencies are possible with the dc system, which is important in satellite and space vehicle applications.

Applications of this control unit include programming controls for missiles, satellites and space vehicles; controlling the memory drums of a computer in exact synchronism with one another and a time base; and controlling the driving motors on high-speed tape recorders, which would eliminate inaccuracies caused by ac motor slip.

The control permits synchronization of any number of dc motors from one time base. It also permits synchronizing any number of slave motors to a master dc motor without the use of a time base.

Development is under way on a compact crystal-controlled oscillator that will have accuracies measurable in parts per million. This unit is presently housed separately from the control circuit in a 5-cu-in. enclosure.

A number of the control units are being released on an experimental basis, while development of the principle continues. Each new application is engineered specifically for the job and necessitates several months of lead time. The techniques at present are not a substitute for applications adequately handled by other controls, primarily for economic reasons.

For more information on this control unit, turn to the Reader-Service card and circle number 102.



A 1.25-in. diam. permanent magnet motor fitted with a resistor-capacitor time base and motor control.



Now your present electronic counter becomes a really good, accurate **DIGITAL VOLTMETER** by simply adding this self-contained, inexpensive

## **dy** 2210 Voltage-to-Frequency **CONVERTER**

Now it is simplicity itself to read voltages in direct digital form using your present electronic counter and this new Dymec DY-2210 Converter. You can also measure the time integral of fluctuating voltages directly in volt-seconds — no more tedious, costly manual data reduction and analysis. Unique design principle of the DY-2210 makes it insensitive to most kinds of noise on the input signal.

The DY-2210 generates pulses at a rate accurately

proportional to the dc input voltage. Zero input produces zero output cycles, 1 volt produces 10,000 cps. A front-panel attenuator provides additional input ranges of 10 v, 100 v and 1000 v. Positive or negative inputs sensed automatically. Models available for ac inputs and remote programming applications. Price: \$660 cabinet, \$650 rack-mount.

For details and demonstration, see your Dymec/Hewlett-Packard representative or write direct.

RACK MODEL, PANEL HEIGHT ONLY 3½"

**DYMEC** A DIVISION OF HEWLETT-PACKARD CO.

6063A PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

DAvenport 6-1755

Dymec/field representatives in all principal areas

CIRCLE 43 ON READER-SERVICE CARD

# NEW PRODUCTS

Covering all new products that might generally be specified by an electronics engineer engaged in the design of original equipment.



## Silicon Transistors Have Gain Of 6 At 20 Mc

629

Types 2N696 and 2N697 diffused-junction, drift-field, npn mesa transistors have a minimum gain of 6 or more at 20 mc and high currents. Both units are designed for use in high-speed switching applications. The 2N697 has a dc pulse current gain that is a minimum of 40 and a maximum of 120; minimum and maximum gains for the 2N696 are 20 and 60. Total power dissipation of the units is 2 w at 25 C. They have a maximum collector-base voltage of 60 v, collector-emitter voltage of 40 v, and an emitter-base voltage of 5 v.

Hoffman Electronics Corp., Dept. ED, 3761 S. Hill St., Los Angeles 7, Calif.

**Price & Availability:** Both units cost \$28.50 each in quantities of from 1 to 99 units, \$19 each in quantities of 100 to 999 units. Availability data on request.

## Price and Availability

PRICE AND AVAILABILITY data is now being added, whenever possible, to the New Product descriptions that appear in *ELECTRONIC DESIGN*. This data will help you to:

- Evaluate the products more intelligently.
- Decide which products to buy now and which to wait for.
- Schedule your orders wisely.
- Get an insight into prices and savings for similar products.

Most manufacturers have been very cooperative in providing us with *Price and Availability* data. Since some of the data arrived after our deadlines, it was impossible to add it to all of the products. The data represents the latest information at the time of publication.



## Weight And Size Of Transistor Reduced

630

These power transistors are said to be half the size and weight of present standard components. Called Spacesavers, they are adaptable to a wide variety of mounting requirements. The units come in eight 3-amp switching types with breakdown voltages of 40, 60, 80 and 100. Direct current gain ranges from 30 to 75 and 60 to 150, and frequency responses are up to 10 and 15 kc. Leakage current at 90 C is 10 ma.

Clevite Transistor Products, Dept. ED, Waltham 54, Mass.

**Price & Availability:** Price on request. Most units are readily available.

# Creative Microwave Technology

Published by MICROWAVE AND POWER TUBE DIVISION, RAYTHEON COMPANY, WALTHAM 54, MASS., Vol. 1, No. 9

## NEW RAYTHEON MAGNETRONS FOR A WIDE RANGE OF APPLICATIONS



### Miniature Drum Counter 631 Is Reversible

Model 3523 four-digit reversible counter has 1/8-in. high numbers and drums that measure 0.46 in. The gears are molded of impact-resistant thermoplastic. Although furnished with a mounting bracket, the lugs may be clipped off and two screws used in the base for mounting. The dimensions of this package would be 1/2 in. wide and 5/8 in. long, not including the length of the drive shaft. Height is 11/16 in.

Haydon Instrument Co., Dept. ED, 165 West Liberty St., Waterbury 20, Conn.

**Price & Availability:** List price is \$4.80 with quantity discounts up to 50%. Availability data on request.

### Tunnel Diode Samples 632 Made Available

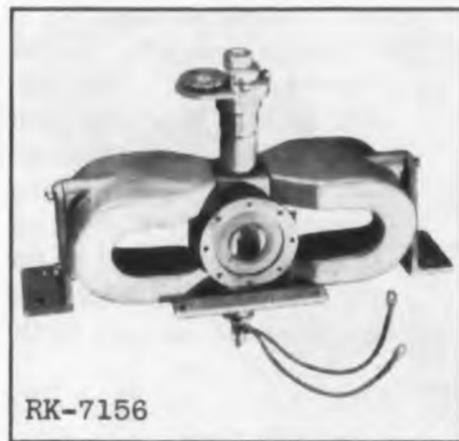
These tunnel diodes have peak-to-valley ratios ranging from 3 to 1 to 10 to 1. Peak currents range from 2 to 4 ma, average. They are packaged in JETEC 30 envelopes. Typical negative resistance is 35 ohms. At peak current, typical voltage is 50 mv; typical voltage at valley current is 200 mv. The maximum power dissipation is 20 mw. Three or four types will be made available.

General Transistor Corp., Dept. ED, Jamaica, L.I., N.Y.

**Price & Availability:** Only engineering samples are available. Price on request.

Designed for C-band systems requiring tunability, the RK-7156 magnetron has a minimum peak power output rating of 250 kilowatts over a frequency range of 5,450 to 5,825 megacycles. Applications include a flight-tested, revolutionary airborne weather radar system. The RK-7156 is in quantity production.

CIRCLE 832  
Reader Service Card



RK-7156

\* \* \*

X-band magnetron for airborne search radar provides one megawatt minimum peak power and 875 watts average



QK-624

power within a frequency range of 9,340 to 9,440 Mc. Designated QK-624, this pulsed-type tube is liquid cooled and should give at least 1,000 hours of reliable service.

CIRCLE 833  
Reader Service Card

\* \* \*

For ground-based and airborne radar systems, the RK-7529 magnetron provides a 2.0 microsecond pulse of 3.5 megawatts minimum peak power over 2,700 to 2,850 Mc. This liquid-cooled tube is interchangeable with other fixed-frequency S-band tubes operating at similar power levels.

CIRCLE 834  
Reader Service Card



RK-7529

\* \* \*

A one kilowatt beacon magnetron, the RK-7578 weighs only 14 ozs., yet will withstand vibrations of 15 G's at 20 to 2,000 cycles and shock up to 100 G's. It is



RK-7578

mechanically tunable and covers the 5,400 to 5,900 Mc range.

CIRCLE 835  
Reader Service Card

\* \* \*

Developed to withstand extreme environmental conditions, the RK-7449 magnetron is a lightweight, compact tube with a minimum peak power output of 45 kilowatts at the operating frequency of 24 kmc. The RK-7449 is required to withstand re-



RK-7449

peated shocks of 50G. Stable operation is guaranteed at vibration frequencies up to 2,000 c.p.s. with 30G applied.

CIRCLE 836  
Reader Service Card

A Leader in Creative Microwave Technology



# NEW



## MINIATURE TRANSFORMERS

FOR

## Transistor

AND PRINTED  
CIRCUIT  
APPLICATIONS

Custom transformers for printed circuits are now available from ADC in five standard case sizes with terminals and inserts on 0.1" grid multiples. Audio, power, and ultrasonic transformers and inductors with maximum electrical performance for each size are being custom designed for transistor and vacuum tube circuitry. Raised mountings prevent moisture from being trapped. Available in Mumetal cases. They meet MIL-T-27-A Grade 5 Class R or S Life X, and can be designed to meet 500 and 2,000 cps vibration.

### TYPICAL RATINGS

Fig.	Description	Primary	Secondary	Maximum Level	Response (CPS)
1	Output	P P collectors 100 ohms CT	600/150 ohms	+33 dbm (2w)	±2db 250-10,000 cps
2	Output	5000 ohms 5ma DC	50/250/600 ohms	+10 dbm (10mw)	±1db 100-10,000 cps
3	Output	P P collectors 1000 ohms CT	4/8/16 ohms	+25 dbm (300mw)	±1db 250-10,000 cps
3	Interstage	Collector, 5000 ohms 1ma DC	P P bases 3000 ohms CT	+5 dbm	±1db 250-5,000 cps
4	Input	50/250/600 ohms	50,000 ohms	+2 dbm	±1db 250-10,000 cps
5	Output	P P collectors 500 ohms CT	4/8/16 ohms	+20 dbm (100mw)	±1db 250-10,000 cps
5	Interstage	Collector 7500 ohms 1ma DC	P P bases 5000 ohms CT	0 dbm	±1db 250-10,000 cps

Fig.	Description	Rating
3	Audio	200 hys 1v 1000 cps 0 DC
5	Power	500 mhys 1v 400 cps 10ma DC

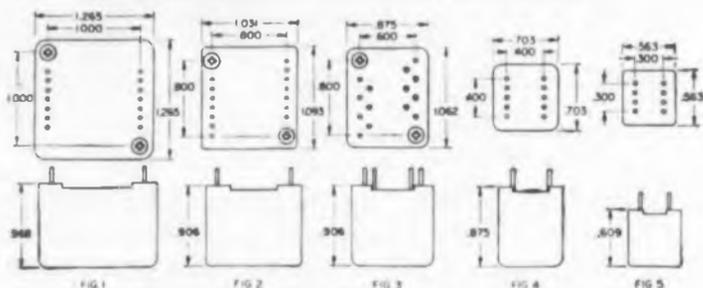
  

Fig.	Description	Rating
3	Low pass	600 ohms input 600 ohms output +10dbm f cutoff 50kc Attenuation 18db per octave
3	High pass	10,000 ohms input 10,000 ohms output +10dbm f cutoff 2kc Attenuation 18 db per octave

Fig.	Description	Primary	Secondary	VA	Regulation
4	Filament	115v 380-420 cps	6.3v .6a	4.0	10%
5	Dual filament	26v 380-420 cps	(1) 6v 5ma (2) 6v 5ma	.2	2%

Note: Other combinations are available with 400 cps max. volt ampere ratings up to 15 for Fig. 1, 10 for Fig. 2, 6 for Fig. 3, 4 for Fig. 4, and 1 for Fig. 5



WRITE TODAY FOR COMPLETE INFORMATION

# ADC

**AUDIO DEVELOPMENT COMPANY**  
2835-13th Avenue South • Minneapolis 7, Minnesota  
TRANSFORMERS • REACTORS • FILTERS • JACKS & PLUGS • JACK PANELS

CIRCLE 45 ON READER-SERVICE CARD

## NEW PRODUCTS

### Precious Metal Paints 603

For electronic components

The Degussa line of precious metal paints and pastes, using silver, gold, and platinum, is for use in the manufacture of condensers, coils, capacitors, oscillators, and other electronic parts. They can also be used in high frequency applications. The coatings are solderable and can be electroplated.

Materials for Electronics, Inc., Dept. ED, 152-25 138th Ave., Jamaica 34, N.Y.

### Transducer 619

Operates analog-to-digital encoders

This Dyna-Servo transducer converts various measurements into a shaft position for operating analog-to-digital encoders, transmitting slidewires, alarm switches, and other devices. A pointer positioned by the shaft indicates the measured variable on a 3.75-in. dial. Readout is any function of the measured variable, as determined by the type of cam used in the rebalancing system. Standard accuracy of the unit is ±0.25% of span.

The Bristol Co., Dept. ED, Waterbury 20, Conn.

Price & Availability: Information stated on request.

### Ultrasonic Degreaser 616

Measures 44 x 18 x 36 in.

Model AC-25 ultrasonic degreaser is self-contained in a stainless-steel cabinet and measures 44 x 18 x 36 in. Using only water and a 110-v, 60-cps connection, the unit removes metal chips, grease, and certain insoluble soils from intricate parts. Components such as small motors, electronic subassemblies, and bearings can be cleaned without dismantling.

Branson Ultrasonic Corp., Dept. ED, 40 Brown House Road, Stamford, Conn.

Price & Availability: Delivery within 30 to 45 days after receipt of order. Price is \$1980 per unit.

### Transistors 604

Silicon-alloy types

Types 2N327A, 2N328A, and 2N329A transistors are general-purpose silicon-alloy units. Series 2N1034 to 2N1037 and 2N1219 to 2N1223 are also silicon units. High-voltage transistors, type 2N1275 and several 60 and 100-v devices, have been added to the line. All transistors are baked at 200 C for 200 hr for thermal stability.

Sperry Rand Corp., Sperry Semiconductor Div., Dept. ED, South Norwalk, Conn.

### Capacitors 615

Flat and round paper-dielectric type

Designated MF for flats, and MR for rounds, these paper-dielectric capacitors come in values from 0.00005 to 10 μf. The flats include units from 3/8 x 1/16 x 1/8 in. to larger sizes. Dimensions for the rounds include units from 3/8 in. in length and 1/8 in. in diam. Operating temperatures range from -55 to +100 C, without derating. Working voltages are from 75 to 1000 v.

Capcon, Inc., Dept. ED, 61 Stanton St., New York 2, N.Y.

Price & Availability: Sample and small quantities available from stock; larger quantities made to order and delivered within 2 to 3 weeks. Prices vary from \$34 to \$125 when ordered in quantities of 1000.

### Motor Generator 612

For remote control servo systems

Engineered to operate as a damping tachometer, a rate generator, or an integrator, this 60-cps motor generator, type V842-001, has applications in servo systems used for remote control. Generator excitation current measured at stall is 0.025 amp. No-load speed is 2800 rpm, and stall torque is 3.4 oz-in.

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

Price & Availability: Delivery and price data furnished on request.

## Transistor Chopper Kit

Plug-in type

591



This transistor chopper kit contains models 50P, 60P, and 70P plug-in choppers. These choppers can be inserted into a standard 7-pin miniature socket or can be soldered into a printed circuit board. They are made to alternately connect and disconnect a load to a signal source; they can also be used as demodulators to convert an ac signal to dc. Models 50P and 60P are germanium units for operation from  $-55$  to  $+90$  C; model 70P uses silicon transistors for high temperature applications to 150 C. Able to stand shock and vibration, the unit is suitable for military use.

Solid State Electronics Co., Dept. ED, 15321 Rayen Street, Sepulveda, Calif.

**Price & Availability:** As an introductory offer, the price is \$199; regular price is \$232. Units are available from stock and can be delivered three days after receipt of order.

## Multiplier-Divider

586

For use with an analog computer



Model MU-500E 350-kc multiplier-divider is for use with a compressed-time-scale analog computer. Solution time is less than 2  $\mu$ sec and phase shift is 1 deg at 12 kc. Time lag, phase shift, and amplitude attenuation are zero for nearly all control and process simulation. Accuracy is 0.25% full scale and the output range is  $\pm 50$  v at  $\pm 10$  ma.

GPS Instrument Co., Inc., Dept. ED, 180 Needham St., Newton 64, Mass.

**Price & Availability:** Information will be furnished on request.

# Solid State Reliability IN A 10 mc Counter



The CMC 700 Series is the only major breakthrough in counting, timing and frequency measuring equipment in the past 10 years. Here is the first successful application of transistors to high frequency counting and timing. Transistors perform all the functions in CMC's 700 series that required 63 tubes in old style counting equipment. These are the most reliable counters ever made.

### TRUE DIGITAL LOGIC CIRCUITRY

By answering an obvious need for a completely new, up-to-date approach to counting and timing instrumentation, CMC has produced solid state instruments with greatly simplified circuitry, using logic "and" and "or" gates.

### LIGHT AND SMALL, LOWER POWER DRAIN

Each 700 series instrument weighs only 27 pounds, measures 7 inches high, 17 inches wide, and 14 inches deep. Power consumption is a meager 46 watts, 1/10 the amount for vacuum tube models.

### DO ALL THESE JOBS

Measure frequency from dc to 10 mc, time interval from 0.1  $\mu$ sec, ratio 1 cps to 1 mc and unlimited multiple period selection. Frequency converters available for higher frequencies. The counter also generates time interval marker pulses from 1  $\mu$ sec to 1 second. Data can be presented on standard decades or inline Nixie tubes. The 700 series will operate digital recording equipment, punches, inline read-outs, and other data handling gear.

**These Features, Too**—Decade count-down time base—frequency divider circuits never need adjustment. Accuracy,  $\pm 1$  count  $\pm$  oscillator stability. Sensitivity, 0.25 v rms; input impedance, 25 k ohms/volt.

**And The Price**—Higher than vacuum tube models. But you can save the difference on down time in the first year. Model 727A Universal Counter-Timer, \$3,500; Model 707A Frequency-Period Meter, \$2,700; Model 757A Time Interval Meter, \$2,500. Rack mount optional at no extra cost. All prices f.o.b. Sylmar, California.

*More Information Available*—Your nearby CMC engineering representative will be happy to arrange a demonstration and provide you with complete technical information. Or you may write Department 19.



**Computer  
Measurements Co.**

A Division of Pacific Industries  
12970 Bradley Avenue, Sylmar, California  
Phone: EMpire 7-2161

CIRCLE 46 ON READER-SERVICE CARD

interfering  
**electromagnetic**  
**energy** •  
 within the frequency range of  
**30 cps to 10.7 kmc**

...can be investigated, analyzed, monitored and measured  
 to the highest practical degree of accuracy with Stoddart  
**Radio Interference & Field Intensity Measuring Systems.**

Stoddart RFI Measuring Equipment is approved for use by all departments of the Department of Defense. Military and commercial equipments are identical... were designed and manufactured to Military Equipment Specifications to meet the requirements of Military Measurement Specifications. Equipments are portable, dripproof, dustproof, and ruggedized for all-weather field use... precise and dependable for sensitive-selective laboratory measurements.

Applications include interference measurement and location, frequency conservation and allocation studies, spectrum signatures, antenna propagation studies, field intensity surveys, RF energy surveillance and monitoring, and verification of the electronic compatibility of modern weapons systems, i.e., missile firing and guidance, computer, telemetering and communications; the measurement of all rotating electrical devices, transmitting and receiving equipment, or any system or equipment capable of producing unwanted radiated or conducted electrical disturbances.

Stoddart instruments are available as individual self-contained units covering specific frequency ranges, or in rack-mounted console systems for laboratory, mobile, airborne and marine use.



M-40A (AN/URM-41)  
30 cps to 15 kc



NM-10A (AN/URM-6B)  
14 kc to 250 kc



NM-20B (AN/PRM-1A)  
150 kc to 25 mc



NM-30A (AN/URM-47)  
20 mc to 400 mc



NM-52A  
(AN/URM-17)  
375 mc to 1000 mc



NM-60A  
(AN/URM-42)  
1 Kmc to 10.7 Kmc

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will give you individual consideration and information in the areas of interference problems or measurement with which you are particularly concerned... provide engineering bulletins, military specification information, descriptions of new measurement techniques and applications... class or individual instruction in the operation, calibration, and maintenance of Stoddart instruments. For prompt service please call "Sales Engineering", HOLLYWOOD 4-9292.

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serving 33 countries in radio interference control

NEW PRODUCTS

Remote Tuned Signal Source 592

Frequency range is 50 to 2000 mc



Made to provide a source of remotely tunable rf power for antenna pattern ranges, model SS 305 signal source covers the frequency range of 50 to 2000 mc, calibrated to an accuracy of  $\pm 2\%$ . It is designed for remote tuning, control, and band switching at distances of more than a mile. The minimum rf output is 80 mw across an impedance of 50 ohms; the output can be sine or square-wave modulated. The instrument weighs 105 lb and can be mounted on standard 19-in. rack panels.

Scientific-Atlanta, Inc., Dept. ED, 2162 Piedmont Rd., N.E., Atlanta 9, Ga.

**Price & Availability:** Price is \$3850. The unit will be available from stock by February 15. Delivery time is 30 days.

Servo Control Valve 623

For go/no-go check-out systems

This servo control valve is a component for go/no-go check out systems. Designed for field use, the unit is readily adaptable to applications requiring constant control of pressure at predetermined check points. The servo valve, used with a transducer for the necessary pressure ranges, plus an amplifier can be used for check-out of pressure sensitive devices on missile or airframes automatically.

Ideal-Aerosmith, Inc., Dept. ED, 3913 Evans Ave., Cheyenne, Wyo.

Low-Pass Filter 628

Handles up to 2 kw

Model FS-23L, 13-element, low-pass filter has a 1-db down frequency of 2300 mc and a power handling capacity of up to 2 kw peak. The maximum insertion loss is 0.5 db in the pass-band; the input vswr is 1.5:1 below 0.1 db. The design is compact.

Frequency Standards, Div. of Harvard Industries, Inc., Dept. ED, P.O. Box 190, Red Bank, N.J.

BOURNS

592

TRIMPOT®

Schweber

FOR IMMEDIATE LARGE QUANTITY DELIVERY AT FACTORY PRICES

2000

Yes! Schweber can sell up to 2000 pieces of any model of BOURNS TRIMPOT® at factory prices.

Sizeable quantities are available for immediate shipment from stock from Schweber's warehouse.

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PHONE 6-6520 TWX G-CY-NY-580

CIRCLE 52 ON READER-SERVICE CARD  
CIRCLE 53 ON READER-SERVICE CARD

## TRIMPOT® MODEL 220

As many as 17 of these compact units can be mounted in a space of just one cubic inch. Designed for printed circuits and modular assemblies, Trimpot Model 220 measures less than 3/16" x 5/16" x 1". Power rating is 1 watt and maximum operating temperature is 175°C. This Potentiometer meets or exceeds Mil-Specs for humidity, salt spray, fungus, sand and dust, as well as acceleration, vibration and shock. Self-locking 15-turn shaft insures sharp, stable settings...exclusive Silverweld® fused-bond termination and ceramic mandrel provide extreme temperature stability. The Model 220 is available in a wide variety of resistance ranges and a choice of two terminal types—gold-plated Copperweld wire or insulated stranded leads.

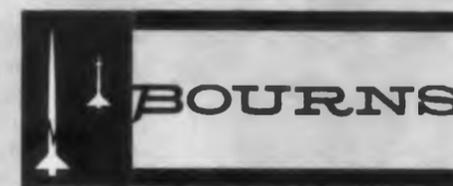
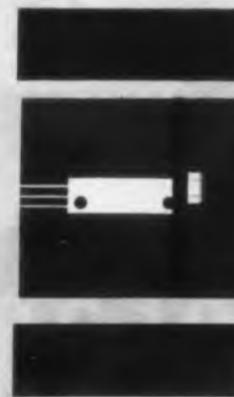
Stocked by leading electronic distributors across the nation, these units are ready for immediate delivery. Write for complete technical data and list of stocking distributors. AVAILABLE AS PANEL MOUNT UNIT (illustrated at right) with same specifications.

Exclusive manufacturers of Trimpot®, Trimit®, Pioneers in potentiometer transducers for position, pressure and acceleration.



ACTUAL SIZE

Subminiature ...  
Proven Reliability



Bourns, Inc., Trimpot Division  
6135 Magnolia Ave., Riverside, Calif.  
Plants: Riverside, California  
and Ames, Iowa

# INSTRUMENT SWITCH QUALITY



## SPECIAL

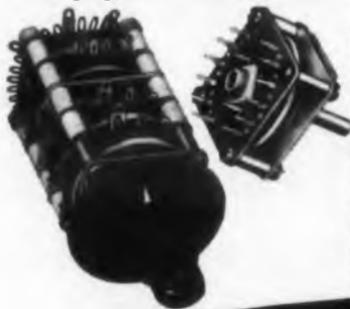
### MINIATURE SWITCHES

**PRINTED CIRCUIT:** 0.031" dia. terminals on last deck mount in printed circuit boards up to  $\frac{1}{16}$ " thick. Up to 6 decks may be ganged.

**DUAL SHAFTS:** Up to 8 decks may be ganged.  $\frac{1}{16}$ " dia. inner shaft may control up to 4 decks or other devices—rheostats, pots, condensers, etc.

**SPRING RETURN.** 1- or 2-way actions. Up to 8 positions each side of rest position. Up to 4 decks, shorting or non-shorting.

**CLUSTER ARM:** Up to 32 fingers. May be ganged with standard decks.



## New Versatility...

## Compactness...Low Cost...

Here is the traditional reliability of instrument-type switches . . . with a great variety of electrical and mechanical features . . . in a compact design that measures only  $1\frac{3}{4}$ " square by 1" for the first deck,  $9/16$ " for each additional deck.

Readily tailored for almost any application, Shallcross **MINIATURE SWITCHES** handle not only r-f, plate and filament currents, but also 60- and 400-cycle power and metering circuits, maintaining a contact resistance of only 0.002 ohms for a minimum of 10,000 operations.

The basic design has silver alloy, multi-leaf wiper arms and button contacts with 1 to 32 positions per pole, 1 to 4 poles per deck, 1 to 19 decks, shorting or non-shorting action. Nylon bushings, alkyd rotors and glass-epoxy stators provide superior strength, wear, insulation, temperature and moisture characteristics.

Shallcross' unique semi-automatic assembly using stock parts insures quick delivery of the exact switches for your requirements. Complete details on this important new switch series will gladly be sent on request by **SHALLCROSS MANUFACTURING CO.**, Selma, North Carolina.

# Shallcross

CIRCLE 49 ON READER-SERVICE CARD

## NEW PRODUCTS

### Ceramic Components 620

#### Three types available

Among the ceramic components available are: ceramic-to-metal seals for use in connectors, headers and other electronic components; piezoelectric transducers for converting mechanical energy to electrical energy, or vice versa, in a wide variety of applications; and small parts that serve as insulators for high-temperature applications, in tubes or flame watcher, or as rigid mountings and spacers.

Minneapolis-Honeywell Ceramics Laboratory, Dept. ED, 1885 Douglas Drive, Minneapolis 22, Minn.  
**Price & Availability:** Made on order only. Sample lots delivered in 30 days after order received. Price varies depending upon individual specifications.

### Electronic Commutator 609

#### 500 times faster than mechanical switches

This miniaturized switching device consists entirely of electronic circuits and is capable of operating more than 500 times faster than mechanical switches. For space exploration, the static commutator will consecutively open and close 60 different channels between sensing devices in a missile and the missile's radio transmitter.

Electronic Systems Development Corp., Dept. ED, 2200 Pacific Highway, San Diego 12, Calif.

### Rotary Switch 614

#### For low-power selector use

Type 212 rotary switch has a body diameter of 1-1/8 in. and is designed for low-power selector applications. Terminals are firmly molded into the housing and cannot turn or twist out of place. Laminated coin silver contacts provide reliable contact life for a minimum of 100,000 cycles through 12 posi-

tions without appreciable increase in contact resistance.

Troxel Corp., Dept. ED, McHenry, Ill.

**Price & Availability:** Delivery is about 3 to 4 weeks from receipt of order. Price based upon quantity and design requirements.

### Magnetic Shields 618

#### Are slotted, overlapping cylinders

These cylindrical enclosures provide low-level shielding for magnetically sensitive devices in electronic circuits. Slots in the cylinder walls permit simple assembly and facilitate bringing out leads. Maximum shielding from a minimum number of layers is obtained by the overlapping of the cylinder walls and butting joint covers. The Netic Co-Netic alloys are insensitive to shock and vibration and need no periodic annealing to maintain effectiveness.

Perfection Mica Co., Magnetic Shield Div., Dept. ED, 1322 N. Elston Ave., Chicago 22, Ill.

**Price & Availability:** Many items available from stock. Others delivered 5 to 7 weeks after receipt of order. Price varies from \$9 to \$50 per unit. Discounts given for large quantity orders.

### Vertical Gyro 613

#### Has 360-deg freedom about outer gimbal axis

This B2115 vertical gyro is a 2-deg of freedom instrument with 360 deg of freedom about the outer gimbal axis and  $\pm 85$  deg freedom about the inner axis. Normal erection rate is between 2 and 4 deg per min. The Scorsby drift rate in 5 min is 0.3 deg per min avg. Designed for missile environments, the gyro can withstand 5 g at 20 to 1000 cps, and 10 g at 1000 to 2000 cps.

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

**Price & Availability:** Delivery and price data furnished on request.

## Disc Thermistor 617

Has matched resistance within  $\pm 5\%$

Previously made only to order, type 34D4 disc thermistor is now available as a stock item. Its resistance is matched to a nominal resistance versus temperature curve within  $\pm 5\%$ . Resistance ranges from 13,096 ohms  $\pm 5\%$  at 0 C to 270 ohms  $\pm 5\%$  at 100 C. The unit is suitable for applications in temperature compensation or temperature measurement.

Victory Engineering Corp., Dept. ED, 519 Springfield Road, Union, N.J.

**Price & Availability:** Delivery is 4 weeks after order received. Price is \$4.20 per unit.

## Receiving Tubes 611

5 types for TV available

Five receiving tubes for TV use include: type 10DR7, a T6-1/2 double triode; type 10EG7, a T9 double triode; types 6GN8 and 8GN8, each of which incorporates a high- $\mu$  triode and a sharp cutoff pentode in a T6-1/2 envelope; and type 12BZ6, a T5-1/2 semi-remote cut-off pentode.

Sylvania Electronic Tube Div. of Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

## Silicon Transistor 621

For industrial control applications

Suitable for industrial controls, type CK942 pnp fusion alloy silicon transistor offers 1- $\mu$ a collector cutoff current, 250-mw power dissipation, and close parameter control over the temperature range of  $-65$  to  $+160$  C. Intended primarily for use in high-temperature audio, switching and dc-amplifier circuits, the unit features a low saturation voltage and good current gain at collector current levels at 50 ma.

Faytheon Co., Semiconductor Div., Dept. ED, 215 First Ave., Needham Heights, Mass.

CIRCLE 818 TO 826 ON READER-SERVICE CARD

*New*

**Low Cost Miniature Trimmer Pot, Series 110.**  
3/4" dia. preset wirewound 1/2-5,000 ohms resistance range variable resistor. Exceptional reliability due to several unique design features.

*New*

**Compact Vernier Variable Resistor, Type VA-45.**  
12-1/2 to 1 reduction. For fine tuning applications. Ball bearing rotation.

*New*

**Higher Reliability Micro-Miniature Composition Control, Series M250.**  
9/32" dia. For miniature transistor hearing aids, miniature radios, telephone equipment and industrial applications requiring tiny size and exceptional reliability.

*New*

**Compact Motor Driven Control, Type MD 45.**  
For remote control functions.

*New*

*CTS Specialists are willing to help solve your variable resistor and switch problems. Contact your nearest CTS office today.*



Circle 818

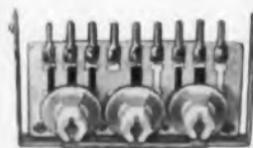
**Space Age Hi Temp Military Control, Series 600.**  
1/2" dia. variable resistor with infinite resolution and better stability and higher reliability than presently available in carbonaceous type units. Uses new CTS-developed hi temp metal-ceramic resistance element.

Burton Browne advertisement



Circle 819

*New*



Circle 820

**67% Smaller Side-By-Side Printed Circuit Ceramic Base Control, Type X153.**

Compact space-saving self-supporting snap-in 2 or 3-section variable and fixed resistor network 1/3 the size of previous units designed for printed circuit applications.



Circle 821

*New*



Circle 822

**Separately Mounted Simple Design Pull-Push and Push-Push Switches, Types SK-1 and SJ.**

13/16" dia. In separately mounted styles for home appliances and other electrical and electronic applications.



Circle 823

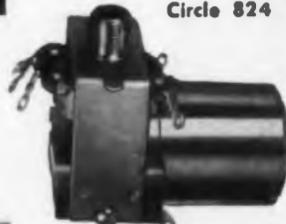
*New*



Circle 824

**Highly Uniform Rugged Rotary Switches, TROLEX Series.**

Exceptionally high uniform reliability is achieved by an entirely new manufacturing concept. For military and commercial applications.



Circle 825

*New*



Circle 826

**Miniature Compact 5/8" Control, Series 200. (Illustrated with switch).**

For limited space applications. Available with standard bushing mounting (illustrated) or economical ear mounting. Special thin ear-mounted model available for portable pocket transistorized radios.

Factories in Elkhart & Berne, Indiana; South Pasadena, California; Asheville, No. Carolina; McHenry, Illinois and Streetsville, Ontario. Sales Offices and Representatives conveniently located throughout the world.

Founded 1896

CHICAGO TELEPHONE SUPPLY  
Corporation

ELKHART • INDIANA

## HERE'S WHY CENTRICORES ARE PROBABLY THE MOST CONSISTENTLY UNIFORM CORES YOU CAN BUY:

The exceptional uniformity you get in tape-wound Centricores is not easy to come by. It's the result of painstaking precision at every stage of the manufacturing process—and, in fact, *before* manufacturing. Three principal factors help produce Centricore uniformity:

**Careful classification of materials**—Raw alloys are first "pedigreed"—meticulously selected, then tested for some 14 parameters, and classified by magnetic properties. We're the largest buyer of nickel alloy magnetic materials in the world... which permits us to choose material for Centricores from an unusually wide distribution of magnetic properties.

**Special winding machines**—We build our own machines, to die-making tolerances, for winding magnetic alloy tape into cores. We also build our own machines for applying insulating coating to the tape. These machines give us far greater uniformity in dimensions, insulation and ultimate performance of Centricores.

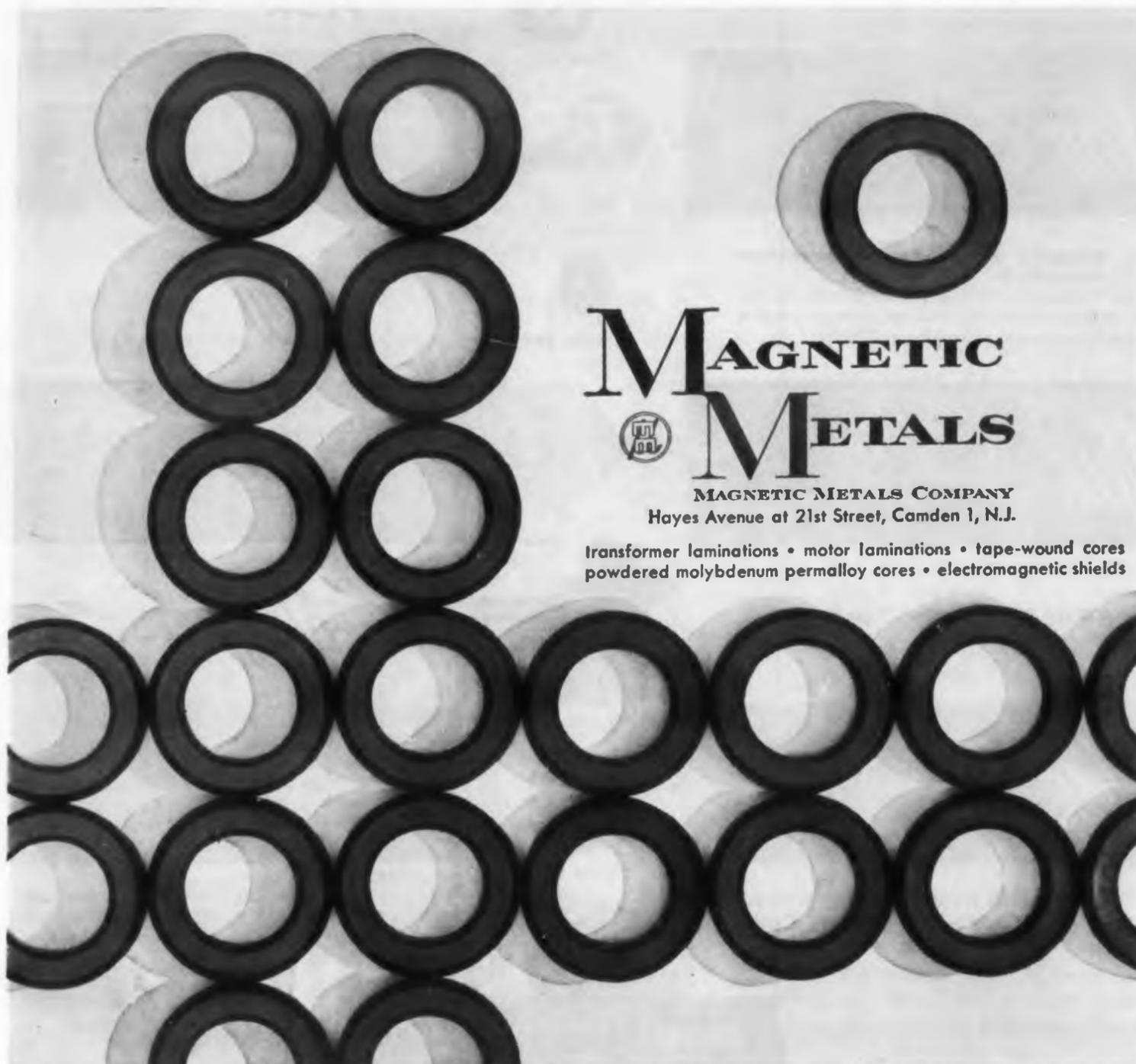
**Closely-controlled annealing**—Annealing—perhaps the most critical phase of the core-making process—is done under precisely regulated atmospheric and temperature stabilized conditions to hold Centricore magnetic performance to uniformly high levels.

Exceptional uniformity from core to core and lot to lot is further assured with Super Squaremu "79", a new high-performance alloy we've developed. It has outstanding magnetic qualities and is remarkably uniform in squareness, thermal stability and gain. Super Squaremu "79" offers an effective solution to problems of variation in magnetic performance.

WRITE FOR BULLETIN C-3

SIZE	MATERIAL	THICKNESS
1	HIGH NICKEL Hymu 80 Squaremu 79 Super Squaremu 79	.001*
THRU	LOW NICKEL Squaremu 49 Carpenter 49	THRU
225	GRAIN-ORIENTED SILICON Crystaligned Microsil	.004*

\*Special sizes, shapes and thicknesses quoted on request.



**MAGNETIC METALS**

MAGNETIC METALS COMPANY  
Hayes Avenue at 21st Street, Camden 1, N.J.

transformer laminations • motor laminations • tape-wound cores  
powdered molybdenum permalloy cores • electromagnetic shields

CIRCLE 47 ON READER-SERVICE CARD

## NEW PRODUCTS

### Transistor Tester

593

Covers a beta range of 0 to 200



Model 902 transistor tester covers a beta range of 0 to 200;  $I_{CBO}$  is from 0 to 50  $\mu$ a, and  $I_{CEO}$  is from 0 to 5 ma. Battery operated, the instrument performs tests at a constant collector voltage of 6 v. Designed to meet laboratory as well as production requirements, it is completely self-contained and incorporates a 50- $\mu$ a meter for direct reading of current. All functions are controlled by two switches.

Transistor Specialties, Inc., Dept. ED, Terminal Drive, Plainview, L.I., N.Y.

**Price & Availability:** Price is \$49.75. Delivery is in 15 days.

### Silver-Zinc Battery

589

For telemetering use in missiles



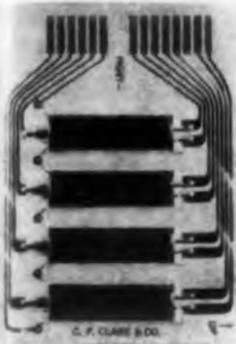
Suitable for telemetering use in missiles, model 6173 silver-zinc battery has 19 15-amp-hr cells for high voltage and 5 10-amp-hr cells for filament power. When discharged at the 7-min rate, the sections yield 90 and 60 amp, respectively. At 30 min, the sections offer 30 and 20 amp respectively. Normal discharge voltages are 28.5 and 7.5 v. Operating temperature range is 0 to 100 F, shelf life is 2 yr, and the battery can be recharged 20 times. It weighs 23 lb and measures 5.5 x 7.5 x 8 in.

Yardney Electric Corp., Dept. ED, 40-50 Leonard St., New York, N.Y.

**Price & Availability:** Price is furnished on request; delivery is within 30 days.

## Mercury-Wetted Relays

595



For printed circuits

The design of this assembly permits single or multiple installation of mercury-wetted contact relays in a printed circuit board. It plugs into a console in the same manner as the logic circuit it serves. Individual switch capsules and coils are affixed to the printed circuit board and sealed by the application of a vinyl coating.

C. P. Clare & Co., Dept. ED, 3101 Pratt Blvd., Chicago 45, Ill.

*Price & Availability: Units are made on order; price will be quoted on request.*

## Fan

625

Delivers 550 cfm

Model 1PB95W propeller fan delivers 550 cfm at a low db rating. It is powered by a continuous duty 115 v, 60 cps, single-phase, shaded pole motor. The motor has a stainless-steel shaft, is corrosive resistant and fungus protected, and is finned to give adequate cooling surface under operation at 50 cps. The propeller is a deep pitch blade protected by a heavy nickel-chrome guard. All hardware is stainless-steel or cadmium-plated. The fan can be used in electronic racks, mobile or stationary generators, military vans, and field vehicles.

McLean Engineering Laboratories, Dept. ED, Princeton, N.J.

*Price & Availability: Units are immediately available from stock at the price of \$33.50 ea in quantities of 1 to 49. There are lower prices for larger quantities.*

## Pot Cores

626

For pulse transformers

Type 332P pot cores, for pulse transformers and similar applications, meet most assembly and mounting requirements. Having a 3/8-in. diameter, they are available in several varieties. One type accepts a No. 1 screw.

Ferroxcube Corp. of America, Dept. ED, Saugerties, N.Y.

*Price & Availability: The product is immediately available from stock. Price is \$0.40 ea for up to 50 pieces.*

Distributed constant delay lines • Lumped-constant delay lines • Variable delay networks • Continuously variable delay lines • Pushbutton decade delay lines • Shift registers •

# ESC EXTRA

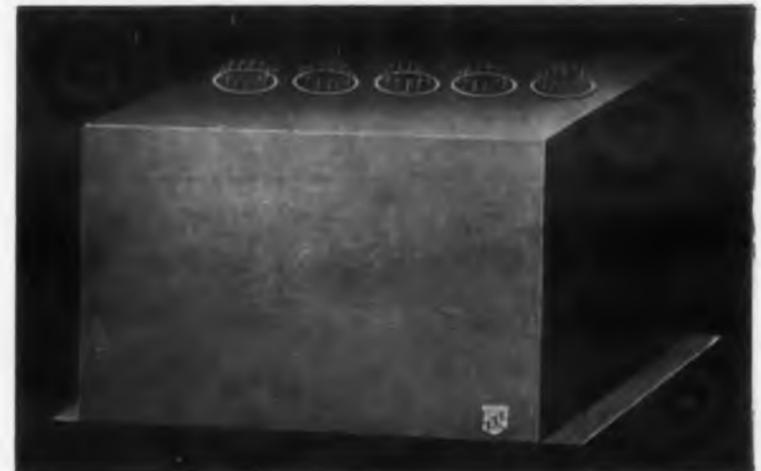
Pulse transformers • Medium and low-power transformers • Filters of all types • Pulse-forming networks • Miniature plug-in encapsulated circuit assemblies

# ESC DEVELOPS DELAY LINE WITH 170 to 1 DELAY TIME/ RISE TIME RATIO

**Model 61-34 Perfected  
For Specialized  
Communications Application**

PALISADES PARK, N. J.—An entirely new Lumped-Constant Delay Line, with a proven 170 to 1 delay time/rise time ratio, has been announced by the ESC Corporation, Palisades Park, N. J. The new delay line, known as Model 61-34, was specifically designed for a specialized communications application calling for the exceptionally high delay time/rise time ratio.

ESC, the world's leading manufacturer of custom built and stock delay lines, is already widely recognized in the electronics industry for its exceptional engineering advances. In October, 1958, ESC broke through an existing design barrier and produced a delay line with a 145 to 1 delay time/rise time ratio. It had been thought, prior to the announcement of the Model 61-34, that ESC had reached the ultimate in this type of delay line.



## SPECIFICATIONS OF NEW DELAY LINE MODEL 61-34

Delay time/rise time ratio: 170/1

Delay: 200 usec.

Rise time: 1.16 usec.

Attenuation: less than 2 db

Frequency response: 3 db = 325 KC

50 taps with an accuracy of  $\pm 0.2$  usec. at each tap.

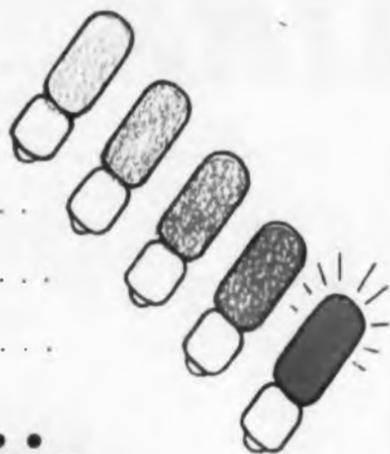
Complete technical data on the new unit can be obtained by writing to

**ESC Corporation, 534 Bergen Boulevard, Palisades Park, New Jersey.**

CIRCLE 48 ON READER-SERVICE CARD

NOW  
NEW  
MODELS

NOT TWICE . . .  
NOT 3 TIMES . . .  
NOT 4 TIMES . . .



BUT...

**5** TIMES  
BRIGHTER

The originator of bright lamps in the glow lamp field, Signalite has now re-created three of its lamps, NE45, NE47 and NE48, developing them into three new models of astounding brilliance for use in high ambient light applications. Designated LNE45, LNE47, LNE48, these new lamps are 5 times brighter than the lamps from which they are patterned (still in the Signalite line).

New 5-Times-Brighter Lamps	Series Resistance (Ohms)	Watts (Nom.)	Circuit Volts A.C.*	Useful Life Hours (Av. A.C.)
 LNE45	12,000 IN	1/2	105-125	5,000
 LNE47	12,000 EX	1/2	105-125	5,000
 LNE48	12,000 EX	1/2	105-125	5,000

\*Max. breakdown voltage 100 V. A.C.

A complete line of circuit components for the APPLIANCE,  
ELECTRICAL AND ELECTRONIC INDUSTRIES.  
FOR ENGINEERING SAMPLES WRITE  
ON COMPANY LETTERHEAD

**Signalite** INCORPORATED  
PRospect 5-2490

37-41 Neptune Highway, NEPTUNE, N. J.

CIRCLE 215 ON READER-SERVICE CARD

## NEW PRODUCTS

### Pressure Transducer

601

Diaphragm is flush-mounted



Available in pressure ranges from 0-100 to 5000 psi, gage and absolute, type 4-327 transducer has the pressure-sensitive diaphragm flush-mounted. Provision is made for adjustment of bridge balance, temperature compensation, and sensitivity external to the unbonded strain gage sensing element. It may be used in missile test stands, aircraft and missile engine test cells, and nuclear reactors.

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

*Price & Availability:* Available from stock. Price quoted on request.

### Miniature Telescoping Universal Joint

624

Backlash is zero

The design of this miniature telescoping universal joint, called Mini-Joint, assures no backlash for the entire assembly. Its applications are in magnetron and klystron drives, servo drives, and wherever precise transmission of information is necessary. Standard assemblies have 0.25 in. lateral travel. Torque ratings of 16, 64, and 256 oz-in. are available.

Falcon Machine & Tool Co., Dept. ED, 209 Concord Turnpike, Cambridge, Mass.

### Microwave Diode

627

Crystal noise figure is 13 db max

Type 1N2792 millimeter wave diode gives low noise mixer performance at 70,000 mc. The crystal noise figure is a maximum of 13 db. Primarily developed for radar and space communications applications, it is also suitable for video detector uses.

Philco Corp., Dept. ED, 4700 Wissahickon, Philadelphia, Pa.

*Price & Availability:* Price is \$250 ea for orders of 1 to 99 and \$166.66 ea for orders of 100 and over. There is currently a delivery time of 35 to 40 days. Units will be available from stock after March 1, 1960.



Low Noise

VHF and UHF

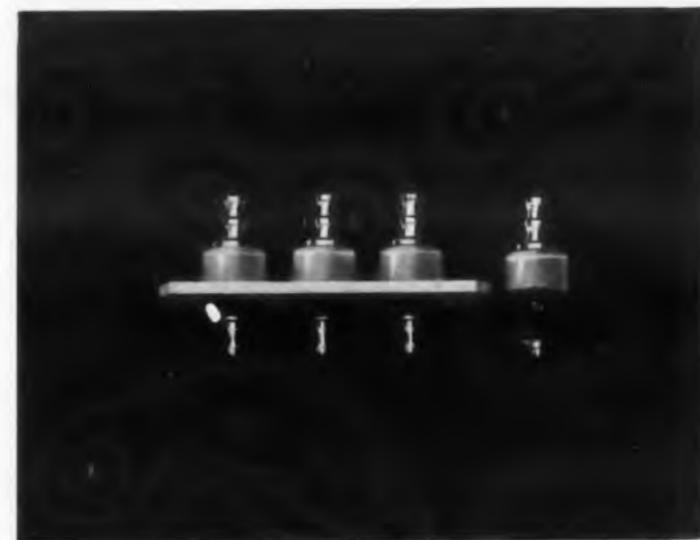
Amplifiers and Preamplifiers  
SERIES 1000

For application as receiver preamplifiers or wide band i. f. amplifiers . . . in scatter communications systems, laboratory, or nuclear research. Eight standard models cover VHF and UHF to 900 mc. High gain, low noise. Special pass bands available.

Advanced techniques permit modification of standard units at minimum cost.

Write for complete details:

**COMMUNITY ENGINEERING CORPORATION**  
P. O. BOX 824 STATE COLLEGE, PA.  
CIRCLE 213 ON READER-SERVICE CARD



**New single-unit, non-turning, hermetic terminal cuts installation costs in HALF!**

- Voltage range — 1500V operating
- Meets MIL-T-27A specifications
- Uniquely constructed — torque resistant
- Single-unit assembly — has no loose parts
- Easy to install — saves at least 50% in installation costs
- No loose parts mean simpler inventory control

Send for Bulletin #599

**LUNDEY ASSOCIATES, INC.**  
RELIABILITY IN COMPONENTS  
694 Main Street, Waltham 54, Massachusetts  
CIRCLE 214 ON READER-SERVICE CARD  
ELECTRONIC DESIGN • February 3, 1960

## Silicon Solar Cells

427

Come in single units and shingle arrays



These silicon solar cells are available in a rectangular configuration, measuring 1 x 2 x 0.05 cm, both in single units and shingle arrays. Series N2009 provides a typical efficiency of 9% and a spectral emissivity of 0.7 at 4 microns wavelength illumination, 0.4 at 11 microns. They are capable of 22.5 mw output at 56.5 and 0.4 v per cell when operated under sunlight levels as found in near space. Series N2000 includes units of several other efficiency levels.

Texas Instruments Inc., Dept. ED, Box 312, Dallas, Tex.

## Relay

426

Measures 2-7/32 x 1-3/32 in.

Engineered to operate on as little as 2 ma, the type 8 telephone relay is 2-7/32 in. long and 1-3/32 in. wide. The long coil construction of the relay permits the use of high resistance coils. It may be used in communication and military applications, as well as in a variety of data processing machines.

Phillips Control Corp., Dept. ED, 59-T W. Washington, Joliet, Ill.

## Mechanical Integrator

431

Output torque is 1 oz-in. max



Model 031-2000 mechanical integrator has an output torque of 1 oz-in. max with a disc input torque (no load) of 0.33 oz-in. The unit weighs 6.5 oz and has a ball displacement of  $\pm 0.750$  in. It may be used as a breadboard item, or as a component in computing systems.

M. Ten Bosch Inc., Dept. ED, Pleasantville, N.Y.

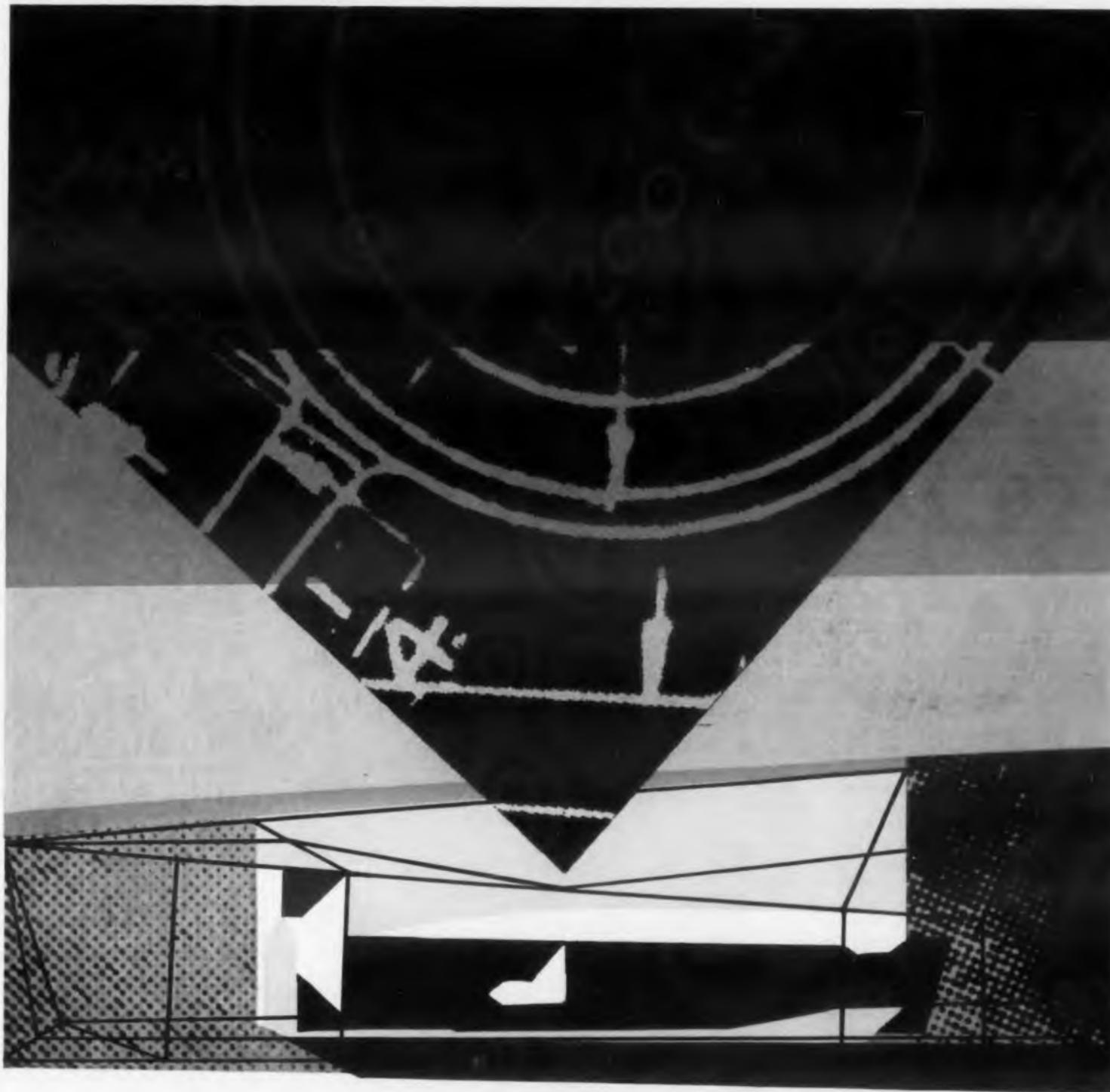
*Price & Availability: Available about 6 weeks after order received. Price on request.*

CIRCLE 55 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 3, 1960

General Motors pledges

## AC QUESTMANSHIP



**AC Seeks and Solves the Significant**—Since GM has pledged its resources to this nation's defense, AC plans to forge to the forefront in the international race for technological superiority. The resolution of scientific problems even more complex than ACHIEVER inertial guidance—that's what AC now has on its agenda / This is AC QUESTMANSHIP. It's an exciting creative quest for new ideas, methods, components and systems . . . to promote AC's many projects in guidance, navigation, control and detection / Questmanship is readily apparent in AC Manufacturing, headed by Mr. Roy McCullough, AC Works Manager. His group "offers an outstanding challenge to engineers capable of understanding the most advanced scientific concepts . . . and developing the techniques and tools to implement those concepts on a production basis" / There may be a position for you on our specially selected staff . . . if you have a B.S., M.S. or Ph.D. in the electronics, scientific, electrical or mechanical fields, plus related experience. If you are a "seeker and solver," you should write AC's Director of Scientific and Professional Employment, Mr. Robert Allen, Oak Creek Plant, Box 746, South Milwaukee, Wisconsin.

**GUIDANCE / NAVIGATION / CONTROL / DETECTION / AC SPARK PLUG**  CIRCLE 900 ON CAREER INQUIRY FORM, PAGE 145

The Electronics Division of General Motors

## A UNIQUE FABRICATION PROCESS FOR THE HOFFMAN MESA TRANSISTOR

BY NORMAN GOLDEN  
Vice-President,  
Research and Development  
Hoffman Electronics Corporation  
Semiconductor Division

The Hoffman mesa transistor is a high-frequency, diffused-junction silicon semiconductor device, usable at temperatures well above the boiling point of water. The manufacturing method of this device is unique in that it uses exclusively photographic techniques for the precise registration of the contacts and mesa area.

Low-resistivity, n-type (negative electrons) silicon slices are carefully lapped and polished to a mirror finish, flat and parallel to four millionths of an inch. Then an extremely complex cleaning procedure is performed, involving the use of high-turbulence ultrasonic agitation with relatively low average power, but peaks of 500 watts. This removes all trace of contamination, yet does not mar the transistor finish. A total of 13 cleaning solutions is used in conjunction with the agitation to attain the required degree of micro-cleanliness and meet the specified Hoffman standard.

An oxide film only two millionths of an inch thick is grown on both surfaces by heating the silicon in wet oxygen at 2200° Fahrenheit. Then gallium is diffused through the oxide layer so that the material is converted from n-type to p-type (positive electrons) conductivity within 130 millionths of an inch.

A photo-sensitive coating is deposited on the silicon slice, and an image of the 260 emitters is photographically printed on the wafer. By means of acid treatment, the oxide film is removed from the strips where the emitters are to be, the photographic emulsion serving as a protection for the remainder of the slice.

A phosphorus diffusion follows, converting the un-oxidized portions of the silicon to n-type conductivity with an approximate depth of 100 millionths of an inch.

At this stage of the Hoffman process, we have made 260 tiny transistors on each slice. However, some of the most difficult problems still remain to be solved.

### PHOTOGRAPHIC REGISTRATION

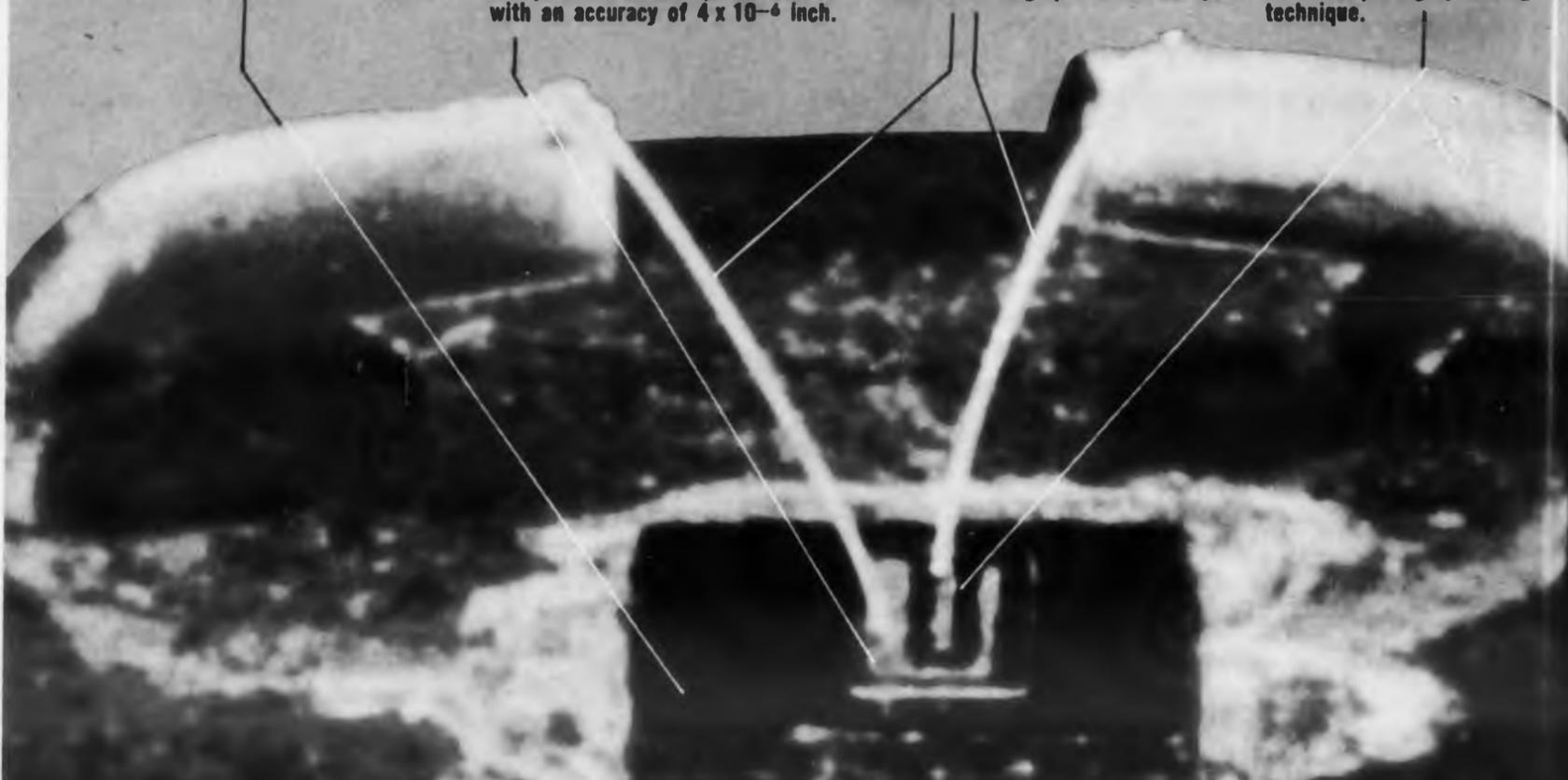
For example, aluminum emitter strips must be registered into each of the 260 diffused phosphorous regions. Here each of the emitter contacts on the evaporation mask is registered with a .001" tolerance to the emitter region. In addition, none of the base contacts may short into any of the emitter regions. Here again, the tolerance is a maximum of .001". The registration itself is done under demanding optical conditions since the process is photographic. The aluminum is evaporated through photographically developed holes. Illumination must be restricted in wavelength, short in duration, and low in intensity. However, the highest accuracy of registration is still required, despite the fact that the emitter diffused regions show up as having only slightly different reflectivity than the base silicon. The registration is done on an optical comparator under conditions of essentially monochromatic illumination. A special fix-

Collector is in electrical contact with case.

Base width is reduced to only one micron by precisely controlled lapping and diffusion techniques to boost frequency handling capability. Silicon slices for these transistors are polished under optical control with an accuracy of  $4 \times 10^{-6}$  inch.

Gold wire bonds to emitter and base are fabricated to withstand 20,000G acceleration. Because parts are so small (wires are only 1/10 the diameter of a human hair), bonding is done under a high-power microscope.

Registration of emitter with U-shaped base makes optimum use of emitter area, results in high efficiency. This configuration is made possible by the precision of Hoffman photographic registration technique.



NOW... HOFFMAN RELIABILITY  
IN TRANSISTORS

## ANNOUNCING THE HOFFMAN 2N696 AND 2N697 NPN DIFFUSED-JUNCTION DRIFT-FIELD SILICON MESA TRANSISTORS WITH THREE TIMES THE HIGH-FREQUENCY POWER GAIN OF SIMILAR DEVICES

By increasing the usefulness of the emitter area, Hoffman engineers have boosted the minimum high-frequency gain at large currents to 6 at 20 mc ( $I_c = 50\text{ma}$ ,  $V_c = 10\text{V}$ )—more than three times the industry standard. Hoffman's unique base-emitter configuration, coupled with a photographic fabrication technique that offers control accuracy of the order of light wavelengths, has also lifted current and frequency characteristics well above industry specifications. Reasonable current gains at 40mc have been measured. Since the photo process is far more controllable than mechanical fabrication, these transistors have exceptionally uniform characteristics. Stability, too, is outstanding, because Hoffman pre-ages every transistor at 300°C and seals it hermetically in an inert-gas atmosphere.

A wide range of useful current gain and operating frequencies makes these units ideal for computer, radar and many other applications. You can count on them in your most important circuit. Reliability is built into every unit.

### ABSOLUTE MAXIMUM RATINGS (25°C)

$V_{cbo}$ Collector-to-base voltage	60V
Total dissipation at case temperature 25°C	2W
Storage temperature range	-65°C to +175°C

### ELECTRICAL CHARACTERISTICS (25°C)

SYMBOL	CHARACTERISTIC	MIN.	MAX.	TEST CONDITIONS
$h_{FE}$	D. C. pulse current gain (2N696)	20	60	$I_c = 150\text{ma}$ $V_c = 10\text{V}$
	(2N697)	40	120	$I_c = 150\text{ma}$ $V_c = 10\text{V}$
$V_{BE}(\text{sat})$	Base saturation voltage		1.3V	$I_c = 150\text{ma}$ $I_B = 15\text{ma}$
$V_{CE}(\text{sat})$	Collector saturation voltage		1.5V	$I_c = 150\text{ma}$ $I_B = 15\text{ma}$
$h_{FE}$	Small signal current gain at $f = 20\text{mc}$	6	9	$I_c = 50\text{ma}$ $V_c = 10\text{V}$
$C_{ob}$	Collector capacitance		35uuf	$I_c = 0\text{ma}$ $V_c = 10\text{V}$
$I_{cbo}$	Collector cutoff current	1.0ua		$V_c = 30\text{V}$ $T = 25^\circ\text{C}$
		100ua		$V_c = 30\text{V}$ $T = 150^\circ\text{C}$

Physical dimensions in accordance with JEDEC 30 (TO 5). Manufactured to meet MIL S 19500B requirements.

mitter with optimum results in high precision of registration

ture is provided so that the operator may precisely register the slice to the mask and then lock the slice into position. This operation takes two to three minutes. The fixture is designed so that the locking procedure itself does not cause any motion of the slice with respect to the mask.

After the photographic image is imprinted on the emulsion, it is developed. Care must be taken at this stage so that no shrinkage of the emulsion occurs. The aluminum is now evaporated through the emulsion holes and thoroughly bonded to the silicon by means of a high-temperature process. When the slice is cooled, a single silicon crystal re-forms, with about one part per million aluminum held in solid solution. For the p-type base connection, this serves to make a sound, non-rectifying contact. In the case of the emitter region, there is much more phosphorus than aluminum in the silicon. Therefore, the recrystallized material remains strongly n-type after the alloying process despite the presence of the aluminum.

The mesa structures are now precisely registered to the base and emitter, and photographically printed onto each slice. This photographic emulsion protects the rectangular-shaped silicon mesa region from an acid solution attack, so that only one to two ten thousandths of an inch of silicon is removed around the entire periphery of the slice except in the vicinity of the emitter and base. Thus, a raised mesa structure has been produced.

#### FINAL ASSEMBLY

A scribing machine, designed by Hoffman, with essentially zero backlash, accurately positions the slices, and a series of scratches is made by a diamond point. The scratches divide the slices into small (.050" x .050") squares which have the actual transistor structures on them.

The individual units must now be alloyed onto the gold-plated bases which have the necessary seals for bringing the emitter, base and collector wires through glass insulators into the package. The reliable operation of these devices requires that the glass and the metal base form a perfect seal.

Fastening of wires onto the extremely tiny emitter and base aluminum strips is now performed. Because of the minuteness of the units, this operation is conducted under a special microscope. In order to locate initially the approximate positions of the bonding chisel, transistor structure and gold wire, it is necessary to work at low magnification. However, the bonding operation itself requires high magnification. To avoid the necessity of refocusing, a stereoscopic zoom microscope is used. The base and transistor are heated to approximately 750°F and a tiny, chisel-pointed tool squeezes a fine (.0007") pure gold wire into the aluminum. This process produces an exceptionally strong bond. In fact, tests have suggested that the bond will stand acceleration in excess of 20,000 g.

Once the gold wires are fastened to the terminal posts on the base, a short acid treatment and a thorough wash are required as a final cleaning operation.

Hoffman then "pre-ages" the transistors by baking them in a high vacuum at about 300°C. The units are never again exposed to room air. They are next transferred into a chamber filled with extremely pure nitrogen. Caps are welded onto the bases, so that the units are completely sealed against contamination.

#### WHAT IS THE RECORD BEHIND HOFFMAN TRANSISTORS?

##### 1 ■ MORE EXPERIENCE IN SILICON TECHNOLOGY.

For seven years—practically the full span of semiconductor history—Hoffman Semiconductor Division has worked exclusively with silicon devices. Company achievements include the world's first commercial silicon diodes, zener diodes and solar cells. Hoffman makes the most extensive line of silicon devices in the industry.

##### 2 ■ MORE EXPERIENCE IN DIFFUSED-JUNCTION DEVICES.

The diffused-junction concept, one of the most important in transistor technology, was adapted by Hoffman as early as 1955. To date, the com-

pany has produced over five million diffused-junction devices—more than any other company in the electronics industry.

##### 3 ■ NEW CONCEPT IN QUALITY CONTROL.

Hoffman has developed a completely new quality assurance and quality control concept which will enable the company to ship devices that meet the most stringent mili-

tary and commercial requirements.

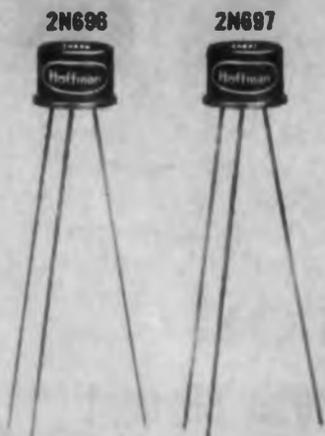
##### 4 ■ RELIABILITY BACKED BY NUMBERS.

Hoffman has made and shipped more than ten million silicon semiconductor devices.

##### 5 ■ A FACILITY DESIGNED ESPECIALLY FOR TRANSISTORS.

Hoffman's new 109,000-square-foot facility was designed especially for the development, production and testing of transistors. It houses ex-

tremely advanced equipment, much of it Hoffman-developed.



For further information and complete technical specifications, contact the factory or your area Hoffman sales engineer.



**Hoffman** / **ELECTRONICS CORPORATION**  
*Semiconductor Division*

1001 Arden Drive, El Monte, California

Plants: El Monte, California and Evanston, Illinois

ABSOLUTE MAXIMUM RATINGS AT 25°C

Forward Current	$I_f$	50 mA
Minimum Breakover Voltage	$V_{bo}$	TSW-30 30V TSW-60 60V
Reverse Breakdown Voltage	$V_r$	TSW-30 30V TSW-60 60V
Storage Temperature		-65°C to 150°C
Ambient Temperature Range		-55°C to +125°C

SPECIFICATIONS AND TYPICAL CHARACTERISTICS  
(At 25°C Unless Otherwise Stated)

		Typical	Max.	Test Conditions
Saturation Voltage	$V_s$	1.0	1.5	Volts $I_c = 50$ mA
Forward Leakage Current	$I_f$	0.1	10	$\mu$ A $V_c = 30$ V
Reverse Leakage Current	$I_R$	0.1	10	$\mu$ A $V_c = -30$ V
Forward Leakage Current	$I_f$	20.	50.	$\mu$ A at 125°C
Reverse Leakage Current	$I_R$	20.	50.	$\mu$ A at 125°C
Gate Voltage to Switch "ON"	$V_{g\text{ On}}$	0.7	1.0	Volts $R_L = 1$ K
Gate Current to Switch "ON"	$I_{g\text{ On}}$	0.1	1.0	mA $R_L = 1$ K
Gate Voltage to Switch "OFF"	$V_{g\text{ Off}}$	1.2	4.0	Volts $I_c = 50$ mA
Gate Current to Switch "OFF"	$I_{g\text{ Off}}$	7.0	10.	mA $I_c = 50$ mA
Holding Current	$I_B$	2.0	5.0	mA $R_L = 1$ K

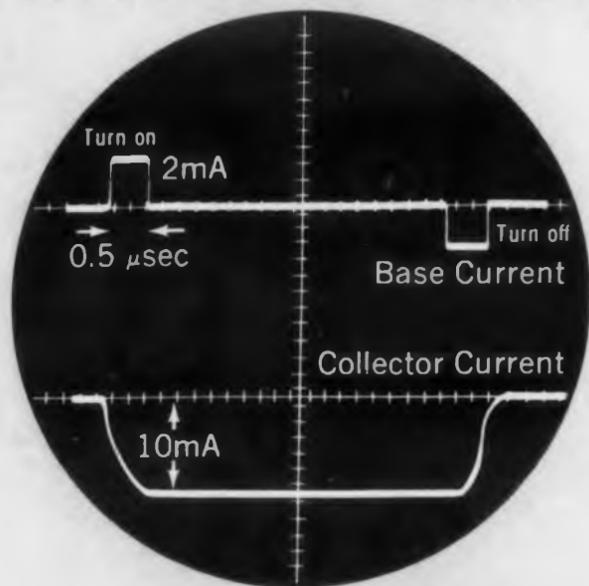
SPECIALLY DESIGNED FOR:

- Miniaturized Memory Circuits
- Ring Counters
- Shift Registers
- Controlled Rectifier Driver
- Flip-Flop Equivalent
- Simplified Information Storage
- 0.3 microsecond Switching

## Transitron

announces a NEW computer element  
for: Greater Reliability • Circuit Simplicity

# THE TRANSWITCH



The TRANSWITCH is a new bistable silicon device that can be TURNED OFF with gate current.

This PNP latching device "remembers" its last gate signal. High current gain, both turn-on and turn-off, leads to greater circuit simplicity and inherent reliability. Excellent linearity of electrical parameters over a wide current range fulfills both low logic level and medium power needs.

Here is a unique device that replaces TWO transistors plus resistors in most bistable circuits and permits increased component density.

Furthermore, the transwitch is FAST . . . requiring only 0.3 microseconds to turn ON or OFF!

The TRANSWITCH is now available from TRANSITRON in the popular JEDEC TO-5 package, ready to solve your switch-on-switch-off requirements.

For further information, write for Bulletin TE-1357A

# Transitron

electronic corporation • wakefield, massachusetts



"Leadership in Semiconductors" SEE YOUR LOCAL AUTHORIZED TRANSITRON DISTRIBUTOR FOR QUANTITIES FROM 1-999.

## NEW PRODUCTS

### Variable High Pass Filter

415

Works with impedances from  
4 to 16 ohms

Model VC-213 variable high-pass filter is designed to allow accurate balance of volume between the woofer and tweeter with only one control. A combination cross-over and level control, it works with any impedance from 4 to 16 ohms. It measures 4 x 2-5/8 x 1-5/8 in. No soldering is needed.

Olson Radio Corp., Dept. ED  
260 S. Forge St., Akron, Ohio.

### Transducer

423

7 pressure ranges available

Type 4-332 transducer is available in 7 pressure ranges from 0-1-1/2 to 0-150 psi differential. Output is  $\pm 100$  v full scale, and the combined effects of linearity and hysteresis are less than 0.05%. The transducer can be downranged to 10% of its rated pressure without loss of accuracy and still provide  $\pm 10$  v at this range. Dimensions are 4 x 3 x 2-1/2 in., and the weight is 2.6 lb.

Consolidated Electrodynamics  
Dept. ED, 360 Sierra Madre Villa  
Pasadena, Calif.

Price & Availability: Quoted on request.

### Switches

424

Produce a single, square-wave pulse

Available in 6 pre-engineered, potted circuit packages, these switches have a circuit that produces a single, square-wave pulse with widths of 0.1 to 10  $\mu$ sec. They can drive loads as low as 5 ohms and can deliver output voltages up to 180 v. Uses include computer and radar consoles, data link, setting and resetting flip-flops, and reflected pulse systems.

Micro Switch, Dept. ED, Freeport, Ill.

Price & Availability: Standard assemblies are available immediately. Prices range from \$9.50 to \$18.60 for ED series.

◀ CIRCLE 58 ON READER-SERVICE CARD

CIRCLE 300 ON READER-SERVICE CARD ▶

**Ceramic Disc Capacitors**

561

**Low voltage type**

415 Type H miniature ceramic disc capacitors are designed to meet the low voltage requirements of transistorized radios, portable wire and tape recorders, electronic timing devices, and other miniature battery-powered or line-powered equipment. Excellent for bypass and coupling, they are offered in these sizes: 0.35 in. in diam x 1/8 in. thick, 0.5 x 1/8 in., and 0.625 x 1/8 in. Phenolic coating and high-temperature wax vacuum impregnation are used. Operating range is +10 to +85 C; working voltage is 50 v dc.

423 Cornell-Dubilier Electric Corp., Dept. ED, S. Plainfield, N.J.  
**Price & Availability:** Units can be immediately furnished in production quantities; price is quoted on request.

**Ultrasonic Delay Line 553**

**Delay time is 5 to 12,000 μsec**

Made to launch and propagate acoustic waves along a wire transmission media, the U.D. series of ultrasonic delay lines offer a range of delay times from 5 to 12,000 μsec. The temperature coefficient is 5 ppm per deg C over the range of -55 to +100 C. The center frequency ranges from 100 kc to 1.2 mc with a maximum bandwidth of 1 mc. The unit can be used with a carrier frequency or without, for pulsed operation. It has a wide range of input and output impedances to allow for optimum impedance matching. It meets military requirements for vibration and shock; both standard and custom designs can be furnished for such applications as computer bit storage, coders, decoders, telemetering systems, radar simulators, missiles, and aircraft.

Curtiss-Wright Corp., Electronics Div., Dept. ED, 620 Passaic Ave., W. Caldwell, N.J.

**Price & Availability:** The price range is \$99 to \$1500 for one unit. Made on order only, it can be delivered 4 to 8 weeks after receipt of order.

**STEMCO THERMOSTATS**

**RANK FIRST IN PRECISION TEMPERATURE CONTROL**

In today's military and commercial projects, you can't afford to overlook any one of these important areas: Reliability, Size, Availability, Economy.

And because Stevens is in production now on the largest number of different types and styles of bimetal thermostats, all these advantages are yours automatically when you specify Stemco thermostats.

1st in Reliability. Proven designs, latest production techniques, most stringent inspection procedures.

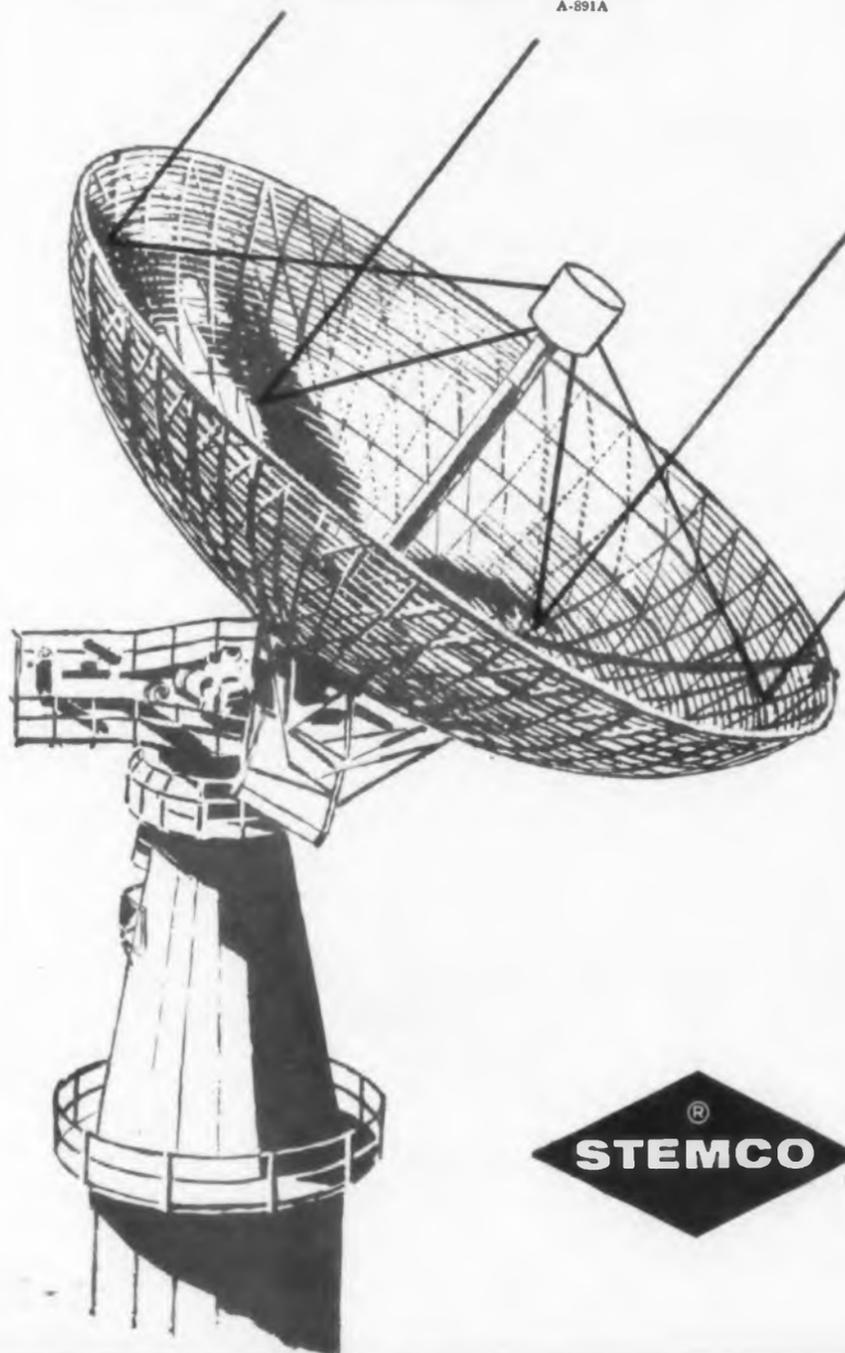
1st in Size. Stemco thermostats score in compactness and lightness without sacrificing performance.

1st in Availability. Tooling for most types is in existence. Flexibility of design cuts lead time on other types.

1st in Economy. Mass production of many standard Stemco types with hundreds of terminal arrangements and mounting brackets cuts your costs.

\*Refer to Guide 400EO for U.L. and C.S.A. approved ratings.

A-891A



**TYPE A\* semi-enclosed.** Bimetal disc type snap action thermostats; give fast response to temperature changes. Can be made to open on rise or close on rise. Single-throw with double make and break contacts. Operation from -20 to 300°F. Lower or higher temperatures on special order. Average non-inductive rating 13.3 amps, 120 VAC; 4 amps, 230 VAC and 28 VDC. Various mountings and terminals available. Bulletin 3000.

**TYPE A hermetically sealed.** Electrically similar to semi-enclosed Type A. Various mountings, including brackets, available. Bulletin 3000.

**TYPE MX hermetically sealed.** Snap acting bimetal disc type units to open on temperature rise. 2 to 6°F differentials as standard. 1 to 4°F differentials available on special order. Depending on duty cycle, normal rating 3 amps, 115 VAC and 28 VDC for 250,000 cycles. Various terminals, mountings and brackets available. Bulletin 6100.

**TYPE MX semi-enclosed.** Construction and rating similar to MX hermetically sealed type. Bulletin 6100.

**TYPE M hermetically sealed.** Bimetal disc type, snap acting thermostats. Also available in semi-enclosed. Operation from -20 to 300°F. Lower and higher temperatures available on special order. Depending on application, rated non-inductive 10 amps, 120 VAC; 3 amps, 28 VDC. Various terminals, wire leads and brackets available. Bulletin 6000.

**TYPE C hermetically sealed.** Also semi-enclosed styles. Small, positive acting with electrically independent bimetal strip for operation from -10 to 300°F. Rated at approximately 3 amps, depending on application. Hermetically sealed type can be furnished as double thermostat "alarm" type. Various terminals and mountings. Bulletin 5000.



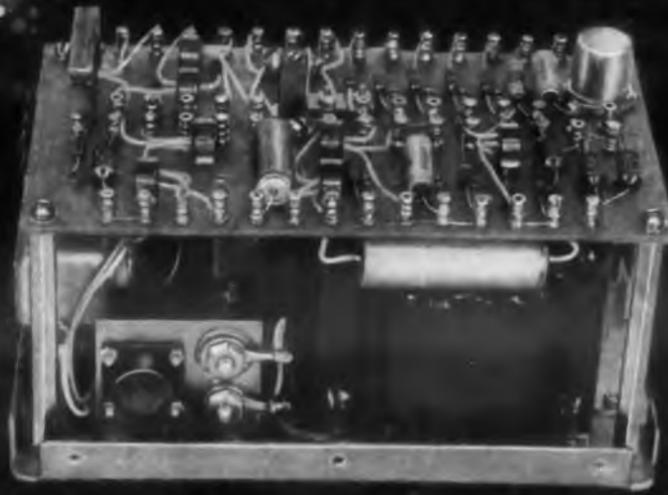
**THERMOSTATS**

**STEVENS** manufacturing company, inc.  
P.O. Box 1007, Mansfield, Ohio

◀ CIRCLE 300 ON READER-SERVICE CARD  
CIRCLE 59 ON READER-SERVICE CARD ▶

# ULTRA-STABLE Transistorized Power Supply

62 A



## AC to DC—regulated $\pm 0.1\%$ for 6 months

### Characteristics

**Input:** 115 V AC 60 cps or 400 cps or

208 V AC 3 phase 60 cps or 400 cps

**Output:** Available in discrete steps of 0.5 volt from

A. 12.0 volts DC to 28.0 V DC at 1.0 ampere

B. 28.0 volts DC to 50.0 V DC at 0.5 ampere

Output is floating and can be used either as a positive or negative supply.

**Load Regulation:** Output voltage is regulated within  $\pm 0.1\%$  from 0.5 to 1.0 ampere.

**Line Regulation:** Output voltage is regulated within  $\pm 0.1\%$  for line variations of  $\pm 10\%$  in voltage and frequency.

**Temperature:** Output voltage is regulated within  $\pm 0.1\%$ , under full or minimum load, over the temperature range of  $-55^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ .

**Ripple:** Less than 1 milli-volt RMS or 3 milli-volts peak to peak.

**Stability:** 0.1% for a period of 6 months under a fixed load and line.

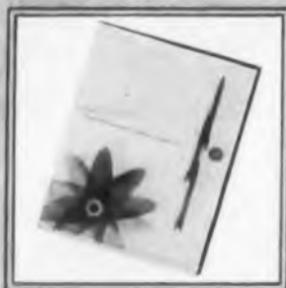
**Reliability:** Better than .95 for a period of 365 days, at 8 hours a day with a life expectancy of 10 years.

**Output Impedance:** Less than 20 micro-ohms at DC.

This unit can be supplied as a DC to DC Power Supply.

### Applications

- Voltage reference in computers and complex networks.
- Laboratory voltage standard.
- Cascaded to provide higher voltages without degradation of performance.



Read about this unit and many other missile and airborne types in the new Daven Catalog of Transistorized Power Supplies!

THE **DAVEN** CO.  LIVINGSTON, NEW JERSEY

TODAY, MORE THAN EVER, THE DAVEN  STANDS FOR DEPENDABILITY



## NEW PRODUCTS

### Time Delay Relay 551

Preset delays are 10 to 180 sec

Developed to meet the reliability requirements of airborne, missile, and space vehicle applications, the STR series time delay relay has a preset time delay of 10 to 180 sec. It offers ambient temperature and voltage compensation. Contacts are instantaneous resetting, isolated load, spdt type. The uses include automatic reset on digital read-out equipment, computer sequencing as well as sequential timing and overload protection.

Curtiss-Wright Corp., Electronics Div., 620 Passaic Ave., W. Caldwell, N.J.

**Price & Availability:** The price is \$52.50 ea for a single order; in quantities of 1 to 9, \$50. Reductions are made for larger orders. Delivery time is 4 to 6 weeks.

### Spray Gun 571

For cathode coating

Coatings of any material which can be melted without decomposing can be applied with this plasma flame spray gun. In electronic applications, cathodes have been successfully coated. The control unit provides all necessary adjustments with complete push button operation and control.

Metallizing Engineering Co., Inc., Dept. ED, 1101 Prospect Ave., Westbury, Long Island, N.Y.

**Price & Availability:** Available by April. Price of complete assembly is \$10,500.

### Terminals and Clips 575

Many types available

A wide variety of spring and fuse clips and lock washer terminals are offered. The lock washer terminals are manufactured with No. 4, 6, and 8 holes with 0.018 brass or phosphor bronze, hot tinned.

Zieric Manufacturing Corp., Dept. ED, 110 Beechwood Ave., New Rochelle, N.Y.

◀ CIRCLE 60 ON READER-SERVICE CARD

## FM Basic Tuner Assembly

573

For use in original equipment

For use in original equipment, type 579 fm basic tuner assembly has a tuned rf stage for good image rejection, stable permeability tuning, and dual limiters providing maximum noise control. The oscillator stage is completely shielded to maintain radiation well below FCC requirements. A six-tube unit, it has a tuning range of 86 to 110 mc. Typical sensitivity is 1  $\mu$ v for 20-db quieting and 2.1  $\mu$ v for 30-db quieting. The typical selectivity is 200 kc at 6 db, the frequency response is 15 to 25,000 cps, and the distortion is less than 0.5% at the 2-v output. The oscillator stage is shielded, maintaining radiation well below FCC requirements. Completely fabricated, the unit is furnished with all critical circuits assembled and aligned.

J. W. Miller Co., Dept. ED, 5917 S. Main St., Los Angeles 3, Calif.

## Shock Machine

565

For production and lab testing

Type 16750 shock machine is designed for production and laboratory testing of small electronic, electromechanical, and mechanical components. It accommodates test specimens weighing up to 20 lb and occupying an 8-in. cube. The unit, called Varipulse, stands 7 ft 3 in. high, and occupies a floor space 12 x 16 in.

Barry Controls Inc., Dept. ED, 700 Pleasant St., Watertown, Mass.

## Transistor Pads

567

Tensile strength is 5500 psi

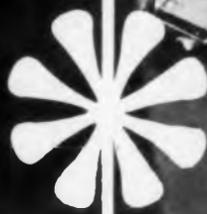
Molded of mineral filled diallyl-phthalate, which conforms to MIL-P-14 D (MDG type) and MIL-P-4889, these transistor pads have a nominal tensile strength of 5500 psi. They resist continuous exposure to 400 F, and offer high dielectric strength.

Delbert Blinn Co., Dept. ED, Box 757, Pomona, Calif.

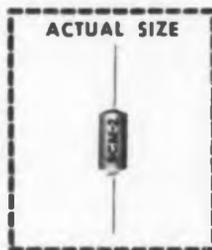
CIRCLE 61 ON READER-SERVICE CARD

# tan-TI-cap<sup>†</sup>

## CAPACITOR STABILITY ASSURED BY 250-HOUR PERFORMANCE LOAD TEST



### ... expanded TI line of type SCM solid tantalum capacitors meets MIL specs



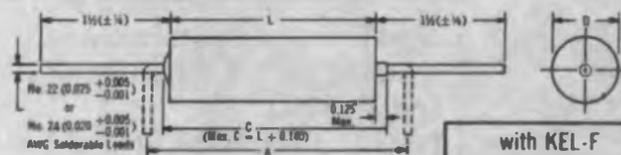
Another assurance to you of Texas Instruments capacitor reliability — 250-hour performance load test on a sample basis of *all* lots of the Type SCM series.

Your margin of design safety is greater with *tan-TI-cap* capacitors. Type SCM capacitors are *100% tested* for capacity, dc leakage and dissipation factor, and are aged under load at elevated tempera-

ture. SCM units in all 203 standard ratings (6 - 35 volts, 1 - 330  $\mu$ fd.) meet and exceed the electrical and mechanical requirements of MIL-C-55057 (Sig. C) and/or MIL-C-21720A (NAVY) specifications for solid tantalum capacitors.

Contact your nearest authorized TI distributor or TI sales office today for your immediate and future delivery requirements.

<sup>†</sup> trademark of Texas Instruments Incorporated



case size	with KEL-F insulating sleeve			with Mylar insulating sleeve**		
	D	L	*A	D	L	*A
F	0.125	0.250	0.482	0.162	0.337	0.5
G	0.175	0.438	0.688	0.210	0.525	1.3
B	0.279	0.650	0.888	0.315	0.735	3.1
H	0.341	0.750	0.988	0.377	0.835	3.9

\* Dimension "A" determined by suspending a one-pound weight from one lead and rotating the case from the vertical position to the horizontal position, and then repeating the procedure for the other lead.

\*\* Meets all requirements of MIL-C-55057 and MIL-C-21720A, including dimensions.



Write to your nearest TI sales office on your company letterhead for Bulletin DL-C 1173 which gives detailed specifications on the complete SCM series.

## TEXAS



## INSTRUMENTS

INCORPORATED  
SEMICONDUCTOR-COMPONENTS DIVISION  
13500 N. CENTRAL EXPRESSWAY  
POST OFFICE BOX 312 • DALLAS, TEXAS



**A Gulton "VO" Series  
button cell battery  
powers this blind man's  
guidance cane**



## rugged...reliable ...rechargeable!

The cane in the man's hand is a proximity guidance device designed by Franklin Institute for the blind.

Requirements called for the power supply to be small enough to fit in the handle of the cane, rugged enough to perform well under abuse, and... to be rechargeable.

After extensive testing, designers chose the Gulton "VO" sealed nickel cadmium button cell battery to do the job.

### How Can You Use These Batteries?

Powering this and other prosthetic devices is only one of many imaginative uses for these rechargeable batteries. Engineers have already designed them into transistorized radios, photo-flash power packs, missiles - wherever *small size, strength, light weight, long life, complete reliability, no maintenance and easy recharging are desired.* Like more information? Write us for Bulletin No. VO-103.

		VO-.080	VO-.180	VO-.250	VO-.500
ELECTRICAL SPECS.	Capacity (1 Hour rate):	80 mah	180 mah	250 mah	500 mah
	Charging Current (1c):	2-10 ma	4-18 ma	5-25 ma	10-40 ma
	Charging Time (Constant Current):	150/lc hrs.	270/lc hrs.	375/lc hrs.	750/lc hrs.
	Trickle Charge Rate:	2-5 ma	2-5 ma	2-5 ma	5-10 ma
	Cell Voltage During Charge:	1.4 V	1.4 V	1.4 V	1.4 V
MECHANICAL SPECS.	Maximum Peak Discharge Current:	1.5 A	3 A	5 A	7.5 A
	Diameter:	.900	.975	1.375	1.375
	Thickness:	.200	.270	.1875	.3125
	Weight:	.25 ounce	.35 ounce	.5 ounce	.75 ounce



Available from stock— GLENNITE BATTERY DISTRIBUTORS  
92-15 172nd Street, Jamaica, New York

**Gulon Industries, Inc.**  
Alkaline Battery Division, Metuchen, New Jersey

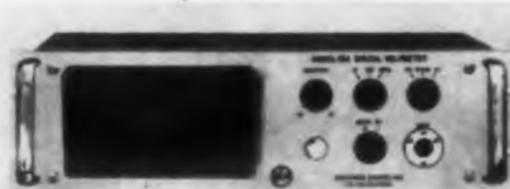
CIRCLE 62 ON READER-SERVICE CARD

## NEW PRODUCTS

### Digital Voltmeter

455

Resolution is 0.01%



Designed for a wide range of dc measurement applications, model V64 voltmeter has 0.01% resolution, high input impedance, and an average measuring time of 0.75 sec per reading. Used with accessories, it can make ac and low-level dc measurements. Its range without accessories is in three steps:  $\pm 9.999$ , 99.99, and 500 v dc.

Non-Linear Systems, Inc., Dept. ED, Del Mar, Calif.

*Price & Availability: After February 15, units will be available from stock at the price of \$825.*

### Temperature Transducers

449

Stand 5000 psi



Able to stand an operating pressure of 5000 psi, type BA-9 temperature transducers have a resistance range of 50 to 5000 ohms at 77 F  $\pm 4\%$ . Response is 0.25 sec in fluid and repeatability is 0.5%. They can be supplied with a Balco element, or with platinum or tungsten.

Transducer Labs., Dept. ED, Glenwood Springs, Colo.

*Price & Availability: \$102; delivery is in 10 days.*

### Pressure Transducers

465

Stands 50 g at 3 kc



For control, telemetry, and propulsion pressure measurement systems, model 100 pressure trans-

## NATIONAL HR KNOBS

Precision made of the finest quality materials and recognized for excellence in design, National's line of HR Knobs are long a favorite of electronics people everywhere. Available in a number of types, styles, sizes and colors, National's comprehensive HR knob (and dial) line makes it possible to meet most of your knob requirements by ordering from catalog stock. A representative catalog listing:



**TYPE HRS:** Top quality Tenite, easy grip knurling, black or grey or to specifications; chrome plated bevel skirt, depressed numerals black enamelled; numbering 180° or 300°.

**TYPE HRT:** Modern, large knobs designed for NATIONAL's receivers, now available by popular request. Deluxe, modern knob is made of black or grey Tenite; chrome plated inlay.

**TYPE HR:** Tenite, easy grip knurling, with or without white dot, or with special markings; black or grey or to specifications.

**TYPE HRB:** Lever knob is ideal for band-switching and for other applications where switch is turned to several index positions. Highly polished, bright zinc alloy die cast, or anodized in a variety of special colors.

National Radio Co. also manufactures many other electronic and electromechanical components. For catalog covering your needs... or for your special design or applications problems, write or call:

**National RADIO CO., INC.**  
MELROSE 76, MASS. NORMANDIE 5-4800

A wholly owned subsidiary of National Co., Inc.  
Export: AD AURIEMA, INC., 85 Broad St., N.Y., N.Y., U.S.A.  
In Canada: CANADIAN MARCONI CO., 830 Bayview Ave., Toronto 17, Ont.

Specifications subject to change without notice.

CIRCLE 63 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 3, 1960

ducer stands 50 g at 3 kc. A potentiometric output type transducer, it yields infinite resolution. It is available for pressure ranges of between 0 and 15 psi and between 0 and 300 psi for corrosive and non-corrosive liquids and gases. It measures 1-1/2 x 1-1/2 x 1-1/4 in. and weighs 6 oz or less.

White Avionics Corp., Dept. ED, Terminal Rd., Plainview, L.I., N.Y.

### Position Encoder

359

Gives data in 17-digit cyclic binary code



Type RD-17 photoelectric shaft-position encoder gives angular position data in 17-digit cyclic binary code with  $\pm 1$  digit accuracy. The 17-digit accuracy for 1 shaft revolution is obtained in unambiguous form without the use of gears. Designed to meet applicable portions of MIL-E-4158B, the 26-lb, 10-in. diam unit includes power supplies, amplifiers and control electronics. Solid or hollow shaft models are available.

Wayne-George Corp., Dept. ED, 588 Commonwealth Ave., Boston 15, Mass.

### Precision Brake

370

For fhp motors



Designed for fhp motors, this precision brake is useful in computer mechanisms, tape transports, and other mechanisms where positive stop is necessary. Braking torque is 2 to 4 lb/in. for shafts to 3/8 in. All parts, including the brake band, are made with special dies to eliminate variations in braking power. A constant duty solenoid is furnished for connection in parallel with the motor. Without load the motor is stopped in less than 1/4 revolution.

Midwest Automatic Control Co., Dept. ED, 510 Third St., Des Moines 9, Iowa.



**Miniature Might.** Tiny Oyster Drills (*Urosalpinx Cinarea*) are noted destroyers of their much larger fellow-mollusks — oysters. One of 80,000 mollusk species, the Oyster Drill feeds on his victims through a shell-piercing snorkel.

**Maximum Precision** for the entire mechanism of this electric timer is assured by MPB bearings mounted on shaft ends and in gear trains. By reducing torque, these stainless steel bearings mean longer life and less maintenance for the timer.

**Man with Miracles.** Sales Manager Ken Broman heads MPB Sales Engineers in their engineering and consultative service to industry. One of these highly experienced MPB technical men is always ready to help solve your miniaturization problems.

## More Miracles in Miniaturization



ACTUAL SIZE OF BEARINGS USED IN ELECTRIC TIMER SHOWN ABOVE

Designing and redesigning to meet modern requirements calls for miniaturization on a grand scale. Components for aircraft or outer space missiles must be reduced to minimum size and weight. Greater precision is needed in complicated, compact mechanisms and expert miniaturization is sought throughout industry. MPB helps you perform miracles in

miniaturization by producing over 500 types and sizes of bearings ranging from 3/8" O.D. down to 1/10" O.D., with specials as required. For an illustrated catalog containing complete facts on these bearings, for engineering advice or both, write **Miniature Precision Bearings, Inc.**, 902 Precision Park, Keene, N. H.

CIRCLE 64 ON READER-SERVICE CARD

# MPB

Helps you perform miracles  
in miniaturization



One of the fastest computing systems ever developed, the UNIVAC Solid-State Computer performs at internal speeds commonly associated with large-scale equipment. Its remarkable speed and storage capacity enable the UNIVAC Solid-State Computer to eliminate much pre-sorting and pre-collating...and combine calculating, reproducing, gang-punching, data-collation, and tabulating in a single run. Each UNIVAC SSC contains over 1,400 printed circuits plated with AUTRONEX ACID GOLD.

## REMINGTON RAND USES AUTRONEX\* ACID GOLD PROCESS TO PLATE UNIVAC PRINTED CIRCUITS

Remington Rand, Division of Sperry Rand Corporation, Utica, New York, uses the AUTRONEX ACID GOLD PROCESS to plate printed circuit boards for their world-famous UNIVAC Solid-State Computer Systems and Equipment. Installation of the patented AUTRONEX ACID GOLD PLATING PROCESS for this work, "...totally eliminated resist failures and rejects in the electroplating phase," according to a report from Remington Rand's Supervisor of Chemical Engineering.

This report goes on to say that "AUTRONEX ACID GOLD in printed circuit production offers definite advantages and promotes the highest quality production." Here are some of these advantages proved in Remington Rand's own laboratories:

1. Harder and more wear-resistant surfaces.
2. Elimination of one step in plating cycle — no cyanide gold strike required.
3. Promotes higher bond strength of circuit to dielectric base material by minimizing danger of damaging the adhesive layer.
4. Solder flow through plated holes is definitely better, thereby improving over-all quality.
5. AUTRONEX ACID GOLD has totally eliminated circuit lifting and rejects on boards plated after etching. Formulations used previously attacked the adhesive and undermined the circuit paths.

The conclusion of the report we have been quoting needs no further comment: "We would like to commend the manner in which your company has serviced us in regards to materials, equipment and valuable advice. In many instances your promptness in making equipment and materials delivery has been instrumental in meeting vital production target dates."

The patented AUTRONEX ACID GOLD PLATING PROCESS has production-proved its unique advantages for over two years in the plants of leading manufacturers the world over. AUTRONEX can help you make a better, more reliable product—probably at far less cost than with any gold plating formulation you may be presently using. Evaluate AUTRONEX ACID GOLD ELECTROPLATE in your own plant, on your own product. We'd be happy to plate sample parts for you at no obligation. Write...wire...or phone. We'll make all the arrangements.

\*Trademark for Sel-Rex patented Acid Gold Plating Process



PRECIOUS METALS DIVISION

**SEL-REX CORPORATION**

NUTLEY 10, NEW JERSEY



The world's fastest and most advanced electronic data processing system for business and scientific use, the UNIVAC Larc Solid-State computer, by the Remington Rand Division, Sperry Rand

Corporation. The new system, which operates up to 200 times faster than any computer in existence, can perform 250,000 additions and subtractions of 12-digit decimal numbers per second.

CIRCLE 65 ON READER-SERVICE CARD

## NEW PRODUCTS

### Decade Transformer

461

Has an accuracy of better than 0.001%



Developed to certify differential transformer displacement, model DRT-5 ratio transformer has a ratio accuracy of better than 0.001%. The resolution is 0.00001, the output impedance is less than 8 ohms and the input impedance is 15,000 ohms at 400 cps. The frequency range is 50 to 10,000 cps and the phase shift is negligible. The instrument is suitable for the calibration of ac meters, ratio boxes, attenuators, amplifiers, and transformers. It can also be used as a bridge circuit ratio arm or a variable ac voltage supply.

G. L. Collins Corp., Dept. ED, 2820 E. Hullett St., Long Beach 5, Calif.

### Time Delay Switch

459

Handles up to 50 amp



This time delay switch handles up to 50 amp without arcing, contact damage, radio interference, audible noise, or vibration. Completely solid state, it has no moving parts and weighs 3 oz. Three types are offered: the light duty series with ratings up to 10 amp, the medium duty series with ratings to 16 amp, and the heavy duty series, with ratings to 32 and 50 amp. The maximum current required is 50 ma and the standard operating voltages are 24 and 31 v dc. The switch contains all hermetically sealed components and the entire unit is hermetically sealed in epoxy resin in an anodized aluminum case. Case dimensions are 1.25 in. in diam and 2 in. in length. The switch meets applicable parts of MIL-R-5757C, MIL-R-6106A, and MIL-R-25018.

George Harmon Co., Dept. ED, 18232 Parthenia, Northridge, Calif.

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for  
**IMMEDIATE  
DELIVERY**  
of  
**ELMENCO**  
*capacitors*

IN QUANTITIES UP TO  
500 PER ITEM  
CONTACT THESE AUTHORIZED  
ELMENCO DISTRIBUTORS

The authorized distributors listed below  
carry a full stock of all Elmenco Capaci-  
tors and can give you Immediate Delivery  
from stock.

**ARIZONA:** Radio Specialties & Appl. Corp., 917  
N. 7th St., Phoenix; Standard Radio Parts Inc.,  
218 N. First Ave., Tucson.

**CALIFORNIA:** Brill Electronics, 610 East 10th  
St., Oakland 6; Electronic Supply Corp., 2085  
E. Foothill Blvd., Pasadena; Federated Pur-  
chaser Inc., 11275 W. Olympic Blvd., L. A. 64;  
Hollywood Radio Supply Inc., 5606 Hollywood  
Blvd., Hollywood 28; Pacific Wholesale Co., 1850  
Mission St., San Francisco 3; Peninsula Elec-  
tronics, 656 South 1st Street, San Jose; Shelley  
Radio Co. Inc., 2008 Westwood Blvd., L. A. 25;  
R. V. Weatherford Co., 6921 San Fernando Rd.,  
Glendale 1; Zack Electronics, 654 High St., Palo  
Alto.

**COLORADO:** Denver Electronics Supply Co., 1254  
Arapahoe St., Denver 4.

**DISTRICT OF COLUMBIA:** Capitol Radio Whole-  
salers Inc., 2120 14 St., N.W., Wash., D. C.

**ILLINOIS:** Newark Electric Co., 223 W. Madi-  
son St., Chicago 6.

**MARYLAND:** Kann-Eliert Electronics Inc., Howard  
& Redwood Sts., Balt. 1.

**MASSACHUSETTS:** Cramer Electronics Inc., 811  
Boylston St., Boston 16; Radio Shack Corp.,  
730 Commonwealth Ave., Boston 17.

**NEW JERSEY:** Federated Purchaser Inc., 1021  
U. S. Rte. 22, Mountainside; Radio Elec. Ser-  
vice Co., Inc., 513 Cooper St., Camden 2.

**NEW MEXICO:** Midland Specialty Co., 1712 Lo-  
mas Bl. N.E., Albuquerque; Radio Specialties  
Co., Inc., 209 Penn Ave., Alamogordo.

**NEW YORK:** Arrow Electronics Inc., 525 Jericho  
Turnpike, Mineola, L. I.; Terminal Radio Inc.,  
85 Cortlandt St., New York 7.

**PENNSYLVANIA:** Almo Radio Co., 412 N. 6th St.,  
Phila. 23; Phila. Electronics Inc., 1225 Vine St.,  
Phila. 7; Radio Elec. Service Co., Inc., 701  
Arch St., Phila. 6

**TEXAS:** All-State Distributing Co., 2411 Ross  
Ave., Dallas 1; Busacker Elect. Equip. Co. Inc.,  
1216 West Clay, Houston 19; Engineering Sup-  
ply Co., 6000 Denton Drive, Dallas 35; Midland  
Specialty Co., 500 W. Paisano Drive, El Paso.

**WASHINGTON:** C & G Radio Supply Co., 2221  
Third Ave., Seattle.

CIRCLE 66 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 3, 1960

It could  
happen...

with

**El-Menco**  
**CAPACITORS!**

**NEW**

*Mylar-Paper Dipped*

**CAPACITORS**

**TYPE  
MPD**

**INSURE FAILURE-PROOF PERFORMANCE!**

Only 1 Failure in 7,168,000 Unit-Hours for 0.1 MFD Capacitors

**Setting a new standard of reliability!**

\*Life tests have proved that El-Menco  
Mylar-Paper Dipped Capacitors — tested  
at 100°C with rated voltage applied —  
have yielded a failure rate of only 1 per  
716,800 unit-hours for 1 MFD. Since  
the number of unit-hours of these capaci-  
tors is inversely proportional to the  
capacitance, 0.1 MFD El-Menco Mylar-  
Paper Dipped Capacitors will yield **ONLY  
1 FAILURE IN 7,168,000 UNIT-HOURS.**

**SUPERIOR FEATURES!**

• Five case sizes in working voltages and ranges:

200 WVDC —	.018 to .5 MFD
400 WVDC —	.0082 to .33 MFD
600 WVDC —	.0018 to .25 MFD
1000 WVDC —	.001 to .1 MMF
1600 WVDC —	.001 to .05 MFD

Write for Technical Brochure Giving Complete Information on the  
El-Menco Tubular Dur-Paper Line.

THESE CAPACITORS WILL EXCEED ALL THE ELEC-  
TRICAL REQUIREMENTS OF E.I.A. SPECIFICATION  
RS-164 AND MILITARY SPECIFICATIONS #MIL-C-91A  
AND MIL-C-25A.

FOR FAILURE-PROOF PERFORMANCE... COUNT ON  
EL-MENCO MYLAR-PAPER DIPPED CAPACITORS...  
FROM MISSILE GUIDANCE SYSTEMS TO DATA PROC-  
ESSING EQUIPMENT!

\*Registered Trade Mark of DuPont Co.

**SPECIFICATIONS**

- TOLERANCES:  $\pm 10\%$  and  $\pm 20\%$ . Closer tol-  
erances available on request.
- INSULATION: Durez phenolic resin impregnated.
- LEADS: No. 20 B & S (.032") annealed copper-  
weld crimped leads for printed circuit application.
- DIELECTRIC STRENGTH: 2 or 2½ times rated  
voltage, depending upon working voltage.
- INSULATION RESISTANCE AT 25°C:  
For .05MFD or less, 100,000 megohms minimum.  
Greater than .05 MFD, 5000 megohm-microfarads.
- INSULATION RESISTANCE AT 100°C:  
For .05MFD or less, 1400 megohms minimum.  
Greater than .05MFD, 70 megohm-microfarads.
- POWER FACTOR AT 25°C:  
1.0% maximum at 1 KC.



**THE ELECTRO MOTIVE MFG. CO., INC.**  
WILLIMANTIC CONNECTICUT

Manufacturers of El-Menco Capacitors

- molded mica • dipped mica • mica trimmer • dipped paper
  - tubular paper • ceramic • silvered mica films • ceramic discs
- Exclusive Supplier To Jobbers and Distributors in the U.S. and Canada  
Arco Electronics, Inc., 64 White St., New York 13, N. Y.

CIRCLE 67 ON READER-SERVICE CARD

**El-Menco**  
*Capacitors*





**Here's a NEW Booklet on Microwave Components** — The facts and figures on many of Bomac's microwave components and test equipment are now available to you in a handy, easy-to-read booklet. Included are descriptions and specifications on: **Waveguide and coaxial line duplexers • Coaxial line monoplexer • Keep alive and recovery electrode supplies • Coaxial load • Variable power dividers • C-band R.F. package • Noise source • Waterloads • Coaxial line to waveguide transitions • Directional waveguide couplers • Magnetron test sets • Low level test set for spot display.**

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**BOMAC laboratories, inc.**

SALEM ROAD • BEVERLY, MASSACHUSETTS  
A SUBSIDIARY OF VARIAN ASSOCIATES

## NEW PRODUCTS

### Maser Amplifiers 572

For systems uses

These microwave maser amplifiers, for advanced systems applications, are particularly suitable for space vehicle communications and tracking, radio astronomy, and ground-to-ground communications. An amplifier noise temperature of less than 10 K is possible in the 1 to 15 mc band with a gain of 20 to 30 db and a bandwidth of 5 to 30 mc. The large electromagnet of most previous masers has been replaced in this unit by a small permanent magnet. The addition of a second cavity to a conventional single-cavity maser increases the bandwidth to 18 mc when the over-all gain is 26 db.

Hughes Aircraft Co., Dept. ED, Florence Ave. and Teale St., Culver City, Calif.

### DC Bridge 574

Sorts 5000 pieces per hr

Model AB-4-5 dc bridge can sort resistors into three groups automatically at the rate of 5000 pieces per hr. It operates with the following accuracies: from 10 to 100 ohms,  $\pm 0.3\%$ ; from 100 ohms to 2 meg,  $\pm 0.1\%$ ; from 2 to 10 meg,  $\pm 0.2\%$ ; and from 10 to 100 meg,  $\pm 0.3\%$ . A built-in seven-dial resistance decade is set to the nominal value of resistance being checked. Tolerance limits for the three bins are set by plug-in units. Electromechanical counters show the number of pieces in each bin.

Industrial Instruments Automation Corp., Dept. ED, 89 Commerce Rd., Cedar Grove, Essex County, N.J.

### Harness Board Posts 569

Made of nickel plated carbon steel

These nickel plated carbon steel posts are driven into the harness board as guides to permit rapid pre-assembly of wiring circuits. Stock sizes include 1/2, 3/4 and a heavier thickness in the 1-1/2 in. length.

◀ CIRCLE 68 ON READER-SERVICE CARD

Extra heavy duty sizes are also available.

John Hassall, Inc., Dept. ED, Cantiague Road, Westbury, Long Island, N.Y.

**Price & Availability:** Available from stock. Special sizes quoted upon request. Typical price per 100 of 3/4 x 0.072 in. in quantities of 1000 is \$2.75.

## Temperature Sensors 568

For temperatures to 500 F

Models S8A and S8B sensors provide sensing of temperatures to 500 F. Resistance is 676 ohms at 25 C and varies at a rate of 3.06 ohms per deg C at 25 C. Model S8B is self adhering. Model S8A is furnished with pressure sensitive installation tape, or can be cemented in place or held by mechanical means. Both type weigh less than 4 g and are calibrated within an accuracy of  $\pm 1\%$ .

Minco Products, Inc., Dept. ED, 740 Washington Ave. North, Minneapolis 1, Minn.

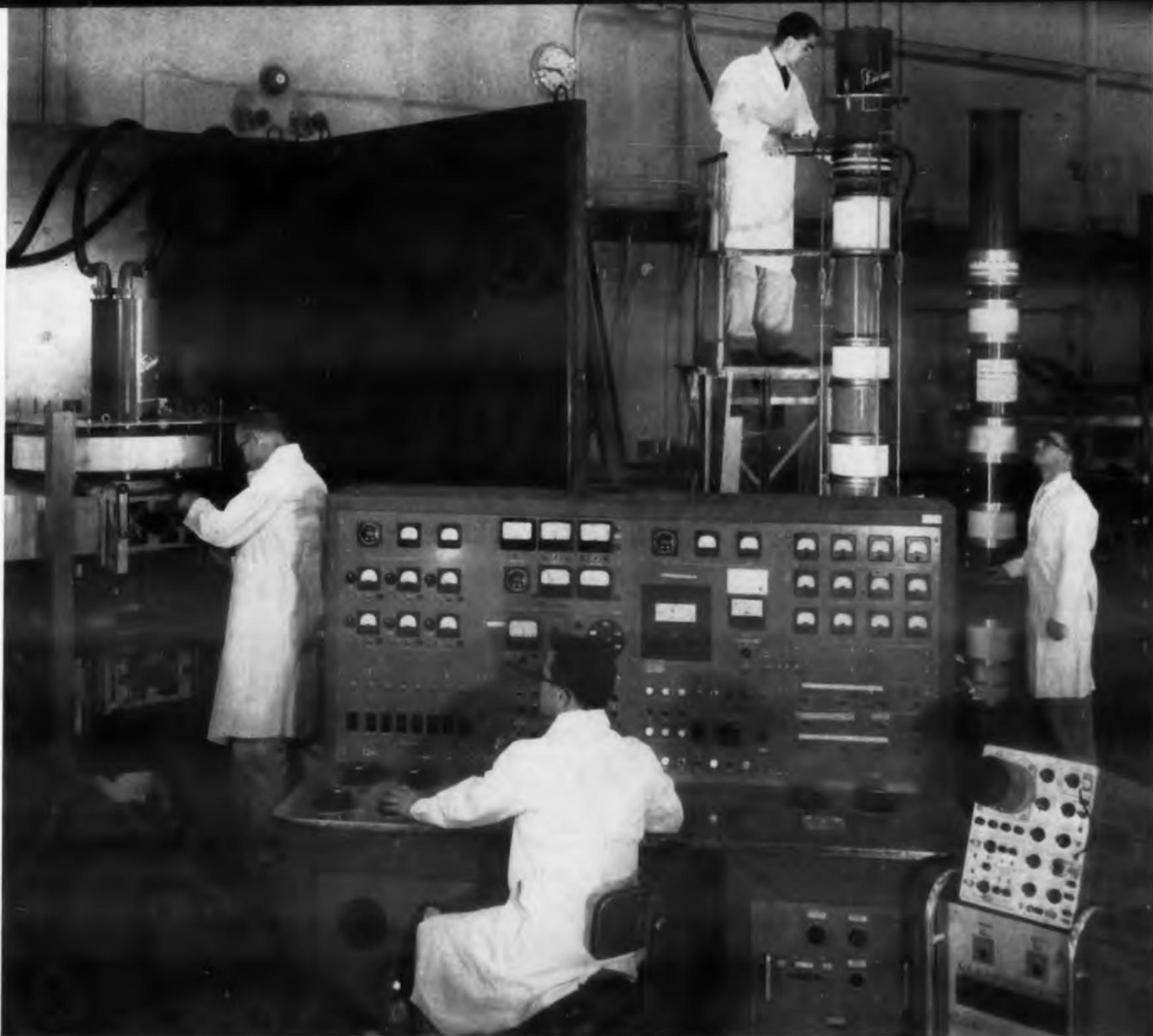
**Price & Availability:** Immediate shipment from stock in quantities to 25. Prices range from \$19.80 ea for 1 or 2 units, down to \$11.90 ea in quantities from 51 to 100.

## Trimming Potentiometer 562

Withstands 100 g acceleration

Model 1W-STK trimming potentiometer withstands acceleration to 100 g, exceeding MIL-R-19, and shock to 50 g, exceeding NAS 710, Procedure III. Two to ten of these potentiometers can be stacked in a row, held together by a steel bolt and nut. They are furnished with longer than average leads. They operate over the temperature range of  $-55$  to  $+140$  C and are rated at 1.3 w at 40 C. A 360-deg wiper maintains its setting. The inductive reactance is not measurable at 100 kc. They exceed NAS 710 for impedance and can be sealed to meet MIL-E-5272A.

Handley, Inc., Dept. ED, 2030 Colorado Ave., Santa Monica, Calif.



Portion of Eimac's extensive super-power klystron production and test area

## MORE EIMAC KLYSTRONS PRODUCED FOR UHF SUPER-POWER RADAR THAN ALL OTHER TUBES COMBINED

A decade ago Eimac decided that negative-grid tubes were impractical to generate high power at UHF. Instead, Eimac developed external cavity klystrons and opened the upper spectrum to high power propagation. With high power at UHF new applications and systems have been made possible.

Custom, laboratory-made tubes can't begin to meet the demands of systems such as UHF space radar. In keeping

with its pioneering tradition, Eimac was a leader in developing super-power, long-pulse klystrons for this system—and followed through with quantity production.

This combination of development and production has placed Eimac klystrons in more tropospheric communications and UHF super-power radar transmitters than all other makes of final amplifier tubes combined. And

Eimac will continue to convert its developments to production to meet the increasing demand.

For high power at ultra-high frequencies, investigate the many advantages of Eimac external cavity amplifier klystrons.

**EITEL-McCULLOUGH, INC.**



San Carlos • California

CIRCLE 69 ON READER-SERVICE CARD

**ADVANCE**  
—YOUR PRODUCTION  
—YOUR PROFITS  
WITH  
**STAMPINGS**



These are actual size  
advance stampings,  
which saved production  
costs.



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when you engineer in stampings. Save on material, labor and assembly costs. Here are just a few of the Advance Stampings, which have been fabricated in various materials to meet tolerance specifications, delivery and price.



- MAXIMUM 4" BLANKS • MAXIMUM 2 3/4" DRAW
- CAPACITY TO 65 TONS

Advance Stamping has been helping metal working industries of various kinds, attain higher production at lower cost, for over 35 years.

Send us your blue prints or samples for quotations. Advance engineers are available to consult on ways to improve your competitive position.

Write for Small Stamping Specialists Brochure



**ADVANCE STAMPING CO.**

12023 Dixie Ave., Detroit 39, Michigan

CIRCLE 209 ON READER-SERVICE CARD

## NEW PRODUCTS

### Communication Filters

436

With 21 channels



For use with multiplex systems, this line of standard-tone filters has 21 channels. The filters have high interchannel attenuation and flat pass band characteristics. They conform to Mil specs. Telemetering filters, from 400 to 70,000 cps, can also be furnished.

Torotel, Inc., Dept. ED, 5512 E. 110th St., Kansas City, Mo.

*Price & Availability:* In quantities of 1 to 10, the standard-tone filters are priced at \$45 ea and can be delivered in 10 days. For larger orders, price and delivery time will be quoted. Price and availability of the telemetering filters, made to customer specifications are also quoted on request.

### Transistorized Choppers

463

Are plug-in type



Models 50P, 60P, and 70P plug-in transistorized choppers can be immediately inserted into a standard seven-pin miniature socket or can be soldered to a printed circuit board. They are designed to alternately connect and disconnect a load from a signal source, are capable of linearly switching or chopping voltages over a dynamic range from a fraction of a millivolt to 10 v, and may be used as demodulators to convert an ac signal to dc. They can be driven from dc to hundreds of kilocycles. Able to stand shock and vibration, they are suited to military, missile, and portable applications. Model 70P is recommended for high temperature uses.

Solid State Electronics Co., Dept. ED, 15321 Rayen St., Sepulveda, Calif.

**TADANAC** BRAND

High Purity

**SILVER**

Approximately 99.9999% pure, this specially refined silver has only cadmium and lead as significant impurities, both in the range of 0.1 to 0.2 ppm. There are three standard forms: 25 troy oz. bars, 10 troy oz. rods and shot.

Other high purity TADANAC Brand metals or compounds include: Special Research Grade antimony, indium and tin. High Purity Grade bismuth, cadmium, indium, lead, tin, zinc and indium antimonide. Send for our brochure—TADANAC Brand High Purity Metals.

**COMINCO**

THE CONSOLIDATED MINING AND SMELTING COMPANY OF CANADA LIMITED  
215 ST. JAMES ST. W., MONTREAL 1, QUEBEC, CANADA - PHONE AVENUE 8-3103  
0163

CIRCLE 210 ON READER-SERVICE CARD

## NEW GENISCO MINIATURE ACCELEROMETER

Weighs only  
3 ounces;  
measures just  
1 1/8" x 1" x 1 7/8"!

The new Model GMA Accelerometer is a fluid damped, potentiometer output instrument, particularly suited for flight and fire control and telemetering applications. Now in production.

### Brief Specifications

Range:  $\pm 0.5$  g to  $\pm 100$  g's  
Natural Frequency: 12 cps to 75 cps  
Linearity:  $\pm 1\%$  of full scale  
Damping: Nominally 0.7 of critical at 75°F.  
Temperature: Operates to specifications between  $-20^\circ\text{F}$  and  $+185^\circ\text{F}$ .  
Vibration: 10 g's, 10-20,000 cps, any axis  
Shock: 50 g's for 7 ms, any axis



MODEL GMA

Send for complete specifications to the Instrument Division:

**Genisco**  
INCORPORATED

2233 Federal Avenue, Los Angeles 64, California

CIRCLE 211 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 3, 1960



The following Fairchild transistors are available from stock for same day shipment in quantities up to

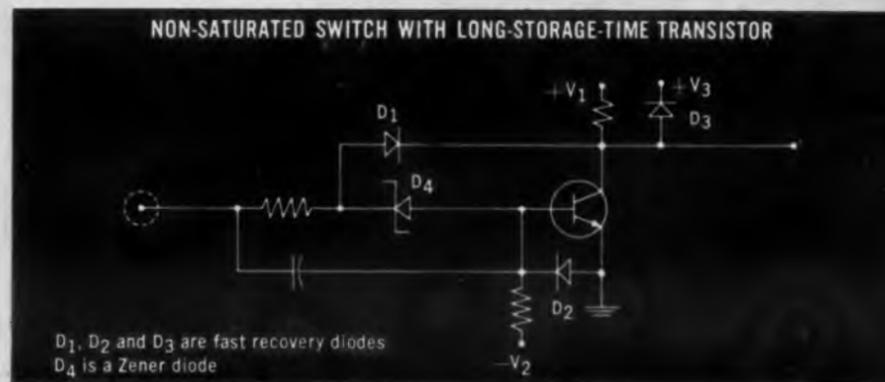
**1000**  
pieces per type.

Standard NPN: 2N696, 2N697. High Voltage NPN: 2N699. High Beta NPN: 2N1420. Low Storage NPN: 2N1252, 2N1253. Standard PNP: 2N131, 2N1132. Mesa: 2N706.

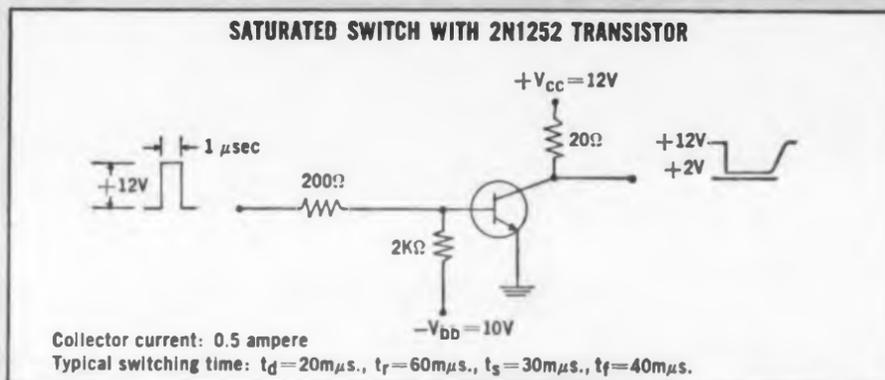


60 HERRICKS ROAD. MINEOLA, L. I., N. Y.  
TWX G-CY-NY-580U PIONEER 6-6520

## RELIABLE SILICON TRANSISTOR SWITCHING



## 9 COMPONENTS REPLACED BY 4



**HOW?** — By using Fairchild's 2N1252 or 2N1253 low storage silicon mesa transistors. The guaranteed low storage characteristic permits a simple saturating circuit to achieve switching speeds that previously required complex non-saturating circuits.

**WHY?** — Improved reliability and reduced cost — one semiconductor instead of five and fewer soldered connections. Power dissipation is only 1/3rd to 1/5th as great, making possible much higher component densities in packaging. Cost and reliability are improved all the way from development through volume production.

**WHERE?** — Switching circuits in general. The 2N1252 and 2N1253 are ideally suited to high-speed high-current switching applications such as magnetic-core drivers, drum and tape write drivers, high-current pulse generators and clock amplifiers. In addition, the transistors are applicable to medium-speed saturated logic circuits.

FAIRCHILD 2N1252 and 2N1253

Symbol	Characteristic	Rating	Min	Typ	Max	Test Conditions
$h_{FE}$	D.C. pulse current gain	2N1252 2N1253	15 30	35 45	45 90	$I_C=150mA$ $V_C=10V$
$P_C$	Total dissipation at 25°C case temperature	2 watts				
$V_{BE SAT.}$	Base saturation voltage			0.9V	1.3V	$I_C=150mA$ $I_B=15mA$
$V_{CE SAT.}$	Collector saturation voltage			0.6V	1.5V	$I_C=150mA$ $I_B=15mA$
$h_{fe}$	Small signal current gain at $f=20mc$	2N1252 2N1253	2 2.5	4 5.5		$I_C=50mA$ $V_C=10V$
$I_{CBO}$	Collector cutoff current			0.1μA 100μA	10μA 600μA	$V_C=20V$ $T=25^\circ C$ $V_C=20V$ $T=150^\circ C$
$t_s+t_f$	Turn off time			75μs	150μs	$I_C=150mA$ $I_{B1}=15mA$ $I_{B2}=5mA$ $R_L=40\Omega$ Pulse width=10ms

For full specifications, write Dept. B-2

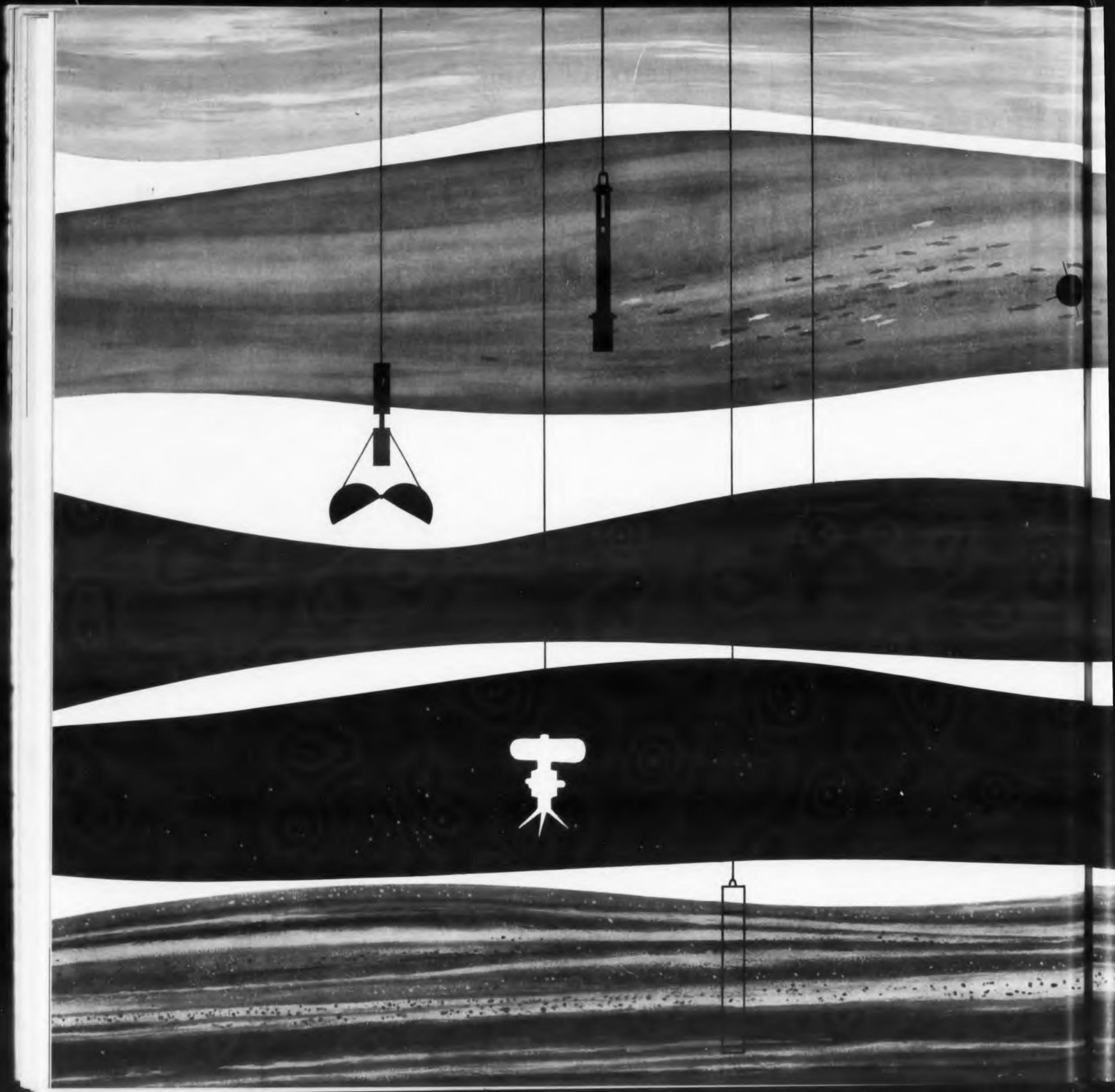


545 WHISMAN ROAD • MOUNTAIN VIEW, CALIFORNIA • YORKSHIRE 8-8161 • TWX: MOUNTAIN VIEW CAL 122  
New York Area: Pioneer 1-4770 • Syracuse: Granite 2-3391 • Philadelphia Area: Turner 6-6623  
Washington D.C.: National 8-7770 • Chicago: Browning 9-5880 • Los Angeles: OLeander 5-6058

◀ CIRCLE 71 ON READER-SERVICE CARD

CIRCLE 72 ON READER-SERVICE CARD

At factory prices of course!





**Lockheed's interest** in the virtually unknown 360,000,000 cubic miles of this planet's oceans, stems naturally out of its underwater environmental development work with the Navy's POLARIS Fleet Ballistic Missile.

Proposed studies in the increasingly important field of oceanography include: oceanographic research vessels; measuring instruments; data collection systems; underwater communication and navigation; and basic research regarding natural phenomena and military aspects of the deep sea.

## EXPLORING THE WORLD OF WATER

**Division Diversification** — Oceanography is typical of Lockheed Missiles and Space Division's broad diversification. The Division possesses complete capability in more than 40 areas of science and technology — from concept to operation. Its programs provide a fascinating challenge to creative engineers and scientists. They include: celestial mechanics; computer research and development; electromagnetic wave propagation and radiation; electronics; the flight sciences; human engineering; magnetohydrodynamics; man in space; materials and processes; applied mathematics; operations research and analysis; ionic, nuclear and plasma propulsion and exotic fuels; sonics; space communications; space medicine; space navigation; and space physics.

**Engineers and Scientists** — Such programs reach far into the future and deal with unknown and stimulating environments. It is a rewarding future with a company that has an outstanding record of progress and achievement. If you are experienced in any of the above areas, or in related work, we invite your inquiry. Please write: Research and Development Staff, Dept. B-21, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense clearance required.

## **Lockheed** / **MISSILES AND SPACE DIVISION**

*Systems Manager for the Navy POLARIS FBM;  
the Air Force AGENA Satellite in the DISCOVERER Program;  
and the MIDAS and SAMOS Satellites; Air Force X-7;  
and Army KINGFISHER*

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

◀ CIRCLE 920 ON CAREER INQUIRY FORM, PAGE 141

# What's the latest score on cartridges?

<input checked="" type="checkbox"/>	<b>1<sup>ST</sup></b>	ceramic cartridge was invented by Sonotone...
<input checked="" type="checkbox"/>	<b>13</b>	years ago. Today, over...
<input checked="" type="checkbox"/>	<b>65</b>	different manufacturers have specified Sonotone for...
<input checked="" type="checkbox"/>	<b>662</b>	models of high-quality phonographs. Altogether over...
<input checked="" type="checkbox"/>	<b>9,000,000</b>	Sonotone Ceramic Cartridges have been used for original and replacement purposes. ('Nuff said!)

## Sonotone CORP.

Electronic Applications Division, Dept. C23-20

ELMSFORD, NEW YORK

In Canada, contact Atlas Radio Corp., Ltd., Toronto

Leading makers of fine ceramic cartridges, speakers, microphones, electronic tubes.

CIRCLE 74 ON READER-SERVICE CARD

## NEW PRODUCTS

### Field Strength Meter

464

Measures pulse, cw, or modulated carriers



Intended for Loran and similar services, this hf-vhf field strength meter measures pulse, cw, or modulated carriers. Having the military designation of AN/PRM-21, the instrument operates from a 12-v battery or 115 v ac. A self-contained comparison pulse generator permits measurements of peak pulse field strength on the cathode-ray indicator. Identification of pulse rates is by means of an internally calibrated timing generator.

ITI Electronics, Inc., Dept. ED, 369 Lexington Ave., Clifton, N.J.

*Price & Availability: Both price and delivery time required are by quotation only.*

### Free Gyros

448

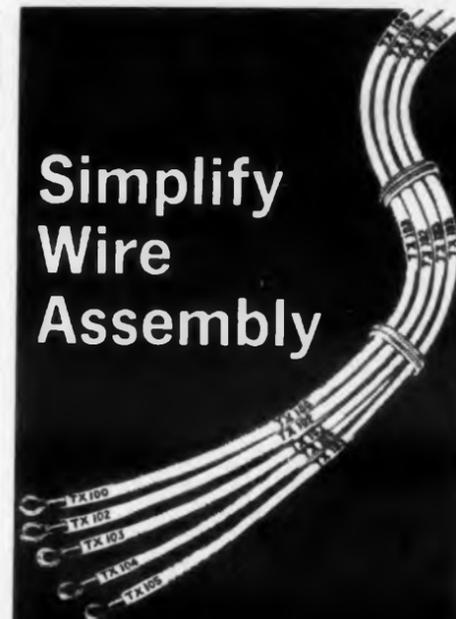
Operate in extreme environmental conditions



Models A2322-01 and A2311-04 free gyros are hermetically sealed and ruggedly constructed to operate in extreme environments. They stand 60 g of shock for 0.11 sec and 60 g vibration along any axis. Containing remotely operable caging and uncaging mechanisms, these units have 260-deg of gimbal freedom at the outer axes and  $\pm 85$  deg of freedom at the inner axes. They can provide output signals of pitch, roll, or yaw. The operating temperature range is  $-65$  to  $+185$  F; the excitation is 115 v, 400 cps, three-phase; and the run-up time is within 1 min. Applications are in missiles and other vehicles requiring guidance or stabilization.

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

## Simplify Wire Assembly



## with a KINGSLEY Wire and Tube Marking Machine

Now you can mark each wire or piece of plastic tubing with its own circuit number... quickly... economically, right in your own plant!

You reduce wire inventories because you need only one color of wire for as many circuits as necessary.

Simplify your assembly methods and speed production with the same machine that has proved so successful in the aircraft and missile industries. Write for details.

### KINGSLEY MACHINES

850 CAHUENGA • HOLLYWOOD 38, CALIF.

CIRCLE 75 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 3, 1960

# TOUGH



## ... AS A TURTLE'S BACK



**ARMAG\*-PROTECTED  
DYNACOR®  
BOBBIN CORES  
AT NO EXTRA COST!**

Tough-as-tortoise-shell Armag armor is an exclusive Dynacor development. It is a thin, non-metallic laminated jacket for bobbin cores that replaces the defects of nylon materials and polyester tape with very definite advantages—and, you pay no premium for Armag extra protection.

Tough Armag is suitable for use with normal encapsulation techniques on both ceramic and stainless steel bobbins. It withstands 180°C without deterioration—is completely compatible with poured potted compounds—has no abrasive effect on copper wire during winding—fabricates easily to close-tolerance dimensions—inner layer is compressible to assure tight fit on bobbin—does not shrink, age or discolor.

Write for Engineering Bulletins DN 1500, DN 1000A, DN 1003 for complete performance and specification data covering the wide range of Dynacor low cost Standard, Special and Custom Bobbin Cores—all available with Armag non-metallic armor.

\*TRADEMARK

# DYNACOR

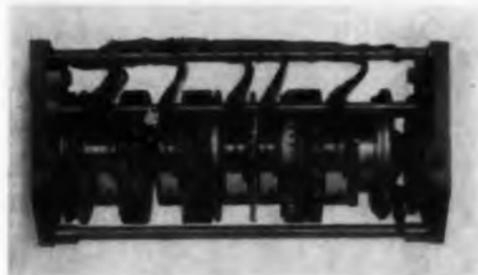
**DYNACOR, INC.**  
A SUBSIDIARY OF SPRAGUE ELECTRIC CO.

1012 Westmore Avenue, Rockville, Maryland  
CIRCLE 76 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 3, 1960

## Analog-to-Digital Converter 457

Direct reading type



This direct reading analog-to-digital converter displays time values in hours, minutes, and seconds. It transmits this information simultaneously as a coded electrical signal by means of coded drum assemblies and pick-off brushes. Step time is 40 msec max and 10 msec min. The brush load is 50 ma at 40 v dc. The operating pressure range is 14.7 to 0.55 psi. The unit has an operation life of 1000 hr and weighs 1.75 lb. It can be used for recording and simultaneous readout of continuous or interrupted industrial or aircraft procedures and processes, and generation of coded digital signals with equivalent visual numerical presentation.

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

*Price & Availability: Price is furnished on request. Delivery time is from 60 to 90 days.*

## Accelerometer Calibrator 451

Frequency range is 50 to 30,000 cps



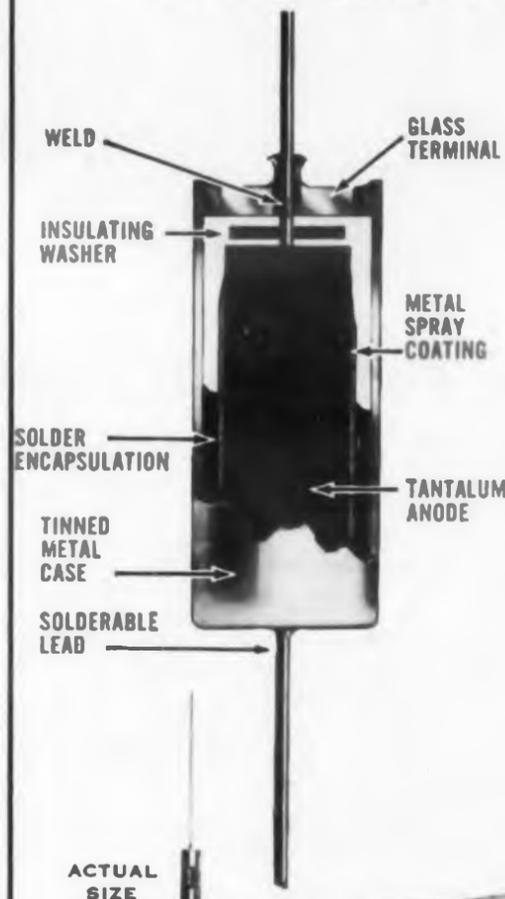
Model 4290 calibration exciter vibrates accelerometers or other small vibration pick-ups at a constant test level over the frequency range of 50 to 30,000 cps. A small accelerometer acts as a monitor for servo regulations of the driving signal generator to obtain the constant level of vibration. Used with model 3301 response recorder, it automatically measures and plots an accelerometer frequency response calibration from 200 to 20,000 cps and indicates mounted resonance up to 50,000 cps.

B & K Instruments, Inc., Dept. ED, 3044 W. 106th St., Cleveland, Ohio.

NO. 2 OF A SERIES

THE SMALLEST **ASTRON**  
SOLID TANTALUM  
CAPACITOR

# SUBMINIATURE



OCCUPIES  
ONLY 0.003 IN.<sup>3</sup>

Astron Tantalum Solid Electrolyte Capacitors are the smallest hermetically sealed units of a given rating available today.

Comparative sizes in cubic inches per microfarad-volt for various types of hermetically sealed and non-hermetically sealed capacitors are shown in the table.

CAPACITOR	RELATIVE CU. IN./MFD-V
Solid Tantalum	1.0
Wet Tantalum Slug**	.8
Etched Tantalum Foil**	4.5
Aluminum Electrolytic**	12
Metallized Mylar†	64
Metallized Paper	68
Paper*	130
Foil Mylar†	210

\*INSERTED TAB  
\*\*MIL QUALITY, NOT HERMETICALLY SEALED  
†REGISTERED DUPONT TRADEMARK

FOR COMPLETE INFORMATION WRITE TODAY FOR BULLETIN E-675A AND FOR ASTRON'S DESIGN ENGINEER PUBLICATION, TECHNIQUES, VOL. 58, NO. 2

ASTRON

# ASTRON

CORPORATION

255 Grant Avenue  
East Newark, New Jersey

SPECIALISTS IN CAPACITOR MINIATURIZATION

CIRCLE 77 ON READER-SERVICE CARD

# NEW!



## LOW-COST D-C POWER SUPPLIES

Standard output voltages from 3 to 1000 VDC at 30% intervals ...  
Maximum powers of 50, 100, 200, 400, 750\*, 1500\*, 3000\*\* watts

These new Sorensen MD supplies form one of the most comprehensive and economical power supply series on the market.

**More than 130 catalog models** to choose from, providing 20 output voltages in the range from 3 to 1000 vdc, inclusive. Sorensen engineers welcome the opportunity to develop non-catalog models for unusual requirements.

**Simple, rugged design** features magnetic voltage regulator to obtain  $\pm 1\%$  regulation against input line variations plus low-impedance silicon rectifier for good load regulation. (Typical regulation from 50% load to full load is 2% to 10%, depending on load current rating. Additional data can be supplied upon request.) Ripple: 1% rms max. (Some units can be supplied with 0.5% max. ripple.)

**Dependable, tubeless construction.** All parts are conservatively rated for continuous duty. Units will withstand output short circuits without damage to components.

**19-inch rack-panel mounting** for all units simplifies application in lab or custom-built equipment.

Rugged MD series supplies are just one example of the outstanding power-supply models offered by Sorensen. **Sorensen controlled power equipment, with the widest line, enables you to make the wisest selection.** Included are: regulated d-c supplies, regulated a-c supplies, variable frequency power sources (frequency changers; for example, 60 to 400 cps), high voltage supplies (to 600 kv, ac or dc), and miniature converters and inverters. Available in an extremely wide variety of input-output combinations. Write for complete specs. Sorensen & Company, Richards Ave., South Norwalk, Conn.

\*Voltage range, these sizes:  
6.3 to 1000 vdc

\*\*Voltage range, this size:  
12 to 1000 vdc



A subsidiary of Raytheon Company

### CONTROLLED POWER PRODUCTS

... the widest line lets you make the wisest choice

CIRCLE 78 ON READER-SERVICE CARD

## NEW PRODUCTS

### Power Supplies

454

Come in recessed and table models



For industrial and laboratory applications where 115 v ac line voltage is available for input, these power supplies are for portable, recessed, or table top use. Models 187 and 189 provide 0 to 120 v ac at 1 amp, 0 to 12 v ac at 2 amp, and 0 to 12 v dc at 2 amp. Models 190 and 191 have the following outputs: 0 to 120 v ac at 3.5 amp, 0 to 10 v ac at 10 amp, 0 to 20 v ac at 5 amp, 0 to 6 v dc at 10 amp, and 0 to 15 v dc at 5 amp. All units also supply line voltage at 10 amp. Accessories can be furnished to increase the dc output to 0 to 300 v at 100 ma and reduce ripple to less than 1%.

Buck Engineering Co., Dept. ED, Marcy St., Freehold, N.J.

**Price & Availability:** Models 187 and 189 are \$79; models 190 and 191 are \$139. They are available from stock.

### Germanium PNP Power Transistor

450

Maximum current rating is 5 amp



Germanium pnp power transistor type 2N1011 has a maximum current rating of 5 amp, a current gain range of 30 to 75 when  $I_c$  is 3 amp dc, and a maximum collector-base voltage rating of 80 v. It dissipates 35 w at 25 C, mounting base temperature. It meets environmental testing requirements. Suited for power switching and power control circuits, it can be used in aircraft power supplies, missiles, and communications power supplies. Other uses are high current switching and audio amplification. It meets the requirements of MIL-T-19500/67.

Bendix Aviation Corp., Red Bank Div., Dept. ED, Long Branch, N.J.

**Price & Availability:** In quantities of 1 to 99, the price is \$10.50 ea; 100 and up, \$7. Delivery time is two weeks on commercial items. When military testing is required, delivery time will be quoted.

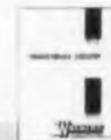
## CUSTOM CIRCUIT PACKAGING

### TRANSISTORIZED



**EVERYBODY KNOWS** ... about Walkirt's popular Plug-in and Cartridge style Circuit Modules, but did you know that we do Custom Packaging too? We'll wrap up YOUR circuitry, or any of our hundreds of digital and logic circuits ... in most any size or shape that your application requires. The photos above illustrate just a few of the many special sizes, shapes and header styles that we've built recently. If you'll send us your requirements, we'd like to quote. You'll be surprised at the economy, and speed of delivery, too!

Write for technical information on DIGITAL and LOGIC circuitry.



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141 W. HAZEL ST., INGLEWOOD 3, CALIF.

CIRCLE 79 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 3, 1960

## LIGHTWEIGHT



## RUGGED



# YARDNEY SILCAD® BATTERIES

Only 1/2 the size, 1/3 the weight of ordinary nickel-cadmium and lead-acid batteries... yet rugged enough for the most adverse conditions!

This is one reason industry is now designing with the long-life, maintenance-free YARDNEY SILCAD — economical, compact, rechargeable power for missiles, rockets, satellites and drones... for guidance, control, telemetering, storing energy supplied by solar energy converters... for such airplane and helicopter applications as engine starting, emergency lighting, power and communications... for portable ground power... and numerous commercial applications.



**YARDNEY  
ELECTRIC  
CORP.**

"Pioneers in Compact Power"®  
40-50 LEONARD STREET, NEW YORK 13, NEW YORK

Patents granted and pending.  
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CIRCLE 80 ON READER-SERVICE CARD  
ELECTRONIC DESIGN • February 3, 1960

## TV Image Storage System

439

Provides instant recall



This TV image storage system, called Electrostore, stores a single frame of television at the touch of a button and makes the stored picture available for prolonged examination on a conventional monitor. The system records the signal in an electrostatic storage tube. The readout of the stored image, as well as the input, is a composite video having standard amplitude and polarity. The system has input and output video bandwidths of 8 mc. The over-all resolution exceeds that of conventional TV systems.

Image Instruments, Inc., Dept. ED, 2300 Washington St., Newton Lower Falls 62, Mass.

## Voltage to Digital Converter

442

Linearity and accuracy are 0.01%



Model MTD-704 voltage-to-digital converter translates input analog voltages into four binary-coded decimal digits, plus sign and overflow digits. The input full scale range is  $\pm 10$  v dc with provision for an extended range of  $\pm 12$  v dc. Linearity and accuracy are rated at 0.01%. The maximum conversion rate is 5000 independent conversions per sec. A completely solid state unit, it meets the environmental requirements of MIL-E-4158B. Modular design is used. Applications are in automatic checkout systems, ground support equipment, and mobile data acquisition systems.

Epsco, Inc., Equipment Div., Dept. ED, 275 Massachusetts Ave., Cambridge, Mass.

Price & Availability: The price can be furnished on quotation only. Delivery time is about 60 days.

the smallest lightest  
**POWER DIVIDERS**  
are from

**TRANSCO PRODUCTS**



most complete line too!...

Design features of Transco's Power Dividers include broad bandwidth and low VSWR.

Here are four examples that have 50 ohm impedance, VSWR less than 1.3 to 1, and weigh only 2.5 to 4 oz:



"L" BAND  
1100-1400 MC  
Type N  
Coax Connector  
Part No. 40011

"S" BAND  
2700-3500 MC  
Type N  
Coax Connector  
Part No. 40013



"C" BAND  
5340-5960 MC  
Type N  
Coax Connector  
Part No. 40009

"X" BAND  
8.2-12.4 KMC  
Type UG 136  
A/U Connector  
Part No. 40015



Transco specializes in designing and manufacturing microwave components and systems for transmission control.

Creative microwave engineers... write for information about your future with this progressive, well established firm.

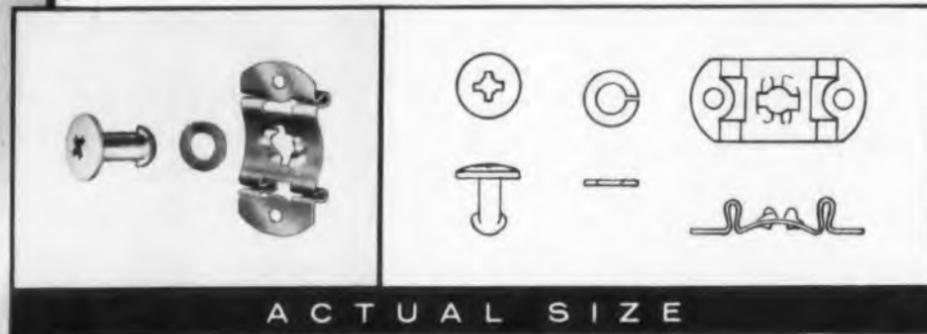
Send for complete Product Data on  
Power Dividers and  
Transco's Coaxial Switches

**TRANSCO PRODUCTS, INC.**  
12210 Nebraska Ave.  
Los Angeles 25, Calif.

CIRCLE 81 ON READER-SERVICE CARD

*Now...  
miniature*

*1/4 turn  
fasteners!*



**LION**  
*miniature*  
**FASTENERS**  
**1/4 TURN OPEN • 1/4 TURN CLOSED**  
**LIGHTWEIGHT • STRONG**  
**MINIMUM ENVELOPE**

A new size has been added to the Lion family of quick-opening fasteners... a miniature size. Small, compact, yet strong and rugged, these miniatures aid in reducing overall dimensions and weight without sacrificing the important advantages of larger Lion Fasteners.

**ALIGNMENT NOT CRITICAL**

Stud "floats" to accommodate misalignment. The hole in the sheet for the stud has an area 60% greater than the stud diameter. This allows a .030 float in all directions.

**WIDE VARIATION IN STACK HEIGHT**

Six different studs accommodate total material thicknesses (both sheets) of .040 minimum to .159 maximum.

Total sheet thickness served by any

one stud may vary as much as .019 without affecting operation. A Lion Miniature Stud, specified for a thickness of .0863, for example, will accommodate total sheet thicknesses from .080 to .099.

**SWAGED-NOSE STUD**

Extra strength and smooth operation are made possible by the exclusive Lion swaged nose design. All the metal is put to work. There are no holes, thin cross pins, or milled slots to weaken the cross-section. Case hardening assures long, trouble-free service without wear.

**LARGER SIZES AVAILABLE**

Lion Fasteners are also available in two larger sizes—No. 5 (mil spec) and No. 2—to meet the needs of air-

craft, missile and ground support equipment. The heads are supplied in a wide variety of styles including oval, flush, wing, ring, notched and knurled.

**FREE!**



**FASTENER HANDBOOK**

Send for your free copy of Southco Fastener Handbook No. 9. Gives complete engineering data on Lion Fasteners and many other special fasteners.

Write to Southco Division, South Chester Corporation, 235 Industrial Highway, Lester, Pennsylvania.

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MISSILES



CIVILIAN



MILITARY



COMMERCIAL

**LION** *Aviation* **FASTENERS**

one of the



CIRCLE 82 ON READER-SERVICE CARD

**NEW PRODUCTS**

**Floated Rate Integrating Gyro 458**

Linearity is 0.02%



Designed to be mounted directly on the frame of missiles or aircraft, model M2514-02 floated rate integrating gyro provides a linearity of 0.02% and an angular momentum of 250,000 gm<sup>2</sup> per sec. It can be used in place of a stable platform in some systems. It can be used in high speed aircraft or missile flights where severe environmental conditions are encountered.

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

*Price & Availability: Prices will be furnished on request. Units are delivered in 60 to 90 days.*

**Phase Detector 446**

Measures from 200 to 1000 mc



Type 205B2 precision phase detector has an accuracy of  $\pm 0.05$  deg or  $\pm 1\%$  from 200 to 1000 mc. Resolution is less than 0.01  $\mu$ sec. A phase angle of less than  $10^{-14}$  x 360 x frequency can be read on the dial. The maximum input signal depends on the sensitivity of the receiver; it is about 20  $\mu$ v for a receiver with a 5- $\mu$ v sensitivity, and about 3 v min when the panel meter is used as an indicator. The impedance is a nominal 50 ohms for input and output. In addition to measuring phase angle between two sine waves, this instrument can be used to measure phase angle of a pulse-modulated or a continuous sine wave, or two pulse-modulated coincident sine waves.

Ad-Yu Electronics Lab., Inc., Dept. ED, 249-259 Terhune Ave., Passaic, N.J.

*Price & Availability: Price is \$2235 fob Passaic. Delivery time is two weeks.*

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CIRCLE 83 ON READER-SERVICE CARD

GENERAL INSTRUMENT SEMICONDUCTOR DIVISION

# JAN TYPE

## GENERAL INSTRUMENT SILICON DIODES

### 1N457 1N458 1N459

When JAN type diodes are required, you can be certain that General Instrument's engineering skills and manufacturing facilities will enable us to deliver them at prices that reflect years of volume production experience.

The General Instrument line of silicon and ger-

manium diodes is the most complete available to the industry, with the widest possible range of characteristics. We also make a complete line of medium and high power silicon rectifiers, including all JAN types. Complete information and data sheets are available upon request.

Code No.	Min. Fwd. DC Cur. @ +1V	Max. Rev. DC Cur. @ Test V.		Test Voltage	Max. Inv. Voltage	Min. Breakdown Voltage*	Avg. Fwd. DC Cur. (Max.)
		25° C.	150° C.				
1N457	20 mA	.025 $\mu$ A	5 $\mu$ A	60V	60V	70V	75 mA
1N458	7 mA	.025 $\mu$ A	5 $\mu$ A	125V	125V	150V	55 mA
1N459	3 mA	.025 $\mu$ A	5 $\mu$ A	175V	175V	200V	40 mA

\*Reverse voltage at which a reverse current of 100  $\mu$ A flows.  
All ratings and characteristics are at 25° C. unless otherwise noted.  
Operating temperature range -80° C. to +200° C.



Semiconductor Division

GENERAL INSTRUMENT CORPORATION

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CIRCLE 84 ON READER-SERVICE CARD

## NEW PRODUCTS

### Cathode Ray Tube

443

For oscilloscope applications



Having a 3-in. rectangular face-plate, type 3BDP cathode ray tube is for oscilloscope applications. An improved replacement for type 3SP, it has a pressed face-plate to minimize parallax errors and a gun structure which provides greater rigidity and improved electrical stability. Focus and deflection are electrostatic. Over-all length is 9 1/8 in.

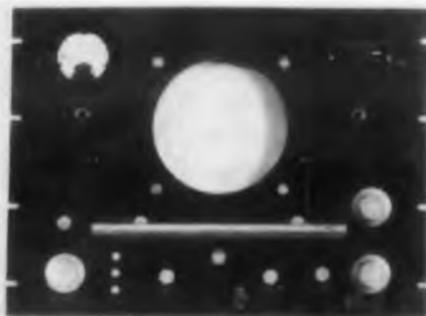
Allen B. Du Mont Labs., Inc., Dept. ED, 750 Bloomfield Ave., Clifton, N.J.

**Price & Availability:** Prices are furnished on request. Except for very large quantity orders, delivery is from stock.

### Test Set

435

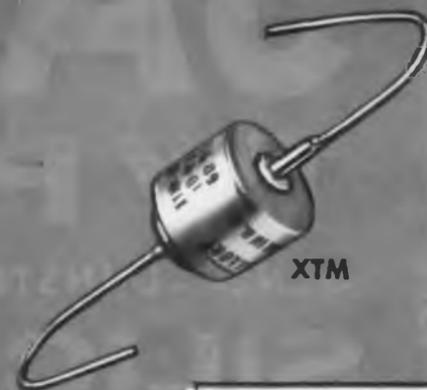
Checks transmission on audio circuits



Model TMS-0100 test set is for checking the characteristics of transmission lines and other voice-band equipment. Using swept-band techniques, it reduces the time needed to check-out a transmission network. A swept-frequency generator provides a sinusoidal wave of adjustable constant amplitude at all frequencies in the voice-band. A measuring system compares the network input and output regardless of the absolute power level. The information is displayed with a cathode ray tube. The unit is housed in a 19-in chassis for rack-mounting or a portable cabinet. A typical use is to check the insertion gain or loss of transmission circuits in service.

Hallamore Electronics Co., Div. of Siegler Corp., Dept. ED, 714 N. Brookhurst St., Anaheim, Calif.

# Choose your High Temperature from the



XTM



XTK



XTL



XTH



M2



XTO



XTV

15 Types of Mallory Tantalum Capacitors to Choose From  
... Seven Types for High Temperatures

Type	Description	Capacity Range	W. Volts DC Rtg. at 85°C	Temp. Range	Case Style	Body Length	Body Diameter
M2	Pellet Anode—Liquid Electrolyte	11-140 mfd.	90-6V.	-55 to +150°C	Metal Case-Axial Leads	.500"	.287" (Body) .484" (Flange)
XTK	Pellet Anode—Liquid Electrolyte	2-70 mfd.	340-8V.	-55 to +175°C	Metal Case-Axial Leads or Terminal	.438" to 1.313"	.625"
XTM	Pellet Anode—Liquid Electrolyte	4-140 mfd.	340-8V.	-55 to +175°C	Metal Case-Axial Leads or Terminal	.566" to 1.800"	.625"
XTL	Pellet Anode—Liquid Electrolyte	3.5-120 mfd.	630-18V.	-55 to +200°C	Metal Case-Axial Terminal	.500" to 2.595"	.875"
XTH	Pellet Anode—Liquid Electrolyte	7-240 mfd.	630-18V.	-55 to +200°C	Metal Case-Axial Terminal	.688" to 4.065"	.875"
XTV	Pellet Anode—Liquid Electrolyte	18-1300 mfd.	630-30V.	-55 to +175°C	Metal Case-Axial Terminal	.563" to 2.750"	1.125"
XTO	Pellet Anode—Liquid Electrolyte	7-240 mfd.	630-18V.	-55 to +200°C	Metal Case-Axial Terminal	.563" to 2.750"	1.125"

#### ... And Eight Other Types

HAT: microminiature, 1-10 mfd., -20 to +85°C, metal case  
 TAS: miniature, solid type, .33-330 mfd., -80 to +85°C, metal case  
 TAM: microminiature, solid type, 6.8-56 mfd., -55 to +85°C, encapsulated  
 TAF: foil type, .25-440 mfd., -55 to +85°C, metal case  
 STNT: subminiature, 2-40 mfd., -55 to +85°C, metal case  
 TNT: miniature, 4-80 mfd., -55 to +85°C, metal case  
 TAP: miniature, 2-30 mfd., -55 to +100°C, metal case  
 TAP2: miniature, 11-140 mfd., -55 to +85°C, metal case

Immediate Delivery on All 15 Types

# e Tantalums

# e MALLORY line

... broadest selection in the industry

When you need tantalum capacitors for high temperature service, look first to the wide Mallory line. You're sure to find a Mallory model right for your requirements—right in reliability . . . and right in rating, size, mounting.

Pioneer in extreme temperature ratings, Mallory gives you a broad choice: 200°C Types XTL, XTH and XTO and 175°C Type XTV—3.5 to 1300 microfarads; smaller 175°C Types XTM and XTK—2 to 140 microfarads; and miniature 150°C Type M2—11 to 140 microfarads. In a variety of hermetically-sealed, corrosion-resistant case styles . . . mounting and terminal arrangements for ordinary or high-shock service.

Choose from 15 types of Mallory tantalums—microminiature to high capacitance, foil or pellet anode, solid or liquid electrolyte, encapsulated or metal case, medium or high temperature. Their reliability is proved by 18,000-hour tests, by over a decade of trouble-free service—with unequalled stability of capacitance, equivalent series resistance and low leakage values.

Write today for technical data . . . and for expert consultation on your circuit requirements, see a Mallory capacitor specialist.

## Mallory Capacitor Company

Indianapolis 6, Indiana

a division of



See Mallory Capacitor Company for a complete line of aluminum electrolytics, tantalum capacitors and motor capacitors



CIRCLE 85 ON READER-SERVICE CARD

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Electronic Wholesalers

### Waterproof Markers

576

The Speedy-Marx line of pressure sensitive electrical markers now come on quickly released cards. These markers, which are unaffected by grease, dirt, and abrasion, are available in constructive and solid numbers, letters, and symbols. Special markers can be ordered.

North Shore Nameplate Inc., Dept. ED, 214-27 Northern Blvd., Bayside 61, N.Y.

*Price & Availability: Minimum order is 25 identical or assorted stock items or 50 identical special items. Stock items, in quantities of 25 to 99, are \$0.195 per card. Special items, in quantities of 25 to 99, are \$0.30 per card. Delivery from stock is immediate; on special orders, one week. Prices are reduced for large quantity orders.*

### Alligator Clips

577

For heavy terminal use, these clips have matched jaws opening to 5/8 in. Both solder and solderless connections are available. They are made of cadmium-plated steel or solid copper.

Herman S. Smith, Inc., Dept. ED, 2326 Nostrand Ave., Brooklyn 10, N.Y.

### High Fidelity Speakers

578

Model K-12-HFC 12 in. coaxial speaker is a two-way extended range system with flat response from 30 to 18,000 cps. Impedance is 8 ohms. Power handling is 15 w program, 30 w peak.

Minneapolis Speaker Co., Dept ED, 3806 Grand Ave. S., Minneapolis 9, Minn.

### Cable Clamps

579

Are made of cadmium-plated carbon steel, heat treated, for performance at temperatures up to 550 F. Presently designed in the 10-32 thread size in 3 bracket lengths of 0.45, 0.65, and 0.85 in. Mounting holes 0.13 in. in diameter permit the use of 1/8-in. aluminum alloy rivets.

Elastic Stop Nut Corp. of America, Dept. ED, 2330 Vauxhall Road, Union, N.J.

### Metal Stampings

580

Strips of base metals such as nickel, kovar, molybdenum steel, and others are clad with tin-lead solders, silver, gold, and related alloys. The clad strip is stamped into discs, washers, and special shapes for automatic joining operations. Other uses are heat sinks, base rings or tabs, diaphragms, and contacts for special electronic applications.

Alloys Unlimited, Dept. ED, 21-01 43rd Ave., Long Island City, N.Y.

### Correction Notice

Type XR-5019 epoxy resin, (ED, Nov. 11, 1959, p 148), has an initial viscosity of 1000 cps at 76 C, and not 100 cps as stated. The product is made by Minnesota Mining and Manufacturing Co., 900 Bush Ave., St. Paul 6, Minn.

# NEW

## THE MOST COMPACT LOW-PASS, HIGH-PASS MICROWAVE FILTERS

### Available for Rated Characteristics

Frequency Standards now introduces a standard line of low-pass and high-pass microwave filters, the smallest and lightest available for rated characteristics.

The filters can handle power capacities of up to 2 KW peak. All have a maximum insertion loss of 0.5 db in their pass-band. Input VSWR below the 0.1 db down point for low-pass filters and above it for high-pass filters is held to 1.5:1 or less.

Units are furnished with Type N RF connectors.

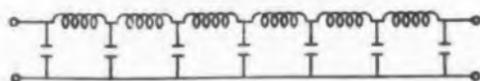
#### LOW-PASS FILTERS

##### Standard Low-Pass Filters Available

Model	1 db Down Frequency
FS 5L	500 MC
FS 12L	1200 MC
FS 23L	2300 MC
FS 31L	3100 MC
FS 60L	6000 MC



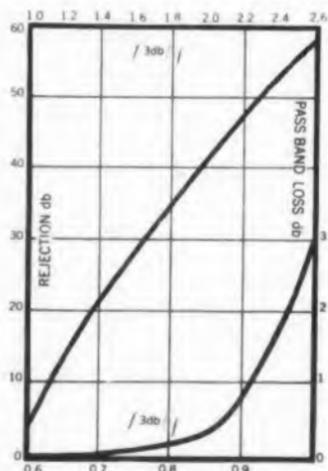
13 ELEMENT NETWORK



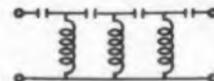
#### HIGH-PASS FILTERS

##### Standard High-Pass Filters Available

Model	1 db Down Frequency
FS 4H	400 MC
FS 9H	900 MC
FS 20H	2000 MC
FS 27H	2700 MC
FS 54H	5400 MC



7 ELEMENT NETWORK



Filters having other 1 db down frequencies, different numbers of elements or other types of RF connectors are available on special request.

Write for Further Information

### FREQUENCY STANDARDS

Division of Harvard Industries, Inc. Box 504, Asbury Park, New Jersey

Phone: PRospect 4-0500 TWX A PK 588

## NEW PRODUCTS

### Directional Gyro 473

Provides attitude information in aircraft and missiles

Type A2215 directional gyro provides accurate attitude information in aircraft and missile applications. A liquid bubble-type vertical sensing element generates error signals proportional to spin axis displacement from horizontal; wiring modifications enable the sensor to be connected to the leveling torquer to complete the inner axis leveling loop. Drift is 4 deg per hr max. The unit stands vibration of 5 g from 20 to 1000 cps, or 10 g from 1000 to 2000 cps. The operative temperature range is  $-54$  to  $+71$  C.

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

### Dust Hood 373

Working area measures 34 x 24 x 19-1/4 in.

With a 34- x 24 x 19-1/4 in. working area, this dust hood, called Microvoid, removes airborne dust particles down to 0.5 micron in diam. An internal positive pressure prevents unfiltered room air from entering the open front. The unit is constructed of optically clear, 1/4 in. Plexiglas with all edges fused and flame polished to eliminate shadows, rough surfaces, and leakage. The hood weighs 35 lb.

Air-Shields, Inc., Dept. ED, Industrial Div., Hatboro, Pa.

### Shielded Air Vent 421

Attenuates rf 100 db min

This shielded air vent provides 100 db min attenuation of rf up to 10,000 mc and beyond. Applications of the unit include: shielded enclosures, test equipment, computers, microwave cabinets, telemetry equipment, scintillation counters, and radiation measuring devices.

Shieldair, Dept. ED, Box 28H, Riverton, N.J.

Price & Availability: Delivery varies according to special features required. Price on request.

◀ CIRCLE 86 ON READER-SERVICE CARD



## Motorized Rheostats 563

For remote control use

These motorized rheostats are used in remote control applications or where a predetermined rate of resistance or voltage change must be smoothly achieved. Standard drives consist of a motor with integral gear reducer, and cam-operated limit switches to accomplish reversal of the control. Assemblies for horizontal and vertical mounting are available.

Ohmite Manufacturing Co., Dept. ED, 3677 Howard St., Skokie, Ill.

## Environmental Chamber 557

Measures 12 x 7 x 10 ft

Measuring 12 x 7 x 10 ft, this walk-in environmental chamber handles all standard tests except altitude. Tests include temperatures as high as +185 F and as low as -90 F soak and -65 F operational as well as fungus, salt spray, sand, dust, sunshine, rain, and humidity. The chamber has a mechanical refrigeration system and a 25-ton CO<sub>2</sub> cooling system. It is suitable for testing all types of mobile ground support equipment, test stands, load banks, and many other items.

American Electronics, American Labs Div., Dept. ED, 1536 E. Ross Ave., Fullerton, Calif.

## Single Crystal Metal 413 Specimens

Usual tolerance is  $\pm 2$  deg

Single crystal specimens in aluminum, cadmium, copper, lead, nickel, silver, tin, and zinc are offered in many sizes and shapes. Almost any crystal orientation may be specified; the usual tolerance is  $\pm 2$  deg. Unusual shapes such as hollow cylinders and tensile test specimens with enlarged ends can be furnished. Electrical, magnetic, and physical properties are excellent. Typical applications are in ferrites, semiconductors, and platinum cobalt crystals.

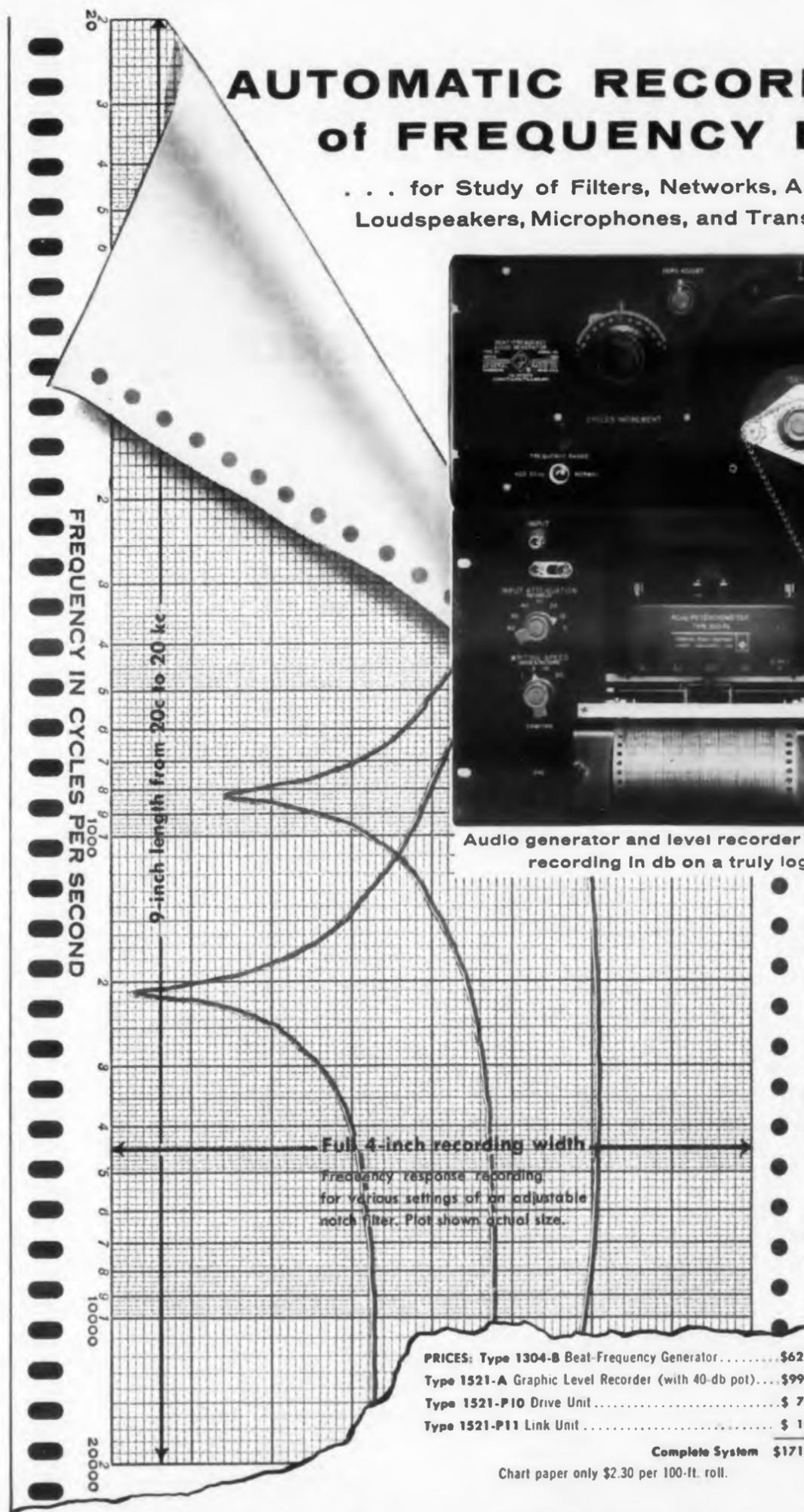
Flow Corp., Dept. ED, 85 Mystic St., Arlington 74, Mass.

# AUTOMATIC RECORDING of FREQUENCY RESPONSE

... for Study of Filters, Networks, Amplifiers, Equalizers,  
Loudspeakers, Microphones, and Transducers of All Types.



Audio generator and level recorder couple mechanically for graphic recording in db on a truly logarithmic frequency scale.



PRICES: Type 1304-B Beat-Frequency Generator.....\$625  
 Type 1521-A Graphic Level Recorder (with 40-db pot)....\$995  
 Type 1521-P10 Drive Unit.....\$ 72  
 Type 1521-P11 Link Unit.....\$ 18

Complete System \$1710

Chart paper only \$2.30 per 100-ft. roll.

### SYSTEM SPECIFICATIONS

Frequency Range: Generator, 20c to 20 kc on logarithmic scale, 20 kc to 40 kc. Recorder, traces rms level from 20c to 200 kc.

Generator Output: flat within  $\pm 0.25$  db from 20c to 20 kc. Output is adjustable from 5 mv to 50v open-circuit. Harmonic distortion is less than 0.25% from 100c to 10 kc, 0.5% below 100c, 1% above 10 kc.

Recorder Sensitivity: 1 mv, maximum (corresponds to 0 db). Can be varied from 1 mv to 1v in 10 steps with input attenuator.

Recorder Range: 40-db full scale, with plug-in potentiometer supplied; 20-db and 80-db pots also available.

Pen Writing Speed: 20 in/sec maximum with 40-db Pot (200 db/sec) with less than 1-db overshoot. Slower speeds (1, 3, or 10 in/sec) selected by panel switch to provide mechanical filtering of rapidly fluctuating levels.

Paper Speeds: 2.5, 7.5, 25, and 75 in/min. Optional slow-speed motor available for speeds from 2.5 to 75 in/hr.

Recorder Accuracy: Static accuracy better than 0.4% of full scale. Fast servo system with low overshoot provides excellent dynamic accuracy.

Write For Complete Information

## GENERAL RADIO COMPANY

Since 1915 — Manufacturers of Electronic Apparatus for Science and Industry

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PHILADELPHIA: Tel. HANcock 4-7419

WASHINGTON, D. C.: Tel. JUNiper 5-1088

SAN FRANCISCO: Tel. WHitecliff 8-8233

LOS ANGELES 38: Tel. HOLlywood 9-6201

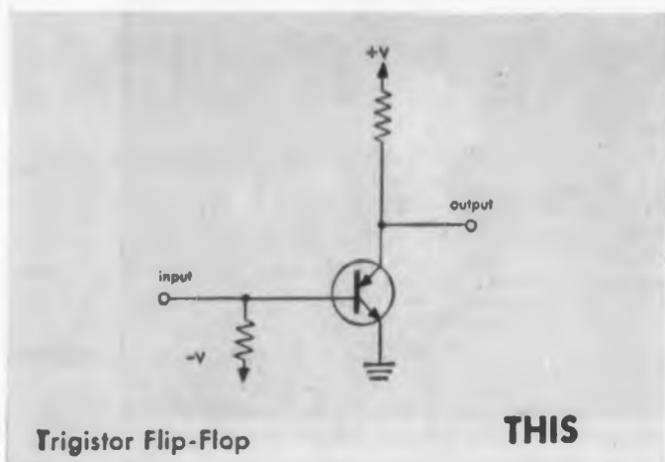
In CANADA, TORONTO: Tel. CHerry 6-2171

We introduced our first cathode-ray oscilloscope with a German-made tube in 1931, and in 1933 substituted a better tube manufactured by Westinghouse. We introduced the linear sweep circuit in 1932. That circuit is still used in today's scopes.

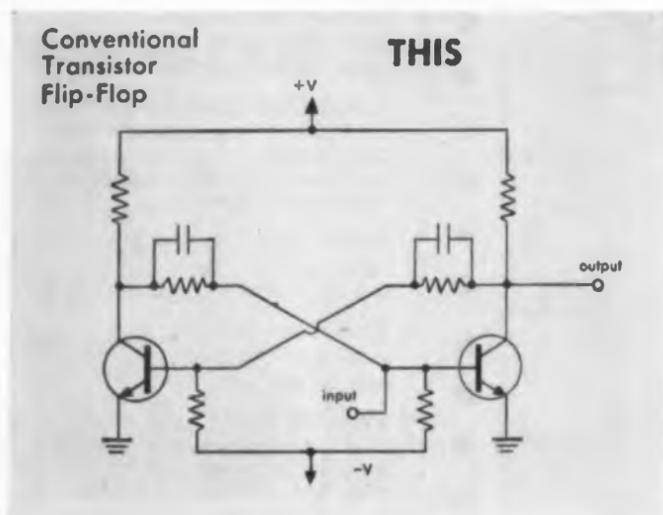
CIRCLE 87 ON READER-SERVICE CARD

announcing

# A "CIRCUIT EQUIVALENT" COMPONENT with flip-flop characteristics



EQUALS



## THE SILICON TRIGISTOR

SSPI

Advanced diffusion techniques at SSPI have produced the Silicon Trigistor – the first commercially available "Circuit Equivalent" semiconductor component, with characteristics comparable to the flip-flop or bistable multivibrator.

The Trigistor is a silicon PNP device with *triggered turn off* as well as triggered turn on control at its base. A low level positive trigger pulse applied to the base turns it on, and it remains on without sustaining base current. A negative trigger pulse on the base turns it off. The 3C Series is designed for bistable switching in the range of 1 to 8 mA collector current with collector voltage ratings to 60V.

Usually the Trigistor will perform the same function as two transistors plus several associated capacitors and resistors. Thus through circuit simplification both smaller size and higher reliability can be achieved.

Available now through your local SSPI representative or by contacting the factory direct.

Write for Bulletin C410-01

## NEW PRODUCTS

### Oscillator Control 564

Provides stable audio sources

Employing a zero temperature coefficient reed and ceramic ferromagnetic structural material, model J-610 oscillator control unit provides stable audio sources when used in recommended tube or transistor circuits. Stability is within 0.01% or 0.1 cycle, whichever is greater. Output voltage is essentially sinusoidal with distortions as low as 0.5% obtainable.

Security Devices Lab., Div. of Sargent & Greenleaf, Inc., Dept. ED, Rochester 21, N.Y.

### Oven 570

For testing and conditioning

Designed for temperature testing and conditioning processes, this forced air circulation oven has a temperature range from 35 to 350 C. The unit has through wall portholes for insertion of thermocouples or electrical test leads, indicating-controlling thermostat, and an automatic overtemperature controller.

Electric Hotpack Co., Inc., Dept. ED, Cottman & Melrose St., Philadelphia 35, Pa.

**Price & Availability:** Delivery 30 days after order received. Prices vary with unit size. Quotation on request.

### Pressure Switch 552

Stands to 200 psi

This miniature, adjustable pressure switch exceeds the requirements of MIL-E-005272B for performance up to 200 psi under vibration, shock, and acceleration test conditions. A pressure capsule and a snap-action switch are contained in a stainless steel housing. The volume of the switch is less than 1 cu in. and the weight is slightly more than 1 oz.

The Bristol Co., Dept. ED, Waterbury 20, Conn.

**Price & Availability:** The price is on quotation only; units are from stock after February 1st.

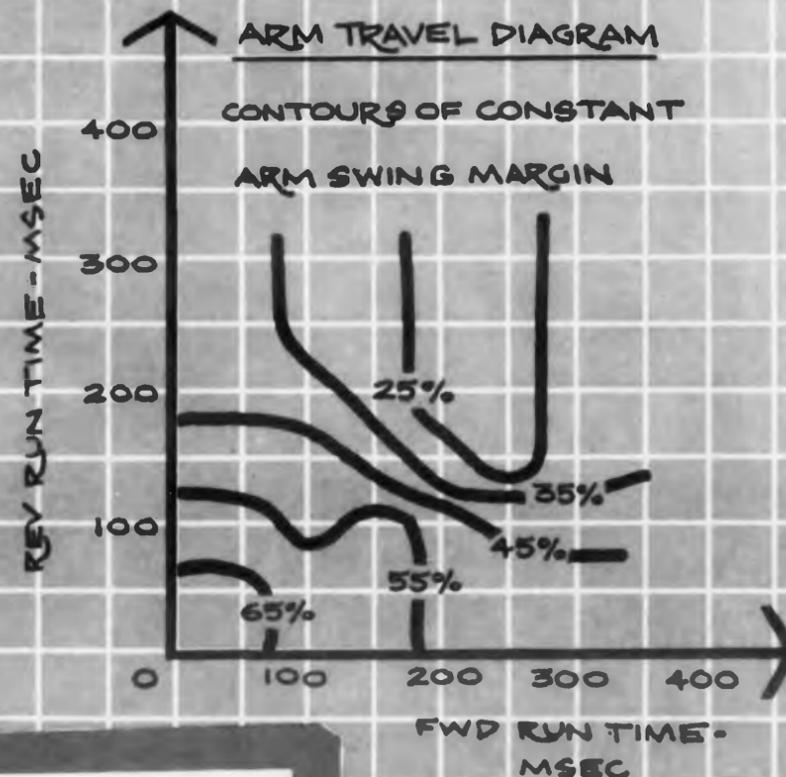
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**SOLID STATE** Products, Inc.

ONE HINDEN STREET • SALEM, MASSACHUSETTS  
PHONE 825-2800

# THE MOST TAPE HANDLER FOR YOUR MONEY

## HERE'S PROOF



1" TAPE 120 IPS  
FULL UPPER REEL

### SPECIFICATIONS

- TAPE SPEED**  
100 and 50 ips, standard.  
Maximum speed: 150 ips.  
Minimum speed: 1.0 ips.
- START TIME**  
3 milliseconds or less.
- STOP TIME**  
1.5 milliseconds or less.
- STOP DISTANCE**  
0.100"  $\pm$  .035" at 100 ips.
- REWIND**  
300 ips constant speed either direction. 1 3/4 minutes for 2400 feet, millisecond start-stop, with 1/2" tape.
- INTERCHANNEL TIME DISPLACEMENT**  
 $\pm$  2 microseconds at 100 ips from center clock to outside track on 1/2" tape.
- COMPUTER INPUTS**  
All functions including speed selection, FWD, REV, FAST FWD, FAST REV, controlled with 0 volt "OFF," -5 volt "ON," level type signal. Other level or pulse control signals can be accommodated on special order.
- BLOCK FEED REP RATE**  
200 blocks/second maximum.
- TAPE TENSION**  
3 oz. nominal, 1/2" tape.  
Maximum tension in guide system, approximately 6 oz.
- SIZE**  
24 1/2" high swing-out panel for 19" rack mount.  
Hinge mounts separately for ease of installation.

## Torquemeter 419

Provides adjustable full-scale torque

This torquemeter provides linear deflection to any full scale torque within 50% to 100% of the sensor maximum torque. The sensor detects dynamic torque transmitted by shafts at speeds to 24,000 rpm without brush contact with the rotating element. Accuracy is within 2% of full scale. Interchangeable sensors have maximum torque ratings of 0 to 1 oz-in. up to 0 to 500 lb-in.

Rotiform Co., Dept. ED, 1509 Colorado Ave., Santa Monica, Calif.

## Pilot Lights 416

Are water-tight

Type 101-8430W water-tight pilot lights measure 1-7/64 in. in length and mount in a single 15/32-in. clearance hole. They have a flat neoprene gasket on the shank of the lens holder and a retained O-ring seal behind the flange of the mounting bushing. No special insulating washers are required. Able to accommodate a T-1-3/4 midget-flange-base incandescent lamp of 1.3 to 28 v, units meet all applicable Mil specs.

Dialight Corp., Dept. ED, 60 Stewart Ave., Brooklyn 37, N.Y.  
**Price & Availability:** The price is quoted on request. Units are immediately available from stock.

## Cleaning Equipment 422

Comes in 3 sizes

This cleaning system is available with up to four or more cleaning stages: a Freon distillate flush, sonic energy clean, sonic energy rinse, and Freon vapor rinse. It may be used for cleaning parts or assemblies which are incompatible with hydrous solution. The complete system has a stainless steel cabinet, and comes in 3 cleaning chamber sizes of 9 x 14, 14 x 20, and 18 x 25 in.

Sonic Energy Products, Dept. ED, Bendix Aviation Corp., Davenport, Iowa.

**Price & Availability:** Delivery 90 days after order is received. Prices quoted on special order.

CIRCLE 89 ON READER-SERVICE CARD

The Potter 906 II, the high-speed digital magnetic tape handler that has come of age gives you higher performance, greater reliability and lower cost than any other tape handler on the market—bar none.

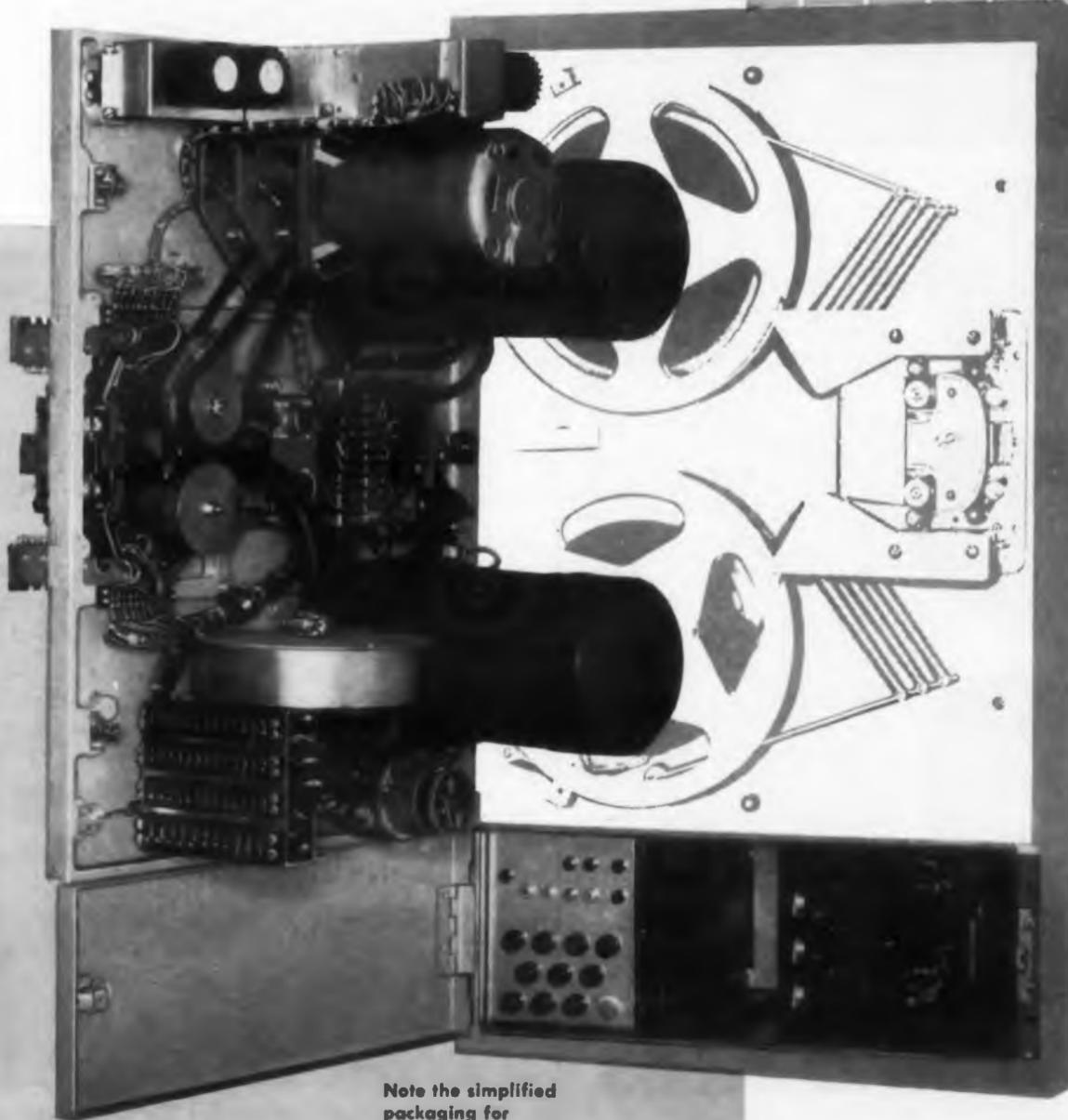
If you're interested in computer efficiency, you'll appreciate the kind of high performance shown by the actual test results plotted to the right. The Potter 906 II is the first and only tape transport to offer full forward-reverse cycling at 120 ips with 1" tape.

You'll be interested, too, in the other advantages that the 906 II now gives you for the first time. Among these are—

1. Low skew tape guide permits conventional recording at 400 bpi density.
2. Densities of 1500 bpi can be achieved by using this transport with the Potter Contiguous Double Transition system—450,000 8-bit characters per second on 1" tape.
3. Transistorized control of all functions simplifies computer design.
4. Simplified packaging for easy maintenance.
5. A price—far below other makes—that proves the economy of superior design.

Compare them any way you like—spec for spec, dollar for dollar, space for space—and you'll agree that the high-performance, low cost, Potter 906 II is the most tape transport at any price.

## MODEL 906 II Magnetic Tape Handler



Note the simplified packaging for accessibility and easy maintenance.

POTTER INSTRUMENT CO., INC.

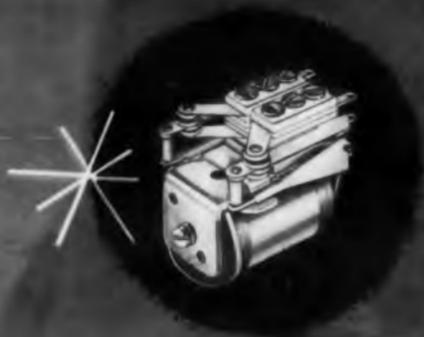


Sunnyside Boulevard, Plainview, L. I., N.Y.  
Overbrook 1-3200

Thinking of  
**SMALL  
RELAYS?**

**ADVANCE**

*builds 'em  
for heavy loads  
and long  
service!*



**Cramped quarters** don't cramp the style of ADVANCE midgets and miniatures. You can use them on loads from 1 to 10 amperes continuously... and at three times their rating intermittently—with complete safety. They'll resist shock and vibration... stand up under temperature extremes. You'll find them readily adaptable to any mounting need... any type of duty. Some examples:



Miniature DC Type  
**MK SERIES**

Extreme light weight and small size—requires only .5 cu. in. mounting space. Switching is above ground, insulation material is silicone glass. Beryllium copper armature hinges provide stability under shock and vibration.



Miniature Telephone Type  
**TQ SERIES**

Only .94 cu. inches in size, yet this relay carries 3-amp. loads in any combination up to 6 PDT. Mechanically secured throughout, it's extremely efficient. Non-gassing insulation. Withstands 10G vibration. Temp. range:  $-50^{\circ}$  to  $+85^{\circ}$ C.



General Purpose Midget  
**GH SERIES**

Engineered for high efficiency in thousands of applications. The small size of these midgets allows installation where space is a problem. Available in open types, 5- and 10-amp. ratings... in dustite plastic enclosures, 5 amps., and 5-amp. plate circuit types.

**AVAILABLE OFF THE SHELF**  
from your local  
Elgin-Advance Distributor

**ELGIN-ADVANCE RELAYS**

A PRODUCT OF ELECTRONICS DIVISION  
ELGIN NATIONAL WATCH COMPANY  
2435 NO. NAOMI ST., BURBANK, CALIF.

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## NEW PRODUCTS

### Potentiometer

433

Available with 0.05% linearity



Designed to meet the environmental requirements of MIL-E-5272B and NAS 710, model 0610M multiturn potentiometer measures 1/2 in. in diam. It has a stop torque-limit of 25 oz-in. Operating temperature range is from  $-55$  to  $+125$  C. It is available with a linearity to 0.05%.

Analogue Controls, Inc., Dept. ED, 200 Frank Road, Hicksville, N.Y.

*Price & Availability: Standard catalog models available in 2 to 4 weeks. Prices on quote.*

### Wattmeter

512

Resolution to 0.01% of rated input



For measurements at sustained accuracy and resolution down to 0.01% of rated input, model 1483 electronic wattmeter provides a low impedance dc output. It can be used to actuate digital meters and to drive strip-chart recorders. Ranges are 250, 500 and 1000 w. Input is 5 amp normal and 10 amp max. The unit measures about 20 x 14 x 10 in., and approximate weight is 27 lb.

Weston Instruments Div. of Daystrom, Inc., Dept. ED, 614 Frelinghuysen Ave., Newark 2, N.J.

### Bandpass Amplifier

429

Has a 30 to 300 mc range



Bandpass amplifier model 330-M4 has an rf gain of 6 db, noise figure of 8 db avg, and a 30 to 300 mc range. The unit is basically a distributed

# new!



## L&N's 4232-B High Precision Guarded Wheatstone Bridge measures to 11,111 megohms

Already, standardizing laboratories are using this L&N Wheatstone Bridge as their prime measuring instrument for all d-c resistance measurements. In the manufacture of high quality resistors, it is being used for making accurate measurements on a semi-production basis.

Unique design features, never before obtainable in a bridge of this accuracy, include guarding to prevent errors resulting from leakage during adverse humidity conditions, and rheostat dial values direct-reading in digits.

**List No.—4232-B High Precision Guarded Wheatstone Bridge.**

**Range—1 ohm to 11,111 megohms.**

**Ratio Arms—Plug and block controlled. Values: 1, 10, 100, 1000, 1000', 10,000, 10,000' and 100,000 ohms.**

**Rheostat—10(10,000 + 1000 + 100 + 10 + 1 + 0.1) ohms.**

**Certificate—L&N Certificate, supplied with each bridge, gives following data: Ratio Resistors: measured values of each resistor given to 0.001% at 25 C. Values will give ratios that are correct to within 0.005%, except 100,000 ohms and 1 ohm, which provide ratios correct to within 0.01%. Rheostat Dials: measured values for each position of 10,000, 1000, 100, 10, 1 and 0.1 ohm dials given at 25 C. Rheostat settings of 200 ohms or more are correct to within 0.005%; below 200 ohms, correct to 0.01 ohm.**

**Limits of Error—Overall error at 25 C with minimum of 1000 ohms in rheostat arm:  $\pm(0.01\% + 0.001 \text{ ohm})$  up to 1.11 megohms.  $\pm 0.02\%$  above 1.11 megohm to 111 megohms.  $\pm 0.2\%$  above 111 megohms to 1111 megohms.  $\pm 2\%$  above 1111 megohms to 11,111 megohms.**

**Case—Metal; 19" x 10 1/2" x 9 1/2" for 19" relay rack mounting. Wt. is 33 1/2 lbs.**

**Price—\$2100.00 f.o.b. Phila. or North Wales, Pa. (subject to change without notice). Order List No. 4232-B from L&N 4908 Stenton Ave., Philadelphia 44, Pa.**

**LEEDS NORTHROP**  
Instruments Automatic Controls • Furnaces

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ELECTRONIC DESIGN • February 3, 1960

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## THERMISTORS and VARISTORS

VECO is first in the minds of most engineers whenever—and wherever—thermistors and varistors are needed . . . . because VECO can always be relied upon for engineering know-how, quality, and fast reliable service as well as rigid quality control.

Manufactured to MIL-Q-5923 and other applicable MIL standards.

VECO glass enclosed thermistors are not adversely affected by radiation.

VECO, a leader in solid state electronics, also manufactures a variety of electronic controls, gas analysis cells, electronic and thermal instruments, medical and biological instrumentation, experimentors and circuit design kits and temperature sensing devices.



Write for free VECO Technical Catalog with data on more than 650 VECO stock items.

Booth 1423 IRE Show  
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108 Springfield Road, Union, N. J.  
MUrdoch 8-7150

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bandpass amplifier coupled to parallel grounded grid amplifier stages having individual outputs. It measures 5-1/4 x 5-1/4 in. with a standard 19 in. relay rack panel.

HRB-Singer, Inc., Dept. ED, Science Park, State College, Pa.

### Silicon Zener Diodes 441

Are rated at 10 w



These 10-w silicon Zener diodes have three-layer seals providing high resistance to temperature extremes, humidity and shock. Designed specifically for commercial equipment applications, they have low Zener impedance and sharp Zener knees. They are furnished in the standard RETMA 10% voltage steps from 5.6 to 27 v.

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

Price & Availability: Priced at approximately \$5.40 ea, units are available from stock.

### Digital Module 430

Has 2 independent circuits



Containing 2 independent circuits, this transistorized module, model ST-102, is designed to drive the firm's line of M-Pac circuits. The output signal switches between 0.7 and 20 v as the input signal crosses the triggering level. Power requirements are 20 v at 7 ma, and -90 v at 0.1 ma.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

Price & Availability: Available from stock. Price is \$59.

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## LOOK INTO CEC CONNECTORS

... see why they're guaranteed to give you highest reliability

The only thing you can't see for yourself is CEC's design and manufacturing experience in multi-contact rectangular connectors with snap-in contacts. That experience is well represented in the following features:

- Portal-hood speeds final assembly, permits full inspection of interior.
- Firmly attached cable clamp secures all wires to each other and to the connector.
- Jackscrews lock plug and receptacle together to withstand 50 g shock and cycling from 54 to 2,000 cps.
- Sturdy hood holds the insulator block... houses and protects the mated connector.
- Insulator block has deeply recessed contact openings and an unusually long insulation creepage path.

Yes, we can deliver. The 50-contact unit shown here is among many CEC types with 26, 34, 42, 50, 75 and 104 contacts.

For complete information, write for Bulletin CEC 4004-X21. Ask about CEC connector designs to your exact requirements.



Four prong retention springs on pin and socket allow each contact to snap into insulator blocks easily, yet resist an axial pull of more than 20 lb. Inspection holes provide built-in quality control, permit visual checking of each wire for proper contact prior to assembly of connector.

Electro Mechanical  
Instrument Division

# CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

## UPPER STRATA STRATEGY!

Friend of ours who always attends the sessions in the lecture halls, starts on the Fourth Floor with Production Items . . . and works his way down to Components on the First Floor. Says his feet tell him it's easier to come down than to go up! And he never misses a trick this way. Sounds like good engineering logic. Why don't you join him this year . . . and see if it doesn't work for you!

*Will Copp*

Wm. C. Copp  
Show Manager



## ON DISPLAY FOR YOU

**NEW IDEAS  
in RADIO-ELECTRONICS  
... 1960!**

Year after year, the IRE NATIONAL CONVENTION AND RADIO ENGINEERING SHOW gets bigger! That's because you and your gigantic radio-electronics industry are surging ahead with NEW IDEAS and remarkable speed to make the Space Age the most exciting time in which to live.

That's why it takes all 4 floors of New York's great Coliseum to show what your industry is doing. Takes 950 exhibitors...takes over 200 papers...takes over 60,000 of your co-workers to view the impressive sight.

If you're not at the IRE CONVENTION AND SHOW this year you'll miss a once-a-year opportunity unequalled in your industry to see progress in action. Plan to be at the Coliseum to see...to hear about...the NEW IDEAS IN RADIO-ELECTRONICS. 1960!

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Waldorf-Astoria Hotel  
and The RADIO ENGINEERING SHOW  
Coliseum, New York City**

**MARCH 21, 22, 23, 24**

**The Institute of Radio Engineers  
1 East 79th St., New York 21, N. Y.**

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## SERVICES FOR DESIGNERS

### Technical Bibliographies 97

World Electronics makes it possible to receive specialized bibliographies in variety of subject areas, eliminating cross references and other time-consuming activities.

You can subscribe to one or many areas of interest. Among the list of titles available for subscription are: semiconductors; transistors and diode circuits; transistor and diode sine and analog circuits; transistor and diode pulse and digital circuits. Each title is broken down into more specific areas of concentration.

Every month, except August, the company sends a list of articles and books covering the selected subject (s). The subscriber files the material in a folder furnished in the first mailing. Such an arrangement provides convenience and a bibliography that is automatically cumulative. All articles and books received during the previous calendar month are included in the list mailed to the subscriber. The lists are not only complete, but also up to date, being only 10 days behind the original published material. All major publications are scanned regularly, foreign as well as American.

World Electronics, Dept. ED., 1805 68th St., Philadelphia 26, Pa.

### Bondable, Dyeable, and Printable 98 Fluorocarbons Available

Raibond represents a class of fluorocarbons which have been treated by RAI to impart colorless bondable, printable and dyeable surfaces. It is an application of radiation-induced graft-copolymerization. By combining the effects of atomic radiation with specific chemical systems, it is possible to modify plastic surfaces to obtain specific and desirable surface properties without significantly altering the other characteristics of the plastic. Raibond can be supplied in many fluorocarbon shapes, and the process can be applied to many different configurations. Items such as large Teflon tubes for electrical tube cores, Teflon rods and plugs for waveguides, gaskets, molded blocks, and thin-wall molded shapes (such as radome covers) can be treated to impart clear, colorless, bondable, and dyeable surfaces on one, some or all surfaces. The firm can apply the Raibond process to the desired material, or supply Teflon and Kel-F sheets, film and rods which have been converted to Raibond.

Radiation Applications Inc., Dept. ED, 370 Lexington Ave., New York 17, N.Y.



actual size  
Model HCM 7/16



### MINIATURE 7/16" INDICATOR

Micro-miniature moving coil, core magnet indicator; 7/16" diameter, 31/32" length. Weight 10 grams; sealed. Available with a pointer or flag display in a wide variety of electrical sensitivities and functions. Data on request. Marion Instrument Division, Minneapolis-Honeywell Regulator Co., Manchester, New Hampshire, U.S.A. In Canada, Honeywell Controls Limited, Toronto 17, Ontario.

**Honeywell**

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### NEW Fractional Horsepower Motor Handbook

**JUST PUBLISHED**...to help the machine designer select and service fractional horsepower motors.

Here are 66 pages brimming with facts, figures and more than 75 diagrams, tables, charts and illustrations, for the first time brought together in a single permanently bound book.

Contents include (1) Application fundamentals, (2) Economics and special features, (3) Care and servicing, (4) A glossary of terms and definitions...plus 10 pages of reference material.

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## Metal Fabrication

105

Manufacturers can now take advantage of a specialized service process that offers efficient fabrication of parabolic reflectors, and the Mecatorn spinning of Nu metal shields, chassis, high voltage heads, and electronic circular containers of all types.

C. W. Torngren Co., Dept. ED, 236 Pearl St., Somerville, Mass.

## Test Instrument Information

106

Any question a purchaser may have pertaining to locating, comparing, evaluating, specifying, or procuring any one of the 5300 electronic test instruments made by 400 manufacturers on the market today will be answered promptly without cost or obligation through use of a new question outline form offered by Technical Information Corp., New York.

The full page outline, giving adequate room for posing problems in detail, is in the form of a postage paid reply letter which can be sent back to the company for answers. Questions on the firm's technical information service, a centralized source of authoritative instrument data, are also invited.

Technical Information Corp., Dept. ED, 41 Union Square, New York 3, N. Y.

## Patent Digests

107

Industrial Patent Research Co., Columbus, Ohio, is offering a patent digest service for management and research and development staffs. These short summaries of patents, free of legal terminology and redundant detail, can be more easily understood by scientific personnel.

Patents to be analyzed are provided by the client to IPR which prepares the analyses in extract-abstract form, and then distributes them to designated personnel of the client company. Examples of patent analyses in typical fields of interest are available.

Industrial Patent Research Co., Dept. ED, 2266 E. Main St., Columbus 9, Ohio.

## Tape Recording

108

Sigma Electric Co., New York N. Y., offers development experience in tape recorder applications involving: pulse operated switching; voice actuated relays; automatic telephone dialing; multiple point remote control, and continuous play or record systems with actuation for start and stop at the end of each cycle.

Sigma Electric Co., Dept. ED, 11 E. 16th St., New York 3, N. Y.

# BENDIX SR RACK AND PANEL CONNECTOR

*with outstanding resistance to vibration*

The Bendix type SR rack and panel electrical connector provides exceptional resistance to vibration. The low engagement force gives it a decided advantage over existing connectors of this type.

Adding to the efficiency of this rack and panel connector is the performance-proven Bendix "clip-type" closed entry socket. Insert patterns are available to mate with existing equipment in the field.

Available in general duty, pressurized or potted types, each with temperature range of  $-67^{\circ}\text{F}$  to  $+257^{\circ}\text{F}$ .

Here, indeed, is another outstanding Bendix product that should be your first choice in rack and panel connectors.



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Export Sales and Service: Bendix International Div., 205 E. 42nd St., New York 17, N. Y.  
Canadian Affiliates: Aviation Electric Ltd., 200 Laurentien Blvd., Montreal 9, Quebec.

Factory Branch Offices: Burbank, Calif.; Orlando, Florida; Chicago, Illinois; Teaneck, New Jersey; Dallas, Texas; Seattle, Washington; Washington, D. C.

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*sets up quickly...easy to operate...  
takes wide range of wire sizes*

### SPECIFICATIONS:

- Min. finished hole size: .18 in.
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- Winding speed: 1500 turns/min.
- Wire range: AWG 44 to AWG 26
- Dual, self-checking turns counting system
- Loading (wire length) counter
- Core range:  $\frac{1}{4}$ " I.D. to 4" O.D. to  $1\frac{1}{2}$ " high

### LABORATORY USE

- Change wire and core size in 45 sec.

### PRODUCTION USE

- 1500 turns per minute
- Insert core and load in 20 sec.

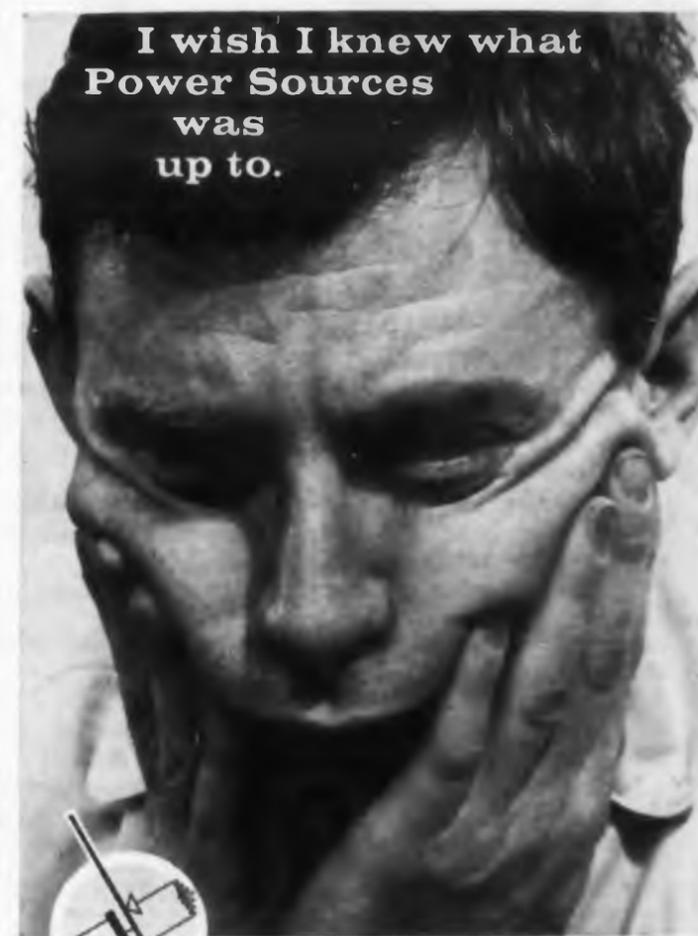
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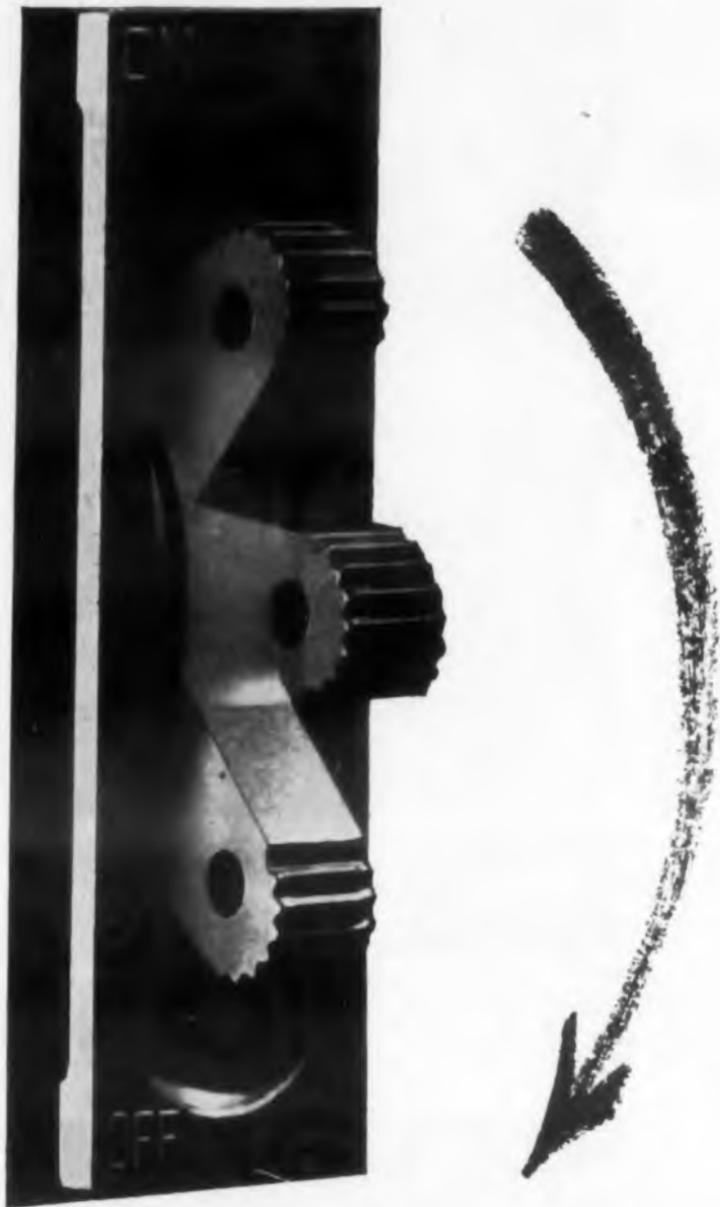


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up to.**

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## NEED A MANUAL POWER SWITCH THAT CAN BE ELECTRICALLY TRIPPED? HEINEMANN HAS IT

Applications are popping up all over for this popular variation on the circuit breaker. It seems that there's nothing that quite fills the same bill.

For want of better terminology, we've called it an electrically-tripped power switch.

First, it's a manual remote switch. Second, it can be electrically turned "off" by a remote contact . . . a timer, an interlock circuit detecting malfunction or an overload condition.

"A switch" to the layman, this specialized breaker is everything to the designer looking for simplicity (switch and lock-out relay in one), interrupting capacity (2000 amperes at 125 V., AC), compactness and low cost.

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If you have any product that should be switched "on" or "off" manually . . . and tripped "off" electrically . . . you should know more about this Heinemann product.

Send for complete data; request Bulletin 3201.



HEINEMANN ELECTRIC COMPANY  156 Plum Street, Trenton 2, N.J.

CIRCLE 112 ON READER-SERVICE CARD

## NEW LITERATURE

### Switches 113

Catalog 77b, 16 pages, contains data on a variety of sealed, environmentproof, and hermetically sealed switches. Applications of the switches include aircraft, spacecraft, rockets, missiles, launching and ground support, ordnance, and mobile use. Information is given on mounting, electrical ratings, operating characteristics, and contact arrangements. Micro Switch, Freeport, Ill.

### Pressure Monitor System 114

This technical manual, five-pages, contains data on the model 203A digital pressure measurement and control system. A block diagram showing interconnection of the pressure transducer, power supply, preamplifier, and amplifier is included in the manual. Technical Industries Corp., 389 N. Fair Oaks Ave., Pasadena, Calif.

### Vinyl Tubing 115

The firm offers samples of extruded tubing made from polyvinyl chloride resins. These samples are 2-1/2 to 6 in. long, and cover 5 grades of tubing, three of which meet various MIL specifications. They come in a folder that is imprinted with charts giving information on the five grades. Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.

### Frame Grid Tubes 116

Production techniques used in the manufacture of frame grid tubes are illustrated and described in this 13-page booklet. Technical data include typical characteristics, limiting values, and base connections for a variety of amplifiers and mixers. Amperex Electronic Corp., 230 Duffy Ave., Hicksville, N.Y.

### Selenium Rectifiers 117

The firm's line of selenium rectifiers is described in bulletin No. 295, an eight-page brochure. Basic rectifier information, product description, and methods of selecting rectifiers are covered in the bulletin. Outline drawings and terminal arrangement tables are included. Radio Receptor Co., Inc., 240 Wythe Ave., Brooklyn 11, N.Y.

### Zener Diodes 118

This eight-page brochure contains articles on referencing and instrumentation with Zener diodes, and output regulation utilizing the switching action of Zener diodes. Detailed circuits, performance curves, and photographs appear in the booklet. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.



\*U.S. Pat. No. 2,732,457

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Band Radios

Spring-leaf design with wide contact area provides:

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MRC proudly presents another series of quality products equally recognized for dependability, and performance. The Micromag, a low-level drift-free magnetic DC amplifier, completely solid state... ideally suited for instrumentation applications where temperature, strain and pressure are to be measured. DC signals in the millivolt region are amplified to the 0 to 5 volts DC range required for telemetering and recording systems.

#### Typical Specifications:

Power / 26-31 volts DC, 10 milliamps  
Input Signal / 0-10 millivolts DC  
Voltage Gain / 500  $\pm$  10%  
Output Load / 100 K ohms  
Linearity /  $\pm$  2%  
Gain Stability /  $\pm$  3% from 0°C to +65°C  
Common Mode Rejection / At DC, 10<sup>4</sup>  
At 60 cps, 10<sup>3</sup>  
At 400 cps, 10<sup>2</sup>

For additional information on MRC's complete line of Micromags, write for Data File No. MA1001.



**MAGNETIC RESEARCH CORP.**  
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Hawthorne, California

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### Connectors and Cables 121

Rack-and-panel connectors made by Ampenol and type RG/U coaxial cables are described in this illustrated four-page brochure. Among the connectors listed are: cable clamps; barrier polarization types with and without shells; printed circuit connectors, and a series of plugs and adapters. Coaxial cables are listed in table form. Schweber Electronics, 60 Herricks Rd., Mineola, L.I., N.Y.

### Power Stacks 122

Bulletin No. 308, four-pages, contains a list of selected power stack assemblies ranging in output from 3 to 30 kw dc. Design data are shown for 125 and 250 v dc units, convection and forced air cooling. The required ac input voltage and the rated output are given for each unit. Radio Receptor Co., Inc., 240 Wythe Ave., Brooklyn 11, N.Y.

### Motor Generator 123

Two-page bulletin No. MO-3.14 provides performance data and design specifications on the RBG-2407 miniature motor-generator. The unit consists of a low inertia control motor and an ac drag-cup rate generator. Motor speed-torque and speed-voltage curves are included in the bulletin. National Pneumatic Co., Inc., 125 Amory St., Boston 19, Mass.

### Gears and Pinions 124

Data on die cast gear and pinion combinations appear in this 10-page catalog. Combinations include: gear and pinion, flanged pinion, cup gear and pinion, plus special units. All are available with hole or shaft. Mechanical specifications and outline drawings are contained in the catalog. Gries Reproducer Corp., 125 Beechwood Ave., New Rochelle, N.Y.

### Welding Equipment 125

Descriptions, design and performance data, and illustrations of electronic welding equipment appear in this four-page catalog. Among the units described are power supplies, welding heads, a control unit, a bench welder, and hand-pieces. Weldmatic Div. of Unitek Corp., 380 N. Halstead Ave., Pasadena, Calif.

### Thermocouple Wire 126

Pure platinum, platinum-10% rhodium, and platinum-13% rhodium thermocouple wires are described in this four-page bulletin, No. TC-2. Physical and electrical properties for standard and premium grades of the 3 wire types are listed. J. Bishop & Co., Platinum Works, Malvern, Pa.



## THE MAGIC ALPHABET



Students of alphabetology will recognize these letters to be "M.R.C." written in the magic alphabet. Engineers everywhere recognize MRC for quality, reliability and outstanding performance.

The airborne power supply shown below is one of a series of highly reliable stable power sources designed to operate from a 115 volt,

400 cycle line and supply well regulated and filtered DC power. Dual magnetic regulation, an exclusive feature of this series, suppresses line transients and compensates for changes in load.

The use of magnetic amplifier circuitry with tantalum capacitors, silicon diodes and rectifiers... coupled with inherent short circuit protection... combine to achieve a degree of reliability unattainable in other types of circuits.

#### SPECIFICATIONS:

Model 40-103-0 is a typical 5 watt supply used extensively in missile instrumentation:

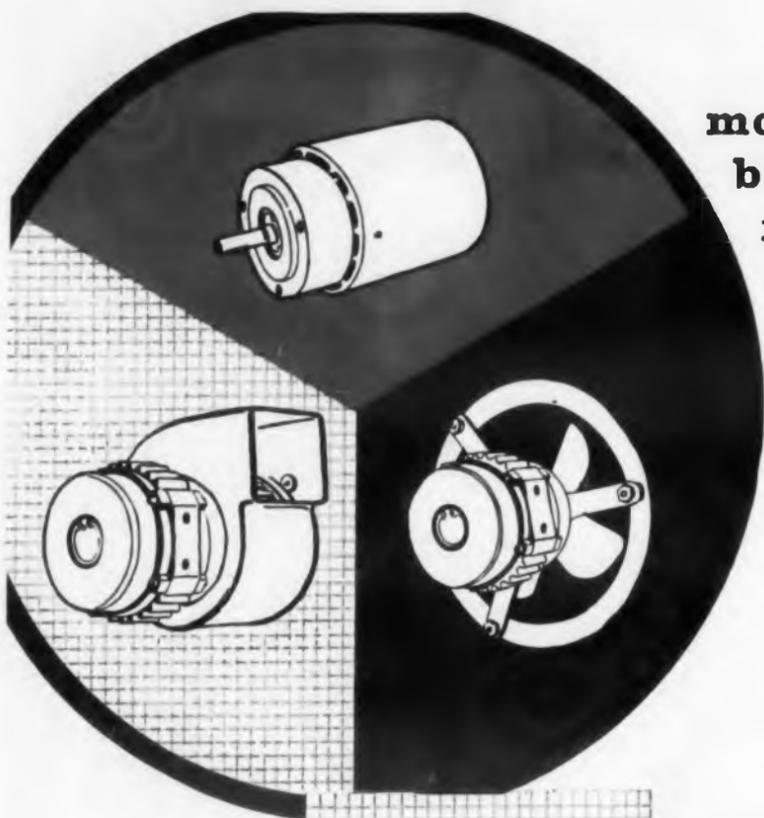
Input / 95-125 V; 380-420 cps  
Output / 4.75 to 5.25 V DC (Adjustable), 0 to 1 amp  
Regulation /  $\pm$  0.1%  
Ripple / 0.5% rms max. at full load

For additional information on MRC's complete line of airborne power supplies, write for Data File PS 1000.

**MAGNETIC RESEARCH CORPORATION**

3160 West El Segundo Boulevard, Hawthorne, California

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## motors blowers fans

### MOTORS

Sub-Fractional H. P.

HP. 1/800 to 1/7  
 C P S 50, 60, 400 or  
 variable  
 Phase 1, 2 or 3  
 Volts 115, 230. Also  
 specials  
 Speeds to 3600 at  
 60 cps  
 to 24000 at  
 400 cps

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C F M to 750 max.  
 Types Single, double,  
 inverted  
 Housings 2 1/4" to 11 1/2",  
 vertical, overall  
 Mountings Flange, foot,  
 cone

### FANS

C F M to 1000 max  
 Types Axial, vane axial,  
 ALTIMATIC®  
 Blades 2" to 12"  
 Mountings Venturi, foot,

OUR FIELD ENGINEERS WILL GLADLY  
 ASSIST YOU IN YOUR COOLING  
 PROBLEMS

Air-Marine motors and cooling units have been designed and tested to meet the specifications of both the military and industry.

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 CIRCLE 128 ON READER-SERVICE CARD

## NEW LITERATURE

### Sealing Alloys 129

Alloys developed for sealing metal to glass are described in this four-page booklet. Called Rodar, Niromet 46, and Niron 52, the alloys have a tensile strength of 150,000 psi. Minimum tensile strength for Niromet 46 and Niron 52 is 70,000 psi; for Rodar it is 65,000 psi. Wilbur B. Driver Co., 1875 McCarter Highway, Newark 4, N.J.

### Threaded Fasteners 130

Catalog 5918 is a guide to the selection of threaded fasteners for high temperature use. The 80-page book contains a complete listing of fastener types, material and configuration for use in temperatures up to 900, 1200, and over 1200 F. Detailed standard drawings of the firm's nuts are included as a further guide to the selection of the correct fastener for the job. Elastic Stop Nut Corp. of America, 2330 Vauxhall Road, Union, N.J.

### Resin Cartridge 131

This one-page data sheet illustrates and describes type PPC TC-459 cartridge kit for packaging epoxy resin. Applications include potting electrical connectors and cable junctions. Data on the preparation of the kit is contained in the bulletin. Electronic Production & Development, Inc., 501 N. Prairie Ave., Hawthorne, Calif.

### Electronic Chronograph 132

Data on a transistorized electronic chronograph that converts varying time intervals into digital coded electrical signals is contained in bulletin No. 104a. The instrument measures time between events to a resolution of 20 msec with an accuracy of 1 part in 10<sup>7</sup> per day. Applications for the quantizer, series LfQ, are included in this two-page data sheet. Computer Equipment Corp., 1931 Pontius Ave., Los Angeles 25, Calif.

## IN-LINE DIGITAL DISPLAY WITH ONE PLANE PRESENTATION



SERIES 10,000

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### OUTSTANDING FEATURES

- Reliable, dependable, no moving parts.
- All digits displayed on front surface viewing screen...quickly seen from any angle of viewing.
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- High-contrast viewing screen insures utmost visual sharpness.
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- Colored digits of your choice for special environmental lighting.
- Individual units may be assembled in groups for convenient panel mounting.
- Dimensions: 1-9/16" wide, 2 3/8" high, 5 3/8" long.



### INDUSTRIAL ELECTRONIC ENGINEERS, Inc.

Engineers and Manufacturers of  
 Fully Automatic Systems and Machines

5528 Vineland Avenue, North Hollywood, Calif.

CIRCLE 133 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 3, 1960

### Explosion-proof Controls 134

This two-color, four-page booklet contains information on indicating, nonindicating, and recording explosionproof controls. The controls are available in a variety of temperature ranges up to 1100 F. Photographs of control models IVS, VS, and RVS appear in the booklet. Partlow Corp., New Hartford, N.Y.

### Switches and Actuators 135

Detailed information on miniature and subminiature plastic-cased snap-action switches and actuators is contained in catalog No. 12. Among the switches described are: push button and plunger switches, toggle switches, lever and roller actuated switches, and limit switches. Haydon Switch, Inc., Waterbury 20, Conn.

### Terminal Blocks 136

Catalog No. 76 contains data on the firm's line of sectional terminal blocks, terminals, and cable and conduit fittings. Complete technical data, detailed en-

gineering specifications and drawings, and photographs are included in the 12-page booklet. Buchanan Electrical Products Corp., Hillside, N.J.

### Rigid Custom Extrusions 137

"A Guide to Rigid PVC Custom Extrusions" is a two-page data sheet that describes the advantages of polyvinyl chloride. The illustrated bulletin includes sections on polyvinyl chloride part design and factors in selecting the plastic material. Alpha Plastics Inc., 78 Okner Parkway, Livingston, N.J.

### Electronic Buying Guide

Over 40,000 items are listed in this 312-page catalog, No. 85, devoted to industrial electronic parts and equipment. Engineering specifications, schematic diagrams, and technical articles are included. The catalog also contains a complete index of products and manufacturers. Write on company letterhead to Radio Shack Corp., Dept. ED, 730 Commonwealth Ave., Boston 17, Mass.

# Build This Superb *Schober* Organ From Simple Kits and SAVE OVER 50%!

LET US SEND YOU FREE DETAILS HOW TO ASSEMBLE A *Schober* ELECTRONIC ORGAN IN SPARE TIME!

The Beautiful *Schober* CONSOLETTA

— the only small organ with two full 61-note keyboards and 22 stops. Requires only 2' x 3'2" floor space! Commercial value approximately \$1600 or more — yet you save over 50% when you build this thrilling instrument!



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Now you can build the brilliant, full-range Schober CONSOLETTA or the larger CONCERT MODEL with simple hand tools. No skills are necessary to construct an instrument with one of the finest reputations among electronic organs. No woodworking necessary — consoles come completely assembled and finished. All you do is assemble clearly marked electronic parts guided by clear illustrations and detailed step-by-step instructions. Even teen-agers can assemble the Schober! You build from kits, as fast or as slowly as you please... at home, in spare time — with a small table serving as your entire work shop!

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The coupon will bring you a handsome 16-page booklet in full color describing Schober organs in detail, plus articles on how easy and rewarding it is to build your own organ and how pleasant and quick it is to learn to play the organ. In addition, we have prepared an exciting 10" hi-fi LP record demonstrating the full range of tones and voices available on the Schober, which you may have for only \$2.00 (refunded when you order a kit). Literature on the Schober is FREE! There is no obligation; no salesman will call.

THE GREAT CONCERT MODEL meets specifications of American Guild of Organists

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You may start building your Schober at once with an investment of as little as \$18.94. The musical instrument you assemble is as fine, and technically perfect, as a commercial organ built in a factory — yet you save over 50% on top-quality electronic parts, on high-priced labor, on usual retail store markup! In your own home, with your own hands you build an organ with *genuine pipe organ tones* in an infinite variety of tone colors to bring into your home the full grandeur of the Emperor of Instruments. You may build the CONSOLETTA for your home, or you may want to build the great CONCERT MODEL for home, church, school or theatre. You save 50% and more in either case.

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109

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Model "YE" by DURANT

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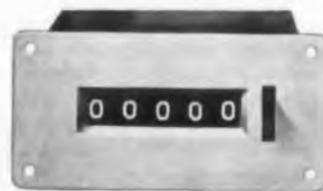
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First high-speed electrically actuated counters with added advantage of electric reset. Clean-cut, legible 3/16" figures, white on black. Ideal for all high-speed electric counting applications — accurate at high, low or intermediate speeds.

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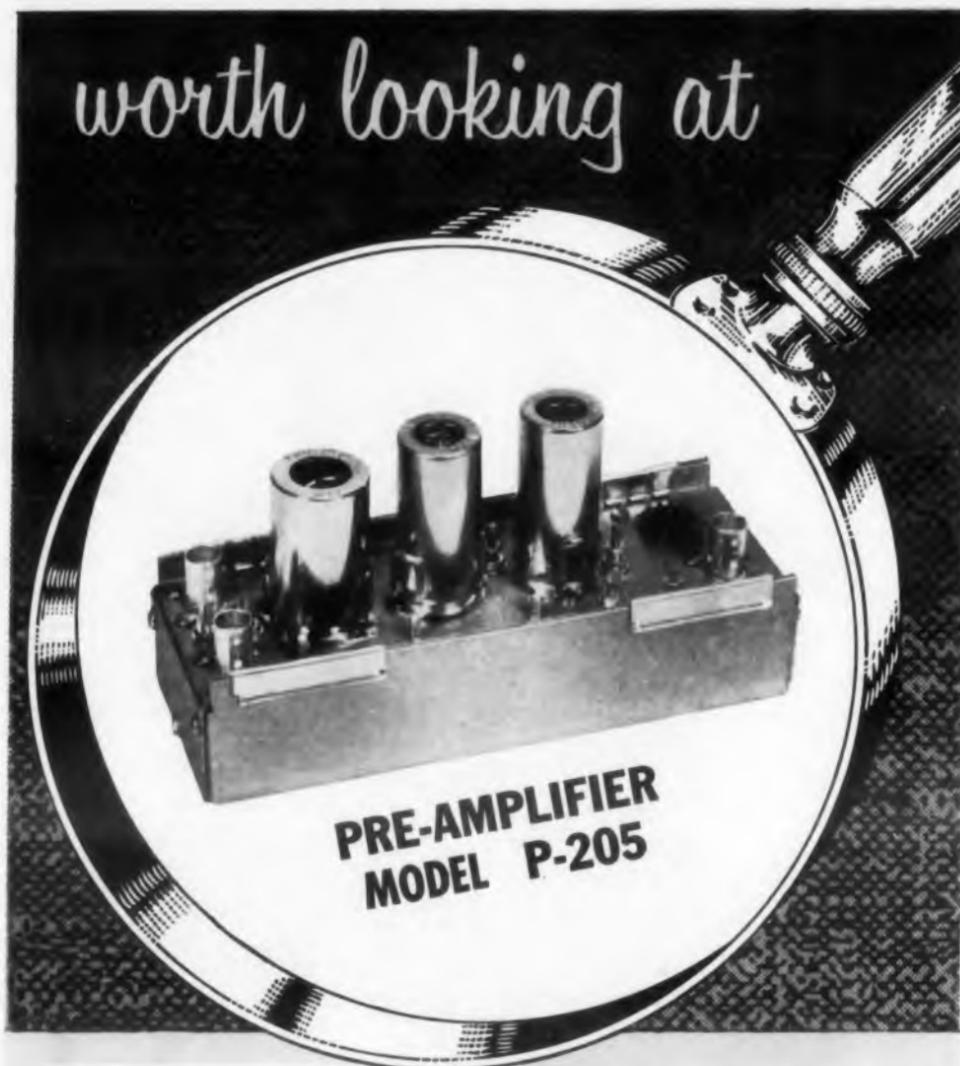


Compact, with great rigidity — entirely enclosed against dust and moisture. Base or panel mount. Speeds to 1500 C.P.M.

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### SPECIFICATIONS P-205, P-205A

Band Center	30 mcs
Band Width	10 mcs (1 db point)
Gain	20 db minimum
Noise Figure	2 db
Input Impedance	P-205 . . . 200-300 ohm balanced
	P-205A . . . 200 ohm unbalanced
Output Impedance	50 ohms*

Prices:  
205 \$150  
205A \$150

### PRE-AMPLIFIER MODEL P-205

The IFI P-205 Series Pre-Amplifier is designed to be fed from a crystal mixer with a 200 to 300 ohm balanced output. The P-205A is designed to be used with 200 ohm unbalanced mixers. Either the P-205 or the P-205A will provide a gain of 20 db in a bandwidth of 10 mcs. Both these units are designed to operate with either the Model 235 (10 mcs IF strip), or the Model 230 (2 mcs IF strip). It is also possible to use these units with other standard 50 ohm input IF amplifiers.

**INSTRUMENTS FOR INDUSTRY, Inc.**  
101 New South Road, Hicksville, L. I., N. Y.

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Graduate engineers with two or more years of circuit application in the fields of electronics or physics are invited to meet with Mr. John Hicks in an informal interview or send complete resume to: Dir. Personnel, IFI, 101 New South Road, Hicksville, New York.

See us at the I.R.E. Show—Booth 1424  
CIRCLE 144 ON READER-SERVIC CARD

## NEW LITERATURE

### Industrial Controls 145

Containing charts, drawings, and diagrams, this booklet, entitled, "Industrial Temperature Measurement and Control," discusses the following topics: ways of responding to temperature; ways of putting temperature response to work; the firm's element for mercury-bulb instrumentation, and a score sheet for the mercury-bulb system. The 23-page booklet also provides basic concepts of electrical, pneumatic, and mechanical controls. The Partlow Corp., 532 Champion Road, New Hartford, N.Y.

### Electron Tubes 146

Trends in the design and manufacture of electron tubes for entertainment, industrial, and military applications are discussed in this 24-page booklet, entitled, "A New Era of Sylvania Electronic Tubes." Sylvania Electric Products Inc., 1100 Main St., Buffalo, N.Y.

### Crystals 147

This 12-page booklet includes an article entitled, "Induction Heating in Zone Refining, Zone Leveling and Crystal Growing." Techniques of growing germanium and silicon crystals are explained and illustrated. An article on coil design and construction also appears in the booklet. Lepel High Frequency Labs, Inc., 55th St. & 37th Ave., Woodside 77, N.Y.

### Tape Transports 148

Illustrated bulletin No. 1618 describes model 5-681 digital-tape recorder/reproducer transport that operates at speeds up to 30 ips, and model 5-682, a transport that operates up to 150 ips. Both are designed for computer, industrial, military, and laboratory applications. Operating characteristics and specifications for both units are included in the brochure. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

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OPERATIONS**



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Dust can be disastrous! Particularly during assembly, potting, inspection, storage of semiconductors, servomechanisms, relays and the like . . . products even "clean rooms" can't adequately protect.

Optically transparent MICROVOID enclosures provide almost 9 cubic feet of dust-free research and production space. A "screen" of moving air—filtered to 0.5 micron

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Moderately-priced standard MICROVOID Dust Hoods available for prompt delivery. Special types accommodate scopes or large instruments. Amber "Plexiglas" types shield against ultra-violet radiation. GET COMPLETE FACTS by writing today or call OSborne 5-5200.

**AIR-SHIELDS, INC.**

INDUSTRIAL DIVISION



**HATBORO, PENNSYLVANIA**

\*Trademark

CIRCLE 149 ON READER-SERVICE CARD  
ELECTRONIC DESIGN • February 3, 1960

## Gyroscope Manual

This technical manual on subminiature rate gyroscopes covers basic principles of operation, operating characteristics, standard types available, transformer pick-off, and use and design of one, two, and three axis sensors for rate and acceleration. General application and operating data are for design use in applications such as fire control systems, autopilots, missile homing, navigation, and instrumentation. The 62-page manual includes a 20-page appendix that contains a complete glossary of gyro technology. Send \$2.00 to Sanders Assoc. Inc., Dept. ED, 95 Canal St., Nashua, N.H.

## Electronic Connectors 154

Catalog No. 60, 16-pages, contains application data on electronic connector types including printed circuit, MS, rack and panel, triaxial, glass seal, BT miniature plugs, receptacles and cable assemblies. Special type connectors are also described. H. H. Buggie Div., Burndy Corp., Toledo, Ohio.

## Ceramic Capacitors 155

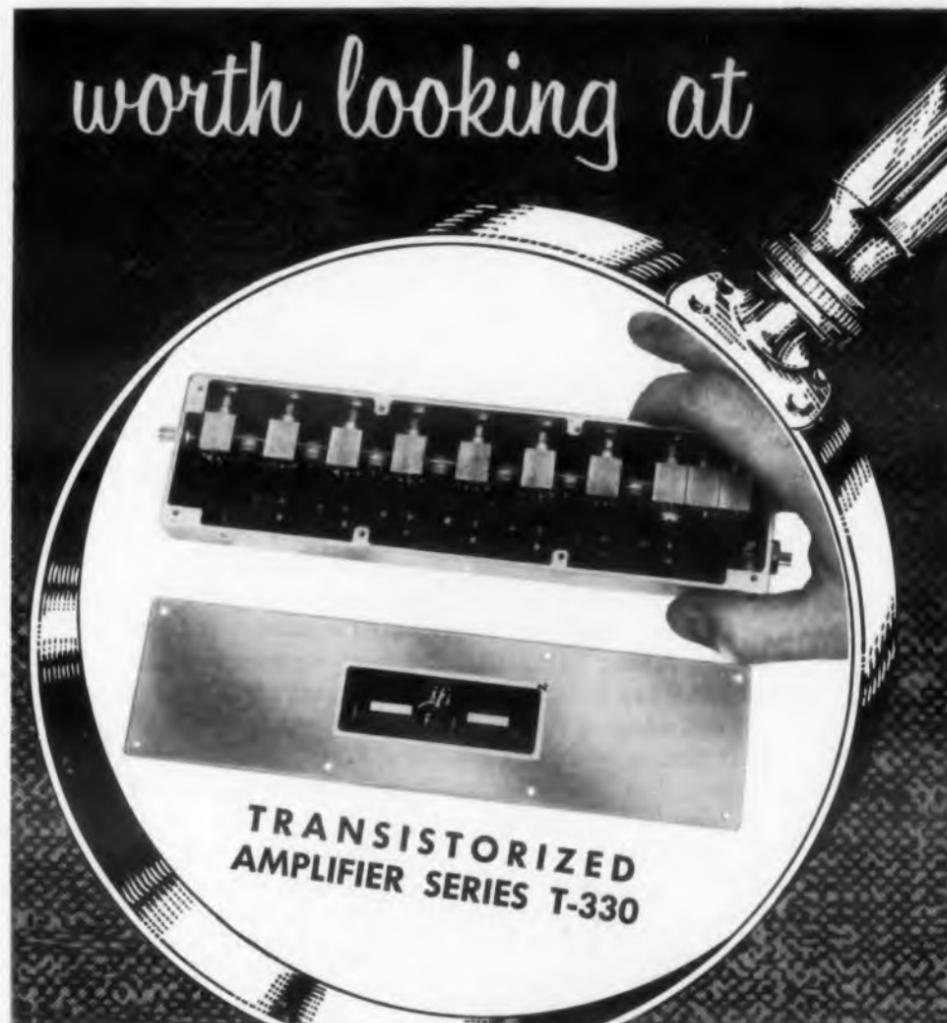
Bulletin No. H-4 describes the firm's series of subminiature ceramic capacitors designed for 1/10-in. modular spacing in printed circuitry, and other tight packages. Mucon Corp., Dept. K, 9 St. Francis St., Newark 5, N.J.

## Washers 156

This brochure contains measurements, weights, sizes, and a complete listing of flat steel, brass, finishing, and lock washers for internal and external use. Accurate Threaded Fasteners, Inc., 2901 W. Montrose, Chicago 18, Ill.

## Games for Electronic Computers 157

This 12-page booklet describes 12 games for matching the machine against the human operator. Adaptation of these games to various computers, including the company's Sexiac electronic digital computer kit, is also explained. Willis G. McCormick Co., 15733 Septo St., Sepulveda, Calif.



## SPECIFICATIONS

Center Freq.	T-330A	30 mc.
	T-330B	30 mc.
Bandwidth	T-330A	10 mc.
	T-330B	3 mc.
Gain	T-330A	80 db min.
	T-330B	100 db min.
Output (max.)	T-330A	+ 5 DBM
	T-330B	+10 DBM
Input Impedance	T-330A	50 ohm
	T-330B	50 ohm
Noise Figure	T-330A	10 db
	T-330B	9 db
Mean Stage Gain	T-330A	11.5 DB
	T-330B	14.0 DB

Quantity	Unit Price
1-10	\$800
11-25	700

A new series of completely transistorized I-F amplifiers offered to fill the need for standardized, high quality units. These T-330 series amplifiers by I.F.I. are available in a variety of center frequencies and bandwidths. They also can be equipped with emitter follower, cathode detector or low noise tube input.

The quality of construction is high. The use of printed circuitry and quality control procedures provide rigid standards. Individual inspection and testing of each unit prior to delivery assure the superior quality of IFI transistorized I-F amplifiers. These transistorized I-F amplifiers meet all applicable military environmental specifications.

INSTRUMENTS FOR INDUSTRY, Inc.

101 New South Road, Hicksville, L. I., N. Y.

*ifi*

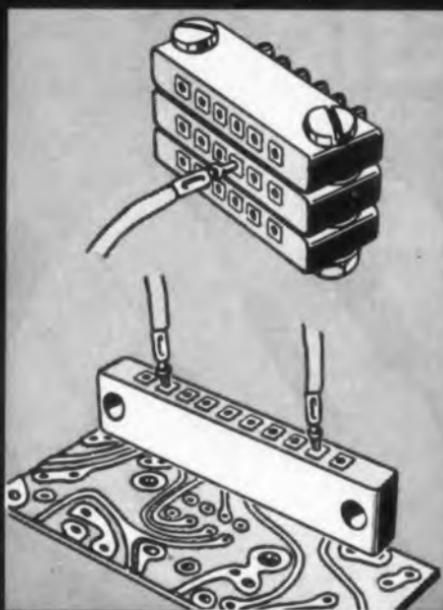


Graduate engineers with two or more years of circuit application in the fields of electronics or physics are invited to meet with Mr. John Hicks in an informal interview or send complete resume to: Dir. Personnel, IFI, 101 New South Road, Hicksville, New York.

See us at the I.R.E. Show—Booth 1424

CIRCLE 159 ON READER-SERVICE CARD

## STILL EASIER TAPER-PIN CONNECTIONS!



That's the purpose of Kulka Type 399 Miniature Taper-Pin Terminal Blocks. On one side, taper-pin receptacles accept AMP Type 53, Burndy or other equivalents for solderless wiring. On the other side, counter-bored brass terminal studs accept wire up to No. 20 AWG. Or the same studs can be slipped through printed-wiring board holes for dip-soldering on reverse side.

These blocks mount upright on printed-wiring board, or flat on any surface. Also, they can be multiple-stacked and held by screws slipped through metal-eyelleted end holes.

Truly miniature — 6-terminal block measures 1<sup>13</sup>/<sub>32</sub>" long; 10-terminal, 2<sup>1</sup>/<sub>32</sub>" long; 1/4" thick; 7/16" high.

LITERATURE... Ask for catalog sheet with complete details. Also Kulka general catalog listing the outstanding selection of terminal blocks.

**KULKA**

**KULKA ELECTRIC CORP.**

633-643 So. Fulton Avenue  
Mount Vernon, N. Y.

CIRCLE 158 ON READER-SERVICE CARD

$$E = \frac{mc^2}{2}$$

## Or How To Find New Leisure Even Though You're An Engineer

IT seems you can't begin to please everybody these days — particularly if they're all marketing people. Ours were happy enough when we discovered the new physical law embodied in  $E = mc/2^*$  and then built the FR-600 analog recorder that embodied the principle. They groused a bit when it took us two years to finish it, but relations were still on a gentlemanly level. Then we published the Ips Corollary and they flew off the handle because this showed that the FR-600 could record the same bandwidth at half the usual speed. (125 kc at 30 ips, giving 48 minutes recording time on a 14-inch reel of tape.) They pointed out that this meant people wouldn't need a second stand-by machine to switch over to on most data runs. They wrung their hands and mumbled about the market being cut in half with one stroke. Things got even worse when it leaked out that the FR-600 made this same doubled recording time possible on every one of our analog recorders ever built. (The new engineer says this is because bandwidth is determined by the reproduce head rather than the record head.) So everyone who had an FR-600 to reproduce on could record the same bandwidths at half the usual speed on our other equipment and get double the usual recording time. We had a hard time explaining *that* away. They threw some nasty phrases at us like 'planned obsolescence' and 'market saturation,' but there was no changing the facts.

Now it seems that instead of plunging down as they predicted, the sales curve is inching up, and they want more of the same kind of information we have published before. We will supply it, but it is not without some misgiving as to how fate may twist it and make it work against us. Perhaps this time the Labor Board will complain. Nevertheless, here it is in one flat unequivocal statement: The FR-600 will work twice as many hours in every working day. This is not to say, mind you, that *you* have to work twice as many hours — just the machine. In fact, you may find new leisure — as they say in the ads. The new engineer says it's because the FR-600 spends more time recording and less being adjusted and maintained. He says — and you might well have a chance at *being* the new engineer if it's not true — that the solid-state circuitry warms up in less than 10 minutes, and maintains FM calibration within 1% for more than 24 hours. That means one calibration a day instead of 3 or 4. We've also eliminated a lot of adjustments by leaving out a lot of parts. Our motives in bringing you these benefits are completely altruistic but you can return the favor by helping to hold up your end of the sales curve.

\*We'll never get rid of all the reprints of our earlier papers on  $E = mc/2$ , the Ips Corollary, etc. unless you write for them in your new-found leisure.

**AMPEX**

AMPEX DATA PRODUCTS CO., 934 CHARTER ST., REDWOOD CITY, CALIF.  
CIRCLE 164 ON READER-SERVICE CARD

## NEW LITERATURE

### Connectors 165

Bulletin No. 115, four pages, contains data on the company's rack-and-panel or cable connectors. Series 8007 is available with 75, 100, and 130 contacts and a screw-actuating device for mating and vibration lock. Series 8008 is available with 80, 95, 110, 125, and 140 contacts, but has no screw-actuating device. The bulletin provides diagrams and photographs. Elco Corp., M St. below Erie Ave., Philadelphia 24, Pa.

### Transistors 166

Complete specifications and characteristics of the firm's line of pnp and npn transistors appear in this 16-page brochure, No. G-200. Sections are devoted to: audio transistors for audio amplifiers and low speed computers; computer transistors; high current computer transistors; bilateral transistors; drift transistors; high voltage transistors; and silicon alloy junction transistors. General Transistor Corp., 91-27 138th Place, Jamaica 35, N.Y.

### Components 167

Contained in this six-page booklet is data on the firm's line of components. Included are: filters, networks, and delay lines; rf and if coils and transformers; special coils and toroids; wirewound resistors, and subassemblies. The booklet is illustrated. Fugle-Miller Labs, Clark, N.J.

### Tube Sockets 168

This two-page data sheet describes 7 and 9 pin miniature tube sockets with shield base, saddle for top mounting, and snap-on base. Specifications and outline drawings for all types are included in the bulletin. Elco Corp., M St. below Erie Ave., Philadelphia 24, Pa.

### Grommets 169

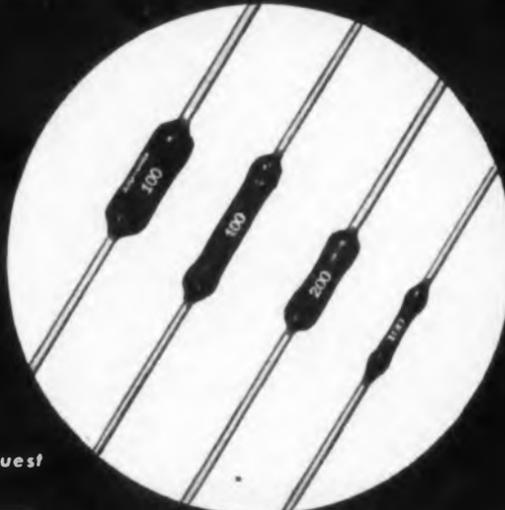
One-piece, solid, nylon grommets are described in this four-page illustrated brochure. Specifications are given in table form. Photographs and outline drawings are included to facilitate installation. Western Sky Industries, 21301 Cloud Way, Hayward, Calif.



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AXIAL-LEAD  
**PRECISION  
WIRE WOUND  
RESISTORS**

WITH EXCLUSIVE SILICONE COATING

STANDARD SIZES OF  
1, 3, 5, 7, 10, 15  
and 20 WATTS



MINIATURE SIZE  
ALL WELDED CONSTRUCTION  
MEETS STRINGENT  
MILITARY REQUIREMENTS  
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MINIMUM SPACE  
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Division of Model Engineering & Mfg., Inc.  
FACTORY:  
HUNTINGTON,  
INDIANA

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ELECTRONIC DESIGN • February 3, 1960

### Connector Potting Form 174

Nylon potting forms from 1/2 to 1-1/2 in. ID are described in a one-page, illustrated bulletin. The forms mold compounds used to pot electrical connectors against the effects of moisture, oil, hydraulic fluid, salt spray, and fungus. Electronic Production & Development, Inc., 501 N. Prairie Ave., Hawthorne, Calif.

### Power Inverter 175

Transistorized power inverter, model TPI-3, designed for operation in any airborne environment, is described and illustrated in this two-page data sheet that outlines its specifications. A simplified circuit diagram is included. Southwestern Industrial Electronics Co., 10201 Westheimer Rd., Box 22187, Houston 27, Tex.

### Switches and Relays 176

The firm's line of electrical switches and relays is described in this four-page brochure. Switches described and pictured include miniature, subminiature, appliance, open blade, general purpose, metal

clad, machine tool, and others. Several types of relays are listed in the brochure. Acro Div., Robertshaw-Fulton Controls Co., Box 449, Columbus 16, Ohio.

### Optical Systems 177

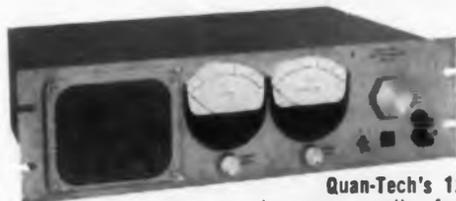
Technical descriptions and photographs of a radar recording camera test set, fire control simulator, radar target folder viewer, and radar film assessor appear in this 16-page booklet. Other systems described in the folder include data display equipment, photogrammetric devices, and visual simulators and trainers. Mast Development Co., Inc., 2212 E. 12th St., Davenport, Iowa.

### PC Connector 178

Series 6003, card-edge type printed circuit connector, is described in a two-page bulletin, No. 116. The connector is available with 14, 21, 31, and 37 contacts at 0.078-in. centers. Specifications and outline drawings are contained in the bulletin. Elco Corp., M St. below Erie Ave., Philadelphia 24, Pa.

*Higher*  
**REGULATION**

*Lower*  
**RIPPLE**



### TRANSISTORIZED POWER SUPPLIES The 120 Series

Quan-Tech's 120 Series units are transistorized, low-voltage d-c power supplies featuring low ripple and closely regulated output. Regulation is to within  $\pm 0.01\%$  or  $\pm 3$  mv for line or load. All electronic circuitry protects each unit from overload or short circuit—recovery is immediate when the fault is removed. Valuable equipment connected externally is protected by presetting current levels of any of the 120 Series. Provisions for remote error sensing are also incorporated. Where reliability rates equally with versatility—look to the 120 Series by Quan-Tech. Write for technical details.

#### SPECIFICATION HIGHLIGHTS

Model	Output Range DC		Regulation			Ripple mv RMS	Price
	Volts	Amps	Line	Load			
121	0.1-15	0-5	$\pm 0.01\%$ or 3 mv	$\pm 0.01\%$ or 3 mv	$\pm 0.01\%$ or 3 mv	.5	\$475.
122	0.1-36	0-3	$\pm 0.01\%$ or 3 mv	$\pm 0.01\%$ or 3 mv	$\pm 0.01\%$ or 3 mv	.5	495.
123	0.1-50	0-2	$\pm 0.01\%$ or 3 mv	$\pm 0.01\%$ or 3 mv	$\pm 0.01\%$ or 3 mv	.5	510.
124	0.1-50	0-5	$\pm 0.01\%$ or 3 mv	$\pm 0.01\%$ or 3 mv	$\pm 0.01\%$ or 3 mv	.5	645.
Also Available							
101	0-8	0-2	$\pm 0.25\%$ or $\pm 25$ mv			1	195.
102	0-14	0-1	$\pm 0.1\%$ or $\pm 10$ mv	$\pm 0.1\%$ or $\pm 10$ mv	$\pm 0.1\%$ or $\pm 10$ mv	1	190.
103	0-30	0-5	$\pm 0.1\%$ or $\pm 10$ mv	$\pm 0.1\%$ or $\pm 10$ mv	$\pm 0.1\%$ or $\pm 10$ mv	1	190.
104B	0-50	0-1	$\pm 0.1\%$ or $\pm 10$ mv			1	375.
105	0-50	0-25	$\pm 0.25\%$ or $\pm 25$ mv			2	205.
112	0-14	0-2	$\pm 0.1\%$ or 10 mv	$\pm 0.1\%$ or 10 mv	$\pm 0.1\%$ or 10 mv	1	240.
113	0-30	0-1	$\pm 0.1\%$ or 10 mv	$\pm 0.1\%$ or 10 mv	$\pm 0.1\%$ or 10 mv	1	240.

Units are available for bench or rack mounting



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# AIRPAX

## SERIES 500

### CIRCUIT BREAKERS

### FAST, SLOW AND INTERMEDIATE TIME DELAY ACTIONS

Airpax series 500 miniature magnetic circuit breakers provide positive protection against damage to components in intricate or simple electronic circuits. Available in series, shunt, and relay types, they offer safety factors which can not be duplicated by fuses, relays or thermal breakers.

These miniature circuit breakers are hermetically sealed and withstand severe shock, vibration, extremes of temperature and a wide range of environmental conditions.

Available in 50 volt DC ratings from 50 MA to 10 AMPERES; 120 RMS volts at 60 or 400 CPS with current ratings from 1 to 10 AMPERES.

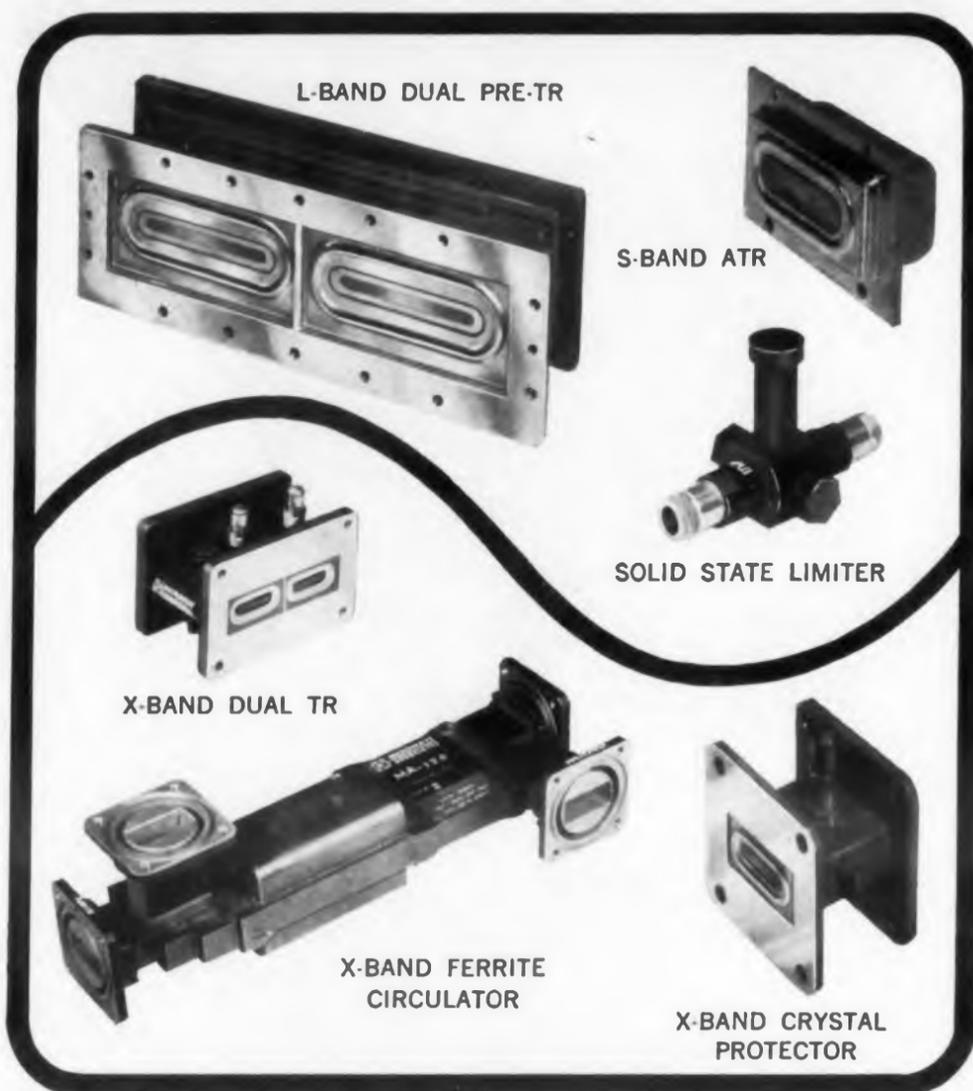
Request Bulletins B-07 and B-16 for complete information.



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CAMBRIDGE, MARYLAND

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Optimum radar performance depends upon selection of the best possible duplexer consistent with your specific requirements.

This is not easy. There are many possible combinations of duplexer devices, each with its own advantages and limitations. Also, components come in a variety of types and packages, each with different inherent characteristics:

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- DUAL PRE-TR
- 4-PORT CIRCULATOR
- BALANCED ATR s
- TEE CIRCULATOR

### FOR CRYSTAL PROTECTION

- TR CRYSTAL PROTECTOR
- SEMICONDUCTOR LIMITER

### FOR SWITCHING & PROTECTION

- DUAL TR

Microwave Associates can help you select the correct duplexer for your system with no second-guessing. Their long term research and development programs on gas tubes, ferrites, semiconductors, solid-state devices, and duplexer assemblies means excellence in duplexer capabilities. Production facilities are geared to rapidly translate new advances into field availability.

No other manufacturer offers you such comprehensive consultation on duplexer problems without obligation. If you are designing, building, or modifying a system we will be glad to work with you. Write or call:



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CIRCLE 184 ON READER-SERVICE CARD

## NEW LITERATURE

### Power Nomographs 185

The nomographs in this eight-page bulletin, No. 5000E, aid in predicting the long term performance of the firm's composition fixed resistors. The information shows how power input, temperature rise, ambient temperature, life, and permanent resistance changes are interrelated. Examples are included to illustrate the use of the nomographs. Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 4, Wis.

### Switches and Terminals 186

This 24-page catalog contains data on multi-circuit push button and stack switches in addition to range heater, motor-reversing, toggle, and slide switches. Details of handles, hardware, shaft styles, and terminals are included. Dimension drawings, wiring diagrams, circuit sequences, and electrical ratings appear in the catalog. Ark-Les Switch Corp., 51 Water St., Watertown 72, Mass.

### Magnetic Triggers 187

Information on magnetic triggers for silicon controlled rectifiers is contained in this four-page brochure. A selection chart showing specifications of full-wave, half-wave and small-size 400-cps models, dimensional diagrams, and charts showing transfer characteristics and output and control signals are included. Avion Div. of ACF Industries, Inc., 11 Park Place, Paramus, N.J.

### Environmental Testing 188

This 10-page brochure contains descriptions and capacities of apparatus required for military and commercial testing of electronic equipment. Tests include shock and vibration, temperature, altitude, humidity, salt spray, sand and dust, pressure, and electronic radiation. Equipment is capable of meeting requirements for most current military specifications. Stavid Engineering, Inc., Plainfield, N.J.

## NEW NYLON & THERMO-PLASTIC PARTS from GRC

Economically mass produced on fully automatic patented machines, GRC nylon parts are available from stock in many sizes and types. GRC uses single cavity techniques, molds in one automatic cycle, gets accurate, uniform parts, ready for immediate use.

These advantages, these economies, apply too, to tiny made-to-order parts to your specifications . . . in quantities of 25,000 to many millions. Write for bulletin describing GRC's unique method for injection molding small plastic parts or send prints for quotation. Ask about our zinc alloy die castings, too!

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### NYLON SCREWS & NUTS

GRC's complete line of high quality, close tolerance molded nylon screws and hex nuts include screws in standard commercial heads—Phillips or slotted types—in sizes from #4 thru 1/4"; hex nuts in ten sizes (#2 thru 5/16") GRC molded nylon miniature machine screws—half the weight of aluminum—in sizes from #2 thru 1/4" make more compact designs possible. GRC's single cavity molding technique adds exceptional uniformity, accuracy, economy to nylon's high strength-to-weight ratio, built-in electrical insulating qualities, stability, resilience and elasticity. GRC's molded nylon fasteners are available from stock in a wide range of types, sizes and lengths.

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### Zipper Tubing 194

Catalog Z-2 discusses the characteristics, construction, applications and specifications of zipper tubing. How-to-use instructions, permanent sealing directions, accessories listing, and ordering information are also included. In addition, the forming, closing and sealing equipment are illustrated and discussed. Alpha Wire Corp., 200 Varick St., New York 14, N.Y.

### Audio Line Amplifier 195

Model CA-5A audio line amplifier is described in this two-page bulletin. The amplifier powers up to 50 headsets in parallel so that audio impulses applied to any of the microphones are transmitted to all connected headsets. The bulletin covers application, specifications and technical description of the unit. Photographs are included. Flite-Tronics, Inc., 3312 Burton Ave., Burbank, Calif.

### Differential Amplifier 196

Complete specifications and operating data of a differential amplifier appear in this six-page brochure, No. 3015-B. Power

supplies, mounting modules, filters, and other accessories are described. The brochure contains photographs and a block drawing of the amplifier. Beckman Systems Div., 325 N. Muller Ave., Anaheim, Calif.

### Word Indicator Lights 197

Catalog No. 159C, 16-pages, describes the Roto-Tellite line of word indicator lights. They have a visible legend area of 15/32 x 1-1/4 in. that will accommodate up to 3 rows of 0.125 in. high characters, 14 per row. Circuit outlines and mounting dimensions are included in the catalog. Master Specialties Co., 956 E. 108th St., Los Angeles 59, Calif.

### Miniature Pulse Transformers 198

Detailed description of miniature pulse transformers for blocking-oscillator pulse coupling, inverting and impedance matching is outlined in bulletin No. PT 160, two-pages. Grain oriented, thin metal core material is used in the transformers. Characteristics are presented in table form. Valor Instruments, Inc., 13214 Crenshaw Blvd., Gardena, Calif.

$$\begin{aligned} 1. z &= f(x, y) & 2. z &= f[g(x), h(y)] & 3. z &= f(u \cdot x, v \cdot y) \\ 4. y_1 &= f_1(x), y_2 = f_2(x), \dots, y_{20} = f_{20}(x) \\ 5. z_1 &= f_1(x, y), \dots, z_4 = f_4(x, y) & 6. u &= z \cdot f(x, y) \\ 7. z &= f(x_1 + x_2 + \dots, y_1 + y_2 + \dots) \end{aligned}$$

## NOW... A NEW APPROACH TO FUNCTION GENERATION

### The Link Analog Function Generator

Link's analog function generator offers a new level of performance for analog computation and simulation. Key to this outstanding performance... a Link-developed *rectilinear servo motor* with solid-state servo-amplifiers and a *ceramic-film resistance element*.

This new function generator eliminates the high drift and complex design of diodes generators, provides high-speed operation without the limited flexibility of optical techniques and the inherent backlash, friction and inertia problems of existing servo generators.

#### IT PROVIDES:

**RELIABILITY**—Modular design • Automatic failure protection • Simplified maintenance

**ECONOMY**—Standardized components • Printed circuits

**FLEXIBILITY**—Plug board programming • Rack mounted or table top use

**VERSATILITY**—Numerous functions or function groups can be generated with minor modification, or by connecting one or more generators in series.

The analog function generator, first of a line of DIALOG\* components and system building blocks to be introduced by Link, is another example of Link's unique computer capability. Thoroughly experienced in analog and digital techniques, Link can provide the most objective, economic solution to computation, simulation and control problems. For additional information on Link's new Function Generator or its broad computer capabilities — and your copy of Link's DIALOG\* catalog — write to Industrial Sales Department.

DIALOG\* (Link *Digital-Analog* System Components and Building Blocks)



\*DIALOG is a Trademark of Link Division, General Precision, Inc.

LINK DIVISION



GENERAL PRECISION INC.

BINGHAMTON, NEW YORK

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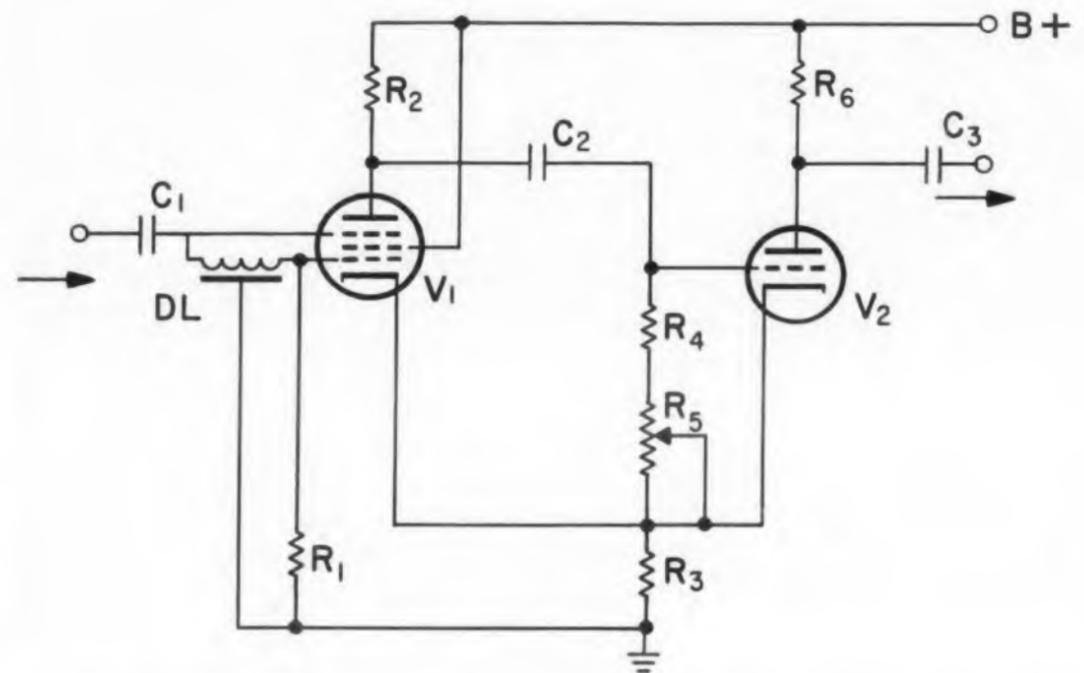
## Modified One-Shot Multi Acts As Pulse Decoder

A SIMPLE method for pulse decoding and producing squared output pulses of predetermined duration is illustrated by the circuit shown. The functions of a coincidence circuit and a separate one-shot multivibrator are here combined in a modified multivibrator circuit.

The pulse decoder, pentode tube  $V_1$ , is connected in a gating circuit to produce single pulses from pairs of pulses spaced  $p$  microseconds apart. The design is such that  $V_1$  is cut off by the positive voltage on its cathode. This bias is established by the drop across  $R_3$  as a result of the current drawn by the normally conducting triode  $V_2$ .

Positive pulses are fed through coupling capacitor  $C_1$  to both the  $p$  microsecond delay line,  $DL$ , and the suppressor grid of  $V_1$ . The delayed pulse output from  $DL$  is applied to the control grid. Conduction of  $V_1$  will not occur until positive signals of proper amplitude and phase are applied to both the control and suppressor grids. This takes place only when pulse input is spaced  $p$  microseconds apart. When  $V_1$  conducts, a negative output pulse is produced at the plate.

This negative pulse is applied, through  $C_2$ , to the grid of triode  $V_2$ , cutting the tube off. It remains cut-off while  $C_2$  discharges. When the cut-



The modified multivibrator circuit acts as a pulse decoder and produces output pulses with a width determined by the time constant  $(R_4 + R_5)C_2$ .

off point is reached, plate current in  $V_2$  again begins to flow. The turn-off time is determined by the time constant of the RC combination  $C_2(R_4 + R_5)$ . This also establishes the output pulse width. As soon as plate current starts to

flow in  $V_2$ , a second switching process occurs, and the normal condition ( $V_2$  on,  $V_1$  off) is re-established.

A. N. Clay, Senior Engineer, ITT Laboratories, Nutley, N. J.

## Square-Loop Core for Short-Circuit Protection

A TRANSFORMER with a square-loop core was used to protect the regulating transistor in a regulated power supply. Basically, transistor regulated power supplies use a transistor in series with the load whose collector-to-emitter impedance is changed to compensate for load varia-

tions. If the regulated output is shorted, the entire unregulated output appears across this transistor. Where the unregulated output is greater than the transistor breakdown voltage, the transistor can be permanently damaged. A fuse in the output circuit will not help since the

transistor breakdown will occur faster than any fuse will blow.

The position of the regulator "isolator" is indicated in Fig. 1; its circuit in Fig. 2. While this basic circuit has previously appeared in the literature (Shea, R. F. "Transistor Circuit Engineering", John Wiley & Sons, p 422), the particular application described here is new.

If a short is placed across the output terminals 3-4 (assume  $T1$  is conducting), the square-loop core material will immediately be saturated by the increased collector current. This current is limited by the base drive provided by windings

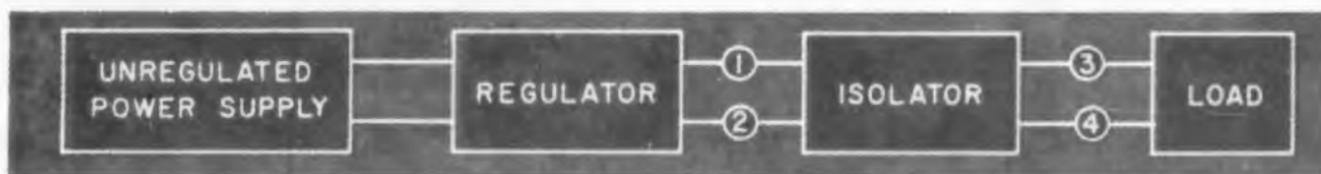


Fig. 1. Isolator is placed between regulating transistor and load.

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## **LEACH RELAY COMPANY**

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*(from original Leach catalog)*

Val Leach, founder of Leach Corporation, wrote the advertisement, left, 27 years ago. In it Mr. Leach laid down a business philosophy that is as valid today as it was in 1933. He knew there would be no room for "yesterday's heroes" among the companies supplying the vital, growing electronics industry. He knew that success would be in direct ratio to uncompromising product reliability. And he also knew that technological progress could only be based on the solving of tomorrow's problems.

Today, Leach continues to provide the industry of flight with reliable, high performance relays and contactors in the tradition of the original Leach Relay Company. Over the years, Leach has also pioneered and developed many other advanced technical products and services. Today, their scope greatly enlarged, Leach designs, engineers and manufactures:

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This year Leach Corporation celebrates its 40th anniversary in electronics with a reaffirmation of Val Leach's time honored principles:

*Solving problems is the core of the Leach philosophy of doing business. Leach will continue to base its success on anticipating customer needs and meeting them with advancements tailored to specific requirements.*

*For electronic sub-systems and electro-mechanical components to meet the requirements of the space age . . .*



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CIRCLE 204 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 3, 1960

117



## WHAT THIS UNUSUAL AC-DC "PLUG-IN" TRANSISTORIZED POWER SUPPLY DESIGN GIVES YOU...



One piece finned aluminum extrusion, achieving high heat dissipation. Most units need no external heat sink to 55° C ambient. All units have adjustable output. Platform mounted standardized subassemblies and components enable quick delivery of a wide range of voltages and currents.



### Specifications:

Input: 105 to 125V AC, 45 to 420 cps, single phase  
Regulation: 0.1% (line or load)  
Stability: Better than 0.25% for 8 hours  
Ripple: 0.02% rms  
Response time: less than 100 microseconds  
Low dynamic impedance



Designed primarily as a component power supply, units are widely used in computers, electronic instrumentation, production test equipment, and quality control check out systems. Best of all, the unique design makes these units available at the lowest possible cost to you.

(Unit pictured above: Model #1R 90-1; 85-95 V; 0-100 ma; Price \$145.00) Prices on other units range from \$100 to \$200.

All solid state — zener diode reference; transistor amplifiers and regulator  
Output Voltages: from 2.0 to 300V DC  
Output Power to 30 Watts  
Reliable short circuit protection  
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## IDEAS FOR DESIGN

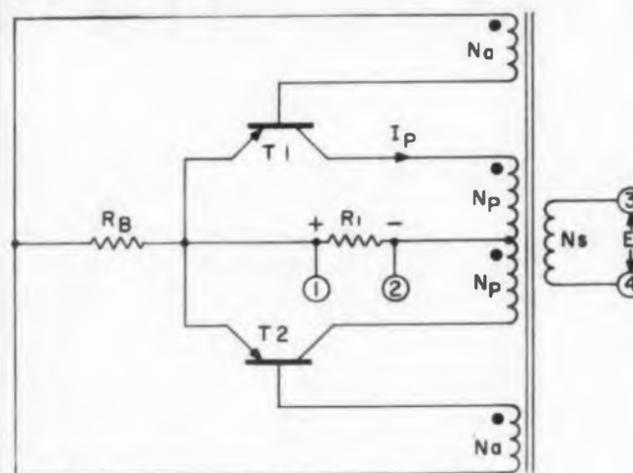


Fig. 2. Square-loop cored transformer causes short circuit at load to appear as a high impedance in series with regulating transistor.

$N_a$ . Since  $E_s$  is constrained to be zero by the short, and since  $E_s = -N_s d\phi/dt$ ,  $d\phi/dt = 0$ . The voltage induced in  $N_a$  will go to zero since it also is a function of  $d\phi/dt$ . Since the base drive is now zero, ideally the transistor's input impedance should be infinite. Actually, since the collector to emitter voltage becomes large (equal to the regulated voltage) some current will be drawn. However, the previously troublesome load short has been converted to a high impedance. The regulating transistor is in no danger of having an overload voltage placed on it.

Resistor  $R_1$  across the regulator output is usually needed since the near no-load condition during shorting is too stringent a design requirement on the regulator. The base resistor ( $R_b$ ) is selected for the desired bias point during normal operation. A value of 40 turns for  $N_p$  and 6-8 turns for  $N_a$  has been successful; with  $N_s$  determined by the power to be handled and the fact that the breakdown voltage should be about 240 per cent of the regulator output (twice the regulator output plus switching spikes).

Stanley Sokol, Design Engineer, Ford Instrument Co. Bldg., 4722, Rm. S9, Redstone Arsenal, Ala.

## Meter Relays Protect TWT's

We have used meter-relays in two applications to prevent electrical damage to traveling wave tubes. The circuit in Fig. 1 is used to prevent helix burn-out due to excessive helix current. Fig. 2 prevents electron gun damage due to electron beam de-focusing caused by improper solenoid magnetizing current.

Fig. 1 uses a high-limit meter-relay. The meter movement is placed in series with the helix and ground. Excessive helix current (maximum helix

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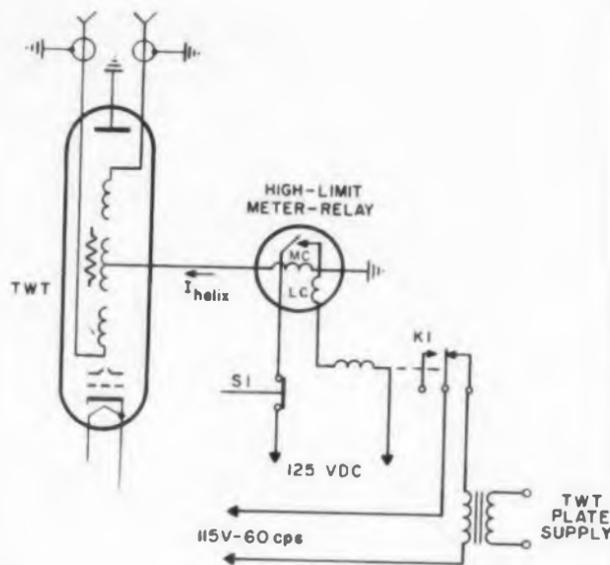
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NOTE:  
LC = LOCKING COIL  
MC = METER COIL

Fig. 1. A high-limit meter-relay protects a TWT from helix burn-out due to excessive helix current.

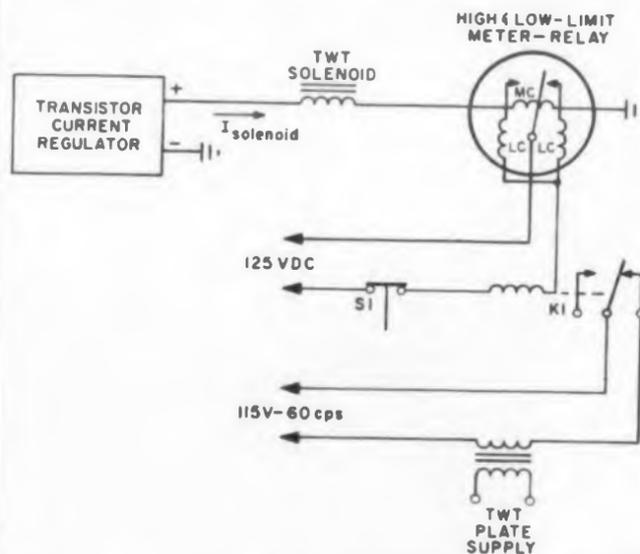


Fig. 2. A high-low limit meter-relay prevents electron gun damage caused by improper solenoid magnetizing current.

current for the tube type) will cause the meter-relay to lock closed, energizing the load relay K1. Energizing K1 removes the primary power from the high voltage TWT supply. Switch S1 in series with the locking circuit is used to clear the meter-relay circuit when the fault has been corrected.

Fig. 2 uses a high-low limit meter-relay. The meter movement is in series with the current regulated solenoid supply and the TWT solenoid. The limits are set to within 15% of the recommended solenoid currents. Should the current exceed the specified limits, the meter-relay will lock closed, energizing K1. This removes the high voltage TWT supply.

In both circuits high voltage is kept off the TWT's until the circuit is manually cleared by pushing push-button switch S1.

Walter W. Frey, Radar Systems, Airborne Instruments Laboratory, a Division of Cutler-Hammer, Inc., Huntington, N. Y.



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Airborne Time Code Generator illustrates high-density packing obtainable with T-Series circuits.



Hinged arrangement of mounting panel facilitates accessibility.



The finished package weighs only 20 lbs.; measures 5" x 8" x 2 3/8". Unit generates 14-digit Point Mugu code, modulating a 1 kc carrier plus a dc time code. Three sine wave and four pulse outputs are also provided, all with only 96 T-Series circuits and 77 watts of input power.



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The use of T-Series transistorized Germanium circuits throughout resulted in great savings as against equivalent equipment designed around vacuum tube circuits. Here are some startling comparisons:

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WEIGHT	20 lbs (including power converters)	160 lbs. (plus fan and power supply)
POWER	77 watts	650 watts (plus power for fan)

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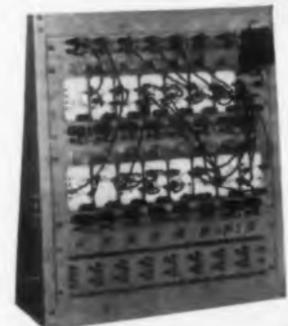
- DESIGN** — You can devote full time to system design problems or unusual circuit requirements, knowing that routine circuit detail has been compatibly pre-engineered and packaged for you.
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- PRODUCTION** — Your production problem is reduced to one of mounting sockets on panels or chassis and providing simple socket-to-socket wiring. Plug in the appropriate circuits and the system is complete.
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Why not let proven EECO T-Series circuits and systems development aids help you solve your equipment design problems?

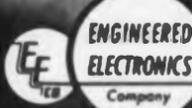
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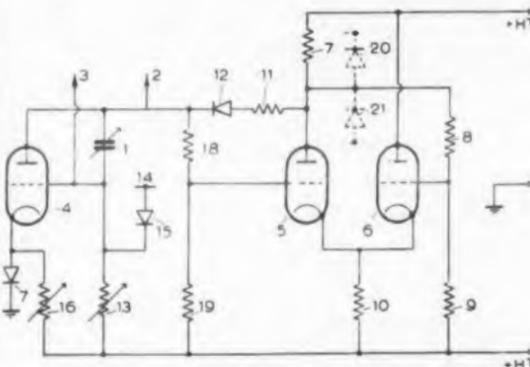
# PATENTS

## Sawtooth Waveform Generator

Patent No. 2,897,453. Hugh Lyon Mansford. (Assigned to EMI Ltd.)

A capacitor is switched from charge to discharge in a manner which facilitates adjustment of the forward and reverse strokes of a sweep circuit.

Capacitor 1 charges through diode 12 in a Miller fashion as set by resistor 13; triode 5 is cut off during the charging period. The voltage across resistor 18 and 19 rises until triode 5 conducts to switch



triode 6 off and, as a result, diode 12 cuts off. Capacitor 1 discharges through tube 14 and resistor 16 in series until triode 5 cuts off to reset the sweep cycle.

## Power Supply

Patent No. 2,905,881. Samuel Aron (Assigned to RCA.)

A regulated, negative, voltage-doubler power is supplied by making one rectifier an adjustable impedance sensitive to changes in the voltage across the load.

The circuit analysis is simplified by considering tube 14 essentially as a diode. Capacitors 16 and 18 will charge to the voltage across secondary winding 20 of transformer 22. Amplifier 40, however, meters any change in the output voltage and adjusts the bias on tube 14 modifying the voltage across capacitor 18 to stabilize the output voltage.

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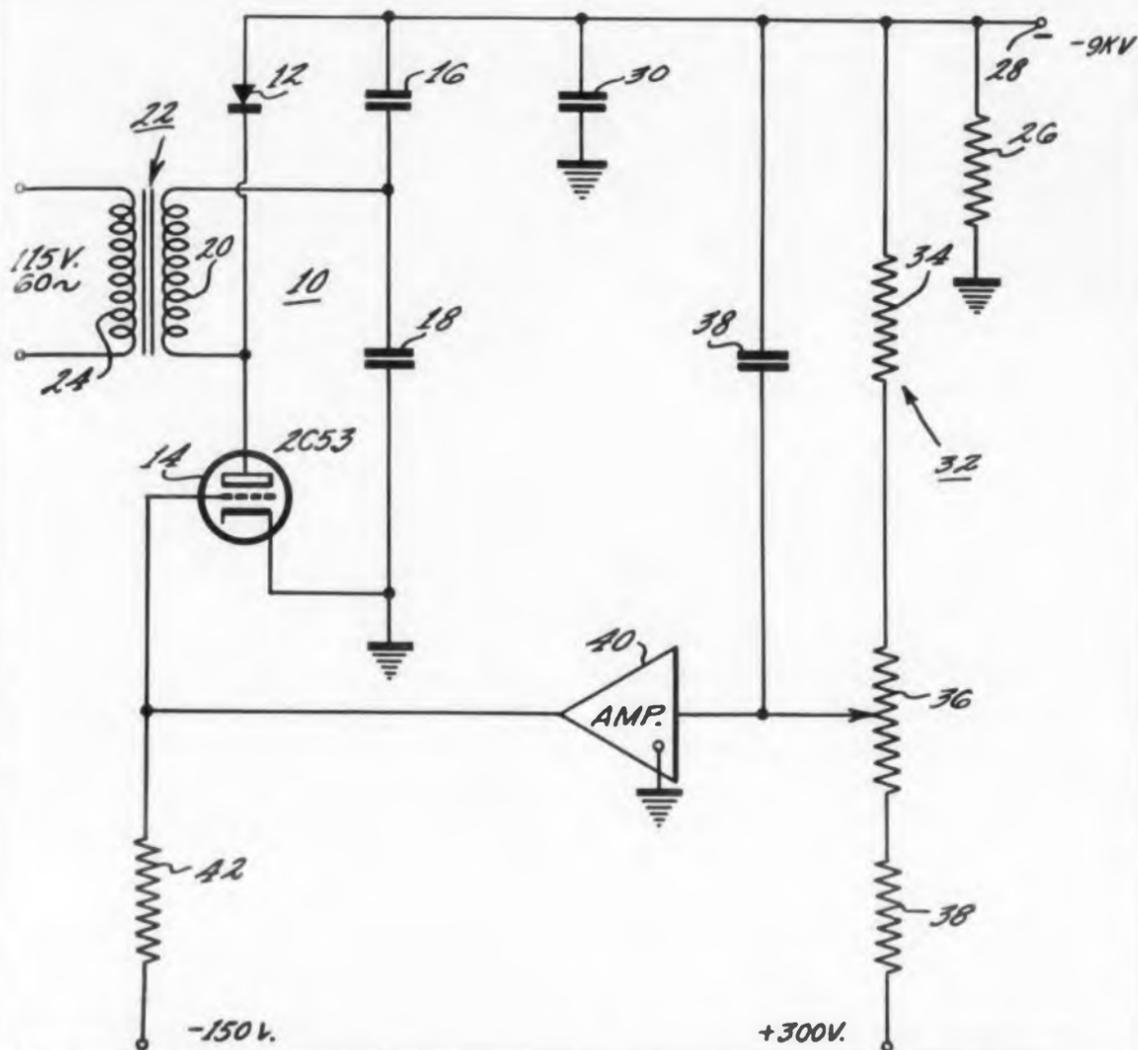
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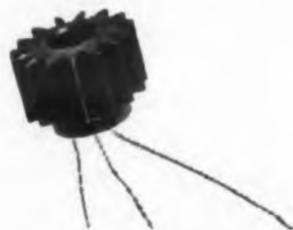
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## BOOKS

### A Technical Writer's Handbook

Margaret Norgaard, Harper & Brothers,  
49 E. 33rd St., New York 16, N.Y., 241  
pp, \$3.75.

"The prime requisites of technical writing are clarity, logic, and accuracy, embodied in a vigorous prose that awakens imagery and carries life, action, and conviction," says the author, who then goes on to show how these requisites can be achieved.

This book offers concrete help to engineers, scientists, businessmen, and government workers in writing a variety of clear and colorful reports planning effective visual presentations, and preparing speeches.

The Handbook covers all aspects of technical writing and answers such prac-

tical questions as: What is good technical writing? Who reads technical literature and what are the emotional factors that color understanding of technical fact? What are the basic methods of research? What are the modern practices in grammar and punctuation, and the logical reasoning behind them? What is the application of logic to technical writing? What constitutes good writing style?

Included are a complete grammar section, stressing modern usage, a punctuation guide, and an analysis of the emotional factors that sway readers. An appendix includes examples of different types of good technical writing.

### Economic Control of Interconnected Systems

Leon K. Kirchmayer, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 207 pp, \$12.50.

Mathematical methods, computers and controllers are applied in this text to obtain the most economic operating conditions for interconnected electric utility systems. A number of important tools

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for the development of optimizing computer controllers are discussed. Specifically, these tools include: the use of theoretical and differential analyzer methods for predicting the dynamic performance of interconnected systems and associated controllers; the development of mathematical models of the process whose operation is to be optimized; the use of mathematical methods to determine equations whose solutions result in optimal economic performance and the integration of computer and controllers to obtain computer-control systems.

The information given is based primarily on a course given by the author to participants in the General Electric Power Systems Engineering Course. The book is suitable for a senior or graduate level course in systems engineering.

Chapter 1 presents descriptive material concerning governing-system and control characteristics necessary for an analysis of the dynamic performance of interconnected systems. Chapter 2 describes various schemes for maintaining frequency, interchange, and economic allocation of generation within a given operating area by automatic computer-controller means.

### Linear Circuit Analysis

*B. James Ley, Samuel G. Lutz and Charles G. Rehberg, McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N.Y., 567 pp, \$12.50.*

The fundamental theory of linear lumped circuits is presented here for either the advanced undergraduate or beginning graduate student. One of the authors' main objectives is to present electric circuit theory as a general method of analysis for all physical problems specified by simultaneous linear integrodifferential equations. In order to accomplish this, electrical and mechanical analogues are treated, and mechanical problems appear throughout the book. In addition to the numerous examples worked out in the text, problems are found at the end of each chapter.

Those aspects of circuit theory that are a common basis for advanced courses are emphasized. Among the topics included are the formulation of network equations and their solution in the time domain by classical methods or in the frequency domain by Fourier or Laplace transforms.



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344012	7 - 16 volts
344024	16 - 32 volts
344125	90 - 125 volts
344250	200 - 250 volts

Maximum current rating 20 amps.

**PHYSICAL CHARACTERISTICS**—Overall length 2<sup>3</sup>/<sub>8</sub>" with fuse inserted • Front of panel length 1<sup>3</sup>/<sub>16</sub>" • Back of panel length 1<sup>1</sup>/<sub>16</sub>" • Panel area front 1<sup>3</sup>/<sub>16</sub>" dia. • Panel area back 1<sup>3</sup>/<sub>16</sub>" dia. • Mounting hole size (D hole) 5/8" dia. flat at one side.

**TERMINAL**—Side—one piece, .025 brass—electro-tin plated • Bottom—one piece, lead free brass, hot tin dipped.

**KNOB**—High temperature styrene (amber with incandescent bulbs—2½ thru 32 volts—and clear with high degree vacuum neon bulbs—90 thru 250 volts) • Extractor Method—Bayonet, spring grip in cap.

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## RUSSIAN TRANSLATIONS

J. George Adashko

# Cascaded Reflex Voltmeter Yields High Input Z, Wide Range

Yu. V. Mikhatskiy

**T**HE REFLEX voltmeter circuit (Fig. 1) has been quite popular lately. This circuit is used for measuring dc voltages from very high resistance sources. Thanks to its heavy negative feedback, the reflex voltmeter circuit has many valuable properties: (a) large input and small output resistance, (b) possibility of measuring a wide

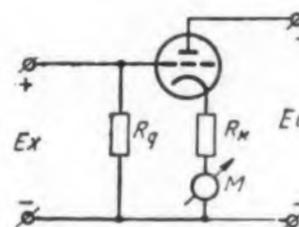


Fig. 1. Basic reflex voltmeter.

range of voltages, (c) scale linearity, (d) high stability. These lead to permanence of calibration with variations in supply voltage and replacement of tubes.

However, the input resistance of the reflex voltmeter usually does not exceed  $10^8$  to  $10^9$  ohms.

Where a higher input resistance is necessary, circuits with electrometer tubes are used. However, electrometer tubes with high resistances,  $10^{13}$  to  $10^{14}$  ohms, do not have many advantages of reflex circuits.

Circuits with electrometer tubes make it possible to measure voltages up to only two or three volts. The use of voltage dividers, in reflex circuits, to insure an input resistance of  $10^{13}$  to  $10^{14}$  ohms is practically impossible, because of the instability of the division coefficient.

However, the cascaded-reflex voltmeter has all the advantages of ordinary reflex voltmeters, but has an input resistance of  $10^{11}$  to  $10^{12}$  ohms.

The input resistance of the reflex circuit is determined by the grid current of the input tube. The principal components of the grid current are the electronic and ionic component, the thermionic grid current, and the conduction currents. The remaining components play a secondary role. The curve of the total grid current is illustrated in Fig. 2.

A feature of the reflex circuit is in operation with large negative bias. In this case the grid current is negative. Consequently, a principal role is

played, in the reflex voltmeter, by the ionic current and by the thermionic grid current. The latter can be reduced substantially by reducing the filament voltage.

The magnitude of the grid current for a given tube depends on the anode current and on the anode voltage; as they decrease, the ion current also decreases. As the anode voltage is decreased, the grid current diminishes rapidly; ionization

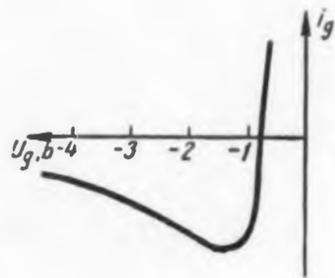


Fig. 2. Grid current vs. grid voltage for the input tube of a reflex circuit.

ceases with the anode at 6 to 9 v. Such a mode is typical of electrometer tubes.

In the cascaded-reflex voltmeter (Fig. 3), the grid current of the first tube is greatly reduced by a substantial reduction in the plate current. This is attained by connecting a very large resist-

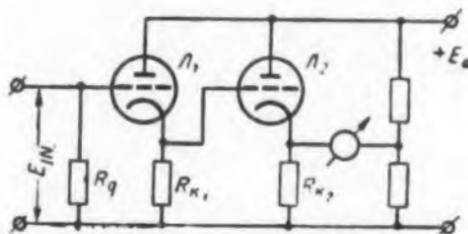


Fig. 3. The cascaded reflex voltmeter.

ance,  $R_{k1}$ , of tens or hundreds of megohms in the cathode circuit.

An experimental verification has shown that, in a type 6S1Zh tube, with  $R_{k1} = 45$  megohms and with a simultaneous reduction of the filament voltage to 4 v, the grid current drops to  $10^{-12}$  amp.

The resistance  $R_{k1}$  serves as grid resistor for the second tube, and must pass the grid-current of this tube. The resistance  $R_{k2}$  should be small but sufficient to permit inclusion of a measuring instrument in the cathode of the second tube.

The cascaded-reflex voltmeter was used for a model of a pulse voltmeter, for measuring the voltage of single and repeated pulses with a very low duty cycle. The diagram of the voltmeter is shown in Fig. 4.

Connected to the input of the circuit is a cathode follower, which makes it possible to measure



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## RUSSIAN TRANSLATIONS

pulse voltages arriving from sources with relatively large output resistance. The pulses are fed from the output of the cathode follower to a diode detector.

The dc voltage across the capacitor of the detector is measured by the cascaded-reflex voltmeter. The first tube in the reflex voltmeter is a 6S1Zh, since the grid leakage resistance of this tube can be made sufficiently large. Consequently the time constant of the discharge of the capacitor is sufficiently large even for a small value of the capacitance. This makes it possible to measure pulse voltages of relatively short duration.

The voltmeter has two ranges, 50 and 250 v. The ranges are changed by a switch at the 250-v setting in Fig. 4 which changes the plate voltage

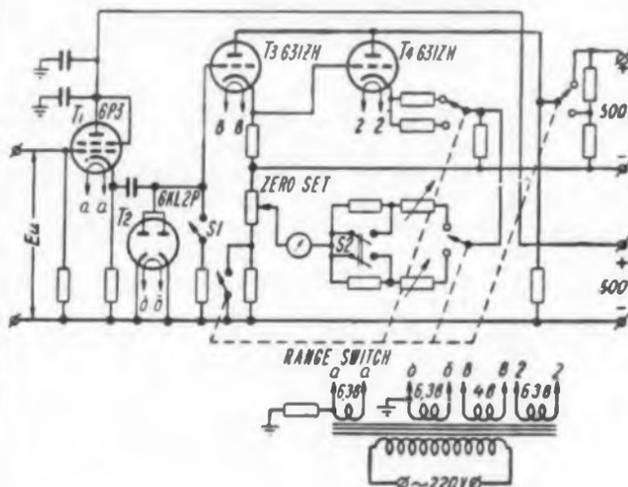


Fig. 4. A pulse voltmeter using the cascaded-reflex circuit.

and switches the resistance of a bridge circuit in the cathode circuit in tube  $T_4$ .

The switch  $S_2$  (in the "single-pulse" position in Fig. 4) serves to retain the same voltmeter calibration during the measurement of single and repeated pulses.

Variation of the resistance in series with the milliammeter compensates for the difference in the dc voltage produced on the grid of  $T_3$  during the charging of the capacitor. Pushbutton  $S_1$  (shown normally open in Fig. 4) serves to drop the voltage and permits rapid discharge of the capacitor. The instrument is fed from stabilized sources.

In the tests of the model the following was noted:

- The voltmeter scale is almost linear.
- After the instrument has warmed up, no differences in readings were observed (the observations lasted for approximately 4 hr.)
- The voltmeter can be used to measure voltages

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■ The effect of input resistance, determined by the leakage resistance and by the grid current of the first tube is  $2 \times 10^{11}$  ohms (time constant of discharge is 400 secs).

[Translated from an article "Cascade Reflex Voltmeter" in the October 1959 issue of Izmeritel'naya Tekhnika (Measurement Engineering).]

## Simple Technique for Measuring Phase and Amplitude in Automatic Control Systems

A. S. Lifshitz and I. A. Dedok

IN THE design of automatic control systems it becomes necessary to determine experimentally the amplitude and phase vs. frequency characteristics of the individual elements and of the system as a whole.

There are several methods for determining the frequency characteristics. The most popular methods use loop oscillographs or low-frequency cathode-ray oscilloscopes to determine the frequency characteristics, or they use a phase meter to determine the phase-frequency characteristics.

Each of these methods has advantages and shortcomings. The determination of the frequency characteristics by loop oscillograph is accurate, but it requires a rather long time to record and interpret the oscillograms.

Determination of frequency characteristics with a cathode-ray oscilloscope involves measurements of the amplitude, frequency, and phase shift of the input signal of the tested element. These involve a great loss of time and reduced accuracy.

A phase meter measures the phase accurately only if the output of the tested element is free of distortion and of noise background, for the latter may cause false readings.

By introducing a phase-shift network and a voltage divider in the circuit for measuring fre-

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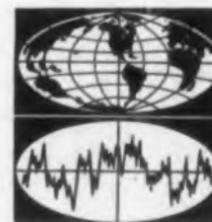
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Mikhatskii, IU. V.

CASCADED REFLEX VOLTMETER YIELDS HIGH INPUT Z,  
WIDE RANGE. Electronic Design, v. 8, no. 3:124-  
127, incl. diags. Feb. 3, 1960.

Translation of an article "Cascade reflex voltmeter"  
in Izmeritel'naiia tekhnika, no. 10, Oct. 1959. 2 refs

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## RUSSIAN TRANSLATIONS

quency characteristics, it is possible to use a cathode-ray oscilloscope and at the same time to reduce the measurement time substantially.

The procedure is to read the phase shift of the phase-shift network, and to read the output-to-input-signal ratio on the voltage-divider scale.

The operating principle of this instrument is based on a comparison of the phase and the amplitude of the output signal of the tested element with the phase and amplitude of the phase-shift network signal.

The phase-shift circuit consists of standard dc amplifiers 1, 2, 3 and a dual sine-cosine potentiometer 4, 5 (Fig. 1).

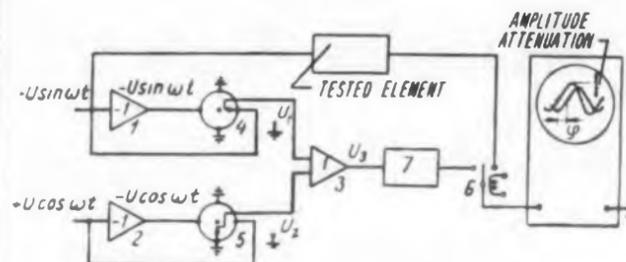


Fig. 1. Equipment for phase and amplitude measurements in automatic control systems. 1, 2, and 3 are standard dc amplifiers; 4 and 5 are a dual sine-cosine potentiometer; 6 is a vibrator; and 7 is a voltage divider.

Potentiometers 4 and 5 receive, respectively, voltages  $\pm U \sin \omega t$ ,  $\pm U \cos \omega t$ . These are applied from the low frequency generator.

The voltages picked off the sliders of potentiometers 4 and 5 respectively are  $u_1 = U \sin \omega t \cos \phi$  and  $u_2 = U \cos \omega t \sin \phi$ , which are then summed by amplifier 3.

$$U_3 = U_1 + U_2 = U \sin \omega t \cos \phi + U \cos \omega t \sin \phi = U \sin (\omega t + \phi)$$

The voltage from the tested link,  $U_{meas}$ , and the voltage from divider 7 are applied to the cathode-ray oscilloscope through vibrator-converter 6.

By rotating the slider of the potentiometer, the phase shift between the voltage  $u_{meas}$  and the voltage  $u_3$  from the phase shifter is reduced to zero, and the values of the amplitudes are equalized with the voltage divider.

If the voltage  $u_3$  is applied to the horizontal deflection plate of a cathode-ray oscilloscope, and the voltage  $u_{meas}$  from the tested link is applied to the vertical deflection plate, an ellipse will be displayed on the cro screen in the general case when the phases and amplitudes do not coincide. (Fig. 2a.)

If the phases are equal, the ellipse degenerates

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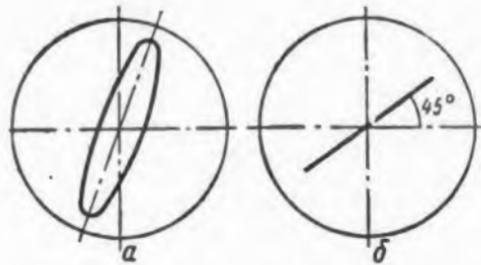


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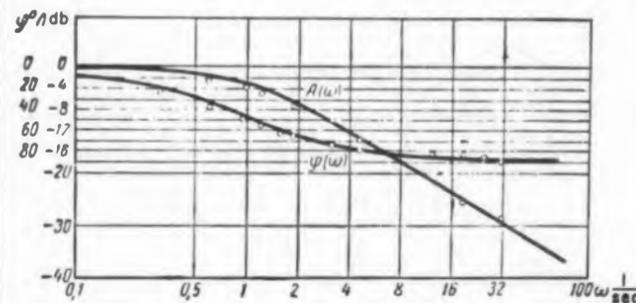
into a straight line which makes an angle of 45 deg with the horizontal (Fig. 2b) if the amplitudes are equal. The accuracy of the measurement of phase and amplitude depends essentially on the precision of the sine-cosine potentiometer of the voltage divider, and on the accuracy of the read-



**Fig. 2.** When the voltage from the phase shifter is not in phase with the measured voltage, an ellipse results as shown in (a). When the voltages are equal and in phase, the pattern in (b) results.

ings. Fig. 3 shows the calculated and experimental values (circles) of the frequency characteristics plotted with this instrument for an element having a transfer function  $W(p) = 1/(1 + pT)$ , with  $T = 1$  sec.

As can be seen from Fig. 3, the experimental



**Fig. 3.** Gain and phase characteristics, calculated (solid lines) and experimental (circles).

results of the phase measurements agree with the calculated ones within one degree, regardless of the value of the measured phase.

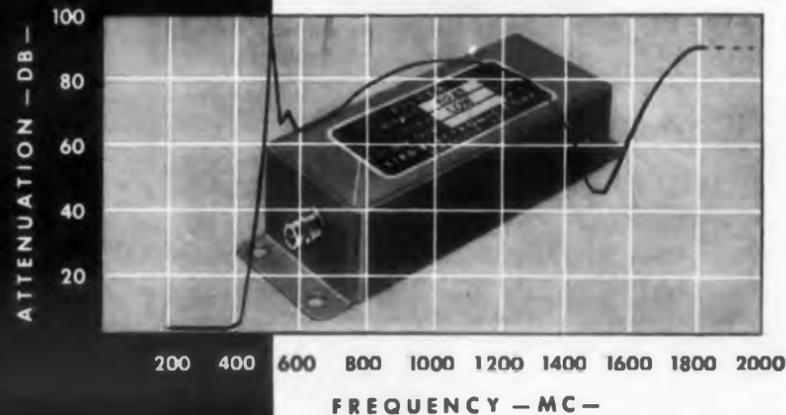
The frequency range of the measured signal is limited by the operating frequencies of the vibrator-converter, which is 400 cps, and ranges from 0 to 40 cps.

The instrument for determining the frequency characteristics is reliable in operation and can be used to investigate commercial automatic control systems.

[Translated from an article "Determination of Frequency Characteristics in the Design of an Automatic Control System" in the October 1959 issue of Izmeritel'naya Tekhnika (Measurement Engineering).]

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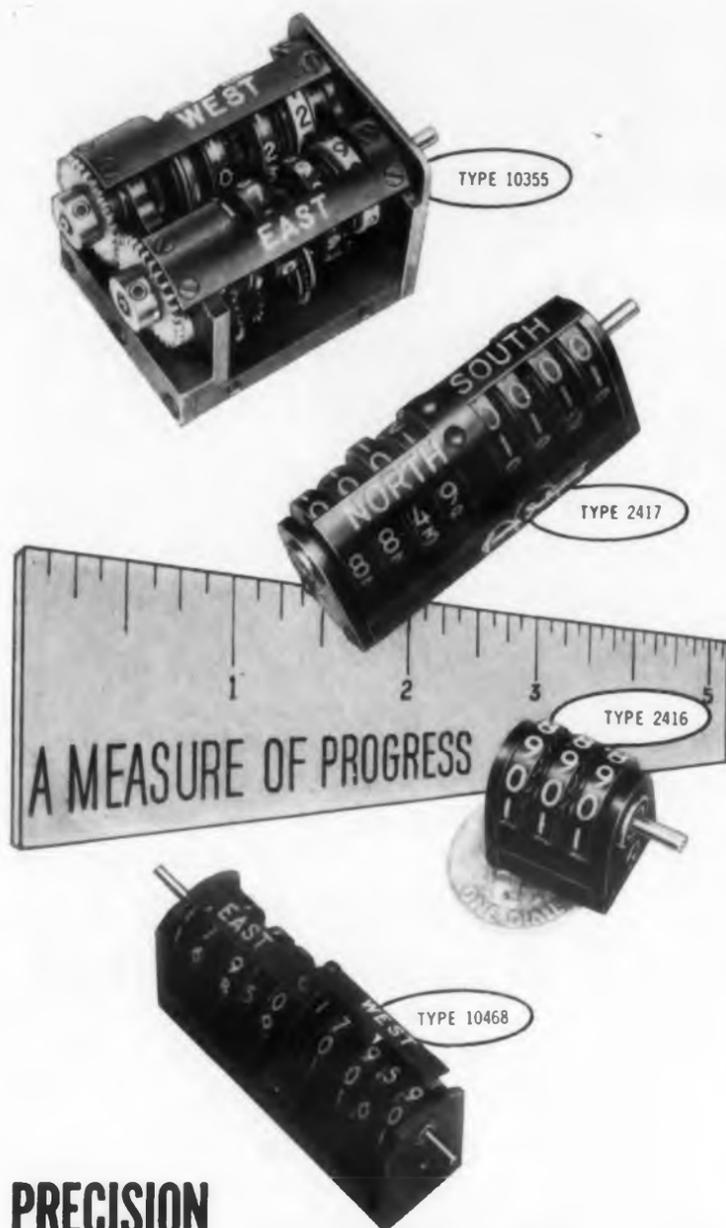
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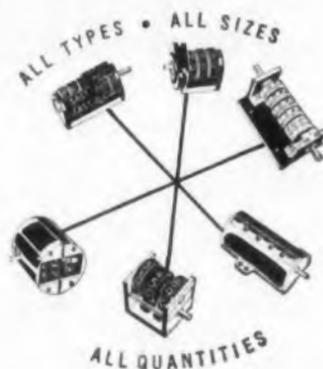
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## GERMAN ABSTRACTS

E. Brenner

# Tuned Transistor Amplifiers

**S**INGLE tuned transistor amplifier stages have finite complex input and output admittances whose resistive and reactive components depend on the operating point and the temperature. In the design of such stages one should distinguish between resistive and reactive matching. Resistive matching refers to the achievement of a desired over-all  $Q$ , with a given tank circuit  $Q$ ,

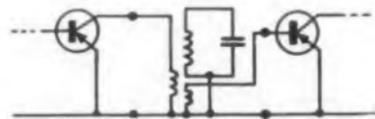


Fig. 1. Ac circuit of narrowband tuned amplifier.

under optimum power transfer conditions. However, the detuning due to the variation of reactance is neglected. Reactive tuning meets a specification for maximum detuning together with a corresponding optimum power transfer.

Considering a common emitter stage (Fig. 1) the equivalent circuit, Fig. 2, may be drawn. In

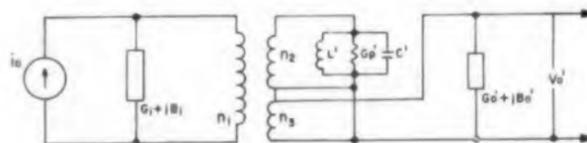


Fig. 2. Equivalent circuit of Fig. 1.

this circuit the transistor input and output admittances are capacitive, that is,

$$Y_i = G_i + j\omega C_i; Y_o = G_o + j\omega C_o$$

Referring all values to the primary ( $n_1$ ) winding, the equivalent circuit shown in Fig. 3 is drawn.

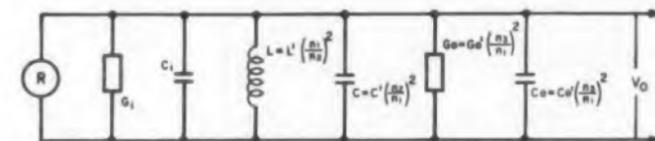


Fig. 3. Circuit equivalent of Fig. 2 at the terminals of  $i_o$ .

The resonant frequency used below refers to the resonant frequency obtained from Fig. 3.

The power delivered to the succeeding stage,  $P_o$  ( $P_o = v_{out}^2 G_o$ ), is related to the maximum power which the stage can deliver by

$$\eta = \frac{P_o}{P_{omax}}, P_{omax} = |i_o|^2 / 4 G_i$$

Using the normalized parameters:

$$q = \frac{G_p}{G_p + G_o + G_o} = \frac{Q \text{ of entire circuit}}{Q \text{ of tank}}$$

and

$$g = G_i / G_p$$

the general expression for  $\eta$  is:

$$\eta = 4gq[1 - q(1 + g)]$$

The optimum resistive match may be shown to occur when:

$$G_o = G_i, G_p = G_i 2Q / (Q_{tank} - Q)$$

yielding the value:

$$\eta_{opt} = (1 - q)^2$$

In the left half of Fig. 4,  $\eta_{opt}$  and  $1/g$  are shown as functions of  $q$ . The detuning due to variation of transistor input and output capacitance is shown, normalized with respect to bandwidth, for 100 per cent of  $C_o$  and  $C_i$  in the right half of Fig.

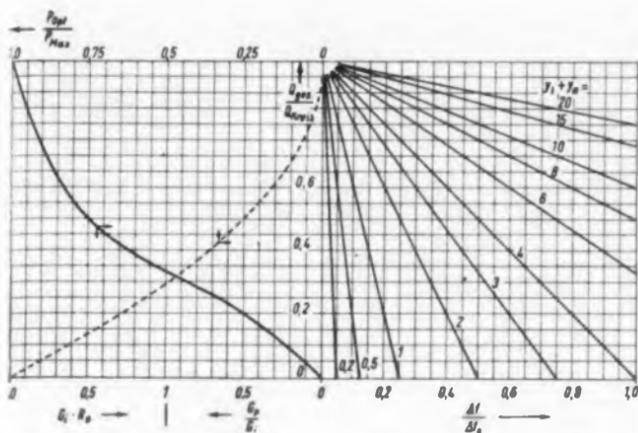


Fig. 4. Chart for resistive matching.

4. Normalized susceptance is used, that is,  $b = \omega C/G$ .

Denoting by  $\Delta f$  the detuning due to 100 per cent change in  $C_o$  and  $C_i$ ,

$$\frac{\Delta f}{\Delta f_B} = \frac{1}{4} (1 - q) (b_o + b_i)$$

In many transistors  $C_i/G_i$  is negligible compared to  $C_o/G_o$  and if base resistance is also neglected, one may write:

$$\frac{\Delta f}{\Delta f_B} \approx \frac{1}{4} (1 - q) \omega_o / \omega_c$$

where  $\omega_c$  is the cut-off frequency of the short-circuit current gain.

When the maximum detuning is prescribed, then Fig. 5 may be used to obtain the circuit

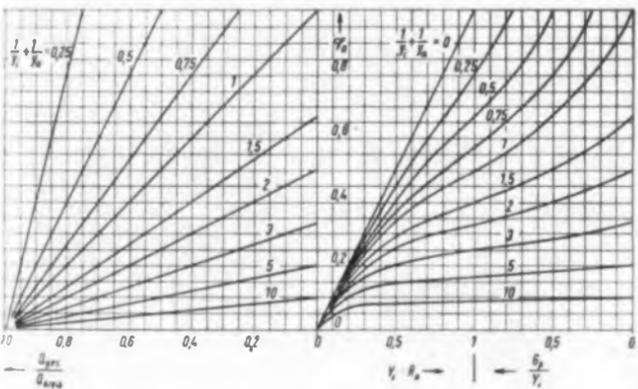


Fig. 5. Chart for reactive matching.

parameters for optimum design. In this chart

$$\psi_o = \Delta f / \Delta f_B$$

For a given value  $\psi_o$ , the optimum  $q$  and susceptance values are found in the left portion of the chart. The family of curves at the right gives the value  $G_p$ . The optimum power transfer is

$$\eta_{opt} = 4 \psi_o^2 / b_i b_o$$

Abstracted from an article by H. Beneking Nachrichtentechnische Zeitschrift, Vol. 12, No. 11, Nov. 1959, pp 543-546.



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## Spurious RF Emissions Predicted From Output Stage Analysis

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1. Operate in the high-frequency range
2. Have a tuned single-ended output
3. Can be represented by lumped, constant parameters.

In analyzing the spectrum, only harmonics of the oscillator frequency are considered. Output frequencies caused by modulation splatter or carrier noise are not.

### Equivalent Transmitter Circuit

This prediction method considers only the transmitter's final output stage. A stage-by-stage analysis, it is felt, does not produce results accurate enough to warrant its cumbersome and tedious calculations. This is because of the numerous random variables, such as lead length, lead placement, and normal component tolerances which are involved.

Fig. 1 is a constant-current equivalent circuit for a transmitter which meets the conditions given above. In this circuit  $Z_L$  represents the impedance

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### SPECIFICATIONS

MODEL	540	530	580	560	780	790	880	840
No. of coil turns	10	3	10	3	10	3	10	3
Diameter (Inches max.)	7/8	7/8	1	1	1 1/4	1 1/4	1 1/2	1 1/2
Standard resistance range in ohms ( $\pm 3\%$ )	25-125K	10-36K	25-150K	10-40K	30-300K	10-90K	50-400K	20-120K
Special resistance to	250K	75K	250K	75K	750K	240K	1 meg	330K



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of the transmission line and the antenna network. The output circuit block consists of the final tuned circuit and the antenna coupling circuitry. It is assumed that the output impedance of the transmitter is large compared with the output circuit and is ignored.

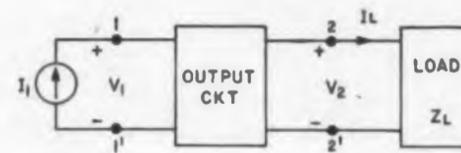


Fig. 1. Constant current equivalent circuit of the transmitter's output stage.

From the network loop equations, the load current can be written as:

$$I_L = I_1 \frac{|Z_T|}{Z_L + Z_{22}}$$

where

$Z_T$  = transfer impedance  $Z_{12} = Z_{21}$

$Z_{22}$  = self impedance of loop 2

$Z_L$  = load impedance

Thus, to predict the output power spectrum, it is necessary to determine:

1. The harmonic currents generated by the tube ( $I_1, I_2, I_3, \dots, I_N$ )
2. The absolute value of the transfer impedance ( $Z_T$ ). Note that only its absolute value is necessary since it alone appears in the numerator.
3. The real and imaginary components of the output impedance  $Z_{22}$ .
4. The real and imaginary components of the load impedance  $Z_L$ .

#### Determining the Harmonic Currents

General methods for obtaining the harmonic currents in tubes operating with various angles of plate current flow have been devised. One of these expresses the instantaneous plate current as:

$$i_p = k \left[ \cos b - \cos \frac{\theta}{2} \right]^{\frac{3}{2}} \quad (1)$$

The Fourier current integral is:

$$I_N = \frac{2k}{\pi} \int_0^{\frac{\pi}{2}} \left[ \cos b - \cos \frac{\theta}{2} \right]^{\frac{3}{2}} \cos nb \, db. \quad (2)$$

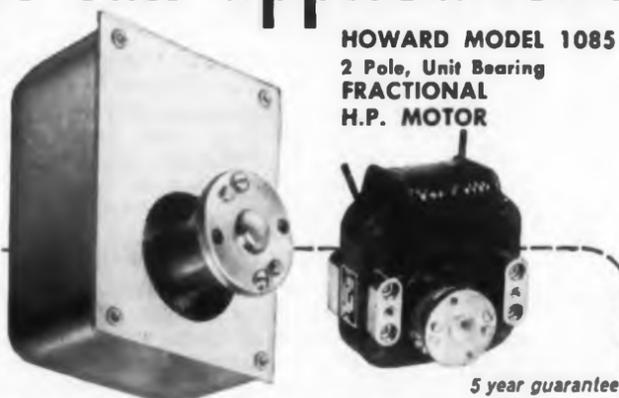
where:  $I_N$  is the current amplitude for each harmonic being considered

$b$  = carrier time angle

$\theta$  = angle of plate current flow with respect to each cycle of the operating frequency.

The maximum value of plate current is:

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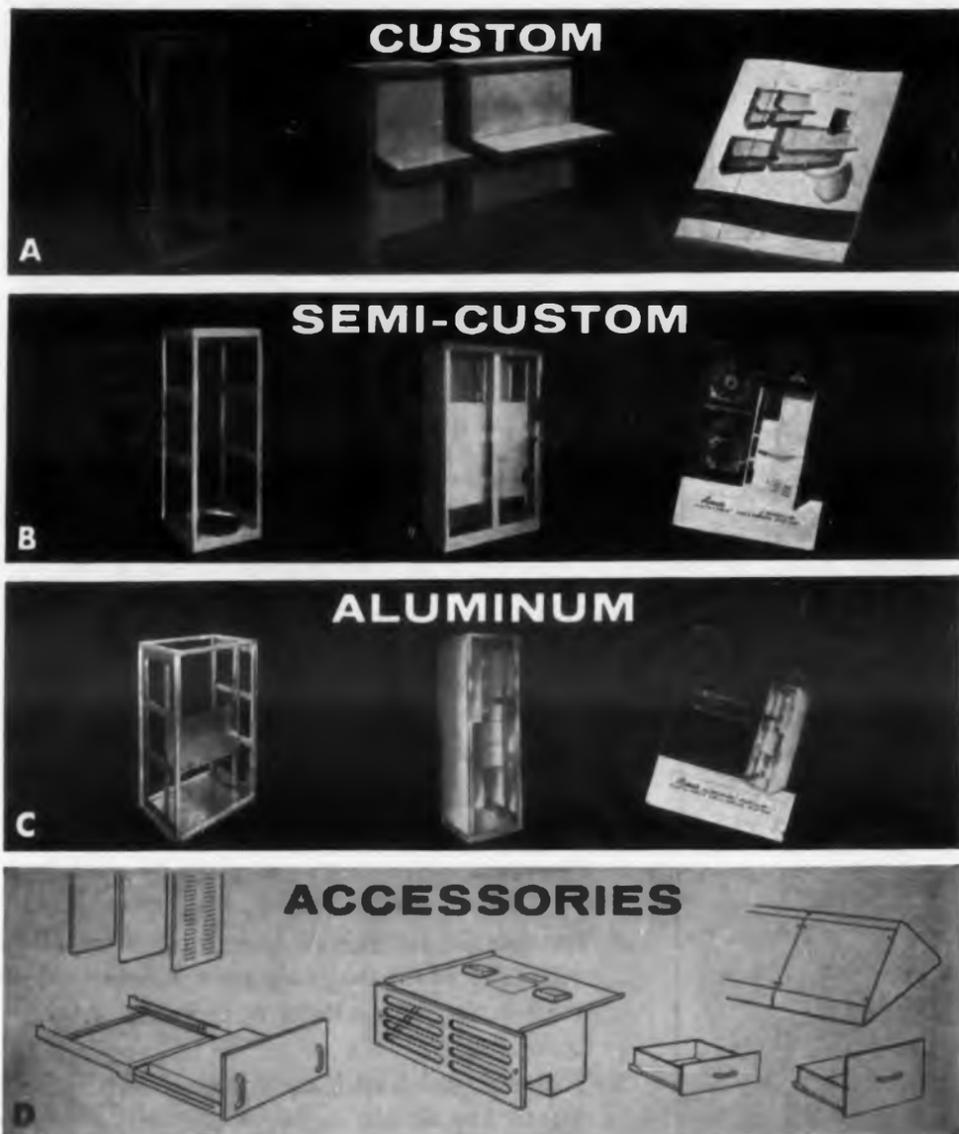
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## DIGEST

$$I_M = k \left[ 1 - \cos \frac{\theta}{2} \right]^{0.5} \quad (3)$$

Peak plate current can also be determined by plotting the load line on the tube characteristic curves.

In a problem involving a given transmitter,  $I_{max}$  and  $\theta$  can be specifically determined from the transmitter's operating characteristics. The absolute values of the harmonic currents can be obtained from Eq. 2.

If it is desired to determine the spurious spectrum for various values of  $\theta$  and  $I_{max}$ , a normalized plot of the ratio of  $I_N$  and  $I_{max}$  is helpful. In Fig. 2,

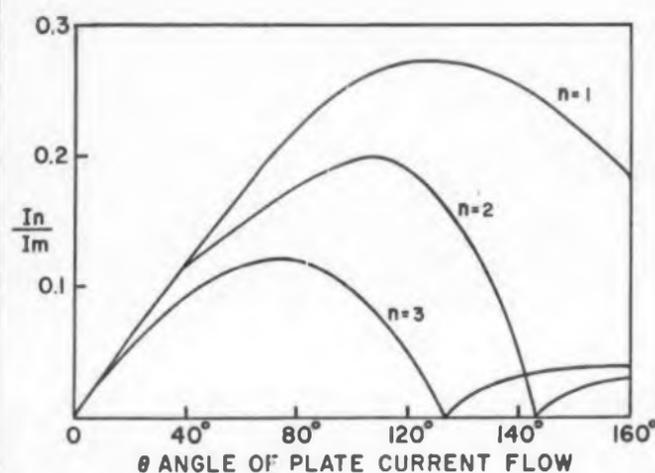


Fig. 2. Illustrative plots of general harmonic current ratio curves.

the ratio  $I_N/I_M$  is plotted for the various angles of plate current flow. Thus, the absolute harmonic current values can be found by multiplying the current ratio corresponding to a certain  $\theta$ , by the output tube's peak current.

This analysis indicates levels of currents associated with frequencies which are harmonically related only to the carrier frequency. If frequency multiplication occurs in a transmitter, frequencies which are harmonically related to the oscillator fundamental frequency must be separately inserted. These additional harmonic currents must be considered at all multiples of the oscillator frequency which are not multiples of the transmitter output frequency. They can be inserted in the equation at the appropriate frequencies, with magnitudes of 0.5 times the value of the envelope described by the carrier harmonics. The number 0.5 was empirically evolved as a correction factor after evaluation of several theoretical and actual test data. This is a rough approximation which

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presently appears to provide adequate accuracy for most prediction purposes. If the worst case is desired, the magnitude of the oscillator harmonics can be made equal to the envelope of the carrier harmonics. The process of inserting these plate currents at the oscillator harmonic frequencies will be shown in the sample problem.

### Sample Problem

To illustrate the technique just described, the power output spectrum of a high-frequency, 2 to 30 mc, three-stage, 100-w cw transmitter was predicted and compared to measured data for the same transmitter. In the transmitter the 3-mc oscillator frequency was multiplied to obtain a 6-mc carrier frequency.

The transmitter's output tube was designed to operate with an angle of plate current flow slightly less than 180 deg. The output current was expressed as the 3/2 power of the grid voltage, and the Fourier components were found as ratios of harmonic currents to the peak plate current. Peak plate current was determined by plotting the operating load line on the tube characteristic curves.

This peak current value was then multiplied by each Fourier harmonic current ratio to yield absolute values of harmonic current at frequencies which are multiples of 6 mc. Since it is known that the transmitter oscillator is operating at 3 mc, harmonic currents are to be expected at all multiple frequencies of 3 mc.

As an approximation, these harmonic currents were inserted in Fig. 3 with magnitudes empirically chosen to be half the magnitude of the

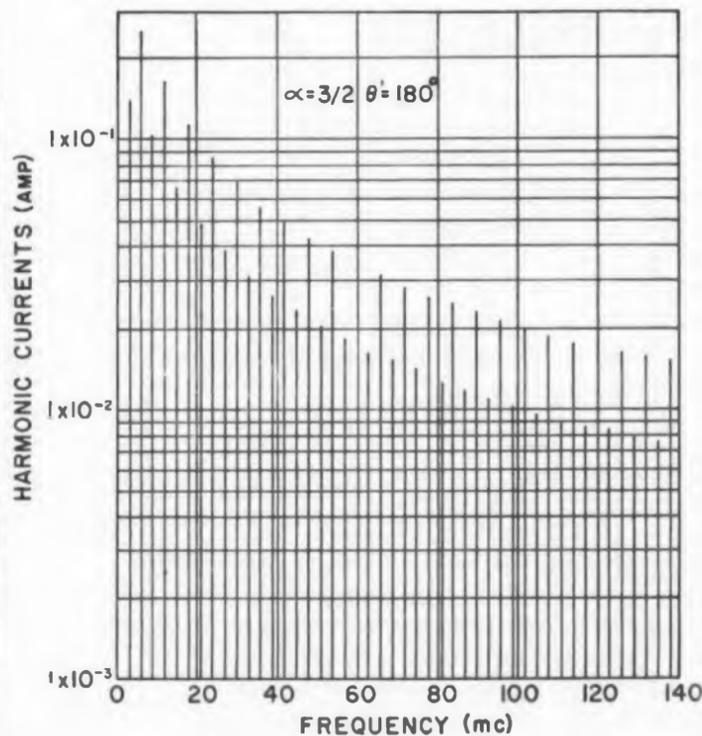


Fig. 3. Theoretical harmonic current content of a power amplifier tube plate current pulse.

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## DIGEST

envelope described by the mathematically predicted currents. Fig. 3 represents the theoretical harmonic current content of the power amplifier tube-plate current pulse.

The output circuit of this transmitter consisted of a tuned LC circuit and a fixed coupling link as shown in Fig. 4.  $Z_{22}$ , the output impedance of this circuit, was determined by averaging a series of bridge measurements taken across the antenna terminals of the transmitter, with the plate lead of the power amplifier tube removed.

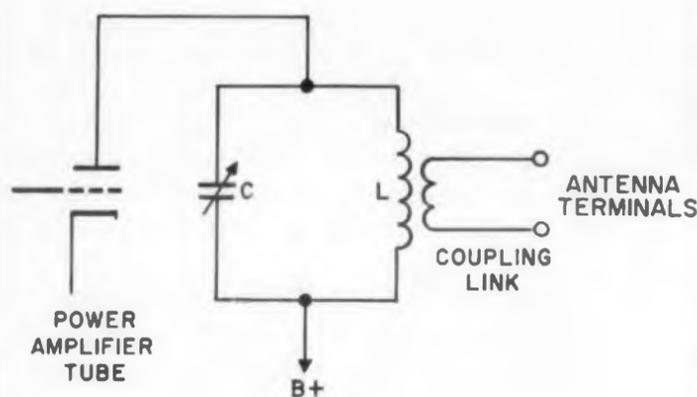


Fig. 4. Output circuit for the sample transmitter.

Much difficulty was encountered in measuring the transfer impedance ( $Z_T$ ). The measuring technique is shown in Fig. 5. The tube-plate lead was connected to a signal generator and the output circuit was driven with a known current. The effective open-circuit voltage developed across

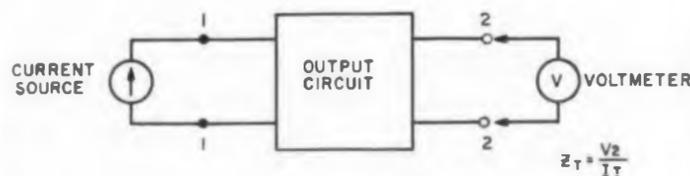


Fig. 5. Circuit for the measurement of the output circuit transfer impedance  $Z_T$ .

the antenna terminals (2) was measured with a high-impedance rf voltmeter.  $Z_T$  was determined by dividing this voltage by the current.

A calibrated dummy load having real and reactive components, provided a known load impedance ( $Z_L$ ).

The portion of the harmonic current reaching the load was calculated from Eq. 1, previously given.

Harmonic power dissipated in the load was

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calculated from:

$$P_N = \frac{I_N Z_T}{Z_{22} + Z_L} R_L \quad (4)$$

where

$R_L$  = the real component of the load impedance.

The resulting predicted power spectra are compared with the actual measured spectrum in Fig. 6. It was suspected that the impedance measuring technique yielded transfer impedance values which were too high at frequencies above 120 mc. The power spectrum calculated from the measured transfer impedance seems to uphold this view since Fig. 6 shows the calculated spectra to

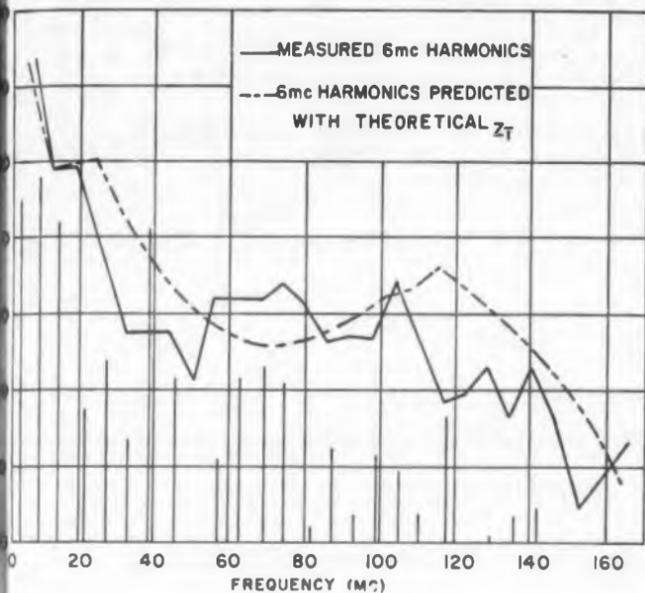


Fig. 6. Measured and theoretical plots of transmitter harmonic output.

be much higher than the measured spectra in the upper range. The vertical lines on Fig. 6 represent the power levels for the oscillator frequency harmonics. These were plotted separately to show their level relative to the carrier harmonics. It was found that the oscillator harmonic currents as estimated were too large in this case to accurately predict the measured values.

#### Conclusions

From the results, it is realized that more measurements must be made before a completely accurate method for estimating these harmonics can be applied to any transmitter. However, the prediction technique described appears to have great promise.

*Digester from a paper, "Prediction Factors Influencing Transmitter Power Spectrum," by James J. Crenca and Donald Berilla, Jansky & Bailey, Inc., and Charles R. Miller, Rome Air Development Center, presented at the Fifth Conference on Radio Frequency Reduction and Compatibility, October 1959, Chicago, Ill.*

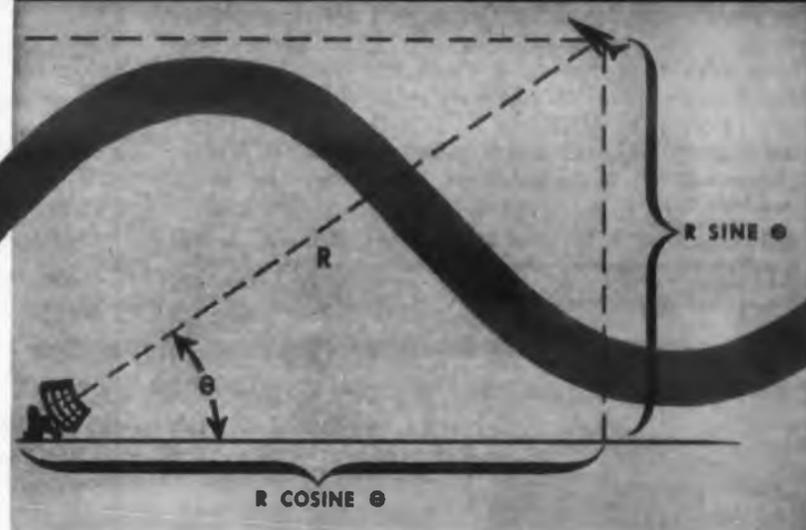
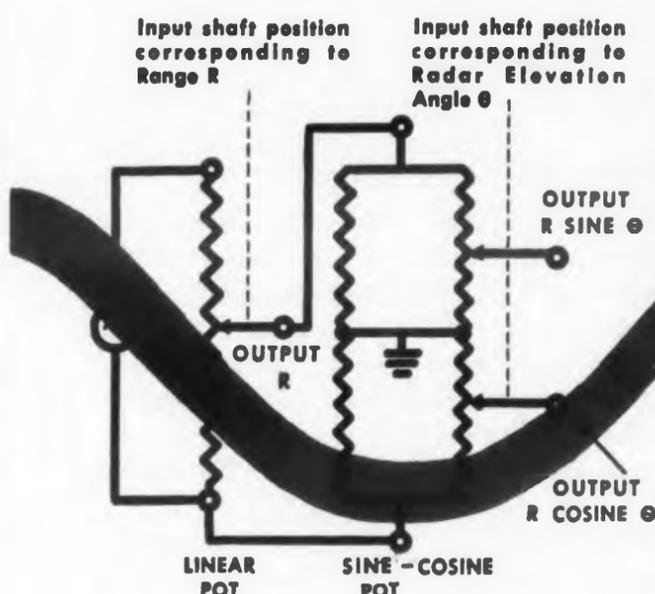
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## SINE-COSINE FILM POTS

★ 0.015% ACCURACY!  
★ INFINITE RESOLUTION!



## COMPARE SYSTEMS ERROR YOURSELF!

Typical example of Radar Tracking System Problem:  
To accurately locate target

Error with Wire-Wound Pots

Error with C.I.C. Film Pots

Range to Target: 50,000 yards  
Radar Elevation Angle: 45°

Quadrature due to Inductance of Windings (@ 1000 cps)... 35  
Resolution ..... 30  
Linearity ..... 50

Quadrature due to Inductance 0  
Resolution ..... 0  
Linearity ..... 8  
8 yds

115 yds

### YOU DON'T HAVE TO ACCEPT THE ERRORS IN WIRE WOUND POTS!

Engineers recognize the obvious superiority of C.I.C. Film Sine-Cosine Pots; THOUSANDS are currently in use in Hawk, Atlas, Nike and other missile systems, as well as in the APS-81, ASG-15 fire control system and AN/ASB-4 Bombing/Navigation system, all used on the B-52 Bomber, AN/APA-125 Radar Indicator, and many others. You too can have superior systems with C.I.C. Film pots. Send us your specifications today!

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## REPORT BRIEFS

### Phase-Modulated Antennas

The resolution of a passive antenna system can be improved through phase-modulation, cross correlation, and synchronous detection. Possible methods for constructing radiation patterns of the form  $(NKx \sin NKx)$  by means of these techniques are presented. The relationship between the coefficients of a linear additive array and those of an equivalent product array is also stated. *Phase-Modulated Antennas*, Charles J. Drane, Jr., Air Force Cambridge Research Center, Bedford, Mass., Apr. 1959, 19 pp, Micro-film \$2.40, Photocopy \$3.30. Order PB 142962 from Library of Congress, Washington 25, D. C.

### Intermediate Frequency Amplifiers

Small-size, very high-gain, high-level-output intermediate frequency amplifiers for use in radio interference measuring sets were designed and constructed. Results of the study and design phase are given. Recommendations for electronic and structural modifications which will result in better production results are made. The factual data section includes a description of the study program, a detailed description of the two types of amplifiers which were investigated. *Intermediate Frequency Amplifiers*, A. W. Pearson, General Electronic Laboratories, Inc., Cambridge, Mass., July 1, 1954-July 1, 1957, 171 pp, Microfilm \$8.10, Photocopy \$27.30. Order PB 143358 from Library of Congress, Washington 25, D. C.

### Coupling Network Design

The problem of broadband coupling-network design is one of primary practical importance in electrical engineering. This report is concerned with the derivation of a method for such network design. The design problem may be stated as follows: "To design a two-port coupling network that presents some prescribed input impedance,  $Z_{in}$ , when terminated in a prescribed load impedance,  $Z_L$ , both input and load impedances being described over a certain band of frequencies." A method for the design of practical lossless ladder networks, based on a point-by-point matching in the frequency domain, is described. *Coupling Network Design Using Discrete-Frequency Data*, P. A. Ligomenides, Stanford Electronics Laboratories, Stanford University, Calif., Oct. 22, 1958, 195 pp, Microfilm \$8.70, Photocopy \$30.30. Order PB 143066 from Library of Congress, Washington 25, D. C.

## Q: What is a Kodak Ektron Detector?

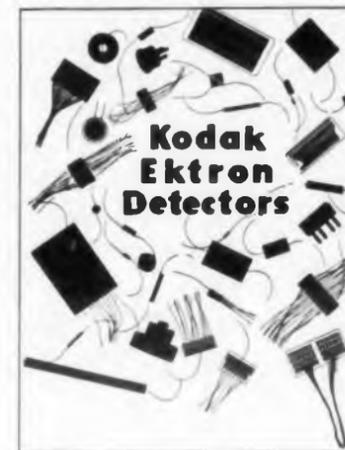
**A:** It is a photosensitive resistor. The photosensitive area can be laid down in any pattern. Response extends to 3.5 microns in the infrared. Unaffected by vibration; high signal-to-noise ratio.

**Q:** What can it be used for?

**A:** For such applications as an infrared sensor in weapons systems, and in instrumentation for process control, analysis, and safety.

**Q:** How can I get the facts about spectral response, types, availabilities, and the like?

**A:** By writing for a new brochure called "Kodak Ektron Detectors."



Write to:

Apparatus and Optical Division  
EASTMAN KODAK COMPANY, Rochester 4, N. Y.

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## Thyratron Provides Double & Triple Coincidence Control



KP-80. Actual Size

The KP-80 is a coincidence thyratron which may be used in double or triple control coincidence circuits, as well as conventional single-signal applications. Operating on the ion deflection principle (registered U.S. Patent Office), the KP-80 provides true symmetrical grid sensitivity in that large signals applied to one grid alone will NOT fire the tube, while small, low current signals applied simultaneously to both grids will cause conduction. The KP-80 is used as an "and" gate, a binary counter, for relay closure, etc. Because it combines many circuit functions, the KP-80 eliminates from 14 to 25 precision circuit components, thus reducing space and weight, and contributing to improved equipment reliability. The KP-80 is found in conveyor selection systems, coding & programming devices, automation control apparatus, etc. A subminiature version is also available (type KP-150) which also provides visual indication as well as double coincidence operation. For details on these and other special purpose electron tubes, contact:

### KIP ELECTRONICS CORPORATION

Dept. 924, Box 562, Stamford, Connecticut

CIRCLE 259 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 3, 1960

# Technical News Editors Wanted

ELECTRONIC DESIGN's editorial staff is expanding again . . . we need men with solid engineering background and excellent news gathering experience to cover research and development news in the industry.

These men will . . . interview experts in all phases of electronics . . . report on industry trends of significance to design engineers . . . post readers on latest electronic thinking gathered from technical conferences and plant visits.

If you are a capable reporter and know electronics, we are interested in talking to you about our news editor openings in New York and Chicago.

Salary open.

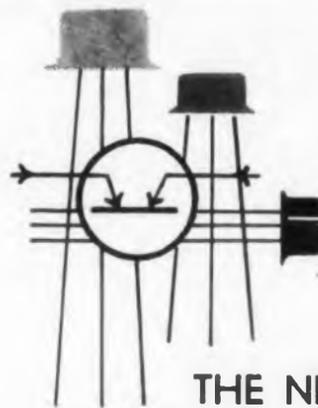
Send complete resume to  
Edward E. Grazda, Editor  
ELECTRONIC DESIGN  
Hayden Publishing Co., Inc.  
830 Third Avenue  
New York 22, N. Y.

## Broadband Components

Results are summarized for the development of ridged guide components in the 3.75 to 15 kmc range. The first objective was concerned with obtaining complete design information on the transmission line properties of the single ridged guide system, and the second objective was concerned with the building of a number of ridged guide components. General design information of single and double ridged guides is presented in graphical form and allows the determination of all the electrical properties of ridged guide transmission lines. The following components are discussed: ridged to rectangular guide adapters, coax to ridged guide adapter, H-bend, termination, crystal mount, tuner, variable attenuator, and slotted section. Performance of these components is in some respects below that of the conventional narrow-band devices. With additional engineering effort, these components are expected to be comparable in performance to the conventional items. *Extremely Broadband Components Development, Samuel Hopfer, Polytechnic Research and Development Co., Inc., Brooklyn, N. Y., Aug. 1954, 80 pp, Microfilm \$4.50, Photocopy \$12.30. Order PB 143102 from Library of Congress, Washington 25, D. C.*

## Thermoelectricity Abstracts

This bibliography represents the accumulation of unclassified references to the literature on thermoelectric research, development, and application resulting from a search of abstract journals, indexes and bibliographies immediately accessible. Some early, as well as current, material are included. Additional bibliographies will be issued at intervals, the objective being to attain as complete coverage of the literature as possible. Arrangement for periodical entries is alphabetical—by author, or by title if author is lacking; and for research reports by issuing agency. Each entry is numbered in preparation for an anticipated index. Abbreviations for journal titles are based on those used by the U.S. Naval Research Laboratory Library. A list of these abbreviations together with the journals which they represent appear on the pages following the introduction. The majority of the journals and books referred to should be available for consultation or borrowing at the larger public or research libraries. Research reports can usually be obtained through established borrowing procedures from the Armed Services Technical Information Agency and the Office of Technical Services. AD and PB numbers are included when known. *Thermoelectricity Abstracts, Naval Research Laboratory, Washington, D. C., May 1959, 104 pp, \$2.50. Order from OTS, Washington 25, D. C.*

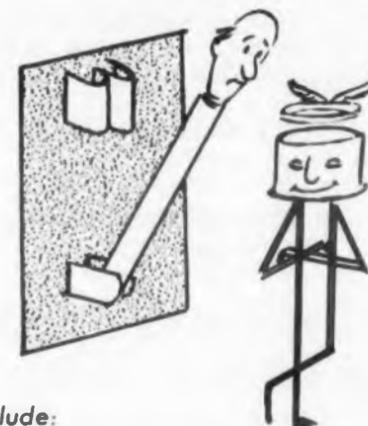


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THE NEAREST AVAILABLE  
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Crystalonics, Inc.  
offers the only

symmetrical P-N-P alloyed Silicon transistors. These units are ideal for bilateral switching circuits, choppers, demodulators, and unidirectional applications requiring extremely low saturation voltages.



The features of these transistors include:

- Typical "Off" resistance over 2000 M $\Omega$  at 10 Volts
- Typical "On" resistance under 5 $\Omega$  at 10 mA.
- Low offset voltage (typically 3 mV)
- Operation to 160 $^{\circ}$  C.
- Fully hermetic sealing in JEDEC 30 package and rugged internal construction for maximum reliability

### ALL PARAMETERS SPECIFY PERFORMANCE IN BOTH DIRECTIONS.

Type	D.C. Beta Min.	V <sub>cb</sub> Max.	V <sub>ce</sub> Max.	RCS Max.	V offset Typ.	f <sub>ab</sub> (Mc) Typ.
C101	6	-30V	-20V	12 $\Omega$	4mV	.4
C102	10	-30V	-15V	9 $\Omega$	3mV	.8
C103	15	-30V	-10V	6 $\Omega$	2mV	1.2

### OTHER SYMMETRICAL TYPES INCLUDE:

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Crystalonics, Inc. also offers the following line of P-N-P alloyed silicon transistors

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2N327A	9-22	-50V	-40V
2N328A	18-44	-50V	-35V
2N329A	36-88	-50V	-30V

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**Crystalonics, Inc.**

249 Fifth Street

Cambridge 42, Massachusetts

Telephone Kirkland 7-2750

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General problems in motivation and navigation in air and space; required background in astronomy, physics, engineering.

Openings also exist in the following areas: Data Systems Research... Controls Analysis... Flight Data Components... Electromagnetic Development... Instrument Design... Airborne Instrumentation Analysis and Design.

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CIRCLE 901 ON CAREER INQUIRY FORM

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CIRCLE 902 ON CAREER INQUIRY FORM

## YOUR CAREER NEWS AND NOTES

Demand for engineers rose appreciably last year in the U.S., resulting in spirited recruiting by industry. But a measure of stability was also evident in the employment picture: numerical shortages dropped and engineering turnover headed for a new decline.

These and other facts on the supply and demand of engineers were disclosed by the Engineering Manpower Commission of the Engineers Joint Council in its ninth annual report.

The commission noted that numerical shortages of engineers "were not widespread because of the large number of engineering graduates available for immediate employment." Last year's B.S. graduates were put at 38,162, "the largest class since 1951; 36 per cent greater than in 1956, and 41 per cent over 1955, the period in which the shortage was most acute."

But the report warned that as the economy expanded, shortages might once more be pronounced, inasmuch as enrollments in engineering schools declined in 1958 and 1959.

"The demand for engineering graduates will increase," the commission said, "and by 1966 there will be 15 graduates recruited for every 10 hired in 1959."

As for engineering turnover, the report said it averaged 9.5 per cent in 1958, a drop from the 11 per cent of 1957, and when the final figures were in, would likely show a further dip to 8.6 per cent for 1959. The main causes of engineer losses were given as resignation, 55 per cent; death and retirement, 9 per cent, and military leave, 6.5 per cent.

Starting salaries last year were reported at new average highs: \$510 a month for B.S. graduates, \$600 for M.S. and \$825 for Ph.D.'s.

*For each of you lads with E.E.,  
Now's the time to flog that degree!  
Never stay in one town  
But keep shifting around—  
Transporting the family is free.*

*Reprinted With the Permission of  
Benson-Lehner Corp.*

What can an electronics company do when it's (1) small; (2) situated in a farming area, and (3) desperately short of engineers? New Hampshire Ball Bearings, Inc., of Peterborough, N.H., like many rural electronics plants, has an answer.

As Arthur N. Daniels, president of the concern, explains it, the solution is to spread thin what engineering talent is available and open a school to train engineering assistants.

New Hampshire Ball Bearings operates the school. A graduate of the Massachusetts Institute of Technology and former War Production Board aide, Sid Doyle, is director of education. The course runs for a year, with work divided equally between the classroom and the laboratory.

The first class was recruited by visiting high schools in the area and explaining the program to seniors. Fifty students applied for training. Twelve were selected. Eight earned diplomas and went to work at New Hampshire Ball Bearings.

The word spread among high school students after that, and they have competed to enroll. Trainees get paid for class work as well as duties in the plant. They can take a job anywhere after they graduate, but most stay and help the company turn out miniature and instrument ball bearings.

Mr. Daniels is pleased with the arrangement. "From cows to calculus," is the way he describes the students' progress.

Pass the word along to service technicians: free training in several aspects of transistor theory and trouble shooting is being offered by the Delco Radio Division of General Motors. Classes, which run a week, are conducted at 30 centers in the country. To apply, fill out an application blank, available from Delco distributors, or write for further information to Ted R. Hayes, Service Manager, Delco Radio Division, Kokomo, Ind.



## Advancement Your Goal?

## Use New Form To Speed Action

ELECTRONIC DESIGN's new Career Inquiry Service form is designed to help engineers advertise themselves. This new service speeds applicants to the jobs they seek. It is the first such service offered in the electronics field and is receiving high praise from personnel managers.

To present your qualifications immediately to the personnel managers of companies that interest you, simply fill in the attached standardized short resume.

Study the employment opportunity ads in this section, and circle the numbers at the bottom of the form that correspond to the numbers of the ads that interest you.

ELECTRONIC DESIGN's Reader Service Department will act as your private secretary and type neat, duplicate copies of your standardized resume and send them to all companies you may select . . . the same day the resume is received. (ELECTRONIC DESIGN will detach the circle number portion of the form so that no company will know how many numbers you circled.)

The standardized resume will permit personnel managers to inspect your qualifications rapidly. If they are interested, they will get in touch with you directly. In the past much time has been lost through personnel-manager requests for resumes from applicants who proved ineligible.

MAIL CAREER INQUIRY SERVICE FORM TO  
READER SERVICE, ELECTRONIC DESIGN, 830 THIRD  
AVENUE, NEW YORK 22, N. Y.

# ELECTRONIC DESIGN CAREER INQUIRY SERVICE USE BEFORE MAR. 16, 1960

After completing, mail career form to *ELECTRONIC DESIGN*, 830 Third Avenue, New York, N. Y. Our Reader Service Department will forward copies to the companies you select below.

3

(Please print with a soft pencil or type.)

Name \_\_\_\_\_ Telephone \_\_\_\_\_

Home Address \_\_\_\_\_ City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_

Date of Birth \_\_\_\_\_ Place of Birth \_\_\_\_\_ Citizenship \_\_\_\_\_

Position Desired \_\_\_\_\_

Educational History				
College	Dates	Degree	Major	Honors

Recent Special Training \_\_\_\_\_

\_\_\_\_\_

Employment History				
Company	City and State	Dates	Title	Engineering Specialty

Outstanding Engineering and Administrative Experience \_\_\_\_\_

\_\_\_\_\_

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Professional Societies \_\_\_\_\_

Published Articles \_\_\_\_\_

Minimum Salary Requirements (Optional) \_\_\_\_\_

Use section below instead of Reader Service Card. Do not write personal data below this line. This section will be detached before processing.

Circle Career Inquiry numbers of companies that interest you

900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924  
925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949

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### Immediate Openings for:

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**Circuit Design Engineers** . . . with experience in design of high-speed switching circuits, pulse techniques, and computer logic. Should be experienced in one or

more of the following areas: navigation, guidance, control circuits, CCM, FM, PCM, PDM, and fusing circuitry.

**Packaging Engineers** . . . with a knowledge of packaging and production techniques in sheet metal and electronic equipment. Will design electronic portions of guided missiles, radars, computers, test equipment. Should have thorough knowledge of circuitry.

**Electromechanical Designers** . . . will design electromechanical equipment and electronic portions of guided missiles, including coordination of effort through the shop. Will work closely with Design Engineers in developing electronic packaging philosophies. Knowledge of electronics, electronic components, and ability to read schematics required. Should have experience in sheet metal equipment design and knowledge of current "state of the art" in electronic equipment.

Call collect CRestview 4-8884 and ask for Mr. Jerry Morris. He will arrange an appointment for you with key personnel at the Bedford Laboratory. If you prefer, send your postcard or letter to Mr. Morris, Raytheon Company, Missile Systems Division, Bedford, Mass.



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CIRCLE 903 ON CAREER INQUIRY FORM

## CAREER COURSES

### ENGINEER-IMPROVEMENT COURSES AND SEMINARS

Below are courses and seminars intended to provide the engineer with a better knowledge of various specialties. Our grouping includes several different types of meetings: National Courses—those held on consecutive days and intended to draw attendees from all geographic areas; One-Day Seminars—one-day intensive seminars which move from city to city; and Regional Lectures—regional symposia or lecture series which generally run one night a week for several weeks.

#### National Courses

##### Course in X-Ray Spectrography, New York

The thirty-fifth Norelco X-Ray School will be devoted entirely to the subject of X-Ray Spectrography. Registration is open to chemists, metallurgists, physicists, production supervisors, quality control engineers and others interested in the application of X-ray Spectrography. Monday through Thursday meetings involve classroom and laboratory work. On Friday, guest speakers discuss interesting problems and how they are handled by specific industries. There is no registration fee. Sessions will be held at the Henry Hudson Hotel, 353 West 57th St., New York, N. Y., during the week of February 15-19.

#### Regional Lectures

##### Managing the Development Engineering Function, AMA, Feb. 10-12, Dallas

In most industries other than chemical, research and development and development engineering are closely allied. In this seminar, the development engineering function will be analyzed and its relationship to research and development will be discussed. This seminar is of interest to all key personnel of both corporate departments and divisions. For further information for this seminar and the following one write to: American Management Association, Hotel Astor, Times Square, New York, N.Y.

##### Evaluation and Measurement of R&D, AMA, Feb. 15-17, New York

The evaluation and measurement of research and development and the various aspects of this broad subject will be discussed at this seminar, as well as the techniques that have been developed for evaluation and measurement. The seminar has been developed for those in the finance area charged with these responsibilities, and for key members of the research and development group.



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**FLIGHT CONTROL SYSTEMS:** Analytical, systems, and component engineers to work in areas such as advanced flight reference and guidance systems. Positions range from analyzing stability and control problems, systems engineering through design, testing and proof of electrical and mechanical equipment—including flight test and production test.

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**EVALUATION:** Graduate engineers with electronic background desiring opportunity in development, qualification and reliability testing. Must have ability to design and develop specialized equipment which can duplicate environmental conditions encountered by advanced projects. Assignment in this work leads directly to a career in design, research or advanced system development.

**ADVANCED GYRO DESIGN:** Engineers with two and up to twenty years' experience in precision gyro and accelerometer development, servo techniques, digital techniques, solid state electronic development, advanced instrumentation and magnetic component design.

**PRODUCTION:** Electrical engineers to assume responsibility for placing complex devices such as platforms, floated gyros, accelerometers, vertical and rate gyros, calibrators and computers into production. Work with design engineers to introduce production know-how and techniques into original design. Responsible for estimating, processing, and tooling during the pre-production phase; directing assembly, calibration, and inspection efforts during initial production phases.

**INSTRUMENTATION:** Development and design in the critical areas of test instrumentation for Aero products. Two years' experience in test instrumentation desired.

To investigate any of the above professional opportunities at the Aeronautical Division, please write in confidence to Bruce Wood, Dept. 369.

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To explore professional opportunities in other Honeywell operations coast to coast, send your application in confidence to H. K. Eckstrom, Honeywell, Minneapolis 8, Minnesota.

*Engineers...*

# RCA and DEFENSE

WEST COAST

No longer does the width of the oceans shield America.

Today an entirely new concept of defensive tools must link arms to guard us. Missiles protect cities and military installations. ASW units scour the seas. BMEWS alerts us to attack. Mach 3 interceptors, anti-missile missiles, listening posts on the floor of the oceans, atomic rockets — they all play a part in the defensive scheme of things, if not now, tomorrow.

A continuous flow of new and better defensive weapons must be developed, designed, and delivered to the armed forces by engineers — this is a *must* for survival. Never in our history have engineers been such a vital cog in this country's security. And this role grows daily.

RCA's own West Coast expansion program has created a number of exceptional career opportunities for creative electronic and mechanical engineers versed in systems, projects, and development and design engineering in these areas: information handling, data processing, electronic countermeasures and missile launch control and checkout systems. Our new, modern electronic center in the San Fernando Valley will be where you'll work and grow *with* RCA on the West Coast.

If you're interested in building your future on solid ground, RCA — the world leader in electronics — is the place to start. Let us hear from you very soon, in all confidence of course.

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**RADIO CORPORATION OF AMERICA**  
WEST COAST MISSILE AND SURFACE RADAR DIVISION

*The name you know is the place to grow!*



CIRCLE 904 ON CAREER INQUIRY FORM

ELECTRONIC DESIGN • February 3, 1960

CIRCLE 921 ON CAREER INQUIRY FORM

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## CAREER COURSES

## PAPER DEADLINES

*Convention Program Chairmen have issued the following deadlines to authors wishing to have their papers considered for presentation.*

Those interested in presenting papers or in suggesting symposia for the 1st Annual Symposium on Human Factors in Electronics, scheduled for Mar. 24-25 in New York, should correspond as soon as possible with Mr. R. R. Riesz, Chairman, Papers Procurement Committee, C/O Bell Telephone Laboratories, Meetings Committee, C/O Bell Telephone Laboratories.

**February 15:** Deadline date for papers of 300-2500 words for the 3rd International Conference on Medical Electronics to be held July 21-27 in London. Papers should deal with problems encountered in the operation of equipment or with limited aspects of a wide subject. The committee has listed the following sessions in which they are particularly interested: instrumentation for biological needs; medical electronics in space research; ultrasonics; the respiratory system; the digestive system; the circulatory system; electronics aids to sight, hearing, and locomotion; the nervous system; and electronic aspects of human engineering. Papers must be double spaced and submitted in triplicate. Send to: *Lee B. Lusted, M. D., Dept. of Radiology, University of Rochester, School of Medicine, Rochester 20, N. Y.*

**March 1:** Deadline for rough draft manuscripts for the Joint Automatic Control Conference, scheduled for September 7-9 in Boston, Mass. Papers may be on any significant aspect of automatic control. Possible topics might include: sampled data, theoretical aspects of computer control, operating results in computer control, nonlinear control, adaptive control, statistical control, cybernetics, super-slow control systems components, actuators, criteria objectives for control, maintenance in complex systems, component dynamics and techniques for testing dynamic system. Final copy deadline is May 1. Papers may be submitted to: *Harvey A. Miller, JACC Program Committee-IRE, Taylor Instrument Cos., 95 Ames St., Rochester 1, N.Y.*

A call for technical papers for the 1960 West Coast Audio Engineering Society Convention scheduled for March 8-11 at the Alexandria Hotel, Los Angeles, Calif., has been issued. Authors are urged to send titles and 25-50 word abstracts immediately to *Walter T. Selsted, Ampex Corp., 934 Charter St., Redwood City, Calif.*

## EXPLORE NEW AREAS AT IBM IN RESEARCH AND DEVELOPMENT OF

# SEMI CONDUCTORS

IBM's explorations in the semiconductor field include theoretical and experimental studies in basic semiconductor science as well as development of advanced devices and technologies. In one current research project, for example, a better physical understanding of the origin of

the negative resistance characteristic of the Esaki diode is being sought. At the same time, development engineers are exploring

applications of this device and have already produced a new solid state oscillator of exceptional simplicity in the 3,000 megacycle range. To date, this represents the deepest incursion into the microwave region via semiconductor electronics. In another project, an NPN double-diffused high-speed drift transistor has been developed that will greatly accelerate logical switching and high-power core driving. Both exploratory investigation and development of these and related electronic devices are expanding at a rapid pace at IBM. To further these programs, well-qualified specialists are required for all areas of device exploration.

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## CAREER OPPORTUNITIES BROCHURES

### Missile and Space Systems

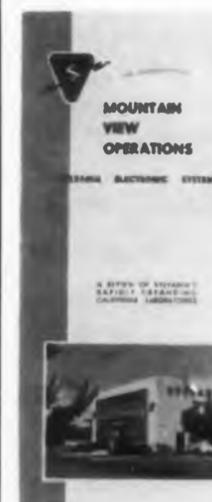


"For Careers In Motion . . ." is an 11-page illustrated brochure describing Missile and Space Systems, a division of the United Aircraft Corp. The division was established to develop concepts and to engineer complete weapon and space systems including missile, orbital, lunar and space projects.

Weapon systems engineering and the complementary skills required for systems engineering are briefly outlined under the following headings: technical military planning, electronic engineering and aeronautical engineering. Advancement prospects, company facilities and benefits are listed.

John W. North, Engineering Dept., Missile & Space Systems, Dept. ED, East Hartford 8, Conn.

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### Mountain View Operations

The Mountain View Operations, a part of Sylvania Electronic Systems, are briefly reviewed in this folder. Work on all aspects of electronic systems from basic research in microwave physics—to development of advanced tube and components—to creation of complete countermeasure and reconnaissance systems is offered. An organization chart, company benefits and community benefits are listed.

Wayne L. Pearson, Sylvania, Dept. ED, P.O. Box 188, Mountain View, Calif.

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