

ELECT D



Fast-switching silicon epitaxial transistors, now "off-the-shelf"... p 74



R O N I C
E S I G N

1981 BY ALAN WOOD



NEW SIZE 8 INTEGRAL GEARHEAD MOTORS

3 Times Torque Load Capacity* of comparable size 8 gearheads

*Will sustain 20 in-oz torque load for 1,000 hours operation and 100 in-oz momentary overload at the maximum ratios.

CPPC one piece gearhead housing eliminates separate gear plates and fastening posts, improves and maintains accuracy through exact alignment of gear clusters, assures smoother operation and more expedient inspection and servicing.



Gearhead and motor are selectable, individual parts enclosed in the same common motor housing.

Clifton Precision, pioneers in postless gearhead construction, introduces the finest in gearhead design—cage-type, one piece gearhead housing machined from a single block of metal. In these units, exact duplication of gear centers is accomplished through simultaneous boring of permanently integrated bearing plates (patent pending). Positive and permanent alignment of gear clusters composed of AGMA precision Classes II and III hardened-steel gears integral with shafts journaled at both ends in ABEC class 5 bearings, minimize deflection and backlash, maximize torque load capacity, insure smoother operation and continued reliability of performance beyond normal endurance life requirements. Cage-type construction facilitates inspection and lubrication while gearhead is mounted simply by removing motor. CPPC motors will stand greater heat than ever before due to the use of new materials. See box at lower right.

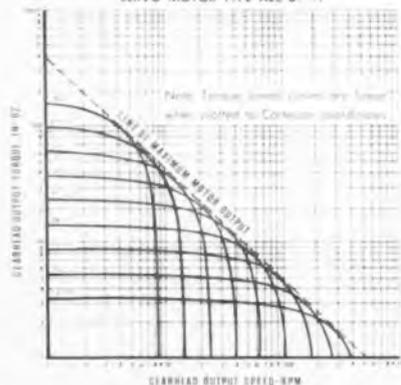
Write for our free pamphlet which gives detailed specifications of our entire gearhead motor and motor-tachometer line, sizes 8, 10 and 11.

STANDARD TYPES			
RATIOS		No. of Clusters	Dir. of Rotation
Size 8	Size 10		
12.09	19.98	2 (3 pass)	reverse
20.63	32.19	3 (4 pass)	direct
34.26	58.28	3 (4 pass)	direct
58.44	93.89	4 (5 pass)	reverse
97.07	169.97	4 (5 pass)	reverse
165.58	273.84	5 (6 pass)	direct
275.02	495.74	5 (6 pass)	direct
469.15	798.70	6 (7 pass)	reverse
779.22	1445.92	6 (7 pass)	reverse

Notes: 1. Day ratio ($\pm 3\%$) is available within the limits of the ratio range at additional cost and may require longer delivery time.
2. Max. backlash = 30 minutes at 2 in-oz reverse gauge load in above units. Inquire if special tolerance is required.

PERFORMANCE CHARACTERISTICS

SIZE 8 INTEGRAL GEARHEAD MOTOR
SERVO MOTOR TYPE ALC 8-1



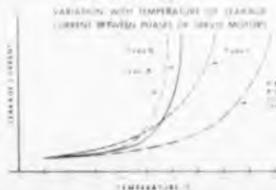
MOTORS

The following CPPC standard motors, electrical characteristics of which can be found in the current CPPC Rotary Components catalog, are offered with our gearheads:

SIZE 8		SIZE 10	
ACH 8-1	AMH 8-3	ACH 10-1	ALH 10-1
ACH 8-4	ALC 8-1	ACH 10-4	ALH 10-5
AMH 8-1	ALC 8-4		

CURRENT LEAKAGE

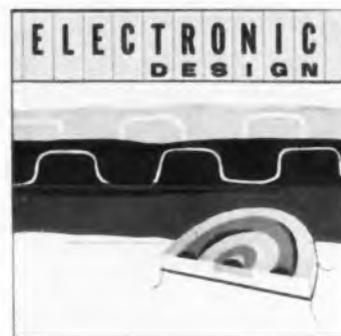
Superiority of insulation in CPPC motors is illustrated by actual comparative curves shown at the right.



CLIFTON PRECISION PRODUCTS CO., INC.
CLIFTON HEIGHTS, PENNSYLVANIA



CIRCLE 1 ON READER-SERVICE CARD



COVER: A perspective drawing of the new, fast-switching silicon epitaxial transistor appears in the foreground. Gas used to create one of the layers in the transistor and the rise and fall of a typical pulse output are graphically represented in the background. For details of the transistor, now off the shelf, see story on p 74.

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ELECTRONIC DESIGN - ONE DAY SERVICE

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607	617	627	637	647	657	667	677	687	697	707	717	727	737	747	757	767	777	787	797	807	817	827	837	847	857	867	877	887	897
608	618	628	638	648	658	668	678	688	698	708	718	728	738	748	758	768	778	788	798	808	818	828	838	848	858	868	878	888	898
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Highlights of the Issue

Energy to Burn

Ever since last fall, when **ELECTRONIC DESIGN** got hot, so to speak, on the subject of energy conversion ("Converting Heat to Electricity," Sept. 28), an energetic editor in our office has kept in close touch with developments and authorities in the field. The result is a new Staff Report in this issue, analyzing three more techniques of energy conversion: batteries, fuel cells and solar cells. The four experts who join in the report worked in close cooperation with our technical editor Howard Bierman.

C. K. Morehouse and J. R. Thomas offer a rundown on the structure and operation of primary and secondary electrochemical cells. It is a good review plus details of the latest developments and applications. Are batteries obsolete in the light of new energy-conversion schemes? Don't you believe it, the authors argue. See p 52.

Maybe you think fuel cells are exotic. It could be that E. M. Cohn could change your view. The idea for a fuel cell, he notes, appears to have originated in 1801. For a wide-angle view of advances since then, start reading on p 62. You'll find out about fuel-cell construction and applications, and what the future holds for this energy source.

Solar energy has been used in the past as a signal generator; now it is finding wider and wider use as a power generator. For a glimpse at the present state of the art, turn to p 68 for an illuminating article by J. Kalman.

On the Microwave Front

An entire section on microwaves—from radically new antennas through cavity design to field measurements of TWT permanent-magnet stacks. It starts on p 175.

Ideas, Anyone

Watch for an important announcement in the next issue on an expanded Ideas for Design Section.

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TEN MEGACYCLE PULSE GENERATOR

FEATURING... HIGH REPETITION RATE WITH A LOWER
THAN 8 MILLIMICROSECONDS
RISE AND FALL TIME

Rutherford

MODEL B-5-A



This unit features an electronic pulse delay that can be set to zero or is continuously variable from .030 microseconds to 500 microseconds in five ranges. Pulse width is continuously variable from .02 to 12.5 microseconds in four ranges.

SPECIFICATIONS: **Amplitude:** 40 volts positive, 45 volts negative • **Attenuator:** 60 db in 1/2 steps • **Polarity:** Both positive and negative pulses simultaneously available • **Output Impedance:** 185 ohms • **Output Decay Constant:** 750 microseconds when terminated in 185 ohms • **Synchronizing Pulse Out:** 10 volts, positive • **Rise Time:** Less than .02 microsecond • **Width:** .03 microsecond • **External Trigger:** Pulse required: 10 volts minimum with rise time less than .05 microsecond • **Pulse Repetition Rate:** Continuously variable from 1 cycle/sec to 10 mc/sec in seven ranges • **Delay:** A fixed delay of .1 microsecond occurs between the synchronizing pulse out and the main pulse.
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Also available in 10 MC double pulse version B5-2



MODEL A-2

TIME DELAY GENERATOR

EXTREME ACCURACY: After calibration: $\pm .1\%$ of full scale. Long term: $\pm 1\%$ of full scale.

FEATURES: 8 to 100,000 microseconds in 5 decimally related ranges.

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pulse generators / pulse systems / accurate time delay generators

CIRCLE 4 ON READER-SERVICE CARD

Redundancy Schemes Promise Higher Reliability

Majority Voting, Adaptive and Quad Techniques Being Designed to Meet Demands of Military

Manfred Meisels
News Editor

RELIABILITY demands of military electronics are forcing development of advanced concepts of redundant circuit design. Majority voting, network and adaptive concepts are com-

manding the interest and winning the support of the armed services, now saddled with the "put in two of everything" approach to redundant design.

Typical of this approach, which only doubles reliability, is the SAGE FSQ-S air defense sys-

tem, where duplicate \$12 million computers are used. Similarly BMEWS plays it safe with two 7090 computers. The pitfalls in this approach to reliability were convincingly demonstrated by last summer's Courier communications satellite, which failed aloft when a selection mechanism between two of its redundant systems failed. Parallel redundant units are certainly feasible in ground systems, where defective equipment can be serviced while standby units take over. In space or aloft the concept and the equipment both fail.

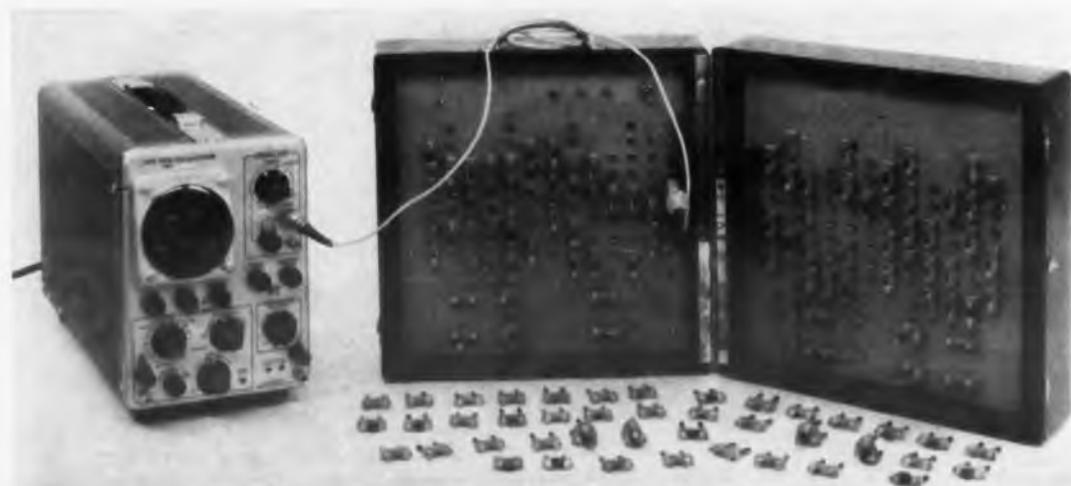
The Air Force, quite aware of these shortcomings, is encouraging development of more sophisticated redundancy concepts. Majority voting techniques and network redundancy, such as the Quad concept developed by Magnavox Research Laboratories, typify current approaches to the problem. A recent contract from the Rome Air Development Center to Aeronautical Radio, Inc. (ARINC), Washington, D.C., calls for design of a "hypothetical computer for a hypothetical satellite" based on majority voting techniques.

In this type of redundancy, the outputs of several circuits performing the same function are scanned by a logic system that transmits a signal representing a majority of the outputs present. Since an odd number of circuits is commonly used, total failure is avoided until more than half the individual circuits fail.

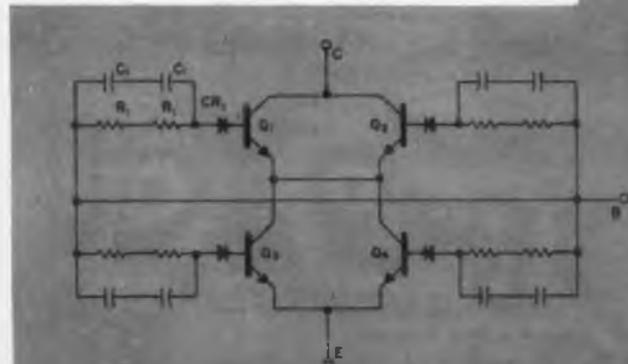
This technique is due largely to the mathematics of C. E. Shannon and the late John von Neumann. ARINC, Hermes Electronics of Boston, Massachusetts Institute of Technology and Elliott Bros., Ltd. of Borehamwood, England, are among the organizations actively studying majority voting techniques. The English firm will incorporate such logic in an airport landing system to be delivered shortly. Majority voting is also being introduced into military computers and data-processing equipment, particularly by IBM and Hermes.

A leading manufacturer of semiconductors is reportedly designing a majority logic diode block, in which several diodes and the selection circuitry are all formed by molecular techniques and housed in a single can.

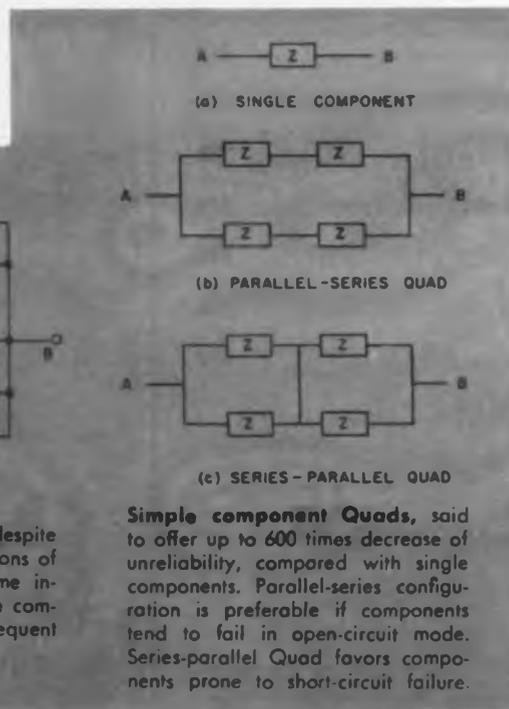
Another proposal, to be announced shortly, combines redundancy and adaptive, self-repairing circuits. Organic semiconductors, grown on the spot, would replace defective components.



Quadded multivibrator continues to function despite random removal of 45 of 128 components. Circuit failed after removal of 46th component, which was replaced for this photo of demonstrator. Although situation is extreme, at least two components must fail before the circuit can fail.



Complex transistor Quad continues to operate despite failure of any single component. Certain combinations of multiple failure will also permit operation. In some instances degradation of performance caused by one combination of component failures is remedied by subsequent failure of additional components.



Simple component Quads, said to offer up to 600 times decrease of unreliability, compared with single components. Parallel-series configuration is preferable if components tend to fail in open-circuit mode. Series-parallel Quad favors components prone to short-circuit failure.

Network redundancy, perhaps best described as the "put in more of everything approach," multiplies the penalties of weight, cost and complexity inherent in any redundant circuitry. It has the virtue, however, of reducing or eliminating the switching problem. Leading exponents of this technique include Magnavox Research Laboratories of Torrance, Calif.; Sylvania; the National Bureau of Standards and General Electric. A redundant power supply designed by GE will be described at this week's Solid State Circuits Conference in Philadelphia. The unit employs network redundancy in critical areas, with some components duplicated up to eight times.

An unusual and rather fully developed technique of achieving ultra-reliable circuitry through network redundancy is the Quad principle being proposed for the military by Magnavox.

Each Quad has a characteristic terminal impedance identical to the impedance of the equivalent single component. Failure of one or more components through short-circuit or open-circuit will alter the terminal impedance of the Quad. Through proper design, however, the circuit can survive a wide variation of impedance among its individual quadded components.

The reliability afforded by quadding depends, of course, on the impedance variations that can be tolerated by the circuit. Each Quad has 81 (3^4) possible modes of operation. Excluding total failure of all the components in the Quad, impedance will vary over a range of 4 to 1. If a reasonable variation of 3 to 1 is specified, the Quad exhibits 35 successful modes of operation.

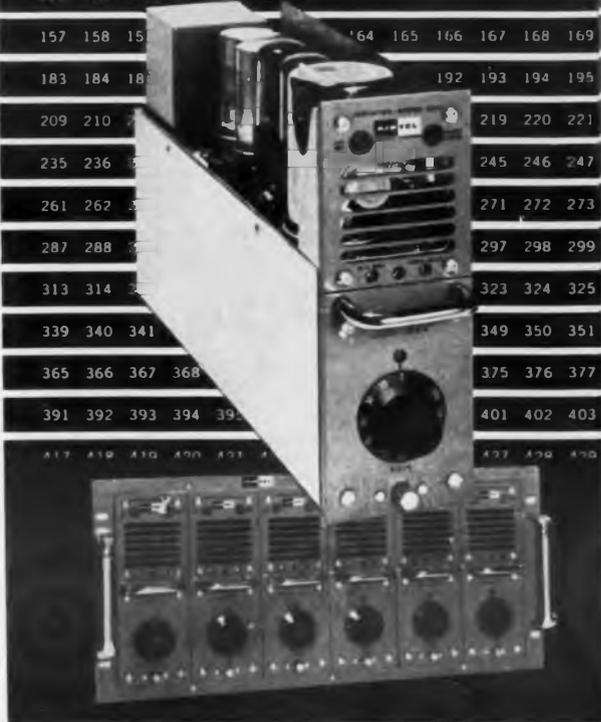
The unreliability for a single Quad with these limitations is reduced to 2.4 times the square of the unreliability of the individual components in the Quad. Thus, for a resistor having a failure rate of 0.0007 per year, the life expectancy of the Quad is increased approximately 600 times.

A similar analysis was performed for a quadded multivibrator built with a total of 128 components. Again assuming reasonable failure rates for individual components, the quadded multivibrator has a one-year reliability of 0.99965, compared with 0.97899 for a conventionally designed unit.

Company spokesmen admit that the increased complexity of the Quad concept poses serious obstacles to its acceptance.

Similar reactions have been elicited from the military, but the Quad concept has by no means been ruled out. One spokesman for the Rome center indicated that "A subtler form of Quad might prove acceptable."

"In any event," he added, "with present component reliability, redundancy appears the only method available in the near future for achieving the desired reliabilities in our systems." ■ ■



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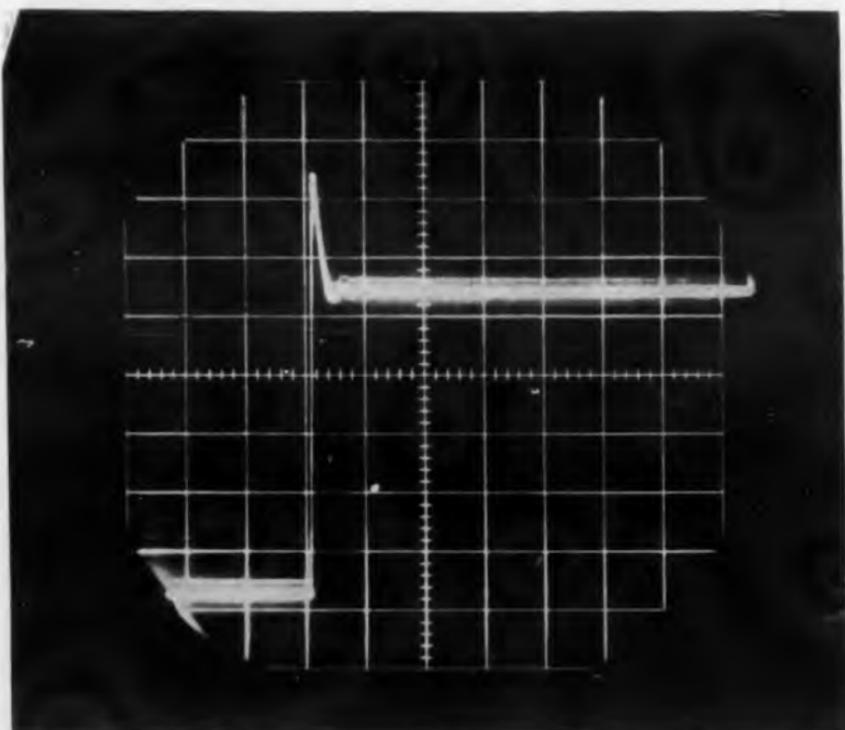
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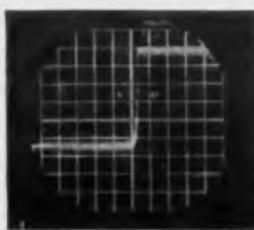
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MTR636-15	6-36	15	±25MV	±50MV	±25MV	±.75V	105-125V	5MV
MTR636-30	6-36	30	±25MV	±75MV	±25MV	±.85V	105-125V	5MV
MTR28-5	24-32	5	±0.1%	±0.1%	±0.1%	±.3V	105-125V	5MV
MTR28-10	24-32	10	±0.1%	±0.1%	±0.1%	±.4V	105-125V	2MV
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NEWS

Design Approaches Vary

ITT Details PCM-FM System; Low-Cost Launching Planned

PPRIVATE industry has already begun competitive design approaches toward development of useful commercial communications satellites.

Many details of a proposed PCM-FM system for an intercontinental television link were disclosed by International Telephone & Telegraph Corp., New York, at the annual meeting of the Institute of Aeronautical Sciences in New York. General Electric Co. engineers also outlined in broad terms their company's planned approach to design of a communications satellite.

Previously Hughes Aircraft Co. moved into the field with the display of an experimental synchronous, or stationary-orbit, type satellite at an American Rocket Society conference in Washington (*ED*, Dec. 21, 1960, p 4). This Hughes experimental satellite model, weighing only 32 lb could be launched with present missile booster capabilities.

American Telephone & Telegraph Corp. has received approval from the Federal Communications Commission for launching of an experimental communications satellite within a year. This planned system would use wide-deviation fm with feedback to achieve commercial quality signal-to-noise ratios with a satellite in a 2,200-mile orbit (*ED*, Nov. 9, 1960, p 4).



FCC has granted ITT Laboratories, Nutley, N. J., permission to use this 40-ft steerable antenna for narrow-band transmission into space. Moon and passive satellites will be used for studying interference problems as well as checking some performance details of a planned PCM-FM active satellite communications system.

For Commercial Satellites

Low-cost launching, which may result from two present Navy projects also discussed at an IAS session on commercial satellites, could act as an added spur to development efforts. Although the government has offered industry the use of National Aeronautics and Space Administration launching facilities at cost, the "cost" can easily amount to far over the \$1 million mark with present boosters.

Navy Developing Aircraft Launching, Considering Use of Polaris-Scout Combination

One of these Navy projects, named Project Caleb, is an effort to develop methods for launching light-weight satellites from high performance aircraft. A launch of this type might put a 25- to 50-lb satellite into orbit at a cost of about \$75,000, according to John D. Nicolides, technical director for astronautics, Navy Bureau of Weapons.

A second approach being considered by the Navy is the use of the first two stages of the Polaris missile, and the top two stages of the Scout rocket. This vehicle, which would be called the Polaris-Sea Scout, might launch a 100-lb satellite, such as the Navy's Transit, for an estimated \$750,000, according to Mr. Nicolides.

The extent of interference that might be encountered if space and ground services operate in the same frequency bands is another problem that has not yet been thoroughly explored. To make actual tests under these conditions, the FCC has granted ITT Laboratories, Nutley, N.J., a license to operate an experimental space research station. Since these experiments, using the moon and passive satellite reflectors, will be performed in the high-density New Jersey area, much valuable information on interference conditions should be gathered.

Tests of timing accuracy, and other important factors in the ITT PCM-FM system will also be performed with the new antenna, Louis Pollack, associate laboratory director, space communications group for ITT, told *ELECTRONIC DESIGN*.

The PCM-FM approach to satellite communications should require only about half the bandwidth to get the same signal-to-noise ratio that might be obtained with a wide deviation fm with feedback system operating at the same power levels, according to Mr. Pollack. He said that ITT's Standard Telephone & Cables, Ltd., subsidiary in England has developed a four-level PCM multiplexer suitable for use in such a system. Test results have been excellent. ■ ■



Enlarged photograph of raw crystal

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CIRCLE 8 ON READER-SERVICE CARD

Two Synchronized CRT's Used in Character Generator

Microfilm Computer Output System Operates at 15,000 Characters/Sec

MICROFILM computer print-out at high speed is accomplished with a new character generator in the DACOM system designed by Recordak Corp. of New York.

In DACOM, (Datascope Computer Output Microfilmer) characters displayed on the face of a cathode-ray tube are photographed on microfilm. Up to 64 lines of 126 characters each can be printed on each microfilm frame. A Datascope character generator is used to convert magnetic tape data to characters on the face of the display tube. DACOM is designed for use with seven-track magnetic tape at rates up to 75 ips if packing density of 200 characters per in. or less is used, giving a print-out rate of up to 15,000 characters per sec.

If high-density tapes are used, a slower tape drive speed is required.

The DACOM system can be rented at about \$7,000 per month or bought for \$285,000 without subsidiary equipment. Delivery will be in 18 to 24 months, according to Recordak, Subsidiary of Eastman Kodak Co.

The Datascope character generator used to perform the binary-to-display conversion in

DACOM makes use of a pair of cathode-ray tubes with synchronized deflection plates. One of these tubes is the display tube, which is photographed on microfilm. An electrostatic deflection plate system is used in this tube to form characters, and a separate magnetic deflection system positions the characters on the screen. The second tube, which displays an unmodulated 16-line raster, might be termed a character generating tube.

In operation the digital data on magnetic tape is fed into a decoding logic section. In this section the character is identified. When the identification is made, a gate associated with that character is selected from a group of 64 gates. With the selected gate a conducting path is set up between one of the photocells in a 64-cell array and the video amplifier of the display tube.

Two sets of 64 optical lenses between the photocell bank and the generating tube form a separate optical path between each photocell and the 16-line raster on the face of the crt. An aperture plate, with 64 characters on it, is inserted between the photocells and the raster. The opaque portions of each character on this

aperture plate cut off the light from the raster display to the phototube, and the transparent portions of each character transmit the light.

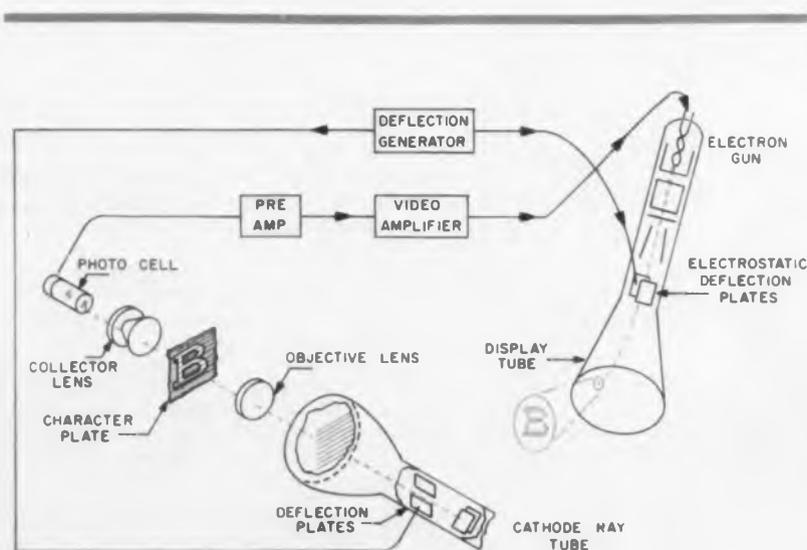
Thus as the beam scans the face of the generating tube, the phototubes associated with each character will receive or not receive light depending on the shape of the character aperture in the character plate.

Since the deflection plates of the generating tube and the electrostatic deflection plates of the display tube are controlled by the same deflection generator, a character is traced out on the face of the display tube.

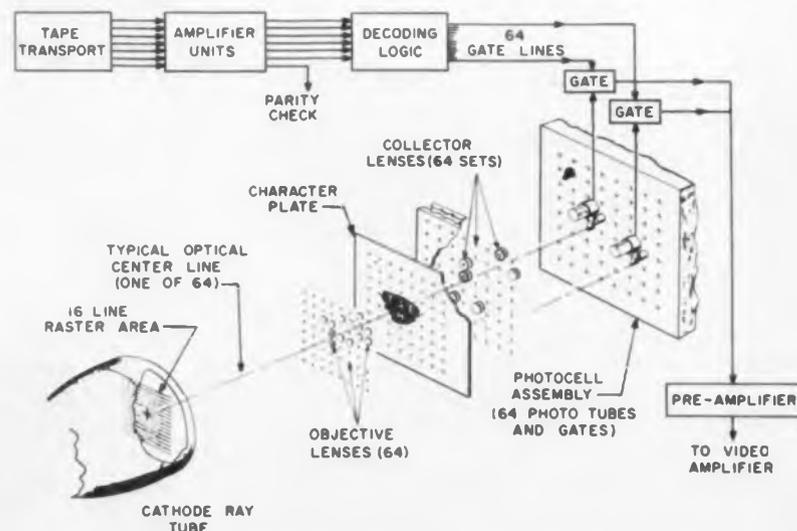
Reverse Technique Also Considered For Microfilm Computer Input

Computer input directly from microfilm might be accomplished with a system like the Datascope character generator operating in reverse. Although some thought has been given to this approach, no actual development work has been done, according to a company spokesman.

In the reverse system, characters printed on microfilm would be enlarged by some optical system and then scanned with light. The charac-



One of the characters in the aperture plate used with the Datascope character generator is enlarged in the diagram to show how it alternately transmits and cuts off the light from the 16-line raster to the photocell. The photocell output is fed to the video amplifier for the display tube, thus intensity-modulating the display electron beam.



Character generator portion of the Datascope system consists of a 16-line raster cathode-ray tube and several optical and electronic units. The optics set up 64 separate optical centerlines to the 64 photocells. The character plate contains apertures for 64 characters. As the beam sweeps over the face of the crt, light from the tube face to the photocells is alternately blocked and transmitted according to the aperture shape.

ter itself would act as the aperture. The photocell output waveform generated by this scanning process could then be matched in a set of matching circuits and the character identified by finding the "best fit."

When the identification was made, a gate could be triggered and the binary representation for the character could be written onto magnetic tape or directed into a computer.

Aside from printing of alphanumeric data, DACOM can be used for plotting data points or for drawing horizontal and vertical axes. If a standard form is being used for the microfilmed documents, this can be added to each microfilm frame by putting a display format into the photographic path between the display tube and the film. A coded transparency is also put into the photographic path, so that each microfilm frame is coded according to some data classification. This allows an automatic scanning machine to retrieve data using to some classification.

Such retrieval machines, and also machines to print full-size documents from the microfilm, will be available as subsidiary equipment to the basic DACOM system. ■ ■



Glass aperture plate used in the Datascope character generator contains 64 characters. The center of each character is lined up with the optical centerline to an associated photocell.

ELECTRONIC DESIGN • February 15, 1961

CIRCLE 9 ON READER-SERVICE CARD ▶

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2N861	25v	150	0.1	30	100	7.5
2N862	15v	150	0.1	20	60	8
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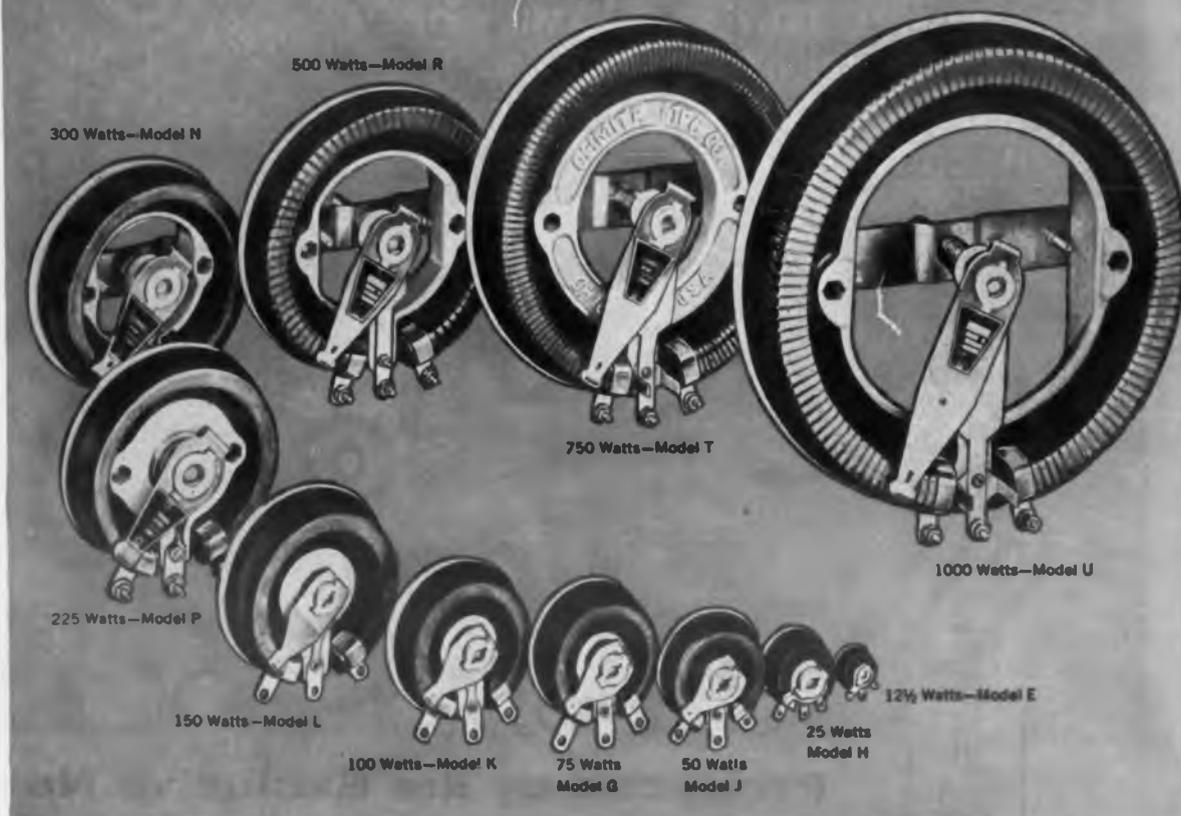
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NEWS

Hughes IR Peltier Cooler

3-Stage Device, Using BiTe
Reported at Military Conference

Thomas E. Mount
West Coast Editor

A PELTIER cooler for infrared detectors, operating at 2 amp and 2 v to achieve a temperature drop from 25 C to -77 C, has been developed by Hughes Aircraft Co.

The new bismuth telluride cooler, described at the IRE Winter Convention on Military Electronics in Los Angeles, provides the same temperature drop as most previous high-current coolers requiring about 20 amp at 0.2 v. Peltier coolers, according to Hughes, will be useful in satellite and missile applications, which require low-current devices.

The Hughes device is a three-stage cooler, using cell loading of about 125 mw. Conventional BiTe is used, however the junctions are cut so that the length over area (L/A) ratio increases. Current required by a Peltier device depends on L/A as follows: $I = \alpha \times T_c / \rho \times L/A$.

In this equation α is the Seebeck coefficient, T_c is the cold temperature in deg C, and ρ is the resistivity of the material.

Most former coolers have used BiTe rods about 0.194-in. diam and 1/4 in. long, giving an L/A ratio of 3.24. To obtain a ΔT of 78.6 C, 15.5 amp at 0.135 v, or 2.1 w, were needed. In the Hughes unit the BiTe is cut to 0.138 x 0.055-in., and three of these pieces are connected in electrical series and thermal parallel. This configuration requires only 3.9 amp at 0.56 v—again 2.1 w—to obtain the same cooling. The L/A in this case is 12.95.

The key to the Hughes device is the cutting of the material. New fabrication techniques, not revealed by Hughes, permit brittle, sensitive BiTe to be cut smaller than was previously feasible, according to the company. In addition to brittleness, the material is extremely susceptible to poisoning and degradation by acids during processing.

Temperature-Controlled Crystal Oven
Also Under Development By Hughes

Other applications under way at Hughes for the new device include crystal and discriminator ovens for satellites and missiles. One temperature-controlled crystal oven already built maintains 20 C by using the Peltier unit to heat or cool as needed. A switching circuit reverses the current direction when necessary. Heating is

Operates on Low Current

more efficient than cooling because an I²R loss is added to the heat in the material. The currents required for this type of temperature control are significantly lower than those needed with conventional Dewar flasks.

Currently under development by Hughes is a discriminator oven that must maintain a stable 20-C temperature in an environment that may change from 85 to -40 C. ■ ■

Sylvania Germanium Epitaxials Reduced 25 Per Cent In Price

Price reductions of approximately 25 per cent on epitaxial germanium mesa transistors have been announced by Sylvania Electric Products, Inc., a subsidiary of General Telephone and Electronics Corp.

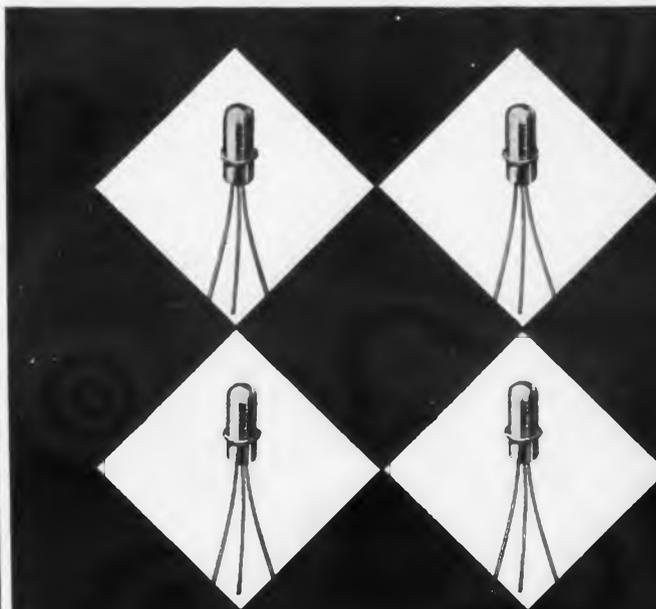
The SYL2300 and SYL2301, improved versions of the 2N705 and 2N711 mesa switching devices, are available from more than 40 franchised distributors throughout the country.

The SYL2300 has been cut from \$27 to \$21 in 1-99 quantity and from \$18 to \$14 in lots of 100-999. The SYL2301 has been reduced from \$18 to \$13.50 in 1-99 and from \$12 to \$9 in 100-999 lots.

The Start of a Computer



Tiny germanium tunnel diode wafer (upper left) is a part of basic circuitry designed by Radio Corp. of America, Camden, N. J., as the first step toward an ultra-swift electronic computer under the Navy-sponsored Project Lightning. Electronic switching speed is 0.25 nsec. Four of the midget units will perform the same job as the circuit board (center), but 1,000 times faster.



AVAILABLE NOW IN MASS PRODUCTION

- the highest r-f operating frequency
- the fastest switching time
- cadmium junctions for cooler operation, greater reliability
- storage temperatures up to 100 C

YOU CAN GET SPRAGUE* MADT® TRANSISTORS AT SENSIBLE PRICES

Sprague Germanium Micro-Alloy Diffused-Base Transistors, well-known for their rugged vhf performance, are now *priced below other transistors* with comparable electrical characteristics. In many areas, this permits designers to improve circuit techniques without necessarily increasing costs. Expanded production facilities enable us to *ship quantity orders on short notice*. Add to this their *ultra-fast switching time*, and you have three good reasons why Sprague MADT® Transistors have achieved their high level of acceptance.

With Sprague Transistors, circuits in vhf amplifiers and oscillators can now operate with collector currents as high as 50 ma . . . with power dissipation up to 50 mw . . . with collector to base voltages to 15 v. They have been application tested through the entire military electronics vhf spectrum.

The application table may well suggest the use of one or more Micro-Alloy Diffused-Base Transistor types in your latest circuit designs.

For complete engineering data on the types in which

• • •

**Sprague micro-alloy, micro-alloy diffused-base, and surface barrier transistors are fully licensed under Philco patents. All Sprague and Philco transistors having the same type numbers are manufactured to the same specifications and are fully interchangeable.*

MICRO-ALLOY DIFFUSED-BASE TRANSISTOR APPLICATIONS	
Type	Application
2N499	Amplifier, to 100 mcs
2N501	Ultra High Speed Switch (Storage Temperature, 85 C)
2N501A	Ultra High Speed Switch (Storage Temperature, 100 C)
2N504	High Gain IF Amplifier
2N588	Oscillator, Amplifier, to 50 mcs

you are interested, write Technical Literature Section, Sprague Electric Co., 347 Marshall St., North Adams, Massachusetts.

You can get off-the-shelf delivery at factory prices on pilot quantities up to 999 pieces from your local Sprague Industrial Distributor.

SPRAGUE®
THE MARK OF RELIABILITY

SPRAGUE COMPONENTS:

CAPACITORS • RESISTORS • MAGNETIC COMPONENTS • TRANSISTORS • INTERFERENCE FILTERS • PULSE NETWORKS
HIGH TEMPERATURE MAGNET WIRE • CERAMIC-BASE PRINTED NETWORKS • PACKAGED COMPONENT ASSEMBLIES

CIRCLE 11 ON READER-SERVICE CARD

SOMETHING NEW IN A SUITCASE...

... Complete transistorized EECO Digital System Breadboard

Designers who want to go places fast systemswise can be sure of getting there on time with an EECO suitcase. It's packed with a complete and integrated breadboarding system designed around mutually compatible EECO T-Series Germanium circuit modules, N Series transistorized decades, and R-Series Minisig[®] sensitive indicators.

Standard 19" amateur-notched panels have the necessary permanent wiring to accommodate any standard EECO Germanium circuit module, and all other circuit interconnections are made by patch cords or plugs, with unique, preprinted circuit cards to guide you. No soldering is required, and experimental arrangements of T-Series circuits can be quickly patched up, changed, or taken down without waste of time or materials.



Bottom half of breadboard suitcase is compactly laid out to store all necessary T-Series circuit modules, circuit cards, patch cords, and compatible power supplies.

EECO T-Series breadboard equipment is available in both suitcase and rack-mounted types. Breadboard Kits of any degree of complexity can be built up in stages, according to the specific panels and number of circuits incorporated. Compatible interconnections between racks or suitcases further enable the designer to expand the equipment into a complete systems development console. Compatible solid-state, convection-cooled power supplies are also available in two different models: ZA-720 is a dual 12-volt, 5-amp supply; ZA-721 is a 12-volt, 1 amp plug-in power supply.

FEATURES

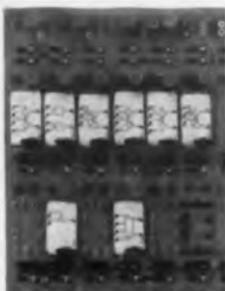
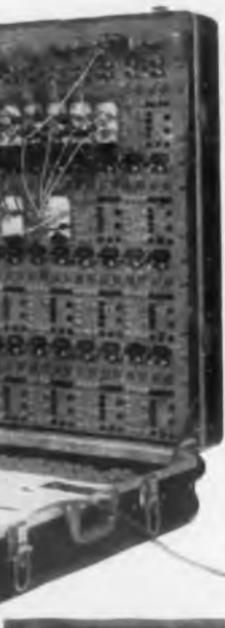
- Permits rapid formulation of digital electrical systems.
- System may be operated slowly to permit inspection of its mode of operation, or over-speed to indicate system derating.
- Operation may be analyzed with a minimum of test equipment.
- Provides a means for rapidly building and testing alternate ways of formulating a system.
- Minimizes wiring errors and the inclusion of defective parts.
- Circuit cards provide a means for rapidly visualizing the system, and facilitate drawing a circuit diagram.
- Circuit cards enable the designer to determine the elements involved, as well as the cost of the system.

A request, on your company letterhead, will bring detailed information on the flexibility of the EECO T-Series Breadboarding equipment, and a demonstration if desired.

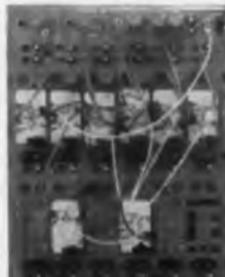


ENGINEERED ELECTRONICS COMPANY
1441 East Chestnut Avenue • Santa Ana, Calif.

CIRCLE 12 ON READER-SERVICE CARD



Circuit cards are selected according to the system it is desired to breadboard and placed on the panel in alignment with the jack pattern. Corresponding T-Series circuit modules are plugged in above each card.



Circuit interconnections are made by patching through holes in the circuit cards. Resulting pattern of symbol cards and patch cords shows a schematic and bill of materials for the system, once it is checked out.

Skybolt Using Magnetic Shift Register

Stamp-Sized Wafer Packages Are Stacked to Form Cascaded, Low-Cost, Low-Power-Consuming Units



Special production techniques have been developed for the GE magnetic shift-register packaging approach. Here components making up one bit for the register are mounted on a rack prior to encapsulation. Reliability goal for the wafer development project is a failure rate of 0.0001 per cent per thousand hours for each component.

ONE OF THE first applications for a new magnetic-core shift-register package is in the guidance computer of the Air Force Skybolt missile.

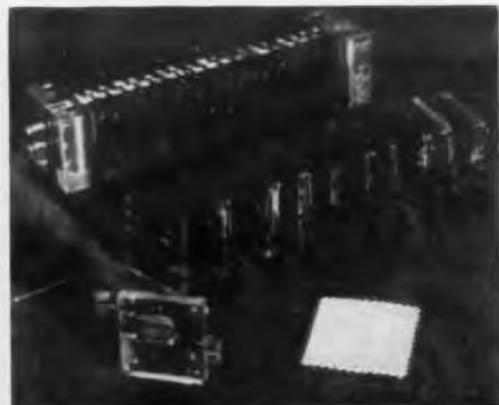
The shift register, consisting of thin, encapsulated wafers each containing one bit, was designed by General Electric Co.'s Heavy Military Electronics Dept. An advanced version using microcomponents, so that wafers are only a third the size of present units, is now under development in the laboratory.

Some of the advantages of the magnetic-core over transistorized shift registers include lower power consumption, ease of automation, lower price, fewer components and connections, and expected higher reliability. Much design effort has been devoted to reducing average power consumption, so that operation at higher speed can be achieved with magnetic elements, according to Burton F. Wagner, GE project engineer.

With a shifting rate of 100 kc, power consumption is about 10 mw per bit. Peak pulse power on the order of 85 mw is necessary for operation at this shifting rate. A 500-kc shift register now being designed is expected to require peak pulse power in the neighborhood of 170 mw. Average power consumption per bit at 400-kc shifting rates is about 55 mw, tests have indicated. No steady-state dc power is consumed by the magnetic core elements.

Operation at these low power levels means that few drivers are necessary for many bits.

The complete circuitry necessary for each shift register bit is encapsulated in a single stamp-size wafer. A wound toroidal ferrite core provides a



Postage stamp gives size comparison for the magnetic-core shift-register wafers developed by General Electric's Heavy Military Electronics Dept. These wafers are tested after encapsulation, and then stacked to form a shift-register module. The entire register module is then encapsulated.

permanent storage medium, a capacitor supplies the temporary storage function, and a diode gives unidirectionality. Necessary resistors are also included in the packages.

With each shift cycle, all magnetic cores are cleared to ZERO. Any core that had been storing a ONE induces a current on an output winding, thus charging an associated capacitor. Then, as a ONE or ZERO is written into the first core in the register, each capacitor is discharged to the input winding for the succeeding core in the register.

The cost, ranging from \$10 per bit downward, is considerably less than that for comparable transistorized registers, according to Mr. Wagner.

Memory Reliability Expected to Exceed That For Electromechanical Devices

Reliability of the encapsulated magnetic-core shift-register memory is expected to be significantly greater than that for drum or other electromechanical memories. The absence of moving parts is one factor favoring reliability. Individual tests of each encapsulated bit to be put in the register can also be performed. When the wafers are stacked to form a register, the entire unit is encapsulated, and further tests are applied.

Accelerated life tests of the wafer elements are currently in progress. However, actual reliability figures have not yet been determined.

The present encapsulated shift-register wafers provide a packing density of 22,860 bits per cu ft, according to GE. Significantly greater densities can be expected, the company said, when new wafers, a third the size of present elements, reach production.

Aside from the speed limitation, however, shift-register memories are not well suited to large storage functions. When storage of about 5,000 or 10,000 bits is necessary, some other medium must be used.

In space and missile computer design, GE is combining these standardized magnetic-core shift-register elements with a standard NOR circuit package. This allows development time to be shortened considerably. Logic is provided by properly arranged NOR's, and single-bit, static storage can be achieved by using two NOR circuits feeding back into each other, giving a flip-flop. The magnetic-core shift-register elements serve as the main memory.

A 50-integrator digital differential analyzer using these two basic elements, for example, requires about 2,200 bits of storage and about 800 logic modules, according to GE. This does not include any special input-output equipment that might be needed. Such an analyzer could be contained in a 0.4-cu-ft package weighing about 25 lb. ■ ■

A NEW
STANDARD
IN 10-TURN
POTENTIOMETERS



CLAROSTAT

SERIES 59M14

A new high in potentiometer capabilities ... the Clarostat Series 59M14. 10-turn, $\frac{7}{8}$ " potentiometer packs more performance per cubic inch than any other multi-turn pot today. Clarostat's unique design permits more winding length in a given diameter than conventional designs. And, price wise, the Series 59M14 is competitive across-the-board.

For all your multi-turn potentiometer needs, compare Clarostat for quality, for value...

SPECIFICATIONS — SERIES 59M14, 10-TURN POTENTIOMETERS

• Diameter	$\frac{7}{8}$ "
• Length	1.55" (Bushing) 1.611 (Servo)
• Maximum Resistance	100,000 ohms
• Indep. Linearity	$\pm .25\%$, To $\pm .05\%$
• Wattage	4.5 watts @ 40 C.
• Taps	Center tap
• Rotations	3600 \pm 10 0
• Maximum Torque	1.0 oz. in.
• Weight	1.0 oz.

WRITE
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COMPLETE
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Compare
CLAROSTAT
CLAROSTAT MANUFACTURING CO., INC.
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NEW CBS

HIGH-POWER



TRANSISTORS

Advantages

- High power output: up to 30 w Class A, 100 w Class B, 1000 w switching
- High voltages . . . high current gains . . . and high working currents
- Low-distortion ring emitter construction
- Hermetically welded JEDEC TO-36 male industrial case

Characteristics

All these CBS high-power transistors have: Max. dissipation, 150 watts* for a typical thermal resistance of 0.5° C/W; max. collector current, 15 amperes; junction temperatures, -65 to +100°C.

Type	Max. W. Diss.*	Max. Thermal Res°C/W	Max. V _{CEO}	Max. V _{CES}	h _{FE} (I _C = 5A)	
					Min.	Max.
2N173	70	1.0	60	50	35	70
2N174	85	0.8	80	70	25	50
2N277	70	1.0	40	40	35	70
2N278	70	1.0	50	45	35	70
2N441	70	1.0	40	40	20	40
2N442	70	1.0	50	45	20	40
2N443	70	1.0	60	50	20	40
2N1100	85	0.8	100	80	25	50

*25°C base mounting temperature.

save costs • space • weight

You can now replace two 40-watt or four 20-watt paralleled power transistors with one CBS PNP high-power transistor. This one design change brings you important transistor . . . component . . . assembly . . . space . . . and weight savings. New economies become possible in power supplies and amplifiers and in high-power switching circuits.

Note the wide line of these CBS PNP high-power transistors, their pertinent characteristics and many advantages. Ask for complete technical data. Order these money-saving units today . . . at factory prices for quantities up to 1000 . . . from your Manufacturers Warehousing Distributor.

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CIRCLE 14 ON READER-SERVICE CARD

NEWS

Guidance Computer Also

Minuteman Soars 4,600 Miles In Successful Maiden Test

GUIDANCE for the successful maiden flight of the solid-fuel Minuteman was handled by the same versatile digital computer used for ground checkout of the missile.

In past ICBM programs only the first stage has been checked on the initial launch. In hopes of speeding up the Minuteman program, however, the Air Force gambled on a test of all three stages and the guidance system on the first shot. The 4,600-mile successful shot demonstrated the soundness of the computer's design concept.

This versatile computer, which must be extremely reliable because of the Minuteman concept of no field repairs, has been designed by the Autonetics Div. of North American Aviation, Inc. It uses an air-bearing type of magnetic-disk memory, with a capacity of about 80,000 bits, to store checkout and testing as well as guidance and control instructions.

Tests will be performed on Minuteman missiles at regular intervals during storage in underground vaults. If an error is detected, the control computer will cause a "no go" signal to be sent to equipment at the launching site. The missile must then be returned to the factory for repair, since modules cannot be replaced in the field (see description of Minuteman reliability concept, *ED*, Sept. 14, 1960, p. 4).

Necessary tests can also be performed under the computer's direction after a launching. If a malfunction is detected, an interrupt signal is sent to a warhead-arming circuit.

On the ground the computer also controls alignment and calibration functions. In flight it solves guidance and flight-control equations, generates missile-steering commands, and controls staging and thrust-control termination.

Air-Bearing Magnetic Disk Memory Chosen For Long Life, Tolerance to Acceleration

Since an air bearing eliminates the mechanical friction found in ball-bearing rotating disks, it was chosen for its expected longer life. Another advantage of the air bearing, according to Dr. William L. Morris, project director for the Minuteman computer, is its acceleration tolerance. The force exerted on the disk is inversely proportional to the separation between it and the head plate. Thus, as the acceleration increases, the bearing increases its force on the disk, preventing

Directs Ground Checks

warping. The usual disk-head plate separation is about 150 millionths of an inch.

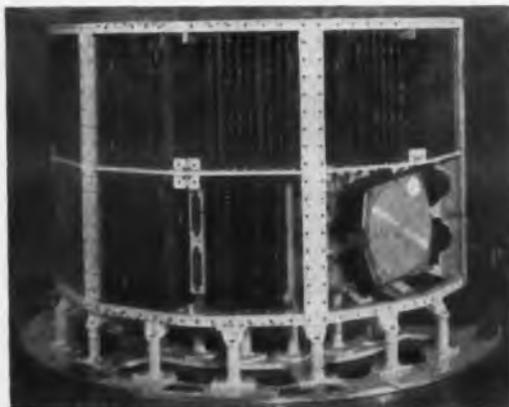
Crosstalk did cause some trouble, according to Dr. Morris, because the bit spacing chosen was only about 1.5 mils. This problem was solved by redesign of the write heads and read and write amplifiers. Crosstalk is now held to 10 per cent of total information magnitude.

In the present memory design, a solenoid spring pulls the disk away from the head plate by about 1/8-in. when the computer is turned on. A 400-cps drive in the computer turns the disk. When the disk reaches a speed of 6,000 rpm, the solenoid is fed current that causes the disk to be thrust toward the head plate. A ball bearing is used for this thrusting action. If power to the drive motor fails, a protective circuit causes power into the solenoid to fail also, and the spring pulls the disk away.

Disk Memory Much Faster Than Mechanical Tape Reader

This disk memory operates at a cyclic rate about a thousand times faster than could be expected with a mechanical tape reader on the ground. Thus checkout and testing are performed many times faster than by current practice, according to Dr. Morris. The extensive ground-checkout equipment normally needed is also eliminated.

The computer, which operates in serial mode, is completely transistorized. The silicon devices and germanium-mesa transistors used have been selected for extremely high reliability and high-temperature characteristics. ■ ■



Ground checkout functions as well as guidance and control tasks are performed by this solid-state computer for the Minuteman inertial guidance system. Autonetics Div., North American Aviation, Inc., designed the unit.



The newest Mincom magnetic tape instrumentation recorder/reproducer, to be announced in detail next month, answers the need for better performance in the intermediate frequencies. Covering bandwidths from 200 cps to 300 kc at 60 ips with improved dynamic range, it fills the gap between Mincom's Model C-100 (125 kc-60 ips) and the Model CM-100 (1 mc-120 ips). The new model also is extremely versatile, offering both FM and Direct recording/reproducing. One-rack compactness, all-transistorized electronics. Wait and see more of this new system's extra capabilities.



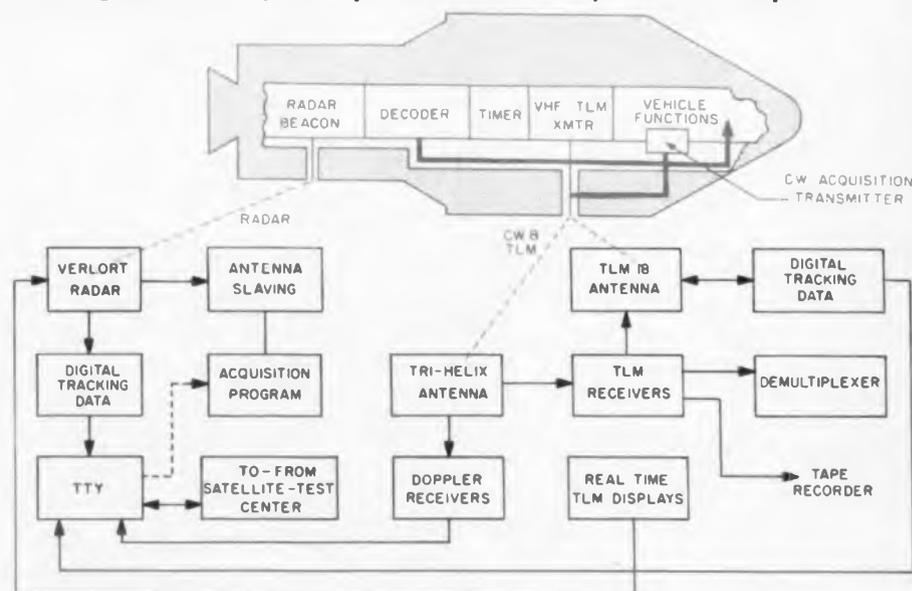
WHERE RESEARCH IS THE KEY TO TOMORROW

MINCOM DIVISION **MINNESOTA MINING AND MANUFACTURING COMPANY**

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CIRCLE 15 ON READER-SERVICE CARD

Radar-Beacon Tracking Used For Discoverers Series

High-Accuracy Discoverer Satellite Tracking Network Integrates Many Complex Electronic System Concepts



Tracking system for Discoverer-program satellites provides four services: tracking data of satellite and recovery capsule; command of system; collection of telemetry information; and master timing. Long-Range VERLORT radar used is modified from a previous system and operates as radar-beacon system to reduce power requirements at ground stations. Analog data are developed as dc voltages by potentiometers for slant range, azimuth and elevation. Digital information is developed by separate encoders and provides tracking data for automatic transmission to test center. Special-purpose orbital computer is included in each radar subsystem. Pulse-beacon transponder carried by Discoverer satellites is redesign of standard microwave missile-borne beacon. Also carried by satellites is multichannel vhf fm/fm telemetry transmitter for recording both environmental and equipment-operating data. Data are demultiplexed from tape and recorded on oscillographs after each pass of satellite. Doppler-telemetry unit is included in system as backup for telemetry tracker and to provide target-acquisition data by reception of cw signal from satellite-borne vhf oscillator. Data-transmission subsystem forwards information to test center at 4-sec intervals.



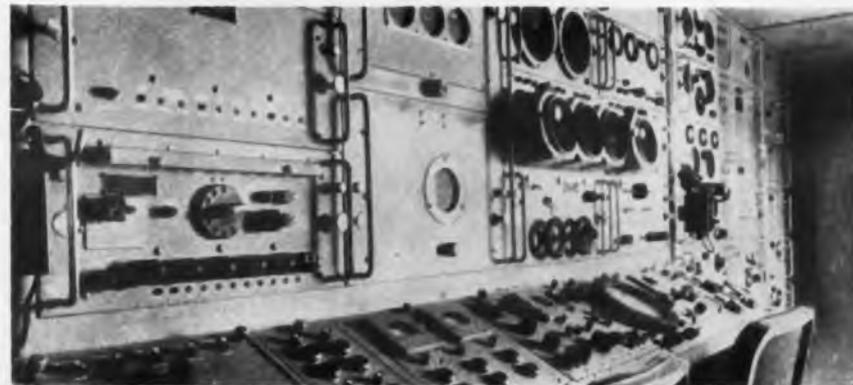
Tri-Helix antenna array receives VHF doppler and telemetry information and permits simultaneous telemetry reception and doppler readout to provide tracking data. Based on a two-axis system, the antenna operates with input signals down to -185 db w. The preamplifier and telemetry multicoupler have a combined noise figure of less than 4 db. Beam width is 20 ± 5 deg. Doppler and timing data are combined for transmission. Present system, developed by Philco Corp., Western Development Laboratories, Palo Alto, Calif., requires manual control, but may be replaced by an automatic unit now under development.



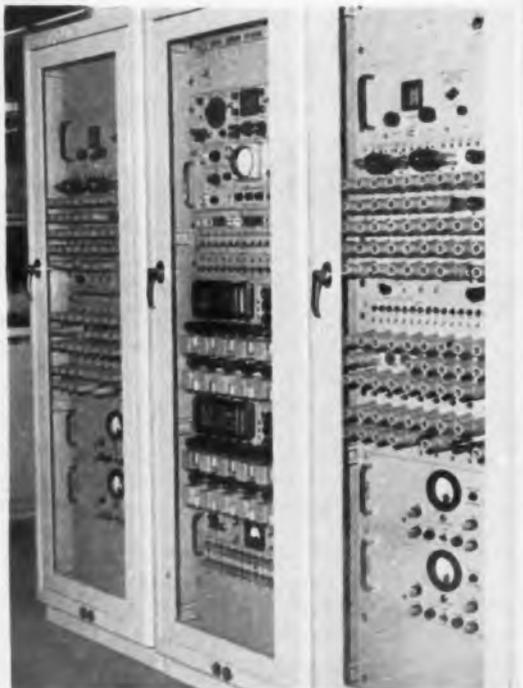
Sixty-ft dish for receiving telemetered rf data is part of the automatic-tracking subsystem with 1,500-nautical-mile range. Dish has 7.6-deg conical scan and scan frequency of 10 cps. It can track and slew to 10 deg per sec and accelerate to 5 deg per sec. Crystal-controlled receiver used, which incorporates phase-lock detection system, has 7-db noise figure and gain of 118.5 ± 3 db.



Time-display systems for world-wide tracking network indicate elapsed time in seconds, minutes, and hours starting several days before each firing. Displays also show estimated time to subsequent events like orbit, re-entry, etc. Basic standard is extremely stable 1-mc oscillator adjusted to WWV timing signal transmissions. Beckman produced 25 displays for network.



Very-Long-Range Tracking (VERLORT) radar locks on and automatically tracks vehicle in range at a rate of at least 10,000 yd per sec with a maximum error of ± 100 yd. System uses a tunable-magnetron transmitter. The antenna is a 10-ft parabolic reflector, with a 2.5-deg bandwidth. Receiver employs a traveling-wave-tube amplifier with a minimum 25-db gain over the frequency range. Receiver noise figure is less than 7 db, and the minimum discernible signal is below -100 dbm.



Complex master timing system for time-indexing data has accuracy of one part in 100 million. Time code is read out every 4 sec in pulse-code words and pulse rates. Two time-code generators are included in each system. Basic 4-sec interval is marked off by 16-bit binary word produced at 20-bit per sec rate by accumulator and scanner circuits.



Transistorized vehicle pulse-beacon transponder, designed by ACF Electronics Div., provides VERLORT radar with pulsed-signals for tracking. Superheterodyne-type receiver used has sensitivity of -70 dbm, stability of $+3$ mc between 0 and 70 C, and an image rejection greater than 45 dbm.



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U.S. ARMY PHOTO

VK[®] Micro-miniature CERAMIC CAPACITORS

Meets MIL-C-11015-18 and 19 (USAF)



UNCASED CASED

- 47-10,000 mmf
- -55°C to 150°C
- 200 vdc rating
- Small case size:
 - .2 x .2 x .1 through 1000 mmf
 - .3 x .3 x .1 through 10,000 mmf
- Also available uncased for complete assembly encapsulation.

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..... Rugged pre-molded flame-resistant outer case assures standard wall thickness, guaranteeing environmental immunity and absolute product uniformity. Square modular shape affords highest capacity per usable volume.

..... Epoxy potting solidly anchors, hermetically seals capacitor within case; increases mechanical strength and eliminates humidity leaks around leads.

..... Resilient, moisture-proof plastic sheathing protects unit during assembly and absorbs thermal shock at extremes of temperature cycling.

..... Uniformly exact dielectric margins around electrodes eliminate short circuiting and breakdown across edges under surge voltages through 400% of rating. Single standard 0.2" lead dimension for all values simplifies circuit design.

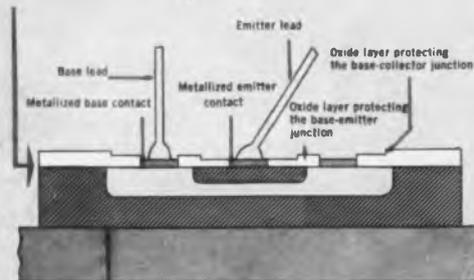
Vitramon[®]

INCORPORATED
Box 544, Bridgeport 1, Conn.

CIRCLE 16 ON READER-SERVICE CARD

NEW SILICON TRANSISTOR TYPES / NEW PARAMETER COMBINATIONS /
NEW STABILITY AND RELIABILITY / NEW SPECIAL ASSEMBLIES

THE PASSIVATED SURFACE: an integral silicon oxide coating completely protecting the junctions against contamination during manufacture and against change with time.



Collector soldered directly to header giving high mechanical strength and maximum power dissipation

MADE POSSIBLE BY

FAIRCHILD'S EXCLUSIVE PLANAR PROCESS

It is of particular significance that Fairchild, the first large-scale producer of silicon mesa types, is now converting all its types to planar structure. Planar is the logical successor to mesa because it offers the same advantages — to an even higher degree — and adds highly desirable characteristics of its own.

THE PLANAR ADVANTAGES:

Complete oxide protection of the junctions. The vital junctions are never exposed to contamination — even in the earliest stages of manufacture. The surface is so impervious that planar transistors could function even without a case.

Unparalleled device stability and extremely low leakage. Leakage is between 1/10th and 1/100th that of other diffused silicon types — and remains low even with prolonged high temperature storage. Other surface dependent parameters are similarly outstanding in stability.

Broadened operating range with more complete characterization. Planar transistors operate in the same range as similar mesa types — but also have useful beta down to microampere currents. Fairchild is guaranteeing many parameters not ordinarily specified.

All parameters equal or surpass mesa. A direct replacement of mesa types with planar equivalents can be done without altering your circuits. Cost is the same, and planar adds an extra safety factor in stability, low leakage, maximum power dissipation, and other ratings.

THESE STANDARD TYPES ARE AVAILABLE IN PLANAR

Fairchild 2N696, 2N697, 2N698, 2N699, 2N706, 2N707, 2N717, 2N718, 2N719, 2N720, 2N1420, 2N1613 and 2N1711. See also the new introductions on the next page.

NEWEST ADDITIONS TO FAIRCHILD'S PLANAR LINE

Besides the conversion of previous types, Fairchild offers a continuing succession of new types in the planar structure:

2N708

PLANAR LOGIC TRANSISTOR

Combining high speed, high beta and high voltage, the 2N708 is a direct replacement for the 2N706. It requires no circuit changes, though it offers higher minimum beta. Like all planar types, the 2N708 offers extremely low leakage and outstanding parameter stability even under sustained high temperature storage.

MAXIMUM RATINGS

P_C @ 25° C case temp.	1.2 watts
V_{CE}	20 v
V_{EBO}	5 v
V_{CBO}	40 v
V_{CEO}	15 v

GUARANTEED PARAMETERS

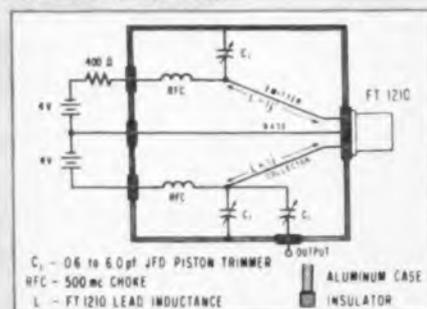
	Min.	Max.
I_{CBO} @ 25° C		25 μ A
@ 150° C		15 μ A
I_{CEX} @ $V_{BE} = +2.5v$, $V_{CE} = 20v$		10 μ A
125° C		
V_{BE} (SAT) @ $I_C = 10mA$, $I_B = 1mA$	.75	.82
V_{CE} (SAT) @ $I_C = 10mA$, $I_B = 1mA$		.40
h_{FE} @ $I_C = 10$, $V_{CE} = 1v$	30	120
h_{fe} @ 100 mc	3	
τ_s @ $I_C = I_{B1} = I_{B2} = 10mA$		25 nsec
t_{on} @ $I_C = 10mA$, $I_{B1} = 3mA$		35 nsec
t_{off} @ $I_C = 10mA$, $I_{B1} = 3mA$, $I_{B2} = 1mA$		75 nsec
C_{ob} @ $V_{CB} = 10v$		6 pf

PLANAR FT1210

FIRST KILOMEGACYCLE SILICON TRANSISTOR

Two nanosecond propagation delay in saturated logic or 500 mc high efficiency output as an oscillator are typical performance. The FT1210 is also the fastest silicon transistor with micro-watt logic capabilities.

FT1210 1 k mc OSCILLATOR



GUARANTEED PARAMETERS AND RATINGS

h_{FE} @ 3mA, 1v	20 min.
V_{CBO}	30 v
V_{EBO}	3.5 v
P_C max @ 25° C ambient	200 mw

TYPICAL CHARACTERISTICS

f_T	800 MC
I_{CBO} @ 150° C, 15v	25 m μ A
C_{ob} @ 0ma, 10v	1.2 pf
C_{ib} @ 0ma, 0.5v	1.6 pf

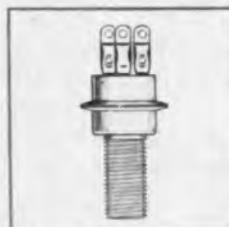
RF SPECIFICATIONS

Available gain, 200 mc	12 db typ.
Oscillator power output, @ 500 mc	25 mW typ.

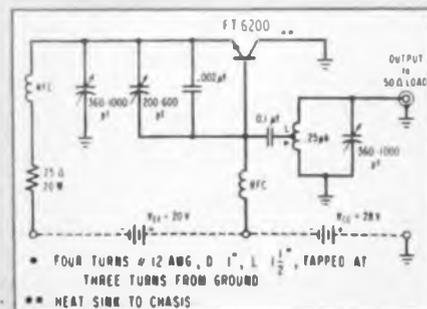
FT6200

30 WATT PLANAR POWER TRANSISTOR

A high frequency transistor suitable for power oscillators, RF amplifiers and memory-driver applications. The FT6200 features a newly developed power package and is the only power transistor offering planar reliability.



FT6200 POWER OSCILLATOR 10 Watts at 10 mc



GUARANTEED PARAMETERS AND RATINGS

V_{CBO}	60 v
V_{EBO}	5 v
V_{CER} @ 10 Ω	40 v
P_C @ 25° C case	30 watts
T_j max	200° C
V_{CE} (SAT) @ $I_C = 1$ amp, $I_B = .1$ amp	1.5 v
V_{BE} (SAT) @ $I_C = 1$ amp, $I_B = .1$ amp	1.5 v
h_{FE} @ $I_C = 500$ mA, $V_{CE} = 5$ v	20

TYPICAL PARAMETERS

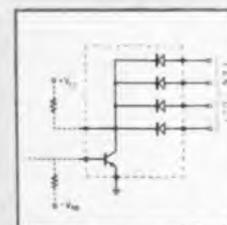
f_T @ 20mc, $V_{CE} = 20$ v, $I_C = 200$ mA	60 mc
P_{out} osc. @ 10 mc	10 watts
Osc. eff. @ 10 mc	50%
$t_{d,r}$ delay + rise @ $I_C = 1$ A	40 nsec

MULTIPLE ASSEMBLIES

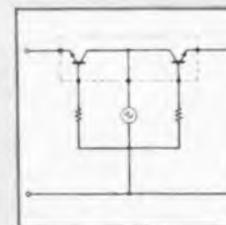
Functional multiples of several transistors and/or diodes with common or isolated electrical connections can now be packaged together by Fairchild. This reduces the number of external soldered connections and makes possible higher packing densities. The planar technique affords the uniformity, stability of parameters and the high yield through assembly necessary to make such multiple units economically and operationally feasible.

FOUR EXAMPLES

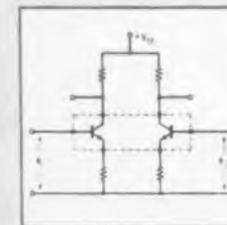
(Assembled in JEDEC TO-5 outline except as otherwise noted.)



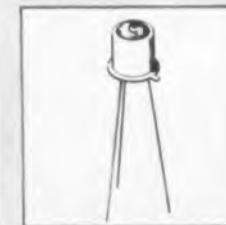
FSP-14 A low level logic block. Consisting in this example of four diodes and one transistor with common electrical connections across the header.



FSP-1 Chopper. Consisting of two planar transistors closely matched in low collector current DC h_{FE} , and having a common collector connection.



FSP-2 Differential amplifier. Consisting of two planar transistors thermally matched and closely matched in DC h_{FE} and V_{BE} , and having all connections with transparent window.



FSP-5 Photo transistor. Consisting of an extremely stable transistor (planar) with high beta at low collector currents, assembled in a JEDEC TO-18 outline with transparent window.

Special assemblies for your requirements

These or other multiple semiconductor devices (transistors, diodes and resistors) packaged in a single assembly are available from Fairchild's Special Products Group. Write for details.

Write today for more information — and a copy of the new 12-page full-color Fairchild Planar Story, which fully explains the process.



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*Now... modern 3½-inch meters
with time-tested Weston movements*

You'll find new design advantages in the familiar, reliable Weston 301 panel instruments. Case and mechanism are redesigned for modern needs—more reliable than ever before—at no increase in cost!

The exclusive **Cormag[®]** mechanism makes the 301 immune to the effects of stray magnetic fields. Instruments can be mounted on magnetic or nonmagnetic panels, close to other instruments, *without* special adjustments. Choose between round or rectangular case, modernistically styled in phenolic plastic.

Another design advantage... New 2½-inch Weston panel instruments—the 201 series—are designed with matching cases and incorporate the same advanced features!

For specifications... information... or the address of your nearest distributor, contact your local Weston representative, or write to: Daystrom, Incorporated, Weston Instruments Division, Newark 12, New Jersey.

*International Sales Division, 100 Empire Street,
Newark 12, New Jersey. In Canada: Daystrom Ltd.,
840 Caledonia Rd., Toronto 19, Ontario.*

Weston 301 Series is available in ac, dc, and RF types... voltmeters, ammeters, milli- and micro-ammeters... in dozens of ranges. Both round and rectangular meters are flush mounted. 301 Series requires 2.82" diameter cutout, 201 Series requires a 2.22" cutout.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION
Reliability by Design

CIRCLE 18 ON READER-SERVICE CARD

NEWS

IR Maser Offers First CW

*Pioneering Communication Uses
Sought With Helium-Neon Tube*

COHERENT-LIGHT communication systems appear significantly closer to realization with news of a cw infrared maser developed at Bell Telephone Laboratories, Murray Hill, N.J. The device, employing a mixture of helium and neon, delivers a principal output of 15 mw at 1.153 microns. Minimum line width is reportedly 10 kc, and beam spread is less than 1 min of arc.

The gas-discharge principle used in this first cw source of coherent light could prove applicable in a wide variety of gases and gas mixtures, according to Bell scientist Dr. Ali Javan, inventor of the device. A family of such masers, considerably more powerful and efficient than the laboratory model demonstrated by Bell, could follow.

Dr. Javan indicated that later versions of the gas discharge maser might operate at wavelengths as short as 5,000 Å. Such a "green" maser would be of considerable interest to Navy scientists, who believe that a transmission "window" in sea water at about 5,000 Å may permit submarine detection by a form of light radar.

The maser's cw operation was demonstrated to the press by transmitting a phone conversation through Kerr-cell modulation of the IR beam, but the communications potential of the device is being seriously investigated at Bell.

"We are studying other gases and a number of unique modulation methods as well, but unfortunately I can't be more specific just yet," Dr. Javan says.

The maser is pumped by a 28-mc signal applied to a 10 to 1 helium-neon mixture in a



Continuously operating IR maser tube is inspected by a Bell Telephone Laboratories scientist, Donald Herriott. Tube contains helium-neon mixture at low pressure, pumped by rf discharge. Light emanating from tube is the normal neon glow and does not indicate the extremely directional IR beam that exits from the ends of the tube.

Source of Coherent Light

slender glass tube at about 1 min of pressure. Helium atoms excited by the signal transfer their energy to the neon atoms through a collision process, thereby creating an excess of neon atoms at a higher energy level.

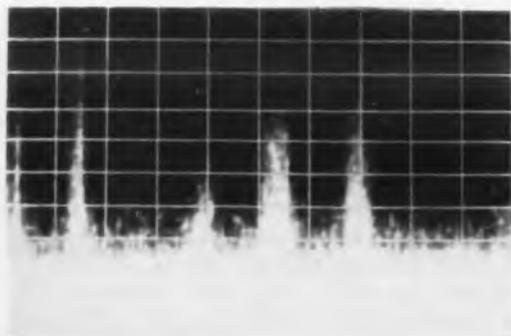
This energy is then surrendered by maser radiation as the neon atoms return to a lower energy level. Since the collision process is relatively efficient and the total of atoms involved is small, the principle lends itself to cw operation with a pumping source of reasonable size. The rf generator used in experiments thus far has an output of approximately 50 w.

Similar in design to the solid-state masers developed to date, the gas maser is built as a Fabry-Perot interferometer with high reflective, multiple-layer dielectric mirrors at each end of the tube. The light is thus reinforced by many trips through the tube, where it gains intensity by stimulating maser action in additional neon atoms.

Because of the many excitation and relaxation levels possible for neon in this system, some 30 different IR wavelengths can be generated by the maser. Principal modes are selected by tuning the interferometer and by maximizing reflectivity of the mirrors for specific frequencies. Thus far five oscillations between approximately 11,000 and 12,000 atoms have been observed.

Coherence of the output, denoting maser action, has been demonstrated by heterodyning two such frequencies to produce easily detected beat notes in the rf region.

Russian scientists are also studying gas discharge masers and have reportedly operated a mercury-zinc unit. These and the better-known single gas masers operate at room temperatures and may prove more feasible for systems use. ■



Coherence and narrowness of cw maser is illustrated by heterodyning the separate frequencies generated by the device. The beat notes shown range from 50 kc to 2 mc. Widths range from 10 to 80 kc.

Silicon Mesa Transistors Sylvania-2N696, -2N697



... current capabilities
... temperature storage
... power dissipation
... switching speed

SYLVANIA SILICON MESA TRANSISTORS: 2N696, 2N697 ELECTRICAL CHARACTERISTICS (25°C)				
	Min	Typ	Max	Units
$V_{CE0} (I_C = 100 \mu A, I_E = 0)$	60	90	—	V
$V_{CE0} (I_{RF} = 10 \mu A, I_{CE0} = 100 \text{ mA})$	40	—	—	V
$I_{CBO} (V_{CB} = 30V, I_E = 0, T = 25^\circ C)$	—	0.1	1.0	μA
$I_{CBO} (V_{CB} = 30V, I_E = 0, T = 150^\circ C)$	—	1.5	100	μA
$V_{EBO} (I_E = 1 \text{ mA}, I_C = 0)$	5.0	8.0	—	V
$h_{FE} (V_{CE} = 10V, I_C = 150 \text{ mA})$ (2N696)	20	—	60	—
for 12 msec and 2% duty cycle (2N697)	40	—	120	—
$V_{BE} (I_C = 150 \text{ mA}, I_B = 15 \text{ mA})$	—	0.9	1.3	V
$V_{CE} (\text{sat.}) (I_C = 150 \text{ mA}, I_B = 15 \text{ mA})$	—	0.4	1.5	V
$h_{FE} (V_{CE} = 10V, I_C = 50 \text{ mA}, f = 20 \text{ MC})$ (2N696)	2.0	—	—	—
(2N697)	2.5	—	—	—
$h_{FE} (V_{CE} = 10V, I_C = 25 \text{ mA}, f = 100 \text{ MC})$ (2N696)	—	1.6	—	—
(2N697)	—	1.6	—	—
$C_{DB} (V_{CB} = -10V, I_E = 0)$	—	15	35	μF

Sylvania-2N696, -2N697 are large-signal NPN devices capable of switching high currents at high speeds with highest reliability. In addition, they are well-suited for high-frequency amplifier applications. Conservatively designed, these Sylvania Silicon Mesa Devices exhibit exceptional *typical* characteristics, provide high power dissipation of 2 watts at 25°C case temperature, and a typical beta of 25 at 500 mA.

Sylvania-2N696, -2N697, hermetically sealed in TO-5 packages, are capable of storage life at 300°C. Too, they demonstrate remarkable uniformity of characteristics and excellent stability on life—the results of improved design, automated techniques and rigid Sylvania in-process quality controls.

Learn more about Sylvania-2N696, -2N697 and other Silicon Mesa Transistors from your Sylvania Sales Engineer or Sylvania Franchised Semiconductor Distributor. For technical data, please write to Semiconductor Division, Sylvania Electric Products Inc., Dept. 182, 1100 Main Street, Buffalo 9, N. Y.

SYLVANIA

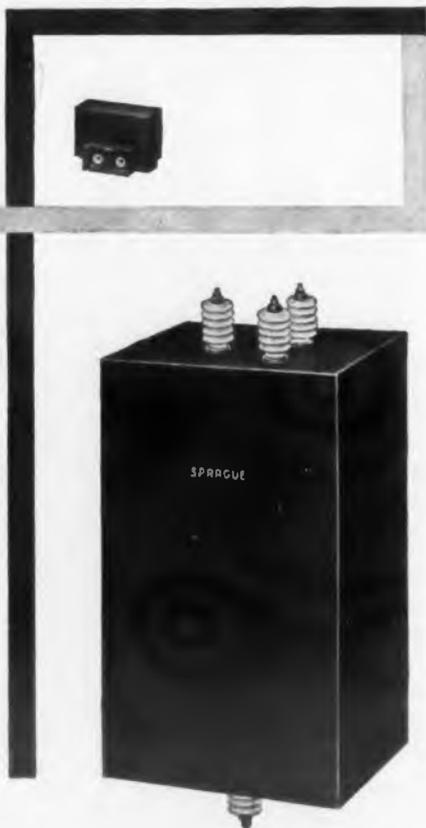
Subsidiary of GENERAL TELEPHONE & ELECTRONICS



PULSE-FORMING NETWORKS

FROM WATTS

to
MEGAWATTS



... and everything in between!

When it comes to pulse capacitors and pulse-forming networks, many complexities in parameters and design factors must be considered. These specialized units must be designed and manufactured by a specialized organization. And because Sprague maintains a highly-technical special engineering section devoted exclusively to pulse capacitors and networks, it has been, from the very beginning, a major supplier of these complex units for radar equipment (ground, marine, aircraft, missile), tube testing, and similar pulse circuit applications.

This special engineering section performs four important functions: One group designs custom units in accord-

ance with required parameters. Another group builds pulse capacitors and networks to these precise specifications. In another area, a group of specially-trained field engineers provides application assistance wherever needed. And yet another independent group works toward the future developing new materials, new design concepts, and new techniques for manufacture.

This concentration on pulse capacitors and pulse-forming networks has enabled Sprague to introduce product improvements such as heliarc sealing of cases, rugged alumina bushing assemblies, Fabmika[®] dielectric, and improved hermetic sealing of closures.

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Save time and money by working with Sprague from the start. Write for Engineering Bulletin No. 10,001 to Technical Literature Section, Sprague Electric Company, 347 Marshall St., North Adams, Massachusetts.

CIRCLE 19 ON READER-SERVICE CARD

WASHINGTON REPORT



John J. Christie

NASA'S INFLUENCE ON COMMUNICATION SATELLITE DEVELOPMENTS is due to increase significantly. The space agency has initiated its first active communications satellite project by seeking bids on Relay. It also has begun preliminary studies on Rebound, an advanced version of its highly successful Echo passive communication satellite.

The Relay low-altitude active communications satellite is scheduled for a Delta vehicle launching in mid-1962. The 85-lb satellite will evaluate the transmission of wideband signals, including TV, multichannel telegraphy and data handling, between the East Coast of the U.S. and the West Coast of Europe.

While the proposed American Telephone and Telegraph Co. satellite will have two packages transmitting and receiving in both directions, Relay will transmit and receive in only one direction at a time. Its second receiver-transmitter package will provide redundancy for added reliability.

Relay will have an additional research mission—the measurement of radiation damage to solar cells and other critical components. Its payload will include a radiation instrument package and test panels of various types of solar cells.

A NASA conference to acquaint prospective bidders with Relay specifications drew representatives from 40 companies, including AT&T and International Telephone and Telegraph's Federal and Kellogg Divisions. About one-fourth of the contenders were aircraft companies. Proposals are due March 6.

The space agency set as a general design objective for Relay an operational life of one year in orbit. Specifications contain stringent reliability and maintainability requirements. For example, it is specified that no circuit adjustment shall be required after a subassembly is installed. If controls must be adjusted after a unit is installed, they must be accessible without removal of any other unit.

NASA's specifications require the successful bidder to deliver four complete satellite assemblies: one prototype, two flight satellites and one flight spare. In addition a structural model with dummy electronics is required for structures tests.

MULTIPLE LAUNCHING OF SPHERES and development of a more rigid, more durable reflector than the inflatable Echo balloon are the twin objectives of Project Rebound.

Preliminary planning envisions Rebound spheres with a much thicker skin, probably of mylar and aluminum foil. A 140-ft diam, compared with Echo's 100 ft, will provide considerably more reflecting surface for higher-altitude operation. Rebound is expected to orbit at about 1,500 miles, or about 500 miles higher than Echo. The Rebound spheres are expected to weigh between 500 and 600 lb, compared with Echo's 136 lb.

Initially it is hoped to launch three spheres from a single

vehicle, but more are planned in subsequent tests. The first multiple launching is projected for 1963 and will probably be accomplished with an Atlas-Agena B vehicle. Meanwhile continuing experiments with Echo will require a launching this year and another in 1962.

When Febound was first under consideration some months ago, a NASA report outlined the purpose and procedure as follows: "Studies indicate that at least 12 passive communications satellites spaced around the world are required to provide essentially continuous communications. For this plan to be economically feasible, several satellites should be placed in orbit by a single vehicle. Initial development under this project will be concerned with the problem of packaging and erection of reflectors upon ejection into orbit. If this work appears promising, then further attention will be directed to the problem of providing period control for multiple passive satellites."

Design and fabrication of Rebound will be done under contract, as in the case of Relay and most upcoming NASA projects.

GREATER EMPHASIS ON OCEANOGRAPHY is reflected in budget provisions for increased spending on research vessels, expeditions and laboratory programs by several federal agencies and by the recent establishment of a National Oceanographic Data Center in Washington.

According to the Office of Naval Research, a priority requirement in instrumentation R&D is a means of translating signals from sensing devices to digital form for on-the-spot recording on magnetic or paper tape. Most R&D for oceanographic instruments will be conducted in Navy laboratories, with industry getting contracts for engineering, packaging and production.

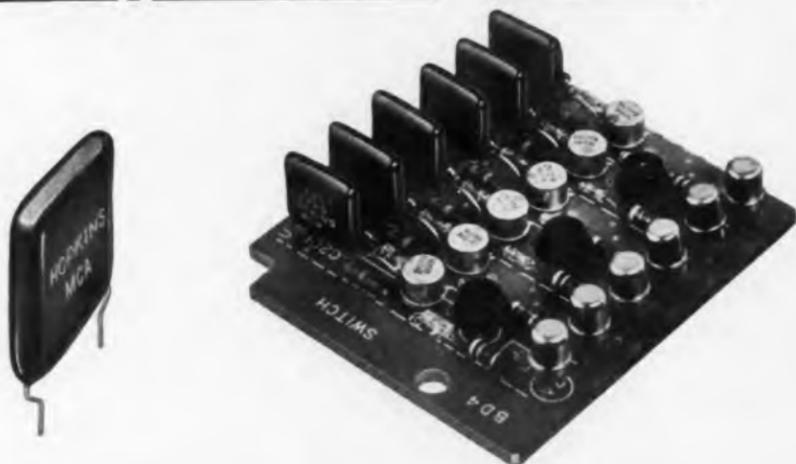
CONTRACT RENEGOTIATION is again a subject of controversy as the staff of the Joint Congressional Committee on Internal Revenue Taxation solicits industry and Government views for a report it must make to Congress by March 31. The March report was required by the last extension of the Renegotiation Act, although the act itself is not due to expire until June 30, 1962. Whether Congress intends to take up the matter at the present session is not clear. However, introduction of bills relating to the general subject of defense industry profits is inevitable.

Industry spokesmen prefer that the Renegotiation Act be allowed to die. If Congress insists on keeping it alive, they urge that some fundamental changes be made. EIA, speaking for the electronics industry, has taken the position that the act has clearly outlived its original purpose, which was to prevent excessive or windfall profits under crash-procurement programs, such as during the Korean War. The association contends that current armed forces procurement regulations and contracting procedures preclude profit-making abuses. It cites the safeguards built into cost-type contracts, a variety of redeterminable contracts and competitive bidding.

If Congress insists on extending the act, EIA and other industry groups would like revisions that would clip the wings of the Renegotiation Board. In a brief filed with the committee staff, EIA called attention to what it termed a "tendency on the part of the board to view renegotiation as essentially a rate-making or public utility type of proceeding" rather than a means of recapturing unconscionable profits, as was intended.

HOPKINS TYPE MCA Mylar*-epoxy capacitors

- thin as a disc, and temperature stable



You can fit these ultra-thin units into the narrowest chassis spaces . . . into printed circuit and transistor layouts . . . into closely stacked arrangements—and get the benefit of excellent temperature stability. Capacitance change is only 1.5% at 85°C.

Low power factor—less than 1% at 1 Kc and 25°C.

Wide temperature range: from -55°C to +100°C at full rated voltage. Units operate at 125°C with 50% derating.

High insulation resistance: 75,000 megohms min. at 100 VDC, 25°C, 2 min.

Long life—extremely stable over long periods of continuous operation at high temperature or exposure to highest humidities.

Epoxy encapsulation. An extra tough coating resists moisture and chemicals . . . permits close stacking without danger of arcing or shorting . . . won't melt or drip under excessive heat . . . is immune to solder damage.

Choice of leads—either straight or formed, to meet specific needs.

TYPE MCA—50 WVDC RATING		DIMENSIONS	
Cap'y. MFDS		A	B
		0.01	0.187
		0.022	0.187
		0.033	0.191
		0.047	0.203
		0.068	0.218
		0.1	0.225
		0.15	0.260
		0.22	0.306
		0.33	0.312

*DuPont trade name

Write for MCA data sheet.

HOPKINS Engineering COMPANY

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CIRCLE 20 ON READER-SERVICE CARD



Cable of TEFLON® cuts costs...controls automated water supply with maximum reliability

CAN YOU AFFORD NOT TO USE "TEFLON"?

- Insulation of TEFLON TFE resins and the new melt-processible TEFLON FEP resins is your logical and most economical choice whenever your cable encounters problems of corrosion... high temperature... space or weight limitations.
- Even when environmental conditions are not extreme, these most reliable of solid dielectric materials can enable your products to set the pace for dependable performance.
- In your next cable application, it will pay you to evaluate the dollars and cents savings in installation, in replacement, in maintenance and downtime made possible by insulation of TEFLON.

A special cable construction with insulation of a Du Pont TEFLON fluorocarbon resin was chosen for new automatic pressure and flow controls in the water system in Denver, Colorado. The location of pump stations and reservoirs restricted the use of overhead services—and, consequently, cables had to withstand underground environment. A ribbon type, 20 conductor cable coated with TEFLON solved the problem. It provides the necessary resistance to soil chemicals and zero moisture absorption, as well as the low capacitance required in the signal circuits. In addition, the cable resists damage from abrasion and handling in unfavorable laying conditions and reduces installed cable costs by approximately 50%.

In a variety of industrial installations, insulation of TEFLON is providing outstanding electrical properties plus the mechanical and chemical properties that assure long, trouble-free life with a minimum of maintenance problems. For more information consult your wire coater who uses TEFLON fluorocarbon resins, or write to: E. I. du Pont de Nemours & Co. (Inc.), Dept. ED-215, Room 2526T Nemours Building, Wilmington 98, Delaware. In Canada—Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.



TEFLON
FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.

BETTER THINGS FOR BETTER LIVING THROUGH CHEMISTRY

CIRCLE 21 ON READER-SERVICE CARD

NEWS

High-Power Magnets Predicted With New Superconductors

Design of lightweight, superconducting magnets in the 100,000-gauss range is forecast with new materials and techniques developed by Bell Telephone Laboratories, Murray Hill, N.J. A 15,000-gauss magnet only 4 in. long and less than 1 in. in diameter using molybdenum-three-rhenium (Mo_3Rh), has been successfully demonstrated.

Tests of niobium-three-tin (Nb_3Sn) indicate that a 100,000-gauss magnet of this material would weigh only several hundred pounds. Magnets of this size and field strength are expected to open new areas in the design of masers, traveling-wave tubes and fusion reactors, Bell spokesmen said.

Most proposals for high-field superconducting magnets have been frustrated because superconduction is quenched by relatively weak magnetic fields. Nb_3Sn , however, is said to retain its superconductivity at fields of more than 88,000 gauss.

Although the properties of this material are fairly well known, its extreme brittleness has prevented fabrication into coils and wires for use in magnets. Bell scientists say they have overcome this difficulty by the following novel technique:

A powdered mixture of niobium and tin is sealed in a niobium tube, which is then extruded through a die as a long wire. Since the niobium and tin are still in their elemental form, the wire remains ductile and can be wound into a coil or other desired shape. Only then is the wire heated in a furnace to react the two metals. The niobium casing itself is not superconducting in high magnetic fields, and it insulates the wire when the magnet is in operation.

The method was developed by Gene Kunzler, Ernest Buehler, Frank Hsu and Jack Wernick, scientists of Bell.

Hazeltine Gets Army Contract For Transportable 40-Ft Antenna

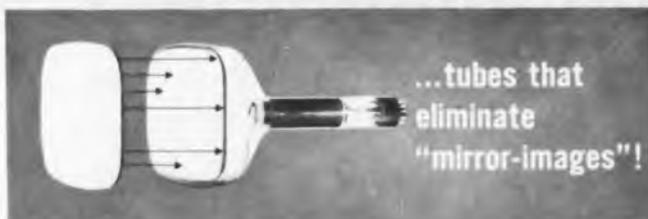
New transportable 40-ft radar antennas to be used with Army air-defense radar are being designed and developed by Hazeltine Corp. of Little Neck, N.Y.

Adaptable to all air-defense ground radars, the OA-1227 can be segmented and transported by helicopter or truck. An experienced Army team can set it up rapidly in the field. According to Army test reports, radar performance has been greatly improved as a result of using the Hazeltine antenna. The antenna is being developed under a \$2.6 million Army contract.

ELECTRON TUBE NEWS

...from SYLVANIA

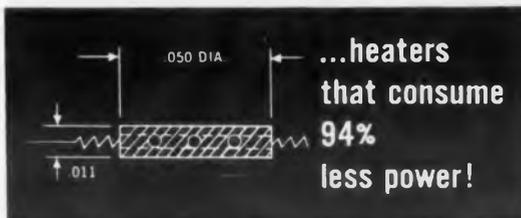
New CRT
developments
stimulate
I&M designs!



...tubes that
eliminate
"mirror-images"!



...tubes with
built-in
reference display
scales!



...heaters
that consume
94%
less power!



...tubes with
built-in character
patterns for
high-speed printing!



...new
multi-trace
type CRT!

SYLVANIA "BONDED SHIELD" CRT's FOR I&M DESIGNS—Now Sylvania adds the advantages of "Bonded Shield" to 19 industrial-military cathode ray tubes. A scratch-resistant, annealed-glass safety cap, Sylvania "Bonded Shield" eliminates conventional safety glass . . . cuts reflecting surfaces 50% . . . dramatically reduces specular images . . . increases apparent light transmission and contrast for improved image readability. Image display is brought "out front" for wide-angle viewing, mounting and styling are simplified, tube face is easily cleaned and vastly strengthened against breakage. Sylvania "Bonded Shield" caps are also available with anti-reflection treatment that can diffuse up to 70% of reflected light. Want more? Several CRT types feature calibrated reference scales permanently etched on the bonded safety cap, thereby reducing viewing

errors caused by parallax. Virtually all popular CRT's, from 3" to 27" can be supplied with Sylvania "Bonded Shield." Investigate its potential with your Sylvania Sales Engineer.

Equivalent Standard Type	"Bonded Shield" Type	Equivalent Standard Type	"Bonded Shield" Type
5FP4A	ST-3082	10SP4	ST-3080
5QP4	ST-3077	12KP4A	ST-3081
5UP1	SC-3074	12LP4A	ST-3115
5UP1	SC-3076*	14BAP4	ST-3101
5ABP1	SC-3119*	16WP4B	ST-2843
5ADP1	SC-3114	17BP4A	ST-3084
7SP4	ST-3078	17HP4B	ST-3086
7TP4	ST-3079	17DWP4	ST-3102
8KP4	ST-3100	24YP4A	ST-3085
10FP4A	ST-3083		

*Denotes Standard Modulation Scale printed on face

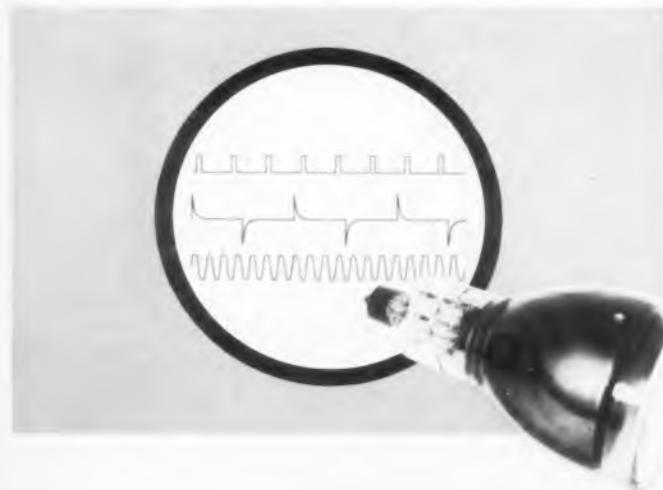
3 high-resolution CRT's for photo-recording applications



The broad capabilities of Sylvania in the field of high-resolution CRT's are well illustrated by the definition-range of three 5" diameter types. SC-3042 has a line width of 0.0075", SC-2782 offers a 0.001" line width, while the ultra-high-resolution SC-2809 provides a line width of 0.0008".

SYLVANIA SC-3042 features electrostatic focus and deflection, minimum pattern distortion and maximum sensitivity. It is available with a choice of eleven screen phosphors ranging from P1 to P25.

SYLVANIA SC-2782, SC-2809 feature aluminized screens, line grain P11 phosphor, conventional magnetic focus and deflection, non-ion trap guns. They simplify associated circuitry requirements, offer significant savings in equipment costs. Screen phosphors other than P11 are also available.



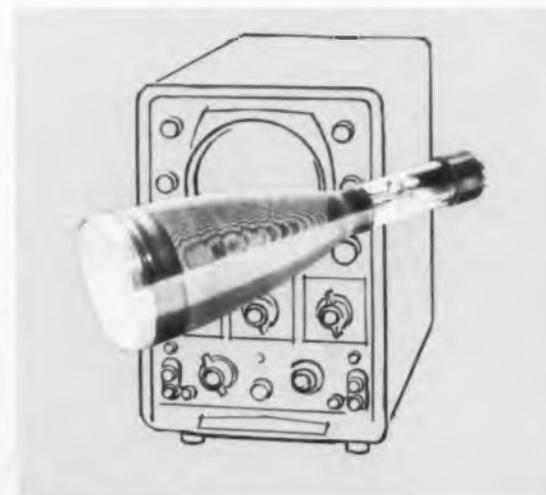
New Sylvania SC-3061 — multi-trace CRT

SC-3061 features three highly reliable, independently controlled electron guns capable of tracing three displays simultaneously on its 10" diameter face. The three guns focus undeflected spots 1 $\frac{3}{8}$ " apart on a common vertical line. The useful horizontal scan of each is approximately 8 $\frac{1}{2}$ ". SC-3061 is electrostatically focused and deflected and features an astigmatism control electrode. Deflection factors, at 5KV anode voltage, are approximately 130V/in. horizontal and 70V/in. vertical. SC-3061 uses P1 phosphor, but several other screen phosphors are also available.

Sylvania spiral accelerator tubes for precision 'scope applications

SYLVANIA-5BGP-, -5BHP- utilize an internal helical resistance coating to provide a uniform increase in accelerating voltage from deflection plates to the screen. They feature high-quality aluminized screens, high deflection sensitivity and accuracy, electrostatic deflection and focus. Both types can be supplied with a wide range of phosphors, all of which are rigidly controlled for premium characteristics.

Absolute Max. Ratings	5BGP-	5BHP-	Units
Anode No. 3 Voltage	13,200	13,200	Vdc
Isolation Shield Voltage	2,300	2,300	Vdc
Deflection Plate Shield Voltage	—	2,300	Vdc
Anode No. 2 Voltage	2,200	2,200	Vdc
Anode No. 1 Voltage	880	880	Vdc



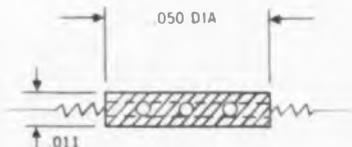
A	#	D	*	G	■	K	:	P	/	S	V	Y
B	\$	E	(H	√	.	~			½	¼	%
C	F)	I						10	X	.	;
N	"	Q	T				4	@	3	6	/	+
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New Sylvania SC-3093 — 3" monoscope CRT for high-speed printing

Custom-built SC-3093 provides signal generation of characters to associated high-speed printing equipment. SC-3093 features electrostatic focus and deflection and provides a built-in 2" sq. target plate with a capability of 64 alpha-numeric characters. Similar monoscope tubes can be supplied to your specifications with a variety of black and white halftone patterns.

New Sylvania low-heater-power CRT's



Developed by Sylvania, the new high-efficiency heater-cathode assembly consumes only 1.5 @ 140mA — less than 6% of the normal CRT heater power requirements. A flat pancake-like structure, 0.05" in diameter and 0.011" thick, it possesses extremely low mass, thereby enhancing resistance to shock and vibration. It is adaptable to practically all present-day CRT designs.

SYLVANIA -3BGP- offers high-deflection sensitivity, electrostatic deflection

and focus, optical-quality, clear, pressed faceplate. It is a compact, direct-view scope tube with face dimensions of 1½" x 3".

SYLVANIA -3BMP- is a 3" diameter tube with flat, clear faceplate. It offers post-deflection acceleration, electrostatic deflection and focus.

SYLVANIA SC-3016 features extremely compact size of only 6" in length and a circular face of 1¼". It provides high-deflection sensitivity, electrostatic focus and deflection.

Key Characteristics	3BGP-	3BMP-	SC-3016	Units
Heater Ratings	1.5V/140mA	1.5V/140mA	1.5V/140mA	
Anode No. 3 Voltage		6600*		Vdc
Anode No. 2 Voltage	2750*	2200*	2750*	Vdc
Anode No. 1 Voltage	1100*	1500*	1100*	Vdc
Face Dimension	1½ x 3¼	3	1¼	inches
Over-all length	9¼	10	6	inches

*Absolute max. ratings

Proven Sylvania capabilities in design and manufacture run the breadth and width of CRT applications — from highly sophisticated radar equipment to automobile ignition testers. The more than 200 Cathode Ray Tube types presently available represent only a small segment of Sylvania product capabilities. If your industrial-military design pre-

sents a CRT problem — look to Sylvania for solutions. Your Sylvania Sales Engineer will be pleased to work with you. For further information, contact the Sylvania Field Office nearest you. Or, for data on specific types, write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. B, 1100 Main St., Buffalo, N.Y.

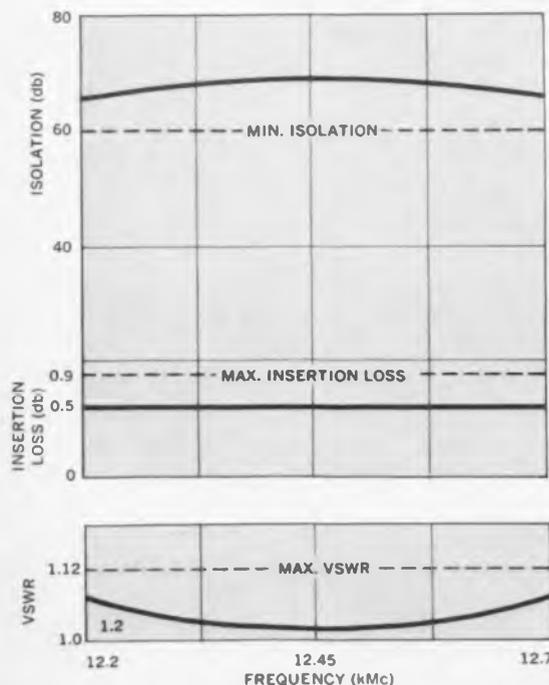
MICROWAVE DEVICE NEWS from SYLVANIA



WR-75 waveguide ferrite isolators provide

- high isolation — low insertion loss
- low VSWR — exceptional compactness

FD-7516 — TYPICAL PERFORMANCE CHARACTERISTICS (25°C)



Sylvania introduces six new, narrow-band, high-performance ferrite isolators for common carrier and commercial microwave systems. Sylvania FD-7511, -7512, -7513, -7514, -7515, -7516 exhibit high isolation to insertion loss ratios, as much as 60 to 1 over a broad frequency range. Lengths are from 2½" to as short as 1½". Sylvania WR-75 Ferrite Isolators exhibit unusually low VSWR and excellent stability over a temperature range of -30°C to +60°C

Investigate the advantages of Sylvania's extensive ferrite device line for your microwave design. Contact your nearest Sylvania Field Office. Or, write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. MDO-B, 1100 Main St., Buffalo 9, N. Y.

TYPE	FREQUENCY (KMC)		MIN. ISO-LATION (db.)	MAX. INSERTION LOSS (db.)	VSWR (Input & Output)	LENGTH (Inches)
	Min.	Max.				
7511	10.7	11.7	20	0.4	1.2	1½
7512	10.7	11.7	40	0.7	1.2	2
7513	10.7	11.7	60	1.0	1.2	2½
7514	12.2	12.7	25	0.4	1.12	1½
7515	12.2	12.7	40	0.6	1.12	2
7516	12.2	12.7	60	0.9	1.12	2½

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**



Tasker Flight Control Equipment Undergoing NAFEC Evaluation Tests

Flight conditions are displayed on air-control radar screens with a new system now under evaluation at the National Aviation Facility Experimental Center in Atlantic City, N.J.

This equipment, designed by Tasker Instruments, Van Nuys, Calif., includes a video-tracker programer, radar aircraft tracker, display-character generators, radar video conditioner, precision approach radar (PAR) consoles, and support equipment.

The video-tracker programer contains a magnetic drum memory that stores more than 200,000 bits of digital information concerning the identity, destination, arrival time, aircraft type, and control data for as many as 50 aircraft. These data are presented to controllers on their radar displays. The radar display consoles use a 21-in. diam daylight-viewable display with alphanumeric symbol printing.

The radar trackers are used to provide continuous position data on all aircraft; they are comprised almost completely of semiconductor circuitry and controlled by digital logic via the programer.

The equipment developed by Tasker will aid the controller in processing aircraft through the crucial ascent and descent phase of air flights—the terminal area. They will aid the controller to monitor and direct all the aircraft within a 30-mi radius of high density air terminals.

If three dimensional radar is added later to the control facility, the system can be adapted to display altitude information.



Control panel (lower right hand side of display tube) of Tasker Corp.'s PAR Display Console contains controls for both FPN-16, and PAR-1 radar. Vacant spaces in upper right hand section will contain speakers used in pilot-to-controller voice communication. Empty slots on each side of horizontal shelf are for head-phone plug-in jacks.

CHANGE NOTICE

SUBJECT: Test Instruments*
DATE OF EFFECTIVITY: At Once

WAS



IS



*Hathaway Denver, recognized for quality in design, development and manufacture of measuring, testing and control instruments, announces the acquisition of the test instrument line formerly produced by Dresser Electronics, SIE Division (formerly Southwestern Industrial Electronics Company).

MEMO TO: Test Instrument Buyers

The line of test instruments formerly produced by SIE will now be manufactured and distributed by Hathaway Denver and will carry the Hathaway Denver label. The line includes:

VOLTMETER (Model R-2)

This completely new voltmeter offers more in a single instrument, in terms of functional versatility, range and accuracy, than has ever been available in an electronic voltmeter.

- 1 MV-1000 V AC and DC
- 10 ohms -10 megohms midscale
- Frequency range 10 cps -1 mc
- DC Distend—upper 10% or 1% of any DC volts range can be expanded to cover the full meter scale.



R-2

MICROSOURCE (Model K-1)

Can be used in conjunction with any standard oscillator in the frequency range of 10 cps-1 mc to produce small, known, controlled test signals. An internal battery and associated polarity reversing switch allow testing of high gain DC amplifiers. Direct reading voltmeter; 10 volts maximum output; continuously adjustable.



K-1

SIGNAL GENERATOR (Model N-2)

Continuously variable over the frequency range from 1 cps to 1 mc in 6 overlapping bands, each having a ratio of over 10:1, this signal generator operates from 115 volt line and produces an output of 0 to 10 volts rms at less than 1% distortion.

- Resistance Meters
- Audio Response Plotters
- Vibration Meters
- Comparison Bridges



N-2



Write for bulletins on these products

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A division of HATHAWAY INSTRUMENTS, INC.

CIRCLE 23 ON READER-SERVICE CARD



SEMICONDUCTOR TEST EQUIPMENT

To Accurately Evaluate Semiconductor Parameters

- Incoming Inspection
- Production Test
- Reliability Systems



20 AMPERE DYNAMIC RECTIFIER ANALYZER

- Forward current 1/5/20 amp. D.C. full scale
- Reverse voltage 250/1000V. peak
- Forward voltage drop 0-1, 0-5V.
- Reverse current from 1 μ a to 50ma. in four ranges
- Self-contained, no external load resistors
- Mirror scale 1% instruments
- Tests under actual operating conditions in accordance with Mil. Specs.

Model 170 Price \$855.00 Delivery: Stock-2 Weeks



75 AMPERE SURGE TEST ADAPTER

- Provides surge current test for silicon rectifiers in accordance with Mil. Specs.
- Continually adjustable to 75 amp. peak
- Self-contained, portable
- Single half wave sinusoidal pulse
- 660, 2500 and 6000 amp. units available
- 1% monitoring accuracy
- Automatic programming available

Model 142 Price \$725.00 Delivery: Stock-2 Weeks



MODULAR DYNAMIC TEST POWER SUPPLY

- Simulator circuit
- Forward current & reverse voltage adjusted independently
- Reduces operating costs by a factor of 50
- Capacity is 20 rectifiers 0.1 to 1 amp. or any combination up to 2 rectifiers, 10 amp. each
- Mirror scale 1% instruments

Model 154D Price \$800.00 Delivery: 2 Weeks



LIFE TEST MODULE

- Self-contained switching module
- Simulator circuit
- Units may be set up in parallel for testing above 10 amp.
- Reduces operating costs by a factor of 50
- Plug-in rack adapters available for 3, 4, and 5 modules
- Forward drop equalizing resistors

Model 180A Price \$250.00 Delivery: Stock-2 Weeks



THERMAL RESISTANCE TEST INSTRUMENT

- Measures junction temperature
- Accuracy within 5% (under standard conditions)
- Heating current 1-5, 1-50 amps.
- Measuring current 1-100ma.
- 1% instruments
- Measuring pulse 100 μ sec.
- Scope display included

Model 149 (Basic Unit) Price \$4200.00 Delivery 6 Weeks
Lower power units available

200 AMPERE DYNAMIC TEST SET

- Forward current 20/200 amp. D.C. full scale
- Reverse voltage 0/1500V. peak
- Forward voltage drop 0-5/10V. peak
- Reverse current from 2 μ a to 250ma. in four ranges
- Self-contained, no external load resistors
- Mirror scale 1% instruments
- Tests under actual operating conditions in accordance with Mil. Specs.

Model 164 (Basic Unit) Price \$11,525.00 Delivery 8-10 Weeks



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CIRCLE 24 ON READER SERVICE CARD

NEWS

ECI Weather Display System Slated for Project Mercury

A weather-display system developed at Electronic Communications Inc.'s Facsimile Div., will be used in Project Mercury, the man-in-space program.

Called the Electronic Messenger, the system is currently in use by the U. S. Weather Bureau for the instantaneous transmission and receipt of daily weather information. In Project Mercury it will be used to speed photos of cloud formations, and other data of special interest in launching of a manned satellite, between six U. S. Weather Bureau stations strategically located throughout Central and South Florida.

Here is how the system will work. Polaroid photos will be taken of the radar scope showing the complete weather pattern, at any given moment, within the range of any particular weather station. Developed and annotated in seconds, this photograph, together with any supplemental written or weather map information desired, is fed into an Electronic Messenger transmitter or transceiver for instantaneous receipt by other weather stations. These weather stations include those located at Cape Canaveral, Miami, Tampa, Patrick Air Force Base, and Daytona.

Youthful Scientist Blasts Off



After a four-hour countdown, at the Naval Ordnance Test Station, China Lake, Calif., 20-year-old Marshall Kriesel of Owatonna, Minn., pushed the launch button on the 11-ft missile that he designed and made himself, with the encouragement of Minneapolis-Honeywell officials. Missilemen said young Mr. Kriesel's "home-made" rocket, which veered off-course and crashed before attaining full altitude, was a highly complex one. Mr. Kriesel, who is going on with missile work, invested four years and \$3,500 in his "bird."

New Tool Measures Ultra-Low Pressures

A laboratory tool for measuring pressure down to about 10^{-10} mm of mercury has been developed at the Westinghouse research laboratories.

The device, known as a photomultiplier ion gage, was developed by the Westinghouse research physicists W. J. Lange, Henry Riemersma, and R. E. Fox as part of an ultra-high-vacuum research program supported by the U. S. Atomic Energy Commission's Project Sherwood. Project Sherwood is a long-range research program aimed toward achieving controlled nuclear fusion for peacetime uses.

In the new pressure-measuring device the heated filament is done away with completely. Rather than use a hot surface to produce the required ionization of the gas, a beam of ultraviolet light is employed. The light is beamed onto a metal surface which has the ability to release electrons under the stimulus of the ultraviolet rays, the company said. These electrons are guided onto a series of similar surfaces which multiply the electrons in speed and number. These electrons then are used to form the ions that are collected and counted in the usual fashion.

Photomultiplier Gauge Useful In Ultra-High-Vacuum Experiments

The photomultiplier ion gage, the physicists pointed out, will be useful in a variety of key ultra-high-vacuum research experiments, being ideally suited to low-pressure studies of hot filament-gas interactions such as those encountered in the ordinary fluorescent lamp, in electronic tubes and in thermionic energy converters.

The gauge is linear with pressure over the range from 10^{-3} to 10^{-10} mm of mercury. This range of pressure is equal to that encountered in space at distances between 50 and 650 miles above the surface of the earth. According to the company, the new device has been used successfully in pressure measurements in space laboratories.

CIRCLE 25 ON READER-SERVICE CARD
TO BE PLACED ON MAILING LIST

SILICON CONTROLLED SWITCHES . . . from SSPI

... Offering efficient switching in the 1-200 mA range and peak pulse current capability to 10 amperes, in the miniature TO-18 package.



- High sensitivity
... 20 μ A firing
- Close firing control
... within $\pm .08V$
- Voltage ratings to 200V
- MIL-S-19500 capability

Type	Maximum Anode Voltage (DC or Peak AC) \pm Volts	Maximum Average Forward Current 75°C mA	Maximum Gate Current to "Fire" μ A	Gate Voltage to Fire \pm Volts	
				Min.	Max.
2N884	15	200	20	.44	.60
2N885	30	200	20	.44	.60
2N886	60	200	20	.44	.60
2N887	100	200	20	.44	.60
2N888	150	200	20	.44	.60
2N889	200	200	20	.44	.60

Now in TO-18

Available for the first time in the miniature TO-18 case, these units offer the same high sensitivity and close characteristics control introduced by SSPI in pioneering PNP devices for control and logic applications.

The precise firing characteristics of these devices make them ideal for timing and time delay circuits, voltage limit detectors, high gain static switching, logic circuits, and related applications.

With the high surge capability of this series, squib firing systems requiring pulse currents up to 5 amperes can be greatly miniaturized without sacrificing design margin. In addition, the low 1 mA holding current level is particularly useful in many programming, control and logic circuits.

Designed to meet the requirements of MIL-S-19500, these units are subjected to extensive temperature storage and cycling, as well as 100% acceptance testing, as a regular part of the manufacturing procedure.

Write for Bulletin C420-03.

CIRCLE 26 ON READER-SERVICE CARD

PROVEN LEADERSHIP IN PNP TECHNOLOGY . . . from SSPI

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NEWS

High-Speed Recording System Uses Film and Electrostatic Tube

A significant advance in the high-speed recording of electronic data as visible and projectable images has been announced by the Kalvar Corp.

The system can transform data at electronic speed into written or numerical characters on film, and into a "TV image" for giant-screen projection, Kalvar scientists said.

An electrostatic tube, the Printapix tube developed by Litton Industries of Beverly Hills, Calif. converts the electronic data to Kalvar film images at the rate of several feet per sec.

Kalvar is reportedly the only photographic film now marketed upon which a "discrete," or localized electric charge can be placed, a basic element of the new system. The patented coating on the plastic-base film is also unique in the photographic field in that the latent image on the exposed film is developed by heat alone in the completely dry process. All chemicals are eliminated by the Kalvar technique which is used in this system.

Polarad Klystron Repair Facility



Repairs on high-power klystrons are being made at Polarad Electronics Corp.'s Microwave Tube Laboratory in Long Island City, N.Y. Polarad engineers find that by cutting the shell of the tube, it is possible to replace the gun and grid structure. With the completion of this rebuilding process, tubes are as good as new at a fraction of the replacement cost, the company claims. Such repairs are reported practical in cases of gaseousness, low emission, and heater failure.

PUT EXTRA
SALES PUNCH IN
NEW PRODUCTS WITH—
**MALLORY
MERCURY
BATTERIES**



FOOLPROOF PICTURES IN 10 SECONDS!

The new Polaroid Electric Eye Land Camera automatically adjusts lens opening and shutter speed. Photo cell circuit is powered by long life Mallory Mercury Batteries, capable of at least one year's service. No chance of corrosive leaks endangering the camera.



PRECISE VOLTAGE REFERENCE SOURCE for instrument calibration and lab tests, Mallory Mercury Reference Battery is accurate within $\pm 1/2\%$ of stated voltage. Glass-free, rugged construction. Can't be damaged by overloads. Eight voltage outputs, 0 to 10.8 volts, in 1.35 volt steps.



HYPOTHERMIA PRECEDING HEART SURGERY involves remote measuring of temperatures. The Tele-Thermometer from Yellow Springs Instrument Co., Inc. does this exacting work, with Mallory Mercury Batteries providing needed high electrical capacity per unit size. (2.5 volt cells, .66" dia. by 1.3", rated 1000 milliamp-hours.)



FIRST ELECTRONIC TIMEPIECE ACCUTRON, by Bulova, guaranteed accurate to one minute per month, is designed to run a full year without battery change. To power the mechanism, Mallory Mercury Batteries assure long life, constant voltage discharge and freedom from gassing and leakage.

Miniaturization . . . portability . . . extra long life . . . name the extra sales factor, and Mallory Mercury Batteries can add it! Want fewer battery changes, longer storage life, fade-free service? Mallory offers far longer life, far higher capacity per unit size than conventional batteries! Batteries must have wide temperature range? Mustn't leak? Make yours Mallory! Their constant discharge voltage is ideal for transistor circuitry, too.

There's a wide availability on a broad line of single or multiple voltage cells. Custom power packs developed on request. Write Mallory, the mercury battery pioneers, for consultation and engineering data.

Mallory Battery Company
North Tarrytown, N.Y.
a division of



In Canada: Mallory Battery Company of Canada, Limited, Toronto 4, Ontario
In Europe: Mallory Batteries, Limited, Dagenham, England

3-D Controlled Approach System Combines Swiss and U.S. Devices

A Swiss fire-control system and an American three-dimensional display system are combined in a new ground-control-approach system called Fledco.

The Fledermaus fire control radar system, produced by Contraves A. G., Zurich, Switzerland, and the Iconorama 3-D display system, designed by Fenske, Fedrick & Miller, Inc., are combined in the mobile prototype system now being operated in Zurich.

The Fledermaus radar unit is designed for high accuracy and resolution in tracking. Iconorama is a data-integration system which processes many inputs and projects the track of an object and information concerning it on a 3-D display unit. Superimposed on this display is a panorama of land surfaces and obstacles, as well as a flight-path grid.

PLUS Printed-Circuit Module Offers Shock-Withstanding Qualities

A modular construction, known as PLUS and consisting of crossed interlocking printed-circuit boards, has been developed by Arthur Ansley Manufacturing Co., New Hope, Pa.

The interlocking boards form a structural column. End plates may also be printed circuits and can carry tube sockets or transistors and plug-in connectors.

The structures can be made in a wide variety of shapes and sizes, including a subminiature version about 3/8 in. square. The development is said to offer advantages in miniaturization by providing maximum circuit-board area in a given space, as well as a rugged, self-supporting structure which is capable of withstanding shock and vibration.



Etched-circuit board held by engineer holds up to 200 components to be measured and recorded for Minute-man program component reliability studies. Board will be inserted in Automatic Component Measuring and Recording System developed by Dymec Div. of Hewlett-Packard Co.

CIRCLE 27 ON READER-SERVICE CARD

Tarzian Silicon Voltage Regulators for Tomorrow's Circuits in Design Today



TARZIAN SILICON VOLTAGE REGULATORS—in ¼-watt, 1-watt and 10-watt classifications—will serve you well as DC power regulators, AC clippers and limiters, and as protective devices in a wide variety of component protection circuits.

Their small size, inherent ruggedness, and physical simplicity are distinct improvements over other types of regulators. Sharp and instantaneous breakdown (avalanche) characteristics and instantaneous recovery are invitations to inventiveness in circuit design.

Tarzian silicon regulators, like Tarzian silicon rectifiers, are made with a unique blend of care and ingenuity that delivers excellent quality at a realistic price. They are available now from factory or warehouse stocks in sample or volume production quantities. Application engineering service is offered without obligation.

Write for your free copy of the new 6-page Tarzian voltage regulator catalog. It contains helpful design and test information and application notes.

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CIRCLE 28 ON READER-SERVICE CARD

¼ Watt Voltage Regulators Specifications 25°C					1 Watt Voltage Regulators Specifications 25°C					10 Watt Voltage Regulators Specifications 25°C				
Type	Case (V)	Lead (in)	Pin (mm)	Power (W)	Type	Case (V)	Lead (in)	Pin (mm)	Power (W)	Type	Case (V)	Lead (in)	Pin (mm)	Power (W)
2575.0	5.0	25	3.0	1000	2575.0	5.0	25	3.0	1000	2575.0	5.0	25	3.0	1000
2575.1	6.2	25	4.1	1000	2575.1	6.2	25	4.1	1000	2575.1	6.2	25	4.1	1000
2575.2	6.8	25	4.7	1000	2575.2	6.8	25	4.7	1000	2575.2	6.8	25	4.7	1000
2575.3	7.5	25	5.3	1000	2575.3	7.5	25	5.3	1000	2575.3	7.5	25	5.3	1000
2575.4	8.2	25	6.0	1000	2575.4	8.2	25	6.0	1000	2575.4	8.2	25	6.0	1000
2575.5	9.1	25	7.0	1000	2575.5	9.1	25	7.0	1000	2575.5	9.1	25	7.0	1000
2575.6	10.0	25	8.0	1000	2575.6	10.0	25	8.0	1000	2575.6	10.0	25	8.0	1000
2575.7	11.0	25	9.0	1000	2575.7	11.0	25	9.0	1000	2575.7	11.0	25	9.0	1000
2575.8	12.0	25	10.0	1000	2575.8	12.0	25	10.0	1000	2575.8	12.0	25	10.0	1000
2575.9	13.0	25	11.0	1000	2575.9	13.0	25	11.0	1000	2575.9	13.0	25	11.0	1000
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2576.1	15.0	25	13.0	1000	2576.1	15.0	25	13.0	1000	2576.1	15.0	25	13.0	1000
2576.2	16.0	25	14.0	1000	2576.2	16.0	25	14.0	1000	2576.2	16.0	25	14.0	1000
2576.3	17.0	25	15.0	1000	2576.3	17.0	25	15.0	1000	2576.3	17.0	25	15.0	1000
2576.4	18.0	25	16.0	1000	2576.4	18.0	25	16.0	1000	2576.4	18.0	25	16.0	1000
2576.5	19.0	25	17.0	1000	2576.5	19.0	25	17.0	1000	2576.5	19.0	25	17.0	1000
2576.6	20.0	25	18.0	1000	2576.6	20.0	25	18.0	1000	2576.6	20.0	25	18.0	1000
2576.7	21.0	25	19.0	1000	2576.7	21.0	25	19.0	1000	2576.7	21.0	25	19.0	1000
2576.8	22.0	25	20.0	1000	2576.8	22.0	25	20.0	1000	2576.8	22.0	25	20.0	1000
2576.9	23.0	25	21.0	1000	2576.9	23.0	25	21.0	1000	2576.9	23.0	25	21.0	1000
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2577.1	25.0	25	23.0	1000	2577.1	25.0	25	23.0	1000	2577.1	25.0	25	23.0	1000
2577.2	26.0	25	24.0	1000	2577.2	26.0	25	24.0	1000	2577.2	26.0	25	24.0	1000
2577.3	27.0	25	25.0	1000	2577.3	27.0	25	25.0	1000	2577.3	27.0	25	25.0	1000
2577.4	28.0	25	26.0	1000	2577.4	28.0	25	26.0	1000	2577.4	28.0	25	26.0	1000
2577.5	29.0	25	27.0	1000	2577.5	29.0	25	27.0	1000	2577.5	29.0	25	27.0	1000
2577.6	30.0	25	28.0	1000	2577.6	30.0	25	28.0	1000	2577.6	30.0	25	28.0	1000
2577.7	31.0	25	29.0	1000	2577.7	31.0	25	29.0	1000	2577.7	31.0	25	29.0	1000
2577.8	32.0	25	30.0	1000	2577.8	32.0	25	30.0	1000	2577.8	32.0	25	30.0	1000
2577.9	33.0	25	31.0	1000	2577.9	33.0	25	31.0	1000	2577.9	33.0	25	31.0	1000
2578.0	34.0	25	32.0	1000	2578.0	34.0	25	32.0	1000	2578.0	34.0	25	32.0	1000
2578.1	35.0	25	33.0	1000	2578.1	35.0	25	33.0	1000	2578.1	35.0	25	33.0	1000
2578.2	36.0	25	34.0	1000	2578.2	36.0	25	34.0	1000	2578.2	36.0	25	34.0	1000
2578.3	37.0	25	35.0	1000	2578.3	37.0	25	35.0	1000	2578.3	37.0	25	35.0	1000
2578.4	38.0	25	36.0	1000	2578.4	38.0	25	36.0	1000	2578.4	38.0	25	36.0	1000
2578.5	39.0	25	37.0	1000	2578.5	39.0	25	37.0	1000	2578.5	39.0	25	37.0	1000
2578.6	40.0	25	38.0	1000	2578.6	40.0	25	38.0	1000	2578.6	40.0	25	38.0	1000
2578.7	41.0	25	39.0	1000	2578.7	41.0	25	39.0	1000	2578.7	41.0	25	39.0	1000
2578.8	42.0	25	40.0	1000	2578.8	42.0	25	40.0	1000	2578.8	42.0	25	40.0	1000
2578.9	43.0	25	41.0	1000	2578.9	43.0	25	41.0	1000	2578.9	43.0	25	41.0	1000
2579.0	44.0	25	42.0	1000	2579.0	44.0	25	42.0	1000	2579.0	44.0	25	42.0	1000
2579.1	45.0	25	43.0	1000	2579.1	45.0	25	43.0	1000	2579.1	45.0	25	43.0	1000
2579.2	46.0	25	44.0	1000	2579.2	46.0	25	44.0	1000	2579.2	46.0	25	44.0	1000
2579.3	47.0	25	45.0	1000	2579.3	47.0	25	45.0	1000	2579.3	47.0	25	45.0	1000
2579.4	48.0	25	46.0	1000	2579.4	48.0	25	46.0	1000	2579.4	48.0	25	46.0	1000
2579.5	49.0	25	47.0	1000	2579.5	49.0	25	47.0	1000	2579.5	49.0	25	47.0	1000
2579.6	50.0	25	48.0	1000	2579.6	50.0	25	48.0	1000	2579.6	50.0	25	48.0	1000
2579.7	51.0	25	49.0	1000	2579.7	51.0	25	49.0	1000	2579.7	51.0	25	49.0	1000
2579.8	52.0	25	50.0	1000	2579.8	52.0	25	50.0	1000	2579.8	52.0	25	50.0	1000
2579.9	53.0	25	51.0	1000	2579.9	53.0	25	51.0	1000	2579.9	53.0	25	51.0	1000

NOTE: Standard tolerance is ± 1%. Power: 100% at 25°C. Maximum power at 25°C. Maximum power at 100°C. Maximum power at 150°C. Maximum power at 200°C. Maximum power at 250°C. Maximum power at 300°C. Maximum power at 350°C. Maximum power at 400°C. Maximum power at 450°C. Maximum power at 500°C. Maximum power at 550°C. Maximum power at 600°C. Maximum power at 650°C. Maximum power at 700°C. Maximum power at 750°C. Maximum power at 800°C. Maximum power at 850°C. Maximum power at 900°C. Maximum power at 950°C. Maximum power at 1000°C.

NEWS

Japanese Continue Push

Designs Range From Gadgetry
To Refined Laboratory Devices

Stuart Griffin

ELECTRONIC DESIGN Japan Correspondent

JAPANESE firms are keeping a continuous stream of new electronic products moving into the market in Japan. Developments range from novel gadgetry for consumer items to more sophisticated electronic developments for use in the research laboratory.

A cathode-ray tube which can produce two different images simultaneously on a single face has been singled out by the Japanese Government's Science and Technology Agency as one of the most practical Japanese inventions of the year. The tube can be used, for example, to show an instantly vanishing image on one half of the screen, and a slowly vanishing image on the other half. In combination with a cathode-ray oscillograph, it can be used to observe mixed sound patterns, such as those caused by the exhaust of an internal combustion engine. The new cathode-ray tube is now being produced by Sanken Co., Numazu City.

Transistorized Clock-Radio Features Built-In Chimes

A clock which chimes at any preset time has been built into an eight-transistor radio built by Nippon Columbia Co., Ltd., Tokyo. The sound of the chimes is amplified through a 6-cm speaker. The watch portion of the unit is being supplied by Citizen Watch Co., Ltd., Tokyo.

An automatic time switch operates the two-band radio, which has another 10-cm speaker. The entire clock-radio combination is about 12.5-in. wide, 2.5-in. high, and 4.5-in. deep. It holds four UM-1 dry-cell batteries.

Another new product on the market is a small push-button interphone using printed wiring. This unit is being marketed by Matsushita Tsushin Industrial Co., Ltd., Yokohama. The interphone, about the size of a book in the pocket version, comes in two models. The TP-101 is for two-way communications, and the TP-301 is for three-way communications.

New Ultrasonic Burglar Alarm Uses Doppler For Motion Detection

A transistorized ultrasonic burglar alarm, using the doppler effect to detect motion within an area, has been introduced by Kanda Tsushin Kogyo Co., Ltd., Tokyo. An alarm is sounded whenever something moves in an area under surveillance. This area surveillance provides

For More New Products

more secure protection than a photoelectric beam-type alarm.

A wireless, two-channel stereo sound system, using earphones, has been developed by Toho Technical Research Laboratory, a branch of Toho Motion Picture Studios.

A titanium condenser microphone, claimed to have improved temperature stability, has been developed by Nippon Electric Co., Ltd., Tokyo, through cooperation with the Musashino Laboratory of Japan Telegraph & Telephone Corp.

Similar steel microphones have a variation of as much as 3 db with a temperature change of about 45 C, while the comparable titanium models remain almost constant. In addition, the titanium has a relatively flat response curve over a wide frequency range.

A finger-tip sized combination microphone and earphone has been put on the market by New Plastics Co., Ltd., Tokyo. Measuring only 19 x 19 x 9-cm, the device has a frequency range of 500 to 5,000 cps.

Outdoor Hi-Fi Stereo System Developed by Toshiba Electric

A high-fidelity stereo sound system design for outdoor performances has been developed by the Tokyo Shibaura Electric Co. in Japan.

The unit operates on a frequency of 40 to 10,000 cycles and consists of four sections, each of which combines three speakers for the low, middle, and high-sound frequencies. Output is rated at 440 w.

The woofer is 19.5-ft high, 8-ft wide, and 13.6-ft deep. Its weight is 5,000 lb. ■ ■



Japanese outdoor hi-fi stereo unit stands 19.5 ft tall. It is specially designed for outdoor performances.

PSI SILICON MICRO- TRANSISTORS FOR ADVANCED COMPUTER DESIGN

TRIPLE DIFFUSED SILICON MESA MICRO-TRANSISTORS - FAST SWITCHING TYPES

PMT 118 and PMT 119 Low level, high beta versions of 2N696 and 2N697 switching transistors.
PMT 113 and PMT 114 Micro equivalents of popular 2N696, 2N697.
PMT 111 and PMT 112 Low saturation, extremely flat beta similar to 2N1409, 2N1410.

New high
performance,
high reliability
Micro-
Transistors
open way to
design of
computers well
beyond today's
standards.



CIRCLE 29 ON READER-SERVICE CARD

PSI silicon Micro-Transistors are fast becoming a major feature in the design of miniaturized high capability computers. A wide selection of Micro-Transistors is available in *production quantities*. High performance versions of many standard transistor types are being introduced.

NOTE THESE OUTSTANDING FEATURES!

Great reduction in size — 1/50th the size of usual computer transistors.

Off-the-shelf delivery — from PSI distributors everywhere. Production quantities on fast delivery from factory.

New low prices — Micro-Transistor prices now comparable to convention-size transistors.

Ease of assembly — Gold ribbon leads ideal for all soldering and welding techniques.

Companion to Micro-Diode — Permits fullest utilization of advanced micro-miniaturization techniques.

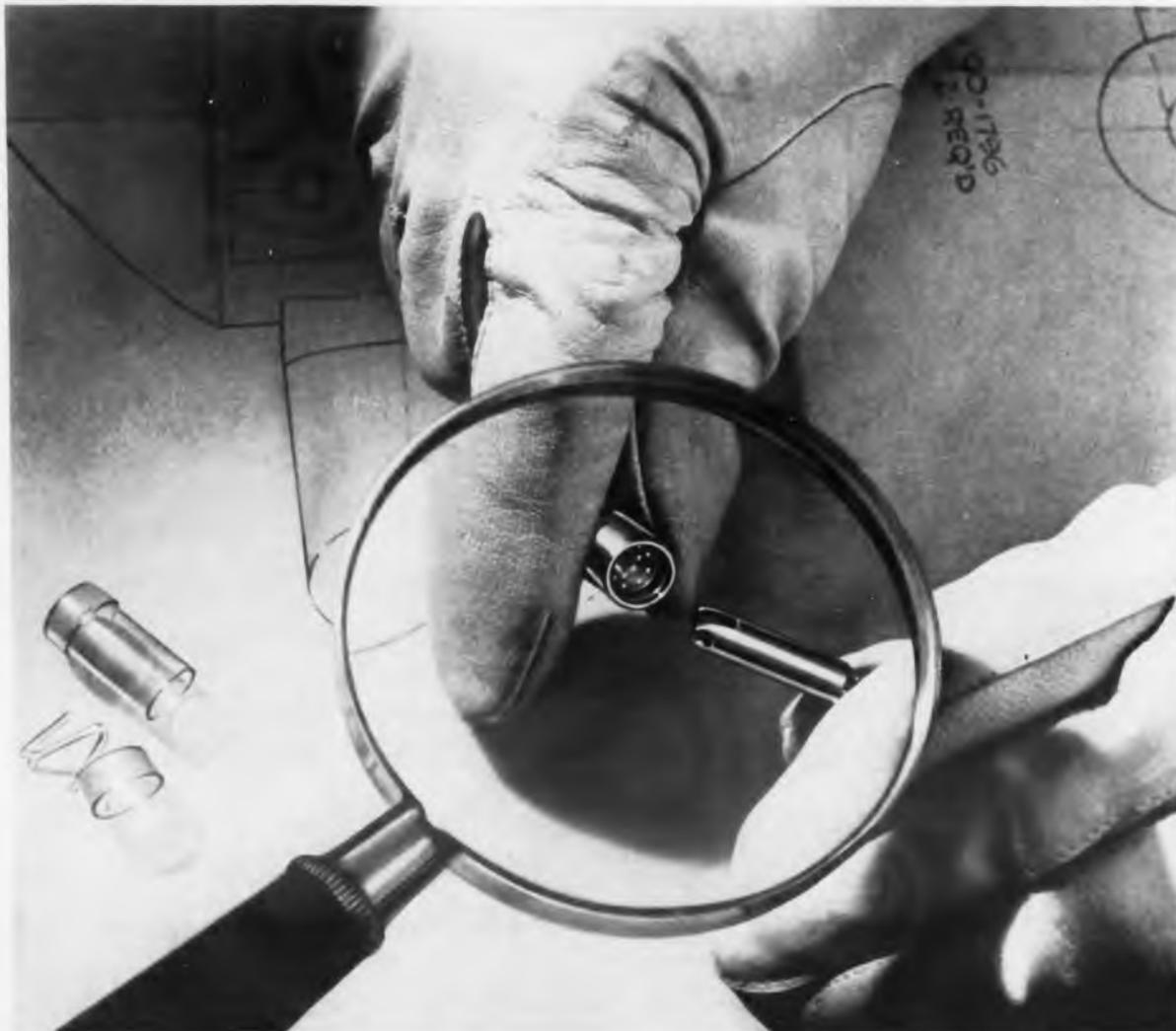
Meets MIL-S-19500B requirements — PSI Micro-Transistors are also given the following Special 100% Processing:

ACTUAL SIZE	High Temperature Aging	Thermal Shock	Moisture Resistance
	200 hrs. @ 200°C	200° to -65°C Three cycles	MIL-STD-202B Method 106A, 5 days

If you are designing a new computer within rigid size and performance specifications it will pay you to talk it over with PSI...field offices are located in all major electronic centers. Phone, wire or write for full details.

Pacific Semiconductors, Inc.

A SUBSIDIARY OF THOMPSON RAMO WOOLDRIDGE INC.
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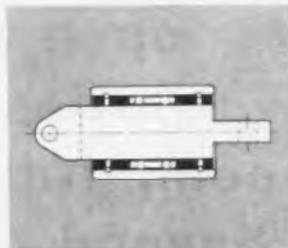
HOW TO GIVE ON-THE-NOSE GUIDANCE TO MODERN "FISH" UNIQUE N/D LINEAR MOTION BEARING FREES GYRO CAGING ACTION

The bearing illustrated is an N/D linear motion precision instrument ball bearing. It was specially designed and built to help solve a critical problem in the guidance system of a high speed anti-submarine torpedo.

PROBLEM: Loss of accuracy in torpedo's guidance system due to hang-up of caging arm in gyro assembly.

SOLUTION: N/D Sales Engineer, in cooperation with manufacturer, found that wear of bushing on caging arm caused hang-up, delaying guidance activation. N/D Engineers set to work to design and build an instrument bearing that operates virtually friction-free. The result: Preservation of the guidance system's pin-point accuracy and reliability.

Should you require ball bearing design information, invite the local N/D Sales Engineer to participate in your early design discussions. He represents one of the industry's largest engineering staffs devoted exclusively to the design and development of miniature and instrument ball bearings. Or, write for new Miniature and Instrument Ball Bearing Catalog, Department L.S., New Departure, Division of General Motors Corporation, Bristol, Connecticut.



This special N/D linear motion instrument ball bearing increased guidance reliability of ASTOR torpedo weapon system developed by Westinghouse.



NEW DEPARTURE

MINIATURE AND INSTRUMENT BALL BEARINGS

CIRCLE 30 ON READER-SERVICE CARD

Data-Handling System Eliminates Need For Complex Installations

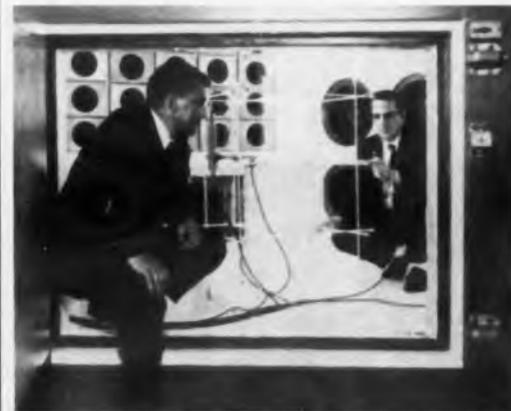
A mobile data-handling system, which will reportedly eliminate the need for complex installations, has been developed for use throughout automotive, processing, defense, and manufacturing industries. The new system, known as RADAC I, is expected to considerably reduce industrial data handling costs.

The system is composed of a Radiplex high-speed programmable multiplexer, capable of sampling both high- and low-level analog information; a Radicon coder for conversion of this analog information into digital form; Radilog digital standard logic circuits which provide necessary programming and timing functions for recording the data in digital computer format; an Ampex FR-400 digital tape transport; and power supplies.

In addition to the basic components, the company reports that RADAC I's capability can be extended with such optional features as digital or analog quick-look recorders, automatic run controls, remote controls, and other devices.

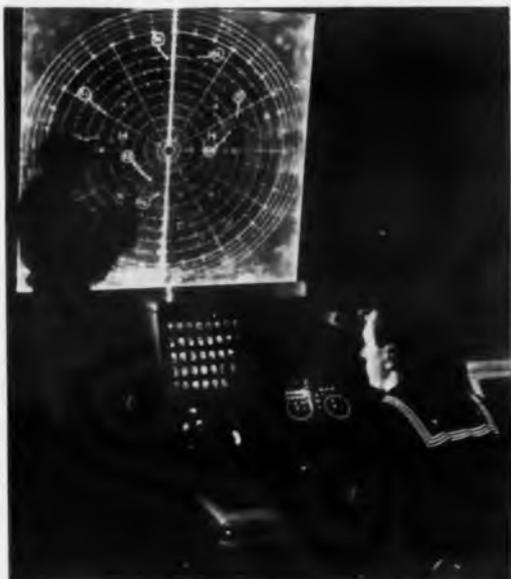
The system reportedly handles up to 45 analog inputs with a resolution of $\pm 10 \mu\text{v}$, to ± 0.1 per cent accuracy. After digital conversion at a maximum word rate of 3.8 kc, the data are recorded in computer format on magnetic tape.

146-Db Acoustic Noise Facility



Noise facility reportedly capable of producing a higher sound-pressure level than ever before in a large-capacity reverberant chamber is examined by Avco engineers. Noise generators feed 146 db into a 200-cu-ft pentagonal reverberant chamber where individual octave-band sound-pressure levels can be maintained within ± 3 db with a specimen as large as 200-cu ft. A total of 36 noise generators and 21 power amplifiers are used in this system. Thirty-four of the noise generators are horn-type, covering a 150 to 9,600 cps frequency range. The remaining 10 are direct-radiating cone noise generators in the 37 to 150 cps range.

Hughes Data-System Display Console



Old grease-pencil method of plotting aircraft, seen in upper left, contrasts sharply with the new Navy display console in foreground, a part of the Naval Tactical Data System. (ED, Sept. 14, 1960, p 20). Developed by Hughes Aircraft Co., Fullerton, Calif., the console displays graphically all aspects of aerial, sea-surface, and submarine warfare for combatant ships within a Naval task force. Soon to be installed in Navy ships, NTDS will cut down human error and will enable command personnel to comprehend the immediate tactical situation. Hughes developed the experimental data display system for the Navy Electronics Laboratory at San Diego, where the units were tested.

Analog-to-Digital Converter Incorporates New Technique

An analog-to-digital converter, incorporating a new technique identified as Capcoder, is in operation at White Sands Missile Range, N.M. Developed by the Towson Laboratories, Inc. of Towson, Md., the model employs a simple technique involving the exchange of charge between capacitors to encode electrical inputs.

T. T. Eaton, president, said similar work is being conducted on another transistorized model for airborne application under Navy sponsorship. The Navy model will offer 10-bit resolution and encoding rates of over 18,000 words per second, including sample and hold features Mr. Eaton said. The input impedance is 1 meg and full scale ranges of 0 to +5 v or ± 2.5 v are available. This unit, employing 45 transistors, is completely contained in a 120-cu-in. volume and requires a power input of only 6 w. According to the company, small sizes can be obtained as a result of circuit simplification.



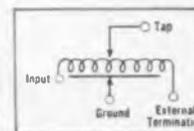
Actual Size: 7/4" x 1" x 15/8"

ESC's Continuously Variable Delay Line, Series 500, offers maximum flexibility as a laboratory test unit or equipment component. Resolution is better than 1/1000 of maximum delay. Shaft rotation of 10 turns, from zero to maximum delay, is continuously variable.

Models Available Immediately from Stock

No.	Min. Delay @ Max. Pos.	Impedance (Ohms)	Rise Time* (Max.)	Attenuation
501	.9 usec.	1,000	.2 usec.	.5 db
502	2.0 usec.	470	.40 usec.	1.2 db
503	4.0 usec.	220	.80 usec.	2.5 db
504	9.0 usec.	100	1.8 usec.	5.0 db
505	15.0 usec.	56	3.0 usec.	9.0 db

*Rise time is proportional to delay



Custom-designed variations are available to meet your most exacting specifications. Locking device or pressure sealed shaft available at no extra cost.

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exceptional employment opportunities for engineers experienced in computer components...excellent profit-sharing plan.

CIRCLE 31 ON READER-SERVICE CARD

UNSHAKEABLE SELF-LOCKING PERFORMANCE IS BUILT INTO AN ELASTIC STOP NUT



*Start with a standard hex nut
and add a metal crown . . .*



*Add "the ring of reliability"—
the easily identified ESNA red nylon locking insert . . .*



*Then roll the crown over smoothly and stake—
the insert is made an integral part of the Elastic Stop nut*

BUILD FASTENER RELIABILITY INTO YOUR PRODUCT!

Take an Elastic Stop nut and mount it on one of your products where vibration is really severe. Shake the daylight out of it in the roughest torture test you can devise—or better still—send it into the field where it's subject to regular use and abuse.

Here's what you'll find: That Elastic Stop nut will stay put! The bolt threads are impressed into the nylon locking collar with such a perfect fit that internal liquid seepage is sealed off. Internal nut and bolt threads are protected against corrosion. The nylon insert locking torque is so smooth that it never galls or distorts bolt threads; and nylon is so wear-resistant that under normal usage you can wrench

the nut on and off the bolt 50 times or more and the nut will still remain tight under vibration! Protect the performance and the reputation of your product by guaranteeing fastener reliability. Try it yourself and see. Send for free test samples. Just tell us the size. Dept. S53-257, Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.



**ELASTIC STOP NUT
CORPORATION OF AMERICA**

CIRCLE 32 ON READER-SERVICE CARD

NEWS

IBM Associative Memory

Experimental Memory Permits Retrieval According to Content

DESIGN of an experimental memory employing core storage elements is reported by the International Business Machines Research Laboratories, Yorktown Heights, N.Y. This announcement, following in the wake of an experimental cryogenic associative memory by the company, is further indication of the present research emphasis on such memory concepts for next-generation computers.

Rather than specifying and extracting information by storage address, the new memory retrieves data according to actual content. Memory search is not sequential; instead, all storage elements are interrogated simultaneously.

These operating features are achieved by interrogating through a mask, itself consisting of ferrite cores. A mask core is provided for each core in a storage plane, but each mask core simultaneously interrogates its corresponding cores in all storage planes.

Mask cores are inscribed so that output from the mask consists of drive pulses whose polarity indicates whether a "1" or a "0" is being searched for. Interrogation is parallel by word, and serial by bit.

Each storage core is designed to yield a small signal when it contains the information being sought, and to generate a large signal when there is a mismatch between stored and interrogating information. These large signals switch suitably designed core detectors, one detector for each storage plane.

Detectors Respond to Mismatch Between Mask and Bit Planes

When a particular bit plane is energized, all the cores respond in the manner described. The matching cores yield a small signal which does not affect the detector cores; the mismatching cores generate a large signal to switch the corresponding detector cores.

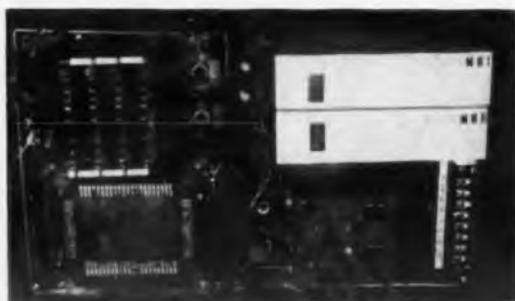
When interrogation is completed, cores corresponding to the desired words have not been switched. These words are then selected and read out.

Another feature claimed for the experimental memory is nondestructive readout. Storage stability has been demonstrated for more than one million interrogating cycles.

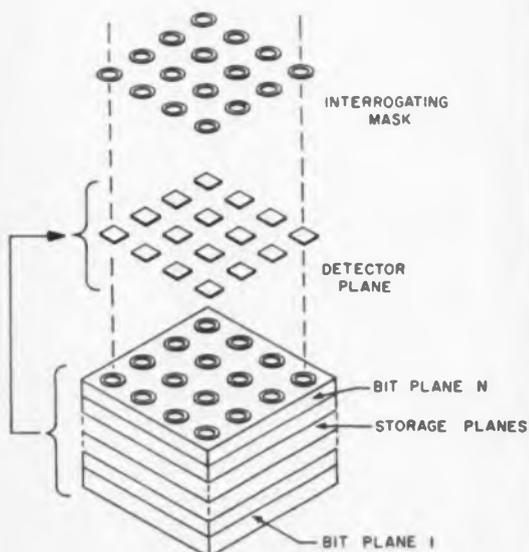
Word lengths of up to 36 bits are said to be feasible with a passive detector. Transistorized

Uses Masking Cores

detectors could handle word lengths of 1,000 bits, according to IBM scientists. Memory capacities of several hundred words could operate with a single interrogation driver. Larger sizes would require parallel operation. ■ ■



Associative memory is shown here in its first, breadboard form. Core structure, of 4-bit capacity is at upper right-hand corner. Remainder of breadboard consists of peripheral equipment, drivers, etc.



Interrogating mask searches all bit planes simultaneously in associative memory. Pulses from interrogating cores correspond to the information desired. If cores in bit plane match the interrogating signal, output is small, and detectors are not switched; mismatch yields a large signal. After interrogation is completed, unswitched detectors correspond to the desired words in the memory.

Versatile Secondary-Emission Amplifier



NEW

7548

SOLVES

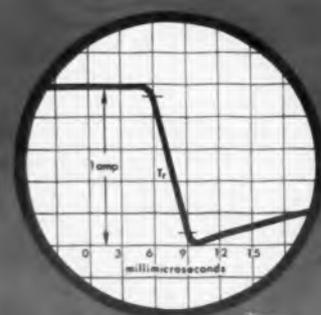
CIRCUIT PROBLEMS

NO OTHER TUBE

CAN

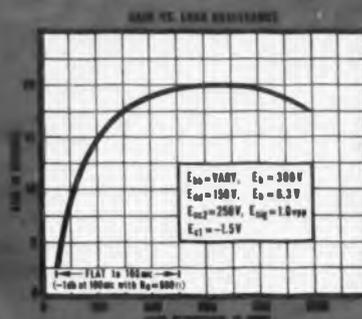
PULSE GENERATOR/AMPLIFIER

- Rise time < 2 ns ultra-fast rise time
- 1 ampere pulse output current into 50-Ohm load
- 200% repetition rate at 100 ns pulse width



... AND WIDE-BAND CLASS A AMPLIFIER

- 250 gain-bandwidth product
- 25,000 μ mhos transconductance at $E_b = 250$ v and $I_b = 18$ ma
- 3.4 pF output capacitance



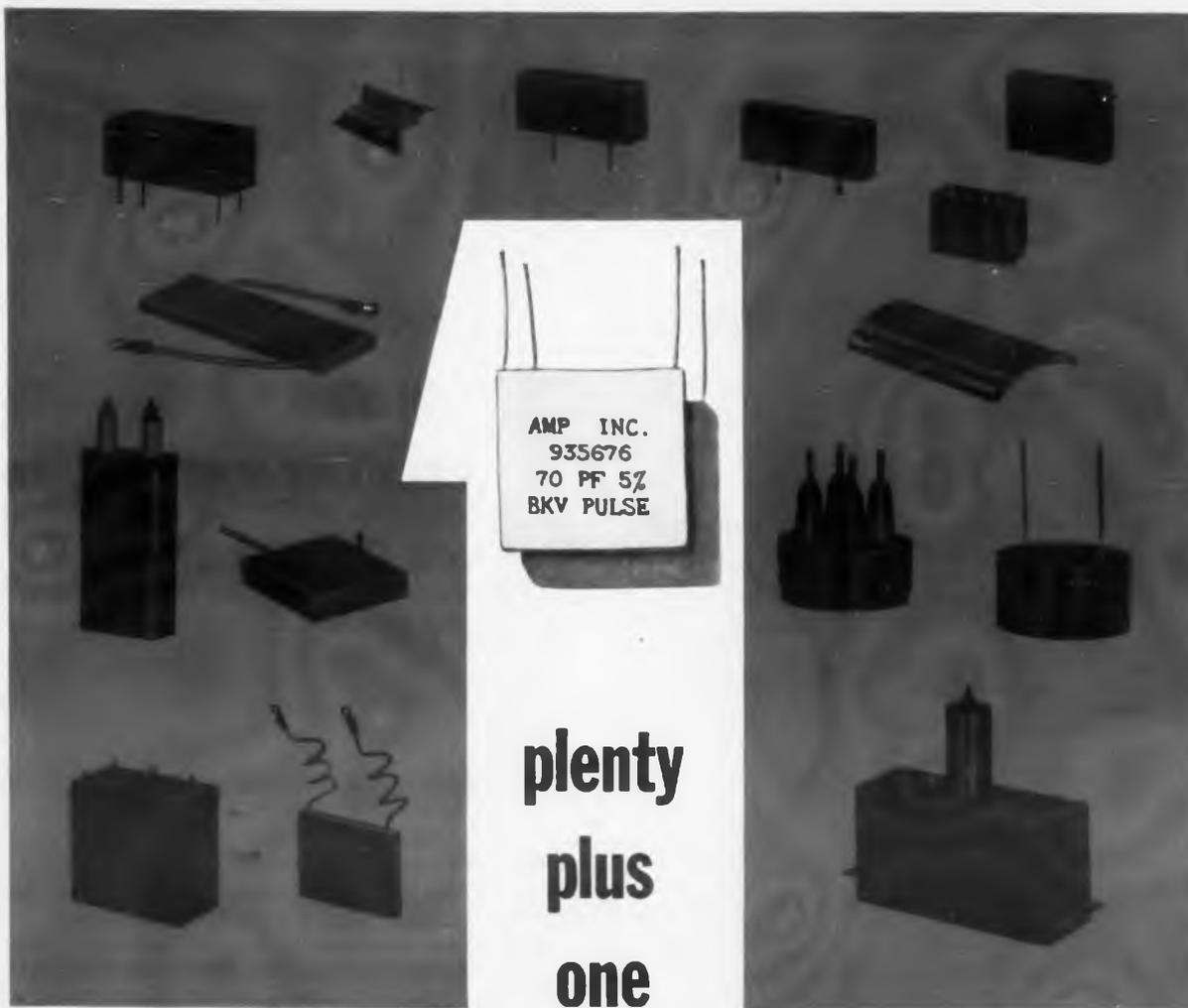
New mass-produced version offers many improvements

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- Relaxed restrictions on dynode voltage
- Lowered threshold voltage requirements
- Output normalized, in or out of phase
- Relaxed regulation requirements for heater voltage
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CIRCLE 34 ON READER-SERVICE CARD

NEWS

Video Tape Recording Standards Are Available from SMPTE

Four proposed American Standards on video-tape recording have been prepared and are available from the Society of Motion Picture and Television Engineers, 55 W. 42nd St., New York 36, N.Y.

Proposed standard VTR 16.2, Dimensions for 2-In. Video Magnetic Tape, specifies the dimensions for the width, thickness, and curvature of 2-in. video magnetic tape.

Characteristics of the Audio Records for 2-in. Video Magnetic Tape Recordings, VTR 16.5 covers the audio records for 2-in. video magnetic tape recordings.

Another standard, VTR 16.6, Dimensions for Video, Audio, and Control Records on 2-In. Video Magnetic Tape, specifies the locations and dimensions of the video, audio, and control records on 2-in. video magnetic tape.

The fourth standard, VTR 16.8, Speed for 2-In. Video Magnetic Tape, specifies the rate of travel of 2-in wide video magnetic tape in recorders.

Powerful Eye on the Sky



Man is dwarfed by the 60-ft radar antenna now under construction at Cornell Aeronautical Laboratory, Inc. of Buffalo, N.Y. When the experimental 50-million-w radar installation begins operating this fall, CAL scientists reportedly will study the ability of "high-peak power" radar to penetrate the earth's ionosphere in order to detect and track ballistic missiles and satellites with greater accuracy and at considerably longer range than is now possible. CAL is conducting this research program for the Defense Department's Advance Research Projects Agency under the supervision of the Army Rocket and Guided Missile Agency. The transmitter for CAL's new installation was designed and built for the Laboratory by FXR, Inc. of Woodside, N.Y.

TV Used for Precision Alignment



Industrial TV for precision alignment of large automated machine tools has been installed at Douglas Aircraft by TELautograph Corp.'s Telautovision Closed-Circuit TV Div. of Los Angeles, Calif. The operator of the company's Drivematic Riveter checks the ram position on each pilot hole to be drilled which is projected on his monitors. He holds a "dead man's" switch which can stop the tape-programed riveter if the monitor indicates it is out of alignment. The riveter positions to a non-accumulative tolerance of 0.30-in.

New Data-Processing Centers In Offing for General Electric

Anticipating that industry shipments of commercial computer equipment will increase 33 per cent within two years, General Electric Co.'s Computer Dept. is planning to open 11 new data-processing centers and 10 additional sales offices in major cities across the nation.

The new data-processing centers will support GE computer installations and will handle data-processing, training, statistical, computing or tabulating problems, data processing service will be sold to banks, utilities, commerce and industry for handling payroll, inventory, accounting, production scheduling, sales analysis, engineering and scientific problems.

The centers scheduled to open next year will be in Chicago, New York City, Philadelphia, Boston, and Cleveland. Those scheduled for opening in 1962 will be in Minneapolis, Seattle, Atlanta, Washington, D.C., Dallas, and the San Francisco Bay Area.



"Right! You're sure of reliability with **DALE** Type WW or HW Resistors"

In planning any circuit, even the most advanced, you can check off one question mark the minute you specify Dale precision resistors.

Resistor reliability in that circuit is assured, under any and all conditions, because of Dale's advanced design and methods of manufacture . . . methods which have reached new levels of achievement as part of Dale's super-high reliability development program.

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

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

Write for Bulletin R-26 with handy cross reference file card



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CIRCLE 35 ON READER-SERVICE CARD

DALE TYPE WW & HW RESISTORS

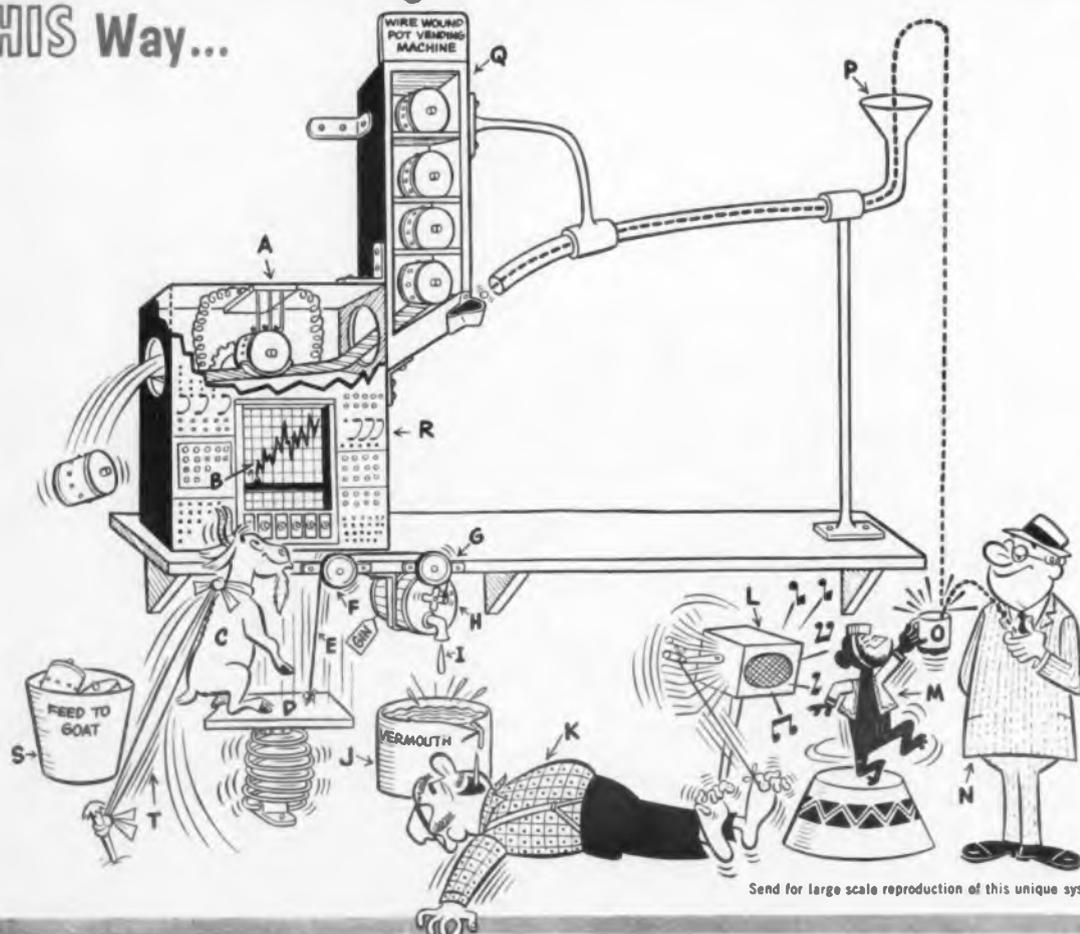
WIRE WOUND • BOBBIN • ENCAPSULATED

Dale bobbin type resistors are impervious to salt spray, humidity, moisture and corrosive gases and vapors. The encapsulating material has very high dielectric strength. The resistors have excellent non-inductive characteristics. They are made to surpass functional requirements of MIL-R-93B. (Some sizes and ranges not included in Mil Specs.) WW prefix meets requirements of characteristic A; HW prefix meets requirements of characteristic C.

- RESISTANCE RANGE: 0.1 ohm to 6 meg-ohms, depending on size.
- TOLERANCE: $\pm 0.2\%$; $\pm 0.5\%$; $\pm 0.1\%$; $\pm 0.25\%$; $\pm 0.5\%$; $\pm 1\%$; $\pm 3\%$.
- RATED AT: 0.1 watt to 2.5 watts, depending on size, type and tolerance.
- TEMPERATURE COEFFICIENT: 0.00002 per degree C.
- TERMINALS: WWA and HWA — axial leads; WWP and HWP — parallel leads; WWR and HWR — radial leads; WWL and HWL — lugs.
- SIZES: Complete range from sub-miniature 5/64"x5/16" to 1/2"x2".



The Few Engineers Who Don't Know About C.I.C. Film Pots Might Solve "Short-Life" Pot Problems THIS Way...



Send for large scale reproduction of this unique system.

Wire-wound pot (A) in analog computer wears down. Vibration of X-Y Recorder Pen, trying to follow resultant noise jiggles, creates erratic pattern (B). Mountain goat (C) thinks pattern looks like old mountain homestead, leaps on platform (D) in attempt to reach home. Platform mounted on coil spring bounces, causes string (E) to pull back on pulleys (F and G). String turns spring-action faucet (H) which releases gin (I). Gin pours into vermouth vat (J) automatically mixing 8 to 1 Martini (how dry can you get?) raising level which forces excess to flow into mouth of happily reclining organ-grinder (K). Martini mixture's potency causes grinder's toes to curl, thereby setting organ (L) into operation. Conditioned monkey (M) hears music, proceeds to

dance, impelling bystander (N) to toss coin into monkey's tin cup (O). Rubber bottom of tin cup bounces coin into funnel-tube (P). Coin is carried through tube to automated Wire-Wound Pot Vending Machine (Q) and releases new wire-wound pot, which rolls into position on miniature railroad tracks (see cutaway of computer—R) and bounces worn-out wire-wound pot into container (S). X-Y Recorder resumes normal pattern, goat (tethered with old inner tube—T), jumps off platform, starts feeding on worn-out pots, while waiting for new pot to wear down—which can happen before you can mumble "potentiometer" backwards.

BUT THE BEST WAY YET...

Use C.I.C. Precision Conductive Film Potentiometers
For Proven* Multi-Million Cycle Life!

*Ask us for list of missiles and aircraft currently using C.I.C. Film Potentiometers.

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... and Here Are a Few Additional Features:



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- INHERENT RELIABILITY
- PRECISION LINEARITY
- LOW OPERATIONAL NOISE
- VIDEO FREQUENCY OPERATION

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You can have any of these precision film pots on their way to you within hours. No need to wait for "custom" pots.

LINEAR SINGLE TURN FILM POTENTIOMETERS

Diameter	Resistance	Linearity
1/2"	1K	± .5%
	10K	± .5%
	50K	± .5%
7/8"	1K	± .5%
	10K	± .5%
	50K	± .5%
1-3/32"	1K	± .25%
	10K	± .25%
	50K	± .25%
2"	1K	± .5%
	10K	± .5%
	50K	± .5%
3"	1K	± .25%
	10K	± .25%
	50K	± .25%
2"	5K	± .25%
	20K	± .25%
	50K	± .25%
3"	5K	± .1%
	20K	± .1%
	50K	± .1%
2"	5K	± .05%
	20K	± .05%
	50K	± .05%

SINE-COSINE SINGLE TURN FILM POTENTIOMETERS

Diameter	Resistance	Conformity
1-3/32"	10K	± .75%
	20K	± .75%
	50K	± .75%
2"	10K	± .25%
	20K	± .25%
	50K	± .25%
3"	10K	± .15%
	20K	± .15%
	50K	± .15%

LINEAR MOTION FILM POTENTIOMETERS

Size	Resistance	Stroke	Linearity
1" Sq.	10K	1" Stroke	± .5%
	20K	1" Stroke	± .5%
	50K	1" Stroke	± .5%
2"	10K	2" Stroke	± .25%
	20K	2" Stroke	± .25%
	50K	2" Stroke	± .25%
3"	10K	3" Stroke	± .1%
	20K	3" Stroke	± .1%
	50K	3" Stroke	± .1%

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CIRCLE 37 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

EDITORIAL

The Rootless Engineer

A not insubstantial number of engineers have employment records little different from those of migrant farm workers.

Both criss-cross the country getting jobs where their talents are in demand. The farmhand usually moves north and south; the electronics engineer, east and west. The farm worker's cycle is easy to predict: it follows the season. The electronics engineer's travels appear considerably more whimsical, since the Department of Defense doesn't award contracts on a strictly seasonable basis. The pay difference for the two groups is significant. The migrant hand averages about \$1,200 a year; the electronics handyman, eight to ten times that amount.

On the surface, it looks as if both might acquire a diversity of experience in a short time. However, the migrant worker knows better; he is aware that he will never break a dollar an hour unless he is on piece work. The itinerant electronics engineer hasn't yet faced reality.

He can still pick up a handsome increase per move. But there is a ceiling on "engineering-only" experience.

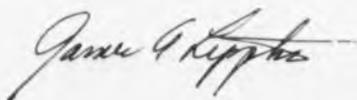
Any engineer's salary is figured not only on his technical ability but also on his administrative ability. Administrative ability is seldom identified as such—it goes under the label of "gets work done on time," "cooperative attitude," "understands company procedures," "inspires confidence on the part of co-workers," "loyal to company," and so on.

Proved administrative ability—the ability to get the right job done—does figure heavily in an engineer's worth. Responsibility is always rewarded.

But industry practice has fostered the development of rootless engineers, unidentified with any long-range goal. Companies doing heavy defense business hire and fire engineers on a schedule based on contract progress.

The rootless, itinerant engineer never really identifies himself with his employer. He never links his goals with the company's goals, he never truly engages in a cooperative endeavor. Instead, he is project-oriented. Six or nine months on one task and he is ready to move. He sees no challenge in the present job.

The rootless engineer, whose orientation is solely the technical job at hand, will have to develop outstanding technical competence to make up for his deficiency of experience in working with others for a common goal. We doubt that this competence will be achieved by a preoccupation with reading and answering help-wanted ads.





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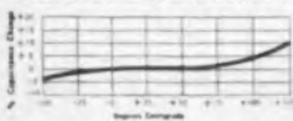
SPECIFICATIONS

Insulation Resistance—Greater than 75,000 megohms when measured at 100 volts D.C. at 25° C. for a maximum of 2 minutes.
Capacity Tolerance—Standard tolerance $\pm 20\% \pm 10\% \pm 5\%$
Winding Construction—Extended foil (non-inductive) MYLAR Dielectric
Lead Variations—Formed or straight leads.
Dissipation Factor—Less than 1% at 1,000 cycles per second at 25° C.
Dielectric Strength—100 volts D.C. for 1 to 5 seconds through a minimum current limiting resistance of 100 ohms per volt.
Temperature Range—May be operated at full rated voltage to 85° C. Derate to 50% when operating at 125° C.

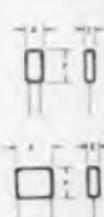
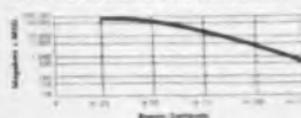
DIMENSIONS 50 VDC Rating

CAP. (MFD)	A	E	F
.01	.215	.187	.582
.022	.258	.187	.582
.033	.331	.194	.404
.047	.331	.270	.452
.068	.331	.270	.500
.1	.400	.305	.525
.15	.471	.260	.480
.22	.510	.306	.601
.33	.612	.312	.700

Capacitance Change vs. Temperature



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CIRCLE 38 ON READER-SERVICE CARD

Graphical Procedure for Transistor Switching Circuit Design

Samuel J. Osler

Philco Corp.
Computer Div.
Philadelphia, Pa.

SINCE three unknowns are contained in the two equations involved in the design of the switching circuit shown in Fig. 1, algebraic solution involves tedious trial and error calculations. Although an adequate solution can be achieved after several attempts, it will not be possible to determine whether the optimum design has been reached. A graphical procedure is presented which, in addition to saving time, defines the selection range of each resistor.

The switching circuit under consideration is shown in Fig. 1. The analysis can be applied to either npn (as shown) or pnp transistors because absolute voltage terms are used. The switching

In addition to eliminating tedious trial and error calculations, the graphical procedure presented defines the selection range of circuit components to permit optimum design solution.

circuit can be in either of two modes:

Mode 1, Q_1 on— Q_2 off and Mode 2, Q_1 off— Q_2 on. Satisfactory operation in Mode 1 requires the base current supplied (I_{BS}) to Q_1 to be equal to or greater than the minimum value of base current required (I_{BR}) to turn Q_1 on while Q_2 is off. Satisfactory operation in Mode 2 requires the absolute value of base to emitter reverse bias voltage (V_{BEFS}) of Q_1 to be equal to or greater than the absolute minimum value of base to emitter voltage required (V_{BEFR}) to hold Q_1 off while Q_2 is on. The conditions for satisfactory operation in Modes 1 and 2 are summarized:

Condition 1 (Mode 1), $I_{BS} \geq I_{BR}$

Condition 2 (Mode 2), $|V_{BEFS}| \geq |V_{BEFR}|$

The design problem is to determine R_C , R_1 and R_2 such that conditions 1 and 2 are satisfied with worst case tolerances applied to the supply volt-

ages and resistors.

To satisfy Conditions 1 and 2, consider operation in Modes 1 and 2.

Mode 1, Q_1 on — Q_2 off

The equivalent circuit is shown in Fig. 2, where

$$I_{BS} = I_1 - I_2$$

Satisfactory operation in the on-off mode requires that Condition 1 be satisfied.

$$I_{BS} = I_1 - I_2 \geq I_{BR}$$

The minimum and thus worst case value of I_{BS} occurs when I_1 is a minimum and I_2 a maximum

$$I_{BS} = I_1 - I_2 \geq I_{BR} \quad (1)$$

Tolerancing the supply voltages and resistors accordingly and substituting in 1

$$I_{BS} = \frac{V_{CC} - I_{CO} R_C - |V_{BEN}|}{R_C + R_1}$$

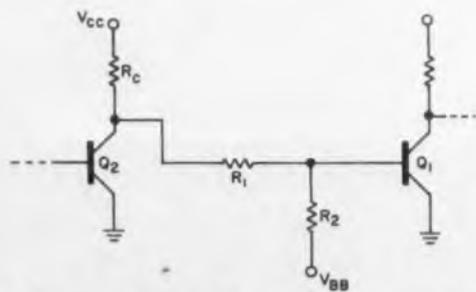


Fig. 1. Reverse bias for Q_1 is provided by R_2 and V_{BB} .

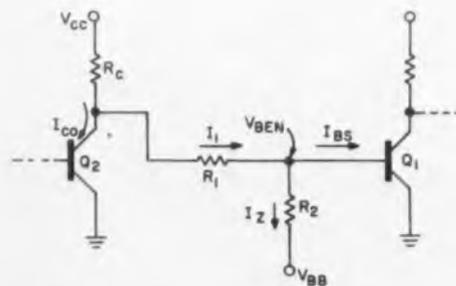


Fig. 2. For Mode 1 operation, Q_1 on and Q_2 off, $I_{BS} = I_1 - I_2 = I_{BR}$.

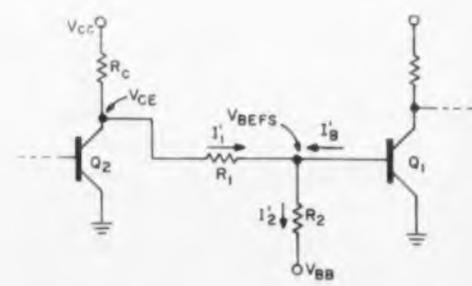


Fig. 3. For Mode 2 operation, Q_1 off and Q_2 on, $V_{BEFS} = |V_{BEFR}|$.

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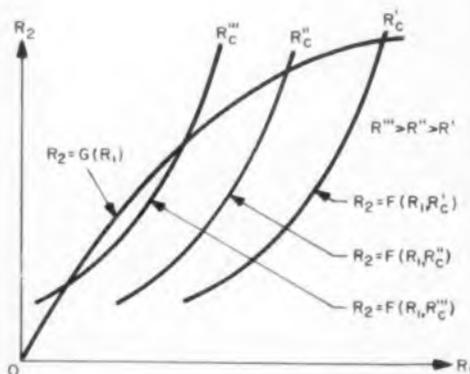


Fig. 4. Composite graph of $R_2 = F(k_1, R_c)$ and $R_2 = G(R_1)$ with R_c as the parameter.

$$\frac{|V_{BB}| + |V_{BEV}|}{R_2} \geq I_{BR} \quad (2)$$

where

- (1) $|V_{BEV}|$ is the maximum absolute value of base to emitter voltage of Q_1 while on.
- (2) I_{CO} is the maximum collector leakage current of Q_2 while off.

Mode 2, Q_1 off— Q_2 on

The equivalent circuit is shown in Fig. 3 where

$$I_2' = I_1' + I_B' \quad (3)$$

Substituting in Eq. 3 and solving for $|V_{BEFS}|$

$$|V_{BEFS}| = \frac{V_{BB} R_1 - V_{CE} R_2 - I_B' R_1 R_2}{R_1 + R_2}$$

Satisfactory operation in Mode 2 requires that Condition 2 be satisfied. Thus, tolerancing the supply voltages and resistors

$$|V_{BEFS}| = \frac{V_{BB} R_1 - V_{CE} R_2 - I_B' R_1 R_2}{R_1 + R_2} \geq |V_{BEFR}| \quad (4)$$

where

- (1) $|V_{CE}|$ is the maximum absolute value of collector to emitter voltage of Q_2 while on.
- (2) I_B' is the maximum base leakage current of Q_1 while off.

The problem reduces to determining values of R_c , R_1 and R_2 such that Eqs. 2 and 4 are satisfied. Satisfying Eqs. 2 and 4 in turn satisfies Conditions 1 and 2 which is the design problem.

As previously mentioned R_c , R_1 and R_2 may be found algebraically by a trial-and-error method. This can be done by assuming a value of R_c ,

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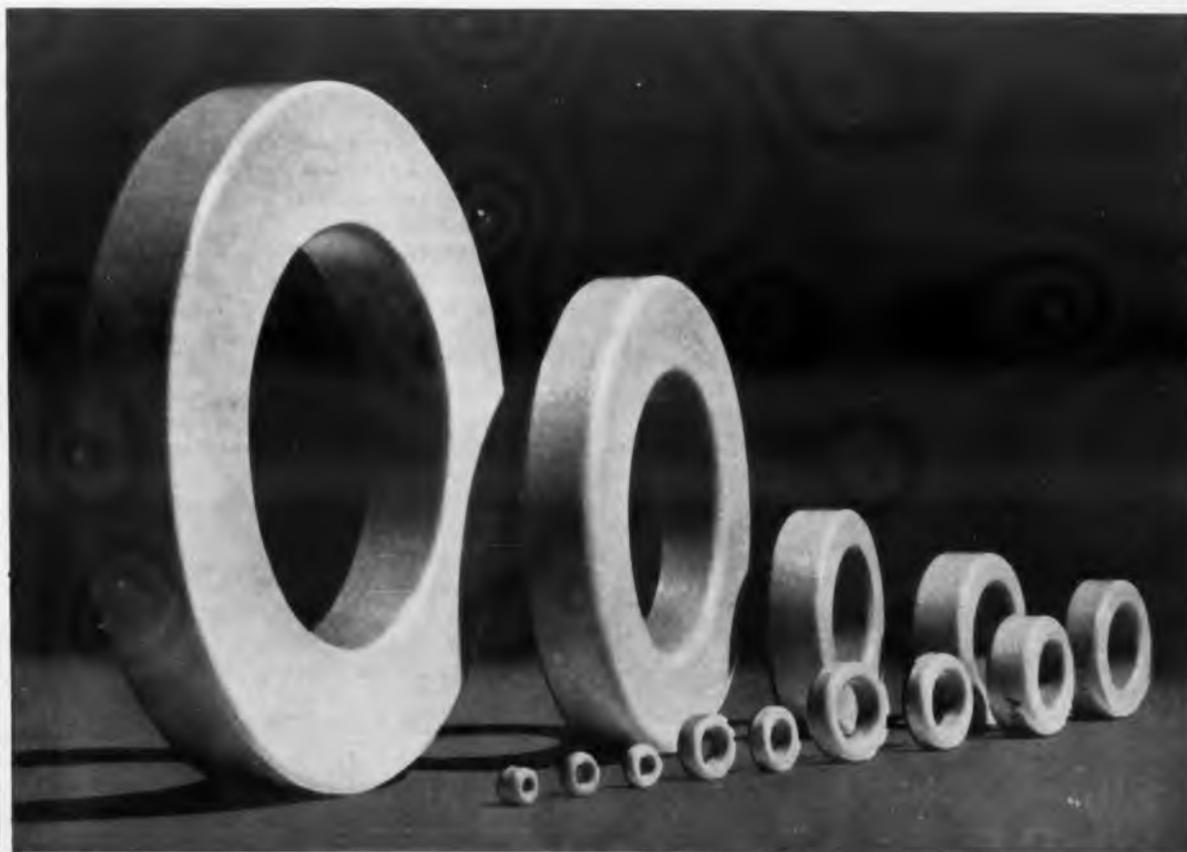
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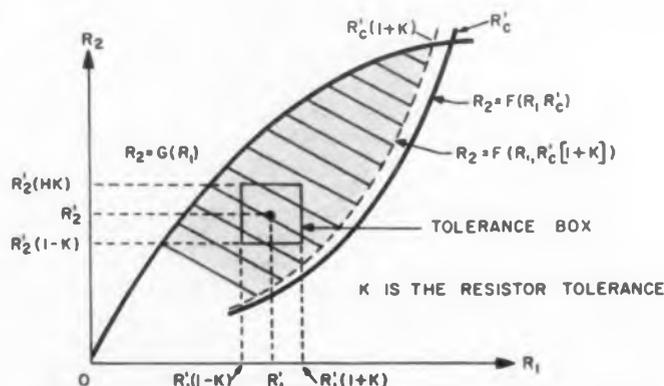


Fig. 5. Graphical solution of R_1 , R_2 and R_c . The shaded region represents the area of satisfactory solution. Since the tolerance box remains in this region, R_1^1 , R_2^1 and R_c^1 are proper solutions.

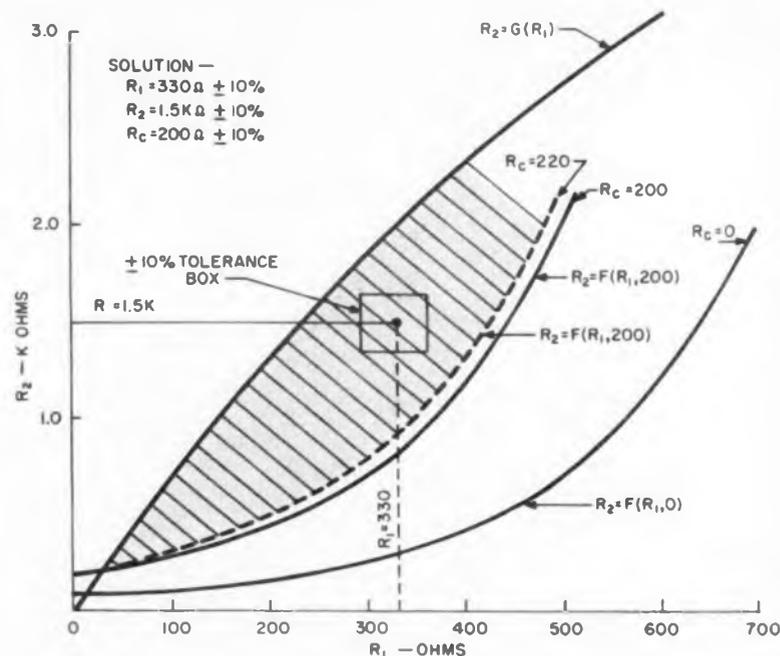


Fig. 6. Graphical solution of the design example used to illustrate the technique.

substituting it in Eq. 2 and then solving Eqs. 2 and 4 simultaneously for R_1 and R_2 . If this solution is not satisfactory, the process is repeated until an adequate solution is determined. Very often several selections of R_c must be made before an adequate solution can be determined and even then an optimum solution is not apparent. To overcome these difficulties a graphical solution is presented.

Procedure for Preparation Of a Graphical Solution

In the following analysis, the resistor tolerances are removed and taken into account graphically. The values of R_c , R_1 and R_2 which make $I_{BS} = I_{BR}$ and $|V_{BEFS}| = |V_{BEFR}|$ are critical values. With the resistor tolerances removed, $I_{BS} = I_{BR}$, and $|V_{BEFS}| = |V_{BEFR}|$; Eqs. 2 and 4 are solved for R_2

$$R_2 = \frac{[|V_{BB}| + |V_{BEN}|] [R_c + R_1]}{|V_{CC}| - I_{CO} R_c - |V_{BEN}| - I_{BR} [R_c + R_1]} \quad (5)$$

$$R_2 = \frac{[|V_{BB}| - |V_{BEFR}|] R_1}{|V_{CC}| + |V_{BEFR}| + I_{BR} R_1} \quad (6)$$

Generally $I_{CO} R_c \ll |V_{CC}| - |V_{BEN}| - I_{BR} [R_c + R_1]$ and can be neglected. Thus, Eq. 5 becomes

$$R_2 = \frac{[|V_{BB}| + |V_{BEN}|] [R_c + R_1]}{|V_{CC}| - |V_{BEN}| - I_{BR} [R_c + R_1]} \quad (7)$$

Eq. 6 gives $R_2 = G(R_1)$ and 7 gives $R_2 = F(R_1, R_c)$. When R_c is used as a parameter and the functions are graphed, their nature is similar to Fig. 4.

With the composite graph, values of R_1 , R_2 and R_c can now be determined that satisfy Conditions 1 and 2. Assume the resistors have a tolerance of $\pm K$. Conditions 1 and 2 are satisfied if the toleranced values of R_1 and R_2 remain within the region bounded by $R_2 = F(R_1, R_c [1+K])$ and $R_2 = G(R_1)$. This is illustrated in Fig. 5. R_1^1 and R_2^1 (when toleranced) remain within the tolerance box shown and since the tolerance box remains in the region bounded by $R_2 = F(R_1, R_c [1+K])$ and $R_2 = G(R_1)$ (shaded region), then R_c^1 , R_1^1 and R_2^1 satisfy Conditions 1 and 2.

Some conclusions are apparent from Fig. 5 with respect to satisfying Conditions 1 and 2.

(1) The larger R_c , the smaller becomes the region for selection of R_1 and R_2 . A critical value of R_c exists (R_{CR}), such that for $R_c > R_{CR}$ no values of R_1 and R_2 will satisfy both Eqs. 2 and 4. Obviously, the maximum and minimum positive values of R_c which satisfy Conditions 1 and 2 are $R_c = R_{CR}$ and $R_c = 0$.

(2) Crossing the $R_2 = F(R_1, R_c [1+K])$ boundary with the tolerance box gives values of $I_{BS} < I_{BR}$ which do not satisfy Condition 1.

(3) Crossing the $R_2 = G(R_1)$ boundary with the tolerance box gives values of $|V_{BEFS}| <$

$|V_{BEFR}|$ which do not satisfy Condition 2.

It was assumed that $I_{CO} R_c \ll |V_{CC}| - |V_{BEN}| - I_{BR} [R_c + R_1]$ could be neglected. The term $I_{CO} R_c$ has the effect of shifting the curve for $R_2 = F(R_1, R_c)$ slightly up and to the left. This shift would tend to violate Condition 1 ($I_{BS} \geq I_{BR}$). To offset this shift and not violate Condition 1, R_1 and R_2 should be selected so as to shift the tolerance box slightly up and to the left which is essentially increasing R_2 and increasing R_1 . Very often $I_{CO} R_c \ll |V_{CC}| - |V_{BEN}| - I_{BR} [R_c + R_1]$ and it is not necessary to adjust R_1 and R_2 as just described. If any doubt exists as to whether Condition 1 is satisfied, the solution should be substituted in Eq. 2 which contains the effects of $I_{CO} R_c$ and verify that $I_{BS} \geq I_{BR}$.

Examination of Eq. 7 indicates that R_2 will remain constant if R_1 is decreased by the same amount that R_c is increased and vice-versa. Therefore, it is only necessary to calculate values of R_1 and R_2 for one value of R_c ($R_c = 0$ is suggested) from which the curve for any value of R_c can readily be determined. This allows a series of curves for different values of R_c to be plotted with very little effort.

Design Example Illustrating the Graphical Procedure

To apply the graphical analysis to a practical design problem, assume it is required to determine R_c , R_1 and R_2 of Fig. 1 with

All-Pass Networks — Part 3

Their Use for High Quality Delay Lines

The versatile all-pass network, which introduces phase shift without attenuation, can vastly improve delay lines. Here, in the third of a series of articles on all-pass networks, Mr. Lubkin shows how to use the networks in these applications. The first part of this series, "The Anatomy of Networks," appeared in the October 12 issue of ELECTRONIC DESIGN. The second part, "Using Networks to Shape Transient Response," appeared in the October 26 issue. Part 4, on ripple, will appear in a subsequent issue.

Yale Jay Lubkin

Loral Electronics Corp.
The Bronx, N. Y.

THE USE of all-pass networks can enable the designer to build delay lines of much higher quality than the vast majority of those now offered for sale. The designer can even take an existing line and add his own all-pass corrective network to produce a line with much better characteristics than he started with.

A delay line is a filter whose primary function is the faithful reproduction of the input waveform at the output terminals, delayed in time by an amount t_d . Since delay lines are generally used for pulse work, the response parameters are usually given for the case where the input is a step. Fig. 1 shows the important characteristics of the input and output waveforms.

Laurent Theorem Gives Delay-to-Rise-Time Ratio

Suppose the transfer function of a low-pass network or delay line is

$$F(\omega) = A(\omega)e^{-j\phi(\omega)} \quad (1)$$

where $A(\omega)$ is the amplitude response and $\phi(\omega)$ is the phase shift. The response of this network to a step will be similar to that shown in Fig. 1 and will have a delay, t_d , and a rise time, t_r . The ratio, t_d/t_r , is a dimensionless quantity widely used as a figure of merit for delay lines and low-pass filters. A theorem of Laurent¹ gives the delay-to-rise-time ratio as

$$R = t_d/t_r = \frac{t_d}{\pi} \int_0^{\infty} A \cos(\phi - \omega t_d) d\omega \quad (2)$$

In general, designs are chosen to maximize R .

Section Efficiency Depends on Available Phase Shift

Suppose we have a low-pass filter or a delay line with an amplitude response $A(\omega) \leq 1$ and a

phase shift $\phi(\omega)$. How can A and ϕ be chosen to maximize the delay-to-rise-time ratio, R ? The available phase shift is defined as the difference between the maximum and minimum values of $\phi(\omega)$. (For a low-pass filter the minimum value will occur for $\omega = 0$.) This difference will always be a multiple of $\pi/2$, and for a network without resistors, it will always be a multiple of π .

The available phase shift is a function of the complexity of the network, and is equal to $\pi/2$ times the sum of the number of poles and the

difference (including sign) between the number of right-half-plane zeros and the number of left-half-plane zeros.

Suppose there are $q\pi$ radians of phase shift available, and the phase shift is linear with frequency. Using Eq. 2, we see that the choice of $A(\omega)$ which will maximize R for this particular phase shift is unity for $\cos(\phi - \omega t_d) > 0$ and zero for other frequencies. Thus A should be unity for $\omega < \omega_c$, where

$$\omega_c = \frac{(q + 1/2)\pi}{t_d} \quad (3)$$

and should be zero for all other frequencies. Thus, substituting in Eq. 2,

$$R = q + \frac{1}{\pi} \quad (4)$$

and the delay-to-rise-time ratio is equal to the number of "undistorted" π 's of available phase shift, the number being arrived at by weighting the actual phase shift according to both phase and amplitude distortion.

In general, a "section" of a minimum-phase-shift network (the usual kind) has an available phase shift of π radians. Eq. 4 indicates the maximum possible value of R for q sections of a low-pass filter. The section efficiency for a particular filter is then the ratio of R for the filter to R given by Eq. 4.

Iterative Delay Lines Easy to Make and Adjust

The usual delay line is composed of a number of identical sections in series. This type of construction is called "iterative" and is preferred because of relative ease of fabrication and adjustment. The section commonly used (Fig. 2), was originated by G. W. Pierce.² This section is in the form of a low-pass tee structure, with series inductances and shunt capacitances and with cou-

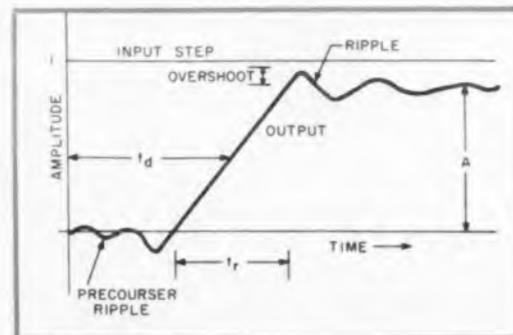


Fig. 1. Step response of a typical delay line with $A =$ gain, $t_d =$ delay time, and $t_r =$ rise time.

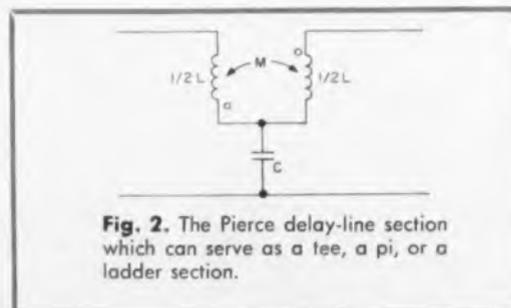


Fig. 2. The Pierce delay-line section which can serve as a tee, a pi, or a ladder section.

pling between the inductances. In a delay line of more than one section, series inductances can be combined into a single inductor. The Pierce section can be used as a tee, a pi, or a ladder section.

Many radar sets designed in World War II and later used the Pierce section without coupling between the inductors, and some manufacturers still make this type of line. This section has two poles and no finite zeros, and no zeros are introduced by cascading sections, so that π radians of phase shift are available per section. The maximum value of R obtainable from a cascade of q such sections is $q + 1/\pi$. In practice these delay lines perform very poorly, with 10-section delay lines having R of 4.3 and 80-section lines having R of 20.

Since the Korean War, most manufacturers have gone to the "compensated" Pierce section (negative coupling between inductors), which has two poles and two zeros and provides very efficient delay lines. The zeros are at $s = \pm(1/M)^{1/2}$, where M is the coupling coefficient. Since they are in opposite half-planes, they have no effect on the phase shift. The maximum R is the same as that of the uncompensated delay line, but the compensated lines are much more efficient. With reasonable care in component selection, Pierce-section delay lines have been made with R of 7.9 for 10-sections and 50 for 100-sections.

Maximal-Flatness Criterion Requires Small Distortion Terms

As the number of cascaded sections increases for a low-pass section, the amplitude cut-off becomes very sharp and the cutoff frequency becomes very small. The series expansion for the amplitude and phase shift is

$$\begin{aligned} A &= 1 + b\omega^2 + d\omega^4 + \dots \\ \phi &= t_d\omega + c\omega^3 + e\omega^5 + \dots \end{aligned} \quad (5)$$

For a large number of sections, it is important that the phase shift at low frequencies be linear. Since successive terms in the expansion differ by a ratio of ω^2 , which can amount to orders of magnitude for small ω , it is desirable that as many as possible of the distortion terms be zero. (The distortion terms are those in ω^3 , ω^5 , etc.) This condition is called the maximal-flatness criterion and is widely used in delay-line and filter design. (In delay-line design, the criterion is generally applied to the phase shift, while in filter design it is applied to amplitude response.)

A delay line is said to have maximal flatness of order m if the first m derivatives of the delay with respect to frequency are zero at the origin. (The delay is the derivative of the phase shift with respect to frequency.) The uncompensated Pierce section is not maximally flat, while the

compensated line, with $M = -1/12$, is third-order maximally flat. It is possible to make a fifth-order line by cascading compensated Pierce sections and all-pass sections.

Maximally Flat Pierce Section Makes Efficient Delay Lines

The phase shift of the Pierce section can be calculated using

$$\cos \phi = 1 + Z_1/2Z_2 \quad (6)$$

where Z_1 is the total series impedance and Z_2 is the total shunt impedance.³

For the Pierce section,

$$\cos \phi = 1 - \frac{\omega^2 LC}{2(1 - \omega^2 MLC)} \quad (7)$$

Expanding the denominator in a power series,

$$\cos \phi = 1 - \frac{\omega^2 LC}{2} - \frac{M\omega^4 L^2 C^2}{2} - \frac{M^2\omega^6 L^3 C^3}{2} + \dots \quad (8)$$

Cos ϕ can also be expanded in a power series

$$\cos \phi = 1 - \frac{\phi^2}{2} + \frac{\phi^4}{24} - \frac{\phi^6}{720} + \dots \quad (9)$$

Since ϕ is an odd function of ω it has a power series composed of odd powers of ω and for a third-order, maximally flat network the coefficient of ω^3 is zero, so

$$\begin{aligned} \phi &= t_d\omega + e\omega^3 + g\omega^5 + \dots \\ \phi^2 &= t_d^2\omega^2 + 2t_d e\omega^4 + \dots \\ \phi^4 &= t_d^4\omega^4 + \dots \\ \phi^6 &= t_d^6\omega^6 + \dots \end{aligned} \quad (10)$$

If Eq. 10 is substituted in Eq. 9,

$$\begin{aligned} \cos \phi &= 1 - \frac{1}{2}(t_d^2\omega^2 + 2t_d e\omega^4 + \dots) \\ &\quad + \frac{1}{24}(t_d^4\omega^4 + \dots) - \frac{1}{720}(t_d^6\omega^6 + \dots) + \dots \end{aligned} \quad (11)$$

Since Eqs. 8 and 11 are true for all values of ω , we can equate terms in the same power of ω . Equating terms in ω^2 ,

$$t_d = \sqrt{LC} \quad (12)$$

Note that L is the total series inductance in one section, and C is the total shunt capacitance in one section. Eq. 12 gives the delay per section. If a delay line is composed of a number of identical sections, the delay is multiplied by the number of sections and the delay for the whole line becomes

$$t_{dt} = \sqrt{L_t C_t} \quad (13)$$

where L_t is the total series inductance of the line

and C_t is the total shunt capacitance. Thus the delay depends only on the total series inductance and shunt capacitance and not on their distribution. This is not true of the rise time.

Equating fourth powers of ω ,

$$-M L^2 C^2 = t_d^4/12 \quad (14)$$

so that $M = -1/12$. Other values of M do not give third-order, maximally flat sections.

If we equate sixth powers of ω we find that

$$e = t_d^5/480.$$

From Eq. 12 of the first article in this series (ED, Oct. 12, 1960), we find that, for the duopole,

$$\begin{aligned} \phi &= \frac{\omega}{r} \left(\frac{4a}{r} \right) + \frac{\omega^3}{r^3} \left(1 - \frac{4a^2}{3r^2} \right) \left(\frac{4a}{r} \right) \\ &\quad + \frac{\omega^5}{r^5} \left(1 - \frac{4a^2}{r^2} + \frac{16a^4}{5r^4} \right) \left(\frac{4a}{r} \right) \dots \end{aligned} \quad (15)$$

Hence $t_d = 4a/r^2$, as before. For the third-order maximally flat all-pass section, the coefficient of ω^3 in Eq. 15 must be zero, so that $a/r = \sqrt{3}/2$. The fifth-order term can be explicitly evaluated, and the coefficient of ω^5 is $-t_d/720$.

Fifth Order Maximally Flat Delay Line Provides High Section Efficiency

The sign of the coefficient of ω^5 in the power-series expansion of the phase shift of the Pierce section is positive, while that in the expansion of the all-pass section is negative. Thus a suitable combination of all-pass and Pierce sections can be found with a zero coefficient for ω^5 in the series expansion for phase shift, and a fifth-order, maximally flat delay line can be made.

Since the coefficient of ω^5 for the all-pass section is $-t_d/720$, and that for the Pierce section is $t_d/480$, any combination of Pierce sections and all-pass sections (of the same impedance) in which the Pierce sections make up 2/5 of the total delay and the all-pass sections make up 3/5 of the total delay, will be fifth-order maximally flat. Delay lines made in this manner will have appreciably better section efficiency than conventional lines.

Commercial, Maximally Flat Pierce Seems Much Better Than Theoretical

The phase and amplitude characteristics of the maximally flat Pierce section are shown in Fig. 3. This section is very nearly ideal, and for a small number of sections, the delay-to-rise-time ratio of the Pierce line will be very nearly equal to the number of sections.

As the number of sections increases, the phase distortion of the Pierce section becomes significant. If the value of R is calculated using Eq. 2, for a 50-section maximally flat Pierce line, R turns

out to be only about 14, much less than that of commercial lines designed to be maximally flat Pierce lines. The improved performance over the theoretical line can be accounted for in three ways:

1. The amplitude cutoff of the line is lower than theoretical because of finite component Q . This actually improves rise time because it cuts gain at frequencies where the phase distortion is severe ($\cos[\omega t_d - \phi] < 0$).
2. Distributed capacitance across the inductors changes the Pierce section into one with somewhat different characteristics. For the right values of capacitance, the phase error is less than for the Pierce section.
3. Because the components used are not ideal, manufacturers do not put all their trust in calculations and they adjust the coupling coefficient, M , for best results. For a finite delay line, overcoupling and overcompensating for the phase error yields a better delay line, particularly when there is appreciable distributed capacitance across the inductors. When M is changed from $-1/12$ (maximally flat) to $-1/11$, the 50-section Pierce line will have a delay-to-rise-time ratio of 28, just about equal

to the best of the 50-section commercial lines.

All-Pass Lines Better Than Pierce Due to Smaller Distortion Terms

The all-pass section can be used directly as a delay line, provided that it is put in series with a low-pass filter which restricts the pass-band. The all-pass network makes a better delay line than the Pierce section because the distortion terms are smaller. A 50-section, maximally flat, all-pass delay line would have a delay-to-rise-time ratio of 28 if the series low-pass filter were ideal, just as with the best commercial units. R could be improved to about 33 by overcompensating. A Pierce section comes very close to being the ideal, series, low-pass filter for the all-pass delay line.

The phase errors of the maximally flat and overcompensated Pierce and all-pass sections are compared in Fig. 4 for sections having unity delay. The phase error for the Pierce section without coupling is also shown. It is evident that:

- The Pierce section without coupling ($M = 0$) makes a very poor delay line (because the phase distortion is very high at low frequencies).
- The all-pass sections are better than the

Pierce sections (because the phase distortion at a given frequency is less).

■ The overcompensated sections are much better than the maximally flat sections for lines of reasonable length—say up to 100 or 150 sections (because though the phase distortion at low frequencies is higher, the distortion is negligible for a line of this length, and the high-frequency phase distortion is less).

Fig. 5 shows the circuits of the maximally flat Pierce and all-pass sections, both for 1- μ sec delay per section and a characteristic impedance of 1,000 ohms. Component values are about the same for overcoupled sections.

Because all the zeros of the all-pass section are in the right-half plane, the available phase shift of the all-pass section is 2π , twice as much as the Pierce section. One practical effect is that, for a given delay, the all-pass components are smaller, hence cheaper. Furthermore, coil losses are smaller, so lines will have less pulse attenuation.

Lastly, the smaller components permit longer delay lines to be built without special techniques, and they behave more nearly like ideal components at high frequencies.

There are some disadvantages to the smaller

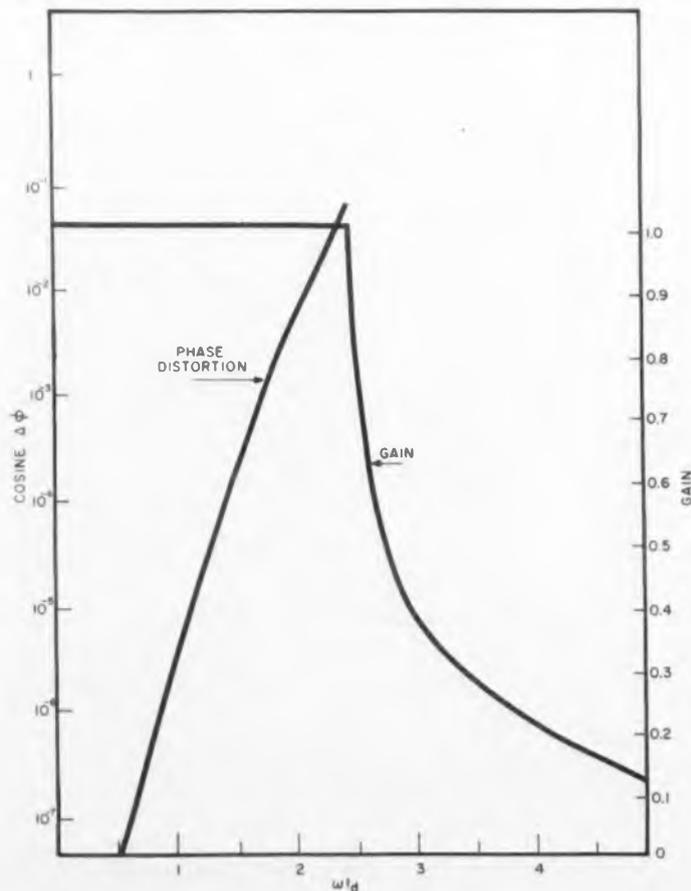


Fig. 3. Phase and amplitude characteristics of the maximally flat Pierce section.

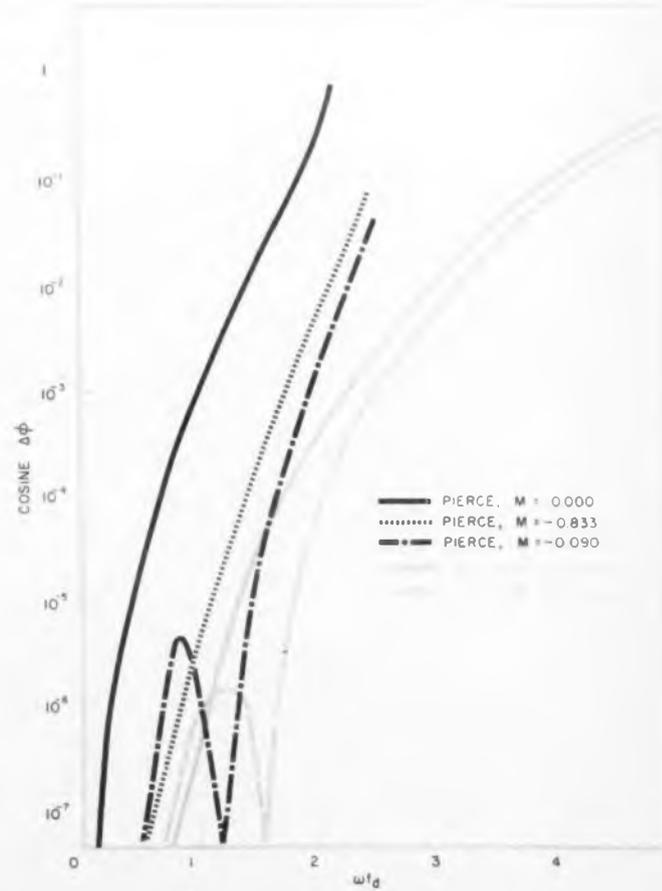


Fig. 4. Phase distortion of maximally flat Pierce, overcompensated Pierce, and all-pass sections.

component values. Since circuit capacitances are small, the effects of associated circuit capacitance will be greater. Very small inductances are difficult to fabricate and couple accurately. The greatest drawback of the all-pass network is its inability to be realized in an unsymmetrical form because of the bridging capacitor.

Use of the unsymmetrical form, illustrated for the Pierce section in Fig. 6, permits automatic adjustment of the coupling coefficient to any value whatever, using closely coupled coils. Instead of two equal inductances in each section, a single autotransformer is used with a total self-inductance of $(1 + M)L$ and with a tap at the desired inductance ML .

A cascade of unsymmetrical sections is electrically equivalent to a cascade of balanced sections. This means that the Pierce line is normally cheaper to make for a given number of sections than the all-pass line. It does not mean that a Pierce line with a given R is cheaper to make than an all-pass line with the same R .

Maximum Practical Number of Sections Determined by Inductor Q

At this point the designer may be tempted to

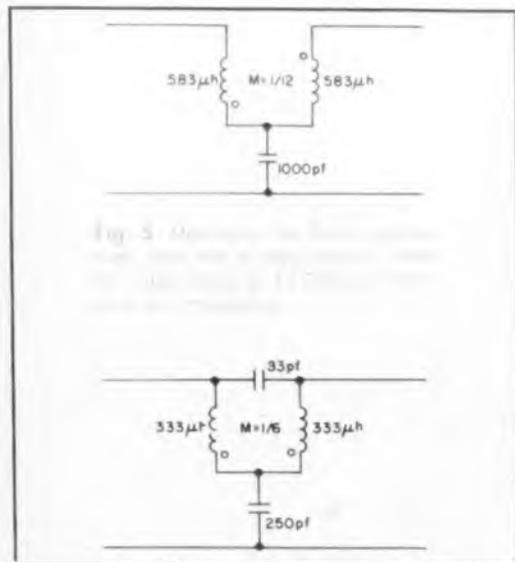


Fig. 5. Symmetrical Pierce section with a coupling coefficient of 1/2.

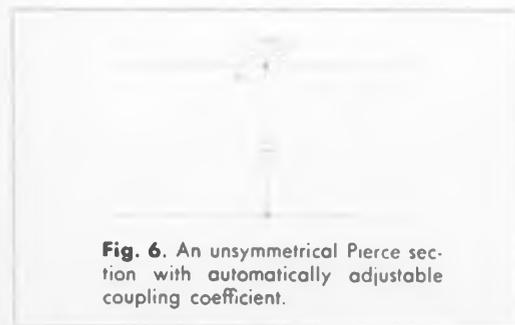


Fig. 6. An unsymmetrical Pierce section with automatically adjustable coupling coefficient.

ask, "Why so much fuss about getting a good section? The difference between the Pierce and all-pass sections isn't so much anyway, and if we want a better delay line, we'll just add more sections."

The answer is that what you do depends on what quality line you want, how much you can afford to pay, and what the competition is doing. A useful rule of thumb is that the maximum practical number of sections you can use is equal to the Q of your inductors.

After World War II, most delay-line manufacturers used the very unsatisfactory, uncoupled-Pierce network and built delay lines with a maximum R of about 20 for 100 sections. Further improvements with this network were not possible at the time because of low inductor Q . About 10 years ago, the Electronic Computer Corp., which is no longer in business, succeeded in getting R of 50 for a 100-section line using overcoupled Pierce sections. By increasing the line length to 125 sections, they could raise R to 60, but further increases caused deterioration in R .

A few years later, they had improved their inductors to the point where 200-section lines were practical and they were able to get R 's of 75 to 80. On occasion, and not repeatably, they were able to make 400-section lines with R of 100. A few years ago, ESC Corp. announced a line with $R = 170$. This high ratio was obtained by stacking about 500 Pierce sections and using specially developed ferrites with very high Q 's. The procedure is normally very expensive.

Cascading Too Many Sections May Not Be Profitable

The major reason that cascading more sections does not pay off too well is that the section efficiency drops as more sections are added, and the drop is faster if the sections are not very good. For two iterative sections in cascade, the gains multiply and the phase errors and delays add.

Experience confirms the mathematical proof which leads to three important conclusions.

1. Section efficiency goes down more rapidly as either the amplitude or phase distortion increases.
2. Phase distortion is probably more important than amplitude distortion.
3. R can actually decrease as the number of sections increases especially if the phase distortion is sufficiently poor.

We can obtain some useful quantitative data on cascading sections. Suppose we have a maximally flat network whose phase shift can be described by

$$\phi = \omega + a\omega^p \quad (17)$$

If we have q sections, then

$$\phi_n = q\omega + qa\omega^p \quad (18)$$

Suppose the associated amplitude characteris-

tic is unity until the phase error is 90 deg, and zero afterward. If p is large, the cosine of the phase error will approach $1 - kw^{2p}$, where k is a constant. The cosine will be very nearly equal to unity for frequencies where the phase error is less than 90 deg. If we substitute in the Laurent equation we find that $R = t_d \omega_0 / \pi$ where ω_0 is the frequency for 90-deg phase error. From Eq. 18,

$$qa\omega_0^p = \pi/2, \text{ and} \quad (19)$$

$$\omega_0 = \sqrt[p]{\pi/2qa} \quad (20)$$

If we substitute this in the equation for R , noting that the delay is q ,

$$R = q^{p-1/p} (p\sqrt{1/2a\pi^p}) \quad (21)$$

and R is proportional to $q^{(p-1)/p}$.

For the Pierce section without coupling, $p = 3$, so R is proportional to $q^{2/3}$. To double R , we have to add 2.8 times as many sections. Thus if we take the figure of $R = 20$ for a 100-section line, we need 400 sections to obtain $R = 50$.

For the third-order, maximally flat Pierce and all-pass sections, R is proportional to $q^{1/5}$. This is nearly true for the overcoupled sections also. An additional 2.35 times as many sections are needed to double R . Referring to previous data, we see that to obtain $R = 50$, we need about 340 sections of maximally flat, Pierce line, about 103 sections of maximally flat, all-pass or overcoupled Pierce line (verified by commercial practice), and only about 83 sections of overcoupled, all-pass line. The advantage of good sections is obvious.

Large Rise-Time Improvements From All-Pass Networks

It is frequently possible to make large improvements in network rise time by using all-pass networks, either as corrective networks, or as basic structural elements. The same considerations apply to fall time since the networks are linear.

What about the other parameters? Do we have to pay a price of deterioration of other characteristics to gain improvements in rise time? In general, the answer is "no." The other major characteristics of a pulse response are droop and ringing. Phase correction with all-pass networks should have little effect on droop, which is determined by an effective network Q . Phase correction can have a very beneficial effect on ringing, and this will be discussed in the next article in this series. ■ ■

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How To Specify Noise



In Precision Linear Potentiometers

When considering wiper-contact resistance in precision linear potentiometers, what are the acceptable limits of Equivalent Noise Resistance? Some specifications—such as NAS-710, MIL-R-12934B, MIL-R-19518—establish the limit at 100 ohms. The authors dispute this figure as a standard. ENR, they say, must, in some way, be related to the circuit of use.

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ACCCEPTABLE levels of Equivalent Noise Resistance in the wiper-contact section of precision linear potentiometers can be specified realistically, using the graphs in this article. Equivalent Noise Resistance (ENR) cannot be stated as a single value, but must, in some way, be related to the circuit of use.

Equivalent Noise Resistance

As a measure of the uniformity of quality in manufacturing their wirewound potentiometers, several manufacturers, some years ago, isolated the factor of wiper-contact resistance and established the following as an internal quality control procedure. Referring to Fig. 1, with the potentiometer connected as a rheostat and an arbitrary 1 ma through the wiper, the contact resistance variation, as the wiper is moved, appears as the equivalent in millivolts; any momentary change of contact resistance, such as an open caused by dust, appears on the oscilloscope as a voltage pulse. The peak value of voltage was called Equivalent Noise Resistance.

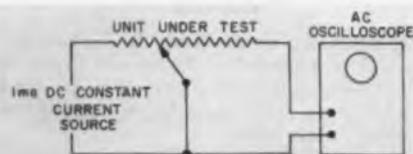


Fig. 1. This circuit was used by some manufacturers to establish Equivalent Noise Resistance.

The general circuit in which precision potentiometers operate is shown in Fig. 2. R_L represents the electrical load in the wiper circuit; R_C , the wiper variable contact resistance due to wiper movement. When R_L is infinite in value, the potentiometer is called a voltage divider; zero wiper current is drawn. When R_L is zero ohms, the potentiometer is called a rheostat (current controlled); all current in the potentiometer passes through the wiper.

When zero wiper current is drawn (R_L is infinite), any level of variable contact resistances does not produce voltage changes: the voltage output is governed entirely by the relative position of the wiper on the potentiometer resistance element. In this instance, the contact resistance variation is totally irrelevant to the performance of the potentiometer.

However, when the potentiometer is operated as a rheostat, the level of current is directly affected by the variable contact resistance, since it is in series with the potentiometer resistance element. Here the performance of the potentiometer is directly affected by its contact resistance characteristics: the variable contact resistance directly produces "noisy" outputs.

From the general circuit considerations discussed above, it follows that a rational criterion for acceptable level of Equivalent Noise Resist-

ance is related to the relative wiper current, or alternatively, to the relative wiper loading. Referring to Fig. 2, this analysis can be made.

It can be shown that, in a linear potentiometer:

$$m = \frac{1}{(1-S)p + \frac{1}{S}}$$

The load current can be shown to be:

$$I_L = \frac{m E_{in}}{R_C + R_L}$$

So that the voltage drop across the contact resistance is:

$$E_C = I_L R_C = \frac{m E_{in} R_C}{R_C + R_L}$$

The change in output voltage due to drop across contact resistance is:

$$\Delta_C = \frac{E_C}{E_{in}} = \frac{m R_C}{R_C + R_L}$$

Since, usually

$$R_C \ll R_L, \Delta_C = \frac{m R_C}{R_L}$$

If $K = \frac{R_C}{R}$ and $p = \frac{R}{R_L}$,

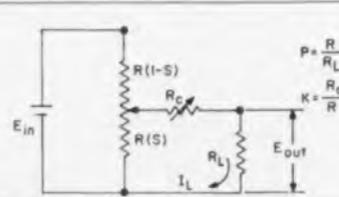


Fig. 2. The general circuit in which precision potentiometers operate.

m = ratio of output voltage to input voltage with load attached, assuming R_C/R_L small.

S = the wiper position as a fraction of rotation

p = the ratio of terminal resistance to load resistance

K = the ratio of variable contact resistance to terminal resistance.

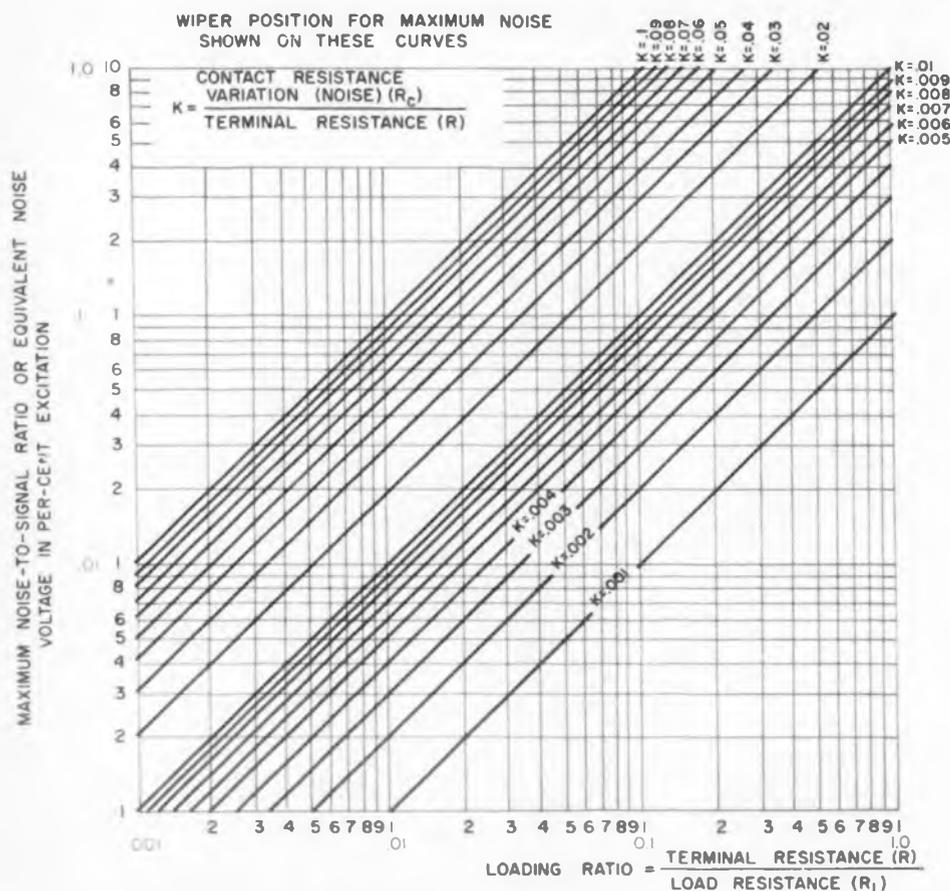


Fig. 3. Wiper position for maximum noise.

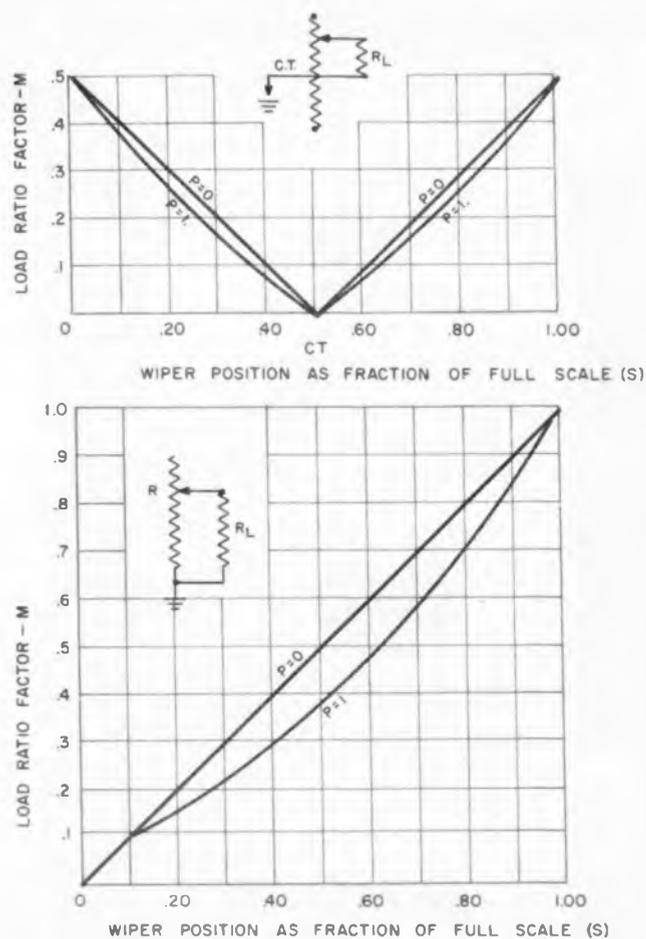


Fig. 4. Load ratio factor (m) vs wiper position shown as a fraction of full scale.

then $\Delta c = m K p = 100 m K p \% = 100 K(m p) \%$

For any given load ratio p , m has a maximum value of 1 when $S = 1$, i.e., when the wiper is at its maximum excursion from the ground terminal. The maximum "noise" voltage due to contact resistance variation corresponding to the equation $\Delta c = 100 K p$ for the circuit of Fig. 2 is shown on Fig. 3.

The data of Fig. 3 is based on maximum load current, resulting when the wiper is opposite the maximum excitation voltage terminal. For different wiper positions, (1) the load current will be less, and (2) the "noise" voltage induced by contact resistance variation will also be correspondingly less. The factor m in the above equation will vary with both wiper position and load. A plot of this factor is shown on Fig. 4. Note that, when the load is connected to the center tap, the load factor m is different from its value with load connected to one end terminal.

How Curves Are Used to Establish Equivalent Noise Resistance

The family of curves shown on Figs. 3 and 4 can now be used to establish the acceptable level of contact resistance variation, or ENR, based on the effect of such variation on potentiometer performance. This is best illustrated by examples: **Example 1.** In a circuit in which a 1-meg load to one excitation terminal appears on the wiper of a 50-K potentiometer ($p = R/R = 0.05$), the nature of the application permits a noise-to-signal ratio of one part in 1,000 (0.1 per cent); referring to Fig. 3, the maximum acceptable ENR is 2 per cent of terminal resistance ($K = 0.02$). Conversely, an ENR of 2 per cent of terminal resistance will introduce a maximum output noise voltage equal to 0.1 per cent of the excitation voltage. If the load was 5 meg instead of 1 meg, the allowable contact resistance variation would be 10 per cent of terminal resistance.

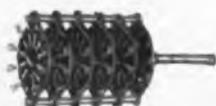
Further, if in actual use the usual area of operation covers only the lower 50 per cent of the pot wiper travel (referring to Fig. 4), m will be 0.49. In the example given above, the effective loading ratio is now 0.0245 (0.05×0.49); for a noise-to-signal ratio of 0.1 per cent therefore, the maximum acceptable ENR is 4.2 per cent of terminal resistance.

Example 2. In a circuit in which a 1-meg load on the wiper of a 50-K potentiometer is connected to the center tap instead, the Load Ratio Factor for maximum noise is 0.5, permitting an ENR equal to 4 per cent of terminal resistance for a noise level of 0.1 per cent of excitation voltage. If the usual area of operation is restricted to ± 25 per cent off on either side of the center tap, the load ratio factor is 0.247 per cent and p is 0.01235 (0.05×0.247) therefore permitting an ENR of 8.4 per cent of terminal resistance for the same output noise level. ■ ■

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Chemical and Solar Power Sources

An ELECTRONIC DESIGN Staff Report

Howard Bierman
Associate Editor

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For space and for many ground-based applications, power sources for electronic equipment must possess such characteristics as light weight, compact size, reliable and unattended operation, high energy per unit weight and volume, and long life. "Converting Heat to Electricity" (*ED*, Sept. 28, 1960, p. 32) outlined the development of thermoelectric, thermionic, and MHD devices to fill these needs. Other approaches, using chemical and solar sources, are likewise being pursued to bring man's dreams of space discoveries nearer to reality.

In this Staff Report, *ELECTRONIC DESIGN* analyzes in depth three techniques of energy conversion—batteries, fuel cells, and solar cells.

Batteries continue to play a most significant role in the healthy growth of electronics; more than \$500 million worth of batteries were produced last year in the U.S. Radios, hearing aids, and test equipment have depended on battery supplies for years; industrial devices, for close to a century. Present-day satellites are equipped with secondary batteries acting as storage devices for solar converters.

Battery-research gains have been slow but steady, relatively devoid of sensational "break-throughs." Over-all performance, however, has been considerably improved; shelf life has been lengthened, and substantial increases in energy-to-weight ratio have been achieved. The latest trends in battery design, improved cell characteristics, and the diversified application areas are discussed in "Batteries—Workhorses for Portable Equipment."

Fuel cells, producing electricity directly from chemical reaction between fuel and oxidant, are not subject to the Carnot limitation imposed on heat engines. Thus, practical fuel cells can operate at 60 to 80 per cent efficiency, almost double the figure achieved with the most efficient steam or diesel engines in use today. Fuel cells are noiseless, have infinite shelf life and are free of hot, noxious by-products. The weight-to-energy ratio of fuel cell systems, estimated in the order of 50 lb per kw, is an attractive prospect for space applications.

An interesting possibility involves the combination of fuel cells with solar or nuclear energy sources. An isotopic source or solar energy could be used to restore the waste by-products of a fuel to the original cathode and anode reactants. Over-all efficiency should be double the value available using the same nuclear source and a heat engine. The progress of fuel cells and their construction are covered in "Fuel Cells—Converting Chemical to Electrical Energy."

In a bright, sunny location, such as Arizona or New Mexico, close to 100 w of electrical energy can be obtained for every square meter of surface covered by currently available silicon solar cells. Outside the earth's atmosphere, this figure approaches 150 w per square meter. Although solar-cell cost is high, ranging from \$300 to \$50 per watt, an appealing feature is the use of free, available energy from the sun; fuels need not be stored or transported. It is obvious, however, that a storage device such as secondary batteries must be included for operation during dark or sunless periods. For extremely long-duration service, such as satellites in orbit, solar cells are ideal since lifetime is limited by the device rather than the fuel supply. Developments in solar cells and their significant characteristics are detailed in "Silicon Solar Cells—Tapping Power from the Sun."

No single conversion technique, thermal, chemical, or solar, can be singled out as the panacea for power demands. Solar cells and fuel cells are still in their infancy, with much research and consequent gains ahead. Batteries, despite their hoary background, have been improved considerably in the past decade with further gains in view for the near future. At the present time, the "best" design for a particular application may well consist of a marriage between two or more of the available conversion schemes.

Batteries—Workhorses for Portable Equipment

In the face of onrushing competition from "exotic" energy-conversion designs, battery-research scientists continue their search to improve cell characteristics. Dry cells do more than light flashlights; secondary or storage batteries are more useful than mere engine starters. The advances in battery performance, new devices under development and the wide scope of applications presently served by batteries are detailed.

C. K. Morehouse and J. R. Thomas

Globe Battery Co.
Div. of Globe-Union, Inc.
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DESPITE threats from more "exotic" energy-conversion schemes under intensive development during the past decade, the electrochemical battery continues to rule as leading contender for the task of powering industrial, military, and space equipment separated from ac power sources. Although there is an aura of glamour about the newer conversion techniques, extensive research and development effort is, and has been, dedicated to the task of improving capacity, shelf life and performance of primary and secondary batteries.

The battery industry has grown steadily since its beginning about 160 years ago; about \$600 million worth of batteries of various types are produced annually in the U.S. alone.

Batteries are electrochemical devices which

convert stored chemical energy directly into electrical energy; they are the most efficient energy converters known today.

Electrochemical cells are generally classified into two groups, primary and secondary, based on the nature of the chemical reactions. Primary cells are discarded when output drops below a usable level. Secondary cells, on the other hand, convert chemical energy by reactions that are essentially reversible. A battery, of either primary or secondary type, consists of two or more cells connected in either a series, parallel, or series-parallel arrangement to provide the needed power. The five basic components of a cell are:

- Anode—the negative electrode from which electrons flow into the external circuit. Anodes are reducing agents which give up electrons and go into solution, forming positive ions.
- Cathode—the positive electrode into which electrons flow from the external circuit. Chemically, cathode materials are oxidizing

- agents which can accept electrons with ease.
- Electrolyte—a solution that permits ionic conduction between anode and cathode.
- Separator—an inert, porous insulating substance to physically separate the anode and cathode; ions in solution can flow between the electrodes.
- Seal—a composition to prevent loss of electrolyte and water while permitting gas to escape.

The electrode processes which occur when electrical energy is withdrawn from a zinc-mercuric oxide primary cell is shown in Fig. 1. Although the chemical reactions vary for each electrochemical cell, the principles are the same.

The theoretical energy that can be withdrawn from a primary or secondary cell depends on the chemical reactions which occur at the anode and cathode. In general, most cells operate below their theoretical limits because of polarization effects, irreversibility of the electrode reactions, or ohmic losses.

Primary Cells: Compact, Disposable Power Source

The four major classes of primary cells are dry, wet, reserve, and fuel or continuous feed. Most of the new developments of the last 10 years have been of the dry, reserve, and fuel-cell types.

Dry cells contain an aqueous electrolyte which is immobilized and does not spill out when the cells are inverted. Three types of dry cells are presently produced in quantity in this country: Leclanché zinc-manganese-dioxide, zinc-mercuric-oxide, and alkaline-zinc-manganese-dioxide. **Leclanché cells:** Approximately 90 per cent of the 2 billion dry cells produced annually in the United States are zinc-manganese dioxide cells,

commonly referred to as Leclanché cells after their inventor.

Two basic cell designs of the Leclanché type are currently being manufactured in a number of different sizes. Cross sections of cylindrical and of flat or layer construction are shown in Figs. 2 and 3.

Most cylindrical cells consist of an amalgamated-zinc can which acts as the anode as well as the cell container. A mixture of manganese dioxide and carbon wet with electrolyte is shaped into a cylindrical core; a carbon rod, the positive terminal, is placed in the center of the mixture, see Fig. 2. A starch-flour gel is used

to separate both electrodes. The entire cell may be dropped into a steel tube surrounded by an insulating jacket to retard cell leakage caused by zinc-can perforation; this type of battery is termed "metal clad." Some manufacturers include modified starch-paste separators to provide a leak-resistant cell. An "inside-out" cell, having the zinc anode at the center of the device, is claimed to be free of leakage due to zinc-can perforation and to make better use of the zinc content.

To provide high voltages for communication equipment, flat-cell constructions have been developed. One such type is shown in Fig. 3.

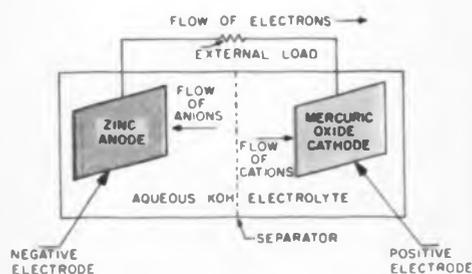


Fig. 1. Flow of electrons and ions during discharge of a zinc-mercuric-oxide primary cell.

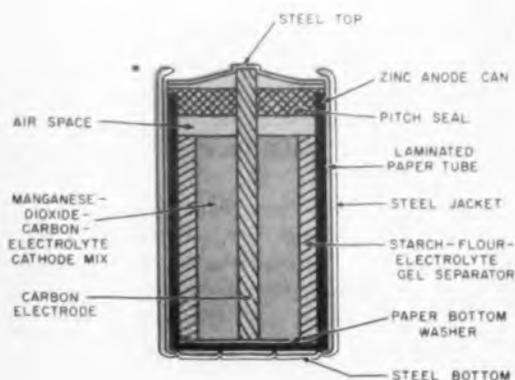


Fig. 2. A cross-sectional view of a Leclanché flashlight battery.

Although most of the manganese dioxide used in dry cells comes from Africa, there is a definite trend to products synthetically prepared by chemical or electrolytic processes. The more costly synthetic materials differ from the naturally occurring manganese dioxide in crystal structure, particle size, impurities, and chemical activity. Their present applications include cells designed for high-current drain usage for industrial and military needs.

The open-circuit voltage of Leclanché cells varies from 1.5 to 1.6 v, decreasing 0.4 mv/C from 25 to -20°C . The ampere-hour and watt-hour capacity are dependent upon cell size and

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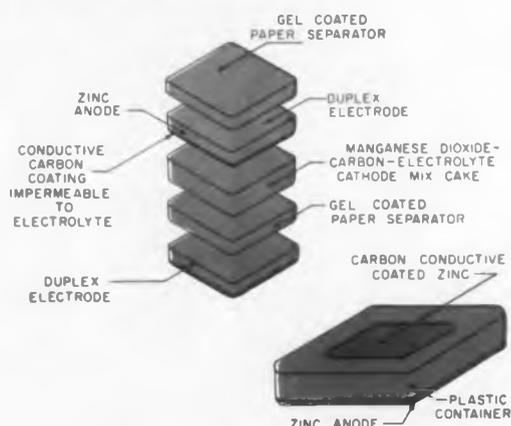


Fig. 3. Typical Leclanché flat cell construction. A flat sheet of zinc acts as a duplex electrode for a layer-built dry cell. One side of the zinc sheet acts as the anode of one cell while the opposite side, bearing an adherent conductive coating, serves as the base of the cathode of the adjacent cell. The two-cell electrodes are separated by gel-coated paper. Cells are stacked to achieve the required voltage, then taped and sealed in wax to eliminate moisture loss.

rate of energy withdrawal. Intermittent type of service is generally preferred, especially for heavy current drain usage. Heavy drain may roughly be defined as any drain which results in a service life of 10 hr or less. Due to freezing of the electrolyte, the cells become inoperative at about -30°C . Low-temperature performance can be extended to below -40°C by changing to an electrolyte with a lower freezing point.

Shelf life is dependent on quality of manufacturer, cell size, cell formulation, and temperature of storage. In general, the smaller the cell size, the shorter the shelf life. Storage temperature has a marked effect on shelf life; the lower the temperature, the longer the shelf life.

A considerable number of tests have been adopted, each intended to simulate some kind of service, as for example, flashlights, portable radios, hearing aids, telephones, or military services. Most tests involve discharging the cell or battery through a constant resistance simulating the current drain required to power the particular equipment. Typical discharge curves and capacity data for Leclanché dry cells compared with other dry cells are shown in Fig. 4. **Zinc-Mercuric Oxide Cells:** These cells use an amalgamated-zinc anode in the form of either a fine powder or a coiled corrugated strip. The cathode consists of a mixture of red mercuric oxide with about 5 per cent graphite

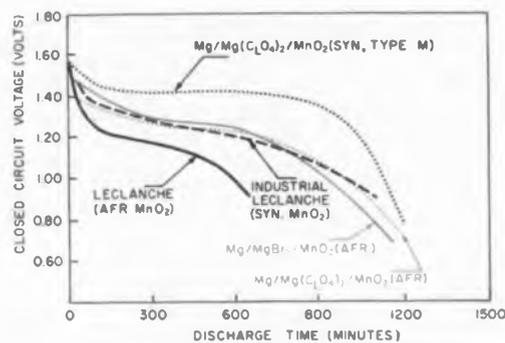


Fig. 4. D-size cells discharged intermittently through 4-ohm resistors, four minutes per hour in an eight-hour day.

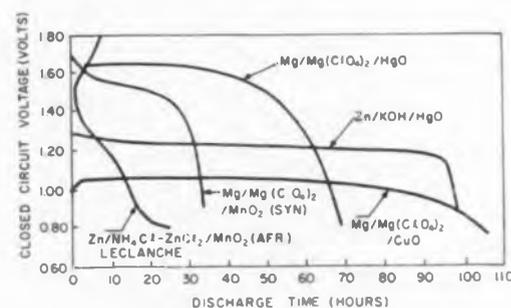


Fig. 6. Penlight (AA-size) dry cells continuously discharged through 50-ohm resistors at 21°C .

molded under pressure into a steel cup or pressed as a discrete part and assembled into the cell, depending on the type of cell produced. An aqueous potassium-hydroxide solution containing zinc oxide acts as the electrolyte and the separator consists of a cellulosic material to immobilize the electrolyte and a barrier material interposed between the cathode and the cellulosic material. A typical construction which is commercially available is shown in Fig. 5. A typical discharge curve for this cell compared with a comparable size Leclanché cell is shown in Fig. 6; the open-circuit voltage is 1.345 v. Advantages over the Leclanché cell include greater w-hr capacity, smaller voltage drop as cell discharges and better shelf life. Unfortunately cost is high.

Alkaline Zinc-Manganese-Dioxide Cells: This cell construction uses a zinc anode and a manganese-dioxide cathode, as does the Leclanché cell, but it has an alkaline electrolyte. The open-circuit voltage is 1.52 v. Its advantages are that it gives better high-rate performance than the Leclanché and that it can be made up easily in very small sizes which are like the zinc-mercuric-oxide cells.

One type, called "crown" cells is very like zinc-mercuric oxide cell. It contains an aqueous sodium-hydroxide electrolyte and is most suitable for low-drain applications. Although these cells

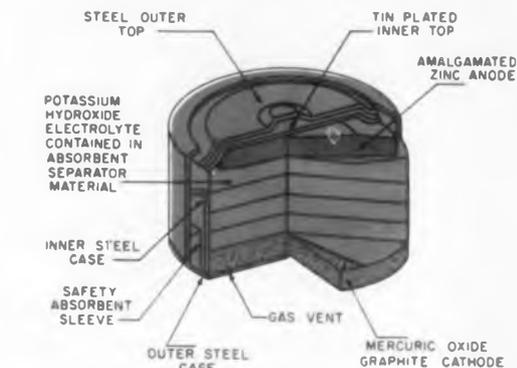


Fig. 5. Cross-section views of a zinc-mercuric-oxide dry cell manufactured by P. R. Mallory Co.

do not give as high a capacity as mercuric-oxide cells of comparable size, they contain a cheaper cathode material. Improved performance with a subsequent increase in material cost can be obtained by adding mercuric oxide to the manganese-dioxide mix.

During the past few years, an "inside-out" construction has been designed for high-drain, continuous-duty applications. This type contains an aqueous solution of potassium hydroxide as the electrolyte and a powdered-zinc anode disposed in a gel.

Higher W-Hr Capacity, Longer Shelf Life Goal of R & D

Magnesium Cells: Magnesium is theoretically more attractive as an anode material than zinc since it has a considerably higher reversible electrode potential and more than twice the amp-hr capacity per unit of weight. Recent developments in this type of cell involve the coupling of a magnesium anode and an aqueous magnesium-bromide or perchlorate electrolyte with such cathode materials as manganese dioxide, cupric oxide, mercuric oxide, and a number of organic compounds. Each of these new dry cells has some desirable characteristics and offers the possibility of replacing conventional dry cells for certain applications. A magnesium flat cell has been developed which uses an aqueous magne-

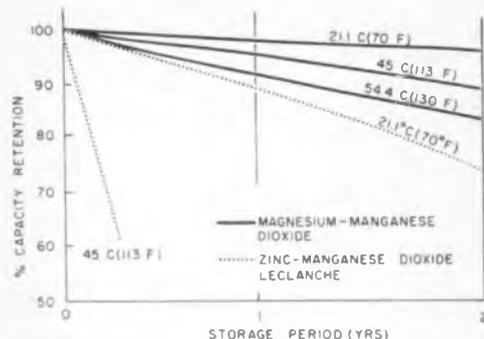


Fig. 7. Shelf life of magnesium-manganese-dioxide flashlight cells vs Leclanché types.

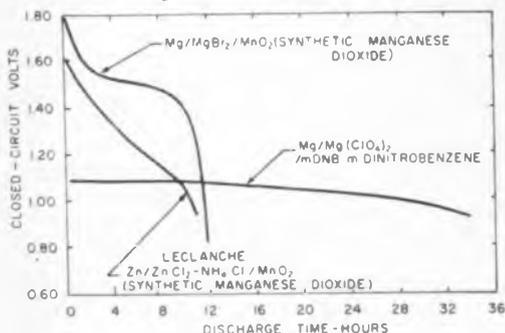


Fig. 8. Various AA-size dry cells discharged continuously through 16.67-ohm resistors.

sium-bromide electrolyte. These cells have a sloping voltage-time discharge curve as does the Leclanché cell, but operate at 0.1 to 0.3 v higher. Magnesium-manganese-dioxide cells have a longer shelf life than Leclanché dry cells, especially at elevated storage temperatures, as shown in Fig. 7.

Discharge curves for various AA-size dry cells are shown in Figs. 4, 6, and 8.

Organic cathode materials, such as aromatic nitro and C-nitroso compounds, are being applied to cell structure. Many of these compounds have from five to eight times the theoretical amp-min capacity of manganese dioxide and mercuric oxide, materials now used in commercial cells. The operating voltage characteristics of the magnesium-organic cells have, in general, a more constant voltage-time discharge curve than the manganese-dioxide cells as shown in Fig. 8. Comparative capacity figures for actual cells are shown in Fig. 9.

Organic-cell development may lead to the use of new materials, many of which are relatively inexpensive and non-strategic, a factor which could eliminate U.S. dependence on foreign ore deposits. Among the technical problems associated with the use of magnesium anodes are cost, delayed action, high impedance, and loss in capacity during light intermittent service. As these problems are solved, magnesium cells will achieve

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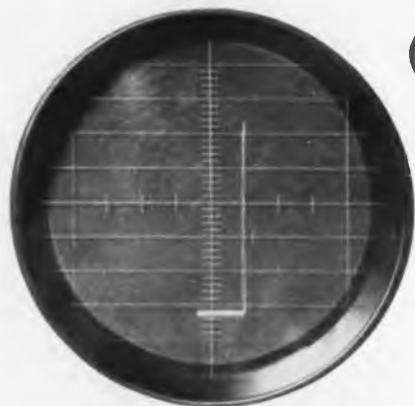


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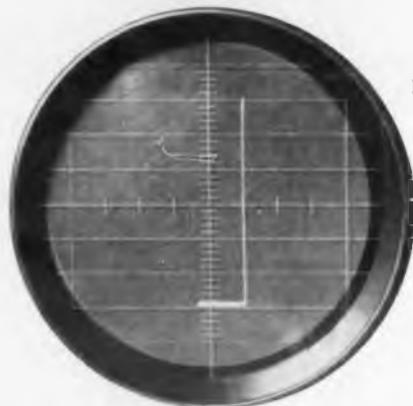
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(before)

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(after)

Reverse leakage tracing after immersion in H_2O_2 , dried without washing (virtually no change).

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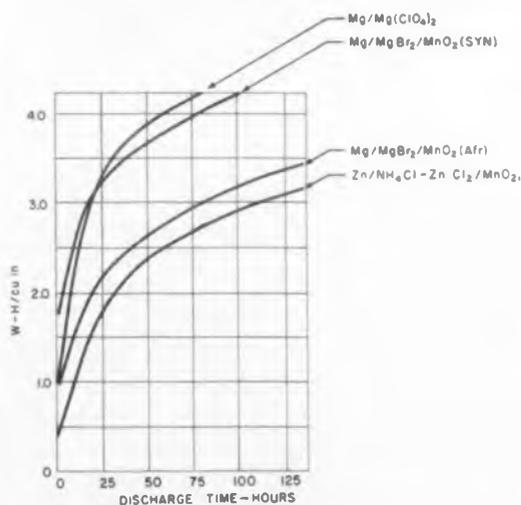
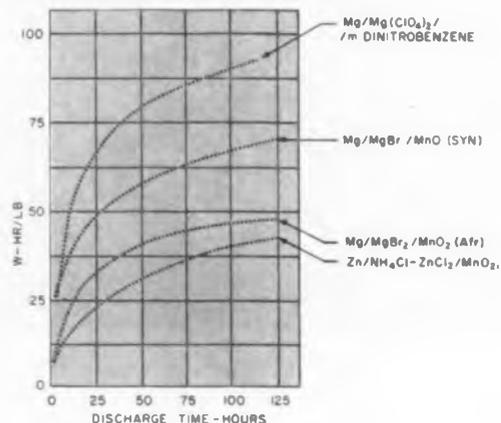


Fig. 9. Capacity and watt-hour per unit weight and volume for various systems.

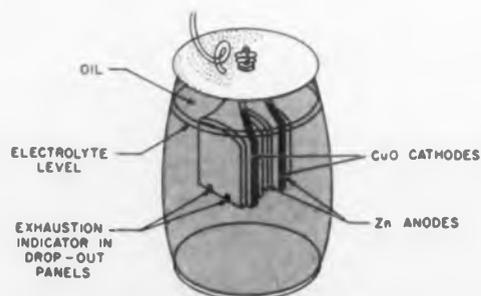


Fig. 10. Basic construction of a zinc-cupric-acid wet cell.

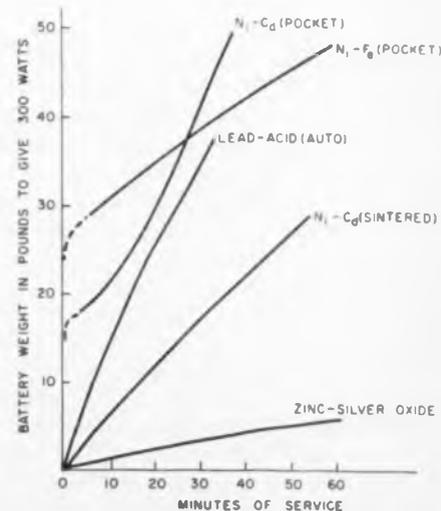


Fig. 11. Comparison of various 300-w secondary cell devices.

commercial significance in the near future.

Air-Dry Cell: Oxygen in the air is used as the cathode component for this type of cell. The first dry-type air cell was produced in this country about a decade ago. These cells contain a zinc anode, an aqueous sodium-hydroxide electrolyte, and a special porous water-repellent carbon positive electrode. The carbon electrode is sufficiently porous to permit adequate access of air and to occlude enough oxygen to maintain the intended rates of discharge. The cells are designed to operate at current drains as high as 60 ma at about 1.05 v.

Air-dry cells are sealed during assembly to prevent drying out during storage; before use, the seal is broken to allow oxygen into the porous carbon electrode. For short continuous operation, these cells perform satisfactorily; in long intermittent discharge service, the electrolyte evaporates resulting in a loss of capacity. The utility of this cell would be greatly enhanced by the development of a sealing membrane which would permit oxygen to enter the cell but prevent water vapor from leaving.

Aluminum and Indium Dry Cells: An aluminum counterpart to the Leclanché cell consists of an Alclad aluminum-anode can, an aqueous aluminum-chloride electrolyte and a manganese-dioxide cathode. Ammonium dichromate is added to the electrolyte to inhibit the corrosion of the aluminum. These cells operate about 0.1 v higher

than the Leclanche with the same sloping voltage-discharge characteristic, but more development is required to improve their performance.

An indium version of the zinc-mercuric oxide cell, using an indium anode in place of zinc, has also been developed as a very small, hermetically sealed cell to power a wrist watch. This all can be sealed, because the indium anode is more resistant to corrosion than zinc. The cells also liberate less gas. Another cell announced recently is the zinc-mercuric dioxy sulfide, which has high capacity and a flat discharge curve like the zinc-mercuric-oxide cell but which can be made in designs similar to the Leclanche cell at a reduced cost.

Solid Electrolyte Cells: Solid electrolyte cells offer potentially long shelf life as compared to cells with liquid electrolytes. In the latter, shelf life is limited by the reaction of the electrodes with the electrolyte and by the evaporation of the electrolyte itself. Solid electrolyte cells are ideal for use in military and other equipment that may be stored for years in a stand-by condition; however, they are limited to applications requiring very low current drains.

High Power, Long Life Offered by Wet Cells

The zinc-cupric-oxide Lalande and the zinc-air cell are two types of wet cells produced in the U.S. These cells are used where high capacity, moderately large currents at constant voltage, and long life are needed. The Lalande cell consists of a zinc anode, a caustic-soda electrolyte, and a cupric-oxide cathode contained in a glass jar. A typical construction is shown in Fig. 10. The cells are usually shipped dry with the electrolyte added prior to usage. In general, Lalande cells are designed to give 500-1,000 amp-hr capacities, and operate between 0.5 and 0.7 v at current drains as high as 15 amp. The air cell, which is considered as a replacement for the Lalande cell, contains a porous-carbon electrode in place of the cupric oxide. The porous-carbon electrode is designed to absorb oxygen from the air, which in turn is reduced in the course of cell discharge. The air cells operate at 1.1-1.2 v with a constant voltage-time discharge curve.

Reserve Cells Fill "One-Shot" Demands

"One-shot" or "delayed-action" reserve batteries are assembled in an inactive state and activated prior to use. Advantages over other conventional primary batteries include: a higher energy output per unit of weight and volume, long shelf life, and high over-all reliability.

In general, the important cells can be classified into three groups, (a) liquid-activated, (b) gas-activated, and (c) heat-activated. The liquid-



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activated, magnesium-silver chloride, magnesium-cuprous chloride, and zinc-silver oxide cells are the most important, the others presently in the development stage or used to a limited extent.

Liquid-Activated Cells: Magnesium-water activated cells are stored dry in an inactive condition in hermetically sealed containers and are activated by adding water. They have the advantage over other reserve-cell systems in that the electrode need not be transported with the battery. One disadvantage is the slow activation time, requiring several seconds to minutes for complete activation. Magnesium-silver-chloride and magnesium-cuprous-chloride are two types of water-activated cells commercially available. The silver-chloride cells operate at 0.2-0.3 v higher than the cuprous-chloride cells and have higher capacities; the cuprous-chloride cells are cheaper, however. Both of these cell systems have a constant voltage-time discharge curve and the heat generated during cell discharge permits operation at temperatures to -54 C.

A new water-activated reserve-cell system under development uses a magnesium anode and organic N-halogen compounds. The N-halogen compounds operate at 0.6-0.7 v higher than the silver-chloride electrode, approaching the poten-

tial of the chloride electrode. Results indicate that batteries can be made which will give nearly twice the w-hr capacity per unit of weight and volume of the magnesium-cuprous-chloride battery based on certain military tests.

Zinc-Silver Chloride Cells: A zinc-silver chloride battery has been designed to provide a moderate-drain, long-life, water-activated battery system. These batteries are reportedly capable of providing up to two years' life in sea water, since corrosion of the zinc in fresh or sea water is negligible under load throughout the life of the battery. Capacities of 40 w-hr per lb and 3 w-hr cu in. have been reported for these cells.

Zinc-Silver Oxide Cells: Zinc-silver oxide reserve cells are high-rate batteries capable of delivering their rated capacities in one to 10 minutes. High watt-hour capacities per unit of weight and volume plus constant voltage during discharge at high-power output levels are valuable features offered. These batteries are stored dry and one type is automatically activated by applying an electric pulse to a squib which ruptures a diaphragm holding back the potassium-hydroxide electrolyte. Activation times in the order of a few tenths of a second have been attained. In order to achieve operation at low temperatures, electric heaters are added to the assembly.

Other reserve battery systems under development are activated either by forcing a reactive gas into the cell or by heating the cell to melt the electrolyte which is a nonconductive solid at ordinary temperatures but which becomes a conducting fluid at high temperatures.

Secondary Cells—Energy Reservoirs for Long-Term Applications

Secondary or storage cells are those which can be discharged and then recharged by reversing the current. Secondary cells are usually used as energy reservoirs or energy storage devices in electrical systems rather than as prime power sources. The cells are almost always sold and used in the form of batteries consisting of a number of identical cells connected in series and usually packaged in a single container. The following criteria are used to evaluate a secondary cell:

- Cost.
- Service life, usually given in terms of the duty cycle.
- Energy-storage capacity, expressed as watt-hours per pound or unit volume.
- Rate at which energy can be withdrawn from the cell—the maximum rate of discharge—expressed in watts per pound or unit

volume, or as the time in which all of the available stored energy can be taken out.

- Rate at which energy can be stored in the cell—the maximum rate at which the cell can be charged—expressed in watts per pound or unit volume, or as the time in which the cell can be recharged.
- Charge retention; or better, rate of loss of charge—the tendency of a battery to dissipate energy stored in it by internal reactions—expressed as the per cent of stored energy lost per unit of time.
- Operating temperature range and the effect of temperature on the other properties.

In some special cases other factors are also important, such as whether the cell can be sealed hermetically and whether it can be operated in any orientation. Of particular interest recently has been the ability of the cell to withstand ac-

celerations experienced in rocket propulsion and ability to operate under zero gravity conditions.

The five types of secondary cells that are commercially available are listed in Table 1 along with some of their important characteristics. Typical performance data are shown in Fig. 11.

High Performance at Low Cost Offered by Lead-Acid Cells

There are more batteries of lead-acid cells made than of all other types combined. They are made in a variety of forms and sizes for many different applications. The largest use is in engine starting for autos, boats, and aircraft.

Cells for high-current, short-duration use are made up of a number of thin-plate electrodes placed quite close together, alternately positive and negative, spaced by porous separators, all plates of one polarity being connected in parallel as shown in Fig. 12. The plates are made by applying a paste of active materials to grids cast from a lead-antimony alloy. Such a battery will not last for more than about a hundred deep discharges and recharges because the active material will flake off the positive plates, but it will last through thousands of shallow high-rate dis-



Fig. 12. Cutaway view of a lead-acid automobile battery showing internal construction. (Courtesy of Globe-Union Inc.)

Table 1. Key characteristics and applications related to secondary batteries.

Type	Application	Advantages	Disadvantages	Service Life		Capacity, light drain (w/hr/lb)	Operating Voltage for light drain (v)
				Float or Shallow Discharge	Regular or Deep Discharge		
Lead-Acid	<ol style="list-style-type: none"> 1. High current for short time (Engine starting) 2. Electrically powered trucks, mine locomotives, etc 3. Emergency power supplies 	<ol style="list-style-type: none"> 1. Low cost 2. High voltage per cell 3. Good capacity, life and charge retention properties 	<ol style="list-style-type: none"> 1. Cannot be charged at temperatures below 0 F. 2. Cannot be hermetically sealed 3. Cannot remain in discharge state too long without damage 	Up to 15 yr	Up to 1,500 cycles	10-15	1.95 to 2.05
Nickel-Cadmium	<ol style="list-style-type: none"> 1. Engine starting in low temperature areas 2. Sealed units used in space vehicles 	<ol style="list-style-type: none"> 1. Ruggedness 2. Long life 3. Can operate from 180 F to -65 F 4. Can be in various charge or discharge states without harm 5. Can be hermetically sealed 	<ol style="list-style-type: none"> 1. High cost 2. Lower cell voltage than lead-acid 	Up to 25 yr	Up to 1,500 cycles	10-12	1.10 to 1.30
Nickel-Iron (Edison cell)	<ol style="list-style-type: none"> 1. Heavy duty lighting and air conditioning for railway cars, materials handling 	<ol style="list-style-type: none"> 1. Extremely rugged 2. Not damaged by over-charge or over-discharge 	<ol style="list-style-type: none"> 1. High cost 2. Poor charge retention 3. Performance drops at low temperature. 	Up to 25 yr	Up to 1,800 cycles	12-13	1.10 to 1.30
Silver-Zinc	<ol style="list-style-type: none"> 1. Specialized military needs where weight and volume are at a premium 	<ol style="list-style-type: none"> 1. High capacity 2. Excellent performance at high discharge rates 	<ol style="list-style-type: none"> 1. High cost 2. Short cycle life 	—	10-300 cycles	40-45	1.40 to 1.50
Silver-Cadmium	<ol style="list-style-type: none"> 1. Low-rate, long life applications 	<ol style="list-style-type: none"> 1. Cycling life and charge retention better than silver-zinc cell 	<ol style="list-style-type: none"> 1. High rate performance not as good as silver-zinc cell 	—	300-1,000 cycles	25-30	1.05 to 1.10



Now! Get premium features in a DVM priced at only \$940

Cubic Corporation announces the V-45—the first low-cost digital voltmeter with premium features. Now industrial users can buy a top-quality, precision four-digit instrument at a price they can justify—only \$940. Here are the premium features you get in a V-45:

Floating Input: Both sides of the input may be floated above or below ground. The floating input circuit provides more than 80 db rejection to 60-cps common-mode signals. A grounded input is also supplied.

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range; and voltages up to 1099.9 may be read on the 1000-volt range. Therefore, the operator need not constantly shift back and forth between ranges when reading close to the normal upper limit of a range.

Transistorized Logic and Drive Circuit: The V-45 DVM uses construction techniques representing the latest state-of-the-art, with all-transistorized circuitry driving reliable stepping switches.

Cubic manufactures a complete line of quality digital instruments, including a-c and d-c voltmeters, ohmmeters, ratiometers, scanners and printer controls. Write for literature to Dept. ED-101, Industrial Division, Cubic Corporation, San Diego 11, California.

CIRCLE 48 ON READER-SERVICE CARD

SPECIFICATIONS

MODEL V-45 DIGITAL VOLTMETER

Input Impedance: 10 megohms at balance.

Ranges: Manually selected, 10% extended range

Low ± 0.000 to ± 10.999 vdc

Mid ± 00.00 to ± 109.99 vdc

High ± 000.0 to ± 1099.9 vdc

Sensitivity: 1 millivolt

Sensitivity Control: Continuously variable from 1 digit to standby lockout.

Power Input: 105-125 vac, 50-60 cps, 25 watts standby, 30 watts operating.

Dimensions: 19" wide, 5 1/4" high, 14" deep, rack or bench mounting with dust-proof switch and bridge section.

Average Balancing Time: Less than 2 sec.



charges provided it is kept at or near full charge.

Lead-acid batteries designed for use in the power train of electrically propelled trucks, mine locomotives, and materials handling equipment are generally discharged over an 8- to 10-hour working day, and then recharged overnight. They cost more than starting batteries but they are still relatively inexpensive. These cells are also assembled of plates, alternately positive and negative, but the plates are thicker and more rugged than those in starting batteries. The positive plates are heavily wrapped in glass fiber to prevent spalling of the active material. Alternatively, each positive plate is made up of a number of pencil-thick cylinders lying side by side in a plane. The cylinder walls are made of inert materials such as glass fibers and synthetic resins, either porous by nature or slotted so as to allow the electrolyte to penetrate. The tubes are filled with tightly packed active material, with a spine of lead alloy running down the center to carry off the current.

Lead-acid batteries used for emergency power supplies are generally very large, stationary batteries in contrast to the previous types which were small enough to be used on mobile equipment. The most important requirements are extremely long life, dependability, minimum maintenance cost, and excellent charge retention. The batteries are always "floated" at a voltage slightly above their open-circuit potential so that they remain fully charged, and under these conditions (assuming that they are not required to discharge frequently) they may last for 25 years. The plates are sometimes constructed by pasting active materials on a lead grid and sometimes by forming the active material from the material of the plate itself by repeated charging and discharging. Often these batteries are made up using grids of pure lead or an alloy of lead with a trace of calcium instead of antimonial lead to improve the charge retention of the battery and the corrosion resistance of the grids.

Nickel Cadmium Cells Rugged, Long-Lived

Nickel-cadmium cells were formerly made by depositing the active materials in pockets in the plates. Now most electrodes are made by sintering nickel powder to form strong porous plates, then depositing the active materials by soaking these plates in solutions of nickel salts or cadmium salts (depending on whether the electrode is to be positive or negative). Cells made from these sintered plate electrodes give

much better performance than those made from the pocket type of electrodes.

Nickel-Iron Cells: This cell, called the Edison cell after its inventor, has been in use since the early 1900's, principally for heavy-duty industrial applications such as materials handling equipment, electric locomotives, and railway car lighting and air conditioning. The negative electrode consists of plates holding the active material in pockets and the positive electrode of perforated nickel tubes filled with a mixture of flake nickel and nickel oxides.

Silver-Zinc Cells: These cells, available only since World War II, have the same over-all reaction as the silver-zinc primary cell. The key to making successful secondary cells from this electrochemical couple was the development of suitable separators to keep the plates apart.

Silver-Cadmium Cells: These cells are almost identical to the silver-zinc cells except for the use of cadmium in place of zinc. Capacities are high although not as high as that of the silver-zinc system. High rate performance is not nearly so good as that of the silver-zinc cell but cycling life and charge retention are much better. ■ ■

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With Many Thanks . . .

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CIRCLE 49 ON READER-SERVICE CARD



Fuel Cells— Direct Conversion of Chemical to Electrical Energy

Conventional heat engines, steam or diesel, operate with no better than 40 per-cent efficiency due to the Carnot limitation. Fuel cells, unrestricted by this factor, have been built with efficiencies exceeding 80 percent. Infinite shelf life, high power per weight and volume plus lack of noxious by-products offer desirable features for many military, industrial, and missile applications.

Ernst M. Cohn

Army Research Office
Office, Chief of Research and Development
Department of the Army
Washington, D.C.

THE FUEL CELL is an electrochemical device for converting chemical energy directly to electrical energy. In contrast to a battery, the fuel cell does not normally contain its own fuel supply; instead, fuel is fed to it when power is demanded.

The idea for a fuel cell appears to have been originated by Sir Humphrey Davy, who published a paper on a zinc-oxygen cell in 1801 and another paper on a coal-oxygen cell in 1802. One may well ask why it has taken so long for fuel cells to become "fashionable." The answer is, in part, that the demand for more efficient energy production has not been too pressing, sources of energy have been abundant and relatively cheap thus far, and—perhaps most important—the sporadic work on fuel cells in the past has been disappointing because of lack of reactivity, breakdown of materials, and expense of the more reactive fuels and cell fabrication.

More Than \$4 Million from Military For Fuel-Cell R&D

Advances in science and technology since World War II, demands for energy for the most diversified purposes, recognition that fossil fuels may become exhausted, and the population explosion have all placed a new perspective on means for energy conservation.

The effect of defense demands on triggering the current feverish activity in this field cannot be overestimated. Even though a large number of U.S. firms, as well as many foreign enterprises, are now funding their own fuel-cell R&D programs, support from the Department of Defense, particularly the Department of the Army, has

greatly spurred world-wide interest in this field. Thus far, the Army has committed about \$1,750,000, the Navy \$1.5 million, and the Air Force \$1 million on fuel-cell work.

Fuel Cell's Basic Components Number Only Six

The basic components of a fuel cell are two reacting chemicals (fuel and oxidant), the housing, two electrodes (an anode that receives the fuel and a cathode that receives the oxidant) and an electrolyte that provides a path for the migration of ions. A basic description of the low-temperature hydrogen-oxygen system is shown in Fig. 1, an ion-exchange membrane assembly is shown in Fig. 2, a high-temperature fuel cell in Fig. 3 and a redox system in Fig. 4.

The anode itself may be the fuel, for example, sodium, magnesium, or zinc; in this case, the metal constitutes a consumable electrode. At low temperatures, up to about 500 C, the activities of bare, non-consumable electrodes are generally too low for practical purposes and must be enhanced by adding catalysts to the fuel cell.

The electrolyte may be a liquid, an ion-exchange membrane, a molten salt, or a solid semiconductor at high temperatures. Liquid and membrane electrolytes may be used together. The electrolyte may be unrestrained or it may be in a suitable carrier, e.g., liquid in asbestos or molten salt in a porous matrix of magnesium oxide.

The fuel-oxidant pair may be any suitable substances that can be made to react electrochemically, or they may be used indirectly in the so-called redox cell (Fig. 4) where the fuel regenerates one ionic species and the oxidant regenerates the other, each in a separate compartment, so that neither fuel nor oxidant actually enters the cell itself.

In the typical hydrogen-oxygen fuel cell, hydrogen gas gives up an electron to the solid elec-

trode and releases ions to a liquid electrolyte. Obtaining sufficient fuel-electrode-electrolyte area presents a serious challenge. If the electrolyte floods the electrode and prevents gas-to-electrode contact, electrons cannot flow; if excessive gas pressure does not permit ion migration through the electrolyte, the process is not complete and electrical output is not available. Simultaneous three-way contact between gas, electrode, and electrolyte must be maintained during operation.

This brief consideration of the components suffices to indicate the wide variety of possible cells, the breadth and ranges of conditions under which cells can be operated, and the spectrum of materials that may be used for their construction. Which combination of chemical reactants, structural components, and operating conditions is chosen depends on the system in which the cell is to be used.

Types of Fuel Cells And Fuel-Cell Systems

Fuel cells may be divided into two classes, the indirect (redox) cells and those that utilize fuel and oxidant directly. Among the latter the following types are distinguished:

Consumable electrode

Low temperature

- liquid electrolyte
- ion-exchange membrane

High temperature

- molten salt
- solid electrolyte

Depending on the reactants and the circumstances of their use, fuel as well as oxidant may be regenerated. The system then includes not only the direct fuel cell but also a regenerator in which chemical, solar, nuclear, thermal, or electrical energy is used to convert products back to reactants.

(continued on p 64)

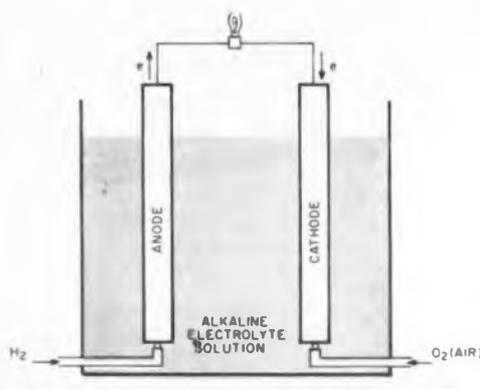
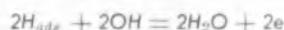
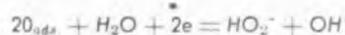


Fig. 1. The basic operation of the low-temperature, liquid electrolyte cell is as follows: hydrogen and oxygen are fed into the cell through specially treated porous electrodes separated by an electrolyte. In the alkaline system shown, hydrogen diffuses through the anode and reacts at the electrode surface with the hydroxyl ions in the electrolyte to produce water. Electrons given to the anode electrode during the process flow through an external load to the cathode where they combine with oxygen and water to form hydroxyl ions. The hydroxyl ions travel through the electrolyte to the anode to complete the process.

Hydrogen is adsorbed at the anode, and the adsorbed hydrogen reacts with hydroxyl ions from the electrolyte



freeing electrons that can do useful electrical work. The cathode adsorbs oxygen according to the reaction



Peroxide is then decomposed catalytically to oxygen and hydroxyl ions, the latter traveling to the anode. Product water must be removed.

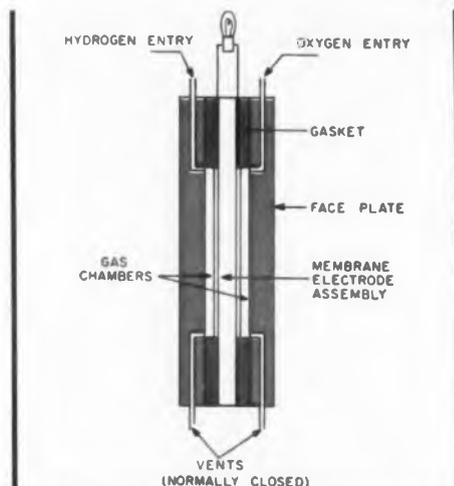


Fig. 2. An ion-exchange membrane can be used instead of or in conjunction with liquid electrolyte. This application was suggested by Dr. W. T. Grubb of the General Electric Research Laboratories. Whereas the liquid alkaline electrolyte as now used in H_2-O_2 cells cannot tolerate carbon dioxide, which would react to form carbonate, an acid-ion exchange membrane may make it possible to use carbonaceous fuels in low-temperature cells. The membrane also aids in avoiding the flooding of porous electrodes by liquid, thus retaining a maximum area of three-phase contact among electrode, gas, and electrolyte.

In the ion-exchange membrane technique, the liquid electrolyte is replaced by a plastic membrane which permits ion migration. Hydrogen and air, fed to opposite sides of the membrane, diffuse through porous electrodes and contact the membrane structure. Electrons are obtained at the hydrogen electrode and routed to the external load. Hydrogen ions penetrate through the membrane and combine with the incoming oxygen and circulating electrons to produce water. The water formed is drained off without the need for special condensation equipment.

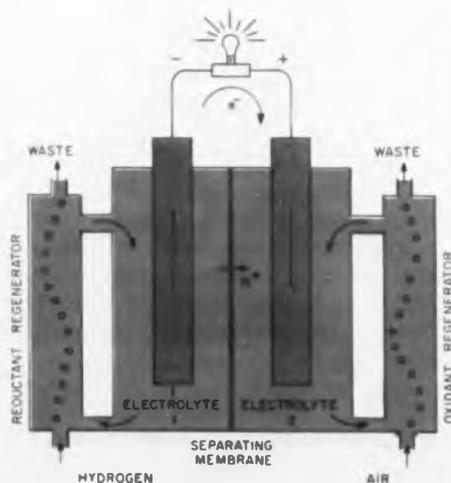


Fig. 4. In the redox (reduction-oxidation) cell, the fuel and oxygen do not react directly with each other. Instead, each electrode and its associated electrolyte is separated from the other by a membrane structure which permits passage of ions. Reactions take place between each electrolyte and its regenerant in exterior regenerators. Hydrogen fuel is fed into one regenerator, where it reduces (adds electrons to) one electrolyte; the electrolyte then passes into the cell, reacts at its electrode to give up electrons, and returns to the exterior regenerator for another cycle. In the other regenerator, air reacts with its electrolyte so as to oxidize (take electrons from) the solution which is then fed into the cell to react at the positive electrode. The cycle is completed by migration of hydrogen ions through the membrane separating both sections.

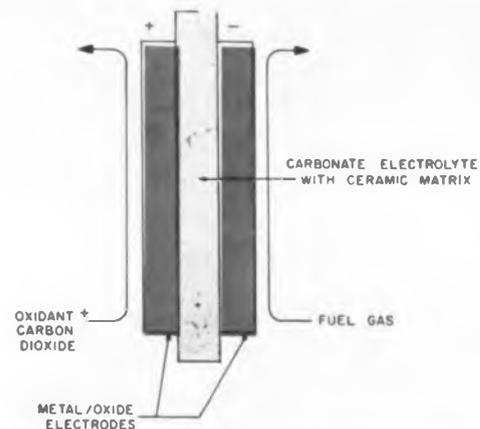
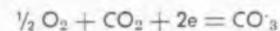


Fig. 3. High-temperature (above 500 C) fuel cells permit the use of relatively inexpensive fuels such as natural and coal gases or vaporized gasoline. The electrolyte is generally molten carbonate held in a porous magnesia matrix; porous electrodes are firmly held to the electrolyte. The fuel does not necessarily combine directly with oxygen; instead, the fuel is generally "cracked" or broken down into hydrogen and carbon monoxide. These gases then pass through the anode where reaction takes place with carbonate ions in the electrolyte. Electrons are donated to the electrode while carbon dioxide and water are formed. The electrons flow through an external load to the cathode where the incoming oxygen combines with carbon dioxide to produce carbonate ions. These ions, in turn, flow back to the anode to complete the cycle.

In the molten carbonate cell, carbon dioxide must be added with the oxygen because the reaction at the cathode is



The carbonate ion migrates to the anode where it reacts with carbon monoxide, for example,



Thus, when carbonaceous fuel is used, some of the reaction product can be recycled to the cathode. Since the maximum useful work available from a fuel cell is the free energy,

$$\Delta F = \Delta H - T\Delta S$$

where ΔH is net heat evolved, T is the absolute temperature, and ΔS is the entropy. Therefore, this high-temperature cell has a lower theoretical efficiency than cells working at lower temperatures.

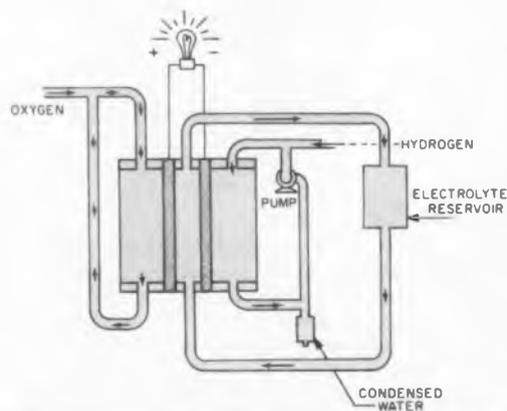


Fig. 5. To speed up reaction, the hydrogen-oxygen fuel cell can be operated under high-pressure conditions with waste heat used to maintain operating temperature. The Bacon cell shown operated at 200 C and 40 atmospheres to produce a current density of 200 amps per sq ft. at 0.8 v. Porous electrodes are made of nickel or nickel plated steel. The electrolyte is prevented from flooding the electrodes due to pressure differences in the cell.

In some cases, the action of the fuel cell itself may be reversed occasionally for regeneration of fuel. Thus, a hydrocarbon fuel cell could drive a vehicle; on a downgrade or while decelerating, the cell might be powered by the movement of the vehicle, water would be electrolyzed, and hydrogen and oxygen stored for subsequent use.

Orbiting space vehicles may use regenerative fuel-cell systems as secondary power sources. Solar energy, converted to electrical energy via solar cells, for example, could regenerate the reactants for use in a fuel cell during periods when the vehicle is not exposed to the sun.

As another example, a zinc-air fuel cell could replace an industrial battery in a warehouse truck. During use, zinc dissolves from the electrode into the electrolyte; during off hours, the zinc is plated back on the electrode by electrical recharging from the network.

The redox cell (Fig. 4) is, of course, constantly being regenerated. It must therefore be regenerable with cheap fuels, and this has been one of the weak spots in its development thus far. Impurities, primarily hydrogen sulfide, from the regenerating fuel have been carried into the cell and caused electrode poisoning. Also, recovery of the most promising oxidant, bromine, appears to require costly and cumbersome equipment. At



Fig. 6. A dramatic example of a fuel-cell application is Allis-Chalmers Research Div.'s tractor demonstration. A total of 1,008 fuel cells, 112 units of nine cells each, are arranged in four banks which can be connected in various series-parallel groups. A mixture of gases is fed through a tubing system under pressure and produces 15-kw output during reaction in an electrolyte. Sufficient output is obtained to drive the 5,270-lb tractor and provide 3,000-lb drawbar pull.

present, this appears to be the least promising type of fuel cell.

Current Status Of Fuel-Cell Development

Although fuel-cell powered equipment has been demonstrated—the "Silent Sentry," a tractor (Fig. 6), a small car—fuel cells have not yet reached the commercial production stage. The primary reasons for this are lack of sufficient scientific and engineering knowledge.

The most advanced systems at present are those in which relatively expensive hydrogen is the fuel and oxygen is the oxidant. A fuel cell with platinum electrodes, consuming hydrogen and oxygen at room temperature, was demonstrated in England in 1839. Low-temperature cells with porous carbon or nickel electrodes, catalyzed by small amounts of platinum, palladium, or silver (the last for the oxygen electrode only) have recently been operated with aqueous alkali (Fig. 1) or with ion-exchange membranes as electrolytes. At ambient pressure and temperature, current densities have been relatively low, mostly 5-25 amp per sq ft of electrode surface, polarization losses are considerable, and the voltage developed at the oxygen electrode has usually been below that calculated theoretically. Cell

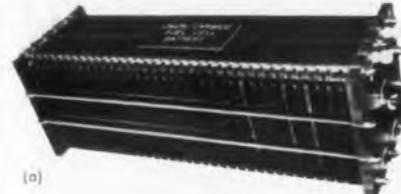
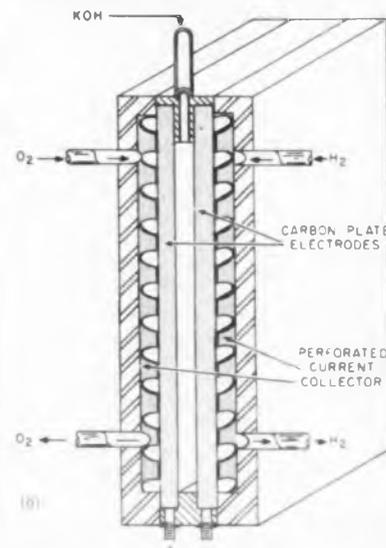


Fig. 7. (a) Up to 600-w output is available from this 6 x 6 x 17 in. flat-plate, multicell hydrogen-oxygen fuel cell constructed by Union Carbide. The basic construction of the cell is shown in (b).



performance often deteriorates with time, and "drowning" of electrodes by filling of pores with liquid electrolyte has been a problem. When an ion-exchange membrane is used as electrolyte physical deterioration has been observed.

Some of these problems appear to have been solved: Justi and coworkers in Germany have developed a "double skeleton catalyst" nickel electrode structure that should overcome the drowning problem as well as maximizing triple contacts among electrode, electrolyte, and reactant for obtaining high current densities—as much as 700 amp per sq ft for the hydrogen electrode at 85 C and 400 amp per sq ft for the oxygen electrode at 0.75 v. The Union Carbide Co. uses specially processed carbon electrodes at up to about 150 F, 10 atmospheres, and 25-250 amp per sq ft.

General Electric Co. and Ionics, Inc., are developing improved ion-exchange cells (see Fig. 2), in which thinner membranes show lower electrical resistance and hence should lead to lower internal losses through heating of the cells, making possible higher current densities than those obtained thus far.

A full description of the Marshall Flying School Ltd., high-pressure cell, (Fig. 5) partly financed by National Research Development Corp. (England), was given by its developer, F. T.

Bacon, at a meeting of the American Chemical Society in 1959. Porous nickel electrodes and 37-50 per cent potassium hydroxide electrolyte at 200 C and 40 atmospheres yield a current density of 200 amp per sq ft at 0.8 v or 500 amp per sq ft at 0.6 v per cell for more than 1,000 hours of operation. Higher current densities appear possible, though probably at the expense of shorter cell life. Stainless steel, nickel, and compressed asbestos are the materials of construction. Fuels other than hydrogen did not work, and the use of air instead of oxygen increased the polarization losses. These limitations as well as the conditions of operation prevent the economical use of small-scale units. As regards weight, Bacon estimated 50 lb/kw for a 44-kw unit (heavier for smaller units) and showed that, though competitive on a weight basis with batteries, such fuel-cell units could not compete with diesel engines which use air as the oxidant. Bacon predicted, however, that large units should eventually be useful for road and rail traction and for augmenting electric power during peak-load periods, for which purpose water could be electrolyzed and stored during off-peak hours.

Cheap Fuels Can Operate High-Temperature Fuel Cells

For operation at temperatures from about 500 to 900 C, see Fig. 3, molten alkali carbonates in a porous magnesia matrix have generally been used as electrolyte. In at least one case, however, this electrolyte is not immobilized in a porous matrix. Electrodes may be porous, sintered, semi-conducting oxides or silver gauze for the cathode (air electrode) and porous or powdered nickel, silver, or iron for the anode. Clay and metal chromites have been used in Russia for electrodes. Operating pressure has been atmospheric.

The principal developers of this kind of cell are researchers at the University of Amsterdam, Consolidation Coal Company near Pittsburgh, Sondes Place Research Institute in England, and two groups of Russian scientists. This system has thus far been limited to much lower current densities, up to 100 amp per sq ft, and has been more troublesome than the liquid electrolyte cell due to the more severe operating conditions. Despite its current drawbacks it is of interest because, being operable at higher temperatures, it can use less reactive fuels (such as propane and carbon monoxide) and is less susceptible to poisoning of electrodes by impurities from the fuel. A high-temperature cell might therefore be operated on gas from a coal gasifier, as envisaged by Gorin and coworkers of Consolidation Coal Co., and thus come as close as possible to realizing the old dream of converting coal directly to electricity.

At still higher temperatures, fuel cells have



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Fig. 8. Producing 200 w at 24-v output, the 30-lb fuel-cell power pack can take the place of a 55-lb engine-generator or 80 lb of secondary batteries. Built by GE for the Marine Corps and the Army Signal Corps, the unit contains 30 ion-membrane fuel cells consuming oxygen from the air and hydrogen produced by decomposition of metal hydride. The metal hydride is contained in reusable, hermetically sealed canisters (at top of unit); a canister weighs 6 lb and provides 14 hrs operation.



Fig. 9. Experimental model of a lightweight regenerative fuel cell under development by Electro-Optical Systems, Inc.

been operated with semiconducting oxides as electrolyte, but little is known about their performance characteristics.

A number of other fuel-cell systems will be mentioned briefly because they appear to have more limited applicability. Regenerative systems, primarily for space use, may utilize alkali (especially lithium) hydride, the ferrous-ferric ion couple, a sulfuric-acid concentration cell, sulfur trioxide and dioxide, cadmium iodide, silver iodide, proflavine-ascorbic acid, thionine-iron, nitrosyl chloride/nitric oxide plus chlorine. Among consumable-electrode systems are magnesium (to be oxidized by nitro- or dinitrobenzene); sodium amalgam and other amalgams, as well as pure aluminum, magnesium, or zinc to be oxidized by air, oxygen, hydrogen peroxide, or halogens. In addition, potential fuels such as ammonia and hydrazine have given promising results. All of these systems have been or are being worked on, and many more have been or could be proposed. Although some may ultimately find application for special purposes in military and space systems or as secondary power sources it appears too early to predict their usefulness now.

Top Firms Team Up To Advance Fuel-Cell Art

During the past year, a phenomenal change has occurred in the fuel-cell field. A large number

of organizations have suddenly taken an active interest in fuel cells and, almost without exception, this interest has centered on hydrocarbon as ultimate fuel source and air as oxidant. Many of the organizations that started in this field earlier have been working on hydrocarbons and oxygenated organic compounds and are continuing their research. But the added impetus of these new groups is bound to accelerate the development of petroleum- and natural-gas-based fuel cells.

A notable fact is the teaming up of companies with non-competitive interests in fuel cells, e.g., Allis-Chalmers with Esso Research and Engineering Co., Standard Oil of Indiana with McGraw-Edison, and some 25 companies sponsoring a joint project at Battelle Memorial Institute.

Another point worth mentioning is that some organizations are looking upon fuel cells as chemical reactors, i.e., devices of potential use for making chemical products, with electricity thrown in as a welcome by-product that could lower the cost of manufacture (in some cases considerably).

The great spurt of interest in hydrocarbon fuel cells makes it appear likely that workable systems, based on products from or fractions of petroleum and natural gas, are not too far from realization. Considering that high-octane gasoline is now being made from crude petroleum at a

reasonably low cost, "tailor-made" fuel-cell fuels from petroleum and methane should be reasonably priced if they are found to be most suitable for fuel-cell consumption.

Hydrocarbon-based fuel cells, particularly those with air cathodes, appear to hold the greatest promise for industrial and domestic, stationary and mobile applications. Although the basic fuel-cell systems for these reactants are already available—the low- and high-temperature cells described—the future fuel cell, operating on organic compounds and air, will differ from the present types about as much as a jet plane differs from that of the Wright brothers.

A considerable amount of research and development is needed before a practical, long-lived, dependable fuel cell of this kind can be realized. For example, more active air electrodes and methods for increasing the flow of oxygen to the electrodes must be found. Homogeneous and heterogeneous catalysis may fulfill these needs as well as that for more active and poison-resistant fuel electrodes. The British Shell laboratories have announced development of better electrodes, but no details have been divulged as yet.

Electrolytes with more desirable properties must be found, particularly materials having higher electrical conductivity and low-temperature liquids that are not affected by carbon dioxide. Membranes, if used, must be durable and

permit higher current densities. Refractory electrolyte matrices must be more resistant to thermal shock. Fuel-cell packs or batteries must be leak-proof and engineered for minimum weight and volume, if this is a critical consideration, or for maximum efficiency in stationary uses, or for necessary short-time overloads.

More Basic Research Required To Speed Device Design

Basic research, much of it supported by armed forces contracts and grants, in electrochemistry, catalysis, and other facets of science is being carried out at many universities, research institutions, and company laboratories. Scientists at the Army's Signal Corps, Ordnance, and Engineers laboratories as well as at the Naval Research Laboratory are also working on some of these problems. Nevertheless, a great deal more basic research will be needed to obtain sufficient insight into the chemistry of fuel-cell reactions for a rational development and engineering effort. The latter will undoubtedly require adapting newly developed materials and processing methods for the creation of optimum fuel-cell packs for each application.

Even for electro-metallurgical purposes, in which fuel-cell outputs might be used without modification, new control equipment will probably have to be developed for regulating the low-voltage, high-amperage dc. Novel electrical equipment will be all the more necessary for such applications as vehicles and power stations. Developments in dc motors, regulators, and "transformers" (to higher voltages and/or ac) will undoubtedly be stimulated by the prospect of practical fuel cells. Thus, a minor revolution in dc electrical engineering is a likely by-product of the realization of a 160-year old dream. ■ ■

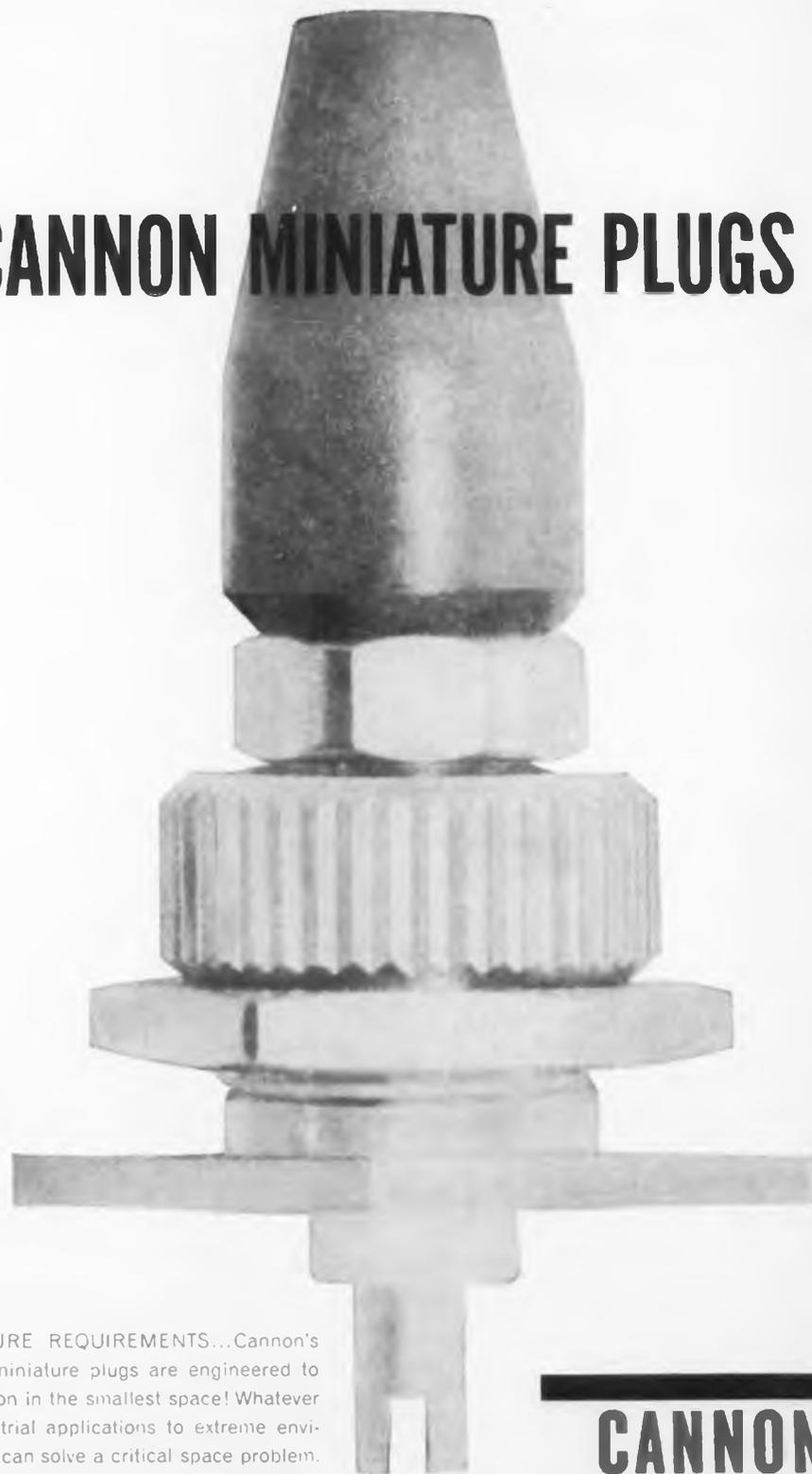
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2. "Fuel Cells. Power for the Future," by D. R. Adams et al., Fuel Cell Research Associates, P. O. Box 157, Cambridge 38, Mass., 1960. This is the only book specifically oriented toward the economic future of fuel cells. It also contains a good technical review.
3. "Status Report on Fuel Cells," by B. R. Stein, Office of Technical Services publication PB 151,804, Dept. of Commerce, Washington 25, D.C. Issued by the Army Research Office, this is the first report of a series intended to collect and review all available information in this field. Details on systems using unusual fuels and oxidants will be found here. The second report should become available from the same source early in 1961 as PB 171, 155. Subsequent reports, to be compiled by the U.S. Army Signal Corps, will also include patent literature.

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Silicon Solar Cells—Tapping Power from the Sun

On a sunny day in Arizona, it is estimated that 1,000 w of energy fall on each square meter of the earth's surface. With the present 10 to 14 per-cent efficiency available from silicon solar cells, more than 100 w per square meter could be harnessed for power applications. Cost is still high per cell but research efforts promise a significant reduction within several years.

Jerome Kalman

General Manager
Solar Systems, Inc.,
Skokie, Ill.

DIRECT CONVERSION of solar energy into electrical energy is presently best achieved by use of silicon solar-energy converters, or solar cells, developed by the Bell Telephone Laboratories in 1954. Advancements in technology and production techniques by licensed manufacturers have resulted in the high-efficiency solar cells powering electronic equipment on most of the American satellites.

To understand fully the advantages of solar converters requires an appreciation of what goes into making them. Very thin wafers (0.020 in.) are sliced from an arsenic-doped silicon ingot which provides a blank of n-type silicon. The wafer is exposed to a highly controlled, high-temperature (1,200 C) boron atmosphere and a diffusion action takes place wherein an extremely

thin layer of boron atoms (0.0001 in.) is formed on the surface of the silicon wafer resulting in a p-type silicon, see Fig. 1. This operation creates a built-in electric field within the wafer in the form of a p-n junction and this field supplies the force which will result in the conversion of light energy into electrical energy. One surface of the wafer is treated so that the boron layer is removed and the n-type silicon material is exposed. Nickel plated contacts are deposited on the wafer in order to make electrical connection; and finally, a solder coating is applied to the nickel surfaces to allow for ease of soldering. Among the current commercial manufacturers of solar cells are International Rectifier Corp., Hoffman Electronics Corp., Texas Instruments, and Solar Systems, Inc. Other companies contemplate commercial production in the near future.

In the fabrication of the solar cell, only atomically pure materials are used. The basic ingredient is silicon which is one of the most abundant materials found on the surface of the earth.

In no case is anything added which has a finite lifetime; as a result, theoretically, the silicon solar cell should have limitless operation in regards to time.

Light energy consists of discrete bundles of energy or photons. The photon has an amount of energy inversely proportional to its wave length, and in order for a photon to cause an effect within the solar cell, it must have sufficient energy to create a hole-electron pair. When light energy strikes the active surface of the solar cells, those photons with sufficient energy impart this energy within the solar cell in the creation of a hole-electron pair. Those pairs in the region of the p-n junction are acted upon by the built-in force; holes are forced into the p-region and electrons into the n-region. An unbalance of the charge carriers within the silicon thus results with a consequent potential voltage developed across the solar cell. If a load is connected between the positive and negative contacts of the cell, a current will flow due to the potential voltage that

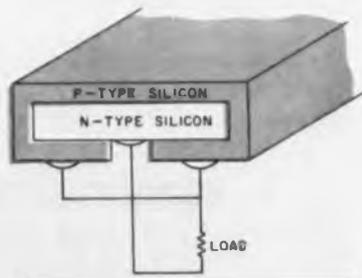


Fig. 1. Cross-sectional view of an arsenic-doped silicon slab (n-type) with a diffused boron layer (p-type) deposited on its surface.

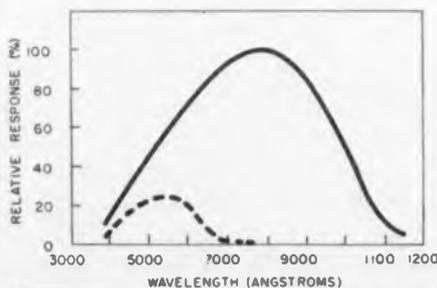


Fig. 2. Spectral response characteristic of silicon and selenium solar cells.

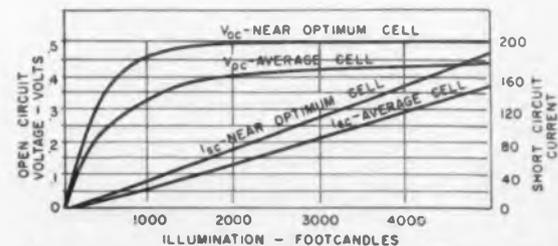


Fig. 3. Short-circuit current, I_{sc} , varies almost linearly with illumination while open-circuit voltage, V_{oc} , flattens out and soon reaches a steady value.

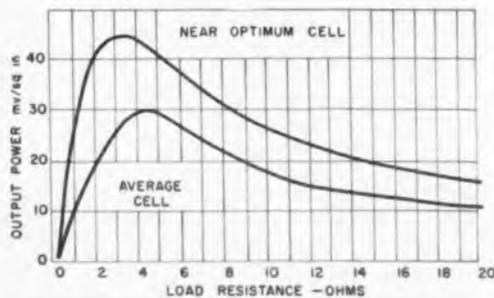


Fig. 4. An optimum load resistance value is indicated in the graph shown; illumination is 5,000 ft-c.

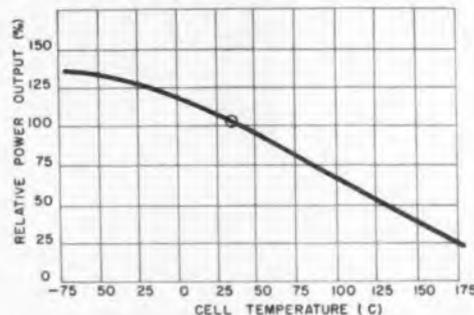


Fig. 6. Variation of silicon solar cell maximum power output with temperature.

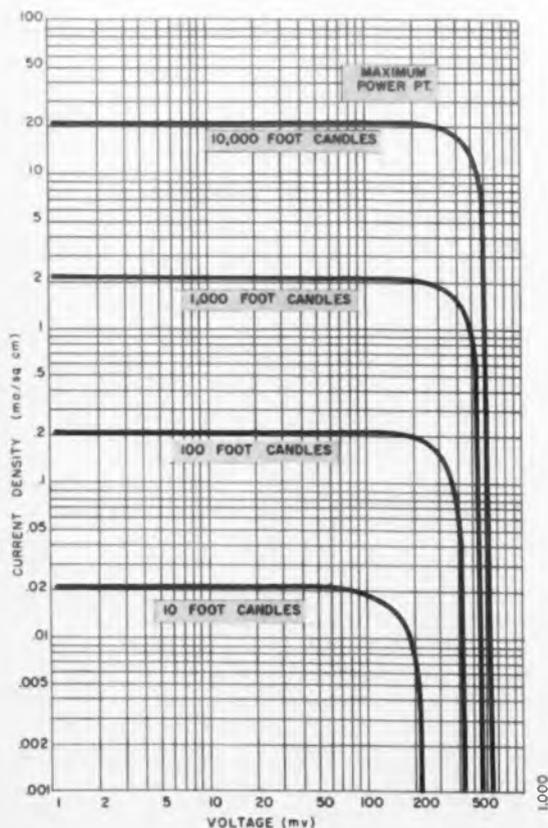


Fig. 5. Typical current-voltage characteristics of a silicon solar cell at various illumination levels.

exists due to the incident photons. Thus, light energy is directly converted into dc electrical energy.

The solar cell is in reality a silicon photovoltaic energy converter. The fact that it favors photon energy in the range of the solar spectral energy distribution (Fig. 2) led to the application of the word "solar" and in the interests of brevity, "solar cell."

The ability of a solar cell to convert light energy is expressed in terms of "conversion efficiency." This represents true efficiency since it indicates the power output per active area of a solar cell divided by the power input per unit area; the power output is measured at the point of maximum power transfer since this represents the point of optimum design. The solar cell is capable of delivering a maximum current (short circuit current), or a maximum voltage (open circuit voltage), or any combination of current and voltage less than the maximums indicated, see Fig. 3. This characteristic must certainly be considered as an advantage since no other converter exhibits such versatility in regard to the applicable load conditions. In the case of space applications, the requirement is for maximum power output per unit area and the load impedance is designed to be that coincidental with the maximum power transfer point of the solar cell, see Figs. 4 and 5.

In the measurement of conversion efficiency, correlation between laboratory-light standards and the solar-energy spectrum has been attempted. On a cloudless summer day at about noon, it was determined that the sun delivered approximately 100 mw per sq cm of solar energy at normal incidence to the surface of the earth. This quantity was considered to be "one sun." In the laboratory, a tungsten-type lamp was utilized operating at a color temperature of approximately 2,800 K. It was determined that the sun and the tungsten source could be made equiva-

lent. This theory has been considerably altered during the past six months since additional characteristics of the solar spectrum have been determined. This necessitates somewhat of a change in original correlation data.

Conversion Efficiency Has Tripled Within a Five-Year Period

At the inception of the solar cell, conversion efficiencies in the order of 4 to 6 per cent were achieved. Detailed studies of the solar cell's characteristics and manufacturing techniques have resulted in currently available solar cells having conversion efficiencies up to 14 per cent. This advancement certainly is outstanding when compared to achievements made in the field of other types of solar energy converters. Notable contributions to the increase in conversion efficiency are "gridding" techniques now employed by the major manufacturers of solar cells. This procedure allows for minutely thin contact strips which emanate from the positive contact of the cell and effectively increase the collection efficiency of the cell by providing "pick-up" areas over a greater amount of the solar cell's active surface. Thus, efficiency retarders such as recombination time effects and series resistance are reduced.

With the development of the gridded-type cell came a greater understanding of the solar energy spectrum as it existed in outer space. It was determined that the greater amount of solar energy in space was due primarily to contributions of energy having wavelengths lower than those favorable to the silicon solar cell. At the same time, a change in spectral response of the solar cell was noted in that the high wavelength portion of the response was shifted even farther towards the high wavelengths. Thus, although the laboratory measurements using a tungsten source indicated high efficiency solar cells, measurement in an actual solar environment indicated



Fig. 7. Wires connecting one of the four solar cell "paddles" to the interior of Pioneer V are checked before launching. Each paddle carries 600 Hoffman Electronic Corp. solar cells on each side. White stripes between cells are painted on the assembly to maintain proper temperature.



Fig. 8. A total of 1,184 cells, 360 2 by 0.5 cm and 824 1 x 2 cm, surround the telemetry transmitter in a cosmic ray detector probe. Glass slides 0.006 in. thick cover the cells to prevent possible radiation damage. The solar cells are used to recharge nickel cadmium batteries supplying 1.25 w to electronic instrumentation contained in the equipment.

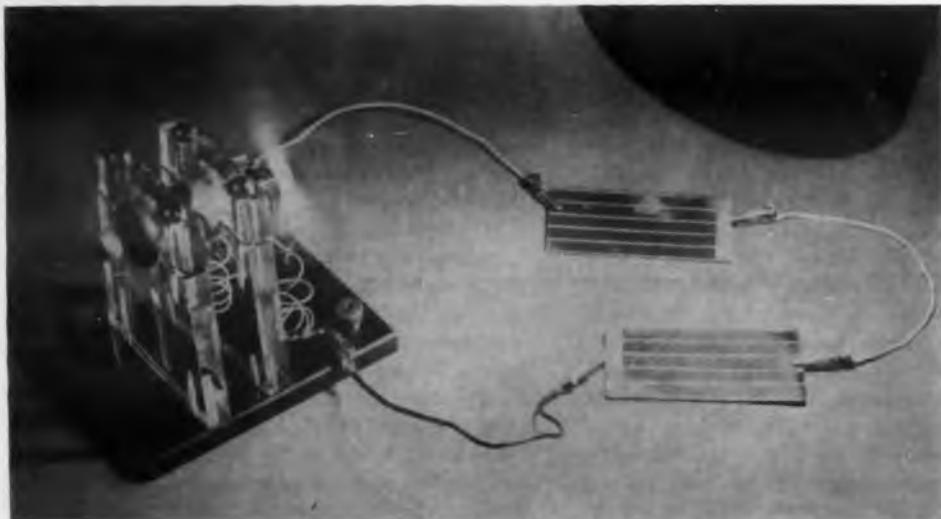


Fig. 9. A small motor is powered by 20-sq cm cadmium-sulphide single crystal solar cells made by the Harshaw Chemical Co., Cleveland, Ohio. The efficiency of single crystal cadmium sulphide cells vary from 5 to 6 per cent.

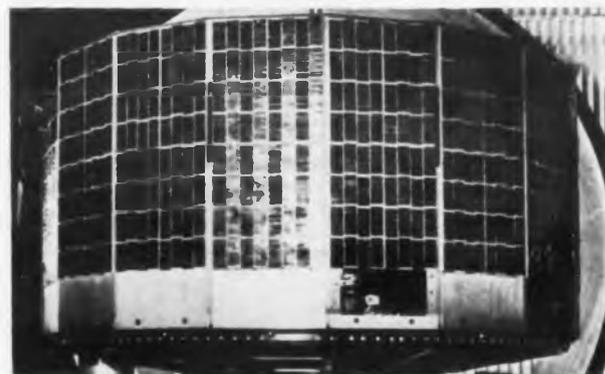


Fig. 10. Tiros I, the first U. S. weather satellite, is equipped with more than 9,000 solar cells supplied by International Rectifier Corp. (Photo courtesy RCA)

a somewhat lower gain. In order to resolve these differences, many companies (including Lockheed, GE and Bausch and Lomb) are presently working towards development of "sunlight simulators," also known as sunshine chambers. These programs have been endorsed by various military agencies who realize the necessity for accurate correlation between laboratory and space measurements. The techniques employed in making a simulator involve utilization of lamps having particular spectral energy contributions. The overall output from such a lamp assembly has to accurately simulate the spectral energy response of sunlight.

Currently Available Cells Can Provide 50 W per Lb.

Solar cells are generally mounted on a substrate which is made from extremely light metal. The geometry of such a substrate is predicated by the type of satellite involved, the propulsion system employed, orbital conditions in which the satellite will operate and over-all power requirements of the satellite. Naturally, the strength of such an assembly is dependent primarily on the metal substrate and the adhesive used to fasten the cells to the substrate. Spectrolab, Inc., Electro-Optical Systems, Inc., Boeing and Lockheed are some of the companies involved in systems study and development.

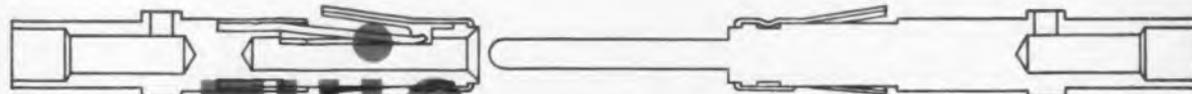


Fig. 11. The 10,640 solar cells mounted atop a 1912 Baker Electric, together with intermediate storage batteries, power International Rectifier Corp.'s solar-powered auto.

The advantage of lightness is a most important one when space power applications are involved. Power-weight ratios of 105 to 110 mw/gm or 50 w/lb are possible from 12 per cent efficient solar cells. To fully utilize this advantage, supporting structures have been designed which have high strength-to-weight ratios and low weight-to-area ratios. Some support substrates are made from honeycomb structures of aluminum and polyester impregnated fibreglass.

The power output from the solar cell decreases with increasing temperature, see Fig. 6. Consequently, design considerations encompass methods of maintaining low-temperature operation in space. That portion of the solar spectrum which is outside of the solar-cell spectral response can create a temperature increase in the solar-cell assembly. Bandpass filters have been developed in the form of interference film filters which are vacuum deposited onto glass cover slides, which are in turn cemented to the top surface of the solar cell. An ultra-violet reflecting filter serves to prevent ultra-violet degradation of the transparent adhesives while the infrared reflecting filter minimizes the heating effects of the IR energy. Although the application of such filters increases the weight of a solar-cell array, considerable improvement in power output is achieved by controlling the temperature of the device in space. Companies involved in these ef-

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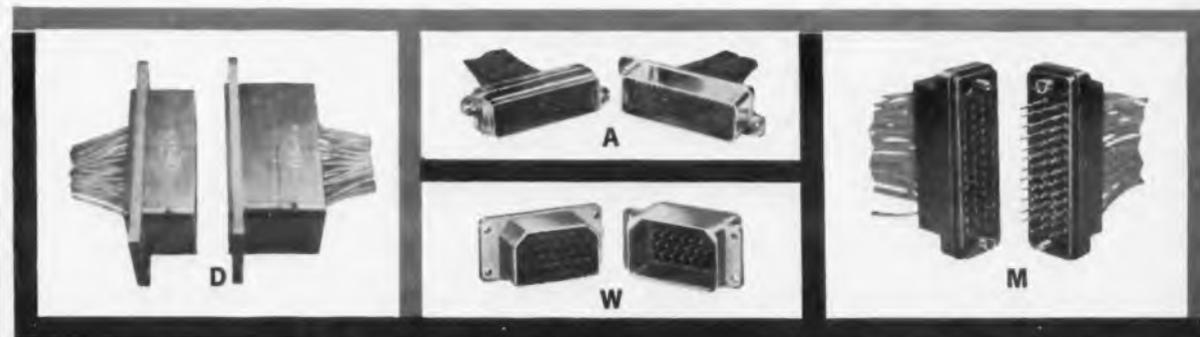
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forts include Optical Coating Laboratory, Bausch and Lomb, Corning Glass and Spectrolab.

R&D May Drop Cost Per Watt From \$300 to \$10

Costs for solar-cell assemblies vary quite considerably with cell efficiency, quantity, and general assembly designs. During the early state of development of the solar cell, cost for power converters was approximately \$1,000 per watt. Today, converters are available for from \$50 to \$300 per watt depending upon efficiency and quantity. The greatest contributions towards this price reduction have been increased yields due to improved production techniques and higher available conversion efficiencies. Further improvements in these avenues together with greater over-all usage by industry should result in available silicon solar-cell power supplies in the neighborhood of \$10 per watt.

Studies of new materials are being made in order to develop a solar cell having the ability to use a greater percentage of the solar spectrum. Gallium-arsenide cells have been made in laboratory quantities with most promising results. However, the cost of the raw material coupled



Fig. 12. Hoffman's transistor radio uses solar cells plus rechargeable battery for long period operation.

with the low production yields achieved with these cells present a formidable cost problem. The coming year should see a resolution of the problem of the feasibility of using gallium arsenide for solar cells.

More and more is being learned about the "space" around us, with each successful satellite launching. The discovery of high-energy radiation fields around the earth has prompted investigation of radiation effects on silicon solar cells. From these studies has evolved the "n on p" silicon solar cell, a device in which n-type material is diffused into p-type silicon. Although in the extremely early states of study, these "n+/p"

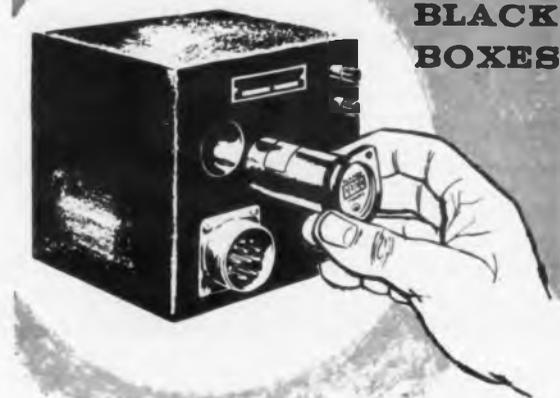
cells hold great promise of providing more consistent high-efficiency silicon solar cells which will have greater resistance to radiation damage.

Coupled with the above investigations is the study of large-area solar cells to achieve maximum reliability in a satellite system; vapor deposition of single-crystal silicon in order to minimize material cost and also allow for large area devices, and general improvements in production techniques so as to provide a maximum of consistent results. These studies, currently under way, will undoubtedly result in further improvements of silicon solar cells for use in future space power applications. ■ ■

Comparison Between Various Energy Conversion Techniques

Conversion Technique	Device Efficiency (per cent)	Advantages	Disadvantages
Batteries	85	<ol style="list-style-type: none"> 1. Compact, self-contained 2. Low cost 3. Brief energy "bursts" possible 4. Can serve extremely wide range of applications 5. Proven reliability 	<ol style="list-style-type: none"> 1. Limited shelf life 2. Limited operating life time
Fuel Cells	60-80	<ol style="list-style-type: none"> 1. Most systems not limited by Carnot cycle 2. Efficiency not dependent on size. 3. No moving parts in cell 4. Noiseless 5. No hot noxious products from most systems 6. Infinite shelf life 7. High potential power/ weight/ and power/volume 8. Fuel regeneration possible 	<ol style="list-style-type: none"> 1. Low voltage per cell 2. Energy "bursts" not possible 3. Limited operative life 4. Low activity of oxygen electrode 5. Fuels are expensive 6. High internal resistance
Solar Cells	10-14	Same as 3, 5, 6 and 7 plus free source of power	<ol style="list-style-type: none"> 1. Low output impedance 2. Performance limited by temperature 3. Orientation towards light source required for high efficiency 4. Energy storage means needs for continuous duty applications

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Compared to a conventional-type 2N706 silicon-switching transistor, the epitaxial 2N743 is more than twice as fast at 10 ma and four times faster at 100 ma (Fig. 1); cost-wise, the 2N743 is about ten per cent higher than the 2N706. In a saturated mode, total switching time (typical) for the 2N743 is 26 nsec at 10 ma and 24 nsec at 100 ma; maximum switching time is 40 nsec at 10 ma and 52 nsec at 100 ma. For the 2N744, typical switching time is 27 nsec at 10 ma and 29 nsec at 100 ma; maximum switching time is 40 nsec at 10 ma and 57 nsec at 100 ma. Storage time is 14 nsec (max) for the 2N743 and 18 nsec (max) for the 2N744. A comparison of the switching characteristics of the conventional 2N706 vs the epitaxial 2N743 is shown in Fig. 2.

The maximum saturation voltage of the 2N743 is essentially constant at 1 v from -55 to $+170$ C; V_{CE} of the 2N706 at 100 ma varies from 2.2 v at

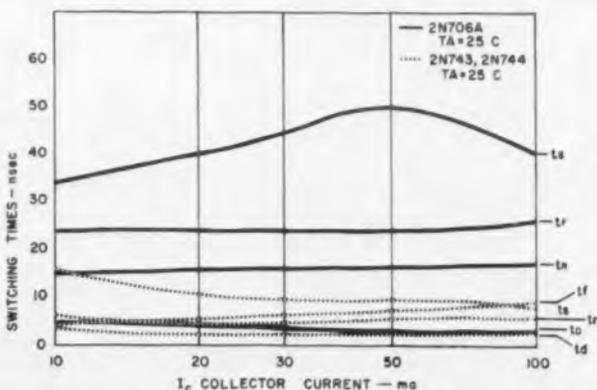


Fig. 1. Comparison of rise, fall, storage and delay times of the epitaxial 2N743 switch vs the conventional-structure 2N706.

THIS IS HOW RESISTORS OUGHT TO LOOK. THIS IS HOW RESISTORS OUGHT TO WORK. CORNING NF RESISTORS DO.

Glass-enclosed, fusion-sealed Corning NF resistors have boiled merrily in salt water for days without showing a jot of change in their electrical characteristics.

These are resistors that are rugged, completely moisture resistant, highly vibration resistant . . . in short, resistors that exceed the requirements of MIL-R-10509C, Char. B, better than any we've seen or heard of.

The key to such fortitude is our NF structure. We start with glass rods with metal oxide applied under heat. This in itself makes a moisture-resistant, almost abnormally stable resistor, as you well know if you have ever used our regular N-style resistors.

We encapsulate this basic unit in a glass envelope and apply glass-to-metal seals at the leads . . . comparable to those in a vacuum tube.

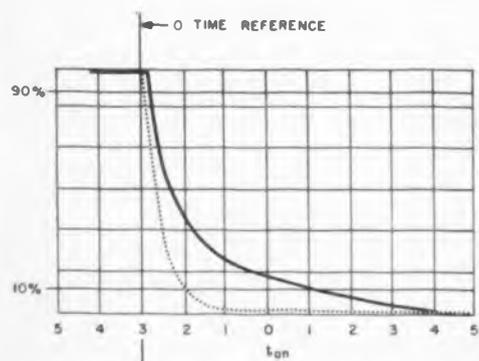
IMMEDIATE DELIVERY • There are two models of this

gem in production, ready for *quick shipment*: the 1/8-watt NF-60 and the 1/4-watt NF-65. Resistance ranges from 100 ohms to 360K ohms. Voltage ratings are 250v and 300v. Full rating at 70°C. with derating to 150°C.

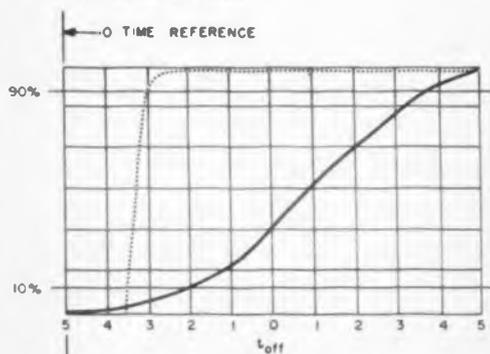
More typical values:

Load life	0.3%
Voltage coefficient	0.001%/v
Temp. coefficient	0.015%/°C
Insulation resistance	100,000 megohms

To get these and other data for your file, just write and ask for Data Sheet CE-2.02. Address: Corning Glass Works, 540 High Street, Bradford, Pennsylvania.



— 2N706 CONVENTIONAL MESA SWITCHING TRANSISTOR
 - - - 2N743 EPITAXIAL SWITCHING TRANSISTOR
 VERTICAL— $I_c = 100$ ma
 HORIZONTAL—5 nsec / DIV



— 2N706 CONVENTIONAL MESA SWITCHING TRANSISTOR
 - - - 2N743 EPITAXIAL SWITCHING TRANSISTOR
 VERTICAL $I_c = 100$ ma
 HORIZONTAL 10 nsec / DIV

Fig. 2. The improved switching characteristics offered by the epitaxial 2N743 are dramatically demonstrated in their comparison with those of the 2N706.

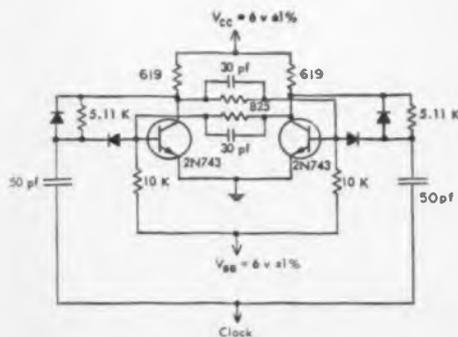


Fig. 3. A 10-mc counting flip-flop, requiring a 3-v trigger, designed to operate from -55 to $+125$ C.



CORNING ELECTRONIC COMPONENTS

CORNING GLASS WORKS, BRADFORD, PA.

CIRCLE 56 ON READER-SERVICE CARD

Oster

new size 11 servo motor

For 400 Cycle Airborne & Ground Control Applications



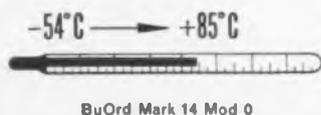
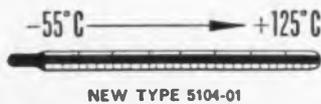
1
SHORTER than Mark 14 Mod 0



2
LIGHTER than Mark 14 Mod 0



3
HIGHER TEMP than Mark 14 Mod 0



4
BETTER FINISH than Mark 14 Mod 0—Tests show that New Type 5104-01's passivated bright finish resists corrosion at least as effectively as black oxide.

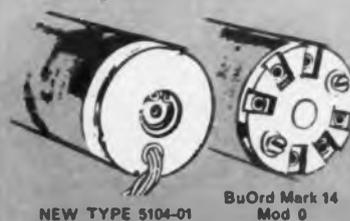
New Type 5104-01 has the same electrical characteristics as Mark 14 Mod 0

EXCITATION FREQUENCY	ROTOR INERTIA	TIME CONSTANT	MAX. STARTING VOLTAGE
400 cps	1.07 gm.cm. ²	15.6 ms	2.6%

	FIXED PHASE		CONTROL PHASE	
	NEW TYPE 5104-01	BUORD MARK 14 MOD 0	NEW TYPE 5104-01	BUORD MARK 14 MOD 0
Input Current	53 ma	53/106 ma	53 ma	53/106 ma
Input Voltage	115V	115/57.5V	115V	115/57.5V
Power at Stall	3.5W	3.5W	3.5W	3.5W
Resistance (R) at Stall	1250 Ohms	1250/312 Ohms	1250 Ohms	1250/312 Ohms
Reactance (X) at Stall	1780 Ohms	1780/445 Ohms	1780 Ohms	1780/445 Ohms
Impedance (Z) at Stall	2175 Ohms	2175/544 Ohms	2175 Ohms	2175/544 Ohms
Effective Resistance (R) at Stall	3800 Ohms	3800/950 Ohms	3800 Ohms	3800/950 Ohms
Nominal Capacity for Unity PF	0.16 mfd.	0.16/0.64 mfd.	0.16 mfd.	0.16/0.64 mfd.

Meets ARP 487. Stainless steel housing used.

5
HIGHER RELIABILITY at LOWER COST than Mark 14 Mod 0—Achieved by eliminating terminal board arrangement and utilizing lead wires.



For your higher reliability, advance design requirements in rotating components, contact your nearest John Oster office.

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Engineers For Advanced Projects:
Interesting varied work on designing transistor circuits and servo mechanisms. Contact Mr. Dallas Nielsen, Personnel Manager, in confidence.

CIRCLE 57 ON READER-SERVICE CARD

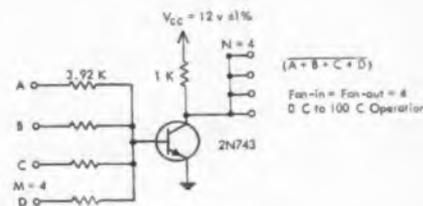


Fig. 4. The maximum operating frequency of the NOR gate shown is 1 mc for two cascaded logic stages.

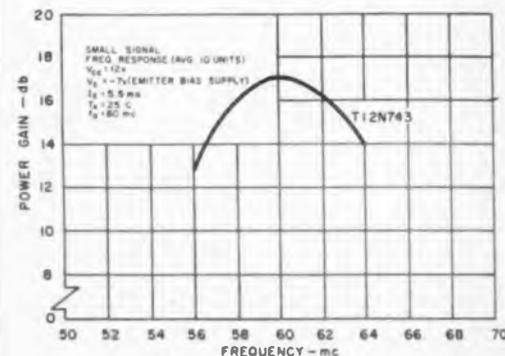
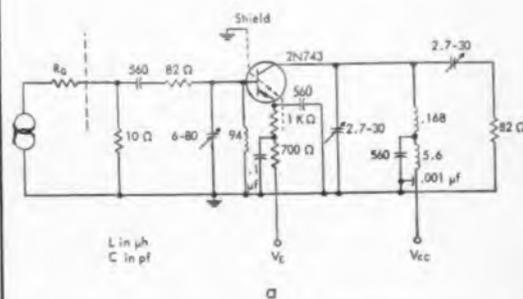


Fig. 6. (a) The small signal, 60-mc amplifier shown is operated common-emitter at the signal frequency and common-base for biasing. The response curve is shown in (b).

25 C to 4 v at 170 C. The low saturation resistance of the epitaxial devices makes them suitable for switching tasks previously requiring medium-power transistors of conventional structure.

The forward current ratio, h_{FE} , for the 2N743 is specified as 10 (min) at 1 and 100 ma and 20 (min) to 60 (max) at 10 ma. Values for the 2N744 are 20 (min) at 1 and 100 ma and 40 (min) to 120 (max) at 10 ma. Typical capacitance values for both types are 3.5 pf at 5 v and f_t (typical) is rated at 400 mc. In quantities of 100 to 999, the 2N743 is priced at \$13.95, the 2N744 at \$15.35.

Typical Computer and RF Amplifier Circuits

The low storage time and low saturation voltage associated with epitaxial transistors are used to advantage in computer circuit design. A flip-

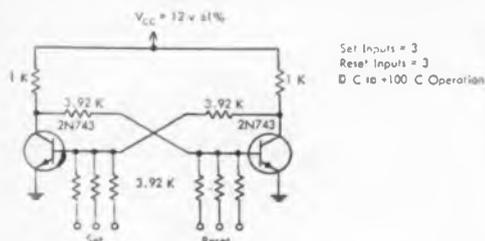
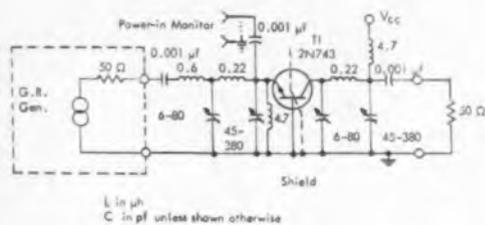


Fig. 5. A direct-coupled flip-flop using TRL with a single power supply.

TEST CONDITIONS

$V_{CC} = 12\text{ v}$
 $f = 70\text{ mc}$
Common Base



RESULTS
(10 UNIT AVE.)

P_{out} (mw)	Power Gain (db)	DC Power	Coll Eff. %	Dist. (mw)	Total Device Dist. (mw)
513	6.0	772	65	257	386

Fig. 7. Schematic of a 70-mc class-C amplifier, with 6-db power gain, capable of 0.5-w output.

flop for 10-mc operation over a -55 to $+125$ C range is shown in Fig. 3; improved wave shapes and operation to 150 C could be achieved by adding an emitter-follower to the output.

A NOR gate, designed for medium-speed applications up to 100 C, is shown in Fig. 4. The low storage time of the epitaxial device eliminates the need for a turn-off base bias supply. The circuit operates at 10-ma collector current, the region of maximum gain and high switching speed. Two NOR circuits can be combined to form a direct coupled flip-flop as shown in Fig. 5.

The low collector-base capacitance and high f_t of the epitaxial transistor may be used to advantage in vhf amplifiers. A small signal, 60-mc amplifier is shown in Fig. 6a; the 82-ohm resistors approximate the input resistance of the transistor. The frequency response curve, Fig. 6b, illustrates the 17-db gain for an unneutralized stage suitable for communication and pulse applications. Another amplifier, designed to deliver 0.5 w at 70 mc is shown in Fig. 7, featuring high efficiency and gain from a 12-v supply.

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

General Instrument Semiconductor... Exclusive!

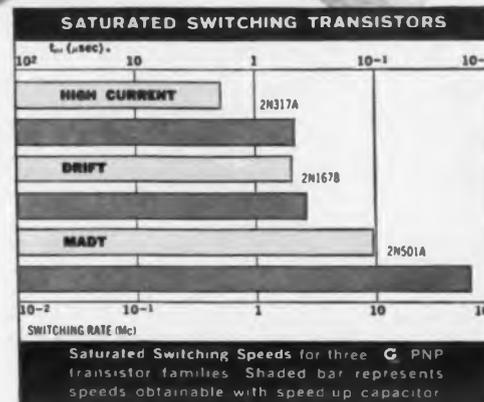
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Only General Instrument offers the MADT, Drift, and Alloyed-Junction Transistors for all your switching needs! The new **G** MADT completes the entire switching spectrum from dc to 50 Mc, as illustrated above. **G** computer semiconductors are immediately available, realistically priced, and produced by advanced manufacturing techniques to assure highest quality and long life.

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General Instrument is your single source of supply for a full range of germanium computer transistors, companion diodes, logic encapsulations and rectifiers. In addition **G** provides complete engineering and reliability design data. The abbreviated specifications below, for exam-

ple, illustrate the range of data available from **G** on its entire line of computer semiconductors. Write today for device information, engineering data and applications assistance on your special computer problems. Contact General Instrument for the name of your local stocking distributor.



RATINGS and CHARACTERISTICS	ALLOYED-JUNCTION		DRIFT		MADT	
	Conditions	2N317A	Conditions	2N1678	Conditions	2N501A
RATINGS		20 v 20 v 180 mw 100°C		60 v 4 v 120 mw 85°C		18 v 2 v 60 mw 100°C
CHARACTERISTICS						
t_{on}	$V_{CE} = 5\text{ v}$	2 μs max	$V_{CE} = 10\text{ v}$	5 μs max	$V_{CE} = 5\text{ v}$	5 μs max
t_{off}	$I_C = 400\text{ ma}$ $V_{CE} = 0.25\text{ v}$	20 min 60 max	$I_C = 20\text{ ma}$ $V_{CE} = 0.25\text{ v}$	25 min	$I_C = 10\text{ ma}$ $V_{CE} = 0.5\text{ v}$	20 min
t_{sw}	$V_{CE} = 5\text{ v}$ $I_C = 1\text{ ma}$	20 Mc typ	$V_{CE} = 5\text{ v}$ $I_C = 20\text{ ma}$ $V_{CE} = 0.25\text{ v}$	28 Mc min 80 Mc typ	$V_{CE} = 0.5\text{ v}$ $I_C = 2\text{ ma}$	130 Mc typ*
$V_{CE(sat)}$	$I_C = 400\text{ ma}$ $V_{CE} = 0.25\text{ v}$	0.95 v max	$I_C = 20\text{ ma}$ $V_{CE} = 0.25\text{ v}$	0.6 v max	$I_C = 10\text{ ma}$ $I_B = 1\text{ ma}$	0.45 v max
$V_{CE(max)}$	$I_C = 400\text{ ma}$ $I_B = 40\text{ ma}$	0.2 v max	$I_C = 20\text{ ma}$ $I_B = 0.8\text{ ma}$	0.25 v max	$I_C = 10\text{ ma}$ $I_B = 1\text{ ma}$	0.20 v max
$t_{on}(r-t)$	$I_C = 400\text{ ma}$ $I_{C(max)} = 20\text{ ma}$ $I_{B(max)} = 10\text{ ma}$ $V_{CE} = 5\text{ v}$	600 nS max	$I_C = 20\text{ ma}$ $I_{C(max)} = 1\text{ ma}$ $I_{B(max)} = 1\text{ ma}$ $V_{CE} = 20\text{ v}$	400 nS typ	$I_C = 20\text{ ma}$ $I_{C(max)} = 2.2\text{ ma}$ $V_{CE(max)} = +0.5\text{ v}$	13 nS typ
$t_{off}(r-t)$		1200 nS max		400 nS typ		14 nS typ

*Gain-bandwidth Product.

†T. M. Philco-GI Micro Alloy Diffused-base Transistors Are Fully Licensed Under Philco Patents

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SEMICONDUCTOR
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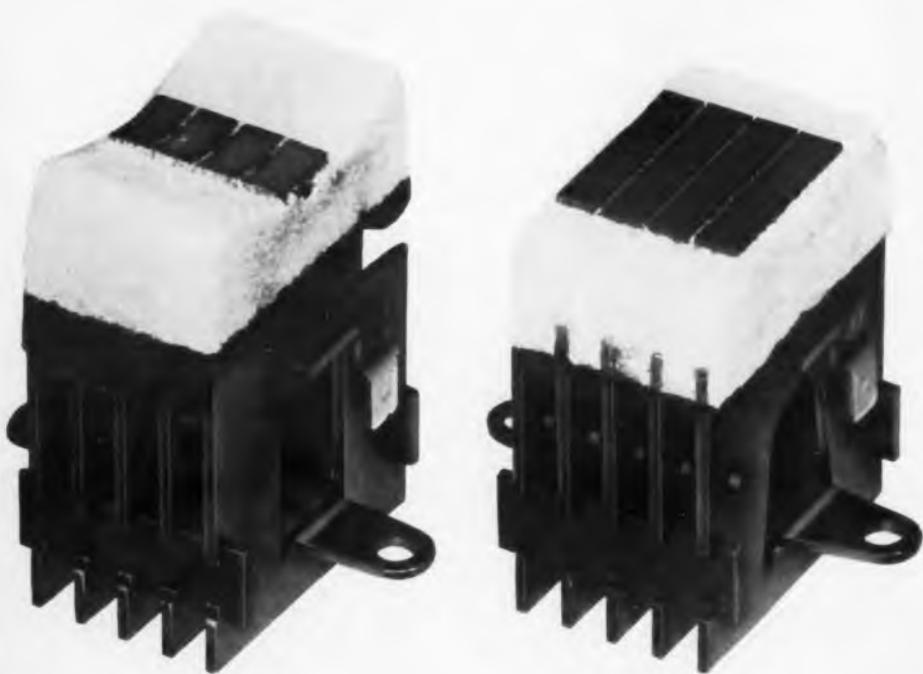
IN CANADA: General Instrument—F. W. Sickles of Canada Ltd., P.O. Box 406, 151 S. Weber Street, Waterloo, Ontario, Canada, Sherwood 4-6101.

CIRCLE 58 ON READER-SERVICE CARD



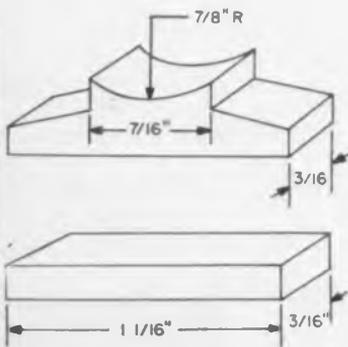
NOW — A BEAM PENTODE
TO REPLACE
400-WATT TETRODES

CIRCLE 59 ON READER-SERVICE CARD



Compact spot coolers bring thermoelectric cooling into practical price range. The white substance around the heads is an epoxy-foam resin.

Low-Cost Thermoelectric Spot Cooler For Sale—Off the Shelf

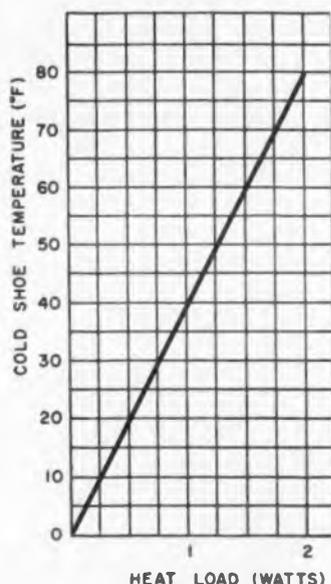


Cold-shoe dimensions for 3M's Model 10-J (top) and 10-L.

COOLING hot spots in electronic equipment is now a practical matter with a new thermoelectric spot cooler. At relatively low cost, the small cooler can pump as much as two thermal watts. Two or more coolers can be used for higher heat loads.

Manufactured by Minnesota Mining and Manufacturing Co. (3M), of 900 Bush Ave., St. Paul, Minn., the cooler, designated Model 10, comprises four sets of efficient, thermoelectric, pn couples, a copper cooling fin, and a cold shoe. A model 10-J has a 7/8-in.-radius, concave, copper cold shoe while a model 10-L has a flat copper shoe.

In addition to the two basic models, 3M offers custom designs for special applications. For



Typical cooling performance of the spot cooler with a heat sink of 77 F forced air. The curve reflects actual operation and includes practical, heat-transfer losses due to thermal contact resistance and thin electrical resistance materials.

example, thermostats can be imbedded in the coolers for temperature control; additional couples and cooling fins can be added to increase cooling capacity; or provisions can be added for liquid cooling of the fins. Normally the fins are cooled by forced air.

The couples and the cold-shoe contacts are imbedded in a closed-cell, epoxy-foam resin, which provides thermal insulation, physical strength, and moisture protection. Cooling efficiency with either model can be raised by improving the surface contact between the cooler and the device being cooled. A silicone grease or epoxy resin can help provide intimate surface contact.

Any reasonably flat, low-voltage dc supply, even a low-ripple battery eliminator, can be used to power one of these spot coolers. Maximum cooling efficiency results with a supply of about 6 v at 8 amp.

In small quantities, up to about 10 units, the coolers are available on immediate delivery. Unit cost is \$35 for quantities up to 9, \$26 for quantities from 10 to 99, and \$20 for 100-unit cooler lots.

For more information on these thermoelectric spot coolers, turn to the Reader-Service Card and circle 252.

Borg Microdials feature digital readout for increased readability and accuracy



MINIMIZE HUMAN READING ERRORS

THREE, FOUR and FIVE-DIGIT MODELS

Borg Direct-Reading Microdials provide faster, more accurate turns-counting readability. They indicate the precise shaft positions of potentiometers or any multiturn device of up to 1,000 turns. Digital readout minimizes human reading errors. The 1330 Series (*above right*) features internal illumination — red light for dark adapted environments or white light. Colors add style to control panels and instruments. Three-digit, ten-turn model with finger-tip brake is standard. All 1330 models display numerals through lenses (1.5x magnification) which are curved for wide-angle viewing. The 1300 Series (*center and bottom right*) is available in three-digit ten-turn, four-digit 100-turn and five-digit thousand-turn models with or without finger-tip brakes. Your nearest Borg technical representative or distributor has complete data.

BORG EQUIPMENT DIVISION

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

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

CIRCLE 60 ON READER-SERVICE CARD



1330 Series
Three-Digit
Ten Turns



1300 Series
Three-Digit
Ten Turns



1300 Series
Five-Digit
1,000 Turns

CONFIGURATIONS

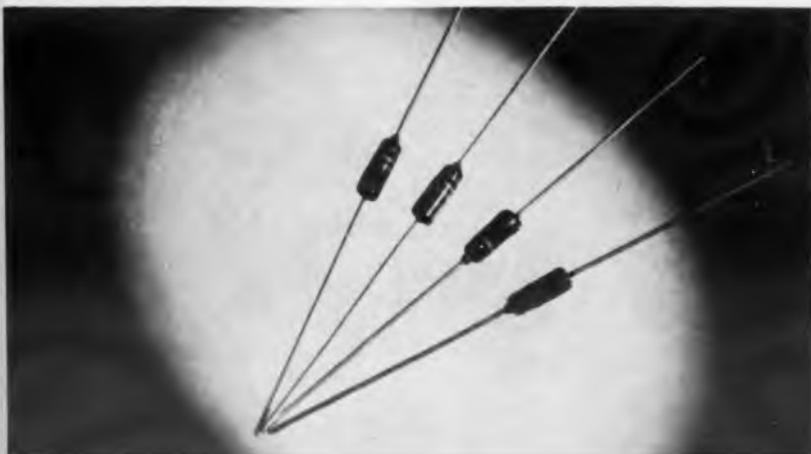
1330 SERIES				
Model No.*	No. Digits	No. Turns	Brake	Color
1331	3	10		Dark Gray
1332	3	10	X	Light Gray
1333	3	10	X	Red
1334	3	10	X	Black
1335	3	10	X	White

*All models available with or without internal illumination — red light (add suffix LR) or white light (LW).

1300 SERIES				
Model No.	No. Digits	No. Turns	Brake	Color
1309	3	10	X	Black
1310	3	10		Black
1304	4	100		Black
1314	4	100	X	Black
1305	5	1,000		Black
1315	5	1,000	X	Black

NEW PRODUCTS

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



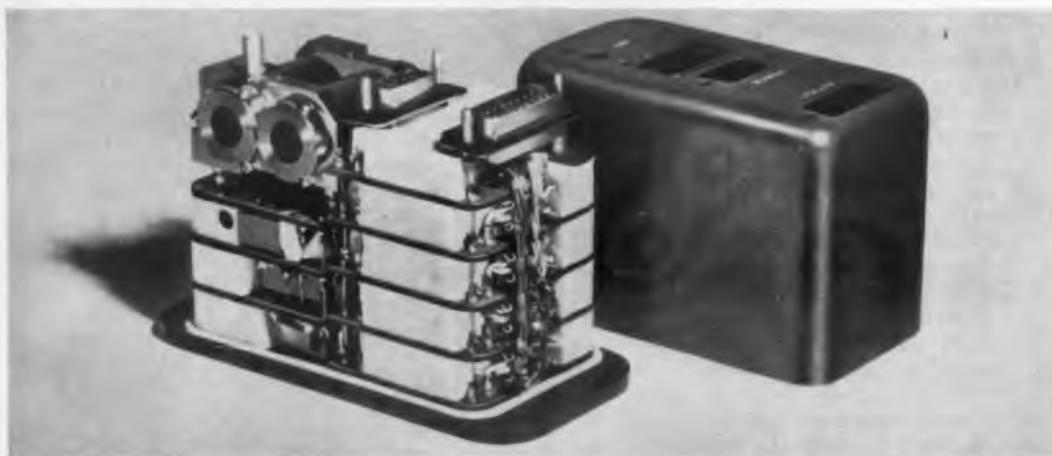
High-Voltage Silicon Diode 254 Has Low Leakage

Type 1N645B high-voltage silicon diode features extremely low leakage. The reverse current is typically 0.025 μ a at 225 v. It provides 400-ma average rectified current, 225 v piv and 600-mw power dissipation. The diode is recommended for such applications as magnetic amplifiers, modulators, demodulators and power supplies.

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

Price: \$4.50 in 1 to 99 quantities.

Availability: From stock.



Command Receiver Weighs 24 Oz

255

The Veri-Min command receiver is a solid-state, dual-conversion, super-heterodyne set designed to receive tone-modulated fm signals in the frequency range of 406 to 450 mc. It weighs 24 oz and displaces 17.9 cu in. In its standard form it has four channels and contains four decoder assemblies. Environmental specifications are: operating temperature, -55 to $+75$ C; shock, 100 g for 4 msec; acceleration, 100 g. Electrical characteristics include: sensitivity, 5 μ v; noise figure, less than 17 db; audio response, ± 1 db, 7 to 22 kc.

Leach Corp., Communications Div., Dept. ED, 18435 Susana Road, Compton, Calif.

Availability: 90 days.

Price: Upon request.



Microminiature Transmitter Displaces 0.026 Cu In.

256

This microminiature transmitter is so small it has been mounted as a tooth in a dental bridge for research. It displaces 0.026 cu in. and weighs 1.2 g. Constructed by a vapor-deposition process, the unit has an output of 50 to 100 kc with a signal-field intensity of 0.002 amp per meter at 0.3 meter range. Input, from a mercury cell battery is 1.2 ma at 1.34 v. Temperature range is $+10$ to $+55$ C. One mercury cell will give 24 hr of operation.

Varo, Inc., Dept. ED, 2201 Walnut St., Garland, Tex.

Price: \$225 in quantities of 1 to 10.

Availability: 45 days.



**Precision Current Source 257
Delivers From 0.1 μ a to 150 ma**

Model CS-140 current governor furnishes 0.1 μ a to 150 ma for load voltages from 0 to ± 100 v. Current may be set to six places by decade knobs arranged to provide 1 ppm resolution. Accuracy at any current setting is 0.01% full scale. Line and load regulation are better than 0.0025% for dc outputs. It may be used as an ac current source from dc to 6 kc with an external modulating signal.

North Hills Electronics, Inc., Dept. ED, Alexander Place, Glen Cove, N.Y.

Price: \$3,250.

Availability: From stock.



**Digital Voltmeter Has 258
"Full-Time" High Impedance**

The series 5000 transistorized digital voltmeter has an input impedance of 2,000 meg that does not depend upon a null condition within the instrument. This "full-time" impedance prevents excessive loading of circuits when the instrument probe is first applied. An average of 200 readings per second is achieved with 0.01% accuracy. Solid-state amplifiers are used to achieve the high input impedance and for precise sign changing. The unit also has decimal and binary-coded decimal outputs for driving a variety of accessories.

Electronic Associates, Inc., Dept. ED, Long Branch, N.J.

Availability: 30 days.

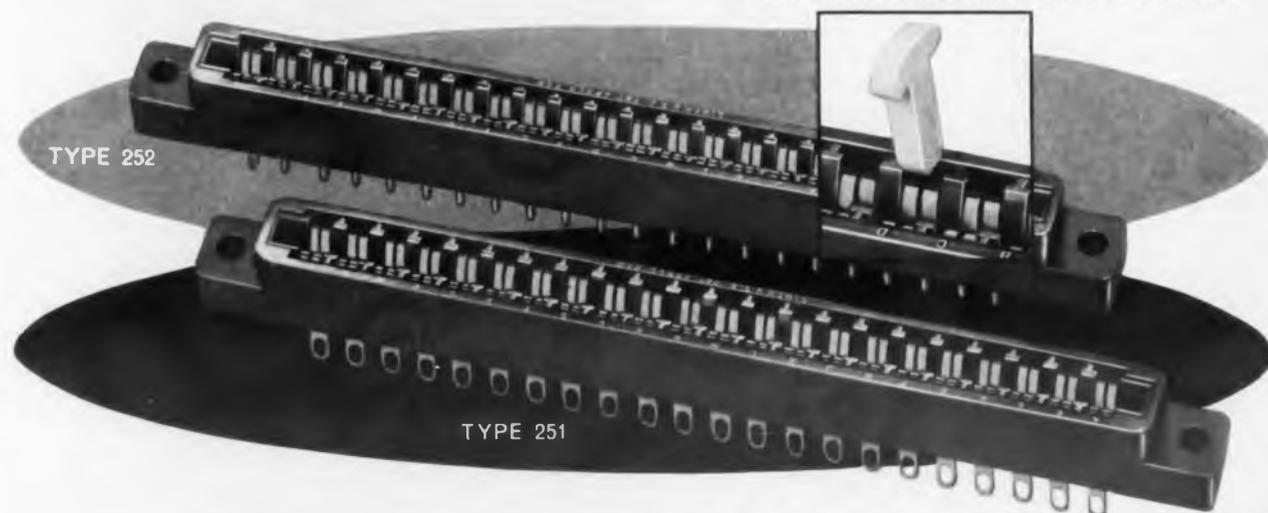
**NEW FROM
CINCH...**

BIFURCATED

Printed circuit

board edge connectors

to maintain positive contact!



NOW AVAILABLE FOR IMMEDIATE DELIVERY! Bifurcated Contact Connectors with two flexing surfaces instead of one to provide positive contact! . . . accommodate irregularities in Printed Circuit Boards.

TWO TYPES—conventional wiring tail (type 251) or dip solder (for .051 dia. hole) (type 252) . . . with 6 to 25 contact positions (12-50 contacts).

INSULATION—glass filled diallyl phthalate type GDI 30 per MIL-M-19833.

POLARIZING KEYS—can be supplied loose, or inserted in any position designated.

FINISHES—phosphor bronze or beryllium copper00003 Min. Sel-rex. gold plated.

PART NUMBERS—customer part numbers imprinted when required.

MEETS MIL-C-2109A (ships) specs for printed wiring board connectors

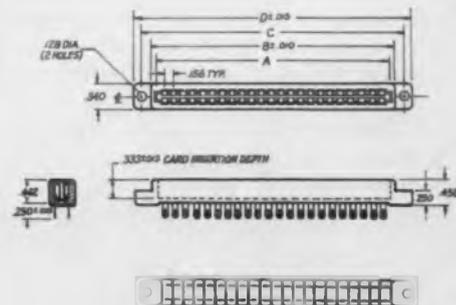
WRITE FOR FULL INFORMATION TODAY! Complete details and performance specifications on new Bifurcated Cinch Printed Circuit Board Edge Connectors are available for the asking. Write for full information now.



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Centrally located plants at: Chicago, Illinois; Shelbyville, Indiana; City of Industry, California and St. Louis, Missouri



Contact* Positions	DIMENSIONS			
	A	B	C	D
6	1.098	1.239	1.531	1.785
7	1.254	1.395	1.687	1.941
8	1.411	1.552	1.844	2.098
9	1.567	1.708	2.000	2.254
10	1.723	1.864	2.156	2.410
11	1.879	2.020	2.312	2.566
12	2.036	2.177	2.469	2.723
13	2.192	2.333	2.625	2.879
14	2.348	2.489	2.781	3.035
15	2.504	2.645	2.937	3.191
16	2.661	2.802	3.094	3.348
17	2.817	2.958	3.250	3.504
18	2.973	3.114	3.406	3.660
19	3.129	3.270	3.562	3.816
20	3.286	3.427	3.719	3.973
21	3.442	3.583	3.875	4.129
22	3.598	3.739	4.031	4.285
23	3.754	3.895	4.187	4.441
24	3.911	4.052	4.344	4.598
25	4.067	4.208	4.500	4.754

*Number of contacts equals contact positions times two.

CIRCLE 61 ON READER-SERVICE CARD >

NEW PRODUCTS

Toggle Switch

722

Measures 0.78 x 0.656 x 1.356 in.



Model B-T1-3P is a three-position toggle switch that measures 0.78 x 0.656 x 1.356 in. Electrical rating is: 5 amp at 120/240 v ac; 3 amp at 30 v dc inductive at sea level; 4 amp at 30 v dc resistive at sea level. It is supplied with a keying tab 0.025-in. thick.

P. R. Mallory & Co., Inc., Milli-Switch Corp., Dept. ED, Gladwyne, Pa.

Logic Module

707

With dual output



One of the Data-Bloc line of compatible digital modules, the model 1321 has delay variable from 0.1 μ sec to 0.7 sec in 5 incremental steps, by means of a front-panel selector, and continuously variable between steps. A level output and a pulse output are provided.

Harvey-Wells Electronics, Inc., Dept. ED, 14 Huron Drive, Natick, Mass.

Price: \$205.

Availability: Delivery from stock.

Motors

732

Fractional hp type



This series of split-capacitor, fractional hp motors are available in ratings from 1/15 to 1/2 hp at 1,050 rpm. They can also be wound for 208- or 230-v operation at 50 or 60 cps. Motors have full

This dry box, pressurized with inert gas, typifies the contaminant-free production environment of Hoffman Semiconductor Division.



Hoffman CERTIFIED SURVIVAL RATE*

— a fresh
angle on
semiconductor
reliability

*Tests Conducted Under Military Surveillance and
Certified by Hoffman Reliability Engineers

The statistical graphs presented here are taken from certified records of the Hoffman Reliability and Statistical Engineering Department, Evanston, Illinois. Hoffman tests are conducted under the surveillance of a resident military inspection team. Reliability data on 1N429 zener reference diodes is available on request.

Constant production checks ensure final excellence. Here silicon wafers are inspected with high-power microscope for optical fitness.

Devices under environmental life test are continually monitored by laboratory personnel. Equipment duplicates severe military-space conditions.

All production and test instruments are calibrated from this control console which, in turn, is checked monthly by National Bureau of Standards.



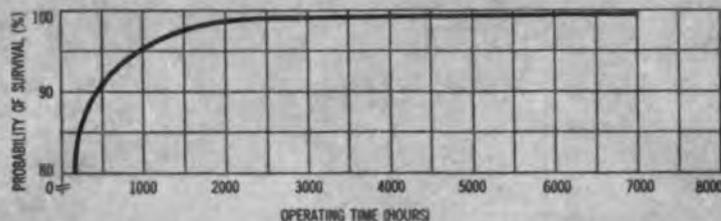
SURVIVAL RATE

At the right is a picture of survival. It depicts the life expectancy of Hoffman silicon zener reference devices, based on continuing tests of representative samples selected from thousands of production units. These samples are tested at 100°C without derating from specifications. Mean time between failures based on a 90 percent customer confidence factor—"failure" meaning any deviation beyond specification tolerances—is 188,477 hours! Life test data indicates mean time between catastrophic failures to be 565,431 hours (as of December 31st, 1960).

PARAMETER STABILITY

These graphs can help you build more reliable equipment with Hoffman devices by permitting you to take into account parameter stability during service life. Although the graphs represent just one type of unit, the 1N429 zener reference diode, the high survival rate and parameter stability are indicative of the degree of reliability built into all Hoffman devices. Research, development, advanced manufacturing techniques, and statistical quality control all provide assurance that the Hoffman products you buy will perform their intended service with maximum reliability.

PROBABILITY OF SURVIVAL with 90% confidence for the 1N429 units



DYNAMIC RESISTANCE

This curve represents the maximum increase in zener resistance experienced by 95 percent of the units tested.



ZENER VOLTAGE

The 5th and 95th percentile curves denote the boundaries for the change in zener voltage (referenced to the initial values) experienced by 90 percent of the units. A visual examination of the median reveals the high degree of stability obtained by the Hoffman devices.



Hoffman / ELECTRONICS CORPORATION
Semiconductor Division

930 Pitner Avenue, Evanston, Illinois

Phone: UNIVERSITY 9-2400

TWX: Evanston, Illinois 900

Plants: El Monte, California and Evanston, Illinois

CIRCLE 63 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

skew, centrifugally cast rotors with distributed wound stators and are capable of meeting UL application tests.

Leece-Neville Co., Dept. ED, 989 Athens St., Gainesville, Ga.

Open-Core Transformers

737

With encapsulated windings



These reactor chokes, and filament, isolation, and high-voltage supply transformers, with windings encapsulated in epoxy resin, range from 15 to 6,000 va, with isolation to 300 kv. Encapsulation gives constant electrical characteristics over a long service life, minimum size and weight, and corona-free operation at rated high voltage. The design has very low capacitance and can be made for operation in air or oil.

Components For Research Inc., Dept. ED, 979 Commercial St., Palo Alto, Calif.

Price: From \$100 to \$990.

Availability: 30-day delivery.

Pulse Rate Integrator

352

Frequency-to-dc type



The series PI-300 pulse rate integrator gives low-impedance dc voltage and current outputs precisely proportional to the frequency or pulse rate of input. Each model operates from 5 cps to a specified upper frequency for full-scale output with an adjustment provided to vary the full scale frequency over a 2:1 range.

Anadex Instruments, Inc., Dept. ED, 14734 Arminta St., Van Nuys, Calif.

Price: \$275 ca.

Availability: 3-week delivery.

83

3 Steps

TO EXCELLENCE IN PW BOARDS

STEP 1



**FUNNEL FLANGE
EYELETS**

Only the United Funnel Flange Eyelet contributes that greater mechanical strength, improved reliability and uniform circuitry so necessary for achieving a superior PW or Etched Circuit Board. Wide range of sizes and lengths meet all board needs.



New Eyelet Selector — FREE
Simplify design, purchasing, inventory, and production. Decide the hole size and grip, and set the calculator to find the exact eyelet you need. Send for your free copy today!

STEP 2



**AUTOMATIC EYELETING
MACHINES**

Only United offers such a complete line of Eyelet Setting Machines. These are backed by more than 50 years' experience in the design and manufacture of precision production machinery for industry. The United Model G Eyeletting Machine feeds eyelets automatically, and is equipped to compensate for variations in board thicknesses for more dependable production.

STEP 3



**COMPONENT INSERTING
MACHINES**

Only from United can you get a complete line of high precision DYNASERT Component Inserting Machines that cut component inserting costs up to 80%! If you insert only a few hundred components a week DYNASERT machines should be considered. DYNASERT Component Inserting Machines automatically feed, trim, bend leads, insert components and clinch with uniform results. Highly engineered single or multi-stage machines available.

These "3 Steps to Excellence" — Funnel Flange Eyelets, Automatic Eyeletting Machine, and Component Inserting Machines . . . can provide that vital extra margin of dependability and value in your PW or Etched Boards. And the investment is surprisingly small. Call or write for complete details.

UNITED SHOE MACHINERY CORPORATION
140 Federal Street, Boston, Mass. • Liberty 2-9100

CIRCLE 64 ON READER-SERVICE CARD

NEW PRODUCTS



Terminal Strips **441**

Wires are connected to this barrier-type terminal strip through small holes located at the base of each terminal. Made of Lexan polycarbonate plastic, the strips have 4, 8, 12, or 16 double terminals. Lengths are 1.370 to 3.7770 in. Elotec Corp., Dept. ED, 1425 N. Lidcombe, El Monte, Calif.



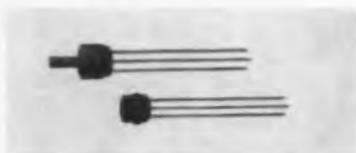
Safety Thermostat **442**

Designed to short a magneto, this thermostat is built into a cylinder-head bolt. Snap-action switch is spst, normally open or closed. Temperature setting range is -65 F to 520 F. Therm-O-Stats, Inc., Dept. ED, P. O. Box 303, Chartley, Mass.



Gyro Spin Motor **443**

Model 108 gyro-spin motor has an epoxy-encapsulated stator and external rotor with cast aluminum squirrel cage. Operating on 400-cps power, it accelerates a 480 g per cm^2 inertia ring in 50 sec and draws 6 w at 23,000 rpm. Less ring, OD is 1-1/4 in., length 3/4 in. Curvin Development Co., Dept. ED, 13740 Saticoy St., Van Nuys, Calif.



Rectifier Series **444**

The 2N1881-2N1885 series, companion to the 2N1595 series, offers greatly improved performance over wider design limits. Cut-off currents and gate firing sensitivity are improved by a factor of 5. The units are available in TO-9 outline. Solid State Products, Inc., Dept ED, 1 Pingree St., Salem, Mass.



Feed-Thru Insulator **445**

This Teflon feed-thru insulator provides a fluorocarbon-silver metal fused seal permitting the device to be soldered directly to the deck. The hermetic seal is oil-proof and withstands shock, vibration, and extremes of temperature. Garlock Inc., Garlock Electronic Products, Dept. ED, Camden 1, N.J.



RF Chokes **446**

These 3-pi rf chokes, the 1100 series, range in inductance from 0.1 mh to 50 mh in 13 steps. Exceptionally high inductance, high Q and low dc resistance with small physical size are claimed for the chokes. Form diameters are 0.187 and 0.250 in. Delta Coils, Inc., Dept. ED, 1128 Madison Ave., Paterson 3, N. J.



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semiconductors"

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6641 W. North Ave.
Oak Park, Ill. Village 8-5556

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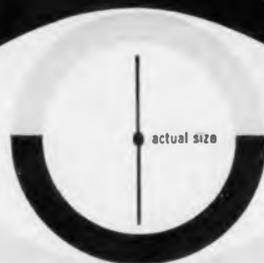
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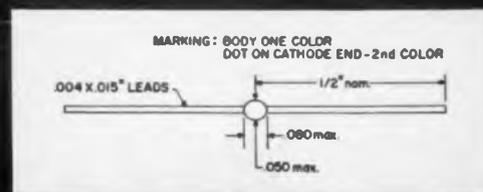
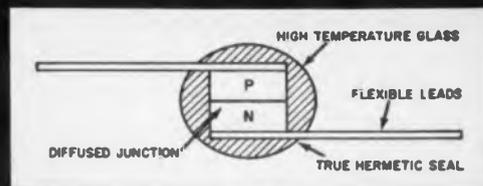
ANOTHER FIRST FROM
Transitron



WITH A TRUE HERMETIC SEAL

**MICRO
ZENER
DIODES**

MEET US AT IRE - BOOTH NOS. 1220-1224



NO COMPROMISE!

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

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

For more information write for Bulletin PB-71E.

TYPE	Voltage ^① @ I _Z = 5 mA (Volts)	Maximum Dynamic Resistance ^② (ohms)	CURRENT RATINGS	
			Maximum Average Operating (mA) Current @ 25° C	@ 100° C
TMD-01*	5.1	15	17.8	4.4
TMD-02	5.6	15	15.5	4.0
TMD-03*	6.2	15	14.5	3.7
TMD-04	6.8	15	13.0	3.3
TMD-05	7.5	15	12.0	3.1
TMD-06	8.2	15	11.0	2.8
TMD-07*	9.1	15	10.0	2.5
TMD-08	10.0	15	9.0	2.3

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

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

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

*Production types

ADDITIONAL CHARACTERISTICS AND RATINGS

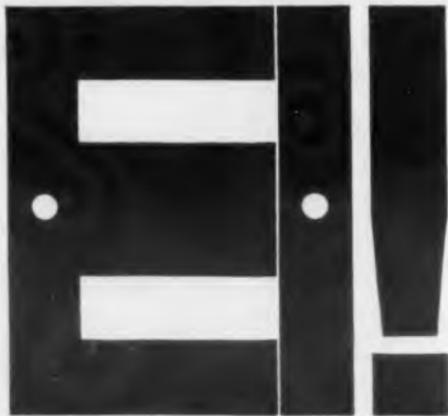
Operating and Storage Temperature Range -55° C to +150° C

Maximum power dissipation at 25° C 100 mW
Typical forward voltage at 5.0 mA 0.75 volt

Transitron
electronic corporation
wakefield, melrose, boston, mass.

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

NOW... HIGHER μ



G-L's new lamination insulation process gives greater permeability than ever before!

Most nickel-alloy laminations have insulation coatings formed by high-temperature oxidation of the base-metal surface. This process produces generally satisfactory insulation. But at the same time it usually causes degradation of lamination permeability. ■ Our new "Hy-Q" insulation process eliminates the undesirable side effect. It makes it possible for us to retain the high permeability achieved by controlled hydrogen annealing. Result: greater — and more uniform — initial permeability in the stack. Better efficiency, too. ■ These performance improvements may allow you to reduce stack size . . . or get more output from the same size stack. Either way, production will be easier, for the "Hy-Q" coating — applied to both sides of the lamination — prevents sticking, facilitates handling. ■ You can have "Hy-Q" laminations in wide variety of shapes, sizes, materials, and standard thicknesses, with immediate delivery from stock. A word from you will bring detailed information. Ask for Bulletin TB 106.



Specialists in magnetic components for the electronics industry

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SA 2336

CIRCLE 67 ON READER-SERVICE CARD

NEW PRODUCTS

Digital Meter

713

Stability is 0.005%



Model 3510 ac/dc digital voltmeter and ratio-meter has a stability of better than 0.005% for periods of several months under normal use. Sensitivity is 0.1 mv; ac accuracy is 0.1% and 2 digits; dc accuracy is $\pm(0.01\%$ and 1 digit). Average balance time for dc is 2 sec; 3 sec for ac.

Electro Instruments, Inc., Dept. ED, 3540 Aero Court, San Diego 11, Calif.

Stand-Off Insulators

590

With Teflon body



The bodies of these stand-off insulators are made of Teflon; turrets are machined from brass rod. The units are unaffected by humidity, mechanical shock and vibration, and are designed for ambient temperatures from -110 F to 500 F, pressure altitudes from 0 to 80,000 ft.

Garlock Electronic Products, Garlock Inc., Dept. ED, Camden 1, N.J.

Data-Scanning Relay

725

Life is 200 million operations



This data-scanning relay has an electro-mechanical relay coil. This relay utilizes two replaceable sealed cartridges containing the arma-

This booklet can answer your questions about instrumentation cable



For example, on page 3 you'll find part of the story about types of insulation Rome Cable Division can supply . . . e.g., Rome Synthinol, a thermoplastic material, compounded mainly of polyvinyl chloride that is available in forms to cope with temperatures from -40°C to $+105^{\circ}\text{C}$.

Or you might find that your needs are best met by Rome Rolene, a light-stabilized polyethylene that can stand up to weathering, oxidation, oils, and most chemicals.

Of course, insulation is only part of the story. In the other pages of "RCD-400 Instrumentation Cable", you'll find other relevant descriptive material, photos, and tables about cable for telemetering, data recording, circuit control testing, and electronic computers.

For your copy, or answers to specific questions about cable, write to Rome Cable Division of Alcoa, Dept. 11-21, Rome, New York.

ROME CABLE
DIVISION OF **ALCOA**

CIRCLE 68 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

superb new NULL DETECTOR



The new Keithley 151, incorporating a unique photo-conductive modulator of Keithley design, is useful wherever a suspension galvanometer can be used, and where a galvanometer is not sufficiently sensitive, fast or rugged. Currents as low as 2×10^{-13} ampere can be detected.

Ranges: 11 linear ranges in 1x and 3x steps, from 100 μ v to 10 v f.s.; 5 non-linear ranges, 0.001 to 10 v f.s., each covering three decades.

Accuracy: Linear ranges, $\pm 3\%$ of f.s.; non-linear, $\pm 10\%$ of input.

Input Resistance: 10 megohms on all ranges. Max. power sensitivity over 10^{-17} watt.

Response Speed: On 100 μ v range, 2.5-sec.; 1-sec. on all others.

Noise: Below 2% f.s. all ranges.

Zero Drift: Less than 10 μ v per day.

Output: 10 volts at 1 ma f.s.

Price: 151 Cabinet Model . \$420.00
151R Rack Model . \$420.00

For full details write:



**KEITHLEY
INSTRUMENTS**

12415 EUCLID AVENUE
CLEVELAND 6, OHIO

CIRCLE 69 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

ture and fixed contacts. Magnetic coupling to the relay permits a dpdt configuration suited for low-level data sampling. Dwell periods are as brief as 250 μ sec and dynamic resistances are less than 1 ohm. Service life is claimed to exceed 200 million operations.

Magnavox Research Laboratories, Dept. ED, 2829 Maricopa St., Torrance, Calif.

Mica Capacitors

716

Range from 1 to 40,000 pf



Types CD15, CD19, CD20 and CD30 dipped-silver mica capacitors cover the capacitance range from 1 to 40,000 pf. Standard ratings are 500, 300 and 100 wvdc. Capacitance tolerances are from $\pm 10\%$ to $\pm 1/2\%$. The line meets MIL-C-5B (proposed) specifications. Models for operation up to 2,500 wvdc at 10,000 pf are also available.

Federal Pacific and Electric Co., Cornell-Dubilier Electronics Div., Dept. ED, 55 Cromwell St., Providence, R.I.

Solid-State Inverter

729

Weights 3.7 lb



Model 90-156-0 solid-state inverter weighs 3.7 lb and occupies less than 65 cu in. of space. It operates on an input of nominal 28 v dc with an output of 115 v, 400 cps, sine wave, single phase, 100 va. Output frequency is factory adjusted to 400 cps $\pm 0.5\%$; stability is $\pm 0.25\%$ from -60 to $+71$ C. Distortion of the sine-wave output is less than 4% under all operating conditions.

Magnetic Research Corp., Dept. ED, 3160 W. El Segundo Blvd., Hawthorne, Calif.

URGENT CALL . . . URGENT PROBLEM!!! man on phone indicates . . . high capacity centrifugal blowers designed to cool his transmitting tubes, delivering insufficient air to meet requirements — current supplier will not redesign!!! “and time waits for no one”.

SOLUTION

TO AN
AIRMOVER
PROBLEM

 **EASTERN DIVISION** — supplier of creative solutions, armed with years of experience, waded in and solved the problem by providing a unit to meet his exact requirement — a unit delivering 2000 cfm at 11" H₂O. Now known as Model FBT 02131B, this unit was **DESIGNED, DELIVERED, TESTED AND ACCEPTED IN 2½ WEEKS**, and with a unit 40% smaller than original design.

Beyond the immediate need, **imc** also pointed out to design engineers oversized airmovers in existing applications — and savings made possible by precisely matching blower, fan and vane axial specifications to each application.

Thus at **imc** there's no need to compromise your cooling requirements . . . **imc** specialists will supply a solution — whether your problem is for air delivery of 1 cfm and up, extreme temperature, weight, space, size or environmental conditions.

Solutions are an **imc** specialty . . . may we send you an airmover equipment portfolio or supply a solution to your specific problem?

imc **MAGNETICS CORP./EASTERN DIVISION**

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OTHER PRODUCTS: heat exchangers/synchronous and torque motors/induction motors/servo motors and motor tachometers/dc motors/dynamotors and inverters
CIRCLE 70 ON READER-SERVICE CARD

NEW PRODUCTS

Cathode-Ray Tube

733

Is direct writing



The Printapix B3C2 tube has 500 conductive elements per linear inch to make a density of 250,000 conductive elements per square inch. Supplementary electrostatic deflection plates permit the generation of alphanumeric characters. It can print characters directly on nonsensitized paper at rates up to 100,000 characters per sec.

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

High-Voltage Converters

717

Outputs from 700 to 1,500 v



This line of dc-to-dc converters has regulated voltage outputs that range from 700 to 1,500 v and the rated current output is 20 μ a. Each unit is hermetically sealed. Size is 2-3/8-in. high x 1-1/2-in. sq. They are available with plug-in base or solder connections.

Fairport Instruments, Inc., Dept. ED, 270 Midway Lane, Oak Ridge, Tenn.

Millimicroammeter

710

Range is 0.001 μ a to 3 ma



Model 1811AR millimicroammeter is a rack-mounted unit for measuring low-level currents from less than 0.001 μ a to 3 ma. The instrument

Instruments that Stay Accurate



After More Than 600 Separate Inspections — One Panel Instrument

Sounds like a lot of inspecting, but it's one of the things that makes possible Simpson's fine panel instruments.

Take pivots, for example, which support the rotating armature of a meter movement. Because Simpson quality standards are so high, Simpson makes its own pivots which require more than 60 separate inspections during manufacture. Among these are 100% inspection under a 100X microscope and sampling inspection under a 400X microscope to check radius, cone angle, finish and other characteristics. One result is pivot points with a radius tolerance maintained to within .000010". Moreover, Simpson inspects each and every group of pivots for correct hardness so they won't deform under rough use.

Through such meticulous care as this, Simpson is able to offer you panel instruments with accuracy limits that are 100% guaranteed . . . instruments with conservative ratings on which you can rely . . . instruments that stay accurate . . . instruments you can specify with confidence.

Write for Catalog 2059A.

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ELECTRIC COMPANY

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Phone: EStebrook 9-1121
In Canada: Bach-Simpson Ltd., London, Ont.

has a high-gain chopper-stabilized amplifier with feedback that eliminates zero adjust and a full-scale voltage drop of only 10 mv on all ranges. It is line-power operated and can withstand high overloads without damage.

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

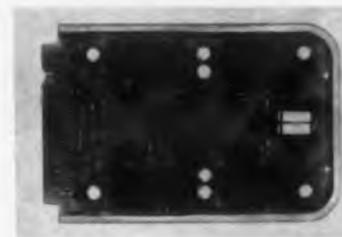
Price: \$169 *job* Mineola.

Availability: From stock.

One-Mc Counter

739

In digital module



The BC-30 counter package, in the S-Pac series of 1-mc digital modules, has four independent counter stages which may be wired for binary or binary-coded decimal operation. It has dip-soldered, etched circuits on a glass-epoxy card that measures 4-7/8-in. wide, 7-in. high, and 9/16-in. thick. Operating temperature range is -20 to 65 C.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

Price: \$96 *ca.*

Availability: Delivery from stock.

Voltage Divider

735

Accuracy is 0.001%



Model VDR-105 secondary standard voltage divider has an accuracy of 0.001%. It is suitable for rack-mounting in a standard 19-in. relay rack or cabinet. It is designed for use in: calibration of resistance-ratio sets, ratio-type transducers, voltage dividers and networks; measurement of relative voltage, current or resistance over a wide range; standardization of laboratory instruments.

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



CIRCLE 72 ON READER-SERVICE CARD

PIONEERING

A new concept in reliability—crimp Poke Home Contacts*—was pioneered and actively developed by Amphenol Connector Division. Removable contacts that are crimped outside of the body of the connector, inspected and then inserted for assembly are available in six connector lines. In Rack & Panel connectors, for example, "Poke Home" economy and reliability are offered in miniature Min Rac 17, aircraft 94 and missile 93 series.



In almost every application area there is an Amphenol connector with Poke Home contacts. Catalog data is available for your use.

AMPHENOL

AMPHENOL CONNECTOR DIVISION
1830 S. 54TH AVE. • CHICAGO 50, ILLINOIS
Amphenol-Borg Electronics Corporation

40 E. FRONT 2, 419, 518

NEW PRODUCTS

Silicon Controlled Rectifiers

697

Rated at 70 amp ac



There are 8 models in the C50 group of silicon controlled rectifiers, with average forward current ratings up to 70 amp max ac, and 110 amp max dc. Peak reverse voltage ratings range from 25 to 400 v. Typical gate current is 15 ma at 1.5 v; maximum gate voltage is 3.0 v. Depending on the use, typical turn-on time is 1.0 to 4.5 μ sec; typical turn-off time is 15 to 25 μ sec.

General Electric Co., Dept. ED, Kelly Bldg., Liverpool, N.Y.

Price: \$67.50 for 200-v units in quantity to OEM.

Spectrum Analyzer 690

For low frequencies



The SA-11 analyzes the spectrum of signals in the frequency range from 0.0025 to 1,000 cps on a real-time basis. There are 7 scales in that range; selectivity on the lowest scale is 0.0037 cps, and 3.75 cps on the 1-kc scale. The band between 0.5 cps and 200 cps is analyzed in 1.6 sec. The system is used in seismology, shock and vibration analysis, and heartbeat analysis.

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

Price: \$37,500.

Availability: 120-day delivery.

◀ CIRCLE 73 ON READER-SERVICE CARD



**FOR
IMMEDIATE
LARGE
QUANTITY
DELIVERY
AT
FACTORY
PRICES**

Yes! Schweber can sell any model of BOURNS TRIMPOT® at factory prices. Sizeable quantities are available for immediate shipment from stock from Schweber's warehouse.

 **Schweber**
ELECTRONICS

60 HERRICKS ROAD, MINEOLA, L. I., N. Y.

PIONEER 6-6520, TWX 9-CY-NY-880U
CIRCLE 74 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

This Top Team of Application Engineers Represents You at Bourns!

NUMBER 12 — APPLICATION SERIES

Consider this crack Trimpot® engineering group an extension of your own staff... because that's exactly what it is. Each of these men is a graduate engineer; each has extensive experience in potentiometer applications; and each is responsible for technical subjects within a specific geographic area. The Bourns specialist assigned to your region therefore becomes well acquainted with your requirements—to help you solve today's problems today!

Because Bourns offers the widest selection of adjustment potentiometers in the nation, these men are in the best possible posi-

tion to steer you to fast answers for your potentiometer needs. If modifications or specials are in order, they'll come up with sound, low-cost solutions. If your problems require direct engineer-to-engineer contact on problems involving design, quality control, or testing, they'll provide it... on the phone or in your office.

Here, in short, is a group of engineers devoted to giving you personal service and personal follow-through on your projects. The phone is right there on your desk—call anytime!



Exclusive designers and manufacturers of Trimpot® potentiometers. Pioneers in transducers for position, pressure, acceleration.
CIRCLE 75 ON READER-SERVICE CARD

NEW PRODUCTS

Synchro Standards 701

Accurate to 2 sec



Designed to simulate the output of a master synchro, models SS-1, 2, and 3 have a ratio accuracy of 10 ppm, equal to 2 sec of arc. Quadrant switching is provided to simulate operation over 360 deg. Similar units can be supplied as resolver standards.

Gertsch Products, Inc., Dept. ED, 3211 S. La Cienega Blvd., Los Angeles 16, Calif.

Price: \$675 up.

Availability: 30 to 45 days.

Miniature Blower 700

OD is 1-1/8 in.



Typically used for spot cooling, this miniature dc blower moves 10 cfm against 0.3 in. of water static pressure. The tube-axial device is 1-1/8-in. in diameter by 3-1/4-in. long, and operates on 27 v dc. Weight is 3.5 oz.

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

Computer Building Block 715

Holds 6 pairs of plug-ins



This computer building block is designed to accommodate six pairs of the firm's operational plug-in

for long-life operation
despite extreme temperatures,
heavy shock, severe vibration

CLARE Type F

subminiature crystal can

RELAY



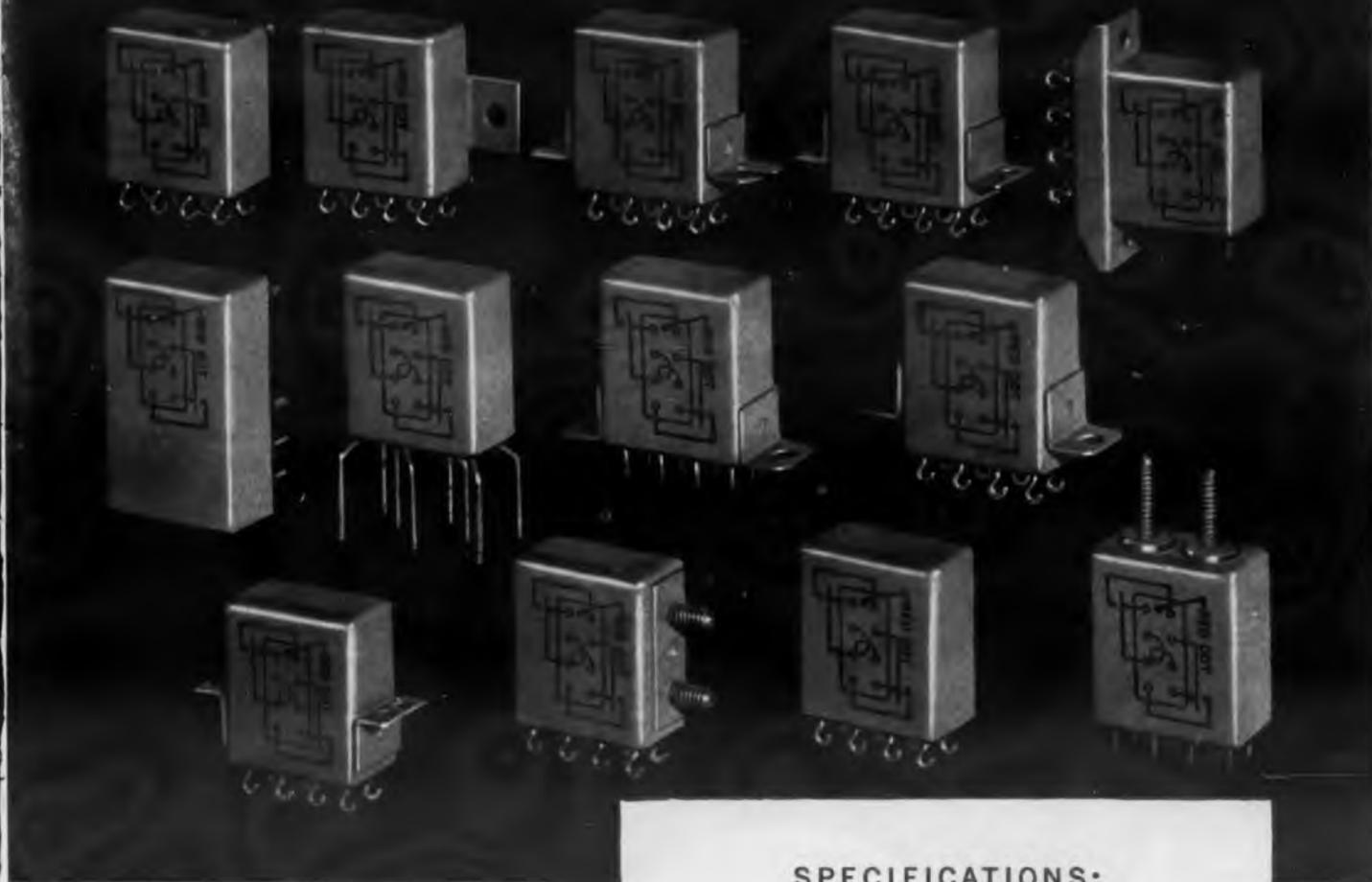
This hermetically sealed relay—no bigger than a postage stamp—is a precise component of unusual flexibility, capable of long-life operation under a wide variety of contact loads.

The Clare Type F is extremely fast and more than moderately sensitive. It is built to withstand temperature extremes, heavy shock and extreme vibration. It has proved its usefulness to advanced circuit designers. Contacts, rated at 3 amperes, are excellent for low-level circuit applications. Terminal arrangement is nicely suited to 2/10 inch grid spacing.

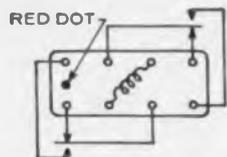
In a variety of terminal and mounting designs, the Clare Type F Relay is of real value for both commercial and military applications.



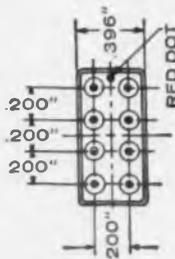
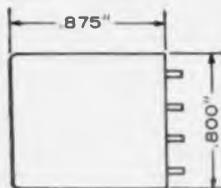
for complete data on construction, circuitry,
performance characteristics and mountings
... write for Catalog 203



SPECIFICATIONS:



wiring—
as viewed from
terminal end



For detailed information, ask your Clare Representative for Catalog 203... or address C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 840 Caledonia Road, Toronto 19, Ont. Cable address: CLARELAY.

Ambient Temperature	.....	-65° C to +125° C.
Shock	.....	65 G's, 11 millisecond duration.
Vibration	.....	5-75 cps at total excursion of 1/8-inch, 75-2000 cps at 20 G's acceleration.
Dielectric Strength	.....	Sea level—1000 volts rms between terminals and frame, and between adjacent circuits; 600 volts rms between contacts of a set. At 80,000 ft., 350 volts rms.
Insulation Resistance	.....	1000 megohms minimum at 125° C.
Coils	.....	Coils from 35 ohms to 10,000 ohms available for a wide range of voltages or currents.
Nominal Operating Power	.....	250 milliwatts.
Total Pickup Time	.....	5.0 milliseconds.
Total Dropout Time	.....	5.0 milliseconds.
Contact Arrangement	.....	2 pdt (2 form C).
Contact Rating	.....	3 amps resistive at 28 vdc or 1 amp resistive at 115 vac; also for low-level applications.
Contact Resistance	.....	0.050 ohm maximum.
Contact Life	.....	250,000 operations minimum at 2 amps; 100,000 operations minimum at 3 amps.
Enclosure	.....	Hermetically sealed, filled with dry nitrogen at 1 atmosphere pressure.
Mounting	.....	All popular mounting arrangements available.
Terminals	.....	Printed circuit; solder; plug-in (matching socket available). Variations of printed-circuit terminal length on 2/10 inch grid spacing available.
Weight	.....	.17 grams.
Military Specifications	.....	MIL-R-5757D.

amplifiers. Dimensions are 17-1/2 x 15 x 3-1/2 in. with 3-1/2 x 19 x 3/16 in. rack panel. The terminal board has a number of uncommitted terminals to permit a variety of computing or simulating operations to be programmed.

Embree Electronics Corp., Dept. ED, 993 Farmington Ave., West Hartford 7, Conn.

DC Static Contactor 708

Has no moving parts



Essentially a relay without moving parts, this dc static contactor will handle up to 70 amp. Operating voltage is 24 to 31 v dc; power needed is 1.5 w. The spst contact closure may be instantaneous or delayed up to 120 sec or more. The 3-oz unit meets environmental specifications.

George Harmon Co., Inc., Dept. ED, 18141 Napa St., Northridge, Calif.

Surge Resistor 705

For 100 to 300 w



The model 20-100 surgitron is a device for controlling turn-on surge currents in equipment drawing 100 to 300 w, 117 v. Threaded pins allow it to be plugged into a connector or bolted to a circuit board. It has a ceramic body and high-temperature contacts.

Hollywood Television Co., Wuerth Surgitron Div., Dept. ED, 1949 Moffett St., Hollywood, Fla.

Price: \$0.30 ea, 10,000 and up.



C. P. CLARE & CO. Relays and Related Control Components

SILICON TRANSISTOR CORPORATION

85 Watts



2N389
2N424

**THE COMPLETE LINE
OF INTERMEDIATE AND HIGH
POWER SILICON
TRANSISTORS**

60 Watts



2N1069,70
2N1487,8,9,90

40 Watts



2N1050
2N1049
2N1048
2N1047

15 Watts



2N1486
2N1485
2N1484
2N1483

Silicon Transistor Corporation also manufactures a Complete Line of Silicon Glass Diodes including JAN Types 1N457, 1N458, 1N459 and Sig. C. Types 1N643, 1N658, 1N661 & 1N663.

FOR IMMEDIATE DELIVERY, CONTACT THESE STC AUTHORIZED DISTRIBUTORS: **Ala:** MG Electrical Equipment Co., Birmingham. **Calif:** Brill Semiconductor Corp., Oakland; Hollywood Radio Supply, Inc., Hollywood; Peninsula Electronic Supply, San Jose; Shelley Radio Co., Inc., Los Angeles; Wesco Electronics, Pasadena; Shanks & Wright, Inc., San Diego. **Fla:** Hammond Electronics, Inc., Orlando; Leader Distributors, Inc., Tampa. **Mass:** Durrell Distributors, Inc., Waltham. **Md:** Valley Electronics, Inc., Towson. **New York:** Arrow Electronics, Inc., Mineola, L. I.; Progress Electronics Co., Inc., New York City; Summit Distributors, Inc., Buffalo. **Penna:** Philadelphia Electronics, Inc., Phila. **Texas:** Lert Company, Houston; Central Electronics, Dallas.



IRE: BOOTH 1326

SILICON TRANSISTOR CORPORATION

NEW PRODUCTS

Component Tester 706

For reliability programs



Designed to simplify and speed component reliability studies, the automatic DY-5572/3 test systems provide punched card records of changes in values with time. The diode-testing system can measure forward and reverse characteristics, saturation voltage, and impedance within a wide range. Another system measures and records characteristics of resistors and capacitors.

Hewlett-Packard Co., Dymec Div., Dept. ED, 395 Page Mill Road, Palo Alto, Calif.

Tuning-Fork Oscillator 693

Accuracy is $\pm 0.002\%$



Using a temperature-compensated, fixed-frequency tuning fork, this oscillator provides accuracy to $\pm 0.002\%$ over a temperature range of 0 to 65 C for any combination of voltage, attitude, and age variables. Frequency ranges from 380 to 6,000 cps. Output may be 0.1 w, sine wave or square wave. The hermetically sealed can has a volume of about 6 cu in.

Fork Standards, Inc., Dept. ED, 1915 N. Harlem Ave., Chicago 35, Ill.

Availability: 1 week for prototypes.

◀ CIRCLE 78 ON READER-SERVICE CARD

Differential DC Voltmeter

694

Accuracy is 0.05%

The model 801H differential dc voltmeter has an accuracy of 0.05% from 0.1 to 500 v. Input resistance at null is infinite over the entire range. Voltage ranges are 0.5, 5, 50, and 500 v dc; an automatic lighted decimal is provided. The meter is available for rack or cabinet mounting.

John Fluke Manufacturing Co., Inc., Dept. ED, P. O. Box 7161, Seattle 33, Wash.

Delay Lines

712

Have low attenuation



This series of lumped constant delay lines consists of m-derived LC networks. Each section is designed to give linear phase shift beyond 70% of the cut-off frequency. Attenuation is less than 1 db per μ sec of delay. Specifications for model DL-2265 are: impedance, 500 ohms $\pm 5\%$; delay time, 1 μ sec $\pm 5\%$; rise time 0.08 μ sec; attenuation, 1 db max.

Dresser Electronics, HST Div., Dept. ED, 555 N. 5th St., Garland, Tex.

Price: \$75 ea.

Optical Comparator 721

For visual inspection

Designed as a portable unit, the Micro Vu 300 provides 20-power magnification for inspection of components ranging in size from microminiature to 3 in. It needs less than 3 sq ft of bench space and weighs 20 lb. It has a 2-1/2 x 9 in. measuring stage with 3 x 3 in. vertical and horizontal travel. Standard dial indicators are used.

Micro Vu, Dept. ED, North Hollywood, Calif.

Price: \$350.

Advertisement

Airborne DC Amplifier



Small, solid state, direct-coupled DC amplifier weighs only six ounces. Less than five cubic inches in volume, this rugged, hermetically sealed instrument is available with solder, plug-in, coax or combination header arrangements and a variety of mountings. DC gain is 200 to 1000 $\pm 0.75\%$. Input capability is 5 millivolts differential at maximum gain; output capability is ± 5 volts into not less than 20K (single-ended).

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California.

CIRCLE 851 ON READER-SERVICE CARD

Weldable Strain Gage



Precise, rugged gage is capable of continuous operation at 800°F and dynamic test to 1500°F. These gages employ one-piece etched wire filaments in swaged stainless steel tubes, and are suitable for use from cryogenic to elevated temperatures. They are also available with inherent temperature compensation (no dummy gages required). Easy installation through the use of stored-energy welding equipment eliminates complicated bonding and curing processes. Also available in integral lead strain gage versions.

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California.

CIRCLE 852 ON READER-SERVICE CARD
CIRCLE 853 ON READER-SERVICE CARD

MICROMINIATURE MULTI-PIN CONNECTORS



Visualize 61 contacts in the diameter of a dime . . . think of slashing connector weight requirements by 33% . . . estimate the dollar savings in time and inventory of a connector with complete interchangeability of parts. This unique combination of advantages—and more—are built-in features of Microdot's new multi-pins.

In airborne and ground support applications where size, weight and reliability are vital factors, Microdot's unique new multi-pin connector stands alone. Available in three shell sizes and a variety of mounting versions, these rugged connectors are adaptable to a wide range of specific applications (you specify from a wide variety of standard, interchangeable multi-pin component parts to arrive at a connector tailored to your specific application).

Inserts are available in a variety of straight power, straight coaxial, and power-coaxial layouts. Power contacts are interchangeable without changing inserts, allowing hermaphroditic contact arrangements (a mixture of male and female contacts within the same plug or receptacle, allowing hot leads to both plug and receptacle). Closed entry, pure coin silver socket contacts allow heavy currents with low temperature rise. Contact resistance is almost nil. Write today for detailed descriptive literature, Bulletin MP-O.

SIZE DESIGNATION	PLUG O.D.	NO. OF COAXIAL CONTACTS	NO. OF POWER CONTACTS
A	$\frac{3}{8}$ "	up to 7	up to 19
B	$\frac{1}{2}$ "	up to 12	up to 37
C	$1\frac{1}{4}$ "	up to 19	up to 61

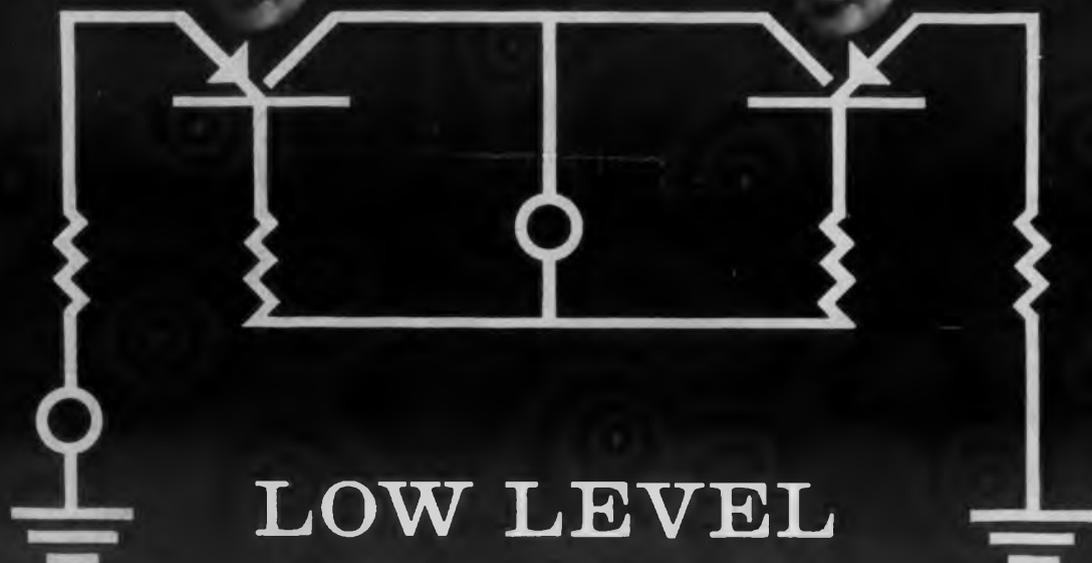
Microdot Multi-Pins are available in disassembled "kit" form or, if you prefer, factory assembled with Microdot cable.

MICRODOT INC.

220-Pasadena Ave./South Pasadena, Calif.



paired
for
perfection...



LOW LEVEL SWITCHING

TYPICAL CHARACTERISTICS

- $I_{CBO}, I_{EBO}, I_{ECR} \dots\dots\dots 1 \text{ m}\mu\text{a}$
- $V_{EC} \text{ (sat)} \dots\dots\dots 1 \text{ mv}$
- Matched Pairs $\dots\dots\dots 50 \mu\text{v}$
- $BV_{CEO}, BV_{EBO}, BV_{ECR} \dots\dots\dots 35\text{v}$

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Solid State Silicon
SWITCH

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CIRCLE 82 ON READER-SERVICE CARD

NEW PRODUCTS

Lightweight Transformers

726

Are custom designed



Series C custom designed transformers have a can size only slightly larger than the core itself. Extended-pin terminal design eliminates internal flex leads and exposes magnet wire and pin-solder connections for continuous inspection.

Magnetic Circuit Elements, Inc., Dept. ED, 3722 Park Place, Montrose, Calif.

Arming Switch

709

Prevents accidental launch

Designed to prevent accidental circuit actuation caused by power transfer under launch conditions, the model EL-1091 switch arms the affected circuits after a predetermined elapsed time. External load is 3-1/2 amp resistive, max; actuation force is preset 1 to 20 g, ± 0.5 g. The switch weighs less than 3/4 lb.

George Harmon Co., Inc., Dept. ED, 18141 Napa St., Northridge, Calif.

Coil Tester

724

Has 0.1% accuracy



This coil tester measures the number of turns on coils with 0.1% accuracy. It measures number of turns on coils without a core and on coils wound on open ferromagnetic cores protruding from the coil. It detects short-circuited turns equal to one turn of number 25 AWG copper wire and checks for the correct amount of short-circuited layers used for time delay on relays.

Maxim Controls Co., Dept. ED, 4734 N. Albina Ave., Portland, Ore.

CIRCLE 83 ON READER-SERVICE CARD

WE
DELIVER
THE
WIDEST
LINE:
1544 Models



REALITIES:

(1) DAYSTROM
DELIVERS
1544 STANDARD
MODELS OF ITS
SQUARETRIM®
PRECISION
POTENTIOMETERS,
THEREBY GIVING
YOU GREATEST
DESIGN LATITUDE;



(2) OUR SPECS
ARE FIELD PROVEN
AND REALISTICALLY
DERIVED FROM
TESTING UNDER



ENVIRONMENTAL STRESS, NOT "IDEAL" LAB CONDITIONS;

(3) WE ORIGINATED THE SQUARE TRIMMING POT,
HOLD MANY BASIC PATENTS ON IT, AND OFFER DESIGN
ADVANTAGES NOT OBTAINABLE WITH ANY OTHER
PRODUCT; (4) OUR HUGE NEW FACILITY IS THE MOST
MODERN OF ITS KIND IN THE WORLD, PRODUCING
THOUSANDS OF POTS PER DAY. CHECK THE SPECS,
THEN THE FACTS BEHIND THE SPECS, AND YOU'LL
SEE WHY DAYSTROM DELIVERS THE BEST.

 **DAYSTROM, INCORPORATED**

POTENTIOMETER DIVISION

ARCHBALD, PENNSYLVANIA • LOS ANGELES, CALIFORNIA

	144 MODELS	96 MODELS	144 MODELS	32 MODELS
SQUARETRIM[®] SERIES NUMBERS	300-00, 300-60, 300-61, 300-64, 300-66, 300-67	301-00, 301-60, 301-61, 301-64	303-00, 303-60, 303-61, 303-66, 303-67, 303-74	311-00, 311-60, 311-61, 311-64
RESISTANCE POWER SIZE OPERATING TEMP. RESOLUTION	10 Ω - 50K 1 watt (still air) 1/2" x 1/2" x 0.187" -55 to +150°C 10 Ω -1.00% 1K-.32% 20 Ω -.77 2K-.23 50 Ω -.65 5K-.20 100 Ω -.52 10K-.125 200 Ω -.50 20K-.096 500 Ω -.36 50K-.086	10 Ω - 50K 1 watt (still air) 1/2" x 1/2" x 0.255" -55 to +150°C 10 Ω -1.00% 1K-.32% 20 Ω -.77 2K-.23 50 Ω -.65 5K-.20 100 Ω -.52 10K-.125 200 Ω -.50 20K-.096 500 Ω -.36 50K-.086	50 Ω - 150K 1.5 watts (still air) 3/4" x 3/4" x 0.280" -55 to +150°C 50 Ω -.065% 5K-.20% 100 Ω -.42 10K-.155 200 Ω -.35 20K-.130 500 Ω -.35 50K-.070 1000 Ω -.30 100K-.062 2000 Ω -.23 150K-.052 5000 Ω -.18	20K - 1MEG 0.5 watts (still air) 1/2" x 1/2" x 0.187" -55 to +85°C 20K 200K 50K 500K 75K 750K 100K 1MEG
Standard Resistance Tolerance	\pm 5% (special tol. on request)	\pm 5% (special tol. on request)	\pm 5% (special tol. on request)	\pm 20%
Temp. Coeff. of Resistance Wire	20 ppm/m°C max. 0° to 100°C	20 ppm/m°C max. 0° to 100°C	20 ppm/m°C max. 0° to 100°C	0.2%/°C, 0° to 100°C
Temp. Coeff. of Potentiometer	50 ppm/°C max. 0° to 100°C	50 ppm/°C max. 0° to 100°C	50 ppm/°C max. 0° to 100°C	50 ppm/°C max. 0° to 100°C
Stability as Voltage Divider	0.2% or 1 resolution max	0.2% or 1 resolution max	0.2% or 1 resolution max	Better than 0.7%. -55 to 85°C
Load Life at Rating	1000 hrs. min. MIL-R-19A (in still air)	1000 hrs. min. MIL-R-19A (in still air)	1000 hrs. min. MIL-R-19A (in still air)	1000 hrs. min. MIL-R-94 (in still air)
Insulation Resistance	50 megohms min. (500V. DC)	50 megohms min. (500V. DC)	50 megohms min. (500V. DC)	50 megohms min. (500V. DC)
Dielectric Strength	500V. AC, 1 min.	500V. AC, 1 min.	500V. AC, 1 min.	500V. AC, 1 min.
Useable Resistance Range	98%	98%	98%	98%
Equiv. Noise Resistance	0.1% or 100 ohms NA 5-710	0.1% or 100 ohms NA 5-710	0.1% or 100 ohms NA 5-710	
Adjustment Ratio	45:1	45:1	45:1	45:1
Screw Turns	42	42	42	42
Rotational Life	10,000 screw rev. min.	10,000 screw rev. min.	10,000 screw rev. min.	10,000 screw rev. min.
Torque	7.5 oz in. max.	7.5 oz in. max.	7.5 oz in. max.	7.5 oz in. max.
Weight	2 grams max.	2 grams max.	7 gr. max.	2 grams max.
Temperature Cycling	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102
Vibration	Exceeds MIL-E-5272C, Proc. I	Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.
Shock	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202
Altitude	Exceeds MIL-E-5272C, Proc. II.	Exceeds MIL-E-5272C, Proc. II.	Exceeds MIL-E-5272C, Proc. II.	Exceeds MIL-E-5272C, Proc. II.
Sand and Dust	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C
Fungus Resistance	All non-nutrient materials	All non-nutrient materials	All non-nutrient materials	All non-nutrient materials
Corrosion Resistance	Similar materials construction 100%	Similar materials construction 100%	Similar materials construction 100%	Similar materials construction 100%
Humidity*	Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.	
Salt Spray*	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	

*Special Order

1544 STANDARD DAYSTRO

DAYSTROM PATENTED PRECISION ROTARY T

EXAMPLE: ZERO BACKLASH



The Daystrom 341 Series rotary potentiometers contain this patented "V" guide which eliminates backlash and resultant error. U.S. Patent 2,856,493.

EXAMPLE: DOUBLE WIPERS, FINER RESOLUTION, AND ABSOLUTE CONTINUITY IN SUBMINIATURE SERIES 341 TEN-TURNS



ACTUAL SIZE

The use of patented double wipers in our 341 Series Potentiometer effectively doubles the resolution...intermittents that normally result from shock and vibration are virtually eliminated.

Coupled with its subminiature size, this stability to environmental stress makes the 341 Series ideal for avionics systems, where it has found many applications (the TITAN missile is an example).

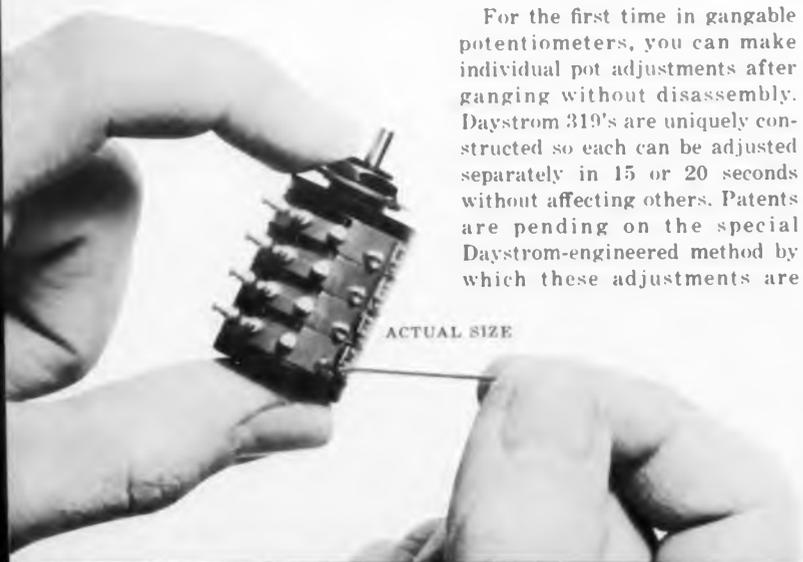
The Series 341 potentiometers are offered in resistance ranges from 1K to 600K, can carry 2.5 watts in still air at 40°C, and operate from -55 to 140°C. They are only $\frac{1}{8}$ " in diameter and 1" long, and meet all applicable MIL specs. The 341 can also be supplied with a patented clutch for servo installation.

EXAMPLE: SPECIAL ADJUSTING DEVICE IN GANGABLE SERIES 319

For the first time in gangable potentiometers, you can make individual pot adjustments after ganging without disassembly. Daystrom 319's are uniquely constructed so each can be adjusted separately in 15 or 20 seconds without affecting others. Patents are pending on the special Daystrom-engineered method by which these adjustments are

made. Because of the simplicity of adjustment after ganging, you can order these potentiometers already ganged at Daystrom in the number needed, then make your final adjustments in seconds. Resistance Range: 100Ω to 200K; Power: 2 watts in still air; Temperature: -55 to 150°C. Meets all applicable MIL specs.

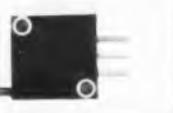
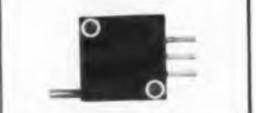
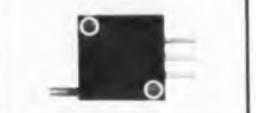
ACTUAL SIZE



	144 MODELS	96 MODELS	144 MODELS	32 MODELS	96 MODELS	96 MODELS	144 MODELS	
SQUARETRIM® SERIES NUMBERS	300-00, 300-60, 300-61, 300-64, 300-66, 300-67	301-00, 301-60, 301-61, 301-64	303-00, 303-60, 303-61, 303-66, 303-67, 303-74	311-00, 311-60, 311-61, 311-64	312-00, 312-60, 312-61, 312-64	313-00, 313-60, 313-61, 313-64	315-00, 315-60, 315-64, 315-67	
RESISTANCE	10Ω - 50K	10Ω - 50K	50Ω - 150K	20K - 1MEG	10Ω - 50K	10Ω - 50K	10Ω - 50K	
POWER	1 watt (still air)	1 watt (still air)	1.5 watts (still air)	0.5 watts (still air)	1 watt (still air)	1.5 watts (still air)	1 watt (still air)	
SIZE	½" x ½" x 0.187"	½" x ½" x 0.255"	¾" x ¾" x 0.280"	½" x ½" x 0.187"	½" x ½" x 0.195"	½" x ½" x 0.187"	½" x ½" x 0.187"	
OPERATING TEMP.	-55 to +150°C	-55 to +150°C	-55 to +150°C	-55 to +85°C	-55 to +150°C	-55 to +200°C	-55 to +150°C	
RESOLUTION	10Ω-1.00% 1K-.32% 20Ω-.77 2K-.23 50Ω-.65 5K-.20 100Ω-.52 10K-.125 200Ω-.50 20K-.096 500Ω-.36 50K-.086	10Ω-1.00% 1K-.32% 20Ω-.77 2K-.23 50Ω-.65 5K-.20 100Ω-.52 10K-.125 200Ω-.50 20K-.096 500Ω-.36 50K-.086	50Ω-0.65% 5K-.20% 100Ω-.42 10K-.155 200Ω-.35 20K-.130 500Ω-.35 50K-.070 1000Ω-.30 100K-.062 2000Ω-.23 150K-.052 5000Ω-.18	20K 200K 50K 500K 75K 750K 100K 1MEG	10Ω-1.00% 1K-.32% 20Ω-.77 2K-.23 50Ω-.65 5K-.20 100Ω-.52 10K-.125 200Ω-.50 20K-.096 500Ω-.36 50K-.086			
Standard Resistance Tolerance	±5% (special tol. on request)	±5% (special tol. on request)	±5% (special tol. on request)	±20%	±5% (special tol. on request)	±5% (special tol. on request)	±5% (special tol. on request)	
Temp. Coeff. of Resistance Wire	20 ppm m °C max. 0° to 100°C	20 ppm m °C max. 0° to 100°C	20 ppm m °C max. 0° to 100°C	0.2%/°C, 0° to 100°C	20 ppm m °C max. 0° to 100°C	20 ppm m °C max. 0° to 100°C	20 ppm m °C max. 0° to 100°C	
Temp. Coeff. of Potentiometer	50 ppm °C max. 0° to 100°C	50 ppm °C max. 0° to 100°C	50 ppm °C max. 0° to 100°C	50 ppm °C max. 0° to 100°C	50 ppm °C max. 0° to 100°C	50 ppm °C max. 0° to 100°C	50 ppm °C max. 0° to 100°C	
Stability as Voltage Divider	0.2% or 1 resolution max.	0.2% or 1 resolution max.	0.2% or 1 resolution max.	Better than 0.7%, -55 to 85°C	0.2% or 1 resolution max.	0.2% or 1 resolution max.	0.2% or 1 resolution max.	
Load Life at Rating	1000 hrs. min. MIL-R-19A (in still air)	1000 hrs. min. MIL-R-19A (in still air)	1000 hrs. min. MIL-R-19A (in still air)	1000 hrs. min. MIL-R-19A (in still air)	1000 hrs. min. MIL-R-19A (in still air)	1000 hrs. min. MIL-R-19A (in still air)	1000 hrs. min. MIL-R-19A (in still air)	
Insulation Resistance	50 megohms min. (500V DC)	50 megohms min. (500V DC)	50 megohms min. (500V DC)	50 megohms min. (500V DC)	50 megohms min. (500V DC)	50 megohms min. (500V DC)	50 megohms min. (500V DC)	
Dielectric Strength	500V AC, 1 min.	500V AC, 1 min.	500V AC, 1 min.	500V AC, 1 min.	500V AC, 1 min.	500V AC, 1 min.	500V AC, 1 min.	
Useable Resistance Range	98%	98%	98%	98%	98%	98%	98%	
Equiv. Noise Resistance	0.1% or 100 ohms. NA 5-710	0.1% or 100 ohms. NA 5-710	0.1% or 100 ohms. NA 5-710		0.1% or 100 ohms. NA 5-710	0.1% or 100 ohms. NA 5-710	0.1% or 100 ohms. NA 5-710	
Adjustment Ratio	45:1	45:1	45:1	45:1	45:1	45:1	45:1	
Screw Turns	42	42	42	42	42	42	42	
Rotational Life	10,000 screw rev. min.	10,000 screw rev. min.	10,000 screw rev. min.	10,000 screw rev. min.	10,000 screw rev. min.	10,000 screw rev. min.	10,000 screw rev. min.	
Torque	7.5 oz. in. max.	7.5 oz. in. max.	7.5 oz. in. max.	7.5 oz. in. max.	7.5 oz. in. max.	7.5 oz. in. max.	7.5 oz. in. max.	
Weight	2 grams max.	2 grams max.	7 gr max.	2 grams max.	2 grams max.	2 grams max.	2 grams max.	
Temperature Cycling	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	
Vibration	Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.	
Shock	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	
Altitude	Exceeds MIL-E-5272C, Proc. II.	Exceeds MIL-E-5272C, Proc. II.	Exceeds MIL-E-5272C, Proc. II.	Exceeds MIL-E-5272C, Proc. II.	Exceeds MIL-E-5272C, Proc. II.	Exceeds MIL-E-5272C, Proc. II.	Exceeds MIL-E-5272C, Proc. II.	
Sand and Dust	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	
Fungus Resistance	All non-nutrient materials	All non-nutrient materials	All non-nutrient materials	All non-nutrient materials	All non-nutrient materials	All non-nutrient materials	All non-nutrient materials	
Corrosion Resistance	Similar materials construction 100%	Similar materials construction 100%	Similar materials construction 100%	Similar materials construction 100%	Similar materials construction 100%	Similar materials construction 100%	Similar materials construction 100%	
Humidity*	Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.		Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.	Exceeds MIL-E-5272C, Proc. I.	
Salt Spray*	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C		Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	

*Special Order

1544 STANDARD DAYSTROM SQUARETRIM®

144 MODELS	144 MODELS	168 MODELS	144 MODELS	96 MODELS	144 MODELS	96 MODELS	NEW
							
315-60, 315-61, 315-72, 315-74	316-00, 316-60, 316-61, 316-64, 316-72, 316-73	318-00, 318-60, 318-61, 318-64	355-00, 355-60, 355-61, 355-64	356-00, 356-60, 356-61, 356-64	357-00, 357-60, 357-61, 357-64	358-00, 358-60, 358-61, 358-64	
50K (still air) 1/2" x 0.200" -55 to +150°C	10Ω - 50K 1 watt (still air) 1/2" x 1/2" x 0.195" -55 to +150°C	10Ω - 50K 1.5 watts (still air) 1/2" x 1/2" x 0.255" -55 to +200°C	10Ω - 50K 1 watt (still air) 1/2" x 1/2" x 0.200" -55 to +200°C	10Ω - 50K 1 watt (still air) 1/2" x 1/2" x 0.195" -55 to +200°C	10Ω - 50K 1 watt (still air) 1/2" x 1/2" x 0.200" -55 to +200°C	10Ω - 50K 1 watt (still air) 1/2" x 1/2" x 0.195" -55 to +200°C	
1.00% 1K-.32% .77 2K-.23 .65 5K-.20 .52 10K-.125 .50 20K-.096 .36 50K-.086	10Ω-1.00% 1K-.32% 20Ω-.77 2K-.23 50Ω-.65 5K-.20 100Ω-.52 10K-.125 200Ω-.50 20K-.096 500Ω-.36 50K-.086						
(special tol. on request)	±5% (special tol. on request)	±5% (special tol. on request)	±5% (special tol. on request)	±5% (special tol. on request)	±5% (special tol. on request)	±5% (special tol. on request)	
°C max 0° to 100°C	20 ppm m °C max 0° to 100°C	20 ppm m °C max 0° to 100°C	20 ppm m °C max 0° to 100°C	20 ppm m °C max 0° to 100°C	20 ppm m °C max 0° to 100°C	20 ppm m °C max 0° to 100°C	
°C max 0° to 100°C	50 ppm °C max 0° to 100°C	50 ppm °C max 0° to 100°C	50 ppm °C max 0° to 100°C	50 ppm °C max 0° to 100°C	50 ppm °C max 0° to 100°C	50 ppm °C max 0° to 100°C	
1 resolution max	0.2% or 1 resolution max	0.2% or 1 resolution max	0.2% or 1 resolution max	0.2% or 1 resolution max	0.2% or 1 resolution max	0.2% or 1 resolution max	
1000 hrs. min (in still air)	1000 hrs. min MIL-R-19A (in still air)	1000 hrs. min MIL-R-19A (in still air)	1000 hrs. min MIL-R-19A (in still air)	1000 hrs. min MIL-R-19A (in still air)	1000 hrs. min MIL-R-19A (in still air)	1000 hrs. min MIL-R-19A (in still air)	
50 megohms min (500V DC)	50 megohms min (500V DC)	50 megohms min (500V DC)	50 megohms min (500V DC)	50 megohms min (500V DC)	50 megohms min (500V DC)	50 megohms min (500V DC)	
500V AC, 1 min.	500V AC, 1 min.	500V AC, 1 min.	500V AC, 1 min.	500V AC, 1 min.	500V AC, 1 min.	500V AC, 1 min.	
98%	98%	98%	98%	98%	98%	98%	
0.1% or 100 ohms NA 5-710	0.1% or 100 ohms NA 5-710	0.1% or 100 ohms NA 5-710	0.1% or 100 ohms NA 5-710	0.1% or 100 ohms NA 5-710	0.1% or 100 ohms NA 5-710	0.1% or 100 ohms NA 5-710	
45:1	45:1	45:1	45:1	45:1	45:1	45:1	
42	42	42	42	42	42	42	
10,000 screw rev. min.	10,000 screw rev. min.	10,000 screw rev. min.	10,000 screw rev. min.	10,000 screw rev. min.	10,000 screw rev. min.	10,000 screw rev. min.	
7.5 oz in. max.	7.5 oz in. max.	7.5 oz in. max.	7.5 oz in. max.	7.5 oz in. max.	7.5 oz in. max.	7.5 oz in. max.	
2 grams max.	2 grams max.	2 grams max.	2 grams max.	2 grams max.	2 grams max.	2 grams max.	
Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	Exceeds MIL-STD-202, Meth. 102	
Exceeds MIL-E-5272C, Proc. I	Exceeds MIL-E-5272C, Proc. I	Exceeds MIL-E-5272C, Proc. I	Exceeds MIL-E-5272C, Proc. I	Exceeds MIL-E-5272C, Proc. I	Exceeds MIL-E-5272C, Proc. I	Exceeds MIL-E-5272C, Proc. I	
Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	Exceeds MIL-STD-202, Meth. 202	
Exceeds MIL-E-5272C, Proc. II	Exceeds MIL-E-5272C, Proc. II	Exceeds MIL-E-5272C, Proc. II	Exceeds MIL-E-5272C, Proc. II	Exceeds MIL-E-5272C, Proc. II	Exceeds MIL-E-5272C, Proc. II	Exceeds MIL-E-5272C, Proc. II	
Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	
All non-nutrient materials	All non-nutrient materials	All non-nutrient materials	All non-nutrient materials	All non-nutrient materials	All non-nutrient materials	All non-nutrient materials	
Similar materials construction 100%	Similar materials construction 100%	Similar materials construction 100%	Similar materials construction 100%	Similar materials construction 100%	Similar materials construction 100%	Similar materials construction 100%	
Exceeds MIL-E-5272C, Proc. I	Exceeds MIL-E-5272C, Proc. I	Exceeds MIL-E-5272C, Proc. I	Exceeds MIL-E-5272C, Proc. I	Exceeds MIL-E-5272C, Proc. I	Exceeds MIL-E-5272C, Proc. I	Exceeds MIL-E-5272C, Proc. I	
Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	Exceeds MIL-E-5272C	

3/8" PREVIEW:
TO BE
INTRODUCED
AT THE
I.R.E. SHOW,
MARCH 20

New Squaretrims only 3/8" square, less than 1/8" thick. Design advantages: smaller, lighter in weight, yet rated at one full watt in still air. Flat, compact 3/8" Squaretrim permits much greater circuit density per cubic inch, needs no mounting brackets for stacking, and the new 3/8" Squaretrim will be offered in a full line of 144 standard models. You get the famous Daystrom precision plus the famous Daystrom wide line and design latitude. Sample quantities will be available immediately after the I.R.E. See them at Booth 1706.

PRECISION POTENTIOMETERS AVAILABLE

DAYSTROM PATENTED PRECISION ROTARY TYPE

EXAMPLE: ZERO BACKLASH



The Daystrom 341 Series rotary potentiometers contain this patented "V" guide which eliminates backlash and resultant error. U.S. Patent 2,856,493.

EXAMPLE: DOUBLE WIPERS, FINER RESOLUTION, AND ABSOLUTE CONTINUITY IN SUBMINIATURE SERIES 341 TEN-TURNS



ACTUAL SIZE

The use of patented double wipers in our 341 Series Potentiometer effectively doubles the resolution...intermittents that normally result from shock and vibration are virtually eliminated.

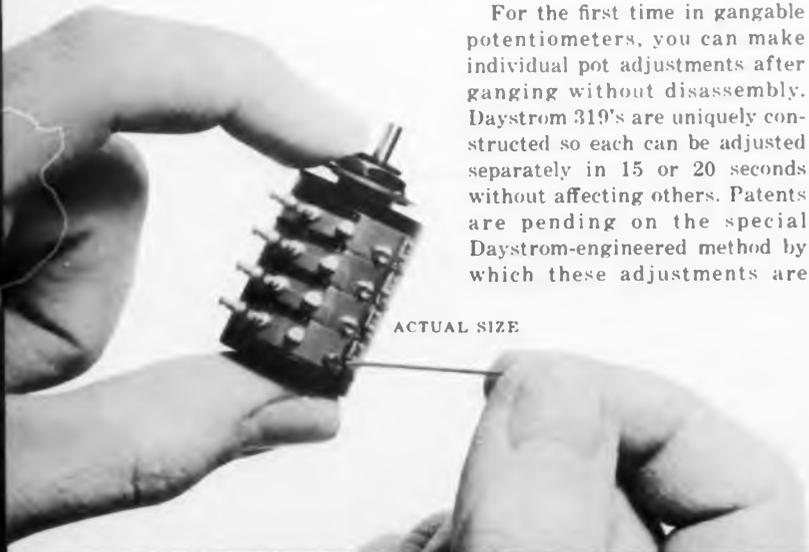
Coupled with its subminiature size, this stability to environmental stress makes the 341 Series ideal for avionics systems, where it has found many applications (the TITAN missile is an example).

The Series 341 potentiometers are offered in resistance ranges from 1K to 600K, can carry 2.5 watts in still air at 40°C, and operate from -55 to 140°C. They are only $\frac{1}{2}$ " in diameter and 1" long, and meet all applicable MIL specs. The 341 can also be supplied with a patented clutch for servo installation.

EXAMPLE: SPECIAL ADJUSTING DEVICE IN GANGABLE SERIES 319

For the first time in gangable potentiometers, you can make individual pot adjustments after ganging without disassembly. Daystrom 319's are uniquely constructed so each can be adjusted separately in 15 or 20 seconds without affecting others. Patents are pending on the special Daystrom-engineered method by which these adjustments are

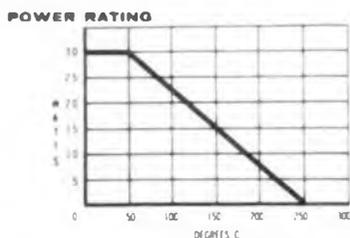
made. Because of the simplicity of adjustment after ganging, you can order these potentiometers already ganged at Daystrom in the number needed, then make your final adjustments in seconds. Resistance Range: 100Ω to 200K; Power: 2 watts in still air; Temperature: -55 to 150°C. Meets all applicable MIL specs.



ACTUAL SIZE

TYPES OFFER DISTINCT DESIGN ADVANTAGES...

EXAMPLE: HIGH POWER, HIGH TEMPERATURE COMBINED IN SUBMINIATURE 314 SERIES



The high temperature stability and power handling capacity of these tiny units is truly impressive. Here, in a case only $\frac{1}{2}$ " by $\frac{11}{32}$ "—it would rattle around in a thimble—is a high-performance potentiometer that will operate to 250°C and dissipate 3 watts in still air at 50°C! In addition, the weight is only 10 grams. Special

complementary and compatible materials plus precision winding techniques, are employed to achieve this capability. Resistance in standard models ranges from 10Ω to 50K. Available with or without stops and all panel mounting modes. Meets all applicable MIL specs.

EXAMPLE: HIGH LINEARITY IN TINY PACKAGE OF SINGLE-TURN 304 SERIES



Where space is at a premium but precision and performance is a must, the subminiature Daystrom 304 Series potentiometers are ideal. The use of a cylindrical

mandrel instead of a conventional card, plus special precision winding techniques, are the design features that permit such exceptional performance in such a small case. Only $\frac{1}{2}$ " in diameter and with case length of mere $\frac{3}{8}$ ", the 304 Series offers linearities of 0.3% to 3% standard, as fine as 0.18% on special order. These tiny potentiometers will carry 2 watts at 50°C in still air, operate from -55 to 125°C. They weigh only 7 grams max., meet all applicable MIL specs. Resistance Range: 10Ω to 50K.

THESE ARE BUT A FEW OF THE ADVANTAGES OF DAYSTROM ROTARY POTENTIOMETERS. SEND FOR SPECIFICATIONS OR CALL YOUR DAYSTROM SUPPLIER FOR ADDITIONAL DATA.

DAYSTROM, INCORPORATED
POTENTIOMETER DIVISION
ARCHBALD, PENNSYLVANIA • LOS ANGELES, CALIFORNIA



Electronic Timer

607

For nuclear applications



The model N-804 timer measures preset and elapsed time with a 60-cycle controlled time base. Maximum time storage is 10,000 sec. Time readout is by four glow transfer tubes. Time resolution is to the nearest second on times longer than 1,000 sec. The unit may be used with any electronically gated scaler as well as with scalers which are stopped and started with mechanical contact closures.

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

Silicon Transistors

662

Operate to 200 C

These four diffused-junction silicon power transistors, of the npn type, 2N1700 through 2N1703, operate at case and flange temperatures from -65°C to 200°C . Dissipation ratings at 25°C range from 5 to 75 w. Alpha cut-off frequency is 1 to 1.2 mc.

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

Price: From \$3.50 ea, 1,000 and up.

Circuit Boards

672

Teflon-glass laminate

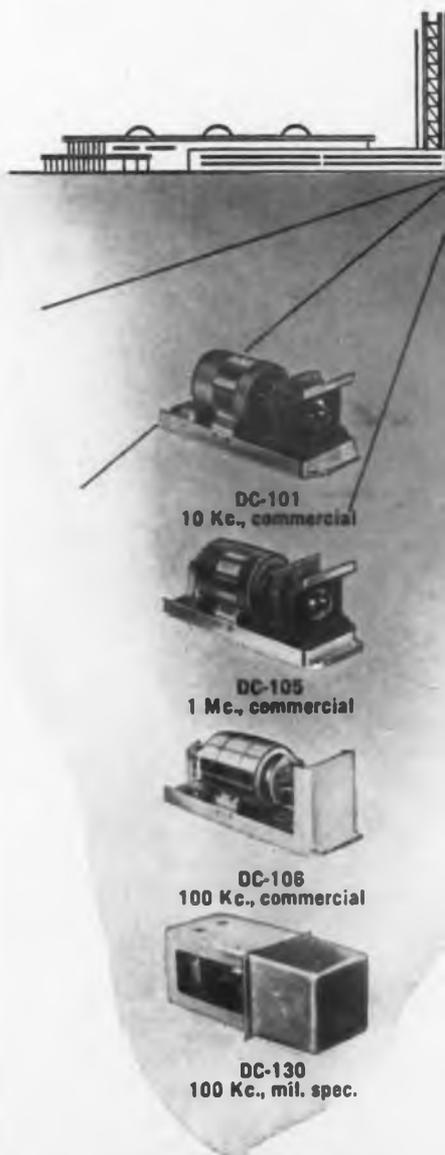
Copper-clad, Teflon-glass laminated circuit board, called Genclad, is available in sizes up to 36 x 34 in., in any thickness, with copper on one or both sides. The nonflammable board may be solder-dipped for 1 min at 550 F. Dielectric constant is 2.56 at 1 mc; dielectric strength is 500 v per mil. No adhesive is used in bonding.

General Plastics Corp., Dept. ED, 55 La France Ave., Bloomfield, N.J.

◀ CIRCLE 83 ON READER-SERVICE CARD

CIRCLE 84 ON READER-SERVICE CARD ▶

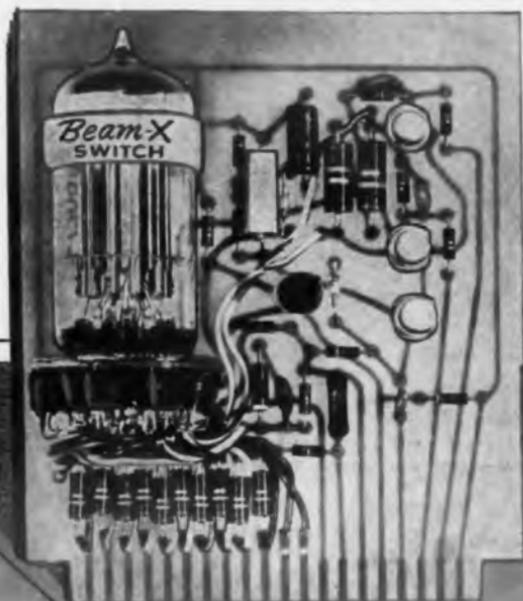
"the Best



FOR DETAILED INFORMATION,
WRITE FOR BULLETIN 1002

★ Trademark of Burroughs Corporation

counter in decades"



NOW . . . THE *Beam-X** COUNTER

The new Burroughs BEAM-X Counter is the lowest cost transistorized decade counter available. The DC-111 Counter, newest product of the Electronic Tube Division, combines the Beam-X switch with transistors in a circuit capable of resolving pulses at 110 Kc. Electrical outputs are provided to operate remote Nixie® tubes, printers, and to perform other circuit functions. This latest addition to the Burroughs Counter line makes possible a number of advantages never before available:

- Use of new Beam-X switch—lowest cost, lightest weight, highest speed, smallest size 10 position electronic counting device.
- Total power consumption of only two watts.
- Elimination of as many as ninety components from counting circuits.
- Increased reliability due to component reduction and use of the ultra reliable Beam-X switch.

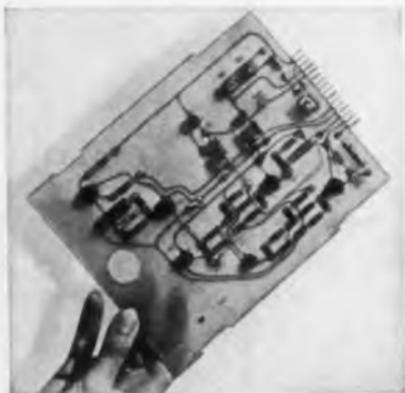
This counter is designed as a plug-in module for use in computers, electronic counters, machine control, automation and test equipment and military systems. The units may be directly cascaded. They can be driven by a twelve-volt signal, and are compatible with existing transistor logic circuits.

ANOTHER ELECTRONIC CONTRIBUTION BY
Burroughs Corporation

ELECTRONIC TUBE DIVISION

Plainfield, New Jersey

Taylor glass-base laminates pop right out as design materials in many applications



There are good reasons for investigating Taylor glass-base laminated plastics as high-strength-to-weight materials in your design. They offer light weight, corrosion resistance, electrical and thermal insulation, and ease of fabrication.

For example, glass-fabric-base laminates have the highest mechanical strength of all laminated plastic materials. They have been successfully used in the fabrication of critical parts, including aircraft parts and bases for printed circuits. They are most valuable where extremely low moisture absorption, increased heat resistance and superior electrical properties are required.

Taylor Fibre produces a number



of different glass-base grades in sheet, rod and tubular form, and copper-clad. Those with phenolic resin are recommended for mechanical and electrical applications requiring heat resistance. Those with melamine are characterized by their excellent resistance to arcing and tracking in electrical applications. They also have good resistance to flame, heat and moderate concentrations of alkalis and most solvents. Those with silicone exhibit very high heat resistance, combined with good mechanical and electrical properties. They also have highest arc resistance. Those with epoxy offer extremely high mechanical strength, excellent chemical resistance, low moisture absorption, and high strength retention at elevated temperatures.

Technical data about these and other Taylor laminated plastics are available. Ask for your copy of the Taylor Laminated Plastics Selection Guide. Taylor Fibre Co., Norristown 48, Pa.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

CIRCLE 65 ON READER-SERVICE CARD

NEW PRODUCTS

UHF Turret Attenuator

632

With fast value change



These step-type turret attenuators permit quick change of db combinations. The removal of 3 set screws allows pad retainer ring to move forward for easy replacement, removal, or rearrangement of pads. Turrets are available in any combination of values from 0.1 db through 60 db, in 0.1-db increments.

Stoddart Aircraft Radio Co., Inc., Dept. ED, 6644 Santa Monica Blvd., Hollywood 38, Calif.

HF Oscilloscope

631

Bandwidth to 15 mc



Designed for laboratory use, the GM 5603 oscilloscope has differential vertical input, bandwidth dc to 15 mc. Sensitivity ranges from 50 mv per cm to 5 v per cm, accurate to $\pm 3\%$. Time base is 40 μ sec per cm to 1 sec per cm, in 21 steps, accurate to $\pm 3\%$. Magnifications of 2x and 5x are provided. The 13-cm flat-faced cathode-ray tube has an accelerating voltage of 10 kv.

N. V. Philip's Gloeilampenfabriegen, EMA Dept., Dept. ED, Eindhoven, The Netherlands.

Accuracy Is Our Policy . . .

A New Products item concerning Hamlin's Magnetic Reed Switches type DRS-5 appeared on p 159 of the Dec. 7, 1960, issue of ELECTRONIC DESIGN. The picture which accompanied the text was incorrect.



HIGH PERFORMANCE 2-Inch Cooling Fan

AiResearch Minifan[®] is an extremely high performance 400-cycle AC motor-driven fan used for cooling airborne or ground electronic and electrical equipment. Model shown has a flow capacity of 53.5 cfm at a pressure rise of 3.44 H₂O, and requires only 69 watts.

Minifan operates up to 125°C. ambient. Its size and weight make it ideal for spot cooling, cold plates or as a cooling package component. The fan can also be repaired, greatly increasing its service life.

Range of Specifications

- Volume flow: 21.5 to 53.5 cfm
- Pressure rise: .6 to 3.44 H₂O
- Speed: 10,500 to 22,500 rpm
- Single, two or three phase power
- Power: 16 to 69 watts
- Standard or high slip motors
- Weight: .36 to .48 lb.

A world leader in the design and manufacture of heat exchangers, fans and controls, AiResearch can assume complete cooling system responsibility. Your inquiries are invited.

*Minifan is an AiResearch trademark.



AiResearch Manufacturing Division
Los Angeles 45, California

CIRCLE 86 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

Control Cable 620

With polyethylene insulation



The thermosetting insulation of Vulkene cable makes it suitable for general usage in air, conduit, underground ducts, or for direct burial. The heat-resistant, chemically cross-linked polyethylene insulation is available on cable with ratings of 600 v or 1,000 v, 2 through 12 conductors, in AWC sizes 14, 12, and 10.

General Electric Co., Chemical and Metallurgical Div., Wire and Cable Dept., Dept. ED, Bridgeport 2, Conn.

Commutating Switch 633

For 10 circuits

This adjustable-pole commutating switch can incorporate as many as 10 independent spst or spdt circuits. Each pole can carry as many as 30 bits of information. All circuits can be adjusted over a 360-deg range to lead or lag any or all other circuits. The unit meets military requirements and has a life expectancy of more than 30 million cycles.

Airflyte Electronics Co., Dept. ED, 535 Avenue A, Bayonne, N.J.

Dual-Channel Plug-In 634

Dc to 500-kc bandwidth

Dual-channel plug-in, type 200, provides dc to 500-kc bandwidth and 1 mv per cm sensitivity. The unit is designed for use with all Analab oscilloscope main frames. Contained within the single plug-in are two amplifier channels and the trigger sweep circuits. Channel A has a maximum sensitivity of 1 mv per cm and channel B has a sensitivity of 40 mv per cm. Both have a bandwidth of dc to 500 kc.

Analab Instrument Corp., Dept. ED, 30 Canfield Road, Cedar Grove, N.J.

CIRCLE 87 ON READER-SERVICE CARD >



Highly complex shapes,

internal and external, formed in one operation to close tolerances in

ALSiMAG CERAMICS

NEW SHAPES NOW PRACTICAL

Technical ceramic parts formerly impossible or available only by expensive machining and grinding are now practical and can be produced in volume to close tolerances and with great uniformity. They include complex and compound curves, thin walls and other difficult design features. This injection molding process is particularly suited to volume production which readily permits amortization of initial tooling costs.

MATERIALS

ALSiMag 614 (High Alumina) and
ALSiMag 704 (Porous and Leachable)

have found widest use. Other ALSiMag ceramic compositions are available. See Property Chart, sent on request.

APPLICATIONS

include but are not limited to:

Electronic and Electrical, such as conical micro-wave tube windows, envelopes, complex internal insulators, cups, encapsulating devices, semi-conductor assembly boats and plugs.

High Temperature, Mechanical and Heat Shock uses such as welding nozzles.

Precision Investment Casting cores of great dimensional accuracy.

Guides for wire and textile machinery.

The use of these ALSiMag ceramics is indicated when high frequencies, high temperatures, heat shock, chemical attack or mechanical wear are involved.

EXPERIENCE

More than two years of steadily increased production from this equipment has given us practical experience which enables us to promptly and accurately answer most inquiries involving complex and difficult shapes. Send blue prints or sketches. Chances are that your "impossible" designs are now practical in ALSiMag ceramics.

A Subsidiary of
Minnesota Mining and
Manufacturing Company



AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENN.

60TH YEAR OF CERAMIC LEADERSHIP

For service, contact American Lava representatives in Offices of Minnesota Mining & Manufacturing Co. in these cities (see your local telephone directory): Boston, Newton Center, Mass. • Chicago, Bedford Park, Ill. • Cleveland, Ohio • Dallas, Texas • Los Angeles, Cal. • New York, Ridgefield, N. J. • Philadelphia, Pa. • St. Louis, Mo. • St. Paul, Minn. • So. San Francisco, Cal. • Seattle, Wash. All other export: Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

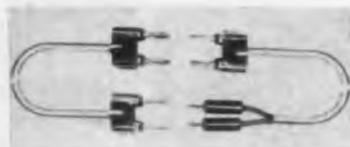
BOOTH 4401 at I.R.E.

NEW PRODUCTS

Patch Cords

489

With 10 terminations



Designed for interconnecting af and rf circuits, these patch cords use 3/4-in. double banana plugs cabled to a wide variety of plugs, connectors, clips and tips. Ten terminations and 3 types of cable are available. Design of the plug permits multiple parallel stacking.

Herman H. Smith, Inc., Dept. ED, 2326 Nostrand Ave., Brooklyn 10, N.Y.

Synchronous Motor

663

With variable pole

An L-shaped variable pole arm on this permanent magnet synchronous motor makes it able to start from dead center. The VP-III is rated at 20 in. per oz at 1 rpm; a high torque model is available, rated at 40 in. per oz at 1 rpm. Standard speeds are from 10 rpm to 1/60 rpm. Rotation may be clockwise or counterclockwise. Supply is 115 v, 60 cps.

Controls Co. of America, Lake City, Inc., Dept. ED, Crystal Lake, Ill.

Frequency-Period Meter

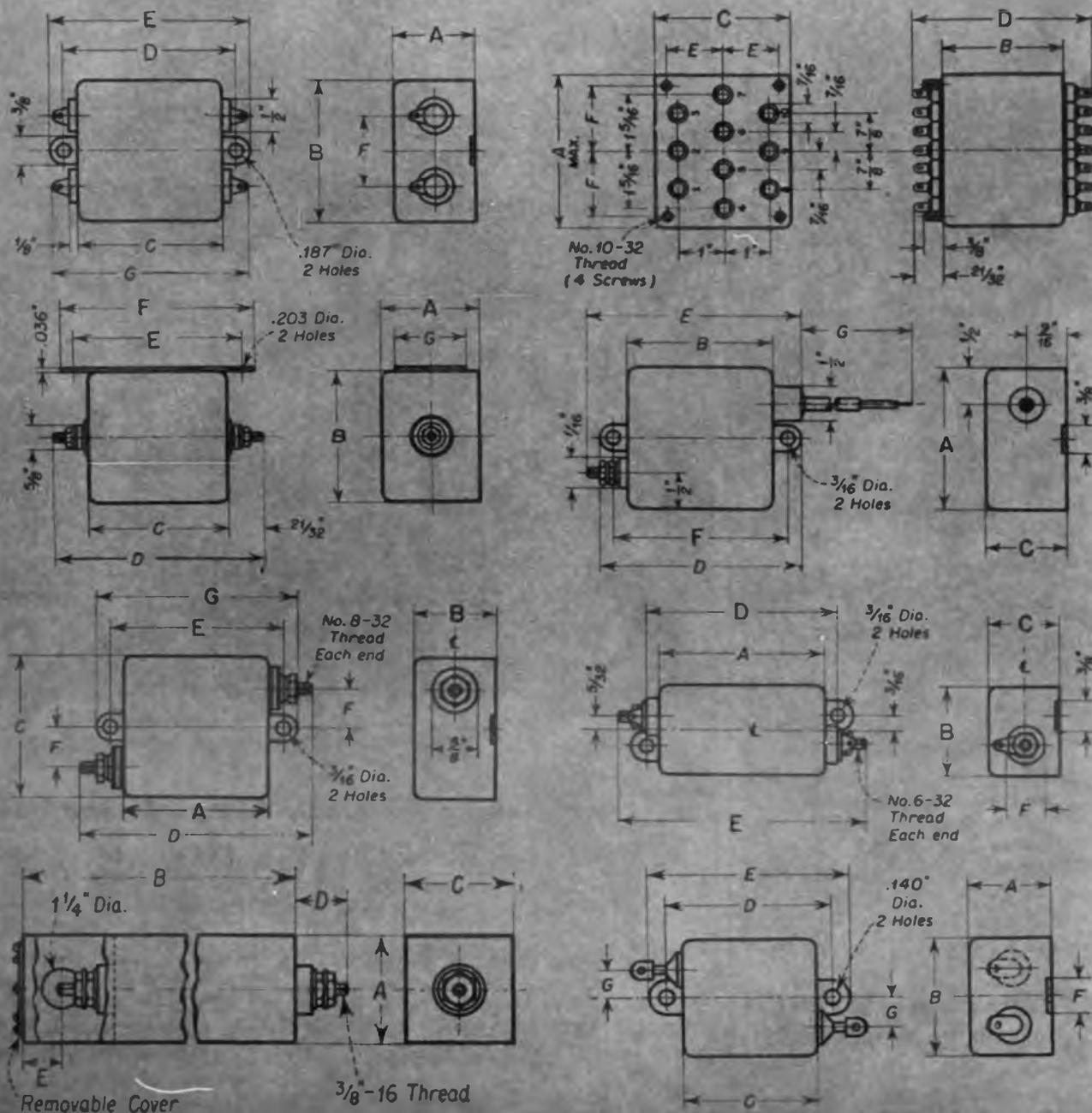
664

Measures dc to 220 mc

The model 737A will measure frequency from dc to 220 mc, period to 0.1 μ sec, and time interval from 0.1 μ sec to 10^7 sec. Readout may be decade or Nixie. The meter uses a solid-state counter and a vacuum-tube heterodyne converter. Decimal point is automatically placed. Stability is 0.2 ppm; sensitivity is 0.25 v rms. The 53-lb meter measures 14 x 17 x 13 in.

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

Price: \$2,400.



we make almost every type of interference filter you've

You probably know the range and diversity of filters that Cornell-Dubilier offers industry and government. Surely you know that CDE pioneered interference filters when many people didn't know what they were for! Yet do you know that CDE is now working on filters for high-temperature operations beyond the state of the art? Even now CDE is developing interference filters with a degree of reliability undreamed of a few years ago. In depth of experience and engineering personnel, CDE offers you unparalleled resources to design and produce the precise system you need for



**CORNELL-DUBILIER
ELECTRONICS DIVISION**
FEDERAL PACIFIC ELECTRIC COMPANY

SYSTEMS ENGINEERING SERVICES

- Electromagnetic Compatibility Studies
- Systems Qualification
- Components Qualification
- RF Field Patterns and Area Surveys
- RF Interference Control
- RF Weapons Systems Management

ENGINEERING AND PRODUCTION SERVICES

RF Suppression Components

PI Filters
Feed-Through Capacitors
L-C Filters
L-Cap Feed-Through Capacitors
Screen Room Filters

Filter Networks

Audio Filters
High- and Low-Pass Filters
Band-Pass Filters
Telemetry Filters
Band Rejection Filters

Double-Target Pyrometer

585

For indication and control



This double-target temperature indicating-controlling pyrometer provides a second control point for secondary or additional action. It is available in 11 ranges between 0 to 400 F and 0 to 3,000 F, plus a test chamber range of -100 to 300 F. The flush-mounting unit measures 6-3/8 x 7 in.

Alnor Instrument Co., Dept. ED,
418 N. LaSalle St., Chicago 10, Ill.

RF Power Monitor

674

Also measures vswr

The feed-through type power monitor measures incident power between 0.2 and 200 mc, reflected power and vswr from 10 to 200 mc. Calibration can be checked against 60 cps. Frequency range of the resistive voltage divider is dc to 200 mc. Accuracy is 5% of full scale; impedance is 51.5 ohms. Model VM-1 has ranges of 15 and 60 w; model VM-2, ranges of 60 and 150 w.

Electro-Impulse Laboratory, Inc.,
Dept. ED, 208 River St., Red Bank,
N.J.

Silicon Diode

671

For TV and fm afc

The type 1N3182 voltage variable capacitor silicon diode is designed for TV and fm afc use. Typical Q is 60; average capacitance is 30 pf. The subminiature diode, of all glass-construction, has a maximum series resistance of 3 ohms and an inverse voltage of 4 v.

Amperex Electronic Corp., Semi-conductor and Special Purpose Tube Div., Dept. ED, 230 Duffy Ave., Hicksville, N.Y.

ever seen ... and thousands you've never seen before!

any interference problem. Today, as part of fast-growing Federal Pacific, CDE offers you more than ever in facilities, plants and people with an "urge to serve" that welcomes your inquiry for everything we make, for everything we can help you design. We have recently issued the above-illustrated brochure to describe the range and breadth of systems engineering services available to you whenever you consult with CDE. May we send you a complimentary copy? Cornell-Dubilier Electronics Division, Federal Pacific Electric Co., General Offices: 50 Paris Street, Newark 1, N. J.

CORNELL-DUBILIER ELECTRONICS DIV.



FEDERAL PACIFIC ELECTRIC COMPANY

growth through creative energy

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Self-Aligning . . . Even with Commercial Tolerances

Vegetable crate construction is generally frowned upon for complex modular installations. But, with Deutsch self-aligning rack-and-panel connectors, commercial tolerances between mounting hole centers are perfectly okay. When the drawer is slid home, each spring-mounted plug floats into engagement with its receptacle. Spring pressure then maintains an environmental seal. For complete information on this easy-to-mount line of cylindrical and rectangular rack-and-panel connectors contact your local Deutschman today or write for Data File C-2.

DEUTSCH

*Electronic Components Division
Municipal Airport
Banning, California*

ADVANCED SPECIFICATION MINIATURE ELECTRIC

CIRCLE 90 ON READER-SERVICE CARD



NEW PRODUCTS

DC Power Supply

660

Is transistorized



Model L3501 power supply is a portable, transistorized unit which measures 6 x 8 x 8 in. Rating is 0 to 35 v at 0 to 1 amp dc. Regulation is 2 mv per 10% line input change and 5 mv from no load to full load. Ripple is held to 250 μ v rms. Parts and workmanship are guaranteed for 2 yr for 24 hr continuous duty, without derating.

Universal Electronics Co., Dept. ED, 1720 22nd St., Santa Monica, Calif.

Price: \$189.50.

Availability: From stock.

Data Converter

657

From paper to magnetic



Model 433 extracts data from punched paper tape and writes them on magnetic tape. Input and output data are completely identical in content. It will accept paper, foil or plastic tapes in widths varying from 5 through 8 level. It includes a paper tape reader capable of reading 120 characters per sec.

Tally Register Corp., Dept. ED, 1310 Mercer St., Seattle, Wash.

Price: From \$26,500.

Availability: 120 days.

Accuracy Is Our Policy . . .

The New Product described on page 112 of the Jan. 4 issue of **ELECTRONIC DESIGN** was incorrectly identified as a multiplexer. The device described was the model 3735 Multiplier manufactured by Donner Scientific Co., Concord, Calif.

RICAL CONNECTORS



KCP SERIES

KT SERIES

KR SERIES

three for dependability at low cost

MEET P&B's FAMILY OF "K SERIES" RELAYS

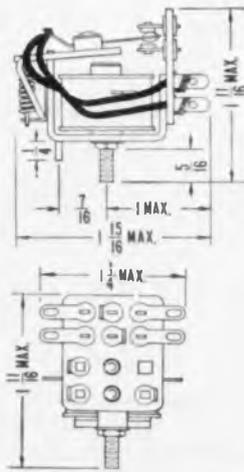
Here are only three of a large family of "K Series" relays by P&B. Blood brothers all, they are distinguished by fine craftsmanship and design maturity. Together they will handle a multitude of switching requirements.

Many design engineers find it saves time, saves money to integrate their circuits with related P&B relays. Makes sense, doesn't it?

KR—A small, lightweight relay used widely in communications and automation. Engineered for long life and dependability. 3PDT max. AC or DC. (See engineering data.)

KT—Designed for antenna switching. Capacitance: 0.5 mmfds between contacts. Terminal board is glass melamine and stack insulation is glass silicone for minimum RF losses to switch 300 ohm antenna line. 3 PDT max. AC or DC.

KC—Low cost plate circuit relay with sensitivity of 125 mw per pole. Factory adjusted to pull-in on specific current values. Available open, hermetically sealed or in clear plastic dust cover with standard octal-type plug. 3 PDT max. DC.



P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

KR ENGINEERING DATA

GENERAL:
Breakdown Voltage: 500 volts rms minimum between all elements.

Temperature Range:
DC Coils—45°C to 85°C.
AC Coils—45°C to 70°C.

Terminals:
Pierced solder lugs standard. Octal 8 and 11 pin plug-in headers available.

Enclosures: Type K—Hermetically sealed.
Type P—clear cellulose acetate dust cover.

CONTACTS:
Arrangements: 3 Form C (3PDT) max.
Material: 1/8" dia. 99.99% silver (gold plated).
Other materials available to increase contact capacity.
Load: 5 amperes 115V 60 cycle resistive.

COILS:
Resistance: 16,500 ohms max. AC or DC.

Power: 1.1 watts minimum to 4 watts maximum for DC at 25°C ambient.

Duty: Continuous.
Insulation: Centrifugally impregnated with insulating varnish.

ONE ORDER TO
ALLIED
FILLS THE
WHOLE BILL

Make **ALLIED**
Your Headquarters For
P&B RELAYS

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to **499**

We stock the complete POTTER & BRUMFIELD line—in depth.

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POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

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CIRCLE 92 ON READER-SERVICE CARD ➤

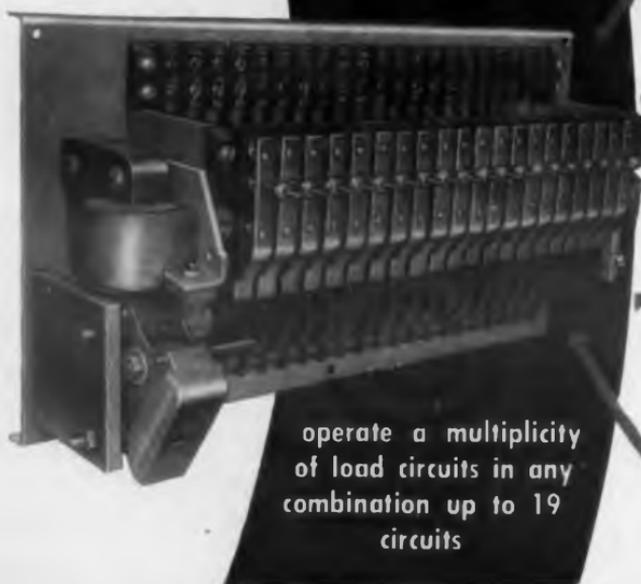
POTTER & BRUMFIELD
Princeton, Indiana

A NEW APPROACH TO
MACHINE PROCESS CONTROL

Step Sequencing

the new
**Eagle
Step
Switch**

use any type of
time or sensing
device to advance
the **Eagle
Step Switch**



operate a multiplicity
of load circuits in any
combination up to 19
circuits

PUSH
BUTTON



LIMIT
SWITCH



INTERVAL
TIMER



PRESSURE
CHANGE



LEVEL
CONTROL



This new Eagle Step Switch also provides:

1 SEQUENCING INTERLOCK
when used with multiple indexing
circuits.

3 MECHANICAL CIRCUIT IN-
TERLOCK by cam action — elim-
inates interlocking relays.

2 10 AMP SWITCH CONTACTS
control load switches direct —
no need for load relays.

4 115 VOLT COIL operates direct
on AC with heavy duty ratchet
mechanism — insures long life.

Write us regarding your count problem, or see your local phone directory or Thomas Register under the heading, "Timers, Electric" for your nearest Eagle Signal representative.

OTHER POPULAR HIGH QUALITY EAGLE TIME-COUNT CONTROLS



SIGNAL COMPANY • Moline, Illinois
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MANUFACTURERS OF A COMPLETE LINE OF INDUSTRIAL TIME-COUNT CONTROLS

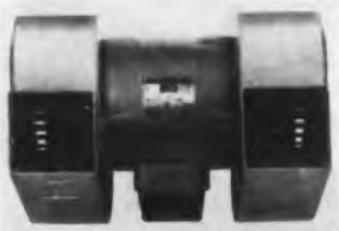
CIRCLE 93 ON READER-SERVICE CARD

NEW PRODUCTS

Dual Blower

659

Centrifugal type



MSA-11100 dual centrifugal blower is designed for air-cooling of high-powered electronic equipment. Operating on 220/440-v, 60-cps, three-phase power, the unit will deliver 1,700 cfm at a static pressure of 1.4 in. of water. Over-all dimensions are 20.60-in. long, 14.63-in. high and 14.90-in. deep.

Torrington Manufacturing Co., Specialty Blower Div., Dept. ED, Torrington, Conn.

Data Equipment

417

For scanning and printing

High-speed facsimile scanning and printing units, model 921 scanner and model 902 printer, are capable of transmitting and printing 600 individual page-size documents in an hour. The scanner accepts random length documents, then transmits the intelligence to the printer for continuous or intermittent "hard copy" print-out. Dry, permanent copies are produced on standard weight paper.

A. B. Dick Co., Dept. ED, 5700 W. Touhy Ave., Chicago 48, Ill.

Transistorized Preamp

658

For image orthicon use



This transistorized preamplifier is mounted in a standard 14-pin image orthicon base socket. With nominal image orthicon tube load, frequency response is ± 1 db to 8 mc. The output stage is an emitter-follower driving a coaxial cable. Terminating impedance is 75 ohms. Input is -6 v with output of 1.5 v peak-to-peak max undistorted.

Thompson Ramo Wooldridge Inc., Dage Div., Dept. ED, Michigan City, Ind.



MACHINES TALK!

over commercial telephone
circuits equipped with

Rixon's sebit 24
data transceiver



Binary information is processed at 2400/1200/600 bits/sec in a nominal 3-KC voiceband such as a long distance toll circuit. Used for passing high speed data of: 3000 w/m teleprinters; machines and computers; slow scan TV; facsimile; time division multiplexers; and sequential telemetering equipment.

- Built-in signal and test monitor
- Fully transistorized
- Fast acting AGC and self-contained, variable amplitude and delay equalization
- Contains highly stable clock for synchronous detection and regeneration of received data signals
- Low error rate . . . highly reliable over non-engineered circuits
- Standard rack mounting.

SPECIFICATIONS AVAILABLE ON REQUEST

THE SEBIT 24 WILL BE ON DISPLAY AT
OUR BOOTH IN THE MARCH I.R.E. SHOW

RIXON

ELECTRONICS, INC.

2414 REEDIE DRIVE
SILVER SPRING, MD.
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CIRCLE 94 ON READER-SERVICE CARD

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THIS CARD
IN THE MAIL

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2. YES NO Please send me also free of charge, any special **MICROWAVES** issues.

3. I do design work I supervise design work I do no design work

4. Address stencil is correct. Please make indicated corrections.

5. Principal Electronic Manufacturing or Service category at this facility.

PLEASE CHECK ONE ONLY

Audio, Communication, Radar, Radio & TV Mfrs.

Instruments, Controls, Test Equipment Mfrs.

Analyzer, Computers, Business Machine Mfrs.

Aircraft, Aircraft Accessories, Guided Missile Mfrs.

Component Parts, Sub-Assembly Mfrs.

Material Mfrs.

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Independent Labs, Consultants, Research Orgns.

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ELECTRONIC DESIGN • February 15, 1961

27* ISSUES IN '61

*27th issue: **ELECTRONIC DESIGNERS' CATALOG**

NEW PRODUCTS

Stepless Control 487

For furnace regulation



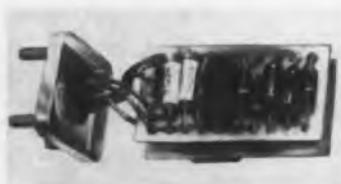
A solid-state switching device, the Power-Prop gives proportional control over the full range of furnace load. It is an input control that will operate from any pyrometer with a proportional dc voltage output signal. The system has no moving parts. It is made in capacities up to 75 amp and up to 230 v ac.

Stepless Controls Corp., Dept. ED, Bear Hill Road, Waltham, Mass.

Availability: Delivery from stock.

Time Delay Relays 604

Solid-state versions



These solid-state timing units, in the Agastat line, are designed for 18- to 32-v dc operation. Delay, on pull-in or drop-out, ranges from 0.01 sec to 10 hr. Internal and external adjustment types, with ratios from 10 to 3,000 to 1, are offered in addition to fixed-time models. Ambient temperature ranges are -55 to 70 C or 125 C, with fixed-condition accuracies of $\pm 3\%$ or $\pm 5\%$. Output may be as high as 5 amp.

Elastic Stop Nut Corp., Elizabeth Div., Dept. ED, Elizabeth, N.J.

Display System 669

Monitors computer

A general-purpose, alphanumeric display system, the dd74 provides readout for large data systems. A

NEW

20 AMP 0-34 VDC

Regulated POWER SUPPLY joins



EASY SERVICE ACCESS

Dual-deck, swing-out back construction provides simple and fast service access without the need to remove unit from rack. All major component terminals are accessible from rear.

CONVECTION COOLED—

no blowers or filters—
maintenance free

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

NO VOLTAGE SPIKES OR OVERSHOOT

Lambda's design prevents output voltage overshoot on "turn on, turn off," or power failure.

MIL QUALITY

Hermetically-sealed magnetic shielded transformer designed to MIL-T-27A quality and performance. Special, high-purity foil, hermetically-sealed long life electrolytic capacitors.

GUARANTEED FOR FIVE YEARS

LA 50-03A	without meters	0-34 VDC	0-5A	\$395
LA 50-03AM	with meters	0-34 VDC	0-5A	425
LA 100-03A	without meters	0-34 VDC	0-10A	510
LA 100-03AM	with meters	0-34 VDC	0-10A	540
LA 200-03A	without meters	0-34 VDC	0-20A	795
LA 200-03AM	with meters	0-34 VDC	0-20A	825



**COMPACT
NO BLOWERS**

5 AMP 3½" HIGH
10 AMP 7" HIGH
20 AMP 10½" HIGH



Patent Pending

Lambda LA Series Power Supplies are compact, convection cooled and rated for continuous duty at 50°C ambient temperature.

LAMBDA Transistorized 5 and 10 AMP LA Series

COMPLETE SPECIFICATIONS OF LAMBDA LA SERIES

DC OUTPUT (Regulated for line and load)

Model	Voltage Range ¹	Current Range ²	Price
LA 50-03A	0-34 VDC	0-5A	\$395
LA 50-03AM	0-34 VDC	0-5A	\$425
LA100-03A	0-34 VDC	0-10A	\$510
LA100-03AM	0-34 VDC	0-10A	\$540
LA200-03A	0-34 VDC	0-20A	\$795
LA200-03AM	0-34 VDC	0-20A	\$825

¹The output voltage for each model is completely covered in four steps by selector switches plus vernier control and is obtained by summation of voltage steps and continuously variable DC vernier as follows:

MODEL	VOLTAGE STEPS
LA 50-03A, LA 50-03AM	— 2, 4, 8, 16 and 0.4 volt vernier
LA100-03A, LA100-03AM	— 2, 4, 8, 16 and 0.4 volt vernier
LA200-03A, LA200-03AM	— 2, 4, 8, 16 and 0.4 volt vernier

²Current rating applies over entire output voltage range

Regulation (line)	Better than 0.05 per cent or 8 millivolts (whichever is greater). For input variations from 100-130 VAC.
Regulation (load)	Better than 0.10 per cent or 15 millivolts (whichever is greater). For load variations from 0 to full load.
Transient Response (line)	Output voltage is constant within regulation specifications for step function line voltage change from 100-130 VAC or 130-100 VAC.
Transient Response (load)	Output voltage is constant within regulation specifications for step-function load change from 0 to full load or full load to 0 within 50 microseconds after application.
Internal Impedance	LA 50-03A less than .008 ohms LA100-03A less than .004 ohms LA200-03A less than .002 ohms
Ripple and Noise	Less than 1 millivolt rms with either terminal grounded.
Polarity	Either positive or negative terminal may be grounded.
Temperature Coefficient	0.025 %/°C

AC INPUT	100-130 VAC, 60 ± 0.3 cycle ³
LA 50-03A	360 watts ⁴
LA100-03A	680 watts ⁴
LA200-03A	1225 watts ⁴

³this frequency band amply covers standard commercial power lines in the United States and Canada.

⁴with output loaded to full rating and input at 130 VAC.

AMBIENT TEMPERATURE AND DUTY CYCLE

Continuous duty at full load up to 50°C (122°F) ambient.

OVERLOAD PROTECTION:

Electrical Magnetic circuit breaker front panel mounted. Special transistor circuitry provides independent protection against transistor complement overload. Fuses provide internal failure protection. Unit cannot be injured by short circuit or overload.

Thermal Thermostat, manual reset, rear of chassis. Thermal overload indicator light front panel.

INPUT AND OUTPUT CONNECTIONS

Heavy duty barrier terminal block, rear of chassis. 8 foot, 3 wire detachable line cord.

METERS

Voltmeter and ammeter on metered models.

CONTROLS:

DC Output Controls Voltage selector switches and adjustable vernier-control rear of chassis.

Power Magnetic circuit breaker, front panel.

Remote DC Vernier Provision for remote operation of DC Vernier.

Remote Sensing Provision is made for remote sensing to minimize effect of power output leads on DC regulation, output impedance and transient response.

PHYSICAL DATA:

Mounting	Standard 19" Rack Mounting
Size	LA 50-03A 3½" H x 19" W x 14⅜" D LA100-03A 7" H x 19" W x 14⅜" D LA200-03A 10½" H x 19" W x 16½" D
Weight	LA 50-03A 55 lb Net 85 lb Ship. Wt. LA100-03A 100 lb Net 130 lb Ship. Wt. LA200-03A 140 lb Net 170 lb Ship. Wt.
Panel Finish	Black ripple enamel (standard). Special finishes available to customers specifications at moderate surcharge. Quotation upon request.

console contains stored memory and character generator. The magnetic memory has full random access, 8-μsec cycle time, and a capacity of 1,024 words of 24 bits. The 45-character repertoire includes numerals, alphabet, marks, and vertical and horizontal tabular ruling lines. Number of scopes is limited only by total character output, 125,000 per sec.

Data Display, Inc., Dept. ED, St. Paul, Minn.

Price: Under \$25,000 per operator station.

Silicone Rubber 668 In aerosol spray

A liquid, room-temperature vulcanizing, red silicone rubber is available in aerosol spray form. The RTV-60 spray is applied directly to the desired surface; cure is obtained by spraying a curing agent on the RTV coating. Where bonding is required, a primer is used. Cure time varies from 15 min to several hours. The material has good physical and electrical properties and is resistant to temperature from -65 F to 600 F.

General Electric Co., Silicone Products Dept., Dept. ED, Watertown, N.Y.

Price: \$14.85 per carton: RTV-60, 3 lb; spray catalyst, 18 oz total.

Servo Potentiometer 503 Linearity to 1.3%



A wirewound servo potentiometer, the 50-M52 has linearity up to 1.3%. Resistance range is 50 to 1,000 ohms; power rating is 2 w at 80 C, derated to zero at 125 C. Standard torque is 0.05 oz-in. It is available with bronze or ball bearings, or sealed construction.

Maurey Instrument Corp., Dept. ED, 7924 S. Exchange Ave., Chicago 17, Ill.

Price: From \$12.

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LAMBDA ELECTRONICS CORP.

615 BROAD HOLLOW ROAD, HUNTINGTON, L. I., NEW YORK 516 MYRTLE 4-4200

LA114



modestly
speaking...

... We've really hit the jackpot with the new DIEHL Vacuum Tube Servo Amplifier. For response, linearity and power output, this new servo amplifier just can't be beat. Here are five reasons why:

- Continuous power output of 75 watts—drives DIEHL servomotors up to 25 watts 60 cycle, 15 watts 400 cycle.
- Minimum phase shift at carrier frequency.
- Plug-in input modules accept a wide range of AC and DC voltages.
- Proven vacuum tubes and printed circuitry assure maximum reliability.
- Separate amplifier and power supply chassis plug together.

Whatever the application, you'll find this newly perfected Vacuum Tube Servo Amplifier by DIEHL a welcome new standard of dependability and convenience. Why not get all the facts today? For additional information and/or applications assistance, contact: Diehl Manufacturing Company, Somerville, New Jersey.

4178

SEE US AT IRE SHOW
BOOTH 1913-15

SPECIFICATIONS

Cat. No. VA075 300
 Output 75 Watts Nominal
 Gain 1000 volts volt in power amplifier with max. feedback. Feedback can be reduced with potentiometer provided, with resulting increase in gain.
 Input Imp. 500 000 ohms
 Phase Shift a) Less than 10° phase lag of envelope at one third carrier frequency.
 b) Less than 2° at carrier frequency.
 Noise 100 MV Max. Input Shorted
 Power Req. Diehl VP3 100 high voltage power supply, or equivalent.



^{1A} Trademark of THE DIEHL MANUFACTURING COMPANY

DIEHL MANUFACTURING COMPANY

A SUBSIDIARY OF THE BINGER MANUFACTURING COMPANY

Somerville, New Jersey

CIRCLE 98 ON READER-SERVICE CARD

NEW PRODUCTS

Signal Generator

656

Provides fm and rf signals



Signal generator 12/U provides fm and unmodulated rf signals for measurements and alignment. One output supplies voltage at nine crystal-controlled frequencies for intermediate frequencies used by receivers to be tested. The second supplies rf output signals in a range of 20 to 100 mc in 5 bands. The rf output is variable from 0.05 to 10,000 μv ; the if output from 0.5 μv to 1 v.

Systems, Inc., Dept. ED, 2400 Diversified Way, Orlando, Fla.

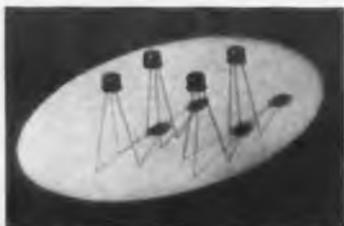
Price: On request.

Availability: 30 days.

Silicon Transistors

653

For fast-switching uses



Silicon mesa transistors 2N497, 2N498, 2N656 and 2N657 are designed for general purpose, medium power, fast-switching applications with mesa reliability. They provide low input impedance, typical collector capacitance of 14 pf, operating range from 10 μa to 500 ma and 4 w power dissipation. All are in the JEDEC TO-5 outline welded package.

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

Availability: From stock.

Accuracy Is Our Policy . . .

The New Products description of the Surge Stop manufactured by the Syntron Co., Homer City, Pa., stated "It delays good reverse characteristics for dissipating energy found in transient voltages." It should have read "It displays good reverse characteristics, etc." The item appeared on page 137 of the Jan. 4 issue of ELECTRONIC DESIGN.



How to double performance of your magnetic tape recorders

Now you can record 125-kc data at 30 ips instead of 60 on most existing data recorders. How? By using the new Ampex FR-600 for playback. New record/playback capability in the FR-600 saves previous equipment from obsolescence with some added benefits of its own—for example, recording 500 kc at 120 ips.

Your curiosity whetted? Write:



AMPEX DATA PRODUCTS COMPANY
Box 5000 Redwood City, California

Motor Generator

608

Vertically positioned



Vertical positioning of this motor generator is said to eliminate shaft deflection and vibration. The brushless, synchronous unit, for defense or industrial uses, will handle 125 kw to 175 kw. Load on the thrust bearings is minimized because of a slight lifting action by magnetic forces in the rotor.

Leach Corp., Inet Div., Dept. ED, 18435 Susana Road, Compton, Calif.

Sampling System

673

Commutated, 12 channels

Using 12 transducers as sensors, the model 512 commutated sampling system provides readouts from any or all of 12 consecutive remote points. Readout is through a digital display; output is ± 10 v dc. Measurement intervals are 1 to 2 sec or 12 per sec. Transducers may be singly balanced or nulled.

Crescent Engineering & Research Co., Dept. ED, 5440 N. Peck Road, El Monte, Calif.

Pressure Transducer

612

With ac-dc input

The model CP53D, a dc-output variable reluctance differential pressure transducer, will operate from 115 v ac or 28 v dc. Pressure ranges are from ± 0.1 to $\pm 2,500$ psid. The unit is capable of measurement in the presence of line pressures up to 5,000 psi. The package combines a variable reluctance pressure transducer and a transistorized carrier-demodulator. Output is 0 to 5 v dc.

Pace Engineering Co., Dept. ED, 13035 Saticoy St., North Hollywood, Calif.

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RAYTHEON
"PROGRAM 2020"
MEETS YOUR
VOLTAGE
REGULATOR
SPECIFICATIONS
FAST AND AT
LOW COST FROM
STANDARD DESIGNS



NEW

LOW-COST RAYTHEON REGULATED DC POWER PACKAGES



SPECIFY A RAYTHEON "RD" POWER SUPPLY AND ELIMINATE POWER SUPPLY DESIGN HEADACHES

132 different ready-to-operate models for standard 19-inch rack installation, 3 to 1,000 volts, 50 to 3,000 watts

These compact Raytheon "RD" units are the complete low-cost solution to your power supply problems without any sacrifice of the heavy-duty industrial performance your specifications demand.

The new power packages utilize ferroresonant (magnetic) voltage regulation coupled with full-wave silicon diode rectification and

capacitive input filtering. Ripple is reduced to within 0.5 to 1.0% depending on model.

Raytheon assures prompt delivery of your selection from 132 different models in 20 voltage steps and 7 power ratings, 3 to 1,000 volts, 50 to 3,000 watts, all for 19-inch rack mounting.



**RAYTHEON
COMPANY**

CHECK THESE BENEFITS OF "RD" POWER SUPPLIES

- Lowest cost consistent with heavy-duty industrial ratings
- 132 models: 3 to 1,000 volts, 50 to 3,000 watts
- Self-protecting; extremely dependable
- DC output filtered and isolated
- Improved load regulation
- 19" rack mounting; 6 sizes, panel heights from 3½" to 28"
- Regulation $\pm 1\%$ for line variation of $\pm 15\%$

Send coupon for free
Selection Guide and
Catalog of 2,020
Standard Designs

RAYTHEON COMPANY

Power Supply and Voltage Regulator Operations
Keeler Avenue, South Norwalk, Connecticut

Please send me

- Raytheon "RD" Product Selection Data #4-290
 Raytheon 2020 Regulator Selection Guide and
Catalog #4-265

Name _____

Title _____

Company _____

City _____ State _____

NEW PRODUCTS

Cathode-Ray Tube 605

With flat face

This rectangular 5-in. cathode-ray tube has a flat face plate for accurate visual observation. The type 5BXP has electrostatic focus and deflection with a low-voltage focus lens. The tube is 17-5/8 in. long; width is 4-5/8, height 2-5/8 in. $\pm 1/16$ in. Accelerator voltage is 2,500 v dc.

Fairchild Camera and Instrument Corp., Allen B. Du Mont Laboratories, Electronic Tube Sales Dept., Dept. ED, 750 Bloomfield Ave., Clifton, N.J.

Price: \$74.50 ea, 1 to 10.

Availability: Several weeks.

Voltage Follower 611

Input impedance is 10^{10} ohms

The model 302E Electrosensor has an input impedance in the region of 10^{10} ohms. Output measurements are within 0.001% of input voltages. Normal frequency response is 1 kc, with response of 10 kc on special order. Output impedance may be less than 1 ohm. Voltage readout range is from 100 mv full scale to 250 v full scale.

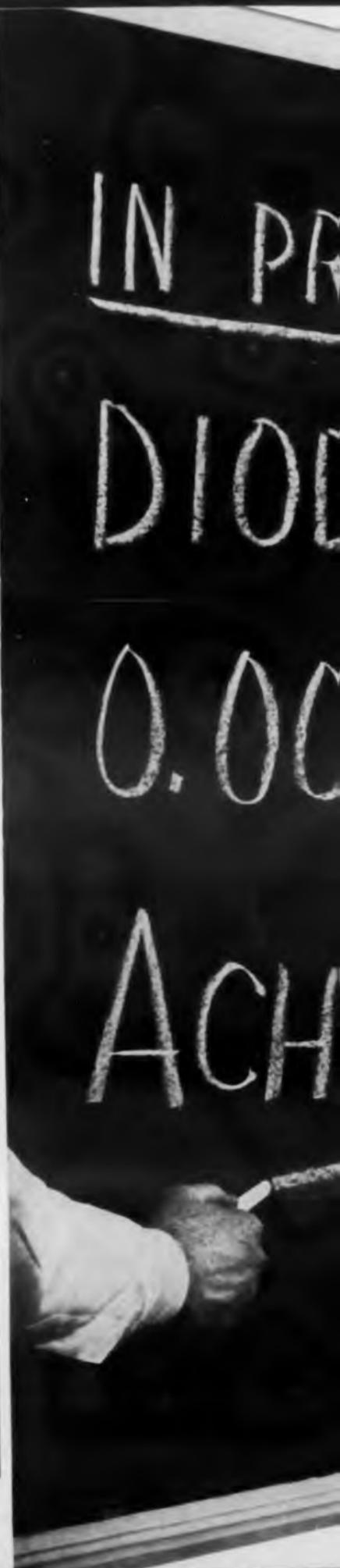
Halex, Inc., Dept. ED, 310 E. Imperial Highway, El Segundo, Calif.

Unidirectional Antenna 665

Range is 6.5 to 58 mc

The 237A-1A antenna provides a horizontally polarized, unidirectional beam with an average free space gain of 8 db over an isotropic antenna, with side lobes 16 db down. Free-space radiation patterns and input impedance are essentially independent of frequency. The peak power-handling capability of antenna and transmission line is 50 kw, with a vswr less than 2.25:1 over the range of 6.5 to 58 mc. The longest element is 70 ft; tower is 105 ft high. The 6,000-lb assembly will withstand 80-mph wind with 1/4-in. radial ice.

Collins Radio Co., Dept. ED, P. O. Box 1891, Dallas 21, Tex.



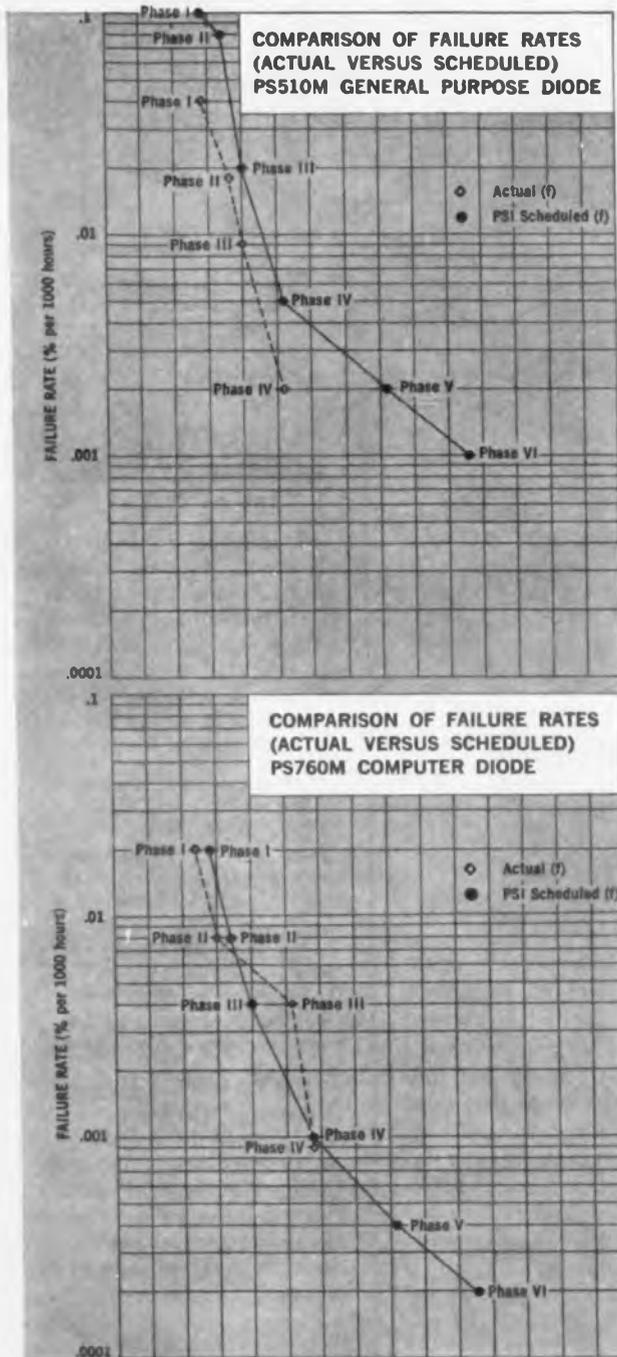
PRODUCTION

DE FAILURE RATE

0.09% / 1,000 hrs.

BEIEVED

RELIABILITY...PROVED



PACIFIC SEMICONDUCTORS, INC., tests indicate failure rate of .0009% per 1,000 hours ACHIEVED for silicon computer diodes... .002% per 1,000 hours ACHIEVED for silicon general purpose diodes

PSI—qualified supplier of all silicon computer and general purpose diodes for the “Minuteman” ICBM guidance system—has undertaken a production and evaluation program designed to furnish “Minuteman” with ultra-high-reliability diodes. The program is being supported by the Air Force Ballistic Missile Division through the Autonetics Division of North American Aviation.

The ultimate reliability objective is a maximum failure rate of .0002% per 1,000 hours for silicon computer diodes, and .001% per 1,000 hours for silicon general purpose diodes—levels heretofore unattainable in the semiconductor industry. To achieve and prove this objective, more than 250,000 silicon diodes are being used to generate in excess of a billion diode hours of test information.

Results to date indicate that PSI is currently supplying “Minuteman” computer diodes with an indicated failure rate of .0009% per 1,000 hours, and general purpose diodes with an indicated failure rate of .002% per 1,000 hours.

Because of the huge quantity of high reliability diodes required in the “Minuteman” program, PSI has been able to make thousands of diode measurements and use these data to control processes. Since the same controls are applied to *all* PSI manufacturing processes—and *not just to a limited and specially isolated line*—PSI is able to supply high-reliability silicon diodes in large quantities and on a regular basis.

If you are associated with a program requiring ultra-high reliability semiconductor devices, you are invited to take advantage of the vast and growing fund of information and large volume production capacity available only at PSI. For full details, write to Richard A. Campbell, Executive Vice President, Pacific Semiconductors, Inc., 14520 Aviation Blvd., Lawndale, California (Los Angeles County).



Pacific Semiconductors, Inc.



A SUBSIDIARY OF THOMPSON RAMO WOOLDRIDGE INC.
CIRCLE 102 ON READER-SERVICE CARD

Electric Thermostat

654

Rated for 25 amp



Model EB-3 electric thermostat is designed for domestic electric oven applications. It is a double-pole, snap-action, single-circuit unit rated for 25 amp at 250 v ac. The hydraulically operated control incorporates the firm's diastat.

Robertshaw-Fulton Controls Co., Indiana Div., Dept. ED, 911 E. Broad St., Richmond 19, Va.

TV System

645

Uses telephone line



The Videx telephone-line television system is capable of transmitting a 400-line resolution image over a standard telephone line in 60 sec. The system substitutes time for bandwidth, and can also be used to modulate a carrier for radio transmission. It includes camera, camera control and transmitter unit, and a direct-view storage tube monitor with receiver unit. The entire system weighs less than 100 lb.

ITT Laboratories, Components and Instrumentation Laboratory, Dept. ED, Fort Wayne, Ind.

Price: From \$12,000 to \$24,000.

Availability: 90-day delivery.

Electronic Counter

413

Range is 10 cps to 1 mc

The Transitron FM-1 electronic counter is designed for research and production. It has modular printed circuit construction and contains self-test circuitry. Specifications are: range, 10 cps to 1 mc; accuracy, ± 1 count for 1 sec, $\pm 0.0001\%$ for 10 sec; input requirements, 0.2 v rms min; connections, BNC type.

Van Norman Industries, Inc., Dept. ED, 186 Granite St., Manchester, N.H.

Price: \$1,325 ea.

Availability: 30 days.



ONE HAS THEM ALL



You get all the important features in stock TIC Trimmers — you don't pay more for a lot of extras.

Every TIC trimmer is bubble tested at 90°C to be certain it is sealed, meeting or exceeding MIL STD-202 for moisture resistance.

The inherent quality construction withstands temperatures to 225°C and shock at 150 G's for 11 milliseconds — vibration 5-3000 cps at 50 G's. Resistances to 100 K ohms are provided without sacrificing reliability as the unique design of the resistance element eliminates the need for using extremely fine resistance wire. Dual wipers on winding and take-off bar provide positive electrical contact and maximum reliability.

A choice of four types of leads are available on all stock trimmers — flexible insulated wire, printed circuit pins or solder lugs on end or bottom of housing.

These twenty-five turn precise trimmers offer *all* the plus features — not just a few. Compare — features — price — reliability. Specify TIC Trimmers. Available from stock for immediate delivery.



TECHNOLOGY INSTRUMENT CORPORATION

555 Main Street, Acton, Massachusetts • Colonial 3-7711

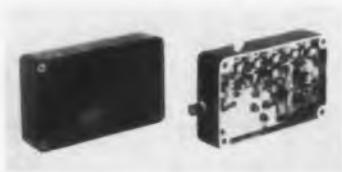
DISTRIBUTED NATIONALLY BY AVNET CORPORATION
CIRCLE 103 ON READER-SERVICE CARD

NEW PRODUCTS

Command Receiver

652

For 406- to 549-mc range



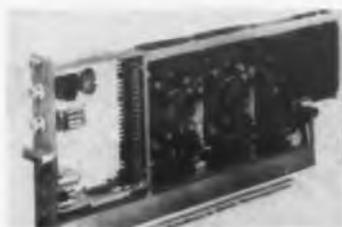
This miniaturized command receiver is for missile flight guidance and safety operations. It is composed of a receiver and a decoder unit. The fm receiver, model 2621, tunes to a fixed frequency in the 406- to 549-mc range, has a sensitivity of $7 \mu\text{v}$ and is usable at deviations of up to $\pm 350 \text{ kc}$. The selectivity characteristic is $\pm 2 \text{ mc}$ at the 60-db points, and image rejection is 60 db. The decoder, model 1801 employs toroid filters and may be supplied with up to 10 channels.

R. S. Electronics Corp., Dept. ED, P.O. Box 11368, Station A, Palo Alto, Calif.

DC Amplifier

497

Bandwidth is 100 kc



Designed for use with interchangeable plug-in input circuit modules, the model 361 dc instrumentation amplifier can be operated in various combinations of fixed or variable gain or bandwidth, manually or remotely controlled. The bandwidth of 100 kc is unaffected by gain changes. Common mode rejection is 1 million between dc and 150 cps. Input impedance at dc is at least 1,000 meg.

Packard Bell Electronics, Packard Bell Computer Corp. Div., Dept. ED, 1905 Armacost Ave., Los Angeles 25, Calif.

Price: \$1,700 up.

Availability: Immediate delivery.

Accuracy Is Our Policy . . .

The picture accompanying the New Products description of the variable frequency generator manufactured by International Ultrasonics, Inc., was incorrect. The item appeared on page 142 of the Jan. 4 issue of *ELECTRONIC DESIGN*.



THE AIL TYPE 132

This high precision instrument combines a high gain, low noise figure, intermediate frequency receiver with a secondary standard of attenuation to deliver extremely accurate measurements in a variety of applications:

- Convenient and accurate method for the measurement of **NOISE FIGURE**.
- Ideally suited to high accuracy, quick laboratory calibration of **rf attenuators** at all frequencies.
- Rapid and accurate in measurement of the **selectivity characteristics** of rf filters, preselectors and similar devices.
- Valuable for measurement of **coupling factors** and directivities.

The Type 132 is designed to operate from the i-f output of a wide variety of standard microwave mixers. In combination with these and a suitable local oscillator it becomes a sensitive detector of microwave energy.

Write for descriptive literature.



**AIRBORNE
INSTRUMENTS
LABORATORY**

DEER PARK, LONG ISLAND, NEW YORK
A DIVISION
OF CUTLER-HAMMER, INC.

CIRCLE 104 ON READER-SERVICE CARD

Magnetic Tape Recorder 464

Measures 2 x 4 x 5 in.



Model PS-303M magnetic tape recorder measures 2 x 4 x 5 in. and weighs 31 oz including 7 oz of tape. It will record dynamic data from 100 to 5,000 cps. It requires 3/4 w of power, supplied by standard mercury cells. Frequency response is flat within ± 3 db from 100 to 5,000 cps and signal-to-noise ratio is better than 30 db. It will record for 1 hr at 1-7/8-ips speed.

Precision Instrument Co., Dept. ED, 1101 Commercial St., San Carlos, Calif.

Stator Yoke 617

Low and medium impedance

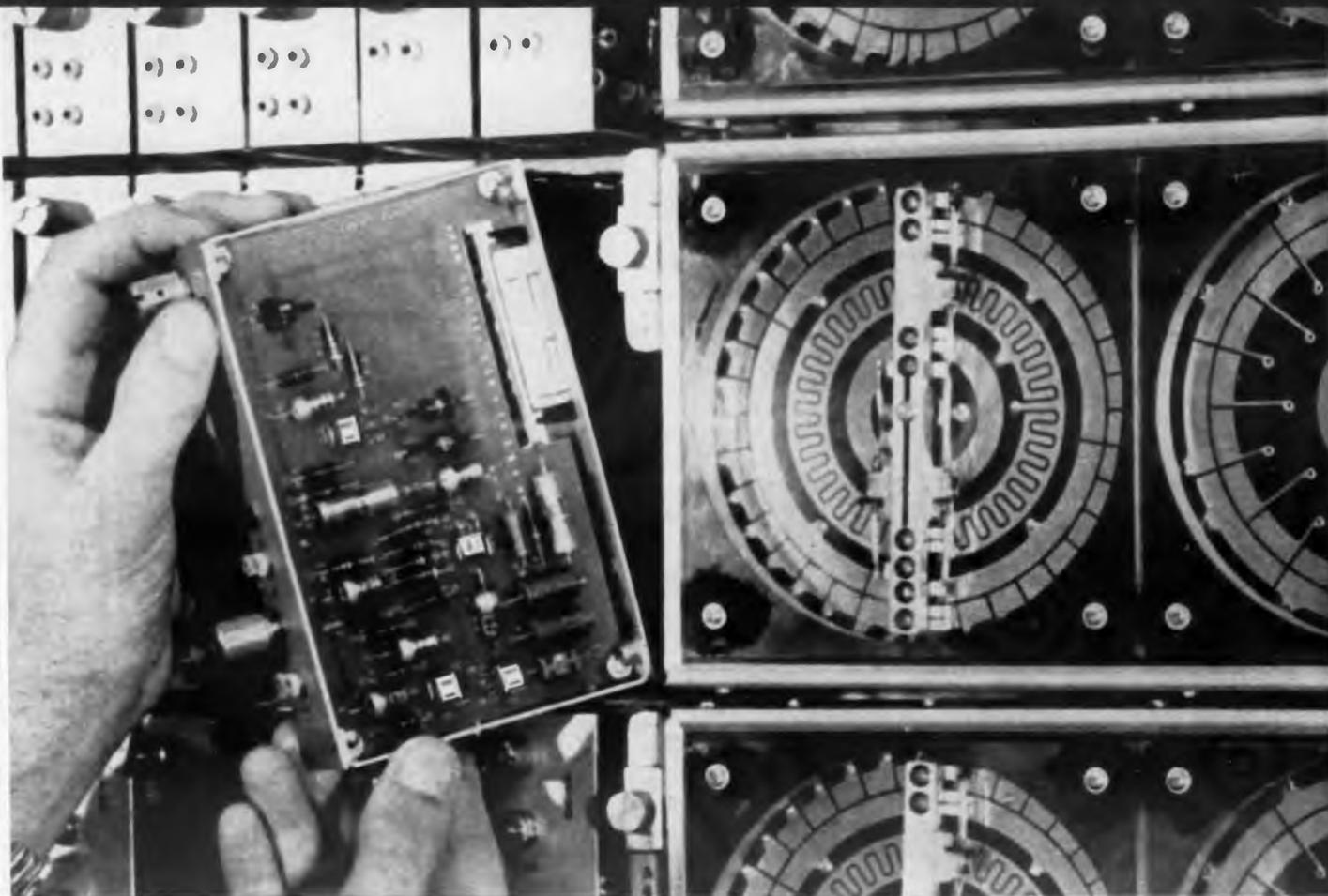


Designed for both low-impedance transistor and medium-impedance cathode-ray tube applications, the series Y58 is available with deflection angles of 52, 70, and 90 deg and fits all 1-1/2-in. neck diameter cathode-ray tubes including 70 deg flat types. The stator type of core permits small effective flux area in relation to inside diameter. Impedances from 0.1 mh to 60 mh may be obtained.

Syntronic Instruments, Inc., Dept. ED, 100 Industrial Road, Addison, Ill.

Availability: 5-week delivery.

CIRCLE 105 ON READER-SERVICE CARD ►



chooses Tung-Sol transistors for automatic air traffic control vocal system

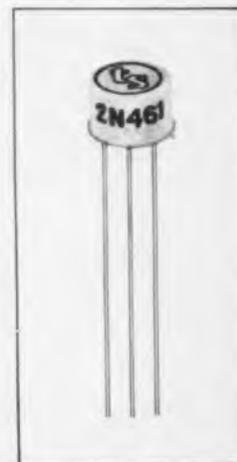
The Cook Electric Automatic Voice Relay is an integral part of a highly advanced system known as Volscan which is designed to relieve the hazards of air traffic congestion over modern airports. The AVR automatically generates flight path instructions vocally to pilots waiting to land, on the basis of data submitted to it by radar. A plane can be brought in every 30 seconds by the system.

Naturally, the highly critical nature of the system's function demanded that components selected to operate in the system meet the highest reliability standards. For this critical amplification and detection circuits in the AVR, Cook specified Tung-Sol transistors. More than 2000 Tung-Sol 2N461 germanium transistors were assigned to these significant tasks. Cook stipulated the reasons for selecting Tung-Sol: "We found

that Tung-Sol transistors more than satisfied the high reliability requirements for this operation. Moreover, Tung-Sol was able to meet a rapid delivery schedule."

Why don't you get the benefit of Tung-Sol component knowledge and experience too? Tung-Sol components — whether transistors, tubes or silicon rectifiers — fill virtually every commercial and military application with unexcelled dependability. Tung-Sol applications engineers will be glad to recommend the best components for your design. Tung-Sol Electric Inc., Newark 4, New Jersey. TWX: NK 193.

Technical assistance is available through the following sales offices: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Texas; Denver, Colo.; Detroit, Mich.; Irvington, N. J.; Melrose Park, Ill.; Newark, N. J.; Philadelphia, Pa.; Seattle, Wash. Canada: Toronto, Ont.



TUNG-SOL®

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Anniversary
1935-1960**

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pressure-sensitive
LABELS

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PRICE

They'll do it faster, better, more economically—and without moistening. Easy, simple to apply, either by hand or with new Avery automatic Labeler. Labels can be applied in exacting register on flat, rounded, concave or irregular surfaces. Ideal for special applications—specific labeling problems. Speeds from 40 to 200 labels per minute. Avery self-adhesive Labels are profitable to use—use them in your business.

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★ Have you seen Avery's new pressure-sensitive Metallics for decorative trim, panels and identification plates?

CIRCLE 107 ON READER-SERVICE CARD



PROTECTS YOUR TUBES, COMPONENTS

—eliminates the old bugaboo of cable entanglement which damages tubes and components in lower chassis each time the one above is withdrawn for service and returned to position.

Our new Cable Retractor's double action maintains constant tension and correct suspension of cable at all times—permits ample cable length for full extension and tilting of chassis without hazard of snagging.

For use with all types of chassis or drawer slides, adjustable to fit varying chassis lengths, simple to install, inexpensive, proven thoroughly reliable in operation.

Mounts on rear support rails on standard 1 3/4" hole increments. Cadmium plated CRS.

Write for Bulletin CR-100F

ORegion 8-7827

WESTERN DEVICES, INC.

600 W. FLORENCE AVE., INGLEWOOD 1, CALIF.

CIRCLE 108 ON READER-SERVICE CARD

NEW PRODUCTS

DC Power Supply

647

Is 1-3/4-in. high



A rack-mounted dc power supply, the 3210-R is 1-3/4-in. high. Output voltage is continuously adjustable from 0 to 32 v; current, from 0.1 amp to 1.25 amp. An automatic limiter maintains load current at the preset level. Ripple is less than 1 mv rms; regulation is better than $\pm 0.1\%$, or 5 mv, for load or line change. Input is 105 to 125 v, 400 cps. Depth is 10 in.

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

Price: \$395.

Availability: 3 to 4 weeks.

Positioning Control

646

Resolution is 1 in 30,000



A positioning control with resolution of 1 part in 30,000, the HA-50 may drive a rotary actuator. It includes a position sensor or combined actuator and sensor, a solid state amplifier, and a digital readout position setter. A cross-over circuit provides fast traverse and transfer to slower speed as preset position is approached.

Jordan Controls, Inc., Dept. ED, 3235 W. Hampton Ave., Milwaukee 9, Wis.

Cable Connectors

641

Rated at 7.5 kv



These cable connectors, in BNC size, are rated at 7.5 kv, 60 cps, at sea level. Cable may be RG-59, 62, 71, or equivalent; impedance is 50 ohms. In the series is a cable plug, EDD 2538; a cable

jack, EDD 2540, and a panel receptacle, EDD 2539. Contacts are beryllium copper, gold plated over silver, retaining ring is phosphor bronze; all other metal parts are brass. A Teflon dielectric is used. The weatherproof connectors will operate at -65 to 260 F, and meet specifications of MIL-E-5272A.

General RF Fittings, Inc., Dept. ED, 702 Beacon St., Boston 15, Mass.

Photocell

455

Cadmium-sulfide type



Model CDS-9 cadmium photocell has a resistance of over 1 meg in darkness and has a broad response to visible light. At 1 to 50 ft-c it will permit direct control of a relay requiring as much as 10 ma for operation. Power dissipation is $1/2$ w continuous, 2 w for 1 min. It is non-polar and may be used for ac or dc, max voltage is 500 v dc or 350 v ac rms.

Pioneer Electric and Research Corp., Dept. ED, 743 Circle Ave., Forest Park, Ill.

Flux Amplifier

639

Is self-testing



This flux amplifier is designed to provide reactor power level data for visual display, recording, control and shutdown or scram use. The unit tests itself each second and actuates a warning circuit in case of failure. Range may be set between $0.1 \mu\text{a}$ and 1 ma. Drift is less than 0.5%; response time is less than 5 msec with 1,000 ft of cable. An integral power supply furnishes 1,400 v for ion-chamber activation. Panel height is 7 in.

General Electric Co., Atomic Power Equipment Dept., Dept. ED, San Jose, Calif.

ELECTRONIC DESIGN • February 15, 1961

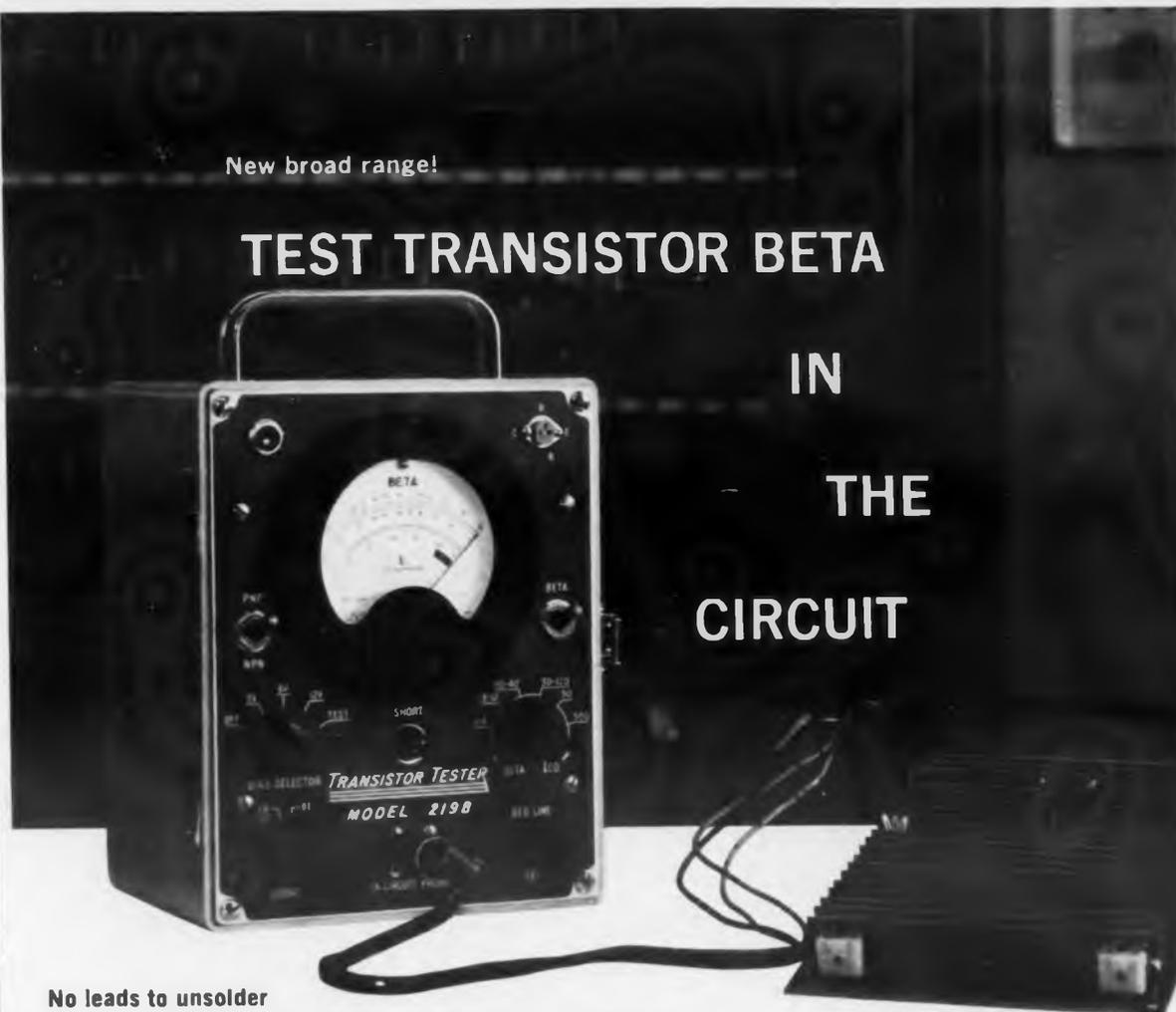
New broad range!

TEST TRANSISTOR BETA

IN

THE

CIRCUIT



No leads to unsolder
Four overlapping Beta Ranges • High meter resolution
Direct reading with test circuit power off

New Sierra 219B 4-range Transistor Tester reads Beta directly in the circuit; also measures I_{co} , Beta out of circuit.

Less downtime and less danger of damage to transistors under test with this new Sierra instrument—battery-operated, light weight, portable, easy to use.

Maintenance, quality control, incoming inspection and production testing are just a few of the applications where you save time and money by testing transistors, even complete assemblies, without unsoldering leads. Model 219B reads Beta in the circuit, 1 to 120. I_{co} is measured on a straightforward basis; collector potentials of 3, 6 or 12 vdc may be selected. All controls are on the front panel . . . an instrument of convenience, speed, accuracy.

Write or phone today for information and demonstration.

sierra SIERRA ELECTRONIC CORPORATION
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Canada: Atlas Instrument Corporation, Ltd., Montreal, Ottawa, Toronto, Vancouver.

Export: Frazar & Hansen, Ltd., San Francisco.

CIRCLE 109 ON READER-SERVICE CARD

SPECIFICATIONS

Test ranges	
Beta	1-4, 3-12, 10-40, 30-120*
I_{co}	0-50, 0-500 μa
Accuracy	
In circuit:	$\pm 20\%$ for external loads over 500 ohms. Improved accuracy above 500 ohms, usable readings below 500 ohms.
Out of circuit:	$\pm 10\%$
Power:	Internal battery, mercury or zinc-carbon type, 600 hrs. av. life; output indicated on front-panel meter.
Operating Temperature:	32 to 149° F
Size:	9" high, 7 $\frac{1}{2}$ " wide, 6 $\frac{1}{2}$ " deep, weight, 10 $\frac{1}{4}$ lb., including batteries.
Price:	\$275.00
	*Beta readings to 300 may be approximated.

6919

115



Background is schematic of world-famous Ward Leonard system of control.

In modern rheostat circuits, it's **SERVICE CONTINUITY THAT COUNTS**

Production stopped. Workers idle. But wages, maintenance costs, and fixed charges go merrily on accumulating.

That's the black picture when an industrial control component—specifically a rheostat—fails. That's why reliability is more important than initial cost. In many cases, these irrecoverable charges and costs can quickly far exceed the replacement cost of the faulty components.

And that's why far-sighted designers are more and more specifying Ward Leonard VITROHM ring rheostats for control circuits where performance is a must... in motor and generator field control circuits... for electronic tube filament circuits... wherever substantial amounts of power must be handled with utmost rheostat reliability.

Ward Leonard ring rheostats, in sizes of 25, 50, 100, 150 and 300 watts, feature W/L's exclusive "twin contact shoe" design. Two sintered, self-lubricating contact shoes minimize wear and assure uniform contact pressure, smooth oper-

ation, and maximum reliability.

Special alloy resistance wire—made to W/L's closely monitored specifications to assure highest stability and lowest practical temperature coefficient—is bonded permanently to ceramic core by Ward Leonard's own VITROHM vitreous enamel.

These are just a few of the reasons why VITROHM ring rheostats give you outstanding reliability in industrial control circuits. There are many more quality-engineered features than we can describe here—for instance, highest grade ceramic base and core, durably bonded tinned alloy terminals, and balanced beryllium copper contact arm. You'll find them all in Bulletin 60RR (and for powers above 300 watts, check W/L plate rheostats in Bulletin 60A). For your copy, and for a list of stocking distributors, write: Ward Leonard Electric Co., 77 South St., Mount Vernon, N.Y. (In Canada: Ward Leonard of Canada, Ltd., Toronto.)

o.s



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ELECTRIC CO.

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RESISTORS • RHEOSTATS • RELAYS • CONTROLS
CIRCLE 110 ON READER-SERVICE CARD

NEW PRODUCTS

Insulation Tester

650

Output is from 0 to 5,000 v rms



Model HV53 high-voltage-insulation tester has a continuous adjustable output of 0 to 5,000 v rms. It has a calibrated high-voltage circuit breaker with a continuously settable trip-point between 10 μ a and 3,000 μ a. It measures 7-1/2 x 3-1/8 x 8-1/2 in. and weighs 8-1/2 lb.

Opad Electric Co., Dept. ED, 43 Walker St., New York 13, N.Y.

Price: \$250 fob NYC.

Delay Timer

649

Replaces thermal delays



A transistorized replacement for thermal time delays, the MT 1103 offers instant reset with repeat accuracy of 3% under voltage and temperature variation. Time delay can be varied from 0.5 to 100 sec. Standard units have spdt or dpdt contacts, rated at 3 amp resistive, and operate from 18 to 32 v dc.

Syracuse Electronics Corp., Dept. ED, P. O. Box 566, Syracuse 1, N. Y.

Price: \$31.50.

Availability: Delivery in 2 to 4 weeks.

Test Fixtures

415

For dielectric tests

This line of interchangeable fixtures is for testing the dielectric strength of insulating solids, films, sheets and liquids. An adapter cup makes possible tests with the sample placed under oil. Primarily intended for use with the firm's Hypot testers, the fixtures may be used with many other instruments when the model 8539 test cage is installed.

Associated Research, Inc., Dept. ED, 3777 W. Belmont Ave., Chicago 18, Ill.

Price: From \$125 to \$250.

Availability: Stock to 30 days.

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150 KV Testing Mobile HYPOT®

Non-destructive testing of power cables, generators, and insulators with AC or DC test potentials to 150 KV. New DC Mobile HYPOT® is easier to handle, cuts costs. Write for bulletin "Mobile HYPOT®"

Model 5500
Typical Mobile HYPOT® provides 0 to 120 kv d.c. at 5 ma. More compact and easier to use than equivalent a.c. test sets. Lower in cost, too.

30 KV Testing Bench HYPOT®

Models available with AC or DC test potentials from 5 to 30 KV. Widely used for insulation testing of cables, distribution equipment and heavy duty motors.

10 KV Testing Portable HYPOT Jr.®

The advanced over potential tester that enables anyone to make high potential breakdown tests. Separate lights indicate excess leakage current and insulation breakdown. Available with test voltages from 1500 v a.c. to 10000 v a.c.



Model 412

INSULATION

Materials
Tester

**Model
4501
Materials
Tester**



New materials testing AC HYPOT® meets ASTM dielectric strength test requirements. Features automatic rate of test voltage rise, transparent test cage that is safety interlocked and complete line of plug-in materials testing fixtures. Write for new bulletin... "HYPOT® Insulation Tester"

VIBROTEST® measures FIVE MILLION Megs

Direct reading a.c. operated megohmmeter for resistance measurement to five million megohms. Drift free, stable and accurate on all ranges.

VIBROTEST® Model 2570 has six megohm ranges: 1-50, 10-500, 100-5000, 1,000-50,000, 10,000-500,000 and 100,000-5,000,000 megohms. Write for bulletin.



Write for Bulletins 10-35,16

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CIRCLE 111 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

Step-Servo Motor 589

Drives variable autotransformers



The model A604A step-servo motor drive provides bi-directional, open-loop control, independent of line frequency, for two Variac variable autotransformers. Resolution is to 0.2 deg at rates to 110 increments per sec. The time for full-scale travel, stepping increments, and the number of units to be actuated can be varied to customer requirement.

Automation Development Corp., Dept. ED, 11824 W. Jefferson Blvd., Culver City, Calif.

Tape Recorder 630

3-5/8-in. diameter



With a diameter of 3-5/8 in. and a length of 3-1/8 in., the model 362 tape recorder will record in 7 or 14 channels on 75 ft of tape. It withstands: vibration of 15 g, 10 to 2,000 cps; shock of 2,000 g for 3 msec on any axis; acceleration of 400 g continuously. The 26-oz unit has a temperature range from -50 to 180 F. Tape speed may be 3-3/4, 7-1/2, 15, or 30 in. per sec; wow and flutter are less than 1%. Power requirement is 24 v dc at 1-amp start and less than 500-ma run.

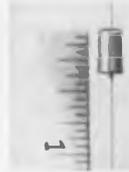
Leach Corp., Dept. ED, 18435 Susana Road, Compton, Calif.
Price: From \$3,000 to \$3,500.
Availability: 30 to 45 days.

RCA Announces The "TO-1" Rectifier

New Tiny, Rugged,
 Tubular, Flangeless,
 Hermetically Sealed In
 Non-Combustible Metal Case

4 New RCA Silicon Rectifiers

for Industrial Applications
 $\frac{3}{4}$ Amp. from 200 to 600v— $\frac{1}{2}$ Amp. at 800v.



Here's RCA's brand-new idea in rectifier case design—four new silicon rectifiers in hermetically sealed flangeless metal packages. These four new types now make silicon rectifiers as easy to handle and mount as other standard tubular components. They are designed to outperform plastic-packaged rectifiers and meet the stringent heat and humidity requirements of

today's industrial and commercial applications. Using a unique combination of a silicon diffused-junction and a new case, these units can be operated at temperatures up to 75°C without derating. They are designed and priced to bring you economy and performance plus easy handling and assembly. Sample these new RCA SILICON RECTIFIERS yourself and put them to work in your product. Call your RCA representative today at the Field Office near you. For additional technical information, write RCA Semiconductor and Materials Division, Commercial Engineering, Section B-18-NN2, Somerville, N. J.

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RCA "TO-1" SILICON RECTIFIERS					
Type	Max Ratings PIV	Max Ratings Forward Current @ 75°C	Max Ratings Recurrent Peak Current @ 75°C	Max Instantaneous Forward Voltage Drop @ 0.5 DC amp @ 25°C	Max Reverse Current @ 25°C and rated PIV
1N3193	200 v	750 ma	6 amp	1.2 v	10 μ a
1N3194	400 v	750 ma	6 amp	1.2 v	10 μ a
1N3195	600 v	750 ma	6 amp	1.2 v	10 μ a
1N3196	800 v	500 ma	5 amp	1.2 v	10 μ a

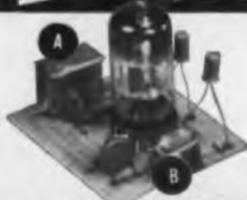
*Resistive or inductive load

RCA SEMICONDUCTOR & MATERIALS DIVISION FIELD OFFICES...
EAST: 744 Broad Street, Newark, N. J., HUmboldt 5-3900 • 731 James Street, Room 402, Syracuse 3, New York, GRAnite 4-5591 • **NORTHEAST:** 64 "A" Street, Needham Heights 94, Mass., HILlcrest 4-7200 • **EAST CENTRAL:** 714 New Center Bldg., Detroit 2, Mich., TRinity 5-5600 • **CENTRAL:** Suite 1154, Merchandise Mart Plaza, Chicago, Ill., WHitehall 4-2900 • P. O. Box 8406, St. Louis Park Branch, Minneapolis, Minn., FEderal 9-1249 • **WEST:** 6355 E. Washington Blvd., Los Angeles, Calif., RAymond 3-8361 • 1838 El Camino Real, Burlingame, Calif., OXFord 7-1620 • **SOUTH:** Calmar Building, 1520 Edgewater Drive, Suite 1, Orlando, Florida, GArden 4-4768 • **SOUTHWEST:** 7905 Empire Freeway, Dallas 7, Texas, FLEetwood 7-8167 • **GOV'T.:** 224 N. Wilkinson St., Dayton, O., BALDwin 6-2366 • 1725 "K" St., N.W., Washington, D.C., FEderal 7-8500

Technological Leadership in Silicon Rectifiers



MINIATURIZATION PLUS LOWER COST



Thin Versatile Co-Netic and Netic Magnetic Shielding Foils

Permit positioning foil-wrapped components A & B closely, minimizing interaction due to magnetic fields . . . making possible compact and less costly systems.

How thin Co-Netic and Netic foils lower your magnetic shielding costs:

- 1) Weight reduction. Less shielding material is used because foils (a) are only .004" thick and (b) cut and contour easily.
- 2) Odd shaped and hard-to-get-at components are readily shielded, saving valuable time, minimizing tooling costs.

These foils are non-shock sensitive, non-retentive, require no periodic annealing. When grounded, they effectively shield electrostatic and magnetic fields over a wide range of intensities. Both foils available from stock in any desired length in various widths.

Co-Netic and Netic foils are successfully solving many types of electronic circuitry magnetic shielding problems for commercial, military and laboratory applications. These foils can be your short cut in solving magnetic problems.



Cuts readily to any shape with ordinary scissors.



Wraps easily.



Inserts readily to convert existing non-shielding enclosures.



Shielding cables reduces magnetic radiation or pickup.



Wrapping tubes prevents outside magnetic interference.

PROTECT VITAL MAGNETIC TAPES

When accidentally exposed to unpredictable magnetic fields, presto!—your valuable data is combined with confusing signals or even erased.



For complete, distortion-free protection of valuable magnetic tapes during transportation or storage. Single or multiple reel Rigid Netic Enclosures available in many convenient sizes and shapes.

Thin pliable foil wraps easily around magnetic tape, maintaining original recorded fidelity.



Rigid Netic (.014" and up in thickness) Shielded Rooms and Enclosures for safe, distortion-free storage of large quantities of recorded magnetic tapes.

Composite photo demonstrating that magnetic shielding qualities of Rigid Netic Alloy Material are not significantly affected by vibration shock (including dropping or bumping) etc. Netic is non-retentive, requires no periodic annealing.

Write for further details today.

MAGNETIC SHIELD DIVISION PERFECTION MICA CO.

1322 No. Elston Avenue, Chicago 22, Illinois

ORIGINATORS OF PERMANENTLY EFFECTIVE Netic CO-Netic MAGNETIC SHIELDING

CIRCLE 113 ON READER-SERVICE CARD

NEW PRODUCTS

Power Supply

For nuclear systems

644



The N-4050 high-voltage power supply has a positive output of up to 5 kv at 2 ma, with negative output on request. It has line and load regulation of better than 0.01%. Voltage output is adequate for almost any type of proportional counter; current output is sufficient for routine scintillation counting. The rack-mounted supply has a panel height of 3-1/2 in., and requires 115 v, 60 cps, 100 w.

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

Photoelectric Verifier

510

Photoelectric sensing is used in the type 2450 verifier to check punched 90-column tabulating cards. Either the Univac 63-character code or the standard 90-column, 37-character code used by tabulating machines may be verified in one pass. Carriage return and card feed are automatically controlled by margin settings.

Sperry Rand Corp., Remington Rand Div., Dept. ED, 315 Park Ave. South, New York 10, N. Y.
Availability: 9-month delivery.

Particle Counter

655

For clean room use



Model PC200A is designed to monitor the presence and distribution of particulate matter in the atmospheres of such areas as clean rooms for precision manufacture and assembly. It presents immediate displays of the numbers of particles present in 15 subranges of sizes from 0.32 microns to 8.0 microns in diameter. Counts appear on decade counters and can be recorded on digital tape or a strip-chart recorder.

Royco Instruments Inc., Dept. ED, 440 Olive St., Palo Alto, Calif.

Price: Cabinet model is \$7,000.

See how much more
you can do with



EXPANDED TEFLON* TUBING



PF expands tubing mechanically to a much larger diameter. In use, tubing is positioned and heated to gel point. On cooling, it recovers its original diameter, shrinking to form a tight fit over the part it encloses.

Advantages of 

EXPANDED TUBING:

- CLAMPS TIGHTLY any inserted object, including irregular shapes and other Teflon tubing
- CHEMICALLY INERT
- LOW PERMEABILITY
- LOW COEFFICIENT OF FRICTION
- TOUGH AND FLEXIBLE
- NON-FLAMMABLE
- EXCEPTIONAL ELECTRICAL PROPERTIES

PF Expanded Tubing is made in all popular thin and standard wall sizes, in 11 colors and it can be printed and cut to the lengths you require.

Send for a free sample and try it yourself or let us show you how it works and what it can do for you.



JUST WRITE,
WIRE OR PHONE.

**PENNSYLVANIA
FLUOROCARBON CO., INC.**

1115 N. 38th Street, Philadelphia 4, Pa.
PHONE: EVERgreen 6-0603 TWX: PH 252

*Du Pont Reg. T.M.

CIRCLE 114 ON READER-SERVICE CARD
ELECTRONIC DESIGN • February 15, 1961

Transistorized Oscillator

621

For airborne use



The combination of this oscillator with 1 or more self-calibrating accelerometers provides a system for count-down and in-flight calibration of vibration sensors. The FO 1060 provides a 200-cps square wave with continuously adjustable amplitude between 0.1 and 10 v peak-to-peak. Model FO 1061 may be manually preset to 20, 100, or 200 cps.

Gulton Industries, Inc., Dept. ED, 212 Durham Ave., Metuchen, N.J.

Test Instruments

426

Multi-purpose type



These portable instruments are designed for general testing requirements and versatility. Ranges for the dc model 911 are: as a voltmeter, from 1 to 1,000 v; as a milliammeter from 0.1 to 100 ma; as an ammeter, from 10 ma to 10 amp. Ranges for the ac model 912 voltmeter are from 3 to 1,000 v. Accuracy is: $\pm 1\%$ full scale value on dc voltmeters and milliammeters ($\pm 2\%$ on 300 and 1,000 v dc); $\pm 2\%$ full scale value on rectifier-type ac voltmeters, 10 through 300 v; $\pm 3\%$ full scale value on rectifier-type ac voltmeters for 1,000 v range and 3 v range above mid-scale.

Weston Instruments Div., Daystrom, Inc., Dept. ED, 614 Frelinghuysen Ave., Newark 12, N.J.

CIRCLE 115 ON READER-SERVICE CARD ►



"Make It Smaller!"

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

Coors

ALUMINA CERAMICS

Coors Porcelain Company

800 NINTH STREET • GOLDEN, COLORADO



ACTUAL SIZE

VIBRATING REED ELECTROMETERS

Outstanding instruments for precise, reliable measurement of extremely small charges, currents and voltages.

Several models are available to serve a variety of applications including radioisotope assays, ion current measurements, pH determinations, and solid-state studies.

For details regarding the various applications, specifications and accessories for all Cary Electrometers, ask for Data File M19-21.

MODEL 31

Detects currents to 10^{-17} ampere. Provided with ten ranges, separate input-preamplifier unit.



MODEL 32

Designed specially for radioisotope studies. Single-unit design, provided with four ranges.



MODEL 36

Offers exceptional response, DC to 10 cps, sensitivity and stability for small currents to 10^{-15} ampere originating in a high impedance source.



APPLIED PHYSICS CORPORATION
2724 South Peck Road, Monrovia, California

CIRCLE 116 ON READER-SERVICE CARD

NEW PRODUCTS

Power Supply

648

Delivers 3 kva



Hydraulically driven, this power supply delivers 3 kva, 3-phase power at 400 cps, continuous duty, into a balanced load, or 1.5 kva at a continuous load unbalance of 20%. It has a simple and reliable self-contained electro-hydraulic on-off control. Performance is independent of installed attitude or ambient pressure and temperature conditions.

Walter Kidde & Co., Inc., Dept. ED, 675 Main St., Belleville 9, N. J.

Sweep Generator

643

Range is 4 to 250 mc



The model 6016 sweep generator has a frequency range of 4 to 250 mc, with continuous tuning. Frequency modulation is 50 cps. Frequency rise is adjustable in 6 steps, 1 to 30 mc. The built-in quartz crystal oscillator has a frequency of 5.5 mc. The 33-lb unit is 17 x 13 x 9 in., and operates from 110/220 v, 40 to 60 cps, 55 w.

EPIC, Inc., Dept. ED, 150 Nassau St., New York 38, N. Y.

Recorder Pen Programmer

468

For pen lift coding



A recorder pen programmer, for recorders using solenoid-operated pen-lift mechanisms, the model

CIRCLE 248 ON READER-SERVICE CARD ►

ELECTRONIC DESIGN • February 15, 1961



**BOONE
DIVISION**

International Resistance Co.

**Close Tolerance
Power Wire Wound Resistors**

New

350°C HOT SPOT—125°C AMBIENT

THERMACOAT[®] MINIATURE PRECISION POWER RESISTORS



New Thermacoat resistors expand circuit design limits significantly by carrying full power even at 125°C ambients. These resistors meet MIL Characteristic V (MIL-R-26C) with an allowable 350°C hot spot, well above the 250-275° customary for resistors of this type.

Thermacoat is the exclusive silicone formulation developed by IRC for its Type AS miniature power wire wound resistors. In addition to the high heat capabilities, Thermacoat is tough and smooth, with high dielectric strength.

Thermacoat resistors have all the other advantages you want—small size, close tolerance, welded connections and permanent markings.

New Thermacoat resistors are available now in sample and production lot quantities. Order them through the sales offices listed on the back cover.

Type AS Resistors | SPECIFICATIONS

Resistance Ranges: Minimum 0.1 ohm; maximum 20K to 175K ohms.
Power: 2, 3, 5, 7, 10-watt sizes, rated at 125° C ambient.

Tolerances: ±1% or ±3% commercial, ±5% MIL standard. Tolerances as close as ±0.05% depending on resistance.

Temperature Coefficient: Averages less than ±25 ppm/°C.

Intermittent duty operation: Higher than rated wattages permitted up to 350°C hot spot limit.

High-frequency applications: Ayrton-Perry non-inductive windings available. Minimum resistance values, 10Ω for ±1% and ±3% tolerance 1Ω for ±5% tolerance. Full details on request.

Terminal strength: Withstand pulls in excess of 10-pound MIL-R-26C requirement.



SPECIFICATIONS

Part No.	Power Rating	Resistance Range	Temperature Coefficient	Material	Dimensions (mm)	Weight (g)	Lead Length (mm)	Lead Spacing (mm)	Lead Diameter (mm)	Lead Material	Lead Finish
AS-1	1/4W	10-100K	±100ppm/°C	Thermacoat	10.0	0.15	10.0	2.5	0.5	22	22
AS-2	1/2W	10-100K	±100ppm/°C	Thermacoat	12.5	0.20	12.5	3.0	0.6	22	22
AS-3	1W	10-100K	±100ppm/°C	Thermacoat	15.0	0.25	15.0	3.5	0.7	22	22
AS-4	2W	10-100K	±100ppm/°C	Thermacoat	17.5	0.30	17.5	4.0	0.8	22	22
AS-5	3W	10-100K	±100ppm/°C	Thermacoat	20.0	0.35	20.0	4.5	0.9	22	22

Dimensions:



TOLERANCES AVAILABLE

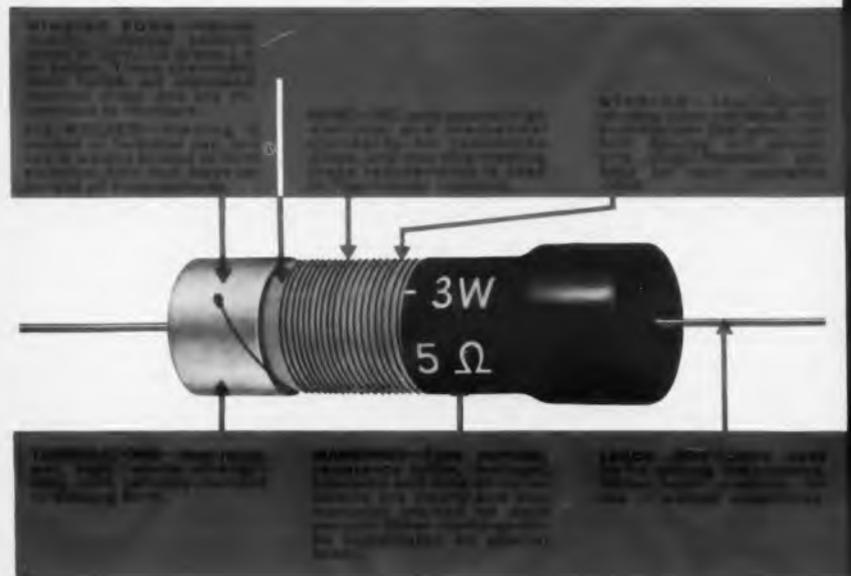
Part No.	Power Rating	Resistance Range	Temperature Coefficient	Material	Dimensions (mm)	Weight (g)	Lead Length (mm)	Lead Spacing (mm)	Lead Diameter (mm)	Lead Material	Lead Finish
AS-1	1/4W	10-100K	±100ppm/°C	Thermacoat	10.0	0.15	10.0	2.5	0.5	22	22
AS-2	1/2W	10-100K	±100ppm/°C	Thermacoat	12.5	0.20	12.5	3.0	0.6	22	22
AS-3	1W	10-100K	±100ppm/°C	Thermacoat	15.0	0.25	15.0	3.5	0.7	22	22
AS-4	2W	10-100K	±100ppm/°C	Thermacoat	17.5	0.30	17.5	4.0	0.8	22	22
AS-5	3W	10-100K	±100ppm/°C	Thermacoat	20.0	0.35	20.0	4.5	0.9	22	22

CONSTRUCTION FEATURES

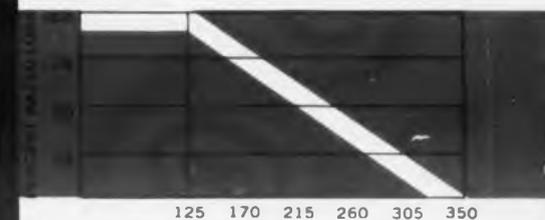
THERMACOAT for 350°C hot spots, 125° C ambients.

IRC developed this modified silicone formulation especially for miniature power resistors. It cures at low temperatures,

hence heat does not distort the windings nor affect temperature coefficients. THERMACOAT is tough and smooth, with high dielectric strength. Its unique ability to withstand 350°C hot spots brings new design latitude to your circuits.



DERATING



125 170 215 260 305 350
AMBIENT TEMPERATURE °C

No derating to 125° C! All sizes of new Type AS miniature power wire wound resistors carry full wattage at high resistance values and high temperatures, because of Thermacoat.

TEMPERATURE RISE



20 40 60 80 100 120 140
PERCENT RATED LOAD (128° C ambient)

In free air, Thermacoat resistors do not reach 350°C hot spot limit, even at 140% of rated power.



BOONE DIVISION
International Resistance Co.
Post Office Box 393
Boone, North Carolina
Amherst 4-8861

IRC SALES OFFICES—Boone Division

ARIZONA—Scottsdale, Carl Mower, Box 1627, 340 N. Marshall Ave., WHitney 5-2471, 5-7813
CALIFORNIA—Hollywood, Los Angeles, International Resistance Co., 1136 N. LaBrea Blvd., HOLLYWOOD 6-2191
CALIFORNIA—San Francisco 24, Logan & Stone, 1485 Bayshore Blvd., DELaware 4-1200
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HAWAII—Honolulu, Bill Cameron Sales, 2612 Peter St., Tel: 772-282
ILLINOIS—Chicago 39, International Resistance Co., 5243 W. Diversey Ave., TUsedo 9-5800
INDIANA—Indianapolis 20, Macnabb, Schroeder & Loomis, 820 E. 64th St., CLIFford 5-6770
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MASSACHUSETTS—Boston 32, Ray Perron & Co., 1870 Centre St., FAirview 3-1008
MICHIGAN—Detroit 3, Koehler-Pasmore Co., 11833 Hamilton Ave., TOWnsend 8-3322
MINNESOTA—Minneapolis 3, The Heimann Co., 1711 Hawthorne Ave., FEderal 2-5457
NEW YORK—New York 6, International Resistance Co., 165 Broadway, Room 2024, COrtlandt 7-9000
NEW YORK—Syracuse 2, International Resistance Co., 314 State Tower Bldg., MARRison 2-0274
OHIO—Cleveland 7, Baehr, Greenleaf & Assoc., 14700 Detroit Ave., ACademy 1-9030
PENNSYLVANIA—Philadelphia 8, IRC Sales Office, 401 N. Broad St., WALnut 2-8900
PENNSYLVANIA—Pittsburgh 34, Jack Coverl Assoc., 320 Jonquil Place, LEhigh 1-4471
TEXAS—Dallas, Jack F. McKinney Sales Co., 1303 Chemical St., RIVERSide 1-1368
WASHINGTON—Seattle 9, Ron Merritt Co., 1320 Prospect St., MUtual 2-7337

IRC Divisions:

Boone Division
Boone, N. C.
Vega Baja, Puerto Rico
Burlington Division
Burlington, Iowa
St. Petersburg Division
St. Petersburg, Florida
Control Components Division
Philadelphia, Pa.
Plastic Products Division
Philadelphia, Pa.
Philadelphia Division
Philadelphia, Pa.
Downingtown, Pa.
Canadian Licensee
International Resistance Co., Ltd.
Toronto, Montreal, Ottawa, Calgary

Printed in U.S.A.

RPP-1 operates the pen lift in 5 distinct code patterns for trace identification. It is specifically designed for use with antenna pattern recorders and X-Y recorders where multiple recordings on the same chart are desired. Weight is 8 lb; rack panel height is 3-1/2 in. Power requirements are 115 v, 50/60 cps, 15 w.

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

Price: \$300 fob Atlanta.

Availability: 2 to 3 weeks.

Differential DC Preamplifier 459

Extends voltmeter range



The range of digital voltmeters is extended to 1 μ v dc with the use of model 459 N differential dc preamplifier. Common mode rejection is 180 db for dc and 130 db for 60 cps with up to 1,000 ohms unbalance in either signal lead. The input can be floated up to ± 250 v with respect to ground. Input resistance is greater than 5 meg.

Colu Electronics, Inc., Kin-Tel Div., Dept. ED, 5725 Kearney Villa Road, San Diego 12, Calif.

Price: \$1,475 fob San Diego.

Availability: One week.

Time-Delay Relay 638

In four timing ranges

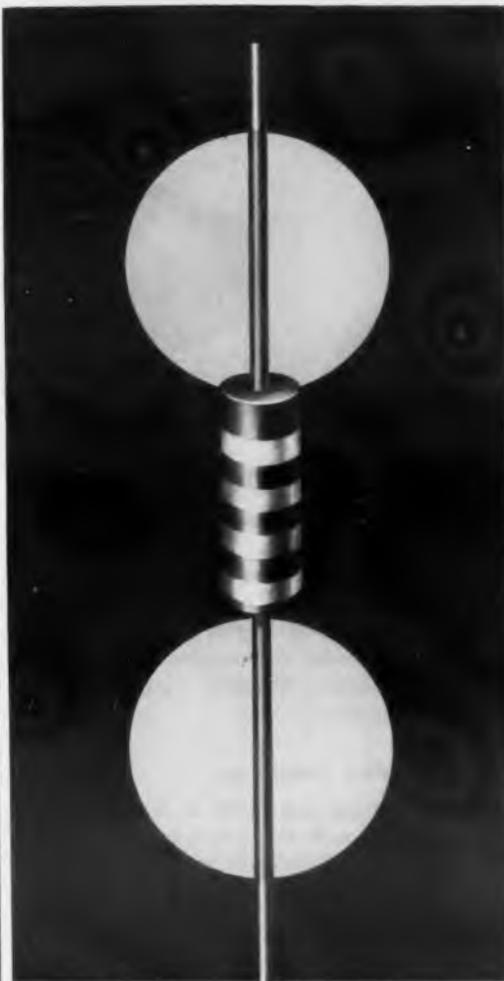


The model T-164 adjustable time-delay relay comes in four timing ranges, four contact arrangements, and two mounting styles. Timing ranges cover from 50 msec to 60 sec, with external push-button reset. Repeatability is 1% short term, 10% long term. With a relay, an RC time circuit, and a two-stage transistor amplifier, the unit operates on 18 to 32 v dc at 10 ma nominal. Contacts are rated at 3 amp, 115 v ac and 29 v dc, both non-inductive. Operating temperature is 32 F to 122 F. Dimensions are 1-29/64 x 2 x 2-5/8 in. high.

General Automatic Corp., Dept. ED, 111 33rd St., Union City, N. J.

◀ CIRCLE 248 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961



Coldite 70+ Resistors Save You Money on Assembly Work!

Stackpole Coldite 70+ resistors solder easier and stay soldered more surely. Thanks to an extra solder coating applied AFTER the usual tin-lead coating, they solder perfectly by ANY method — dip or iron. Moreover, resistance variations from normal soldering heat are negligible.

CIRCLE 117 ON READER-SERVICE CARD

Get a head-start on production with "solder-coated" resistors

You can pretty well take for granted that any one of several leading resistor brands will meet or exceed your performance requirements. But there's another factor to be considered too—ease of handling on your assembly lines. Mainly that means ease of soldering—and here Stackpole Coldite 70+ "solder-coated" fixed composition resistors stand head and shoulders above the field. Not only do these famous cold-molded resistors meet today's critical specifications, but they provide unmatched "solderability" on any hand or automatic, open wiring or printed circuit operation. That makes not only for a real saving in assembly work, but also stands to reduce subsequent service costs resulting from poor soldered connections.

ELECTRONIC COMPONENTS DIVISION
STACKPOLE CARBON COMPANY, ST. MARYS, PA.

STACKPOLE
Coldite 70+
FIXED COMPOSITION RESISTORS

CERAMAG® FERROMAGNETIC CORES • SLIDE AND SNAP SWITCHES • VARIABLE COMPOSITION RESISTORS • CERAMAGNET® CERAMIC MAGNETS • FIXED COMPOSITION CAPACITORS • ELECTRICAL CONTACTS • BRUSHES FOR ALL ROTATING ELECTRICAL EQUIPMENT • HUNDREDS OF RELATED CARBON, GRAPHITE AND METAL POWDER PRODUCTS

AXIMAX MINIATURE 400CPS FANS

AXIMAX 1



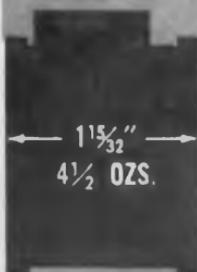
12 to 23 CFM
11,400 to
22,500 RPM



- Extremely compact and lightweight— $1\frac{1}{2}$ " x $1\frac{1}{4}$ ", 4 ozs.
- 115 or 200 VAC, 1 ϕ or 3 ϕ , 400 cps.
- Airflow reversible.
- Built to Military Specifications.



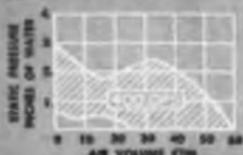
AXIMAX 2



24 to 60 CFM
8,000 to
20,000 RPM



- Size: 2" x $1\frac{1}{2}$ ". Weight: 4½ ozs.
- 115 or 200 VAC, 320 through 1600 cps, 1 ϕ or 3 ϕ
- High altitude (Altivar)® and high density designs available.
- Airflow reversible.
- Built to Military Specifications.



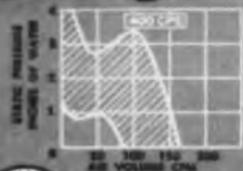
AXIMAX 3



70 to 165 CFM
9,000 to
22,000 RPM



- Size: $3\frac{1}{4}$ " x $2\frac{3}{8}$ ". Weight: 14 ozs.
- 115 or 200 VAC, 400 and other cps, 1 ϕ or 3 ϕ .
- High altitude (Altivar)® and high density designs available.
- Airflow reversible.
- Built to Military Specifications.



Appropriate cam-locking mounting clamps are available from Rotron for servo-mount Aximax fans.



Write for Complete
Technical Details,
or Submit Your
Cooling Problems for
Recommendations



ROTRON
MANUFACTURING CO., INC.
WOODSTOCK, NEW YORK

"AXIMAX" is a registered trademark of Rotron Manufacturing Co., Inc.
CIRCLE 118 ON READER-SERVICE CARD

NEW PRODUCTS

X-Y Plotter

640

Accurate to 0.05%



This 30 x 30-in. X-Y plotter is accurate to 0.05% of full scale and repeats exactly from any direction. No servo mechanisms are used in the solid-state plotter. Input can be from IBM cards, punched paper tape, or keyboard. Slewing speed is up to 20 in. per sec. Printing head contains 12 symbols, any of which can be selected at will; other print sectors can be added to plot digital or symbol information.

Gerber Scientific Instrument Co., Dept. ED, Hartford, Conn.

Wire Dispenser

508

Consisting of 10 high-impact plastic tubes held in a rack, this dispenser feeds precut wires one at a time. Wires may be clipped in the tube. Racks may be stacked, placed on the bench top, or hung where desired.

Products For Industry, Inc., Dept. ED, 1704 Summer St., Stamford, Conn.

Printed Circuits

637

On glass-bonded mica



Printed circuits, for ferrite memory systems, missile control circuitry, and other uses, are produced on Mykroy glass-bonded mica. The 0.0005-in. copper conductive path may be located within holes, in grooves or counterbores on one or both surfaces. The material is dimensionally stable, moistureproof and noncombustible, radiation-resistant, and will maintain a volume resistivity of 100 K per cm through 300 C.

Electronic Mechanics, Inc., Dept. ED, 101 Clifton Blvd., Clifton, N. J.

Price: About \$0.04 per sq in., in volume.

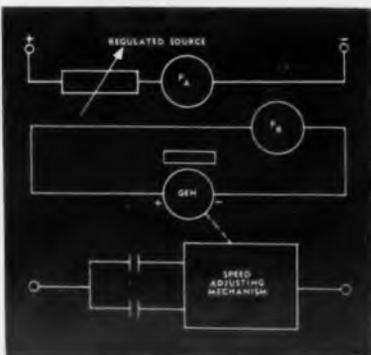
THE MARK OF QUALITY



Ultra-sensitive relays

HELPFUL DATA FOR YOUR CIRCUITRY IDEA FILE

The circuit drawing below indicates just one of the hundreds of ways many manufacturers utilize Micropositioner[®] polarized relays to solve complex control problems.



ADJUSTABLE SPEED CONTROL WITH TWO-COIL MICROPOSITIONER[®]

The output of a d-c tachometer generator (such as a Barber-Colman type BYLM) coupled to the rotating shaft, whose speed is to be regulated, is impressed on one coil of a two-coil Micropositioner.

The other coil is supplied with an adjustable input from a regulated source. The contacts operate appropriate devices to raise or lower the speed of the shaft being controlled.

If your projects involve similar types of control, why not test the Micropositioner in your circuits? Write for technical bulletins.

BARBER-COLMAN MICROPOSITIONER[®] POLARIZED D-C RELAYS

Operate on input power as low as 40 microwatts. Available in three types of adjustment: null seeking... magnetic latching "memory"... and form C break-make transfer. Also transistorized types with built-in preamplifier. Write for new quick reference file.



BARBER-COLMAN COMPANY

DEPT. N, 1883 ROCK STREET, ROCKFORD, ILLINOIS

CIRCLE 119 ON READER-SERVICE CARD

Transfer Function Analyzer

642

For random or periodic signals



A tool for determining the response characteristics of control, structural, and servo systems, as well as electrical networks, the model OF-3 transfer function analyzer uses a cross-spectral density technique. It operates with driving signals that are random or complex periodic, obtains the causal relationship between two signals, and gives the output as Nyquist or Bode plots. It is applicable to vibration, acoustic, servo, human response and related fields.

Gulton Industries, Inc., Dept. ED, 212 Durham Ave., Metuchen, N. J.

Price: From \$25,000 to \$30,000.

Video-Switching Systems

509

This transistorized, modular video-switching system consists of 12 inputs and outputs, amplifiers, vertical interval control circuitry, power supplies, and 5 auxiliary effects amplifiers, all housed behind 35 in. of panel space on a standard rack. It is with either binary- or decimal-switching logic control.

Gotham Broadcasting Corp., Tarc Electronics Div., Dept. ED, 48 Urban Ave., Westbury, N. Y.

DC Voltage-Current Source

467

Voltage accuracy is 0.0075%

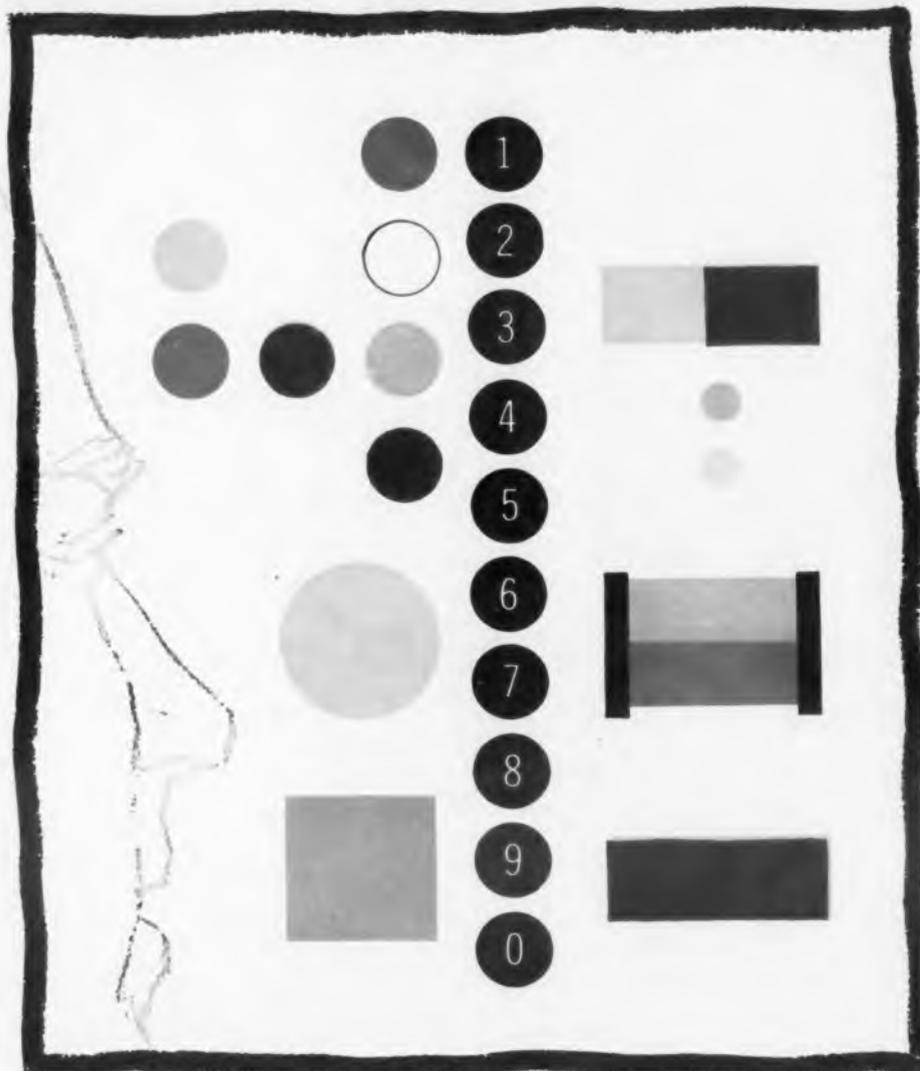


Model 401 is a completely transistorized dc absolute voltage-current source. It has voltage accuracy of 0.0075% and an absolute current accuracy of 0.025%. Stability for voltage outputs is 0.003%; for current outputs it is 0.005%. All outputs are short-circuit-proof.

Rotek Instrument Corp., Dept. ED, 733 Concord Ave., Cambridge, Mass.

Price: \$1,075.

Availability: Stock to 10 weeks.



IMPACT!

When a light comes on . . . or changes color . . . it immediately draws attention. Then add operator reaction . . . "hit that light when it turns red!". These are basic elements of today's sophisticated control panels.

Attention and reaction are built into all Control Switch lighted pushbutton switches. Round or rectangular buttons that light up in one, two, three or four colors, with monitor and control of up to four circuits.

For monitoring only, Control Switch indicator lights are available in hundreds of sizes, shapes, colors and circuits.

Write today for technical data on the industry's most versatile and complete line of lighted switches and indicator lights. If you have an unusual panel problem, let us solve it with a custom design.

CONTROLS COMPANY OF AMERICA
CONTROL SWITCH DIVISION
1406 Delmar Drive • Folcroft, Pennsylvania
TELEPHONE LUdlow 3-2100 • TWk SHRN-H-502

Manufacturers of a full line of switches, controls and indicators for all military and commercial applications. All standard units stocked for immediate delivery by leading parts Distributors.

CIRCLE 120 ON READER-SERVICE CARD



THE IDEAL
SCOPE FOR
ALL
INVESTIGATIONS
FROM DC
TO 5 MC

FOR EXTENDED GENERAL PURPOSE APPLICATIONS DU MONT 440 5 MC OSCILLOSCOPE

- DC to 5 MC bandwidth in vertical amplifier.
- Sensitivity from 50 mv/cm to 500 volts full scale.
- Sweep speeds continuous from 0.2 usec/cm to 10 sec full scale.
- Rise time 0.08 usec or less.
- Selection of auto, driven or single sweep.
- Balanced input on all ranges.
- 500 kc bandwidth on horizontal axis.

When "general-purpose" applications include frequencies approaching 5 MC, the new Du Mont 440 is the all-around answer. A relatively low-cost scope of superlative performance and dependability, the 440 offers a host of operational advantages extending the value and precision of the instrument. Such advantages include: 17 sweep speeds, accurately calibrated from 1 usec/cm to 200 milliseconds to lock in any recurring phenomena within this range; accelerating potential of 5 kv for extra-bright displays; a sweep arming feature for triggering of a single sweep; A sweep expander; a ten-step attenuator for any signal from 50 mv/cm to 500 volts full scale.

The Du Mont 440 oscilloscope is the new standard for extended general-purpose applications, and costs only

\$595

(440R, RACK MOUNTED \$595)

DU MONT

WRITE FOR COMPLETE DETAILS,
OR ASK FOR A DEMONSTRATION.
THESE UNITS ARE AVAILABLE NOW!

ALLEN S. DU MONT LABORATORIES, CLITTON, N. J.

DIVISIONS OF **FAIRCHILD**
CAMERA AND INSTRUMENT

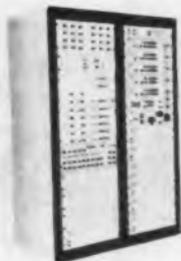
CIRCLE 121 ON READER-SERVICE CARD

NEW PRODUCTS

Memory-Core Tester

Is fully automatic

635



A completely integrated system for automatic production-line testing of ferrite magnetic memory cores, the type 2102 can be programmed to accept or reject cores to a wide variety of specifications. It generates four different programs of current driving pulses, variable in timing and amplitude. A calibrated sensing system compares core output at five specific times against six known and variable amplitude levels. The system is self-checking.

Digital Equipment Corp., Dept. ED, Maynard, Mass.

Price: \$20,000.

Availability: 8 weeks.

Hall-Effect Generators

687

Thin-film metal-deposited Hall-effect generators, made of indium arsenide, are now available. The probes have a Hall output voltage exceeding 1 v at 10,000 gauss. The four electrodes are attached by printed-circuit techniques.

G. R. H. Halltest Co., Dept. ED, 157 S. Morgan Blvd., Valparaiso, Ind.

RF Power Meters

Range is 100 kc to 200 mc

636



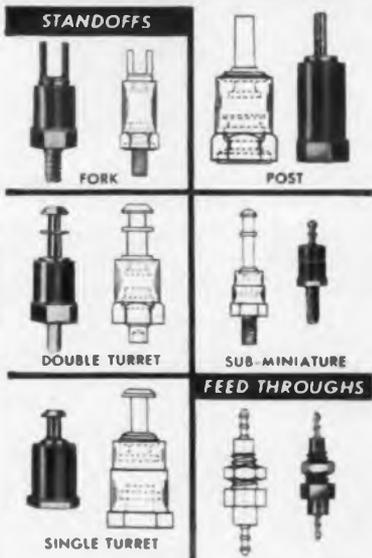
These rf power meters, of the absorption type, operate in the range of 100 kc to 200 mc. Power is measured in 2 to 6 ranges from 1.5 w full scale to 1,500 w full scale, at an accuracy of $\pm 5\%$. A resistive voltage divider is used. Meter calibration may be checked against dc or 60 cps.

Electro-Impulse Laboratory, Inc., Dept. ED, 208 River St., Red Bank, N. J.

Price: \$60 to \$250.

WHITSO STANDOFF TERMINALS

...Largest Line Available



DIALYL PHTHALATE AND MELAMINE BODY MATERIALS TO MEET MILITARY STANDARDS

Get the exact standoff or feed through terminal you want from a full range of types, sizes, body materials and plating combinations. Specials can be supplied to specification. The Whitso line is complete to the fullest extent of every industrial, military and commercial requirement.

Standoff terminals include fork, single and double turret, post, standard, miniature and sub-miniature body types—male, female or rivet mountings—molded or metal base. Feed through terminals are furnished standard or to specification.

Plating Combinations: Many terminal and mounting combinations furnished as standard.

Specials: Body materials and plating combinations, also dimensions, can be supplied to specifications.

PROMPT DELIVERY IN ECONOMICAL QUANTITY RUNS

Get facts on the most complete, most dependable source for terminals and custom molded parts. Request catalog.



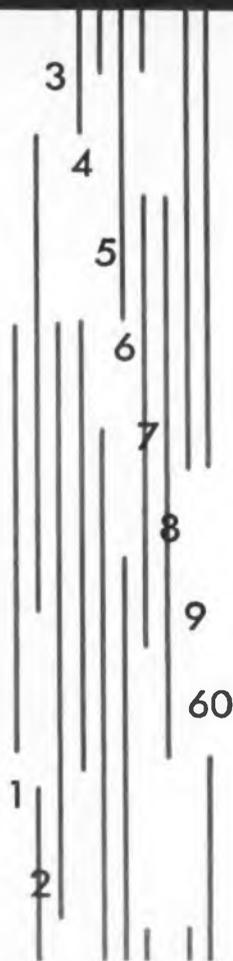
WHITSO, INC.

9326 Byron Street, Schiller Park, Illinois
(Chicago Suburb)

CIRCLE 122 ON READER-SERVICE CARD

CIRCLE 124 ON READER-SERVICE CARD ►

verify
events
permanently
in
milliseconds



Brush Operations Monitors' response to signals is virtually instantaneous—less than 4 milliseconds. Multiple high-speed events are clearly defined from start to stop, on a common time base—and at rates up to 500 per second. Portable 30 channel or rack-mounting 100 channel models record sharp reproducible traces with fixed-stylus electric writing that provides the utmost in reliability. "Built-in" transistor switching to eliminate relays is optional. No direct writing recording system can match the capabilities of Brush Operations Monitors for industrial and military analysis and control. Write for complete specifications and application data.

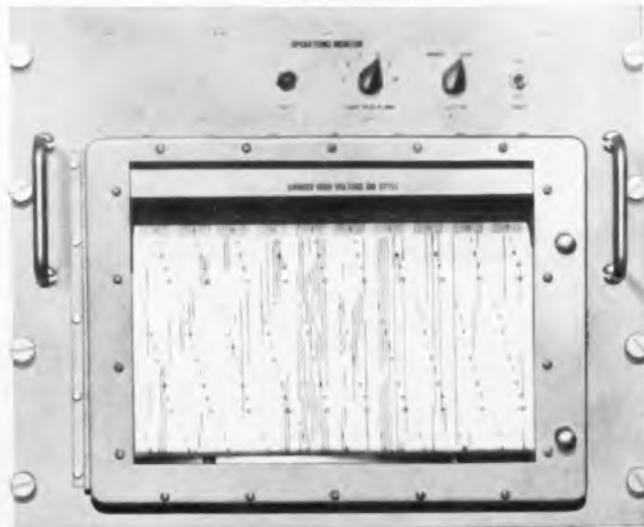
brush INSTRUMENTS

DIVISION OF

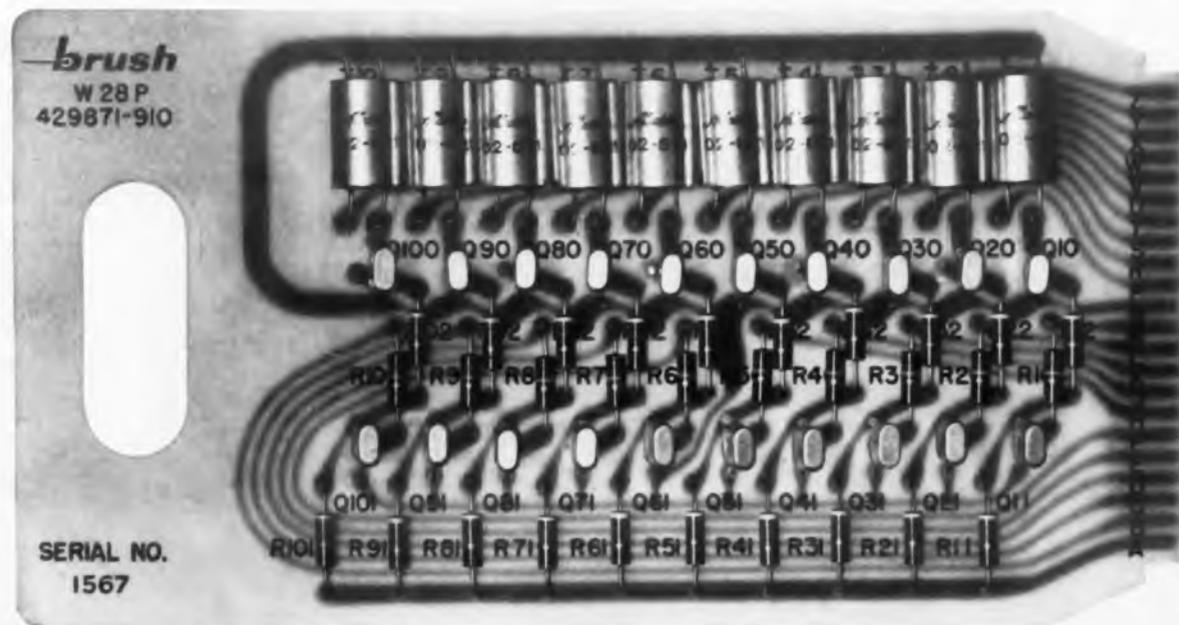
37TH AND PERKINS

CLEVITE
CORPORATION

CLEVELAND 14, OHIO



compact
transistor switching
for
millisecond
monitoring



The new Brush Trans-Switcher eliminates relays—greatly simplifies your problems of operations monitoring. Designed to take full advantage of the fast response and high resolution of Brush Operations Monitors, this compact, solid-state switching unit accepts up to 100 different "on-off" signals in a broad range of pulse shapes and amplitudes. Interchangeable, plug-in decade boards are designed to accept different voltage ranges and modes of operation. Avoid the "black box" approach—specify the *standard* Brush Trans-Switcher for the ultimate in precise, reliable monitoring. Write for complete details.

brush INSTRUMENTS

DIVISION OF
37TH AND PERKINS **CLEVITE** CORPORATION CLEVELAND 14, OHIO



Vacuum Gage

For micron range



Continuous pressure measurement, in the range of 0 to 1,000 microns of mercury, is provided by this thermocouple vacuum gage. The sensing elements, noble metal thermopiles, maintain their characteristics and hold calibration over extended use in any atmosphere. Gage tube volume is less than 1/2 cu in. The device has internal voltage regulation.

Temperature Engineering Corp., Dept. ED, Riverton, N. J.

Potting Compound

688

A clear silicone potting and imbedding compound, LTV 602 cures at 70 to 80 C to a flexible, resilient solid. The cured material is self-supporting and non-flowing. Useful temperature range is -65 to 175 C; thermal shock requirements of MIL-STD-202A are met.

General Electric Co., Silicone Products Dept., Dept. ED, Waterford, N. Y.

Price: \$10.50 to \$7.00 per lb.

Availability: Commercial quantities available.

Power Supply

In modular form

500



A regulated power supply module, the model P-30-1 has an input of 115 v rms $\pm 10\%$, 1 phase, 55 to 400 cps. Output may be 12 to 20 v at 0 to 1 amp, or 26 to 30 v at 0 to 1 amp, or 10 to 33 v at 0 to 0.75 amp. Load regulation is $\pm 0.05\%$, zero to full load; line regulation is $\pm 0.05\%$ for 105 to 125 v line. Ripple is 3 mv peak-to-peak max, and recovery time is 50 μ sec. As many as 10 units may be connected in series. The unit weighs 4-1/2 lb and measures 8 x 5 x 3-1/4 in.

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

Price: \$88.

◀ CIRCLE 249 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

485



How to hit the jackpot...

IF YOU HAVE A MOISTURE PROBLEM, Waters APW $\frac{1}{2}$ sealed potentiometer is so watertight and heat resistant, it operates reliably even in boiling water. Completely unaffected by humidity and water vapor, two common causes of pot failures in aircraft and missiles. Also available with servo face as Waters WPW $\frac{1}{2}$. Write for bulletin APW.

IF YOU REQUIRE A HERMETIC SEAL, Waters APH $\frac{1}{2}$, designed for soldering directly to the panel, not only maintains a hermetic seal behind the panel, but is itself tightly sealed against outside atmosphere and salt spray by means of double "O" ring shaft seal. Passes liquid immersion tests per MIL-E-5272A and, excluding the shaft, the Mass Spectrometer Test with leak rate less than 1×10^{-7} cc/sec. N.T.P. Write for bulletin APH.

IF YOU WANT TO READ A FUNCTION OF RESISTANCE DIRECTLY, Waters Dialpot $\text{\textcircled{R}}$ gives you the answers to these questions: Where is the slider? At what angle is the pot set? At what percentage of voltage is the pot set? Dial calibrated with equal graduations from 0 to 10 in the 300° winding angle. Scribe line on base. Plug-in feature is ideal for printed circuitry. Write for bulletin APD.

WATERS MANUFACTURING, INC. • WAYLAND • MASS.

POTENTIOMETERS • COIL FORMS • POT HOOK $\text{\textcircled{R}}$ PANEL MOUNTS • TORQUE WATCH $\text{\textcircled{R}}$ GAUGES • C'TROL $\text{\textcircled{R}}$ METER/CONTROLLER • INSTRUMENTS
CIRCLE 123 ON READER-SERVICE CARD



NEW PRODUCTS

Test Set

486

For vswr and attenuation



The model SP 160 test set, for determining vswr and attenuation values of rf components or circuits, operates over a frequency range of 200 to 475 mc. In conjunction with a dual-trace oscilloscope, it provides instantaneous readings of vswr or attenuation for the device under test. The generator section has a response that is flat within 5% over its maximum sweep width, an output of more than 0.75 v into 50 ohms, and is equipped with a variable frequency marker.

Telonic Industries, Inc., Dept. ED, Beech Grove, Ind.

Teflon Tape

686

A pressure-sensitive tape of virgin Teflon and inert filler, Fluorolin 101D resists heat distortion up to 500 F. Coefficient of thermal expansion is 2×10^{-6} . The tape has high-wear resistance and low-compression set. It comes in 18-yd rolls, 0.010 gage, up to 10 in. wide.

The Joclin Manufacturing Co., Dept. ED, Lufberry Ave., Wallingford, Conn.

Price: \$9.90 to \$35.40 per roll.

Availability: 3-day delivery from stock.

Pressure Transducers

472

Are 0.035-in. thick

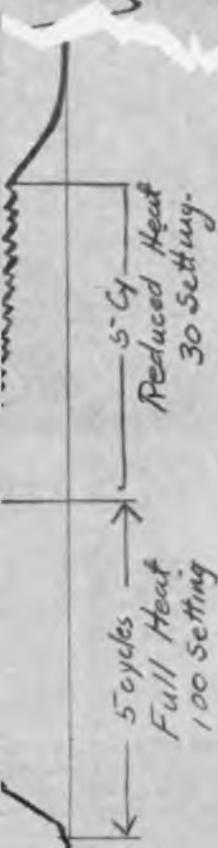


The series 200 pressure transducers have a thickness of 0.035 in. and an over-all size of 1 x 1 in. The sensitive area is 1 sq cm. Hermetically sealed, they may be used in the pressure range from 15 in. Hg to 100 psi. Frequency response and sensitivity are said to be high; linearity is good and hysteresis low.

Spitz Laboratories, Inc., Dept. ED, Yorklyn, Del.

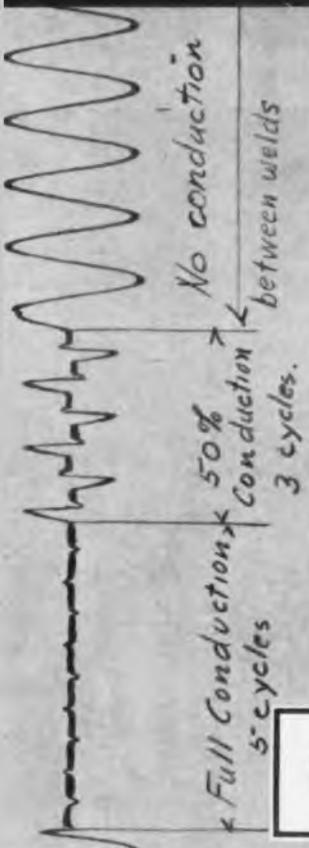
Price: \$40.

Availability: 2 weeks.



Oscillogram of Welding Current Pattern D.C.
 Taken from shunt
 in lower arm of welder.

Shows gradual build-up
 and decline of welding current.
 Essential in making
 good spot welds



this is a record

Oscillogram taken
 across ignitron tubes.



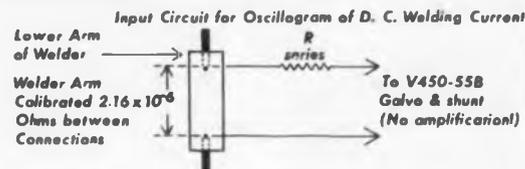
These welder phase-shift heat-control patterns were directly recorded with a Honeywell 906 Visicorder at Bristol Aircraft (Western) Limited in Winnipeg.

Since the welding heat generated is proportional to the square of the current value, phase shift must be accurately controlled in order to determine the heat value. If the phase shift dial is not accurately calibrated, the result is too much or too little heat, and a poor weld.

In this application, the Visicorder is an essential guide to accurate calibration, since ink-type re-

orders do not cover the sensitivities and frequencies needed and an oscilloscope would present a continually changing pattern since most recording periods are less than 10 cycles. The directly-recorded Visicorder patterns allow a convenient study of the exact time when the current wave form was being cut off.

Here is the circuit used in this test.



of phase shift



The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for recording as many as 36 channels of data.

REFERENCE DATA:
Send for Bulletin HC-1012



The Model 1108 Visicorder, with many automatic features and the convenience of pushbutton controls, is ideal for intermediate uses requiring up to 24 channels of data.

REFERENCE DATA:
Send for Bulletin HC-1108



The Model 906B Visicorder incorporates time and grid lines—simultaneously records up to 14 channels. Completely self-starting for remote operation.

REFERENCE DATA:
Send for Bulletin HC-906B

NEW MODEL!

The NEW Model 1406 economically brings outstanding Visicorder features to the low frequency (DC. to 200 cps) recording field.

REFERENCE DATA:
Send for New Bulletin HC-1406

The Honeywell Visicorder is the pioneer, completely proven, and unquestioned leader in the field of high-frequency, high-sensitivity, direct-recording ultra-violet oscillography. Here are some of the reasons why Visicorders provide the most accurate analog recordings available: constant flat response and sensitivity of galvanometers; grid-lines simultaneously recorded with traces to guarantee exact reference regardless of possible paper shift or shrinkage; flash-tube timing system for greater accuracy of time lines; superior optics for maximum linearity of traces.

No matter what field you are in . . . research, development, computing, rocketry, product design, control, nucleonics . . . the high-frequency (DC to 5000 cps) Visicorder oscillograph will save you time and money in data acquisition.

Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Minneapolis-Honeywell Regulator Co.
Industrial Products Group, Heiland Division
5200 E. Evans Avenue, Denver 22, Colorado

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Honeywell



Industrial Products Group

CIRCLE 125 ON READER-SERVICE CARD

AC Motors

375

In 4500 frame size



Units in this 4500 frame series of ac motors, with an OD of 5-3/8 in., are available with 1- to 3-phase, 26- to 230 v, 25- to 400-cps inputs. Outputs are provided to 1-1/2 hp in the induction motors, up to 300 in. per oz stall torque as torque motors, and from 1/200 to 1/3 hp in hysteresis synchronous motors. All can be wound for 1 to 4 speed operation. The standard temperature range is -55 C to 71 C; units operating to 150 C are available.

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

Availability: Approximately eight weeks.

Sealing Alloy

689

An alloy for high-density alumina seals, Fernico-5 is composed of iron, nickel and cobalt. Its coefficient of expansion is close to that of high-density alumina up to 600 C. Damping capacity and oxidation resistance are high.

General Electric Co., Metallurgical Products Dept., Dept. ED, Detroit 32, Mich.

Magnetic Amplifiers

477

From 75 hp to 400 hp



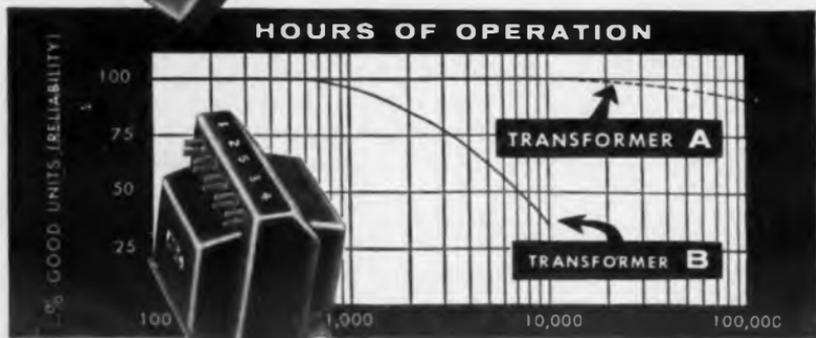
Magnetic amplifiers in 7 sizes, from 75 hp to 400 hp, in the Mega-Power 1310 series are recommended for uses requiring controlled dc power for variable-speed dc motor drives. The static devices are said to offer more compactness and reliability, longer life and less maintenance than conventional motor-generator power supplies.

Vickers Inc., Electric Products Div., Dept. ED, 1815 Locust St., St. Louis 3, Mo.



Long Life RUNS IN THE FAMILY!

Transformer A in the chart will deliver ten times more hours of dependable performance than transformer B. An engineer designing for reliability over a long period will want transformer A.



Transformer A and B are identical in appearance. They can both pass electrical inspection tests. The quality of the materials, workmanship, and design are all hidden from view so that no physical inspection can be made. So how do you tell? Which is A, and which is B?

The best way to tell is to know the manufacturer. If you're not already a customer we'd like to number you among those who *know from experience* that they have transformer reliability *inside*, when it says ADC on the *outside*. Over 15,000 custom transformer designs in nearly 25 years have proven beyond a doubt that long life just plain runs in the ADC family.

**Designing for Reliability?
Look to ADC!**

ADC

ADC INCORPORATED

2835-13TH AVENUE SOUTH • MINNEAPOLIS 7, MINNESOTA
PACIFIC BRANCH North Hollywood, California

TRANSFORMERS • REACTORS • FILTERS • JACKS AND PLUGS • JACK PANELS
CIRCLE 126 ON READER-SERVICE CARD

NEW PRODUCTS

Digital Data System

456

Is solid state



Model O-64 solid-state digital data system is designed to transmit variable and go-no-go signals in digital form. Signals are transmitted in serial form over a single cable pair, coaxial link or microwave channel. It will accept either high- or low-level input voltages.

Moore Associates, Dept. ED, 2600 Spring St., Redwood City, Calif.

Tube Shields

685

Designed for maximum heat dissipation, and for retention of the tube in shock and vibration, these shields fit 9T9 type tube bulbs. Base part No. is T9-2001-7H; tube shield assembly is No. T9-2027-5H.

International Electronic Research Corp., IERC Div., Dept. ED, 135 W. Magnolia Blvd., Burbank, Calif.

Silicon Rectifiers

474

Weigh less than 0.75 g



Available in plastic (7MP) and ceramic (7MH) packages, these miniature silicon rectifiers weigh less than 0.75 g and measure 3/8 by 0.200 in. in diameter. They are rated at 750 ma average, and 50 to 600 piv. Operating ambient temperature is from -65 to +100 for the plastic unit and -65 to +150 for the ceramic units. Type 7MH meets military specifications and is insulated and hermetically sealed, in an axial-lead package. The 7MP is plastic-encapsulated for chassis mounting.

Standard Rectifier Corp., Dept. ED, 620 E. Dyer Road, Santa Ana, Calif.

ROYAL MULTI- CONDUCTOR CABLES

For simple or complex constructions, Royal has the know-how and capacity to fill your multi-conductor cable requirements. Royal Multi-Conductor Cables are designed, made, and quality-controlled to give you the cable characteristics you want most on the job — easy workability, foot-after-foot quality, topmost dependability. Send us your cable specifications . . . or ask to have our representative call.

ROYAL ELECTRIC CORPORATION
301 Saratoga Avenue
PAWTUCKET, RHODE ISLAND
In Canada: Royal Electric Company (Quebec) Ltd.,
Pointe-Claire, Quebec

ROYAL
ELECTRIC **TYPE**
... an associate of

CIRCLE 127 ON READER-SERVICE CARD
ELECTRONIC DESIGN • February 15, 1961

Enclosed Relays 626

For motor starting



Start-winding contact ratings to 25 amp are available in the type 83 relay. Current-operated, it functions as a single-pole, normally open motor-starting relay for heavy-duty single-phase capacitor motors which are used in appliances. The type 84 is a voltage-operated single-pole relay, which may be normally open, normally closed or double-throw for pilot or power duty applications. Coil ratings are to 230 v ac, contact ratings to 1/2 hp or 16 amp resistive. Contacts and coils are enclosed. Terminals may be screw, quick-connect, or solder type. Size is 1-7/8 x 1-1/4 x 1-1/4 in.

Essex Wire Corp., RBM Controls Div., Dept. ED, Logansport, Ind.

Film Capacitors 592

Low temperature coefficient



These subminiature Teflon capacitors, developed for missile guidance systems, have temperature coefficients from 0 to 120 ppm per deg C. Tolerances to 0.1% are available. These units have the self-healing characteristics of metallized film capacitors.

Component Research Co., Inc., Dept. ED, 3019 S. Orange Drive, Los Angeles 16, Calif.



George Jones' business is to mind yours...

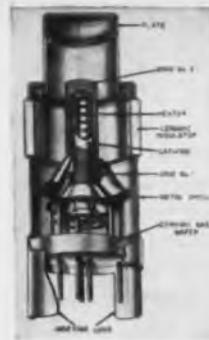
As a Field Engineer for RCA Industrial Receiving Tubes, George Jones minds your business in several ways—and all to your advantage.

It's up to George to see that you, the customer, have accurate information on new and developmental industrial receiving tubes as fast as it's available, to give you the earliest possible start in your new designs.

George must also determine whether your application requires a tube of special design. If so, he analyzes the need and relays data back to our design-development engineers for possible action.

And as an engineer with 27 years experience in tube application, George is ready to provide you every assistance in finding the RCA tubes best suited to your needs. It was he, for example, who helped a large R & D lab in the northeast select RCA's developmental nuvistor tetrode (see inset) for the design of a unique nuclear radiation checking and counting device.

George Jones' work—putting the vast accumulated knowledge and experience of RCA at your disposal—is another advantage you get in relying on RCA industrial receiving tubes.



Cutaway of RCA's developmental nuvistor tetrode for industrial applications. The nuvistor design assures extraordinary performance and low power drain in a tube of very small size and weight. It is valuable in applications where mechanical shock and vibration present difficulties.



The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA

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EAST: 744 Broad Street, Newark 2, New Jersey.
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NEW PRODUCTS

Pulse Generator

471

For single or double pulses



A decade-pulse generator, the GO 1005 can be used for determining transmission characteristics and transient response of amplifiers and networks, or for testing frequency and amplitude limits of electronic counters. It provides positive or negative, single or double rectangular pulses of up to 100 v amplitude at prf from 10 cps to 1 mc. Signal delay and pulse duration ranges are 250 μ sec to 100 msec.

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

Stake Nuts

684

Minimum thickness requirements for these miniature floating and nonfloating stake nuts are 0.040 and 0.030 respectively. The push-out, torque-out and thread-locking features each exceed all the requirements of MIL-N-25027.

Kaynar Manufacturing Co., Inc., Kaylock Div., Dept. ED, Box 2001, Terminal Annex, Los Angeles 54, Calif.

Tester Kit

479

For diodes and transistors



The IT-10 transistor-diode checker tests both low-power and high-power transistors for shorts, opens, leakage, current gain, as well as forward and reverse current of crystal diodes. A reversing switch is provided. The tester checks its own power supply, and may be used for continuity testing. Cabinet measures 3-3/4 x 3-1/16 x 3-1/8 in.

Daystrom, Inc., Heath Co., Dept. ED, Benton Harbor, Mich.

Price: \$6.95.

GERMANIUM POINT
CONTACT
DIODES:

round
pegs
for
round
holes



Some semiconductor manufacturers substitute down-graded gold bonded diodes for germanium point contact types. When this happens you don't get the diode you need. You get square pegs for round holes.

Germanium point contact diodes and gold bonded diodes are made by completely different manufacturing processes. So, they have inherent physical differences. And they have inherent electrical differences. When you specify germanium point contact diodes from Hughes you never get a substitute.

Hughes germanium point contact diodes are ideal for application in high frequency detectors, discriminators and

modulators—they have a higher Q, lower capacity and extremely fast recovery. Hughes germanium point contact diodes have been thoroughly proven through years of commercial and military use. Several types are JAN qualified.

So when you need the unique capabilities of a germanium point contact diode, specify Hughes. You will always get a reliable, high performance, completely stabilized, fully-tested Hughes germanium point contact diode.

For further information write for data sheet DS-89, Hughes Semiconductor Division, Marketing Department, Newport Beach, California.

Creating a new world with Electronics

HUGHES

HUGHES AIRCRAFT COMPANY
SEMICONDUCTOR DIVISION

SPECIFICATIONS @ 25°C unless otherwise stated

TYPE	Minimum PIV (V)	Minimum Forward Current @ +1V (mA)	Max. Reverse Current		Maximum Average Forward Current (mA)	Maximum Forward Surge Current for 1 Sec. (mA)	Reverse Recovery		
			I _R (μA)	V _R (V)			Max. T _{RR} to R (μSec.) (KΩ)	When Switched I _F (mA)/V _R	Circuit
1N34A	75	5	-500	-50	30	500			
1N38B	125	4	-6	-3	50	500			
1N54A	50	5	-7	-10	50	500			
1N58A	100	4	-600	-100	50	500			
1N66	60	5	-50	-10	50	500			
1N67A	80	4	-5	-5	30	300			
1N68A	130	3	-625	-100	30	350			
1N69A	75	5	-500	-50	40	400			
1N70A	125	3	-300	-50	30	350			
1N81A	50	3	-10	-10	30	350			
1N88	100	2.5	-100	-50	30	300			
1N89	100	3.5	-100	-50	30	250			
1N90	75	5	-500	-50	30	250			
1N95	75	10	-500	-50	30	250			
1N97	100	10	-100	-50	30	250			
1N99	100	10	-50	-50	30	300			
1N116	75	5	-100	-50	30	250			
1N117	75	10	-100	-50	30	250			
1N119	60	5	See Note 1		25	500	0.5	50	30/35
1N120	70	5	See Note 2		25	500	0.5	50	30/35
1N126A*	75	5	-850	-50	30	350			IBM "Y"
1N127A*	125	3	-300	-50	30	300			IBM "Y"
1N128*	50	3	-10	-10	30	300			
1N142	100	5	-100	-100	60	400			
1N191	60	5	-125	-50	30	300	0.5	50	30/35
1N192	70	5	See Note 3		30	300	0.5	50	30/35
1N198*	60	5	-250	-50@75°C	30	300			
1N198A	100	5	-250	-50@75°C	30	300			
1N198B	100	4	-250	-50@75°C	30	300	0.3	100	2/6
1N268	30	6	-25	-10		300			JAN 256
1N290	120	5	-100	-100	30	300			
1N294	70	5	-800	-50	50	500			
1N297	100	3.5	-100	-50	35	500			
1N298	85	30@+2V	-250	-40	50	500			
1N480	60	5	-125	-50@60°C			0.5	50	30/35
1N636	60	2.5	-10	-10	30	300			JAN 256

Notes: 1. Dynamic back resistance at 55°C between -10V and -50V is 400K minimum.
2. Dynamic back resistance is 55°C between -10V and -50V is 200K minimum.
3. Dynamic back current <50μA at 10V peak.

*JAN versions available.

Note: All Hughes germanium point contact diodes are limited to a maximum forward conductance of 25mA@+1V.

Test System

484

For transistor life



This transistor life-test system has individual collector current controls for up to 220 transistors undergoing oven-life testing. Other functions include monitoring and control of collector voltages and monitoring of elapsed time and oven temperature. It is compatible with any oven operating over a temperature range of 25 to 150 C ±1 C. Card modules, which can accommodate transistors of any type in groups of 25 to 50, are used.

Tenco Electronics, Inc., Dept. ED, 108 Cum-
mington St., Boston 15, Mass.

Price: \$5,000 plus the cost of the oven.

Availability: 30 to 60 days.

Indicator Light

683

A moisture-proof subminiature indicator light meeting the high-impact shock tests of MIL-S901B, the L20046 is rated for 60,000 hr of operation minutes at 5 v. It has sealed construction, stainless steel case, and a variety of lens colors.

Controls Co. of America, Control Switch Div.,
Dept. ED, Folcroft, Pa.

Power Supplies

476

Regulated to 0.1%



These plug-in transistor-regulated power supplies are for industrial and military applications. The TMA series is rated at 1/4 amp, output from 7 to 30 v, with regulation of 0.1% for line or load variations. The EM series, using an extruded aluminum case, is available in current ratings of 1/2, 1, and 2 amp up to 60 v, with line and load regulation of 0.1%. Ripple is 2 mv rms max. Supply voltage is 105 to 125 v, 60 to 400 cps.

Transistor Devices, Inc., Dept. ED, 40 Factory
St., Cedar Grove, N.J.

Availability: 30-day delivery.



CIRCLE 130 ON READER-SERVICE CARD

Now... 2,000 VA 50-20,000 cps

CML Model M1435D ELECTRONIC GENERATOR

SPECIFICATIONS:

- Output: 2,000 VA
- Frequency range: 50 to 20,000 cps
- Frequency stability: $\pm 0.25\%$
- Voltage regulation: 1.0% no load to full load
- Voltage stability: $\pm 0.25\%$
- Distortion: less than 1.0%
- Weight: 1,050 pounds
- Dimensions: 66" x 27" x 26" (mobile)
- Other high power units are available with this wide frequency range. Any of these units can be integrated into two and three-phase systems.

Write for complete technical data on Model M1435D or other CML high-power generators ranging in size from 6 to 100,000 watts and from DC to 50,000 cps.



**COMMUNICATION MEASUREMENTS
LABORATORY, INC.**

a Subsidiary of Tenney Engineering, Inc.

350 Leland Avenue, Plainfield, New Jersey • PLainfield 4-5502

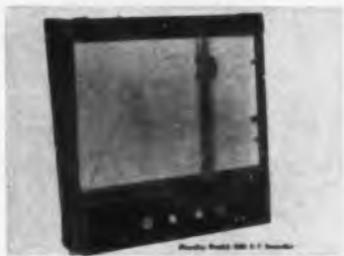
CIRCLE 131 ON READER-SERVICE CARD

NEW PRODUCTS

X-Y Recorder

661

Plots variable against time



The rack-mounting model 2DR recorder will plot one variable against time, draw cartesian coordinate curves from two related sources of dc information, and accept ac input data on either or both axes. The 16-dc input voltage ranges cover from 0.5 mv per in. to 50 v per in. on each axis. The ac input ranges are from 0.1 v per in. to 20 v per in. in eight calibrated steps. A variable range feature provides scale adjustment. Panel height of the unit is 17-1/2 in. and depth is 6-1/2 in. Pen speed is 20 in. per second.

F. L. Moseley Co., Dept. ED, 409 N. Fair Oaks Ave., Pasadena, Calif.

Molding Compound

357

Dimensionally stable, Alkyd 446 cures rapidly at low pressure and has little or no post-mold shrinkage. It has been used successfully in housing and internal parts of airborne relays.

Allied Chemical Corp., Plastics Div., Dept. ED, 40 Rector St., New York 6, N.Y.

Disk Thermostat

483

With internal heater



The type 29T is a snap-action, bimetal disk thermostat. An internal heater is used to lower the operating point of the thermostat, and to provide operation to a narrow differential. Rated to 350 F at 25 amp resistive, or 1/2 hp inductive, at 120/240 v ac, the unit may be spst or spdt. Various mounting flanges and terminal arrangements are available.

Therm-O-Disc, Inc., Dept. ED, Mansfield, Ohio.

KOH-I-NOOR

PRECISION MATCHED
INSTRUMENTS

Koh-I-Noor offers draftsmen an important new dimension in a comprehensive line of instruments and accessories meticulously matched to provide new high levels of professional performance, efficiency and convenience.

No. 3065



No. 3060

NOW... TWO KOH-I-NOOR RAPIDOGRAPH TECHNICAL FOUNTAIN PENS

In 7 "color-coded" precision line widths: 00, 0, 1, 2, 2½, 3, 4. Uses India (or regular) ink for ruling, lettering, tracing or writing with equal facility.

MODEL NO. 3065: A new model with 7 interchangeable drawing point sections, each color-coded to indicate a different line width. Best buy for the professional who requires frequent change of line widths. Each drawing point section complete with airtight refillable ink cartridge. Interchange is accomplished quickly, cleanly. Comes in handy desk top container.

MODEL NO. 3060: The regular Koh-I-Noor Rapidograph "Technical" Fountain Pen with self-contained automatic filling system, and pocket clip is a standard drafting room tool.

KOH-I-NOOR RAPIDOGUIDE AND TEMPLATES

for use with corresponding
Rapidograph Fountain Pen

Rapidoguide: High quality lettering guides with elevating metal rails, developed to fit the seven different point sizes of Rapidograph Technical Fountain Pens. Each has upper and lower case letters, numerals, and characters all on one guide.

Templates: Precision engineered for use with Rapidograph Pen, Koh-I-Noor Drawing Pens, Leads and Holders.

Write for Descriptive Literature

KOH-I-NOOR

INCORPORATED
Bloomsbury 24, New Jersey

CIRCLE 132 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

Motor-Tachometer 594

Size 10, 1.375-in. long



This new line of miniature instrument servo motors and motor-tachometers has units measuring as much as 1/3 shorter than standard. The size 10 motor-tachometer is 1.375 in. long, rather than the usual 2-in lengths. Units are available in sizes 8, 10 and 11, operationally identical to the longer units they replace. They fulfill the requirements of MIL-E-5272C.

Control Data Corp., Cedar Engineering Div., Dept. ED, 5806 W. 36th St., Minneapolis 16, Minn.

Coaxial Relays 586

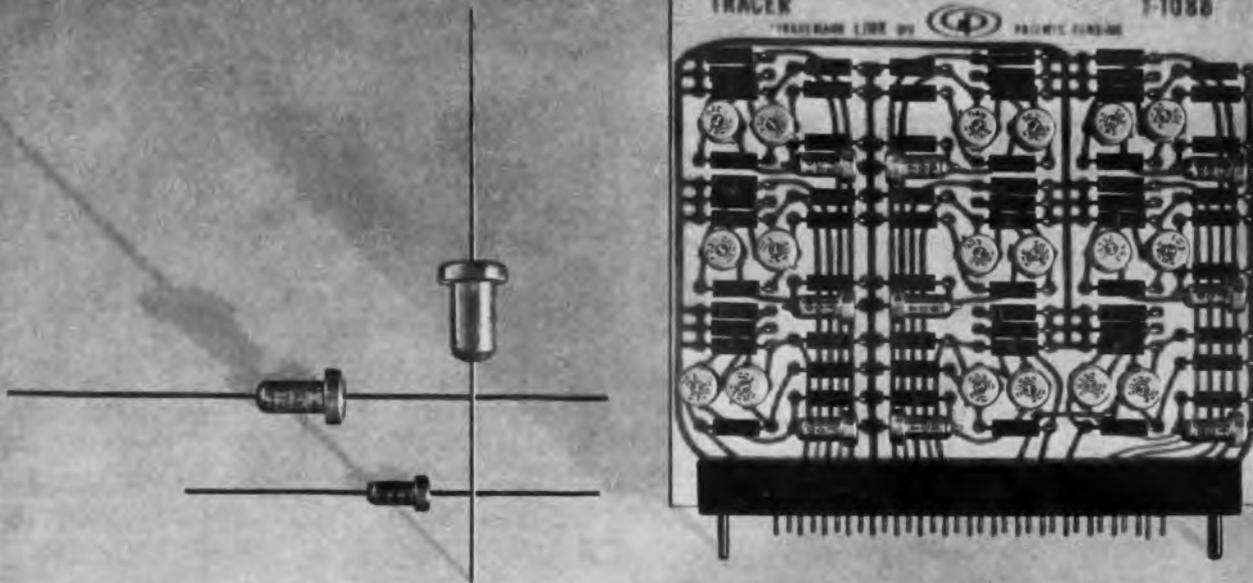
Low crosstalk and vswr



Series RB coaxial relays have a crosstalk rating of 40 db min, 0 to 470 mc; vswr is less than 1.2, 0 to 1,000 mc. Antenna transfer rating is 150 w max. Series includes units of 1-w and 2-w ratings, for ambient temperatures of 25 C, 80 C, and 125 C. Coil voltages are 6, 12, 24/26.5, 48, and 115 v. The 3-oz unit has maximum dimensions of 2-1/8 x 1-7/8 x 45/64 in.

Allied Control Co., Inc., Dept. ED, 2 East End Ave., New York 21, N.Y.

CIRCLE 133 ON READER-SERVICE CARD ►



Link Division of General Precision, Inc. specified ITT capacitors for this vital portion of its Tracer Identification and Control System, which demands utmost reliability and long life expectancy from every component.

TOTAL PROCESS CONTROL AND DISCIPLINED PRODUCTION DELIVER

HIGH-RELIABILITY WET-ANODE TANTALUM CAPACITORS FROM ITT

ITT wet-anode tantalum capacitors meet MIL-C-3965B—a fact proved by independent laboratory qualifications tests on ITT capacitors. The reliability and long life expectancy of these competitively-priced capacitors are direct results of ITT's total process control and disciplined production procedures, above and beyond testing standards more stringent than normal industry practice—and backed by ITT's world-wide facilities and experience.



Phone these ITT-CD Capacitor Sales Offices:

Albuquerque	AX 9-8013	Los Angeles	MI 6-6325
Boston	CA 7-2980	Miami	MI 4-3311
Chicago	SP 7-2250	Minneapolis	WE 8-0457
Cleveland	GR 5-3080	New York	LO 5-1820
Dallas	EM 1-1765	Philadelphia	TR 8-3737
Dayton	BA 8-5493	Phoenix	WH 5-2471
Denver	KE 4-5081	Rochester	FI 2-1413
Detroit	TO 8-3322	San Francisco	LY 1-7321
Fort Wayne	NA 0841	Seattle	MA 2-5433
Kansas City	JE 1-5236	St. Louis	EV 2-3500

IN STOCK AT ITT DISTRIBUTORS:

- TWO TYPES—M-Type and P-Type, for applications from -55 to 85 and 125 C. respectively
- 29 VALUES—from 1.75 to 330 mfd over a working voltage range to 125 VDC and maximum surge voltages to 140 VDC
- COMPACT AND RUGGED—sintered tantalum slug in fine-silver cases for 2000-hour life at maximum temperature and working voltage
- GUARANTEED—to 80,000 ft. and accelerations of 20 G's with a 0.1 in. excursion in 50-2000 cps range
- LONG STORAGE LIFE—tantalum-oxide dielectric is completely stable; assures trouble-free operation

COMPLETE SPECIFICATIONS ON ITT wet- and solid-anode tantalum capacitors are available on request. Write on your letterhead, please, to the address below.

ENGINEERS: Your ITT representative has a complete set of qualifications and quality control tests for your inspection.

NEW PRODUCTS

Delay Line

596

In slab configuration



The type 159 magnetostrictive delay line has 3 fixed outputs, including one of 30.00 μ sec. Pulse repetition rate is 615 kc; input pulse width is 0.8 μ sec. Input and output impedance is 500 ohms, and insertion loss is about 50 db. Signal-to-noise ratio is 20:1. Output rise time, 10 to 90%, is 0.4 μ sec. It operates over a temperature range of 0 to 50 C with a temperature coefficient of delay of about 100 ppm per deg C.

Delttime, Inc., Dept. ED, 608 Fayette Ave., Mamaroneck, N.Y.

Sine-Cosine Potentiometers

587

Conformity from 1.0 to 0.1%



The PSC series of sine-cosine potentiometers can be furnished in conformities from 1.0 to 0.1% peak-to-peak. Watch-case threads permit ganging with no increase in body diameters. Terminals are sealed in epoxy resin. Case size ranges from 1 to 6 in. in diameter. Shaft diameters are 1/8 and 1/4 in. Normally furnished with servo mounting and ball bearings; other mountings and sleeve bearings available.

Accuracy, Inc., Dept. ED, 4 Gordon St., Waltham, Mass.

The Important Difference In Digital Voltmeters ...

Check the design and construction features pictured here. These are the subtle marks of quality that exemplify the engineering leadership of NLS ... the *important difference* between NLS digital voltmeters and those of other manufacturers. These are the engineering innovations that assure accuracy and rugged reliability ... that minimize maintenance and downtime ... that add to the long-term efficiency and usefulness of NLS instruments. Yes, there's

more to a digital voltmeter than meets the eye ... so look behind the front panel and beyond the specification sheet before you buy! Call on your NLS representative to demonstrate the instrument of your choice ... to show what engineering leadership means to you in digital voltmeter performance and usefulness. Write today for the NLS catalog that describes the world's most complete line of digital voltmeters ... by purpose, by price!



Originator of the Digital Voltmeter

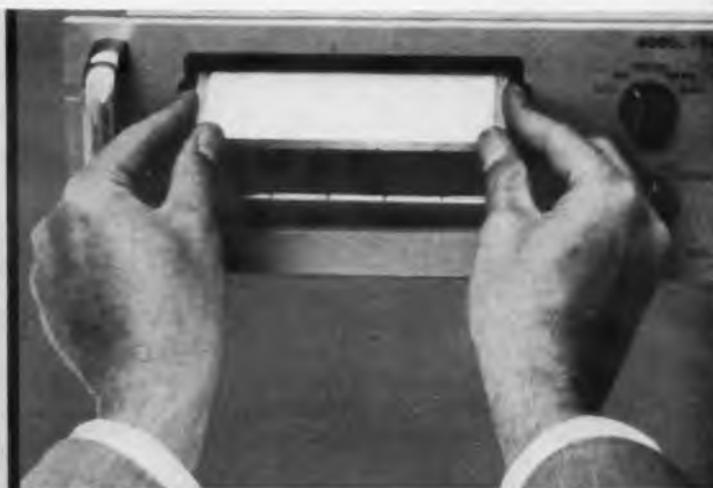
non-linear systems, inc.

DEL MAR, CALIFORNIA



1

PLUG-IN MODULAR CONSTRUCTION simplifies servicing, drastically reduces maintenance costs, keeps instruments on the job. More than 99% of the components of the NLS V44, Series 20 and Series 30 instruments are mounted on plug-in modules.



2

SNAP-OUT READOUT, exclusive on all NLS digital instruments, permits 20-second bulb replacement through front panel without tools. Precisely engraved readout numerals can be read all day from close up or far away without eye fatigue.



3 **COMPACT DESIGN** — illustrated by the 5/4"-high NLS 484 DVM, complete with recording controls — is one of the more obvious clues to superior engineering. Even the lowest cost NLS instruments are more compact with fewer cables and connections. Result: greater reliability.



4 **"NO-NEEDLESS-NINES" LOGIC** in Series 30 results from a new concept in transistor logic which eliminates unnecessary, time-consuming cycling of stepping switches through their 9's and 0's positions. This increases accuracy, speed, reliability and usefulness, particularly in systems applications.



5 **FULLY AUTOMATIC OPERATION**, pioneered by NLS, includes automatic selection and indication of range and polarity. Human error is virtually eliminated.



6 **PLUG-IN ACCESSORIES** can be mated in minutes with an NLS digital voltmeter to form hundreds of combinations. These include AC/DC converters, preamplifiers, input scanners, and virtually every type of data recorder.



7 **"NO POTS AT ALL" STABILITY** of the NLS V44 DVM is checked by the "boil in oil" test at 158°F. This feature eliminates all trimming of decade and amplifier circuits.



8 **PLUG-IN OIL-BATH STEPPING SWITCHES** in Series 30 instruments outlast dry switches by a factor of five . . . completely eliminate periodic disassembly for manual lubrication of switches.

Pressure Transducers 599

Withstand 450 F



This series of differential transformer and variable reluctance pressure transducers, for military and industrial uses, perform at temperatures between -65 F and 450 F. The PX series differential transformer has a nominal output of 40 mv per v input at 2,000 cps. The PR series variable reluctance pressure transducer has an output of 15 mv per v at 2,000 cps. Both units have an over-all length of 3.22 in. max and diameter of 1.535 in. max. They will withstand 35-g shock for 11 msec in any direction.

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

Snap-Action Thermostat 627

For appliances



Typical applications of the Adjustasnap thermostat, a snap-action bimetal blade device, include refrigeration and air-conditioning equipment, appliances, and control of ambients. It may be supplied with fixed or adjustable setting and a custom enclosure. Contacts are rated up to 200 w at 240 v. The unit operates from 0 to 250 F; adjustable range is 50 F, with a tolerance of ± 5 F or ± 2 F. Differential is 3 F to 25 F.

Essex Wire Corp., RBM Controls Div., Dept. ED, Logansport, Ind.

◀ CIRCLE 135 ON READER-SERVICE CARD

NOW COMMERCIALY AVAILABLE!

TRANSISTORIZED PULSE GENERATORS

NEW!... 3500 SERIES

- Wide-Range Performance
- Modular Flexibility
- Exceptional Reliability
- Compactness, Low Power



MODEL 3550A

These 3500 Series instruments offer a terrific, compact, "something new" in development of variable parameter pulse instrumentation.

They provide, through simplified, transistorized circuitry, a performance range which actually exceeds that of more complex, expensive equipment... and, unlike their bulky counterparts, they expand your instrument-dollar's value through simple, inexpensive, almost unlimited (modular) expansion of applications—particularly valuable on systems work and new programs where it is impossible to predict exact instrumentation requirements at project initiation.

Series is wholly solid state. Its reliability, unattainable through tube techniques, and thorough time-to-failure test results suggest application to complex systems where reliability and life are paramount considerations. The basic equipment is applicable to a broad range of applications: development and test of RADAR, digital computer circuitry, navigational systems, missile guidance and control, transient testing, etc.

Substitution or addition of inexpensive, physically and functionally interchangeable modules will provide high sensitivity external triggering, ultra slow time base, long delays, wide pulses for biological research, relay design, physical phenomenon study, etc.

Basic 3500 Series instruments provide unrestricted output power duty cycle and: Repetition Rates to 2 mc; Delays from 0.25 to 1,000 μ s; continuously variable Pulse Widths from 0.1 to 1,000 μ s; Rise Time faster than 0.02 μ s; Amplitude 12 v open circuit from 50 Ω . Only 20" x 6 $\frac{1}{4}$ " x 9 $\frac{3}{4}$ " deep overall, or mounts in rack as standard 5 $\frac{1}{4}$ " panel. Weighs only 25 lbs.

Here are a few of the many expansions of specifications possible through interchange only of modules: Widths and Delays from 100 μ s to 1 sec; Rise Time to 10 nanoseconds; Current to 300 ma; Voltage to 20 v; dual or complementary outputs.

The 3500 Series Transistorized Pulse Generators is comprised of two basic instruments. Model 3550A provides a single output channel, with variable rep rate, delay, duration, amplitude, polarity. Model 3565A adds a second output channel operating from the same rep rate triggers, with independent control of delay, duration, amplitude and polarity.

Write for complete data: Bulletin 3500

Representatives in Major Cities



Electro-Pulse, Inc.

A SUBSIDIARY OF SERVO CORPORATION OF AMERICA
6711 S. SEPULVEDA BLVD., LOS ANGELES 45, CAL.—OREGON 8-2244

CIRCLE 136 ON READER-SERVICE CARD

NEW PRODUCTS

Cathode-Ray Tube

3-beam, rectangular



Each of the 3 beams in this 4 x 6-in. rectangular cathode-ray tube is independently controllable, with common accelerator and heater connections. Each beam scans a separate area of the metallized screen, permitting 3 simultaneous displays. The type 7BFP is electrostatically focused and deflected; post accelerator voltage is 9,000 v dc.

Fairchild Camera and Instrument Corp., Allen B. Du Mont Laboratories, Electronic Tube Div., Dept. ED, Clifton, N.J.

Tie-Clamp

425

This combination wire tie-cable clamp cuts material costs and speeds assembly by eliminating separate cable clamps, mounting screws and wire ties. The polyethylene device snaps into a 0.250 in. diam hole and adjusts to 30 sizes between 1/8 in. and 1-5/16 in.

Richco Plastic Co., Dept. ED, 3722 W. North Ave., Chicago 47, Ill.

Price: From \$7.40 to \$13.95 per thousand depending on quantity.

Power Amplifier

613

Up to 4 hp



The mechanical power amplifier No. 13TAA0024 will amplify the output of a 1/30-hp servo motor to deliver and control up to 4 hp. The device provides continuous power over a 50:1 speed range, with higher ranges available, and will amplify torque from any control input device. An external cooling system dissipates heat for continuous heavy-duty operation.

Seneca Falls Machine Co., Electronics Div., Dept. ED, Fyfe Building, Seneca Falls, N.Y.

MR. JAMES SAYS:

LET US SUPPLY OUR STANDARD OR CUSTOM-DESIGNED TRANSFORMERS TO GIVE YOU MAXIMUM EFFICIENCY, SMALLEST SIZE, AND MINIMUM COST!"



INSTRUMENT TRANSFORMERS



A complete line of unique input and low power transformers designed for instrumentation circuits where accuracy, balance, precision with both electromagnetic and electrostatic shielding are required.

MINIATURE TRANSFORMER



.750 in.

Miniature transformers based on the universally used C-2450 kit for circuit application in input, inter-stage and output. Efficient transistor coupling with JAMES transformers reduces costs, increases efficiency and improves reliability.

SUB-MINIATURE TRANSFORMER



5 in.

Micro-miniature designs based on the C-2650 kit provide 1/2-inch diameter encapsulated designs with unique plug and solder in finish... the correct way to design transistor circuits.

Contact "Mr. James" for technical consultation on the correct transformers for your application. Write for further information and technical manuals on JAMES transformer kits and standard transformer designs. Custom designed samples in 76 hours at moderate cost.

TRANSFORMERS • CHOPPERS • RELAYS

JAMES

ELECTRONICS INC.

4050 N. Rockwell, Chicago 18, Illinois
CO 7-6333

Cable Tester

616

Tests 101 circuits



This equipment will test 101 circuits at the rate of 30 conductors per sec. Each wire is checked to ground and to every other wire. It will check continuity at 2 amp, leakage to ground and adjacent circuits at 500 v, and indicate leakage resistance to 100 meg. Circuit terminal numbers are indicated by Nixie readout.

Sturup, Inc., Dept. ED, 50 Silver St., Middletown, Conn.

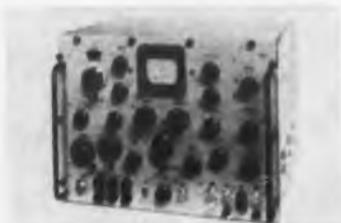
Price: \$2,950.

Availability: 6-wk delivery.

Pulse Generator

615

Combined with synchroscope



Combining a pulse generator with a synchroscope in a single unit, the PGB-1 generates rectangular voltage pulses while providing the means of observing and measuring them. The pulses, generated with adjustable width, duration, amplitude repetition rate and polarity, are displayed on the quantitative cathode-ray synchroscope. Trigger rate is between 20 and 200 cps in ratios of 10 or 100. There are 4 ranges of sweep time between 1 and 625 usec. Pulse delay range is 2 to 200 μ sec; pulse width, from 0.2 to 20 μ sec in 2 overlapping ranges.

Schaevitz Engineering, Director of Marketing, Dept. ED, P. O. Box 505, Camden 1, N.J.



BRIEF SPECIFICATIONS

OUTPUT

± 10 volts at 4 milliamps load
 ± 20 volts at 2 milliamps load

TOTAL DC GAIN

In excess of 250,000

FREQUENCY RESPONSE

dc to 200 kcs

DRIFT REFERRED TO INPUT

1 millivolt/30°C change
 $\frac{1}{2}$ millivolt/24 hours with constant temperature

JUNCTION CURRENT

2×10^{-4} amperes for full output

POWER REQUIREMENTS

(Operates from Model 3805 Power Supply)
 $\pm 22\frac{1}{2}$ volts dc (8 ma maximum drain) and
12 volts peak-to-peak center tapped,
400 cps (2 ma maximum drain)

PRICE

\$400.00

Quantity discounts available

The amplifier built with a

HIGH CONFIDENCE FACTOR



NEW DONNER SOLID STATE
OPERATIONAL AMPLIFIER
OFFERS RUGGED
ENVIRONMENTAL RELIABILITY

Using silicon transistors and semi-conductors throughout, Donner's new Model 3801 operational amplifier provides high gain, wide bandwidth and chopper stabilization paths over a broad range of ambient conditions. In standard form, the Model 3801 will operate reliably from 0°C to +55°C in relative humidity of 95%. Special versions have been made for temperature ranges as wide as -10°C to +80°C. The amplifier will withstand shock of 30 g and meet all specifications to an altitude of 50,000 feet.

Originally developed, used, and tested in critical missile applications, the amplifier is available as an off-the-shelf item at regular stock prices. This amplifier has found acceptance wherever reliability and minimum size and volume are important considerations. The standard version weighs 3 ounces and possesses external dimensions of 3¾ inches long by 2¼ inches wide by ½ inch thick. A hermetically sealed version which occupies only 2 cubic inches is also available.

Companion to the Model 3801 is the Model 3805 Power Supply capable of furnishing all power for 10 Model 3801 amplifiers.

Complete information on the Model 3801 Solid State Amplifier is ready now. Call your nearby Donner engineering representative or write Dept. 36.

**DONNER SCIENTIFIC
COMPANY**

A Subsidiary of Systron-Donner Corporation

CONCORD, CALIFORNIA • MULBERRY 2-6161

NEW PRODUCTS

Power Supplies

597

Outputs to 15 kw



These laboratory power supplies consist of motor-alternators providing 60-cps, 3-phase, 4-wire, and 400-cps, 3-phase, 4-wire service, and an alkaline battery pack providing 24 to 28 v dc. They are available in 2 power ranges: series LPC-210 provides 5 kw at 400 cps, unity to 0.8 pf; series LPC-230 provides 15 kw at each frequency. Voltage regulation, static load, is 0.5% no load to full load; static line $\pm 0.25\%$ for $\pm 15\%$ line voltage. Frequency is regulated to $\pm 0.25\%$.

Electric Specialty Co., Dept. ED, 211 South St., Stamford, Conn.

Fractional HP Motors 609

From 1/150 hp to 1/3 hp



These 2-, 4- and 6-pole shaded pole and 6-pole split capacitor motors are available in ratings from 1/150 hp at 3,000 rpm to 1/3 hp at 1,075 rpm. They can be wound for 115-v, 208-v, or 230-v operation at 50 or 60 cps, and can be engineered for single or double shafts, thermal protectors, special mounting rings, terminals or other features to fit individual motor package needs.

Leece-Neville Co., Dept. ED, 989 Athens St., Gainesville, Ga.

if you need compact cooling devices
...you need



WESTINGHOUSE THERMOELECTRIC COOLERS

NOW AVAILABLE AT REDUCED PRICES

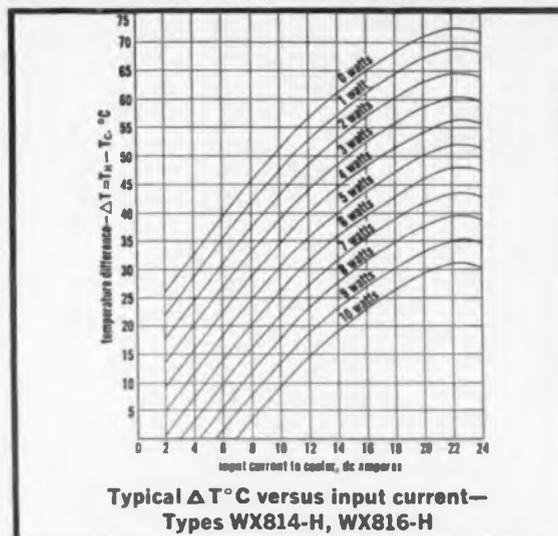
Now you can have the space and weight savings of Westinghouse "Component-Matched" thermoelectric coolers—with new cost savings, too. Prices are reduced on standard units, up to 50%!

Exclusive Westinghouse "Component-Matched" configurations! With no moving parts, Westinghouse Thermoelectric coolers provide dependable, compact, lightweight cooling where it is necessary to reduce component temperature below ambient. These unique "Component-Matched" coolers feature exterior cooling surfaces or inner-cooled chambers with tailor-made dimensions to fit specific requirements. As a result of new production facilities, a wide range of configurations can be offered to electronic equipment designers.

Only Westinghouse guarantees minimum ΔT ratings! Recent Westinghouse improvements in thermoelectric materials and assembly techniques have made it possible to guarantee minimum ΔT ratings for each cooling unit. Thus, a designer can select the unit he needs knowing in advance what the temperature drop will be from the hot to the cold side of the cooler.

Immediate military and industrial applications include: Photocells, photomultiplier tubes / Germanium transistors / Infrared detectors / Mechanical and electrical instruments / Laboratory and portable medical equipment / Controlling temperatures of solids, liquids and gases.

Westinghouse engineers who developed these new thermoelectric coolers will be glad to provide engineering assistance in your applications. For full information, contact your local Westinghouse representative, or write: Westinghouse Electric Corporation, Semiconductor Dept., Youngwood, Pennsylvania. SC-1000



**"Buy and Try"—from Westinghouse distributors
—standard WX814 and WX816 Coolers for
immediate delivery at new reduced prices.**

EASTERN

ACK SEMICONDUCTOR, INC.	Birmingham 5, Ala./FA 2-0588
CAMERADIO	Pittsburgh, Pa./EX 1-4000
CRAMER ELECTRONICS, INC.	Boston, Mass./CO 7-4700
ELECTRONIC WHOLESALERS INC.	Melbourne, Florida/PA 3-1441
GENERAL RADIO SUPPLY CO., INC.	Camden, N. J./WO 4-8560
GENESEE RADIO PARTS CO.	Buffalo, N. Y./DE-9661
KANN-ELLERT ELECTRONICS, INC.	Baltimore, Md./TU 9-4242
MILGRAY ELECTRONICS	New York, N. Y./RE 2-4400
RADIO & ELECTRONIC PARTS CORP.	Cleveland, Ohio/UT 1-6060
SCHWEBER ELECTRONICS	Long Island, N. Y./PI 6-6520

MIDWESTERN

ELECTRONIC COMPONENTS FOR INDUSTRY CO.	St. Louis, Mo./WO 2-9917
INTER-STATE RADIO & SUPPLY CO.	Denver 4, Colo./TA 5-8257
LENERT CO.	Houston, Texas/CA 4-2663
RADIO DISTRIBUTING CO.	Indianapolis, Ind./ME 7-5571
SEMICONDUCTOR SPECIALISTS, INC.	Chicago, Ill./NA 2-8860
S. STERLING CO.	Detroit, Mich./BR 3-2900
UNITED RADIO, INC.	Cincinnati, Ohio/MA 1-6530
WHOLESALE ELECTRONICS SUPPLY	Dallas, Texas/TA 4-3001

WESTERN

ELMAR ELECTRONICS	Oakland, Calif./TE 4-3311
HAMILTON ELECTRO SALES	Los Angeles, Calif./BR 2-9154
NEWARK ELECTRONICS CO.	Inglewood, Calif./OR 4-8440

You can be sure... if it's
Westinghouse



Westinghouse

SILICON POWER
RECTIFIERS
AND
TRANSISTORS

NOW IN STOCK

YOU CAN OBTAIN
UP TO 1000 PIECES
OF MOST TYPES
AT
FACTORY PRICES
FROM

Schweber
ELECTRONICS

60 HERRICKS ROAD.

MINEOLA, L. I., N. Y.

PIONEER 6-6520.

TWX G-CY-NY-580U



CIRCLE 141 ON READER-SERVICE CARD

CIRCLE 140 ON READER-SERVICE CARD

HIGH-ACCURACY, WINDING COMPENSATED RESOLVERS

Kearfott precision resolvers are high accuracy units particularly applicable to analog computers and automatic control systems. The resolvers are capable of holding the angular arc error to accuracies within 20 seconds from electrical zero. A compensator winding provides feedback voltage for a resolver isolation amplifier. Unity gain from the amplifier input to resolver rotor output is made possible by adjustment of a resistor. Since compensator and rotor winding voltages vary with temperature and frequency in a parallel manner, the feedback loop is automatically adjusted to compensate for these variations.



TYPICAL PERFORMANCE DATA

Unit No.	R980-41D	T980-003	425506
Size	11	15	25
Accuracy (Max Error from E.2.)	5 minutes	5 minutes	20 seconds
Function Error	.1% max	.05% max	.01% max
Excitation (400 cps)	60 volts	60 volts	115 volts
Transformation Ratio (Rotor to Stator)	980 ± .020	980 ± .010	980 ± 2%
Phase Shift	7.5 lead	8.5 lead	0° ± 1 min

Write for complete data



KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

NEW PRODUCTS

Resonant Reed Relay

372

Has self-holding feature



This self-holding resonant reed relay provides selective, positive contact without the use of auxiliary holding relays. It is unaffected by acoustic and mechanical vibration, and rejects transients up to 25 msec duration. There are 4 reeds, responsive to 75, 95, 115 and 135 cps. Narrow or broad response bandwidth and wider frequency range is optional. Response time is 500 msec max; contacts, rated at 2 amp, 115 v 60 cps resistive, have a minimum life of 100,000 cycles.

P. R. Mallory & Co. Inc., Dept. ED, Indianapolis 6, Ind.

Price: \$6 ea in lots of 1,000.

Availability: Two weeks.

Closed-Cell Sponge

681

This closed-cell Viton and Fluorel sponge, a foamed fluorinated polymer, has a standard density 1/4 that of the solid product. It is resistant to fuels and to perchloroethylene. Standard size is 9-in. square, up to 1/2-in. thick.

Industrial Electronic Rubber Co., Dept. ED, 31945 Aurora Road, Solon 39, Ohio.

Motor Regulator

481

For 1/50 hp to 1 hp



The Reactron is a static ac power-compensating transformer which, in conjunction with silicon rectifiers, provides constant but infinitely adjustable motor speeds, in ratios up to 100:1, on dc shunt-type motors directly from ac power supply. The motor may be operated at full-load torque at all speeds, and up to three times full-load torque intermittently. Units are available with motors in 1/50- through 1-hp models.

Vee-Arc Corp., Dept. ED, Westboro, Mass.

MAGNETRON CONNECTORS



Specify JETTRON for all types of magnetron connectors for vital military or commercial equipment. Complete facilities for the design and production of "specials" and other precision components including sockets and cable assemblies.

Magnetron Input Connector Cat. 9000 C

Fits 4J52A and similar Magnetrons. Features floating heater contact, eight prong heater cathode contact of silver plated heat treated beryllium copper. Moulded silicone encloses metal body.



Magnetron Input Connector Cat. 9005-C



Fits 4J52A and similar Magnetrons. Features identical to Cat. 9000-C. In addition has 75 mil thick silicone insulated cables for higher potential applications. Made with 4700 µF built-in capacitor.

Magnetron Input Connector Cat. 9040

One of the many "Specials" Jettron has made. Basic Input Connector with floating heater contact. Supplied with or without bypass capacitor. Normally potted to the magnetron input end.



Magnetron Input Connector Cat. 9050



Fits Miniature Magnetrons such as L-3028B. Beryllium copper heater and cathode contacts assure dependable contact. Silicone cup fits snugly over magnetron input end. Leads insulated with silicone.

Magnetron Input Connector Cat. 9060

Fits Miniature Magnetrons such as L-3028B. Feature similar to Cat. 9050 but supplied with silicone enclosure. Leads extend directly from body of connector. Normally potted to magnetron input end.



Call or write for bulletins on special sockets, magnetron and other connectors

JETTRON PRODUCTS • INC

56 Route 10, Hanover, New Jersey
Telephones: TUCKER 7-0571-0572

• Sales Engineers in Principal Cities

CIRCLE 143 ON READER-SERVICE CARD

Relays by Stromberg- Carlson



Telephone-type quality • reliability durability

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

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

What's more, we go beyond just the manufacture of relays. If you desire, we can also provide wired mounting assemblies.

Our relays are available in a wide range of types, of which these are representative:

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

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

TYPE BB: up to 100 Form "A" springs.

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

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

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

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

STROMBERG-CARLSON
A DIVISION OF
GENERAL DYNAMICS

CIRCLE 144 ON READER-SERVICE CARD
ELECTRONIC DESIGN • February 15, 1961

Operational Amplifiers

382

Solid state, with booster



These miniature plug-in amplifiers use neither choppers nor tubes to attain high performance. The operational amplifier, model A-2, has an open-loop voltage gain of 100,000 and a gain-bandwidth product of 500 kc. The common-mode rejection ratio is 7.5 million to 1. Linearity is within 0.1% in an output swing of ± 10 v; drift is less than 1 mv over a 45-F ambient temperature change. Its output current of 1.0 ma at 10 v may be boosted to 100 ma by the companion G-2 power booster. The A-2 is 5-in. long x 2-1/4 in. x 1 in., and weighs 12 oz.

Schlumberger Corp., Ridgefield Instrument Group, Dept. ED, Ridgefield, Conn.

Price: A-2, \$195; G-2, \$75.

Sound Survey Meter

680

A sound survey meter for field use, the portable type B weighs 1 lb. It indicates sound pressure levels for 40 to 125 db, and has a frequency response within standard tolerances in the 45- to 8,000-cps spectrum. A vibration pick-up is provided. The solid-state meter uses a mercury cell.

The Korfund Co., Inc., Dept. ED, 22F Cantiague Road, Westbury, N. Y.

Cable Terminations

469

With dummy loads



These ConheX cable terminations, with built-in dummy loads, may be mated with snap-on or screw-on connectors of 50 or 75 ohms. Units are made on order to provide proper impedance match and power capacity, and are available in any value of resistance and tolerance required. The dummy load is made of solid brass, gold plated, machined to accept standard resistors of the 1/2-w non-inductive type.

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



SHOWN TWICE NORMAL SIZE



HIGH PERMEABILITY FERRITE

Kearfott's MN-30 ferrite is a highly machinable, high-permeability ferrite for use in magnetic cores. Its low losses and high saturation magnetization permit efficient application at frequencies up to 500 kc, while eddy current losses are minimal due to the material's high resistivity. Custom shapes and sizes available with dimensional tolerances within $\pm .001$, density ranges from 4.9 to 5.0 gm/cm³. High quality and uniformity are assured through special compounding techniques, automatic control of firing, and rigid quality control.

TYPICAL CHARACTERISTICS

Initial Permeability at 21°C and 5 kc	3000 Min.
Maximum Permeability, measured at 2000 gauss	6000
Flux density at 7 oersteds, using Rowland Ring Test Circuit and Fluxmeter	4600 gauss
Flux Excursion for 1 oersted	3500 gauss
Retentivity (B _r)	1300 gauss
Coercivity (H _c)	0.13 oersteds
Loss Factor 1 μ Q at 50 kc	7.5 x 10 ⁻⁶
Loss Factor 1 μ Q at 500 kc	30 x 10 ⁻⁶
Temperature Coefficients of initial permeability (% per °C):	
From -30°C to +125°C	0.28
Curie Temperature	over 180°C
D. C. Resistivity	250 ohm-cm

(All magnetic properties are held
within a tolerance of $\pm 15\%$)

Write for complete data



**KEARFOTT DIVISION
GENERAL PRECISION, INC.**

Little Falls, New Jersey

NEW PRODUCTS

Power Supply

457

For ac-dc devices



Model CV-1171-PS is designed to provide 110 v dc for small appliances from 400-cps distribution systems. It is a self-contained unit measuring 2 x 5-1/2 x 1-1/2 in., weighing 0.9 lb. Input is 115 v 400 cps; output is 110 v, 300 ma dc. It has a 5-min overload capacity of 700 ma at 90 v min.

Espey Manufacturing & Electronics Corp., Saratoga Industries Div., Dept. ED, Saratoga Springs, N.Y.

Alkaline Manganese Battery

679

This alkaline manganese battery was developed specifically for hearing aids. The N-size cell gives 140-hr service on discharge to nominal 0.9 v, with another 20 hr of useful life.

P. R. Mallory & Co., Inc., Mallory Battery Co., Dept. ED, North Tarrytown, N. Y.

Price: \$0.30.

Building Blocks

388

For digital applications



Plug-in building blocks for digital computer applications provide flip-flop, multivibrator and univibrator elements in any combination. Frequency response of the flip-flop elements is above 20 kc; multivibrators are available with any frequency from 250 cps to 20 kc. The univibrator may have any pulse duration from 4 μ sec to 4 msec. The silicone rubber encapsulated units are 2-3/4 x 3-1/8 x 1/2 in., weigh 2 oz, and contain 2 elements in any combination.

Marketing Computers, Inc., Dept. ED, 50 St. Benedict, Florissant, Mo.

Price: \$14 in sample quantities.

Availability: 1 week.



VAX-5.5-LC



VAX-4.5-GR



VAX-4.5-LC

GLOBE

makes the blower you



	blower	nom. dia.	power	design point
VAX-4-FC	TAX-1-VS	1"	d.c.	10 cfm. @ 0.3" H ₂ O not pictured
	VAX-2-MM	2"	d.c.	37 cfm. @ 1.5" H ₂ O
	VAX-2-MC	2"	400 ~ a.c.	50 cfm. @ 2.1" H ₂ O
	VAX-3-BD	3"	d.c.	80 cfm. @ 1.2" H ₂ O
	VAX-3-FC	3"	400 ~ a.c.	100 cfm. @ 3.5" H ₂ O
	VAX-3-GN	3"	115v. a.c./d.c.	70 cfm. @ 1.5" H ₂ O
	VAX-4-FC	4"	400 ~ a.c.	95 cfm. @ 2.2" H ₂ O (140 cfm. @ 2.1" H ₂ O)*
	VAX-4.5-LC	4.5"	400 ~ a.c.	77 cfm. @ 5.0" H ₂ O (140 cfm. @ 5.0" H ₂ O)*
	VAX-4.5-GR	4.5"	115v. a.c./d.c.	220 cfm. @ 1.8" H ₂ O
	VAX-5.5-LC	5.5"	400 ~ a.c.	300 cfm. @ 3.0" H ₂ O
	STAX-3-FC	3"	400 ~ a.c.	30 cfm. @ 14.0" H ₂ O

*at 25,000 feet

most stocked for 24-hour prototype delivery

For any electronic cooling problem that comes down your road, look to Globe! This big new line of vaneaxial blowers may meet your need right now. Or Globe will design and develop a special blower for your application (it's not as difficult as you think). Because we make all kinds of motors, we can control all the variables—size, weight, high temperature performance, and MIL spec factors.

A.C. blowers are for 60,400 cycle, or variable frequency; a.c./d.c. blowers are for universal operation. Globe also makes a complete line of miniature centrifugal and tube-axial blowers and open fans. Request Bulletin VTC from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.

GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS, ACTUATORS, TIMERS, CLUTCHES, BLOWERS & FANS, MOTORIZED DEVICES
CIRCLE 147 ON READER-SERVICE CARD

Servo Accelerometer

369

Has high sensitivity



Of closed loop-servo design, the model PAV-1S variable range servo accelerometer has a threshold sensitivity of better than 1 part in 100,000. In range between ± 1 g to ± 30 g, the unit may be adjusted to provide any full scale range between 30% and 95% of maximum. The 3-oz accelerometer operates on ± 15 v dc at $\pm 10\%$ at ± 7 ma, or 28 v dc $\pm 10\%$ at 15 ma. Output is either ± 7.5 v dc or 0.5 v dc at 1.5 ma.

Palomar Scientific Corp., Dept. ED, 4039 Transport St., Palo Alto, Calif.

Price: \$670.

Availability: 6 to 8 weeks.

15-g Synchros

675

Improved brush configurations on all size 8, 10, and 11 synchros and resolvers permit operation in the vibration spectrum of 10 to 2,000 cps at 15 g. The feature is common to all units at no increase in price.

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

AC/DC Converter

499

With automatic range selection



Used with a digital voltmeter, the 125E ac to dc converter automatically selects the proper range between 1 mv and 1 kv. It is suited for automatic data logging and system testing jobs where a wide range of ac voltages are being measured. Input impedance is 10 meg. Output voltage will be within 0.01% of final value in less than 6 sec for full scale excursion at the lowest frequency, 30 cps.

Non-Linear Systems, Inc., Dept. ED, Del Mar, Calif.

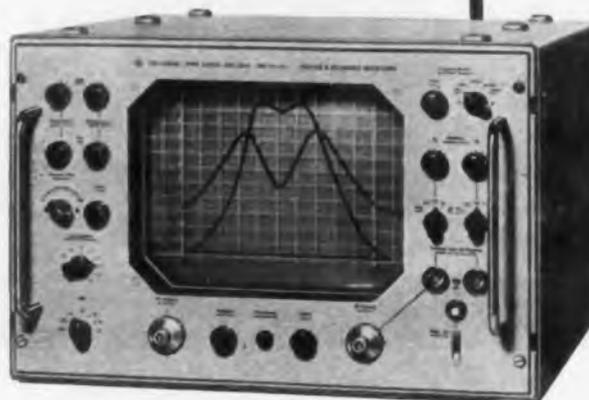
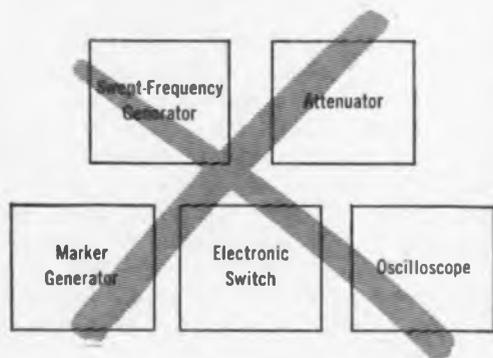
Price: \$1,500.

Availability: Immediate delivery.

need!

THE POLYSKOP

ONE INTEGRATED SWEEP-FREQUENCY SYSTEM REPLACES FIVE UNITS



TYPE SWOB

TWO CHANNEL FREQUENCY RESPONSE DISPLAY FOR TWO AND FOUR TERMINAL NETWORK MEASUREMENTS.

The Polyskop Type SWOB is a visual display swept-frequency signal generator with a frequency range of 500 kc to 400 mc. It provides an automatic display of the response a given quantity exhibits with a change in frequency, thereby replacing time-consuming point-by-point measurements with display curves which render instantaneous answers. Measurement and alignment work may be relegated to semiskilled personnel, and production tests may easily be carried out by unskilled workers.

Outstanding Advantages of the POLYSKOP:

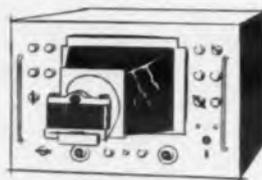
- Saves time — Solves problems up to 50 times faster.
- Saves money — Relieves skilled personnel from routine work.
- Universal usefulness — Wide frequency range (0.5 to 400 mc) covers radio and television upwards to UHF.
- Dual-trace display — Facilitates simultaneous checking of two mutually independent quantities.
- Completely self-contained measuring system — Control of error sources.
- Large screen scope display — Giving a resolution compatible with the accuracy which can be obtained with the system.
- Delivery from stock.



ROHDE & SCHWARZ

111 Lexington Ave., Passaic, N. J. • PRescott 3-8010

**A DAY'S WORK IN
LESS THAN
ONE SECOND!**



By employing a single lens Reflex 35 mm. camera in conjunction with the Polyskop, documentation is fast, simple and inexpensive. Resultant picture is a complete record, including graticule, frequency curves, serial number and date. Camera attachment is hinged for direct viewing.

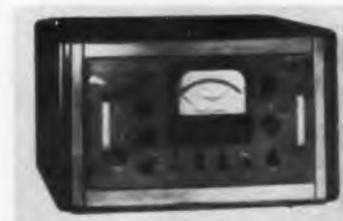
**WRITE FOR 8-PAGE
POLYSKOP BROCHURE**

NEW PRODUCTS

Meter Calibrator

387

General utility type



The model 600 meter calibrator is designed for checking ac and dc voltage and current meters in shop areas. There are 7 ac and dc voltage ranges, between 0 to 2.5 v and 0 to 500 v; 13 dc current ranges, between 0 to 100 μ a and 0 to 1,000 ma; and 7 precision resistance decades from 25 ohms to 2.5 meg. Accuracy on all ranges is 3/4% of full scale, except for the 0.2% accuracy in resistance ranges. The rack-mounting unit is 10.5-in. high and 15-in. deep. Where greater accuracy is required, 1/4% on all ranges is available with the addition of the model 600A auxiliary unit.

Mid-Eastern Electronics, Inc., Dept. ED, 32C Commerce St., Springfield, N.J.

Price: Model 600, \$995; model 600A, \$595.

Connector Caps

678

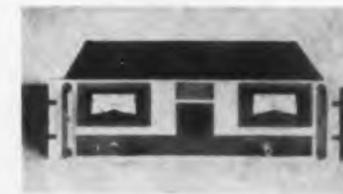
Vinyl protection caps for rectangular connectors are made in 12 sizes. In addition to protecting connectors from impact damage, the bright yellow caps keep out moisture, dust, and contamination.

S. S. White Industrial Div., Plastics Dept., ED, 10 E. 40th St., New York 16, N. Y.

DC Power Supplies

482

Regulation is 0.1%



Current regulation of 0.1% from no load to short circuit and $\pm 10\%$ line voltage variation, over an output range of 0 to 20 v, is provided by the IQ series dc power supplies. The transistorized units are made in 6 ranges: 2, 6, 10, 15, 25, and 50 amp. Ripple is held to less than 600 μ v, with transient response less than 50 μ sec. Power requirement is 105 to 125 v ac, 60 cps.

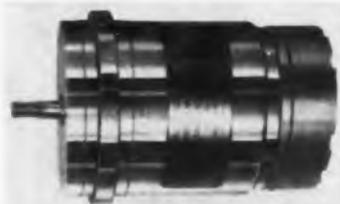
Universal Electronics Co., Dept. ED, 1720 22nd St., Santa Monica, Calif.

Price: \$925 for 15-amp model IQ20-15A.

CIRCLE 148 ON READER-SERVICE CARD

Size 328 Resolvers

Error in less than 20 sec



Maximum error from electrical zero does not exceed 20 sec in these size 28 resolvers. They function as 4-wire control transmitters, control differential transmitters, and control transformers. A system composed of 3 such units has a total error that is less than 35 sec. For use with 400-cps power, excitation voltages are 90 v and 115 v. Operating temperature range is -55 C to 125 C. Model Z5153-004 has a power input of 0.180 w; model Z5163-001, 4.6 w, and model Z5193-001, 1.60 w. BuOrd numbers have been assigned.

General Precision, Inc., Kearfott Div., Dept. ED, 1150 McBride Ave., Little Falls, N.J.
Availability: 60 to 90 days.

Phosphor Coating

677

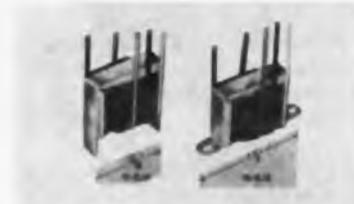
Used on more than 200 different cathode-ray tube types, P31 phosphor is reported to increase brightness by an average 60% gain. The color and persistence characteristics of P31 make it a replacement in most P1 and P2 requirements where there is bright ambient light.

Thomas Electronics, Inc., Industrial and Military Cathode-Ray Tube Div., Dept. ED, 118 Ninth St., Passaic, N. J.

Audio Transformers

421

Rated from 0.15 to 10 w



These transistor audio transformers range from 0.15 to 10 w. They are designed for interstage, driver and output applications. TA-53 and TA-54 are rated at 0.15 w and measure 13/16 x 5/8 x 11/16 in.; TA-52 and TA-55 are rated at 0.3 w and measure 1-5/8 x 13/16 x 3/4 in. Five other units range from 0.5 to 10 w.

Chicago Standard Transformer Corp., Dept. ED, 3501 W. Addison St., Chicago 18, Ill.

Price: From \$3.61 to \$7.06 ea.

Availability: Immediate through distributors.

411



ENGINEERED COMPONENTS

for the Electronics Industry



Now on hand for prompt delivery—reliable Garlock CHEMELEC® Miniature Sockets (upper left), Insulators (upper right), Connectors (right).

Now—Garlock Electronic Components are immediately available wherever and whenever needed!

Through a new, widespread distributor organization, Garlock now offers fast delivery of CHEMELEC Stand-off and Feed-Thru Insulators, Subminiature Tube and Transistor Sockets, and Connectors. Here, too, is an increased opportunity for close-at-hand assistance from Garlock distributors experienced in applying electronic products.

Take advantage of on-the-spot availability—specify these skillfully engineered Garlock electronic components. Reliable under the most severe conditions, they are ideal for high temperature, high voltage, high frequency service on missile guidance, fire control, tracking, and radar systems. Garlock has the technical personnel and modern facilities to produce components of all materials—Teflon† TFE and FEP, Nylon, Delrin†, C.T.F.E.**—and in a range of sizes, designs, and tolerances to fit your exact needs.

At your disposal, too, for development of new electronic products, Garlock maintains complete electrical, chemical and physical laboratories staffed by top-flight engineers. Your Garlock Electronic Products representative will be glad to discuss specific products and service with you. Call him at the nearest of these locations:

ABBETT & HUSTIS 1245 Highland Ave. Needham 92, Mass.	J. Y. SCHOONMAKER CO., INC. 5328 Redfield Ave. Dallas 35, Texas
BOB BRAY 18 North Mentor Ave. Pasadena, Calif.	LAKE ENGINEERING CO. LTD. 767 WarJen Ave. Scarborough, Ontario
CARL HOWER 340 N. Marshall Ave. Scottsdale, Arizona	NAUDAIN-BOHAKER & CO. Suburban Sta. Bldg., Rm. 1032 Philadelphia 3, Pa.
DON SMITH SALES CO. 2320 N. 45th St. Seattle 3, Washington	RUDAT & EWING 636 Waverley St. Palo Alto, Calif.
GRANT SHAFFER COMPANY 14241 Fenkel Ave. Detroit 27, Michigan	SCOTT & STEFFEN, INC. 1836 Euclid Ave. Cleveland 15, Ohio
HILL AND GRAY, INC. 41½ Harrison St. Oak Park, Illinois	SOUTHERN SALES COMPANY 105 Lakeshore Drive Angola, Indiana
J. P. DEARIE AND CO. P. O. Box 66 Mountain Lake, New Jersey	R. E. CATHEY CO. 1789 Fulton St. Denver 8, Colorado
	STANLEY K. WALLACE ASSOCS. INC. P. O. Box 67 Lutz, Florida

You may also obtain more information by writing for Catalogs AD-169 and AD-171, Garlock Electronic Products, Garlock Inc., Camden 1, New Jersey.

GARLOCK

ELECTRONIC PRODUCTS

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

†Registered Trademark **polychlorotrifluoroethylene
†DuPont Trademark

CIRCLE 149 ON READER-SERVICE CARD

LOUD AND CLEAR!



RADIATION MODEL 3115 FM TELEMETRY TRANSMITTER PROVIDES...

- Carrier frequency stability to within $\pm 0.01\%$
- Frequency response within 0.5 db from 100 to 100,000 cps
- 2 watts minimum output
- Virtual immunity to extreme environments
- Low microphonics
- Reliability proven in Tiro 1, Redstone, Jupiter, Snark and other missile programs
- Off-the-shelf availability

For complete information on the Model 3115 ask for: Technical Bulletin RAD B-102. Write Dept. ED-2.



RADIATION
INCORPORATED

Melbourne, Florida

CIRCLE 150 ON READER-SERVICE CARD

PYROFILM
RESISTOR

4000

HOUR

LOAD
LIFE
TEST

*Proves PyroSeal® Resistors
Unequaled
in reliability and stability*

SEND FOR COMPLETE TEST REPORT. YOURS WITHOUT OBLIGATION.

PYROFILM RESISTOR COMPANY, Inc.

U.S. Highway #46, Parsippany, New Jersey

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CIRCLE 151 ON READER-SERVICE CARD

146

NEW PRODUCTS DC Power Supply

Has two outputs



Two dc power supplies are combined in an 8-1/4-lb package. One supply delivers 2, 6 and 12 v dc, selectable; the other 1 to 30 v dc, variable. Outputs may be used separately or simultaneously. Power sources may be 115 v ac, 50 to 2,000 cps or aircraft or marine ac/dc, 20 to 35 v. Transistor circuitry is used throughout.

R-K Labs, Dept. ED, Box 291, Buena Park, Calif.

Price: \$199.50 ea.

Magnet Material

676

A magnetically oriented, rubber-bonded barium ferrite, Plastiform 1 has high coercive force and an energy product of about 1 million gauss oersted.

Easily machined or cut, the material has high impact strength and will not chip in use. It is available in rings, sheets and strips.

Leyman Corp., Dept. ED, 5178 Crookshank Road, Cincinnati 38, Ohio.

Power Regulator

493

For computer operation



The type NPR solid-state power regulator controls the output of a power supply for operation of computer elements, providing closely regulated voltages at low impedance. Input is +16 v and -16 v; output is +12 v at 250 ma and -12 v dc at 500 ma. The +12-v output is adjustable to within 1% from 10 to 16 v.

Ransom Research, Dept. ED, 374 W. 8th St., San Pedro, Calif.

Price: From \$67.50 to \$57.40.

Availability: Delivery from stock.

WHY AIR FORCE HAS ADOPTED MICROFILM FOR ENGINEERING DRAWINGS

Recently the Air Force issued new contract requirements of vital importance to companies that are doing—or intend to do—business with its various activities. In essence, the Air Force has made the use of microfilm mandatory for most engineering data and records relating to items delivered by contractors and their vendors.

The new requirements (MCP-71-77) incorporate standards and specifications issued earlier by the Department of Defense for its Engineering Data Micro-Reproduction System. The Air Force move is indicative of the importance of microfilm to the government in saving time, money, and space.

The Air Force is convinced that working with microfilm is easier than working with paper, that it is more efficient and costs less. Filmwork, in other words, is easier and more practical than paperwork for engineering drawings and records.

This is not news to the many industries that use microfilm today. They know that microfilm is a highly efficient and effective production communication tool. They know that microfilm can do many jobs much faster and much more accurately, with almost fantastic savings in time and money.

**3M makes
microfilm easy
to use**

ELECTRONIC DESIGN • February 15, 1961

Dielectric Test Set

Has motorized output



Model K15-2M high-voltage ac dielectric test set is a one-piece unit with a motorized output control and a continuously variable output of 0 to 15 kv rms and a 2-kva capacity. Waveform distortion is below 5% and a dual-scale kv meter is connected directly at the output for accurate voltage indication.

Peschel Electronics, Inc., Dept. ED, Towners, Patterson, N.Y.

Price: \$1,190 ea.

Availability: Two week delivery.

Playback Assembly

422

The PA-8414 magnetic head playback assembly is designed to operate with built-in time delay, directly on an FR-100 tape transport. Fourteen channels are controlled by one micrometer. A stag-

454

gered array of heads provides fixed time delays between tracks.

Applied Magnetics Corp., Dept. ED, P. O. Box 368, Santa Barbara Airport, Goleta, Calif.

DC Power Supply

466

Output to 350,000 v



Model 2350-8 dc power supply has an output range up to 350,000 v. It is designed for dielectric testing of cables and klystron apparatus, for particle accelerators and the study of high-voltage discharges. The unit provides continuous current of 8 ma at any output voltage and has 2% rms ripple. Auxiliary filters reduce ripple to 0.01%.

Sorensen & Co., Inc., Dept. ED, Richards Ave., South Norwalk, Conn.

Price: \$13,500.

Availability: Four months.



When data is on microfilm in FILMSORT Aperture Cards, facts that speed production are at your finger tips in just 90 seconds. And with a THERMO-FAX "Filmac" Reader-Printer you can take more than a look—you can take an enlarged copy in seconds.

Microfilm really became practical for industry only a few years ago when Minnesota Mining and Manufacturing Company introduced THERMO-FAX "Filmac" Reader-Printers. For the first time, the advantages of a reader and a printer were combined in one compact, low cost unit. Today there's a "Filmac 200" Reader-Printer that has a huge viewing screen, simple pushbutton operation, makes copy after copy in 18" x 24" size or half size prints of engineering drawings and data from microfilm in FILMSORT Aperture Cards. A "Filmac 100" Reader-Printer delivers 8½" x 11" copies in seconds, too.

FILMSORT Aperture Cards and "Duplicard" Copy Cards long used by government and industry are designed to

meet military specifications and standards. These are the punch cards that make microfilm so easy to file, find, and use.

FILMSORT Microfilm Copiers, Mounters, and Readers are designed exclusively for FILMSORT Aperture Cards. They are engineered to make your microfilm system profitable.

Get the proof!

For complete information on how 3M makes microfilm so easy to use, for details about military microfilm standards and specifications, and for a free copy of "How to Put Microfilm to Work," mail this coupon today.

Please rush me information on how 3M makes microfilm so easy to use, details about the Department of Defense specifications, free copy of "How to Put Microfilm to Work."

Name _____ Title _____

Company _____

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City _____ Zone _____ State _____

3M
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PRODUCTS

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... WHERE RESEARCH IS THE KEY TO TOMORROW

Dept. FCD-2151, St. Paul 6, Minn.



CIRCLE 154 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961



A NEW CLASS B INSULATION WITH RESILIENT WEAVE AND HIGH DIELECTRIC STRENGTH UNDER STRETCH

Natvar Teraglas is a new flexible insulating material comprising a base fabric, woven from polyester (polyethylene terephthalate, or "Dacron") warp yarns and continuous filament glass filler yarns, coated with an improved varnish, possessing exceptional dielectric strength under elongation. It will withstand Class B (150°C) operating temperatures.

In view of the higher dielectric strength of Natvar Teraglas compared to bias varnished cambric, thinner sections or fewer layers may be used to provide the voltage breakdown protection desired. Consequently, at comparable tape prices, a significant saving may be realized in production costs, while permitting up grading to Class B (150°C) temperatures.

Natvar Teraglas will prove advantageous in many applications—for insulating motors, generators, transformers, cables, switch gear, busbars, and other apparatus and equipment where resiliency and high dielectric strength are desirable.

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147



Defining "Loss" in Wave-Filter Specifications



There are two kinds of power-loss measurements of primary concern in filter work. These are called *Transducer Loss* and *Insertion Loss*. Because of their similarity, they are often used indiscriminately with the result that filter-design specifications are sometimes ambiguous. Much of this confusion can be eliminated when exact meanings of these two terms and differences between them are understood clearly. It is the purpose of this article to tie down meanings of the terms *Transducer Loss* and *Insertion Loss*.

Filters Are Transducers

A transducer is, by definition, any device that can receive energy from one system or systems and deliver it to another system or systems. A wave-filter is a transducer in the field of inductive components since it is capable of being actuated by waves from one or more transmission systems and of supplying related waves to one or more other transmission systems.

Text and derivations that follow make reference to an ideal transducer. While, of course, there is no such thing as an ideal or theoretically perfect transducer, concept of such a device is most useful. An ideal transducer is defined as one that transfers the maximum possible power from source to load without dissipation of power.

Such a hypothetical ideal transducer: (a) dissipates no energy; and (b) when connected between source and load presents to each its conjugate impedance. Conjugate impedances occur when two connected networks have equal resistive components, and reactive components are equal in magnitude but opposite in sign ($R_B = R_L$ and $X_B = -X_L$).

Transducer Loss

Transducer Loss is the ratio of power which an ideal transducer would deliver to a specified load from a specified source to the power delivered from the same source to the same load by the actual transducer.

Transducer loss is determined as follows. Power relationships are derived from the elementary circuit diagrams of Figs. 1(a) and 1(b).

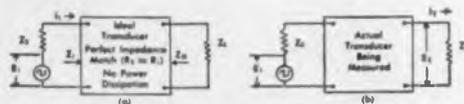


Fig. 1

Transducer Loss in db

$$= 10 \log \frac{(I_1)^2 R_L}{(I_2)^2 R_L} \quad (1)$$

and, since Z_0 and Z_1 are conjugate by definition and $R_0 = R_L$,

$$I_1 = \frac{E_1}{2R_0}, \text{ and } I_2 = \frac{E_2}{Z_t}$$

Substituting and clearing,

Transducer Loss in db

$$= 10 \log \frac{(E_1)^2 Z_t^2}{4(E_2)^2 R_0 R_L} \quad (2)$$

This article considers only the majority of cases where Z_0 and Z_L are purely resistive. Substituting, in such cases, R_0 for its equal, Z_1 in equation (2) gives

Transducer Loss in db

$$= 10 \log \frac{(E_1)^2 R_t}{4(E_2)^2 R_0} \quad (3)$$

Equation (3) is correct even if reactance is present in the load impedance Z_L , provided that R_L represents the equivalent parallel resistance of Z_L .

Insertion Loss

Insertion loss resulting from connecting a transducer into a transmission system is the ratio of power delivered to that part of the system following the transducer, before insertion of the transducer, to power delivered to that same part of the system after insertion of the transducer.

Power relationships for determination of insertion loss are derived from the elementary circuit diagrams of Fig. 2.

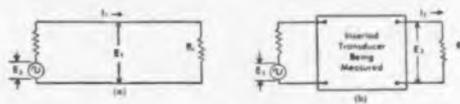


Fig. 2

Insertion Loss in db

$$= 10 \log \frac{(I_1)^2 R_L}{(I_2)^2 R_L} \quad (4)$$

Or, since E_1 and E_2 are proportional to I_1 and I_2 , respectively, equation (4) becomes

Insertion Loss in db

$$= 10 \log \frac{(E_1)^2}{(E_2)^2} = 20 \log \frac{E_1}{E_2} \quad (5)$$

Circuit impedances do not enter into the expression even though they obviously affect the quantities involved and, hence, the numerical result. However, equations do represent a true power ratio under all conditions.

Comparison Between Transducer And Insertion Losses

It is obvious that *Transducer Loss* and *Insertion Loss* are not the same. Both ratios use power delivered to the load through the actual transducer as denominators of the expressions but numerators differ. *Transducer Loss* compares power delivered to the load through an ideal transducer with power delivered to the load through the actual transducer. *Insertion Loss* compares power delivered to the load with the transducer omitted completely from the circuit with power delivered to the load through the actual transducer.

Special note should be made that the value of E_1 in equation (3) and E_2 in equation (5) are NOT equal. With this fact in mind, the two equations can be defined in the same terms by writing E_2 in equation (5) in terms of E_1 in equation (3). This yields the following expression of *Insertion Loss* in terms of *Transducer Loss*:

$$\text{Insertion Loss} = \text{Transducer Loss} + 10 \log \left[\frac{R_L}{R_L + R_0} \right]^2 - 10 \log \left[\frac{R_L}{4R_0} \right] \quad (6)$$

It is now obvious what results from indiscriminate use of the term *Transducer Loss* and *Insertion Loss*. If a filter is required with an insertion loss of 7.5 db but transducer loss is specified, the filter is manufactured with a T. L. of 7.5 db. When measured by the customer it exhibits an insertion loss

of 7.5 db plus a factor of $10 \log \left[\frac{R_L}{R_L + R_0} \right]^2 - 10 \log \left[\frac{R_L}{4R_0} \right]$

which puts it out of specification. It is the purpose of this article to emphasize the fact that *Insertion Loss* and *Transducer Loss* are different. The only time they can be considered to have the same value is the condition under which $R_L = R_0$. That this is true can readily be seen if the reader will refer to equation (6) and observe that the last two terms cancel out. This is the only time *Insertion Loss* Equals *Transducer Loss*.

Reference: IRE Standards on Audio Systems and Components, 36IRE3.51.

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Yellow Springs Instrument Co., Dept. ED, Box 106, Yellow Springs, Ohio.

Price: \$495.

Availability: From dealer stock.

Diode-Shipping Package

424

This diode-shipping package, called Test-Pak, allows the purchaser to test incoming diodes without removing them from the package. It consists of a styro-foam block which encases the diodes and holds the diode leads in a rigid position. A special test jig is furnished with each shipment. Diodes are packed 20 to a package, 5 packages to a box.

Delta Semiconductors, Inc., Dept. ED, 835 Production Place, Newport Beach, Calif.

Summary Network

651

Withstands 100-g shock

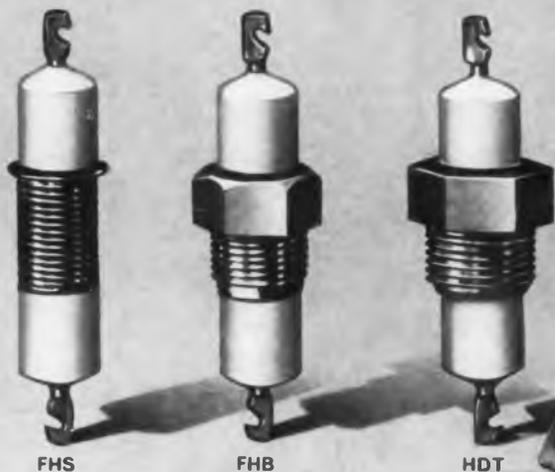


This summary network is in effect a distributed constant delay line and is designed to withstand 100-g shock. It has a total delay time of 1.6 μ sec \pm 0.026 and a tap delay of 0.8 μ sec \pm 0.013. Impedance is 600 ohms \pm 10% and operational temperatures are from -65 to +165 F.

Nytronics, Inc., Essex Electronics Div., Dept. ED, 550 Springfield Ave., Berkeley Heights, N.J.

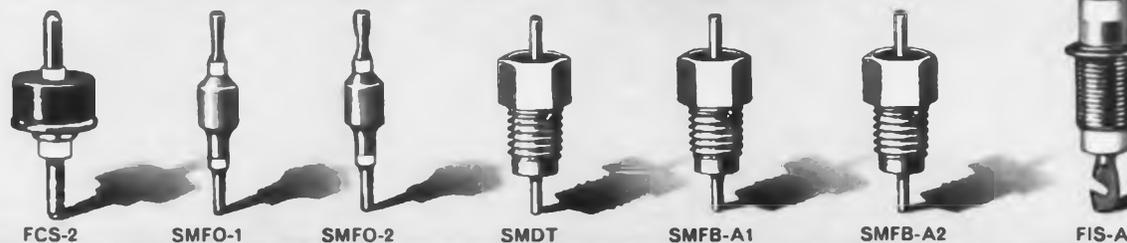
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ELECTRONIC DESIGN • February 15, 1961



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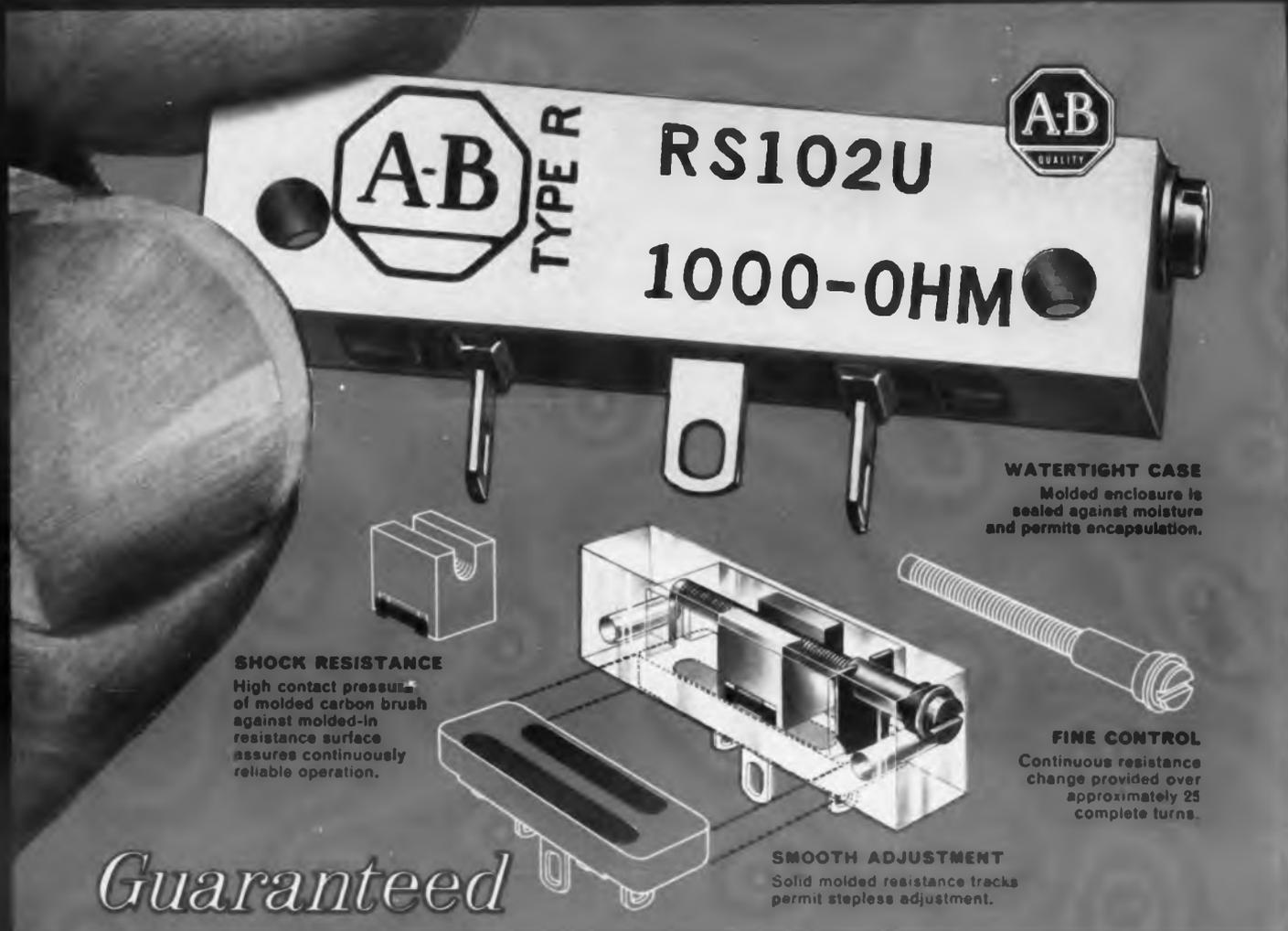
capacitors. Thus, unusual attenuation—75 db and more—is possible in the frequency range from 100 Mcps to 8000 Mcps.

Although designed for low power applications, the Allen-Bradley low pass filters are available in ratings up to 2000 volts and with maximum d-c or low frequency a-c current ratings up to 20 amperes. These miniature filters provide single hole mounting—directly on metal shields. Also, they are usually interchangeable with conventional feed-thru capacitors, but provide far greater suppression of undesired radiation and feedback. Send for Technical Bulletin 5410.

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

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*Test Report #71801, Sept. 1960, United States Testing Company.



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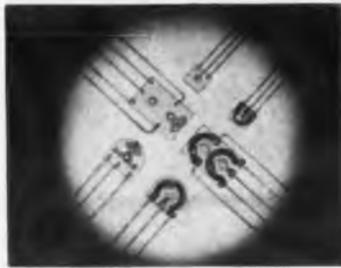
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Centralab Div., Globe-Union, Inc., Dept. ED, 900 E. Keefe Ave., Milwaukee, Wis.

Price: From \$0.25 to \$0.80 ea.

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Atlas Transformer Co., Dept. ED, 1839 Moore St., San Diego 1, Calif.

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Tele-Tronics Corp., Dept. ED, 12786 Western Ave., Garden Grove, Calif.

Price: Model 700, \$1,295; Model 700-S, \$1,495.

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Sage Instruments, Inc., Dept. ED, 9 Bank St., White Plains, N.Y.

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

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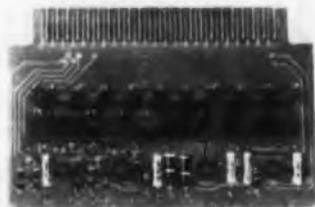
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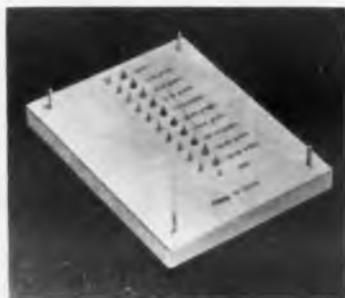
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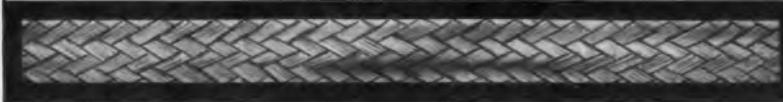


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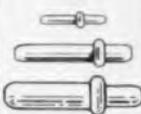
602

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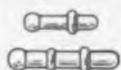
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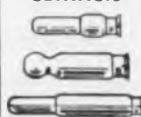
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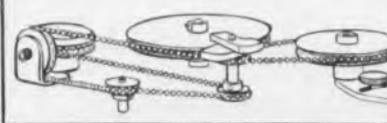
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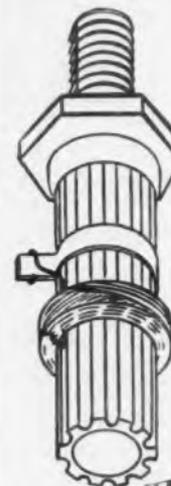
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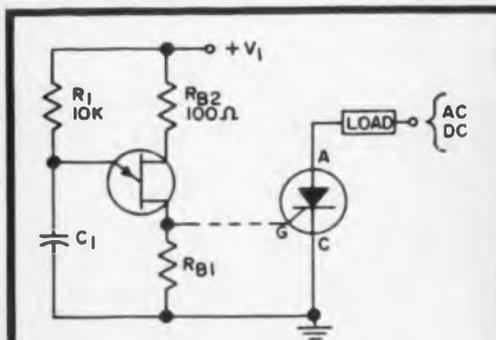
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3 transistors*
1 diode
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1 relay
2 capacitors
8 resistors

Unijunction Circuit Equivalent

1 unijunction transistor
1 Zener diode
1 relay
1 capacitor
4 resistors

SAVINGS: \$3.30 (*germanium transistors)
\$16.50 (*silicon transistors)

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2 capacitors
5 resistors

Unijunction Circuit Equivalent

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1 potentiometer
1 capacitor
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Intrinsic Standoff Ratio (η)	0.47 to 0.62
Interbase Resistance (R_{BB})	4.7K to 9.1K
Peak Point Emitter Current (I_{EP}) ($V_{EB} = 25$ volts)	2N1671A: 25 μ a max. 2N1671B: 6 μ a max.
Emitter Reverse Current (I_{ER}) ($V_{EB} = 30$ volts)	2N1671A: 12 μ a max. 2N1671B: 0.2 μ a max.
Base-One Peak Pulse Voltage	2N1671A, B: 3 volts min.
(In SCR circuit shown, $V_1 = 20V$, $C_1 = 0.2 \mu$ fd, $R_{B1} = 20\Omega$)	

For fast delivery at factory-low prices, call your G-E distributor.

Progress Is Our Most Important Product

GENERAL ELECTRIC

CIRCLE 165 ON READER-SERVICE CARD

NEW PRODUCTS

Selector Switch

625

Solenoid-driven



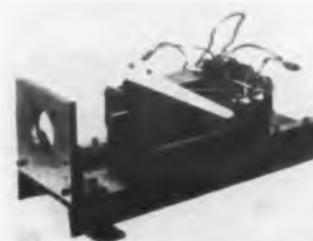
The Pacsol D size rotary solenoid, together with its detent mechanism, measures 1-5/8 in. long. Up to 10 wafers may be stacked on the output shaft, with an additional length of 11/64 in. per wafer. The package has a diameter of less than 1-1/2 in. The solenoid steps 360 deg in 30-deg increments and is single-pulse operated. Power input is 60 w for 10 wafers.

Illinois Tool Works, Licon Div., Dept. ED, 6606 W. Dakin St., Chicago, Ill.

Dynamometer

629

Tests to 20,000 rpm



Called compact, efficient, and reliable, the model No. D-1101 is capable of speeds to 20,000 rpm and loads to 7 hp. A weight scale indicates in.-lb generated by the test motor. Output torque is changed by varying the resistance of the rheostat grids connected to the armature of the generator and by varying the voltage input to the generator field. A power supply capable of 50 v, 20 amp, and a rheostat with a rating up to 4,000 w is required.

Electronic Specialty Co., EEMCO Div., Dept. ED, 4612 W. Jefferson Blvd., Los Angeles 16, Calif.

High Voltage AC Testers

412

Are mobile

These mobile, high-voltage ac testers are available with outputs up to 20 kv at 10 kva and to 30 kv at 5 kva. Output, through a 10-ft shielded cable, is continuously variable from zero to max. A 4-1/2-in. kilovolt-meter assures accurate measurements unaffected by regulation or load varia-

tions. Weight ranges from 150 to 250 lb depending on rating.

Associated Research, Inc., Dept. ED, 3777 W. Belmont Ave., Chicago 18, Ill.

Price: From \$1,000 to \$1,900 per unit.

Availability: 45 to 60 days.

Power Supply

4 amp ac or 3 amp dc



The model 4025 power supply delivers 0 to 150 v ac or 0 to 200 v dc at 4 and 3 amp respectively. The unit has transformer isolation from line voltage, an output impedance of 15 ohms, a recovery time of 30 msec for half-current step changes, and dual 3-1/2-in. meters. It weighs 35 lb and measures 8 in. wide, 9 in. high and 12 in. deep.

Eder Engineering Co., Inc., Dept. ED, 1568 S. First St., Milwaukee 4, Wis.

Price: \$149.95 complete, \$125.38 less meters.

Digital Module

Has 4 flip-flops



This model FF-30 basic flip-flop has 4 identical, independent bistable elements. One set and two reset inputs are provided; each of these is expandable to 10 inputs per side. The unit operates between dc and 1 mc; temperature range is -20 C to 65 C. Not-and logic is used. Measurements are 4-7/8 wide, 9/16 thick, and 7 in. high. Circuits are etched and dip-soldered on glass-epoxy cards.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

Price: \$76.

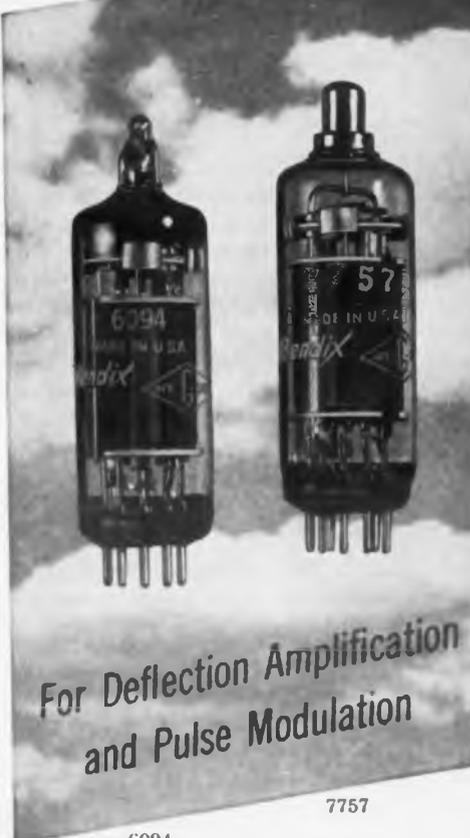
Availability: From stock.

603

601



Bendix Craftsmanship at work for you



For Deflection Amplification
and Pulse Modulation

6094 7757



For Series Regulation
and Pulse Modulation

6384 6889

FOUR SPECIAL BENDIX® TUBES with wide voltage and power capabilities. Bendix miniature tube type 7757 and type 6094, high perveance beam power amplifiers, are designed to operate at high voltages during vibration and shock conditions. They are free from internal arcing in aircraft, military and industrial applications. Tubes 6384 and 6889 also operate at high voltages (up to 3,000 volts on the plate and 1,000 volts on the screen). Their characteristics include high pulse output and closely controlled high-voltage cut-off, ideally suiting them to pulse modulation and high voltage regulation. Write for complete information today.

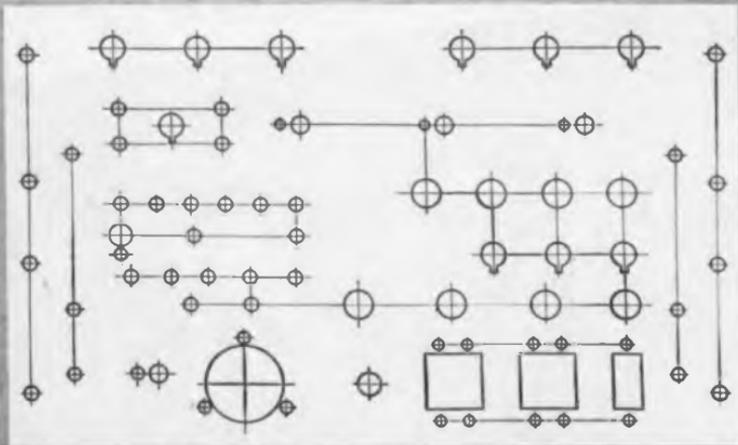
ELECTRON TUBE PRODUCTS

Red Bank Division

EATONTOWN, NEW JERSEY



RAYTHEON PANEL COMPONENTS FIT RIGHT INTO YOUR DESIGNS



for equipment that deserves
the precision-engineered look



PANEL BRACKETS

Provide rigid support under shock or vibration
• Mount single or double panels • Meet military specifications • Cold-rolled carbon steel, cadmium plated.

KNOB LOCKS

Prevent control movement by shock or vibration or accidental movement • No slippage • Replace potentiometer mounting hardware • Match standard Raytheon knobs • Available in Mirror or Matte finish.

SHAFT LOCKS

For use with screwdriver-adjusted controls • Constant friction drag prevents accidental rotation • Provide seal against dirt and moisture • Replace standard mounting hardware • Under knob and standard types available.

CAPTIVE HARDWARE

Stainless steel construction • Wide assortment of matching stock sizes and styles • Meet military specifications • Neoprene gasket provides dirt and moisture seal.

WRITE FOR DATA

Complete technical data and specifications are available on Raytheon's full line of quality panel hardware and control knobs. Please write to: Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Mass.



Raytheon Panel Components Available From Local Franchised
Raytheon Distributors



RAYTHEON COMPANY

Industrial Components Division

CIRCLE 167 ON READER-SERVICE CARD

NEW PRODUCTS

Data Switch

623

Has 2,240 positions



A typical model of this data switch has 40 single-pole switches, each of which can be manually positioned to select one of 56 contacts on glass-fiber laminated printed circuit boards. Modular components permit assembly for manual insertion of data into computers, test equipment, communications networks, process control systems, and other applications. The unit extends 6 in. behind the mounting panel; 12 switches may be arrayed in less than 5 in. of length.

Instrument Systems Corp., Dept. ED, College Point 56, L.I., N.Y.

Diallyl-Phthalate Varnishes

512

Varnishes based on diallyl-phthalate resins have been developed for general coating, sealing, and encapsulation use. Cured Dapon resin coatings are resistant to moisture, chemicals, fungus, weathering and aging over a wide temperature range.

Food Machinery And Chemical Corp., Chemicals & Plastics Div., Dept. ED, Chrysler Bldg. E., 161 E. 42nd St., New York 17, N. Y.

Charging Control

514

For use with 2-rate battery chargers, this automatic charge-control unit switches the rate as required to prevent undercharge or overcharge. State of charge is checked every hour. Shipping weight is 12 lb.

The Electric Storage Battery Co., Exide Industrial Marketing Div., Dept. ED, Rising Sun & Adams Aves., Philadelphia 20, Pa.

Fork Oscillator

588

Length is 2-9/16 in.



The type 25 subminiature fork-oscillating unit is of bi-metal construction, hermetically sealed;

*fabricated
to your exact
specification*



beryllium copper

SPRINGS AND FLAT STAMPINGS

BTI custom built stampings offer the design engineer endless possibilities in beryllium copper parts fabrication. By special processing, intricately formed pieces can be made to precision tolerance and flatness.

Various types of beryllium coppers are available ranging from .002 to .090 inches in thickness. Special designs can include drawing, stamping, punching, slotting, in curved, cupped or angular arrangements. Fixture heat treating guarantees all tempers to spring for long fatigue life.

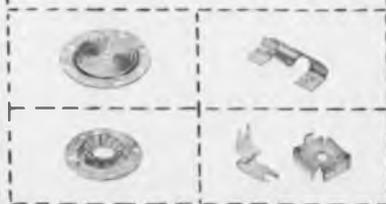
BTI offers universal tooling for maximum cost reductions or special tooling for long run production jobs.

*Write today for Bulletin
No. E 106 describing the
advantages of engineering
with BTI special beryllium
parts and stampings.*



**BRAUN TOOL & INSTRUMENT
COMPANY, INC.**

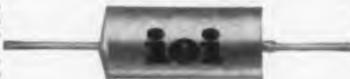
138 Fifth Ave., Hawthorne, N. J.



CIRCLE 168 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

iei TANTALUM SOLIDS



meet or surpass
MIL-C-26655A
requirements

iei Solid Tantalum electrolytic capacitors ("TD" Series) give unwavering stability from subfreezing -80 to broiling +125 C. Also low dissipation factor, low d-c leakage and long life whether in storage or operation.

iei Series "TD" solid tantalum dry slug units, made by specialists in design and manufacture of miniature capacitors, have shock-resistant construction, true hermetic seals and are performance-stabilized for 250 hours before shipment.

iei recommends Series "TD" solids for data processing, ASW, missile and airborne equipment and for all other demanding applications where big reliability and small size are of utmost importance. 0.33 to 330 microfarads, 6 to 35 WVDC. Write for 4-page bulletin 2743.

International Electronic Industries, Inc.
Box 9036-12, Nashville, Tenn.

iei

AN **SPS** COMPANY

where reliability replaces probability

CIRCLE 169 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

diameter is 5/8 in., length 2-9/16 in. Weight is 2 oz. Stock frequencies are 400 and 500 cps. Accuracies of $\pm 0.002\%$ and $\pm 0.02\%$, in temperature ranges from -65 C to 125 C, are available. The type 25T is for use in transistor circuits; type 25V is used with a double triode. Termination is 7-prong miniature base.

American Time Products, Inc., Dept. ED,
61-20 Woodside Ave., Woodside 77, N.Y.

Digital Clock 516

Operating from a 100-kc input, the DC-116 digital clock provides an output in hours, minutes and seconds on a 24-hr basis. A preset pulse may be generated for system control. Output is suitable for driving a high-speed tape punch, and may be either decimal or binary-coded decimal form.

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

Cadmium-Plating Solution 511

A high-purity cadmium fluoborate plating solution, C-576 contains less than 0.00003% silver, and less than 0.00005% copper. The 50% solution is prepared specifically for electronic requirements.

Fisher Scientific Co., Dept. ED, 717 Forbes Ave.,
Pittsburgh 19, Pa.

Price: \$6.80 per pint.

Solder-Type Alloy 513

Said to be 50% more conductive than standard 50-50 lead-tin solder, 157BN alloy has a highly active flux core that is inert after carbonization. It has a low melting point and will accept a wide range of plating.

Eutectic Welding Alloys Corp., Dept. ED, 40-40
172nd St., Flushing 58, N. Y.

Speed-Sensitive Switch 595

Withstands 400 F



The model S-10 speed-sensitive switch has an operating temperature range of -65 to 400 F. Rated performance for the unit is a switching error not to exceed $\pm 1.5\%$ of the rated speed over all environmental conditions. The unit may be supplied with as many as three normally open or closed switches, allowing for up to three speed settings. All moving parts are mounted on precision miniature ball bearings. The 1-lb unit measures 2.437 x 2.437 x 3.65 in.

The Cosmodyne Corp., Dept. ED, 12833
Simms Ave., Hawthorne, Calif.

DRAFTING TRENDS



This is a size comparison between the 10" POST Versalog and its 5" replica, the POST Pocket Versalog.

The trend to "COMPACT" slide rules

Why a small slide rule?

Users of America's best-selling POST Versalog, in the regulation 10" desk size, have been known to covet a 5" POST Pocket Versalog, and even buy one . . . as a more easily carried convenience . . . as a spare . . . or just for the sheer joy of having, like a gun collector, a "matched pair."

It took more than requests from pleased users of the 10" Versalog to convince our marketing people that the need actually existed for a premium-priced 5" pocket rule with 23 scales. Our technical men were even harder to convince that high Versalog standards of accuracy could be maintained in miniature.

Who can use them?

That there is a need has since been proved by the thousands of engineers, architects, scientists, and students who have bought and used a POST Pocket Versalog in preference not only to the larger version, but

after comparing it with other smaller makes.

As to accuracy, we are still amazed at the exquisite job our production team has done in miniaturization—the 5" Pocket Versalog includes every one of the 23 scales found on its much larger counterpart and, in addition, bears engine-divided calibrations of such sharpness and clarity that no magnifier is needed.

Own a Versalog for less

To further popularize this fine instrument, POST dealers are offering it at a special low price for a limited time. All models come with a hand-crafted leather case and spring pocket clip. Also available with hard-bound instruction text.

For further information, ask your POST dealer. Or, for free literature, price data and name of nearest dealer, write to Frederick Post Company, 3644, North Avondale Avenue, Chicago 18, Illinois.



SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

CIRCLE 170 ON READER-SERVICE CARD

■ A production reality based on 20 years of crystal engineering experience...

Miniature Wide Band-Pass Crystal Filters Delivered In Quantity...To Specification

Filters just recently considered as "state of the art" are now a *production* reality. In addition to its many stock narrow band filters, Midland offers prototype and production quantities of practical Miniature Wide Band Filters in the .5 to 30 mc range. These filters are of exceptional quality.

Shown below are specifications for ten of our stock wide band filters, as well as actual characteristic response curves. These filters are actually being delivered to major weapons system manufacturers in quantities — to specification.

THESE ARE NOT LABORATORY CURIOSITIES OR IN PROTOTYPE DEVELOPMENT STAGE

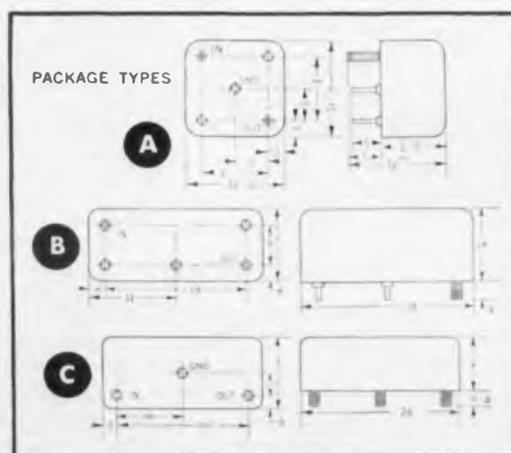
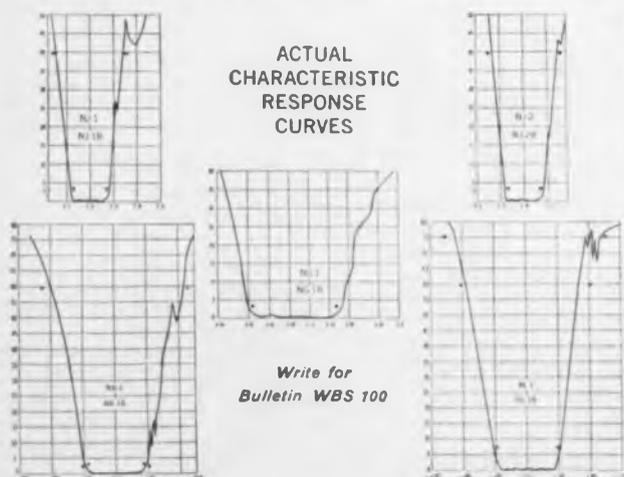
Type	Center Freq.	3db Bandwidth Minimum	40db Bandwidth Max.	60db Bandwidth Max.	75db Bandwidth Max.	Ultimate Discrim. Minimum	Insertion Loss Max.	Impedance ohms	Inband Ripple Max.	Package Type
NJ-1	7.2MC	160KC	300KC			60db	6db	13K	1db	A
NJ-1B	7.2MC	160KC	300KC			60db	6db	13K	.5db	B
NJ-2	7.4MC	160KC	300KC			60db	6db	13K	1db	A
NJ-2B	7.4MC	160KC	300KC			60db	6db	13K	.5db	B
NG-1	5.09MC	160KC	350KC			60db	6db	20K	1db	A
NG-1B	5.09MC	160KC	350KC			60db	6db	20K	1db	B
NB-1	10.7MC	200KC		450KC		75db	12db	50	1db	A
NB-1B	10.7MC	200KC		450KC		85db	8db	50	.5db	B
RL-1	11.5MC	80KC		160KC	200KC	85db	6db	50	.5db	C
RL-1B	11.5MC	80KC		160KC	200KC	90db	5db	50	.5db	B

Operating Temp.: -55°C to +90°C

Shock: 100g

Vibration: 15g to 2KC

Units hermetically sealed



A limited number of opportunities for filter and communications engineers and technicians are available. Write Mr. Robert A. Crawford, Chief Engineer, Filter Division.

Midland

MANUFACTURING COMPANY • 3155 Fiberglas Road, Kansas City 15, Kansas

WORLD'S LARGEST PRODUCERS OF QUARTZ CRYSTALS

DIVISION OF PACIFIC INDUSTRIES, INC.

CIRCLE 171 ON READER-SERVICE CARD

MID 1-61

156

NEW PRODUCTS

DC Power Supplies

593

Current to 15 amp



Providing continuously variable output dc voltages in the 0 to 50 v range from 105 to 125 v single-phase, 48 to 62 cps input, these units are available in two series: Y, having 0.1% regulation, and Z, with 0.01% regulation. In each series there are models with maximum output current ratings of 2, 5, 10, and 15 amp. Stability is $\pm 0.25\%$ and $\pm 0.05\%$, and ripple is 2 mv and 1 mv max, respectively.

Consolidated Avionics Corp., Dept. ED, 800 Shames Drive, Westbury, L.I., N.Y.

Force Gage

A gram and ounce force gage is offered to qualified switch users. It normally sells for \$7.50. Send \$1 with letterhead request stating name and engineering title.

Cherry Electrical Products Corp., Dept. ED, Highland Park, Ill.

Self-Extinguishing Epoxies

515

These epoxy resins, made self-extinguishing through substitution of bromine on the epoxy molecule, may be cured or hardened with the common curing agents. Resin X-3442 is a semi-solid with about 49% bromine; X-3441.1, a solid, contains about 19% bromine.

Dow Chemical Co., Dept. ED, Midland, Mich.
Price: \$1.00 to \$2.01 per lb.

Crowbar Tube

598

Rated to 3 kv



This subminiature cold cathode trigger tube, designed for crowbar operation, is rated from 350 to 3,000 v dc on the anode, with a hold-off voltage of 3,500 v dc. The WC-28 has a peak cathode rating of 10 to 1,000 amp; grid pulse amplitude is 230 v for 10 μ sec max.

Electronic Industries, Inc., Dept. ED, 18 Marshall St., South Norwalk, Conn.

Availability: 10-day delivery.

Mechanical Filters

For fm mobile radio



A mechanical filter designed for mobile radio equipment, the F455YA-120 has a 455-ke center frequency and a passband of 12 ke to match a ± 5 -ke transmitter deviation. Another filter, the F455YA-320, with a 455-ke center frequency and a 32-ke passband, is suited for wide-band mobile equipment applications.

Collins Radio Co., Western Div., Dept. ED, 2700 W. Olive Ave., Burbank, Calif.

Potted Switch Leads

519

The Milli-Switch line is now available with potted leads. They are intended to provide a strong, positive joint with low-temperature solder. All basic switches in the line conform to MIL-S-6743.

P. R. Mallory & Co. Inc., Milli-Switch Corp., Dept. ED, Gladwyne, Pa.

Indicator Light

520

The L16,200 indicator light has a watertight lens available in 7 colors. Case is anodized aluminum; the 6-, 14- or 28-v lamp may be replaced from the front of the panel.

Controls Co. of America, Control Switch Div., Dept. ED, Folcroft, Pa.

Storage Drum

With 4 channels

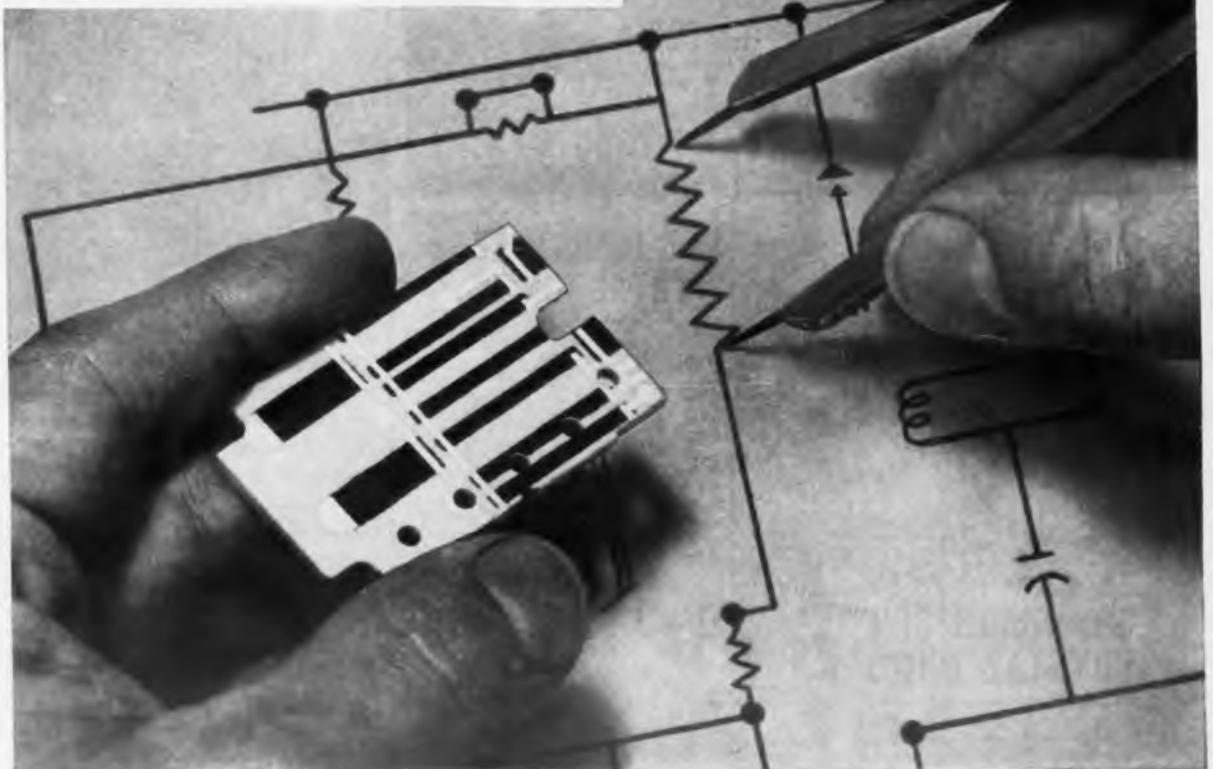


A typical model of this magnetic storage drum has 4 channels, 2 of which provide adjustable delays of up to 6 sec accommodating either complex waves or pulses. The unit uses a synchronous drive motor and hydraulically-damped gear box. Delay variation may be accomplished manually or through servo control. It may be supplied in a variety of frequency responses, delay adjustments, head configurations and number of recording tracks.

Instrument Systems Corp., Dept. ED, College Point 56, L.I., N.Y.

591

Resistor shown was fitted into the space available on this printed circuit simply by varying the blend of Du Pont's new Resistor Compositions. Conventional resistors would require redesign of circuit and more space.



Du Pont announces—New Resistor Compositions that permit varied resistance values without changing geometric form ... simplify design, save space

Now, new Du Pont Resistor Compositions offer a second dimension for controlling resistance. You can vary resistance values by changing the composition of the resistor without the need for altering the geometric form. These new resistor compositions give you greater design flexibility, essential for miniaturized circuits. Du Pont Resistor Compositions are available at three approximate resistance values: 500, 3,500 and 10,000 ohms/square per mil thickness, and they can be blended to give a range of intermediate values.

Du Pont Resistor Compositions are easy to apply ... may be brushed, dipped, screen-printed or sprayed. Surfaces can be fired under normal atmospheric conditions in the 1100-1400°F. range.

Printed resistor patterns and coated rods have abrasion and impact resistance similar to fired silver coatings and show only small variations in resistivity under humidity, overload, tem-

perature and voltage conditions as typical laboratory data show:

Temperature coefficient ± 350 ppm./°C. from -55°C. to +125°C.
Voltage coefficient Less than .02%/volt, negative
Humidity exposure $\pm 1\%$ change after 250 hr. @ 95% relative humidity
Overload $\pm 0.5\%$ change with standard short-time overload
Temperature cycling $\pm 1\%$ change after 5 cyclings from -55°C. to +125°C.
Load life $\pm 2\%$ change after 1,000 hr. at 70°C. at full load

Fired samples are available for your own evaluation. Request them on your letterhead, indicating application you have in mind. Complete technical information will also be sent. Write: Du Pont, Electrochemicals Dept., Ceramic Products Div., Wilmington 98, Delaware. Du Pont does not manufacture resistors ... produces only resistor compositions and other high-quality conductive coatings: gold, silver, platinum and palladium.

DU PONT RESISTOR COMPOSITIONS



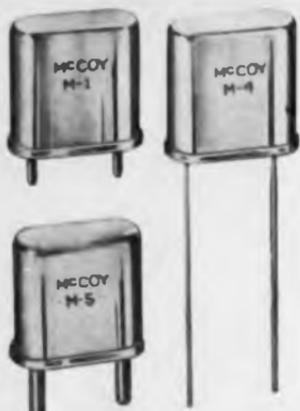
BETTER THINGS FOR BETTER LIVING... THROUGH CHEMISTRY

CIRCLE 172 ON READER-SERVICE CARD

McCoy

a synonym for quality,
stability, and dependability in

CRYSTALS and CRYSTAL FILTERS

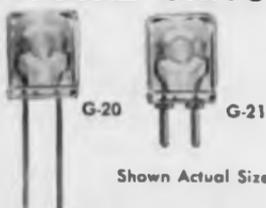


STANDARD SIZE CRYSTAL UNITS

The crystals that made the name of McCoy a synonym for quality. Metal encased, the M-1, M-4, and M-5 are available in frequencies from 500.0 kc to 200,000 mc.

Shown Actual Size

ALL-GLASS CRYSTAL UNITS



Shown Actual Size

HC-18/U type. Meet new CR-73/U and CR-74/U specs. Available 5000 kc to 200.0 mc.

SUB-MINIATURE CRYSTAL UNITS

Fill the need for miniature crystals from 1.0 mc to 200.0 mc. Meet specs MIL-C-3098B and ARINC No. 401



Shown Actual Size

CRYSTAL FILTERS

Band pass types from 1.0 mc to 30.0 mc center frequency with 6 db band widths of 0.01% to 4.0% of center frequency. Single side band types from 1.0 mc to 20.0 mc frequency with 3 db band-widths from 1.0 kc to 10.0 kc.



Write for free, illustrated catalog



Regardless of size, weight, or shape, McCoy crystals and filters will deliver the utmost in stability under extreme conditions of shock and vibration. Our research section will be pleased to assist you.

McCoy

ELECTRONICS CO.
Dept. ED-2,
MT. HOLLY SPRINGS, PA.
Phone: HUNter 6-3411

CIRCLE 173 ON READER-SERVICE CARD

NEW PRODUCTS

DC Motor

622

Weights 4.7 lb



Weighing 4.7 lb with radio noise filter, the model 2030 dc motor produces 0.33 hp at 14,000 rpm, continuous duty, and 0.62 hp at 8,750 rpm, intermittent duty. The 26-v dc unit is 7.48 in. long by 2.44 in. wide. An integral clutch-brake provides fast stopping and irreversibility in power-off condition, and holds 3 in.-lb torque with the motor de-energized. The square-frame motor is rated to 260 F, altitude to 150,000 ft.

Hoover Electric Co., Dept. ED, Hangar #2, Port Columbus, Columbus 19, Ohio.

Printed-Circuit Kit

518

Each printed-circuit kit contains enough copper-clad board, liquid etchant, etch-resistant terminal pads, and resistant tape to make 3 circuit boards. An etchant tray is provided with the Quik-Cirkit.

Advanced Designs Inc., Dept. ED, 914 Lullaby Lane, South Vienna, Va.

Price: \$5 per kit.

Availability: Immediate.

Transfer Function Analyzer

744

Range is 0.01 to 200 cps



A transfer function analyzer, for frequency response measurements, the model 711 has a range of 0.01 to 200 cps. Noise rejection is 40 db; accuracy is 0.25 db or 2 deg. The data are presented as in-phase and quadrature components, as well as amplitude and phase vs frequency.

Boonshaft and Fuchs Inc., Dept. ED, Hathoro Industrial Park, Hathoro, Pa.

Price: \$4,855.

very big in BWOs

Eight years ago, the first commercial backward wave oscillator took shape in the patient hands of wave tube pioneer Ray Stewart. With meticulous care and consummate skill, he evolved a precision lens system for forming a hollow electron beam, and developed techniques for producing a fantastically accurate helix pitch and placement relative to the beam.

The result was an oscillator of truly exceptional characteristics. But because Ray Stewart will never be satisfied with the merely exceptional, each BWO he builds . . . and he has built thousands . . . is better than the one before it.

This is the reason why Ray's BWOs can be guaranteed for 500 hours, and why they consistently outlive their guarantees. Ray's company is the only electron tube manufacturer devoted exclusively to the production of backward wave oscillators. The tube shown here is one of a series covering the frequency range 1-18 kmc.



Write for the new Stewart Engineering brochure and a set of specification sheets. When you've found out about the low operating costs of Stewart BWOs, we promise you'll be very big with your company's treasurer.

**STEWART
ENGINEERING
CORPORATION**



SANTA CRUZ · CALIF.

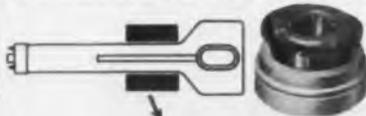
CIRCLE 174 ON READER-SERVICE CARD
ELECTRONIC DESIGN • February 15, 1961



a **spot** is a **spot**
is a high
resolution **spot**
with

CELCO YOKES

- **Celco YOKES**
keep spots **smallest**
- **Celco YOKES**
keep spots **roundest**
- **Celco YOKES**
keep spots **sharpest**



Use a **CELCO DEFLECTION YOKE** for your high resolution applications.

In a **DISPLAY SPOT?** call **Celco!**

Celco

*Constantine Engineering
Laboratories Co.*

Main Plant: MAHWAN, N. J. DAvis 7-1123

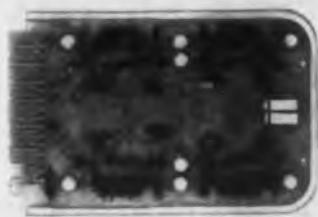
• Pacific Division - Cucamonga, Calif. - YUkon 2-2688

CIRCLE 175 ON READER-SERVICE CARD
ELECTRONIC DESIGN • February 15, 1961

Shift Register

740

Rate is 1 mc



One of the series S group of 1-mc plug-in digital modules, the SR-30 is a prewired, four-stage shift register which can operate at any rate up to 1 mc. It is designed to operate in all modes. Set and reset inputs are provided for parallel loading of information; a common reset input is included for simultaneous clearing of all stages.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

Price: \$96.

Availability: Delivery from stock.

Neon Indicator Light

517

The L15,100 neon indicator light has a built-in 62-K resistor. It is rated at 0.001 amp, 115 v ac, and weighs 0.020 lb. The light has front or rear panel mounting, 3-lens colors, and an MS 25252 NE20 lamp.

Controls Co. of America, Control Switch Div., Dept. ED, Folcroft, Pa.

Miniature Accelerometer

746

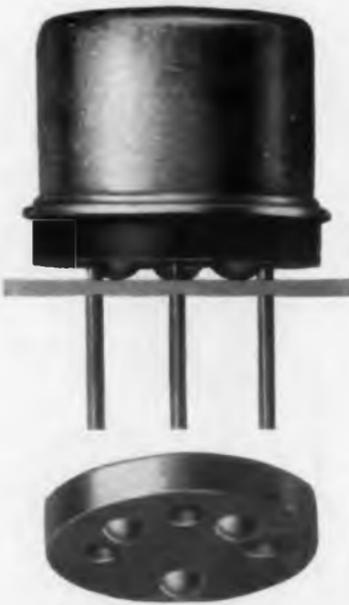
Has less than 0.75% error



Designed to measure accelerations parallel to mounting surfaces, the type 4-203 strain gage accelerometer has combined linearity and hysteresis error of less than 0.75% of full range. Cross-axis sensitivity is less than 0.01 g per g. Operating temperature range is -70 to 300 F. Damping is 0.7 ± 0.1 of critical at 77 F. The gage is made in ranges from ± 5 g to ± 500 g.

Bell & Howell Co., Consolidated Electro-dynamics Corp., Dept. ED, 360 Sierra Madre Villa, Pasadena, Calif.

FIRM FOOTING



FOR TRANSISTORS

Transipads put a little extra security into printed-circuit assemblies. For a cost you count in pennies. A Transipad mounting is rock solid. It eliminates strain on delicate leads, provides vibration-proof separation between them. It isolates the transistor case from contact with printed conductors. And, perhaps most important, it provides a built-in air space to dissipate the heat of soldering (how many transistors have you lost lately through heat shock?). Transipads come in sizes and styles to fit most transistor types; some will convert lead arrangements from in-line to pin-circle, or vice-versa; others will widen lead spacing. Samples and drawings are yours for the asking. A note or a phone call will bring them.



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Switching Transistors and Diodes

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2SC89
2SC90
2SC91

Hitachi semi-conductors provide the basis for the excellent capacity of the Hitachi Electronic Computer HITAC 103.

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Back of HITAC 103.

 **Hitachi, Ltd.**

Tokyo Japan

Cable Address: "HITACHY" TOKYO

NEW PRODUCTS

Photo Transducer

356

For shaft angle



This photo transducer incrementally converts shaft angle to digital measurement information. Maximum speed varies from 15,000 rpm at 128 counts per revolution to 1,250 rpm at 2,048 counts. It provides sampling rates up to 45,000 counts per sec. Output is 12 v at 1 ma; maximum operating temperature is 55 C. The 19-oz unit is 4.68 in. long over-all, with OD from 2.75 to 3.5 in.

Hydro-Aire Co., Electronics Div., Dept. ED,
3000 Winona Ave., Burbank, Calif.

Pulse-Train Modules

748

For step-servo control



These pulse-train generating modules are designed to act as pulse sources for step-servo motors and controllers. Ten versions of model A502 are made in five pulse ranges, from 4 to 16 up to 65 to 300 pulses per sec, and two temperature ranges, -55 C to 70 C and to 125 C. The 2-oz units operate on 28 ± 5 v dc.

Automation Development Corp., Dept. ED,
11824 W. Jefferson Blvd., Culver City, Calif.

Price: \$99 ea, 70 C; \$164 ea, 125 C.

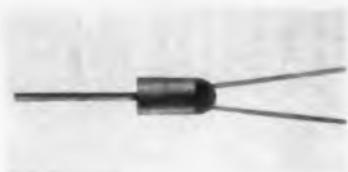
Availability: Stock to 30 days.

Accuracy Is Our Policy . . .

The photograph, accompanying the New Products description of an indicator light made by Control Switch Div. of Controls Co. of America, on page 52 of ELECTRONIC DESIGN's Jan. 18 issue, does not show the light described.

Microminiature Thermocouples 749

Probe OD is 0.014 in.



The HT microminiature thermocouple is made for use in the range from cryogenic environments to +3,000 F. The probe measures 0.014 in. in diameter, with several sheath materials and lengths. A response time of 13 msec has been achieved.

Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., Dept. ED, 42 4th Ave., Waltham 54, Mass.

Solid-State Chopper 354

Range is 5 to 50 kc



Model C-3001 is a solid-state and magnetic system, which provides the equivalent of a chopper and an input transformer. Drive or carrier frequency is nominally 15 to 20 kc; range is 5 kc min, 50 kc max. Common-mode rejection is in excess of 120 db. Typical drift will not exceed 10 μ v over 24 hr.

James Electronics Inc., Dept. ED, 4050 N. Rockwell St., Chicago 18, Ill.

Ventilating Unit 734

Delivers 350 cfm



Model KP701, 19-in. rack-mounting ventilating unit delivers 350 cfm of filtered air from twin blowers. It uses 7 in. of panel space. The unit is powered by a permanent split-capacitor motor. The motor is rated at 1.3 amp.

Kooltronic Fan Co., Dept. ED, P.O. Box 504, Princeton, N.J.



Slip Rings?

To provide excellent electrical properties and long equipment life for slip rings, we manufacture and supply fine and coin silver in the form, size, finish and degree of hardness most convenient for the manufacturer and least productive of scrap.

Photo courtesy of Breeze Corporations, Inc., Union, New Jersey



Adjustable Contacts?

The Handy & Harman Bimet shown here is used as an adjustable contact in a Rimset thermostat for control of residential heating, cooling and air conditioning. It is made of fine silver for optimum conductivity and reliability, and clad with bronze to give a more machinable, easily threaded surface. Handy & Harman bimetal give you uniformly clad precious metal just where you need it, with no excess. Available in gold and silver and their alloys in strip, overlays, inlays, edge lays and thru-lays.

Photo courtesy of Penn Controls, Inc., Goshen, Indiana



Rotary Switches?

Low contact resistance and ability to withstand corrosion make silver ideal for switch parts. The stationary contacts of this rotary switch are made of fine silver...the multiple leaf brushes are of durable silver alloy. Life tests of one million operations, representing several years of normal use, show that "Zero" resistance of 0.001 ohm through the switch body changes by less than 0.0005 ohm.

Photo courtesy of Leeds & Northrup Company, Philadelphia, Pa.

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HANDY & HARMAN CAN HELP YOU DO IT

Gold and silver...and their alloys...possess a combination of characteristics that offers unique advantages to the electronics and electrical industries. Their excellent electrical and thermal conductivity makes them ideal for a vast range of applications, particularly in subminiature components. Their ability to resist corrosion imparts long service life and dependability to critical control items. The fact, too, that they can be obtained in so many convenient forms...wire, strip, sheet, powder, bimetal, flakes and plating anodes...lends them unusual versatility.

These are only a few examples of the ways in which Handy & Harman precious metals are used in the electronics and electrical fields. Perhaps they will suggest some ideas to help you apply them advantageously in your own products or operations. Our technical staff invites your inquiries. No obligation.

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NEW **M**ethode "FORK" CONTACTS

completely interchangeable with
available types
with FULL RADIUSED CONTACTS
for smoother mating

IMMEDIATE DELIVERY!

Available in three different styles: for mounting upright printed circuit panel, parallel to printed circuit panel or for 45 angular mating. Fabricated from spring tempered phosphor bronze, finished with gold plating.



Microphotographic
view of Methode
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Available in bulk or on disposable plastic strips to users of specified dimensions for easy mounting.



Enlarged view

Applications are limitless as determined by your design, ingenuity and needs. We invite your inquiry.

SAMPLES and detailed literature are available



7447 W. Wilson Ave. • Chicago 31, Ill.

CIRCLE 179 ON READER-SERVICE CARD

NEW PRODUCTS

Dielectric Strength Tester Is corona-free

351



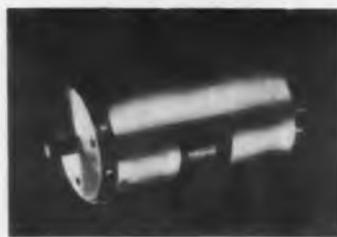
Special construction is embodied in the model 4303 dielectric strength tester to eliminate creation of corona discharge. All high-voltage components are immersed in an oil-filled tank. Ratings are 20, 30, and 35 kv. Corona pick-up network and corona detector are accessories.

Associated Research, Inc., Dept. ED, 3777 W. Belmont Ave., Chicago 18, Ill.

AC Potentiometer

10-turn type

747



The 7800 series of 10-turn precision potentiometers is designed for ac circuits. The units are 2-in. in diameter. They have high input impedance and low output impedance, thereby substantially reducing quadrature and loading effects. Standard model 7803 has an impedance range of 1 K to 200 K and covers a frequency range of 400 to 1,000 cps.

Beckman Instruments, Inc., Helipot Div., Dept. ED, 2500 Harbor Blvd., Fullerton, Calif.

Pulse Transformer

Is encapsulated

731



This pulse transformer operates in a blocking oscillator circuit and includes the use of a high-quality ceramic ferrite cup core. Its rugged encapsulated construction enables its use in salt atmosphere marine applications.

Lockheed Electronics Co., Avionics and In-

Application data on

counting tubes

and counting tube circuits



DEKATRON GC10D
Cold cathode glow tube
for totalizing, sorting,
programming, special
computing and control
circuits. One of four
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From the blueprint or sketch to the finished injection molded parts or products, Swenson offers highly skilled, creative, imaginative design and engineering assistance. A complete program of quality control, in conjunction with our continual research into new materials and production methods, assures you of top quality moldings.

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ELECTRONIC DESIGN • February 15, 1961



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dustrial Products Div., Dept. ED, 6201 E. Randolph St., Los Angeles 22, Calif.

DC Power Supplies

353

Output 0 to 25 v



The model TR-30-100, a transistorized, voltage-regulated dc variable power supply, provides 0 to 25 v dc from input of 105 to 125 v, 50 to 60 cps. Output current is 0 to 100 ma; regulation is 0.5%, line and load. Ripple is 0.1% or 25 mv max. The supply plugs into an octal socket. Weight is 2 lb 2 oz; dimensions are 3-1/4 x 3-3/8 x 4-1/4-in. high.

Acopian Technical Co., Dept. ED, 927 Spruce St., Easton, Pa.

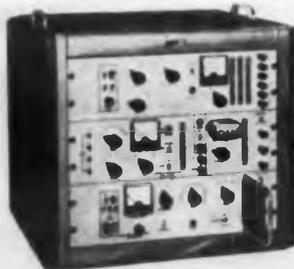
Price: \$50.

Availability: Delivery from stock.

Module Testers

738

For digital elements



Developed for testing the 1-mc T-Pac series of digital modules, these test units check all standard characteristics and functions. Model LET-10 tests the logical element package and provides some signals for FST-10, which checks static flip-flop, thyatron driver, synchronous generator, and serial memory, and for the MPT-11, which tests sense amplifier, inhibit driver, and selector switch magnetic core memory packages.

Computer Control Co., Dept. ED, 983 Concord St., Framingham, Mass.

Price: \$7,269 for the 3 units in metal cabinet.

Availability: 120-day delivery.

**NEW
Midget Rotary
Tap Switch**



**Grayhill
Series 45**

ACTUAL SIZE

— meets most environmental requirements
per MIL-E-5272 and MIL-S-3786

COMPLETELY NEW — A real midget — genuine Grayhill quality. Conservatively rated to break one ampere at 115 VAC, resistive circuit, and to carry 5 amperes — life expectancy 100,000 cycles. Single deck, single pole, shorting or non-shorting, totally enclosed — provided with 2 to 6 positions (stop standard on 2 to 5 positions) and 6 positions normally supplied as continuous rotation. The Series 45 incorporates 60° indexing with a stop strength of 10 pound inches, and a rotational torque of approximately 12 ounce inches.

Complete specifications and prices available on request.

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GRAYHILL**



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Grayhill offers a full line of Rotary Tap Switches, Push Button Switches, Test Clips, Binding Posts, and other miniature electrical and electronic components. Ask for current catalog

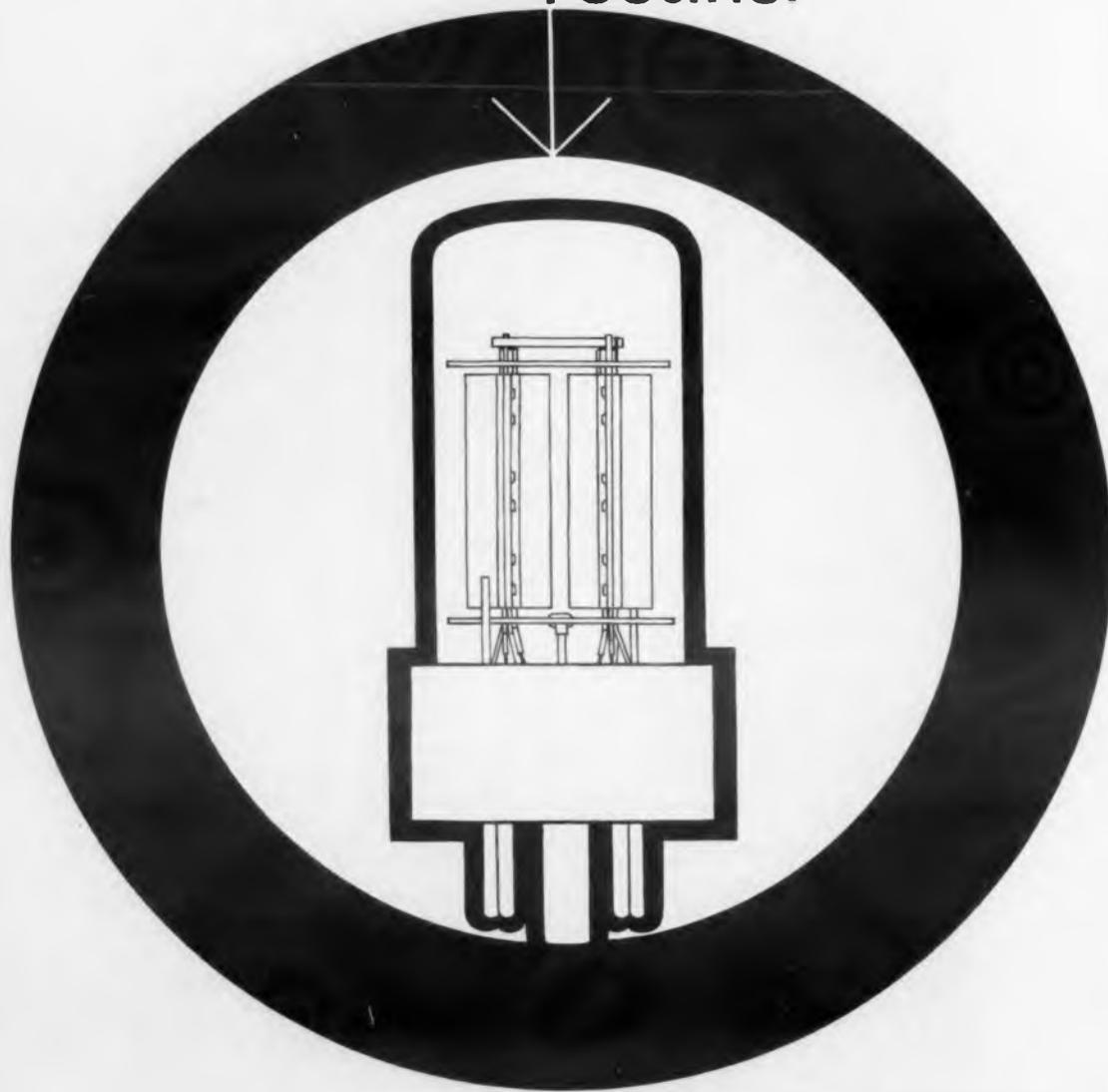
Grayhill
1961

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GZ34 5AR4

full-wave
rectifier



Indirectly heated full-wave rectifier primarily intended for use in a.c. mains operated equipment.

Maximum design centre ratings				
P.I.V. max.			1.5 kV	
$I_{a(pk)}$ max.			750 mA	
C max.			60 μ F	
Capacitor Input				
$V_{a(50Hz)}$	2 x 450	2 x 500	2 x 550	V
I_{out} max.	250	200	160	mA
R_{lim} min. (per anode)	125	150	175	Ω

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NEW PRODUCTS

Heat Radiators

745

For high wattage



Designed for transistors and diodes where 200-w or more dissipation is needed, the 4AL series heat radiators also function as a chassis. With very low thermal resistance and high radiation capability, efficiency approaches that of an infinite heat sink. Width is 4-1/2 in., length up to 12 ft in 1/2 in. increments. Height is 1.03 in.

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

DC Motor

750

Battery-operated



A 1-in. diam, battery-powered dc motor, the HYQM operates from 4.5 to 30 v dc. Governed versions are made, with speeds from 1,500 to 5,000 rpm; the ungoverned motor has a torque of 0.5 oz-in. at 10,700 rpm. Efficiency is 57%; stall torque is 2.3 oz-in. Rotation may be clockwise or counter-clockwise. Motors are rated to 200 F.

Barber-Colman Co., Dept. ED, Rockford, Ill.

Ultrasonic Cleaner

719

Console type



These console-type ultrasonic cleaners are available with one, two and three chambers. All

MEV105

ELECTRONIC DESIGN • February 15, 1961

controls are mounted on the sloping front panel. Working cabinet height is 30 or 36 in. Each type of unit is available in six sizes from 2- to 13-gal-lon capacities. Optional accessories include: 0- to 60-min timer; automatic-reset timer; line-voltage switch and meter for varying line-voltage compensation.

National Ultrasonic Corp., Dept. ED, 111 Montgomery Ave., Irvington, N.J.
Price: From \$895 to \$3,000.

Synchro-Receiver

718

Locks in position



Type 9614-02 synchro-receiver has an integral brake which closes to lock the receiver in position. The receiver may then act as a transmitter. The receiver is a 26-v, 400-cps synchro with 1.5-deg accuracy; the brake solenoid is 35 or 115-v dc. Damping time is 2 sec. The unit is 2-3 16-in. long x 1-1 16 in. in diameter.

John Oster Manufacturing Co., Avionic Div., Dept. ED, Racine, Wis.
Availability: 60 to 90 days.

DC Power Supplies

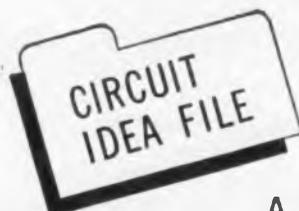
355

Transistor-regulated



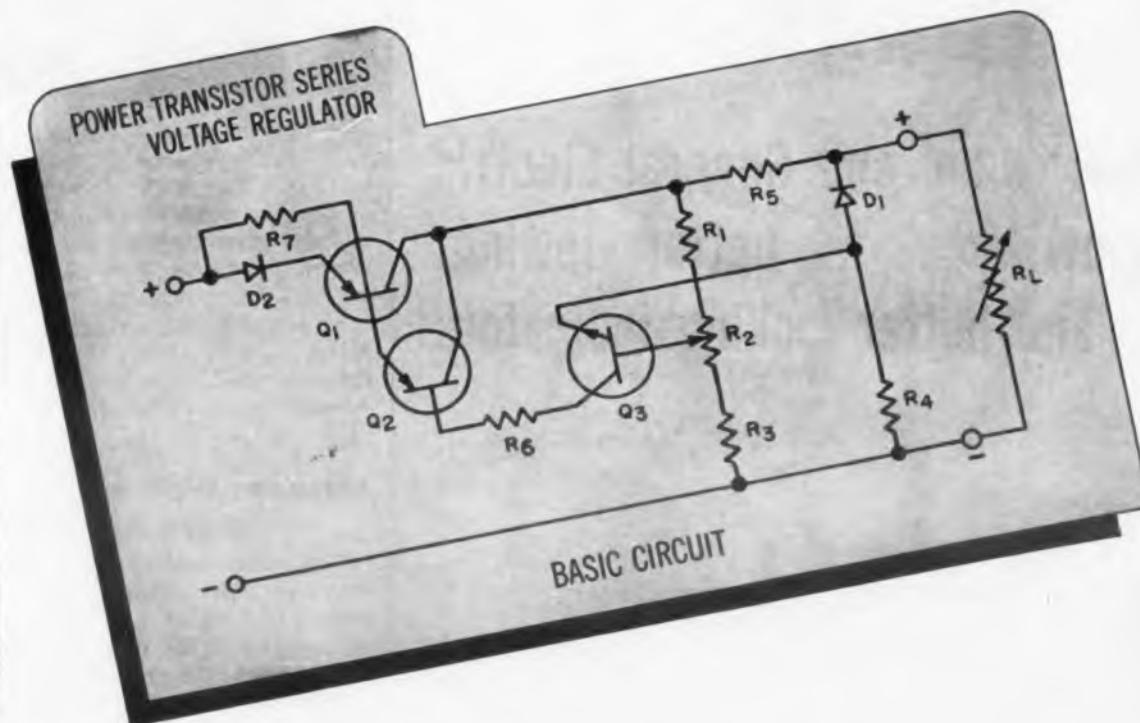
The all-silicon model 322 delivers 20 v dc from 115-v, 400-cps input. Output is adjustable over a 10% range. Rated output current is 50 ma; ripple is less than 2 mv rms. Regulation is better than 0.1% from full load to 50% load. The 1-lb supply operates at ambient temperatures from 0 to 65 C. The similar model 269 delivers 250 v dc at 250 ma. Ripple is less than 15 mv rms; regulation is better than 0.4% from full load to 50% load, over a 20% line voltage change. Weight is 4 lb.

Hycon Manufacturing Co., Dept. ED, 1030 S. Arroyo Parkway, Pasadena, Calif.
Availability: From stock.



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New Transistor Applications



Does your regulated power supply burn out when short-circuited? If so, Honeywell's improved high current voltage regulation circuitry can help you. Check these basic circuit features:

- Short-circuit protection up to 60°C.
- 1% regulation at 21 volts output from 0 to 3 amperes load current.
- Output impedance of less than 0.07 ohm.
- Open circuit regulation at high temperatures with no power-wasting bleeder.

- Circuit simplicity.
- Versatility. The basic circuit can be easily adapted to operate at higher load currents over wide output voltage ranges or over wider temperature ranges.

For a complete description of the features, theory of operation and adaptations of this circuit—plus circuit design procedures—send for Application Note ANIC. Simply fill out and return the coupon below to: Honeywell, Dept. ED-2-52, Minneapolis 8, Minnesota.

COMPONENTS

Q ₁ —Honeywell 3N49	R ₁ —180 ohm
Q ₂ —Honeywell 2N1263	R ₂ —100 ohm
Q ₃ —2N169A	R ₃ —390 ohm
D ₁ —Voltage Reference Diode (1N763 or equivalent)	R ₄ —4700 ohm
D ₂ —3 ampere Silicon Diode (1N1581 or equivalent)	R ₅ —0.02 ohm
	R ₆ —3300 ohm
	R ₇ —20-50 ohm
	R _L —Load

Honeywell

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SINCE 1885

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- Please send me your Application Note ANIC detailing a Series Voltage Regulator.
- Please have a Honeywell field engineer call on me at my convenience.

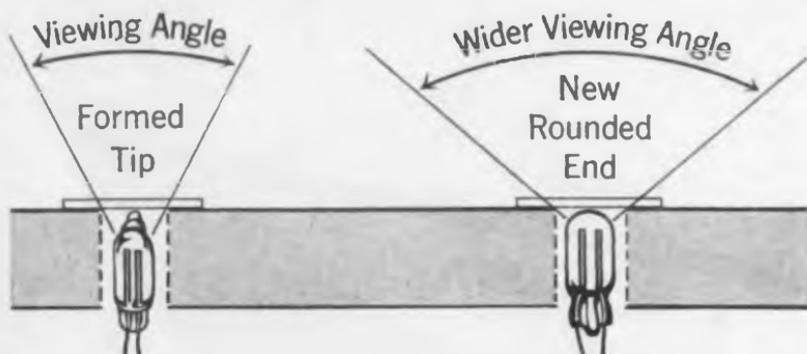
Name _____
Address _____
Company _____
City _____ State _____

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ROUND-END



New round end General Electric glow lamps for better viewing ... and better looking indicators!



New shape of the Round End Glow Lamp brings its electrodes nearer to the end of the bulb—giving it a much wider viewing angle when flush mounted (see illustration above). And if the Round End Glow Lamp is placed beneath translucent material, the lighted area has a more uniform appearance.

The rounded end of clear-glass gives a distortion-free light when viewed end-on from any angle. Because of its smooth round end, this lamp can be used as a protruding element, thus improving the appearance of the panel.



New General Electric NE-2M (for standard brightness) and NE-2P (for high brightness)

Glow Lamps are more thoroughly described in the engineering data sheet, #3-9289. For your free copy, write: General Electric Company, Miniature Lamp Department M-112, Nela Park, Cleveland 12, Ohio.

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GENERAL  ELECTRIC

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PRODUCTION PRODUCTS

Imprinting Machine

261

Marks 3,000 parts per hour



Components without leads, with axial or radial leads, or with axial leads at one end, in diameters between 1/8 in. and 1/2 in. can be imprinted at rates up to 3,000 per hour by the model PAF-AG offset machine. The imprints, made by master plates with quick-change type inserts, may be 2-7/8 in. long x 1-5/8 in.

Markem Machine Co., Dept. ED, Keene 55, N.H.

Price: From \$2,500 to \$3,500.

Availability: 45 to 60 days.

Automatic-Welding System

262

Operates on 115 or 120 v

This unit assembles and welds up to 300 sub-miniature electronic components per min. It can be used with any of the firm's ac or dc standard power supplies. The system measures 48 x 36 x 48 in., plus the power supply console.

Raytheon Co., Apparatus & Systems Div., Dept. ED, 1415 Providence Turnpike, Norwood, Mass.

Commutator-Connector

263

Triples manual output

This commutator connecting machine, for fractional hp motors, can turn out 65 motors per hr on No. 32 bar stock as compared to the manual output of 20 per hr. An unskilled worker can operate the machine, which performs a complete wire-insertion operation in 1/3 sec.

Joyal Products Co., Warner Equipment Co., Dept. ED, 250 McWhorter St., Newark, N.J.

Soldering Machine

264

Solder capacity is 320 lb

This printed-circuit soldering machine has a solder capacity of 320 lb. Dual solder-waves lift solder up to the board or object to be soldered.

WOULD 30 DAY DELIVERY HELP? Then call Helipot. We'll deliver BECKMAN® Panel Meters... in a variety of styles, shapes and models... within 30 days after receipt of your order. Specials may take 45 days.

Fact is, quick delivery and customer service go along with every BECKMAN meter... voltmeters, ammeters, milliammeters, and microammeters... in sizes ranging from 2½" to 4½".

Best of all, they are excellent meters... and we can prove it! A Certified Test Report (which you may have for the asking) gives details of rigidly controlled tests conducted to find out just how good our meters are. In all cases, units tested met or exceeded MIL-M-10304A. Like we said: they are excellent meters.

Clearly, if you need panel meters, call Helipot. Delivery is dependable, quality is excellent, and the price is right. The other things we could say in favor of these meters are contained in the latest meter Data File. Send for it: your meter problems will be solved.



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MU 4-0940

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ELECTRONIC DESIGN • February 15, 1961

Wave length is 10 in. Maximum width of solder touching the board at one time is 1-1/2 in. Power requirement of pot is 5,100 w; requirement of motors is 110 v, 2.2 amp. The machine can be furnished with a 220-v (1- or 3-phase), 440- or 550-v pot.

Dee Electric Co., Dept. ED, 1101 N. Paulina St., Chicago 22, Ill.

Price: \$2,175 ea.

Availability: 20 days.

Orienting Table

265

Accurate to 1 min of arc

This table simplifies the orienting of semiconductor crystals prior to slicing, and is accurate to 1 min of arc. The automatic-slicing machines produce wafers with thicknesses from 0.025 to 0.007 ± 0.0005 in. Speed of the spindle is controlled up to 9,200 rpm by a current variator.

Fitchburg Engineering Corp., Electronic Div., Dept. ED, Fitchburg, Mass.

Price: Orienting table, \$1,100; slicing machine, \$12,240.

Availability: 90 days.

Circuit-Board Drilling Machine

266

Controlled by magnetic tape

This circuit-board drilling machine has a hole-positioning accuracy of 1/1000 in. Designated type 440, the device is coupled to a magnetic-tape control and can drill 40 holes per minute with each of four drill heads. The instrument has an optical programmer said to increase operating speed and reduce positioning errors. A contour-stylus programmer enables the machine to rout contours and divide multi-circuit boards.

Micro-Path, Inc., Dept. ED, Clifton, N.J.

Price: \$27,000; optional contour styles, \$2,000.

Transformer Winder

267

Handles round, square and rectangular wire

This heavy-duty winder handles round, square and rectangular wire without changing wire guides. Rectangular and square coils are wound without pounding. Wires can be sizes 2 to 24 AWG. Winding speeds are 25, 50, 85 and 165 rpm and winding range is 2.5 to 50 turns per in. The machine is furnished with a 5-hp motor and weighs 2 tons.

Geo. Stevens Manufacturing Co., Dept. ED, Pulaski at Peterson, Chicago 46, Ill.

Price: \$11,000.

Availability: Four to six weeks for delivery.



WHAT'S LIFE ALL ABOUT?

In precision potentiometers, Engineers and Purchasing Agents are becoming more concerned with the overall life of the units they buy. They are learning to evaluate potentiometers better. They know that in precision potentiometers, it's useful life that counts! Useful life... Performance over life... Conformity in terms of resolution, noise and environmental characteristics, over life.

How long after you put a potentiometer in a system can you expect it to operate without degrading the system itself? What would you expect to happen at the end of one-fifth, one-half or three-fourth's rated life? Would you expect degradation? And to what degree? These are the questions asked by the more sophisticated Engineers and PA's. They have learned to understand life better. They no longer think of life in terms of millions of cycles but rather how much of life is useful.

When you want useful life in precision potentiometers, look to Fairchild! Fairchild builds units that operate to 20-million cycles with very little degradation, and with initial performance characteristics far superior to those of any other manufacturer!



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TRANSDUCERS • RATE GYROS • POTENTIOMETERS • ACCELEROMETERS

CIRCLE 190 ON READER-SERVICE CARD



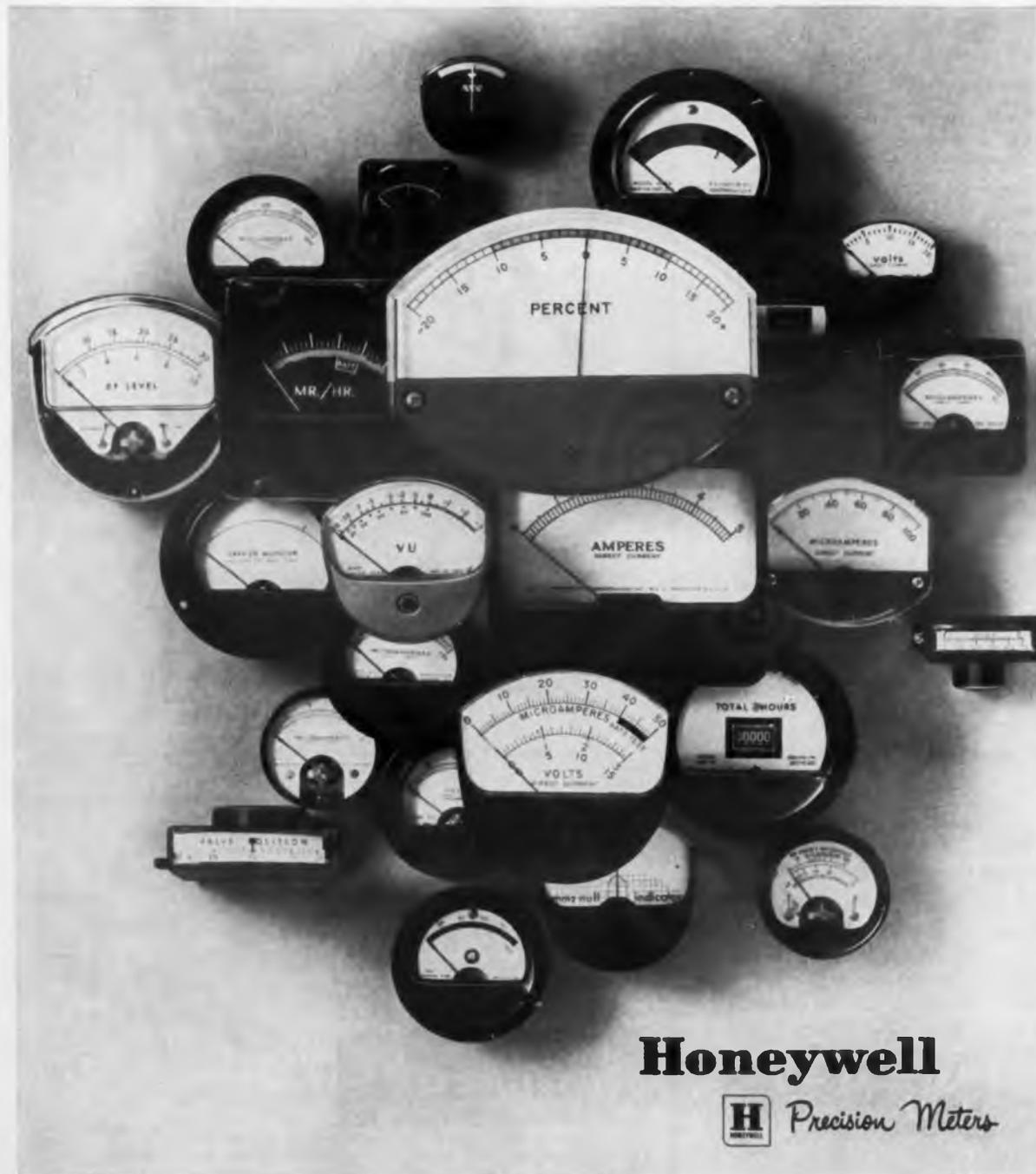
Get the facts of "POT" life. Write

for this informative catalog that describes Fairchild's complete line of high-precision, wirewound potentiometers — for aircraft systems, missiles, computer assemblies, calibration controls, servomechanisms, industrial control systems.

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Precision Meters

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PRODUCTION PRODUCTS

Soldering Machine

268

Controls heating period



A timing control circuit in the model 186B soldering machine assures uniform heating to each solder joint on multi-pin connectors. In addition, a programming system gives visual indication of the pin to be soldered and the color and number of the wire. A footswitch advances the program to the next pin when the predetermined soldering time has elapsed.

Virginia Electronics Co. Inc., Dept. ED, River Road at B&O Railroad, Washington 16, D.C.

Price: \$375 ea.

Availability: From stock after Jan. 15, 1961.

Power Supply

269

For miniature welders

This stored-energy power supply is for miniature electronic welders. Designated type VTW-29, the unit delivers a step-free, adjustable output of 0.01 to 40 w-sec in 0.001 sec. It is housed in a cabinet occupying less than 1 sq ft of bench space.

Hughes Aircraft Co., Vacuum Tube Products Div., Dept. ED, 2020 Short St., Oceanside, Calif.

Price: \$315.

Availability: Two weeks.

Automatic Relay Tester

270

Presents performance-test results

This automatic relay tester presents performance-test results immediately as process control information. The tape-controlled unit classifies information by converting absolute measurements into cellular form. The results are presented by a visual readout device and recorded on a standard printer. At present, it provides cellular classification of eight parameters. The programmed unit provides information on tests for coil resistance, contact resistance, pickup voltage or current, drop-out voltage or current, pickup bounce time, drop-out bounce time, pickup operate time and drop-out operate time.

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

Etching Machine

271

Double- or single-sided

The model 700 spray etching machine does double- or single-sided etching on circuit boards or nameplates up to 16 x 19-1/2 in. Etching time is less than 2 min using ferric chloride. All common etchants may be used. The heated tank holds 24 gallons. Construction is polyvinyl chloride and titanium. Boards are held horizontally in an adjustable rack.

Centre Circuits, Inc., Dept. ED, P. O. Box 165, 1101 N. Atherton St., State College, Pa.

Drilling Machine

272

For printed-circuit panel boards

Model M-100 drilling machine is designed for high-production drilling of printed-circuit panel boards. Using solid carbide drills, accuracy is ± 0.005 in. with a capacity of 10,000 holes per hr in epoxy glass. Feed rate is adjustable from 0 to 4 in. per sec; drill sizes are from No. 60 to 1/8 in. Air consumption is 8 to 10 cfm at 100 psig with full 20,000 rpm; electrical requirements are 110 v ac, 60 cps, 5 amp.

Motion Control Machines, Dept. ED, 2704 W. Burbank Blvd., Burbank, Calif.

Price: Price is \$2,750 fob Burbank.

Transformer Winder

273

Compact, multiple type



Model 407-AM, a compact multiple transformer winding machine, is especially suited for long production runs. It winds multiple paper-section power, audio, ballast, and similar types of coils at speeds up to 2,000 rpm, using 18 through 44 AWG wire. Coil OD may be 9 in. max if round, 4-1/2 in. if rectangular; maximum coil length is 6 in. Special features include a spiraling device, an electric pre-determining counter, and a carriage shift for adding extra turns in coil margins.

Geo. Stevens Manufacturing Co., Inc., Dept. ED, Pulaski Road at Peterson, Chicago 46, Ill.

Price: \$2,415 fob Chicago.

Availability: 2-week delivery.

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PRODUCTION PRODUCTS

Hot Automatic Machine

274

For condenser caps



This machine automatically attaches wire to motor condenser caps. The caps, in strip form, are coated with solder. The machine melts the solder, crimps the cap, and affixes the wire. It is capable of handling 5,000 to 7,000 units per day. Caps are furnished in rolls of 10,000. They are made to customer specification.

Patton-MacGuyver Co., Dept. ED, Edgewood Station, Providence, R.I.

Slicing Machine

275

Accuracy within ± 0.0001 in.

This automatic machine, designed for slicing silicon or germanium wafers, provides repeatability accuracy of the cross-feed index to within ± 0.0001 in. The 2-speed dc table drive motor is controlled by a regulated power supply.

Reid Brothers, Inc., Dept. ED, Beverly, Mass.

Setting Machine

276

Sets eyelets in terminal boards

This machine provides for completely automatic feeding and setting of six twin-connector eyelets in a plastic-insulating terminal board. The terminal board measures 2.5 x 1.5 in. and is 3/16-in. thick. Eyelets are set in an irregular pattern.

United Shoe Machinery Corp., Eyelet Dept., Dept. ED, 140 Federal St., Boston 7, Mass.

C-Ring Assembly Press

277

For high-speed operation

This assembly press is designed to eliminate manual operations and is claimed to speed assembly output 300%. It can be furnished to handle C-rings of all sizes. Required input is 115 v ac at 60 cps.

Altomac Corp., Dept. ED, 863 Washington St., Canton, Mass.



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Sure! Powertron's Autosonic cleaner uses feedback control the way missile guidance systems do—to ensure maximum reliability and efficiency. Feedback control keeps the Autosonic electronically tuned to peak cleaning efficiency, and makes it genuinely self-tuning. Anyone who can flip a switch can use an Autosonic. What's more—the Autosonic is guaranteed to clean almost anything better, cheaper, and faster than other ultrasonic cleaners.



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 ELECTRONIC DESIGN • February 15, 1961

Ultrasonic-Impact Grinder 278

For semiconductor and other electronic devices

Model 2-333 can machine an area up to 1-3/8 in. in diameter. It also has general-purpose applications, including soldering and cleaning. An air-cooled, 300-w magnetostrictive transducer is incorporated in the tool.

Raytheon Co., Apparatus & Systems Div., Dept. ED, 1415 Providence Turnpike, Norwood, Mass.

Automatic Forming Machine 279

For printed-circuit components

This forming machine is designed for the automatic forming, bending and cutting of resistor and diode leads for components of printed-circuit boards. It accepts different sizes of resistor and diode bodies and all carded resistors. The length of cuts and bends can be adjusted without additional tooling. Extra attachments include a hopper feed, a taped-reel feed, lead clamps and heat-sink stress relief shapers.

Design Tool Co., Div. of Federal Manufacturing and Engineering Corp., Dept. ED, 1055 Stewart Ave., Garden City, N.Y.

Price: \$650.

Axial-Lead Component Marker 280

Marks 2,600 components per hour

This machine, type 146A, prints trademark, polarity symbol and band, and desired code markings on diodes, capacitors, resistors, and other axial-lead components at a production rate of 2,600 per hour. Components with diameters from 0.08 to 1 in., body lengths from 1/4 to 1-1/8 in. and over-all lengths from 1-3/4 to 4-1/4 in. are accepted. The machine measures 18 x 11 x 12 in.

Markem Machine Co., Electrical Div., Dept. ED, Keene, N.H.

Price & Availability: \$1485; delivery 75 to 90 days.

Leak Detection Tester 281

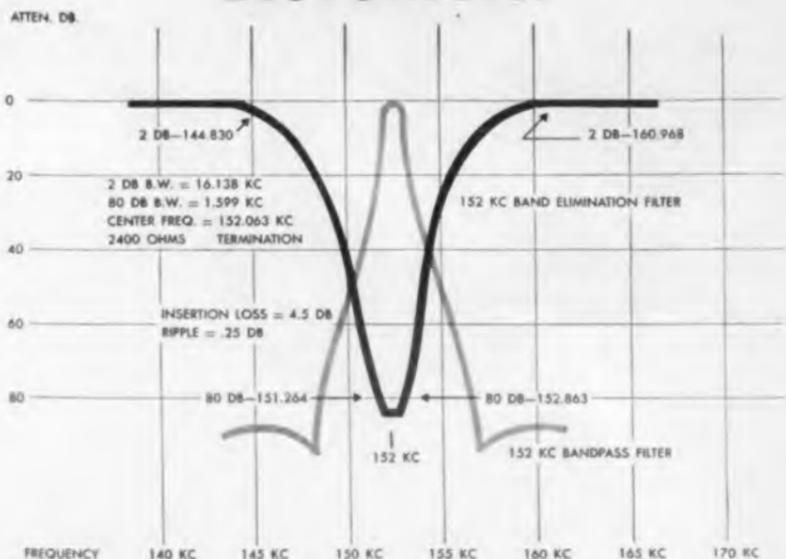
Speeds production testing

This semiautomatic leak detection tester can be attached directly to the firm's leak detector. It tests devices such as capacitors, transistors, and vacuum tubes. It has spring-loaded mechanical valves which are electrically tripped in proper sequence.

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

*High selectivity,
attenuation and precision matching of . . .*

NEW HILL FILTERS ASSURE FAST, PRECISE MEASUREMENT OF INTER-MODULATION DISTORTION



Actual operational curves, obtained from point-to-point readings, from Hill 34900 and 34800 filters developed to fulfill customers' specific requirements.

These two highly stable, precision-matched Hill Electronic filters permit fast, exceptionally accurate measurement of inter-modulation distortion in communications systems. A band elimination filter places a narrow, deep notch in the white noise being passed through the equipment under test. Distortion generated in the notch is then isolated for measurement by the narrow band filter.

The high degree of selectivity and attenuation of these filters, and the excellent alignment of one within the other are demonstrated in the actual operational curves shown above. Used together, these filters provide 80 db attenuation from 6 to 252 kc.

This is a typical example of Hill's creative engineering that develops outstanding solutions to customers' specific problems involving LC and crystal control filters as well as precision frequency sources and other crystal devices.

WRITE FOR BULLETINS 34800/900

They contain details and specifications concerning the filters described above.



HILL ELECTRONICS, INC.

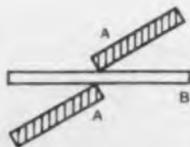
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new north multi-contact multi-purpose connectors



▲ prongs of fork contact
■ flat pin contact



These new, compact and highly efficient plug and receptacle type connectors provide maximum connection concentration in a limited space. They are designed for electronic applications in cable-to-cable, cable-to-fixture, fixture-to-fixture, and are available in 40, 60, 80 and 100 pin sizes.

Firm contact is assured by the unique torsion pressure principle in which beveled end flat blade male connectors seat into flat, fork shaped female blades placed at an angle to the male plugs—assuring double contact, providing minimum contact resistance.

The new design of the mounting hardware features a handy locking bolt for securing the plug to the receptacle and a removable cover with captive screw for rapid wiring or inspection. The permanent cable clamp is adjustable to accommodate varied cable sizes. All connectors are available with either solder or taper tab terminals.

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NORTH ELECTRIC COMPANY

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CIRCLE 197 ON READER-SERVICE CARD

PRODUCTION PRODUCTS

Diode Classifier

282

Operates automatically



Model 1820 automatic diode classifier sorts diodes at a rate in excess of 1,200 per hr. The diodes are fed to an oven unit where they are brought up to temperature and tested for reverse leakage characteristics at various reverse voltages. They are then ejected into the correct bin and counted. Shorted and open diodes are also separated. The temperature of the oven is adjustable up to 200 C.

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

Availability: 60 to 90 days.

Conveyor Furnace

283

For applications in the 300- to 1,100-C range

Type LAC-55M conveyor furnace is a box-type heating chamber with a custom-built loading table at the front end and a water-jacketed cooling section at the discharge end. The unit is designed for close temperature-control applications in the 300- to 1,100-C range, ± 0.5 C. A three-zone temperature control within the 36-in. chamber obtains correct temperature curves for the work being processed. Applications include highly critical alloying of electronic components and metal bonding and soldering.

C. I. Hayes, Inc., Dept. ED, 896 Wellington Ave., Cranston 10, R.I.

Wire-Coding Machine

284

For Teflon-coated wire

This wire-coding machine automatically de-reels, straightens, color codes, thermal strips and cuts to length a wide range of wire sizes. Duplicate sets of up to six bands of different colors can be simultaneously applied and sintered into the Teflon surface. Spacing of bands and cut-off lengths are adjustable.

Radio Corp. of America, Industrial Controls Div., Dept. ED, 12605 Arnold Ave., Detroit 39, Mich.

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flexible power for forward scatter

75 kW CW to 10 kW

The Varian VA-853 CW amplifier klystron features an extremely flexible power range at 755 to 965 Mc — from 75 kW to as low as 10 kW. Provides new possibilities in the development of troposcatter systems. Designed to meet USAF specifications for forward scatter tubes.

One power amplifier serves the entire output range. Power can be varied easily by adjustment of the beam voltage. Drives from a 5 W exciter. High gain — 50 db — is provided by five internal cavities. Compactly designed, with input and output couplings preset for flat rf lines. Just tune to desired frequency; no other physical adjustments are necessary.

Noncritical electromagnet provides a self-centering mount; the tube can be removed as a unit, inserted directly — no need for roll-out dollies.

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MICROWAVES

The MicroWaves Section

Antenna-design activities continue at a feverish pace. Recently, the National Aeronautics and Space Administration, through its Jet Propulsion Laboratory faculty, awarded study feasibility contracts for advanced space tracking antennas to four companies: Blau-Knox, Hughes, North American and Westinghouse. A tracking antenna 200- to 250-ft in diameter is envisioned which will increase deep-space communication capabilities 10 to 30 times over existing facilities.

This section continues a discussion of current antenna designs and contemporary research started in the Nov. 23 issue of *ELECTRONIC DESIGN*. Other articles in this issue leave the exotic field of advanced antenna design and tackle problems in "getting out the equipment."

Time-domain techniques and pattern synthesis are only two areas being researched in the search for better ways to produce and control radiation patterns. Many more are treated in

**New Concepts in Antenna Research
Promise Unusual Control of Radiation
Pattern p 175**

A scholarly analysis of coaxial and flat plate cavities for use in the 500-mc range has been reduced for the design engineer into equations in table form in

**Designing Cavities
For the 500-Mc Range p 180**

A clever way to measure the field of permanent-magnet stacks for TWTs is covered in

**TWT Periodic-Permanent-Magnet
Stacks Evaluated Automatically . p 184**

The latest in amplifiers, parametric and traveling-wave, are presented along with other recently announced products in this issue's coverage of

Microwave Products p 186

New Concepts in Antenna Research Promise Unusual Control of Radiation Pattern

Simultaneous scan through time-domain techniques, and pattern synthesis by logical switching are only two of the promising new approaches to radiating microwave energy surveyed in this article. In the Nov. 23 issue of ELECTRONIC DESIGN these three Hughes antenna experts gave a review of electronic scanning techniques that are fairly far advanced. This article touches on areas just now emerging, or close to emergence from the theoretical stages.

L. A. Gustafson, L. N. Shestak, L. Stark
Hughes Aircraft Co.
Culver City, Calif.

CONTEMPORARY antenna research is advancing along many lines. Theoretical antenna-design information which has been available can be tested with the increasing availability of components that permit electronic control of microwave energy. Many parameters of antenna systems can be controlled, which gives rise to new modulation and beam-steering techniques. Time-modulation techniques are a possibility.

Time-Domain Techniques For Simultaneous Scan

One of the newest and most important concepts employed in advancing microwave antenna design is that of Time Domain Techniques.¹ The essence of these so-called four-dimensional systems is the periodic modulation of one or more antenna parameters either to increase information-handling capacity or to realize unconventional radiation-pattern characteristics. The modulated parameter may be the physical dimensions of the antenna, the energy distribution function over the antenna aperture, the frequency, or even the physical location of the phase center.

When one parameter of an antenna is modulated periodically in time, the signal which the

antenna transmits or receives is modulated with the same periodicity. The resultant signal can be represented as a line spectrum of frequencies centered about the carrier frequency and separated by the modulation frequency. If the power in each spectral line is measured as a function of the direction of arrival, an antenna radiation pattern can be associated with each spectral frequency.

For low sidelobe application, the pattern associated with the carrier frequency is optimized with respect to sidelobe suppression. For simultaneous-scan operation, the modulation is so chosen that a pencil beam pointing in a slightly different direction is associated with each spectral frequency. This results in a system which "looks" simultaneously in all directions of interest. The virtue of this technique is that it supplies additional pattern control whereby the extreme design and construction tolerances required to achieve low sidelobes with a conventional antenna may be relaxed. In simultaneous-scan operation, the data-producing capability of the antenna is greatly increased.

The basic technique of simultaneous scan may be explained from the point of view of Fourier series expansion of periodic functions. When a parameter of the antenna is modulated periodically in time, its radiation pattern will be expressible in the form of such a series.¹ In particu-

lar, if the modulation is superimposed upon an antenna operating at an rf angular frequency ω , then its complex, time-varying, voltage radiation pattern is expressible in the form of an infinite series of products of a pattern function and a harmonic of the modulation frequency. In the simultaneous-scan technique, each pattern and its beam direction is associated with the harmonic frequency of the term of that pattern in the infinite series.

Simultaneous Scan Uses Linear Array Antenna. As an illustration of the technique, consider a linear array of N elements which are sequentially excited by equal rectangular rf pulses cut from a continuous wave. This array excitation is readily expressed in mathematical terms as a series of N contiguous pulses, one for each array element. The excitation envelope would repeat every $N\tau$ seconds, τ being the pulse width. The radiation from an array with this excitation can be analyzed in terms of its spectral frequency components and may be written as an infinite sum of $\sin u_n/u_n$ terms. Each n corresponds to the n^{th} harmonic of the modulation frequency, its pattern function, and the pattern beam direction, $n\theta$, which is measured from broadside.

Thus the scheme gives the desired property of beams pointing simultaneously in various directions, each associated with a detectable frequency component (see Fig. 1). Analogous results

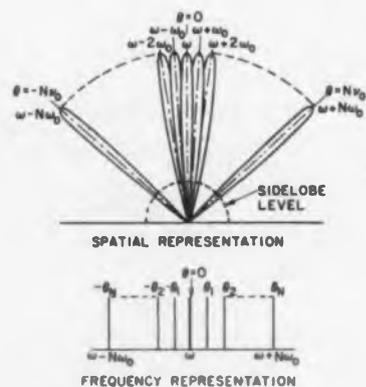
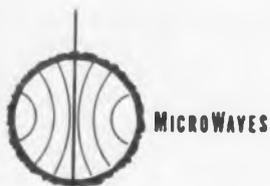


Fig. 1. Time-domain electronic scanning produces beam pointing simultaneously in various directions.

are obtained for signal reception, and proper signal processing gives the desired angular information. Pulsed, two-way radar operation is also possible with this technique.

It must be emphasized here that this effective electronic scanning is obtained without the use of phase shifters which must be precisely controlled. Instead, simple on-off switching of the array elements produces the scanning, thus eliminating many perplexing control problems.

For a simple example of sidelobe suppression by modulation of antenna parameters, consider a linear array with excitation uniform in both amplitude and phase. Such an antenna has a radiation pattern which is given by $g(\theta) = 2 l_0 [\sin kl_0 \sin \theta] / kl_0 \sin \theta$ where l_0 is the half length of the array. This pattern exhibits a -13.2 -db sidelobe level which can be reduced considerably by modulation of the array length in simple fashion.

Let the half length of this array be modulated such that $l = l_0 [1 + \beta f(t)]$ where β represents the percentage modulation of the length. If $f(t)$ is chosen to be a square wave, the time average component of the resultant radiation is the typi-



Fig. 3. Experimental end-fire radiator consisting of dipoles which are individually fed.

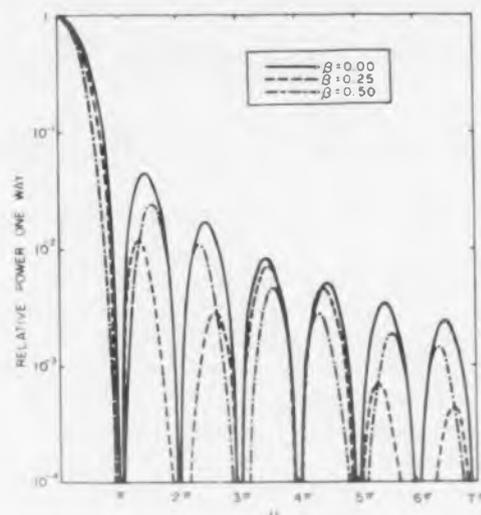


Fig. 2. Sidelobe reduction shown by time-average patterns of square-wave switched array with uniform distribution. The term $1\beta 1$ represents the percentage of modulation of length of array.

cal $\sin u/u$, however there is also a multiplicative factor, $\cos [kl_0 \beta \sin \theta]$. This term has the effect of reducing the sidelobe level well below -13.2 db. The extent of this suppression for various values of the percentage modulation β is indicated in Fig. 2. For the optimum value, $\beta = 0.25$, a 7-db reduction in level is realized. It should be emphasized that the order of magnitude of this reduction is achieved by the simplest form of modulation on an array containing no amplitude taper.

The foregoing analysis is presented only as an indication of the effectiveness of time-domain operation as a means of sidelobe suppression. By use of the excitation parameter alone, or by a combination of length and excitation modulation, considerably greater suppression can be realized.

Early-Warning Antennas Made Smaller by New Arrays

To detect low-flying aircraft, the search radar should be operated from high altitude. Compared to ground installation, this extends the distance to the radar's horizon and lowers the minimum



Fig. 4. Linear Yagis array of end-fire elements. Vertical dimension is within 0.3 wavelength of the lowest frequency.

altitude of the beyond-the-horizon propagation. Design objectives are to produce high-gain antennas which physically are small so that drag on the aircraft is small.

Since radar range depends heavily on antenna gain, high-gain antennas are imperative. Unfortunately, efficient generation of extremely high-level rf power is best accomplished at lower frequencies. Thus, the antenna designer must make his antenna physically large. Airborne Aircraft Early-Warning arrays have, until now, been of the mechanically scanned broadside-beam type. The large volume swept by a rotating array needs a large radome atop or below the fuselage.

Volumetric Arrays. An antenna for Aircraft Early Warning may take one of several forms. Antenna specialists at establishments such as the Naval Research Laboratory, Dalmo Victor, and General Bronze Electronics have been working on volumetric arrays in the form of two-dimensional broadside arrays of end-fire radiators which would more efficiently utilize the space required by presently used antennas. They also seek to make the radome a more integral part of

the volumetric array so as to effect some drag reduction. A final objective of their work is to achieve improved antenna gain from the volume.

Planar Arrays. At Chance Vought and Hughes Aircraft Co. the problem has been approached through the design of planar (flat-slab) arrays which are endwise to the slipstream instead of broadside to it. Integral antenna-radomes of this type have demonstrated the ability to reproduce the electrical characteristics of conventional broadside antennas. The lower drag of these units is expected to improve the radar aircraft performance greatly by increasing time on station. The required surveillance may then be accomplished with fewer operating units.

Design of such low drag antennas places stringent conditions on the end-fire radiators. The vertical-plane radiation pattern of the end-fire antenna is determined by the *H*-plane pattern of the individual end-fire radiators and must be achieved in a minimum length to limit the swing circle of the assembly. Classical end-fire antenna studies indicate that for maximum gain the beamwidth is $63^\circ/\sqrt{L}$, *L* being radiator length in wavelengths, with the first sidelobe approximately -9 db. During a current program at Hughes Aircraft Co. it has been shown, analytically and experimentally, that a combination of amplitude tapering and large inter-element phase shift can produce practical end-fire arrays with beamwidths in the order of $50^\circ/\sqrt{L}$ and -20 db *H*-plane sidelobes. Fig. 3 shows a 2.75-wavelength experimental array of dipoles individually fed according to the results of a mutual coupling analysis. Fig. 4 shows an experimental full-size one-dimensional array of end-fire radiators which combines the radar low-frequency array with an orthogonally polarized higher frequency IFF antenna. The assembly uses modified Yagi arrays as end-fire elements. The electrical components of this assembly are all contained within a vertical dimension of 0.3 wavelengths at the lowest frequency.

Pattern Synthesis To Control Antenna Radiation

Antenna-pattern synthesis is also an active area in antenna research. It deals with the theoretical derivation of design techniques which are needed for proper control of the angular dependence of antenna radiation.

Recent contributions in this field include:

- the synthesis of optimum-difference patterns for use in monopulse applications
- synthesis of optimum sector beams
- a beam-forming technique useful when different shape requirements must be imposed on various parts of the beam.

The above techniques apply to linear or rectangular aperture antennas. Early this year the

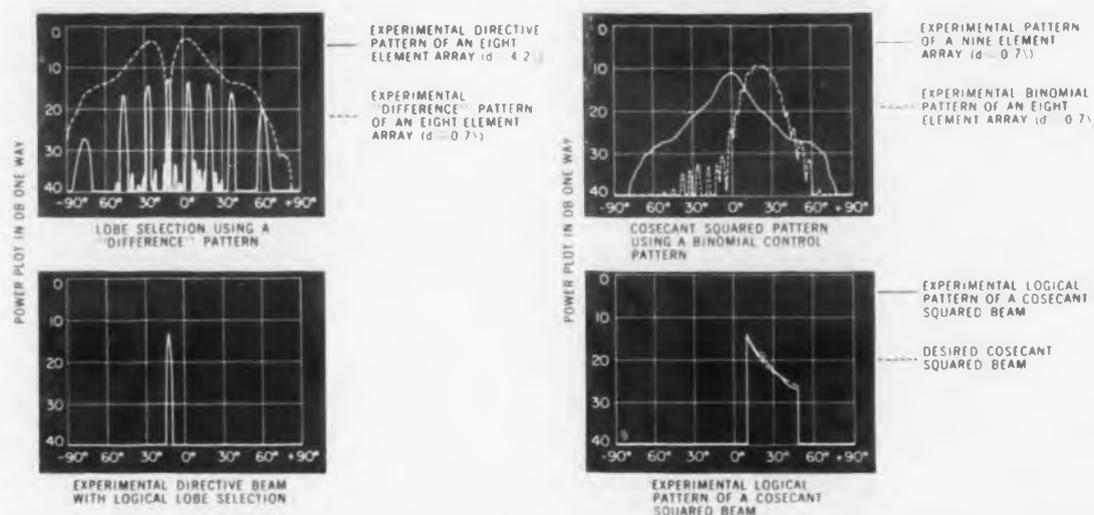


Fig. 5. Examples of patterns obtained through logical synthesis. Only two simple antennas were used to get these unconventional results.

synthesis of optimum directive patterns by means of circular apertures also appeared in print.^{2,3} A more difficult problem is the synthesis of arbitrary patterns by means of nonplanar antennas. The cone, a surface of considerable importance, has recently been successfully treated.^{4,5} The problem of optimum excitation of a surface of arbitrary curvature for the highest power on target has also been solved, but under certain restrictive conditions.

Logical Pattern Synthesis. The patterns obtainable through conventional synthesis are limited in quality because of physical restrictions. For example, with an antenna of a given size there is a certain gain figure that cannot be exceeded no matter what aperture excitation is used. On the other hand certain applications require the use of arrays whose effective length is unlimited but in which the inter-element spacing is so large that multiple-angle constructive interference produces secondary beams.

To overcome interference from secondary beams a technique has been developed which uses "logic," in the digital-computer sense, to combine several patterns, compare their signals, and decide which signals to display and which to reject. The several patterns may be obtained from the same antenna, by interconnecting the various elements in prescribed ways, or the patterns may come from several antennas operating side by side. Some of the results of logical pattern synthesis are shown in Fig. 5. The patterns shown are experimental verification of the syn-

thesis theory. As indicated in the illustrations, only two antennas, each with very few elements, were employed, yet the resulting patterns would be unachievable by conventional methods even with the use of many more elements.

Nonlinear Processing. Another synthesis technique for overcoming the dimensional limitations of the antenna applies various linear or nonlinear operations to the individual signals obtained from each element of an array. The nonlinear operations consist mostly of products of the signals derived from single elements or groups of elements. Such schemes have been shown to simulate the performance of larger antennas having many more elements. Certain serious difficulties arise, however, in the presence of multiple targets, and this type of processing also results in a rather poor signal-to-noise ratio.

Correlation Processing. A procedure which successfully simulates the performance of larger antennas with closely spaced elements and does not suffer the drawbacks of the nonlinear processing is the correlation processing scheme. This type of processing in its simplest form uses a matched filter for a processor and trades signal frequency bandwidth for the physical size of the antenna. The correlating antennas apply, therefore, to wide-band systems. This is not a serious limitation since modern radar systems require large bandwidth for other purposes as well.

Information Theory. The latest synthesis problem to come under study is the application of information theory to the antenna, which is treated



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as an active processor in the transmission and detection of signals. The objective is to determine the ultimate theoretical limits of the antenna as an information gathering device.

Research Also Includes Other Directions of Study

With the advent of space exploration the study of rarefied-atmosphere voltage breakdown has been accelerated. Antenna malfunctions caused by voltage breakdown are usually observed during portions of rocket flights in the upper reaches of the atmosphere. The source of the problem is the fact that the rf field adjacent to an antenna can sufficiently accelerate free electrons in a rarefied atmosphere to cause ionizing collisions with the gas molecules. The resulting ionized air acts as a mismatched rf attenuator thus causing signal loss and standing waves in the antenna structure. The effect is naturally frequency and altitude sensitive and is most troublesome at 1,000 mc and 150,000 ft. However, voltage breakdown is observed at all microwave frequencies and at altitudes as low as those used operationally by current manned aircraft. Essentially the same effect occurs near the surface of a hypersonic vehicle when the temperature is sufficient to produce a plasma layer. Experimental and theoretical study of this problem is being pursued by many organizations, e.g., Stanford Research Institute and Lockheed Missile and Space Div. The work is concerned with the basic mechanisms which are involved in frequency-power, level-altitude dependence.

Random deviations from ideal antenna characteristics and the noise introduced by antenna systems are two areas of related interest in current research. These are relatively new fields of study and are indicative of the growing refinement of antenna performance. Topics which have been recently studied are the effects of 1. variations due to manufacturing tolerances, 2. component (i.e., phase shifters, powers dividers, etc.) characteristic imperfections, 3. inadequate means of controlling the components, 4. noise in the antenna positioning platform, and 5. noise introduced into the system by the antenna itself. Important investigations have been done by people throughout the industry.

In contrast to the trend toward antenna research based on considerations of the antenna as a complex active system, work continues along conventional lines. The development of ex-

tremely wide-band antennas started at the University of Illinois and has been carried on and expanded at Collins Radio and Sylvania, as well as at Illinois. The fundamental concepts for radiating elements of this type can be explained in terms of the relationship of dimensions to frequency.

In one approach the shape of the antenna is described essentially by angular relationships, and in another the design is based on logarithmic functions wherein the radiation pattern and impedance vary periodically with the logarithm of the frequency. The variation over a period can be made negligible, and the period can extend over a very large frequency interval. In angular design approach, since the pattern depends on the antenna's shape as a function of frequency and the antenna is essentially angular, the pattern simply rotates with frequency. If the pattern is symmetrical with respect to the rotation axis, it will appear to be frequency insensitive over a range corresponding to the extent of angle variation, which for spiral-type configurations may be many radians. Any antenna of such nature would have a finite size that determines its lower "cut-off" frequency and would perform satisfactorily for all higher frequencies up to the point where the feed point design becomes a limiting factor. Typical bandwidths for these types of antenna range up to 20:1.

Some of the recent experimental research done in this area is concerned with the antenna performance obtained when a reflecting surface is used to produce unidirectional radiation patterns. Another important direction of study makes use of the log-periodic element for devising frequency independent arrays. Extremely broadband high-gain antennas have been realized by this means. More recently, effort has been devoted to the development of radiation pattern expressions for spiral-type elements and the incorporation of these elements in scanning arrays. ■ ■

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cathodes or hurtling electrons that generate noise in conventional amplifiers. It is so quiet that only the noise made by matter itself in heat vibrations remains. But at a temperature close to absolute zero, this also is silenced. Even very faint signals from satellites can be clearly amplified and studied for their possibilities.

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MICROWAVES

Designing Cavities in the 500-Mc Range

Here are practical equations for designing coaxial and flat plate cavities in the 500-mc range. Dr. Kiriloff compiled these handy tables after a thorough analysis of coaxial, flat plate and transmission line types. The latter is not included because of its limited applicability.



Dr. A. Kiriloff,
Research Engineer
Columbia University*
New York, N. Y.

TWO TYPES of cavities of particular usefulness in the 500-mc range are the coaxial $\lambda/4$ cavity and the flat-plate cavity.

These cavities find practical applications in the construction of frequency multipliers in radar circuits.

The $\lambda/4$ coaxial cavity is preferable for these particular applications, because:

1. Tuning is easier.
2. Radiation into the space is zero.
3. Bandwidth of the resonance curve is variable depending on the coupling system associated with cavity.

The flat-plate cavity is frequently a satisfactory compromise because it is easier to manufacture and the bandwidth can be made broader.

In designing a coaxial $\lambda/4$ cavity, it is merely necessary to determine the dimensions shown in Fig. 1, Table I. Length of inner conductor l is determined as a function of frequency: $l = \lambda/4$.

* Now with Polytechnic Research & Development Co., Inc., Brooklyn, N. Y.

The characteristic impedance, Z_0 , is normally chosen equal to the terminating resistance from Eq. 1, Table I.

The important feature of the cavity is the coupling system associated with the cavity, which determines the loaded Q , Q_L , bandwidth and loss.

The relation between Q_L and unloaded Q , Q_{un} , of the cavity is given by Eq. 5, Table I.

The solution to Q_L for the coaxial cavity with electrostatic coupling is given by Eq. 6 of Table I.

The values of Q_L (and bandwidth) are determined by:

- position of probe (from the closed side of cavity), angle θ_1
- load of the coupling system, R
- capacity of probe, C

General considerations for electrostatic and magnetic couplings for the coaxial cavity are given in Fig. 4.

For electrostatic probes, the variation of Q_L and bandwidth as a function of θ_1 is plotted for constant R and C . The variation of Q_L and bandwidth as a function of R for constant C and θ_1 is also given.

For magnetic probes, the variation of Q_L and bandwidth as the function of θ_1 for constant R is illustrated.

Sample Design Illustrates the Procedure

It is convenient to represent the design procedure by a specific example, which illustrates and explains the technique.

As an example, suppose $f = 451$ mc, $l = \lambda/4 = 6.53$ in., $2h = 7.5$ in., $Z_0 = 52$ ohms, $a = 1.5$ in. (ID), $b = 5.8$ in. (OD).

From Eq. 4, unloaded Q (Q_{un}), $\cong 4,500$ (assuming silver plated conductors).

From Eq. 6, for the coupling system associated with cavity:

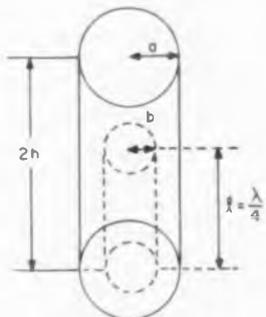
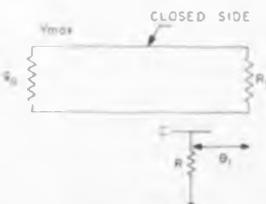
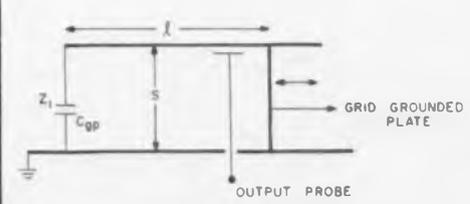
$$\begin{aligned}\theta_1 &= 2.5 \text{ deg} \\ C &\cong 10 \text{ pf} \\ R &\cong 100 \text{ ohms} \\ Z_0 &= 50 \text{ ohms} \\ Q_L &= 104 \\ BW &\cong 4.3 \text{ mc}\end{aligned}$$

The design procedure for the flat-plate cavity is the same as for $\lambda/4$ coaxial cavity.

Cavities operating near 450 mc have a variety of practical applications, particularly as fre-

Table I. Equations and Parameters Used in Design of Cavities in the 500-mc Range

MICROWAVES

	Radiation Resistance R_{eq}	Characteristic Impedance Z_0 And Wave Impedance Z_ω	Unloaded Q_{un}^1	Coupling System Associated With Cavity ¹	Tuning
Coaxial $\frac{\lambda}{4}$ Cavity 	R_{eq} is practically zero, cavity is completely shielded	$Z_0 = \frac{138}{\sqrt{\epsilon}} \log_{10} \frac{a}{b} \quad (1)$ $Z_\omega = \frac{1}{\sqrt{\sigma^2 + \omega^2 \epsilon^2}} (\alpha + j\beta) \quad (2)$ <p>Z_ω is simplified for the lossless case (TEM-modes) as an intrinsic wave impedance for free space</p> $\zeta = Z = \sqrt{\frac{\mu_0}{\epsilon_0}} = 376.7 \text{ ohms} \quad (3)$ <p>where:</p> <p>Z_0 — characteristic impedance, in ohms</p> <p>ϵ — dielectric constant, numerical</p> <p>a — outer tube (ID) in inches (radius)</p> <p>b — inner tube (OD) in inches (radius)</p> <p>Z_ω — wave impedance in ohms</p> <p>$\omega = 2\pi f$ in radians</p> <p>σ — conductivity, mhos/unit</p> <p>$\alpha + j\beta$ — transfer function</p> <p>α — attenuation, in db</p> <p>β — phase shift, in radians</p> <p>$\epsilon_0 = 8.854 \times 10^{-12}$ — dielectric constant, absolute vacuum, in farad/meter</p> <p>$\mu_0 = 1.256 \times 10^{-6}$, magnetic permeability, absolute vacuum, in henry/meter</p>	$Q_{un} = \frac{\lambda}{4\delta + 7.2h \frac{\delta}{a}} \quad (4)$ <p>(See circuit, Fig. 1)</p> <p>where:</p> <p>δ — skin effect depth $= 1.5 \times 10^{-4} \lambda^{1/2} K_1$</p> <p>$= \frac{2.6}{f^{1/2}} \times K_1$ in inches</p> <p>$K_1 = 1$ (for copper)</p> <p>a — radius of outer conductor in inches (ID)</p> <p>b — radius of inner conductor in inches (OD)</p> <p>$2h$ — length of cavity</p> <p>l — length of inner conductor $= \frac{\lambda}{4}$</p>	<p>The relation between loaded and unloaded Q of cavity is given by equation:</p> $\frac{1}{Q_L} = \frac{1}{Q_{un}} + \frac{1}{Q_{ext}} \quad (5)$ <p>Q_L — loaded</p> <p>Q_{un} — unloaded</p> <p>Q_{ext} — loading due to external circuit</p> <p>Loaded Q_L for the coaxial cavity with electrostatic coupling is given by:</p> $\frac{1}{Q_L} = \frac{1}{Q_{un}} + \frac{4R_b}{n\pi Z_0} + \frac{4g_a}{n\pi y_0} \quad (6)$ $= \frac{4}{n\pi Z_0} \left(R_u + R_b + \frac{g_a}{y_0^2} \right)$ $= \frac{4}{n\pi Z_0} \times \left(\frac{n\pi Z_0}{4Q_{un}} \right) + \frac{4}{n\pi Z_0}$ <p>$\times (Z_0^2 \omega^2 c^2 R \sin^2 \theta_1)$ (See circuit, Fig. 2)</p> <p>where:</p> <p>g_a — conductance of load in mhos at vswr max</p> <p>y_0 — admittance</p> <p>$\frac{g_a}{y_0^2}$ is very small and neglected in Eq. 6</p> <p>R — load</p> <p>θ_1 — position of electro-static probe c from closed side in degrees</p> <p>c — capacitance of probe</p> <p>R_i — resistance of inner conductor</p>	Tuning of the cavity is realized by: <ol style="list-style-type: none"> Variation of length of inner conductor, $l = \frac{\lambda}{4}$ Variation of micrometric condenser formed with inner conductor (piston)
	<p>Fig. 1. Cavity consists of two coaxial tubes one side of which is closed. Other side may be open or closed by metallic ring with micro-metric condenser between the closed side and the inner conductor. The inner conductor may be adjusted by fine thread.</p>	<p>Fig. 2. Circuit of coaxial cavity.</p>			
Flat Plate Cavity	$R_{eq} = 9,600 \frac{D^2}{\lambda^3} \quad (1)$ <p>where:</p> <p>R_{eq} — in ohm/cm</p> <p>D — distance between bar and grid grounded plate in cm or inches</p> <p>λ — length of wave in same units</p>	$Z_0 = 377 \frac{S}{\omega} \quad (2)$ <p>(See circuit, Fig. 3)</p> <p>where:</p> <p>Z_0 — in ohms</p> <p>S — distance between rectangular bar of cavity and grid grounded plate</p> <p>ω — width of rectangular bar of cavity in cm or inches</p>	$Z_1 = Z_0 \tan \beta l \quad (3)$ $= \frac{1}{2\pi f C_{RP}}$ <p>where:</p> <p>Z_1 — in ohms</p> <p>$\beta = \frac{2\pi}{\lambda}$ (wave number)</p> <p>l — length of copper rectangular bar of cavity in cm or in.</p> <p>C_{RP} — capacitance of tube used (as input capacity)</p>		<p>Fig. 3. Diagram of flat-plate cavity.</p>

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TIME: 100 to .01 seconds.

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Using Alfred Model 623 Microwave Oscillator (left) to test small signal and saturation gain of Model 503 Traveling Wave Tube Amplifier. Microwave Leveler, Alfred Model 704, holds power output from oscillator constant within ± 1 db.

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MICROWAVES

quency multipliers in radar circuits. The circuit in Fig. 5 shows an application in the 300-500-mc range, where lumped tuned circuits are not easy to apply. The particular circuit illustrated shows a $\lambda/4$ coaxial cavity doubler-tripler (2×3) conversion going from 75 mc to 450 mc.

A comparison of the flat-line cavity to the coaxial cavity for a doubler-tripler 75-mc to 350-mc application points up their differences. Test results show the following: bandwidth for the coaxial cavity is 4.2 mc; for the flat-line cavity it is 3.4 mc. Outputs are approximately the same. The coaxial cavity has electrostatic coupling very close to short-circuited end, capacity of coupling ≈ 10 pf. load ≈ 100 ohms. Flat-line cavity has direct coupling very close to short-circuited end. Radiation effect of the flat-line cavity, whole system is ≈ 9 ohm; R_{co} of $\lambda/4$ cavity is practically zero. ■ ■

Acknowledgments

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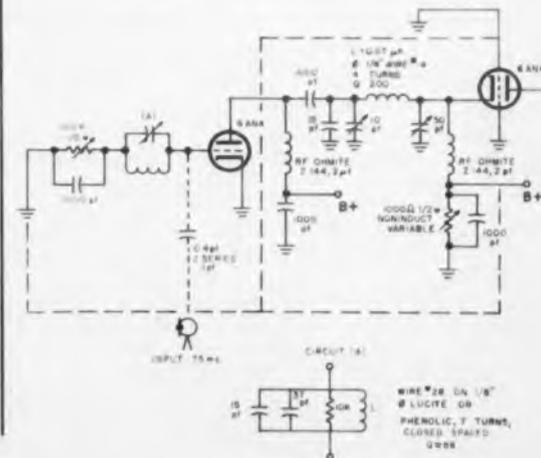
The writer wishes to acknowledge his indebtedness to Professor J. Bose of Columbia University for permission to publish this article. The writer is also grateful for the valuable suggestions from Supervisors Stephen Abrams and Cormac Walsh, to Salvatore Rubiano for his important assistance in the construction of cavities, to Frank McIntyre for his assistance in correcting and preparing this paper.

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DOUBLER: 75mc-150mc

TRIPLER 150mc-450mc

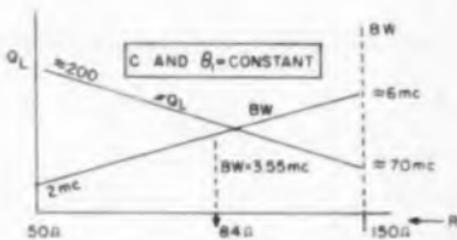
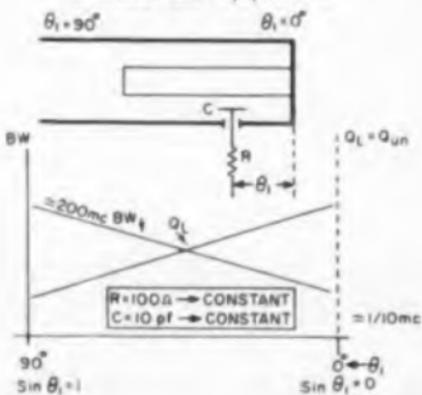


3R

ELECTROSTATIC PROBE

$$R_b = Z_0^2 \omega^2 C^2 R \sin^2 \theta_i$$

IF $Z_0 \omega = \text{CONSTANT}$
VARIABLE ARE R, θ_i , AND C



MAGNETIC PROBE

$$R_b = \frac{\omega^2 M^2 \cos \theta_i}{R}$$

$\theta_i = 90^\circ$ $\theta_i = 0^\circ$

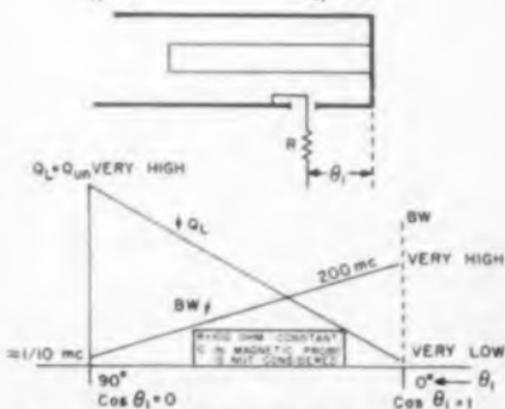


Fig. 4. Effect of electrostatic and magnetic coupling for coaxial cavities.

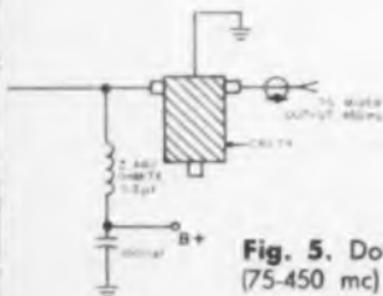


Fig. 5. Doubler-tripler circuit (75-450 mc) using $\lambda/4$ cavity.



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MICROWAVES

TWT Periodic-Permanent-Magnet Stacks Evaluated Automatically

A new method of evaluating the magnetic field created by a stack of periodic permanent magnets is described by author Jacobs. Use of the Hall effect make the method simple.

J. Jacobs

Radio Corp. of America
Electron Tube Div.
Harrison, N.J.

THE HALL EFFECT can be used in the evaluation of the axial field created by an arrangement of periodic permanent magnets such as those used for focusing the electron beam in traveling-wave tubes. The Hall effect states that when a conductor carrying a current is placed in a magnetic field, a potential difference is generated on a plane in quadrature with both the current and the magnetic field. A semiconductor

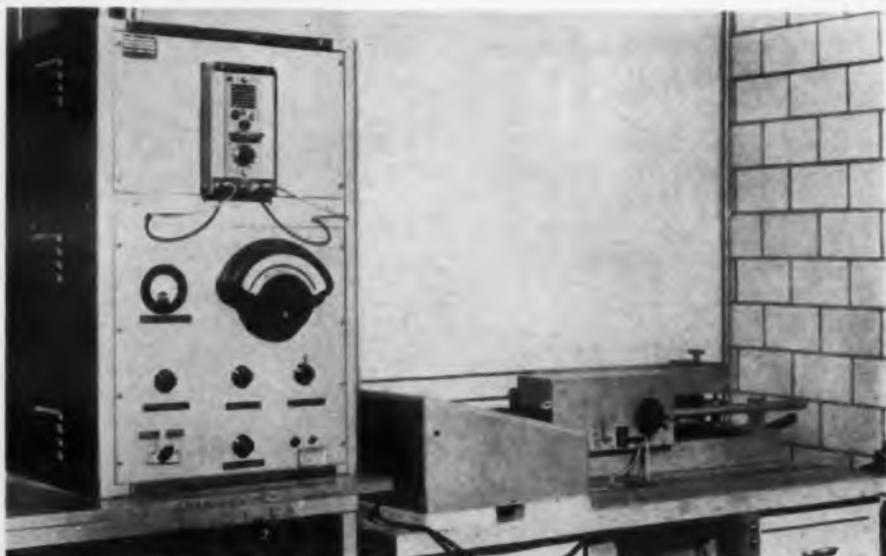


Fig. 1. Test set up for measuring magnetic field of periodic permanent magnets

crystal is very suitable as the sensor of the magnetic field set up by periodic permanent magnets.

Fig. 1 shows the electromechanical setup used in this method. A probe consisting of a crystal on the tip end of a rod is driven through the bore of a stack of assembled periodic-permanent-magnet disks. The probe is mounted on a carriage coupled to the shaft of an ac synchronous motor by a rack-and-pinion assembly; a cradle supports the stack of magnets. The probe is aligned and positioned on the center of the stack by a piece of nonmagnetic tubing. A dc power supply provides a bias current to the Hall crystal.

Magnet Field Plotted On X-Y Recorder

A multi-turn potentiometer fed by a constant dc voltage is also coupled to the rack by a suitable gear. This potentiometer senses the probe position as the crystal senses the magnetic field. Both the potential differences sensed by the Hall crystal and those picked up by the multi-turn potentiometer are applied to an X-Y recorder. Magnetic field as a function of probe position is plotted.

After the magnetic field of the stack is recorded, a standard magnet disk is probed and a record is made of its magnetic field on the same chart used to plot the unknown stack. A calibrating constant (gausses per division) can then be obtained from this plot for use in determining the peak deflections of the unknown periodic magnetic field. The sensitivity of the Hall probe used in the equipment illustrated is 72.5 mv per amp of control per kilogauss of field. The sensitivity of the X-axis of the recorder is 10 mv per in.

The inaccuracy associated with slewing speed may be avoided by use of the correct carriage-probe speed within the recorder ratings. Recorder nonlinearity, if any, may also be avoided by selection of a standard magnet having a value close to that of the field of the magnet stack. Automatic recording has the advantage of eliminating the subjective errors which result from point-by-point measurement with a ballistic galvanometer.

The graphic representation obtained by this method provides a useful and easy-to-read record of the magnetic field. ■ ■



SWEEP SIGNAL SOURCES



X775A

DELIVERY FROM STOCK

**for fast, visual
reflectometer tests
ranges from 2 to 40 KMC**

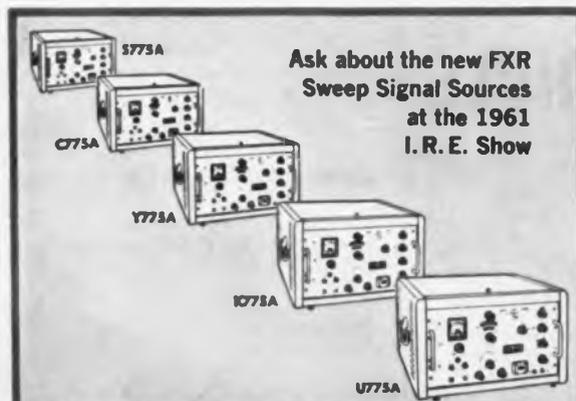
Another breakthrough in measuring convenience has been achieved by the newly expanded FXR family of self-contained, direct reading sweep signal sources. Coverage is now provided as high as 40 KMC. Each unit utilizes a permanent magnet BWO as the tunable RF source.

Output power can be equalized at any detection point relative to the response of the detection element through use of FXR's

- Direct Reading Frequency Dials for Setting Upper and Lower Band Ends
- Integral AGC Circuit Keeps Output Flat to ± 0.5 db
- AGC Provision Eliminates Need for Slow Response Radiometer Set-ups
- Convenient, Portable, Versatile

exclusive built-in AGC circuit. This circuit provides a flat (± 0.5 db level) on modulated signal throughout the swept frequency range when used with matched bolometers and directional couplers. This AGC provision eliminates the need for using slow response radiometers, and allows for visual VSWR or Reflection Coefficient tests.

FXR FAMILY OF ALL ELECTRONIC SWEEP SIGNAL SOURCES



Ask about the new FXR
Sweep Signal Sources
at the 1961
I. R. E. Show

Model Number	Frequency Range (KMC)	Approx. Minimum Power Out.	OUTPUT		Price
			Waveguide Type	Connector	
S775A	2.0-4.0	70 mw	($\frac{1}{2}$ " Coax Type N)		\$2750
C775A	4.0-8.0	20 mw	($\frac{1}{2}$ " Coax Type N)		\$2800
X775A	8.2-12.4	20 mw	WR-90	UG-39/U	\$2900.
Y775A	12.4-18.0	10 mw	WR-62	UG-419/U	\$3300.
K775A	18.0-27.0	5 mw	WR-42	UG-595/U	\$3700.
U775A	27.0-40.0	5 mw	WR-28	UG-599/U	\$4300.

Characteristics and prices subject to change without notice.

GENERAL SPECIFICATIONS

SWEEP RATE (Resolution): 0.1 to 300 KMC/sec linear with time
 SWEEP WIDTH: approximately 200 KC to full frequency range
 OUTPUT SIGNAL: CW, square wave (internal 000 to 1200 cps)
 FREQUENCY DIAL ACCURACY: $\pm 1\%$ for fixed frequency operation
 $\pm 2\%$ for sweep frequency operation
 POWER REQUIREMENTS: 115/230 v., 60/50 cycles, 200 w.
 DIMENSIONS: 12 $\frac{1}{2}$ " high x 21 $\frac{1}{4}$ " wide x 10" deep
 WEIGHT: 70 lbs.

FXR OFFICES IN NEW YORK • BOSTON • LOS ANGELES
 REPRESENTATIVES IN ALL MAJOR CITIES THROUGHOUT THE WORLD



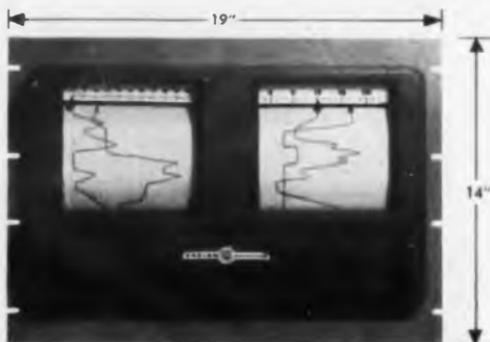
FXR, Inc.

Design • Development • Manufacture
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 WOODSIDE 77, N. Y. • TWX: NY 43745

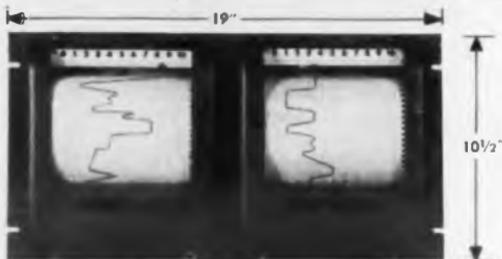
PRECISION MICROWAVE EQUIPMENT • HIGH-POWER PULSE MODULATORS • HIGH-VOLTAGE POWER SUPPLIES • ELECTRONIC TEST EQUIPMENT
 CIRCLE 202 ON READER-SERVICE CARD

VARIAN Potentiometer RECORDERS

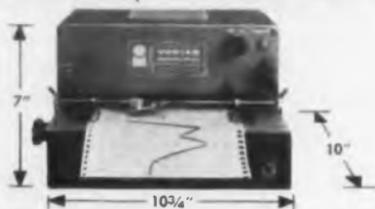
More performance in less space



G-22 FOUR CHANNELS IN 14"; DEPTH ONLY 11½" BEHIND FRONT PANEL



G-11A TWO CHANNELS IN 10½"; DEPTH ONLY 5½" BEHIND FRONT PANEL



G-10 ONE CHANNEL < ½ CU. FT.

THREE COMPACT CHOICES

Using one quarter the space of many comparable potentiometer recorders, the Varian family packs exceptional function into very little space. Interchangeable input chassis accommodate full-scale signal voltages from 10mv to 500v dc., temperatures from -200°C to $+1500^{\circ}\text{C}$, and 1mA current recording. The Varian recorders have 1% accuracy, ¼% of-span sensitivity, 1 or 2½ second balancing time, full-span zero adjust, Zener diode or mercury cell reference. A selection of chart speeds from ¼"/hour to 16"/minute lets you pick the time resolution you need.

In addition to being rack-mountable, the G-22 and G-11A are portable for use in many locations. A wide range of accessories — such as retransmitting slidewires, alarm contacts and event markers — helps broaden the outstanding functional versatility outlined above. Chances are a Varian recorder can serve your need. Write Instrument Division for detailed specifications.



VARIAN associates
PALO ALTO 21, CALIFORNIA

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CIRCLE 203 ON READER-SERVICE CARD



MICROWAVES

MICROWAVE PRODUCTS



Microwave Oscillators

546

Use tunnel diodes

These stable microwave oscillators use tunnel diodes in specially designed circuits. The oscillators are complete packages ready for use as signal sources, local oscillators, etc., in applications where small size and long life are required. The SS-100 is mechanically tuned over to its 1,050- to 1,400-mc range. The center frequency of the SS-104 is specified in the range from 800 to 1,400 mc. It can be electronically tuned over a range of 5% of its center frequency. Both units require 0.2 v dc to produce several tenths of a milliwatt output.

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

Mixer-Preamplifier Series

547

Covers 0.25 to 17 Gc



Each of the 11 units in the I series of mixer-preamplifiers covers a portion of the spectrum between 0.25 and 17 Gc. They consist of either a coaxial or waveguide mixer in conjunction with a low-noise preamplifier packaged in a single unit. The vswr for signal and local oscillator inputs is from 1.2 to 2.2 depending on the frequency range and the type of mixer selected. Each model can be obtained with a single-ended or balanced input, a symmetrical bandpass, specified bandwidth, gain, and noise figure.

Orion Electronic Corp., Dept. ED, 108 Columbus Ave., Tuckahoe, N. Y.

MICROWAVES



S-Band Amplifiers 548
Have 75-mc bandwidth

This family of broadband, parametric amplifiers includes an S-band nondegenerate model that gives bandwidths up to 75 mc at 15-db gain. Noise figure, including circulator loss, for the S-band model is 3 db over the frequency range of 2.8 to 2.96 Gc; gain variation is no greater than 3 db from -40 C to 50 C. The unit also meets the vibration requirements of MIL-E-5400D. Other units are available for applications at L, C, and X bands; all are designed with gallium-arsenide varactor diodes.

Texas Instruments, Inc., Dept. ED, 6000 Lemmon Ave., Dallas 9, Tex.



X-Band Amplifiers 549
Have gain over 50 db

Using folded waveguide structures, these X-band traveling-wave amplifiers have saturation gains of more than 50 db. The 307H has a 100-kw peak power output (500 w average) with a minimum of 50 kw over an 8.5- to 9.5-Gc frequency range. It has 54-db saturation gain and operates with a 38-kv beam voltage. The grid-controlled 308H has a 15-kw peak power output (150 w average), an 8.6- to 9.9-Gc frequency range, and a 53-db saturation gain. Beam voltage is 24 kv; the beam can be modulated with a pulse of less than 500 v. Pulse rise times of 10 to 50 μ sec can be achieved. The 308H weighs 14 lb; the 307H weighs 21 lb.

Hughes Aircraft Co., Microwave Tube Div., Marketing Dept., Dept. ED, 11105 Anza Ave., Los Angeles 45, Calif.

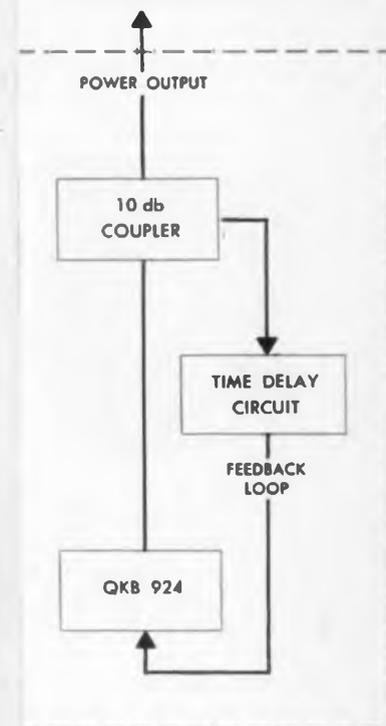
CIRCLE 204 ON READER-SERVICE CARD ►

ELECTRONIC DESIGN • February 15, 1961



QKB 924

MO PA
STABILIZED OPERATION

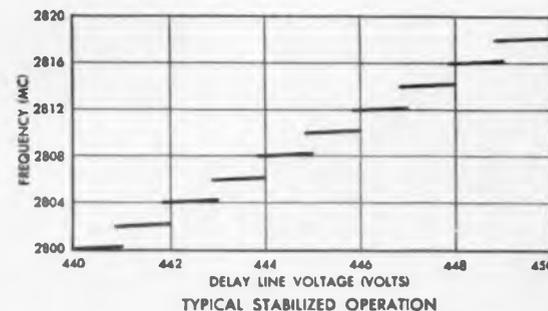


New Raytheon master oscillator assures extreme stability in frequency diversity transmitters

The QKB 924 voltage tunable "O" type backward wave oscillator with the feedback circuit shown above provides a highly stable master driver-local oscillator for S-Band MOPA chains.

External feedback through a delay line provides a 10:1 or more increase in frequency stability—performance that is particularly suitable for frequency diversity MTI applications. The frequency vs. voltage curve of the circuit is essentially flat at discrete steps over the entire 2,700 to 3,200 Mc range. Power output is typically 100 milliwatts with a delay line tuning voltage of 350 to 700 volts. Models are also available at frequencies through X-Band.

Write for detailed application information to Raytheon Company, Microwave & Power Tube Division, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario.



RAYTHEON COMPANY

MICROWAVE AND POWER TUBE DIVISION



BOSTON, MASS., BRowning 2-9600 • ENGLEWOOD CLIFFS, N. J., LOwell 7-4911 • BALTIMORE, MD., Southfield 1-0450 • CHICAGO, ILL., NATIONAL 5-4000
DAYTON, OHIO, BAIdwin 3-8128 • LOS ANGELES, CALIF., PLYmouth 7-3751 • CANADA: WaterloO, Ont., SHERwood 5-6831



MICROWAVES

Power Supply

572

Output to 10 kv



A regulated tube power supply, the model Z851-2 has output voltage adjustable from 0 to 10 kv. Current range is 0 to 100 ma; ripple content is 0.4% max. Overload relay protection is provided, with activation current manually set within the range 25 ma to 100 ma. Power requirement is 208 v ac, 3-phase, 60 cps.

FXR, Inc., Dept. ED, 25-26 50th St., Woodside, N. Y.

Price: \$3,500.

Availability: 60 to 90 days.

Bandpass Filters

565

With single-knob tuning



Covering a range of 0.5 Gc to 18 Gc, these bandpass filters give single-knob tuning of 2, 3, and 4-section cavities. The 81 models, for the uhf, L, S, C, X, and Ku bands, provide a variety of rejection characteristics. They are designed for laboratory and systems applications.

John Gombos Co., Inc., Dept. ED, Webro Road, Clifton, N. J.



CACHERIS

ADEN

SCHAFFNER

SAKIOTIS

People, Products, Potential...*a unique combination of imaginative ...of advanced ferrite devices and low-noise amplifiers... typifies*

The accelerated research and development program of Motorola's Solid State Devices Laboratory has produced a significant number of "firsts" in the past two years: the first broadband, microsecond ferrite switch at X-band; an S-band parametric amplifier with highest reported gain-bandwidth product; the first compact UHF isolator. These Motorola microwave devices—many others, as well—are already performing vital functions in advanced military

and industrial electronic systems. ★ Research emphasis continues for a growing number of devices. Included are VHF and microwave phase shifters, delay lines, circulators and switches for low-power, rapid, electronic control. Also, in progress are even more exotic microwave transmission and control devices, ultimately utilizing Motorola thin-film forms of ferrimagnetic, ferroelectric, semi-conductor, and piezoelectric solids. ★ As a result of its full-scale assault

MOTOROLA INC. / Solid State



DR. ARTHUR L. ADEN, PH. D. (Applied Physics); Manager, Solid State Electronics Dept.; applied physics, electrodynamics, solid state devices R&D, and microwave applications of magnetic ferrites.

JOHN C. CACHERIS, M.S.E.E.; Manager, Solid State Devices Laboratory; solid state devices R&D; awardee of several patents for microwave ferrite applications, and author of numerous technical publications.

NICHOLAS G. SAKIOTIS, B.E.E.; Section Head (microwave ferrite devices), Solid State Devices Laboratory; winner of several important awards, including the PGMTT Annual Award for Outstanding Contributor to the Microwave Art, 1956, and the Scientific Research Society of America "Applied Science Award", 1959.

DR. GERALD SCHAFFNER, PH. D. (E. E.); Section Head (low-noise amplifiers) Solid State Devices Laboratory; microwave device research and development, microwave instrumentation, and low-noise solid state amplifier design and development.

REPRESENTATIVE DEVICES

(for full details, circle appropriate number in coupon below):

1. *Compact UHF Isolators*: weigh less than 9 ozs. and occupy less than 6 cubic inches, provide more than 10 db isolation with low insertion loss.
2. *VHF and UHF Low-Noise Amplifiers*: VHF parametric amplifier tunable from 180-270 mc, high gain, requires only 1.0 milliwatt pump power. UHF parametric amplifier, similar in appearance, is tunable from 400-460 mc, yields 13 db gain, very low pump power.
3. *S-Band Parametric Amplifier*: features highest gain-bandwidth product presently available.
4. *X-Band Switching Circulator*: for advanced high-power applications and extreme environmental characteristics.
5. *High-Speed, Broadband Switch*: first broadband, microsecond solid state switch of its kind, better than 18% bandwidth at X-band.
6. *Broadband Y-Circulator*: offers 20 db isolation at C-band with 1/2 db insertion loss, can also be used as high-speed switch.
7. *Faraday Rotation Circulators*: employ high-performance ferrite material developed at Motorola, permit simultaneous use of single antenna for transmitting and receiving, even in CW systems.

*Engineered Reliability...
Precision Quality Control*

JOHN C. CACHERIS, *Manager, Solid State Devices Laboratory*
Solid State Electronics Department • Motorola Inc.
8201 East McDowell Road, Scottsdale 4, Arizona

Please send full details on the devices circled:

1 2 3 4 5 6 7

- Please send me solid state microwave devices applications information.
- Please have a representative call to discuss my microwave applications.
- I wish to consider an engineering proposal on my special problem (briefly outline requirements).

NAME _____

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*engineering leadership and planned development
Motorola's Solid State microwave capabilities.*

on the frontiers of solid state electronics, Motorola's broad range of engineering talent is particularly well qualified to analyse your problems. Rapid, economical and practical solutions are assured. For prompt attention to your device requirements, use coupon at right. ☆ *Experienced engineers and scientists desiring to participate in the forward area of solid state materials and integrated circuitry development, as well as in solid state device design, are invited to apply directly to Dr. Arthur L. Aden.*



Electronics Department

MICROWAVES

Broadband Y-Circulator

553

Range is 2.7 to 3.3 Gc



Model CS-902 is a lightweight, compact broadband Y-circulator for use in duplexing systems as well as with masers and parametric amplifiers. It covers a range of 2.7 to 3.3 Gc with a minimum isolation of 20 db and a maximum insertion loss of 0.4 db. The vswr is 1.3:1 max; power handling is 5 kw, peak. With a dummy load, this device can be used as a broadband isolator; with factory modifications, it can be used as a broadband iso-attenuator or amplitude modulator. Similar models are made for frequency ranges of 5.4 to 6.7 Gc, 6.8 to 8.0 Gc, and 2.2 to 2.4 Gc.

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

Availability: 30-day delivery.

Traveling-Wave Amplifier

582

Noise figure below 5 db

The WJ-212 traveling-wave amplifier covers the 1- to 2-Gc band with spot noise figures below 3 db and fixed-voltage noise figures below 5 db across the band. It is compatible in size, weight, and power supply requirements with present solenoid-focused low-noise tubes. Cathode-operating temperature is 650 C.

Watkins-Johnson Co., Dept. ED, 3333 Hillview Ave., Palo Alto, Calif.

Price: \$2,950.

Availability: 4 to 8 weeks.

← CIRCLE 206 ON READER-SERVICE CARD

a big step forward in
broadband RF amplification

OCTAVE RF AMPLIFIERS 40 to 600 mcs

- low noise figure • low power drain
- high gain • broadband operation
- flat gain characteristic



Model HFW Octave RF Amplifiers feature low noise, high gain, low power drain *plus* dependability and easy maintenance. Four basic amplifiers are available, with the following frequency responses:

40 to 80 mcs • 80 to 160 mcs
160 to 320 mcs • 300 to 600 mcs

Two additional units cover the 100-400 mcs region as follows:

100 to 200 mcs • 200 to 400 mcs

Conservatively speaking, these equipments offer a practical and realistic answer to nearly all broadband amplification requirements.

TYPICAL PERFORMANCE CHARACTERISTICS Model HFW-303

Input frequency:	300-600 mcs
Input, output impedance:	50 ohms
Input, output V.S.W.R.:	Less than 1.5 in bandpass region
Noise figure (average):	7 db
Gain:	30 db
Primary power requirements:	115 VAC, 60 cps
Size (L.W.H.):	19" x 12½" x 7"
Mounting dimensions:	Standard 19" relay rack

Write for further information.

Applied Research inc.

76 South Bayles Avenue, Port Washington, N. Y.

CIRCLE 207 ON READER-SERVICE CARD



MICROWAVES

Rotary Joint

504

Handles 4 megawatts peak

The inline type, high-power, rotary joint, model RJSL-1A, has a power handling capacity of 4 megawatts peak, and 25 kw average. It has coaxial non-contacting choke joints, ball bearings and an O-ring type pressure seal. Operating between 2,240 and 2,300 mc, the vswr is 1.2; insertion loss is 0.02 db. The flanges are type UG-435A/U.

Canoga Corp., Dept. ED, Box 550, Van Nuys, Calif.

Price: \$2,500 ca.

Availability: 60 days.

Signal Generator

579

Stability is 0.01 ppm



For operation in the Ka band, 32 to 37.5 Gc, the model 100 signal generator has a frequency stability of 0.01 ppm, short term, and 1 ppm, long term. Average power output is 15 mw. A rack-mounting configuration is available. Other models in this line provide coverage from L band to K band.

Strand Labs, Inc., Dept. ED, 294 Centre St., Newton 58, Mass.

Accuracy Is Our Policy . . .

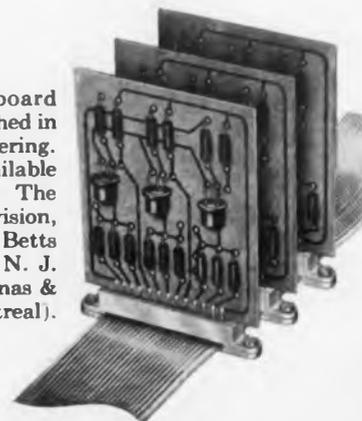
In the New Products description of a Ku-band isolator on page 153 of the Jan. 18 issue, the manufacturer's name was inadvertently omitted. The model IKuH8 isolator is made by Raytheon Co., Special Microwave Device Operations, 130 Second Ave., Waltham 54, Mass. It handles 135-kw peak and 100-w average power at frequencies between 16 and 17 Gc. Insertion loss is 0.3 db max; isolation is 13 db min, 20 db max. The 2.44-in. long unit, weighing 1.4 lb, has a vswr of 1.06 max. For further information on this Ku-band isolator, turn to the Reader-Service card and circle 405.

NEW... POS-E-KON

Trademark

PRINTED BOARD CONNECTORS

For Flat Conductor Cable
and Flexible Etched Circuitry . . .



Direct cable-to-board contact accomplished in seconds . . . no soldering. For details on available designs, write to The POS-E-KON Division, The Thomas & Betts Co., Elizabeth 1, N. J. (In Canada, Thomas & Betts Ltd., Montreal).

Ask For Publication P2-39



THOMAS & BETTS

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We specialize in heavy wire
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Equipped with the largest selection of winding machines, **UNIVERSAL** offers coils from 1/16" Fin. I.D. up to 30" O.D.

WIRE RANGE FROM #2—#30.

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The most COMPLETE line of TOROIDAL equipment in the world.

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ELECTRONIC DESIGN • February 15, 1961



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Hamburg Tang,
Chief Metallurgist
ALLOYS UNLIMITED

NEW CUSTOMED SOLDER PREFORMS IMPROVE AUTOMATIC SOLDERING

New customed preforms consist of an accurately predetermined amount of a specific alloy. The proper melting temperature and correct volume of solder are assured. Labor costs are lowered. Production increases. Scrap is eliminated. Get the facts today! Write for 8 page Guide to Preform Soldering.

21-01 43rd Ave., Long Island City 1, N. Y.

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PLASTIC EXTRUSIONS...ANY SHAPE OR SIZE

ACE is one of America's leading mass producers of plastic extrusions and all types of precision parts. Any shape, form or color. Any type of plastic. Small runs or large runs. Huge stocks for immediate delivery. Quick, low-cost service on specials. Write, wire or call for samples, price lists and technical bulletins.

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ACE PLASTIC COMPANY 91-58 VAN WYCK EXPWY. JAMAICA 35, N. Y.
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ELECTRONIC DESIGN • February 15, 1961

MICROWAVES

Backward-Wave Oscillator 564 For Ku band



For use in the Ku band, the 326H permanent-magnet backward-wave oscillator tube is designed for use in test equipment and commercial instrumentation. Operating from 12.4 to 18 Gc, output is 10-mw min, rising to 65 mw in the center of the band.

Hughes Aircraft Co., Microwave Tube Div., Dept. ED, 11105 Anza Ave., Los Angeles 45.

Broad-Banded Absorbers 409

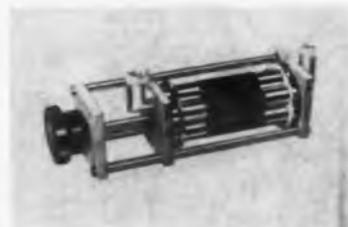
These absorbers, known as types BB and BP, provide attenuation from 35,000 mc down. It is down to 50 mc in the case of the BB-96. Fire resistant and rugged, the need for a supporting structure has been eliminated in the erection of these "building-block" absorbers.

McMillan, Dept. ED, Brownsville Ave., Ipswich, Mass.

Price: \$5 per sq ft and up.

Availability: Delivered in 4 weeks.

Turret Attenuator 410 Usable to 10 Gc



The AS series of coaxial turret attenuators is usable up to 10 Gc. They give a choice of 6 values of attenuation from 0 to 20 db, with an accuracy of ± 0.5 db; max vswr is 1.4:1 from 4 to 10 Gc. The devices, which may be mounted on panel or chassis, are normally supplied with type N female connectors; types BNC, TNC, C, and HN are available.

Microlab, Dept. ED, 570 Mount Pleasant Ave., Livingston, N.J.

Price: \$280 ea.

Availability: From stock.

NOW... S-BAND, NON-DEGENERATE AMPLIFIERS

with bandwidths up to 75 mc
at 15 db gain!



FOR MILITARY ENVIRONMENTS!

Broadband parametric amplifiers for applications at L, S, C, and X band are available now from Texas Instruments. The S-band model, designed with a TI XD-500 gallium arsenide diode, gives bandwidths up to 75 mc at 15 db gain. Gain variation is no greater than 3 db over temperatures ranging from -40°C to $+50^{\circ}\text{C}$, and the unit meets the vibration requirements of MIL-E-5400D. Noise figure, including circulator loss is 3 db. The associated circulator is a miniaturized, three-port ferrite unit with 0.5 db insertion loss and 20 db isolation.

TYPICAL MODEL S-22 SERIES SPECIFICATIONS

frequency	2.8 to 2.96 Gc
bandwidth	40 mc
gain	15 db
noise figure (includes circulator loss)	3 db
pump frequency diode	X band Texas Instruments XD-500 $F_c \cong 70$ kmc at -2v bias
temperature range	-40°C to $+50^{\circ}\text{C}$
vibration	per MIL-E-5400D
pump power	50 mw

For details on TI's S-band amplifiers, write for Bulletin No. DLA-1217. For information on specific applications at all frequencies, contact **MARKETING DEPARTMENT**.

TEXAS  INSTRUMENTS
INCORPORATED
P. O. BOX 6015
DALLAS 22, TEXAS
APPARATUS DIVISION

CIRCLE 212 ON READER-SERVICE CARD

PRD previews/reviews/design notes

Measuring Microwave Frequencies

Of the four basic microwave measurements, i.e., (1) VSWR (2) Power (3) Attenuation and (4) Frequency, the latter is probably the easiest to determine. There are available, of course, many frequency meters with varying degrees of accuracy. These are generally either tunable cavity-type resonators or devices which utilize a harmonic of a low frequency standard.

Cavity Frequency Meters

Cavity-type frequency meters, both coaxial and waveguide, make use of the absorption (reaction) or transmission properties of selectively tuned resonators. In use, the meter is inserted between the signal source and the r-f detector indicator. The reaction or absorption type instrument is tuned to obtain a decrease in power level at the detector and, consequently, is particularly useful as a search frequency meter. The transmission type unit passes only those frequencies within the pass band of the resonant cavity and so is most convenient for monitoring or filtering purposes.

Of the dozens of frequency meters available from PRD, among the most popular and simplest to use are the

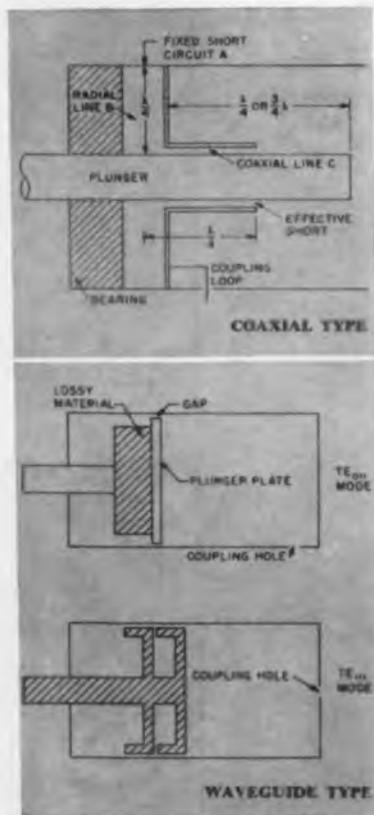


PRD 555

PRD 555-579 Series. They are high precision, direct reading, hermetically sealed, temperature compensated instruments and are particularly useful for laboratory and production line testing or as secondary standards.

At X band frequencies the PRD 559-A or B, which are available in both reaction and transmission types, are accurate to 0.015% with readout directly in megacycles.

Typical cross sectional views are shown for both coaxial and waveguide resonating cavities in this series of precision meters.



UHF Frequency Meter

Another popular and useful meter in the UHF television band is the PRD 587-A, which is accurate to $\pm 0.2\%$. It can be used for alignment of tuned circuits and oscillators in the frequency range of 250 to 1000 megacycles. The direct reading dial has a scale length of 60 inches for easy and accurate readout. For convenience and protection

CIRCLE 213 ON READER-SERVICE CARD

the meter is housed in a metal carrying case with a handle.



PRD 587-A

Precision Heterodyne Frequency Meter

An instrument that uses the heterodyne principle with a crystal oscillator as its standard is the PRD 504 Precision



PRD 504

Heterodyne Frequency Meter. It has an extended range of 100 to 10,000 megacycles and is accurate to 0.002%. This versatile and portable instrument is used for laboratory and field testing of transmitters, receivers, and signal generators. A cathode ray tube is provided for zero-beat indication on the front panel.

If you would like some assistance with your frequency measuring problems, please contact our Applications Engineering Department.

We have many interesting openings for engineers...contact Mr. John R. Zabka

PRD
ELECTRONICS, INC.
A Subsidiary of Harris-Intertype Corporation
Formerly Polytechnic Research & Development Co., Inc.

209 Tillary Street, Brooklyn 1, N. Y.
1/Leter 2-6800
1808 Costinela Ave., Inglewood, Cal.
ORegon 8-8923



Chart Stamp

556

For microwave impedance



This microwave impedance chart stamp, No. RRDP-1, makes a clear, scaled impression of the Smith chart. Designed primarily to stamp notebooks for plotting recorded data, it obviates pasting in the conventional paper charts.

Radar Design Corp., Dept. ED, Pickard Drive, Syracuse 11, N.Y.

Price: \$9.50 each.

Availability: From stock.

High-Speed Microwave Switch 743

Consists of three identical switching cells

This high-speed microwave switch consists of three identical switching cells. Each cell has 17-db isolation and 1.5-db insertion loss. Specifications include: rise time, 10 nsec max; decay time, 10 nsec max; frequency, 5.4 to 5.9 kmc; isolation, 40 db min; insertion loss, 4.8 db max; power requirement, 150 mw.

General Precision Inc., Kearfott Div., Dept. ED, 14844 Oxnard St., Van Nuys, Calif.

Price: On request, to customer specs.

Availability: 60 days.

Tunable RF Filters 580

Insertion loss under 1.5 db

The TTF series of tunable rf filters uses 5 resonant line sections, capacity loaded to tune over a 2:1 range. The Q of each section is over 500; insertion loss is less than 1.5 db. For general use, they operate at 50-ohms impedance, have a vswr of 1.5:1 max and an rf leakage over 120 db below the input level. Four models cover ranges between 250 and 2,500 mc, each with a 5% bandwidth. Cabinet models measure 7 x 5 x 10 in.; panel size for rack mounting is 6-3/4 x 4-3/4 in. Type BNC connectors are standard, with TNC or N types available.

Telonic Engineering Corp., Dept. ED, Laguna Beach, Calif.

MICROWAVES

Air Dryer

406

Delivers 600 cu ft per day



The model 600 pole-mounted air dryer will deliver 600 standard cu ft of dry air per day at pressures from 0 to 15 psig. The fully automatic unit, encased in an aluminum cabinet, operates within an ambient temperature range of -40 F to 120 F. Compression, cooling, and desiccation will reduce the relative humidity of hot air from 100% to less than 2% at 70 F.

Puregas Equipment Corp., Dept. ED, Copiague, N.Y.

Waveguide Plug

491

This fast-opening and-closing rectangular plug is designed for pressure-testing microwave waveguides. It provides an air-tight seal for the ends of waveguide sections and may be put in place or removed quickly during pressure-testing operations. They are available in a wide variety of sizes and shapes.

Moeller Manufacturing Co., Dept. ED, Racine, Wis.

Flexible Absorber

408

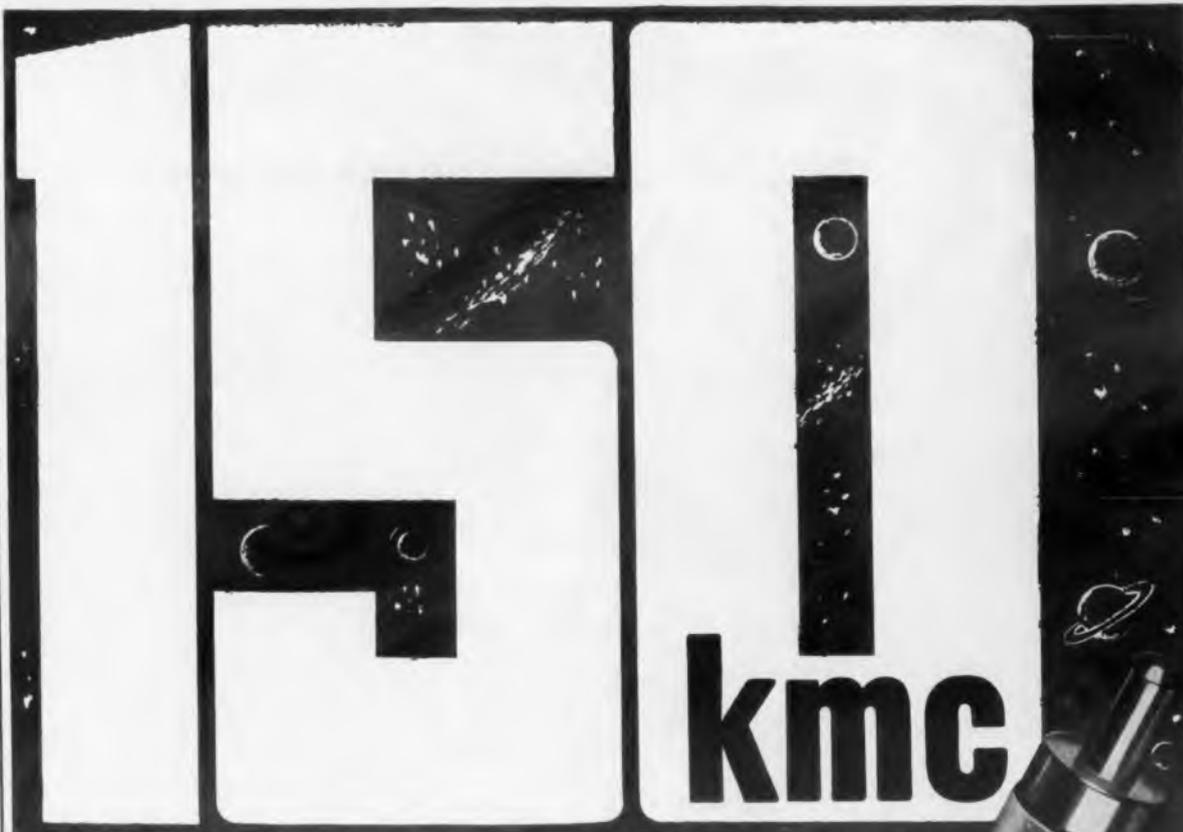
Is easily worked, non-breakable



With an attenuation of 50 db per cm at 8.2 Gc, this encapsulated ferrite, designated CMA-450, provides the electrical properties of a rigid material, yet is easily worked and non-breakable. Its dielectric constant is 10 at 20 mc.

Custom Components, Inc., Dept. ED, Caldwell, N.J.

Availability: 10-day delivery from stock.



GALLIUM ARSENIDE VARACTOR DIODES

FROM

TYCO SEMICONDUCTOR CORP.

ARE

- Readily Available
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- Conventionally Packaged
- Sensibly Priced

You can now realize low noise, high frequency performance in your microwave applications with the new Tyco Semiconductor AP-1 series of point contact gallium arsenide varactor diodes.

The AP-1 series is packaged in a conventional double ended ceramic/metal cartridge furnished with an adapter to convert to single ended use or can readily be fabricated in a variety of package configurations on short notice to meet your specific size requirements. All Tyco Semiconductor varactors are subjected to rigid electrical inspection and temperature cycling prior to shipment.

Immediate shipment at sensible pricing of TSC AP-1 series varactor diodes will assure you of high performance in your parametric amplifier, harmonic generator and other advanced microwave applications.

For additional information — or immediate shipment, Call or Write:



TYCO SEMICONDUCTOR

C O R P O R A T I O N
BEAR HILL · WALTHAM 54 · MASSACHUSETTS

TWINBROOK 9-2400



Electrical Characteristics (Measured at 25°C Ambient Temperature)

Sym.	Parameter	Test Conditions	AP-1	AP-2	AP-3	AP-4	AP-5	AP-6	Unit
BV_R	Reverse Breakdown	$I_R = 10 \mu A$	6.0 min for Entire Series						V
C_T^*	Total Capacitance	$V = 0, f = 1mc$	.5 to 1.5 for Entire Series						μF
Q^{**}	Figure of Merit	$V_R = 2V, f = 10 kmc$	6 min	7 min	9 min	11 min	13 min	15 min	
f_{CO}	Cut-off Frequency	$V_R = 2V$	80 min	70 min	90 min	110 min	130 min	150 min	kmc

*Case Capacitance is 0.4 μF nominal

** $Q = \frac{1}{\omega C_j} = \frac{1}{\omega C_j}$ where C_j is the junction capacitance measured at -2.0 volts



family potrait!

Met the *whole* Ace family yet? Or have your requirements to date in precision pots been only in $\frac{1}{2}$ " or wirewound? The famous Ace reliability, quality control and mass production facilities are not just limited to the above, no sir! Just consider Ace's *complete* range of standard sizes for instance — not just $\frac{1}{2}$ ", $\frac{3}{4}$ ", $\frac{7}{8}$ ", $1\frac{1}{16}$ ", but sizes including A.I.A., up to 6"!

All these, in bushing, servo and universal mounts, in potentiometer and trimmer parameters. And . . . there are specials, multi-gangs, quick-cup-change designs, linear and non-linears and rectilinears — all in standard and special accuracies and conformities, both in wire-wound and conductive plastic. In short, when you can get Ace-quality in your every potentiometer need, get it the easy way: see your ACErep! Write for complete catalog!



This 3" AIA ACEPOT® (shown 1/3-scale) meeting all MIL specs, is available, in a range of accuracies, for prompt delivery.

ACE ELECTRONICS ASSOCIATES, INC.
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 SOMerset 6-5130 TMX SMVL 181 West. Union WUX

Acepot® Acetrim® Acetoset® Acopohm® *Reg. Appl. Int.

CIRCLE 215 ON READER-SERVICE CARD



Absorption Wavemeters

With direct readout

570



This series of three broadband wavemeters, with direct readout, gives full coverage from 1 to 8 Gc with an accuracy of 0.07%. The readout device consists of a precision film-driving mechanism. All units have N-type connectors. Absorption is 10% min; loaded Q is 1,000.

Frequency Standards, Dept. ED, P. O. Box 504, Asbury Park, N.J.

Availability: 30-day delivery.

FM Deviation Meter

583

Range is 4 to 1,024 mc

Carrier-frequency range of the model 791D fm deviation meter is 4 to 1,024 mc. Deviation is read directly from 200 cps to 125 kc, or down to 10 cps with external readout. A counter type discriminator gives deviation-measuring accuracy of 3%, verifiable against an internal standard.

Marconi Instruments, Dept. ED, 111 Cedar Lane, Englewood, N. J.

Pi-Line Attenuator

576

Diameter is 3 in.



A miniature, S-type continuously variable π -line attenuator, the model No. 4426-10 has a diameter of 3 in. Frequency range is 2 to 4 Gc; attenuation range is 0 to 10 db. The vswr is 1.30 max, and insertion loss is 0.2 db max. It will handle 10 w average power, or up to 5 kw peak.

Antenna & Radome Associates, Dept. ED, 27 Bond St., Westbury, N.Y.

Price: \$220.

Availability: 4-week delivery.



New TRAK Type 2959,
1.5 KMc, tuneable
± 50 Mc

NEW Miniature MICROWAVE OSCILLATOR CAVITIES

now available

TRAK Electronics Company, Wilton, Connecticut, announces the formation of TRAK MICROWAVE CORPORATION to increase its developmental facilities for triode cavities in r-f signal generation from 500 Mc upwards. Present low, medium and high power cavities are available for application in grid pulse, plate pulse, and CW service.

TRAK expanded its Microwave Cavity line, which started in 1949, by adding the following 7 NEW miniature Cavities in 1960:

TRAK Type 9127-L	At 1090 Mc, tuneable ± 25 Mc, available from 900—1200 Mc.
TRAK Type 2958	At 925 Mc, tuneable ± 50 Mc, available from 500—2200 Mc.
TRAK Type 2959	At 1.5 KMc, tuneable ± 50 Mc, available from 500—2200 Mc.
TRAK Type 9127-SL	At 2 KMc, tuneable ± 100 Mc, available from 800—7000 Mc.
TRAK Type 9127-S	Available in 3 segments of S-Band: 2700—3000 Mc, 3000—3300 Mc, 3300—3600 Mc.
TRAK Type C-3138	Tuneable 2700—3400 Mc.
TRAK Type 9127-C	Tuneable 5400—5900 Mc.

ALSO, OSCILLATORS ENGINEERED to your specifications!

We invite you to write for new TRAK MICROWAVE CAVITY BULLETIN.



TRAK MICROWAVE CORPORATION
Subsidiary of
TRAK Electronics Company
5006 N. Coolidge Avenue
Tampa 3, Florida
REdwood 6-6422

CIRCLE 216 ON READER-SERVICE CARD
ELECTRONIC DESIGN " February 15, 1961

MICROWAVES

Radar Test Set 559
For 3-cm band



For use with radar equipment operating in the 3-cm band, 8.5 to 9.6 Gc, the test set type 8GM1003 measures peak and average power, noise level, magnetron and klystron frequency, magnetron pulse envelope, vswr, if bandpass and, in combination with an oscilloscope, the frequency spectrum of the magnetron pulse. Power requirement is 110 to 245 v, 40 to 60 cps.

N. V. Philips' Gloeilampenfabrieken, EMA Dept., Dept. ED, Eindhoven, The Netherlands.

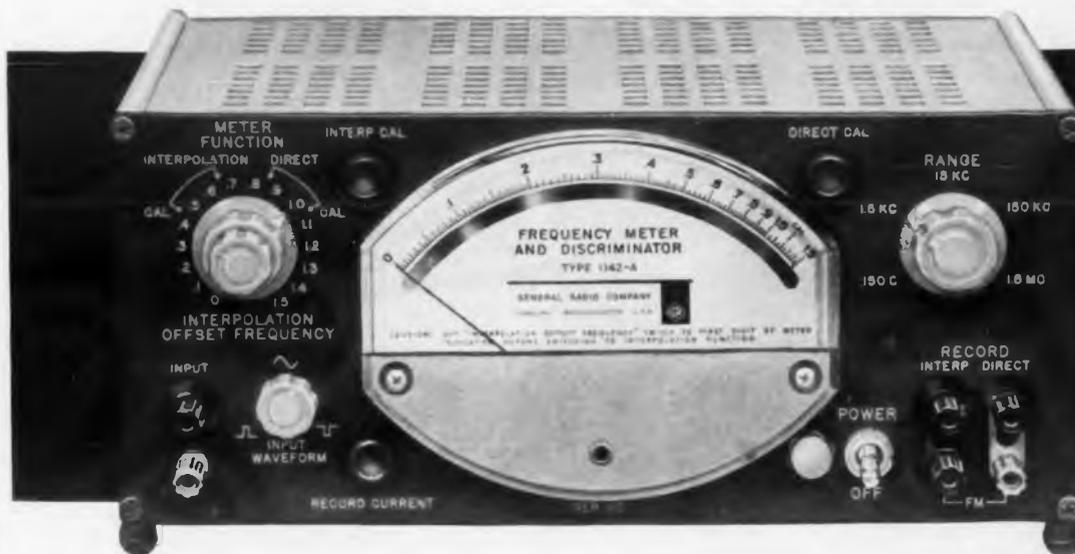
RF Diodes 563
With all-glass construction



This series of subminiature silicon point-contact diodes, of all-glass construction, is designed for use in rf circuitry. The 1N830 series is recommended for vhf and uhf video detection and general-purpose rf rectification in coaxial and printed-circuit applications. The 1N831 series is designed for low-noise rf mixer applications at signal frequencies below 4 Gc. The 1N832 series, for low-noise broadband mixer use between 4 and 10 Gc, replaces 1N23 and 1N415 types. Microwave Associates, Inc., Dept. ED, Burlington, Mass.

CIRCLE 217 ON READER-SERVICE CARD ▶

New Frequency Meter and Discriminator



3c to
1.5 Mc,
Direct Reading,
±0.2% Accuracy

... Simple, Direct Frequency Measurements

... Simplifies Recording of Drift and Stability

... A Highly Linear Pulse-Count Discriminator
for Measurements of FM Deviation and Incidental FM.

FREQUENCY METER

- Logarithmic meter maintains constant accuracy, even at one-tenth of full scale.
- Calibrated interpolator . . . effectively expands meter scale by a factor of 10 . . . permits readings to 3 significant figures from any of the 15 preset references on each range.
- Higher frequency measurements can be made by heterodyne techniques. This method also permits drift measurements up to one part in 10⁶, or better, when using stable frequency standards.
- Readings independent of input waveform. Sensitivity: 20 mv rms from 20c to 150 kc, rising to 200 mv at 3c and 1.5 Mc.
- Built-in calibration.

Type 1142-A
Frequency Meter and
Discriminator . . .
\$495

DISCRIMINATOR

- Output: 15v, full scale, on all ranges
- Low Noise: Residual fm more than 100 db below full output
- Linearity: Same as output current accuracy statement

RECORDER OUTPUTS

- Adjustable output provides current proportional to input frequency up to 5 ma to drive recorders.
- Interpolator output for high-impedance recorders provides voltage proportional to frequency deviation from preset references.

A C C U R A C Y

Output Current:
±0.05% of range setting +0.05% of measured frequency, below 15 kc; ±0.1% of range setting +0.1% of measured frequency above 15 kc

Additional Meter Error:
Direct reading, ±1% above 10% of full scale. Interpolating, ±0.1% of range switch setting.

Write For Complete Information

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- *Greatest versatility!*
- *Highest accuracy!*
- *Widest range!*

NARDA transistorized POWER METER

What's most important to you in a power meter? Accuracy? Portability? Independence from line voltage deviations? Wide range? Stability? Rapid warm-up?

Not that you have to make a choice... or a compromise... any longer. The Narda Model 440 Power Meter gives you all these features! Completely transistorized and powered by a nickel-cadmium battery, rechargeable during operation or overnight, it offers two low-power scales in addition to the five standard scales (see below), a built-in charger with



MODEL 440... \$250

state-of-charge indicator and protection against overcharging, and freedom from internal heating caused by vacuum tubes.

Moreover, the 440 provides up to 18 ma bias current, enabling you to use the widest selection of bolometers and thermistors. In short, the 440 is the most versatile unit available to provide accurate direct-reading measurements of cw or pulsed-power automatically, over any frequency range for which there are bolometer or thermistor mounts. For complete data, contact your nearest Narda representative, or write us directly. Address: Dept. ED-11.

SPECIFICATIONS

POWER RANGES: 7 SCALES

•0.01 mw full scale	.....	-30 to -20dbm
•0.03 mw full scale	.....	-25 to -15dbm
0.1 mw full scale	.....	-20 to -10dbm
0.3 mw full scale	.....	-15 to -5dbm
1.0 mw full scale	.....	-10 to 0dbm
3.0 mw full scale	.....	-5 to +5dbm
10 mw full scale	.....	0 to +10dbm

*4.5 ma bolometers give best results on these scales.

Range Switch: 0.01 to 10 mw (full scale)

Accuracy: 3% of full scale reading

Bolometers & Thermistors: All 100 and 200 ohm, requiring up to 18 ma bias.

Battery Charger: Built-in; continuous or overnight. (Battery operable 16 hrs. before recharge required.)



MICROWAVES PRODUCTS

Aluminum Oxide Ceramic 399

For radome applications

Type AD-995, 99.5% aluminum oxide ceramic, was designed for radome applications. At 9,200 mc, loss tangent at room temperature is 5.9×10^{-5} . With a dielectric constant of 9.27, the loss factor at room temperature is 5.5×10^{-4} at 9,200 mc. Flexural strength is 28,900 psi at 2,000 F and 15,300 psi at 2,500 F. Maximum working temperature is 3,200 F. Specific gravity is 3.8.

Coors Porcelain Co., Dept. ED, 600 Ninth St., Golden, Colo.

Price: Depends on configuration of custom parts. *Availability:* Made to order, 8 to 10 weeks.

Absorbing Plastic 505

Temperature range -70 C to +150 C



This absorbing plastic, called Microloss, can be used from -70 C to +150 C without deterioration. It may be easily worked into medium power attenuators, mode absorbing rings, etc. It will not support fungus growth. The plastic is available in 12-in. rod lengths, round or rectangular.

Coax Devices, Dept. ED, Box V, Chelsea 50, Mass.

Price: \$30 to \$60, standard shapes.

Power Loads 400

To 50 w at 1 Gc

The PL series of power loads has 12 models covering a frequency range of 300 to 1,000 mc, with power capacity of 10, 25, or 50 w cw. Termination is a molded, non-resistive ferrite absorber, giving a vswr of 1.20:1 max. Peak power capacity is 1,000 times the average rating. The loads are available with BNC, TNC, N, or C connectors and are furnished calibrated at 4 frequencies.

Maury & Associates, Dept. ED, 10373 Mills Ave., Pomona, Calif.

Price: \$75 to \$92.50.

Availability: 2 to 3 weeks.



the narda microwave corporation

118-160 HERRICKS ROAD, MINEOLA, L. I., N. Y. • PIONEER 6 4650

CIRCLE 218 ON READER-SERVICE CARD

Coaxial Attenuator**507**

Handles 100 w cw



This modified version of the model AU-10 can withstand 100 w of cw power for 24 hours with no change in performance characteristics. Insertion loss is zero. The device provides up to 60 db of attenuation in the 300 mc to 5 Gc range.

Merrimac Research & Development, Inc., Dept. ED, 517 Lyons Ave., Irvington, N.J.

Metal-Film Resistance Cards**401**

For microwave attenuation

These metal-film resistance cards can be punched, drilled, sheared and machined. They measure 5 x 12 in. and have thicknesses of 0.025, 0.032 and 0.062 in. Resistivity range is 25 to 750 ohms per square. Maximum surface temperature should be held to 130 C. Standard values include 50, 100, 125, 150, 180, 200, 300, 377, 400 and 500 ohms per square. Applications include use as microwave attenuators and terminations.

Filmohm Corp., Dept. ED, 48 W. 25th St., New York 10, N.Y.

Availability: From stock.

Waveguide Shorting Switches**502**

Ranges from 2.6 to 40 Gc



The model 80 waveguide shorting switch series covers the frequency range of 2.6 to 40 Gc with 8 sizes. The vswr in open position is 1.02 max; in the closed or shorted position, vswr is 125 min. The hand-operated, plunger type switches are made of standard waveguide and flanges. Insertion loss is negligible in the open position. Solenoid relay actuation is available on request.

Waveline Inc., Dept. ED, Caldwell, N.J.

1 kw Hughes traveling wave tubes in S-Band



Now available in production quantities, these new and improved tubes offer you 1 kw of pulsed output power, with low power input, minimum heat generation and high reliability.

All these Hughes S-band tubes are lightweight, compact and ruggedly built to withstand the most severe environmental conditions—and provide long life. Each has been fully tested in the field.

Three of these tubes provide full octave frequency ranges of 2.0 to 4.0 kmc and you have a choice of either 1/2 or 1% duty, in either ungridded or gridded versions, and with gains up to 37 db. All are permanent magnet periodically focused.



311H Gridded, 1 kw minimum peak power output, 1% duty, 36 db small signal gain @ 50 mw input. Weight: 13 lbs. Length: 17-7/16". Meets usual customer requirements of MIL-E-5400, Class I environmental tests.



312H Gridded 1 kw minimum peak power output, 1/2% duty, 36 db small signal gain @ 50 mw input. Weight: 11 lbs. Length: 15-3/8". Meets usual customer requirements of MIL-E-5400, Class I environmental tests.



304H Ungridded, 1 kw minimum peak power output, 1% duty, 37 db small signal gain @ 1 mw input. Weight: 12 1/2 lbs. Length: 17-31/32". Meets usual customer requirements of MIL-E-5400, Class I environmental tests.



313H Ungridded, 1 kw minimum peak power output over the center portion of the band, 1/2% duty, 36 db small signal gain @ 1 mw input. Weight: 17 1/2 lbs. Length: 16-5/8". Meets usual customer requirements of MIL-E-1 environmental tests.

For information wire or write:
11105 Anza Ave.
Los Angeles 45, Calif.

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2 watts



4 watts



and 7 watts

in hundreds of resistance values, tapers, shafts and multi-ganged arrangements. And we're famous for engineering special models and delivering them at economical prices. Mallory Controls Company, Frankfort, Ind.

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& jacks



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controls



vitreous
enamel resistors



rotary
switches

CIRCLE 220 ON READER-SERVICE CARD



MICROWAVES PRODUCTS

Waveguide Duplexers

Are balanced type

398



These balanced waveguide duplexers are claimed to minimize incoming signal loss to the receiver, and to provide matching over a broader frequency range and greater protection against receiver crystal burnout than is possible with the branched duplexer. Units are available in L, S, C, S1, Ku, K, Ka, and X bands. The duplexer shown is designed for frequencies of 8,490 to 9,578 mc at a transmitter power of 200 kw max; duplexer loss is 1.2 db max, and isolation is 10 db min. The vswr is 1.4 max; vrwr high level is 1.2 max.

Bomac Laboratories, Inc., Dept. ED, Salem Road, Beverly, Mass.

Microwave Amplifiers

10- to 15-db noise

578



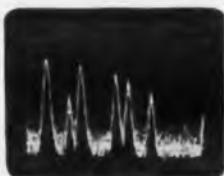
Covering a frequency range from 500 mc to 18 Gc, the 5000 series amplifiers provides 10- to 15-db noise figures with 25-db or more gain. Each unit consists of traveling wave tube, power supply, and a focusing solenoid with power supply if required. Each power source has a wide adjustment range so that new tube types may be accommodated. The tube may be directly coupled to a front panel BNC connector for external modulation. The units may be operated with input power from 50 to 450 cps.

Alfred Electronics, Dept. ED, 897 Commercial St., Palo Alto, Calif.

Price: From \$3,150 to \$5,500.

Availability: 60-day delivery.

Discrete signals in noise background are easily detected and measured on SB-7bZ display. Automatic high sampling rate (6.7/sec.) speeds measurements.



versatility + economy

Panoramic's ULTRASONIC SPECTRUM ANALYZER SB-7bZ

200 cps to 300kc



Up to 25 μ v sensitivity and exceptional dynamic range with simple, convenient operation are combined in one compact, low-priced instrument. Standard equipment at military installations and in industry, the SB-7bZ is ideally suited for:

- Ultrasonic noise and vibration analysis
- Communication system analysis—wire carrier and VLF radio
- FM Telemetry subcarrier channel analysis
- General Fourier analysis

The SB-7bZ features:

- Variable sweep width: 0 to 200kc
- Amplitude scales: 40db log, 20db linear and 2.5db expanded
- Resolution: variable from 100 cps to 2kc
- Sensitivity: 25 μ v for full scale deflection, calibrated to measure signals as low as 25 μ v
- Sweep rate: 6.7/sec., synchronized to power line, plus provisions for variable sweep rates when used with accessory equipment
- 5" high-persistence CRT Tube

Write, wire, phone now for detailed specifications bulletin; and ask to be put on our regular mailing list or the PANORAMIC ANALYZER featuring application data.



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CIRCLE 221 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

Isolate and gate a pulse. Intensified pulse has been isolated by a Model SD-1 Multi-pulse Spectrum Selector.



Analyze the pulse on the scope of any Polarad Spectrum Analyzer.*



COMPLEX SPECTRUM DECODING

10 to 44,000 mc.

**Signal Analysis for
Missiles, Telemetry, IFF,
Beacons and Radar**

The Polarad spectrum selector permits spectrum analysis and decoding of any selected pulse within a multiple pulse train. Sweep, gate width and position can be controlled. Model SD-1 permits the selection and gating of a group of pulses up to 180 μ sec. in length (Model SD-IX permits 350 μ sec.)

Works with POLARAD Models TSA, TSA-S, TSA-W, SA-84 and SA-84W spectrum analyzers.

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43-20 34th St., Long Island City 1, N. Y.

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for specifications. Ask your nearest Polarad representative (in the Yellow Pages) for a copy of "Notes on Microwave Measurements."

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INSTRUMENTS

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Representatives in principal cities.

Microwave Components

558

For 4-mm and 2-mm bands



A series of microwave components for generation, detection and measurement in the 4-mm and 2-mm band is available. The units are of original design rather than scaled down from the longer bands. The series features a claw-flange construction for optimum coupling.

N. V. Philips' Gloeilampenfabrieken, EMA Dept., Dept. ED, Eindhoven, The Netherlands.

Standing-Wave Detector

560

For vswr of 1.03 to 300



A precision standing-wave detector for the 8-mm band, the type PP 4382 Q measures vswr from 1.03 to 300. Frequency range is 31 to 36 Gc. Probe carrier displacement is 30-mm max, with an accuracy of adjustment to 0.01 mm. Probe penetration is adjustable to 2 mm. Flanges are Franco-British standard type Z.83.0019.

N. V. Philips' Gloeilampenfabrieken, EMA Dept., Dept. ED, Eindhoven, The Netherlands.

CIRCLE 222 ON READER SERVICE CARD ►

get the size, specs and mobility you need with

SANBORN RECORDERS

2 Channels . . . 35" high mobile cart
. . . choice of 4 plug-in preamps

Interchangeable plug-in "850" type preamplifiers in Carrier, DC Coupling, Phase Sensitive Demodulator and Low Level types, for inputs ranging from microvolts to hundreds of volts . . . Internal MOPA available when carrier or chopper excitation is required . . . heated stylus, rectangular coordinate recording on 50 mm wide channels . . . transistorized circuits . . . frequency response to 125 cps within 3 db, at 10 mm peak-to-peak. Model 297 can also be used in optional portable case or rack mounted in 10½" of panel space.



1 Channel . . . 20 lbs. briefcase size
. . . 10 mv/div DC Model . . .
10 mv rms/div AC strain gage Model

Extremely compact, highly versatile recorders for general purpose DC inputs (Model 299) and AC strain gage recording (Model 301). Two chart speeds: 5 and 50 mm/sec . . . inkless, rectangular coordinate recording . . . response from DC to 100 cps within 3 db, at 10 div peak-to-peak . . . gain stability better than 1% to 50°C and for line voltage variation from 103 to 127 volts. Model 299 has balanced to ground input, 10 switch-selected sensitivities, calibrated zero suppression. Model 301 has wide sensitivity ranges, can be used with strain gages and inductive transducers, provides excitation voltage of approximately 4.5 volts rms at 2400 cps, and has uncalibrated zero suppression.

Two 50 mm wide channels . . . separate floating input DC amplifiers . . . 4 chart speeds . . . mv or volt inputs

Operate this 1-cubic-foot recorder vertically, horizontally, or tilted at a 20° angle on carrying handle. Inputs are floating and guarded . . . 12 sensitivities from 0.5 mv/mm to 20 v/cm . . . response DC to 125 cps within 3 db, at 10 div peak-to-peak . . . max. non-linearity 0.25 mm . . . common mode rejection 140 db min. DC . . . built-in 10 mv calibration signal and electrical limiting . . . internal 1 sec. timer . . . monitor output connectors for each channel. Galvanometers are rugged, low impedance type with velocity feedback damping; most circuitry for each channel is mounted on a single, easily serviced card.



For complete details contact your nearest Sanborn Sales-Engineering representative. Sales representatives are located in major cities throughout the United States, Canada and foreign countries.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman Street, Waltham 54, Massachusetts

SIMPLE. RELIABLE

DIRECT CONTROL PROGRAMMING



**INDUSTRIAL
TIMER** PUNCHED CARD
AND
PUNCHED TAPE
**PROGRAMMING
EQUIPMENT**

Automatic equipment designed to provide direct control, without coding or decoding, for as many as 85 individual load circuits, through 30 or more different steps of an industrial process.

The Programmer is governed by a simple, punched vinyl card. The card or tape is advanced from position to position by a simple external switch closure signalled by feedback, time, limit switch, thermostat, and many others.

Programming equipment operated by punched tape is also available. Modular design permits addition of accessory banks of memory-type load relays. Industrial Timer Programmers are now in use for the automatic control of steel and aluminum blooming mills, structural steel fabrication, batching solid rocket fuels, and many other industrial processes.

Complete information in Bulletin 100, sent on request. Write or phone.



INDUSTRIAL TIMER CORPORATION

1419 McCarter Highway
Newark 4, New Jersey

CIRCLE 223 ON READER-SERVICE CARD



MICROWAVES PRODUCTS

Coaxial Load

554

Rated at 300 w



Model DRL-9LT, with LT connectors, is a 300-w load for use in the 1- to 6-Gc frequency range. It is also available with type N or 7/8-in. line connectors.

Radar Design Corp., Dept. ED, Pickard Drive, Syracuse 11, N. Y.

Price: \$225.

Availability: Delivery from stock.

Broadband Isolator

402

Isolation is 30 db min

The broadband isolator model X11OLI, 5-in. long, provides a minimum isolation of 30 db with a maximum vswr of 1.10 and a maximum insertion loss of 1.0 db over a range of 8.2 to 12.4 Gc.

E & M Laboratories, Dept. ED, P. O. Box 2427, Van Nuys Station, Van Nuys, Calif.

Price: \$175 ea; \$85 to \$160 ea, 6 to 1,000 units.

Availability: 14-day delivery from stock.

Coaxial Attenuator

403

Variable 0 to 500 mc



The coaxial attenuator, model RDA-1196, is continuously variable from 0 to 25 db over the frequency range of 0 to 500 mc, with an accuracy of ± 0.5 db. Insertion loss is 1 db maximum. Type BNC connectors are standard; TNC and N available.

Radar Design Corp., Dept. ED, Pickard Drive, Syracuse 11, N.Y.

Price: \$185.

Availability: From stock after Jan. 1.

**Large changes in
Inductance,
Electrically**



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CIRCLE 225 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

**Antenna Cover**

552

Withstands 50-lb force



These conical, fiber glass covers, called Para-Dome, are designed to withstand a wind force of 50 lb per sq ft. Signal attenuation between 2,000 and 6,200 mc is less than 0.1 db. Standard models cover reflectors of 4, 6, 8 and 10 ft.

Tower Construction Co., Dept. ED, 2700 Hawkeye Drive, Sioux City, Iowa.
Availability: 15-day delivery.

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404

For twt stack applications

Type F-310, barium ferrite permanent magnetic material, is for periodically focused twt stack applications. Properties include: residual induction, 2,190 gauss; coercive force, 1,850 oersteds; intrinsic coercive force, 3,450 oersteds; electrical resistivity, 10×10^6 ohm per cm at 25 C. Temperature is 450 C.

D. M. Steward Manufacturing Co., Dept. ED, Chattanooga, Tenn.

Price: On request.

Availability: 4 weeks.

Slotted Sections

555

Type C



Model RDZ-1237C is one of a series of precision slotted sections with type N, BNC, TNC, HN or LT series connector in the 1.5- to 12.4-Gc range. The section has a residual vswr of 1.06 max to 12.4 Gc and mounts on standard carriages.

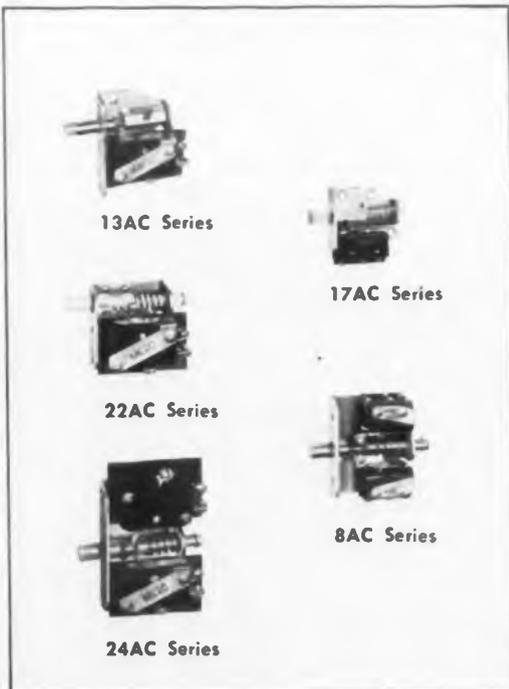
Radar Design Corp., Dept. ED, Pickard Drive, Syracuse 11, N.Y.

Price: \$225.

Availability: 4-week delivery.

NEW

DOOR INTERLOCK SWITCH eliminates momentary circuit break during re-set



A few of the many different door interlock switches available. Write for Data Sheet 186 or see the Yellow Pages for the nearby MICRO SWITCH Branch Office.

A new model in MICRO's line of protective door interlock switches, the "13AC" is designed to eliminate that momentary power interruption when the interlock is re-set upon closing the door. This feature is particularly desirable on electronic equipment such as data processing consoles, transmitters or computers.

Door interlock switch assemblies automatically break the power circuit when a door or drawer is opened, make it easy to intentionally energize the circuit for check or test, and eliminate the use of dangerous jumpers or tie-downs. When the door is closed, these devices automatically re-set so that next time the door is opened, power is safely cut off.

MICRO SWITCH door interlocks are the ultimate in reliability as protective devices on cabinets and enclosures containing electronic equipment that may be hazardous to personnel. More than 150 models include environment-proof and high temperature designs, subminiature and multi-circuit assemblies and some with self-lubricating thermo-plastic actuating rods.

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MICRO SWITCH Precision Switches

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- Direct in-line readout*
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The Model 710A is the most compact, versatile, and easy to operate precision impedance bridge available today.

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Resistance: 0-12 megohms in 8 ranges.	Storage Factor (Q): 0 to 1000 at 1 kilocycle.
Accuracy: $\pm(0.1\% + 1 \text{ dial division})$	Accuracy: $\pm(2\% + 0.005)$
Capacitance: 0 to 1200 microfarads in 7 ranges.	SWITCHES: All switches use silver alloy contacts to insure the highest accuracy.
Accuracy: $\pm(0.2\% + 1 \text{ dial division})$	INPUT POWER: 115/230 volts, 50 to 800 cycles, 12 watts.
Inductance: 0 to 1200 henrys in 7 ranges.	DIMENSIONS: Cabinet length, 9 inches; width, 7 inches; height, 6½ inches.
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Dissipation Factor (D): 0 to 1.000 at 1 kilocycle.	
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National Connector Corp., Dept. ED, 311 Fifth Avenue N., Minneapolis 1, Minn.

**Alumina-Ceramic Inserts Made 286
For Transistor Firing Boats**

Made to customer specifications, the ALSiMag 614 alumina-ceramic inserts have a long life in fusion-firing boats. They can be made in sample quantities at a reasonable cost.

The inserts position the metallic dots in relation to the silicon or germanium wafer during the furnace operation. ALSiMag 614 stands normal firing temperatures.

American Lava Corp., Dept. ED, Manufacturers Road, Chattanooga 5, Tenn.

**Cable Jacketing Process 287
Places No Limit On Length Of Run**

The jacketing process used by Alpha Wire Corp. in the manufacture of neoprene and polyvinylchloride jackets for multi-conductor cables places no limit on the minimum length of the run. A single foot of jacketing can be furnished. The number of cable conductors may be as specified, provided the ID does not exceed 4 in. The customer specifies performance characteristics.

Alpha Wire Corp., Dept. ED, 200 Varick St., New York 14, N. Y.

**Reports of Laboratory Work 288
Present Latest Techniques**

Designed to bring authoritative answers to typical problems encountered in laboratory procedures, the Laboratory Guide Reports cover the latest laboratory techniques as well as conventional approaches. Each month, subscribers receive at least four reports drawn from more than 300,000 test programs conducted by New York Testing Laboratories. The annual fee for this service is less than \$20.

New York Testing Laboratories, Dept. ED, 47 West St., New York 6, N.Y.

New Technique Permits 100-Lb Investment Castings

289

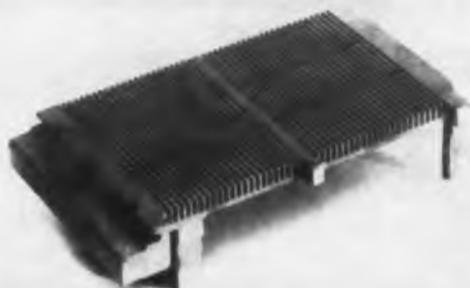
The ceramic-shell casting process at Arwood Corp. can produce intricately shaped investment castings that weigh up to 100 lb. Besides increasing casting size, the process offers these advantages:

- More intricate coring.
- Finer grain structure.
- Better and more consistent surface finish.
- Sounder castings (made possible by greater freedom in engineering the casting setup).
- Production of shapes previously impossible.
- Less finishing needed.

This casting technique consists of building up successive monolithic ceramic layers around a wax or a plastic and wax casting set-up. The number of layers depends upon the thickness required to withstand molten metal pressure. In general, six layers are used to build up a thickness of 1/4 in.

The firm also does solid-mold casting with wax or plastic patterns and shell-mold casting, using frozen mercury patterns.

Arwood Corp., Dept. ED, 321 W. 44th St., New York 36, N.Y.



Made by the ceramic shell process, this heat-exchanger part is for use on a die modulator in a jet plane.



A gyroscope component cast in 17-4-PH steel is shown in comparison to an ordinary sized investment casting.

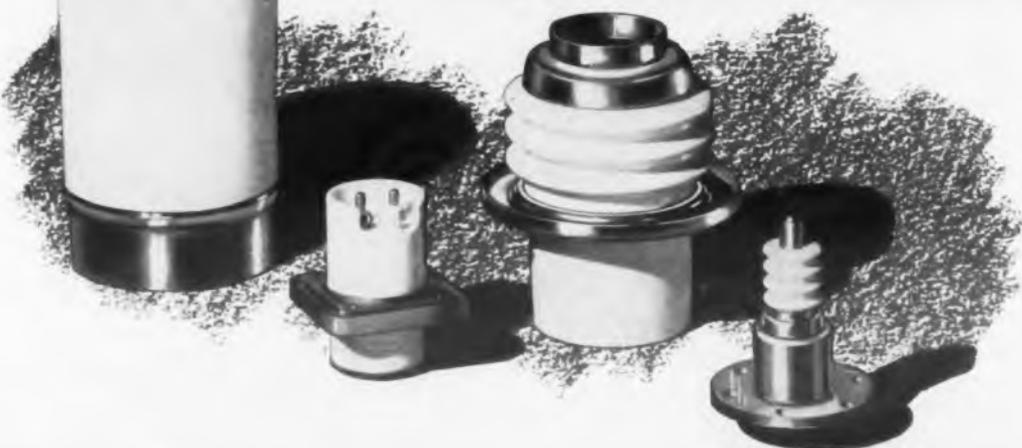


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CIRCLE 231 ON READER-SERVICE CARD

102-G

DESIGN DECISIONS

Featuring the clever and unusual in packaging, appearance design, and circuitry in electronic equipment.

Novel Techniques Boost Performance, Cut Size and Power of Tape Recorders

Fig. 1. Astronaut recorder in Mercury capsule has coaxial reels mounted on opposite sides of the main-frame casting. Recorder has no conventional, pinch-drive rollers.

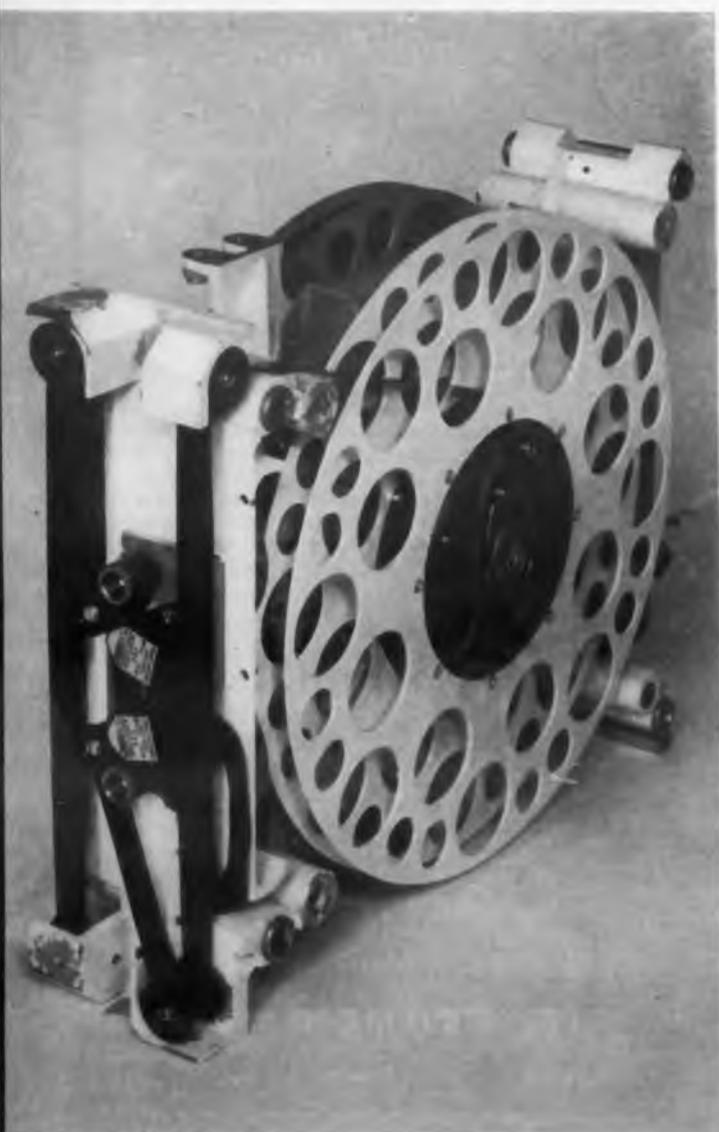
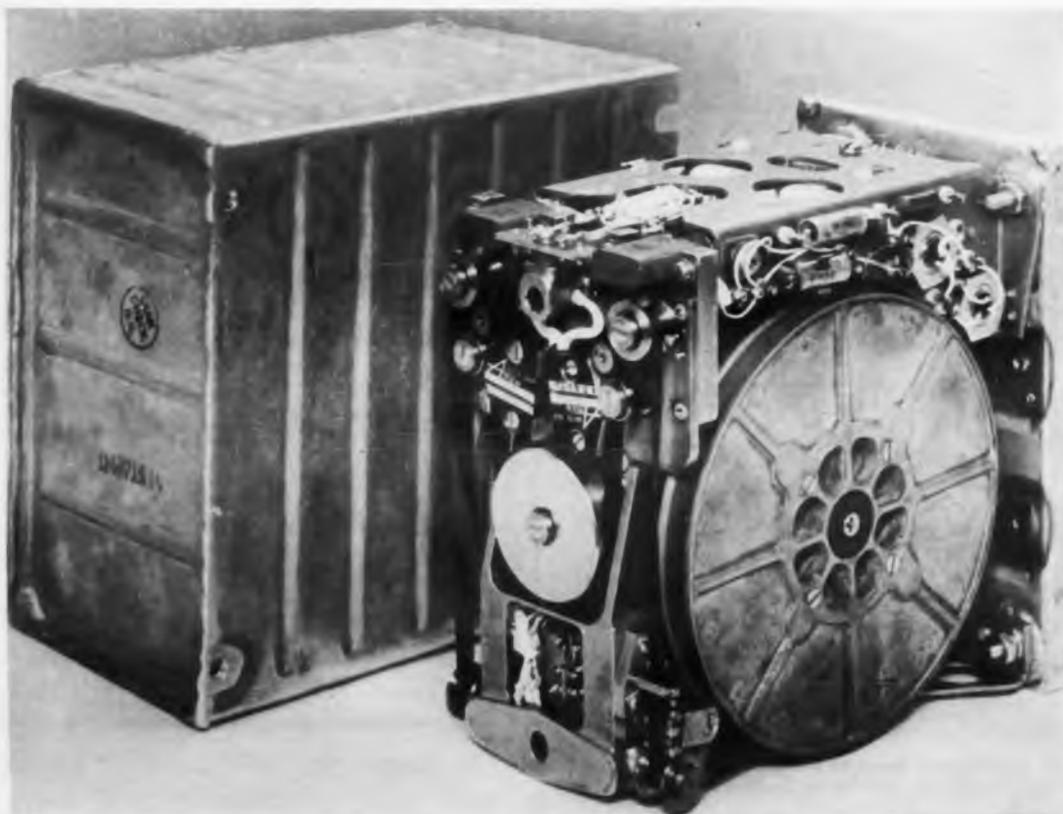


Fig. 2. Synchronous motor in Courier recorder provides excellent speed regulation, avoids brush problems. Spring driven reels obviate take-up motors, brakes, clutches.



DESIGNING magnetic-tape recorders for today's air and space craft can pose unusual challenges. Requirements for minimum size and power consumption are now accompanied by other demands which can complicate the designer's job. Some of these problems and their solutions can be seen in some recorders developed by Consolidated Electrodynamics Corp.'s Drs. R. L. Sink and J. G. Frayne at CEC's Datalab Div.

Coaxial-Reel Astronaut Recorder Designed for Oxygen Environment

For example, the recorder in the Mercury "Man-in-Space" capsule (Fig. 1), had to work in a 100 per cent oxygen environment. Hence, all materials had to be tested in oxygen for irritating or objectionable odors, for toxic gases, for oxidation or other chemical effects, and for flash fire or explosion. To contain the ozone emitted, motors had to be sealed in separate aluminum containers.

To eliminate the effect of ozone on the non-metallic drive belts, a belt of nylon webbing was designed. It was impregnated with silicone rubber which vulcanized at room temperature.

Original specifications for the Mercury recorder called for a silicone-paint finish, or a type requiring a 500-F curing temperature. This heat would have warped and annealed the parts the paint was intended to protect. An air-dry silicone paint solved this problem. Though it showed poor abrasion resistance, it was adequate in all other respects. Further research proved epoxy paint satisfactory for the application too.

To minimize volume, the Datalab engineers mounted the take-up and supply reels on opposite sides of the main-frame casting. Both reels use a coaxial shaft, mounting hubs (which contain the reel drive), and brake mechanism. The read/write heads are mounted on the side of the main casting. The tape passes over them as it moves between reels.

Power requirements were greatly reduced and tape deformation minimized by discarding the conventional, solenoid-operated, pinch-drive rollers in favor of twin, 270-deg, tape-contact, wrap-around capstans. They provide isolation from reel flutter and supply the friction between tape and capstan to assure positive tape drive.

For satellite-borne recorders, reliability is naturally of primary importance. The Courier recorder (Fig. 2), for example, was designed to operate for 1,000 hr without losing efficiency. With a weight of only 5 lb, it can record, reproduce, and erase teletype communications between the earth and the satellite. It can accept



This is the FIRST Space Cabin Simulator used by the Air Force School of Space Medicine to successfully confine 2 men for a 30 day period in a simulated space condition. The creation of this device was the result of the combined efforts of Honeywell's Manned Systems Engineering Section and is one of the many examples of Honeywell's unique capabilities in the fields of environmental control and space technology.

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CIRCLE 901 ON CAREER INQUIRY FORM, PAGE 247



Said J. Stefan and L. Boltzmann: "The total radiation from a black body is proportional to the fourth power of the absolute temperature of the black body."

Radiation is usually associated with high temperatures. Yet very cold bodies emit a radiation which can be highly significant in missile and space applications. The problem faced by infrared scientists, trying to detect variations in radiation from low temperature atmospheres, can be likened to detecting a one-foot cube of ice from a distance of five miles.

Lockheed Missiles and Space Division scientists are deeply engaged in studying the problems of infrared emission from the earth and its atmosphere, as seen from orbital altitudes. Although the earth resembles a black body at 300° Kelvin, the emission from its atmosphere, under some circumstances, is much colder. To make measurements under these circumstances, Lockheed has evolved radiometric equipment with one of the most sensitive detection systems yet conceived.

Scientists and engineers must also take careful measurements of a potential employer. Lockheed Missiles and Space Division in Sunnyvale and Palo Alto, California, on the beautiful San Francisco Peninsula, invites this close scrutiny. As Systems Manager for the DISCOVERER and MIDAS satellites and the POLARIS FBM, Lockheed preeminence in Missiles and Space creates positions in many disciplines for outstanding engineers and scientists.

Why not investigate future possibilities at Lockheed? Write Research and Development Staff, Dept. M-13B, 962 West El Camino Real, Sunnyvale, Calif. U.S. citizenship or existing Department of Defense industrial security clearance required.

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DESIGN DECISIONS

frequencies to 50 kc for 5 min on one channel at a tape speed of 30 ips. Its tape can be reversed to reproduce the signal in reverse time sequence.

AC Motor in Courier Recorder Cuts Flutter and Speed Variations

Use of an all-metal capstan drive, driven by a 400-cps synchronous motor assures low flutter and long life. Though the motor requires a solid-state inverter to supply its ac power, it provides one per cent speed control and eliminates brush problems.

The motor transfers its torque by friction on a spring-loaded, steel drive ring through a rubber coupling on the drive shaft to two capstan shafts. The 0.02-in. thick drive ring is free to deflect, but it is held in alignment with the drive shaft and the capstan-drive wheels by a flanged wheel on ball bearings. The pressure can be adjusted by moving the drive shaft against the drive ring.

Twin, rubber-covered, tape-drive capstans eliminate the need for pinch rollers and solenoids. They also provide positive tape-drive isolation from reel-induced flutter.

To minimize power requirements, take up motors were eliminated. Instead, an unusual spring-driven reeling system has been employed. "Neg'ator" springs apply a reverse torque through the common shaft. They apply constant tension to the tape.

Microswitches stop the recorder at the end of a record or reproduce cycle. These are actuated by cams driven by a gear reducer on the reel shaft. A potentiometer on this shaft provides a voltage proportional to the amount of tape still on the record reel. A potentiometer rotation of 316 deg signals the expenditure of a full 775-ft length of tape.

Flangeless Reels Take More Tape, Give Smoother Operation in Smaller Package

Some particularly unusual approaches were used in designing an airborne recorder for an automatic data-handling system. Most noticeable innovation in this recorder (Fig. 3), is the absence of conventional flanged reels. These were discarded because of several disadvantages. For one, their fixed diameter precludes making the package length less than twice the reel diameter. Further, because the flanges have thin sections, severe vibration or shock can induce violent vibration in the flanges.

This interferes with the uniform motion of the

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ELECTRONIC DESIGN • February 15, 1961

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Ultimate in space and weight saving. Hermetically sealed to meet MIL-T-27A specifications. Frequency range 30-10,000 cps maximum levels to 30 mw. Designed to meet the most stringent applications.

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Encased in special material formed into rugged deep drawn cases that afford maximum magnetic shielding. Excellent fidelity for levels to 10 mw. Wide frequency range is consistently achieved. Meet all MIL-T-27A specifications.

Type MH

Designed to meet MIL-T-27A specifications for speech circuit applications including transistorized optimum response from low to high frequency. Maximum power ranges to 100 mw. Hermetically sealed.

Type SMO

SMO open construction affords maximum flexibility in both electrical and mechanical considerations. Though subminiaturized, these units exhibit unusually high efficiency and wide frequency response. New design leads to greater dependability and higher performance.



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Fills need for an economical, compact, quality transformer. Weighs one ounce yet is fully impregnated and sealed in a drawn aluminum case. Ideal for portable broadcast, aircraft, mobile service, etc. High fidelity characteristics are provided, uniform within approximately 1 db from 30 to 20,000 cycles.

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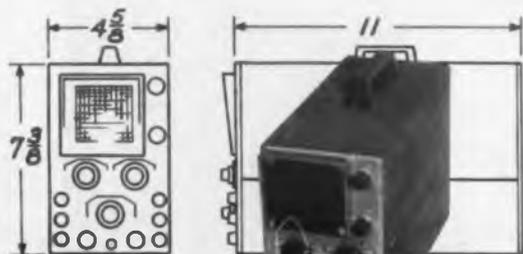
CIRCLE 235 ON READER-SERVICE CARD

Supplied in handy pencil-type holder ready to use.

DESIGN DECISIONS



Fig. 3. Flangeless reeling system in this airborne recorder cuts size, increases tape capacity, and improves environmental immunity.



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Model 10-10

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The little 10-10 has big applications. Use it in industrial, medical and general service fields for computer "read out" and for voltage, frequency and phase shift measurement. It features identical vertical and horizontal AC or DC coupled amplifiers, external sync terminal, external capacity binding posts for sweep rates lower than 5 cps, transformer-operated power supply, voltage-regulated B+ and bias and excellent specifications. 3RP-1 CR tube included. Send for free Heathkit catalog or see your nearest Heathkit dealer.

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*Add 40¢ for state sales tax if you are located in Pennsylvania.

CRUCIBLE STEEL COMPANY OF AMERICA

CIRCLE 237 ON READER-SERVICE CARD

tape. Also, the tape cannot be wound tightly on a flanged reel because it is difficult to remove air entrapped between each tape layer. Because flanges must keep tape in place, the full reel diameter cannot be used.

The flangeless reeling system uses tapered rollers above and below the supply and take-up hubs. In normal operation, these rollers do not touch the tape. Under severe environmental conditions, the rollers keep the tape in position on the hub.

This technique increases the tape-holding capacity by 17 per cent over the normal 7,200-ft capacity of a standard 15-in. flanged reel using one-mil Mylar tape. Furthermore, it winds the tape more uniformly and maintains more uniform tension by using a follower roller that "squeezes" the entrapped air from the layers of tape and controls the tape-tensioning brakes.

The basic design concepts behind the tape recorders discussed here can be found in "Design Tape Recorders for Minimum Size, Weight, and Power" by Dr. Sink and Dr. Frayne in *ELECTRONIC DESIGN*, Nov. 23, 1960.

Solid-State Carrier Amplifier Improves Control With Square Waves

By using a 10-kc square-wave carrier instead of the conventional sine-wave carrier, a solid-state strain-gage amplifier provides easier control of the output amplitude. In addition, the amplifier requires less filtering than do amplifiers with sine-wave carriers and the amplified signals are more easily reconstituted after demodulation.

Zener diodes with a zero temperature coefficient are used to shape the square waves. They keep the square waves at a constant amplitude over a 220-F temperature range for long intervals. Before they are shaped, the square waves are derived from an overdriven amplifier which is fed by a sine-wave oscillator.

This novel carrier amplifier is a product of Video Instruments Co., Inc. of Santa Monica, Calif.

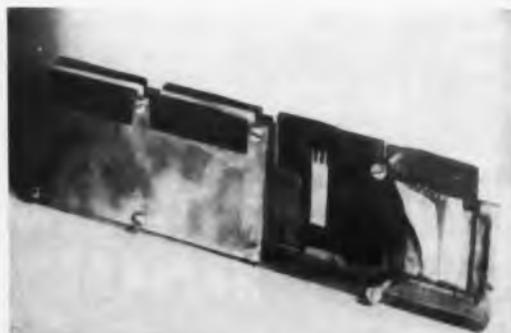
Low Impedance Lines Minimize Voltage Spikes in DC Transmission

An extra-low impedance transmission line was used in the Univac Lark and Univac III computers to distribute dc voltages. The low impedance—approximately 1/30 ohm—was necessary to minimize spikes of voltage due to fast switching.

The low impedance was obtained by using small spacing between lines and large cross-sectional areas.

The lines used were about 6 ft long. They were made by sandwiching a film of mylar dielectric between brass shim stock 6 ft long by 6 to 10 in. wide, and folding the sandwich several times around the longitudinal axis.

Several of these lines are mounted side by side in the section of conduit shown below.



Section of conduit contains several low-impedance lines for dc transmission. Low impedance minimizes voltage spikes due to fast switching.

NEW! Self-Check Rate of Turn Gyro Tells you "GO!" or "NO GO!"

Here is built-in reliability you can depend on. Just prior to flight, when it really counts, you can determine whether the new Honeywell Rate of Turn Gyroscope, Model JRS Series, is functioning properly by just pressing a switch . . . Green light — "GO!" . . . Red light — "NO GO!" It's just that simple. In missile applications, it can be even simpler. Manual "press-to-test" can be eliminated by programming an automatic gyro integrity check into the countdown network.

This new Honeywell Rate Gyro is designed expressly for flight control and instrumentation in missiles and aircraft where severe ambient conditions prevail . . . and at the same time where low threshold, minimum hysteresis, excellent linearity, high natural frequency, high signal-to-noise ratio, and ruggedness are essential.

Viscous damping is temperature compensated to maintain a virtually constant damping ratio over the entire operating temperature range of -65°F to $+175^{\circ}\text{F}$.

Honeywell inertial components and engineering experience are available to assist in the solution of your gyro problems. Write for Bulletin JRS to Minneapolis-Honeywell, Boston Division, Dept. 10, 1400 Soldiers Field Road, Boston 35, Mass., or call your local Military Products Group office. Sales and Service offices in all principal cities of the world.

Honeywell

 Military Products Group



Honeywell Rate Gyro, Type JRS Series. Shown approx. 1/2 size

PERFORMANCE DATA

- EXCELLENT LINEARITY: As low as 0.25% of full scale
- LOW HYSTERESIS: Less than 0.1% of full scale
- LOW THRESHOLD: Less than 0.01 degree/second
- MICROSYN PICKOFF: Variable reluctance type providing infinite resolution and high signal-to-noise ratio
- FULL SCALE RATE: As low as 10 degree/second
- FULL SCALE OUTPUT: Up to 15 volts
- RUGGED: Withstands 100 G shock
- VIBRATION: Operates at 12 G shock to 2,000 cps
- SIZE: 2.11" diam. x 4.60" long
- WEIGHT: 2.2 lbs.

Consult Honeywell for your specific gyro requirements

Self-Check Feature Is Used to Determine that:

- (a) Gimbal is free to rotate
- (b) Restraining Spring is able to return gimbal to zero position
- (c) Pickoff generates proper signal, proportionate to gimbal deflection
- (d) Gimbal Deflection is proportionate to given torque exerted upon it
- (e) Gyro Wheel rotates at proper speed
- (f) Dampening Ratio of gyro is within acceptable limits



CIRCLE 238 ON READER-SERVICE CARD



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 #IR 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

All components readily accessible

CONSOLIDATED AVIONICS CORPORATION

A SUBSIDIARY OF CONSOLIDATED DIESEL ELECTRIC CORPORATION

800 Shames Drive • Westbury, L. I. • EDgewood 4-8400

CIRCLE 239 ON READER-SERVICE CARD

NEW LITERATURE

Strain-Gage Pressure Transducer 290

Bulletin 4326, two pages, describes type 4-328 strain-gage pressure transducer. Electrical, mechanical and physical specifications are given. Wiring and dimensional diagrams are included. Consolidated Electrodynamics Corp., Transducer Div., 360 Sierra Madre Villa, Pasadena, Calif.

Miniature Electromanometer System 291

Bulletin 1156, two pages, describes and illustrates a miniature electromanometer system. The unit is a precision-measuring device that provides secondary pressure standard accuracies for lab, field or industrial applications. Specifications and a block diagram are given. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

Free Space Room Design 292

This 12-page bulletin gives free space room design elements. Included are charts for estimating room dimensions according to frequency and antenna size, a table of absorber performance, three typical design problems and solutions, and information on specification pitfalls. McMillan Industrial Corp., Brownsville Ave., Ipswich, Mass.

Thermion 293

Technical Report No. 4-3-9-A, 9 pages, is entitled "The Thermion: Theory and Practice," by Professor L. F. Eastman. It describes the thermion's applications for testing vacuum-tube thermal conditions and reliability. Chapters include: vacuum-tube thermal conditions and reliability, description of the thermion and its performance, description of the use of the thermion, and conclusions and recommendations. Graphs, references and a biographical sketch are included. Rescon Electronics Corp., 151 Bear Hill Road, Waltham 54, Mass.

Micro-Vellum Process 294

This 12-page brochure describes and illustrates the firm's half-sizing technique, called the microvellum process. This technique reduces drawings by recording on 35-mm microfilm and printing from the microfilm by electrostatic process onto engineering vellum. This reduces the storage space required for blueprint files. The firm has a microfilm service for films conforming to military specifications. Diagrams and price sheets are included. Delta Blue Print Co., 5742 Tujunga Ave., North Hollywood, Calif.

TEST EQUIPMENT

BY...tensor

PORTABLE AC-DC REFERENCE SOURCE

MODEL
5890
~~~~~  
\$495



Here is a completely self contained standard for meter calibration. Accuracy is held to .25% of set voltage. Supplies are regulated and one watt of power is available from 0 to 100 volts.

### INCREMENTAL ANALYZER



MODEL 5880 \$250 ~~~~~

This general purpose input adapter for high impedance recorders is used to allow the display of any voltage, current, resistance or temperature measurable on the units VOM. Increments of any part of the range may be expanded to full scale readout on a recorder or sensitive DC millivoltmeter.

### ARBITRARY FUNCTION GENERATOR

MODEL  
5846  
~~~~~  
\$495



Covering the frequency range of .001 to 10 cycles per second, waveforms are programmed by shaped cams. In addition to the selected function, a square wave at the same frequency is also produced. Function derived can modulate a 60 cycle or other frequency carrier to yield a suppressed-carrier waveform useful in servo testing.

For detailed information, send for data sheets.

tensor

ELECTRIC DEVELOPMENT CO., INC.

1873 Eastern Parkway Brooklyn 33 New York
HY 5-9200

CIRCLE 240 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961



Capacitors for **NO COMPROMISE** Circuit Design

Unusual requirements in capacitance, tolerance, case size or configuration no longer need compromise your circuit designs. **SOUTHERN ELECTRONICS'** engineers are experienced in solving these problems to the extent that non-standard capacitors have become routine at **SEC**.

SEC has developed multiple block capacitors that are now saving space and weight in a production missile. Two 12mfd capacitors were designed to take less space than one, with improved electrical characteristics. In another application, **SEC** eliminated 6 tubular capacitors, utilizing a single can, 6 terminals and a common ground. **Result:** Room for additional components, easier wiring, and a less expensive component.

SEC, in addition to designing special capacitors to save weight and space, has developed dual-dielectrics to solve unusual temperature coefficient problems, and has introduced special dielectrics and oils for extreme high temperature and high voltage applications.

This engineering know-how has resulted in the use of **SEC capacitors** in twelve U.S. missiles, analog computers, and many radar and communications services.

SEC capacitors are manufactured in a wide range of capacitance to meet your needs from 100mmf to any higher value, with tolerances as low as 0.1%. They are made under unusually critical quality control standards, and meet or exceed the most rigid MIL-SPECS.

See our new sub-miniature polystyrene capacitors at the IRE Show, Booth 2217, N.Y. Coliseum.



**SOUTHERN
ELECTRONICS**
Corporation

150 WEST CYPRESS AVENUE
BURBANK, CALIFORNIA

CIRCLE 241 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

Moly Permalloy

295

Bulletin EM-30, Edition 1, 16 pages, describes moly permalloy for use in the miniaturization field of electronics. The bulletin gives testing data, hysteresis loops, special heat-treating data, magnetization curves, core-loss graphs and typical physical, mechanical and magnetic properties. Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa.

Decade-Counter Modules

296

This four-page data sheet describes types DC-111-A and DC-111-B switch-transistor decade-counter modules. Mechanical and electrical specifications and output-capability information are given. Suggested transistor circuits for use with the counters are included. Burroughs Corp., Electronic Tube Div., P.O. Box 1226, Plainfield, N.J.

Magnetic and Electronic Equipment

297

Bulletin PI-B01, 12 pages, illustrates and describes 31 items of magnetic and electronic equipment. Performance data and specifications are given for dry-type transformers, voltage-regulating transformers, voltage-stabilizing transformers, saturable reactors, power supplies and magnetic-amplifier-controlled battery chargers. Acme Electric Corp., Cuba, N.Y.

Radio-Transmitting Equipment

298

This four-page, illustrated brochure describes the firm's 11-type radio-transmitting equipment. Designed for high-frequency communication systems, the equipment can be used in applications such as traffic control or news-gathering and emergency communications. Specifications and performance characteristics are included. Westrex Corp., Communications Equipment Dept., 540 W. 58th St., New York 19, N.Y.

Photoelectric Catalog

299

Photoelectric catalog No. 60, 24 pages, describes and illustrates new developments in high-speed, ultra-sensitive and impulse-actuated controls; tubeless photoelectric controls; safety controls; photoelectric and electronic timing controls; controls with built-in sensing heads, remote sensing heads and miniature remote sensing heads; plug-in mounted controls; light sources with built-in and remote heads and miniature heads; and controls actuated by current surge and impact. Included are a photoelectric control/light source distance chart, a conversion chart, and application and dimensional diagrams. Auton, Inc., Box 722HA, Danville, Ill.

Stepping Motors

BI-DIRECTIONAL HIGH RELIABILITY POSITIVE LOCK

Compact and lightweight Curtiss-Wright bi-directional digital motors index precisely and lock positively between each angular rotation when converting electrical pulses to mechanical motion in missile, aircraft, automation and actuation applications. Ruggedly constructed and dynamically balanced for long life and reliable service under severe environmental conditions, shock and vibration. Low power required for high speed operation.

Temperature: -65°F to $+165^{\circ}\text{F}$

Vibration: 20 G's to 500 CPS

Shock: 30 G's for 11 milliseconds
along each axis

AD NO. 4507



Write for latest complete
components catalog #502

TIME DELAY RELAYS • DELAY LINES • ROTARY
SOLENOIDS • DIGITAL MOTORS • TIMING DEVICES
• DUAL RELAYS • SOLID STATE COMPONENTS



Electronics Division
CURTISS-WRIGHT CORPORATION
East Paterson, New Jersey

CIRCLE 242 ON READER-SERVICE CARD

Thermal Time Delay Relays



Instant Reset

Voltage Compensated

Vibration Resistant

Precision-built Curtiss-Wright thermal time delay relays reset instantly when de-energized — provide the same delay period for each succeeding cycle. Compensated for wide voltage variations. Available in either 28V DC or 115V AC, 60 or 400 cps. Chatter-free operation, under severe shock and vibration conditions. Small sized, hermetically sealed, temperature compensated for precise, reliable operation and long life. Preset time delays from 10 to 180 seconds with SPST, SPDT or DPDT snap action contacts.



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components catalog #505

TIME DELAY RELAYS • DELAY LINES • ROTARY
SOLENOIDS • DIGITAL MOTORS • TIMING DEVICES
• DUAL RELAYS • SOLID STATE COMPONENTS

Electronics Division
CURTISS-WRIGHT CORPORATION
East Paterson, New Jersey

CIRCLE 243 ON READER-SERVICE CARD

Transistor Logic Elements for Defense

Use these logic modules for easier, faster, computer design

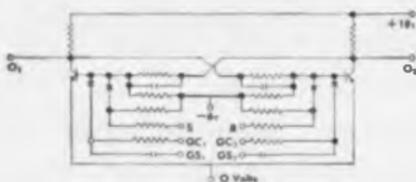
Encapsulated elements operate at high frequency over wide temperature range

- Fast switching speed of 1 mc/second
- Standard 6 volt logic
- Rugged, uniform packaging

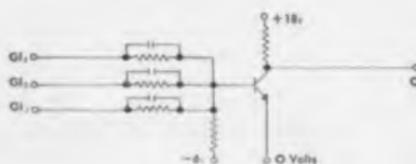


Series M Transistor Logic Elements now provide maximum reliability and high frequency performance over an extended temperature range of -40 C to $+125\text{ C}$. Pre-designed for immediate use in breadboard, prototype or production equipment, these compatible logic modules find versatile defense applications in digital computer and data handling systems. Encapsulation in high-temperature epoxy material, semi-transparent for easy inspection of internal assembly, affords protection from extreme environmental conditions of humidity, shock and vibration. Metal feed-through sleeves improve mounting flexibility, while uniform packaging and terminal arrangement facilitate interconnection of modules.

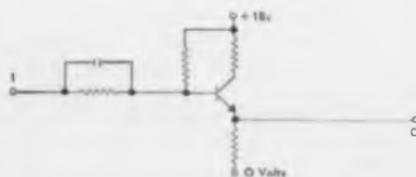
Reasonably priced and available for prompt delivery, General Electric Transistor Logic Elements are manufactured from thoroughly tested, quality components. These saturating and resistance-coupled modules are also offered in circuit and packaging variations, custom designed to meet specific engineering requirements.



Transistor Binary (Type M-264) —provides two gate control inputs, two gate signal inputs, and two direct resistance inputs for the set and reset of the flip-flop. Intended for use in counters and shift registers, it drives up to four, fully loaded, Series M Transistor NOR-Gates at each of the two outputs.



Transistor NOR-Gate (Type M-134) —performs pulse inversion and logic functions OR and AND. Each of the two separate elements of this common emitter switch drives four additional, fully loaded, Series M Transistor NOR-Gates. Three inputs are furnished for each element.



Transistor Emitter Follower (Type M-31-10) — consists of two separate elements with individual input and output terminals. Both elements are capable of driving up to ten, fully loaded, Series M Transistor NOR-Gates. Applications are found in impedance transformation and in driving logic elements without inversion or significant degradation in the transmitted pulse.

176-52

Progress Is Our Most Important Product

GENERAL ELECTRIC

DEFENSE ELECTRONICS DIVISION

HEAVY MILITARY ELECTRONICS DEPARTMENT • SYRACUSE, NEW YORK

CIRCLE 244 ON READER-SERVICE CARD

NEW LITERATURE

Plastic Ruler

300

This 6-in. plastic engineering ruler shows the 1959 ARDC model atmosphere table of atmospheric pressure and temperatures encountered at altitudes up to 2,000,000 ft. Temperature inversions at 90,000, 180,000 and 325,000 ft are given to hundredths of degrees. Tenney Engineering, Inc., 1090 Springfield Rd., Union, N.J.

Rubber-Neoprene Cables

301

Bulletin No. 1134, 30 pages, contains information on the splicing and terminating of shielded and unshielded cables. Included in the illustrated booklet are tape selector and quantity estimating charts, product information, and a purchase-planning aid sheet. The Okonite Company, Passaic, N.J.

Test Instrument Catalog

302

Illustrated catalog No. ES-9, 24 pages, lists the firm's line of integrated instruments for automatic measurement of sound, vibration and strain. Instruments listed include: accelerometers, amplifiers, analyzers, deviation bridges, filters, level recorders, megohmmeters, oscillators, strain-gage equipment, test jig, vibration control equipment and voltmeters. Applications and specifications are given. B & K Instruments, Inc., 3044 W. 106th St., Cleveland 11, Ohio.

Tape-to-Tape Converter

303

Brochure 3C, four pages, describes a magnetic tape-to-tape converter designed for missile applications. Modifications for industrial applications are suggested. A block diagram of the instrument is included. Computer Control Co., Inc., 983 Concord St., Framingham, Mass.

Electronic Switch

304

Brochure No. BX-535, 24 pages, contains 50 illustrations. It covers theory of operation, circuit design information, characteristic curves, and applications of the firm's Beam-X switch. Burroughs Corp., Electronic Tube Div., Plainfield, N.J.

Selenium Rectifiers and Diodes

305

Two-page Bulletin, No. ED-298 tabulates specifications of selenium rectifier stacks and gives forward and reverse characteristics of diodes in graphic form. Outline drawings are included. Radio Receptor Co., Inc., Selenium Div., 240 Wythe Ave., Brooklyn 11, N.Y.



New operational amplifier 200 KC gain-bandwidth product

from unity to open loop

COMPACT . . . ALL SOLID STATE
FULL DIFFERENTIAL

RIG's new, transistorized Operational Amplifier Model A-2 is now your *one-best DC amplifier choice*: as a miniature, completely reliable instrument pre-amplifier . . . for versatile, multiple-unit use in complex data-handling and process control systems . . . and for customary analog computing applications.

Check and *compare* the A-2's unmatched combination of electrical, mechanical, and cost specifications:

OPEN LOOP GAIN — 100,000
RISE TIME — Less than 10 microseconds at unity gain, and at gain of ten: less than 100 microseconds at gain of one hundred.
DRIFT (referred to input) — Less than two millivolts over 75°F to 120°F change of ambient; less than 100 microvolts over eight-hour period at constant temperature.
COMMON-MODE REJECTION RATIO — Up to 500,000 to one at open loop.
OUTPUT LOADING CAPABILITY 10K at ± 10 volts.
LINEARITY — Within 0.1% in output swing of ± 10 volts.
SIZE — 5¼" x 2½" x 1¼"
WEIGHT — 12 oz. COST — \$195.00

Request RIG-AMP Technical Bulletin for complete details.

ALSO AVAILABLE Companion, plug-in Power Booster for use with Amplifier A-2 in driving heavy instrument systems, rotary amplifiers, and small DC servos.



**RIDGEFIELD
INSTRUMENT GROUP**

a Schlumberger division
Ridgefield, Conn., P.O. Box 337, Idlewood 8-6571

SPECIAL-PURPOSE ANALOG COMPUTERS FOR DATA HANDLING AND CONTROL, ELECTRONIC COMPONENTS, NMR AND ESR SPECTROMETERS, MAGNETIC RESONANCE ANALYTICAL SERVICES

CIRCLE 245 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

Molded Tubular Capacitors 306

This four-page bulletin describes series 3811 and 38M molded tubular capacitors. It gives electrical and mechanical specifications and standard ratings. John E. Fast Co., 3598 N. Elston Ave., Chicago 18, Ill.

Rectifier Columns

Bulletin SR-370, 16 pages, gives specifications, electrical principle and operating data on a series of high-voltage rectifier columns. Diagrams, tables, and performance characteristics curves are included. Write on company letterhead to International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

Power Source 307

Bulletin 502, two pages, describes model LDS-1500 50-w. low-distortion, variable-frequency power source. Specification data are given. Krohn-Hite Corp., 580 Massachusetts Ave., Cambridge 39, Mass.

DC Power Supplies 308

Bulletin 105, two pages, describes and illustrates a series of transistor-regulated dc power supplies. Four models are given. Electrical and physical specifications are included. Opad Electric Co., 43 Walker St., New York 13, N.Y.

Antenna Towers 309

This 68-page booklet describes the firm's facilities, capabilities and experience in designing, fabricating and erecting steel and aluminum structures. Radar and antenna towers and antenna structures are described and illustrated. Dresser-Ideco Co., Dept. DP, 875 Michigan Ave., Columbus 15, Ohio.

Solderless Terminals 310

This eight-page bulletin, No. 264, illustrates a line of solderless terminals giving stock number, hole diameter, stud and wire size and price. Crimping tools also are described. Vaco Products Co., 317 E. Ontario St., Chicago 11, Ill.

How to keep computers compact

You can often save space, weight and money in equipment employing sine-cosine operations by "designing in" Gamewell Sinusoidal Potentiometers. Far lighter and more compact than gears, cams, and other complicated mechanisms, they're widely used in analog computers, data converters, Tacan systems, and radar components. Advanced design produces functions with smoothness and precision unobtainable by other resistive methods. For details and latest catalog, write THE GAMEWELL COMPANY, 1398 Chestnut Street, Newton Upper Falls 64, Mass. A Subsidiary of E. W. Bliss Co.



CONDENSED SPEC OF RVG-30XS-4

Resistance	16,000 ohms $\pm 5\%$
Conformity	1.0% peak to peak
Starting Torque	0.5 oz. in. max.
Angular Accuracy	$\pm 0.7^\circ$
Weight	2 oz. max.
Mechanical Rotation	Continuous
Electrical Rotation	360°
Nominal Life	350,000 cycles



RVG-30XS-4

BLISS
Gamewell

PRECISION POTENTIOMETERS

INTEGRALS OF
HIGH PERFORMANCE

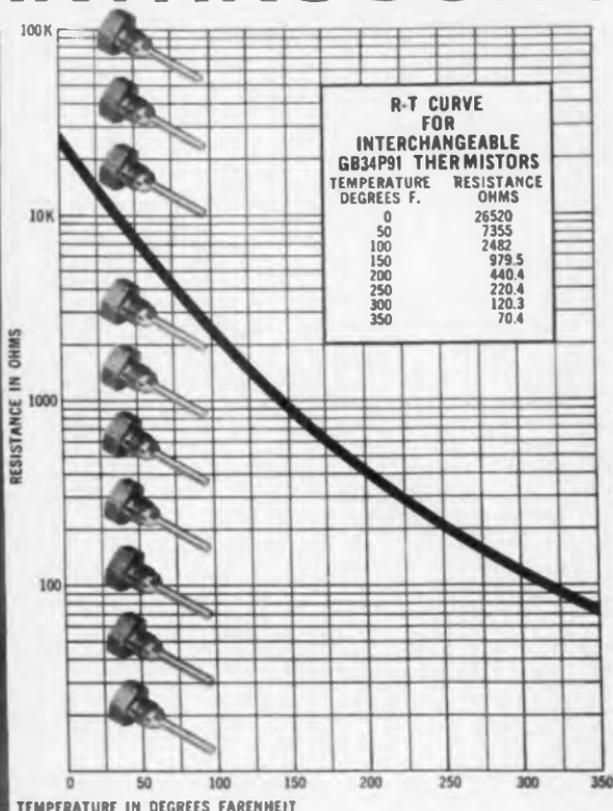
CIRCLE 246 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

BREAKTHROUGH!

in
thermistor
design

Fenwal
Electronics
new
"identical"
thermistors
permit
complete



interchangeability!

What do you need from a thermistor in the way of performance? Reliability? Extreme stability? High shock resistance? Long life? Fenwal Electronics can supply it. But Fenwal Electronics' thermistors provide an additional important characteristic all their own: **they can be supplied with identical resistance temperature curves.**

That means that now, for the first time, you can have complete interchangeability. It means you can rely absolutely on consistently accurate resistance changes versus temperature of Fenwal Electronics' thermistors. It means also you can now achieve accurate, multi-point temperature indication or control through a single system without having to calibrate out each individual sensor.

From Fenwal Electronics...THE MOST COMPLETE LINE OF PRECISION THERMISTORS



BEADS & GLASS PROBES... 0.008" to 0.100" diameter. Resistance values: 500 ohms to 100 megohms.

DISCS... 0.1" to 1" diameter. Resistance values: 5 ohms to 1,000 ohms.

WASHERS... .75" diameter. Resistance values: 5 ohms to 3,000 ohms.

RODS... 0.053" to 0.123" diameter varying lengths. Resistance values: 500 ohms to 500,000 ohms.

PROBE Assemblies Built to your specific requirements in enclosed and mounted in individual housings as "packages" and ready to install.

E-I Matched pairs Thermistor beads matched by voltage-current characteristics and mounted in special hermetically sealed stems designed for use in thermal conductivity gas analysis instruments.

From Fenwal Electronics...MORE HELP ON THERMISTOR PROBLEMS



• Thermal Experimental Kit — to help you expedite operations at the bread board stage. Just \$19.95 at electronics jobbers.



• New Thermistor "Computer" — 5" x 8" "computer" reduces lengthy computations to single "slide rule" setting. Yours for the asking.



• New Probe and Housing Brochure — Gives selection of probe designs.



• New Thermistor Catalog (EMC.)

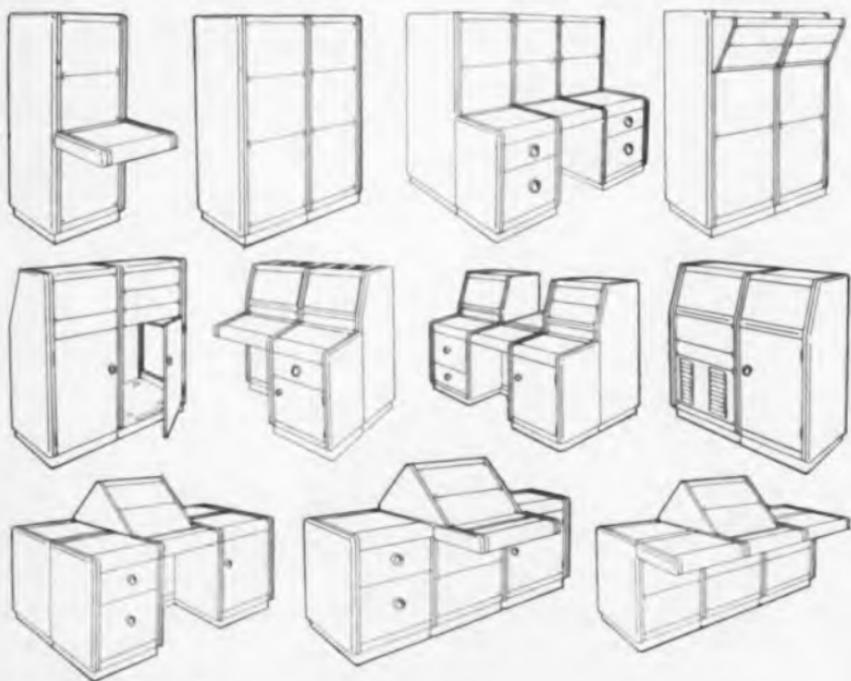
For complete information, or the name of the Fenwal Representative in your area, write:



*Probes can be supplied individually calibrated at all desired temperatures. When interchangeability is required, they can be supplied with identical resistance-temperature characteristics.

33 MELLETT STREET, FRAMINGHAM, MASSACHUSETTS

CIRCLE 247 ON READER-SERVICE CARD



HUNDREDS OF BASIC EMCOR STANDARD FRAMES TO BUILD YOUR ENCLOSURE SYSTEM

Just a few of the thousands of control center combinations, attained through the use of the EMCOR MODULAR ENCLOSURE SYSTEM, are illustrated here. The ultimate in enclosure flexibility is available through hundreds of EMCOR Standard Basic Frames and thousands of component parts. The EMCOR Fine Line of Quality features simplicity in assembly. With a standard screwdriver, you can assemble a control center to meet your electronic, instrument or electro-mechanical housing problem. You eliminate costly enclosure design time and modification of custom type units. Only EMCOR, the originator of the Modular Enclosure System, provides the ultimate in design, beauty, rugged structural capabilities and quality controlled craftsmanship in the fabrication of metal enclosures. Let EMCOR "Know-How" serve and save for you!

Condensed Version of Catalog
106 Available Upon Request.



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Originators of the Modular Enclosure System

INGERSOLL PRODUCTS

Division of Borg-Warner Corporation
430 Congdon • Dept. 1221 • Elgin, Ill.

CIRCLE 751 ON READER-SERVICE CARD

NEW LITERATURE

Magnetic Clutches 312

Catalog No. 63, 48 pages, contains dimensional drawings and specifications data of the firm's line of magnetic clutches and precision differentials that meet Mil specs. Sterling Precision Corp., Instrument Div., 5 Sintsink Drive E., Port Washington, L.I., N.Y.

Direct-Recording Oscillograph 313

This 36-page manual describes applications of the firm's direct-reading Visicorder oscillograph. Included are reports on missile component testing, drone surveillance, and transistor testing. Schematic diagrams and graphs are given. Minneapolis-Honeywell Regulator Co., 5200 E. Evans Ave., Denver, Colo.

Testing Machines 314

This eight-page brochure, Tinius Talks Vol. 12, No. 2, traces the development of the electronic null-balance principle as applied to indication systems, stress-strain recorders, and strain instrumentation. Developments in automatic read-out systems for printing test data are discussed. Tinius Olsen Testing Machine Co., 417 Easton Road, Willow Grove, Pa.

Precision Electrical Instruments 315

This eight-page catalog contains summary specifications of an English firm's line of products. Included are precision test instruments, components, synchros and servomotors, servo equipment, and telefacsimile equipment. Muirhead Instruments Inc., 441 Lexington Ave., New York 17, N.Y.

RF Interference Filters 316

This eight-page, two-color data sheet describes L-Cap rf interference filters. Specifications, performance data and applications are given. Performance curves and dimensional diagrams are included. Devco, Inc., 24 Maple Court, East Longmeadow, Mass.

Phase Controllers and SCR Amplifiers 317

Bulletin No. 6071, four pages, describes and illustrates the firm's line of modular phase controllers and SCR amplifiers. Transfer characteristics, specification charts, wiring diagrams and application information are given. The units are for power-control applications. General Electronic Control, Inc., 8001 Bloomington Freeway, Minneapolis 20, Minn.

Connectors

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MSM

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*if
it's
coax
we
make
it!*



Technical Brochures are available upon request.

Automatic



METAL PRODUCTS CORP.

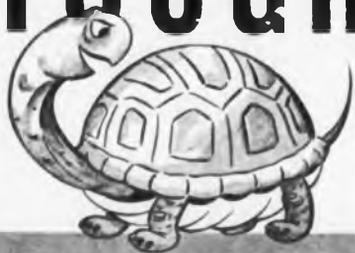
323 BERRY ST., B'KLYN 11, N.Y.

Telephone: EVergreen 8-8057

CIRCLE 752 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

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.

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DYNACOR

DYNACOR, INC.
A SUBSIDIARY OF SPRAGUE ELECTRIC CO.
1012 Westmore Ave.

CIRCLE 753 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

Transistorized Pulse Generator 318

This 12-page booklet describes the uses and applications of pulse generators with particular emphasis on high-speed transistorized circuits. The features, advantages, and limitations of a new all solid-state pulse generator designed for use with transistorized circuitry are explained. Each specification of the portable unit is presented together with the practical limitations and special applications. Valor Instruments, Inc., 13214 Crenshaw Blvd., Gardena, Calif.

Subminiature Switches 319

Catalog No. 20-1, 16 pages, describes the firm's line of subminiature switches. Dimensional drawings, force and movement specifications, electrical ratings and photographs are given. The W. L. Maxson Corp., Unimax Switch Div., Ives Road, Wallingford, Conn.

Synchro Mounting Instructions 320

This eight-page, two-color brochure gives details and illustrations on mounting and zeroing synchros and servomotors, fixing gears or pinions. Tables provide information on mounting-panel drilling and recommended screw sizes. A parts list is included. Muirhead & Co., Ltd., Muirhead Instruments Inc., 441 Lexington Ave., New York 17, N.Y.

Digital Voltmeters 321

This 10-page folder discusses factors to consider in purchasing a digital voltmeter. The pocket guide gives specifications, features and applications of the firm's instruments. Non-Linear System, Inc., Del Mar, Calif.

Receiving Tubes 322

This bulletin gives specifications and base diagrams for more than 60 Mullard receiving tubes. These tubes are for hi-fi, am-fm, TV and industrial applications. Characteristics for Mullard-frame grid tubes are included. International Electronics Corp., 81 Spring St., New York N.Y.

Control Components Guide 323

This eight-page booklet contains illustrations and specifications for the division's line of products. The components include military-telemetering pressure transducers, high-accuracy pressure transmitters, high-voltage pressure transmitters and displacement-position transducers. International Resistance Co., Control Components Div., 401 N. Broad St., Philadelphia 8, Pa.

HOW TO BLOW UP A 2.2 CFM BREEZE WITH A ONE-INCH CUBE...



***Specify the Sanders MINICUBE® Blower
... the only cooling unit
in a reliability-proved 1.25 oz. package!***

Reliability-proved? Yes! Its original job was lowering ambient temperature in miniaturized airborne equipment. Here, it had to meet acceleration, shock, vibration and temperature requirements of military specifications for missile and aircraft applications. It did so well, the word got around. Now, it's being used in commercial applications, too.

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Input Voltage: 6.3 or 26 volts (adaptable to 115 volts), 400 cps; 5.2 volts, 800 cps; single- or two-phase
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Life: 500 hours at 110C; longer at lower temperatures
Size: 1" x 1" x 1"
Weight: 1¼ oz.

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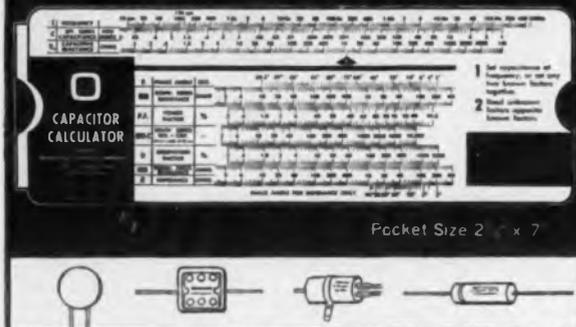
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Get \$10.00 plus a by-line for the time it takes you to jot down your clever design idea. Payment is made when the idea is accepted for publication.

Demodulator Helps Measure Distortion In AM Transmitters

AN INEXPENSIVE demodulator, easily constructed from readily available components, was found to be extremely valuable in studying the audio characteristics of amplitude modulated radio transmitters.

The circuit, Fig. 1, was used successfully with radio transmitters ranging from 2 to 247 mc.

It was especially useful in determining the amount of audio harmonic distortion when used with distortion analyzers such as the Hewlett Packard Model 330B. Because the circuit uses 1N34 crystal diodes, it requires no external power source. Further, no adjustment or tuning is necessary since it has an untuned antenna circuit and an audio filter. The latter is a low-pass,

constant-K type designed for a cut-off frequency of approximately 60 kc. This keeps the audio response substantially flat over a large passband and yields a true measurement of the harmonic content present in the transmitted audio envelope. Some advantage might be obtained in the vlf range by replacing the 2.5-mh choke in the antenna circuit with a vhf choke in order to overcome any loss of impedance by distributed capacity. However, this refinement was not tried since the purpose of the design was to develop a more universal accessory.

The 2.5-mh choke in the antenna circuit is shunted by a 1-K resistor and crystal diode to keep its load constant on both positive and nega-

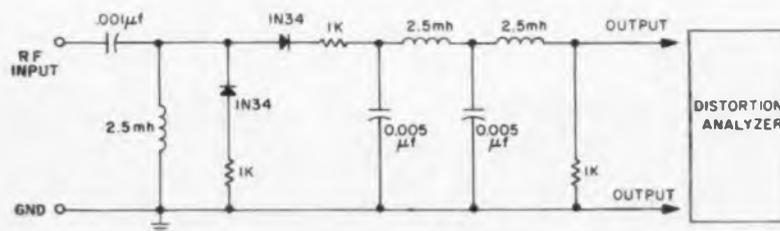


Fig. 1. Demodulator circuit is used for observing the audio harmonic distortion of am radio transmitters.

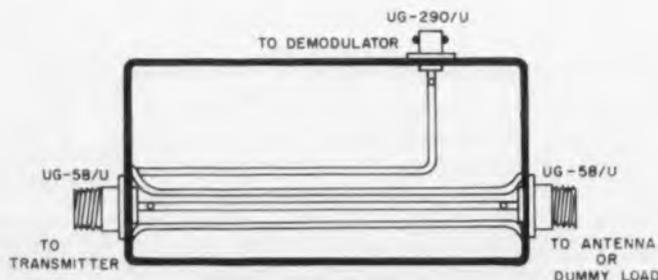


Fig. 2. With coaxial transmission lines demodulator circuit can be connected to antenna using a wall outlet box and appropriate connectors.

tive halves of the rf wave. It is important to keep the polarities of the crystals as shown in the schematic. The constant-K filter is designed for a 1-K input and output impedance. Fortunately, standard 2.5-mh chokes fitted very nicely into the filter design. Those used were rated at 250 ma (about 17 ohms dc resistance). Actually, the current normally passed through them is only a few milliamperes, but these chokes were chosen because their low resistance would result in improved filter characteristics.

Circuit Couples Directly To Antenna

Coupling this device to the transmitter is very simple. For the usual case, a single wire held in the proximity of the transmitter antenna terminal will suffice. Or, depending upon the amount of radio frequency power being transmitted, a small dipole can be used. In order to read distortion directly on the Hewlett Packard Model 330B, enough rf energy must be fed to the demodulator to obtain at least one volt of audio from the output terminals at the fundamental audio frequency. However, for weaker signals, satisfactory results were achieved with the Set Balance control adjusted for 1 v on the meter scale (10 per cent) and the audio input control of the analyzer cut back accordingly. The per-cent distortion observed was then multiplied by 10 to obtain the true figure. On this basis, audio output as low as a tenth of a volt would suffice.

For the vhf range where coaxial transmission lines are used, a method published in the RCA Field Support Material pamphlet has been used successfully. A modified version of this is shown in Fig. 2. A wall outlet box with a UG-58 U connector at each end was used. A stiff, heavy wire (AWG #10) is connected between the center terminals of the UG-58's. Similar wires soldered to the ground sides of the UG-58's were spaced about 1/8 in. from the center conductor to keep the vswr low. A pick-up loop consisting of a similar wire grounded to the box at one end was run parallel to the center conductor and spaced about 1/8 in. from it for approximately three quarters of the length of the box, then terminated in a UG-290/U connector.

Paul K. Johnson, U. S. Army Signal Material Support Agency, Fort Monmouth, N.J.

● SUGGESTED APPLICATIONS

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IGNITRONS

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● DC MOTOR CONTROL

● VARIABLE DC SUPPLIES

● DC TO DC CONVERTERS

● FREQUENCY CHANGERS

● INVERTERS

RELAYS

SWITCHES

CONTACTORS

CIRCUIT BREAKERS

● DYNAMIC BRAKING

● CONSTANT CURRENT SUPPLIES

● PULSE WIDTH MODULATION

● IGNITRON FIRING

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The first SCR to meet MIL-S-19500/108 is now available in production quantities from General Electric. This is natural. G.E. originally developed the SCR, now offers a wide range of current ratings including the new C8, 1.3 amp and C55, 70 amp types. General Electric provides much of the know-how and ideas on how to apply the SCR... brought in reduced prices based on large volume production... and has reams of reliability and test data, the kind you should know about.

The G-E SCR is changing a lot of old ideas about power control and switching, in terms of circuit design *and* cost. Can you afford to wait any longer? Call your G-E Semiconductor District Sales Manager today. He'll give you all the help you need.

Rectifier Components Department, Section 23B8, General Electric Company, Auburn, New York. In Canada: Canadian General Electric, 189 Dufferin Street, Toronto, Ont. Export: International General Electric, 150 E. 42nd St., N. Y. 17, N. Y.

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GENERAL  ELECTRIC

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**Delay-to-Rise-Time
Ratio in
Only 6 in³**

Total Delay 1.5 μ sec
Rise Time 0.03 μ sec
Impedance 500 ohms
PRF 2.5 mc
Attenuation 1 db
Distortion 5%
TC +150 ppm, ± 15 ppm (-10°C to $+50^{\circ}\text{C}$)

Some of the toughest performance specs we've seen in 12 years of delay line engineering are crammed into the $\frac{1}{2}$ " x 2" x 6" case of this lumped constant line. Used by a data processing equipment manufacturer, the unit requires uncommon care in component selection and in circuit layout to achieve the desired 50 to 1 delay-to-rise-time ratio in the space allowed.

Special cores and toroidal winding techniques promote maximum Q, and, when coupled with custom miniature capacitors, desired LC characteristics are obtained within the specified space. An ingenious termination further reduces distortion at tapped outputs and appreciably enhances the pulse time characteristic.

Even if your delay line requirements are not so critical, this same Shallcross ingenuity may pay big dividends in reducing size, cost, or circuit complexity for you. Why not outline your needs to us?



STEPPING ACCURATELY

Typical of longer Shallcross delay lines, this variable lumped constant unit provides a total delay of 24.65 μ sec in 15 steps calibrated to 0.05 μ sec accuracy. Delay-to-rise-time is 100:1—and in a hermetically-sealed package measuring only 2" x 4" x 7 $\frac{1}{4}$ ".

Of course variations can be made for your requirements—in impedance, taps, rise time, attenuation and so forth. These are regular occurrences with the many hundred designs produced by Shallcross delay line specialists.

Shallcross Manufacturing Co. Selma, North Carolina

Precision wirewound resistors, Switches, Instruments, Delay lines, Resistance networks, Audio attenuators

DELAY LINES



VARIABLE DELAY

Continuously adjustable delays from 0 to 0.5 μ sec with 0.005 μ sec resolution are attainable in this typical Shallcross unit. Maximum rise time is 0.06 μ sec at maximum delay.



DISTRIBUTED CONSTANT



LUMPED CONSTANT

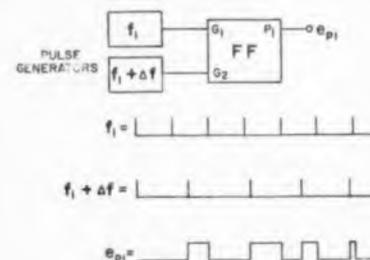
Shallcross' family of distributed constant and lumped constant lines utilize the latest refinements in inductors, capacitors, winding, trimming and packaging techniques.

IDEAS FOR DESIGN

A Random Pulse Generator

To check coupling and clamping circuits, a quick and inexpensive random pulse generator was needed which would vary its pulse width at a random rate.

The problem was simply solved with the cir-



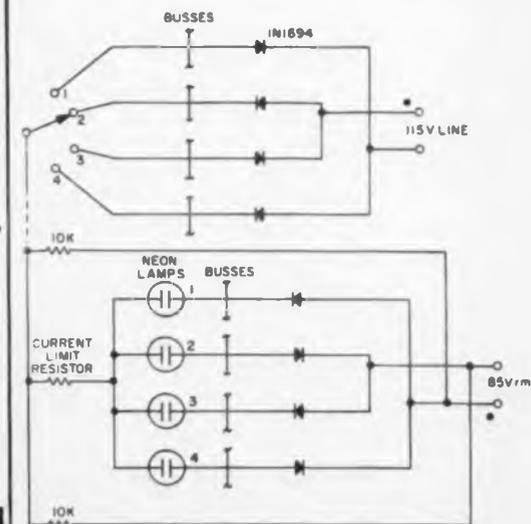
cuit shown. It is an arrangement that has been accidentally connected many times before.

Any variation in the output can be obtained by varying the frequency of $f_1 + \Delta f$.

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

Separate Lamps Controlled Over Single Line

Four separate lamp circuits can be remotely activated over a single control wire by using the rectifier arrangement shown in the figure. The circuit uses the four possible combinations of phase and polarity that can be obtained by half-wave rectification of the ac line. Relative polarity



Four (or more) remotely located lamps can be controlled over a single interconnecting line.

of the 115-v source and the "remote" 85-v lines are indicated by the plus and minus signs.

The desired bulb can be lighted by connecting the control wire to the corresponding switch position. Firing of more than one lamp is prevented by reducing the remote ac voltage to about 85 v rms. The 10-K, 2-w resistors connected from the control wire to the 85-v supply help to minimize the effect of stray control line capacity which could cause improper lamp firing.

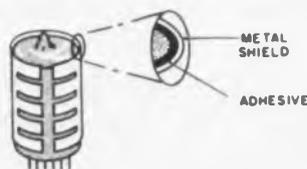
It is possible to extend the circuit so that more than four lamps can be controlled. One control wire is required for every four lamps, with the same eight diodes sufficient for all lamps. Also, relays can be substituted for the neon lamps.

Note that, with appropriate switching, several lamps may be energized simultaneously. Thus, a binary coding may be employed, with decoding accomplished by using diode AND circuits, relays, etc. In this way, 15 functions may be switched over a single control line.

K. C. Herrick, System Engineer, Reflectone Electronics Corp., Stamford, Conn.

Metal Foil Sticks To Tube, Conducts Heat

Heat can be rapidly conducted from the glass walls of a vacuum tube by applying a recently developed, adhesive-coated metal foil wrapper. Available through Shawmut, Inc., of Brockton, Mass., the wrapper can be formed to fit snugly around the tube and is held fast by a high temperature resistant adhesive. The thin layer of adhesive, which has a thermal conductivity many times that of air, holds the wrapper in intimate contact with the glass surface and eliminates the film of air present when an ordinary metal heat shield is used. A metal clamp can be used to support the tube and serve as a heat sink. In addition to improving the conduction of heat from all portions of the tube surface, the wrapper also acts as an electrical shield, while the adhesive film serves as a cushion to damp vibration and shock.



Metal foil sticks firmly to glass walls of vacuum tube, conducts heat away. Slits are made so that foil will stick tightly to irregular surface.

R. H. Wyner, President, Shawmut, Inc., Stoughton, Mass.; Dr. M. Mark, Consulting Engineer, Cambridge, Mass.

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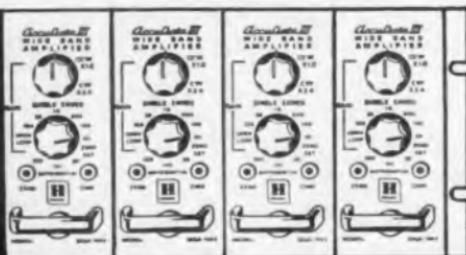
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NEW! WIDE-BAND D-C AMPLIFIER



AccuData III

Can you use
10 VOLT OUTPUT
for a wider range
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In the new all-transistor AccuData III, low level signals from a wide variety of transducers can be amplified up to 10 volts with a high degree of accuracy. At 30 mv full scale input the noise error (0-10 cps) is less than 0.007%; common mode voltage transients are less than 0.008%; and zero drift is less than 0.007%. The total error, therefore, is only 0.022% — a new level of accuracy.

The Honeywell AccuData III Amplifier is particularly useful in high accuracy data handling systems where pick-up problems associated with long cable runs and ground loops must be completely eliminated.

The high 10 volt output allows direct connection between transducer and a wide selection of output devices including:

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Either single ended or differential input ranges may be selected with a frequency range up to 20 kc. Input impedance is 20 megohms single-ended and 2 megohms differential. Seven amplifiers mounted in a 19 inch relay rack occupy a height of less than 5¼ inches. No cooling fans are required since the amplifier heat dissipation is only 8 watts.

Write for Bulletin BS DISA-3 to Minneapolis-Honeywell, Boston Division, Dept 10, 40 Life Street, Boston 35, Massachusetts.

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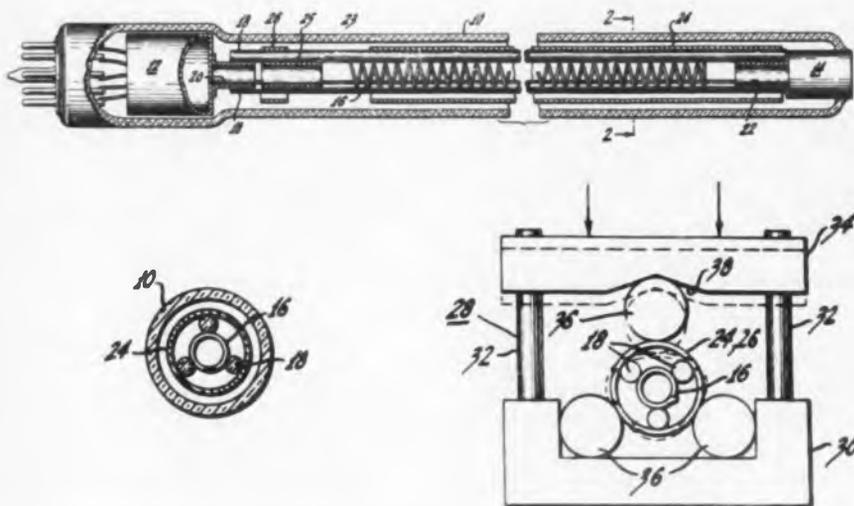
CIRCLE 759 ON READER-SERVICE CARD

TWT and Method of Manufacture
Patent No. 2,943,228. B. Kleinman. (Assigned to RCA)

In a traveling-wave tube the helix-ceramic rod assembly is clamped by deforming the tube body or by having a shaped cylinder supported by the tube enclosure. The elasticity of the cylinder tends to restore the original circular

shape, pressing the rods against the helix.

A method of manufacturing the tube is shown in which a steel cylinder 24 is compressed along three lines due to the force on rods 36 as plate 34 moves downward. Helix 16 and rods 18 are inserted so that when the force on plate 34 is removed, clamps 24 and 26 hold them in a rigid subassembly.



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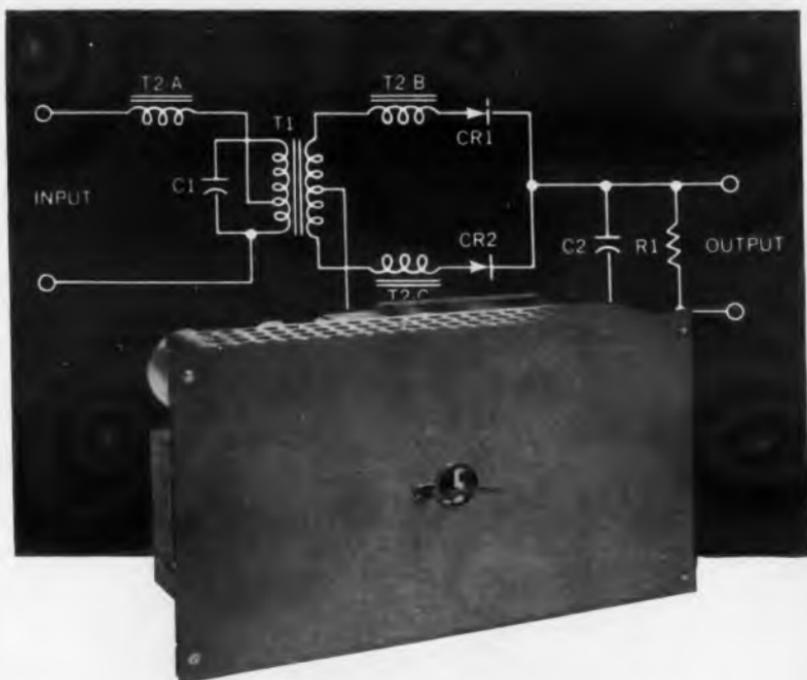
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ELECTRONIC DESIGN • February 15, 1961



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Write for complete MD data . . . Or, better, send for the new Sorensen catalog, listing over 400 power equipment models, plus the name of your Sorensen representative. Sorensen & Company, Richards Ave., South Norwalk, Conn.

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(Numbers preceding dash in model designation indicate output voltage; those following dash indicate maximum current.)

Model	50 watt	Price	Model	200 watt	Price	Model	750 watt	Price
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MD 12-4.2		145	MD 12-16.7		215	MD 12-62.5		423
MD 28-1.8		137	MD 28-7.2		184	MD 28-26.8		336
MD 48-1.1		131	MD 48-4.2		179	MD 48-15.7		315
	100 watt			400 watt			1500 watt	
MD 6.3-15.9		\$194	MD 6.3-63.5		\$348	MD 6.3-239		\$921
MD 12-8.4		171	MD 12-33.3		292	MD 12-125		735
MD 28-3.6		158	MD 28-14.3		247	MD 28-53.6		567
MD 48-2.1		152	MD 48-8.4		231	MD 48-31.3		525



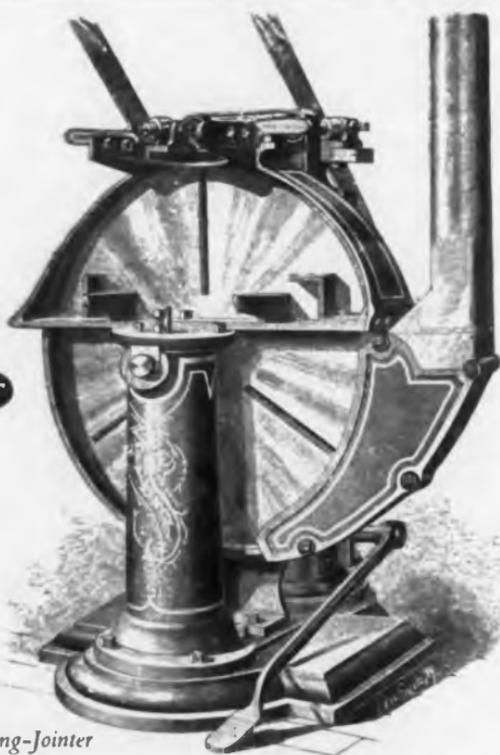
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Exclusive *Paraforming* method of tube making without artificial heat or pressure. Makes perfectly flat side walls, square inside corners, and very small radius on the four outside corners—and does it all at the time of actual spiral winding. No sharp outside edges to cut wire. No need for wedges to tighten wire. Full rigidity and physical strength. Permits winding coils to closer tolerances. Allows faster automatic stacking of coils. Approved and used by leading manufacturers. No extra cost!



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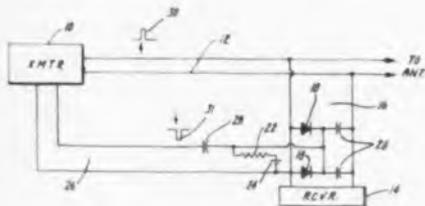
CIRCLE 764 ON READER-SERVICE CARD

Transmit—Receive Device

Patent No. 2,959,778. W. E. Bradley
(Assigned to Philco Corp.)

A semiconductor diode operated as a transmit-receive device gates the receiver according to the transmitter output to make a radar effective at very short range. The transmitter "spike" is not seen and the receiver is responsive as soon as the transmitter pulse terminates.

At quiescence, diodes 18 are back-biased by battery 24 and the receiver is open. A video pulse 31, synchronous with the transmitter pulse 30, drives the diodes to conduct hard and short-circuit the receiver input. When the transmitter pulse terminates, the diodes again are cut off and the receiver can respond to nearby targets.

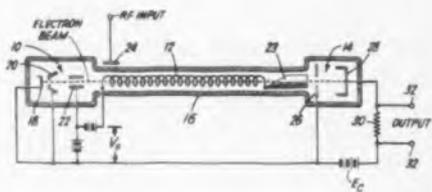


Frequency Discriminator

Patent No. 2,956,199. H. B. Briskin (Assigned to Sylvania Electric Products, Inc.)

A TWT frequency modulation discriminator operates by sorting electrons according to velocity.

Signal is applied to a dispersive helix 12 on which the wave propagates at a velocity prescribed by the instantaneous frequency. Interaction of the wave with the beam modulates the velocity of the electrons in the beam. Subsequently, the electrons are sorted by an apertured disk which is normally at the cathode voltage. Thus the quantity of electrons which pass through load resistor 30, at any instant, depends upon the frequency of the applied signal.



FAST WARM-UP UHF TRIODE MACHLETT ML-7210 PLANAR TRIODE provides stable operation in 12 seconds



The Machlett Laboratories offers the designer a new planar triode designed for pulsed or CW operation requiring fast warm-up time. The ML-7210 reaches a stable operating temperature within 12 seconds and can withstand high shock and vibration. Its low grid-cathode capacitance reduces loading of input stages.

The ML-7210, available now from stock, employs a pancake coil heater, with heat reflecting baffles to provide extremely fast heating without loss of structural rigidity.

Plate-Pulsed Oscillator and Amplifier Class C

Maximum Ratings, Absolute Values

Pulse Length	3	μsec
Duty Factor	0.0025	
Peak Plate Pulse Supply Voltage	3500	volts
DC Grid Bias Voltage*	-150	volts
Peak Plate Current from Pulse Supply	2.8	amps
Average Plate Current	7.0	mA
Average Grid Current	3.0	mA
Average Plate Dissipation	25	watts
Average Grid Dissipation	1.5	watts

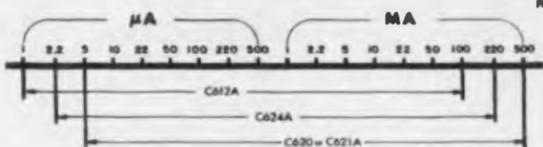
For full technical data on this or any other Machlett tube type, write:

The Machlett Laboratories, Inc., 1063 Hope Street, Springdale, Conn.

Subsidiary of Raytheon Company

CIRCLE 766 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961



MODEL C612A

Regatron Programmable
CONSTANT-CURRENT POWER SUPPLIES

There's a lot that's special about Regatron Constant-Current Power Supplies . . . 0.1% regulation (above 2.2 μ a) . . . a modulation input . . . zero to maximum-range vernier . . . wide range (see diagram above). And for use in automatic or semiautomatic applications, you'll have the advantage of the exclusive Regatron programming feature.

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Wide-Band

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Typical of the line, specifications of the Model CM210 waveguide T-circulator include: frequency range, 6150 to 7550mc; isolation, 20db min.; insertion loss, 0.20db max.; VSWR, 1.15db max.; size, 3" x 3 1/4" x 3 3/4"; connectors mate with UG/50/U.

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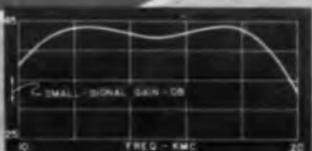


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BOOKS

Digital Computer and Control Engineering

Robert Steven Ledley, McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y., 835 pp, \$14.50.

Covering nearly all aspects of digital computers and controls, this book is written from a fully detailed, engineering point of view. It is meant to be used as a textbook by senior or graduate engineering students or as a reference by the practicing engineer. The material is presented in five sections: concepts of programming, digital systems design, logical design as applied to digital circuits, current methods in logical design of both serial and parallel arithmetic components, and the design of digital circuits,

using solid-state and magnetic-core components.

Using and Understanding Probes

Rudolf F. Graf, Howard W. Sams & Co., Inc., 1720 E. 38th St., Indianapolis 7, Ind., 192 pp, \$3.95.

This book helps the engineer or technician select the right test probe and use it correctly to trouble-shoot practically any kind of electronic equipment. Types of probes covered are: direct, isolation, high-voltage, low-capacitance, rectifying, demodulating, signal-tracing and signal-injection. Data on the different types of probes available are also included. Illustrations are used throughout the book.

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Ultrasonics

Benson Carlin, McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y., 309 pp, \$11.50.

This book is aimed at the practicing engineer who needs complete coverage of ultrasonics from the design consideration of ultrasonic crystals to the experimental measurement of ultrasonic waves. It contains information on the theory and methods of generating waves, circuits and electronic considerations, and data on the mechanical and electrical design of systems. Now in its second edition, the book has been revised to include recent developments.

Analysis and Design of Feedback Control Systems

George J. Thaler and Robert G. Brown, McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y., 648 pp, \$14.50.

A text for senior or graduate courses in feedback control theory, this book was first published under the title, "Servo-mechanism Analysis." This revised edi-

tion provides several chapters on design based on current industrial practices. Subject matter is integrated so that polar and logarithmic frequency-response methods are presented with root-locus methods.

Electromagnetic Fields, Energy, and Forces

Robert M. Fano, Lan Jen Chu, and Richard B. Adler, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 520 pp, \$12.

Written as a textbook for third-year electrical engineering courses at Massachusetts Institute of Technology this book develops a consistent macroscopic theory of electromagnetism and discusses the relation between circuit theory and field theory. It covers the electromagnetism of moving bodies and the process of electromechanical energy conversion. It emphasizes the synthesis of fields as opposed to the analysis of fields and introduces a power series technique for analyzing quasi-static fields and quasi-stationary systems.



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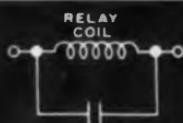
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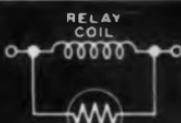
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RELAY APPLICATION QUIZ



DIODE RESISTOR SHUNT

Here are some commonly used arc-inhibiting circuits. All arc-inhibiting circuits have a predominant effect on one relay performance characteristic; when selecting a circuit, which operating characteristic should you check; A, relay operate time; B, relay release time; or C, relay motor torque?

Arc-inhibiting devices are circuits that absorb the energy induced by an inductor when the current through the inductor is interrupted. The induced emf assumes a polarity such that current flow will keep the relay energized over the period required for the energy to be absorbed by the device. The answer is B.

WHAT DOES THIS MEAN IN TERMS OF RELAY CIRCUIT DESIGN?

It means that when an arc-inhibiting device is used across a relay motor coil, consideration must be given to its effect on switching time as well as its ability to absorb energy. To eliminate all arcing, contact voltages must be kept below 12 volts, but of course, no device should be used that will clip or dissipate the coil voltage. The more energy that is absorbed by the device, the longer the contact life.

In the following comparison of the devices shown in the illustration, the components were selected to limit the induced emf in a 28-volt subminiature relay motor coil and also to fit within a subminiature relay housing.

DEVICE	VALUE	MAX. EMF (Volts)	DELAY TIME (Msec)	RATING AND COMMENT
Capacitor shunt	10 mfd	10	4.0	Good but large and expensive for high temperature use.
	0.22 mfd	120	0.05	
Zener diodes (2)	50 volts	190	0.2	Must be rated above coil voltage; expensive.
Varistor shunt	Globar 432BNB-35	64	1.2	Good; resistance must be high near coil voltage; may have high temperature problems.
Diode Resistor shunt	470 ohms	80	3.9	Best device of the four; small, inexpensive, and safe.

Filtors' research department has prepared a comprehensive monograph on this subject entitled, "Effects of Arc-Inhibiting Circuits on Relay Operation." Send 50 cents to Filtors, Incorporated, or contact your Filtors' Sales representative for your copy.

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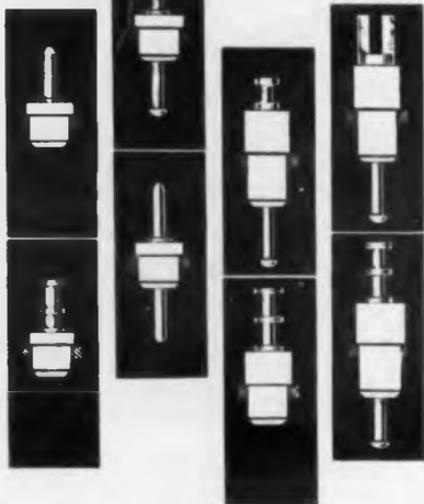
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BOOKS

Publishing in the USSR

Boris I. Gorokhoff, Indiana University Publications, Bloomington, Ind., 308 pp, \$6.

A survey of book, periodical and newspaper publishing in the Soviet Union, this book includes topics such as censorship and copyright. It emphasizes publications in science and technology, especially those issued by the All-Union Institute of Scientific and Technical Information. Scientific journals are also listed.

Electromagnetic Energy Transmission and Radiation

Adler, Chu and Fano, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 621 pp, \$14.50.

One of the textbooks in the Massachusetts Institute of Technology curriculum, this book treats electromagnetic waves and oscillations in one, two and three space dimensions, using time-domain, complex-frequency-domain and energy

points of view. The authors try to provide a balance of emphasis between physical considerations and analytical technique.

Infrared Radiation

Henry L. Hackforth, McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y., 303 pp, \$10.

This is a general reference and introduction to infrared radiation. It begins with a discussion of the basic principles of infrared radiation and its sources. The second part of the book covers applications in scientific research, in industry and in space technology. Infrared-system design considerations are also included.

Magnetic Amplifiers Principles and Applications

Paul Mali, John F. Rider, Publisher, Inc., 116 W. 14th St., New York, N. Y., 112 pp, \$2.45.

Written for the technician, this book begins with an elementary discussion of magnetism and goes on to discuss self-

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starting and three-legged core magnetic amplifiers, compensating magnetic amplifiers and polarized magnetic amplifiers. Maintenance and troubleshooting are covered from the practical viewpoint. A final section on system applications is included. Easily understood diagrams are used throughout.

Digital Computer Principles

Wayne C. Irwin, D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J., 321 pp, \$8.

An introduction to the fundamentals of digital computers, this book is directed to the reader with no previous experience in this area. It begins with a discussion of computation methods, including the binary system and the four fundamental arithmetic operations. Subsequent chapters develop topics essential to the use of digital computers, including programming techniques. The last chapter presents some of the newer concepts and systems-organization methods now being explored.

Magnetic Amplifiers— Principles and Applications

Paul Mali, John F. Rider Publisher, Inc., 116 W. 14 St., New York, N.Y., 112 pp, \$2.45.

Presuming only a fundamental knowledge of electricity, this text starts with a review in the field of magnetism, electromagnetism and magnetic circuitry. From the basics of magnetism, the text then discusses the saturable reactor, self-starting and three-legged core magnetic amplifiers, compensating magnetic amplifiers, and variations of these. Having established the theory of the magnetic amplifier, the text next goes into amplifier gain, feedback, and general uses and construction. From here, the very important topic of maintenance and troubleshooting is covered from a practical viewpoint. A final section on system applications shows diagrammatically a vast number of practical applications of magnetic amplifier circuitry, together with a thorough discussion of each application. A glossary is included for convenient reference.

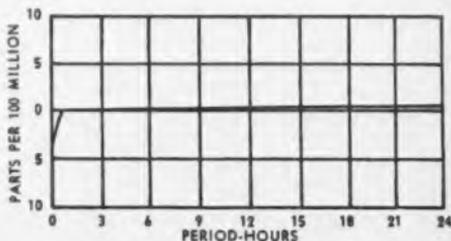
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GERMAN ABSTRACTS

E. Brenner

Using Transistors

AN IDEAL switch is a two-terminal, two-position device that in one position has no voltage across it (independently of the current); in the other position it has no current through it (independently of the voltage). Differences between practical and ideal switches fall into the four categories indicated in Fig. 1. These differences are a result of leakage resistance and current, switch impedance and contact voltage, and coupling between switch and controller.

In the circuit I' is the leakage current with sistor as a switch operates on the static charac-

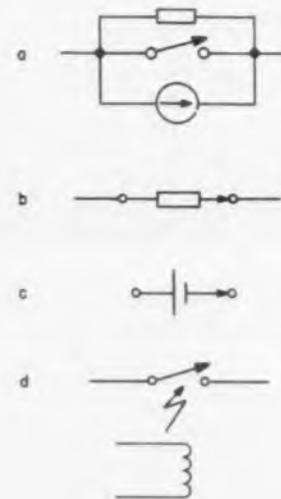


Fig. 1. Imperfections of "ideal" switching devices: (a) leakage with switch "open" (b) non-zero switch impedance (c) contact potentials with switch closed (d) coupling from control circuit to switched branch, shown as with relay circuits.

Junction as Switches

teristics indicated by the heavy lines of Fig. 2. Operation imperfections arise because these lines do not coincide with the coordinate axes. The simplified equivalent circuit of Fig. 3 may be used to deduce the static performance of the switching transistor.

In the circuit, I' is the leakage current with the switch "open." This current is strongly temperature-dependent. With the switch "closed"

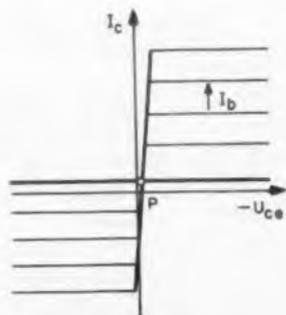


Fig. 2. Static characteristics.

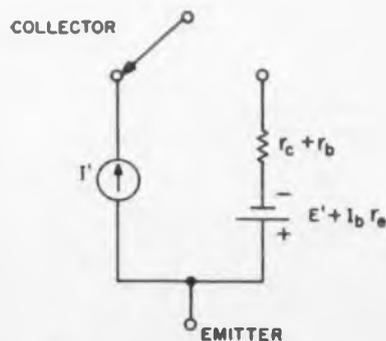
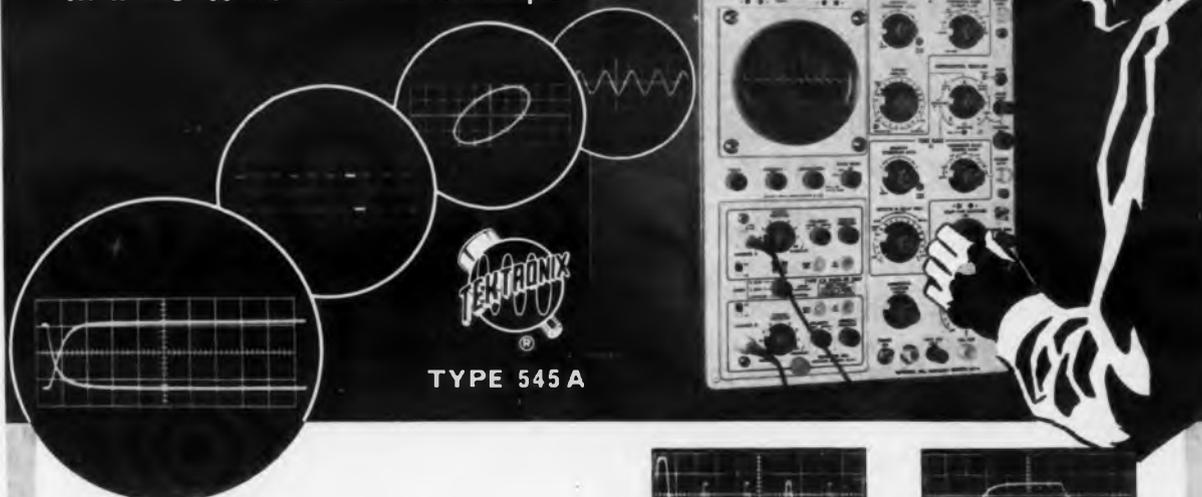


Fig. 3. Simplified equivalent circuit for static conditions.

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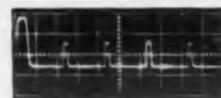
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GERMAN ABSTRACTS

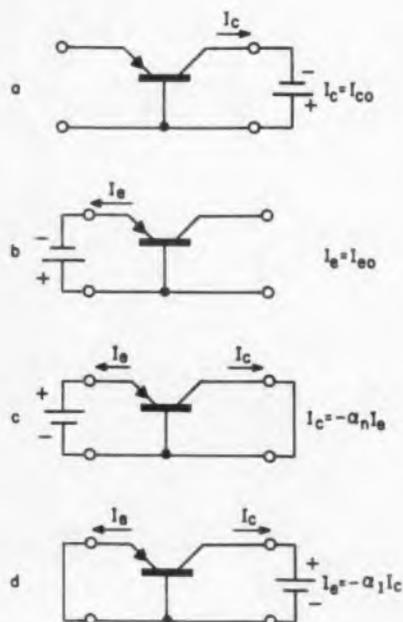


Fig. 4. Definition of normal and inverse parameters.

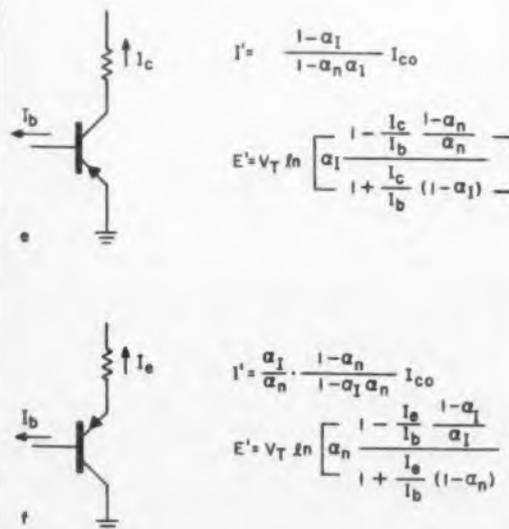


Fig. 5. Grounded emitter (e) and grounded collector (f) configurations.

there appears the series resistance $r_c + r_b$ and a "contact" potential $E' + I_b r_b$, where E' depends on I_e and I_b . When the positions of the emitter and collector are reversed, I' and E' are markedly smaller. The relevant transistor parameters,

*R. L. Bright, Communications & Electronics, 1955, pp 11-121.

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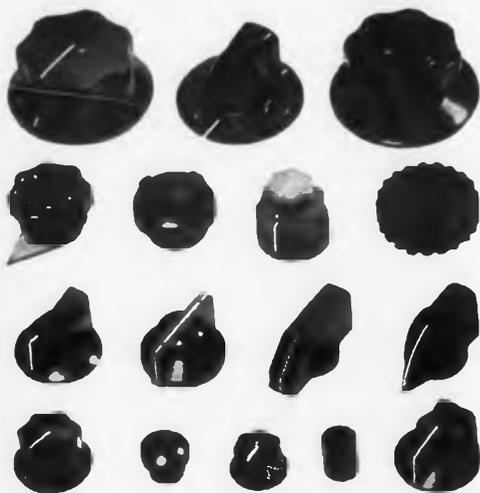
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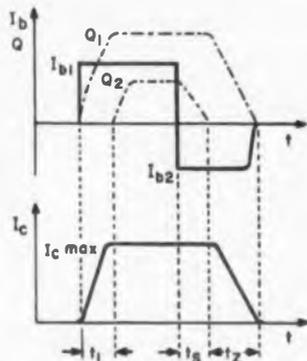


Fig. 6. Time dependence of currents and charge during a switching cycle.

as well as the two configurations, are shown in Figs. 4 and 5. Typical values are:

For Fig. 5e: $E' = 5.8$ mv $I' = 4.6$ μ a

For Fig. 5f: $E' = 0.5$ mv $I' = 0.5$ μ a

The dynamic behavior of the switch is characterized by the time delay necessary for the required change in base charge to take place. Fig. 6 indicates the effect of a change in the base current waveform on the collector current. The base charge consists of two components, Q_1 and Q_2 , the latter arising when $I_{b1} > I_{bmin}$ where

$$I_{bmin} = (1 - \alpha_N) I_{cmax}$$

It can be shown, referring to Fig. 5, that

$$t_{1,2} = \frac{I_{cmax}}{I_{b1,2}} \cdot \frac{1}{\omega_N}$$

$$t_s \approx \frac{I_{b1} - I_{bmin}}{I_{b2}\omega_N} \cdot \frac{1 - \omega_N/\omega_1}{1 - \alpha_N\alpha_I}$$

where ω_N and ω_1 are the upper radian cutoff frequencies of the transistor in the normal inverse states respectively. For a typical transistor

$$\alpha_N = 0.98$$

$$\alpha_I = 0.8$$

$$\omega_N = 30 \omega_I = 30 \times 10^6 \text{ rad/sec}$$

$$I_{sI} = I_{s2} = I_{cmax} = 10 \text{ ma}$$

$$t_1 = t_2 = 0.03 \text{ } \mu\text{sec}$$

$$t_s = 0.6 \text{ } \mu\text{sec}$$

These formulas lead to shorter switching times than can be realized practically. Moreover, thermal instability can be caused by the interaction of thermal and electrical values.

The original paper also cites examples of the design of choppers, switches and power amplifiers.

Abstracted from an article by G. Meyer-Broetz, *Telefunken Zeitung*, Vol. 33, No. 128, June 1960, pp 85-98.

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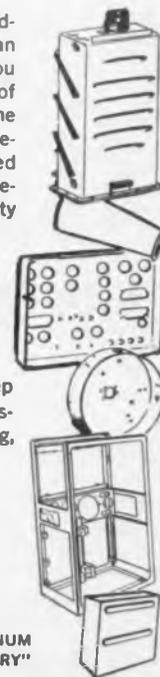
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A RECENT Swiss development is an electronic decade counter tube capable of counting rates ranging from 200,000 to 1,000,000 pps. Manufactured by Elesta A. G., Bad Ragaz (SG), Switzerland, the tube features a non-symmetrical cathode arrangement. Further, the tube is said to be very small in size, with low current consumption and no tube heating problems.

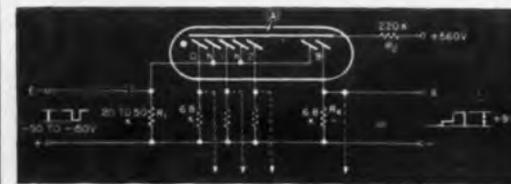


Fig. 1. Special arrangement of flash and auxiliary hold-off cathodes permits counting rates of up to 1,000,000 pps.

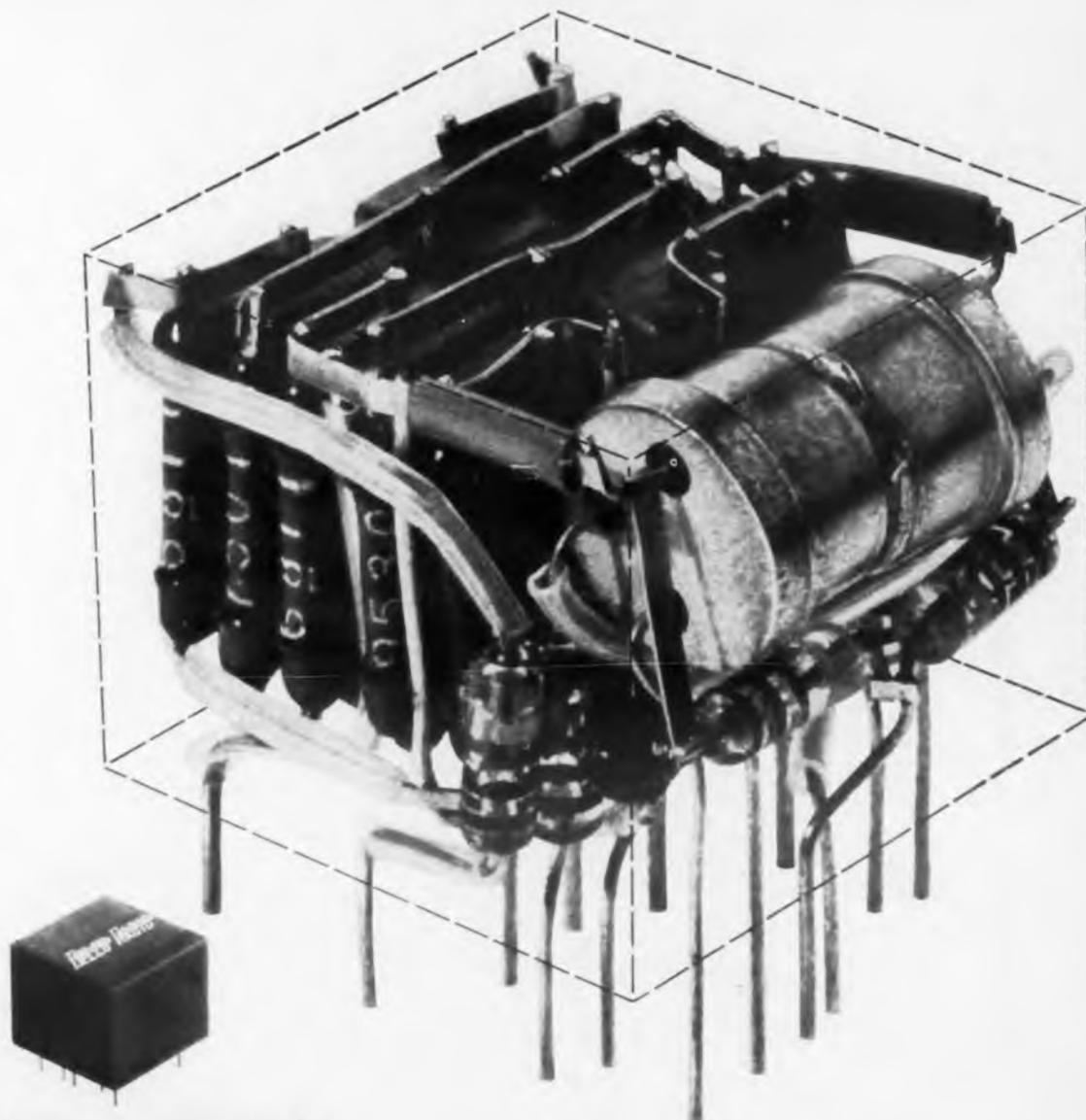
Twenty cold cathodes of identical construction are mounted fan-shape about a cylindrical anode A, Fig. 1. Ten of these cathodes (numbered 0 to 9) are connected to the negative pole of the supply voltage by way of the external 6.8-ohm resistors.

Ten auxiliary cathodes are placed between the "main" cathodes, 1, 2, 3, etc. They are connected through a common 20-50-K resistor, to the negative terminal. The tube is energized by a 560-v supply. A series resistor R_2 in the anode circuit reduces this voltage by one half.

Cathode 1 flashes and causes an anode potential difference of 280 v. By probe effect, the two adjacent auxiliary cathodes pick up a portion of the current which, in turn, causes an initial positive potential of 15-25 v to appear across the input resistor R_1 . This blocks off any triggering of the auxiliary cathodes. Cathode 1 therefore fires evenly.

Now, if a discrete counting pulse is applied to input E , overcoming the "biasing" voltage across R_1 , the potential on h rises above the 280 v operating value, triggering the auxiliary cathode located immediately to the right of cathode 1. Because of its overlap, this cathode is partially within the field of the existing discharge. The potential difference across R_2 rises, the potential on 1 drops below 280 v, and the discharge of 1 is cut-off. The removal of the pulse from R_1 restores a positive potential which transfers the discharge to the next cathode—and so on. The successive application and removal of counting pulses produces step-like gradients. Once the discharge reaches 9, the potential difference developed across the last resistor R_2 can be used for the next decade.

Digested from R. Hübner, "Neue Elektronische Dekadenzählrohren für hohe Zahlgeschwindigkeiten" in Technica (Switzerland), No. 11, 1960, pp 670-671 (in German). Appeared in English in European Technical Digests, Sept., 1960, pp 13-14.



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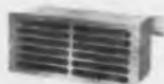
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REPORT BRIEFS

Telemetry System Study

A telemetry system study has been conducted to evaluate both experimentally and analytically the performance capability and potential of standard systems. A design plan for an improved telemetry system is also provided. Volume 1 contains an analysis of each of the four basic systems: PCM-FM, PDM-FM, FM-FM, and PAM-FM. The analyses have been developed and verified experimentally. The criteria for comparing the relative performance of the several systems are derived and the comparisons are presented. *Telemetry System Study, Volume 1 (of three). Analysis and Design, J. G. Hammond, Aeronutronic, Newport Beach, Calif., Feb. 6, 1957–Nov. 30, 1959, 283 pp, Microfilm \$11.10, Photocopy \$44.10. Order PB 147919-1 from Library of Congress, Washington 25, D.C.*

Ferrite-Coupled Lines

An analysis is presented of ferrite-coupled TEM-mode transmission lines. Both the reciprocal and nonreciprocal transmission properties of a two-line or two-mode system have been analyzed for the case where the axis of dc magnetization is along the direction of transmission. The analysis was applied to the case of a transmission system which consists of two conductors plus a shield. *Theory Of Ferrite-Coupled Transmission Lines Networks, Philip S. Carter, Jr., Lockheed Aircraft Corp., Sunnyvale, Calif., Feb. 27, 1959, 28 pp, Microfilm \$2.70, Photocopy \$4.80. Order PB 147672 from Library of Congress, Washington 25, D.C.*

Dielectrics

Boron nitride and an alumina ceramic have been tested and found to possess high temperature dielectric properties surpassing that of the best single crystal sapphire. Reconstituted mica was also used to prepare pure dielectrics for use as electrical insulation at 500 C. The report discusses the development of techniques for high temperature pressing and firing of these materials to preserve the desirable high temperature dielectric properties. Included in the illustrated report is a bibliography and a 17-page annotated survey of the literature on preparation, purification and dielectric properties of aluminum oxide. *Synthesis and Purification of Dielectric Materials, Westinghouse Electric Corp. for WADC, Oct. 1959, pp 141, \$2.75. Order PB 161366 from U. S. Department of Commerce Field Office, 1031 S. Broadway, Los Angeles 15, Calif.*

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Cooling Semiconductor Devices

This handbook was prepared to aid electronic engineers in the thermal design of reliable military electronic equipment. Enumerated are recommended principles and techniques for the thermal design of electronic equipment using semiconductor devices. *Air Force Handbook: Methods of Cooling Semiconductor Devices*, Steven K. Morrison and James P. Welsh, Army Signal Research and Development Laboratory, Fort Monmouth, N.J. Report on Contract AF 30(602)1842, May 1960, 74 pp, 17 ref., Microfilm \$4.50, Photostat \$12.30. Order PB 148783 from Library of Congress, Photoduplication Service, Publications Board Project, Washington 25, D.C.

Electrostatic Focusing

A new technique has been developed for constructing tubes employing the planar periodic electrostatic focusing of an electron-sheet beam. Use of this technique permits both mechanical ruggedness and excellent alignment of the electrodes. The technique, in brief, consists in assembling the entire tube structure in separate halves, grinding their surfaces simultaneously with an abrasive wheel, and then bolting the two halves together at each end. Experimental tubes were constructed, and gave excellent beam transmission through the electrostatically focused structure, in one case as high as 99.8 per cent. *Construction of Tubes Employing Planar Periodic Electrostatic Focusing*, Burton J. Odelson and McKay R. Bradley, Diamond Ordnance Fuze Laboratories, Washington, D.C., May 16, 1960, 31 pp, 8 ref., Microfilm \$3.00, Photostat \$6.30. Order PB 148464 from Library of Congress, Photoduplication Service, Publications Board Project, Washington 25, D.C.

Planning Systems

A general concept for the formulation of detailed design and evaluation criteria for complex developmental systems is outlined. Achievements necessary to develop a suitable end product are described. The report points out that any process begins with the need for a system, and that a general description and an understanding of performance requirements are necessary to accomplish the mission. A group of combined functional elements for efficient system design are defined. Theoretical mechanization requirements are validated by the design, construction, and evaluation of an experimental model. *Planning Philosophy for Complex Systems*, Naval Research Laboratory, Washington, D.C., Aug. 1959, 12 pp, \$0.50. Order PB 151764 from U. S. Department of Commerce Field Office, 1031 S. Broadway, Los Angeles 15, Calif.

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REPORT BRIEFS

Network Topology

The theory of linear graphs, or topology, is applied to passive and active networks. Some simplifications to the determination of equations for current and voltage gain are discussed. The calculation of the minimum number of network trees required to represent active networks is considered, and methods for simplifying the establishment of the required trees are examined. In addition, the active equations for the parametric amplifier are derived topologically. *The Use Of Network Topology With Active Circuits*, Keats A. Pullen, Jr., Ballistic Research Laboratory, Aberdeen Proving Ground, Md., Feb. 1960, 97 pp, Microfilm \$5.40, Photocopy \$15.30. Order PB 147649 from Library of Congress, Washington 25, D.C.

2200-Mc Telemetry System

A 2200-mc multi-channel telemetry relay system was developed to provide a high-capacity net interlinking all data-recording sites and receiving stations. In addition, simultaneous calibration of all stations was made possible. The relay employs the super-heterodyne principle to translate all the vhf telemetry signals as a unit to the microwave region for transmission to the recording stations. The system features a large dynamic range and uses close channel spacing for efficient use of bandwidth. A *Microwave Telemetry Relay*, Leonard S. Taylor, Integrated Range Mission, White Sands, N. M., Apr. 1958, 88 pp, Microfilm \$4.80, Photocopy \$13.80. Order PB 147367 from Library of Congress, Washington 25, D.C.

Picture Transmission

This report examines several fundamental aspects of the picture-scanning process used in electrical facsimile or telephoto systems. In particular, scanning processes are analyzed with respect to the relation between the required time-bandwidth product and the unavoidable degradation of resolution which usually results. Upper bounds on the performance of such systems are given, together with several improved methods of scanning which hold promise for getting closer to ideal conditions than those presently in use. *The Scanning Process in Picture Transmission*, A. E. Laemmel, Microwave Research Institute, Polytechnic Institute of Brooklyn, N.Y., Mar. 1957, 51 pp, Microfilm \$3.60, Photostat \$9.30. Order PB 146371 from Library of Congress, Photoduplication Service, Publication Board Project, Washington 25, D.C.



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Ultra High Temperatures

Final report covering a four-year study of various chemical and physical phenomena at temperatures up to 5,000 K. This report summarizes the work reported in previous technical notes. *Study of Ultra High Temperatures, Research Institute of Temple University for WADC, April 1959, pp 26, \$1.00. Order PB 161460 from U. S. Department of Commerce Field Office, 1031 S. Broadway, Los Angeles 15, Calif.*

Cooling Electronic Equipment

A comprehensive thermal design handbook has been prepared to assist engineers in designing cooling systems for Air Force ground electronic equipment. Various modes of heat transfer, as well as theory, data, and computational methods for achieving successful thermal designs, are discussed. Text is written for engineers without a heat transfer background and for thermal engineering specialists interested in electronic equipment cooling systems. Separate chapters are devoted to thermal design, natural cooling methods, forced air cooling, liquid cooling, thermal criteria, and thermal limitations of parts. Also included are four appendixes, a list of references, 196 diagrams and illustrations, and 47 tables. *Handbook of Methods of Cooling Air Force Ground Electronic Equipment, J. P. Welsh and T. J. Walsh, Cornell Aeronautical Laboratory, Inc. and Rome Air Development Center, June 1959, \$8.00. Order PB 161264 from OTS, U. S. Department of Commerce, Washington 25, D.C.*

Paramagnetic Maser

Theoretical calculations showing the effects of various types of cross relaxation mechanisms on maser inversion ratio are given. Examples of three spin, four spin, and five spin processes are compared to experiments which have been described in the recent literature. Transient solutions of the rate equations are obtained and methods of measuring the cross relaxation probability described. The design of a superconducting iron-cored electromagnetic is described. It is anticipated that this magnet will allow the use of longer slow-wave structures than are possible with the conventional laboratory electromagnet. *Research and Development of a Solid State Paramagnetic Maser, Roy W. Roberts and Harold D. Tenney, Melabs., Palo Alto, Calif., Quarterly progress (scientific) report No. 7, Apr 9, 1960, 37 pp, Microfilm \$3.00, Photostat \$6.30. Order PB 148403 from Library of Congress, Photoduplication Service, Publication Board Project, Washington 25, D.C.*

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STANDARDS AND SPECS

Dry Cells and Batteries Spec Now Includes Transistor Batteries

Covering new tests and performance requirements, the seventh edition of this specification includes batteries for use with transistors. Some of the other classifications included in this revision are: No. 6 Dry cells; A, B, and C batteries; and A/B pack batteries. Sponsored by the National Bureau of Standards, the American Standard Specifications for Dry Cells and Batteries, C18.1-1959 is available from the American Standards Association, 10 E. 40th St., New York 16, N. Y. at \$0.25 per copy.

Methods of Assessing TV Receivers Properties Established

Methods of assessing the essential properties of a TV receiver under standard conditions are established by this IEC publication. The publication's primary purpose is to permit comparison of the results of measurements in different laboratories. The measurement techniques cover the electrical, acoustical, and optical properties of television-broadcast receivers designed for monochrome vision reception of 405-, 525-, 625-, and 819-line transmissions of either negative or positive modulation and the associated am- or fm-sound channel. Copies are available from American Standards Association, 10 E. 40 St., N.Y. at \$10.00 per copy.

ASA Compiles Shock, Vibration Pickup Calibration Methods

This comprehensive document describes most calibration methods used today and covers specifically constant acceleration, sinusoidal motion, and transient motion. Methods that are currently limited in use or are less accurate are included in an appendix; as their usefulness and accuracy are established, they will be moved into the main body of future revisions of the standard. American Standard Methods for the Calibration of Shock and Vibration Pickups, S2.-1959, is available from the American Standards Association, 10 E. 40th St., New York 16, N. Y. at \$2.50 per copy.

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WHAT IS RELIABLE RELAYABILITY?
IT'S ELGIN ADVANCE'S ABILITY TO
BUILD A RELIABLE QUALITY RELAY
LIKE THE SENSITIVE MQ SERIES.

THE MQ SERIES CRYSTAL-CAN-SIZE HERMETICALLY SEALED RELAY IS AVAILABLE IN THREE SENSITIVITIES TO MEET VARYING MILITARY AND INDUSTRIAL REQUIREMENTS. THESE CURRENT-OPERATED RELAYS COME WITH PLUG-IN PINS FOR PRINTED CIRCUIT USE, SOLDER HOOKS AND 3-INCH LEADS AND A VARIETY OF MOUNTING ARRANGEMENTS. ALL CONNECTIONS ARE SPACED ON 0.2 INCH GRID.

SPEC	MQA	MQB	MQC
Pull-in Power (@ 25°C)	250 MW	100 MW	50 MW
Contact Rating (Res @ 28VDC or 115VAC)	2 amps	1 amp	1 amp
Operating and Release Times	5 MS ea	6 MS ea	7 MS ea
Shock	50G	35G	20G
Contact Arrangement: DPDT			
Temperature Range: -65°C to +125°C			
Dimensions: 0.875 in. h x 0.800 in. w x 0.396 in. thk			
Weight: 0.6 oz.			
Life (at rated load): 100,000 operations minimum			

ELGIN advance RELAYS 

THE ELECTRONICS DIVISION OF
ELGIN NATIONAL WATCH COMPANY
2435 N. NAOMI ST., BURBANK, CALIF.

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MINIATURE BAND PASS & LOW PASS RF FILTERS

TELONIC'S new TBP Band Pass Filters cover the frequency range from 200 to 2000 megacycles and may be easily set to any band-pass value between 2.5% and 25%. They are available with 2, 3, or 4 sections depending on bandpass and rejection requirements. Electrical performance of the TBP filters corresponds to resonant cavities or tank circuits with unloaded Q's of over 200, and their DC resistance is essentially infinite both to ground and from input to output. Small size and rugged construction make these filters ideal for missile and aircraft applications. Special temperature resistant coil-forms and spacers assure a high degree of mechanical stability and allow operation at temperatures over 100°C. Available with BNC or other standard connectors.

Typical specifications for a 4-Section Filter

Center Frequency	200-2000 mc.
Pass Band Width	2.5-25%
Pass Band Attenuation	0.5 db \pm .2 db per section at 3% B.W. 0.2 db \pm .1 db per section at 12.5% B.W. Less than 1.5:1 50 ohms
Pass Band VSWR	
Impedance	
Nominal Power Input	Over 15 watts
Connectors	Type BNC, TNC or N
Material	18% Silver Nickel
Weight	Approximately 5 ounces

Price — \$125.00 to \$30.00 depending on type and quantity.

MINIATURE LOW PASS FILTERS

Telonic also manufactures the TLP Series of Low Pass RF Filters exhibiting the same quality and high degree of performance as in the band pass units. These Low Pass Filters are available for any cut-off frequency from 200 to 2000 mc in 5 mc increments.



ENGINEERING CORP.
Laguna Beach, California

For complete data on both types write for data file TE-1

CIRCLE 800 ON READER-SERVICE CARD

Revision of MIL-P-13949 Adds Five New Types of Laminates

Revision B of MIL-P-13949A adds to the spec five new types of glass-fabric laminates; general-purpose, temperature-resistant, and flame-retardant types using epoxy-resin as well as melamine- and silicon-resin types. The spec establishes rigid tolerance classes for thickness and for warp or twist in addition to normal tolerances. The following requirements have been added: maximum copper-foil resistivity to assure reliable conductivity, solder tip on etched specimens to check for blistering, flammability for most types, bond strength on 1/8-in. strips, and flexural strength at high temperatures for the glass-fabric based epoxy resin type. In this spec, the "etching-process and etchant-removal" paragraphs are modified, specifying ferrite chloride solution at room temperature and substituting 10% oxalic-acid solution for the hydrochloric-acid solution. The full name of the spec is Plastic Sheet, Laminated, Copper Clad (For Printed Wiring), MIL-P-13949B. Though not yet available, copies will be distributed by Armed Services Electro-Standards Agency, Fort Monmouth, N. J.

U.S. Standardization Activities Described In NBS Document

A descriptive inventory of the work and objectives of organizations, both public and private, involved in standardization activities is contained in this recently published NBS document. Each organization is listed alphabetically with a brief description of its standardization area and accomplishment. A comprehensive index covers almost all widely known product areas and lists the organizations in each field. This 210-page directory is available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Specify Standardization Activities in the United States, National Bureau of Standards Miscellaneous Publication 230. The cost is \$1.75.

Resistance Value Symbols Calified In MIL-R-26C

The examples of symbols for resistance values have been clarified in the latest issue of MIL-R-26C. The quality assurance provisions have been revised to incorporate the latest paragraphs on responsibility for inspection. The latest information on packaging requirements has also been added to the spec. Mil-R-26C, Amendment 1, Resistors, Fixed, Wirewound (Power Type).

CIRCLE 801 ON READER-SERVICE CARD

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fastest reading!

*Here's 50,000 ips writing speed with
the results at your fingertips*

The print-out record shown here illustrates a typical dynamic test employing 15 traces. Take special note of:

- * 1 - Trace numbering
- * 2 - Trace interruption
- * 3 - Full-width timing lines (0.01, 0.1 or 1.0 sec. intervals)

Trace identification and timing lines are optional features, as are grid lines (1/10" or mm) and galvanometer block heaters. Eighteen Type 7-300 Galvanometers are available covering a range of 1.62 microamps per inch at 6 cps and 46.1 milliamps per inch at 5000 cps.

**CHECK THESE STANDARD FEATURES... ALL INCLUDED
IN THE BASIC 18-TRACE TYPE 5-124 SELLING FOR \$2,290**

5 Pushbutton-selected speeds • 7" by 200' print-out record capacity • High intensity mercury-vapor light source • Automatically regulated galvanometer lamp circuit • Intensity control • Unexposed footage indicator • Individual input connectors • 15¼" long x 13" wide x 7¾" high • 115 volts, 60 cps, 250 watts

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CEC sales and service office or write for Bulletin CEC 5124-X6.*

Data Recorders Division

CEC

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INDOX I

and

INDOX VI**Permanent Magnets****Make Possible Simple, More Compact TWT Design**

If your line of microwave equipment includes traveling wave tubes, you will be interested in Indiana Steel's amazing ceramic permanent magnets called INDOX.

Unlike heavy Alnico materials, INDOX offers designers of microwave equipment a new, light, inexpensive and easy-to-assemble permanent magnet in the sizes, shapes and strengths necessary for today's critical applications.

For example, in periodic focusing traveling wave tubes, INDOX can supply a much higher flux density due to its higher intrinsic coercive force. And INDOX pieces may also be magnetized prior to assembly without appreciable loss of flux density.

Not only does INDOX open new doors of design, but Indiana Steel now offers two grades of INDOX to meet special microwave design problems—INDOX I and INDOX VI.

INDOX I

In addition to having a higher intrinsic coercive force than Alnico, INDOX I is an inexpensive material manufactured to design specifications at moderate die cost. Irreversible flux density losses do not occur until very low operating temperatures are reached. And INDOX I produces a greater flux density than many other materials when operating low on the demagnetization curve. (See curve below.)

INDOX VI

Through extensive research in Indiana's R&D laboratories, a new, more powerful INDOX material has now been released for use in microwave equipment, particularly the TWT's. Having a greater energy product, INDOX VI can be used when a greater flux density is required or when a smaller magnet must be used.

AVAILABLE FROM STOCK NOW!

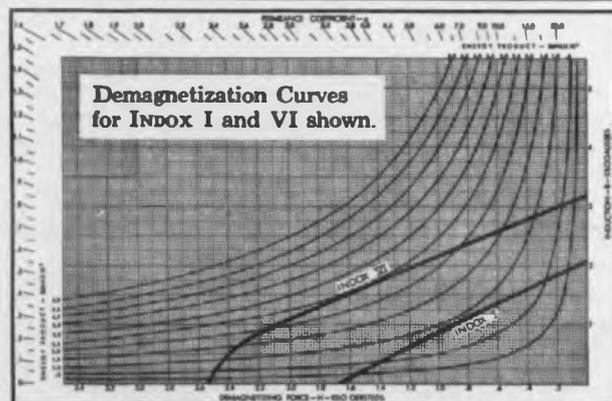
Many unground sizes of INDOX I and VI magnets are now in stock. If required, magnets may be ground to closer tolerance prior to assembly. Magnets may be magnetized before or after shipment, as desired.

DESIGN ENGINEERING NOTE:

Indiana manufactures the widest selection of permanent magnet materials, available in thousands of sizes and shapes. Therefore, you can depend upon Indiana to give unbiased advice in choosing the correct magnet material for your application.

What are your permanent magnet requirements in the broad-band microwave field? It's likely an experienced Indiana application engineer can help you, so write for full information. Request Bulletin 18M-2 (INDOX I and V) and Bulletin 353M-2 (INDOX VI).

NEW! Recently published data on predicting effect of low temperature on INDOX V and VI, compiled by Indiana scientists. For your copy, write for Applied Magnetics, Fourth Quarter, 1959.

**TYPICAL CHARACTERISTICS**

	INDOX I	INDOX VI
Coercive Force (H _c) oersteds	1,825	2,550
Residual Induction (B _r) gauss	2,200	3,200
Peak Energy Product (B _r H _c)	1.0 x 10 ⁶	2.4 x 10 ⁶
Reversible Permeability	1.2	1.06
Temperature Coefficient	-0.19%/°C	-0.19%/°C
Magnetization Field for Saturation, oersteds	10,000	10,000
Chemical Composition	BaFe ₁₂ O ₁₉	BaFe ₁₂ O ₁₉
Specific Gravity	4.7 or 0.17 lb/cu in	4.5 or 0.162 lb/cu in

DIVISION OF
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GENERAL CORPORATION

INDIANA STEEL PRODUCTS

VALPARAISO, INDIANA

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INDIANA PERMANENT MAGNETS

CIRCLE 802 ON READER-SERVICE CARD

**LETTERS****A Word from Convair**

A news story in the Nov. 23, 1960, issue of ELECTRONIC DESIGN stated that present real-time trajectory measuring systems do not have the high accuracy of the Ballistic Camera System.

You may be interested to know that a system is currently in use at the Air Force Missile Test Center, which does exceed real-time trajectory information to accuracies which equal or exceed Ballistic Camera System accuracies. This system, known as AZUSA Mark II, was designed and developed by Convair Astronautics, San Diego. It was installed at Atlantic Missile Range, evaluated this past year, and is now being used actively for trajectory instrumentation and real-time impact prediction.

The Ballistic Camera System was used as the standard of comparison in evaluating the AZUSA Mark II. Under ideal conditions, using cameras of 300-mm focal length, angular measurements can be made to accuracies of 2 to 3 sec of arc. The specifications for the AZUSA Mark II called for angular accuracies of 2 sec of arc, not including refraction errors and atmospheric inhomogeneities. A total of 155 test runs were made, taking measurements simultaneously with Ballistic Cameras and AZUSA Mark II. The results show a difference between the Ballistic Camera System and AZUSA Mark II of only 3 or 4 sec of arc. This "difference" includes Ballistic Camera errors, AZUSA Mark II errors, refraction errors, and errors due to atmospheric inhomogeneities.

W. D. Walker
Chief Electronics Engineer
Convair
San Diego

On Transistorized Motors . . .

On pp 36-37 of your Nov. 23, 1960 issue I see an article titled "Transistorized DC Motors Moving into Production." Upon reviewing this article I find that an incomplete picture of the transistorized dc motor subject is given the reader; both with respect to the state of the art and to the individuals responsible for pioneering in this

field. I feel that it would be appropriate to review the actual facts, which are as follows:

In the period from 1945 to 1948 the writer, while engaged in an R&D project for the Signal Corps, had occasion to design and make a dc motor in which commutation was accomplished electronically. The specific device consisted of a pair of revolving magnets on a common shaft; one of which served as the driver and the other as signal generator, phased so as to supply pulses for maintenance of continuous rotation. A miniature triode tube was employed. I did not, at the time, consider this device to have any commercial value and no patent applications were pursued either by me or by the client.

Early in 1953 I conceived the idea of using this same basic scheme for dc motor commutation, but employing transistors. In June, 1953, a finalized concept of such a motor was recorded by me and successful working models reduced to practice in January of 1954.

The original motor is generically identical to that shown in your photograph on p 37, invention of which you have credited to a Dr. Harry Stockman. This structure incidentally is covered in U.S. patent No. 2,719,944 issued in 1955. Further development along this line has been carried out by me and several additional patents on these motors have been issued and/or are pending. We have had in production a transistorized motor known as "Type TR" for several years.

Harrison D. Brailsford
Brailsford & Company, Inc.
President
Rye, N.Y.

... And a Reply

There is no question about Mr. Brailsford's priority as an inventor in the transistor motor field, and he should be commended for having conceived these ideas at the early date indicated. My ignorance about this earlier work in the field probably stems from my specific approach: to improve upon oscillating and rotating electro-mechanical systems by analyzing them in light of the Nyquist stability criterion, restricting myself to linear network there exclusively (no iron permitted).

My strict departure from iron core structures in dc motors provides a distinction from the motors covered by the Brailsford patent, in which core-free designs were not foreseen. My motor, designed exclusively for educational purposes, utilizes a spinning bar magnet. If the motor were provided with soft iron pole pieces, it just could not rotate, since my design does not utilize the cleverly designed circular magnets patented by Mr. Brailsford. The most significant difference, however is that my motor operates in an ultrasonic "super-regenerative mode," bringing the



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BY *Therm-O-Disc*



TYPE A—Adjustable

- Slow make or break contacts
- For operating temperatures up to 550°F.
- Resistive load—1500 watts at 120 VAC

TYPE HL

- Single pole, single throw or double pole, single throw
 - Manual or automatic reset
- Preset, snap action, non-adjustable
- For operating temperatures up to 300°F.
- Resistive load—40 amperes at 125 VAC 25 amperes at 250 VAC



TYPE 11T-11

Best suited for controlling temperatures in air streams same ratings as TYPE 11T-21

Designed for surface mounting also available for watertight mounting

- High ratings with minimum size
 - Single pole, single throw or single pole, double throw
- Preset, snap action, non-adjustable
- For operating temperatures up to 350°F.
- Blade or screw terminals, exposed or enclosed disc
- Resistive load—6000 watts at 240 VAC 3000 watts at 120 VAC
- Inductive load—10 amps, full load at 120 VAC 5 amps, full load at 240 VAC



TYPE 11T-21

TYPE AF & AL

- For fan motor or limit control
- 3" or 7" sensing element
 - Snap action—adjustable
 - For operating temperatures up to 300°F.
 - Fan or limit rating— $\frac{1}{2}$ h.p. at 120/240 VAC and 125 volt amperes at 120/240 VAC



TYPE WA

Best suited for controlling temperatures in air streams same ratings as TYPE WC



TYPE WC

- Designed for surface mounting (with or without mounting bracket)
- Preset, snap action, non-adjustable
 - Single pole, single throw
 - For operating temperatures up to 350°F.
 - Blade or screw terminals, exposed or enclosed disc
 - Resistive load—2500 watts at 240 VAC 1650 watts at 120 VAC
 - Inductive load—4.4 amps, full load at 120 VAC 2.2 amps, full load at 240 VAC



TYPE 20T

- Refrigeration and air conditioning control
 - Hermetically sealed in all-metal case
 - Single pole, single throw
- For operating temperatures up to 200°F.
- Resistive load—1000 watts at 120/240 VAC



Detailed information on request Minimum production order quantity accepted—25



THERM-O-DISC, Incorporated Mansfield, Ohio

CIRCLE 804 ON READER-SERVICE CARD

LETTERS

driving current pulse faster to a higher value.

The lack of a core structure in my motor and the use of ultrasonic oscillations speak against Mr. Brailsford's claim that his motor is "generically identical" to mine. Neither Mr. Brailsford nor I can patent a motor principle. What he has patented is a transistor motor, and as time goes on, other inventors will patent other transistor motors. Mr. Brailsford retains, however, his established priority, and further inventions in the field will add to the credit we owe him, not detract from it.

Harry E. Stockman
Waltham, Mass.

Cheers for Maintainability, RFI

After reading the excellent series of articles, "Designing for Maintainability" in the Oct. 26, 1960, issue, I am wondering if you could let us have another collection of these articles. I would like to circulate them among engineers in our electronics department.

N. G. Dennis
Woodward Governor Co.
Rockford, Ill.

In the past several months you have been issuing articles on radio frequency interference. I would very much like to have a complete set of these articles for ready reference. This series of articles fills a void that has long existed, i.e., the gap between the inception of an idea and hardware design. Never before have I seen this area covered so adequately in a publication such as yours.

Stanley Becker
Airborne Instruments Laboratory
Deer Park, L.I., N.Y.

If available, may we have a reprint of your outstanding staff report on "Designing for Maintainability" for our files on maintenance design guidelines for submarine electronic equipment. Apparently that issue was in such demand that it was not delivered to our Circuit Group subscribers. We here in Electric Boat's circuit design section of Systems Application are looking forward to more detailed reports in this most critical electronic design area.

S. B. Ensley
Electric Boat Div.
General Dynamics Corp.
Groton, Conn.

The series of articles, "Designing for Maintainability," being of considerable interest to a num-

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**the precision-made, miniature-size flexible coupling with ZERO BACKLASH*

This is a TINYMITE Flexible Coupling

You save space and weight with Renbrandt Miniature Flexible Couplings. They have torsional rigidity, angular and linear flexibility, low inertia . . . and yet are ENTIRELY FREE OF BACKLASH. The unique disc-type design assures long life at a moderate price. A complete line is available for $\frac{1}{16}$ " through $\frac{1}{2}$ " shafts in all combinations. Many hub styles, including clamp and set screw.

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Heinz Mueller fans and blowers have shown outstanding ability to meet military specifications for performance and extreme durability. Now, these same characteristics are also available for commercial applications . . . wherever precision is vital.

Call a Heinz Mueller engineer for design help on the "tough ones." We've already solved something close to the problem you're facing now.



BLOWER

Delivers 75 C.F.M. at 6000 R.P.M. using 2 $\frac{3}{4}$ " blower wheel. With filter for radio noise suppression. Military or commercial specifications. Motors 6 to 220 volt D.C. or 60 cycles A.C. 400 cycles on special request. Blowers from 2 to 200 C.F.M. with 1" to 4" wheels.



TUNNEL FAN

Weights only 14 oz., but delivers 150 C.F.M. at 3100 R.P.M. 4" fan. Can supply 2 C.F.M. to 250 C.F.M. with 2" to 10" blades. FAN—Miniature precision design delivers 20 C.F.M. at 10,000 R.P.M. 2" dia. 10-blade fan. Motor 27.5 volt D.C. Weight 4 oz.



METAL FAN BLADES

2" to 5" diam. Sizes Aluminum or steel. Fans can be furnished with plain hole, metal hub or rubber grommet. Maximum air movement. Minimum horsepower requirement. Maximum air quietness.

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ELECTRONIC DESIGN • February 15, 1961

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CIRCLE 895 ON READER-SERVICE CARD

ELECTRONIC DESIGN • February 15, 1961

ber of project groups working on government research projects for various weapon systems, we would like to request 10 copies of this issue.

Mary Ellen Padin
Dunlap and Associates, Inc.
Stamford, Conn.

Our group designs test equipment and control circuits, and your magazine has enabled us to remain abreast of the new developments. Your feature article of "Designing for Maintainability" was very impressive. We would like to obtain 15 reprints of the article.

G. Orsi
Automatic Electric Co.
Northlake, Ill.

Factorial Experimentation Growing

An item appearing on p 28 of the Nov. 23, 1960, issue of ELECTRONIC DESIGN caught my eye. [The news story referred to stated that the Fort Huachuca experiments will be one of the first engineering applications of factorial design.] Factorial designs have been fruitfully used for more than 10 years. I wrote my thesis on industrial and design engineering applications of factorial designs.

Dr. Martin Brumbough used factorials in the early '30s at Colonial Radio—now Sylvania. Dr. Harry Romig at Bell Telephone (now with Operations Research Inc.) used factorials in the early '20s. The Navy, with Dr. William Pabst, used factorial experiments in ordnance work in the '40s—on design applications and tests.

What's so new? In fact, though this method is not outmoded, we are using more advanced techniques such as Random Balance Experimentation, Multivariate Analysis, Monte Carlo, Queuing Theory, etc., on current work as a normal, everyday part of the design task. We have an Air Force contract to determine applicability of these techniques to the art of prediction.

A four-factor experiment involving four variables will result in erroneous data and, in my opinion, is a very dangerous one to have our Army rely on. The effect of the fifth factor is most significant. The statistical design, from what you report, seems to have a lot to be desired.

Please understand that we are pleased that the U. S. Army is using factorials. I only wanted to point out that others have for long periods of time used statistically designed experiments.

Richard M. Jacobs, Manager
Reliability & Quality Assurance Dept.
Sylvania Electric Products Inc.
Waltham, Mass.

► Mr. Jacobs and other statistical experimenters would like to see factorial experiments used more widely in engineering.

Metal Sleeved
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"CS" Clipper

miniature-precision-wire wound
POWER RESISTORS
provide outstanding performance
features vital in today's complex
and highly reliable circuitry.

10 Watt Rating Actual Size

"CS" type designates a structural adaptation of long proven silicone coated SAGE Resistors by the addition of exterior heat sink sleeves. Design simplification and adherence to basic heat transfer principles speak for this product in terms of expected reliability over long life.

If you require anything beyond low grade (unspecified stability) power resistors you surely will benefit by investigating these features:

MINIATURE SIZE, or cooler hot spot operation for given size and wattage. Metal heat sink sleeves when clip mounted provide 2 for 1 increase in assigned wattage ratings over free air conditions.

PRECISION: to ±.05% tolerance and low values to .05 Ω.

STABILITY: TC of ±20 ppm/°C. Typical 1000 hour (full) load life drift .5%. Although design hot spot temperatures are less than 275°C, units are unharmed by prolonged exposure as high as 350°C.

MECHANICALLY RUGGED to withstand rough assembly techniques plus vibration and shock hazards.

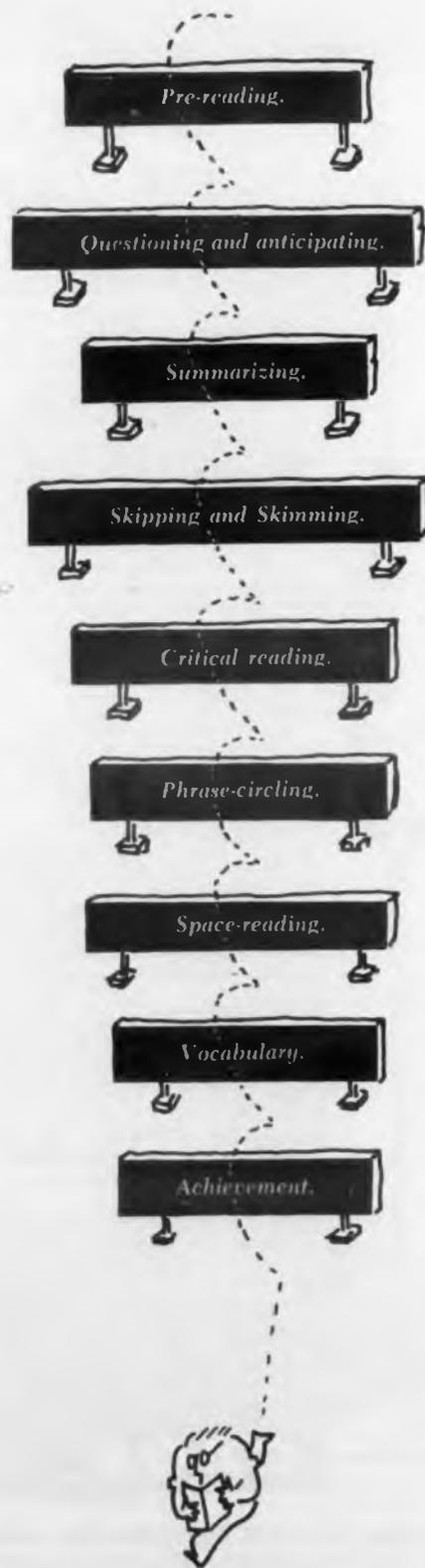
DIELECTRIC STRENGTH: 1000 volts rms minimum.

Style	Length in.	Diameter in.	Power Rating		Resistance 05 Ω to
			Free Air	Body Mounted	
CS3W	3/4	3/16	3	6	36,000 Ω
CSR5W	1	5/16	5	10	80,000 Ω
CSS7W	1 1/4	7/16	7	14	100,000 Ω
CSR7W	1 1/2	7/8	8	16	150,000 Ω
CS10W	1 3/4	1	10	20	220,000 Ω

Test samples available on request.

SAGE

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CIRCLE 808 ON READER-SERVICE CARD



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Part 4

Myron Q. Herrick
Development Research Institute
New York, N. Y.

Today, more than ever before, it is your responsibility to be a critical reader. Here are some steps to take that will give you a sound basis for evaluation of any practical prose, and a summation of what has gone before.

YOU READ practical prose in the first place for information. But if your reading is to be useful to you, if you are to read efficiently, you must evaluate what you read, accepting only the statements that stand up under inspection and comparison. To a degree, everyone reads critically, if only when he decides if he likes or dislikes a selection.

Critical reading first requires a healthy skepticism towards the printed word, so that your mind can be free for the assessment of any statement you meet. No statement has authority simply because it has been printed; any authority it has is gained by passing the tests of reason and comparison. No precise formula or recipe can be given for evaluation of a selection, but there are two steps you can take that will give you a sound basis for evaluation of any practical prose. First, make a running analysis of a selection as you read it; second, make a comparative analysis of a selection after you have read it.

Full comprehension of a selection is mandatory for critical reading of it, and of course all the reading skills should be employed to that end. Two skills in particular will help you make a running analysis of a selection: understanding of techniques of paragraph development and reading with questions in mind.

In making a running analysis, you should dif-

ferentiate between an author's reports and his evaluations. A report is an account of an event as it happened. There is the first-hand report made by a person who has actually witnessed an event; and there is a second-hand or hearsay report that is based on the first-hand reports of others.

An evaluation is a judgment inferred from first- and second-hand reports. An evaluation can appear by itself, or can be thoroughly mixed into parts of a report. It is possible, of course, for a writer to have all the facts right and still draw the wrong conclusions.

Confusion between reports and evaluations is easy, therefore, and must be avoided by the reader. Here is where a healthy skepticism about the printed word, plus an understanding of paragraph development and reading with questions in mind, will help you test the strength and validity of an author's thesis, purpose and evidence. Extensive use of marginal notes, especially when you wish to distinguish reports from evaluations, will facilitate running analysis and subsequent comparative analysis.

This series has presented the basic techniques of efficient reading. The over-all target is to practice these techniques until they have become habits.

The technique presented in this series may be briefly summarized as follows:

1. **Pre-reading.** Use this technique to get a systematic overview of any article or book of practical prose.

2. **Questioning and anticipating.** Use pre-reading as the basis for addressing specific questions to your author and to anticipate the steps of his discussion. Use questioning and anticipating as an aid to concentration as well as comprehension.

3. **Summarizing.** Use pre-reading and the question technique as bases for summarizing all important articles and books. Pre-reading gives

the basic outline of a complete summary. The question technique aids in filling in the outline.

4. **Skipping and Skimming.** After pre-reading, decide what may be skipped, what need only be skimmed, what needs a thorough reading.

5. **Critical reading.** Use pre-reading as an aid to critical reading. Find out ahead of time what conclusions the author is going to draw in his article. Critically evaluate the steps he takes to get there as you read along.

6. **Self-pacing.** Get in the habit of constantly improving your reading rate by pressing against the very limits of your current capacity for a few minutes every day. Time yourself every now and then to see how you are doing.

7. **Phrase-circling.** Circle phrases until they begin to stand out to you as separate wholes.

8. **Space-reading.** Help the phrases hang together, smooth out your eye movements by reading just above the line of type.

9. **Vocabulary.** Help yourself be a better phrase reader, a more effective businessman, by improving your vocabulary. "Use a word three times and it's yours."

10. **Columnar reading.** Help yourself be a better phrase reader by widening your span of recognition through columnar reading in your newspaper, news magazine, or trade journal.

11. **Environment.** Read under adequate, glareless light. Try to set aside a special place for all your serious reading. See your eye man regularly for an eye check.

12. **Achievement.** At the beginning of this series, you measured your reading speed. Now, to see how much you have improved, turn to p 204 and read "Novel Techniques Boost Performance, Cut Size and Power of Tape Recorders" which contains 1,031 words. Divide the number of minutes into 1,031 and compare this rate to your original score.

We hope that this series of articles has done for you what it has for thousands of others. There is nothing dramatically new in what we have told you and for that very reason many people tend to overlook its value. The techniques sound simple enough, but there is no surer way to replace bad reading habits than to practice in the use of these new skills. Ten minutes of practice each day for a few weeks can save you countless hours in the future, and at the same time sharpen your perception of the written word, making you not only a skilled reader, but also, in the larger concept, a more efficient and successful individual. ■ ■

A 64-page book, giving the how, what, and why of reading improvement, is available to individuals. Send \$2.00 to Developmental Research Institute, Dept. E-61, 500 Fifth Ave., New York 36, N. Y.

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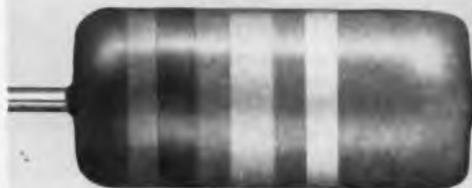
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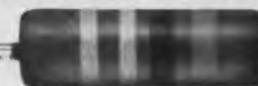
2 WATT



1 WATT

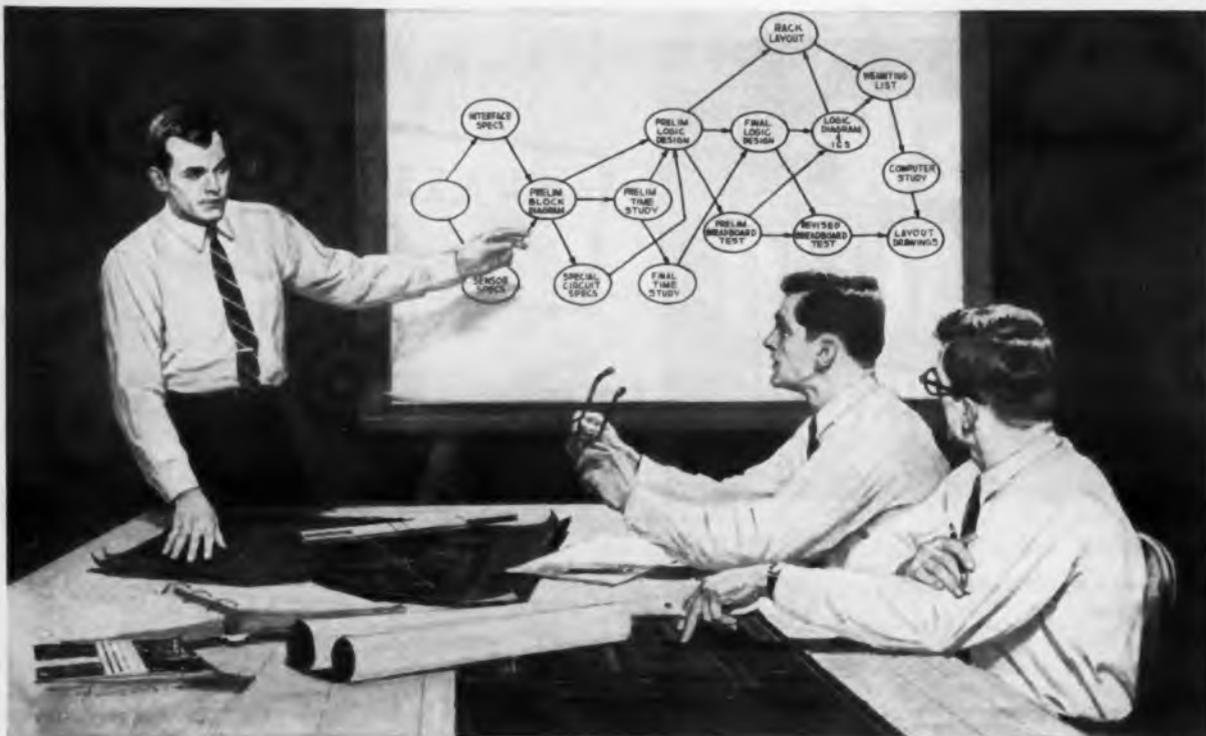


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CIRCLE 813 ON READER-SERVICE CARD



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ENGINEERING PLANNING, time estimates and evaluations were once conducted almost exclusively at the management level, and deadline assignments passed down to design engineers. The result: bottleneck delays and unrealistic completion dates.

By applying PERT (Program Evaluation & Review Technique), however, General Electric's Light Military Electronics Department is solving the problem in a systematic fashion—one that works to the strong advantage of the individual engineer as well as program management. As one of its essential features, PERT recognizes that the creative engineer himself is in the best position to evaluate the requirements of his own work.

A DIAGNOSTIC AND PROGNOSTIC TECHNIQUE

Based on initial time estimates and subsequent progress reports—both submitted by engineers doing the actual work at each stage—PERT formalizes all related steps toward a program's completion into an analytical network. Computer analysis then provides both a diagnostic and prognostic means for combining time, talent and resources to assure a high probability of success in meeting overall deadlines.

The use of the PERT technique is just one aspect of LMED's forward looking endeavors to utilize the judgment and enhance the creativity of the individual engineer. At Light Military, the engineer finds himself in direct contact with the problems and decisions that influence his professional activities. He finds that management is not imposed on him—it depends on him.

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CIRCLE 902 ON CAREER INQUIRY CARD

YOUR CAREER NEWS AND NOTES

Financial help in advanced studies at Hughes Aircraft Co., Culver City, Calif., has enabled 600 engineers to obtain their master's or Ph.D. degrees in the past 11 years, the company states. The program provides financial aid to Hughes engineers working for advanced degrees while they continue to work on research projects at Hughes.

Two Hughes engineers cited as men who took advantage of the program and now have important positions in the company were Dr. Leo Stoolman and Dr. Warren E. Mathews. Dr. Stoolman started working for his doctorate at California Institute of Technology in 1949 and received it four years later. He is now manager of the Aerospace Vehicles Laboratory, Hughes Research and Development Laboratories. Dr. Mathews started at Cal Tech in 1950 and received his doctorate three years later. Dr. Mathews is now assistant director of the laboratory and manager of the Infrared Laboratory.

This year, Hughes will award 24 fellowships for doctoral candidates and 132 for master's candidates.

Younger engineers are more active in obtaining patents, according to a study of 4,415 Purdue University graduates. The study showed that the greatest number of patents were granted within the first ten years after graduation.

One of the things an engineer dreads is answering a "blind ad"—one of those glowing accounts of a job opportunity that sounds ideal until one discovers that "Box XYZ" is his own company.

An engineer who has since mended his ways provides us, rather than his psychiatrist, with this switch on the old trap:

The company of which he was part owner was about to fold, so the engineer whipped up an ad describing an "opportunity" with his own company. The details neatly dovetailed with his own qualifications.

The best applicant he interviewed described his current job in detail, including salary, boss' likes and dislikes, and so on. At the end of the interview, the engineer called the applicant's boss, played on his idiosyncrasies as described by the applicant, and incidentally said he understood the jobseeker was unhappy. He added that he was very interested in that job, if it should fall vacant. The applicant was naturally eased out and the engineer got his job.

Moral: caveat jobseeker.

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.

(Please print with a soft pencil or type.)

Advancement Your Goal? Use CONFIDENTIAL Action Form

ELECTRONIC DESIGN's Confidential Career Inquiry Service helps engineers "sell" themselves to employers—as confidentially and discreetly as they would do in person. The service is fast. It is the first of its kind in the electronics field and is receiving high praise from personnel managers.

To present your job qualifications immediately to companies, simply fill in the attached resume.

Study the employment opportunity ads in this section. Then circle the numbers at the bottom of the form that correspond to the numbers of the ads that interest you.

ELECTRONIC DESIGN will act as your secretary, type neat duplicates of your application and send them to all companies you select—the same day the resume is received.

The standardized form permits personnel managers to inspect your qualifications rapidly. If they are interested, they will get in touch with you.

Painstaking procedures have been set up to ensure that your application receives complete, confidential protection. We take the following precautions:

- All forms are delivered unopened to one reliable specialist at *ELECTRONIC DESIGN*.
- Your form is kept confidential and is processed only by this specialist.
- The "circle number" portion of the form is detached before the application is sent to an employer, so that no company will know how many numbers you have circled.
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If you are seeking a new job, act now!

Name _____ Telephone _____

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Position Desired _____

Educational History				
College	Dates	Degree	Major	Honors

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Outstanding Engineering and Administrative Experience _____

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Published Articles _____

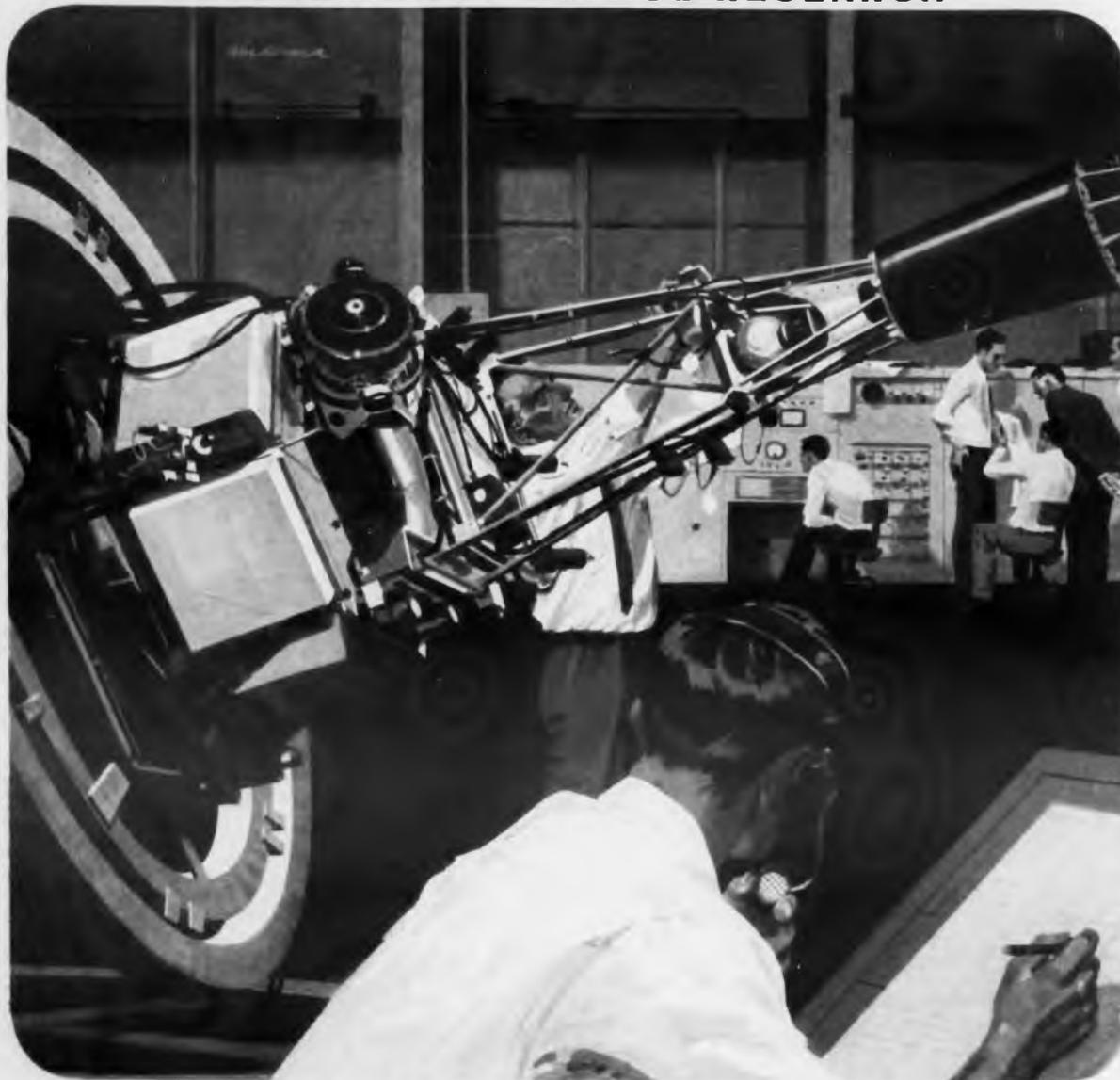
Minimum Salary Requirements (Optional) _____

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

PIONEERING IN SPACE RESEARCH



DEVELOPMENT OF LUNAR SPACECRAFT

The "Ranger" series of spacecraft, designed first to explore the environment and later to land instrument capsules on the Moon, are now being developed and tested at Jet Propulsion Laboratory.

Illustrated is a "Ranger" proof-test model undergoing design verification testing at the Laboratory. Here design features are tested and proved, operational procedures developed and handling experience gained for the actual construction of the initial flight spacecraft.

This is one phase of JPL's current assignment from the National Aeronautics and Space Administration—to be responsible for the Nation's unmanned lunar, planetary and interplanetary exploration.

An advanced program such as this provides numerous objectives and incentives for qualified engineers and scientists who are eager to help solve the complex problems of deep space exploration.

Such men are welcome at JPL.



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CIRCLE 903 ON CAREER INQUIRY FORM

CAREER NEWS

Engineering education was cited as an important part of any national program to cut engineering lead time in a recently published survey, "Ideas, Inertia and Achievement." Conducted by the American Society of Mechanical Engineers, the survey presents the views of 88 corporations and research institutions in the United States and Western Europe.

Two qualities are necessary in an engineer if he is to help his country overcome the time lag between a scientific discovery and its first engineering utilization, according to Gordon S. Brown, MIT dean of engineering, in one section of the survey.

One is the ability to point out deficiencies in existing devices. The other is sufficient depth of fundamental training to be able to do something about the deficiencies.

To provide graduates with the needed training, MIT is in the midst of a five-year revamping of its engineering curriculum. The result will be an updating of both the professors and the laboratories, according to Dr. Brown. To develop both sides of the above-mentioned qualities in students, MIT will emphasize both a basic sciences education and an exposure to the latest engineering advances.

A combined engineering-medical doctor educational program at the master's degree level that has been established at the Drexel Institute of Technology, Philadelphia, was described by Dr. James G. Hilton, director, Laboratory for Endocrine Research, Dept. of Medicine, St. Luke's Hospital, New York City.

Engineers will study biology and physiology; physicians in turn will take concentrated courses in mathematics, electronic and mechanical engineering. The two groups will then continue with a joint program in advanced engineering subjects. A key part of the program will be the joint research on which both doctors and engineers will cooperate.

The University of Nebraska is starting a small-scale program very similar to the Drexel program, Dr. Hilton added, and Johns Hopkins University has worked out a curriculum for a four-year program for a doctorate in biomedical engineering. The last program, however, is for engineers only.

Computer abstracts on 3-in. by 5-in. filing cards will be soon available at costs from \$30 per category to \$250 for all categories from Cambridge Communications, 238 Main St., Cambridge 42, Mass. These are the same abstracts which have been published by the Institute of Radio Engineers in the proceedings of the professional group on electronic computers.

Management and engineers don't agree on the question of the professional status of engineers. The results of a survey of 295 engineers and 55 managers in six major industries, including electronics, just published by the Professional Engineers Conference Board for Industry, Inc., Washington, D.C., show that while engineers think they are not being treated professionally, their managers think they are.

For example, the survey indicated that 90 per cent of the managers regarded the engineers as among those employes in their company who were making the most valuable contributions. Meanwhile, less than half the engineers thought they were so regarded.

Particularly interesting in the survey was the difference between the attitudes of engineers in those companies which encouraged engineering professionalism and those which did not. Forty-four per cent of the engineers in the "pro-engineering-professionalism" companies agreed that their management really believed in the professional status of the engineers. Only 7 per cent of the engineers in the "other" type of company agreed with this.

Instead, 53 per cent of the engineers in the second type of company said that engineers were a "sort of commodity—let go quickly if business is poor." Only 17 per cent of the engineers in the "pro-professionalism" companies held this view.

Engineers in both types of companies were against unions, the report showed, but the anti-union feeling was much stronger among the engineers in the first type of firm.

Among things which engineers feel they can do to increase their professional stature were:

- Increase their communication skill (so that they can articulate their desires to management as well as be more useful on the job).
- Increase their technical abilities.
- Increase their integration with broad company objectives.

The survey indicated that many engineers have higher personal aspirations than most managers appreciate. The engineers' satisfactions come from creative, challenging work. (Their dissatisfactions come from low pay and slow salary progression.)

Two criteria for professionalism rated highly by the engineers were, "becoming more like lay lawyers and doctors," and "being utilized as full professionals, not as technicians." The managers on the other hand thought that technical competence and a high standard of ethics were important to engineering professionalism.

Primary objective of the study was to find out what engineers and managers mean by the term "engineering professionalism" and how each group thinks it can be best advanced.

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CIRCLE 904 ON CAREER INQUIRY FORM

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CIRCLE 912 ON CAREER INQUIRY FORM

250

CAREER NEWS

"Military electronics continues to be the most bullish area for executives and the demand will be greater in '61," according to J. H. Higgins, head of the electronics division, Cadillac Associates, Inc., Chicago employment agency.

A vice president of personnel for a West Coast electronics firm recently told Higgins that he can't keep up with the requests for personnel by department heads in his firm. The West Coast vice president said that he may place 10 men then get an order for 250 more engineers.

Mr. Higgins commented that many companies are missing out on valuable manpower by being too specific in their job experience requirements, but at the same time many engineers are being too specific in their selection of geographic areas and types of jobs.

• • •

Better career selection will result from a common program for all freshman and sophomore engineering students, Cornell University predicted recently. In explaining why students entering Cornell's engineering school in the fall of this year will go through a uniform program of basic studies for their first two years, Prof. Dale R. Corson, dean of the college of engineering, said this will help the student to learn something about the engineering fields available before making his selection. After he selects his degree field at the end of his sophomore year, the student will specialize in that field for the next three years. (Cornell adopted a five-year undergraduate engineering program in 1946.)

In addition to the basic studies in mathematics, physics, chemistry, and English, Cornell hopes to develop the student's talents for applying fundamentals, Corson said.

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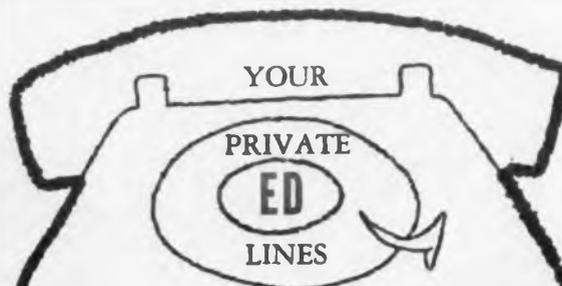
Scientists are not as excited about the classical concepts of professional freedom as they were once thought to be, according to a survey of 57 researchers working at one large midwestern university.

Some key questions, with a breakdown of answers given, show the trend:

- Should a scientist be free to choose his own projects? Only 47 per cent thought so.
- Should scientific judgment be suspended until all the facts are in? Twelve per cent believed it should.

- Should there be free access to all scientific information? Only 20 per cent felt there should.

One "pure" scientist uncovered by the survey was asked what he thought "freedom" meant,



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and replied that it was the opportunity "to ruminate on pay." Another, of a more practical turn of mind said that the greatest hazard to professional freedom was the number of daily interruptions he had to put up with.

• • •

"Continental Classroom," the nation-wide early-morning TV educational series, is offering a course in probability and statistics, since Jan. 30th.

Monday through Friday at 6:30 am on the NBC network, the sessions cover central limit theorem, normal distribution, physical interpretation of probability, and application of probability and statistics.

On Mondays, Wednesdays, and Fridays, the undergraduate course "Probability and Statistics" is taught by Frederick Mosteller, professor of mathematical statistics at Harvard. On the other two days, the emphasis is directed towards the teaching of the subject.

• • •

Most difficult teaching tasks for the advanced teaching machines promised for the future may well be that of teaching ordinary engineers the machine's own principles of operation. Any engineer who has sat through a "hairy" technical session will appreciate the following comment made in England by a consultant, Mr. R. H. Tizard, during the question and answer session following a paper on adaptive teaching machines by Mr. Gordon Pask, a partner in the British firm Systems Research Ltd. It comes from the Transactions of the British Society of Instrument Technology, London.

"I have known Mr. Pask for a number of years; I have known his teaching machine for quite a time, and I have even been taught by it. For a long time I tried to understand its mysteries from Mr. Pask's patient explanations, and have failed. Now I have read his paper six times, and only last time, this very morning, did I begin to understand what it was all about.

"After struggling hard over the diagrams for a long time I had begun to conclude that the whole system was based on the theory that the learning power of the human brain is bound up with the random connections between cells. I wondered whether Mr. Pask has wired up his machine at random and had then allowed a process of Darwinian selection to take place (among the elements), the unfit being those that burst into flames on plugging it in. . . ."

The ensuing hour's discussion, however, did not make it especially clear whether Mr. Tizard ever did really understand.



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CIRCLE 906 ON CAREER INQUIRY FORM

ENGINEERS • SCIENTISTS

SATIN

... *An Experimental System for
High-Altitude Air Traffic Control*

Under a contract with the Federal Aviation Agency and jointly supported by the Department of the Air Force, MITRE is designing and implementing an experimental en route Air Traffic Control system. The system, called SATIN (for SAGE Air Traffic Control Integration), utilizes area control techniques to provide positive separation of all high-altitude en route traffic regardless of the route chosen or navigation used.

Through application of a SAGE digital computer and its associated radar, beacon, and radio network, SATIN permits inclusion of both the Boston and New York centers into a single high-altitude control area. The system automatically correlates radar and beacon data with flight plan information to establish a current position for each aircraft under control. Conflict prediction takes place automatically as does the transfer of information for intra- and inter-center coordination.

Initial parts of the experimental system are now in operation with major testing scheduled for next year.

Openings are currently available for engineers and scientists with experience or an interest in Air Traffic Control.

Inquiries may be directed in confidence to
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- **Aircraft Flight and Electronic Systems**—Largest supplier of airborne centralized flight data systems; also working with other electronic controls and instruments including missile and submarine applications.
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CIRCLE 908 ON CAREER INQUIRY FORM

ELECTRONIC DESIGN • February 15, 1961

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 geographical 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.

Summer Courses at Case

A two-week summer course in digital control systems engineering will be held at Case Institute of Technology, June 31 through Aug. 11, under the direction of Dr. Harry Mergler, associate professor of mechanical engineering. Tuition is \$300.

A three-week summer study course in process-control theory for practicing engineers will be directed by Dr. Donald P. Eckman, professor of mechanical engineering, July 10-29. Tuition is \$400.

Applications for both courses should be addressed to Herbert Schultz, manager of special programs, Case Institute of Technology, University Circle, Cleveland 6, Ohio.

PAPER DEADLINES

Convention Program Chairmen have issued the following deadlines to authors wishing to have their papers considered for presentation.

Feb. 15: Deadline for 50- to 100-word summaries for the 1961 Spring Conference of the Chicago Professional Group on Broadcast and Television Receivers of the Institute of Radio Engineers. The conference will be held June 15 and June 16, 1961, at the O'Hare Inn, Des Plaines, Ill. Emphasis will be placed on advanced development papers in the radio-television field and related areas. Papers should be limited to approximately 2,500 words and the presentation to 20 minutes. Potential authors should submit three copies of the summary including title of paper, author's name, position, title, company and affiliation to: Mr. Neil Frihart, Motorola, Inc., 4545 W. Augusta Blvd., Chicago 51, Ill.

March 1: Deadline for papers for the International Convention of the Institute of Radio Engineers to be held March 20 to March 23, 1961, at the Coliseum and Waldorf-Astoria Hotel in New York City. Send papers to: Dr. G. K. Teal, Program Chairman, Institute of Radio Engineers, Inc., One E. 79th St., New York 21, N.Y.

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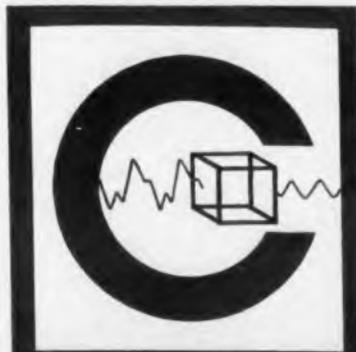
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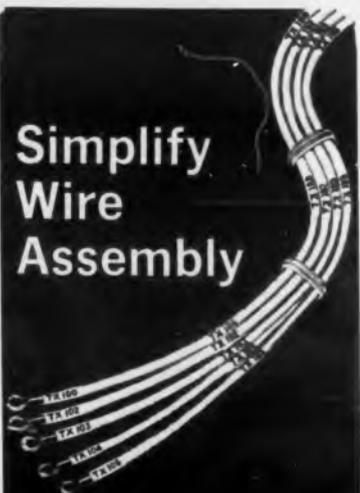
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302	312	322	332	342	352	362	372	382	392	402	412	422	432	442	452	462	472	482	492	502	512	522	532	542	552	562	572	582	592
303	313	323	333	343	353	363	373	383	393	403	413	423	433	443	453	463	473	483	493	503	513	523	533	543	553	563	573	583	593
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305	315	325	335	345	355	365	375	385	395	405	415	425	435	445	455	465	475	485	495	505	515	525	535	545	555	565	575	585	595
306	316	326	336	346	356	366	376	386	396	406	416	426	436	446	456	466	476	486	496	506	516	526	536	546	556	566	576	586	596
307	317	327	337	347	357	367	377	387	397	407	417	427	437	447	457	467	477	487	497	507	517	527	537	547	557	567	577	587	597
308	318	328	338	348	358	368	378	388	398	408	418	428	438	448	458	468	478	488	498	508	518	528	538	548	558	568	578	588	598
309	319	329	339	349	359	369	379	389	399	409	419	429	439	449	459	469	479	489	499	509	519	529	539	549	559	569	579	589	599

600	610	620	630	640	650	660	670	680	690	700	710	720	730	740	750	760	770	780	790	800	810	820	830	840	850	860	870	880	890
601	611	621	631	641	651	661	671	681	691	701	711	721	731	741	751	761	771	781	791	801	811	821	831	841	851	861	871	881	891
602	612	622	632	642	652	662	672	682	692	702	712	722	732	742	752	762	772	782	792	802	812	822	832	842	852	862	872	882	892
603	613	623	633	643	653	663	673	683	693	703	713	723	733	743	753	763	773	783	793	803	813	823	833	843	853	863	873	883	893
604	614	624	634	644	654	664	674	684	694	704	714	724	734	744	754	764	774	784	794	804	814	824	834	844	854	864	874	884	894
605	615	625	635	645	655	665	675	685	695	705	715	725	735	745	755	765	775	785	795	805	815	825	835	845	855	865	875	885	895
606	616	626	636	646	656	666	676	686	696	706	716	726	736	746	756	766	776	786	796	806	816	826	836	846	856	866	876	886	896
607	617	627	637	647	657	667	677	687	697	707	717	727	737	747	757	767	777	787	797	807	817	827	837	847	857	867	877	887	897
608	618	628	638	648	658	668	678	688	698	708	718	728	738	748	758	768	778	788	798	808	818	828	838	848	858	868	878	888	898
609	619	629	639	649	659	669	679	689	699	709	719	729	739	749	759	769	779	789	799	809	819	829	839	849	859	869	879	889	899

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10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	
1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191	201	211	221	231	241	251	261	271	281	291
2	12	22	32	42	52	62	72	82	92	102	112	122	132	142	152	162	172	182	192	202	212	222	232	242	252	262	272	282	292
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5	15	25	35	45	55	65	75	85	95	105	115	125	135	145	155	165	175	185	195	205	215	225	235	245	255	265	275	285	295
6	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156	166	176	186	196	206	216	226	236	246	256	266	276	286	296
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8	18	28	38	48	58	68	78	88	98	108	118	128	138	148	158	168	178	188	198	208	218	228	238	248	258	268	278	288	298
9	19	29	39	49	59	69	79	89	99	109	119	129	139	149	159	169	179	189	199	209	219	229	239	249	259	269	279	289	299

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308	318	328	338	348	358	368	378	388	398	40																			

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Meets military specifications
Conventional controls for simple operation
Uniquely versatile dual plug-ins providing:

1. X-Y records of repetitive waveforms
(\hookrightarrow 166C Display Scanner Plug-in)
2. New sweep delay convenience
(\hookrightarrow 166D Sweep Delay Generator Plug-in)
3. Widely versatile input capabilities
(\hookrightarrow 162A Dual Trace Amplifier Plug-in)

These are the scopes you have been waiting for! Built to exacting military specifications, they offer instantly expandable measurement capability—when you need it. It's easy! Just add a moderately priced plug-in unit!

Both \hookrightarrow 160B and 170A employ the same vertical and time-axis plug-ins providing the widest range of application with minimum plug-ins and minimum investment. Details of these plug-ins are given on the opposite page.

New \hookrightarrow 160B and 170A follow MIL-E-16400C for shock, vibration, humidity and temperature. Important features include high stability tube-transistor circuits, regulated dc filament voltages and premium components throughout. Power transistors in efficient heat sinks insure cool operation; etched circuits on translucent epoxy glass simplify circuit tracing and servicing.

Simple, conventional controls speed set-up time and actual measuring. Improved preset triggering insures optimum operation for almost all conditions with just one adjustment—even on signals down to 2 mm deflection. Both \hookrightarrow 160B and 170A give you big, bright presentation on a 5" CRT, with a clear, steady trace free from bloom or halo.

A push-button beam finder automatically locates off-screen beam or trace (especially useful for operation by inexperienced personnel). And to increase general-purpose usefulness: 24 calibrated sweep times, 0.1 μ sec/cm to 5 sec/cm, \pm 3% accuracy. Vernier extending slowest sweep to 15 sec/cm. Seven-range magnifier increasing fastest sweep to 0.02 μ sec/cm. Horizontal sensitivity 0.1 v/cm to 10 v/cm. Vernier extending minimum sensitivity to 25 v/cm. \hookrightarrow 160B, \$1,850.00; \hookrightarrow 170A, \$2,150.00.

versatility for the \hookrightarrow 160B and 170A scopes!

SPECIFICATIONS— \hookrightarrow 160B and 170A with \hookrightarrow 166A Plug-in

VERTICAL

Bandwidth: \hookrightarrow 160B, 15 MC
 \hookrightarrow 170A, 30 MC

Voltage Calibrator: 9 calibrated ranges \pm 3%. 0.2 mv to 100 v peak to peak

Current Calibrator: 5 ma peak to peak \pm 3%

HORIZONTAL

Bandwidth: dc to 1 MC

Sensitivity: 7 ranges 0.1 v/cm to 10 v/cm. Vernier extends minimum sensitivity to 25 v/cm

Input Impedance: 1 megohm shunted by 30 pf

SWEEP GENERATOR

Internal Sweep: 24 ranges, 0.1 μ sec/cm to 5 sec/cm, \pm 3%. Vernier extends slowest sweep to 15 sec/cm

Magnification: 7 calibrated ranges, X1, X2, X5, X10, X20, X50 and X100. Increases fastest sweep to 0.02 μ sec/cm

Triggering: Internal, power line or vertical input signal (2 mm or more vertical deflection); external ($\frac{1}{2}$ v peak to peak or more)

Trigger Point: Positive or negative going voltage. Trigger level of external sync signal adjustable —30 to +30 volts

PRICE:
 \hookrightarrow 160B, \$1,850.00 (cabinet or rack mount)
 \hookrightarrow 170A, \$2,150.00 (cabinet or rack mount)

Data subject to change without notice. Prices f.o.b. factory.



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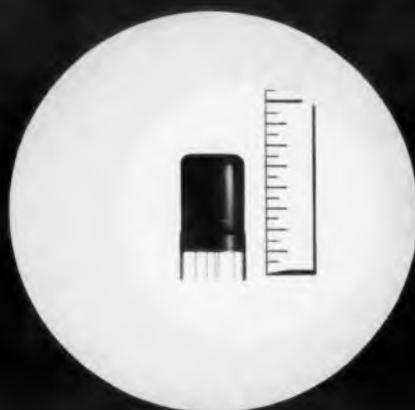
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RCA-6CW4

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For Television Tuners. RCA-6CW4 nuvistor triode in VHF TV Tuners makes possible satisfactory reception in fringe areas and other locations where signal levels are extremely weak. This tiny tube with giant performance gives RCA Victor's *New Vista* tuner up to 45% more picture pulling power in weak signal areas than the best tuner previously available. It has proved so successful that RCA Victor has introduced 12 new color-TV receivers with the nuvistorized tuner.

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