July 14, 1961

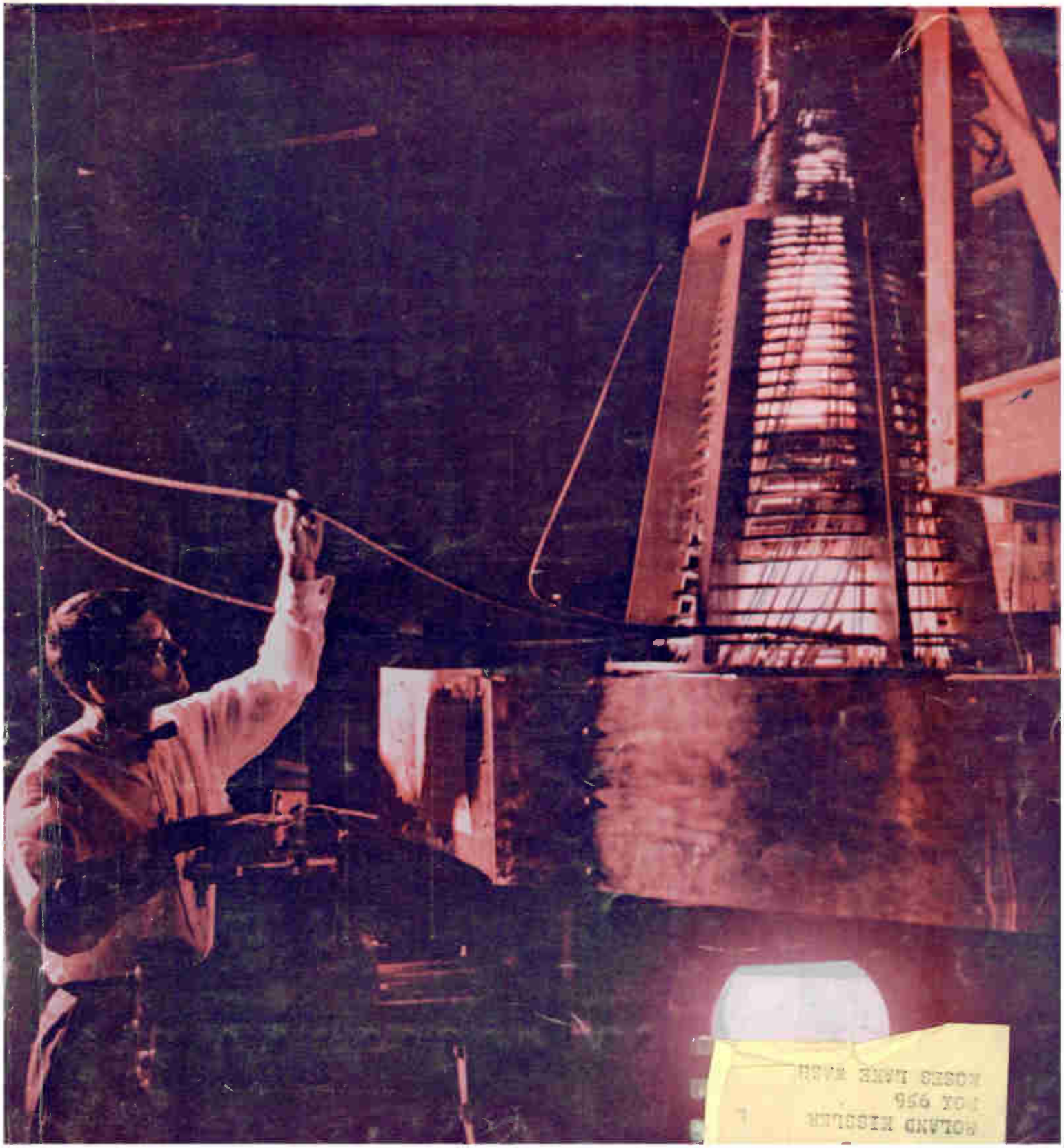
electronics

Traveling-wave plasma gun for space propulsion studies (below), p 47

Photoconductive-electroluminescent system recognizes patterns, p 54

How to modify an f-m broadcast transmitter for compatible stereo, p 60

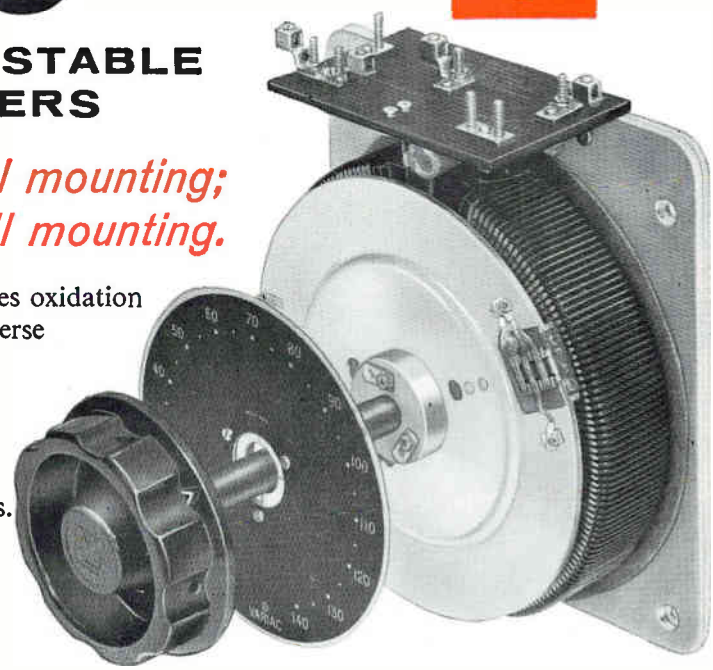
A McGraw-Hill Publication 75 Cents



NEW W30 Variac®

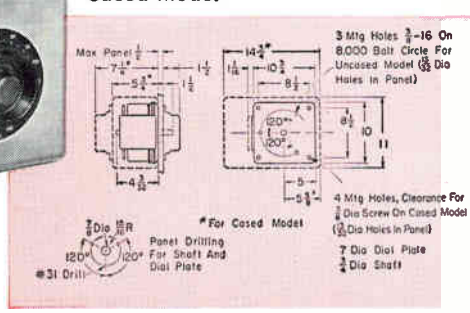
CONTINUOUSLY ADJUSTABLE AUTOTRANSFORMERS

Uncased for back-of-panel mounting; cased models for bench or wall mounting.



- Patented Duratrak brush track practically eliminates oxidation and deterioration, provides long life even under adverse environmental and load conditions.
- Excellent thermal coupling between coil and base allows high current rating.
- High-silicon, low-loss core material.
- All models are available as motor-driven assemblies.
- Ball-bearing units at slight extra cost.

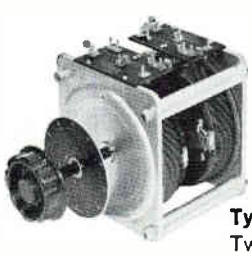
Type W30M . . . $97.00
Cased Model



Can be connected for output-voltage range from 0 to line voltage or 0 to 17% above line voltage (overvoltage connection).

Type	Input Voltage	Output for Line-Voltage Connection: KVA	Voltage Range	Rated Current	Maximum Current	Output for Overvoltage Connection: Voltage Range	Rated Current	Price
W30	120	4.32	0 to 120	30	36	0 to 140	30	$75.00
W30M*	120	3.84	0 to 120	28	32	0 to 140	28	97.00
W30H	240	3.74	0 to 240	12	15.6	0 to 280	12	75.00
	120	—	—	—	—	0 to 280	6	
W30HM*	240	3.74	0 to 240	12	15.6	0 to 280	12	97.00
	120	—	—	—	—	0 to 280	6	

No-Load Loss: 35 watts at 60 cps with rated input voltage.



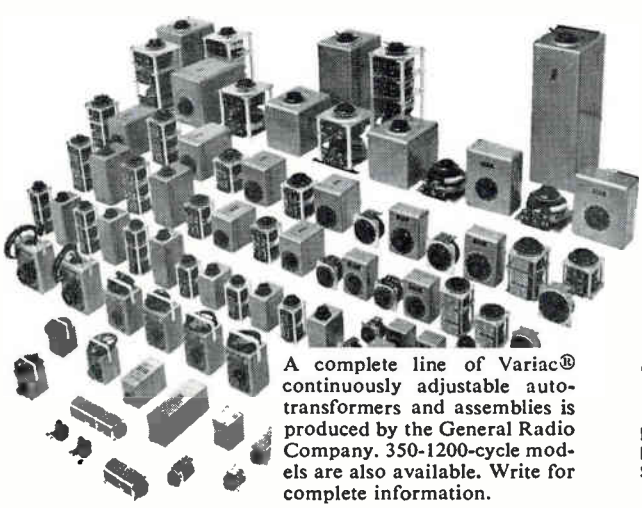
GANGED MODELS

Two- and three-gang assemblies of W30-model Variacs available either cased or uncased.

Type W30G2 . . . $160.00
Two-gang Uncased Model

Type	Connection	Input Voltage	KVA	Voltage Range	Rated Current	Maximum Current	Price
W30G2	Parallel Series	120	8.6	0 to 140	60.0	72.0	$160.00
		240	8.6	0 to 280	30.0	36.0	
W30G2M*	Parallel Series	120	7.7	0 to 140	56.0	64.0	190.00
		240	7.7	0 to 280	28.0	32.0	
W30G3	Parallel 3-Phase Wye	120	13.0	0 to 140	90.0	108.0	240.00
		240	15.0	0 to 240	30.0	36.0	
W30G3M*	Parallel 3-Phase Wye	120	11.5	0 to 140	84.0	96.0	275.00
		240	13.3	0 to 240	28.0	32.0	
W30HG2	Parallel 3-Phase, Open-Delta	240	7.5	0 to 280	24.0	31.2	160.00
		240	6.48	0 to 280	12.0	15.6	
W30HG2M*	Parallel 3-Phase, Open-Delta	240	7.5	0 to 280	24.0	31.2	190.00
		240	6.48	0 to 280	12.0	15.6	
W30HG3	3-Phase Wye	480	13.0	0 to 480	12.0	15.6	240.00
W30HG3M*	3-Phase Wye	480	13.0	0 to 480	12.0	15.6	275.00

*Cased Model



A complete line of Variac® continuously adjustable autotransformers and assemblies is produced by the General Radio Company. 350-1200-cycle models are also available. Write for complete information.

write for Complete Information

GENERAL RADIO COMPANY

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July 14, 1961

electronics

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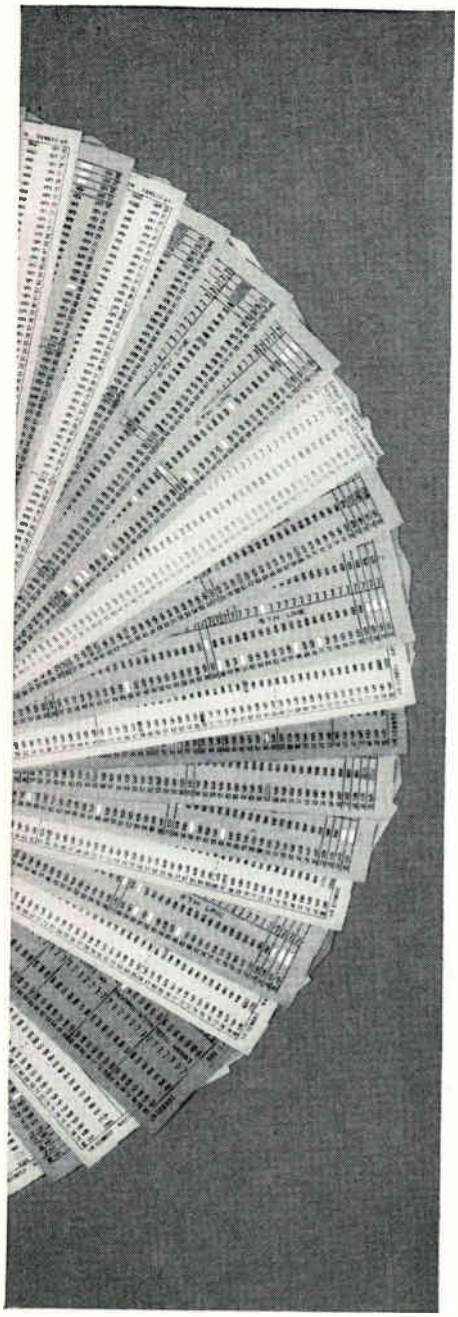
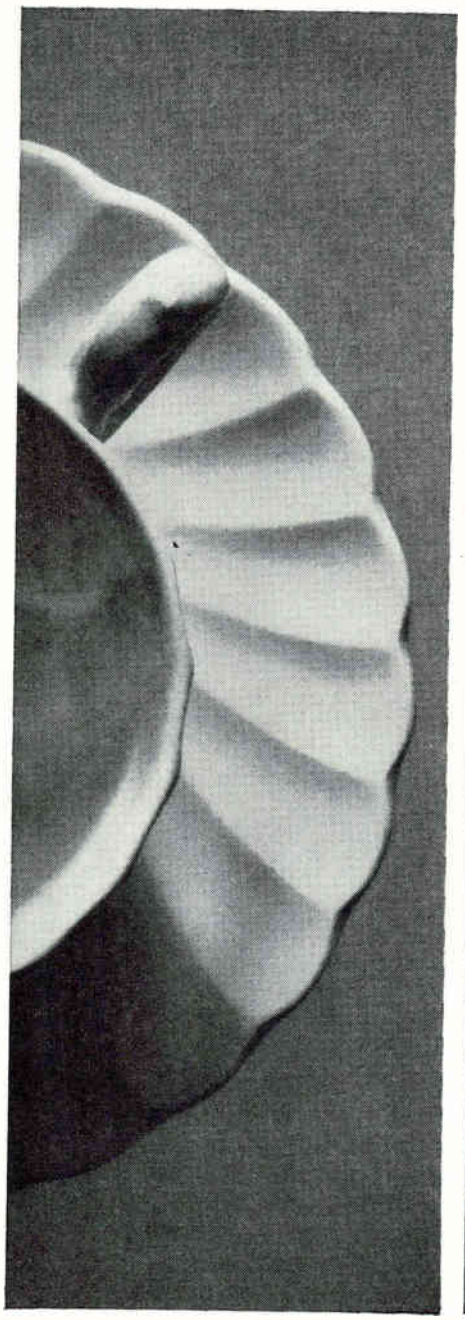
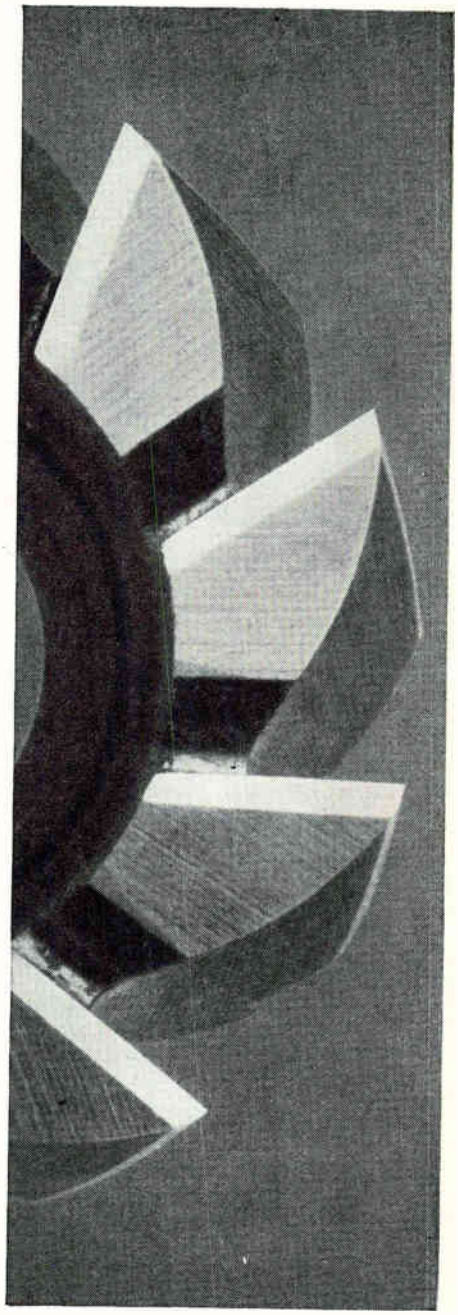
Counting controls for industry, defense and space exploration



On data processing equipment, and on a wide range of modern office machines Veeder-Root counters provide businessmen with that extra measure of control.



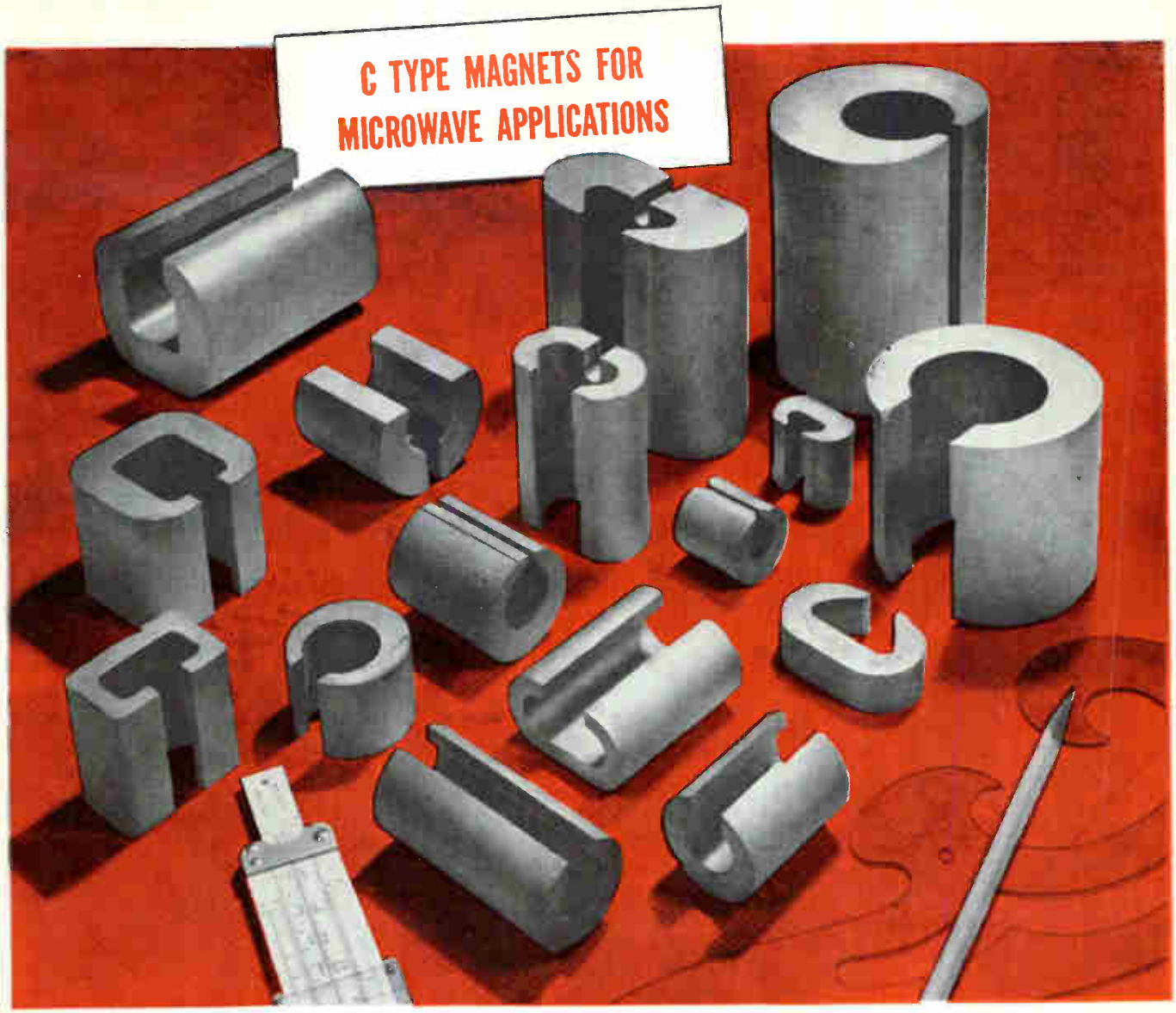
A perfect cup of tea every time . . . thanks to Veeder-Root electrical counters that help fill teabags faster and with greater accuracy than ever before.



Precision control of milling machines, lathes and drill presses is assured with the Veeder-Root electronic counter that's designed for high speed bi-directional operation.

Visualize, systemize, modernize . . . with Veeder-Root counters! For an automatic way to watch output, activate machinery and integrate operations, consider Veeder-Root counters. Design them into new machines or install them on existing equipment. Either way these versatile counters provide better control at a surprisingly low cost. For details, write Veeder-Root Inc., 70 Sargeant St., Hartford 2, Connecticut.

count on . . . VEEDER-ROOT



C TYPE MAGNETS in a wide range of sizes to meet your design needs in ★Transverse Field Isolators ★Differential Phase Shifters ★Duplexers

Arnold C-type Alnico Magnets are available in a wide selection of gap densities ranging from 1,000 to over 7,500 gausses. There are six different basic configurations with a wide range of stock sizes in each group.

The over-all size and gap density requirements of many prototype designs can be met with stock sizes of Arnold C Magnets, or readily supplied in production quantities.

When used in transverse field isolators, Arnold C Magnets supply the magnetizing field to bias the ferrite into the region of resonance, thus preventing interaction between microwave networks and isolating the receiver from the transmitter. These magnets are also used in differential phase shifters and duplexers, and Arnold is prepared to design and supply tubular magnets to provide axial fields in circular wave guides.

A feature of all Arnold C Magnets is the excellent field uniformity along the length of the magnet. Versatility in design may be realized by using multiple lengths of the same size magnet stacked to accomplish the needs of your magnetic structure.

Let us work with you on any requirement for permanent magnets, tape cores or powder cores. ● For information on Arnold C Magnets, write for Bulletin PM-115. Address *The Arnold Engineering Company, Marengo, Illinois.*

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SPECIALISTS in MAGNETIC MATERIALS

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electronics
July 14, 1961 Volume 34 Number 28

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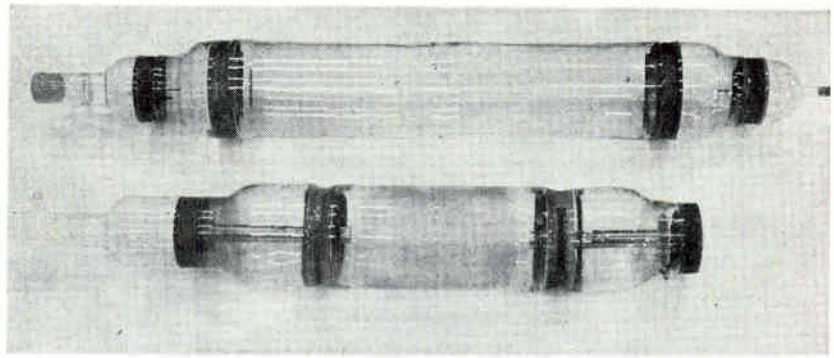


PLASMA ENGINEERING. Photo above shows split-anode Phillips ionization gage discharge tubes used to produce plasma at General Electric Research Laboratory. This is just one of a number of varied devices and techniques that are described in Assistant Editor Wolff's article in this issue on generating and heating plasma.

The report is the first in a series designed to acquaint you with what's going on today in the study of plasma and its potential engineering applications. Plasma research is being conducted by groups of anywhere from a few to more than a hundred at government agencies, scientific institutions, colleges and universities, and industrial installations here and abroad. The U. S. effort has been estimated at roughly $50 to $60 million annually. Of this, approximately $28 million represents current expenditures for AEC's Project Sherwood program of controlled thermonuclear research.

To bring you up to date on this work, Wolff visited more than a dozen laboratories and contacted researchers at many more. He found strong interest both in studies of plasma itself and in possible applications to such fields as power conversion, propulsion and communications. These applications, which will be outlined in a later article, require that plasma first be generated. For information on how this is being done, turn to p 47.

Coming In Our July 21 Issue

MORE MEDICAL ELECTRONICS. Associate Editor Bushor's series on medical electronics continues next week with additional information on prosthetics. In this report, which is Part V in the series, you'll read about touch hearing devices, blind readers, and artificial organs and limbs.

ADDITIONAL FEATURE MATERIAL to appear next week includes: a one-megawatt r-f generator for plasma heating by H. M. Hill, Jr. of Princeton University; a transient recorder that monitors power lines by F. Trainor of Admiral Corp; and automatic gain control for superregenerative amplifiers by J. H. Kuck of Johns Hopkins University.

Resistors?

STACKPOLE matches every requirement

If you have a burning yearning for improved resistor dependability coupled with on-time deliveries, here's a hot tip:

In Performance Stackpole Coldite 70+ fixed composition resistors go well beyond MIL-R-11 requirements—with added dividends in load life, moisture resistance and humidity characteristics. For extra reliability, their carbon resistance elements and outer insulating shells are cold-molded of similar materials. These are formed by a new process into a solid, homogeneous structure that remains free from catastrophic failure or erratic changes in resistance in severe environments.

In Production Stackpole Coldite 70+ Resistors remain one of the easiest components to solder either by dip or iron. They're the only resistors having leads that are solder dipped—not once, but twice—in addition to the usual tin coating. That's why leads stay smooth and tarnish free even after months in storage.

In Appearance it's hard to match their smooth, glossy finish and uniform, easily-read color codes. And this attractive appearance lasts even after scrubbing with solvents.

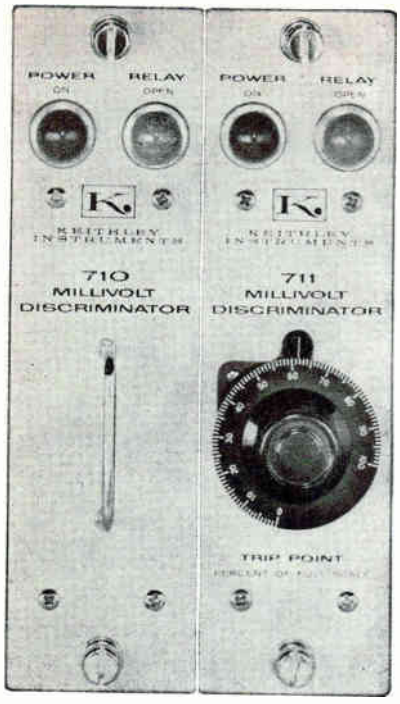
Stackpole Coldite 70+ Resistors are available in MIL-R-11 Type RC-20 (½-watt), Type RC-32 (1-watt), and Type RC-42 (2-watts) . . . in all standard resistance values, and at ordinary resistor prices.

Electronic Components Division
STACKPOLE CARBON COMPANY
St. Marys, Penna.

STACKPOLE
Coldite 70+®
fixed composition **RESISTORS**

CERAMAG® FERRITE CORES • VARIABLE COMPOSITION RESISTORS • SLIDE & SNAP SWITCHES • CERAMAGNET® CERAMIC MAGNETS • FIXED COMPOSITION CAPACITORS • BRUSHES FOR ALL ROTATING ELECTRICAL EQUIPMENT ELECTRICAL CONTACTS • GRAPHITE BEARINGS, SEAL RINGS, ANODES • HUNDREDS OF RELATED CARBON & GRAPHITE PRODUCTS.

CIRCLE 5 ON READER SERVICE CARD 5



new, millivolt discriminators

The new Keithley Models 710 and 711 are extremely stable, light-modulator dc amplifiers operating a thyratron tube and relay. They are identical except for method of trip level adjustment. Uses include a broad range of Go, No-Go automatic control applications such as testing of diode and capacitor leakage currents, controlling temperatures, sorting resistors in automatic bridges. They can also be used in nuclear safety installations and numerous process control functions. The discriminators are fail-safe in that failure of any component creates the alarm condition. They are immune to vibration, chatter-free, can be made locking or non-locking, and can be floated up to 500 volts above ground.

Sensitivity: 0.2 to 10 mv; can be extended with internal resistive divider.

Max. Source Impedance: 100 K

Repeatability of Trip Point: Better than 200 microvolts.

Speed of Response: 40 to 60 milliseconds with signal 50% larger than trip level.

Price: Model 710.....$450.00
Model 711.....$470.00

for details write

KEITHLEY
INSTRUMENTS

12415 EUCLID AVENUE
CLEVELAND 6, OHIO

COMMENT

Computers Today

I enjoyed reading the special report "Computers Today".

There is one statement that makes the input to the Minicard system seem slower than it actually is. This was brought to my attention by G. L. Loomis of our Apparatus Optical division. You mention that less than eight Minicard records an hour is the maximum input rate for cards with 12 pages. Actually, the camera can record at least 80 cards per hour consisting of five columns of code and 12 legal-size pages. All-code Minicard records can be exposed at the rate of 250 cards per hour, and Minicard records consisting of 200 characters of code and six document pages can be exposed at the rate of 90 cards per hour. Film records with only a little code and few pages of documents can be recorded at a much faster rate.

I think I know how the confusion came about. The Minicard film record is sometimes referred to as a "document." It would be very easy to get the impression that the Minicard system would record only 80 documents (legal-size pages) per hour.

The rest of the Minicard section is fine and the research and development department agrees with you that efficiency would be improved if Minicard handling and output operations were carried out automatically by one unit. Future equipment may appear with more capabilities but costs for such automation are generally higher.

CHRISTOPHER S. HYDE
EASTMAN KODAK
ROCHESTER, N. Y.

Patent Legislation

The item in *Comment* (p 6, June 9) titled "Patent Legislation," is very interesting to me. I offer you some more comments which might be of interest.

Based on many years of work as a patent attorney (No. 16,634) and as project engineer and manager in several of our large national corporations, it is my experience that corporate patent agreements depend for their binding contractual validity upon the considerations contained in the individual's employment agreement.

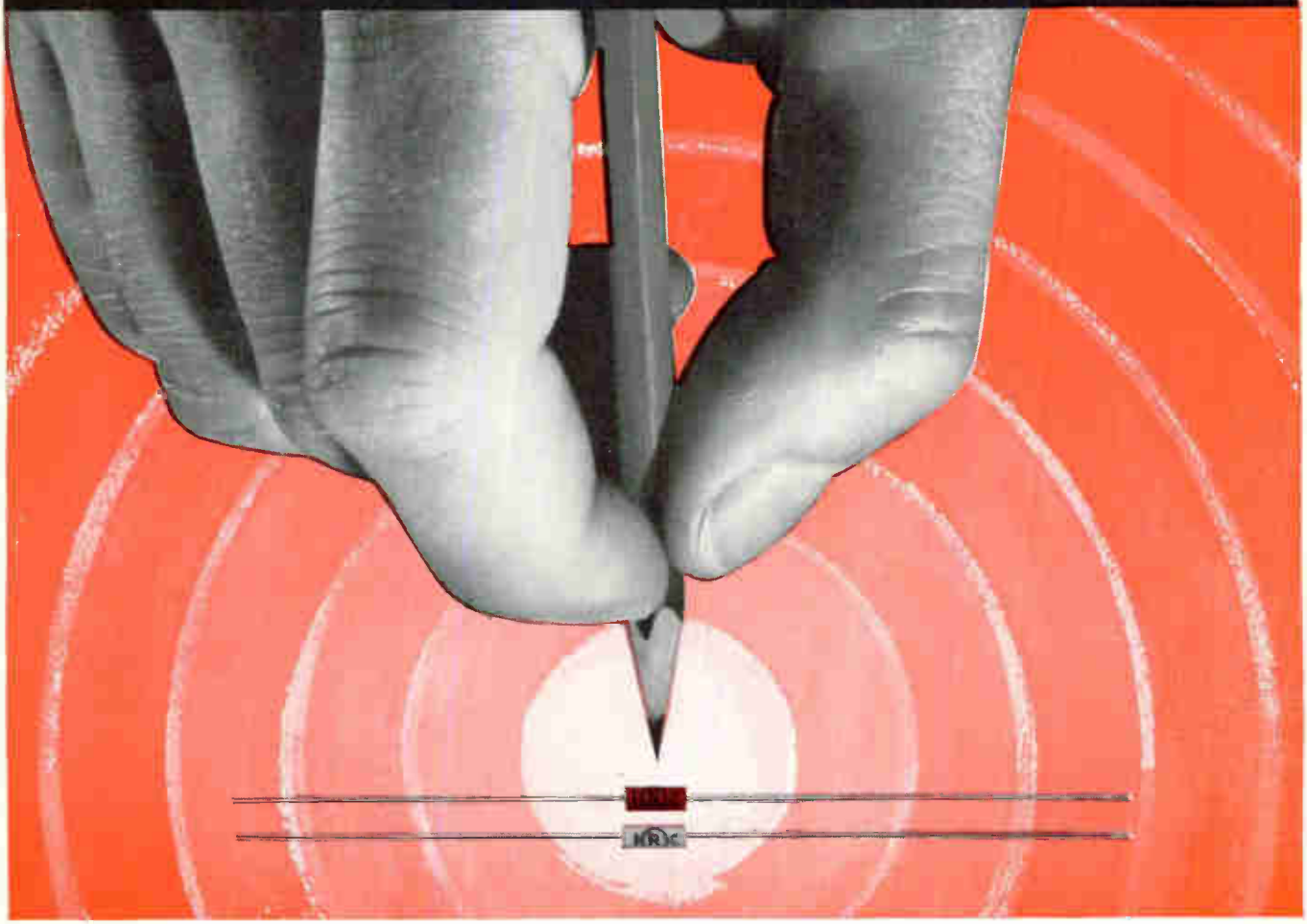
It is neither logical nor just to make a distinction between rights arising from "work financed and directed by corporations" and rights derived from "R&D work paid for by the government." Contracts for such work are quite removed from the nature and objectives of routine supply contracts. In clear contract terms, the contractor's proposal promises to apply his outstanding scientific and engineering talents. In this situation, the expectation of patentable inventions cannot be denied to governmental scientific and engineering staffs, when granted so liberally to corporations. It has been my experience that inventors feel that, in both cases, some violence is done to the individual's rights, and they do not strain themselves to produce valuable disclosures. We pay for such policies in retarded national scientific progress.

Another interesting aspect of this situation arises from the statutory test for an invention requiring that it contribute an advance not expected of a man of "normal skill" in the art. As the ELECTRONICS editorial stated, "Companies hire engineers and scientists with the foreknowledge that inventions may and should emerge from the work financed and directed by the corporation." This expectation of the results of normal skill clearly places most disclosures below the level required by statute for patentability. I do not believe that inventions result only from "a flash of genius." More realistic criteria of patentability should be applied.

I share Mr. Meissner's feeling that more realistic patent policies and practicing what we preach would improve and even stimulate our scientific and engineering progress. Personally, I nominate a higher regard for the individual's patent rights and a more realistic evaluation of what is patentable, as the most important and needed changes.

CHARLES F. CARROLL, JR.
1030 MONUMENT ST.
PACIFIC PALISADES, CALIF.

In PRECISION FILM RESISTORS if it's news, expect it first from IRC



Industry First... RN55 Precision Film Resistors in RC07 Size

Replace Fixed Composition Resistors

Every critical circuit forced to attain smallness through use of RC07 style composition resistors can now be upgraded. To make this possible, IRC offers both metal film and deposited carbon precision resistors in a new subminiature size.

1. the first time a molded RN55 resistor is available completely interchangeable in physical size with the RC07
2. meets or exceeds performance of precision films (MIL-R-10509), which means lower noise, better TC, superior all-around stability than fixed composition RC07's (MIL-R-11)
3. surpass RC07's even when run at the MIL-R-11 rating of ¼ watt @ 70° C
4. uniform, molded bodies just right for automated assembly . . . immune to damage by normal transit and handling

For top resistor performance without any space penalty, specify new IRC Type EM or DM units for every miniature circuit. Full details in a new 12-page bulletin. International Resistance Company, 401 North Broad St., Philadelphia 8, Pennsylvania.

CAPSULE SPECIFICATIONS

	Metal Film	Deposited Carbon
Wattage	1/10 watt @ 125 C derated @ Zero load @ 175 C	1/10 watt @ 125 C ⅛ watt @ 70 C derated @ Zero load @ 165 C
Temperature coefficient	± 25 PPM ("E" Char.) ± 50 PPM ("C" Char.) ± 100 PPM ± 150 PPM	+200/—500 PPM ("D" Char.)
Resistance	50 ohms min. 100K ohms max.	10 ohms min. 301K ohms max.
Standard tolerance	± 1%	± 1%
MIL-R-10509D	RN55 Characteristic E and C	RN55 Characteristic D
Size	.250" ± .031" x .093" ± .005" dia.	.250" ± .031" x .093" ± .005" dia.
IRC designation	EM	DM

IRC

Now you can monitor directly, continuously ....on operating

Solid State hp 344AR Noise Figure Meter

Compact hp 344AR Noise Figure Meter assures you that your radar is continuously operating at peak performance, and you are enjoying maximum range. The instrument's fast meter response lets you optimize or adjust the system during operation or maintenance. Model 344AR is designed for the utmost in dependability—it is militarized, solid state, very compact and very rugged.

On this sturdy 5¼" high instrument system noise figure is measured on a time-shared basis with the radar scan. The unit has high sensitivity to minimize signal and transmitter losses; the noise source may be decoupled 20 db from the main transmitter line. Two alarm functions give visible and electrical indication when an allowable noise figure is exceeded, or a noise source malfunctions.

High voltage on antenna slip rings is eliminated with a remote noise source modulator operated with low voltage triggers. Other features include quick, easy front panel calibration, and remote metering and alarms if desired.

FREE APPLICATION NOTES INCLUDE CONSIDERATIONS FOR AUTOMATIC MEASUREMENT OF NOISE FIGURE ON A CONTINUOUS BASIS

Write hp direct for Application Note 43—"Continuous Monitoring of Radar Noise Frequency". Discussion includes description of hp 344AR and its application to radar systems.

noise figure and automatically radars!

Separate Modulator, Noise Source

Versatile hp 344AR Noise Figure Meter operates on either a 25 or 30 MC IF frequency. It is designed for pulse radars with repetition rates of 90 to 500 pps; also, its high sensitivity and compact design make it very valuable in all radars, including high PRF and CW Types. In its free-run mode it measures receiver noise figure without turning on the transmitter or radar timing circuitry. Thus periodic measurement and maintenance procedures are simplified.

The 344AR's noise source and modulator are separate units which may be mounted on the antenna mast or in an aircraft. In the first case, high voltage connections are short and beyond slip rings. In the second case, you save weight and space and measure noise figure on the ground through low voltage connections.

Operation

The hp 344AR measures noise figure by operating a standard noise source and comparing the noise output of equipment under test when the noise source is off to the noise output when the noise source is on. Since the hp 344AR measures in synchronism with the radar, the noise source and measuring circuitry are triggered by a pulse from the radar's timing circuit, occurring at the end of the radar scan.

SPECIFICATIONS

hp 344AR Noise Figure Meter

Input Frequency:	25 or 30 MC, as specified
Bandwidth:	1 MC
Input Sensitivity:	Requires 35 db ± 5 db gain between noise source and 344AR input
Input Impedance:	75 ohms nominal. Passive termination during radar scan
Return Loss:	20 db from 20 to 40 MC
Accuracy:	± 0.5 db, 0 to 12 db; ± 1 db, 12 to 20 db
Repetition Rate:	90 to 500 pps, as specified
Total Duty Factor:	0.075 + (100 μsec) × (PRF)
Input Trigger:	3 v pos. peak, 3 μsec duration
Output:	100 μamp into 2,000 or 3,000 ohms
Temperature Range:	0 to 52° C
Humidity:	95%
Power:	115 v ± 10%, 50/1,000 cps, 20 to 40 watts (depending on noise source and duty cycle)
Dimensions:	5¼" high, 19" wide, 8" deep.
Price:	$1,600.00 approximate. Depends on options and modifications.

hp 340B/342A Noise Figure Meters

General-purpose instruments making possible, in minutes, receiver and component alignment jobs that once took hours. Simplify accurate alignment; encourage better maintenance; better performance.

hp **340B** automatically measures, continuously displays noise figure of IF amplifiers or microwave devices with output at 30 or 60 MC. Other frequencies on special order. Operates both temperature limited diodes or hp 347 Waveguide Noise Sources. $715.00 (cabinet) $700.00 (rack).

hp **342A**, similar, operates on 30, 60, 70, 105, 200 MC. 30 MC and 4 other frequencies between 38 and 200 MC on special order. $815.00 (cabinet) $800.00 (rack).

(Note: Models 340B and 342A available only in the U.S.A. and Canada.)

hp **343A VHF Noise Source**, temperature limited diode broadband source, 10 to 600 MC, 5.2 db excess noise, $100.00.

hp **345B IF Noise Source**, 30 or 60 MC (others to order); 4 impedances, 5.2 db excess noise. $100.00.

hp **347A Waveguide Noise Source.** Argon gas discharge tubes in waveguide sections; for bands S, G, J, H, X, P, 2.6 to 18.0 KMC, 15.2 db excess noise. $200.00 to $300.00.

hp **349A UHF Noise Source**, 400 to 4,000 MC (wider range with correction), 15.2 db excess noise, $325.00.

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Data subject to change without notice. Prices f.o.b. factory.

Ever seen a ten-milliamp circuit breaker? You have now. This Heinemann hydraulic-magnetic circuit breaker is rated at exactly 0.010 amperes. We could just as easily have made its rating 0.5 or 1.7 amps or, for that matter, any integral or fractional current value you might spec, up to 100 amps. A simple change in the winding of the solenoid overload coil would do the trick. • When you need precise overcurrent protection, even at very low current levels, think of the possibilities of the Heinemann breaker. It is temperature stable (no de-rating or trip-point juggling); it is available with any of several inverse time delays (or instantaneous-trip action); and it can be had in models ranging in size from subminiature on up. The Heinemann Engineering Guide, Bulletin 201, will give you detailed information. Write for a copy.

HEINEMANN ELECTRIC COMPANY 176 BRUNSWICK PIKE, TRENTON 2, N.J.

SA 2401

ELECTRONICS NEWSLETTER

Generates Continuous Field of 126 Kilogauss

CONTINUOUS MAGNETIC FIELD of better than 126 kilogauss has been generated at MIT. It is believed to be highest continuous field ever produced. Achievement is expected to pave way for accelerated research advances in superconductivity, semiconductor materials and other areas of solid-state physics, as well as in fusion investigations.

The record-high continuous field was achieved in core of solenoid magnet invented by Henry H. Kolm of MIT and built by High Voltage Engineering Corp., Burlington, Mass. Design enabled MIT Laboratory to operate magnet at current level of 10,000 amperes and to force 320 gallons of water per minute through coil for heat dissipation.

Magnet consists chiefly of long copper ribbon six inches wide, tapering to one-and-one-half inches at the end. Ribbon is scored with 3,000 square slots and is wound into cylinder to form magnet. Slots form channels through which water is forced for cooling.

Samples of semiconductors, other materials can be placed in a two-inch aperture at center. Successful test of coil consumed 1.88 megawatts. Limit of available power at present laboratory was reached during test, and ultimate capability of magnet is still unknown. Kolm, formerly of MIT Lincoln Laboratory, is staff member of Air Force-financed National Magnet Laboratory now under construction at MIT.

Gas Laser Employs Design Innovations

OPERATION of a helium-neon gas, continuous wave laser has been achieved by Raytheon. The 1.2-micron infrared beam supplies coherent energy for eventual system applications in space communications, and military systems.

Firm's gas laser is similar in principle to the device developed by Bell Telephone Laboratories, with mechanical and optical design innovations. Mirror alignment has been found to be a critical factor in gas laser operation. Detection of the output has been made with a military infrared receiver. Investigation of other combinations of gases will be made in its continuing laser research program, Raytheon says.

Last winter the firm announced a commercially available solid-state optical laser, using a ruby crystal. The unit requires only a fraction of the input power usually required for operation with this material. This was achieved by optical housing design.

NASA Orders Test Gear For Ion/Nuclear Engines

NEW TESTING EQUIPMENT has been ordered by the National Aeronautics and Space Administration for ion and nuclear engine power use in space. Connecticut Aircraft & Nuclear Engine Laboratory of Middletown, Conn., has been given a $589,000 contract to build a test facility at NASA's Lewis Research Center in Cleveland to be used to develop space radiators and condensers.

To be completed in 15 months the facility will include a space environment chamber and a closed-loop system for the flow of working liquid metal. Heat dissipation of the facility will be 1,800 degrees Fahrenheit. The problem in ion and nuclear power for space vehicles is to get rid of the excess heat

Mass Motion In Solids Getting New Attention

RESEARCH to determine the mechanism of atomic movement in solids is underway this week in the University of Arizona's new solid-state physics laboratory.

Work will be done with silver halide solids (such as silver bromide) in an attempt to show that the mechanism of mass motion in solids will change when high pressure is applied. Behavior patterns of various known impurities in the otherwise pure metals will also be studied.

Employed will be the high pressure technique, the radioactive tracer method, and electrical conductivity measurements of the solids.

West Germany Joining 11-Nation Space Push

BONN—West Germany last week decided to participate in an 11-na-

Quantum Amplification Intrigues Soviets

VIENNA—Soviet Professor Nikolai Bassow told TASS last week the first light-ray generators have already been designed and completed. He gave no other details. He also said wireless communication with other planets is possible only through light generators.

Lew Arzimovich, an academician, believes "atomic wireless stations fitted with quantum amplifiers will play a practical role within the next five to 10 years."

Bassow thinks "light-ray generators will allow minute observation of the moon's surface. Quantum electronics has already made it possible for wireless systems to enter the parameter of visible waves."

Soviets say "yet another reason exists to make quantum amplification in the range of visible waves exciting: one sender of such a range could transmit simultaneously tens-of-thousands of tv programs."

tion European space program. The program, originally proposed and vigorously promoted by the British, involves development of a three-stage rocket for the launching of communication satellites and other peaceful projects.

Bonn's decision virtually assures that the much-discussed program will finally get off the ground. The Germans have agreed to chip in 20 percent of the total development cost of nearly $200 million. Without this contribution, Britain and its partners would have been forced to drop the project.

Britain's Blue Streak is slated for the rocket's first stage, France's Veronique for the second stage. The third stage will be jointly developed —as will the electronic gear—by the participating nations, with Germany expected to play a leading role.

Nations expected to participate: Britain, the three Scandinavian countries, Switzerland, Germany, France, Italy, Belgium, Holland and Spain.

Soviets Claim Fast Semiconductor Testing

MOSCOW—An automatic device which will measure optical and electrical properties of semiconductor materials 50 to 100 times faster than conventional apparatus has been designed at the Latvian University in Riga, the Soviets claimed last week.

Tass said the "relaxation combine" will, in half an hour, yield spectral prints giving a full picture of the electronic processes in a solid body.

The device "is used at Riga for investigation of so-called ion crystals which are models for study of semiconductors," say the Soviets. No other details are given.

20,000-Ft 'Antenna' Riding On Schooner

A THIN COPPER-CLAD WIRE was hoisted 20,000 feet into the atmosphere from the deck of an ocean-going schooner off the coast of Fort Pierce, Fla., last week in an experiment to study low frequency propagation over long distances.

Pickard & Burns, Inc., of Needham, Mass., a subsidiary of Gorham Corp., did the hoisting by an "Aerocap" (balloon).

The experiment, conducted for the Air Force, uses a one-million volt generator in the ship to charge the wire with low frequency pulses similar to lightning, says Wilbur H. Norton, Gorham president. Scientists from Rome Air Development Center indicate future practical applications are possible in long-distance communications and navigation. (See ELECTRONICS, p. 53, July 22, 1960)

Transistor Radar-Operated Altimeter Weighs 15 Lb

THE Seattle Development Laboratory of Minneapolis-Honeywell reports this week it has developed a radar-operated altimeter it says will measure altitude up to 2,000 ft within a 12-in. range. Barometric altimeters, may err as much as 37 ft, firm says.

The new altimeter uses transistors, weighs about 15 lb. The company says 10 applications have been developed for the instrument, which it describes as "the first major development in altimetry in 10 years." Two possible uses: in space vehicles landing on the moon and in an Army automatic landing system for helicopters.

Japan: Three Groups Become Associations

THREE DIVISIONS of the Federation of Japan Electric Communications Industrial Associations have separated and formed their own associations. Reason: each division has grown so big it no longer needs a 'parent' federation.

The new associations: Electronic Industries Assocation of Japan, (JEIA) headed by Fumio Iwashita, president of Toshiba; Communications Industries Association of Japan, headed by Toshihide Watanabe, president of NEC; and Wires and Cables Maker's Association, headed by Zenzo Nishida, former vice president of Furukawa Electric Engineering Company.

In Brief . . .

DOUGLAS AIRCRAFT CORP. is selected out of nine companies, gets $450,000 NASA study contract for developing orbital placement technique and engineering design specifications for Project Rebound spacecraft. Project Rebound is a passive communications satellite program.

JAPANESE electronics output totaled $1.1 billion in 1960. It was $932 million in 1959, U. S. Department of Commerce reports.

CUBIC CORP. receives $1.7-million Air Force contract to provide data-handling equipment for the Atlantic Missile Range.

TEXAS INSTRUMENTS INCORPORATED gets an Air Force contract of $268,000 to design and develop an unattended marine seismic monitoring system.

UNITED KINGDOM EXPORTS of electronic products to the United States in 1960 totaled $19.6 million—a drop of more than 10 percent from the record level of nearly $22 million in 1959.

A BIBLIOGRAPHY on power supplies, compiled by Armed Services Technical Information Agency, is now available through the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Price: $5.

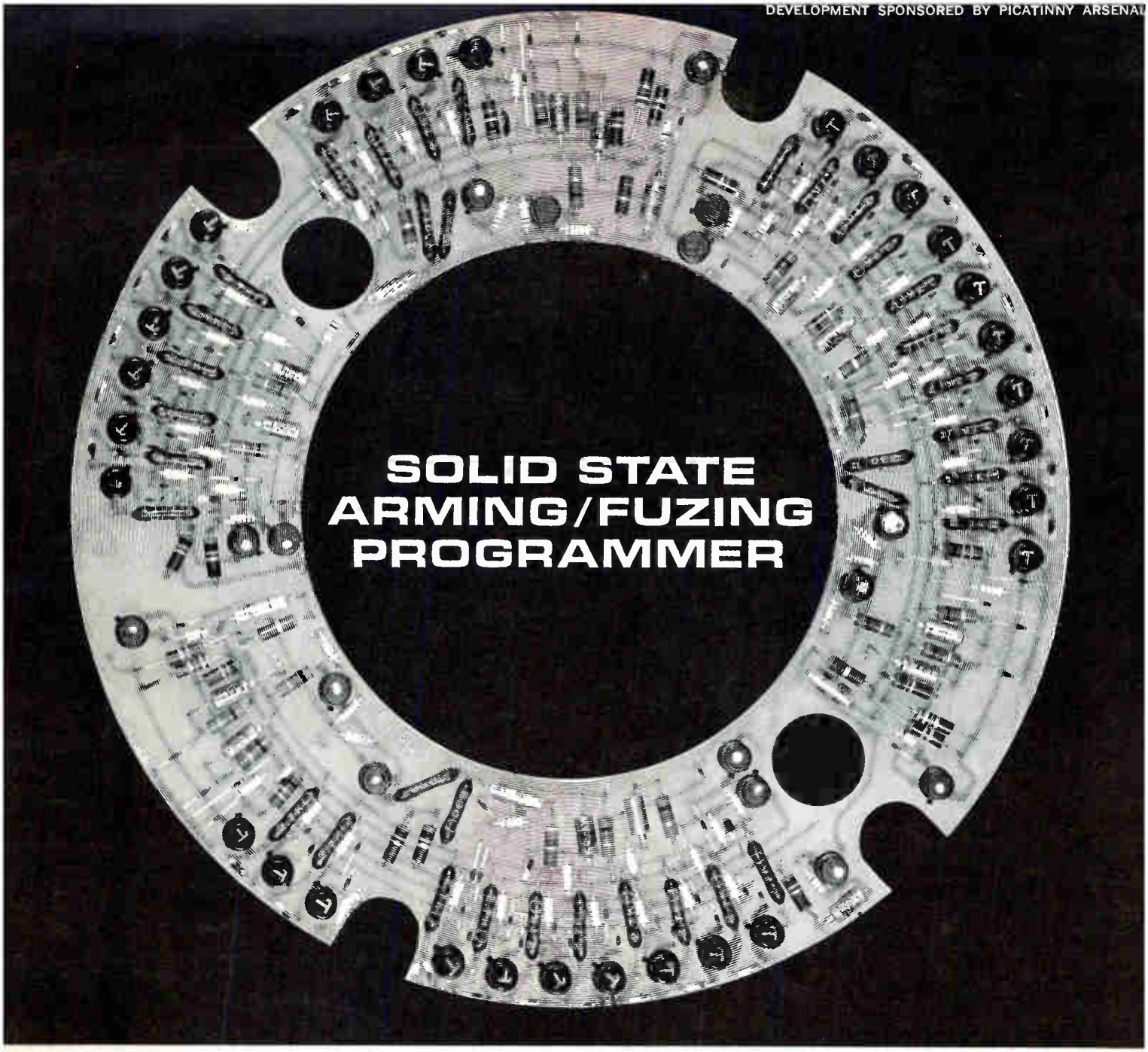
TOSHIBA'S $15.3-million central laboratory—called the largest electrical engineering research laboratory in Asia—goes into partial operation at Kawasaki, near Tokyo.

FEDERAL ELECTRICAL CORP., Paramus, N. J. gets $37.1-million Air Force contract for operation and maintenance of the Dew Line early warning radar system.

RAYTHEON gets $11.6-million FAA contract for 40 radar bright display systems for air traffic control.

HAZELTINE CORP. of Little Neck, N. Y gets $1.2-million Navy contract for 8,000 antisubmarine sonobuoys.

DEVELOPMENT SPONSORED BY PICATINNY ARSENAL



All-electronic digital timing programmer controls atomic warheads with better than 0.1% accuracy under extreme environmental conditions

Developed in cooperation with the U. S. Army Tactical Atomic Warhead Laboratory at Picatinny Arsenal under a program of supporting research, this new digital timing programmer represents a significant advance in the state-of-the-art for arming/fuzing devices. For this particular application, the programmer includes two identical channels, each with a 4-stage, adjustable timing program *accurate to within 0.1%* under any combination of temperature (—65°F to +165°F), voltage (26.5 ±5.5 Vdc), vibration (50 g's/2000 cps), shock and acceleration (100 g's). This new standard of accuracy under rugged environmental conditions is, however, practically meaningless until it is combined with another, equally important consideration always present in modern atomic weapon systems — *reliability*. The programmer's proven solid state design, *without any moving parts*, together with the unique packaging methods utilized, potentially offers a safety-reliability level substantially higher than previously attainable.

This arming/fuzing device is only one specific application of Tempo's exclusive solid state digital programmer design. Circuit versatility permits an almost infinite number of applications. Number of functions to be controlled is limited only by the allowable physical size of the device. Timing increments can be as close as 10 microseconds. Functions can be fixed or variable in time from the application of power or from a control signal. Two basic characteristics, however, are present in all versions; a high degree of accuracy and maximum reliability — both guaranteed under a wide range of extreme environmental conditions. If these characteristics are vital requirements of *your* timing programmer, Tempo can help you.

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ELECTRIC
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ELEMENTS FOR ALL APPLICATIONS AS WELL AS COMPLETE TRANSDUCER ASSEMBLIES FOR MOST APPLICATIONS, SUCH AS UNDERWATER SOUND AND VARIOUS ORDNANCE AND MISSILE DEVICES.

Sprague-developed mass production and quality-control techniques assure lowest possible cost consistent with utmost quality and reliability. Here too, complete fabrication facilities permit prompt production in a full, wide range of sizes and shapes.

Look to Sprague for today's most advanced ceramic elements — where continuing intensive research promises new material with many properties extended beyond present limits.

YOUR INQUIRIES ARE INVITED

WRITE FOR LITERATURE

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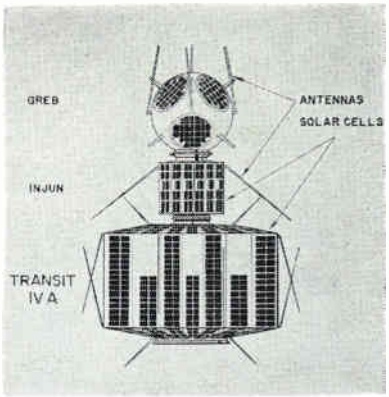
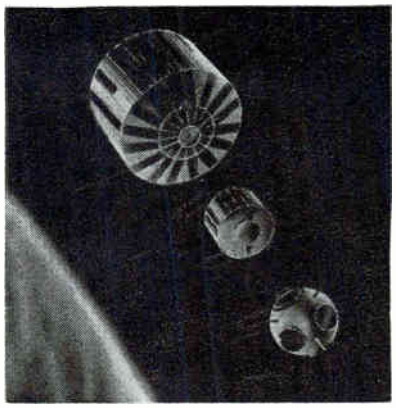
THE MARK OF RELIABILITY

WASHINGTON OUTLOOK





LAUNCHING of the first nuclear device into space has cleared the way for multiple use of atomic power for space use in the next few years.

In the artist's conceptions above, Transit IV-A and its two pick-a-back satellites Injun and Greb are depicted as assembled in the nose cone of the launch rocket (left) and moments after leaving the launch vehicle (right). Nuclear power plant, a tiny SNAP (Systems for Nuclear Auxiliary Power) generator built by Nuclear division of The Martin Company, was fastened to base of Transit IV-A.

The big hurdle to sending a nuclear device into space has been more a diplomatic than technical one. The State Department and the Administration as a whole have had long and serious debates over the political vulnerability of shooting nuclear devices into space. The fear has been that a launch may fail and land in another country. Remember the fuss when a U.S. rocket exploded and landed in Cuba?

Now, however, the decision has clearly been made. The technical advantage of using atomic power in space will not be withheld because of diplomatic reasons.

THE ELECTRONICS INDUSTRY will benefit from a recent Interstate Commerce Commission decision upholding cheaper freight rates. The action came recently when the ICC held that sharply reduced freight rates now offered by eastern and western railroads under their "Piggyback" Plan III were legal.

Electronics manufacturers such as the Radio Corporation of America and Tung Sol Electric urged approval of the rates. Under the plan, the railroads haul shipper-owned truck trailers or containers on flatcars for a flat fee regardless of content. This is lower than normal rail fees based on commodity classification and generally lower than truck rates.

PATENT PROCEDURES in the U.S. may be revamped. A new Dutch proposal for handling patents is creating a stir of interest in the U.S. and Europe. Under the plan, patent applications would be published shortly after they were filed, but actual issuing of a patent on the filing would not be done until a necessity for it is shown.

The theory behind the Dutch scheme is that a large number of patents granted are never used. Thus, the patent department would not waste time processing patent applications only to have them remain dormant. If need to process a patent is not shown at the end of seven years, the application will be abandoned.

Patent Commissioner David L. Ladd says the U.S. may be forced to go to something like the Dutch system to break the logjam of pending patent applications. Currently, this amounts to 196,000 applications—some three to four years of processing work. One way or the other, Commissioner Ladd says, patent processing is going to be speeded up.

...tough going ahead!

E-I GLASS-TO-METAL SEALS

DESIGNED FOR THE SPACE AGE


INDIVIDUAL TERMINALS

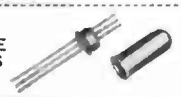

COLOR CODED TERMINALS


MULTI-LEAD TERMINALS


CONDENSER END SEALS


THREADED SEALS


CUSTOM SEALS


MINIATURE CLOSURES


TRANSISTOR CLOSURES

Utmost reliability is assured under severest environmental conditions. E-I Glass-to-Metal Seals have proven their ability to withstand extremes of temperature, high mechanical shock and vibration, and wide pressure changes in thousands of critical commercial and military applications.

E-I offers a Complete Line of economical standard seals, facilities for designing special seals and custom service for the sealing of components of your own manufacture. Call or write for literature or recommendations on your specific sealing problems.

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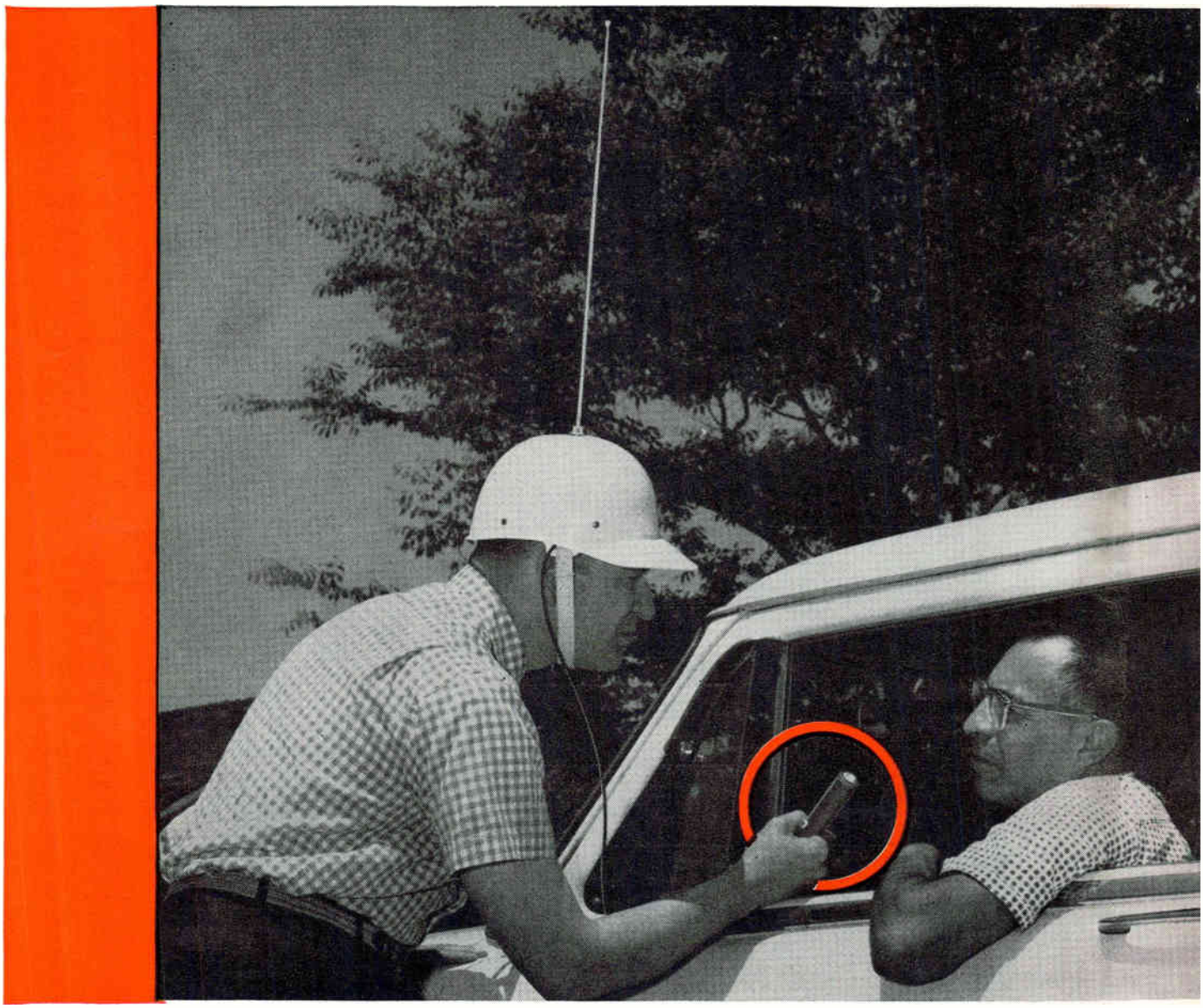
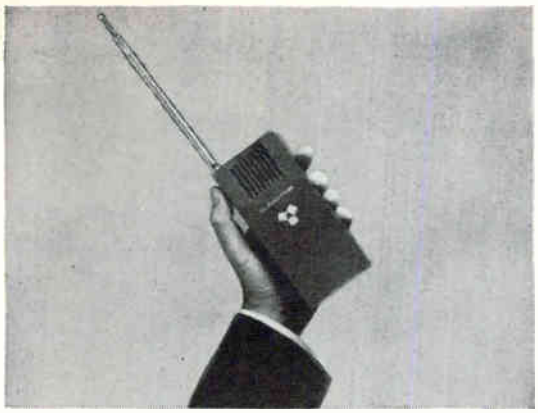
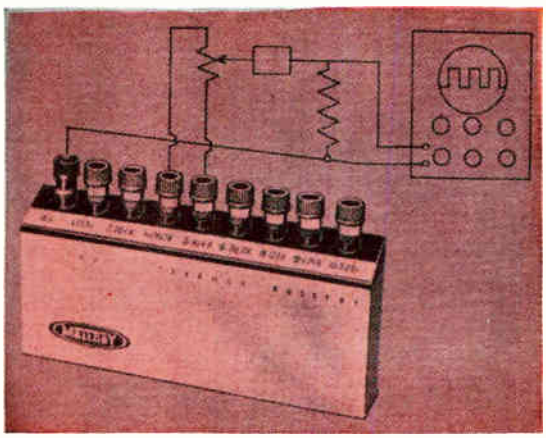
Mallory Mercury Batteries give you product features your customers like



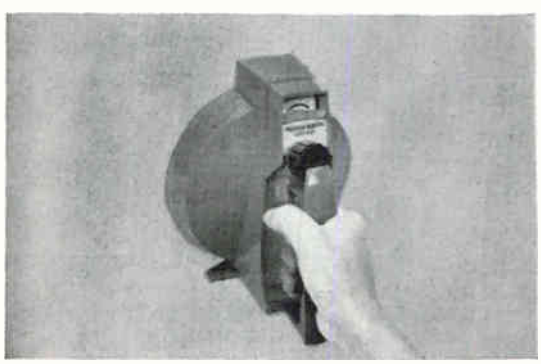
VEGA-MIKE ALL-TRANSISTOR WIRELESS MICROPHONE, made by Vega Electronics Corporation, is a self-contained broadcasting station with its own transmitter, antennae and power source, but with no connecting wires. Low-cost operating power is provided by one TR-115-R Mallory Mercury Battery, which delivers at least 20 hours' reliable, fade-free service at a cost of only about 5 cents per hour. The tiny mercury cell aids portability, fits neatly into the barrel of this miniaturized device.



TRANSISTORIZED CITIZENS BAND TRANSCEIVER, by Cadre Industries Corporation, is powered by Mallory Mercury Batteries. Ideal for the set's miniaturization and portability, these tiny cells are powerful enough to deliver a full-range signal—steady and fade-free—continuously for 24 hours. Cadre found Mallory engineering assistance valuable in solving power supply problems.



MALLORY MERCURY VOLTAGE REFERENCE BATTERY, for instrument calibration and laboratory tests; accurate within ±½% of stated voltage. Non-glass, rugged construction. EMF is not changed by impact, vibration, heavy momentary overloads, or sustained loads within rated capacity. Eight outputs, 0 to 10.80 volts, in 1.35v steps. Available from leading laboratory supply houses and from Mallory distributors.



PORTABLE ELECTROMAGNETIC RADIATION DETECTOR, made by Sperry Microwave Electronics Co., a division of Sperry Rand Corp., responds to all energy from 400 to 10,000 mc, integrates the energy so the total field can be read on the meter. Mallory Mercury Batteries are used as the built-in reference voltage source. Their constant output over long periods of time makes possible precise meter calibration. Their miniaturized size fits the tight space requirements of this two-pound, hand-held instrument.

For extra miniaturization . . . extra portability . . . extra dependability . . . power your new products with Mallory Mercury Batteries.

Pioneered and perfected by Mallory, these unique batteries give you far more watt-hours per pound and per cubic inch than any other commercial dry cell. They last 3 to 7 times longer, depending on drain. They give exceptional power-life and stability even in extremely miniature sizes.

Constant voltage over their long service life makes Mallory Mercury Batteries ideal for transistor circuitry. Voltage output is precise and stable for use as a reference source in instrument circuits. Cells coming from production have voltage consistent within a few millivolts.

They'll last up to six years on the shelf, with minimum capacity loss. Double steel case with molded grommet seal assures freedom from leakage. And they'll operate over wide temperature ranges; newest types have high output even at 0°F.

Mallory Mercury Batteries are available in a broad line of standard single or multiple voltage cells, and in special power packs designed to your requirements. Write for consultation and engineering data.

Mallory Battery Co., North Tarrytown, N. Y.
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P. R. MALLORY & CO. Inc.
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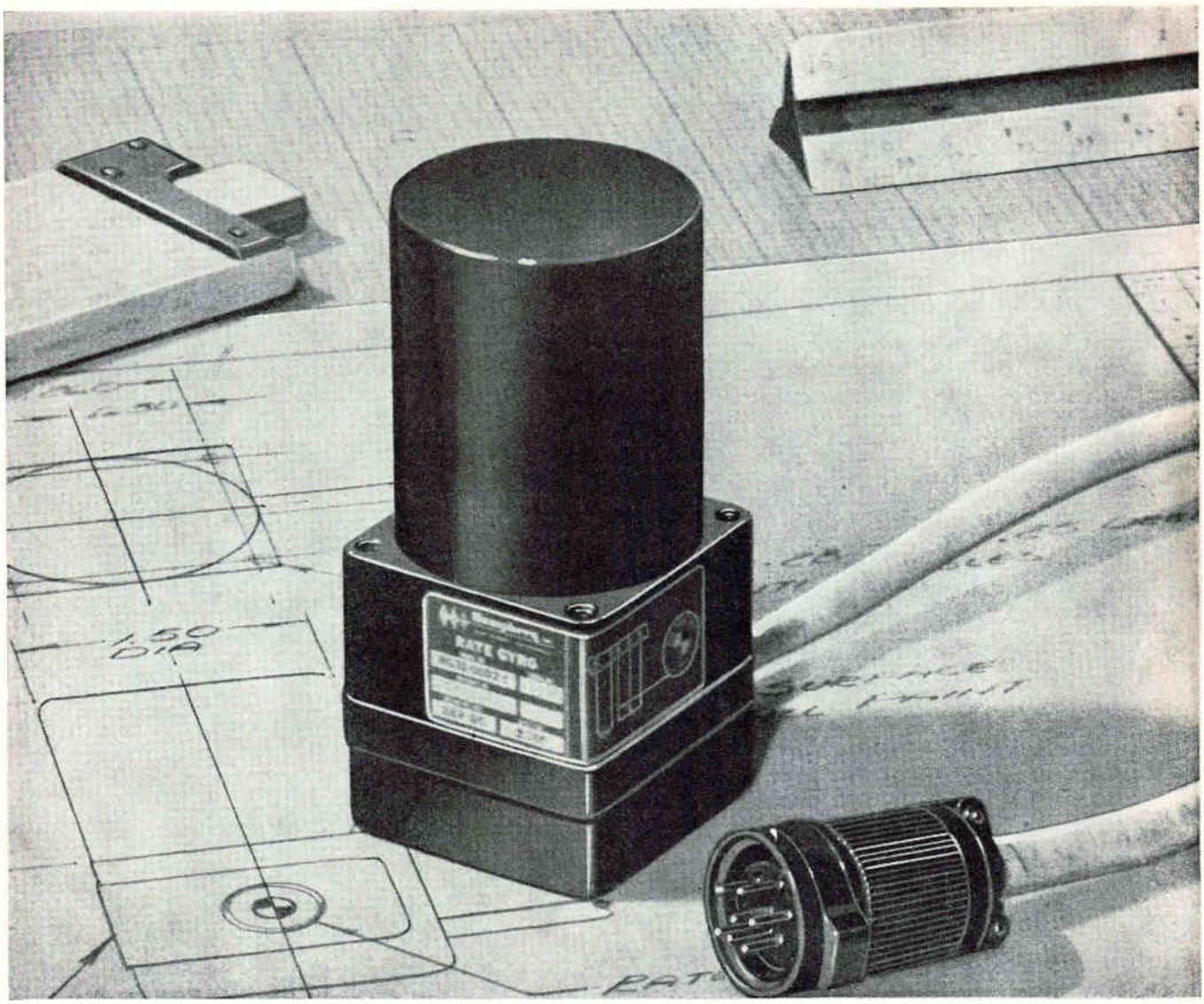
In Canada: Mallory Battery Co. of Canada Ltd., Toronto 4, Ont.
In Europe: Mallory Batteries Ltd., Crawley, Sussex, England

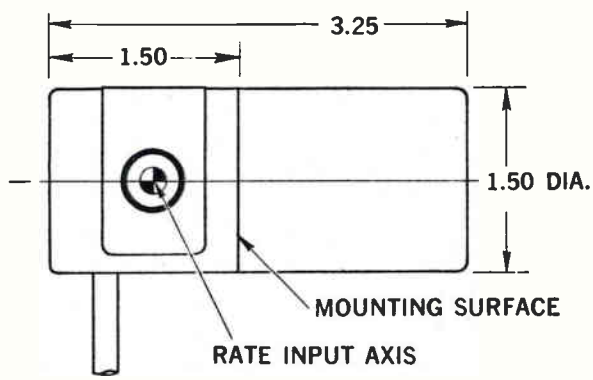


Smallest complete d-c rate gyro

For stabilization and instrumentation systems on target drones and missiles, Humphrey, Inc. has developed a new sub-miniature rate gyro that saves ⅓ on weight and size. The new RG31 rate gyro weighs only 11 oz. and measures only 1½" diameter by 3¼" long. It operates on readily-available 28-volt d-c power. The d-c motor is maintained at constant speed by a governor. The built-in noise filter reduces r. f. interference to meet stringent standards of MIL-I-16910A.

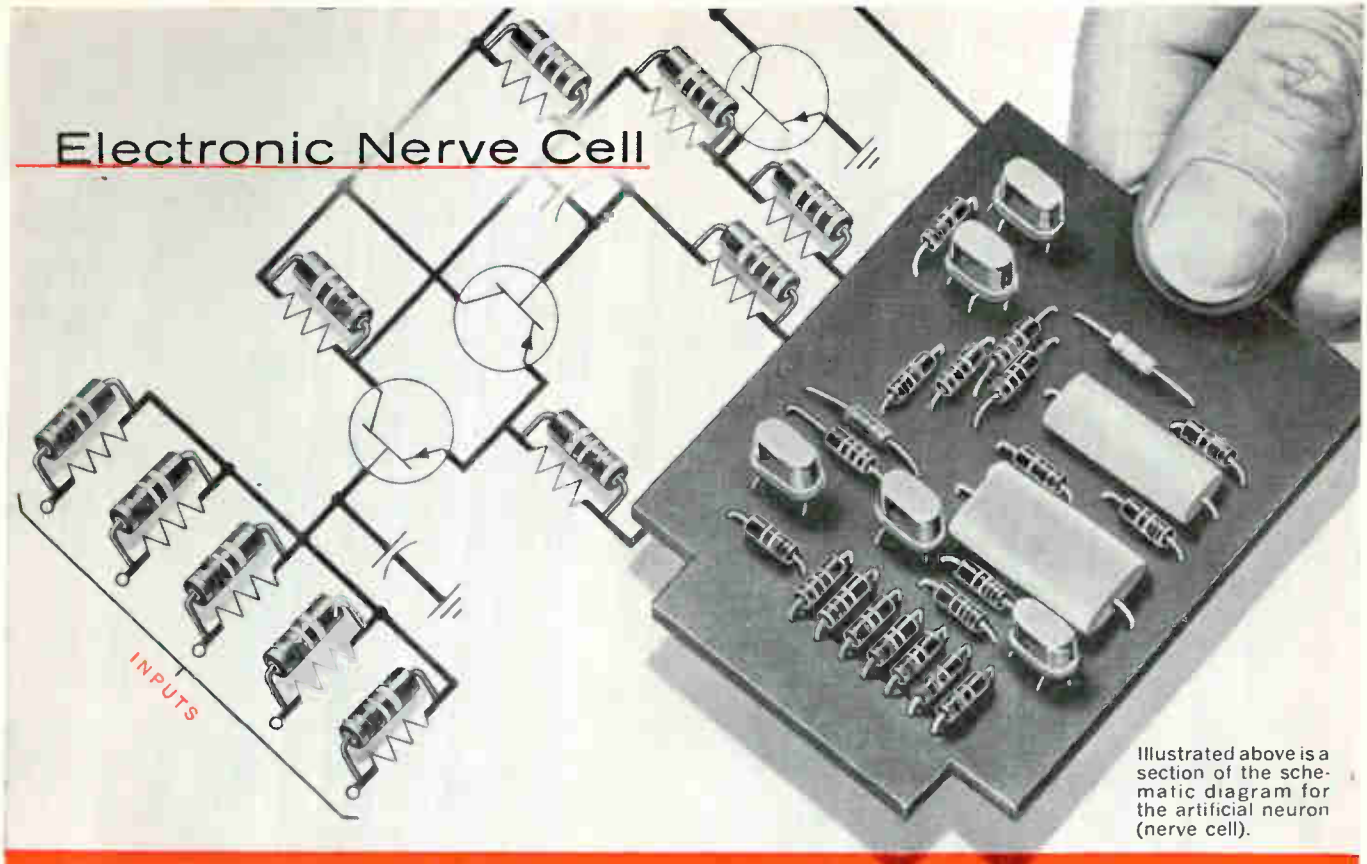
This new Humphrey rate gyro features a high-resolution, dual-wiper potentiometer for a strong, usable output signal. A dry gas damper is used to achieve a damping factor of 0.8 ±0.1. The whole unit is hermetically sealed, including the r. f. filter. The RG31 rate gyro is available in rate ranges from ±40°/second to ±1500°/second. The simplicity of the straightforward design of this instrument insures outstanding reliability.

Humphrey, Inc. specializes in the design and production of ultra-miniature guidance instruments. A miniature accelerometer with outstanding characteristics is another recent development. For more information on the RG31 rate gyro or for help with any of your guidance instrument requirements, write today to Humphrey, Inc., Dept. HE-7, 2805 Canon Street, San Diego 6, California. Eastern Division is located at 9430 State Rd., Philadelphia 14, Pa.



Dimensions—RG31 rate gyro

Humphrey Inc.
ELECTRO-MECHANICAL INSTRUMENTS



Illustrated above is a section of the schematic diagram for the artificial neuron (nerve cell).

Goal of New Research Project:
MORE EFFICIENT COMMUNICATION SYSTEMS

A-B QUALITY

Research to explore the information processing in nervous systems is now underway at Bell Telephone Laboratories. Here, scientists are experimenting with newly developed electronic elements which are designed to imitate the actions of a living nerve cell. Too little is yet known about living cells to permit exact electronic duplication. However, experiments with groups of artificial neurons have roughly duplicated some of the eye's basic reaction to light. This new approach to studying basic nerve network functions can provide clues for stimulating further exploration into the fundamentals of the transmission of intelligence.

Allen-Bradley is very happy that the quality of their hot molded resistors caused them to be selected for these exacting experiments. With their uniform properties and conservative ratings—A-B resistors will provide the same superior performance in your electronic circuits. Be certain you specify A-B hot molded resistors—especially for your critical jobs. Send for Publication 6024.

A-B Hot Molded Composition Resistors

SHOWN ACTUAL SIZE

Hot molded composition resistors are available in all standard EIA and MIL-R-11 resistance values and tolerances.

*Pending MIL Spec Assignment

Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee 4, Wis. • In Canada: Allen-Bradley Ltd., Galt, Ontario

ALLEN-BRADLEY Quality Electronic Components

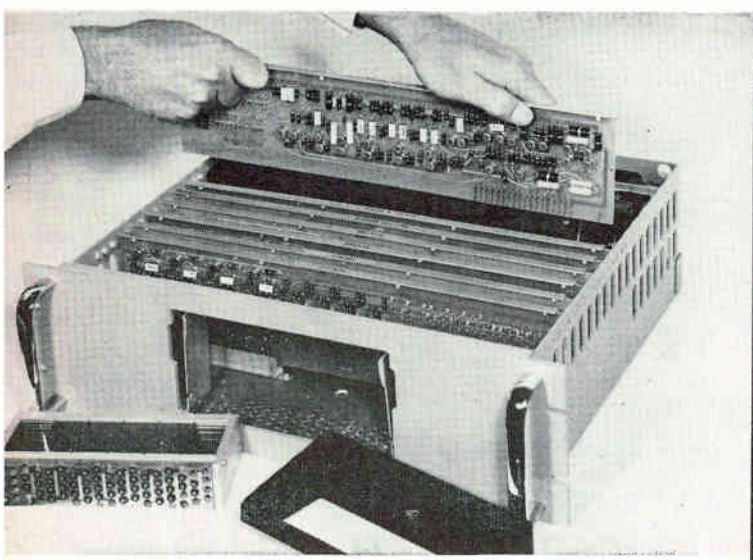
The Important Difference In Digital Voltmeters...

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!

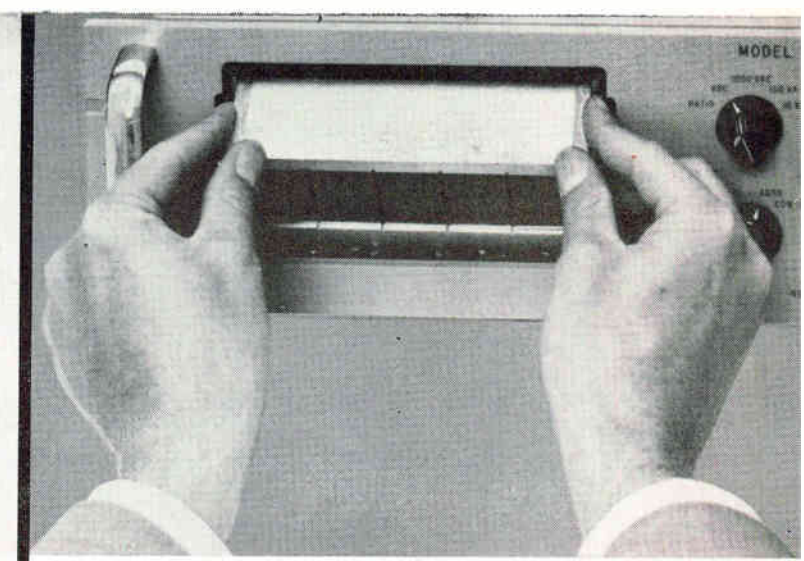
Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR, CALIFORNIA



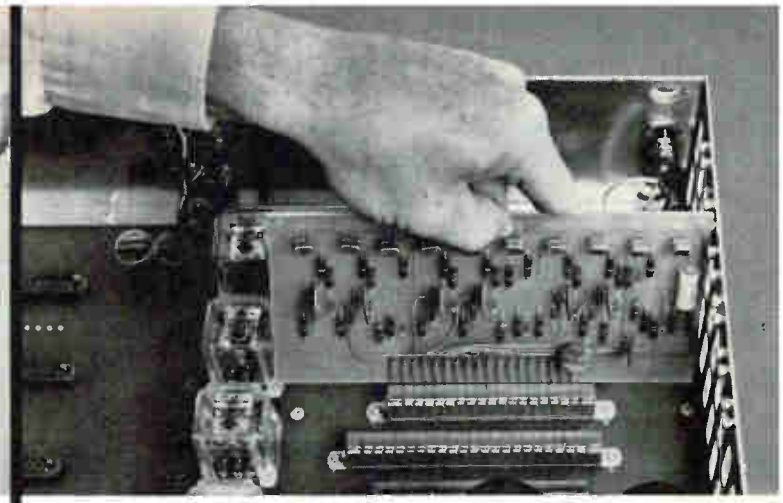
1 **PLUG-IN MODULAR CONSTRUCTION** *simplifies servicing, drastically reduces maintenance costs, keeps instruments on the job. More than 99% of the components of the NLS V44, Series 20 and Series 30 instruments are mounted on plug-in modules.*



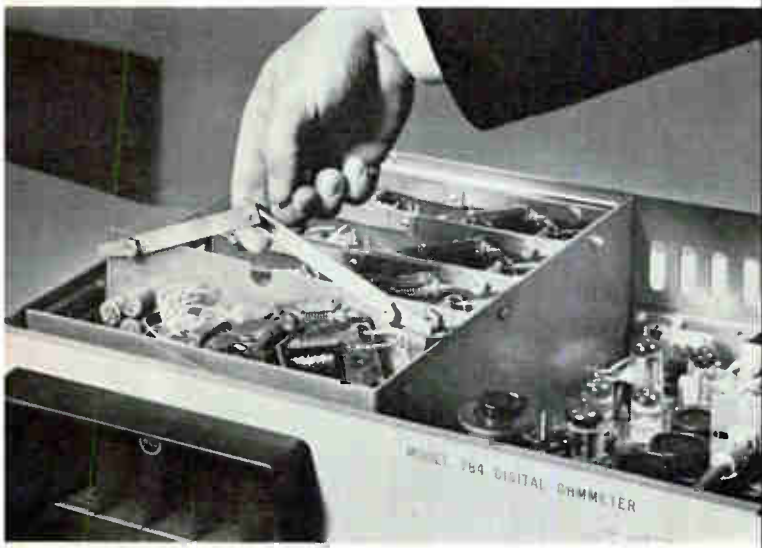
2 **SNAP-OUT READOUT,** *exclusive on all NLS digital instruments, permits 20-second bulb replacement through front panel without tools. Precisely engraved readout numerals can be read all day from close up or far away without eye fatigue.*

CIRCLE 20 ON READER SERVICE CARD

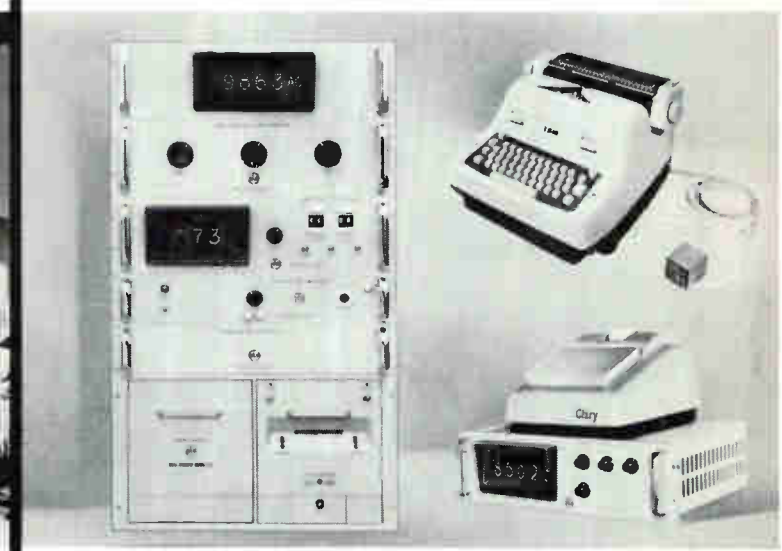
3 **COMPACT DESIGN** — *illustrated by the 5¼"-high NLS 484 DVM, complete with recording controls – is one of the more obvious clues to superior engineering. Even the lowest cost NLS instruments are more compact with fewer cables and connections. Result: greater reliability.*



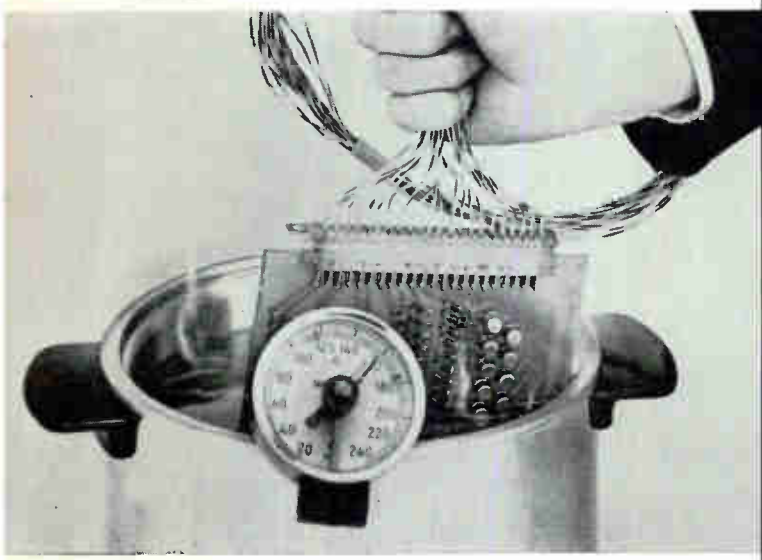
4 **"NO-NEEDLESS-NINES" LOGIC** *in Series 30 results from a new concept in transistor logic which eliminates unnecessary, time-consuming cycling of stepping switches through their 9's and 0's positions. This increases accuracy, speed, reliability and usefulness, particularly in systems applications.*



5 **PLUG-IN STEPPING SWITCHES** — *exclusive with NLS — are standard even on lowest cost Industrial models. Results: switch replacement is a one-minute cinch instead of a half-day chore — troubleshooting is as easy as shifting switches and noting changes in the readout.*



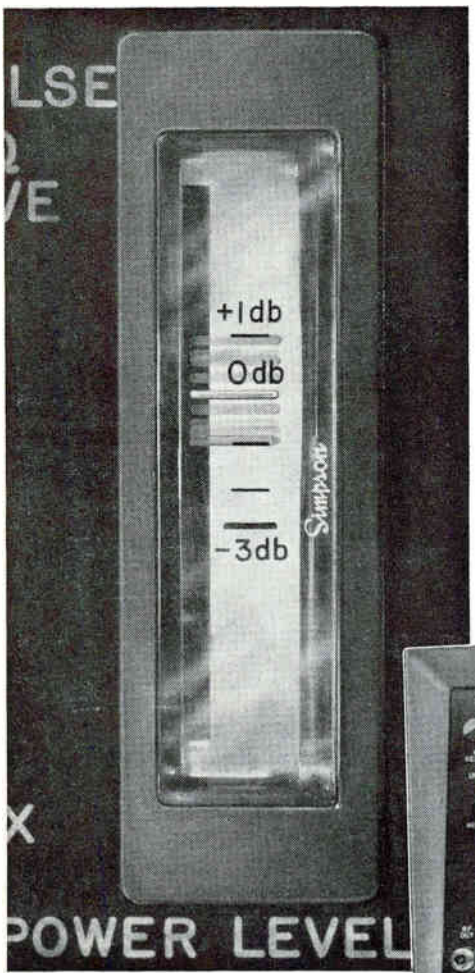
6 **PLUG-IN ACCESSORIES** *can be mated in minutes with an NLS digital voltmeter to form hundreds of combinations. These include AC/DC converters, preamplifiers, input scanners, and virtually every type of data recorder.*



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.*

...OUTPUT CONSTANT ±1 db



with *MELABS* new Swept Frequency Signal Generator

Available . . . a new series of swept frequency signal generators covering L, S, C and X band frequencies. These generators use a BWO tube as signal source, incorporate the exclusive MELABS Power Regulator as a built-in feature. This regulator operates solely upon BWO tube output—permits amplitude modulation without incidental frequency modulation—provides swept output at 10 mw that is maintained constant within ± 1 db throughout the entire range. Sweep width is continuously adjustable from full frequency range to less than 10 mcs. Units can be switched to manual tuning for use as a signal generator, have linearly calibrated dials accurate to ±1%. The built-in variable attenuator also operates on BWO tube output and provides continuous control of unregulated output over a 40 db range without causing a change in frequency.

The generator "package" is broken down into two units to reduce weight, facilitate easy carrying by one man. The same power supply/sweep unit can be used with any of the MELABS electronically tuned generators.

The many built-in features of these generators tend to reduce materially the amount of external equipment necessary for accurate visual presentation of equipment characteristics. Operation is simple, straightforward.

SPECIFICATIONS (Similar for all units)

POWER OUTPUT: Regulated, 10 mw ±1 db. Unregulated, continuously adjustable over 40 db range.

INTERNAL MODULATION: For regulated power: **Pulse,** 1-10 usec. width, prf, 100-5000 cps. **Square wave,** repetition rate 1000 cps with ±10% front panel adjustment.

EXTERNAL MODULATION: Any type, unregulated only.

SWEEP: .03 to 30 cps with sweep widths continuously adjustable to 100% of Frequency Range.

DIMENSIONS: 11"H, 8"W, 21¼"D, each unit.

WEIGHT: Power supply, approx. 65 lbs. **RF heads,** approx. 35 lbs.

AVAILABLE MODELS: RF heads,
Model **SGL-2,** 1-2 kmc.....2600.00
Model **SGS-2,** 2-4 kmc.....2300.00
Model **SGC-2,** 4-8 kmc.....2400.00
Model **SGX-2,** 8-12 kmc....2600.00

POWER SUPPLY/SWEEP UNIT (required far each RF head)
Model **SGO-2** 900.00
will operate with any of the listed RF heads.

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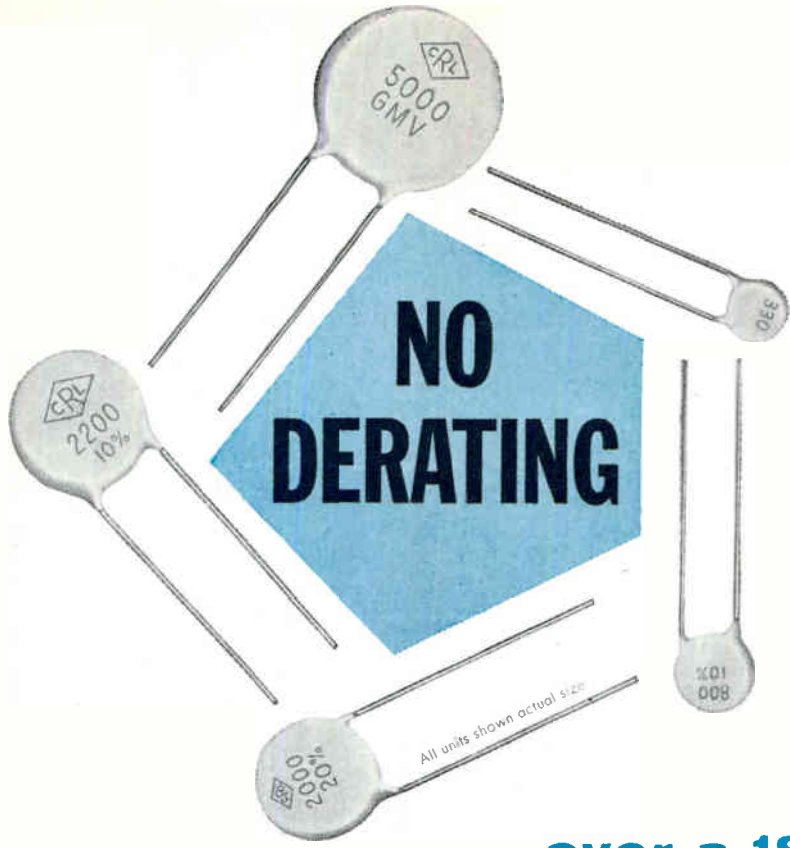


over a 180° C range with Centralab's temperature stable Ceramic Capacitors

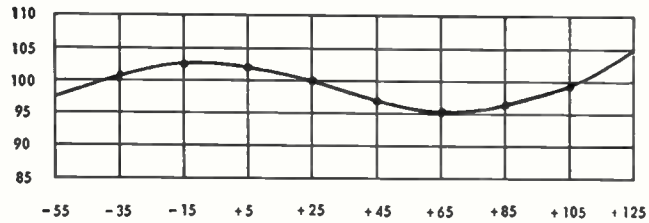
These low-cost Type CE ceramic disc Hi-Kaps® have been extensively tested over an 18 month period by prime contractors in the missile and radar fields. Their findings: *the excellence of the* CENTRALAB *design parameters for standard commercial units permits the identical capacitors to be used in military applications.*

In radio-TV as well as military usage, these units operate from —55° C to +125° C without derating. They last longer than paper or mica capacitors, and their small size makes them economical to work with. Semi-stable Type CF CENTRALAB Hi-Kaps® offer similar advantages.

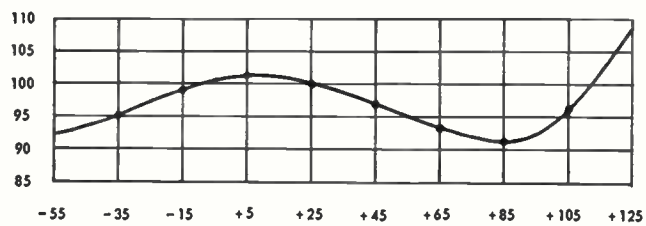
SPECIFICATIONS

CAPACITIES: 150-6200 mmf
SIZE: .290"—.920" diameter, .156" thick
WORKING VOLTAGE: 500 VDC
LEAKAGE RESISTANCE: Initial, 10,000 Megohms minimum; after humidity test, over 1000 Megohms
POWER FACTOR: 2% Max. at IKC
TOLERANCES: GMV, ±20%, ±10%, +80—20%

TYPE CE—% of 25°C Capacity vs. Temperature in °C



TYPE CF—% of 25°C Capacity vs. Temperature in °C



Detailed information on these and many other CENTRALAB ceramic capacitors can be found in Catalog 42-857. Write for your free copy.

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ELECTRONIC SWITCHES • VARIABLE RESISTORS • CERAMIC CAPACITORS • PACKAGED ELECTRONIC CIRCUITS • ENGINEERED CERAMICS

Ferrite-Filled Waveguide Is Described

LONDON—Packing the halls of the British Institution of Electrical Engineers a few days ago, 1,000 delegates from more than 14 countries heard components discussed at the International Conference on Components and Materials used in Electronic Engineering.

In the five days the conference lasted, 109 papers were presented divided between 14 basic component areas ranging from resistors, microwave ferrites, magnetic materials for data storage, piezoelectric and magnetostriction devices through to the best attended session of all, microminiaturization.

Designed for specialist attendance, quality of the papers was high. Indicative of the level is a representative title, Ferromagnetic Resonance in Yttrium Iron Garnet.

To fit such a heavy program within the time scale and still allow time for discussion, the IEE adopted the rapportage system where a special introductory lecture set the pattern for each session, followed by a rapporteur summarizing the highlights and controversial points of all papers selected for that session. But the hoped-for discussions failed to materialize, little new being added to that already covered in the papers.

Trends within the fields were not readily apparent. Most papers reviewed past progress rather than looking ahead. But among forward-looking contributions, two highlighted new techniques in the microwave ferrite field.

One presented by K. J. Button and B. Lax revealed quantitive design methods for reciprocal ferrite phase shifters using a simplified theory for calculating phase shift in ferrite specimens suitable for reciprocal phase shifter use.

The newly developed theory connects the dielectric concentration of the microwave field within the ferrite with the increases of permeability change when a low value d-c field magnetizes the ferrite.

Another notable paper, that by P. J. B. Clarricoats and D. C. Chambers, showed that a small diameter ferrite-filled circular waveguide acts as a backward-wave structure. With suitable dimensional parameters the backward-wave mode is the only propagation present. Typical application envisaged is in microwave bandpass filters.

Design details on variable-field ferrite attenuators and power dividers came in a paper from R. J. Benzie describing a four-port variable attenuator where ferrite phase shift controls the power division between two exit ports.

Also described is a reflective switch using a cross-polarization waveguide system with a ferrite controlling the polarization rotation.

Two new techniques interesting to quartz crystal manufacturers held out promise of synthetic crystals of quality comparable to natural quartz. Described by C. S. Brown of the General Electric Company, England, one method uses impure siliceous rock as the nutrient supply of quartz.

Modification of the aqueous growth solution from sodium carbonate to potassium carbonate eliminates the ingress of aluminum into the crystal so the quality crystals are now growable from impure nutrients.

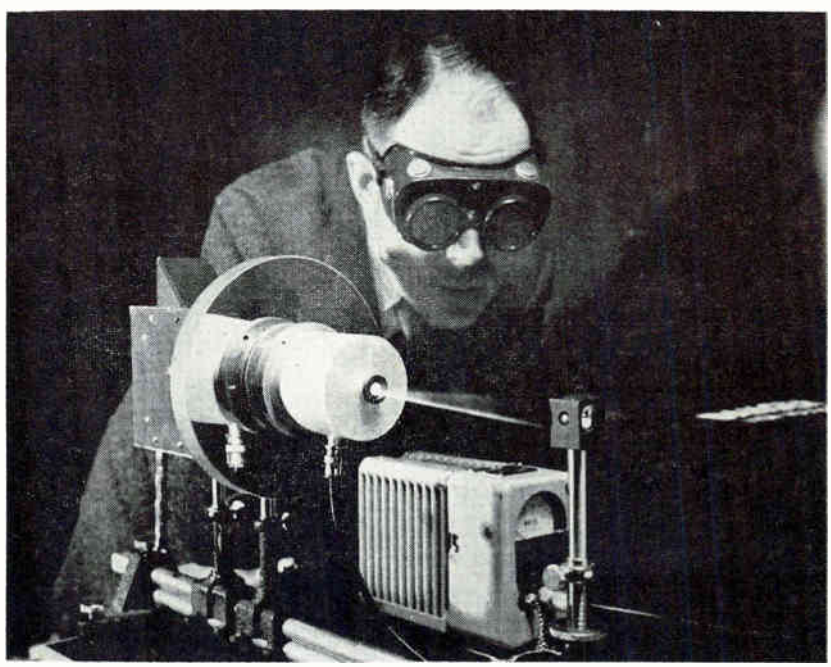
Another approach produces synthetic crystals whose mechanical losses over a −55 to 90 deg C temperature range equal those of natural quartz. Here the technique used involves reducing the synthetic crystal growing rate to between 0.1 and 0.6 mm per day.

Also in the piezoelectric area is a crystal design that reduces size of low frequency crystals. Developed at the British Post Office Engineering Department, the crystal shape consists of identical cantilever arms extending from a common central point to form a symmetrical element.

Typical size figures for an 800 cps quartz element is only 36 × 9 × 2 mm and a 250 cps ethylene diamine tartrate element is only slightly bigger (30 × 15 × 1.5 mm).

Among conventional components, main new developments reported accrued in the ceramic capacitor field. Technique reported by R. A. Hill and A. W. Stirling produces ceramic capacitors in the range

Crystal Unit Modulates Laser Beam



Solid-state light beam modulator developed by Sperry is capable of microwave frequency operation. Device will be a component of optical maser communication system

0.5-1 microfarad for working voltages from 3 to 50 v d-c. The technique consists of chemically reducing a ceramic disk to make it conducting, firing silver electrodes on each face of the disk and then reoxidizing in air at high temperature for a preset time.

Oxygen diffuses through the electrodes converting layers of ceramic material beneath the silver to a high resistance dielectric, so that the highly conducting portion of the ceramic acts as a common electrode between two thin insulated layers. Typical dimensions for an 0.5 microfarad capacitor is 0.5 inch thick and 0.030 inch diameter.

Microminiaturization session, although the best attended, yielded no surprises. Three papers described the current state of the art in the UK. Revealed in a British government contribution was the prime emphasis government research laboratories were laying on microcircuits followed by investigations into solid circuits. Little work is being done on micromodules. Development work is proceeding on miniature transistors and diodes with dimensions less than 0.125 inch diameter and 0.05 inch depth.

Surprisingly absent from such a conference were papers on thin-film magnetic storage systems, only one paper describing the three main types of thin-film computer memories now being investigated: the spot array system on a planar substrate, the uniform film on planar substrate and the electroplated uniform field on a cylindrical substrate.

Electronics Tops Japan's Patent List

TOKYO—Japanese Patent Agency announced foreign registrations accounted for 30 percent of patents applied for last year, double pre-World War II averages.

Of the total number of patent applications, both Japanese and foreign, electronics patents accounted for 29.8 percent. Second: organic chemicals at 18.3 percent.

Some 69,700 patents were approved last year by the Agency, the largest number since patent laws began in Japan in 1888.

Ultraminiature Thin-Film Transistors

Experimental thin-film transistors have been produced by evaporation techniques in array form by RCA. These majority-carrier devices (shown here enlarged) are made with successive layers of cadmium sulfide and metals may open way to mass production of microminiature transistor circuits. Amplification factors are on the order of 50 to 60

Armed Services Name Programs Where New R&D Money Will Go

WASHINGTON—Here are some areas in which the military will spend the $6 billion slated for research and development in fiscal year 1962:

Army needs surface-to-surface missiles for a wide variety of ranges. Army also would like a departure from normal communications techniques—telephone service to all units using possibly broadband or some other new technique.

Army needs improvements in combat surveillance, data processing, means to disrupt the enemy's communications and other electronic equipment.

Navy's share of the R&D fund totals $1.3 billion: $450 million for Polaris; $200 million for applied and basic research; $100 million for support facilities—such as gear for the Pacific Missile Range; and $450 million for exploratory work and for component development.

Navy expresses enthusiasm for contracts with a reliability clause. The bomb-nav system contractor for the A2F-1 gets a premium bonus for the proven accuracy of the system.

One qualification USAF plans to stress more is equipment survivability.

And another is the use of digital techniques in command and control systems.

There will be greater emphasis on reconnaissance and intelligence devices; and for versatile electronic systems for aircraft navigation that can be used by planes operating from a number of dispersed airfields.

Radars with greater range and resolution are needed for detection of silent satellites.

The most urgent need, USAF said, is defense against enemy ballistic missiles. The Soviets reportedly are pushing hard for such a defense.

When they achieve it, military men say, the U. S. will see the biggest propaganda splash yet by the Soviets.

These facts were reported re-

R&D Money . . .

cently at the IRE's 5th National Convention of Military Electronics in Washington, D. C.

Speakers included John R. Rubel, Assistant Secretary of Defense; Brockway McMillan, Assistant Secretary of the Air Force; James H. Wakelin, Assistant Secretary of the Navy; and Edward G. Witting, Deputy Assistant Secretary of the Army.

Rubel cited five pitfalls the Department of Defense tries to steer clear of: (1) developing exotic systems for which there is no real need; (2) duplication of effort; (3) overstated requirements; the design is needlessly complicated by excessive miniaturization, automation, etc.; (4) devoting too much attention to exotic elements of a system while paying too little to "uninteresting components"; (5) allowing so much delay in translating state-of-the-art achievements into hardware that the hardware is obsolete before it is operational.

Army's Witting said about five percent of R&D money goes into basic research to universities, nonprofit organizations and industry. More than 90 percent is for applied research.

A total of 50 percent of Army's R&D money goes for four large systems: Nike-Zeus, Pershing, Mauler and Advent.

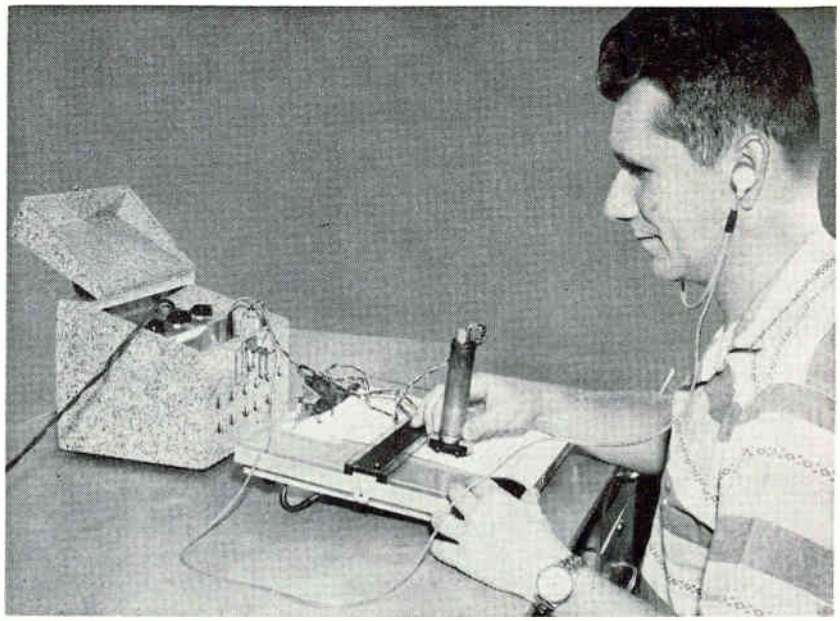
Witting said firepower has bypassed communications and mobility in progress.

Nevertheless, Army has feasibility studies for a new generation Pershing missile.

USAF's McMillan indicated a change in Air Force contractural policy. In the late fifties, USAF relied almost entirely on the weapons system approach, with the exception of ballistic missiles which have always been managed by the Ballistic Missile division and contracted by the subsystem method to industry.

In the future, Electronics Systems division, Hanscom Field, Bedford, Mass., will have prime responsibility for the various electronic systems.

Industry will take Air Force-developed specifications and develop the hardware.



Light and dark patterns of letters are picked up by hand-held photocell probe of experimental reading device for the blind

Computer Helps Make Machine for Blind

DIGITAL COMPUTER is helping develop a reading machine for the blind. Work going on at Battelle Memorial Institute research is sponsored by its National Institutes of Health and the Veterans Administration.

First programmed to recognize shape of each letter of alphabet, a computer is next taught to simulate groups of photocells that recognize the newly acquired alphabet. It is finally coupled directly to an experimental reading device so that the combination operates as a single machine.

Photocells in miniature arrays switch reading-machine oscillators on to generate a specific pitch when sufficiently darkened by part of a letter. The blind learn to interpret these sequences of chordlike tone combinations as letters.

Faced with problem of finding a photocell array that will generate most distinctive combination of tones for each letter of alphabet, researchers use an IBM 650 to simulate the action of photocells activating oscillators on a reading device. This allows investigation of different types of photocell arrays simply by programming the computer.

A big problem was in programming letters of the alphabet and combinations of photocells in a way that provides interaction between the programmed letters and the programmed photocells. The solution to the problem breaks each alphabet letter into bits by placing it under a screen made up of 119 rows and 104 columns. A square in the screen is considered on if a predetermined amount of it is covered by a part of the letter.

Initial programming results in simulating five photocell arrays selected as potentially easy to recognize. This is done for evaluation and to demonstrate the technique. Lead wires from the computer readout panel connect directly to on-off switches of reading-machine oscillators.

A tape-recorded series of tones produced by each of five programmed photocell arrays will be played back while reading alphabet to determine which set of tones is easiest to recognize. Only those that pass the computer test will be built into reading machines for evaluation by the blind.

Research pattern recognition by computers could lead to applications in postal, banking and insur-

ance operations, says John K. Wetherbee, director of systems engineering study. A computer programmed by this technique could also investigate new ways of transmitting information between individuals.

Pnpn Diodes in Private Automatic Phone Net

AN ELECTRONIC private automatic branch exchange (PABX) was described in three papers presented recently at an AIEE meeting at Cornell University. The system has been under construction and test for 15 months at the Automatic Electric Laboratories, Northlake, Ill.

The system had its origin in a 100-line private automatic exchange (PAX) for internal use only, to be an expanded copy of the PAX, except for a general improvement of the circuits, and addition of circuits necessary for the addition of supervisory signals, conferences access and trunk circuits.

Features of the 100-subscriber exchange include: space division switching network using silicone *pnpn* diodes, direct trunk facilities that allow the operator to link her telephone directly to a trunk, thereby bypassing the electronic exchange in event of a malfunction.

How Inhomogeneity Affects Semiconductors

INHOMOGENEITY has an adverse influence on galvanomagnetic effects in semiconductors, according to a new Air Force research study on the transport properties of indium antimonide and semiconducting diamond.

Tests showed that even slight inhomogeneities in carrier concentration or magnetic field can cause considerable current distortion in high-mobility materials in the presence of a strong magnetic field. This distortion can destroy the symmetry of the measured galvanomagnetic effects and cause negative and abnormally large positive magnetoresistance effects.

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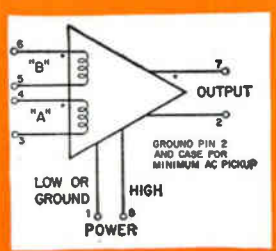
MAGNETIC AMPLIFIERS

60 CPS

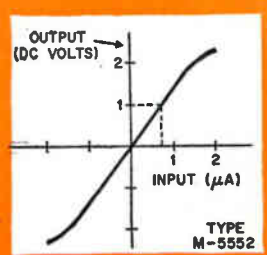
PREAC®

Fifty db power gain and full linear output with but milli-microwatt input power are inherent characteristics of the PREAC magnetic amplifier. Thermocouples, strain gauges, pressure transducers or high impedance sources may supply the input signal. Null drifts are as low as 1.0 micro-microwatt. Other applications include null and error detection, integration and summing, and use in sensitive micro-voltmeter and micro-ammeter circuits.



ELECTRICAL CONNECTIONS

TRANSFER CHARACTERISTICS



SPECIFICATIONS FOR 60 CPS PREAC AMPLIFIERS

TYPE	DC Microamperes Input for 1 DC Volt Output, 5K Load		Control Winding Resistance—Ohms		Bandwidth—CPS, with Tabulated Input Loop Resistance	
	Winding A	Winding B	Winding A	Winding B	Winding A	Winding B
M-5549	4.8	7.4	65	188	0.26 CPS/0.1K	0.6 CPS/0.1K
M-5550	1.2	7.4	980	188	0.32 CPS/2K	0.6 CPS/0.1K
M-5551	2.4	2.4	490	490	0.5 CPS/1K	0.5 CPS/1K
M-5552	0.7	7.4	2600	310	0.13 CPS/3K	0.6 CPS/0.1K

AIRPAX also produces a complete line of 400 CPS PREAC magnetic amplifiers.

AIRPAX ELECTRONICS INCORPORATED

SEMINOLE DIVISION FORT LAUDERDALE, FLA

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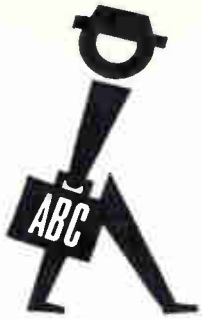
CIRCLE 27 ON READER SERVICE CARD



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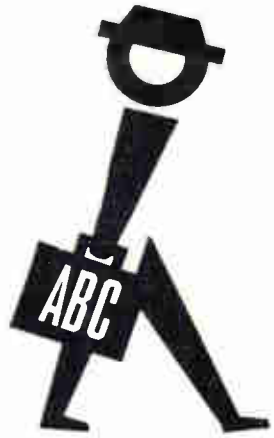

there . . .

almost everywhere

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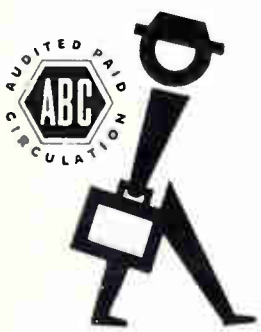
Knowing full well that sales messages must reach a responsive audience in order to be effective, our advertisers are also interested in the ABC auditor's call. The hard, and sometimes cold, facts he reports about our circulation provide you with an informed basis for investing your advertising money.

Yes, the ABC auditor has been here . . . and he will be here again, calling to check on how well we are doing our job and to provide the facts to help us *and our advertisers* do even better.



electronics

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NEW MIL RESISTORS...from OHMITE

"INSULATED" MIL-R-26C RESISTORS

Wire-wound, Sealed in Silicone-Ceramic

NEW MIL-R-26C AMENDMENT 2 IN BRIEF: By means of this new amendment, specification MIL-R-26C is extended to include three sizes of *insulated, wire-wound* resistors with axial leads. The new insulated resistors meet all requirements of MIL-R-26C including a dielectric strength test (1000-volt, V-block) and an insulation resistance test (100-volt, V-block). Currently, tolerance is specified as 5% and maximum ambient temperature rating as 275°C.

INSULATED RESISTOR CONSTRUCTION: A single layer of resistance alloy wire is wound on a ceramic core. Metal end caps, with axial leads attached by welding, are then fitted snugly over each end of the core. A molded jacket of silicone-ceramic material completes the unit by sealing the entire assembly.

Through research and advanced production know-how, Ohmite is able to introduce this advanced product line to meet the demanding new requirements of its Military and Industrial customers.

Mil Des.	Char.	Watts	Resist. Range*	Length ±.020	Dia. ±.020
RW67	V G	6.5 5.0	0.10 to 3600 ohms	0.917	0.323
RW68	V G	11.0 8.0	0.10 to 8200 ohms	1.823	0.343
RW69	V G	3.0 2.5	0.10 to 910 ohms	0.542	0.230

*MIL-R-26C limit for single-layer winding.

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CIRCLE 29 ON READER SERVICE CARD

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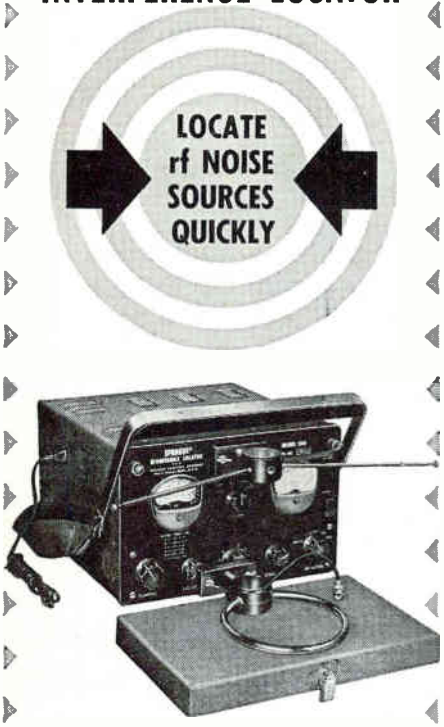
MODEL 500
INTERFERENCE LOCATOR



This versatile instrument is a highly sensitive interference locator—*with the widest frequency range of any standard available unit!* Model 500 tunes across the entire standard and FM broadcast, shortwave, and VHF-TV spectrums from 550 kc. to 220 mc. in 6 bands.

It's a compact, portable, rugged, versatile instrument—engineered and designed for most efficient operation *in practical field use.* It features a transistorized power supply, meter indications proportional to carrier strength as well as sensitivity of 5 microvolts minimum for 5% meter deflection over entire tuning range.

For full details, send for brochure IL-106.

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THE MARK OF RELIABILITY

Where Electronics Stands in Spain

By DOMINICK CURCIO
McGraw-Hill World News

MADRID—There are 30 companies known to be manufacturing electronic equipment of some kind, in some quantity, in Spain. Six of them appear to be doing the bulk of the business, which is not yet large, and all of these are owned in part by companies in other countries. (Spanish law requires that a minimum of 51 percent of the ownership must be native.)

The remaining companies, mostly small in size, are largely supported by local capital, but some do have a little outside financial support and most are equipped with foreign patents and licenses.

Sales statistics are unavailable, and will probably not be available until the industry is a year or two farther along in development; some men think it is currently growing at about eight percent per year. But the total volume is still small, and much of it is in the entertainment field.

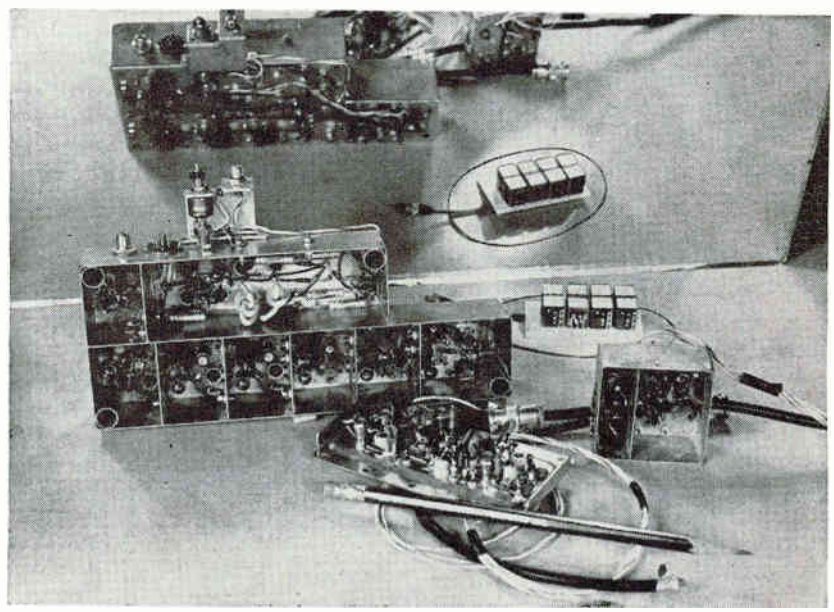
Manufacturers are importing most of the needed components. Materials needed for their production are in short supply. Exports of finished equipment are going largely to the Middle East and North Africa. The concentration is chiefly upon transmitting and receiving equipment, and many companies rely largely upon the production of domestic appliances for the bulk of their domestic income at this time.

Government purchases of electronic equipment do not represent an appreciable part of the available business.

The few large plants employ up to 3,500 people, have been in business 10 to 15 years, and their equipment is reasonably modern. The smaller firms employ 15 to 20 people, and much of their work is by hand methods. The degree of automation goes down sharply with the size of the operation.

There is not yet any great amount of research or development going on. Skilled workers and engineers are scarce. The fact that a government school is increasing its output of skilled men and another graduating more engineers will help but cannot quickly overcome the shortage. Independent schools, and mail-order schools, are trying to fill the gap, with somewhat

Airborne Receiver Operates 10,000 Hours



Solid-state aircraft receiver with 10,000 hour time between failures was built for Air Force by Sylvania. At right (rear) is microminiature unit which will be 1/10 size of present version

spotty results reported to date.

Pay for skilled men averages between $2 and $2.50, with just a few earning $4. Unskilled men are plentiful, and their cost is low. Women are rare in the manufacturing field. The labor force belongs to one union patronized by the government.

Spain's electronics industry is, for all practical purposes, quite new. Oddly enough, although it does not yet turn out a wide variety of products it does momentarily appear to have more than adequate capacity to supply conventional domestic entertainment needs due to current economic conditions within the country and relatively low buying power.

This is, however, beginning to change as the economy improves and, in the electronics industry specifically, there are some signs that increasing sales pressure by the larger firms may force the smaller ones to grow or die.

Three-Gun, 23-Inch Color Tv Tube Promised

CHICAGO—A 23-inch 90-degree three-gun color picture tube offering 283 square inches of viewing surface was promised by Motorola at its dealer convention here recently.

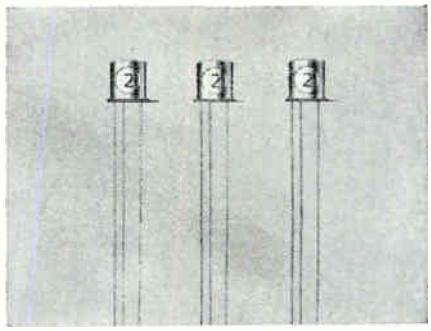
The company showed a 23-inch color console, little deeper than a conventional black and white set and five inches shallower than conventional 17-inch color models. The 23-inch color consoles will be available to public within the coming year.

F-M stereo table receivers, delayed by tooling time, will be available by New Year's, consoles before that time said Edward R. Taylor, company executive vice president. F-M will add 20 to 25 percent to the price of a stereo console, a larger proportion to the cost of table sets.

Reverberration will be extended to 80 percent of consoles including a portable one priced at $249.95. A stereo portable will be priced at $77 and a travel a-m/f-m clock radio at $79.95. Also shown was a six-transistor table radio with accessory brackets for hanging on the wall.

Advertisement

Three New Additions to the Sprague MADT* Transistor Line



The Sprague Electric Company has added a new series to their highly-successful line of Micro-Alloy Diffused-base Transistors.

The new units, Type 2N768, 2N769, and 2N779A are high-speed switching transistors in TO-18 cases. Their unique electrical characteristics further expand the varied applications to which Sprague MADT Transistors can solve circuit design problems.

Type 2N768 is a micro-energy switch designed for low current, low voltage, high speed applications.

Type 2N769 is the fastest switching transistor yet developed. It will operate reliably at speeds in excess of 100 mc.

Type 2N779A is manufactured with tighter parameter control than any other transistor in the industry. It is ideally suited for NOR logic and other super-critical applications.

These hermetically-sealed germanium transistors are made by a controlled-etch process to insure extreme uniformity. Maximum frequency capabilities have been improved by graded-base construction. Automated manufacturing techniques have brought about increased production efficiency, permitting favorable reductions in prices. This is why Sprague MADT Transistors can offer you greater performance per dollar than other high-speed devices in low-current switching circuits.

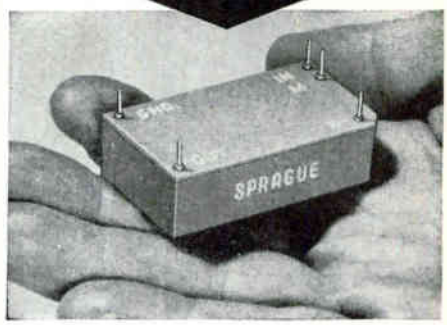
For prompt application engineering assistance, write Commercial Engineering Section, Transistor Division, Sprague Electric Company, Concord, N.H.

For complete engineering data sheets, write Technical Literature Section, Sprague Electric Company, 35 Marshall St., North Adams, Mass.

*trademark of Philco Corp.

CIRCLE 212 ON READER SERVICE CARD

Something NEW in counting techniques!



Sprague type 73Z1 core-transistor DECADE COUNTERS

Here is a simple yet versatile, low-cost yet reliable component for counter applications. Counting to speeds of 10 kc, the 73Z1 decade counter provides an output signal for every 10 input pulses, then resets in preparation for the next cycle. For higher counting, two or more counters may be cascaded. Typical characteristics are shown below.

CHARACTERISTIC	INPUT	OUTPUT
Amplitude	1.5 to 8 volts	6.5 volts
Pulse Width	1 μsec min.	35 μsec
Impedance	100 ohms	20 ohms

Utilizing two rectangular hysteresis loop magnetic cores and two junction transistors to perform the counting operation, the 73Z1 counter is encapsulated in epoxy resin for protection against adverse environmental conditions. It has five terminals −B+ (12v ±10%), input, output, ground, and manual reset.

The 73Z1 counter is available as a standard item. However, "customer engineered" designs can be supplied when other counting cycles, speeds, and package configurations are required for special applications.

For complete technical data or application assistance on the 73Z1 counter or other Sprague components, write to Special Products Division, Sprague Electric Co., 35 Marshall St., North Adams, Mass.

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THE MARK OF RELIABILITY

CIRCLE 31 ON READER SERVICE CARD

Digital Data Transmission System Using Building Block Techniques

DIGITAL COMMUNICATION system that can handle 16 different inputs simultaneously has been developed by Electronics division of ACF Industries, Inc. The technique for rapid synchronous transmission of asynchronous digital data over bandwidth limited media such as telephone lines uses modular equipment. Outputs from up to 16 different punch card, teleprinter, tape or other digital processing machines are combined and transmitted at 4,800 bits a second over a single channel to the receiver point.

Acronymed ABCD for ACF Building Block Communication Devices, the system includes a set of plug-in functional building blocks that are combined to implement any special data transmission requirement. Blocks measure 7 in. high, 16 in. deep and either 3½ or 7 in. wide. Each block is made up of interchangeable logic cards, and functional groups of blocks are mounted in a rack having a self-contained power supply. Additional blocks and new input/output equipment can be added.

Building blocks fall into three catagories: input/output multiplexers, modulator and demodulator devices, and auxiliary equipment including code converters and security controllers. Typical input device is an asynchronous-to-synchronous multiplexing system that converts all input data into one synchronous serial stream. An on-line security device can be inserted after the multiplexer to encode classified data.

Outputs from several digital data machines are transmitted over single channel by ACF Industries' ABCD processing system

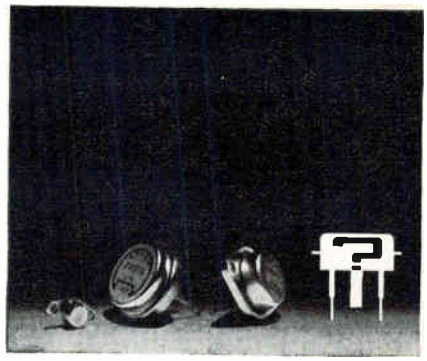
A proposed application for the system is intercomputer communication. Data from a remotely located computer could be transmitted to another computer over telephone lines.

Computer Charts Hurricane, Gives 24-Hour Warning

COMPUTER provides reliable 24-hour warning of hurricane path, somewhat less reliable 48-hour estimates, University of Chicago scientists recently told American Meteorological Society meeting at Miami Beach.

Calculations required to solve dynamic, rapidly changing hurricane problem would be all but impossible if tackled by hand, according to research associates Akira Kasahara and Prof. George W. Platzman. But programmed as subroutine, forecast of hurricane movement can be executed in course of predicting "steering flow" which determines trajectory of hurricane.

Treating 20-mile high atmosphere as two-dimensional sheet of air, for sake of simpler calculations, path prediction scheme subtracts vortex whirlpool equations from those describing storm's dynamic properties, leaving steering flow equation. Computer solves lifted-out equation for size of storm and its interaction with steering flow over forecast period to compute predicted path.



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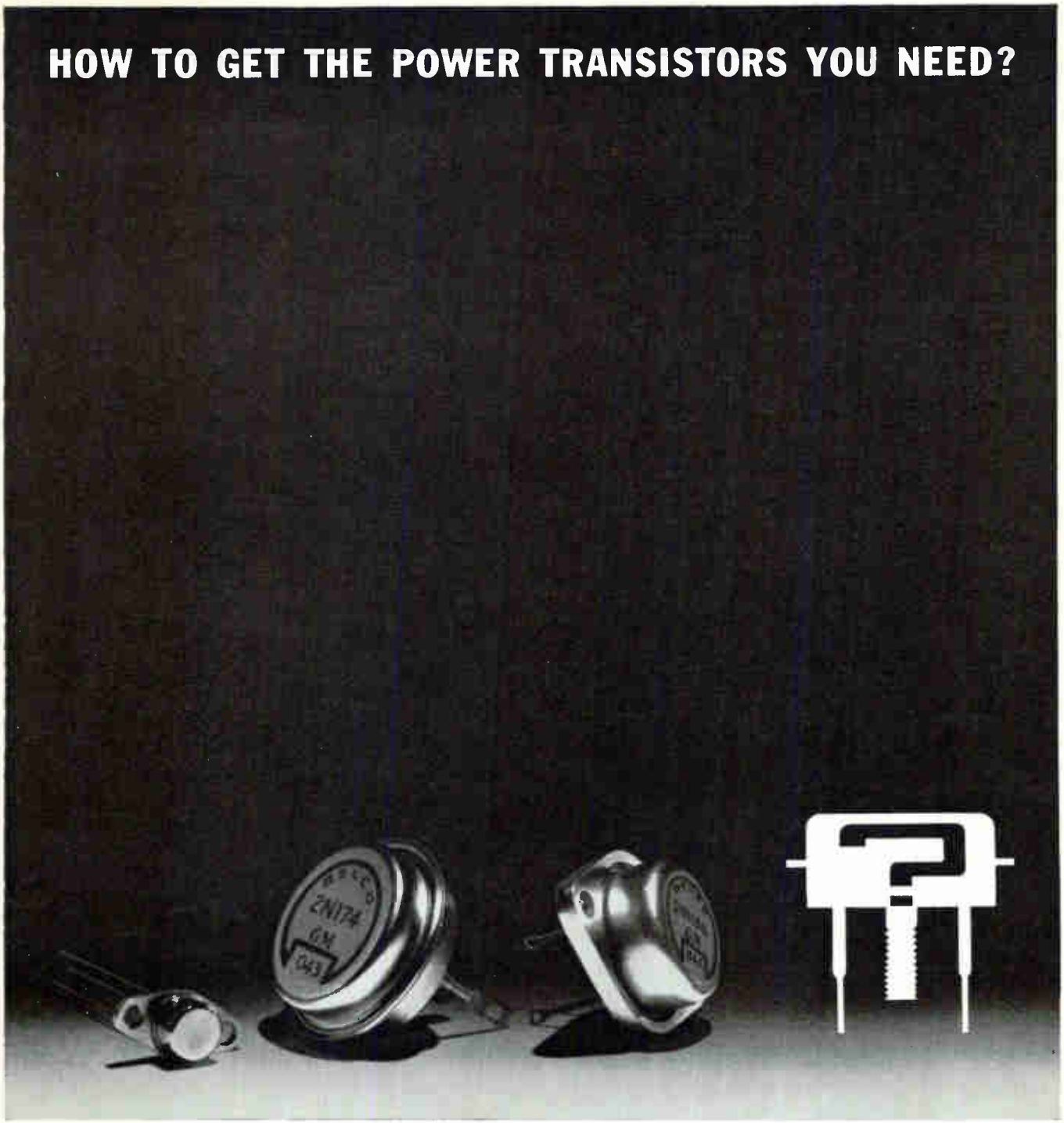
CIRCLE 32 ON READER SERVICE CARD

HOW TO GET THE POWER TRANSISTORS YOU NEED?



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We've made, by the millions, both large and small power transistors. Both diamond and round base. Both industrial and military types. And each in a wide variety of parameters that have proved themselves reliable in nearly every conceivable application.

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MEETINGS AHEAD

July 16-21: Conf. on Medical Electronics & Conf. on Elec. Tech. in Med. & Bio., IFME, JECMB, PGBME of IRE; Waldorf Astoria Hotel, New York City.

July 18-20: Western Plant Maintenance & Eng. Show; Pan Pacific Audit., Los Angeles.

July 20-21: Air Lines Comm. Admin. Council, AEEC, Saxony Hotel, Miami Beach, Fla. NOTE: This meeting was formerly scheduled for June 22-23.

July 24-26: Air Traffic Control Symposium, Electronic Maintenance Engineering Assoc. (EMEA); Mayflower Hotel, Washington, D. C.

Aug. 13-18: Magnetohydrodynamics Seminar, Penn State Univ., University Park, Pa.

Aug. 16-18: Electronic Circuit, Packaging Symposium; Univ. of Colorado, Boulder, Colo.

Aug. 22-25: WESCON, L. A. & S. F. Sections of IREM WEMA; Cow Palace, San Francisco.

Aug. 23-Sept. 2: National Radio & TV Exhibition, 1961 British Radio Show; Earls Court, London.

Aug. 23-25: Gas Dynamics Symposium, ARS, Northwestern Univ., Evanston, Ill.

Aug. 28-Sept. 1: Heat Transfer Conf., International; Univ. of Colorado, Boulder, Colorado.

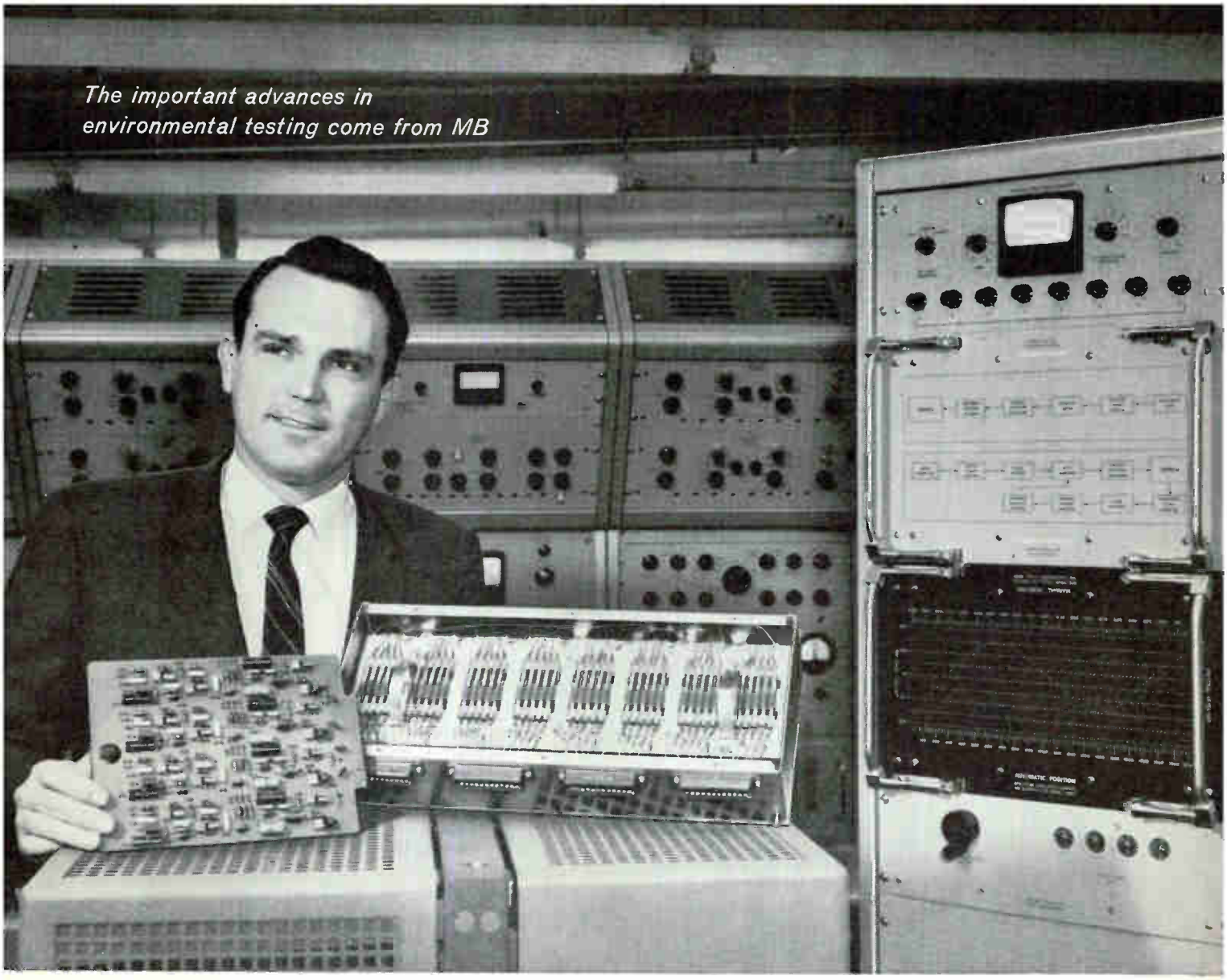
Aug. 30-Sept. 1: Semiconductor Conf., AIME; Ambassador Hotel, Los Angeles.

Sept. 4-9: Analog Computation, International Conf., International Assoc., for Analog Comp., and Yugoslav Nat. Comm. for ETAN, Belgrade, Yugoslavia.

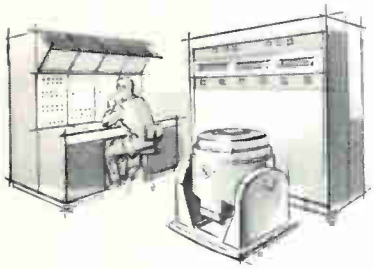
Sept. 11-15: Instrument-Automation Conf. and Exhibit, ISA; Sports Arena, Los Angeles.

Oct. 9-11: National Electronics Conf., IRE, AIEE, EIA; SMPTE; Amphitheatre, Chicago.

Nov. 14-16: Northeast Research & Engineering Meeting, NEREM; Commonwealth Armory and Somerset Hotel, Boston.



Production random vibration now practical with MB completely automatic spectrum equalizer



Heart of the MB automatic equalization system is the multi-channel transistorized amplifier which provides amplitude control. The plug-in printed circuit assembly shown above contains four of these channels. Frequency control is provided by the 80-channel filter assembly in the compact metal box.

MB's completely automatic spectrum equalizer simplifies test procedure and makes production random vibration testing practical. It effects tremendous savings in test time and money for missile and aircraft manufacturers. The reason: set-up time has been completely eliminated. Using solid state magnetostrictive filters with correct phase properties plus servo systems on each of eighty channels in the 15 to 2000 cps spectrum, vibration shaker systems can be completely equalized within 5 seconds.

Savings in time and labor over previous equalization methods can easily mean thousands of dollars per missile tested. Still another advantage is the greatly increased accuracy of accumulated test data. The spectrum is continuously monitored in narrow bandpass channels and compensation automatically made *during* test run.

Automatic spectrum equalization is another of MB's important and continuing contributions in the field of environmental testing.

MB ELECTRONICS

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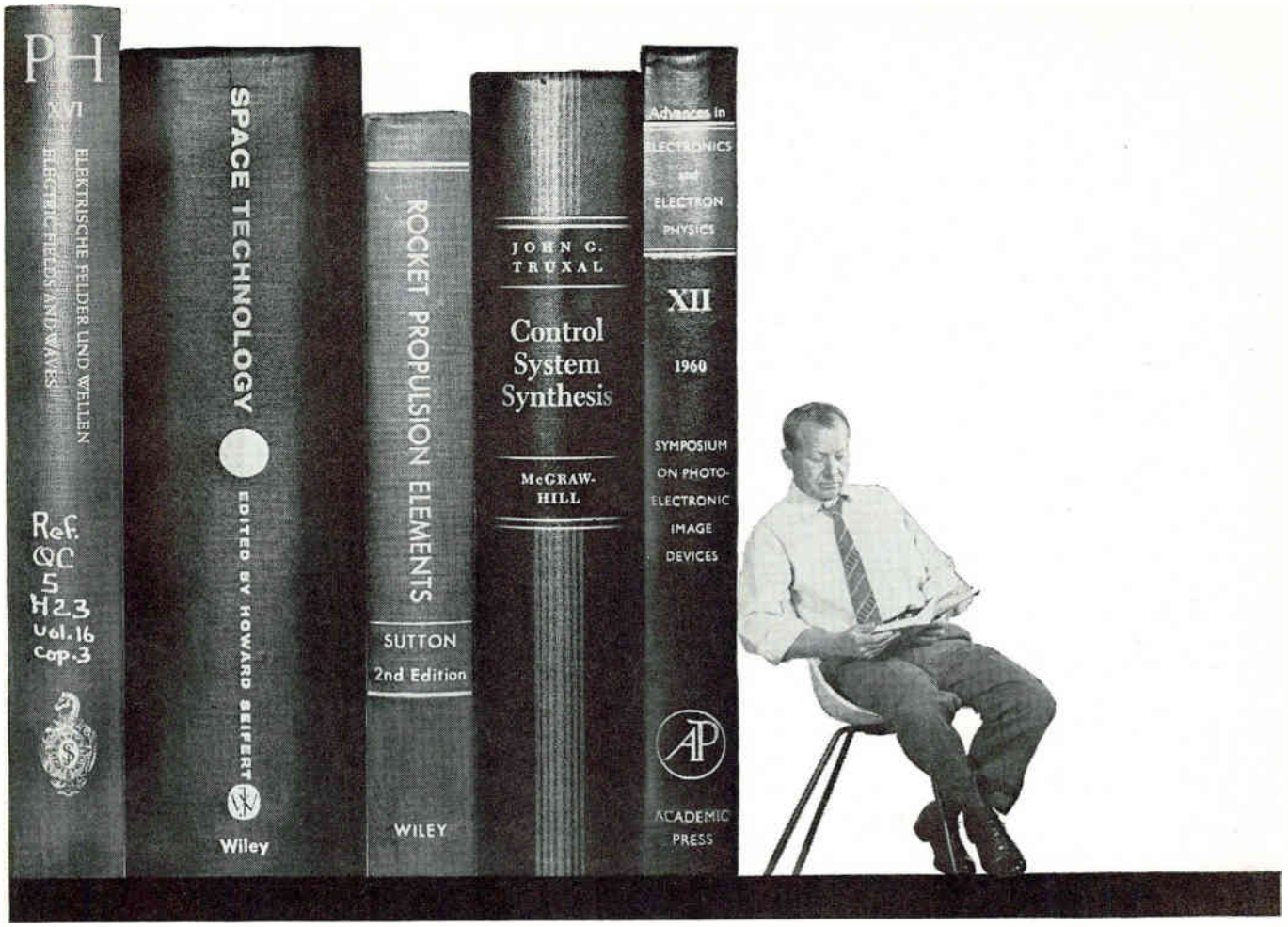

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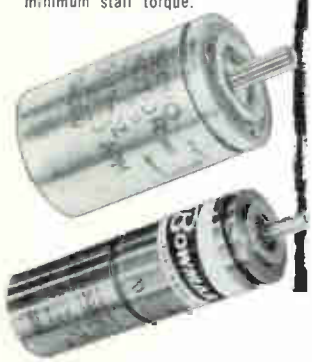
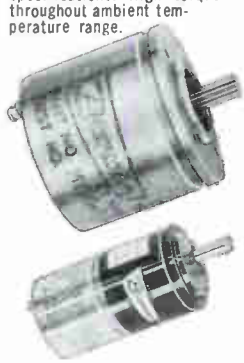


SIZE 10

Six types available—26 or 115 volt fixed phase—Split, center tapped or plain control phase for 26 or 36 volt operation. High compression glass molded terminals, extremely shock resistant, meet high altitude specifications. High torque throughout ambient temperature range.



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'PANCAKE' SIZE 11

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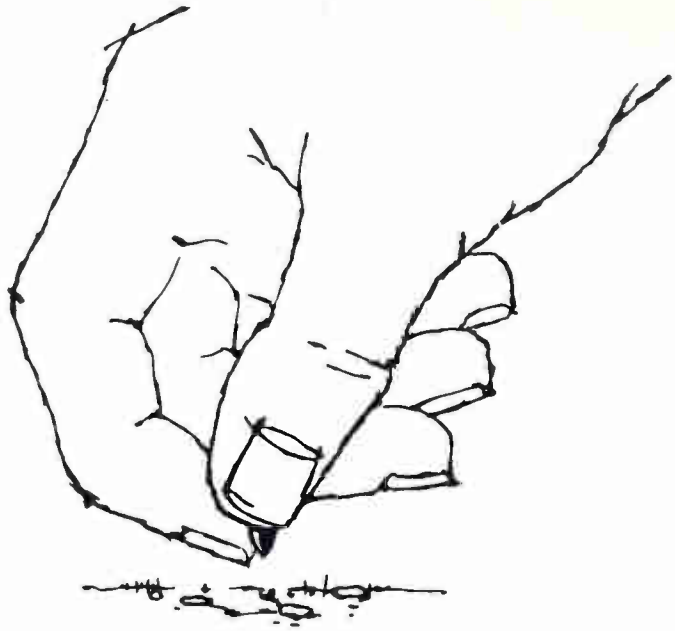

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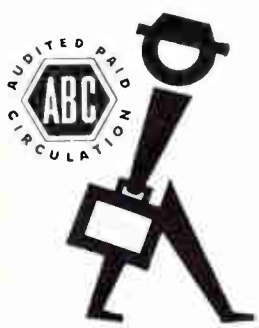

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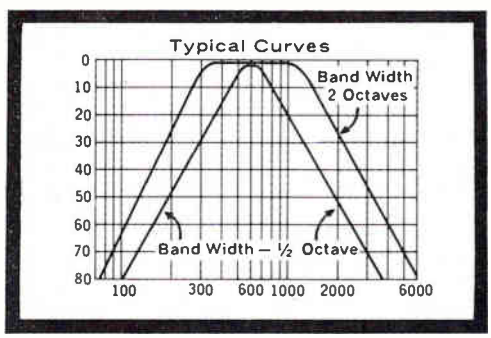

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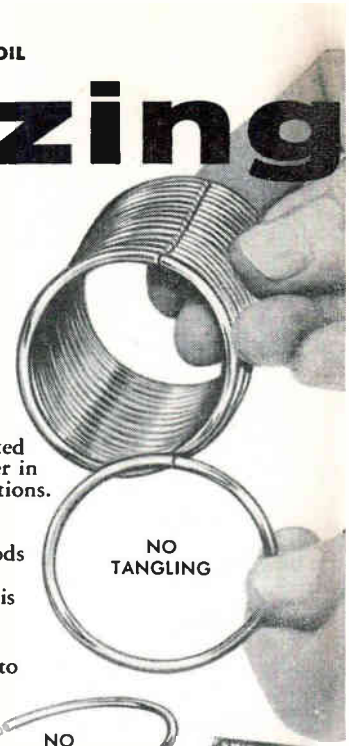

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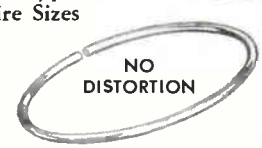

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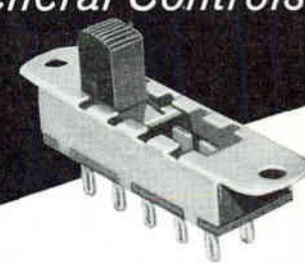

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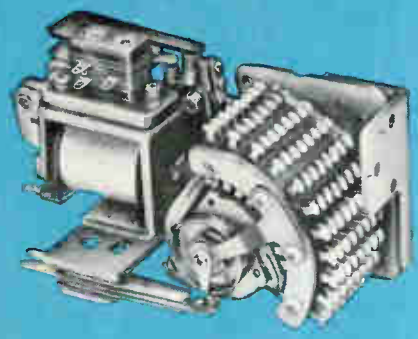
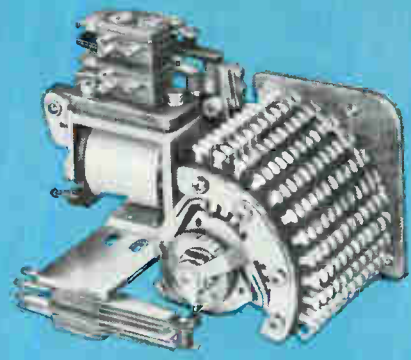


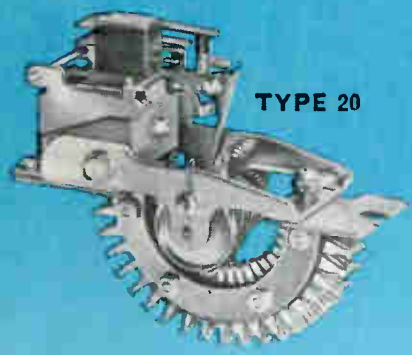
TYPE 210
Up to twelve 10-point levels
or four 30-point levels



TYPE 211
Up to twelve 11-point levels
or four 33-point levels

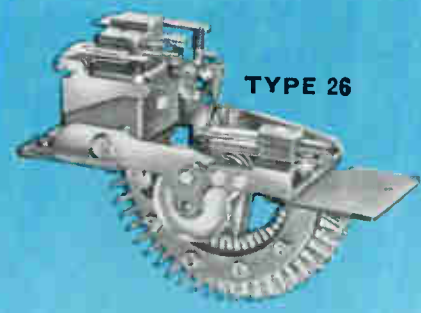
CAM-OPERATED

TYPE 200
Up to eight cams with 30, 32
or 36 tooth ratchets



TYPE 20

Up to sixteen 20-point levels
or twelve 40-point levels



TYPE 26

Up to sixteen 26-point levels
or twelve 52-point levels

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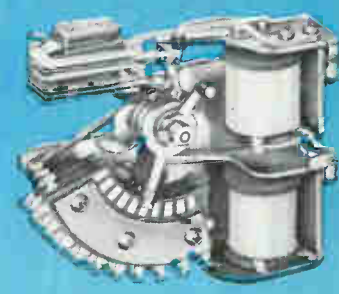

Up to three 10-point levels

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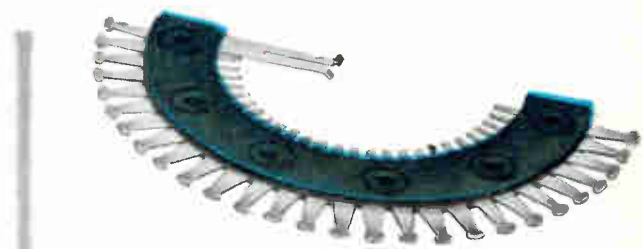
Designers who count on CLARE stepping switches as components for complex counting, totalizing and sequence-control equipment know that from the wide CLARE line they can select the exact switch their application requires. If necessary, CLARE engineering will provide special switch designs.

CLARE stepping switches are available as spring-driven, cam-operated or direct-drive switches with capacities from 10 to 52 points. All may be hermetically sealed in nitrogen or oil, or provided with dust covers.

All CLARE stepping switches are well known for their long life, high capacity and minimum maintenance through millions of precise stepping operations. For complete information write for Catalog 202.

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.



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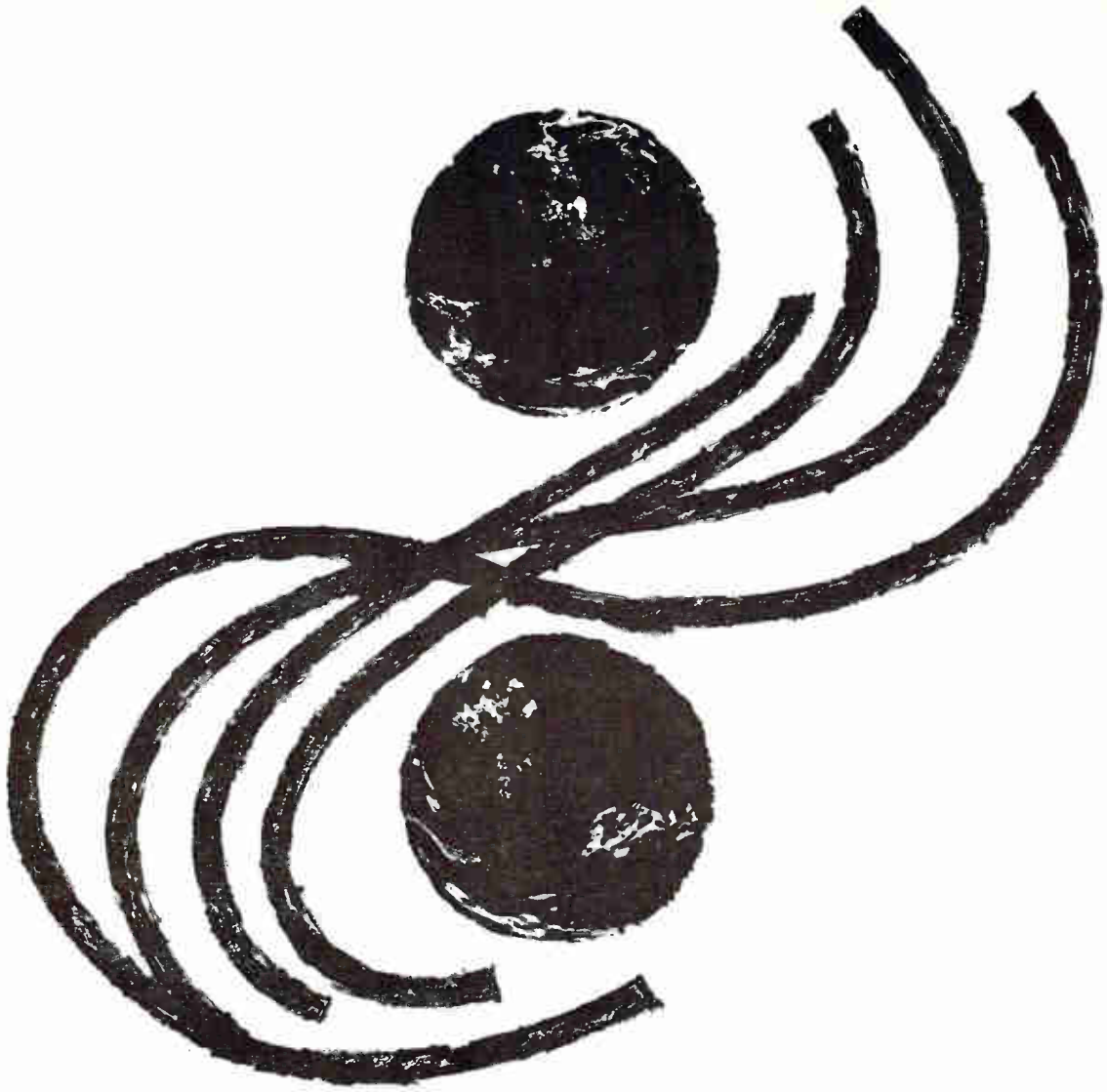
Relays and related control components

CIRCLE 41 ON READER SERVICE CARD



Said Johann Kepler: *"The planets move in elliptical orbits about the sun, and the square of their periods of revolution are proportional to the cube of their mean distances from the sun."*

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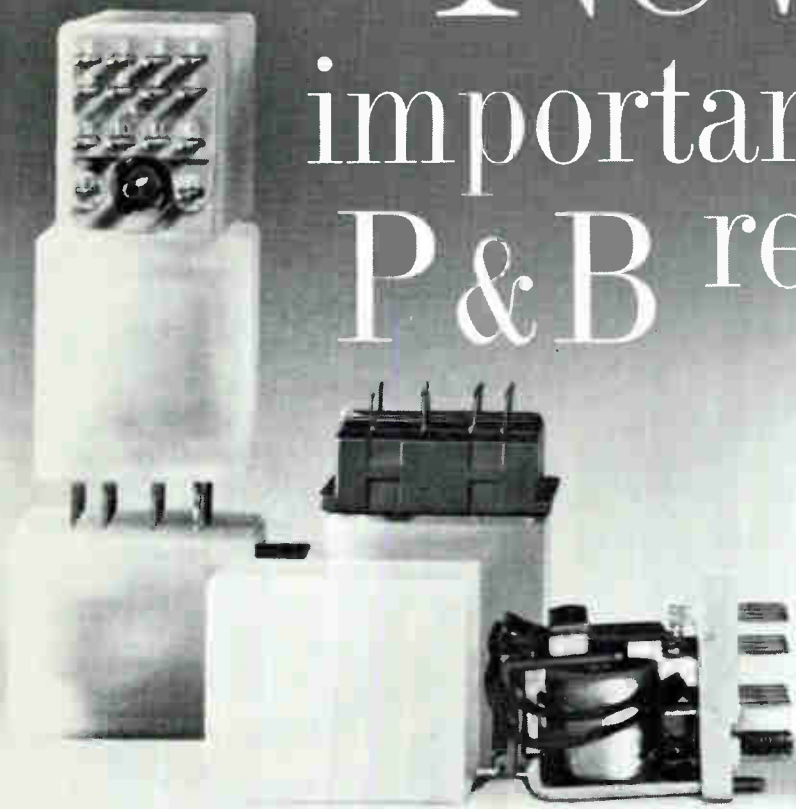

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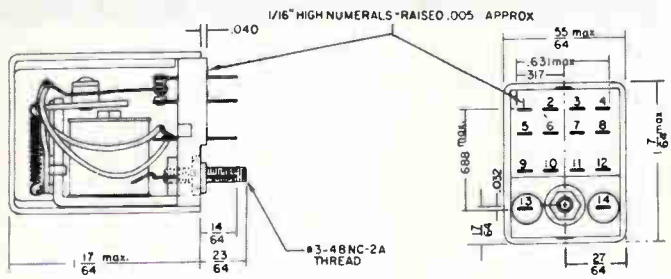

KHP SERIES SPECIFICATIONS

CONTACTS:
Arrangement: 4 Farm C, 2 Form Z.

Material: 3/32" dia. Silver standard. Silver cadmium axide and gald alloy available.

Rating: 3 amps @ 30 volts DC or 115 valts AC resistive for 100,000 aperotians.

COILS:
Resistance: 11,000 ahms max.

Temperature: Operating Ambient: —45°C. to +70°C.

Power: 0.5 watts min operate @ 25°C. 0.9 watts nam. @ 25°C. 2.0 watts max. @ 25°C.

TIMING VALUES:

Nominal Voltage @ 25°C.	Max. Values
Pull-in time	15 ms
Drap-out time	5 ms

INSULATION RESISTANCE: 1500 megohms min.

DIELECTRIC STRENGTH:
500 Volts RMS 60 cycles between contacts.
1000 Valts RMS 60 cycles between other elements.

MECH. LIFE: In excess of 100 million cycles.

SOCKET: Solder lug or printed circuit terminals. Available as accessory.

DUST COVER: Standard.

TERMINALS: Solder lug and taper tab.

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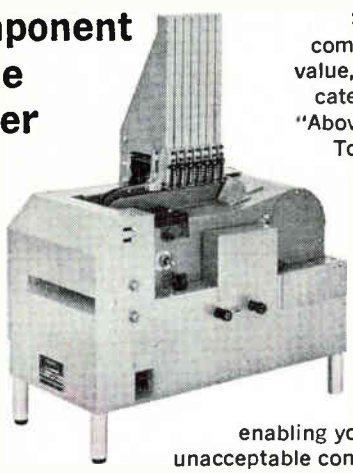
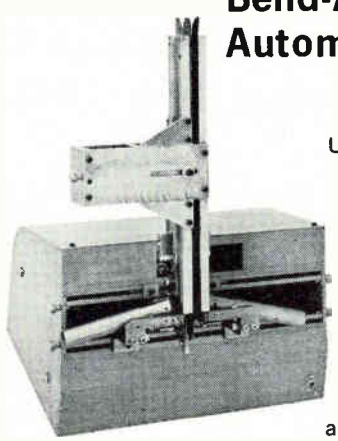


Swiftly tests axial-lead components for electronic value, sorts them into three categories: "Acceptable," "Above Tolerance," "Below Tolerance." Cuts waste, saves time, lowers production costs. Operates with most commercial go-no-go comparators, or with electronic intelligence for more complex sorting. Quickly pays for itself by enabling you to detect and reject unacceptable components immediately upon delivery. Use the Model "T" on the production line, or to select high-precision components from incoming standard lots while weeding out unacceptable units at the same time.

Bend-Amatic Model "U" Automatic Component Dispenser



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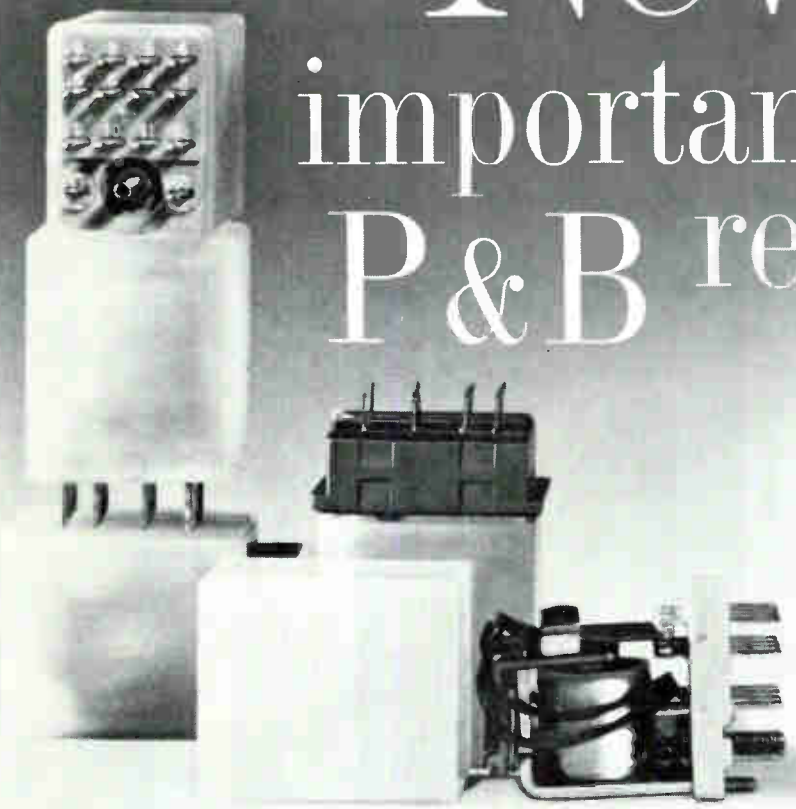

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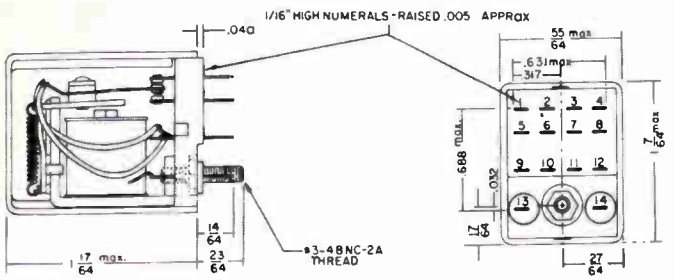

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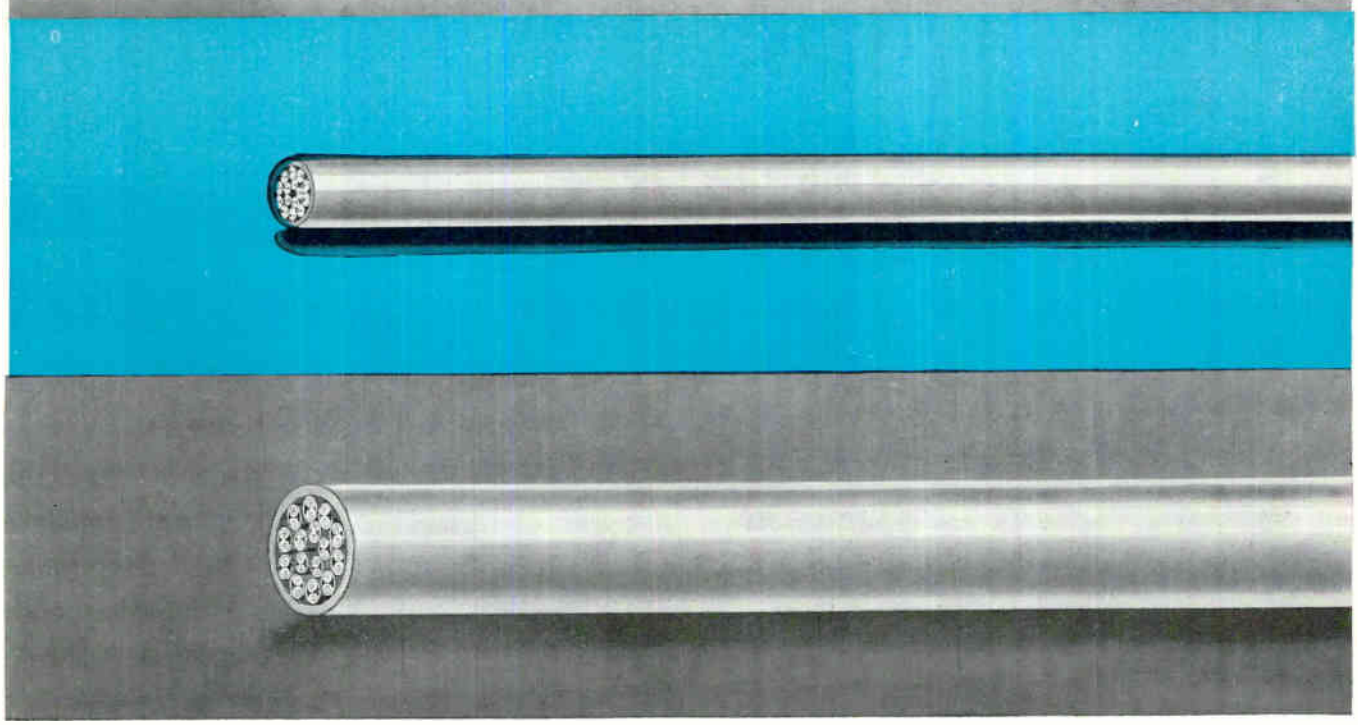

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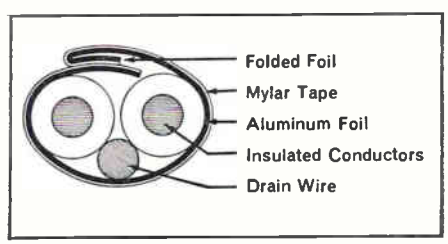

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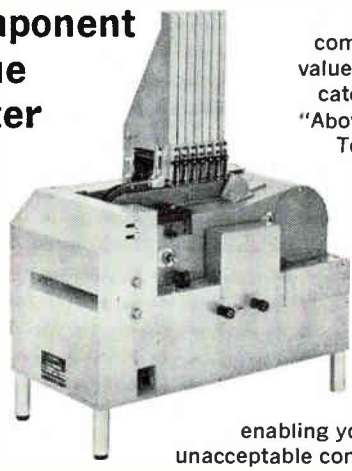

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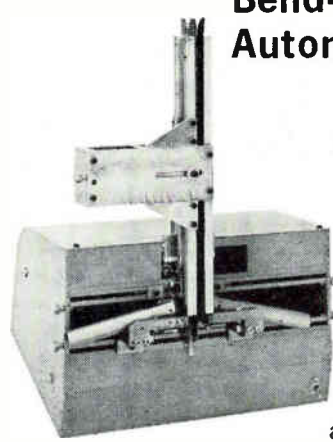

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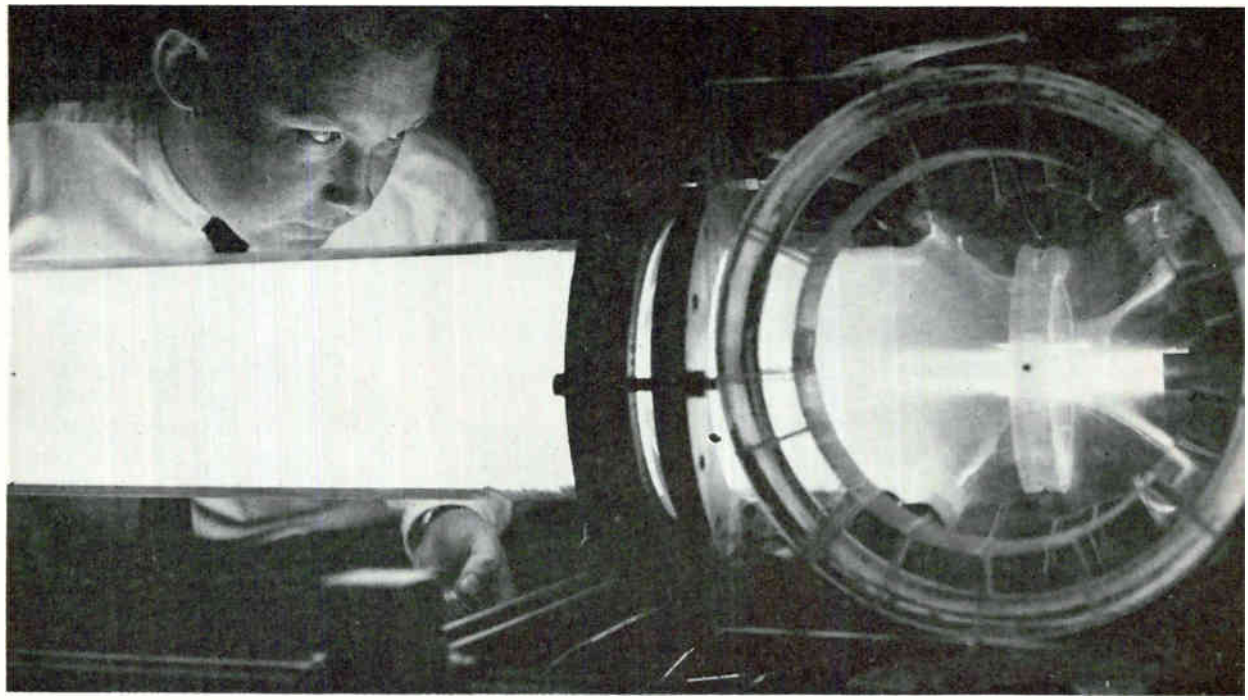


Rail gun (at right) fires plasma burst into vacuum of 10^{-6}mm of mercury for studies of plasma flow around space vehicles at Grumman Aireraft Engineering Corp. Electric-field plates at mouth of rail gun and Helmholtz coils measure plasma velocity

Plasma Engineering—Part I: Generating and Heating Plasma

By MICHAEL F. WOLFF
Assistant Editor

PLASMA COMPRISES more than 95 percent of the matter in the universe. Behavior of plasma can be visualized as that of an electrically conducting fluid; its interaction with magnetic fields has long been studied under the name magnetohydrodynamics (MHD) by astrophysicists concerned with the origin of stars. Here on earth, where lower temperatures have prevented the natural formation of plasma, plasma was of interest for about 20 years only as it occurred in gaseous discharges such as carbon arcs and fluorescent lamps.

Within the past decade, however, electronics engineers have found themselves drawn more into plasma work through the controlled thermonuclear fusion program, missile reentry studies and power conversion. Today, work in these areas is leading to applications of such direct interest to our industry as the use of plasma in circuit devices. Such applications will be described in a future article.

In present plasma research, whether it be aimed at fundamental studies of the plasma itself, or a particular application such as power conversion and propulsion, considerable effort is devoted to generating and heating the plasma. There are numerous methods for supplying the energy to electrons in a gas that will produce the ionization required to form a plasma. These techniques are both electromagnetic and nonelectromagnetic. The former include using a-c discharges, electromagnetic shock tubes and electron beams, as well as techniques such as d-c discharges that are primarily electrical. Nonelectromagnetic techniques include use of diaphragm shock tubes and contact ionization of cesium vapor.

Alternating-current discharges used in producing plasma include microwave and lower frequency dis-

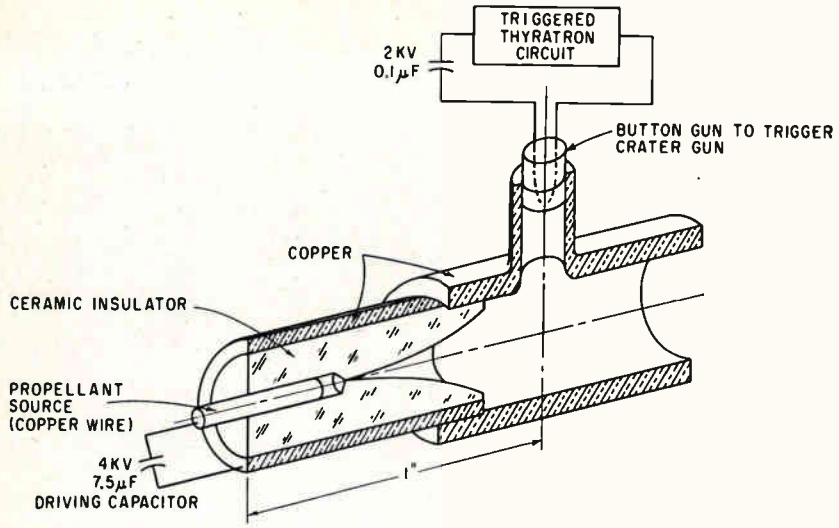


FIG. 1—Crater gun at Stevens Institute of Technology delivers to plasma it produces up to 20 percent of energy stored in driving capacitor

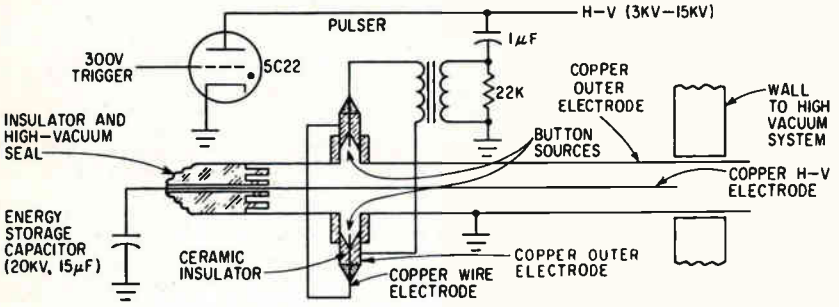


FIG. 2—Coaxial rail gun shown in photo on p 47 is triggered by series-connected button guns and generates high-velocity copper plasma

charges. The latter generally range from around 0.1 to 10 Mc and are employed for what is termed r-f preionization. Here the gas, which may be initially exposed to ultraviolet or x-radiation to get a trace of ionization, is subjected to peak power in the kilowatt range, producing a few-percent ionization. In Princeton's B-3 Stellarator[1], for example, a 250-Kc generator applies 200 v for 1 msec to achieve 7 to 8 percent ionization in hydrogen or helium.

One method of inducing an r-f discharge is to use the gas as the secondary of a transformer. This is done, for example, in a technique developed at Air Force Cambridge Research Labs for injecting plasma into a betatron.[2] Here 25 Kw of pulsed r-f power is applied to a single-turn coil surrounding a toroidal discharge vessel. Power source is a pulsed r-f amplifier fed by an oscillator and direct-coupled to a tuned circuit consisting of the inducing coil in parallel with a tuning capacitor. Plate and screen voltages for the four parallel tetrodes in the amplifier are supplied by capacitor discharges lasting about 10 msec. Plasmas have been produced in various gases at pressures down to 8×10^{-7} mm of mercury.

Another method is to use the gas as the dielectric of a capacitor by connecting an r-f oscillator to electrodes across the tube containing the gas. In both methods, however, ionization occurs because the oscillatory motion of the electrons is transferred to random motion upon collision with the gas atoms, the container or the electrodes.

Microwave cavity technique is common for producing steady-state plasmas. The cavity is filled with gas and a discharge occurs when the frequency of the microwave field is adjusted to equal the resonant frequency of the cavity. This technique is useful at high pressures, defined as pressures where the collision frequency is of the order of the microwave frequency or higher. Typically, for 3 Gc with hydrogen or helium this might be in the range of fractions to tens of mm of mercury.

At low pressures (on the order of microns of mercury) steady-state plasmas with densities of 10^{11} to 10^{12} particles per cu cm can be produced by cyclotron resonance heating in crossed microwave electric and static magnetic fields. As carried out at MIT and Bell Labs, a gas-filled quartz cylinder is placed coaxially in a microwave cavity which, in turn, is held between the poles of an electromagnet.[3] Cavity is driven from a 50-watt, variable-frequency, S-band magnetron in the TE_{111} mode. Tube diameter is made small compared to the cavity diameter so the electric field of the TE_{111} mode is uniform to better than 1 percent over the tube cross-section.

The microwave frequency is tuned to the resonant frequency of the cavity (ω) and the magnetic field adjusted until the electron cyclotron frequency (eB/m) equals ω. Input power is then increased until breakdown occurs.

Alternating and direct-current discharges are often used in devices called plasma guns and plasma jets. A plasma gun accelerates the plasma it creates to velocities exceeding 10^7 cm per sec through use of nonuniform or time-varying magnetic fields. The term gun is usually reserved for pulse-type devices, producing transient plasmas; the term jet implies a device for producing a continuous stream of plasma. Ionization in plasma produced by guns is probably between 50 and 90 percent, with typical thermal temperatures ranging from 20,000 to 100,000 deg K.

Accelerating force in plasma guns is the $j \times B$ Lorentz force (where j is the density of the current in the plasma and B the flux density of the magnetic field induced by these currents) as well as thermal pressure. Direction of force, and hence of the accelerated plasma, is controlled by varying the magnetic field configuration.

One of the earliest guns developed is the so-called button gun. This gun produces plasma by a high-current (1,000 to 10,000 amps), pulsed (0.1 to 0.5 μsec) discharge in vacuum between the ends of two deuterium-soaked titanium wires embedded in a resin button. (Other materials are used when it

is not required that deuterium be accelerated.) Plasma formed by vaporizing and ionizing the wire electrodes comes off in an expanding torus that is shaped and accelerated by its own magnetic field. The resulting plasma—magnetic entity is referred to as a plasmoid and has the ability to cross an externally-applied d-c magnetic field.[4]

Deuterium-soaked titanium washers have been stacked with alternately-spaced insulators in a cylindrical configuration termed the stack or washer gun. One such gun developed at Lawrence Radiation Lab has a trigger electrode in the washer hole at one end of the stack. The end washers and the trigger electrode are connected; a discharge between the trigger electrode and the first washer is initiated from a thyratron-controlled pulse transformer and generates plasma within the hole so that the main discharge will pass through the center of the stack. Current of 15,000 amp with a 24-μsec period is supplied from a 7.5-μf capacitor charged to 10 Kv and connected through an ignitron to the end washers.[5]

The original concept of the button gun has led to such devices as the crater gun, shown in Fig. 1, and the rail gun.[6] The rail gun is derived from the button gun by drawing the wires out approximately one meter beyond the point where they are shorted. Result is that the plasma is formed within the gun and continues drawing current as it travels down the rails to the exit. These guns are often referred to as motors because the magnetic fields interacting with the currents in the plasma are produced by these currents, thus yielding, in effect, series motors.

A modification of the rail gun in which the wires are replaced by a coaxial electrode arrangement is known as the coaxial rail gun, an example of which is shown in Fig. 2. The button guns used to trigger the rail gun in Fig. 2 are similar to crater guns. Each button gun has a film of graphite on the ceramic separating the inner and outer electrodes. This slightly conductive path breaks down when it receives a voltage pulse, thereby vaporizing the copper. Resulting plasma burst shorts the main capacitor, vaporizing the inner rail gun electrode.

A common way of initiating the discharge in these guns is with the plasma formed by shorting a capacitor bank with a fine wire. Another way is to admit the gas from which the plasma is to be formed by a fast-acting valve as in the hydromagnetic gun used at Los Alamos Scientific Lab.[7]

Power supply for the hydromagnetic gun is a 45-μf capacitor bank connected to the gun through ignitrons whose breakdown limits bank voltage to less than 15 Kv. The ignitrons are triggered with time delay of a few hundred μsec after the valve is opened to allow the gas to spread throughout the gun barrel before applying voltage. Discharge current is a damped oscillation of roughly 14-μsec period and 200,000 amp peak. Guns have also been built to produce 2 to 5-μsec bursts of energetic deuterium plasma using a 1.7-μf bank at 20 Kv.[8]

An axially symmetric but noncylindrical discharge tube is used at Lockheed Missiles and Space Div to study plasma acceleration.[9] Device has a flat, solid electrode and an open ring electrode. Gas is admitted at the flat electrode end; a capacitor discharge through the tube produces a current pinch at the solid electrode end which, with the aid of Joule heating, forces plasma through the ring electrode.

Although electrode plasma guns are simple in concept, electrode erosion introduces impurities into the plasma and shortens gun lifetime. For this reason, much attention has been devoted to electrodeless guns. (See the front cover.) Operating principle of these devices is analogous to that of the induction motor. A puff of gas is admitted at one end of a cylindrical glass tube and made conducting by preionization. A rapidly increasing magnetic field is then created by exciting coils coaxial with the tube. This time-varying magnetic field induces currents in the ionized gas that result in a repulsive force to accelerate the plasma.

The pulsed accelerator under study at Litton Systems is an example of one arrangement for energizing the coils in this type of gun. Eighteen coils are sequentially excited by discharging 30-Kv capacitors through a 5-ohm transmission line and 3-element spark gap. Result is a traveling magnetic field that accelerates the plasma toroid formed at the first few coils. Before reaching the first coil, gas is preionized by a d-c glow discharge.

Another approach to an electrodeless gun is used in the CHALICE program at Stevens Institute of

DEFINING PLASMA

Plasma comes from the Greek for mold or matrix. The word was used by Tonks and Langmuir in the 1920's to describe oscillations in ionized gases and identify the nearly neutral region in an arc discharge.

At present, the term plasma defines any mixture of particles, some of which are charged, whose spatial dimension exceeds the Debye length and where the percentage of the mixture that is ionized contains an approximately equal number of positive and negative particles so that the overall aggregate is electrically neutral.

Debye length (also called Debye shielding distance) is a measure of the distance at which a given negative particle is shielded by the surrounding positive particles. In cgs units, the Debye length is given by $(kT/4\Pi ne^2)^{\frac{1}{2}}$ *where* k *is Boltzmann's constant,* T *is kinetic temperature,* n *is electron density and* e *is the charge on an electron.*

From the above definition it can be seen that plasma need not be restricted to gases; in fact, there can be two kinds of plasma in solids. The first type is where there are either electrons and positively charged donors, or holes and negatively charged acceptors. A second type of plasma occurs in an intrinsic semiconductor where there are only holes and electrons.

Generally, however, plasma describes a gas which in addition to meeting the criteria given above is in such a state of ionization that it becomes conductive enough to be affected by magnetic fields. At temperatures above 20,000 K ionization is 100 percent for most gases and there are no neutral particles—only positive ions and negative electrons. This completely ionized or "true" plasma is considered a fourth state of matter and is what is most frequently meant by the term plasma

Technology.[10] Gun consists basically of a single-turn coil wound about a cylinder containing deuterium at room temperature and 0.1 mm of mercury pressure. The gas is subjected to a high-frequency oscillating electric field created by an underdamped (ringing) capacitor discharge through the coil. Discharge of the 1-μf, 6-Kv capacitor is triggered by a plasma switch fired from a thyratron pulser. This step yields a plasma temperature on the order of 10,000 K.

Next, a 50,000-joule, 50-Kv bank with a ringing period of 2 μsec is discharged through the coil. Electric field induced in the plasma by the rapidly increasing current produces azimuthal currents in the plasma that give rise to an axial magnetic field between the coil and the plasma current sheath. Result is to drive the plasma toward the central axis so rapidly that it is first shock-heated and then compressed adiabatically, forming a hot thread along the axis.

The coil is shaped so the axial magnetic field strength is strongest at the coil edges, thus providing a magnetic mirror configuration. However, one mirror is made more resistive than the other so the magnetic field is opened and the plasma accelerates out of the gun.

To obtain high-speed plasmas, it is necessary to minimize inductance so as to get a fast-rising magnetic field. For example, spark gaps and insulators being developed for the electrodeless gun at the Institute of Physics in Uppsala, Sweden are expected to increase discharge current to 750,000 amp and reduce rise time to 0.28 μsec with a 4.4-μf, 30-Kv capacitor bank. Thus, total inductance of the bank and spark gap will be 7×10^{-9} henries[11]. In this gun, the pulsed capacitor discharge excites a flat, single-turn primary coil behind a thin porcelain disk that is one end of a cylindrical discharge tube. A solenoid surrounding the tube gives a longitudinal field up to 5,000 gauss.[12]

Propagation of high-velocity shock waves down the constant-area channel of a shock tube is another method of producing hot, highly-ionized plasma. Method is also advantageous in that the properties of the plasma formed behind the shock front are uniform and readily determinable.

One method of producing such shocks is with the bursting diaphragm type of tube. Here a low and high-pressure volume are separated by a thin diaphragm which, when punctured, allows a compression wave to move from the high to the low-pressure region and steepen into a planar shock front.[13]

Chemically driven diaphragm shock tubes yield Mach numbers up to around 20; for Mach numbers on the order of a few hundred there are various electrically driven gas discharge shock tubes such as the T-tube. The T-tube consists essentially of a pair of electrodes in the arms of a glass T filled with gas. A capacitor bank is discharged across the electrodes, causing an increase in gas pressure and formation of a shock wave. Return lead of the circuit is oriented so that the magnetic field associated with the current surge is perpendicular to the current path, resulting in acceleration up the expansion leg.[14]

In the T-tube the plasma driving force rapidly diminishes with increasing distance from the localized magnetic fields of the accelerator. One solution is to add a time-rising axial magnetic field along the expansion leg; another is to use different geometries.

An electrically driven conical shock tube used at Space Technology Labs consists of a tapered glass tube with a solid nickel electrode at the small end and a large ring electrode at the other.[15] Deuterium is fed through a port in the ring electrode and a discharge is produced by transferring the energy from a 6.2-μf, 24-Kv capacitor bank through a triggered spark gap.

Another type of shock tube, which is actually similar to the hydromagnetic plasma gun, is the magnetic annular shock tube.[16] Here the gas is confined in the annular region between two concentric cylinders whose radii are large compared to their annular spacing. Radial currents created by discharging a capacitor bank across two cylindrical tungsten electrodes give rise to an azimuthal magnetic field of 10,000 to 20,000 gauss that is the driving force for high-velocity shock waves.

Two types of bias field have been used ahead of the shock front to provide uniform gas breakdown at the electrodes and containment during acceleration. In one, a solenoid around the tube provides an axial magnetic field and the gas is preionized by a 10-amp, 1-Mc discharge. The second is an azimuthal magnetic field obtained by discharging a capacitor bank through a conductor at the axis of the tube combined with the axial field produced by two solenoids, one of which is inside the annular region and the other outside. Preionization in this case is with an electrodeless discharge in the vicinity of the electrodes.

Shock velocities above 5×10^7 cm per sec have been produced when using a sufficiently strong azimuthal bias field that the cyclotron radius of the ions in the shock is small compared with the size of the channel.

Direct-current discharges involving the generation of plasma include sparks, glows and arcs. In a spark discharge, ionization is usually dense along a narrow path; arcs and glows produce considerable volumes of plasma. A glow discharge (see Fig. 3A)[17, 18] is characterized by a potential drop across the discharge of the order of several hundred volts and current of a few milliamperes. Current in an arc discharge is in the 1 to 1,000-amp range while voltages are lower than in the glow discharge (usually about 30 to 90 v).

The electric arc discharge[17-19] has found considerable use as the energizing source in devices called plasma jet generators, or simply plasma jets. They are so named because they produce a sustained, continuous plasma flow compared to the plasma bursts of microsecond and millisecond duration produced by guns and shock tubes.

Fundamentally, an arc discharge consists of three regions: the arc column and the cathode and anode fall spaces. The fall spaces extend only a few tenths of a millimeter from the electrode surfaces and are regions of high potential gradient and energy density as compared with the arc column itself. (See Fig. 3B.[20]) In a normal arc discharge the anode voltage is approximately equal to the ionization potential of the gas.

In the ordinary low-intensity open arc used to treat materials, some 80 percent of the input energy

is dissipated in the arc column, leaving as radiant energy. Column temperature is around 5,000 K. To obtain greater energy concentration and temperature requires increasing current density until the arc is converted to one where the current density dissipated on the electrode surface is greater than can be removed by radiation and conduction alone. When this occurs a plasma jet issues from the arc region.[21, 22]

One way to obtain such an increase in current density is to confine all or part of the arc column in a chamber or nozzle into which relatively cold fluid flows under pressure. Cooling the periphery of the column lowers thermal ionization and, therefore, the conductivity. This action constricts the conduction path and crowds the arc current closer to the center of the plasma, thereby increasing current density and, hence, temperature.

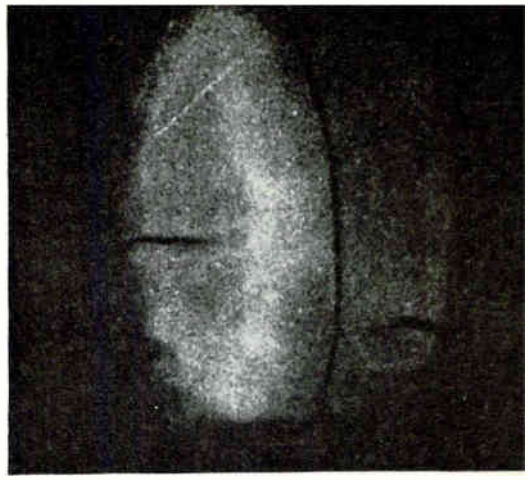
Essentially, most fluid-stabilized plasma jet generators have a chamber closed at one end by a solid electrode; at the other end there is a pierced-plate electrode through which the jet issues. The arc may be struck by touching the electrodes, connecting with a wire, or by r-f pulsing. The fluid (water or gas) can be introduced axially or tangentially. The latter produces a vortex along the axis of the discharge and is termed a vortex-flow stabilized or Gerdien arc. For additional arc constriction, the chamber or nozzle may be surrounded with a solenoid.

Some arc generators are constructed so that the diffusion of heat from the plasma column sets up a gradient that confines the column. These are known as wall-stabilized arcs. While operation can be smooth, increased heat load generally lowers efficiency.

An example of a magnetically confined arc is provided by the hollow-cathode arc used at MIT.[23] An outgrowth of research related to the DCX controlled thermonuclear fusion program, the hollow-cathode arc operates with a refractory metal cathode through which a continuous flow of argon is maintained. Magnetic induction of a few hundred gauss confines the arc to a column that has approximately the same diameter as the cathode and extends from the cathode to the anode.

Total power input is of the order of 1 to 2 Kw; plasma with a density in the range 10^{13} to 10^{14} electrons per cu cm and approximately 50 percent ionized is produced in a vacuum. Cathode sputtering is negligible and the arc has been run continuously for 8 to 10 hours with a tantalum cathode.

Under study also are annular-type jets where the arc strikes radially from an inner to an outer electrode and is rapidly rotated with a magnetic field. Avco's magnetic annular arc generator falls into this category.[24]



Kerr cell photo of electrodeless plasma accelerator at Institute of Physics, Uppsala, Sweden, shows plasma ring traveling from right to left at 5 × 10^6 cm/sec. Exposure time is 10^{-7} sec

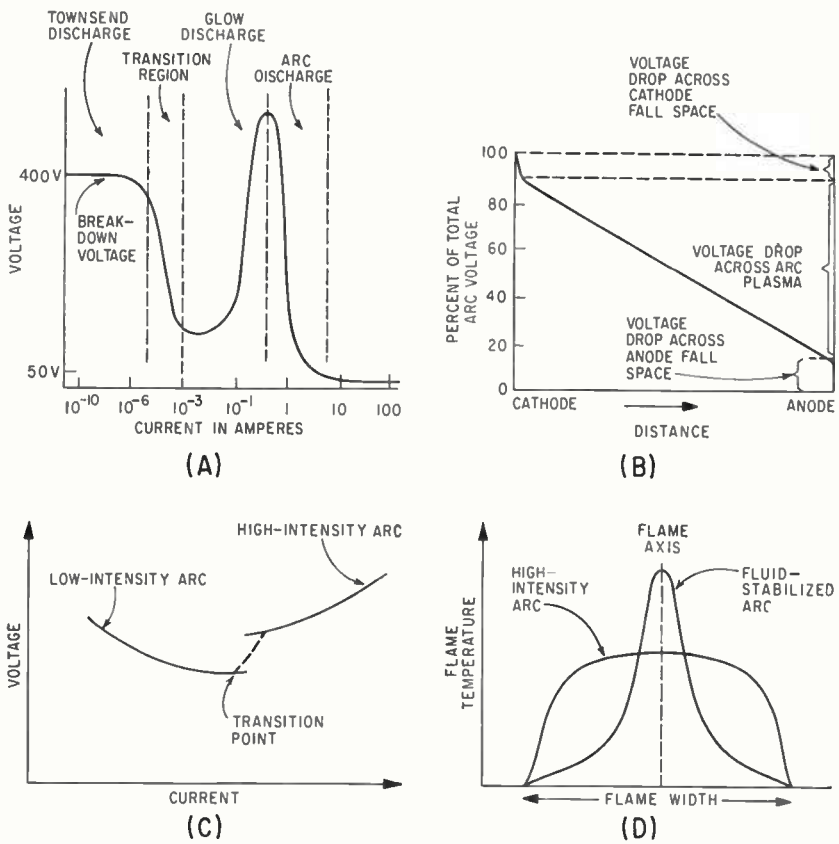


FIG. 3—Self-sustaining gaseous discharges have characteristics as in (A). Voltage distribution in low-intensity arc is shown in (B); arc has negative characteristic compared with positive characteristic for high-intensity arc such as used at Vitro Labs (C). Radial temperature distribution of high-intensity arc is compared with that of fluid-stabilized arc in (D)

A second method of operating a stable arc at higher power and temperature than for a low-intensity arc is to increase the current density at the anode face of a low-intensity arc of the proper configuration until the energy input to the anode surface is great enough to vaporize the electrode material. When this occurs, a jet of electrode plasma issues from the surface. (Confined arcs generally have nonconsumable electrodes so that the plasma is derived from the gas or liquid injected into the arc chamber.)

From Fig. 3C it can be seen that the current—voltage characteristic in this so-called high-intensity arc reverses from the customary negative to positive.[20] The anode fall space dissipates 60 to 70 percent of

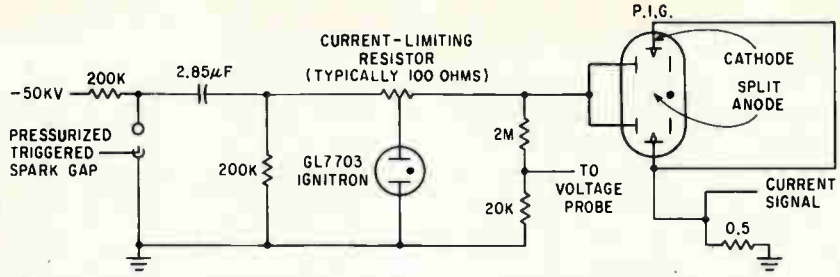


FIG. 4—Split-anode Philips ionization gage discharge tube used at General Electric Research Lab receives positive potential at peak of externally applied magnetic field by closing of triggered spark gap. Ignitron shorts current through discharge about 100 μsec after discharge begins

the total arc power. Because of this efficient transfer of energy to the anode, vaporization occurs rapidly enough for energy to be carried away at the rate required for stable operation. Thus, the arc is considered self-stabilized.

Visible tail flame of the high-intensity arc has a volume several times that of the jet from a fluid-stabilized arc at equivalent power levels (see Fig. 3D).[25] This makes the high-intensity arc useful for such applications as re-entry simulation while the steeper temperature gradient makes the fluid-stabilized arc useful for such applications as cutting materials.

Although anode energy density in the high-intensity arc can exceed 100 Kw per cu cm, electrode erosion and limitation of plasma composition to the vaporized anode material limits the practicability of the solid-anode, high-intensity arc. For this reason, researchers at Vitro Labs have developed a fluid-transpiration arc.[26] This arc uses a porous anode through which liquids or gases can be injected to form a plasma. Vaporization of the anode is not required to maintain the arc in the high-intensity mode and the outflowing gas from the anode cools the surface to a temperature low enough to prevent erosion. Using argon and porous graphite electrodes, more than 75 percent of the 50-Kw arc input power is delivered to the gas; electrode erosion rates of 10^{-5} gm per sec have been observed.

Somewhat similar to the d-c arc plasma is the induction plasma generated in MIT Lincoln Labs' electrodeless plasma torch.[27] Plasma is generated at atmospheric pressure by using inductive coupling at 4 Mc. The torch uses vortex stabilization and produces a plasma whose peak temperature ranges from 14,000 K to 19,000 K. Total energy transferred to the plasma ranges from 52 to 57 percent of the input power.

For large-scale facilities where electrode power in the megawatt range is required, a-c arcs are being used. GE's Missile and Space Vehicle Dept. has developed a three-phase, 2.5-Mw air arc that can be operated with either carbon or copper electrodes. With carbon electrodes maximum power input is 14.5 Mw and approximately 2.5 Mw is added to the test gas. With water-cooled copper electrodes, approximately 1.5 Mw of air power at electrode contamination levels of less than 1 percent is produced. Maximum power input is 5 Mw.

Westinghouse has developed a magnetically confined diffuse arc for d-c or single-phase a-c operation. Arc is drawn across the gap between two 12-inch-diameter toroidal electrodes and then rotated around the gap at high speed by a d-c magnetic field. Approximately 55 percent of inputs up to 15 Mw is transferred to the plasma whose temperature ranges up to about 12,000 K. Three-phase arc now under investigation would use four electrodes, possibly run at 50 Mw.

A frequently used method for continuously producing plasma makes use of the Penning-type discharge (also called a Philips ionization gage or P.I.G. discharge). Basically, the device consists of two grounded cylindrical cathodes on a common axis with a cylindrical anode between them that is positive with respect to ground. An axial magnetic field produced by an external solenoid forces the emitted electrons to oscillate between the cathodes and restrains them from collecting on the anode. Interaction of the trapped electrons with a low-pressure gas results in the formation of a plasma.

Electrostatic potential gradients that exist in a P.I.G. discharge over dimensions large compared to the Debye length can be utilized to eject the positive ions in a directed beam that is neutralized by escaping electrons.[28]

Split-anode P.I.G discharge tubes have been constructed at General Electric Research Lab for producing a highly ionized, clean

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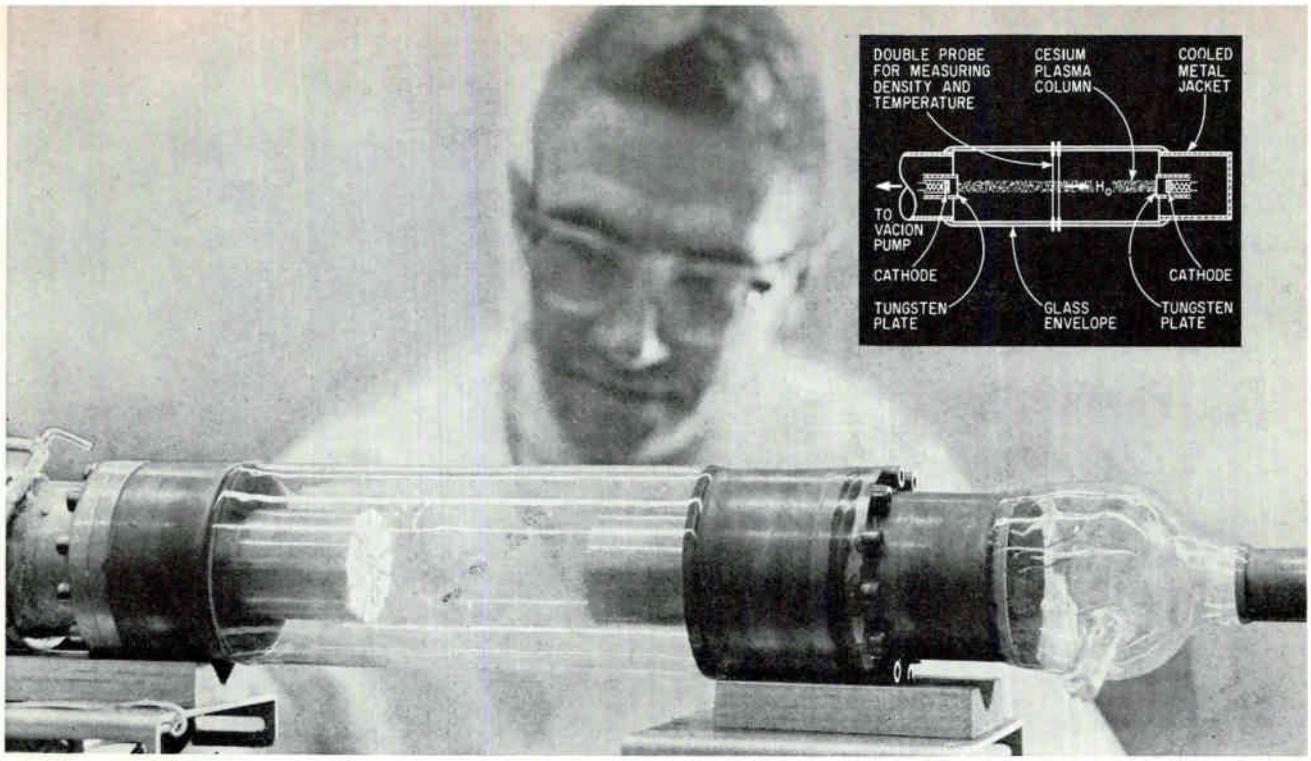

FIG. 5—Cesium plasma generator used at Hughes Research Labs has two facing plasma emitters in a homogeneous axial magnetic field H_o. Vapor pressure is around 10^{-5} to 10^{-6} mm of mercury

deuterium plasma in a mirror geometry magnetic field.[29] Microwave measurements have indicated greater than 80 percent ionization in a hydrogen plasma. Circuit is shown in Fig. 4.

Plasma beams have also been generated with pool-type Hg^+ discharge tubes. By locating a field of thermionically emitted electrons behind an ion acceleration mesh, researchers at Convair have obtained beams 3.6 cm in diameter with densities of 2×10^8 ions per cu cm of 100-ev Hg^+ ions 15 cm from the extractor.[30]

Plasma can also be produced by the interaction of an electron beam with a gas. At Sperry Gyroscope Co., an electron beam fired by a gun into a drift tube containing hydrogen has yielded plasma of 10^{11} particles per cu cm density at pressures around 1 micron. The 600-v electron beam is focused by a longitudinal magnetic field while a slight positive potential at the ends of the tube maintains the plasma in a uniform condition.

Ionization mechanism here is the kinetic energy of the beam; this differs from an electrical discharge in that no field gradient is maintained. Thus, technique allows producing uniform rates of ionization per unit length.

Method of generating highly ionized steady-state plasmas that is used in several laboratories combines thermionic electron emission with contact ionization of cesium vapor. At Hughes Research Labs, densities above 10^{12} ions per cu cm at 90 percent ionization have been measured in a quiescent plasma column generated by the apparatus shown in Fig. 5.[31]

Here ions are emitted by contact ionization of cesium on two hot tungsten plates and electrons are emitted thermionically at the center of the plates. Plasma is thus continuously generated at both ends of the 10-cm column which is 1 cm in diameter. Direct-current magnetic field of the order of a few hundred oersteds minimizes radial plasma diffusion, providing a well-defined quiescent column.

Densities above 10^{14} electrons and ions per cu cm are considered possible over smaller volumes with this technique.

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Sandwich module, volume 6 cubic inches, uses flow-table principles to recognize 12-bit digital word

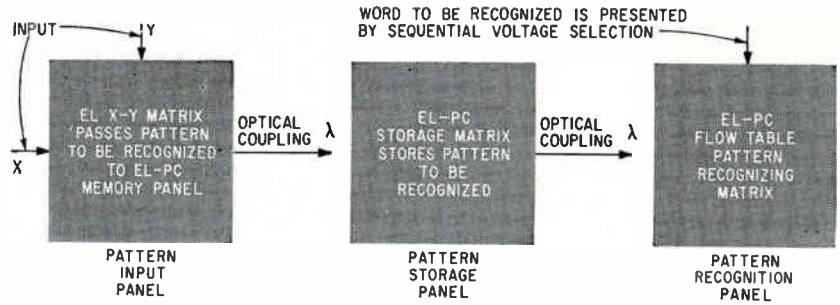

FIG. 1—Recognition panel on right receives control pattern by optical coupling from center storage panel; interrogated digital words are applied by voltage selection. Read-in panel (left) couples input pattern one-word-at-a-time to storage panel

Electroluminescent-Photoconductive

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RECENT INTEREST in electroluminescence and photoconductivity has led to the development of a new class of logical devices. Many conventional logic devices, including rings and shift registers, have been transformed directly to EL-PC counterparts, with emphasis on combinational circuits[1-6]. This article describes EL-PC elements used in a developmental self-organizing pattern recognizer, based on the flow table logic concept[7-8].

The pattern recognizer works on stepping or shift-register principles using photoconductors and electroluminescent cells as active elements. An ON condition is stepped from stage to stage when the digital information presented to it matches a pattern of binary words that it has been programmed to accept. Procession of the ON condition (lit element) to the output stage indicates pattern recognition.

The device consists of three panels (Fig. 1) composed of matrix arrays of EL and PC elements. The first is an EL X-Y select panel (left) in a 4 × 7 element array, any area of which can trigger a geometrically corresponding EL-PC memory cell in a 4 × 7 element storage panel (center), that in turn optically gates an 8 × 8 element EL-PC flow table panel (right), capable of recognizing 4-word, 3-bit binary patterns. Each panel is electrically independent but is optically coupled to an adjacent panel.

Input to the recognizer panel is a pattern of twelve binary digits that have been divided into four smaller words of 3 binary bits each. There are four stepping stages (Fig. 2) each programmed to recognize one 3-bit word. The first word steps an ON condition to first-stage A if this input word corresponds to the pattern in the recognizer gate A; the second word input, if correct, transfers the ON condition to the second stage, and so on, until the fourth 3-bit word steps the ON condition to the fourth and final stage.

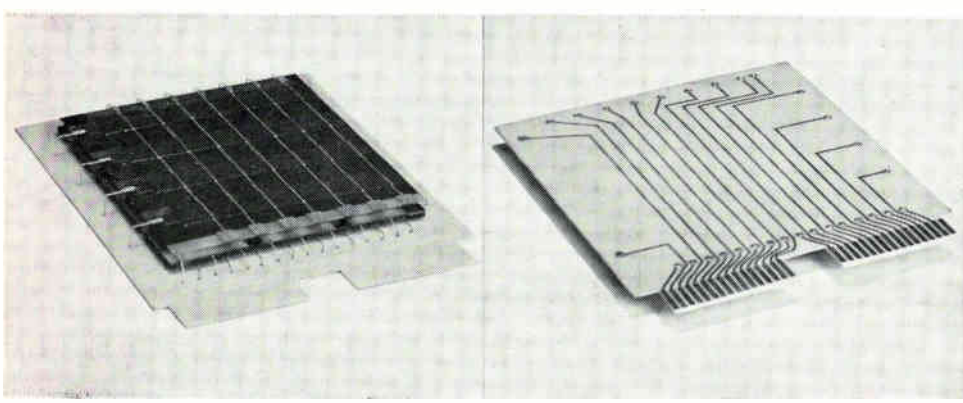
The complete stepping sequence, from first to last stage, can be completed only if the input word pattern corresponds exactly to the word pattern programmed into the recognizer.

The device can accept different recognition patterns without alteration to wiring or to physical construction. This is permitted by altering the pattern of illuminated controlling photoconductors in the flow table (recognizer) panel, shown schematically by Fig. 2.

The recognizer panel is programmed by exciting series-connected photo-conductive elements, which act as gates to control the stepping sequence. Thus, the device will step from one stage to the next only if the 3 digit word input coincides with the set of photoconductor gates that have been opened in that stage's control circuit.

Figure 3 is a schematic of the device and is laid out in flow-table fashion, whereas Fig. 2 was pre-

*This work was done while the author was with IBM Product Development Laboratory, Poughkeepsie, New York.



Recognizer consists of three panels in an electrically independent but optically coupled sandwich, with top view on left and bottom view on right

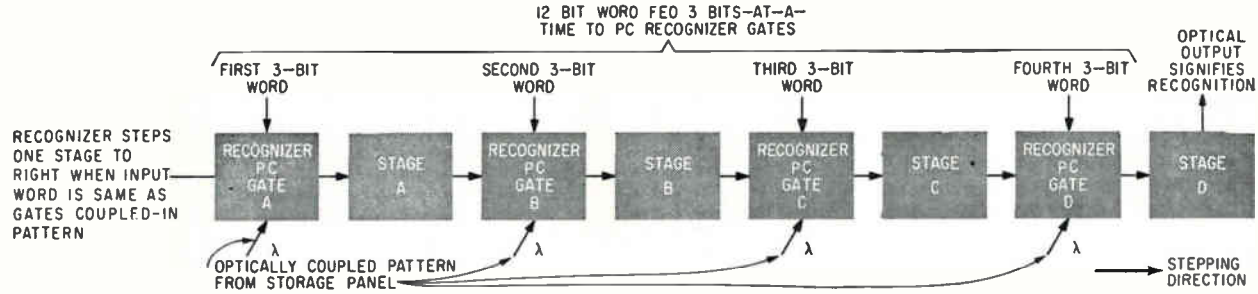


FIG. 2—Twelve-bit binary words are applied to the recognizer for interrogation. They are divided into 4 smaller words of 4 bits each, translated to decimal equivalent, then applied electrically to successive recognition gates, where they are compared with the pattern coupled-in from the storage panel

Pattern Recognizer Organizes Itself

sented as a simple stepper for ease of explanation.

There are four stages to the recognizer (only the recognition panel is shown in Fig. 3) each having seven sections 1-7. These seven sections correspond to the translated value of a 3-bit input word with value zero omitted.

The object of the recognizer is to step flow-table fashion, from the home column of the first stage (A) to the appropriate section of the last stage (D). Since photoconductor gates 4, 5, 6 and 7 are shown illuminated in Fig. 3 (in conducting condition) the sequence of input words must have equivalent binary values, requiring the four binary words to be 100, 101, 110, 111 respectively; that is, a twelve-bit word: 100101110111.

Initially, the home position of stage A is assumed ON, and is held ON by voltage from word-input switch *S*. The first input word (4) moves switch *S* to position 4, where transfer element 4, and then latching element 4, come on. Switch *S* next returns to the home line and turns on the home-position of stage B. Subsequent input words 5, 6 and 7 move the switch to line 5, 6 and 7 with an intermediate move to home in each case, so that the last word (7) turns on section 7 of stage D, giving a recognition output.

Figures 2 and 3 describe the recognizer's operating principles; Fig. 4 is a single stage of the recognizer, shown with actual electroluminescent and photoconductor transfer and latching elements. The PC control gates that are energized optically from the storage panel are omitted. Operation of Fig. 4 is as follows. The home stage is assumed ON with the home electroluminescent lamp LL_H (latching lamp—home) illuminating its optically connected latching photoconductor (LP_H), so elements LL_H and LP_H

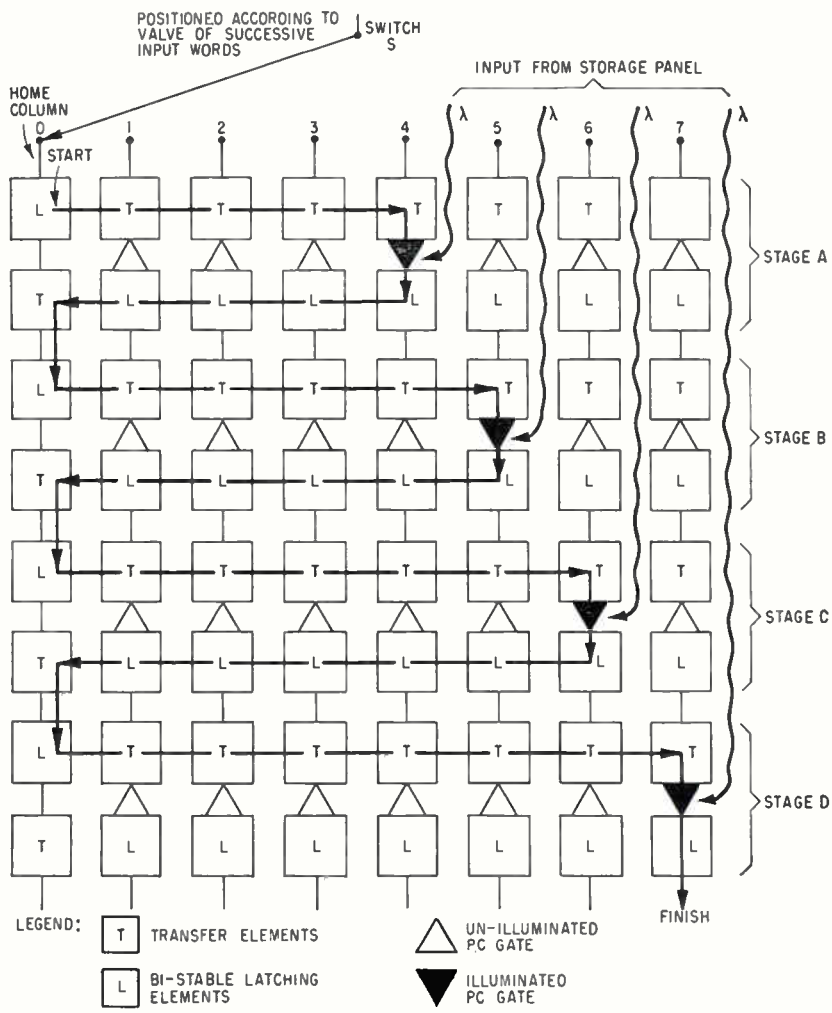


FIG. 3—Photocells illuminated from storage panel (shown darkened), require four input words of values 4,5,6 and 7, respectively, to step recognizer flow-table-fashion along path traced out by arrows

fact as a latching or memory pair. If the first 3-bit input word is 4 (as in Fig. 3) word switch S moves to position 4 to transfer the ON condition horizontally from the home position to position 4.

The supply to vertical line 4 excites transfer lamp (TL_4) in section 4 since TL_4 has a ground path through the home-stage photoconductor LP_H. Photoconductor LP_4 returns slowly to its high resistance condition with lamp LL_H off. With section 4 transfer lamp TL_4 ON, its light output couples with transfer photoconductor, TP_4 turning it to low resistance so that it can trigger the latching elements of section 4. Section 4 transfer-photoconductor TP_4 is in series with section 4 latching LL_4 thereby providing this lamp with a path to ground. Hence latching lamp LL_4 lights. Since the latching lamp is optically coupled to its series photoconductor (LP_4) this photoconductor is turned to low resistance, and provides a ground path for the lamp. Thus, section 4 latching stage holds itself ON until switch S returns to the home section and is independent of the condition of the home-stage photoconductor LP_H. On returning switch S to the home position in readiness for the next 3 bit input word, home elements of the stage shown in Fig. 4 are not excited, but instead, photoconductor LP_4 provides a temporary ground path for the transfer-lamp of the succeeding stage's home section. Thus, the succeeding stage is primed in readiness for the next input word.

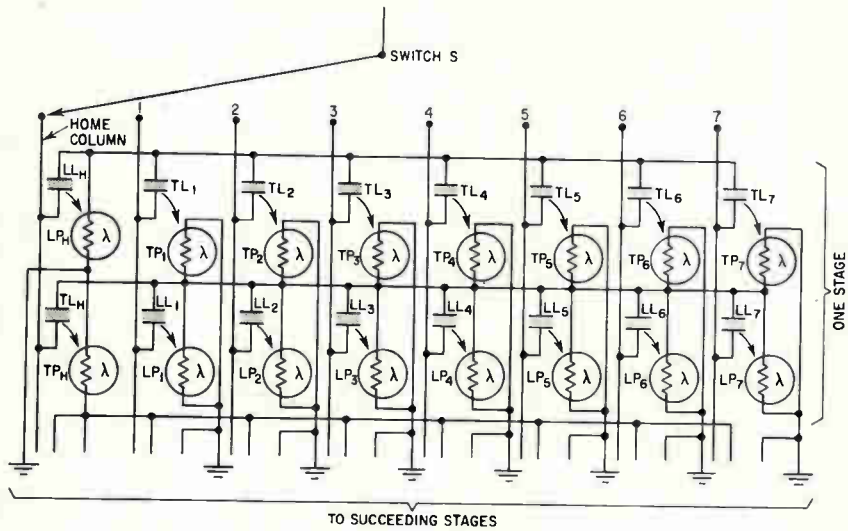


FIG. 4—Voltage selection switch S moves to position 4 and turns on transfer EL-PC elements. Transfer elements then turn on latching pair LL_4 and LP_4 before their grounding photoconductor in the home section (LP_H) returns to high resistance. Gating photoconductors are omitted for clarity

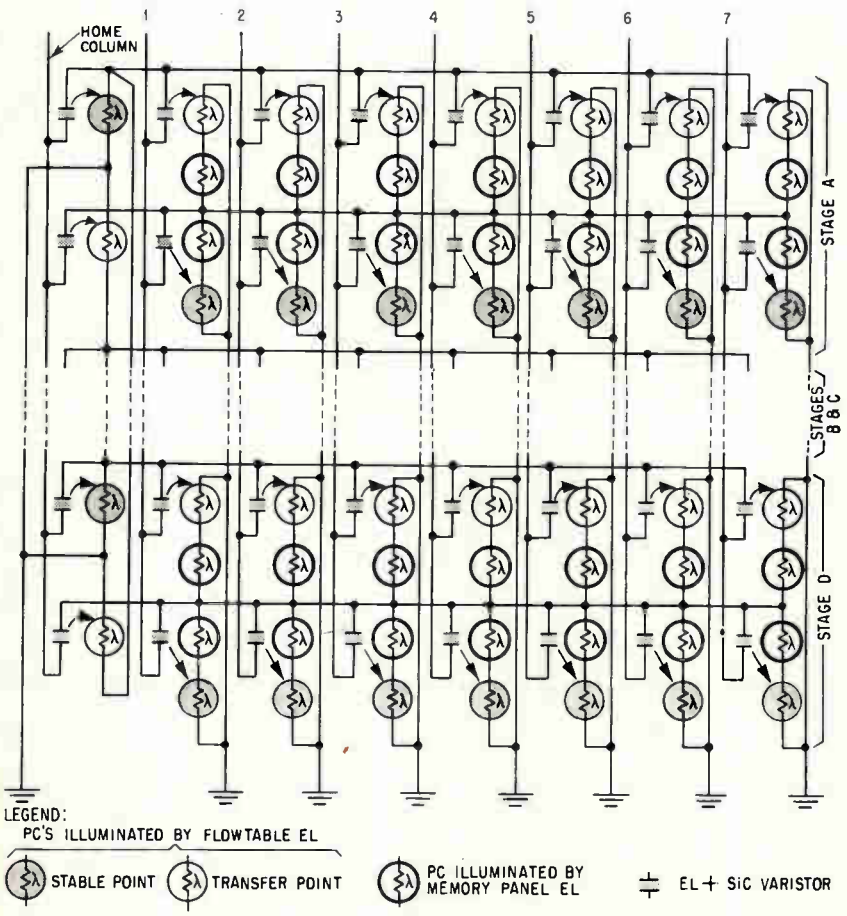


FIG. 5—Recognizer panel shown with gating photoconductors inserted in series with each transfer photoconductor and each latching photoconductor. Although only one gating photoconductor is theoretically necessary for each section, two are included for electrical balance

Figure 5 is an expanded version of Fig. 4 and shows the programming gate-photoconductors. These gate photoconductors, as shown in Fig. 1, are controlled by optical coupling from the center (storage) panel of the recognizer sandwich. The storage panel can be set up in any desired pattern and remains illuminated in this pattern illuminating the photoconductor pattern recognizing gates in the same pattern until its supply is removed. Only one pair of PC gates is set in any stage at one time.

Figure 6B shows the schematic arrangement of EL-PC elements in the pattern storage panel and Fig. 6A shows X-Y panel that couples the pattern into storage panel.

The input pattern is obtained from the matrix of EL lamps in Fig. 6A. This is a conventional cross-suppressed crossed grid panel controlled by voltage selection of horizontal and vertical drive lines. The input to this trigger panel need only be a short pulse for each element, since the storage panel elements latch to their supply once they've been optically triggered.

A large number of recognizers,

each storing a unique pattern, could be interrogated in parallel to locate a pattern. Such an approach compares favorably in speed and cost with table-lookup procedures used in some higher speed computers.

Except for the common substrate and structural materials, the entire device is constructed of EL's and PC's. In the flow table and X-Y panels, SiC series varistors are used to increase the brightness-voltage non-linearity of the EL's and to suppress crosstalk.

The characteristics of the EL-SiC elements have been described elsewhere[9]. Unencapsulated CdSe photoconductive pills are also used throughout. The photoconductors are selected before use for uniformity of photosensitivity (± 25 percent) and dark resistances greater than 200 megohms.

Typically the three panels are each operated at 300-350 volts at 1,000 cycles. Pattern storage is accomplished by manual switching of the XY panel. The trigger sensitivity of the storage panel is about 0.020 footcandle second. The storage panel is erased by voltage interruption; its brightness is approximately 10-20 foot-lamberts.

Under single-shot operation, speeds of three to four milliseconds per logical decision or transition from one stable position to the next, have been obtained. Under continuous operation the flow table ring operates about five to ten times slower per decision element because of the slow photoconductor decay times which limit the speed of return to a single word line. This latter restriction is particularly true when a common line is used to drive the home column, because voltage is returned to the home column on alternate switching cycles, and at high speeds some bits tend to hang up. Sequential application of voltage to the four stable positions in the home column results in fastest operation by allowing a longer interval for photoconductor recovery. Selection of photoconductors on the basis of rise and decay characteristics should provide for further improvements in circuit speed. Optimum speeds were obtained at an applied frequency of 1,000 cps. Higher and lower frequencies resulted in lower speeds. Higher frequencies than 1,000 cps, however, appear undesirable because of well known EL maintenance characteristics.

The assembled EL-PC module, exclusive of the printed circuit mounting board, measures 4.25 inch × 4.50 inch × 0.3 inch and thus occupies a volume of about six cubic inches. Linear expansion of the order of the device results in an exponential increase in logical capability.

The EL-PC pattern recognizer and flow table devices provide supplement to combinational circuits. They offer a new approach to parallel data processing and decrease the distinction between the device and the system. They similarly promise all the advantages of modularity: small size, low power and potential low cost and reliability.

The author acknowledges the assistance of B. Narken in the device fabrication and the encouragement of R. S. Schwartz, P. R. Low and E. J. Skiko.

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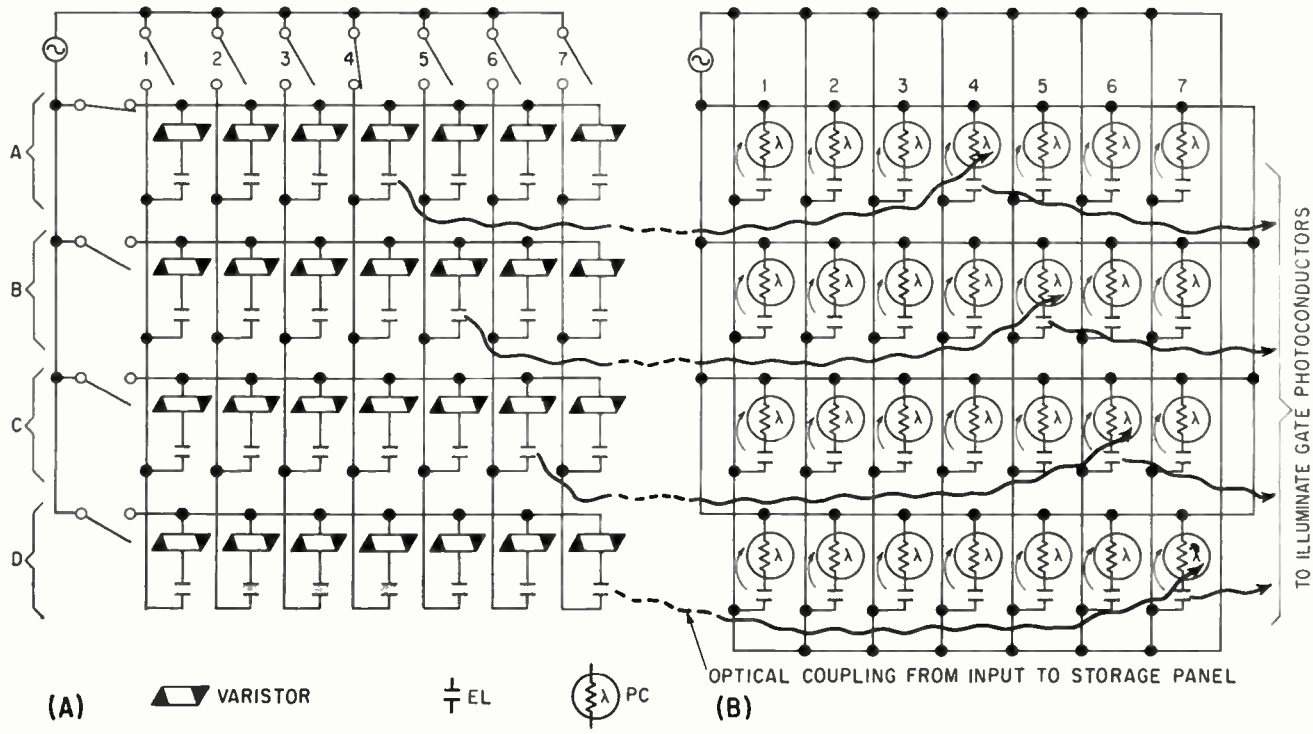

FIG. 6—Input panel (A) is serially excited to trigger memory panel (B). Once memory panel is triggered according to recognition pattern it latches-up and illuminates photoconductors in recognition panel

Zigzag-Line Couplers

High-power, high-efficiency element couples microwave energy across one-inch air gap with almost complete power transfer. Having no mechanical contacts, coupler has a long lifetime

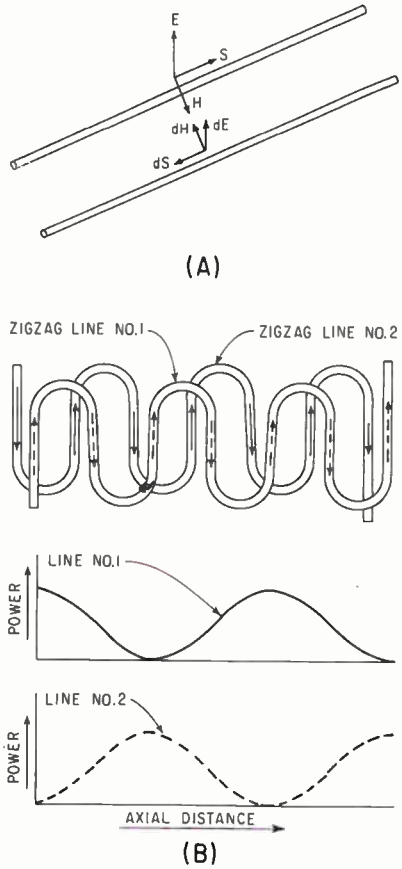

FIG. 1—Coupling between two parallel conductors (A) and coupling between zigzag lines (B)

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MOST commercially available high-power uhf or microwave switches are coaxial and use either gold- or silver-plated r-f contacts to assure electrical continuity. Since arcing may occur during switching, special provisions such as enclosing the contacts in a vacuum or in an inert gas are usually used. The use of precious-metal plating or special design to minimize arcing makes these switches expensive.

The zigzag-line coupler is a co-directional coupler in which arcing is not present because there are no mechanical contacts between electrical parts. It does not require precious metals or special atmospheres.

An exact solution for the zigzag-line coupler problem is difficult because of its nonuniform field configuration. However, qualitatively here's how the coupler transfers energy from one zigzag line to another. If two parallel transmission lines have mutual coupling along their length so that a wave traveling in one line induces a wave that travels in the same direction in the other line, power originally fed to one line will be progressively transferred to the other. As the reverse process is also true, power will be transferred back and forth between the lines. The power-transfer phenomenon is that of spatial beating between coupled transmission lines. Ordinarily, nature does not allow such transfer of energy.

The normal coupling between two parallel conductors of different transmission lines is illustrated by electric (E), magnetic (H) and poynting vectors (S) in Fig. 1A. The two poynting vectors indicate power flowing in opposite directions because a wave on one line will incite a wave that travels in the opposite direction on the other line. However, if the conductors are two parallel zigzag lines, and if one line is half a pitch ahead of the other as shown in Fig. 1B, a wave impressed on zigzag line No. 1 will travel down the first leg of the line and to the right, whereas the induced wave in zigzag line No. 2 will travel up the line, but also to the right. Power is then gradually transferred from line No. 1 to line No. 2 until all power in line No. 1 is transferred to line No. 2. Beyond this point, the reverse process takes place and power is gradually transferred from line No. 2 to line No. 1. Coupled helices work on the same principle[1, 2]. Like coupled helices, if the coupled zigzag lines have the same velocity of propagation, the proper coefficient of coupling and the proper length, all of the power in one line can be transferred to the other. Pitch of the zigzag is not critical but the pitch angle should not be greater than 45 degrees or power transfer efficiency will be impaired. The distance between two zigzag lines is critical as it determines the coupling coefficient and the space-beat wavelength. A slight change in this

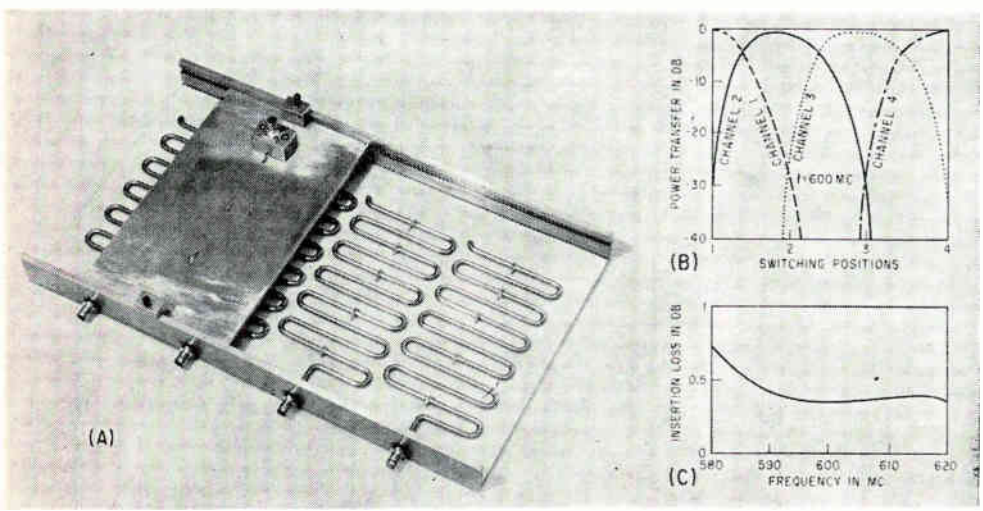

FIG. 2—Four-position linear switch (A), power switching in each channel (B) with insertion loss (C)

Transfer Microwave Power

distance changes the operating frequency band but maintains almost the same power transfer efficiency.

Using the zigzag-line coupler as coupling element, several uhf switches were constructed. Typical of these is the four-position linear switch with constant input impedance shown in Fig. 2A. Here, the switch consists of five identical zigzag lines. The four output zigzag lines are stationary and on a plane $\frac{1}{8}$ in. above a conducting sheet. The fifth (input) zigzag line is on a plane $\frac{1}{2}$ in. above the stationary lines. All zigzag lines are insulated from the conducting ground plane by $\frac{1}{8}$-in. Teflon sheet. Power fed into the input zigzag line can be transferred successively to each of the four stationary lines by moving the input zigzag line into coupling position with one of the four output zigzag lines. During switching, the power at one output line decreases at the same rate that it increases at the next line; therefore, because power is transferred gradually an almost constant input impedance is maintained. Figure 2B shows the power in each of the four switch channels as a function of switching position at the design center frequency of 600 Mc. Figure 2C is plot of average insertion loss of the experimental model.

A four-position rotary switch with constant input impedance is shown in Fig. 3A. The operating principle of this switch is similar to that just described except it is built with a circular configuration. Spacing between the rotating and the stationary zigzag line is about one inch. All zigzag lines are insulated from the cylinder wall by a $\frac{1}{4}$-in. Teflon sheet. Figure 3B is plot of the insertion lost and crosstalk.

The two-position linear switch shown in Fig. 4A consists of three stationary zigzag lines arranged in parallel and about $1\frac{1}{8}$ in. apart. The center line is the input and the two outer lines are outputs. Between the stationary zigzag lines are two shorter, movable zigzag lines. Each movable line is suspended midway between the center line and one of the output lines. The switch is in an 8 × 8 × 11-in. aluminum box. Switching is accomplished by moving the two shorter zigzag lines parallel to the stationary lines. When a movable zigzag line is in coupling position, power in the center line is transferred to the movable line and simultaneously retransferred to an output line. Thus, a double sequence of power transfer occurs. Virtually no power is transferred if the movable line is in an incorrect position. The two movable zigzag lines are arranged so that when one is in the maximum coupling position, the other is in the minimum coupling position. A plot of the insertion loss and crosstalk of the experimental model is shown in Fig. 4B. A wider bandwidth can be obtained if the switch is matched to the 50-ohm coaxial cable.

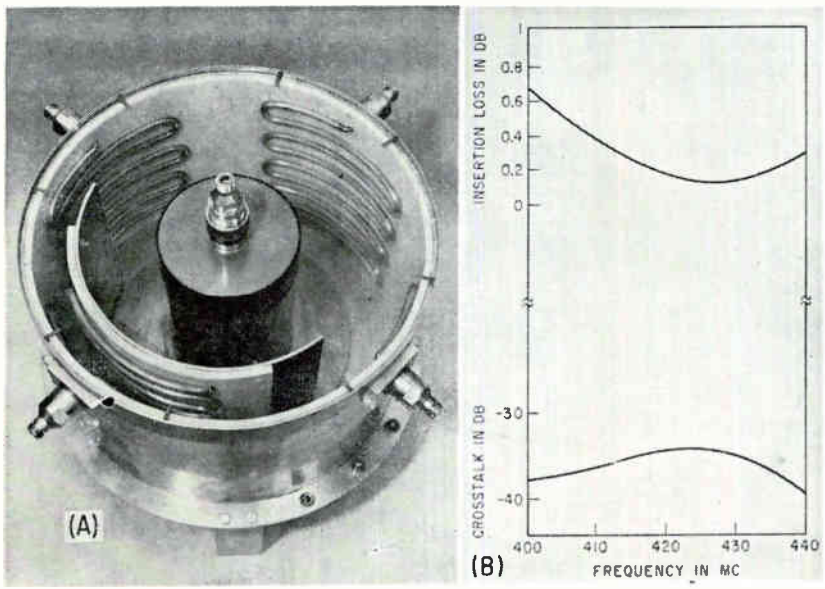

FIG. 3—Four-position circular switch (A) with insertion loss and crosstalk curves shown in (B)

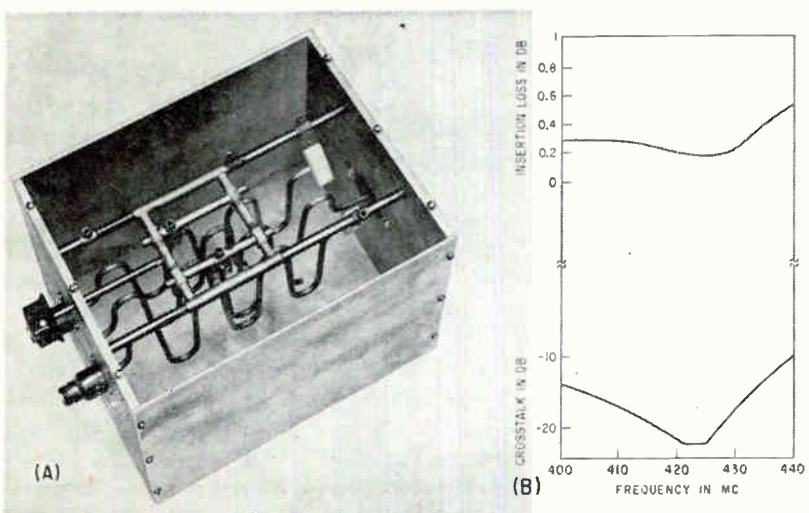

FIG. 4—Two-position zigzag switch (A) with associated insertion loss and crosstalk shown in (B)

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Modifying an F-M Transmitter for

To transmit compatible stereo with the system recently adopted by the FCC, the

STEREOPHONIC f-m broadcasting, as recently adopted by FCC, requires additional equipment not now used for conventional monophonic broadcasting and also places more stringent requirements on f-m transmitters.

Besides conventional stereo program sources, such as tape decks, disk reproducers and multiple microphones, Zenith's f-m station WEFM in Chicago, Illinois, uses the system as shown in Fig. 1.

The left and right stereophonic program sources are fed to a dual 600-ohm fader. Outputs of the fader are applied to 15-Kc low-pass filters to remove spurious components above 15 Kc. The two filter outputs are applied to identical preamplifiers connected in a hybrid circuit to form sum (A + B) and difference (A − B) audio signals. The two preamplifiers matrix the left and right stereophonic program sources to form the main and subcarrier audio-modulation signals.

The sum (A + B) and difference (A − B) audio signals are each applied to identical program amplifiers that drive matched 75-μsec preemphasis networks. The subcarrier-outgoing line (A − B) has an additional 28.5-μsec time-delay equalizer to match the envelopes of the main and stereophonic subcarrier signals. The program amplifiers deliver sufficient output to overcome the loss in the 75-μsec preemphasis networks and still drive the transmitter exciter to 100-percent modulation.

Another portion of the audio console, substantially identical to the program portion, is also included but not shown. In this amplifier, the matrix can be disabled so that left and right stereophonic signals from either the original stereophonic program sources or the demodulated radiated signal can be auditioned. This monitor amplifier is also usable as an emergency program studio amplifier.

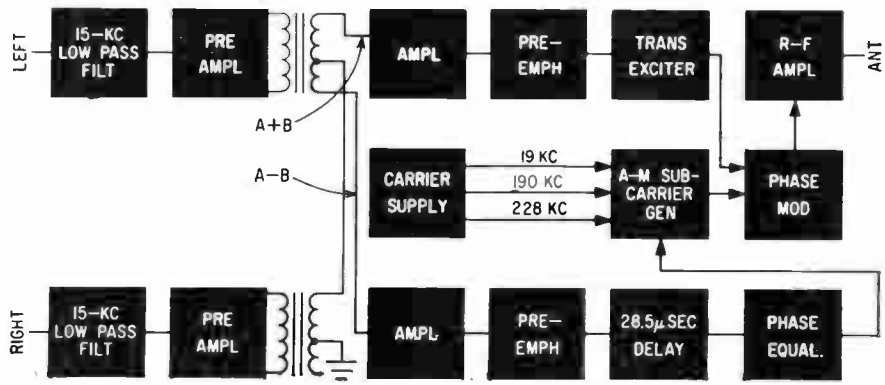

FIG. 1—Block diagram of stereo system installed at WEFM, Chicago, Ill.

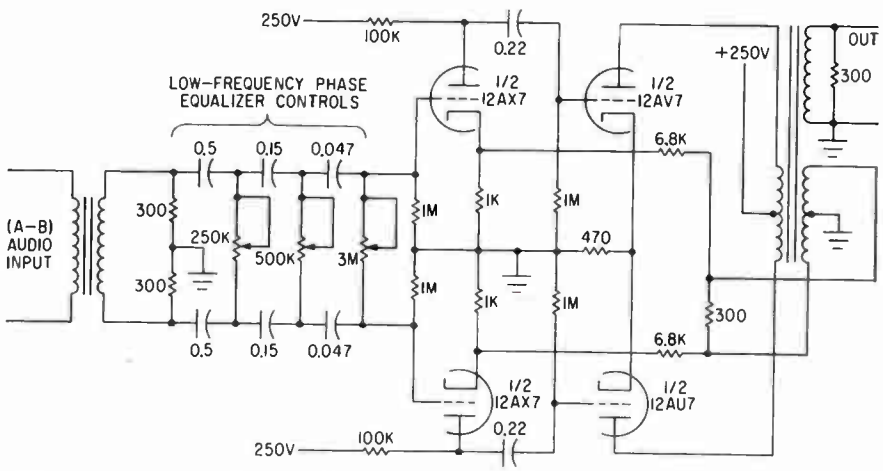

FIG. 2—Audio amplifier and low-frequency phase equalizer used in the A—B channel

Compensation is required in the (A − B) channel for phase displacements of the sum (A + B) audio, which arise mainly in the audio and modulator stages of the transmitter exciter. The low-frequency phase equalization is done by three variable R-C high-pass filter sections, each having a cutoff frequency that can be adjusted between 5 and 25 cps as shown in Fig. 2. These adjustments allow the subchannel compensation to match and equalize the phase characteristics of the main channel.

The audio amplifier section of the phase equalizer provides sufficient gain to drive the double-sideband suppressed-carrier a-m subcarrier generator (Fig. 3) with low distortion because of the large amount of inverse feedback.

To generate an extremely low distortion 38-Kc a-m subcarrier, a two-step or double-modulation system is used.

The first step is accomplished in four-diode doubly balanced ring modulator D_1 through D_4. This ring modulator is driven by a 190-Kc carrier and phase equalized difference (A − B) audio supplied by the audio amplifier and low-fre-

Compatible Stereo Multiplex

f-m transmitter must be modified. Here is how one typical f-m station is doing it

quency phase equalizer. The resultant signal is a double-sideband suppressed-carrier a-m subcarrier that is passed through a bandpass filter having a 190-Kc center frequency and a 3-db bandwidth of 60 Kc. The output of the bandpass filter is amplified by two-stage feedback amplifier V_1 that drives ring modulator D_5 through D_8.

The second ring modulator is driven by a 228-Kc carrier and by the output of the 190-Kc bandpass filter. The product of this modulation process is the 38-Kc double-sideband suppressed-carrier a-m subcarrier. This signal is passed through a lowpass filter having an upper-cutoff frequency of 100 Kc so that both the 190-Kc and 228-Kc frequencies, as well as other spurious components, are removed.

The 19-Kc pilot subcarrier is applied to feedback amplifier V_2 where it is mixed with the 38-Kc a-m subcarrier from the 100-Kc lowpass filter. This combination is amplified by the feedback amplifier and subjected to a $1/f$ frequency response characteristic in the output transformer. The $1/f$ frequency response characteristic converts the phase modulation provided by the auxiliary phase modulator to frequency modulation.

A carrier suppression of better than 40 db below maximum modulation is possible with the double-sideband suppressed-carrier a-m subcarrier generator. A carrier-suppression level of better than 60 db below maximum modulation can be maintained for shorter intervals. The nonharmonic distortion of the generator is approximately 60 db below maximum modulation.

The carrier supply provides the three carrier frequencies, 190 Kc, 228 Kc and 19 Kc, used by the double-sideband suppressed-carrier a-m subcarrier generator. These carriers are derived from a common source to insure constant phase and frequency relationship.

The common source for the carrier supply is 19-Kc crystal-controlled oscillator V_1 shown in Fig. 4. This feeds cathode follower V_2 providing the 19-Kc pilot subcarrier, and also frequency doubling full-wave rectifier D_1 and D_2 whose output is amplified by V_3 providing a 38-Kc signal. This signal is shaped by monostable multivibrator V_4 that in turn delivers squarewave pulses to a pulse-forming circuit to trigger blocking oscillator V_5 that provides sharp pulses for harmonic generation.

A bandpass filter tuned to the 6th harmonic of the 38-Kc blocking oscillator delivers a 228-Kc carrier that is amplified by V_6 and fed to an output terminal.

A bandpass filter tuned to the

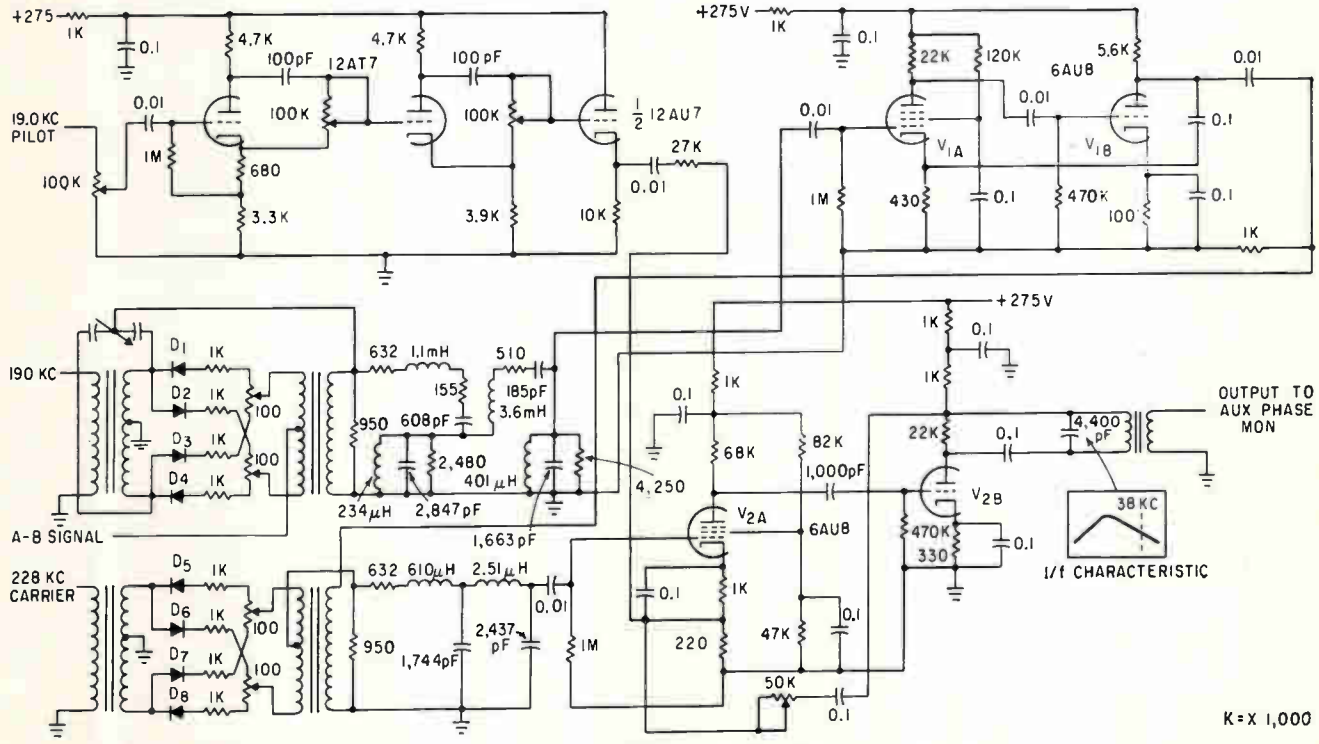

FIG. 3—Double-sideband, suppressed-carrier a-m subcarrier generator has a 1/f response

5th harmonic of the 38-Kc blocking oscillator delivers a 190-Kc carrier that is amplified by V_7 and fed to an output terminal.

The auxiliary phase modulator provides for frequency modulating the main carrier by the stereophonic subcarrier. It is inserted in one of the final multiplier stages of the transmitter so that the signal undergoes an additional nine times frequency multiplication before being radiated by the antenna.

The auxiliary phase modulator input and output frequencies are both 11.055 Mc.

The output of the double-sideband suppressed-carrier a-m subcarrier generator which contains the 38-Kc stereophonic subcarrier and the 19-Kc pilot subcarrier, is applied to a ring modulator, shown in Fig. 5, which is balanced for carrier as well as modulation. The modulation is the stereophonic subcarrier and the pilot subcarrier. The output amplifier of the double-sideband suppressed-carrier a-m subcarrier generator has a $1/f$ frequency characteristic so that the phase modulator produces frequency modulation.

The carrier for the ring modulator is supplied by a limiter-driver combination fed by the 11.055-Mc signal from the transmitter exciter.

The limiter removes any amplitude modulation in the multiplier chain due to inadequate bandwidth in the tuned circuits preceding this stage.

The output of the double-balanced ring modulator becomes an amplitude-modulated 11.055-Mc carrier with carrier suppressed. A portion of the limited 11.055-Mc carrier is shifted 90 degrees and added to the output of the balanced-ring modulator. The resultant signal becomes a phase-modulated signal identical to that obtained when using the conventional Armstrong method of frequency modulation.

The signal is then fed to a two-stage amplifier which provides the proper r-f level for the frequency multipliers in the Collins 734A transmitter. L.S.

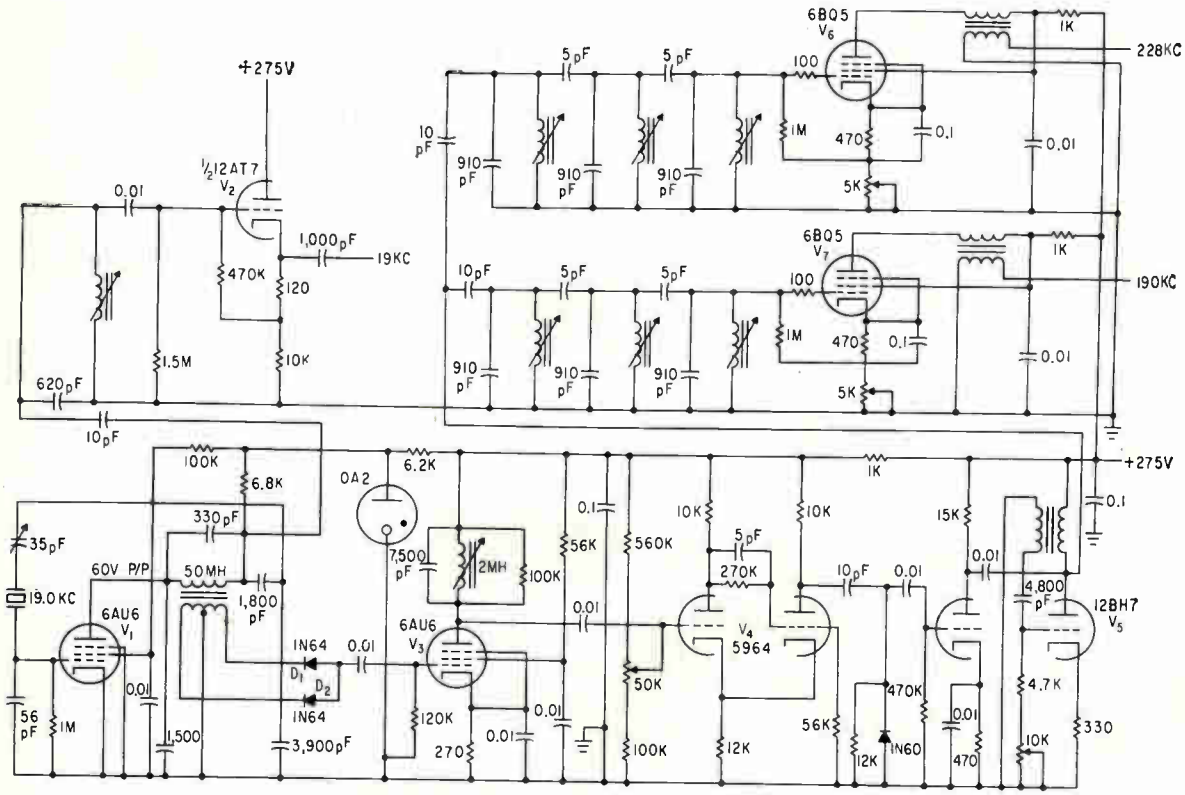

FIG. 4—Carrier supply generates 19 Kc, 190 Kc and 228 Kc from a crystal-controlled oscillator

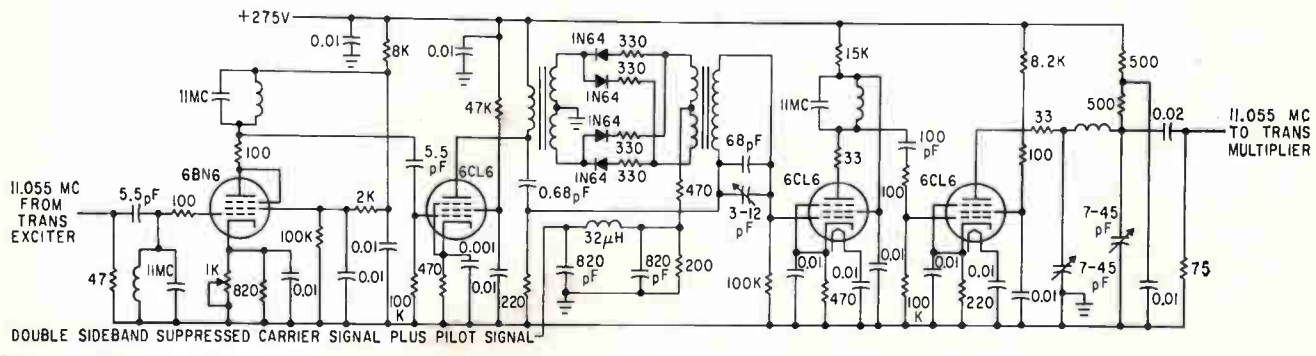

FIG. 5—Phase modulator accepts both the main channel and the modulated subcarrier plus pilot signal

Measuring Low-Level R-F Voltage With Servo Feedback Techniques

These techniques produce a truly linear response to voltage in spite of instrument's use of a diode detector at its input. Feedback loop produces an output voltage that is a linear duplicate of the r-f input

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WITH THE TRANSISTOR and more recently, the tunnel diode, increased emphasis has been placed on low-level r-f measurements. A unique circuit approach provides accurate low-level measurements over a wide voltage and frequency range.

The most common method for measuring r-f voltages is to use a thermionic vacuum diode detector and a d-c voltmeter. This provides a high input impedance, fairly wide bandwidth and good stability, and thus is adequate for a great many applications. However, drift makes it difficult to use a thermionic diode as a detector much below the l-v level.

For low-level measurements, a semiconductor diode will generally have a higher frequency response than a tube. A lower signal-to-noise ratio can be achieved because the diode operates at a much lower temperature than the tube. The d-c drift is about 5,000 times less than that of a tube. The zero-voltage current flowing through a dark junction is determined primarily by thermocouple effects and will cause drifts of only a few microvolts, thus allowing detection at a much lower level than that possible using a tube.

Conventional low-level r-f voltmeters apply the diode-detector output to a high-gain d-c amplifier that drives the meter circuits. This technique is limited in that the diode detection characteristics are not linear, being square law in the millivolt region, linear above 1 volt, with a transition region between. Thus, to have a meter with a wide measuring range, either separate meter scales must be used for each part of the detection characteristics, or complex linearizing networks must be designed for each range. While both of these methods are workable, overall calibration is difficult because of the temperature dependence of the detector characteristics. Several nonlinear scales on a meter face give poor resolution because the scales are crowded at one end and there is the possibility of reading the wrong scale. Linearizing networks have the disadvantage that each range must be separately adjusted to compensate for diode nonlinearity.

In the r-f millivoltmeter described, the meter's seven voltage ranges cover from 10 mv rms to 10 volts rms full scale, and operate within rated accuracy over the frequency range of 500 Kc to 1,000 Mc.

The idea is to generate by feed-

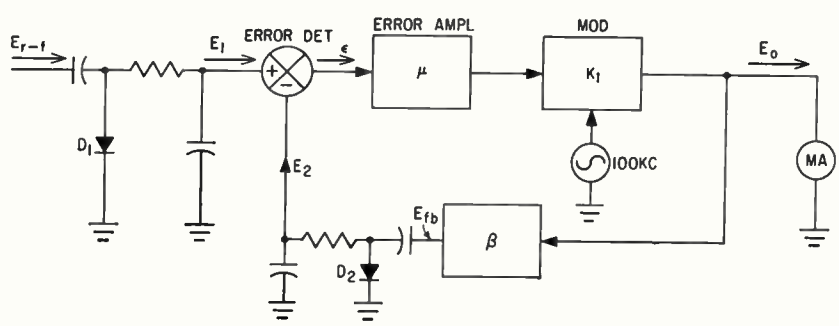

FIG. 1—Simplified diagram of r-f voltmeter

back a low frequency sine wave whose amplitude is equivalent to that of the unknown r-f input and to measure its magnitude instead of the r-f.

Figure 1 shows the principle. The input r-f is detected by a semiconductor diode, and the d-c signal is fed to an error detector. Any difference between it and the feedback reference voltage is amplified and controls the output of a modulator operating on a 100-Kc carrier.

Magnitude of the 100-Kc output is proportional to the magnitude of the error. The modulator output is fed back through the range attenuator to a second diode whose detection characteristics are closely matched to those of the r-f detector diode. The d-c is used as the reference for the error detector and, as long as the loop gain is high, the error tends to zero. Since the two detected d-c voltages are approximately equal and the detection characteristics of the diode detectors are the same, the amplitude of the l-f feedback signal must be equal to that of the input r-f. Thus, a measure of the amplitude of the feedback 100 Kc is equivalent to a measure of the input r-f regardless of any nonlinearity in detector characteristics.

This approach is a closed-loop, nonlinear, positioning servo system. The nonlinear detection characteristics of the feedback diode vary the closed-loop transmission of the system to compensate for the nonlinear detection characteristics of the r-f detector, thus providing an output 100 Kc that is linearly related to the input r-f. Mathematical analysis of this system over the full range of input voltage is made difficult by the nonlinear feedback. However, analysis can be simplified by breaking it into three voltage regions—a high-level region where the diodes are linear, a low-level region where the diodes are square law and a transition region between (Fig. 2).

In the high-level region, above 0.5 volt where the diodes are linear, linear servo analysis applies. The d-c output of each detector is the peak value of the a-c input or 1.414 times the rms value and can be expressed as $E_1 = (2)^{\frac{1}{2}} E_{r-f}$ and $E_2 = (2)^{\frac{1}{2}} E_{f_b} = (2)^{\frac{1}{2}} \beta E_o$ where E_1 is the output of the r-f detector and E_2 is the output of the feedback detector.

Error signal ϵ is

$$\epsilon = E_1 - E_2 = (2)^{1/2} E_{r-f} - (2)^{1/2} \beta E_o$$

Since the transfer functions of the error amplifier and the modulator are linear, the 100-Kc output signal is $E_o = \mu K_1 \epsilon$ or $\epsilon = E_o/\mu K_1$. Thus

$$E_o/\mu K_1 = (2)^{1/2} E_{r-f} - (2)^{1/2} \beta E_o$$

$$E_o/E_{r-f} = (2)^{1/2}\mu K_1/[(2)^{1/2}\mu K_1 \beta + 1] \quad (1)$$

If the loop gain, $\mu K_1 \beta$, is large compared to 1, the closed loop transfer function can be approximated by $E_o \cong E_{r-f}/\beta$. This equation indicates that the output is linearly related to the input r-f and is determined by the setting of the range attenuator.

The exact value of β depends upon the sensitivity of the metering circuit. A high-sensitivity metering circuit would allow β to be unity and require the minimum forward gain (μK_1). However, reducing the forward gain requires increased gain in the meter circuits. Since the meter is outside the feedback loop, variation in its gain will not be degenerated by the feedback and large errors can be introduced in the meter reading unless it is also stabilized by feedback; meter sensitivity would have to be varied to change range.

A second approach is to meter at a high signal level where no gain outside the feedback loop is required and a simple detector is adequate. Although this method requires more forward gain than the previous method and the feedback signal must be heavily attenuated after metering, it puts all gain inside the feedback loop, thereby reducing a possible source of error. It allows the use of a stable and simple meter circuit operating over a constant voltage range. It allows the range to be changed by varying the amount of attenuation. It is much easier to achieve stable and accurate attenuation using capacitance-divider techniques in the β network, rather than varying the sensitivity of the metering circuit. Thus, in this design a full-scale meter sensitivity of 30 v rms was selected. At this level a simple semiconductor diode detector can be used with good linearity over the full meter scale and still not exceed the peak-inverse voltage of inexpensive diodes.

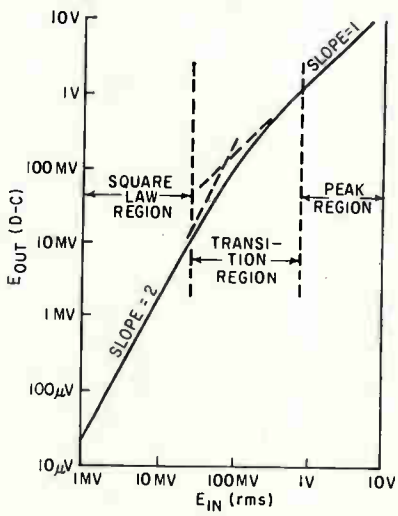

FIG. 2—Diode characteristic shows three regions of curve that are analyzed

With a 30-v full-scale sensitivity, the amount of attenuation required for a 10-v full-scale range is $\beta = 10/30 = 0.33$. The amount of forward gain necessary for 1-percent accuracy in the linear region is $\mu K_1 = 300/(2)^{\frac{1}{2}} = 212$, this value being derived from the criterion that $E_o/\mu K_1 \leqq E_{r-f}/100$.

The second region to be analyzed mathematically is that of voltages below about 30 mv where the diodes act as square-law detectors, giving a d-c output proportional to the square of the input r-f. Here, $E_1 = \alpha_1 E_{r-f}^2$ and $E_2 = \alpha_2 E_{f_b}^2 = \alpha_2 \beta^2 E_o^2$. In this region the constant of proportionality, α, depends upon temperature, diode type and detector load. Its value will typically be about 15 for a germanium diode at 300 K working into a high-impedance load. Thus, 1 mv of r-f will give about 15 μv of d-c while 10 mv gives 1.5 mv d-c.

Using this square law, the error is $\epsilon = E_1 - E_2 = \alpha_1 E_{r-f}^2 - \alpha_2 E_{f_b}^2 = \alpha_1 E_{r-f}^2 - \alpha_2 \beta^2 E_o^2$. The output of the modulator must equal the input error signal times the forward gain. Thus

$$\epsilon = E_o/\mu K_1 = \alpha_1 E_{r-f}^2 - \alpha_2 \beta^2 E_o^2$$

$$E_o^2 = \frac{1}{\beta^2}\frac{\alpha_1}{\alpha_2} E_{r-f}^2 - \frac{E_o}{\alpha_2 \mu K_1 \beta^2} \quad (2)$$

It might seem that the algebra is not complete because there are E_o terms on both sides of the equation. However, the equation was written in this form because it is more evident that if $E_o/\alpha_2 \mu K_1 \beta^2$ is small compared to $\alpha_1 E_{r-f}^2/\beta^2 \alpha_2$, then $E_o \cong (\alpha_1/\alpha_2)^{\frac{1}{2}} E_{r-f}/\beta$. Since the charac-

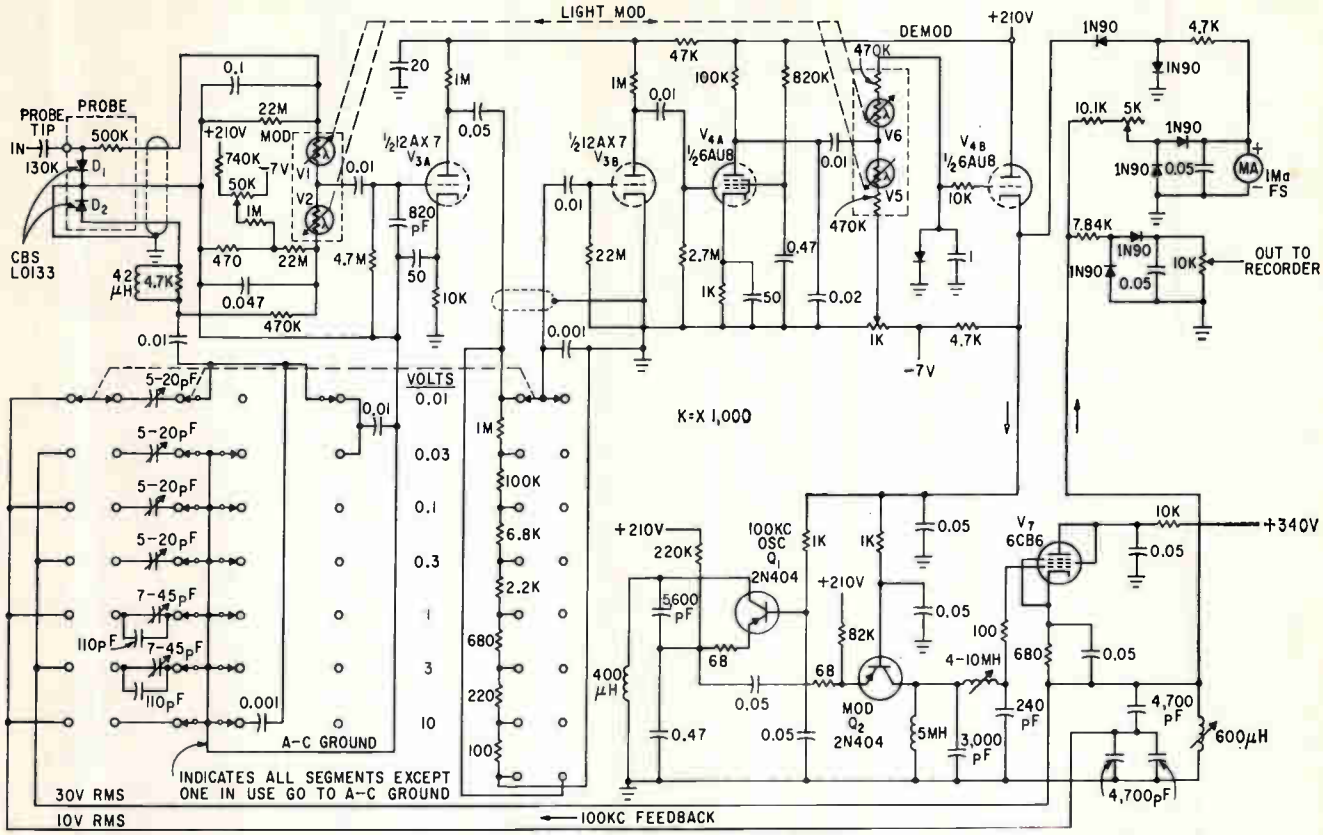

FIG. 3—Schematic of r-f voltmeter. Modulator block corresponds to error detector of Fig. 1 and modulator of Fig. 1 corresponds to Q_1 of this drawing

teristics of the r-f detector and the feedback detector are carefully matched, $a_1 = a_2$ and the square root of the ratio is unity. Thus, $E_o \cong E_{r\text{-}f}/\beta$. This equation indicates that, as in the high-level case, when the loop gain is high the output is linearly related to the input r-f and is determined by the setting of the range attenuator. However, where before only $(2)^{\frac{1}{2}}\ \mu K_1\beta$ had to be large compared to one, now $E_o/a_2\ \mu K_1\beta^2$ must be small compared to $a_1\ E_{r\text{-}f}{}^2/a_2\ \beta^2$. Expressing the error as a percentage of full scale, full-scale error is $\cong (a_1/a_2)^{\frac{1}{2}}/E_{FS}$ $2\ a_1\ \beta^2\ \mu K_1$. Assuming that $a_1 = a_2 = 15$ and using a full-scale (FS) sensitivity of 30 v rms, the forward gain for an error of less than 1 percent on a full-scale range of 10 mv is $\mu K_1 > 10^6$. While this is a large amount of gain, it is easily attained by chopper techniques in the error amplifier.

The third region, the transition region between 30 mv and ½ volt, is extremely difficult to analyze.

The solution of the equations involve Bessel functions and the mathematics become complicated. However, in any region, the output of the r-f detector is a function of the input, that is, $f(E_{r\text{-}f})$, and that the output of the feedback detector is a function of the feedback signal, that is, $f(E_{fb}) = f(\beta E_o)$. The difference between the detector outputs must be equal to E_o divided by the forward gain. Thus $\epsilon = f(E_{r\text{-}f}) - f(\beta E_o) = E_o/\mu K_1$ (3). As both as $E_o/\mu K_1$ is small compared to $f(E_{r\text{-}f})$, $f(\beta E_o)$ will approximately equal $f(E_{r\text{-}f})$. Since the functions are identical $\beta E_o \cong E_{r\text{-}f}$, or $E_o \cong E_{r\text{-}f}/\beta$.

Knowing the magnitude of the detector output at full scale on each of the ranges in the transition region will allow calculating the gain for a 1-percent error. The criterion of a 1-percent error requires that $E_o/\mu K_1 \leqq f\ (E_{r\text{-}f})/100$, deriving this criterion from Eq. 3. If 100 mv of r-f input produces 100 mv d-c, the gain for a 1-percent error on a 100-mv full-scale range is $\mu K_1 = 100\ E_{FS}/f(E_{r\text{-}f})$ equals 100 $\times$ 30/0.1 = 30,000.

Thus, the minimum forward gain varies from 212 to 1,000,000, the exact value being unimportant as long as the minimum is exceeded on each range. High accuracy is needed only in the feedback attenuator and the diode match.

To achieve the stable, high-gain, characteristics in the error amplifier, the differential input is converted into a 50-cps square wave in a photochopper modulator (V_1 and V_2 of Fig. 3). The modulator section corresponds to the error-detector portion of Fig. 1. Conventional a-c amplifying techniques are used with V_{3A}, V_{3B} and V_{4A}. A range attenuator in the plate circuit of V_{3A} is ganged with the feedback range attenuator to keep total loop gain relatively constant at about 40 db for full scale.

An increase in differential input causes the synchronous demodulator to decrease the negative bias on the grid of V_{4B}. This tube's cathode, whose potential controls the 100-Kc output signal, goes more positive.

A portion of V_7's cathode-tuned circuit accomplishes part of the feedback attenuation. Two levels of 100-Kc signals are carried to the feedback range attenuator, which uses capacitive dividing techniques. Trimmers are adjusted in the factory calibration.

F-M Magnetic Tape System Records

Distortionless recordings of low-frequency signals can be made with a conventional tape recorder machine using this frequency-modulation and demodulation system

By KENNETH D. BROADFOOT,*
Wilmer Institute, The Johns Hopkins Hospital, Baltimore, Md.

THIS SYSTEM enables low-frequency action potentials from nerve fibers to be recorded without distortion on a conventional tape recorder. The system uses a 7.5 Kc carrier that is frequency modulated by the signals to be recorded. This modulated carrier is then recorded on tape at frequencies that the tape recorder will faithfully reproduce. Here the carrier ranges from 5.5 Kc to 9.5 Kc. Upon playback, the carrier frequency passes through a demodulator that completely removes the carrier, thus recovering in undistorted form the original nerve signal.

The modulator consists of twin triode V_1 and pentode V_2 as shown in Fig. 1A. Half of the triode, V_{1A} is a direct-coupled amplifier with its gain adjusted so that with an input signal of 8 volts peak the voltage swing on V_{1A} plate is just sufficient to fully modulate the carrier, a total frequency excursion of 4 Kc. Control R_{13} sets the center frequency f_o by adjusting the quiescent d-c potential on V_{1A} plate.

The following stage is a Miller-effect transitron oscillator for which the frequency of oscillation is set by the d-c potential to which R_5 is returned. This frequency dependence is indicated in the equation $t = CV/(e/r) = CVr/e$ (to a close approximation), where t = period of oscillation, e = voltage to which R_5 is returned, $r = R_5$, C = plate to grid capacitor, and V = Miller run down voltage. Since frequency is the reciprocal of the period t, then $f = e/CVr$. Hence, the frequency of oscillation of the circuit is directly proportional to the voltage e.

The plate potential of V_{1A} is adjusted to set f_o. With 140 volts at the anode of V_{1A} the center frequency is 7.5 Kc. When a signal is applied to V_{1A} grid its plate potential changes by an amount depending on the amplitude of the modulating signal and with the same rate of change of amplitude. This in turn causes the frequency of the carrier to change with the modulating signal.

The Miller tube, V_2, is made self-oscillating by capacitive coupling between its screen grid and suppressor grid thus employing the negative resistance effect obtained with pentodes, so that the circuit has no stable states. The crystal diode, 1N98, prevents the suppressor grid from being driven excessively positive at the start of the rundown period.

To avoid loading the plate of Miller tube V_2 by the output circuit, a cathode follower V_{1B} is placed between the modulator output and the V_2 plate. As the voltage swing at the plate of V_2 is too large, the grid circuit of V_{1B} is tapped to V_2 plate resistor near the high voltage end. This also assists in decoupling V_2 from the effects of load changes.

The demodulator, shown in Fig. 1B, consists of three twin triodes V_3, V_4 and V_5. As the bandwidth of the tape recorder is limited to about 10 Kc, the signal at V_{3A} input is approximately sinusoidal. Therefore to provide a suitable triggering pulse for the demodulator tube V_5, a squaring circuit is required.

Tube-half V_{3A} is an a-c coupled amplifier to bring the low level carrier signal from the tape up to a level suitable for operating the squarer tube V_4 which is connected

*Now with University of Sydney, Australia

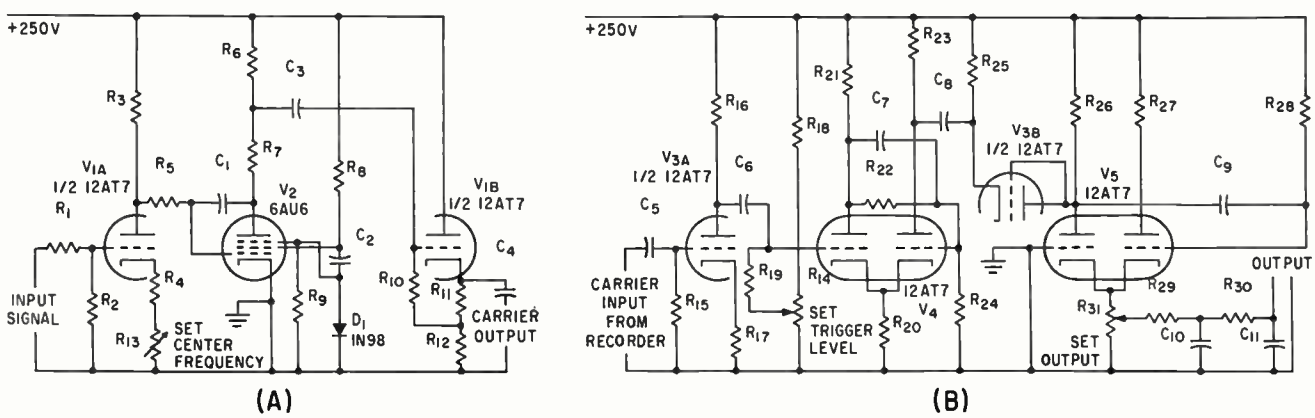

FIG. 1—Schematic for recording-system modulator (A) and demodulator (B)

Low-Frequency Nerve-Fiber Potentials

as a conventional Schmitt trigger circuit. The trigger level can be set by R_{14}, which is adjusted so that for a minimum input carrier signal of 100 millivolts peak-to-peak, the circuit triggers and a square waveform is present on V_1 right-hand plate. This square wave is differentiated by C_8 and R_{26}. The negative going edge of the square wave from V_1 triggers the demodulator tube through V_{3B} connected as a diode.

Tube V_5 is a monostable multivibrator which, when triggered by pulses from V_1, gives a fixed width square wave output of 40 microseconds duration. Since the width is constant and the frequency of the trigger pulses varies with modulating signal, average level of the resultant square wave output will be directly proportional to the signal at the modulator input.

The output from V_5 is taken from the cathode. This makes it easier to direct couple to a succeeding amplifier if it is required to reproduce zero or very low frequency signals through the system since the quiescent d-c level is lower at the cathode than at the anode. Also, connection to the cathode ensures that the output signal is in phase with the signal input to the system. The d-c output, and simultaneously the overall gain, can be adjusted by potentiometer R_{31}.

At the output, the carrier is removed by an R-C low-pass filter (tapered ladder C_{10}, R_{29}, C_{11}, R_{30}) and the output is a replica of the input waveform.

Power supply requirements for the system are 250 volts at 35 ma, and 6.3 volts a-c at 1.5 amp.

Results are shown in three plots. Figure 2A is a plot of modulator linearity over a carrier frequency range of 5.5 Kc to 10 Kc.

Output voltage of the demodulator for a sine-wave input of frequency 5.5 Kc to 9.5 Kc is shown in Fig. 2B. Overall linearity of the system is shown in Fig. 2C.

Indications are that this system of recording will save film during a long experiment. It is useful to be able to photograph action potential waveforms for later analysis. The tape can be edited at leisure after an experiment, the pertinent sections played back through an oscilloscope, and the waveforms photographed.

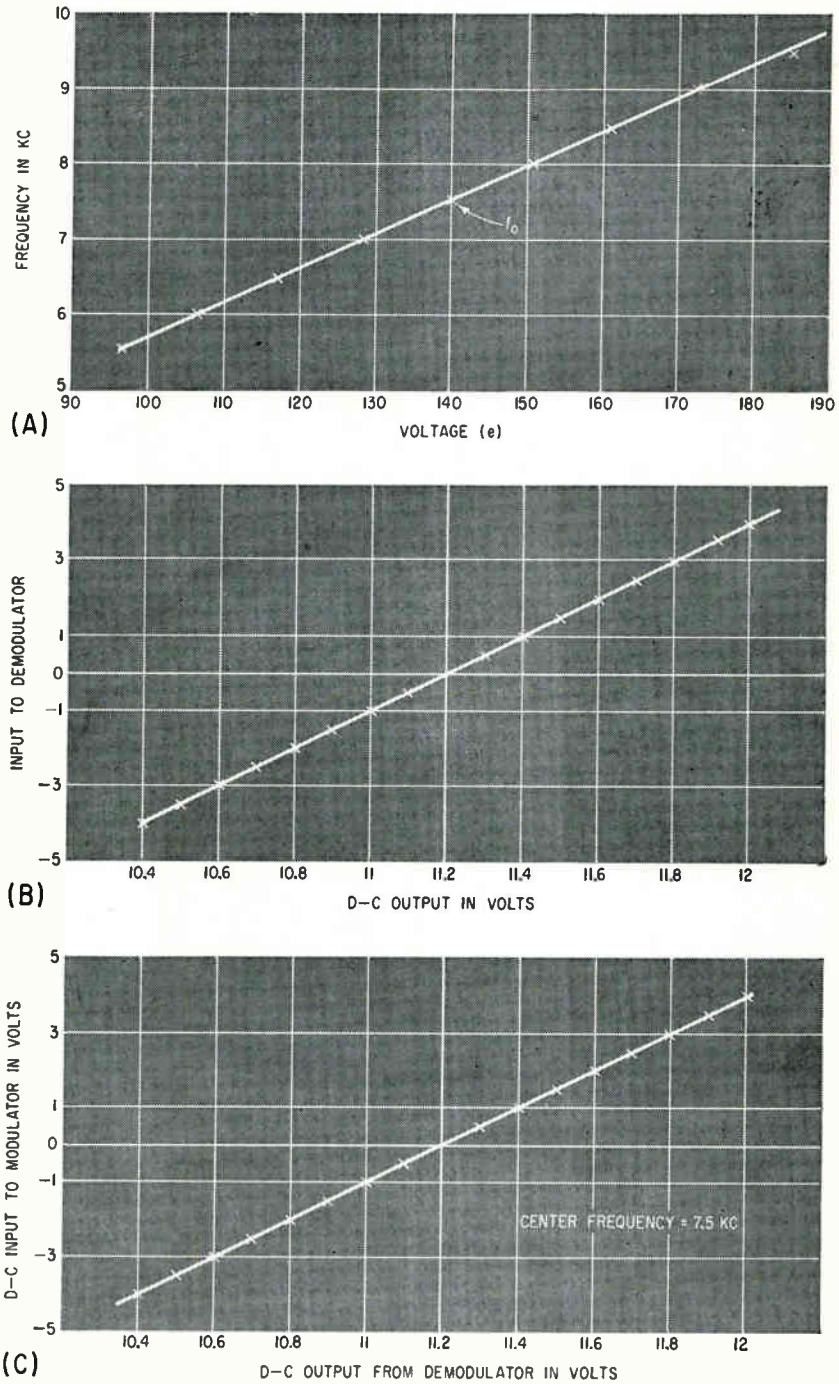

FIG. 2—Modulator linearity from 5.5 to 10 Kc (A); demodulator linearity for sine-wave inputs from 5.5 to 9.5 Kc (B); and overall linearity of the system (C)

The author acknowledges that facilities for this project were made possible by U. S. Public Health Service Grant B-2591.

Zener Diode Creates Logarithmic Pulse Amplifier

Amplifier operates over three decades. Zener diode is the logarithmic device. Circuit is all solid state and is largely unaffected by minor temperature changes

By DAVID OPHIR,
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Dept. of Physics,
Technion—Israel Institute
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MANY PHYSICAL research projects require a logarithmic analysis of pulse amplitudes. There are two basic approaches to logarithmic pulse amplification: one is to use an element with a logarithmic characteristic; the other is to use nonlinear feedback around amplifier stages.[1] Nonlinear feedback has the disadvantage that an accurate characteristic over three decades requires a large number of stages.

Elements with a logarithmic characteristic, such as the grid voltage-grid current[2] curve of a triode, or the backward characteristic of a semiconductor diode, entail high resistances and therefore are not suitable for pulse amplification.

The possibility of using a Zener diode for logarithmic amplification has been briefly discussed.[3]

The diode should have low temperature dependence and low impedance in the working range.

The low temperature dependence requires Zener diodes with breakdown voltages in the range 4 to 6 volts. The low-impedance requirement necessitates relatively large currents through the Zener diode.

Work leading toward development of the 3-decade amplifier has been based on extensive tests of Zener diodes. It has been found that the behavior of the diode in a pulse circuit could be predicted from its d-c characteristic. The

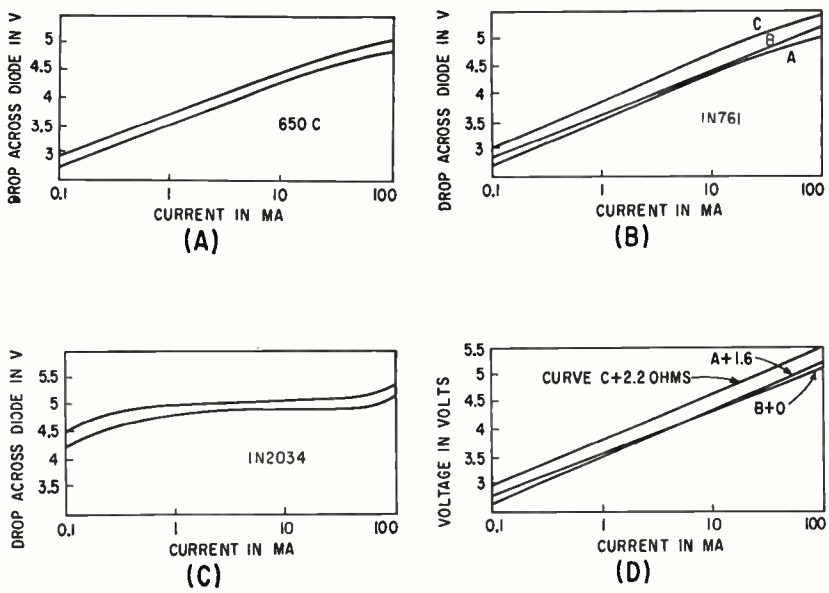

FIG. 1—Characteristics of selected Zener diodes (A) and (B) show a close approximation to the logarithmic curve desired. Typical characteristics of unsatisfactory diodes are shown at (C). The curves in (B) can be straightened by adding a small resistor, giving the curves shown in (D)

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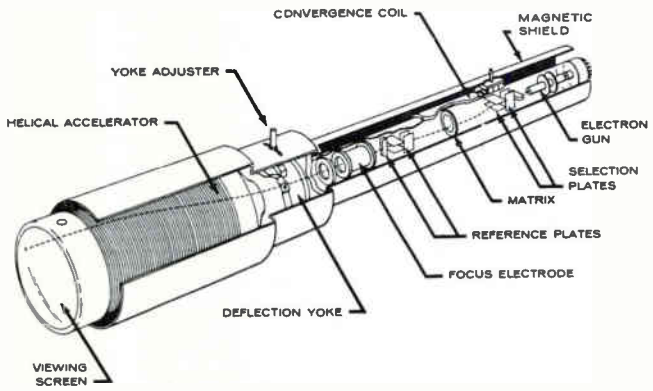

The fundamentals of operation are basically simple. As in more conventional cathode-ray tubes, a beam of electrons is generated in an electron gun, accelerated, and introduced into a field between co-planar electrostatic plates. A special element, called the "matrix," is located at a precise distance beyond the deflection plates. The matrix is a thin beryllium-copper disc centered on the electron gun axis at right angles to the beam. Commonly, sixty-four minute characters in an 8 x 8 array are precision etched through the matrix disc. This permits selection of any character with a six-bit binary code. (Up to 256 characters have been provided for special applications.)

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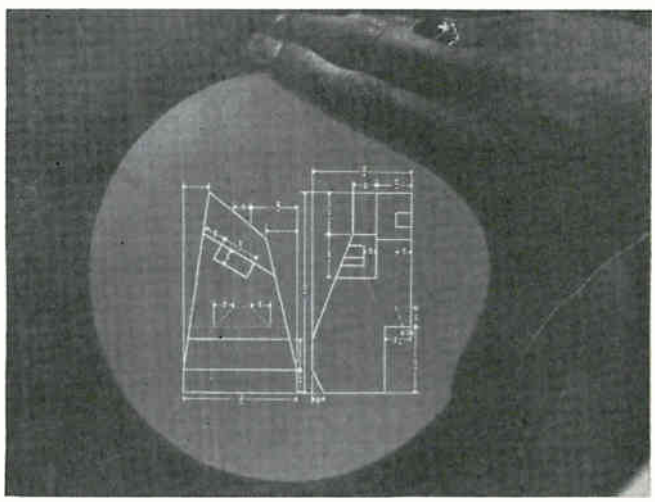

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CIRCLE 69 ON READER SERVICE CARD 69

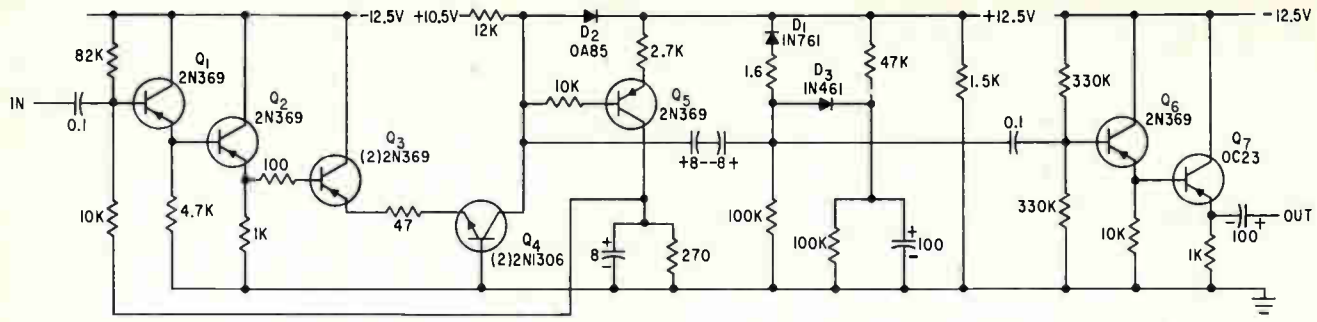

FIG. 2—Logarithmic diode is D_1, with characteristic straightened with 1.6-ohm resistor. Transistors Q_3 and Q_4 are both two units in parallel

diodes tested were: 1N761, 1N763, 1N2032, 1N2034 and 650C. Of each type, 8 to 12 diodes have been tested.

The tests proved that the most satisfactory results would be obtained with types 1N761 and 650C. Even with these types, only five out of eight diodes tested could be adapted to pulse work. It is expected that other types of Zener diodes with a breakdown voltage of about 4 volts will give similar results. Figure 1A shows the characteristics of some 650C diodes that offered the best results; Fig. 1B shows similar curves for 1N761 diodes. Figure 1C shows typical characteristics that are not considered satisfactory (type 1N2034 diode).

From Fig. 1, it is seen that to obtain the logarithmic behavior over three decades a straightening of the curve at the upper region is required. This straightening is obtained by adding in series with the Zener diode a small resistor of 0 to 2.5 ohms, with the exact value selected for each diode. Figure 1D shows the straightened characteristics for the 1N761 diodes presented in Fig. 1B.

A good approximation for the straightened characteristic is $E = K \ln (I - I_o)$, where K is a constant and I_o is quiescent current.

For the logarithmic amplification of pulses the characteristic required is $\Delta E = K \ln \Delta I$.

This result can be approached by keeping ΔI much greater than I_o.

This implies that even the smallest pulse to be amplified should supply a large ΔI relative to I_o. On the other hand, from the low-impedance requirement, I_o should be relatively large.

The requirement of the amplifier was for voltage amplification of pulses between 10 mv and 10 v.

A satisfactory compromise was reached by using an I_o of the order of 90 μa, with ΔI for a 10 mv pulse of the order of 200 μa, and ΔI for a 10 v pulse of the order of 200 ma.

The amplifier was designed to accept the pulses from a multiplier-phototube linear preamplifier that provided pulses of 10 mv to 10 v at relatively low impedance.

The logarithmic amplifier performs: (1) linear power amplification; (2) transformation of the low-impedance voltage source; (3) logarithmetic amplification; and (4) output power amplification. Figure 2 shows the complete diagram.

Stages Q_1, Q_2 and Q_3 provide linear power amplification. Stage Q_4 transforms the voltage source into a high impedance current source that feeds Zener diode D_1.

The d-c drift of operating point of Q_4 is taken care of by the feedback circuit consisting of stage Q_5.

Diode D_2 protects Q_4 from large voltage peaks. Diode D_3 decreases the overshoots. Stages Q_6 and Q_7 provide power amplification to work into a 72-ohm coaxial line.

Figure 3 shows the response of the amplifier at 25 C and at 50 C.

A constant level of about 0.2 v has to be removed from the base line of the pulse.

The characteristic was obtained with pulses of 0.2 μsec rise time and 2 μsec duration.

At the low input level of 10 mv, rise time of the output pulse is of the order of 1 μsec and decreases rapidly so that for a 30-mv input pulse the output pulse has about the same rise time as the input pulse. This effect is caused by the higher capacitance of the Zener diode at this current level.

The small deviation from the straight logarithmic response at low input voltages is due to the compromise in choosing ΔI_{min} and I_o.

Temperature dependence between 25 C and 50 C is small and can be reduced even further by a negative-temperature-coefficient resistance in series with the 100,000 ohm resistor in series with D_1.

Work on the amplifier was sponsored in part by Air Force Cambridge Research Center, Air Research and Development Command, USAF, through its European Office.

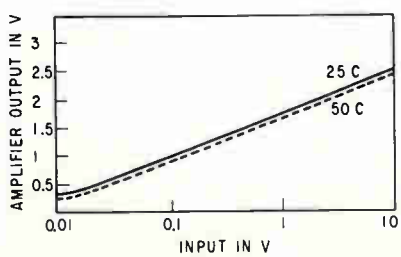

FIG. 3—Slight temperature effect in amplifier characteristic can be decreased by negative temperature coefficient resistor

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(2) S. Chao, Logarithmic Characteristic of Triode Electrometer Circuits, *Rev of Sci Instr*, Dec. 1959.
(3) M. R. Nicholls, Zener Diode Characteristics, *Electronic Eng*, p. 559, Sept. 1959.

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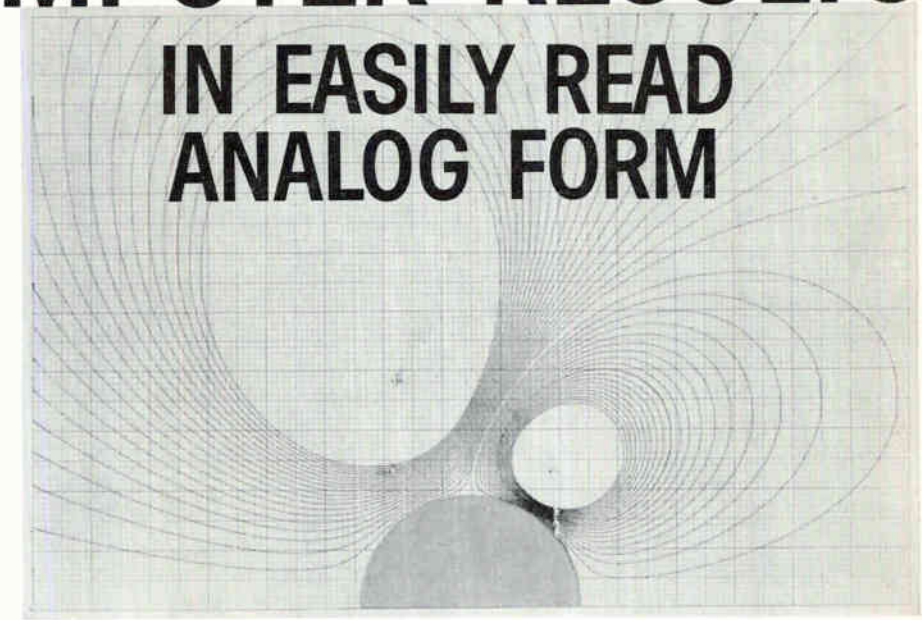

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Megamp Switch Is Developed for Plasma Study

By R. BUSER, P. WOLFERT AND J. SULLIVAN

U. S. Army Signal R and D Lab., Fort Monmouth, N.J.

CURRENTS of several million amperes are switched by simultaneous firing of several arc channels in an air-gap switch. Electrical and mechanical design techniques have made possible equal current division among the arc channels.

The switching system was developed for a plasma research facility. More than 3,000 switch firings have been accomplished in more than a year without failure. The switch can be used for other high-current applications, such as high-energy particle diagnostics and production of shock waves.

The multiple-arc channel air-gap switch in Fig 1 discharges a 480-μf capacitor bank charged to 20 Kv. The bank supplies 100,000 joules to two single-turn loops surrounding a discharge tube used to produce plasmas (ELECTRONICS, Aug. 5, 1960).

Mechanical parts comprising the switch include a brass cathode, brass or stainless steel cathode face, brass anode and five stainless steel firing pins insulated by Teflon sleeves, as shown in Fig. 2. Spacings of gap, insulation sleeves and firing pins are adjusted with a gage during assembly, and different gages permit adjustment in a few minutes for other bank voltages.

In operation, a single pulse fires the hydrogen thyratron in Fig. 1. Capacitor C_1, charged to about 12 Kv, is discharged through the pulse transformer primary. Transformer output triggers the Scylla-type switch for the main trigger capacitor, which is charged to about 80 Kv. This energy is fed through coaxial cables to the trigger pins, which when fired start discharge of the main capacitor bank.

Analysis of breakdown indicates conditions required for simultaneous firing of parallel arc channels. Short rise-time voltage above breakdown applied simultaneously to identical gaps does not produce simultaneous firing. Statistically varying time lag t_s between voltage application and onset of ignition is given by $n = n_o \exp -t/t_s$, where n is number of unfired gaps, n_o is total number of gaps and t is total trigger time. Time t_s depends on ion concentration before start of discharge, overvoltage, electrode surface properties and geometry.

Another statistically varying time lag, t_f, immediately following t_s is the formative time lag needed for spark buildup. It is a complex function of voltage, pressure, electrode spacing and gas. Total trigger time, $t = t_s + t_f$, is about 10^{-8} second with 100-percent overvoltage. When all differences in air gaps are considered, 500-percent overvoltage assures simultaneous ignition in 10^{-8} second or less.

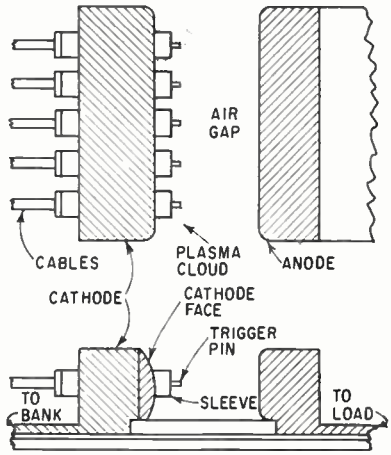
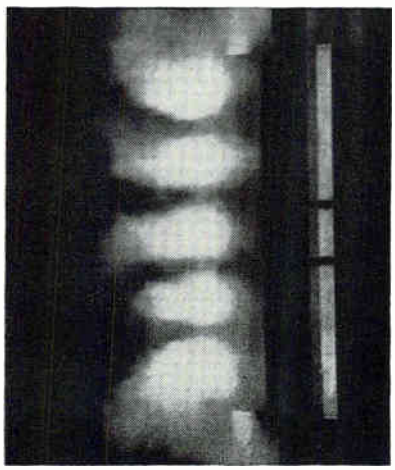


FIG. 2—Careful mechanical design and close dimensional tolerances permit nearly simultaneously firing of arc channels

Trigger capacitor voltage varies with number of pins fired even if current in a single gap is finally limited by circuit elements. One or more gaps may fire early because of time lag variations, with the energy loss causing a weak arc across late-firing pins or non-firing of pins. This problem can be overcome using cable lengths that delay the voltage pulse more than t.

Original voltage across the main electrodes is 5 to 10 percent below breakdown. Almost simultaneous triggering creates the plasma cloud shown in Fig. 2, which effectively shortens the gap and enables the original voltage to initiate breakdown.

The breakdown mechanism cannot actually be separated as described, but if field inhomogeneities resulting from space charges and irradiative effects are considered, a time lag of about 10^{-7} second can be expected. As breakdown is approached, a larger plasma cloud is created; t_s and t_f are shortened, increasing the prob-



Capacitor bank is discharged through five arc channels simultaneously in high-current switch

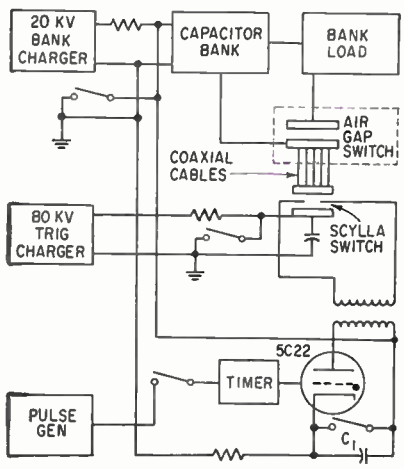


FIG. 1—Capacitor bank supplies energy to discharge tube that produces dense plasmas

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PR 15-10M	0-15	0-10	1	3½	19	13⅞	$345.00
PR 38-5M	0-38	0-5	2	3½	19	13⅞	$325.00
PR 80-2.5M	0-80	0-2.5	1.5	3½	19	13⅞	$325.00
PR 155-1M	0-155	0-1	1	3½	19	13⅞	$325.00
PR 310-0.6M	0-310	0-0.6	0.5	3½	19	13⅞	$345.00
PR 15-30M	0-15	0-30	4	7	19	13⅞	$495.00
PR 38-15M	0-38	0-15	2	7	19	13⅞	$475.00
PR 80-8M	0-80	0-8	1.5	7	19	13⅞	$450.00
PR 155-4M	0-155	0-4	1	7	19	13⅞	$430.00
PR 310-2M	0-310	0-2	0.5	7	19	13⅞	$430.00

Model PR 15-10M

Model PR 15-30M

REGULATION:

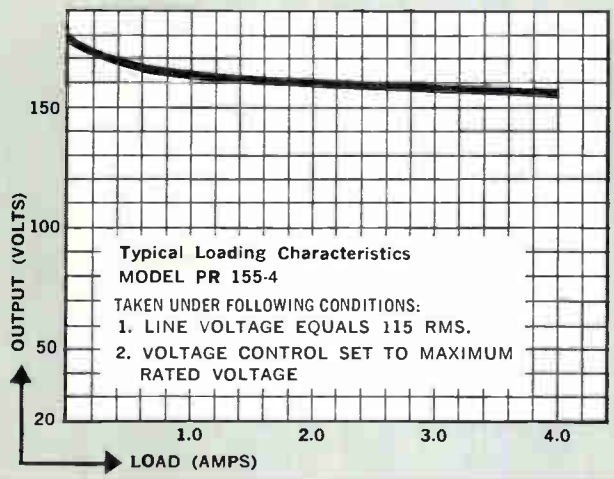
LINE: ±1% for 115±10 v ac line change at any output voltage within specified range.

LOAD — *at maximum output voltage:*

Less than 2% output voltage change for 50-100% load change (3% for PR 15-10M and PR 15-30M).

Less than 4% output voltage change for 25-100% load change (6% for PR 15-10M and PR 15-30M).

(See Graph below for typical load characteristics)



PR GROUP FEATURES:

"FLUX-O-TRAN" CONSTANT VOLTAGE TRANSFORMER:
Delivers regulated square-wave voltage to rectifier, improving rectifier utilization, and reducing output ripple.

ADJUSTABLE WIDE-RANGE OUTPUT:
Continuously variable voltage control permits output settings from 0 to maximum rating.

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Special "Flux-O-Tran" transformer and DC overload circuit breaker allow output to be shorted without damage to unit. Ideal for lighting lamps and charging capacitive loads.

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Reliable, efficient, full-wave rectification.

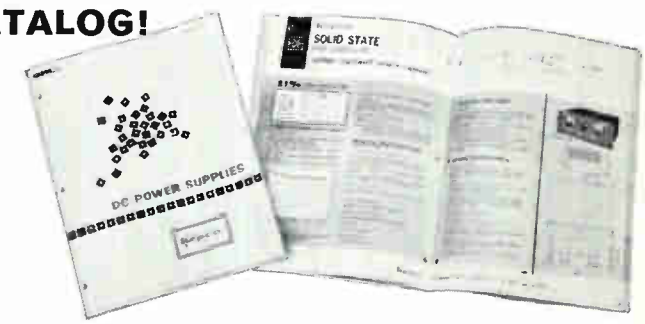
CAPACITIVE FILTERING:
Provides excellent ripple reduction and minimizes transient response characteristics.

NO VOLTAGE OVERSHOOT:
No output voltage overshoot from turn-on, turn-off or power failure.

NEW 32 PAGE POWER SUPPLY CATALOG!

Featuring:

- 11 Kepco design groups including new "SM", "HB", and "PR" models.
- Separate listing and description of programmable current/voltage regulated models.
- Special nomograph of voltage drop vs. wire size and supply current.
- *Dual index to all models:*
  by DESIGN GROUP (inside front cover);
  by OUTPUT VOLTAGE (inside rear cover).



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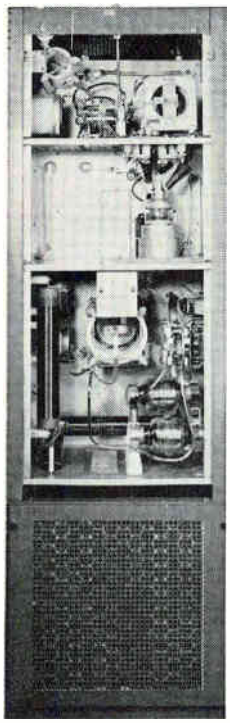

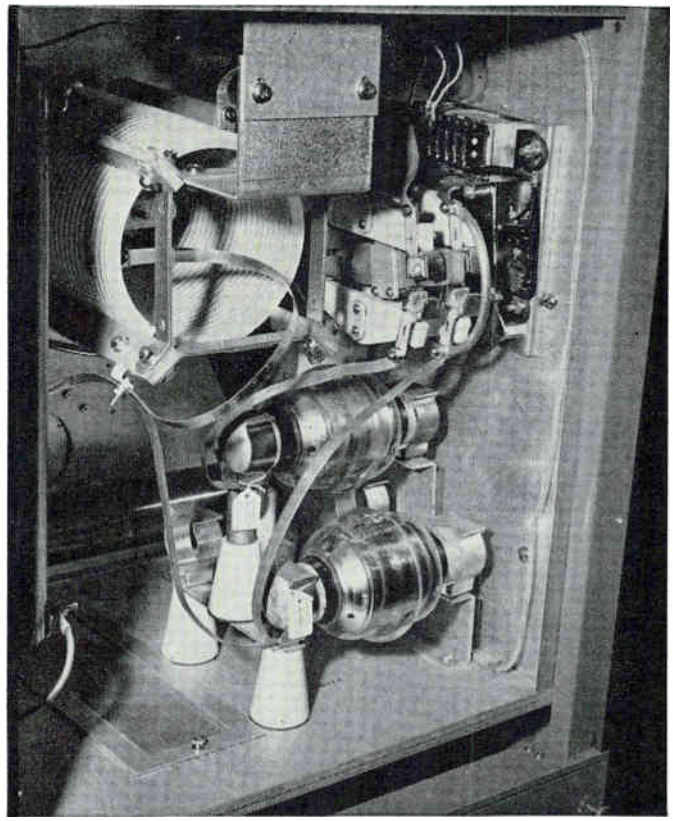

Gates Radio Company Broadcast Transmitter utilizing Jennings type M-100 and M-750 Vacuum Fixed Capacitors.

JENNINGS VACUUM CAPACITORS

FOR ELECTRONIC ENGINEERS WHO WANT COMPACT EFFICIENCY

► OR HIGHER CURRENT RATING ► OR LOWER INDUCTIVE LOSSES

Witness how Gates Radio Company has created a smaller, more efficient transmitter through the use of these high voltage fixed vacuum capacitors. Vacuum dielectric results in very low dielectric losses thus making capacitors more efficient. All copper construction and large surface area permits high current ratings. And, most important, unlike other types of capacitors, vacuum capacitors are self healing after moderate overloads.

Jennings also manufactures a complete line of variable vacuum capacitors. Their vacuum dielectric permits a maximum amount of capacitance at high voltages to be packed into an extremely small physical space, thus reducing inductive losses. They also feature the lowest minimum capacities and highest maximum to minimum ratio of capacitance change attainable anywhere.

Catalog literature of Jennings complete line of vacuum capacitors is available upon request.

RELIABILITY MEANS VACUUM / VACUUM MEANS Jennings®

JENNINGS RADIO MFG. CORP., 970 McLAUGHLIN AVE., SAN JOSE 8, CALIF., PHONE CYpress 2-4025

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ability of equal current distribution in the air-gap switch.

The application required knowledge of high-frequency noise produced by the switch, which was monitored when trigger only and when trigger and bank were fired. The trigger produced most noise. From 0 to 20 Mc, noise level was higher at 110 and 600 Kc and about 4 Mc. The lower two are natural ringing frequencies of the bank and trigger circuit and the third results from plasma oscillation.

Polar Relay Adaptor Corrects Coil Polarity

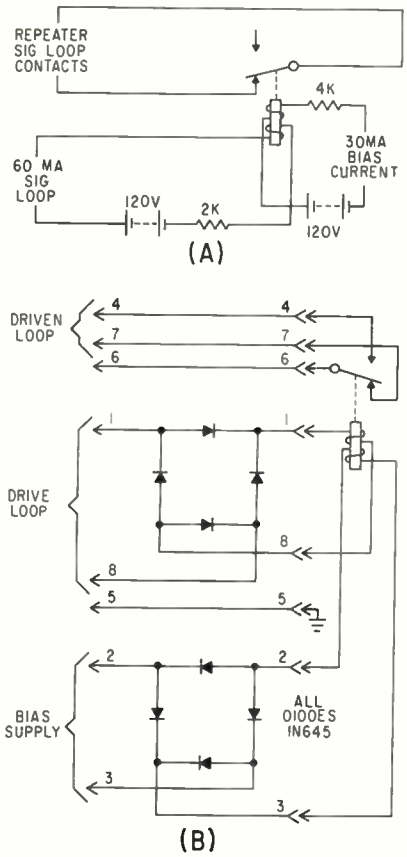
By R. E. PAFENBERG, Arlington, Va.

POLARITY-CORRECTING adaptor for polar relays was designed for neutral signal operation in teletypewriter communications systems. The adaptor, which fits into a standard octal socket and accepts the octal base of the relay, is also suitable for other applications of polar relays. Derated silicon diodes in bridge circuits ensure correct polarity of both coils.

Polar relays are used almost universally as teletypewriter signaling relays. In neutral or on-off signal operation, which is standard in many large teletypewriter communications systems, one of the dual windings is supplied with a fixed bias current. Signal current of the correct polarity is fed through the other winding. One requirement for distortion-free operation is a ratio of signal current to bias current of 2:1 to overcome flux of the bias winding and of the permanent magnets in the relay.

A variety of equipments are often used in teletypewriter central offices with input and output configurations that are not always compatible. Also, different transmission standards may be encountered among central offices and other elements of the same facility. In such cases, circuits are usually isolated by repeater relays. A typical teletypewriter signal circuit is shown at (A) in the figure. Resistance values include that of the current-limiting resistors, the loop and the relay windings.

Operating flexibility in these systems is often obtained with



Polar relay (A) in typical neutral-signal teletypewriter circuit is protected (B) by two diode bridges

patch boards, although permanent and semipermanent circuit changes are also accomplished by strapping signal cable distribution frames. Deficiencies in sytems engineering, reversing conductors in cable splices and frame strapping can result in reversing polarity in signal circuits. These conditions are often corrected temporarily by reversed patch cords or similar expedients. Although these measures are generally effective, they can increase equipment down time and deviations from usual practice can confuse operating personnel.

The circuit at (B) in the figure ensures that bias and signal current to the relay in neutral signal systems is of the correct polarity. The two diode bridges permit current to flow in only one direction in each of the two relay windings. Miniature silicon diodes permit compact packaging of the circuit, and because their voltage and current ratings far exceed expected values, they add to reliability.

The adaptor unit has been tested on circuits at 60 and 100 words per minute with no deterioration in relay performance.

In jeder Sprache, wo auch immer,
ist die Bedeutung die gleiche. Präzision oder Precision, als Wort und als Handelsmarke, ist der Schlüssel zu den höchsten Wertmasstäben in der Magnetbandaufzeichnung. Precision Bandgeräte bieten beispiellose Genauigkeit, Verlässlichkeit und Vielseitigkeit in der Aufzeichnung von wissenschaftlichen Daten und benötigen dennoch bei weitem weniger Platz, Strom und Fürsorge als gewöhnliche Bandgeräte. Fordern Sie Einzelheiten an—in jeder Sprache!
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la définition est la même. Le mot, le marque Précision est synonyme des plus hauts standards d'opération en enregistrement sur bande magnétique. Les enregistreurs "Précision" offrent une exactitude, une sûreté et une souplesse hors-concours dans l'acquisition de données scientifiques. Pourtant les exigences d'encombrement, de puissance ou d'entretien sont moindre que des appareils d'enregistrement conventionnels. Demandez-nous des détails, en n'importe quelle langue!
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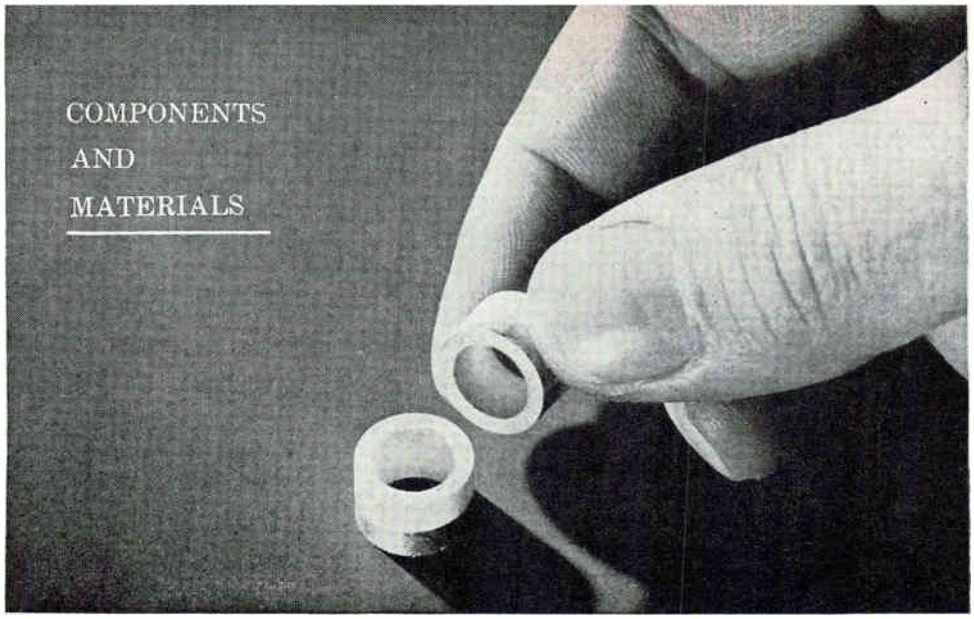


Beryllia cylinders have thermal conductivity greater than cast aluminum, very low loss tangent at microwave frequencies. Significance: Cement cylinders into power transistors to operate at power ratings required, forget weight and size hitch

Overcoming the Heat and Insulation Rub

By PATRICK E. LANNAN,
Vice President, Frontier Electronics Co
Cleveland 9, Ohio

THE SMALL PAYLOAD of a high-altitude sounding rocket posed a cooling and insulation problem for a tracking transmitter required to broadcast a continuous vhf signal for at least 20 minutes.

Rocket specification for the electronics sought a battery-powered transmitter with a power output of 300 milliwatt that would fit into a space less than 16 cubic inches, and would weigh less than one pound including battery.

This requirement was met by Frontier Electronics with the help of materials engineers at Brush Beryllium. They came up with a miniature telemetering transmitter that weighs only 17 oz, and occupies a volume of 10.4 cu in. Three tiny beryllium oxide cylinders, see photo above, solved the heat problems created by the electronic circuit confined in this small space.

Design of the transmitter is based on an oscillator operating at one-half the frequency or from 112.5 Mc to 122.5 Mc, and doubling in output to obtain power in the 225 Mc to 245 Mc band.

The crystal oscillator uses a fifth overtone crystal in the base of the transistor, and the collector is tuned to the crystal frequency. The collector supply voltage is regulated to improve stability with battery life.

A driver amplifier is used to isolate the power amplifier from the oscillator and improve stability. The output of the transistor oscillator can be 75 milliwatt, and could be used directly if loading were no problem. The power amplifier uses two 2N1141 transistors in parallel and operates the crystal frequency.

The power amplifier provides a power output of 500 milliwatt at the crystal frequency and utilizes a common base configuration, as does the driver amplifier. Frequency doubling is accomplished by a voltage variable capacitor or varactor, a nonlinear device whose capacitance varies according to the instantaneous voltage dropped across it.

The highly nonsinusoidal output waveshape enriches the harmonics and the tank is tuned to the second harmonic of the oscillator frequency. Filter circuits are then used to eliminate a fundamental frequency as well as higher order harmonics. The power output is then at least 300 milliwatts at the desired frequency, and less than one microwatt at any other frequency.

Each of the transistor circuits is operated in grounded base configuration, whereas the r-f transistors are internally connected collector to shell or case.

Since the collector is operated at the r-f frequency, the case must be insulated from ground with a low loss, high-temperature material.

Frontier engineers had to find a suitable material that could dissipate heat. Since neither a fan or convection cooling could be used in this small space, the heat from the transistor case must be conducted to the chassis and exterior case to operate the transistors at the required power ratings.

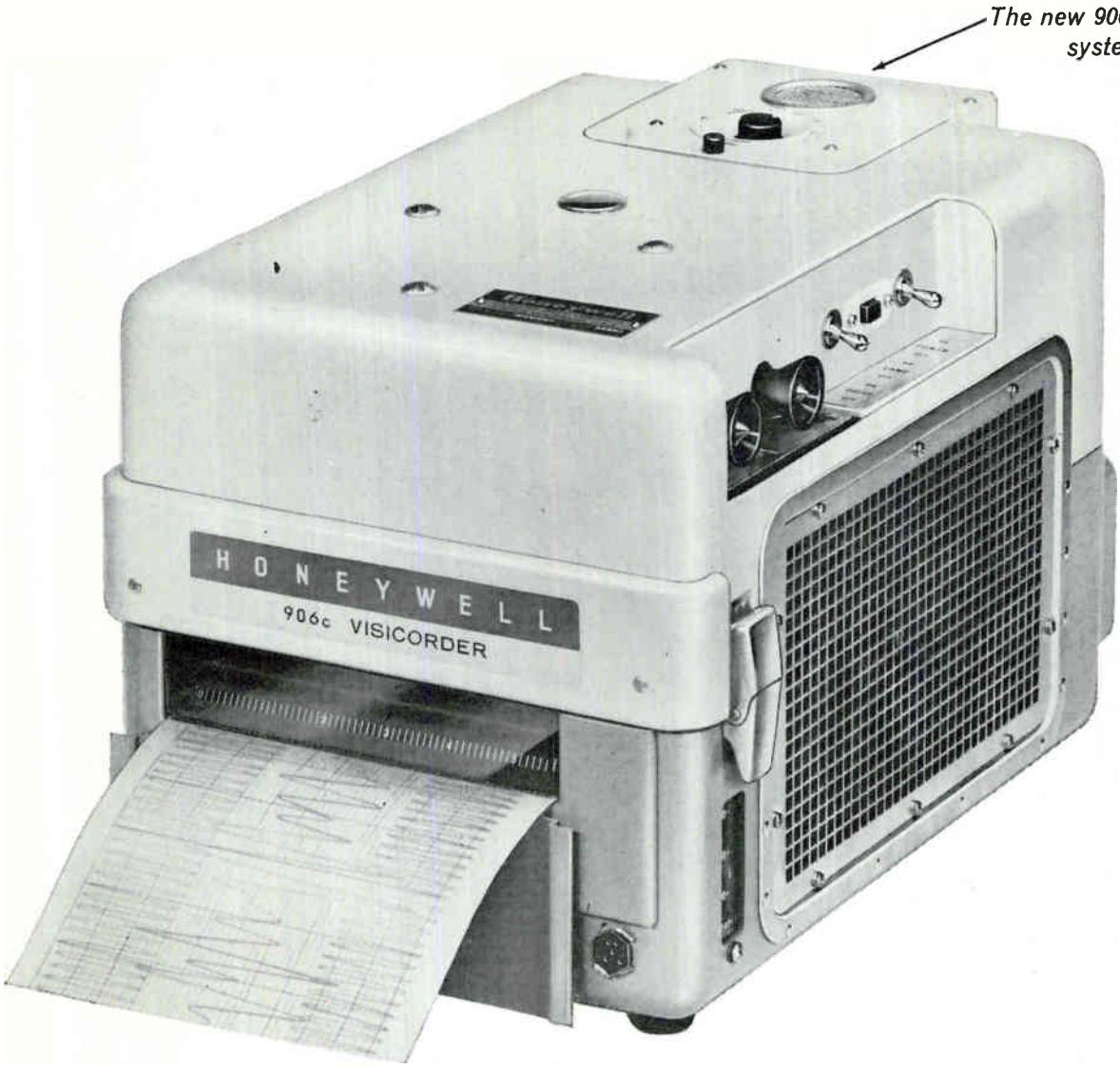
Ordinarily, the transistor case is connected to a metal heat sink, such as cast aluminum, to radiate this excess of power. At these frequencies however, such a radiator would put an excess of capacitance across the tank circuit, in addition to increasing weight and size.

This dilemma was solved by using beryllia, molded and ground to the desired shape. This material has a thermal conductivity of 0.58 cal/sec/cm per deg. C, measured at 25 C. This is greater than aluminum, and at the same time has a

PROPERTIES OF BERYLLIA

Specific gravity	3.008
Melting point, deg F	4658
Specific heat, btu/lb/deg F	0.24
Thermal conduct, btu/hr/ft²/F/ft.	125
Coef of expan, in/in/F x 10^{-6}, room temp to 500F	4.4
Compress strength, psi	114,000
Tensile strength, psi	18,000
Modulus of rupture, psi	35,000
Modulus of elasticity, psi x 10^6	45
Dielectric const, 10^7 cps	5.9
Loss factor, 10^7 cps	0.0004

room temperature values



What's *different* about the NEW 906C VISICORDER OSCILLOGRAPH?

At first glance you may see no difference at all. Just the same functional lines and compact size that you have come to recognize in the Visicorder.

They have not changed since 1956, when the Visicorder principle of oscillography made immediate readout of high frequency data possible for the first time.

Until now, all the improvements that have maintained the Visicorder's record of leadership have been internal:

—increased capacity to 14 channels
—higher frequency response (0-5000 cps)
—simultaneously recorded grid lines
—self-starting lamp for remote operation

But the 906C has a new feature you *can* see, (look carefully at the back of the case) and one that represents still another breakthrough; a built-in flash tube timing system which not only generates its own time base, but which can also be triggered *externally*. You can, in other words, use the 906C's timing system to record time lines simultaneously with data. Or you can trigger the timing circuit externally—either by supplying a pulsing voltage of only +10v into 20K ohms impedance, or simply by causing impedance to drop to 100 ohms or less through shorting-out or other means.

Thus your "time" signal may actually be an event marker related to shaft rotation, belt movement, or any other effect which might be more conveniently fed to the timing circuit than to a galvanometer.

(Owners of Visicorders 906, 906A, and 906B will be glad to know that only a *field-change* is necessary to economically and easily add this timing system to their instruments).

Write today for full information on the brand-new 906C Visicorder. Ask for Catalog HC-906C. Or call us at SKyline 6-3681, Direct Distance Dialing Code 303.

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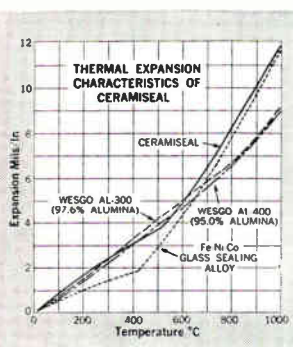

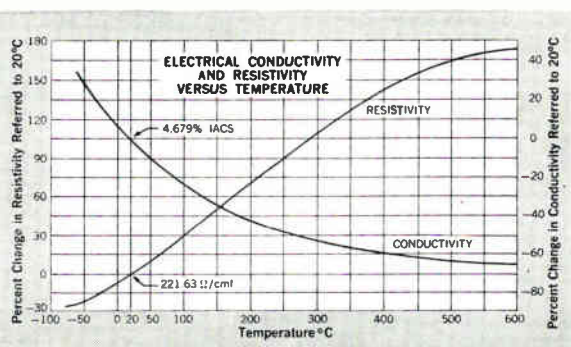

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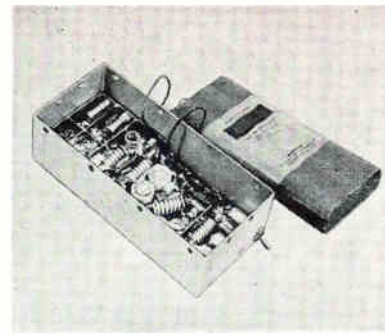


Telemetering transmitter weighs 17 oz, measures 1 7/16 in. × 2 3/16 in. × 4 3/4 in.

very low loss tangent at microwave frequencies well beyond the required loss tangent at the 245-Mc frequency.

When it was first determined that beryllia might be satisfactory for this purpose, the requirements were explained to engineers at the Brush Beryllium Co. Intrigued with the possibilities of using beryllium oxide in this application, research sample units were manufactured for test.

The initial results were rewarding, since the transistors could now be operated at much higher dissipation level than previously, and the loss of power due to dielectric losses in the material were almost nonexistent. A second series of samples were produced which were ground on their inside dimension to the outside dimension of the transistor case, and the units were metallized on one surface, so that they could be soldered to the case proper.

The transistors were cemented into the beryllium oxide cylinder to improve heat dissipation. These units proved satisfactory and final prototype models were fabricated using this type of heat sink.

The dissipation in the power output transistors was increased to that which would be allowed using metal heat sinks, while maintaining the collector and therefore the case above ground.

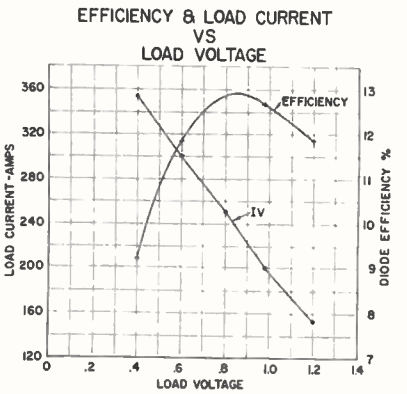
Thermionic Diode Tested For High Performance

SIGNIFICANT ADVANCES in thermionic power systems for space applications were reported by Tapco New Devices Laboratories of Thompson Ramo Wooldridge, Inc.

A recent thermionic converter design delivered an actual efficiency of 13 percent at the 200-watt power level. In other tests under the same contract, a different approach to solar concentrator fabrication produced high solar concentration efficiencies.

Performance curves for the thermionic converter are shown in the graph.

The thermionic converter, currently undergoing tests, is electron bombardment heated. Since the efficiency figure shown in the graph is an actual efficiency, exclusion of

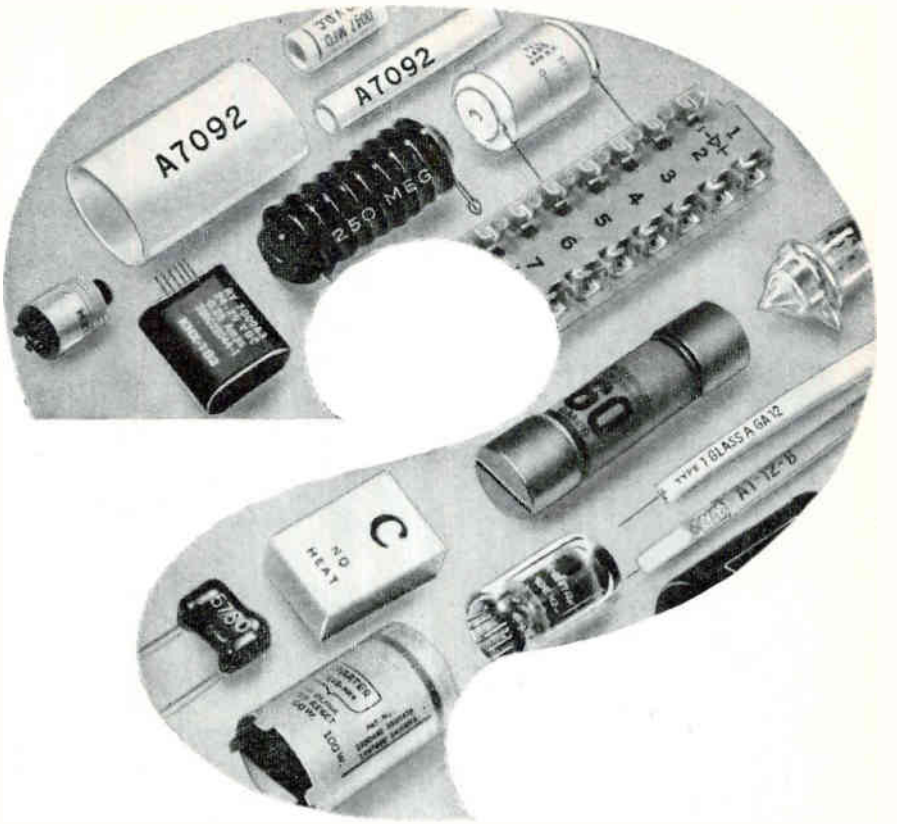


Performance curves of thermionic converter

Bell jar simulates space environment for thermionic converter, here shown undergoing performance test at Tapco

calculated losses associated with this method of heating means that a corrected converter efficiency in excess of 15 percent was obtained.

The high power, lightweight device was produced by Thermo Electron Engineering Corporation under a subcontract to TRW.



practical answers to your marking problems

This 12-page booklet explains how the electrical or electronic product *you* make can be marked — at production speeds — with clear imprints that hold. Are you looking for a way to mark odd shapes — a *practical* short-run marking method — an ink that will hold on an unusual surface, or withstand temperature, handling, moisture or other conditions? This catalog describes machines, printing elements and inks that will meet *your* requirements in the marking of products ranging from subminiature components to panels and chassis. There are special sections with practical answers to color banding, Underwriters' Laboratories manifest label legend marking, tape and label printing, wire and tube marking, efficient "in-line" marking. For your copy of the Markem Electrical Catalog, write Markem Machine Co., Electrical Division, Keene 5, New Hampshire.

MARKEM

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Slides Guide and Control Board Assembly

Projector mounted on tripod gives assembler a one-to-one image of the assembly

MILITARY SYSTEMS PRODUCTION today often requires the rapid output of many small lots of varying assemblies, subject to frequent change orders. In turn, production techniques stress simplicity, versatility and speed with accuracy. If basic setups or equipment can be used repeatedly, operators' learning times for any single assembly are minimized.

A technique satisfying these requirements is used by the York Division of the Bendix Corporation, York, Pa. It was initially devised to guide assembly of printed wiring boards for military computer units produced intermittently. Each run required varying quantities of 580 boards. Engineering changes between runs made board stockpiling impractical and also required a safeguard against production of obsolete boards.

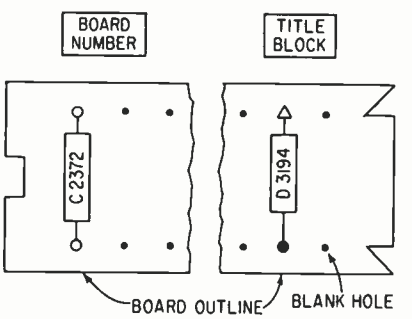
The company uses slide projectors to show assemblers the type and location of components in the assemblies. But unlike conventional visual aids which primarily instruct assemblers, Bendix-York makes the slides an integral part of production processes and controls. The slides make it unnecessary for assemblers to use model boards, assembly drawings or schematics. The projected view becomes the model for assembly and inspection. Slide filing and modification routines prevent production of obsolete boards.

Boards for the computer were made in four standard component insertion hole patterns, which satisfied component positions for all 580 boards. This simplified production in this case; positions not needed for a specific circuit were merely left blank on the board and the corresponding slide. The techniques are adaptable to other cases.

Board outlines and component hole positions are printed in black on white cards, four times actual size. The card margin contains a box for the board number and a title block for the slide number, issue date, revision and date, system number and change level.

Component outlines are rubber-stamped in position and component numbers are stamped inside the component outlines. The component numbers include an identifying letter (*D* for diode, *R* for resistor, etc.) and the significant digits. Part polarity is shown by a triangle facing the appropriate lead end, as in the sketch.

Slides are filed in indexed boxes



Sketch shows how master cards are prepared

The master is photographed on 35 mm film and the negative is taped between glass plates and used as a slide. The slides are filed in a box. The location of each slide and any changes made to the slide are noted on an index inside the file box cover.

Each assembly station is provided with a slide projector, mounted on a tripod so projection is down onto the top of the work table. The assembler has a blank printed wiring board painted white and a movable rack which holds several boards. The top of the rack is raised so leads can be inserted in the boards.

When an assembler receives a production order, he takes the corresponding slide from the file box and puts it in the projector. The image falls exactly on the dummy white board (projector height is set in advance). Since the slide is a negative, the assembler sees a bright white-on-white pattern on the board.

The assembler notes the position and part number of each component on the white board and places the same part in the boards on the rack. After inserting the components, he moves the rack so each production board comes under the projector. He then observes whether the projected components and polarities coincide with the assembly.

After each use, the slide is returned to the file box. If an engineering change is to be made, the slide is pulled from the box by the process engineering department. The master sheet is pulled from the master file. White paper is pasted over the area to be changed on the master. The master is restamped, changes are noted on the title block and a new slide is made and

Opportunities for:

Aerospace Vehicles Engineers

The Aerospace Vehicles Laboratory of the Space Systems Division has openings for nearly one hundred engineers who have experience in stress, structures, propulsion, mechanisms, control systems, equipment installation or heat transfer which can be applied to advanced aerospace weapons systems or vehicles. The Aerospace Laboratory is concerned, as a result of SURVEYOR and other contracts, with lunar and space exploration, air to air missiles and ICBM defense systems. The openings are for both junior and senior mechanical engineers, electronic engineers, physicists and aeronautical engineers. Some of the openings are described below:

Structures

Senior Dynamicist. Must be capable of performing advanced analysis in structural mechanics. Will be required to calculate response of complex elastic systems to various dynamic inputs including random excitation. Must be capable of original work in developing advanced analytical techniques.

Loads Analyst. To establish structural design criteria for advanced missiles and spacecraft. Should be capable of determining external airload and inertial force distributions.

Reliability Analyst. To perform statistical analysis of structural loads and strength properties for the purpose of establishing structural reliability criteria on a probability basis.

Stress Analyst. To perform advanced stress analysis of complex and redundant missile and spacecraft structures. Will be required to solve special problems in elasticity, plasticity, short time creep and structural stability.

Design. Experience is required in preliminary and final structural engineering and design, including preliminary stress analysis. A knowledge of the effects of extreme temperature environment and hand vacuum, plus a background in materials is desired.

Heat Transfer

Space Vehicle Heat Transfer. Basic knowledge of radiation conduction and convection heat transfer with application to thermal control of space vehicles is required. Knowledge of spectrally-selective radiation coating, super-insulations and thermal vacuum testing is of particular value.

Aerothermodynamicist. Experience in hypersonic real gas dynamics, heat transfer, abalation; re-entry vehicle design, detection; shock layer, wake and rocket exhaust ionization; and anti-missile system requirements will be most useful.

Equipment Installation

Packaging and Installation Engineer. To perform optimum packaging and installation design for missile and/or spacecraft units, considering amount and geometric shape of space available as well as weight and center of gravity distribution requirements. Must be capable of analyzing structural adequacy of unit under extreme environmental conditions.

Controls

Optical Devices. Design, development, procurement and test operations are involved. Considerable experience in the field of optical devices for space applications such as star, horizon, sun and moon trackers.

System Test. To plan and supervise the operations of a flight control system laboratory. Air bearing tables and a wide variety of optical mechanical and electrical equipment are involved.

Control System Analysis. Requires engineers at various levels of experience including senior men capable of taking over-all project responsibility in the synthesis and analysis of control systems.

Circuit Design and Development. Experience in design and development of transistorized control system circuits, including various types of electronic switching and modulation techniques is required.

If you are a graduate mechanical engineer, electronic engineer, physicist or aeronautical engineer, with experience applicable to the above openings, please airmail your resume to: **Dr. F. P. Adler,** Manager, Space Systems Division, Hughes Aircraft Company, 11940 W. Jefferson Blvd., Culver City 61, California.

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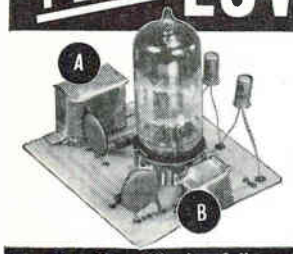
SPACE SYSTEMS DIVISION

MINIATURIZATION PLUS LOWER COST



Thin Versatile Co-Netic and Netic Magnetic Shielding Foils

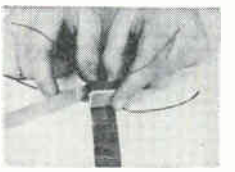
Permit positioning foil-wrapped components A & B closely, minimizing interaction due to magnetic fields . . . making possible compact and less costly systems.

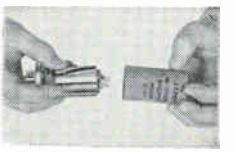
How thin Co-Netic and Netic foils lower your magnetic shielding costs:
1) Weight reduction. Less shielding material is used because foils (a) are only .004" thick and (b) cut and contour easily.
2) Odd shaped and hard-to-get-at components are readily shielded, saving valuable time, minimizing tooling costs.

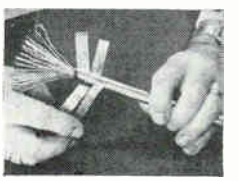
These foils are non-shock sensitive, non-retentive, require no periodic annealing. When grounded, they effectively shield electrostatic and magnetic fields over a wide range of intensities. Both foils available from stock in any desired length in various widths.

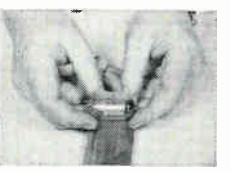
Co-Netic and Netic foils are successfully solving many types of electronic circuitry magnetic shielding problems for commercial, military and laboratory applications. These foils can be your short cut in solving magnetic problems.


Cuts readily to any shape with ordinary scissors.


Wraps easily.


Inserts readily to convert existing non-shielding enclosures.

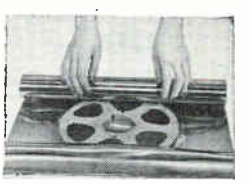

Shielding cables reduces magnetic radiation or pickup.


Wrapping tubes prevents outside magnetic interference.

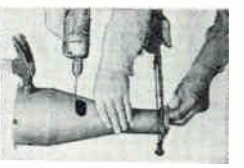
PROTECT VITAL MAGNETIC TAPES

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 to 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

filed. Appropriate instructions are also sent to final assembly and test departments.

Once a change order has been received and a new slide is being prepared, an obsolete board cannot be produced. Assemblers cannot obtain the slide until the new one is placed in the file box and, as noted above, there are no drawings on the line.

A visual aid similar to the master card is used to guide terminal insertion before board assembly. Instead of making a slide, terminal positions are stamped in black and the card is given to the terminal inserter. For wiring, wire color and length are noted. For board-to-board wiring in unit frames, vertical black lines represent board edges. Lighter, horizontal lines indicate wire routes and terminations.

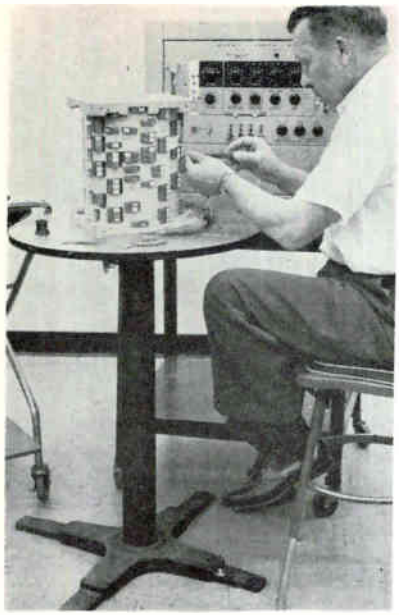

Cards guide terminal or eyelet installation

Table and Bar Stool Make Assembly Stand

ROTATING STAND, made from a restaurant table base and bar stool parts, is used by Litton Systems Inc., Woodland Hills, Calif., in the assembly of magnetic storage drums.

A leveler built into the cast-iron table base prevents wobble. The swivel mechanism of a bar stool, including arms which support the table top, is inserted into the table base column. Litton added a lock to hold the swivel at any position and made a round aluminum top, tapped for retaining bolts.

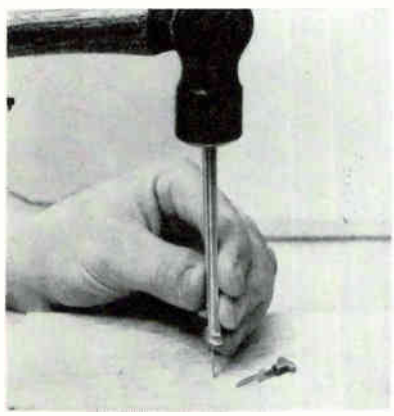
Drums are bolted to the top and passed from one assembly or test operation to the next. The top is 24 inches in diameter, large enough to allow several assemblers to work on a 20-inch drum. The stand weighs 80 pounds and will carry up

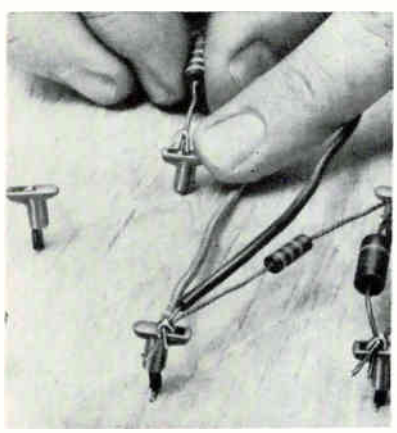


Technician mounts read/write heads on drum

to 250 pounds. It cost $79.50, including the lock, top and labor; lowest bid for a custom-built stand was $480.

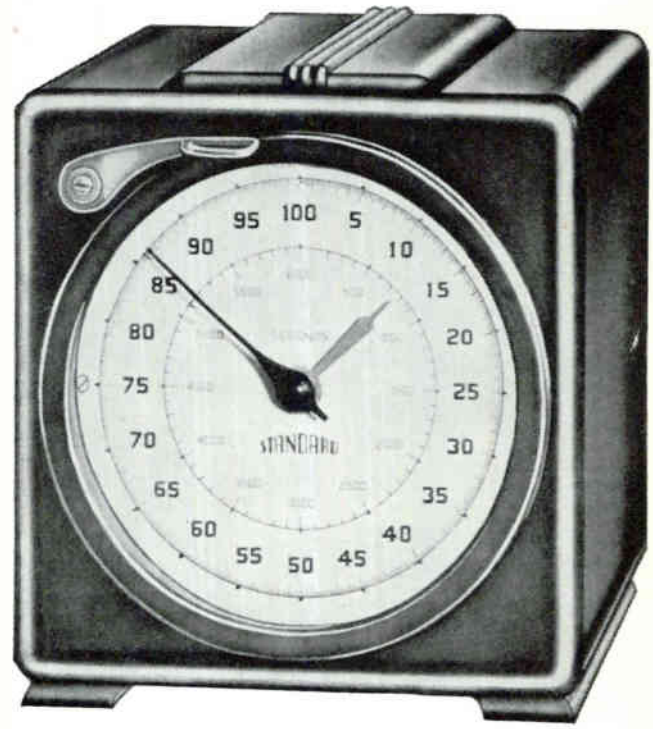
Nail Clip Connectors





Clip type connectors, which can be driven like a nail into harness boards or breadboards, are offered by E-Z-Hook Test Products, Covington, Ky. The clips are driven by an adaptor (top photo) and will hold four or more wires

THE ONE TIMER WITH ALL THE FEATURES...



STANDARD TRADEMARK

Only in a STANDARD instrument do you get all the features "most wanted" in an interval timer:

UNEXCELLED PRECISION—Consistent, continuous accuracy over years of use. Accuracy to ±.001 second available in standard models.

INSTANTANEOUS ELECTRIC RESET—A "must" in many instrument complexes—a plus benefit for all other applications.

PROVEN MECHANISM—Synchronous motor driven—electric clutch operated. Proved reliably accurate and dependable by years of service.

CHOICE OF CONTROL—Start, stop and reset can be manual, by electric circuit or output of electronic tubes.

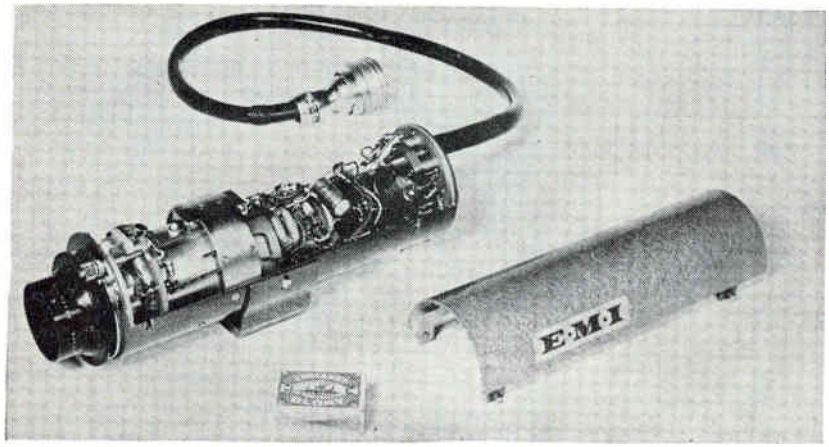
RANGE OF MODELS—Portable or panel mounting—in a wide selection of accuracies and ranges.

Request Catalog No. 198-B

THE STANDARD ELECTRIC TIME COMPANY
89 LOGAN ST., SPRINGFIELD, MASS.

CIRCLE 83 ON READER SERVICE CARD

New On The Market

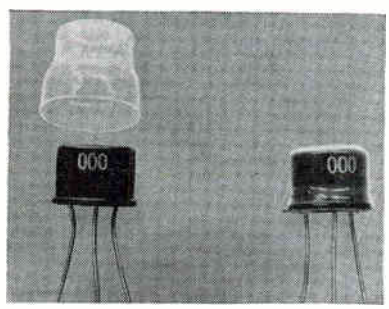


Small TV Camera

LESS THAN 3 IN. DIAMETER

CLOSED-CIRCUIT tv camera is 9 inches long and less than 3 inches in diameter. The Minicamera is small enough to scan the interior of a 3-inch pipe, or to fit into a hospital light fixture to observe an operation. Camera will operate without special protection in noise or vibration, such as wind tunnels and rocket motor testing sites. Only essential components are in the camera itself; others are housed in the control unit, which can be placed some distance away. Performance and picture quality remains as high as in a standard-size camera. The equipment is marketed exclusively in the U. S. by the Electronics Div. of Fairbanks, Morse & Co., 100 Electra Lane, N. Y., for EMI Electronics, Ltd.

CIRCLE 301 ON READER SERVICE CARD



Plastic Insulator

HEAT SHRINKING

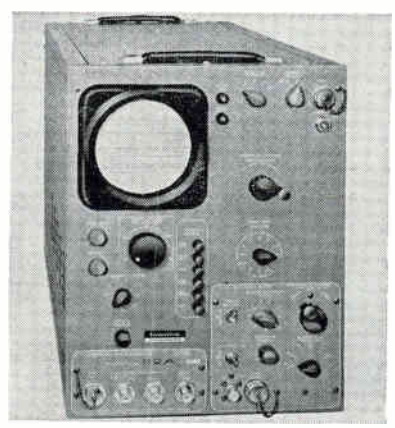
PREFORMED heat shrinkable sleeving fits standard case sizes of semiconductor devices. The formed sleeve is slipped over the case and locked into place by heating the lower part, causing it to shrink and form a skintight encapsulation. The preforms can be used for electrical or chemical insulation and a variety of sizes are available. Manufacturer is Rayclad Tubes Inc., Redwood City, Calif.

CIRCLE 302 ON READER SERVICE CARD

Sampling Oscilloscope

2 Gc BANDPASS

HIGH SPEED sampling oscilloscope has a rise time of less than 0.2 ns and an equivalent bandpass of approximately 2 Gc (6 db down) and 1.7 Gc (3 db down). Sensitivity is better than 3 mv per cm, noise is less than 600 μv; sweep rates to



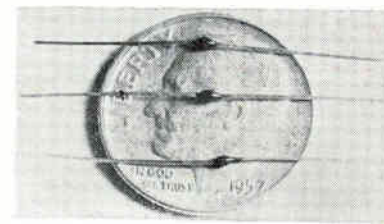
0.05 ns per cm. Model 112A permits display of kilomegacycle ringing and the switching characteristics of tunnel diodes and parametric amplifiers. Options available as built-in features include dual channel inputs, d-c coupled inputs, camera controls, step attenuator and X-Y recorder outputs. Price of basic instrument is $4,000, with delivery in 4 to 6 weeks, from Lumatron Electronics, Inc., New Hyde Park, N. Y.

CIRCLE 303 ON READER SERVICE CARD

Silicon Diodes

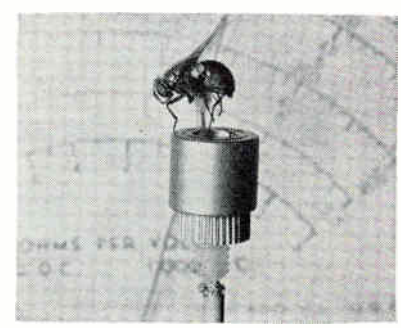
MINIATURES; PIV'S TO 100 V

SERIES of silicon microdiodes in microminiature packages exceed the most stringent military requirements for humidity resistance. The piv's range from 40 to 100 v; power



dissipation at room temperature is 250 mw; average rectified current rating is 75 ma. Manufacturer of MD04, MD06, MD08 and MD10 diodes is General Instrument Semiconductor Div., 65 Gouverneur St., Newark 4, N. J.

CIRCLE 304 ON READER SERVICE CARD



Piezoelectric Transducers

LOW-NOISE SENSOR

VARIABLE piezoelectric transducer can be used to measure shock velocity, blast pressure, compression and expansion wave durations, force, and other parameters. Wind tunnel testing, hydraulic pressure measurement, and rocket and missile tests are typical applications. The Variducer will withstand temperatures up to 300 C, can also be

Set the date you need any standard type coaxial cable on the job, and Chester will meet it . . . with from-stock shipments of one of the country's most complete lines of coaxial cable.

With Chester cable you can make a quick selection of exactly the right cable for each specific application. From micro-waves to missles . . . in conformance with military or commercial specifications . . . for military or commercial applications . . . there's a Chester cable tailored to **your** design and requirement.

For special cable problems, you can depend on Chester to custom-engineer the correct cable to meet your specifications. Select the type conductor, insulation, jacket, and armor which your requirements demand. But, be sure **you select Chester** for the cable "job-tailored" for you.

NEW, Chester's fact-packed coaxial cable selection guide. Write for your free copy.

CHESTER CABLE CORP.
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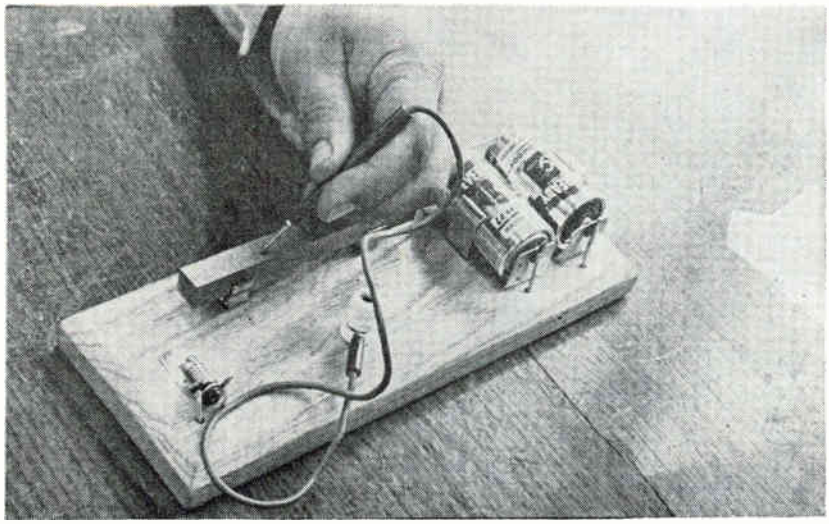
SPECIFY CHESTER WIRE AND CABLE FOR ALL YOUR ELECTRONIC EQUIPMENT NEEDS
Coaxial Cables • Hook-Up Wire • Multi-Conductor Cable • Appliance Wire • Audio Wire • Miniature Wire and Cable • High Voltage Wires • High Frequency Wires • Antenna Loop Wire • Annunciator Wire • Telephone Wires and Cables • Television Transmission Lines

prestressed to any level within its rating by a simple adjustment, before or after installation. The V-1 series uses barium-titanate sensors; the V-2 series use lead-zirconate for high temperature or high sensitivity applications. Prices begin at $100, with delivery in 30 days, from Mirax Chemical Products Corp., 4997 Fyler Ave., St. Louis 9, Mo.

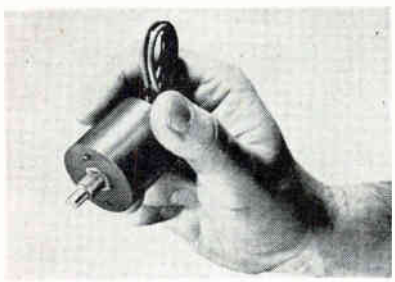
CIRCLE 305 ON READER SERVICE CARD



Conducting Plastic
HIGH CONDUCTIVITY

PLASTIC MATERIAL by Mesa Plastics Co. 12270 Nebraska Avenue, Los Angeles 25, Calif., has excellent conductivity. Photograph shows 3-volt bulb lighted by two 1½ volt batteries wired in series with a probe and a bar of the plastic. Applications of the material include waveguides, r-f connectors and electronic components. Pilot use has shown it is adapted to the production of printed circuits where a flush surface is desired.

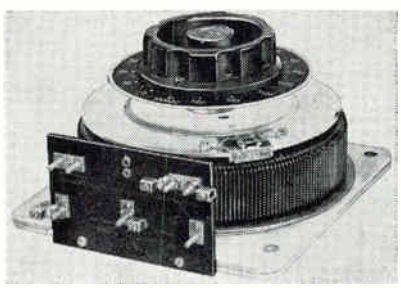
CIRCLE 306 ON READER SERVICE CARD



Encapsulated Potentiometer
EXPLOSION-PROOF

ENCAPSULATED molded-composition potentiometer is explosion-proof and waterproof. The R1 is rated at three watts for standard applications and two watts for military (MIL-R-94B). Maximum operating temperature is 125 C, with a life of 100,000 rotations under full load; resistances from 100 ohms to five megohms, ±10 percent. The potentiometer is 1½ × 1½ in., can be supplied with wire or lug terminations. Price is $2 to $10, four to eight week delivery, from Reon Resistor Corp., 155 Saw Mill River Rd., Yonkers, N. Y.

CIRCLE 307 ON READER SERVICE CARD



Autotransformers
30-AMPERE UNITS

GENERAL RADIO CO., West Concord, Mass. Type W30 Variac autotransformers are available in single and two- or three-gang combinations. Providing smooth, continuous, manual control of a-c voltage from zero to 17 percent above input line voltage, the units can be used in testing and development work, for variable lighting, temperature regulation, motor speed control and calibration, and adjustment of voltage in power supplies and aging racks.

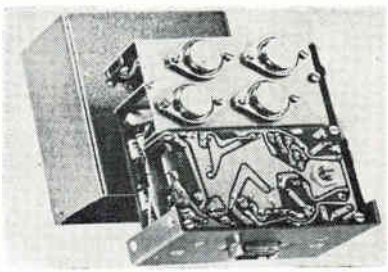
CIRCLE 308 ON READER SERVICE CARD

Size 5 Components
SYNCHROS ADDED

LINE OF SIZE 5 synchros, by Transicoil Div., Daystrom Inc., Worcester, Pa., completes a family of size 5 components.

Synchros have high accuracy, reliability and quality, meet applicable requirements of MIL-E-5272. Stainless steel housings offer protection from environmental extremes and insure stability of performance in spite of temperature fluctuations.

CIRCLE 309 ON READER SERVICE CARD



Operational Amplifier
HIGH-GAIN

BOONSHAFT AND FUCHS, INC., Hatboro Industrial Park, Hatboro, Pa. A solid-state chopper and oscillator in this all-transistorized amplifier provide for a stability of 10 μv in 24 hr. The TR-1 has a loop gain of 10^7. Output power from 0 cps to 1Kc is ± 50 v at 20 ma. For a ± 25 v output, current is 100 ma. Input impedance is approximately 1 megohm. Open loop output impedance is 250 ohms. For a loop gain of 10 (10:1 feedback) output impedance is 0.1 ohm.

CIRCLE 310 ON READER SERVICE CARD

Marking Inks
FOR COMPONENTS

WORNOW PROCESS PAINT CO., 1218 Long Beach Ave., Los Angeles 21, Calif. Wornowink, series M, is an

Reliable products depend on reliable parts

The worldwide success of Japan's transistor radios is a tribute to their highly efficient yet minute components, of which the ultra-small Mitsumi IFT Poly-vari-con is typical. With other superb Mitsumi parts, it is being extensively used by leading radio manufacturers.

For Transistor Radio Parts

I F T
Intermediate Frequency Transformer

POLY-VARI-CON
Variable Capacitor

Mitsumi Parts

MITSUMI ELECTRIC CO., LTD.
1056-1, Koadachi, Komae-cho, Kitatoma-gun, Tokyo, Japan

CIRCLE 203 ON READER SERVICE CARD

..HIGH VOLTAGE TESTING
of Electronic Cables, Components, Materials and Completed Assemblies

Mobile D-C HYPOT®

Rugged . . Mobile . . for Production, Installation and Maintenance Testing

Output . . 120 kv models provide up to 5000 microamperes d-c. 75 and 45 kv models offer up to 10 ma, d-c.

115v A-C Line . . Input through three-conductor power cord with standard two prong plug and grounding clip.

Self-Contained, Fully Portable . . Single mobile housing with rubber tired wheels and push handle contains metering circuitry and high voltage supply (oil immersed above 45 kv).

Safe, Simple Operation . . Direct reading of insulation leakage current. Fully interlocked, cabinet grounded, output cable shielded . . to protect operator and equipment.

. . for Every Application

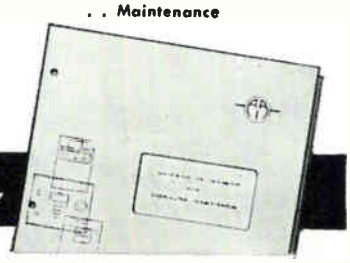
Heavy Duty HYPOTS®
A-C or D-C, to 150 kv.

Bench Type HYPOTS®
A-C to 35 kv, 2 kva
D-C to 45 kv, 25 ma

Mobile HYPOTS®
A-C to 30 kv, 10 kva
D-C to 120 kv, 10 ma

Portable HYPOTS®
A-C to 10 kv, 230 va
D-C to 5 kv, 2 ma

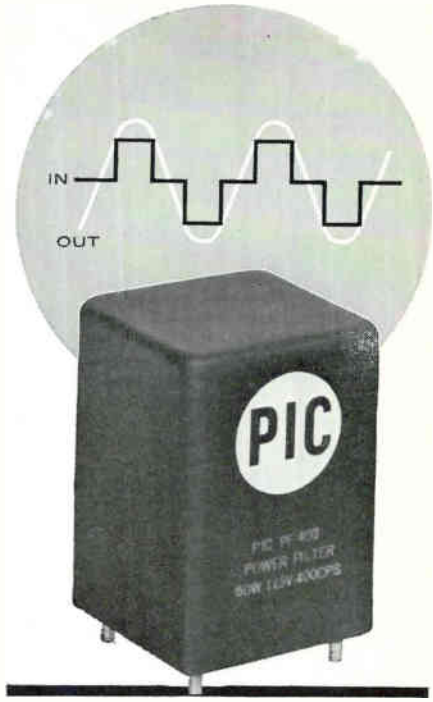
Write for Manual J-67
"Methods for Insulation Testing . . Engineering . . Production . . Maintenance



4-35.9

ASSOCIATED RESEARCH, Incorporated
"Electrical Testing Instruments Since 1934"
3781 W. Belmont Ave., Chicago 18, Illinois

CIRCLE 204 ON READER SERVICE CARD



PIC Power Filters
bring sine waves out of solid state inverters

Solid state inverters can now deliver 400 cps sine waves from DC power sources. PIC 120 volt, 400 cps power filters make this possible . . . in filter ratings from 15 watts to 1000 watts. These new filters change square waves, quasi-square waves, and other solid state inverter wave shapes into sine waves *containing less than 1% harmonic distortion* . . . with an efficiency of better than 90%.

Polyphase Instrument Company's series of PF400 power filters also eliminate harmonic distortion from 400 cps alternators. Stock filters handle a wide range of load power factors, and can be used in multiple to filter polyphase sources.

Get complete details from your Polyphase representative, or write directly to Filter Department, Polyphase Instrument Company, and ask for our Bulletin 77F.

POLYPHASE
PIC Instrument Company
Bridgeport, Penna.

PULSE TRANSFORMERS • FILTERS • DELAY LINES
MAGNETIC AMPLIFIERS • CUSTOM TRANSFORMERS • NETWORKS

CIRCLE 87 ON READER SERVICE CARD

When you install Hickory Brand I. M. Coaxial Cable, the need for spinning or supporting the cable to a separate messenger is completely eliminated! The high-strength, galvanized solid steel messenger is an integral part of the cable jacket and can be gripped, pulled and tensioned using standard techniques without breaking!

Conductor insulation and dielectric material is polyethylene for maximum operation efficiency making these cables especially adaptable to applications requiring high, very high and ultra-high frequencies.

If Hickory Brand Supported Coaxial Cables spark an idea for you, write us for advice and complete information today!

For FREE SAMPLE, send request on your letterhead to

HICKORY BRAND
Electronic Wires and Cables

Manufactured by
SUPERIOR CABLE CORPORATION, Hickory, North Carolina

4643

epoxy marking ink that provides good adhesion to glass, metal and thermosetting plastic surfaces with complete resistance to abrasion, solvents, chemicals, acids and alkalis. Cured inks will meet appropriate military specifications.

CIRCLE 311 ON READER SERVICE CARD

Microwave Oscillator

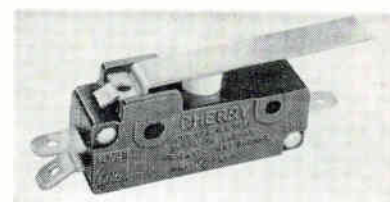
LABORATORY FOR ELECTRONICS INC., 1079 Commonwealth Ave., Boston 15, Mass. Microwave oscillator has a tunable frequency range of 2,000 to 2,500 Mc and short-term stability of five parts in 10^8.

CIRCLE 312 ON READER SERVICE CARD

Shock Recorder
STATISTICAL TYPE

INERTIA SWITCH INC., 311 W. 43rd St., New York 36, N. Y., announces a unidirectional, four channel statistical shock recorder. Range: each channel can be set anywhere between 1 and 25 g. Accuracy: ± 5 percent. Frequency response: 0-40 cps (min). Temperature range: − 65 F to + 250 F. Conforms to MIL-E-5272.

CIRCLE 313 ON READER SERVICE CARD

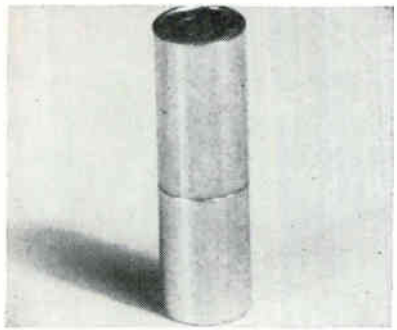


Snap-Action Switch
HINGED-LEVER ACTUATOR

CHERRY ELECTRICAL PRODUCTS CORP., West Deerfield Rd., Highland Park, Ill. Series E13-00H switch features low operating force hinged-lever actuator. Case-pivoted actuator arm is available with roller, straight lever with length and form variations for cam, roller or straight line actuation. Low cost basic switch design has standard

mounting holes. Terminals accept standard quick connect or solder wiring connections.

CIRCLE 314 ON READER SERVICE CARD



Coaxial Bolometers
FOR MICROWAVES

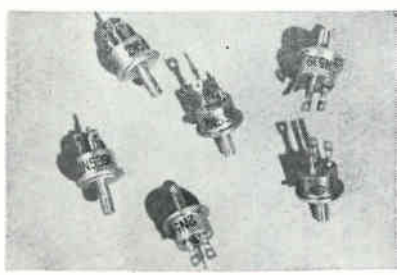
MICROWAVE SEMICONDUCTOR & INSTRUMENTS INC., 116-06 Myrtle Ave., Richmond Hill 18, N. Y. The 102 series of coaxial bolometers of the 1N26 type case is announced. Bias resistance values available are 200 and 100 ohms at either 8.75 or 4.5 ma. The bolometers give a true square law response curve of less than 1 percent up to 0.2 mw. Series is hermetically sealed and features gold plated contact surfaces.

CIRCLE 315 ON READER SERVICE CARD

Magnets

INDIANA GENERAL CORP., Indiana Steel Products Div., Valparaiso, Ind. Ceramic magnet material, Indox VI-A, for periodic-focused twt's has an intrinsic coercive force of 3,000 oersteds at room temperature.

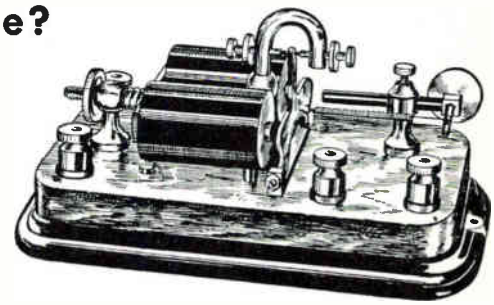
CIRCLE 316 ON READER SERVICE CARD



Power Transistors
SIX TYPES

CBS ELECTRONICS, 100 Endicott St., Danvers, Mass. Six medium power industrial transistors feature mix dissipation of 30 w at a base-mounting temperature of 25 C. Each

where have the simple relays gone?



Many, of course, have disappeared along with the relatively simple jobs they were asked to perform. (A good telegraph relay* or pulse repeater today, for example, should not only be small but able to transfer its contacts on a milliwatt or so about 500 times a second for half a billion operations — and then be repairable, adjustable and lovable besides.) But there are still plenty of naive, uncomplicated loads around that ask only to be switched on and off, at reasonable intervals, by a device that doesn't have so many parts and fancy thingamajigs that it may become temperamental and refuse to work without being coaxed.

For such applications we are happy to say we have a paragon of ingeniously simple, fool-proof relay design. It won't make the same confidence-inspiring noise as the classic above and it's not for telegraphy, but you can see through its enclosure and watch its contacts surely open and close. The designer *started* with the familiar enclosure and octal plug-in base and then developed the relay accordingly (with UL requirements in mind); he didn't just take an existing relay and tack on a new base and enclosure. As a result, the parts make the best use of the volume ($1\frac{5}{16}$" square x $2\frac{1}{16}$" high) and are big, simple, rugged and few in number. The base is specifically designed to carry the 10 amp. loads the relay will switch.

The relay is designated "Series 46" and intended for general purpose, heavy-duty DPDT switching on AC or DC inputs. Rated DC loads are 5 amps at 28 volts, 1 amp. at 120 volts; AC, 1200 volt-amperes per pole with 240-volt and 10-amp. maximums. Life ranges from 10 million operations with 1-amp. loads to half a million with 10-amp. loads. The relay can be as sensitive as 200 milliwatts DC, or 0.2 v-a AC.

We've looked at what else is available for the same modest price and the "46" specs give us considerable hope. If your problem has been the right specs but the wrong price, or vice-versa, perhaps you'd like the 46 AC and DC bulletins. In the meantime, always remember: You can be sure if it's Sigma, it's simple.

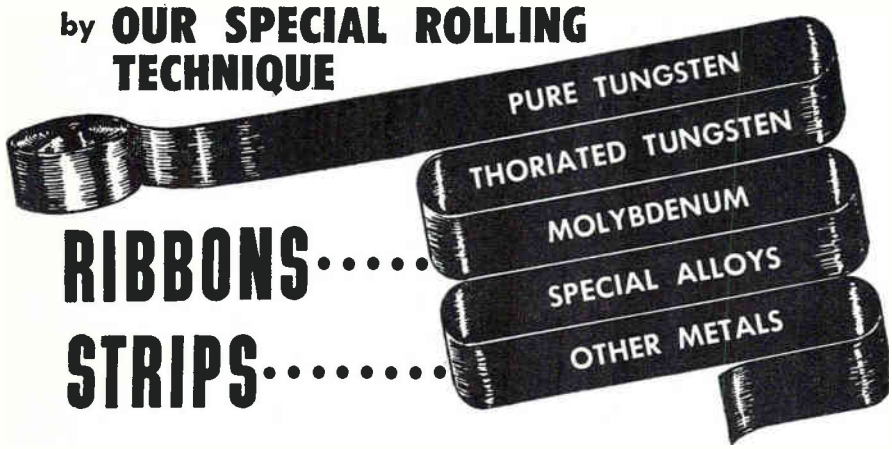
*Plug (octal, that is) for Sigma Series 72 relay

SIGMA

SIGMA INSTRUMENTS, INC.
62 PEARL ST., SO. BRAINTREE 85, MASS.

METALS for ELECTRONIC APPLICATION rolled ULTRA THIN

by OUR SPECIAL ROLLING TECHNIQUE



RIBBONS.....
STRIPS.....

TOLERANCES CLOSER THAN COMMERCIAL STANDARDS

Note: for highly engineered applications—strips of TUNGSTEN and some other metals can be supplied

rolled down to .0003 thickness

- **Finish: Roll Finish—Black or Cleaned**
- **Ribbons may be supplied in Mg. weights if required**

Developed and Manufactured by

H.CROSS CO.

3229 BERGENLINE AVE., UNION CITY, NEW JERSEY
Tele: Union City, N. J.: UN. 3-1134
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CIRCLE 205 ON READER SERVICE CARD

60 NOW ~~50~~ WATTS! IN A *DURABLE* SOLDERING PENCIL

EXTRA-LONG-LIFE ELEMENT
DOUBLE-LIFE CLAD TIP

Does the work of 100 watts yet weighs but 2 ounces!

New unique design in handle ventilation, plus stainless steel housing, insures a cool handle.

A new development makes possible a multi-coated copper tip which gives long life under the severe conditions brought about by the powerful 60 watt rating.

MODEL 24S—
Equipped with ¼" XTRADUR TIP for extra long life. Solder adheres to working surface only. No drip or creep.

WRITE FOR CATALOG
showing most complete line of Industrial Irons and Long-Life Clad Tips.

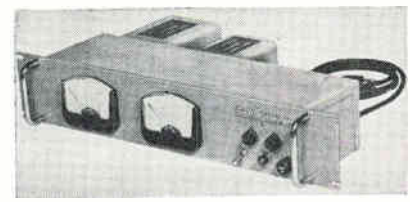
INDUSTRY'S No. 1
HEXACON
SOLDERING IRON

HEXACON ELECTRIC CO.
130 WEST CLAY AVENUE, ROSELLE PARK, N. J.

SERVING INDUSTRY FOR A QUARTER OF A CENTURY

weighs less than 5 grams and requires only ⅓ sq in. of chassis space. They are suitable for use in servo motor controls, power amplifiers, converters, regulated power supplies and low-speed power switches.

CIRCLE 317 ON READER SERVICE CARD



D-C Power Supplies
AND MODULES

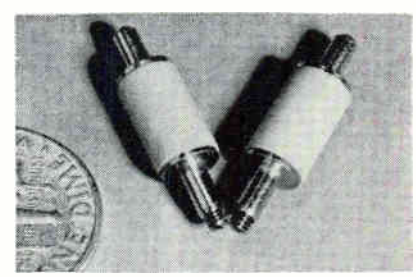
TECHNIPOWER INC., 18 Marshall St., South Norwalk, Conn. Line of d-c power supplies and modules can satisfy a wide variety of the component type applications found in laboratories, test equipment and finished product. It is possible to select a power supply that exactly fits the application in terms of voltage, power and regulation accuracy. The rugged modules are available in rack mounted configurations both metered and unmetered.

CIRCLE 318 ON READER SERVICE CARD

Tank Circuits

JFD ELECTRONICS CORP., 6101 Sixteenth Ave., Brooklyn 4, N. Y. Tank circuits offer tuning ranges from 165 to 1,000 Mc in five overlapping units.

CIRCLE 319 ON READER SERVICE CARD



Varactor
GALLIUM ARSENIDE

RAYTHEON CO., 215 First Ave., Needham, Mass. Gallium arsenide varactor is intended for use as a preamplifier in radar systems. It has a frequency cutoff of 150 Gc. Semiconductor properties of gallium arsenide permit h-f amplifica-

tion at higher levels and with less noise than found in similar parametric amplifiers employing silicon or germanium.

CIRCLE 320 ON READER SERVICE CARD

Conversion Hold Unit

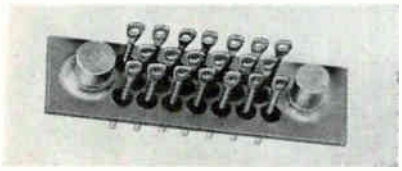
PACKARD BELL ELECTRONICS, 1905 Armacost Ave., Los Angeles 25, Calif. Unit samples a 1 μsec segment of incoming signal and holds result for conversion to digital representation.

CIRCLE 321 ON READER SERVICE CARD

Pulse Generator
PROGRAMMED TYPE

TEXAS INSTRUMENTS INC., P. O. Box 6027, Houston 6, Texas. Programmed pulse generator provides 10 pulse times with front panel controls for selecting any combination of these pulse times individually for each output. Up to 4 independent outputs can be provided. Repetition rate is up to 25 Mc; rise/fall times, less than 6 μsec; 0-5 v amplitude, continuous variable; output impedance, 93 ohms.

CIRCLE 322 ON READER SERVICE CARD



Hermetic Connectors
MICROMINIATURE

ESCON, INC., 735 Branch Ave., Providence, R. I. Type EHMM

LOOK HERE FOR ANSWERS TO YOUR RELAY PROBLEMS

IT'S WHAT'S INSIDE THAT COUNTS IN TIME DELAY RELAYS

Especially when milliseconds count! Note the printed circuit construction of Leach's optional output time delay relays. This economical line of off-the-shelf electronic units includes time delays on release and time delays on operate—in a timing range of 100 milliseconds to 60 seconds. These standard components are available with fixed or adjustable timing to meet your most critical requirements. And they're all 100% inspected during manufacture for highest reliability!

Bulletin TD-200.

WE'RE LOADED WITH LITERATURE...

Write for bulletins, write for information, write for details and specifications. Or mail your request on the Reader-Service Card!

BLOCK THAT SHOCK!

Leach balanced-armature relays provide high resistance to shock (50 G's) and vibration (15 G's to 2000 cps). They meet or exceed MIL-R-25018, MIL-R-5757C and MIL-R-6106C. Choose from 4,000 variations of 20 basic types! *Bulletin BA-859.*

NOT A SQUARE IN THE WHOLE FAMILY!

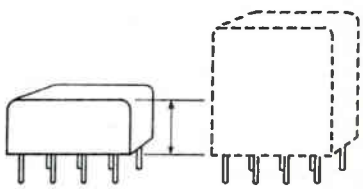
2 PDT, 3 AMP · 4 PDT, 5 AMP · 6 PDT, 5 AMP · 2 PDT, 10 AMP · 4 PDT, 10 AMP

When only a round can relay will fit your need, Leach offers this family group in contact configurations of 2, 4 and 6 PDT and in contact ratings ranging from dry circuit to 10 amps.

Bulletin RC-300.

SUBMINIATURE CRYSTAL CANS, TOO!

Want big performance, compact size? Get both in a wide range of standard relay configurations. Dual coils... balanced rotary armature for 2 amp, 2 PDT switching in aerospace and electronic control applications. *Bulletin CC-M200 and M101.*



WHAT'S HALF OF A SUBMINIATURE?

Answer: The new Leach Half-Size Crystal Can Relay. Half the height of a subminiature but boasting the same base dimensions, the same performance! Amazing.

Bulletin CC-M250.

LEACH CORPORATION, 18435 Susana Road, Compton, California • District offices and field representatives in principal cities of U.S. • Export: Leach International, S.A. Forty-one years of serving the control needs of the aircraft, missile and electronic industries

LOOK TO LEACH

MICRO-MINIATURE RELAY STYLE 6A

For Printed Circuits

Less Space

Lower Mounting Height

Terminals & Mounting Conform to 0.2" Grid Spacing

For reliable switching of low-level as well as power loads. Style 6A will operate at coil power levels below most larger current-sensitive relays in its general class, yet easily switches load currents of 2 amps resistive and higher at 26.5 VDC or 115 VAC. Contact arrangement to DPDT.

Unique construction permits flexible wiring and a variety of schematics. Withstands 50 G shock and 20 G vibration to 2000 cycles.

Meets applicable portions of specifications MIL-R-5757C and MIL-R-25018 (USAF) Class B, Type II, Grade 3.

Call Or Write For Additional Information

PRICE ELECTRIC CORPORATION

306 Church Street • Frederick, Maryland
MOnument 3-5141 • TWX: Fred 565-U

microminiature hermetically sealed connectors will mate with all standard corresponding microminiature plastic connectors incorporating socket contacts. They are compression sealed. Bodies and pins are fused with glass, providing a guaranteed reliability that meets or exceeds MIL-C-8384. Current rating is 3 amp, voltage breakdown 1,200 v rms at sea level, 350 v rms at 60,000 ft.

CIRCLE 323 ON READER SERVICE CARD

Light Pulse Generator

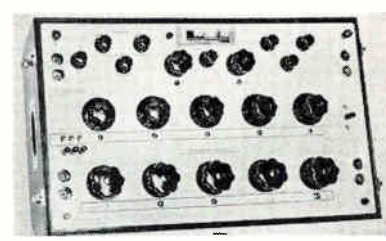
UNILECTRON INC., 129 Binney St., Cambridge 42, Mass. Unit provides a single, point-source light pulse of high intensity with a duration of 0.3 μsec.

CIRCLE 324 ON READER SERVICE CARD

Secondary Standard
HIGH ACCURACY

EPSCO INC., 275 Massachusetts Ave., Cambridge 39, Mass. The VRS611 secondary standard reference source offers selectable voltages, in 1 mv steps, from 0 to ±11.112 v —supplies up to 10 ma at all voltages—and an absolute accuracy of ± 0.025 percent. It is suited for precise calibration of telemetry equipment, and lab and production instruments.

CIRCLE 325 ON READER SERVICE CARD



Capacitance Bridge
HIGH VOLTAGE

ROHDE & SCHWARZ SALES CO. (USA), INC., 111 Lexington Ave., Passaic,

N. J. Designed for studies of dielectric losses as a function of test voltage as well as capacitance measurements from 1 pf to 100 μf, this h-v capacitance bridge features an accuracy of 0.1 percent ± 1 pf and a maximum test voltage of 1,000 v a-c. Frequency range of the bridge is 50 cps to 10 Kc.

CIRCLE 326 ON READER SERVICE CARD

H-V D-C Supply
COMPACT UNIT

DEL ELECTRONICS CORP., 521 Homestead Ave., Mt. Vernon, N. Y. Model PSC 30-3-4 compact instrumented power supply, rated 30 Kv at 3 ma, is designed for all commercial and lab applications and insulation testing. With an input of 115 v 60 cps it has a ripple of 0.5 percent per ma. It has 10 percent regulation no load to full load. It features reversible polarity.

CIRCLE 327 ON READER SERVICE CARD

Digital Recording Head

FMA, INC., 142 Nevada St., El Segundo, Calif. Mounted within a camera, the head correlates digital data and photographic images on the same film.

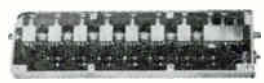
CIRCLE 328 ON READER SERVICE CARD

Mesa Transistor
SWITCHING TYPE

MOTOROLA SEMICONDUCTOR PRODUCTS INC., 5005 E. McDowell Road, Phoenix 8, Ariz. Type 2N835, a *npn* silicon epitaxial mesa switching transistor, has a typical storage time of 16 nsec. Typical collector capacitance is 2.8 pf, while saturation voltage is 0.15 v at 10 ma (typi-

WE'VE BEEN HIDING UNDER A BUSHEL BASKET

SERIES M-200
I-F AMPLIFIERS



T-330 TRANSISTORIZED
I-F AMPLIFIERS

LOG-LIN
AMPLIFIERS

SERIES M-500
WIDE BAND AMPLIFIERS

SERIES 300
VIDEO AMPLIFIERS

SERIES P-205
PRE-AMPLIFIERS

SERIES M-400 HIGH POWER
DISTRIBUTED AMPLIFIERS

Not by choice, but because we've been up to our ears in developing some of the nation's most sophisticated electronic counter-measures systems.

With the lid off, we applied our hard earned engineering and production experience and knowledge in developing a line of IFI amplifiers that meet some pretty tough specifications at lower cost than you'll find elsewhere. ***Available for immediate delivery.***

Take a moment now to write for data sheets on IFI amplifiers, and judge for yourself.

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INSTRUMENTS FOR INDUSTRY, INC.

101 NEW SOUTH ROAD
HICKSVILLE, L. I., NEW YORK

CIRCLE 93 ON READER SERVICE CARD

GUDELACE®...

the lacing tape with a NON-SKID tread

You can't see it, but it's there! Gudelace is built to grip—Gudebrod fills flat braided nylon with just the right amount of wax to produce a non-skid surface. Gudelace construction means no slips—so no tight pulls to cause strangulation and cold flow.

But Gudelace is soft and flat—stress is distributed evenly over the full width of the tape. No worry about cut thru or harshness to injure insulation . . . or fingers.

Specify Gudelace for *real* economy—faster lacing with fewer rejects.

Write for free Data Book.
It shows how Gudelace and other Gudebrod lacing materials fit your requirements.

GUDEBROD BROS. SILK CO., INC.

ELECTRONICS DIVISION
225 West 34th Street
New York 1, New York

EXECUTIVE OFFICES
12 South 12th Street
Philadelphia 7, Pa.

CIRCLE 206 ON READER SERVICE CARD

ELECTRONICS DIVISION

of Space Technology Laboratories, Inc.

Offers Immediate Assignments in Southern California

The continuing growth and diversification of Space Technology Laboratories, Inc. creates immediate career openings in the Communication, Electromechanical, Guidance, and Space Physics Laboratories of STL's Electronics Division.

In supporting STL's expanding contributions to the Advent, OGO, Atlas, Titan, and Minuteman programs, this division's responsibilities include analysis, design, and development of advanced guidance, control, and communications systems—at every phase from applied research through electronic product and ground support equipment design.

Immediate career opportunities exist here for outstanding engineers and scientists in the fields of:

- Digital computers
- Logical design
- Communication systems analysis
- Parts application
- Electronic packaging
- Electromechanical systems development
- Ground support circuit design
- Systems design and integration
- Equipment systems—checkout and evaluation
- Support equipment systems design
- Control systems analysis
- Electromechanical design
- Space communications systems
- Telemetry systems design
- Antenna systems
- R-F transistor equipment design
- Transistor circuit design
- Guidance systems analysis
- Materials and processes
- Reliability
- Aerospace ground equipment design

All qualified applicants, regardless of race, creed, color or national origin, are invited to communicate with Dr. R. C. Potter, Manager of Professional Placement and Development.

SPACE TECHNOLOGY LABORATORIES, INC.

a subsidiary of Thompson Ramo Wooldridge Inc.

P. O. Box 95005J1, Los Angeles 45, California

cal). Device has a guaranteed max gain bandwidth product of 300 Mc.

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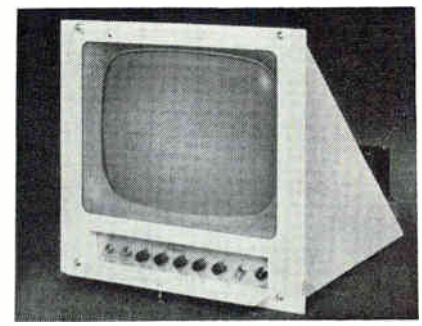


Data Display Scope
TRANSISTOR-DRIVEN

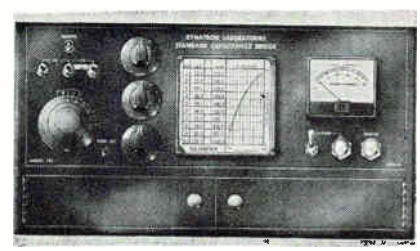
KAUKE & CO., INC., 1632 Euclid St., Santa Monica, Calif. Model MS-2 has been developed for use as a visual, quick-look, output device for a wide variety of data systems. All circuitry but the picture tube itself is solid state and it features a self-contained power supply. A typical application for the unit is in producing a bar graph display of time multiplexed telemetering channels.

CIRCLE 330 ON READER SERVICE CARD

Galvanometer Indicator

COMPUTER INSTRUMENTS CORP., 92 Madison Ave., Hempstead, L. I., N. Y. Indicator replaces the return spring with a servo system using a precision film potentiometer.

CIRCLE 331 ON READER SERVICE CARD



Capacitance Bridge
TRANSISTORIZED

DYNATRON LABORATORIES, 71 Glenn Drive, Camarillo, Calif. A capacitance bridge for determining the value of any capacitor has been designed to measure capacitance ranges from fractions of a $\mu\mu$f to 1,000 $\mu\mu$f. Available in either standard rack mounting or in console units.

CIRCLE 332 ON READER SERVICE CARD

PRODUCT BRIEFS

MULTIPLEX ADAPTER for stereo system. H. H. Scott, Inc., 111 Powdermill Rd., Maynard, Mass. (333)

OPERATIONAL AMPLIFIER loop gain 10^7. Boonshaft and Fuchs, Inc., Hatboro Industrial Park, Hatboro, Pa. (334)

DIP COATING COMPOUND one part epoxy. Emerson & Cuming, Inc., Canton, Mass. (335)

TRANSISTOR CHOPPER microminiature device. Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif. (336)

BRAKES & CLUTCHES high torque. Clifton Precision Products Co., Inc., 5050 State Road, Drexel Hill, Pa. (337)

A-C REGULATOR solid state. Twinco Inc., 10 Chenery St., Roxbury, Mass. (338)

ROTARY SOLENOID vibration resistant device. Singer-Bridgeport, 915 Pembroke St., Bridgeport 8, Conn. (339)

SENSITIVE RELAYS high speed. Airpax Electronics Inc., Cambridge, Md. (340)

SIGNAL SIMULATOR for pcm checkout. Electro-Mechanical Research, Inc., Sarasota, Fla. (341)

POWER TRANSISTORS diffused silicon. Tyco Semiconductor Corp., Waltham, Mass. (342)

POTENTIOMETER TESTER wide range. F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena, Calif. (343)

CRYSTAL FILTER 10.7 Mc unit. Hughes Aircraft Co., P. O. Box 90904, Airport Station, Los Angeles 45, Calif. (344)

SHORTING SWITCHES for single waveguide. Microwave Development Laboratories, Inc., Natick, Mass. (345)

OSCILLOGRAPH built-in timer. Minneapolis-Honeywell Regulator Co., 5200 E. Evans Ave., Denver 22, Colo. (346)

SMALL METER core-magnet movement. Pace Electrical Instruments Co., 70-31 84th St., Glendale 27, N. Y. (347)

how North Atlantic's instrument servos fill the five major systems jobs . . . exactly.

Measurement, remote display, data conversion, control, computation . . . Name the task and it's probable that the North Atlantic man can show you how to meet it precisely from NAI's comprehensive line of 3" and 2" vacuum tube and all solid state instrument servos.

Production models are available for high- and low-level ac, dc, synchro, strain gage, thermocouple, resistance bulb and other inputs. Most can be supplied with choice of pointer, counter, torque shaft or digitizer outputs. All utilize flexible design that permits any combination of input-output features to be supplied rapidly to user requirements, for both ground and airborne applications. Some are described below.

SBI-201
Single Pointer DC Ratiometer

Input
Denom. 5-50v
Num. 10 mv-100v
Accuracy
±.2 to ±.5% fs
Resolution
.1 to .2%
Response
.25 sec. fs

SBI-401
A-to D Converter

Input
10 mv to 100v dc
Accuracy
±.1% fs
Resolution
from 0.05%*
Response
from 2 sec fs*
*depending on encoder used

SBI-501
Shaft Position Repeater

Input
ac, dc or synchro
Accuracy
±.1 to ±.5% fs
Resolution
.05 to .25%
Response
7 sec. @ 15 oz-in

SBI-502
Three-Digit Counter Readout

Input
ac, dc, or synchro
Accuracy
±0.5 to .1% fs
Resolution
.02 to .05%
Response
15 sec. fs

SBI-509
Dual Scale Readout

Input
ac, dc, or synchro
Accuracy
.05 to .1% fs
Resolution
.02 to .05%
Response
6 sec. fs

If there's a critical job for an instrument servo in your system design, it will be worth your while to talk to your North Atlantic engineering representative. For his name, call or write today. Or request Catalog SFC-1 for complete data.

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TERMINAL DRIVE, PLAINVIEW, L. I., NEW YORK • OVerbrook 1-8600
See us at Wescon—Booth 2812-2814

TELEMETRY BY TELE-DYNAMICS

1 and 2 -watt Transistorized FM Transmitters

If you've a need for light—17 ounces—extremely compact—20 cu. in.—215 to 260 telemetry transmitters, specify Tele-Dynamic's Type 1053A and Type 1055A.

Providing one- or two-watt true FM output respectively, they employ dependable silicon transistors for high efficiency and offer better than 0.01% frequency stability. Type 1055A uses germanium transistors in the output stage. Each will operate reliably at any altitude and under any environment. Pressurized aluminum cases seal out the effects of altitude, humidity, salt spray, sand and dust.

These units, representative of Tele-Dynamic's latest creative effort in the complete telemetry field, are capable of being combined into various custom systems and are low in cost.

For detailed technical bulletins, call the American Bosch Arma marketing offices in Washington, Dayton or Los Angeles. Or write or call Tele-Dynamics Division, American Bosch Arma Corporation, 5000 Parkside Avenue, Philadelphia 31, Pa. Telephone TRinity 8-3000. 8412

TELE-DYNAMICS
DIVISION
AMERICAN BOSCH ARMA CORPORATION
5000 Parkside Ave., Philadelphia 31, Pa.

Literature of the Week

STANDARD RELAYS Potter & Brumfield, Princeton, Ind. An 8-page catalog showing more than 40 standard P&B relays is available. (348)

DISTORTION ANALYZER Ortho Filter Corp., 7 Paterson St., Paterson 1, N. J. A technical data page describes a distortion analyzer filter for the measurement of the total harmonic content of an a-c signal. (349)

SWITCH CATALOG Donald P. Mossman, Inc., Brewster, N. Y. A 4-page catalog covers a line of standard push button, lever and turn switches. (350)

HEAT SINKS Vemaline Products Co., Franklin Lakes, N. J. An 8-page catalog presents a line of heat sinks and dissipators, with graphs, curves, tests and detail drawings. (351)

DIGITAL VOLTMETER Franklin Electronics Inc., E. Fourth St., Bridgeport, Pa. Bulletin 31 covers an all-electronic voltmeter for precise measurement of voltages from 0.0001 to 1,200 v d-c. (352)

HIGH-SPEED COUNTER Veeder-Root Inc., Danvers, Mass., announces a product bulletin on electronic high-speed bidirectional counter, series A-1805. (353)

DUAL SPEED DRIVE Technology Instrument Corp. of Acton, 533 Main St., Acton, Mass. Features and specifications of the type DSD-40 miniature dual speed drive are contained in a 2-page data sheet. (354)

VACUUM COMPONENTS F. J. Stokes Corp., 5500 Tabor Road, Philadelphia, Pa. Data sheet 567 covers water-cooled baffles for preventing back-streaming of pump vapors in vacuum systems. (355)

REFLECTOR ANTENNAS Philco Corp., Government and Industrial Division, 3875 Fabian Way, Palo Alto, Calif., has released report WDL-TR-1500 entitled, "Re-

TIC OF ACTON

TYPE 335-A
ultra-low frequency
PHASE METER

FEATURES:

- Direct Reading from 0 to 360° in 6 Ranges of 60° each
- 0.0001 cps to 1.0 cps in Decade Ranges
- Phase Accuracy ±1° from 0.0001 cps to 0.1 cps; ±2° from 0.1 cps to 1.0 cps

This unit measures the phase angle in degrees between two sinusoidal or non-sinusoidal voltages within the frequency range from 0.0001 cps to 1 cps. A wide variety of applications are offered in the field of: servomechanisms, vibration studies and other low frequency phenomena. Readings of phase angles are indicated directly on a large 5″ meter which has 6 full scale ranges of 360°, 300°, 240°, 180°, 120°, and 60°.

SPECIFICATIONS...

Amplitude Range: 1 to 30v rms sine wave with no d-c component.

Input Impedance: Not less than 100k ohms.

Wave Form: Will measure all sine waves and complex wave forms provided that the applied signals have no d-c component. The applied signals should not have more than one positive-going or one negative-going zero-axis crossing per cycle.

Dimensions: 19″ x 10-½″ x 13-½″

Cabinet: Aluminum with gray wrinkle finish. Gray baked enamel front panel.

For full details write or call:

TIC
For further information write
TECHNOLOGY INSTRUMENT CORP.
533 MAIN STREET, ACTON, MASS.
8530 WILSHIRE BLVD.
BEVERLY HILLS, CALIF.

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flector Antennas for Radio and Radar Astronomy." (356)

WAVEGUIDE FLANGES Microwave Development Laboratories, Inc., 15 Strathmore Road, Natick, Mass. Catalog FA-61-1 is a well indexed booklet covering a wide range of waveguide flanges. (357)

RATE TURNTABLE Dunn Engineering Corp., 225 O'Brien Highway, Cambridge, Mass., offers a 4-page brochure on a turntable for inertial guidance tests. (358)

ROTARY SOLENOIDS Ledex Inc., 123 Webster St. Dayton, O. Leaflet No. 6 contains three thought stimulators for the engineer designing for compactness through the use of rotary solenoids. (359)

STAMPINGS The Cly-Del Mfg. Co., 16 Sharon Road, Waterbury 20, Conn. Bulletin describes engineered, high-volume contract production of eyelets, drawn shells, and metal stampings for the electronic manufacturing market. (360)

TRIMMER POTENTIOMETER CTS Corp., Elkhart, Ind. Data sheet describes a single turn commercial composition trimmer pot for small space p-c use. (361)

AMPLIFIERS RHG Electronics Laboratory, Inc., 94 Milbar, Blvd., Farmingdale, L. I., N. Y. Brochure 1010A gives detailed specifications of a line of pulse r-f and i-f amplifiers. (362)

MESA TRANSISTORS National Semiconductor Corp., Danbury, Conn. A 6-page brochure covers the 2N756A-2N760A *npn* silicon diffused mesa transistors. (363)

DATA PROCESSING Systems Division of Beckman Instruments, Inc., 2400 Harbor Blvd., Fullerton, Calif. Model 210 data acquisition and data processing systems are described in an eight-page bulletin. (364)

PRECISION POTENTIOMETERS The Gamewell Co., Newton Upper Falls 64, Mass. A 42-page catalog shows a line of precision potentiometers and rotary switches. It is available by request on company letterhead.

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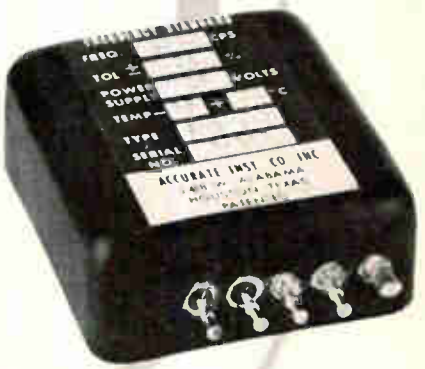

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Type SM — 1" x 1" x 1½", weight approx. 2 oz.

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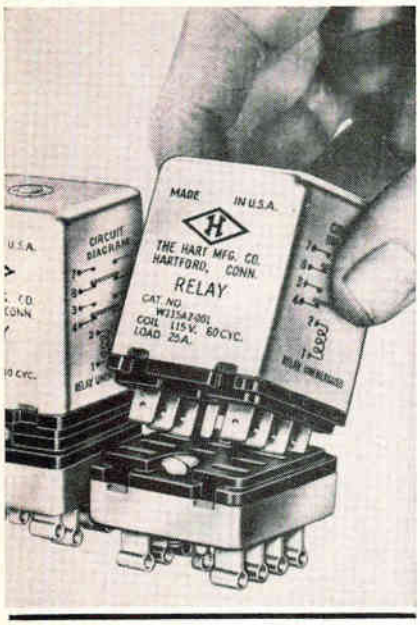

More compact than most 10 amp relays

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Long, trouble-free service—Simple, functional construction with oversized solid silver contacts and contact bar assure long-time, dependable switching. Series W relays have given well over a million cycles at a 15-amp load.

SPECIFICATIONS

CONTACTS:

Arrangement—dpdt, double break, double make. Other arrangements and sequences.

Load—25 amp resistive, 120 or 240 V a-c
25 amp ind., 120 V a-c (75% p.f.)
12½ amp ind., 240 V a-c (75% p.f.)
1 hp 120 V a-c, 2 hp 240 V a-c
25 amp resistive 28 V d-c

MOUNTING: Panel, side or socket

DIMENSIONS: 1½ x 1½ x 1⅞ inches.

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COMPLETE DATA and specifications are available—new 8-page Relay Guide.

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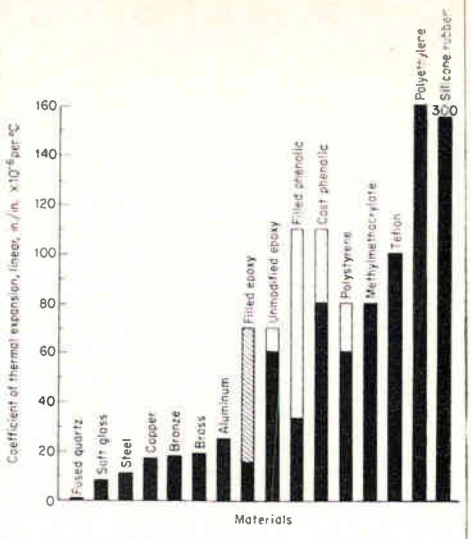

FIG. 6-6. Effect of filler content on coefficient of thermal expansion for an epoxy resin as compared with coefficients of thermal expansion for various other materials.

Electronic Packaging with Resins

By C.A. HARPER

McGraw-Hill Book Company, Inc., New York, 1961, 339 *p*, $11.

SELECTING the right resin and process to cast, pot, impregnate or encapsulate an electronic component or assembly is a problem occuring with increasing frequency under the impact of such design requirements as higher environmental resistance, miniaturization and modular packaging. And there are a number of subsidiary problems, including materials compatibility, selection of manufacturing equipment, protecting the product from damage during processing and materials costs.

Any book that helps the design or process engineer understand these problems and chart a course through the welter of available materials is well worth the reading. This book does that, concisely and clearly. It outlines—with liberal support by tables, charts, references and illustrations—the basic epoxies, polyesters, silicones and other resins; their solid, flexible, foam, gel and conductive variations; their catalysts, fillers, diluents and other modifiers; effects of environments; and special high-temperature materials.

The book is also valuable as a practical guide to embedment techniques. Throughout the chapters on

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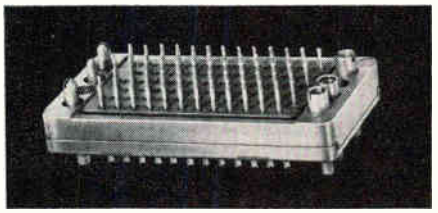

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materials and testing are frequent summaries of practical techniques and a few tricks of the trade. In addition, the last three chapters review tools, molds, fixtures, finishing operations, processing equipment and manufacturing controls. The information on casting and potting methods is extensive. But there is only scanty information on impregnation and hardly any on encapsulation methods.—G.S.

Statistical Theory of Communication

By Y.W. LEE

John Wiley & Sons, Inc., New York, 503 *p,* $16.75.

Y. W. LEE'S BOOK fills an important gap among textbooks on statistical communication. The book is intended as introductory material for a graduate level course; however, because of the excellent pedagogical treatment it is recommended to those engaged in modern communication work.

The first part of the book analyzes the basic concepts and tools needed in statistical communication work. Harmonic analysis of periodic and transient functions is reviewed and extended to random functions. The concepts of random variables, probability distribution, statistical moments, time and ensemble averages are discussed at great length. The concepts of autocorrelation and power spectrum as well as the techniques pertaining to their use are well treated and recur as a main theme throughout the text. An excellent discussion of the differences and similarities between convolution and correlation is given.

The second part of the book takes up the measurement of correlation, the detection of periodic signals masked by noise and the analysis and synthesis of optimum filters. The required mathematical techniques such as calculus of variations and the solution of the Wiener-Hopf integral equation are developed in the course of the treatment as their need arises. The last two chapters cover the synthesis of optimum linear systems by expanding correlation functions into orthonormal functions.

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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.

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detection of non-periodic signals imbedded in noise are missing; however, as the author points out, "this is an introductory book."

The outstanding quality of the text is the skilled and lucid presentation of the subject matter.—H. HODARA, *Head of Space Communications, Research and Development Div., The Hallicrafters Co., Chicago, Ill.*

Self-Saturating Magnetic Amplifiers

By G.E. LYNN, T.J. PULA, J.F. RINGELMAN and F.G. TIMMEL

McGraw-Hill Book Co., Inc., New York, 217 *p*, $8.

DISCUSSED in this volume are square-loop magnetic materials, operation of self-saturating magnetic amplifiers, design techniques and test materials. Omitted is the usual discussion of a simple reactor circuit, instead the authors delve immediately into a consideration of self-saturating circuits. The treatment is nonrigorous but permits one to design complex circuits with minimum cut-and-try experimentation.—J.C.

Digital Computer Fundamentals

By T.C. BARTEE

McGraw-Hill Book Co., Inc., New York, 342 *p*, $6.50.

AN IDEAL textbook for a college course in digital computers, this book is well written and easily understood. All phases of digital computers, from arithmetic to programming to internal circuitry are discussed on a basic level. Topics are not covered deeply enough for the book to be of reference value to someone already familiar with computer work.—W.E.B.

Selected Semiconductor Circuits Handbook

By S. SCHWARTZ, et al.

John Wiley & Sons, Inc., New York, 529 *p*, $12.

CHAPTERS 2 through 10 of this book, which cover building-block ampli-

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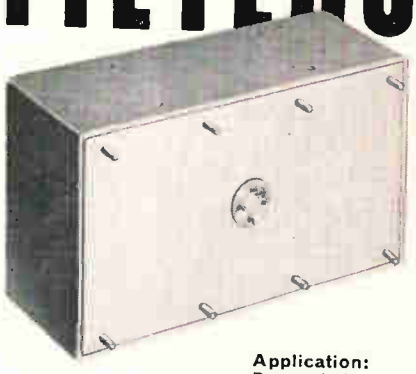

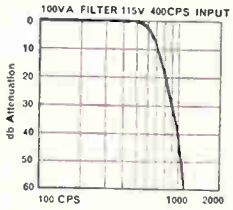

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fiers, oscillators, switching and logic circuits, and power supplies and converters, were originally prepared for the U.S. Navy as a handbook of selected circuits. The authors have added an introduction and a final chapter on semiconductor-magnetic circuits. Each chapter leads off with a brief outline of design philosophy with appropriate equations and a bibliography. This material is billowed by a collection of selected circuits each with component values and a brief description; 126 circuits in all. A useful handbook for the designer of semiconductor circuits.—J.C.

Oscillator Circuits

By T.M. ADAMS

Howard W. Sams Co., Inc., Indianapolis, Ind., 1961, 125 *p*, $2.95.

ADMITTEDLY written for the novice, this book covers the spectrum of common electronic oscillator circuits in a narrative nonmathematical manner. An interesting approach to circuit illustration uses four-color schematic diagrams, each color representing a different current; blue stands for plate current, red for feedback current, and so forth. Should prove a useful refresher volume for the graduate engineer familiar with the basics of electronic oscillators, but who lacks a solid physical feel of their operation.—R.M.B.

Riddles in Mathematics

By E.P. NORTHRUP

D. Van Nostrand Co., Inc., Princeton, N. J., 1961, 262 *p*, $4.50.

THIS is a fascinating book for anyone interested in mathematics. Although all except the last three chapters require only high school math to be understood, those with training in college mathematics will meet many old friends and many new problems based on already familiar concepts. A real understanding of some of the strange pitfalls that await the unwary mathematician, as well as many hours of enjoyable intellectual gymnastics will be derived from a careful reading. —W.E.B.

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Model No.	Frequency Ronge (mcs.)	Power Ronge Incident & Reflected (watts)	RF Connectors and Impedance
263	0.5 - 225	0 - 10; 100; 1000	Type N* 52 ohms
706N	28 - 2000	0 - 400	Type N* 52 ohms
711N	25 - 1000	0 - 30; 75; 300	N plus 83-1R Adapters
712N	25 - 1000	0 - 2.5; 5; 10	N plus 83-1R Adopters
722N	1000 - 3000	0 - 4	Type N 52 ohms
723N	1000 - 3000	0 - 12	Type N 52 ohms
40588	28 - 2000	0 - 4000	1⅝" Flonge 51.5 ohms
445A10	20 - 2000	0 - 40,000	3⅛" Flonge 50.0 ohms

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576N6	28 - 2000	0 - 400	Type N* 52 ohms
596N2	1000 - 3000	0 - 4	Type N 52 ohms
596N3	1000 - 3000	0 - 12	Type N 52 ohms
40288	28 - 2000	0 - 4000	1⅝" Flange 51.5 ohms
442A9	28 - 2000	0 - 12,000	3⅛" Flange 50.0 ohms

RF OUTPUT DIRECTIONAL COUPLERS

Model No.	Frequency Ronge (mcs.)	Coupling Attenuotion	RF Connectors and Impedance
313N3	300 - 2000	30 db	Type N* 52 ohms
313N5	60 - 2000	50 db	Type N* 52 ohms
442A40	200 - 1000	40 db	3⅛" Flonge 50.0 ohms

ABSORPTION TYPE RF WATTMETERS

Model No.	Frequency Range (mcs.)	Power Range (watts)	RF Connectors and Impedance
621N	1 to over 1000	0 - 120 milliwotts	Type N* 52 ohms
625C5	50 - 1000	0 - 120	Type C 50 ohms
651N	25 - 1000	0 - 25; 100; 500	Type N 52 ohms
611A7	50 - 1000	0 - 1200	3⅛" Flonge 50 ohms
612A	44 - 1000	0 - 6000	3⅛" Flonge 50 ohms

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Model No.	Frequency Ronge (mcs.)	RF Power Dissipation (watts)	RF Connectors and Impedance
603N	3000	20 (air cooled)	Type N 52 ohms
633N	3000	50 (air cooled)	Type N* 52 ohms
636N	3000	600 (air cooled)	Type N* 52 ohms
638A	2000	6000 (water cooled)	3⅛" Flonge 50.0 ohms

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152N	500 - 4000		Type N 50 ohms

*Also available with UHF, C, and HN Connectors.

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SUBSIDIARY OF THE Bendix CORPORATION

Sylvania Opens Plant for Welded Parts

THE PARTS DIVISION of Sylvania Electric Products Inc. recently opened a new plant in Warren, Pa., for the production of welded components for the electrical-electronics industry.

Because the new building and its manufacturing equipment "are designed specifically for weld production," says Merle W. Kremer, vice president and general manager of the division, "it has been possible to confine this complex operation to a building containing only 20,000 sq ft of manufacturing and associated space."

Marion E. Pettegrew, a senior vice president of Sylvania, says the new plant is the latest move in a continuing modernization program of the Parts Division. The division, with headquarters in Warren, has eight other plants—four in Warren, and one each in Nelsonville, O.; Naugatuck, Conn.; York, Pa., and Titusville, Pa.

The plant produces automatic leads and custom welded assemblies for such electrical-electronic product lines as receiving tubes, incandescent and other types of lamps, semiconductors, and resistors.

An automatic lead consists of two or more kinds of wire welded together to make electrical connections between the current supply and the functional components inside a radio tube or lamp. A custom weld assembly is a piece of wire joined to an irregular or unusual shaped metal part which is used in the manufacture of electronic components.

Kremer points out the Sylvania Parts Division, which was formed in 1950, began as a supplier of electrical leads for the company's own tube and lamp divisions. Since that time the demand for specialized types of welded assemblies for new applications has increased greatly. More than 50 percent of the division's weld sales are to outside manufacturers, he adds.

Citing one example of the capabilities of the new plant and its equipment, Kremer explains that some of the new machines, designed and built in the division's own equipment development plant, are capable of producing more than one million of a certain type of welded assemblies each week. This is in contrast to a rate of 200,000 per week under previous methods.

He says rate of production has been increased over 500 percent, while precision and quality are improved over old methods. Despite the constant emphasis on automatic production, the division's employment has increased each year since the division was formed.

Kremer predicts the next big area of demand for weld products will come from the resistor industry, which is beginning to use automatic welded assemblies in producing hard glass encapsulated resistors.

Unitron Erecting New Facility

UNITRON, INC., has begun construction on a new office, laboratory and fabricating plant in Garland, Texas. The 8,000-sq ft building is expected to be completed in September.

Unitron concentrates on the design and production of solid state power conversion equipment. The firm's components are used in missile construction for both airborne units and ground support installations.

Officers of the company are: Donald E. Davis, president; John Harrison, vice president; and Arthur W. Wier, secretary-treasurer. The firm was incorporated in Texas in June 1960.

Wolsky Named Director Of New Mallory Lab

SUMNER P. WOLSKY has been appointed director of the new Laboratory for Physical Science of P. R. Mallory & Co., Inc., in Boston, Mass. The lab will specialize in research in thin films and semiconductors, for application to electronic components and circuits.

Wilford Beasley Joins The Birtcher Corp.

WILFORD BEASLEY has been appointed chief engineer of The Birtcher Corp./Industrial Division, Monterey Park, Calif. He will direct the division's engineering activities in the design of electronic cooling/retention devices and in

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SOLID STATE RELIABILITY

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- MODULAR CONSTRUCTION—full flexibility to meet special requirements
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Decade Resistor provides accuracy of 0.05% + 0.005 Ω. Ranges from 0.0 to 9,999 in 0.1 Ω steps, 0.0 to 99,999 Ω in 1.0 Ω steps and 0.0 to 999,990 Ω in 10.0 Ω steps.

Temperature coefficient less than 0.002% per degree C. Maximum currents, 0.1 Ω is 0.5 amp, 1.0 Ω is 0.5 amp, 10 Ω is 330 MA, 100 Ω is 100 MA, 1K Ω is 33 MA, 10K Ω is 10 MA.

Price $99, with quantity discounts.

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Voltage Divider offers total resistance of 1000 Ω, 10,000 Ω and 100,000 Ω.

Linearity is 0.01%, temperature coefficient is 0.001%.

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Availability 30 days, soon in stock.

Durable attractive box for laboratory use or metal protective cover for OEM applications.

Weighs one pound, measures 3¾" x 4" x 5".

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Beasley was formerly senior project engineer at Hoffman Electronics Corp.

Philco Appoints H. Edward Rice

H. EDWARD RICE has been named vice president-operations of Philco Corporation's Government and Industrial Group headquartered in Philadelphia. He will coordinate the manufacturing operations of the Group's five divisions.

Prior to joining Philco, Rice was manager of manufacturing for the General Electric Company's Light Military Electronics Department in Utica, N. Y.

Auerbach Electronics Names Sisson

ROGER L. SISSON, management consultant in the field of information technology, will direct advanced programs at Auerbach Electronics Corp., Philadelphia, Pa., it was announced by Isaac L. Auerbach, president of the company. He will be responsible for initiating new programs and directing special projects in the field of information technology.

Previously, Sisson was manager of program analysis at Aeronutronic, a division of Ford Motor

Co., where he also directed system design and programming for the Army tactical operations central.

Rogers Corporation Adds to Facility

ROGERS CORP. has begun an addition to its Manchester, Conn., plastics plant to double capacity for manufacture of diallyl phthalate molding compounds.

In August, 1959, Rogers began commercial production of these materials, which are increasingly used for electronic insulation, specifically for connectors, terminal boards, and various aircraft and missiles components.

Norden Division Hires Richard Sirrine

RICHARD C. SIRRINE has joined United Aircraft Corp.'s Norden Division, Norwalk, Conn., as assistant chief-applied physics branch. He comes to Norden from General Electric's Advanced Semiconductor Laboratory where he was manager of the surface studies group.

Motorola Promotes Robert Learned

ROBERT E. LEARNED, has been promoted to the new position of pro-

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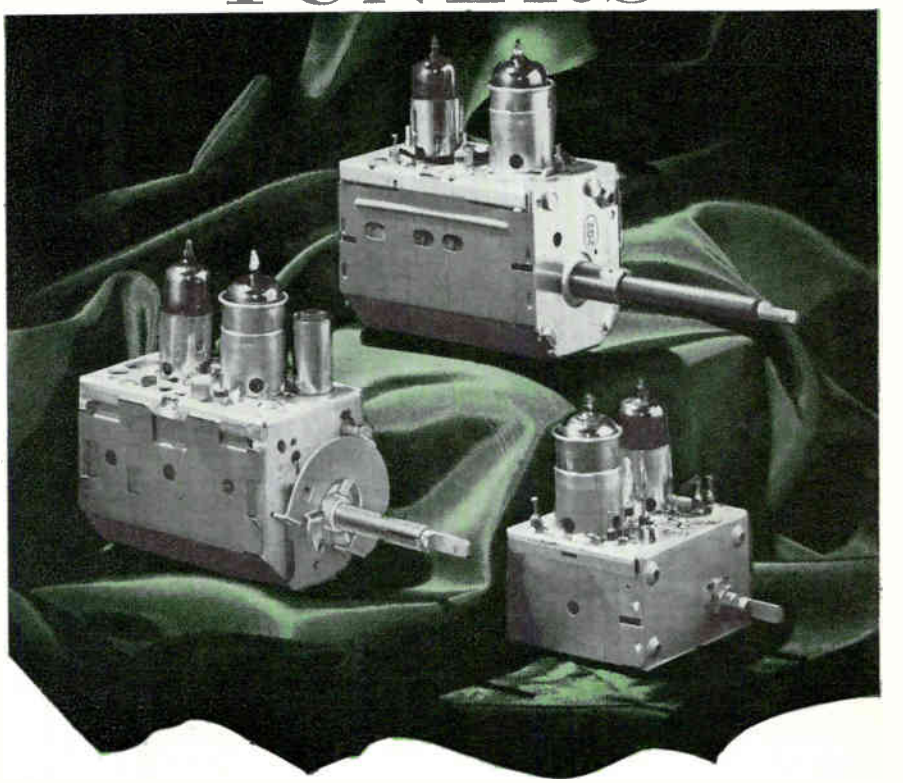

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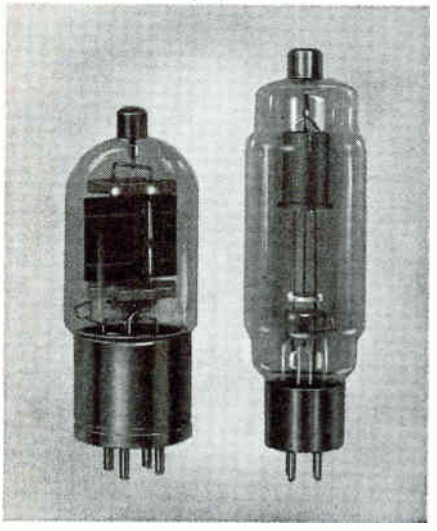

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In the field of radar, transients must also be removed. These high voltage, high vacuum clippers and rectifiers are designed to give the high efficiency and careful control demanded in modern equipment.

The 4B31 is primarily a clipper tube, but can also be used as a high voltage rectifier. The 8020W is a high voltage, half wave rectifier designed for high ambient temperatures. It has been tested to withstand a shock of 375G. High operating frequencies and high peak inverse voltages of the 8020W preclude the use of gas filled rectifiers.

	4B31	8020W
Peak Inverse Volts	16,000	40,000
Fil. Voltage	5.0	5.0
Fil. Amperes	5.0	6.0

Cetron Rectifiers are capable of Meeting All Requirements of JAN Military Specifications

Cetron Engineers are always ready to assist in your tube requirements.

BE CERTAIN WITH CETRON—FOR THYRATRONS, RECTIFIERS, TRIODES AND PHOTO CELLS

CETRON ELECTRONIC CORPORATION

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duction manager for diodes at Motorola's Semiconductor Products Division in Phoenix, Ariz.

Previously, Learned had been chief electrical engineer for diode products manufactured by Motorola. In his new position, he will be responsible for diode and rectifier production and final testing.

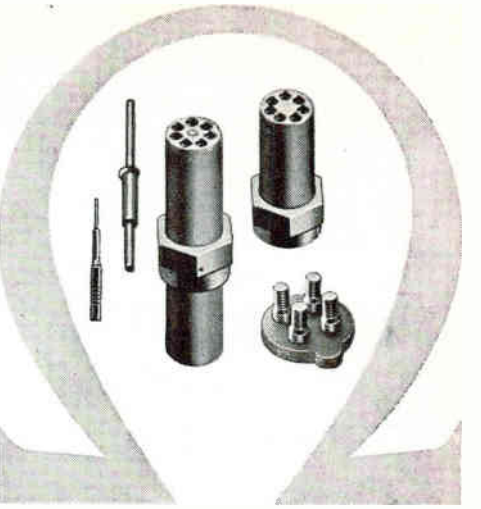
STELMA Appoints R. L. Plouffe

ROBERT L. PLOUFFE has joined STELMA, Inc., Stamford, Conn., as vice president, director of engineering.

Plouffe comes to STELMA, designer and manufacturer of telecommunications equipment, after several years as director of the digital systems laboratory, of ITT Federal Laboratories, a division of ITT. There he directed research, development, and systems engineering activities for communications networks.

Donald L. Johnson Takes New Post

DONALD L. JOHNSON has been named manager-manufacturing section of General Electric's Defense Systems Department. In his new position, he will be responsible for all assembly operations, materials, quality control, manufacturing engi-



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neering, and all facilities of the Defense Systems Department.

Prior to this assignment, Johnson was manager of the department's support and implementation section.

Lockheed Names Two Assistant G-M's

LOCKHEED Missiles and Space Division has created two new general management positions.

S. W. Burriss was named to the position of assistant general manager—Polaris Missile System. D. J. Gribbon was promoted to assistant general manager—Satellite System.

Burriss has been with Lockheed since 1954, and Gribbon since 1938.

PEOPLE IN BRIEF

George Stollsteimer advances at International Resistance Co. to manufacturing superintendent. **Fred A. Peck** transfers from Hughes Aircraft Co. to Consolidated Electrodynamics Corp., data recorders division, as director of quality control. **Otis W. Adams** of the Armour Research Foundation, Illinois Institute of Technology, accepts the position of supervisor of solid state chemistry research. **Joseph R. Ikola** leaves the Polydyne Engineering Corp. to join Omega Precision as chief engineer of the connector division. **Gordon B. Baumeister**, formerly with Ekco Products Co., named president and a director of Electro-Sonic Laboratories. **Edward A. Hebditch** transfers from Arthur D. Little, Inc., to Gulton Industries as executive assistant to the president. **William M. Brown** of the University of Michigan's Institute of Science and Technology appointed head of the radar lab. **Theodore S. Hoffman** promoted to vice president and manager of Hoffman Electronics' semiconductor division. **Warren R. Yuenger**, previously with Cubic Corp., joins the Ling-Altec Research Div., Ling-Temco Electronics, as research scientist. **Modesto Matarrese**, ex-Douglas Aircraft Co., appointed program coordinator of General Precision's antisubmarine warfare unit.

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24-510 RADIFLO LEAK DETECTOR – The foremost production-line instrument for 100% leak testing of transistors, diodes, relays, and other small sealed components. Only detector of its kind available, the semi-automatic 24-510 offers lowest unit cost for production testing and highest sensitivity, 1×10^{-11} atm cc/sec air. Bulletin CEC 24510-X4. If you are interested in submitting sample parts for Radiflo application study, call your nearest CEC sales and service office for free estimates and further details.

Analytical & Control Division CEC

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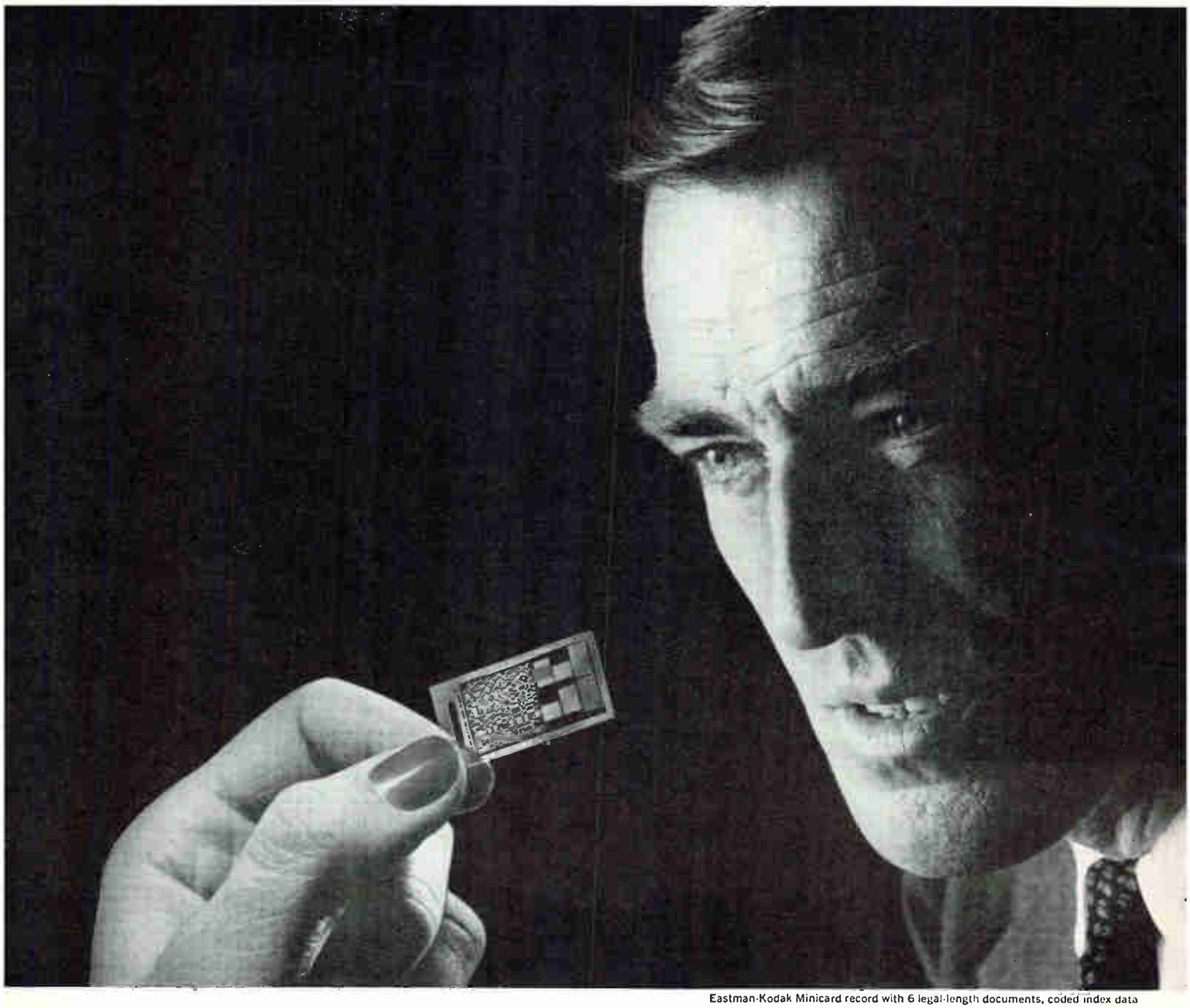

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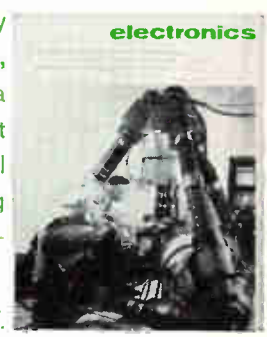

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CITY..... ZONE..... STATE.....

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PROFESSIONAL DEGREE(S).....

MAJOR(S) .....

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- ☐ Aerospace
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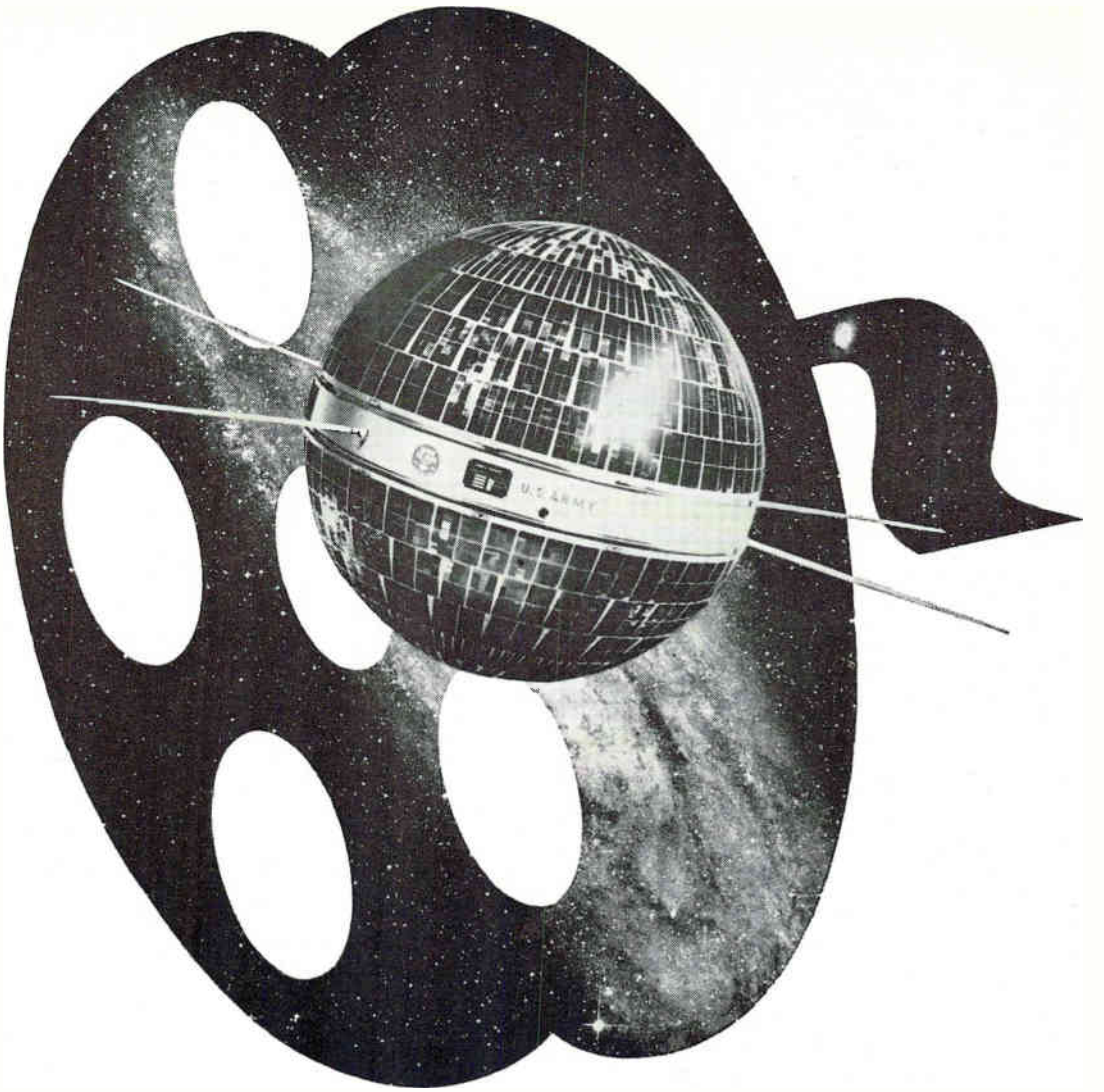

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IBM scientists have developed a process of fabricating cryogenic memory planes in a single, automatic cycle. Although still experimental, such work could result in larger, more reliable cryogenic computer memories.

The 135-cryotron memory plane developed by IBM is about the size of a postage stamp. It is built up in 19 thin layers of metal and insulating material. Each layer is evaporated onto a glass substrate through a precisely made pattern or mask. The proper mask for each layer is registered to the required accuracy by means of an automatic mask changer mechanism inside the vacuum system. The control techniques developed by IBM are so sensitive that the evaporation process can form lines finer than a human hair and metallic films so thin they are invisible to the unaided eye.

The IBM engineering group that developed this new method of automatically fabricating experimental memory planes found it had to move back and forth across technical boundaries to achieve its results. Circuit design engineers, for example, worked closely with physicists and mathematicians to develop special circuits that would operate within the limits imposed by film characteristics and control techniques. This integrated approach to systems development has helped make possible many of the advances that IBM has made recently in such fields as semiconductors, microwaves, optics and magnetics. If imaginative problem-solving in any of these areas interests you—and you have a degree and experience in engineering, mathematics, or one of the sciences—we'd like to hear from you.

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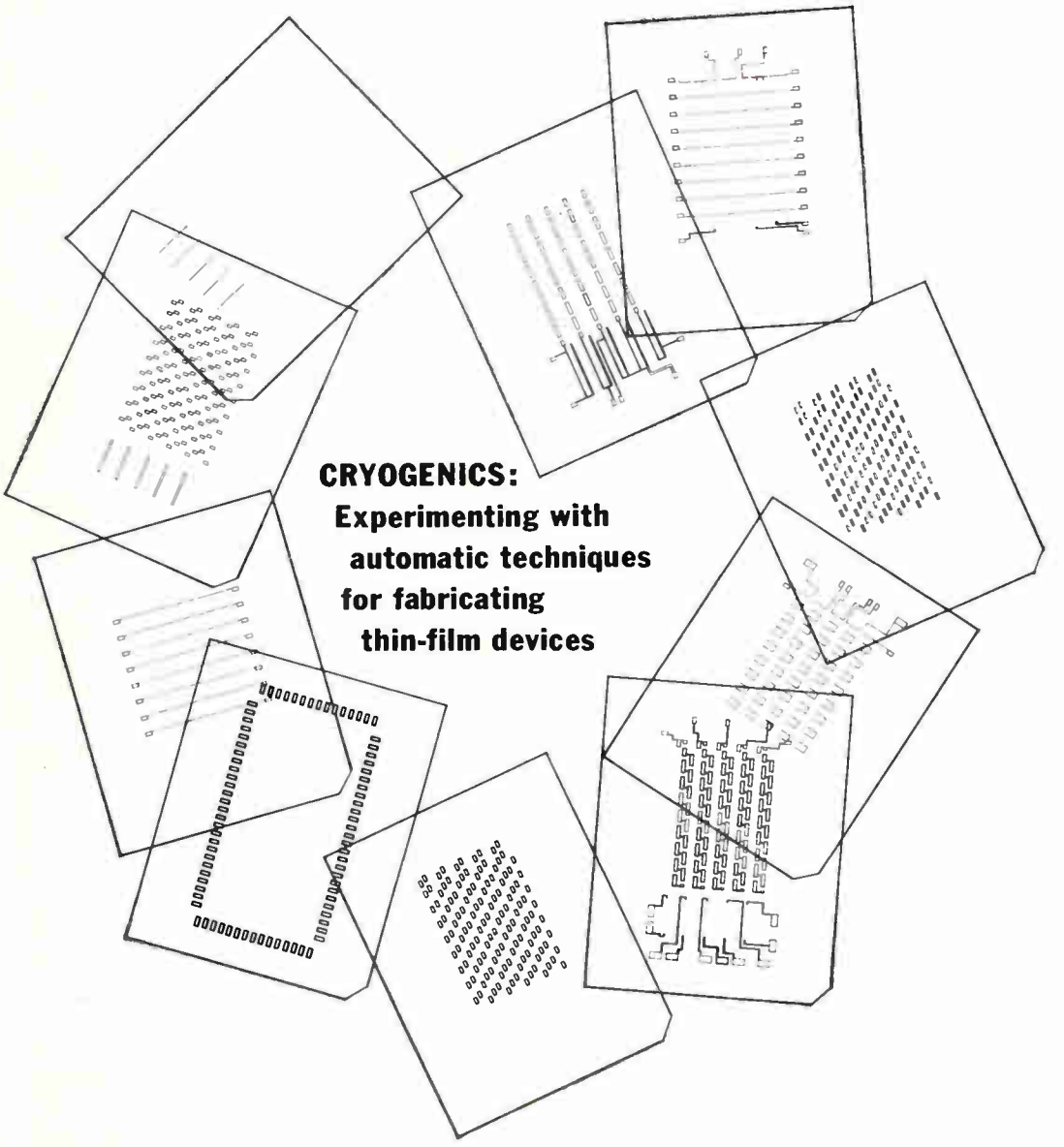

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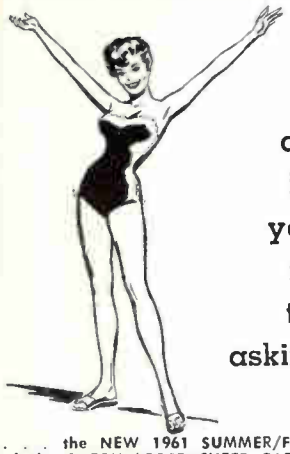

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1B24A	8.50	5BP1A	9.50	262B	2.50	832	2.00	5930/2A3W	2.00
1B35	1.85	5C22	12.50	FP-265	5.00	832A	6.75	5932/6L6WGA	2.00
1B35A	3.00	5CP7A	9.50	267B	5.00	833A	35.00	5933/807W	1.75
1B59/R1130B	7.50	5CP11A	9.50	271A	9.00	836	1.00	5933WA	5.00
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2-01C	12.50	5SP1	25.00	HF-300	25.00	872A	3.50	5977/6K4A	1.25
2AP1A	5.00	5SP7	25.00	300B	5.00	884	1.25	5979/BS1	4.00
2BP1	7.50	6AC7W	.35	304TH	30.00	885	.65	5980/BS2	6.00
2C36	22.50	6AG7Y	.75	304TL	40.00	913	8.50	5987	7.50
2C39	4.25	6AK5W	.90	309A	2.50	918	.65	5992	2.00
2C39A	8.50	6AN5	1.75	310A	2.50	920	2.50	5993	4.00
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2C40	7.00	6AS6	.85	313C	1.00	931A	3.00	6012	3.50
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2C52	1.50	6BM6A	30.00	347A	1.00	1500T	125.00	6045	1.15
2D21	.50	6C4W	2.50	348A	2.00	1614	2.75	6050	1.00
2D21W	1.00	6C21	12.50	349A	1.50	1616	.50	6072	1.50
2E22	2.50	C6J	10.00	350A	3.50	1619	.20	6073	.75
2E24	2.50	C6J/A	15.00	350B	1.00	1620	3.50	6074	1.50
2E26	2.50	C6J/K	20.00	352A	6.00	1624	.75	6080	2.50
2E30	2.50	6J4WA	1.00	354A	7.50	1625	.35	6080WA	5.00
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2K28	25.00	6SC7GTY	1.00	401A/5590	1.00	5641	1.75	6101/6J6WA	.85
2K29	25.00	6SJ7WGT	1.25	403A/6AK5	.65	5642	2.00	6108/BS213	2.50
2K30	50.00	6SL7WGT	.75	403B 5591	2.75	5643	3.00	6109/BS404	1.00
2K34	75.00	6SN7W	.50	404A/5847	7.50	5644	2.50	6111A	2.00
2K35	250.00	6SN7WGT	.75	407A	3.50	5647	3.50	6112	2.00
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2K42	125.00	6SU7GTY	.85	409A/6AS6	1.00	5654/6AK5W	1.00	6130/3C45	5.00
2K43	135.00	6V6GTY	.75	416B/6280	30.00	5654/6AK5W/6096	1.25	6135	1.50
2K44	125.00	6X4W	.75	417A/5842	8.25	5656	2.50	6136/6AU6WA	1.35
2K45	20.00	6X5WGT	1.00	418A	10.00	5663	.75	6137/6SK7WA	1.50
2K47	125.00	7AK7	1.50	420A/5755	3.75	5670	1.00	6146	3.35
2K48	50.00	7BP7A	5.00	421A/5998	7.50	5675	8.50	6147	2.25
2K50	70.00	7MP7	17.50	429A	6.50	5678	1.25	6161	50.00
2K54	10.00	10KP7	15.00	GL-434A	5.00	5686	1.85	6186/6AG5WA	1.50
2K55	15.00	12AT7WA	1.25	450TH	40.00	5687	1.50	6189/12AU7WA	1.50
2P21	30.00	12AY7	1.00	450TL	40.00	5691	5.00	6197	1.50
2X2A	.80	12DP7	7.50	CK-503AX	.75	5692	2.50	6198	85.00
3AP1	2.00	12GP7	12.50	CK-510AX	1.00	5693	3.50	6201/12AT7WA	1.75
3B23/RK-22	2.00	16F	10.00	576	12.50	5696	.75	6202/6X4WA	1.50
3B24	.35	C16J	20.00	577	12.50	5702	1.50	6211	.75
3B24W	2.50	FG-17	5.00	578	5.00	5703	.85	6216	2.00
3B24WA	5.00	HK-24	2.00	KU-610	4.00	5718	.60	6236	150.00
3B25	2.50	25T	10.00	NL-623	8.50	5719	.60	6252	15.00
3B26	2.25	25Z6WGT	1.50	KU-627	4.00	5721	125.00	6263	9.00
3B28	3.00	26Z5W	1.50	631-P1	4.00	5725/6AS6W	1.00	6264	9.00
3B29	5.00	FG-27A	20.00	673	15.00	5726/6AL5W	.60	6265/6BH6W	2.75
3BP1	2.50	FG-32	6.00	676	25.00	5727/2D21W	1.00	6282/BL-11	65.00
3C/4B24	4.00	FG-33	17.00	677	35.00	5749/6BA6W	.75	6293	4.50
3C22	15.00	35T	10.00	701A	3.00	5750/6BE6W	1.50	6299	37.50
3C23	4.85	35TG	1.25	707B	.75	5751/12AX7W	1.50	6322/BL-25	12.50
3C24/24G	4.00	FG-41	50.00	NL-710	10.00	5751WA	1.60	6336	8.75
3C45	3.00	FP-54	100.00	714AY	10.00	5763	1.75	6345	3.50
3D21A	2.50	FG-57	6.00	715B	2.50	5768	35.00	6350	1.75
3D22	8.00	RK-60/1641	.85	715C	12.50	5777	125.00	6352	8.50
3E22	3.00	RK-61	2.35	719A	7.50	5778	125.00	6364	150.00
3E29	6.00	FG-67	3.85	720AY-EY	20.00	5783	2.00	6390	150.00
3GP1	1.50	HY-69	2.00	721A	.35	5787	2.00	6438	5.00
C3J	8.50	RK-73	.25	721B	3.75	5796	8.00	6463	1.00
C3J/A	10.00	BL-75	3.00	723A/B	2.85	5799/VX-21	3.00	6517/QK358	250.00
3J21	35.00	RK-75/307A	.50	725A	5.00	5800/VX-41	5.00	6533	5.00
3J31	50.00	FG-81A	4.00	726A	2.00	5801/VX-33A	2.25	6550	3.50
3K21	125.00	FG-95	17.50	726B	3.00	5802/VX-32B	2.25	6807	20.00
3K22	125.00	FG-104	25.00	726C	8.50	5803/VX-55	2.25	6897	20.00
3K23	250.00	FG-105	10.00	750TL	87.50	5814A	1.35	6907	15.00
3K27	150.00	F-123A	4.00	NL-760	20.00	5822A	55.00	8005	7.50
3K30	50.00	F-128A	25.00	BL-800A	50.00	5828	3.00	8008	7.75
3KP1	7.50	HF-200	10.00	802	4.50	5829	.75	8013A	3.00
3X3000A1	148.00	203A	2.50	803	2.50	5836	60.00	8014A	25.00
4-65A	9.00	211	2.50	804	12.50	5837	60.00	8020	2.00
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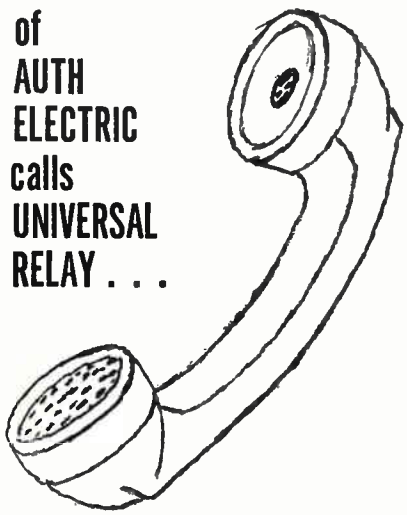

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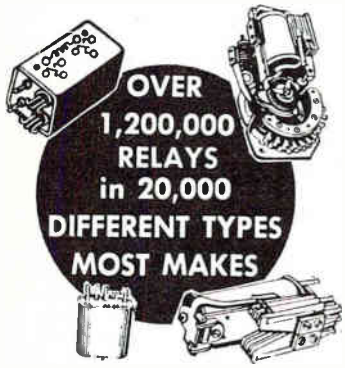

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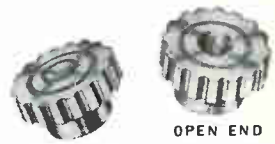

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Which AC/DC digital voltmeter should you buy?

...seven questions to help you decide

1. Is it reliable, dependable?

A rather general question, and one you often get rather general answers to. But with such an important consideration, you should get answers like these:

The stepping switches in the KIN TEL 502B AC/DC digital voltmeter are guaranteed for two years. KIN TEL can make this guarantee because it operates stepping switches conservatively, driving them with DC (as in telephone service) at a rate somewhat below their peak speed. This gentler drive gives the 502B a longer life, makes it capable of more sensitive measurements, eliminates the need for stepping switch adjustments or other maintenance, and greatly reduces down time.

When servicing is ultimately needed, KIN TEL-trained personnel in 22 different maintenance shops throughout the country are prepared to put your 502B in factory condition with minimum delay.

Each 502B is manufactured on a true production-line basis. KIN TEL has used this method in building over 10,000 "standard-cell-accuracy" instruments, instruments known for their consistent, trouble-free performance.

2. Does it have automatic range selection for AC and DC?

Auto-ranging is a convenience. It makes your job a little easier, a little surer. It permits unattended operation with a printer to record voltages on the range giving the best resolution.

The KIN TEL 502B has it.

3. Does it have a single-plane readout?

A single-plane readout reduces reading errors. Each number is displayed individually. There are no superimposed outlines of "off" digits. You can read the numbers as easily from the side as from the front.

The KIN TEL 502B has a single plane readout.

4. Can you program it?

A programable instrument is a more useful instrument. It can be used with a printer for unattended checkout of missile components, quality control of specific items, and other automated measurements.

You can program the 502B. It's the only standard off-the-shelf digital voltmeter controllable by remote contact closures. With the AC converter control set to REMOTE, closures command any desired sequence of measurements at 10-volt AC, 100-volt AC, 1000-volt AC, auto-range AC, or auto-range DC.

5. Will it over-range on both AC and DC?

A loaded question, perhaps, since the KIN TEL 502B is the *only* digital voltmeter on the market with AC and DC over-ranging. But this is an important feature, not just an extra one.

The 502B displays 4 complete digits plus a 5th over-ranging digit (0 or 1). This 5th digit gives ten times more resolution at the often-measured decade points (1, 10, 100 volts) than 4-digit voltmeters that lose a digit changing from .9999 to 1.000. This means you get the useful accuracy of a 5-digit voltmeter over a large part of the measurement range while retaining the stability, reliability, and price advantage of a 4-digit instrument.

6. Does it offer the highest accuracy?

Of course, none of the features listed so far are worth a dime if you can't depend on what the instrument tells you. So let's be specific:

With the 502B, DC measurements are accurate to within .01% of reading ± one digit. AC accuracy is the highest in the industry — within 0.1% *of reading* or ± 3 digits (0.03% of full scale) for signals between 30 cps and 10 kc up to 10.000, 100.00, or 1000.0 volts on the respective range scales. With manual or programed ranging, this same accuracy is maintained up to 15.000 or 150.00 volts for signals between 50 cps and 7 kc.

This accuracy is maintained by a constant and automatic calibration of the metering circuit against an unsaturated mercury-cadmium standard cell.

7. Is it worth what it costs?

The KIN TEL 502B costs $4245, and is delivered from stock. Compare it – what it does and what it costs – with any other AC/DC digital voltmeter. We think that when you do, the 502B will rate the same answer on this question that it has on the other 6: yes.

Write direct for complete details on this exceptional voltmeter. Representatives in all major cities.

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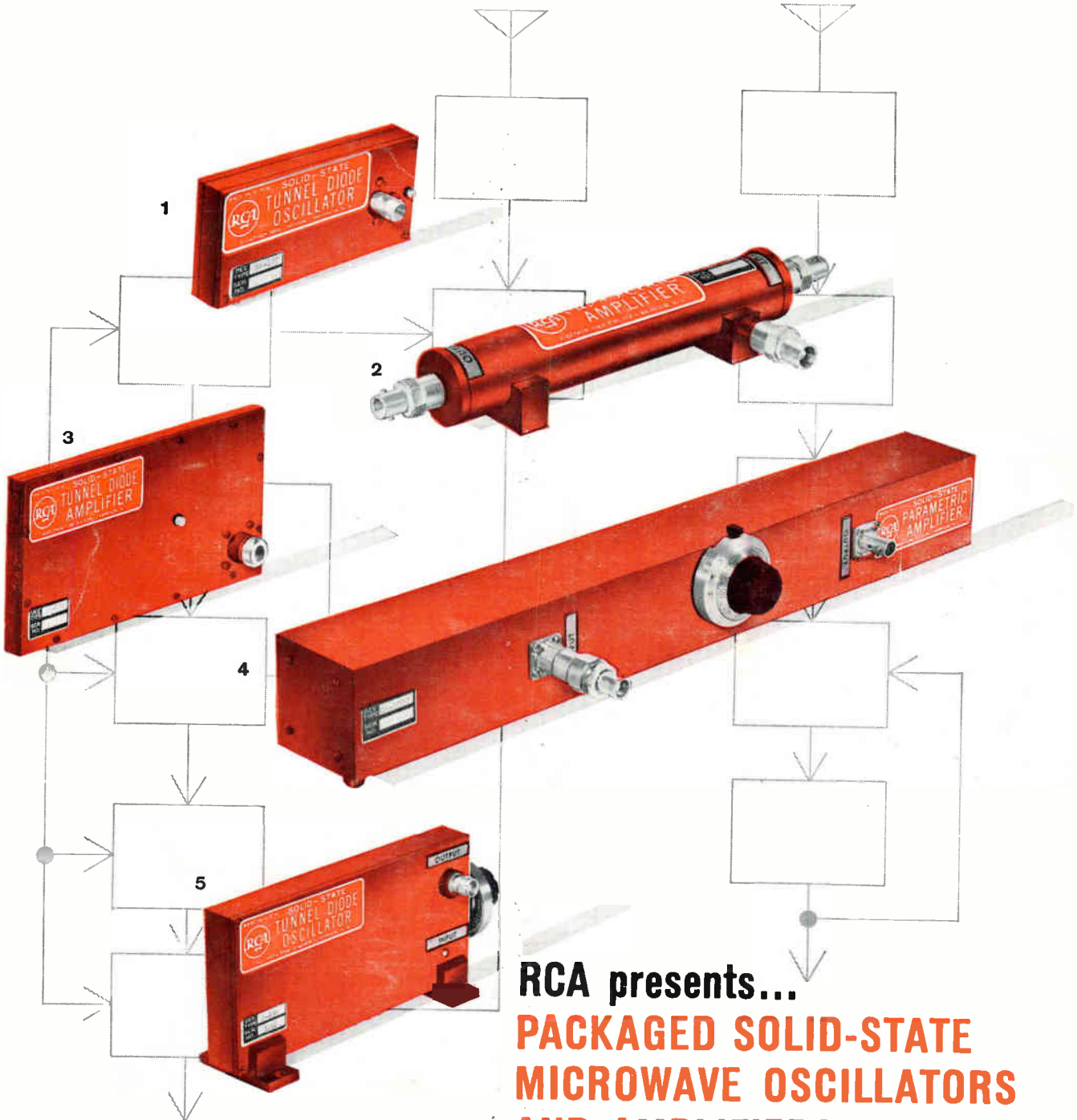

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