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MAY 23, 1958

electronics

engineering edition

Nuclear Detector for Oil Surveys ...p 61

Alarm Uses Neon Warbler ...p 74

Airborne Tv System ...p 66

for the HIGHEST in RELIABILITY

UTC products are the most copied in the world. This is only natural, since we maintain the largest laboratories and engineering staff in our field. However, copying alone cannot provide the measure of uniformity and reliability inherent in UTC units. To provide for the maximum in quality and reliability, continuing programs of quality control and quality improvement are constantly maintained in our laboratories.

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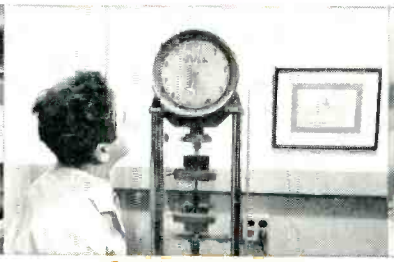
Qualitative micro analysis.

Vibration stress analysis.

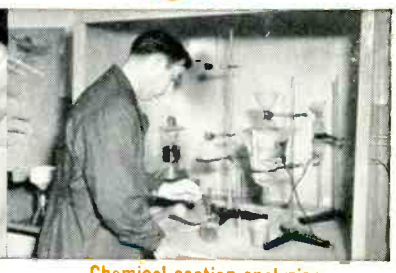
Torque testing of standard assemblies.

Checking uniformity of thermoplastic compounds.



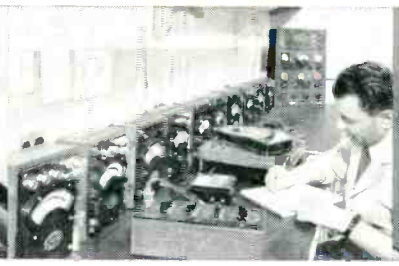
Quantitative checking of weld strength.

Hermetic terminals on microscope check.



Chemical section analyzing new materials.

Microscope analysis of dissected units.



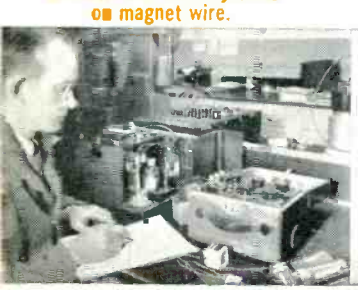
Calibration to primary standards.

Pilot plant hydrogen annealing.

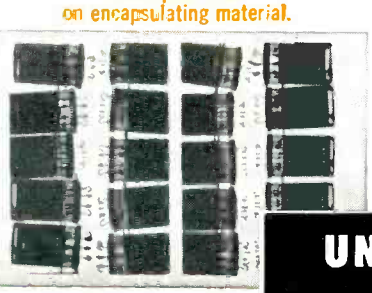
Seal tests under extremes of cold, heat, and altitude.

Abrasion and mercury tests on magnet wire.

Pilot plant run on encapsulating material.



Corrosion testing on insulating materials.



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electronics engineering edition

A McGRAW-HILL PUBLICATION • VOL. 31, NO. 21 • MAY 23, 1958

Issue at a Glance

Airborne Tv System. Ultrahigh-frequency f-m television transmission system developed by Philco for U.S. Navy provides military reconnaissance link from helicopter to surface command post. See p. 66.....COVER

Gamma-Ray Detector Aids Oil Field Surveys. Radioactive tracers introduced into water in an oil-producing formation are detected by G-M tubes feeding transistor circuit. Instrument is self-contained in a 1-in. diameter tube .....p 61
By F. E. Armstrong

Transistor Chopper Drives Accurate Clock. Synchronous clock motor is driven by a-c pulsed output of a transistorized chopper control circuit .....p 64
By Richard H. Williams

Airborne Tv System for Military Reconnaissance. Helicopter-mounted i-o camera output is relayed over 50 mile range by 30-w uhf f-m transmitter .....p 66
By N. Sher and J. F. Fisher

Automatic Speech Amplitude Control. Increases amount of intelligence transmitted over radio communication system under adverse conditions by altering energy distribution of speech.....p 71
By Lyle R. Battersby

Alarm System Uses Gated Neon Warbler. Conelrad alarm generates own warning signal, monitors key-station modulation and turns off local carrier .....p 74
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DIGEST continued

electronics

May 23, 1958 Vol. 31, No. 21

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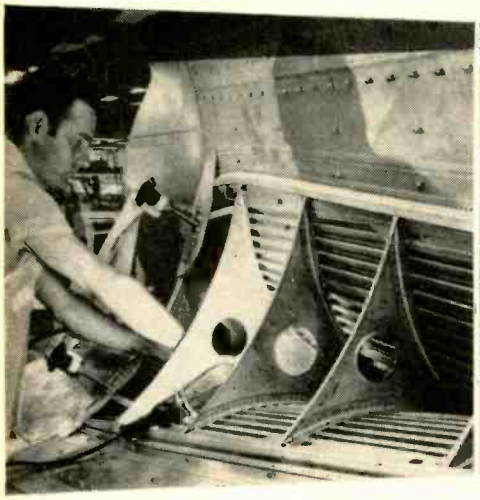

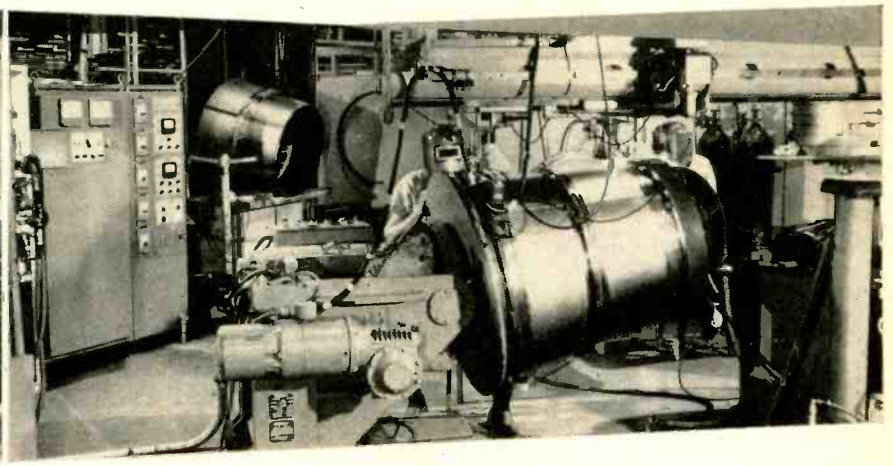

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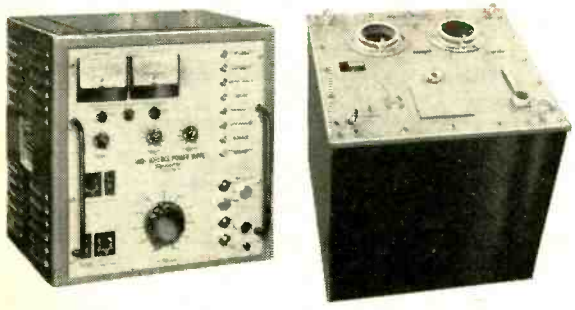
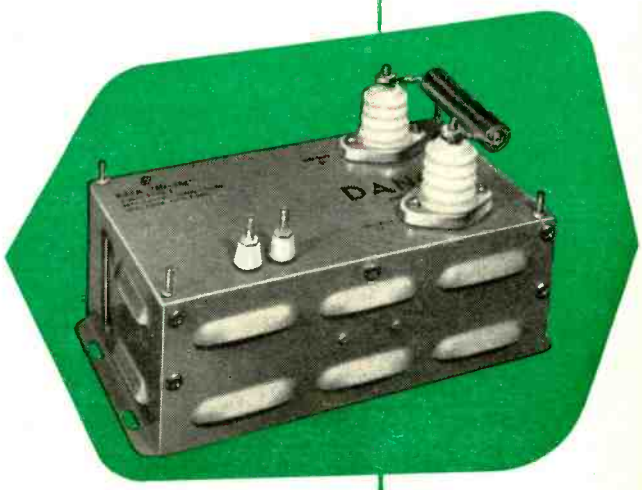
1000 Series, Rack-Mounted DC Supplies
0-1 to 0-60 KV, 2-500 ma. Rugged construction, conservative design, with full self-protection. Selenium rectifiers in models below 10 ma rating. Ripple; below 2.5% rms for max. current at max. voltage. Polarity reversible, with center-tap provision if desired.



2000 Series
0-1 and 0-250 KV; 5 to 3000 ma. Two-unit design, for remote operation and maximum safety for personnel and equipment. Conservative rating, simple operation. Polarity reversible.



9000 Series, "HI-SEL" DC Power Packs
Five models, from 0-5 KV and 5 ma up to 0-30 KV and 5 ma. Low ripple at all ratings. Selenium rectifiers and air-insulated design. Can be mounted in any position.

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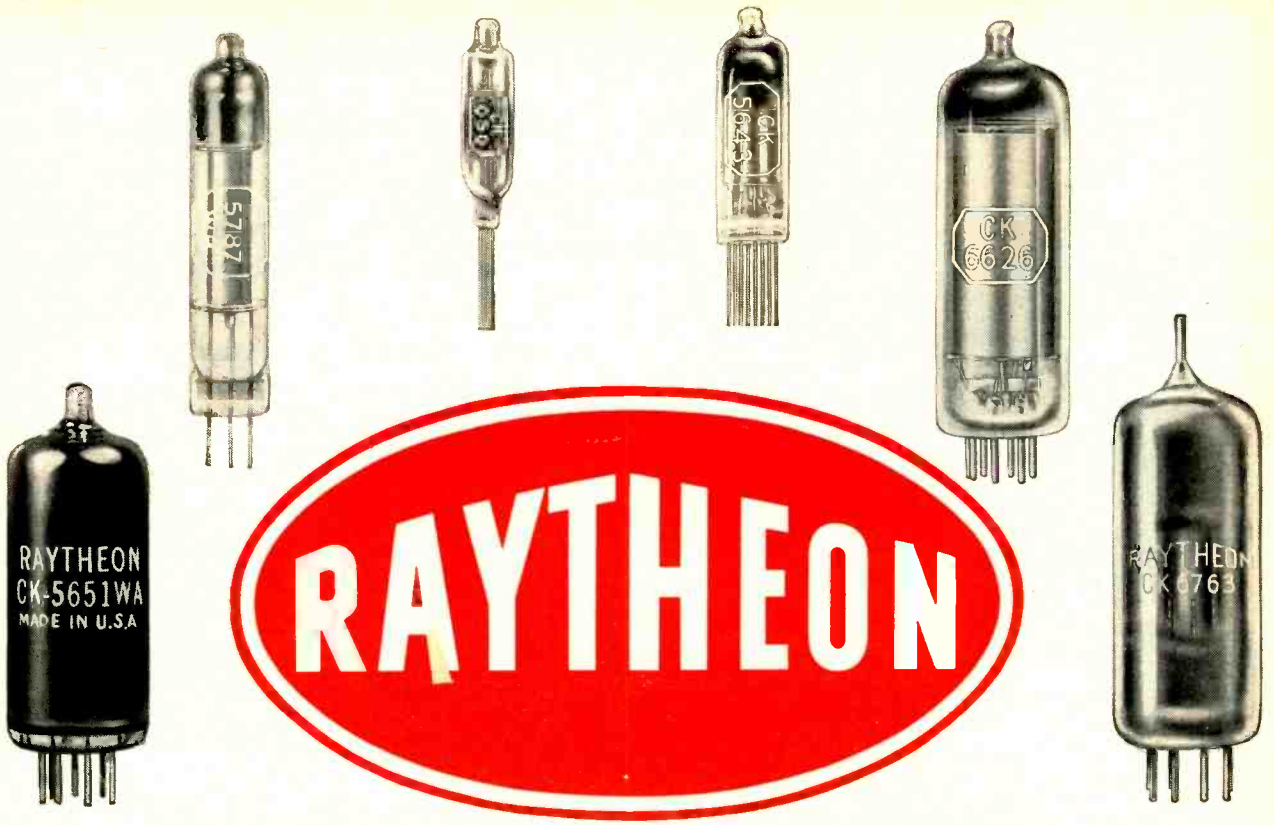

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VOLTAGE REGULATOR TUBES			
OA2, OA2WA, CK6626	Miniature	150 volts,	5 to 30mA
OB2, OB2WA, CK6627	Miniature	108 volts,	5 to 30mA
CK5787WA	Submin.	98 volts,	5 to 25mA
CK6542	Submin.	150 volts,	5 to 25mA

VOLTAGE REFERENCE TUBES			
CK5651, CK5651WA	Miniature	85 volts,	1.5 to 3.5mA
CK5783WA	Submin.	85 volts,	1.5 to 3.5mA
CK6213	Submin.	130 volts,	1 to 2.5mA

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Raytheon offers Corona Voltage Regulator Tubes for higher voltages in a wide range of ratings; also a variety of Radiation Counter Tubes.

COLD CATHODE RECTIFIERS			
CK5517	Miniature	PIV = 2800	I_o = 12mA
CK6174	Miniature	PIV = 2800	I_o = 3mA
CK6659 (CK1042)	Submin.	PIV = 2800	I_o = 8mA
CK6763	Miniature (Ruggedized)	PIV = 2800	I_o = 12mA

THYRATRONS		
RK61	Submin.	For control receivers in model aircraft, boats, etc.
CK1054	Submin.	
CK5643	Submin.	For general purpose military use

LIGHT INDICATOR		
CK1050	Submin.	Low drain, grid controlled indicator for semiconductor circuitry.

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CIRCLE 4 READERS SERVICE CARD

ELECTRONICS NEWSLETTER

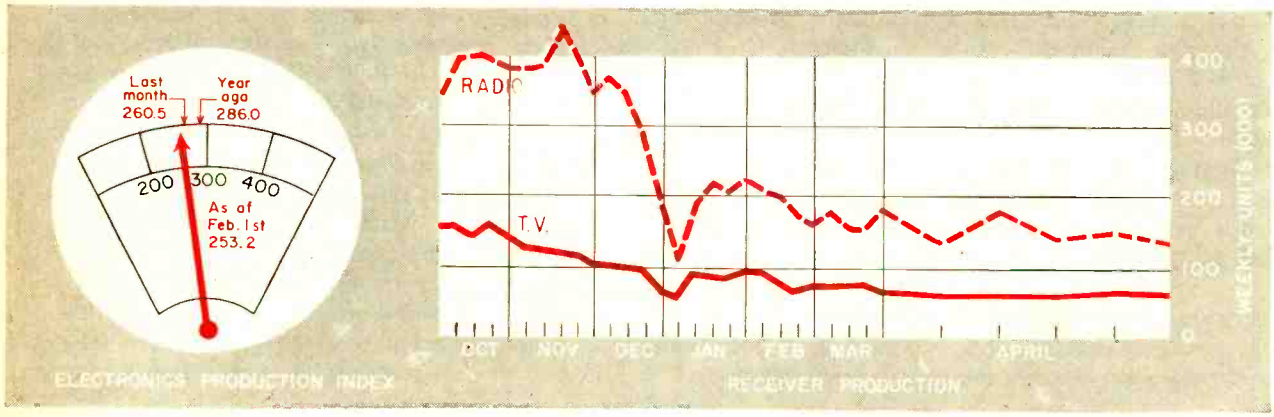
RUSSIA'S THIRD SPUTNIK, launched last week, appears from first reports to be carrying instruments similar to those on a USSR rocket fired Feb. 21 (ELECTRONICS, May 2, p 19).

ELECTRIC-POWERED MAGNETIC PROPULSION system looms as a strong possibility for maneuvering a manned satellite in outer space. New concept stems from studies and experiments in magnetohydrodynamics sponsored by USAF Office of Scientific Research at the Avco Manufacturing Corp.'s Research Laboratory (ELECTRONICS, Jan. 24, p 17 and Apr. 11, p 14). Magnetic thrust engine would take over after launching of spaceship by chemical propellant rockets; the magnetic engine would alter the craft's orbit altitude while it circled the earth or would power it to the moon or other planets. Thrust is produced by using a magnetic field to accelerate and expel a neutral plasma of fully ionized gas. Device would eliminate need to separate ions, an integral part of an ion rocket system, and might have other advantages.

NEW ENGLAND ELECTRONICS FIRMS are cheered by optimistic reports from two quarters. First National Bank of Boston says the industry's growth is favorably influencing the region's economic foundation and offers special promise for the year ahead. Associated Industries of Massachusetts, which quizzed 100 Massachusetts electronics firms and got 61 replies after last fall's defense stretchouts, reports: Electronics production employment by June 1 will be three percent ahead of last October. Survey also showed: (1) there has been no reduction in number of persons in basic research; (2) there will be a 10 percent overall increase in the number of engineers and a five percent rise in technicians by June 1 over Oct. 1957.

INFORMATION THEORY IN RUSSIA continues to get priority attention, it is indicated by a Tass report about a recent meeting of the Moscow Engineers Club. More than 200 Soviet scientists and engineers were told that "on a frequency of 3,000 cycles, with a certain amount of interference, 300 telephone conversations, and not just one, can be held simultaneously on one line." Mathematician Vladimir Siforov said that in the future radio stations will be able to use dozens of times more shortwave bands for broadcasting than at present.

EARTH SATELLITE-BORNE TELESCOPE and tv equipment weighing about a ton require solution of the problems of automatic stabilization and control, says James H. Doolittle, chairman of the National Advisory Committee for Aeronautics. He told the Senate's Special Committee on Space and Astronautics that the job was a straightforward one that "could be accomplished with reasonable promptness if sufficient scientific and technical manpower is assigned to the work."



FIGURES OF THE WEEK

RECEIVER PRODUCTION

(Source: EIA)	May 2, '58	Apr. 25, '58	May 3, '57
Television sets, total	77,344	84,999	81,864
Radio sets, total	149,604	162,421	280,490
Auto sets	39,754	48,574	103,015

STOCK PRICE AVERAGES

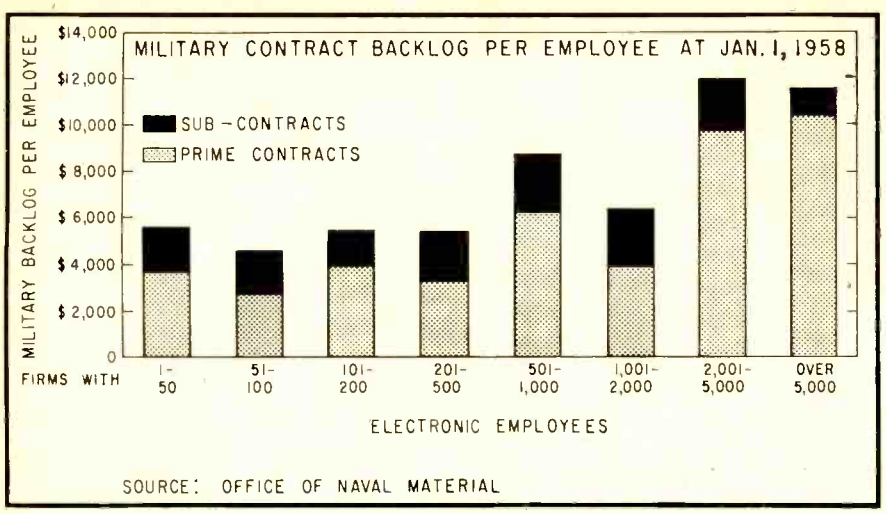
(Source: Standard & Poor's)	May 7, '58	Apr. 30, '58	May 8, '57
Radio-tv & electronics	46.24	45.57	51.88
Radio broadcasters	61.21	59.16	69.36

FIGURES OF THE YEAR

Totals for first two months

	1958	1957	Percent Change
Receiving tube sales	56,466,000	82,031,000	—31.2
Transistor production	6,061,955	3,221,000	+88.2
Cathode-ray tube sales	1,178,046	1,489,223	— 2.1
Television set production	804,396	914,887	—12.1
Radio set production	1,903,418	2,350,294	—19.0
TV set sales	1,030,213	1,148,796	—10.3
Radio set sales (excl. auto)	954,705	1,088,392	—12.3

MORE FIGURES NEXT PAGE



Military Backlog $4.9 Billion

Prime contracts run four percent ahead of last year. Subcontracts are down about 16 percent

ELECTRONICS PRODUCERS should rack up sales of $8.3 billion this year—$600,000 million above the record 1957 high of $7.7 billion. Existing military backlogs give good reason for predicting this increase in business.

The Office of Naval Material reports current military backlog figures in its recently released sixth annual survey of electronics industry capabilities.

As of Jan. 1, 1958, the total military contract backlog of the electronics industry amounted to $4.922 billion, about one percent ahead of the backlog of Jan. 1, 1957. However, the 1958 prime contract backlog of $4.206 billion was four percent ahead of the 1957 figure; while the subcontract backlog trailed the 1957 one by 16 percent.

Average military backlog per employee for Jan. 1958 was $10,088. This is an increase of $718 over the average military backlog per employee figure of Jan. 1957.

The backlog-per-employee figures vary according to company size. As of Jan. 1, 1958, firms with over 5,000 employees averaged $11,413 in backlog per employee. Firms with 51 to 100 employees averaged $4,485. In most cases, size of backlog as well as backlog per employee was, as might be expected, larger for larger firms.

On the average, 85.4 percent of military backlogs were in prime contracts. However, the proportion of prime and subcontracts varied considerably with company size.

Firms with over 5,000 employees had an average of 92.0 percent of their military backlogs in prime contracts. The survey also shows that companies with 51 to 100 employees had an average of 58.2 percent of their military backlogs in prime contracts.

Reveals USAF's Weapons Plans

AIR FORCE weapon system planning was revealed in considerable detail by Lt. Gen. C. S. Irvine, Deputy Chief of Staff, Materiel, at Sylvania's formal opening ceremonies recently for its new Amherst Engineering Laboratory in Williamsville, N. Y.

The evolution of manned aircraft is planned as follows:

Mach 2, above 75,000 ft altitude: Convair's electronics-laden B-58 Hustler will replace the B-47 intermediate-range bomber and provide support for long-range B-52's, conceivably as electronic countermeasures planes. Eight or 10 B-58's are currently operable. Flight tests prove that speed (and it is assumed, range) is better than expected.

An air-to-surface guided missile is in the works for the Hustler. It will have to be faster than the B-52's Hound Dog missile since the B-58 flies faster than Hound Dog will. North American's Hound Dog will be ready for flight testing next summer.

Mach 3, above 100,000 ft altitude: North American's B-70 (ELECTRONICS, Feb. 21, p 15) and F-108 will reveal a radical departure from present configuration. Radar systems will have to possess far greater range than is currently possible with present airborne sets. The B-70 will carry and air launch an MRBM (Medium Range Ballistic Missile). Three companies are currently working on design details of this 500-mi range ballistic bird.

Mach 5 or 6: Not yet being designed, this later generation of hypersonic vehicles will be introduced into the program only in the event that the gap between operational B-70s and manned space

TRANSISTOR AND TUBE SALES, MONTHLY

(Source: EIA)	Feb. '58	Jan. '58	Feb. '57
Transistors, units	3,106,708	2,955,247	1,785,000
Transistors, value	$6,806,562	$6,704,383	$5,172,000
Receiving tubes, units	29,661,000	26,805,000	44,460,000
Receiving tubes, value	$25,650,000	$23,264,000	$36,631,000
Picture tubes, units	556,136	621,910	728,363
Picture tubes, value	$11,210,527	$12,341,927	$13,134,778

EMPLOYMENT AND EARNINGS, MONTHLY

(Source: Bur. Labor Statistics)	Feb. '58	Jan. '58	Feb. '57
Prod. workers, comm. equip.	349,800	362,000	394,600
Av. wkly. earnings, comm.	$79.75	$79.15	$80.18
Av. wkly. earnings, radio	$78.98	$77.40	$76.80
Av. wkly. hours, comm.	38.9	38.8	40.7
Av. wkly. hours, radio	39.1	38.7	40.0

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The VacIon high vacuum pump has no equal for simplicity, cleanliness, and compactness. Get the complete story in the VacIon High Vacuum Pump Engineering Bulletin — write for your copy today!

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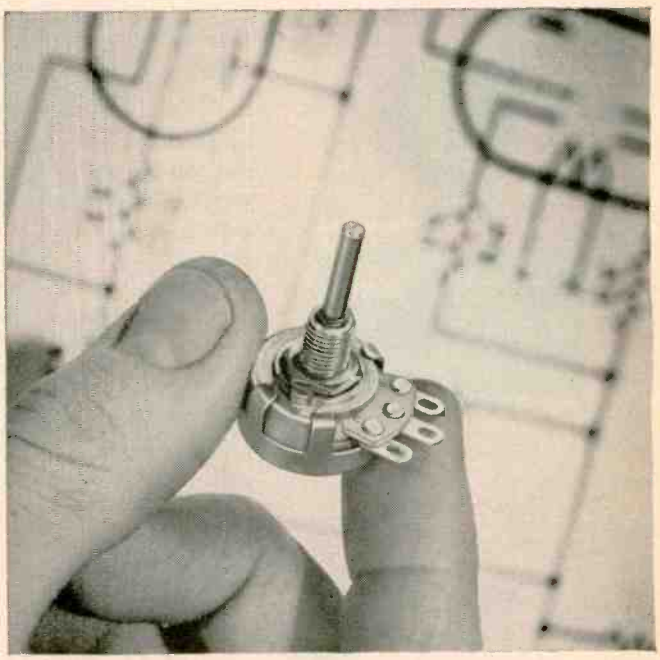
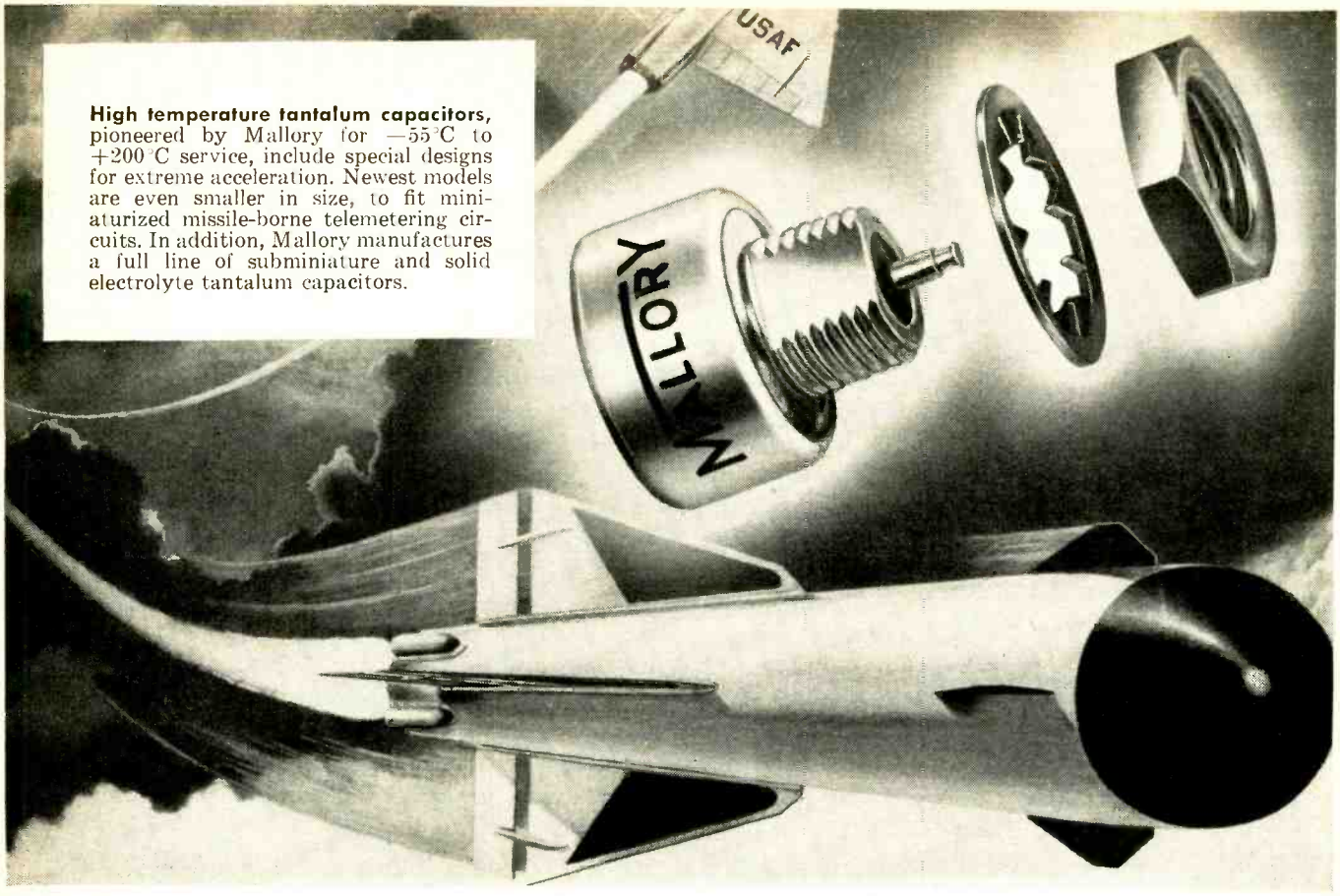
For Greater Reliability...

Ideal power for transistors is the mercury battery, pioneered by Mallory. High energy in small volume, long life and constant discharge characteristics make this battery valuable in miniaturized, self-powered equipment. Another Mallory development is the Solidion® solid state battery, capable of storage for over 15 years. It is ideal for stockpiled systems.



New high temperature miniature wirewound control . . . only ¾" in diameter, is designed for ambient temperatures of 200°C and up. It has exceptionally high power dissipation for its size—rated 5 watts at 145°C. Control is gold plated to assure maximum shelf life, resistance to corrosion and high heat transfer. Easily adaptable to hermetically sealed mounting.



High temperature tantalum capacitors, pioneered by Mallory for —55°C to +200°C service, include special designs for extreme acceleration. Newest models are even smaller in size, to fit miniaturized missile-borne telemetering circuits. In addition, Mallory manufactures a full line of subminiature and solid electrolyte tantalum capacitors.

. . . *in Missile Guidance Systems*
MALLORY Components and Services

In today's accelerated defense programs, electronic missile guidance systems need an extra measure of dependability in order to perform a critical service at a precise moment. You can build this extra dependability into research circuits, prototypes and production models—when you specify Mallory precision-made components.

When your problems are new or unusual, you can get expert assistance from the experienced Mallory application engineering team. Because of the wide range of components we supply, you can count on us for engineering consultation not only on component design and application, but also in other important areas such as contact metallurgy and sub-assembly manufacturing.

Shown here are just a few of the Mallory products and services that can help put peak reliability in your missile guidance circuitry. It will pay you to check your needs against the broad Mallory line. Write today for a consultation on your specific projects. For prompt delivery of stock components, call on your nearby Mallory distributor.

Serving Industry with These Products:

Electromechanical — Resistors • Switches • Tuning Devices • Vibrators
Electrochemical — Capacitors • Mercury and Zinc-Carbon Batteries
Metallurgical — Contacts • Special Metals • Welding Materials

Parts distributors in all major cities stock Mallory standard components for your convenience.

Expect more . . . get more from

P.R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA

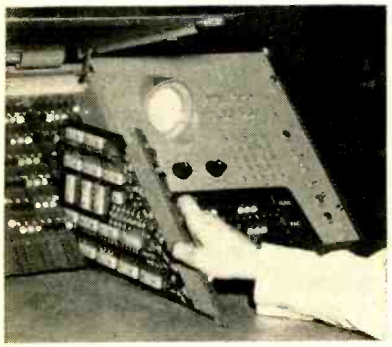
flight (Dynasoar) drags out for too long a period.

First step toward space: North American's X-15, early next year, will carry Capt. Iven Kincheloe to over 100-mi altitude and faster than 3,600 mph. A transponder beacon carried in the nose of the plane will help ground radar stations track the test flights. Major electronic equipment to be used consists of transducers and telemetering gear to measure, record and transmit flight data.

Dynasoar: After the X-15, Dynasoar, or a similar type project, should result in a vehicle that will safely put a man in orbit for one or more trips around the earth before landing. Presumably the Dynasoar vehicle will require advanced-type electronic telemetering and control equipment.

Space vehicles: As a natural outgrowth of knowledge gained from these experiments, the Air Force will probably develop piloted space vehicles with weapon deployment and counter-offensive capabilities. These will perform within the earth's gravitational field but well outside 99 percent of its atmospheric envelope.

10,000-Transistor Computer Out



Transistors are mounted on 332 printed-circuit cards for ease of access

TRANSISTORIZED computers are beginning to appear in the marketplace.

Philco Corp.'s Transac, now being delivered to its first customers after almost three years of development and field tests, uses 10,000 surface-barrier transistors in 332 all-transistor printed-circuit cards. The

WASHINGTON OUTLOOK

THE ADMINISTRATION'S PROPOSAL to set up a new civilian space agency to run our electronics-laden space exploration program seems to be in trouble on Capitol Hill. On one hand, the proposal is beset by charges that broad civilian authority over space research could sorely restrict vital military projects. But it is also criticized for establishing too limited civilian powers over space exploration.

Both Pentagon spokesmen and congressional leaders such as Sen. Styles Bridges (R., N.H.) believe that the Defense Dept.'s role in space operations is downgraded by expanding the National Advisory Committee on Aeronautics into a new civilian space research with over-all control over the program.

Still, men such as Sen. Clinton P. Anderson (D., N.M.) lament the fact that civilian considerations, in their opinion, are being pushed to the side under the proposed new setup.

These opponents are peeved over provisions putting the new agency under the direction of a committee consisting of only eight government representatives and nine nongovernment specialists (NACA is run by a committee dominated by government officials) and barring the civilian space agency from space programs peculiar to or primarily associated with military weapon systems or military operation.

Says Anderson: "So few things in modern life could not be described as peculiar to military operations that if the same test were used in the rest of our national affairs, we would have a military dictatorship."

The crux of the squabble over civilian vs military control of space is the question of who is to determine whether a specific space project is of a military nature, and thus a function of the Defense Dept.'s Advanced Research Projects Agency, or a nonmilitary nature to be put under the aegis of the newly proposed National Aeronautics and Space Agency.

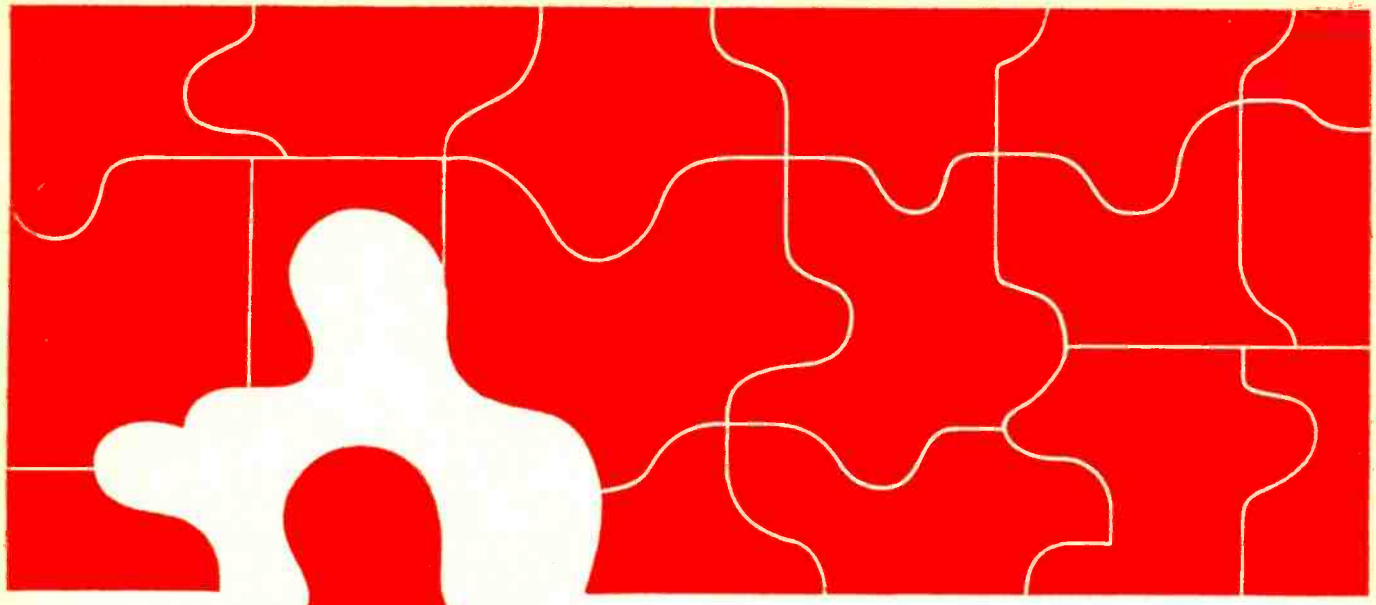
Deputy Defense Secy. Quarles told the Senate Space Committee that ultimately the questions would be answered by the President. Quarles's statement, of course, begs the question. The President's decisions will be based on advice from his technical advisers. The general consensus is that the Pentagon-NASA relationship on space will be comparable to the Pentagon-NACA relationship on aeronautical research.

The outlook is that the new agency will be engaged mostly in basic research in its own laboratories and in contractor facilities. The Defense Dept. will continue to pull the strings on the more costly phases of hardware development.

- **The Defense Dept.'s ARPA** now has before Congress budget requests totaling $520 million for fiscal 1959, starting July 1. Of this sum, all but $72 million is earmarked for military space projects.

  ARPA wants to push work on improved guidance systems to put artificial earth satellites into more precise orbits. It wants to develop satellites to provide communication relay stations, to survey weather patterns, to serve as navigational aids and to act as early warning reconnaissance stations against enemy attack.

  Other key space electronics projects are to develop satellite tracking and monitoring systems and to speed up work on ballistic missile early warning systems. Of next year's budget, $157.4 million is earmarked for the latter project—in addition to sums in the Air Force's budget.



Puzzled by ground loop problems? How to rescue microvolt signals from volts of noise?

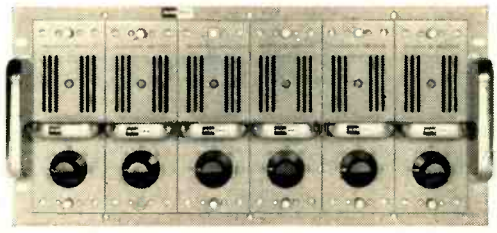
HERE'S WHY KIN TEL'S DIFFERENTIAL DC AMPLIFIERS FIT IN INSTRUMENTATION SYSTEMS

160 db DC, 120 db 60 cycle common mode rejection with balanced or unbalanced input ■ Input completely isolated from output ■ Input and output differential and floating ■ 5 microvolt stability for thousands of hours ■ .05% linearity, 0.1% gain stability ■ Gain of 10 to 1000 in five steps ■ >5 megohms input, <2 ohms output impedance ■ 120 cycle bandwidth ■ Integral power supply

These are just a few of the many outstanding features of the Model 114A differential DC amplifier . . . features that make this amplifier *really work* in instrumentation systems...features that will help solve *your* instrumentation problems today.

Ideal for thermocouple amplification, the 114A eliminates ground loop problems; allows the use of a common transducer power supply; permits longer cable runs; drives grounded, ungrounded or balanced loads, and can be used inverting or non-inverting.

For additional information and technical literature on this exceptional instrument, write or call KIN TEL – the world's largest manufacturer of precision, chopper-stabilized DC instruments.



KIN TEL 114A differential DC amplifiers ...convenient, interchangeable plug-in mounting in either 6-amplifier 19″ rack mount modules or single-amplifier cabinets.

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KIN TEL
A Division of Cohu Electronics Inc.

circuit cards in the arithmetic and control circuits are stacked library-fashion behind the control console face for easy accessibility (photo, p 12).

The new unit is an all-binary, parallel, asynchronous computer with magnetic-core storage. It comes in two models. The smaller model operates on 36-bit words, uses punched paper tape or punched cards as input-output media. The larger model's word is 48 bits long. The bigger machine can work with up to 256 magnetic-tape transport units besides punched cards and paper tape.

Tape units will operate at 150 in./sec, read or write 90,000 alphanumeric or 150,000 numeric characters a sec. The 16-channel tape will contain 12 numeric bits (or two 6-bit coded alphanumeric characters), plus two parity-check channels and two timing channels. Magnetic tape also makes possible the use of off-line high-speed printers and other transcribing gear.

Magnetic-core storage for both models is a basic unit of 4,096 words. The memory of the larger computer can be expanded in 4,096-word blocks of 65,536 words.

MILITARY ELECTRONICS

• **New light weight,** highly accurate Doppler radar navigation set, to be designed and developed by General Precision Labs, will go into IBM's bomb-nav system (AN/ASQ-28) for North American's B-70.

Raytheon is supplying Doppler radar for Sperry's bomb-nav system in Convair's B-58 (ELECTRONICS, Feb. 21, p 15).

• **An improved** solid-propellant Bomarc, ground-to-air electronically guided interceptor missile with a 400-mi range (ELECTRONICS, Feb. 21, p 36), is scheduled to begin a several-years-long test program soon. Program will be carried out by USAF and prime contractor Boeing. The current Bomarc model, which has a 200-mi range, has been fired approximately 40 times to date. Four Bomarc launching sites are under construction in the U. S.

• **First step** toward putting a 100-ft balloon into orbit took place last month when NACA successfully sent a 12-ft balloon to 50 miles by rocket. Having a 100-ft balloon in orbit will be useful in studying long range communications, NACA director Hugh L. Dryden says.

• **"Introduction** of single sideband (SSB) radio equipment into the fleet is being accelerated," Rear Admiral H. C. Bruton, Director of Naval Communications, says. Also, "We have great hopes for meteor scatter as a means of solving some of our ship-to-shore communications problems."

• **British IRBM** under development by de Havilland Propellers is now officially confirmed. Firm says the missile, which eventually will be test fired at Australia's Woomera range, could carry a thermonuclear warhead "with extreme accuracy over a range of several thousand miles to a surface target."

De Havilland also confirmed that Rolls-Royce is providing the power plant and Sperry Gyroscope Co. the guidance system.

BBC Perfects Video Recorder

BRITISH BROADCASTING CORP. engineers have designed and built a video tape recorder after two years of development in the BBC research lab.

Known as VERA (Vision Electronic Recording Apparatus), the new recorder uses ½-in. wide tape.

The British recorder utilizes longitudinal recording. BBC tape travels at 200 ips, carries a 15-min program on a 20½-in. diam reel.

The new unit records on three tracks, two for video and one sound, to produce the 2.5-mc bandwidth required for the BBC 405-line, 25-frame tv system. Longitudinal technique offers the advantage of easy splicing, is conducive to simultaneous recording and monitoring.

There's no color tv broadcast in Britain at present, but BBC engineers feel VERA is not limited to black and white.

Electronic amplifiers used in two-lever steering and transmission control developed by Ford (left) and electronic computers used in steering, acceleration and brake control developed by GM (right) cause our industry to ask . . .

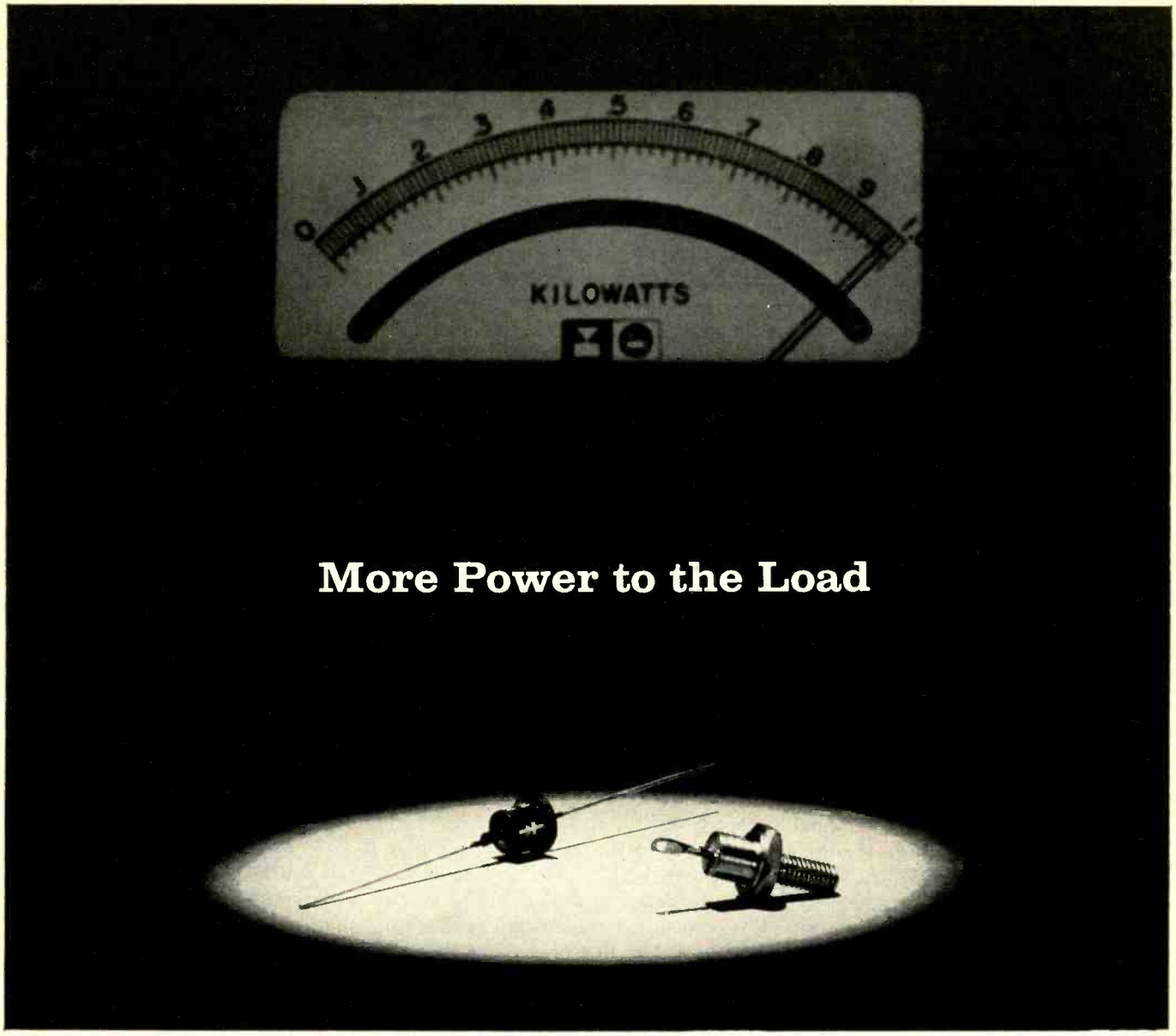
Electronic Cars: How Soon?

A GM SPOKESMAN told ELECTRONICS a few days ago that if current prototypes of electronic auto controls prove practical and salable, an enormous new market will open for component manufacturers.

Conventional operator's controls, he said, may be completely eliminated within the next few years.

Two new developments giving weight to this prediction were announced by GM and Ford at the Governors' Committee for Highway Safety conference last month.

In the system demonstrated by GM's Research Staff, a single con-



More Power to the Load

Hughes medium power, silicon rectifiers

The exceptionally high efficiency of these rectifiers, obtained by advanced development and construction techniques, makes possible power supply design which was previously impossible. Efficiency like this means less power loss in the rectifier and, for a given size of rectifier, more power to the load. Cooler operation also results, thereby contributing increased life since there is less heat to dissipate.

In most instances, the voltage drop across the rectifier is so small—and it is constant throughout the life of the rectifier—that it may be neglected in power supply design. The low drop improves regulation of the power supply too.

So specify the types listed at right and capitalize fully upon the advantage of high rectifier efficiency. In addition to the types shown, Hughes has two groups of 1N-numbered units, one with a lead-mount configuration and the other in the standard JETEC 7/16" hex package.

For literature or a visit from one of our sales engineers, please write: HUGHES PRODUCTS, Semiconductor Division, International Airport Station, Los Angeles 45, California

STUD-MOUNT TYPES

	Peak Inverse Voltage (Volts)	Average Rectified Current @ Specified Case Temperature (Amps max.)	(Degrees C)	Average Inverse Current (mA, max.)*
HR10671	100	3.0	150	0.5
HR10673	200	3.0	150	0.5
HR10675	300	3.0	150	0.5
HR10677	400	3.0	150	0.5
HR10679	500	2.0	135	0.5
HR10681	600	2.0	135	0.5

LEAD-MOUNT TYPES

	Peak Inverse Voltage (Volts)	Average Rectified Current @ Specified Ambient Temperature (mA max.)	(Degrees C)	Average Inverse Current (mA, max.)*
HR10422	100	350	100	0.1
HR10423	200	350	100	0.1
HR10424	300	350	100	0.1
HR10425	400	350	100	0.1

* Averaged over one cycle at full rated conditions of current, voltage, and temperature with a resistive load.

Creating a new world with ELECTRONICS

HUGHES SEMICONDUCTORS

HUGHES PRODUCTS

trol lever substitutes for steering wheel, accelerator pedal and brake pedal. System uses a four-inch control lever which can be manipulated in any direction. Pushing forward accelerates car, pulling back applies brakes. Sidewise movement in desired direction steers car. Steering ratio is varied with speed.

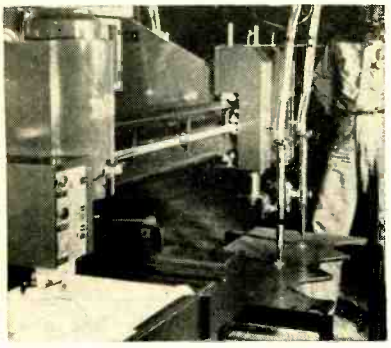
As the driver steers, the computer determines the wheel angle required to make the desired turn based on lever displacement and car's speed. Brake and accelerator controls are operated by servos.

A GM spokesman said an analog computer with d-c operational amplifiers is used at present. He cautioned, however, that production models, when made, may be radically different. Transistorized computers are a probability, but present model uses vacuum tubes.

In system demonstrated by Ford, only the steering and speed range are controlled. Two control levers replace the conventional steering wheel and transmission shift lever.

Right or left turns are made by moving steering control in the corresponding direction. When steering, an error signal is generated between a potentiometer connected to the lever and a slave in the steering linkage. The signal is boosted by a servo amplifier whose output is applied to a torque motor which drives a spool in a hydraulic valve. This valve controls hydraulic circuit used to move front wheels.

Electronic Tracer



No templates are needed by electronic tracer control which scans line drawings and steers steel-cutting torches. Tracer system consists of vibrator-type scanner, phototransistor and a closed-loop servo. Unit was developed by Canadian Westinghouse, Ltd., for National Cylinder Gas Company

FINANCIAL ROUNDUP

• **Western Electric** offers minority stockholders (general public) rights to subscribe to 2,853 additional shares of common stock at $50 per share, and at rate of one new share for each 10 shares held. This will raise $142,650. Same opportunity is being offered to all other stockholders (American Telephone & Telegraph), explains a spokesman for WE. AT&T, which owns some 99.8 percent of Western Electric stock, will subscribe to 1,565,665 shares of stock via the right offering and will contribute $78.3 million to WE's coffers. Proceeds are to be used for plant expansion, added working capital and general corporate purposes.

• **Aircraft Radio Corp.**, Boonton, N. J., recently paid its 100th uninterrupted quarterly cash dividend. The latest payment, this Spring, was 20 cents per share.

• **Belock Instrument**, College Point, L. I., N. Y., and **Sonic Industries**, Lynbrook, L. I., N. Y., announce abandonment of the plan for Belock to acquire Sonic through exchange of shares. Belock is primarily engaged in military electronic systems work and also manufacturers marine navigation equipment. Sonic makes hi-fi equipment, phonographs and radios.

• **Avionics Corp. of America**, Philadelphia, Pa., issues 99,125 shares of common stock at $3 per share. Avionics develops and manufactures electronic test equipment and also makes electronic and electrical components. New money will be used for plant construction and for working capital. Underwriting is being handled by Milton D. Blaunder & Co. and Amos Treat & Co., both of New York, and Hallowell, Sulzberger, Jenks, Kirkland & Co. of Philadelphia, on a best efforts basis.

• **Maine Industrial Building Authority** announces that its rate for insuring industrial mortgages will be one percent. The recently created MIBA insures mortgage loans granted to local industrial development corporations up to 90 percent of the cost of new industrial projects. Maine looks for increased electronics activity in the Pine Tree State as a result of new plant financing through MIBA.

• **Smith-Corona** and **Marchant Calculators** stockholders will vote June 26 on a previously announced proposal to merge the firms. S-C is headquartered in Syracuse, N. Y., and Marchant's headquarters are in Oakland, Calif. The merged firm would be known as Smith-Corona Marchant. Proposed agreement also provides for stock of two firms to be exchanged on basis of 1¼ shares of Smith-Corona for 1 share of Marchant.

Mobile Radio to Double by 1968

DETROIT—Mobile radio use will double in next ten years, $14 million will be spent on equipment, and licensees will exceed 600.

These are predictions by the National Mobile Radio System which held its 10th annual meeting in Detroit last week.

Among design features shaping up for the future in the growing medium are message recorders, direct dial systems, personal paging devices and smaller transistorized units working automatically.

System president, Norman Medlar, says mobile radio is "definitely booming", especially in western U. S. He says future developments must entail educating potential users to the values of mobile radio.

Tomorrow's customers are expected to include a growing number of municipal and medical users, as well as industrial services needing rapid links between field and base personnel.

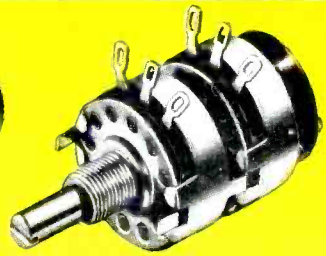
NMRS membership today draws on 286 license holders. In 1949

THE FIRST POTENTIOMETER to satisfy CHARACTERISTIC "Y" of MIL-R-94

The Type J (RV-4)

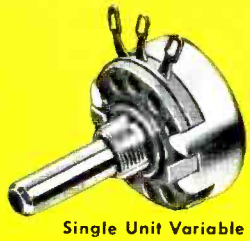
The popular Type J potentiometer is designed for operating continuously at 70° C ambient at full rating of 2 watts. Control is always smooth—without abrupt resistance changes—because of the solid, hot molded resistance element that is used. Even initially, noise characteristics are extremely low, but actually improve with use. The Type J potentiometer is made in single, dual, and triple units with various types of shafts, and with a built-in line switch. It is also furnished encapsulated in epoxy resin. Total resistance values range from 50 ohms to 5 megohms. Taps can be supplied. Type J is available in all standard tapers.

Triple Unit Control with Plain, Short Shaft



Dual Element Control with 125 v Line Switch

Single Unit with Short Shaft and Lock Type Bushing

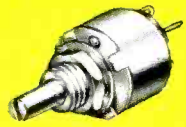


Single Unit Variable Resistor with Long Shaft

ALLEN-BRADLEY
Hot Molded Composition POTENTIOMETERS

The Type G (RV-6)

This tiny potentiometer—only ½ inch in diameter—is designed for use where space must be conserved without sacrificing performance. The solid, hot molded resistor element assures long operating life, and low noise level which improves with use. Full rating of ½ watt at 70° C ambient. Available with plain or lock type bushings, and with line switch. The Type G can also be supplied encapsulated in epoxy resin. Total resistance values from 100 ohms to 5 megohms. Available in all standard tapers.



With Plain Type Bushing

With 125 v Line Switch

With Lock Type Bushing

Encapsulated

When you want the ultimate in performance—potentiometers that not only satisfy—but exceed—the most rigid moisture resistance and thermal cycling requirements of MIL-R-94B, Characteristic "Y"—insist on Allen-Bradley.

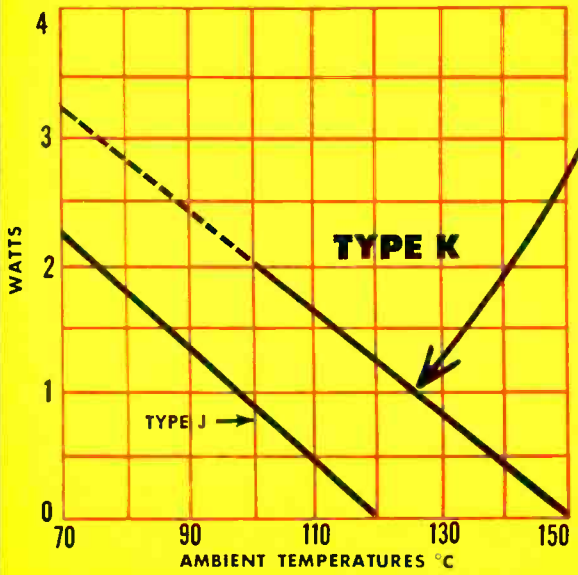
Write for Technical Bulletin 5200

A-B QUALITY

Allen-Bradley Co.
222 W. Greenfield Ave.
Milwaukee 4, Wis.
In Canada:
Allen-Bradley Canada Ltd., Galt, Ont.

3-58-E

1 WATT AT 125°C!



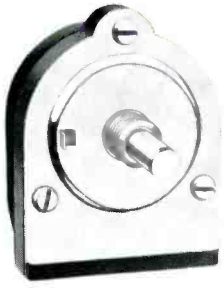
Comparison between Type K and Type J variable resistors—power ratings vs. ambient temperature. Type K far exceeds the requirements of MIL-R-94B.

TYPE K
HIGH TEMPERATURE
Hot Molded Composition Potentiometer

Especially designed for high temperature applications, the Type K has ultraconservative ratings of 1 watt at 125° C, 2 watts at 100° C, and 3 watts at 70° C ambient temperatures. It can be operated at 150° C—under "no load" conditions. Thus, the Type K potentiometer far surpasses the requirements of characteristic "Y," of MIL-R-94B. The solid, hot molded resistor element assures long life, smooth operation, and low "noise"—particularly after long use. Identical in size and physical construction to the well-known Type J potentiometer. Also furnished in the same types and resistance ranges.

For Industrial Electronic Applications

Rugged...Reliable!



Available with plain, lock type, or watertight bushings. Shafts available as plain round or with screwdriver slots.

Two types of mountings furnished. One-hole, back-of-panel mounting, at left; or front-of-panel mounting, above.

TYPE H Hot Molded Composition Potentiometer

The Type H variable resistor is especially designed for applications requiring smooth control and long life—in a 5-watt rating. The dual track, solid resistance element eliminates all moving metal-to-metal electrical contacts, making it outstanding for its low "noise" characteristics, both initially and after long use. It provides an operating life of over 100,000 cycles with no appreciable change in resistance. The Type H is rated 5 watts at 40° C, with a maximum continuous voltage of 750 volts. Total resistance—50 ohms to 2.5 megohms.

For Printed Circuits

TYPE F—Only ½ inch in diameter, yet rated ¼ watt at 70° C. Gold plated terminals for reliable soldering. With slotted shafts only.

Flat...Compact

TYPE T—Rated ½ watt at 70°C. Using cover as actuator results in a very thin unit...ideal for miniaturized equipment. 100 Ohms to 5.0 megohms.

ALLEN-BRADLEY
QUALITY

Electronic Components

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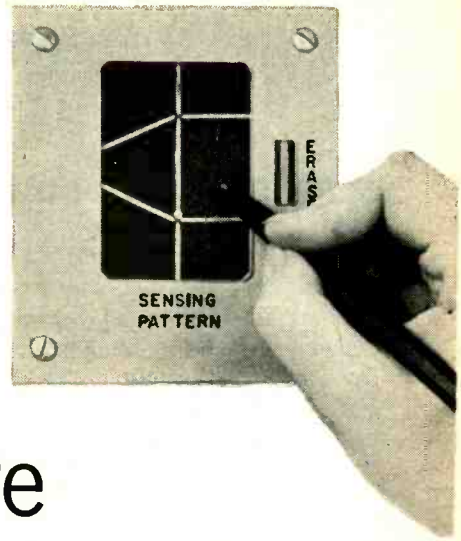
3-58-E

Write a numeral here



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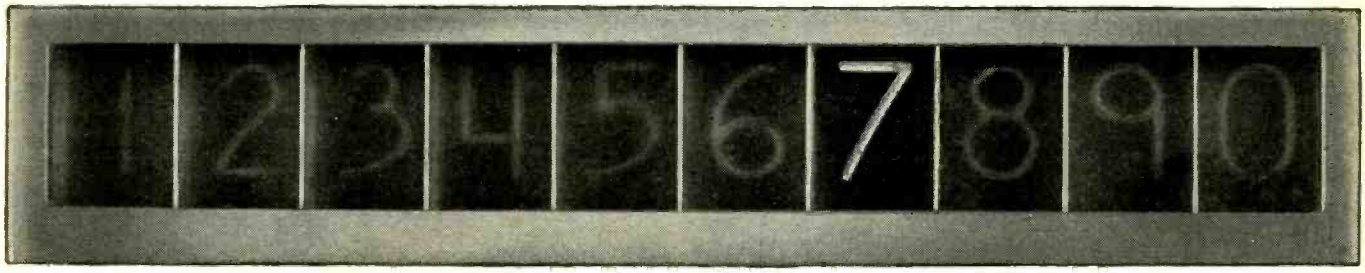
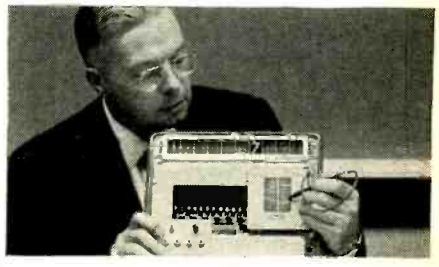


on new Bell Labs machine

A new device invented at Bell Laboratories "reads" a numeral while it is being written and instantly converts it into distinctive electric signals. The signals may be employed to make a numeral light up in a display panel, as above, or they may be sent to a computer or to a magnetic "memory" for storage.

The writing is done with a metal stylus on a specially prepared surface. Two dots, one above the other, are used as reference points. Seven sensitized lines extend radially from the dots. Transistorized logic circuits recognize numerals according to which lines are crossed.

The concept of a number-reader has interesting possibilities as a new means of communication from humans to machines. For example, in an adjunct to a telephone, it might provide inexpensive means of converting handwritten data into signals which machines can read. The signals could be transmitted through the regular telephone network to a teletypewriter or computer at a distant point. In this way, a salesman might quickly and easily furnish sales data to headquarters, or a merchant might order goods from a warehouse.



Tom Dimond, a B.S. in E.E. from the University of Iowa, demonstrates an experimental model of his number-reading invention. A similar device can also be made to read alphabetical characters. Small size and low power requirements result from transistor circuitry.

Modern communication involves many more fields of inquiry than the transmission and reception of sound. The experimental number-reader is but one example of Bell Telephone Laboratories work to improve communications service.

BELL TELEPHONE LABORATORIES
World Center of Communications Research and Development

←CIRCLE 11 READERS SERVICE CARD

there were only 43. Today's operator runs an average of 50 mobile units.

Microwave Group Probes Solid State

EFFECTS OF FERRITES and solid-state amplifiers on microwave were demonstrated this month at a three-day symposium sponsored by the IRE Professional Group on Microwave Theory and Techniques at Stanford University.

One paper told about ferrite phase shifter for 200 to 600 mc. The two-dimensional device exhibits less than 1 db loss, is capable of 360 deg phase shift.

Also disclosed was a ferrite serrodyne that makes possible translation of X-band signals up to 50 kc.

Other new ferrite devices introduced at a session included broadband rotators using quadruply ridged circular waveguide, a high-power load isolator with power capacities of 3 kw at S-band and a low-energy ferrite switch. Switch uses a rectangular ferrite ring in transverse plane of the rectangular waveguide and a single wire loop in H-plane for magnetizing.

Specific solid-state devices discussed included a uhf maser amplifying at 300 mc and pumped at 5,300 mc. The amplifier gives a 10-db gain and a 100-kc bandwidth. It uses chromium-doped potassium cobalticyanide at 1.6 K.

Follow the Sun

Heliostat which deflects sunlight into solar furnace is centered on sun by group of phototubes and servo controls. Furnace is stationary so its instrumentation is not disturbed. Operator at GE missile lab checks temperature (6,000 F) with pyrometer

New Computers Shown on Coast

LOS ANGELES—Highlights of the Western Joint Computer Conference held recently were the unveiling of three digital computers and a mechanical translation system.

Rapid handling of large amounts of complex data is feature of Sperry Rand's M-460 stored-program computer. Sychronous logic with a 2-mc clock rate is used. The computer operates in the parallel binary mode with 30-bit instruction and 15 or 30-bit data words.

A model of a special-purpose digital computer using diode and resistor logic and approximately 1,000 high-speed transistor pulse amplifiers was announced by Bell Labs. Quartz ultrasonic delay lines are used in its entirely solid-state storage unit.

Primary advantage of the RCA 501 transistor computer system, described at the conference, is its high tape and data speed.

The University of Washington described a Russian-to-English mechanical translation system having 30-megabit permanent storage with 50-millisecond access time.

Engineers Study Executive Roles

SACRAMENTO, CALIF.—Engineering management is getting more attention on the West Coast these days.

This was obvious here recently at the Seventh Regional IRE convention. About 1,500 attended; 56 exhibitors showed wares.

Educational sessions delved into proper engineering school curricula, with the management problem in mind. Audience-participation symposium stressed the complexity of engineering management.

Technical papers covered computer applications, microwave devices, missile tracking gear, among other subjects.

MEETINGS AHEAD

May 19-June 2: International Civil Aeronautics Organization, ICAO, Conf., Maison de Aviation Internationale, Montreal, Canada.

May 27-28: Second EIA Conf. on Maintainability of Electronic Equip., Univ. of Penn., Phila.

June 2-4: National Telemetering Conference, AIEE, ISA, ARS, Lord Baltimore Hotel, Baltimore, Md.

June 2-4: Automation and Computers, Short Course and Conf., Univ. of Texas, College of Engineering, Austin, Texas.

June 4-6: Armed Forces Communications and Electronic Assoc., Exhibit, Hotel Sheraton Park, Washington, D. C.

June 5-6: Second National Conference on Production Techniques, IRE, PGPT, Hotel New Yorker, New York City.

June 9-13: Automation Seminar, Fourth Annual, Pennsylvania State Univ., University Park, Pa.

June 16-18: Electrical Contact Seminar Div., Pennsylvania State Univ., University Park, Pa.

June 16-18: Military Electronics Second National Convention, Sheraton Park Hotel, Washington, D. C.

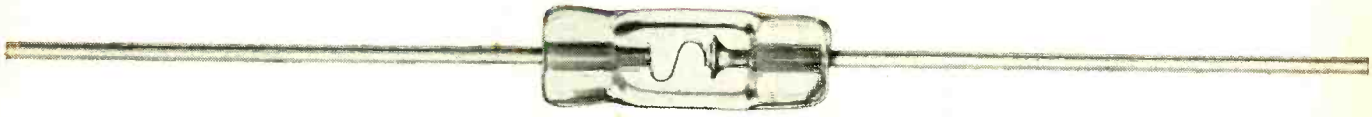
June 17-27: Two-Week Special Summer Program in Switching Circuits, Massachusetts Institute of Technology, Cambridge, Mass.

June 18-20: Radio Wave Propagation, Statistical Methods, Univ. of Calif. Engineering Extension, Los Angeles, Calif.

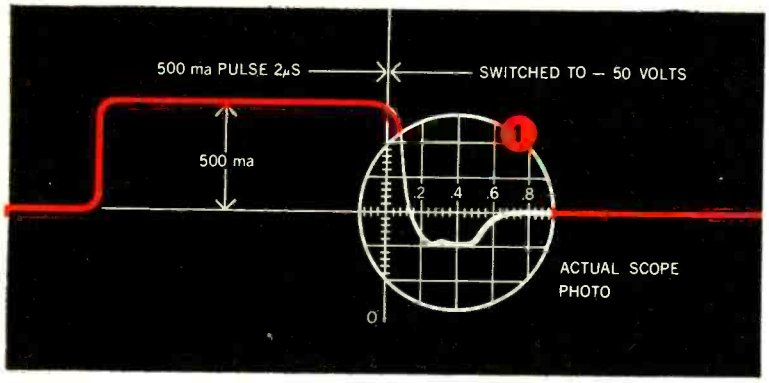
July 6-18: Underwater Missile Engineering, Graduate Course, Penn State Univ., University Park, Pa.

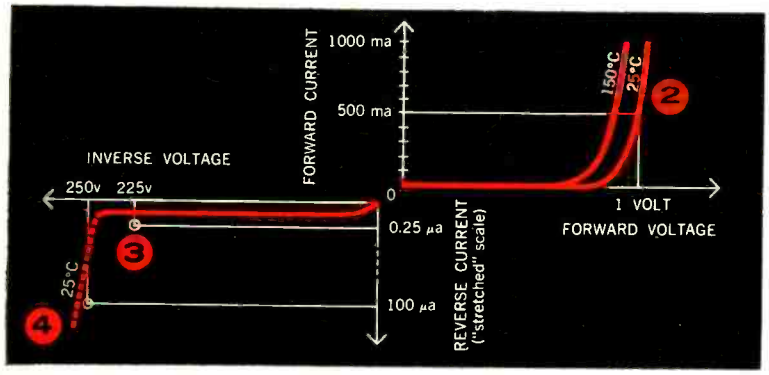
July 16-18: Forestry, Conservation Communications Assoc. (FCCA), Ninth Annual Conf., Parker House, Boston, Mass.

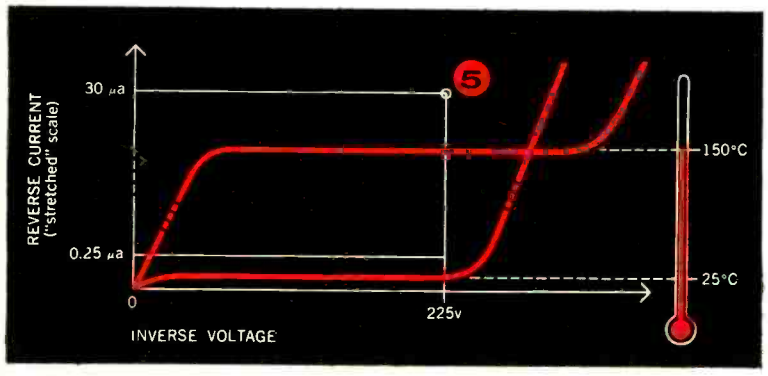
1/2-AMPERE FAST



SWITCHING DIODE







NEW FROM SPERRY is this high-temperature S-130 series silicon diode which gives you greater current-handling capability than germanium diodes – *with no sacrifice in recovery time!*

Check for yourself the performance characteristics of this new diode in the graphs at left . . . then compare them with our *minimum* specifications below.

1 **FAST RECOVERY.** Maximum recovery time is 0.8 microseconds to return to 10 K ohms. Recovery test switches from a forward current 2 microsecond pulse of 500 ma, to a reverse voltage of –50 volts with a loop impedance of 1 K ohm.

2 **HIGH FORWARD CONDUCTANCE.** The forward current specification is 400 ma at 25° C with 1.0 volt maximum drop under static (d-c) conditions. Conductivity increases with temperature – diagram shows typical "x-y" plots at 25° and 150° C.

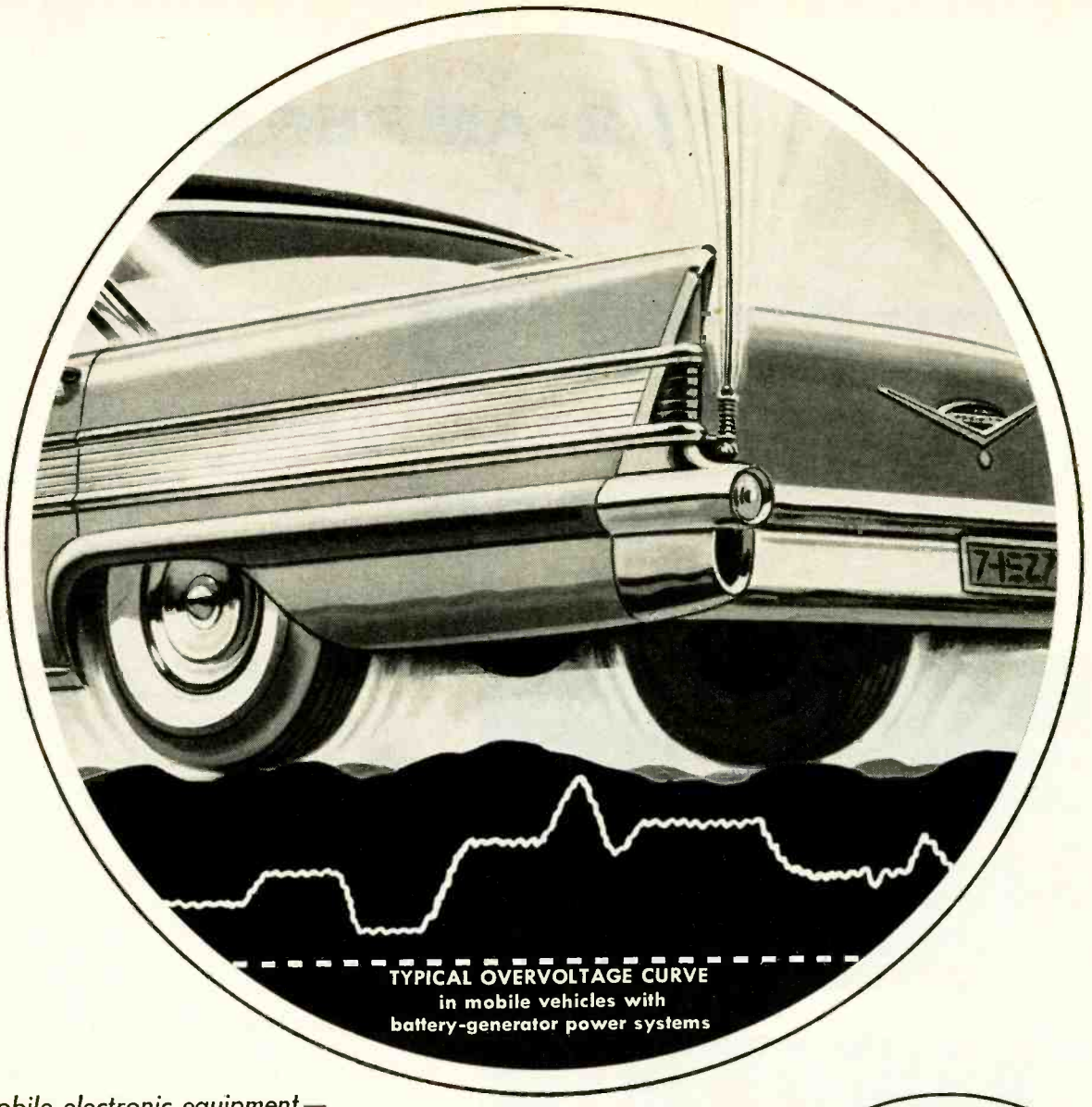
3 **LOW LEAKAGE** at high inverse voltage. Specification at 25° C is maximum 0.25 μa at rated voltages.

4 **HIGH INVERSE VOLTAGE.** Saturation voltages can be supplied in a range from 40 to 200 volts for this high current series.

5 **HIGH-TEMPERATURE OPERATION.** Typically, leakage current is no greater than 30 μa at working inverse voltage and 150° C. Diodes are rated for both operation and storage at temperatures from –65° to +150° C.

SPERRY SEMICONDUCTOR DIVISION
SPERRY RAND CORPORATION
South Norwalk, Connecticut

ADDRESS ALL INQUIRIES: *Marketing Department, Great Neck, N. Y., or Sperry Gyroscope offices in Brooklyn, Cleveland, Seattle, San Francisco, Los Angeles, New Orleans, Boston, Baltimore, Philadelphia.*



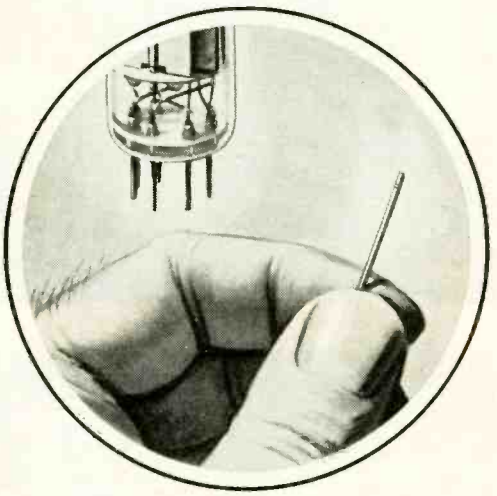
For mobile electronic equipment—

New Cathodes Lick The Overvoltage Threat

High heater voltages ordinarily doom electron tubes to a short life. But Superior's new cathode alloy, Cathaloy® A-31, gives them a resistance to overvoltage damage unmatched by any other alloy.

This has been proved in car radios and other mobile electronic equipment. Voltages commonly range upwards of 25% over specification. And tubes with these new Superior cathodes consistently outlast others—by hundreds of hours.

This significant advance in electron tube performance is one of the practical benefits that keep coming your way from the laboratories of Superior Tube . . . world's leading independent supplier of cathodes for electron tubes. For information on Superior cathodes, write for Catalog Section 51, Superior Tube Company, 2500 Germantown Ave., Norristown, Pa.



Survives high heater voltage. New Superior Tube cathode prolongs electron tube life in mobile electronic equipment.

Superior Tube

The big name in small tubing

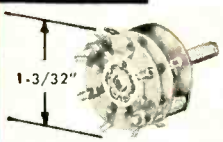
NORRISTOWN, PA.

Johnson & Hoffman Mfg. Corp., Mineola, N.Y.—an affiliated company making precision metal stampings and deep-drawn parts, such as those used in the electron guns that go with this new cathode.

thousands of "SPECIALS" without DELAY!

THESE 22 SERIES OF STANDARD SWITCHES WILL HANDLE ALMOST ANY LOW-CURRENT APPLICATION . . .

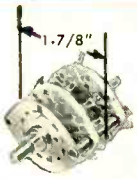
ROTARY



MINIATURE: 8, 10, and 12 positions; up to 18 contacts per wafer.
Series A

SMALL: Up to 12 positions in phenolic, Mycalex, or steatite insulation.
Series F

ADAPTABLE: 8, 10, 12, and 14 positions; many variations; economical.
Series J, K, N



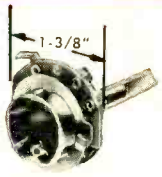
GENERAL PURPOSE: Up to 12 positions; 30°, 45°, 60° throw.
Series H

LOW COST: Up to 12 positions; staked or strut screw construction.
Series QH

18-POSITION: Single or double eyelet fastening of clips.
Series L

24-POSITION: 15° throw handles complex circuits.
Series MF

LOW COST: 2 to 5 positions; fits in limited space.
Series 50, 53

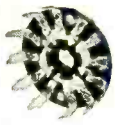


SIMPLE SWITCHING: Up to 5 positions combined with AC switch.
Series 52, 54

SIMPLE SWITCHING: Up to 4 positions; numerous variations.
Series 20

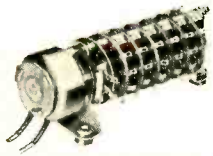
LEVER OPERATED: 2 to 5 positions; numerous versions using std. wafers.
Series 185

CONCENTRIC SHAFTS: Dual and triple shafts with many wafer types.



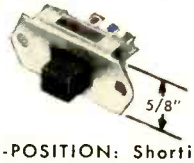
FOR PRINTED CIRCUITS: Special lug designs for direct insertions.

CUSTOM-MADE TO YOUR EXACT SPECIFICATIONS FROM STANDING TOOLS

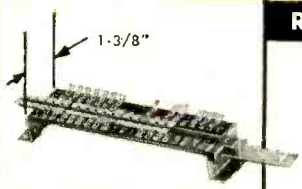


SOLENOID SWITCH: Oak wafers with G. H. Leland type of Rotary Solenoid.

SLIDE



2-POSITION: Shorting type with floating slider.
Series 70

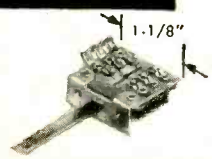


COMPLICATED SWITCHING: 2 to 4 positions; up to 20 poles; very thin.
Series 150

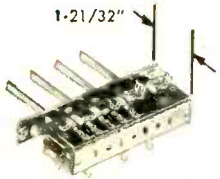
ROTARY SLIDE

COMPACT—2 to 4 positions; max. switching in min. space.
Series 160

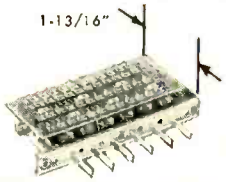
PUSHBUTTON



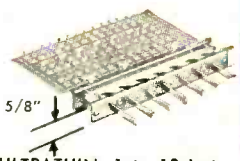
SINGLE BUTTON—1 to 4 poles; spring return and push-push.
Series 170, 175



SIMPLER CIRCUITS: 3 to 12 buttons; very adaptable unit.
Series 80



COMPLICATED CIRCUITS: 1 to 18 buttons, up to 32 contacts each.
Series 130



ULTRATHIN: 1 to 12 buttons; up to 14 contacts per button.
Series 131

EACH SWITCH IS PRETOOLED IN NUMEROUS VARIATIONS. DETAILS ON ANY SERIES ARE AVAILABLE ON REQUEST

For Recommendations on Unusual Applications, send us a sketch and short description.

OAK MFG. CO.

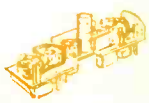
1260 Clybourn Ave., Dept. G, Chicago 10, Illinois
Phone: MOhawk 4-2222

SWITCHES

ROTARY SOLENOIDS

CHOPPERS

VIBRATORS



SPECIAL ASSEMBLIES

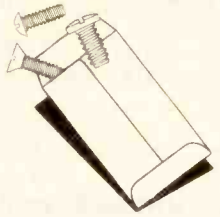
NYLO-FAST ALL-NYLON FASTENINGS OPEN NEW HORIZONS IN ELECTRONIC DESIGN AND FABRICATION

NYLO-FAST's low dielectric constant and high dielectric strength reduce the number of components in many assemblies by eliminating the need for insulating bushings, washers and couplings.

Consolidating several functions in one fastening, (NYLO-FAST also offers high resistance to heat, shock, vibration and chemical solvents) this new product cuts assembly costs and permits space saving by reducing "safety arc" space.

Recognizing these advantages, designers throughout industry and in several government departments now specify "NYLO-FAST fastenings."

Don't just take our word for it. Make your own most rigorous tests. Determine the value of these new fastenings to you, in design engineering and practical, profitable fabrication. Write today for the NYLO-FAST sampling kit.



ANTI-CORROSIVE METAL PRODUCTS — PLASTICS DIVISION

ANTI-CORROSIVE
METAL PRODUCTS CO., INC.
CASTLETON-ON-HUDSON, NEW YORK

NEW PERFORMANCE FEATURES

NEW OPERATING CONVENIENCE

TYPE 543 DC-to-30 MC OSCILLOSCOPE

This new fast-rise oscilloscope with the Tektronix Plug-In Feature is extremely versatile and easy to operate. With a single Type 53/54 fast-rise plug-in preamplifier the Type 543 handles the usual applications in the DC-to-30 MC range. Many other inexpensive plug-in units are available for the more-specialized jobs, including one for transistor rise, fall, delay and storage time testing.

MAIN CHARACTERISTICS

VERSATILITY
Nine Available Plug-In Preamplifiers—Wide Band, Dual Trace, Low Level, Differential, and others for specialized applications.

HIGH PERFORMANCE
DC to 30 MC with fast-rise plug-in units.
DC to 24 MC with dual-trace plug-in unit.
0.02 μsec/cm to 15 sec/cm sweep range.

EASY OPERATION
24 Calibrated Direct-Reading Sweep Rates.
Sweep Magnification—2, 5, 10, 20, 50, and 100 Times.
Preset Triggering—Eliminates triggering adjustments in most applications.
Single Sweep Operation—Lockout-Reset Circuitry for one-shot recording.

HIGH WRITING RATE
250 cm/μsec. 10-kv accelerating potential assures bright trace for operation in single-sweep applications, and with low sweep repetition rates.

TYPE 543 PRICE, without plug-in units **$1200**

Type 53/54K Fast-Rise Unit	**$125**
Type 53/54C Dual-Trace Unit	**$275**
Type 53/54R Transistor Test Unit	**$300**

Prices f.o.b. factory.

Please call your Tektronix Field Engineer or Representative for complete specifications and, if desired, to arrange for a demonstration at your convenience.

ADD SWEEP LOCKOUT to your Tektronix Type 531 and 541 Oscilloscopes—order Modification Kit

K531 Sweep Lockout, Tek. 040-118 . . . . . **$25**

for Type 532
K532 Sweep Lockout, Tek. 040-147 . . . . . **$25**

Tektronix, Inc.

P. O. Box 831 • Portland 7, Oregon

Phone CYpress 2-2611 • TWX-PD 311 • Cable: TEKTRONIX

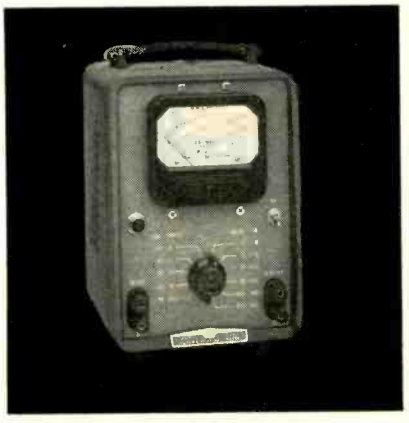
CIRCLE 59 READERS SERVICE CARD

There's a "one-best voltmeter" for every job... and you'll find it here!

Makeshift measurement—where you *stretch* a faithful but outmoded instrument to or beyond its limitations—this takes time. Save engineering time by choosing and ordering now the "one-best" *-hp-* voltmeters fitting your measurement need. *-hp-* offers a complete array of precision, dependable voltmeters, each specifically suited to a given type of voltage measuring job. Check the brief data here, then ask your *-hp-* representative for demonstration—*on your bench and on your problems!*

WIDE RANGE—10 cps to 4 MC

-hp- 400D, probably the best *-hp-* voltmeter ever built. Covers all frequencies 10 cps to 4 MC. Extremely sensitive, accurate within ±2% to 1 MC, measures 0.1 mv to 300 v. Direct reading in dbm. 10 megohm input impedance insures negligible loading on circuits under test. New amplifier circuit with 56 db feedback insures maximum stability and freedom from change due to external conditions. $225.00.



MULTI-PURPOSE to 600 KC—$200

-hp- 400AB, unique value, broad utility and long-term dependability in a low cost laboratory instrument. Covers 10 cps to 600 KC, measures from 0.3 mv to 300 v in 11 ranges. High stability, high sensitivity, accuracy ± 2% full scale from 20 cps to 100 KC. 10 megohm input impedance; 25μμf shunt. Meter reads direct in volts and dbm. $200.00.

EXTREME ACCURACY of 1%

-hp- 400H, designed for users who need highest accuracy within ± 1% to 500 KC, ± 2% to 1 MC and ± 5% full range. Covers frequency range 10 cps to 4 MC. Has 5" meter with mirror scale, measures voltages 0.1 mv to 300 v. High 10 megohm resistance minimizes circuit disturbances; amplifier with 56 db feedback insures lasting stability. Direct reading in db or volts. Extremely high quality throughout. $325.00.

-hp- also offers a broad variety of voltmeter accessories including voltage dividers, connectors, shunts and multipliers to extend the useful range of your equipment. Details on request from your -hp- representatives or direct; or see page 46 of current -hp- catalog.

makes over 350 basic test instruments for science, industry and the military

STANDARD OF INDUSTRY—
20 cps to 700 MC

-hp-410B, perhaps the most widely used of all precision voltmeters. In addition to 20 cps to 700 MC ac coverage, serves as a dc voltmeter with over 100 megohms input impedance. Also is ohmmeter for measurements 0.2 ohms to 500 megohms. For ac measurements, input capacity 1.5 $\mu\mu$f, 10 megohms input impedance, employs radical *-hp-*developed diode probe which virtually eliminates circuit loading. $245.00.

NEW!

-hp- 400L Logarithmic Voltmeter

High accuracy

10 cps to 4 MC

5″ true log voltage scale

Linear 12 db scale

10 db range steps

Generous scale overlap

New, convenient *-hp-* 400L is a unique instrument combining a specially designed logarithmic meter movement with the many desirable features of *-hp-* 400D and 400H voltmeters.

Model 400L's logarithmic voltage scale plus unusually long scale length provides an instrument of maximum readability and an accuracy which is a *constant percentage of the reading*. Voltage scales are more than 5″ long, with a 12 db scale spread across the full scale length. The meter is mirror backed for maximum accuracy. A range switch changes voltage sensitivity in 10 db intervals. This feature, together with the 12 db scale, provides generous overlap and is of particular convenience in work involving decibel levels.

Other features of the new 400L include exceptional long term stability, high sensitivity, high input impedance, large overload capacity, compact size and highest quality construction.

Model 400L may also be used as a stable amplifier.

SPECIFICATIONS *-hp-* 400L

Voltage Range:	0.3 mv to 300 v, 12 ranges, 1-3-10-30 sequence.
Frequency Range:	10 cps to 4 MC
Accuracy:	± 2% of reading, or ± 1% of full scale, whichever is more accurate, 50 cps to 500 KC; ± 3% of reading, 20 cps to 1 MC; ± 5% of reading, 10 cps to 4 MC (Includes line voltage changes 103 to 127 volts.)
Long Term Stability:	G_m reduction in amplifier tubes to 75% nominal causes less than 0.5% error, 20 cps to 1 MC
Calibration:	Calibrated in RMS value of sine wave. Log voltage scale, 0.8 to 3 v and 0.3 to 1 v. Db scale − 12 to + 2 db. 10 db intervals between ranges.
Input Impedance:	10 megohms shunted by 15 $\mu\mu$f, 1 to 300 v. 25 $\mu\mu$f shunt on 0.001 to 0.3 v range.
Amplifier Usage:	Output terminals permit 400L to amplify small signals or monitor waveforms with an oscilloscope.
Power Supply:	115/230 v ± 10%, 50/1,000 cps, approx. 100 watts.
Price:	*-hp-* 400L (cabinet) $325.00. *-hp-* 400LR (rack) $330.00.

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

HEWLETT-PACKARD COMPANY
4650A PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U. S. A.
Cable "HEWPACK" • DAvenport 5-4451
FIELD ENGINEERS IN ALL PRINCIPAL AREAS

Lumped-constant

DELAY LINES

the way you want them!

For standard 19-inch rack mounting

Epsco has met these limits — what are yours?

- Delays from 20 millimicroseconds to 200 milliseconds or longer, if desired.
- Delay to rise time ratios up to 50.
- Delay tolerance of 0.1% or 10 millimicroseconds, whichever is greater.
- Characteristic impedance tolerance of 1% from 50 to 5,000 ohms.
- Spurious signals measured at the terminated input after twice delay time can be held to less than 1%.
- Temperature compensation to ±10 ppm/°C over a range of −50°C to +150°C. (Patent pending)

If you're involved with lumped-constant delay lines, draw closer. Epsco has application-engineered a wide range of such devices for coding, decoding, telemetering systems, speech synthesis, auto and cross-correlation, trigger delay, pulse forming circuits, etc.

Unique packaging is our meat: just tell us your space, configuration and mounting requirements and performance specifications. If you are concerned with environmental problems, we will test your delay lines for shock, vibration, moisture, altitude, temperature, etc., in Epsco's own in-plant environmental laboratory.

Custom engineering-production of electronic components (shift registers, magnetic logic elements, delay lines, special pulse transformers, etc.) is our specialty. You can count on Epsco's cooperation and conscientious service right down the line. Your inquiry will receive prompt action. Write for Delay Lines Technical Bulletin DL-55.

Epsco, Incorporated, Dept. R127, 108 Cummington St., Boston 15, Mass.

START-TO-FINISH cooperation . . . an Epsco guarantee

Epsco COMPONENTS

New 5-megawatt ferrite isolator for high-power radars

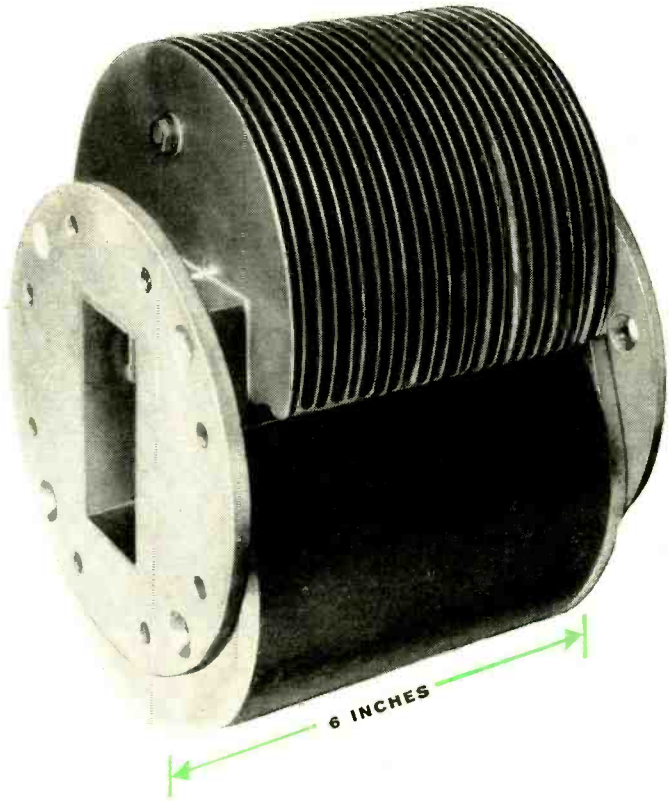
FORCED AIR COOLED!

Another Sperry contribution to improved performance of radar systems is this new Model D44S1 ferrite isolator. It boosts efficiency of S-band radars by allowing optimum operation of high-power tubes.

In addition, this isolator protects high-power tubes from load mismatches, and eliminates frequency and power variations due to changing load impedances. It is rated at 5 megawatts peak, 5 kilowatts average, and features insertion loss of less than 0.3 db. Compact and small, the Model D44S1 measures only 6 inches in length and 8 inches in diameter. And its air-cooled design eliminates the extra expense and weight of liquid-cooling accessories.

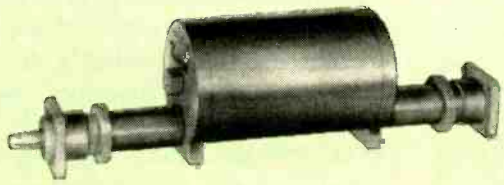
Currently Sperry has under development or in production a wide variety of ferrite devices in addition to those shown here. These include megawatt duplexers, coaxial duplexers, octave-plus bandwidth isolators and attenuators, high-speed switches, modulators and choppers.

Sample quantities of the listed units are available immediately from our stock for test and evaluation in your system, with a view to production tailored to your specific requirements. Contact our nearest district office for further information.



MODEL D44S1 SPECIFICATIONS

Power: 5 mw peak, 5 kw average
Frequency: 2700-2900 mc
Insertion loss: less than 0.3 db
Isolation: 10 db min.
Cooling: Forced air



COAXIAL FERRITE ISOLATORS

MODEL	USE	FREQ. RANGE	MAX. AV. POWER	INSERTION/ISOLATION		DIMENSIONS
A44L1	Radar	1250-1365 mc	400 w	1 db	10 db	3" dia. x 13.25"
A44S1	Radar	2700-3100 mc	10 w	1 db	10 db	1.5" dia. x 5"
D44L1	Relay	1700-2400 mc	30 w	1.5 db	21 db	3" dia. x 13.25"
A44S4	ECM	2000-4000 mc	400 w	1 db	10 db	3" dia. x 13.25"

X-BAND FERRITE COMPONENTS

MODEL	USE	FREQ. RANGE	MAX. AV. POWER	INSERTION/ISOLATION		DIMENSIONS
A44X1	Isolator	8200-12400 mc	400 w	1 db	10 db	1.5" dia. x 5"
A43X1	Variable Attenuator	8500- 9600 mc	10 w	1 db	30 db var.	1.5" dia. x 2"

MICROWAVE ELECTRONICS DIVISION

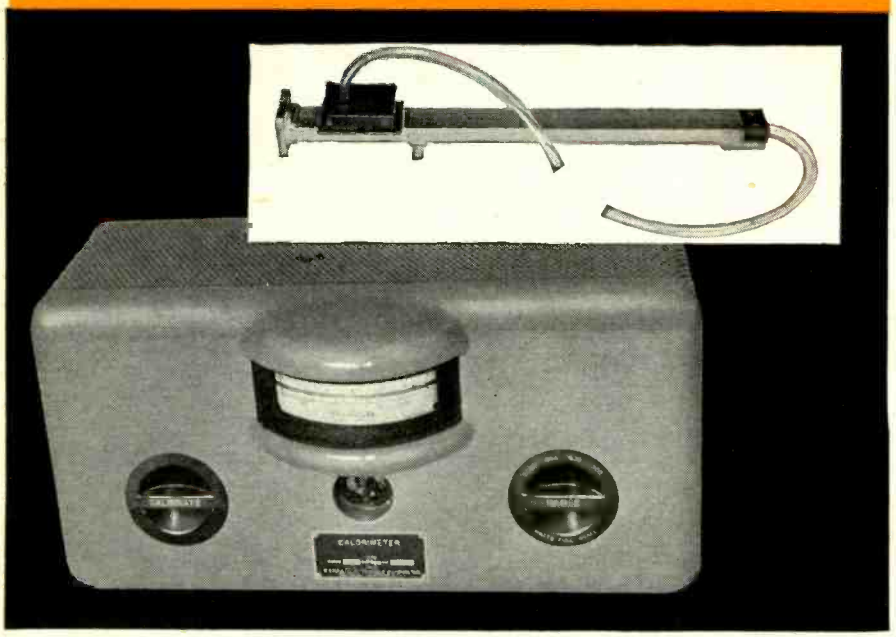
SPERRY GYROSCOPE COMPANY

Great Neck, New York

DIVISION OF SPERRY RAND CORPORATION

BROOKLYN • CLEVELAND • NEW ORLEANS • LOS ANGELES • SAN FRANCISCO • SEATTLE. IN CANADA: SPERRY GYROSCOPE COMPANY OF CANADA, LIMITED, MONTREAL, QUEBEC

Accurate, rapid microwave power measurements



Calorimeter, X-Band Water Load!

Now Sierra offers a new and highly convenient means of obtaining accurate measurements of power from a few watts to kilowatts—at any frequency 7 KMC to 10 KMC.

Model 190A Calorimeter, together with Model XB187A Water Load, measures rf power with approximately 2% accuracy. The Meter consists of a differential thermopile, millivoltmeter, long flow-path valve, water calibrator heater, and appropriate calibrating switches, meter damping resistors, etc. It operates by measuring the temperature of water before and after power has been dissipated in the water load, and presenting the differential on the millivoltmeter.

Model XB187A Water Load, designed for use with 190A Calorimeter, has frequency range of 7 KMC to 10 KMC, VSWR less than 1.2 over full range.

SPECIFICATIONS

Model 190A Calorimeter
- **Full Scale Ranges:** 300, 600, 1,500, 3,000 w.
- **Max. Pressure:** 50 psi.
- **Meter Sensitivity:** 1.5 millivolts.
- **Thermopile Sens.:** 1 mv per °C.
- **Weight:** Approx. 21 lbs.
- **Dimensions:** 8¼" x 9" x 17".

Model XB187A X-Band Water Load
- **Frequency Range:** 7 KMC to 10 KMC.
- **VSWR:** Less than 1.2 full range.
- **Power:** 1 Kw cw, 300 Kw peak.
- **Coupling:** UG-52/U choke flange.
- **Probe:** Fixed. BNC UG-290/U.
- **Size, Weight:** 18½" long. Approx. 2¼ lbs.

Specifications subject to change without notice.

Model 189A Differential Thermopile

Converts differential temperatures in flowing liquids to electrical energy. Has 30 pairs of copper-advance junctions enclosed in watertight case. Electrical connections through sealed banana jacks. Water connections to ¼" tubing through Uniflare fittings. Internal resistance approx. 5 ohms; output voltage approx. 1 mv per °C; max. pressure 75 psi; wt. 15 oz. *Write for bulletin!*

Sierra Electronic Corporation

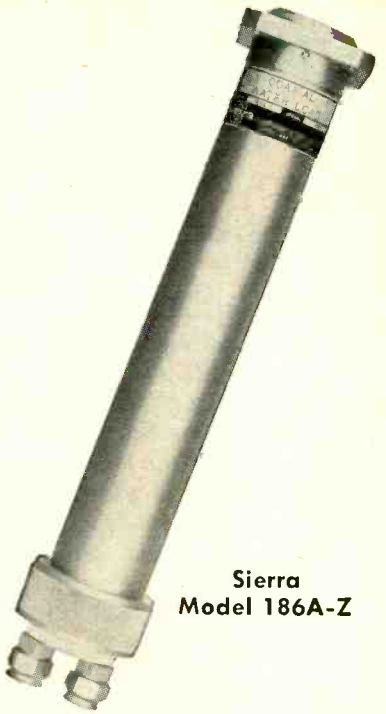
A Subsidiary of Philco Corporation

3664A Bohannon Dr., DAvenport 6-2060, Menlo Park, Calif.

Sales Representatives in major cities

CANADA: Atlas Instrument Corp., Ltd., Toronto, Montreal, Vancouver, Winnipeg

EXPORT: Frazar & Hansen, Ltd., San Francisco, New York, Los Angeles



Sierra Model 186A-Z

NEW!

Liquid-cooled

COAXIAL LOAD

Sierra Model 186A series are new high accuracy water loads specifically designed for use with Sierra Model 190A Calorimeter. The new loads provide swift, sure and simple measurements of powers from 100 watts to 2000 watts with an accuracy of approximately 2%. Model 186A-Z covers the frequency range from dc to 1500 MC; Model 186A-W from 750 MC to 4000 MC. With oil coolant, Model 186A-Z can be used to 4000 MC. Both models have low VSWR over frequency range. When used with Sierra 190A Calorimeter, calibration can be made with 60 cycle line current. The dissipative element in the load is a metallic film resistor which insures extreme time and temperature stability.

Sierra 186A series loads are designed for use with rigid 1⅝" coaxial transmission line (mating with UG-50/U.) Request Bulletin.

Can this experience in unique cooling applications help solve a problem for you?

Custom designed cooling is our business at Ellis and Watts. For example, we have recently engineered and built highly specialized equipment for the following applications:

- Liquid coolers for electronic components (bulletin 94)
- Cooling Klystrons with air to liquid heat exchangers (bulletin 95)
- Special units to cool airborne electronic gear (bulletin 99)
- Cooling equipment for huge complex electronic computers (bulletin 102)
- Electronic console and rack coolers (bulletin 105)
- Small portable field units to cool huts filled with electronic gear for missile ground support, battlefield television, communications and radar (bulletin 106)
- Conditioning systems for Radome shelters (bulletin 108)
- Mobile cooling units for trailer-mounted electronic systems for missile and aircraft ground support (bulletin 111)
- Units to cool automatic landing devices for carrier and land-based aircraft (bulletin 122)
- Cooling equipment for fixed or mobile flight training simulators (bulletin 124)
- Dewpoint control equipment for pressurized radar waveguides (bulletin 128)

These are but a few examples. On land (MIL-E-5272A), on the sea (MIL-E-16400B), in the air (MIL-E-5400B) — even in outer space (MIL-E-8189A) — E-W specialized cooling equipment guarantees the performance of your electronic systems, independent of environmental conditions, for military or commercial applications.

If your project involves cooling . . . it's a job for Ellis and Watts. We are staffed with specialists who will analyze your requirements, submit a proposal, design and build equipment promptly and to your complete satisfaction. Field installation and maintenance services available.

Ellis and Watts Products, Inc., Dept. E, Cincinnati 36, Ohio
Please send the following information:

☐ Bulletin 94 95 99 102 105 106 108 111 122 124 128 (circle numbers desired)
☐ Cooling load calculating Nomogram
☐ Booklet "How to determine requirements for cooling electronic equipment"

Name.....Title.....

Company.....

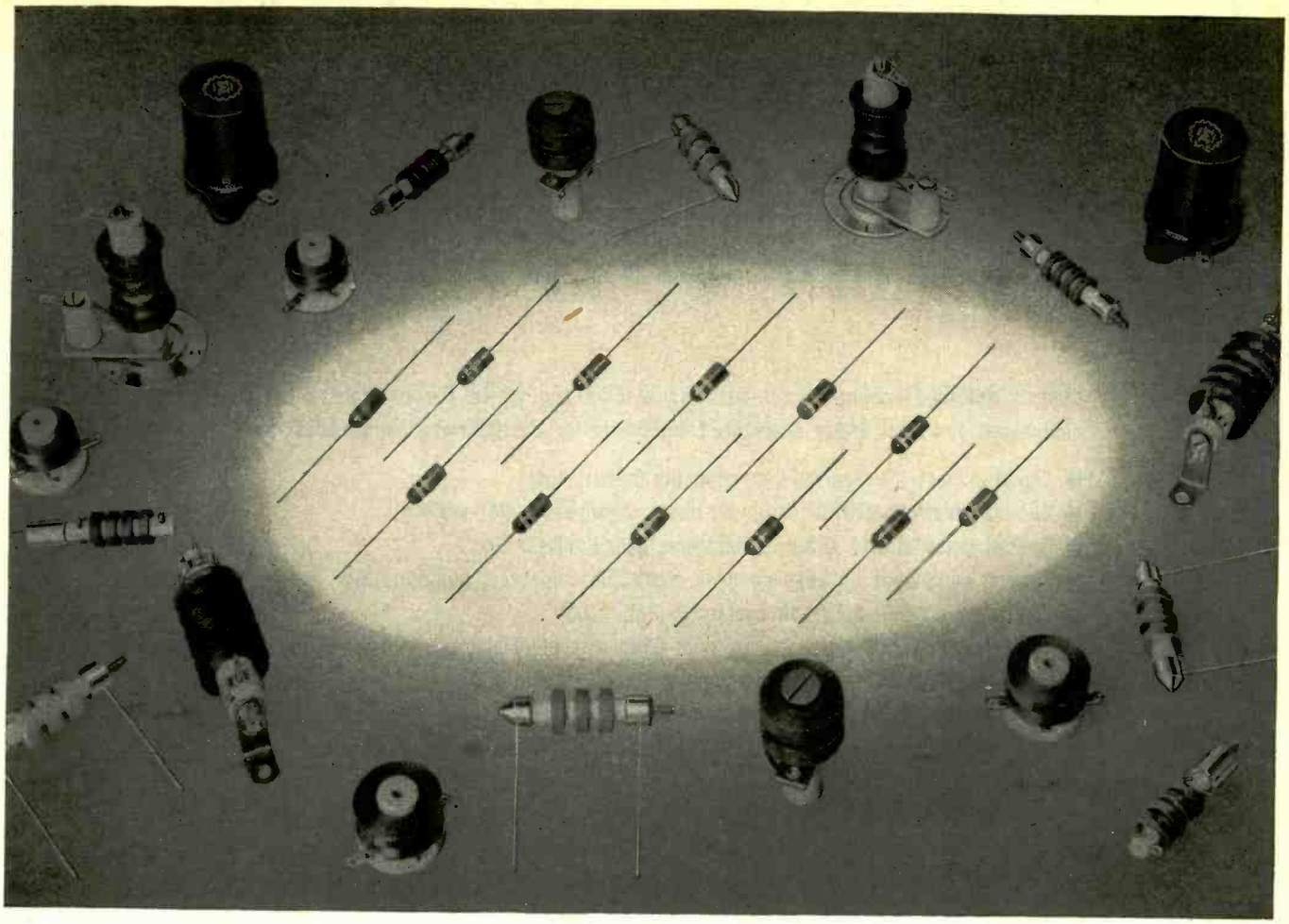
Address.....

City.....Zone.....State.....

ELLIS AND WATTS PRODUCTS, INC.

Cincinnati 36, Ohio.

Designers and builders of MIL-AC Units



Encapsulated Inductances

Millen DESIGNED for APPLICATION encapsulated coils provide another advance in the r-f inductor field. Modern application requires miniature, heat and cold resistant, hermetically sealed, and abrasion resistant r-f inductor assemblies. The James Millen Manufacturing Company has pioneered many advances in the r-f inductor field, including the now standard 4 pi r-f choke, the axial lead r-f choke, and the miniature r-f choke. Developments have now made possible another advance, the No. 34301 and No. J301 encapsulated inductors—hermetically sealed—miniature size. Ambient temperature minus 55 degrees to plus 100 degrees C.

NO. J301 MINIATURE ENCAPSULATED INDUCTANCES

DESIGNED for APPLICATION miniature inductances are: extremely small (see table at right)—hermetically sealed—wound on axial lead Carbonyl cores—color coded. Coils are available in RETMA standard values plus 25, 50, 150, 250, 350, 500, and 2500 microhenries. Coils are three layer solenoids up to 350 microhenries. From 360 to 2500 microhenries coils are pi-wound. Current rating 50 to 600 milliamperes depending on coil size. Inductance ± 5%. Special coils on order.

NO. 34301 STANDARD ENCAPSULATED INDUCTANCES

Encapsulated DESIGNED for APPLICATION axial lead phenolic form r-f inductances. Hermetically sealed—heat resistant—abrasion proof—color coded. 1 to 350 microhenries available in RETMA standard values plus 25, 50, 150, 250, and 350 microhenries. Inductance ± 5%. Values available in same progression as J301 coils listed in the table at the right. Solenoid winding for 1 to 15 microhenries. Universal pi winding from 20 microhenries to 350 microhenries. Current rating 250 to 1500 milliamperes, depending on coil size. Ambient temperature range—minus 55 degrees to plus 100 degrees Centigrade. Size: ⅜ inches diameter × ⅞ inches long. Special coils on order.

COIL NUMBER	INDUCTANCE MICROHENRIES	DIAMETER INCHES	LENGTH INCHES
J301-25	25	3/16	9/16
J301-33	33	3/16	9/16
J301-47	47	3/16	9/16
J301-50	50	3/16	9/16
J301-82	82	3/16	9/16
J301-100	100	3/16	9/16
J301-120	120	3/16	9/16
J301-150	150	3/16	9/16
J301-200	200	3/16	9/16
J301-220	220	3/16	9/16
J301-250	250	3/16	9/16
J301-300	300	3/16	9/16
J301-330	330	3/16	9/16
J301-350	350	3/16	9/16
J301-360	360	7/32	5/8
J301-390	390	7/32	5/8
J301-430	430	7/32	5/8
J301-470	470	1/4	1 1/16
J301-500	500	1/4	1 1/16
J301-510	510	1/4	1 1/16
J301-560	560	1/4	1 1/16
J301-620	620	1/4	1 1/16
J301-680	680	9/32	3/4
J301-750	750	9/32	3/4
J301-820	820	9/32	3/4
J301-910	910	9/32	3/4
J301-1000	1000	9/32	3/4
J301-1200	1200	5/16	1 3/16
J301-1300	1300	5/16	1 3/16
J301-1500	1500	5/16	1 3/16
J301-1800	1800	5/16	1 3/16
J301-2000	2000	3/8	7/8
J301-2200	2200	3/8	7/8
J301-2400	2400	3/8	7/8
J301-2500	2500	3/8	7/8

NEW HI-LO RELAY

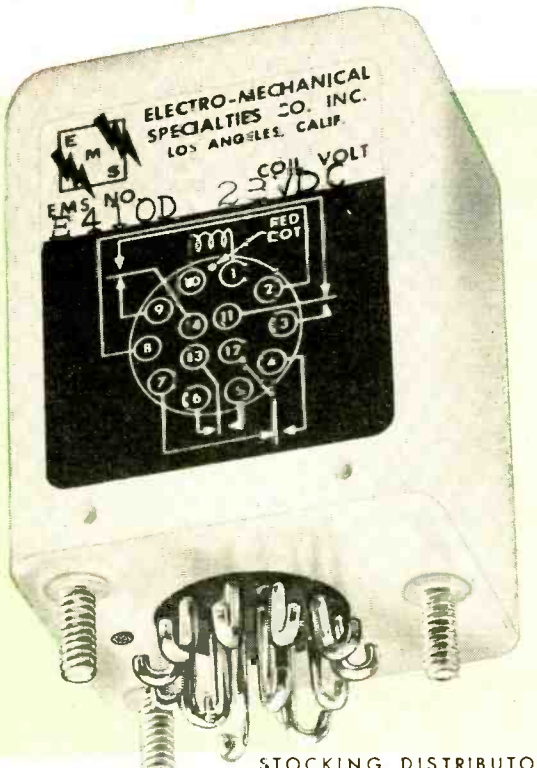
ONLY RELAY WITH DRY CIRCUIT *and* 10 AMPS

HERMETICALLY SEALED • 4 PDT

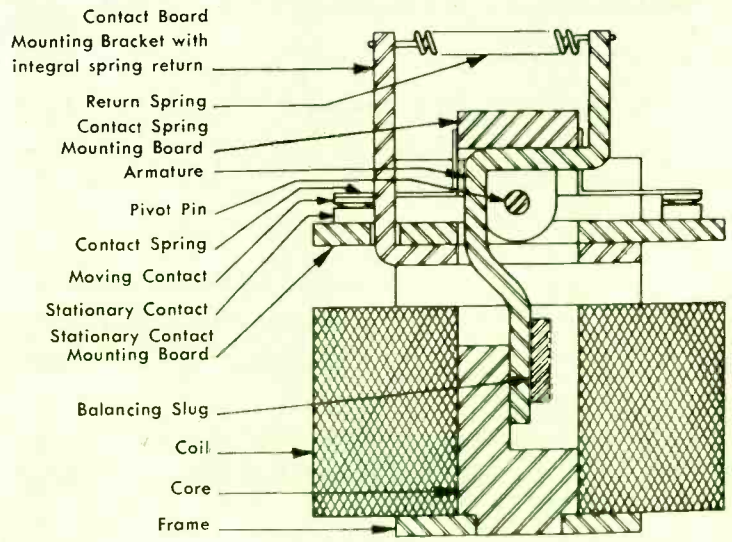
Here is the only relay known to combine dry circuit and 10 amps in a single enclosure. It's available, *in stock*, for 24 hour delivery from Relay Sales, the world's largest relay distributor. We now have in stock 33 different EMS relays in one, two, three and four pole models.

BALANCED ARMATURE MAKES EMS RELAY COMPLETELY VERSATILE. ALL MODELS SURPASS MIL R SPEC 5757C, 6106C, 25018

Write for Complete Details in Bulletin 8601.



SPECIAL EMS CONSTRUCTION FEATURES



STOCKING DISTRIBUTORS OF ALL TYPES OF RELAYS BY LEADING MANUFACTURERS

Advance Relays · Automatic Electric · Clare · Neomite-Elgin · Guardian Electric · Leach · Phillips Controls · Potter & Brumfield · Struthers-Dunn · Terado · Besson & Robinson · RBM · Electro Mechanical Specialties

RELAY SALES, Inc.

P. O. BOX 186-A • WEST CHICAGO, ILL.

WRITE FOR COMPLETE RELAY CATALOG C-9

AMP-EDGE HAS THE EDGE ON PRINTED CIRCUITS

The new AMP-Edge Connector gives you . . .

greater flexibility— your printed circuit area and completed unit are not limited by the size of connection, as found in alternate methods of edge connection.

greater design versatility— they can be applied in any arrangement to any section of the perimeter of the printed circuit.

two-way cost reduction— production time and material costs are reduced through solderless termination of the connector to the wire (4,000 terminations per hour) and the ease of applying the Edge Connector to the printed circuit without molded parts.

Additional information is available upon request.

AMP INCORPORATED

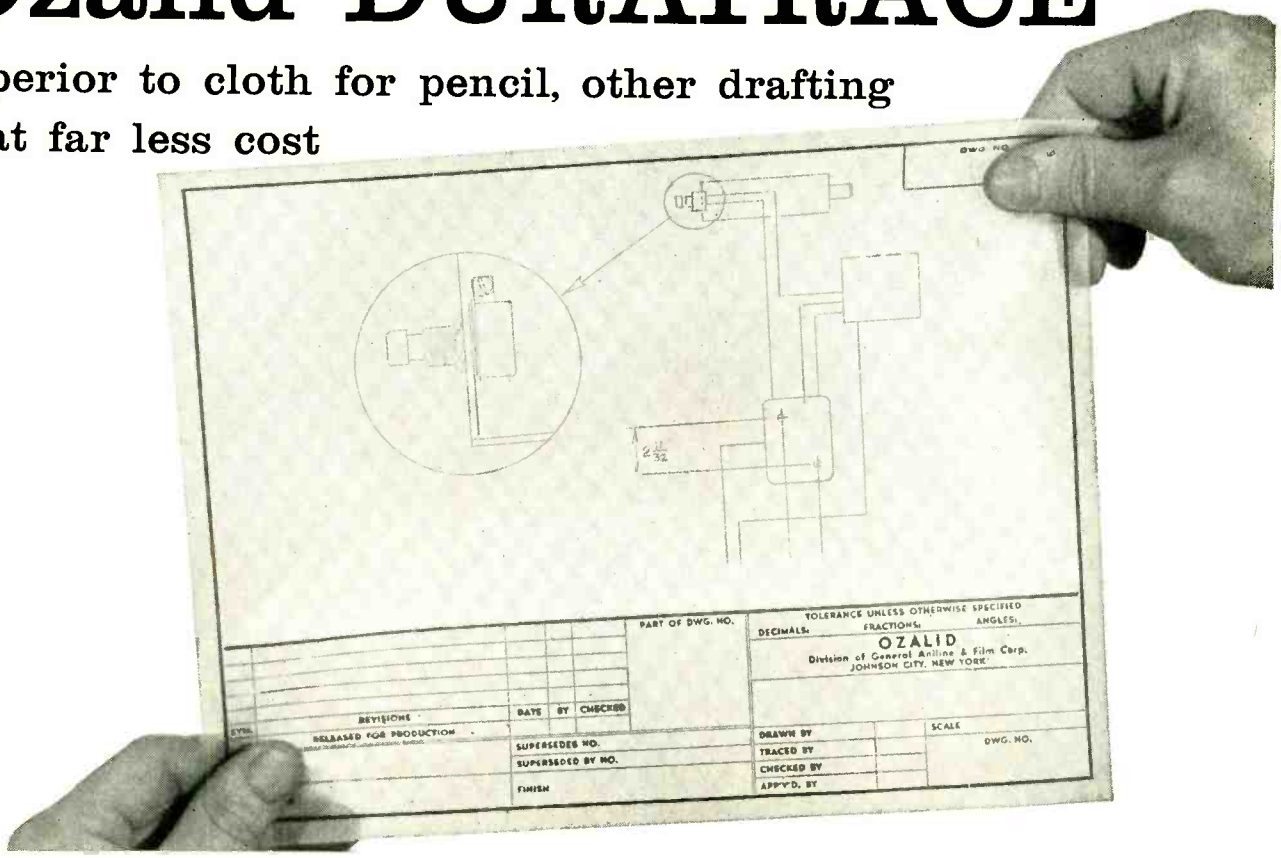
GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through wholly-owned subsidiaries in: Canada • England • France • Holland • Japan

A really NEW drawing material...

Ozalid DURATRACE®

superior to cloth for pencil, other drafting —at far less cost



Extremely durable, practically ageless—that's new Ozalid Duratrace drawing film. Duratrace can speed your drafting operations, insure greater accuracy and finer prints. It can be used under all climatic conditions and it will still maintain its exceptionally high-dimensional stability.

And Duratrace saves you money! Not only will it outperform the highest quality, moistureproof pencil tracing cloths in every respect—it actually costs 15% to 20% *less!*

HERE ARE A FEW OF ITS OUTSTANDING ADVANTAGES:

- **Makes drafting easier, improves accuracy** Duratrace has an exclusive new fiber-free matte surface that takes pencil better than any cloth available. It lets you use *hard* pencils for greater accuracy, cleaner drawings. It erases easily and quickly without smudging. And Duratrace lies *flat*, won't curl—even after being rolled for long periods.
- **Gives you better prints, faster** The very high translucency of Duratrace means faster copying in your whiteprint or blueprint machine—copies with maximum contrast. Duratrace won't stretch, melt or peel in your copying machine. Distortion of drawings is ended.
- **Stands up to roughest usage—indefinitely** Easy to handle and file, Duratrace resists wear and tear—is almost ageless! Its fold and tear strengths far exceed those of cloth, most other films. Duratrace can't fray, become "dog-eared," crack, chip, or turn brittle. It's nonyellowing . . . *really* waterproof; can be filed indefinitely, without deterioration!

Why not test this advanced new drawing material and discover for yourself its many advantages and applications? Just mail the coupon and you will receive free sample and price information.

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Products for Design

A Division of General Aniline & Film Corporation
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Please send me a free test sample of Ozalid DURATRACE. I understand there is no obligation.

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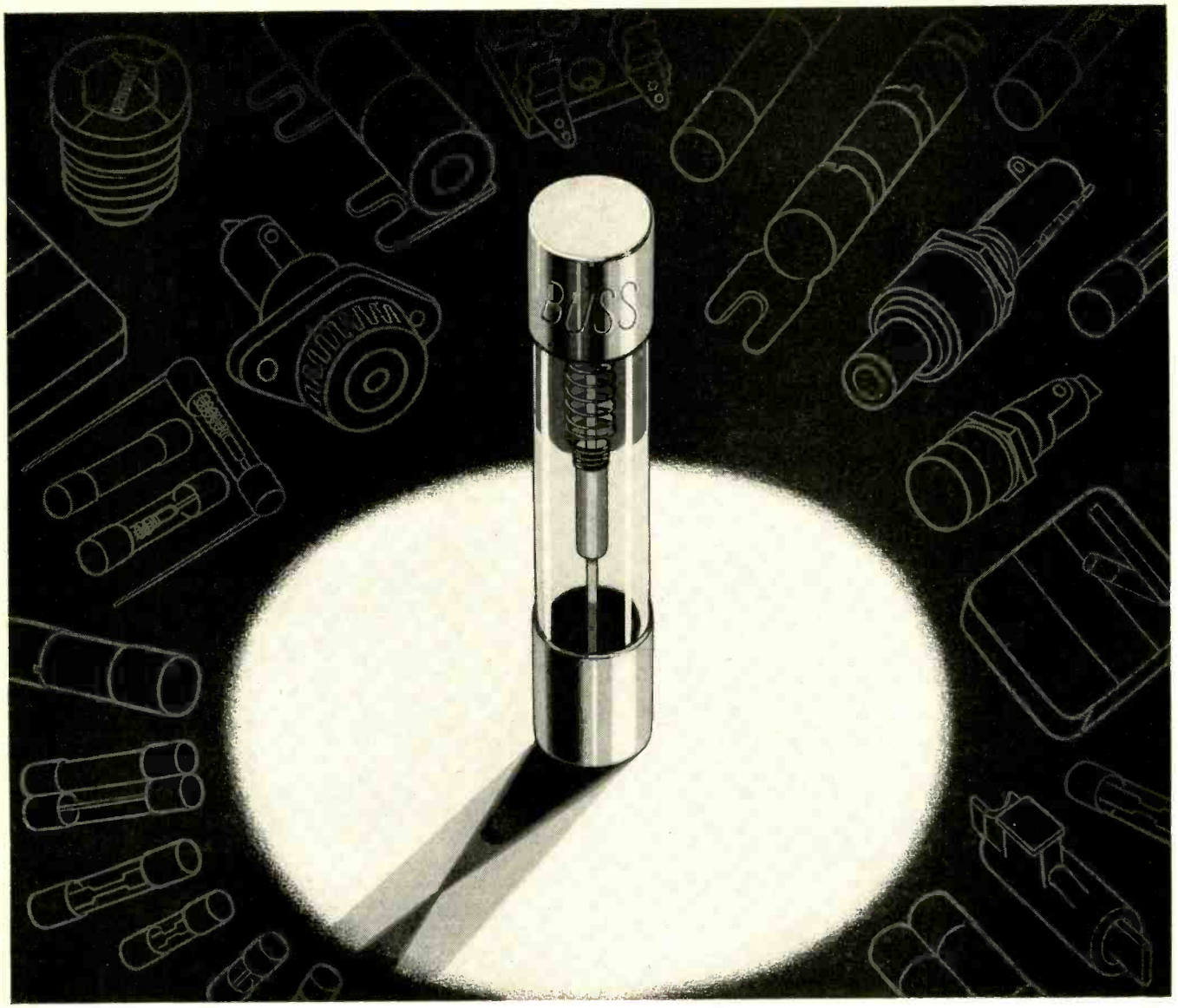


How BUSS fuses can help you solve electrical protection problems

BUSS offers the widest possible selection of fuses to meet your exact electrical protection requirements. The complete BUSS line of fuses includes: single-element, quick-blowing type; single-element for normal circuit protection type; dual-element, slow blowing type and signal or visual indicating types . . . ranging in sizes from 1/500 ampere up — plus a companion line of fuse clips, blocks and holders.

ELECTRONIC TESTING ASSURES DEPENDABILITY: With BUSS fuses, dependable electrical protection is not left to chance. Every BUSS fuse is tested in a sensitive electronic device that automatically rejects any fuse not correctly calibrated, properly constructed and right in all physical dimensions.

By operating as intended, BUSS fuses provide maximum protection against damage due to electrical fault and—BUSS fuses eliminate shutdowns caused by needless blows. Hence, BUSS fuses help the good name of your product for service and reliability.

FUSE ENGINEERING HELP: If you have a special problem in electrical protection, BUSS engineers are at your service — and in many cases can save you engineering time by helping you choose the right fuse for the job. Whenever possible, the fuse selected will be available in local wholesalers' stocks that your device can be serviced easily.

For more information on the complete line of BUSS and FUSETRON Small Dimension Fuses and Fuseholders, write for bulletin SFB.

Bussmann Mfg. Division McGraw-Edison Co., University at Jefferson, St. Louis 7, Mo.

BUSS fuses are made to protect . . . not to blow, needlessly

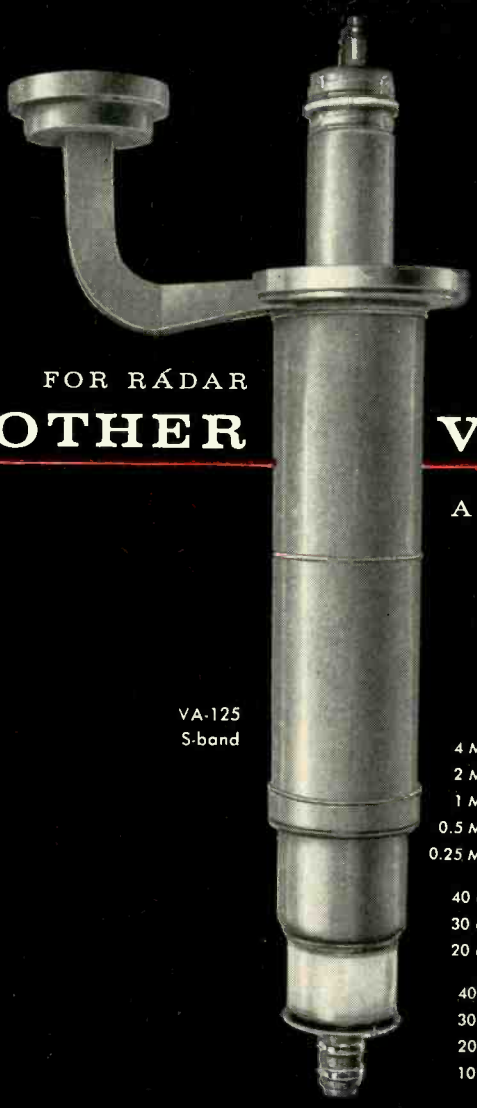
FUSETRON
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

A complete line of fuses for home, farm, commercial, electronic, automotive and industrial use. 558

FOR RÁDAR

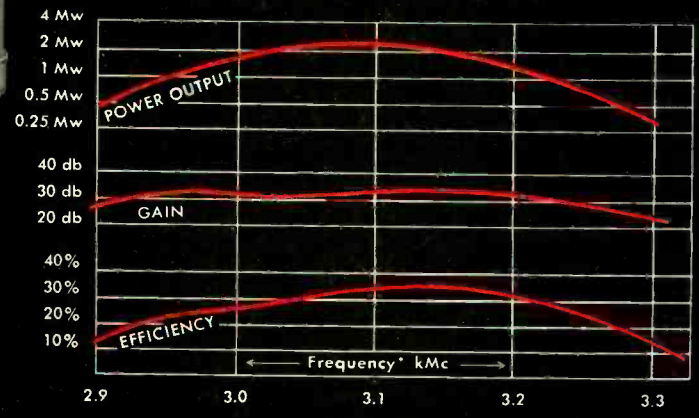
ANOTHER VARIAN FIRST

A MEGAWATT **TWT** AMPLIFIER



VA-125
S-band

TEST DATA AT 110 KV 6 μs PULSE



*Also available at other S-band frequencies

HIGH EFFICIENCY—30% • WIDE BANDWIDTH—12%
HIGH GAIN—30 db • HIGH PEAK POWER—Over 1 Mw

Varian is first with a commercially available megawatt Traveling Wave Tube amplifier. This tube gives system engineers greater freedom in radar design—a full megawatt of power over a major portion of the S-band without tuning. Interchangeable with the 1 Megawatt VA-87 Klystron for broadband operation.

Varian makes a wide variety of Klystrons and Wave Tubes for use in Radar, Communications, Tests and Instrumentation, and for Severe Environmental Service Applications. Over 100 are described and pictured in our new catalog. Write for your copy.

VA-87

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TUBE DIVISION
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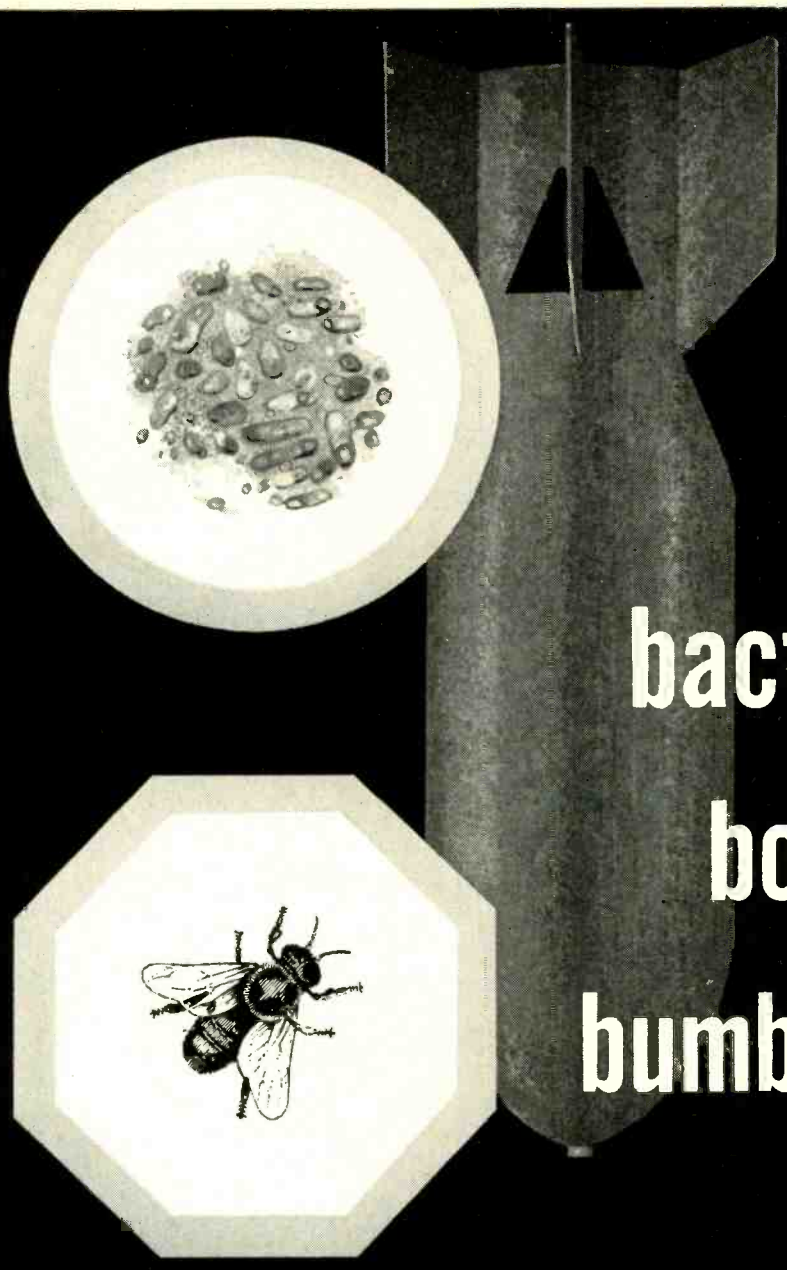

bacteria... bombs... bumblebees

Broad, comprehensive engineering experience is the firm foundation for advanced thinking and scientific development for the future.

Bendix-Pacific has developed unique instrumentation for biological testing . . . created devices which have contributed materially to the state of the bombing art . . . has extensive missile guidance experience dating back to the start of Navy's Bumblebee Program.

Current active developments include servo valves for missiles and their launchers, actuators for turbo prop pitch control, sonic altimeters for low flying aircraft, submarine sonar systems, and high resolution radar for helicopters. These programs provide only a few of the building blocks used at Bendix-Pacific in advanced work on many types of weapons systems.

Exceptional career opportunities for skilled engineers are available. The day-to-day association with challenging problems in many and varied scientific fields at Pacific Division will be rewarding. You are invited to write R. A. Lamm, Director of Engineering, and obtain more information about Bendix-Pacific and your future.

Bendix
PACIFIC DIVISION
Bendix Aviation Corporation
NORTH HOLLYWOOD, CALIF.

ADVANCED THINKING FOR SYSTEMS AND PRODUCTS IN AIRBORNE RADAR . . . HYDRAULICS . . . MISSILE GUIDANCE . . . ELECTRO-MECHANICS . . . DECCA NAVIGATION . . . SONAR . . . TELEMETRY

ANDREW CORPORATION offers a wealth of engineering experience in the field of super power RF transmission devices. A broad line of standard equipment is offered and ANDREW facilities for the development and production of special equipment are without equal.

Available on a production basis is antenna equipment in all of the new, very large waveguide and transmission line sizes, including high power coaxial lines designed with specially shaped inner conductors and insulators to substantially increase voltage ratings.

Typical too, of this equipment are patch panels such as the 9" line model shown above, used for occasional rearrangement of antenna and transmitter connections.

For high speed circuit switching, ANDREW has developed peak reliability, non-contacting waveguide switches such as the 21" model above. Similar switches are also supplied with transitions for use with coaxial line.

Of definite advantage to you is the completeness of the ANDREW line which permits a systems approach with integrated equipment for best performance of the overall system.

Our newly expanded production facilities assure prompt deliveries.

We would welcome your inquiries for product information and engineering assistance on:

Antennas · Feed Horns · Switches · Patch Panels · Duplexers · Power Dividers · Filters · Coaxial Line · Waveguide · Transitions · Adaptors · Bends · Hangers · Dehydrators

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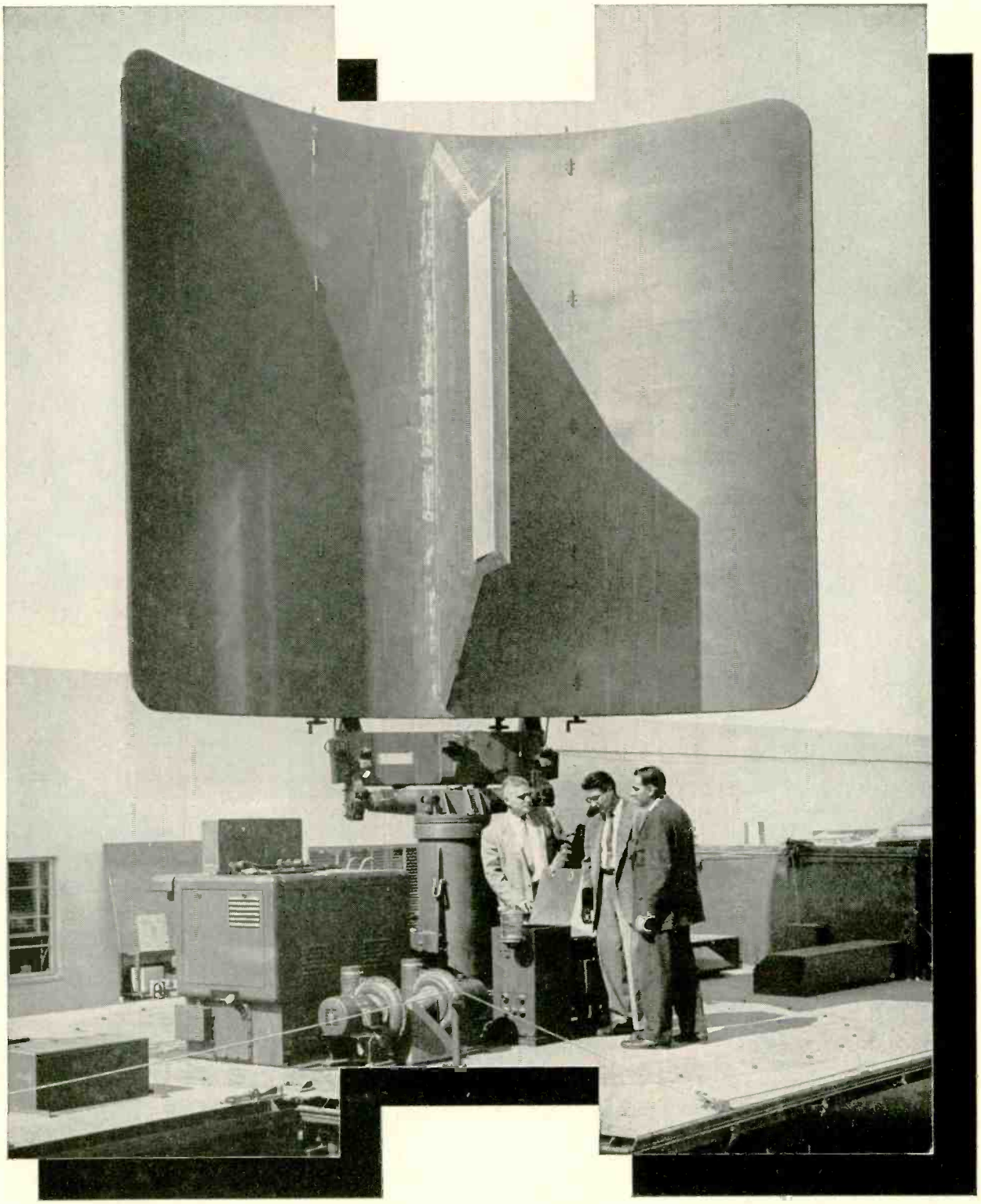
HOW TO SEE IN



ALL DIRECTIONS AT ONCE

They add new dimension to defense

Three dimensional radar . . . it is a positioning of radar beams in space by electronic rather than mechanical means. It provides three-dimensional target data from a single antenna, transmitter, and receiving channel. It is a radical new weapon for national defense.

Engineers at the Hughes Ground Systems Division in Fullerton are responsible for pioneering this advancement (see antenna at left). But even more importantly, these same engineers are working on an elaborate radar warning system which will not only provide this complete radar data, but also translate it into meaningful information and relay it to central communications centers.

Other Hughes activities offer similar engineering challenge. The Research and Development Laboratories in Culver City, for example, are probing into the effects of nuclear radiation on electronics equipment, studying advanced microwave theory and applications, examining communications on a global scale, and developing new methods for insuring product reliability.

The Hughes Products engineering team makes electronics useful in solving industrial problems. For example, this group has just unveiled an industrial electronics system which will automate a complete and integrated line of machine tools.

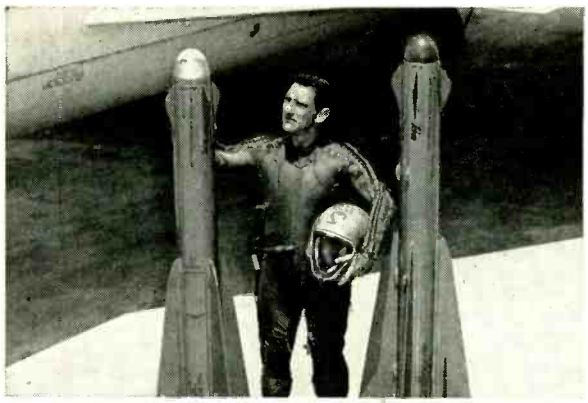
The diversity of Hughes activity offers prospective employees opportunity to build a rewarding career in a highly progressive and expanding environment.

New commercial and military contracts have created an immediate need for engineers in the following areas:

Communications	Microwaves
Reliability	Crystal Filters
Circuit Design	Computer Engineering
Systems Analysis	Field Engineering
Vacuum Tubes	Semiconductors

Write, briefly outlining your experience, to Mr. Phil N. Scheid, Hughes General Offices, Bldg. 17B-1, Culver City, California.

Advanced research on the Maser (Microwave Amplification by Simulated Emission of Radiation) performed by the R&D Laboratories is directed towards applications of a portable, airborne Maser for missiles and aircraft.

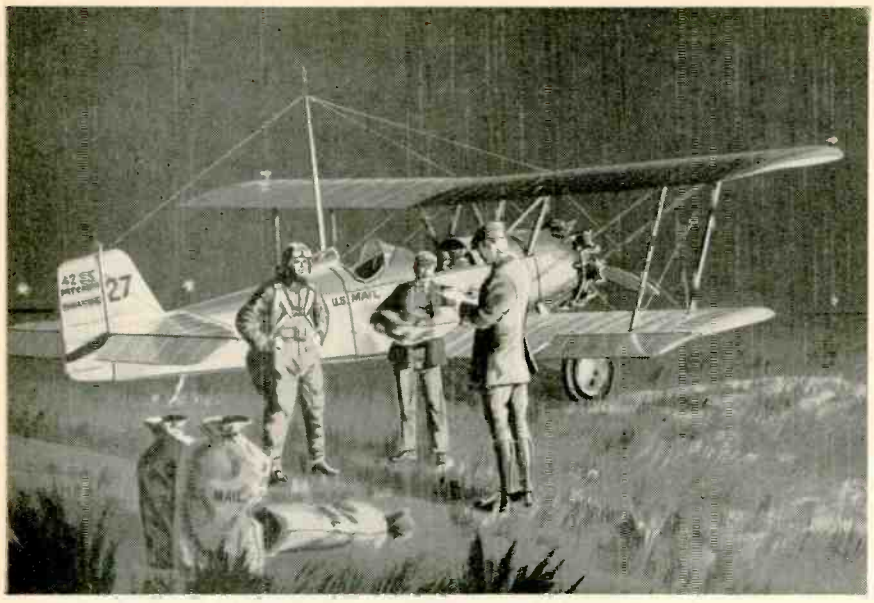


Falcon missiles have been an important factor in establishing Hughes as a leader in advanced airborne electronics. Manufactured in Tucson, Arizona, the Falcon missiles have both infrared and radar guidance systems.

Creating a new world with ELECTRONICS

HUGHES

HUGHES AIRCRAFT COMPANY
Culver City, El Segundo,
Fullerton and Los Angeles, California
Tucson, Arizona

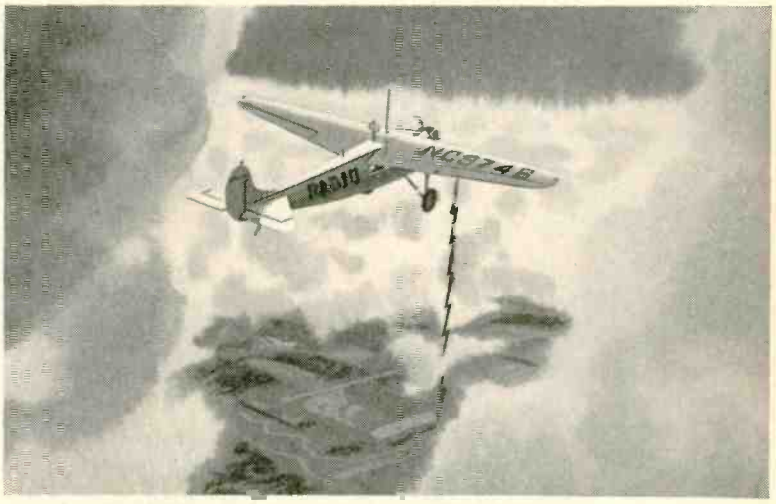


ARC installed first radio range receiving equipment, with six foot rigid rod antenna, which was used on "Mailwing" biplanes by Pitcairn Aviation, 1928.

ARC developed and manufactured first practical radio shielding for spark plugs, 1929.

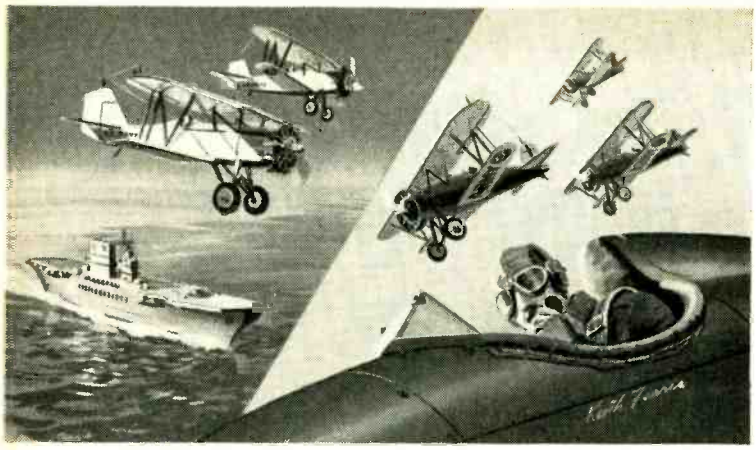
ARC's laboratory and flying field at Boonton, N. J., 1929.

ARC radio range receiving equipment went to Antarctica with Admiral Byrd on polar expedition aboard his Ford Tri-motor, 1929.



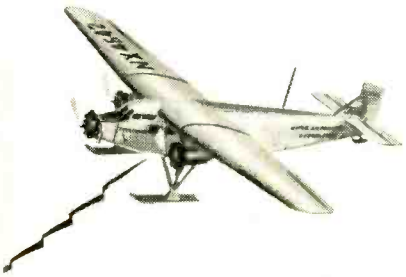
Early radio altimeter work was carried on by ARC in 1929.

First Blind Flight was by Jimmy Doolittle in aircraft equipped with ARC radio range receiver, 1929.



The first successful two-way voice radio equipment standardized for use on Army and Navy fighter aircraft was another important ARC communications development, 1931.

ARC designed first beacon receivers for Douglas M-2 mail planes of National Air Transport, later part of United Air Lines. An historic milepost in the development of today's radio aids to navigation.



CELEBRATING 30 YEARS

OF PROGRESS IN AIRBORNE ELECTRONICS

Pilots wore goggles in 1928 . . . cockpits were open to the weather and biplanes still resembled box kites. Flying the Atlantic was so new it was front page news and air mail routes were the newest thing in communications. That was the year a group of radio engineers got together to develop instruments to help pilots navigate with more precision than "seat of the pants" flying.

That's when Aircraft Radio Corporation was born.

On these pages some of the organization's accomplishments over the past 30 years are noted, along with a few of today's precision instruments of navigation and communications.

These are the mileposts that testify to a rich fund of experience and engineering skill . . . of a group dedicated to the science of airborne electronics for greater safety and progress in aviation.

Dependable Airborne Electronic Equipment Since 1928

Aircraft Radio Corporation **BOONTON, NEW JERSEY**

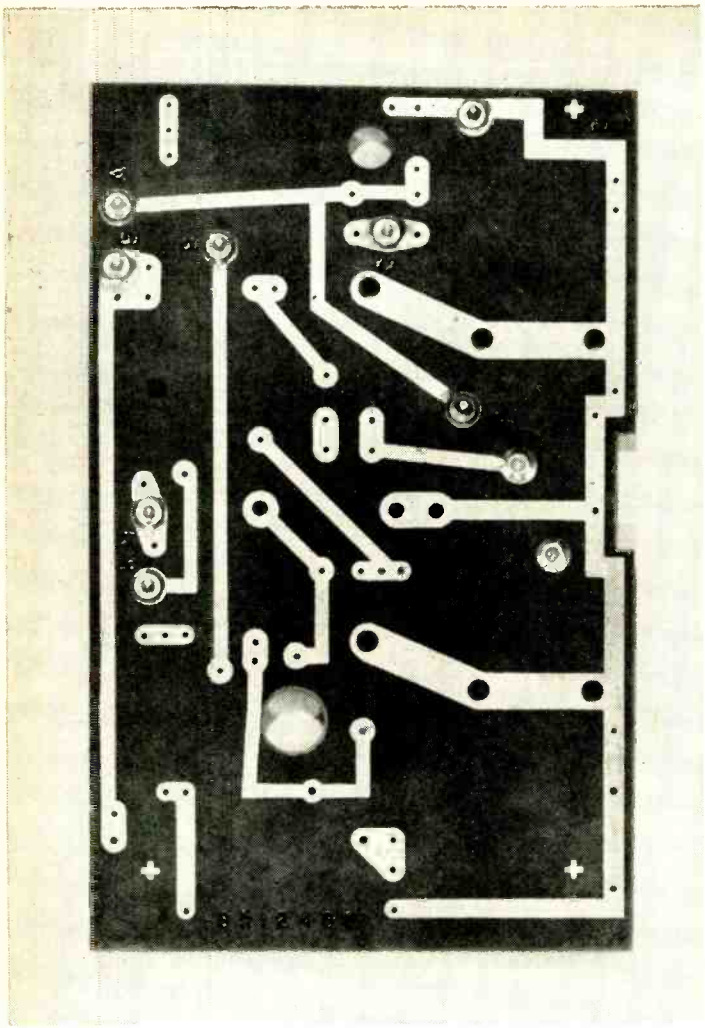
OMNI/LOC RECEIVERS • MINIATURIZED AUTOMATIC DIRECTION FINDERS • COURSE DIRECTORS • LF RECEIVERS AND LOOP DIRECTION FINDERS UHF AND VHF RECEIVERS AND TRANSMITTERS (5 TO 360 CHANNELS) • INTERPHONE AMPLIFIERS • HIGH POWERED CABIN AUDIO AMPLIFIERS 10-CHANNEL ISOLATION AMPLIFIERS • OMNIRANGE SIGNAL GENERATORS AND STANDARD COURSE CHECKERS • 900-2100 MC SIGNAL GENERATORS

ARC
TYPE 21A
DIRECTION FINDER

ARC
COURSE DIRECTOR CD-1
WITH DUAL OMNI 15-D

ARC
TYPE H-14A
SIGNAL GENERATOR

ARC
TYPE 210 360-CHANNEL
TRANSCEIVER



How CDF Di-Clad† can solve your printed-circuit problems

The CDF line of copper-clad laminates in all grades is now known by a new name—Di-Clad. Di-Clad grades meet the varying needs of design, production, and operation of electronic equipment. Grades other than those described are also available.

Di-Clad 28E. For high mechanical strength, low moisture-absorption, and good insulation resistance, CDF Di-Clad laminates of epoxy resin laminated with glass fabric offer the designer a strong, reliable combination.

Di-Clad 112T. A Teflon* glass-fabric laminate offering the best dielectric properties over a wide temperature and frequency range.

Send us your requirements and let our engineers help you select the right grade for your application.

†Trademark of Continental-Diamond Fibre Corporation
*Du Pont trademark for its tetrafluoroethylene resin.

Di-Clad 2350. An economy paper-base phenolic grade having good tensile, flexural, compressive, and impact strength. Adequate for most non-critical printed-circuit applications. Can be cold punched and sheared up to 5/64 of an inch in thickness.

CONTINENTAL-DIAMOND FIBRE
A SUBSIDIARY OF THE Budd COMPANY • NEWARK 16, DEL.

TYPICAL Di-Clad PROPERTY VALUES

	Di-Clad 2350	Di-Clad 26 (NEMA XXXP)	Di-Clad 28 (NEMA XXXP)	Di-Clad 28E (NEMA G-10)	Di-Clad 112T Teflon*
BOND STRENGTH—0.0014" foil (lbs. reqd. to separate 1" width of foil from laminate)	6 to 10	6 to 10	6 to 10	8 to 12	4 to 8
MAXIMUM CONTINUOUS OPERATING TEMPERATURE (Deg. C.)	120	120	120	150	200
DIELECTRIC STRENGTH (Maximum voltage per mil for 1/16" thickness)	800	900	850	650	700
INSULATION RESISTANCE (Megohms) 96 hrs. at 35°C. & 90% RH (ASTM D257, Fig. 3)	500	150,000	600,000	100,000	75,000
DIELECTRIC CONSTANT 10^6 Cycles	4.5	4.0	3.6	4.9	2.6
DISSIPATION FACTOR 10^6 Cycles	0.040	0.026	0.027	0.019	0.0015
ARC-RESISTANCE (Seconds)	5	10	10	130	180
TENSILE STRENGTH (psi.)	18,000	16,000	12,000	48,000	23,000
FLEXURAL STRENGTH (psi.)	27,000	21,000	18,000	70,000	13,000
IZOD IMPACT STRENGTH edgewise (ft. lbs. per inch of notch)	0.80	0.45	0.42	12.0	6.0
COMPRESSIVE STRENGTH flatwise (psi.)	32,000	28,000	25,000	62,000	20,000
BASE MATERIAL OF LAMINATE	Paper	Paper	Paper	Medium-weave, medium-weight glass cloth	Fine-weave, medium-weight glass cloth
COLOR OF UNCLAD LAMINATE	Natural	Natural greenish	Natural	Natural	Natural

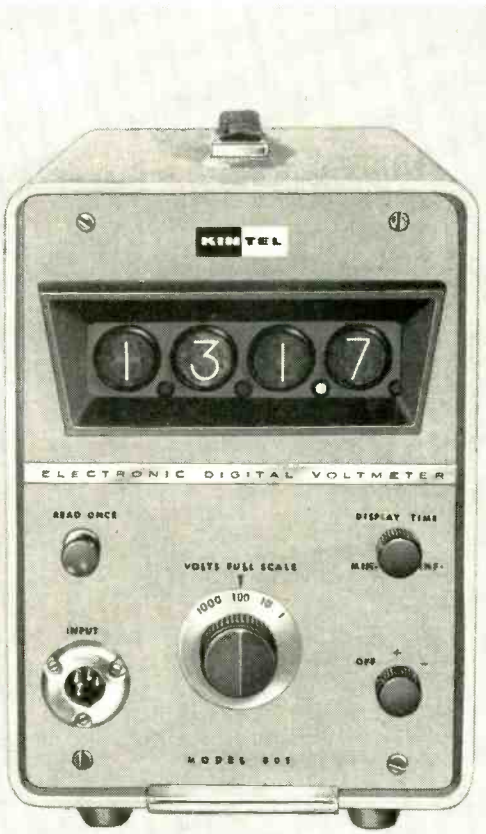
All these standard grades are available with 0.0014" and 0.0028" or thicker electrolytic or rolled copper foil on one or both surfaces. Other metal foils and other resin-and-base combinations can be supplied on special order.

*Du Pont Trademark

ALL-ELECTRONIC DIGITAL VOLTMETER...ONLY $960

MEASURE
MILLIVOLT TO
KILOVOLT WITH
0.1% ACCURACY

no moving parts
digital in-line readout
70 millisecond conversion time
adjustable display time
direct voltage conversion



Here at last is a portable all-electronic digital voltmeter that measures DC voltages from .001 to 1000 volts with 0.1% accuracy. In less than 1/10 of a second the measured voltage is presented in clear numerical form on a digital in-line readout that even unskilled personnel can read quickly and accurately, with little possibility of error. *Direct* voltage measurement by successive approximation provides accuracy and sensitivity previously obtainable only in the delicate, complex and expensive instruments. Extremely stable operation – continuous calibration against an internal reference.

The low price of the Model 801 allows you to put one on every bench. Its accuracy and reliability are assured by KIN TEL's years of design and manufacturing experience . . . experience gained in the manufacture of more than 10,000 precision electronic instruments.

BRIEF SPECIFICATIONS (model 801)

Ranges . . . 0.000 to 1.599; 00.00 to 15.99; 000.0 to 159.9; 0000. to 1000 volts (manual ranging and polarity)
Accuracy . . . 0.1% of full scale
Readout . . . 4 digits plus decimal point
Input Impedance . . . 20,000 ohms per volt*
Conversion Rate . . . 10 per second
Conversion Time . . . approximately 70 milliseconds
Display Time . . . Adjustable from approximately .1 second to infinity (plus push-button *read once* control)
Dimensions . . . 11" high x 7½" wide x 20" deep
Power Requirements . . . 105 to 125 volts, 60 cycle AC, 180 watts

*The Model 802 provides 10 megohms input impedance. Price $1190. In other special models the binary coded decimal and decimal outputs are externally available to permit use as an analog to digital converter.

5725 Kearny Villa Road, San Diego 11, California. Phone BRowning 7-6700

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A Division of Cohu Electronics Inc.

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MAJOR INTERNATIONAL CARRIERS SELECT

Edo LORAN

FOR JET-AGE LONG RANGE NAVIGATION

PAN AM

B·O·A·C

QANTAS

CUBANA

LORAN has long been recognized as the reliable, highly accurate system of long range navigation. LORAN is already implemented and in service over North Atlantic and Pacific air routes, with immediate expansion planned to cover other important areas, too.

Now, LORAN becomes an even more practical navigation system, with the development by Edo of a simplified, lightweight, *pilot-operated* unit. This compact equipment, weighing only 26 pounds installed, can be mounted in the cockpit. From it the pilot obtains directly read line-of-position information, without having to consult tables or make complicated calculations.

Thoroughly tested in trans-oceanic operation, Edo LORAN has been ordered by Pan American World Airways, BOAC, Qantas and Cubana for installation in their upcoming fleets of Boeing and Douglas jet aircraft. Many other international carriers have also indicated their intention to use LORAN to assure precise, reliable long range navigation.

EDO AIRBORNE LORAN, Model 345
Control panel and 3-inch scope are mounted in cockpit for operation by pilot or co-pilot. Receiver (left) occupies ¾ ATR rack. Installed weight of complete system is only 26 lbs., and compact unit requires only a small fraction of space formerly required. Designed and manufactured by Edo, a major supplier of advanced electronic systems for the U.S. Navy—sonar, radar, ASW equipment.

For the complete data on Edo Model 345 Airborne Loran, send for Technical Manual #501, Dept. T-5.

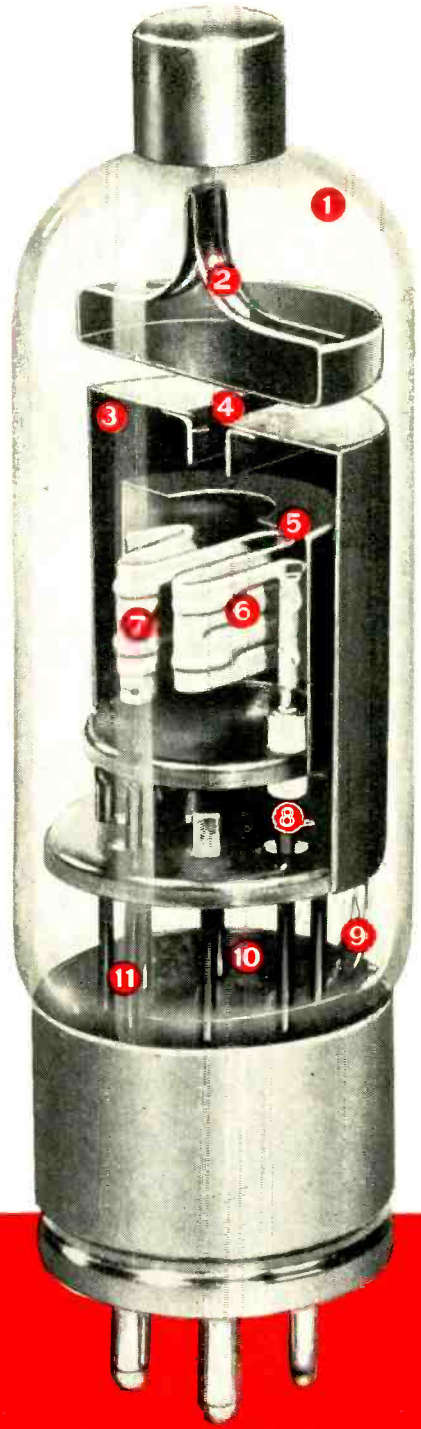
EDO Corporation

College Point, Long Island, New York

Manufacturers of a Trusted Line of Marine and Airborne Electronic Equipments

Amperex® proves there's room for **extra engineering** even in standard replacement tubes!

The hard core of the Amperex line has always been a group of electrically unique "proprietary" types, available from no other manufacturer. However, the Amperex name has come to mean concrete engineering benefits even in standard communications and industrial tubes, above and beyond plug-in interchangeability. Thanks to a manufacturing philosophy of untiring perfectionism – combined with the most recent techniques of production, quality control and applications research – the Amperex replacement tubes shown here offer tighter tolerances, greater uniformity, extra ruggedness in critical applications, plus remarkable freedom from common defects and failures: in short, an extra dimension of quality.



for example

here's what happens when Amperex combines ultramodern production techniques with uncompromising manufacturing integrity to make a standard replacement tube better...

Amperex C3J/5632 THYRATRON

with these **Amperex** *extras:*

1. hard glass envelope
2. rigid anode connection
3. rugged grid cylinder
4. anti grid-emission slot
5. heat shield prevents excessive grid temperatures
6. reinforced cathode with special emitting material
7. ceramic insulators
8. heavy leads allow high peak-currents
9. highly effective getter
10. rugged powder-glass base
11. 8 supports give mechanical strength

AMPEREX ELECTRONIC CORP., 230 Duffy Avenue, Hicksville, L. I., N. Y. In Canada: Rogers Electronic Tubes & Components, 11-19 Brentcliffe Road, Leaside, Toronto 17.

other **Amperex** replacement tubes with **extra engineering:**

Amperex 6146
HIGH-SENSITIVITY BEAM POWER TUBE

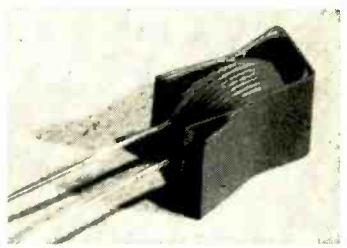
Amperex 4X500A
TETRODE

Amperex C3JA/5864
THYRATRON

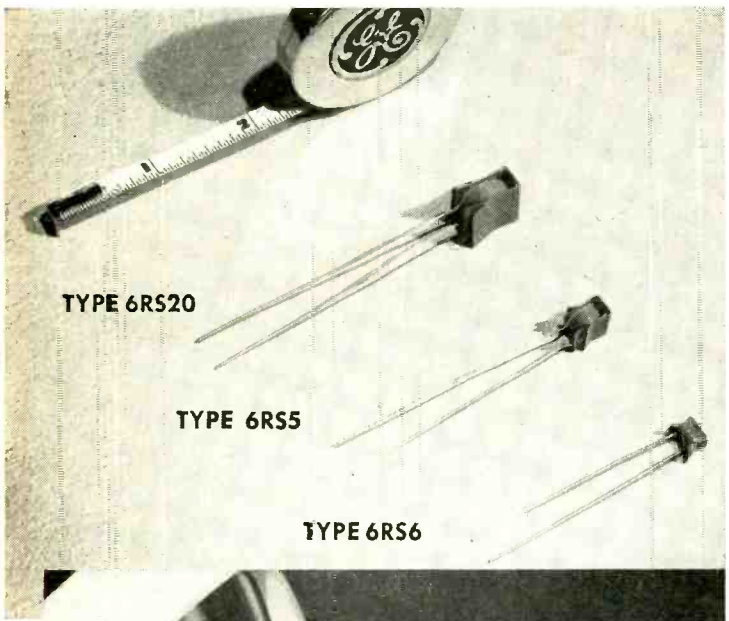
(same as C3J/5632 above, but with increased inverse peak voltage rating)

ask your distributor about **Amperex** *replacement tubes with extra engineering for industrial and communications applications*

NEW SELENIUM RECTIFIERS



Clip Assembly Vac-u-Sel* Rectifiers priced up to 75% less, with space savings up to 50%.



Three new clip assembly selenium rectifiers are now being produced in quantity by General Electric using the Vac-u-Sel process.

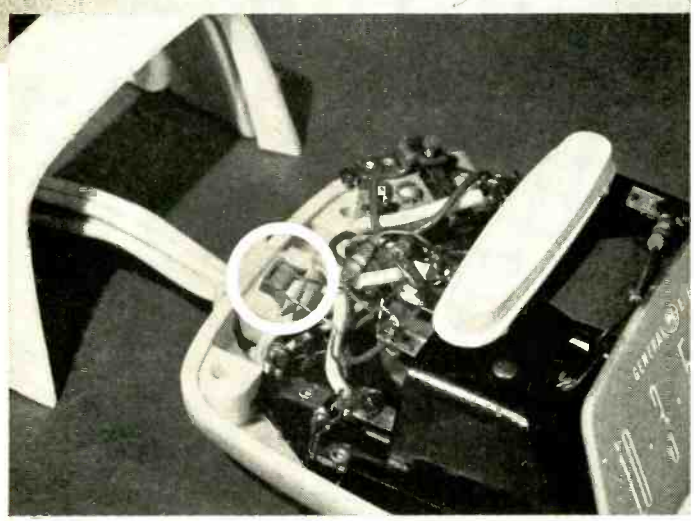
Sizes and Ratings—Type 6RS6 uses 5/32" diameter cells and is rated 2.5 ma; Type 6RS5 uses 9/32" cells and is rated 8 ma; Type 6RS20 uses 15/32" cells and is rated 25 ma. Each size can take from one to six cells depending on the voltage rating (from 37 to 378 volts PIV).

Applications—Vac-u-Sel clip assembly rectifiers are designed for applications on half-wave, doubler, center-tap or bridge circuits. They are low in cost—from 20 to 35 cents each in quantity lots. They are designed to replace rectifiers up to twice as large in applications such as small household appliances, instruments, low power control devices and other electrical and electronic equipment.

For complete information, contact your G-E Apparatus Sales Office. **Semiconductor Products Dept., General Electric Company, Lynchburg, Virginia.**

**Registered Trade-mark General Electric Company*

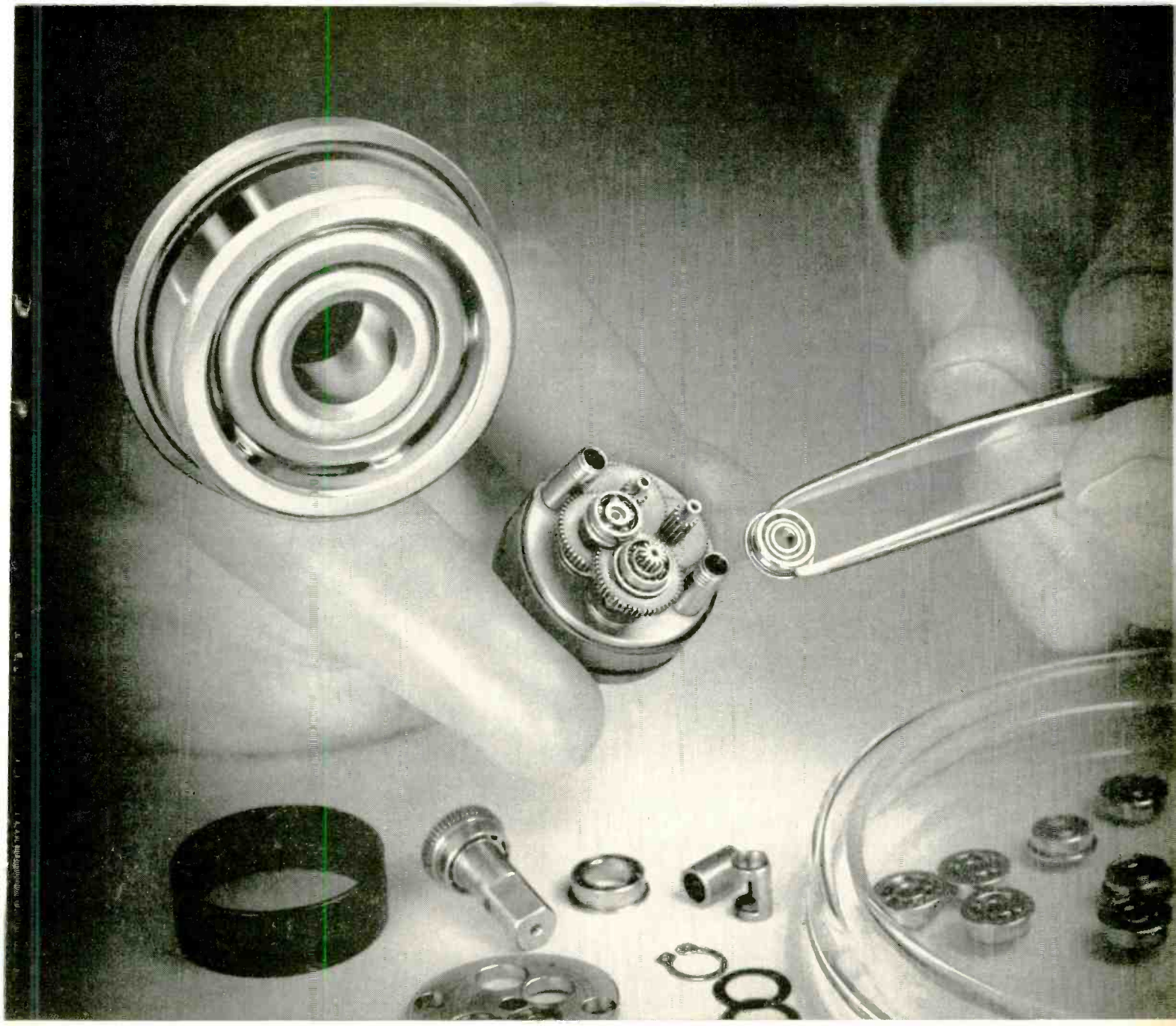
The advantages of Vac-u-Sel rectifiers lie in General Electric's precision vacuum process for obtaining a pure, more even deposition of selenium over the entire cell surface. This results in longer life — even at high operating ambients and better-than-normal rated current. Performance can be reliably predicted from unit to unit.



Encircled is the tiny Vac-u-Sel clip assembly rectifier now being used in the compact Sleep-Guard® Control of the General Electric Automatic Blanket.

Progress Is Our Most Important Product

GENERAL ELECTRIC



Barden Precision SFRI-5 miniature bearings as used in a computer gear train.

Specify **BARDEN** *Precision miniature ball bearings*

Precision-built computer gear trains must have uniformly low torque and minimum backlash; mounting surfaces for the bearings should be simple to manufacture.

Barden Precision miniature-size bearings have the required low torque. Their low eccentricity and closely controlled radial play assure minimum backlash. Precision flanges provide accurate positioning surfaces and permit through-boring, eliminating the need for housing shoulders.

Barden Precision miniature bearings are built to the same high standards of consistent quality as Barden's larger instrument sizes.

Barden Precision means not only dimensional accuracy but performance to match the demands of the application.

Your product needs *Barden Precision* if it has critical requirements for accuracy, torque, vibration, temperature, or high speed. For less difficult applications, the *predictable* performance of *Barden Precision* bearings can cut your rejection rates and teardown costs.

Write today for your copy of Catalog Supplement M1 which gives dimensions, performance and engineering data on *Barden Precision* ball bearings 5/8" O.D. and smaller.

THE BARDEN CORPORATION

45 E. Franklin St., Danbury, Connecticut • Western office: 3850 Wilshire Blvd., Los Angeles 5, California

SPECIFY BARDEN PRECISION BALL BEARINGS FOR: INSTRUMENTS • AIRCRAFT ACCESSORIES • COMPUTERS AND RECORDERS • MACHINE TOOL AND TEXTILE SPINDLES • OTHER PRECISION APPLICATIONS

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COMPLETE LINE 125° C

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Oster®

- Both Damping and Integrating types available with parameters to your requirement.
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- Assembled under closely controlled environmental conditions.

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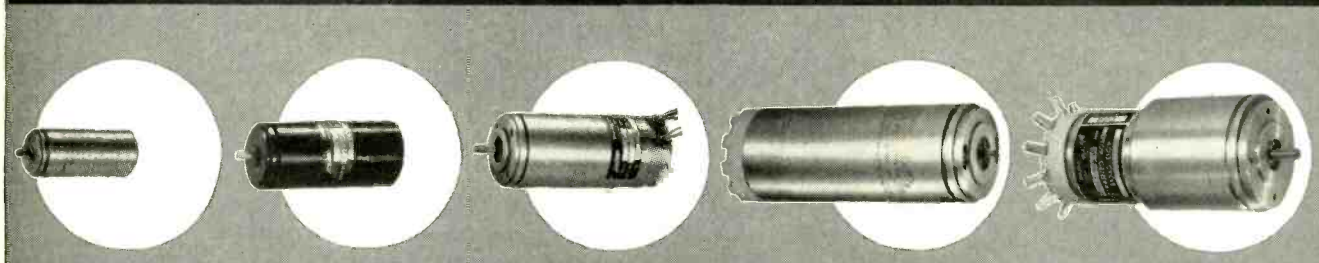

400 CPS SERVO MOTOR — TACHOMETER GENERATORS

Oster Type	Size	Length Inches	Wt. Oz.	Rotor Inertia gm cm²	MOTOR					GENERATOR				
					Rated Voltage		No load speed RPM	Watts per phase @ Stall	Stall Torque OZ. IN.	Excit. Volt.	Output Volts per 1000 RPM	Lin.% to 3600 RPM	Null MV	Phase Shift @ 25°C
					Ø 1	Ø 2								
8MTG-6201-01	8	1.850	2.3	0.77	26	40/20	6,500	2.2	0.16	26	0.25	0.5	15	± 5°
*10MTG-6228-02	10	2.157	4.2	0.72	115	115/57.5	9,500	2.8	0.26	115	0.45	1.5	19	±10°
10MTG-6229-12	10	2.100	2.9	1.09	33/16.5	52/26	9,500	3.0	0.28	26	0.45	1.5	13	±10°
*10MTG-6229-03	10	2.100	2.9	1.09	26	26	10,500	3.0	0.26	18	0.3	1.5	12	±10°
10MTG-6229-15	10	2.100	2.9	1.09	26	26	10,500	3.0	0.26	26	0.3	1.5	12	±10°
*10MTG-6232-05	10	2.104	4.2	1.1	115	36/18	6,500	3.5	0.26	115	0.30	1.5	15	±10°
11MTG-6251-13	11	2.531	7.0	1.3	115	115/57.5	6,500	3.5	0.63	115	0.55	0.5	19	±10°
11MTG-6251-00	11	2.531	7.0	1.1	115	40/20	6,500	3.5	0.63	115	0.55	1 5	19	±10°
11MTG-6254-01	11	2.200	6.0	1.1	115	115/57.5	6,500	3.5	0.63	115	0.55	1.5	19	±10°
15MTG-6280-01	15	3.281	14.0	5.3	115	115/57.5	5,000	6.2	1.5	115	3.0	0.2	13	± 5°
†*15MTG-6276-03	15	3.875	15.0	4.4	115	57.5	8,500	5.8	0.70	115	2.75	0.2	13	± 0.5°
18MTG-6302-02	18	3.680	20.0	5.7	115	115/57.5	9,000	16.0	2.7	115	3.0	0.2	13	± 5°
18MTG-6302-04	18	3.680	20.0	5.7	115	115/57.5	4,800	9.2	2.4	115	3.0	0.2	13	± 5°

*These units designed for 85°C ambient but same characteristics can be designed for 125°C. †Additional 21.4 watts for heater, the values given are independent of ambient temperature.

Other products include servos, synchros, resolvers, motor-gear-trains, AC drive motors, DC motors, servo mechanism assemblies, reference and tachometer generators, servo torque units, actuators and motor driven blower and fan assemblies.

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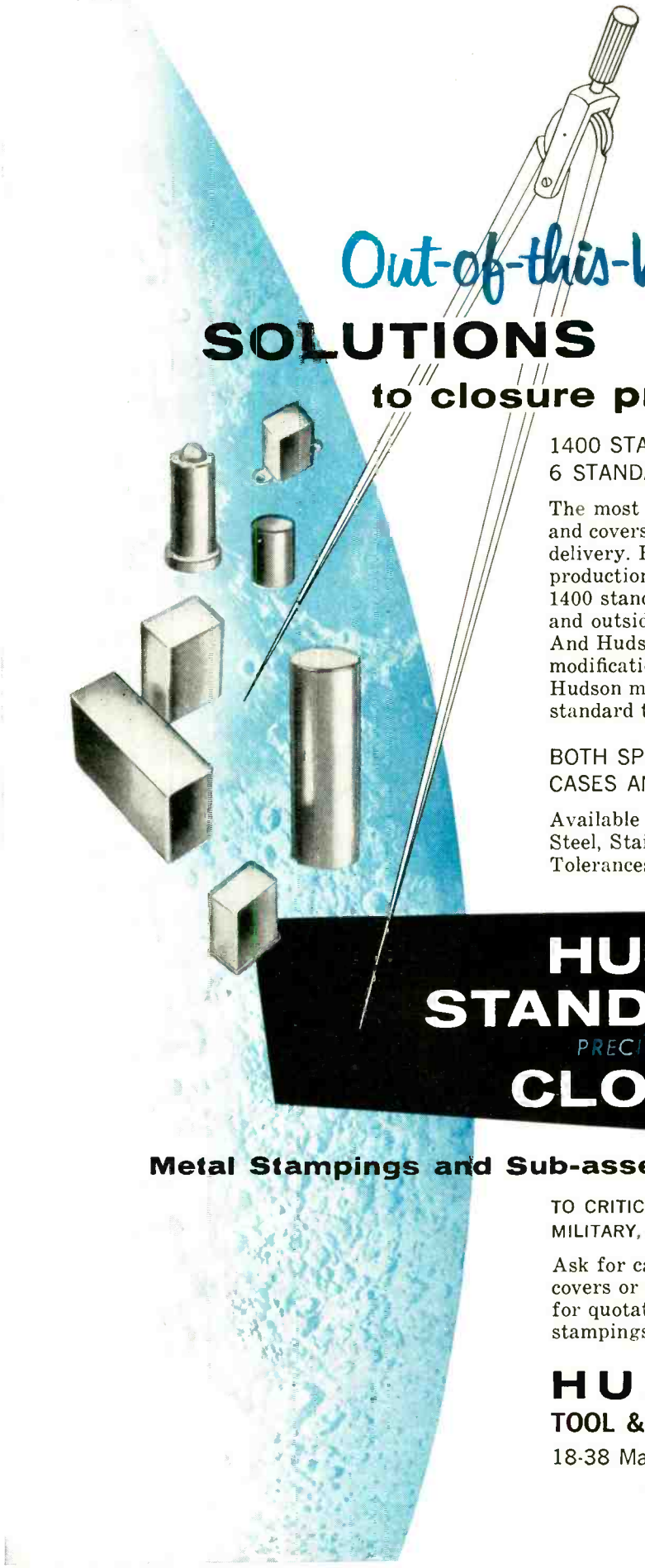
Engineers For Advanced Projects: Interesting, varied work on designing transistor circuits and servo mechanisms. Contact Mr. Robert Burns, Personnel Manager, in confidence.



Out-of-this-World SOLUTIONS to closure problems

1400 STANDARD SIZE CLOSURES—
6 STANDARD METALS AVAILABLE

The most complete line of standard cases and covers in the industry... in stock for fast delivery. Hudson offers designers and production engineers the economy of over 1400 standard size closures with both inside and outside covers in six standard metals. And Hudson is fully equipped to put ANY modification in ANY closure in ANY position. Hudson mass production methods and standard tooling save you time and money!

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Available in—Mu Metal, Aluminum, Steel, Stainless Steel, Brass, Copper. Tolerances available to ±.005".

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Ask for catalog on standard cases and covers or send drawings and specifications for quotations on custom closures, metal stampings or sub-assemblies.

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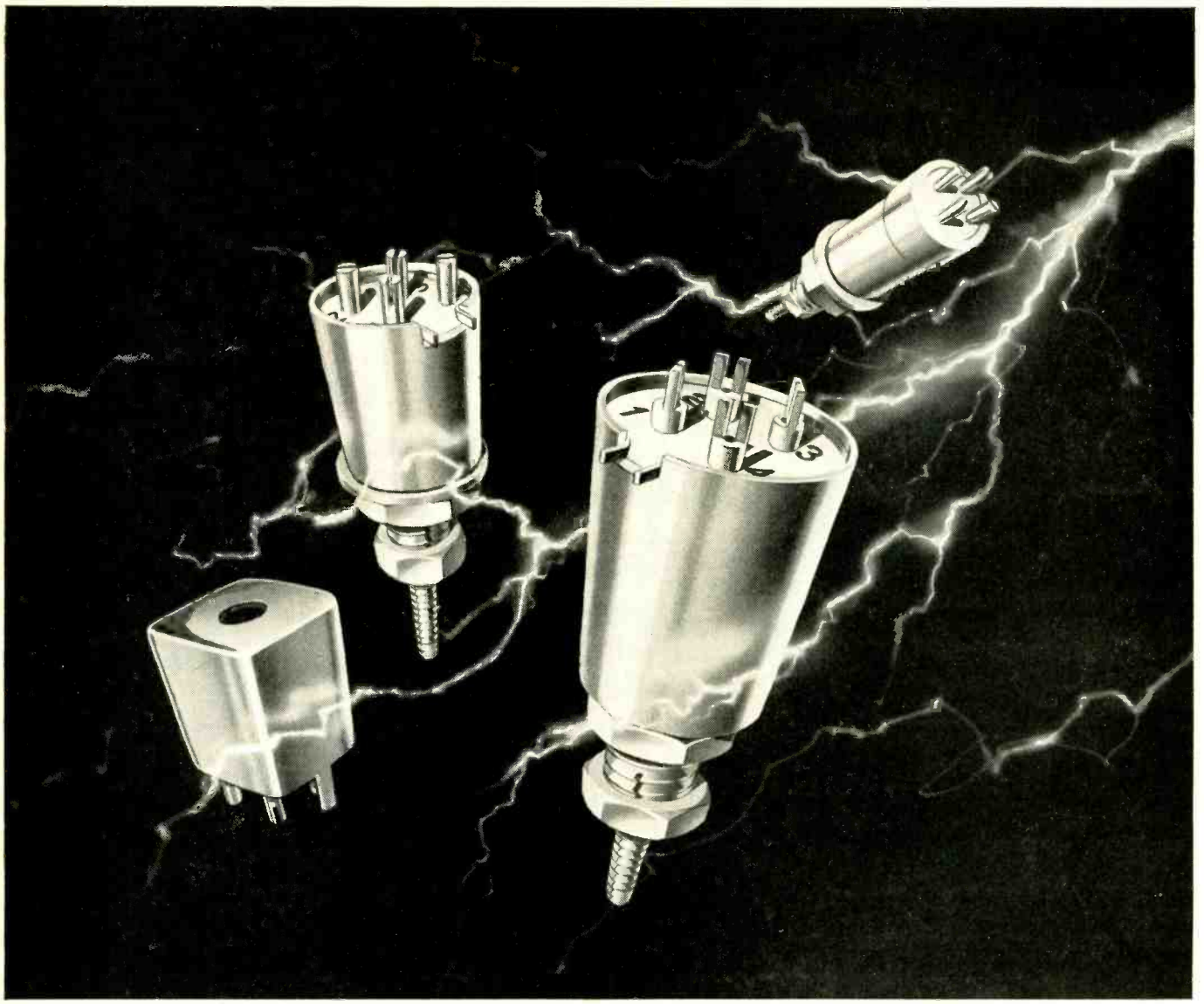


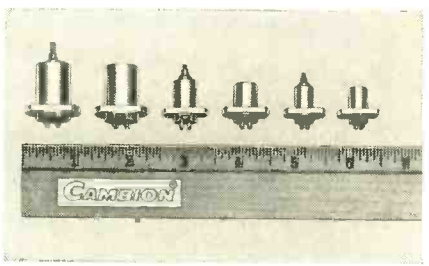
These shielded coil forms offer the utmost in reliability due to their unique design and construction. Dimensions when mounted, including terminals, are: LS-9, 7/16" diameter x ½" high; LS-10, 5/8" x 15/16"; LS-11, 15/16" x 17/32". Each form mounts by a single stud. Single layer or pie-type windings to your specifications. LS-14 is double-ended for primary and secondary windings with separate tuning slugs for independent tuning of each section; its overall length excluding tuning slugs is 1 13/64"; OD is ½". See photograph below for new aluminum housing shielded coil forms.

Reliability – under any condition!

Cambion® miniaturized shielded coil forms are highly shock resistant. With mechanically enclosed, completely shielded coil winding, they bring all the ruggedness and dependable performance you require for your "tight spot" applications — IF strips, RF coils, oscillator coils, etc.

Cambridge Thermionic Corporation combines *quality control* with *quantity production* to supply exactly the components you need, in any amount. Our *quality control* includes material certification, checking each step of production, and finished product. And Cambion *quantity production* means we can fill your orders for any volume, from smallest to largest.

Any Cambion coil form may be wound to your specifications in any desired quantity. For samples, specifications and prices, write to Sales Engineering Dept., Cambridge Thermionic Corporation, 437 Concord Ave., Cambridge 39, Mass. On the West Coast contact E. V. Roberts and Associates, Inc., 5068 West Washington Blvd., Los Angeles 16 and 1560 Laurel St., San Carlos, Cal.



New aluminum housing shielded coil forms with anodized finish. Available in three sizes, as variable tamper-proof units with positive locking mechanism and more precise tuning, or as fixed shielded coil forms. Flange mounted by means of two number 2-56 screws. Mounted heights above chassis are 7/8", 5/8", and ½" (in variable units exclusive of tuning element).

CAMBRIDGE THERMIONIC CORPORATION

CAMBION®

Makers of guaranteed electronic components, custom or standard

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CIRCLE 45 READERS SERVICE CARD →

Transitron

SILICON TRANSISTORS

Now... The widest POWER RANGE in the industry!

New high power transistors have just been added to the Transitron line, increasing power ratings to 85 watts. Now, whatever the application, you can choose from the broadest power range in the industry . . . with Transitron reliability built into every transistor.

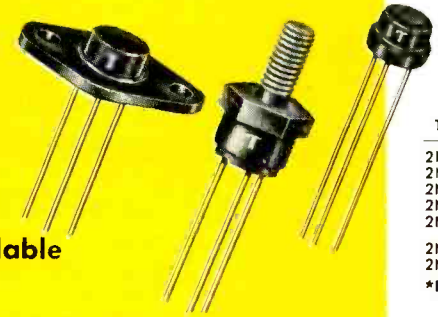
HIGH POWER

- Ratings to 85 watts
- Operation to 5 amps
- Low Rcs, 1.5 ohms typical
- Voltage Ratings to 60V
- High Current Gain
- High Speed Switching

Type	Maximum Power Dissipation at 25°C case (watts)	Minimum D.C. Common Emitter Current Gain B	Typical Collector Saturation Resistance (ohms)	Maximum Collector Voltage Vc (volts)
ST400	85	15@2 amps	1.5@2 amps	60
ST401	85	20@2 amps	2.5@2 amps	60
ST402	50	15@2 amps	4.0@2 amps	60
ST403	50	15@2 amps	3.0@2 amps	45

MEDIUM POWER

- Operation to 500 ma
- Ratings to 5 watts
- Low Rcs, 6 ohms typical
- High Speed Core Driving
- Heat Sink Mountings available

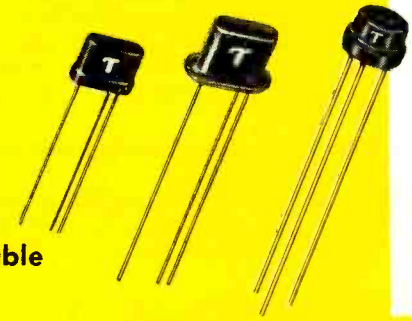


Type	Maximum Power Dissipation at 25°C case (watts)	Maximum Collector Voltage VcMax (volts)	Minimum D.C. Common Emitter Current Gain B	Typical Collector Saturation Voltage (volts)
2N545*	5	60	15@500 ma	3V@500 ma
2N547	5	60	20@500 ma	3V@500 ma
2N498	4	100	12@200 ma	4V@200 ma
2N497	4	60	12@200 ma	4V@200 ma
2N551	5	60	20@ 50 ma	1V@ 50 ma
2N243	.75	60	9@ 5 ma	3.5V@20 ma
2N244	.75	60	28@ 5 ma	3.5V@20 ma

*Fast Switching Type

SMALL SIGNAL

- Operation to 175°C
- Low Ico at Rated Vc max.
- High Current Gain
- Three package sizes available



Type	Minimum Common Emitter Current Gain, β	Maximum Collector Voltage Vcc Peak (Volts)	Typical Cut-off Frequency (MC)	Maximum Collector Cut-off Current at 25°C at Vc MAX (μa)
2N543	80	45	15	.5
2N480	40	45	11	.5
2N475	20	45	10	.5
2N336	78	45	13	50
2N334	18	45	11	50
2N118	18	30	4	10
2N119	36	30	4	10
ST904	18	30	4	10
ST905	36	30	4	10

WRITE FOR BULLETIN TE-1353

Transitron

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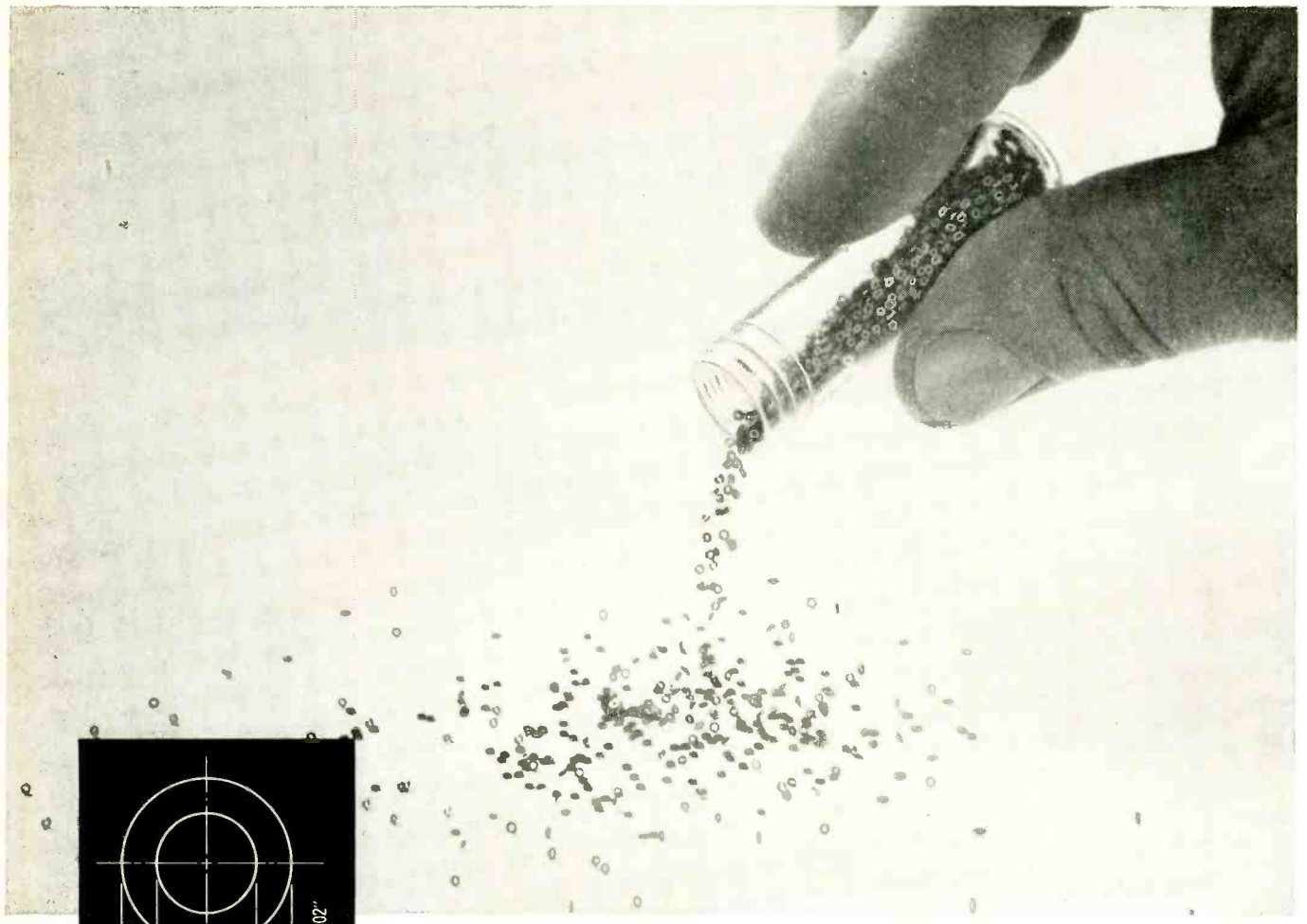
Transistors Diodes Regulators Rectifiers



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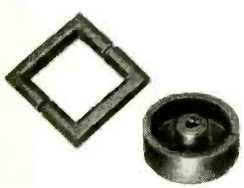
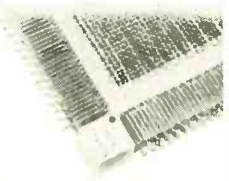


FERRAMIC CORES

PRECISION STEATITES



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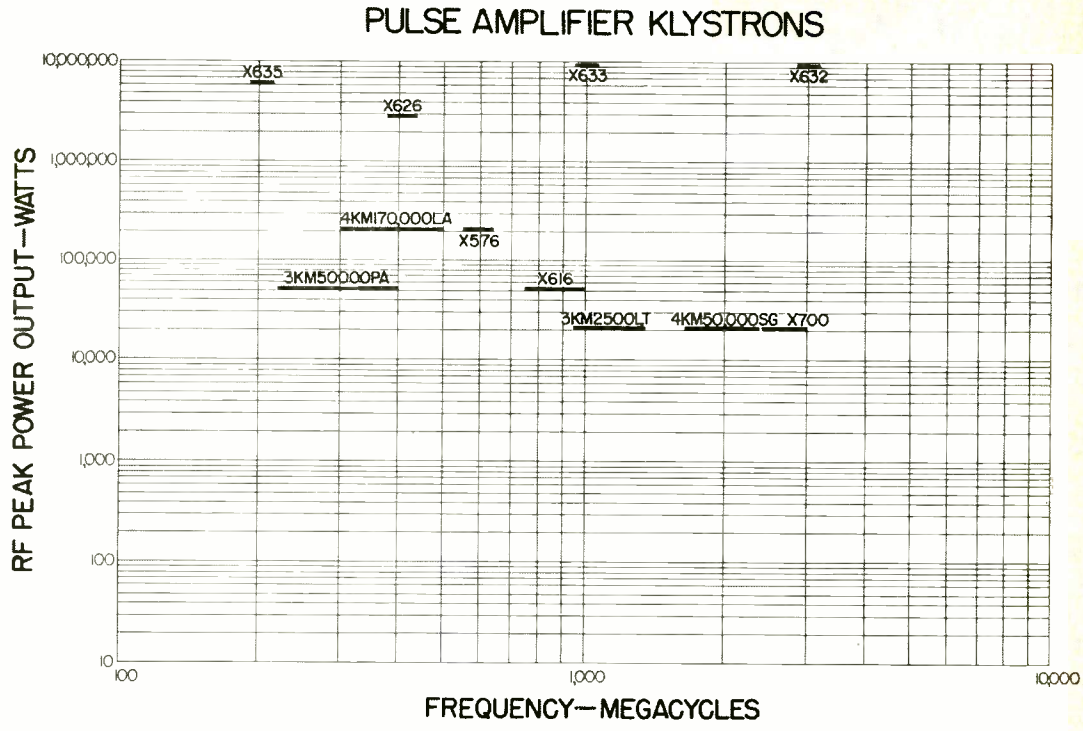
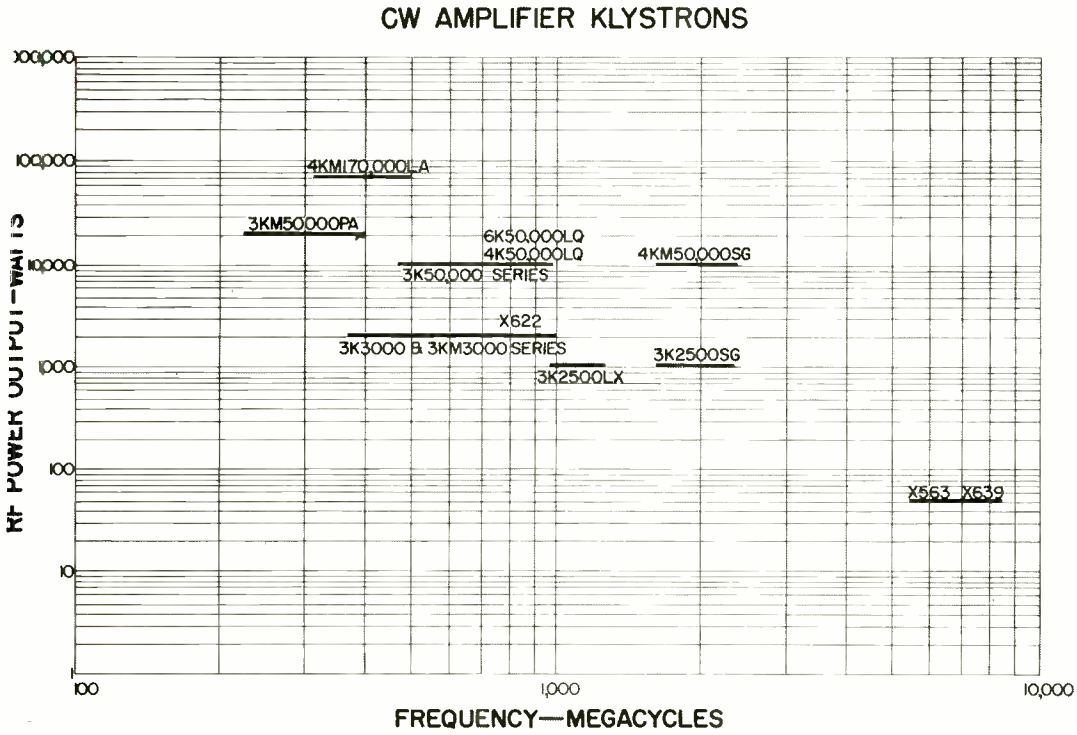


...from VHF into SHF



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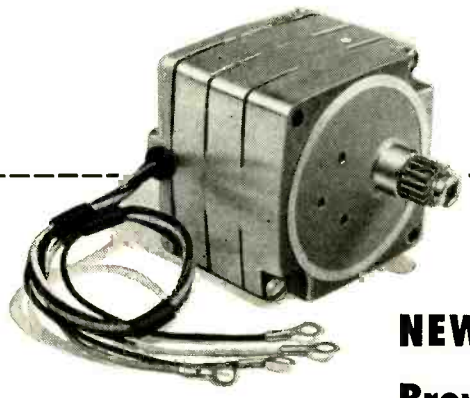

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330	44:1	4	10	7.6	.11	70
148	10:1	5	20	7.0	.11	70
44	30:1	15	50	7.6	.11	70
22	60:1	30	120	7.6	.11	70

SYNCHRONOUS

RPM†	Gear Ratio	Pull-In Torque, Min. (oz.-in.)	Continuous Torque (oz.-in.)	Power (watts) Loaded	Current (amps) Loaded	Temp. Rise Reg. F.
180	10:1	12	12	19	.21	100
180	10:1	3.5	4	13	.11	65
90	20:1	14	12	11	.095	55
60	30:1	13.5	12	13	.11	65
30	60:1	27.5	12	13	.11	65

†1/6 less at 50 cycles. Some speeds available at 25 cycles.

††6.0 watts in field winding, balance in amplifier winding.

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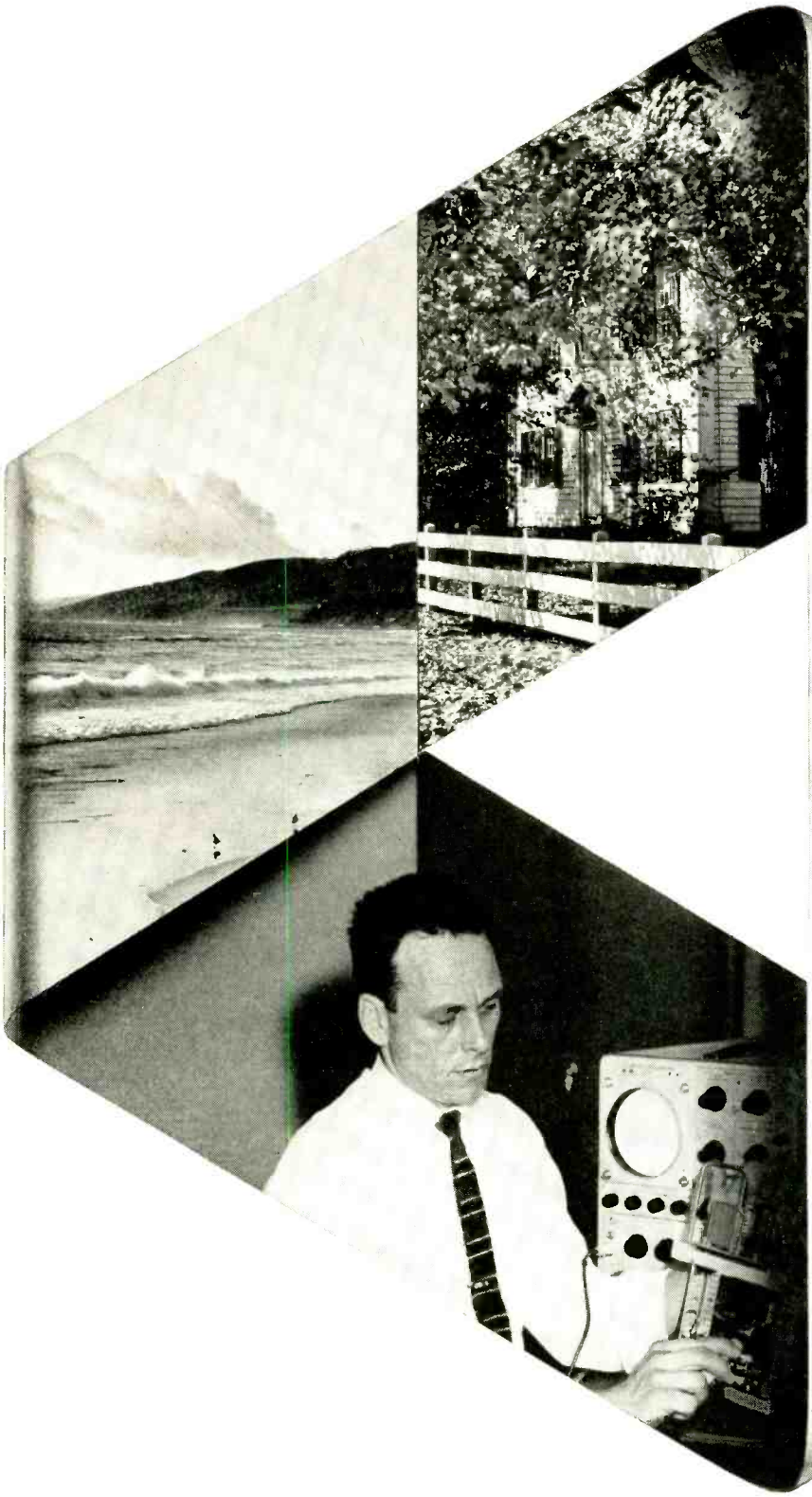

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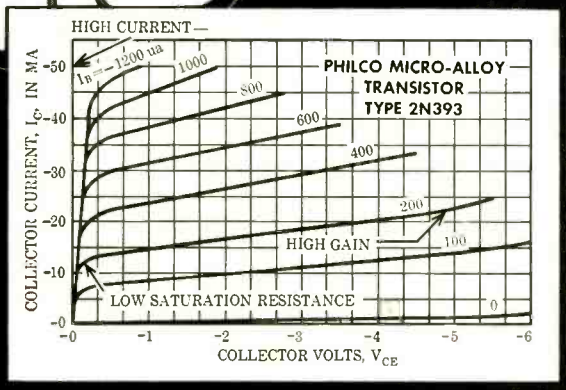

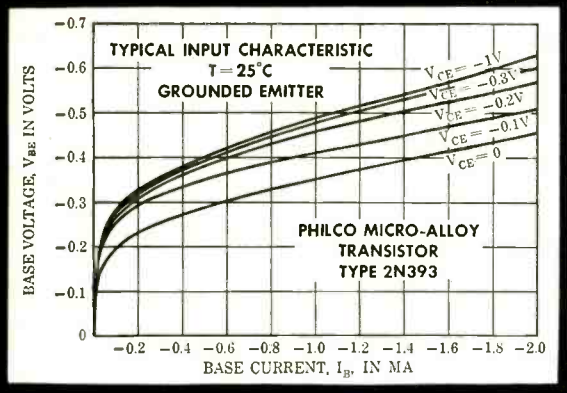

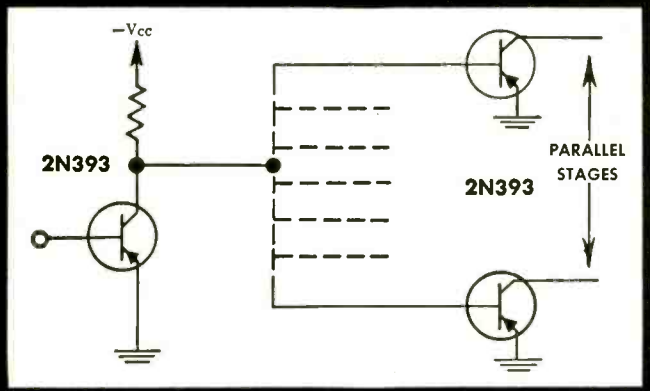

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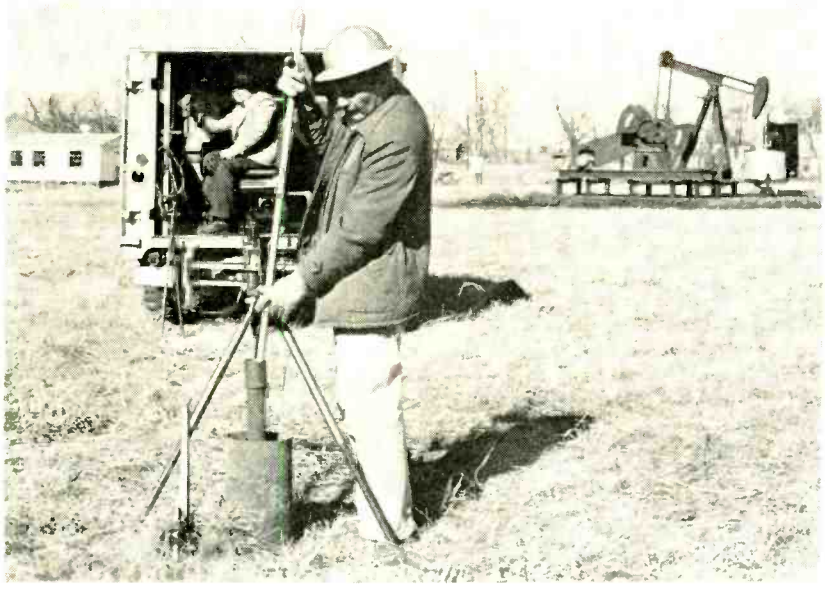
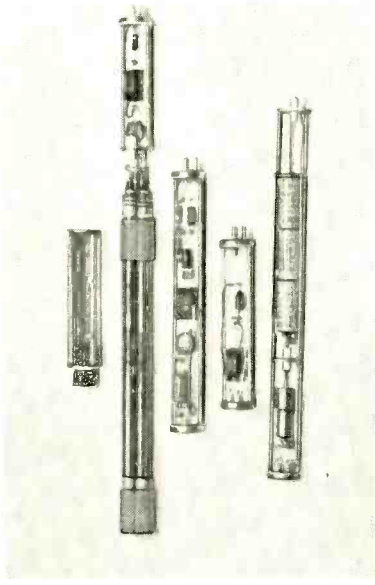


Field engineer lowers assembled gamma-ray probe into wellbore prior to beginning logging operation. In rear is mobile unit containing recording instruments



Plug-in subassemblies inserted in 1-in. diam tube make up probe

Gamma-Ray Detector Aids Oil Field Surveys

Transistorized probe, using Geiger-Muller tubes, detects and measures gamma radiation from radioactive tracers applied to waters and brines in petroleum reservoirs. Instrument is self-contained in a 1-in. diameter steel pipe and operates for as long as 250 hours at depths of 5,000 feet and hydrostatic pressures of 2,000 psig. It has good stability between 70 F and 130 F

By **F. E. ARMSTRONG,** Division of Petroleum, Bureau of Mines, U. S. Dept. of the Interior, Bartlesville, Okla.

APPLICATION of radioactive isotopes as tracers in the study of the flow of waters and brines in petroleum reservoirs[1] is aided by the instrument described in this article. It was designed for use in experiments by Bureau of Mines engineers. Such experiments involve adding a gamma- or beta-emitting radioisotope to water being injected into an oil-producing formation, and detecting and measuring the radioactivity of the water upon its appearance at an oil well.

Instruments suitable for this work must have a sensitivity greater than that required for uranium prospecting,[2] must fit into small-diameter wells, and be capable of reliable operation under ambient conditions that may be normally expected in shallow, water-flooded petroleum reservoirs ranging from 500 to 4,000 feet in depth. Operating pressures exceeding 2,000 psig are not uncommon at the bottom of such comparatively shallow wells. Maximum temperatures seldom exceed 135 F.

The sensitivity of a gamma-ray

well-logging probe may be defined in several ways.[3] With Geiger or scintillation-detection units, counts per minute per milliroentgen per hour is probably the most easily understood and useful presentation of information although not the one most commonly used by industry. Since most radioactivity measurements made within wellbores by or for the petroleum industry need be only relative, little or no attempt is made generally toward absolute calibration of gamma-ray logging tools. The sensitivity of most commercial logging equipment is given in terms of inches of deflection of the pen on the recorder chart versus radioactivity, usually in milliroentgens per hour, at the probe. Actually, the accuracy of any quantitative determination made within a wellbore is questionable because hole-size variation, heterogeneity of the media, self absorption and well-fluid absorption detract greatly from the reliability of the determination. The statistical nature of any radiation measurement also becomes of great importance in gamma-ray well logging. By proper adjustment of the time constant of the recording instrument and logging speed of the probe, the effect of low sensitivity may be in large measure compensated, although at the cost of logging speed. It is not, however, possible to correct for the effects of poor instrumental stability; thus, in the final analysis, stability is the most important single criterion in the design of a gamma-ray logging tool.

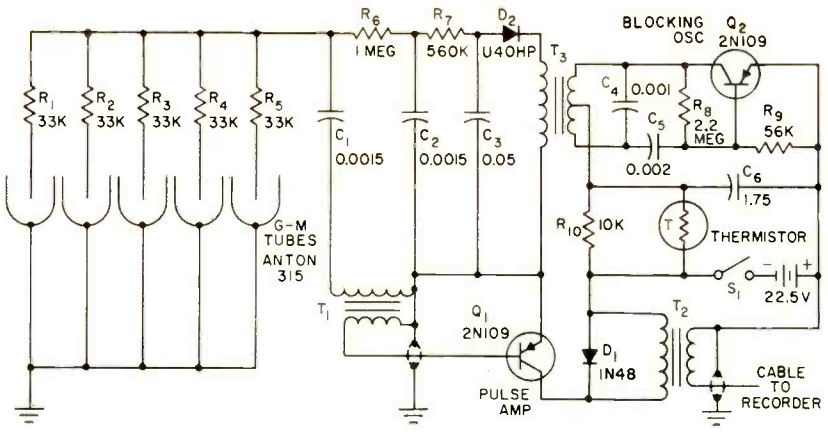


FIG. 1—Schematic of gamma-ray probe. High voltage for G-M tubes is provided by blocking oscillator Q_2 and selenium rectifier D_2. Simple but effective temperature compensation is achieved through the use of a thermistor

Detector Choice

Sensitivity of a radiation-detection device is essentially a function of the product of sensitive volume and detection efficiency. In other words, the sensitivity of a G-M tube with an effective volume of 100 cubic in. and an efficiency of 2 percent is the same as that of a scintillation crystal of 4 cubic in. and an efficiency of 50 percent. Practically, however, in a comparison of logging instruments using these two detectors, the scintillator would have the greater output because of the difference in spectral energy sensitivity. In general, the output of scintillators decreases and that of G-M tubes increases with an increase in spectral energy. This fact alone makes the scintillator a logical choice in logging detectors, because of the lower energies present in the radioactive constituents of rock formations. Ionization chambers, almost universally used in the larger diameter commercial logging instruments, are neither sensitive enough nor amenable to miniaturization to the degree that they may be used in instruments of 1-in. diameter.

Temperature

Although the inherent sensitivity of the scintillation detector makes it the first choice in selecting a suitable detection device for the small-diameter logging instrument, other characteristics rule it out as a practical choice. The temperature sensitivity of the multiplier phototubes that must be used with the scintillation crystal require that they be cooled if the ambient temperatures in which the instrument is to be operated appreciably exceed 100 F. The high-voltage supply for the tube must be more stable by a factor of 10 to 100 than that required for G-M tube operation. The low output-pulse amplitude of the device requires incorporation of wide-band amplifiers to increase the pulse amplitude up to a level that may be transmitted to the surface without becoming lost in the circuit noise. It is quite possible to solve these problems and still maintain the required 1-in. outside diameter of the instrument. However, with the exception of a need for spectral-energy determinations within the wellbore, it is questionable whether the added sensitivity would be worth its cost in complexity and added maintenance. The problem of cooling the multiplier phototube is extremely difficult in probes of this size, although many applications are apparent in wells where temperatures do not exceed 100 F.

Thus, G-M tubes were decided upon for this probe. A choice exists in a design of this nature between one large tube and a cluster of smaller tubes. The large tube is a simple, rugged unit but has the disadvantage of lower sensitivity and a higher operating voltage. Sensitivity may be improved somewhat by complex cathode-design features, but it is difficult to reduce the operating voltage level much below 900 or 1,000 v and maintain reliability. The smaller tube has the advantage of a higher volume sensitivity and a lower operating voltage. The disadvantages of the small tube are a higher total cost, a somewhat steeper plateau for the bundle of tubes than for a single large tube, and greater difficulty in mounting. The operating voltage of the smaller tube is less than 700 v resulting in fewer problems in power-supply design and leakage or corona effects. The output pulse of the smaller tube is considerably shorter in duration and somewhat smaller in amplitude. This, of course, is an advantage where high counting rates may be

encountered because of the reduction in dead time. The matter of dead time of the detection unit is important because it is the principal limiting function in attempting to increase sensitivity by simply increasing the number of G-M tubes used. The response of the unit becomes quite nonlinear at higher counting rates where large numbers of G-M tubes are employed. For this reason, the number of G-M tubes used in the described instrument is limited to five.

Description

The probe consists of a cluster of five small G-M tubes, a transistor high-voltage supply, a transistor pulse-shaping and amplifying stage, and a mercury-cell battery pack, housed in a stainless-steel tube. The various components of the probe circuit are assembled on small terminal boards that plug together to form the complete circuit unit. This kind of construction allows rapid substitution of spare units for field maintenance.

Figure 1 is a schematic drawing of the probe circuit. The G-M tubes are halogen-quenched and operate at about 650 v. They are about $\frac{5}{16}$ in. in diameter and 8-in. long, and were designed particularly for geophysical work. Five 33,000-ohm isolation resistors R_1 through R_5 are used, one between each G-M tube and the coupling capacitor C_1. A 1-megohm resistor R_6 provides quenching. A subminiature audio transformer T_1 matches impedance between the G-M tubes and the base of the pulse amplifier Q_1. Transistor Q_1 operates without bias and conducts little or no current, except during the period of an applied pulse. As the amplitude of the pulse from the G-M tubes is sufficient to drive Q_1 into saturation, the amplifier also serves as a pulse-shaping and leveling stage. A second subminiature audio transformer T_2 matches the collector load impedance to that of the cable (about 50 ohms). Crystal diode D_1 across transformer T_2 prevents overshoot at the collector and damps out any tendency toward ringing in the output circuit. The output pulse at the surface is about 80 μsec and 0.1 v in amplitude. Rise time is about 3 μsec and the pulse is quite square.

Power Supply

The high-voltage supply consists of a blocking oscillator, a subminiature audio transformer T_3 used as a voltage step-up device, a miniature high-voltage selenium rectifier D_2, and a simple R-C filter. Similar supplies have been described.[4] Because of the frequencies involved and the low current drain, enough filtering is achieved by two small capacitors. Although the capacitors are rated at 600 v no difficulty has been experienced during long periods of operation at 700 v. A second simple R-C filter isolates the power-supply oscillator from the battery source and prevents coupling with the pulse amplifier. A thermistor that shunts decoupling resistor R_{10} provides somewhat crude but effective temperature compensation. Regulation of the output voltage is satisfactory over the normal operating range of the instrument which is 80 to 125 F.

The power supply for the circuit is three mercury batteries in series supplying 22.5 v at 1.1 ma. The rated capacity of the batteries used is 350 milliampere-hours, allowing a practical useful life of more than 250 hours. Slide switch S_1 in the head of the probe is used to energize the circuit when the cable is connected.

The outer shell of the probe is a welded stainless-steel tube with a 1-in. outside diameter and a 0.064-in.-thick wall. The ends of the shell are sealed with O-ring assemblies. The inner conductor of the logging cable is insulated with 0.025-in. polyvinyl plastic covered with 0.005-in. nylon to protect the insulation from abrasion by the steel armor. The seal through which the cable enters the probe is a simple neoprene compression ring that seals directly upon the outer layer of the insulation as shown in Fig. 2. Only every other wire of the armor is clamped in the head of the probe to insure that the cable will break at the probe if the instrument becomes lodged in the hole and cannot be pulled free. The plug at the bottom of the probe is a solid steel section 10-in. long, added to increase the weight of the instrument.

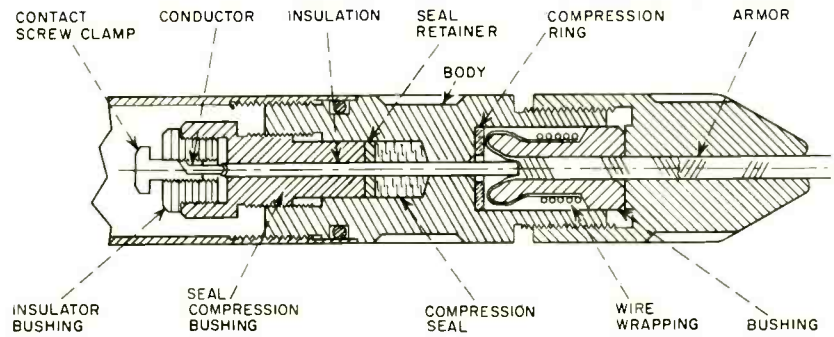


FIG. 2—Cross-section of cable-head assembly shows details of method used to seal probe against pressures which may rise as high as 2,000 psig

The complete assembly rests upon a coil spring in the bottom of the probe shell, which maintains pressure upon the contact between the cable terminal and the probe circuit. The spring also serves as a shock absorber if the instrument should strike an obstacle in the hole or the bottom of the well while being lowered. A screen-covered container in the probe holds a dessicant to reduce the amount of moisture accumulated in the assembly as a result of opening the probe under field conditions.

The instrument has been used intermittently in the field for more than a year with satisfactory results. About 20,000 feet of hole was logged during this time.

REFERENCES

(1) J. W. Watkins, E. S. Mardock, F. E. Armstrong and R. J. Heemstra, Waterfloods Benefit by Radioactive Tracer Techniques, *The Petroleum Engineer*, p B-53, Sept. 1957.

(2) A.E.C. Pub. TEL-87.

(3) R. E. Fearon, Gamma-Ray Well Logging, *Nucleonics*, p 67, Apr. 1949.

(4) A.E.C. Pub. HW-39338.

Transistor Chopper

Transistorized control circuit including a frequency-determining crystal oscillator feeds a voltage chopper which doubles the 28-v d-c supply and divides the driving frequency. The a-c pulsed output then drives a synchronous clock motor. System measures time intervals from 10 sec to minutes with a accuracy of 0.02 percent over a temperature range from —55 to + 70 C

RICHARD H. WILLIAMS Electronic Test Equipment Department, Sandia Corporation, Albuquerque, New Mexico

ACCURATE MEASUREMENT of time intervals from 10 sec to several minutes when the only source of electrical power is 28 v d-c is occasionally necessary in military applications. Generally, the problem is solved by using mechanically governed d-c motors to operate a clock through an electromechanical clutch. Expected system errors are ±0.20 percent of the measured time interval over a temperature range from —55 to +70 C and an additional error of ±0.01 sec per start and stop for clutch variations. For some applications the accuracy of this system is inadequate.

With a moderate increase in clock size, a long-time-interval measuring clock operating on +28 v can be made almost as accurate as the clutching error. Besides increased accuracy, the more accurate clock can replace less accurate clocks already in the field on a retrofit basis.

A schematic diagram of an improved time-interval clock system is shown in Fig. 1. The transistorized crystal oscillator generates an 800-cps square-wave signal. A pulse train enters the bistable voltage-doubling chopper which provides the a-c power necessary to operate a synchronous clock motor.

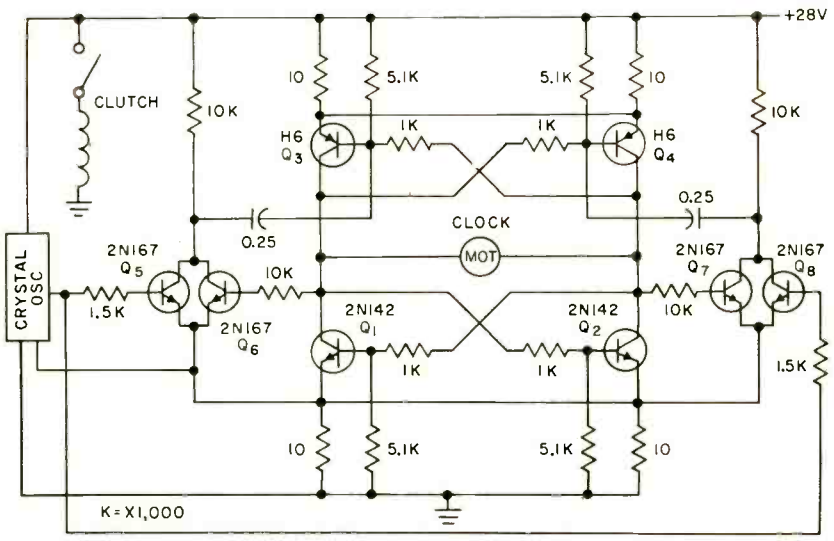


FIG. 1—Time-interval clock uses bistable voltage doubling chopper to provide a-c power necessary to drive synchronous clock motor with 0.02-percent accuracy

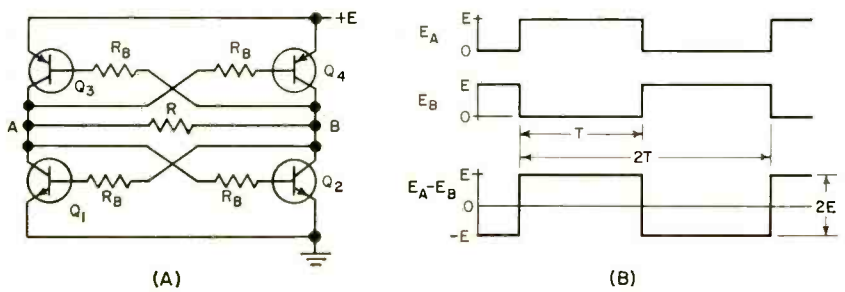
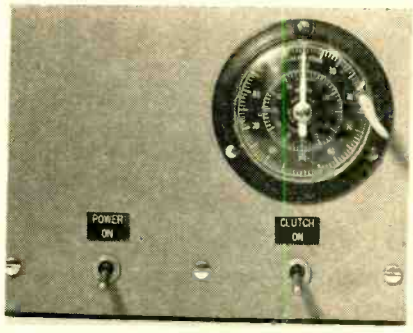


FIG. 2—Voltage-doubling chopper utilizes complementary symmetry feature of transistors (A) to double input voltage to that appearing across the load in (B)

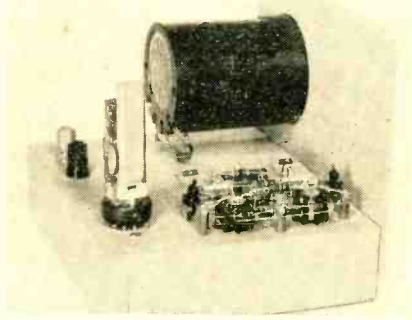
Voltage-Doubling Chopper

Operation of the voltage-doubling chopper is described by reference to its circuit removed from the system and shown in Fig. 2. This back-to-back flip-flop is a result of the complementary nature of *pnp* and *npn* transistors. Resistor R is the load. When transistors Q_1 and Q_4 are biased on and consequently collector-to-emitter impedance is near 1 ohm, transistors Q_2 and Q_3 are biased off and their collector-to-emitter impedance is greater than several hundred thousand ohms. In this state the potential at point B is $+E$ while at A it is zero. Since

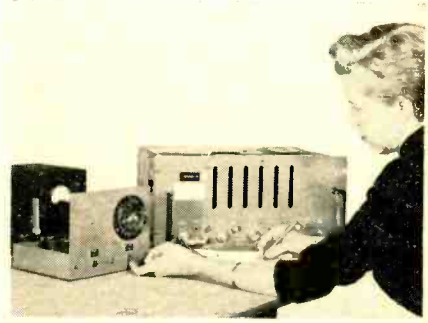
Drives Accurate Clock



Transistorized clock occupies same panel as mechanically governed clock



Side view of time-interval clock system shows mounting of circuit components



Technician makes proper adjustments of time-interval clock using counter

the circuit is bistable, the two pairs of transistors can be switched and the potentials at A and B can be reversed.

When the circuit is triggered by a pulse train of frequency f, the waveforms obtained at A and B are shown in Fig. 2B where T is the reciprocal of the frequency. The voltage across R is the voltage at A minus the voltage at B as shown in Fig. 2B, and has a peak-to-peak magnitude of $2E$.

When the circuit is triggered at frequency f, it chops the supply voltage at frequency of $f/2$ and the peak-to-peak output voltage across load R is double the magnitude of the d-c supply. Since low-power trigger pulses control a much greater a-c power level in load R, circuit efficiency is good. When supply voltage E in Fig. 2A is +28 v the square wave across load R has a peak-to-peak magnitude $2E$ of 56 v.

For a 800-cps frequency, the frequency of the square wave across R is 400 cps. The Fourier series of the square wave yields the rms magnitude of a fundamental voltage component E_{rms} as $2\ (2)^{1/2}\ E\pi$. With $2E$ equaling 56 v, E_{rms} equals 25.4 v.

Synchronous Motor

Small synchronous clock motors run at synchronous speed with square wave excitation as well as with sinusoidal excitation. Therefore, when transistors of sufficient current rating are used, load R can be replaced by a 25-v, 400-cps, 6.5-w synchronous motor as shown in Fig. 1. Square wave harmonics higher than the fundamental are absorbed as losses within the synchronous motor.

Oscillator

In choosing an oscillator for the time-interval clock system, resistors, inductors, capacitors, a fork or a crystal could have been used for frequency control. The crystal oscillator was chosen because the development of low-frequency duplex crystal blanks has made available crystals which are small, trouble free, and stable in the anticipated environments of military applications. Using a duplex crystal without an oven, a stability greater than ±0.02 percent of the output frequency over a temperature range from −55 to +70 C is expected.

The steering circuit is composed of transistors Q_5, Q_6, Q_7 and Q_8. If Q_3 and Q_2 of the voltage-doubling chopper are on, then Q_6 of the steering circuit is biased on and Q_7 is off. When a trigger pulse from the oscillator pulse train occurs, transistors Q_5 and Q_8 which normally are off, are biased on for the duration of the pulse.

No output appears at the collector of Q_5 since parallel transistor Q_6 is already on. However, since Q_7 is off, a negative pulse appears at the collector of Q_8 which biases Q_1 on. When Q_4 is on, the voltage-doubling chopper changes to its other bistable state so that Q_3 and Q_2 are off and Q_1 and Q_4 are on. The circuit can switch back to its original stable state by application of another trigger pulse.

Time accuracy of the chopper is a function of the oscillator frequency which can be controlled to ±0.02 percent. The original mechanically governed d-c clock motor had a time accuracy of ±0.2 percent. For the temperature range −55 to +70 C, the chopper circuit provides an operating accuracy improvement by a factor of ten while the clutching error remains the same. The improved accuracy was great enough to make a decrease in the clutch errors unnecessary. Extra components illustrated in Fig. 1 can be packaged as an extension to the back of existing d-c clock geometery.

Reliability

The system satisfies the military requirements of reliability. Crystal-controlled oscillators and snychronous motors are among the most reliable devices. Transistor circuits can, with design care, be made reasonably reliable too. Should any failure occur which prevents trigger pulses from reaching the voltage-doubling chopper, a-c signals do not appear across the motor so that free-running operation is impossible in the absence of trigger pulses.

The author thanks G. S. Mills, R. A. Richards and those individuals in the Electronic Test Equipment Department who aided him with their advice and criticism.

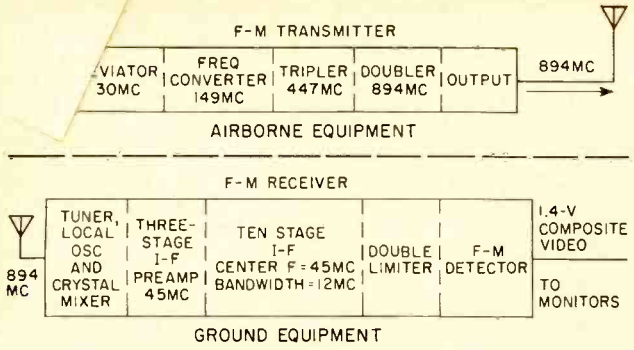


FIG. 1—Elements of airborne and ground-based tv equipment

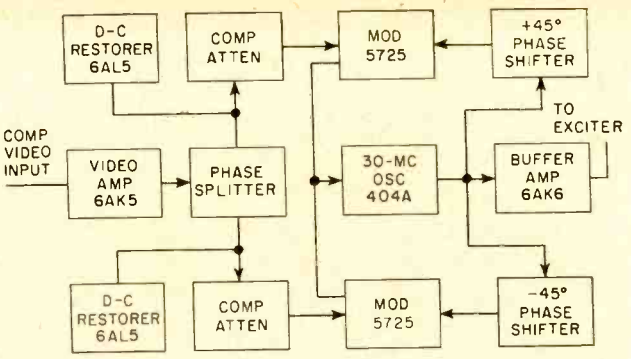


FIG. 2—Frequency deviator has feedback-controlled oscillator

Composite video signal from helicopter-carried image-orthicon camera chain is transmitted to ground or surface-vessel installations within 50-mile line-of-sight range by 30-w frequency-modulated transmitter operating in 780 to 900-mc frequency band. Besides military use, system supplies pickup for commercial network telecasts of conventions, parades and the like

Airborne Tv System for

By **NISSON SHER** Research Section Manager, Research Division

Philco Corporation, Philadelphia, Pa.

JOSEPH F. FISHER Engineering Section Manager, Government & Industrial Division

COMPARED TO conventional a-m techniques, frequency modulation of a television transmitter can result in higher efficiency, improved signal-to-noise ratio for lower video frequencies and a more compact physical unit. For these reasons it was decided to employ f-m in an air-to-ground uhf tv system for military reconnaissance from a helicopter. Transmission can be on any of ten 12-mc channels in the range of 780 to 900 mc.

System Description

Figure 1 shows a block diagram of the transmitting and receiving equipment. The image orthicon camera chain is a commercial unit which produces a 525-line interlaced picture having a field frequency of 60 cps. Its output is a composite video signal, having a level of 1v p-p on a 75-ohm coaxial cable. Applied to the input of the transmitter, this signal produces a radiated signal having a maximum deviation of 10 mc.

The transmitter includes a deviator operating at a frequency of 30 mc, a crystal-controlled frequency converter, tripler, doubler, driver and output stage. The final stage delivers approximately 30 w of r-f power to a 50-ohm load.

One of the transmitting antennas is an omnidirectional vertically polarized array having a power gain of 6 db which results in an effective radiated power of 120 w. Under line-of-sight conditions, the transmission range is approximately 50 miles.

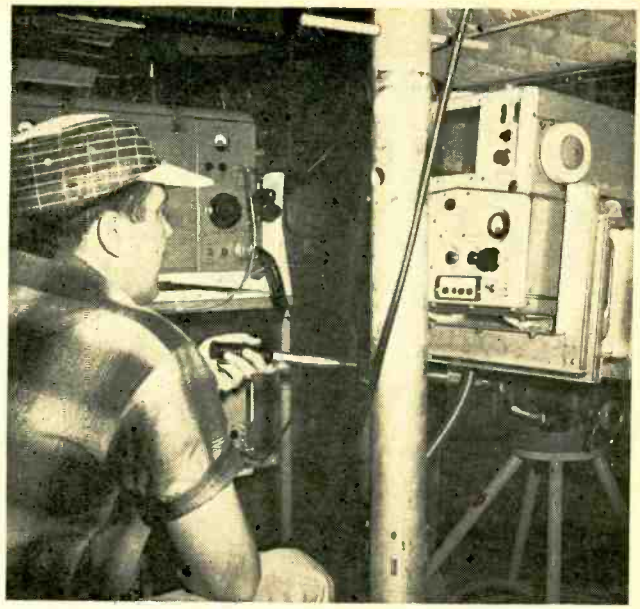
Power for the transmitter and sync generator are obtained from an inverter which converts the 28-v d-c available from the generator on the helicopter to 115-v, 400 cps.

The receiving equipment which may be ground based or installed on a surface vessel, comprises an antenna, wideband f-m receiver and a bank of 17-inch monitors.

Various types of vertically polarized receiving antennas, including a quarter-wave stub, a 4-ft dish, a 2-ft dish, a helix and a three-bay stacked array, are used with the receiver. The antenna used for a particular installation depends on the distance and altitude of the transmitter and the proximity of objects which create multipath. Under multipath conditions, f-m eliminates ghost or repeat images. However, in their place, the picture has a scintillating appearance commonly called prune wrinkle.

Deviator

The composite video voltage from the camera chain contains frequency components up to 5 mc. This voltage is applied to the 6AK5 input tube of the deviator, shown in Fig. 2, to frequency modulate the three-tube deviable frequency oscillator composed of a



Television camera is positioned in open door of helicopter (left). Quarter-wave stub transmitting antenna extends below body when airborne. Internal view of helicopter (right) shows arrangement of camera chain and adjunct equipment

Military Reconnaissance

404A and two type 5725 tubes.

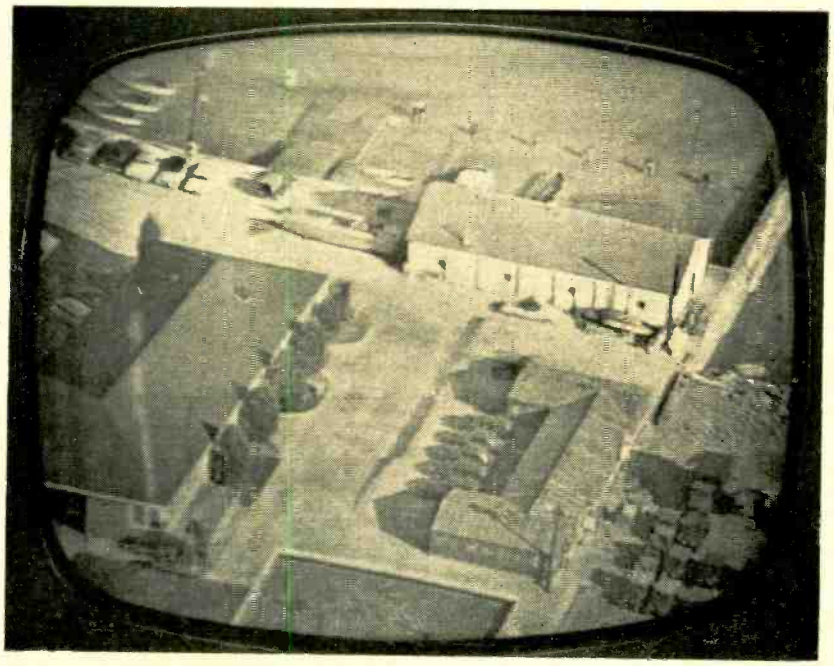
The frequency of oscillation is determined by the phase characteristic of the feedback path. For video voltages at sync-tip level, the deviator oscillates at a frequency of 29.17 mc, while for video voltages at white level the oscillator frequency is 30.84 mc.

Frequency deviation with video input level is linear and a deviation of 1.67 mc (30.84 to 29.17 mc) results in a total deviation of 10 mc after tripling and doubling in the succeeding stages of the transmitter.

The d-c restorers set the frequency for sync-tip level close to one edge of the band and hold it there for video signals having different average values. The video voltages applied to the d-c restorers are approximately 6 v p-p for good restoration. Compensated attenuators in the feeds to the modulator tubes set the video signal level applied to the suppressor grids at 1 v.

The r-f voltage from the oscillator's plate circuit is fed to the control grids of the two modulator tubes through 45-deg phase-shifting networks. As a result the plate currents of these tubes are 90 deg out of phase when operating at 30 mc and the total plate current is the vector sum of the individual plate currents. This current develops a voltage at the grid of the oscillator that is in phase with the plate current of the modulator tubes since the parallel-resonant circuit connected to the grid of oscillator is tuned to 30 mc. Under these conditions the circuit will oscillate at 30 mc.

Since video signals of equal am-



Picture on 17-in. monitor was transmitted from airborne camera chain by uhf f-m

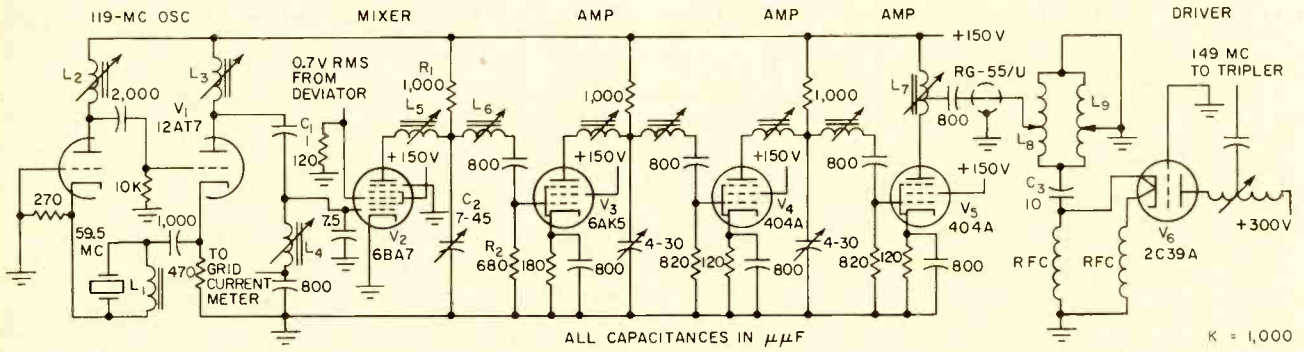


FIG. 3—Transmitter exciter consists of local oscillator, mixer, three amplifier stages and driver that provides 3-w to tripler stage

plitude and opposite polarity are applied to the suppressor grids of the modulators, the plate current of one modulator may be increased while that of the other modulator decreases. Under these conditions, the phase of the resultant plate current and the phase of the voltage applied to the oscillator grid changes. To sustain oscillation, the frequency adjusts itself so that the required phase characteristic is maintained. Thus, the amplitude of the applied video signal controls the frequency.

The 30-mc f-m signal is applied to the exciter, at a level of 0.7 v rms, through a 6AK6 buffer.

Exciter

The transmitter exciter and driver are shown in Fig. 3. The local oscillator is a crystal-controlled oscillator-doubler. Control for 894-mc operation is provided by a 59.5-mc series-mode crystal; L_1 resonates the shunt capacitance of the crystal while L_2 tunes the stray circuit capacitance at 59.5 mc. The double-tuned circuit consisting of L_3, L_4, C_1 and stray capacitance is sharply resonant at 119 mc. This interstage coupling rejects unwanted oscillator harmonics and provides higher gain than a single-tuned circuit. Proper tuning of the oscillator is indicated by a peak in the grid current of the mixer.

The 30-mc signal from the deviator, with a maximum deviation of 1.67 mc, is applied to grid three of the mixer. The sum of 30 mc and 119 mc is produced at the grid of V_2 by the T-coupled type double-tuned interstage network comprised of L_5, C_2, L_6 and R_2 along with stray capacitance. Primary and secondary tuning are provided by L_5 and L_6 respectively, C_2 controls the degree of coupling and load resistor R_2 determines bandwidth. Plate current is supplied through R_1 a 1,000-ohm resistor with negligible r-f loading effect.

Interstage response is maximally flat, with a 3-db bandwidth of 32 mc. Similar interstage networks are used at the outputs of the first and second voltage amplifiers. The T-coupled interstage network was selected in preference to the pi-coupled because the distribution of stray coil capacitance in the former yields a higher gain-bandwidth product.

The output circuit of the third

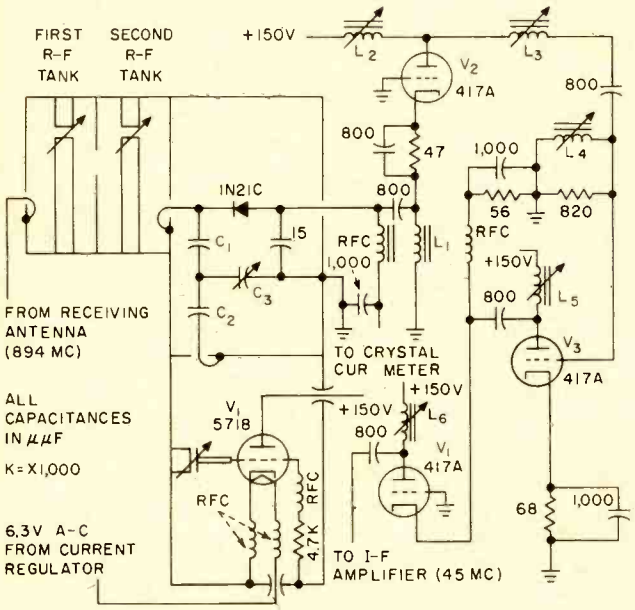
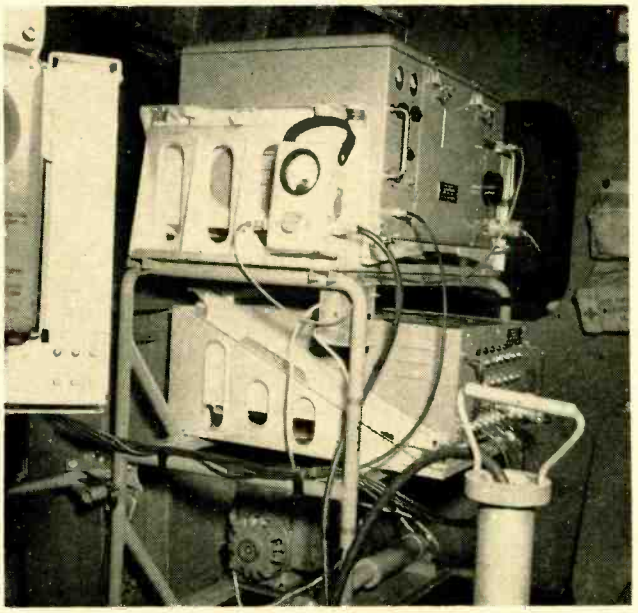


FIG. 4—Double-tuned coaxial tanks provide selectivity for receiver tuner. Unit provides 40 db rejection of image frequency



Transmitter (top) and sync generator (center) and mounted over 400-cps rotary inverter. Tube at right supports stub antenna

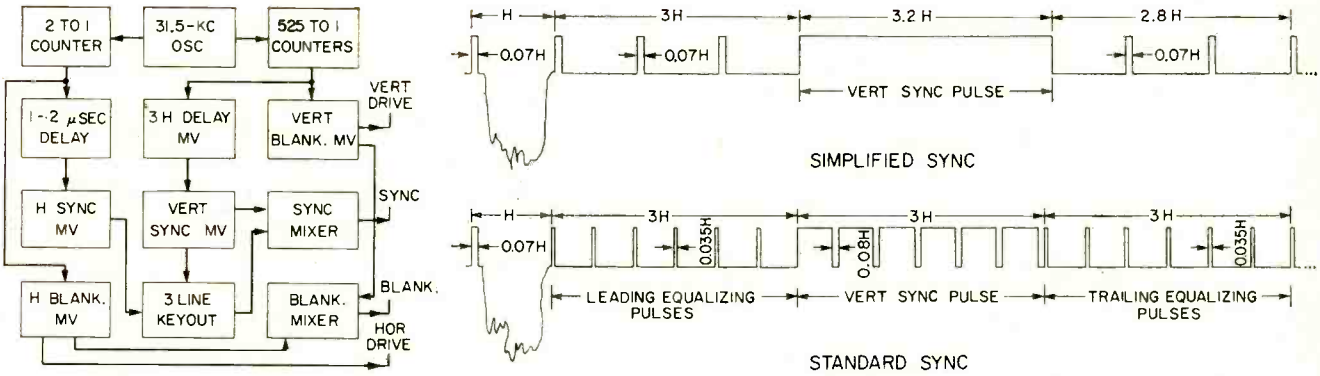


FIG. 5—Simplified-sync generator used in airborne system and its output compared to commercially used sync signals

amplifier is of a different form since it must be coupled through the coaxial cable to the driver. The circuit is double-tuned and consists of L_7, a short length of RG-55/U, L_8, L_9, C_3 and stray capacitance. Capacitor C_3 acts as an impedance step-up transformer with the input capacitance of V_6 to transform the low input resistance of V_6 to a higher value across L_9; L_8 and L_9 are modified Mallory flat-spiral tuning elements, the former controlling the coupling to L_7 and the latter tuning the secondary circuit. The RG-55/U cable affects both coupling and tuning.

A signal level of 0.3 w drives the grounded-grid driver stage to an output of 3 w to feed the frequency tripler which follows. The driver operates class A with zero bias and a plate current of 60 ma. The coupling between V_6 and the tripler is similar to that between V_5 and V_6.

A frequency tripler and doubler, using grounded-grid 5876 pencil triodes, raise the center frequency to 894 mc and increase the deviation to 10 mc. A 2C39A first power amplifier delivers 6 w to the input of the transmitter output stage, another 2C39A. All coupling interstage networks from the output of the tripler through the antenna circuit are double-tuned pi-equivalents with capacitance coupling, transitionally coupled for a flat response of 10 mc in each stage and an overall response of 10 mc between 1-db points.

Output Stage

The 2C39A output stage is operated with a plate voltage of 900 v and a plate current of 110 ma. The input drive of 6 w produces an output power of 30 w across a 10-mc band into a 50-ohm antenna. The input signal is applied through a fixed tap on the center conductor of a grid-cathode coaxial line. Tuning of this circuit is accomplished by a sliding shorting plunger with spring finger contacts to both inner and outer conductors.

The antenna coupling circuit is double-tuned and transitionally coupled; its primary is formed by the grid-plate coaxial line, with an adjustable shorting plunger. Coupling is provided by an adjustable capacitive probe inserted into the plate line and by a short length of RG-55/U. The secondary of the double-tuned circuit comprises a coaxial filter cavity with variable-capacitance end loading for tuning and a sliding contact connection to the 50-ohm antenna line to control loading.

The 30-w output from the filter cavity is fed to the transmitting antenna through several feet of RG-9/U.

Receiver

As shown in Fig. 1, the superheterodyne receiver consists of two passive tunable preselector stages, a local oscillator and crystal mixer, a low-noise i-f preamplifier, a high-gain i-f amplifier of ten stages, two cascaded limiters and an f-m detector. The i-f center is 45 mc and the overall bandwidth is 10 mc between the 1-db down points. Video output for maximum transmitter deviation is approximately 1.4 v into a 75-ohm load.

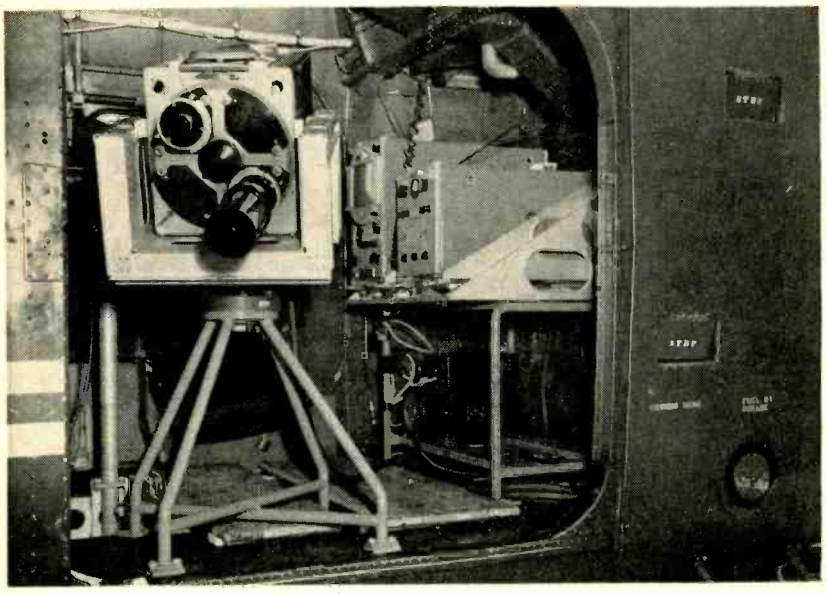
The received signal at the antenna is coupled to the receiver tuner in Fig. 4 by low-loss RG-17/U coaxial cable, 50 to 150 feet in length. Selectivity ahead of the 1N21C mixer diode is provided by a double-tuned coaxial circuit. The antenna signal is coupled to the first tank by a grounded loop, which presents a 50-ohm load to the coaxial cable.

Coupling between the two preselector tanks is through a transitional rectangular aperture with a 3-db bandwidth of 18 mc, so as to provide 40 db of rejection at the image frequency, which is 90 mc above the signal frequency. The insertion loss of the preselector is about 0.5 db. Secondary loading is furnished by the mixer diode through a grounded loop.

The local oscillator is a subminiature triode operated as a grounded-plate Colpitts oscillator with coaxial tuning, operating at 45 mc above the signal frequency. Local oscillator drive to the crystal is furnished by a grounded loop and capacitance-T divider C_1, C_2, C_3, which permits adjustment of oscillator injection without affecting the tuning of the r-f tank. The injection level is controlled by C_3 and tuning of all three coaxial circuits of the tuner is obtained through a variable loading capacitance at one end of each line.

I-F Amplifiers

The i-f preamplifier, also in Fig. 4, receives the 45-mc output of the mixer by a plug-in coaxial fitting. The first stage of the preamplifier is a grounded-grid triode having a



Closeup view of camera installation in helicopter shows camera control unit and power supply at upper right; 60-cps inverter is at lower right

broadly resonant single-tuned input circuit because of the low input resistance of the grounded-grid stage. This type of input stage was selected so the constant loading on the i-f side of the mixer diode would minimize the interaction with the tuning on the r-f side.

To preserve a good noise figure, the input stage is followed by an overcoupled double-tuned circuit and a series amplifier composed of two 417A tubes. The double-tuned input network to the series amplifier, L_2, L_3, L_4, and single-tuned output L_6, comprise a flat triple with a response 0.3 db down at 40 and 50 mc and a 3-db bandwidth of approximately 15.5 mc.

Single-tuned circuit L_5, between the two sections of the series amplifier is broadly resonant because of the heavy loading by the grounded-grid 417A. Neither this circuit nor the one containing L_1 has a serious effect on overall preamplifier response.

The preamplifier is followed by the main i-f amplifier, limiters, and a wide-band discriminator. All i-f and limiter stages are inductive pi-equivalent double-tuned circuits, transitionally coupled, with an overall response 0.3 db down at 40 and 50 mc. The response of the entire receiver is 10 mc between 1-db points and is 25 db down at adjacent channel centers.

The noise figure of the i-f preamplifier is about 2.6 db and 8.5 to 10 db for all ten channels of the entire receiver, as measured at the input connector.

Sync Generator

A block diagram of the airborne sync generator is shown in Fig. 5. By eliminating the equalizing pulses and serrations in the vertical sync pulse, relatively simple circuitry has been achieved. In all other respects the sync, blanking, and drive waveforms are identical to the standard EIA signals used for commercial tv broadcasting.

Under these conditions of operations, sync performance including interlace has been good. Standard EIA sync and the simplified sync signal are illustrated.

Application

This airborne system, including the simplified sync generator, was used to supply video from the camera pickup in the helicopter to the NBC network for two Wide Wide World telecasts in the spring of 1957.

Technical operation of the airborne transmitting equipment and receivers was under the control of engineers from the Bureau of Ships and the Philco Corporation. In both telecasts it was possible, using standard television broadcast equipment, to strip the nonstandard sync in a stabilizing amplifier, lock a ground-based sync generator to the nonstandard sync and reinsert standard EIA sync for the network broadcasts.

The first air pickup was from the San Diego area where the receiving equipment was ground based and the second was from over the Atlantic Ocean near Miami, Florida, where the receiving equipment was located on the aircraft carrier *U. S. S. Franklin D. Roosevelt.*

Alternate Operating Modes

During the course of development, the use of sine-wave subcarrier synchronization in place of impulsive sync was investigated. In this method 1.3-mc carrier bursts (extending from blanking to white level) replace the horizontal and vertical sync pulses.

Elimination of the blacker-than-black region required for conventional impulse sync permits greater deviation of the transmitter by the video information and results in slightly better receiver signal-to-noise ratio. Comparative tests of the two methods of synchronization under conditions of severe multipath indicate more stable performance for impulsive sync. Under normal propagation conditions, there is no observable difference in performance between the two.

Tests were also performed using a 525-line, 2-to-1 interlaced, 20-frame system for the purpose of investigating the potentialities of operation with either narrower bandwidths or greater deviation ratios. Performance under various propagation conditions was at least as good as that obtained with the 30-frame system.

To reduce the effects of flicker arising from the lower frame rate, experimental 17-in. picture tubes using phosphors with longer persistence than P-4 were fabricated and installed in the monitors. Some evidence of smearing of rapidly moving objects was obtained because of the longer persistence.

The authors gratefully acknowledge the efforts of the many Bureau of Ships and Philco Research personnel who contributed to the successful development and testing of this system which was developed for the U. S. Navy Bureau of Ships under Contract No. NOBSR-63394 (1714).

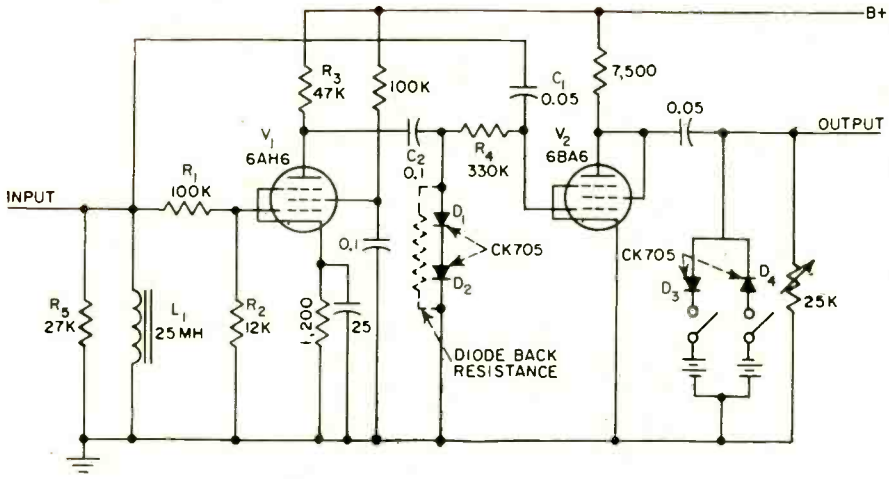


FIG. 1—Circuit of automatic amplitude control for audio section of radio transmitter

Automatic Speech Amplitude Control

Two miniature vacuum tubes and four crystal diodes provide automatic amplitude control for speech frequencies to increase amount of intelligence transmitted over radio communication system under adverse conditions. Differentiating network changes energy distribution of speech so that input amplitude variations of up to 35 db over range of 300 to 3,000 cps are reduced to only about 1 db at output, with relatively little distortion

By LYLE R. BATTERSBY
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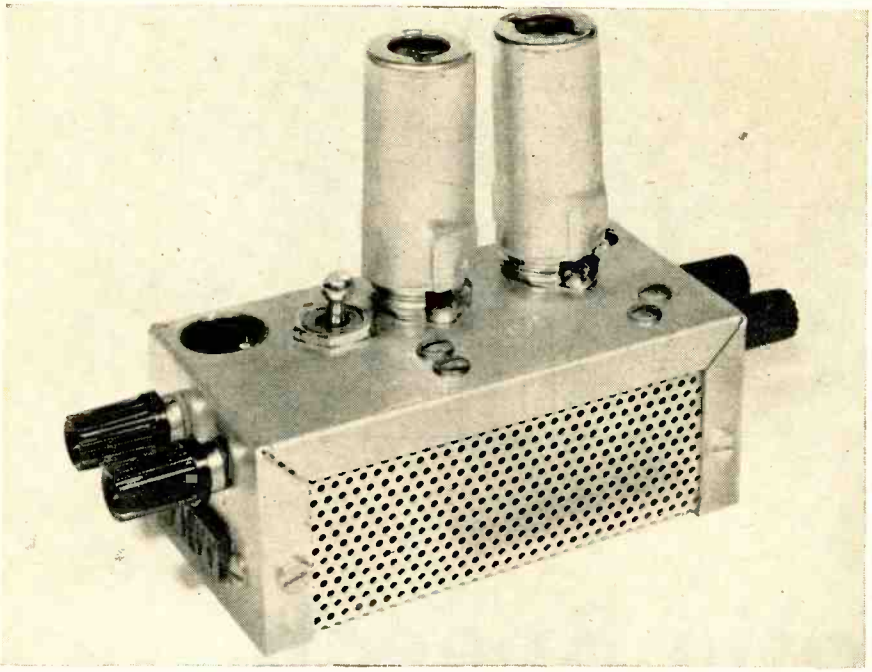
IN RADIO communication systems it is essential that the r-f carrier be modulated fully to obtain maximum transmitter efficiency and to provide the best signal-to-noise ratio at the receiver. This is not possible with ordinary speech which contains strong as well as weak signals unless some means are provided for modifying the speech amplitude characteristics.

Devices presently used for this purpose include companders, volume limiters, clippers, peak limiters and others, used singly or in combination. The dynamic control range obtained and the distortion introduced by such devices varies widely, as does their complexity. For military application such a device should preferably have small size, weight and power drain, provide a wide dynamic control range and have a minimum of distortion.

The automatic speech amplitude control to be described is such a device and includes means for modifying the amplitude characteristics of speech to modulate an r-f carrier more effectively with a maximum of the intelligence to be transmitted and a minimum of distortion.

The speech wave is first differentiated and then applied to an automatic amplitude control circuit of unique design which preserves the waveform over a wide dynamic input range. Input speech variations of 35 db or more are thus reduced at the output to approximately 6 db with negligible distortion. To further reduce these output variations and to limit rapid noise peaks, the speech wave is then lightly clipped. The resultant output variations are only about 1 db.

Basically, this method of speech amplitude control has much less dis-



Miniaturized automatic amplitude control unit, designed for insertion in speech frequency line, consumes 11 watts. Plate power input at normal levels is about 3 w

tortion than that of systems which utilize clipping of 35 db or more to obtain a wide dynamic control range. In practice, it has been demonstrated that the distortion introduced by this method is too small to be detected by the listener and it also provides much larger dynamic range than that obtainable with systems which use relatively light clipping alone to reduce the speech amplitude variations.

Circuit Description

A circuit diagram of the automatic amplitude control is shown in Fig. 1. For convenience, the circuit operation will be described in terms of sine-wave input. It will prove helpful to think of electron tubes V_1 and V_2 as separate amplifiers fed from a common source.

The sine-wave input acting across differentiating inductor L_1 is applied through voltage divider network R_1-R_2 to the grid of V_1 and through C_1 to the grid of V_2.

On the positive alternation of the input cycle the grids of both tubes become less negative and an amplified negative-going voltage is developed across load resistor R_3 of V_1. This voltage is applied through C_2 to a voltage divider network consisting of R_4, C_3 and R_5 in parallel with L_1 and R_1 and R_2. The amplified negative-going signal appearing at the junction of R_4 and C_3, which would normally be applied to the control grid of V_2 in the absence of C_1, is returned to the input circuit. As this feedback voltage is in opposition to the applied signal voltage, the signal voltage is reduced and the dynamic range of V_1 thus extended. Simultaneously the amplified signal appearing at the plate of V_1 is effectively reduced at the control grid of V_2. Diodes D_1 and D_2 do not operate as rectifiers but only as high resistances during this positive alternation of the input cycle.

Reducing Output

During the negative alternation of the input cycles, diodes D_1 and D_2 provide, in conjunction with C_2, a negative bias for the control grid of V_2 which is derived from the amplified signal of V_1. This bias for any input amplitude is much larger than the signal voltage applied through C_1. As a result, the change in plate current of V_2 caused by the signal is small, and the output voltage varies only within small limits.

On the negative alternation of the input cycle, as the control grids of V_1 and V_2 become more negative, the amplified voltage across R_3 moves in a positive direction. When the positive-going voltage exceeds the voltage on C_2, crystal diodes D_1 and D_2 operate as rectifiers. The current through the diodes increases the charge on C_2 and thus increases the negative bias applied to the control grid of V_2. At the same time, the amplified signal voltage on the plate of V_1 is electrically disconnected from the grid of V_2, which now receives the signal voltage through C_1. Because the negative input signal applied through C_1 to V_2 is small compared to the negative d-c bias remaining on this grid, the change in plate current of V_2 is small and the output voltage again varies only within small limits.

To further reduce the output variations, crystal diodes D_3 and D_4 are used to lightly clip the positive and negative peaks of the output wave. The resultant output signal level then varies in the order of 1 db for an input level variation of 35 db. Diode bias batteries determine the minimum level (3 v) at which the diodes will conduct, and the potentiometer serves to adjust the output voltage to the desired clipping level.

The total power consumption of the unit is 11 watts. Plate power input is about 6 watts at 250 volts with no signal applied, and decreases with increasing signal to 1 watt at maximum input levels. Plate power input at normal speech levels is approximtely 3 watts.

The time constant governing the attack time in amplitude control devices operating at speech frequencies is usually a compromise between two requirements: action fast enough to control the peaks and action slow enough so as not to compress later portions of speech after early portions have caused the gain reduction. In addition, the release time must be slow enough to insure quick recovery after strong signal input.

Peak Clipping

The amplitude control described, without peak clipping, meets the above requirements satisfactorily in systems in which the output variations can be in the order of 6 db. Such applications include sound systems and radio receivers. For transmitter application, however, where maximum modulation capability is a requirement, these variations should be reduced to a minimum. For this reason, peak

clipping is provided in the unit.

To keep the circuitry as simple as possible and minimize the number of components required, no special provision has been made for balanced peak clipping. In practice it was found that crystal diodes of the type utilized are quite uniform and therefore the selection of diodes having similar characteristics is not a problem. For optimum results, however. the diodes should have a forward resistance of 100 ohms or less and a back resistance of about 400,000 ohms.

Speech Wave Modification:

In tests conducted to determine the effects of harmonic distortion on the intelligibility of speech, it has been established that the low-frequency vowels contain the major portion of speech power, yet contribute very little to intelligibility. The higher frequency consonants carry little power but are the principle means of conveying intelligence. If the maximum of the intelligence in speech is to be transmitted, some means must be provided to raise the energy level of the consonants to a value comparable to or preferably above that of the vowels. This may be accomplished by filtering or, more simply, by applying the speech wave to a R-C or R-L differentiating network.

By differentiating the speech wave, the energy distribution is changed so the energy in any one component is proportional to the square of the frequency; the energy of the consonants is thus increased.

Speech Energy

The energy distribution curves for normal conversational speech and differentiated speech are shown in Fig. 2. The differentiated curve shows the degree to which the energy in the frequency components above and below 1,000 cps is accentuated or suppressed relative to the 1,000-cps component.

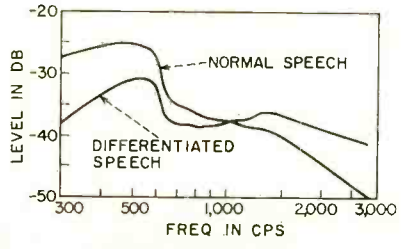


FIG. 2—Energy distribution curves for normal and differentiated speech

It is seen that the energy distribution in the pass band of 300 to 3,000 cps is considerably more uniform for differentiated speech than for normal speech. Whereas the higher frequency components are increased in energy, those at the lower frequencies are attenuated. The latter is of particular importance in systems involving speech clipping. Because of the reduced level of the low-frequency components, they are clipped to a lesser degree resulting in a reduction in amplitude of the harmonics that fall in the pass band.

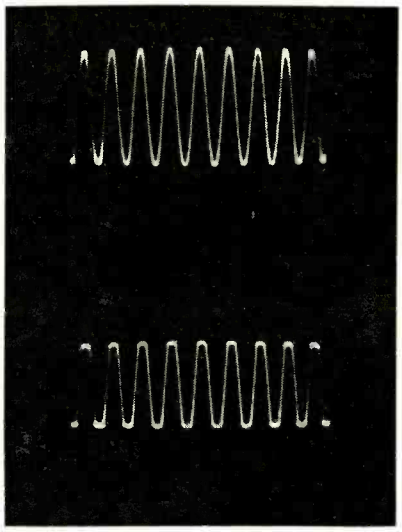


FIG. 3—Waveforms showing degree of clipping required for pure 1,000-cps sine wave (above) to limit output variations to approximately 1 db. Wave below is clipped 5.8 db

From the foregoing, it can be seen that speech differentiation, as used in combination with the described speech amplitude control, provides an effective method of speech transmission. In addition to providing high modulation capability, a maximum of the speech intelligence is transmitted with a minimum of distortion.

Experimental Results

The unclipped steady-state output levels were measured at two different input levels and at 300 and 3,000 cps. For 38 db input amplitude, the difference in output levels was only about 1.5 db at both frequencies.

With peak clipping, noise peaks and rapid input variations in the order of 37 db are reduced at the output to approximately 1 db. As the frequency response of the amplitude control unit is flat in the pass band of 300 to 3,000 cps, the output variation to be expected for any frequency within the pass band is less than 0.1 volt for a 2-volt output.

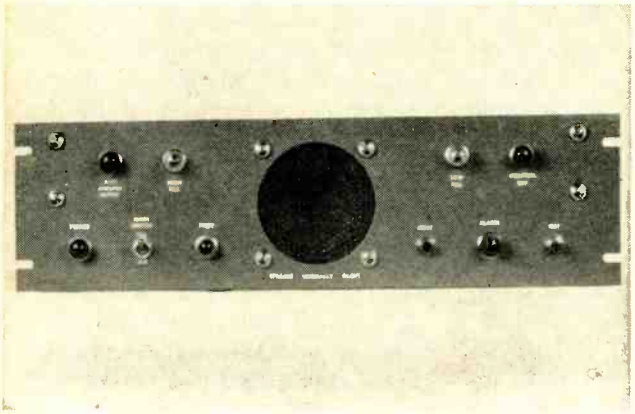
While only the speech pass-band has been considered here, measurements have shown the device to be useful at frequencies up to 250 kc. The waveform in Fig. 3 show the degree of clipping required to limit normal output variations to about 1 db. The sine wave resulting from an input level approximately 35 db above the amplitude control threshold (0.1 volt) is clipped less than 6 db. Rapid changes in input level, or noise peaks requiring more than this amount of clipping, are usually of short duration and therefore the distortion introduced by such clipping is small.

Intelligibility

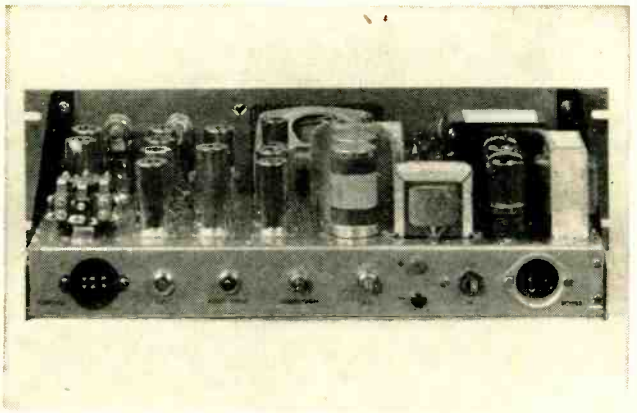
Extensive tests to determine the degree to which voice peaks can be distorted without adversely affecting intelligibility show that 6 db of peak clipping is barely noticeable, 12 db is not objectionable, and 24 db of clipping can be tolerated. These tests indicate that the described method of amplitude control, normally requiring less than 6 db of peak clipping, should have little effect upon speech intelligibility. That this is the case has been verified by numerous listening tests.

The effectiveness of differentiated, compressed, lightly clipped speech in the presence of noise has been demonstrated in laboratory tests. These tests have shown that the effect of noise upon intelligibility under conditions of a −6 db signal-to-noise ratio is negligible.

Recent field tests with portable f-m transceivers show that a marked increase in received audio output power is obtained when the transmitter is equipped with the amplitude control unit. On the basis of listener reports, the improvement in audio recovery resulting from full frequency deviation of the transmitter appears to be greater than 3 db.



Standard relay-rack construction is used, with 3½-in. front panel



Connections to rear of chassis include remote power control (left)

Alarm System Uses

Two neon oscillators, alternately keyed at 2 cps in gated amplifier, provide locally generated warble alarm in Conelrad or carrier-off warning system. Modulation of monitored signal is audible only in case of alert or prolonged carrier interruption. System is controlled by avc voltage of 1.5 v or more from any receiver. Power to external circuits may be removed automatically when receiver avc voltage is off more than ten seconds

By **RONALD L. IVES** Palo Alto, California

THE RADIO OPERATOR at the time of a Conelrad alert is necessarily a busy person, and the alarm system should avoid adding to his burden. The complete alarm should therefore have all of the following features:

(1) Warn operator of Conelrad alert,

(2) Shut off controlled carrier promptly on alert, or on extended failure of key-station carrier, but not on momentary carrier interruptions,

(3) Indicate plainly what is taking place,

(4) Fail safe.

To perform these functions certain standarized signals are emitted from the key station. Those detectable at the receiver are shown in Fig. 1. A one-chassis assemblage to perform all desired functions with optimum fail-safe provisions, can be constructed using standard components, and will operate dependably on an avc voltage of as little as 1.5 v.

The warning device turns on an audio system if the avc of the monitor receiver fails for more than 0.5 sec, and turns the alarm off but not the audio when avc resumes. Power controlled by the system is shut off on receipt of a sustained 1,000-cps note or loss of avc for more than 10 sec. These functions are detailed in Fig. 2. The arrangement enables the operator to hear all Conelrad and similar announcements subsequent to a carrier shut-off while relieving him of the necessity of monitoring key-station program continuously.

Test and reset controls are provided on the panel, as are pilot lights indicating both normal and abnormal operation. Failure of most critical components will shut off the controlled power. A block diagram of the complete system is shown in Fig. 3.

AVC Control

Referring to Fig. 4, control of this system is by the avc output of almost any receiver. Required voltage excursion from no-signal to full-signal can be anything above 1.5 v and the no-signal voltage need not be exactly zero. Close-differential operation of the alarm is avoided by using amplified avc through control-tube V_{10A}, which is cut off by normal avc voltage but draws plate current when avc fails.

This plate current biases off oscillator V_{11A} with no avc but permits oscillation when avc is normal. The oscillator output is amplified by conventional triode V_{11B}, and its output in turn is rectified by dual ger-

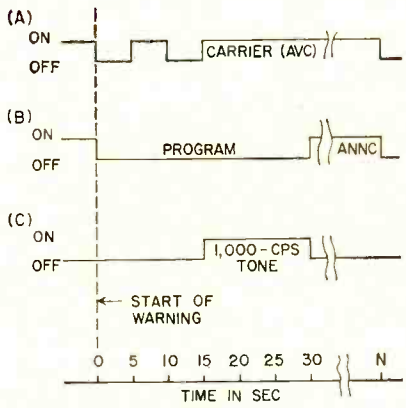


FIG. 1—Typical sequence of carrier (A), program (B) and warning-tone (C)

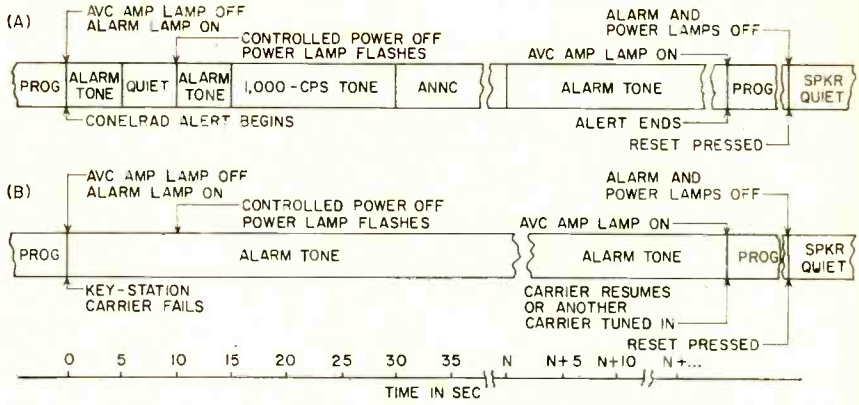


FIG. 2—System operation during Conelrad alert (A) and key-station carrier failure (B) gives indication of relative time intervals involved during possible alert

Gated Neon Warbler

manium diodes. The rectified output is regulated by the NE-51 which also functions as a panel pilot. The amplified avc output is nominally −55 volts whenever the avc input is above a predetermined value such as −1.5 v. A tap on the output voltage divider of the avc amplifier provides −5-v bias for the 1,000-cps amplifier.

A TEST pushbutton disconnects the avc amplifier from the receiver and applies +8 v to the amplifier input. The cathode voltage of V_{11A} and plate voltage of V_7 and V_{10A} is regulated at +108 v by V_{12}, which also supplies regulated voltage to the a-f control tube. The frequency of oscillator V_{11A} is not critical in this application, although its harmonics may interfere with other devices in the vicinity. As the avc amplifier will perform at any frequency from 0.5 to 500 kc, retuning to prevent interference presents no problem.

Time Delay

The input resistor and capacitor of the avc amplifier, plus the 0.1-μf filter capacitor in the rectified output of V_{11B} produce a delay of about 0.5 sec between failure of receiver avc output and failure of amplified avc output. This makes any controlled device immune to short-term interruptions of the carrier as received, whether they are caused at the transmitter, or by switching transients or other power vagaries that are of local origin.

The output of the avc amplifier is fed to a-f control tube V_7, alarm-control tube V_{1B} and half of power-control tube V_{11A} through 1-megohm isolating resistors. The audio system will operate from the detector output preceding the volume control of any standard receiver and provide enough output to override room noises up to about 100 dbm. The audio is silent under normal conditions, but turns on and stays on until reset whenever the avc output of the receiver fails for more than 0.5 sec. The main audio amplifier is conventional and capable of 10 w output. Volume control is provided for setting level.

A branch takeoff is provided at the plate of V_{11} to feed the 1,000-cps amplifier. A secondary input for the alarm signals from V_{2B} appears at the grid of phase inverter V_{2A}. No volume control is provided for the alarm signals, which should be audible as far from the speaker as possible under all conditions. Tested range of audibility is about 1,000 feet under business-district conditions of ambient noise and more than 250 feet under airport conditions.

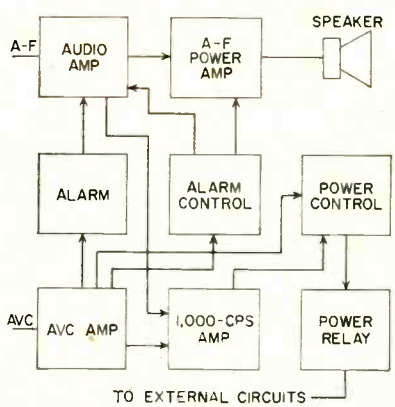


FIG. 3—Functional diagram of complete alarm system and control circuits

Audio Control

Control of the audio system is by thyratron V_7 and its associated relay. Under normal conditions the avc amplifier provides more than adequate hold-off voltage for the tube. Failure of the avc allows the tube to fire, closing the relay contacts and completing the ground return of the entire audio system. Resumption of avc output thereafter has no effect on this circuit, which must be manually reset before it can be silenced.

Panel indication of alarm operation is provided by a neon bulb connected between the audio system plate supply and return. When the system is inoperative voltage across this bulb is zero. As soon as the system becomes operative, voltage across the bulb and resistor is about 200 v, giving visual indication of the condition.

To guard against the effects of tube aging, the screen of the thyratron is biased at +8 v. This insures firing even when the tube has operated cut off for extended periods

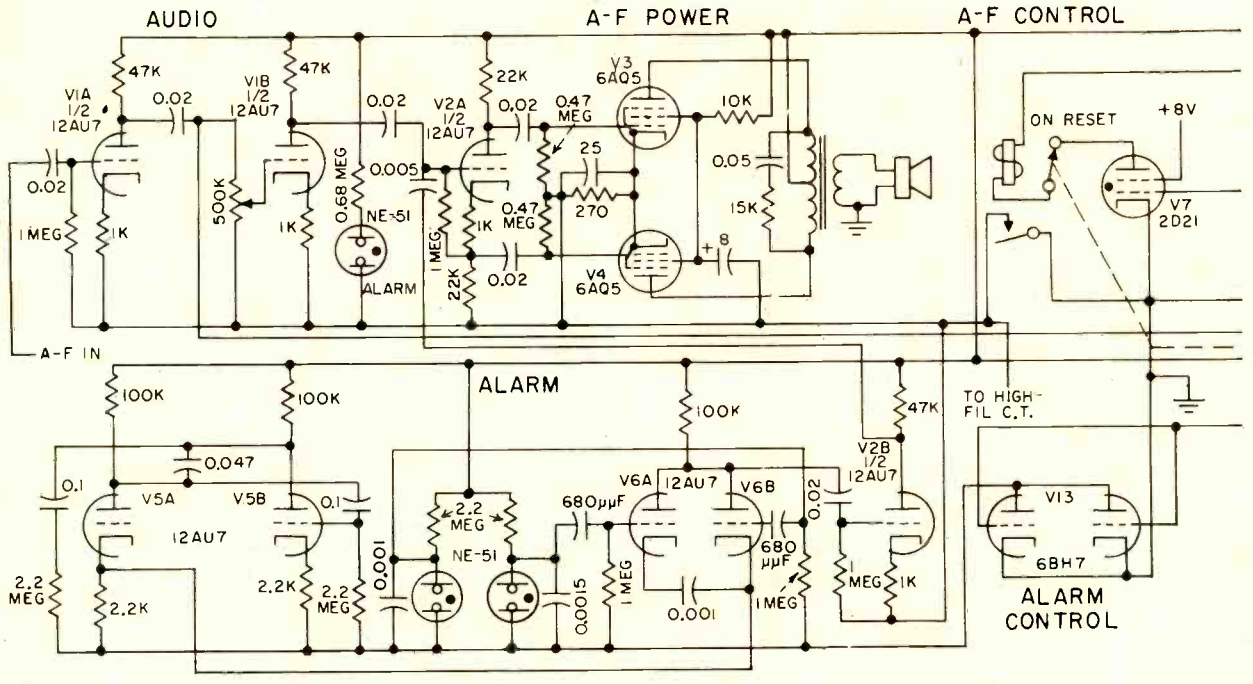


FIG. 4—Schematic of signal-selective Conelrad alarm. Fail-safe provisions are maximized when all tubes are pre-aged in non-

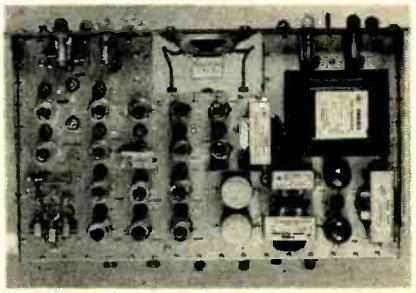
or has aged nearly to the replacement point. The relay is essential because the series thyratron introduces a roar into the audio system and tends to sputter and cut off when strong a-f signals are received. Capacitive filters adequate to eliminate this also cause strong R-C oscillation in the control-tube circuit.

Alarm Signal

The audible alarm must not be confused with anything else in the environment. Steady tones are therefore ruled out in most instances, as there are too many of them already present in industrial areas. Intermittent beeps are better, but resemble too closely the fire-alarm signals in many rural areas as well as a number of aeronautical stall alarms. The simplest alarm seems to be a two-tone warble, and the hearing response of most of the population indicates that both tones should be below 1,000 cps. A number of experiments indicate that the two tones will be a more effective alarm if their frequencies do not have a common factor.

The alarm signal generator consists of multivibrator V_{9}, operating at about 2 cps, controlling gated audio amplifier V_{8} which in turn feeds a straight audio amplifier V_{2B}. Signals are generated by two neon oscillators tuned to around 400 and 600 cps but having no common factor. They are capacitively coupled to the gated amplifier so that the tones are alternately fed into V_{2B} and thence into the audio power stage. This generator is controlled by the amplified avc through ground-return gate V_{13}. Whenever the avc from the receiver fails, and only then, the alarm is operative. When the avc voltage is restored the alarm stops, but the thyratron-controlled main audio system remains in operation so that announcements can be heard.

The multivibrator has plate-to-plate and cathode-to-cathode capacitors in addition to those usually present. These make minor changes in the switching rate of the multivibrator but also markedly reduce thumps in the output of the gated amplifier. Other combinations of C, R and L will perform the same process, but usually at considerably higher cost.

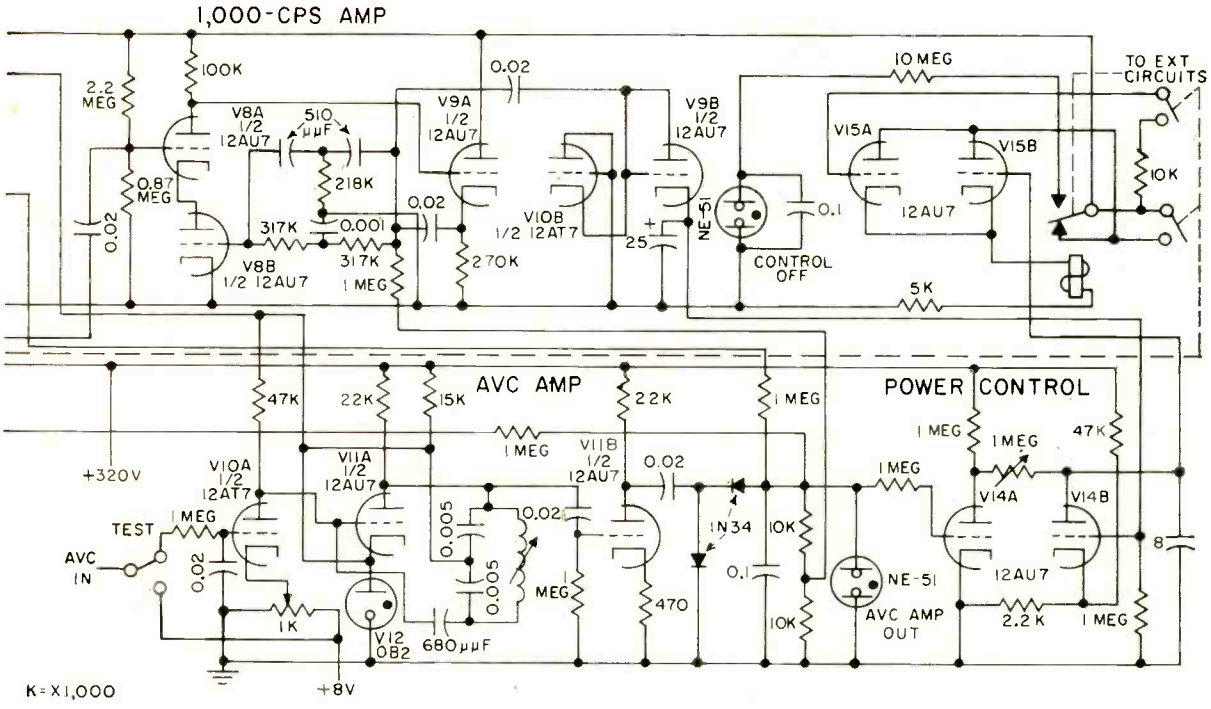


Careful layout permits chassis size of 10 by 17 by 2 in. with recessed speaker

1,000-cps Amplifier

To use the sustained 1,000-cps tone which is in integral part of the Conelrad alarm signal sequence, a selective amplifier is employed. This consists of series amplifier V_{8}, the upper grid of which is the signal input, and the lower grid the feedback input. Feedback is negative for all frequencies except the fundamental of the twin-T network, and zero at that frequency. A cathode follower, V_{9A}, fed from the plate of V_{8A} reduces circuit loading. The other half of twin triode V_{9} is part of the full-wave output rectifier along with V_{10B}. The other half of V_{10} is the avc amplifier control tube.

With a 0.5-v tone input to the main audio system, output of the tuned amplifier after rectification is +25 v when the input frequency is from 950 to 1,050 cps, +1 v at 900 and 1,100 cps, and negligible at all other frequencies. Bias for this



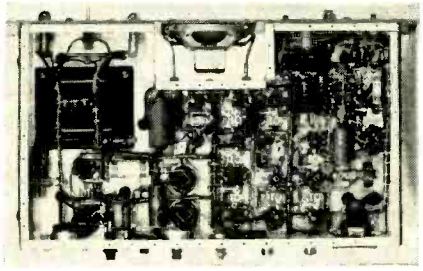
critical service 200 hours, then installed six months only and finally replaced by another similar batch

frequency-selective amplifier is provided by a tap on the avc amplifier bleeder. In consequence the selective amplifier is out of operation when the key station carrier is off due to saturation of triode V_{8B}. The system is therefore immune to background heterodynes and other extraneous tones. Voltage output of this amplifier is nearly constant through a wide range of inputs, so the signal produced by the 1,000-cps tone is substantially immune to fading and similar troubles.

Control of External Circuits

Power control is accomplished by two tubes. In the first a relay is held closed by the cathode current of dual triode V_{15}, whose two halves are paralleled and whose grids are normally held positive. One set of relay contacts is in series with the plate supply, so if the circuit is broken power will not be restored until the control is manually reset. Release of the relay armature switches on a front-panel flashing neon indicator, giving clear indication that external power is off.

The grid of this tube is connected to the plates of control tube V_{11}, both halves of which are normally cut off. Any sustained positive d-c output from the 1,000-cps amplifier causes V_{14B} to draw plate current, discharging the 8-μf plate capacitor and drawing down the grid voltage to cut off V_{15} in about 3 sec. This time can be altered by changing the capacitance from cathode to ground of V_{9B}.



Cabling is used for power leads while signal wiring connects point-to-point

Continued failure of the avc likewise shuts off the power control circuit through a time-delay system. When the grid of V_{14A} falls to ground potential the tube draws plate current, immediately lowering its plate voltage and slowly discharging the 8-μf plate capacitor of V_{14B} through the 1-megohm variable resistor. After a definite time lapse (here set at 10 sec) the grid voltage of V_{15} is reduced to cutoff value, the cathode relay drops out, and external power circuits are opened. As all of these circuits will operate with relatively great voltage differentials, minor shifts in tube sensitivities have little effect.

The power supply is conventional as to plate voltage, but the filament supply is dual. The high-filament circuit is connected through its center tap to the return of the audio system so that heater voltage is always within safe limits. The low-filament circuit is biased at about +80 v with respect to ground for the same reason.

Failure of any tube filament will immediately light one of the two filament-alarm lights on the main panel and also the interior light adjacent to the failed tube. Failures of main power-control tube V_{15} or of main avc amplifier tube V_{11} will immediately shut off the controlled power, as will a power-supply failure. Other failures will be apparent through routine test procedures.

Operating experience with this alarm shows that its response to both Conelrad test broadcasts and continued power failures from both local and remote key stations meets all of the specifications outlined at the beginning of this article.

Photoformer Solves

Photoelectric function generator provides smooth reproduction of complex curve slopes up to 90 degrees, with slopes greater than 90 degrees simulating switching with blacklash. Distortion generated by nonlinearity of crt sweep and spot-to-phototube distance is corrected on an aluminum loft layout

By **ROBERT W. MALOY**

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PHOTOFORMERS are function generators used with analog computers to simulate problems containing a variable which is an arbitrary function of another variable. Examples of problems simulated include transition from laminar to turbulent flow and drag versus air speed while crossing the sound barrier.

To use the photoformer a curve of the desired function must be drawn on graph paper and the area above the curve must be rendered opaque. The graph is then photographed and developed to provide an image that is opaque below the curve and transparent above. This enables the phototube to distinguish between a positive and negative error.

When the area below the curve of the developed plate is opaque the phototube senses spot-position error by failure of the light from the crt to pass through the opaque area, or by overabundance of light with the spot in the transparent area. Photographing and developing these plates for use in the photoformer also offers opportunity for recheck at a later date.

When used in the photoformer, the plate is placed between a crt and a phototube. A voltage is impressed on the horizontal plates of the crt to position the spot on the graph. The phototube, vertical amplifier and deflection plates, shown in Fig. 1, are connected in a closed loop and drive the spot up until the phototube is able to see approximately half of the spot. The output voltage is taken from the vertical amplifier and fed to computer.

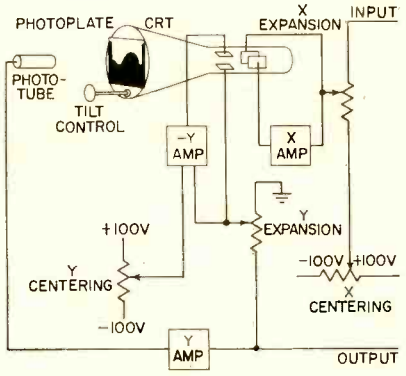


FIG. 1—Block diagram of photoformer crt deflection system. Photoplate, containing image of waveshape, is placed between phototube and crt. Closed loop deflection system enables phototube to sense crt spot-position error. Spot is then driven to the point on plate where phototube sees it

Design Consideration

Measurement of crt linearity and spot-to-phototube distance effects can be made with a precision-notched aluminum plate. Output voltage can be measured at the various steps with a precision potentiometer. A number of horizontal sweeps are made using an aluminum graph set at various heights to give the variation in output for different inputs.

The results of these tests indicate the existence of an error curve composed of two major components, the greater being approximately proportional to Y^2 and directed toward Y equal to zero, primarily as a result of deflection nonlinearity; the lesser being approximately proportional to $(X^2 + Y^2)^{8/3}$ and directed upward as a result of variation in spot-to-phototube distance with variation in spot position.

Although the Y equals zero line can be made to show unmeasureable distortion by offsetting the phototube or the photographic plate from the scope axis, the advantage is outweighed by increased distortion at the edge of the graph. Inaccuracies as high as 1,200 mv exist as a result of this nonlinearity.

To correct this, instead of using the customary 10 in. by 10 in. square of graph paper, a master set of coordinates is layed out on a 20 in. by 20 in. aluminum loft layout with distortion built in to correct for these defects. Tracing paper is placed over these coordinates when drawing a graph for re-

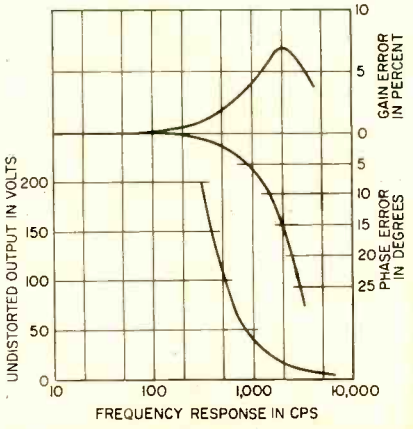
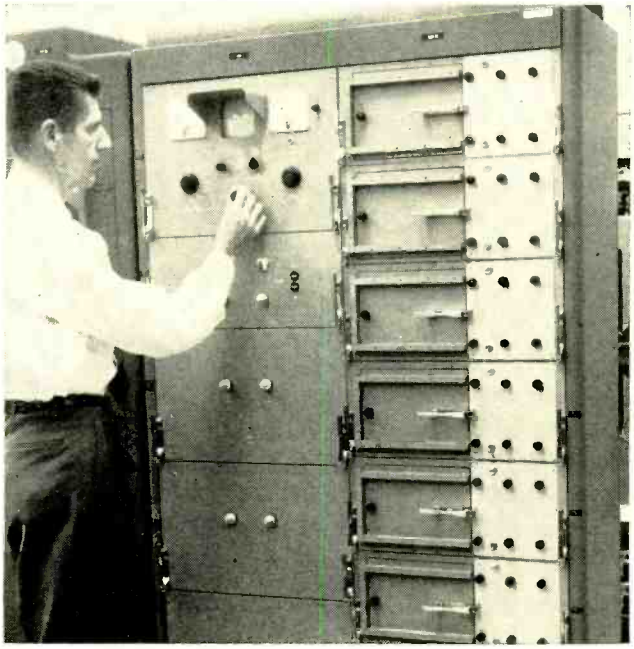
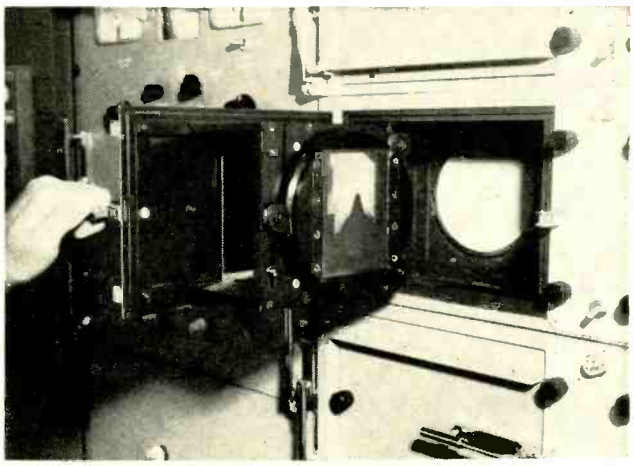


FIG. 2—Frequency response, phase error and gain error curves of photoformer. Response is flat to about 300 cps

Sound Barrier Problems





Slide chamber, which holds photoplate, is at left. Cathode ray tube is at right. Photoplate is easily accessible

Operating the calibration panel of the photoformer. In addition to the panel, equipment consists of amplifier-power supply chassis containing crt and slide chamber

production. Since loft layouts are readily capable of accuracies of 0.005 in. these errors can be reduced to an equivalent 50 mv. Also it is impractical to draw the graph to greater accuracy than $\pm \frac{1}{64}$ in. With 20 in. equal to 200 volts, this represents an error of ±156 mv.

In discussing the inaccuracies of the system the light output of the crt must also be considered. Because of the lack of phosphor homogeneity, light output of the crt varies with spot position to give about 300 cps of 10 percent variation per sweep. Since about one half of a 3-v diameter spot is exposed, this represents about an equivalent ±75-mv error. Thus, the total system error is 330 mv. This is favorable when compared with the errors that occur as a result of straight-line approximations in other types of function generators.

Frequency response is limited by the decay characteristics of the crt phosphor. Unfortunately, the decay rate is considerably slower for the low-spot brilliance used in photoformers than for the higher intensity used by tube manufacturers in plotting their curves. By using a crt with a P-15 phosphor, frequency response, as shown in Fig. 2, is within 1 percent at 300 cps. To have a flat frequency response it is necessary for the gain of the system feeding the crt plates to be constant for all frequencies of interest. To accomplish this, capacitors are provided across input and feedback resistors in the −Y amplifier to counterbalance the reactances of the scope plate and Y gain control.

Common with analog computing equipment, the frequency response values are only valid if the amplitude-frequency product is low enough to stay within the rise-rate limitation of the system. In this case it is possible to have a 200-v peak-to-peak swing at 300 cps.

Drift of the unit must properly be divided into two parts since the total drift will be the curve slope times the drift of the input section plus the drift of the output section. Drift in the output section is dependent on spot size, variation in spot intensity, and phototube sensitivity. The Y amplifier and phototube drift is within 150 mv per hour and drift of the X amplifier is within 15 mv per hour.

Stability is a problem with photoformers because the feedback loop is only closed when the spot is partially hidden by the graph. Consequently, a certain amount of drift in one direction or the other, dependent on the portion of the spot that is originally set to peek over the edge of the graph, will cause the system to lose control and come to rest at either the upper or lower output limit.

With this unit it is customary for at least 5 of the 6 channels to operate continually for 24 hours without losing position on the graph. Also, the door may be opened and shut and the spot can be expected to return to its proper position. A diode network, sensitive relay and neon light are provided to warn the operator in case the spot does leave its position on the graph. External connections for this warning are provided as additional indication at the main console.

Noise was found to be about 50 mv rms without phototube selection. Since the sum of the Y and −Y amplifier outputs cause the spot to remain on the graph, reduction of −Y amplifier output of noise frequencies causes an increase in output noise. Consequently, a lead network is used in the −Y amplifier in contrast to the lag network in the Y amplifier.

Chassis layout is based on sev-

eral different requirements. It must be convenient to use, easy to service, and must have sufficient crt-to-phototube distance to make the spot-to-phototube distance nearly constant. Nine inches was chosen somewhat arbitrarily as a suitable compromise. Also, close proximity of the phototube to its amplifier is required to reduce the line capacity to achieve the best possible frequency response.

The K1112P15 crt was chosen because it was designed for photoformer use. The P15 phosphor has the highest speed that the manufacturer recommends for the purpose. It is installed directly behind the door, supporting the photographic plate, so that it can be conveniently removed. The phototube, a type 6291, is mounted to the right of the door for the same reason. This type of phototube was chosen because smaller tubes have insufficient gain, and larger tubes enhance the spot.

Phototube voltage divider resistors, wirewound for stability, are mounted directly outside the phototube compartment on a piece of micarta that is used as a side of the compartment. Resistors mount on screws that also serve as feedthrough terminals. A Plexiglas cover over the resistors protects

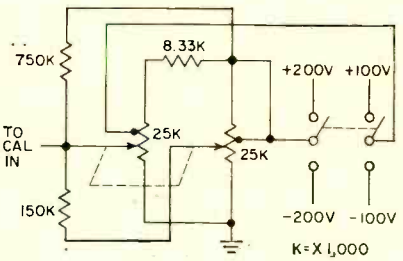


FIG. 4—Precision potentiometer circuit provides various input voltages into photoformer for calibration purposes

maintenance personnel against shock.

The door has a permanently-attached photographic plate holder mounted about 4 in. from the front. A mirror is placed between the door front and the plate holder to reflect the light sideways from the crt to the phototube. The door also supports the graph-tilt control and is three-shoulder constructed to prevent entrance of light.

The X and Y amplifiers are mounted on a separate chassis that plugs into a receptacle adjacent to the phototube. Spare amplifier chassis are provided to reduce lost-operating-time cost. To further reduce maintenance costs, photoformer chassis, power supply and control chassis were made plug-in units.

Possible variations in crt beam current, which might adversely affect the stability of the system, are eliminated by a 4-megohm resistor placed in series with the crt cathode. See Fig. 3. A neon tube was connected from the heater to the cathode to avoid possibility of this voltage exceeding the manufacturer's rating. Although use of such a large cathode resistor may appear objectionable, each of the 12 tubes have operated for an average of over 5,000 hours in this circuit with only one failure.

Filament transformers were mounted on the photoformer chassis to avoid the need for connectors with extra high-voltage terminals and to reduce line loss. Input to the Y amplifier is a cathode follower with the shield tied to the cathode to minimize phototube output capacitance. Low capacitance is necessary for bandwidth due to the use of a 1-megohm phototube load resistor, which was used to achieve high output with low spot intensity. Low spot intensity is necessary to avoid burning the phosphor since the spot may rest in the same position for hours.

Amplifier Gain

Although the gain of the Y amplifier alone is in the order of 250, this must be multiplied by the spot-to-phototube gain to get the loop gain. The effective spot diameter is 3 v and the voltage generated by the phototube in moving the spot from the dark to fully in view is 15 v. Thus, the effective Y amplifier gain is 1,250. To produce the 200-v peak-to-peak required output, the spot shifts from 44 percent in view to 56 percent.

Since the closed loop gain must be set up for each graph and rechecked daily and the spot shift is not sufficient to effect stability, this gain is entirely adequate.

The calibration panel contains a precision potentiometer for setting input voltages for calibration to any desired value between 0 and ± 150 volts and a triple scale output voltmeter that may be referenced to 0 or ± 100 volts. The potentiometer is a 15-turn dual-tapped unit with external resistor network to provide about four times as much linearity with load as is available with a single unit as seen in Fig. 4.

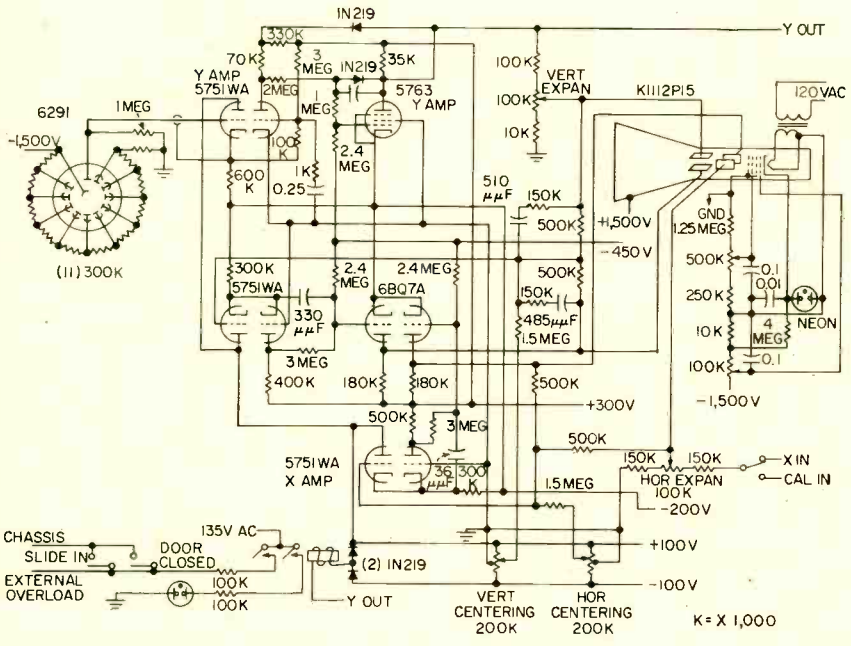
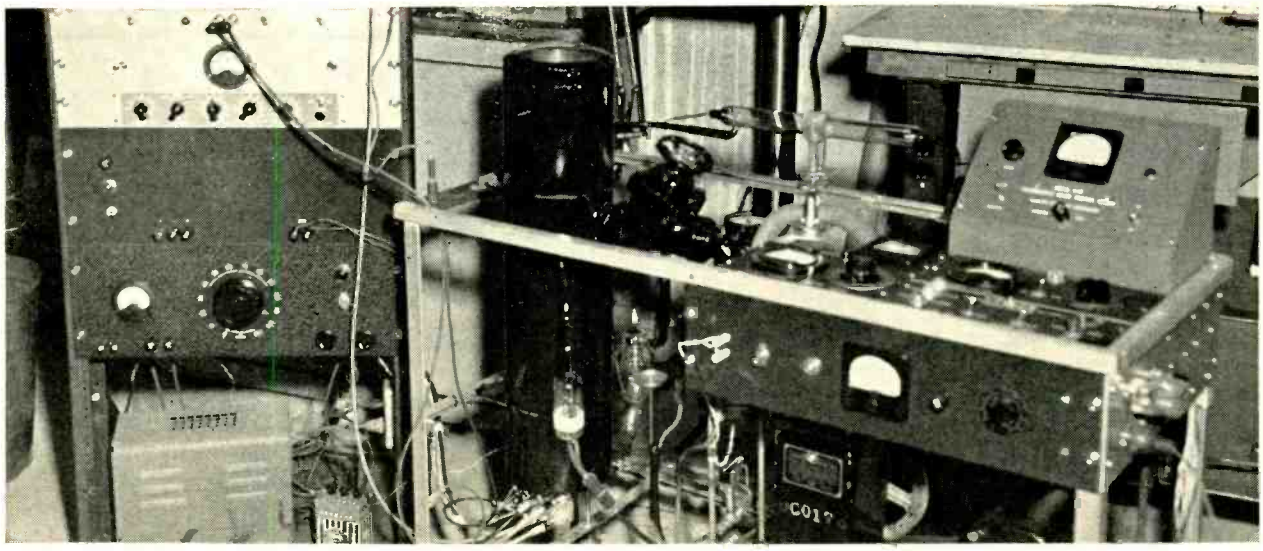


FIG. 3—Schematic of photoformer crt deflection system. Input to Y amplifier is cathode follower with cathode shield provided to minimize phototube output capacitance, achieving crt low spot intensity. Effective Y amplifier gain is about 1250



First experimental model of the Peritron. Vacuum tank is a 6-in. diam 30-in. long, seamless brass tube mounted in an angle iron table. Screen is viewed through a convex Pyrex window sealed to a shoulder turned in the upper end of the tank. Relay rack contains control circuits

Cathode-Ray Tube Adds Third Dimension

Cathode-ray screen is mounted within vacuum tube behind transparent viewing globe. Screen is driven in oscillation toward and away from the observer along the Z-axis. Electron gun illuminates screen from the rear. Electromagnetic pickup on moving assembly gives output signal proportional to instantaneous position of screen along Z-axis. Beam is gated on for small portion of cycle and phasing of gate permits spot to appear in any plane in Z-axis. Possible uses in air-traffic control applications are discussed

By **EDWARD L. WITHEY*** Physicist, Instrument Research Company, Brighton, Massachusetts

DATA can be presented in true three dimensions with an experimental cathode-ray tube called the Peritron. The fluorescent screen of the tube is harmonically displaced with respect to an electron gun. Three-dimensional images are produced by X, Y, and Z-gating.

For effective operation, persistence of the screen phosphor (and duration of the beam gate) must be short in comparison with the period of screen oscillation. Also, the screen must oscillate at a frequency equal to or greater than the flicker fusion frequency of the eye. Both of these conditions are met easily in practice.

A large screen can be driven through an appreciable amplitude with comparatively small driving power if the system is in a vacuum since there is then no air load. Large-amplitude oscillation at frequencies up to about 30 cps is facilitated if the mass of the moving structure is kept at a minimum. Since sound is not transmitted by a vacuum, proper acoustic isolation of the drive assembly results in essentially silent operation.

The first experimental model of the tube, as illustrated, has a screen consisting of a mica disk 1 mm thick and 18 cm in diam. It is coated on the under surface with a General Electric P-11 phosphor having a short decay characteristic. Light output is limited to es-

* Now with Advance Industries, Inc., Cambridge, Mass.

Interior assembly of the first experimental model. Screen drive motor, crank assembly, electron gun, and screen are all mounted on a base plate. Entire assembly slides into the bottom end of the vacuum tank. Motor drives a brass flywheel which operates a crank linkage to a sliding pushrod. A cross piece on the rod connects to two 3/32-in. aluminum rods which slide through two brass guide tubes to drive the screen. The pushrod contains a small permanent magnet in a hole drilled on its axis. Solenoidal pickup coil surrounding the pushrod and mounted on the bearing assembly provides sinusoidal output signal relating to instantaneous position of the screen

sentially the same duration as the beam gate.

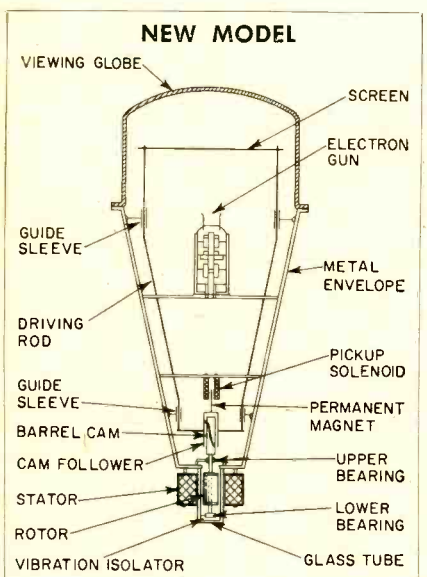
Crank linkage was selected to give a total screen amplitude of three cm. For the 18 cm diam screen, the XY to Z deflection ratio is 6:1. An electron spot can be placed anywhere within the total volume of 730 cu cm swept out by the screen per cycle.

Display Generation

Figure 1 shows the essential elements used to generate three-dimensional patterns for the display. The X- and Y-input amplifiers drive the electron-gun deflection plates conventionally. Output from the electromagnetic Z pickup on the moving-screen assembly is fed into a pickup amplifier. Deflection and focus corrections and the Z-gate signal are derived from the output of this amplifier. Correction signals are mixed with the X- and Y-input signals in the amplifiers in the correct proportion to balance out apparent lateral spot deflections caused by screen oscillation. Signals are phased correctly by the adjustable phasing networks.

A third pickup amplifier output passes through a phasing network to provide a modulation voltage for the first anode. This voltage maintains a constant spot diameter throughout the amplitude of screen travel.

The fourth pickup amplifier output used in the Z-gate circuit allows time selection of the positive grid gate pulse for the Z-axis. To allow speed-control flexibility in the experimental model, a d-c motor is operated by an adjustable d-c supply to drive the oscillating assembly.



Improvements include: induction motor with stator outside vacuum system; barrel-cam screen-drive for true harmonic screen motion; larger screen moving through a greater amplitude; glass dome; and sound isolators

Signal Circuitry

Figures 2 and 3 show the signal circuits. The X- and Y-input amplifiers, Fig. 2, are identical. They consist of a triode input stage driving push-pull deflection amplifiers. Current-balancing potentiometers in the plate circuits provide X and Y positioning.

The Z pickup, Fig. 3, consists of a small stationary coil surrounding the screen pushrod. A permanent magnet mounted in the pushrod generates an output voltage which relates in time and phase to the instantaneous screen position. The pickup voltage is fed to a preamplifier consisting of two 12AX7 sections, V_{9A} and V_{9B}, in cascade. Phase-shift control is provided by V_{7A} driving a phase bridge made up of an interstage transformer, capacitor and potentiometer.

Output from the bridge drives a cathode follower, V_1, Fig. 2. Outputs of V_1 are mixed with the X- and Y-input voltages in the cathode potentiometers of the input tubes. Phase and mixing controls are adjusted to give a deflection signal capable of balancing out the deflection component due to screen displacement.

The amplified pickup voltage at the output of V_{9B}, Fig. 3, is fed to V_{11A} to provide focus correction. Correction amplitude is set by the grid-circuit gain control. Phase is adjusted by the series capacitor and potentiometer shunting the tube. This a-c modulation voltage is mixed with the d-c voltage at the first anode of the electron gun.

Z-Axis Control

Tubes V_{7B}, V_{11B}, and V_8 comprise the Z-axis control circuit. This circuit places a spot on the Z-axis at a Z position in the screen cycle determined by a d-c Z-input signal. Tube V_{7B} impresses the amplified Z-pickup voltage across a phase bridge consisting of a transformer, potentiometer and saturable reactor.

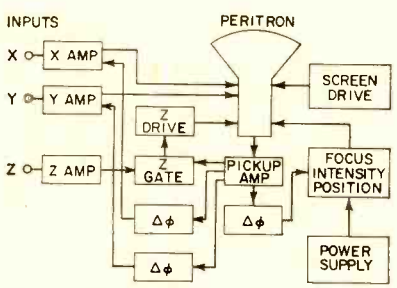


FIG. 1—Logic employed for generating three-dimensional patterns on display tube described in text

The d-c Z-input signal drives d-c amplifier V_{11B} which varies the reactance. This action results in a signal of adjustable phase at the grid of thyratron V_8. Flexibility is provided by a reversing switch in the primary of the bridge transformer to allow a 180-deg phase shift. The thyratron is wired in

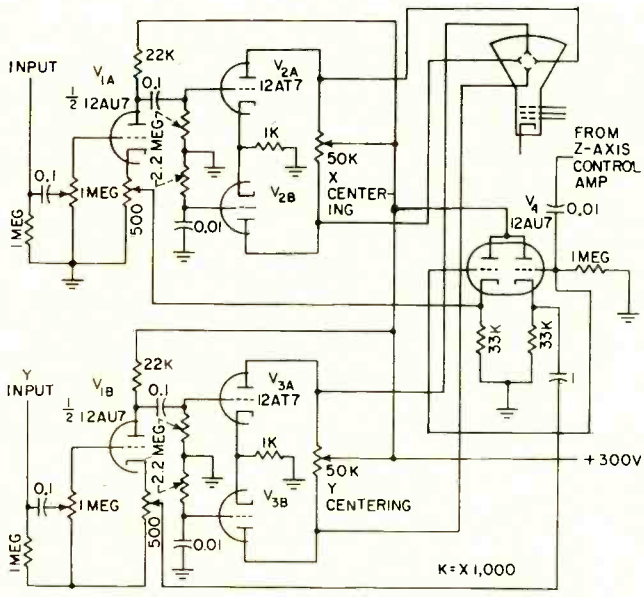


FIG. 2—Display tube and X- and Y-input amplifier portions of signal circuits used with three dimensional tubes

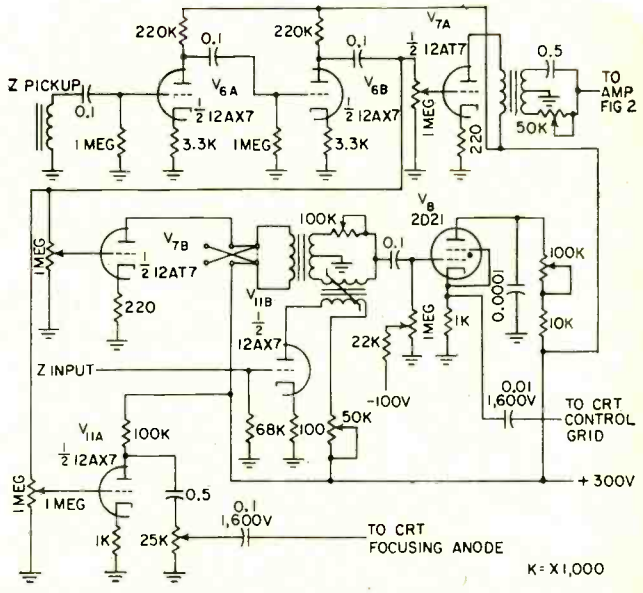


FIG. 3—Z-input amplifier and Z-axis control circuits for the display tube generate gate to produce spot on screen at right time

an R-C discharge circuit. When the tube fires, the shunt capacitor discharges through the tube to provide a short, large-amplitude, positive pulse across the 1,000-ohm cathode resistor. This pulse passes to the control grid of the electron gun and gates the beam on for several μsec per cycle of screen travel. The on portion of the cycle and the spot position on the Z-axis are determined by the magnitude of the Z-input voltage.

Air Traffic Control

One method of translating altitude and position data from the airport radar into a three-dimensional display is shown in Fig. 4. The system uses a storage tube with independent electron guns for reading and writing and a storage matrix capable of maintaining discrete levels of charge.

The airport radar drives the sweep of the writing gun. The altitude signal for the corresponding X-Y target is placed on the storage matrix as a quantity of charge. The storage tube provides scan (sweep) conversion between the radar and the display tube as well as independence of time base between the two systems.

An X-Y sweep generator develops a raster-type scan to drive the reading gun and the display tube in synchronism. The Z-axis signals from the display-tube pickup and from the storage tube are fed to an amplitude comparator containing appropriate amplifying and shaping circuits. The comparator produces a Z-gate pulse. This pulse turns on the display-tube grid at the instant of amplitude identity between the stored Z charge and the Z-pickoff signal.

The Z-pickoff voltage also drives the XYZ error modulator, which provides the X-Y sweep and Z-focus corrections. A portion of the voltage is returned to the Z-drive circuit providing a closed-loop feedback system for maintaining constant screen frequency.

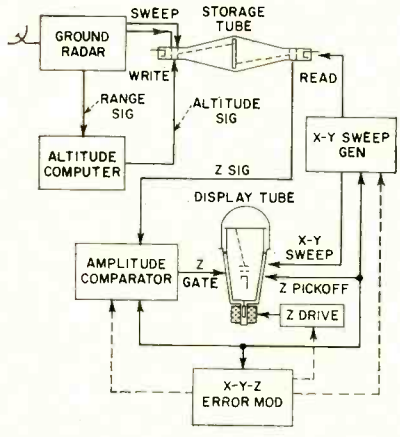


FIG. 4—One method of translating altitude and position data from the airport radar into a three-dimensional display. Error signals are shown in dashed line

Assume that a single-target aircraft will be at any one of 10 discrete altitudes from 1,000 to 10,000 ft. Assume next that the reading gun will recognize one of the 10 corresponding discrete levels of charge placed on the storage tube by the altitude signal from the radar. Assume, further, that the vibrating screen passes sequentially through 10 discrete positions. Each of these positions has a corresponding level of pickoff voltage. For each position, one complete X-Y scanning frame is generated.

Ten frames are presented to the screen as it passes through its 10 levels from one amplitude extreme to the other, each half cycle. Assume, finally, that a target aircraft at 6,000 feet causes a charge of six units to be placed on the storage matrix at a certain X-Y position. This Z signal of six will be presented to the comparator 10 times per half cycle of screen travel. Coincidence will be obtained only when the screen is at level six and generates a six on the pickup output. Coincidence produces a grid gate, placing a spot on the screen.

In an actual system, the levels would be integrated into a smooth, continuous function. Actual resolution on all axes would be a function of the parameters of the radar set, storage tube, display tube, system bandwidth and other factors.

ʌsistor A-C Amplifier

Versatility and reliability are gained in transistor a-c amplifier using multiple feedback loop. Shunt and series loop used in a single stage enable such circuit properties as voltage and current gain, input and output impedance to be preselected and accurately controlled independent of variable transistor parameters. Preselection of circuit properties permits amplifier to be adapted to fit a particular application

By **HOWARD LEFKOWITZ,** Electronic Engineer, U. S. Naval Ordnance Laboratory, Sliver Spring, Maryland

ONE POSSIBLE METHOD used in designing reliably stable transistor circuits is to employ negative feedback in each stage. Since overall feedback loops around three or more stages present considerable stability problems, the use of negative feedback about each stage virtually eliminates problems of oscillation and substantially reduces design effort.

In addition, the use of both shunt and series feedback loops in each stage makes the amplifier versatile by enabling the circuit designer to preselect several circuit properties, such as voltage gain and input impedance or current gain and output impedance, to fit a particular application. With a large amount of negative feedback the amplifier properties may be made independent of the active device.

Circuits for Analysis

The steps in designing a transistor a-c amplifier are: analysis of a-c circuit (small-signal approximation), selection of operating point (large-signal considerations) and analysis of d-c circuit (bias-point stability).

Shown in Fig. 1 is the circuit to be analyzed. It uses both shunt and series feedback loops. Also illustrated is a possible method of obtaining bias-point stabilization through the use of both collector-voltage feedback, R_F, and collector-current feedback, R_E. For a-c analysis, if R_F is not much greater than R_f, then the effective shunt a-c voltage feedback loop resistance may be considered the equivalent resistance of resistors R_F and R_f in parallel.

Figure 2 illustrates the a-c equivalent circuit derived from Fig. 1 and is based on the assumption that $R_B >> R_{in}$, $R_B >> R_g$, and resistor $R_f << R_F$. Using this equivalent

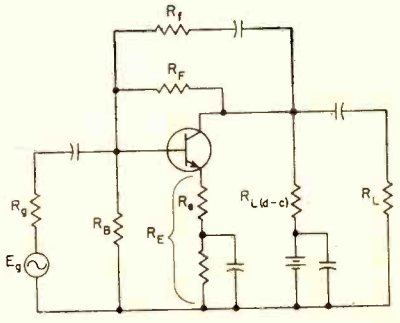


FIG. 1—Transistor a-c amplifier using both shunt and series feedback loops. Multiple loop enables circuit properties to be preselected and controlled independent of transistor parameters

circuit and reducing the transistor and its associated feedback loops to four-terminal networks valid in small-signal approximation, the circuit in Fig. 3 may be obtained. Matrix analysis techniques may be used for reducing the Fig. 3 circuit to one four-terminal network so that relations for the circuit properties may be found.

Using the assumptions of a good junction transistor, the small-signal voltage gain may be derived as follows

$$A_v \cong \frac{R_f R_L(R_e - \alpha_{fb} r_e) + r_c R_L(h_{11b} + R_e)}{R_f R_L(r_b + R_d) + r_c(h_{11b} + R_e)(R_L + R_f)} \quad (1)$$

where R_d is equal to $r_e + R_e$ and h_{11b} is equal to $r_e + r_b\ (1 - \alpha_{fb})$. Assuming $\alpha r_e >> R_e$ the small-signal voltage gain may be simplified to

$$A_v \cong \frac{-\alpha_{fb} r_e R_f R_L + r_c R_L(h_{11b} + R_e)}{R_f R_L(r_b + R_d) + r_c(h_{11b} + R_e)(R_L + R_f)} \quad (2)$$

Assume $R_f >> h_{11b} + R_e$ and $r_c >> R_f$ the small-signal voltage gain becomes

$$A_v \cong - \frac{\alpha_{fb}}{h_{11b} + R_e} \times \frac{R_L R_f}{R_L + R_f} \quad (3)$$

If the two above assumptions hold and $R_L >> R_f$ for example, large amount of shunt voltage feedback; and $R_e >> h_{11b}$ for example, large amount of series current feedback, then

$$A_v \cong - \frac{\alpha_{fb} R_f}{R_e} \quad (4)$$

For good junction transistors alpha is about 0.95 or better. Therefore

$$A_v \cong - \frac{R_f}{R_e} \quad (5)$$

Small-Signal Current Gain

To compute the small-signal current gain additional assumptions

Uses Multiple Feedback

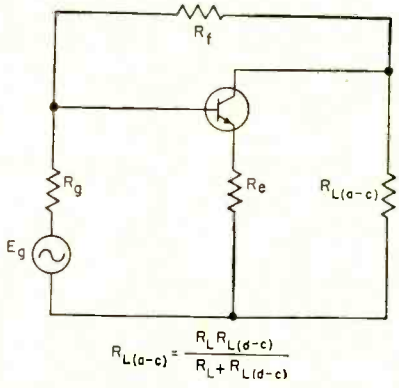


FIG. 2—Equivalent a-c circuit derived from network in Fig. 1

such as the following will have to be made:

$$r_e >> R_f \text{ and } R_f >> h_{11b} + R_e$$

Applying the above assumptions, the small-signal current gain may be determined as

$$A_i \cong \frac{\alpha_{fb} R_f}{R_L + (1-\alpha_{fb})R_f + (h_{11b}+R_e)} \quad (6)$$

For the assumptions of large series and shunt feedback and a good junction transistor: $R_e >> h_{11b}$, $R_L >> R_f$, $\alpha_{fb} = 1$

$$A_i \cong -\frac{R_f}{R_L + R_e} \quad (7)$$

The small-signal power gain may be computed using the following simple relation

$$A_p \cong A_v A_i \quad (8)$$

The small-signal input resistance may be found as

$$R_{in} \cong \frac{(R_L+R_f)(h_{11b}+R_e)}{R_L+(h_{11b}+R_e)+(1-\alpha_{fb})R_f} \quad (9)$$

For the following assumptions: $\alpha_{fb} = 1$, $R_e >> h_{11b}$,

$$R_{in} \cong \frac{(R_L + R_f)R_e}{R_L + R_e} \quad (10)$$

For large shunt feedback $R_L >> R_f$, the input resistance becomes

$$R_{in} \cong \frac{R_L R_e}{R_L + R_e} \quad (11)$$

and if $R_L >> R_e$ the input resistance approaches the value of the series feedback resistor, R_e.

The small-signal output resistance may be determined as follows:

$$R_{out} \cong \frac{(R_f + R_g)(h_{11b} + R_e) + (1 - \alpha_{fb})R_f R_g}{R_g + (h_{11b} + R_e)} \quad (12)$$

With following assumptions: $R_f >> R_g$, $\alpha_{fb} \cong 1$, $R_e >> h_{11b}$, then

$$R_{out} \cong \frac{R_f R_e}{R_g + R_e} \quad (13)$$

If $R_e >> R_g$, then the output resistance approaches the value of the shunt feedback resistor, R_f.

Practical Amplifier

Given the following specifications for the design of a reliable transistor amplifier: Minimum transistor short-circuit current gain $\alpha_{fb} = 0.97$, transistor short-circuit input impedance, $h_{11b} = 30$ ohms, generator impedance = 1,000 ohms, load impedance = 3,000 ohms, desired voltage gain = 15 and desired input impedance = 1,000 ohms.

Using Eq. 3 and assuming that $R_f >> R_L$:

$$A_v \cong -\frac{\alpha_{fb} R_L}{h_{11b} + R_e}$$

Substituting and solving for R_e: R_e equals 164 ohms.

Since nearest standard value is 160 ohms, from Eq. 10

$$R_{in} \cong \frac{(3{,}000 + R_f)(30 + 130)}{3{,}000 + 30 + 130}$$

With R_{in} equal to 1,000 ohms, R_f equals 16,700 ohms. Since nearest standard value is 16,000 ohms, from

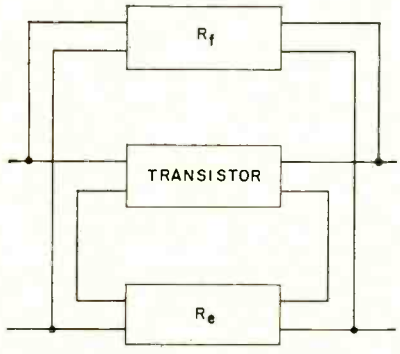


FIG. 3—Circuit shown can be used for matrix analysis technique. Matrix is derived by using equivalent a-c circuit shown in Fig. 2 and reducing transistor and feedback loops to 4-terminal networks

Eq. 3, quantity A_v is equal to −12.9. This is slightly less than the desired 15. Selecting a smaller series feedback resistor, R_e, will tend to increase the voltage amplification. Therefore, if R_e is selected to be 130 ohms, Eq. 9 becomes

$$R_{in} \cong \frac{(3{,}000 + R_f)(160)}{3{,}000 + 160 + .03R_f}$$

With R_{in} equal to 1,000 ohms, R_f equals 20,600 ohms. Let R_f equal 20,000 ohms, then A_v equals 15.8. From Eq. 9, R_{in} equals 980 ohms. Using R_f equal to 20,000 ohms and

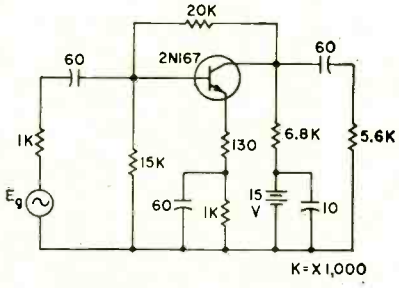


FIG. 4—Practical transistor a-c amplifier with selected component values. Use of 20,000-ohm shunt feedback resistor provides d-c and a-c voltage feedback and eliminates two components

R_e equal to 130 ohms, the desired voltage gain and input impedance may be obtained within 5 percent and 2 percent respectively. These may be designed closer to desired values using non-standard resistors.

Using the above determined values, the output impedance R_{out} from Eq. 12 becomes 3,280 ohms. The current gain A_i from Eq. 6 becomes 5.16. Therefore, the power gain A_p equals 81.5 or 19.1 db.

The design may now be completed by a selection of the quiescent operating point and the application of some type of d-c feedback to stabilize the operating point over the desired temperature range. Figure 4 illustrates a completed design having the above a-c characteristics. The 20,000-ohm shunt feedback resistor is used to provide d-c as well as a-c voltage feedback, resulting in a saving of two components.

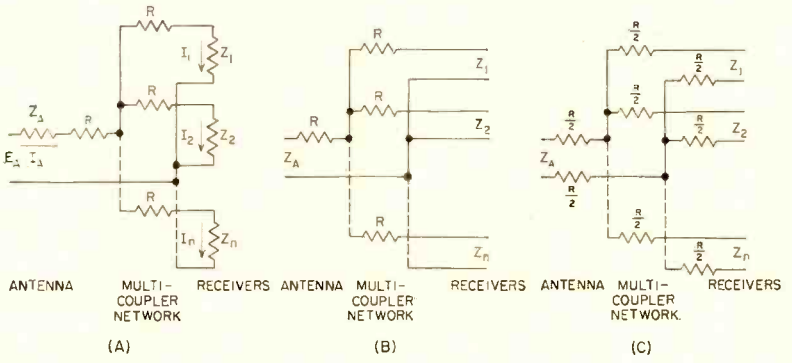


FIG. 1—Loop currents for n-set multicoupler network when one receiver is connected to one antenna is shown in (A). Impedance looking into multicoupler circuit from coaxial and twin-lead transmission lines, shown in (B) and (C) respectively, must match antenna impedance to use nomograph

Multicoupler Nomograph for Tv Antenna Networks

Resistance and power loss in multicoupler connecting two or more tv receivers to one antenna is determined quickly using straightedge. Parameters required are network characteristic impedance and number of receivers

By ANTHONY PAOLANTONIO

Research and Engineering Division, Airborne Instruments Laboratory, Inc., Mineola, N. Y.

MASTER TELEVISION antenna systems usually consist of one or more antennas, one or more distribution amplifiers and transmission lines for coupling antennas to receivers. The multicoupler network discussed here is shown in Fig. 1A. It replaces the electron-tube distribution amplifiers and can be used with either twin lead or coaxial transmission lines as shown in Fig. 1B and 1C. Symmetrical construction of the network is based on the assumption that the characteristic impedance of the tv receivers and the antenna are the same.

Prior to connecting receivers to an antenna, it is advantageous to know the multicoupler network resistance, the power loss incurred, and the isolation between receivers. These quantities may be computed quickly using the nomograph shown in Fig. 2.

To determine circuit characteristics when four receivers are connected to one antenna, draw a straight line from 4 on the n scale through 300 on the Z scale and extend the line until it crosses the R scale. The multicoupler network resistance is found to be 180 ohms; the power loss and isolation are read as 12 db opposite 4 on the n scale.

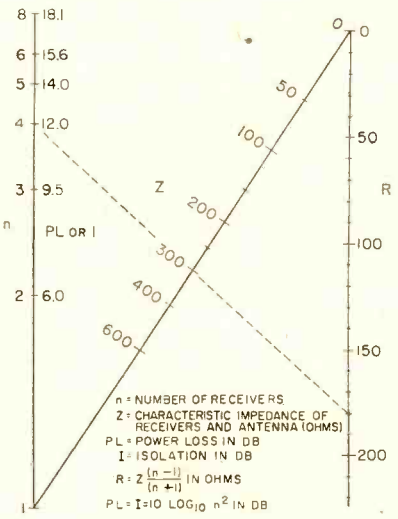


FIG. 2—Nomograph for n-set multicoupler. Since the multicoupler circuit is symmetrical, isolation between receivers is equal to power loss when both values are expressed in decibels

Field tests conducted in a metropolitan area indicate that within a 5, 10 and 20-mile radius from a transmitting antenna, eight, four and two receivers respectively can be coupled to one antenna without loss of picture contrast range. These figures are conservative ratings based on the use of an in-line, folded-dipole antenna having one high-band and one low-band element with a single reflector. Illumination from the transmitting antenna was direct line-of-sight.

The value of R is noncritical. Closest standard 10-percent EIA value is sufficiently accurate for all applications. Since R becomes small as n increases beyond a value of eight, R can, for all practical purposes, be made equal to Z whenever $n > 10$.

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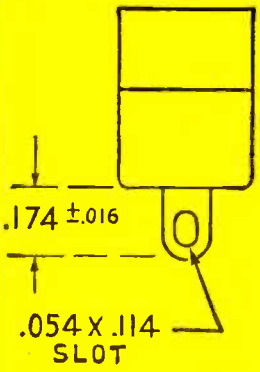
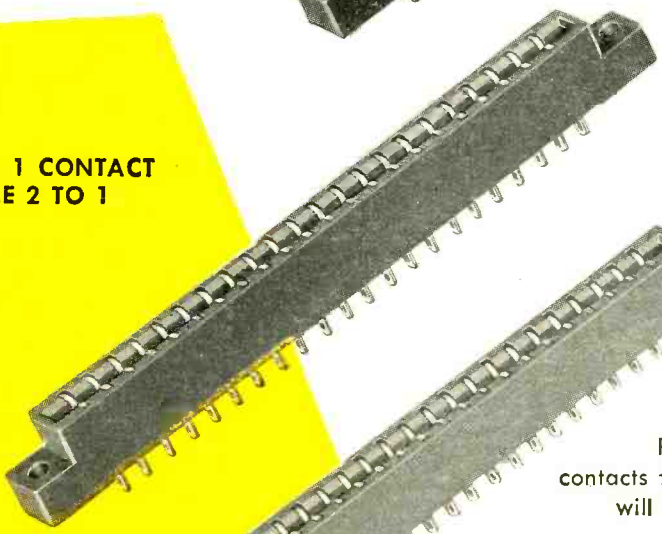
G. P. BLACK

After the basic part numbers under the components shown, the number designates the number of contacts. The letters A, B, C, or D, designate melamine, orlon filled diallyl phthalate, General Purpose black or asbestos filled diallyl phthalate respectively. All contacts are phosphor bronze with P-92-3-03 finish (.0003 silver followed by .00003 gold flash). Type one contact, reproduced here, which takes a standard #20 stranded copper wire for conventional soldering is ready for delivery. Parts with wire wrap contacts and/or contacts for dip soldering to a printed board will be available for future requirements.



TYPE 1 CONTACT
SCALE 2 TO 1

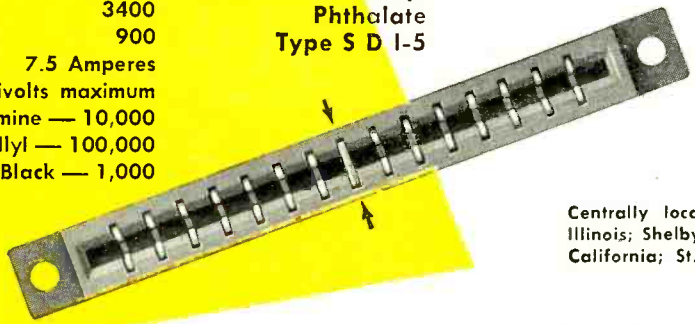


22585—22 B-1
Orlon filled Blue
Diallyl Phthalate
Type M D G

24585—25 A-1
Mineral filled
Melamine 592 or
equivalent
Type M M E

Pre-assembled polarizing key (illustrated) in any connector in any contact position when desired is designated by the last letter of the connector assembly, e.g., 24585-15D-1-T designates a connector with 15 contact *positions* with Asbestos filled Diallyl Phthalate insulator body and a polarizing key in contact cavity T, thus there will be only 14 usable contacts.

VOLTAGE BREAKDOWN	Volts AC-RMS	DC
Sea level	3000	4500
50,000 Feet	900	1200
RECOMMENDED WITHSTANDING VOLTAGE		
Sea level	2200	3400
50,000 Feet	700	900
Current Rating	7.5 Amperes	
Contact Resistance at Rated Current	20 millivolts maximum	
Insulation Resistance in Megohms	Melamine — 10,000	
	Diallyl — 100,000	
	G.P. Black — 1,000	



24585—15-D-1-T
(Below Enlarged)
Asbestos filled
Diallyl
Phthalate
Type S D I-5

Centrally located plants at Chicago, Illinois; Shelbyville, Indiana; LaPuente, California; St. Louis, Missouri.

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Photocell Measures Raindrop Size

DETERMINING raindrop size is regarded by the University of Michigan as one of the first steps toward possible weather control. A $26,000 grant from the National Science Foundation is being used for the study. Electronic equipment will play a major role.

A. Nelson Dingle, associate professor of meteorology, is directing the two-year investigation, which began this month. He indicated that there is little scientific knowledge of raindrop sizes. He believes results of his work will be useful for a variety of things, such as helping to reduce erosion of newly planted land and improving radar detection of storms so as to determine the amount and type of rain in them.

Findings also may help to evaluate artificial rainmaking by distinguishing artificially generated rain from natural rain on the basis of drop size differences.

Chief tool of the investigation is the raindrop-size spectrometer, a device that measures and counts raindrops without disturbing them. It consists mainly of two black boxes mounted at the ends of two arms. One box contains a light source, the other a photoelectric cell and an electronic amplifier.

As the arms whirl about three times a second, the photocell watches a spot in the light beam. When a raindrop passes through that spot, the amount of light that falls on the photocell tells the size of the drop. In the heaviest rain, the device records about 50 drops per second. The recording apparatus consists of a panel of electronic instruments in a nearby room.

Comet Shows CRT Beam Direction

By J. J. WORMSER

Electrical Engineering Dept., Southwest Research Institute, San Antonio, Texas

KNOWING the direction of beam travel in cathode-ray oscillography can aid in some types of testing. In studying Lissajou patterns, for example, trace direction can indicate phase relationship of vertical and horizontal deflection voltages.

Trace direction can be determined by intensity modulating the electron beam of an oscilloscope. This method does not disturb the horizontal and vertical input circuits. Furthermore, intensity modulation is relatively independent of display size.

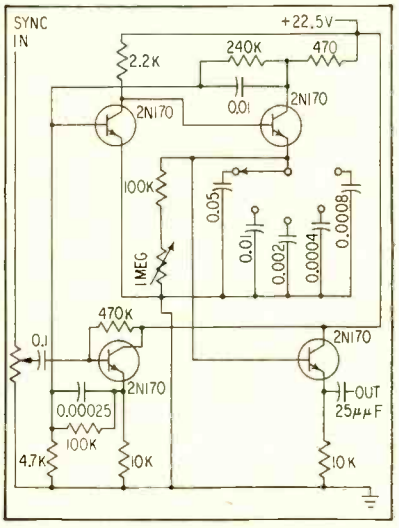


FIG. 1—Transistorized crt beam-direction marker has direct-coupled emitter follower to isolate oscillator from load

A sawtooth signal is used for modulation because, when properly used on the Z-axis, the resulting comet-shaped pulse clearly indicates trace direction. Although practically any type of sawtooth generator can be used, it should supply at least 15 volts peak modulating voltage. For measurements in the audio range, it should supply pulse lengths of from 20 milliseconds to 20 microseconds with a flyback time of less than one microsecond.

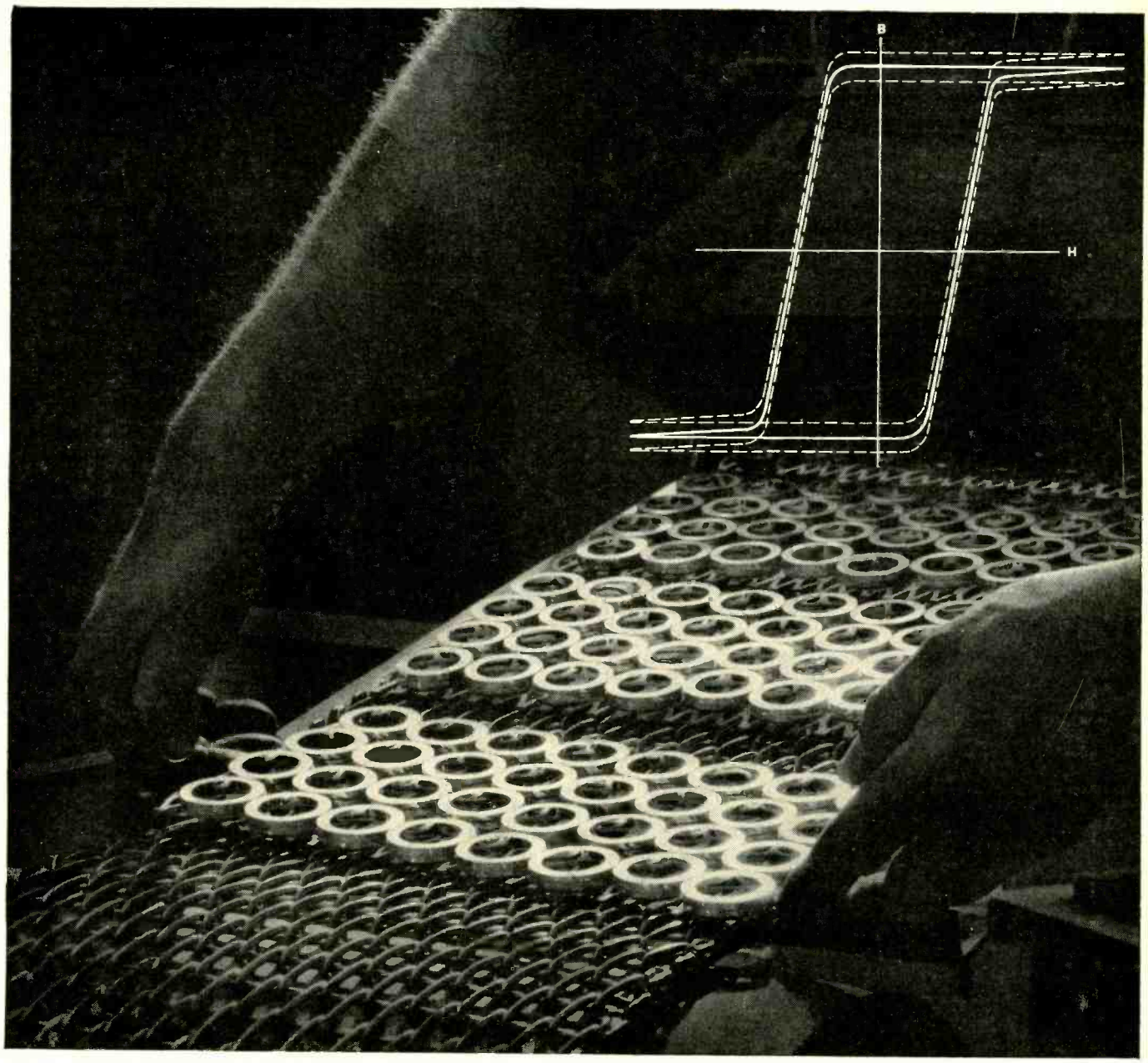
Free-running oscillations are usually satisfactory, but, if external synchronization is desired, either of the deflection voltages can be used to synchronize the sawtooth oscillator at fundamental frequencies. For harmonic synchronization a suitable triggering circuit must be included.

The circuit in Fig. 1 is a free-running multivibrator-type sawtooth generator. It is isolated from the synchronizing signal source and modulation load by emitter-follower circuits. Output waveform is a series of positive-rising negative-decaying sawtooths with peak amplitudes of 17 volts across 10,000 ohms.

Controls are provided for adjusting amplitude of the synchronizing signal and sawtooth pulse lengths. Pulse lengths can be varied from 22 milliseconds to 15 microseconds

High Speed Data Handler

Recording and transcribing system handles 10,000 samples of information a second on its 100 channels. It was originally conceived by North American Aviation and developed by Minneapolis-Honeywell. The system incorporates multiplexing feature and provides analog to digital conversion



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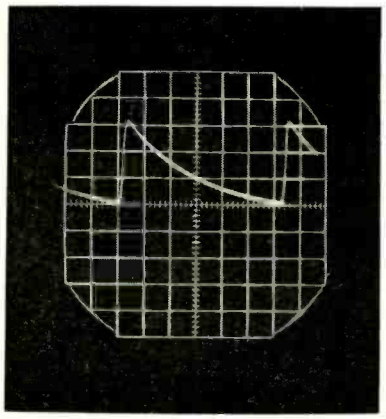
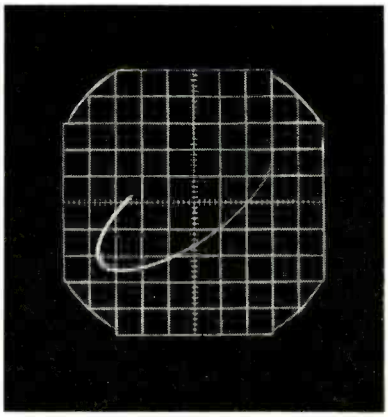
MAGNETICS inc.

**Paper No. 58-71, Winter General Meeting, AIEE, February, 1958. Flux Reset Test is one of two tests proposed for standardization.*



Generator output is shown with vertical scale of 5 volts per cm and horizontal scale of 2 microseconds per cm



Lissajou display of 70-kc signal shows vertical voltage leading horizontal by an angle of 38 degrees

with flyback time of 0.5 microsecond. The circuit drains 5 milliamperes total current from a 22.5-volt dry cell battery. Free-running frequency stability is adequate for most uses.

Most commercial oscilloscopes when used with this circuit indicate trace direction oriented with the comet nose. Orientation of the comet depends not only upon trace direction but also upon polarity of Z-axis modulation.

A direct method for determining initial orientation is to connect the marker output to the oscilloscope vertical input. Use the internal sweep at a low frequency. In this instance, the steep slope of the waveform indicates inverse horizontal trace direction. Then reconnect the marker output to the Z-axis input. Adjust the marker frequency controls until one or more stationary comet appears. Comet orientation respective to the known trace direction can then be noted.

Phase determination can be accomplished in the conventional manner by constructing a centered Lissajou on the screen and measuring the ratio of Y intercept to Y maximum which ratio equals the trigonometric sin of the phase angle between deflection signals. This technique by itself provides only information respecting phase magnitude.

By using the trace marker to indicate direction, phase position can be determined quickly without disturbing either deflection circuit. If the oscilloscope deflection is standard with upward and right-hand directions corresponding to positive input deflection voltages, vertical input voltage leads horizontal voltage if the trace rotation, as indicated by the marker, is found to be clockwise. Conversely, the horizontal leads the vertical for a counterclockwise rotation.

Whip Antennas Track Missiles

ELECTRONIC and analog computer techniques are combined in a recently announced system for tracking missiles optically and photographically (see ELECTRONICS, April 4, 1958, p. 49). The system can also indicate when a missile has departed from its planned course and must be destroyed.

Called Electronic Missile Acquisition system (EMA II), it is undergoing evaluation by the Army at Aberdeen Proving Grounds.

A prime feature of the equipment is that it provides instant acquisition. The time required for scanning and locking on a target is eliminated. In addition, total response time is also reduced since it is not necessary to drive a dish-type antenna.

The system consists of an antenna array, preamplifiers, two radio receivers, data transmission and comparison circuits for telescope tracking and an analog computing system developed by Magnetic Amplifiers, Inc.

An array of whip antennas is spaced around the theodolite. They receive an unmodulated r-f signal from a beacon in the missile. A phase difference in the r-f received by each antenna corresponds to the propagation time from the source.

These phase- related signals are amplified in phase-stabilized preamplifiers and delivered to the receivers. The receivers convert the r-f to audio frequency, maintaining phase intelligence. The a-f signals are also amplified in phase-stable amplifiers.

Outputs from the receivers are delivered to two phase-angle computers. These, in turn, produce two output signals that are proportional to the phase differences in the input signals.

The theodolite computer receives the output signals from the two phase computer channels and, in conjunction with resolvers attached to the azimuth and elevation axes of the theodolite, derives signals proportional to the angular deviation of the theodolite axes from the computed target angles.

The theodolite computer circuitry would produce an error signal varying widely as a function of target angle. In order to maintain a constant error voltage per degree of angular error, compensating amplifiers are also incorporated into the system.

Electronic Chopper Uses New Photocells

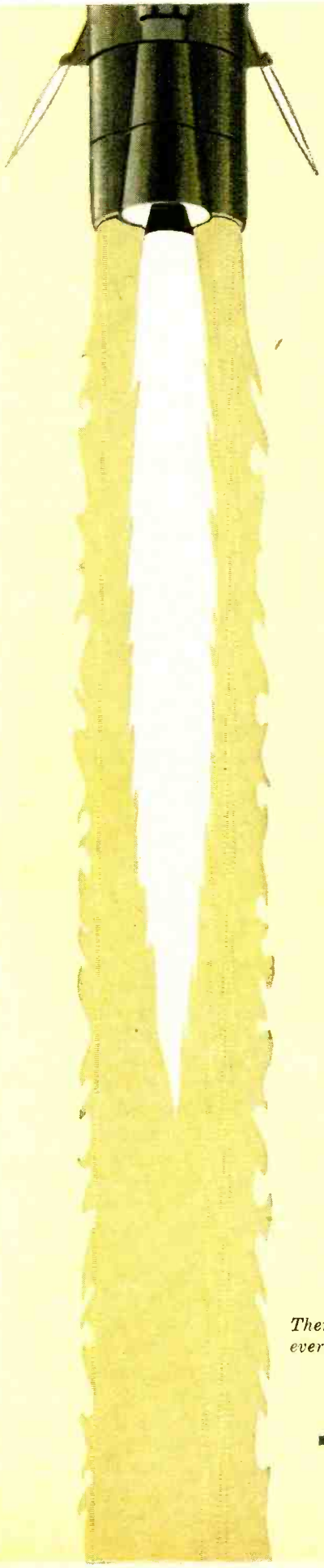
By RICHARD G. SEED

Sensiton Corp.* Lexington 73, Mass.

PHOTOCONDUCTIVE choppers have been of considerable recent interest, and a number of firms have been exploring both their design and application. This is possible because of the increased knowledge of solid-state devices in the past decade, including the development of several simple, highly sensitive photocells, especially cadmium sulfide and cadmium selenide.

The photoconductive chopper is a narrow class within the larger class

*Now with Sylvania Electric Products, Inc., Woburn, Mass.



INET tailor-made 400-cycle ground power unit serves **ATLAS** missile

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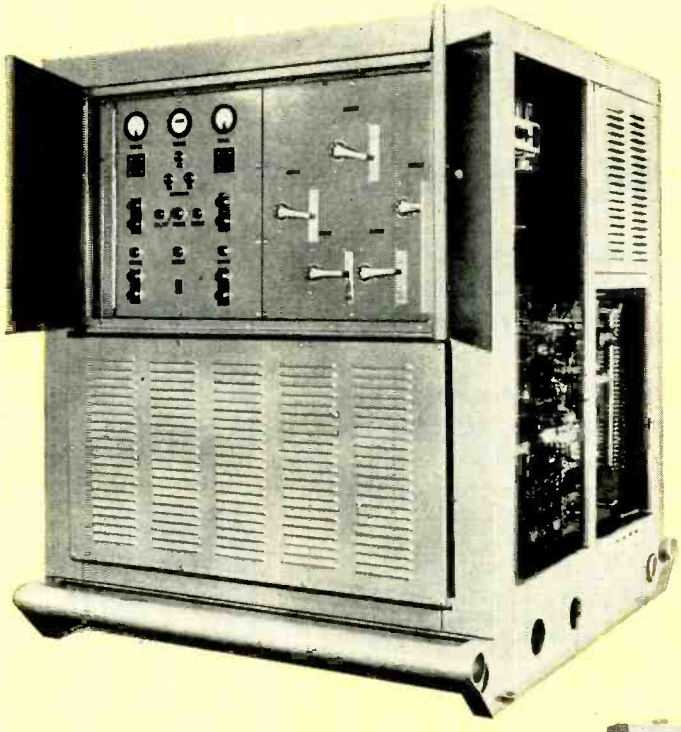
Used for pre-flight calibration of the Atlas electrical systems, Leach's 400-cycle unit met all Convair's specifications . . . performed as one of the most successful pieces of test equipment used in this USAF project.



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of nonmechanical choppers also now receiving wider attention. Other examples include magnetoresistive, Hall-effect, rectangular hysteresis, magnetic-core, modulated-diode and transistor choppers.

The basic photoconductive chopper arrangement is illustrated in Fig. 1. R_1 is usually fixed and serves to prevent burn-up of the photocell. A value of 0.3 megohms is used. R_2 is a variable resistor that can be adjusted for maximum conversion efficiency. A value of about 2.2 megohms seemed best. Resistors R_2 and R_1 may be combined.

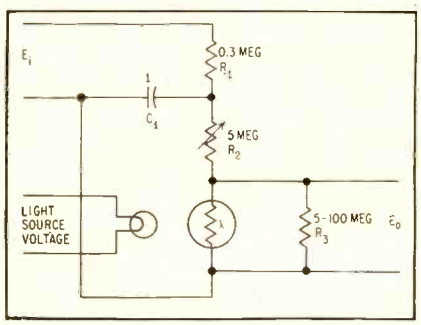

FIG. 1—Photoconductive chopper offers low noise level and resistance to vibration

R_3, the photocell parallel impedance, may be 5 to 100 megohms and serves as an upper limit on effective photocell resistance. Output impedance is determined by the cell and the impedance R_3 in parallel. In the dark condition photocell resistance increases to values as high as thousands of megohms, and the output impedance thus cannot exceed R_3. As the high dark resistance tends to vary largely among cells and is reached only very slowly, this arrangement tends to produce more uniform and a consistent output signals. In many cases R_3 may be omitted.

C_1 averages d-c signal input fluctuations so that they do not exceed light source chopping frequency. The light source should be mounted in immediate contact with the photocell with the filament lined up with the sensitive area of the detector. A thin electrostatic shield was found to reduce a-c pickup from the light source. The entire closed unit of light source, resistors and photocell should also be enclosed in a light tight and electrostatic shield.

The varying intensity of the

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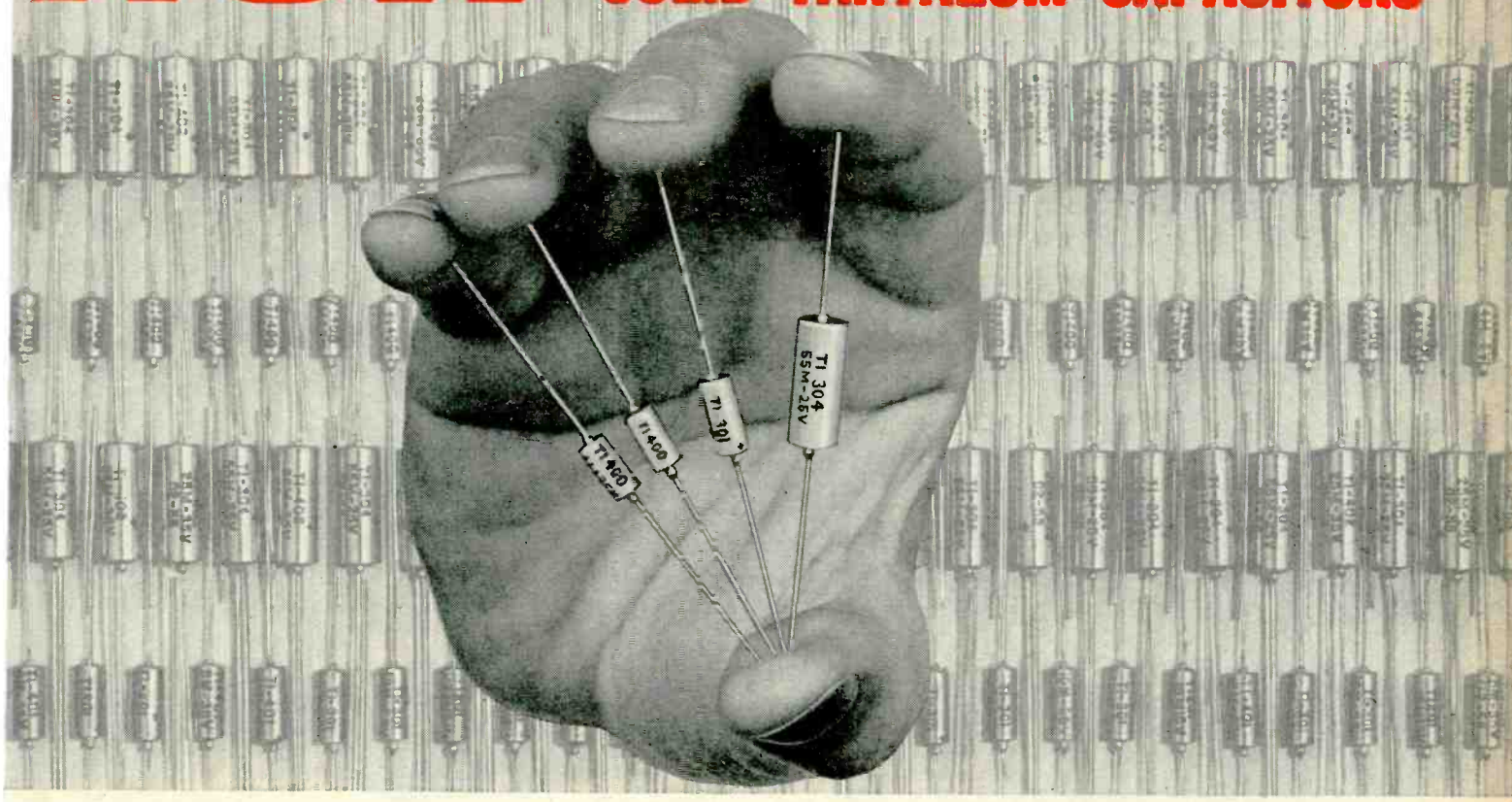
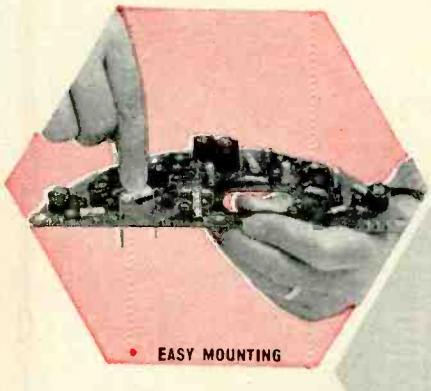
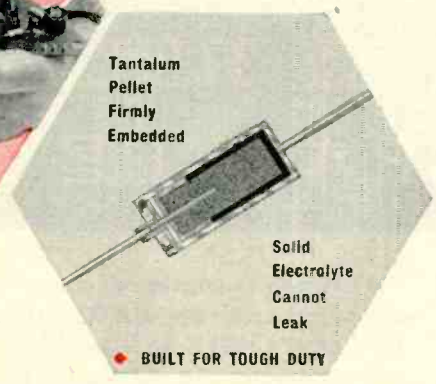




• EASY MOUNTING



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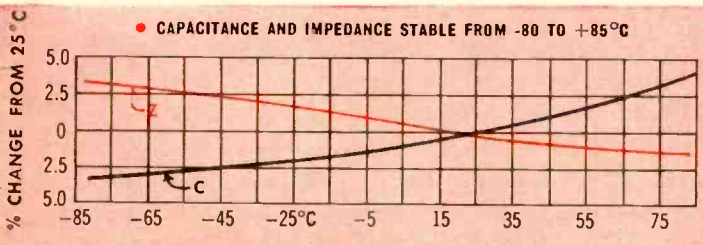

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6-Volt	22 μf	33 μf	47 μf	60 μf	200 μf
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25-Volt	5	10	15	35	55
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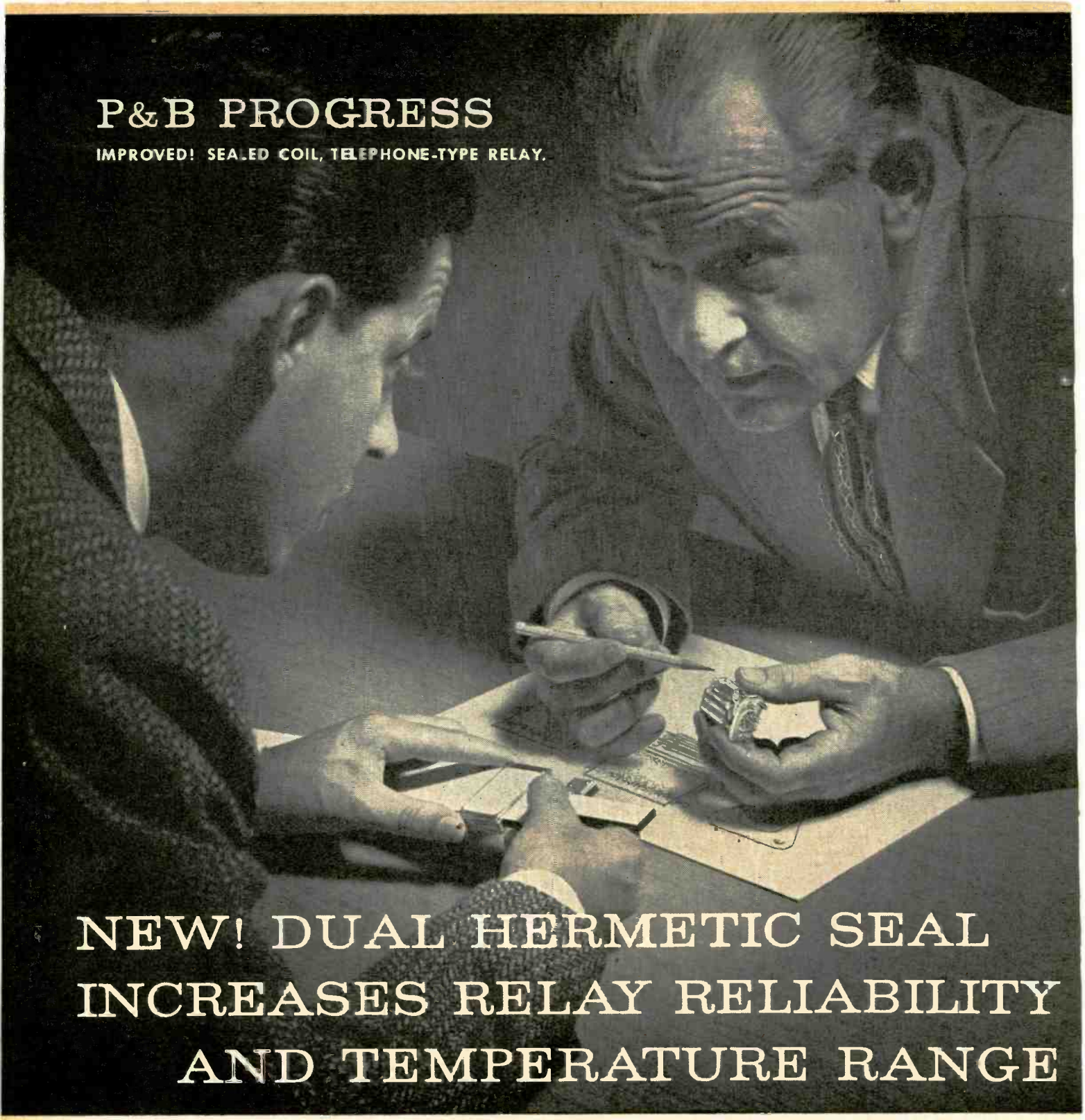

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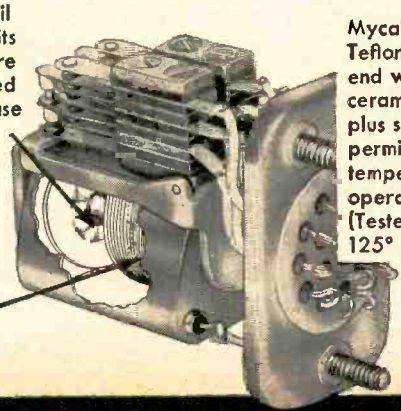
LOOK AT THESE GREAT NEW FEATURES

New bobbinless coil saves space, permits use of more ampere turns of Teflon coated wire with no increase in coil diameter.

Hermetically sealed coil prevents gases from contaminating contacts.



Mycalex stack, Teflon wire and end washers and ceramic pushers, plus sealed coil, permit high temperature operations. (Tested up to 125° C.)

Hermetically sealing the coil of the MH "Seal-Temp" substantially increases the reliability and life of this popular telephone-type relay. Considered a major reason for relay failure, contact contamination due to outgassing of the coil has been eliminated by this sealing process.

The "Seal-Temp" has a temperature range considerably broader than ordinary relays... from −65° C to +125° C. This is achieved by constructing the stack of Mycalex, employing ceramic pushers, and by using Teflon coated wire throughout.

For applications where reliability, long life and broad temperature ranges are required, the MH "Seal-Temp" relay could well be the answer. Write, wire or call today for complete information.

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light source causes the photocell resistance to vary substantially, and the impressed d-c signal voltage drop appears mostly across load R_2 or mostly across the photocell PC_1, depending on their relative resistances.

Conversion efficiency is defined as the ratio of peak to peak a-c output voltage signal to d-c input signal in percent. The most efficient circuit for modulation consists of a photocell in series with a resistor whose value is the square root of the product of maximum and minimum photocell resistance. Using the circuit arrangements described, conversion efficiencies of 20 percent have been obtained and more than 40 percent with miniature tungsten filaments. For resistance variations of 100 to 1, the maximum conversion efficiency is 80 percent.

Several problems exist in photoconductive choppers. One is the noise or spurious signal produced by the light source in the load from the self-generating effect in the photocell when there is no d-c signal. This has been as low as 25 microvolts at room temperature. There is no reason to believe that this could not be reduced considerably.

Unfortunately there is a tendency for this photovoltaic signal to increase with temperature in cadmium sulfide. However, it can to a very large extent be canceled by an appropriate d-c bias on the photocell and series resistors R_1 and R_2. For long term stability the light source and self-generating effect should be stable.

Some self-generating effects can also be caused by thermal gradients. The potovoltaic effect originates mostly at the contacts to the crystalline material. It can be reduced by carefully shielding the contacts from radiation and by use of suitable contact materials deposited in suitable ways. These include indium and aluminum deposited by evaporation or alloying or both. Some self-generating effect can result from crystalline inhomogeneities. These can only be reduced by careful crystal growth or by crystal selection after growth.

Nonlinearities in the voltage-current characteristic, at some reasonable fixed illumination level, can

also cause nonlinear a-c output. This effect is, unfortunately, particularly pronounced at low voltages. Its causes are mainly the same source as for the self-generating effect, rectifying junction at contacts to the crystal and to a small extent inhomogeneities in the crystal itself.

It is customary to operate these converters at an a-c frequency of 50 to 60 cycles, which results in a light frequency and output signal of 100 or 120 cycles. This frequency doubling is very convenient as electronic filtering can be used to reduce the level of 60-cycle pickup from both the light source and associated equipment.

The optical modulation of a standard tungsten filament at 60 cps is only about 3 to 6 percent. If on the other hand a half-wave 50-cycle voltage signal is used with a standard miniature tungsten filament, almost complete light modulation can be obtained. This gives only a 50-cps output. However, a neon bulb such as NE-47 or the argon bulb AR-3 can be used for frequencies well beyond the response of the photocells. Adequate chopping has been obtained with frequencies up to 400 cps using the cadmium sulfide photocells.

Conversion efficiency depends on light intensity, and with efficient light input power, conversion efficiency can be as high as desired, probably up to about 95 percent. However, this may reduce bulb life. The neon light source is a poor match for cadmium sulfide, better for cadmium selenide. Argon works better with cadmium sulfide, whereas the tungsten filaments are convenient sources of intense light for both cadmium sulfide and cadmium selenide.

Filaments, however, are very sensitive to vibration. In addition care must be exercised in the use of tungsten filament light sources since even a low-power bulb may heat the photocell and cause a 15-20 percent change in resistance. This can be avoided by adequate thermal shielding even though the bulb and photocell are almost touching.

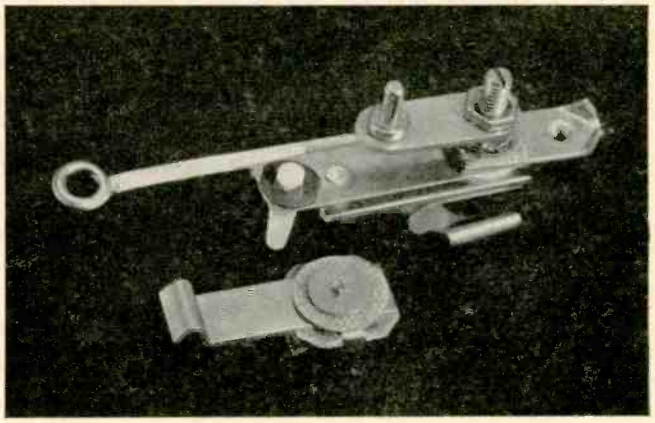
Temperature sensitivity may also be considered a problem. The impedance of the cadmium sulfide

6 Taylor-Fabricated Laminated Plastic Insulators Protect Control Elements of GE Automatic Toaster

These insulators for the pop-up mechanism, color control unit, and heating element in the General Electric Automatic Toaster are made of continuous filament woven glass fabric with melamine resin bond. This Taylor Fibre Co. material was selected for its ability to withstand the temperatures encountered in the toasting operation, its excellent arc resistance and mechanical strength, and its cost, which is lower than that of the mica insulators formerly used.

Another factor in the decision was the capacity of Taylor Fibre Co. to produce the fabricated parts to specification, and in the large quantities required, at reasonable cost.

You, too, may have applications which can utilize the combination of physical, mechanical and electrical properties found only in laminated plastics. Our application engineers will be glad to discuss them with you, offer engineering assistance, and recommend a Taylor grade that will fit your specific requirements. Our plants at Norristown, Pa., and La Verne, Calif., are both fully equipped for fast supply of basic materials and finished parts. Write us for detailed information or to arrange for a Taylor Fibre man to call on you. TAYLOR FIBRE CO., Norristown 40, Pa.



Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

photocell may vary as much as 15 percent from −80 to 60 C, which variation will adversely effect output but at less than a linear dependence. Short-term amplitude output changes up to 5 percent have been observed apparently because of slight resistance changes with temperature and of instability in neon lamp output.

The time constant for photoelectric response of cadmium sulfide is inversely proportional to illumination. Thus at low levels of illumination the conversion efficiency may be limited by low-frequency response.

A complete design theory for photoconductor choppers needs to be worked out. Such a design theory must include design for maximum conversion efficiency and minimum noise level.

Any unit will have a fundamental noise limit. Noise will comprise two terms, the Johnson noise in resistor R_s and photocell noise. The photocell noise may contain two terms, a random fluctuation term and a self-generating term.

The self-generating term might be limited by random thermal gradients. The random fluctuation term can be expected to comprise two components: the Johnson noise of an equivalent resistor and an excess noise, in power proportional to 1/f and sometimes called semiconductor noise.

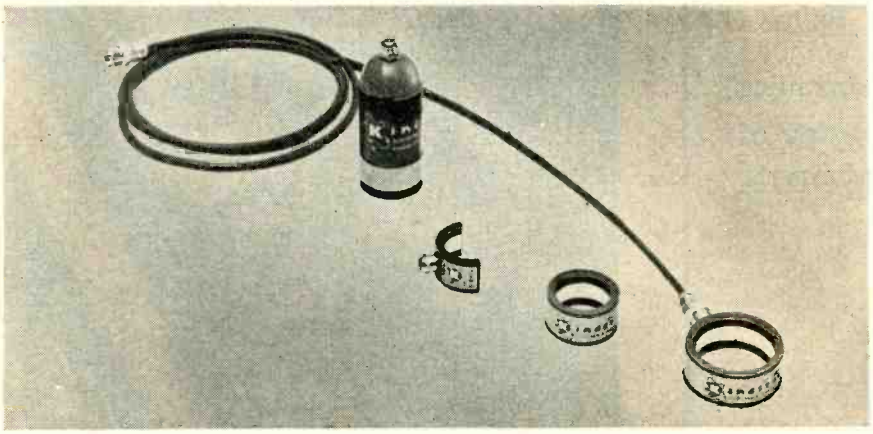
In exceedingly good units the 1/f noise may be less than the Johnson noise of an equivalent resistor. But this has not been observed in cadmium sulfide or selenide at line frequencies.

A noise voltage as low as 6 microvolts across 6.3 megohms at 50 cps with a 4-cycle bandwidth has been obtained. This noise level compares favorably with the best precious metal mechanical choppers, which is about 1 microvolt across 0.1 megohm.

Photoconductive choppers, when properly designed and built, would appear to have the following advantages: low noise level (at least competitive with mechanical choppers), more economical (especially for low-noise signals), insensitive to shock and vibration and long life (with suitable nonfilament light source).

Oscilloscope Without a Direct Connection Probe

IF THE DESIRED information is wave-shape, rather than precise wave-magnitude, the absorption analyzer is probably the most convenient instrument to use. Its loading on the circuit under test is an absolute minimum and the speed and ease of testing are far greater than any other known method.



Electrostatic pick-up detects the signal at a component with minimum loading

No direct connection is made with the circuitry being tested. Instead the pick-up is brought near the tube or component and a true electrostatic signal is picked up.

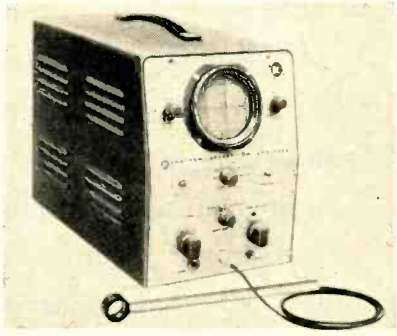
In order to prevent any random charge from being picked up, a common negative conductor is connected to the circuit of the tube under test. The common negative is between the pick-up grid of the test circuit and ground of the circuit under test. With this arrangement a capacitive coupling is created and difficulties of stray charge are eliminated.

Since glass envelopes of most electron tubes are cylindrical, a ring-type conductor is used at the end of the pickup. It is surrounded by a phenolic substance, which in turn is surrounded by an outer metallic shield. The outer ring, or shield, is grounded to eliminate stray signals. The inner conductor and plate of the tube form the capacitive coupling.

Tuned Circuit

At the high frequencies, where the circuit under test would become heavily loaded, a tuned circuit is used in the coupling circuitry to maintain high impedance. Since coupling capacity is inversely proportional to distance between the plate of the tube under test and the inner ring of the pickup, loading of the circuit can be controlled to a great degree by the person using the instrument.

With coupling pulses or square waves, allowances must be made for the fact that the coupling becomes an effective differentiator. The frequency range exhibiting this effect depends upon the network time constant. At frequencies in the audio range, however, the ability of the test circuitry to display a usable wave form is determined only by input amplitude and coupling efficiency.



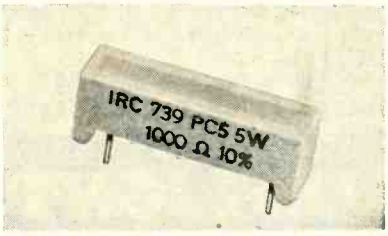
Waveform is displayed on the scope by picking up the electrostatic field around a component

Ease of Testing

Considerable time is saved with the oscilloscope since it is not necessary to pull any tubes or remove the chassis to check the signal at a particular tube. Performance of

Resistor for Automatic Assembly

A RECTANGULAR ceramic case with bench-like legs at either end has been built around a 5 w resistor by International Resistor Company. The resistor was designed for easy feed and mounting in automatically assembled printed circuit boards.



Resistor legs make a stable mount for automatic assembly on printed circuit board

It is a wire wound resistor and has a maximum dissipation of 5 w when mounted on a 105 C printed circuit board or 7 w at 105 C in air.

Because of their simple shape, they sell for less since they cost less to make. The automatic assembly design permits the user to mount the resistors for less money and thereby receive a further cost reduction.

Resistor Legs

The legs decrease the heat conducting contact area between the printed circuit board and the resistor. The resistance element is uniformly and tightly wound on a glass fibre core. Tinned copper leads are sealed in a rectangular ceramic case with special cement to protect and insulate the resistor. Induction is 0.17 μh for the 5 ohm resistors, 8 μh for the 2,400-ohm resistors and 33 μh for the 9,000-ohm resistor. *International Resistance Company, Boone Plane, Box* 393, *North Carolina.*

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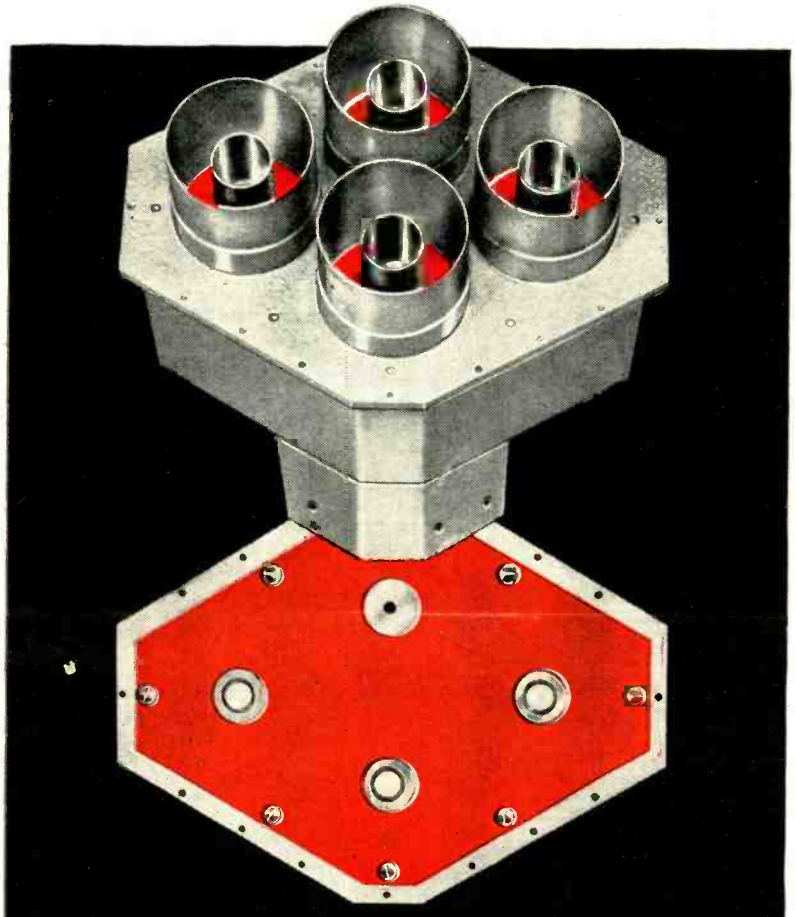
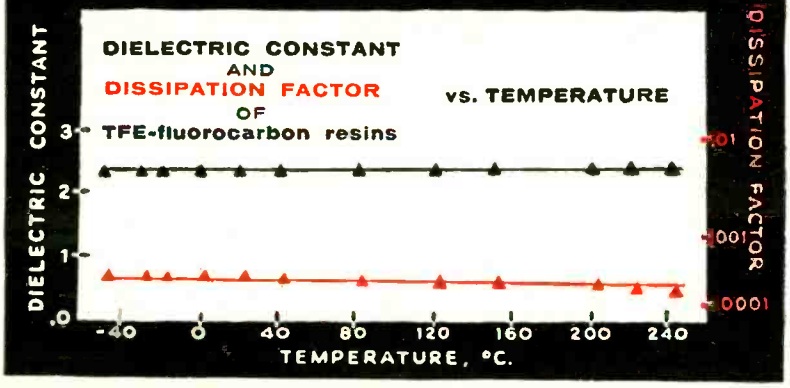
ELECTRONIC DESIGN NEWS

Design of 3⅛-inch coax switch to handle 55 KW made possible by Du Pont TEFLON®

TFE-fluorocarbon resins



TV TRANSMITTER SWITCH handles high powers with very low loss thanks to a machined layer of TFE-fluorocarbon resin. Reverse side of connector plate shows coaxial core connections through layer of TFE resin. A flat metal bar (not shown) switches power from top input connection to three outputs. Graph of properties shows why dielectric losses remain low regardless of operating temperatures. Switch is made by Thompson Products, Inc., Electronics Division, Cleveland, Ohio; and distributed by Andrew Corp., Chicago, Ill.



When increased power allocations by the FCC resulted in the need for a switch to handle greater powers and higher frequencies, engineers of Thompson Products, Inc., were faced with a major redesign problem. It looked as though the higher requirements would make their new multi-position switch for 3⅛" rigid coaxial line obsolete. Needed were models that could handle 55,000 watts of average RF power and could cover the full UHF band to 1000 megacycles. The problem was solved by changing to a TFE-fluorocarbon resin for the dielectric.

Both electrical and mechanical properties of TFE resins proved important in this design. The resin is used to make sheet dielectric for backing the grounded connector plate and a strong shaft for turning the switching bar. One of the biggest problems—impact cracking—was entirely eliminated. In addition to their unique UHF properties, TFE resins have a Class H temperature rating. 260°C. continuous rating permits increased operating temperatures in the switch. The extremely low dielectric constant of TFE resins is a natural for this microwave design. TFE resins have a minimum dissipation factor, unexcelled by any other solid. Characteristic curves for these electrical factors show that they remain flat with regard to both temperature (see graph) and frequency (60 cps to 3000 mc).

This remotely controlled, motor-operated switch is another example of the use of Du Pont TFE resins to assure **RELIABILITY** and **SAFETY** in electronic operations. We will be glad to send you information covering design data and applications of these outstanding dielectric materials.

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In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec.

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each tube can be observed while operating in its own circuit and all checking can be done from top-side —the most accessible place to test the signal at a tube.

Sensitivity

Any combination of 12 tuned circuits from 3 mc to 240 mc, with band widths up to 5 mc can be installed in the unit. These tuned circuits add to the unit a sensitivity of 200 μv per inch at most frequencies. Built-in detector circuits preclude the necessity for an external detector. Both the tuned circuits and detector can be by-passed with a switch on the front panel. This allows the input to be applied directly to the scope vertical amplifier which has a sensitivity of 2 mv per inch or approximately 10 to 1 over conventional oscilloscope sensitivity.

Testing Shielded Circuits

Making a test which requires physical contact is often very difficult with shielded equipment. An example is a weather radar IF strip in air-borne equipment which has a shield plate on the bottom of the IF section. When this plate is removed it upsets the circuitry so a definite check of the defective stage by conventional methods is time consuming and often misleading. By looping the ring probe over the successive stages while the plate shield is intact, the defective stage can be isolated and the plate removed for further inspection of the circuit. Another example is coupling in aeronautical direction finders. Remote-control tuning automatically selects frequency in the finders. If the circuits are loaded by a physical connection, bridge balance is distributed and the unit hunts trying to find a stable condition. The ring probe eliminates this problem and isolates the stage without any chance of misinterpretation by unstable circuits.

A direct prope can be used to convert to a highly sensitive direct-contact scope

A direct probe accessory converts the unit to a highly sensitive conventional scope. *Kingston Electronic Corp., Medfield, Mass.*

Pen Recorder

Accessory Transducers Add Versatility to Pen Recorder at Practical Cost

THE RECORDING mechanism of a pen recorder is the same regardless of whether it displays a d-c voltage or an a-c line frequency. It is the transducing element which must be changed to record different kinds of information.

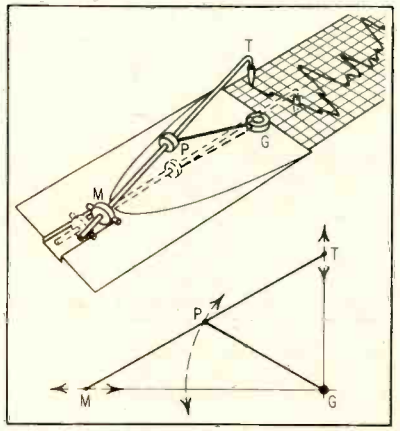


FIG. 1—Jeweled pivots convert curvilinear motion of the galvanometer movement to rectilinear motion. Rectilinear pen recordings have the same shape as a plotted graph and can be measured with a straight edge ruler.

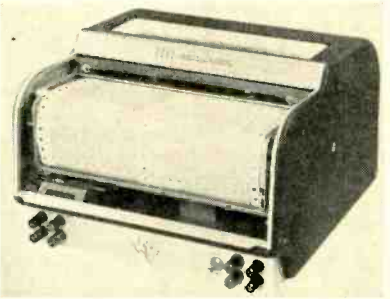
Ordinarily a complete recorder must be purchased for each different type of measurement. The complete recorder, because of its precision must be much more expensive than the transducing element which converts the desired measurements into a suitable recorder input.

Texas Instruments felt they could expand their customer potential by manufacturing accessory transducers and eliminating this unnecessary added expense. Each accessory, when connected to a parent re-

corder, provides the proper circuitry for performing the same task as a one-package pen recorder. And a parent recorder can be used with as many different accessories as desired. Overall accuracy of a recorder-accessory combination is two percent. It is the sum of a one percent accuracy for the recorder and a one percent accuracy for the accessory.

Electrical Parameters

Accessories for recording seven different electrical parameters are available at the present time. A seven range *ac-dc voltage* monitor with a minimum of 1 v to give a 10 percent deflection and a maximum of 1000 v to give full-scale deflection; a seven range *ac current* monitor which measures from a minimum of 250 ma full-scale; a *line frequency* monitor to measure frequency deviation in three ranges, 45-55, 55-65 or 375-425 cps; an expanded scale *a-c line voltage* monitor to measure 80-130 v, 160-260 v or 320-520 v rms; an *a-c current* monitor in any single range of the seven range a-c monitor; and a *line service* monitor which combines in a single accessory a line voltage, current, and frequency monitor.

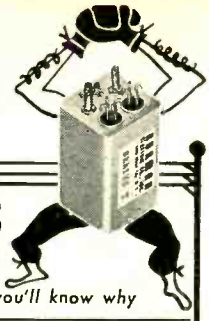


Accessory transducers enable the writing mechanism of one pen recorder to be used for many different types of measurements Unnecessary duplication of the high cost writing mechanism is eliminated.

Parent Pen Recorder

A galvanometer movement is used to drive the writing pens. To

the leading contender in the sensitive relay class!



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*Designed by Richard H. Dorf

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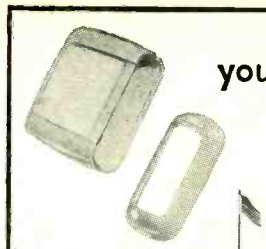

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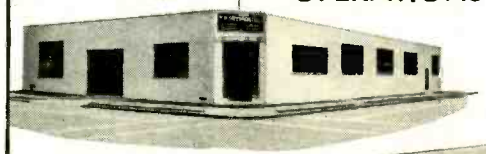

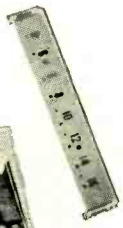

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Contacts: Rated 100 Ma, insulation to signal coil rated 300 volts DC.

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convert the curvilinear motion obtained from the galvanometer to a true rectilinear motion, a special pen linkage was designed. It writes the signal in its true shape on a rectilinear chart. Time-consuming interpolations, computations, and curvilinear illusions are eliminated, and signal magnitudes can be measured with a ruler.

Straight-Line Motion

The writing pen arm *MT*, Fig. 1 is attached to the swinging end of the galvanometer arm *PG* at point *P*. The pivot point for the galvanometer is *G*. Distances *PM PT*, and *PG* are equal, therefore if *M* is limited to fore-and-aft motion along line *MG*, the pen point *T* will always have motion perpendicular to *MG*. In the Texas Instruments' recti/rite system the principle has been modified so *PG/PM* equals *PM/PT*.

Paper is fed over a flat "writing desk" permitting chart notations while the unit is recording. Ten separate chart speeds are available to the operator for recording. *Texas Instruments Inc. Industrial Instrumentation Division, 3609 Buffalo Speedway, Houston, Texas.*

Metal Film Microwave Attenuator Cards

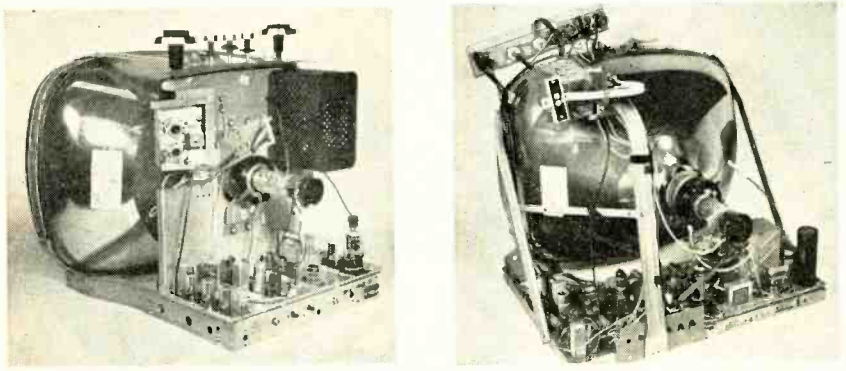
RESISTANCE CARDS have been extended to include highly stable microwave attenuator material. The base is a fine weave glass cloth impregnated with high temperature thermosetting resin. It meets MIL-P-18177. The resistance material is a thin metal film, approximately 50 millionths of an inch thick, uniformly deposited on one surface of the plastic. A protective coating is provided over the metal film.

The combination—of a metal resistance film, deposited on a laminated fibre glass plastic base which is dimensionally stable and has low moisture absorption—offers good microwave attenuator material. Maximum surface temperature should be limited to 130 C.

Standard resistance cards are 5 x 12 inches and 0.025, 0.032, or 0.062-inches thick. *Filmohm Corp., 48 W. 25 Street, N. Y. 10, N. Y.*

Triangular Chassis Cuts TV Production Costs

By W. R. PETRICK and L. R. TRAVIS, Television-Radio Division, Westinghouse Electric Corp., Metuchen, N. J.



Relatively massive tv chassis (left) has been replaced by a lighter, less costly triangular chassis (right) which frames the picture tube and printed circuit board

LIGHTER, more economical television receiver chassis design has evolved from the concept of a triangular structure to support the cathode ray tube, use of printed circuit boards and elimination of conventional deflection yoke supports.

The triangle consists of the chassis as the base, the crt as one leg and channel section brace as the other leg. A triangle is inherently rigid. Further, each leg of the design is functional: the chassis carries most components, the tube strengthens the chassis and the tuner is mounted on the brace.

This design concept and subsequent refinements have decreased weight 3 pounds and lowered chassis costs some 20 per cent in 3 years, despite a steady rise in the cost of basic materials. Tooling costs are lower because of parts standardization. The one basic chassis (with varied side support and brace lengths) is used in 4 tv set models: manual and power tuned 90 and 110-degree tube models. The horizontal chassis simplifies wiring and service.

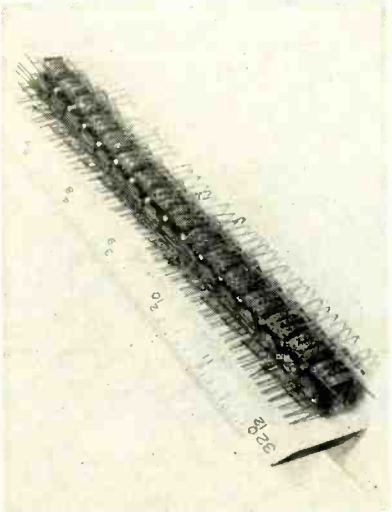
Printed circuit boards permit the frame to function as a chassis, promoting lightness, flexibility, low tooling costs. However, since the board does not carry all components, a small plate is provided on the frame. The plate also stiffens the frame.

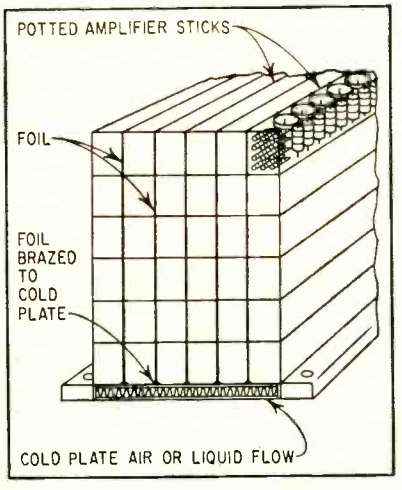
The board is mounted with trimount studs, which are relatively low in cost, easy to assemble and prevent board cracking by allowing motion between the board and the frame. Large board size (8 13/16 inches by 11½ inches) is made possible by metal supports joining the center shields of each tube socket. These provide rigidity needed for tube insertion and extraction, prevent warping during dip soldering and give a good electrical ground.

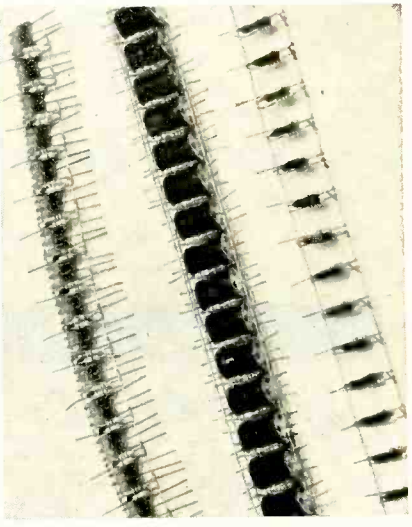
Using a single large board rather than several smaller boards reduces board processing costs and waste space and also avoids interconnection costs and errors.

To use the crt as one triangle leg, a tube mounting was devised

DESIGN TRENDS: High Density Component Sticks







Extreme miniaturization through maximum component density and elimination of module racks and support structures is the aim of this packaging design developed by Francis Associates, Marion, Mass. The project is supported by Massachusetts Institute of Technology's Instrument Laboratory. Technique allows density up to 130 components a cubic inch. A 5,000-transistor computer would occupy ¼ to ⅓ cubic foot. Sticks of components are built up by subminiature tube welding techniques. At left is experimental stick containing 36 interconnected digital switches. At right are subassemblies. Potting sticks in resin gives them a strength like reinforced concrete. End equipment would be assembled as diagrammed. Interleaved sheets of foil would carry heat to cold plate which would also act as mounting base

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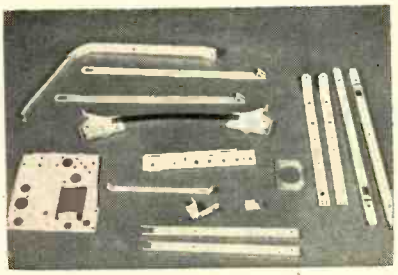
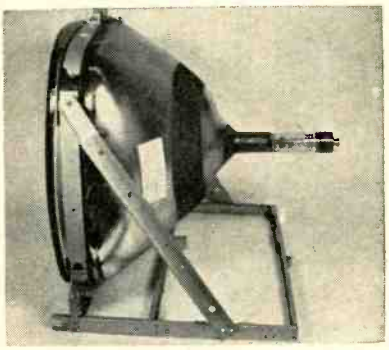
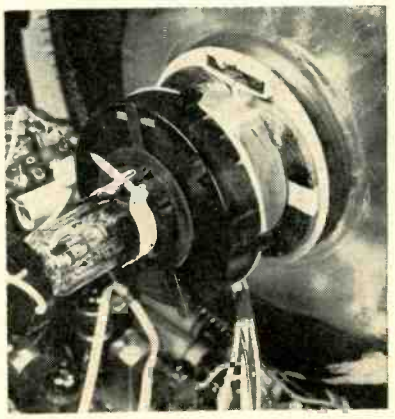


Basic parts of the triangular chassis before assembly



Triangular structure assembled with tube straps in place



Slotted sleeve and clamp hold yoke on neck of picture tube

which takes advantage of the short distance between the tube mounting and the center of gravity. It is a pair of conforming supports fixed to the chassis frame and tied together and about the tube by steel straps.

The lower strap is riveted to the riveted frame assembly. The upper straps have holes at one end which hook onto the tube support. A triangle at the other end, welded to the strap, allows the straps to be bolted together.

Rubber and tape at the tube's bottom and top corners isolate it from the straps, prevent damage and help hold the tube in place by friction.

Instead of a rear support for the

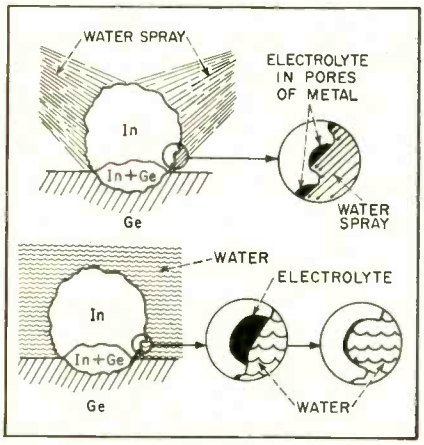
crt, a slotted sleeve on the yoke back cover is clamped to the crt neck. A properly sized aluminum clamp limits pressure on the neck.

The third leg, the brace, connects the top of the tube strap with the chassis frame. It stiffens the crt support, avoiding use of costlier structures to hold up the tube's rear. A weld-bolt joins it to the strap and it is fastened at the bottom with self-tapping screws.

Jet Spray and Soak Cleanse Transistors

By JAMES E. GREEVER

General Electric Co., Syracuse, N. Y.

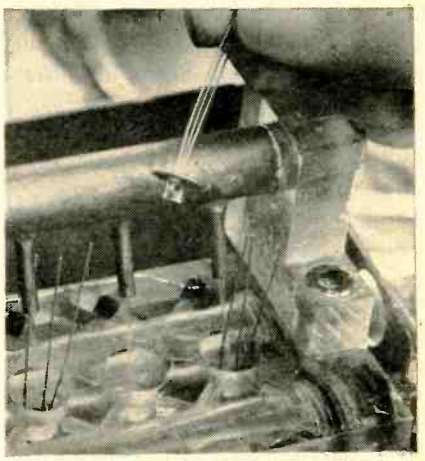


Jet spray (top) leaves electrolyte in pores for later removal by soaking (bottom)

WASHING ELECTROLYTES from semiconductor devices after junctions have been etched pose several production problems. Determinations must be made of final cleanliness, while bearing in mind production requirements for speed in cleaning and water conservation.

The best method of washing semiconductor devices is a water jet spray followed by a soaking. The jets remove the bulk of the electrolyte and soaking cleans out the residue in the metals' pores. Deaereated water is needed to avoid air bells which would block water from the pores.

Four to 6 commercial jet sprays arranged in a circle suffice for preliminary cleaning of a normal *pn* germanium rectifier. Two-dot transistors, such as GE's *pnp*, require that the jets cover both dots at once and the germanium itself. Soft or tap water may be used in some



Transistor is removed from electrolyte and quickly placed in jet spray. Dried electrolyte is hard to remove

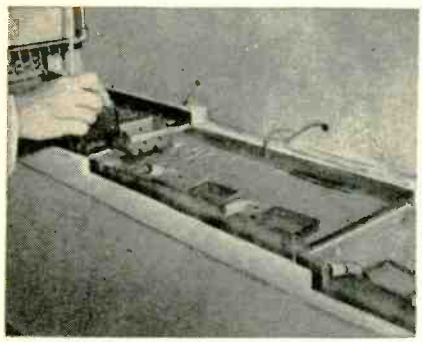
cases to reduce water cost, since the final wash is in deionized water. However, careful analyses must be made of the pH and purity of the water and the electrochemistry of the metals involved. Formations which might occur on the metals would cause failure of the device.

Sequenced beakers of water, cascade baths or free-flowing troughs are all usable for soaking, depending on production rates and water cost. Beakers are suitable for laboratory quantities and for evaluation, the others for production.

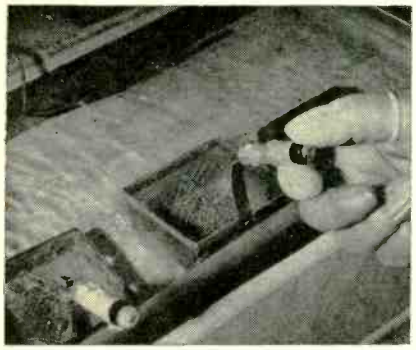
A cascade is 2 or more trays joined in step-fashion. Fresh water is fed into the topmost tray, overflows into the second tray and so on until it reaches the drain. Units to be cleaned are put into the lowest tray first and moved successively upward. The final wash is in the top tray. Water must flow into the top tray fast enough to be completely replaced during the washing cycle. Otherwise, the semiconductors will be subject to contamination. Flow rate can be judged by the continuous addition of NaOH and prepared phenolphtalein indicator, which makes water pinkish.

Free-flowing troughs have the added advantage of a forceful stream of fresh water contacting the units. Tests indicate that washing time, compared with cascades, is 300 percent less. However, a trough cannot be used at full efficiency except in some type of etching automation.

Purity of water, flow rates, temperature and time cycles must be determined. For exceptional clean-



Soak in cascade bath follows spray. Multimillion-ohm hot water flows from left to right, parts move right to left



Transistor assemblies are placed in wire baskets for easy handling in cascade

liness, water with resistance of 500,000 ohms and higher is required. This is achieved in production by commercial deionizers since distillation is costly.

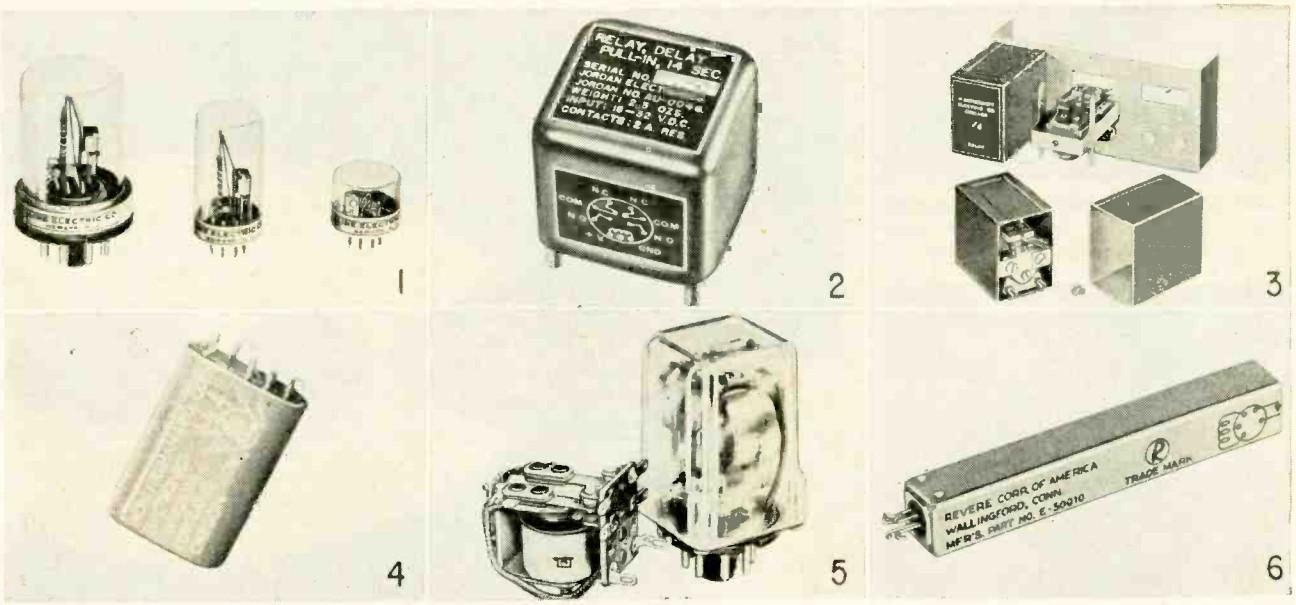
Electrical evaluation of the devices over a period of time will establish the purity required. Ph readings indicate cleanliness and are balanced against the end electrical yield for a standard of minimum quality.

Laboratory tests show efficiency of various washing cycles. For example, 20 etched subassemblies were rinsed for 1 minute in each of 4 beakers of pure hot water. Another 20 got 2-minute rinses. The 2 groups were soaked 24-36 hours in stoppered flasks of pure water. A third flask of water served as a standard. The group rinsed 1 minute increased the pH of the pure water by 1.74. The 2-minute rinse gave a superior pH increase of 0.56.

A similar test indicated efficiency of cascade washing cycles. The pH difference over pure water was: 5-minute wash, 1.70; 10-minute wash, 0.89; 15-minute, 0.45, and 20-minute, 0.41. The optimum washing cycle was judged to be 15 minutes.

CIRCLE 76 READERS SERVICE CARD→

Introduce More New Relays



(1) Line Electric, thermal time delay relay. (2) Jordan Electronics, time delay relays. (3) Magnecraft Electric, dustproof relays. (4) Iron Fireman Mfg., microminiature relay. (5) Struthers-Dunn, general purpose relays. (6) Revere Corp. of America, spst relay.

Confronted with the complex circuitry in today's military equipment, design engineers must have the most reliable components at their beck and call. Small, rugged, precision relays play a big role here.

Line Electric Co., 271 So. 6th St., Newark 3, N. J., (300), announces a miniature thermal time delay relay with high shock and vibration characteristics. It offers delays as low as 250 millisec. The $\frac{1}{8}$ in. diameter contacts can carry 3 amperes at 115 v, 60 cps noninducting current, for a minimum of 250,000 operations.

Now available from **Jordan Electronics Div.** of The Victoreen Instrument Co., 3025 W. Mission Rd., Alhambra, Calif., (301) are time delay relays featuring transistorized circuitry with RC network which permits intervals from 50 millisec to several hours.

Magnecraft Electric Co., W. Grand Ave., Chicago 51, Ill., (302), announces that in order to provide protection against dust, combined with convenient accessibility, removable metal enclosures have been developed for Class 22 relays. The enclosures may be mounted on customer's strip, panel or chassis.

A tiny relay for missile use is in production by **Iron Fireman Mfg. Co.**, 2838 S.E. Ninth Ave., Portland 2, Ore., (303). It can withstand temperatures ranging from 100 deg below freezing to 45 deg above the boiling point of water.

General purpose relays offered by **Struthers-Dunn, Inc.**, Pitman, N. J., (304), combine high contact reliability with small size and light weight. Grade 5 melamine bonded fibre glass insulation is used for contact supports. The relays are available in spdt, dpdt and 3 pdt types.

Revere Corp. of America, Wallingford, Conn., (305), reports contacts of the new spst Glaswitch relays are hermetically sealed in glass envelopes containing dry nitrogen and a helium tracer, preventing contact contamination from volatiles.

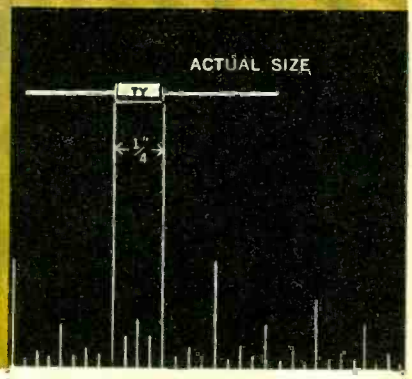
For more information use READER SERVICE CARD

Counter-Timer transistorized

Potter Instrument Co., Inc., Sunnyside Blvd., Plainview, L.I., N. Y. Featuring preset interval generating, timing and counting functions in a compact package, the model 860 frequency time counter is a transistorized unit with visual, in-line readout. Timing and frequency features include direct measurement of frequency from 0 to 150 kc, frequency ratio determination, period measurements for 1

Solitan®

the truly dry tantalum capacitor!



NEW SOLID-STATE ELECTROLYTE CAPACITORS BY CORNELL-DUBILIER • SOLITAN capacitors are specifically designed for transistor application in computer and military circuits. Solid electrolyte tantalum assures extreme resistance to shock and vibration, wider useful temperature characteristics, stability of capacitance in spite of aging or temperature variations, freedom from corrosion or leakage. Cornell-Dubilier has SOLITAN tantalum capacitors in production quantities. Write for 4-pg. Bulletin No. 537 to Dept. 000, Cornell-Dubilier Electric Corp., South Plainfield, N.J.

SOLITAN

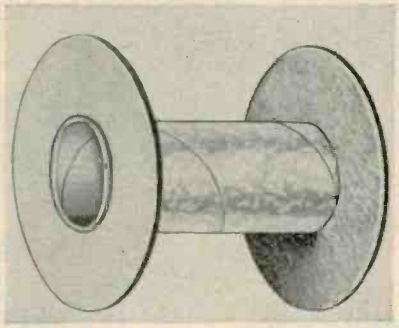
Specifications and Features

- Ratings up to 6.0 mfd. at 35 volts DC Working, or 60.0 mfd. at 6 volts
- Wider useful temperature characteristics within range of −80°C to +85°C
- Freedom from corrosion and leakage
- Extremely small size
- Remarkable stability of capacitance with time and temperature
- Metal cased, hermetically sealed

Consistently Dependable

CORNELL-DUBILIER CAPACITORS

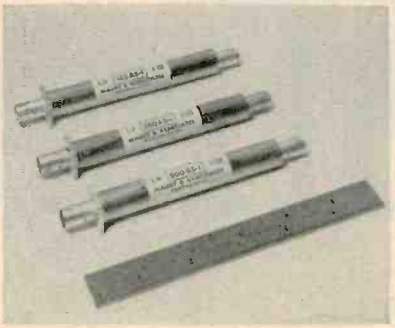
or 10 cps, predetermined counting to any number up to 9,999 with extension in steps of 10 or 100 to 999,900, and external count gating. **Circle 306 on Reader Service Card.**



Bobbins
withstand 250 C

FORM-IT PRODUCTS, INC., 1619 W Walnut St., Chicago 12, Ill., announces a recently developed high temperature bobbin that meets and exceeds military specifications for class H insulation. The bobbin has been tested and approved to withstand temperatures up to +250 C. The unit is in use now for windings in airborne equipment, aircraft and missiles.

Specifications include material thickness from 1/32 in. to 1⅛ in. round, square, or rectangular shapes. Bobbins are available for ⅜ in. to 1½ in. i-d coil sizes and any diameter of flange. **Circle 307 on Reader Service Card.**

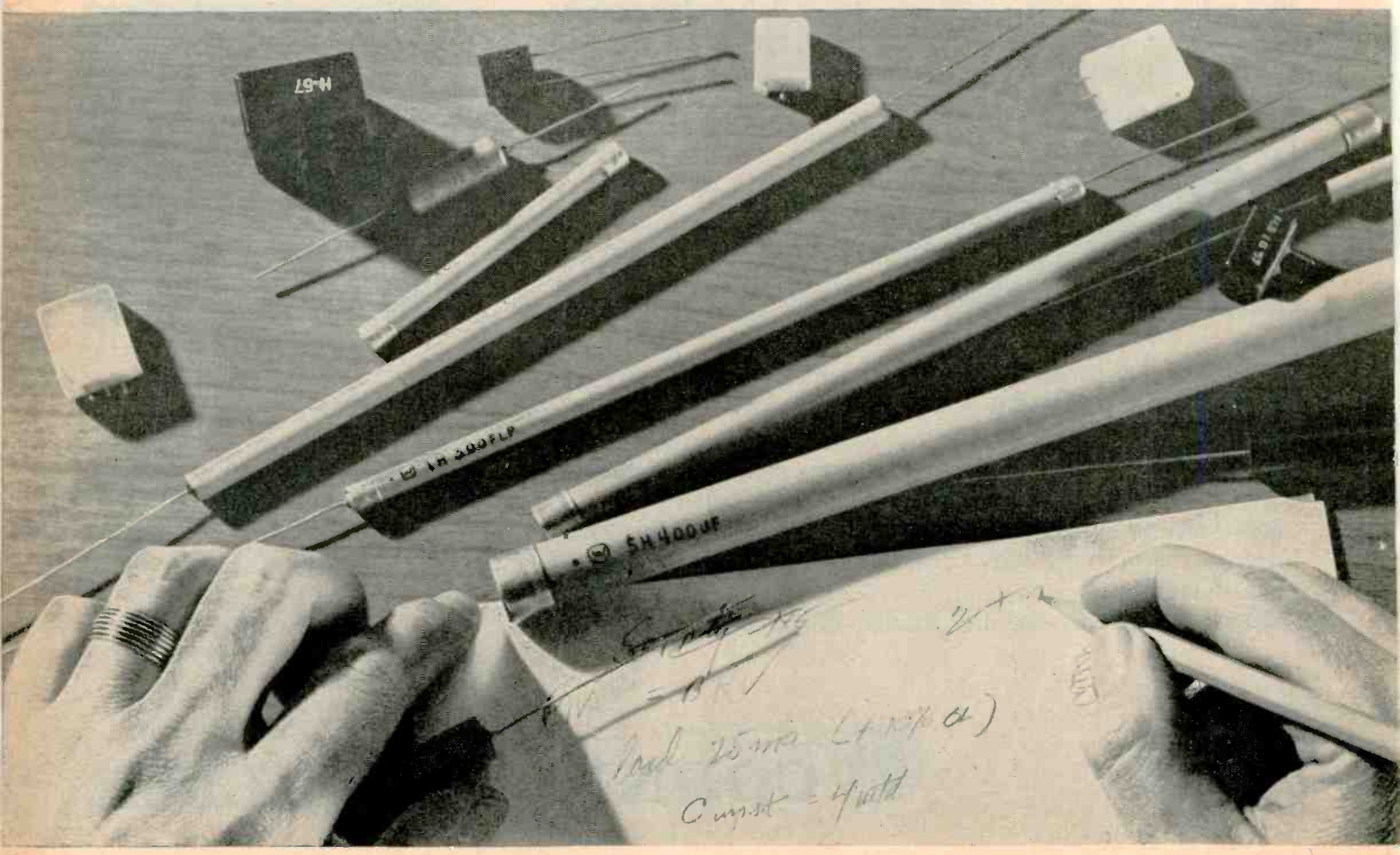


Low Pass Filters
miniaturized

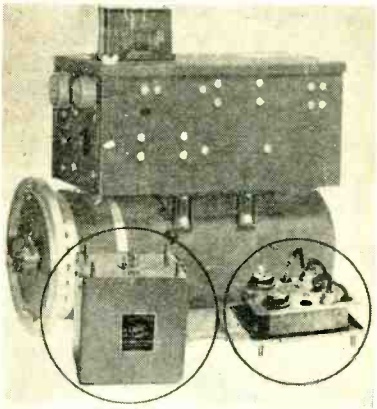
MAURY & ASSOCIATES, 10373 Mills Ave., Pomona, Calif. Series A2 low pass filters feature low insertion loss, miniaturization and rugged construction. They have BNC connectors on both ends, and can be obtained with or without mounting flanges. The filters can be obtained to meet any cutoff frequency between 100 and 1,000 mc. **Circle 308 on Reader Service Card.**

Servo Amplifier
transistorized

JOHN OSTER MFG. CO., 1 Main St., Racine, Wisc., has developed a compact − 55 C to + 125 C transistorized servo amplifier with variable damping or feedback control and a wide range of input impedances. Output power is up to 10 w. Type AMP-9616 can be designed to drive a servo motor-generator with



standard 115/57.5 v control phase or 40/20 v control phase without the need of an output transformer. Open loop power gain is up to 90 db. **Circle 309 on Reader Service Card.**



Frequency Changers use semiconductors

Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N. J., announces new Transpac transistorized frequency changers. These new static designs convert any given input frequency to a new frequency at power levels and eliminate the disadvantages of vacuum tube or mechanical conversion equivalents. The new models are ideal for powering all a-c operated equipment, gyro and servo mechanisms, magnetic amplifiers, and are intended for all types of laboratory and industrial applications. **Circle 310 on Reader Service Card.**

Stampings flat sheet metal

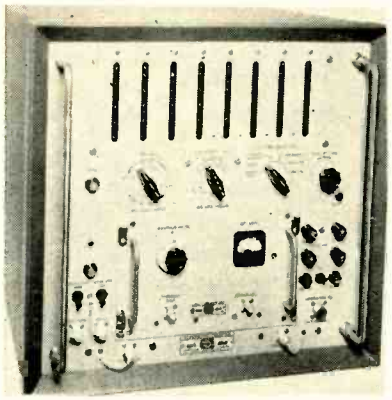
Techniques, Inc., 52 Jackson Ave., Hackensack, N. J., has available a new service for providing flat sheet metal stampings in any size, shape, or metal in thicknesses up to 0.006 in. Parts are free of burrs, accurate, and concentric. Tolerances are normally ± 0.005 in. Closer tolerances can be provided where required. **Circle 311 on Reader Service Card.**

Multiplexer for pdm telemetry

Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif., has developed a new device for pdm commutating and coding. The 40-101 Plexicoder commutates signals from up to 90

transducers at 112.5 samples per second and converts them into duration-modulated pulses suitable for telemetering or magnetic tape recording.

In the Plexicoder, low-speed magnetic switching at the input, with high-speed commutation and coding accomplished by interrupting a light beam, replaces rotating wiper-arm assemblies and wide-band chopper-stabilized amplifiers. Circle 312 on Reader Service Card.



H-F Counter high reliability

Northeastern Engineering, Inc., Manchester, N. H., announces a new high-frequency 10 mc electronic counter. It features an eight place digital readout with no meters.

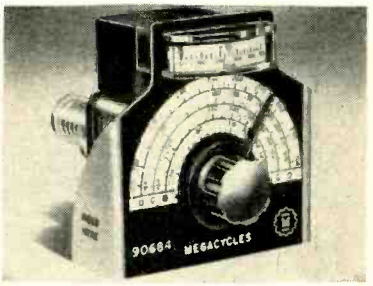
Reliability not heretofore obtained in h-f counters is achieved by improved circuitry which has eliminated many troublesome diode circuits, the company claims. Weight, size and heat are considerably reduced through the use of a silicon rectifier power supply. Circle 313 on Reader Service Card.

Sliding Shorts noncontacting

Polytechnic Research and Development Co., Inc., 202 Tillary St., Brooklyn 1, N. Y. New sliding shorts which can be accurately adjusted to any reactance, are available in frequency ranges from 12.4 to 75 kmc. With short-circuit vswr's of up to 100:1, they are said to be the most useful terminating impedances in waveguide measurements, apart from matched loads. The new units consist of a section of waveguide in which a short-circuiting plunger can be moved by means of a micrometer drive. This is a noncontacting short of the two-section coaxial-filter type. Circle 314 on Reader Service Card.

Power Transistors used in converters

Bendix Aviation Corp., Long Branch, N. J., announces a new series of power transistors for converter and switching circuits. They have a 5-ampere maximum current rating and can switch power up to 250 w. They are provided in current gain ranges of 15-30, 20-40 and 30-60 at a collector current of 3 amperes d-c. Collector-to-emitter breakdown ratings are 40, 70 and 80 v to eliminate burnout in h-v applications. Circle 315 on Reader Service Card.



Frequency Meters cover wide range

The James Millen Mfg. Co., Inc., 150 Exchange St., Malden, Mass. The No. 90680 series of in-

dicating frequency meters cover the range of 170 kc to 700 mc. This range is covered by five basic units (heads), each designed specifically for its own frequency range. Each head has three or four plug-in inductor/probes and the same number of individual frequency calibrations. A single 500 μa, end-indicating, plug-in instrument is used with each of the heads. The indicating circuit is so sensitive that even the output from a grid dip meter is enough for full scale deflection at most frequencies. **Circle 316 on Reader Service Card.**

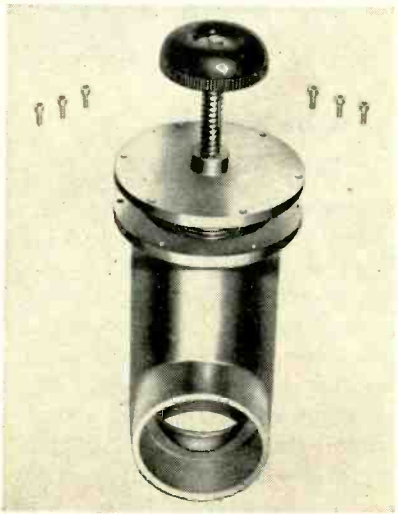
Pressure Pickup for test stand use

Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif. Type 4-323 pressure pickup, designed for a wide range of gage and absolute pressure measurements, is particularly suited to rocket and engine test stand uses. Operating without damage at temperatures from — 300 F to + 300 F it provides nominal output of 40 mv. Pressure ranges from 7.5 to 5,000 psi gage or absolute are available in one unit without configuration changes. **Circle 317 on Reader Service Card.**

R-F Attenuators for laboratory use

Jerrold Electronics Corp., 23rd and Chestnut Sts., Philadelphia 3, Pa., has introduced two variable attenuators offering 0 to 62.5 db at-

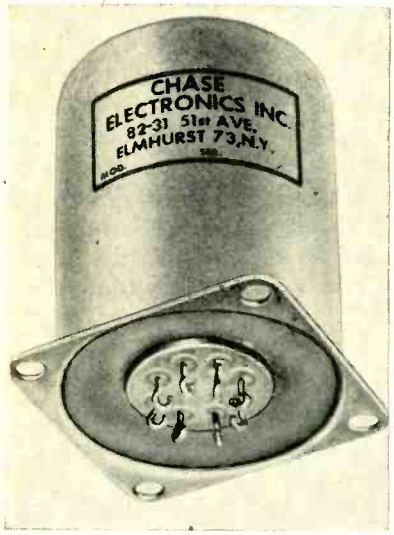
tenuation in 0.5 db steps from d-c to 500 mc. Models AV50 and AV75 utilize precision, carbon-deposited resistors for highest accuracy. They exhibit a maximum insertion loss of only 0.25 db from d-c to 250 mc, and 0.5 db from 250 mc to 500 mc. Each attenuator incorporates a newly developed rotary, coaxial switch that features a floating rotor with dual wiping, self aligning contacts mounted in a Tel-F dielectric. Model AV50 has a characteristic impedance of 50 ohms and utilizes improved type BNC connectors. The AV75 has a characteristic impedance of 75 ohms and utilizes F series, constant impedance connectors. **Circle 318 on Reader Service Card.**



High-Vacuum Valve bellows sealed

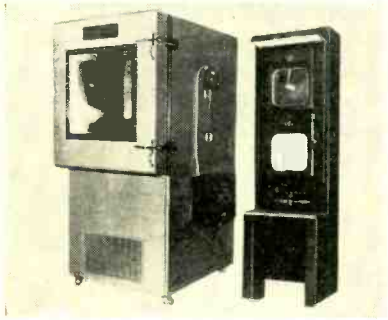
VEECO VACUUM CORP., 86-P Denton Ave., New Hyde Park, L. I., N. Y., expands its line of bellows sealed valves for high-vacuum service with the introduction of its 3-in. model. Sizes now range from ⅛ in. through 3 in. The new right angle unit provides positive shutoff in high vacuum systems where leak-tightness is essential. Designated the R-300-S, the brass valve has very high conductance, the result of an unusually large stroke, short flow path through the valve, and an unobstructed, full-size port. A multiple thread on the stem reduces the number of turns required for full opening. The valve, de-

signed for solder connection, may be installed in any position. Circle 319 on Reader Service Card.



Magnetic Amplifier
for airborne uses

Chase Electronics, Inc., 82-31 51st Ave., Elmhurst 73, N. Y. Model CE-LL-400 low-level magnetic amplifier is especially developed for airborne applications in which the input power derives from thermocouple, strain gages, thermistor bridge, photovoltaic cell, current shunt and the like. Price for sample is $65; per lots of 100, $30 each. Circle 320 on Reader Service Card.



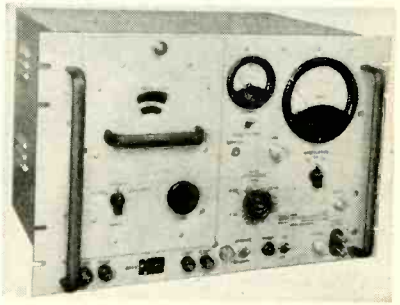
Test Chambers
30 cu ft space

Tenney Engineering, Inc., 1090 Springfield Road, Union, N. J., offers temperature test chambers with 30 cu ft of work space, and

outer dimensions of 4½ ft wide by 5 ft deep by 7¼ ft high.

These standard units feature low temperature ranges of − 40 F, − 100 F, − 120 F, high temperature ranges of + 240 F or + 350 F optional; also optional these units can provide for relative humidities of 20 to 98 percent (limited by + 35 F dewpoint) and 5 percent at + 160 F.

Heliarc welded, stainless steel interior with a positive seal dual door gasket, the series 30 require no installation service other than a simple plug-in connection. Circle 321 on Reader Service Card.



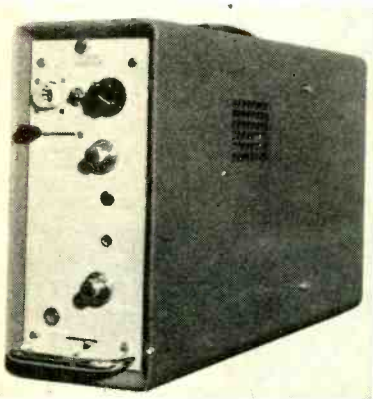
Modulation Meter for 15 kc-1,000 mc

Empire Devices Products Corp., Amsterdam, N. Y. Model MM-120 is a sensitive modulation meter for a-m generators and transmitters. It basically consists of a superhet receiver and circuits designed to measure accurately modulation on signal levels as low as 0.01 v. It covers the 15 kc to 1,000 mc range by means of two easily changed plug-in tuning units, thus fulfilling the functions of two separate instruments but avoiding duplication of costly components common to both frequency ranges. Circle 322 on Reader Service Card.

Shift Register two-cores-per-bit

Airtronics, Inc., Bethesda, Md. A new two-cores-per-bit shift register operates at speeds up to 500 kc. The maximum shifting rate of the DK107 is above a megacycle. All components including two cores and four gold-bonded germanium

diodes are encapsulated in epoxy. Units are provided with solder lug headers, plug-in bases, and solder pins for printed circuitry. **Circle 323 on Reader Service Card.**



D-C Amplifier
true differential

SANBORN Co., Industrial Div., 175 Wyman St., Waltham 54, Mass. Model 450-1800A amplifier is designed to drive an optical galvanometer, oscilloscope or tape recorder. Input characteristics include an impedance of 200 K differentially between terminals (balanced), or 100 K each input lead to ground (single-ended); common mode rejection at d-c is 100 db, to 400 cps 80db, and from 400 cps to 30 kc 74 db; equivalent input drift is ± 2 μv; equivalent input noise is 5 μv peak to peak (0-10 cps), 20 μv (0-1,000 cps), 50 μv (0-30 kc). Two outputs provide either ± 8 v into 5,000 ohms at fixed gain or ± 50 ma swing with 8 smoothly adjustable gains. **Circle 324 on Reader Service Card.**

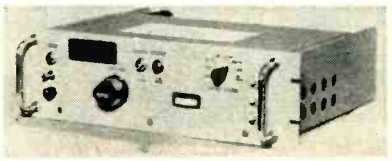
Manometer
and microphone

TELCO INC., 47 rue de la Division Leclerc, Gentilly, France, announces an electronic micromanometer and microphone for

intracardiac catheterism. Dimensions of the transducer are 0.1 in. diameter by 0.3 in. overall length. It is slipped into the human heart at the end of a 0.02-in. diameter coax cable. This cable is imbedded in a double lumen catheter. Intracardiac pressures and sounds are simultaneously translated into a frequency-modulated signal. **Circle 325 on Reader Service Card.**

D-C Power Supplies wide-range units

Sorensen & Co., Inc., Richards Ave., South Norwalk, Conn., offers two Magnetic Rangers, tubeless wide-range regulated 5-36 v d-c power supplies, the MR36-15 with 0-15 ampere output and the MR36-30 with 0-30 ampere output. Units feature ± 0.25 percent regulation accuracy, 0.2 sec response time, 105-125 v a-c input, 150 mv ripple, and continuously variable outputs. They have magnetic amplifier control circuits with transistorized power references and zener diode comparison circuits. **Circle 326 on Reader Service Card.**

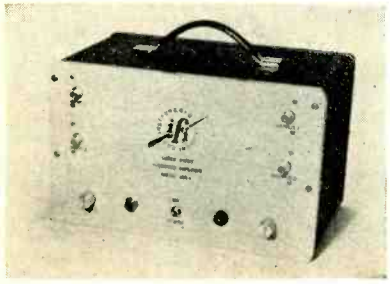


Frequency Standard long term stability

Lavoie Laboratories, Inc., Matawan-Freehold Road, Morganville, N. J. The LA90 5-mc frequency

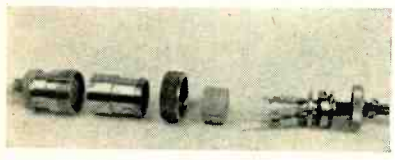
standard offers long term stability to better than one part in one billion (1×10^{-9}), in a compact package. In its design, the unit incorporates a new approach to precise crystal oven regulation.

Due to the inherent stability of the quartz element and proper crystal aging, long term operation results in temperature shifts of less than 0.01C. Environmental temperature range is 0 C to 50 C. Circle 327 on Reader Service Card.



Wideband Amplifier
bilateral unit

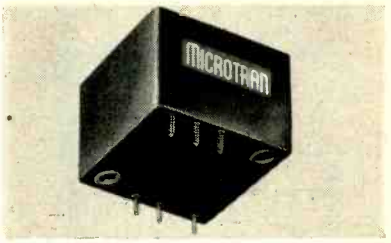
Instruments For Industry, Inc., 150 Glen Cove Road, Mineola, N. Y. The Super Video amplifier model M-395A is a new and improved version of the M-395. The company has improved the l-f response from 1,000 cycles to approximately 250 cycles, increased the gain from 70 db to 80 db, improved the output voltage capabilities from 1 v rms to 2 v rms and reduced the hum output from 40 mv to 25 mv. The cutoff characteristic has been changed so that there is a gradual falloff from 50 mc to approximately 70 mc. Weight is reduced from 45 to 30 lb. Circle 328 on Reader Service Card.



Connectors
high temperature

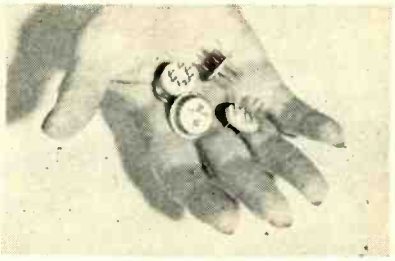
AMP Inc., Harrisburg, Pa., has available connectors employing high temperature stainless steel, high temperature silver alloy contacts, special temperature resistant

ceramic dielectric materials, and fine silver seals for high altitude and extreme atmospheric conditions. The 7-contact radiation resistant connector for 7-16 Awg wire is illustrated. It features crimped on contacts. The connector was developed for use in an operating environment of 100,000 ft plus altitude, a minimum corona starting voltage of 560 v and flashover voltage of 960 v. **Circle 329 on Reader Service Card.**



Transformers
molded construction

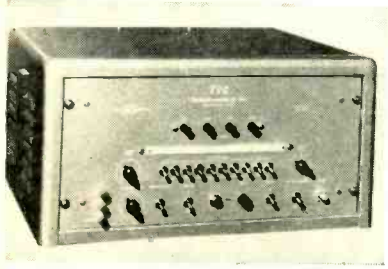
MICROTRAN CO., INC., 145 E. Mineola Ave., Valley Stream, N. Y., has available a line of transistor driver and transistor output transformers in molded construction. They are designed to meet the requirements of MIL-T-27A class R and S grade 2 or 4. Reliable life is 10,000 hr minimum. High temperature epoxy is used in the molding of these units for protection against temperature extremes. Mounting is by means of standard channel ears, threaded studs, or inserts. Terminal pins are arranged for use with dip soldered printed circuitry. **Circle 330 on Reader Service Card.**



Solid Pin Headers
for tube bases

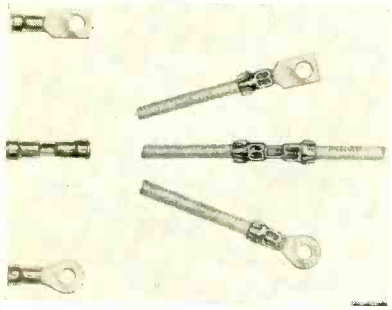
ADVANCED VACUUM PRODUCTS, INC., 122 Liberty St., Stamford, Conn., announces a new line of

solid pin headers, for use as electronic tube bases, that can withstand temperatures of 700 C. Pins of molybdenum, Monel, Kovar, copper-cored nickel can be hermetically sealed to 95 percent Al_2O_3 by brazing with silver, copper or nickel gold. **Circle 331 on Reader Service Card.**



Sweep Generator has high output

TEL-INSTRUMENT ELECTRONICS CORP., 728 Garden St., Carlstadt, N. J., announces the type 1105 radar-video sweep generator, a new test instrument for radar sweep checking. Featuring high output and very low harmonic distortion, the instrument provides for the observation of frequency-vs-amplitude characteristics of wide band circuitry, such as radar and video amplifiers and filters. Ten crystal-controlled frequency markers of 0.01 percent accuracy are provided to indicate one to 10-mc points. **Circle 332 on Reader Service Card.**



Terminals and connectors

AMP INC., Harrisburg, Pa., announces a new line of Strato-Therm high temperature, heat resistant terminals and connectors for

aircraft and missile circuits. The new line gives sound electrical and mechanical performance at continuous temperatures as high as 1,200 F and at cyclic temperatures as high as 2,000 F.

Both terminals and connectors provide fully circumferential support to the wire insulation for vibration resistance. Wire size range covers 22 through 10 Awg. The Strato-Therm line includes flag, spade, ring tongue, slotted tongue and rectangular tongue terminals as well as a complete line of parallel and butt connectors. A catalog is available. **Circle 333 on Reader Service Card.**

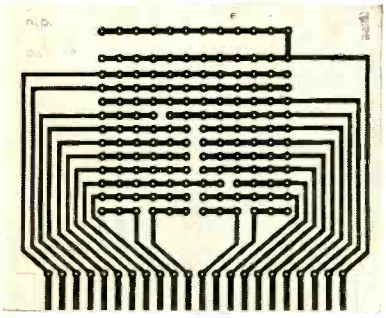
Ultrasonic Cleaner for lab, production

ALCAR INSTRUMENTS, INC., 17 Industrial Ave., Little Ferry, N. J., has a new ultrasonic cleaner for small part cleaning, blind hole washing, removal of radioactive contamination, p-c cleaning and the like. The electronic generator delivers 50 w of power to crystal transducers mounted on the bottom of the 6 in. by 6 in. by 6 in. stainless steel tank. It holds 2 quarts of liquid. Price is $350. **Circle 334 on Reader Service Card.**

Force Transducer with high output

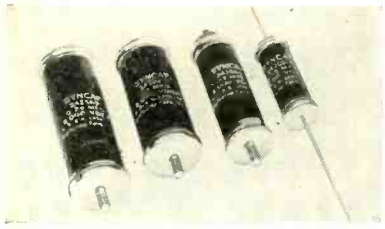
EDCLIFF INSTRUMENTS, P. O. Box 565, Monrovia, Calif. Model 9-1 differential transformer type force transducer features the high output

of 1.68 v full scale with input of 115 v a-c at 60 cps into a 5,000 ohm resistive load. Temperature drift and sensitivity at zero are maximum of 2 percent at full scale per 100 F. Present units have 75-lb or 240-lb capacity with a ring element design. Units weigh a maximum of 3 lb and are packaged in a case 3½ in. diameter by 2 in. (excluding connections). They meet or exceed the environmental requirements of MIL-E-005272B. **Circle 335 on Reader Service Card.**



Diode Board
for computers

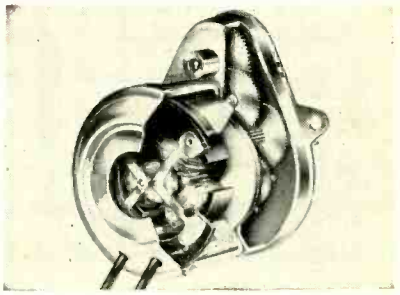
TECHNIQUES, 52 Jackson Ave., Hackensack, N. J. Computer designers will find packaging problems simplified by integrating the new compact diode board into equipments. It will find use in such applications as converting binary to decimal, straight decimal to binary coded decimal, and other notations. As many as 48 diode and resistor elements can be mounted on the p-c, 22 terminal plug-in board. Over-all board dimensions are 3½ in. by 4 in. by ⅛ in. **Circle 336 on Reader Service Card.**



H-V Capacitors
plastic film type

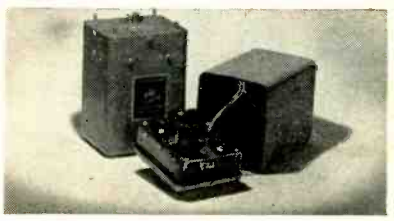
H. D. & K. LABS, INC., P.O. Box 172, Shelburne Falls, Mass. Syncap

is the trade name for a new line of glass encapsulated, hermetically sealed, h-v, plastic film capacitors. They were developed for use in low current power supplies, oscilloscopes, audio coupling and bypass, electronic computers and other h-v applications. Standard units are available in a voltage range of from 600 v d-c to 20,000 v d-c and with capacitance values of from 100 $\mu\mu$f to 1 μf. Temperature range is from −55 C to 65 C at full voltage rating, and may be extended to 85 C by derating to 70 percent. **Circle 337 on Reader Service Card.**



D-C Motor miniaturized

CRAMER CONTROLS CORP., Centerbrook, Conn. Type 800 d-c motor offers an extended range of output speeds, coupled with high torque, low current drain, and excellent speed stability. Output speeds range from 900 rpm to 2 rpd with gear train, and from 960 to 3,000 rpm without gear train, providing maximum torques of 30 oz in. and 0.6 oz in., respectively. Current drain may be as low as 30 ma, depending on the particular application. Voltage ratings are from 3 to 30 v d-c. **Circle 338 on Reader Service Card.**



H-V Power Packs transistorized

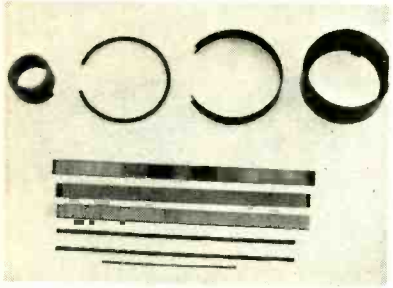
ELECTRONIC RESEARCH ASSOCIATES, INC., 67 Factory Place, Cedar

Grove, N. J. New miniaturized models of high voltage regulated power packs incorporate advanced circuitry and improved transistor types which permit full input voltage to be rapidly applied and disconnected abruptly without deterioration of performance. High surge current such as produced by sudden connection or disconnection of capacitances will not cause transient burnout. The units may be completely short circuited without damage to the semiconductors or other components. Circle 339 on Reader Service Card.

F-M Receiver covers 55-260 mc

Nems-Clarke Co., 919 Jesup-Blair Drive, Silver Spring, Md., announces type 1701-A f-m special purpose receiver. It is designed to cover a 55 to 260 mc range with an i-f frequency of 21.4 mc and an i-f bandwidth of 2 mc. Video response is 100 cps to 2 mc.

It is constructed for standard relay rack mounting. Circle 340 on Reader Service Card.



Wire Wound Windings simplify design

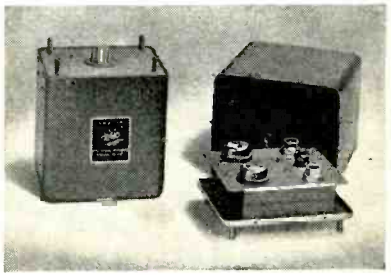
Brys Instrument Co., 7026 Sixth Ave., Brooklyn 9, N. Y., has announced a service created to provide greater flexibility for electronic

designers who have unique problems in electronics and mechanical design where precision wire wound windings are to be designed as an integral part of their systems. Potentiometer and resistor manufacturers will benefit. **Circle 341 on Reader Service Card.**

Audio Tube hum-free

CBS-Hytron, A Division of Columbia Broadcasting System, Inc., 100 Endicott St., Danvers, Mass., announces the 7025 twin triode with folded-coil heaters. The new tube was developed for original equipment and replacement use in high-fidelity amplifiers where it is said to minimize hum and noise generation.

A high-mu double triode, the 7025 is ruggedly constructed and utilizes precise grid and mica tolerances for consistently low microphonism. **Circle 342 on Reader Service Card.**



Inverters transistorized

Electronic Research Associates, Inc., 67 Factory Place, Cedar

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MEMO:

NEW PRODUCTS RELEASES

TO: ALL MANUFACTURERS

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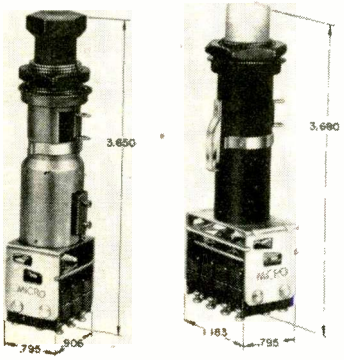
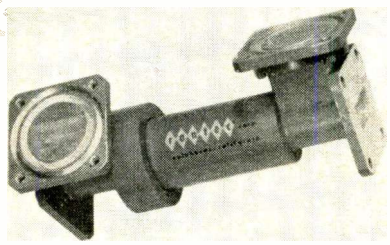
Grove, N. J., has a line of high power transistorized inverters with ratings from 100 w up to several kva. These units transform low voltage d-c to either 60 cps or 400 cps a-c and completely eliminate the drawbacks of vibrating or mechanical equivalents. They are self-starting, diode stabilized designs, which use special "E" core magnetic circuits. **Circle 343 on Reader Service Card.**



Pushbutton Switch
wide selection

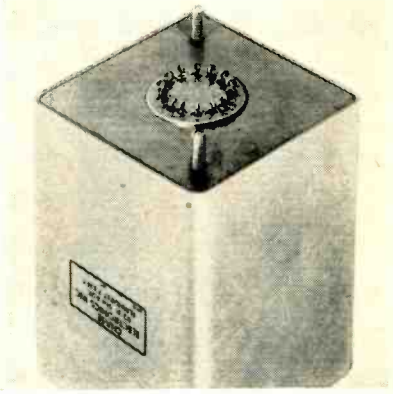
MICRO SWITCH, a division of Minneapolis-Honeywell Regulator Co., Freeport, Ill., announces the 50PB line of precision lighted push button switches. Short-stroke momentary, long-stroke momentary, alternate-action, two position alternate-action, magnetically held and turn-to-hold switches are available. **Circle 344 on Reader Service Card.**



Circulator
light and rugged

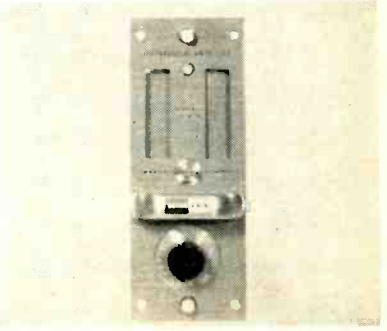
RANTEC CORP., P.O. Box 18 Calabasas, Calif. Model RX810C circulator is a broadband, compact, four part device utilizing the principle of Faraday rotation of the plane of polarization of microwave

energy. The design is a compromise between size and bandwidth, being 4⅛ in. long and operating over the band 8.4-10.2 kmc with a minimum of 13 db isolation and 0.35 db insertion loss. The circulator is extremely light, rugged, and can be pressurized to 30 psig. Circle 345 on Reader Service Card.



Magnetic Amplifier push-pull types

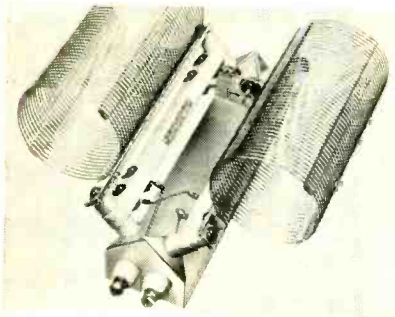
Chase Electronics, Inc., 82-31 51st Ave., Elmhurst 73, N. Y. Model CE-21 is a sensitive push-pull magnetic amplifier for operating twin loads such as p-p magnetic amplifier power stage, having two control coils differentially connected, a polarized relay of differential type, etc. Complete specifications are available. Circle 346 on Reader Service Card.



D-C Amplifier differential type

KinTel, a division of Cohu Electronics, Inc., 5725 Kearny Villa Road, Box 623, San Diego 12, Calif., announces the model 114A

differential d-c amplifier in which the input and output are each completely isolated and completely floating. The transistorized unit provides extremely high common-mode rejection, very low drift, high output capability, and excellent stability and linearity . . . all unaffected by load or gain changes. Complete specifications are available. **Circle 347 on Reader Service Card.**



Balun Coil Kit with wiring data

BARKER & WILLIAMSON, INC., Canal St., & Beaver Dam Rd., Bristol, Pa. Model 3976 balun coil kit utilizes a single compact mounting bracket with coils mounted at 90 deg. It is suitable for connecting either 75 ohms unbalanced to 300 ohms balanced, or 75 ohms unbalanced to 75 ohms balanced. The air-wound bifilar coils are designed for operation on the 80 through 10 meter bands without tuning. Unit has a rating of 1 kw on ssb, 500 w c-w and 250 w maximum a-m phone. **Circle 348 on Reader Service Card.**

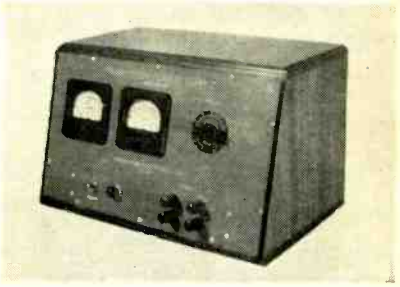
Measuring Bridge for high voltage

RENUPP CO., 3457 Greenfield Ave., Los Angeles 34, Calif., announces type 2801 Schering's commutable

precision measuring bridge for high voltage. The unit is used for capacity and dielectric loss measurements of all sorts of capacitors. This bridge allows measurements at service voltages and frequencies. **Circle 349 on Reader Service Card.**

Lab Drying Oven priced at $55

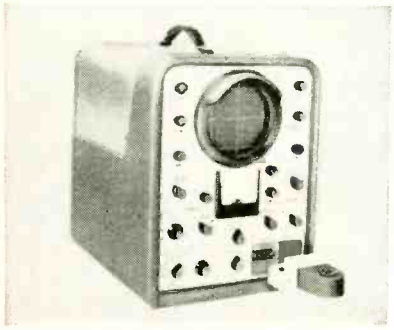
GRIEVE-HENDRY CO., INC., 1401 W. Carroll Ave., Chicago 7, Ill. Model LO-200-C is a constant temperature laboratory oven with temperature range to 200 C (400 F), with shelves adjustable for height every half inch. The oven has features which make it ideal for drying, baking, annealing, sterilizing, evaporating and heat treating. Inside dimensions are 12 in. wide by 10 in. deep by 10 in. high. **Circle 350 on Reader Service Card.**



Power Supplies for transistor field

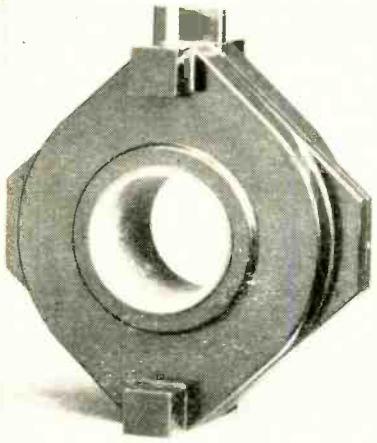
FERROTRAN ELECTRONICS CO., 693 Broadway, New York 12, N. Y., has developed two series of tubeless power supplies with special application to the transistor field. Used in the transistor lab, they can operate high powered audio amp-

lifiers, i-f amplifiers, converters, and inverters. In the radar, guidance, tv and radio labs, they can be used as sources of d-c filament voltage, magnetic amplifier supply voltages, bias voltages, and the like. Circle 351 on Reader Service Card.



Relay Analyzer
fast and accurate

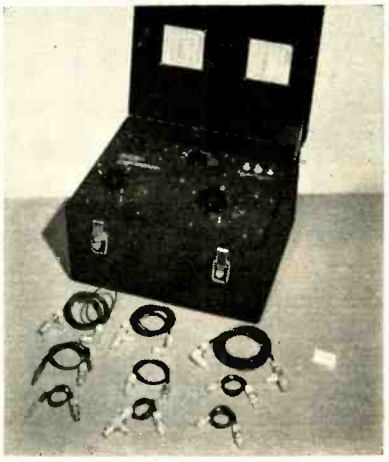
Schmeling Electronics, 20 First St., Keyport, N. J. Model 140 universal relay analyzer provides fast, accurate testing of relays under actual contact loading including dry circuit switching. It checks every phase of relay operation. A cycling circuit permits automatic cycling of the relay at a rate selected by the operator. Adapters to accommodate various relay types may be plugged into the front panel. Circle 352 on Reader Service Card.



Charging Chokes
new design

Osborne Electronics Corp., 712 S. E. Hawthorne Blvd., Portland,

Ore., announces new charging chokes for electronic systems. In the construction of this charging choke, the company has developed a new encapsulating technique to provide a casting that would withstand a temperature range from −40 C to +105 C. The layer-wound coil is encapsulated in a special material developed to resist corona effects as well as voltage and temperature shock. Circle 353 on Reader Service Card.



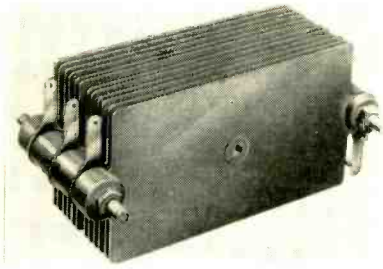
Fuel Gage Tester
accurate to 0.1%

TELECTRO INDUSTRIES CORP., 35-16 37th St., Long Island City 1, N. Y. The MD-1 is designed to test and calibrate aircraft capacitance type fuel gages, and qualifies under MIL-T-8579. It is a direct reading, precision variable capacitor with a range from 10 to 6,200 $\mu\mu$f. Through the use of a main dial and a vernier dial, the technician can easily read all capacitance values in increments of 0.1 $\mu\mu$f. Circle 354 on Reader Service Card.

Inverter Supply
transistorized

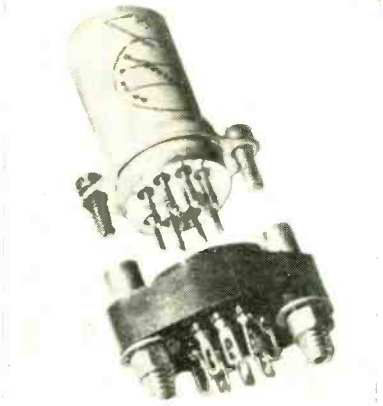
MAGNETIC AMPLIFIERS, INC., 632 Tinton Ave., New York 55, N. Y. Model SIS-40311 static inverter

supply is a high accuracy d-c to 400 cycle inverter. Frequency accuracy as high as 0.01 percent is offered. The diminutive size (2 lb), ruggedness and high accuracy of this component make it valuable for use with computers, ballistic missiles, radar systems and aircraft. Further details are given in bulletin S864. **Circle 355 on Reader Service Card.**



Selenium Rectifiers
high temperature

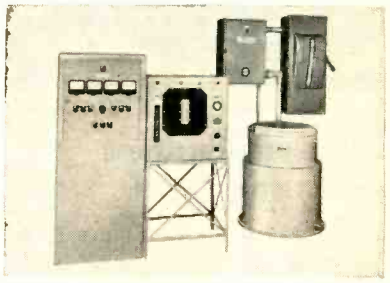
INTERNATIONAL TELEPHONE AND TELEGRAPH CORP., 100 Kingsland Road, Clifton, N. J., has a new line of Federal high temperature selenium rectifiers, engineered for specific applications to 28 v d-c aircraft power supplies, where ambient temperatures range from −65 to + 125 C. They provide high electrical output per unit of weight and volume, and good voltage regulation from 20 to 200 amperes typical output. **Circle 356 on Reader Service Card.**



Plug-In Relay
rugged device

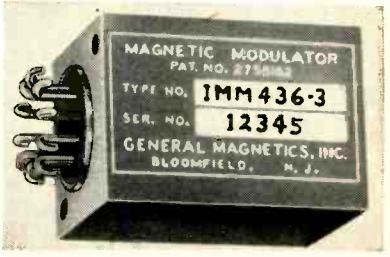
HI-G, INC., Bradley Field, Windsor Locks, Conn. New HG-2SMP series relay is a plug-in unit with an

asbestos filled melamine socket designed specifically for performance exceeding standard socket units. Rotary action and rugged construction make this unit suitable where reliability and rapid interchangeability are required. Contacts are rated up to 5 amperes and 250 v with coil operating voltages of 6 to 115 v a-c or d-c. Contact arrangement is 1 or 2 pdt. Sockets are available with several types of gold plated terminals, and can be mounted above or below chassis. **Circle 357 on Reader Service Card.**



Induction Heaters
wide applications

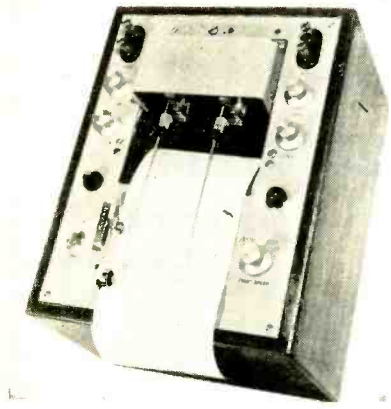
ROBOTRON CORP., 21300 West Eight Mile Road, Detroit 19, Mich. A full line of induction heating units is available in three frequency ranges: low frequency, 7½ to 1,750 kw, 1-10 kc, motor generator powered; medium frequency, 3 to 50 kw, 450 kc, electronic generator equipped; and high frequency, ¾ to 20 kw, 27.1 mc, electronic generator equipped. **Circle 358 on Reader Service Card.**



Magnetic Modulator
miniaturized unit

GENERAL MAGNETICS INC., 135 Bloomfield Ave., Bloomfield, N. J. A new line of miniaturized magnetic modulators is especially engi-

neered for printed circuit wafer designed structures and circuit assemblies, New "Mag Mod" components offer design advantages including: (1) faster time relay; (2) negligible hysteresis; (3) extreme stability — ambient temperature range from — 65 C to + 135 C; (4) compact size; (5) light weight; (6) infinite life for complete reliability. Circle 359 on Reader Service Card.



Strip Chart Recorder direct-writing

MANDREL INDUSTRIAL INSTRUMENTS, 5134 Glenmont Drive, Houston, Texas. The ER-20 direct-writing strip chart recorder is designed for recording electrical data from d-c to 100 cps. Featuring direct-coupled amplifiers which give a sensitivity of 2 mv/mm, it is priced at $550 including amplifiers. Stylus deflection on each channel is 40 mm, with an accuracy of 2 percent. Electrosensitive paper eliminates the need for any inking system. Circle 360 on Reader Service Card.

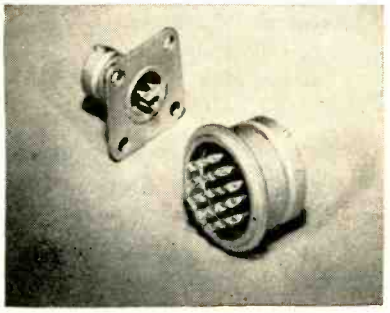
Capacitor Test Chamber self-contained, portable

CONRAD, INC., 141 Jefferson St., Holland, Mich., has a new design capacitor coefficient testing chamber. It has an adjustable indicating temperature control for the range of + 150 C to — 70 C, with proportioning action for heating or cooling demand, whichever is being controlled. This equipment permits stability of items on test to

as close as ± 1/10 F, as measured with static load conditions. Circle 361 on Reader Service Card.

Recorder
dual-channel unit

BRUSH INSTRUMENTS, Division Clevite Corp., 3405 Perkins Ave., Cleveland, Ohio. The Mark II dual channel recorder is claimed to be a practical production tool to be used on many work benches where direct writing recording has previously been considered too complicated and expensive. It provides immediately visible, permanent chart recordings on two channels over a wide amplitude and frequency range (d-c to 100 cps). Oscillograph and amplifiers are incorporated as an integral unit operated by connecting its one power cord to any a-c outlet. Sensitivity is 10 mv per chart line. Circle 362 on Reader Service Card.



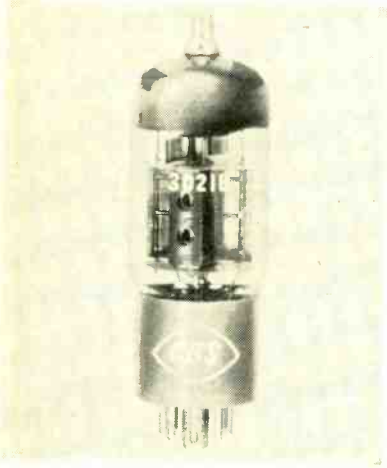
Tiny Connectors
give true sealing

THE DEUTSCH CO., 7000 Avalon Blvd., Los Angeles 3, Calif. Two new series of miniature electrical

receptacles—the DM5600 and DM-5606—are available. Units are designed to give true hermetic sealing against high g forces, heat and cold extremes, pressure and atmospheric variations, vibration and corrosion.

The hermetic seal is obtained by a Deutsch process in which special alloy conductor pins are fused in a furnace with compression glass insulation into a specially designed steel shell.

Available in standard and square flange types, the units mate with the DM6502 rack and panel plug and DM9700 series miniature push-pull plugs. Circle 363 on Reader Service Card.



Beam Power Tube compact, economical

CBS-Hytron, Parker St., Newburyport, Mass., announces the new USN-3D21B pulse modulator, a compact, economical beam power tube capable of delivering 21 kw in 10 μsec pulses. The 3D21B may also be used as a h-v blocking oscillator, hard switch tube, deflection amplifier, and regulator or pass tube in h-v supplies.

The tube features an open-type plate of large area for high thermal dissipation, a non-warping cathode, and gold-plated special alloy grids with heavy side rods and oversize heat radiators.

A button stem and large leakage slots in the support micas contribute to its h-v capabilities; the tube is rated to withstand a plate pulse voltage of 5 kv. Circle 364 on Reader Service Card.

Literature of

MATERIALS

Infrared Transmitting Materials. Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, N. Y. A new brochure provides revised comparative information on 15 different infrared transmitting materials suitable for use as optical elements. Transmission curves are included for the 11 most important materials. **Circle 365 on Reader Service Card**

COMPONENTS

Crystal Filters. Burnell & Co., Inc., 10 Pelham Parkway, Pelham, N. Y. A 4-page brochure includes technical data, typical and representative curves of crystal filters that have been developed and are manufactured by the company. Symmetrical band pass filters, asymmetrical or ssb filters, narrow band and wide band filters are described. **Circle 366 on Reader Service Card.**

Magnetic Shields. Magnetic Shield Division Perfection Mica Co., 1322 North Elston Ave., Chicago 22, Ill. Data sheet 135 illustrates and describes the new multi-laminae, smaller space factor, hydro-formed complex configuration, non-shock sensitive, non-retentive Netic Co-Netic magnetic shields for guidance control devices. **Circle 367 on Reader Service Card.**

P-C Standards. Cleveland Metal Specialties Co., 1783 E. 21st St., Cleveland 14, Ohio, has published a book entitled "Military Standards For Printed Circuits". Price is 75 cents to defray handling and postage charges. **Circle 368 on Reader Service Card.**

Servo Catalog. Daystrom Transicoil Corp., Worcester, Montgomery County, Pa. A 22-page catalog describes the company's complete line of servo motors, motor generators and synchros. A photographic description of the facilities and service available at the company

the Week

are also included. Circle 369 on Reader Service Card.

Solid Delay Lines. Anderson Laboratories, Inc., 501 New Park Ave., West Hartford, Conn., has issued a 4-page bulletin describing their facilities for research, design and manufacture of specialized high quality ultrasonic solid delay lines. Circle 370 on Reader Service Card.

EQUIPMENT

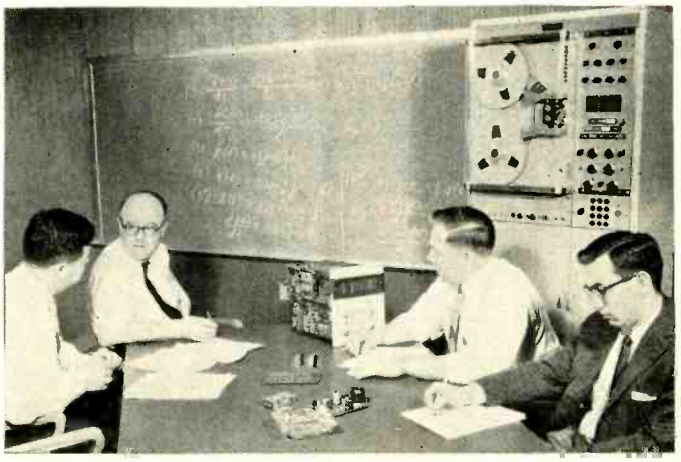
Digital Modules. Computer Control Co., Inc., 92 Broad St., Wellesley 57, Mass. Catalog T contains 14 pages of descriptive information and technical specifications on the new transistorized T-PAC one megacycle digital modules. Availability of the company's services is also noted. Circle 371 on Reader Service Card.

Ferromagnetic Computing Amplifier. Airpax Products Co., City of Plantation, Ft. Lauderdale, Fla. A four-page folder has been issued as a supplement to bulletin 221. It contains tentative ratings and specifications for 60-cps Ferrac amplifiers. Circle 372 on Reader Service Card.

Pulse Handling Instruments. Rutherford Electronics Co., 8944 Lindblade St., Culver City, Calif., has issued a comprehensive catalog of their pulse handling instruments. It lists two types of time delay generators and four basic types of pulse generators with several modifications thereof. Circle 373 on Reader Service Card.

FACILITIES

Cable Systems. Robertshaw-Fulton Controls Co., 401 N. Manchester, Anaheim, Calif. Facilities and capabilities of a new custom electronic cable manufacturing center for missile and aircraft requirements is explained in technical bulletin RF-582. Circle 374 on Reader Service Card.



EAI Enters Control Fields

ELECTRONIC ASSOCIATES, INC., Long Branch, N. J., enters the automatic data processing and process control fields by forming a control instrumentation section within the company's engineering department. Heading the new group is German physicist Wolfgang Harries, pictured (second from left) with other members of the new section—Irving Bogner, D. A. Baumann and Stephen Marcy.

EAI president Lloyd F. Christianson points out the company has gained much information about process operation and control requirements in various industries. The firm's experience over the years came largely through simulation and analysis of customers' problems at its various computation centers. Present plans call for close liaison between the control instrumentation section and the computation center personnel, to offer maximum benefit to customers.

In speaking of the control instrumentation group, Harries said it would be concerned with data logging, closed loop control systems, computer entry, and computer linkage systems.

He revealed that for more than a year EAI has been conducting an intensive development program on such items as low level amplifiers, transducer calibration units, electronic multipliers, voltage-digital converters, universal digital logic elements, and controlled format digital tape recorders. All of these systems building blocks employ solid state techniques and are designed for maximum flexibility.

Typical of contracts in process says the company, is a system which automatically scans and digitizes the outputs of numerous vapor chromatographers and prepares the digital information for computer analysis. "This system is particularly interesting because it will significantly increase reactor efficiency in a petroleum plant by faster and more precise analysis of reactor products," Harries explains.

He notes that his group will also be concerned with military applications.

MM&M Appoints

NEW manager of application engineering for the industrial controls division of Manning, Maxwell & Moore, Inc., is Edmund R. Lehmann. Previously he was with Fisher & Porter (Canada) Ltd., and McColl-Frontenac Oil Co. He is a past president of the Montreal, Quebec, chapter of the Instrument Society of America.

Data-Controls Adds to Staff

FIVE personnel additions to the recently formed Data-Control Systems Inc., Danbury, Conn., are announced.

F. E. Farris, formerly with Philips Electronics Inc., becomes assistant to the president.

David Zeller, Owen J. Ott and Clark A. Denslow, all previously associated with Electro-Mechanical Research Corp., join the company as research engineer, senior research engineer and industrial engineer, respectively.

Joseph H. Marchese, formerly with Kaman Aircraft Corp., is hired as research engineer.

Data-Control Systems is now initiating production of proprietary products in the missile telemetry field. Present plans envisage the development of information handling systems together with improved components for these systems.

Set Up New Firm In California

HAVING left their positions with the U. of California, Radiation Laboratory, W. M. Brobeck and C. E. Andressen, Jr. recently formed their own organization in Oakland, Calif. The new firm, William B. Brobeck & Associates, will specialize in engineering research, design and development.

Name Schooley To New NRL Post

APPOINTMENT of Allen H. Schooley (picture) as associate director of research for electronics at the U. S. Naval Research Laboratory is announced. He succeeds Robert M. Page, now director of research.

Schooley had recently resumed his position as superintendent of

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We would like to send you more detailed specifications for the instruments pictured. May we?

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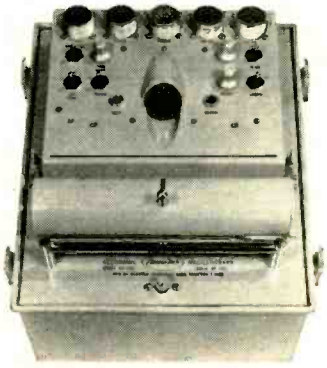

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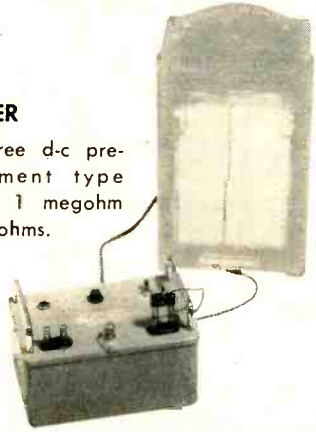

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DYNASTROKE LINEAR FORCE MOTOR

0.5 milliwatts / gram, 0.05% accuracy, moving-coil movement.

$35.00

NRL's electronics division after a year's leave of absence. During this time, he served under the terms of the Mutual Assistance Pact as an advisor to the Brazilian Navy in matters related to the establishment of a Brazilian Naval Research Institute in Rio de Janeiro.

Name Harcher Works Manager

RECENT appointment at Clevite Transistor Products, Waltham, Mass., moves Albert J. Harcher (picture) from production manager to the position of works manager.

Harcher was formerly associated with CBS-Hytron, as plant manager for both the Newburyport and Kalamazoo tv picture tube operations. Earlier he had served the company as temporary plant manager in Lowell, Mass., and as chief engineer in charge of developing rectangular tv picture tubes.

Sylvania Buys More Land

TWENTY-SIX acres of land in Santa Cruz, Calif., were recently purchased by Sylvania Electric Products, Inc., for future expansion of its computer component manufacturing operations. Since last November, the company's Sylvania Electronic Systems division has been operating a small facility, employing 25 manufacturing people,

in leased quarters at Santa Cruz.

Gordon McClure, manager of the present operation, said the company has no immediate plans for construction. Size of the operation and number of employees needed are still to be determined.

Helms Joins Giannini

NEW chief engineer of the Giannini Transducer Division, Pasadena, Calif., is Walter Helms. He comes to his new post from Dallas, Texas, where he held a number of design and supervision engineering positions with Chance Vought Aircraft, Inc.

Fenwal Gets New Sales Manager

H. J. ANDREWS (picture) has been promoted from sales engineer to sales manager of Fenwal Electronics, Inc., Framingham, Mass. He will be responsible for all company sales, including precision thermistors, custom designed thermistor probes and assemblies and special high precision temperature indication and recording instruments.

Little Takes New Position

PHILLIPS PETROLEUM Co. hires Richard I. Little as electronics engi-

neer with its atomic energy division.

The company operates the Idaho chemical processing plant, the engineering test reactor, the materials testing reactor, and the special power excursion reactor test facilities for the AEC at the National Reactor Testing Station west of Idaho Falls.

Executive Moves

Carroll M. White, manager of EIA's Mobile Radio Communication, has resigned to accept a position as executive secretary of the Special Industrial Radio Services Association (SIRSA), effective July 1, 1958.

Harry P. Troendly is upped to group vice-president of Borg-Warner Corp., Chicago, Ill. He comes to the central office management group from the corporation's Spring Division where he had been president since 1953.

Plant Briefs

Pecar Electronics, sound equipment distributors, has moved to larger quarters at 11201 Morang at Somerset, Detroit 24, Mich. The new location, with 7,000 sq ft of floor space marks the seventh major expansion in the past 12 years.

Nems-Clarke Co., Silver Springs, Md., announces expansion of floor space 21,000 sq ft in an adjacent building.

Eo Electronics, Inc., manufacturers and developers of electronic instruments, has moved into its newly completed plant located at Morris Ave., Mountain Lakes, N. J.

Peschel Electronics, Inc., h-v test equipment specialists, moves its office and plant to a newly acquired 204-acre site in Towners, N. Y.

F. J. Stokes Co. of Canada, Ltd., Canadian subsidiary of F. J. Stokes Corp., Philadelphia, Pa., has moved its Toronto headquarters to 4198 Dundas Street West.

Heath Co., a subsidiary of Daystrom, Inc., moves to a larger plant

Using Thermistors

Edited by

FENWAL ELECTRONICS

Thermistors are "thermal resistors" with a high negative temperature coefficient of resistance — semi-conductors with amazing sensitivity.

Thermistors discussed here — for liquid level measurement and as altimeters.

Liquid level measurement: When a thermistor is suspended in air in series with a light bulb and battery, the bulb lights, because the thermistor heats and resistance drops, permitting current to flow to the bulb. Reversing this process, a thermistor submerged in a liquid (Fig. 1) cools, extinguishing the light. This is a liquid level indicator. A liquid level control substitutes a relay for the light bulb.

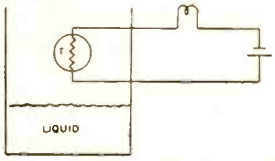


Fig. 1

Altimeter: A hypsometer, an extremely sensitive altimeter, is a thermistor placed at a liquid's surface (Fig. 2); thermistor resistance is a function of the liquid's boiling point, which depends on the altitude. A hypsometer of this type can measure altitude from sea level to over 125,000 feet with precision better than 1% of the measured pressure.

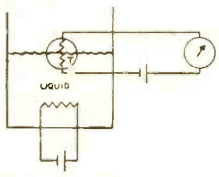


Fig. 2

Designers: If you are considering thermistors, write for more information about their tremendous possibilities to FENWAL ELECTRONICS, INC., 24 Mellen St., Framingham, Mass.

Fenwal Electronics

Design — Engineering — Production of Precision Thermistors

CIRCLE 122 READERS SERVICE CARD

in Benton Harbor, Mich. The manufacturing operation, formerly occupying seven buildings, is now carried on in a new 140,000-sq ft building.

Remington Rand Univac, Division of Sperry Rand Corp., relocates its purchasing division to Plant One in Univac Park, St. Paul, Minn. At this time, its facilities in Plant Eight on North Prior Ave. are closed.

News of Reps

MANUFACTURER'S reps, **Mosher & Peyser** of Needham, Mass., now handles sales of fabricated plastic and metal parts in the six New England states for Universal Unlimited of Glen Cove, L. I., N. Y.

William J. Herbert is appointed by the **T. Louis Snitzer Co.**, electronics manufacturers' reps of Los Angeles, Calif., to head the company's new San Diego area office in La Jolla, Calif. He was formerly an electronic engineer with the U. S. Navy Electronics Lab in San Diego.

Electro Tec Corp., South Hackensack, N. J., slip ring assembly and precision component manufacturer, names **Service Equipment Electronics Co.** as representative for its Ohio and Michigan territory.

The **Carl G. Chafin Co.** is appointed by WYCO Metal Products of North Hollywood, Calif., to represent them in San Diego and Imperial counties. Rep firm will sell WYCO's line of racks, panels, cabinets and chassis for the electronic industry.

Vines and Company will sell the line of amplifiers for Instruments For Industry, Inc., Mineola, N. Y., in the states of Utah, Wyoming and Colorado.

Sales of General Transistor Corp. products will be handled by **Hollingsworth and Still** in the southeast U. S., including Alabama, Georgia, Florida, Tennessee, North and South Carolina.

NEW BOOKS

Passive Network Synthesis

By J. E. STORER
McGraw-Hill Book Co., New York, 1957, 319 p, $8.50.

In recent years network synthesis has become an essential part of electrical communications; strangely, however, in the last decade not a single text has appeared on the subject. As a result, a great need has existed for some time, both in industry and in the graduate schools, for such a text. Storer's book is the first to fulfill this need; others are in preparation.

The author assumes familiarity with network analysis, he discusses the realizability conditions giving simple proofs. He covers the basic synthesis techniques for driving point and transfer functions, and treats briefly the approximation problem.

Driving Point Impedance—The book is divided into four parts. In the first part the properties of the driving point impedance are stated and proved from energy considerations. These proofs establish the desired results in a simple way; however, since they do not show the relationship between the impedance function and the network matrix, they lead only to limited results. Methods for testing the realizability conditions are covered briefly.

Driving point synthesis of two element networks leading to the Foster and Cauer forms is given and their relationship to Hurwitz polynomials is established. The Brune and Bott-Duffin method of synthesis is discussed with a brief mention of the Miyata approach.

Realizability conditions of a two-pair-terminal matrix are developed and the Cauer method of synthesis of a reactive matrix is presented, followed by the Darlington method.

The second part of the book covers the image parameter method, frequency transformations, lattice analysis and properties, constant resistance synthesis, and maximally

flat delay lines. The purpose of this part is not clear; the image-parameter method is treated in many undergraduate texts and the topics on frequency transformation and delay lines are part of the approximation problem.

Synthesis Techniques—The third part gives a good coverage of the important synthesis techniques for transfer functions; however, their properties are treated lightly. The realizability conditions are first established, followed by the Darlington and Weinberg methods. The ladder forms of l-c and r-c networks are developed and the Guillemin method for general r-c networks is presented. A brief discussion of synthesis using active networks is also included.

Approximations—In the last part the approximation of a given response by realizable functions is considered; the approximation problem in the frequency domain is introduced and its solution by expansion into orthogonal polynomials is attempted. The potential analogy method is presented and applied to the filter problem with the Butterworth and Tchebycheff responses as applications. The final chapter gives a short discussion of time domain approximations.

The last part is not as clearly and simply presented as the other three; with the phase and time domain synthesis neglected, the material is not well balanced and the selection of the various methods is rather arbitrary. However, this is due mainly to the state of development of this relatively new field.

The book is well written and can be easily read without much preparation; its simple and complete coverage of the important realization techniques illustrated with many examples and developed with the minimum of supporting material will make it a valuable reference to the practicing engineer. For the graduate student it will serve as an introduction to the basic concepts of network synthesis. — ATHANASIOS PAPOULIS, *Polytechnic Institute of Brooklyn, N. Y.*

COMMENT

On Sidebands . . .

The article "Selection of Modulation for Speech Communications" by George J. Kelley (Mar. 28, p 56) covered the various aspects of f-m, a-m, suppressed-carrier SSB and suppressed DSB quite thoroughly. However, no mention was made of an SSB system which transmits a small pilot carrier for the purpose of phase-locking the receiver oscillator. This system, known as synchronous single-sideband, has many applications in communications systems. Its main advantage lies in the fact that, because of the transmission of the pilot carrier, the frequency stability required of the system can be reduced considerably.

Because the receiver oscillator is phase-locked to the transmitted pilot carrier, the frequency of the receiver oscillator is made identical to the frequency of the pilot carrier, with the result that the sidebands are detected with no frequency error. It is our experience that this system rates very highly on the many characteristics that are evaluated by Mr. Kelley.

The synchronous single-sideband system has its main application in the vhf region where the application of suppressed-carrier SSB would require a frequency stability which is beyond the present state of the art.

It is not clear why the author assigns equal bandwidth to every system covered in the paper. It would seem feasible to make the bandwidth of the SSB system one half the bandwidth of the other three. Since spectrum conservation is extremely important, this could be a most important factor in the decision as to which system should be employed for a given communication problem. Instead of being assigned a weighting factor of zero as indicated in Fig. 3 of the paper, it could probably carry the greatest weight of any of the various factors listed.

With regards to the performance of the various systems for various degrees of speech clipping, it seems impractical to consider clipping below the 11 db clipping level as indicated in Table II of the paper. The amount of distortion introduced by clipping below this level increases rapidly with the result that the reproduced speech signal has a very definite disagreeable quality.

Roy A. Richardson
Motorola Inc.
Chicago, Ill.

. . . and Standing Waves

An error has been noted in "Standing Wave Ratio Conversion Chart" by John Lory (Jan. 31, p 56). Equation 5 derived by the author does not apply to power standing-wave ratios as he asserts, but rather to voltage standing-wave ratios.

The expression for the measured value of the power standing-wave ratio is

$$\rho' = \frac{P'_i + P'_R}{P'_i - P'_R}$$

where P'_i and P'_R are the magnitudes of the incident and reflected powers at the measuring site. The incident and reflected powers at the load are P_i and P_R. Mr. Lory erred when he used P_i rather than P'_i in his equation 3, corresponding to the equation above.

Accounting for an insertion loss K,

$$P'_i = \frac{P_i}{1-K} \quad \text{and} \quad P'_R = (1-K)P_R.$$

The standing-wave ratio characterizing the load is

$$\rho = \frac{P_i + P_R}{P_i - P_R}$$

and the correct relationship between the measured and actual values of power standing-wave ratios becomes

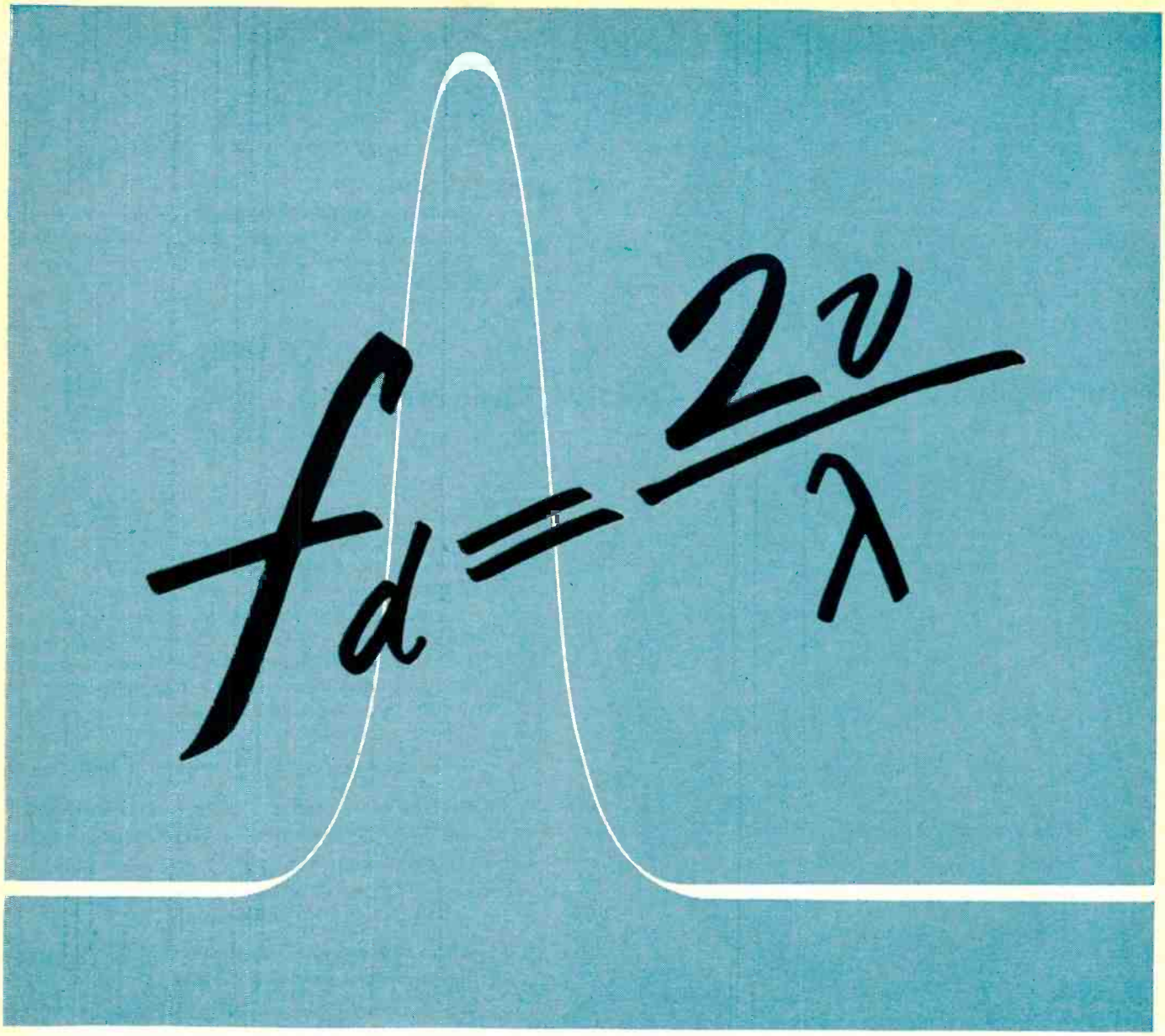
$$\rho' = \frac{2\rho - (\rho - 1)(K)(2 - K)}{2 + (\rho - 1)(K)(2 - K)}$$

William H. Nester
General Electric
Syracuse, N. Y.

. . . I have checked the derivation of my equations, and as Mr. Nester points out, an error was made.

Although the equations as they appear in the article are erroneous, the chart is correct if the axes are relabeled MEASURED VOLTAGE SWR and ACTUAL VOLTAGE SWR.

John Lory
Sperry Gyroscope
Great Neck, L. I., N. Y.



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INERTIAL GUIDANCE ENGINEER John V. Prikazsky tells why airborne computer development at IBM Owego, N. Y., offers him the creative engineering career he always wanted.

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Positions are at Syracuse and Utica, N. Y. facilities.

Please address your resume to Mr. E. A. Smith, Dept. 5-E

If your qualifications approximate job "specs," he will arrange a convenient interview.

MISSILE GUIDANCE SECTION

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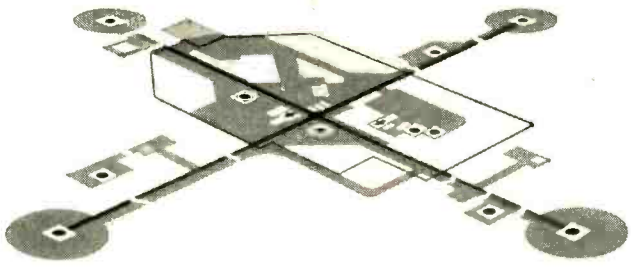
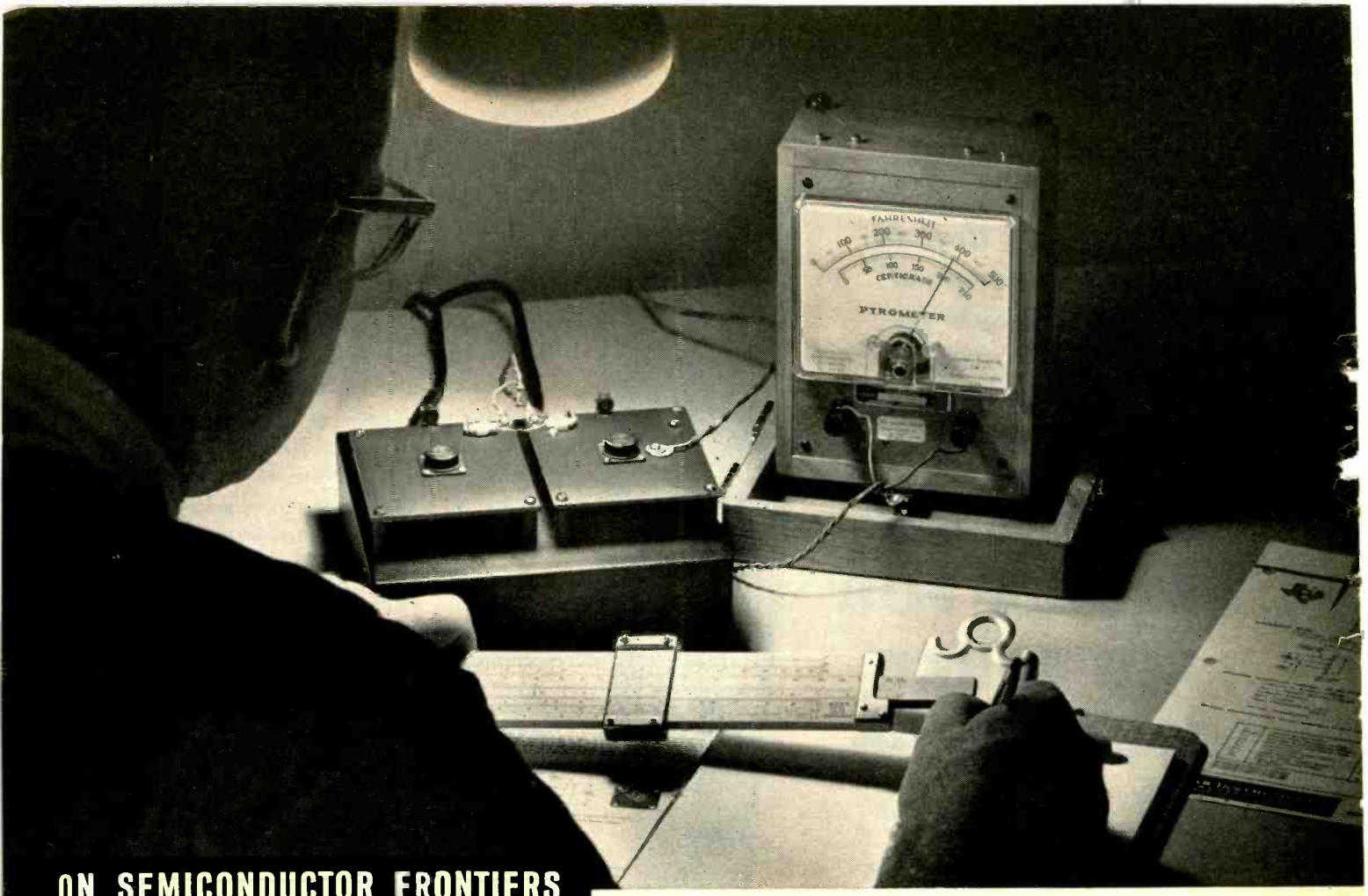


GENERAL ELECTRIC GUIDED MISSILE CONTROL FACILITY WS107A-1



ON SEMICONDUCTOR FRONTIERS

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On this frontier, there is plenty of room for electronic engineers, physical chemists, solid state physicists, and others to build America's electronic future. If *you* are interested in joining other leading engineers and scientists at the industry's most modern research, development and production facilities – write or call for more information on 28-year-old Texas Instruments, recognized leader of the semiconductor industry. You will discover up-to-date supplemental benefits – profit sharing, insurance, retirement programs, and company-sponsored educational assistance.

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PHYSICAL CHEMISTS

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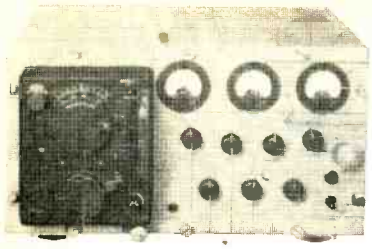

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TS-118 R.F. Wattmeter
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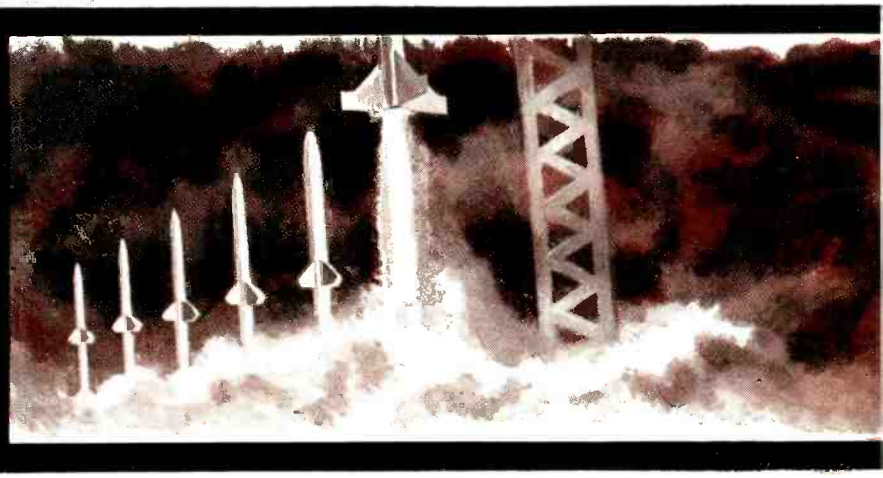

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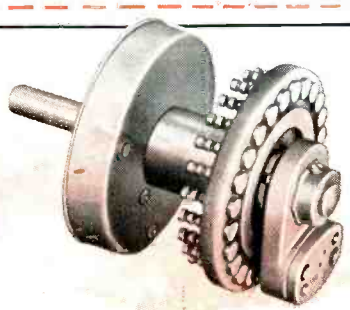

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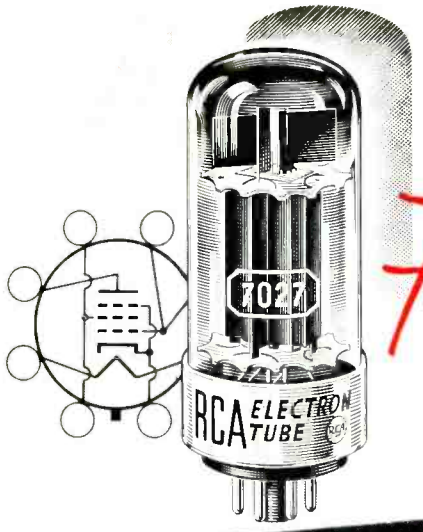

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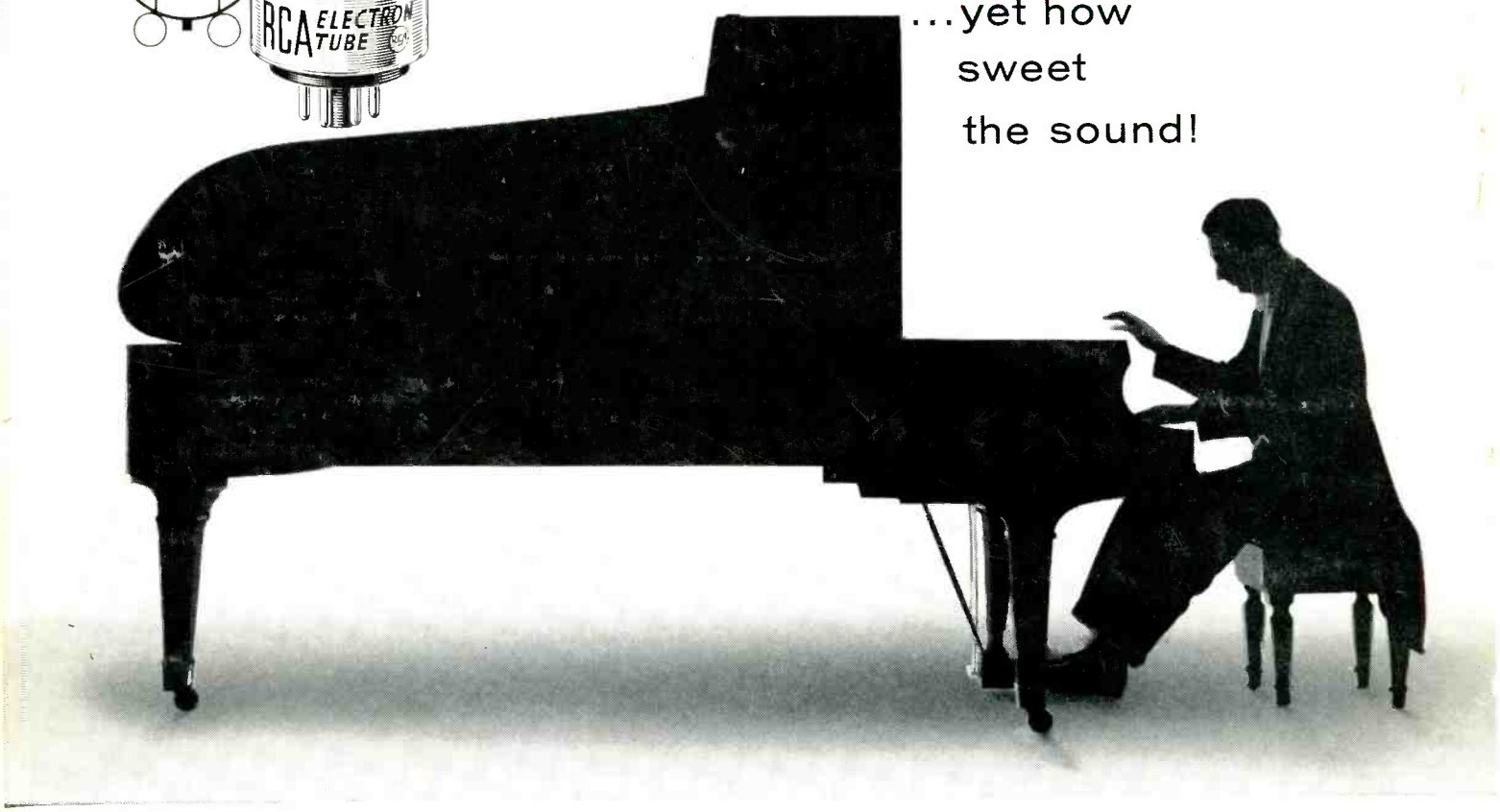

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